

Study of the intra-seasonal predictability of the ITCZ migration and of the associated heavy rainfall over the northern southwestern Indian Ocean basin.

Andréa Cachard.

Encadrés par :  
Sylvie Malardel, François Bonnardot, Hélène Vérèmes.

2 juin 2022

## Objectives :

- Setting up a method for automatic detection of the ITCZ with model output fields
- Developing a probabilistic product with the 50 members of the ECMWF ensemble forecast at the intra-seasonal scale, with extended-range forecast from one week to four weeks

## Outlines of the presentation

- 1 A quick reminder of the ITCZ
  - Definition
  - Location around the world
  - Zoom on the Indian Ocean
- 2 Automatic detection of the ITCZ
  - Method
- 3 Climatology
  - Climatology with ERA5
  - Onset from 2017 to 2020
- 4 Application to ensemble forecasting
  - Replay situation : onset of season 2021/2022.
- 5 Results with ERA5
  - Results obtained for ERA5
- 6 Conclusion

The Intertropical Convergence Zone (ITCZ) is an east-west-oriented low-pressure region near the equator where the surface northeast and southeast trade winds meet. This convergence zone creates updrafts and therefore convective systems. Associated with these systems is heavy precipitation.

The ITCZ is a very important climatic feature in the tropics where it interacts with the global atmospheric and oceanic circulation on a planetary scale.

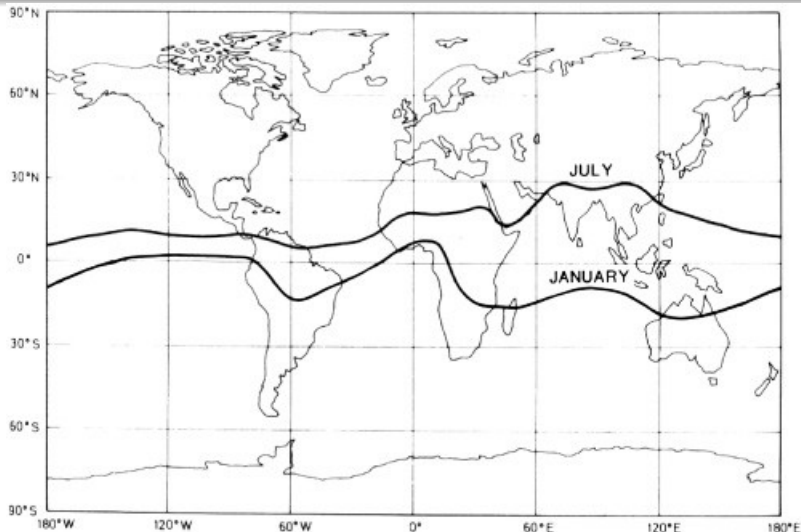
The ITCZ generates heavy rainfall events that can be dangerous for humans and their properties but it is also an essential source for the water resource.

The main issues with these heavy rainfall events are :

- torrential rain and floods
- Water resources
- Agriculture
- change of wind direction → consequences on fishing

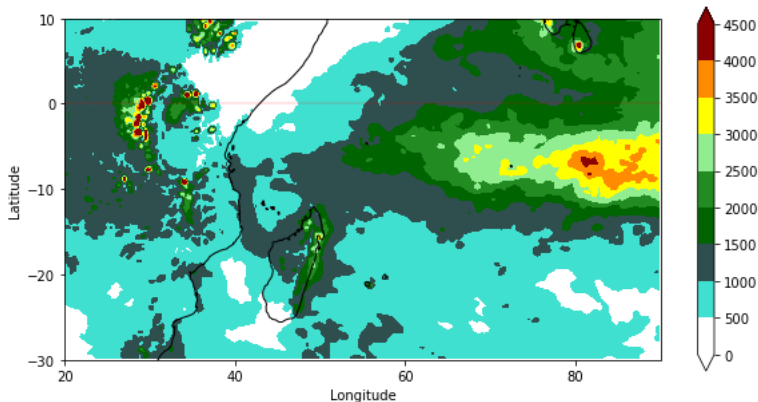
Presentation of the topic  
A quick reminder of the ITCZ  
Automatic detection of the ITCZ  
Climatology  
Application to ensemble forecasting  
Results with ERA5  
Conclusion

Definition  
Location around the world  
Zoom on the Indian Ocean



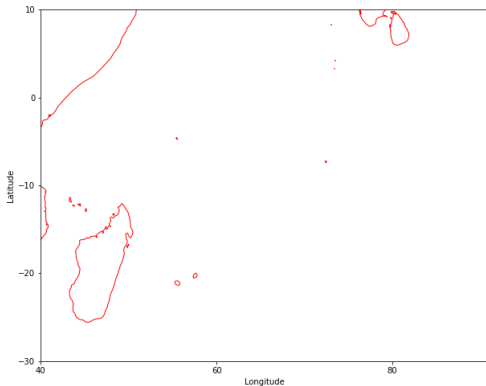
Location of the ITCZ around the globe during the year. ([https://link.springer.com/referenceworkentry/10.1007/1-4020-3266-8\\_10](https://link.springer.com/referenceworkentry/10.1007/1-4020-3266-8_10))

- Strong migration :  $25^{\circ}\text{N}$  in July and  $10/15^{\circ}\text{S}$  in January.
- It is active with an important annual rainfall.



*1 year rain accumulation in mm (2021) from ERA5.*

Work area : from longitude 40°E to 90°E and from latitude 10°N to 30°S.

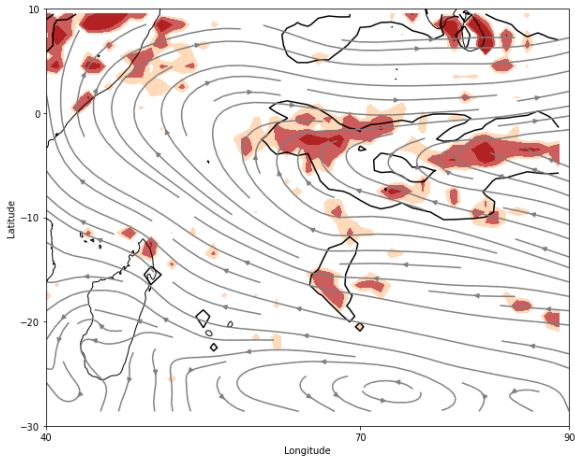




## basin configuration

1. **During boreal summer (June → September) :**
  - ITCZ is located in the northern hemisphere
2. **Transition period (October/November and April/Mai) :**
  - NET (Near Equatorial Through)
3. **During boreal winter (December → March) :**
  - Monsoon thalweg
  - meteorological equator

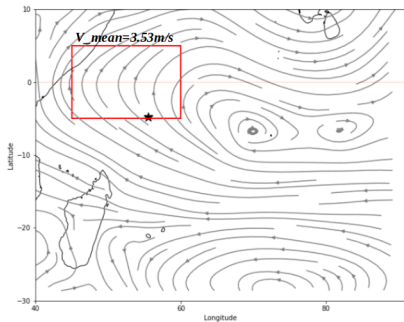
## NET is located in the cyclonic curvature of the trade wind



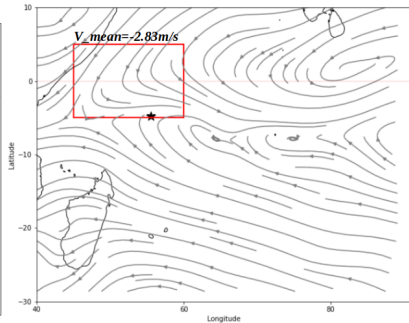
*Example of NET in october 2021 with convergence at 850hPa(colors) and precipitations in mm (black contours) from ERA5.*

## Monsoon flux index

Monsoon flux index = average meridional wind in the red box



10/2021



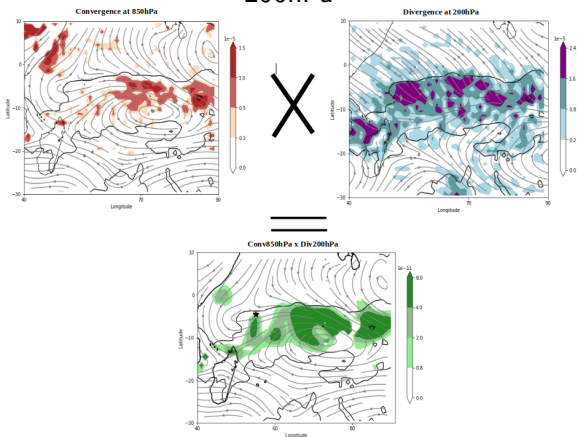
12/2021



*Representation of the average meridional winds for each week of each month during the last three years.*

## ITCZ position index : field determination

Position of the ITCZ : Convergence at 850hPa and Divergence at 200hPa



## ITCZ position index : method

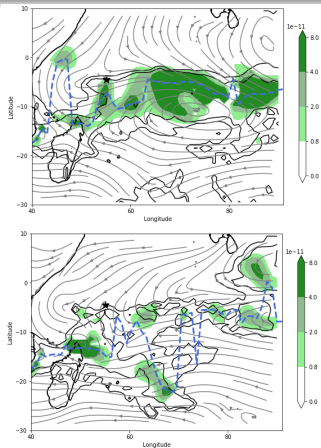
1. Calculate the maximum of *Conv850* x *Div200* field for each longitude.
2. Find the most common latitude range between these maxima
3. Find the first point that is part of this latitude range starting from the East and from the West of the basin.
4. From this point (n), we calculate the position of the next point (n+1) by looking for the max of *Conv850* x *Div200* between the position of point  $n \pm 2^\circ$ .
5. Choose the best diagnosis according to the precipitation

## ITCZ position index : step n°1

formula used to calculate the maximum of the parameter :

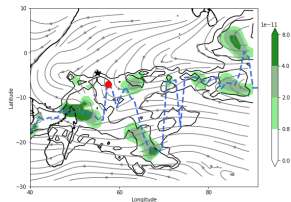
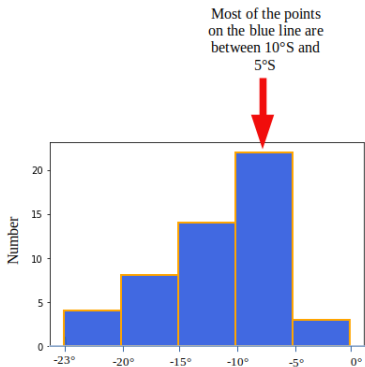
$$\phi_E = \frac{\int_{\phi_1}^{\phi_2} \phi [\cos(\phi)P]^N d\phi}{\int_{\phi_1}^{\phi_2} [\cos(\phi)P]^N d\phi}$$

(Article : *Seasonal and Interannual Variations of the Energy Flux Equator and ITCZ. Part I : Zonally Averaged ITCZ Position.* ADAM et al, 2015)

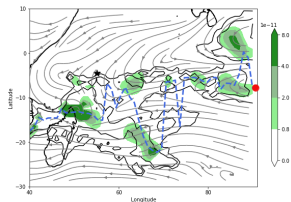


Application of the formula on two examples

## ITCZ position index : step n°2 & 3



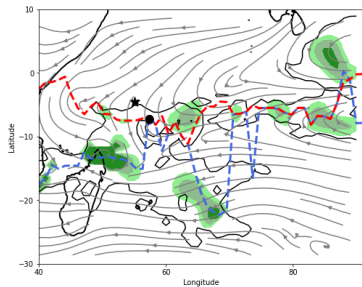
*First point between 5°S and 10°S starting from the west*



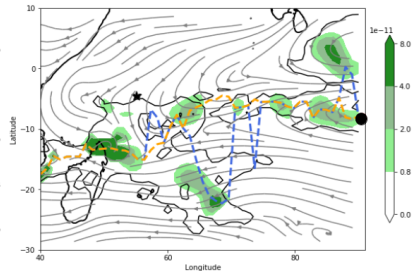
*First point between 5°S and 10°S starting from the east*



## Step n°4 : Sliding window method

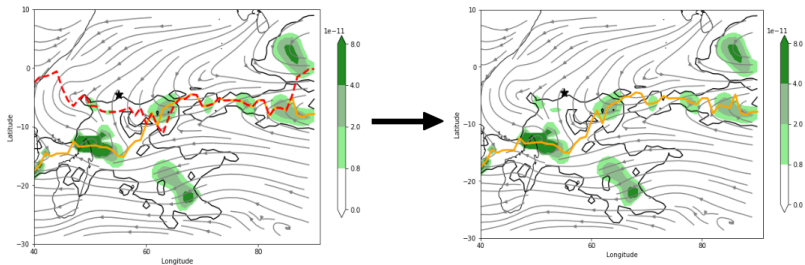


*Red = result starting from the west*



*Orange = result starting from the east*

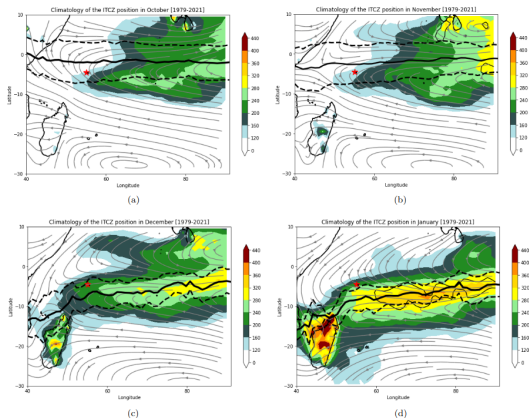
## ITCZ position index : Step n°5



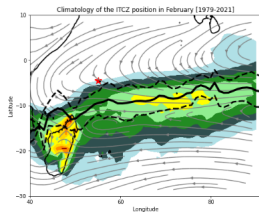
## ERA5

- ERA5 is the re-analysis of the 5th generation European medium-range weather prediction center
- provides hourly estimates of a large number of atmospheric, land and oceanic climate variables.
- the best horizontal resolution is  $0.25^{\circ} \times 0.25^{\circ}$  ( 30km)
- 137 vertical levels (from the surface up to a height of 80km)

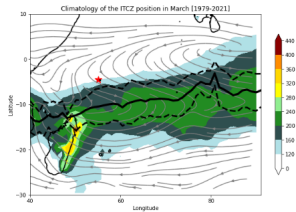
## monthly climatology with ERA5 data over the period 1979-2021



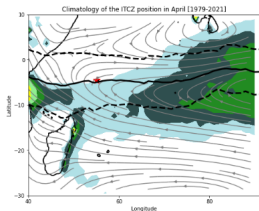
Average accumulated rainfall over a month(in colors),monthly average climatology of ITCZ position(black line) and standard deviation(dotted lines).



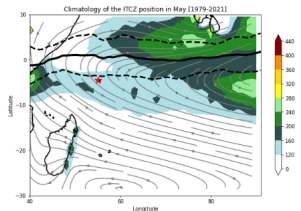
(e)



(f)

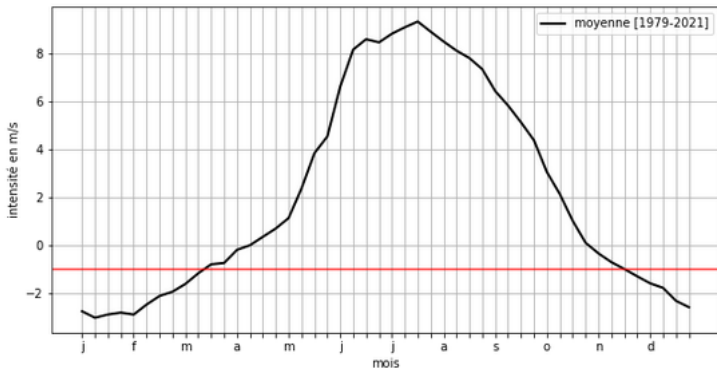


(g)

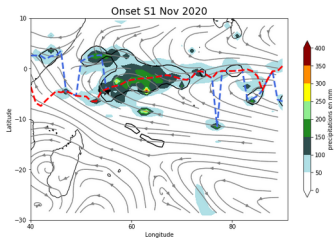
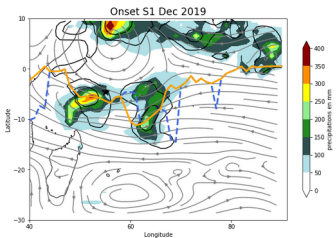
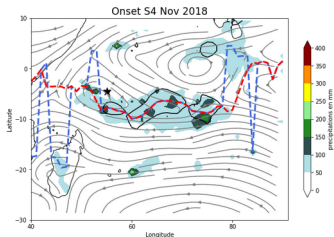
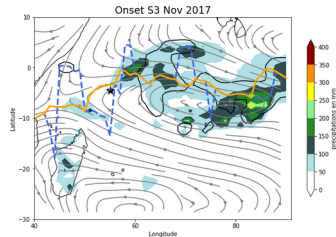


(h)

## Average monsoon flow index



## Onset of the last 4 seasons

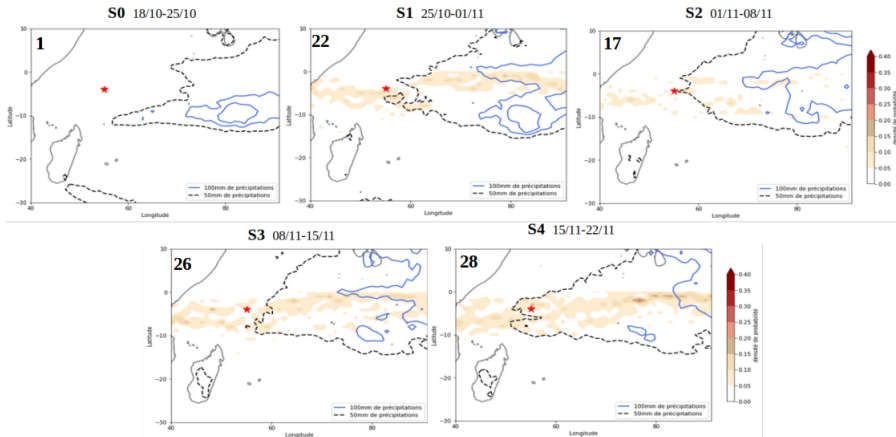


## Monthly forecast of ECMWF

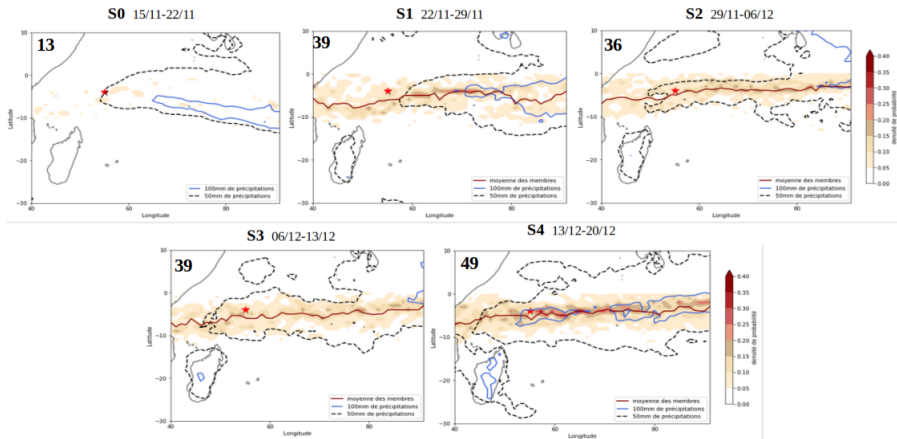
- 51-members ensemble
- forecast extended to 46 days
- 1° horizontal resolution



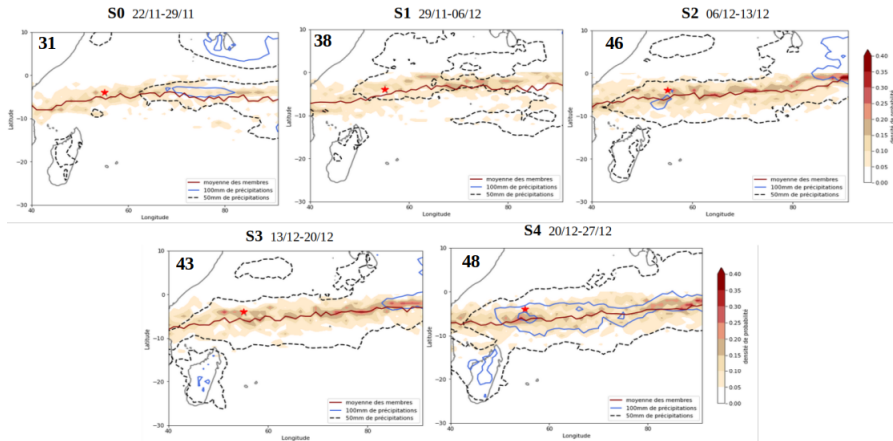
# Run of 18/10/2021



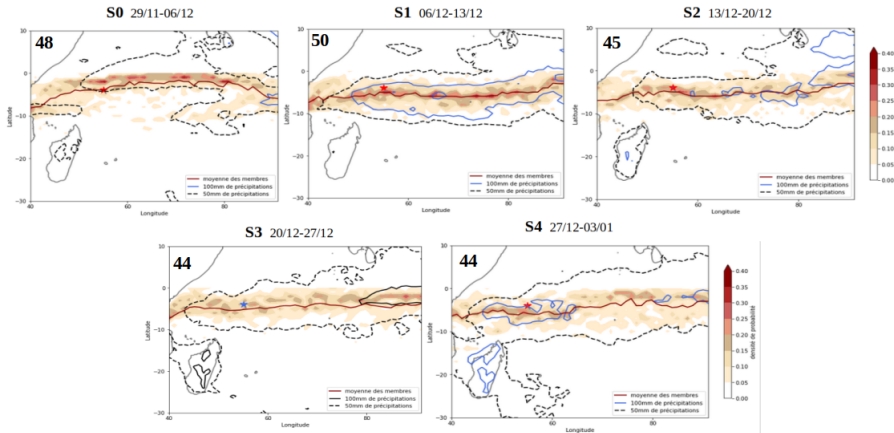
# Run of 15/11/2021



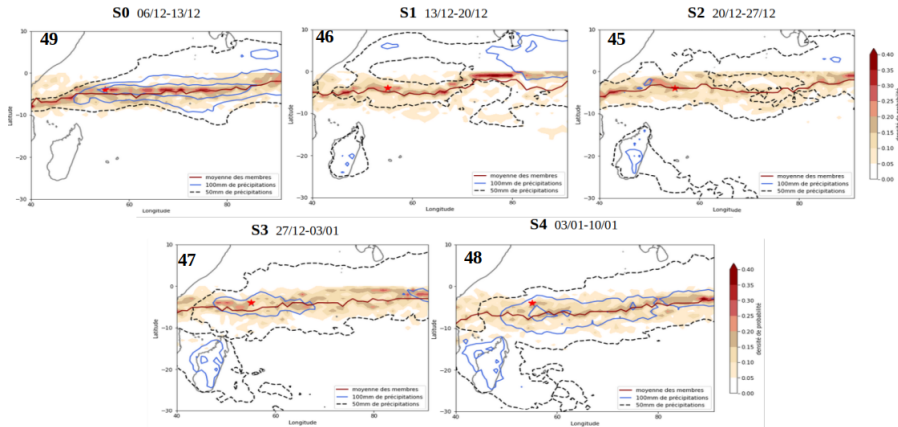
## Run of 22/11/2021



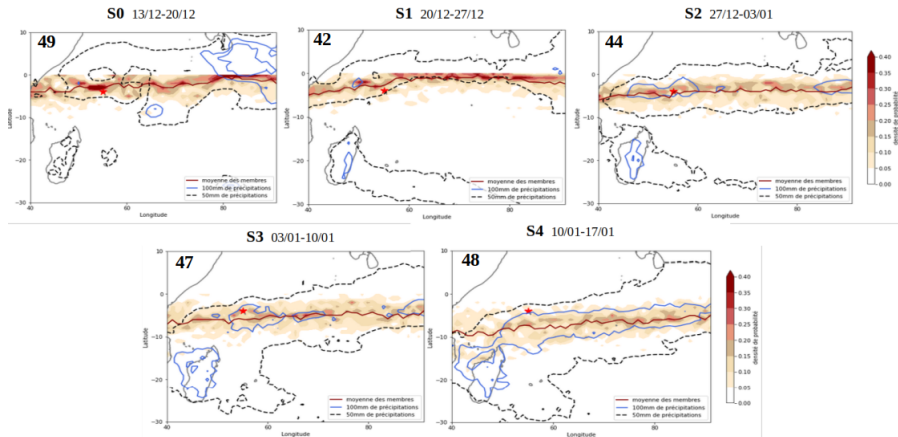
## Run of 29/11/2021

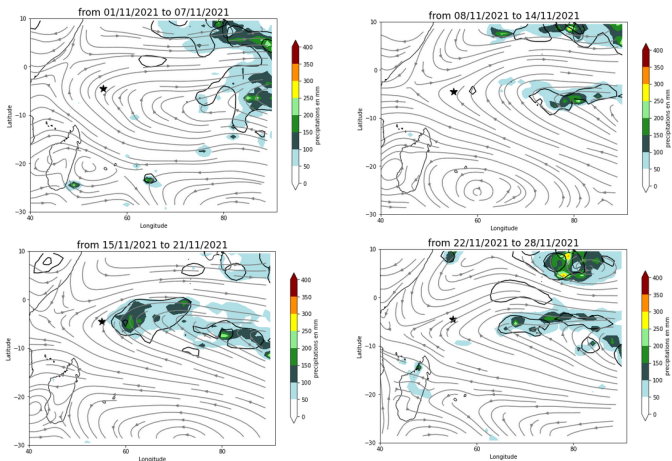


# Run of 06/12/2021

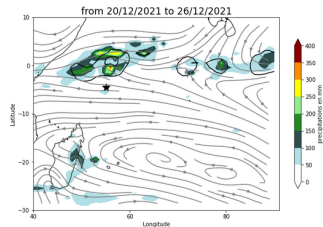
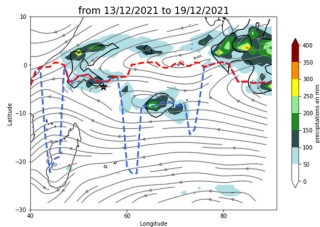
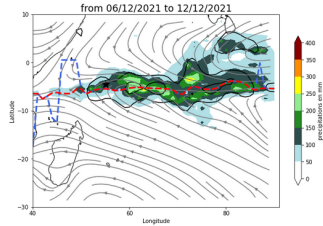
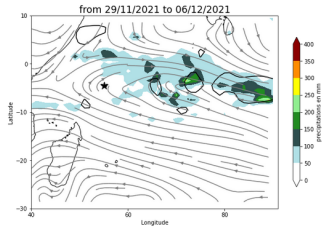


# Run of 13/12/2021

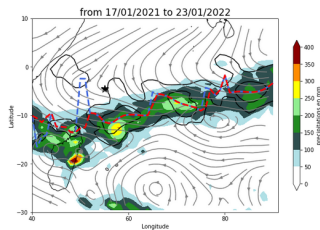
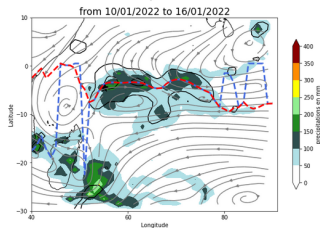
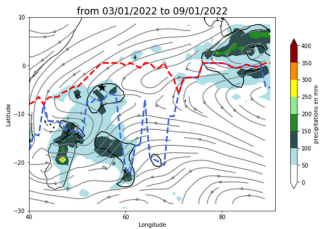
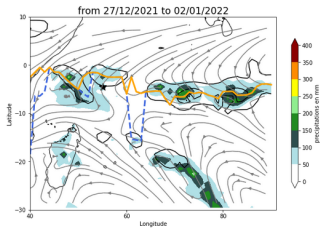




Rain accumulation over one week in mm (colors), ConvxDiv(black contours), winds flux (grey)







## Onset of 2021 :

- ITCZ delay well anticipated by ECMWF
- Good anticipation of the onset (2 weeks in advance)

## Method :

- works well when the ITCZ is active

Thank you.