W O R L D M E T E O R O L O G I C A L O R G A N I Z A T I O N

COMMISSION FOR INSTRUMENTS AND METHODS OF OBSERVATION

TASK TEAM ON REVISION OF THE INTERNATIONAL CLOUD ATLAS

First Session

Geneva, Switzerland

18 to 22 November 2013

FINAL REPORT

DISCLAIMER

Regulation 43

Recommendations of working groups shall have no status within the Organization until they have been approved by the responsible constituent body. In the case of joint working groups the recommendations must be concurred with by the presidents of the constituent bodies concerned before being submitted to the designated constituent body.

Regulation 44

In the case of a recommendation made by a working group between sessions of the responsible constituent body, either in a session of a working group or by correspondence, the president of the body may, as an exceptional measure, approve the recommendation on behalf of the constituent body when the matter is, in his opinion, urgent, and does not appear to imply new obligations for Members. He may then submit this recommendation for adoption by the Executive Council or to the President of the Organization for action in accordance with Regulation 9(5).

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EXECUTIVE SUMMARY

The first session of the CIMO Task Team on Revision of the International Cloud Atlas (TT-ICA) was held from 18 to 22 November 2013 at the WMO Headquarters in Geneva, Switzerland.

After commencing with a brief report from the Chair of the TT-ICA, Dr Steve Cohn, in which he praised the dedication, diligence and team spirit of the Task Team over the previous four months, the session was provided with a presentation by the Chair of the ICG-WIGOS Task Team on WIGOS Regulatory Material, to set the context within which revision of the International Cloud Atlas, Volume I of which comprises Annex 1 of the WMO Technical Regulations, was being considered by CIMO. The session next revisited its Terms of Reference and Work Plan, to ensure its work over the preceding months had addressed all matters assigned to it.

Each task leader then provided a summary of the work performed under their assigned task, the conclusions reached by the sub-group that had addressed that task, and the implications for the proposal that the Task Team would submit to the CIMO Management Group (CIMO-MG) in regard to revision of the ICA. The work and conclusions of each task group was discussed in detail by the session, in the broader context of the work performed under all tasks. An overall proposal to CIMO-MG was agreed to, as was a suggested strategy on how best to implement the required work efficiently and effectively, and an estimate of the resources required to carry out the work was prepared.

The session then drafted its final report and agreed to prepare by correspondence before the end of the year its final report to CIMO MG-11, which is scheduled to be held in Geneva during March 2014.

AGENDA

1. **ORGANIZATION OF THE SESSION**

    1.1 Opening of the Session
    1.2 Adoption of the Agenda
    1.3 Working Arrangements of the Session

2. **REPORT OF THE CHAIR**

3. **THE WIGOS FRAMEWORK CONTEXT: UPDATING WMO REGULATORY MATERIAL**

4. **REVIEW OF TERMS OF REFERENCE AND WORK PLAN**

5. **REVIEW OF THE SUITABILITY OF THE CURRENT ICA (TASK 1)**

6. **REVIEW OF THE ICA GRAPHICAL DECISION AID (TASK 2)**

7. **SURVEY OF MEMBER REQUIREMENTS (TASK 3)**

8. **WEB SURVEY OF ALTERNATIVE CLOUD ATLASES (TASK 4)**

9. **CLOUD IMAGE METADATA AND TEMPLATE (TASK 5)**

10. **DIGITIZATION OPPORTUNITIES INCL NEW CLASSIFICATIONS (TASK 6)**

11. **RESOURCE ESTIMATION FOR THE PROPOSED SOLUTION**

12. **FINAL REPORT TO CIMO MANAGEMENT GROUP**

13. **DRAFT REPORT OF THE SESSION**

14. **CLOSURE OF THE SESSION**

GENERAL SUMMARY

1. ORGANIZATION OF THE SESSION

1.1 Opening of the Session

1.1.1 The first session of the CIMO Task Team on Revision of the International Cloud Atlas (TT-ICA) was opened on Monday 18 November 2013 at 9:00am, by its Chair, Dr Stephen Cohn, who greeted the participants and commended them for their hard work during the preceding months. Dr Cohn noted with pleasure that all but one of the active members of the Task Team were in attendance. He passed on the apologies of Ms Colleen Rae, who had been unable to participate in the meeting due to a number of prior commitments in South Africa. The list of participants in the session is provided in Annex I.

1.1.2 Dr Ondras then welcomed the participants to Geneva. He noted the ICA connection with WIGOS and the WMO Regulatory Material, and stressed the connection of the work of the Task Team to WIGOS, one of five priorities of WMO. He noted that a key activity under the WIGOS Framework Implementation is updating the WMO Regulatory Material. He reminded the participants that Volume I of the ICA comprises Annex 1 of the WMO Technical Regulations, and requested them to consider during the session whether this should remain the case, or whether the ICA should instead comprise part of the WIGOS regulatory material. Should the ICA be updated, and if so how? He noted that the members of the Task Team had each been selected because of their wealth of expertise in this area and had been working very well together. He also noted that the ICG-WIGOS Task Team on WIGOS Regulatory Material would be meeting during the following week and would welcome a brief from TT-ICA, and that ICG-WIGOS-3 is scheduled to be held in February 2014 and would benefit from a report on the findings of TT-ICA. He thanked the participants for their contribution and wished them a successful session.

1.2 Adoption of the Agenda

In consideration of the provisional Agenda for the meeting, the Chair suggested that the first part of Item 12 be considered immediately after Item 3, to ensure the session kept its Terms of Reference and Work Plan closely in mind during the coming week. With this change, the Agenda was adopted as reproduced at the beginning of this report.

1.3 Working Arrangements for the Session

The working hours and tentative timetable for the meeting were agreed upon.

2. REPORT OF THE CHAIR

2.1 Dr Cohn delivered his report to the session. He noted that the team had been assembled only in July and that it was a good and diverse group of experts who were very familiar with the ICA. He described how the team has had a very aggressive schedule of work from August to October, on which it had made very good progress. He reminded the session that its primary goal is to provide the CIMO MG with advice on the need for web-based adaptation of the ICA, what that should involve, and what it should contain.

2.2 Dr Cohn briefly described the seven tasks that the work had been divided into:

- A review of the suitability of the current ICA;
- A review of the graphical decision aid contained in Volume I of the current ICA;
- A survey of WMO Member requirements in regard to revision of the ICA;
- A survey and examination of alternative cloud atlases currently available on the web;

- Preparation of a template for cloud images for a revised ICA and specification of the metadata to accompany each image;
- An examination of opportunities for enhancement of the ICA (new classifications, more imagery, etc.);
- Preparation of a detailed report to the CIMO-MG-11, to be held in March 2014, which recommends a course of action for the ICA and provides an estimate of the resources expected to be required to carry out the work.

2.3 Dr Cohn advised the session that he had provided a brief report of the work of the team thus far to the CIMO Guide Editorial Board meeting held the previous week in Geneva, at which he asked the Board to consider whether it should be responsible for more than just the CIMO Guide. He reported that the Editorial Board was of the view that this was a matter for the Management Group to provide direction on.

2.4 Dr Cohn closed by reminding the session that there was much to accomplish during the session, with the expectation that most of the work of the Task Team should be completed by the end of the week.

3. THE WIGOS FRAMEWORK CONTEXT: UPDATING WMO REGULATORY MATERIAL

3.1 Mr Russell Stringer, Chair of the ICG-WIGOS Task Team on WIGOS Regulatory Material (TT-WRM), provided the session with a brief presentation describing the context in which the session should address its work, and about the parallel work currently underway by the TT-WRM to update the WMO Regulatory Material to reflect the implementation of the WIGOS Framework.

3.2 Mr Stringer described WIGOS as a collective identity for all observing systems and as providing a framework for integration, interoperability, optimal evolution and the achievement of best practices for observing systems. He noted the ten key activity areas on which WIGOS framework implementation is focused, highlighting in particular the revision of the WMO regulatory material to better reflect the integrated approach of WIGOS to observing system operation and management.

3.3 Mr Stringer described the respective roles played by the WMO Technical Regulations and, soon, their new Annex, the WIGOS Manual, in facilitating global standardization of Member's observing system practices. He pointed out the Volume I of the ICA currently comprises Annex I of the Technical Regulations, so is a particularly important WMO document. He asked the session whether it should remain as an Annex to the Technical Regulations, or whether perhaps the ICA should in future be redefined as an Annex to the WIGOS Manual. He also observed that, while the WMO Technical Regulations are particularly terse and direct, describing primarily *what* is required of Members, Volume I of the ICA tends to be descriptive and explanatory, describing *how* and *why* clouds should be observed. Should its style be more like that of the Regulatory Material? Mr Stringer concluded his presentation by asking the session to consider these questions during its deliberations, and perhaps to refer them to the CIMO Management Group should the Task Team see merit in this.

4. REVIEW OF THE TERMS OF REFERENCE AND WORK PLAN OF THE TASK TEAM

4.1 The session next briefly reviewed its Term of Reference (Annex II) and Work Plan (Annex III), to ensure that each would be addressed during the deliberations of the session and to ensure that nothing had been omitted during the course of its work over the previous four months.

5. REVIEW OF THE SUITABILITY OF THE CURRENT ICA (TASK 1)

5.1 Ms Eliane Thürig-Jenzer briefly summarized the work completed under this task during August 2013. She noted that after TT-ICA was first formed but before it had commenced its work, the ICA had been simply digitized (scanned) and posted on the WMO website, so it was this

digitized version of the ICA that the Task 1 sub-group had examined for suitability. Task 1 of the TT-ICA Work Plan was to review the current ICA, in its digital form, to

a) Assess its current suitability or shortcomings as a web-based ICA; and
b) Consider desirable features if revised (e.g. modular design, structures that facilitate multiple uses, etc.)

5.2 Ms Thürig-Jenzer described how the TT-ICA (all members) had been asked to answer both questions a) and b) above and to provide the information back to her as task leader. The consensus views were then summarized, discussed and refined during a teleconference on 22 August 2013. The main findings of the task group are as follows.

Assessment of the ICA's current suitability or shortcomings as a web-based ICA

5.3 Making the ICA electronically available, as it is now (a simply scanned version of the original hard copy document, in two large pdf files), has gone a long way in satisfying the suitability requirements. A text search facility is possible, and the language used in this excellent technical resource is short, clear and precise (e.g. definitions and descriptions).

5.4 However a number of shortcomings was identified by the Task Team which, if addressed, would better address the modern requirement for both a hard copy reference text and a web-based product. The Task Team noted the following in regard to the current ICA:

- The ICA is divided into two parts (books) Volume I and II;
- Images and technical description are separated, with the latter in Volume II;
- The document size is too large for electronic viewing (Volume I 180 pages, Volume II 212 pages);
- No hypertext links;
- User unfriendly format;
- Old-fashioned layout of the cloud decision aid and its drawings;
- Limited technical detail available with each image (e.g. height of cloud base);
- Cloud classification is shown for one climatic region only;
- Using arrows on top and right hand side of images to reference various features in the image is antiquated for web-based products;
- Quality of scanned images varies, to the extent many are not usable as a reference or teaching resource. The electronic scanning has highlighted deficiencies in some of the original photography. About half the black and white images are very poor as digital images; varying success has been achieved with the colour images, but there are a lot of white balance issues, etc.;
- Especially for inexperienced observers, defining the species is difficult when there are several cloud types in the one image.

Consideration of desirable features to capture if the ICA is revised (e.g. modular design, structures that facilitate multiple uses, etc)

5.5 The desirable features identified by the Task Team are described under separate headings below, including images and their description and explanation; imagery in general; a description of the desired metadata; the structure and layout of how a web-based ICA should facilitate multiple uses.

5.6 ***Images in relation to their description:***

- Combine descriptive and explanatory text with a few images of each genera, species, variety;
- Have a comprehensive image library available for each genera, species, variety etc. that is available by selecting, rather than displayed by default;

- Include as many graphics as possible rather than, or in addition to, tables. For example, graphics of the polar, temperate and tropical tropopause showing the height ranges of the étages within these regions (as on p. 35 of Volume I);
- The same cloud classification should be shown for different regions (polar, midlatitude, tropical) where they can differ in appearance;
- Include more examples of cloud pictures from around the world, including pictures from satellite and radar, showing cloud from a different vantage point;
- Highlight signs of possible dangerous weather phenomena. Include comments on the importance of watching a cloud for different purposes - consider the interests of different people;

5.7 ***Images, graphics in general***

- Images must be of the technical excellence achieved in the current Volume II. (e.g. good examples of C_L2 evolving into C_L3 before reaching C_L9 as seen on pages 15, 16 and 17) ;
- Images must demonstrate photographic excellence. That is, subject in focus, no white balance issues, suitable contrast, a ground-based point of reference etc.; Consider the difficulty in estimating cloud height;
- Video clips and time lapse imagery would be invaluable and very welcome for teaching purposes. They pick up detail that is not apparent with a casual 1 minute glance at the sky let alone a still image, it can show the transition of C_L2 to C_L3 to C_L9; it can show the constantly changing appearance of C_M4, which is rarely evident to the naked eye;
- The opportunity should be available to compare two or more pictures at a time;
- An alternative method of clearly highlighting particular details in an image should be provided without obscuring the image, rather than using the arrows currently used.

5.8 ***Enhanced metadata***

- A more comprehensive explanation of each image (metadata) is desirable, which could include surface air and dew point temperatures for low étage clouds, mean sea level pressure analysis, aerological sounding or measure of stability, radar imagery if the cloud is precipitating, manual estimation of height of cloud base height and ceilometer data (if available), etc.

5.9 ***Structure and layout***

- The ICA should be a single web-based product of a modular format with a sophisticated search engine;
- It must remain simple and clear, have a good Web-Menu page with self-explanatory navigation and to go back "home" rapidly;
- The decision aid should be updated into a flow chart with distinctive graphics (infographics).
- The ICA should cater for different levels of users weather professionals, novices and keen;
- The ICA should be also accessible as a .pdf file for attractive hardcopy or reading on portable devices;
- Selected pieces of information should be accessible and printable separately, e.g. Volume I, one and/or all clouds and meteors with their reference image and technical description, the graphical decision aid;
- User friendly switching between different languages should be provided for.

Conclusion

5.10 The ICA should meet both the requirements of a web-based document and the high demands of a precise, short and clear manual. Keeping all ICA users in mind, the revised ICA should serve as the primary, authoritative reference for all observers, a basic manual for instruction and a reference-book for user consultation, and while mainly for professional observers, it should also cater to non-professionals. The desirable features include more visual objects (e.g. photos,

time lapse images, graphics, video clips, navigation aids), enhanced information about the images, a self-explanatory navigation facility (e.g. links between images and technical description) and a user friendly search engine to enable users to simply and quickly locate the particular information they seek.

6. REVIEW OF THE ICA GRAPHICAL DECISION AID (TASK 2)

6.1 Ms Marinés Campos summarized the work completed under this task during August 2013 on behalf of the Task Lead, Ms Colleen Rae. Task 2 of the TT-ICA Work Plan was to ascertain the suitability of and need for revision of the graphical decision aid currently contained in Volume I, Part II, Section II.8.3 (page 99-101) (reproduced in Annex IV).

6.2 The pictorial tree is used in training meteorological professionals to provide a rapid graphical method of coding (the code specifications and coding procedures are provided in Volume I, Part II, Section II.8.2.). The current diagram consists of a number of small boxes and illustrations (schematic drawings in black and white). Each picture illustrates the state of the sky corresponding to the code figure (displayed in the top right hand corner.) The pictures and boxes are connected by arrows. The boxes contain brief criteria to be considered in succession until the correct code figure is found.

The work performed

6.3 The Task Team analyzed:

- Whether there is still a need for manual cloud coding pictorial guides;
- If the pictorial guides are suitable;
- If cloud physics or observational meteorology has changed such that any or all of the pictorial guides are no longer suitable;
- If the pictorial guide would benefit by inclusion of updated illustrations and/or cloud images;
- Whilst not within the terms of reference, if the table of symbols for clouds corresponding to the figures of the C_L, C_M and C_H would benefit by the inclusion of appropriate cloud illustrations and/or images.

Alternative Decision Aid diagrams in use:

6.4 During the course of its work, the Task Team identified the following alternative decision aids in use around the world:

- http://www.metoffice.gov.uk/media/pdf/r/i/Cloud_types_for_observers.pdf The UK Met Office has a decision tree with images. The drawings are very precise and can enhance certain cloud features so should be kept alongside the images.
- http://www.rmets.org/weather-and-climate/observing/interactive-cloud-key The Royal Meteorological Society ”Online Cloud Identification Guide” is an example of a decision tree limited to genus identification.
- http://www.meteoschweiz.admin.ch/web/de/klima/messsysteme/boden.Par.0014.DownloadFile.tmp/beobachterhandbuch.pdf This is a contemporary flow diagram from Meteoswiss with YES/NO decisions and excellent illustrations.
- Decision Aid Diagram used in the South African Weather Service’s Training Department. It has no images but includes detailed criteria for differentiating clouds.
- Decision Aid Diagram used by the Road Office (AGVP), Santa Cruz , Argentina.

Analysis and Conclusions

6.5 The Task Team found as follows:

a) Manual synoptic observations of cloud are performed regularly at over 5000 land based sites and by about 3000 ships. So there is a need to include some form of the decision aid in a new ICA.
b) The decision aid is invaluable in training meteorological professionals.

c) The concise description of each code figure is excellent; the illustrations are very good in general, most of them are very precise in highlighting certain cloud features.
d) The current guide should be revised:
   - The layout can be improved;
   - Images to accompany the schematic drawings should be included; have a classic image associate with each illustration;
   - The table of symbols for clouds corresponding to the figures of the C_L, C_M and C_H would benefit by the inclusion of appropriate cloud illustrations;
   - The special coding instruction referred to in II.8.3.1(e) page 98 should be incorporated into the C_L flow diagram (references observations when combinations of C_L 1,5,6,and 7 are present);
   - Improve the illustrations associated with C_L 1 and 4 and C_H9;
   - Small wording changes should be considered in some places, e.g.
     - C_L7 – explain what bad weather is
     - C_M4 – add “often lens shaped”
     - C_M9 – add “generally at several levels”
     - C_H1 – add “not invading”
   - The decision boxes could be improved by converting the pictorial guide into a more contemporary flow diagram format that includes YES/NO decisions.
   - A second decision aid should be included, aimed at amateur observers, and being limited to classification of genera only.

7. SURVEY OF MEMBER REQUIREMENTS (TASK 3)

7.1 Mr Ernest Lovell, Task Lead for this task, summarized the work completed under this task between August and October 2014. The task involved surveying WMO members on their views in regard to the need for a revision of the International Cloud Atlas, and to ascertain their basic needs, the features they would like to see in a revised ICA and as to whether they see a need for declassification of any existing cloud classifications or addition of new classifications.

7.2 The Task Team had agreed that the survey should be comprehensive and cover each volume of the ICA, and that it should explore Members’ views on the need for inclusion of additional sections which would be useful and applicable in a Web-based version. The Task Team had also considered that, while the survey should primarily be aimed at meteorological professionals, it should also cater for those from different disciplines and professions.

7.3 The survey was drafted by the sub-group responsible for this Task, then reviewed and revised during a Task Team teleconference. The survey questions can be found at Annex V. The web version of the survey was prepared using Survey Monkey and linked to the CIMO website. A letter was distributed to all Permanent Representatives of WMO Members requesting completion of the survey. 198 responses were received before 19 November 2013. The countries providing responses and the number of responses from each are tabulated in Annex VI.

Summary Analysis of Survey Results

7.4 **Questions 1, 2, 3 – Name, Organization and Profession:** These questions were compulsory hence a 100% response was obtained. The majority of the respondents were in the field of Meteorology, with 68% being Meteorologists and 12% Meteorological Technicians or Weather Observers. Most of the remainder were distributed between graduate students, researchers, school teachers, air traffic controllers, hydrologists and non-professionals.

7.5 **Questions 4, 5, 6, 7 – Popularity of the Atlas and the purpose for using it, as well as any alternative references if the Atlas is not being used:** Of 185 responses, the majority of the respondents (65%) use some version (volume) of the ICA, with 36% using both Volume I and Volume II, and 19% using either Volume I or Volume II. 47% use the Cloud Atlas as both an operational reference and a training manual.

7.6 **Questions 8, 9, 10** – **Would the respondent prefer a web-based version of the Cloud Atlas and would they prefer it to include an extensive library of cloud images suited to their region?** Of 168 responses, 85% indicated that would use the ICA more if it were on the World Wide Web, and a similar percentage are of the view that the ICA should have an extensive library of cloud images tailored to their climatic region.

7.7 **Questions 11, 12 – Is the current content of the Cloud Atlas just right? If not, would a web base version be more appealing if the cloud images include additional metadata (e.g. Surface temperature, MSLP analysis, aerological soundings, Stability indices, observed Height of cloud base, altitude, location of cloud relative to the sun.)** Notably, 79% of the 158 respondents agreed that the current content is just right. Of the 13% who indicated that there is too little detail in the current content, there was strong support for the addition of information on season, cloud base, stability indices and altitude above mean sea level of viewing location, and some support for surface temperature, MSLP analysis, aerological sounding and cloud location relative to sun's position.

7.8 **Questions 13, 14 – Viewing of images from different perspectives:** Of 155 respondents, 78% are of the opinion that the images should be shown from different perspectives. Of these, 72% consider that Satellite images should be included, 63% images from Aircraft, and 59% images from High Altitude (alpine) sites.

7.9 **Questions 15, 16, 17** - **Cloud classifications in terms of their Genera, Species, Varieties and Supplementary Features.** 61% of the 150 respondents consider none of the current cloud classifications to be obsolete or redundant. 26% are unsure. Of the remaining 13% (19 respondents), a wide variety of views was evident on which classifications should be removed and why. 39% of the 147 respondents answered no to a question on whether additional classifications are warranted. 43% are unsure and 18% (27 respondents) answered yes. Some of the suggestions for new classifications are:

- Volcanic and upper atmospheric (nacreous, noctilucent) clouds
- Asperatus as a supplementary feature
- Salt cloud found in Argentina which reduces the visibility and affects the soil
- Pyrocumulus dust clouds
- Cloud types as features associated with deep convection
- Ship trails

7.10 **Questions 18, 19, 20, 21, 22 – Making synoptic observations (manual or automated) and adequacy of the explanations currently given for coding cloud types CL, CM and CH.** Of 146 respondents, 77% perform synoptic observations, with 74% of 108 respondents providing some form of manual input. 83% of 82 respondents consider the current content and format of the current cloud coding scheme to be satisfactory.

7.11 **Questions 23, 24 – Requirement of respondent's organization to provide weather information to the public and interest in / willingness to contribute images to a web-based version of the ICA.** The organizations of 84% of 118 respondents are required to provide weather education to public special user groups. 62% of 141 respondents indicated interest in and/or willingness to provide imagery for the ICA. Notably, of the 34% of the remainder who are unsure, for many this is because they lack the authority to answer the question on behalf of their organization.

7.12 **Question 25 – Comments** 42 respondents provided a concluding comment. Of these, there were two main themes. The majority welcome the proposal to modernize the ICA, some noting that improvement to the ICA would be a great support to meteorologists in their understanding of the physical characteristics of clouds. Better images could be used and more detailed description of the atmospheric phenomena could be included. The other group of respondents warned against changing the ICA too much because of the need to maintain homogeneity and historical reference, noting that the existing ICA is very satisfactory. One

respondent suggested it would be good if amateurs and cloud observer organizations could contribute cloud photos.

8. WEB SURVEY OF ALTERNATIVE CLOUD ATLASES (TASK 4)

8.1 Mr Michael Bruhn, Task Leader for this task, summarized the work completed under this task during August and September 2013. The task involved performing a search for existing, alternative, web-based cloud atlases and examining the strengths and weaknesses of each, to provide guidance to be used for the other tasks.

Initial Review

8.2 More than 60 sites were identified of which 29 were shortlisted for survey based on meeting two criteria:

- Site included at least one image and a technical description of each of the 10 cloud genera.
- Images were of such quality that genera identification was possible.

These criteria excluded dozens of sites such as storm spotter/thunderstorm sites, regardless of their usually spectacular imagery.

Comprehensive Review

8.3 The shortlisted sites were then surveyed using more rigorous criteria:

i. Content of the website;
   - Multiple examples of each genera.
   - Examples of each species, variety, supplementary feature and accessory cloud.
   - Quality imagery, good resolution, in focus, colour - not black and white, good depth of field to show perspective and a ground reference for perspective.
   - Images were of meteorological excellence; i.e. classic rather than confusing examples.
   - Metadata accompanying imagery at least equivalent to that of International Cloud Atlas (ICA) Volume II.
   - Technical descriptions of cloud forms at least equivalent to and consistent with the ICA Volume I Part II – 3. (Descriptions of Clouds).
   - Accurate cloud identification.

ii. Appearance of the website;
   - Good use of colour, not colour for the sake of colour.
   - Easy to read text, sufficient contrast between text and background and an easy to read font.
   - Quality imagery.
   - Simplicity, not too much information on each page.

iii. Usability of the website;
   - Simple and well organised.
   - Minimal scrolling.
   - Consistent layout.
   - Prominent logical navigation that includes features such as back buttons and site maps.

Discussion

8.4 The comprehensive review identified that most sites fall short of these criteria in content. Most had reasonable but incomplete imagery. Technical description was extremely limited, if existing at all. A consistent feature of most of these sites was frequent incorrect classification of cloud. A review of these sites is in Annex VII.

8.5 Four sites met most but not all of the content criteria. These sites are, in no particular order:

- Wolken (Clouds) Online.
- MeteoSwiss – Visual Obs.

- SkyStef's Weather.
- UK Met Office – Cloud Type for Observers

8.6 **Wolken (Clouds) Online:** Image library is large and of excellent photographic and meteorological quality. Also includes 30 time-lapse images but these lack detail of timing of images (how many per minute) and speed of play (frames per second). Covers most of the ICA Volume I - Description of Clouds chapter but the image metadata is not consistently up to the standard of ICA Volume II. This detracts from the reader having access to the logic of how the cloud identification has been made. The site is region/country specific. It contains images from two sources, predominantly Germany with a reasonable number for the United States. Site usability could be improved by removing need to constantly use browser back button. Search engine is a positive.

8.7 **MeteoSwiss – Visual Obs:** Content includes almost complete coverage of ICA Volume I. Has comprehensive observing guidelines and aids. Images are excellent but relatively limited in number and unique to a region/country. Image metadata equals ICA Volume II. Appearance and usability of the site is excellent. Outstanding resource.

8.8 **Skystef's Weather:** Has an incomplete image library but meteorologically excellent in quality. Includes time lapse and comprehensive case studies but has limited coverage of ICA Volume I. Metadata not up to ICA Volume II standard. Hyperlinked database pages that act as a search engine enhance the usability. Lack of navigating consistency can be frustrating and pages that have a black background reduce appearance. Contains numerous time-lapse images that include images per minute and frames per second metadata.

8.9 **UK Met Office UK – Cloud Type for Observers:** Has a complete image library that varies in photographic quality; it is not consistently up to a desirable standard. Time series of images are good for displaying cloud development. Most images are of meteorological excellence. Meteorological metadata is good but would benefit from being attached to each image rather than included in bodies of text. ICA Volume I coverage meets national but not international requirement. Appearance is very good but with possibly too much text on some pages. Usability is limited as the pdf is without bookmarks.

8.10 **Sites not fully reviewed:** Komfort ABC has good technical content and image library. Usability was difficult, but the team was unable to determine if that was due to language or browser issues.

8.11 **Sites deficient in content but with an outstanding feature/s:** Two sites each had an outstanding feature that could benefit a web based WMO ICA. These features were:

- Royal Meteorological Society - cloud identification decision tree. Fool proof for determining cloud genera and concept could be improved to include species, varieties, supplementary features and accessory clouds.
- Cloud Appreciation Society – Find a Cloud/Search function. Easy to use but comprehensive database search tool based on use of image tags. Tags such as "classic example", "halos" and "pyrocumulus/ fumulus" are available.

Conclusions

8.12 No suitable alternative web-based international cloud atlas exists. There are three sites that almost equal the ICA in content. However, these sites are all limited as they were designed for a specific country or region, not international use. Two of the sites had further disadvantages in that one was inconsistent with image metadata and the other inconsistent with image quality. The remaining site, MeteoSwiss, was excellent in content, appearance and usability. It has a modern approach to illustrations and aids that would benefit a new WMO ICA.

8.13 The Task Team decided to recommend to CIMO MG that it approach Meteoswiss to enquire if WMO might use the Meteoswiss illustrations in redeveloping the ICA graphical decision aid, should WMO decide to go ahead with a revision of the ICA.

8.14 The Sub-group responsible for this task suggested the Task Team give consideration to including a search engine in the ICA similar to that used by the Cloud Appreciation Society. It also suggested that a cloud identification decision tree similar to the Royal Meteorological Society's be incorporated as it would benefit non-professional users.

9. CLOUD IMAGE METADATA AND TEMPLATE (TASK 5)

9.1 Mr. Jim Trice, Task Leader for this task, summarized the work completed under this task during September and October 2013. The task involved specifying the meta-data that should be included with each cloud image in a revised ICA, and designing a template for each cloud image to be included in the ICA.

Part 1. Specification of the metadata that should accompany each image in a new ICA.

Methodology

9.2 The main information gathering tool for this part of the task was to be the survey of WMO members, so the Task 5 sub-team helped to shape the questions for the survey in order that the relevant information was gathered. The questions in the survey relevant to Task 5 were Questions 9 through 14 inclusive (see Section 7 above and Annex V).

9.3 The results of the survey were not due to be available until November so the sub-team discussed the metadata content in the current ICA and came up with some preliminary ideas. These ideas were discussed with the Task Team as whole (via e-mail and teleconference) and a preliminary report was prepared, then refined once the results of the other tasks became available.

Conclusions

9.4 **Making more metadata available:** A web-based ICA would have significantly more scope for collecting and displaying metadata. The use of icons would prevent the page becoming cluttered, effectively hiding the metadata unless it was required by the viewer. The additional metadata could be used for the purposes of searching and cross-referencing cloud types, features, or in the case of time-lapse photography, demonstrating evolution/development. An analysis of results of the Member survey showed that there was significant backing to the concept of including more metadata (Qn 10), as well as giving guidance on which types of metadata would be more useful (Qn 12). However, the large proportion of respondents for Qn 11 which stated that the current content was 'just right' gives us reason to be cautious when considering change to the compulsory metadata or accompanying descriptions.

9.5 The task team concluded that in order to satisfy the requirement for more metadata, two extra classes of metadata should be defined (Supplementary Metadata and Search Metadata). The Compulsory Metadata should remain largely unchanged with the exception of extra data in the position field to capture lat/longs and height AMSL, and extra metadata for time-lapse photography (if used). All three classes of metadata are set out below.

9.6 **Compulsory Metadata:** These should include the following:

- Name of photogragher;
- Location;
- Date;
- Direction photograph is taken (either in compass points or relative to the sun);
- Local time;
- Accompanying description (see 9.9 below);
- Cloud Classification (in the form C_L=, C_M=, C_H=);
- Time lapse metadata (for time-lapse photography only).

9.7 **Supplementary Metadata:** These should include the following:

- Photographic metadata, e.g. wide angle shot – see recommendation 9.10);

- Surface air temperature;
- Surface dewpoint or humidity;
- Stability Indices;
- Cloud Base.

9.8 **Search metadata:** These should include the following:

- Cloud Genus;
- Cloud Species;
- Cloud Variety;
- Climatic Region, e.g., polar, temperate, tropical;
- Surface classification, e.g., marine, savannah, wetland, desert;
- Type of photography, e.g., till, time-lapse, movie;
- Common use terms/local variations; pyrocumulus, fumulous, banner cloud, whale cloud;
- Image tags, e.g. striated cloud tops, virga.

9.9 **Accompanying Descriptions:** Feedback from the task team and from the WMO member survey suggested that we should look to preserve the form and content of the accompanying descriptions. The Task 5 sub-team provided an analysis of the current accompanying descriptions by identifying features that the current descriptions have in common (see below). The Task Team as a whole concluded that these accompanying descriptions should form part of the compulsory metadata:

- Classification of the cloud(s), and very brief (<10 words) accompanying description which can include a description of pattern, weather type relevant to the photo, transitions, development;
- Description of the photograph and rationale for classification;
- Notes on formation/development/transition;
- Consideration of climatic region and/or surface type and frequency of occurrence;
- Notes on synoptic situation and how this relates to the elements observed in the photograph.
- Further guidance:
  i) The description should be brief (guideline 50-150 words). Each section can be expanded on in the 'Supplementary Reference Information' sections.
  ii) Reference should be made to all 'tags' that are in the photograph e.g. 'dark, horizontal base', 'fibrous tops', 'isolated fragments', etc.

9.10 **Photographic Metadata:** During early discussion the task team agreed that the only factor that is likely to be of significant use in still photography is whether the photo was taken in wide angle or zoomed mode. This wasn't thought to be important enough to include in the Compulsory Metadata and should therefore be captured in the Supplementary Metadata (where available). If time-lapse photography is included in the revised ICA then the following metadata must be captured: capture period (either Time Start and Time Stop, or Interval between photos) and replay rate (frame rate per second).

Part 2) Design of a template for an individual cloud image (format, accompanying description, metadata, etc).

Methodology

9.11 This part of the task commenced with consideration of the wider context of the revised ICA. Discussions focussed on the following points:

- Preserving the reference aspect of the revised ICA;
- Should the new ICA include a search function;

- Should the new ICA include more ability to reference clouds by, for example, climatic region, land surface type, convective/layered clouds, time lapse photography etc.;
- Should the new ICA include more, and different types, of metadata – see Part 1) of Task 5;
- Should the new ICA have a twiki aspect with users (or perhaps selected users) able to contribute images and metadata;
- Should the new ICA include an update to the co-ordinate system that's used to identify cloud features in the current ICA;
- Should the new ICA include a zoom function so that users can zoom in on selected parts of the cloud image;
- Guidelines on photographic composition.

After discussion with the Task Team as a whole, all suggestions were incorporated into a model template (see Annex VIII), which was further discussed by the Task Team.

Conclusions

9.12 **Reference Imagery :** The task team agreed that it would be best to preserve the current imagery in the new ICA and that the best way to do this was that in a revised ICA the best available image should be chosen as the 'front-page' for each cloud type, but with the 'reference image' (that from the current ICA) available via a 'reference imagery' icon.

9.13 **Search Function :** Search functions are common to virtually all web-pages and the Task Team considered that having a search function would add a very useful element that is missing from the pdf version of the current ICA that is available online.

9.14 **Reference Functions :** Web pages allow information to be referenced in a variety of ways via icons (e.g. polar imagery, desert imagery, maritime clouds, convective clouds, time-lapse imagery etc.). There was general agreement amongst the Task Team that the web-page should allow the imagery to be referenced in different ways. Discussion focused on what types of referencing should be included, with general agreement for the following:

- Climatic Region;
- Cloud Genus;
- Time-lapse photography;
- Maritime photography;
- Alpine photograpghy;
- Photographs taken from aircraft.;
- Satellite imagery;
- Referencing clouds that are similar (but not the same).

9.15 **Making more metadata available :** The task team was in agreement that more metadata should be made available in the new ICA. Using the web-page format and tools such as icons this extra information can be made available without cluttering the front-page for each cloud variety or making the CA less user-friendly. Discussion focused on what metadata and also whether it should be compulsory or optional. The Compulsory Metadata, Supplementary Metadata and Search Metadata classes were defined by the Task Team (see Part 1 above).

9.16 **Updating the Image Navigation Co-ordinate System :** The Task Team agreed that the existing co-ordinate system for referencing cloud features within the imagery was now looking dated. The main alternative option that was put forward was an 'image tags' system that social networking sites use, although it was noted that there are likely to be alternatives and the selection of a particular technique should be left to the design team responsible for performing the update, should it occur. N.B. Any tags used would form part of the Search Metadata.

9.17 **Zoom function :** The Task Team agreed that using a zoom function in conjunction with digital photography would give a greatly enhanced experience when looking to identify or study

particular features in a cloud. There is more than one way of accomplishing this functionality but the Task Team considered that both a zoom function and the ability to download the full-sized image would be worthy of inclusion in an updated ICA.

9.18 **Guidelines on photographic composition :** There are some conventions for photographing clouds that lead to images being captured in a way that is useful for the cloud-observer and the Task Team agreed that there should be some guidelines on photographic composition provided to those providing new imagery:

- Images should contain some ground features to enable the viewer to determine element size.
- With some genera, correct identification is only possible if as much of the celestial dome is displayed as possible. N.B. The design Team should be provided a list of these genera.
- Highly zoomed images of layered cloud should be avoided on the basis that it's not possible to verify the identification.
- The design team would need to review the requirements regarding the quality of the imagery:
    - Minimum number of colours;
    - Minimum resolution;
    - Minimum image size.

N.B. Requisite image quality will be driven how clearly photographs display on screen.

Additional Resourcing Considerations and Consequent Scaling Aspects of a Revised ICA

9.19 Assuming the ICA is to be revised, the following considerations will be important when scoping the work and taking into account available resources.

9.20 **Supplementary metadata:** The number of sets of expanded metadata (radar, satellite, radiosonde, imagery taken from aircraft, etc). Collecting and compiling expanded sets of metadata and making them available on a web format is likely to absorb significant resources. It is possible that much of this resource could be provided by Members as an in-kind contribution (by collecting the supplementary metadata) but central resources would still be required for compilation and publication. Concentrating on the following 3 scenarios may help to clarify what is practicable:

- Expanded metadata for each cloud genera (total of 10 examples)
- Expanded metadata for each cloud species/genera combination (total of 31 examples)
- Expanded metadata for each cloud species/genera/variety combination (total of approx. 100)

9.21 **Links to similar cloud types:** Providing links to different cloud types will be useful to enable users to study differences between similar clouds. The following are 2 scenarios which give a degree of scalability to this concept:

- Providing links to similar clouds can be provided fairly easily via an icon (as shown in the example template).
- Extending the concept to provide a commentary on the significant differences between the examples and a justification for the different classifications. This would provide a very useful training resource.

9.22 **Image Tags:** It is not currently clear how much central resource will be required to produce the image tags as the technical solution for this concept has not yet been decided. The main driver for the amount of central resourcing required will be whether the Members are able to create the tags or whether this needs to be done centrally:

- Central 'tagging' requires extra resource and amount of tagging may need to be limited to match the number of extra images and the resource available.

- Member ‘tagging’ would enable all extra images to be tagged in advance of being submitted to an implementation task team. In this case the amount of extra imagery for the revised ICA may need to be scaled downwards.

10. DIGITIZATION OPPORTUNITIES INCLUDINF NEW CLASSIFICATIONS (TASK 6)

10.1 Mr George Anderson, Leader of this task, summarized the work completed between September and November 2013. The task of this group was to assess the opportunities for enhancement of the ICA afforded by publication in digital form: specifically, to:
(a) determine the need for any additional new classifications to be included in the Cloud Atlas (such as 'asperatus' and 'anthropo'-clouds) and the feasibility of reporting these; and
(b) assess opportunities afforded for inclusion of more imagery.

10.2 In reviewing the contents of the current ICA, it had been noted in general that:

- Some clouds, and cloud features, named and featured in other publications, and in common English language usage, were either:
  - not included in the ICA at all,
  - not featured in sufficient detail,
  - not named, and/or
  - did not form part of the current classification scheme.
- Some aspects of the text in Volume 1 were in need of modernisation. Specifically:
  - in regard to the style of language used (i.e. to remove obsolete, old-fashioned words, no longer understood by a modern audience) and,
  - to ensure that the text was updated to take account of the latest science.

10.3 The sub-group's initial discussions were carried out by e-mail. The sub-group reported specific findings and initial conclusions to the rest of the Task Team by e-mail and these were subsequently discussed via web-conferences. Web-conference discussion resulted in conclusions and initial agreement to preliminary recommendations. The sub-group considered feedback from the WMO Members survey and also took account of conclusions resulting from the work of the other Task groups. These preliminary conclusions and recommendations were comprehensively discussed and, where necessary, further revised during the session.

General Conclusions

10.4 After lengthy discussion, the session concluded that as a **general principal, the revised edition of the International Cloud Atlas (ICA) should be the world's authoritative, primary source of cloud classification. It should be fully comprehensive and contain the most up-to-date information**. The ICA should:

- **Include all clouds within the Earth's atmosphere, viewed from the Earth's surface**. Specifically: in addition to tropospheric clouds, the ICA should comprehensively include high atmospheric clouds - i.e. stratospheric / nacreous clouds, and polar mesospheric / noctilucent clouds.
- **Define all names and terms associated with cloud features, even if not necessarily included in the formal classification scheme**. This should be done for those names not included in the official classification scheme by their inclusion in a newly added Glossary, which would be illustrated with images.

10.5 Adoption of the above principles would ensure that a new, revised ICA would be the definitive cloud classification reference document. It was considered by the session that failure to ensure that a revised Cloud Atlas is fully comprehensive, and consequently failure to meet the needs of all users, professional and amateur, could result in the proliferation of non-official cloud names (e.g., via the internet and other publications) and in users utilising other, rival cloud reference sources, which may not necessarily contain accurate information and classifications.

10.6 It was concluded that there is scope for modernisation of text and cloud classification (Volume 1) and, inclusion of new, modern photographs and associated text (Volume 2) to generally improve the quality of imagery, and also to illustrate a variety of cloud features that are currently either not included and/or not classified in the present ICA. The scope for addition of new Imagery includes:

- new photographs to provide more up-to-date, modern examples of clouds, or cloud features;
- new photographs of improved quality. This includes, in a few cases, inclusion of new 'reference' images;
- new photographs to show differences in varying geographic / climatic and topographic areas and seasonal variations;
- additional photographs to illustrate certain clouds, or specific cloud features;
- new photographs to illustrate new classifications and cloud features not previously included in the ICA;
- inclusion of time-lapse images and video clips to show the development of clouds, or cloud features with time;
- Inclusion of appropriate supporting metadata images, such as synoptic charts, satellite images, radio-sonde soundings.

Specific Conclusions

10.7 The session's deliberations next turned to more detailed consideration of new candidates for inclusion in the cloud classification scheme. In doing so, it considered at length the criteria that it must adopt for assessing whether a new classification was required for a particular candidate, or whether it might be dealt with by inclusion in a Glossary of commonly used terms, without being formally added as a new classification. The following principles were adopted:

- To warrant classification, a candidate must be unique, and not be classifiable under an existing classification (in terms of visual appearance, including transparency and macro-scale and micro-scale appearance. [Ref: ICA Volume 1, II.1]);
- To warrant classification, the second fundamental criterion, consistent with the existing classifications, is that a candidate must be visually distinctive and unique. including transparency and macro-scale and micro-scale appearance of features. [Ref: ICA Vol 1, II.1];
- Potential operational significance of a candidate strengthened its case for inclusion.

Having discussed at length these principles for consideration of new candidates, the session then reached the following conclusions.

10.8 **Asperatus:** 'Asperatus' is a visually distinctive cloud feature, which is not described by any of the current cloud classifications. In particular, it is not described by the variety 'undulatus'. The feature does not, in general, relate to macroscopic elements of clouds (Varieties) but does generally relate to microscopic elements (Supplementary Features). If the overall principles of Section 10.7 above were to be adopted, **'Asperatus' should be classified as a new Supplementary Feature**. A description for the cloud feature given in Graeme Anderson's MSc dissertation is broadly acceptable, but requires some slight modification to emphasise its difference from undulatus. An appropriate, modified description is:

- *'A formation made up of well-defined, wave-like structures in the underside of the cloud, more chaotic and with less horizontal organisation than undulatus. Asperatus is characterised by localised waves in the cloud base, either smooth or dappled with smaller features, sometimes descending into sharp points, as if viewing a roughened sea surface from below. Varying levels of illumination and thickness of cloud can lead to dramatic visual effects*.'

10.9 The feature is not considered to have any operational importance, but is visually distinctive. If adopted as a Supplementary Feature there would be no requirement to report it in the synoptic code.

10.10 **Anthropogenic clouds:** There is a case for the specific classification of clouds caused by human activities. The prime example is that of aircraft condensation trails (contrails) spreading out into persistent cirri-form clouds. Such a classification should utilise the existing 'mother-cloud' terminology. The Latin 'hominus' could be used to create a new mother-cloud: 'homogenitus'. If the principles of Section 10.7 above are to be adopted, **aircraft condensation trails (contrails) that spread out into cirri-form clouds, and other clouds (e.g. so.called 'fumulus') that are clearly observed to have originated from human activity, should be given the mother-cloud classification**: 'homogenitus'.e.g.: cirrus homogenitus; cumulus homogenitus.

10.11 Feedback effects on the earth's climate due to large areas of cirrus formed from the spreading out of contrails are, as yet, unknown. Consequently, the reporting of anthropogenic cirri-form clouds', using the synoptic code, may provide information potentially useful for future research on climate change. FM12-XII Ext. SYNOP code permits the reporting of contrails in Section 3 – Supplementary information using code tables 3778 and 2752. Code table 2752 reports the persistence, amount of sky coverage and time of commencement of the contrail/s.

10.12 **Cloud features associated with severe convective storms:** The cloud classification scheme does not recognise certain specific, well-defined, visually distinctive cloud features associated with severe convective storms. (e.g. refer to terms within "NOAA Technical Memorandum NWS SR-145 - A Comprehensive Glossary of Weather Terms for Storm Spotters").

10.13 It is an anomaly that features such as 'arcus' and 'mamma' are classified, but other potentially significant features associated with severe convective storms, such as the 'wall cloud', are not currently featured within the Cloud Atlas or included in the cloud classification scheme.

10.14 Early reporting of certain cloud features associated with severe convective storms may be important for the forecasting of severe weather. The early identification and reporting by observers of, for example, a rotating wall could have the potential for saving lives.

10.15 The session identified some candidate features. However, recognising that the Task Team does not have expertise specific to severe storms, it is recommended that an appropriate authority (e.g. National Severe Storms Laboratory, USA) should be invited to compile a short list of important cloud features of particular relevance for storm spotters. **These significant features should be added to the classification scheme as Supplementary Features**.

10.16 **Stratospheric and mesospheric clouds:** Stratospheric (nacreous) and mesospheric (noctilucent) clouds are inadequately covered in the present ICA under the heading of 'Special clouds'. Additional photographs should be included to illustrate classifications, and the text should be updated to accommodate the latest science. Following the principles of Section 10.4 above, **these clouds should be removed from the 'Special clouds' section and should instead feature in a new section specifically for high-atmospheric clouds**. Potentially, there is scope for creating a Volume 3 of the ICA to cover these clouds.

10.17 The session concluded that the full noctilucent cloud classification scheme could appropriately be included in the ICA. This would be based on the original classification document: **"**The International Noctilucent Cloud Manual (dated 1970) - WMO 250 TP138," together with the updated manual, "Observing Noctilucent Clouds", published by the International Association of Geomagnetism & Aeronomy (IAGA) in 2006. Liaison with IAGA would be required to establish an agreed way forward to update (if required) and publish the classification scheme within the ICA.

10.18 Reporting of noctilucent clouds may be of relevance to research on global climate change and/or space weather. FM12-XII Ext. SYNOP code permits the reporting of nacreous and noctilucent clouds in Section 3 – Supplementary information using code tables 3778, 0521 and 0700.

10.19 **Fallstreak holes or Hole-Punch clouds:** Fallstreak Holes (Hole-punch clouds) and Canal Clouds are considered to be visually distinctive features not presently classified within the Cloud Atlas. The formation mechanism for this cloud feature is documented in the scientific literature. The feature occurs only in thin layers of super-cooled cloud. This may have some operational relevance, such as an indication of potential for icing. The feature is characterised by a generally circular hole forming as a result of glaciation initiated in a thin layer of super-cooled altocumulus or cirrocumulus cloud. Fallstreaks (virga), or wisps of cirrus are typically observed beneath the hole as ice crystals fall out to a lower level. A similar linear (distrail) feature may occur where there has been some interaction between an aircraft and the supercooled cloud layer. After detailed discussion, the session concluded that, by the principle of section 10.7 above, these **should be added to the cloud classification scheme as a 'supplementary feature'** (possibly using the Latin 'cavus' or 'cavum' (hole, hollow)).

10.20 As a supplementary feature, there would be no requirement to report this feature in the synoptic code.

10.21 **Clouds associated with fires, volcanic eruptions and industry:** Clouds associated with fires, volcanic eruptions and industry are currently covered briefly within the ICA. There are unofficial names, widely used in English language publications, e.g. *pyrocumulus, pyrocumulonimbus.* Pyrocumulus is a cumuliform cloud that is produced naturally above bush/wild/forest fires and erupting volcanoes by the rising thermals created by heating at ground level. The prefix '*pyro-*' is derived from the Greek language, (pyr, meaning fire) and is not suitable for use in the Latin-based cloud classification scheme. **These unofficial names (illustrated with photographs) should be included within a Glossary**. In addition to above, the clouds should be given official classification compliant with the existing classification scheme, based on the use of Latin-derived suffixes *–genitus and -mutatus* as used in the 'mother-clouds'. The Latin 'flamma' or 'ignis', for fire, could be adopted. The unofficial names pyrocumulus and pyrocumulonimbus should be given new official 'Mother-cloud' classifications:

- Pyrocumulus could be classified as, e.g., cumulus flammagenitus
- Pyrocumulonimbus could be classified as, e.g., cumulonimbus flammagenitus.

10.22 *Fumulus* is a man-made pyrocumulus cloud typically forming above industrial cooling towers. Much of the moisture that rises and condenses to form cumulus cloud is emitted from the cooling towers themselves. This variant of pyrocumulus could be classified as *cumulus homogenitus.*

10.23 FM12-XII Ext. SYNOP code permits the reporting of clouds from fires and clouds from volcanic eruptions in Section 3 – Supplementary information using code tables 3778, 0521 and 0700. One of the four spare indicators in Code table 0521 (C_s – Special Clouds) could be assigned clouds formed by industry, if deemed necessary.

10.24 **Orographic clouds:** Some orographic clouds around the world have unofficial, common-language names. For example:

- 'Banner cloud' on the Matterhorn
- 'Levanter' off the Rock of Gibralter
- 'Table cloth' (Table Mountain, South Africa).
- 'Pile d'assiettes' ('pile of plates' multi-layered lenticular clouds)

These (and other well-known orographic clouds) should be specifically included, with imagery, in a Glossary.

10.25 **Roll clouds:** Roll clouds are currently recognised in ICA Volume 1, II.3.7.2, under the classification stratocumulus stratiformis. However, the definition of the species stratiformis refers to clouds spread out in an extensive horizontal sheet or layer. This does not match the typical appearance of roll clouds observed throughout the world. Roll clouds are often incorrectly identified

as ‘arcus’ roll clouds. As a roll cloud is not attached to a parent cloud the association with this supplementary feature is inappropriate. Roll clouds are an example of an undular bore. They are a soliton, and a classic example is the Morning Glory of the Gulf of Carpentaria. After detailed discussion, the session concluded that the clouds **should be added to the ICA as a new cloud Species**. The Latin ‘volutus’ (or other appropriate Latin name) could be adopted as a name.

10.26 Roll clouds may be of some operational significance (e.g. aviation safety). FM12-XII Ext. SYNOP code has no reference to stratocumulus stratiformis in the form of a roll cloud. One of the four spare indicators in Code table 0521 (C_s – Special Clouds) could be assigned to ‘volutus’ (roll cloud).

10.27 **Kelvin-Helmholtz waves:** Kelvin-Helmholtz waves are a short-lived but visually distinct cloud feature. The feature is not currently classified within the Cloud Atlas. The formation mechanism, vertical shear of the horizontal wind, may be of some significance to the safety of small aircraft. Kelvin-Helmholtz waves are of some operational significance in that they indicate an area of horizontal wind shear. After detailed discussion, the session concluded that **Kelvin-Helmholtz waves should be added to the cloud classification scheme as a Supplementary Feature**.

10.28 The Latin ‘fluctus’ (wave / billow) was suggested as an appropriate name. FM12-XII Ext. SYNOP code has no reference to Kelvin-Helmholtz waves. One of the four spare indicators in Code table 0521 (C_s – Special Clouds) could be assigned to Kelvin-Helmholtz waves although this is probably not necessary for this short-lived feature.

10.29 **Meteors:** The **section ‘Meteors’ could be expanded to include additional images and text** to provide a more comprehensive description of meteors. The Glossary may also be used.

11. RESOURCE ESTIMATION FOR THE PROPOSED SOLUTION

11.1 Taking into account the work performed under Work Plan Tasks 1 to 6 described in sections 5 to 10 above, which are based on member input through the Member Survey, on results of the Task Team’s investigation of relevant web collections of cloud images, and on the expert knowledge and past experience of the Task Team members, and taking into account the need to propose a reasonable scope of activity which can be accomplished within a limited time and cost, the Task Team compiled two options for the consideration of the CIMO Management Group.

11.2 The first option (Option 1) allows for great improvement in the CA, taking advantage of the characteristics of a web-based rather than paper-based format. Improvements are made in both the content and the usability of the ICA, and these improvements enable its content to be adapted for additional purposes by a much wider audience than is presently possible. This update would meet the challenges of maintaining the ICA as the global authoritative reference standard for cloud observation and classification, and at the same time make it much more accessible for broader professional and public enthusiast use. This recommended option does not fully address all potential updates and improvements to the ICA, but is proposed as a very significant advance at reasonable cost. The required resources for this update are estimated to be between $250,000 (optimistic) and $400,000 (pessimistic), with work to be accomplished in between 12 and 24 months.

11.3 If resources for the first, recommended, option, are unavailable, the Task Team proposes an alternative Option 2. This option provides for minimal changes to the current ICA, replacing a limited number of existing images whose quality is deemed inadequate for a web version, updating text only where it is clearly dated or inaccurate, and updating the graphical decision aid. The result of this option would be a small advance from essentially the current PDF scan of the ICA now on the WMO website. This option also proposes to add bookmarks for a minor improvement in navigability. It retains many disadvantages present in the current ICA. The image set remains

incomplete, for example representing mid-latitude clouds but not those other climatic regions. It maintains much of the inflexibility of the existing ICA, failing to take significant advantage of its web format for increased functionality and appeal to a wider audience. It does not respond to Member input suggesting a need for additional metadata, and it does not acknowledge the recent interest from professionals and the public in using the ICA. The only advantage of Option 2 over Option 1 is its lower cost. The required resources for this update are estimated to be approximately $50,000, with work to be accomplished over a period of approximately 7 months.

11.4 More detail for each option is provided below.

OPTION 1: Significant Improvement (strongly recommended)

11.5 This, the preferred option of the Task Team, involves measured changes to the existing ICA to address the highest priority requirements, which were determined based on WMO Member input, the overall principles adopted to assist decision-making by the Task Team, and the Task Team's findings under each of the Work Plan tasks.

11.6 ***Usability improvements:***

- Add bookmarks for navigation. Break into smaller PDFs to enable some to be used in other formats;
- Create a truly modular CA that is user-friendly, containing internal links for easy navigation and a search capability based on image tags.

11.7 ***Content improvement and expansion:***

- Significantly expand the range and amount of imagery to reflect climatic and seasonal variation, while maintaining inclusion of current reference imagery;
- Modestly expand mandatory metadata, and significantly expand optional metadata included where beneficial:
    - Example of added mandatory metadata: Cloud base height;
    - Examples of added optional metadata where available and appropriate: aerological sounding, synoptic context, radar view, imagery as viewed from aircraft and satellite, time-lapse imagery where it would be clearly beneficial;
- Update and expand text as required for accuracy and clarity;
- Update use of language to be more familiar for a modern audience;
- Design and include an updated graphical decision aid;
- Add a Glossary of terms with images;
- Expand cloud classifications with additions recommended by TT-ICA.

11.8 ***Template design:***

- Significantly expanded to take advantage of modularity and additional metadata

11.9 ***Extended purpose/audience:***

- Modular design facilitates additional use by and for other audiences such as training

11.10 ***Not Included:***

- Addition of an extensive upper atmosphere cloud classification section (perhaps as a Volume III). Although this will be recommended separately to the CIMO Management Group for consideration, it would require liaison and collaboration with IAGA and other WMO technical commissions to reach final agreement on the details of the path forward, so should, in the opinion of the Task Team, be treated separately.

11.11 ***Advantages:***

- All inaccuracies removed, to make it the global authority on the subject;

- All images of high quality, hence more instructive and more eye-catching and visually appealing;
- Improved decision tree to increase its appeal to all user groups;
- Glossary added to address the need to include terminology not formally recognized with formal classification but in common use within different user groups;
- Language modernized throughout, to make the ICA more accessible to younger users, who are unfamiliar with the terminology of previous centuries;
- Result is modular and flexible, providing opportunities for significantly increased functionality for, e.g., trainers to adapt it into meteorological training modules;
- Improvements directly address Member requirements, and acknowledge recent public and professional interest (e.g. storm spotters);
- Another major update is not likely to be required for many years;
- Image set is more comprehensive and internationally representative, addressing the need to represent clouds viewed from varied climatic regions and seasons, making it more useful to a global audience;
- Improved image template provides for additional metadata, to increase understanding of the conditions surrounding or leading to a particular cloud occurrence;
- Enables additional modules to be easily linked by interested users. E.g, (1) A wiki site can be added outside of the ICA allowing Members or the public to provide supplementary cloud images and metadata for their own use; (2) ICA content could be easily incorporated into Members training tools; (3) ICA content could be extracted and reformatted for purposes such as creating an abridged version of the ICA or a simplified version for use in schools;
- Future updates can be relatively inexpensive, providing a future return on current investment;
- Enables cost effective future addition of a Volume III on Upper Atmosphere cloud classification, if deemed appropriate.

11.12 ***Disadvantages:***

- Higher cost than Option 2 (see Resource Requirements below).

<u>OPTION 2: Minimal Improvement (not recommended)</u>

11.13 Republish existing content in PDF form with minor improvements in the following areas.

11.14 ***Usability improvements:***

- Add bookmarks for navigation. Break into smaller PDFs to enable some to be used in other formats.

11.15 ***Content improvement and expansion:***

- No content expansion;
- Update/replace existing imagery only where required for image quality. This does not include any expansion of imagery. To minimize resources required, replacement imagery would be selected by WMO/designee without input from Member representatives;
- Update text only where it is deemed inaccurate and there is an essential need for update;
- Design and include an updated graphical decision aide.

11.16 ***Template design***

- Unchanged.

11.17 ***Extended purpose/audience:***

- None.

11.18 ***Advantages:***

- Some improved image quality;
- Inaccuracies removed;
- Improved decision tree;
- Inexpensive, relative to Option 1 (see Resource Requirements below).

11.19 ***Disadvantage:***

- Language used remains obsolete;
- Result has very limited flexibility, missing opportunities for increased functionality;
- Result does not acknowledge recent public and professional interest [eg storm spotters];
- Another update is likely to be required soon;
- Image set remains incomplete. The CA still does not represent climatic regions and therefore does not address a strong concern in the user survey;
- Result does not provide additional metadata, and therefore does not increase the value of the ICA in that respect.

Resource Estimation

11.20 Having agreed on the preferred solution it would propose to the CIMO Management Group, the session turned to the task of estimating the resources required to carry out the work implied. In doing this, it first made a number of assumptions, as follows:

- The costs of the work of the follow-on Task Team are restricted to those of one or two face-to-face meetings. Most of its work will be conducted remotely;
- Much of the work of selecting imagery and updating text is performed by experts whose time is contributed by their organization as an in-kind contribution. Additional resources required in association with these tasks would be to cover travel for meetings and intensive periods of focused effort;
- Some of the work can be organized and contributed within NMHS organizations (e.g. vetting and filtering candidate cloud images and metadata). In addition to distributing the required work, this is a strategy to include imagery that is geographically diverse and more globally representative;
- Key, specialist work, for which the expertise is not available internally (web-editing and layout) is performed by professional consultants: this represents a significant cost;
- Much of the administrative work (letters to PRs, assembling material once it arrives, etc) is performed within the Secretariat by temporary staff employed for the purpose: this also represents a significant cost;
- Printing costs: The cost of translation, and production and printing of a limited number of hard copies of the revised International Cloud Atlas, is excluded from the cost of the revision project itself. (i.e. Is not considered here).

11.21 The session estimated that, for Option 1, the updated Cloud Atlas would require approximately 700 images (for resource estimation, assume 1000 maximum) to represent all those to be included in the revised ICA. The estimate of 700 was based on a detailed breakdown of how many images might be required for each of the approximately 100 different classifications, including examples from different climatic regions and seasons, plus meteors, plus those items included in the Glossary, etc. It was not a ball-park figure, but a quite detailed estimate. It was noted that the current Cloud Atlas includes approximately 173 images in Vol. II.

11.22 A secretariat member (SEC) would need to be employed on short term contract for 6 to 9 months. That person would be responsible for secretariat support to the follow-on Task Team (TT, composed of experts from WMO Members organizations), which leads the activity. Three Member image experts (in-kind) would need to be assigned to be image assessors. Several additional Member text experts (in-kind) would need to be assigned to update written material as required.

11.23 The TT would request WMO Member organizations to gather, vet, and submit candidate cloud examples with metadata, with the request limited to a maximum number of examples and limited to examples that are needed to represent the expanded scope of the ICA. The TT would create a request letter to PRs (SEC support), including a list of the desired Cloud types and features that will need to be represented, the required and desired metadata that must accompany each example. It is estimated that the time required to complete this process and for all images (with a list of the metadata available for each image) to be submitted to the WMO secretariat would be 3 to 4 months. Assume that up to 5000 candidate images (to be reduced to 700) are submitted to an automated (web-based?) system.

11.24 On receipt, SEC sorts the (5000) submitted images and accompanying metadata lists, and files them, ready for assessment by the image experts. (2 weeks.) The image experts, working remotely, then assess images and accompanying metadata for correct classification and merit (4 weeks, based on 2 min per image). Face-to face meeting of image experts to agree/finalize the 700 images (2 weeks).

11.25 Email from SEC to 'owners' of the 700 to request accompanying metadata to be sent, plus signed agreement to license use of image. Metadata arrives and is sorted by SEC. (6 weeks)

11.26 In parallel, text experts update text where obsolete and have it reviewed (6 months total).

11.27 Employ IT Consultant to put together the new ICA and publish it on the web (2 months)

11.28 Overall resources required: 12 months (plus 12 months contingency), plus:

- Short Term Secretariat Staff: $100,000-$150,000
- 2 Face-to-Face Meetings of Task Team: $50,000-$100,000
- Meeting of image experts: $25,000
- Meeting of text experts: $25,000
- IT Consultant: $50,000
- Contingency: $0-$50,000
- TOTAL: $250,000 - $400,000

11.29 With the significantly reduced scope of the work involved in the Option 2 solution, the session concluded the task should require less than $50,000, most of that required for an IT consultant to publish the document on the web.

12. CLOSURE OF THE SESSION

The session closed on Friday, 22 November 2013 at 15:32 hours.

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Terms of Reference for CIMO Task Team on Revision of the WMO Cloud Atlas (TT-RCA)

1. Review the current Cloud Atlas and assess the desirability and its suitability for simple reproduction (as is) in digital form on-line
2. Ascertain the suitability / need for revision of the graphical decision aid currently contained in Vol. I, Part II (II.8.3).
3. Perform a web-survey of alternative existing forms of cloud atlas, and briefly summarize their key features, strengths and weaknesses.
4. Survey WMO Members on their requirements for revision of the Cloud Atlas (basic need, desired features)
5. Assess opportunities for enhancement of the WMO Cloud Atlas afforded by publication in digital form.
    a. In particular, assess opportunities afforded for inclusion of more imagery, allowance for clouds appearing differently (e.g. looking down on clouds from alpine location), or being classified differently in different climatic/meridional regimes (e.g. Cu2 in tropics = Cb in polar region).
    b. Specifically, determine the need for additional new cloud classifications to be included in the CA (such as asperatus and anthropo-) and the feasibility of reporting these.
    c. Specify the metadata that should accompany each image in a new CA.
    d. Design a template for an individual cloud image (format, accompanying description, metadata, etc)
6. Summarize work of the TT (ToRs 1-5)
    a. Prepare a summary report including a recommendation to CIMO MG with regard to revision of the CA
    b. Provide a Project Proposal to the CIMO Management Group for the recommended solution (Include a description of the recommended steps involved, and estimate the resources required (time, staff, funding)).

(Revised 20 November 2013)

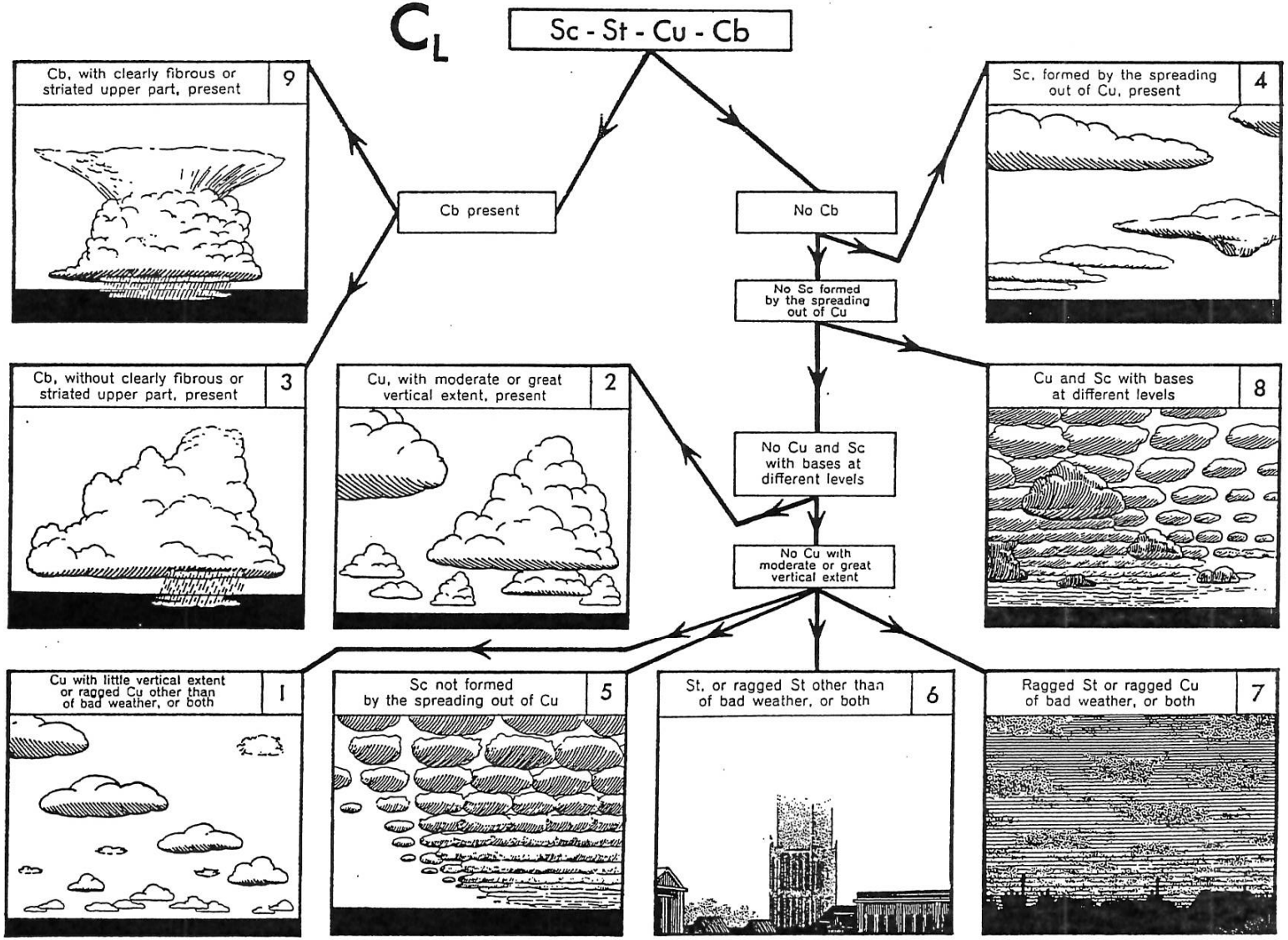
WorkPlan of WMO CIMO Task Team on Revision of the International Cloud Atlas (2013)

No.	Task description	Person responsible	Action	Deliverable	Deadline for deliv.	Status [%]	Comments
1.	Review the current ICA, in its digital form. a) Assess its current suitability, or shortcomings as a web-based ICA. b) Consider desirable features if revised (e.g. modular design, structures that facilitate multiple uses, etc.)	**ELIANE,** plus ALL participate; (CA experts, ETR, ITD, Pubs, …)	1. Fast-start: Brainstorm as a smaller group (email) 2. Lead TT discussion 3. Summarize findings 4. Revise short report in the light of outcomes of Tasks 3 and 4	Dot point list of options Dot point list of preferences Prelim short report on requirements. Revised report on requirements.	22 Aug 2013 22 Aug 2013 28 Aug 2013 30 Oct 2013	100% 100% 100% 95%	**ToR 1** **Webex 2: 22 Aug** Action 4 a joint effort between sub-groups 1, 3, 4
2.	Ascertain the suitability / need for revision of the graphical decision aid currently contained in Vol. I, Part II (II.8.3) (page 97-102 of Vol 1.)	**COLLEEN** (lead) ERNEST, MIKE, ELIANE, MARINES, and others	1. Discuss current suitability. 2. Brainstorm possible improvements. 3. Prepare short report on recommendations. 4. Lead TT discussion. 5. Revise short report in light of TT discussion	Short report on recommendations	22 Aug 2013 22 Aug 2013 4 Sep 2013 4 Sep 2013 11 Sep 2013	100% 100% 100% 100% 50%	**ToR 2** Involvement of WMO ETR specialists? **Webex 3: 4 Sep**
3.	Survey WMO Members on their requirements for revision of the ICA (basic needs, desired features)	**ERNEST** plus CLAIRE/SYLVIE, COLLEEN, (help from WMO/CIMO /CPA area)	1. Fast-start: discuss and summarize objectives and questions. 2. Lead TT discussion 3. Prepare and release survey 4. Collect and analyze results 5. Prepare report on Member requirements 6. Lead TT discussion 7. Finalize report	List of key items of info to be obtained. Finalized survey Short report on Member requirements	22 Aug 2013 22 Aug 2013 4 Sep 2013 9 Oct 2013 16 Oct 2013 16 Oct 2013 23 Oct 2013	100% 100% 100% 100% 100% 100% 95%	**ToR 4** Entrain survey expertise at WMO/HQ (CPA? CIMO?) **Webex 2: 22 Aug** **Webex 3: 4 Sep** Include question on need for additional/new cloud types. (T5) **Webex 5: 16 Oct** Include question on

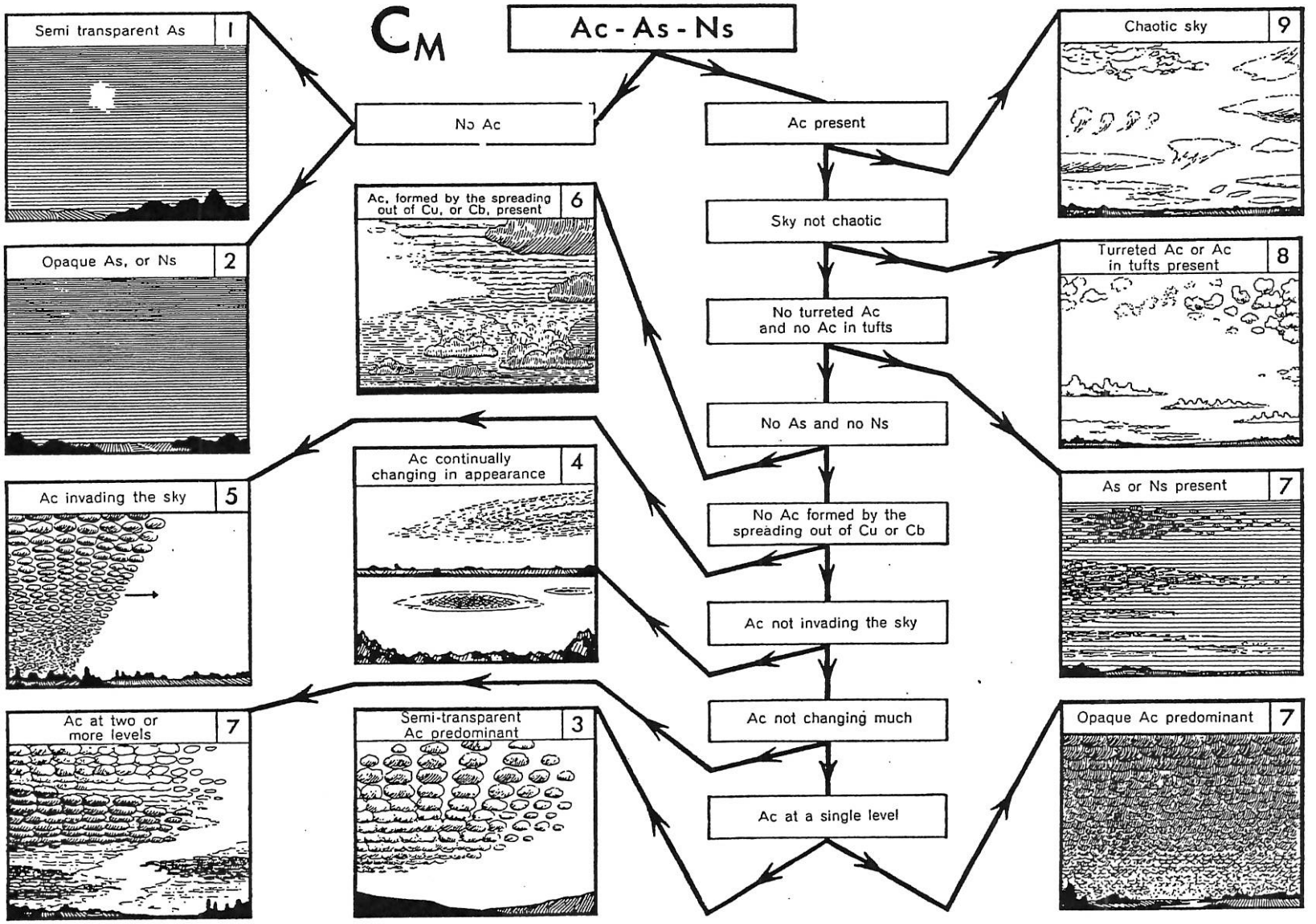
No.	Task description	Person responsible	Action	Deliverable	Deadline for deliv.	Status [%]	Comments
							need for more imagery. (T5)
4.	Perform a web-survey of alternative existing (web-based) forms of cloud atlas, and briefly summarize their key features, strengths and weaknesses.	**MIKE**. JIM, IGOR, (input encouraged from ALL) familiarity with what is required in an ICA.	1. Perform survey 2. Prepare short report 3. Lead TT discussion 4. Revise short report in light of TT discussion	Draft short report on findings and recommendations Finalized short report on findings and recommendations	11 Sep 2013 18 Sep 2013 18 Sep 2013 25 Sep 2013	100% 100% 100% 100%	**ToR 3** **Webex 4: 18 Sep** May result in recommending particular external experts (web site authors) be coopted for 2014 work.
5.	Specify meta-data and design a template to describe each cloud image i. Specify the metadata that should accompany each image in a new CA. ii. Design a template for an individual cloud image (format, accompanying description, metadata, etc)	**JIM,** GEORGE, MIKE (+input from Tasks 3 and 4	1. Discuss requirements 2. Prepare short report on requirements 3. Lead TT discussion 4. Finalize report on requirements for metadata 5. Design template	Draft report on metadata reqs and ICA Image template. Final report on metadata reqs and ICA Image template.	11 Sep 2013 18 Sep 2013 18 Sep 2013 30 Oct 2013 30 Oct 2013	100% 100% 100% 99% 90%	**ToR 5c/d** Use reports from T3 and T4 as input. **Webex 4: 18 Sep** Template design will require involvement of CPA, ITD, Pubs. May be better left to next TT.
6.	Assess opportunities for enhancement of the WMO Cloud Atlas afforded by publication in digital form: a) determine the need for additional new cloud classifications to be included in the CA (such as asperatus and	**GEORGE,** COLLEEN, ERNEST, MIKE, MARINES	1. Initial discussion of each topic (a and b). 2. Await survey results and prepare paper with discussion and recommendations each topic.	Short paper on considerations and preliminary conclusions/recommendations.	16 Oct 2013 30 Oct 2013	100% 100%	**ToR 5a/b**

No.	Task description	Person responsible	Action	Deliverable	Deadline for deliv.	Status [%]	Comments
	anthropo-) and the feasibility of reporting these. b) assess opportunities afforded for inclusion of more imagery, allowance for clouds appearing differently, etc.		3. Lead TT discussion 4. Finalize report	Short report on TT recommendations.	30 Oct 2013 06 Nov 2013	100% 95%	**Webex 6: 30 Oct**
7.	Report on activity	**STEVE** plus ALL members	1. Prepare a project proposal for follow-on work (include resource requirements and timeline) 2. Prepare draft final report of the TT once all Tasks are complete. 3. Discuss and refine report 4. Finalize report and submit to CIMO MG	Final report delivered to CIMO MG	13 Nov 2013 22 Nov 2013 31 Jan 2014	50% 20% 0%	**ToR 6** **TT meeting in Geneva** tentatively planned for **18-22 Nov 2013**. Deadline for submission of input documents to CIMO MG expected to be 31 January 2014.

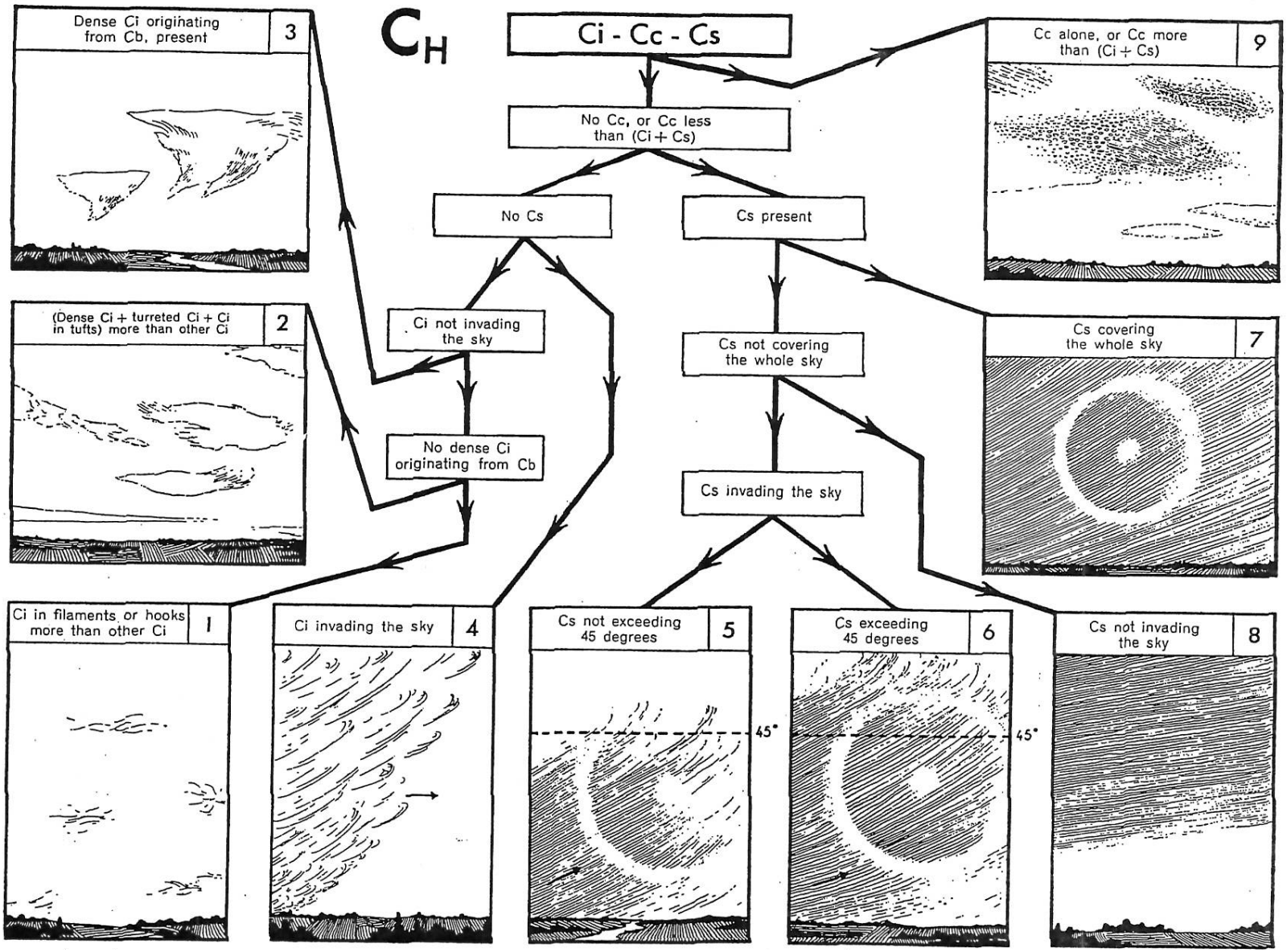
INTERNATIONAL CLOUD ATLAS VOLUME I, PART II, GRAPHICAL DECISION AID



INTERNATIONAL CLOUD ATLAS VOLUME I, PART II, GRAPHICAL DECISION AID



INTERNATIONAL CLOUD ATLAS VOLUME I, PART II, GRAPHICAL DECISION AID



MEMBER SURVEY ON THE ICA

Introduction

WMO's Commission for Instruments and Methods of Observation has selected a Task Team to examine options for revision of the WMO International Cloud Atlas (ICA).
In order to effectively carry out this task, we wish to canvass the views of a wide cross-section of the global meteorological community.

The current ICA can be found online at:

Volume I: http://library.wmo.int/pmb_ged/wmo_407_en-v1.pdf
Volume II: http://library.wmo.int/pmb_ged/wmo_407_en-v2.pdf

We would be grateful if you would complete this survey by answering all questions as comprehensively as possible.

It is expected that it will take you between 10 and 15 minutes to complete the survey.

We thank you in advance for your participation.

---

1. Please provide your name:

2. Please provide the name of your organization:

3. What is your profession?

- ☐ Meteorological Technician / Weather Observer
- ☐ Meteorologist
- ☐ Graduate (Researcher)
- ☐ School Teacher
- ☐ Non-professional
- ☐ Other (please specify)

4. Do you use the International Cloud Atlas?

- ☐ Yes, Volume 1
- ☐ Yes, Volume 2
- ☐ Yes, 1956 Abridged Atlas
- ☐ Yes, both Volumes 1 and 2
- ☐ Yes, 1956 Abridged Atlas with one or both of the other volumes
- ☐ No, I do not use the International Cloud Atlas

5. (If yes to 4.) You said that you use the International Cloud Atlas. For what purpose do you use the International Cloud Atlas?

- ☐ As an operational reference
- ☐ As a training resource
- ☐ As both an operational reference and a training resource
- ☐ Just for interest
- ☐ Other (please specify)

6. (If no to 4.) You said that you do not use the International Cloud Atlas. Which option best describes the reason? (If the reason is not listed, please use the comment field under "other" to explain why)

- ☐ You use an alternative
- ☐ The ICA is considered obsolete by you or your organization
- ☐ You were not aware of the existence of the ICA.
- ☐ You or your organization has too few copies of the ICA
- ☐ Other (please specify)

7. (If a to 6.) You said that you use an alternative cloud atlas. Who developed the alternative that you use?

- ☐ You
- ☐ Your organization
- ☐ Some other source

8. Would you or your organization use the ICA more if it were on the World Wide Web?

- ☐ Yes
- ☐ No, the same
- ☐ No, less

9. Would a web-based version be more appealing if it had an extensive library of cloud images that could be tailored to your climatic region?

- ☐ Yes
- ☐ No
- ☐ Not sure

10. Would a web based version of the ICA be more appealing if each image had a comprehensive description and explanation, and ancillary information such as the synoptic or mesoscale conditions at the time of occurrence, and perhaps a weather map or satellite image?

- ☐ Yes, the more detail the better
- ☐ No, the same amount of explanation and description as in the Current ICA is sufficient
- ☐ Not sure

Layout of Images in the Current Version of the International Cloud Atlas

The excerpt below is a typical entry from Volume II of the current edition of the International Cloud Atlas.

B. Colman, Denali National Park (Alaska, U.S.A.), 26 May 1984, 1245 hours (towards SSE)

Altocumulus lenticularis

Numerous small Altocumulus patches are seen in the photograph. At 1 a pile of smooth lens-shaped elements is visible. Three apparent waves are defined by the fibrous elements with crests at 2, 3, 4. The wave signature is also seen in the Cirrus at 5. A vigorous short-wave trough was approaching from the west, the local area experiencing an increasing SW flow at all levels (right to left in the photograph).

$C_L = 2$, $\mathbf{C_M = 4}$, $C_H = 1$

The main features of the above image are:-
i) a photograph of the cloud(s) surrounded by numbered arrows pointing to particular features;
ii) Some metadata for the photograph along the bottom of the photograph;
iii) The name of the cloud(s) featured;
iv) Description/supplementary info on where and when the photo was taken;
v) Notes to describe the features captured in the photo and pointed out by the numbered arrows around the border;
vi) Notes on the synoptic situation, the airmass, or cloud development/dissipation; and
vii) Synoptic coding of the scene depicted in the photograph.

11. Is the current content (as shown in the example) :

- ☐ Just right
- ☐ Too much
- ☐ Too little

12. (If too little at 11.) You said there was too little detail in the International Cloud Atlas. Which of the following information should we also include?

- ☐ Surface temperature details for low étage clouds;
- ☐ MSLP analysis;
- ☐ Aerological sounding;
- ☐ Stability indices;
- ☐ Observed height of cloud base;
- ☐ Altitude (height above MSL) at which the picture was taken;
- ☐ Cloud location relative to the sun's position;
- ☐ Season (winter, summer, wet, dry, etc.);
- ☐ Other (please specify)

13. Should the ICA include images of cloud seen from different perspectives?

- ☐ Yes
- ☐ No

14. (If yes to 13.) You said that the International Cloud Atlas should include of clouds from different perspectives. Should the images include photographs of clouds taken from:

- ☐ High altitude (alpine) sites
- ☐ Aircraft
- ☐ Satellites
- ☐ Other (please specify)

Cloud are categorized in the ICA in terms of their genus (19 possible classifications), species (14 possibilities), variety (9 possibilities) and/or supplementary features (7 possibilities).

These are tabulated below.

Genus	**Level**
Cirrus	High
Cirrocumulus	High
Cirrostratus	High

Altocumulus	Medium
Altostratus	Medium
Nimbostratus	Medium
Stratocumulus	Low
Stratus	Low
Cumulus	Low
Cumulonimbus	Low

Species	**Abbreviation**	**Description**	**Cloud types**
Humilis	hum	Flattened, base wider than height	Cu
Mediocris	med	Width of base and height approximately equal	Cu
Congestus	con	Height larger than width, cauliflower tops	Cu
Fractus	fra	Ragged shreds of clouds	Cu, St
Nebulosus	neb	Thin veil or layer with no distinct features	St, As, Cs
Stratiformis	str	Very extensive horizontal sheet or layer	Sc, Ac, Cc
Calvus	cal	Smooth tops, loosing cauliflower appearance, no cirrus	Cb
Cappilatus	cap	Distinct icy regions with fibrous, striated appearance (anvil, plume or disordered mass of cirrus)	Cb
Floccus	flo	Small tufts of cloud, with ragged lower portions, often virga	Ac, Cc, Ci
Castellatus	cas	Turrets connected by a common base, sometimes arranged in lines	Sc, Ac, Cc, Ci
Lenticularis	len	Wave cloud, almond or lens shaped	Sc, Ac, Cc
Fibratus	fib	Nearly straight, or slightly curved, no hooks	Ci, Cs
Spissatus	spi	Dense enough to appear grey toward the sun	Ci
Uncinus	unc	Comma- or hook shaped, not rounded tuft of cloud	Ci

Variety	**Abbreviation**	**Description**	**Cloud types**
Intortus	in	Irregularly curved, tangled	Ci
Vertebrates	ve	Looking like ribs, fishbones	Ci
Undulatus	un	Patches or rolls with parallel undulations, billows	Sc, Ac, As, Cc, Cs
Radiatus	ra	Broad parallel bands, appearing to converge due to perspective	Cu, Sc, Ac, As, Ci
Lacunosus	la	Thin cloud with regularly spaced holes (rare)	Ac, Cc
Duplicatus	du	More than one layer, at slightly different levels	Sc, Ac, As, Ci, Cs
Translucidus	tr	Translucent enough to show positions of sun or moon	St, Sc, Ac, As
Perlucidus	pe	Broad layers or patches, with spaces (occasionally very small) that allow blue sky	Sc, Ac
Opacus	op	Completely masks sun or moon	St, Sc, Ac, As

Feature	Description	Cloud type
Arcus	Squall roll preceding Cb, shelf cloud	Cb
Incus	Anvil cloud, mature thunderstorm	Cb
Mammatus	Pouches hanging from upper cloud, often anvil clouds; occur when cold moist air is met by rising drier and warmer air	Cb (Sc, Ac, As, Ci, Cc)
Precipitation	Precipitation reaching the ground, may appear as dark region beneath clouds	Cb, Nb
Virga	Fall streaks from precipitating clouds, which evaporate before reaching the ground	Cb, Cu con, St, Sc
Tuba	Funnel clouds of any type	Cb
Contrails	Lingering remnants of aircraft exhaust and accompanying condensation	

15. With regard to the different possibilities shown on the previous page, do you consider any of these to be obsolete or redundant today?

- ☐ Yes
- ☐ No
- ☐ Not sure

16. (If yes to 15.) Please specify which genus, species, variety or feature (one or more) you consider to be redundant or obsolete, and why you consider it (them) to be so.

17. With regard to the different cloud classifications tabulated earlier, do you consider that there are any new or previously overlooked cloud types that are missing from these tables and should included in a future edition of the ICA?

- ☐ Yes
- ☐ No
- ☐ Not sure

18. You said that the International Cloud Atlas should contain additional classifications. Please suggest a name for the missing genus, species, variety or feature (one or more), describe its appearance and the conditions under which it occurs, and why you think it is important to include it in the ICA.

19. Does your organization make synoptic observations?

- ☐ Yes
- ☐ No

20. Otherwise, does your process of making synoptic observations require entry of manual input?

- ☐ Yes
- ☐ No
- ☐ Not sure

21. The WMO coding regulations for the CL, CM and CH cloud types are found in Volume I of the ICA, on pages 75 to 98. The information provided is set out in the following format; • Technical specifications • Non Technical specifications • Commentary (expansion of technical and non Technical specifications). • Special coding instructions • Further remarks. Is the current content and format satisfactory?

- ☐ Yes
- ☐ No
- ☐ Not Sure

22. You said that the coding regulations for the CL, CM and CH cloud types are found in Volume I of the ICA, on pages 75 to 98 were unsatisfactory. Please explain how they could be improved.

23. Are you or your organization required to provide weather education to public special user groups, for example, fishermen, aviators, firefighters?

- ☐ Yes
- ☐ No
- ☐ Not sure

24. Would you and/or your organization be interested in and willing to contribute images (with appropriate metadata) to a web-based ICA image library?

- ☐ Yes
- ☐ No
- ☐ Not sure

25. Should you wish to provide any comments on the survey, or regarding revision of the ICA, please do so in the box below.

You have now reached the end of this survey. Many thanks for your time and effort.

RESPONDENTS TO MEMBER SURVEY

Country	Number of Responses
Argentina	9
Bangladesh	1
Barbados	3
Burundi	1
Canada	1
Caribbean	1
Cayman Islands	1
China	1
Congo	1
Croatia	1
Dominican Republic	1
Estonia	1
Finland	1
France	1
Germany	1
Guinea	1
Hong Kong	3
Iceland	1
Indonesia	1
Italy	1
Japan	1
Jordan	1
Kazakstan	2
Kenya	1
Korea	1
Kuwait	1
Latvia	2
Macedonia	1
Mauritius	1
Moldova	1
Mozambique	2
Nepal	1
Netherlands	1
New Zealand	4
Pakistan	1
Poland	1
Qatar	1
Romania	1
Saint Lucia	1
Senegal	1
Slovakia	3
Slovenia	3
Sweden	2
Trinidad and Tobago	1
Turkey	2
UK	4
Uruguay	2
USA	83
Uzbekistan	3
Yemen	3
Zimbabwe	1
Unknown*	30

* Note: Insufficient details provided to ascertain the country.

WEB SURVEY OF ALTERNATIVE CLOUD ATLASES: RESULTS RELATIVE TO CRITERIA FOR ICA

	Website	Strengths	Weaknesses	Merit
1	Wolken Online Comments relate to German version English abbreviated version: Clouds Online	• Includes virtually all of ICA Volume I Part II – 3 "Descriptions of Clouds". • Large library of high quality digital images. • Exceptional cloud photos. • Site includes a search engine. • Neat easy to navigate site other than constant use of browser back button.	• No coding details or decision tree. • No hierarchal tree for alternative method of navigation. • Limited image descriptions and not enough image specific identification logic. • Small field of view in some images results in debatable cloud identification. • Few errors such as "Cbinc" instead of "Cb cap inc"	Yes, exceptional image library but generally not enough image metadata
2	MeteoSwiss – Visual Obs	• Includes all of ICA Volume I Part II (except .5 and .6) and Part III.2. • Covers general and specific cloud formation mechanisms. • Excellent illustrations e.g. pg. 43 • Excellent images with descriptions/details from pg. 247. • Excellent cloud observing guidelines/aids including decision trees. • Is in an ideal format to be downloaded and/or printed. • Simple, neat tidy appearance.	• Image library relatively small and represents a unique geographic/climatic region. • Etage heights European specific. • Large pdf file - most of 319 pages.	Yes, technically superb and good design.
3	Cloud types for observers UK Met Office	• Includes almost all of ICA Volume I Part II and, region specific, all that it needs of Part III.2. • Covers cloud formation mechanisms. • Provides basic metadata that in some cases includes height of cloud base. • Very good cloud observing guidelines/aids. Includes coding decision trees. • Has a few series of images that show cloud development. • Very good document to be read online or downloaded/printed. • Simple, neat tidy appearance	• Cloud heights relative to UK conditions. • Some images limited by age and/or poor quality/resolution. • Metadata not up to standard of current ICA. • Few technical issues such as: "Examples of stratocumulus (genera and species) are: • Stratocumulus *cumulogenitus"* • Navigating limited as no bookmarks in the pdf. • Too much information on a lot of pages – often it was difficult to find a focal point.	Yes but at 72 pages, not as complete as #2. Some excellent images and descriptions; it offers an alternative style to #2.
4	SkyStefs weather page	• Includes frequency of occurrence (in the local area) e.g. twice per year • Good section on optics e.g. rainbow, fogbow, halo etc.	• Metadata limited to WMO classification of cloud; direction photo taken and camera EXIF data. • Not enough detail, ICA	Yes, alternative site layout, navigation and content.

		• Quick links to images for most (not all) species and varieties (using WMO classification and/or Alphabetical list of clouds). • Nice way of making exif data appear – via small camera icon. • Includes time-lapse movies (with photo interval and frame rate information; e.g. image every 3 sec with video displaying 20 images/second). • Some great case studies which include synopsis, remote sensing (inc. sat-pics& radar loops) and series of photos showing development through the day. • Excellent images. • Good hyperlinked cloud database page.	coverage limited to Volume I Part II -2 and bit of Part III -2. • Some navigating opens orphaned new tabs. • Small image library. • No explanation/logic of how each image cloud identification was made. • White text on black background on some pages was hard on the eye.	Meteorologically excellent images and consistently good cloud ident'.
5	Royal Meteorological Society	• Good decision tree	• Classic image of each genera but no technical description	Yes, decision tree can be adapted to be more precise
6	The Cloud Appreciation Society – Find a Cloud Type	• Huge and excellent image library • Good image search engine but it permits technically incorrect genre, species, variety etc. combinations. • Has limited optical and weather phenomena imagery	• Incomplete species indexes (eg no Cu con) • Inaccurate cloud identification • Limited metadata – mostly genera, species and variety with photographer name and date • No technical descriptions	Yes – image search engine, frame layout and image library
7	Clouds	• Good top level overview. • Includes generic methods of formation (& diagrams). • Includes precipitation associated with this cloud e.g. drizzle	• Cloud images small and poor resolution -need updating.	No
8	Windows to the Universe.	• Includes associated weather type. • Includes a 'how clouds form' section which contains the 4 processes. • Good imagery (but limited examples). • Clouds can be referenced by process e.g. 'clouds formed by air being forced to rise'.	• Only 1 example per cloud genus. • Variable metadata e.g. no date/time etc. • Question some of the meteorology: "Cirrus clouds predict fair weather"? • Won't mention description and image of Ns!	No
9	Cloud Observation	• Reasonable quality and quantity of images	• Site concentrates on genera • Images too small – hard to	No

	s	• Compact and easy to use site • Good attempt at condensing genera description • Small atmospheric optics library with no technical description	confirm cloud identification • Limited metadata – mostly genera, species and variety with photographer name and date • Briefness of genre descriptions resulted in inaccuracies	
10	Names of Clouds – Get your cloud right		• Too much text and too few images • Navigation confusing – needs a hierarchal tree • Indifferent technical descriptions, sometimes very good – else bad beyond description • Image of Ns with a rainbow!	No
11	WeatherScape – Clouds	• Reasonable quality and quantity of images	• 4th cloud etage – convective • Technical comments inaccurate (e.g. Ns often has drizzle) • Inconsistent approach to including species and varieties – has all Cu species but no Ci species	No
12	John Farley's Weather photos	• Tornado/thunderstorm specific with few other cloud images	• Disorganised hyperlinked document • Poor quality imagery • Too small field of view on many images	No
13	In the Clouds Photography	• Site set up by an atmospheric scientist with a keen interest in photography. • Some excellent images	• Limited number of images	No
14	Clouds and Cloud Identification – Dave Parker		• Poor resolution, out of focus and washed out imagery • Incorrect identification • Messy navigation	No
15	Classification of Clouds	• Good technical content including brief cloud physics	• Only 1 image per genera • Non existent navigation – have to use scroll bar	No
16	Catologo de Nevens	• Very good images and large library • Brief technical descriptions	• Limited metadata • Image library large but lacks many species and varieties	No
17	John Flude	• Very good images and reasonably sized library	• Metadata limited to genera with occasional species and variety • No technical descriptions • Some inaccurate identifications • Pages too long – scroll bar	No
18	Weerstation	• Images accessed through	• Language barrier aside –	No

	– Leeu Warden	hypertext links in Schedule Clouds Layout Table	navigation difficult • Images too small a field of view • Too much text • Example of poor navigation	
19	Idokep	• Excellent images • Brief description with each image • Stunning panoramas	• Clicking on thumbnail opens larger images minus all metadata • Too much information on opening page – scroll bar = poor navigation	No
20	Wolstanton Weather – Clouds	• Detailed description with each image	• No arrows or numbers used in images to highlight features identified in description • Images too small a field of view • Images mid-size and not expandable • Navigating cumbersome • Incomplete coverage of species, varieties ….	No
21	Komfort ABC	• Comprehensive coverage of genera, species and most varieties • Good technical content	• Hypertext linked contents from top of main page – page too long • Additional images and detail available by clicking on images in main page – not obvious navigation. • Dead links that keep going back to home page!	Offers but does not deliver! Is it my web browser and or language difficulties?
22	Gordo's Cloud Gallery	• Great images	• Poor navigation • 4th etage • Images too small a field of view • Navigation cumbersome	No
23	CloudMan	• Limited to "The 12 basic cloud classifications"	• Unique (for wrong reason) cloud formation chart • Images too small a field of view	No
24	Very rare clouds	• Example of sites that display awesome/rare clouds	• Too specific	No
25	EOSC 1114 Storms	• All in one single page that contains fair bit of information	• No navigation; more like a pdf file	No
26	Clouds	• Pdf version of a book: "Weather"	• Navigation non existent	No
27	Photo Library	• Example of a photo image library		No
28	Australian Severe Weather	• Huge image library – particularly Cb related	• Indifferent quality of images – particularly older ones • Poor cloud identification • Poor navigation	No

29	Wikipedia		• Attempts to be a condensed version of ICA Volume I with a handful of images • Views like a never ending pdf file	No

PROPOSED CLOUD IMAGE TEMPLATE AND METADATA LAYOUT

Example template

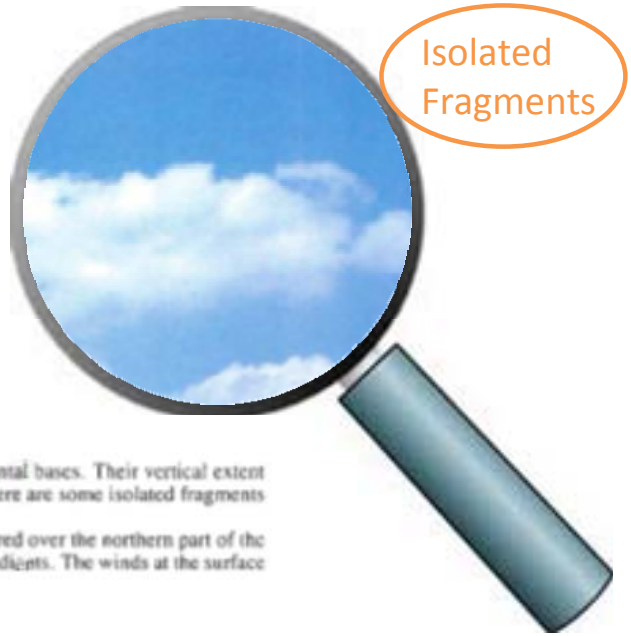
Similar Clouds

Download full-size image

M – supplementary metadata

S – search metadata

Isolated Fragments



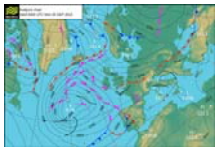
A. Viaut, Paris (France), 28 April 1952, 1305 hours (towards NE)

Cumulus humilis with haze

These Cumulus clouds are scattered; most of them are fairly dense masses with definite horizontal bases. Their vertical extent is small and they are consequently of the species humilis. In the vicinity of the main clouds there are some isolated fragments (1, 2). Haze veils the distant units.
The station was in old maritime polar air on the south-western margin of a cold upper low centred over the northern part of the Federal Republic of Germany, but far from any front and in a zone of weak surface pressure gradients. The winds at the surface were light N to NE, turning to NW aloft.

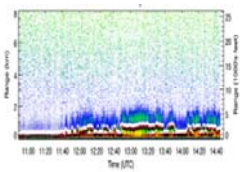
$C_L = 1, \quad C_M = 0, \quad C_H = 0$

Supplementary Reference Information

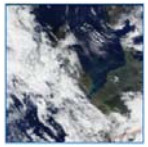


MSLP Analysis

Aerological Sounding



Ground based Remote Sensing



Satellite Imagery

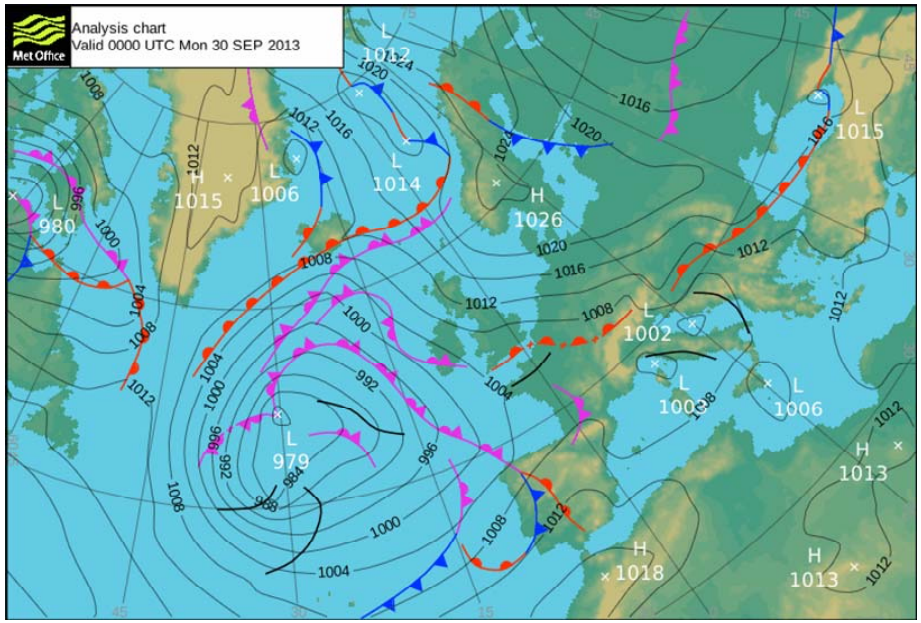
Video/time-lapse imagery

Additional Imagery

Reference Imagery

Example template

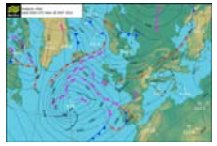
Supplementary Reference Information – MSLP Analysis



Comments relating to MSLP Analysis

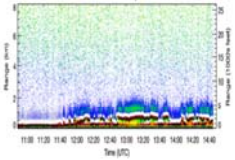
e.g. Analysis shows a high theta-w SE'ly airflow over N. France, associated with a frontalysing warm front leading to extensive low cloud formation.

Supplementary Reference Information

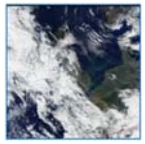


MSLP Analysis

Aerological Sounding



Ground based Remote Sensing



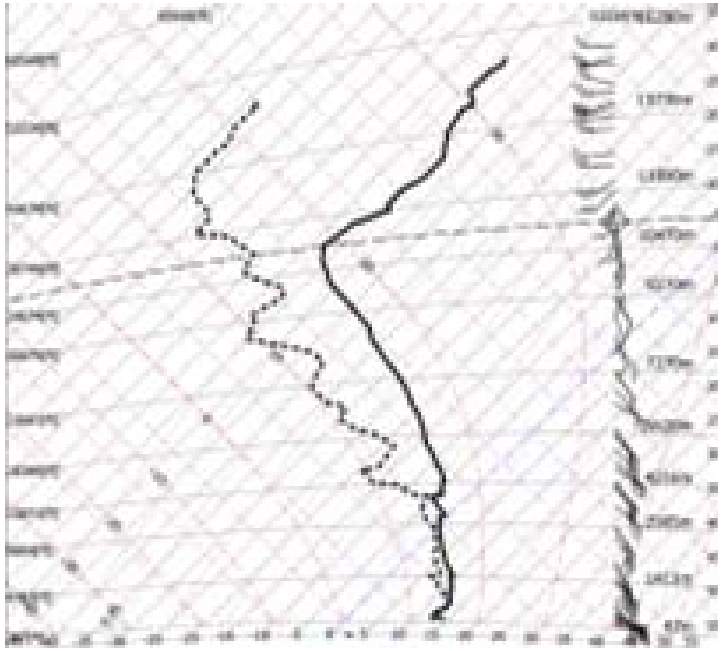
Satellite Imagery

Video/time-lapse imagery

Additional Imagery

Example template

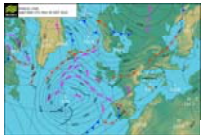
Supplementary Reference Information – Aerological Sounding



Comments relating to Aerological Sounding

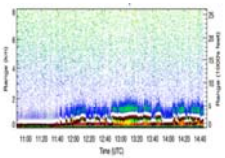
e.g. Weak inversion at around 700 mb indicating cap for cloud tops is just above the zero degree isoltherm.

Supplementary Reference Information

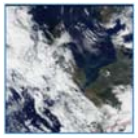


MSLP Analysis

Aerological Sounding



Ground based Remote Sensing



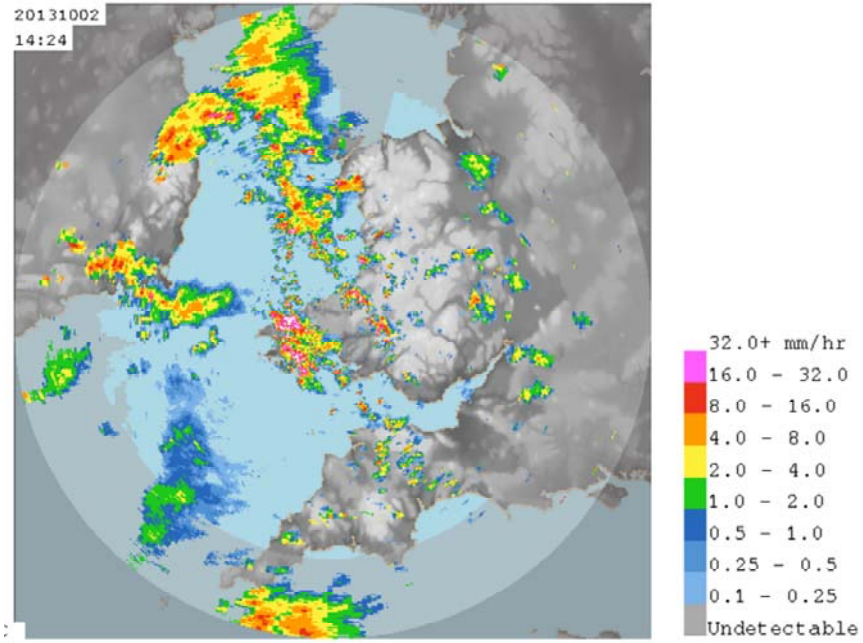
Satellite Imagery

Video/time-lapse imagery

Additional Imagery

Example template

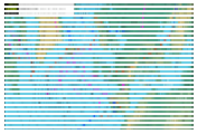
Supplementary Reference Information – ground-base remote sensing



Comments relating to Aerological Sounding

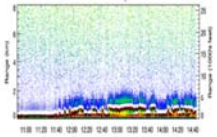
e.g. Intense rainfall associated with convective activity

Supplementary Reference Information

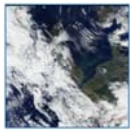


MSLP Analysis

Aerological Sounding



Ground based Remote Sensing



Satellite Imagery

Video/time-lapse imagery

Additional Imagery

Example template

Supplementary Reference Information – Additional Imagery

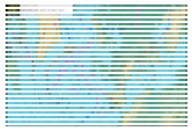
Margaret Worral, Firth of Forth, Scotland, 15th June 2012, 1500 hours (towards S)

Comments relating to Additional Imargey.
e.g. This is an example of the same cloud but the photo was taken in the tropics. Note the significantly deeper depth of cloud.

M – supplementary metadata

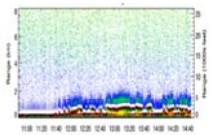
S – search metadata

Supplementary Reference Information



MSLP Analysis

Aerological Sounding



Ground based Remote Sensing

Satellite Imagery

Video/time-lapse imagery

Additional Imagery