EUROPEAN COMMISSION
JOINT RESEARCH CENTRE

21 November 2018,16:00 UTC

2018 - South-West Indian Ocean Tropical Cyclones

Past events, current situation and seasonal forecast

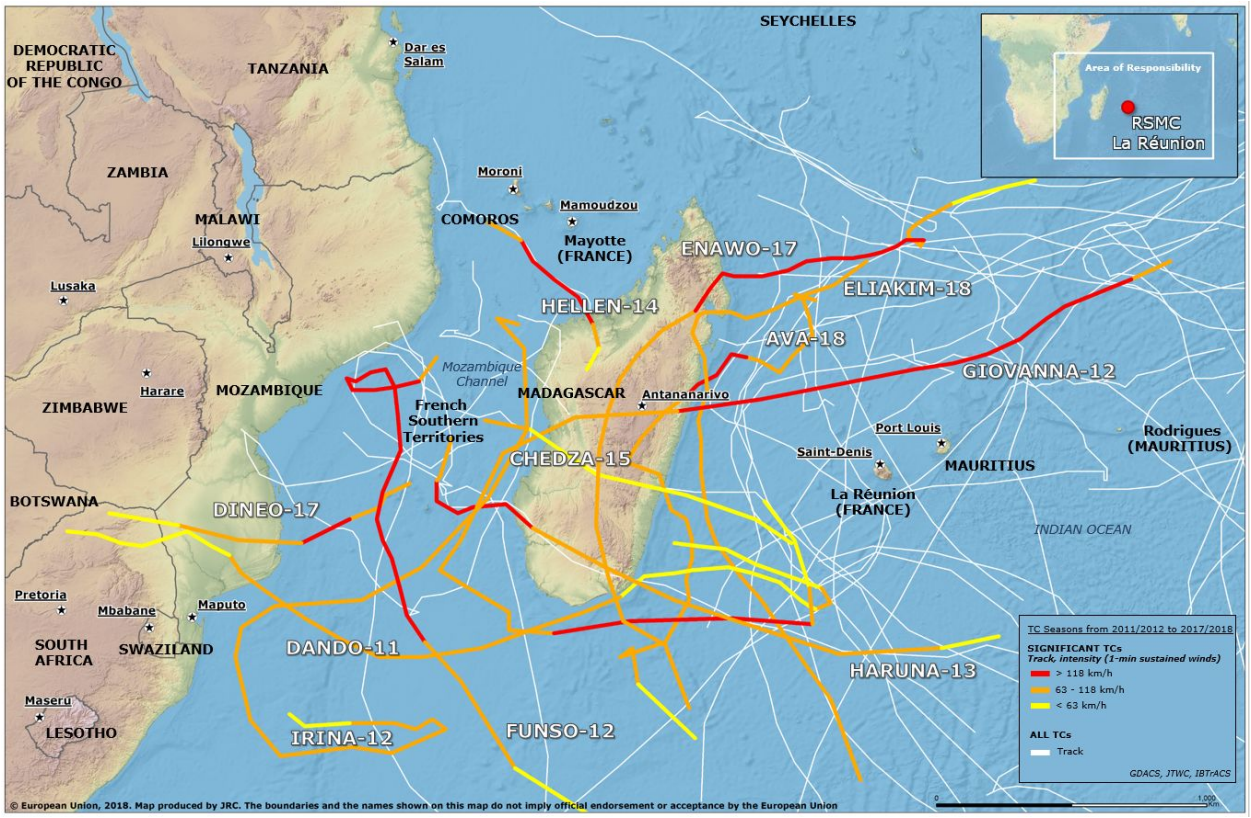


Figure 1 *- Tropical Cyclones in the South-West Indian Ocean (from 2011/12 to 2017/18).*

1. Executive Summary

- The Tropical Cyclones (TCs) season in the South-West Indian Ocean runs from November to April. On average, between 9 and 10 systems (tropical storm strength or stronger) form in this area.
- The TCs that form in this basin could affect several African vulnerable countries, causing fatalities and damage, that could require international assistance.
- The analysis of the last 18 years shows that the TCs in this basin cause the death of at least 20 people every season (except in 2015/16) and in 7 seasons the death toll exceed 100.
- The new tropical cyclone season 2018/19 officially started on 15 November 2018 (TCs already formed: ONE in Sep, ALCIDE and BOUCHRA in Nov) and, according to the available forecasts, the TC activity for this season is forecast to be near normal.
- It should be noted that even the tropical depressions or the remnants of a TC could also have a high humanitarian impact due to the amount of rainfall that could produce and the consequent floods and landslides. Moreover a larger number of smaller events could cause strong rainy conditions for a prolonged period and thus increase the vulnerability of the affected country.
- Given the uncertainties associated with the long term forecasts, those indications are only indicative and the level of attention and preparedness of the potentially affected countries should be high even if forecasts indicate normal TC activity.
- JRC is closely following the events with a series of analytical products that may be of help in the situation assessment and impact estimation.

CONTENTS

2. Introduction

The Tropical Cyclones (TCs) season in the South-West Indian Ocean basin (southern hemisphere, up to 40°S, from the African coast to 90° E, including Mozambique Channel) officially starts on **15 November** and finishes on **30 April**, with the highest number of events between January and March. On average, between 9 and 10 named systems (tropical storm or higher strength) form in this basin, with 4-5 becoming "tropical cyclone" (equivalent to Hurricane / Typhoons in other basins, see Annex 2). This area is monitored by the TC Regional Specialized Meteorological Centre (RSMC) La Réunion - Météo France. The main characteristics of this area are presented below, while the number of fatalities in each season are shown on the next page.

TCs in the SW Indian Ocean (from the African coast to 90°E)	
Season	**15 November - 30 April**
RSMC	RSMC La Réunion - Tropical Cyclone Centre / Météo-France
Areas of cyclogenesis	In general between 5°S and 20°S (few: south of 20°S and north of 5°S, 13% over the Mozambique Channel[1])
Exposed areas[2]	Botswana, Comoros, Diego Garcia, La Réunion, Lesotho, Madagascar, Malawi, Mayotte, Mauritius, including Rodrigues, Mozambique, Scattered Isl., Seychelles, South Africa, Swaziland, Tanzania, Zimbabwe

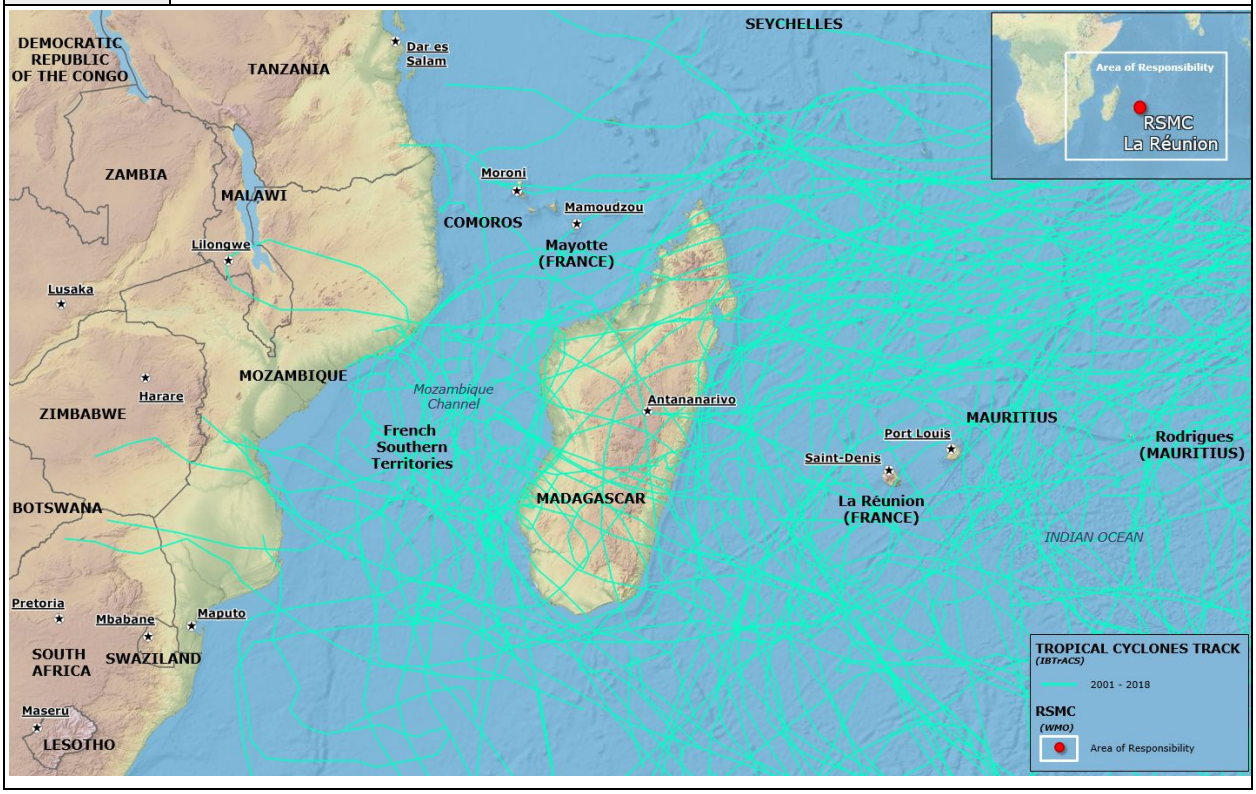


Table 1 and Figure 2 - *Main characteristics of TCs in the SW Indian Ocean, for 2001-2018 TCs (source: IBTrACS, GDACS), TC Regional Specialized Meteorological Centre (RSMC) and area of responsibility (source: WMO).*

[1] See http://severe.worldweather.wmo.int/TCFW/RAI_Training/Cyc_Bassin_SWI_oct2013_LANGLADE.pdf
[2] Including the areas potentially affected by the TC remnants, see more information at: http://www.wmo.int/pages/prog/www/tcp/documents/OperationalPlan_TCP-12_WMO-1178_2016_En.pdf

The averaged number of Tropical Cyclones (TCs) that form over the SW Indian Ocean is smaller compared to the numbers of the Atlantic and NW Pacific Ocean basins (see Table 2), but they could affect some vulnerable African countries, causing fatalities and damage and could require international assistance.

The total number of fatalities / people affected in each TC season are shown in Fig. 3, while the figures by country are in Annex 3. Based on this analysis, Madagascar is the country mostly affected in this basin, in term of number of fatalities and people affected, followed by Mozambique.

Basin	*Tropical Storm or stronger (Vmax ≥ 63 km/h)*	*Hurricane/Typhoon (Vmax ≥ 119 km/h)*
Atlantic	12.1	6.4
NE/Central Pacific	16.6	8.9
NW Pacific	26.0	16.5
N Indian	4.8	1.5
SW Indian	9.3	5.0
Aus SE Indian	7.5	3.6
Aus SW Pacific	9.9	5.2
Globally	**86.0**	**46.9**

***Table 2** - Averaged TC number by basin[3] (source: NOAA)*

It should be noted that the tropical depressions or the remnants of a TC could reach several African countries and have a high humanitarian impact due to the amount of rainfall[4] that could produce and the consequent floods and landslides (e.g. TC DINEO remnants caused severe floods and landslides in Zimbabwe and Botswana). Moreover a large number of smaller events could cause strong rainy conditions for a prolonged period and thus increase the vulnerability of the affected country. For example during the 2011/12 season, in less than two months, 4 TC systems (DANDO, FUNSO, GIOVANNA, IRINA) affected several African countries.

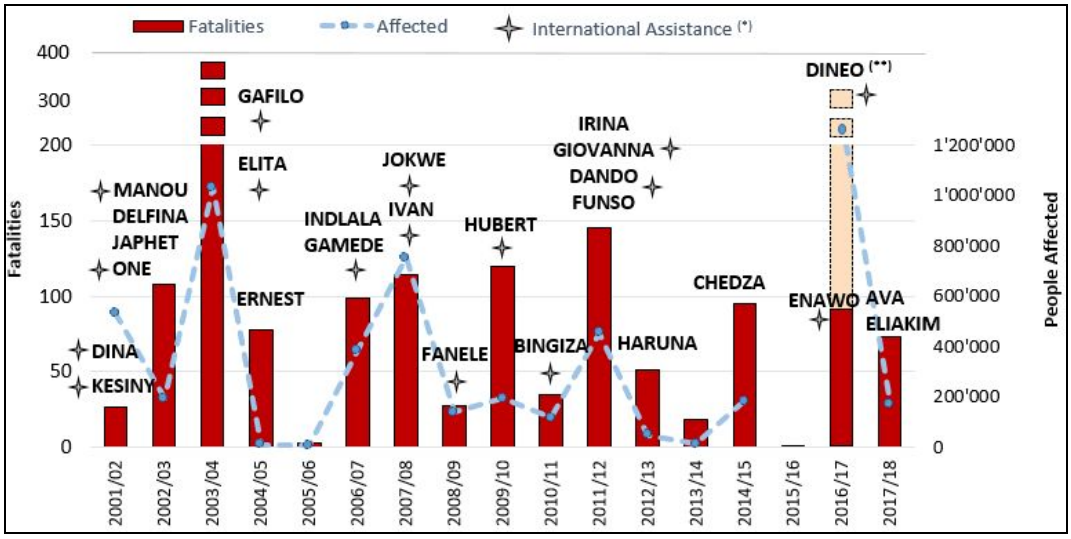


***Figure 3**: Number of fatalities and people affected by TC season from 2001/02 to 2017/18 (source: EM DAT-CRED) and (*) international assistance: UN OCHA financial support (source: UN OCHA, https://fts.unocha.org) and EU Solidary funds (http://ec.europa.eu/regional_policy/en/funding/solidarity-fund/). The most significant TCs per TC season are also included in the Figure. (**) includes the effects of its remnant (Ex-DINEO).*

[3] Based on data from 1981-2017 (1981/82 to 2016/2017 for the Southern Hemisphere). The values are based on data supplied by the WMO Regional Meteorological Center responsible for tropical cyclone forecasting for that particular basin (*source: NOAA*).

[4] TCs that form in this areas could cause large amount of rainfall during their passage and consequent floods, e.g: in La Reunion: DENISE-1966: 1825 mm/24 h, GAMEDE-2007: 4869 mm/4 days, HYACINTHE-1980: 6083 mm/15 days - see: http://severe.worldweather.wmo.int/TCFW/RAI_Training/Cyc_Bassin_SWI_oct2013_LANGLADE.pdf

3. Past events (2011/12 - 2017/18)

3.1. Overview

This analysis has been focused on the TCs that formed over the SW Indian Ocean, including the Mozambique Channel. All TC tracks of the period analysed (2011-2018) categorised by season are shown in Fig. 4, the total number of fatalities / people affected by season are in Fig. 5, the total number of TCs by season in Fig. 6 and by month in Fig. 7, while the Alerts issued by GDACS[5] are shown in Fig. 8.

Based on this analysis, over the last seven seasons, GDACS issued **4 Red Alerts** (*GIOVANNA-2012, BEJISA-2014, ENAWO-2017, AVA-2018*) and **7 Orange Alerts**.

The most significant events of the TC seasons since 2011 have been analysed in detail in Section 3.2.

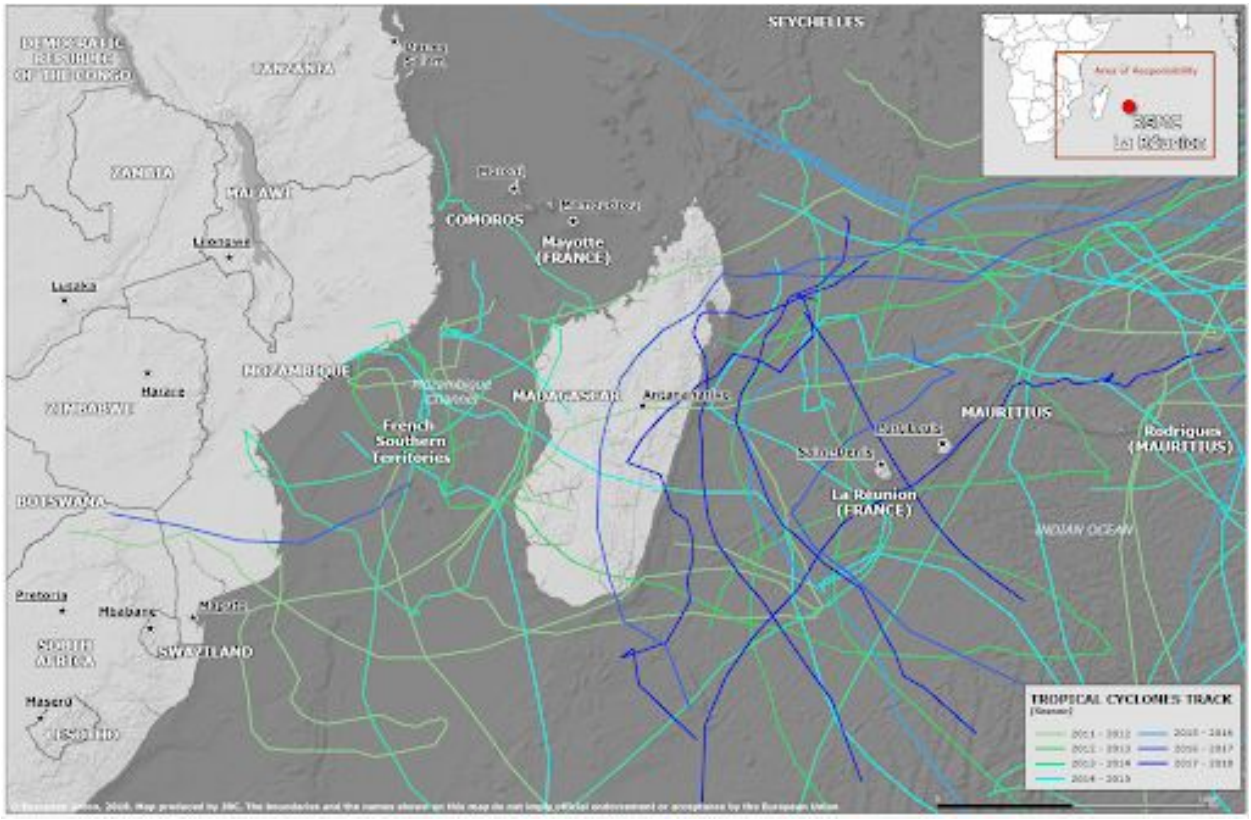
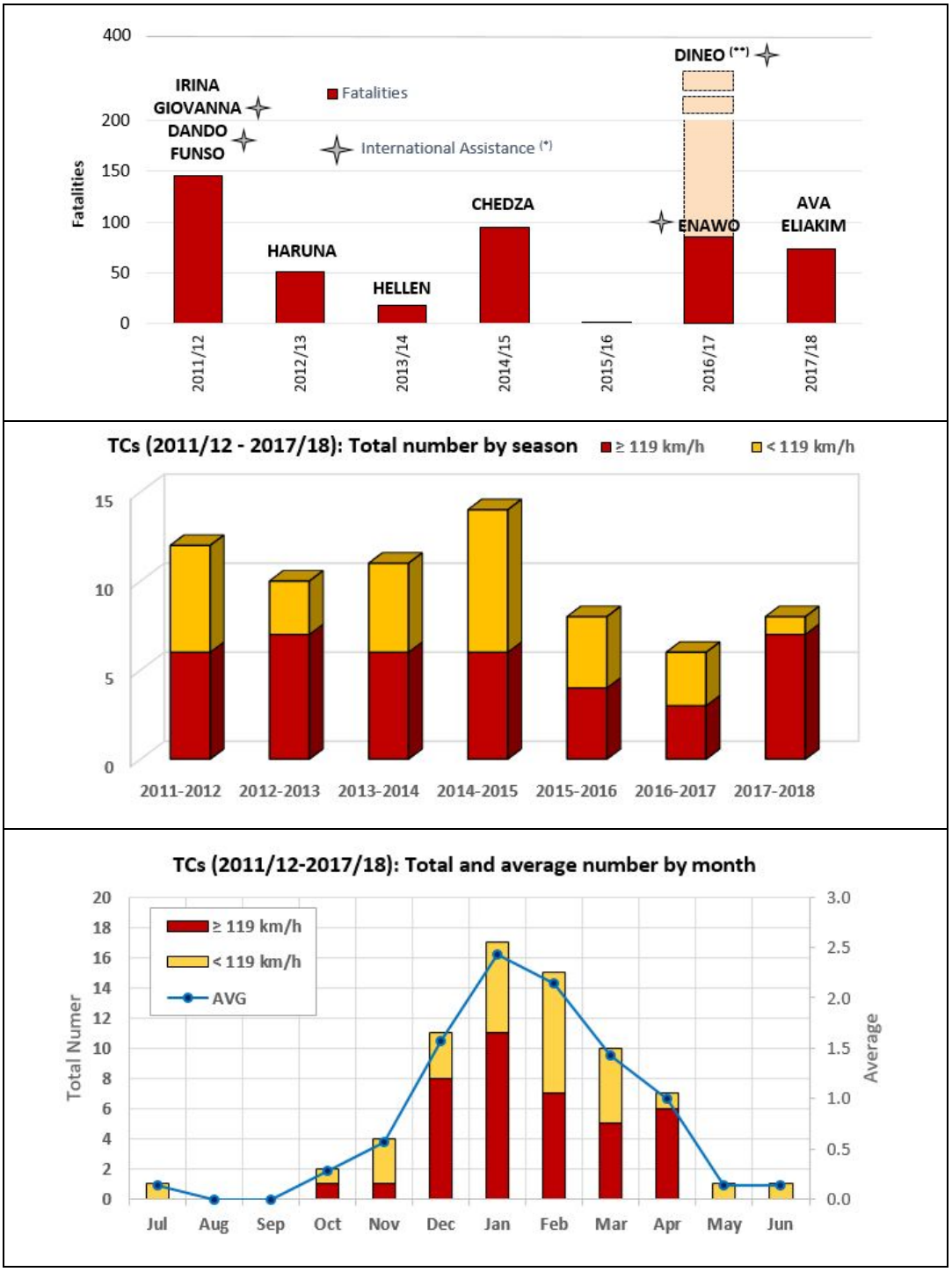


Figure 4 *- Tropical Cyclones in the SW Indian Ocean 2011/12-2017/18 by TC season.*

[5] Global Disasters Alerts and Coordination System (GDACS, www.gdacs.org) includes the estimation of the impact due to this type of events to alert the humanitarian community and improve the preparedness. A detailed description of this system is provided in Annex 2.



Figures 5 - 7 *- TOP (Figure 5): Number of fatalities by TC season (from 2011/12 to 2017/18) and international assistance / UN OCHA financial support (*) source: UN OCHA, https://fts.unocha.org). MIDDLE (Figure 6): Total number of TCs by season and intensity, where vmax ≥ 119 km/h = "tropical cyclone", see Table 3 and Annex 2. BOTTOM (Figure 7): Total and average (2011-2018) number of TCs by intensity and month. Sources: impact (EM DAT-CRED), TCs (JTWC), (**) includes the effects of its remnant (EX-DINEO) in ZIMBABWE.*

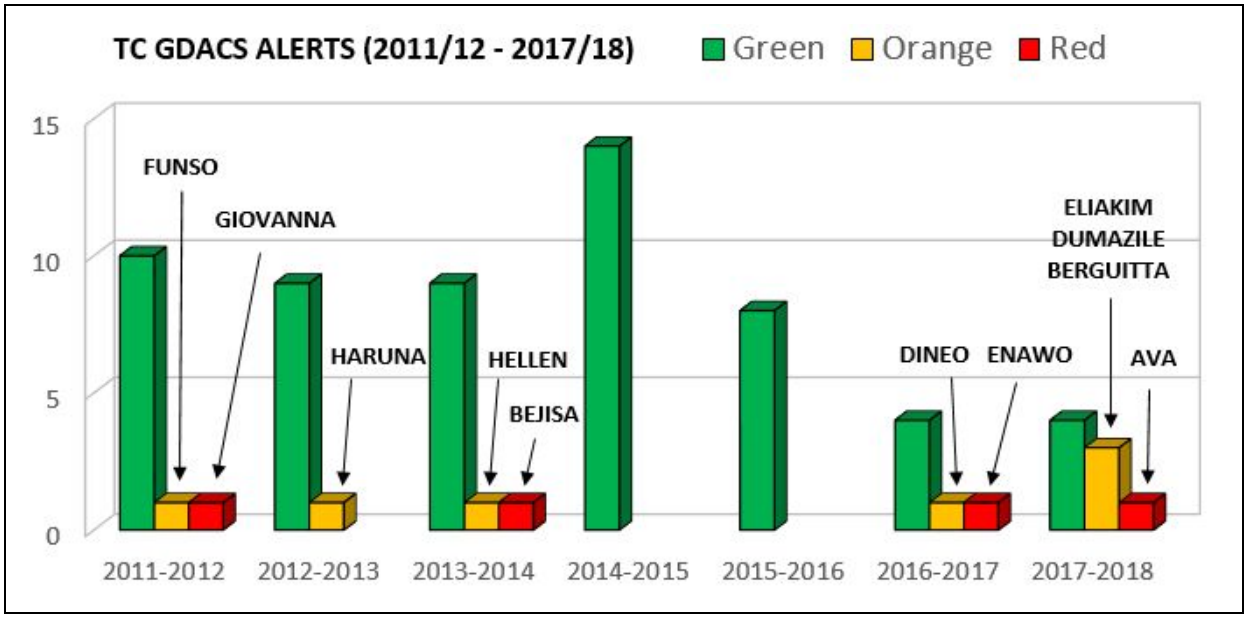


Figure 8 - *All TC final GDACS Alerts (Green, Orange, Red) for SW Indian Ocean (2011/12-2017/18).*

NOTE: The equivalent Saffir-Simpson Hurricane Wind Scale (SSHWS) has been included in this report, that is based on 1-min sustained wind speed, although this is not the official scale/winds used in the SW Indian Ocean basin, that is based on 10-min averaged winds (see Table 3 and Annex 2).

US SSHWS*		SW Indian Ocean	Australian name and category		South Pacific (East of 160E)	NW Pacific	Arabian Sea /Bay of Bengal
Tropical depression	-	**Tropical depression**	Tropical low	-	Tropical depression	Tropical depression	Depression or severe depression
Tropical storm	-	**Moderate tropical storm**	Tropical cyclone	1	Tropical cyclone *(Gale)*	Tropical storm	Cyclonic storm
Tropical storm	-	**Severe tropical storm**	Tropical cyclone	2	Tropical cyclone *(Storm)*	Severe tropical storm	Severe cyclonic storm
Hurricane	1	**Tropical cyclone**	Severe tropical Cyclone	3	Tropical cyclone *(Hurricane)*	Typhoon	Very severe cyclonic storm
Hurricane	2 - 3	**Intense tropical cyclone**	Severe tropical cyclone	4	Tropical cyclone *(Hurricane)*	Typhoon	Very severe cyclonic storm
Hurricane	4 - 5	**Very intense tropical cyclone**	Severe tropical cyclone	5	Tropical cyclone *(Hurricane)*	Typhoon	Super cyclonic storm

Table 3 - *Global Tropical Cyclone Terminology (source: BOM)*
*Note: *SSHWS uses 1-minute wind averages, whereas 10-minute wind averages used in the other areas*

3.2. Relevant PAST events

As shown above, the number of TCs and fatalities in this basin is smaller compared to the ones of the Hurricane and Typhoon seasons, however 16 events required international assistance over the last 18 years. (see Fig. 3), and 4 of them over the last 7 years. In this report the period **2011-2018**, has been analysed in detail and the most significant TCs events have been selected considering at least one of these parameters:

- number of fatalities > 10
- economic loss and humanitarian > 1 Billion Euro
- economic support from UN OCHA
- EUCPM activation.

The following information for all 11 TCs identified had been included in Table 4 (next page). For most of these events, a GDACS RED or ORANGE alert had been issued.

Impact

- TC time period: from the formation until its dissipation (source: GDACS)
- TC intensity: information provided for the peak intensity (source: GDACS)
    - Maximum 1-min sustained winds[6] (vmax) and equivalent Category of the Saffir-Simpson Hurricane Wind Scale (SSHWS), see Annex 2
    - Classification[7]:
        - vmax ≤ 62 km/h (equivalent to a tropical depression)
        - vmax 63-118 km/h (equivalent to a tropical storm)
        - vmax ≥ 119 km/h (“tropical cyclone”, equivalent to a hurricane / typhoon)

  Note: The TC classification is based on 1-min sustained wind speed, and not on the official SW Indian Ocean scale, based on 10-min winds (see Table 3 and Annex 2).
- Humanitarian and economic impact: the information on the direct losses are provided, in terms of number of deaths and direct economic losses (source: EM DAT - CRED[8])
- Affected area: the most affected countries.

Early Warning System

- GDACS Alert level: when the Red/Orange alert was issued;
- GDACS Alert - Lead time: when the first Red/Orange alert was issued;

Response

- Humanitarian response: total amount of the requested funds (source: UN OCHA, https://fts.unocha.org) and of which from European Commission's Humanitarian Aid and Civil Protection Department;
- Copernicus EMS activations: the activation code is listed for Rapid Mapping and Risk & Recovery activations;
- EUCPM Activation: mode of activation.

[6] For the difference between 1-min max. sust. winds and 10-min average, see Annex 2.
[7] It is not the official scale used by RSMC Nadi, see Annex 2
[8] Values converted to EUR from USD

TC Season	TC INFORMATION (GDACS)			IMPACT			EARLY WARNING SYSTEM (GDACS)	RESPONSE			
	Name	Dates active	Peak Intensity TD, TS, TC *1-min sust. winds (km/h), equivalent SSHWS*	Fatalities	Direct Econ. Loss (million Euro)	Areas affected (alphabetical order, bold: highest nr. of dead)	GDACS Max Alert Level, (Lead Time)	Humanit. funds (OCHA) Million euro	of which from ECHO (Million Euro)	EUCPM activation	Copernicus EMS activation
17-18	**AVA**	2 - 9 Jan	TC *176 km/h, Cat 2*	73	*n.a.*	**Madagascar**	RED *(2 Jan)*	n.a.	n.a.		EMSR264
	ELIAKIM	15 - 21 Mar	TS *102 km/h*	21	*n.a.*	**Madagascar**	ORANGE *(15 Mar)*	n.a.	n.a.		EMSR274
16-17	**ENAWO**	3 - 11 Mar	TC *231 km/h, Cat 4*	81	18	**Madagascar**	RED *(3 Jan)*	13.7	1.5	Pre-alert 06/03/2017-04/04/2017)	EMSR197
	DINEO+ Ex-DINEO(*)	13-17 Feb	TC *130 km/h, Cat 1*	258(*)	181(*)	Botswana, Malawi, **Mozambique**, South Africa, **Zimbabwe**(*)	ORANGE *(14 Feb)*	6.5			
14 - 15	**CHEDZA**	16-18 Jan	TS *93 km/h*	89	32	**Madagascar**, Malawi, Mozambique, Réunion, Zimbabwe	GREEN				
13 - 14	**HELLEN**	28 Mar - 1 Apr	TC *241 km/h, Cat 4*	17	*n.a.*	Comoros, **Madagascar**, Mozambique	ORANGE *(31 Mar)*				
12 - 13	**HARUNA**	19-25 Feb	TC *185 km/h, Cat 3*	42	22	**Madagascar**, Mozambique	ORANGE *(20 Feb)*				
11-12	**DANDO**	10-16 Jan	Subtropical Depression (**)	20	*n.a.*	**Mozambique**, South Africa	n.a.	3.7	0.2		
	FUNSO	19-28 Jan	TC *222 km/h, Cat 4*	10	*n.a.*	Madagascar, Malawi, **Mozambique**	ORANGE *(19 Jan)*				
	GIOVANNA	9-21 Feb	TC *232 km/h, Cat 4*	35	88	**Madagascar**, Mauritius, Réunion	RED *(Orange: 10 Feb, Red: 13 Feb)*	3.9	1.0		
	IRINA	29 Feb -10 Mar	TS *111 km/h*	80	*n.a.*	**Madagascar**, Mozambique, Swaziland, South Africa	GREEN				

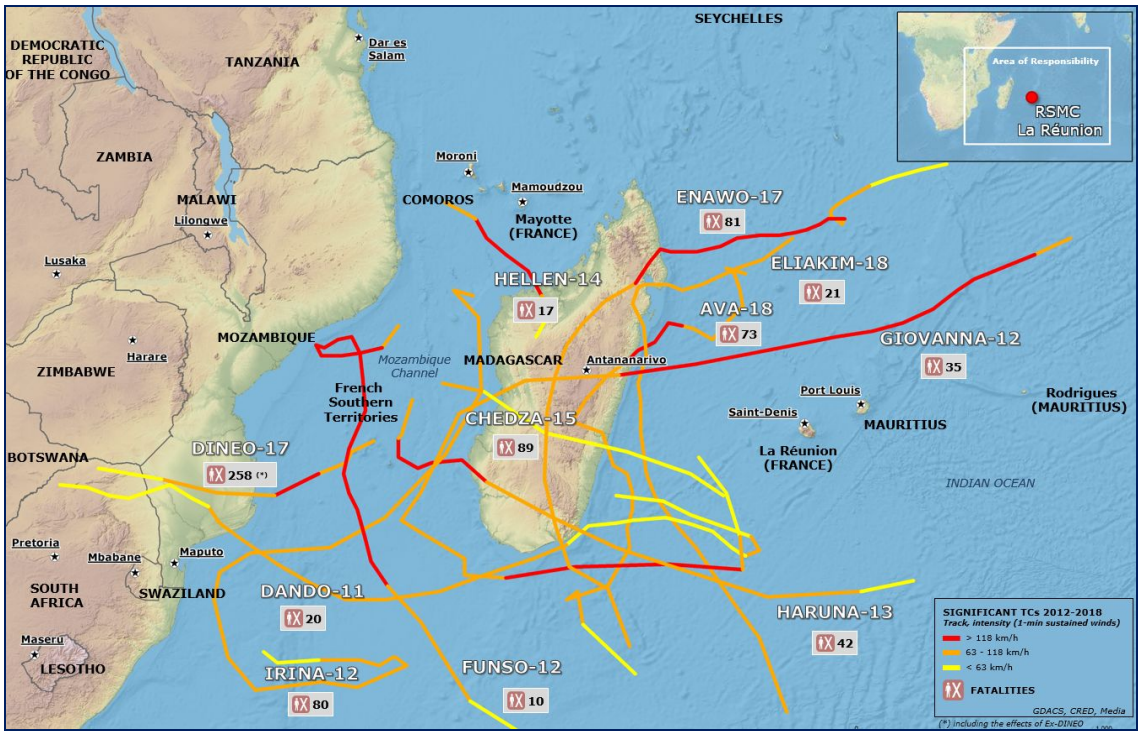


Table 4 and Figure 9 - *Relevant TCs in SW Indian Ocean (2011/12 - 2017/18). Data sources: TC information (GDACS, JTWC, IBTrACS), Humanitarian impact (EM DAT-CRED), Response (ECHO, OCHA, Copernicus EMS). (**) includes the effects of its remnant (EX-DINEO), (**) Subtropical depressions not included in GDACS.*

4. Current Situation (2018/19)

As mentioned above, the South-West Indian Ocean tropical cyclone season typically runs from 15 November to 30 April, however, so far, 3 systems have already formed:

- ONE (15-17 Sep 2018) formed on 15 September over the SW Indian Ocean south-west of Diego Garcia, moved south-southwest over water (far from land) and it dissipated on 17 September.
- ALCIDE (6-12 Nov 2018) formed over the SW Indian Ocean and started moving towards Madagascar, strengthening first into an intense tropical cyclone and then weakening and dissipating off the coast of NE Madagascar.
- BOUCHRA (10-20 Nov 2018) formed over the southern Indian Ocean on 10 Nov. It moved first over the area between the two basins (SW and SE Indian Ocean), strengthening, then it started moving SW, weakening and dissipating (see Figure 10).

→ **On-going events: No active TCs**

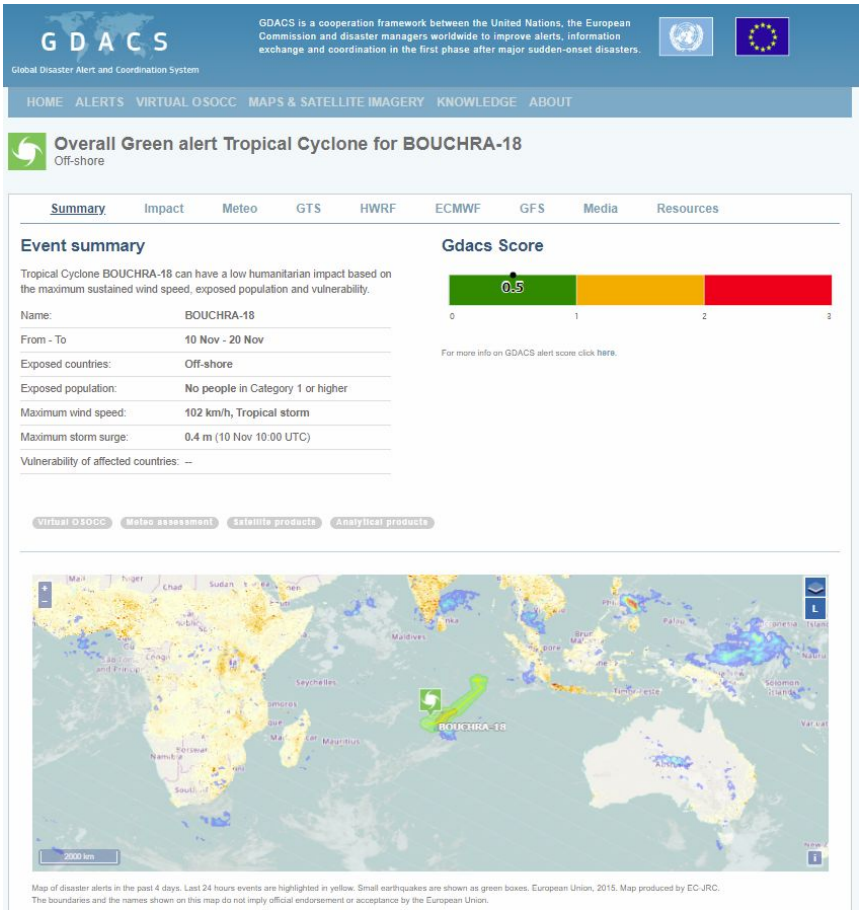


Figure 10 *- Tropical Cyclone BOUCHRA in the South-West Indian Ocean, November 2018 (GDACS).*

5. Seasonal Forecast (2018/19)

During the year several national meteorological centres and scientific agencies perform forecasts on how many tropical cyclone will form during a season and/or how many tropical cyclones will affect a particular country. The available seasonal forecasts for the SW Indian Ocean basin of various weather centres and agencies are analysed and summarised in Table 5. For the local and/or country forecasts please refer to the list contained in Section 7. Additional information can be found in Annex 4 and in:
https://habiter-la-reunion.re/wp-content/uploads/2018/11/CP-Me%CC%81te%CC%81o-France-Pre%CC%81visions-cycloniques-2018-2019pdf.pdf

Near Normal cyclone activity over the SW Indian Ocean for 2018/19 season.

Period	Center *(issued)*	Forecast		Average	Current Season 2018/19
		Activity	Number of systems ≥ TS*	Number of systems ≥ TS*	Number of systems (*)
Total season *(From Nov 2018 to Apr 2019)*	RSMC Reunion / Meteo France *(Nov 2018)*	Near normal 60% of probability	8-11	10	RSMC Reunion - Meteo France: - 1 TD in Sep - 2 ≥ TS in Nov JTWC: → 1 TS in Sep → 2 ≥ TS in Nov
	SWIOCOF-7[9] *(Oct 2018)*	Near average		10	
	ECMWF *(Oct 2018)*	Near normal	8.1	8.0	
Remaining season (**) *(From Dec 2018 to May 2019)*	**ECMWF** *(Nov 2018)*	Near normal	7.3	7.4	

(*) number of systems (tropical storm or higher strength) that could differ from center to center, since they may refer to different intensities (winds average, classification) and locations, see Table 3 and Annex 2.
(**) extended period including also May 2019

***Table 5** - 2018/19 seasonal forecasts based on main weather centres and agencies.*

→ Reduced probability of TC genesis over the eastern part of the basin (East of 70° E)[10] and over the Mozambique channel; increased probability of TC genesis over the central areas of the basin.

NOTE:

- The seasonal averages and forecasts include the TCs that form over the water and remain offshore and the ones that could make landfall or move close to the coasts.

- It should be also noted that the latest seasonal SST (Sea Surface Temperature) forecasts point to an El Nino event forming and prevailing in the period from Dec 2018 to Feb 2019 (~80% chance) and in the period from Mar to May 2019 (55-60% chance). Studies show that when El Niño is sufficiently strong could reduce the TC activity (see details in Annex 4).

[9]SWIOCOF-7 (Seventh Session of the South-West Indian Ocean Climate Outlook Forum taken place in Mauritius 17-20 Sep 2018
[10]http://commissionoceanindien.org/fileadmin/user_upload/FILES_DI4/Statement_-_SWIOCOF-7_-_2018.pdf

6. Conclusions

- The Tropical Cyclones (TCs) season in the South-West Indian Ocean officially starts on 15 November and finishes on 30 April, with the highest number of TCs between January and March. On average, every season, between 9 and 10 named systems (tropical storm or higher strength) form, with 4 - 5 becoming “tropical cyclones” (equivalent to Hurricane / Typhoons).

- The TCs forming in this basin could affect several vulnerable African countries, causing damage and deaths, that could require international assistance. Over the last 18 years, 16 events required international humanitarian intervention (OCHA funding). Moreover at least 20 people died in this basin every season (except in 2015/16 season, < 20 deaths) and in 7 seasons the death toll exceeded 100 deaths. The deadliest seasons had been: 2004/05 (TC GAFILO), 2011/12 (IRINA, GIOVANNA, FUNSO, DANDO) and 2016/17 (DINEO and its remnant). Among the various countries affected, Madagascar is the one mostly affected, in term of number of fatalities and people affected, followed by Mozambique.

- In this report, 11 TCs have been selected and analysed in detail for the seasons 2011/12-2017/18, considering the impact on the affected countries (in terms of deaths, direct economic losses) and the international humanitarian support (OCHA funding and EUCPM activation). According to this analysis, over this period 4 TCs required humanitarian support (2 in 2011/12 season and 2 in 2017/18 season) and, for these significant events, GDACS issued a RED or ORANGE alert.

- The new TC season 2018/19 officially started on 15 November 2018 (3 TCs have already formed: ONE in Sep, ALCIDE and BOUCHRA in Nov) and, according to the available forecasts, the TC activity for this season is forecasted to be near normal. El Niño could also influence the TC activity.

- It should be noted that tropical depressions and low pressure systems in general, including the remnants of a TC (e.g. Ex-DINEO that caused floods and landslides in Zimbabwe and Botswana) in general could produce large amount of rainfall and consequent flood and landslide events, damage and fatalities, and could have a high humanitarian impact. Moreover a large number of smaller events could cause strong rainy conditions for a prolonged period and thus increase the vulnerability of the affected country. For example during the 2011/2012 season, in less than two months, 4 TCs (DANDO, FUNSO, GIOVANNA, IRINA) affected several African countries.

- Given the uncertainties associated with the long term forecasts, these indications (seasonal forecasts) are only indicative and the level of attention and preparedness of the potentially affected countries should be and remain high even if forecasts indicate normal TC activity.

- JRC is following the events with a series of analytical products that may be of help in the situation assessment and impact estimation.

7. TC information relevant links

- GDACS: http://www.gdacs.org
- ERCC portal: http://erccportal.jrc.ec.europa.eu/
- Copernicus EMS: http://emergency.copernicus.eu/mapping/list-of-components/
- Reliefweb: https://reliefweb.int/
- VOSOOC: https://vosocc.unocha.org/
- UN OCHA:http://www.unocha.org/
- Disaster Charter: https://disasterscharter.org
- UNOSAT-UNITAR: https://www.unitar.org/unosat/
- EM-DAT - The Emergency Events Database - Université catholique de Louvain (UCL) - CRED, D. Guha-Sapir - www.emdat.be, Brussels, Belgium

Tropical Cyclone (TC) background information:

- WMO - Global Guide to Tropical Cyclone Forecasting: https://cyclone.wmo.int/
- WMO Regional Association I – Tropical Cyclone Operational Plan for the South-West Indian Ocean:http://www.wmo.int/pages/prog/www/tcp/documents/OperationalPlan_TCP-12_WMO-1178_2016_En.pdf

Tropical Cyclone (TC) - Past events:

- Joint Typhoon Warning Center Best Track SHemisphere: http://www.metoc.navy.mil/jtwc/jtwc.html?southern-hemisphere
- NOAA Historical TCs track: https://coast.noaa.gov/hurricanes/
- NOAA IBTrACS: https://www.ncdc.noaa.gov/ibtracs/
- Meteo France: http://www.meteo.fr/temps/domtom/La_Reunion/webcmrs9.0/anglais/index.html

Tropical Cyclone (TC) - Formation, ongoing events and forecasts:

- WMO Severe weather Information Centre: http://severe.worldweather.org/
- WMO - Tropical Cyclone Forecaster website: http://severe.worldweather.wmo.int/TCFW/
- RSMC La Reunion - Meteo France: http://www.meteofrance.re/cyclone/activite-cyclonique-en-cours
- Joint Typhoon Warning Center: http://www.metoc.navy.mil/jtwc/jtwc.html
- NOAA-HWRF (Hurricane Weather Research and Forecasting system): http://www.emc.ncep.noaa.gov/gc_wmb/vxt/HWRF/index.php
- NOAA Climate Prediction Center, SOUTH ASIA WEATHER AND CLIMATE: http://www.cpc.ncep.noaa.gov/products/international/sasia/sasia.shtml
- NOAA-NESDIS: Multiplatform Tropical Cyclone Surface Winds Analysis (MTCSWA): http://www.ssd.noaa.gov/PS/TROP/mtcswa.html
- RAMMB: http://rammb.cira.colostate.edu/research/tropical_cyclones/
- Meteo France - TC season (15 Nov 2018): https://habiter-la-reunion.re/wp-content/uploads/2018/11/CP-Me%CC%81te%CC%81o-France-Pre%CC%81visions-cycloniques-2018-2019pdf.pdf
- SWIOCOF-7 - Statement of the 7th Session of the SWIO Climate Outlook Forum: http://commissionoceanindien.org/fileadmin/user_upload/FILES_DI4/Statement_-_SWIOCOF-7_-_2018.pdf

National Meteorological and Hydrological Services (NMHSs)

- Botswana:http://www.gov.bw
- Comoros: http://www.anacm-comores.com/
- Kenya: http://www.meteo.go.ke/
- La Reunion: http://www.meteofrance.re/
- Madagascar:http://www.meteomadagascar.mg/
- Mayotte: http://www.meteofrance.yt/
- Malawi: http://www.metmalawi.com/
- Mauritius: http://metservice.intnet.mu/
- Mozambique: http://www.inam.gov.mz/index.php/pt/
- Namibia: http://www.meteona.com/
- Seychelles: https://www.meteo.gov.sc/#/
- South Africa: http://www.weathersa.co.za/
- Swaziland: http://www.swazimet.gov.sz/
- Tanzania: http://www.meteo.go.tz/

JRC Emergency Reports:

- 2018 - Caribbean Tropical Cyclones: Past events, current situation and seasonal forecast http://portal.gdacs.org/GDACSDocuments/013-TC_Seasonal_Forecast_CaribbeanRegion.pdf
- 2018 - NW Pacific Typhoons: Past events, current situation and seasonal forecast http://portal.gdacs.org/GDACSDocuments/015-NW%20Pacific%20Typhoons_update.pdf
- 2018 - South Pacific Tropical Cyclones: Past events, current situation and seasonal forecast

8. References and contact points

Contact points within JRC / EC: Disaster Risk Management Unit

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ANNEXES

Annex 1 - Detailed Map

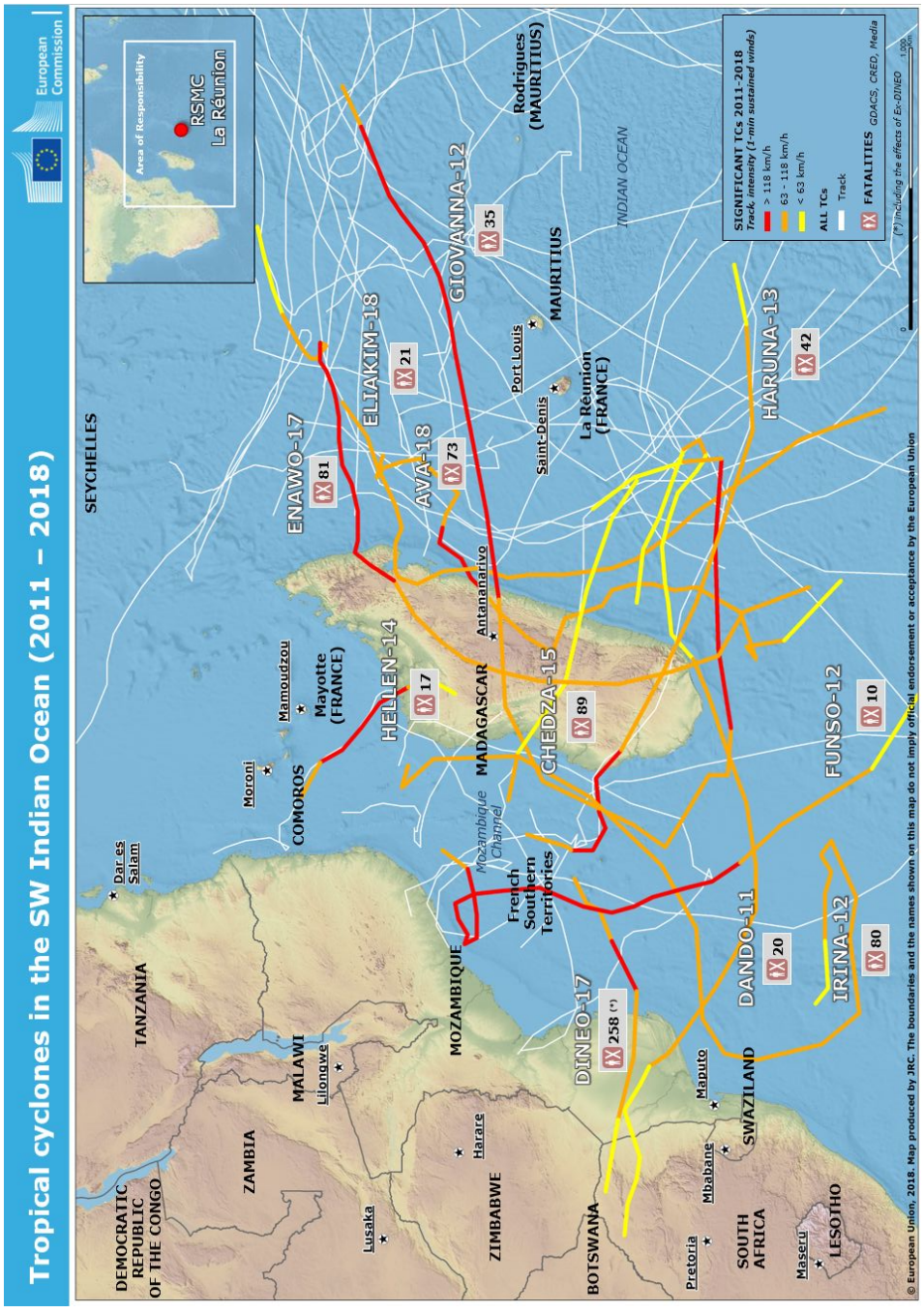


Figure A1.1 *- Tropical Cyclones in the SW Indian Ocean (from 2011/12 to 2017/18 season).*

Annex 2 - GDACS TC Alerts

JRC is responsible for the operation of GDACS (Global Disaster Alerting Coordination System), that plays a major role in alerting the international community to humanitarian emergencies during natural disasters. The alerts of GDACS (Green, Orange, Red) are elaborated based on the severity of the event, the population involved and the vulnerability of the countries (see Table A2.1. GDACS also sends e-mail and SMS alerts to subscribed recipients. A detailed description of GDACS can be found in the GDACS Guidelines available at:
http://www.gdacs.org/Documents/GDACS%20Guidelines%202014_-_FINAL.PDF

GDACS ALERTS		
	**GREEN ALERT**	Moderate event, International Assistance not likely
	**ORANGE ALERT**	Potential local disasters, International Assistance might be required
	**RED ALERT**	Potentially severe disasters, International Assistance is expected to be required

Table A2.1 *- GDACS Alerts.*

Tropical Cyclones (TCs) are among the most dangerous natural disasters, causing every year extensive damage and deaths in several countries around the world. They have three destructive effects (strong wind, heavy rain and storm surge). GDACS includes the analysis of all TCs occurring worldwide.

TC information:
JRC set up an automatic routine that includes the TC bulletins produced by the National Oceanic and Atmospheric Administration (NOAA) and the Joint Typhoon Warning Center (JTWC) into a single database, covering all TC basins. This information is used in GDACS for the wind impact, and as input for the JRC storm surge system. JRC has recently developed new tools for the analysis of the TC impacts and included new sources (NOAA Hurricane Weather Research and Forecast - HWRF and Global Forecasting System - GFS, global high resolution model of the European Centre for Medium-Range Weather Forecast -ECMWF).
→ SW Indian Ocean: JTWC data

Wind
The GDACS alert levels for the TCs are based on the risk formula that includes:

- TC wind speed[11] (hazard)
- Population affected
- Vulnerability of the affected country

The equivalent Category based on the Saffir-Simpson Hurricane Wind Scale (SSHWS), 1-min sustained winds, is also indicated in GDACS (see next page).
The overall alert for a Tropical Cyclone comes from **wind effects.**

Recently, in order to avoid too many false alerts or flip-flop effects due to the too early forecast and change of track direction or intensity, the alert level for forecast data with longer than 3 days lead time is limited to Orange Alert, even if Red Alert is estimated.

[11] GDACS, JTWC, NOAA wind information based on 1-min sustained winds; other centers: 10-min average (see "GUIDELINES FOR CONVERTING BETWEEN VARIOUS WIND AVERAGING PERIODS IN TROPICAL CYCLONE CONDITIONS": https://www.wmo.int/pages/prog/www/tcp/documents/WMO_TD_1555_en.pdf)

Storm Surge

Storm surge is an abnormal rise of water above the predicted astronomical tides, generated by strong winds and by a drop in the atmospheric pressure. It was implemented in the HyFlux2 code, routinely used in GDACS to model inundation due to tsunami run-up.

The GDACS alert levels are based on the maximum storm surge height:

- Green: < 1.0 m;
- Orange: 1.0m - 3.0 m;
- Red: > 3.0 m.

It should be noted that the estimation of the sea level is strongly dependent on the initial data (wind velocity and direction). The sea level change according to each bulletin that was available.

JRC is preparing a new alert system that will include all the effects (winds, rainfall, storm surge).

TC Classification used in GDACS

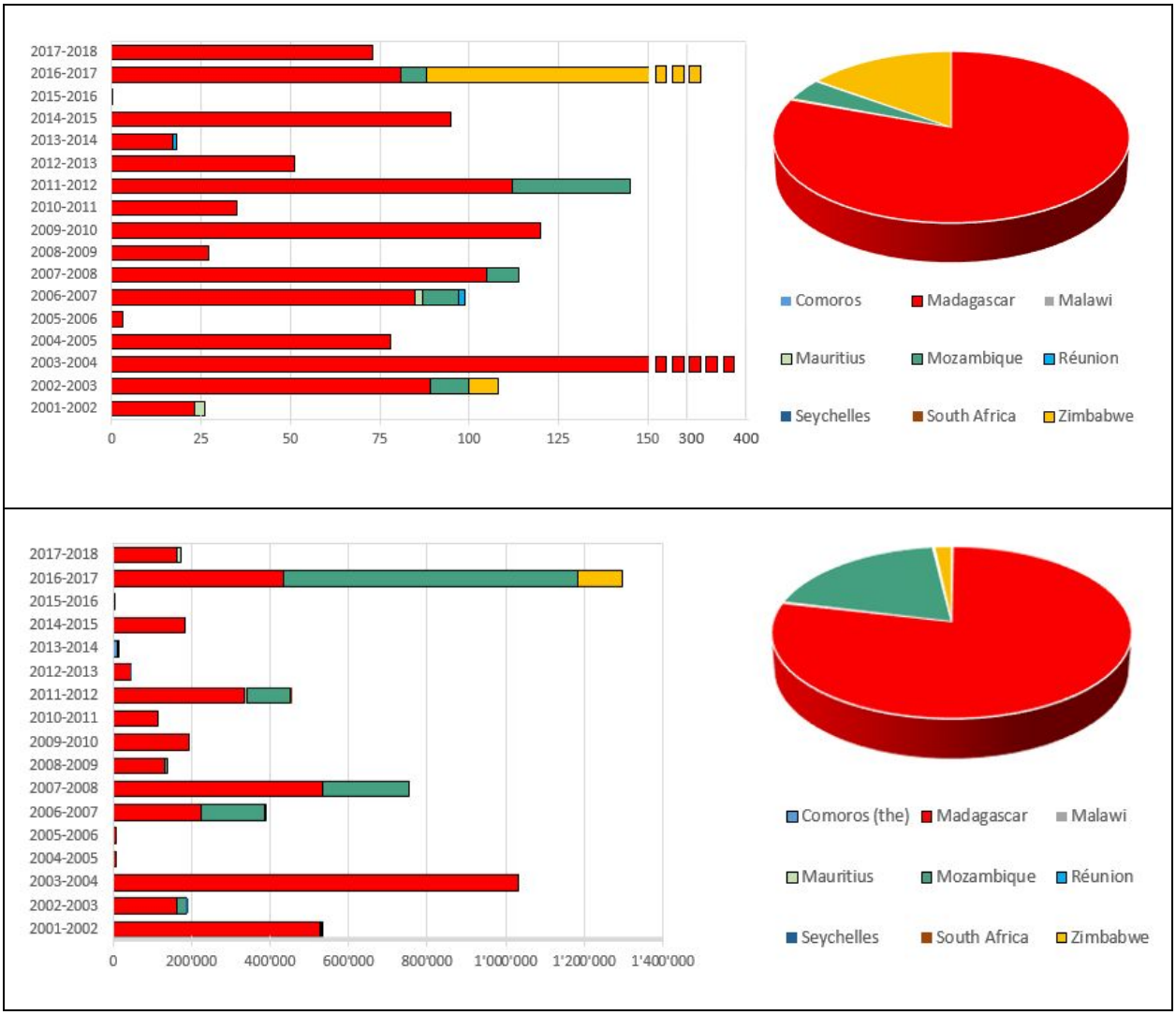
The equivalent Category based on the Saffir-Simpson Hurricane Wind Scale (SSHWS) is used in this report and in the previous JRC TCs seasonal reports, as well as it is the scale used in GDACS. The SSHWS is the official scale used by NOAA-NHC for the North Atlantic TC basin and is a scale from 1 to 5, based on the hurricane's 1-min sustained wind speed and it estimates the potential property damage (see Table A2.2).

Note: for the SW Indian Ocean basin, the RSMC La Reunion / Meteo France uses the following classes: Tropical Depression, Moderate Tropical Storm, Severe Tropical Storm, Tropical Cyclone, Intense Tropical Cyclone and Very Intense Tropical Cyclone based on 10-min average winds. The comparison between the scales could be found at: http://www.bom.gov.au/cyclone/about/intensity.shtml.

Saffir-Simpson Hurricane wind Scale (SSHWS), source NOAA-NHC		
Hurricane CATEGORY	**1-min sustained winds (km/h)**	**Types of Damage Due to Hurricane Winds**
Cat. 1	119 - 153	Well-constructed frame homes could have damage to roof, shingles, vinyl siding and gutters. Large branches of trees will snap and shallowly rooted trees may be toppled. Extensive damage to power lines and poles likely will result in power outages that could last a few to several days.
Cat. 2	154 - 177	Well-constructed frame homes could sustain major roof and siding damage. Many shallowly rooted trees will be snapped or uprooted and block numerous roads. Near-total power loss is expected with outages that could last from several days to weeks
Cat. 3 *Major Hurricane*	178 - 208	Well-built framed homes may incur major damage or removal of roof decking and gable ends. Many trees will be snapped or uprooted, blocking numerous roads. Electricity and water will be unavailable for several days to weeks after the storm passes
Cat. 4 *Major Hurricane*	209 - 251	Well-built framed homes can sustain severe damage with loss of most of the roof structure and/or some exterior walls. Most trees will be snapped or uprooted and power poles downed. Fallen trees and power poles will isolate residential areas. Power outages will last weeks to possibly months. Most of the area will be uninhabitable for weeks or months.
Cat. 5 *Major Hurricane*	≥ 252	A high percentage of framed homes will be destroyed, with total roof failure and wall collapse. Fallen trees and power poles will isolate residential areas. Power outages will last for weeks to possibly months. Most of the area will be uninhabitable for weeks or months

Table A2.2 -*TC Classification (Saffir-Simpson Hurricane Wind Scale), used in GDACS (see NOAA-NHC: http://www.nhc.noaa.gov/aboutsshws.php).*

Annex 3 - Fatalities and people affected by country



Figures A3.1 & A3.2: *TC Seasons from 2001/02 to 2017/18: Number of fatalities (top panel) / Number of people affected (lower panel), source: EM DAT-CRED.*

Annex 4 - TC Seasonal forecast details

According to the study of Jury, 1993[12], the tropical cyclonic activity decreases over the SW Indian Ocean during strong El Niño-Southern Oscillation (ENSO) events: only a few cases are observed during the January-March period. This pattern is attributed to changes in large-scale thermodynamic parameters.

Although El Niño is correlated with an increase in tropospheric moisture and sea-surface temperatures, it is also associated with an equatorward shift of the subtropical jet. **When El Niño is sufficiently strong,** the latter effect may dominate the former, **inhibiting tropical cyclone activity.**

Based on the latest ensemble of the available seasonal forecast platforms (8 Nov 2018) as compiled by the Climate Prediction Center (CPC) of NCEP/NWS (USA) and the International Research Institute (IRI) for Climate and Society[13] of the University of Columbia (USA), **El Nino is forecast forming and prevailing** during Northern Hemisphere winter 2018-19 (~80% chance) and into spring 2019 (55-60% chance) as captured in Fig. A4.2 & A4.3 pointing to **conditions inhibiting higher than normal TC activity.**

According to the latest ECMWF seasonal forecast, the **number of tropical storms or higher strength is forecast to be about 7 (very close to climate mean)** for Dec 2018 to May 2019 period (see Fig. A4.1).

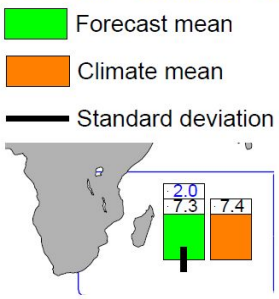
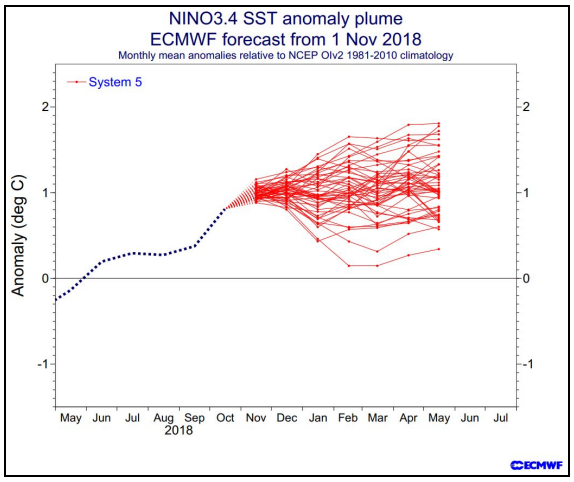


***Figure A4.1** - Latest ECMWF SEAS5 seasonal forecast of Tropical Storm Frequency from Dec 2018 to May 2019.*



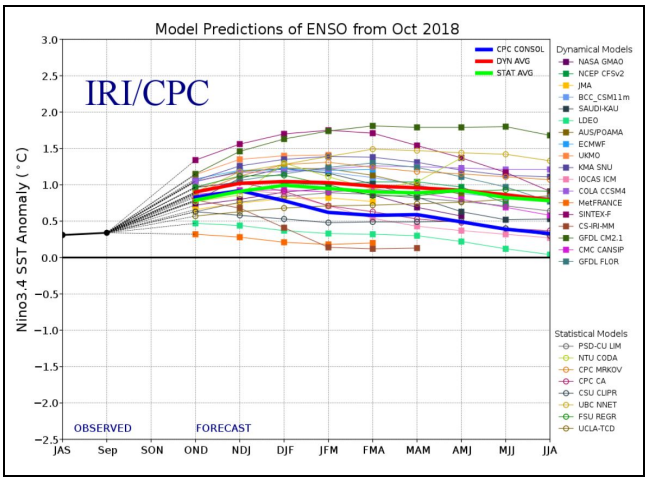


***Figure A4.2 & A4.3** - Latest SEAS5 SST anomaly plume (left panel) based on 1 November 2018 00 UTC (left panel). Latest seasonal predictions (issued on 8 November 2018) as compiled by CPC and IRI (right panel).*

Additional (background) information on the association between ENSO and cyclone activity over the SW Indian Ocean (besides Jury, 1993) can be found in the joint latest report of the Climate Prediction Center (NCEP/NWS of USA) and International Research Institute for Climate and Society of University of Columbia (see footnotes).

[12] Jury M.R., 1993. A preliminary study of climatological associations and characteristics of tropical cyclones in the SW Indian Ocean Meteorol. Atmos. Phys. 51 101–15.
[13] http://www.cpc.ncep.noaa.gov/products/analysis_monitoring/enso_advisory/ensodisc.pdf

Annex 5 - TC basins and monitoring systems

The Tropical Cyclones (TCs) formed in particular areas of the globe, named TC "basins" (see Fig. A5.1 below) and in particular seasons. These area are monitored as a result of an international cooperation, coordinated (global/regional levels) by the World Meteorological Organization (WMO). The TC Regional Specialized Meteorological Centres (**RSMCs**) and the Tropical Cyclone Warning Centres (**TCWCs**) have the regional responsibility to provide advisories and bulletins, including meteorological information on all TCs in the world

The active TCs can be found on the WMO Severe Weather Information Centre website:
http://severe.worldweather.wmo.int/

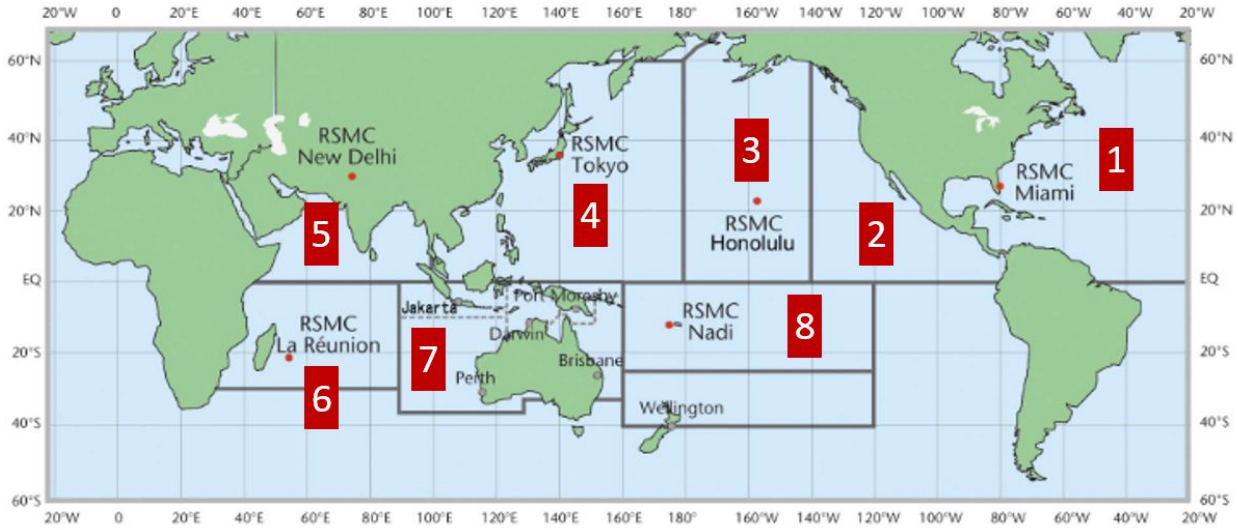


Figure A5.1 *- TC "basins" and Warning Centres responsible for monitoring / forecasting*
Numbers in red squares are explained in Table (see next page)
(Background source: WMO http://www.wmo.int/pages/prog/www/tcp/Advisories-RSMCs.html)

Besides RSMCs and TCWCs, other global weather centres, university institutions and agencies are providing short to medium range forecasting while some of them have also the ability to perform long-range integrations needed for compiling monthly and even seasonal forecasts.

TC bulletins from different sources have not the same format and information (e.g. different wind averaging period[14] and classification), therefore the JRC set up an automatic routine for GDACS that includes the TC bulletins produced by the National Oceanic and Atmospheric Administration (NOAA) and the Joint Typhoon Warning Center (JTWC) into a single database, covering all TC basins, and recently, also the medium weather forecast information coming from NOAA (HWRF, GFS) and ECMWF (see Annex 2).

[14] GUIDELINES FOR CONVERTING BETWEEN VARIOUS WIND AVERAGING PERIODS IN TROPICAL CYCLONE CONDITIONS: https://www.wmo.int/pages/prog/www/tcp/documents/WMO_TD_1555_en.pdf

TROPICAL CYCLONE BASINS AND WARNING CENTERS (RSMCs, TCWCs)				
		Basin	**Area**	**Warning Center**
NH	**1**	North Atlantic	North Atlantic Ocean, Gulf of Mexico, Caribbean Sea	RSMC Miami-Hurricane Center/NOAA/NWS National Hurricane Center, USA http://www.nhc.noaa.gov/index.shtml
	2	Northeast Pacific	North-east Pacific Ocean (from Mexico to 140°W)	RSMC Miami-Hurricane Center/NOAA/NWS National Hurricane Center, USA http://www.nhc.noaa.gov/index.shtml
	3	Central Pacific	Central North Pacific Ocean, (from 140°W to 180°W)	RSMC Honolulu-Hurricane Center/NOAA/NWS, USA http://www.prh.noaa.gov/hnl/cphc/
	4	Northwest Pacific	Northwest Pacific Ocean (from 100°E to 180°E)	RSMC Tokyo-Typhoon Center/Japan Meteorological Agency http://www.jma.go.jp/en/typh/
	5	North Indian	North Indian Ocean (from 100°E to 45°E), including Bay of Bengal and Arabian Sea	RSMC-tropical cyclones New Delhi/India Meteorological Department http://www.imd.gov.in
SH	**6**	South-West Indian	South-West Indian Ocean (from African coast to 90°E)	RSMC La Réunion-Tropical Cyclone Centre/Météo-France http://www.meteofrance.re/cyclone/activite-cyclonique-en-cours
	7	Australian region	South-East Indian Ocean, Arafura Sea, Gulf of Carpentaria, Coral Sea Solomon Sea and Gulf of Papua	Bureau of Meteorology, Australia (TCWCs:Perth, Darwin, Brisbane) http://www.bom.gov.au/cyclone/index.shtml TCWC-Port Moresby/National Weather Service, Papua New Guinea http://www.pngmet.gov.pg/ TCWC-Jakarta/ Meteorological and Geophysical Agency, Indonesia http://www.bmkg.go.id
	8	Southern Pacific	South-West Pacific Ocean Tasman Sea	RSMC Nadi-Tropical Cyclone Centre/Fiji Meteorological Service http://www.met.gov.fj/current_warnings_b.php TCWC-Wellington/Meteorological Service of New Zealand http://www.metservice.com/warnings/tropical-cyclone-activity

Table A5.1 - *TC "basins" and Warning Centres responsible for monitoring / forecasting. (NH=Northern Hemisphere, SH=Southern Hemisphere).*