

WORLD METEOROLOGICAL ORGANIZATION
TECHNICAL DOCUMENT

WMO/TD-No. 577

TROPICAL CYCLONE PROGRAMME

Report No. TCP-12

TROPICAL CYCLONE OPERATIONAL PLAN
FOR THE
SOUTH-WEST INDIAN OCEAN

2008 Edition



SECRETARIAT OF THE WORLD METEOROLOGICAL ORGANIZATION
GENEVA - SWITZERLAND

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INTRODUCTION

The development of national and regionally coordinated systems for the detection, monitoring, forecasting and warning of tropical cyclones is one of the primary objectives of the WMO Tropical Cyclone Programme. The RA I Tropical Cyclone Committee for the South-West Indian Ocean expressed the view that a tropical cyclone operational plan would be instrumental in improving these systems by strengthening the coordination and enhancing the cooperative effort in its region. It also felt that an operational plan would be a valuable source of information for the operational services.

The groundwork having been carried out by a study group set up for the purpose, the Committee at its fifth session (Seychelles, September 1981) formulated this Tropical Cyclone Operational Plan for the South-West Indian Ocean, which was adopted by Regional Association I (Africa) at its eighth session in November 1982.

The operational plan will be kept under review by the RA I Tropical Cyclone Committee and it will be amended from time to time in accordance with the provisions of Resolution 10 (XI-RA I).

The Tropical Cyclone Operational Plan for the South-West Indian Ocean has been made available to all concerned through this publication. This new edition incorporates all changes to the plan up to and including those made in 2008 and its loose-leaf form will facilitate further updating in the years ahead.

CHAPTER I

GENERAL

1.1 Introduction

Under the regional component of the WMO Tropical Cyclone Programme, groups of Members act in concert to improve their warning systems with a view to reducing the loss of life and mitigating the damage to property caused in their respective countries by tropical cyclones. In the South-West Indian Ocean this cooperative effort is effected through the RA I Tropical Cyclone Committee for the South-West Indian Ocean. To this end, and more specifically in order to ensure the most effective coordination and cooperation within the Region, between the Members* concerned, this Tropical Cyclone Operational Plan for the South-West Indian Ocean has been formulated by the RA I Tropical Cyclone Committee. It defines the forecasting and warning responsibilities of all cooperating Members. It also sets out the existing arrangements in the Region for provision of observational data and exchange of information and contains information on practices and procedures of regional significance. This operational plan is designed to serve not only as a record of agreed international arrangements but also as a valuable source of information for the operational services. Information on national practices or other matters which are not the subject of consideration at the international level but may be of interest to the operational services is given in attachments to the relevant chapters and does not form a part of the plan.

Thus the plan describes the existing internationally coordinated systems and arrangements agreed upon by the RA I Tropical Cyclone Committee, with a view to making the best use of currently available facilities for attaining the most effective tropical cyclone warning system for the Region. The Committee has also established a complementary Technical Plan which catalogues the plans, that is, foreseen activities, aimed at the development and improvement of this warning system. The operational plan is designed to be evolutionary in nature and it is intended that it be changed from time to time by the RA I Tropical Cyclone Committee to show the improvements in the warning system which flow from the attainment of the goals in the Technical Plan or the strengthening of the coordination within the Region achieved through the Committee.

1.2 Terminology used in the South-West Indian Ocean

1.2.1 Equivalent terms (terminology actually used)

	English		French
	Wind Characteristics		Caractérisation des Vents
(i)	Average/mean wind speed	(i)	Vitesse moyenne du vent
(ii)	Sustained wind speed	(ii)	Vitesse du vent soutenu
(iii)	Gust	(iii)	Rafale

* In this operational plan, the term Members is used to mean the Members of the RA I Tropical Cyclone Committee for the South-West Indian Ocean.

	English		French
	Classification of weather disturbances		Classification des perturbations météorologiques
(i)	Low pressure area	(i)	Zone dépressionnaire
(ii)	Extra-tropical disturbance	(ii)	Dépression extratropicale
(iii)	Sub-tropical disturbance	(iii)	Dépression subtropicale
(iv)	Zone of disturbed weather	(iv)	Zone perturbée
(v)	Tropical wave	(v)	Onde tropicale
(vi)	(Generic term) tropical disturbance	(vi)	(Terme générique) perturbation tropicale
(vii)	Tropical depression	(vii)	Dépression tropicale
(viii)	Moderate tropical storm	(viii)	Tempête tropicale modérée
(ix)	Severe tropical storm	(ix)	Fort tempête tropicale
(x)	Tropical cyclone	(x)	Cyclone tropical
(xi)	Intense tropical cyclone	(xi)	Cyclone tropical intense
(xii)	Very intense tropical cyclone	(xii)	Cyclone tropical très intense

	English		French
	Tropical disturbance characteristics		Caractéristiques d'une perturbation tropicale
(i)	Centre	(i)	Centre
(ii)	Eye	(ii)	Oeil
(iii)	Centre fix	(iii)	Position du centre
(iv)	Confidence in the centre position	(iv)	Confiance sur la position du centre
(v)	Direction of movement	(v)	Direction du déplacement
(vi)	Speed of movement	(vi)	Vitesse de déplacement
(vii)	Storm tide	(vii)	Marée de tempête
(viii)	Storm surge	(viii)	Onde de tempête

	English		French
	Marine warnings		Avis pour la marine
(i)	Weather warning	(i)	Avis météorologiques
(ii)	Near gale warning	(ii)	Avis de grand frais
(iii)	Gale warning	(iii)	Avis de coup de vent
(iv)	Storm warning	(iv)	Avis de tempête
(v)	Hurricane warning	(v)	Avis d'ouragan
	Terms related to the warning system		Termes utilisés dans le système d'avis
(i)	Cyclone advisory	(i)	Bulletin météorologique préliminaire concernant un cyclone
(ii)	Cyclone season	(ii)	Saison cyclonique

1.2.2 Meaning of terms used in international exchanges in the South-West Indian Ocean

Wind characteristics :

Average/ mean wind speed*: speed of the wind averaged over the previous 10 minutes (in the following classification, the wind speed, as it is described in the definitions, relates either to observed winds at least in half of the circulation *near the centre*, or to observed winds *within the system* in nearly all of the depression circulation).

Sustained wind speed*: surface wind speed averaged over the previous 1 minute (this value is sometimes used as the mean wind speed, particularly in Region IV).

Gust*: instantaneous peak value of surface wind speed.

Classification of weather disturbances :

Low pressure area: region of the atmosphere in which the pressures are lower than those of the surrounding region at the same level and where the cloud masses do not appear to be organized.

Extra-tropical disturbance: synoptic scale low pressure area outside of the tropics or former tropical disturbance having lost its tropical characteristics.

Sub-tropical disturbance: synoptic scale low pressure area having during its life, characteristics which could belong to both tropical and extra-tropical depressions. In the South West Indian Ocean, the genesis of such system is regularly observed over the South of Mozambique Channel.

Zone of disturbed weather: non-frontal synoptic scale low pressure area originating in the tropics or sub-tropics with enhanced convection and light surface winds.

Tropical wave: trough or cyclonic curvature maximum in the trade wind easterlies or equatorial westerlies. The wave may reach maximum amplitude in the lower middle troposphere, or may be the reflexion of an upper-troposphere cold low or equatorial extension of a mid-latitude trough.

* In the first approximation and over sea, gust is approximately 1.41. x average wind speed (averaged over 10 minutes) and sustained wind speed (averaged over 1 minute) is approximately 1.14 x average wind speed.

Tropical disturbance: generic term for a non-frontal synoptic scale low pressure area, originating over tropical or sub-tropical waters with organized convection and definite cyclonic surface wind circulation (wind estimated to be not exceeding 27 knots (50 km/h, force 6 in the Beaufort scale)).

Tropical depression: tropical disturbance in which the maximum of the average wind speed is estimated to be in the range 28 to 33 knots (51 to 62 km/h, force 7 in the Beaufort scale).

Moderate tropical storm: tropical disturbance in which the maximum of the average wind speed is estimated to be in the range 34 to 47 knots (63 to 88 km/h, force 8 or 9 in the Beaufort scale).

Severe tropical storm: tropical disturbance in which the maximum of the average wind speed is estimated to be in the range 48 to 63 knots (89 to 117 km/h, force 10 or 11 in the Beaufort scale).

Tropical cyclone: tropical disturbance in which the maximum of the average wind speed is estimated to be in the range 64 to 89 knots (118 to 165 km/h, force 12 in the Beaufort scale).

Intense tropical cyclone: tropical disturbance in which the maximum of the average wind speed is estimated to be in the range 90 to 115 knots (166 to 212 km/h).

Very intense tropical cyclone: tropical disturbance in which the maximum of the average wind speed is estimated to exceed 115 knots (212 km/h).

Tropical disturbance characteristics:

Centre of the tropical disturbance: geometric centre of the cloud eye or, if not discernible, the wind/pressure centre.

Eye of the tropical disturbance: relatively clear and calm area inside the circular wall of the convective clouds, the geometric centre of which is the centre of the tropical disturbance.

Centre fix of the tropical disturbance: estimated location of the centre of a tropical disturbance.

Confidence in the centre position: degree of confidence in the centre position of a tropical disturbance expressed as the radius of the smallest circle within which the centre may be located by the analysis.

"Position good" implies a radius of 30 nautical miles (55 km) or less,
"Position fair", a radius of 30 to 60 nautical miles (55 to 110 km) and
"Position poor", a radius of greater than 60 nautical miles (110 km).

Direction of movement of the tropical disturbance: direction towards which the tropical disturbance centre is moving.

Speed of movement of the tropical disturbance: speed of movement of the centre of the tropical disturbance.

Storm tide: actual sea level as influenced by a weather disturbance. The storm tide consists of the normal astronomical tide and the storm surge.

Storm surge: difference between the actual water level as influenced by a meteorological disturbance (i.e., the storm tide) and the level which would have been attained in the absence of the meteorological disturbance (i.e., astronomical tide). Storm surge results from the shoreward movement of water combined with the comparatively minor effects of low barometric pressure.

Marine Warnings:

Weather warning: meteorological message issued to provide appropriate warnings of hazardous weather conditions.

Near gale warning: warning of mean wind speeds in the range of 28 to 33 knots (51 to 62 km/h, force 7 in the Beaufort scale).

Gale warning: warning of mean wind speeds in the range of 34 to 47 knots (63 to 88 km/h, force 8 or 9 in the Beaufort scale).

Storm warning: warning of mean wind speeds in the range of 48 to 63 knots (89 to 117 km/h, force 10 or 11 in the Beaufort scale).

Hurricane warning: warning of mean wind speeds of 64 knots or higher (118 km/h or higher, force 12 in the Beaufort scale).

Terms related to the warning system:

Cyclone advisory: priority message for exchanging information between national meteorological services or meteorological offices concerning tropical disturbances or incipient tropical disturbances : observational data of special significance (e.g., radar eye report), analyses (e.g. of satellite imagery) ; forecasts (e.g. of movement), warnings issued nationally.

Cyclonic season: period of the year during which most of the tropical disturbances occur. In the South- West Indian Ocean, this period is between 1 November and 30 April (for Mauritius and Seychelles: this period is between 1 November and 15 May).

1.3 Units used in international exchanges

(a) The following units/indicators are used for marine purposes:

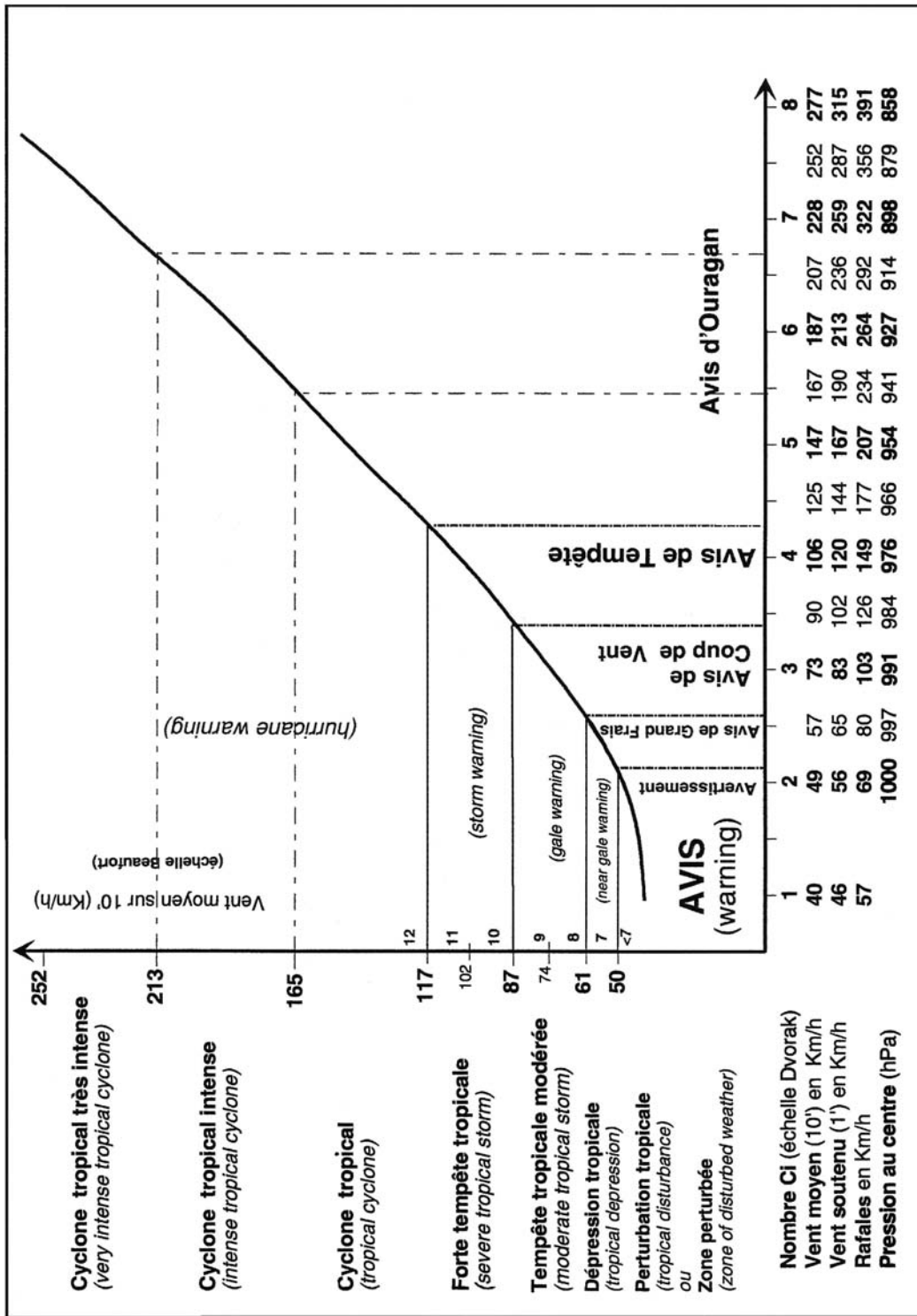
- (i) Distance in nautical miles, the unit (nm) being stated;
- (ii) Location (position) by degrees and, where possible, tenths of degrees of latitude and longitude expressed in words;
- (iii) Direction to the nearest sixteen points of the compass or in degrees to the nearest ten, given in words;
- (iv) Speed (wind speed and rate of movement of systems) in knots, the unit (kt) being stated;
- (v) Confidence in the centre position in nautical miles (nm);

(b) The following units/indicators are used in non-coded segments of exchanges, other than marine bulletins:

- (i) Distance in kilometres (km) or nautical miles (nm);
- (ii) Location (position) by degrees and tenths of degrees in figures of latitude and longitude and/or bearing on the sixteen point compass and distance from well-known fixed place(s);

- (iii) Direction in degrees to the nearest 10, given in figures;
- (iv) Speed (wind speed and rate of movement of system) in kilometres per hour (km h^{-1}) or knots;
- (v) Confidence in the centre position in kilometres (km) or nautical miles (nm).

1.4 Classification of tropical disturbances adopted for use in the South-West Indian Ocean area of RA I



1.5 Identification of tropical cyclones

The list of names to be used for identifying tropical storms and cyclones in the South-West Indian Ocean area, within the area bounded by 5°S, 90°E, 30°S and 30°E, has been established by the Committee at its seventeenth session in October 2005 for the 2006/2007 cyclone season. The names chosen are:

CYCLONE SEASON 2008/2009		CYCLONE SEASON 2009/2010		CYCLONE SEASON 2010/2011	
<u>Names</u>	<u>Provided by</u>	<u>Names</u>	<u>Provided by</u>	<u>Names</u>	<u>Provided by</u>
ASMA	<i>Mauritius</i>	ANJA	<i>Madagascar</i>	ABELE	Lesotho
BERNARD	<i>Seychelles</i>	BONGANI	<i>Mozambique</i>	BINGIZA	Malawi
CINDA	<i>Mozambique</i>	CLEO	<i>France</i>	CHERONO	Kenya
DONGO	<i>Malawi</i>	DAVID	<i>South Africa</i>	DALILOU	Comoros
ERIC	<i>France</i>	EDZANI	<i>Botswana</i>	ELVIRE	Mauritius
FANELE	<i>Swaziland</i>	FAMI	<i>Zimbabwe</i>	FRANCIS	Seychelles
GAEL	<i>Madagascar</i>	GELANE	<i>Swaziland</i>	GILADI	Tanzania
HINA	<i>Mauritius</i>	HUBERT	<i>Mauritius</i>	HAINGO	Madagascar
IZILDA	<i>Mozambique</i>	IMANI	<i>Comoros</i>	IGOR	France
JADE	<i>France</i>	JOEL	<i>Tanzania</i>	JANI	Botswana
KAGO	<i>Botswana</i>	KANJA	<i>Kenya</i>	KHABONINA	Swaziland
LISEBO	<i>Lesotho</i>	LUNDA	<i>Malawi</i>	LUMBO	Mozambique
MAGOMA	<i>Comoros</i>	MOHONO	<i>Lesotho</i>	MAINA	Zimbabwe
NEWA	<i>Tanzania</i>	NIGEL	<i>Seychelles</i>	NALEDI	South Africa
OWAMI	<i>Swaziland</i>	OLYMPE	<i>France</i>	ONANI	Malawi
PULANE	<i>Lesotho</i>	PAMELA	<i>Tanzania</i>	PAULETTE	Seychelles
QOLI	<i>South Africa</i>	QUENTIN	<i>Kenya</i>	QILOANE	Lesotho
RUTE	<i>Malawi</i>	RAHIM	<i>Comoros</i>	RAFAEL	France
SAMA	<i>Namibia</i>	SAVANA	<i>Mozambique</i>	STELLA	South Africa
TSHOLO	<i>South Africa</i>	THEMBA	<i>Swaziland</i>	TARI	Comoros
UZALE	<i>Comoros</i>	UYAPO	<i>Botswana</i>	UNJATY	Madagascar
VIMBAI	<i>Zimbabwe</i>	VIVIANE	<i>Mauritius</i>	VITA	Tanzania
WADA	<i>Botswana</i>	WALTER	<i>South Africa</i>	WILLY	Mauritius
XYLO	<i>Madagascar</i>	XANGY	<i>Madagascar</i>	XIMENE	Mozambique
YAMBA	<i>Tanzania</i>	YEMURAI	<i>Zimbabwe</i>	YASMINE	Kenya
ZITA	<i>Seychelles</i>	ZANELE	<i>Lesotho</i>	ZAMA	Swaziland

A tropical disturbance or subtropical disturbance is named when reaching the stage of moderate tropical storm (validated T-number 2.5 on the Dvorak scale during six consecutive hours). As soon

as one of the two Sub-regional Tropical Cyclone Advisory Centres* (Madagascar if the tropical storm is centered west of 55°E, Mauritius if the storm is centered between 55° and 90°E) decides to name a disturbance, the RSMC La Réunion – Tropical Cyclone Centre shall immediately be informed by fax 262.262.92.11.48 (Operational centre) and, if necessary, by any other appropriate means, to ensure that the given name appears in the bulletins issued by the RSMC. Following consultation with RSMC La Réunion and taking into consideration its intensity analysis and arriving at a consensus, the sub-regional tropical cyclone Advisory Centre in the area which the disturbance is located (Madagascar if the tropical storm is centred west of 55°E, Mauritius if the storm is centred between 55° and 90°E) shall name the disturbance and immediately inform the RSMC La Réunion by fax (262.92.11.48) and, if necessary, by any other appropriate means, to ensure that the given name appears in the bulletins issued by the RSMC.

The Meteorological services in the South West Indian Ocean region will use the name from the list of names already designated to identify that tropical storm until it moves out of the area, becomes an extra-tropical storm, or ceases to qualify as a moderate tropical storm.

In the latter case the storm will continue to bear the attributed name preceded by an EX in all bulletins associated with the storm.

The above arrangement relates only to the identification of tropical cyclone by use of names and does not imply a restriction on tropical cyclone warnings which shall be issued in accordance with provisions of chapter V for named and unnamed tropical cyclones.

* The term "Sub-regional Tropical Cyclone Advisory Centre" is agreed upon by the RA I Tropical Cyclone Committee for use within the South-West Indian Ocean region by its Members. It has not been adopted by Regional Association I or by any other WMO constituent body.

ATTACHMENT I-A

TERMS AND UNITS USED FOR NATIONAL PURPOSES

A. The meanings of terms used for national purposes by Members as indicated are given below:

National cyclone bulletin: A public release by a national Meteorological Service giving warnings or warning information, where appropriate, along with details on a tropical cyclone. (This term is used by Mauritius and Mozambique). (Pro-formas used by various Members for issue of national cyclone bulletins are given in Attachment I-B.)

Tropical cyclone warning: A warning against the possible disastrous effects of a tropical cyclone, including the effects separately or jointly of hurricane force winds, torrential rainfall and dangerous sea conditions. (This term is used by Mauritius and Mozambique).

B. Madagascar

1. Bulletin

Special meteorological bulletin: A bulletin issued by the Cyclone Forecasting Centre, Antananarivo for broadcast by Radio Television Malgache whenever a cyclone may affect the area of Madagascar or if a change occurs in the development of a cyclone for which a preliminary warning has already been issued.

2. Categories of warnings

Preliminary warning: A warning issued by the Meteorological Service for the safeguard of the population whenever a cyclone, which could threaten Madagascar in the days ahead, has been detected by the Meteorological Service. This warning is included in the special meteorological bulletin.

Warning of threat: A warning issued by the Meteorological Service for the safeguard of the population when a cyclone directly threatens a part of Madagascar but the danger is not imminent. This warning is included in the Special Meteorological Bulletin.

Warning of imminent danger: A warning issued by the Meteorological Service for the safeguard of the population when a cyclone is threatening a part of Madagascar and constitutes a danger for the population.

C. Malawi

Categories of warnings

Information stage: Issued when the cyclone is within 45 and 55°East and 5 and 20°South. This is updated every 24 hours.

Alert stage: This is issued when the cyclone is between 500 and 1,000 km from Malawi boarder, and is likely going to affect the country. It is updated every 6 hours.

Warning stage: This is issued when the cyclone is within 500 km from Malawi boarder. It is updated every 3 hours.

ATTACHMENT I-B

PRO-FORMAS FOR ISSUE OF NATIONAL CYCLONE BULLETINS(a) Pro-forma used by Tanzania

Cyclone bulletin No. (*number*) issued at (*hour, date*) by the Meteorological Office at (*place*) for (*country*) and its coastal waters. At (*time, date*), (*intensity*) cyclone (*name*) was analyzed to be centred near ...ES, longitude ...EE or ... km/nm ... of (*place*). Maximum wind speed of ... km/h/knots occurs ... km/nm to the ... of the centre and hurricane force winds in excess of 117 km/h/63 knots extend outward ... km/nm from the centre. Cyclone (*name*) is forecast for the next ... hours to move towards the ... at ... km/h knots and to (*change in intensity*).

The following warnings are issued:

Precautions to be taken include:

The next bulletin of this series will be issued at (*time*).

Message dispatched by

Authority	Tel. No. or other facility	Time dispatched (local time)	Dispatched
AB	XXXX	-----	-----
CD	XXXX	-----	-----
EF	XXXX	-----	-----
GH	XXXX	-----	-----

(b) Pro-forma used by Madagascar

Special meteorological bulletin No. / *

- Name of the cyclone
- Intensity of the cyclone
- Position of the centre of the cyclone in relation to a publicly known landmark (cities or geographical landmarks) in kilometres and in the 16 point compass.
- Forecast movement of the centre, direction in the 16 point compass and speed in kilometres/hour.
- Developments and probabilities of occurrence (time and regions concerned) of the meteorological phenomena accompanying the cyclone.
- Category of the alert followed by the name of the main place of the region concerned.
- Message number.
- Time of issuing.

* Initial of the depression or cyclone

- Sent by.
- Received by.

(c) Pro-forma used by Malawi* and Mauritius

(First, second, third) Cyclone bulletin issued at hours (date).

Statement of warning status

Name, intensity, size of cyclone

Position of centre by distance and direction (and by latitude and longitude)

Movement of cyclone centre

Statement of probability and time of:

Hurricane wind (speed in gusts, direction)

Exceptional rainfall (indication of amount, if possible)

Storm surge (height, tide - applicable to Mauritius only)

Reminders about precautions against damage: by wind
 rain and floods
 sea and coasts

Message dispatched by

Authority	Tel. No. or other facility	Time dispatched (local time)	Dispatched
AB	XXXX	----	----
CD	XXXX	----	----
EF	XXXX	----	----
GH	XXXX	----	----

* Shortened version

CHAPTER II

THE OBSERVING SYSTEM AND OBSERVING PROGRAMMES

2.1 Networks of synoptic land stations

The list of implemented regional basic synoptic network surface and upper air stations of Members of the Committee is given in Table 1. Other stations are:

<u>Index number</u>	<u>Name of station</u>
67003	FOMBONI (MOHELI)
67001	MORONI ICONI
67017	VOHEMAR
67023	SAMBAVA
67037	BESALAMPY
67107	ANTSIRABE
67131	MOROMBE
67273	ANGOICHE
67237	NAMPULA
67241	LUMBO
67285	PEBANE
67205	MOCIMBOA DA PRAIA
67231	CUAMBA
67221	MARRUPA
67346	CHANGALANE
67335	XAI XAI

2.1.1 The regional basic synoptic network

The list of implemented regional basic synoptic network surface and upper-air stations of Members of the Committee is given in Table 1.

Additional surface observations at one-hourly intervals may be requested by any Member, whenever a cyclone becomes an imminent threat to the Member, from the following stations:

<u>Member</u>	<u>Stations</u>
France (La Réunion)	All stations
Mauritius	All stations
Comoros	All stations
Madagascar	All stations

and the following:

<u>Index number</u>	<u>Name of station</u>
63881	Sumbawanga (0300-1800 UTC)
67215	Pemba
67237	Nampula
67283	Quelimane
67297	Beira
67323	Inhambane
67341	Maputo

Additional radiowind observations will be made at the synoptic hours indicated whenever a named cyclone is within 500 km of the station, by the following stations:

<u>Index number</u>	<u>Name of station</u>	<u>Time of observation</u>
61976	Serge-Frolow (Ile Tromelin)	00 (radiosonde)
61988	Rodrigues, Port Mathurin	12
61995	Vacoas (Mauritius)	12 (radiosonde)

N.B. Requests shall be addressed by the Director of the National Meteorological Service making the request to the Director of the National Meteorological Service concerned. A message cancelling the request shall be sent as soon as additional observations are no longer required.

When a tropical cyclone is forecast to threaten a Member country, its NMC should initiate enhanced observation programmes for its stations, to maximize its observational input to the RSMC La Réunion, by increasing the coverage or increasing the scheduled frequency of observations.

2.1.2 Other networks

Surface observations at one-hourly intervals may be requested by any Member, whenever a cyclone becomes an imminent threat to the Member, from the following additional stations:

<u>Index number</u>	<u>Name of station</u>
67003*	FOMBONI (MOHELI)
67017*	VOHEMAR
67023*	SAMBAVA
67037*	BESALAMPY
67107*	ANTSIRABE
67131*	MOROMBE
67237	NAMPULA

The request should be addressed to the National Meteorological Service concerned.

2.2 Mobile ship stations

Whenever there is an intensifying tropical disturbance in the area, all relevant NMSs should endeavour to increase the number of ship observations in the immediate area of the disturbance by:

- (a) Requesting relevant Voluntary Observing Ships (VOS) to make 3-hourly observations and to include sea state groups as far as possible. This communication will take place through the existing marine communications systems;
- (b) Appealing to non-VOS vessels to send informal weather observations to the nearest NMS via radio stations or other means of communication.

* Unlimited list. All stations are able to make hourly OBS

Both (a) and (b) could be achieved by adding the necessary text to all marine forecasts covering the area of the disturbance. Alternatively, NMSs could contact directly, vessels known to be in the area.

Member states receiving ship reports are urged to distribute the same to all other countries.

Members should transmit the observations – with the least delay – to the RSMC La Réunion and the two Sub-regional Tropical Cyclone Advisory Centres in Mauritius and Madagascar.

2.3 Aircraft reports

Aircraft reports which are of particular importance for cyclone analysis or forecasting will be exchanged on a priority basis.

The RSMC La Réunion - Tropical Cyclone Centre will, when possible, provide radar observations, made from C160 Transall aircraft on scheduled flights, giving the position of the cyclone centre as closely as possible, when the centre is sufficiently close to the flight path to be detected.

2.4 Special stations

2.4.1 Regional radar network

Members shall exchange, in particular, with the RSMC La Réunion - Tropical Cyclone Centre as a first priority, radar information concerning cyclone eye fixes, as well as other radar data. For this purpose, they may:

- use Part A of code form FMM 20 V - RADOB and/or apply the procedures described in Table 2; or
- exchange the data in plain language by any appropriate means available (SSB, telefax, telephone, etc.).

The example of Mauritius and Réunion has shown that this solution appears to be more flexible, less demanding, thus more effective during cyclonic alert periods when operational staff is already kept busy with other tasks.

The list of operational weather radar stations is as follows:

<u>Station name</u>	<u>Lat. °S</u>	<u>Long. °E</u>	<u>Wavelength</u>	<u>Make</u>
La Réunion	21	55 doppler	10 cm	GEMATRONIK
Trou aux Cerfs*	20	57	10 cm	EEC
Beira	20	35	10 cm	MRL-5
Xai-Xai	//	//	//	//
Durban	29°58'	30°57'	5 cm	Enterprise C-band
Ermelo	26°31'	29°59'	5 cm	Enterprise C-band
Pietersburg	23°30'	29°25'	5 cm	Enterprise C-band
Bokaa	//	//	//	EEC

* Temporarily out of order

2.5 Meteorological satellites (ground segment)

2.5.1 APT/WEFAX/HRPT

In relation to the tropical cyclone detection, monitoring and forecasting services, Members will operate and maintain satellite data reception equipment as follows:

- . Botswana MSG Station at Gaborone
- . Comoros MSG, SYNERGIE, Station at Moroni and Hahaya
- . France (Réunion) Eumetcast, NOAA, FY2, PDUS, APT/WEFAX, HRPT and MDD/PDUS Station at St. Denis
- . Kenya MSG, SYNERGIE,, NOAA at Nairobi and Mombasa
- . Lesotho MSG Station at Maseru
- . Madagascar MSG, SYNERGIE,, HRPT Station at Toamasina, Antananarivo
- . Malawi MSG
- . Mauritius MSG, SYNERGIE,, NOAA
Station at Vacoas
- . Mozambique MSG, Messir Station at Maputo
- . Namibia ?
- . Rep. of South Africa MSG, NINJO Station at Pretoria
- . Seychelles MSG, SYNERGIE,, Messir vision Station at Mahé
- . Swaziland MSG, SYNERGIE, Messir
- . Tanzania MSG, SYNERGIE, Station at Dar-es-Salaam and Synergie at Zanzibar
- . Zimbabwe MSG, SYNERGIE, Station at Belvedere-Harare

In order to enable comparisons with each other of results obtained, Members and, in particular, the RSMC La Réunion - Tropical Cyclone Centre, will exchange on a priority basis analyses of satellite information on tropical cyclones. The text of cyclone advisories for this purpose will take the form:

- (a) Time of picture, identification of satellite;
- (b) Position of centre in degrees and tenths of degrees;
- (c) Intensity: T number of estimated maximum wind speed and central pressure;
- (d) Other characteristics deduced from the picture, e.g. development characteristics, estimated extent of winds of specified speeds.

2.5.2 Data collection platforms (DCP)

The list of data collection platforms is as follows:

<u>Location</u>		<u>Lat.</u>	<u>Long.</u>
63995	Aldabra		
63998	Desroches		
63996	Farquhar		
63999	Praslin	(to be filled out by Members concerned)	
67017	Vohemar		
67019	Analalava		
67131	Morombe		
67152	Ranohira		
67056	Ambatomainy	17°41S	45°40E
67079	Tsiroanomandidy	18°46S	46°03E
67135	Beroroaha	21°40S	45°10E
67179	Bekily	24°13S	45°19E

DCP France (Réunion)

61968	Iles Glorieuses		
61970	Ile Juan de Nova	(to be filled out by La Réunion)	
61972	Ile Europa		
61976	Ile Tromelin		

TABLE 1 - LIST OF IMPLEMENTED OBSERVING STATIONS

**Stations and observations programmes comprising the basic synoptic network
for tropical cyclone forecasting in the South-West Indian Ocean**

Refer to WMO Volume A for an up-to-date list of stations and observational programmes.

TABLE 2 - RADAR EYE REPORTS - REPORTING PROCEDURES

Definition of eye or centre. Derive the eye or centre position from a continuous and logical sequence of observations. Ideally, the radar-derived eye is readily apparent as an echo-free area, circular or oval in shape, contained within the wall cloud. It is the geometric centre of this echo-free area that will be reported as the eye location. If the wall cloud is not completely closed, it is still usually possible to derive an eye location with a high degree of confidence by sketching the smallest circle or oval that can be superimposed on the inner edge of the existing portion of the wall cloud. If the wall cloud is not well-developed but a centre of circulation is identifiable then this feature should be observed and reported similarly to an eye.

Terminology. If the central region of a storm is defined by an identifiable wall cloud, report the fix as an "EYE". If a centre of circulation is recognizable but not well-defined by a wall cloud, report the fix as a "CNTR". If the eye or centre is only occasionally recognizable, or there is some other reason to suspect an uncertain central organization, the fix should be designated "PSBL EYE" or "PSBL CNTR". Include a remark with eye fixes to indicate the degree of confidence in the fix. Qualifying remarks will not, ordinarily, be applied to centre fixes. The following guidelines are meant to be suggestive rather than absolute: If the wall cloud is closed, or almost closed, and the resultant eye is symmetrical, include as a remark the phrase "GOOD FIX" in all observations. If the derived fix is believed to be useful although ambiguous due to lack of completeness of the wall cloud, e.g. less than 50% or because of lack of symmetry of the eye configuration, include the remark "POOR FIX". The phrase "FAIR FIX" will be used to express an intermediate degree of confidence.

Use of spiral band overlays. Spiral band overlays may be used when the centre of the storm is over water to estimate the location of the eye or centre whenever it is indistinct, out of range, or whenever the radar beam is overshooting the centre of the storm. Normally at least 90 and preferably 180 degrees arc of a spiral band must be present on the radarscope to assure a usefully accurate estimate of the storm's centre position. Standard overlays are available with 10, 15 and 20 degrees crossing angles. Since the crossing angle of a given band may increase from near zero degrees at the eye to more than twenty degrees at distances over 170 km/90 nm from the centre, the most satisfactory results can be expected by use of the spiral band overlay which best fits the intermediate portions of the band. Control setting should be carefully adjusted to enhance the definition of the spiral bands. Depending on the particular type of radar, it may be more convenient to trace the centres of the spiral bands on a map-type overlay before fitting the spiral band overlay. If the eye position is determined principally by means of a spiral band overlay, the report should indicate this. For example:

15 DEG SPRL OVERLAY EYE 2033S 6046E

Encoding location of eye or centre. Record and report co-ordinate positions of the eye or centre to the nearest minute of latitude and longitude by means of unpunctuated five-character groups. A position of 18°35' south, 58°17' east should appear on observation forms and teletype transmissions as 1835S 5817E. Record, but do not transmit, azimuth and range data from which coordinate positions are derived.

Movement of eye or centre. Determine the speed and direction of movement of an eye or centre from the change of position measured over the previous one-hour interval. Report eye or centre movement by using a four-digit group. Two digits will represent the hundreds and tens value of the direction, to the nearest ten degrees, from which the eye or centre is moving. The third and fourth digits will represent the speed in metres per second. For example, if the eye movement were determined to be from 096 degrees at 7 metres per second, the movement group would be coded as 1007. Example:

MAURITIUS 150300 UTC EYE 2033S 6005E D55 1007 GOOD FIX

(where D55 means diameter of eye 55 kilometres).

CHAPTER III**TROPICAL CYCLONE ANALYSIS AND FORECASTING**3.1 Forecasting of tropical cyclone movement and changes in intensity3.1.1 Regional arrangements

The responsibility for analysis and forecasting development and movement of tropical storms in the area lies with the National Meteorological Service of each of the Members. However, in addition to the exchange of observational data needed for analysis and forecasting, at present the main special arrangements for co-operation and co-ordination in these matters are:

- (a) Utilizing available regional observational and telecommunication networks and data processing capacity, enhanced to the extent possible, the RSMC La Réunion - Tropical Cyclone Centre shall issue advisory statements during cyclone occurrences at 6-hourly intervals, directed to Pretoria RTH and Nairobi RSMC/RTH for distribution to NMCs, and to Toulouse for dissemination via EUMETCAST, in respect of the following products:

Analysis:

- (i) position of established tropical cyclones/depressions;
- (ii) direction and speed of movement of each system;
- (iii) central pressure of each system;
- (iv) maximum wind and wind distribution of each system;
- (v) reference to location of prominent synoptic features (ITCZ, upper troughs, etc.);

Prognosis:

- (i) forecast positions of tropical systems at 12, 24, 36, 48, 60, 72 hours;
- (ii) intensity (Dvorak) at 12, 24, 36, 48, 60, 72 hours;

Prognostic reasoning incorporating reference to:

- (i) satellite imagery interpretation;
- (ii) observational inferences and tendencies;
- (iii) dynamic interpretation of interaction processes;
- (iv) climatological, persistence and statistical guidance.

On a similar basis the Sub-regional Tropical Cyclone Advisory Centres* should also issue advisory statements, where appropriate, for their respective areas of responsibility (see Chapter IV, section 4.1).

* See footnote to Chapter I, section 1.5

In addition to the above products, the RSMC La Réunion - Tropical Cyclone Centre will issue on a routine basis the products indicated in Table 3. The list of those products will be issued through on GTS or AFTN (Table 3).

- (b) Each Member shall make full use of services provided by the RSMC La Réunion - Tropical Cyclone Centre and, where applicable, by the Sub-regional Tropical Cyclone Advisory Centre*;
- (c) Where considered necessary and feasible, there will be exchange of views on tropical storm forecasts among the forecasters of the National Meteorological Services of the Members. This exchange of views between forecasters will be preceded by an exchange of data as set out in Chapters II and V.

The Sub-regional Tropical Cyclone Advisory Centre* in Madagascar will disseminate advisories to Comoros and all Committee Members on the continent. The Sub-regional Tropical Cyclone Advisory Centre* in Mauritius will disseminate advisories to Seychelles.

3.1.2 National activities

NMCs shall use available facilities to enable, to the maximum extent possible, speedy reception of the above products, and adaptation for national purposes.

Information given in available tropical cyclone advisories and other guidance material will be taken into consideration by national Meteorological Services when preparing tropical cyclone forecasts, avoiding unnecessary duplication of monitoring effort except for fine tuning which may be advisable through access to locally acquired radar surveillance data, ship reports, etc.

The prime role of the NMCs is to convert the technical information into meaningful severe weather forecasts and warnings (strong winds, heavy precipitation and flooding, storm surge, rough seas and swell and environmental damage) for national purposes in terms of the established national cyclone warning system well-known to the community. NMCs may direct queries to the RSMC La Réunion - Tropical Cyclone Centre or to the Sub-regional Tropical Cyclone Advisory Centre* concerned, with respect to possible amendments to the predicted behaviour of a tropical cyclone which may have become apparent since receipt of the previous advisory statement.

3.2 Forecasting of storm surges and cyclonic swell

The responsibility for storm-surge and cyclonic swell forecasting lies with the national Meteorological Service of the Member concerned.

3.3 Forecasters' tools

If possible, NMCs will put at the disposition of their forecasters the best tools such as work stations.

3.4 New regular cyclone information Bulletin for the South-West Indian Ocean

The RSMC La Réunion provides, on a daily and yearly basis, a new Cyclonic Information Bulletin for the South-West Indian Ocean. This bulletin is bilingual (French and English) and available at 12 UTC. The heading is AWIO21 (French edition) and AWIO20 (English edition) (Table 3).

The name adopted for the bulletin is the following:

* See footnote to Chapter I, section 1.5

French edition: "BULLETIN SUR L'ACTIVITE CYCLONIQUE ET LES CONDITIONS METEOROLOGIQUES TROPICALES SUR LE SUD-OUEST DE L'OCEAN INDIAN"

English edition: "BULLETIN FOR CYCLONIC ACTIVITY AND SIGNIFICANT TROPICAL WEATHER IN THE SOUTH-WEST INDIAN OCEAN"

The bulletin will comprise two parts: the first listing Warning Summaries, the second on tropical weather activity (Tropical Weather Discussions).

Regular dissemination of this bulletin will supplement the operational system for cyclone information established by the RSMC La Réunion, for Meteorological Services of the South-West Indian Ocean.

TABLE 3

CYCLONE BULLETINS ISSUED BY RSMC/TROPICAL CYLONE CENTRE LA REUNION

Bulletins		Headings	Dissemination time
Marine Warnings	English	WTIO20, 22, 24	GTS 00, 06, 12, 18 UTC
	French	WTIO21	Same
RSMC Bulletins	English	WTIO30	GTS 00, 06, 12, 18 UTC
	French	WTIO31	Same
Satellite Bulletins	English	TPIO20	GTS as soon as possible after the satellite's passage
	French	TPIO21	same
ICAO Advisories	English	- FKIO20	AFTN 00, 06, 12, 18 UTC GTS 00, 06, 12, 18 UTC
"BUFR" Bulletins	-	ATIO01	GTS 00, 06, 12, 18 UTC
"Best-Track" Bulletins	-	AXIO20	GTS within one month after the cyclone's death
Cyclonic information Bulletin	English	AWIO20	GTS 12 UTC
	French	AWIO21	GTS 12 UTC

ATTACHMENT III-A

TROPICAL CYCLONE ANALYSIS AND FORECASTING

The South African Weather Service (SAWS) has access to two global Models, ECMWF and Bracknell, via the GRID data collectives on the GTS. It is also running its own limited area (Eta) model (38 levels, 80 km resolution) and a spectral global model (28 levels, 100 km resolution). Both of the prediction models run in Pretoria are ex NMC Washington and are run on a Cray J90 mainframe.

A tropical cyclone prediction system is semi-operational. It is based on the "bogussing" of tropical cyclones into the Eta Model analyses.

CHAPTER IV

TROPICAL CYCLONE ADVISORIES AND WARNINGS

4.1 Tropical cyclone advisories

The RSMC La Réunion - Tropical Cyclone Centre will be responsible for providing cyclone watch over the whole region with the most skillful advisory diagnosis available concerning the technical parameters which specify the location, intensity, dimensions and future track of tropical disturbances, as atmospheric systems, in the region. The Sub-regional Tropical Cyclone Advisory Centre* in Madagascar will issue advisories for the region between the eastern coast of Africa and 55°E while the Sub-regional Tropical Cyclone Advisory Centre* in Mauritius will issue advisories for areas between 55°E and 90°E, in each case, taking into account advisories provided from the RSMC La Réunion - Tropical Cyclone Centre.

NMCs should utilize the advisory statements issued by the RSMC La Réunion - Tropical Cyclone Centre as the basis for its national cyclone warning strategies. Full use should also be made of the advisory statements issued by the Sub-regional Tropical Cyclone Advisory Centres* for their respective areas of responsibility.

4.2 Warnings for land areas and coastal waters

Each Member shall continue to be solely responsible for issue of warnings for its land areas and coastal waters. These warnings shall be based on tropical storm analyses and forecasts which rely on the co-ordinated and co-operative arrangements made in the Region and indicated in this operational plan.

Warnings issued for a specific area are in several cases intercepted or become available in neighbouring areas. While the above-mentioned national responsibilities shall be fully recognized, efforts shall be made to co-ordinate warnings issued by different Members, to the extent possible, with a view to strengthening the warning system for the Region and to minimizing confusion among the users of such warnings. Members will therefore exchange information on the status of national warnings. Pro-formas used by various Members for issue of national cyclone bulletins are given in Attachment I-B.

The NMCs must assist in the dissemination of warnings to threatened communities as rapidly as possible, in view of the fact that cyclone warnings are very "perishable" products and delays in dissemination produce an adverse effect on their usefulness to the public, to some extent similar to inaccuracies in prediction.

4.3 Warnings for the high seas

GMDSS

In the framework of the Global Maritime Distress and Safety System (GMDSS), the RSMC La Réunion - Tropical Cyclone Centre provides special meteorological bulletins for the area located between equator and 40°S and between the African coastline and 90°E. Regular bulletins for the area located between equator and 30°S and between 55°E and 95°E are provided by the Mauritius Meteorological Service. Those bulletins are transmitted by satellite via INMARSAT, by the RSMC La Réunion, through the earth station at Aussaguel (France).

* See footnote to Chapter I, section 1.5.

4.3.1 Areas of responsibility

More than one Member can issue warnings for the high seas for any given area.

Members having official responsibility for issuing forecasts and warnings for the high seas are:

Madagascar - Sea areas from 10°S to 30°S between the African coast and 60°E, and from 5°S to 30°S between 60°E and 70°E.

Mauritius - Sea areas from equator to 30°S between 50°E and 90°E.

Mozambique - Sea area in the Mozambique Channel from 12°S to 25°S.

Comoros and La Réunion (France) also issue bulletins with warnings for the Comoro archipelago and the area between equator and 40°S, and 40°E and 90°E, respectively.

The implementation of the GMDSS will modify progressively these responsibilities according to the Joint WMO/IOC Technical Commission for Oceanography and Meteorology (JCOMM).

4.3.2 Form and content of bulletins

Tropical cyclones are classified in marine bulletins for the high seas as:

- (i) Tropical depression;
- (ii) Moderate tropical storm;
- (iii) Severe tropical storm;
- (iv) Tropical cyclone;
- (v) Intense tropical cyclone;
- (vi) Very intense tropical cyclone.

Warnings to be issued for the high seas shall be:

- (i) Near gale warning;
- (ii) Gale warning;
- (iii) Storm warning;
- (iv) Hurricane warning.

When no warnings are to be issued, that fact shall be stated in the bulletins.

In the bulletins, the warning shall be preceded by information concerning the origin of the warning, such as the time of the data (synoptic chart, satellite imagery, etc.) on which the warning was based (see section 4.3.4 below).

4.3.3 Schedule of issue of bulletins

Bulletins with warnings for the high seas shall be issued immediately they become necessary and as detailed in WMO Publication No. 9, Volume D.

4.3.4 Marine cyclone monitoring centres

To provide inputs to the coordination of warnings for the high seas the following Meteorological Centres are designated as marine cyclone monitoring centres^{*} for the portions of the region as indicated:

RSMC La Réunion - Tropical Cyclone Centre	full region
Sub-regional Tropical Cyclone Advisory Centre ^{**} , Madagascar	west of 55°E
Sub-regional Tropical Cyclone Advisory Centre ^{**} , Mauritius	east of 55°E

Each of these centres will prepare and make available to Members concerned, at 6-hourly intervals for all cyclones centred within its designated area as set out above, the following:

- (i) Data time together with position of cyclone centre, direction and speed of movement, maximum wind speed, radius of gale force winds;
- (ii) 12-hour forecast of centre position and maximum wind speed.

Members issuing bulletins for the high seas containing cyclone warnings (see section 4.3.2 above) will request the above-mentioned information from the RSMC La Réunion - Tropical Cyclone Centre and the relevant marine cyclone-monitoring-centre^{***} and make full use of it.

4.4 Warnings for aviation

In accordance with the International Civil Aviation Organization (ICAO) Air Navigation Plan (ANP) for the Africa-Indian Ocean (AFI) Region, warnings of tropical cyclones for international air navigation are issued as SIGMET messages, by designated meteorological watch offices (MWOs), each of which provides information for one or more specified Flight Information Regions (FIRs) or upper Information Regions (UIRs). The boundaries of the FIRs/UIRs are defined in ICAO ANP for the AFI Region (Doc. 7474).

SIGMET information is provided in accordance with WMO-No.49 - Technical Regulations, Volume II (Meteorological Services for International Air Navigation).

The RSMC La Réunion - Tropical Cyclone Centre disseminates advisory information on positions of the centre of the tropical cyclone to the designated MWOs as appropriate for use in the preparation of SIGMETs.

^{*} The term "marine cyclone-monitoring-centre" is agreed upon by the RA I Tropical Cyclone Committee for use within the South-West Indian Ocean region by its Members. It has not been adopted by Regional Association I or by any other WMO constituent body.

^{**} See footnote to Chapter I, section 1.5.

^{***} The term "marine cyclone-monitoring-centre" is agreed upon by the RA I Tropical Cyclone Committee for use within the South-West Indian Ocean region by its Members. It has not been adopted by Regional Association I or by any other WMO constituent body.

ATTACHMENT IV-A

**WARNINGS FOR THE PUBLIC AND FOR
COASTAL WATERS - NATIONAL PRACTICES**

France (La Réunion)

Daily, three bulletins are issued for coastal waters and high seas, and three for the public. In case of cyclone threat, the frequency of these bulletins is increased progressively to become tri-hourly when the danger is imminent. These bulletins include the following:

- Position and movement of the cyclone;
- Influence on the local weather, by sectors;
- Wind speed and direction;
- State of the sea.

Madagascar

(a) Warnings for the public

The pro-forma shown in Attachment I-B(b) is used. These warnings are addressed as priority messages via the telecommunication networks of the Police and Army to the administrative authorities to enable them to make appropriate arrangements for safeguarding human life and limiting material damage.

(b) Warnings for coastal waters

The pro-forma shown in Attachment I-B(b) is used for broadcast by Radio Television Malagasy except that they comprise in addition a part relating to the state of the sea.

ATTACHMENT IV-B

SOUTH AFRICA WEATHER SERVICE (SAWB)

**TROPICAL CYCLONE ADVISORIES ISSUED BY THE
CENTRAL FORECAST OFFICE (CFO), PRETORIA**

- (i) The "WTIO" bulletins from the RSMC La Réunion are automatically downloaded to Pretoria and these messages re-routed to other regional centres on the sub-continent.
 - (ii) The above information is also included into the FQZA31 FAPR "High Seas" Bulletin which is issued from CFO at 08h40 and 14h40 UTC daily. The full text of the tropical cyclone warning from La Réunion is included when necessary.
 - (iii) The message FQZA81 (*) which is broadcast via Burum LES and IOR satellite consists of the FQZA31 message mentioned above with the addition of the forecast area "Madagascar East" and the forecasts FQIO21/22 from the RSMC La Réunion.
 - (iv) Where a tropical cyclone moves into the SAWS's "Coastal Bulletin" area (which also includes the Mozambique Channel), the full text from the RSMC La Réunion will again be included.
 - (v) The CFO provides a 6-hourly cloud analysis utilizing Meteosat imagery. Any visible tropical cyclone vortices will be included – with due reference to positions reported by the RSMC La Réunion.
 - (vi) The CFO operates a 24-hour shift throughout the year and are thus frequently called upon to provide ad hoc information on tropical cyclones in its area of responsibility – by telephone, fax, radio and Inmarsat (the office operates its own Inmarsat – C terminal).
- (*) The bulletin is referred to as "METAREA VII east of 20°E"
-

CHAPTER V

EXCHANGE OF INFORMATION

5.1 Telecommunication systems

Observational data and processed information required for the cyclone warning services and also cyclone warnings for international purposes shall be exchanged over the GTS. Such information, including Special APT Cyclone Bulletins, Special Radar Cyclone Bulletins, cyclone centre forecast positions and cyclone warnings for international purposes shall be added to collective messages of basic data for transmission to RTH Nairobi. The RTH Nairobi shall transmit these bulletins to all Members of the Committee.

Advisories shall be provided by the RSMC La Réunion - Tropical Cyclone Centre issued in English and French at least twice daily. The RSMC La Réunion - Tropical Cyclone Centre shall disseminate these advisories.

Cyclone advisories, including radar eye reports, satellite imagery, cyclone analyses, other information of special importance for cyclone analyses and forecasting, forecast centre positions and status of local warnings, as well as the views of the forecasters on cyclone forecasting and warnings shall be exchanged as follows:

Botswana	-	South Africa	(GTS 64kbps)			
Comoros	-	La Réunion	(GTS, TCP/IP)			
Comoros	-	Madagascar	(TCP/IP)			
Comoros	-	Tanzania	(TCP/IP)			
Madagascar	-	La Réunion	(TCP/IP, GTS)			
Madagascar	-	Mauritius	(GTS, TCP/IP)			
Madagascar	-	Mozambique	TCP/IP	Malawi -	South Africa	GTS
and (TCP/IP						
Malawi	-	La Réunion	TCP/IP			
Mauritius	-	La Réunion	(GTS TCP/IP)			
Mauritius	-	Seychelles	(TCP/IP)			
Swaziland	-	South Africa	TCP/IP [64 kbps], GTS			
Lesotho	-	South Africa	(GTS 64kbps, TCP/IP)			
Zimbabwe	-	South Africa	(GTS 64kbps)			
Malawi	-	Mozambique	(TCP/IP)			
Mozambique	-	South Africa	(GTS 128kbps)			
Kenya	-	Tanzania	(GTS 64kbps)			
Kenya	-	South Africa	(GTS 64kbps)			
Seychelles	-	La Reunion	(TCP/IP, GTS)			

5.2 Schedule for exchange of cyclone advisories

Cyclone advisories shall be exchanged at intervals of 6 hours. These messages shall be given high priority. Consultation between forecast offices on cyclone forecasting and warning will take place when needed. The exchanges between the Sub-regional Tropical Cyclone Advisory Centre** in Mauritius and the RSMC La Réunion - Tropical Cyclone Centre shall be made every hour in cases where cyclones are in the vicinity of one of these islands.

** See footnote to Chapter I, setion 1.5.

ATTACHMENT V-A

LIST OF ADDRESSES AND TELEPHONE NUMBERS

COUNTRY	MAIL ADDRESS	TELEX/FAX/E-MAIL	TELEPHONE NUMBER
AUSTRALIA Gary Foley Regional Director (Western Australia)	PO Box 1370 West Perth Western Australia 6872	Fax: (61-8) 926 32297 E-mail: gfoley@bom.gov.au Web: www.bom.gov.au	(61-8) 926 32210 (direct)
BOTSWANA Ms G.K. Ramothwa Director of Meteorological Services (G.K. Nthobatsang)	P.O. Box 10100 Gaborone	Fax: (267) 3956 282 Fax: (267) 3956 282	(267) 3956 281/4 (267) 3956 284
COMOROS Poundja Mohammad Ali Bay Director of Meteorological Office Ibrahim Kassim Chief of Forecasting Services	P.O. Box 78 Moroni	Telex: 241 PUBLIC KO Fax: (269) 730 447, 731 468 E-mail: dgacm@snpt.km jamnagarlibay@yahoo.fr Fax: (269) 730 447, 731 468 E-mail: aimpsi@snpt.km kassim@snpt.km	(269) 730 948 Home: (269) 731 339 (269) 732 135, 731 593
FRANCE G Therry Director of Meteorological Service P. Rémois Head of Network and Operations	P.O. Box 4 97491 Saint-Clotilde Cédex La Réunion France P.O. Box 4 97491 Saint-Clotilde Cédex La Réunion France	Fax: 262 262 921 147 E-mail : Gerald.Therry@meteo.fr Tel Res : +262 262 921 100 +262 262 921 100 Web: www.meteo.fr	(262) 262 921 100 Home: 262 921 155, 262 971 407 (262) 262 921 107 Home: 262 921 162
LESOTHO B.T. Sekoli Director of Meteorological Services Attention: J.R. Mphethi	P.O. Box 772 Maseru	Fax: (266) 325057 (266) 350325 E-mail: bulane@lesoff.co.za	(266) 325041 (266) 317250
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ATTACHMENT V-B

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CHAPTER VI

QUALITY CONTROL AND MONITORING

6.1 Quality control of observational data

National Meteorological Services will make extra efforts to ensure that all observational data disseminated during periods of cyclone threat to the area have been controlled for correctness. Wherever appropriate verification of reports or of elements of reports will be requested of the observing station and communication channels will be kept open to facilitate this, particularly in cases where an enhanced observing programme is being carried out.

In the exchange of data during periods of cyclone threat, queries concerning reports on which there is doubt should be addressed to the relevant National Meteorological Centre.

6.2 Monitoring of exchange of information

Monitoring will be carried out by the RSMC La Réunion – Tropical Cyclone Centre, the Sub-regional Tropical Cyclone Advisory Centres^{*} and NMCs in accordance with their standard procedures. Special attention will be given to identification of deficiencies during the cyclone season in the flow of observational data and processed information relating to cyclone analysis and forecasting with a view to appropriate remedial action being taken.

* See footnote to Chapter I, section 1.5.

CHAPTER VII

TROPICAL CYCLONE INFORMATION SERVICES

Members will exchange information on a non-real-time basis as required for the establishment of tropical cyclone data files and information services nationally. The information will include available annual charts of cyclone tracks in the appropriate area, with the intensity of the cyclone at each position marked in accordance with WMO regulations and recommended practices. Also to be included are available classifications of cyclones by month, intensity and movement, as well as groupings over periods of years made in accordance with the standard periods stated in WMO regulations and recommended climatological practices.

In compliance with these recommendations, RSMC La Réunion establishes the final official trajectories (and information on intensities) for each disturbance which occurred during the season. The relevant data are on the GTS in bulletins called "best-track bulletins" (with heading AXIO20) within 1 month after the end of each cyclonic event. On the other hand, a computer file including all this information, and supplemented as required, is established at the end of the cyclone season.

This file complies with the WMO recommended format (Attachement VII-A). It is sent to the NOAA National Climate Data Center (NCDC) in Asheville, (North Carolina, USA) and is also available to any Member of the Committee upon request.

Members maintaining tropical cyclone information files which are at the disposal of all Members of the Committee, as well as other WMO Members and research institutions are:

France (La Réunion)

- | | |
|---------|--|
| On disk | - Complete file of tropical disturbances observed in the South-West Indian Ocean since 1850 (includes almost 1200 disturbances). |
|---------|--|

Madagascar

- | | |
|------------------|---|
| On magnetic tape | - Identification, position, intensity, characteristics of meteorological elements, direction and speed of movement; |
| On diskettes | - Trajectory of all depressions and all cyclones in the region since 1911; |

Mozambique

- | | |
|--------------|--|
| On microfilm | - Surface weather maps for the South-West Indian Ocean area. |
|--------------|--|

GLOBAL TROPICAL CYCLONE TRACK AND INTENSITY DATA SET – REPORT FORMAT

Position Content

1- 9	Cyclone identification code composed by 2 digit numbers in order within the cyclone season, area code and year code. 01SWI2000 shows the 1st system observed in South-West Indian Ocean basin during the 2000/2001 season. Area codes are as follows: ARB = Arabian Sea ATL = Atlantic Ocean AUB = Australian Region (Brisbane) AUD = Australian Region (Darwin) AUP = Australian Region (Perth) BOB = Bay of Bengal CNP = Central North Pacific Ocean ENP = Eastern North Pacific Ocean ZEA = New Zealand Region SWI = South-West Indian Ocean SWP = South-West Pacific Ocean WNP = Western North Pacific Ocean and South China Sea
10-19	Storm Name
20-23	Year
24-25	Month (01-12)
26-27	Day (01-31)
28-29	Hour- universal time (at least every 6 hourly position -00Z,06Z,12Z and 18Z) Latitude indicator: 1=North latitude; 2=South latitude
31-33	Latitude (degrees and tenths)
34-35	Check sum (sum of all digits in the latitude)
36	Longitude indicator: 1=West longitude; 2=East longitude
37-40	Longitude (degrees and tenths)
41-42	Check sum (sum of all digits in the longitude)
43	position confidence* 1 = good (<30nm; <55km) 2 = fair (30-60nm; 55-110 km) 3 = poor (>60nm; >110km) 9 = unknown
Note*	Confidence in the center position: Degree of confidence in the center position of a tropical cyclone expressed as the radius of the smallest circle within which the center may be located by the analysis. " position good " implies a radius of less than 30 nm, 55 km; "position fair", a radius of 30 to 60 nm, 55 to 110km; and "position poor", radius of greater than 60 nm, 110km.
44-45	Dvorak T-number (99 for no report)
46-47	Dvorak CI-number (99 for no report)
48-50	Maximum average wind speed (whole values) (999 for no report).
51	Units 1=kt, 2=m/s, 3=km per hour.
52-53	Time interval for averaging wind speed (minutes for measured or derived wind speed, 99 if unknown or estimated).
54-56	Maximum Wind Gust (999 for no report)

57	Gust Period (seconds, 9 for unknown)
58	Quality code for wind reports: 1=Aircraft or Dropsonde observation 2=Over water observation (e.g. buoy) 3=Over land observation 4=Dvorak estimate 5=Other
59-62	Central pressure (nearest hectopascal) (9999 if unknown or unavailable)
63	Quality code for pressure report (same code as for winds)
64	Units of length: 1=nm, 2=km
65-67	Radius of maximum winds (999 for no report)
68	Quality code for RMW: 1=Aircraft observation 2=Radar with well-defined eye 3=Satellite with well-defined eye 4=Radar or satellite, poorly-defined eye 5=Other estimate
69-71	Threshold value for wind speed (gale force preferred, 999 for no report)
72-75	Radius in Sector 1: 315°-45°
76-79	Radius in Sector 2: 45°-135°
80-83	Radius in Sector 3: 135°-225°
84-87	Radius in Sector 4: 225°-315°
88	Quality code for wind threshold 1=Aircraft observations 2=Surface observations 3=Estimate from outer closed isobar 4=Other estimate
89-91	Second threshold value for wind speed (999 for no report)
92-95	Radius in Sector 1: 315°-45°
96-99	Radius in Sector 2: 45°-135°
100-103	Radius in Sector 3: 135°-225°
104-107	Radius in Sector 4: 225°-315°
108	Quality code for wind threshold (code as for row 88)
109-110	Cyclone type: 01= tropics; disturbance (no closed isobars) 02= <34 knot winds, <17m/s winds and at least one closed isobar 03= 34-63 knots, 17-32m/s 04= >63 knots, >32m/s 05= extratropical 06= dissipating 07= subtropical cyclone (nonfrontal, low pressure system that comprises initially baroclinic circulation developing over subtropical water) 08= overland 09= unknown
111-112	Source code (2 - digit code to represent the country or organization that provided the data to NCDC USA. WMO Secretariat is authorized to assign number to additional participating centers, organizations) 01 RSMC Miami-Hurricane Center 02 RSMC Tokyo-Typhoon Center 03 RSMC-tropical cyclones New Delhi 04 RSMC La Reunion-Tropical Cyclone Centre 05 Australian Bureau of Meteorology 06 Meteorological Service of New Zealand Ltd.

07 RSMC Nadi-Tropical Cyclone Centre
08** Joint Typhoon Warning Center, Honolulu
09** Madagascar Meteorological Service
10** Mauritius Meteorological Service
11** Meteorological Service, New Caledonia
12 Central Pacific Hurricane Center, Honolulu

Note** no longer used

Headings 1-19 Cyclone identification code and name; 20-29 Date time group;
30-43 Best track positions;
44-110 Intensity, Size and Type;
111-112 Source code.



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La Réunion Tropical Cyclone Centre

Tropical Cyclone RSMC / South-West Indian Ocean

1. Functions of the Centre

The Direction of Météo-France in La Réunion has been formally designated as the Regional Specialized Meteorological Centre (RSMC) - Tropical Cyclones for the South-West Indian Ocean during the 45th session of WMO/Executive Council (Geneva, June 1993), with effect on 1 July 1993.

The area of responsibility of the RSMC includes the tropical and subtropical areas of the South-West Indian Ocean from 05°S to 30°S west of 90°E, including the Mozambique Channel.

The primary mission of the RSMC/La Réunion is to provide appropriate guidance information (analyses, forecasts, prognostic reasoning,...) to the 14 Members of the RAI Tropical Cyclone Committee (Botswana, Comoros, France, Lesotho, Madagascar, Malawi, Maurice, Mozambique, Namibia, Seychelles, South Africa, Swaziland, Tanzania, Zimbabwe) for all the tropical disturbances occurring in its area of responsibility. However, beyond this fundamental operational function, the RSMC has the role to become the regional core for all the other activities conducted in the field of tropical cyclones such as, for instance, Training and Research/Development. And if the RSMC has, of course, initially given priority to its operational missions, it is now considering the allocation of extra resources to these two areas.

In addition to its responsibilities as an RSMC, Météo-France La Réunion has numerous other national and international responsibilities. Within the GTS, it is a hub in the regional telecommunication network. In the framework of GMDSS, it has the responsibility to prepare marine forecasts and warnings for extensive parts of METAREA VII-OI and METAREA VIII-S. Furthermore, with the role of assisting the MWO's of the whole region in the preparation of SIGMET messages for tropical cyclones, ICAO has designated it as its Regional Tropical Cyclone Advisory Centre.

Météo-France La Réunion takes also an active part in the International Buoys Programme in Indian Ocean (IBPIO). It regularly organizes the deployment in tropical or polar areas, of drifters, from ships calling at La Réunion.

2. Human resources

The overall manpower of Météo-France La Réunion is a bit less than one hundred people, all divisions included, of which 18 are engineers (class 1 WMO) and about 50 are technicians (class 2 WMO).

2.1 Forecast

The team of forecasters consists of 5 senior forecasters and 15 class II forecasters working under the direction of a chief-forecaster. The service is organized in such a way to allow the 24-hours assignment of one (or two during critical periods) senior forecasters exclusively to the monitoring, tracking and forecasting of the tropical disturbances occurring in the RSMC's area of responsibility.

In order to preserve a maximum of the forecasters' time for reasoning, all the tasks that could be automated, have been automated. For instance, in order to cope with the necessary introduction of new bulletins, a software has been developed which on the basis of the information regularly entered by the forecaster in a data-base, generates then disseminates automatically the different tropical cyclone bulletins issued by the RSMC.

2.2 Research and Development

Till July 1998, Research and Development capacities of the RSMC were limited. Till this date actually, the Center gave priority in terms of allocation of human resources, to the strengthening of operational teams.

However, after this necessary first step, the RSMC is now in position to do more in this essential domain. Thus, the creation of a high-level research and development team in the tropical cyclones area, has been decided by the General Direction of Météo-France. This team, supported by the National Centre of Meteorological Research of Météo-France in Toulouse, has joined the RSMC on the 1 August 1998 and includes 3 researchers-ingeneers, 2 university teachers, one computer scientist, and 6 to 7 students-trainees on average per year. This team can also receive researchers from the different countries of the Indian Ocean, and will be strengthened in the future.

3. Facilities

3.1 Telecommunications

In the Regional Meteorological Telecommunication Network (RMTN), the Centre of Saint-Denis/La Réunion is a hub connected with several countries by a number of reliable and high speed links. Functions of telecommunication are completely automated, and only one controller is requested.

Thanks to a TCP/IP 256kbits/s link via Toulouse, the Centre is connected to the two Regional Telecommunication Centres of Eastern and Southern Africa (Nairobi and Pretoria).

This connection with Toulouse, securitized with a 64 kbits/s (Numeris) link is a real umbilical cord for the RSMC. Thanks to this, the Centre can access to all the databases of Météo-France and in particular to the outputs of the French (ARPEGE) and ECMWF global models.

The RSMC is also equipped with:

- a data reception station (MDD, METEOSAT Data Dissemination) which allows the reception of the three MDD channels (Bracknell, Rome and Toulouse) and offers a solution for alternative reception of alpha-numerical messages and graphical products in case of failure of the telecommunication system.
- a Data Reception System (DRS) for the direct satellite reception of the numerous DCPs that have been installed in the region during the last years.

A server of meteorological messages and bulletins, operational since 1991, gives to the NMCs of the region the possibility of directly accessing to the data and bulletins collected or produced by the RSMC, and also to information (for instance, received from Toulouse) that is not available through the programmes of the RMTN.

The Centre resorts also to Internet, especially to exchange data at the regional level where this network is a good alternative to traditional links. E-mail allows for example the collect of the Seychelles' observations and the dissemination, daily more and more important, of very numerous messages to South Africa, Madagascar, Comoros and Seychelles.

Because of the intense traffic due to the sending of numerical model outputs to Mauritius Island, the FTP protocol has been installed between the 2 islands, and gives complete satisfaction.

Furthermore, the RSMC has now a specialized server with restricted access, where all the meteorological data available on its SYNERGIE servers can be found via the URL:

www.meteorologie.eu.org/CMRS

Finally, for the countries who have not Internet access yet, or in the aim to provide a cheap spare possibility, the RSMC, in collaboration with Worldspace, has accepted to put some of its elaborated products (plottings, models outputs, cyclone warnings) on the server RANET.

3.2 Meteorological satellites receiving systems

Through a HRPT station (installed in November 1990 and regularly upgraded till then) and a PDUS station (installed at the end of 1995 and upgraded in 2000), the RSMC has now real-time access to high resolution digital data from both the European geostationary meteorological satellites METEOSAT (0° and 63° for the moment) and the American TIROS polar-orbiting satellites.

The software used for the processing of HRPT imagery has been developed by the Space Meteorology Centre in Lannion and by the RSMC/La Réunion. Besides the usual functions (calibration, navigation, zoom, enhancement, etc...), it offers different tools that have been developed in order to help the forecasters in the analysis of tropical cyclones (overlaying and fitting of various logarithmic spirals, overlaying of "compass-cards" for easier cross-analysis with the wind observations available in the tropical cyclone area, etc...).

3.3 Radar

At the end of 1993, a 10 cm Doppler radar has been installed on a site in upper Saint-Denis, about 600 meters high and 12 km away from the Meteorological Centre. This radar is operated by remote control. Raw data are processed on the site and the different products (PPI, CAPPI,...) are transmitted to the centre via a 9600 b/s specialized line.

The view of the radar is totally clear from the east to the north and the west-south-west, sectors of origin of more than 95% of tropical cyclones approaching La Réunion. It permits nearly continuous coverage of tropical cyclones within about 350/400 km of the coast and, therefore, effective monitoring of those that threaten the island. This results in more accurate forecasts of the final track and impact in terms of strong winds and heavy rain, and finally in better warnings and better timing in the final phase of the alert process.

This radar opens also up very interesting possibilities for Research and Development on the effects that the orography can have on the core structure of landfalling tropical cyclones and, more generally speaking, combining radar observations with data collected in real-time by the network of about 25 automatic stations implemented on the island, on the effects the orography has on heavy rain distribution (La Réunion holds all the rainfall world records between 12 hours and 15 days, all these records being associated with the passage of tropical cyclones over or in vicinity of the island).

The installation of a second radar in the South of the island is being studied.

3.4 SYNERGIE

“SYNERGIE” (same meaning as SYNERGY in English) is the name of the system developed by Météo-France. This system is used by all the forecasters of Meteo-France to synthesize the more and more abundant meteorological information and then to elaborate the documents resulting of their cross-analyses. SYNERGIE is an abbreviation of « Système Numérisé d'Exploitation Rationnelle et de Gestion Interactive et Evolutive » (Digitized System of Rational Exploitation and of Interactive and Upgradeable Handling) of the meteorological data.

Thanks to this tool, the forecaster can build a conceptual model of the real state of the atmosphere by displaying on his workstation all the available meteorological information (conventional data, NWP products, satellite and radar imagery...). To be noted is the fact that processing and storage of all the numerical data collected through the local imagery acquisition systems (radar, satellite...) or directly received from Toulouse via TRANSMET are simultaneously done on two servers SUN E450, one hot spare of the other. Quick and securitized access is then possible in real-time from any « client » workstation.

SYNERGIE offers a wide range of possibilities: displaying all the available meteorological information with possibility of overlaying, objective analyses, vertical profiles, animation, bulletin composition, etc.). Furthermore, thanks to its competence, RSMC/La Réunion has been chosen to participate to the validation of the new and expected modules for expertise and for monitoring the tropical cyclones before their integration in the new version 3.5 of the software.

Finally, one of the most important possibilities of SYNERGIE is to re-display past interesting meteorological situations like the cyclone CONNIE, studied by the trainees during the international workshop organized at La Réunion

4. Cyclone monitoring

As a result of the lack of aircraft reconnaissance and the fact that conventional data are very limited in the RSMC area of responsibility, the monitoring of tropical cyclones is essentially based on satellite imagery, except when these systems are within the scope of La Réunion or Mauritius radars.

Of course, all the information available is combined to determine the position and intensity of tropical cyclones. But the satellite-based DVORAK technique (used since 1982 by the RSMC) is generally the only means available to estimate intensity and, in most cases, no information other than satellite imagery is available to determine the centre location.

4.1 Satellite coverage

Until the 1995-1996 tropical cyclone season, the tropical cyclone watch at the RSMC relied almost exclusively on the use of TIROS HRPT imagery which provides a very good spatial resolution but suffers greatly from a lack of temporal resolution. In fact, depending on the orbits of the TIROS satellites and on the distance from La Reunion of the monitored tropical cyclones, 4 to 5 NOAA images of the latter (but only 1 or 2 when the cyclones are located on the far eastern portion of the RSMC's area of responsibility) are received daily.

The implementation in 1995 of the PDUS now permits a far better coverage of the western portion of the RSMC area of responsibility within which all the inhabited lands of the region are located. Even if the resolution is less than with TIROS imagery (10 by 6 kilometres at La Réunion's longitude and, of course, less to the east) and if the viewing angle can cause large errors if uncorrected, the 30 mn intervals imagery, the possibility of animation and the access to the water vapor images notably improve the capacity for the analysis of tropical cyclones situated west of about 65° East and of their environment.

Furthermore, since 1996, the WEFAX GMS imagery that covers the far eastern portion of the RSMC area of responsibility is integrated in quasi real-time on SYNERGIE, which offers a better environment for its analysis than the PC's software used before.

Finally, since June 1998 (and still for a few years), the RSMC receives the satellite pictures from METEOSAT 5 (which has moved from 0° to the 63°E, for the international experiment INDOEX) This is a very good improvement for the cyclonic survey in this area, where no operational and permanent global satellite coverage exists, as satellite INSAT data are still not available.

In the future, satellites « METEOSAT Second Generation » (MSG), will offer numerous new products and increased spatial and temporal resolutions. The RSMC will then be equipped in such a way to receive the new data and to deal with the big quantity of information.

4.2 RSMC mean position errors

The following table gives the estimated mean position errors (km) for the 8 last tropical cyclone seasons regarding the different class of cyclone intensity (*number of cases in brackets*). It must be kept in mind, that these mean position errors which are calculated by comparison of the operational fixes with the after-the-fact "best-tracks", are not absolute errors as the "best-tracks" remain, by nature, approximations of the ground truth.

Saison	All intensities		CI \geq 2.0		CI \geq 3.0		CI \geq 5.0	
	km	(n)	km	(n)	km	(n)	km	(n)
1990-1991	52 km	(193)	52 km	(180)	46 km	(136)	39 km	(14)
1991-1992	62 km	(231)	59 km	(208)	63 km	(110)	35 km	(39)
1992-1993	39 km	(215)	38 km	(205)	33 km	(116)	16 km	(39)
1993-1994	58 km	(442)	58 km	(423)	53 km	(328)	31 km	(87)
1994-1995	38 km	(345)	38 km	(341)	32 km	(238)	25 km	(51)
1995-1996	41 km	(282)	41 km	(273)	39 km	(189)	27 km	(68)
1996-1997	39 km	(376)	39 km	(366)	37 km	(250)	25 km	(61)
1997-1998	37 km	(174)	38 km	(147)	39 km	(58)	22 km	(8)
1998-1999	32 km	(181)	32 km	(174)	25 km	(75)	15 km	(24)
1999-2000	34 km	(331)	35 km	(305)	26 km	(197)	17 km	(51)
2000-2001	34 km	(168)	34 km	(164)	25 km	(111)	18 km	(42)

5. Cyclone forecasting

5.1 Track and intensity forecasting

Track and intensity forecasts rely to a great extent on the numerical model outputs available at the RSMC.

These fields are analysed to evaluate the constraints imposed on the tropical cyclones by their environment. This subjective analysis added to the observation data, derived from satellite and other sources allows to determine how the current behaviour of the cyclone will be influenced.

5.2 Numerical forecast models

Many numerical forecast models are used by the RSMC forecasters:

1. Statistical model:

Based on the tropical cyclones historical file maintained by RSMC/ La Réunion (which contains today the data of about 1170 tropical cyclones of the period 1848-2001), a simple « analogs » model have been developed. However, the interest of this model for operational forecasting is rather limited, although it is helpful to new or young forecasters for acquiring the necessary climatological knowledge.

These kind of models allows to have quickly access to track and intensity cyclone forecasts. For the moment, those models are essential to make forecasts at short range (<12 hours).

2. Baroclinic models:

Among all the global numerical weather prediction models available at RSMC, the most useful are ECMWF model IFS, and French model ARPEGE. The French one is a global model with stretched area over Europe. A new version of ARPEGE, with its focus point on the Indian ocean (called "ARPEGE/Réunion"), has routinely been used by forecasters from December 1998 till mid-2001.

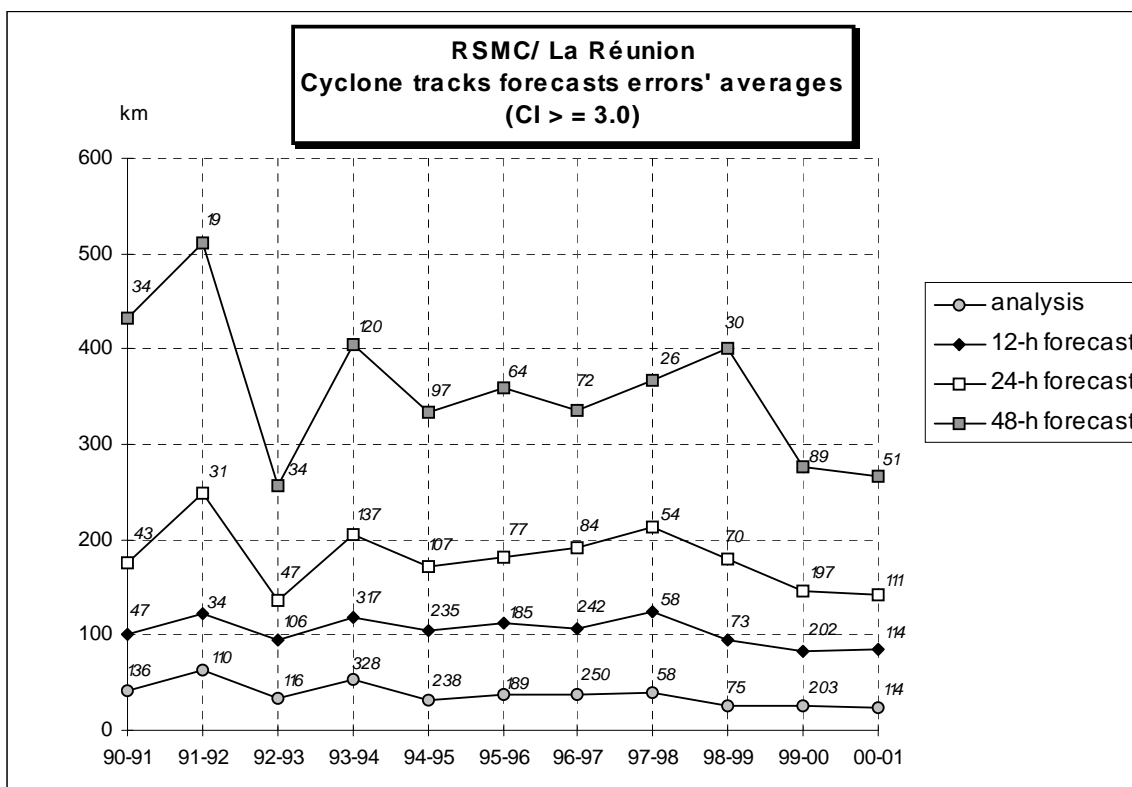
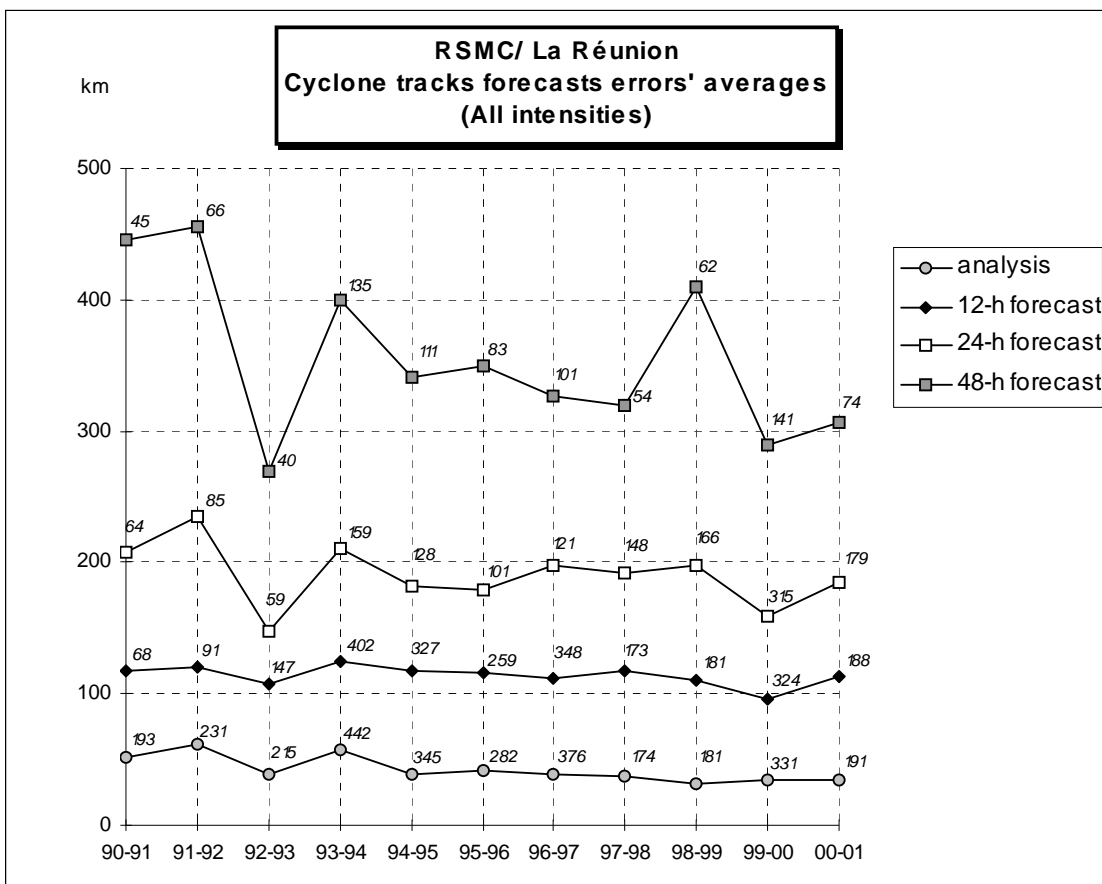
From cyclone season 2001-2002, a new operational model will be used, constituted of the uniform resolution global model ARPEGE, coupled with fine mesh and limited area model ALADIN over the Indian Ocean (called "ARPEGE/Tropique"). Physical parameterizations have been especially calculated for the cyclone forecast, and the bogussing method will be used for the analysis.

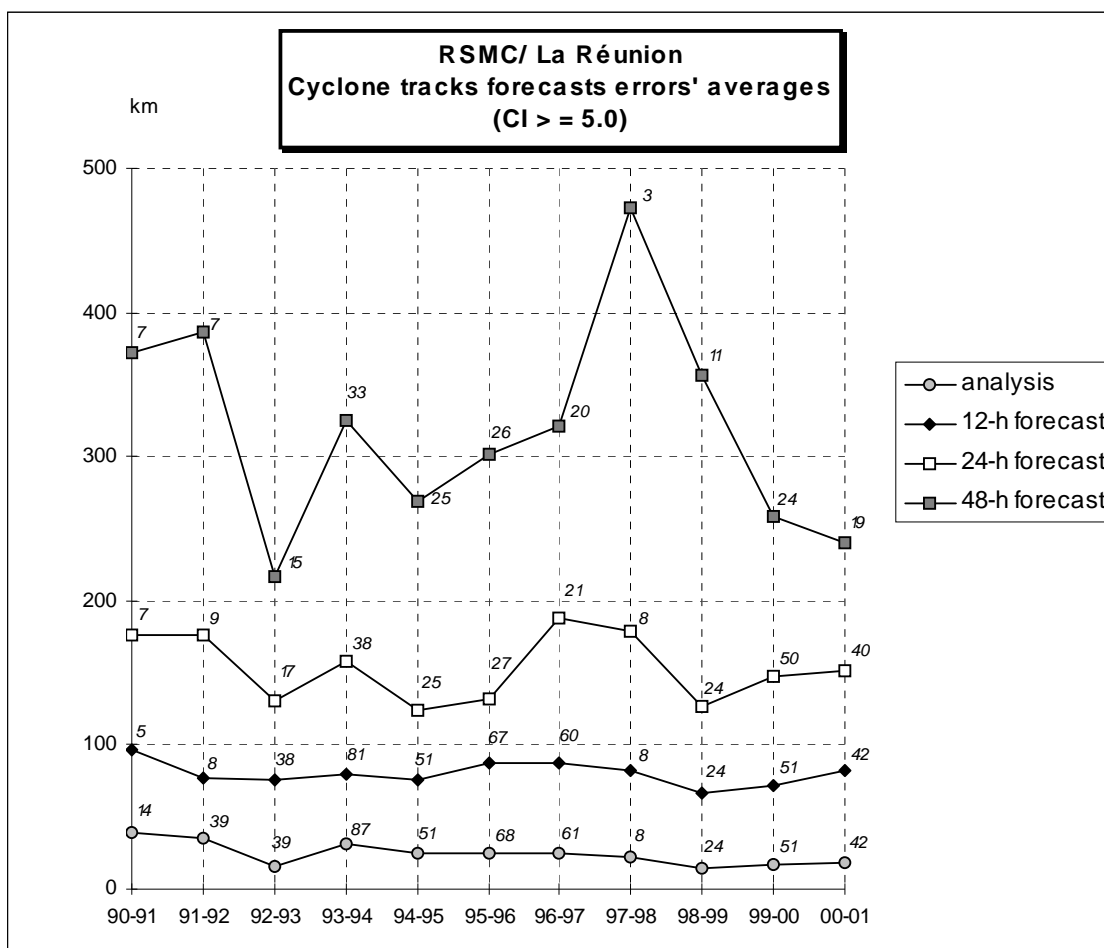
5.3 Evaluation of RSMC forecasts

Since 1990, detailed forecast performance statistics are prepared at the end of each tropical season. Graphs below give the results for different intensity families (intensity of the tropical cyclone at the initial position).

Note: The initial positioning error is not removed from these verification statistics. Moreover, these statistics are not adjusted for forecast difficulty using the CLIM model forecasts.

(in italics : number of forecasts)





5.4 Storm surge model

In La Réunion, due to the profile of the coast and the bathymetry, storm surge is not a fundamental problem, but on some portions of the coast the risk is significant for specific tracks and situations.

A numerical storm surge model developed by Météo-France for La Réunion, has been implemented at RSMC in December 1996. It is possible to run this model in real-time whenever a tropical cyclone is forecast to affect the island. But through multiple runs of the model, the RSMC has elaborated an atlas of pre-computed storm surges which are available for graphical display on a computer and for interactive determination by the forecaster of the Maximum Envelope of Waters (MEOW) given the uncertainty in the forecast situation.

6. Operational products of the RSMC

6.1 Bulletins

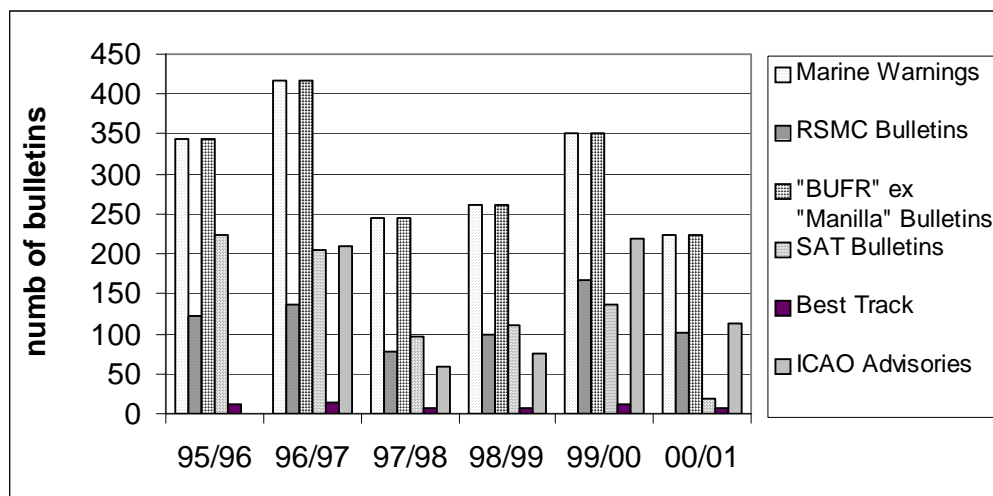
The RSMC issues different kinds of bulletins : Marine Warnings, « RSMC » Bulletins, Satellite bulletins, ICAO Advisories, « BUFR » (ex « Manila ») bulletins, « best track » bulletins, and, since September 1999, a daily bulletin about cyclone activity in the South-West Indian ocean.

Bulletins		Headings	Dissemination time
Marine Warnings	English	WTIO20, 22, 24	GTS 00, 06, 12, 18 UTC
	French	WTIO21	Same
RSMC Bulletins	English	WTIO30	GTS 00, 06, 12, 18 UTC
	French	WTIO31	Same
Satellite Bulletins	English	TPIO20	GTS as soon as possible after the satellite's passage
	French	TPIO21	same
ICAO Advisories	English	- FKIO20	AFTN 00, 06, 12, 18 UTC GTS 00, 06, 12, 18 UTC
"BUFR" Bulletins	-	ATIO01	GTS 00, 06, 12, 18 UTC
"Best-Track" Bulletins	-	AXIO20	GTS within one month after the cyclone's death
Cyclone information Bulletin	English	AWIO20	GTS 12 UTC
	French	AWIO21	GTS 12 UTC

The « RSMC Bulletins » which are issued twice daily are the more complete bulletins. They provide, in particular, position and intensity forecasts with prognostic reasoning for the coming 48 hours.

Satellite bulletins are issued for each TIROS satellite picture of the tropical cyclones. They contain information on the position of the centre with the confidence degree, direction and speed of movement, central pressure and maximum wind speed with Dvorak T and CI numbers.

Number of bulletins issued by LA REUNION RSMC (1995-2001)



6.2 MDD dissemination

Some RSMC's graphical products and bulletins are disseminated on the MDD (Meteosat Data Dissemination).

6.3 Cyclone data base

At the end of each tropical cyclone season, the RSMC “best-tracks” digital data are mailed to the National Climatic Data Center (Ashville-USA) and to some other interested Centres (as the Meteorological Centre of United Kingdom in Bracknell). The access to this data base will be soon available on the RSMC website.

7. Activities of Research, Training and Communication of the RSMC

7.1 Research and development

The aim is to strengthen the RSMC forecasting capabilities through the development of new models and through the improvement of the objective guidance. The “Cellule Recherche Cyclone (CRC)” (Cyclone Research Unit) gives to the RSMC the capacity to undertake this vital task. The CRC has as well, the mission to improve the knowledge about the cyclones of the Indian Ocean.

Furthermore, researchers of the Region could be temporarily attached to this unit and participate to the developments.

The CRC has 3 different fields of development :

- Development of specific tools for the forecasters.

In this domain, the CRC deals with statistical models, improvement of the coupled model ARPEGE/ALADIN, and follows the ECMWF’s work on the ensemble prediction system.
- Improvement of the analyse of the tropical cyclones and of the physical parametrizations in the numerical forecast models.

The CRC’s goal is to keep on studying impact of the observations in the ARPEGE/Tropique (instead of the ARPEGE/Réunion), especially with the QuikScat data, as soon as they are available to be assimilated in the database in Toulouse.

The CRC will study as well the impact of the high resolution winds derived from the water vapor channel (HWW) of METEOSAT on the analyse of cyclone structures.

Furthermore, as soon as the assimilation system with ALADIN will be ready , it will be tested with fine resolution data on the tropical cyclones (SATGEO, ERS).

Study of intensification and cyclogenesis mechanisms of the tropical cyclones is a field where the CRC must actively participate. Specific parametrizations on the convection, adapted to the cyclone environment, and air-sea interactions with strong winds are studied in collaboration with the “Centre National de Recherche Météorologique (CNRM) “ (National Centre of Meteorological Research) of Météo-France in Toulouse.

- Studies of the process to better understand the functioning of the tropical cyclones and their interaction with the environment.

The aim of this work is to connect the precursors, in terms of potential vorticity, of the tropical cyclones in the Indian Ocean. Concurrently, a potential vorticity inversion method is developed.

The CRC studies as well the interactions between the oscillations (MJO, QBO, ENSO) of the Indian Ocean basin and the cyclone activity.

7.2 Training

RSMC plays a key role in the region, in the field of training activities. In particular, the RSMC organizes with the WMO, each 2 years since 1999, and during 2 weeks, a training course/workshop in English and in French for the african countries, members of the Cyclone Committee.

Furthermore, as part of the regional cooperation, the RSMC regularly receives meteorologists of the area during the 3 or 4 most active months of the cyclone season.

Because of its functions, the RSMC is brought to participate to numerous seminars or international conferences.

7.3 Annual publication

The RSMC/La Réunion publishes an annual report in French and English on the cyclone season of the South-West Indian Ocean basin. About 300 of these copies are distributed in the region (in particular to the Members of the RA I Tropical Cyclone Committee) and further, to many meteorological offices and scientific institutes all over the world. This publication describes at length the formation, evolution and effects of each tropical cyclone observed during the season, provides best-tracks, statistics, satellite pictures, charts, and other relevant information.
