ATELIER mi-projet
1er et 2 juin 2022, île de La Réunion

PISSAR

Monitoring of the MJO and equatorial waves for operational subseasonal prediction of tropical cyclones and weather regimes

Thierry Lefort , Philippe Peyrillé

ECMWF Newsletter No. 102 – Winter 2004/05

Starting up medium-range forecasting for New Caledonia in the South-West Pacific Ocean – a not so boring tropical climate

Perspectives: go for a week 2 forecast !

Hovmöller diagrams, which present anomalies averaged over a longitude, might be a powerful tool to predict anomalous blocking situations, or major changes in weather patterns. We should learn how to use them in an efficient way.

Finally, tropical cyclone activity in the south-west Pacific Ocean has proven to be very sensitive to the **Madden-Julian Oscillation**, and a statistical model has just been developed (Leroy, 2004) which shows good skill at least for Week 2.

All these new products should enable us to **extract some valuable information for the second week, at least for a certain category of users**. For sure, more work is to come for tropical forecasters !

Is is worth the trouble ? Back in 2006…

27th Conference on Hurricanes and Tropical Meteorology, 24-28 April 2006, Monterey, CA

11C.1

INCORPORATION OF EQUATORIAL WAVE MODES INTO TROPICAL SYNOPTIC METEOROLOGY: IS IT WORTH THE TROUBLE?

John Molinari*, David Vollaro and Carl Schreck
Department of Earth and Atmospheric Sciences
The University at Albany/SUNY
Albany, New York

Weickmann 2001), but much work remains. We argue that there is considerable potential value for forecasting in developing synoptic models of equatorial wave signatures on satellite and on weather maps.

The value of the direct use of equatorial wave theory in operational tropical weather forecasting

Thierry Lefort, Frédéric Ferry, Philippe Peyrillé,
Météo-France

The 4th WMO Workshop on Monsoon Heavy Rainfall (MHR-4)

Toward an operational use of equatorial wave theory

Application to the 2019 Indian Monsoon onset and withdrawal

Thierry Lefort, Météo-France

**Virtual International Conference on the
"Future directions of Subseasonal to Seasonal Prediction over South Asia",**

29-31March 2021, IITM, Pune, India

Methodology: illustration

Newsletter #15 of WMO/S2S Project

S2S Newsletter No. 15 November, 2020

Subseasonal-to-Seasonal S2S Prediction Project

WWRP World Weather Research Programme

WCRP World Climate Research Programme

Newsletter

In This Issue ...

News:

- The 2020 monsoon over Asia and Africa: *how well the S2S models performed*
- Key to predict heatwaves over the Yangtze River basin 20 days in advance
- S2S AI/ML Competition in 2021
- WMO S2S 9th Steering/Liaison Group Meeting
- S2S Webinar Series
- A news article on S2S forecasts
- New S2S LG members
- Call for articles in S2S Newsletter

Topics:

1. What is S2S?
2. Six sub-projects in S2S Phase II
3. Upcoming Events

1. What is S2S ?

To bridge the gap between medium-range weather forecasts and seasonal forecasts, the World Weather Research Programme (WWRP) and World Climate Research Programme (WCRP) launched a joint research initiative in 2013, the Subseasonal to Seasonal Prediction Project (S2S). The main goal of this project is to improve forecast skill and understanding of the subseasonal to seasonal timescale, and to promote its uptake by operational centres and exploitation by the applications communities.

Phase II of the S2S project began in January 2019 and will continue until 2023. A new set of scientific sub-projects has been developed, as outlined in the sidebar in next pages. Enhancements to the database will be

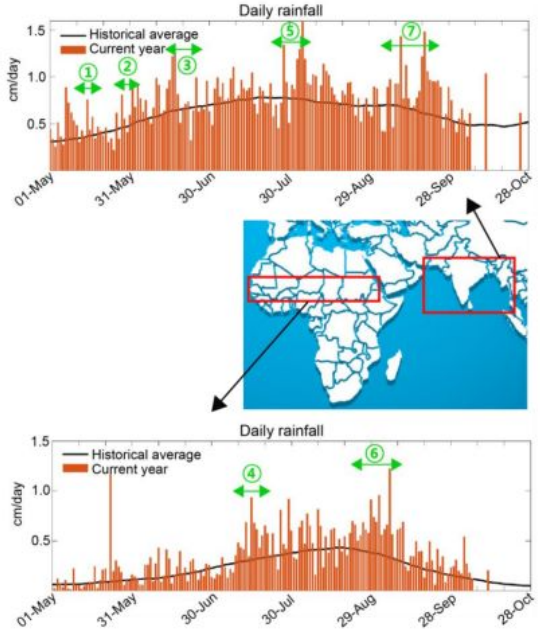


Fig. 1 : TRMM daily rainfall over the South Asian domain (top) and over the African monsoon domain (bottom). Corresponding domains are denoted with red rectangles (middle) (Source: W. Boos http://worldmonsoons.org).

The 2020 monsoon over Asia and Africa: *how well the S2S models performed*

Thierry Lefort and Philippe Peyrillé (*Meteo-France*)

The monsoon has been abundant over both Asian and African (Fig. 1)

The tropical atmosphere is more predictable at subseasonal range than the extratropics

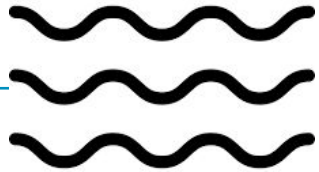
Like for seasonal range, but not for the same reason :

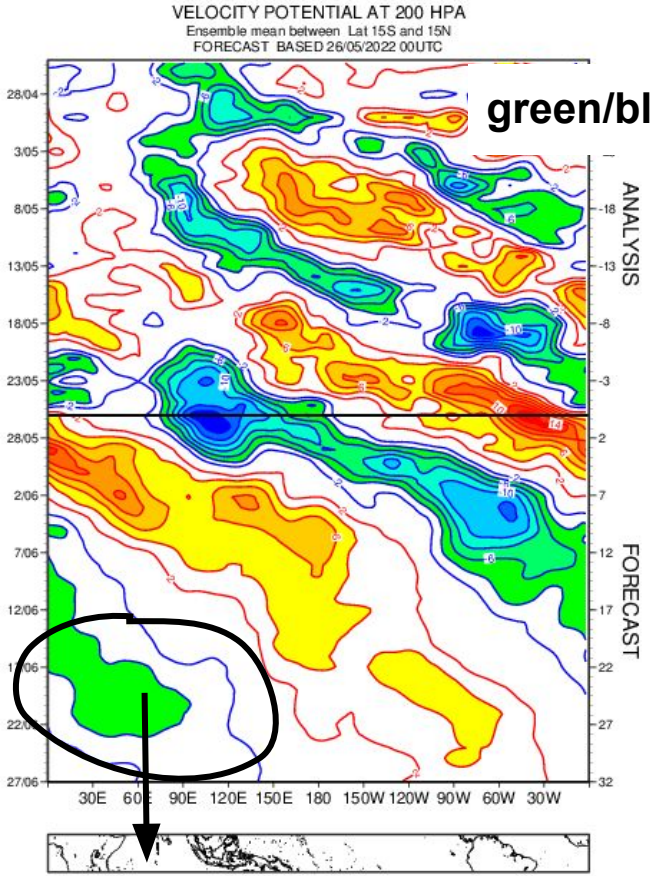
Falko Judt, 2019: Atmospheric Predictability of the Tropics, Middle Latitudes, and Polar Regions Explored through Global Storm-Resolving Simulations :

- The tropical atmosphere has longer predictability than the extratropical atmosphere
- The relatively long predictability of **equatorial waves** provides an explanation for why the tropics have longer predictability than the extratropics

concept of potential predictability

Waves in the atmosphere: example





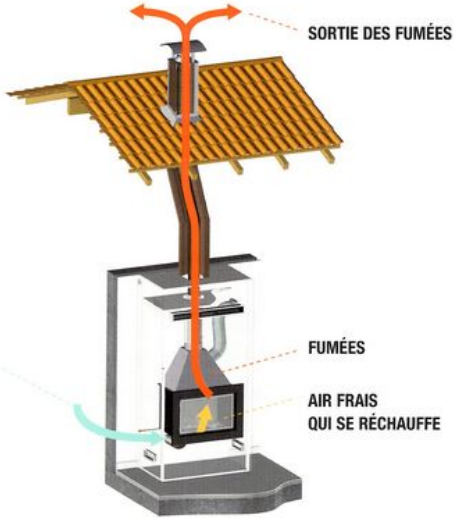
green/blue: good chimney draft

passed
4 weeks

present

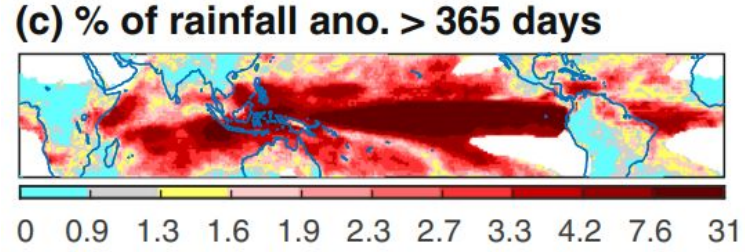
future

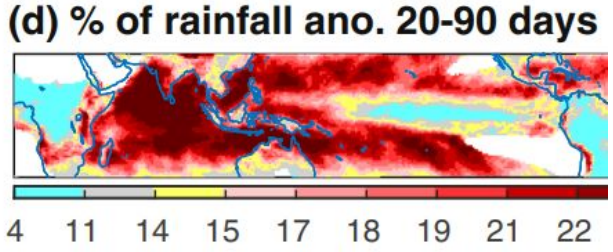
4 weeks

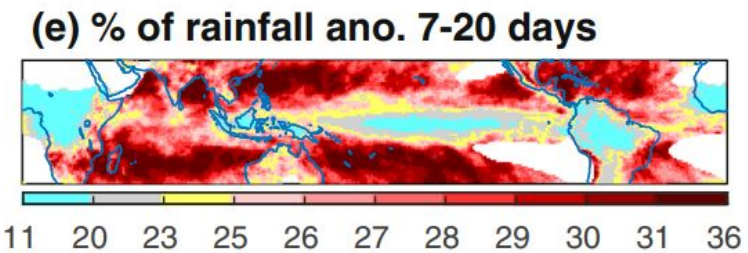


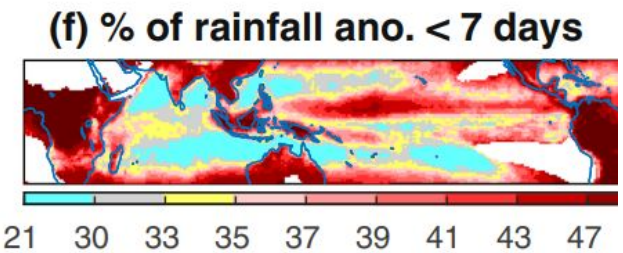
Propagation brings predictability

But… not all tropical climates are equally predictable

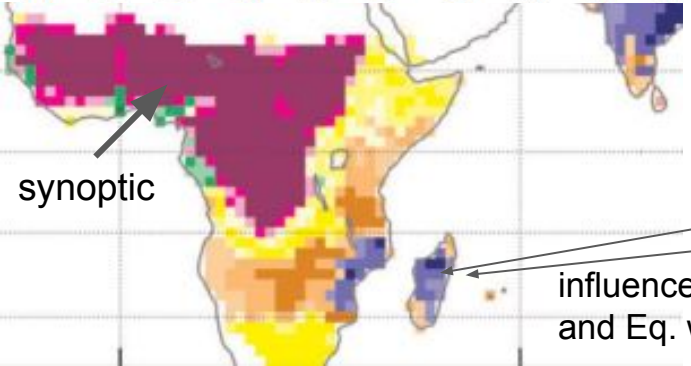




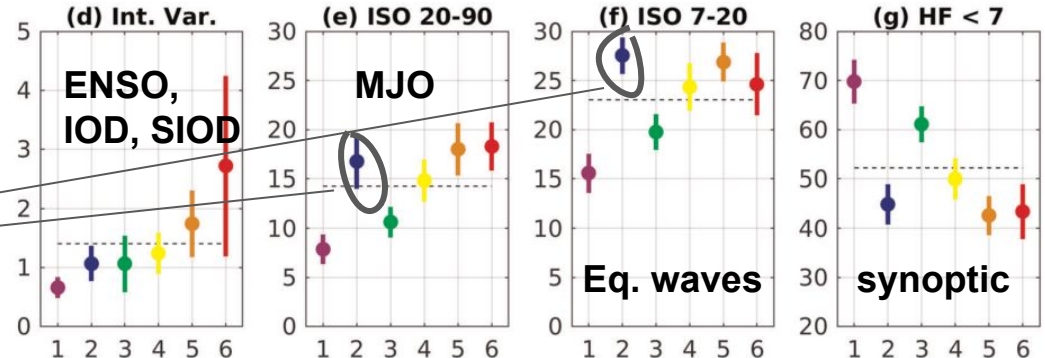




Moron et Robertson, 2020: Tropical rainfall subseasonal-to-seasonal predictability types

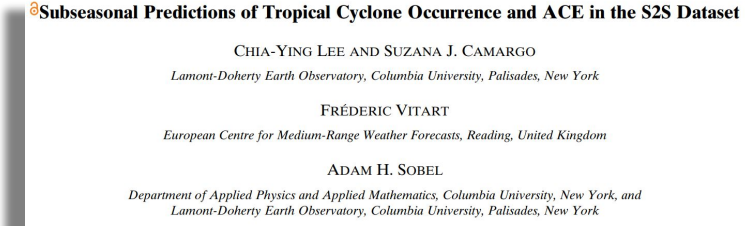


influenced by MJO and Eq. waves



Skill of numerical models to predict the risk of tropical cyclones

- S2S models better simulate the influence of MJO wind signal on TC frequency than they simulate the influence of the MJO convection signal.
- Generally speaking, the S2S models are more skillful in predicting TC occurrence during favorable Madden–Julian oscillation phases.
- favorable MJO phases are associated with better forecasting skills for predicting total TC occurrence.
- winds generated by the S2S models are around 50 kt.
- Among the six models examined here, the ECMWF model has the best performance (Fig. 3). It is skillful in predicting TC occurrence up to 4 weeks in all TC basins, except in the NI where the model is skillful up to week 3.



Subseasonal Predictions of Tropical Cyclone Occurrence and ACE in the S2S Dataset

CHIA-YING LEE AND SUZANA J. CAMARGO

Lamont-Doherty Earth Observatory, Columbia University, Palisades, New York

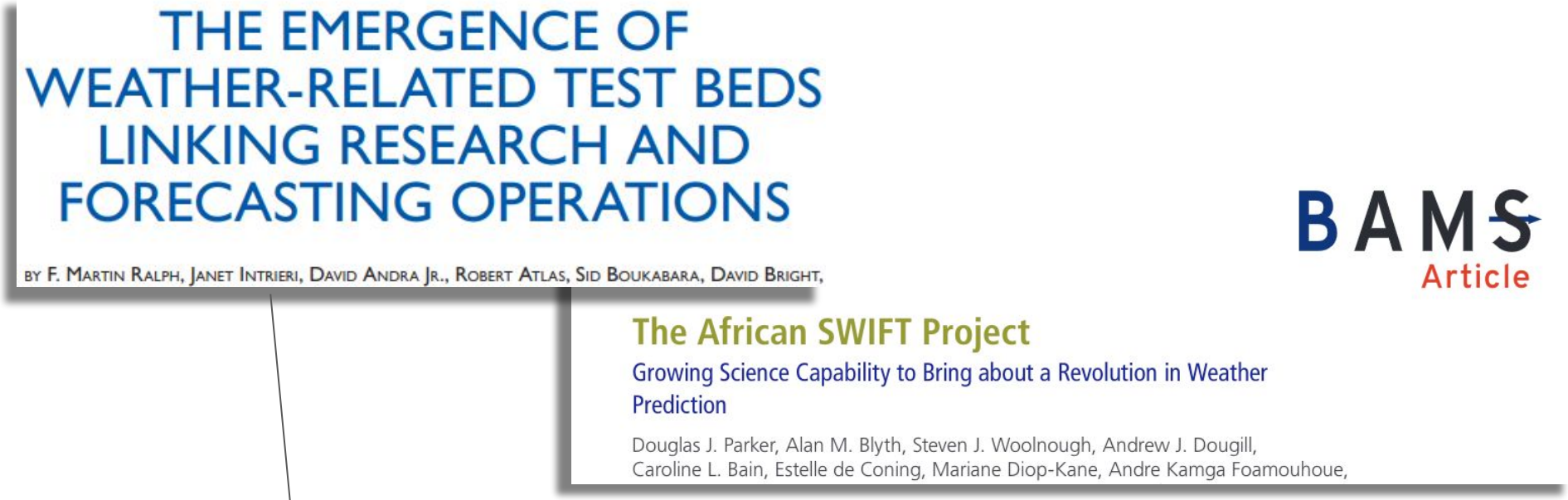
FRÉDERIC VITART

European Centre for Medium-Range Weather Forecasts, Reading, United Kingdom

ADAM H. SOBEL

Department of Applied Physics and Applied Mathematics, Columbia University, New York, and Lamont-Doherty Earth Observatory, Columbia University, Palisades, New York

Linking research to operations (R2O) through testbeds



The testbed methodology is built around the principles of **coproduction** …

Each operational Met. Service is working with a small number of forecast users and scientists to **design, produce, evaluate, and develop operational forecast products to support decision-making in the user's particular application**

On the use of testbeds…it started with Jacob Bjerknes in 1917

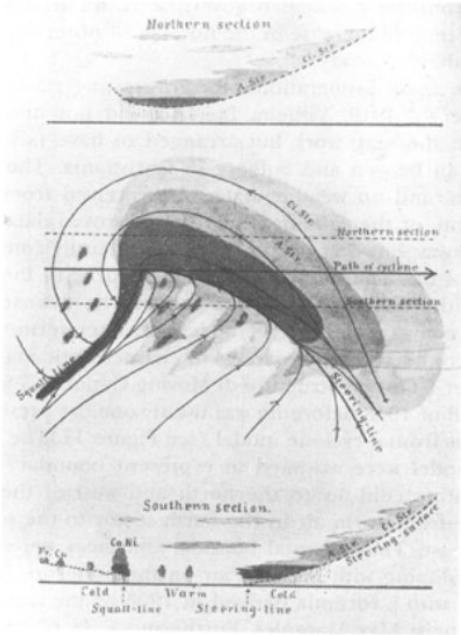


FIGURE 1 Jack Bjerknes's cyclone model: streamlines, clouds, and precipitation and vertical cross-sections north and south of the center. (From Bjerknes, 1919.)

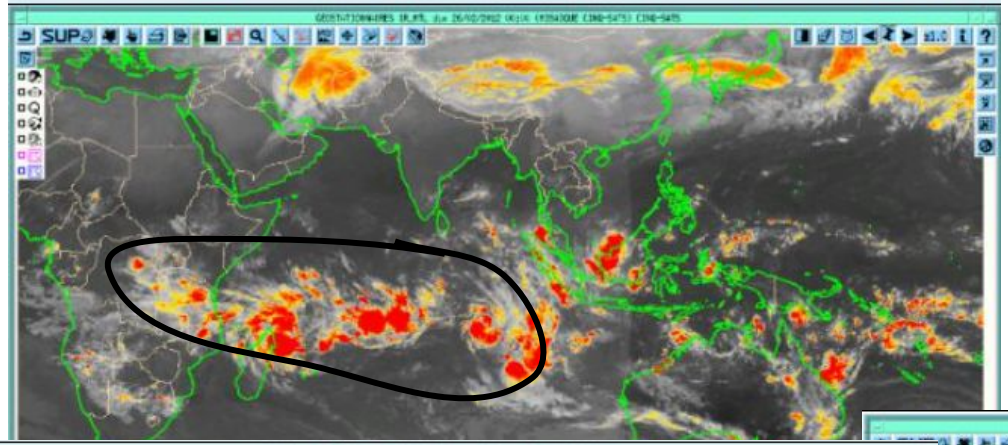
Vilhelm Bjerknes left wartime Germany and arrived in Bergen in the summer of 1917 with two young assistants, Jack Bjerknes and Halvor Solberg. He realized that he would not have in Bergen the resources for a theoretical attack on the problem of weather prognosis and planned instead a **push toward practical weather forecasting** by offering a special **summer forecasting service for agriculture…**

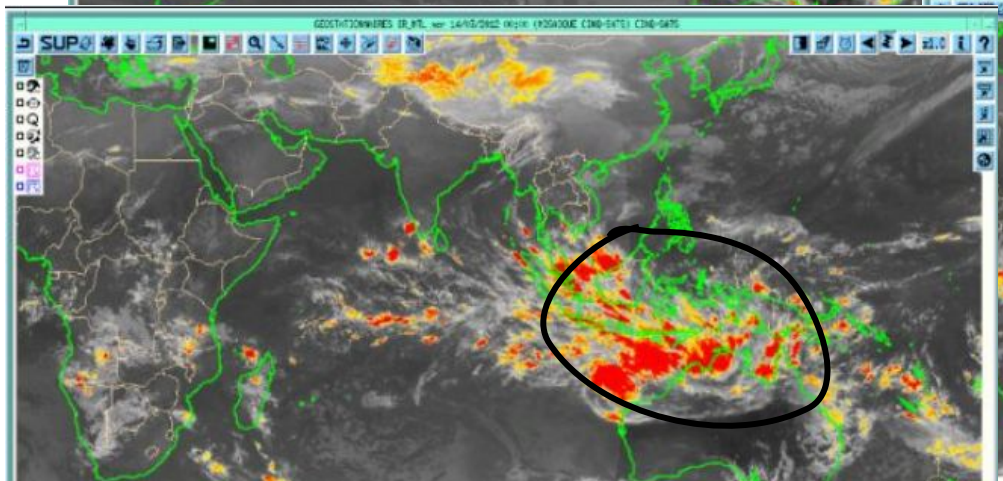
…From the improved data network in Norway, however, Jack could again identify convergence lines of the type he had studied in Leipzig, as they moved along the Norwegian coast. Moreover, **he discovered that these convergence lines, which were later termed fronts, were connected with cyclones in characteristic manner**. In a paper ("On the Structure of Moving Cyclones") written in the fall of 1918 before he was twenty-one, he presented his famous frontal cyclone model

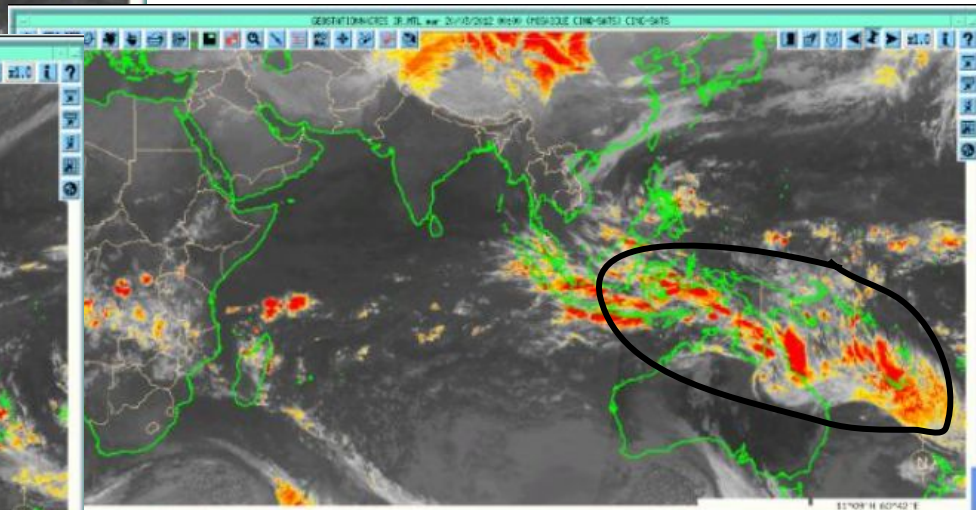
Concepts and methodology

- **A seamless approach**
  - to document the state of the atmosphere and the ocean through a continuity of scales from the seasonal to the synoptic scale and even to the mesoscale convective scale
- **An meteorological object-based approach**
  - enables to follow in space and time; example: a wet anomaly or a cyclonic gyre
- **Develop and exploit parameters that have better predictability than rainfall**
  - Ex: Precipitable water instead of rainfall, velocity potential (divergent part of the flow)
- **Using anomaly fields but also total fields**
  - Total fields help recognize climatological objects like ITCZ, monsoon trough, onset of the monsoonal flow, etc.
- **Using a multi-model approach**

Following meteorological objects at a large time-space scale





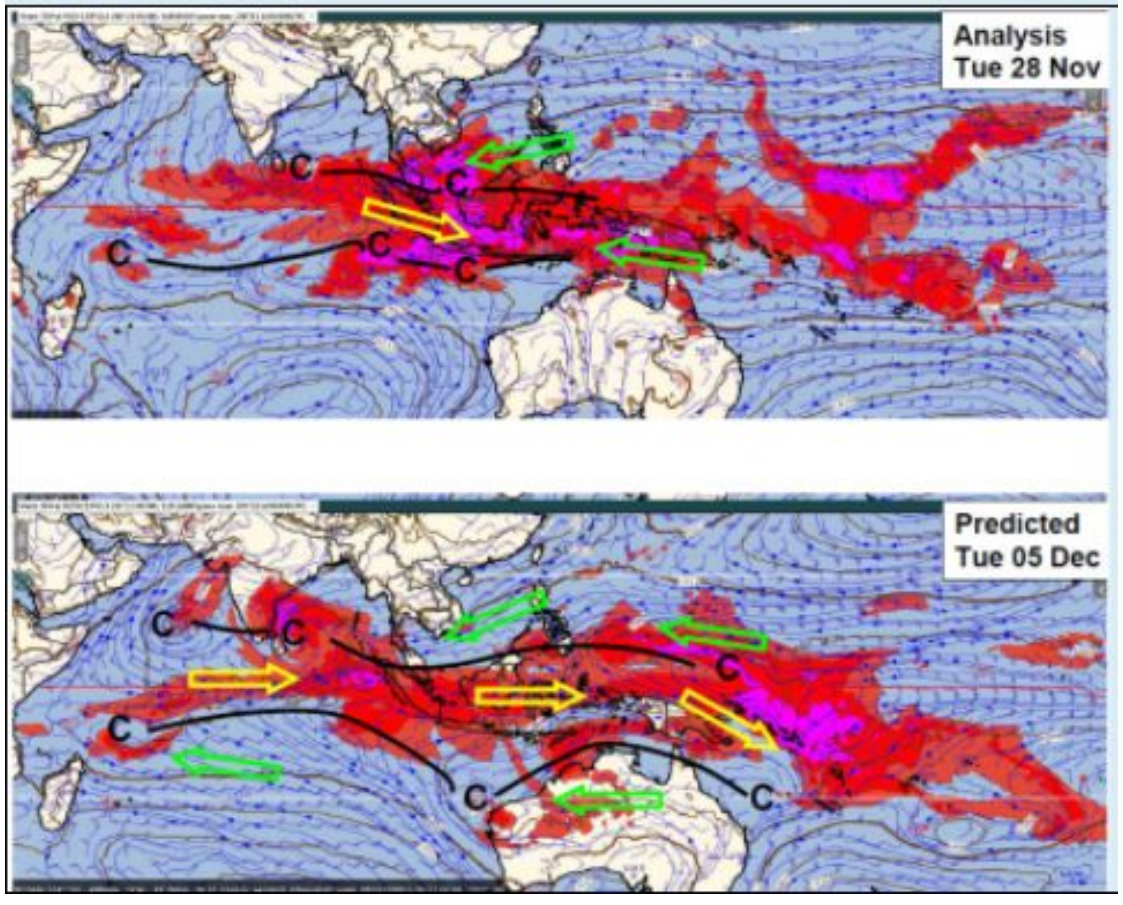


basin scale, within a 3- week window

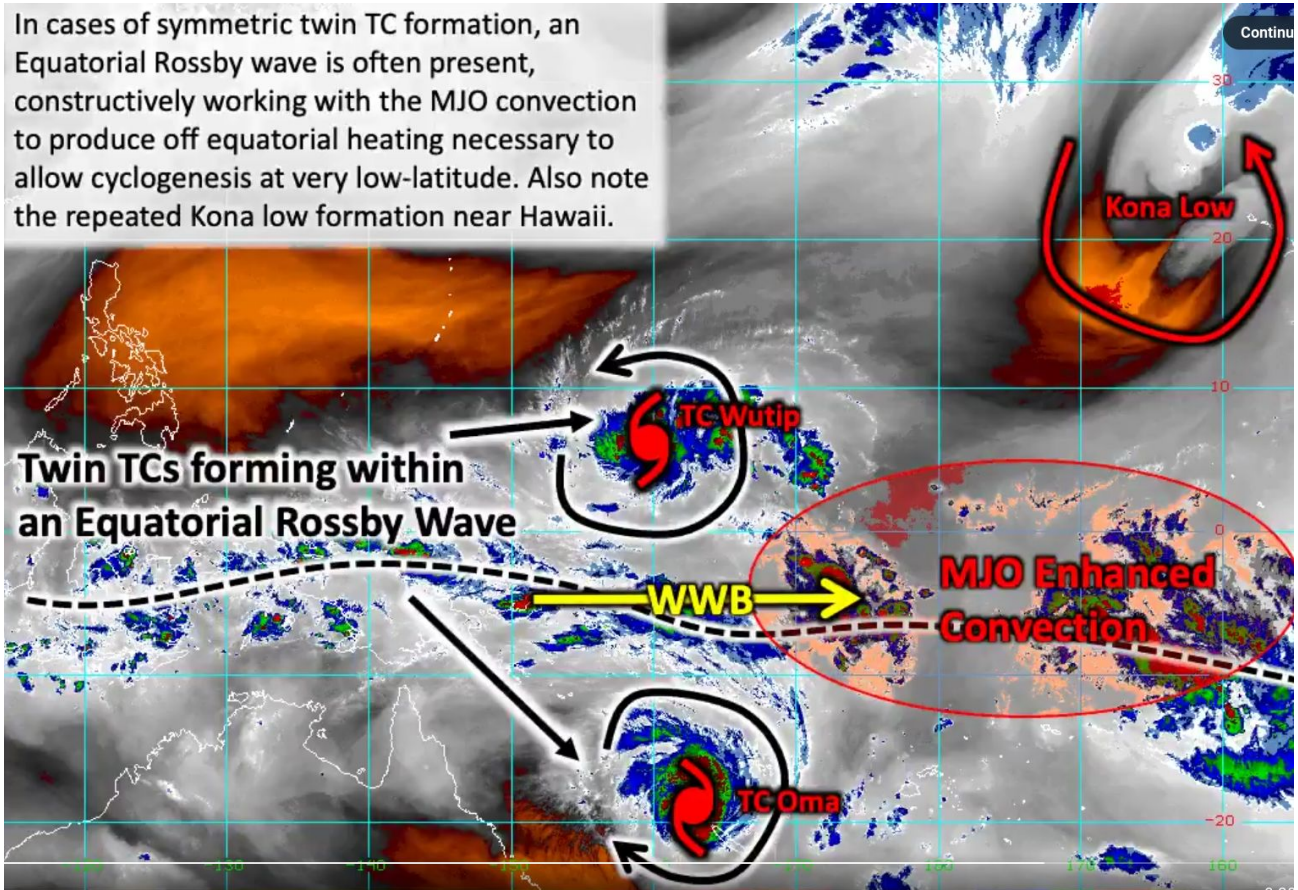
Several scales on the same weather map

total fields:

- ➔ wind 925hPa
- ➔ mslp
- ➔ Moisture content 500hPa (wet bulb potential temp.)

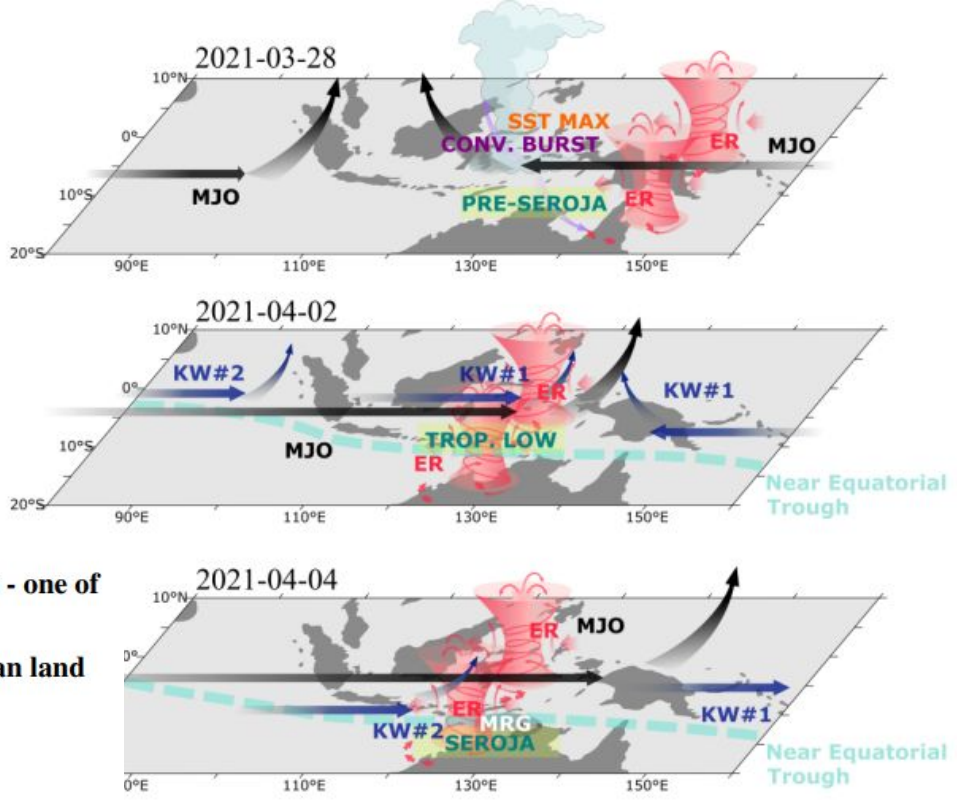


Following meteorological objects on a satellite picture



Philippe Papin
@pppapin

Object-based approach



The role of tropical waves in the genesis of Tropical Cyclone Seroja - one of the first tropical cyclones to have a significant impact on Indonesian land

Beata Latos*

Institute of Geophysics Polish Academy of Sciences, Warsaw, Poland

FIG. 9. A conceptual diagram of meteorological drivers of TC Seroja. Abbreviations are as follows: SST MAX - maximum of the Sea Surface Temperatures; CONV. BURST — Convective Burst; KW — Convectively Coupled Kelvin Wave; ER — Convectively Coupled Equatorial Rossby Wave; MJO — Madden-Julian Oscillation; TROP. LOW — Tropical Low; MRG — Mixed-Rossby Gravity Wave.

The Madden-Julian oscillation

Authors: Jon Gottschalck, Vernon Kousky, Wayne Higgins, and Michelle L'Heureux

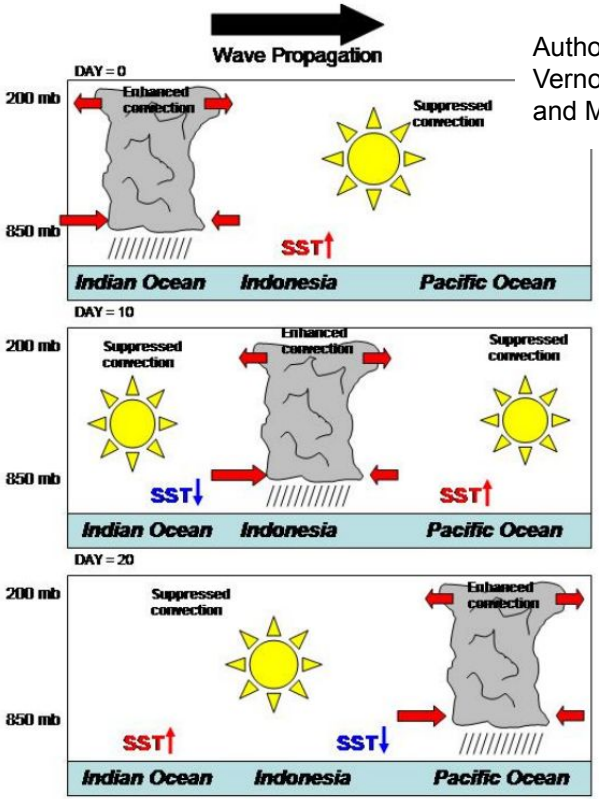


Figure 1: Equatorial vertical cross section of the MJO as it propagates from the Indian Ocean to the western Pacific. Red arrows indicate direction of wind and red (blue) SST labels indicate positive (negative) SST anomalies respectively. Figure adapted from Madden and Julian, 1971; 1972.

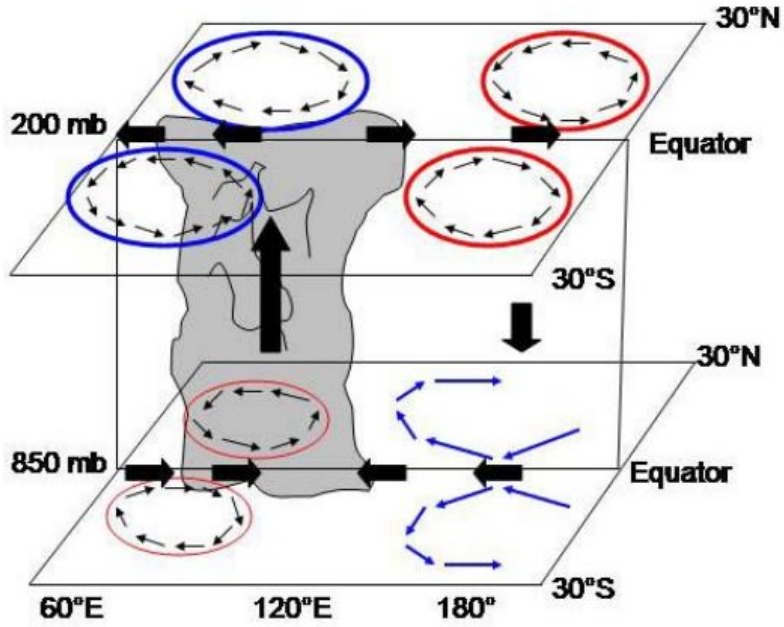


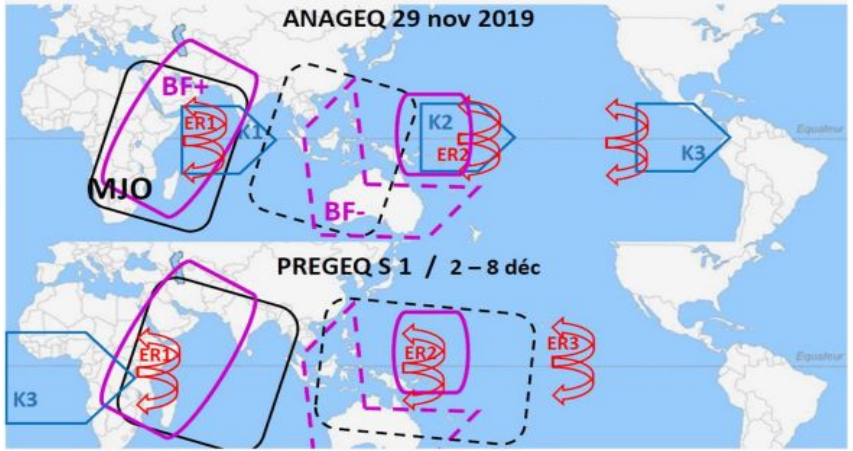
Figure 2: Schematic of the vertical three-dimensional structure of an established MJO. Figure adapted from Rui and Wang (1990). Blue (red) ovals indicate anticyclonic (cyclonic) circulations. Black arrows indicate wind direction and rising (sinking) motion.

synthesis MJO + eq.waves: table and schematic

Si MJO robuste, on récapitule dans un tableau:

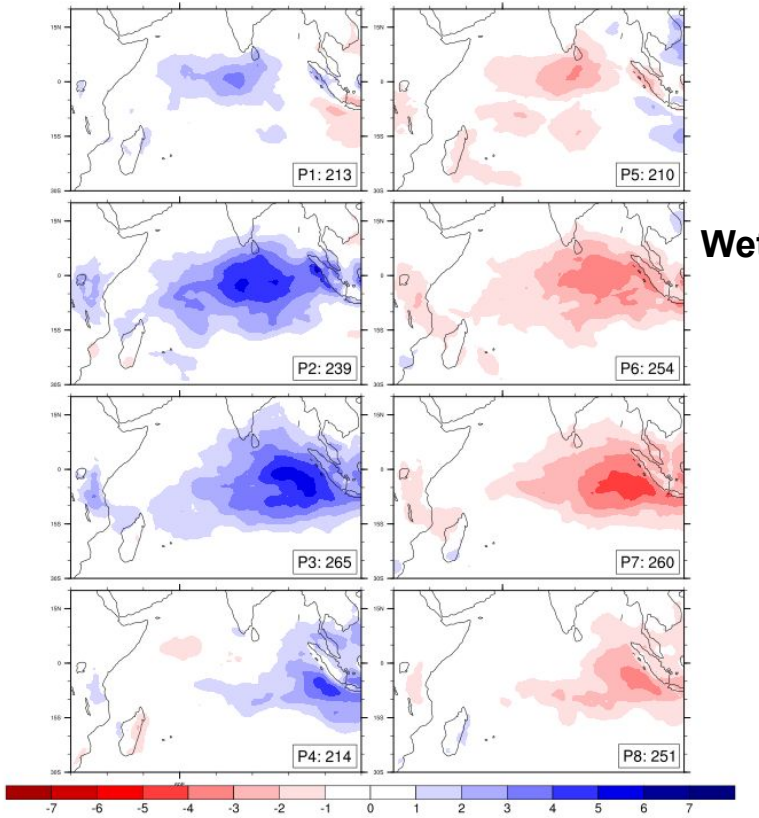
	S1	S2	S3	S4	S5
Phase MJO prévue	2	3	4	5	6
Intensité	forte	modérée	modérée	faible/mod	faible/mod

Exemple d'ANAGEQ-PREGEQ S1



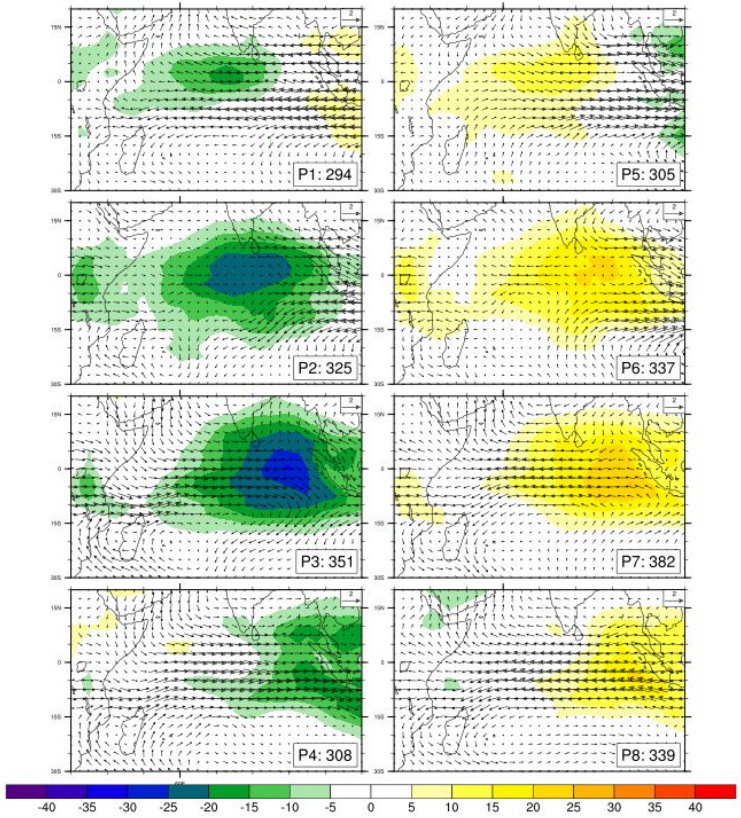
Composite charts anomalies from MJO

Anomalies : GPCP precipitation (mm/day) - Nov to Apr 1997-2013



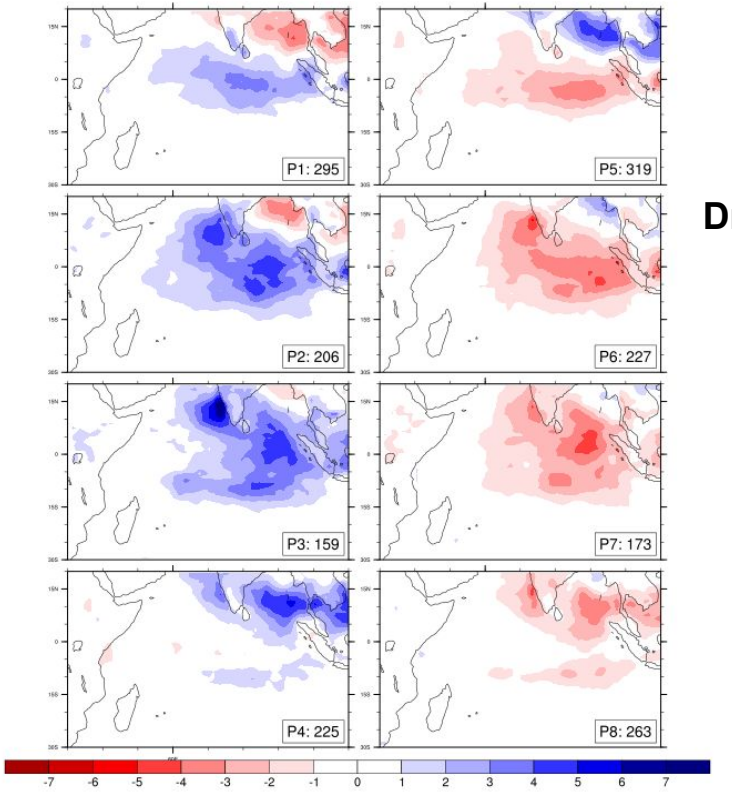
Wet season

Anomalies : OLR (W/m^2) and 850 hPa winds - Nov to Apr 1990-2013



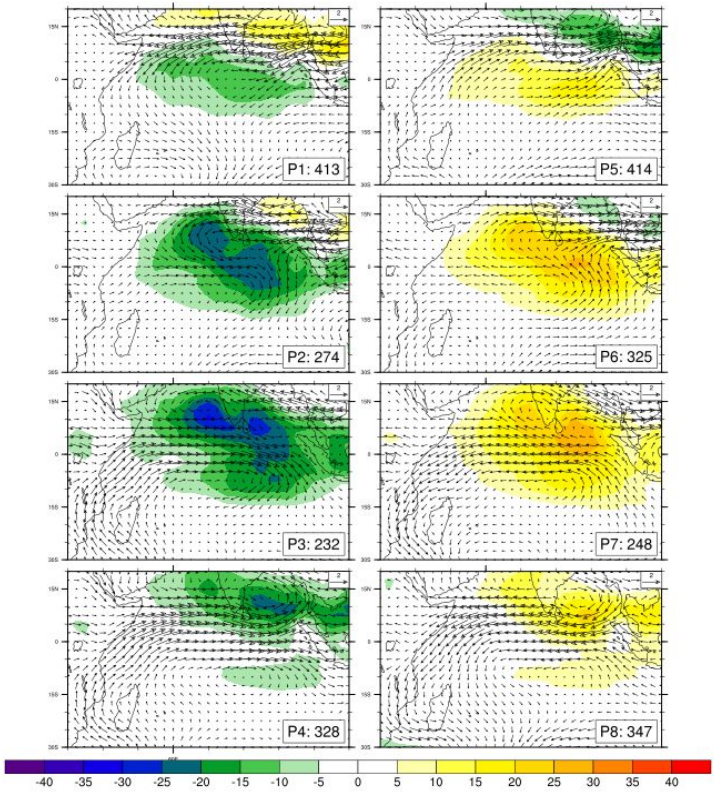
Dry season anomalies from MJO

Anomalies : GPCP precipitation (mm/day) - May to Oct 1997-2013



Dry season

Anomalies : OLR (W/m^2) and 850 hPa winds - May to Oct 1990-2013



Is there an agreement between numerical output and anomalies expected from the MJO ?

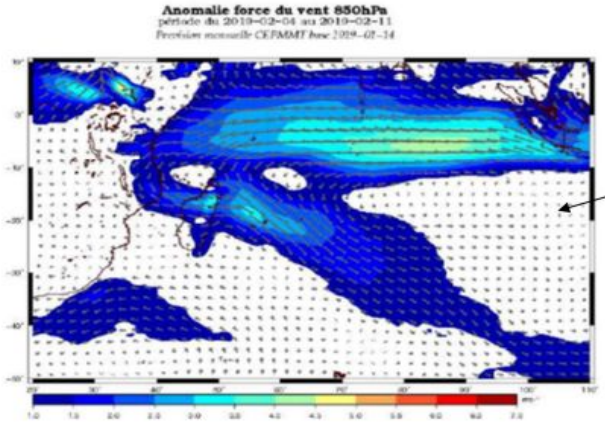
extrait d'un bulletin expérimental de DIROI

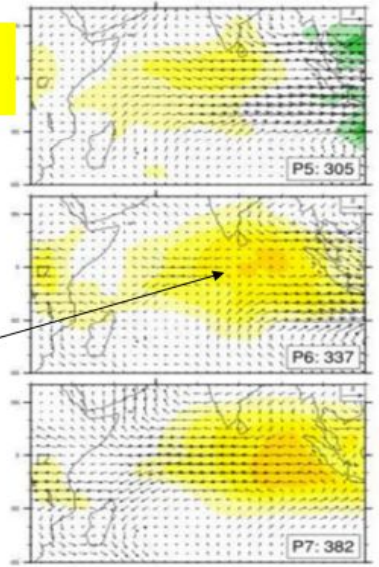
MAYOTTE

- En S3, retrait du flux trans-équatorial cohérent avec la MJO qui se décale en P6.

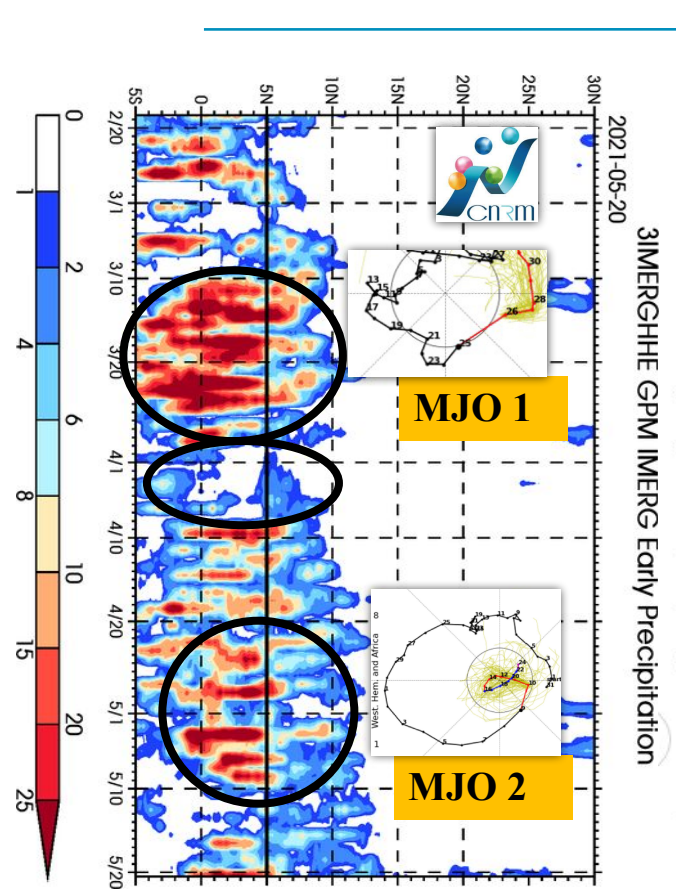
Carte CEP du jour vent 850

Cartes composite OLR et vent 850

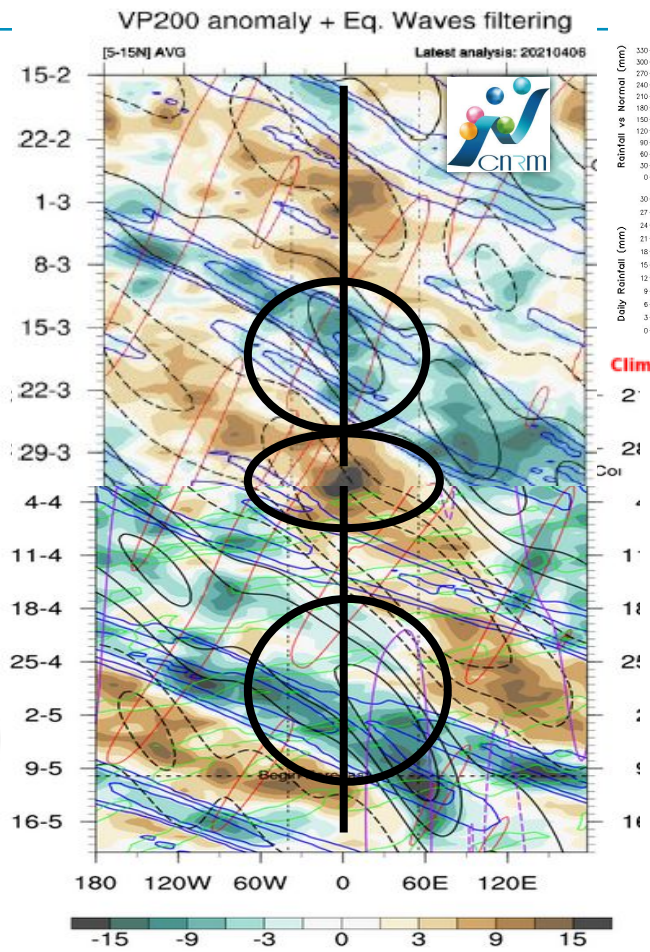


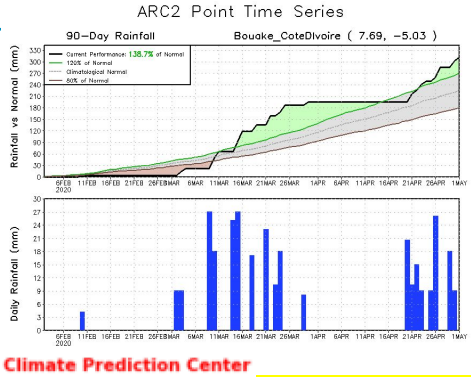


What can distinguish a MJO event from another ?



Precip IMERG 10W-10E



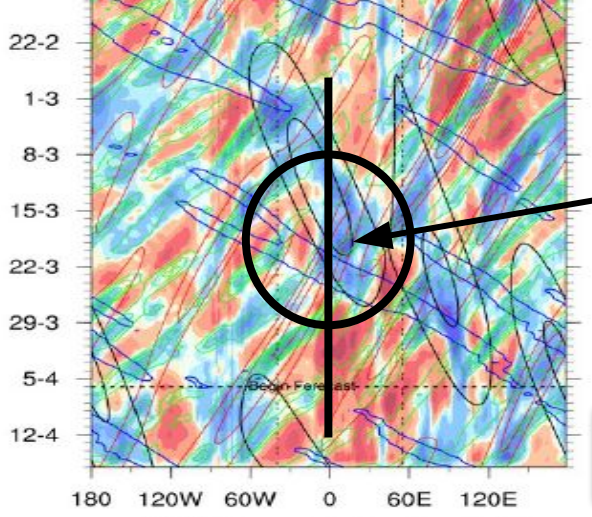


Precip Bouake, Ivory Coast

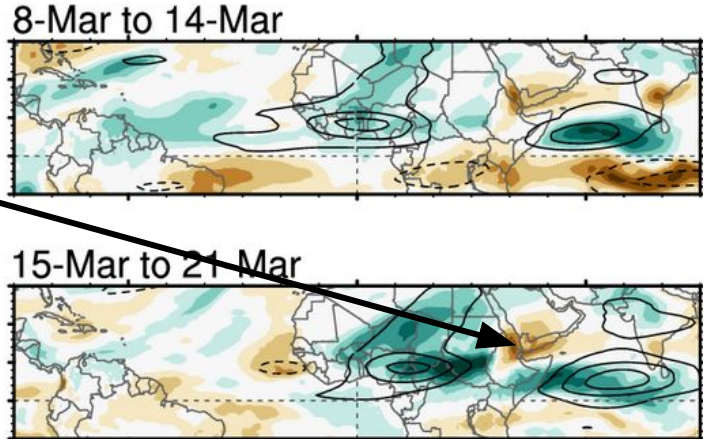
2 pre-monsoon wet spells fit with VP200 very well

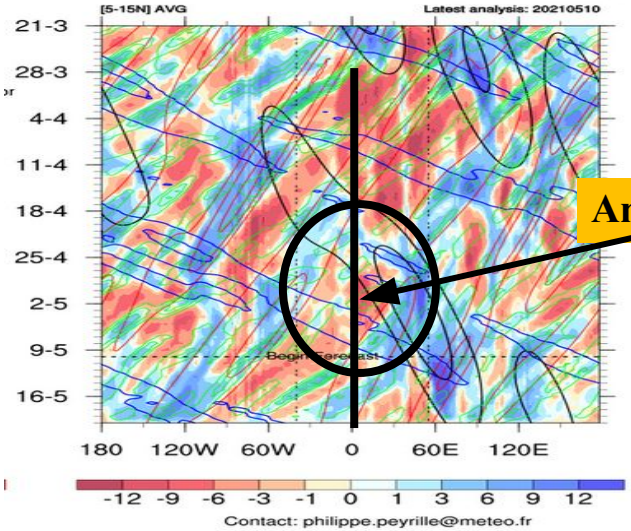
1st event was much more efficient

Why ?



Ano PW > 0





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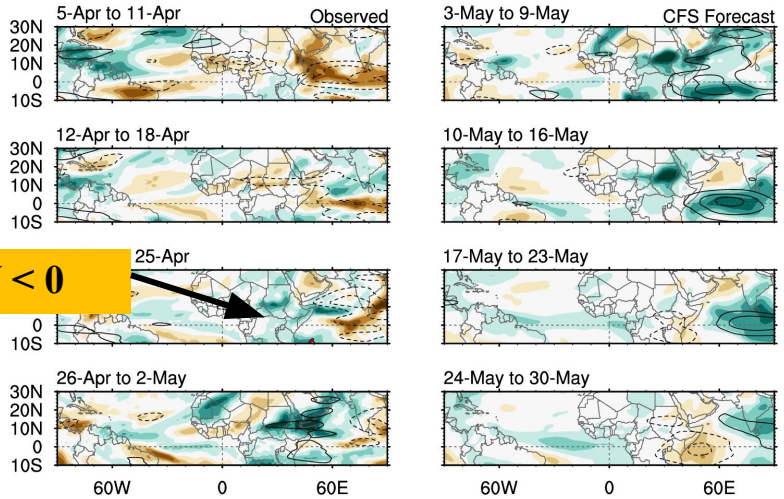


7-day PWAT with CFS forecasts

MJO
Kelvin x2
Low
ER

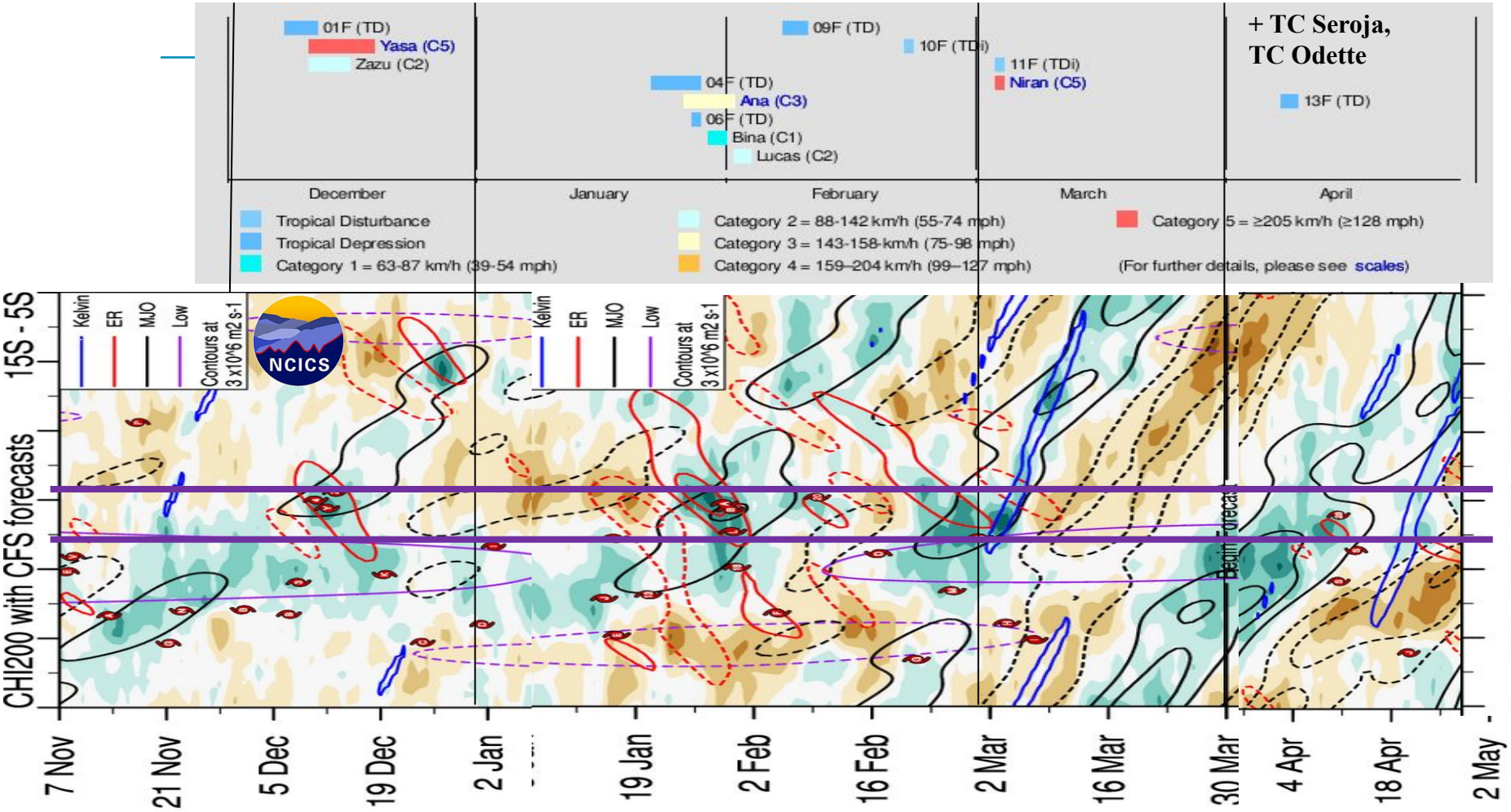
Contours every 3 kg m-2

Carl Schreck
carl_schreck@ncsu.edu

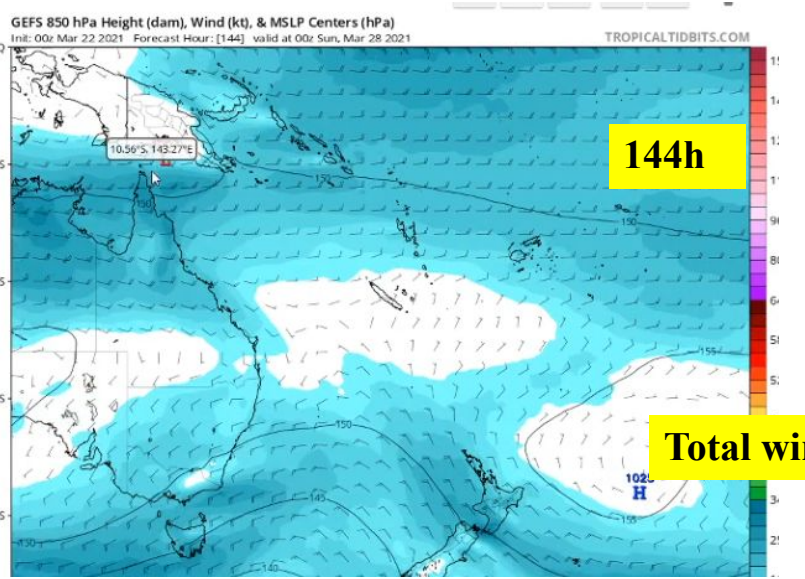
ncics.org/mjo

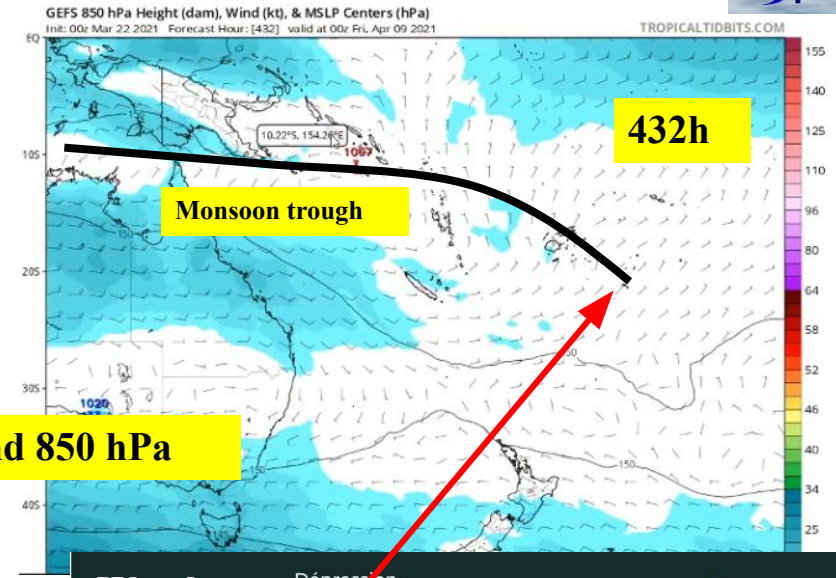
Mon 2021-05-03 1014 UTC

TC outbreaks versus VP200 in the southwest Pacific Ocean



Total field is needed





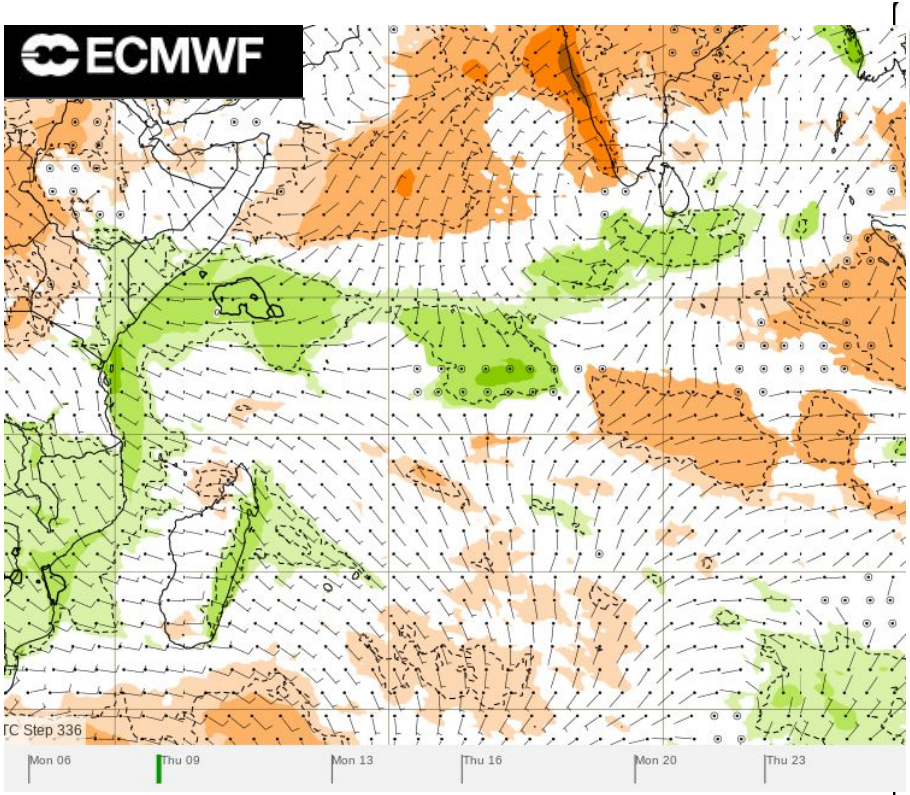
Total wind 850 hPa

Weather type	Dépression tropicale ou cyclone	Coup d'ouest	Fortes pluies	Fortes chaleurs
Alizé stable	Exclu	Exclu	Exclu	/
Alizé instable	/	Exclu	Favorisé	Favorisé
Temps tropical	Favorisé	/	Favorisé	Favorisé
Perturbation australe	Exclu	Favorisé	/	Exclu
Anticyclonique faible	Exclu	Exclu	Exclu	/

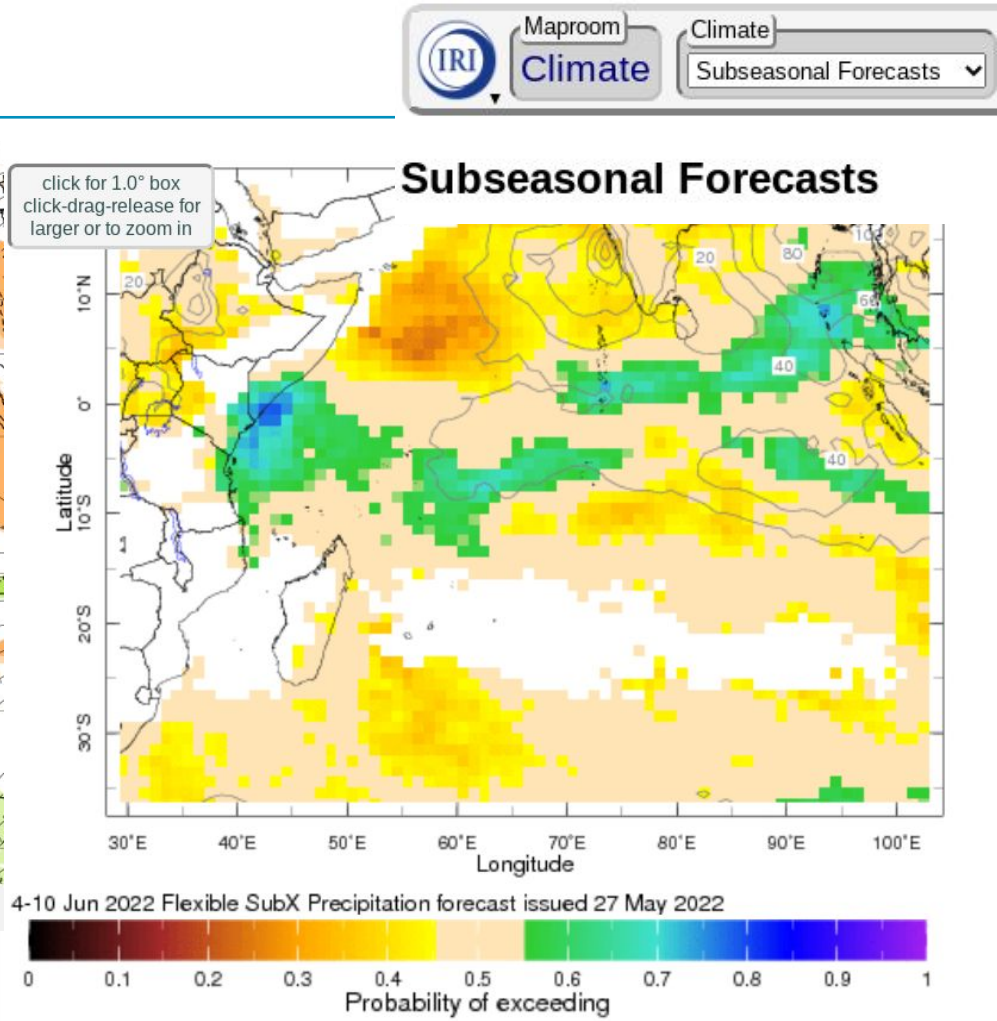
l 9 Apr

Total field makes the link with the weather type approach and thus the synoptic scale

Multi-model approach



Week 2



Etapes de la méthode

1. Identification des anomalies de basse fréquence en cours et prévues
2. Analyse / Prévision de la MJO
   - Canonique en indice RMM traditionnel ?
   - S'exprime dans d'autres paramètres que l'OLR ? En VP200 ? En U850 ?
3. Prévision des ondes équatoriales de Kelvin et Rossby (surtout en S1/S2)
4. Synthèse des acteurs S2S (ingrédients propagatifs et stationnaires: VP200)
   - Anomalies attendues selon cartes composite si MJO robuste
   - *Elaboration ANAGEQ-PREGEQ (PREvision Graphique des ondes EQuatoriales)*
5. Etude des paramètres finaux des modèles numériques de prévision infra-saisonnière (pluie, vent basses couches, tempêtes tropicales)
   - Champ total en moyenne hebdomadaire (seulement pour océan Indien)
   - Anomalies hebdomadaires (brutes, calibrées) et cohérence avec composite MJO et ondes
   - EFI (Extreme Forecast Index)
   - Probabilités de cyclogenèse
6. Rédaction bulletin technique; Nebul technique (*Consultation bulletins étrangers*)
7. Transcription pour le grand public ou des usagers professionnels sous forme d'information à valeur décisionnelle.

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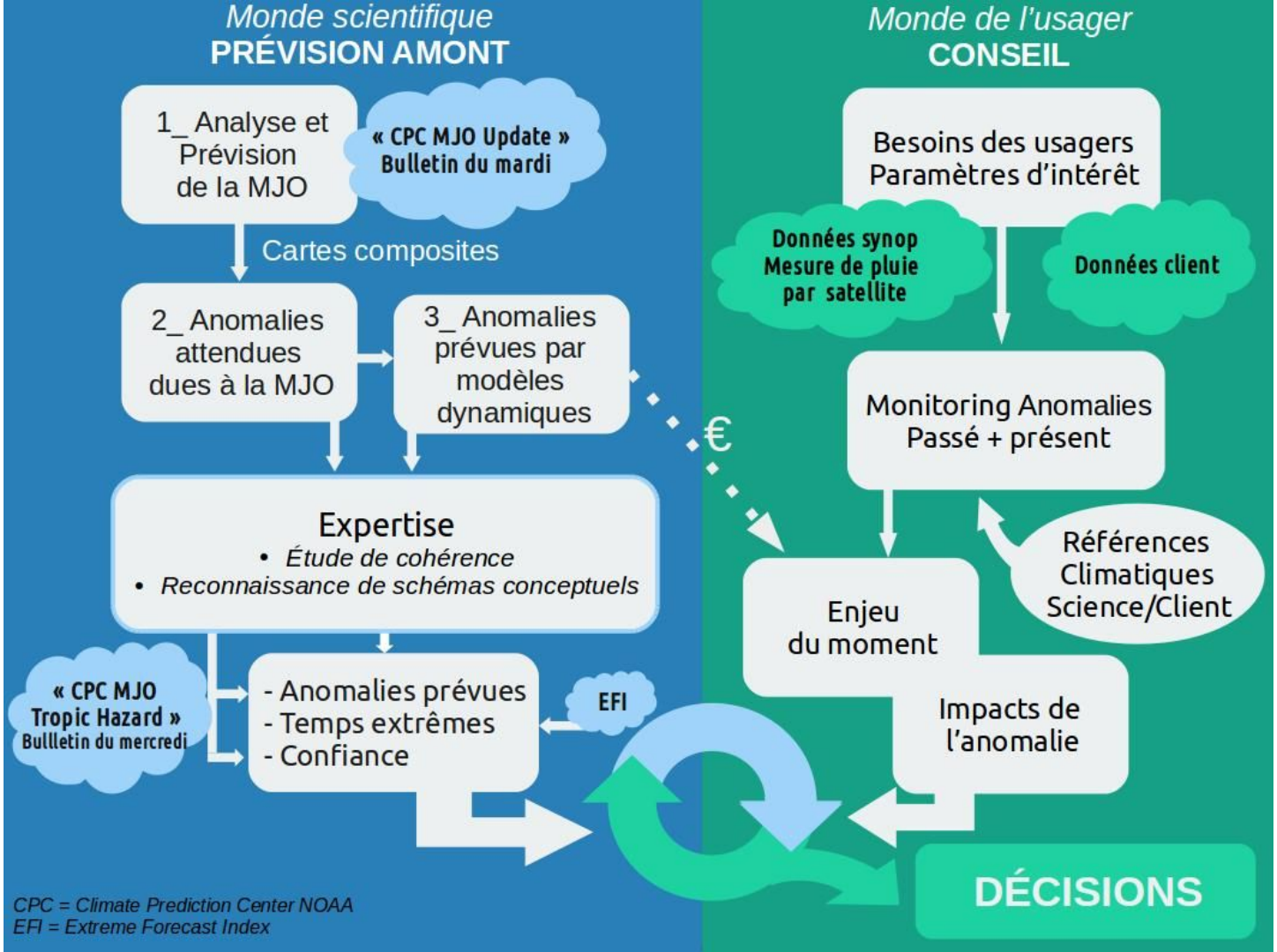
Monde scientifique
PRÉVISION AMONT
1_ Analyse et Prévision de la MJO
« CPC MJO Update »
Bulletin du mardi
Cartes composites
2_ Anomalies attendues dues à la MJO
3_ Anomalies prévues par modèles dynamiques
Expertise
• Étude de cohérence
• Reconnaissance de schémas conceptuels
« CPC MJO Tropic Hazard »
Bullletin du mercredi
- Anomalies prévues
- Temps extrêmes
- Confiance
EFI
Monde de l'usager
CONSEIL
Besoins des usagers
Paramètres d'intérêt
Données synop
Mesure de pluie par satellite
Données client
Monitoring Anomalies
Passé + présent
€
Références
Climatiques
Science/Client
Enjeu du moment
Impacts de l'anomalie
DÉCISIONS
CPC = Climate Prediction Center NOAA
EFI = Extreme Forecast Index

Take-away messages

The MJO and CCEW are the ones who pull the strings

At subseasonal range, numerical models predict the behaviour of the **artists** better than the one of the **puppets**

Take-away message

- Testbeds are a powerful tool for the transfer of research to operations
- A human intervention adds value in the process of delivering user-oriented meteorological information, at least for certain categories of users.
  - in exploiting/extracting the best of numerical prediction and physical conceptual models
  - in accompanying the model outputs through comprehensive words for decision-making
- Weather forecasters and climatologists (seasonal forecasters) should work together

gran mersi, oplesir *mi romersi azot*