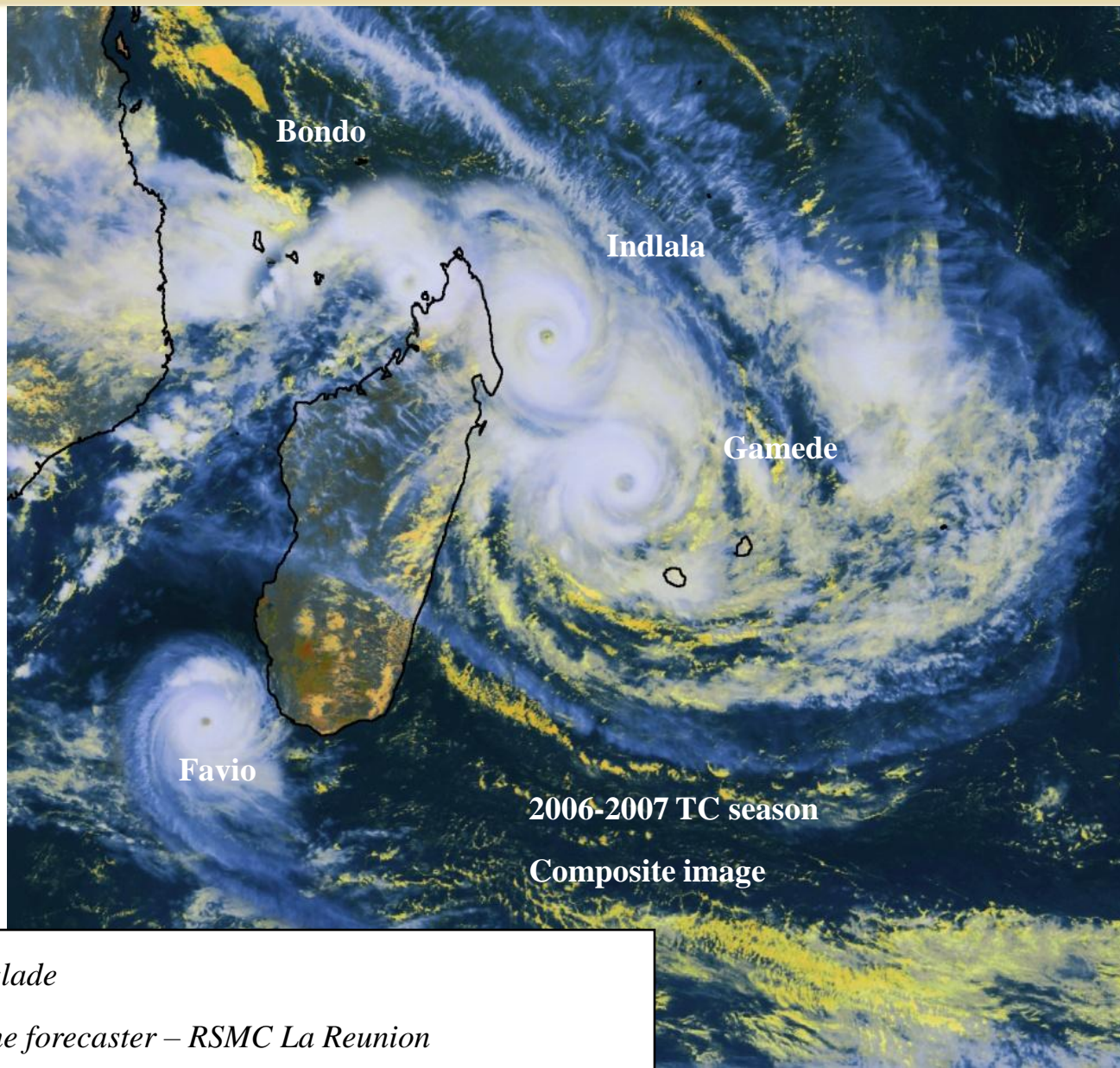


The South West Indian Ocean cyclone basin



**METEO
FRANCE**

Sébastien Langlade

Tropical cyclone forecaster – RSMC La Reunion

OUTLINE

1. Introduction- Global cyclonic activity
2. Southwestern Indian Ocean (SWIO) TC activity
 - Practices in use
 - Mean synoptic pattern over SWIO
 - Monthly and space distribution
 - Interannual evolution
 - Typical tracks



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Basic definitions

DEFINITIONS:

A tropical cyclone is the generic term for a non-frontal synoptic scale low-pressure system over tropical or sub-tropical waters with organized convection (i.e. thunderstorm activity) and definite cyclonic surface wind circulation (Holland 1993)

Max wind < 34 kt → Tropical depression

33 kt < max wind < 64 kt → Tropical storm

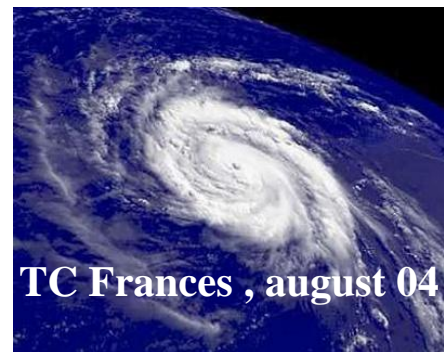
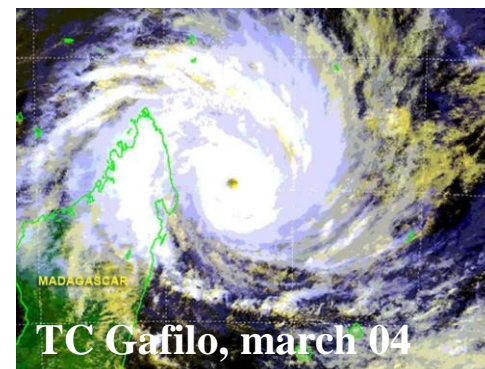
Max wind > 63 kt → « **hurricane** » (north ATL, NEPAC)

« **typhoon** » (the NWPAC west of the dateline)

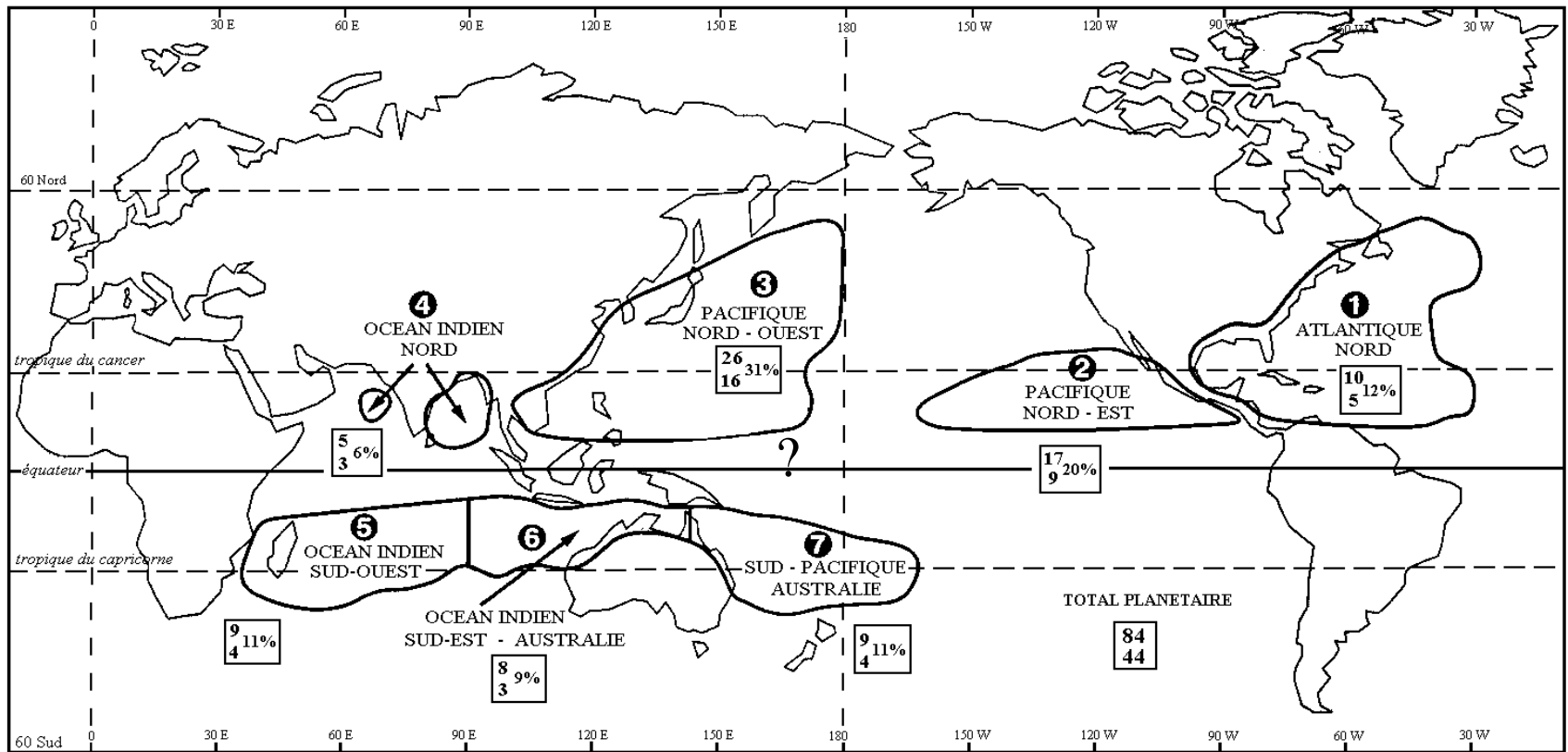
« **severe tropical cyclone** » (the SWPAC and SEI east of 90E)

« **very severe cyclonic storm** » (the North IND)

« **tropical cyclone** » (the SWIO)



Cyclone basins



Statistiques sur la période 1968-1990

A
B
C%

A : Nombre annuel moyen de tempêtes et cyclones tropicaux

B : Nombre annuel moyen de cyclones tropicaux

C : Pourcentage de la population mondiale (tempêtes et cyclones)

D'après Charles J. Neumann, in *Global Guide of Tropical Cyclone Forecasting*, WMO/TD N°560, 1993.



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Tropical cyclone: a major threat



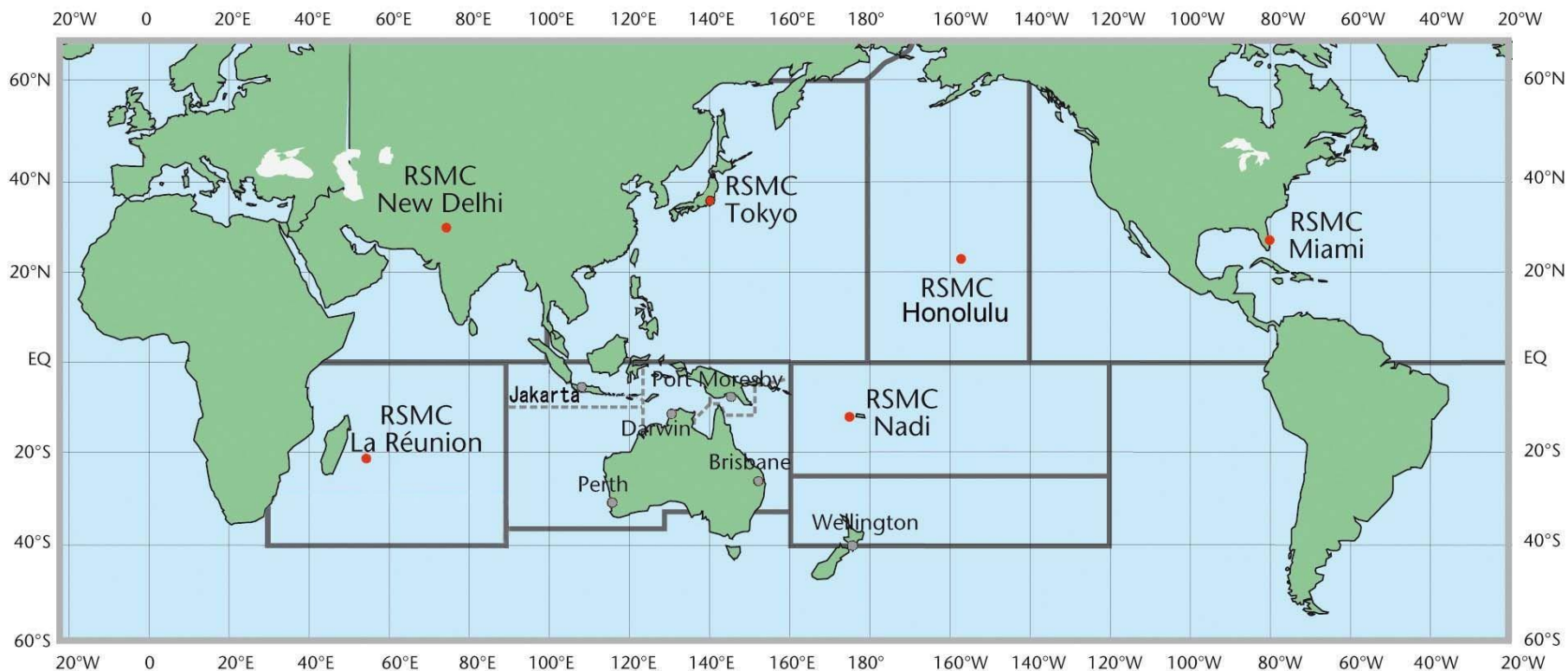
Wind and storm surge damage during super typhoon Haiyan, november 2013, Philippines.



**METEO
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World cyclone watch

TCP, tropical cyclones programme, programme of the World Weather Watch created in 1972 by WMO



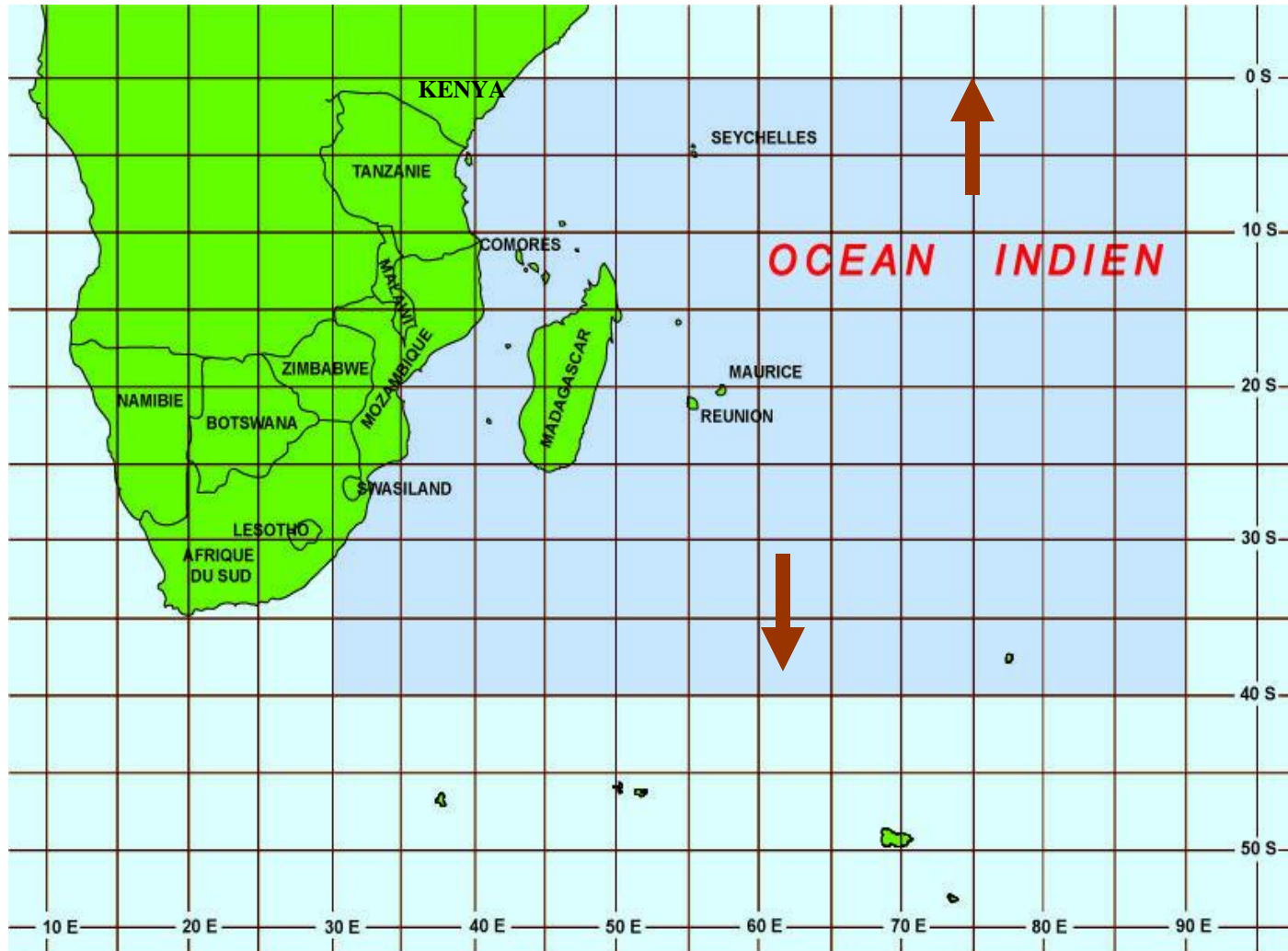
A specific organisation leaded by WMO : 6 RSMCs (Regional Specialized Meteorological Centres) and 6 TCWCs (Tropical Cyclone Warning Centres)

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The South West Indian Ocean cyclone basin



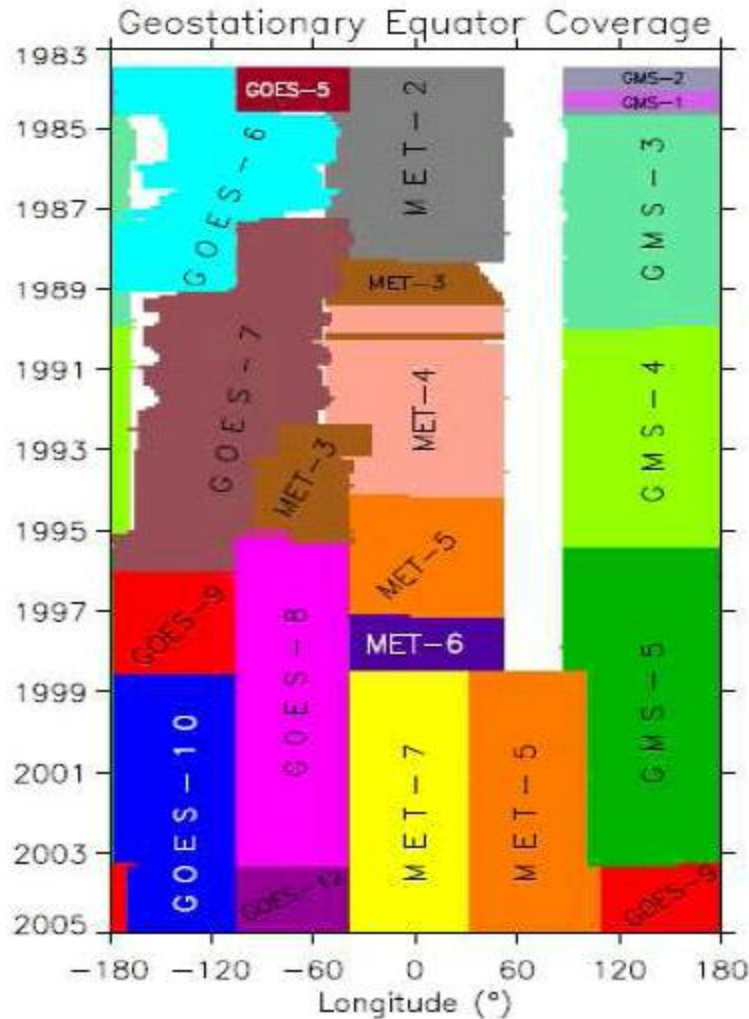
Sept 1985:
Eastern border
shift:
80E → 90E

Area of Responsibility extended southwards (30S → 40S) and northwards (05S → 0) since september 2003.



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The South West Indian Ocean cyclone basin



- Partial geostationary coverage until may 1998 !
 - TC tracking and analysis mainly based on polar satellite data before.
 - Satellite imagery reception issues and lack of digital Imagery until november 1990
- **Heterogeneous quality of the TC data base**



Dvorak scale used in the South West Indian Ocean

Practices in the SWIO :

- Dvorak scale used since 1982
- Wind-Pressure relationship: newly used of Courtney&Knaff (2009) – Atkinson & Holliday (1977) used before
- Criteria: average wind (10mn)

Modifications in September 1999 :

- Conversion factor between 1 min and 10 min winds changes from 0,80 to **0,88**
- Gust factor changes from 1,5 to **1,41**.

Recommandations from Harper et.al (2010):

Conversion factor from 1min to 10 min is **0.93** (open sea)

Gust factor for a 3 sec gust associated with a 10 min average wind is **1.23** (open sea)



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Classification of tropical disturbances in the South West Indian Ocean basin

WIND FORCE

No clear circulation center

< 28 kt (< 51 km/h)

28-33 kt (51-63 km/h)

34-47kt (**63-88** km/h) ← **NAMING**

48-63 kt (89-117 km/h)

64-89 kt (**118-165** km/h)

90-115kt (166-212 km/h)

> 115 kt (> 212 km/h)

STAGE

Disturbance area

Tropical disturbance

Tropical depression

→ *Moderate tropical storm*

Severe tropical storm

Tropical cyclone

Intense tropical cyclone

Very intense tropical cyclone

The wind force is averaged over 10 mn.



**METEO
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Naming in the South West Indian Ocean

TC names 2017/2018

NAMES	Provided by
Ava	Madagascar
Berguita	Seychelles
Cebile	Zimbabwe
Dumazile	Swaziland
Eliakim	Kenya
Fakir	Comoros
Guambe	Mozambique
Habana	Botswana
Iman	Mauritius
Jobo	Lesotho
Kanga	South africa
Ludzi	Malawi
Melina	Tanzania
Nathan	France
Onias	Zimbabwe
Pelagie	Madagascar
Quamar	Comoros
Rita	Seychelles
Solani	Swaziland
Tarik	Mauritius
Urilia	South africa
Vuyane	Lesotho
Wagner	Kenya
Xusa	Malawi
Yarona	Botswana
Zacarias	Mozambique

List changing on 1st july

List of names defined during the Tropical Cyclone Comitee (TCC, every 2 years), among the propositions of the 15 members

Naming criteria –Op plan:

- Gale force winds (observed or estimated) present near the low pressure center in a significant portion of the cyclonic circulation.***
- Both tropical and subtropical disturbances can be named***

Naming :

- Mauritius east of 55E***
- Madagascar west of 55E***



**METEO
FRANCE**

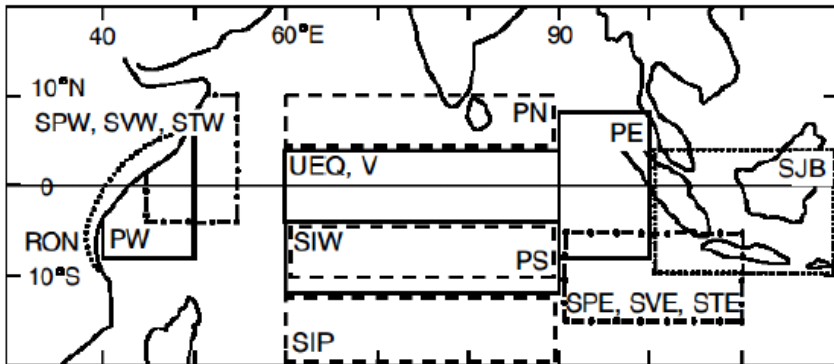
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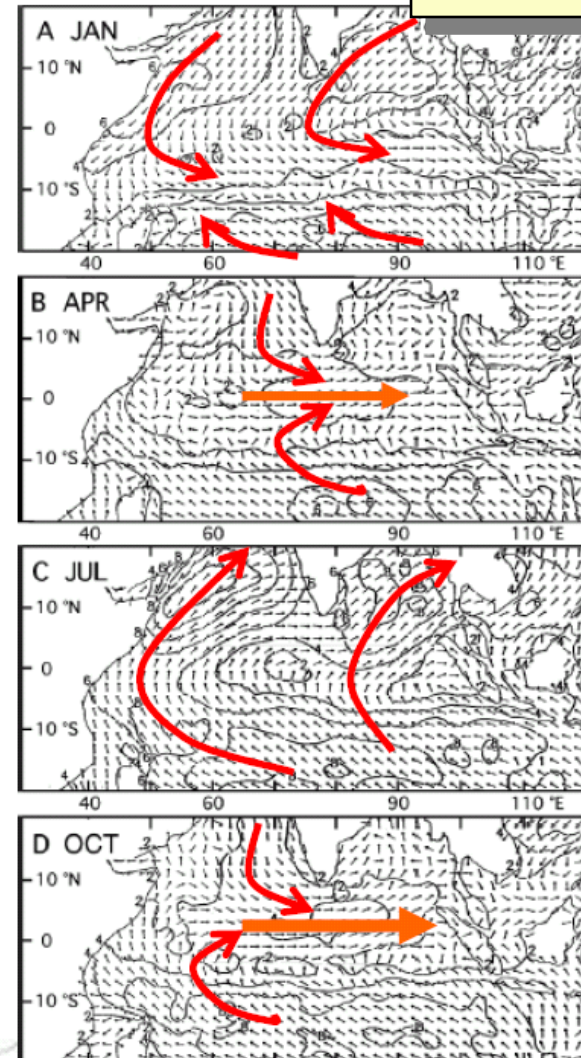
Equatorial wind patterns

Hastenrath et al., 2004



- Annual cycle dominated by the shift between the southern and northern summer monsoon : seasonal shift of the inter-hemispheric pressure gradient .

- Equatorial westerlies: enhanced with strong east-west gradient pressure with weak near equatorial southern trade winds



METEO
FRANCE

Austral summer (January to March)

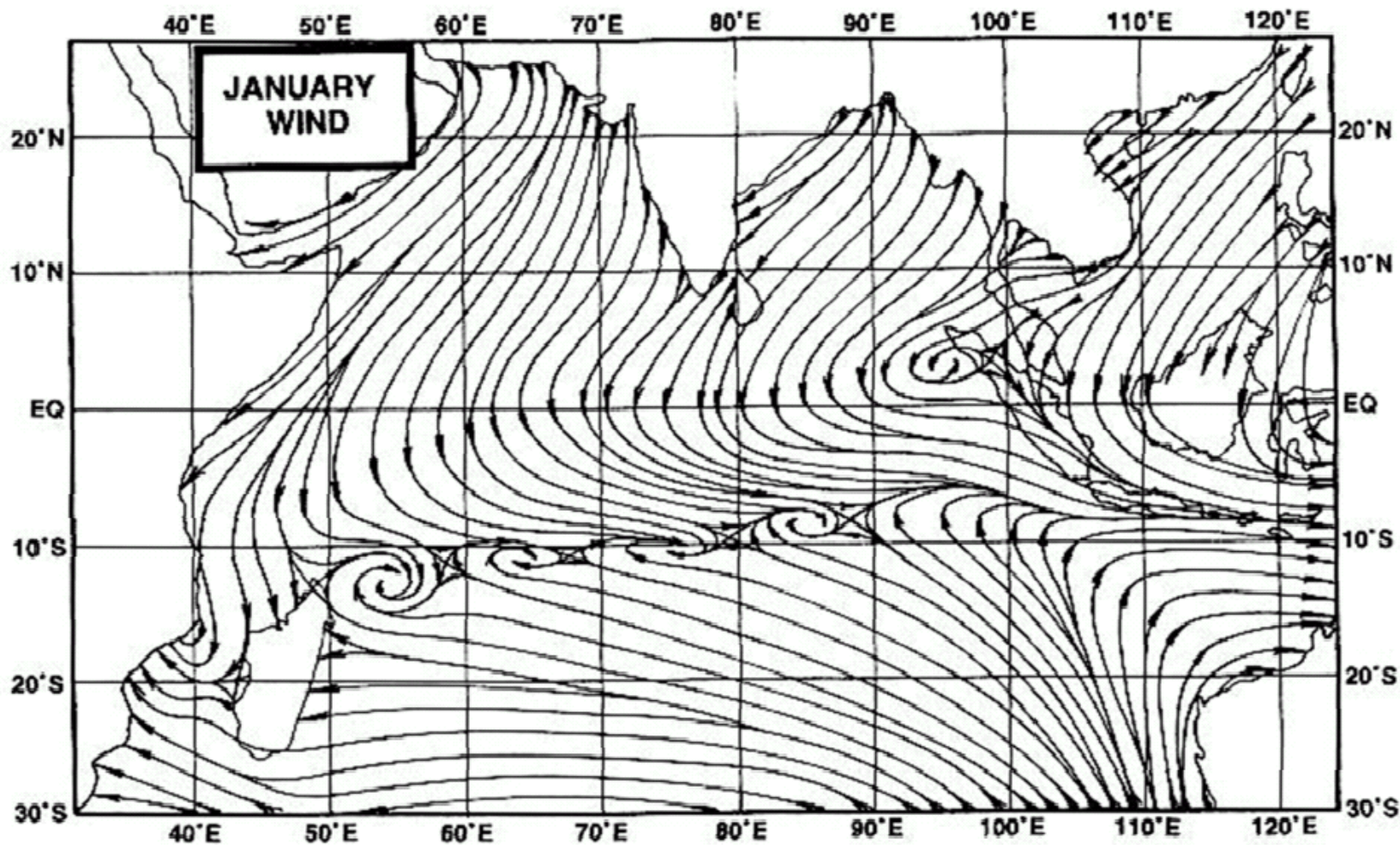


Figure 2.6. Mean surface level streamline analyses over the Indian Ocean for January (Sadler, 1975).



**METEO
FRANCE**

Austral summer (January to March)

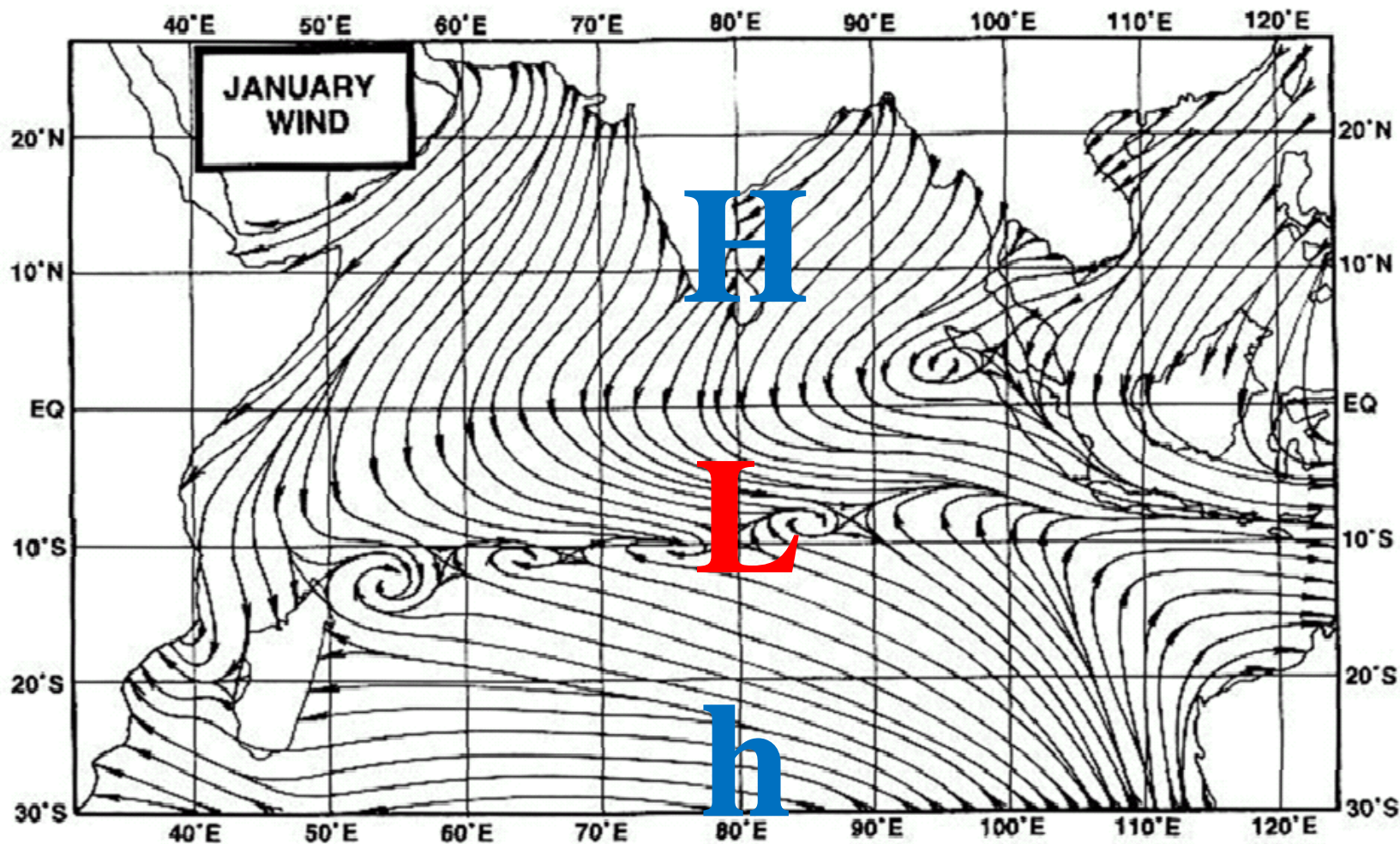


Figure 2.6. Mean surface level streamline analyses over the Indian Ocean for January (Sadler, 1975).



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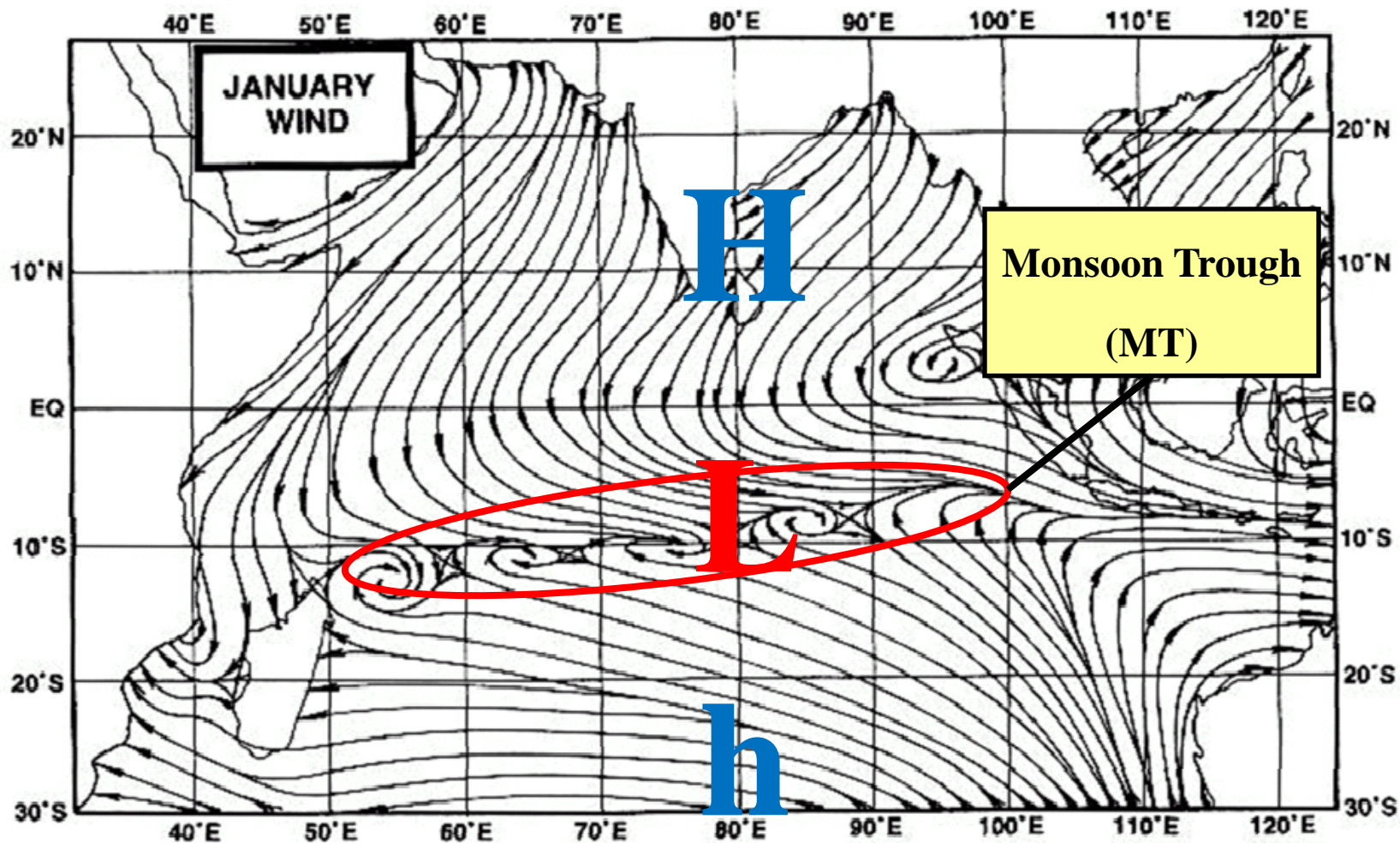
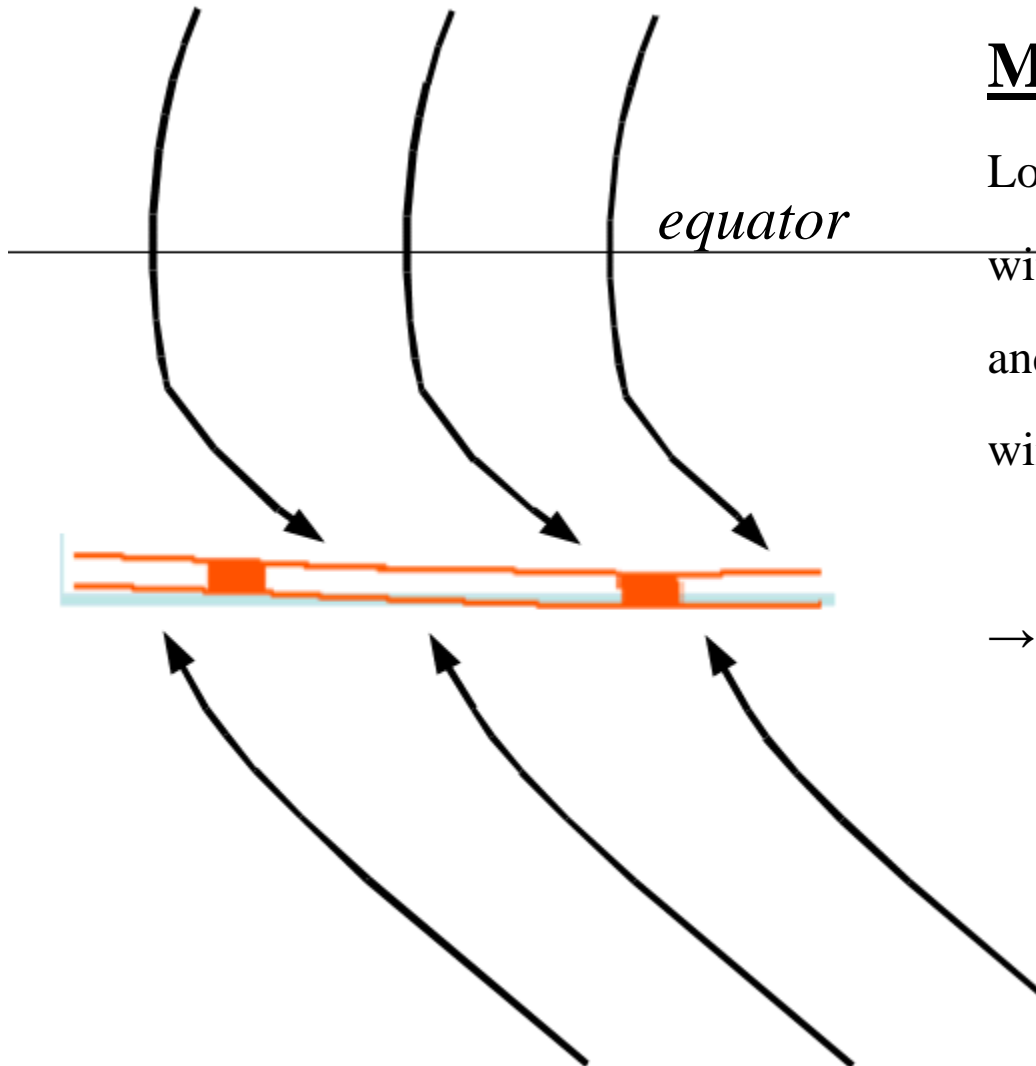


Figure 2.6. Mean surface level streamline analyses over the Indian Ocean for January (Sadler, 1975).



**METEO
FRANCE**

Austral summer (January to March)



Monsoon Trough définition:

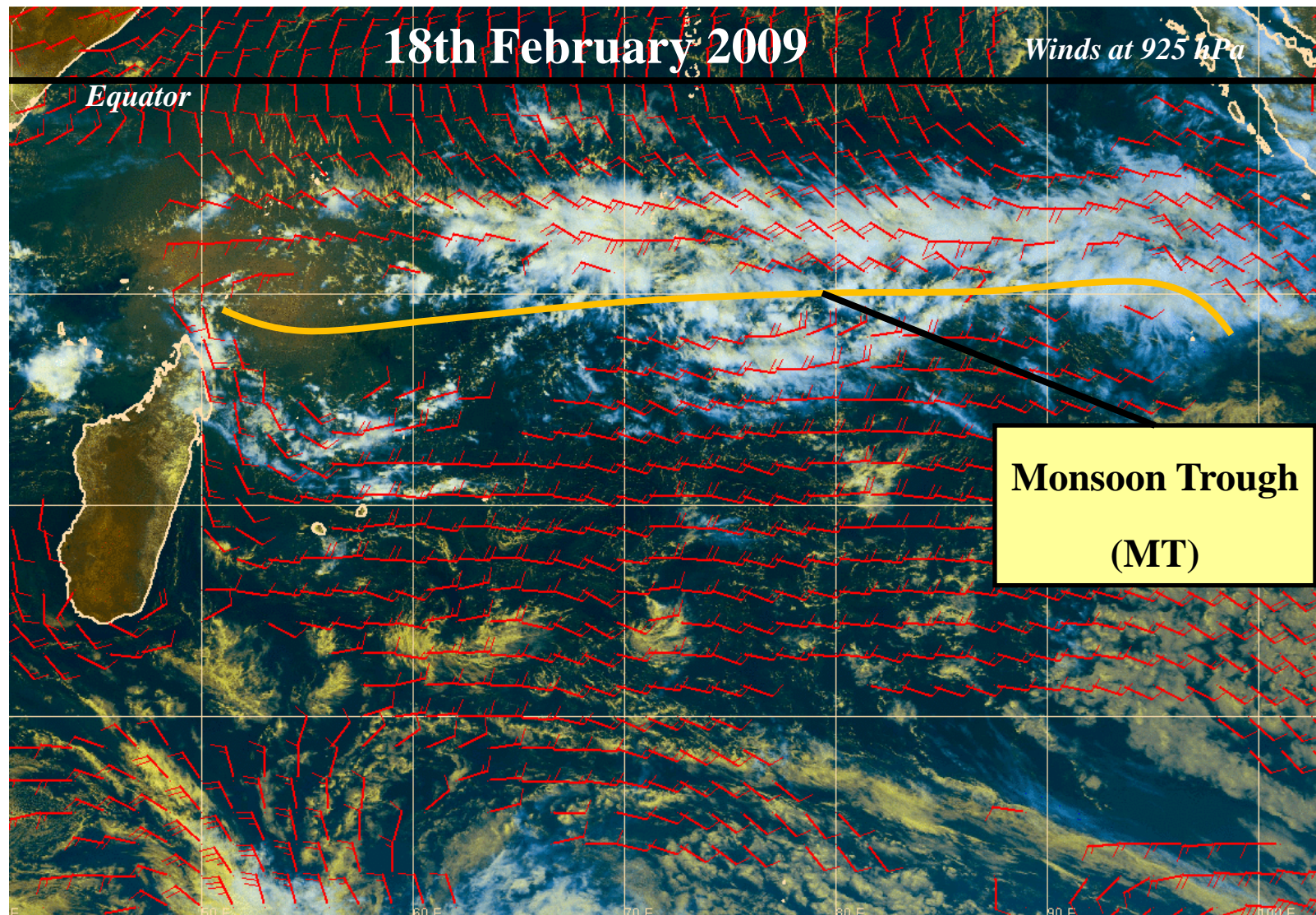
Low level trough (surface to 850 hPa) located within the mixing area between the monsoon and tradewinds flow. Associated equatorial winds have a strong meridional component.

→ **Low level large scale vorticity associated.**



**METEO
FRANCE**

Austral summer (January to March)



Austral winter (June to August)

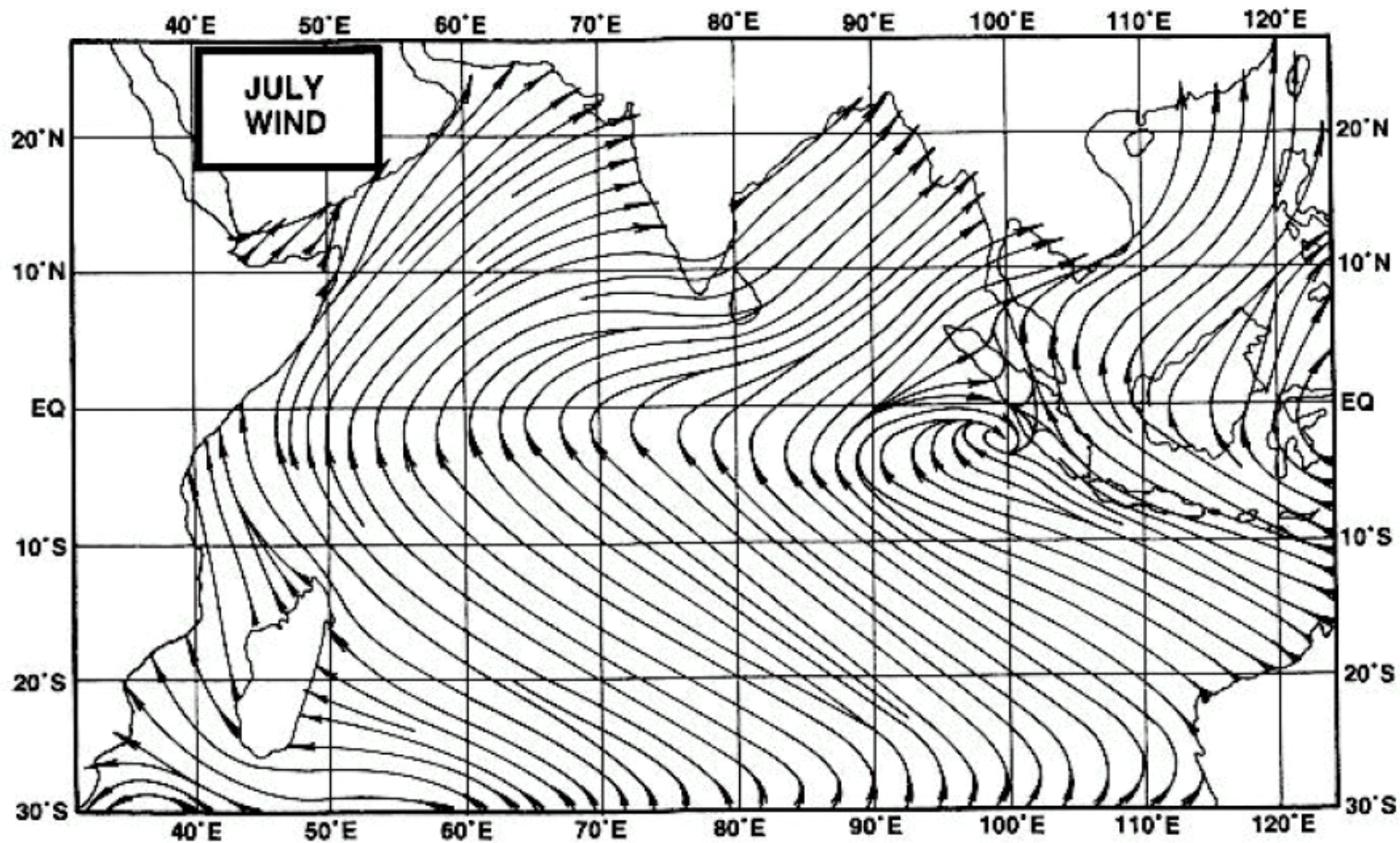


Figure 2.8. Mean surface level streamline analyses over the Indian Ocean for July (Sadler, 1975).



**METEO
FRANCE**

Austral winter (June to August)

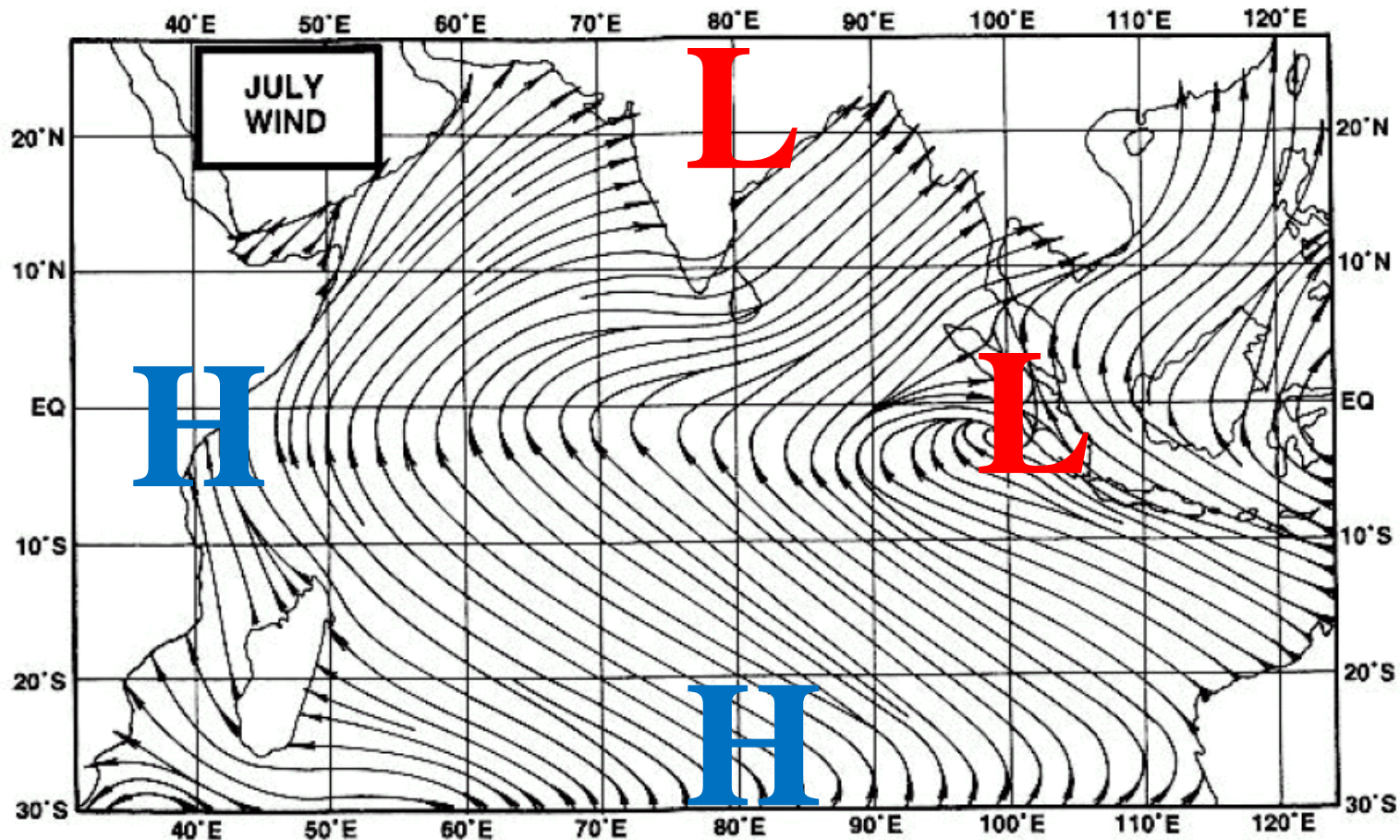


Figure 2.8. Mean surface level streamline analyses over the Indian Ocean for July (Sadler, 1975).



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Austral winter (June to August)

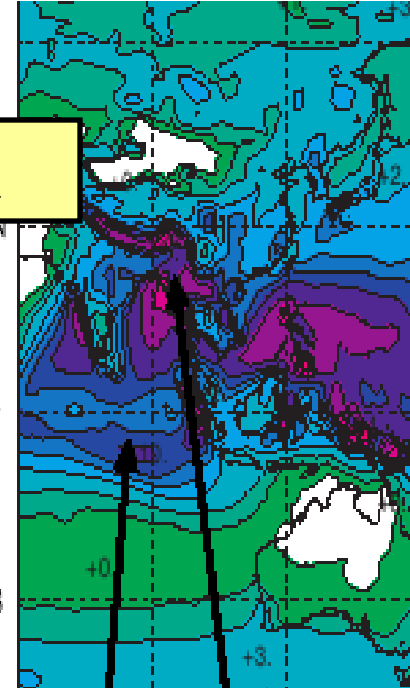
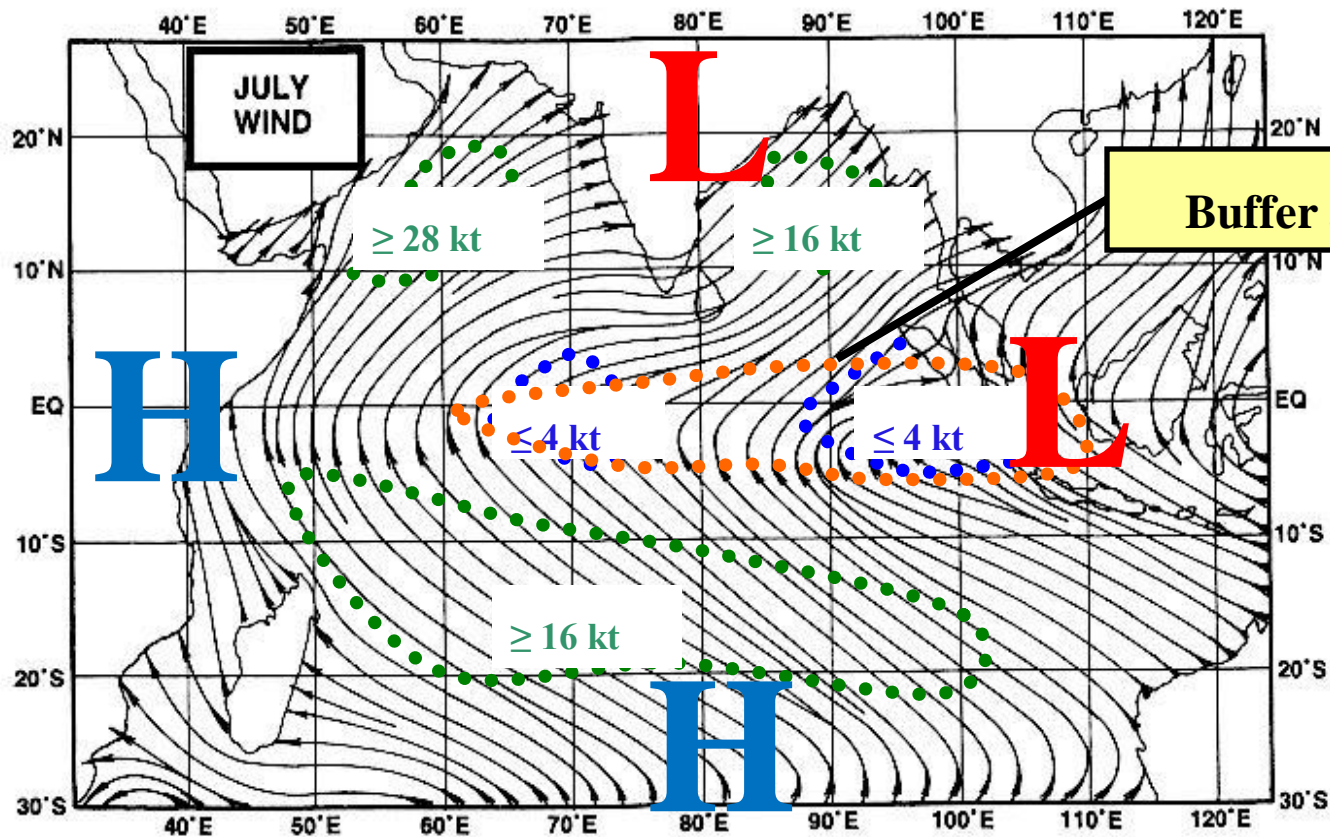
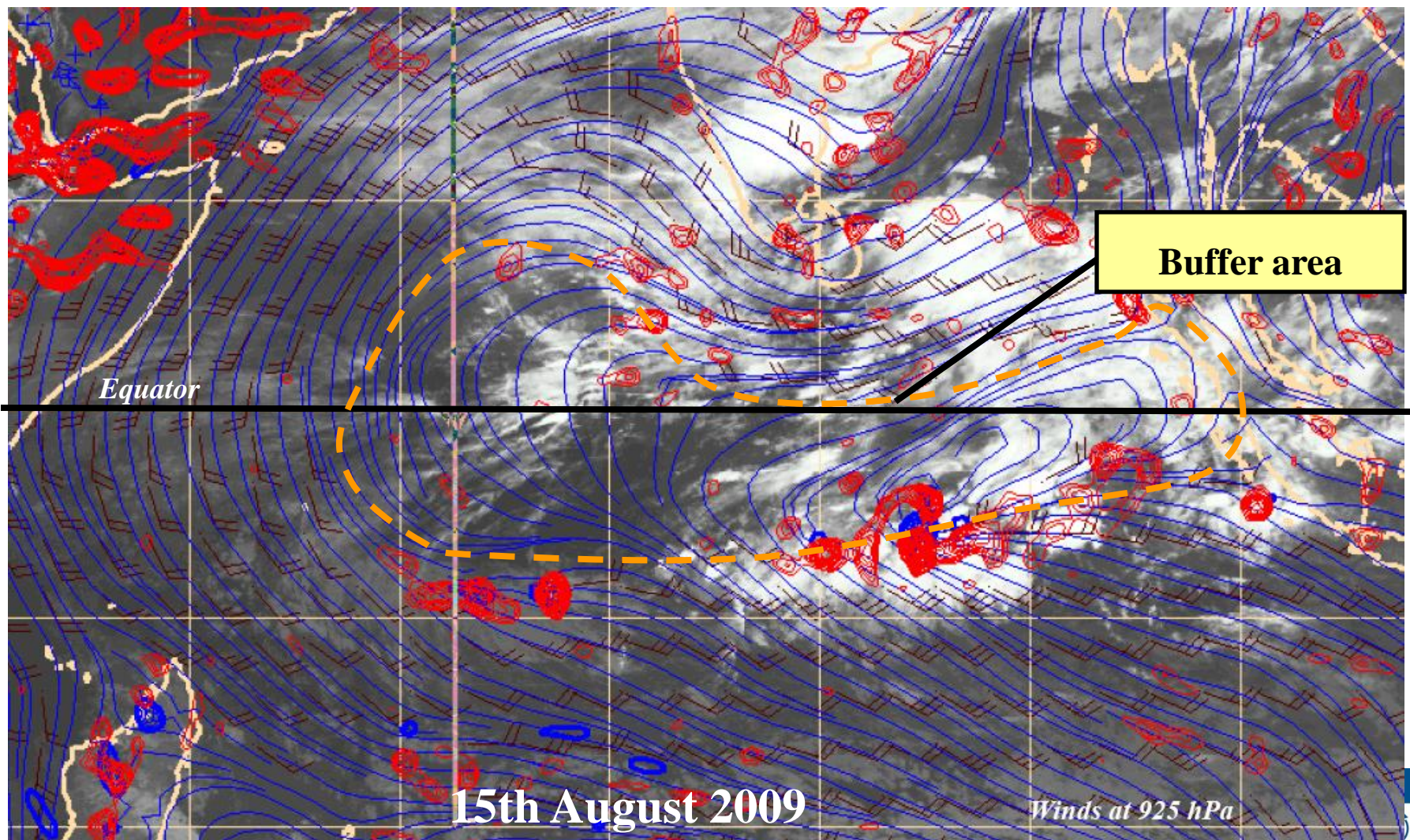


Figure 2.8. Mean surface level streamline analyses over the Indian Ocean for July (Sadler, 1975).



METEO
FRANCE

Austral winter (June to August)



Austral spring / autumn

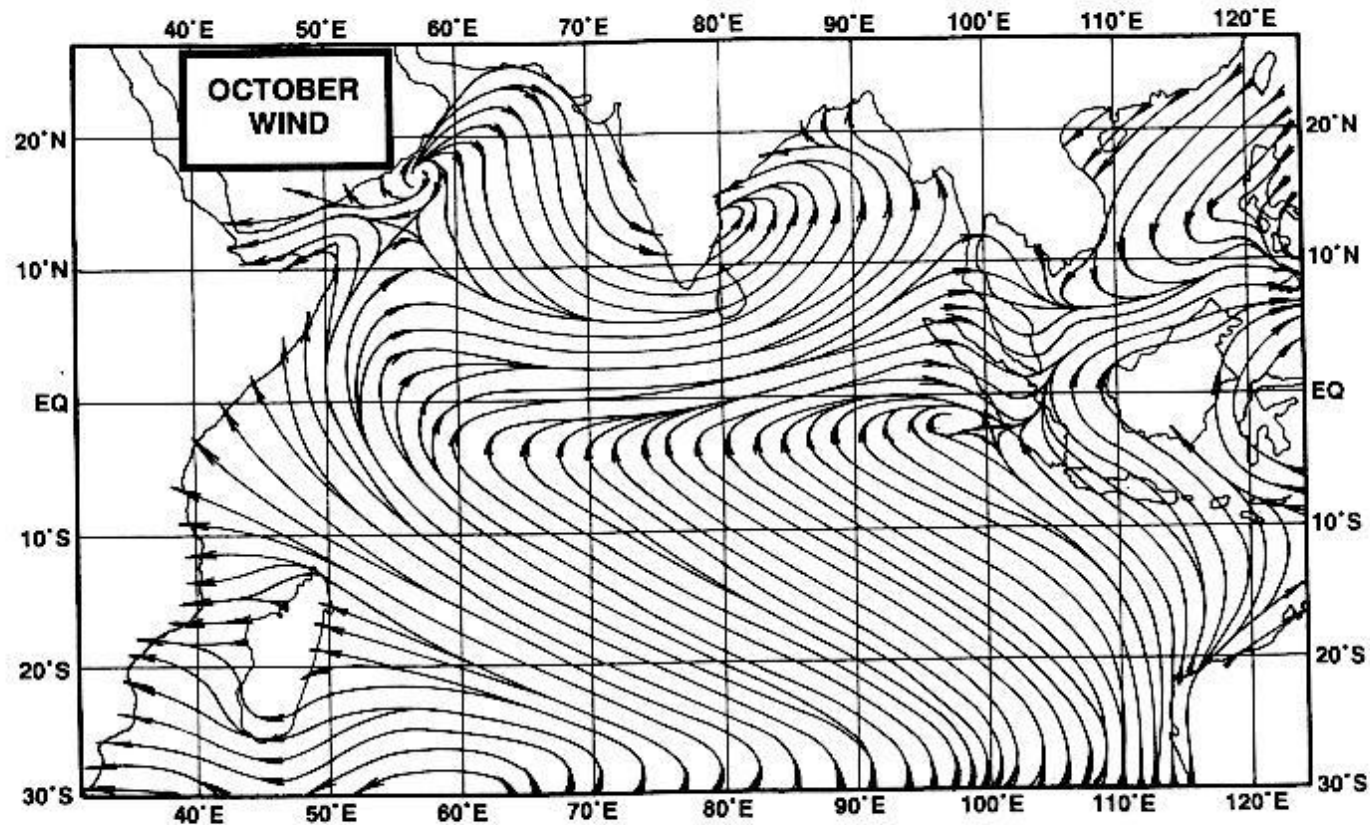


Figure 2.9. Mean surface level streamline analyses over the Indian Ocean for October (Sadler, 1975).



**METEO
FRANCE**

Austral spring / autumn

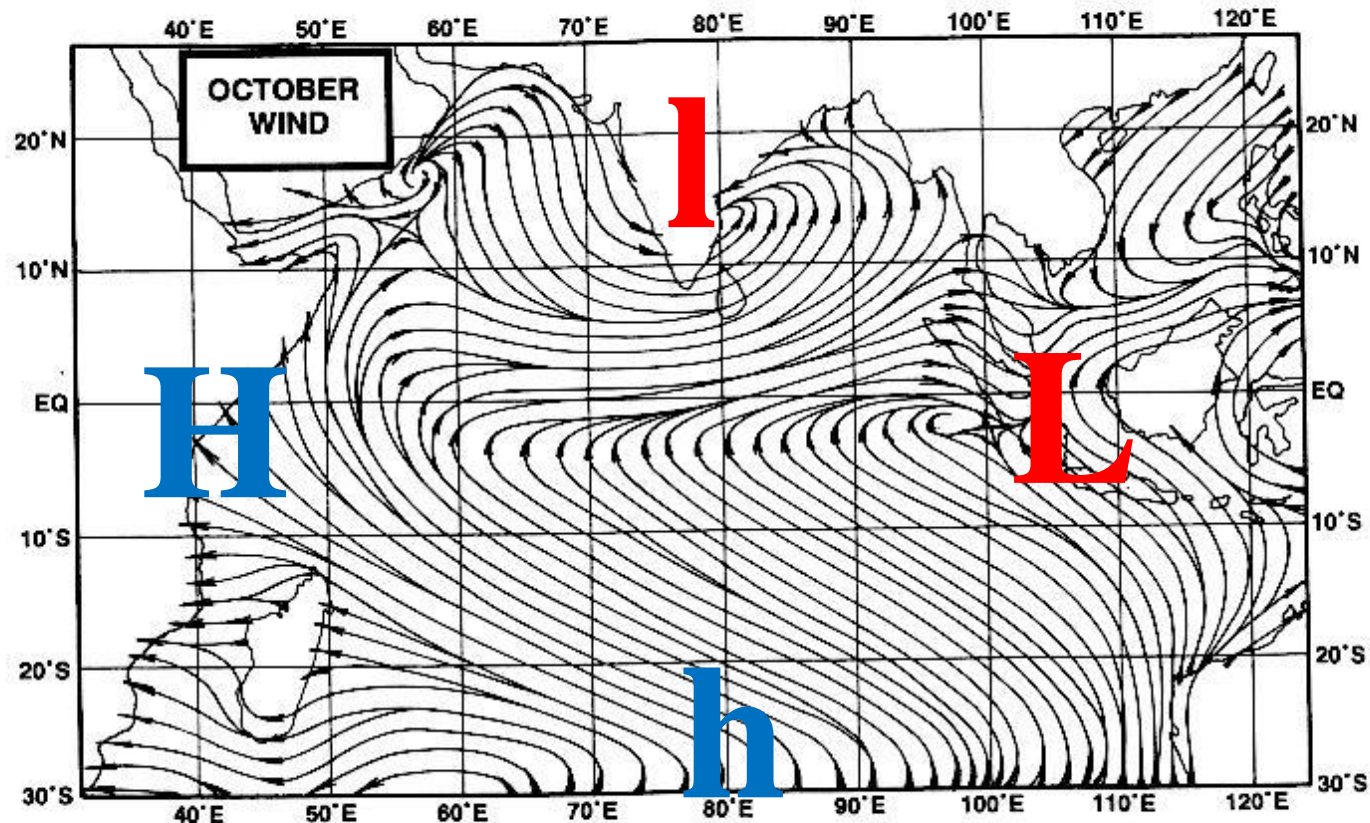


Figure 2.9. Mean surface level streamline analyses over the Indian Ocean for October (Sadler, 1975).



METEO
FRANCE

Austral spring / autumn

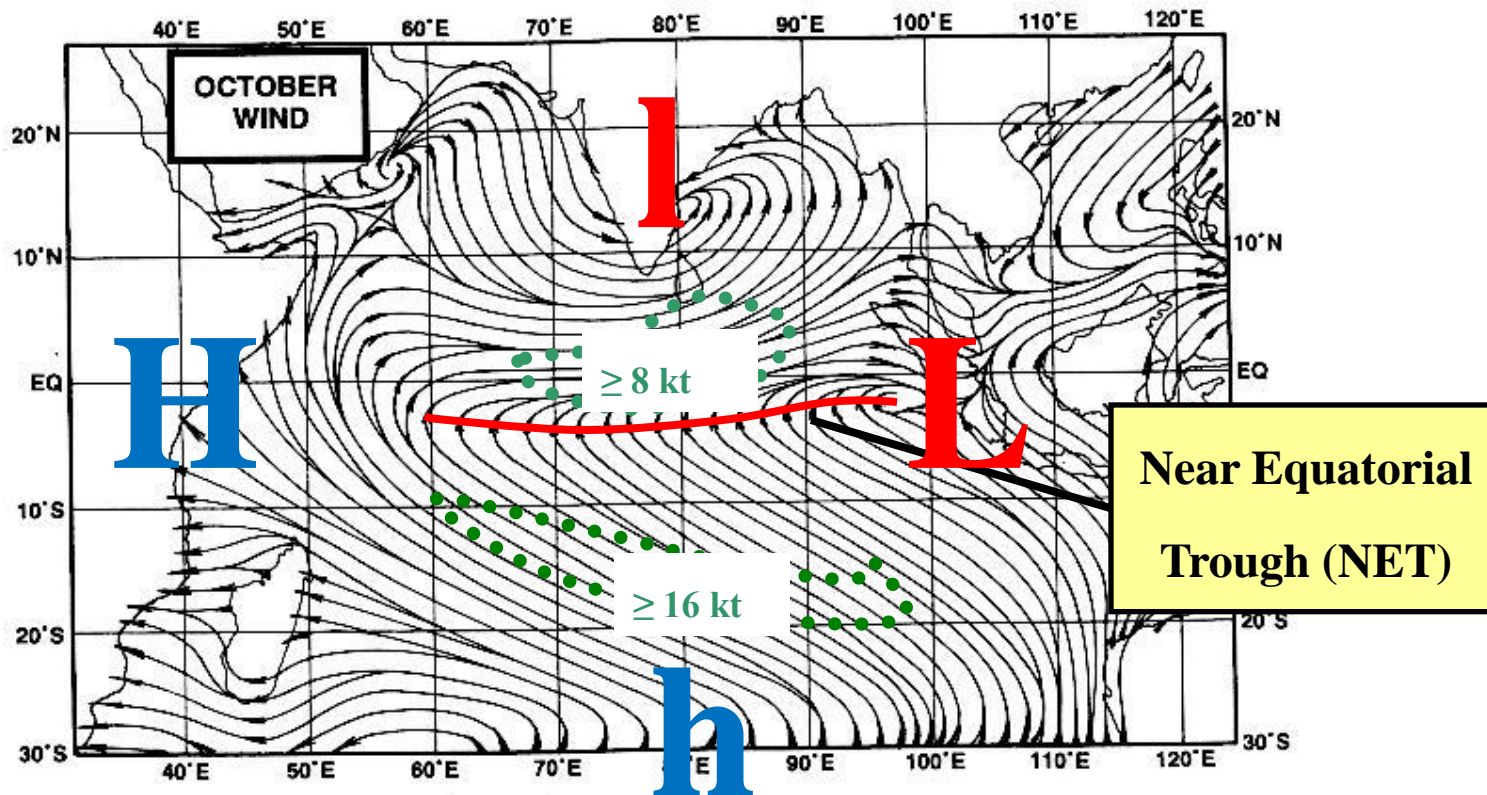
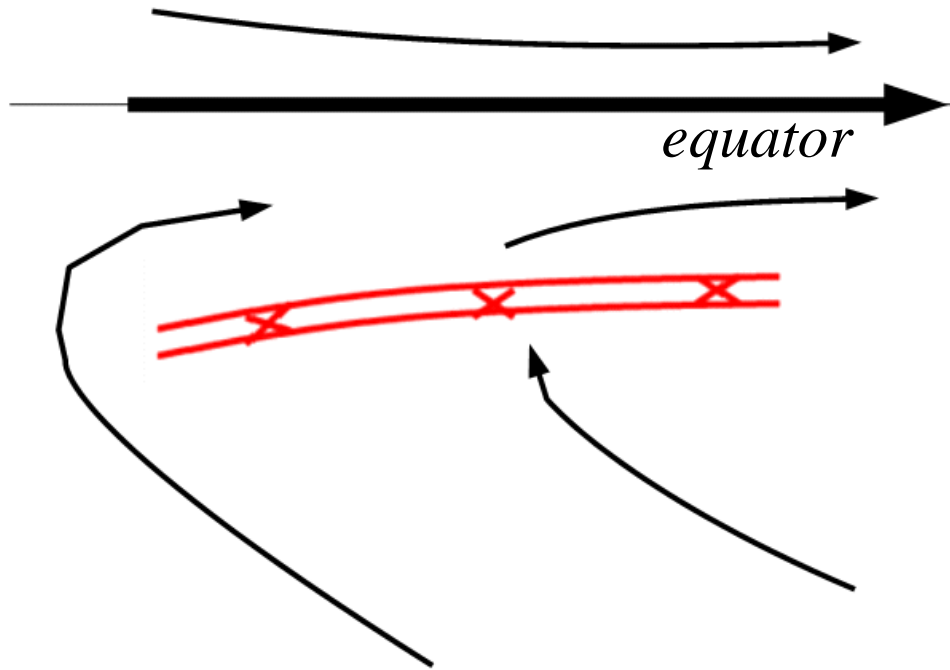


Figure 2.9. Mean surface level streamline analyses over the Indian Ocean for October (Sadler, 1975).



**METEO
FRANCE**

Austral spring / autumn



Near Equatorial Trough

définition:

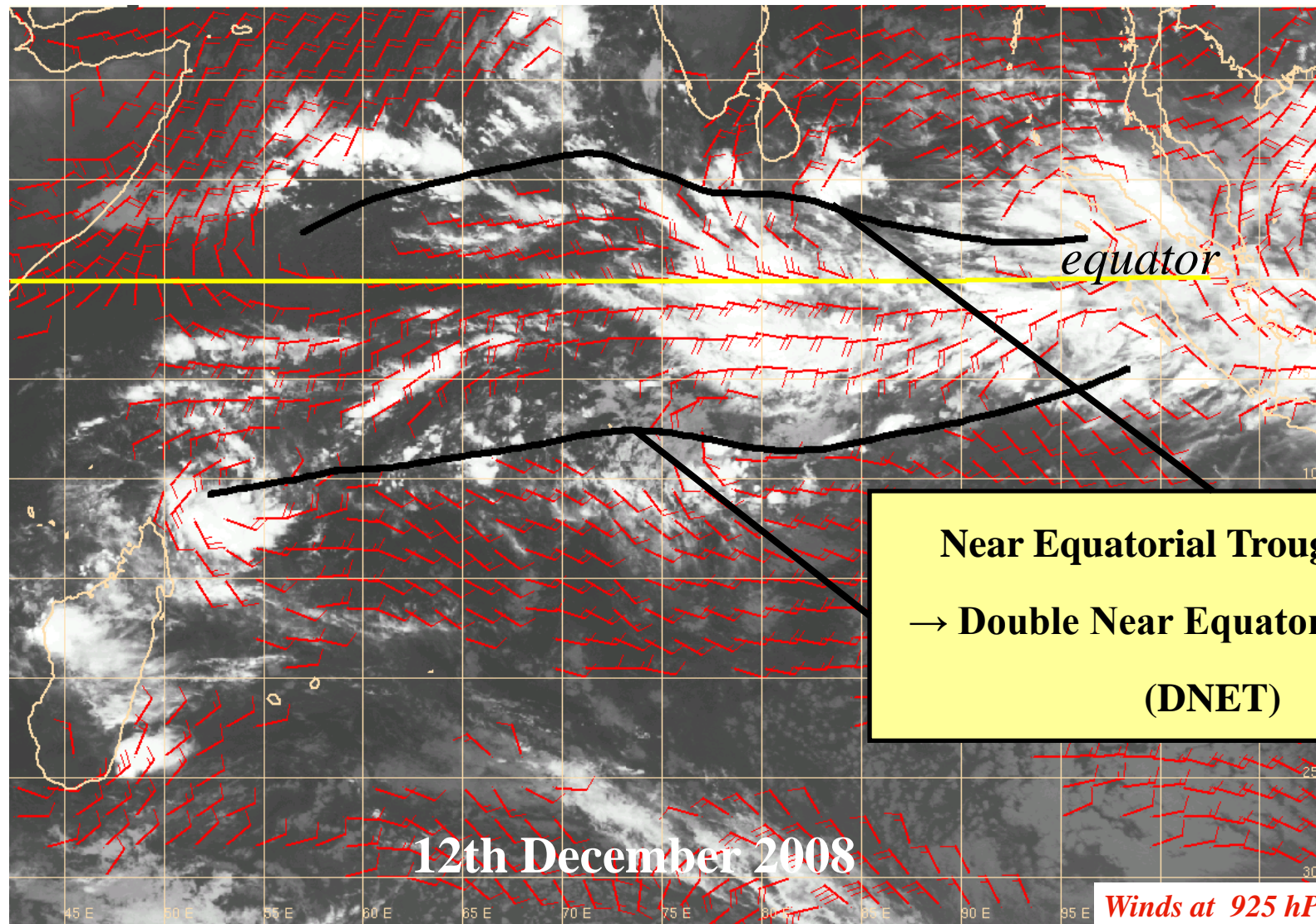
Low level trough (surface to 850 hPa)
associated with equatorial winds with a strong
zonal (westerly) component.

→ **Low level large scale vorticity associated.**



**METEO
FRANCE**

Austral spring / autumn



Near Equatorial Troughs (NET)
→ **Double Near Equatorial Troughs (DNET)**

OUTLINE

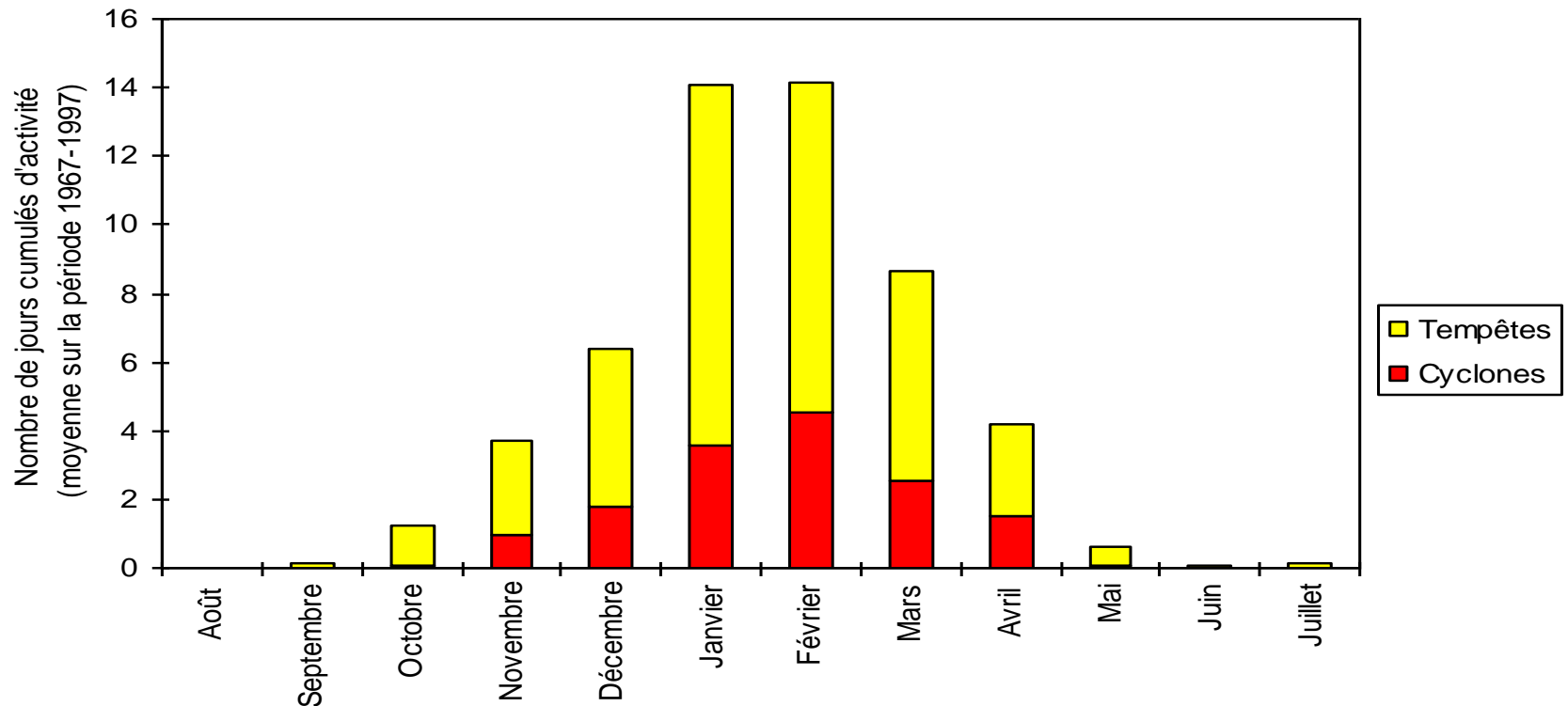
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Monthly variation in cyclone activity

(cumulated days)

Monthly variation of cyclone activity in the South-West Indian Ocean

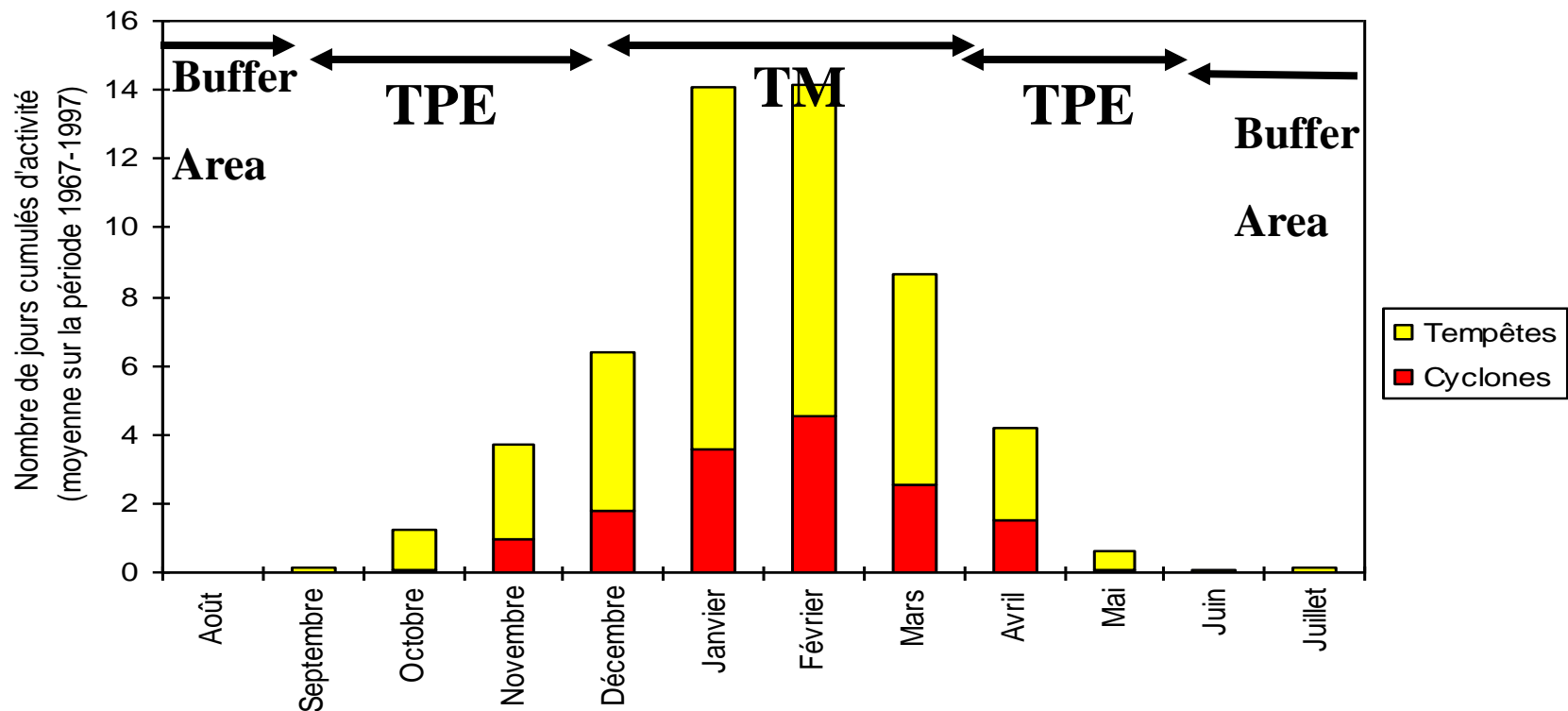


Each saison : 1 july to 30 june, since july 2002 (before :1 august to 31 july). 9/10 of tropical disturbances are formed from the 15th of november to the 30th of april, period usually called « official cyclonic season »

Monthly variation in cyclone activity

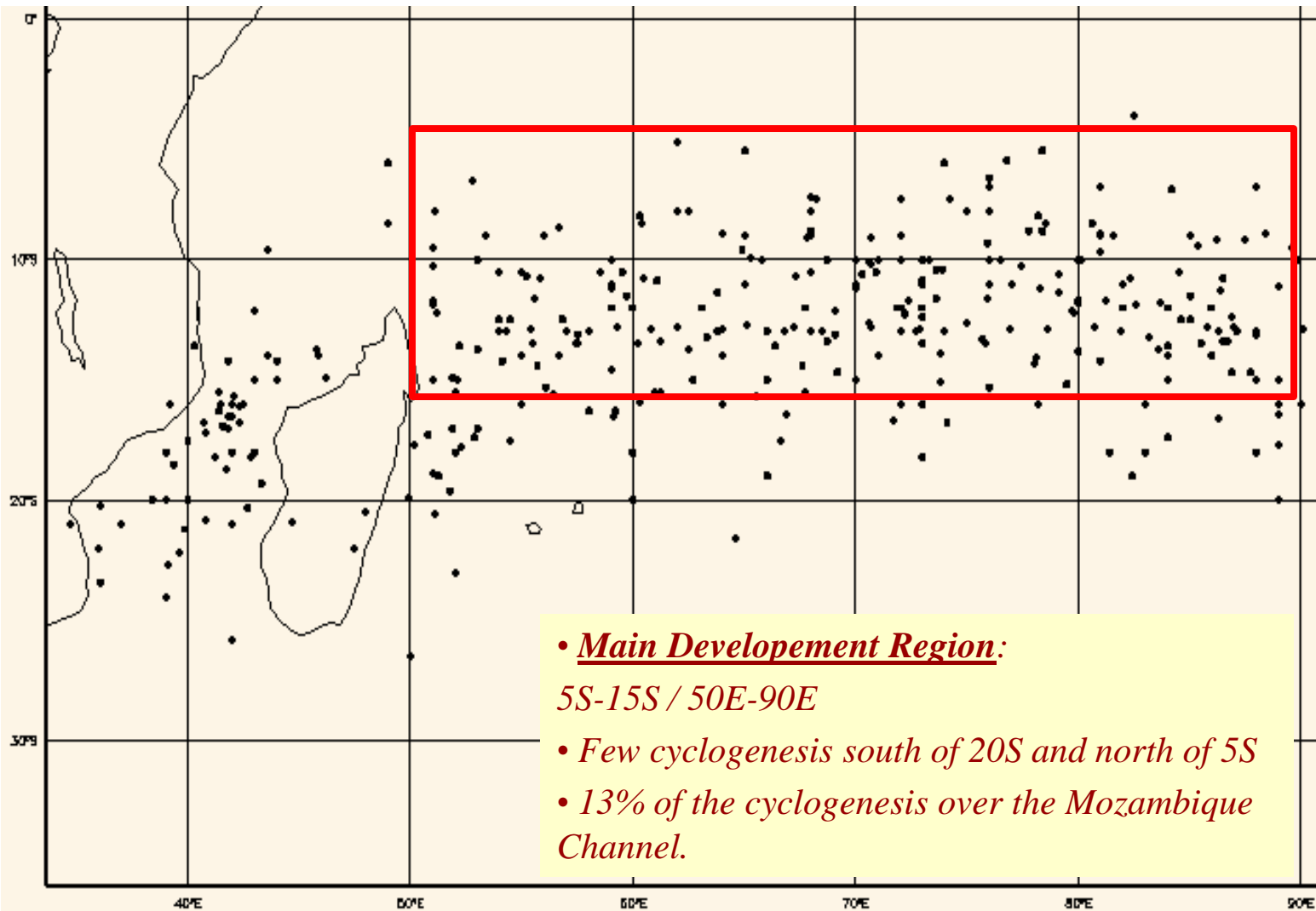
(cumulated days)

Monthly variation of cyclone activity in the South-West Indian Ocean



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Cyclogenesis over the basin from 1966 to 2000

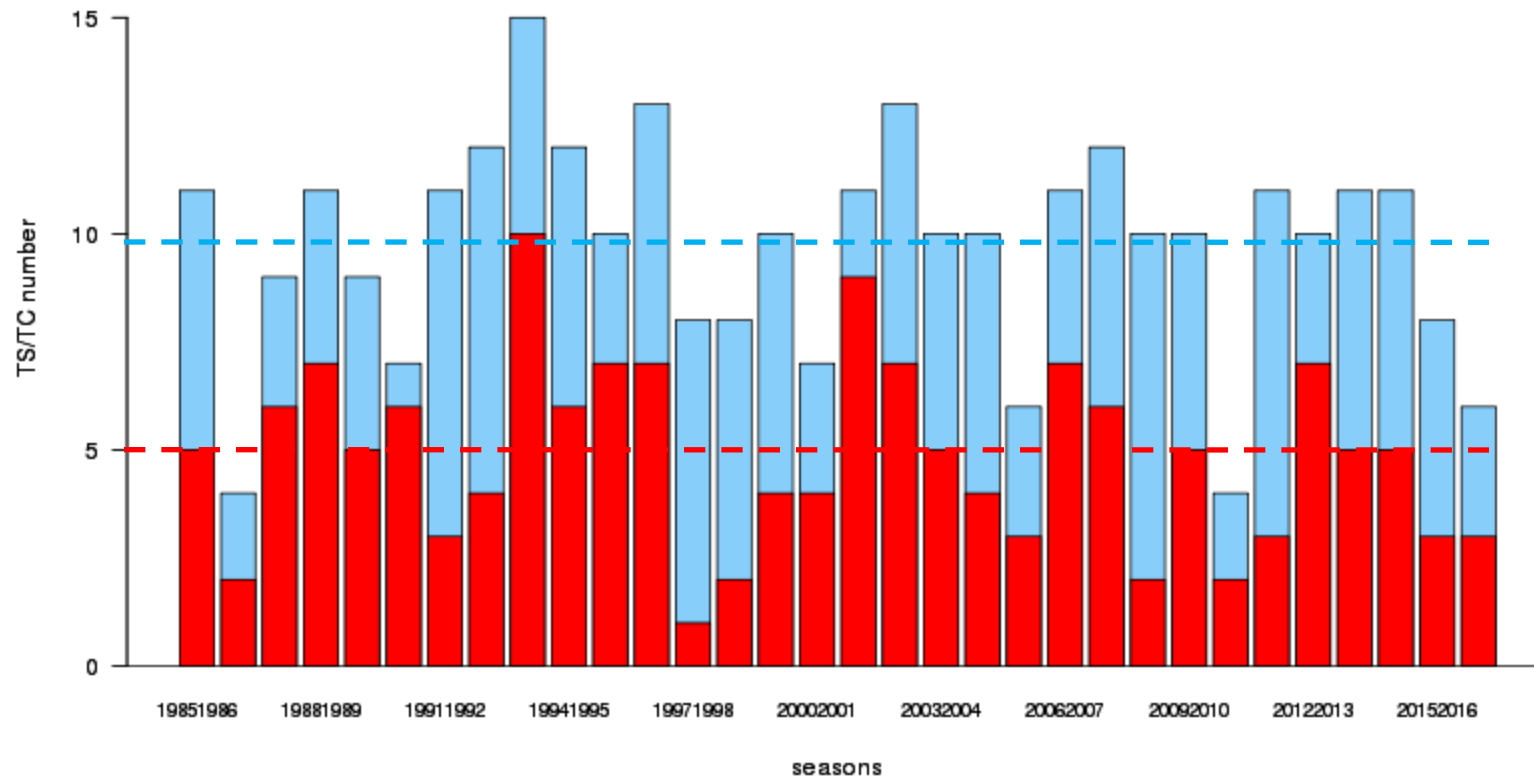


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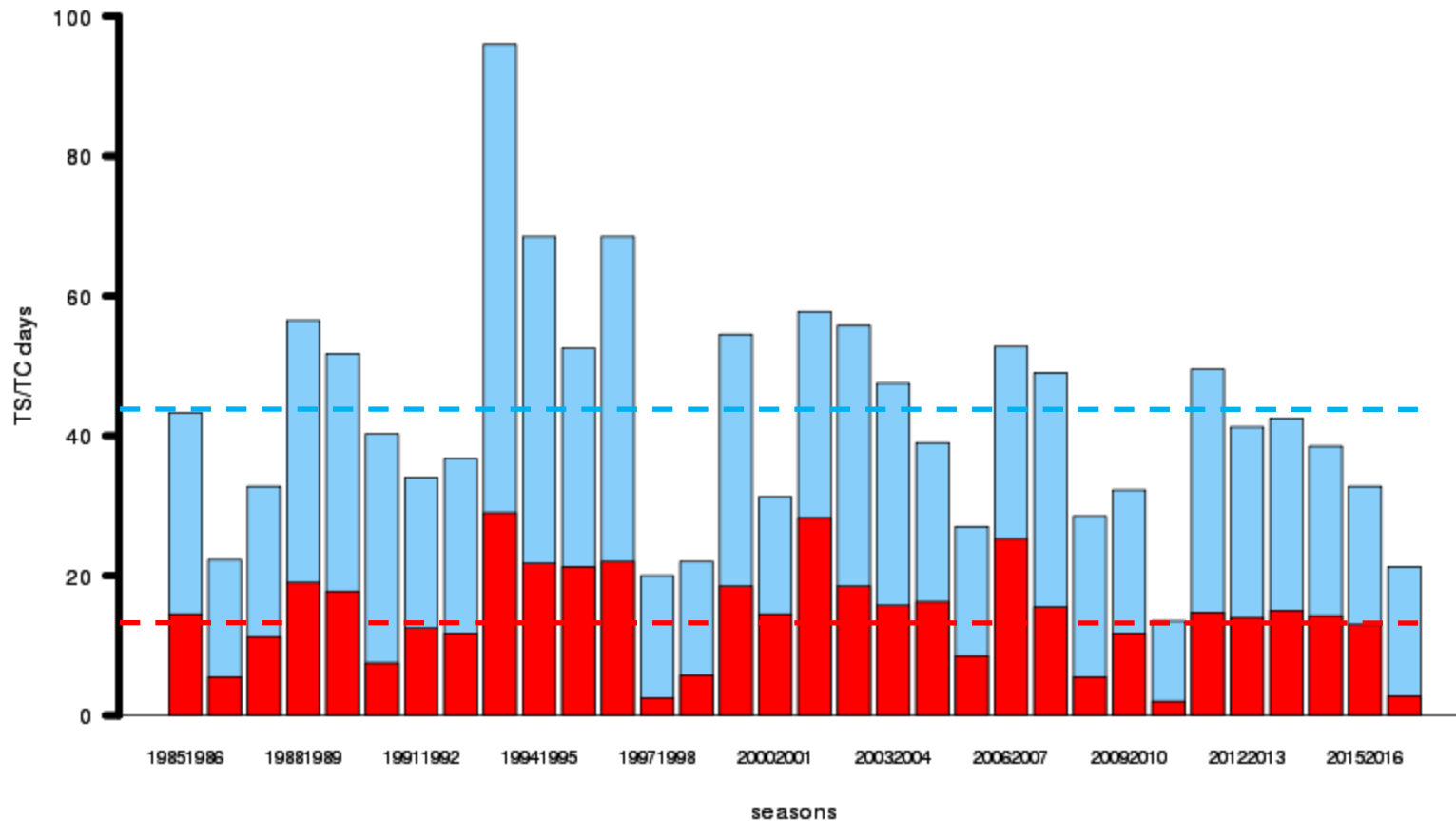


Inter-annual variation of TS/TC number



1985-2015 mean values: 9.9 named systems with 5 TC per year

Inter-annual variation of TS/TC days



1985-2015 mean values: 43.5 TS/TC days with 14.7 TC days per year



**METEO
FRANCE**

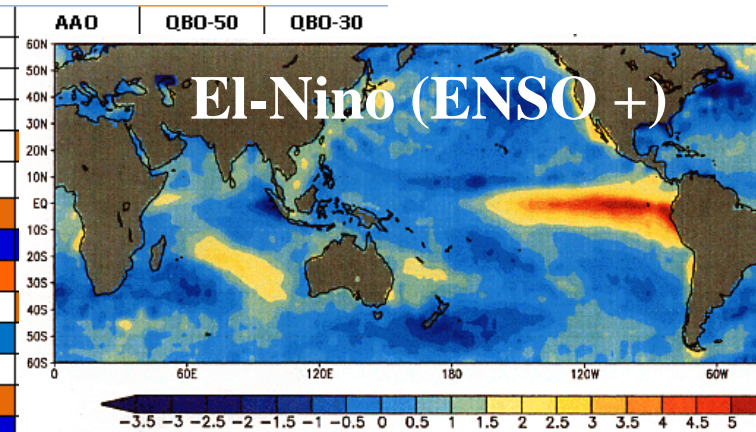
Inter-annual variation of TC activity

Saison	Ace	jour_tt_ct	jour_ct	nb_tt_ct	nb_ct	Qualificatif	MB	SIOD	AAO	QBO-50	QBO-30
19851986	-0.1	0.0	0.0	0.4	0.0		-0.2	0.3	0.0	0.9	1.0
19861987	-1.3	-1.2	-1.3	-2.4	-1.4	inf.	1.3	0.0	-0.2	-0.2	-0.8
19871988	-0.8	-0.6	-0.5	-0.4	0.5	inf.	0.8	-0.1	0.2	0.5	0.7
19881989	0.3	0.8	0.6	0.4	0.9	sup.	-1.2	-0.2	0.5	0.4	0.0
19891990	0.2	0.5	0.4	-0.4	0.0		0.4	-0.4	-0.1	-1.1	-0.4
19901991	-0.6	-0.2	-1.0	-1.2	0.5	inf.	0.4	0.5	-0.1	0.9	0.9
19911992	-0.6	-0.6	-0.3	0.4	-0.9	inf.	1.7	-1.0	-1.0	-0.4	-1.1
19921993	-0.4	-0.4	-0.4	0.8	-0.4		0.9	1.2	-0.3	0.2	0.9
19931994	2.8	3.1	2.1	2.1	2.3	sup.	0.4	0.2	0.6	0.2	-0.6
19941995	1.1	1.5	1.0	0.8	0.5	sup.	1.0	-0.8	0.4	-0.1	0.7
19951996	0.8	0.5	0.9	0.0	0.9	sup.	-0.5	-0.1	0.3	0.3	-0.4
19961997	1.2	1.5	1.1	1.2	0.9	sup.	-0.2	0.7	-0.2	-1.1	-0.1
19971998	-1.6	-1.4	-1.8	-0.8	-1.8	inf.	2.6	-1.6	0.1	0.7	0.1
19981999	-1.2	-1.3	-1.3	-0.8	-1.4	inf.	-1.1	1.4	0.8	-0.6	0.2
19992000	0.6	0.6	0.6	0.0	-0.4	sup.	-1.1	0.0	0.8	1.0	0.6
20002001	-0.4	-0.7	0.0	-1.2	-0.4	inf.	-0.6	0.8	-0.6	-0.3	-1.1
20012002	1.6	0.8	2.0	0.4	1.9	sup.	0.0	-0.6	0.5	-0.6	0.6
20022003	0.6	0.7	0.6	1.2	0.9	sup.	0.9	-0.5	-0.2	0.7	0.0
20032004	0.3	0.2	0.2	0.0	0.0		0.3	0.6	-0.3	-0.8	-0.1
20042005	0.2	-0.3	0.2	0.0	-0.4		0.7	0.2	0.1	0.9	0.1
20052006	-0.9	-1.0	-0.9	-1.6	-0.9	inf.	-0.5	1.2	-0.3	-1.6	-1.0
20062007	1.0	0.5	1.5	0.4	0.9	sup.	0.6	1.3	-0.1	1.1	0.4
20072008	0.3	0.3	0.1	0.8	0.5		-1.2		0.5	-1.7	-0.6
20082009	-1.1	-0.9	-1.3	0.0	-1.4	inf.	-0.6		0.7	1.0	1.0
20092010	-0.4	-0.7	-0.4	0.0	0.0	inf.	1.2		-0.4	-0.1	-1.3
20102011	-1.8	-1.8	-1.8	-2.4	-1.4	inf.	-1.6		0.3	0.9	1.0
20112012	0.1	0.4	0.0	0.4	-0.9		-0.7		0.7	0.1	-1.1
20122013	-0.3	-0.1	-0.1	0.0	0.9		0.0		0.1	-1.3	-0.2
20132014	0.3	-0.1	0.0	0.4	0.0		-0.1		0.2	1.3	1.1
20142015	0.0	-0.3	-0.1	0.4	0.0		0.6		0.7	-1.4	-2.0
20152016	-0.1	-0.6	-0.2	-0.8	-0.9	inf.	2.1				
20162017	-1.4	-1.3	-1.7	-1.6	-0.9	inf.					

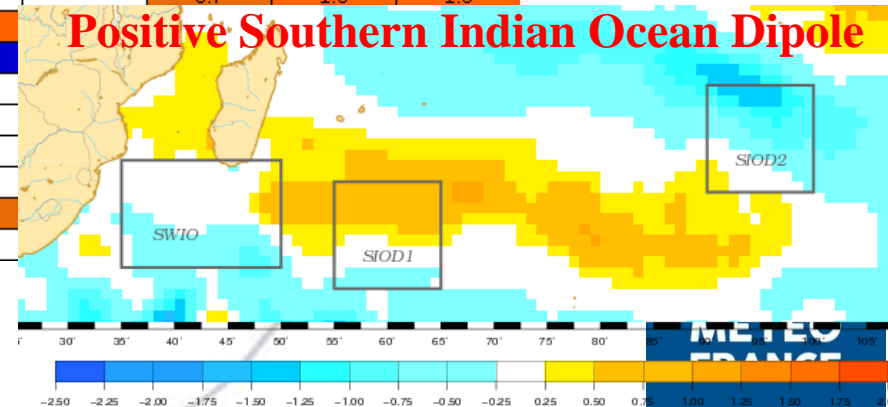


Inter-annual variation of TC activity

Saison	Ace	jour_tt_ct	jour_ct	nb_tt_ct	nb_ct	Qualificatif	MB	SIOD
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19861987	-1.3	-1.2	-1.3	-2.4	-1.4	inf.	1.3	0.0
19871988	-0.8	-0.6	-0.5	-0.4	0.5	inf.	0.8	-0.1
19881989	0.3	0.8	0.6	0.4	0.9	sup.	-1.2	-0.2
19891990	0.2	0.5	0.4	-0.4	0.0		0.4	-0.4
19901991	-0.6	-0.2	-1.0	-1.2	0.5	inf.	0.4	0.5
19911992	-0.6	-0.6	-0.3	0.4	-0.9	inf.	1.7	-1.0
19921993	-0.4	-0.4	-0.4	0.8	-0.4		0.9	1.2
19931994	2.8	3.1	2.1	2.1	2.3	sup.	0.4	0.2
19941995	1.1	1.5	1.0	0.8	0.5	sup.	1.0	-0.8
19951996	0.8	0.5	0.9	0.0	0.9	sup.	-0.5	-0.1
19961997	1.2	1.5	1.1	1.2	0.9	sup.	-0.2	0.7
19971998	-1.6	-1.4	-1.8	-0.8	-1.8	inf.	2.6	-1.6
19981999	-1.2	-1.3	-1.3	-0.8	-1.4	inf.	-1.1	1.4
19992000	0.6	0.6	0.6	0.0	-0.4	sup.	-1.1	0.0
20002001	-0.4	-0.7	0.0	-1.2	-0.4	inf.	-0.6	0.8
20012002	1.6	0.8	2.0	0.4	1.9	sup.	0.0	-0.6
20022003	0.6	0.7	0.6	1.2	0.9	sup.	0.9	-0.5
20032004	0.3	0.2	0.2	0.0	0.0		0.3	0.6
20042005	0.2	-0.3	0.2	0.0	-0.4		0.7	0.2
20052006	-0.9	-1.0	-0.9	-1.6	-0.9	inf.	-0.5	1.2
20062007	1.0	0.5	1.5	0.4	0.9	sup.	0.6	1.3
20072008	0.3	0.3	0.1	0.8	0.5		-1.2	
20082009	-1.1	-0.9	-1.3	0.0	-1.4	inf.	-0.6	
20092010	-0.4	-0.7	-0.4	0.0	0.0	inf.	1.2	
20102011	-1.8	-1.8	-1.8	-2.4	-1.4	inf.	-1.6	
20112012	0.1	0.4	0.0	0.4	-0.9		-0.7	
20122013	-0.3	-0.1	-0.1	0.0	0.9		0.0	
20132014	0.3	-0.1	0.0	0.4	0.0		-0.1	
20142015	0.0	-0.3	-0.1	0.4	0.0		0.6	
20152016	-0.1	-0.6	-0.2	-0.8	-0.9	inf.	2.1	
20162017	-1.4	-1.3	-1.7	-1.6	-0.9	inf.		



Positive Southern Indian Ocean Dipole



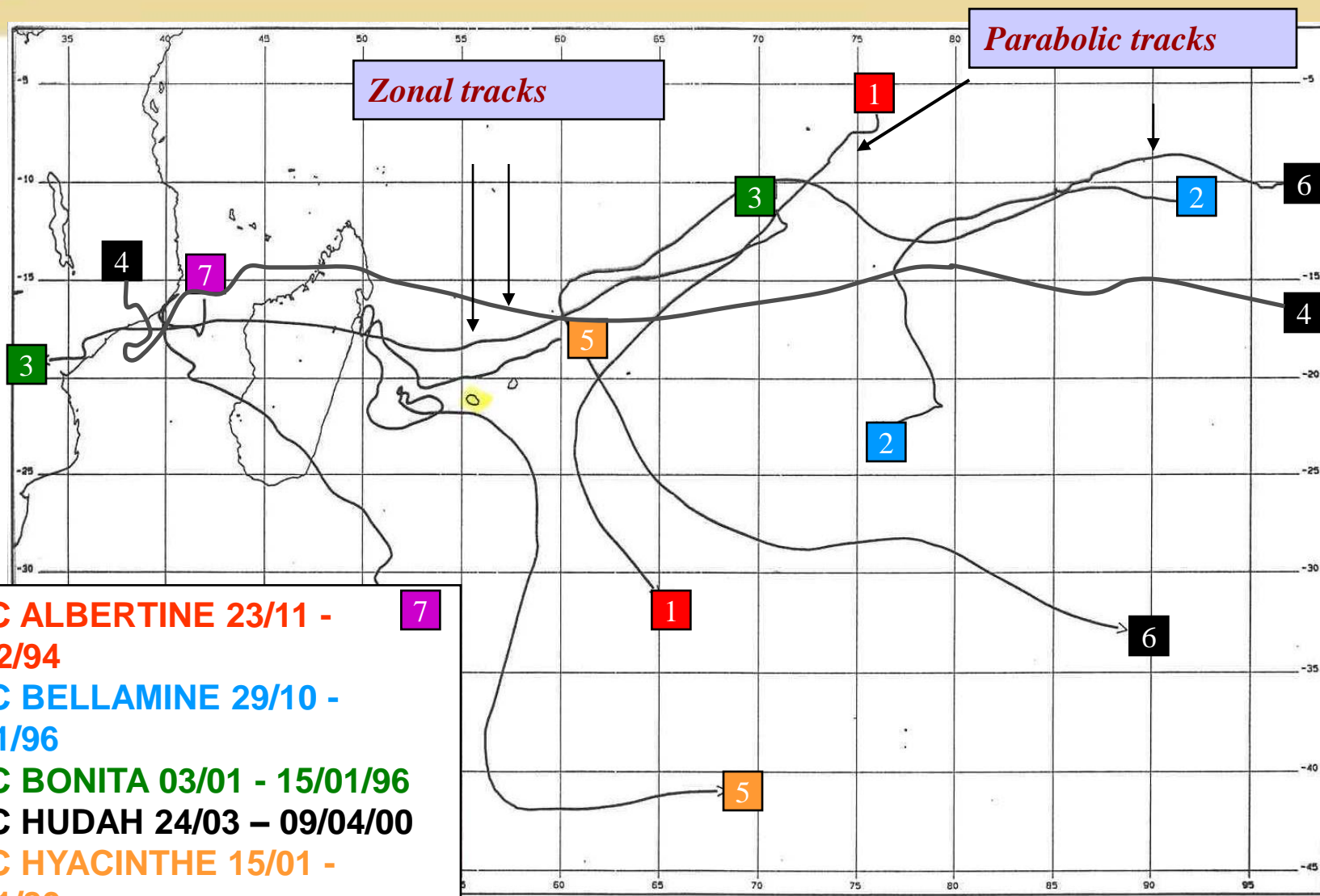
OUTLINE

1. Introduction- Global cyclonic activity
2. **Southwestern Indian Ocean (SWIO) TC activity**
 - Practices in use
 - Mean synoptic pattern over SWIO
 - Monthly and space distribution
 - Interannual evolution
 - **Typical tracks**



**METEO
FRANCE**

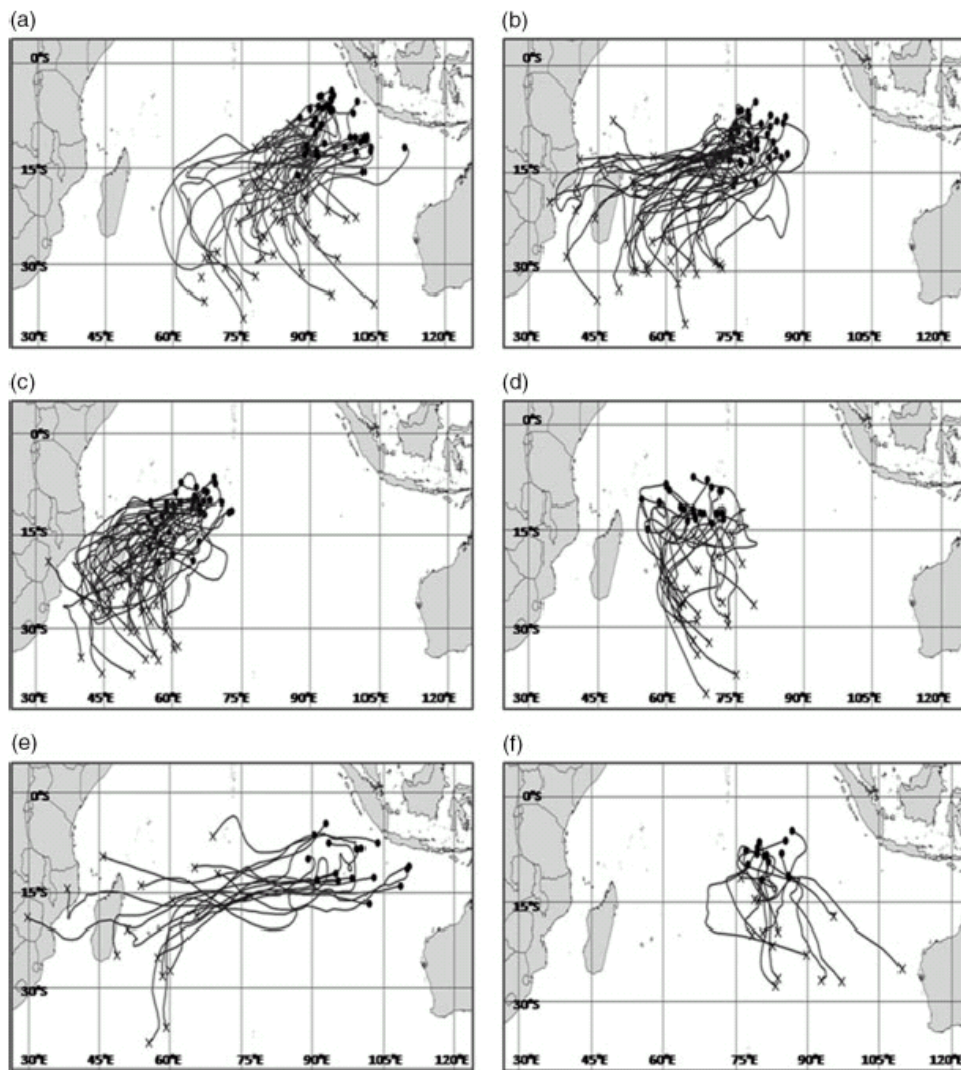
Some typical tracks



- 1. TC ALBERTINE 23/11 - 03/12/94
- 2. TC BELLAMINE 29/10 - 12/11/96
- 3. TC BONITA 03/01 - 15/01/96
- 4. TC HUDAH 24/03 - 09/04/00
- 5. TC HYACINTHE 15/01 - 31/01/80
- 6. TC ODILLE 29/03 - 17/04/94
- 7. TS DESSILIA 16/01 - 24/01/93



Some typical tracks



Ash & Matyas, 2010

Influence of ENSO and SIOD on
SWIO TC tracks:

-ENSO + / SIOD -

→ more polewards tracks

-ENSO ~ or ENSO - / SIOD +

→ more westwards tracks

Figure 2. Six TC trajectory clusters, arranged according to group size, within the main development regions for the southern Indian Ocean between 54°E and 110°E. a) C1, eastern genesis/southwest-south movement; b) C2, central/west-southwest; c) C3, western/west-southwest; d) C4, western/south-southeast; e) C5, eastern/west; f) C6, central/south-southeast.



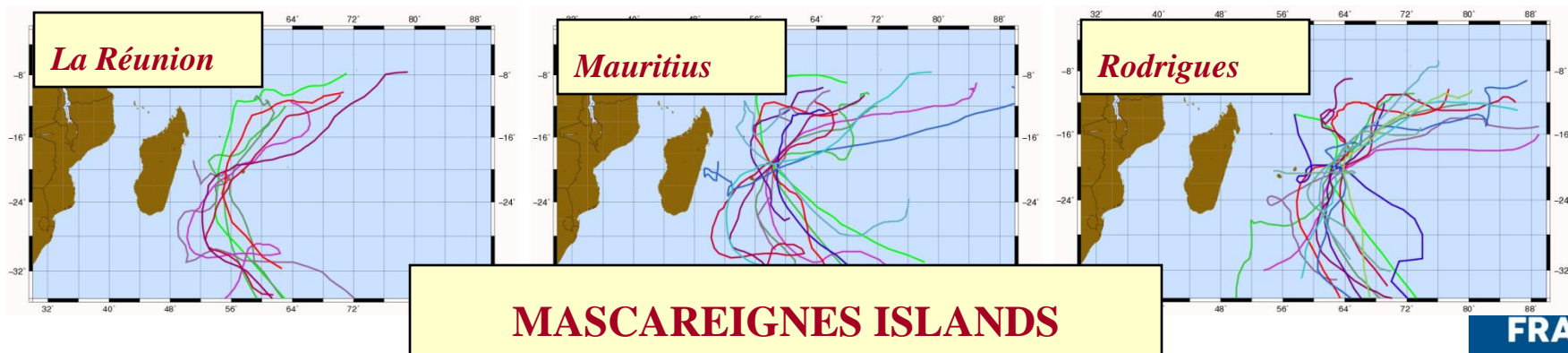
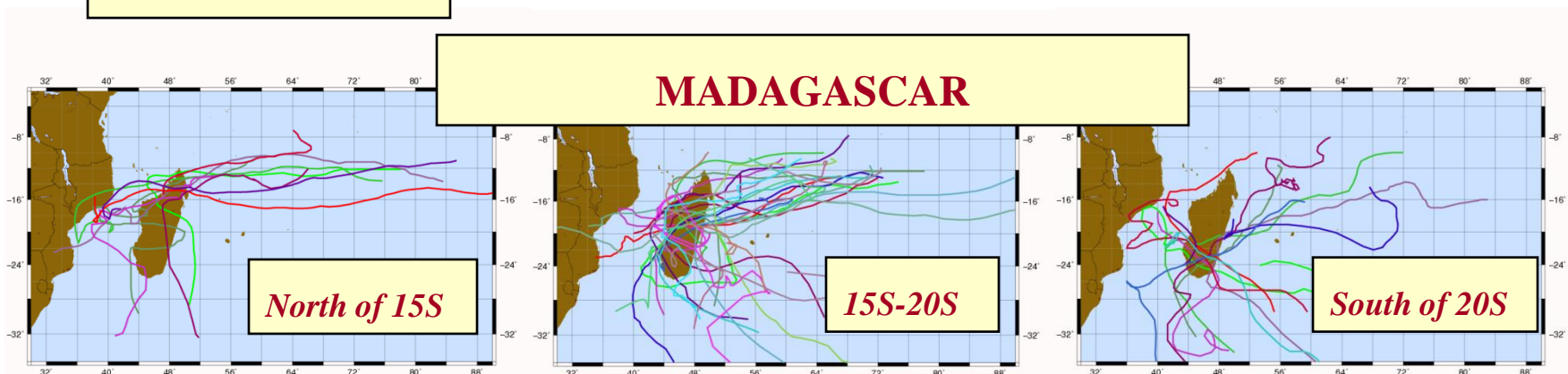
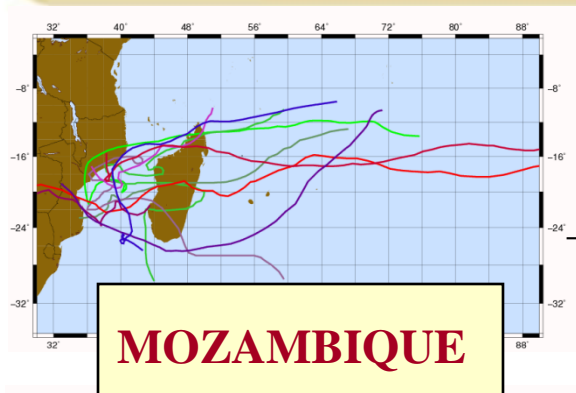
**METEO
FRANCE**

Some typical tracks

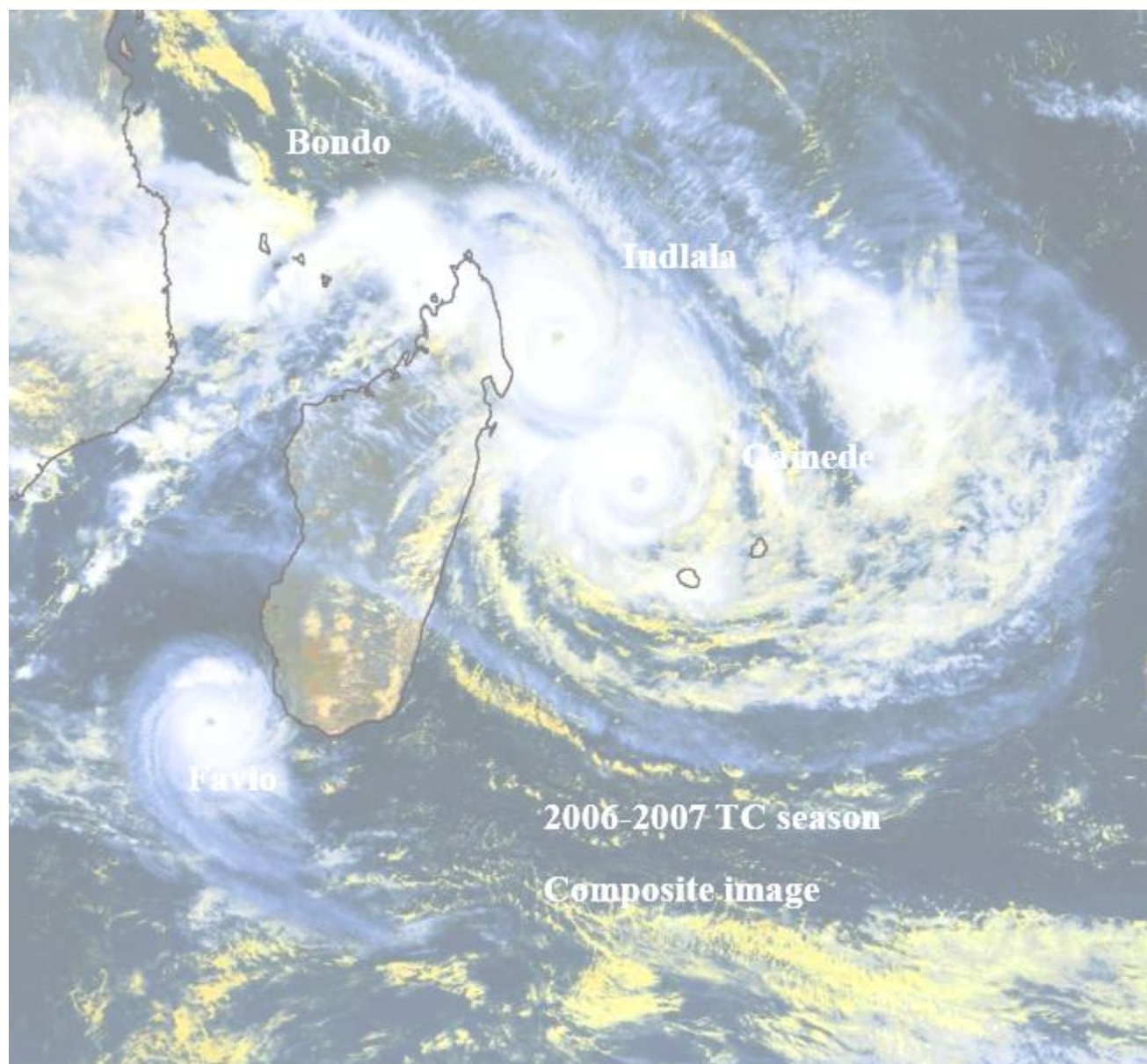
TC impacts over SWIO inhabited areas

(67/68 → 12/13)

→ relationship between track type / genesis location and impacted areas



Thank you for your attention !



**METEO
FRANCE**