Regional Association I – Tropical Cyclone Operational Plan for the South-West Indian Ocean

Tropical Cyclone Programme

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CONTENTS

CONTENTS (ii)

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 2019 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 to ensure the most effective coordination and cooperation within the Region, between the Members[1] 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)

	Wind Characteristics	**Caractérisation des Vents**
(i)	Average/mean wind speed (over 10 min)	Vitesse moyenne du vent (sur 10 min)
(ii)	Sustained wind speed (over 1 min)	Vitesse du vent soutenu (sur 1 min)
(iii)	Gust	Rafale

1 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.

	Classification of weather disturbances	Classification des perturbations météorologiques
(i)	Low pressure area	Zone de basses pressions
(ii)	Extra-tropical depression	Dépression extratropicale
(iii)	Sub-tropical depression	Dépression subtropicale
(iv)	Sub-tropical storm	Tempête subtropicale
(v)	Zone of disturbed weather	Zone perturbée
(vi)	Tropical wave	Onde tropicale
(vii)	(Generic term) Tropical low system	(Terme générique) Système dépressionnaire tropical
(viii)	Tropical disturbance	Perturbation tropicale
(ix)	Tropical depression	Dépression tropicale
(x)	Moderate tropical storm	Tempête tropicale modérée
(xi)	Severe tropical storm	Forte tempête tropicale
(xii)	Tropical cyclone	Cyclone tropical
(xiii)	Intense tropical cyclone	Cyclone tropical intense
(xiv)	Very intense tropical cyclone	Cyclone tropical très intense
(xv)	Remnant low	Dépression résiduelle
(xvi)	Filling low	Dépression se comblant
(xvii)	Dissipating low	Dépression se dissipant
(xviii)	Post-tropical depression	Dépression post-tropicale

	Tropical low system characteristics	Caractéristiques d'un système dépressionnaire tropical
(i)	Centre	Centre
(ii)	Eye	Oeil
(iii)	Centre fix	Position du centre
(iv)	Confidence in the centre position	Confiance quant à la position du centre
(v)	Direction of movement	Direction du déplacement
(vi)	Speed of movement	Vitesse de déplacement
(vii)	Storm tide	Marée de tempête
(viii)	Storm surge	Onde de tempête

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

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

Wind characteristics

Average/ mean wind speed[2]: 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/forecast winds at least in half of the circulation *near the centre*, or to observed/forecast 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[2]: 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 depression: synoptic scale low pressure area outside of the tropics or former tropical low system having lost its tropical characteristics.

Subtropical depression: synoptic scale low pressure area having during its life, characteristics which could belong to both tropical and extra-tropical depressions 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)[3]. In the Southwest Indian Ocean, the genesis of such system is regularly observed over the South of Mozambique Channel.

Subtropical storm[3]: synoptic scale low pressure area having during its life, characteristics which could belong to both tropical and extra-tropical depressions in which the maximum of the average wind speed is estimated to be in the range 34 and 63 knots (i.e. between 63 and 117 km/h, Beaufort force 8, 9, 10 or 11). In the Southwest Indian Ocean, the genesis of such a 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 unorganized enhanced convection.

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 low system: generic term for a non-frontal synoptic scale low pressure area, originating over tropical or sub-tropical waters with organized convection and *[TCC-24 agreement]* cyclonic surface wind circulation.

Tropical disturbance: tropical low system in which the maximum of the average wind speed is estimated to be not exceeding 27 knots (50 km/h, force 6 in the Beaufort scale)).

Tropical depression: tropical low system 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 low system 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 low system 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).

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[2] 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.

[3] Adopted at RAI TCC-25 (2023) and will be in operations from TC season 2024-2025. In 2023-2024, the generic "Subtropical Depression" term continues to be used regardless of the value of the maximum 10-min winds."

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

Remnant low: a former tropical low system that has weakened and is no longer associated with established and/or organized convection.

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

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

Post-tropical depression: a former tropical low 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 low system characteristics:

Centre of the tropical low system: geometric centre of the eye within the cloud system or, if not present, the wind/pressure centre.

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

Centre fix of the tropical low system: estimated location of the centre of a tropical low system.

Confidence in the centre position: degree of confidence in the centre position of a tropical low system 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", implies a radius of 30 to 60 nautical miles (55 to 110 km) and

"Position poor“, implies a radius of greater than 60 nautical miles (110 km).

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

Speed of movement of the tropical low system: speed of movement of the centre of the tropical low system.

Intensity of the tropical low system: usually defined as the maximum 10-minutes average/mean wind speed existing (or estimated to exist) within the clockwise circulation.

(N.B.: intensity can also refer to the minimum central pressure associated to the low system).

Rapid intensification (RI): a tropical low system is said to have undergone “rapid intensification” whenever its intensity underwent an increase of 30 knots or greater in a 24 hours period of time (corresponds to the 94.4th percentile of the cumulative frequency distribution of 24h maximum wind speed changes).

(N.B: RI can also be defined by a 24h central pressure drop of at least 25 hPa, corresponding to the 5th percentile of 24h pressure changes.)

Explosive intensification: a tropical low system can be said to have undergone “explosive intensification” whenever its intensity underwent an increase of 45 knots or greater in a 24 hours period of time (corresponds to the 98.8th percentile of the cumulative frequency distribution of 24h maximum wind speed changes).

(N.B.: Explosive intensification can also be defined by a 24h central pressure drop of at least 45 hPa, corresponding to the 1st percentile of 24h pressure changes.)

Storm tide: actual sea level as influenced by a meteorological 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 wind 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-force wind 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-force wind 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-force wind warning: warning of mean wind speeds of 64 knots or higher (118 km/h or higher, force 12 in the Beaufort scale - i.e. hurricane force).

WWMIWS: The IMO/WMO Worldwide Met-Ocean Information and Warning Service (WWMIWS) is the internationally coordinated service for the promulgation of meteorological warnings and forecasts to vessels undertaking international or national voyages. Tropical cyclone warnings issued for the WWMIWS are promulgated through GMDSS satellite and radio communication channels.

Terms related to the warning system

Cyclone advisory: priority message for exchanging information between national meteorological services or meteorological offices concerning tropical/subtropical low systems or incipient tropical/subtropical low systems : 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 time period of cyclone risk 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 (usually from November to April or May), corresponding to the period when most of the disturbances likely to influence them occur.

1.3 Units used in international exchanges

(a) The following units/indicators are used for marine (WWMIWS) purposes, in accordance with the WMO Manual on Marine Meteorological Services (WMO No.558):

(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 preferably expressed in numbers:

e.g. "12.2S, 168.4E"

(iii) Direction of motion to the nearest sixteen points of the compass or in degrees to the nearest ten, given in figures:

e.g. "SOUTHSOUTHEAST" or "160 DEGREES"

(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);

(vi) Pressure in hectopascals (hPa), the unit being stated;

(vii) Time in Universal Time Co-ordinated (UTC), the unit being stated.

(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);

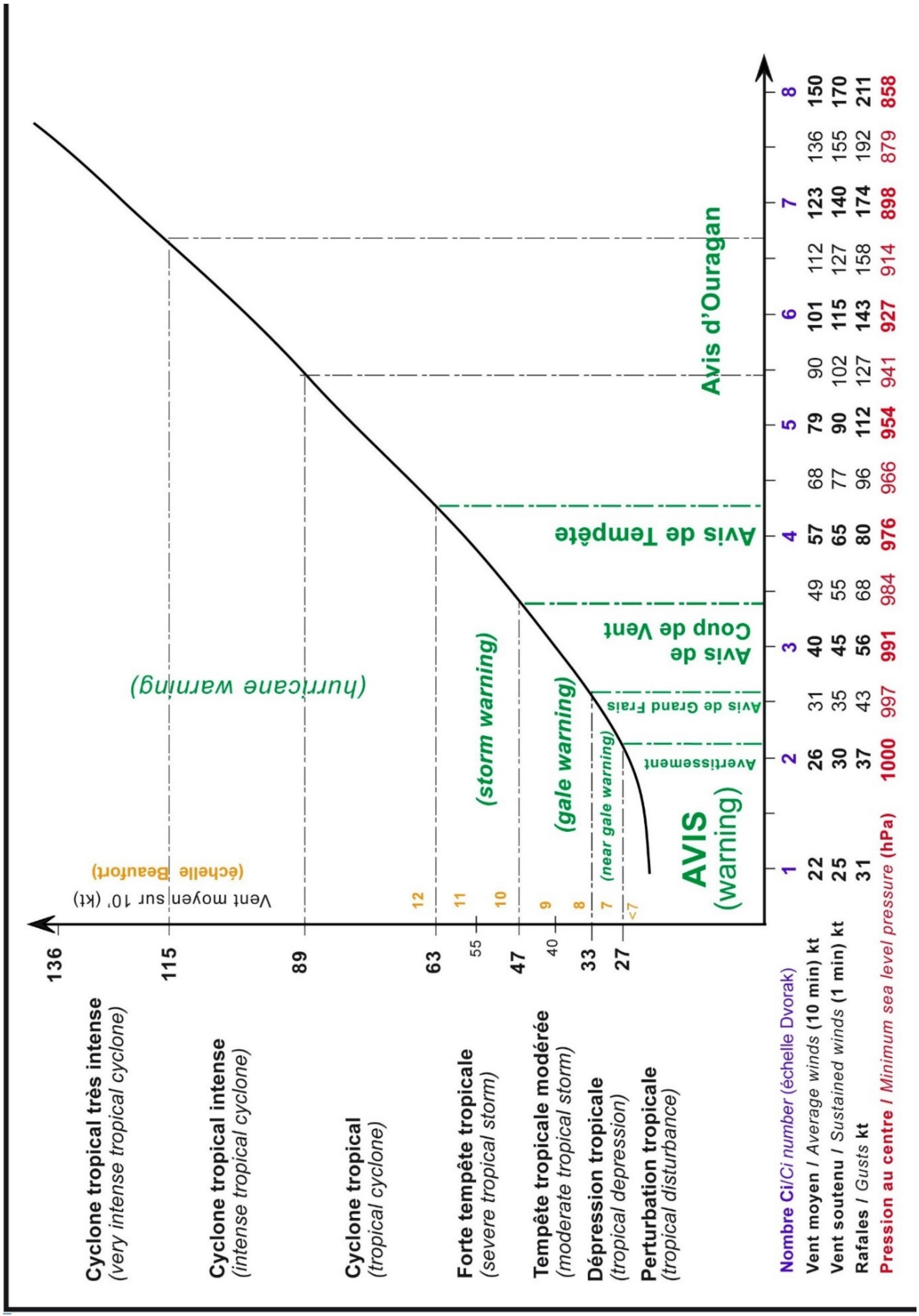
(ii) Location (position) by degrees and tenths of degrees in figures of latitude and longitude and/or bearing on the sixteen-point compass and distance from well-known fixed place(s);

(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) or knots;

(v) Confidence in the centre position in kilometres (km) or nautical miles (nm).

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



Note: The univocal pressure-wind relationship shown at the bottom of the diagram is purely indicative. In practice, this relationship is adapted on a case by case basis in order to take into account the natural variability of the pressure-wind relationship, which can be modified by parameters such as the intensity of the low-pressure system, the size 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 and naming of tropical low systems

Tropical and subtropical low systems of the South-West Indian Ocean basin are identified by a number attributed in chronological order of appearance within the cyclone season of reference. The numbers are given and incremented sequentially by the RSMC La Reunion whenever it deems appropriate to disseminate an advisory on a new system.

The numerical identifier will be supplemented by a name whenever the tropical or subtropical low system will reach a sufficient intensity and satisfy the naming criteria. This naming will facilitate the designation and communication on the system. But it is recalled that, as a good practice, in any case a national system should be based on the naming itself. The naming criteria and naming procedure are detailed hereafter.

A tropical or subtropical low system 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[4] 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 low system 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 appropriate sub-regional centre formally names the low system. In case the technical discussion doesn't achieve a consensus, the final decision to name shall be taken by the RSMC.

The name is chosen, following alphabetical order, from a predefined list of names validated for the basin and for the cyclone season of reference (starting each season with the name with the initial letter "A"), except when a tropical system already named in the South-East Indian Ocean (east of 90° E) shifts to 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 names to identify storms within the basin. Whenever named a storm will keep its name during the rest of its life cycle.

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 storms and unnamed systems.

The list of names to be used in the South-West Indian Ocean area for identifying tropical (or subtropical) storms that will develop during the next seasons within the area bounded by Equator to 40°S west of 90°E to the east coast of Africa, has been validated by the Committee. The names chosen (with genders and countries of origin) are included in the table of next page.

As a reminder, it was decided during the twenty-first session (2015) that the three lists of names shown hereafter will serve as the reference and basis to establish the future lists, just rotating them forward and changing the names having been used operationally during the corresponding ended cyclone seasons, replacing them by new names provided by the Members (and never used before).

4 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.

Cyclonic season / Saison cyclonique 2023-2024			Cyclonic season / Saison cyclonique 2024-2025			Cyclonic season / Saison cyclonique 2025-2026		
Names / Noms	**Provided by / Fournis par**	**Gender / Genre**	**Names / Noms**	**Provided by / Fournis par**	**Gender / Genre**	**Names / Noms**	**Provided by / Fournis par**	**Gender / Genre**
ALVARO	Mozambique	M	**ANCHA**	Comoros	F	**AWO**	Malawi	N
BELAL	Mauritius	M	**BHEKI**	Eswatini	M	**BLOSSOM**	Seychelles	F
CANDICE	France	F	**CHIDO**	Zimbabwe	F	**CHENGE**	Tanzania	M
DJOUNGOU	Comoros	N	**DIKELEDI**	South Africa	F	**DUDZAI**	Zimbabwe	F
ELEANOR	Zimbabwe	F	**ELVIS**	Seychelles	M	**EWETSE**	Botswana	N
FILIPO	Botswana	M	**FAIDA**	Tanzania	F	**FYTIA**	Madagascar	F
GAMANE	Eswatini	F	**GARANCE**	France	F	**GEZANI**	South Africa	M
HIDAYA	Tanzania	F	**HONDE**	Malawi	M	**HORACIO**	Mozambique	M
IALY	Madagascar	F	**IVONE**	Mozambique	F	**INDUSA**	Kenya	F
JEREMY	Seychelles	M	**JUDE**	Seychelles	M	**JULUKA**	Eswatini	M
KANGA	South Africa	N	**KANTO**	Madagascar	F	**KUNDAI**	Zimbabwe	M
LUDZI	Malawi	N	**LIRA**	Lesotho	M	**LISEBO**	Lesotho	F
MELINA	Tanzania	F	**MAIPELO**	Botswana	F	**MICHEL**	France	M
NOAH	France	M	**NJAZI**	Malawi	F	**NOUSRA**	Comoros	F
ONIAS	Zimbabwe	M	**OSCAR**	France	M	**OLIVIER**	Mauritius	M
PELAGIE	Madagascar	F	**PAMELA**	Tanzania	F	**POKERA**	Malawi	F
QUAMAR	Comoros	M	**QUENTIN**	Kenya	M	**QUINCY**	Seychelles	F
RITA	Seychelles	F	**RAJAB**	Comoros	M	**REBAONE**	Botswana	N
SOLANI	Eswatini	M	**SAVANA**	Mozambique	F	**SALAMA**	Comoros	F
TARIK	Mauritius	M	**THEMBA**	Eswatini	M	**TRISTAN**	France	M
URILIA	South Africa	N	**UYAPO**	Botswana	N	**URSULA**	Kenya	F
VUYANE	Lesotho	M	**VIVIANE**	Mauritius	F	**VIOLET**	South Africa	F
WAGNER	Kenya	M	**WALTER**	South Africa	M	**WILSON**	Mozambique	M
XUSA	Malawi	N	**XANGY**	Madagascar	M	**XILA**	Madagascar	M
YARONA	Botswana	N	**YEMURAI**	Zimbabwe	F	**YEKELA**	Eswatini	M
ZACARIAS	Mozambique	M	**ZANELE**	Lesotho	F	**ZAINA**	Tanzania	F

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 Mozambique while in Mauritius it is called "Cyclone bulletin"). (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

Bulletin on Cyclogenesis Risk: A bulletin issued whenever there is a risk of cyclogenesis in the vicinity of the country (e.g. West of 55°E) and, if possible, by providing an overall estimate of the threat or potential degradation of local weather conditions. This bulletin is intended to draw the attention of the Public and invite them to follow the evolution of weather conditions.

Special Cyclone Advisory: An advisory bulletin issued by the Antananarivo Cyclone Forecast Centre on national scale, through all available channels and a priori on Malagasy Radio Television relating to the evolution of a Tropical Low System with a detailed description of the analysis (Position, Intensity, Observed Motion), the forecast up to 3 to 5 days, alerts if they exist, as well as the measures to be taken.

2. Categories of warnings

Les conditions cycloniques adoptées par Madagascar se rapportent à du coup de vents ou plus, associé à un Système Dépressionnaire Tropical.

Preliminary warning (Green Alert): A preventive advisory aiming at alerting the population to closely follow the meteorological situation. It is issued by the Meteorological Service when it anticipates that cyclonic conditions might impact the country in the 5 to 2 days ahead. This warning is included in the Special Cyclone Advisory.

Threat warning (Yellow Alert): A warning aimed at protecting the population. It is issued by the Meteorological Service when it forecasts that cyclonic conditions are deemed to affect the country (direct threat) in the next 48 to 24 h. This warning is included in the Special Cyclone Advisory.

Warning of imminent danger (Red Alert): A warning aimed at protecting the population issued by the Meteorological Service when cyclone conditions are threatening the country at short range (12 hours before impact) and thus constitute a potential danger for people and goods.

Post-Hazard Watch (Blue Alert): A warning issued by the Meteorological Service for the safeguard of the population when the tropical low system is moving away, raising awareness of the population in the part of the island still exposed to dangerous residual hazards, such as overflowing rivers or risk of landslides, which can still constitute a danger.

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 latitude ...☐S, longitude ...☐E or ... km/nm ... of (*place*). Maximum wind speed of ... km/h/knots occur ... 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 or the existing tropical system.
- Category of the alert followed by the name of the main place of the region concerned.
- Time of issuing.

* Initial of the depression or cyclone

- Sent by.
- Received by.

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

(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:

Cyclonic wind (speed in gusts, direction)

Exceptional rainfall (indication of amount, if possible)

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	-----	-----

(d) Pro-forma used by Mauritius

(First, second, third…………………) cyclone bulletin issued at ……………… hour (date).

Statement of warning status

Name, intensity of cyclone

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

Movement of cyclone centre

Statement of Probability and time of:

- Cyclonic wind (direction and mean speed, speed in gusts)
- Rainfall intensity (light, moderate, heavy, violent)

[*] Shortened version

- Sea state (rough, very rough, high, phenomenal with wave/swells height and direction)
- Storm surge

Reminders about precautions against the following hazards:

- Wind
- Rain and floods
- Visibility
- State of sea and coasts
- Strong winds

(N.B.: Cyclonic winds include speed in gusts of at least 120 km/h).

ATTACHMENT 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, the table below 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: Wind speed conversion factors for tropical cyclone conditions (after Harper et al. 2010).

Exposure at +10 m		Reference Period	Gust Factor $G_{\tau,To}$				
			Gust Duration τ (s)				
Class	Description	T_o (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) 5. As noted in the previous section, it is technically not possile 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 the table below.

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: 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.

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

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.

CHAPTER II

THE OBSERVING SYSTEM AND OBSERVING PROGRAMMES

2.1 Networks of synoptic land stations

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

Index number	Name of station
67003	FOMBONI (MOHELI)
67001	MORONI ICONI
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.

2.1.2 Other networks

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

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.

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)
67023*	SAMBAVA
67037*	BESALAMPY
67107*	ANTSIRABE
67131*	MOROMBE
67237	NAMPULA

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

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[6]:

Index number	Name of station	Time of observation
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.

2.2 Mobile ship stations

Whenever there is an intensifying tropical system 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;

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

[6] RAI TCC-25, 2023: Mauritius Meteorological Services used to launch radiosonde once daily. However, hydrogen generator is faulty and currently upper air observations is halted.

(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.

The RSMC La Réunion - Tropical Cyclone Centre will, when possible, provide radar observations, made from aircrafts 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

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	20.9	55.4	10 cm Doppler	GEMATRONIK
La Réunion	21.2	55.6	10 cm Doppler/polarimetric	GEMATRONIK
Beira	20	35	10 cm/Doppler/Dual Polarization	Vaisala C-band
Xai-Xai	//	//	//	//
Durban	29.707	31.081	10cm	SELEX S-band
Ermelo	26.498	29.984	10cm	SELEX S-band
Polokwane (Pietersburg)	23.500	29.420	10cm	SELEX S-band
Skukuza	24.974	31.600	10cm	C-band
Mauritius	20.297	57.516	10cm	JRC S-band

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 PUMA 2015, SYNERGIE and Station at Gaborone

Comoros MSG, PUMA 2015, SYNERGIE, Station at Moroni / Hahaya

Eswatini MSG, PUMA 2015, SYNERGIE, Messir

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 PUMA 2015/MSG Station at Maseru

Madagascar Station MSG, PUMA 2015/SYNERGIE, Lightning sensors

Malawi MSG, PUMA 2015, lightning sensors

Mauritius MSG, SYNERGIE, MESSIR, PUMA 2015 Station at Vacoas

Mozambique MSG, PUMA 2015 and Messir Station at Maputo

Namibia ?

Rep. of South Africa MSG and SUMO (local software), Stations at Pretoria, Johannesburg, Durban, Bloemfontein, Port Elizabeth and Cape Town

Seychelles MSG, PUMA 2015, SYNERGIE, PUMA Station at Mahé

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.

2.5.2 Data collection platforms (DCP)

The list of data collection platforms is as follows: (to be filled out by Members concerned)

	WMO ID	Locations	Latitudes	Longitudes
DCP Seychelles	6399?	Coetivy Island	07° 75S	56° 15E
	63995	Aldabra Island	09° 24S	46° 12E
	63994	Desroches Island	05°69S	53° 65E
	63996	Farquhar Island	10°11S	51° 18E
	63981	Praslin Island	04°19S	46° 12'E
	67131	Morombe	21°45'S	43°22'E
	67152	Ranohira	22°33'S	45°24'E
DCP France (Réunion)	61968	Îles Glorieuses	11°58S	47°28E
	61970	Île Juan de Nova	17°04S	42°72E
	61972	Île Europa	22°33S	40°33E
	61976	Île Tromelin	15°88S	54°52E

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

The former reference for an up-to-date list of stations and observational programmes was the WMO Volume A. This is now available on the following website: [Observing Systems Capability Analysis and Review Tool (OSCAR) (wmo.int)]

See also: Pub.9-Vol.A Legacy Page | World Meteorological Organization (wmo.int)

TABLE 2 - RADAR EYE REPORTS - REPORTING PROCEDURES

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

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

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

15 DEG SPRL OVERLAY EYE 2033S 6046E

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

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

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

(where D55 means diameter of eye 55 kilometres).

CHAPTER III

TROPICAL CYCLONE ANALYSIS AND FORECASTING

3.1 Forecasting of tropical cyclone movement and changes in 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:

<u>Analysis</u>:

(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.);

<u>Prognosis</u>:

(i) forecast positions of tropical systems at 12, 24, 36, 48, 60, 72 hours; 96 and 120 hours desirably

(ii) intensity (Wind) at 12, 24, 36, 48, 60, 72 hours; 96 and 120 hours desirably

<u>Prognostic reasoning</u> incorporating reference to:

(i) satellite imagery interpretation;

(ii) observational inferences and tendencies;

(iii) dynamic interpretation of interaction processes;

(iv) numerical weather prediction, climatological, persistence or statistical guidance.

On a similar basis the Sub-regional Tropical Cyclone Advisory Centres[4] should also issue advisory statements, where appropriate, for their respective areas of responsibility (see Chapter IV, section 4.1).

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.

To support the NMCs in this task, in its preliminary bulletins, the RSMC adds first-level information on wind, rain and sea impacts when significant impacts (thresholds to be reached) are expected on one of the territories of the member countries over the next 72 hours.

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. The RSMC La Réunion will however strive to provide guidance whenever possible.

3.3 Forecasters' tools

If possible, NMCs will put at the disposal of their forecasters the best tools such as workstations. In addition, access to the websites made available and maintained by both RSMCs La Reunion and Pretoria is detailed in the Attachment III-A.

3.4 Daily cyclonic 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 INDIEN"

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*See footnote to Chapter I, section 1.5

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

The bulletin will comprise two parts: the first listing Warning Summaries, the second on tropical weather activity (Tropical Weather Discussion) including prognosis of tropical cyclogenesis for the next few days.

This text bulletin is supplemented by a graphical product called “cyclogenesis risk prognosis map for the South-West Indian Ocean” which visually synthesizes the essential information about the likelihood of formation of a tropical storm during the next 5 days, as assessed by the RSMC La Reunion duty tropical cyclone forecaster. This probability map, discriminating short range and medium range cyclogenesis forecast, is made available daily (before 12 UTC) on the Météo-France and RSMC websites:

http://www.meteo.fr/temps/domtom/La_Reunion/webcmrs9.0/anglais/index.html

http://www.meteofrance.re/cyclone/activite-cyclonique-en-cours

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
ICAO Advisories **(Tropical Cyclone Advisories - Text or Graphical)**	English	**FKIO20 (Text)** **PZXD01, 02, 03 (Graphical)**	**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**
Cyclonic information Bulletin	English	**AWIO20**	**GTS** 12 UTC
	French	**AWIO21**	**GTS** 12 UTC

ATTACHMENT III-A

TROPICAL CYCLONE ANALYSIS AND FORECASTING

ACCESS to DATA and PRODUCTS via RSMCs' Websites

RSMC La Reunion

- RSMC La Reunion public website (to be upgraded at the latest in November 2024):

http://www.meteo.fr/temps/domtom/La_Reunion/webcmrs9.0/francais/index.html (french)

http://www.meteo.fr/temps/domtom/La_Reunion/webcmrs9.0/anglais/index.html (english)

Access to warnings and advisories issued by RSMC La Reunion:

- Extranet website for TCC members (english/french - secured access)

https://pro.meteofrance.com/

Access to RSMC products and access to NWP products including Arome Indian Ocean and Ensemble forecast from various NWP centers

- Experimental responsive maps for RSMC forecast and products:

http://www.meteo.fr/temps/domtom/La_Reunion/meteoreunion2/HIBISCUS_GPA/ (english)

http://www.meteo.fr/temps/domtom/La_Reunion/meteoreunion2/HIBISCUS_GP/ (french)

Access to RSMC graphical forecasts and products along with probabilistic forecast of TC related hasards. Products available here are planned to be available on the new version of the public RSMC website (November 2024)

RSMC Pretoria

The South African Weather Service (SAWS) utilizes a range of deterministic and probabilistic NWP models over the terrestrial and marine domain of responsibility within WMO RA1. SAWS currently runs a number of variants of the UKMO Unified Model (UM) locally on a CRAY mainframe. In particular, a 4 and 1.5 km resolution UM ver10.1. For marine forecasting applications, SAWS makes routine use of the UKMO 12km global forecast for wind as well as sea and swell predictions. Marine forecasting operations are also supported by deterministic and probabilistic NWP products of NCEP GFS Africa Desk. In order to further support RA1 member countries in their daily operations, RSMC Pretoria also hosts access to the AROME model at 2.5 km resolution, over the SW Indian Ocean domain (hosting is via the SWFP / RSMC Pretoria website http://rsmc.weathersa.co.za/login.php), with secure access to AROME kindly provided by La Reunion.

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CHAPTER IV

TROPICAL CYCLONE ADVISORIES AND WARNINGS

4.1 Tropical cyclone advisories

The RSMC La Réunion - Tropical Cyclone Centre will be responsible for providing cyclone watch over the whole region with the most skillful advisory diagnosis available concerning the technical parameters which specify the location, intensity, dimensions and future track of tropical low systems within its area of responsibility. 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 their 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

Whenever a tropical low system makes landfall on the African continent and within its Area of Responsibility, RSMC La Reunion will continue to monitor it as long as a low-level circulation remains discernible and will continue to disseminate technical bulletins that will serve as a guidance for RSMC Pretoria that conducts the Severe Weather Forecasting Programme (SWFP) for the Southern Africa Region.

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 low systems 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 Tropical Cyclone Warnings for the high seas (WWMIWS)

WWMIWS

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* See footnote to Chapter I, section 1.5.

The IMO/WMO Worldwide Met-Ocean Information and Warning Service (WWMIWS) is the internationally coordinated service for the promulgation of meteorological warnings and forecasts.

The WWMIWS guidance and coordination for marine meteorological maritime safety information messages issued on EGC (SafetyNET), NAVTEX and HF NBDP communication systems covering the following areas:

- warnings and forecasts for the High Seas;
- warnings and forecasts for coastal, offshore and local waters (including ports, lakes and harbour areas).

Operational guidance for handling and formatting meteorological information is given in detail in the Annex IV of the WMO Technical Regulations (Manual on Marine Meteorological Services – WMO-No. 558).

The provision of warnings for weather systems that produce average wind speeds of 34 knots and greater are a mandatory requirement of the WWMIWS.

In relation to international marine requirements, the WWMIWS coordinates the broadcast of forecasts and warnings to vessels at sea through the Global Maritime Distress and Safety System (GMDSS), which includes SafetyNET satellite communications.

As part of the WWMIWS coordination, there are the following types of Centres:

Issuing service means a National Meteorological Service which has accepted responsibility for ensuring that meteorological warnings and forecasts for shipping are disseminated through approved Enhanced Group Call satellite systems to the designated area (METAREA) for which the Service has accepted responsibility under the WWMIWS.

Preparation service means a National Meteorological Service which has accepted responsibility for the preparation of warnings and forecasts for parts of or an entire designated area (METAREA) in the WMO system for the dissemination of meteorological forecasts and warning to shipping under the WWMIWS and for their transfer to the relevant Issuing Service for broadcast.

The METAREA Coordinator is responsible for ensuring that TC warnings for the WWMIWS in their METAREA are issued onto the appropriate GMDSS communication system.

4.3.1 Areas of responsibility for high seas

Members having official responsibility as an Issuing Service within the WWMIWS for issuing warnings on approved Enhanced Group Call satellite systems are South Africa (METAREA VII) and Mauritius (METAREA VIII(S)).

Members who may be considered as a Preparation Service within the WWMIWS for preparing warnings and transferring them to the relevant Issuing Service are:

La Reunion (France) for sea areas encompassed between equator and 40°S and between the African coastline and 90°E

Members who produce bulletins covering the high seas, and which do not form part of the WWMIWS are:

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

Mauritius - Sea areas from equator to 30°S between 50°E and 95°E.

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

Comoros and La Réunion (France) also issue bulletins with warnings for the Comoros archipelago and the area between 5° S and 30°S and from African coastline to 90°.

4.3.2 Format and content of warnings for the WWMIWS

The format and content of warnings issued for the WWMIWS, as outlined below, has been derived from guidance provided in the Manual on Marine Meteorological Services (WMO No.558).

TC warnings for the WWMIWS shall use the following wind warning category labels:

- Gale force wind warning (Beaufort force 8 or 9);
- Storm-force wind warning (Beaufort force 10 or 11);
- Hurricane-force wind warning (Beaufort force 12 or over).

Any TC-related wind warning issued for the WWMIWS should include the following content (excluding any relevant system metadata requirements):

(a) Header label for marine radio broadcast purposes (“SECURITE”)

Note: This label needs to be visible on any product provided to mariners with the potential to be read out on marine radio systems.

(b) Type of wind warning (GALE, STORM-FORCE, HURRICANE-FORCE WIND WARNING)

(c) Name of the issuing centre

(d) Name of the system and name of the basin

(e) Date and time of reference in UTC

(f) Type of disturbance (Tropical cyclone);

(g) Location of disturbance (latitude and longitude)

(h) Central pressure (hPa)

(i) Intensity (maximum 10-minute average winds in knots)

(j) Direction and speed of movement of the disturbance

(k) Extent of affected area in nautical miles

(l) Wind speed (knots) and direction in the affected areas

(m) Sea and swell condition in affected areas (in qualitative terms)

(n) Expected location and intensity at 12 and 24 hours time periods.

(o) Indication of when next warning will be issued.

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

4.3.3 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[7] for the portions of the region as indicated:

RSMC La Réunion - Tropical Cyclone Centre	full region
Sub-regional Tropical Cyclone Advisory Centre[4], Madagascar	west of 55°E
Sub-regional Tropical Cyclone Advisory Centre[4], 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 and 24-hour forecasts of centre position and maximum wind speed.

Members issuing bulletins for the high seas containing cyclone warnings (see section 4.3.1 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.

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[7] 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 FORCOASTAL WATERS - NATIONAL PRACTICES

France (La Réunion)

Daily, three bulletins are issued for coastal waters and high seas, and three for the public.. 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.

In the event of a cyclonic threat, monitoring bulletins detail the impacts by parameter (strong winds, heavy rains/thunderstorms and coastal floodings, etc.). They are updated as necessary.

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.

Mauritius: THE CYCLONE WARNING SYSTEM (MAURITIUS AND RODRIGUES)

Class I: Issued not less than 36 hours, nor more than 48 hours, before the occurrence of gusts of 120 kilometres per hour

Class II: Issued so as to allow, as far as practicable, 12 hours of daylight before the occurrence of gusts of 120 kilometres per hour

Class III: Issued so as to allow, as far as practicable, 6 hours of daylight before the occurrence of gusts of 120 kilometres per hour.

Class IV: Issued when gusts of 120 kilometres per hour are recorded in some places and are expected to continue.

Safety Bulletin: Issued for the purpose of:

1. lifting the cyclone warning class III or cyclone warning class IV, as the case may be; and
2. informing the public of the existence of any severe weather conditions associated with the cyclone and other environment risk, depending on the nature and extent of the damage occurred during the passage of the cyclone

Termination: Issued when outdoor risks have considerably decreased

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ATTACHMENT IV-B

SOUTH AFRICA WEATHER SERVICE (SAWS) - TROPICAL CYCLONE ADVISORIES ISSUED BY THE NATIONAL FORECAST CENTRE (NFC), PRETORIA

(i) The "WTIO" bulletins (in English) from the RSMC La Réunion are automatically downloaded to Pretoria and these messages are 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 NFC at 08h40 and 14h40 UTC daily. The full text of the tropical cyclone warning from La Réunion is included when applicable.

(iii) The message FQZA81 FAPR ([8]) which is broadcast on approved Enhanced Group Call satellite systems consists of the FQZA31 FAPR message mentioned above with the addition of the forecast area "Madagascar East" and the forecasts FQIO21/22 from the RSMC La Réunion.

(iv) In the event that 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. SAWS Coastal forecast bulletin header is FQZA30 FAPR

(v) SAWS produces graphic and text guidance for 5 days ahead for RA1 members, through the WMO Severe Weather Forecast Programme[9] (SWFP) web URL: essential Tropical Cyclone guidance information (such as current speed, movement, intensity, position etc) sourced from official La Reunion guidance is replicated into SWFP products to aid forecaster awareness and information dissemination within the RAI region

(vi) NFC operates 24/7 throughout the year and is thus frequently called upon to provide ad hoc information on tropical cyclones in its area of responsibility – by telephone or email

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[8] The bulletin is referred to as "METAREA VII east of 20°E"

[9] Resolution 15, 18th World Meteorological Congress

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, 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 and TCP/IP (data line + internet))
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 64kbps and TCP/IP, internet only)
Malawi	-La Réunion	(TCP/IP)
Mauritius	-La Réunion	(GTS, TCP/IP)
Mauritius	-Seychelles	(TCP/IP)
Swaziland	-South Africa	(GTS 64 kbps and TCP/IP (data line + internet))
Lesotho	-South Africa	(GTS 64 kbps and TCP/IP (internet only))
Namibia -	-South Africa	(GTS 64 kbps and TCP/IP (data line + internet))
Zimbabwe	-South Africa	(GTS 64kbps and TCP/IP (internet only))
Malawi	-Mozambique	(TCP/IP)
Mozambique	-South Africa	(GTS 64 kbps and TCP/IP (internet only))
Kenya	-Tanzania	(GTS 64kbps)
Kenya	-South Africa	(GTS 64kbps and TCP/IP (internet only))
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[4] 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.

ATTACHMENT V-A

LIST OF ADDRESSES AND TELEPHONE NUMBERS

Removed from the operation Plan and circulated directly to the members to avoid to have it publicly made available (through the WMO website)

ATTACHMENT V-B

LIST OF FOCAL POINTS FOR RA I / TCC

Removed from the operation Plan and circulated directly to the members to avoid to have it publicly made available (through the WMO website)

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 Centres4 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.

CHAPTER VII

TROPICAL CYCLONE INFORMATION SERVICES

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

In compliance with these recommendations, RSMC La Réunion establishes the final official trajectories (and information on intensities) for each significant storm which occurred during the season. The relevant data are on the GTS in bulletins called "best-track bulletins" (with heading AXIO20) if possible 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. Easy access to this file and to the associated cyclone data will be provided through free availability on the Météo-France and RSMC websites.

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 1300 disturbances).

Madagascar

On disk	- Identification, position, intensity, characteristics of meteorological elements, direction and speed of movement;
On magnetic tape	- Identification, position, intensity, characteristics of meteorological elements, direction and speed of movement;
On PC with Windows 98	- Excel extraction : 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.

ATTACHMENT VII-A

GLOBAL TROPICAL CYCLONE TRACK AND INTENSITY DATA SET REPORT FORMAT[10]

Headings	Content
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.

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
	AUI = Australian Indian Ocean Region
	AUP = Australian Pacific Ocean Region
	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)
30	Latitude indicator:
	1=North latitude;

10 The report format "Attachment VII-A" has been updated in 2002 with the descrition of the new sectors for the radius winds and in 2021 with the new area codes related to the australian regions, following the merging of the three Tropical Cyclone Warning Centers (TCWC Brisbane, Darwin, Perth) in a single one (TCWC Melbourne) in the South Pacific.

Position	Content
	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:

Position	Content
	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 0º-90º
76-79	Radius in Sector 2: 90º-180º
80-83	Radius in Sector 3: 180º-270º
84-87	Radius in Sector 4: 270º-360º
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 0º-90º
96-99	Radius in Sector 2: 90º-180º
100-103	Radius in Sector 3: 180º-270º
104-107	Radius in Sector 4: 270º-360º
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 (non-frontal, 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 centres, organizations)

Position	Content
	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

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

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 Cyclones RSMC for the 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 1st July 1993.

The area of responsibility of the RSMC encompasses 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, Eswatini, France, Kenya, Lesotho, Madagascar, Malawi, Mauritius, Mozambique, Namibia, Seychelles, South Africa, Tanzania, Zimbabwe) for all the tropical low systems occurring within 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. Within the framework of GMDSS (Global Maritime Distress and Safety System), 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 MWOs (Meteorological Watch Offices for aviation) 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. Météo-France has also contributed to the RAMA moored buoy array in the near-equatorial waters.

2. Human resources

The overall manpower of Météo-France La Réunion is about 80 people, among which 21 are engineers (class 1 WMO) and about 40 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 6 senior forecasters working under the supervision 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 enable the 24-hours assignment of one (or two during daytime once a system is monitored) senior forecaster(s) dedicated to the monitoring, tracking and forecasting of the tropical (or subtropical) low systems occurring within the RSMC's area of responsibility.

In order to preserve a maximum of the forecaster's time for reasoning, all the tasks that could be automated, have been automated. For instance, the generation of all the bulletins and advisories is done semi-automatically, on the basis of the inputs and information regularly entered by the forecaster in a data-base. The dissemination unfolds automatically thereafter.

Re-analyses are regularly performed in delayed time in order to update an "operational" best-track database which is routinely used for different operational tasks like the update of the track and intensity information displayed on the public websites of Meteo-France

http://www.meteofrance.re/cyclone/activite-cyclonique-en-cours

http://www.meteo.fr/temps/domtom/La_Reunion/webcmrs9.0/anglais/index.html

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 has integrated, in January 2006, 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), the University of La Réunion and Météo-France. The current staff of the CRC consists of 3 researchers-engineers, a head of research and 1 IT specialist. But the CRC’s workforce is greatly strengthened by the hosting of several researchers coming from the National Centre for Scientific Research and from the University of La Réunion and of numerous students-trainees, PhD students and post-doctoral fellows.

3. Facilities

3.1 Telecommunications

Within the Regional Meteorological Telecommunication Network (RMTN), the Centre of Saint-Denis/La Réunion is a hub connected with other meteorological centres by a number of reliable links including some high speed ones. Functions of telecommunication are completely automated, and only one controller is required to supervise the system.

The Centre is connected to the two Regional Telecommunication Centres (RTC) 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 upgrading: it has thus been raised to 12 Mbits/s in 2017 (from 4 Mbits/s in 2008), with automatic backup at 6 Mbits/s on either link through the new “load balancing” architecture.

This connection with Toulouse constitutes a real and vital umbilical cord for the RSMC. Owing to it, the Centre can access all the databases of Météo-France and can in particular receive the outputs of the French models: ARPEGE, AROME/Indian (a very high resolution limited area model that covers the main portion of the RSMC’s area of responsibility), and also the ECMWF (European Centre), UK Met Office and NCEP (GFS) global models outputs. Tropical cyclone track forecasts derived from different U.S. or Japanese models are also made available in real-time to the RSMC.

The RSMC is also equipped with:

- a data reception station Eumetcast which enables 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.
- a multi-protocols dissemination system (by fax, SMS messages, vocal messages).

A server of meteorological messages and bulletins provides the National Meteorological Services (NMSs) of the region with the possibility of direct access to the data and advisories 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 relies on 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 of 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 its support to the regional Severe Weather Forecasting Programme (SWFP) hosted by the South African Weather Service (RSMC Pretoria), the RSMC also provides to the member states involved in this project specific products and numerical fields retrieved from its Limited Area Model AROME/Indian. Supplemented by new products derived from ensemble forecasts, these fields are readily accessible via a password protected specialized website (extranet) since the end of 2010.

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

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.
- an Eumetcast data receiving station (installed in September 2005) enabling the acquisition of imagery from the European geostationary meteorological satellites of second generation (MSG-METEOSAT 10 and 8 – the latter has replaced Meteosat 7 in early 2017 that was decommissioned on 1st April after more than 10 years of invaluable and distinguished service) and of the Japanese geostationary satellite Himawari (covering the eastern portion of the Indian Ocean).
- 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 based in Lannion (western France).

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 at a distance of 11 km 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 re-established 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 enables 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 and warning system for the island.

The lack of coverage on the southeastern to southwestern sectors of the island was virtually eliminated in 2012 following the implementation of a second radar (Doppler and polarimetric) settled in the hinterland at the summit of an old inactive volcanic crater (at Plaine des Cafres).

Those radars offer very interesting opportunities for Research and Development on the effects that the orography can have on the core structure of landfalling tropical cyclones and, more generally speaking, by 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 almost 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).

On a more operational perspective, the implementation of this second radar also corresponded to a pre-requisite requirement for the monitoring of the heavy rainfall and induced flooding in the main high stake catchment basins by the Unit of Hydrological Watch created in 2010, as having, in particular, led to the development and qualification of an island scale and radar-based map of rainfall amounts.

Finally, the assimilation of these radar data in a meso-NH numerical model or in the AROME model is one of the major opportunities offered for research but also with the view of operational prospect and application at medium range.

3.4 SYNOPSIS

"SYNOPSIS" is the name of the workstation system and software developed by Météo-France that is used by all the forecasters at Météo-France to visualize and synthetize the more and more abundant meteorological information and then to elaborate the documents resulting of their cross-analyses.

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

SYNOPSIS replaced in 2018 the former SYNERGIE system which had been the operational workstation of all the Meteo-France forecasters for more than 20 years. SYNOPSIS has been developed with a more up to date computer technology which enable the forecasters to benefit from workstations having greater interoperability. Like its predecessor, SYNOPSIS offers a wide range of facilities: displaying all the available meteorological information with possibility of overlaying objective analyses, creating vertical profiles, animation, elaboration of graphical products like SIGWX charts, etc…).

Since the 2022-2023 season, the SYNOPSIS tool includes a cyclone module dedicated to the assessment of cyclonic phenomena, which now officially replaces "Synergie-cyclone".

Among the numerous functionalities offered by those modules with specialization in handling the tropical systems and their related analysed and forecast data, one of the most useful is the capability to automatically display cyclone track forecasts received from all the different NWP models with associated specific treatments (like relocation, consensus, etc…).

SYNOPSIS is also used to replay past interesting meteorological situations, a useful training facility used during the WMO-sponsored regional attachment trainings organized at RSMC La Réunion, where forecasters from the AR 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.

4. Cyclone monitoring

As a result of the lack of aircraft reconnaissance and the fact that conventional data are very sparse in the RSMC's area of responsibility, the monitoring of tropical low systems essentially relies on satellite imagery, except when these systems are within the scope of La Réunion or Mauritius radars (or Mozambique radars – but those latter ones are out of order at the present time).

Of course, all the information available is combined to determine the position and intensity of tropical low systems, 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 in the past decades of a new generation of research satellites and sensors, new means have emerged since 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. Although requiring a specific expertise and having some inherent limitations, those much valuable microwave data, generally accessible in near-real time via dedicated Internet websites, but which can also for a great portion be displayed directly on the Synopsis workstations, have taken an increasing weight in the 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 monitoring 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 low systems, 4 to 6 NOAA images of the latter (but only 1 or 2 when the storms were 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 satellites Metop having joined the NOAA satellites since 2007, the satellite monitoring of tropical low systems is now mostly based 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's area of responsibility within which all the inhabited lands of the region are located. Even if the resolution is much coarser compared to TIROS imagery (10 by 6 kilometres at La Réunion's longitude and, of course, even less to the east) and if the viewing angle can cause large parallax errors if uncorrected, the 30 min intervals imagery, the possibility of animation and the access to the water vapour imagery notably improved the capacity for a better monitoring and analysis of the tropical low systems 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, then its replacement by METEOSAT 7 in December 2007 (above 67°E) and then by METEOSAT 8 (MSG1) in February 2017 (above 41.5°E) have enabled the RSMC to benefit (since May 1998) from half-hourly imagery of the entire Indian Ocean (and now every 15 minutes). 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 the workstations.

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 coming from research satellites had started to be used for operational purpose since cyclone season 1998-1999. Since then they have taken an increasing importance. 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, structure and intensity of the tropical systems. SSMI (Special Sensor Micro-wave Imager), SSMIS, TRMM (Tropical Rainfall Measurement Mission – till April 2015), AMSR2 and GPM are worth mentioning, but AMSU data (Advanced Microwave Sounding Unit) derived from the TIROS and Metop satellites also 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 low system, 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 assess correctly the high wind speeds and strong gradients present in the core of strong storms (and so the intensity of the mature tropical cyclones).

Data from the pioneering European satellite ERS2 were received before its fatal failure early in 2001. 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 winds retrieved from the Ascat scatterometers aboard the Metop satellites have been made 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. The data from the Indian scatterometer radar Oceansat were also accessible temporarily between 2011 and early 2014, before the fatal failure of the instrument. The global scatterometer coverage was therefore drastically reduced once again, this loss having been only very partially and temporarily compensated by the advent of the RapidScat scatterometer onboard the International Space Station.

However a new "golden" era has just started for scatterometer data acquisition. With the advent of data data provided by new satellites (CFOSAT, HY-2B), in addition to the Ascat data from the Metop satellites (A, B , C right now) and the Oceansat-2 data (ScatSat), it is now almost guaranteed to get a daily or multi-daily coverage of any tropical low system in terms of scatterometer swaths.

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.

In addition to the direct use of their raw track forecasts, the relevant fields are analysed to evaluate the constraints imposed on the tropical low systems by their environment. This subjective analysis added to the observation data, derived from satellite and other sources of guidance enables to determine how the current behaviour of the cyclone will be influenced.

5.2 Global and regional numerical forecast models

Many numerical forecast models are used by the RSMC forecasters.

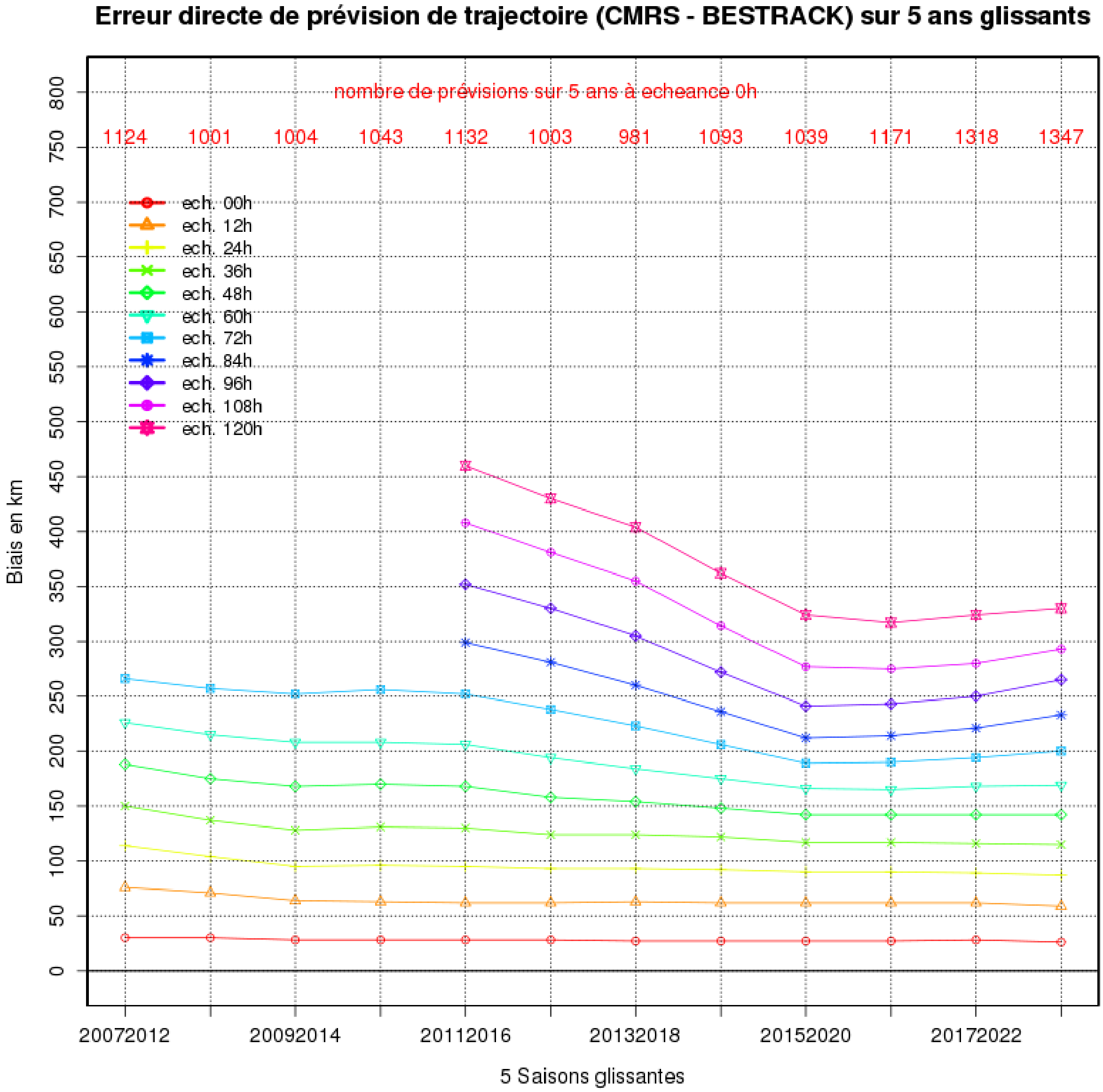
Among all the global numerical weather prediction models available at the RSMC, the most useful are the ECMWF model, the UKMO model, the U.S. GFS model and of course the French models ARPEGE and the very high resolution (2.5 km horizontally) limited-area model AROME/Indian. The latter explicitely resolves convection and covers the major part of the RSMC's Area of Responsibility. It was operationally implemented during cyclone season 2015-2016. And it is a local specific version of the Meteo-France model AROME specially adapted to the better handling of tropical low systems.

Additionally, since the 2004-2005 cyclone season, track forecasts derived from U.S. models outputs are routinely received at the RSMC providing to the forecasters a sufficient set of models to enable the application of forecasting strategies like consensus. The forecasts from the Japanese model have also come in addition (since the end of 2013). Besides, ensemble prediction forecasts from the European Centre (EPS) and from the French model ARPEGE (PEARP), are received and taken into consideration to try to anticipate cyclogeneses or to assess the degree of confidence or uncertainty of the forecasts. An innovative product has been developed and implemented operationally for this latter purpose: a probabilistic cone of uncertainty around the track forecast based and designed from the ensemble prediction of the EC model (EPS), which provides a dynamical indication of the real uncertainty of the current track forecast.

From 2023 onwards, a high-resolution 2.5 km ensemble forecast (PEARO) will be operational over the high-stakes area (presence of inhabited land) of the south-west Indian Ocean. This ensemble forecast will enable us to better describe the uncertainties associated with fine-scale processes, and increase our ability to characterize the impacts associated with a cyclone.

5.3 Evaluation of the RSMC forecasts

Since 1990, forecast performance statistics are verified at the end of each cyclone season. The graph below gives the track forecasts verification (5 years-running means of direct positioning errors) for forecasts lead times up to 72h. Considering the improvement in track forecasting (with 3 days forecasts now as good than were the 36h forecasts just a decade 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 issue, 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 has been implemented at the RSMC in December 1996. Initially used for La Réunion and Mayotte Islands it is now possible (since 2013) to run this model in real-time whenever a tropical cyclone is forecast to affect any territory of the region. But through multiple runs of the model, the RSMC has also elaborated an atlas of pre-computed storm surges for all the coastal areas of the South-West Indian Ocean, that 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.

For Reunion and Mayotte islands more specifically, Meteo-France and the RSMC can now also make use of the very high resolution operational model Hycom-2D. While for the swell forecasts, Meteo-France is relying on the ultra high resolution coastal waves model Wave Watch 3 (up to 100 m resolution for the bathymetry within the lagoon of Mayotte).

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) that has been supplemented since November 2016 with a graphical related product displayed on the RSMC website.

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**
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 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 (Asheville-USA) for integration within the global IBTrACS database and to some other interested Centres (as the United Kingdom Met Office in Exeter). The access to this database is also possible via 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. The integration of the CRC within the LACy (Laboratory of the Atmosphere and of Cyclones) has allowed a strengthening of collaborations with searchers from the region and at national and international levels as well. Since 2013 the CRC, henceforth called "Cyclone Team" of the LACy, has thus contributed, as a project leader or as a partner, to about ten research programmes either at national or international level.

The fundamental mission of the "Cyclone Team" of the LACy is to propose, lead and coordinate, in liaison with the French National Centre for Meteorological Research, activities in Research/Development aiming at improving the forecast of cyclones at Meteo-France and more generally the knowledge about tropical systems. The team is therefore directly involved in research activities and its effective missions relate 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 “Cyclone Team” of the LACy is related to numerical modelling although numerous initiatives have also recently been undertaken in the observation field of tropical cyclones. The activities are mainly oriented towards meso-scale modelling through the development of operational models (initially ALADIN-Réunion and then AROME/Indian) and of the Meso-NH model, the French research community model.

The Aladin-Réunion model was a specific version of a parent area limited model initially developed for Europe and that have been adapted for the South-West Indian Ocean basin (with a 8 km horizontal resolution) with the main goal of improving track and intensity forecasts of tropical cyclones. Since 2012 the “Cyclone Team” of the LACy has contributed to the development of the AROME/Indian model which covers a major part of the RSMC’s area of responsibility and which was implemented operationally in April 2016. The Team has in particular been involved in the development and transfer to operations of the ocean coupling within the AROME/Indian model and has started to work – since 2018 – towards the implementation of a high-resolution Ensemble prediction system which should be soon transferred to operations. It also designed a configuration of the model in research mode with a 3D-Var assimilation scheme having the capacity to ingest and assimilate a great number of conventional and radar/satellite observations, these latter ones being crucial on an oceanic area rather devoid of in situ measurements like the Indian Ocean.

The non hydrostatical Meso-NH model is for its own run to make research on the inner dynamics of tropical cyclones and to study related aspects like interactions with orography. This model, considered as a laboratory for the AROME model, constitutes one of the main tools of the French research community. Since 2013 the LACy has greatly contributed to the improvement of the Meso-NH model through the implementation of new physical parameterizations, of an electrical scheme and of a new microphysical scheme coupled with an aerosols emission scheme. Since 2016 the priority has been given to the development of an integrated numerical model having the ability to simulate the full spectrum of interactions between a tropical cyclone and its environment. A first prototype, based on the the atmospheric models AROME/Indian and Meso-NH, the 3D oceanic models NEMO-Indian and CROCO, and the WaveWatch3 (WW3) waves model, has been set up in 2017. It is currently run and experimented within the frame of the INTERREG V Indian Ocean ReNov’Risk-Cyclones research programme. Other works aiming at developing a pre-operational version of the AROME/Indian model coupled to NEMO and WW3 are also underway including being the topic of a doctoral thesis.

Since 2015, the “Cyclone Team” of the LACy has also carried out numerous actions aiming at increasing the observing capabilities of the South-West Indian cyclones. This endeavour includes the acquisition of several instruments aiming at sampling the properties of clouds and precipitations (cloud radar, an X-band rain radar, disdrometer, regional network of automatic weather stations) and the set up of a regional network for atmospheric water vapour observation based on the GNSS technology. The Team also lead the organization of a field campaign during 2019 in the basin. Another goal of the Team is to be gradually involved in different ambitious current or future space programmes like GPM, SENTINEL or EARTHCARE, through the establishment of a satellite validation station based on the campus of the University of La Reunion and via the integration of its ground instruments within the global observing networks IGS (International GNSS System) and GLOSS (Global sea level Observing System).

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 RA 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 (like the IWTC workshops – International Workshop on Tropical Cyclones).

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 strives to publish an annual report in French and English on the cyclone season of the South-West Indian Ocean basin. 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.

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