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

T E C H N I C A L D O C U M E N T

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TROPICAL CYCLONE PROGRAMME

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TROPICAL CYCLONE OPERATIONAL PLAN FOR THE SOUTH-WEST INDIAN OCEAN

2012 Edition

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2012 Edition

C O N T E N T S

CONTENTS

C O N T E N T S

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 2012 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 (over 10 min)	(i)	Vitesse moyenne du vent
(ii)	Sustained wind speed (over 1 min)	(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 disturbanceor (preferably) Tropical system	(vi)	(Terme générique) Perturbation tropicale ou (préférentiellement) Système dépressionnaire tropical
(vii)	Tropical depression	(vii)	Dépression tropicale
(viii)	Moderate tropical storm	(viii)	Tempête tropicale modérée
(ix)	Severe tropical storm	(ix)	Forte 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
(xiii)	Remnant low	(xiii)	Dépression résiduelle
(xiv)	Filling low	(xiv)	Dépression se comblant
(xv)	Dissipating low	(xv)	Dépression se dissipant
(xvi)	Post-tropical depression	(xvi)	Dépression post-tropicale

	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.

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 (average wind speed 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).

Remnant low: A former tropical system that has weakened and is no longer associated with established and/or organized convection. Within the related low-pressure circulation the maximum estimated average wind does not exceed 27 knots (50 km/h, force 6 on the Beaufort scale).

Filling low: A former tropical system undergoing sustained weakening and whose related minimum pressure is raising.

* For converting the wind speeds of different averaging periods such as 1-min, 2-min, 3-min and 10-min, WMO Tropical Cyclone Programme recommends to follow the guidelines as shown in the ATTACHMENT 1-C.

Dissipating low: A former tropical system in the final decaying phase that is doomed to vanish rapidly.

Post-tropical depression: A former tropical system (tropical depression, tropical storm or tropical cyclone) in the extra-tropical transition phase, which no longer presents all the characteristics of a tropical system but has not yet completed its transition and cannot, therefore, be considered an extra-tropical depression and qualified as such.

This is usually a transient stage lasting in most cases less than 24 hours.

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 – i.e. near gale force).

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 – i.e. gale force).

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 – i.e. storm force).

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.

Cyclone season: in the South-West Indian Ocean, the cyclone season lasts from 1 July of year N to 30 June of year N+1, bearing in mind that tropical low-pressure systems are rare during the austral winter (from June to September) and that the risk of cyclone formation is highest during the austral summer. As the risk of cyclones varies over the basin, some Member countries of the Tropical Cyclone Committee for the South-West Indian Ocean have defined, on the basis of their domestic needs, a specific duration of the cyclone season, which is actually shorter (from November to April or May), because that is when most of the disturbances likely to concern them occur.

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);

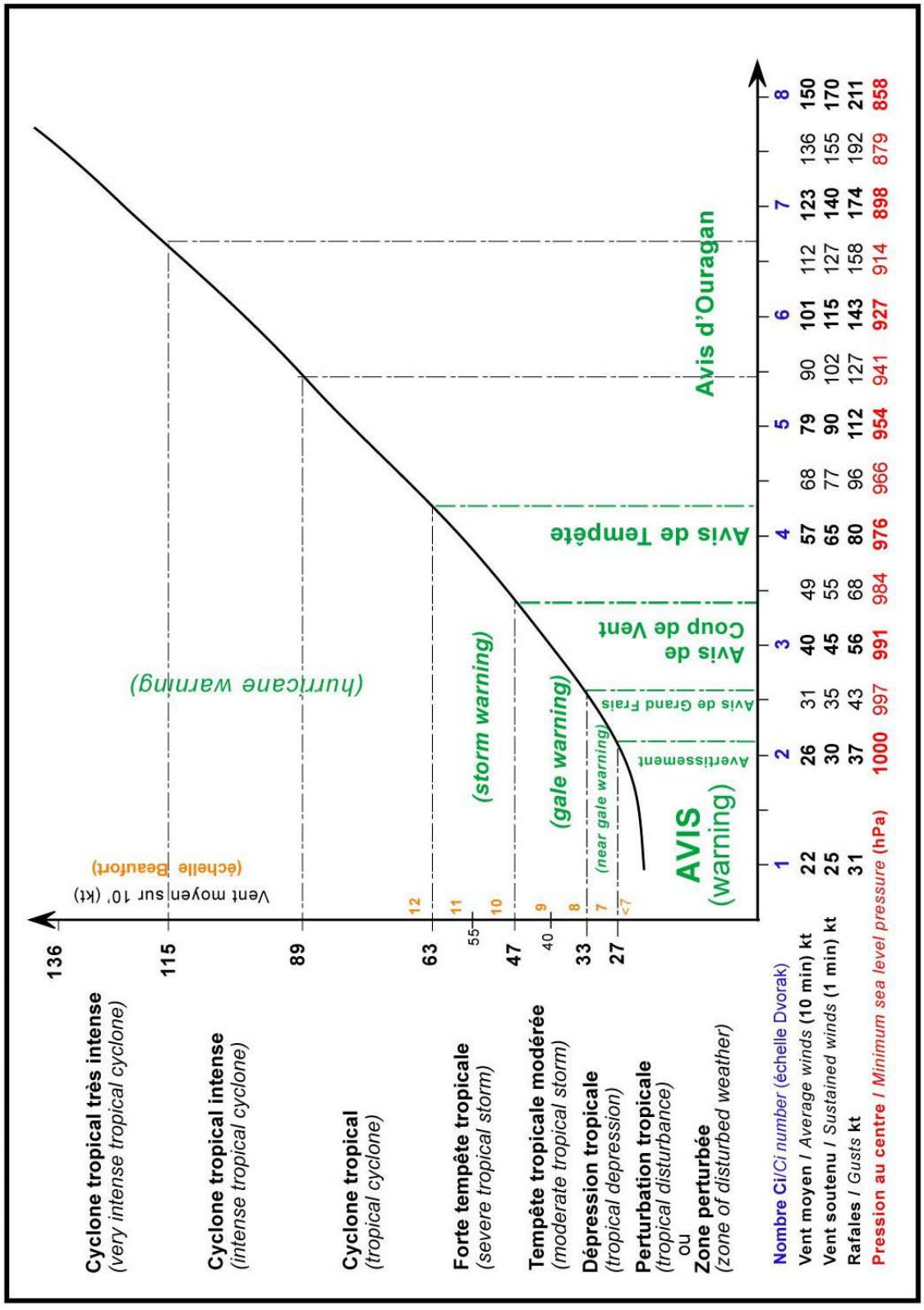
(ii) Location (position) by degrees and tenths of degrees in figures of latitude and longitude and/or bearing on the sixteen point compass and distance from well-known fixed place(s);

(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



Note: The univocal pressure-wind relation shown at the bottom of the diagram is purely indicative. In practice, this relation is adapted to specific situations in order to take into account the natural variability of the pressure-wind relation, which can be affected by parameters such as the intensity of the low-pressure system, the magnitude of the low-pressure circulation and the extension of related winds, the environmental pressure, latitude, the speed of movement and the radius of maximum winds.

1.5 Identification of tropical storms/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 Equator to 40°S west of 90°E to the east coast of Africa, has been established by the Committee at its twentieth session in September 2012 for the following cyclone seasons. The names chosen with genders are:

CYCLONE SEASON 2012/2013		**CYCLONE SEASON 2013/2014**		**CYCLONE SEASON 2014/2015**	
Names	Provided by	Names	Provided by	Names	Provided by
ANAIS	*France (F)*	**AMARA**	*Tanzania (M)*	**ADJALI**	*Comores (F)*
BOLDWIN	*South Africa (M)*	**BEJISA**	*Swaziland (M)*	**BANSI**	*Mauritius (M)*
CLAUDIA	*Madagascar (F)*	**COLIN**	*Seychelles (M)*	**CHEDZA**	*Botswana (F)*
DUMILE	*Swaziland (F)*	**DELIWE**	*Zimbabwe (F)*	***DIAMONDRA***	*Madagascar (F)*
EMANG	*Botswana (F)*	**EDILSON**	*Mozambique (M)*	**EUNICE**	*Zimbabwe (F)*
FELLENG	*Lesotho (F)*	**FOBANE**	*Lesotho (M)*	**FUNDI**	*Kenya (M)*
GINO	*Mauritius (M)*	**GUITO**	*France (M)*	**GLENDA**	*South Africa (F)*
HARUNA	*Zimbabwe (F)*	**HELLEN**	*South Africa (F)*	**HALIBA**	*Swaziland (M)*
IMELDA	*Seychelles (F)*	**IVANOE**	*Mauritius (M)*	**IKOLA**	*Tanzania (F)*
JAMALA	*Comores (M)*	**JIRANI**	*Comores (M)*	**JOALANE**	*Lesotho (F)*
KACHAY	*Kenya (F)*	**KATUNDU**	*Malawi (M)*	**KESHA**	*Seychelles (F)*
LUCIANO	*Mozambique (M)*	**LETSO**	*Botswana (M)*	**LUGENDA**	*Mozambique (M)*
MARIAM	*Tanzania (F)*	**MIRANA**	*Madagascar (F)*	**MAHARA**	*Malawi (N)*
NJAZI	*Malawi (M)*	**NASERIAN**	*Kenya (F)*	**NATHAN**	*France (M)*
ONIAS	*Zimbabwe (M)*	**OPANG**	*Lesotho (M)*	**OSCAR**	*South Africa (M)*
PELAGIE	*Madagascar (F)*	**PAYA**	*Comores (F)*	**PULENG**	*Lesotho (F)*
QUILIRO	*Comores (M)*	**QUERIDA**	*Tanzania (F)*	**QUENELLE**	*Madagascar (F)*
RICHARD	*Seychelles (M)*	**ROMANE**	*France (F)*	**ROSELINA**	*Mozambique (F)*
SOLANI	*Swaziland (F)*	**SINGANO**	*Malawi (N)*	**SITARA**	*Comores (F)*
TAMIM	*Tanzania (M)*	**TARUS**	*Kenya (M)*	**TARIK**	*Mauritius (M)*
URILIA	*South Africa (F)*	**UNAMI**	*Botswana (F)*	**UMALI**	*Zimbabwe (M)*
VUYANE	*Lesotho (F)*	**VUMA**	*Mozambique (M)*	**VUNTU**	*Botswana (F)*
WAGNER	*Kenya (M)*	**WAMIL**	*Mauritius (F)*	**WEZI**	*Malawi (F)*
XUSA	*Malawi (F)*	**XOLILE**	*South Africa (F)*	**XOLANI**	*Swaziland (M)*
YARONA	*Botswana (F)*	**YASMINE**	*Seychelles (F)*	**YOLANDE**	*France (F)*
ZACARIAS	*Mozambique (M)*	**ZAMILE**	*Swaziland (F)*	**ZITA**	*Seychelles (F)*

A tropical or subtropical disturbance is named when it reaches the moderate tropical storm stage (maximum average wind speed, as defined in paragraph 1.2.2, corresponding to gale force winds – observed or estimated – present near the low-pressure centre in a significant portion of the cyclonic circulation). When RSMC La Reunion or the sub-regional tropical cyclone advisory centre* in charge of the area where the disturbance occurs (Madagascar, if the disturbance is centred west of 55°E, or Mauritius, if the disturbance is centred between 55°E and 90° E) notices that the tropical or subtropical disturbance in question approaches the intensity of a moderate tropical storm, the centres get in touch and consult each other. If the technical consultation concludes that the moderate tropical storm stage has been reached, the competent sub-regional centre formally names the disturbance.

The name is chosen, following alphabetical order, from a list of names already designated, except when a low-pressure system already named in the South-East Indian Ocean (east of 90° E) reaches the South-West Indian Ocean. In this case the original name is kept unchanged.

Meteorological services in the South-West Indian Ocean will use exclusively the designated name to identify that tropical storm until it moves out of the area, becomes a post-tropical or extra-tropical depression or, having weakened, ceases to qualify as a moderate tropical storm, in which case the storm will continue to bear the given name preceded by EX in all bulletins associated with the disturbance.

The procedure described above concerns exclusively the naming of tropical storms and does not imply any restriction with regard to tropical cyclone warnings, which shall be broadcast in accordance with the provision of chapter 5 applicable to both named cyclones and unnamed disturbances.

* 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 border, 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 border. 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 ...□S, longitude ...□E 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. ...../ ....Time...../Date.....[*]

- 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.
- Time of issuing.
- Sent by.
- Received by.

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

[*] Initial of the depression or cyclone

[*] Shortened version

(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 - apllicable 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	-----	-----

ATACHMENT I-C

GUIDELINES FOR CONVERTING BETWEEN VARIOUS WIND AVERAGING PERIODS IN TROPICAL CYCLONE CONDITIONS

This note is based on recommendations from Harper et al. (2010) and extracts from Knaff and Harper (2010), providing advice on why, when and how "wind averaging conversions" can be made.

a) Why Convert Wind Speeds?

From the observational perspective, the aim is to process measurements of the wind so as to extract an estimate of the **mean** wind at any time and its **turbulence** properties. From the forecasting viewpoint, the aim is, given a specific wind speed metric derived from a process or product, to usefully predict other metrics of the wind. Typically these needs revolve around the concept of the mean wind speed and an associated peak gust wind speed; such that the statistical properties of the expected level of wind turbulence under **different exposures** can be used to permit useful conversions **between peak gust wind speed** estimates.

b) When to Convert Wind Speeds?

Wind speed conversions to account for varying averaging periods only apply in the context of a maximum (peak gust) wind speed of a given duration observed within some longer interval. Simply measuring the wind for a shorter period of time at random will not ensure that it is always higher than the mean wind (given that there are both lulls and gusts). It is important that all wind speed values be correctly identified as an estimate of the **mean wind** or an estimate of a **peak gust**.

Once the mean wind is reliably estimated, the random effects of turbulence in producing higher but shorter-acting wind gusts, typically of greater significance for causing damage, can be estimated using a "gust factor". In order for a gust factor to be representative, certain conditions must be met, many of which may not be exactly satisfied during a specific weather event or at a specific location:

- Wind flow is turbulent with a steady mean wind speed (**statistically stationary**);
- Constant surface features exist within the period of measurement, such that the boundary layer is in equilibrium with the underlying surface roughness (**exposure**);
- The conversion assumes the mean wind speed and the peak gust wind speed are at the same **height** (e.g. the WMO standard observation height +10 m) above the surface.

c) How to Convert Individual Point-Specific Wind Speeds

Firstly, the mean wind speed estimate V should be explicitly identified by its averaging period T_o in seconds, described here as V_{To} , e.g.

V_{600} is a 10-min averaged mean wind estimate;
V_{60} is a 1-min averaged mean wind estimate;
V_{3} is a 3-sec averaged mean wind estimate.

Next, a peak gust wind speed should be additionally prefixed by the gust averaging period τ , and the time period over which it is observed (also termed the **reference period**), described here as $V_{\tau,To}$, e.g.

$V_{60,600}$ is the highest 1-min mean (peak 1-min gust) within a 10-min observation period;
$V_{3,60}$ is the highest 3-sec mean (peak 3-sec gust) within a 1-min observation period.

The "gust factor" $G_{\tau,To}$ then relates as follows to the mean and the peak gust:

$$V_{\tau,To} = G_{\tau,To} V ,$$

where the (true) mean wind V is estimated on the basis of a suitable sample, e.g. V_{600} or V_{3600}.

On this basis, Table 1 provides the recommended near-surface (+10 m) conversion factors $G_{\tau,To}$ between typical peak gust wind averaging periods, which are a strong function of the exposure class because the turbulence level varies depending on the surface roughness. Table 1 only provides a range of indicative exposures for typical forecasting environments and Harper et al. (2010) or WMO (2008) should be consulted for more specific advice regarding particular types of exposures - especially if it is intended to calibrate specific measurement sites to "standard exposure".

Table 1 Wind speed conversion factors for tropical cyclone conditions (after Harper et al. 2010).

Exposure at +10 m		Reference Period T_o (s)	Gust Factor $G_{\tau,To}$				
Class	Description		*Gust Duration* τ (s)				
			3	*60*	*120*	*180*	*600*
In-Land	Roughly open terrain	3600	1.75	1.28	1.19	1.15	1.08
		600	1.66	1.21	1.12	1.09	1.00
		180	1.58	1.15	1.07	1.00	
		120	1.55	1.13	1.00		
		60	1.49	1.00			
Off-Land	Offshore winds at a coastline	3600	1.60	1.22	1.15	1.12	1.06
		600	1.52	1.16	1.09	1.06	1.00
		180	1.44	1.10	1.04	1.00	
		120	1.42	1.08	1.00		
		60	1.36	1.00			
Off-Sea	Onshore winds at a coastline	3600	1.45	1.17	1.11	1.09	1.05
		600	1.38	1.11	1.05	1.03	1.00
		180	1.31	1.05	1.00	1.00	
		120	1.28	1.03	1.00		
		60	1.23	1.00			
At-Sea	> 20 km offshore	3600	1.30	1.11	1.07	1.06	1.03
		600	1.23	1.05	1.02	1.00	1.00
		180	1.17	1.00	1.00	1.00	
		120	1.15	1.00	1.00		
		60	1.11	1.00			

Some example applications of the above recommendations are:

- To estimate the expected “off-land” 3-sec peak gust in a 1-min period, multiply the estimated “off-land” mean wind speed by 1.36
- To estimate the expected “off-sea” 3-sec peak gust in a 10-min period, multiply the estimated “off-sea” mean wind speed by 1.38
- To estimate an “at-sea” 1-min peak gust in a 10-min period, multiply the estimated “at-sea” mean wind speed by 1.05

Note that it is not possible to convert from a peak gust wind speed back to a **specific** time-averaged mean wind – only to the **estimated true mean** speed. Hence to estimate the “off-sea” mean wind speed given only a peak observed gust of 1-min duration (τ = 60 s) measured in a 10-min period (T_o = 600 s), multiply the observed 1-min peak gust by (1/1.11) = 0.90. This does not guarantee that the estimated mean wind will be the same as the 10-min averaged wind at that time but, because the 10-min average is normally a reliable estimate of the true mean wind, it will likely be similar. In all cases, measurement systems should aim to reliably measure the mean wind speed and the standard deviation using a sample duration of not less than 10-min (WMO 2008), i.e. V_{600}. Additional shorter averaging periods and the retaining of peak information should then be targeted at operational needs.

d) Converting Between Agency Estimates of Storm Maximum Wind Speed *Vmax*

This is a slightly different situation from converting a point specific wind estimate because the concept of a storm-wide maximum wind speed *Vmax* is a metric with an associated spatial context (i.e. anywhere within or associated with the storm) as well as a temporal fix context (at this moment in time or during a specific period of time). While it may be expressed in terms of any wind averaging period it remains important that it be unambiguous in terms of representing a mean wind or a peak gust. Agencies that apply the WMO standard 10-min averaged *Vmax* wind have always applied a wind-averaging conversion to reduce the maximum “sustained” 1-min wind value (a 1-min peak gust) that has been traditionally associated with the Dvorak method (Dvorak 1984, Atkinson and Holliday 1977)1. As noted in the previous section, it is technically not possible to convert from a peak gust back to a specific time-averaged mean wind – only to the estimated true mean wind speed. However, in Harper et al. (2010) a practical argument is made for nominal conversion between $Vmax_{60}$ and $Vmax_{600}$ values via an hourly mean wind speed reference, and the recommendations are summarised in Table 2.

1 As detailed in Harper et al. (2010), this traditional assumption is without a firm basis.

It can be noted that the recommended conversion for at-sea exposure is about 5% higher than the "traditional" value of 0.88 (WMO 1993), which is more appropriate to an off-land exposure. This has special implications for the Dvorak method because "at sea" is the typical exposure of interest where such conversions have been traditionally applied.

Table 2 Conversion factors between agency estimates of maximum 1-min and maximum 10-min averaged tropical cyclone wind speed *Vmax*. (after Harper et al. 2010).

$Vmax_{600}=K\ Vmax_{60}$	At-Sea	Off-Sea	Off-land	In-Land
K	0.93	0.90	0.87	0.84

e) References

Atkinson, G.D., and C. R. Holliday, 1977: Tropical cyclone minimum sea level pressure/maximum sustained wind relationship for the Western North Pacific. *Mon. Wea. Rev.,* **105**, 421-427.

Dvorak, V.F., 1984: Tropical cyclone intensity analysis using satellite data. NOAA Tech. Rep. NESDIS 11, *National Oceanic and Atmospheric Administration*, Washington, DC, 47 pp.

Knaff, J.A. and B.A. Harper, 2010: Tropical cyclone surface wind structure and wind-pressure relationships. In: Proc. WMO IWTC-VII, *World Meteorological Organization* , Keynote 1,La Reunion, Nov.

Harper, B.A.,, J. D. Kepert, and J. D. Ginger, 2010: Guidelines for converting between various wind averaging periods in tropical cyclone conditions. *World Meteorological Organization*, TCP Sub-Project Report, WMO/TD-No. 1555.

WMO 1993: Global guide to tropical cyclone forecasting. Tropical Cyclone Programme Report No. TCP-31, *World Meteorological Organization*, WMO/TD – No. 560, Geneva.

WMO 2008: Guide to meteorological instruments and methods of observation. *World Meteorological Organization* , WMO-No. 8, 7th Ed, 681pp.

C H A P T E R 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:

Index number	Name of station
67003	FOMBONI (MOHELI)
67001	MORONI ICONI
67017	VOHEMAR
67023	SAMBAVA
67037	BESALAMPY
67107	ANTSIRABE
67131	MOROMBE
67273	ANGOCHE
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:

Member	Stations
France (La Réunion)	All stations
Mauritius	All stations
Comoros	All stations
Madagascar	All stations

and the following:

Index number	Name of station
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:

Index number	Name of station	Time of observation
61976	Serge-Frolow (Ile Tromelin)	12 (radiosonde)
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:

Index number	Name of station
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.

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.

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

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:

Station name	Lat.°S	Long.°E	Wavelength	Make
La Réunion	21	55 doppler	10 cm	GEMATRONIK
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 / 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,, Station at Vacoas
. Mozambique	MSG, Messir Station at Maputo
. Namibia	?
. Rep. of South Africa	MSG, NINJOStation 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, KIA and Mwanza
. Zimbabwe	MSG, SYNERGIE, Station at Belvedere-Harare, Bulawayo and Victoria Falls

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:

Location		Lat.	Long.
63995	Aldabra		
63998	Desroches		
63996	Farquhar		
63999	Praslin	(to be filled out by Members concerned)	
67017	Vohemar		
67019	Analalava		
67131	Morombe		
67152	Ranohira		
67079	Tsiroanomandidy	18□46S	46□03E

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).

C H A P T E R III

TROPICAL CYCLONE ANALYSIS AND FORECASTING

3.1 Forecasting of tropical cyclone movement and changes in intensity

3.1.1 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 Regular cyclone information Bulletin for the South-West Indian Ocean

The RSMC La Réunion provides, on a daily and yearly basis, a 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:

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"

* See footnote to Chapter I, section 1.5*

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, 26**	**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 demise
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.

C H A P T E R 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).

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:

* See footnote to Chapter I, section 1.5.

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 95°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:

* 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.

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 Advisory Centre (TCAC) 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.

** 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 Mr P.Phage 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 Y. Gregoris Director of Meteorological Service P. Rémois Deputy Director For operational matters direct e-mail contact with the RSMC is :	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 : yves.gregoris@meteo.fr Tel Res : +262 262 921 100 +262 262 921 100 Web: www.meteo.fr RSMC's e-mail : rsmc_tcc.la_reunion@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 14515 Maseru	Fax: (266) 325057 (266) 350325 E-mail: bulane@lesoff.co.za	(266) 325041 (266) 317250
MADAGASCAR Direction de la Météorologie et de l'Hydrologie Raelinera Nimbol Directeur Général Raveloarisoa	P.O. Box 1254 Antananarivo 101	Fax: (261) 20.22.408.23 E-mail: meteo@moov.mg Fax: (261) 20.22.408.23	(261) 20.22.408.23 (261) 20.22.407.75

COUNTRY	MAIL ADDRESS	TELEX/FAX/E-MAIL	TELEPHONE NUMBER
Sahondrarilala Directeur des exploitations Météorologique Ratovoharison J.M. Victor Directeur des applications de la météorologique		E-mail: meteo,dem@moov.mg Fax: (261) 20.22.40.581 E-mail: meteo.dma@moov.mg	(261) 20.22.408.23 (261) 20.22.408.23
MALAWI Director of Meteorological Services Attention: Lucy Mtilatila	Meteorological HQ P.O. Box 2 Chileka	Telex: WEATHER MI Fax: (265) 1692 329 E-mail: metdept@metmalawi.com	(265) 1692 201 (265) 1692 333 Director: (265) 1692 312
MAURITIUS Director of Meteorological Services	St Paul Road Vacoas	Fax: (230) 686 1033 E-mail: meteo@intnet.mu	Direct: (230) 969 5626 Office: (230) 686 1031/2 (Home: (230) 696 6088) (Home: (230) 686 4743
MOZAMBIQUE Mr. Moises BenesseneDirector of Meteorology Mussa Mustafa Chief Forecasting	P.O. Box 256 Maputo	Telex: 6259 SMMMP MO Fax: (258) 1 491 150 E-mail: moises-b@inam.go.mz E-mail: mussa.mustafa@inam.gov.mz mozmet@inam.gov.mz	(258) 1 491 258 465 138 (Airport)
REP. OF SOUTH AFRICA I.T. Hunter Deputy Director Maritime Service	Private Bag X097 Pretoria 0001	Fax: (27 12) 367 6032 E-mail: ian@weathersa.co.za Web: www.weathersa.co.za	(27 12) 3
SEYCHELLES Mr. Vincent Amelie Assistant Director of Meteorological Service	Division of Home Affairs, Environment and Transport P.O. Box 181 Victoria, Mahe, Seychelles	Fax: (248) 384 078 E-mail: v.amelie@meteo.gov.sc v	(248) 384 065/66/68
SWAZILAND E.D. Dlamini Director of Meteorology Attention: S.M.Nkambule	P.O. Box 58 Mbabane	Telex: 2001 WD Fax: (268) 40 41 530, (268) 40 46 438 E-mail: weather@realnet.co.sz	(268) 40 46 274 (268) 40 48 859
UNITED REPUBLIC OF TANZANIA Director General Attention: A.L. Kijazi	Tanzania Meteorological Agency P.O. Box 3056 Dar-es-Salaam	Fax: (255) 22 2460 718/735 (255) 22 2460 772 E-mail: met@meteo.go.tz cfo@meteo.go.tz	(255) 22 2460 706-8/735 (255) 22 2460 772
ZIMBABWE Director	P.O. Box BE 150	Telex: 40004 METEO ZW	(263) 4 774 891

COUNTRY	MAIL ADDRESS	TELEX/FAX/E-MAIL	TELEPHONE NUMBER
Meteorological Services Attention: D. Manatsa	Belvedere Harare	Fax: (263) 4 774 890/7 E-mail: weather@utande.co.zw Web: www.weather.utande.co.zw	(263) 4 774 894
RA I			
Coordinator of National Research Focal Points B.S. Nyenzi	Directorate of Meteorology P.O. Box 3056 Dar-es-Salaam United Rep. of Tanzania	Telex: 41442 HEWA Fax: (255) 51 110231 E-mail: bnyenzi@nyenzi.com	(255) 51 110227
WMO Subregional Office for Eastern and Southern Africa Attention: S. Njoroge	P.O. Box 47464 Nairobi Kenya	Fax: (254) 2 57373 E-mail: wmo.nairobi@lion.meteo.go.ke E-mail: stephen.njoroge@lion.meteo.go.ke	(254) 2 577371

ATTACHMENT V-B

LIST OF FOCAL POINTS FOR RA I/TCC

Member	Meteorological	Hydrological	DPP	Research	Training
BOTSWANA	Ms GK Nthobatsang GKNthobatsang@gov.bw	Ms GK Nthobatsang GKNthobatsang@gov.bw	Ms GK Nthobatsang GKNthobatsang@gov.bw	Ms GK Nthobatsang GKNthobatsang@gov.bw	Ms GK Nthobatsang GKNthobatsang@gov.bw
COMOROS	Mr M. Ali Bay Poundja jamnagaralibay@yahoo.fr	Mr M. Ali Bay Poundja jamnagaralibay@yahoo.fr	Mr M. Ali Bay Poundja jamnagaralibay@yahoo.fr	Mr M. Ali Bay Poundja jamnagaralibay@yahoo.fr	Mr M. Ali Bay Poundja jamnagaralibay@yahoo.fr
FRANCE (La Reunión)	Mr Yves Gregoris yves.gregoris@meteo.fr	Mr Yves Gregoris yves.gregoris@meteo.fr	Yves Gregoris yves.gregoris@meteo.fr	Mr Matthieu Plu matthieu.plu@meteo.fr	Ms Géraldine Rayot geraldine.rayot@meteo.fr
LESOTHO	Ms M Mahahabisa mahahabisa@lesmet.org.ls	Mr Rapule Pule dwa@ilesotho.com	Mr Mot'soane Seboka newu@ilesotho.com	Ms Kuena Morebotsane morebotsane@lesmet.org.ls	Mr Limomane Peshoane peshoane@lesmet.org.ls
MADAGASCAR	Raveloarisoa Sahondrarilala Meteo.dem@moov.mg	Mr Razafindrabe Simon razafisim@yahoo.fr	Mr Rakotonirainy Louis de Conzague sp.bngrc@bngrc.mg	Ms N Raholijao meteo.dem@moov.mg or meteo@moov.mg	Mr Rakotovazaha Oliviea servasia1@yahoo.fr
MALAWI	Ms Lucy Mtilatila metdept@metmalawi.com	Mr Chirwa hydrology@malawi.net	Director relief@snd.mw.org	Mr A. Kamdonyo metdept@metmalawi.com	Mr A. Kamdonyo metdept@metmalawi.com
MAURITIUS	Mr B Dunputh meteo@intnet.mu	Mr R Mungra meteo@intnet.mu	Mr M. Beebeejaun meteo@intnet.mu	P. Goolaup meteo@intnet.mu	Mr R. Mungra meteo@intnet.mu
MOZAMBIQUE	Mr. Moises Benessene	Mr Moises Benessene	Mr Moises Benessene	Mr Moises Benessene	Mr Moises benessene

Member	Meteorological	Hydrological	DPP	Research	Training
	Moises_b@inam.gov.mz	moises_b@inam.gov.mz	Moises_n@inam.gov.mz	Moises_b@inam.gov.mz	Moises_b@inam.gov.mz
NAMIBIA	Mr Victor Kaurimuje Kaurimuje_vm@yahoo.com.uk	Mr G Von Langenhoven langenhoveng@mawrd@gov.com.na	Mr JK Kangowa jkangowa@opm.gov.na	Mr Z Mufhaandga zmufhaandga@yahoo.com	Mr Franz Uirab fuirab@meteona.com
SOUTH AFRICA	Mr MC Nkosi nkosi@weather.co.za	Mr Tshepo Ngobeni ngobeni@weather.co.za	Mr Ian Tyrell Hunter ian@weather.co.za	Mr Ian Tyrell Hunter ian@weather.co.za	Mr Ian Tyrell Hunter ian@weather.co.za
SEYCHELLES	Mr Vincent Amelie v.amelie@meteo.gov.sc	Mr Vincent Amelie v.amelie@meteo.gov.sc	Mr Vincent Amelie v.amelie@meteo.gov.sc	Mr Vincent Amelie v.amelie@meteo.gov.sc	Mr Vincent Amelie v.amelie@meteo.gov.sc
SWAZILAND	Mr SP Gumede Sp_gumede@swazimet.gov.sz	Mr Dumsani Mndzebele Wrb-wcon@realnet.co.sz	Mr Jameson Ginindza ndtf@africaonline.co.sz	Mr SP Gumede Sp_gumede@swazimet.gov.sz	Mr SP Gumede Sp_gumede@swazimet.gov.sz
TANZANIA	Mr Philbert F. Tibaijuka tibaijukap@meteo.go.tz	Mr Julius M. Mihayo Dwr-maji@intafrica.com	Mr Mohamed R. Matitu mrmatitu@meteo.go.tz	Dr. E.J. Mpeta empeta@meteo.go.tz	Ms. Tabu E. Mrutu met@meteo.go.tz
ZIMBABWE	Mr H Temba htemba@weather.utande.co.zw	Mr Meka 263-4-722733	Mr Pawadyira eprzim@africaonline.co.zw	Mr C Mutasa cmutasa@weather.utande.co.zw	A Tsiga atsiga@weather.utande.co.zw

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.

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* See footnote to Chapter I, section 1.5.

C H A P T E R 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 occured 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.

ATTACHMENT VII-B

TROPICAL CYCLONE PASSAGE REPORT FORM

TC Number (RSMC No.) _____

Station/ buoy/ship Number	Minimum Sea Level Pressure		Maximum Sutained Wind		Peak Gust		Rainfall	
	hPa	Time Observed (UTC)	(10 min. ave.) mps	Time Observed (UTC)	mps	Time Observed (UTC)	Amount mm	Date Observed

_____

METEO FRANCE

Direction Interrégionale de la Réunion

BP 4 97491 Ste-Clotilde CEDEX Tél +262 262 92 11 00

Fax direction +262 262 92 11 47 Fax exploitation +262 262 92 11 48

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 the Equator to 40°S and west of 90°E to Africa (therefore including the Mozambique Channel).

The primary mission of the RSMC/La Réunion is to provide appropriate guidance information (analyses, forecasts, prognostic reasoning,...) to the 15 Members of the AR I Tropical Cyclone Committee (Botswana, Comoros, France, Kenya, Lesotho, Madagascar, Malawi, Mauritius, Mozambique, Namibia, Seychelles, South Africa, Swaziland, Tanzania, Zimbabwe) for all the tropical disturbances occuring in its area of responsibility. However, beyond this fundamental operational function, the RSMC has the role to become the regional focal centre for all the other activities conducted in the field of tropical cyclones such as, for instance, Training and Research/Development.

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 of preparing marine forecasts and warnings for extensive portions of the METAREA VII-OI and METAREA VIII-S areas. 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 RSMC/La Réunion as its Regional Tropical Cyclone Advisory Centre.

Météo-France La Réunion takes also an active part in the International Buoys Programme in the Indian Ocean (IBPIO), implementing pressure recorders for instance and regularly organizing the deployment in tropical or polar areas of drifters from ships calling at La Réunion. More recently, Météo-France has also contributed to the RAMA moored buoy array in the near-equatorial waters.

2. Human resources

The overall manpower of Meteo-France La Réunion is a bit less than 90 people, of which 19 are engineers (class 1 WMO) and about 50 are technicians (class 2 WMO). This manpower includes some staff completely dedicated to the RSMC, both for operational activities or for Research/Development.

2.1 Forecast

The team of tropical cyclone forecasters consists of 5 senior forecasters working under the direction of a team manager who acts as the operational head of the RSMC/Tropical Cyclone Warning Centre. The service is organized in such a way to allow the 24-hours assignment of one (or two during critical periods) senior forecaster(s) exclusively dedicated to the monitoring, tracking and forecasting of the tropical disturbances occuring 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 and then disseminates automatically the different tropical cyclone bulletins issued by the RSMC.
Re-analyses are regularly performed in slightly delayed time in order to foster an "operational" best-track database which is routinely used for different operational tasks like the update of the track and intensity information displayed on public website of Meteo-France
(http://www.meteo.fr/temps/domtom/La_Reunion/).

Besides their operational activities the tropical cyclone forecasters are involved during the rest of the time in training and development tasks.

2.2 Research and Development

Since August 1998, a high-level research and development team in the tropical cyclones field has joined the RSMC. This team, the Cyclone Research Cell (CRC), is supported by the National Centre for Meteorological Research of Météo-France based in Toulouse and includes 3 researchers-engineers, 1 computer specialist and about 3 students-trainees on average per year. The activities of this team are partly led in cooperation and effective synergy with the Laboratory of Atmospheric Physics of the University of La Réunion. In January 2006 the CRC has hence entered a Joint Unit of Research called LACy (Laboratory of the Atmosphere and of Cyclones) which gathers researchers from the National Centre for Scientific Research (NCSR)/University of La Réunion/Météo-France.

3. Facilities

3.1 Telecommunications

Within 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 links including some high speed ones. Functions of telecommunication are completely automated, and only one controller is requested to supervise the system.

The Centre is connected to the two Regional Telecommunication Centres of Eastern and Southern Africa (Nairobi and Pretoria) thanks to a TCP/IP link via Toulouse. The capacity of this link is subject to frequent upgrades : it has thus been raised to 4 Mbits/s in 2008 (from 512 kbits/s since 2005).

This connection with Toulouse, which is secured by a 512 kbits/s (Numeris) additional backup link, constitutes a real and vital umbilical cord for the RSMC. Owing to it, the Centre can access to all the databases of Météo-France and in particular to the outputs of the French (ARPEGE, ARPEGE-TROPIQUES – a specific version of the ARPEGE model that includes cyclone vortex bogussing – and ALADIN/Réunion – a high resolution limited area model that covers the main portion of the RSMC' area of responsibility), ECMWF (European Centre) and UK Met Office global models outputs.

The RSMC is also equipped with :

- a data reception station RETIM Africa which allows the reception through a technology close to TV reception (IP/DVB) of alpha-numerical messages, satellite imagery, Numerical Weather Prediction outputs at 64 kbits/s.

- system of multi-protocols warning dissemination (by fax, SMS messages, vocal messages).

A server of meteorological messages and bulletins, operational since 1991, gives to the National Meteorological Services (NMSs) 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 programs of the RMTN.

The Centre also increasingly resorts to Internet, especially to exchange data at the regional level where this network is a good alternative to traditional links. Either through on-line mode

using the ftp protocol, as for NMSs from Seychelles, Comoros or Madagascar, or either by e-mail, as for Mozambique, South Africa, Djibouti and others, the Internet has become an essential communication media.

In the frame of the Severe Weather Forecasting Demonstration Project (SWFDP) the RSMC also provides to the member states involved in this project specific products and numerical fields retrieved from its Limited Area Model ALADIN/Réunion. Supplemented by new products derived from ensemble forecasts, these fields will become accessible via a password protected specialized website (extranet) before the end of 2010.

Furthermore, the RSMC has a specialized server with restricted access, where meteorological data available from its SYNERGIE servers can be found.

Finally, for the countries who have no Internet access yet, or in the aim to provide a cheap backup possibility, the RSMC, in collaboration with Worldspace, has accepted to put some of its elaborated products (plottings, models outputs, cyclone warnings) on the RANET server.

3.2 Meteorological satellites receiving systems

The RSMC owns several satellite imagery receiving systems :

- a doubled HRPT station dedicated to the direct reception of imagery from the American TIROS polar-orbiting satellites.
- a station enabling the direct reception of imagery from the European Metop polar-orbiting satellites.
- a PDUS station enabling the real-time direct reception of high resolution digital data from the European geostationary meteorological satellite METEOSAT 7.
- an Eumetcast data receiving station (installed in September 2005) enabling the acquisition of imagery from both the European geostationary meteorological satellites of first (METEOSAT 7) and second generation (MSG-METEOSAT 9).
- A direct receiving station of the Chinese geostationary satellite (FY-2).

The software used for the processing of all this imagery has been developed by the Meteo-France Space Meteorology Centre in Lannion.

3.3 Radar

At the end of 1993, a 10 cm Doppler radar has been installed on a site in upper Saint-Denis, at about 700 meters elevation 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. After a service disruption following the blown off of this radar by intense tropical cyclone DINA end of January 2002, a new radar replaced the former one and reestablished full normal radar operation at the end of 2002. A complete change of the software took place end of 2008.

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 for the island.

Moreover this radar allows 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 assimilation of these radar data in a meso-NH numerical model is one of the major opportunities offered for research but also with the view of operational prospect at more or less longer range.

The lack of coverage on the southeastern to southwestern sectors of the island will be virtually eliminated by the end of 2011 with the planned implementation of a second radar to be settled in the hinterland (at Plaine des Cafres).

3.4 SYNERGIE

"SYNERGIE" (same meaning as SYNERGY in English) is the name of the workstation system and software developed by Météo-France and used by all the forecasters of Météo-France to visualize and synthetize 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 » (Digitalized 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 (conventionnal 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 (message switch system) are simultaneously done on two servers, permanently acting as a backup of each other. Quick and secured access is then possible in real-time from any « client » workstation.

SYNERGIE offers a wide range of possibilities : displaying all the available meterological information with possibility of overlaying objective analyses, vertical profiles, animation, bulletin composition, etc.). Furthermore, a specific module of expertise (called "SYNERGIE-Cyclones") for monitoring tropical disturbances has been added since the 4.0 version of the software. La Réunion RSMC has been highly involved in validating the module and still actively participates with its experience and expertise in improving it. Among the numerous functionalities offered by this module with specialization in handling the tropical systems related analysed and forecast data, one of the most useful is the capability to automatically display cyclone track forecasts from all the different NWP models received with associated specific treatments (like relocation, consensus, etc…).

Finally, one of the most interesting possibilities offered by SYNERGIE is to re-display past interesting meteorological situations, a useful training facility applied during the WMO-sponsored regional workshops organized at La Réunion where forecasters from the RA I region can practise on the workstations with real situations.

Since the end of 2004 and owing to a project sponsored by the European Commission (EDF/IOC project) aiming at improving the transmission and data processing of meteorological information, all the NMSs from the RSMC neighbouring countries have been equipped with the same SYNERGIE software of data visualization and processing system. The exchange of expertise has thence been greatly facilitated and has incidentally given more sense to the regional cooperation around the RSMC.

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 (the latter one being out of order at the present time).

Of course, all the information available is combined to determine the position and intensity of tropical cyclones, but, in most cases, no information other than satellite imagery is available to determine the centre location and intensity of a tropical system. Thus, the satellite-based DVORAK technique (used since 1982 at the RSMC) remains the main tool available to estimate storms' intensities. However, with the advent on the recent past years of a new generation of research satellites and sensors, new means have emerged at the end of the 1990s, some of them very powerful. It is namely the case for those whose radiometers and sensors investigate in new ranges of

frequencies like microwave frequencies. Those microwave data, generally accessible in near-real time via dedicated Internet websites, have taken an increasing weight in tropical cyclone monitoring, since some associated new techniques or algorithms developed in the past years have already demonstrated to add significant skill and accuracy in tropical cyclone analysis.

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 sampling. In fact, depending on the orbits of the TIROS satellites and on the distance separating La Reunion from the monitored tropical cyclones, 4 to 6 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) were received daily.

While the tropical cyclone forecasters are still making the most of these polar-orbiting satellite images, with the first European polar-orbiting meteorological satellite Metop having joined the NOAA satellites since 2007, the satellite monitoring of tropical systems is now mostly focused on geostationary imagery. The implementation in 1995 of the PDUS station had initiated the process, enabling acquisition of the imagery from the METEOSAT satellite set above the Gulf of Guinea and which covers the western portion of the RSMC area of responsibility within which all the inhabitated 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 min intervals imagery, the possibility of animation and the access to the water vapor images notably improved the capacity for better monitoring and analysis of tropical cyclones situated west of about 65° East and of their environment.

But the decisive achievement occurred in 1998 with the advent of a perennial operational geostationary coverage of the whole basin : the displacement (initially in the frame of the international experiment INDOEX) of METEOSAT 5 from 0° to 63°E and then its replacement by METEOSAT 7 in December 2007 (above 67°E) have enabled the RSMC to benefit (since May 1998) from half-hourly imagery of the entire Indian Ocean. The visualization of the imagery of the Japanese geostationary satellite covering the western Pacific (and also the eastern Indian Ocean – including the easternmost portion of the RSMC's area of responsibility) is also integrated within SYNERGIE.

Following the launch and operational commissioning of the first METEOSAT Second Generation satellites (MSG), the RSMC was equipped in 2005 in such a way to receive the new data and to deal with the visualization of the new satellite products. With their new channels and increased spatial and temporal resolutions (images every 15 min) the MSG satellites have provided additional coverage of the western part of the basin with excellent quality imagery for the Mozambique Channel and Madagascar.

Other sources of data come from research satellites that had started to be used for operational purpose since cyclone season 1998-1999. Since then they have taken an increasing importance and are now considered like additional operational tools. These satellites of a new generation, by providing data and images in specific ranges of frequencies ("micro-waves") bring extensive valuable information on the centre and intensity of the tropical systems. SSMI (Special Sensor Micro-wave Imager), SSMIS, Aqua and TRMM (Tropical Rainfall Measurement Mission) are worth mentioning, but AMSU data (Advanced Microwave Sounding Unit) derived from the TIROS and Metop satellites also greatly contribute to more accurate analyses.

Besides the microwave data, scatterometer data deserve a special mention. Their derived windfields have demonstrated to provide, when available over a tropical disturbance, valuable objective information on the position of the surface centre (particularly interesting in the case of incipient or sheared systems) and on the extent of the near gale force and gale force winds around the centre. However they do not have the skill and capability to analyse the high wind speeds and strong gradients present in the core of strong storms (and so the intensity of the tropical cyclones). Unfortunately, European satellite ERS2 underwent fatal failure early in 2001 and its scatterometer data were not available anymore since that time (but the altimetric data are still available).

However NASA's satellite named QuikScat (for Quick Scatterometer) launched mid-1999 made up for this loss of ERS2 data until its own fatal failure in November 2009. The SeaWinds scatterometer radar aboard QuikScat benefited from a much larger swath compared to that of ERS, so ensuring much better spatial coverage. Up to two daily orbits on each tropical system could be

acquired and made visible through Internet websites. Provided some expertise (in particular to resolve the wind ambiguities that may result in mispositioning of circulation centers), these QuikScat scatterometer data were a powerful assistance in tropical cyclone analysis and monitoring. Since 2007 additional winds coming from the Ascat scatterometer aboard the Metop satellite are available contributing to an increase of the number of data despite a more restricted geographical coverage and a different scanning technique (generating two separate narrow swaths of data) but with the advantage of being less affected by rain contamination than QuikScat. Since the demise of QuikScat the global scatterometer coverage, now assumed by the single Ascat, has been drastically reduced resulting in a clearly felt negative impact on operational activites.

5. Cyclone forecasting

5.1 Track and intensity forecasting

Track and intensity forecasts rely to a great extent on the numerical models 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 more than 1200 tropical cyclones of the period 1848-2007), a simple « analogs » model have been developed. This kind of models enables a quick access to track and intensity cyclone forecasts.

a. Track forecast

While this model is helpful for new or young forecasters to acquire the necessary climatological knowledge of the cyclones in the basin, its interest for operational track forecasts is limited beyond 12h range. This model can also be used as an elaborated reference for assessing the skill of more sophisticated models of track forecasts.

b. Intensity forecast

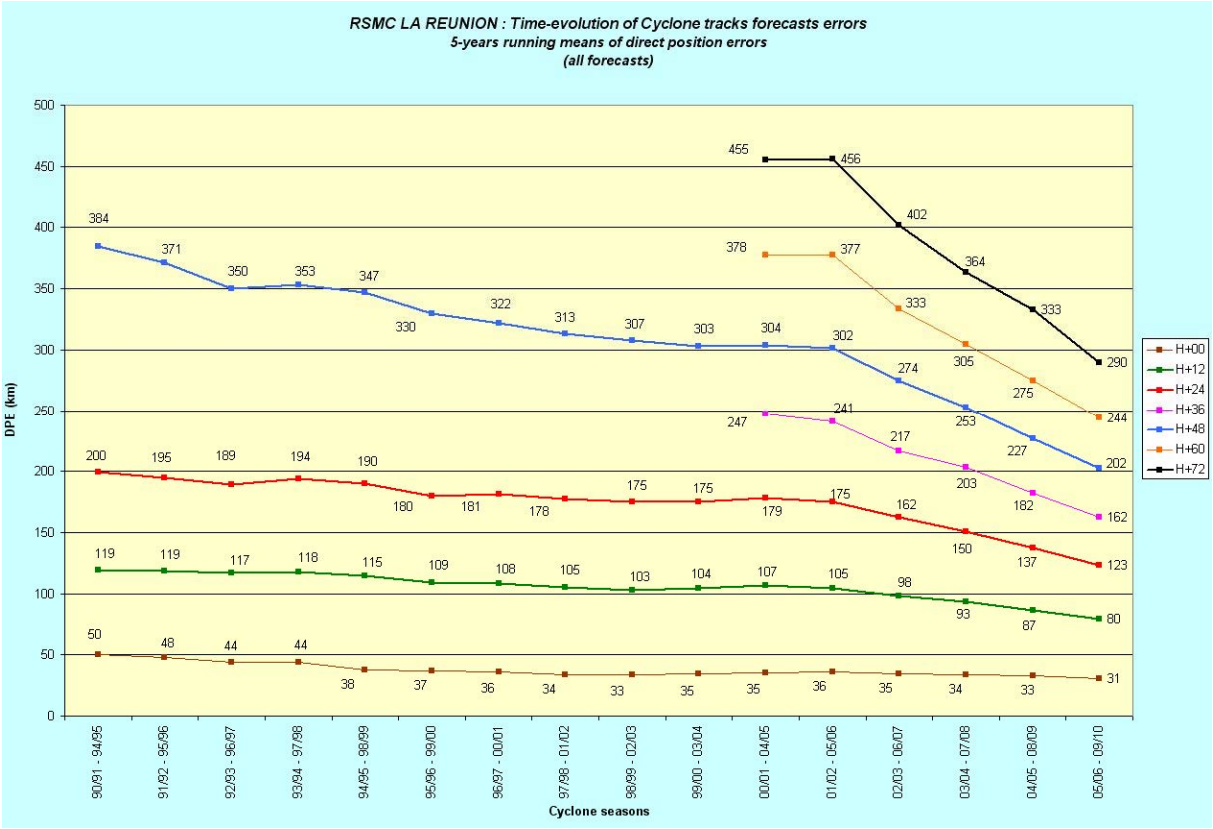
Intensity forecasts remain much more challenging than track forecasts especially because of the limited performances of the present operational models in this field. Thence statistical models are still competitive for intensity forecasts.

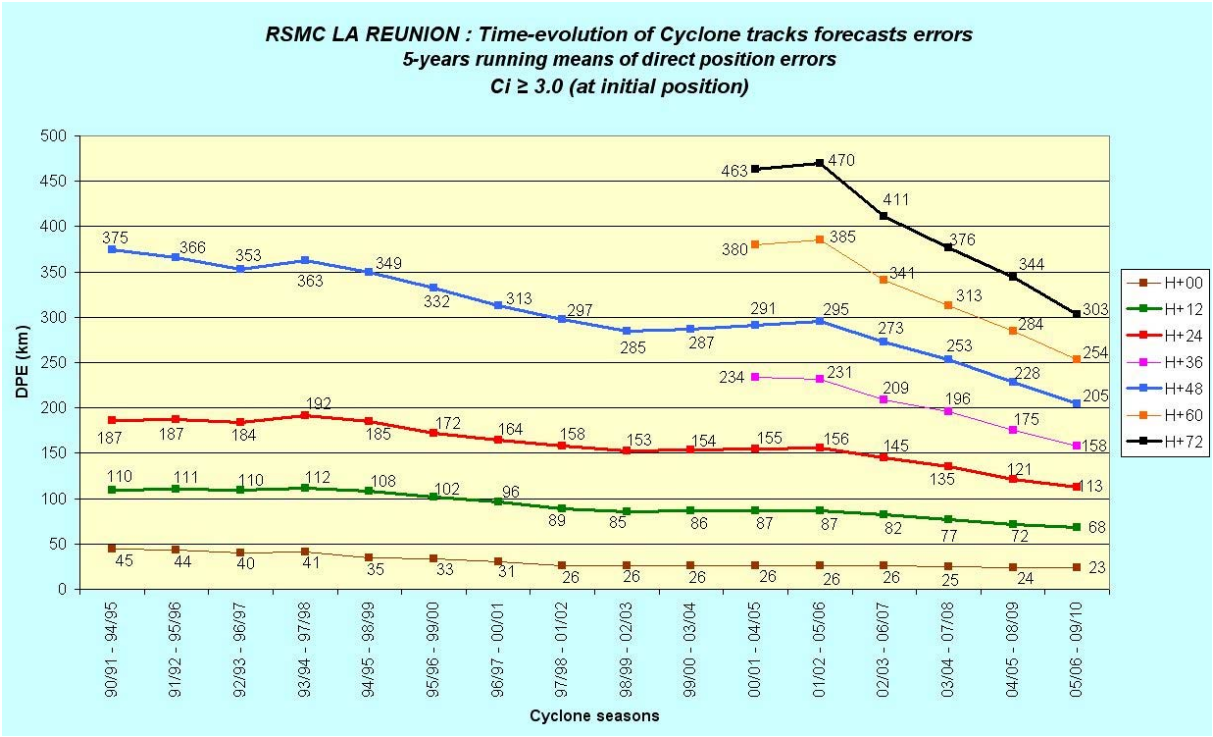
2. Global models :

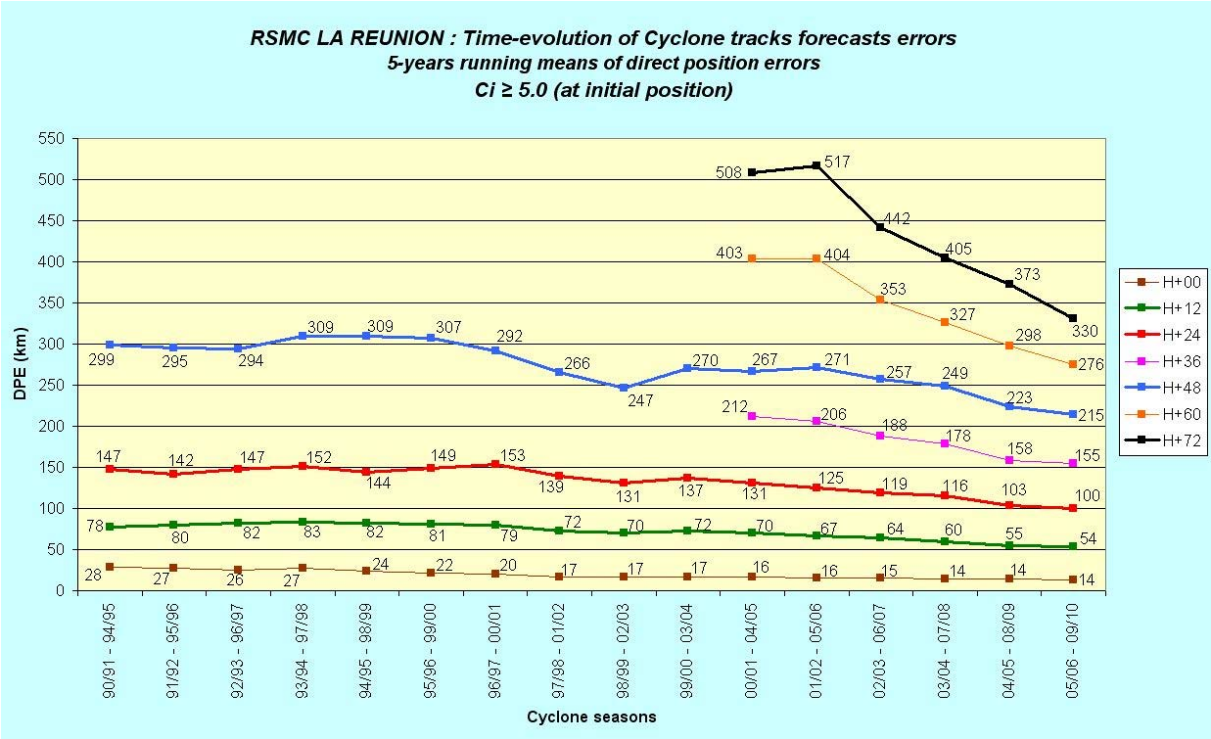
But the RSMC's cyclone forecasters rely mostly on the forecasts coming from the NWP outputs since the dynamical models have shown impressive progress in the past few years. Among all the global numerical weather prediction models available at RSMC, the most useful are the ECMWF model, the UKMO model and of course the French model ARPEGE for which a specific version with uniform resolution has been fitted to oceanic tropical regions (ARPEGE Tropiques). Additionally, since the 2004-2005 cyclone season, track forecasts derived from U.S. global models outputs are routinely received at the RSMC providing to the forecasters a sufficient set of models to enable the application of recent forecasting strategies like the consensus. Besides, ensemble prediction forecasts from the European Centre and, more recently, from the French model ARPEGE (PEARP) are received and taken into consideration to assess the degree of confidence or uncertainty of the forecast or to try to anticipate cyclogeneses.

5.3 Evaluation of the RSMC forecasts

Since 1990, detailed forecast performance statistics are prepared at the end of each tropical season. Graphs below give the track forecasts verification (5 years-running means direct positioning errors) for different intensity stratification (intensity of the tropical cyclone at the initial position) and for forecasts lead times up to 72h. Considering the improvement in track forecasting (with 3 days forecasts now as good as were the 48h forecasts just a few years ago), the RSMC has extended its forecasts maximum lead time up to 5 days (starting from early 2010).







5.4 Storm surge model and cyclone swell model

In La Réunion, due to the profile of the coast and the bathymetry, storm surge is not a fundamental problem, although 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.

The swell model is even more useful considering the potential hazard represented by breaking waves generated on La Reunion coastline by the swell associated to tropical cyclones travelling in the area. This model is being run at the present time upon request when a storm is threatening the island. But it is planned in the future to produce daily maps of the sea-state and cyclone swell generated by active tropical systems in the SouthWest Indian Ocean.

6. Operational products of the RSMC

6.1 Bulletins

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

Bulletins		Headings	Dissemination time
Marine Warnings	English	**WTIO20, 22, 24, 26**	**GTS** 00, 06, 12, 18 UTC
	French	**WTIO21**	Same
RSMC Bulletins	English	**WTIO30**	**GTS** 00, 06, 12, 18 UTC

	French	**WTIO31**	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** generally within one month after the cyclone's demise
Tropical outlook and Cyclone information Bulletin	English	**AWIO20**	**GTS** 12 UTC
	French	**AWIO21**	**GTS** 12 UTC

The « RSMC Bulletins » are the more complete advisories. They provide, in particular, position and intensity forecasts with prognostic reasoning for the coming 72 hours (maximum forecast range extended in 2003 – was 48 hours previously) and also a further outlook with the 96h and 120h forecasts.

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 United Kingdom Met Office in Exeter). The access to this data base will be soon available on the RSMC website.

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

7.1 Research and development

The main goal is to strengthen the RSMC forecasting capabilities through the development of new models or through the improvement of existing ones and to provide better objective guidance to the forecasters. The "Cyclone Research Cell (CRC)" is in charge of this vital task. The CRC has also the mission to improve the knowledge about the cyclones of the Indian Ocean. Since 1st January 2006 the CRC is linked to the National Centre for Scientific Research (NCSR) and to the University of La Réunion as a team of the joint Laboratory of the Atmosphere and of Cyclones (LACy). The integration of the CRC within the LACy has allowed a strengthening of collaborations with searchers from the region and at national level as well.

The fundamental mission of the CRC is to propose, lead and coordinate, in liaison with the National Centre for Meteorological Research, activities in Research/Development aiming at improving the forecast of cyclones at Météo-France and more generally the knowledge about tropical systems. The CRC is therefore directly involved in research activities. The effective missions of the CRC rely to 3 main fields of activities:

- Research
- Scientific support and development of specific tools for the forecasters.
- Formation

The main field of activities of the CRC is numerical modelling. Since 2004 the CRC has oriented its activities towards meso-scale modelling as developing an operational model called ALADIN-Réunion and as experimenting a Meso-NH research model. The Aladin-Réunion model is a specific version of a parent area limited model initially developed for Europe and that have been adapted for the SouthWest Indian Ocean basin with the main goal of improving track and intensity forecasts of tropical cyclones. With its 10 km high resolution and its 3D-Var assimilation scheme it has the capacity to ingest and assimilate a great number of conventional and satellite observations, these latter ones being crucial on an oceanic area rather devoid of in situ measurements like the Indian

Ocean. A specific wind bogus has been implemented in order to improve tropical cyclone track prediction.

Optimisation of assimilation algorithms and studies about the impact of observations are some of the main research activities performed with ALADIN-Réunion. The 1 km resolution non hydrostatical Meso-NH model is for its own runned to make research on the inner dynamics of tropical cyclones and to study related aspects like interactions with orography.

For these two models works aiming at introducing ocean-atmosphere coupling are endeavoured with the prospect of studying the effects of oceanic specific patterns and structures on the cyclones and with the ultimate objective to improve intensity forecasts of tropical cyclones.

7.2 Training

The RSMC plays a key role in the region, in the field of training activities. In particular, since 1999 the RSMC organizes, generally every 2 years and with the support of WMO, a 2 weeks training course/workshop in English and in French for the African countries, members of the AR I Tropical Cyclone Committee.

Furthermore, as part of the regional cooperation, the RSMC regularly hosts meteorologists of the area for attachments 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.

Finally, since the achievement of the EDF/IOC aforementioned project, the RSMC plays an important role in technical expertise and assistance of the neighbouring National Meteorological Services equipped with similar computer systems.

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. Numerous copies are distributed in the region (in particular to the Members of the Tropical Cyclone Committee) and beyond, 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-tracked maps of trajectories, statistics, satellite pictures, and other relevant information.