WORLD METEOROLOGICAL ORGANIZATION

# INTERNATIONAL CLOUD ATLAS

## Volume I

Revised edition 1975

# MANUAL ON THE OBSERVATION OF CLOUDS AND OTHER METEORS

(Partly Annex I to WMO Technical Regulations)

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NOTE

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## METEORS OTHER THAN CLOUDS

## PREFACE TO THE 1939 EDITION[1]

The first published[2] classification of clouds only dates back to the beginning of the 19th century and was the work of Lamarck (1802). This celebrated naturalist did not set out to classify *all* possible clouds; he confined himself to distinguishing certain forms which seemed to him to be the manifestation of general causes which it would be useful to recognize. But this work, in spite of its real value, did not make any impression even in France and his nomenclature does not seem to have been used by anyone. Perhaps this was due to his choice of somewhat peculiar French names which would not readily be adopted in other countries or perhaps the paper was discredited through appearing in the same publication (Annuaire Météorologique), as forecasts based upon astrological data.

One year later Luke Howard published in England a cloud classification which, in striking contrast, achieved very great success and which is the basis of the existing classification. Whereas Lamarck contented himself with defining and naming a certain number of interesting forms, Howard set out to establish a complete classification covering all possible cases. He distinguished three simple, fundamental classes—Cirrus, Cumulus, Stratus—from which all others were derived by transition or association. This conception is in some respects incorrect. If Cirrus and Cumulus are entitled to occupy a privileged position in the classification, the first representing the purest type of cloud formed of ice crystals in the high regions of the atmosphere, and the second being pre-eminently a cloud of liquid particles in the lower regions, what Howard calls Stratus does not constitute a type of the same order as the preceding two. It is not defined in terms relating to the physical state of its elements, and it may be found at any altitude. From a practical point of view, however, Howard arrived at much the same results as Lamarck. Four of Lamarck's five principal types appear under different names in Howard's nomenclature. It is remarkable that these two men, of such different scientific culture and never having come in contact with each other, should have arrived independently at such compatible results.

In 1840, the German meteorologist Kaemtz added Stratocumulus to Howard's forms, giving a precise definition which is in agreement with modern usage.

Renou, Director of the observatories at Parc Saint-Maur and Montsouris gave in his "Instructions météorologiques" (1855) a classification of clouds to which may be ascribed the definite origin of several names in the present nomenclature: Cirro-Cumulus, Cirro-Stratus, Alto-Cumulus and Alto-Stratus. He was the first to introduce the two latter types into the "Bulletin de l'Observatoire de Montsouris" and his example was soon followed by the observatory at Upsala. He thus introduced clouds of medium height between low clouds and those of the Cirrus family and began the development of the idea which resulted in the adoption of height as a criterion, established later by Hildebrandsson. To him is also due the definite distinction at different levels between detached and continuous clouds.

In 1863, Poey, who took observations at Havana, made known some original ideas which did not perhaps receive as much respect as they deserved, firstly because good and bad were so closely associated in them and also because he set out to create a classification of all types, without any reference at all to the main outlines which since Howard had been slowly but surely emerging from the successive attempts in Europe. It should, however, be remembered that credit is due to

[1] The preface to the 1939 edition was nearly identical with that of the 1932 edition. The modifications introduced into the text of the 1939 edition consisted of revised abbreviations of cloud forms, changes in the clouds code and changes in the symbols and descriptions of various weather phenomena.

[2] In this brief historical note, much use has been made of Louis Besson's very interesting work: *Aperçu historique sur la Classification des Nuages*, Mémorial de l'Office National Météorologique de France, No. 2, Paris 1923.

him for defining Fracto-Cumulus, some radiatus varieties (under the name of Fracto-) and mammatus varieties (under the name of Globo-). In particular, he described very clearly the central sky in a depression by distinguishing the two layers, one above the other: the sheet of Altostratus (under the name of Pallio-Cirrus) and the layer of Fractostratus or of Fractocumulus (under the name of Pallio-Cumulus).

In 1879, Hildebrandsson, Director of Upsala Observatory, was the first to use photography in the study and classification of cloud forms. In his work entitled: "Sur la classification des nuages employée à l'Observatoire Météorologique d'Upsala", he included an atlas of 16 photographs. The classification adopted was that of Howard with a few modifications. These changes concerned especially Nimbus, which was not assigned to every rainy cloud complex (notably not to Cumulo-Nimbus), but only to the dark, lower layer of a rainy sky, Stratus which was assigned to fog raised from the ground and remaining at some distance from the Earth and Cumulo-Stratus which, following Kaemtz's example, was assigned to heavy, heaped up masses of Cumulus; from Kaemtz, Hildebrandsson also adopted Strato-Cumulus. In his first work, Hildebrandsson kept closely to his desire to adhere to Howard's plan, but at the same time took later works into consideration.

A little later, Weilbach and Ritter proposed classifications too greatly divergent from Howard's (which in the main had already been generally accepted) to have any chance of success—as happened later in the case of those of Maze, Clayton and Clement Ley. Credit is, however, due to these authors for interesting definitions of species (subdivisions of large genera) or of varieties (particular aspects to be observed at different heights) and to Weilbach for the introduction of Cumulo-Nimbus or thunder cloud, clearly distinguished from Cumulus even when "compositus".

Finally in 1887, Hildebrandsson and Abercromby published a classification of clouds in which they endeavoured to reconcile existing customs and, while keeping to Howard's scheme, to effect an inclusion of later acquisitions, notably those due to Renou (introduction of Alto-Cumulus and of Alto-Stratus, distinction at each stage between the detached and continuous forms) and to Weilbach (introduction of Cumulo-Nimbus, the allocation of Cumulus and thundery clouds to a distinct family). Abercromby had previously made two journeys round the world (thus giving a fine example of scientific probity) in order to assure himself that the cloud forms were the same in all parts—a fact that is, however, only true as a first approximation. One of the principal characteristics of this classification is the importance attached to height as a criterion, since in the opinion of the authors the foremost application of cloud observations was the determination of the direction of the wind at different altitudes. They grouped the clouds in four levels, the mean heights of which they fixed provisionally from measurements made in Sweden. The international classification was the direct offspring of Hildebrandsson's and Abercromby's classification without any great modification.

The International Meteorological Conference, held at Munich in 1891, expressly recommended these authors' classification and gave its sanction to the appointment of a special committee entrusted with its final consideration and publication with illustrations in atlas form. This committee met at Upsala in August 1894 and proceeded to choose the illustrations to be reproduced. With this object in view, an exhibition of more than three hundred cloud photographs or sketches had been arranged. The publication commission, consisting of Hildebrandsson, Riggenbach and Teisserenc de Bort, had to contend with great technical and more particularly financial difficulties. In the end, Teisserenc de Bort took upon himself the sole responsibility for the production of the atlas which appeared in 1896. This work contained 28 coloured plates accompanied by a text in three languages (French, German, English) giving definitions and descriptions of the clouds together with instructions on how to observe them.

The classification laid down in the International Atlas soon became official and came into almost general use in all countries. Nearly all meteorologists who subsequently published cloud studies adopted this nomenclature; but frequently it was found to be lacking in details; thus a number of meteorologists—notably Clayden and Vincent—were led to create new species or varieties without interfering with the primary forms.

Thus, thanks to a sustained effort, initiated by Howard, continued by Renou and then by Hildebrandsson and the International Meteorological Committee, an end was made to the confusion which had reigned for nearly a century in one of the most important domains of meteorology. The first International Atlas constituted a great advance by making cloud observations throughout the world truly comparable with one another.

The 1910 reprint, which contained only slight modifications, had been exhausted for many years when the International Commission for the Study of Clouds was created in London in 1921. The President, Sir Napier Shaw, started the revision of the classification by bringing forward for discussion a memoir in which he gave his own personal ideas and appealed to all members to make suggestions; the enquiry thus set on foot grew so rapidly that in 1925, Sir Napier Shaw's successor thought it necessary to concentrate all the activities of the Commission upon the problem of the revision of the International Atlas.

This task had become necessary for several reasons. First of all, there was a very practical reason: it was becoming urgent that the observers should be supplied with new atlases lest the quality of the observations should degenerate and differences of interpretation reappear. But, in addition to this practical reason, there were also deeper ones: the work of 1896, remarkable as it had been at the time, was evidently not perfect. From the single, but essential point of view of the standardization of observations, the experience of thirty years had revealed several gaps and instances of lack of precision, which had led to incompatible traditions in different nations as regards certain points. Moreover, meteorology had developed considerably, especially since aviation had become general. When Teisserenc de Bort and Hildebrandsson published the first atlas, the principal problem they had in mind was the general circulation; they considered the clouds above all as aerial floats, capable of revealing upper currents, and were intent upon producing a classification which would make the different types of clouds correspond with heights determined as exactly as possible. But since that period, meteorologists had become more and more interested in clouds *as such*. The multiplication of cloud observations and the extended data included in synoptic messages—which received due recognition in the new international code, Copenhagen 1929—made possible direct synoptic studies of their distribution and paved the way for the idea of "sky" and "cloud system", the value of which had been clearly demonstrated by the International Cloud Week, organised by the Commission for the Study of Clouds in 1923.

Observations from aeroplanes made familiar cloud aspects which were previously unknown, made them known more intimately and more completely; finally, new theories normally based upon the hydrodynamical and thermodynamical interpretation of soundings determined their physical signification and their rôle in disturbances. These new and very interesting points of view had to be definitely recognised.

When the Commission for the Study of Clouds met in Paris in 1926 to take account of the results of the vast enquiry which it had inaugurated and to lay the foundations of a new atlas, it found itself confronted by an abundance of literature and very diverse suggestions. Very wisely, it adopted the principle that it should only touch with extreme caution a classification which had stood the test of years and been received as it were with unanimous agreement by our predecessors. It decided to make only such modifications as were necessary to dissipate misunderstandings and further the uniformity of observations, at the same time, however, laying less stress upon the importance of height as a basis of classification.

While recognizing the necessity of paving the way for a secondary classification, it took care not to attempt its completion nor to subdivide excessively the main categories henceforth called "genera"; it made a rule only to introduce "species" which were generally accepted by all, leaving the way clear for progressive additions in future. Having thus given witness to a prudent, conservative spirit and placed the work of 1896 in a secure position, the Commission for the Study of Clouds proceeded, on the other hand, to give practical satisfaction to the new spirit. Having from the outset considered it premature to attempt a cloud classification based upon physical properties —reserving the study of that question until after a new International Cloud Year (conceived in connection with and to be realized at the same time as the Polar Year 1932-1933)—it adhered to this attitude and refused to rely upon any theory, however attractive it might appear. Nevertheless, it decided to put on record information which had been acquired by observation in the sky or on the charts. Thus it was resolved to include:

(1) A chapter on the observation of clouds from aircraft for which the well-known work of Mr. C.K.M. Douglas, aviator as well as meteorologist, was largely drawn upon;

(2) A classification of "types of skies", based upon the cloud structures in depressions, as emerging from the work of the Norwegian and French schools; in order to mark the importance of this innovation, the title of the Atlas was altered to "International Atlas of Clouds and of Types of Skies".

The Commission for the Study of Clouds met a second time in Zürich in September 1926 to make definite arrangements for the projected atlas. Meanwhile, an imposing collection of photographs of clouds, skies and aerial views—borrowed mainly from the collections of Messrs. Cave, Clarke and Quénisset and of the Fundacio Concepcio Rabel—had been assembled to provide abundant illustrations for the atlas.

In order that the Commission's project should be subjected to the widest criticism before the final atlas was undertaken, the Director of the French Office National Météorologique decided to issue at the expense of his Office the Commission's project in the form of a "Provisional Atlas". The wide distribution of this atlas answered the purpose perfectly; remarks and suggestions flowed in from all parts of the world. These numerous documents were examined at Barcelona in 1929 by the Commission and all the suggestions were examined and classified with great care. The illustration of the Atlas was also carefully reviewed and the Commission's task in this respect was facilitated to an extraordinary extent by the magnificent exhibition of cloud photographs arranged by the Fundacio Concepcio Rabel at the time of the meeting.

The Commission for the Study of Clouds met again at Copenhagen in September 1929 at the time of the meeting of the Conference of Directors. The suggestions received since the meeting at Barcelona were considered and the final scheme agreed, except for a few details. It was proposed that an extract of the Complete Atlas for the use of the observers should be published quickly in order to facilitate the application of the new International Code, in which observations of the types of skies figured largely.

The question of publication could be approached in exceptionally favourable circumstances, thanks to the truly magnificent gift of a Catalonian Maecenas, Rafael Patxot, to whom cloud science was already indebted for the interesting work of the Fundacio Concepcio Rabel; this generous contribution made it possible to print 1 000 free copies of the Complete Atlas and to offer it, as also the abridged edition, for sale at a very low price. A Sub-Commission was appointed, with Professor Süring as President, to prepare a programme for the Cloud Year and to study the physical processes of cloud formation and evolution with a view to compiling eventually an appendix to the General Atlas. Two other appendices were suggested, one on tropical clouds, the other on special local formations and the preparation of these two parts was delegated to Dr. Braak and Dr. Bergeron respectively. The Conference of Directors approved the Commission's propositions in their entirety and delegated its powers, as far as the production of the atlas was concerned, to a special Sub-Commission.

The work was carried out largely at Paris in the course of 1930 by Messrs. Süring, Bergeron, and Wehrlé. The German and English translations were prepared by Dr. Keil, Mr. Cave and the Meteorological Office, London. The abridged edition finally appeared in 1930, just before the new code came into force. Another year was required to finish the illustrations of the Complete Atlas and the chapters not included in the abridged edition. Meanwhile, the Süring Sub-Commission had held meetings at Brussels (December 1930) and at Frankfurt (December 1931), and it seemed opportune to incorporate in the Complete Atlas a part of the work relating to the observation of clouds and hydrometeors.

The book now appearing bears the sub-title: "I. General Atlas" (the second and following volumes will consist of the appendices to be published later) and consists of a text and a collection of 174 plates.

The text is divided into five sections:

(1) CLOUDS — The amended text of the old Atlas. The principal modifications are:

(*a*) the definition of Cirrocumulus which is more restricted than formerly;

(*b*) the distinction between Cumulus and Cumulonimbus; the latter being characterised by ice crystals in its summit or by showers;

(*c*) the distinction between Altocumulus and Stratocumulus;

(*d*) the introduction of Nimbostratus (low Altostratus) in order to avoid confusion (due to the equivocal definition of Nimbus) between the low, rainy layer resulting from the downward extension of Altostratus and the very low, closely packed clouds (Fractostratus or Fractocumulus of bad weather) which often form beneath the Altostratus or the above-mentioned low layer.

The commentaries to the definitions have been considerably enlarged in the form of "Explanatory remarks", written from a very practical standpoint with special reference to the needs of observers and stressing the distinctions between kindred forms. In some cases, species have been introduced but as previously stated this secondary classification is intentionally limited to cases on which there is unanimous agreement; it is moreover considerably simplified by the addition of a certain number of varieties common to different levels. In order to mark the fact that the names of the clouds have become symbols, the etymology of which should not be unduly stressed, they have in all cases been written as a single word.

(2) CODE — The second part consists of a practical and detailed commentary for the use of observers, with explanatory remarks concerning the general arrangement and hints how to avoid confusion in the specifications of the new code of low, middle and high clouds; it would perhaps be more appropriate to call it a code of the types of skies, since the arrangement of cloud masses in the sky plays an essential rôle in it and it has been conceived in such a fashion that all types of sky classified in the fifth part can be represented by the combination of three figures.

It was thought best to abstain from all "synoptic" considerations in the text, the observer being supposed to ignore the general situation; nevertheless, it is not desirable that he should be deprived entirely of the real help to be derived from connecting the type of sky with the evolution of disturbances. There will therefore be found at the end of this section a diagram showing where the different lower, middle and upper skies specified in the code are situated relative to a disturbance.

(3) CLOUD DIARY — This section, which has been inserted at the suggestion of Dr. Bergeron, has been taken from the papers prepared by the Süring Sub-Commission for the Cloud Year. It includes a model table for noting cloud observations and detailed instructions of how entries should be made in it. These are supplemented by precise descriptions of different hydrometeors or weather phenomena, a subject which has given rise to divergent national traditions and in which there was need of amendment and unification.

(4) OBSERVATION OF CLOUDS FROM AIRCRAFT — As the classification of clouds is based upon their appearance as seen from the ground, it seemed useful to add a note on their appearance from the point of view of the observer in an aircraft, inasmuch as the more complete knowledge which he may acquire from the fact that he can get near to and on top of them (at least, in the case of lower and middle clouds) makes it possible to simplify the classification considerably by including only the really essential distinctions in structure. The increase in the number of meteorological flights especially in connection with temperature soundings, necessitated the inclusion of this chapter.

(5) TYPES OF SKIES — The enumeration of the genera or even of the species of clouds in the sky at a given moment does not suffice to characterize the type of sky, that is to say, to specify precisely the sector of the disturbance affecting the place of observation and, in consequence, it does not indicate the general character of the "weather". What really characterizes the type of sky is the aggregate of individual clouds and their *organization*. A special classification of skies is therefore needed which, while being in accordance with the experience of qualified observers, shall also be consistent with the nature of the physical processes and the structure of disturbances. In addition, such classification facilitates the identification of cloud genera and in certain cases (especially in thundery conditions) it compensates, at least in parts, for vagueness.

*Collection of plates* — The total number of plates is 174 (101 photographs taken from the ground, 22 from aeroplanes and 51 for types of sky), 31 of which are in two colours. Two colours are used where there is occasion to distinguish the blue of the sky from the shadows of the clouds. Most of these are included in the abridged edition, which is intended for the use of the general mass of observers who need detailed guidance. Each plate is accompanied by explanatory notes and a schematic representation on the same scale as the photograph, setting out its essential characteristics.

Thanks to the generosity of Mr. Cave, who has done so much for cloud science, the appendix dealing with tropical clouds edited by Dr. Braak, constituting Volume II of the complete work, has already appeared in French in connection with the requirements of the Polar Year. It is hoped that the appendix dealing with special clouds, constituting Volume III will appear soon. This will include, in particular, Professor Störmer's beautiful photographs of stratosphere clouds. Finally, it is also hoped that the results of the Cloud Year will enable the Süring Sub-Commission to prepare a fourth volume dealing with the physical processes involved in the formation of clouds, which will be epoch-making in the history of meteorology.

E. DELCAMBRE,
President of the International
Commission for the Study of Clouds.

## PREFACE TO THE 1956 EDITION

The International Commission for the Study of Clouds (C.E.N.) of the International Meteorological Organization (I.M.O.), created in 1921, was dissolved by the Extraordinary Conference of Directors (London, 1946). It was replaced by the *Committee for the Study of Clouds and Hydrometeors* (C.C.H.), established by the International Meteorological Committee of the International Meteorological Organization in compliance with a resolution of the Commission for Synoptic Weather Information (Resolution 16, C.S.W.I., Paris 1946). The Conference of Directors of the International Meteorological Organization instructed the C.C.H. to prepare a revised and up to date version of the *International Atlas of Clouds and Types of Skies* (Resolution 153, CD, Washington 1947). The decision to prepare a new atlas was inspired, on the one hand, by the exhaustion of the previous 1939 edition and, on the other hand, by new developments in our knowledge of clouds and hydrometeors, as well as by modifications in international cloud codes.

The Committee for the Study of Clouds and Hydrometeors held several sessions in which the following members participated: A. Viaut, T. Bergeron, J. Bessemoulin, W. Bleeker, C.F. Brooks, C.K.M. Douglas, L. Dufour, N.R. Hagen, B.C. Haynes, M. Mézin, J. Mondain and H. Weickmann.

An Editing Committee, consisting of M. Mézin (President), R. Beaufils (Secretary), R. Beaulieu, J. Bessemoulin and M. Bonnet, prepared documents between sessions.

In 1951, when the I.M.O. was replaced by the World Meteorological Organization (W.M.O.), the Committee for the Study of Clouds and Hydrometeors proposed to the First Congress of W.M.O. that the new edition of the Cloud Atlas should consist of four volumes and it presented a draft of Volumes I, II and III. Volumes I and III covered essentially the same ground as Volume I of the present Atlas and Volume II was a collection of photographs of clouds and meteors. Volume IV was intended to be a treatise on the physics of clouds and meteors.

The First Congress of the World Meteorological Organization decided (Resolution 18, Cg-I) to refer the draft to the Commission for Synoptic Meteorology (C.S.M.) for further study and completion. The Committee for the Study of Clouds and Hydrometeors itself became a "Working Group for the Study of Clouds and Hydrometeors" attached to the Commission for Synoptic Meteorology (Resolution 35, Cg-I).

The contents of the Atlas and plans for its publication were discussed at the Second and Third Sessions of the Executive Committee (Lausanne, 1951; Geneva, 1952). It was decided that an Abridged Atlas in one volume consisting of a condensed text and a selection of photographs, for the use of surface observers, and an Album designed to meet the limited but special needs of airborne observers, should also be prepared (Resolution 9, EC-II; Resolution 36, EC-III).

The Working Group for the Study of Clouds and Hydrometeors presented to the First Session of C.S.M. (Washington, 1953) an improved version of the original draft submitted to Congress. The improvement resulted from further study at various sessions of the Working Group and from remarks received from members of the Commission to whom copies had been distributed.

The Commission for Synoptic Meteorology recommended (Recommendation 49, CSM-I) that the Complete Atlas should consist of only two volumes (Volume I containing the text and Volume II the plates). It also formally recommended the publication of an Abridged Atlas and of an International Cloud Album for airborne observers. Finally, C.S.M. considered that a compendium on the physics of clouds and meteors, though highly desirable, should not at present form part of the Cloud Atlas.

The Working Group for the Study of Clouds and Hydrometeors was dissolved by C.S.M. However, a few individuals were requested to continue and to complete the work of the Committee for the Study of Clouds and Hydrometeors.

At its Fourth Session (Geneva, 1953), the Executive Committee adopted Recommendation 49 of C.S.M. and directed the Secretary-General to take the necessary steps, in consultation with the President of C.S.M. when required, for an early publication of the Atlas (Resolution 30, EC-IV).

The English text was then passed to Mr. E.G. Bilham for editing, in accordance with the wishes of the Commission for Synoptic Meteorology and a decision by the Executive Committee.

During the translation of the text of the Complete Atlas into French, for which Mr. J. Bessemoulin was responsible in accordance with a request by C.S.M., it became obvious that many parts required thorough revision. A special editing committee was then established consisting of the following persons: Dr. W. Bleeker, Dr. M.A. Alaka, Mr. R. Beaufils and Mr. J. Bessemoulin. This committee met several times in Geneva and in De Bilt and established the final English and French texts.

The President of the Commission for Synoptic Meteorology accepts responsibility for the changes thus made in the original text which was studied at the First Session of the Commission; these changes were necessary in order to avoid ambiguities and internal inconsistencies.

The content of the present Volume I, which is essentially descriptive and explanatory, differs materially from that of the former "General Atlas".

The grouping of clouds into "cloud families" has been abandoned; the classification into genera has been maintained but some details in the definitions have been modified.

The species and the varieties have been extended and considerably modified. The same remark applies to the "accidental details" which have been renamed "supplementary features" and "accessory clouds". A new concept, that of "mother-cloud", has been introduced.

Certain "special clouds" are discussed separately; a brief description is given of the most important of these clouds, such as nacreous clouds, noctilucent clouds, etc.

The "Note on the Observation of Clouds from Aircraft" of the former General Atlas has been replaced by a chapter describing the particular appearance presented by clouds when they are observed from aircraft.

The part "Types of Skies" of the former General Atlas has been deleted. New points of view have arisen and existing ideas, particularly with regard to tropical skies, are in the course of evolution, thus making it difficult to synthesize the various existing concepts.

The chapter "Definition of Hydrometeors" of the former General Atlas has been considerably expanded. The former classification of hydrometeors has been replaced by a classification dividing meteors into four groups. The term "hydrometeors" designates the first of these groups, and applies solely to aqueous meteors. The descriptions of the hydrometeors are based mainly on those adopted at Salzburg in 1937. The other groups of meteors are "lithometeors", "photometeors" and "electrometeors".

The parts intended primarily for the use of observers have also been expanded. Part III contains more elaborate instructions for observing clouds and meteors. Part IV gives two models of a "Journal of clouds and meteors". Part V contains detailed instructions and pictorial guides for the coding of clouds.

The final change consists of the addition of Appendices providing information of a general nature and an Alphabetical Index to simplify consultation of the Atlas.

Volume II is a collection of 224 plates in black and white and in colour, the object of which is to illustrate the text of Volume I. The plates consist of photographs of clouds (viewed from the

Earth's surface and from aircraft) and of certain meteors; each photograph is accompanied by an explanatory legend.

The French Meteorological Service has contributed materially to the preparation of the texts and the photographic plates and their legends. The Netherlands' Meteorological Service also gave considerable assistance during the final stages of the preparation of the Cloud Atlas.

The undersigned who have been closely connected with the preparation and publication of the Cloud Atlas wish to thank all those who have contributed to the texts, and in particular Messrs. J. Bessemoulin and R. Beaufils of the French Meteorological Service and Dr. M.A. Alaka of the Secretariat of W.M.O., for their enthusiastic assistance during the final phase of the composition of the text. They also thank all the persons who provided photographs to illustrate the International Cloud Atlas.

W. Bleeker,
President of the Commission
for Synoptic Meteorology

A. Viaut,
President of the Committee for the Study
of Clouds and Hydrometeors

De Bilt, Paris, 4 April 1956.

## PREFACE TO THE PRESENT EDITION

The previous edition of the *International Cloud Atlas*, which appeared in 1956, consisted of two volumes: Volume I, containing a descriptive and explanatory text, and Volume II, containing a set of plates intended to illustrate the text. The present publication is a new edition of Volume I designed to replace the original edition. The preface describes the circumstances which led to the decision to publish a new edition and pays tribute to the numerous meteorologists who have devoted part of their time and efforts to the preparation of this new, and greatly improved, version of the text of the Atlas.

At its fourth session (Wiesbaden, 1966), the Commission for Synoptic Meteorology (CSM) examined the replies received from Members to an inquiry on the visibility criteria used for reporting mist and fog and also on the question of whether mist and fog should be considered as one and the same hydrometeor. It is pointed out in this connexion that, in the 1956 edition of the *International Cloud Atlas*, these phenomena were treated as two distinct hydrometeors.

CSM considered that mist and fog were produced by the same processes and that they should be regarded as one and the same hydrometeor, on the understanding, however, that the terms "fog" and "mist" might continue to be used to denote different intensities of the phenomenon, the term "mist" being synonymous with a slight fog, and the visibility limit of 1 000 metres, used hitherto, being maintained as a criterion of intensity.

At the same session, CSM also examined a proposal to revise the definitions and descriptions of hydrometeors contained in the 1956 edition of the *International Cloud Atlas*. The reason for the proposal was that there had been important advances in the physics of hydrometeors since CSM had recommended the use of the descriptions.

The Commission agreed that such a review was needed, particularly as regards hydrometeors appearing in polar and mountainous areas. For this purpose it decided to set up a Working Group on Description of Hydrometeors (Resolution 8 (CSM–IV)) composed of the following members: L. Dufour (Belgium), chairman of the group and representative of the Commission for Aerology, G. A. Gensler (Switzerland), E. Hesstvedt (Norway), H. D. Parry (United States of America), B. V. Ramanamurthy (India) and A. Rouaud (France).

The group recommended, in the first place, that a cloud should be classified as a hydrometeor, which would call for a change in the definition of "cloud", which did not refer to such a classification. The definition of "meteor" also had to be changed, because the latter had hitherto been defined as "a phenomenon other than a cloud...". The group also reviewed all the definitions and descriptions of hydrometeors other than clouds.

Following the recommendations made by the Working Group on Description of Hydrometeors set up by Resolution 8 (CSM–IV), CSM recommended, at its fifth session (Geneva, 1970), that the revised definitions and descriptions of hydrometeors other than clouds should be adopted and that Volume I of the *International Cloud Atlas* should be amended accordingly (Recommendation 41 (CSM–V)). At its twenty-second session, the Executive Committee approved this recommendation and requested the Secretary-General of WMO to arrange for the publication of the revised text (Resolution 14 (EC–XXII)).

In view of the fact that the 1956 edition of Volume I of the *International Cloud Atlas* was out of print and that the principle adopted by Sixth Congress to the effect that any publication constituting an annex to the *Technical Regulations*—which was partially true of Volume I of the Atlas—

should be transformed into a Manual, the Advisory Working Group of the Commission for Basic Systems (CBS—formerly the Commission for Synoptic Meteorology (CSM)) considered, at its second session (Geneva, 1971), that a preliminary draft of a new edition of the volume should be prepared, containing, in principle, only such texts as had the legal status of provisions of the Technical Regulations, including, of course, the revised definitions adopted by CSM at its fifth session.

In accordance with the above-mentioned decision of the CBS Advisory Working Group, an expert (Mr. A. Durget, France) was invited to revise Volume I of the *International Cloud Atlas*. At its sixth session (Belgrade, 1974), CBS recommended that the draft revised text should be published to replace the 1956 edition and that the Secretary-General should be requested to arrange for the publication of an appropriate amendment to the *Abridged Atlas* to bring it into line with the new edition of Volume I of the *International Cloud Atlas* (Recommendation 18 (CBS-VI)). At its twenty-sixth session, the Executive Committee approved this recommendation and requested the Secretary-General to implement it (Resolution 3 (EC-XXVI)).

During his work on the revision of the Atlas, the expert decided that it was virtually impossible, and certainly not desirable, to exclude from the *Atlas* those parts of the 1956 edition which did not have the legal status of the provisions of the Technical Regulations. Some of those parts could not, in fact, be separated from the passages to which they referred and which were retained as being provisions of the Technical Regulations without their deletion seriously affecting the clarity and consistency of the work. Other parts not having the status of Technical Regulations and whose inclusion in the Atlas was not strictly speaking indispensable deserved none the less to be maintained in view of their great value for users of the Atlas. Part IV, however, of the 1956 edition of Volume I—entitled "Journal of clouds and meteors"—had not been included in the new edition since it was not of international interest.

Since the two volumes of the *International Cloud Atlas* are well known under this title, the same title has been retained for the present edition. But for reasons of consistency with other WMO publications constituting annexes to the *Technical Regulations* and accordingly described as "Manuals", this publication also bears the subtitle "*Manual on the observation of clouds and other meteors*".

Moreover, those parts of the book having the legal status of Technical Regulations are distinguished from the rest by a different type of print. Similarly, a system of paragraph numbering similar to that used in the *Technical Regulations* has been employed.

As a consequence of the adoption of the new definition of "cloud", which is now regarded as a hydrometeor, and having regard to the corresponding change in the definition of "meteor", it was thought necessary to re-arrange the layout of the Atlas completely, by changing the order of the parts and chapters so as to give the definitions of "meteor" and "hydrometeor" before dealing in detail with clouds and other meteors.

The present edition of Volume I thus consists of three parts. The first, in addition to the new definition of "meteor", contains a general classification of meteors into hydrometeors (including clouds), lithometeors, photometeors and electrometeors, as well as definitions of each of these four groups of phenomena. These various texts have been taken from Chapter I of Part II of the 1956 edition of Volume I, taking into account, in their wording, the new concepts set forth in Recommendation 41 (CSM-V) approved by Resolution 14 (EC-XXII).

Part II deals exclusively with clouds. It recapitulates, with a few essentially drafting changes, the various chapters dealing with clouds in the 1956 edition of Volume I: definition of a cloud and classification of clouds; definitions of the genera, species and varieties, etc., of clouds; descriptions of clouds; orographic influences; clouds as seen from aircraft; special clouds; observation of clouds from the Earth's surface; the coding of clouds in the codes $C_L$, $C_M$ and $C_H$ and the corresponding symbols.

Part III deals with meteors other than clouds. It consists of three chapters: classification of, and symbols for, meteors other than clouds; definitions and description of meteors other than clouds; and observation of these meteors from the Earth's surface. The texts relating to hydrometeors have been introduced in the new version given in Recommendation 41 (CSM–V), with certain drafting amendments.

The three appendices to the 1956 edition of Volume I, namely: Appendix I — Etymology of Latin names of clouds, Appendix II — Historical bibliography of cloud classification, and Appendix III — Bibliography of cloud nomenclature, have been maintained unchanged in the present edition of the Atlas. The alphabetical index of words and expressions has also been maintained with appropriate updating.

On behalf of the World Meteorological Organization, I should like here to express my gratitude to Mr. L. Dufour and to the members of his working group, as well as to Mr. A. Durget, for their valuable contributions to the preparation of this edition of the volume.

D. A. Davies

D. A. DAVIES
Secretary-General

## INTRODUCTORY NOTE

Certain parts of this publication constitute Annex I to the *Technical Regulations* and have the legal status of standardized practices and procedures.

The sections, paragraphs and sub-paragraphs having the status of an Annex to the *Technical Regulations*, except for the footnotes, are numbered in bold type. In Chapter III.2 only the definitions printed in italics have this status.

# PART I — DEFINITION OF A METEOR AND GENERAL CLASSIFICATION OF METEORS

## I.1 — DEFINITION OF A METEOR

A meteor is a phenomenon observed in the atmosphere or on the surface of the earth, which consists of a suspension, a precipitation, or a deposit of aqueous or non-aqueous liquid or solid particles, or a phenomenon of the nature of an optical or electrical manifestation.

Note: The names of certain meteors are sometimes also used to denote other related concepts. For instance, the word "snow" indicates a hydrometeor (ensemble of falling particles), a snow cover (ensemble of particles lying on the ground) and the substance snow (as in "snow blown from mountains", snowball). The constituent particles of snow in the three above-mentioned cases are snow crystals or snowflakes.

Certain meteors are furthermore designated by the name of their constituent particles. For example, the hydrometeor "snow grains" is an ensemble of falling snow grains.

## I.2 — GENERAL CLASSIFICATION OF METEORS

Meteors present a great diversity of character. However, by taking into account the nature of their constituent particles or the physical processes involved in their occurrence, it is possible to classify them into four groups, namely hydrometeors, lithometeors, photometeors and electrometeors.

### I.2.1

### Hydrometeors

A hydrometeor is a meteor consisting of an ensemble of liquid or solid water particles suspended in or falling through the atmosphere, blown by the wind from the Earth's surface, or deposited on objects on the ground or in the free air.

(*a*) Hydrometeors consisting of a *suspension* of particles in the atmosphere are: clouds, fog ("fog" and "mist") and ice fog;

(*b*) Hydrometeors consisting of *a fall* of an ensemble of particles (precipitation) are: rain, drizzle, snow, snow grains, snow pellets, diamond dust, hail and ice pellets.

These hydrometeors originate mostly in clouds. The following table lists the cloud genera [1] in which hydrometeors consisting of falling particles originate.

These particles may reach the Earth's surface or may completely evaporate while falling;

NOTE: When the falling particles reach the place of observation, it is usually easy to determine their nature. As hydrometeors of the type under consideration are closely associated with certain cloud genera, the identification of their constituent particles often facilitates, especially at night, the identification of the clouds in the sky. Therefore the following table may serve as a guide for cloud identification.

[1] The abbreviations, definitions and description of cloud genera appear in Part II of the Atlas (cf. Chapters II.1, II.2 and II.3, respectively).

| HYDROMETEORS \ GENERAL | As | Ns | Sc | St | Cu | Cb | No Cloud |
|---|---|---|---|---|---|---|---|
| Rain | + | + | + | | + | + | |
| Drizzle | | | | + | | | |
| Snow | + | + | + | + | + | + | |
| Snow grains | | | | + | | | |
| Snow pellets | | | + | | + | + | |
| Diamond dust | | | | | | | + |
| Hail | | | | | | + | |
| Small hail | | | | | | + | |
| Ice pellets | + | + | | | | | |

Hydrometeors consisting of falling particles occur either in the form of more or less uniform (intermittent or continuous) precipitation or as showers. Showers are characterized by their abrupt beginning and end, and by the generally rapid and sometimes violent variations in the intensity of the precipitation. Drops and solid particles falling in a shower are generally larger than those falling in non-showery precipitation. Whether the hydrometeors occur as showers, or not, depends on the clouds in which they originate. Showers fall from dark convective clouds (mainly Cumulonimbus, rarely Cumulus); non-showery precipitation usually falls from stratiform clouds (mainly Altostratus and Nimbostratus).

NOTE: It is thus possible, at night and in doubtful cases during the day, to identify clouds by the character of their precipitation.

(*c*) Hydrometeors consisting of ensembles of particles *raised* by the wind from the Earth's surface are drifting snow, blowing snow and spray. They are confined to the lower layers of the atmosphere;

(*d*) Hydrometeors consisting of a deposit of particles occur:

(i) Either as drops of water: deposit of fog droplets and dew;

(ii) Or as an ensemble of ice particles, more or less individually distinguishable in spite of the fact that they are often partially linked together: white dew, hoar frost and rime;

(iii) Or as smooth homogeneous layers of ice in which no pellet structure can be distinguished: glaze.

NOTE: Snow or water from precipitation, lying on the ground, is, by convention, not considered as a hydrometeor.

### I.2.2
### Lithometeors

A lithometeor is a meteor consisting of an ensemble of particles most of which are solid and non-aqueous. The particles are more or less suspended in the air, or lifted by the wind from the ground.

(*a*) The lithometeors which have more or less the character of suspensions in the atmosphere are haze, dust haze and smoke; they consist of very small dust particles, of sea-salt particles or of combustion products (e.g. from forest fires).

(*b*) The lithometeors resulting from the action of the wind are drifting and blowing dust or sand, dust storm or sandstorm, and dust whirl or sand whirl.

### I.2.3
### Photometeors

A photometeor is a luminous phenomenon produced by the reflection, refraction, diffraction or interference of light from the sun or the moon.

Photometeors are observed:

(*a*) Either on or inside clouds: halo phenomena, coronae, irisations and glory;

(*b*) Or on or inside certain other hydrometeors or certain lithometeors: halo phenomena, coronae, glory, rainbow, Bishop's ring and crepuscular rays;

(*c*) Or in more or less clear air: mirage, shimmer, scintillation, green flash and twilight colours.

### I.2.4
### Electrometeors

An electrometeor is a visible or audible manifestation of atmospheric electricity.

Electrometeors either correspond to discontinuous electrical discharges (lightning, thunder) or occur as more or less continuous phenomena (Saint Elmo's fire, polar aurora).

NOTE: When spouts appear at sea, their presence is revealed by a cloud column or cone and by a "bush" made up of water droplets raised up from the surface of the sea. In this case, therefore, they come under the group of hydrometeors wherein they form a fifth category.

When they appear on land, the bush is made up of particles, most of which are solid and non-aqueous; in such a case, spouts cannot strictly be classified as hydrometeors. However, the presence of the cloud column or cone is a basic criterion and therefore spouts are classified in this Atlas, within the group of hydrometeors.

# PART II — CLOUDS

# II.1 — INTRODUCTION

## II.1.1

## Definition of a cloud

A cloud is a hydrometeor consisting of minute particles of liquid water or ice, or of both, suspended in the free air and usually not touching the ground. It may also include larger particles of liquid water or ice as well as non-aqueous liquid or solid particles such as those present in fumes, smoke or dust.

## II.1.2

## Appearance of clouds

The appearance of a cloud is determined by the nature, sizes, number and distribution in space of its constituent particles; it also depends on the intensity and colour of the light received by the cloud and on the relative positions of observer and source of light (luminary) with respect to the cloud.

Appearance is best described in terms of the dimensions, shape, structure, texture, luminance and colour of the cloud. These factors will be considered for each of the characteristic cloud forms. A general *exposé* on the luminance and colour of clouds is given below.

### II.1.2.1

### LUMINANCE

The luminance [1] of a cloud is determined by the light reflected, scattered and transmitted by its constituent particles. This light comes, for the most part, direct from the luminary or from the sky; it may also come from the surface of the earth, being particularly strong when sunlight or moonlight is reflected by ice- or snow-fields.

The luminance of a cloud may be modified by intervening haze. When haze is present between the observer and the cloud, it may, depending on its thickness and the direction of the incident light, either diminish or increase the luminance of the cloud. Haze also diminishes the contrasts which reveal the shape, structure and texture of the cloud. Furthermore, the luminance may be modified by optical phenomena such as haloes, rainbows, coronae, glories, etc. which are described under "Photometeors" in Part III of this Atlas.

During daytime, the luminance of the clouds is sufficiently high to make them easily observable. On a moonlit night, clouds are visible when the moon is more than a quarter full. In its darker phases, the moon is not bright enough to reveal clouds far from it, especially when the latter are thin. On a moonless night, clouds are generally invisible; sometimes, however, their presence may be deduced from the obscuration of stars,[2] of polar aurora, of zodiacal light, etc.

Clouds are visible at night in areas with sufficiently strong artificial lighting. Thus, over large cities, clouds may be revealed by direct illumination from below. A layer of clouds, so illuminated, may provide a bright background against which lower cloud fragments stand out in dark relief.

When a not very opaque cloud is illuminated from behind, its luminance is maximum in the direction of the luminary. It decreases away from the luminary; the thinner the cloud, the more

[1] "Luminance" is a technical term adopted for use in photometry by the "International Lighting Commission" — XIth session, Paris, July 1948. This term supersedes the term "brightness".
Definition: "Luminance" is a photometrical quantity, which is the quotient of light intensity, in a given direction, by the projection of the area of the emitting surface on a plane perpendicular to that direction.

[2] The blotting out of stars near the horizon is often due to haze alone.

rapid the decrease. Clouds of greater optical thickness [1] show only a slight decrease in luminance with distance from the luminary. Still greater thickness and opacity make it impossible even to determine the position of the luminary. When the sun or moon is behind a dense isolated cloud, the latter shows a brilliantly illuminated border, and luminous streaks alternating with shadowed bands may be seen in any haze around it.

The optical thickness of a cloud layer often varies from one portion of the layer to another; the luminary may therefore be perceptible through one part of the cloud but not through another. As a result of the varying optical thickness, the luminance of the cloud layer, especially at short angular distances from sun or moon, may change considerably with time owing to the movement of the cloud.

In the case of a uniformly and sufficiently opaque cloud layer, the luminary may be perceptible when it is not too far from the zenith, but may be completely masked when close to the horizon. Sufficiently opaque cloud layers sometimes show a maximum luminance at the zenith when the sun or moon is at low elevation.

The light reflected from a cloud to the observer is maximum when the cloud is opposite to the luminary. The luminance is stronger the greater the denseness of the cloud and its thickness in the line of sight. When sufficiently dense and deep, the cloud reveals shades of grey showing a more or less clear relief; the more tangential the direction of illumination, the more extensive the range of shades.

Finally, it should be realized that appreciable differences in luminance exist between clouds composed of water droplets and clouds composed of ice crystals. Ice crystal clouds are usually more transparent than water droplet clouds owing to their thinness and to the sparseness of the ice particles. Certain ice crystal clouds, however, occur in thick patches and, moreover, have a high concentration of ice particles. When these clouds are illuminated from behind, they show marked shading.[2] They are, however, brilliantly white in reflected light.

II.1.2.2

### Colour

Since light of all wavelengths is almost equally strongly diffused by clouds, the colour of the latter depends primarily on that of the incident light. Haze between observer and cloud may, however, modify cloud colours; it tends, for instance, to make distant clouds look yellow, orange or red. Cloud colours are also influenced by special luminous phenomena which are described under "Photometeors" in Part III of this Atlas.

When the sun is sufficiently high above the horizon, clouds or portions of clouds which chiefly diffuse light from the sun are white or grey. Parts which receive light mainly from the ~~blue~~ sky are bluish grey. When the illumination by the sun and the sky is extremely weak, the clouds tend to take the colour of the surface below them.

When the sun approaches the horizon, its colour may change from yellow through orange to red; the sky in the vicinity of the sun and the clouds show a corresponding coloration. The colours of the clouds may, however, still be influenced by the blue of the sky and the colour of the underlying surface. Cloud colours, furthermore, vary with the height of the cloud and its relative position with regard to observer and sun.

When the sun is close to the horizon, high clouds may still look almost white whilst low clouds exhibit a strong orange or red coloration. These differences in colour make it possible to obtain an idea of the relative altitudes of the clouds. The observer should, however, be aware of the fact

[1] The optical thickness of a cloud is the degree to which the cloud prevents light from passing through it. The optical thickness depends on the physical constitution and the dimensions of the cloud.

[2] Shading refers to contrasts in luminance or gradations of colour.

that clouds at the same level appear less red when seen towards the sun than when viewed away from it.

When the sun is just above or on the horizon, it may redden the under surface of a cloud; if this surface is corrugated, its coloration is distributed in bands alternately lighter (yellowish or reddish tint) and darker (other tints), which make the relief more apparent.

When the sun is just below the horizon, the lowest clouds, in the shadow of the earth, are grey; the clouds at the middle levels are rose coloured and those very high may be whitish.

At night, the luminance of clouds is usually too weak for colour vision; all perceptible clouds appear black to grey, except those illuminated by the moon, which present a whitish appearance. Special illumination (fires, lights of large cities, polar aurora, etc.) may, however, sometimes give a more or less marked colouring to certain clouds.

II.1.3

## Principles of cloud classification

Clouds are continuously in a process of evolution and appear, therefore, in an infinite variety of forms. It is possible, however, to define a limited number of *characteristic forms*, frequently observed all over the world, into which clouds can be broadly grouped. A classification of the characteristic forms of clouds, in terms of "genera", "species" and "varieties" has been established. Definitions and descriptions of each of the characteristic forms corresponding to this classification are given in the following chapters. Intermediate or transitional forms, although observed fairly frequently, are not described in this Atlas; they are of little interest, as they are less stable and as their appearance is not very different from that indicated in the definitions of the characteristic forms.

Finally, there exists a group of clouds, rarely or occasionally observed, not included in the present classification. Some of these so-called "special clouds" consist for the greater part or in their entirety of non-aqueous liquid or solid particles. The definition of a cloud given on page 3 is therefore not applicable to all special clouds.

Special clouds are dealt with separately in Chapter II.6.

II.1.3.1

### GENERA

The classification of clouds, introduced in this Atlas, is essentially based on ten main groups, called genera, which are mutually exclusive.

II.1.3.2

### SPECIES

Most of the genera are subdivided into species. This subdivision is based on the shape of the clouds or their internal structure. A cloud, observed in the sky, belonging to a certain genus, may bear the name of *one* species only.

II.1.3.3

### VARIETIES

Clouds may exhibit special characteristics which determine their variety. These characteristics are related to the different arrangements of the macroscopic elements of the clouds and their greater or lesser degree of transparency.

A given variety may be common to several genera. Furthermore, the same cloud may show characteristics pertaining to *more than one* variety. If this is the case, all the appropriate variety names are included in the name of the cloud.

II.1.3.4

SUPPLEMENTARY FEATURES AND ACCESSORY CLOUDS

The indication of genus, species and varieties is not always sufficient to describe a cloud completely. A cloud may show supplementary features attached to it, or may be accompanied by accessory clouds, sometimes partly merged with its main body. "Supplementary features" and "accessory clouds" may occur at any level of the cloud, or above or below it.

One or more supplementary features or accessory clouds may be observed simultaneously with the same cloud.

II.1.3.5

MOTHER-CLOUDS

Clouds may form in clear air. They may also form or grow from other clouds, called "mother-clouds"; two cases can be distinguished.

(*a*) A *part* of a cloud may develop and more or less pronounced extensions may form. These extensions, whether attached to the mother-cloud or not, may become clouds of a genus different from that of the mother-cloud. They are then given the name of the appropriate genus, followed by the name of the genus of the mother-cloud with the addition of the suffix "genitus" (e.g. Cirrus altocumulogenitus, Stratocumulus cumulogenitus).

(*b*) The *whole* or a *large part* of a cloud may undergo complete internal transformation, thus changing from one genus into another. The new cloud is then given the name of the appropriate genus, followed by the name of the genus of the mother-cloud with the addition of the suffix "mutatus" (e.g. Cirrus cirrostratomutatus, Stratus stratocumulomutatus). The internal transformation of clouds should not be confused with changes in the appearance of the sky resulting from the relative movement of clouds and observer.

**II.1.4**

**Table of classification of clouds**

See page 13.

**II.1.5**

**Table of abbreviations and symbols of clouds**

See page 14.

## II.1.4 TABLE OF CLASSIFICATION OF CLOUDS

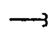
| GENERA | SPECIES | VARIETIES | SUPPLEMENTARY FEATURES AND ACCESSORY CLOUDS | MOTHER-CLOUDS | |
|---|---|---|---|---|---|
| | | | | GENITUS | MUTATUS |
| Cirrus | fibratus<br>uncinus<br>spissatus<br>castellanus<br>floccus | intortus<br>radiatus<br>vertebratus<br>duplicatus | mamma | Cirrocumulus<br>Altocumulus<br>Cumulonimbus | Cirrostratus |
| Cirrocumulus | stratiformis<br>lenticularis<br>castellanus<br>floccus | undulatus<br>lacunosus | virga<br>mamma | — | Cirrus<br>Cirrostratus<br>Altocumulus |
| Cirrostratus | fibratus<br>nebulosus | duplicatus<br>undulatus | — | Cirrocumulus<br>Cumulonimbus | Cirrus<br>Cirrocumulus<br>Altostratus |
| Altocumulus | stratiformis<br>lenticularis<br>castellanus<br>floccus | translucidus<br>perlucidus<br>opacus<br>duplicatus<br>undulatus<br>radiatus<br>lacunosus | virga<br>mamma | Cumulus<br>Cumulonimbus | Cirrocumulus<br>Altostratus<br>Nimbostratus<br>Stratocumulus |
| Altostratus | — | translucidus<br>opacus<br>duplicatus<br>undulatus<br>radiatus | virga<br>praecipitatio<br>pannus<br>mamma | Altocumulus<br>Cumulonimbus | Cirrostratus<br>Nimbostratus |
| Nimbostratus | — | — | praecipitatio<br>virga<br>pannus | Cumulus<br>Cumulonimbus | Altocumulus<br>Altostratus<br>Stratocumulus |
| Stratocumulus | stratiformis<br>lenticularis<br>castellanus | translucidus<br>perlucidus<br>opacus<br>duplicatus<br>undulatus<br>radiatus<br>lacunosus | mamma<br>virga<br>praecipitatio | Altostratus<br>Nimbostratus<br>Cumulus<br>Cumulonimbus | Altocumulus<br>Nimbostratus<br>Stratus |
| Stratus | nebulosus<br>fractus | opacus<br>translucidus<br>undulatus | praecipitatio | Nimbostratus<br>Cumulus<br>Cumulonimbus | Stratocumulus |
| Cumulus | humilis<br>mediocris<br>congestus<br>fractus | radiatus | pileus<br>velum<br>virga<br>praecipitatio<br>arcus<br>pannus<br>tuba | Altocumulus<br>Stratocumulus | Stratocumulus<br>Stratus |
| Cumulonimbus | calvus<br>capillatus | — | praecipitatio<br>virga<br>pannus<br>incus<br>mamma<br>pileus<br>velum<br>arcus<br>tuba | Altocumulus<br>Altostratus<br>Nimbostratus<br>Stratocumulus<br>Cumulus | Cumulus |

NOTES:

1. The etymology and the meaning of the Latin names are given in Appendix I.
2. Mother-clouds, other than those mentioned in the above table, may be observed, though seldom.
3. Species, varieties, supplementary features and accessory clouds are listed approximately in descending order of frequency of their occurrence; mother-clouds are listed in the same order as the genera.

## II.1.5 TABLE OF ABBREVIATIONS AND SYMBOLS OF CLOUDS

### GENERA

| Designations | Abbreviations | Symbols |
|---|---|---|
| Cirrus | Ci |  |
| Cirrocumulus | Cc |  |
| Cirrostratus | Cs |  |
| Altocumulus | Ac |  |
| Altostratus | As |  |
| Nimbostratus | Ns |  |
| Stratocumulus | Sc |  |
| Stratus | St |  |
| Cumulus | Cu |  |
| Cumulonimbus | Cb |  |

### SPECIES

| Designations | Abbreviations |
|---|---|
| fibratus | fib |
| uncinus | unc |
| spissatus | spi |
| castellanus | cas |
| floccus | flo |
| stratiformis | str |
| nebulosus | neb |
| lenticularis | len |
| fractus | fra |
| humilis | hum |
| mediocris | med |
| congestus | con |
| calvus | cal |
| capillatus | cap |

### VARIETIES

| Designations | Abbreviations |
|---|---|
| intortus | in |
| vertebratus | ve |
| undulatus | un |
| radiatus | ra |
| lacunosus | la |
| duplicatus | du |
| translucidus | tr |
| perlucidus | pe |
| opacus | op |

### SUPPLEMENTARY FEATURES AND ACCESSORY CLOUDS

| Designations | Abbreviations |
|---|---|
| incus | inc |
| mamma | mam |
| virga | vir |
| praecipitatio | pra |
| arcus | arc |
| tuba | tub |
| pileus | pil |
| velum | vel |
| pannus | pan |

### MOTHER-CLOUDS

#### GENITUS

| Designations | Abbreviations |
|---|---|
| cirrocumulogenitus | ccgen |
| altocumulogenitus | acgen |
| altostratogenitus | asgen |
| nimbostratogenitus | nsgen |
| stratocumulogenitus | scgen |
| cumulogenitus | cugen |
| cumulonimbogenitus | cbgen |

#### MUTATUS

| Designations | Abbreviations |
|---|---|
| cirromutatus | cimut |
| cirrocumulomutatus | ccmut |
| cirrostratomutatus | csmut |
| altocumulomutatus | acmut |
| altostratomutatus | asmut |
| nimbostratomutatus | nsmut |
| stratocumulomutatus | scmut |
| stratomutatus | stmut |
| cumulomutatus | cumut |

NOTES:

1. The names and abbreviations of the genera are always written with an initial capital.
2. Genera, species, varieties, etc. in the above tables are arranged, as far as possible, in decreasing order of the altitudes at which they are usually observed.

# II.2 — DEFINITIONS OF CLOUDS

II.2.1

## Some useful concepts

II.2.1.1

### HEIGHT, ALTITUDE, VERTICAL EXTENT

It is often important to refer to the level at which certain parts of a cloud occur. Two concepts can be used for the indication of such a level, namely "height" and "altitude".

The *height* of a point, e.g. the base or the top of a cloud, is the vertical distance from the point of observation (which may be on a hill or mountain) to the level of that point.

The *altitude* of a point, e.g. the base or the top of a cloud, is the vertical distance measured from mean sea level to the level of that point.

Surface observers generally use the concept of height, aircraft observers the concept of altitude.

The *vertical extent* of a cloud is the vertical distance between the level of its base and that of its top.

II.2.1.2

### ETAGES

Surface and aircraft observations have shown that clouds [1] are generally encountered over a range of altitudes varying from sea level to the level of the tropopause, i.e. to 18 kilometres (60 000 feet) in the tropics, 13 kilometres (45 000 feet) in middle latitudes and 8 kilometres (25 000 feet) in polar regions. By convention, the part of the atmosphere in which clouds [1] are usually present has been vertically divided into three "étages": high, middle and low. Each étage is defined by the range of levels at which clouds of certain genera occur most frequently. These genera are:

(*a*) Cirrus, Cirrocumulus and Cirrostratus for the high étage (high level clouds);

(*b*) Altocumulus for the middle étage (middle level clouds);

(*c*) Stratocumulus and Stratus for the low étage (low level clouds).

The étages overlap and their limits vary with latitude. The approximate heights of the limits are as follows:

| *Etages* | *Polar Regions* | *Temperate Regions* | *Tropical Regions* |
|---|---|---|---|
| High | 3–8 km (10 000–25 000 ft) | 5–13 km (16 500–45 000 ft) | 6–18 km (20 000–60 000 ft) |
| Middle | 2–4 km (6 500–13 000 ft) | 2–7 km (6 500–23 000 ft) | 2–8 km (6 500–25 000 ft) |
| Low | From the Earth's surface to 2 km (6 500 ft) | From the Earth's surface to 2 km (6 500 ft) | From the Earth's surface to 2 km (6 500 ft) |

With regard to the cloud genera not mentioned above, the following remarks may be made:

(*a*) Altostratus is usually found in the middle étage, but it often extends higher;

[1] Except "nacreous clouds" and "noctilucent clouds" *(see Chapter II.6: "Special Clouds")*.

(*b*) Nimbostratus is almost invariably found in the middle étage, but it usually extends into the other étages;

(*c*) Cumulus and Cumulonimbus usually have their bases in the low étage, but their vertical extent is often so great that their tops may reach into the middle and high étages.

When the height of a particular cloud is known, the concept of étages may be of some help to the observer in identifying this cloud. Its genus can then be determined by making a choice from among the genera *normally* encountered in the étage corresponding to its height.

II.2.2

## Observational conditions to which definitions of clouds apply

The definitions of clouds given in the present Atlas apply, unless otherwise specified, to observations carried out under the following conditions:

(*a*) The observer is at the earth's surface, either on land in areas without mountainous relief or at sea;

(*b*) The air is clear; no obscuring phenomena such as fog, haze, dust, smoke, etc., are present;

(*c*) The sun is sufficiently high to provide the usual luminance and coloration;

(*d*) The clouds are so high above the horizon that effects of perspective are negligible.

It will be necessary to adapt the definitions to other conditions. In many cases this can easily be done; for example, by night, when the moon is in its brighter phases, it may play, with regard to the illumination of clouds, a rôle analogous to that of the sun.

**II.2.3**

## Definitions of clouds

**II.2.3.1**

### Genera

Consideration of the most typical forms of clouds leads to the recognition of ten genera. The definitions of the genera given below do not cover all possible aspects, but are limited to a description of the main types and of the essential characteristics necessary to distinguish a given genus from genera having a somewhat similar appearance.

*Cirrus*

Detached clouds in the form of white, delicate filaments or white or mostly white patches or narrow bands. These clouds have a fibrous (hair-like) appearance, or a silky sheen, or both.

*Cirrocumulus*

Thin, white patch, sheet or layer of cloud without shading, composed of very small elements in the form of grains, ripples, etc., merged or separate, and more or less regularly arranged; most of the elements have an apparent width of less than one degree.

*Cirrostratus*

Transparent, whitish cloud veil of fibrous (hair-like) or smooth appearance, totally or partly covering the sky, and generally producing halo phenomena.

*Altocumulus*

White or grey, or both white and grey, patch, sheet or layer of cloud, generally with shading, composed of laminae, rounded masses, rolls, etc., which are sometimes partly fibrous or diffuse and which may or may not be merged; most of the regularly arranged small elements usually have an apparent width of between one and five degrees.

*Altostratus*

Greyish or bluish cloud sheet or layer of striated, fibrous or uniform appearance, totally or partly covering the sky, and having parts thin enough to reveal the sun at least vaguely, as through ground glass. Altostratus does not show halo phenomena.

*Nimbostratus*

Grey cloud layer, often dark, the appearance of which is rendered diffuse by more or less continuously falling rain or snow, which in most cases reaches the ground. It is thick enough throughout to blot out the sun.

Low, ragged clouds frequently occur below the layer, with which they may or may not merge.

*Stratocumulus*

Grey or whitish, or both grey and whitish, patch, sheet or layer of cloud which almost always has dark parts, composed of tessellations, rounded masses, rolls, etc., which are non-fibrous (except for virga) and which may or may not be merged; most of the regularly arranged small elements have an apparent width of more than five degrees.

*Stratus*

Generally grey cloud layer with a fairly uniform base, which may give drizzle, ice prisms or snow grains. When the sun is visible through the cloud, its outline is clearly discernible. Stratus does not produce halo phenomena except, possibly, at very low temperatures.

Sometimes Stratus appears in the form of ragged patches.

*Cumulus*

Detached clouds, generally dense and with sharp outlines, developing vertically in the form of rising mounds, domes or towers, of which the bulging upper part often resembles a cauliflower. The sunlit parts of these clouds are mostly brilliant white; their base is relatively dark and nearly horizontal.

Sometimes Cumulus is ragged.

*Cumulonimbus*

Heavy and dense cloud, with a considerable vertical extent, in the form of a mountain or huge towers. At least part of its upper portion is usually smooth, or fibrous or striated, and nearly always flattened; this part often spreads out in the shape of an anvil or vast plume.

Under the base of this cloud which is often very dark, there are frequently low ragged clouds either merged with it or not, and precipitation sometimes in the form of virga.

### II.2.3.2

### Species

Observed peculiarities in the shape of clouds and differences in their internal structure have led to the subdivision of most of the cloud genera into species. A cloud observed in the sky, belonging to a certain genus, may bear the name of one species only; this means that the species are mutually exclusive. On the other hand, certain species may be common to several genera.

The fact that several species may be distinguished in a given genus, does not imply that a specific cloud must necessarily receive the name of one of those species. When, for a cloud of a given genus, none of the definitions of the species relevant to the genus is applicable, no species is indicated.

*Fibratus*

Detached clouds or a thin cloud veil, consisting of nearly straight or more or less irregularly curved filaments which do not terminate in hooks or tufts.

This term applies mainly to Cirrus and Cirrostratus.

*Uncinus*

Cirrus often shaped like a comma, terminating at the top in a hook, or in a tuft the upper part of which is not in the form of a rounded protuberance.

*Spissatus*

Cirrus of sufficient optical thickness to appear greyish when viewed towards the sun.

*Castellanus*

Clouds which present, in at least some portion of their upper part, cumuliform protuberances in the form of turrets which generally give the clouds a crenelated appearance. The turrets, some of which are taller than they are wide, are connected by a common base and seem to be arranged in lines. The castellanus character is especially evident when the clouds are seen from the side.

This term applies to Cirrus, Cirrocumulus, Altocumulus and Stratocumulus.

*Floccus*

A species in which each cloud unit is a small tuft with a cumuliform appearance, the lower part of which is more or less ragged and often accompanied by virga.

This term applies to Cirrus, Cirrocumulus and Altocumulus.

*Stratiformis*

Clouds spread out in an extensive horizontal sheet or layer.

This term applies to Altocumulus, Stratocumulus and, occasionally, to Cirrocumulus.

*Nebulosus*

A cloud like a nebulous veil or layer, showing no distinct details.

This term applies mainly to Cirrostratus and Stratus.

*Lenticularis*

Clouds having the shape of lenses or almonds, often very elongated and usually with well-defined outlines; they occasionally show irisation. Such clouds appear most often in cloud formations of orographic origin, but may also occur in regions without marked orography.

This term applies mainly to Cirrocumulus, Altocumulus and Stratocumulus.

## TABLE OF SPECIES AND THE GENERA WITH WHICH THEY MOST FREQUENTLY OCCUR

| GENERA / SPECIES | Ci | Cc | Cs | Ac | As | Ns | Sc | St | Cu | Cb |
|---|---|---|---|---|---|---|---|---|---|---|
| fibratus (fib) | + | | + | | | | | | | |
| uncinus (unc) | + | | | | | | | | | |
| spissatus (spi) | + | | | | | | | | | |
| castellanus (cas) | + | + | | + | | | + | | | |
| floccus (flo) | + | + | | + | | | | | | |
| stratiformis (str) | | + | | + | | | + | | | |
| nebulosus (neb) | | | + | | | | | + | | |
| lenticularis (len) | | + | | + | | | + | | | |
| fractus (fra) | | | | | | | | + | + | |
| humilis (hum) | | | | | | | | | + | |
| mediocris (med) | | | | | | | | | + | |
| congestus (con) | | | | | | | | | + | |
| calvus (cal) | | | | | | | | | | + |
| capillatus (cap) | | | | | | | | | | + |

*Fractus*

Clouds in the form of irregular shreds, which have a clearly ragged appearance. This term applies only to Stratus and Cumulus.

*Humilis*

Cumulus clouds of only a slight vertical extent; they generally appear flattened.

*Mediocris*

Cumulus clouds of moderate vertical extent, the tops of which show fairly small protuberances.

*Congestus*

Cumulus clouds which are markedly sprouting and are often of great vertical extent; their bulging upper part frequently resembles a cauliflower.

*Calvus*

Cumulonimbus in which at least some protuberances of the upper part are beginning to lose their cumuliform outlines but in which no cirriform parts can be distinguished. Protuberances and sproutings tend to form a whitish mass, with more or less vertical striations.

*Capillatus*

Cumulonimbus characterized by the presence, mostly in its upper portion, of distinct cirriform parts of clearly fibrous or striated structure, frequently having the form of an anvil, a plume or a vast, more or less disorderly mass of hair. Cumulonimbus capillatus is usually accompanied by a shower or by a thunderstorm, often with squalls and sometimes with hail; it frequently produces very well-defined virga.

## II.2.3.3

### VARIETIES

Various *arrangements of the macroscopic elements* and the greater or lesser *degree of transparency* have led to the introduction of the concept of varieties. A given cloud may bear the names of different varieties, which means that varieties are not mutually exclusive [1]. On the other hand, certain varieties may be present in several genera. The fact that a number of varieties has been established does not imply that a specific cloud must necessarily receive the name of one or more of those varieties.

The definitions of the varieties are given below. The varieties intortus, vertebratus, undulatus, radiatus, lacunosus and duplicatus refer to the arrangement of macroscopic elements; the varieties translucidus, perlucidus and opacus refer to the degree of transparency.

*Intortus*

Cirrus, the filaments of which are very irregularly curved and often seemingly entangled in a capricious manner.

*Vertebratus*

Clouds, the elements of which are arranged in a manner suggestive of vertebrae, ribs, or a fish skeleton.

This term applies mainly to Cirrus.

*Undulatus*

Clouds in patches, sheets or layers, showing undulations. These undulations may be observed in fairly uniform cloud layers or in clouds composed of elements, separate or merged. Sometimes a double system of undulations is in evidence.

[1] The varieties translucidus and opacus provide the only exception to this rule.

This term applies mainly to Cirrocumulus, Cirrostratus, Altocumulus, Altostratus, Stratocumulus and Stratus.

TABLE OF VARIETIES AND THE GENERA
WITH WHICH THEY MOST FREQUENTLY OCCUR

| VARIETIES \ GENERA | Ci | Cc | Cs | Ac | As | Ns | Sc | St | Cu | Cb |
|---|---|---|---|---|---|---|---|---|---|---|
| intortus (in) | + | | | | | | | | | |
| vertebratus (ve) | + | | | | | | | | | |
| undulatus (un) | | + | + | + | + | | + | + | | |
| radiatus (ra) | + | | | + | + | | + | | + | |
| lacunosus (la) | | + | | + | | | + | | | |
| duplicatus (du) | + | | + | + | + | | + | | | |
| translucidus (tr) | | | | + | + | | + | + | | |
| perlucidus (pe) | | | | + | | | + | | | |
| opacus (op) | | | | + | + | | + | + | | |

*Radiatus*

Clouds showing broad parallel bands or arranged in parallel bands, which, owing to the effect of perspective, seem to converge towards a point on the horizon or, when the bands cross the whole sky, towards two opposite points on the horizon, called "radiation point(s)".

This term applies mainly to Cirrus, Altocumulus, Altostratus, Stratocumulus and Cumulus.

*Lacunosus*

Cloud patches, sheets or layers, usually rather thin, marked by more or less regularly distributed round holes, many of them with fringed edges. Cloud elements and clear spaces are often arranged in a manner suggesting a net or a honeycomb.

This term applies mainly to Cirrocumulus and Altocumulus; it may also apply, though very rarely, to Stratocumulus.

*Duplicatus*

Superposed cloud patches, sheets or layers, at slightly different levels, sometimes partly merged.

This term applies mainly to Cirrus, Cirrostratus, Altocumulus, Altostratus and Stratocumulus.

*Translucidus*

Clouds in an extensive patch, sheet or layer, the greater part of which is sufficiently translucent to reveal the position of the sun or moon.[1]

This term applies to Altocumulus, Altostratus, Stratocumulus and Stratus.

*Perlucidus*

An extensive cloud patch, sheet or layer, with distinct but sometimes very small spaces between the elements. The spaces allow the sun, the moon, the blue of the sky or over-lying clouds to be seen.[2]

This term applies to Altocumulus and Stratocumulus.

*Opacus*

An extensive cloud patch, sheet or layer, the greater part of which is sufficiently opaque to mask completely the sun or moon.[1]

This term applies to Altocumulus, Altostratus, Stratocumulus and Stratus.

## II.2.3.4

### SUPPLEMENTARY FEATURES AND ACCESSORY CLOUDS

Clouds sometimes have supplementary features attached to them or may be accompanied by other usually smaller clouds, known as accessory clouds which are separate from their main body or partly merged with it. A given cloud may present simultaneously one or more supplementary features or accessory clouds, which means that supplementary features and accessory clouds are not mutually exclusive.

The definitions of the supplementary features and accessory clouds are given below.

(*a*) Supplementary features

*Incus*

The upper portion of a Cumulonimbus spread out in the shape of an anvil with a smooth, fibrous or striated appearance.

*Mamma*

Hanging protuberances, like udders, on the under surface of a cloud.

This supplementary feature occurs mostly with Cirrus, Cirrocumulus, Altocumulus, Altostratus, Stratocumulus and Cumulonimbus.

[1] The varieties translucidus and opacus are mutually exclusive.

[2] The variety perlucidus may be observed in combination with the varieties translucidus or opacus.

## TABLE OF SUPPLEMENTARY FEATURES AND ACCESSORY CLOUDS AND THE GENERA WITH WHICH THEY MOST FREQUENTLY OCCUR

| GENERA / SUPPLEMENTARY FEATURES AND ACCESSORY CLOUDS | Ci | Cc | Cs | Ac | As | Ns | Sc | St | Cu | Cb |
|---|---|---|---|---|---|---|---|---|---|---|
| incus (inc) | | | | | | | | | | + |
| mamma (mam) | + | + | | + | + | | + | | | + |
| virga (vir) | | + | | + | + | + | + | | + | + |
| praecipitatio (pra) | | | | | + | + | + | + | + | + |
| arcus (arc) | | | | | | | | | + | + |
| tuba (tub) | | | | | | | | | + | + |
| pileus (pil) | | | | | | | | | + | + |
| velum (vel) | | | | | | | | | + | + |
| pannus (pan) | | | | | + | + | | | + | + |

*Virga*

Vertical or inclined trails of precipitation (fallstreaks) attached to the under surface of a cloud, which do not reach the Earth's surface.

This supplementary feature occurs mostly with Cirrocumulus, Altocumulus, Altostratus, Nimbostratus, Stratocumulus, Cumulus and Cumulonimbus.

*Praecipitatio*

Precipitation (rain, drizzle, snow, ice pellets, hail, etc.) falling from a cloud and reaching the Earth's surface.

This supplementary feature is mostly encountered with Altostratus, Nimbostratus, Stratocumulus, Stratus, Cumulus and Cumulonimbus.

*Arcus*

A dense, horizontal roll with more or less tattered edges, situated on the lower front part of certain clouds and having, when extensive, the appearance of a dark, menacing arch.

This supplementary feature occurs with Cumulonimbus and, less often, with Cumulus.

*Tuba*

Cloud column or inverted cloud cone, protruding from a cloud base; it constitutes the cloudy manifestation of a more or less intense vortex.[1]

This supplementary feature occurs with Cumulonimbus and, less often, with Cumulus.

(*b*) Accessory clouds

*Pileus*

An accessory cloud of small horizontal extent, in the form of a cap or hood above the top or attached to the upper part of a cumuliform cloud which often penetrates it. Several pileus may fairly often be observed in superposition.

Pileus occurs principally with Cumulus and Cumulonimbus.

*Velum*

An accessory cloud veil of great horizontal extent, close above or attached to the upper part of one or several cumuliform clouds which often pierce it.

Velum occurs principally with Cumulus and Cumulonimbus.

*Pannus*

Ragged shreds sometimes constituting a continuous layer, situated below another cloud and sometimes attached to it.

This accessory cloud occurs mostly with Altostratus, Nimbostratus, Cumulus and Cumulonimbus.

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[1] See the definition of "spout", paragraph III.2.1.5.

## II.3 — DESCRIPTIONS OF CLOUDS

### II.3.1
**Cirrus (Ci)**
(Howard 1803)

#### II.3.1.1
Definition

Detached clouds in the form of white, delicate filaments or white or mostly white patches or narrow bands. These clouds have a fibrous (hair-like) appearance, or a silky sheen, or both.

#### II.3.1.2
Species

*Cirrus fibratus* [1] (Ci fib) — Besson 1921, CCH 1953

Nearly straight or more or less irregularly curved white filaments which are always fine and do not terminate in hooks or tufts. The filaments are, for the most part, distinct from one another.

*Cirrus uncinus* (Ci unc) — Maze 1889

Cirrus without grey parts, often shaped like a comma, terminating at the top in a hook, or in a tuft the upper part of which is not in the form of a rounded protuberance.

*Cirrus spissatus* [2] (Ci spi) — CCH 1953

Cirrus in patches, sufficiently dense to appear greyish when viewed towards the sun; it may also veil the sun, obscure its outline or even hide it. Cirrus spissatus often originates from the upper part of a Cumulonimbus.

*Cirrus castellanus* [3] (Ci cas) — CCH 1953

Fairly dense Cirrus, in the form of small, rounded and fibrous turrets or masses rising from a common base, and sometimes having a crenelated appearance. The apparent width of the turret-like protuberances may be smaller or greater than one degree when observed at an angle of more than 30 degrees above the horizon (cf. Cirrocumulus castellanus, paragraph II.3.2.2).

*Cirrus floccus* (Ci flo) — Vincent 1903, CEN 1930

Cirrus in the form of more or less isolated, small, rounded tufts, often with trails. The apparent width of the tufts may be smaller or greater than one degree when observed at an angle of more than 30 degrees above the horizon (cf. Cirrocumulus floccus, paragraph II.3.2.2).

1 Formerly called Cirrus filosus (Clayton 1896, CEN 1930).
2 Formerly called Cirrus densus and Cirrus nothus (Besson 1921, CEN 1926).
3 Formerly called Cirrus castellatus (Ley 1894).

## II.3.1.3

### VARIETIES

*Cirrus intortus* (Ci in) — CCH 1953

Cirrus, the filaments of which are very irregularly curved and often seemingly entangled in a capricious manner.

*Cirrus radiatus* (Ci ra) — CEN 1926

Cirrus arranged in parallel bands which, owing to the effect of perspective, appear to converge towards one point or towards two opposite points of the horizon. These bands are often partly composed of Cirrocumulus or Cirrostratus.

*Cirrus vertebratus* (Ci ve) — MAZE 1889, OSTHOFF 1905

Cirrus, the elements of which are arranged in a manner suggestive of vertebrae, ribs, or a fish skeleton.

*Cirrus duplicatus* (Ci du) — MAZE 1889

Cirrus arranged in superposed layers at slightly different levels, sometimes merged in places. Most Cirrus fibratus and Cirrus uncinus belong to this variety.

## II.3.1.4

### SUPPLEMENTARY FEATURES AND ACCESSORY CLOUDS

Cirrus sometimes shows mamma.

## II.3.1.5

### CLOUDS FROM WHICH CIRRUS MAY FORM

Cirrus clouds often evolve from virga of Cirrocumulus or Altocumulus (Ci cirrocumulogenitus or Ci altocumulogenitus), or from the upper part of a Cumulonimbus (Ci cumulonimbogenitus).

Cirrus clouds may also form as a result of the transformation of non-uniform Cirrostratus by evaporation of its thinner parts (Ci cirrostratomutatus).

## II.3.1.6

### MAIN DIFFERENCES BETWEEN CIRRUS AND SIMILAR CLOUDS OF OTHER GENERA

Cirrus clouds are distinguished from *Cirrocumulus* by their mainly fibrous or silky appearance and by the absence of small cloud elements in the form of grains, ripples, etc.

Cirrus clouds are distinguished from *Cirrostratus* by their discontinuous structure or, if they are in patches or bands, by their small horizontal extent or the narrowness of their continuous parts. Cirrus near the horizon may be difficult to distinguish from Cirrostratus, owing to the effect of perspective.

Cirrus clouds are distinguished from *Altocumulus* by their mainly fibrous or silky appearance and by the absence of cloud elements in the form of laminae, rolls, etc.

Thick Cirrus clouds are distinguished from *Altostratus* patches by their smaller horizontal extent and their mostly white appearance.

II.3.1.7

PHYSICAL CONSTITUTION

Cirrus is composed almost exclusively of ice crystals. These crystals are in general very small, a fact which, together with their sparseness, accounts for the transparency of most Cirrus clouds.

Dense Cirrus patches or Cirrus in tufts may nevertheless contain ice crystals large enough to acquire an appreciable terminal velocity, so that trails of considerable vertical extent may form. Sometimes, though not very frequently, the ice crystals in the trails melt into small water droplets; the trails are then greyish, in contrast with their usual white appearance, and may give rise to the formation of a rainbow.

The trails curve irregularly or slant as a result of wind shear and of the variation in size of the constituent particles; consequently, Cirrus filaments near the horizon do not appear parallel to it.

Halo phenomena may occur; circular haloes almost never show a complete ring, owing to the narrowness of the Cirrus clouds.

II.3.1.8

EXPLANATORY REMARKS

Cirrus tufts with rounded tops often form in clear air. Fibrous trails may appear under the tufts; the tops then gradually lose their roundness. Subsequently, the tufts may disappear completely; the clouds are then in the form of filaments.

Cirrus in the form of filaments may develop also from dense Cirrus patches, from Altocumulus castellanus and floccus and, occasionally at very low temperatures, from Cumulus congestus.

The following special remarks can be made with regard to the colours of Cirrus.

At all times of day, Cirrus not too close to the horizon is white, in fact whiter than any other cloud in the same part of the sky. With the sun on the horizon it is whitish, while lower clouds may be tinted yellow or orange. When the sun sinks below the horizon, Cirrus high in the sky is yellow, then pink, red and finally grey. The colour sequence is reversed at dawn.

Cirrus near the horizon often takes a yellowish or orange tint owing to the great thickness of air traversed by the light in passing from the cloud to the observer. These tints are less conspicuous in lower cloud genera.

**II.3.2**

**Cirrocumulus (Cc)**

(HOWARD 1803; RENOU 1855)

**II.3.2.1**

DEFINITION

Thin, white patch, sheet or layer of cloud without shading, composed of very small elements in the form of grains, ripples, etc., merged or separate, and more or less regularly arranged; most of the elements have an apparent width of less than one degree.

### II.3.2.2

#### Species

*Cirrocumulus stratiformis* (Cc str) — CCH 1953

Cirrocumulus in the form of a relatively extensive sheet or layer, sometimes showing gaps, breaches or rifts.

*Cirrocumulus lenticularis* (Cc len) — Ley 1894, CEN 1930

Cirrocumulus patches shaped like lenses or almonds, often very elongated and usually with well-defined outlines. These more or less isolated clouds are mostly smooth and are very white throughout. Irisation is sometimes observed on these clouds.

*Cirrocumulus castellanus* [1] (Cc cas) — CCH 1953

Cirrocumulus, some elements of which are vertically developed in the form of small turrets, rising from a common horizontal base. The apparent width of the turrets is always less than one degree, when observed at an angle of more than 30 degrees above the horizon. The presence of this cloud is an indication of instability at its level.

*Cirrocumulus floccus* (Cc flo) — Vincent 1903, CCH 1953

Cirrocumulus composed of very small cumuliform tufts, the lower parts of which are more or less ragged. The apparent width of the tufts is always less than one degree, when observed at an angle of more than 30 degrees above the horizon. As in the case of Cirrocumulus castellanus, the presence of these clouds is an indication of instability at their level. Cirrocumulus floccus sometimes results from the evolution of Cirrocumulus castellanus the base of which has dissipated.

### II.3.2.3

#### Varieties

*Cirrocumulus undulatus* (Cc un) — Clayton 1896, CCH 1953

Cirrocumulus showing one or two systems of undulations.

*Cirrocumulus lacunosus* [2] (Cc la) — CCH 1953

Cirrocumulus in a patch, sheet or layer, showing small more or less regularly distributed round holes, many of them with fringed edges. Cloud elements and clear spaces are often arranged in a manner suggesting a net or a honeycomb.

### II.3.2.4

#### Supplementary features and accessory clouds

Small virga may be present, particularly under Cirrocumulus castellanus and floccus. Cirrocumulus occasionally shows mamma.

[1] Formerly called Cirrocumulus castellatus (Ley 1894).

[2] Formerly called Cirrocumulus lacunaris (CEN 1930).

II.3.2.5

### Clouds from which Cirrocumulus may form

Cirrocumulus often forms as a result of the transformation of Cirrus or Cirrostratus (Cc cirromutatus and Cc cirrostratomutatus). Cirrocumulus may also form as the result of a decrease in size of the elements of a patch, sheet or layer of Altocumulus (Cc altocumulomutatus).

II.3.2.6

### Main differences between Cirrocumulus and similar clouds of other genera

Cirrocumulus differs from *Cirrus* and *Cirrostratus* in that it is rippled or subdivided into very small cloudlets; it may include fibrous, silky or smooth portions which, however, do not collectively constitute its greater part.

Cirrocumulus differs from *Altocumulus* in that most of its elements are very small (by definition, of an apparent width less than one degree when observed at an angle of more than 30 degrees above the horizon) and without shading.

II.3.2.7

### Physical constitution

Cirrocumulus is composed almost exclusively of ice crystals; strongly supercooled water droplets may occur but are usually rapidly replaced by ice crystals.

A corona or irisation may sometimes be observed.

II.3.2.8

### Explanatory remarks

Cirrocumulus in the shape of lenses or almonds may be produced by local orographic lifting of a layer of moist air.

In middle and high latitudes, Cirrocumulus is usually associated, in space and time, with Cirrus or Cirrostratus, or with both. In low latitudes, Cirrocumulus is less often accompanied by Cirrus or Cirrostratus.

A cloud should not be called Cirrocumulus if it consists of a patch of incompletely developed small elements, such as those sometimes observed on the margin of a patch or sheet of Altocumulus or those sometimes present in separate patches at the same level as Altocumulus.

In case of doubt, a cloud should be given the name Cirrocumulus only when it has evolved from, or is obviously connected with Cirrus or Cirrostratus.

**II.3.3**

## Cirrostratus (Cs)

(Howard 1803; Renou 1855)

### II.3.3.1

DEFINITION

Transparent, whitish cloud veil of fibrous (hair-like) or smooth appearance, totally or partly covering the sky, and generally producing halo phenomena.

### II.3.3.2

SPECIES

*Cirrostratus fibratus* [1] (Cs fib) — BESSON 1921, CCH 1953

A fibrous veil of Cirrostratus in which thin striations can be observed. Cirrostratus fibratus may develop from Cirrus fibratus or Cirrus spissatus.

*Cirrostratus nebulosus* (Cs neb) — CLAYDEN 1905

A nebulous veil of Cirrostratus which shows no distinct detail. The appearance of this veil may vary considerably from one case to another. It may be so light that it is barely visible; it may also be relatively dense.

### II.3.3.3

VARIETIES

*Cirrostratus duplicatus* (Cs du) — MAZE 1889, DE QUERVAIN 1908, CCH 1953

Cirrostratus arranged in superposed sheets or layers, at slightly different levels, sometimes partly merged.

*Cirrostratus undulatus* (Cs un) — CCH 1953

Cirrostratus showing undulations.

### II.3.3.4

SUPPLEMENTARY FEATURES AND ACCESSORY CLOUDS

None worth mentioning.

### II.3.3.5

CLOUDS FROM WHICH CIRROSTRATUS MAY FORM

Cirrostratus may be produced by the merging of elements of Cirrus or Cirrocumulus (Cs cirromutatus, Cs cirrocumulomutatus), by ice crystals falling from Cirrocumulus (Cs cirrocumulogenitus), by the thinning of Altostratus (Cs altostratomutatus) or by the spreading out of the anvil of a Cumulonimbus (Cs cumulonimbogenitus).

[1] Formerly called Cirrostratus filosus (Clayton 1896, CEN 1930).

II.3.3.6

MAIN DIFFERENCES BETWEEN CIRROSTRATUS AND SIMILAR CLOUDS OF OTHER GENERA

Cirrostratus is distinguished from *Cirrus* by the fact that it occurs in the form of a veil which is usually of great horizontal extent.

Cirrostratus differs from *Cirrocumulus* and *Altocumulus* by the lack of a more or less regular macroscopic structure (grains, ripples, laminae, rounded masses, rolls, etc.) and by its diffuse general appearance.

Cirrostratus differs from *Altostratus* by its thinness and by the fact that it may show halo phenomena. Cirrostratus near the horizon may be mistaken for Altostratus. The slowness of the apparent movement and the slowness of the variations in optical thickness and in appearance, both characteristic of Cirrostratus, give useful guidance in distinguishing this cloud from Altostratus and also from Stratus.

Cirrostratus may be confused with very thin *Stratus* which, at angular distances of less than 45 degrees from the sun, may appear very white. Cirrostratus differs, however, from Stratus by being whitish throughout, and by the fact that it may have a fibrous appearance. Moreover Cirrostratus often displays halo phenomena, whereas Stratus does not, except occasionally at very low temperatures.

Cirrostratus differs from a veil of *haze* by the fact that the latter is opalescent or has a dirty yellowish to brownish colour. It is sometimes difficult to discern Cirrostratus through haze.

II.3.3.7

PHYSICAL CONSTITUTION

Cirrostratus is composed mainly of ice crystals. The smallness of these crystals, their sparseness and the fact that Cirrostratus has at most only a moderate depth, account for the transparency of this cloud through which the outline of the sun is visible, at least when the latter is not too close to the horizon.

In certain types of Cirrostratus, some of the ice crystals are large enough to acquire an appreciable terminal velocity, so that trailing filaments are formed, which give these Cirrostratus clouds a fibrous appearance.

Halo phenomena are often observed in thin Cirrostratus; sometimes the veil of Cirrostratus is so thin that a halo provides the only indication of its presence.

II.3.3.8

EXPLANATORY REMARKS

Cirrostratus, not completely covering the sky, may be straight-edged and clear-cut; more often, however, it shows an irregular border fringed with Cirrus.

Cirrostratus is never thick enough to prevent objects on the ground from casting shadows, at least when the sun is high above the horizon. When the sun is low (less than about 30 degrees) the relatively longer light path through a Cirrostratus veil may reduce the light intensity so much that shadows do not exist.

The remarks about the colours of Cirrus are, to a great extent, also valid for Cirrostratus.

## II.3.4

## Altocumulus (Ac)

(RENOU 1870)

### II.3.4.1

DEFINITION

White or grey, or both white and grey, patch, sheet or layer of cloud, generally with shading, composed of laminae, rounded masses, rolls, etc., which are sometimes partly fibrous or diffuse and which may or may not be merged; most of the regularly arranged small elements usually have an apparent width between one and five degrees.

### II.3.4.2

SPECIES

*Altocumulus stratiformis* (Ac str) — CCH 1953

Altocumulus in an extensive sheet or layer, composed of separate or merged elements. This is by far the most frequent species.

*Altocumulus lenticularis* (Ac len) — LEY 1894, CEN 1930

A patch of Altocumulus, in the shape of a lens or almond, often very elongated and usually with well-defined outlines. This patch is either composed of small elements, closely grouped together, or consists of one more or less smooth unit. In the latter case, there are pronounced shadings. Irisation is occasionally visible.

*Altocumulus castellanus* [1] (Ac cas) — CCH 1953

Altocumulus which presents, in at least a fraction of its upper part, cumuliform protuberances in the form of turrets which give this cloud a crenelated appearance. The cumuliform cloud elements have a common horizontal base and appear to be arranged in lines. The castellanus character is especially evident when the cloud is seen from the side.

The presence of this cloud is a sign of instability at its level; when it acquires a considerable vertical extent, Altocumulus castellanus becomes Cumulus congestus, and sometimes Cumulonimbus.

*Altocumulus floccus* (Ac flo) — VINCENT 1903

Altocumulus consisting of small tufts of cumuliform appearance; the lower parts of these tufts are more or less ragged and are often accompanied by fibrous trails (virga of ice crystals). The presence of these clouds is an indication of instability at their level. Altocumulus floccus sometimes forms as a result of the dissipation of the base of Altocumulus castellanus.

### II.3.4.3

VARIETIES

*Altocumulus translucidus* (Ac tr) — CEN 1930

A patch, sheet or layer of Altocumulus, the greater part of which is sufficiently translucent to reveal the position of the sun or moon. This variety often occurs in the species stratiformis and lenticularis.

[1] Formerly called Altocumulus castellatus (LEY 1894).

*Altocumulus perlucidus* (Ac pe) — CCH 1953

A patch, sheet or layer of Altocumulus in which the spaces between the elements allow the sun, the moon, the blue of the sky or higher clouds to be seen. This variety often occurs in the species stratiformis.

*Altocumulus opacus* (Ac op) — CEN 1930

A patch, sheet or layer of Altocumulus, the greater part of which is sufficiently opaque to mask completely the sun or moon. Most often, the base of this variety of Altocumulus is even and its apparent subdivision into merged elements results from the irregularity of its upper surface. The under surface is sometimes uneven and the elements then stand out in true relief. The variety opacus occurs fairly often in the species stratiformis.

*Altocumulus duplicatus* (Ac du) — MAZE 1889, DE QUERVAIN 1908, CEN 1926

Altocumulus comprising two or more broadly horizontal superposed patches, sheets or layers, close together, sometimes partly merged. This variety occurs in the species stratiformis and lenticularis.

*Altocumulus undulatus* (Ac un) — CLAYTON 1896, CEN 1930

Altocumulus composed of separate or merged elements, either elongated and broadly parallel, or arranged in ranks and files having the appearance of two distinct systems of undulations.

*Altocumulus radiatus* (Ac ra) — CEN 1926

Altocumulus showing approximately straight, parallel bands which, owing to the effect of perspective, appear to converge towards one point, or two opposite points of the horizon.

*Altocumulus lacunosus* [1] (Ac la) — CCH 1953

Altocumulus, in a sheet or layer or in patches showing more or less regularly distributed round holes, many of them with fringed edges. Cloud elements and clear spaces are often arranged in a manner suggesting a net or a honeycomb. The details change rapidly.

### II.3.4.4

SUPPLEMENTARY FEATURES AND ACCESSORY CLOUDS

Virga may appear with most of the species of Altocumulus. Altocumulus floccus frequently dissipates, leaving very white trails of ice crystals, which are then identified as Cirrus.

Mamma are sometimes visible in Altocumulus.

### II.3.4.5

CLOUDS FROM WHICH ALTOCUMULUS MAY FORM

Altocumulus may form by an increase in size or a thickening of at least some elements of a patch, sheet or layer of Cirrocumulus (Ac cirrocumulomutatus), by subdivision of a layer of Stratocumulus (Ac stratocumulomutatus), or by transformation of Altostratus or Nimbostratus (Ac altostratomutatus, Ac nimbostratomutatus).

[1] Formerly called Altocumulus lacunaris (CEN 1930).

Altocumulus may also be produced by the spreading out of the summits of Cumulus clouds which reach a stable layer while in the process of vertical development (Ac cumulogenitus). Occasionally, the stable layer cannot stop the vertical development completely; in this case, after a temporary spreading out, the Cumulus clouds resume their growth above the stable layer, at least in places. Thus, the Altocumulus may appear on the lateral portion of Cumulus.

Altocumulus may also be observed on or near the lateral portion of Cumulonimbus. This Altocumulus often forms while the mother-cloud is still in the Cumulus stage. The clouds are nevertheless, by convention, called Altocumulus cumulonimbogenitus.

### II.3.4.6

### Main differences between Altocumulus and similar clouds of other genera

Altocumulus sometimes produces descending trails of fibrous appearance (virga). When this is the case, the clouds are regarded as Altocumulus and not as *Cirrus*, as long as they have a part without a fibrous appearance or a silky sheen.

Altocumulus may sometimes be confused with *Cirrocumulus*. In case of doubt, if the clouds have shading, they are by definition Altocumulus, even if their elements have an apparent width of less than one degree. Clouds without shading are Altocumulus if most of the regularly arranged elements, when observed at an angle of more than 30 degrees above the horizon, have an apparent width between one and five degrees.

An Altocumulus layer may sometimes be confused with *Altostratus*; in case of doubt, clouds are called Altocumulus if there is any evidence of the presence of laminae, rounded masses, rolls, etc.

Altocumulus, with dark portions, may sometimes be confused with *Stratocumulus*. If most of the regularly arranged elements have, when observed at an angle of more than 30 degrees above the horizon, an apparent width between one and five degrees, the cloud is Altocumulus.

Altocumulus in scattered tufts may be confused with small *Cumulus* clouds; the Altocumulus tufts, however, often show fibrous trails (virga) and moreover are, in their majority, smaller than the Cumulus clouds.

### II.3.4.7

### Physical constitution

Altocumulus is, at least in the main, almost invariably composed of water droplets. This is evident from the fairly low transparency of the macroscopic elements and from the fact that the latter show sharp outlines when separate. Nevertheless, when the temperature is very low, ice crystals may form. If the droplets then evaporate, the cloud becomes entirely an ice cloud and its macroscopic elements cease to present sharp outlines. The formation of ice crystals may take place in all species of Altocumulus; it occurs most frequently in Altocumulus castellanus and floccus.

A corona or irisation is often observed in thin parts of Altocumulus. Parhelia or luminous pillars are sometimes seen in Altocumulus, indicating the presence of tabular-shaped ice crystals.

### II.3.4.8

### Explanatory remarks

During the initial stages of its formation, Altocumulus is frequently a fairly smooth cloud of moderate horizontal extent. This cloud then subdivides into more or less regularly arranged small elements, in the form of laminae or tessellations.

Altocumulus in the shape of lenses or almonds often forms in clear air as a result of local orographic lifting of a layer of moist air.

Altocumulus frequently occurs at different levels in the same sky and is in many instances associated with Altostratus. In this case, the air is often hazy immediately below the sheets or layers of Altocumulus or between the elements constituting them.

## II.3.5

## Altostratus (As)

(Renou 1877)

### II.3.5.1

### Definition

Greyish or bluish cloud sheet or layer of striated, fibrous or uniform appearance, totally or partly covering the sky, and having parts thin enough to reveal the sun at least vaguely, as through ground glass. Altostratus does not show halo phenomena.

### II.3.5.2

### Species

Altostratus is not subdivided into species owing to the uniformity characterising its appearance and general structure.

### II.3.5.3

### Varieties

*Altostratus translucidus* (As tr) — CEN 1926

Altostratus, the greater part of which is sufficiently translucent to reveal the position of the sun or moon.

*Altostratus opacus* (As op) — Besson 1921

Altostratus, the greater part of which is sufficiently opaque to mask completely the sun or moon.

*Altostratus duplicatus* (As du) — Maze 1889, de Quervain 1908, CEN 1926

Altostratus composed of two or more superposed layers, at slightly different levels, sometimes partly merged.

*Altostratus undulatus* (As un) — Clayton 1896, CEN 1930

Altostratus showing undulations.

*Altostratus radiatus* (As ra) — CEN 1926, CCH 1953

Altostratus showing broad parallel bands which appear to converge towards one point or towards two opposite points of the horizon.

### II.3.5.4

### Supplementary features and accessory clouds

Virga and praecipitatio may be clearly visible.
Pannus clouds may be observed under Altostratus.
Altostratus may show mamma.

II.3.5.5

## Clouds from which Altostratus may form

Altostratus may evolve from a thickening veil of Cirrostratus (As cirrostratomutatus); it is sometimes formed by the thinning of a layer of Nimbostratus (As nimbostratomutatus).

Altostratus may also develop from an Altocumulus layer; this happens when widespread ice crystal trails (virga) fall from the latter (As altocumulogenitus).

Sometimes, particularly in the tropics, Altostratus is produced by the spreading out of the middle or upper part of Cumulonimbus (As cumulonimbogenitus).

II.3.5.6

## Main differences between Altostratus and similar clouds of other genera

Sheets or layers of Altostratus may, on rare occasions, degenerate into patches which may be confused with dense *Cirrus* of comparable optical thickness. Altostratus patches however have a greater horizontal extent and are predominently grey.

A high and thin layer of Altostratus may be mistaken for a veil of *Cirrostratus*. It is sometimes possible to identify the doubtful cloud by remembering that Altostratus prevents objects on the ground from casting shadows and that it may show a ground glass effect. Furthermore, if halo phenomena are present, the doubtful cloud is Cirrostratus.

Altostratus sometimes has gaps, breaches or rifts; care must then be exercised not to confuse it with an *Altocumulus* or *Stratocumulus* sheet or layer showing the same features. Altostratus is distinguishable from Altocumulus and Stratocumulus by its more uniform appearance.

A low, thick layer of Altostratus may be distinguished from a similar layer of *Nimbostratus* by the presence in Altostratus of thinner parts through which the sun is, or could be, vaguely revealed. Altostratus is also of a lighter grey and its under surface is usually less uniform than that of Nimbostratus. When, on moonless nights, doubt exists regarding the choice of the designation Altostratus or Nimbostratus, the layer is by convention called Altostratus, if no rain or snow is falling.

Altostratus is distinguishable from *Stratus*, with which it may be confused, by its ground glass effect. Furthermore, Altostratus is never white, as thin Stratus may be when observed more or less towards the sun.

II.3.5.7

## Physical constitution

Altostratus nearly always appears as a layer of great horizontal extent [several tens or hundreds of kilometres (several tens or hundreds of miles)] and fairly considerable vertical extent [several hundreds or thousands of metres (several hundreds or thousands of feet)]. It is composed of water droplets and ice crystals. In the most complete case, three superposed parts may be distinguished, namely:

(*a*) an upper part, composed wholly or mainly of ice crystals,

(*b*) a middle part, composed of a mixture of ice crystals, snow crystals or snowflakes and supercooled water droplets,

(*c*) a lower part, composed wholly or mainly of ordinary or supercooled water droplets or drops.

In some cases, the cloud may consist of only two parts, either:

— an upper part like (*a*) and a lower part like (*c*) or
— an upper part like (*b*) and a lower part like (*c*).

Less frequently, the entire cloud may also be like (*a*) or like (*b*) alone.

The constituent particles in the lower part of Altostratus are so numerous that the outline of the sun or moon is always dimmed and the surface observer never sees halo phenomena. In the thickest parts, the position of the luminary may be completely concealed.

Raindrops or snowflakes are often present in Altostratus and below its base. When precipitation reaches the ground, it is generally of the "continuous" type and in the form of rain, snow or ice pellets.

II.3.5.8

EXPLANATORY REMARKS

The under surface of Altostratus occasionally exhibits a mamillated or ragged appearance due to precipitation trails (virga of rain or snow). Isolated virga are clearly seen when rain, before evaporating, falls farther in some places than in others.

The presence of precipitation sometimes makes it difficult to distinguish a cloud base; this is particularly the case when uniformly falling snow completely evaporates, before reaching the ground. If, however, snow melts rapidly into rain, an apparent base may be observed at the melting level, as the visibility through rain is greater than through snow. This "base" is very clearly visible when the rain layer is thin, which is the case for instance if the raindrops quickly evaporate; it may be completely obscured when the rain layer is thick.

Pannus clouds may be present; they occur under the Altostratus in the lower turbulent layers when these are moistened by evaporation from precipitation. Pannus clouds also show a tendency to form near the 0° C (32° F) level where the cooling of the air by melting snow increases the instability of the layer underneath. In the initial stage of their formation, pannus clouds are small, sparse and well separated, and usually occur at a considerable distance below the under surface of the Altostratus. Later, with a thickening Altostratus and a lowering of its base, this distance is greatly reduced. At the same time, the pannus clouds increase in size and number and may merge into a quasi-continuous layer.

## II.3.6

## Nimbostratus (Ns)

(CEN 1930)

### II.3.6.1

DEFINITION

Grey cloud layer, often dark, the appearance of which is rendered diffuse by more or less continuously falling rain or snow, which in most cases reaches the ground. It is thick enough throughout to blot out the sun.

Low, ragged clouds frequently occur below the layer, with which they may or may not merge.

### II.3.6.2

SPECIES

No species are distinguished in Nimbostratus.

### II.3.6.3

VARIETIES

Nimbostratus has no varieties.

### II.3.6.4

SUPPLEMENTARY FEATURES AND ACCESSORY CLOUDS

The main supplementary features of Nimbostratus are praecipitatio (rain, snow or ice pellets) and virga.

Pannus clouds may frequently be observed under Nimbostratus.

### II.3.6.5

CLOUDS FROM WHICH NIMBOSTRATUS MAY FORM

Nimbostratus usually develops from thickening Altostratus (Ns altostratomutatus); it may also, though rarely, result from the thickening of a layer of Stratocumulus (Ns stratocumulomutatus) or Altocumulus (Ns altocumulomutatus).

Nimbostratus also sometimes forms by the spreading out of Cumulonimbus (Ns cumulonimbogenitus) or, very rarely, when these clouds produce rain, by the spreading out of Cumulus congestus (Ns cumulogenitus).

### II.3.6.6

MAIN DIFFERENCES BETWEEN NIMBOSTRATUS AND SIMILAR CLOUDS OF OTHER GENERA

Thin Nimbostratus may be confused with thick *Altostratus*. Nimbostratus generally has a darker grey colour than Altostratus. By definition, Nimbostratus is sufficiently opaque throughout to hide the sun or moon, whereas Altostratus hides the luminary only when the latter is behind the thickest parts. If on dark nights, doubt exists regarding the choice of the designation Nimbostratus or Altostratus, the cloud is by convention called Nimbostratus when rain or snow reaches the ground.

Nimbostratus is distinguished from a thick layer of *Altocumulus* or *Stratocumulus* by the lack of clearly defined elements or its lack of a distinct lower surface.

Nimbostratus is distinguished from thick *Stratus* by the fact that it is a dense cloud producing rain, snow or ice pellets; the precipitation which may fall from Stratus is in the form of drizzle, ice prisms or snow grains.

When the observer is beneath a cloud having the appearance of a Nimbostratus, but accompanied by lightning, thunder or hail, the cloud should by convention be called *Cumulonimbus*.

### II.3.6.7

PHYSICAL CONSTITUTION

Nimbostratus generally covers a wide area and is of great vertical extent. It is composed of water droplets (sometimes supercooled) and raindrops, of snow crystals and snowflakes, or of a mixture of these liquid and solid particles. The high concentration of particles and the great vertical extent of the cloud prevent direct sunlight from being observed through it. The cloud produces rain, snow or ice pellets which, however, do not necessarily reach the ground.

II.3.6.8

EXPLANATORY REMARKS

An observer at the Earth's surface usually sees Nimbostratus develop from thickening Altostratus, the base of which gradually lowers. When the cloud becomes thick enough throughout to mask the sun, it is called Nimbostratus.

Nimbostratus usually appears as if illuminated from inside. This is a result of the absence of small cloud droplets in its lower parts,[1] whereby more light penetrates from above than in the case of non-precipitating clouds of the same depth.

Although Nimbostratus generally has no clear under surface, an apparent base is sometimes discernible. This "base" is situated at the level where the snow melts into rain and is due to the poorer visibility in snow than in rain. The melting level can be seen only when it is sufficiently low and when the precipitation is not too heavy.

The under surface of Nimbostratus is often partially or totally hidden by pannus clouds resulting from turbulence in the layers under its base, which are moistened by partial evaporation of precipitation. At first, these pannus clouds consist of separate units; they may later merge into a continuous layer extending up to the Nimbostratus. When the pannus covers a large expanse of the sky, care should be exercised in order not to confuse it with the under surface of Nimbostratus. Although pannus clouds have a tendency to dissipate, chiefly by the coalescence of their small particles with raindrops or snowflakes falling through them, they continue to reform. In heavy precipitation, however, the pannus particles are swept out faster than they can be replaced and the pannus clouds disappear.

In the tropics, particularly during short lulls in the rainfall, Nimbostratus can be seen breaking up into several different cloud layers, which rapidly merge again. The clouds then often show a very characteristic livid colour with variations of luminance, probably due to internal lacunae.

**II.3.7**

**Stratocumulus (Sc)**

(KAEMTZ 1841)

**II.3.7.1**

DEFINITION

Grey or whitish, or both grey and whitish, patch, sheet or layer of cloud which almost always has dark parts, composed of tessellations, rounded masses, rolls, etc., which are non-fibrous (except for virga) and which may or may not be merged; most of the regularly arranged small elements have an apparent width of more than five degrees.

**II.3.7.2**

SPECIES

*Stratocumulus stratiformis* (Sc str) — CCH 1953

Rolls or large rounded masses arranged in an extended sheet or layer. The elements are more or less flattened. This species is the most common.

Sometimes, notably in the tropics, Stratocumulus stratiformis occurs in the form of a large single roll (roll cloud).

[1] The small cloud droplets are swept out by the precipitation or they evaporate owing to the presence of colder raindrops or snowflakes in the cloud.

*Stratocumulus lenticularis* (Sc len) — LEY 1894, CEN 1930

Stratocumulus in the shape of lenses or almonds. This species of Stratocumulus is fairly rare. It may be composed of elements most of which have an apparent width greater than five degrees when observed at an angle of more than 30 degrees above the horizon, or it may consist of one more or less smooth and usually dark unit.

*Stratocumulus castellanus* [1] (Sc cas) — CCH 1953

Stratocumulus consisting of more or less cumuliform masses, arranged in lines, rising from a common horizontal base. The more or less vertically developed upper part presents a crenelated appearance, especially when seen from the side. The cumuliform masses may grow to a considerable size and develop into Cumulus congestus or even Cumulonimbus.

Note: The species "Stratocumulus floccus" has not been introduced in the classification in view of the difficulty of distinguishing flocculent elements of Stratocumulus from Cumulus clouds.

### II.3.7.3

### Varieties

*Stratocumulus translucidus* (Sc tr) — CEN 1930

A patch, sheet or layer of Stratocumulus, nowhere very dense, the greater part of which is sufficiently translucent to reveal the position of the sun or moon; the cloud may even allow the blue of the sky to be faintly distinguished at the junction of its elements.

*Stratocumulus perlucidus* (Sc pe) — CCH 1953

A patch, sheet or layer of Stratocumulus in which the spaces between the elements allow the sun, the moon, the blue of the sky or higher clouds to be seen.

*Stratocumulus opacus* (Sc op) — CEN 1930

Dense Stratocumulus, composed of a continuous or nearly continuous sheet or layer of large dark rolls or rounded masses, most of which are sufficiently opaque to mask the sun or moon. The base of Stratocumulus opacus is sometimes even, and its apparent subdivision into merged elements results from the irregularity of its upper surface. More often, however, the under surface is uneven, and the elements stand out in true relief.

*Stratocumulus duplicatus* (Sc du) — CCH 1953

Stratocumulus comprising two or more broadly horizontal superposed patches, sheets or layers, close together, sometimes partly merged. This variety occurs in the species stratiformis and lenticularis.

*Stratocumulus undulatus* (Sc un) — CLAYTON 1896, CEN 1930

A layer composed of fairly large and often grey elements, arranged in a system of nearly parallel lines. Transverse lines, crossing the main system are sometimes visible. Stratocumulus undulatus occurs in the species stratiformis.

*Stratocumulus radiatus* (Sc ra) — CEN 1926

Stratocumulus showing broad, nearly parallel bands which, owing to the effect of perspective,

[1] Formerly called Stratocumulus castellatus (LEY 1894, CEN 1930).

appear to converge towards a point or towards two opposite points of the horizon. This variety should not be confused with Cumulus arranged in files ("cloud streets"). Stratocumulus radiatus occurs in the species stratiformis.

*Stratocumulus lacunosus* (Sc la) — CCH 1953

Stratocumulus, in a sheet or layer or in patches, showing more or less regularly distributed round holes, many of them with fringed edges. Cloud elements and clear spaces are often arranged in a manner suggesting a net or a honeycomb. The details change rapidly.

## II.3.7.4

### Supplementary features and accessory clouds

Stratocumulus may show mamma; its under surface then presents an accentuated relief in the form of udders or inverted mounds which sometimes appear to be on the point of detaching themselves from the cloud. Stratocumulus mamma should not be confused with certain kinds of Altostratus opacus with a wrinkled appearance.

Virga may also occur under Stratocumulus, especially at very low temperature.

The feature praecipitatio rarely occurs; when present, the precipitation (rain, snow or snow pellets) is only of weak intensity.

## II.3.7.5

### Clouds from which Stratocumulus may form

Stratocumulus may form from Altocumulus when the small macroscopic elements grow to a sufficient size (Sc altocumulomutatus).

Stratocumulus sometimes forms near the base of Altostratus, or more often of Nimbostratus, as a result of turbulence or convection in the layers moistened by evaporating precipitation (Sc altostratogenitus or Sc nimbostratogenitus); it may also form by transformation of Nimbostratus (Sc nimbostratomutatus).

Stratocumulus may develop as a result of the lifting of a layer of Stratus or as a result of the convective or undulatory transformation of Stratus, with or without change of height (Sc stratomutatus).

Stratocumulus is often formed by the spreading out of Cumulus or Cumulonimbus (Sc cumulogenitus[1] or Sc cumulonimbogenitus[2]). Ascending currents producing Cumulus or Cumulonimbus slow down as they reach a higher layer of stable air. When the convective clouds approach this layer, they tend to spread out, forming a patch of Stratocumulus which either surrounds the cumuliform columns like a shelf, or tops them. Whether the former or the latter case occurs, depends on the speed of the ascending currents and the degree of stability of the higher layer. Not infrequently, the convective clouds dissipate completely and only the Stratocumulus remains.

Note: In the cases described above, the Cumulus or Cumulonimbus always gradually widens into the Stratocumulus patch or sheet. Cumulus or Cumulonimbus clouds can, however, also enter or transpierce a pre-existing layer of Stratocumulus formed independently of them. When this occurs, the convective clouds do not widen upward towards the Stratocumulus layer and a thinned or even a cleared zone frequently appears in the Stratocumulus around the cumuliform columns.

[1] The clouds formerly called Stratocumulus vesperalis and Stratocumulus cumulogenitus are, according to the new classification presented in this Atlas, both indicated as Stratocumulus cumulogenitus.

[2] Formerly included under Stratocumulus cumulogenitus.

Stratocumulus may also form from Cumulus as a result of strong wind shear.

A particular form[1] of Stratocumulus cumulogenitus often occurs in the evening when convection ceases and, in consequence, the domed summits of the Cumulus clouds flatten.

## II.3.7.6

### Main differences between Stratocumulus and similar clouds of other genera

Stratocumulus may, in extremely cold weather, produce abundant ice crystal virga, sometimes accompanied by a halo; it is then nevertheless distinguishable from *Cirrostratus* by the fact that it still shows some evidence of the presence of rounded masses, rolls, etc. Furthermore, the opacity of Stratocumulus is greater than that of Cirrostratus.

Stratocumulus may sometimes be confused with *Altocumulus* having dark parts. If most of the regularly arranged elements, when observed at an angle of more than 30 degrees above the horizon, have an apparent width of more than five degrees, the cloud is Stratocumulus.

The differentiation of Stratocumulus from *Altostratus*, *Nimbostratus* and *Stratus* is based on the fact that Stratocumulus shows evidence of the presence of elements, merged or separate. Furthermore, in contrast with Altostratus which often has a fibrous appearance, Stratocumulus always appears non-fibrous, except at extremely low temperatures. The above criteria apply in addition to those based on the character of the precipitation and the nature of its particles, which sometimes provide a clue to the identity of the cloud.

Stratocumulus differs from *Cumulus* in that its elements usually occur in groups or patches and generally have flat tops; if however, Stratocumulus tops are in the form of domes, they rise, unlike those of Cumulus, from merged bases.

## II.3.7.7

### Physical constitution

Stratocumulus is composed of water droplets, sometimes accompanied by raindrops or snow pellets and, more rarely, by snow crystals and snowflakes. Any ice crystals present are usually too sparse to give the cloud a fibrous appearance; during extremely cold weather, however, Stratocumulus may produce abundant ice crystal virga which may be accompanied by a halo. When Stratocumulus is not very thick, a corona or irisation is sometimes observed.

## II.3.7.8

### Explanatory remarks

The appearance of Stratocumulus is similar to that of Altocumulus, but owing to its generally lower height, the elements of Stratocumulus look larger and, at times, smoother than those of Altocumulus.

The Stratocumulus elements are often arranged in lines or groups, showing a single or double system of undulations. The elements may be more or less separate; more often, however, the cloud layer is continuous, sometimes with gaps. The under surface of such a continuous cloud layer is often uneven and presents a relief in the form of wrinkles, mamma, etc.

[1] Formerly called Stratocumulus vesperalis.

## II.3.8

## Stratus (St)

(HOWARD 1803; HILDEBRANDSSON AND ABERCROMBY 1887)

### II.3.8.1

DEFINITION

Generally grey cloud layer with a fairly uniform base, which may give drizzle, snow or snow grains. When the sun is visible through the cloud, its outline is clearly discernible. Stratus does not produce halo phenomena except, possibly, at very low temperatures.

Sometimes Stratus appears in the form of ragged patches.

### II.3.8.2

SPECIES

*Stratus nebulosus* (St neb) — CLAYDEN 1905, CCH 1953

Nebulous, grey, fairly uniform layer of Stratus. This is the most common species.

*Stratus fractus* [1] (St fra) — CEN 1930, CCH 1953

Stratus occurring in the form of irregular ragged shreds the outlines of which change ceaselessly and often rapidly.

### II.3.8.3

VARIETIES

*Stratus opacus* (St op) — BESSON 1921, CCH 1953

Patch, sheet or layer of Stratus, the major part of which is so opaque that it completely masks the sun or moon. This is the most common variety.

*Stratus translucidus* (St tr) — CEN 1926, CCH 1953

Patch, sheet or layer of Stratus, the major part of which is sufficiently translucent to reveal the outline of the sun or moon.

*Stratus undulatus* (St un) — CLAYTON 1896, CCH 1953

Patch, sheet or layer of Stratus showing undulations. This variety does not occur very frequently.

### II.3.8.4

SUPPLEMENTARY FEATURES AND ACCESSORY CLOUDS

The only supplementary feature of Stratus is praecipitatio (drizzle, snow and snow grains).

[1] Formerly called Fractostratus.

II.3.8.5

## Clouds from which Stratus may form

Stratus may develop from Stratocumulus. This occurs when the under surface of the latter lowers, or loses its relief or its apparent subdivisions, for any reason other than the release of precipitation (St stratocumulomutatus).

A common mode of Stratus formation is the slow lifting of a fog layer, due to warming of the Earth's surface or an increase in wind speed.

Stratus fractus of bad weather is often produced by Altostratus, Nimbostratus or Cumulonimbus (St fra altostratogenitus, St fra nimbostratogenitus or St fra cumulonimbogenitus); it may also result from precipitating Cumulus (St fra cumulogenitus).

II.3.8.6

## Main differences between Stratus and similar clouds of other genera

Occasionally, owing to the wind, Stratus locally assumes the form of coarse fibres (Stratus fractus) which differ from those constituting *Cirrus* in that they are much less white (except towards the sun), not so diffuse, and usually change their appearance rapidly.

A thin Stratus layer may be confused with *Cirrostratus*. Stratus, however, is not so completely white except towards the sun; furthermore, coronae may be observed in Stratus.

Stratus is distinguished from *Altostratus* by the fact that it does not blur the outline of the sun (no ground-glass effect).

A thick Stratus layer may be confused with *Nimbostratus*. The following criteria serve to distinguish between these two cloud genera:

(*a*) In general, Stratus has a more clearly defined and more uniform base than Nimbostratus. Moreover, Stratus has a "dry" appearance, which contrasts fairly strongly with the "wet" appearance of Nimbostratus.

(*b*) A relatively thin layer of Stratus allows the outline of the sun or moon to be clearly visible at least through its thinnest parts; Nimbostratus masks the luminary throughout.

(*c*) When the cloud under observation is accompanied by precipitation, it is fairly easy to distinguish Stratus from Nimbostratus if it is borne in mind that Stratus can produce only weak falls of drizzle, snow or snow grains, whereas Nimbostratus nearly always produces rain, snow or ice pellets. A difficulty arises, however, when precipitation falling from a higher cloud passes through the layer of Stratus. In this case, a dark and uniform layer of Stratus closely resembles a Nimbostratus and may very easily be confused with it.

(*d*) Stratus is more likely to occur during a calm or with a light wind than with a strong wind, whereas Nimbostratus is usually associated with moderate or strong winds. However, this criterion alone should not be used as a basis for distinction.

(*e*) The occurrence of a thick Stratus layer is not usually preceded by the existence of other clouds in the low and middle étages. Nimbostratus, on the other hand, nearly always succeeds other clouds, usually of the middle étage, or develops from a pre-existing cloud.

Stratus is distinguished from *Stratocumulus* by the fact that it shows no evidence of the presence of element, merged or separate.

Stratus fractus is distinguished from Cumulus fractus in that it is less white and less dense. Furthermore, it shows a smaller vertical development, since it owes its formation mainly to turbulence without thermal convection.

II.3.8.7

PHYSICAL CONSTITUTION

Stratus is usually composed of small water droplets; this cloud may, when very thin, produce a corona round the sun or moon. At low temperatures, Stratus may consist of small ice particles. The ice cloud is usually thin and may, on rare occasions, produce halo phenomena.

Stratus, when dense or thick, often contains drizzle droplets and sometimes snow or snow grains; it may then have a dark or even a threatening appearance. Stratus with a low optical thickness, when observed at more than 90 degrees from the sun, often shows a more or less smoky, greyish tint like that of fog.

II.3.8.8

EXPLANATORY REMARKS

Stratus forms under the combined effect of cooling in the lower layers of the atmosphere, on one hand, and turbulence due to the wind, on the other. Over land, the cooling may be a result of nocturnal radiation, which is particularly marked when clouds are absent and the wind is weak, or by advection of relatively warm air over colder ground. Over sea, the cooling is mainly due to advection.

Stratus is sometimes observed as more or less joined cloud fragments with varying luminance. These Stratus fractus clouds constitute a transitory stage during the formation or the dissipation of the more common extensive uniform Stratus layer. The transitory stage is usually very short.

Stratus fractus clouds may also form as accessory clouds (pannus) under Altostratus, Nimbostratus, Cumulonimbus and precipitating Cumulus; they develop as a result of turbulence in the moistened layers under these clouds.

**II.3.9**

**Cumulus (Cu)**

(HOWARD 1803)

**II.3.9.1**

DEFINITION

Detached clouds, generally dense and with sharp outlines, developing vertically in the form of rising mounds, domes or towers, of which the bulging upper part often resembles a cauliflower. The sunlit parts of these clouds are mostly brilliant white; their base is relatively dark and nearly horizontal.

Sometimes Cumulus is ragged.

**II.3.9.2**

SPECIES

*Cumulus humilis* (Cu hum) — VINCENT 1907

Cumulus characterized by only a small vertical extent and appearing generally as if flattened. Cumulus humilis clouds never give precipitation.

*Cumulus mediocris* (Cu med) — CCH 1953

Cumulus clouds of moderate vertical extent, with small protuberances and sproutings at their tops. Cumulus mediocris clouds generally give no precipitation.

*Cumulus congestus* (Cu con) — MAZE 1889

Strongly sprouting Cumulus with generally sharp outlines and often great vertical extent. The bulging upper part of Cumulus congestus frequently resembles a cauliflower. Cumulus congestus clouds may produce precipitation; in the tropics, they often release abundant rain in the form of showers.

Cumulus congestus clouds sometimes resemble narrow, very high towers. The tops of these towers are formed of cloudy "puffs", which may detach themselves successively from the main body of the cloud. They are then carried away by the wind and disintegrate more or less rapidly, occasionally producing virga.

Cumulus congestus results from the development of Cumulus mediocris, or sometimes of Altocumulus castellanus or Stratocumulus castellanus.

Cumulus congestus often changes into Cumulonimbus; the transformation is revealed by the smooth appearance or by the fibrous or striated texture of its upper portion.

*Cumulus fractus* [1] (Cu fra) — POEY 1863, CCH 1953

Small Cumulus clouds with very ragged edges and with outlines continuously undergoing changes which are often rapid.

### II.3.9.3

VARIETIES

*Cumulus radiatus* (Cu ra) — CCH 1953

Cumulus, usually of the species mediocris, arranged in files nearly parallel to the wind direction (cloud streets). As a result of perspective, these files seem to converge towards a point or towards two opposite points of the horizon.

### II.3.9.4

SUPPLEMENTARY FEATURES AND ACCESSORY CLOUDS

One or more of the following supplementary features and accessory clouds may be associated with Cumulus: pileus, velum, virga, praecipitatio (the precipitation occurs generally in the form of showers), arcus (rarely), pannus (rarely) and tuba (very rarely).

### II.3.9.5

CLOUDS FROM WHICH CUMULUS MAY FORM

The formation of Cumulus is often preceded by the occurrence of hazy spots out of which the clouds develop.

Cumulus may originate from Altocumulus (Cu altocumulogenitus) or Stratocumulus (Cu stratocumulogenitus). It may also form as a result of the transformation of Stratocumulus or Stratus (Cu stratocumulomutatus or Cu stratomutatus); the latter case frequently occurs in the morning over land.

[1] Formerly called Fractocumulus.

Cumulus fractus of bad weather is formed under Altostratus, Nimbostratus, Cumulonimbus or precipitating Cumulus (Cu fra altostratogenitus, nimbostratogenitus, cumulonimbogenitus or cumulogenitus).

II.3.9.6

MAIN DIFFERENCES BETWEEN CUMULUS AND SIMILAR CLOUDS OF OTHER GENERA

Cumulus is distinguished from most *Altocumulus* and *Stratocumulus* by the fact that Cumulus clouds are detached and dome-shaped. When viewed from a distance, Cumulus clouds may appear merged, owing to the effect of perspective; in this case, they should not be confused with Altocumulus or Stratocumulus.

Cumulus tops may spread and form Altocumulus cumulogenitus or Stratocumulus cumulogenitus. They may also enter or transpierce pre-existing layers of Altocumulus or Stratocumulus or they may merge with Altostratus or Nimbostratus. In all such cases, the appellation Cumulus should be used as long as the cumuliform clouds remain detached from one another or as long as they show a relatively considerable vertical extent.

When a very large precipitating Cumulus cloud is directly above the observer, it may be confused [1] with *Altostratus* or *Nimbostratus*. The character of the precipitation may then help in distinguishing Cumulus from the latter clouds; if the precipitation is of the showery type the cloud is Cumulus.

Since Cumulonimbus generally results from the development and transformation of Cumulus, it is sometimes difficult to distinguish Cumulus with a great vertical extent from *Cumulonimbus*. The cloud should be named Cumulus as long as the sprouting upper parts are everywhere sharply defined and no fibrous or striated texture is apparent. If it is not possible to decide on the basis of other criteria whether a cloud is to be named Cumulus or Cumulonimbus, it should by convention be called Cumulus if it is not accompanied by lightning, thunder or hail.

Cumulus fractus is distinguished from *Stratus fractus* by its generally greater vertical extent and its usually whiter and less transparent appearance. Cumulus fractus, furthermore, sometimes has rounded or dome-shaped tops, which are always lacking in Stratus fractus.

II.3.9.7

PHYSICAL CONSTITUTION

Cumulus is composed mainly of water droplets. When of great vertical extent, Cumulus may release precipitation in the form of rain showers.

Ice crystals may form in those parts of a Cumulus in which the temperature is well below 0° C; they grow at the expense of evaporating supercooled water droplets, thereby transforming the cloud into Cumulonimbus. In cold weather, when the temperature in the entire cloud is well below 0° C (32° F), this process leads to the degeneration of the cloud into diffuse trails of snow.

II.3.9.8

EXPLANATORY REMARKS

Cumulus develops in convection currents which occur when the lapse rate in the lower layers is sufficiently steep. Such steep lapse rates result from heating of the air near the earth's surface; they also result from cooling or advection of cold air in the higher layers or, finally, from lifting of air layers with vertical expansion.

[1] The probability of confusing a Cumulus with Altostratus or Nimbostratus is greatly reduced if the observer keeps a more or less continuous watch on the sky, as recommended in Chapter II.7.

Over land, the diurnal variation in Cumulus activity is generally pronounced. On clear mornings, with the sun rapidly heating the surface of the ground, conditions are favourable for the formation of Cumulus. This formation may begin early, when the lapse rate is steep and the relative humidity is high; it begins late, if it occurs at all, when the lapse rate is small and the relative humidity is low. After having reached a maximum, usually in mid-afternoon, the Cumulus activity decreases and finally the clouds disappear in the late afternoon or early evening.

Over the open oceans, the diurnal variation of Cumulus is so small that its existence is sometimes doubtful, but when it exists, maximum Cumulus activity appears to occur in the late hours of the night.

Near coasts, Cumulus may form over the land by day in connection with the sea breeze and over the sea by night in connection with the land breeze.

The ascending motion of convection currents is slowed down or even stopped when these currents reach stable layers, particularly inversions. The characteristics of Cumulus clouds depend, in the main, on the vertical distance between the condensation level and the base of the stable layer, and on the degree of stability and the thickness of the stable layer itself. When the stable layer is very stable, it may cause the tops of Cumulus clouds which reach its level to spread out. When the layer is not very thick, the spreading out of the tops of Cumulus clouds may be only partial and some tops may penetrate it.

A low level of condensation and a high stable layer are favourable to considerable vertical development and, therefore, to the formation of Cumulus mediocris or Cumulus congestus. When the level of condensation and the stable layer are close together, any Cumulus clouds which may form have a flattened appearance (Cumulus humilis); they may spread out, becoming either Altocumulus or Stratocumulus, both of which are often very persistent. It may happen that the level of condensation rises gradually in the course of the day until its height exceeds, sometimes considerably, that of the base of the stable layer; the Cumulus clouds then dissipate. Nevertheless, even when the height of the base of the stable layer is less than that of the condensation level, upward convection currents may be able to enter the stable layer so that the ascending air may reach its level of condensation. This is one of the cases when the Cumulus formed belongs to the species humilis or, rarely, to the species mediocris.

Since the condensation level and the stable layer are usually much farther apart in the tropical regions than in other regions, the vertical extent of Cumulus in the tropical regions is generally much greater than elsewhere.

When a well-developed Cumulus is observed opposite the sun, the diffuse reflection of the sunlight falling on the surface of the cloud reveals the relief of the protuberances by very pronounced differences in luminance. When illuminated from the side, Cumulus shows strongly contrasted shading. When lighted from behind, the Cumulus appears relatively dark, with an extremely brilliant border. Against a background of ice clouds, not too near the horizon, Cumulus appears a little less white than these clouds and its margins appear grey, even when the Cumulus is directly illuminated by the sun. Whatever the illumination of the Cumulus may be, its base is generally grey.

## II.3.10

## Cumulonimbus (Cb)

(Weilbach 1880)

### II.3.10.1

Definition

Heavy and dense cloud, with a considerable vertical extent, in the form of a mountain or huge towers. At least part of its upper portion is usually smooth, or fibrous or striated, and nearly always flattened; this part often spreads out in the shape of an anvil or vast plume.

Under the base of this cloud which is often very dark, there are frequently low ragged clouds either merged with it or not, and precipitation sometimes in the form of virga.

### II.3.10.2

SPECIES

*Cumulonimbus calvus* (Cb cal) — CEN 1926

Cumulonimbus in which the sproutings of the upper part are more or less indistinct and flattened and have the appearance of a whitish mass without sharp outlines. No fibrous or striated parts are visible. Cumulonimbus calvus usually releases precipitation; when the latter reaches the ground, it is in the form of showers.

*Cumulonimbus capillatus* (Cb cap) — CEN 1926

Cumulonimbus characterized by an upper portion having cirriform parts of clearly fibrous or striated structure, frequently in the shape of an anvil (Cumulonimbus capillatus incus), a plume or a vast more or less disorderly mass of hair. In very cold air masses the fibrous structure very often extends virtually throughout the cloud.

Cumulonimbus capillatus is usually accompanied by a shower or by a thunderstorm, often with squalls and sometimes with hail; it frequently produces very distinct virga.

### II.3.10.3

VARIETIES

Cumulonimbus does not present any varieties.

### II.3.10.4

SUPPLEMENTARY FEATURES AND ACCESSORY CLOUDS

One or more of the following supplementary features and accessory clouds may be associated with Cumulonimbus: praecipitatio, virga, pannus, incus, mamma (mamma are observed either on the base of the cloud or, more frequently, on the under surface of the projecting portion of the anvil), pileus, velum, arcus and tuba (rarely).

### II.3.10.5

CLOUDS FROM WHICH CUMULONIMBUS MAY FORM

Cumulonimbus sometimes develops from Altocumulus castellanus or Stratocumulus castellanus (Cb altocumulogenitus or Cb stratocumulogenitus); in the former case the base of the Cumulonimbus is unusually high. Cumulonimbus may also form as a result of the transformation and development of a portion of Altostratus or Nimbostratus (Cb altostratogenitus or Cb nimbostratogenitus). In the majority of the foregoing cases, the transformation into Cumulonimbus passes through the Cumulus congestus stage.

Cumulonimbus most commonly evolves from Cumulus congestus which was formed in the normal manner [1] (Cb cumulogenitus, Cb cumulomutatus).

[1] See paragraphs II.3.9.7 and II.3.9.8.

II.3.10.6

### Main differences between Cumulonimbus and similar clouds of other genera

When Cumulonimbus covers a large expanse of the sky, it can easily be confused with *Nimbostratus*, especially when identification is based solely on the appearance of the under surface. In this case, the character of the precipitation may help to distinguish Cumulonimbus from Nimbostratus. If the precipitation is of the showery type, or if it is accompanied by lightning, thunder or hail, the cloud is by convention Cumulonimbus.

Certain Cumulonimbus clouds appear nearly identical with *Cumulus congestus*. The cloud should be called Cumulonimbus as soon as at least a part of its upper portion loses the sharpness of its outlines or presents a fibrous or striated texture. If it is not possible to decide on the basis of the above criteria whether a cloud is a Cumulonimbus or Cumulus, it should by convention be called Cumulonimbus if it is accompanied by lightning, thunder or hail.

II.3.10.7

### Physical constitution

Cumulonimbus is composed of water droplets and, especially in its upper portion, of ice crystals. It also contains large raindrops and, often, snowflakes, snow pellets, ice pellets or hailstones. The water droplets and raindrops may be substantially supercooled.

II.3.10.8

### Explanatory remarks

The conditions under which Cumulonimbus clouds occur are similar to those which are favourable for the development of Cumulus congestus (see paragraph II.3.9.8). The transformation of a Cumulus congestus into a Cumulonimbus is due to the formation of ice particles in its upper part which consequently loses, at least in spots, the sharpness of its outlines or acquires, at least partially, a fibrous or striated texture.

Cumulonimbus clouds may appear either as isolated clouds or in the form of a continuous line of clouds resembling a very extensive wall.

In certain cases, the upper portion of Cumulonimbus clouds may be merged with Altostratus or Nimbostratus. Cumulonimbus may also develop within the general mass of an Altostratus or Nimbostratus.

Low, ragged accessory clouds (pannus) often develop under Cumulonimbus; these clouds are at first separated from one another, but they may later merge so as to form a continuous layer partially or totally in contact with the Cumulonimbus base.

Cumulonimbus may be described as a "cloud factory"; it may produce more or less thick patches or sheets of Cirrus spissatus, Altocumulus, Altostratus or Stratocumulus by the spreading out of its upper portions and by the dissipation of the subjacent parts. The spreading of the highest part usually leads to the formation of an anvil; if the wind increases strongly with altitude, the cloud top spreads only downwind, assuming the shape of a half anvil or in some cases of a vast plume.

Cumulonimbus is rare in polar regions and more frequent in temperate and tropical regions.

## II.4 — OROGRAPHIC INFLUENCES

II.4.1

### Occurrence, structure and shapes of orographic clouds

In an airflow crossing a hill, mountain or ridge, orographic clouds may occur below, at or above the level of the top of the obstacle. The aspect of these orographic clouds may differ notably from the usual aspect of any of the ten cloud genera. Orographic clouds are nevertheless always classified under one or other of these genera.[1] The most common orographic clouds belong to the genera Altocumulus, Stratocumulus and Cumulus.

The physical constitution of an orographic cloud is on the whole similar to that of clouds of the genus in which it is classified. The size and concentration of water droplets or ice particles and the intensity of precipitation, if any, are greatest in areas where the orography leads to ascending motion; they are smallest in areas where the relief causes descending motions.

An orographic cloud, being linked with the terrestrial relief, generally moves very slowly, if at all, although the wind at the cloud level may be strong. In certain cases, the speed of this wind is revealed by markings in the cloud, as for instance by separate elements which move from one end of the cloud to the other. The continuous change in the internal cloud structure is often very evident.

An orographic cloud generally has its maximum thickness over the area where the air current is lifted to its highest point; thickness progressively diminishes towards the ends of the cloud. Orographic clouds may assume many different forms; they may be attached to the obstacle or detached from it.

In the case of an isolated mountain, orographic clouds often have the form of a collar surrounding the mountain or that of a cap covering the peak. Collar and cap are both fairly symmetrical. These clouds give little or no precipitation.

Elongated hills or mountains may induce the formation of precipitating clouds of great extent against their windward slopes. Such clouds crown the ridge and dissipate just beyond it. Observed from a point on the leeward side, the clouds often resemble a bank (föhn bank or föhn wall).

When the wind is strong, orographic clouds may form near the summit, streaming away from the mountain on the leeward side (smoking mountain).[2] This type of cloud should not be confused with snow blown from the crest or peak.

Quite often, one or a pile of several orographic clouds, usually belonging to the species lenticularis, appears above the hill or mountain, sometimes slightly up-wind or down-wind.[3]

Mountain ranges or even relatively small ridges over low land may produce stationary waves in the air current crossing them.[4] When the air is sufficiently moist, orographic clouds may appear at the wave crests and it is then possible to observe one cloud above the summit[5] or a little up-wind and one or several others down-wind. In the latter case, the clouds occur at regular intervals of several kilometres. Wave clouds may also appear at different levels simultaneously.

The waves to leeward are sometimes accompanied in the lower layers by large stationary eddies with horizontal axes, in the upper part of which a cloud bar may appear ("rotor cloud").

[1] Nacreous clouds are not included in the adopted classification, in spite of the fact that they may be regarded as high altitude orographic clouds.

[2] As observed, for example, on the down-wind side of the Matterhorn.

[3] As, for example, in the case of the "Contessa del Vento", observed near the summit of Etna.

[4] The wave tops may sometimes extend beyond the high étage into the stratosphere.

[5] This phenomenon is observed in the Riesengebirge, for example, where the cloud is called "Moazagotl" in the local language.

II.4.2

## Changes in the shape and structure of clouds due to orographic influences

Existing clouds, arriving over a mountainous or hilly area, may change in shape and structure as a result of the topography, which influences the air current carrying the clouds and may affect those at levels many times exceeding the levels of peaks or crests.

In the case of clouds situated at heights comparable with that of the obstacle, the following modifications may be observed.

Above the mountain or hill and a short distance to windward, the clouds frequently assume a much greater vertical extent, especially if sproutings and protuberances already exist. The clouds also become denser. Precipitation may start or increase in intensity. Leeward of the crests, the clouds have a tendency to thin out and even to dissipate, while the precipitation ceases.

With regard to clouds at higher levels, the following remarks may be made.

The clouds may dissipate above the mountain and reappear to leeward, forming a föhn gap. On other occasions, they split into lenticular patches, often at different heights.

## II.5 — CLOUDS AS SEEN FROM AIRCRAFT

II.5.1

### Special problems involved

II.5.1.1

DIFFERENCES BETWEEN THE OBSERVATION OF CLOUDS FROM AIRCRAFT AND FROM THE EARTH'S SURFACE

The information on clouds which can be gained by an airborne observer differs in important respects from that which is obtainable from the Earth's surface. An airborne observer is undoubtedly in a position to secure more complete knowledge of the vertical distribution of the clouds, their amounts, their respective altitudes, their structure and the appearance of their upper parts or surfaces, as well as the nature of their constituent particles.

The appearance of the clouds is closely related to the position of the aircraft with respect to the clouds. For this reason, it is necessary to state the condition to which the descriptions of clouds, as seen from an aircraft, refer. The descriptions of the genera, given in Sections II.5.2 and II.5.3 below, correspond to the most frequent appearance of clouds when observed 500–1 000 metres (1 650–3 300 feet) below their base, 500–1 000 metres (1 650–3 300 feet) above their upper surface, or from within.

II.5.1.2

FIELD OF VISION

The field of vision of an airborne observer increases with altitude, as a result of the recession of the horizon. Extended vision is also favoured by the usual increase with altitude of the transparency of the air. Thus, an observer in an aircraft is often able to survey at a glance one or more extensive cloud ensembles.

II.5.1.3

APPEARANCE OF CLOUDS

(*a*) *The effect of perspective*

When an aircraft flies at or near their level, clouds tend, owing to the effect of perspective, to assume the appearance of a more or less continuous layer, even if they are in fact detached.

(*b*) *Apparent width of cloud elements*

The criteria based on the apparent width of cloud elements, adopted for distinguishing between certain cloud genera (Cirrocumulus, Altocumulus, Stratocumulus) when seen from the ground, are of little use to an airborne observer, whose distance from the cloud may vary within wide limits. The altitude of the clouds may in some cases constitute the only criterion by which their genus can be determined.

(*c*) *Outlines of clouds*

The outlines of clouds appear less distinct and more ragged as the observer approaches them.

*(d) Base of clouds*

The appearance of the cloud base changes with distance; the base generally looks more diffuse and more ragged as the observer draws nearer. At close range, relief becomes difficult to distinguish. Thus, an opaque Altocumulus layer, for example, may show a base not very different from that of an Altostratus.

*(e) Upper surface of clouds*

The airborne observer often has to identify clouds from their upper surface. This is sometimes difficult owing to the similar appearance of clouds of different genera, when viewed from above.

The upper surface of clouds is usually better defined than their base; it is also brighter and shows stronger differences in luminance. It may appear either smooth or rough, clear-cut or diffuse.

The upper surface of a layer of cloud may be flat or it may show fairly well-defined undulations of varying width [10 to 1 000 metres (33 to 3 300 feet)], suggesting ocean waves ("sea of cloud"). It may also have rounded protuberances or flattish domes, arranged sometimes in ranks or files, with a fleecy appearance. Not infrequently, well-marked protuberances or sproutings may be observed at the upper surface of a cloud layer; such protuberances and sproutings may spring from the layer itself or may have pierced the layer from below. The protuberances and sproutings may be in the form of well-developed domes or towers and, on some occasions, are so numerous that it becomes difficult to distinguish the surface from which they emerge. When the towers are of great vertical extent and not very wide, the observer has the impression of flying in a "cloud forest".

Sometimes a cloud veil (velum) covers the flattish domes belonging to layers with fleecy appearance, or the lateral portions of well-developed towers. Such veils are occasionally extensive enough to connect the tops of several domes or towers or to connect the tops of some towers with the sides of others. The veils may be so thick that the underlying clouds are partially or totally masked.

Observations of the upper surface of clouds are very useful, since they provide, in an indirect manner, information regarding the degree of instability of the atmosphere.

### II.5.1.4

### ICING

The formation of an ice deposit may be observed on different parts of an aircraft when flying in supercooled clouds or precipitation. The intensity and characteristics of the icing [1] vary from case to case; they depend primarily on the degree of supercooling and the diameters of the droplets, their concentration, as well as on factors relative to the aircraft.

### II.5.1.5

### TURBULENCE IN CLOUDS AND IN THEIR VICINITY

Vertical currents (ascending and descending) may occur in clouds or in their vicinity. The successive jolts felt in an aircraft when it passes from one such current to another constitute what aviators call "turbulence". The degree of this turbulence depends on the intensity and the dimensions of the vertical currents and also on the characteristics of the aircraft.

[1] The main types of icing (soft rime, hard rime, clear ice and glaze) are defined and described in Part III (Meteors other than Clouds).

II.5.1.6

VISIBILITY IN CLOUDS

Within clouds, even if they are very thin, visibility is always less than in the surrounding clear air. Some clouds are dense enough to reduce visibility almost to zero.

II.5.1.7

PHOTOMETEORS ASSOCIATED WITH CLOUDS

Certain photometeors (haloes, coronae, etc.) not visible to an observer below a thick cloud, may be visible to an airborne observer inside the cloud and sufficiently close to its upper surface. When the observer is above a cloud patch, sheet or layer, he may see a glory or a fog-bow if the cloud is composed of water droplets, or he may observe halo phenomena if the cloud is composed of ice crystals.

II.5.2

## Descriptions of clouds as observed from aircraft

II.5.2.1

CIRRUS

Cirrus usually occurs at altitudes between 3 and 8 kilometres (10 000 and 25 000 feet) in polar regions, between 5 and 13 kilometres (16 500 and 45 000) feet in temperate regions and between 6 and 18 kilometres (20 000 and 60 000 feet) in the tropics. In the temperate zone, the Cirrus of polar air masses occupies lower levels than the Cirrus of tropical air masses.

*Below the cloud.* Viewed from below, Cirrus sometimes shows white, delicate filaments or white or mostly white patches or narrow bands; usually, however, the cloud appears to have no distinct structure. Cirrus is distinguishable from Cirrocumulus by the absence of regularly arranged rounded or granular cloudlets, and from Cirrostratus by the fact that it consists of separate elements.

*Within the cloud.* Cirrus is composed, almost exclusively, of ice crystals. The observer may often see the glitter of these crystals in the sunlight. Halo phenomena, when present, are generally confined to the small halo.

*Above the cloud.* Seen from above, Cirrus, when in full sunlight, is always very bright. Thin Cirrus may resemble the upper surface of a layer of haze; dense Cirrus has a more or less milky appearance. Lower clouds or the ground are frequently visible through Cirrus. Neither a glory nor an undersun occurs. A small slightly brighter area is often visible around the aircraft's shadow.

II.5.2.2

CIRROCUMULUS

Cirrocumulus most frequently occurs above 3 kilometres (10 000 feet) in polar regions, 5 kilometres (16 500 feet) in temperate regions and 6 kilometres (20 000 feet) in tropical regions.

*Below the cloud.* Viewed from below, Cirrocumulus appears as a thin patch, sheet or layer, composed of white, very small rounded elements without shading, merged or separate. The more or less horizontal bases of these elements lie at the same level.

*Within the cloud.* Cirrocumulus is composed, almost exclusively, of ice crystals; supercooled water droplets may occur, but are usually rapidly replaced by ice crystals. The observer has the impression of flying in a thin fog. The small halo is the only halo phenomenon which may be observed. Turbulence is light, except in Cirrocumulus castellanus where it can be more pronounced.

*Above the cloud.* Viewed from above, Cirrocumulus elements, with their soft outlines resembling cotton wool, are similar to Cumulus humilis clouds in shape and size. In the case of Cirrocumulus castellanus, the elements have a common base and are more vertically developed. No undersun is observed.

## II.5.2.3

### Cirrostratus

Cirrostratus most frequently occurs above 3 kilometres (10 000 feet) in polar regions, 5 kilometres (16 500 feet) in temperate regions and 6 kilometres (20 000 feet) in tropical regions.

*Below the cloud.* Viewed from below, Cirrostratus appears as a transparent, more or less homogeneous whitish veil, totally or partly covering the sky and generally producing halo phenomena. It is usually difficult to recognize the base.

*Within the cloud.* Cirrostratus not uncommonly occurs in several layers. The crystalline nature of its constituent ice particles is often revealed by their glitter in the sunlight. Every kind of halo phenomenon may be observed. In the lower portion of the cloud, particularly near the base, slight turbulence may be experienced.

*Above the cloud.* Viewed from above, the appearance is practically the same as that of Cirrus, except for its greater breadth of continuous sky cover. The upper surface may be well defined and flat or diffuse with bulging parts resembling Cirrocumulus. The ground, usually visible through a thin Cirrostratus veil, is hardly perceptible through a thick cloud veil. An undersun may be observed; other halo phenomena are rare.

## II.5.2.4

### Altocumulus

Altocumulus most frequently occurs at altitudes between 2 and 4 kilometres (6 500 and 13 000 feet) in polar regions, between 2 and 7 kilometres (6 500 and 23 000 feet) in temperate regions and between 2 and 8 kilometres (6 500 and 25 000 feet) in tropical regions.

Altocumulus may be observed in several forms, the most important of which are described below.

(*a*) *Altocumulus in a sheet or layer with detached elements* (Altocumulus stratiformis)

This type of Altocumulus is generally less than 500 metres (1 650 feet) thick.

*Below the cloud.* Viewed from below, this cloud appears in the form of a broken sheet or layer. It may be either translucent throughout or partly translucent and partly opaque and its colour is either white or white and grey.

*Within the cloud.* This type of Altocumulus is composed of small water droplets, sometimes accompanied by ice crystals. Light icing may occur. Turbulence is weak to moderate.

*Above the cloud.* When viewed from above, this type of Altocumulus appears smooth and undulated or it presents a fleecy appearance. In both cases, there are more or less distinct gaps through which glimpses of lower clouds or the ground can be obtained. Sometimes, the layer is pierced by the tops of well-developed cumuliform clouds which formed at a lower level. Occasionally, thin sheets or patches are situated about 100 to 300 metres (330 to 1 000 feet) above the main layer (Altocumulus duplicatus). A glory, sometimes accompanied by a fog bow, may be observed on the cloud elements. An undersun may appear, usually in the hazy, ice crystal-filled parts between the cloud elements.

(*b*) *Altocumulus in a sheet or layer with merged elements* ("solid" Altocumulus stratiformis)

This type of Altocumulus is usually less than 500 metres (1 650 feet) thick. Occasionally, it has a dark appearance suggesting a considerably greater depth; in such cases, it generally consists of two or more layers. The total thickness from the base of the lowest to the top of the highest layer is usually less than 2 000 metres (6 500 feet).

*Below the cloud.* Viewed from below, this cloud appears in the form of a white and grey or entirely grey sheet or layer, showing more or less marked differences in opacity. When observed from a short distance, the elements appear large and dark, and this type of Altocumulus then looks exactly like Stratocumulus.

*Within the cloud.* This type of Altocumulus is composed of small water droplets, sometimes accompanied by ice crystals. Variations in visibility are fairly distinct; they are particularly apparent at night when the lights of the aircraft are on. There may be considerable icing. Turbulence is usually weak, but may be moderate.

*Above the cloud.* When seen from above, this cloud usually appears continuous except for crevices which mark the thinner borders of the elements. The upper surface is either smooth and undulated or it has a fleecy appearance. Glory, fog bow and undersun may be observed, sometimes simultaneously.

(*c*) *Lens-shaped patches of Altocumulus* (Altocumulus lenticularis)

The vertical extent of Altocumulus lenticularis is usually not more than 200 metres (660 feet); orographic Altocumulus lenticularis may however have a much greater depth.

*Below the cloud.* Viewed from below, this cloud appears diffuse. Frequently it is partly translucent. It is either completely white or white and grey. Irisation is occasionally visible.

*Within the cloud.* Turbulence is usually weak, but it may be moderate.

*Above the cloud.* Viewed from above, a thin Altocumulus lenticularis, though transparent enough to reveal the ground, looks fairly dark. Thick Altocumulus lenticularis on the other hand looks white; bright glories may be observed on it.

(*d*) *Altocumulus with cumuliform tops rising from a common base* (Altocumulus castellanus)

*Below the cloud.* Viewed from below, Altocumulus castellanus shows a more or less horizontal and fairly extensive base, resembling that of a layer of Altocumulus. Just below the cloud, visibility is reduced by haze. Turbulence increases as one approaches the base.

*Within the cloud.* Within the higher towers or chimneys, which constitute the upper part of Altocumulus castellanus, turbulence is generally strong and electrical discharges may be observed. Visibility is variable. Icing may occur.

*Above the cloud.* Viewed from above, this cloud strongly resembles well-developed Cumulus clouds with their bases buried in a haze layer or a cloud layer of smooth and wavy appearance. The vertical extent of the cumuliform towers and "chimneys" is variable; some of them may develop into Cumulus congestus or even into Cumulonimbus, giving thunderstorms at high altitudes.

(e) *Altocumulus in tufts* (Altocumulus floccus)

*Below the cloud.* Viewed from below, the patches of Altocumulus floccus appear diffuse. The clouds are whitish or dark and are not all exactly at the same level. Turbulence is weak to moderate below Altocumulus floccus.

*Within the cloud.* Light icing may occur; turbulence is variable, ranging from weak to fairly strong.

*Above the cloud.* Viewed from above, the cloud units look like small Cumulus clouds surrounded by, or more or less emerging from, a milky white area. Altocumulus floccus usually has a thickness of 500 to 1 000 metres (1 650 to 3 300 feet). The cumuliform tufts may sometimes reach a vertical extent of 2 to 3 kilometres (6 500 to 10 000 feet); in this case the cloud mass as a whole looks like Altocumulus castellanus seen from above.

II.5.2.5

## ALTOSTRATUS

Altostratus usually occurs at altitudes between 2 and 4 kilometres (6 500 and 13 000 feet) in polar regions, between 2 and 7 kilometres (6 500 and 23 000 feet) in temperate regions and between 2 and 8 kilometres (6 500 and 25 000 feet) in tropical regions. Not unfrequently, however, the upper parts of Altostratus extend beyond the indicated upper limits of 4, 7 and 8 kilometres (13 000, 23 000 and 25 000 feet). The thickness of Altostratus may range from 1 000 to more than 5 000 metres (from 3 300 to more than 16 500 feet).

*Below the cloud.* Viewed from below, the base of Altostratus, which is nearly flat, has a diffuse and hazy appearance; this is due to the fact that rain or snow falls from it, usually without reaching the ground however. Some parts of the cloud layer are thin enough to allow the sun to be vaguely visible through them.

*Within the cloud.* Depending on the part traversed and the position of the aircraft relative to the level of 0°C (32°F), the following constituent particles may be observed within Altostratus: water droplets (supercooled or not), raindrops, ice crystals, snow crystals or snowflakes. In that part of the cloud which consists of ice crystals alone, the number of particles per unit volume is usually relatively small.

The airborne observer can distinguish two types of Altostratus, clearly differing in internal structure.

The first type of Altostratus consists of a very homogeneous layer, often with its upper surface reaching to great altitudes. Visibility in this layer is usually fair and the Earth's surface is visible through a considerable cloud depth. Halo phenomena, often bright, may be observed.

The second type of Altostratus consists of many patches, sheets or layers of water cloud, sometimes connected by virga or by precipitation. The precipitation often obscures the stratified structure, so that the Altostratus may appear as a thick single layer with large clear spaces. Visibility is thus very variable within the cloud; it may be less than 100 metres (100 yards) locally. At night, the open spaces can easily be perceived with the aid of the lights of the aircraft. Altocumulus patches are usually present at the top of this Altostratus.

In both types of Altostratus, turbulence is weak and confined to the lower parts, but it may be strong when there is internal convection. Icing is generally light.

*Above the cloud.* Viewed from above, the upper surface of the first type of Altostratus is similar to that of Cirrostratus. The upper surface of the second type resembles that of a layer of

Altocumulus. The frequency and types of optical phenomena observed on the upper surface of Altostratus are the same as those observed on Cirrostratus and Altocumulus.

Note: When the air in which Altostratus develops is unstable or becomes unstable, internal convective movements produce cumuliform protuberances which may rise considerably above the general cloud mass and may even develop into Cumulonimbus. Tops of Cumulus congestus or Cumulonimbus may also be observed above a layer of Altostratus, when the instability of the subjacent air is sufficient to produce convective currents, strong enough to transpierce the layer of Altostratus.

For a description of the phenomena observed outside and within these convective parts, the reader is referred to paragraphs II.5.2.9 and II.5.2.10 (Cumulus and Cumulonimbus).

### II.5.2.6

### NIMBOSTRATUS

The main body of Nimbostratus almost invariably occurs at altitudes between 2 and 4 kilometres (6 500 and 13 000 feet) in polar regions, between 2 and 7 kilometres (6 500 and 23 000 feet) in temperate regions and between 2 and 8 kilometres (6 500 and 25 000 feet) in tropical regions. Very often, however, the base is situated below 2 kilometres (6 500 feet); not infrequently the upper surface is found beyond the indicated upper limit of 4, 7 and 8 kilometres (13 000, 23 000 and 25 000 feet). Nimbostratus is generally thicker than Altostratus; its vertical extent ranges from 2 to 8 kilometres (6 500 to 25 000 feet).

*Below the cloud.* Viewed from below, Nimbostratus is grey and often dark; its base appears diffuse or indefinite as a result of rain or snow, which generally reaches the ground. When the precipitation is heavy, it is even impossible to distinguish any base.

Pannus is often encountered under Nimbostratus. Turbulence is stronger in the pannus than in the Nimbostratus immediately above it.

*Within the cloud.* The physical constitution of Nimbostratus is similar to that of Altostratus, but its constituent particles are generally larger and more numerous. This, combined with the usual great vertical extent of Nimbostratus, is responsible for the fact that it is somewhat dark inside the lower parts of the cloud. While Nimbostratus is essentially a layer cloud, cumuliform convective clouds of considerable vertical extent may form in it.

In Nimbostratus visibility is poor, often less than 50 metres (50 yards) in places.

Icing of varying intensity may occur. Turbulence, though generally moderate, may become fairly strong when there is internal convection.

*Above the cloud.* Viewed from above, the upper surface of Nimbostratus is in many cases similar to that of Cirrostratus and Altostratus. It looks diffuse and fairly smooth and it sometimes shows a flat, undulated or fleecy appearance. In unstable air masses, Cumulus congestus or Cumulonimbus, embedded in the Nimbostratus, may rise above its upper surface.

Optical phenomena like glory, fog bow and undersun are sometimes visible.

### II.5.2.7

### STRATOCUMULUS

Stratocumulus usually occurs below an altitude of 2 kilometres (6 500 feet); its thickness ranges between 500 and 1 000 metres (1 650 and 3 300 feet). Like Altocumulus, Stratocumulus may take several forms, the most important of which are described below.

(*a*) *Stratocumulus in a sheet or layer with detached elements* (Stratocumulus stratiformis)

*Below the cloud.* Viewed from below, this cloud appears in the form of a sheet or layer, consisting of fairly extensive elements which are whitish, grey, or both whitish and grey. Owing to its somewhat greater vertical extent and especially to its higher water content, Stratocumulus is darker than Altocumulus.

*Within the cloud.* This type of Stratocumulus is composed of water droplets which, at low temperatures, are occasionally interspersed with ice crystals. The observer has the impression of flying in a dense fog with variations in visibility, which are sometimes small, sometimes rather large. Icing is at times fairly severe. Turbulence is generally moderate, but often more severe than in the corresponding type of Altocumulus.

*Above the cloud.* Viewed from above, this type of Stratocumulus, like Altocumulus with detached elements, has a somewhat fleecy appearance. Protuberances and sproutings are sometimes in evidence. They either spring from the layer itself or they constitute the upper parts of Cumulus congestus and Cumulonimbus, which have penetrated the layer from below. Marked open spaces or crevices are often visible. A glory, fog bow and undersun may be observed, sometimes simultaneously.

(*b*) *Stratocumulus in a sheet or layer with merged elements* ("solid" Stratocumulus stratiformis)

*Below the cloud.* Viewed from below, the base of this type of Stratocumulus is usually distinct and corrugated; true relief may, however, be revealed only by differences in luminance.

*Within the cloud.* This type of Stratocumulus is composed of water droplets which, at sufficiently low temperatures, are interspersed with ice crystals; raindrops, snow pellets, snow crystals and snowflakes may also be present. The observer has the impression of flying in dense fog. There may be moderate icing. Turbulence is generally moderate.

*Above the cloud.* Viewed from above, the upper surface appears sometimes flat. Most of the time, however, it is more or less undulated or in the form of long parallel bands. Protuberances and sproutings may be visible. Often, the air immediately above this type of Stratocumulus is hazy. A glory, fog bow and undersun may be observed, sometimes simultaneously.

The cloud sheet or layer often closely follows the irregularities of the terrain. The resulting bulges and depressions with their different luminance (lighter bulges, darker depressions) then give a good indication of the topographic features (rivers, lakes, coasts, hills, etc.). The latter may also be discerned through breaks in the cloud.

### II.5.2.8
### STRATUS

Stratus usually occurs between the Earth's surface and an altitude of 2 kilometres (6 500 feet). The thickness of Stratus ranges between ten and several hundred metres (ten and several hundred feet).

*Below the cloud.* Viewed from below, a Stratus layer or patch looks generally grey; at times, it exhibits differences in luminance. Its base may be clearly defined, diffuse, or ragged. When the sun is visible through Stratus its outline is not blurred (no ground glass effect).

*Within the cloud.* Stratus is composed of small water droplets and sometimes of ice crystals; drizzle droplets, ice prisms and snow grains may also be present. The denseness of the cloud gradually increases towards the top where the very fine water droplets may be so numerous that visibility is reduced almost to zero. Variations in denseness and visibility are also observed in the horizontal direction. There may be light to moderate icing. Turbulence is light to moderate.

*Above the cloud.* Viewed from above, the upper surface of Stratus generally shows undulations (usually of short wavelengths) and sometimes displays protuberances. In strong winds the undulations are more pronounced and humps and hollows, closely reflecting the irregularities of the ground, may be observed (compare Stratocumulus). Often the air immediately above the upper surface is hazy. A glory, fog bow and undersun may be present, sometimes simultaneously.

II.5.2.9

CUMULUS

Cumulus occurs in various sizes and degrees of development, from Cumulus humilis with a vertical extent ranging from some tens to some hundreds of metres (from some tens to some hundreds of feet), through Cumulus mediocris the vertical extent of which ranges from a few hundreds of metres to about two kilometres (from a few hundreds of feet to about 7 000 feet), to Cumulus congestus with a vertical extent sometimes exceeding 5 kilometres (16 500 feet).

(*a*) *Cumulus humilis*

*Below the cloud.* Viewed from below, Cumulus humilis clouds usually show a horizontal base. Turbulence is generally moderate.

*Within the cloud.* Cumulus humilis is composed of water droplets (sometimes supercooled). An observer flying through it has the impression of being in dense fog, with large variations in visibility. Ascending currents of about 2 to 5 metres (7 to 17 feet) per second may be encountered. Turbulence is sometimes severe, especially during the formation and growth of the cloud; it diminishes when the cloud ceases to grow.

*Above the cloud.* Viewed from above, Cumulus humilis clouds often appear to be floating in a hazy layer from which their rounded tops emerge. Most of the tops extend to nearly the same level. Sometimes the individual clouds are widely spaced; sometimes they are close together and sufficiently flat to resemble patches of Stratocumulus. There is usually no turbulence above Cumulus humilis.

(*b*) *Cumulus mediocris*

*Below the cloud.* Viewed from below, the usually horizontal base of Cumulus mediocris is a little darker than that of Cumulus humilis. Turbulence is often strong.

*Within the cloud.* Cumulus mediocris is composed of water droplets (sometimes supercooled). Visibility is variable, often very poor or even zero. There may be light to moderate icing. The speed of ascending currents may exceed 5 metres (17 feet) per second; turbulence is fairly severe.

*Above the cloud.* Viewed from above, these Cumulus clouds show slight or moderate protuberances or bulges, the sizes of which may vary appreciably from one cloud to another. White cloud veils (pileus, velum) are sometimes observed over Cumulus mediocris.

Cumulus mediocris clouds may occasionally be arranged in files oriented in the direction of the wind; such "cloud streets", when viewed from a considerable distance, look like Stratocumulus.

Note: The Cumulus mediocris includes cumuliform clouds with variable vertical development (prethunderstorm convection sky), which usually have ragged borders and torn tops. These clouds rapidly reach the stage of Cumulonimbus after a short passage through that of Cumulus congestus.

(*c*) *Cumulus congestus*

*Below the cloud.* Viewed from below, Cumulus congestus, which presents great contrasts of shade and light, shows a relatively dark base. Under the base, which is nearly horizontal and fairly often ragged, visibility is good, except during precipitation. Turbulence is usually strong.

*Within the cloud.* Cumulus congestus is composed mainly of water droplets; ice crystals may form in those parts where the temperature is well below 0°C (32°F). Raindrops may occasionally be observed. Visibility is generally very poor, but varies within a considerable range. There may be fairly considerable icing. Ascending currents sometimes exceed 10 metres (33 feet) per second and turbulence is often severe. Electrical discharges may occur.

*Above the cloud.* Viewed from above, Cumulus congestus, when sunlit, presents a more dazzling appearance than the other types of Cumulus. The upper parts, with well-defined, strongly shaded protuberances and sproutings, have the shape of large cauliflowers, huge chimneys or towers. The tops, which may reach widely differing levels, sometimes emerge from a layer of haze or from a more or less continuous layer of cloud.

Veils (pileus, velum), sometimes connecting several clouds, may frequently be observed.

II.5.2.10

### CUMULONIMBUS

The base of Cumulonimbus is usually found at altitudes below 2 kilometres (6 500 feet); the top can often reach altitudes exceeding 10 kilometres (35 000 feet). The vertical extent of Cumulonimbus ranges between 3 and 15 kilometres (10 000 and 50 000 feet).

*Below the cloud.* Viewed from below, Cumulonimbus generally looks dark. Under the often frayed base, pannus clouds in the form of ragged shreds are frequently observed. They occasionally constitute a kind of dark roll (arcus) under the forward and lower periphery of the Cumulonimbus. Visibility may be poor in the precipitation (heavy showers of rain, snow or hail). Turbulence is often severe.

*Within the cloud.* Cumulonimbus is composed of water droplets and, especially in its upper portion, of ice crystals. It also contains large raindrops and, often, snow crystals, snowflakes, snow pellets, ice pellets or hailstones. The water droplets and raindrops may be substantially supercooled. This supercooled water is often present in such large amounts that it leads to rapid formation of ice on aircraft; this seems to be particularly frequent when the supercooled water drops are interspersed with ice crystals.

In the lower and middle portions of the cloud, it is dark and the visibility is very low, often zero; in the upper portions, the illumination may be strong, but the visibility is poor. Vertical currents (ascending and descending), often exceeding 15 metres (50 feet) per second, are observed; the down-drafts are mostly present in areas of heavy precipitation. Turbulence is severe.

Electrical discharges (lightning) may occur; they seem to be most frequent in that portion of the cloud where the temperature is between 0°C and —2°C (32°F and 28°F).

*Above the cloud.* Depending on its stage of development, Cumulonimbus has the appearance either of Cumulus congestus, with its strong contrasts in luminance, or of dense Cirrus, often in the shape of huge plumes or anvils, with wavy or bulging parts. When illuminated by the sun, it has a dazzling appearance with very great contrasts in luminance. The main body of a Cumulonimbus sometimes emerges from a layer of stratiform clouds. Cloud veils of various dimensions (pileus, velum) may surround the cloud. Usually no haloes are observed.

II.5.3

## Fog and haze as seen from aircraft

Fog and haze may appropriately be considered in this chapter, as they frequently resemble certain types of cloud.

II.5.3.1

### FOG

Fog is composed of very small water droplets (and sometimes minute ice particles) in suspension in the atmosphere, reducing the visibility at the Earth's surface. The vertical extent of fog ranges between a few metres (a few feet) and several hundreds of metres.

*Flying within fog*, the airborne observer also experiences low visibility. Icing, when it occurs, is generally very light. In the case of shallow fog, turbulence is non-existent or light; in fog of larger vertical extent, turbulence may be light to moderate.

*Above the fog*. Viewed from above, fog has the appearance of a smooth layer of Stratus; it is sometimes flat, sometimes slightly undulated or it displays rounded masses of various dimensions.

### II.5.3.2

### HAZE ALOFT

Haze aloft is composed of extremely small particles which scatter the light. The scattering action increases with the concentration of the particles.

Layers of haze aloft may be encountered by the airborne observer up to altitudes of about 5 kilometres (16 500 feet).

*Below the haze*. Viewed from below, haze aloft appears as a veil with a dark blue or blackish tint. An airborne observer, entering such a haze layer from below, experiences a gradual reduction in visibility.

*Within haze aloft*, it is often difficult to determine whether the aircraft is in haze alone or in clouds which may be embedded in it. Flying upward out of a layer of haze, a rapid improvement in horizontal visibility is usually observed.

*Above the haze*. Viewed from above, haze aloft tends to hide the landscape. The scattered light is especially strong in the direction of the sun. Looking in this direction, ground features are impossible to distinguish, except perhaps when the landscape includes very bright areas (water surfaces). In the direction away from the sun, visibility towards the ground is better.

The upper limit of haze aloft forms a horizon. Flying immediately above haze and looking down obliquely, it is almost impossible to distinguish any clouds which may be embedded in it, unless the tops of these clouds emerge above the haze layer. As is the case with many stratiform clouds, the upper limit of the haze coincides with the base of a stable air layer (often a temperature inversion).

## II.6 — SPECIAL CLOUDS

II.6.1

### Nacreous clouds
(Mohn 1893)

II.6.1.1

#### Definition

Clouds resembling Cirrus or Altocumulus lenticularis and showing very marked irisation, similar to that of mother-of-pearl; the most brilliant colours are observed when the sun is several degrees below the horizon.

II.6.1.2

#### Physical constitution

The physical constitution of nacreous clouds is still unknown. However, the simultaneous occurrence of various diffraction colours in more or less irregular patterns indicates the presence of minute particles. It has been suggested that these particles may be water droplets or spherical ice particles.

II.6.1.3

#### Explanatory remarks

Nacreous clouds are rare and they seem to occur only in certain regions. They have been observed mainly in Scotland and Scandinavia, but have occasionally been reported from France in winter during periods with a strong, broad, deep and homogeneous westerly to north-westerly current, and from Alaska. According to measurements made by Störmer, the nacreous clouds observed in southern Norway occurred at an altitude between 21 and 30 kilometres (70 000 and 100 000 feet).

By day, nacreous clouds often resemble pale Cirrus. After sunset, they are characterized by brilliant colours, which are more extensive and more intense than the localized irisation which often appears on the edges of thin tropospheric clouds (e.g. Altocumulus lenticularis). Irisation reaches its maximum brilliance when the sun is several degrees below the horizon. Later, with the sun still further down, the various colours are replaced by a general coloration which changes from orange to pink and contrasts vividly with the darkening sky. Still later, the clouds become greyish, then the colours reappear, though with greatly reduced intensity, before they finally fade out. Up to about two hours after sunset, the nacreous clouds can still be distinguished as tenuous grey clouds standing out against the starry sky. If there is moonlight, they may be visible throughout the night.

Before dawn, the above sequence is repeated in reverse order.

If, after sunset, Cirrus and nacreous clouds co-exist, the nacreous clouds still show bright colours after the Cirrus has already turned grey.

Nacreous clouds are stationary or move very slowly. This does not necessarily mean, however, that the wind speed at their level is low.

II.6.2

## Noctilucent clouds

(JESSE[1] 1890)

II.6.2.1

### DEFINITION

Clouds resembling thin Cirrus, but usually with a bluish or silvery, or sometimes orange to red colour; they stand out against the dark night sky.

II.6.2.2

### PHYSICAL CONSTITUTION

The physical constitution of noctilucent clouds is still unknown. According to Störmer and Vestine[2] there is some evidence that they are composed of very fine cosmic dust.

II.6.2.3

### EXPLANATORY REMARKS

Noctilucent clouds have very seldom been seen and then only in the northern parts of the middle latitude zone of the northern hemisphere during summer, when the sun was 5 to 13 degrees below the horizon. Measurements have shown that their altitude ranges between 75 and 90 kilometres (250 000 and 300 000 feet).

Noctilucent clouds become visible at about the same time as first magnitude stars. They are at first greyish, then more and more brilliant and, as time advances, they appear bluish white like tarnished silver. This sequence of changes is then repeated in reverse order.[3]

Noctilucent clouds are more frequently observed and appear more brilliant after midnight than before midnight. They have been observed to move with speeds ranging from about 50 metres per second (100 knots) to more than 250 metres per second (500 knots), usually from the north-east or east.

II.6.3

## Condensation trails (contrails)

Contrails are clouds which form in the wake of an aircraft when the atmosphere at flying level is sufficiently cold and humid. When just formed, they have the appearance of brilliant white streaks; soon however they show pendant swellings like inverted mushrooms. Often they are short-lived, but especially when Cirrus or Cirrostratus is present, they may persist for several hours. Persistent trails spread progressively, frequently forming large patches of fluffy or fibrous clouds, having the appearance of Cirrus or patches of Cirrocumulus or Cirrostratus; in fact it is sometimes impossible to distinguish old contrails from these clouds.

Contrails may produce halo phenomena with exceptionally pure colours.

[1] See Appendix III: "Bibliography of cloud nomenclature".

[2] C. Störmer. — Height and velocity of luminous night clouds observed in Norway, 1932. *Publication No. 6 of the University Observatory, Oslo 1932;* E. H. Vestine — Noctilucent clouds. *Journal of the Royal Astronomical Society of Canada*, 1934, pp. 249-272, 303-317 (including extensive bibliography). Cf. further summary in *Bull. Amer. Meteorol. Soc.*, Vol. 16, 1935, pp. 49-50.

[3] Noctilucent clouds sometimes appear reddish in the immediate vicinity of the horizon.

The main factor in the formation of contrails is the cooling of the exhaust gases which have a high water vapour content as a result of the combustion of fuel. Condensation nuclei provided by the exhaust gases of the engines also assist in their formation.

A type of contrail different from that described above and with a much shorter life sometimes develops as a result of expansion in eddies from propeller- and wing-tips.

II.6.4

### Clouds from waterfalls

High waterfalls produce spray which virtually saturates the air. The down-drafts caused by the falling water are often compensated by upward currents in their vicinity, lifting the saturated air and forming, above the waterfall, a cloud resembling a Cumulus.

The spray itself may cause brilliant rainbows.

II.6.5

### Clouds from fires

The combustion products from big fires, e.g. forest fires or fires in petrol stores, often assume the appearance of dense, dark and sprouting clouds which develop vertically to great height, either retaining its sprouting aspect up to the top or spreading out at a certain level. In spite of the similarity of form between such fire clouds and clouds produced by ordinary convection (Cumulus congestus and Cumulonimbus), the former can easily be recognized by the rapidity of their development and by their dark colour.

Fire clouds often diffuse into the ambient atmosphere, resulting in the lithometeors smoke or haze. Combustion products, such as those from large tropical bush fires or from forest fires, may be carried by the wind to great distances. They assume the appearance of thin, stratiform veils and may be distinguished, though not always easily, from ordinary stratiform cloud veils by their special colouring and occasionally by the blue appearance of the sun or moon when seen through them, or by their acrid odour.

Fires releasing sufficient water vapour and producing a great deal of heat may also initiate the formation of real Cumulus or Cumulonimbus clouds, which are often carried far from the fire by the wind and then develop in accordance with local atmospheric conditions, even producing precipitation and thunderstorms. Not uncommonly (e.g. in forest fires) these convective clouds, which from a certain level upwards are composed mainly of water droplets, bulge up out of the smoke cloud. Sometimes (e.g. in prairie fires) there is little smoke and only the convective clouds are visible.

II.6.6

### Clouds from volcanic eruptions

Clouds produced by volcanic eruptions look in general like strongly developed cumuliform clouds with rapidly growing protuberances; they may spread out at a high altitude over vast areas. In such a case the sky assumes a peculiar tint which may persist for several weeks.

These clouds may also produce strong electrical manifestations.

Clouds from volcanic eruptions are composed mainly of dust particles or other solid particles of different sizes. Some portions, however, may consist almost entirely of water droplets; these portions sometimes release precipitation. Some volcanoes producing pasty, siliceous lava, emit vitreous filaments the fall of which, when seen from a distance, may have the appearance of a snow shower.

II.6.7

**Clouds resulting from industry**

These clouds have very diverse origins; the following are mentioned only as examples: clouds of smoke and steam in industrial areas, smoke clouds created for frost protection purposes, clouds of insecticide gas or powders in agricultural areas.

II.6.8

**Clouds resulting from explosions**

When an explosion is very large, it is usually accompanied by a cloud of smoke and dust. Above this cloud, velum or pileus are often seen. Sometimes the propagation of shock waves is manifested by dark rings or bands moving with extreme rapidity.

# II.7 — OBSERVATION OF CLOUDS FROM THE EARTH'S SURFACE

## II.7.1

## Introduction

The observation of clouds should begin with the identification of all the clouds present. This should be followed by an estimation or a measurement of the cloud amounts, of the height of the clouds, their speed and direction of movement and their optical thickness.

An almost continuous watch on the sky is necessary for correct cloud observations. This is particularly important for the identification of clouds, in view of the infinite variety of forms in which they occur and in view of their continual evolution. Thus, continuous observation may make it possible to identify "difficult" clouds by recalling their recent history, during which they may have passed through a more easily recognizable phase. A continuous watch on the sky is also very useful in determining the genus of the clouds from which some of the clouds present may have originated (mother-clouds).

Cloud identification is also sometimes facilitated by observing the sky as a whole. For instance under certain thundery situations, clouds not uncommonly assume peculiar forms which are difficult to identify. However the thundery character of the sky as a whole may assist in the identification of the individual clouds.

Observation of the sky as a whole is also useful because it enables the observer to obtain an impression of the general character of the sky. In certain cases, he may be able to describe the sky in general terms such as fibrous, striated, sharp, diffuse, etc.

The observer should be aware of the fact that, in different meteorological situations, clouds of the same genera, species and varieties, occurring in approximately the same amount and at the same levels, may give different impressions. For instance, in a convective sky during an outbreak of cold polar air, the clouds at all levels look sharper than similar clouds during an invasion of unstable tropical air; their shapes also differ, being broader in polar air and more turreted in tropical air. Differences also occur as a result of the wind shear in the vertical. When the shear is slight, the clouds look "heavier" than in the case of a rapid change of wind with height, which causes the clouds (e.g. trade wind Cumulus) to lean.

During daytime it is advisable for the observer to use spectacles fitted with properly oriented polarizing glasses or with red or dark yellow curved glasses. Such spectacles should preferably be provided with opaque side wings to shut out light coming from the sides. In the absence of special spectacles the observer may advantageously examine clouds by reflection in a black mirror. These devices are also useful for minimizing the dazzling effect of bright sunlight. They are almost indispensable when observing very thin clouds such as certain Cirrus clouds, which are barely visible against the blue of the sky, or when there is haze more or less veiling the clouds.

At night the sky should be examined from a dark place, well away from lights, especially when the atmosphere is hazy. The observation should not be made before the observer's eyes are adapted to the darkness.

## II.7.2

## Identification of clouds

The identification of clouds consists in identifying the genus, the species, the varieties, the supplementary features and accessory clouds, the mother-cloud and the meteors associated with the clouds.

II.7.2.1

### Identifying the genus

The identification of the genus of a cloud should be based primarily on the definitions and descriptions detailed in Chapter II.3 of the present Volume, and on comparison with the relevant illustrations of Volume II of this Atlas. Identification is facilitated by considering, in succession, the criteria indicated in the Tabular Guide below.

Sometimes a knowledge of the height of a cloud is also helpful in identifying its genus. Thus in case of doubt, the genus can be identified by making a choice from among the genera normally found at the height of the observed cloud.

It should be noted that several cloud genera may be present in the sky at the same time.

### TABULAR GUIDE FOR THE IDENTIFICATION OF THE GENUS OF CLOUDS

| | DISTINCTIVE FEATURES | GENERA IN WHICH THE FEATURES OCCUR | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Ci | Cc | Cs | Ac | As | Ns | Sc | St | Cu | Cb |
| GENERAL SHAPE AND GROUPING OF CLOUDS AND CLOUD ELEMENTS | Detached, with a flattened appearance | | | | | | | | | P | |
| | More or less developed vertically — detached | P | P | | P | | | P | | U | U |
| | More or less developed vertically — having a common base | P | P | | P | | | P | | | |
| | Thin, with detached filaments | U | | | | | | | | | |
| | Thin, grouped in sheaves or ending in a hook or tuft | U | | | | | | | | | |
| | Spread out in a patch, sheet or layer, subdivided into more or less regularly arranged laminae or rounded masses, the apparent width of most of the elements being — less than 1 degree [1] | | E | | | | | | | | |
| | — between 1 and 5 degrees | | | | U | | | | | | |
| | — more than 5 degrees [2] | | | | | | | E | | | |
| | Spread out as a veil totally or partly covering the sky | | | E | | E | E | | U | | |
| STRUCTURE AND TEXTURE | Silky sheen | U | P | P | | | | | | | S |
| | Fibrous (hair-like) | U | | P | P | P | | | | | S |
| | Granular | | U | | P | | | | | | |
| | Undulated or rippled | | U | P | P | P | | P | P | | |
| | Ragged | | | | | | | | P | P | |
| | Uniform base | | | U | | U | U | | U | U | P |
| | Diffuse base | | | | | P | U | | P | | P |
| OPTICAL THICKNESS | Thin clouds, through which the disk of the sun or moon can be seen | U | U | E | P | | | P | P | P | |
| | Translucent clouds, revealing only the position of the sun or moon | P | P | | U | U | | P | P | P | |
| | Opaque clouds | | | | P | U | E | U | U | U | E |
| SHADING | Without shading | U | E | U | P | | | P | P | P | |
| | Partly shaded | P | | P | U | P | P | U | P | U | U |
| | Shaded throughout | | | | P | U | U | P | U | | P |

1 This is approximately the apparent width of the little finger at arm's length.
2 This is approximately the apparent width of three fingers at arm's length.

## TABULAR GUIDE FOR THE IDENTIFICATION OF THE GENUS OF CLOUDS
*(continued)*

| | DISTINCTIVE FEATURES | GENERA IN WHICH THE FEATURES OCCUR | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Ci | Cc | Cs | Ac | As | Ns | Sc | St | Cu | Cb |
| SUPPLEMENTARY FEATURES AND ACCESSORY CLOUDS | Incus | | | | | | | | | | S |
| | Mamma | P | P | | P | P | | P | | | P |
| | Virga | | P | | P | U | U | P | | P | P |
| | Praecipitatio — uniform (intermittent or continuous) | | | | | P | U | P | P | | |
| | Praecipitatio — in the form of showers | | | | | | | | | P | U |
| | Arcus | | | | | | | | | P | P |
| | Tuba | | | | | | | | | P | P |
| | Pileus | | | | | | | | | P | P |
| | Velum | | | | | | | | | P | P |
| | Pannus | | | | | P | U | | | P | U |
| HYDROMETEORS | Rain | | | | | P | U | P | | P | U |
| | Drizzle | | | | | | | | P | | |
| | Snow | | | | | P | P | P | P | P | P |
| | Snow pellets | | | | | | | P | | P | P |
| | Snow grains | | | | | | | | P | | |
| | Ice pellets | | | | | P | P | | | | P |
| | Hail | | | | | | | | | | P |
| PHOTOMETEORS | Halo phenomena | P | | U | P | | | | P | | S |
| | Corona | | P | P | U | P | | P | P | P | |
| | Irisation on clouds | | P | | P | | | P | | | |
| | Rainbow | | | | | | | | | P | P |
| ELECTROMETEORS | Lightning, thunder or thunderstorm | | | | | | | | | | P |

The meaning of the symbols is as follows:

E means that the feature concerned is *essential* to the genus;
U means that the feature is *usual*;
P means that the feature is *possible*, occurring sometimes in certain species;
S means that the feature may occur only at the *summit* or upper portion of the cloud.

II.7.2.2

### IDENTIFYING THE SPECIES

The species of a cloud should be identified on the basis of the definitions and descriptions and by comparing the observed cloud with the relevant illustrations. If the observed cloud does not present the characteristics of any of the species defined in this Atlas, no species should be mentioned.

When several clouds of one and the same genus are present in the sky, these clouds do not necessarily all belong to the same species.

II.7.2.3

IDENTIFYING THE VARIETIES

The identification of the variety or varieties of a cloud should be based on the definitions, descriptions and illustrations given in this Atlas. Only those varieties which are clearly recognized should be indicated.

The same cloud may show characteristics pertaining to more than one variety; in this case all these varieties should be mentioned.

II.7.2.4

IDENTIFYING THE SUPPLEMENTARY FEATURES AND THE ACCESSORY CLOUDS

The definitions, descriptions and illustrations provide a basis for the identification of any supplementary features and any accessory clouds which may be present. One or more supplementary features and accessory clouds may be observed simultaneously with the same cloud.

II.7.2.5

DETERMINING THE MOTHER-CLOUD

The determination of the mother-cloud, if any, from which the cloud under observation may have originated, requires a knowledge of the evolution of the clouds and hence a careful watch on the sky. The observer should also have recourse to the relevant definitions, descriptions and illustrations.

No mention should be made of mother-clouds if there is any doubt as to the origin of the observed clouds or as to the manner of their formation ("genitus" or "mutatus").

II.7.2.6

IDENTIFYING METEORS ASSOCIATED WITH THE CLOUDS

Meteors other than clouds, associated with them, should be identified on the basis of their definitions and descriptions [1]. They should always be recorded together with the clouds with which they are associated, since they often provide important information about the physical processes occurring in the clouds; their presence may even be decisive in identifying certain cloud genera.

II.7.3

## Total cloud cover and cloud amount

The *total cloud cover* is the fraction of the celestial dome covered by all the clouds visible.

The term *cloud amount* [2] in reference to a genus, a species, a variety, a layer or a certain combination of clouds designates the fraction of the sky covered by clouds of that genus, species, variety, layer or combination of clouds. The estimation of cloud amounts may be difficult if some of the clouds present are only partly visible or temporarily completely concealed. This is often the case when the clouds occur in superposed patches or layers. The observer may then obtain a sufficiently reliable estimate of the cloud amount(s) by observing the sky over a period of time, as clouds previously hidden by other clouds may, owing to their relative movement, become visible. When clouds occur in superposition, the sum of the different cloud amounts may of course exceed the total cloud cover.

[1] See Part III of this Volume.
[2] Formerly called "partial cloudiness".

It should be noted that, owing to the effect of perspective, gaps existing between clouds near the horizon may not be visible to the observer. Only gaps which are visible from the observer's position should be taken into account in estimating cloud cover or cloud amount.

An estimate should always be made of the total cloud cover and also of the cloud amounts of the various genera present; the cloud amounts of the different species or varieties of clouds belonging to the same genus and of the different layers should also be noted. On dark nights, only the total cloud cover can be determined and the observer should then take note of the proportion of the sky in which the stars are dimmed or completely hidden by clouds.

The estimation of the total cloud cover and of cloud amounts should be made from an open place from which the whole celestial dome can be seen. When the celestial dome is partially hidden by obstructions such as mountains, or by haze, fog or smoke, the total cloud cover and the cloud amounts should be estimated from the unhidden fraction. When a part of the celestial dome is veiled by precipitation, this part should be considered as covered by the precipitating cloud.

II.7.4

## Height and altitude

The observer should measure or estimate the *height* of the cloud base above the level of his point of observation or the *altitude* above mean sea level. If possible, the *vertical extent* of the clouds should also be determined. The way in which information regarding the height or altitude is obtained (estimation, measurement by pilot-balloon, by cloud searchlight, ceilometer, etc.) should always be stated.

II.7.5

## Direction and speed of movement

By convention, the *direction* of movement of a cloud is that *from* which the cloud moves; for example, if the movement of a cloud is from south-west to north-east, the recorded direction of movement is "south-west".

The *speed* of a cloud is the speed of its horizontal movement.

An observation of the sky should include a determination of the direction and, whenever possible, also of the speed of movement of the clouds or their macroscopic elements. In most cases this direction and speed give a good approximation of the direction and speed of the wind at cloud level. It should be noted, however, that the movement of a cloud as a whole may be very different from that of its macroscopic elements; this applies, in particular, to orographic clouds. Such a difference, when observed, should be recorded.

In order to reduce errors due to vertical motion, measurements made with nephoscopes or similar devices should preferably refer to clouds which are not too far from the zenith.

II.7.6

## Optical thickness

The *optical thickness* of a cloud is the degree to which the cloud prevents light from passing through it. The optical thickness depends on the physical constitution and on the dimensions of the cloud.

The following scale enables the observer to give a qualitative estimate of the optical thickness by means of a number:

1 Very weak — the blue of the sky is discernible through the cloud.

2 Weak — the cloud hides the blue of the sky, but does not prevent the sun from casting shadows; such a cloud is usually white but may be light grey.

3 Moderate — the cloud has a good general luminance, but noticeable shading in places; when it occurs in an extensive sheet or layer, the cloud is light grey.

4 Strong — the cloud is strongly shaded; when it occurs in an extensive sheet or layer, it appears dark grey; when the layer is discontinuous or is formed of scattered elements, the parts directly exposed to the sun are white and fairly brilliant.

5 Very strong — the cloud is dark, except for the parts exposed to the sun, which are brilliantly white; the cloud has a threatening appearance.

The observer should record the optical thickness; the direction in which the clouds or cloud layers have the greatest thickness should also be noted.

II.7.7

## Observations of clouds made from mountain stations

The procedure for observing clouds from mountain stations is the same as that for low level stations, when the mountain station is at a level lower than that of the base of the clouds. As mountainous country provides numerous reference points, information about height or altitude can often be given with considerable accuracy.

When clouds are observed below station level, they should be indicated separately. A description should be given of the upper surface of such clouds; features such as a flat or an undulated surface, the presence of towering cumuliform clouds above the top of the layer should be recorded. In estimating the cloud amount, the places where mountains transpierce a patch, sheet or layer of clouds are considered as covered with clouds.

II.7.8

## Observation of special clouds

II.7.8.1

### Nacreous and noctilucent clouds

When nacreous or noctilucent clouds are observed, an exact record should be kept of the dates and times corresponding to successive aspects of the clouds, and of the azimuth and angular elevation of the different parts of the clouds.

Sketches, or even better, photographs should be made, whenever possible, of these rarely observed clouds. When stars are present in the vicinity of the clouds, their position in relation to the clouds should be noted, thereby providing reference marks from which the altitude of the clouds may be determined. The horizon provides another useful reference mark.

For best photographic results, an objective of wide aperture and highly sensitive plates or films should be used. Colour filters should not be employed. Colour photography is eminently suitable for showing the irisation on nacreous clouds.

The focal length of the objective should always be stated and careful records should be kept of the date and time of each photograph, and of the azimuth and angular elevation of any landmarks from which the direction of the optical axis may be determined.

II.7.8.2

### Other special clouds

The occurrence of other special clouds (see Chapter II.6 above) should be mentioned in the records of observations in the same way as ordinary clouds. The nature of the special clouds, and whenever possible their origin, should be stated.

# II.8 — THE CODING OF CLOUDS IN THE CODES $C_L$, $C_M$ AND $C_H$ AND CORRESPONDING SYMBOLS

## II.8.1

## INTRODUCTION TO THE CODING OF CLOUDS

The codes $C_L$, $C_M$ and $C_H$ presented in this Atlas, provide a convenient way of describing clouds in meteorological reports, by means of figures selected from tables of specifications.

In section II.8.2, the code specifications and coding procedures are discussed in detail. The information listed below is given for each code figure:

(*a*) A technical specification.

(*b*) A non-technical specification.

(*c*) A commentary which enlarges on the technical and non-technical specifications by giving further information concerning the appearance and evolution of the clouds in question.

(*d*) Special coding instructions which explain the procedure for the selection of the correct code figure when the clouds, described in the specification of the code figure in question, occur simultaneously with other clouds. The instructions give the code figures which are automatically excluded when the clouds described in the specification are present, and formulate the conditions under which other code figures have priority.

(*e*) Further remarks which are sometimes included to supply information which cannot be classified under any of the above sections.

The selection of the correct code figures requires, in the first place, observation of the sky as a whole and, in the second place, an almost continuous watch on the sky.

The first requirement arises from the fact that certain code specifications apply not only to the particular genera, species or varieties of the individual clouds, but also to the aspect of the sky as a whole. In addition, there are situations in which the aspect of the sky as a whole is immediately recognizable, whereas the cloud forms present are difficult to identify.

The second requirement stems from the fact that certain code specifications are directly related to the evolution and development of individual clouds or of the total cloud cover. An almost continuous watch on the sky is also necessary in situations when the appearance of the sky at the time of observation is so confusing that it is impossible to select the correct code figure, except by relating the existing transitional cloud forms with the characteristic forms from which they evolved.

It will be noted that the $C_L$ code is used to indicate clouds of the genera Stratocumulus, Stratus, Cumulus and Cumulonimbus, the $C_M$ code to indicate clouds of the genera Altocumulus, Altostratus and Nimbostratus, and the $C_H$ code to indicate clouds of the genera Cirrus, Cirrocumulus and Cirrostratus.

The criteria for coding have been summarized, for ease of reference, in the form of pictorial guides (cf. pages 99, 100 and 101).

## II.8.2

## CODE SPECIFICATIONS AND CODING PROCEDURES

### II.8.2.1

**$C_L$-clouds of the genera Stratocumulus, Stratus, Cumulus and Cumulonimbus**

**II.8.2.1.1**

$C_L = 0$

(*a*) TECHNICAL SPECIFICATION

*No $C_L$-clouds.*

(*b*) NON-TECHNICAL SPECIFICATION

*No Stratocumulus, Stratus, Cumulus or Cumulonimbus.*

**II.8.2.1.2**

$C_L = 1$

(*a*) TECHNICAL SPECIFICATION

*Cumulus humilis or Cumulus fractus other than of bad weather* [1], *or both.*

(*b*) NON-TECHNICAL SPECIFICATION

*Cumulus with little vertical extent and seemingly flattened, or ragged Cumulus other than of bad weather* [1], *or both.*

(*c*) COMMENTARY

The clouds corresponding to the code figure $C_L = 1$ include the following:

(i) Cumulus clouds which are in the initial stages of formation or in the last stages of dissipation.

(ii) Cumulus clouds which are completely formed but are frayed by a fairly strong and sufficiently turbulent wind; these Cumulus fractus clouds are well separated and generally look white. The difference between these clouds and Cumulus fractus of bad weather is indicated in the commentary on specification $C_L = 7$.

(iii) Cumulus clouds which are completely formed with clear-cut horizontal bases; these clouds have either a flattened or deflated form, or show somewhat rounded tops without a cauliflower appearance.

(*d*) SPECIAL CODING INSTRUCTIONS

If there is no Stratocumulus at another level, and no Cumulonimbus or Stratocumulus cumulogenitus, but at least one of the existing Cumulus clouds is of the species mediocris or congestus, the coding $C_L = 2$ is used.

If Cumulonimbus is present, the coding should be $C_L = 3$ or 9, as the case may be.

If, in the absence of Cumulonimbus, there is Stratocumulus cumulogenitus, the coding is $C_L = 4$.

If there is no Stratocumulus at another level, and no Cumulonimbus, no Cumulus congestus or mediocris and no Stratocumulus cumulogenitus, and if the Cumulus fractus and humilis are not the predominant $C_L$-clouds,[2] the coding should be $C_L = 5$, 6 or 7, as the case may be.

If, in the absence of Cumulonimbus and Stratocumulus cumulogenitus, there is Stratocumulus non-cumulogenitus, the base of which is at a level different from that of the base of the observed Cumulus, the coding should be $C_L = 8$.

[1] "Bad weather" denotes the conditions which generally exist during precipitation and a short time before and after.

[2] The Cumulus fractus and humilis are considered not to be predominant if the sky cover of the clouds of at least one of the specifications $C_L = 5$, $C_L = 6$ or $C_L = 7$ is greater than the combined sky cover of the Cumulus fractus and Cumulus humilis.

**II.8.2.1.3**

$C_L = 2$

(*a*) TECHNICAL SPECIFICATION

*Cumulus mediocris or congestus, with or without Cumulus of species fractus or humilis or Stratocumulus, all having their bases at the same level.*

(*b*) NON-TECHNICAL SPECIFICATION

*Cumulus of moderate or strong vertical extent, generally with protuberances in the form of domes or towers, either accompanied or not by other Cumulus or by Stratocumulus, all having their bases at the same level.*

(*c*) COMMENTARY

The clouds corresponding to the code figure $C_L = 2$ are Cumulus mediocris or congestus. On days with fresh or strong wind, these Cumulus clouds have irregular bases and may be ragged in places. In middle latitudes, on hot days with a thundery tendency, and also frequently in low latitudes (trade wind zones), Cumulus clouds are in general of the species congestus with a clear-cut horizontal base and a bulging upper part resembling a cauliflower; these clouds are sometimes in the form of a tower, sometimes in the form of a complex mass of protuberances.

Cumulus congestus may sometimes give precipitation in the form of showers.

(*d*) SPECIAL CODING INSTRUCTIONS

The presence of Cumulus mediocris or congestus precludes the use of code figures $C_L = 1$, 5, 6 and 7.

If Cumulonimbus is present, the coding should be $C_L = 3$ or 9, as the case may be.

If, in the absence of Cumulonimbus, there is Stratocumulus cumulogenitus, the coding is $C_L = 4$.

If, in the absence of Cumulonimbus and Stratocumulus cumulogenitus, there is Stratocumulus non-cumulogenitus, the base of which is at a level different from that of the base of Cumulus mediocris and congestus, the coding is $C_L = 8$.

(*e*) FURTHER REMARKS

Cumulus mediocris and congestus clouds, especially the latter, often appear in a sky where Cirrus spissatus ($C_H = 2$ or $C_H = 3$) is also present; furthermore, they are frequently accompanied by Altocumulus formed by the spreading out of Cumulus (Ac cumulogenitus, $C_M = 6$).

Sometimes, the protuberances of Stratocumulus castellanus develop so strongly that they reach the stage of Cumulus mediocris or congestus; the coding is then $C_L = 2$, and not $C_L = 5$. An analogous evolution may occur in Altocumulus castellanus; the coding is then again $C_L = 2$, and not $C_M = 8$.

**II.8.2.1.4**

$C_L = 3$

(*a*) TECHNICAL SPECIFICATION

*Cumulonimbus calvus, with or without Cumulus, Stratocumulus or Stratus.*

(*b*) NON-TECHNICAL SPECIFICATION

*Cumulonimbus the summits of which, at least partially, lack sharp outlines, but are neither clearly fibrous (cirriform) nor in the form of an anvil; Cumulus, Stratocumulus or Stratus may also be present.*

(*c*) COMMENTARY

The principal characteristic of this sky is that none of the Cumulonimbus clouds present has yet reached the stage of Cumulonimbus capillatus.

Cumulonimbus calvus clouds evolve from Cumulus congestus; they usually develop later into Cumulonimbus capillatus. The Cumulonimbus calvus therefore generally constitutes an intermediate stage between Cumulus congestus and Cumulonimbus capillatus. Cumulonimbus calvus clouds are distinguished from Cumulus congestus, on the one hand, by the fact that the clear-cut outlines and the cauliflower appearance, characteristic of the upper part of Cumulus congestus, have at least partially disappeared; they are distinguished from Cumulonimbus capillatus, on the other hand, by the fact that no portion of their upper part has yet a clearly fibrous or striated appearance, or any development in the form of an anvil, a plume or a mass of hair.

(*d*) SPECIAL CODING INSTRUCTIONS

The presence of Cumulonimbus precludes the use of code figures $C_L$ = 1, 2, 4, 5, 6, 7 and 8.

As soon as at least a part of one of the Cumulonimbus clouds present becomes clearly fibrous or striated, the coding is $C_L$ = 9.

(*e*) FURTHER REMARKS

The smooth part of a Cumulonimbus calvus may become hidden by new domes produced by other convective up-thrusts. Although the cloud mass then temporarily assumes the appearance of Cumulus congestus, it is still to be called Cumulonimbus calvus and coded $C_L$ = 3.

Sometimes, a cloud which has the appearance of Cumulus congestus is accompanied by lightning, thunder or hail. The cloud is then Cumulonimbus calvus and the coding $C_L$ = 3 is applicable.

**II.8.2.1.5**

$C_L = 4$

(*a*) TECHNICAL SPECIFICATION

*Stratocumulus cumulogenitus.*

(*b*) NON-TECHNICAL SPECIFICATION

*Stratocumulus formed by the spreading out of Cumulus ; Cumulus may also be present.*

(*c*) COMMENTARY

Stratocumulus cumulogenitus most often results from the spreading out of Cumulus which, while in process of vertical development, reaches a stable layer. Sometimes, when this layer is very stable, the ascending currents are stopped and the whole cloud mass spreads out. On some occasions, the stable layer cannot stop the rising motion altogether; in this case, the Cumulus clouds, after a temporary spreading out, resume their growth above the stable layer, at least in some places. Thus, Stratocumulus cumulogenitus may occur at any level between the base and top of Cumulus clouds.

The observer should know how to distinguish real Stratocumulus cumulogenitus from Stratocumulus penetrated by Cumulus clouds. He should realize that the transformation of Cumulus clouds into Stratocumulus cumulogenitus is a continuous process, generally marked by gradual widening of the Cumulus clouds towards the spreading out level. In the case of a pre-existing

Stratocumulus, entered or transpierced by a Cumulus, the latter does not widen upwards towards the Stratocumulus and a thinned or even a cleared zone may surround the Cumulus column.

Stratocumulus cumulogenitus may also form by the spreading out of the upper part of Cumulus clouds as a result of strong wind shear.

A particular form of Stratocumulus cumulogenitus often occurs in the evening when convection ceases and, in consequence, the domed summits of Cumulus clouds flatten. The clouds then assume the appearance of patches of Stratocumulus.

(*d*) SPECIAL CODING INSTRUCTIONS

The presence of Stratocumulus cumulogenitus precludes the use of code figures $C_L = 1$, 2, 5, 6, 7 and 8.

If Cumulonimbus is present, the coding is $C_L = 3$ or 9, as the case may be.

(*e*) FURTHER REMARKS

Stratocumulus cumulonimbogenitus which is very similar to Stratocumulus cumulogenitus should be coded $C_L = 3$ or 9 as long as the Cumulonimbus is observed. If the Cumulonimbus has disappeared, the presence of Stratocumulus cumulonimbogenitus requires the coding $C_L = 4$.

When Cumulus clouds form beneath pre-existing Stratocumulus non-cumulogenitus and these Cumulus clouds grow sufficiently for their tops to enter or transpierce the layer of Stratocumulus, without spreading out, the correct coding is $C_L = 8$.

### II.8.2.1.6
### $C_L = 5$

(*a*) TECHNICAL SPECIFICATION
*Stratocumulus other than Stratocumulus cumulogenitus.*

(*b*) NON-TECHNICAL SPECIFICATION
*Stratocumulus not resulting from the spreading out of Cumulus.*

(*c*) COMMENTARY

These Stratocumulus clouds, which occur at one or more levels, usually consist of grey or whitish sheets or layers which almost always have dark parts. They are composed of fairly large elements, separate or merged. Wind shear and turbulence may give the Stratocumulus a ragged appearance in places.

Sometimes this Stratocumulus produces precipitation the intensity of which is always very weak.

(*d*) SPECIAL CODING INSTRUCTIONS

If there are no Cumulus clouds at another level, and no Cumulonimbus, Cumulus congestus or mediocris and no Stratocumulus cumulogenitus, and if the Stratocumulus non-cumulogenitus is not the predominant $C_L$-cloud,[1] the coding should be $C_L = 1$, 6 or 7, as the case may be.

[1] The Stratocumulus non-cumulogenitus is considered not to be predominant if the sky cover of the clouds of at least one of the specifications $C_L = 1$, $C_L = 6$ or $C_L = 7$ is greater than the amount of the Stratocumulus non-cumulogenitus.

If there are no Cumulus clouds at another level, and if there is no Cumulonimbus nor Stratocumulus cumulogenitus, but there are some Cumulus mediocris or Cumulus congestus clouds at the same level as the Stratocumulus non-cumulogenitus, the coding is $C_L = 2$.

If Cumulonimbus is present, the coding should be $C_L = 3$ or 9, as the case may be.

If, in the absence of Cumulonimbus, there is Stratocumulus cumulogenitus, the coding is $C_L = 4$.

If there is no Cumulonimbus and no Stratocumulus cumulogenitus, but there are Cumulus clouds the base of which is at a level different from that of the Stratocumulus non-cumulogenitus, the coding is $C_L = 8$.

(*e*) FURTHER REMARKS

When the protuberances of Stratocumulus castellanus develop strongly, they may reach the stage of Cumulus mediocris or congestus; the coding should then not be $C_L = 5$ but $C_L = 2$.

Stratocumulus non-cumulogenitus is often broken up into patches which should also be coded $C_L = 5$. Such patches should not be confused with those formed as a result of the spreading out of Cumulus or Cumulonimbus, for which the coding $C_L = 5$ cannot be used.

Sometimes a layer of Stratocumulus assumes a menacing appearance and its base becomes diffuse in places, indicating a process of transformation into Nimbostratus. If the transformation is complete in a substantial continuous portion of the layer, as is evidenced by the absence of elements, this portion is identified as Nimbostratus and is reported in the appropriate code figure of the $C_M$ code.

## II.8.2.1.7

$C_L = 6$

(*a*) TECHNICAL SPECIFICATION

*Stratus nebulosus or Stratus fractus other than of bad weather* [1], *or both.*

(*b*) NON-TECHNICAL SPECIFICATION

*Stratus in a more or less continuous sheet or layer, or in ragged shreds, or both, but no Stratus fractus of bad weather* [1].

(*c*) COMMENTARY

The Stratus nebulosus generally consists of a single layer with a fairly uniform base, usually grey but occasionally dark or menacing.

The Stratus fractus clouds constitute a transitory stage during the formation or the dissipation of a layer of Stratus. The differences between this (ordinary) Stratus fractus and Stratus fractus of bad weather are pointed out in the commentary on $C_L = 7$. When Stratus fractus clouds occur beneath a layer of Stratus nebulosus, they may be either fragments which become merged with the base of the layer when the latter is in the process of thickening, or fragments detached from the base when the layer is in the process of breaking up.

(*d*) SPECIAL CODING INSTRUCTIONS

If there is no Cumulonimbus, no Cumulus congestus or mediocris, no Stratocumulus cumulogenitus and no Stratocumulus non-cumulogenitus together with Cumulus at a different level, and if the Stratus is not the predominant $C_L$-cloud,[2] the coding should be $C_L = 1$, 5 or 7, as the case may be.

[1] "Bad weather" denotes the conditions which generally exist during precipitation and a short time before and after.

[2] The Stratus is considered not to be predominant if the sky cover of the clouds of at least one of the specifications $C_L = 1$, $C_L = 5$ or $C_L = 7$ is greater than the amount of Stratus.

If there is no Cumulonimbus, no Stratocumulus cumulogenitus and Stratocumulus non-cumulogenitus together with Cumulus at a different level, but there are some Cumulus mediocris or Cumulus congestus clouds, the coding is $C_L = 2$.

If Cumulonimbus is present, the coding should be $C_L = 3$ or 9, as the case may be.

If, in the absence of Cumulonimbus, there is Stratocumulus cumulogenitus, the coding is $C_L = 4$.

If there is no Cumulonimbus and no Stratocumulus cumulogenitus, but there are Cumulus and Stratocumulus non-cumulogenitus with their bases at different levels, the coding is $C_L = 8$.

### II.8.2.1.8
$C_L = 7$

(*a*) TECHNICAL SPECIFICATION

*Stratus fractus or Cumulus fractus of bad weather*[1], *or both (pannus), usually below Altostratus or Nimbostratus.*

(*b*) NON-TECHNICAL SPECIFICATION

*Stratus fractus of bad weather*[1] *or Cumulus fractus of bad weather, or both (pannus), usually below Altostratus or Nimbostratus.*

(*c*) COMMENTARY

Stratus fractus of bad weather or Cumulus fractus of bad weather, or both (pannus), often form beneath the base of a lowering Altostratus or a Nimbostratus. As a rule, they become increasingly numerous and merge into a more or less continuous layer. The pannus clouds appear dark or grey against a background of lighter grey formed by the base of the cloud layer above them which is usually visible through gaps or interstices in the pannus layer. Stratus fractus of bad weather or Cumulus fractus of bad weather are also often present beneath the base of a Cumulonimbus or a precipitating Cumulus.

Pannus clouds covering the entire sky are distinguishable from Stratus nebulosus and Stratocumulus by their ragged base.

It is important to pay due attention to the differences between Stratus fractus and Cumulus fractus corresponding to the code figure $C_L = 7$, on the one hand, and Stratus fractus of the specification $C_L = 6$ and Cumulus fractus of the specification $C_L = 1$, on the other hand. The following remarks may serve as a guide.

Stratus fractus clouds of the specification $C_L = 7$ always occur in conjunction with clouds of other genera; they are generally numerous and appear dark or grey against the lighter grey background of the base of the cloud layer above them. They almost always have a certain character of instability and they generally move fast and change shape rapidly. They are usually accompanied by precipitation.

Stratus fractus clouds of the specification $C_L = 6$ may occur alone, in which case they appear grey when viewed towards the sun and white when viewed away from the sun. They look similar to Stratus fractus of the specification $C_L = 7$ when seen against a background of other clouds, such as a Stratus nebulosus layer; however, they are not accompanied by precipitation.

Cumulus fractus clouds of the specification $C_L = 7$ always occur in conjunction with clouds of other genera; they are generally numerous and stand out dark or grey against the lighter grey background formed by the base of the clouds above them. Like Stratus fractus of the same specification, Cumulus fractus clouds of bad weather almost always have a certain character of instability. They are frequently accompanied by precipitation.

[1] "Bad weather" denotes the conditions which generally exist during precipitation and a short time before and after.

Cumulus fractus clouds of the specification $C_L = 7$ always occur in conjunction with clouds of other genera; they are generally numerous and stand out dark or grey against the lighter grey background formed by the base of the clouds above them. Like Stratus fractus of the same specification, Cumulus fractus clouds of bad weather almost always have a certain character of instability. They are frequently accompanied by precipitation.

Cumulus fractus clouds of specification $C_L = 1$ mostly occur alone and are well separated. They are characteristically white, appearing almost brilliant when viewed away from the sun and showing shading when viewed towards the sun. These clouds are frequently observed when the wind at their level is fairly strong and turbulent.

(*d*) SPECIAL CODING INSTRUCTIONS

If there is no Cumulonimbus, no Cumulus congestus or mediocris, no Stratocumulus cumulogenitus and no Stratocumulus non-cumulogenitus together with Cumulus at a different level, and if the pannus clouds are not the predominant $C_L$-cloud [1], the coding should be $C_L = 1$, 5 or 6, as the case may be.

If there is no Cumulonimbus, no Stratocumulus cumulogenitus, and no Stratocumulus non-cumulogenitus together with Cumulus at a different level, but if there are Cumulus mediocris or Cumulus congestus clouds, the coding is $C_L = 2$.

If Cumulonimbus is present, the coding should be $C_L = 3$ or 9, as the case may be.

If, in the absence of Cumulonimbus, there is Stratocumulus cumulogenitus, the coding is $C_L = 4$.

If there is no Cumulonimbus and no Stratocumulus cumulogenitus, but if there are Cumulus and Stratocumulus non-cumulogenitus with their bases at different levels, the coding is $C_L = 8$.

### II.8.2.1.9

$C_L = 8$

(*a*) TECHNICAL SPECIFICATION

*Cumulus and Stratocumulus other than Stratocumulus cumulogenitus, with bases at different levels.*

(*b*) NON-TECHNICAL SPECIFICATION

*Cumulus and Stratocumulus other than that formed from the spreading out of Cumulus; the base of the Cumulus is at a different level from that of the Stratocumulus.*

(*c*) COMMENTARY

The code figure $C_L = 8$ applies when Cumulus clouds form beneath patches or a sheet or layer of Stratocumulus non-cumulogenitus. The Cumulus may thrust into the Stratocumulus more or less deeply or even transpierce it. The Cumulus does not, however, spread out and form Stratocumulus cumulogenitus.

The code figure $C_L = 8$ also applies when Cumulus clouds are observed above Stratocumulus.

(*d*) SPECIAL CODING INSTRUCTIONS

The simultaneous occurrence of Cumulus and Stratocumulus other than cumulogenitus with their bases at different levels, precludes the use of code figures $C_L = 1$, 2, 5, 6 and 7.

If Cumulonimbus is present, the coding should be $C_L = 3$ or $C_L = 9$, as the case may be.

If, in the absence of Cumulonimbus, there is Stratocumulus cumulogenitus, the coding is $C_L = 4$.

[1] The pannus clouds are considered not to be predominant if the sky cover of the clouds of at least one of the specifications $C_L = 1$, $C_L = 5$ or $C_L = 6$ is greater than the amount of pannus clouds.

**II.8.2.1.10**

$C_L = 9$

(*a*) TECHNICAL SPECIFICATION

*Cumulonimbus capillatus (often with an anvil), with or without Cumulonimbus calvus, Cumulus, Stratocumulus, Stratus or pannus.*

(*b*) NON-TECHNICAL SPECIFICATION

*Cumulonimbus, the upper part of which is clearly fibrous (cirriform), often in the form of an anvil, either accompanied or not by Cumulonimbus without anvil or fibrous upper part, by Cumulus, Stratocumulus, Stratus or pannus.*

(*c*) COMMENTARY

Cumulonimbus capillatus clouds evolve from Cumulonimbus calvus; they are distinguished from Cumulonimbus calvus clouds ($C_L = 3$) by the appearance of their upper portions. The upper part of a Cumulonimbus capillatus shows a clearly fibrous or striated structure and frequently has a form resembling that of an anvil, a plume or a huge mass of hair; a Cumulonimbus calvus has no fibrous or striated parts.

Among the numerous possible cases covered by $C_L = 9$, the following two are frequently observed:

(i) Cumulonimbus clouds with a clear-cut horizontal base which is sometimes partially or totally hidden by pannus. Such Cumulonimbus clouds occur during hot, thundery days in middle latitudes and, frequently, in the humid zones of low latitudes.

(ii) Cumulonimbus clouds with their base frayed by a fairly strong wind and occasionally accompanied by pannus.

(*d*) SPECIAL CODING INSTRUCTIONS

The presence of Cumulonimbus precludes the coding $C_L = 1, 2, 4, 5, 6, 7$ and 8; if at least one Cumulonimbus cloud present is of the species capillatus, the coding $C_L = 3$ is also precluded.

(*e*) FURTHER REMARKS

The cirriform parts of Cumulonimbus capillatus may become invisible when the cloud passes over the point of observation. When this occurs, the cloud should nevertheless be classified as Cumulonimbus capillatus on the basis of its history, and the coding $C_L = 9$ should be used. The same applies when the cirriform parts of Cumulonimbus capillatus become hidden by other clouds.

The occurrence of lightning, thunder or hail sometimes provides the only indication of the presence of a Cumulonimbus. Although it is not possible, in this case, to decide whether the cloud belongs to the species calvus or capillatus, the coding is, by convention, $C_L = 9$.

Sometimes, when the 0°C (32°F) level is low, the fibrous structure of its upper part spreads through the whole Cumulonimbus capillatus, which then degenerates into a cirriform cloud mass (coding $C_H = 3$); the coding $C_L = 9$ is maintained for the sky under observation, as long as at least one Cumulonimbus cloud remains in sight or is known to be present.

Cumulonimbus capillatus sometimes produces cloud masses which may become detached from it and assume an independent identity. Very often they have the appearance of Cirrus, Altocumulus, Altostratus or Stratocumulus. When coding the state of the sky, these clouds are considered in the same manner as other clouds of corresponding genera.

**II.8.2.1.11**

$C_L = /$

(*a*) TECHNICAL SPECIFICATION

*$C_L$-clouds invisible owing to darkness, fog, blowing dust or sand, or other similar phenomena.*

(*b*) NON-TECHNICAL SPECIFICATION

*Stratocumulus, Stratus, Cumulus and Cumulonimbus invisible owing to darkness, fog, blowing dust or sand, or other similar phenomena.*

**II.8.2.2**

### $C_M$-clouds of the genera Altocumulus, Altostratus and Nimbostratus

**II.8.2.2.1**

$C_M = 0$

(*a*) TECHNICAL SPECIFICATION

*No $C_M$-clouds.*

(*b*) NON-TECHNICAL SPECIFICATION

*No Altocumulus, Altostratus or Nimbostratus.*

**II.8.2.2.2**

$C_M = 1$

(*a*) TECHNICAL SPECIFICATION

*Altostratus translucidus.*

(*b*) NON-TECHNICAL SPECIFICATION

*Altostratus, the greater part of which is semi-transparent ; through this part the sun or moon may be weakly visible, as through ground glass.*

(*c*) COMMENTARY

The greater part of this Altostratus cloud, which is of a greyish or bluish colour, is translucent enough to reveal the position of the luminary. This Altostratus usually comes into existence by the continuous evolution of a gradually thickening veil of Cirrostratus. Sometimes, especially in the tropics, it may be produced by the spreading out of the middle or upper part of a Cumulonimbus.

Altostratus does not show halo phenomena.

(*d*) SPECIAL CODING INSTRUCTIONS

The presence of Altostratus precludes the use of code figures $C_M = 3$, 4, 5 and 6.

If the major part of the Altostratus is dense enough to hide the sun or moon completely, the correct coding is $C_M = 2$.

When Altocumulus is also present, the coding should be $C_M = 7$, 8 or 9, as the case may be.

**II.8.2.2.3**

$C_M = 2$

(*a*) TECHNICAL SPECIFICATION

*Altostratus opacus or Nimbostratus.*

(*b*) NON-TECHNICAL SPECIFICATION

*Altostratus, the greater part of which is sufficiently dense to hide the sun or moon, or Nimbostratus.*

(*c*) COMMENTARY

The Altostratus cloud corresponding to the code figure $C_M = 2$ is of a darker grey or a darker bluish grey than Altostratus translucidus and it is sufficiently dense over the greater part of its extent to mask completely the sun or moon. It may occur in several layers. Altostratus opacus may result from the thickening of a layer of Altostratus translucidus, from the merging of the elements of a sheet or layer of Altocumulus, from the spreading out of the middle or upper part of a Cumulonimbus, from thinning of Nimbostratus or from the horizontal extension of Cirrus spissatus.

Nimbostratus, which is also to be coded $C_M = 2$, has a denser and darker appearance than Altostratus opacus; its base is at a comparatively low level and generally has a diffuse and "wet" appearance. Nimbostratus results either from the evolution of a thick layer of Altostratus opacus or from the merging of the elements of a thick sheet or layer of Altocumulus opacus or Stratocumulus opacus. It may also evolve from Cumulonimbus clouds.

(*d*) SPECIAL CODING INSTRUCTIONS

The presence of Altostratus or Nimbostratus precludes the use of code figures $C_M = 3$, 4, 5 and 6.

If the cloud is Altostratus and its major part is not dense enough to hide the sun or moon, the correct coding is $C_M = 1$.

When Altocumulus is also present, the coding should be $C_M = 7$, 8 or 9, as the case may be.

(*c*) FURTHER REMARKS

When pannus clouds accompanying the layer of Altostratus opacus or Nimbostratus become merged into a continuous layer, so that the Altostratus or Nimbostratus can no longer be seen, the coding $C_M = 2$ should be replaced by $C_M = x$; the pannus clouds are coded $C_L = 7$.

**II.8.2.2.4**

$C_M = 3$

(*a*) TECHNICAL SPECIFICATION

*Altocumulus translucidus at a single level.*

(*b*) NON-TECHNICAL SPECIFICATION

*Altocumulus, the greater part of which is semi-transparent; the various elements of the cloud change only slowly and are all at a single level.*

(*c*) COMMENTARY

The coding $C_M = 3$ applies to Altocumulus in patches or sheets at the same level, or to Altocumulus in a layer; the various elements of these clouds are neither very large nor very dark. If the cloud elements change at all, they do so in a hardly perceptible manner. Altocumulus coded $C_M = 3$ does not progressively invade the sky.

It is to be noted that the sky may contain several Altocumulus patches or sheets of different optical thickness. According to the definitions of the varieties translucidus and opacus, individual patches or sheets can be called Altocumulus translucidus or Altocumulus opacus, when their greater part is, respectively, translucent enough to reveal the position of the sun or moon, or sufficiently opaque to hide the luminary completely. When the code specifications speak of Altocumulus translucidus or opacus, however, they relate to the totality of Altocumulus clouds. The coding $C_M = 3$ refers therefore to a situation in which semi-transparent Altocumulus is predominant.

(*d*) SPECIAL CODING INSTRUCTIONS

The presence of Altocumulus precludes the use of code figures $C_M = 1$ and 2. In addition, the fact that the Altocumulus clouds change only slowly, if at all, precludes the use of code figure $C_M = 4$ and the fact that they do not invade the sky progressively precludes the use of code figure $C_M = 5$.

If the sky is not chaotic and there are no Altocumulus castellanus or floccus and no Altostratus or Nimbostratus, but there is Altocumulus translucidus accompanied by Altocumulus cumulogenitus, the coding is $C_M = 6$.

If the sky is not chaotic and there is no Altocumulus castellanus or floccus, but there is Altocumulus translucidus accompanied by Altostratus or Nimbostratus, the coding is $C_M = 7$.

If, when the sky is not chaotic, Altocumulus castellanus or floccus is present, the coding should be $C_M = 8$, even when other Altocumulus species predominate.

If the sky is chaotic, the coding should be $C_M = 9$.

(*e*) FURTHER REMARKS

Rules for coding a sky in which Altocumulus translucidus (not invading the sky) is present at two or more levels are given under code figure $C_M = 7$.

**II.8.2.2.5**

$C_M = 4$

(*a*) TECHNICAL SPECIFICATION

*Patches (often lenticular) of Altocumulus translucidus, continually changing and occurring at one or more levels.*

(*b*) NON-TECHNICAL SPECIFICATION

*Patches (often in the form of almonds or fishes) of Altocumulus, the greater part of which is semi-transparent; the clouds occur at one or more levels and the elements are continually changing in appearance.*

(*c*) COMMENTARY

The irregularly arranged elements of the Altocumulus patches of the specification $C_M = 4$ are continually changing in shape; they often appear to be dissolving in some places and forming in others. The fact that the cloud patches are of limited horizontal extent and that their elements are continually changing implies that these clouds belong usually to the variety translucidus and only rarely to the variety opacus. The patches as a whole may have the form of large lenses and may occur at one or more levels. The clouds are not progressively invading the sky.

The coding $C_M = 4$ is applicable not only to the above described patches which consist of numerous relatively small, continually changing elements but also to those relatively stable clouds which consist of one single smooth lenticular element or of a pile of such elements.

These clouds may occur in the form of accessory clouds (pileus, velum) either near or fairly distant from the upper part of Cumulus or Cumulonimbus clouds.

Lenticular clouds are frequently observed in hilly or mountainous regions.

(*d*) SPECIAL CODING INSTRUCTIONS

The presence of patches of Altocumulus such as those described in the above commentary precludes the use of code figures $C_M = 1$, 2 and 3.

If the sky is not chaotic and there are no Altocumulus castellanus, floccus or cumulogenitus and no Altostratus or Nimbostratus, but the Altocumulus patches described above are accompanied by Altocumulus clouds progressively invading the sky, the coding should be $C_M = 5$.

If the sky is not chaotic and if there are no Altocumulus castellanus of floccus and no Altostratus of Nimbostratus, but Altocumulus cumulogenitus is present, the coding should be $C_M = 6$.

If the sky is not chaotic and if there is no Altocumulus castellanus or floccus, but Altostratus or Nimbostratus is present, the coding should be $C_M = 7$.

If the sky is not chaotic, but Altocumulus castellanus or floccus is present, the coding should be $C_M = 8$.

If the sky is chaotic, the coding should be $C_M = 9$.

### II.8.2.2.6
$C_M = 5$

(*a*) TECHNICAL SPECIFICATION

*Altocumulus translucidus in bands, or one or more layers of Altocumulus translucidus or opacus, progressively invading the sky; these Altocumulus clouds generally thicken as a whole.*

(*b*) NON-TECHNICAL SPECIFICATION

*Semi-transparent Altocumulus in bands, or Altocumulus in one or more fairly continuous layers (semi-transparent or opaque), progressively invading the sky; these Altocumulus clouds generally thicken as a whole.*

(*c*) COMMENTARY

The main characteristic of the Altocumulus clouds corresponding to the code figure $C_M = 5$ is that they are invading the sky progressively. This means that there exists a cloud ensemble gradually coming up from one part of the horizon and advancing in the direction of the zenith, whereby the cloud amount increases. The border of the cloud system often passes the zenith and may finally reach the horizon at the compass point opposite to that from which the cloud first appeared. At any moment that the observer looks at the sky, he will see that the cloud system extends down to the horizon in the direction in which the clouds initially appeared; it is also in this direction that the clouds are usually thickest. The main part of the cloud system consists of one or more cloud layers, wholly or partially translucent or wholly or partially opaque. The forward portion of the cloud system, often in the process of dissipation, may consist of small frayed Altocumulus elements or of rolls or bands, usually observed at a single level and consisting of semi-transparent clouds. This forward portion may cover a large expanse of the sky.

The coding $C_M = 5$ is no longer used as soon as the forward edge has reached the part of the horizon opposite to that where the clouds first appeared, or when the forward edge has ceased its progress.

(*d*) SPECIAL CODING INSTRUCTIONS

The presence of Altocumulus precludes the use of code figures $C_M = 1$ and 2; the fact that the Altocumulus under observation is progressively invading the sky precludes, in addition, the use of code figures $C_M = 3$ and 4.

If the sky is not chaotic and there are no Altocumulus castellanus or floccus and no Altostratus or Nimbostratus, but there is Altocumulus cumulogenitus present, the coding should be $C_M = 6$.

If the sky is not chaotic and there is no Altocumulus castellanus or floccus, but Altostratus or Nimbostratus is present, the coding should be $C_M = 7$.

If the sky is not chaotic, but Altocumulus castellanus or floccus is present, the coding should be $C_M = 8$.

If the sky is chaotic, the coding should be $C_M = 9$.

(*e*) FURTHER REMARKS

Altocumulus progressively invading the sky may at the same time be changing either partially or as a whole, into Altostratus or Nimbostratus. If the Altocumulus has partly changed into Altostratus or Nimbostratus, i.e. if in a part of the Altocumulus, the evidence for the existence of elements (laminae, rolls, rounded masses, etc.) has disappeared, the coding becomes $C_M = 7$ instead of $C_M = 5$. As soon as the evidence for the existence of elements has disappeared throughout, the coding is $C_M = 1$ or $C_M = 2$, as the case may be.

### II.8.2.2.7

$C_M = 6$

(*a*) TECHNICAL SPECIFICATION
*Altocumulus cumulogenitus (or cumulonimbogenitus).*

(*b*) NON-TECHNICAL SPECIFICATION
*Altocumulus resulting from the spreading out of Cumulus (or Cumulonimbus).*

(*c*) COMMENTARY

Altocumulus cumulogenitus results generally from the spreading out of the summits of Cumulus clouds which, while in vertical development, reach a stable layer. Occasionally, Cumulus congestus clouds in vertical development meet stable layers which cannot stop their growth completely; in this case, the Cumulus clouds, after a temporary spreading out, resume their growth above the stable layer, at least in places. Thus, the Altocumulus cumulogenitus may appear on the lateral portion of Cumulus congestus clouds.

Owing to its mode of formation, Altocumulus cumulogenitus occurs in patches. Initially, these patches, with large and dark elements, are fairly thick and opaque; their under surface may show a rippled relief. Later on, the patches thin out and finally break into separate elements. The same sky often shows Altocumulus patches in various stages of evolution.

When the Altocumulus cumulogenitus patches are seen in profile, they may show, especially at their borders, a cumuliform appearance. Care should be exercised not to confuse such patches with Altocumulus castellanus.

Furthermore, Altocumulus cumulogenitus should not be confused with the anvil of a Cumulonimbus or with Cirrus spissatus cumulonimbogenitus, both of which may show mamma at their lower surface and may resemble Altocumulus. However, Altocumulus never has the fibrous structure, the silky sheen and the whiteness of the anvils or of the Cirrus spissatus.

The Altocumulus accompanying Cumulonimbus (Ac cumulonimbogenitus) is also coded $C_M = 6$; it often forms before the mother-cloud has reached the Cumulonimbus stage.

(*d*) SPECIAL CODING INSTRUCTIONS

The presence of Altocumulus precludes the use of code figures $C_M = 1$ and 2; the fact that the Altocumulus under observation is Altocumulus cumulogenitus (or cumulonimbogenitus) precludes, in addition, the use of the code figures $C_M = 3$, 4 and 5.

If the sky is not chaotic and there is no Altocumulus castellanus and floccus, but Altostratus or Nimbostratus is present, the coding should be $C_M = 7$.

If the sky is not chaotic, but Altocumulus castellanus or floccus is present, the coding should be $C_M = 8$.

If the sky is chaotic, the coding is $C_M = 9$.

### II.8.2.2.8
### $C_M = 7$

(*a*) TECHNICAL SPECIFICATION

*Altocumulus translucidus or opacus in two or more layers, or Altocumulus opacus in a single layer, not progressively invading the sky, or Altocumulus with Altostratus or Nimbostratus.*

(*b*) NON-TECHNICAL SPECIFICATION

*Altocumulus in two or more layers, usually opaque in places, and not progressively invading the sky ; or opaque layer of Altocumulus, not progressively invading the sky ; or Altocumulus together with Altostratus or Nimbostratus.*

(*c*) COMMENTARY

The specification $C_M = 7$ includes the following skies:

(i) Patches, sheets or layers of Altocumulus at different levels; these patches, sheets or layers may be Altocumulus translucidus usually opaque in places, or Altocumulus opacus. The elements of this Altocumulus are not changing continually; the clouds are not progressively invading the sky.

(ii) Patches, sheets or a layer of Altocumulus opacus at a single level. The elements are not changing continually; the clouds are not progressively invading the sky.

It is to be noted that the sky may contain several Altocumulus patches or sheets of different optical thickness. According to the definitions of the varieties translucidus and opacus, individual patches or sheets can be called Altocumulus opacus or Altocumulus translucidus when their greater part is, respectively, sufficiently opaque to mask the sun or moon completely, or translucent enough to reveal the position of the luminary. However, when the code specifications speak of Altocumulus opacus or translucidus, they relate to the totality of Altocumulus clouds. The case of $C_M = 7$ under discussion refers therefore to a situation in which opaque Altocumulus is predominant.

(iii) Altocumulus together with Altostratus or Nimbostratus which may be observed in the following arrangements:

(1) A single or a multiple layer showing partly the characteristics of Altocumulus, partly those of Altostratus or Nimbostratus. This sky results from often occurring transformation processes by which Altocumulus locally changes and acquires the appearance of Altostratus or Nimbostratus, or Altostratus or Nimbostratus breaks up into Altocumulus.

(2) Altostratus translucidus or opacus above patches of Altocumulus at one or several levels.

(3) A rather low grey veil, often hardly discernible, together with higher Altocumulus.

(*d*) SPECIAL CODING INSTRUCTIONS

(1) Remarks regarding the skies described under (i) and (ii).

The presence of Altocumulus at two or more levels or of Altocumulus which is predominantly opaque precludes the use of code figures $C_M = 1$, 2 and 3.

If the sky is not chaotic, and there is no Altocumulus castellanus or floccus or cumulogenitus and if the Altocumulus present is not progressively invading the sky, but is continually changing, the coding is $C_M = 4$.

If the sky is not chaotic and there is no Altocumulus castellanus or floccus or cumulogenitus, and if the Altocumulus present is invading the sky progressively, the coding is $C_M = 5$.

If the sky is not chaotic and there is no Altocumulus castellanus or floccus, but there is Altocumulus cumulogenitus, the coding is $C_M = 6$.

If the sky is not chaotic, but there is Altocumulus castellanus or floccus, the coding is $C_M = 8$.

If the sky is chaotic, the coding is $C_M = 9$.

(2) Remarks regarding the skies under (iii).

Altocumulus coexisting with Altostratus or Nimbostratus precludes the use of code figures $C_M = 1, 2, 3, 4, 5$ and 6.

If the sky is not chaotic and if Altocumulus castellanus or floccus is present, the coding is $C_M = 8$.

If the sky is chaotic, the coding is $C_M = 9$.

### II.8.2.2.9
$C_M = 8$

(*a*) TECHNICAL SPECIFICATION
*Altocumulus castellanus or floccus.*

(*b*) NON-TECHNICAL SPECIFICATION
*Altocumulus with sproutings in the form of small towers or battlements, or Altocumulus having the appearance of cumuliform tufts.*

(*c*) COMMENTARY

These two species of Altocumulus have a cumuliform appearance; this feature is more marked in Altocumulus castellanus than in Altocumulus floccus.

Altocumulus castellanus is composed of turrets which appear to be arranged in lines; the turrets generally have a common horizontal base, which gives the cloud a crenelated appearance.

Altocumulus floccus clouds occur in white or grey scattered tufts with rounded and slightly bulging upper parts; they are often accompanied by fibrous trails (virga). These clouds resemble very small, more or less ragged Cumulus.

(*d*) SPECIAL CODING INSTRUCTIONS

The presence of any Altocumulus castellanus or floccus precludes the use of code figures $C_M = 1 - 7$.

If Altocumulus castellanus or floccus is part of a chaotic sky, the coding is $C_M = 9$.

(*e*) FURTHER REMARKS

When some of the Altocumulus castellanus or floccus present develop into Cumulus mediocris or congestus, or into Cumulonimbus, they become subject to the rules for coding $C_L$-clouds.

**II.8.2.2.10**

$C_M = 9$

(*a*) TECHNICAL SPECIFICATION
*Altocumulus of a chaotic sky, generally at several levels.*

(*b*) NON-TECHNICAL SPECIFICATION
*Altocumulus of a chaotic sky, generally at several levels.*

(*c*) COMMENTARY

The main characteristic of this sky is its chaotic, heavy and stagnant appearance. The clouds of the middle étage consist of superposed, more or less broken cloud sheets of ill-defined species or varieties, with all transitional forms from a rather low and opaque Altocumulus to a high, translucent and fibrous veil of Altostratus. This sky also generally exhibits a diversity of clouds belonging to the low and high étages.

(*d*) SPECIAL CODING INSTRUCTIONS

The presence of Altocumulus of a chaotic sky precludes the use of code figures $C_M = 1 - 8$.

**II.8.2.2.11**

$C_M = /$

(*a*) TECHNICAL SPECIFICATION
*$C_M$-clouds invisible owing to darkness, fog, blowing dust or sand or other similar phenomena, or because of a continuous layer of lower clouds.*

(*b*) NON-TECHNICAL SPECIFICATION
*Altocumulus, Altostratus and Nimbostratus invisible owing to darkness, fog, blowing dust or sand or other similar phenomena, or more often because of the presence of a continuous layer of lower clouds.*

**II.8.2.3**

## $C_H$-clouds of the genera Cirrus, Cirrocumulus and Cirrostratus

**II.8.2.3.1**

$C_H = 0$

(*a*) TECHNICAL SPECIFICATION
*No $C_H$-clouds.*

(*b*) NON-TECHNICAL SPECIFICATION
*No Cirrus, Cirrocumulus or Cirrostratus.*

**II.8.2.3.2**

$C_H = 1$

(*a*) TECHNICAL SPECIFICATION
*Cirrus fibratus, sometimes uncinus, not progressively invading the sky.*

(*b*) NON-TECHNICAL SPECIFICATION
*Cirrus in the form of filaments, strands or hooks, not progressively invading the sky.*

(c) COMMENTARY

The Cirrus clouds corresponding to the code figure $C_H = 1$ most often occur in the form of nearly straight or more or less curved filaments (Cirrus fibratus); more rarely, they are shaped like commas topped with either a hook or a tuft which is not rounded (Cirrus uncinus). Cirrus fibratus and uncinus not uncommonly appear in the same sky with Cirrus of the other species; the code figure $C_H = 1$ may be used only if the sky cover of Cirrus fibratus or uncinus or of a combination of these clouds is greater than the combined sky cover of other Cirrus clouds. Cirrus, coded $C_H = 1$, is not progressively invading the sky.

(d) SPECIAL CODING INSTRUCTIONS

The collective predominance of Cirrus fibratus and uncinus over Cirrus clouds of the other species precludes code figure $C_H = 2$; the fact that the Cirrus fibratus and Cirrus uncinus are not invading the sky progressively precludes, in addition, the use of $C_H = 4$.

If there is no Cirrostratus present and the amount of Cirrocumulus is less than that of Cirrus, and if one of the Cirrus clouds in the sky is Cirrus spissatus cumulonimbogenitus, the coding is $C_H = 3$.

If Cirrostratus is present and if the amount of Cirrocumulus is less than the combined sky cover of Cirrus and Cirrostratus, the coding is $C_H = 5$, 6, 7 or 8, as the case may be.

If the amount of Cirrocumulus is greater than the combined sky cover of Cirrus and Cirrostratus, the coding is $C_H = 9$.

**II.8.2.3.3**
$C_H = 2$

(a) TECHNICAL SPECIFICATION
*Cirrus spissatus, in patches or entangled sheaves, which usually do not increase and sometimes seem to be the remains of the upper part of a Cumulonimbus; or Cirrus castellanus or floccus.*

(b) NON-TECHNICAL SPECIFICATION
*Dense Cirrus, in patches or entangled sheaves, which usually do not increase and sometimes seem to be the remains of the upper part of a Cumulonimbus ; or Cirrus with sproutings in the form of small turrets or battlements, or Cirrus having the appearance of cumuliform tufts.*

(c) COMMENTARY

The clouds of the above specification are Cirrus spissatus non-cumulonimbogenitus, or Cirrus castellanus or floccus, or a combination of the above species.

The Cirrus spissatus clouds consist of patches of sufficient optical thickness to appear greyish when viewed towards the sun. They sometimes have borders of entangled filaments (variety intortus) and may give the erroneous impression that they are the remains of the upper part of a Cumulonimbus.

Cirrus castellanus shows small fibrous turrets or rounded protuberances, rising from a common base; Cirrus floccus has the form of more or less isolated tufts, often with trails.

The above-mentioned clouds may be accompanied by Cirrus fibratus or uncinus; the sky cover of Cirrus spissatus non-cumulonimbogenitus, Cirrus castellanus or floccus or of any combination of these clouds is greater, however, than the combined sky cover of Cirrus fibratus and uncinus.

(*d*) SPECIAL CODING INSTRUCTIONS

The collective predominance of Cirrus spissatus, castellanus and floccus over the other Cirrus clouds, precludes the use of code figure $C_H = 1$; the fact that none of the Cirrus spissatus present clearly or presumably originated from Cumulonimbus precludes the coding $C_H = 3$.

If there is no Cirrostratus present and the amount of Cirrocumulus is less than that of Cirrus, and if there is Cirrus fibratus or uncinus invading the sky progressively, the coding is $C_H = 4$.

If Cirrostratus is present and if the amount of Cirrocumulus is less than the combined sky cover of Cirrus and Cirrostratus, the coding is $C_H = 5$, 6, 7 or 8, as the case may be.

If the amount of Cirrocumulus is greater than the combined sky cover of Cirrus and Cirrostratus, the coding is $C_H = 9$.

### II.8.2.3.4

$C_H = 3$

(*a*) TECHNICAL SPECIFICATION

*Cirrus spissatus cumulonimbogenitus.*

(*b*) NON-TECHNICAL SPECIFICATION

*Dense Cirrus, often in the form of an anvil, being the remains of the upper parts of Cumulonimbus.*

(*c*) COMMENTARY

The coding $C_H = 3$ is used only when at least one Cirrus cloud present in the sky provides direct or indirect evidence of having originated from a Cumulonimbus. This Cirrus spissatus cumulonimbogenitus may be accompanied by Cirrus spissatus clouds of doubtful origin, by Cirrus castellanus or floccus, or by Cirrus fibratus or uncinus.

The observer, by keeping a continuous watch on the sky, may be able to witness the development of Cirrus spissatus from the upper part of a Cumulonimbus. Often, however, he has no direct information about the origin of Cirrus spissatus. There may nevertheless be sufficient indirect evidence to indicate, with reasonable certainty, that a Cirrus spissatus present in the sky originated from a Cumulonimbus. Thus, a Cirrus spissatus cumulonimbogenitus frequently reveals its origin by the hairy or frayed appearance of its edges, by its general anvil-like shape, or by its optical thickness which is often sufficient to veil the sun, obscure its outlines or even hide it.

(*d*) SPECIAL CODING INSTRUCTIONS

The presence of Cirrus spissatus cumulonimbogenitus precludes the use of the code figures $C_H = 1$ and 2.

If no Cirrostratus is present and the amount of Cirrocumulus is less than that of Cirrus, and if there is Cirrus fibratus or uncinus invading the sky progressively, the coding is $C_H = 4$.

If Cirrostratus is present and if the amount of Cirrocumulus is less than the combined sky cover of Cirrus and of Cirrostratus, the coding is $C_H = 5$, 6, 7 or 8, as the case may be.

If the amount of Cirrocumulus is greater than the combined sky cover of Cirrus and Cirrostratus, the coding is $C_H = 9$.

### II.8.2.3.5

$C_H = 4$

(*a*) TECHNICAL SPECIFICATION

*Cirrus uncinus or fibratus, or both, progressively invading the sky; they generally thicken as a whole.*

(*b*) NON-TECHNICAL SPECIFICATION

*Cirrus in the form of hooks or of filaments, or both, progressively invading the sky ; they generally become denser as a whole.*

(*c*) COMMENTARY

The main characteristic of the Cirrus clouds corresponding to the code figure $C_H = 4$ is that they are invading the sky progressively. This means that the ensemble of clouds extends to one part of the horizon and its forward edge is moving towards the opposite part of the horizon.

The clouds occur most frequently in the form of strands trailing from a small hook or tuft (Cirrus uncinus); less frequently, they are in the form of straight or irregularly curved filaments (Cirrus fibratus).

The clouds usually seem to fuse together in the direction of the horizon from which they first appeared, but no Cirrostratus is present.

(*d*) SPECIAL CODING INSTRUCTIONS

The presence of Cirrus invading the sky progressively precludes the use of code figures $C_H = 1$, 2 and 3.

If Cirrostratus is present and is invading the sky progressively and the amount of Cirrocumulus is less than the combined sky cover of Cirrus and Cirrostratus, the coding is $C_H = 5$ or 6, as the case may be. If the Cirrostratus is not (or no longer) invading the sky progressively, the coding is $C_H = 7$ or 8, as the case may be.

If the amount of Cirrocumulus is greater than the combined sky cover of Cirrus and Cirrostratus, the coding is $C_H = 9$.

### II.8.2.3.6

$C_H = 5$

(*a*) TECHNICAL SPECIFICATION

*Cirrus (often in bands) and Cirrostratus, or Cirrostratus alone, progressively invading the sky ; they generally thicken as a whole, but the continuous veil does not reach 45 degrees above the horizon.*

(*b*) NON-TECHNICAL SPECIFICATION

*Cirrus (often in bands converging towards one point or two opposite points of the horizon) and Cirrostratus, or Cirrostratus alone ; in either case, they are progressively invading the sky, and generally growing denser as a whole, but the continuous veil does not reach 45 degrees above the horizon.*

(*c*) COMMENTARY

The main characteristic of the sky corresponding to the code figure $C_H = 5$ is the presence of Cirrostratus invading the celestial dome progressively but with its continuous part still less than 45 degrees above the horizon. The veil of the Cirrostratus may be preceded by Cirrus clouds, often in long filaments (Cirrus fibratus), or shaped like commas (Cirrus uncinus), frequently arranged in bands crossing a part of the sky and seemingly converging towards one point or towards two opposite points of the horizon (variety radiatus). The Cirrus clouds may also have a form resembling a fish skeleton (variety vertebratus).

(*d*) SPECIAL CODING INSTRUCTIONS

The presence of Cirrostratus precludes the use of code figures $C_H = 1, 2, 3$ and 4; the fact that the Cirrostratus is invading the sky progressively precludes, in addition, the coding $C_H = 7$ and 8.

If the continuous veil of Cirrostratus progressively invading the sky extends more than 45 degrees above the horizon, the coding should be $C_H = 6$, provided that the amount of Cirrocumulus is less than the combined sky cover of Cirrus and Cirrostratus.

If the amount of Cirrocumulus is greater than the combined sky cover of Cirrus and Cirrostratus, the coding is $C_H = 9$.

### II.8.2.3.7

$C_H = 6$

(*a*) TECHNICAL SPECIFICATION

*Cirrus (often in bands) and Cirrostratus, or Cirrostratus alone, progressively invading the sky ; they generally thicken as a whole ; the continuous veil extends more than 45 degrees above the horizon, without the sky being totally covered.*

(*b*) NON-TECHNICAL SPECIFICATION

*Cirrus (often in bands converging towards one point or two opposite points of the horizon) and Cirrostratus, or Cirrostratus alone ; in either case, they are progressively invading the sky, and generally growing denser as a whole ; the continuous veil extends more than 45 degrees above the horizon, without the sky being totally covered.*

(*c*) COMMENTARY

The main characteristic of the sky corresponding to the code figure $C_H = 6$ is the presence of Cirrostratus invading the celestial dome progressively with its continuous part more than 45 degrees above the horizon but not covering the sky completely.

The veil of the Cirrostratus may be preceded by Cirrus clouds often in long filaments (Cirrus fibratus) or shaped like commas (Cirrus uncinus), frequently arranged in bands crossing a part of the sky and seemingly converging towards one point or towards two opposite points of the horizon (variety radiatus). The Cirrus clouds may also have a form resembling a fish skeleton (variety vertebratus).

(*d*) SPECIAL CODING INSTRUCTIONS

The presence of Cirrostratus precludes the use of code figures $C_H = 1, 2, 3$ and 4; the fact that the Cirrostratus is invading the sky progressively precludes, in addition, the coding $C_H = 7$ and 8.

If the continuous veil of Cirrostratus progressively invading the sky does not extend more than 45 degrees above the horizon, the coding should be $C_H = 5$, provided that the amount of Cirrocumulus is not greater than the combined sky cover of Cirrus and Cirrostratus.

If the amount of Cirrocumulus is greater than the combined sky cover of Cirrus and Cirrostratus, the coding is $C_H = 9$.

### II.8.2.3.8

$C_H = 7$

(*a*) TECHNICAL SPECIFICATION

*Cirrostratus covering the whole sky.*

(*b*) NON-TECHNICAL SPECIFICATION
*Veil of Cirrostratus covering the celestial dome.*

(*c*) COMMENTARY

Cirrostratus covering the whole sky usually occurs as a light, uniform and nebulous veil showing no distinct details (Cirrostratus nebulosus), or as a white and fibrous veil with more or less clear-cut striations (Cirrostratus fibratus).

The Cirrostratus veil is sometimes so thin that it is hardly visible and halo phenomena, especially frequent in thin Cirrostratus, provide the only evidence for its presence. The Cirrostratus may also be relatively dense.

Cirrus at different levels and Cirrocumulus may accompany the Cirrostratus.

(*d*) SPECIAL CODING INSTRUCTIONS

The presence of Cirrostratus precludes the use of code figures $C_H = 1$, 2, 3 and 4; the fact that the Cirrostratus covers the whole sky precludes, in addition, the coding $C_H = 5$, 6, 8 and 9.

(*e*) FURTHER REMARKS

When a veil of Cirrostratus is concealed in places by clouds at a lower level, or when the horizon is dark or hidden partially or totally by haze, smoke, etc., the observer should not report $C_H = 7$ unless he is sure (for instance from continuous observation) that the Cirrostratus really covers the whole sky. If any doubt exists, the coding should be $C_H = 8$, unless it is known that the veil was invading the sky progressively, in which case the coding $C_H = 6$ is used.

If there are gaps or clear intervals in the veil, through which it is possible to distinguish the blue of the sky, the coding should be $C_H = 8$.

When by a process of continuous transition, a thin layer of Altostratus translucidus follows upon a complete veil of Cirrostratus, the two together covering the whole sky, the code figure $C_H = 7$ should be used simultaneously with the coding $C_M = 1$ (if no Altocumulus is present) or $C_M = 7$ (if Altocumulus is present).

### II.8.2.3.9
$C_H = 8$

(*a*) TECHNICAL SPECIFICATION
*Cirrostratus not progressively invading the sky and not entirely covering it.*

(*b*) NON-TECHNICAL SPECIFICATION
*Cirrostratus not progressively invading the sky and not completely covering the celestial dome.*

(*c*) COMMENTARY

The sky corresponding to the code figure $C_H = 8$ is characterized by the presence of a veil of Cirrostratus which is not (or no longer) invading the sky progressively and which does not completely cover the celestial dome; the edge of the veil may be clear-cut or frayed. The code figure $C_H = 8$ also applies to patches of Cirrostratus, increasing in amount or not.

Cirrus and Cirrocumulus (not predominant) may also be present.

(*d*) SPECIAL CODING INSTRUCTIONS

The presence of Cirrostratus precludes the use of the code figures $C_H = 1$, 2, 3 and 4.

If Cirrocumulus is not the predominating $C_H$-cloud and if the Cirrostratus is invading the sky progressively, the coding is $C_H = 5$ or 6, as the case may be.

If Cirrostratus covers the whole sky, the coding is $C_H = 7$.

If Cirrocumulus is the predominant $C_H$-cloud, the coding is $C_H = 9$.

**II.8.2.3.10**

$C_H = 9$

(*a*) TECHNICAL SPECIFICATION
*Cirrocumulus alone, or Cirrocumulus predominant among the $C_H$-clouds.*

(*b*) NON-TECHNICAL SPECIFICATION
*Cirrocumulus alone ; or Cirrocumulus accompanied by Cirrus or Cirrostratus, or both, but Cirrocumulus is predominant.*

(*c*) COMMENTARY

The code figure $C_H = 9$ may be used only if Cirrocumulus is either the only $C_H$-cloud present, or if its amount is greater than the combined sky cover of any coexisting Cirrus and Cirrostratus.

When Cirrocumulus is the only $C_H$-cloud in the sky, its elements are frequently grouped into more or less extensive patches with very characteristic small wavelets. When Cirrocumulus occurs together with Cirrus or Cirrostratus, these clouds are often associated in composite patches, usually in a process of continual internal transformation.

(*d*) SPECIAL CODING INSTRUCTIONS

If the amount of Cirrocumulus is less than the combined sky cover of the other $C_H$-clouds, the coding is $C_H = 1, 2, 3$ or 4, as the case may be, provided that Cirrostratus is not present; it is $C_H = 5, 6, 7$ or 8, as the case may be, in the presence of Cirrostratus.

**II.8.2.3.11**

$C_H = /$

(*a*) TECHNICAL SPECIFICATION
*$C_H$-clouds invisible owing to darkness, fog, blowing dust or sand or other similar phenomena, or because of a continuous layer of lower clouds.*

(*b*) NON-TECHNICAL SPECIFICATION
*Cirrus, Cirrocumulus and Cirrostratus invisible owing to darkness, fog, blowing dust or sand or other similar phenomena, or more often because of the presence of a continuous layer of lower clouds.*

II.8.3

## PICTORIAL GUIDES FOR THE CODING OF CLOUDS IN THE CODES $C_L$, $C_M$ AND $C_H$

II.8.3.1

### Description and procedure

A rapid graphical method of coding is provided by pictorial guides, consisting of a number of small boxes and of pictures. Each picture illustrates schematically the sky corresponding to the code figure shown at its top right-hand corner.

The boxes and pictures contain brief criteria which are to be considered in succession until the correct code figure is found. The boxes are connected to each other and to the pictures by thick arrowed lines. In order to find the correct code figure, the following procedure is used:

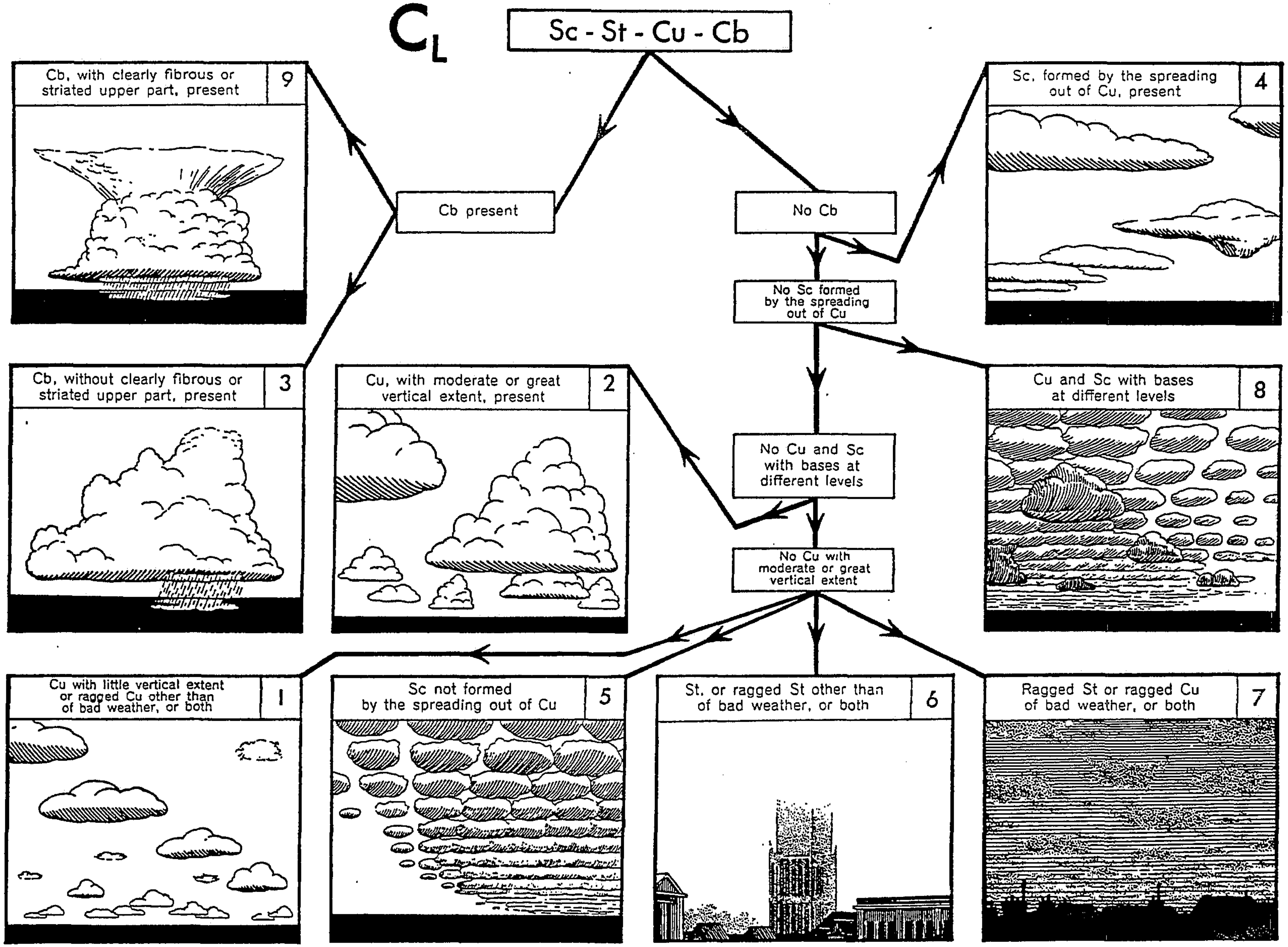
(*a*) Start from the box at the top of the diagram and follow one of the two arrowed lines leading out of this box.

(*b*) Proceed from box to box as long as all successive boxes contain criteria which are applicable to the observed sky.

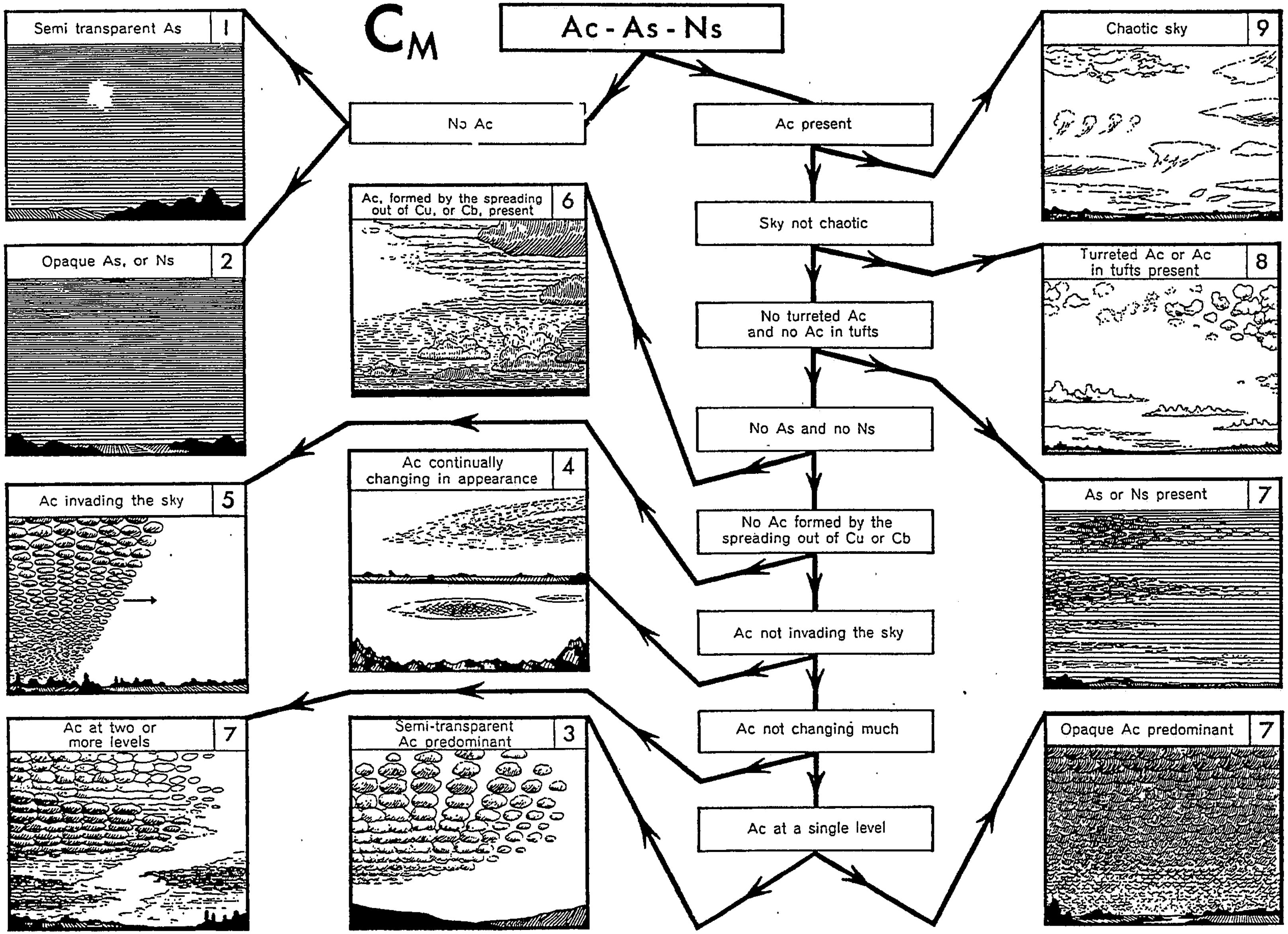
(*c*) When this procedure leads to a box with a criterion which is not applicable to the observed sky, go back to the previous box and follow the other arrowed line leading out of this box.

(*d*) If this arrowed line leads to a box, repeat the procedure described under (*b*) and (*c*).
If this arrowed line leads to a picture, the code figure printed on its upper right-hand corner is the correct code figure to be reported.

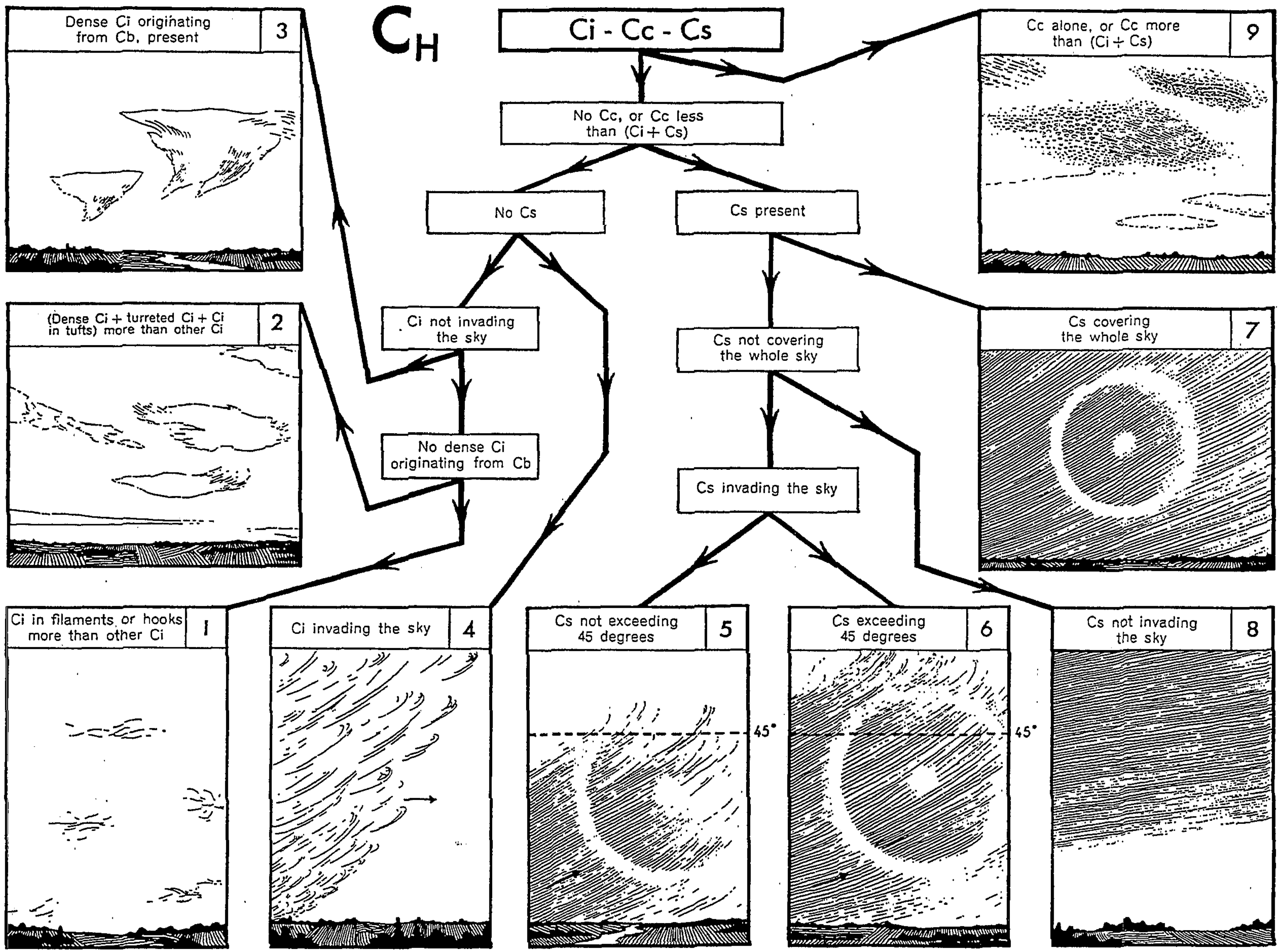
(*e*) If all the successive boxes contain criteria which are applicable to the observed.sky, the procedure will finally lead to a box from which two or more arrowed lines terminate in pictures. Read the criteria on these pictures. If only one picture contains a criterion applicable to the observed sky, the code figure printed on it is the code figure to be reported. If more than one picture contains a criterion applicable to the observed sky, consult the special coding instructions under the various code figures.



$C_L$
Sc - St - Cu - Cb
Cb present
No Cb
Cb, with clearly fibrous or striated upper part, present
9
Sc, formed by the spreading out of Cu, present
4
No Sc formed by the spreading out of Cu
Cb, without clearly fibrous or striated upper part, present
3
Cu, with moderate or great vertical extent, present
2
Cu and Sc with bases at different levels
8
No Cu and Sc with bases at different levels
No Cu with moderate or great vertical extent
Cu with little vertical extent or ragged Cu other than of bad weather, or both
1
Sc not formed by the spreading out of Cu
5
St, or ragged St other than of bad weather, or both
6
Ragged St or ragged Cu of bad weather, or both
7



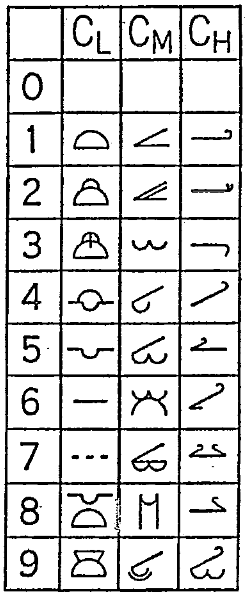
$C_M$
Ac - As - Ns
No Ac
Semi transparent As 1
Opaque As, or Ns 2
Ac present
Sky not chaotic
No turreted Ac and no Ac in tufts
No As and no Ns
No Ac formed by the spreading out of Cu or Cb
Ac not invading the sky
Ac not changing much
Ac at a single level
Chaotic sky 9
Turreted Ac or Ac in tufts present 8
As or Ns present 7
Opaque Ac predominant 7
Ac, formed by the spreading out of Cu, or Cb, present 6
Ac continually changing in appearance 4
Semi-transparent Ac predominant 3
Ac invading the sky 5
Ac at two or more levels 7


C_H
Ci - Cc - Cs
No Cc, or Cc less than (Ci + Cs)
No Cs
Cs present
Ci not invading the sky
No dense Ci originating from Cb
Cs not covering the whole sky
Cs invading the sky
Dense Ci originating from Cb, present
3
(Dense Ci + turreted Ci + Ci in tufts) more than other Ci
2
Ci in filaments or hooks more than other Ci
1
Ci invading the sky
4
Cs not exceeding 45 degrees
5
45°
Cs exceeding 45 degrees
6
45°
Cs not invading the sky
8
Cs covering the whole sky
7
Cc alone, or Cc more than (Ci + Cs)
9

## II.8.4

### SYMBOLS FOR CLOUDS CORRESPONDING TO THE FIGURES OF THE $C_L$, $C_M$ AND $C_H$ CODES

The clouds corresponding to the different figures of the $C_L$, $C_M$ and $C_H$ codes may be represented by means of symbols. These symbols are as follows.



# PART III — METEORS OTHER THAN CLOUDS

# III.1 — CLASSIFICATION AND SYMBOLS OF METEORS OTHER THAN CLOUDS

## III.1.1

## Classification [1] of meteors other than clouds

The classification of meteors other than clouds is shown in the following table:

| *Group* | *Designation of meteor* | *Symbol* | *Designation of meteor* | *Symbol* |
|---|---|---|---|---|
| Hydrometeors [2] | (*a*) Consisting of a suspension of particles in the atmosphere | | (*c*) Consisting of ensembles of particles raised by the wind | |
| | Fog | ≡ and ═ | Drifting and blowing snow | |
| | "Fog" | ≡ | Drifting snow | |
| | "Mist" | ═ | Blowing snow | |
| | Ice fog | | Spray | |
| | (*b*) Consisting of a fall of an ensemble of particles (precipitation) | | (*d*) Consisting of a deposit of particles | |
| | | | Deposit of fog droplets | |
| | Rain | • | | |
| | Supercooled rain | | Dew | |
| | Drizzle | , | Dew proper | |
| | Supercooled drizzle | | Advection dew | |
| | Snow | * | White dew | |
| | Snow grains | | Hoar frost | |
| | Snow pellets | | Hoar frost proper | |
| | Diamond dust | | Advection hoar frost | ] |
| | Hail | ▲ | Rime | V |
| | Small hail | △ | Soft rime | |
| | Ice pellets | | Hard rime | |
| | | | Clear ice | |
| | | | Glaze | ∿ |
| | | | (*e*) Spout | )( |

[1] The general classification of meteors is the subject of Part I of this Volume.
[2] The definition of a hydrometeor is given in section I.2.1, Part I, of this Volume.

| *Group* | *Designation of meteor* | *Symbol* | *Designation of meteor* | *Symbol* |
|---|---|---|---|---|
| Lithometeors [1] | (*a*) Consisting of a suspension of particles in the atmosphere | | (*b*) Consisting of ensembles of particles raised by the wind | |
| | Haze | ∞ | Drifting and blowing dust or sand | $ |
| | Dust haze | S | Drifting dust or sand | $ |
| | Smoke | | Blowing dust or sand | $ |
| | | | Dust storm or sandstorm | |
| | | | Wall of dust or sand | |
| | | | Dust whirl or sand whirl (dust devil) | |
| Photometeors [1] | Halo phenomena: solar | ⊕ | Bishop's ring | |
| | lunar | | Mirage | |
| | Corona: solar | | Shimmer | No symbols established |
| | lunar | | Scintillation | No symbols established |
| | Irisation on clouds | | Green flash | No symbols established |
| | Glory | | Twilight colours | No symbols established |
| | Rainbow | ⌒ | Crepuscular rays | No symbols established |
| | Fog bow | | | |
| Electrometeors [1] | Thunderstorm | | Saint Elmo's fire | |
| | Lightning | < | Polar aurora | |
| | Thunder | T | | |

[1] Definitions of a lithometeor, photometeor and electrometeor are given in Part I, paragraphs I.2.2, I.2.3 and I.2.4, respectively.

## III.1.2

## Symbols for meteors other than clouds

### III.1.2.1

Basic symbols to be used for meteors other than clouds are shown in the table under paragraph III.1.1.

### III.1.2.2

It is possible to provide information concerning the character (intermittent or continuous) and intensity (slight, moderate or heavy) of precipitation by certain arrangements of the basic symbols. The following table, established for rain, illustrates various arrangements which may be used for this purpose.

| INTENSITY \ CHARACTER | INTERMITTENT | CONTINUOUS |
|---|---|---|
| slight | • | •• |
| moderate | : | ∴ |
| heavy (dense) | ⁝ | ⁘ |

### III.1.2.3

Combinations of two basic symbols of meteors may be used to indicate the occurrence of mixed precipitation or the occurrence of a thunderstorm accompanied by precipitation or dust storm or sandstorm. For example, the symbol $\overset{\bullet}{*}$ or $\overset{*}{\underset{*}{\bullet}}$ denotes a mixture of falling raindrops and snowflakes; the symbol $\overset{\bullet}{\text{ꓘ}}$ indicates thunderstorm with rain at the place of observation.

### III.1.2.4

In addition to the basic symbols, several auxiliary symbols have been established to provide information concerning the showery character of precipitation and also the variation with time of various meteors and their location with respect to the station. These symbols are the following:

| | |
|---|---|
| $\nabla$ | shower, slight |
| $\overline{\nabla}$ | shower, moderate or heavy |
| \|x | has increased (or formed) during the preceding hour |
| x\| | has decreased during the preceding hour |
| x] | during the preceding hour, but not at the moment of observation |
| (x) | not at the station, but within sight [estimated distance less than 5 km (3 miles)] |
| )x( | within sight and at an estimated distance of more than 5 km (3 miles) |

Useful supplementary information about meteors can thus be given by combining the above auxiliary symbols with one, or sometimes two, basic symbols. For example, the symbol ≡| denotes fog which has become thinner during the preceding hour; the symbol $\overset{\bullet}{\nabla}]$ indicates shower(s) of rain during the preceding hour, but not at the time of observation.

# III.2 — DEFINITIONS AND DESCRIPTION OF METEORS OTHER THAN CLOUDS *

## III.2.1

## Hydrometeors other than clouds

### III.2.1.1

### HYDROMETEORS CONSISTING OF A SUSPENSION OF PARTICLES IN THE ATMOSPHERE

#### (1) FOG

***Definition***

*A suspension of very small, usually microscopic water droplets in the air, reducing visibility at the Earth's surface.*

Commentary

The reduction in visibility depends on the structure of the fog, especially on the number of droplets per unit volume and on the size distribution of the droplets. This structure is determined mainly by the nature of the atmospheric aerosol, the mode of fog formation and its age. It may vary a great deal in time and space.

The conditions resulting from the simultaneous occurrence of fog and heavy air pollution in urban and industrialized areas, with chemical reactions between fog droplets and various pollutants going on, are widely referred to as "smog" (e.g. smoke and fog).

In practice, the terms "fog" and "mist" are used to indicate the different intensities of the phenomenon, the term "mist" being synonymous with light fog.

The term "*fog*" is used when the hydrometeor fog reduces horizontal visibility at the Earth's surface to less than one kilometre.

When illuminated, individual fog droplets are frequently visible to the naked eye, they are then often mean to be moving in a somewhat turbulent manner. The air in "fog" usually feels raw, clammy and wet.

"Fog" forms a whitish veil which covers the landscape; it may, however, when mixed with dust or smoke, take on a faint coloration.

The term "*mist*" is used when the hydrometeor fog does not reduce horizontal visibility at the Earth's surface to less than one kilometre.

"Mist" forms a generally fairly thin, greyish veil which covers the landscape.

NOTE: In the interior of continents at temperatures below −10°C sometimes fog may form, usually from freezing of droplets, being composed of ice crystals, which like diamond dust gives rise to optical phenomena.

#### (2) ICE FOG

***Definition***

*A suspension of numerous minute ice particles in the air, reducing the visibility at the Earth's surface.*

* Only those definitions which are printed in italics have the status of Annex to the *Technical Regulations*.

Commentary

Ice fog is observed at high latitudes, usually in clear calm weather, when the temperature is below −30°C.

It forms when water vapour, mainly resulting from human activities, is introduced into the atmosphere. This vapour condenses forming droplets which freeze rapidly into ice particles having no well-defined crystalline form.

The diameter of these particles varies approximately between 2 and 30 microns; and the lower the temperature the smaller the diameter of the particles, which may sometimes be a few microns only when the temperature is between −40°C and −50°C.

Owing to their form, these particles do not produce halo phenomena. These phenomena are produced in ice fog only when it contains diamond dust.

Visibility is usually much reduced in ice fog, especially in inhabited areas where it is often less than 50 m.

## III.2.1.2

## HYDROMETEORS CONSISTING OF A FALL OF AN ENSEMBLE OF PARTICLES (PRECIPITATION)

### (1) Rain

***Definition***

*Precipitation of drops of water which falls from a cloud.*

Commentary

The diameter and concentration of raindrops vary considerably according to the intensity of the precipitation and especially according to its nature (continuous rain, rain shower, storm rain, etc.).

Clouds may sometimes include an abnormally large number of fine particles, for example of dust or sand, lifted from the ground during a storm. These particles may be carried to the ground with the raindrops (mud rain), often after having been carried over great distances.

### (2) Supercooled rain

***Definition***

*Rain with temperature of drops below 0°C.*

Commentary

On impact with the ground, with objects on the ground surface and with aircraft in flight, drops of supercooled rain form a mixture of water and ice having a temperature of 0°C.

### (3) Drizzle

***Definition***

*Fairly uniform precipitation in very fine drops of water very close to one another, which falls from a cloud.*

Commentary

Drizzle is a sort of rain in which the diameter of the drops is usually less than 0.5 mm. The drops appear almost to float, thus making visible even slight movements of the air.

Drizzle falls from a continuous and fairly dense layer of cloud, usually low, sometimes touching the ground (fog), and only from a layer of stratus.

The amount of precipitation in the form of drizzle is sometimes considerable (up to 1 mm per hour), especially along coasts and in mountainous areas.

NOTE: The drops falling on the edge of a rain zone, or during a light rainfall, may be as small as drizzle drops, owing to partial evaporation; raindrops are then distinguished from drizzle drops in that they are more scattered. When the cloud from which the precipitation comes can be identified, there can be no mistake as drizzle can fall only from stratus.

### (4) Supercooled drizzle

***Definition***

*Drizzle with temperature of drops below 0°C.*

Commentary

On impact with the ground, with objects on the ground surface and with aircraft in flight, drops of supercooled drizzle form a mixture of water and ice having a temperature of 0°C.

### (5) Snow

***Definition***

*Precipitation of ice crystals, singly or agglomerated, which falls from a cloud.*

Commentary

The form, size and concentration of snow crystals differ considerably according to the temperature at which they form and the conditions in which they develop. A fall of snow usually includes various types of snow crystals and almost all types of crystal may be observed during a single fall of snow.

Small droplets of frozen water are often attached to snow crystals. When there are few of these droplets the crystalline structure is still very visible, when there are many, the structure is scarcely visible any more.

At temperatures higher than about −5°C, the crystals are generally agglomerated into snowflakes.

### (6) Snow grains

***Definition***

*Precipitation of very small opaque white particles of ice which falls from a cloud. These particles are fairly flat or elongated; their diameter is generally less than 1 mm.*

Commentary

When the grains hit hard ground, they do not bounce. Except in the mountains, they usually fall in small quantities, mostly from stratus or from fog and never in the form of a shower. This precipitation corresponds as it were to drizzle and occurs when the temperature is between 0°C and −10°C approximately.

### (7) SNOW PELLETS

***Definition***

*Precipitation of white and opaque ice particles, which falls from a cloud. These particles are generally conical or rounded. Their diameter may attain 5 millimetres.*

Commentary

These grains are brittle and easily crushed; when they fall on hard ground they bounce and often break up.

Precipitation of snow pellets in showers together with snowflakes, normally occur when temperatures near the surface are near 0°C.

Snow pellets are composed of a central nucleus covered with frozen cloud droplets. Owing to the interstices between the nucleus and the frozen droplets, the density of snow pellets is generally low, being less than 0.8 g $cm^{-3}$.

Snow pellets form when a particle of ice, usually a crystal, collects cloud droplets which rapidly freeze. Crystals have been observed which are not completely surrounded by droplets, being in the intermediate stage between the snow crystal and snow pellet.

### (8) DIAMOND DUST

***Definition***

*Precipitation which falls from a clear sky in very small ice cristals, often so tiny that they appear to be suspended in the air.*

Commentary

Diamond dust can be observed in polar regions and continental interiors especially in clear, calm and cold weather.

It forms at temperatures less than −10°C in a rapidly cooling airmass; it is usually composed of well-developed crystals, plates especially, the diameter of which may be anywhere between about 30 and 200 microns, the commonest being about 100 microns.

These crystals, which are visible mainly when they sparkle in the sunlight, give rise to generally well-marked halo phenomena.

In diamond dust, visibility is very variable; the lower limit is over 1 km.

### (9) HAIL

***Definition***

*Precipitation of either transparent, or partly or completely opaque particles of ice (hailstones), usually spheroidal, conical or irregular in form and of diameter very generally between 5 and 50 millimetres, which falls from a cloud either separately or agglomerated into irregular lumps.*

Commentary

Falls of hail always occur in the form of showers; they are generally observed during heavy thunderstorms.

Hailstones usually form around a nucleus which is not necessarily at their geometric centre. These nuclei, which may be anywhere between a few millimetres and one centimetre in diameter, are spheroidal or conical in form; they are composed of transparent or opaque ice, the latter being the commoner.

It is difficult to classify hailstone structures owing to the large number of varieties which may occur, even among hailstones of the same form and dimensions collected during a single fall. Certain structures are however more common than others, for instance that of a nucleus surrounded by alternating layers of opaque and transparent ice. This "onion-skin" formation is not observed in all hailstones; some consist of transparent or opaque ice only. There are not usually more than five layers except in very large hailstones which have been known to have twenty or more.

Hailstones may be partly composed of spongy ice, which is a mixture of ice, water and air consisting of a framework of ice in which water and air bubbles are trapped; they sometimes contain large cavities filled with air.

Hailstones are mainly of a density between 0.85 g $cm^{-3}$ and 0.92 g $cm^{-3}$; but may be of lower density than 0.85 g $cm^{-3}$ if they have large cavities.

The hailstone forms when a nucleus collects cloud droplets or drops of rain. There is no general agreement on the nature of this nucleus; the tendency is however to admit that it is usually a particle of small hail which has formed round a snow pellet.

## (10) Small hail

### *Definition*

*Precipitation of translucent ice particles, which falls from a cloud. These particles are almost always spherical and sometimes have conical tips. Their diameter may attain and even exceed 5 millimetres.*

### Commentary

Usually, small hail is not easily crushable and when it falls on hard ground it bounces with an audible sound on impact.

Small hail always occurs in showers.

Small hail consists of snow pellets totally or partially encased in a layer of ice, the interstices being filled with ice, or ice and water; a thin shell only may be frozen. Small hail is of relatively high density, between 0.8 g $cm^{-3}$ and exceptionally 0.99 g $cm^{-3}$.

Small hail forms by penetration of liquid water into the interstices of a snow pellet; this water may come from cloud drops or partial melting of a snow pellet.

Small hail is an intermediate stage between the snow pellet and the hailstone. It differs from the snow pellet in its partially smooth surface and its higher density. It differs from the hailstone particularly in its smaller size.

## (11) Ice pellets

### *Definition*

*Precipitation of transparent ice particles, which falls from a cloud. These particles are usually spheroidal or irregular, rarely conical. Their diameter is less than 5 millimetres.*

### Commentary

Usually ice pellets are not easily crushable; when they fall on hard ground they generally bounce with an audible sound on impact.

Precipitation in the form of ice pellets generally falls from altostratus or nimbostratus.

Ice pellets may be in part liquid; their density is usually near to, or above, that of ice (0.92 g $cm^{-3}$).

III.2.1.3

## HYDROMETEORS CONSISTING OF ENSEMBLES OF PARTICLES RAISED BY THE WIND

### (1) DRIFTING SNOW AND BLOWING SNOW

***Definition***

*An ensemble of snow particles raised from the ground by a sufficiently strong and turbulent wind.*

Commentary

The occurrence of this hydrometeor depends on the wind conditions (speed and gustiness) and the state and age of the surface snow.

There are two sorts of phenomenon: drifting snow and blowing snow.

#### (*a*) DRIFTING SNOW

***Definition***

*An ensemble of snow particles raised by the wind to small heights above the ground.*

Commentary

Very low obstacles are veiled or hidden by the moving snow. The motion of the snow particles is more or less parallel to the ground.

Vertical visibility is not sensibly diminished, nor horizontal visibility at eye level [1].

#### (*b*) BLOWING SNOW

***Definition***

*An ensemble of snow particles raised by the wind to moderate or great heights above the ground.*

Commentary

The concentration of the snow particles may sometimes be sufficient to veil the sky and even the sun. The snow particles are nearly always violently stirred up by the wind.

Vertical visibility is diminished according to the intensity of the phenomenon; the horizontal visibility at eye level [1] is generally very poor.

When the phenomenon is severe it is difficult to appreciate that snow is also present at the same time in the form of precipitation.

### (2) SPRAY

***Definition***

*An ensemble of water droplets torn by the wind from the surface of an extensive body of water, generally from the crests of waves, and carried up a short distance into the air.*

Commentary

When the water surface is rough, the droplets may be accompanied by foam.

When strong gales blow down from the mountains (foehn gales) on to the surface of a lake, spray may locally take the form of moving vortices.

[1] Eye level is defined as 1.80 m above the ground.

III.2.1.4

## HYDROMETEORS CONSISTING OF A DEPOSIT OF PARTICLES

### (1) Deposit of fog droplets

***Definition***

*Deposit of non-supercooled fog (or cloud) droplets on objects the surface temperature of which is above 0°C.*

Commentary

This hydrometeor is observed especially in high areas where orographic clouds are frequent.

The intensity of the deposit depends on the duration and granulometry of the fog (or clouds) and on the speed of impact of the droplets. It is also a function of the wettability and interception coefficient of objects, this coefficient being particularly high for conifer leaves.

When the phenomenon is marked, the droplets collected run together and drip on to the ground. In certain regions, the amount of water falling from trees in this way during a single night may be the equivalent of the rainfall from a moderate shower.

### (2) Dew

***Definition***

*Deposit on objects of water drops produced by the direct condensation of water vapour from the surrounding air.*

Commentary

There are two sorts of dew: dew proper and advection dew.

#### (*a*) dew proper

***Definition***

*Deposit of water drops on objects, the surface of which is sufficiently cooled, generally by nocturnal radiation, to bring about the direct condensation of the water vapour from the surrounding air.*

Commentary

Dew proper is deposited ordinarily on objects at or near the ground, mainly on their horizontal surfaces.

Dew is observed especially during the warm part of the year when the air is calm and the sky clear.

Dew should not be confused with the deposit of drops from low fog on exposed surfaces, not in the case of plants, with the droplets of water they exude—a phenomenon known as *guttation* which often takes place at the same time as deposit of dew but which can also occur separately.

#### (*b*) advection dew

***Definition***

*Deposit of water drops on objects, the surface of which is sufficiently cold to bring about direct condensation of the water vapour contained in the air coming into contact with this surface, usually through a process of advection.*

Commentary

Advection dew is deposited mainly on vertical exposed surfaces. It is observed especially during the cold part of the year when relatively warm damp air suddenly invades a region after a period of moderate frosts.

Advection dew must not be confused with the deposit of fog droplets nor with the pseudo-dew observed in humid weather on certain exposed surfaces covered by a thin film of hygroscopic substances.

### (3) White dew

***Definition***

*A deposit of white frozen dew drops.*

Commentary

White dew must not be confused with an amorphous form of hoar frost.

### (4) Hoar frost

***Definition***

*A deposit of ice on objects generally crystalline in appearance, and produced by the direct "sublimation"* [1] *of water vapour from the surrounding air.*

Commentary

There are two sorts of hoar frost: hoar frost proper and advection hoar frost.

#### (*a*) hoar frost proper

***Definition***

*A deposit of ice, which generally assumes the form of scales, needles, features or fans and which forms on objects the surface of which is sufficiently cooled, generally by nocturnal radiation, to bring about the direct "sublimation" of the water vapour contained in the ambient air.*

Commentary

Hoar frost proper is deposited ordinarily on objects at or near the ground, mainly on their horizontal surfaces.

Hoar frost is observed especially during the cold part of the year when the air is calm and the sky clear.

#### (*b*) advection hoar frost

***Definition***

*A deposit of ice which generally assumes crystalline form and which forms on objects, the surface of which is sufficiently cold to bring about the direct sublimation of the water vapour contained in the air coming into contact with this surface, usually through a process of advection.*

[1] The term sublimation is used in the meaning of passage from the gaseous to the solid state; it is in inverted commas to call attention to the fact that this hydrometeor develops but does not form in this way.

Commentary

Advection hoar frost is deposited mainly on vertical exposed surfaces.
Advection hoar frost is observed especially during the cold part of the year when relatively warm damp air suddenly invades a region after a long period of hard frosts.

### (5) RIME

***Definition***

*Deposit of ice generally formed by the freezing of supercooled fog or cloud droplets on objects the surface temperature of which is below or slightly above 0°C.*

Commentary

There are three sorts of rime: soft rime, hard rime and clear ice.

#### (*a*) SOFT RIME

***Definition***

*Fragile rime consisting mainly of thin needles or scales of ice.*

Commentary

At and near the ground, it is deposited under calm or low wind conditions on all sides of exposed objects.
Soft rime easily drops on shaking the objects.
It mainly forms with temperatures of the ambiant air lower than −8°C. At temperatures well below −8°C the formation of soft rime does not necessarily require the presence of fog.

#### (*b*) HARD RIME

***Definition***

*Granular rime, usually white, adorned with crystalline branches of grains of ice more or less separated by entrapped air.*

Commentary

At and near the ground, it is deposited mainly on the surface of objects exposed to at least moderate wind. In the wind-ward direction, the deposit may increase to form a thick layer.
In the free atmosphere it may occur on the parts of aircraft exposed to the relative wind.
It is formed by the rapid freezing of the water remaining in the liquid state after cessation of supercooling so that the droplets freeze more or less individually, leaving interstices.
Hard rime is rather adhesive but can, however, still be scratched off the object.
Hard rime mainly forms with temperatures between −2°C and −10°C.

#### (*c*) CLEAR ICE

***Definition***

*Smooth compact rime, usually transparent, fairly amorphous, with a ragged surface, and morphologically ressembling glaze.*

Commentary

At and near the ground clear ice is deposited mainly on the surface of objects exposed to the wind; it is observed specially in mountain regions.

In the free atmosphere, it occurs chiefly on the part of the aircraft exposed to the relative wind.

It is formed by the slow freezing of the water remaining in the liquid state after cessation of supercooling which is therefore able to penetrate the interstices between the grains of ice before freezing.

Clear ice is very adhesive and can only be removed from the objects by breaking or melting off.

Clear ice is formed in nearly any case with temperatures of the ambiant air between 0 and −3°C.

NOTE: The processes resulting in the formation of the different kinds of rime may on some occasions occur nearly simultaneously and, more frequently consecutively during a longer period and even repeatedly alternating. Thus on the exposed objects after a certain time very heterogenous "overall deposits" can be observed with various transitional states within the deposit.

### (6) Glaze

***Definition***

*A smooth compact deposit of ice, generally transparent, formed by the freezing of supercooled drizzle droplets or raindrops on objects the surface temperature of which is below or slightly above 0°C.*

Commentary

Glaze covers all the parts of surfaces exposed to precipitation; it is generally fairly homogeneous and morphologically resembles clear ice.

At and near the ground, glaze is observed when drizzle droplets or raindrops fall through a layer of subfrost point temperature of sufficient depth.

In the free atmosphere, it is observed when aircraft are exposed to supercooled precipitation.

Glaze forms by the slow freezing of the water remaining in the liquid state after cessation of supercooling which is therefore able to penetrate the interstices between the particles of ice before freezing.

The deposit of ice formed by the freezing of fog or cloud droplets not supercooled at the time of impact with objects the temperature of which is well below 0°C, is also known as glaze.

NOTE: Glaze on the ground must not be confused with ground ice, which is formed when:

(*a*) Water from a precipitation of non-supercooled drizzle droplets or raindrops later freezes on the ground;

(*b*) Snow on the ground freezes again after having completely or partly melted; or

(*c*) Snow on the ground is made compact and hard by traffic.

## III.2.1.5

## Spout

***Definition***

*A phenomenon consisting of an often violent whirlwind, revealed by the presence of a cloud column or inverted cloud cone (funnel cloud), protruding from the base of a Cumulonimbus, and of a "bush" composed of water droplets raised from the surface of the sea or of dust, sand or litter, raised from the ground.*

Commentary

The axis of the funnel cloud is vertical, inclined or sometimes sinuous. Not uncommonly, the funnel merges with the bush.

The air in the whirlwind rotates rapidly, most often in a cyclonic sense; a rapid rotary movement may also be observed outside the funnel and the "bush". Further away, the air is often very calm.

The diameter of the cloud column, which is normally of the order of ten metres (ten yards), may in certain regions occasionally reach some hundreds of metres (some hundreds of yards).

Several spouts may sometimes be observed connected with one single cloud.

Spouts are often very destructive in North America (tornadoes), where they may leave a path of devastation up to 5 kilometres (3 miles) wide and several hundred kilometres (several hundred miles) long.

Weak spouts are occasionally observed under Cumulus clouds.

III.2.2

## Lithometeors

III.2.2.1

### LITHOMETEORS CONSISTING OF A SUSPENSION OF PARTICLES IN THE ATMOSPHERE

#### (1) HAZE

***Definition***

*A suspension in the air of extremely small, dry particles invisible to the naked eye and sufficiently numerous to give the air an opalescent appearance.*

Commentary

Haze imparts a yellowish or reddish tinge to distant bright objects or lights seen through it, while dark objects appear bluish. This effect is mainly a result of scattering of light by the haze particles. These particles may have a colour of their own which also contributes to the coloration of the landscape.

#### (2) DUST HAZE

***Definition***

*A suspension in the air of dust or small sand particles, raised from the ground prior to the time of observation by a dust storm or sandstorm.*

Commentary

The dust storm or sandstorm may have occurred either at or near the station or far from it.

#### (3) SMOKE

***Definition***

*A suspension in the air of small particles produced by combustion.*

Commentary

This lithometeor may be present either near the Earth's surface or in the free atmosphere. Viewed through smoke, the sun appears very red at sunrise and sunset; it shows an orange tinge when high in the sky. Smoke from relatively nearby cities may be brown, dark grey or black. Smoke in extensive layers originating from fairly near forest fires scatters the sunlight and gives the sky a greenish-yellow hue. Evenly distributed smoke from very distant sources generally has a light greyish or bluish hue.

When smoke is present in large quantities, it may be distinguished by its smell.

Note: When the lithometeor "smoke" is present in the free atmosphere, it is, by convention, distinguished from clouds of smoke (clouds from fires or clouds resulting from industry) by its diffuse appearance and by the absence of any discernible outlines.

## III.2.2.2

## LITHOMETEORS CONSISTING OF ENSEMBLES OF PARTICLES RAISED BY THE WIND

### (1) DRIFTING AND BLOWING DUST OR SAND

*Definition*

*An ensemble of particles of dust or sand raised, at or near the station, from the ground to small or moderate heights by a sufficiently strong and turbulent wind.*

Commentary

The wind conditions (speed and gustiness) necessary to produce these lithometeors depend on the nature, the state and the degree of dryness of the ground.

#### (*a*) DRIFTING DUST OR DRIFTING SAND

*Definition*

*Dust or sand, raised by the wind to small heights above the ground. The visibility is not sensibly diminished at eye level.*[1]

Commentary

Very low obstacles are veiled or hidden by the moving dust or sand.

The motion of the particles of dust or sand is more or less parallel to the ground.

#### (*b*) BLOWING DUST OR BLOWING SAND

*Definition*

*Dust or sand, raised by the wind to moderate heights above the ground. The horizontal visibility at eye level*[1] *is sensibly reduced.*

Commentary

The concentration of the particles of dust or sand may sometimes be sufficient to veil the sky and even the sun.

### (2) DUST STORM OR SANDSTORM

*Definition*

*An ensemble of particles of dust or sand energetically lifted to great heights by a strong and turbulent wind.*

[1] Eye level is defined as 1.80 m (6 feet) above the ground.

Commentary

Dust storms or sandstorms generally occur in areas where the ground is covered with loose dust or sand; sometimes, after having travelled over more or less great distances, they may be observed over areas where no dust or sand covers the ground.

The forward portion of a dust storm or sandstorm may have the appearance of a wide and high wall which advances more or less rapidly. *Walls of dust or sand* often accompany a Cumulonimbus which may be hidden by the dust or the sand particles; they may also occur without any clouds along the forward edge of an advancing cold air mass.

(3) DUST WHIRL OR SAND WHIRL (DUST DEVIL)

***Definition***

*An ensemble of particles of dust or sand, sometimes accompanied by small litter, raised from the ground in the form of a whirling column of varying height with a small diameter and an approximately vertical axis.*

Commentary

These lithometeors occur when the air near the ground is very unstable as, for instance, when the soil is strongly heated by insolation.

III.2.3

## Photometeors

(1) HALO PHENOMENA

***Definition***

*A group of optical phenomena in the form of rings, arcs, pillars or bright spots, produced by the refraction or reflection of light by ice crystals suspended in the atmosphere (cirriform clouds, diamond dust, etc.).*

Commentary

These phenomena, when formed by refraction of the light of the sun, may show colours, while halo phenomena produced by the light of the moon are always white.

(*a*) The most frequent halo phenomenon, called the *small halo*, appears as a white or mostly white luminous ring of 22 degrees radius with the luminary at its centre. The small halo shows a faint red fringe on the inside and, in some rare cases, a violet fringe on the outside. The portion of the sky inside the ring is conspicuously darker than the rest of the sky.

(*b*) A circular halo with a radius of 46 degrees, called the *large halo*, is sometimes observed; this halo is much less common than the small halo and is always less bright.

(*c*) A white *luminous pillar* in the form of a broken or continuous trail of light may be observed vertically above and below the sun or moon.

(*d*) Tangent arcs are sometimes seen on the outside of the small or the large halo; these arcs touch the circular halo at its highest or lowest points (*upper tangent arc* and *lower tangent arc*, respectively). The arcs have a form which varies with the angular altitude of the luminary; they are often short and may even be reduced to a bright spot.

(*e*) Occasionally, the *upper* and *lower circumzenithal* arcs may be observed; they appear to lie in horizontal planes. The upper circumzenithal arc (brightly coloured, with red on the outside and violet on the inside) is a rather sharply curved arc of a small horizontal circle near the zenith; the lower circumzenithal arc is a flat arc of a large horizontal circle near the horizon. The upper arc occurs only when the angular altitude of the luminary is less than 32 degrees; the lower arc occurs only when the angular altitude of the luminary is more than 58 degrees. The upper arc touches the large halo, if visible, when the angular altitude of the luminary is about 22 degrees; the lower arc touches the large halo when the angular altitude of the luminary is about 68 degrees. The arcs become increasingly separated from the large halo, as the angular altitude of the luminary departs from the above values. Circumzenithal arcs may be observed without the large halo being visible.

(*f*) The *parhelic circle* is a white, horizontal circle at the same angular altitude as the sun. Bright spots may be observed at certain points of the parhelic circle. These spots occur most commonly a little outside the small halo (*parhelia*, often brilliantly coloured); occasionally, bright spots *(paranthelia)* are seen at an azimuthal distance of 120 degrees from the sun and, very rarely, opposite the sun *(anthelion)*. [1] The corresponding phenomena produced by the moon are called: *paraselenic circle*, *paraselenae*, *parantiselenae* and *antiselene*. [1] Parhelia and paraselenae are sometimes connected with the small halo by obliquely oriented *arcs of Lowitz*.

(*g*) The *undersun* is a halo phenomenon produced by reflection of sunlight on ice crystals in clouds. It appears vertically below the sun in the form of a brilliant white spot, similar to the image of the sun on a calm water surface. It is necessary to look downward to see the undersun; the phenomenon is therefore only observed from aircraft or from mountains.

### (2) CORONA

***Definition***

*One or more sequences (seldom more than three) of coloured rings of relatively small diameter, centred on the sun or moon.*

Commentary

In each sequence the inside ring is violet or blue and the outside ring is red; other colours may occur in between. The innermost sequence usually shows a distinct outer ring of reddish or chestnut colour, called the "aureole", the radius of which is generally not more than 5 degrees.

Coronae are due to the diffraction of light from the luminary, passing through mist, fog or through a thin cloud composed of very small water or ice particles. The radii of the aureole and of the successive, approximately equidistant, red rings are greater the smaller the particles. Except when the particles are very uniform in size, the colours observed in coronae are less pure and fewer than those of rainbows.

Sometimes coronae, seen in cloud, have a distorted form, owing to differences in the size of the particles in various parts of the clouds. Distorted coronae of small radius may also be observed around the moon when not full, because of the crescent or gibbous form of the luminary.

### (3) IRISATION

***Definition***

*Colours appearing on clouds, sometimes mingled, sometimes in the form of bands nearly parallel to the margin of the clouds. Green and pink predominate, often with pastel shades.*

[1] When the parhelia, paranthelia or the anthelion are particularly bright, they are often called mock suns; paraselenae, parantiselenae, and the antiselene, when bright are sometimes called mock moons.

Commentary

Irisation colours, often brilliant, resemble those observed on mother-of-pearl.

Within about 10 degrees from the sun, diffraction is the main cause of irisation. Beyond about 10 degrees, however, interference is usually the predominant factor. Irisation extends at times to angles exceeding 40 degrees from the sun; even at this angular distance from the luminary the colours may be brilliant.

(4) GLORY

*Definition*

*One or more sequences of coloured rings, seen by an observer around his own shadow on a cloud consisting mainly of numerous small water droplets, on fog or, very rarely, on dew.*

Commentary

The coloured rings are due to the diffraction of light; their arrangement is the same as in a corona.

Airborne observers often see a glory around the shadow of the aircraft in which they are flying.

Note: When the shadow seems to be very large, because the clouds or fog are near the observer, it is called a "Brocken spectre", whether a coloured glory is seen or not.

(5) RAINBOW

*Definition*

*A group of concentric arcs with colours ranging from violet to red, produced on a "screen" of water drops (raindrops, droplets of drizzle or fog) in the atmosphere by light from the sun or moon.*

Commentary

This phenomenon is mainly due to refraction and reflection of light. When rainbows are produced by the sun, their colours are usually brilliant; when produced by the moon their colours are much weaker or sometimes absent.

(*a*) The *primary rainbow* is a coloured bow which appears on a "screen" of water drops when light from the luminary falls upon them. The coloured bow is opposite the luminary by which it is produced and its centre is on the prolongation of the line joining the luminary and the observer. Thus, the rainbow may form a complete ring when seen from a high tower or from an aircraft.

It is very rare that all the so-called "colours of the rainbow" (red, orange, yellow, green, blue, indigo and violet) are observed. The size of the drops or droplets determines which colours are present and the width of the band occupied by each of them. In all cases the violet is on the inside (radius of the arc 40 degrees) and the red on the outside (radius of the arc 42 degrees). The sky is darker outside the bow than inside.

(*b*) In addition to the primary rainbow, there may be a *secondary bow*, much less bright than the primary, and with a breadth almost twice that of the primary. The red is on the inside (radius of the arc 50 degrees) and the violet on the outside (radius of the arc 54 degrees).

(*c*) Rainbows may be bordered by narrow coloured bows (green, violet or orange) due to interference. These bows are called *supernumerary bows*; they occur inside the primary rainbow or outside the secondary rainbow, but rarely with the latter.

(*d*) The *fog bow* is a primary rainbow due to refraction and reflection, and to a minor extent to diffraction, of sunlight or moonlight in very small water droplets; it appears on a "screen" of fog or mist. The fog bow consists of a white band, usually fringed with a thin red band on the outside and a thin blue band on the inside.

### (6) BISHOP'S RING

***Definition***

*A whitish ring, centred on the sun or moon, with a slightly bluish tinge on the inside and reddish brown on the outside.*

Commentary

Bishop's ring is due to the diffraction of light passing through a cloud of exceedingly fine dust of volcanic origin, which is occasionally present in the high atmosphere. The radius of the ring is about 22 degrees.

The colours of a Bishop's ring are not very distinct; they are particularly faint in rings observed around the moon, which usually shows only a pale red fringe.

### (7) MIRAGE

***Definition***

*An optical phenomenon consisting mainly of steady or wavering, single or multiple, upright or inverted, vertically enlarged or reduced, images of distant objects.*

Commentary

Objects seen in a mirage sometimes appear appreciably higher or lower above the horizon than they really are; the difference may amount to as much as 10 degrees. Objects located below the horizon or hidden by mountains may become visible ("looming"); objects which are visible under normal circumstances, may disappear during the occurrence of a mirage.

Mirages are due to the curving of light rays passing through layers of air the refractive index of which changes considerably with height as a result of differences in density. They are therefore generally observed when the temperature of the Earth's surface differs markedly from that of the air above. A mirage may occur as a *lower mirage* over intensely heated water surfaces, soils, beaches, roads, etc. or as *upper mirage* over snow fields, cold sea surfaces, etc.

### (8) SHIMMER

***Definition***

*The apparent fluttering of objects at the Earth's surface, when viewed in the horizontal direction.*

Commentary

Shimmer occurs chiefly over land when the sun is shining brightly. It is due to short period fluctuations of the refractive index in the surface layers of the atmosphere. Shimmer may reduce the visibility appreciably.

### (9) SCINTILLATION

***Definition***

*Rapid variations, often in the form of pulsations, of the light from stars or terrestrial light sources.*

Commentary

The apparent brilliance, colour and position of the stars or lights undergo variations, owing to fluctuations of the refractive index in the portions of the atmosphere through which the rays of light pass; this phenomenon is thus analogous to shimmer.

Other factors being equal, scintillation is more marked the longer the path traversed by the light through the atmosphere. The scintillation of stars is consequently more pronounced near the horizon than at the zenith; for the same reason the scintillation of lights from terrestrial sources is more pronounced over plains than on mountain summits.

### (10) Green flash

***Definition***

*A predominantly green coloration of short duration, often in the form of a flash, seen at the extreme upper edge of a luminary (sun, moon, or sometimes even a planet) when disappearing below or appearing above the horizon.*

Commentary

Flashes up to an altitude of several degrees have sometimes been observed.

Although the colour of the phenomenon is predominantly green, blue and violet may also be visible, particularly when the air is very transparent.

The phenomenon can only be seen if the horizon is clearly visible. [1] It is more frequently observed over sea than over land.

No completely satisfactory explanation has so far been given for the green flash but it is most probable that the different refrangibility of light of different colours plays an important rôle in its formation.

### (11) Twilight colours

***Definition***

*Various colorations of the sky and of the peaks of mountains at sunset and at sunrise.*

Commentary

Twilight colours are produced by refraction, scattering or selective absorption of light rays from the sun in the atmosphere. In clear, cloudless air, the following phenomena may be observed:

(*a*) In the direction of the sun a glow, called *purple light*. This purple light is in the form of a segment of a large luminous disk; it extends upwards from the horizon.

The purple light rises gradually, reaching a maximum both in size and luminance when the sun is 3 or 4 degrees below the horizon; it then descends and disappears when the sun is about 6 degrees below the horizon (end of civil twilight). Occasionally, when this first purple light has disappeared, the phenomenon repeats itself with less intensity.

(*b*) In the direction opposite to the sun, the *Earth's shadow* and the *twilight arch*. The Earth's shadow gradually rises above the horizon opposite to the sun; it appears as a segment of a disk, of dark blue colour, sometimes with a violet tinge. The shadow is often bordered on its upper edge by a rose violet ribbon known as the twilight arch. Above this arch a faint purple or yellow colour is sometimes discernible.

[1] On very rare occasions the green flash may be observed when the sun disappears behind relatively close obstacles, such as mountains, the upper edge of a cloud bank near the horizon or even the roof of a building.

(*c*) *Alpenglühen.* Near sunset, the sun may be hidden for a low-level observer, while the mountain tops may still be in the sun's direct rays; the mountain tops then assume a rosy or yellow tint. This phenomenon is known as "Alpenglühen". It disappears after a short period of blue coloration, when the shadow of the Earth reaches the mountain tops. Sometimes a second or even a third Alpenglühen may be observed as a result of the illumination of snow-fields by the first or second purple light.

(*d*) *Crepuscular rays.* One sometimes observes dark bluish streaks which radiate from the sun across the purple light. These streaks are the shadows of clouds at or below the horizon; they are often called crepuscular rays. Occasionally, the shadows may cross the sky, becoming visible again at the antisolar point (anticrepuscular rays).

Note: The name "crepuscular rays" is also used, though not universally, to denote shadowed bands cast by clouds on a layer of haze at any time of the day.

III.2.4

## Electrometeors

### (1) THUNDERSTORM

***Definition***

*One or more sudden electrical discharges, manifested by a flash of light (lightning) and a sharp or rumbling sound (thunder).*

Commentary

Thunderstorms are associated with convective clouds and are most often accompanied by precipitation which, when it reaches the ground, is in the form of a shower of rain, snow, snow pellets, ice pellets or hail.

LIGHTNING

***Definition***

*A luminous manifestation accompanying a sudden electrical discharge which takes place from or inside a cloud or, less often, from high structures on the ground or from mountains.*

Commentary

Three main types of lightning can be distinguished:

(*a*) *Ground discharges* (popularly called thunderbolts). This type of lightning occurs between cloud and ground; it follows a tortuous course and is usually branched downward from a distinct main channel (streak or ribbon lightning).

(*b*) *Cloud discharges* (popularly called sheet lightning). This type of lightning takes place within the thundercloud; it gives a diffuse illumination without a distinct channel being usually seen. This type of lightning includes the so-called heat lightning, consisting of diffuse light flashed from distant thunderstorms, seen at horizon.

(*c*) *Air discharges.* This type of lightning occurs in the form of sinuous discharges, often ramified but with a distinct main channel, passing from a thundercloud to the air and not striking the ground. It frequently includes a long quasi-horizontal part. The name "streak lightning" is also applied to this type of lightning.

Note: A luminous globe has occasionally been observed, soon after a discharge to ground. This globe, the dimension of which has been reported to be generally between 10 and 20 cm (4 and 8 in.), but is said sometimes to reach one metre (one yard), is known as ball lightning. It moves slowly in the air or on the ground and usually disappears with a violent explosion.

THUNDER

***Definition***

*A sharp or rumbling sound which accompanies lightning.*

Commentary

At a short distance the sound is brief, sharp and violent. When a lightning discharge to ground is very close, a sound of short duration like that of tearing paper followed by a second sound like "vit" can often be distinguished before the sharp final crack.

From a distant discharge, the thunder is heard as a dull rumbling or a prolonged roll which varies in strength. The duration of a roll of thunder, except in mountainous regions, rarely exceeds 30 to 40 seconds.

Owing to the difference between the speeds of propagation of light and sound, lightning is seen before the associated thunder is heard. The time interval increases with increasing distance between place of discharges and observer. When the distance exceeds twenty kilometres (12 miles) thunder is not heard. Sometimes thunder is not audible even when the discharge occurs at appreciably shorter distance; this is due to the refraction of sound waves in the lower layers of the atmosphere.

(2) SAINT ELMO'S FIRE

***Definition***

*A more or less continuous, luminous electrical discharge of weak or moderate intensity in the atmosphere, emanating from elevated objects at the Earth's surface (lightning conductors, wind-vanes, masts of ships) or from aircraft in flight (wing tips, propellers, etc.).*

Commentary

This phenomenon may be observed when the electrical field near the surface of objects becomes strong. It often appears in the form of violet or greenish plumes or egrets, clearly visible at night.

(3) POLAR AURORA

***Definition***

*A luminous phenomenon which appears in the high atmosphere, in the form of arcs, bands, draperies or curtains.*

Commentary

Polar aurorae are due to electrically charged particles ejected from the sun during solar eruptions, acting on the rarefied gases of the higher atmosphere. The particles are channeled by the Earth's magnetic field, so that polar aurorae are most frequently observed in the vicinity of the magnetic poles. Measurements have indicated that the altitude of the lower limit of polar aurora is approximately 100 kilometres (62 miles) [occasionally as low as 60 kilometres (37 miles)], while the upper limit ranges between 100 and 400 kilometres (62 and 250 miles) [occasionally as high as 1 000 kilometres (620 miles)].

The luminance of polar aurorae is very variable; it is often comparable with that of clouds illuminated by the full moon, but may occasionally be much greater.

The colour of polar aurora is in most cases white with greenish or greenish-yellow tinge. Sometimes this tinge extends throughout the aurora, except for lower red fringes.

# III.3 — OBSERVATION OF METEORS OTHER THAN CLOUDS FROM THE EARTH'S SURFACE

III.3.1

## Introduction

The observation of meteors other than clouds should include the identification of the meteors, the measurement, whenever possible, of their characteristic elements and, for certain meteors, the identification of the clouds with which they are associated. The record should include the intensity, form, times of appearance and disappearance and of any marked changes during the period of occurrence.

The importance of continuous observation is emphasized.

III.3.2

## Observation of hydrometeors other than clouds

These hydrometeors may occur in the form of particles suspended in the atmosphere (e.g., fog), of precipitations (e.g., rain, drizzle, snow, hail), of particles raised by the wind (e.g., drifting or blowing snow, spray) or else in the form of deposits (e.g., dew, hoar-frost, rime, glaze). In the case of precipitation, mention should be made as to whether it is more or less uniform (intermittent or continuous) or of the showery type. For special studies, samples of rain water may be kept for analysis. Exceptionally big hailstones should be weighed and measured and, if possible, photographed whole and in cross-sections.

Photographs of hydrometeors in the form of deposits may be of value. The thickness of layers of rime or glaze should be measured.

When a spout is observed, the height, diameter, sense of rotation and path of the cloud funnel (tuba) should be noted. It might also be of importance to obtain information about any damage done.

III.3.3

## Observation of lithometeors

Lithometeors may occur as particles raised from the ground (e.g. drifting or blowing dust or sand, dust storm or sandstorm), or as particles almost suspended in the atmosphere (haze, dust haze or smoke).

Whenever possible, records should include information regarding the height to which the meteor extends and any abnormal colouring.

III.3.4

## Observation of photometeors

Detailed descriptions, accompanied if possible by drawings and photographs, should be given of important or exceptional photometeors. As already stated, photometeors associated with clouds should be recorded with the cloud observations.

Special devices, such as polarizing glasses and a black mirror, recommended for observing clouds (paragraph II.7.1) are also very useful for observing photometeors.

III.3.5

### Observation of electrometeors

Records of lightning should include information as to the type, intensity, frequency of flashes and the range of azimuths over which discharges are observed; time between lightning and thunder should also be noted. Care should be taken to distinguish between lightning and its possible reflection on clouds or haze.

In the case of Saint Elmo's fire, it should be stated whether the phenomenon appears in a cloud, in precipitation or in clear air, etc.

Exceptional polar aurorae should be described in detail.

# APPENDICES

# APPENDIX I

## ETYMOLOGY OF LATIN NAMES OF CLOUDS

### 1. GENERA

CIRRUS — From the Latin *cirrus*, which means a lock of hair, a tuft of horsehair, a bird's tuft.

CIRROCUMULUS — From the Latin *cirrus* and *cumulus*.

CIRROSTRATUS — From the Latin *cirrus* and *stratus*.

ALTOCUMULUS — From the Latin *altum*, which means height, upper air, and *cumulus*.

ALTOSTRATUS — From the Latin *altum* and *stratus*.

NIMBOSTRATUS — From the Latin *nimbus*, which means rainy cloud, and *stratus*.

STRATOCUMULUS — From the Latin *stratus* and *cumulus*.

STRATUS — From the Latin *stratus*, past participle of the verb *sternere*, which means to extend, to spread out, to flatten out, to cover with a layer.

CUMULUS — From the Latin *cumulus*, which means an accumulation, a heap, a pile.

CUMULONIMBUS — From the Latin *cumulus* and *nimbus*.

### 2. SPECIES

FIBRATUS — From the Latin *fibratus*, which means fibrous, possessing fibres, filaments.

UNCINUS — From the Latin *uncinus*, which means hooked.

SPISSATUS — From the Latin *spissatus*, past participle of the verb *spissare*, which means to make thick, to condense.

CASTELLANUS — From the Latin *castellanus*, derived from *castellum*, which means a castle or the enceinte of a fortified town.

FLOCCUS — From the Latin *floccus*, which means tuft of wool, fluff or nap of a cloth.

STRATIFORMIS — From the Latin *stratus*, past participle of the verb *sternere*, which means to extend, to spread out, to flatten out, to cover with a layer, and *forma*, which means form, appearance.

NEBULOSUS — From the Latin *nebulosus*, which means full of mist, covered with fog, nebulous.

LENTICULARIS — From the Latin *lenticularis*, derived from *lenticula*, diminutive of *lens* meaning a lentil.

FRACTUS — From the Latin *fractus*, past participle of the verb *frangere*, which means to shatter, to break, to snap, to fracture.

HUMILIS — From the Latin *humilis*, which means near the ground, low, of small size.

MEDIOCRIS — From the Latin *mediocris*, which means medium, keeping to the middle.

CONGESTUS — From the Latin *congestus*, past participle of the verb *congerere*, which means to pile up, to heap up, to accumulate.

CALVUS — From the Latin *calvus*, which means bald, and, in a wider sense, is applied to something stripped or bared.

CAPILLATUS — From the Latin *capillatus*, which means having hair, derived from *capillus* which means hair.

## 3. VARIETIES

INTORTUS — From the Latin *intortus*, past participle of the verb *intorquēre*, which means to twist, to turn, to entangle.

VERTEBRATUS — From the Latin *vertebratus*, which means having vertebrae, in the form of vertebrae.

UNDULATUS — From the Latin *undulatus*, which means having waves, waved; derived from *undula*, diminutive of *unda*, which means wave.

RADIATUS — From the Latin *radiatus*, derived from the verb *radiare*, which expresses the idea of having rays, being radiant.

LACUNOSUS — From the Latin *lacunosus*, which means having holes or furrows.

DUPLICATUS — From the Latin *duplicatus*, past participle of the verb *duplicare*, and expressing the idea of doubled, repeated, something double.

TRANSLUCIDUS — From the Latin *translucidus*, which means transparent, diaphanous.

PERLUCIDUS — From the Latin *perlucidus*, which means allowing light to pass through it.

OPACUS — From the Latin *opacus*, which means shady, shadowy, thick, bushy.

## 4. SUPPLEMENTARY FEATURES AND ACCESSORY CLOUDS

INCUS — From the Latin *incus*, which means anvil.

MAMMA — From the Latin *mamma*, which means udder or breast.

VIRGA — From the Latin *virga*, which means rod, stick, branch.

PRAECIPITATIO — From the Latin *praecipitatio*, which means a fall (down a precipice).

ARCUS — From the Latin *arcus*, which means bow, arch, arcade, vault.

TUBA — From the Latin *tuba*, which means trumpet, and, in a wider sense, tube, conduit.

PILEUS — From the Latin *pileus*, which means a cap.

VELUM — From the Latin *velum*, which means sail of a ship, flap of a tent.

PANNUS — From the Latin *pannus*, which means piece of cloth, piece, shred, rag, tatter.

# APPENDIX II

## HISTORICAL BIBLIOGRAPHY OF CLOUD CLASSIFICATION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VINCENT, J. — Notes bibliographiques sur les nuages (Classification et nomenclature). *Observatoire Royal de Belgique, Annuaire Météorologique pour 1909*, tome 76, Bruxelles, 1909, pp. 126-128.

1921

BESSON, L. — La classification détaillée des nuages en usage à l'Observatoire de Montsouris. *Annales des Services Techniques d'Hygiène de la Ville de Paris*, tome 1, Paris, 1921, pp. 297-318.

1921-1937

COMMISSION INTERNATIONALE POUR L'ÉTUDE DES NUAGES. — Circulaires C.E.N. et Procès-verbaux des sessions de la Commission, de 1921 à 1937.

1923

BESSON, L. — Aperçu historique sur la classification des nuages. *Mémorial de l'Office National Météorologique de France*, n° 2, Paris, 1923.

1930

INTERNATIONAL COMMISSION FOR THE STUDY OF CLOUDS. — International Atlas of Clouds and States of the Sky, Abridged Edition for the use of Observers, Paris, 1930, 50 p. Reprinted in 1939, under the title: International Atlas of Clouds and of Types of Skies, Abridged Edition for the use of Observers.

1932

INTERNATIONAL COMMISSION FOR THE STUDY OF CLOUDS. — International Atlas of Clouds and States of the Sky, tome 1, General Atlas, Paris, 1932, 106 p. Reprinted in 1939, under the title: International Atlas of Clouds and of Types of Skies, tome 1, General Atlas.

INTERNATIONAL COMMISSION FOR THE STUDY OF CLOUDS. — International Atlas of Clouds and States of the Sky, tome 2, Atlas of Tropical Clouds, Paris, 1932, 27 p.

1949-1953

COMMITTEE FOR THE STUDY OF CLOUDS AND HYDROMETEORS. *Final Reports and Reports of sessions of the Committee*, from 1949 to 1953.

# APPENDIX III

## BIBLIOGRAPHY OF CLOUD NOMENCLATURE

The following bibliography gives brief references to books, publications or documents in which, so far as it is possible to ascertain, the various types of cloud are mentioned, described or studied *for the first time.*

The various types of cloud are listed in the same order as in the Table of Classification of Clouds at the beginning of Part II of the present Volume.

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### 1. Cirrus

CIRRUS

— HOWARD 1803.
On the modifications of clouds, etc., l.c. Appendix II.

CIRRUS FIBRATUS

— This type of cloud was initially called *Cirrus filosus* by CLAYTON in 1896 (Discussion of the cloud observations, etc., l.c. Appendix II).

— The use of the term *filosus* was extented to Cirrocumulus and to Altocumulus by BESSON in 1921 (La classification détaillée des nuages, etc., l.c. Appendix II).

— The term *filosus* was applied to Cirrostratus by the INTERNATIONAL COMMISSION FOR THE STUDY OF CLOUDS (C.E.N.) in 1930 (International Atlas of Clouds and States of the Sky, Abridged Edition for the use of Observers, etc., l.c. Appendix II).

— In 1951 [1] the COMMITTEE FOR THE STUDY OF CLOUDS AND HYDROMETEORS (C.C.H.) replaced the term *filosus* by the term *fibratus* which is etymologically preferable. Moreover, the use of this term was limited to Cirrus and to Cirrostratus (Reports of the third session, Paris, January 1951).

CIRRUS UNCINUS

— MAZE 1889.
Sur la classification des nuages, etc., l.c. Appendix II.

CIRRUS SPISSATUS

— The appellation *Cirrus spissatus* was introduced by C.C.H. in 1949 (Final Report of the first session, Paris, August 1949). It replaced both the following two appellations:

— *Cirrus densus*, introduced by BESSON in 1921 (La classification détaillée des nuages en usage à l'Observatoire de Montsouris, etc., l.c. Appendix II);

— *Cirrus nothus*, introduced by C.E.N. in 1926 (Reports of the session in Paris, April 1926, published in Circular 47 of C.E.N.).

CIRRUS CASTELLANUS

— The term *castellatus* (subsequently replaced by the term *castellanus*) was introduced by LEY in 1879, in the appellation *Stratus castellatus* (Clouds and weather signs, etc., l.c. Appendix II).

— In 1903, VINCENT described in detail Altocumulus castellatus (Études sur les nuages: III. Les variétés de l'alto-cumulus, etc., l.c. Appendix II).

— In 1951, C.C.H. replaced the term *castellatus* by the term *castellanus* which is etymologically preferable to it. The use of this term was extended to Cirrus, Cirrocumulus and Stratocumulus (Reports of the third session, Paris, January 1951).

[1] The dates referring to C.C.H., mentioned in the present Appendix, are those of the sessions of C.C.H. which were held from 1949 to 1953. On the other hand, in Part II.3: "Descriptions of Clouds", the dates of the sessions of C.C.H. have been replaced by the date of dissolution of this Committee (1953).

CIRRUS FLOCCUS

— The term *floccus* was introduced by VINCENT in 1903, in the appellation *Altocumulus floccus* (Études sur les nuages: III. Les variétés de l'alto-cumulus, etc., l.c. Appendix II).

— In 1930, C.E.N. extended the use of this term to Cirrus (International Atlas of Clouds and States of the Sky, Abridged Edition, etc., l.c. Appendix II).

— The term *floccus* was later applied to Cirrocumulus by C.C.H. (Final Report of the second session, Paris, June 1950).

CIRRUS INTORTUS

— The term *intortus*, applied to Cirrus, was introduced by C.C.H. in 1951 (Reports of the third session, Paris, January 1951).

CIRRUS RADIATUS

— The term *radiatus* was introduced by C.E.N. in 1926, and it was applied to Cirrus, Altocumulus and to Stratocumulus (Reports of the session in Paris, April 1926, published in Circular 47 of C.E.N.).

— In 1949, C.C.H. extended the use of this term to Altostratus (Final Report of the first session, Paris, August 1949).

— During the final editing of the Atlas, the use of the term *radiatus* was extended to Cumulus.

CIRRUS VERTEBRATUS

— The cloud form *vertebratus* was described by MAZE in 1889, under the appellation *striga pennata* which means: (cloud) band having the appearance of a bird feather, fern leaf, skeleton of a fish, etc. (Sur la classification des nuages, etc., l.c. Appendix II).

— The appellation *Cirrus vertebratus* was introduced by OSTHOFF, in 1905 (Die Formen der Cirruswolken, etc., l.c. Appendix II).

CIRRUS DUPLICATUS

— The appellation *Cirrus duplicatus* was introduced by MAZE in 1889 (Sur la classification des nuages, etc., l.c. Appendix II).

— In 1908, DE QUERVAIN described in detail Altostratus duplicatus (Beiträge zur Wolkenkunde, etc., l.c. Appendix II).

— The use of the term *duplicatus* was later extended to Cirrostratus and to Altocumulus by C.C.H. (Final Report of the second session, Paris, June 1950).

— During the final editing of the Atlas, the use of the term *duplicatus* was extended to Stratocumulus.

## 2. Cirrocumulus

CIRROCUMULUS

— HOWARD 1803.
On the modifications of clouds, etc., l.c. Appendix II.

— RENOU 1855.
Instructions météorologiques, etc., l.c. Appendix II.

CIRROCUMULUS STRATIFORMIS

— The term *stratiformis* was introduced by C.C.H. in 1949, and it was applied to Cirrocumulus, Altocumulus and Stratocumulus (Final Report of the first session, Paris, August, 1949).

CIRROCUMULUS LENTICULARIS

— The term *lenticularis* was introduced by LEY in 1894, in the appellation *Stratus lenticularis* (Cloudland, etc., l.c. Appendix II).

— In 1930, C.E.N. extended the use of this term to Cirrocumulus, Cirrostratus, Altocumulus and to Stratocumulus (International Atlas of Clouds and States of the Sky, Abridged Edition, etc., l.c. Appendix II).

— C.C.H. subsequently limited the use of the term *lenticularis* to Cirrocumulus, Altocumulus and Stratocumulus (Final Report of the first session, Paris, August 1949).

CIRROCUMULUS CASTELLANUS — LEY 1879 and C.C.H. 1951.
Same references as for Cirrus castellanus.

CIRROCUMULUS FLOCCUS — VINCENT 1903 and C.C.H. 1950.
Same references as for Cirrus floccus.

CIRROCUMULUS UNDULATUS — The appellation *Cirrocumulus undulatus* was introduced by CLAYTON in 1896. Although the author has not mentioned other genera, he has stressed the fact that "this characteristic of clouds is found at every altitude" (Discussion of the cloud observations, etc., l.c. Appendix II).

— The use of the term *undulatus* was explicitly extended to Cirrus, Altocumulus, Altostratus, Stratocumulus, Stratus and Cumulus, by C.E.N. in 1930 (International Atlas of Clouds and States of the Sky, Abridged Edition, etc., l.c. Appendix II).

— C.C.H. subsequently limited the use of this term to Cirrocumulus, Altocumulus, Altostratus, Stratocumulus and Stratus (Final Report of the second session, Paris, June 1950).

— During the final editing of the Atlas, the use of the term *undulatus* was extended to Cirrostratus.

CIRROCUMULUS LACUNOSUS — The cloud form *lacunar* was described by VINCENT in 1903, and this term was applied to Cirrus, Cirrocumulus and Cirrostratus (Études sur les nuages: I. Les nuages lacunaires, etc., l.c. Appendix II).

— The term *lacunaris* was introduced by C.E.N. in 1930, and only applied to Cirrocumulus and to Altocumulus (International Atlas of Clouds and States of the Sky, Abridged Edition, etc., l.c. Appendix II).

— In 1951, C.C.H. replaced the term *lacunaris* by the term *lacunosus* which is etymologically preferable to it (Reports of the third session, Paris, January 1951).

— During the final editing of the Atlas, the use of the term *lacunosus* was extended to Stratocumulus.

## 3. Cirrostratus

CIRROSTRATUS — HOWARD 1803 and RENOU 1855.
Same references as for Cirrocumulus.

CIRROSTRATUS FIBRATUS — CLAYTON 1896, C.E.N. 1930 and C.C.H. 1951.
Same references as for Cirrus fibratus.

CIRROSTRATUS NEBULOSUS — The appellation *Cirrostratus nebulosus* was introduced by CLAYDEN in 1905 (Cloud studies, etc., l.c. Appendix II).

— The term *nebulosus* was later applied to Stratus by C.C.H. (Final Report of the second session, Paris, June 1950).

CIRROSTRATUS DUPLICATUS — MAZE 1889, DE QUERVAIN 1908 and C.C.H. 1950.
Same references as for Cirrus duplicatus.

CIRROSTRATUS UNDULATUS — CLAYTON 1896 and C.C.H. 1953.
Same references as for Cirrocumulus undulatus.

## 4. Altocumulus

ALTOCUMULUS — RENOU 1870.
Bulletin de l'Observatoire de Montsouris, Paris, 1870.

— HILDEBRANDSSON 1889.
Rapport sur la classification des nuages, etc., l.c. Appendix II.

ALTOCUMULUS STRATIFORMIS — C.C.H. 1949.
Final Report of the first session, Paris, August 1949.

ALTOCUMULUS LENTICULARIS — LEY 1894, C.E.N. 1930 and C.C.H. 1949.
Same references as for Cirrocumulus lenticularis.

ALTOCUMULUS CASTELLANUS — LEY 1879, VINCENT 1903 and C.C.H. 1951.
Same references as for Cirrus castellanus.

ALTOCUMULUS FLOCCUS — VINCENT 1903.
Étude sur les nuages: III. Les variétés de l'alto-cumulus, etc., l.c. Appendix II.

ALTOCUMULUS TRANSLUCIDUS — The term *translucidus* was introduced by C.E.N. in 1926, in the appellation *Altostratus translucidus* (Reports of the session in Paris, April 1926, published in Circular 47 of C.E.N.).

— In 1930, C.E.N. extended the use of this term to Altocumulus and to Stratocumulus (International Atlas of Clouds and States of the Sky, Abridged Edition, etc., l.c. Appendix II).

— The term *translucidus* was later applied to Stratus by C.C.H. (Final Report of the second session, Paris, June 1950).

ALTOCUMULUS PERLUCIDUS — The term *perlucidus*, applied to Altocumulus and to Stratocumulus, was introduced by C.C.H. in 1951 (Reports of the third session, Paris, January 1951).

ALTOCUMULUS OPACUS — The term *opacus* was introduced by BESSON in 1921, in the appellation *Altostratus opacus* (La classification détaillée des nuages en usage à l'Observatoire de Montsouris, etc., l.c. Appendix II).

— In 1930, C.E.N. extended the use of this term to Altocumulus and to Stratocumulus (International Atlas of Clouds and States of the Sky, Abridged Edition, etc., l.c. Appendix II).

— The term *opacus* was later applied to Stratus by C.C.H. (Final Report of the second session, Paris, June 1950).

ALTOCUMULUS DUPLICATUS — MAZE 1889, DE QUERVAIN 1908 and C.C.H. 1950.
Same references as for Cirrus duplicatus.

ALTOCUMULUS UNDULATUS — CLAYTON 1896, C.E.N. 1930 and C.C.H. 1950.
Same references as for Cirrocumulus undulatus.

ALTOCUMULUS RADIATUS — C.E.N. 1926.
Reports of the session in Paris, April 1926, published in Circular 47 of C.E.N.

ALTOCUMULUS LACUNOSUS — VINCENT 1903, C.E.N. 1930 and C.C.H. 1951.
Same references as for Cirrocumulus lacunosus.

## 5. Altostratus

ALTOSTRATUS — RENOU 1877.
Bulletin de l'Observatoire de Montsouris, Paris, 1877.

— HILDEBRANDSSON 1889.
Rapport sur la classification des nuages, etc., l.c. Appendix II.

ALTOSTRATUS TRANSLUCIDUS — C.E.N. 1926.
Reports of the session in Paris, April 1926, published in Circular 47 of C.E.N.

ALTOSTRATUS OPACUS — BESSON 1921.
La classification détaillée des nuages en usage à l'Observatoire de Montsouris, etc., l.c. Appendix II.

ALTOSTRATUS DUPLICATUS — MAZE 1889 and DE QUERVAIN 1908.
Same references as for Cirrus duplicatus.

ALTOSTRATUS UNDULATUS — CLAYTON 1896, C.E.N. 1930 and C.C.H. 1950.
Same references as for Cirrocumulus undulatus.

ALTOSTRATUS RADIATUS — C.E.N. 1926 and C.C.H. 1949.
Same references as for Cirrus radiatus.

## 6. Nimbostratus

NIMBOSTRATUS — C.E.N. 1930.
International Atlas of Clouds and States of the Sky, Abridged Edition, etc., l.c. Appendix II.

## 7. Stratocumulus

STRATOCUMULUS — KAEMTZ 1840.
Vorlesungen über Meteorologie, etc., l.c. Appendix II.

STRATOCUMULUS STRATIFORMIS — C.C.H. 1949.
Final Report of the first session, Paris, August 1949.

STRATOCUMULUS LENTICULARIS — LEY 1894, C.E.N. 1930 and C.C.H. 1949.
Same references as for Cirrocumulus lenticularis.

STRATOCUMULUS CASTELLANUS — LEY 1879 and C.C.H. 1951.
Same references as for Cirrus castellanus.

STRATOCUMULUS TRANSLUCIDUS — C.E.N. 1926 and C.E.N. 1930.
Same references as for Altocumulus translucidus.

STRATOCUMULUS PERLUCIDUS — C.C.H. 1951.
Reports of the third session, Paris, January 1951.

STRATOCUMULUS OPACUS — BESSON 1921 and C.E.N. 1930.
Same references as for Altocumulus opacus.

STRATOCUMULUS DUPLICATUS — MAZE 1889, DE QUERVAIN 1908 and C.C.H. 1953.
Same references as for Cirrus duplicatus.

STRATOCUMULUS UNDULATUS — CLAYTON 1896, C.E.N. 1930 and C.C.H. 1950.
Same references as for Cirrocumulus undulatus.

STRATOCUMULUS RADIATUS — C.E.N. 1926.
Reports of the session in Paris, April 1926, published in Circular 47 of C.E.N.

STRATOCUMULUS LACUNOSUS — VINCENT 1903, C.C.H. 1951 and C.C.H. 1953.
Same references as for Cirrocumulus lacunosus.

## 8. Stratus

STRATUS — HOWARD 1803.
On the modifications of clouds, etc., l.c. Appendix II.

— HILDEBRANDSSON 1887.
Remarks concerning the nomenclature of clouds for ordinary use, etc., l.c. Appendix II.

STRATUS *(continued)* — ABERCROMBY 1887.
Suggestions for an international nomenclature of clouds, etc., l.c. Appendix II.

STRATUS NEBULOSUS — CLAYDEN 1905 and C.C.H. 1950.
Same references as for Cirrostratus nebulosus.

STRATUS FRACTUS — This type of cloud was initially called *Fractostratus* by C.E.N. in 1930 (International Atlas of Clouds and States of the Sky, Abridged Edition, etc., l.c. Appendix II).
— In 1949, C.C.H. replaced this appellation by *Stratus fractus*, which is more in accordance with other appellations of species (Final Report of the first session, Paris, August 1949).

STRATUS OPACUS — BESSON 1921 and C.C.H. 1950.
Same references as for Altocumulus opacus.

STRATUS TRANSLUCIDUS — C.E.N. 1926 and C.C.H. 1950.
Same references as for Altocumulus translucidus.

STRATUS UNDULATUS — CLAYTON 1896, C.E.N. 1930 and C.C.H. 1950.
Same references as for Cirrocumulus undulatus.

## 9. Cumulus

CUMULUS — HOWARD 1803.
On the modifications of clouds, etc., l.c. Appendix II.

CUMULUS HUMILIS — VINCENT 1907.
Atlas des Nuages, etc., l.c. Appendix II.

CUMULUS MEDIOCRIS — The term *mediocris*, applied to Cumulus, was introduced by C.C.H. in 1951 (Reports of the third session, Paris, January 1951).

CUMULUS CONGESTUS — MAZE 1889.
Sur la classification des nuages, etc., l.c. Appendix II.

CUMULUS FRACTUS — This type of cloud was initially called *Fracto-Cumulus* by POEY in 1863 (Sur deux nouveaux types de nuages observés à La Havane, etc., l.c. Appendix II).
— In 1949, C.C.H. replaced this appellation by *Cumulus fractus*, which is more in accordance with other appellations of species (Final Report of the first session, Paris, August 1949).

CUMULUS RADIATUS — C.E.N. 1926 and C.C.H. 1953.
Same references as for Cirrus radiatus.

## 10. Cumulonimbus

CUMULONIMBUS — WEILBACH 1880.
Formes des nuages en Europe septentrionale, etc., l.c. Appendix II.

CUMULONIMBUS CALVUS — C.E.N. 1926.
Reports of the session in Paris, April 1926, published in Circular 47 of C.E.N.

CUMULONIMBUS CAPILLATUS — C.E.N. 1926.
Reports of the session in Paris, April 1926, published in Circular 47 of C.E.N.

## 11. Special clouds

NACREOUS CLOUDS

— MOHN, H. 1893.
Perlemorskyer, *Videnskabselskab*, no. 10, Christiania, 1893.
Also published under the title "Irisierende Wolken" in *Meteorologische Zeitschrift*, 10. Jahrg., Berlin, 1893, pp. 80-97, 460.

NOCTILUCENT CLOUDS

— JESSE, O. 1890.
Untersuchungen über die sogenannten leuchtenden Nachtwolken, *Sitzungsberichte der Kgl. Preussischen Akad. der Wissenschaften*, Koenigsberg, 1890, 1891.

— STÖRMER, C. 1932.
Height and velocity of luminous night clouds observed in Norway, 1932. *Observatory of University of Oslo*, no. 6, Oslo, 1932.

— VESTINE, E. H. 1934.
Noctilucent clouds. *Journal of the Royal Astronomical Society of Canada*, Ottawa, July-August, September 1934, pp. 249-272, 303-317 (including extensive bibliography).

— A summary of the articles mentioned above was published in the *Bulletin of the American Meteorological Society*, vol. 16, Washington, February 1935, pp. 49-50.

# ALPHABETICAL INDEX OF WORDS AND EXPRESSIONS

In the following Index, the names of *clouds* and other *meteors* and the relevant terms and expressions are arranged in alphabetical order.

Each of the terms or expressions is followed by the number(s) of the page(s) on which it appears in this volume. These numbers are accompanied in some cases by an indication of the type of text in which the term or expression appears.

*Comments on the use of the Index*

1 — When a term or expression occurs in only one text, the figure following is that of the page number in the text.

2 — When a term or expression occurs in several texts, the page references to the texts are each preceded by an indication of the type of text. This indication is given in abridged form, in accordance with the table below.

3 — In the case of names designating *species, varieties, supplementary features* and *accessory clouds*, the information regarding these names is followed by an indication of the various *genera* with which the subdivisions or features occur and of the corresponding pages.

*Meaning of abbreviations used*

Aircr. — Clouds as seen from aircraft
Bib. — Bibliography of cloud nomenclature
Cod. — Coding of clouds in the codes $C_L$, $C_M$ and $C_H$
Def. — Definition (of a word or an expression)
Des. — Descriptions of clouds
Ety. — Etymology of Latin names of clouds
Int. — Introduction (for descriptions of clouds)
Obs. — Observation of clouds and meteors from the Earth's surface.

## INDEX