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A comparative study on the genesis of North Indian Ocean cyclone Madi (2013) and Atlantic Ocean cyclone Florence (2006)

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A presentation
by
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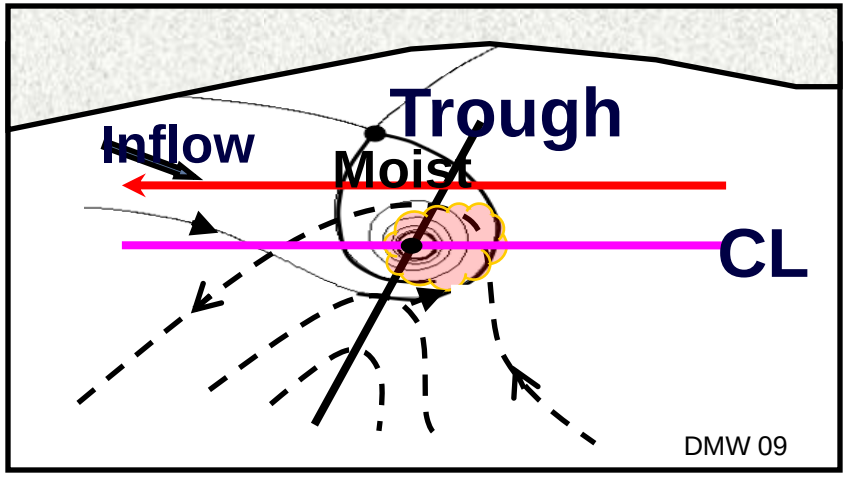
Scientific problem

"To understand the role of the wave pouch in the vorticity upscale cascade (H1 in the marsupial paradigm) and in preventing the dry air intrusion (H2 in the marsupial paradigm)"

Dunkerton et al., 2009

- Marsupial paradigm (H1-H3)
  - H1- Roll up of vorticity/ wave breaking
  - H2- Pouch region
  - H3- Meso-scale vortices

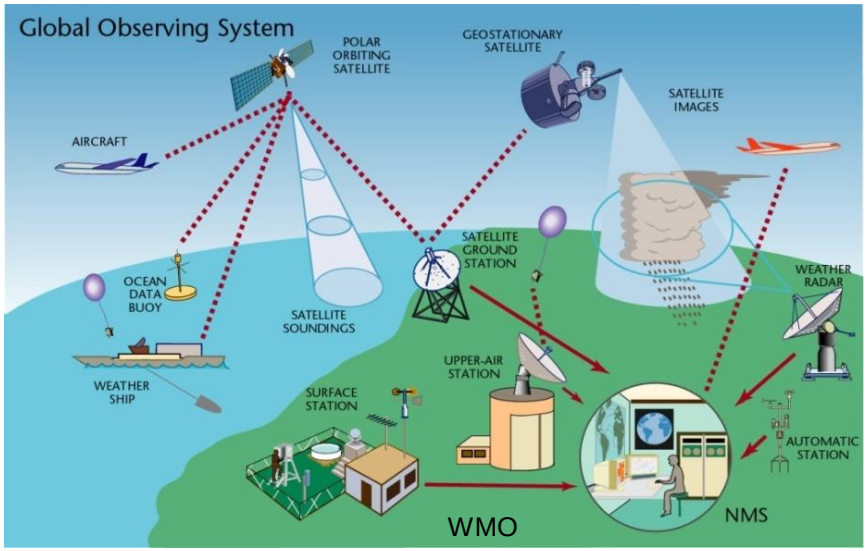


Objectives:

➢ **To compare the genesis sequence of a NIO (moist tropical) cyclone and AO (dry dusty) cyclone.**

Data and methodology

- IMD and NHC best track dataset
- MODIS AOD – 550nm
- AI data (1ºx1.25º)
- GOES satellite imagery
- MSG Satellite images
- ERA interim (0.125ºx0.125º)
- NCEP ADP upper air and surface observations
- Satellite Radiances

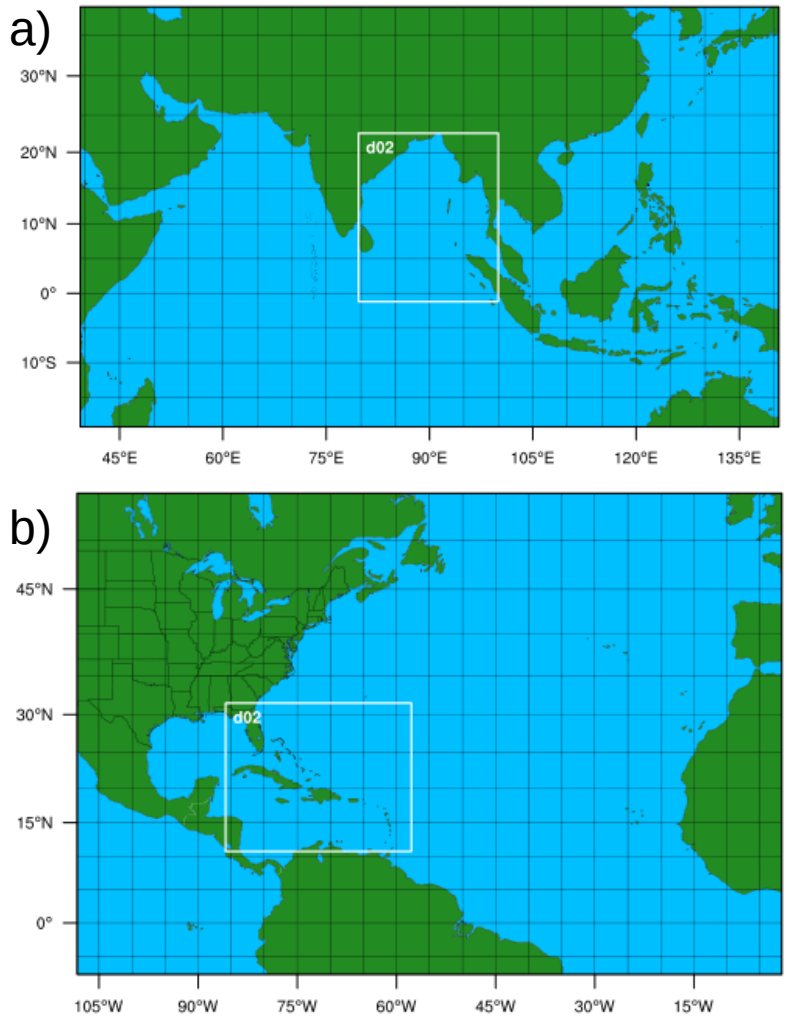


Satellite Sensors	Satellite Platform
AMSU A	NOAA 15,16,18, EOS Aqua and METOP-2
AMSU B	NOAA-15, 16, 17
AIRS	NOAA-18, and METOP -2
MHS	EOS Aqua

High resolution analysis is created using 3Dvar assimilation

Experimental design

Weather Research and Forecasting - WRF (Version 3.6.1) & WRFDA

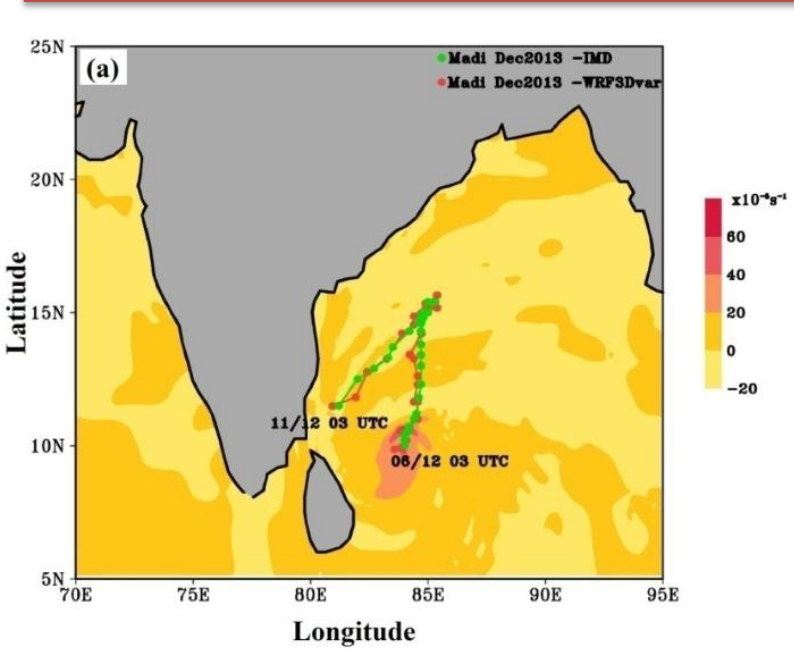


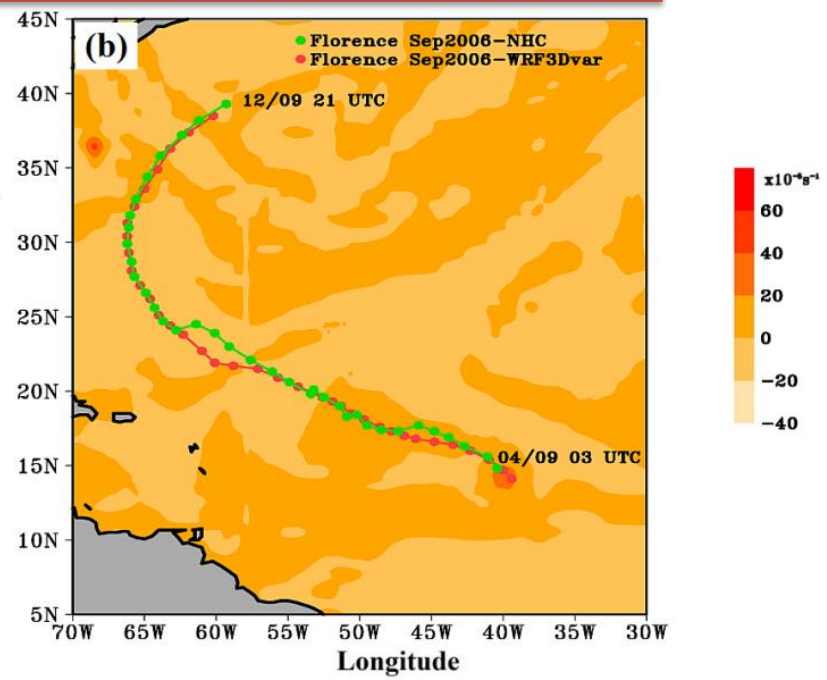
Details	Configuration
Dynamical core	ARW, compressible, Non-hydrostatic
Horizontal grid distance	18km(Domain 1), 6km (Domain 2)
Vertical levels	64
Model top	100 hPa
Initial and boundary conditions	GFS analysis (0.5 x 0.5), 6 hourly
Time step	30 s
Microphysics	Thompson
Long wave radiation	RRTM
Short wave radiation	Dudhia scheme
Surface layer	Monin Obukhov similarity theory
Land surface	Noah Land surface
PBL	Mellor Yemada Janjic
Cumulus	Kain-Fritch scheme

Simulation verification

Track

Madi	Florence





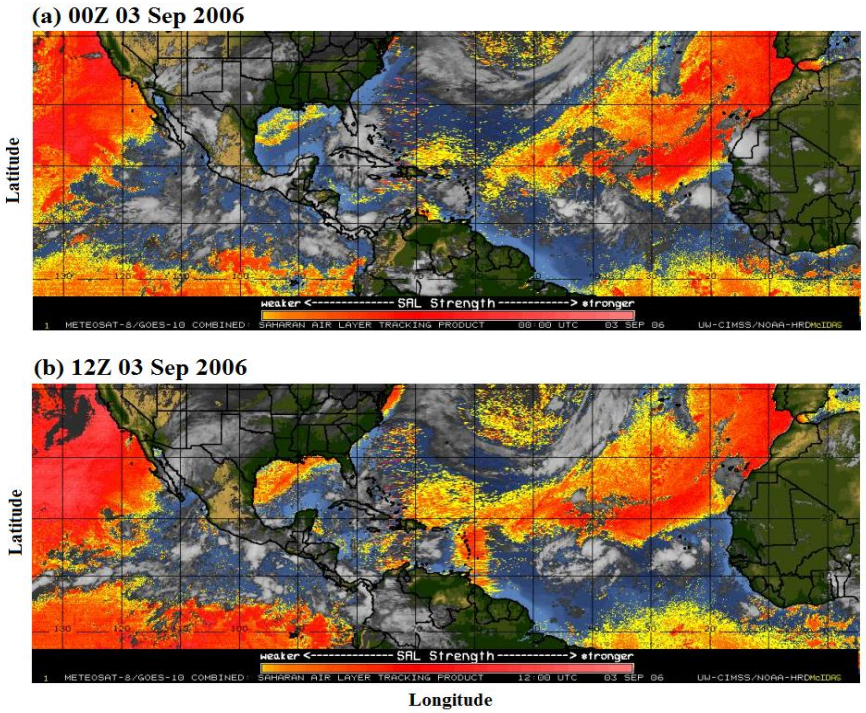
Best track in green and 3Dvar analysis in red

- **Formed on 6 December 2013**
- **Category 1 on 8 December 2013**
- **Formed on 3 September 2006**
- **Category 1 on 10 September 2006**

3Dvar analysis shows matching track for both the cyclones

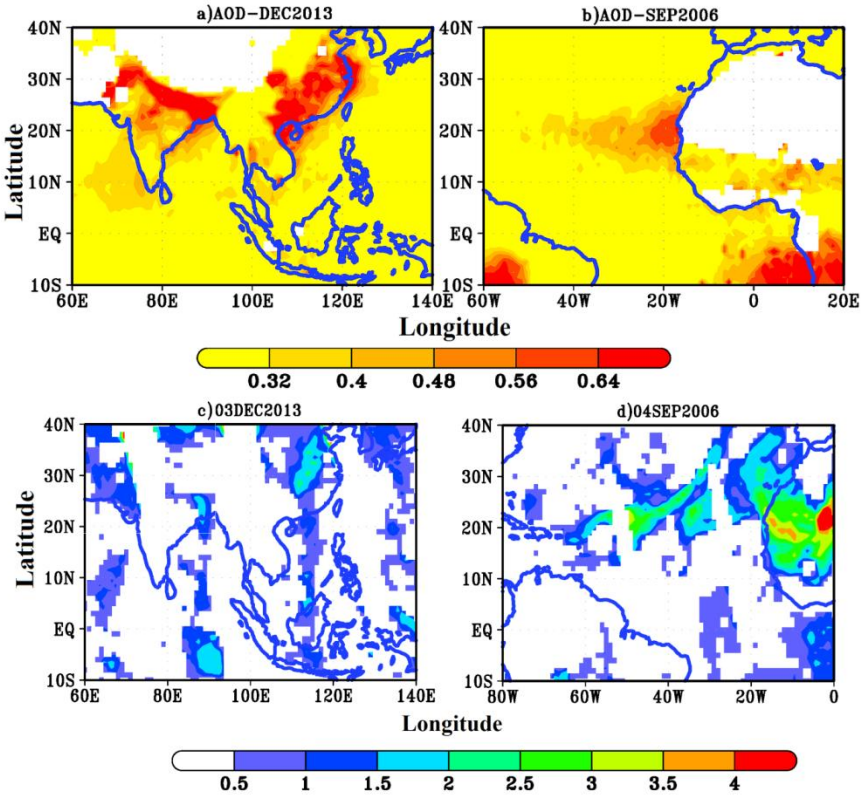
Dry air and moist tropical

METEOSAT-8/GOES-10 SAL



Yellow red shadings indicate likely SAL regions with increasing amounts of dust content

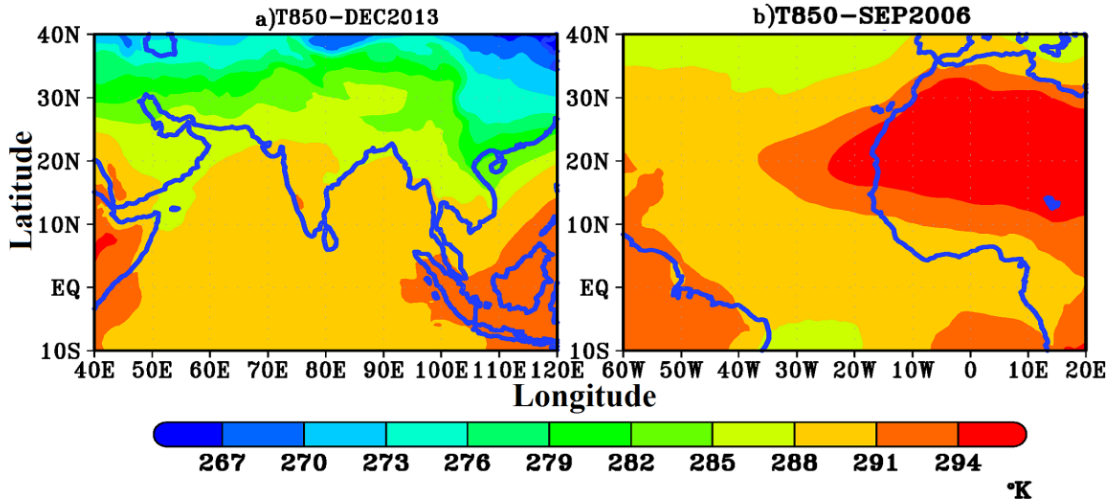
AOD and AI

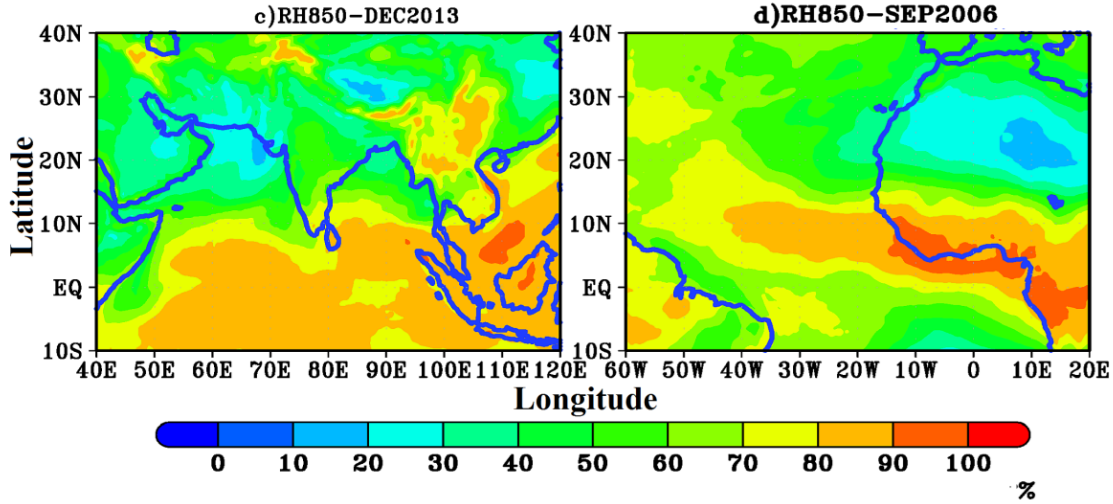


Heavy dust areas are indicated by AOD > 0.5 and AI > 3

Dry air and moist tropical

T-850 hPa

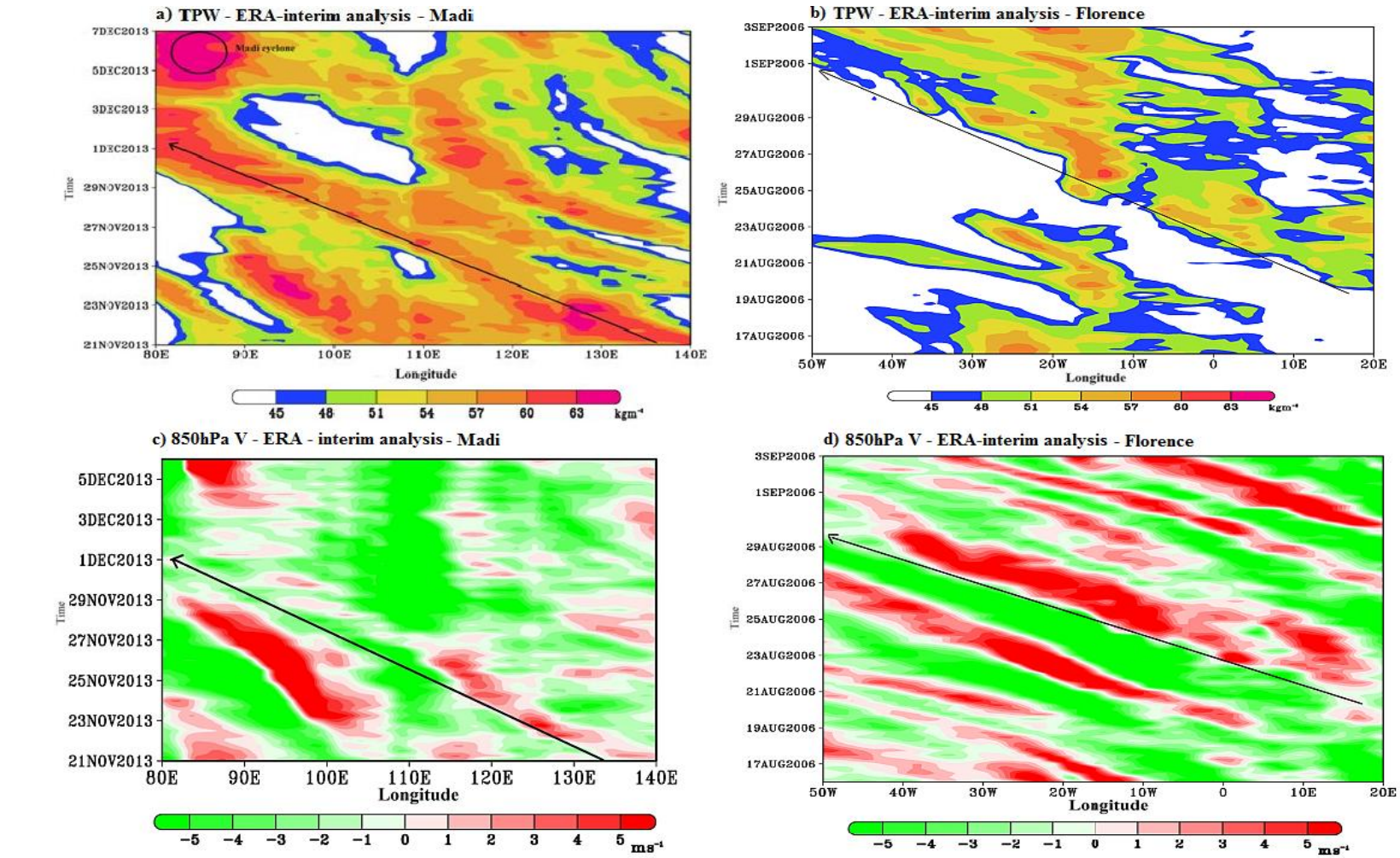




RH-850 hPa

The SAL region is associated with the air temperature (850hPa) more than 290K and RH < 70%

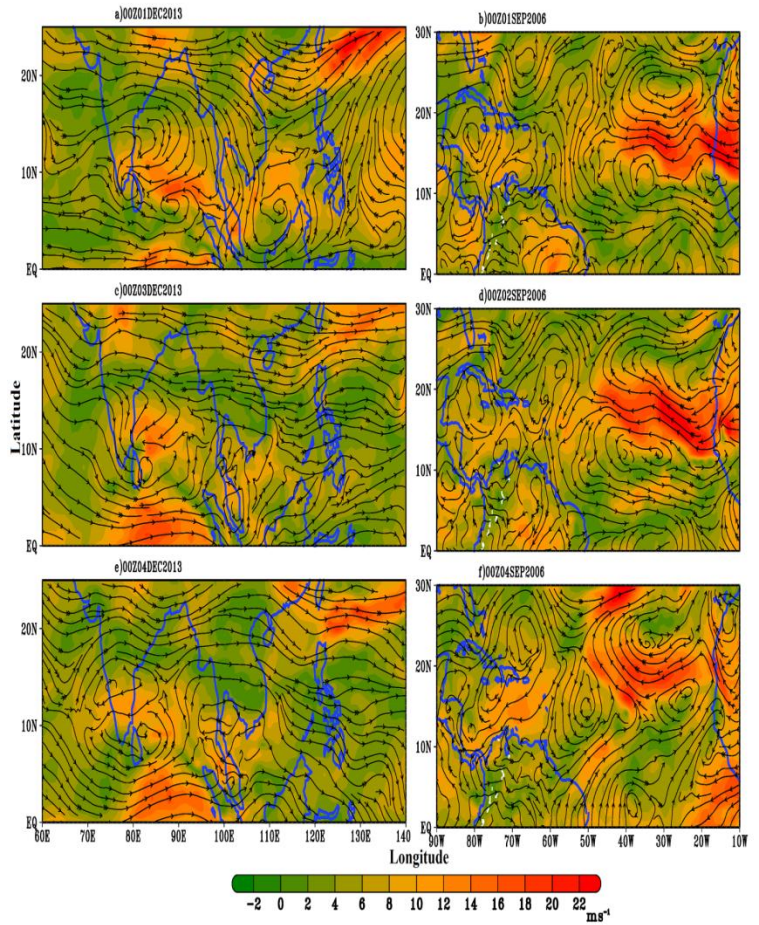
Parent disturbance tracking



Both these cyclones are originated from the westward moving parent disturbance

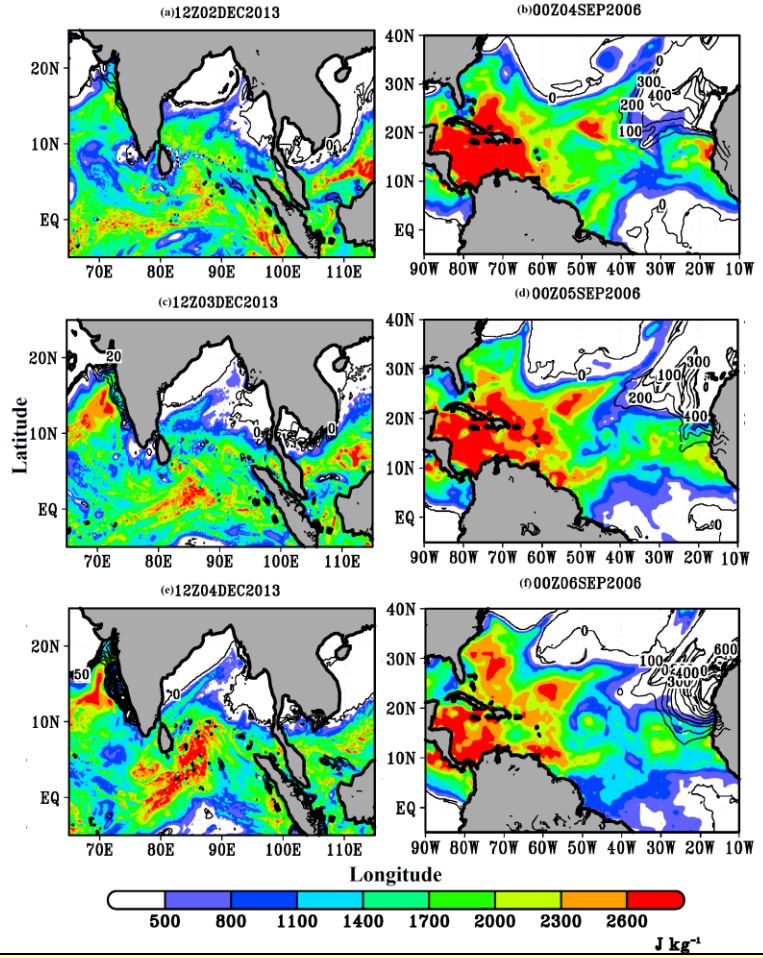
Parent disturbance tracking

Madi Florence



Wind speed and streamlines (850 hPa)

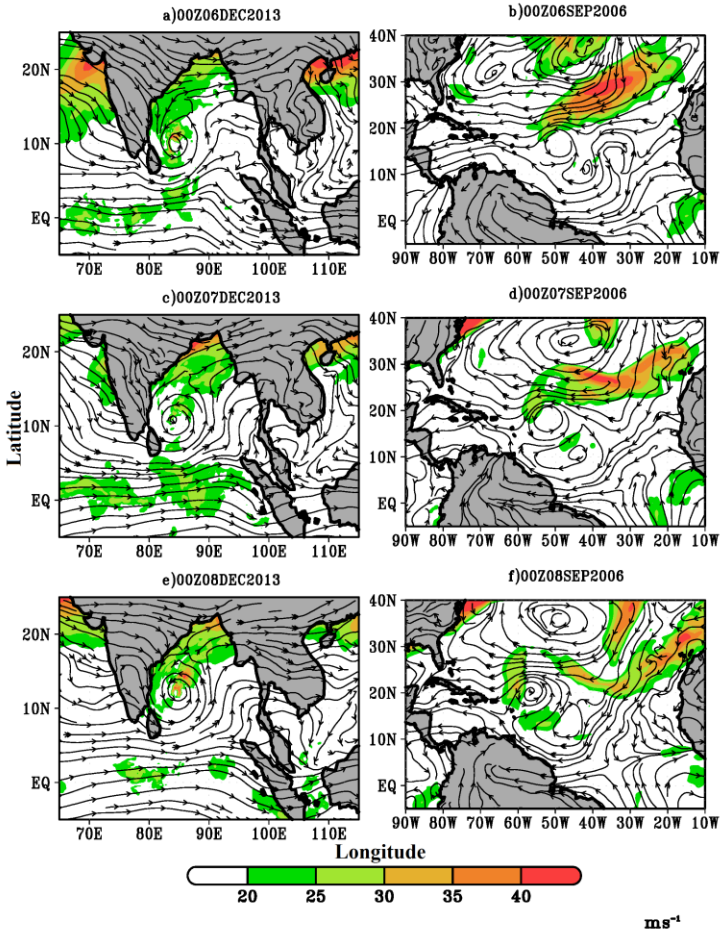
Madi Florence



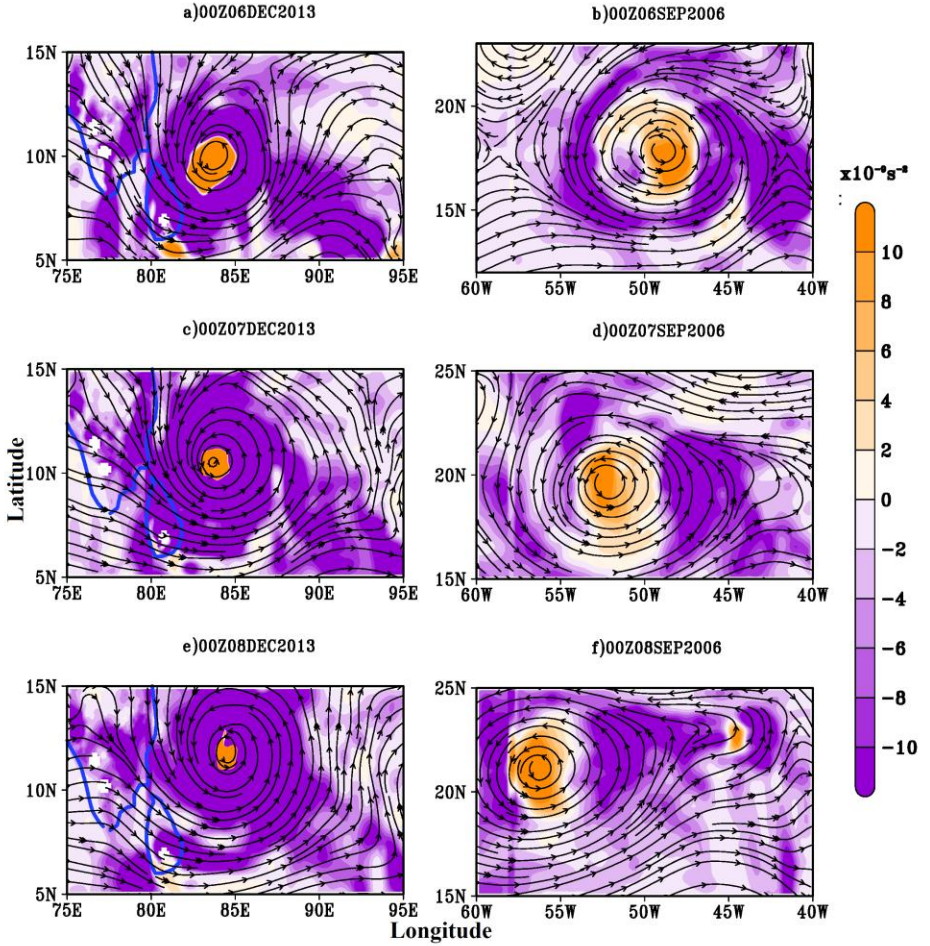
CAPE and CIN

Shear and Okubo – Weiss parameter

Madi Florence



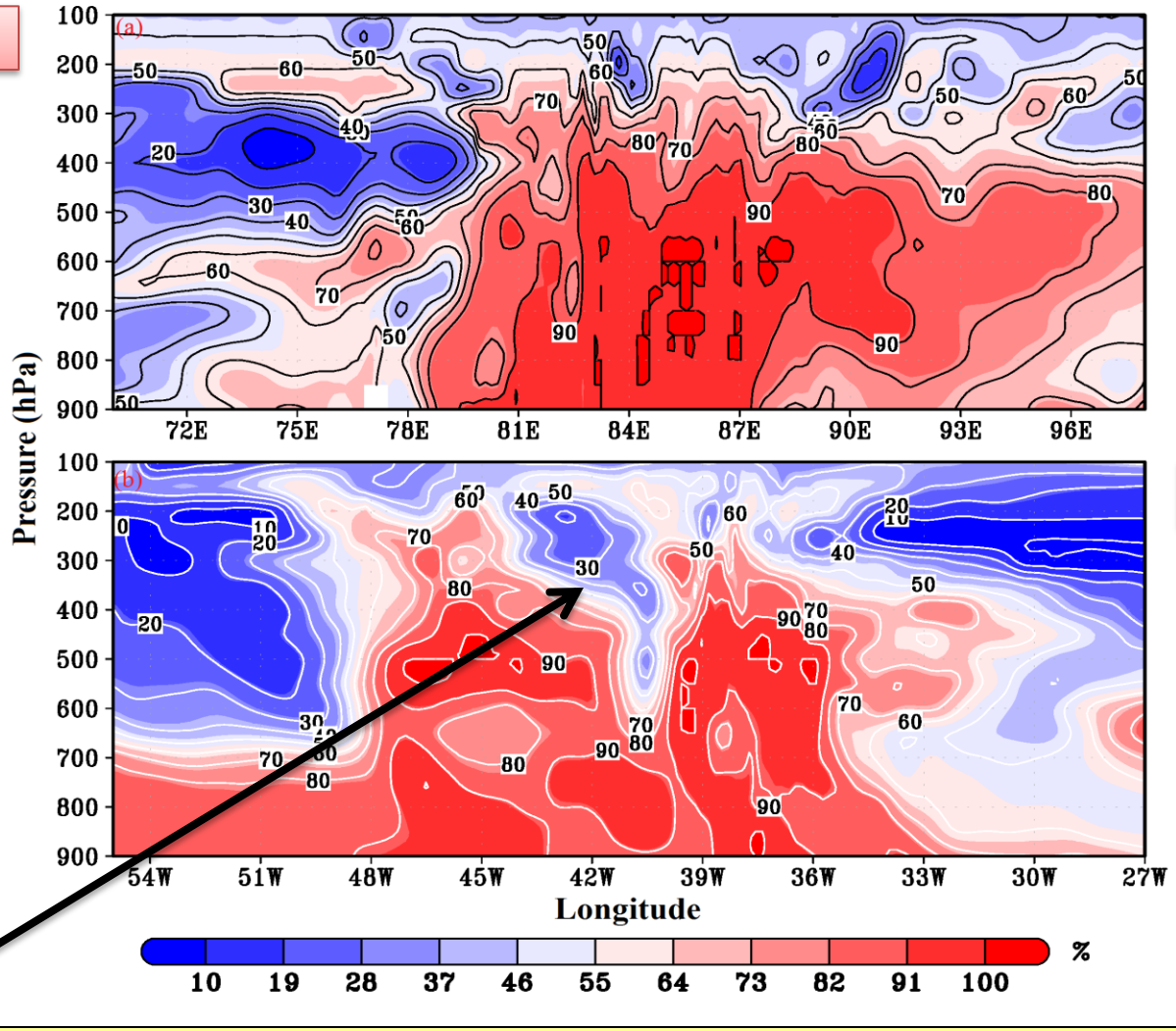
Madi Florence



Florence vortex grew into unusually large size than Madi vortex

Dry air intrusion – RH cross section

Madi

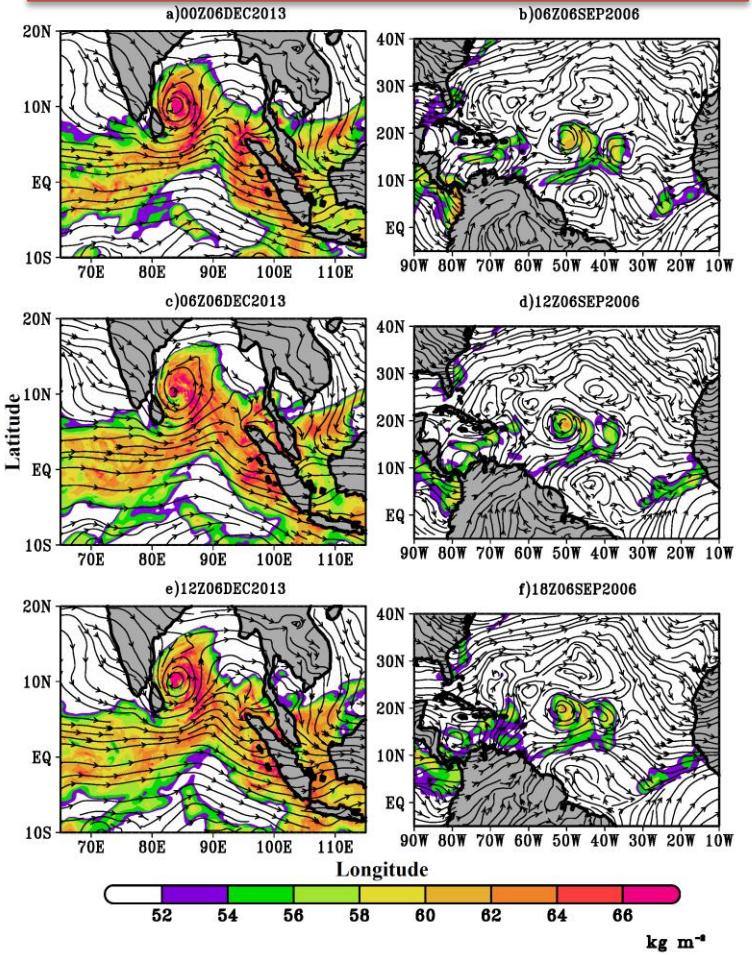


Florence

Dry air intrusion into the core of the vortex of Florence cyclone

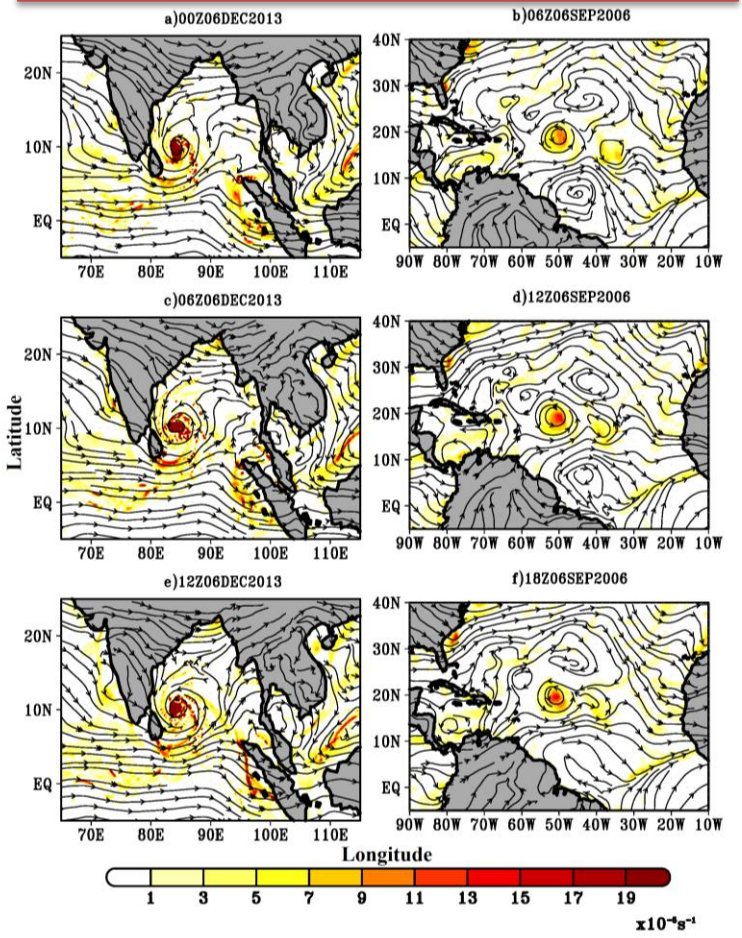
TPW and Vorticity

Madi **Florence**



Pouch acted as a protective region (H2) from the series of dust outbreaks

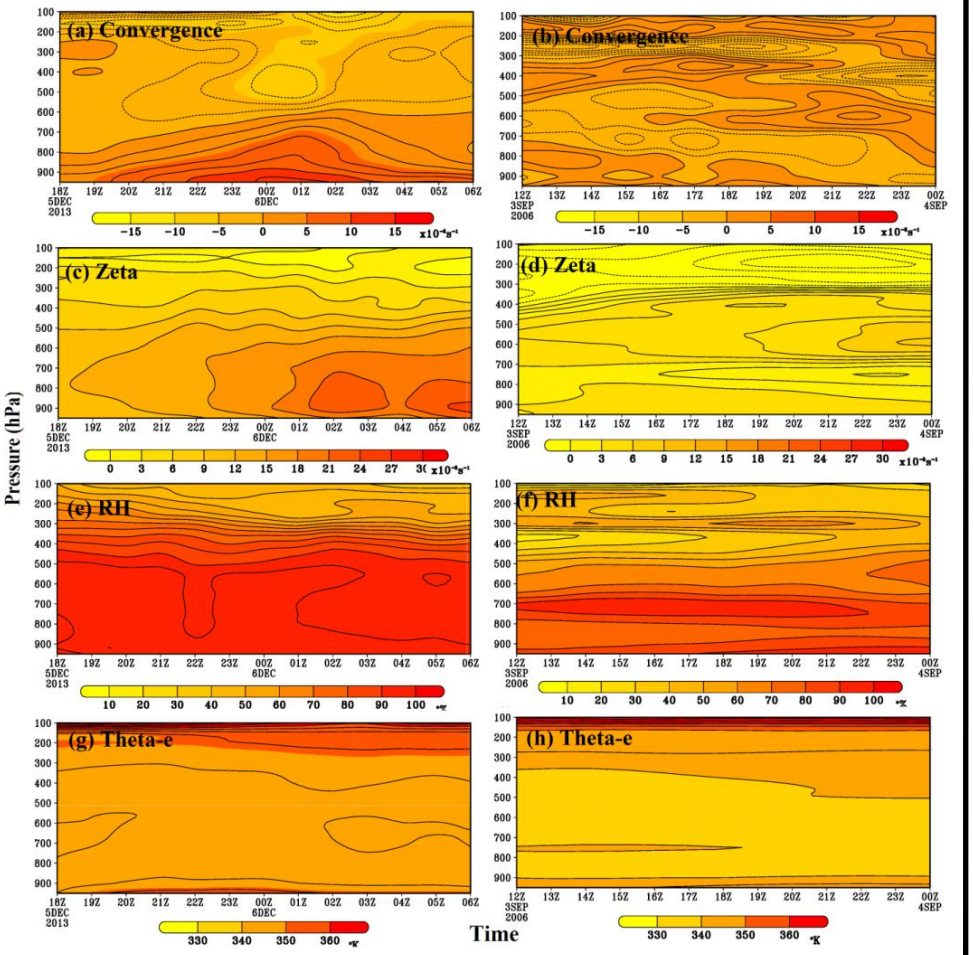
Madi **Florence**



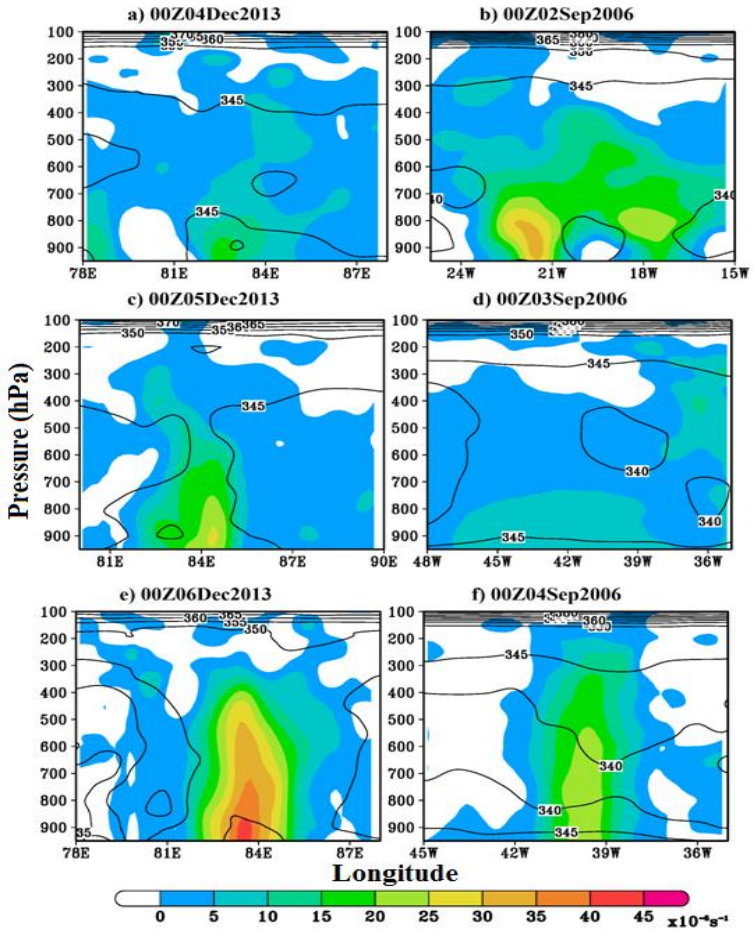
Vorticity upsacle cascade (H1) in the marsupial paradigm

Intensification within the pouch

Madi Florence



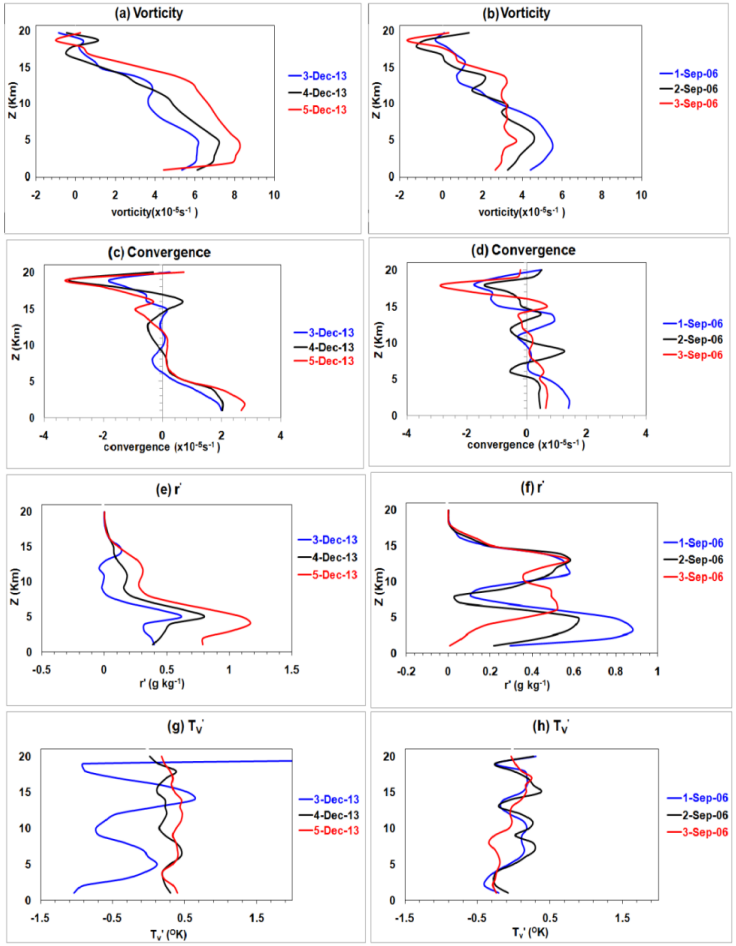
Madi Florence



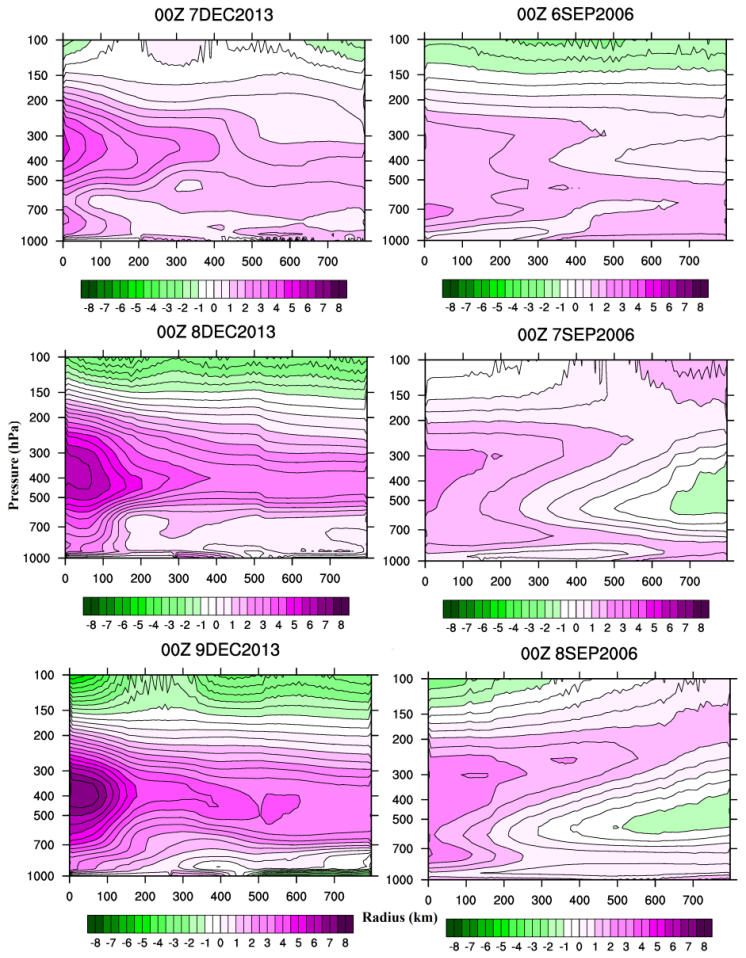
Vortex of Florence cyclone is weak

Vertical profiles and warm core

Madi Florence



Madi Florence



Madi cyclone is associated with strong warm core

Conclusions

- A modelling study has been carried out to understand the similarities and differences in the genesis sequence of a NIO tropical cyclone Madi (6-13 December, 2013) and Atlantic Ocean cyclone Florence (3-12 September, 2006).
- The presence of dust over AO and NIO region was confirmed using microwave imageries of SAL from Wisconsin University, MODIS AOD and OMI AI products.
- Both the cyclones are found to be formed in the vicinity of the ITCZ and the parent disturbance of these cyclones is traced backward in time using TPW.
- Large values of CAPE is accompanied by small values of CIN prior to the genesis of Madi cyclone which is favourable for the formation of deep convection. In the case of Florence cyclone, denser contours of CIN near to the African coast (CIN ~ 500 J Kg^{-1}) indicate the presence of convective inhibition area.
- Analysis of the deep layer shear indicates comparatively less values of shear in the genesis environment of Madi cyclone but the value of deep layer shear is high to the north of cyclone Florence.
- The transformation of tropical storm to tropical cyclone was quick in case of Madi but tropical storm Florence encountered an area of large wind shear and delayed its intensification till 10 September 2006.

Conclusions

- It has been noted that the failure to organize the system made Florence to grow to an unusually large size compared to that of Madi cyclone.
- The developed 3DVAR analysis using WRF model and WRFDA-3DVAR provides the compelling evidence for the intrusion of dry air into the core of the vortex of Florence cyclone that delayed the organization of the vortex into hurricane strength.
- As the warm and dry air intruded into the core of Florence, it began to weaken and failed to develop as quickly as that of Madi cyclone.
- It is seen that the wave pouch plays a more important role in the vorticity upscale cascade (H1 in the marsupial paradigm) in the case of tropical cyclone Madi than in preventing dry air intrusion (H2 in the marsupial paradigm), whereas in the case of hurricane Florence, the pouch acted as a protective region (H2) from the series of dust outbreaks than the vorticity upscale cascade (H1 in the marsupial paradigm).

Thank you...