

Assimilation of INSAT AMVs in NCMRWF NWP system: An Evaluation of the Indian Summer Monsoon Onset Features

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OUTLINE

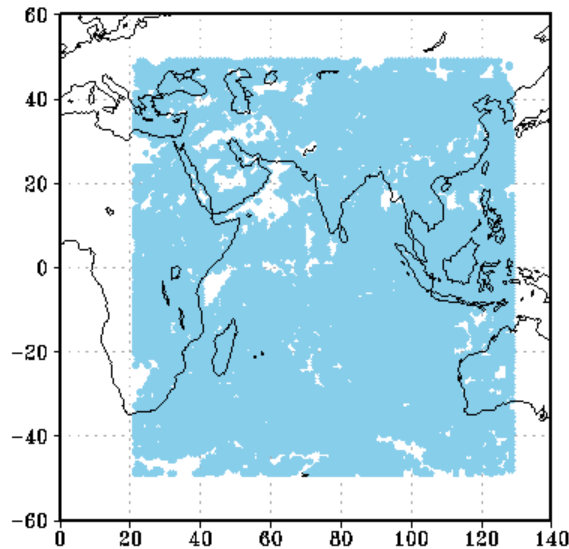


- **Validation of INSAT AMVs**
 - ✓ first guess
 - ✓ in-situ winds

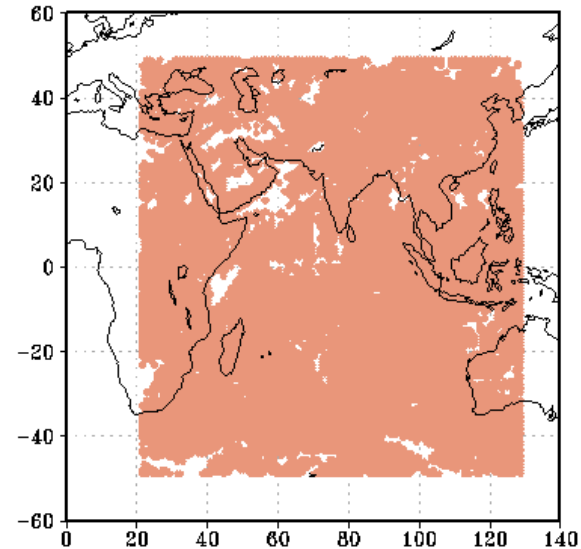
- **OSE with INSAT(3D & 3DR) AMVs**
 - ✓ monsoon onset (Bay of Bengal, Arabian Sea)
 - ✓ verification of analysis and forecast

Spatial Coverage of INSAT(3D & 3DR)

INSAT-3DR (74° E)



INSAT-3D (82°E)



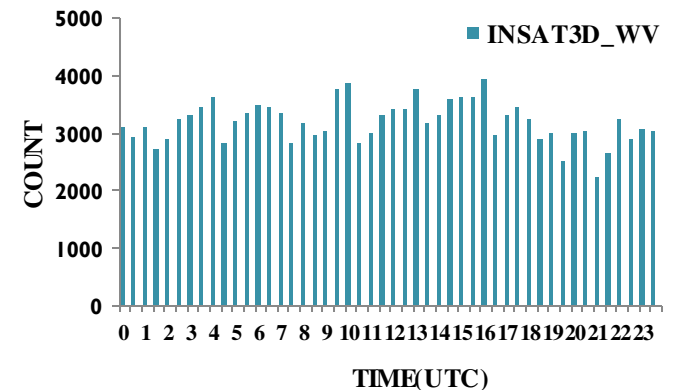
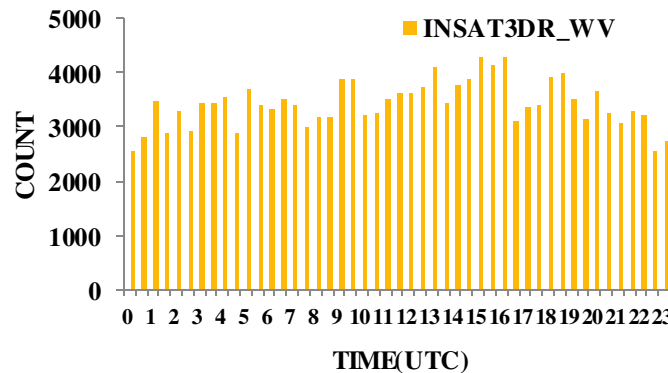
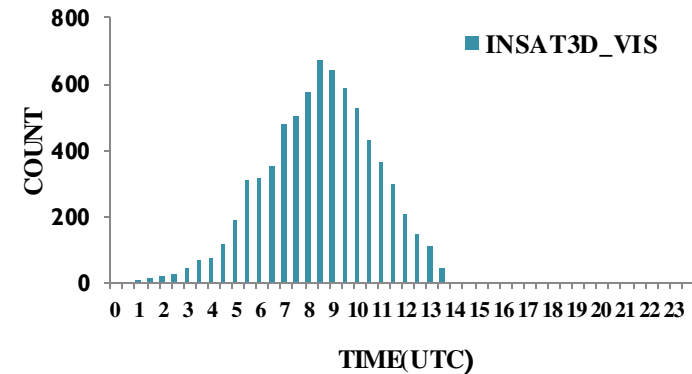
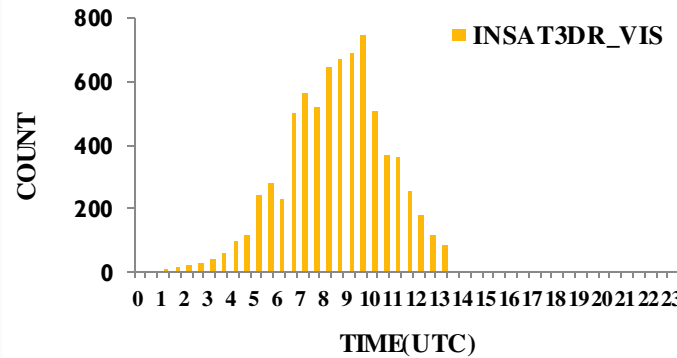
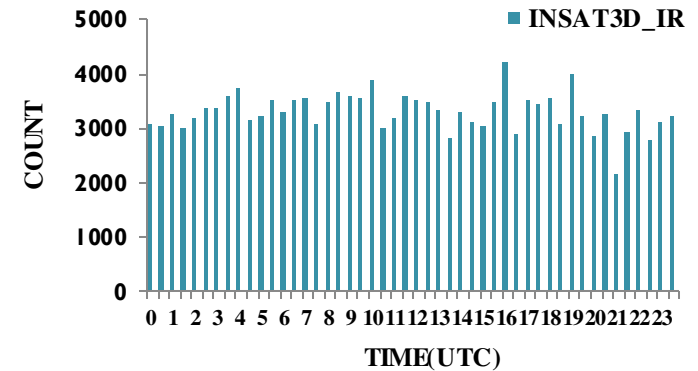
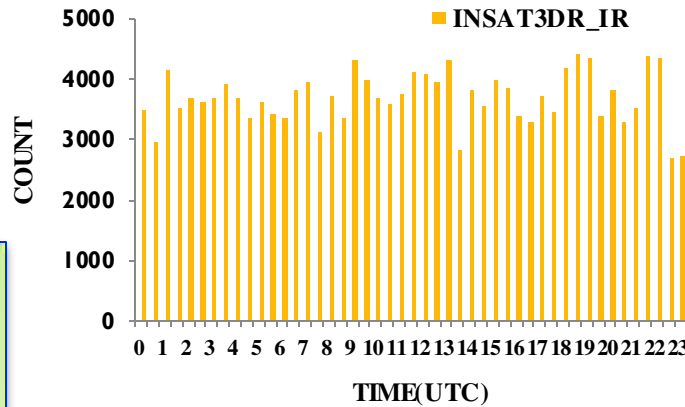
- **Located at different longitude**
- **Due to sector generated product AMVs from both INSAT-3D & 3DR are available over same geographical area**

Monthly average reception of INSAT-3D & INSAT-3DR for May 2020

AMVs from each INSAT (3D & 3DR) are available at every 30 minutes interval

✓ INSAT-3D starting at 0000 UTCs (0000,0030 UTC...)

✓ INSAT-3DR starting at 0015 UTCs (0015,0045 UTC...)



Validation of INSAT-3DR AMVs against NCMRWF First Guess



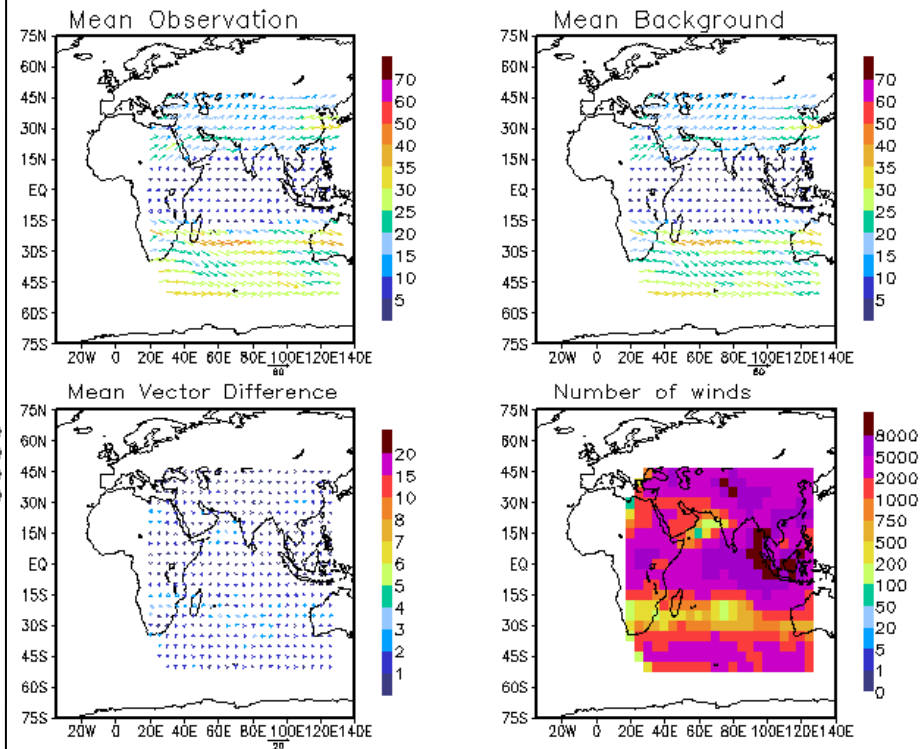
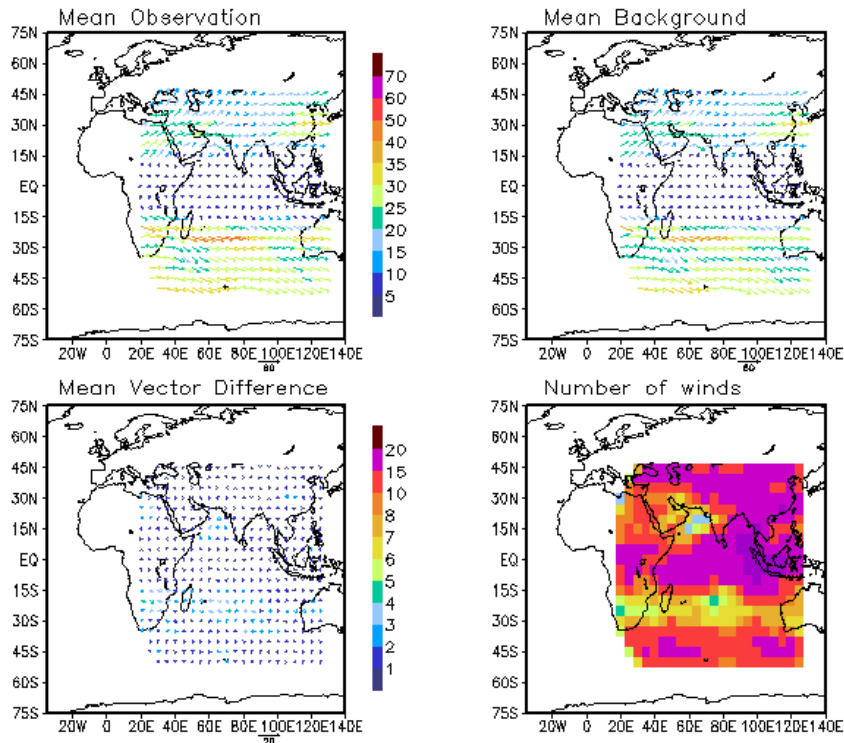
IR WINDS (High Level)

INSAT-3DR

INSAT-3D

INSAT-3DR IR, High Level, Above 400 hPa, May 2020

INSAT-3D IR, High Level, Above 400 hPa, May 2020

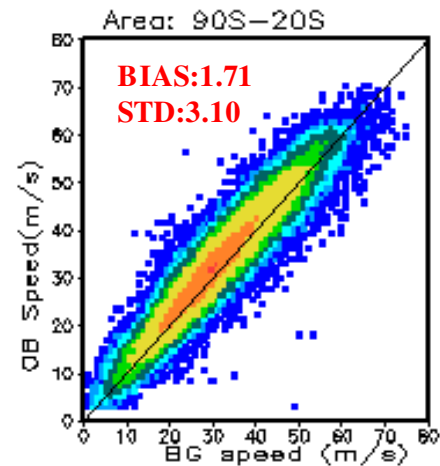
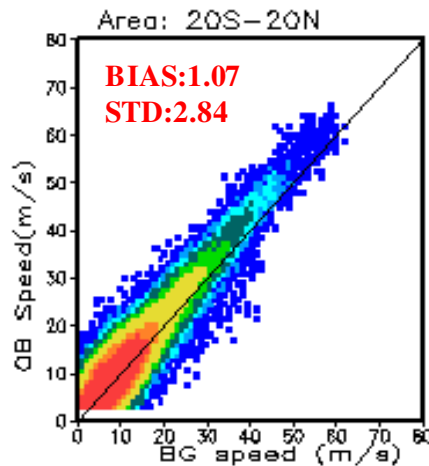
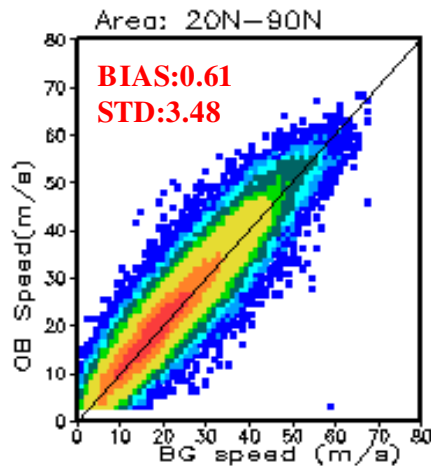


as per NWP-SAF criteria

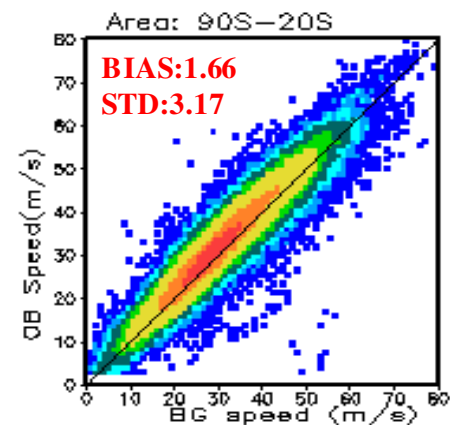
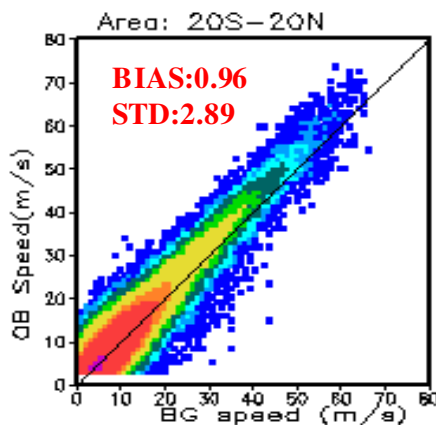
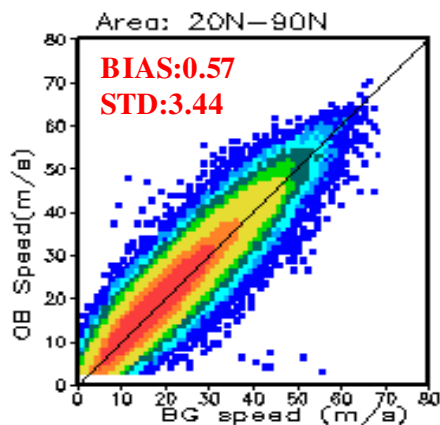
Speed Bias Density Plots

IR WINDS (High Level)

INSAT-3DR



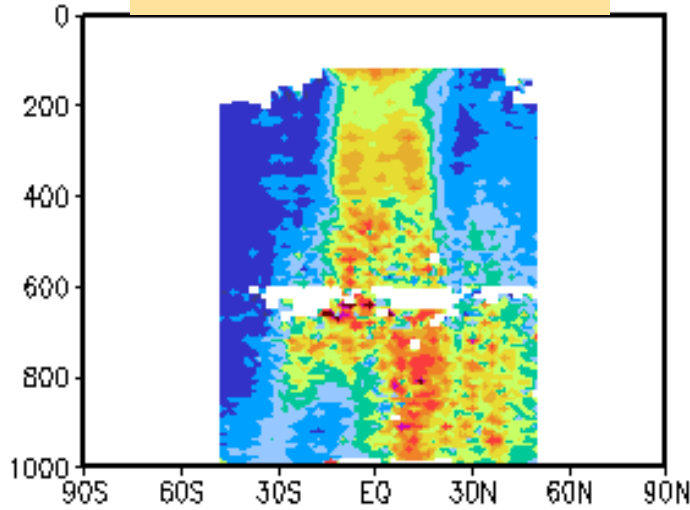
INSAT-3D



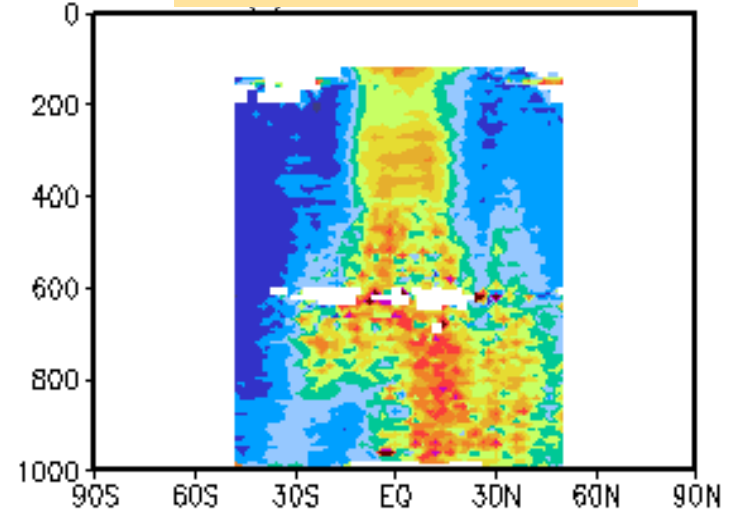
NRMSVD zonal average at different pressure level



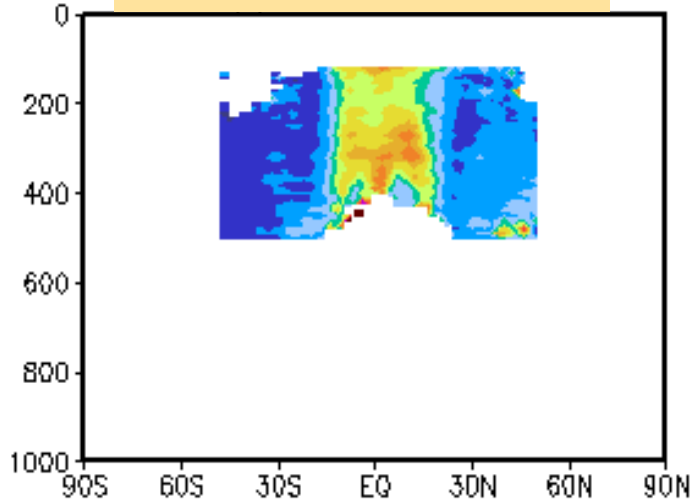
INSAT-3DR IR Winds



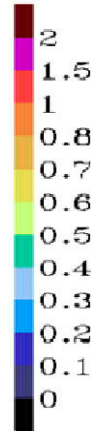
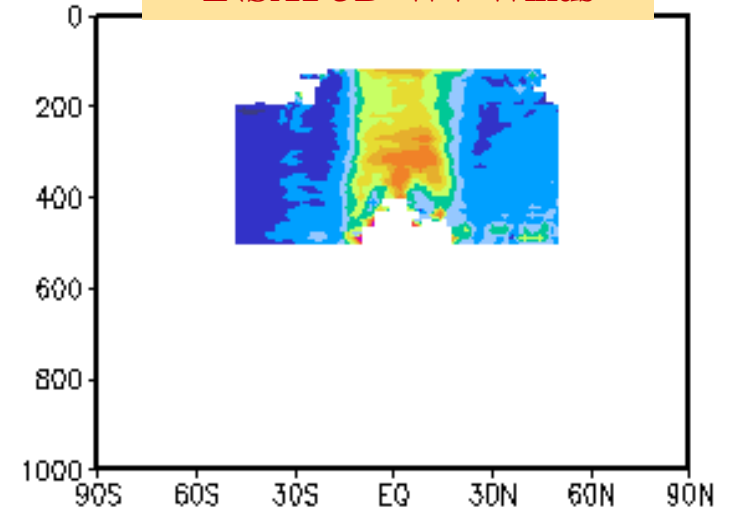
INSAT-3D IR Winds



INSAT-3DR WV Winds



INSAT-3D WV Winds



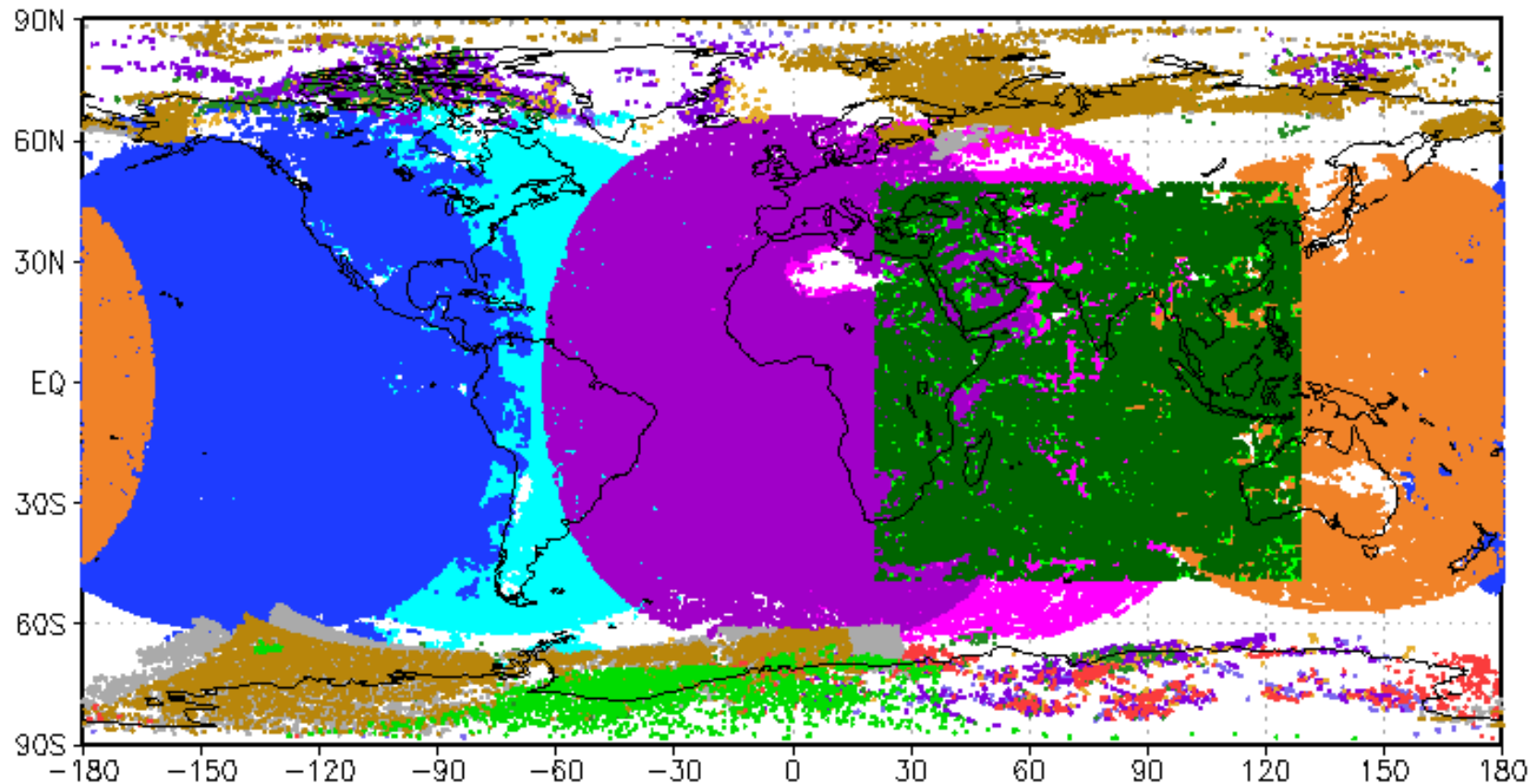
Validation against In-situ Winds

Satellite	Northern Hemisphere			Tropics			Southern Hemisphere		
	Bias	RMSVD	No. of collocations	Bias	RMSVD	No. of collocations	Bias	RMSVD	No. of collocations
	High Level IR Winds								
INSAT-3D	0.36	6.57	9535	0.42	4.73	15447	1.83	5.99	395
INSAT-3DR	0.52	6.57	5314	0.39	4.72	11488	1.61	5.90	374
Mid Level IR Winds									
INSAT-3D	-0.75	5.16	2989	-0.57	3.93	656	-0.55	4.98	283
INSAT-3DR	-0.97	5.06	1268	0.39	4.72	260	-1.91	5.25	184
Low Level IR Winds									
INSAT-3D	0.19	4.73	1994	1.15	4.18	2111	-0.68	4.83	918
INSAT-3DR	0.07	4.20	1476	1.09	4.29	1147	-0.10	4.81	484
WV Winds									
INSAT-3D	0.61	6.89	19633	0.76	5.28	18583	0.80	6.43	1699
INSAT-3DR	0.60	6.73	10457	0.90	5.19	11620	1.30	6.80	699

As per CGMS criteria

AMVs received at NCMRWF on a typical day at 00UTC

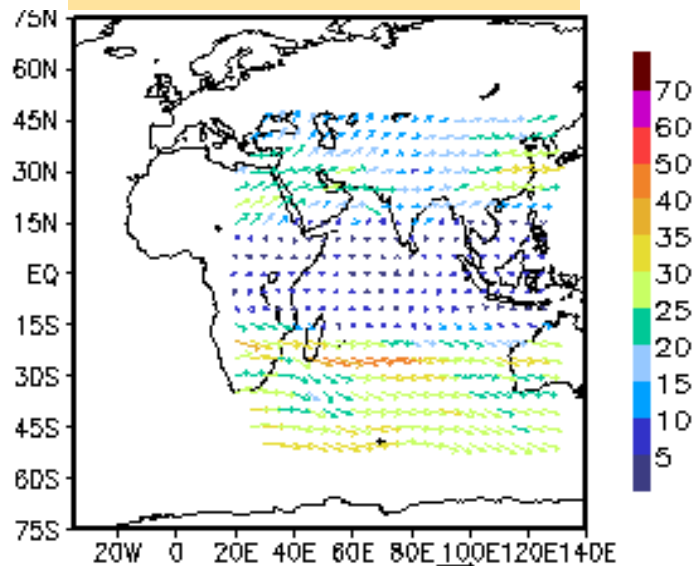
GOES-16(898830) GOES-17(1794222) NOAA-18(699) NOAA-19(1010) METEOSAT-8(118433)
 METEOSAT-11(121488) NPP(17433) NOAA-20(14527) MODIS/Terra(840) MODIS/Aqua(2196)
 METOP-A(4048) METOP-B(1437) INSAT-3D(28927) INSAT-3DR(52032) HIMAWARI-8(117220)



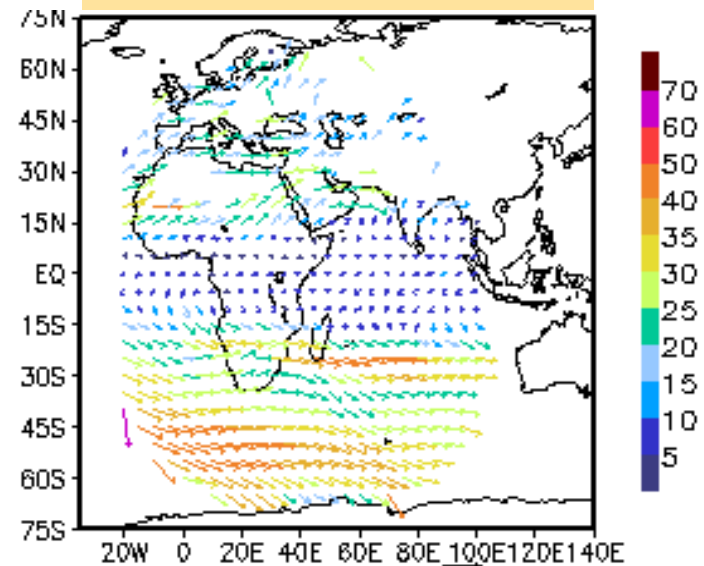
Mean wind flow of INSAT and Meteosat-8 IR Winds



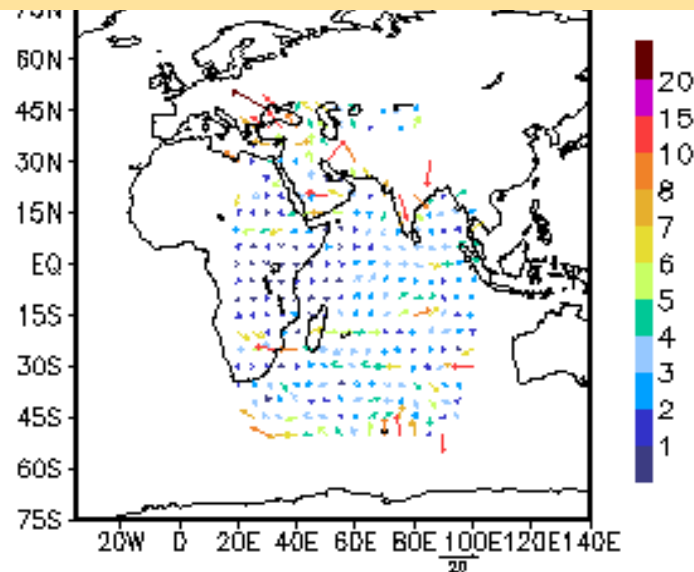
Mean INSAT AMVs



Mean Meteosat-8 AMVs



Mean Vector Difference (INSAT-Meteosat-8)

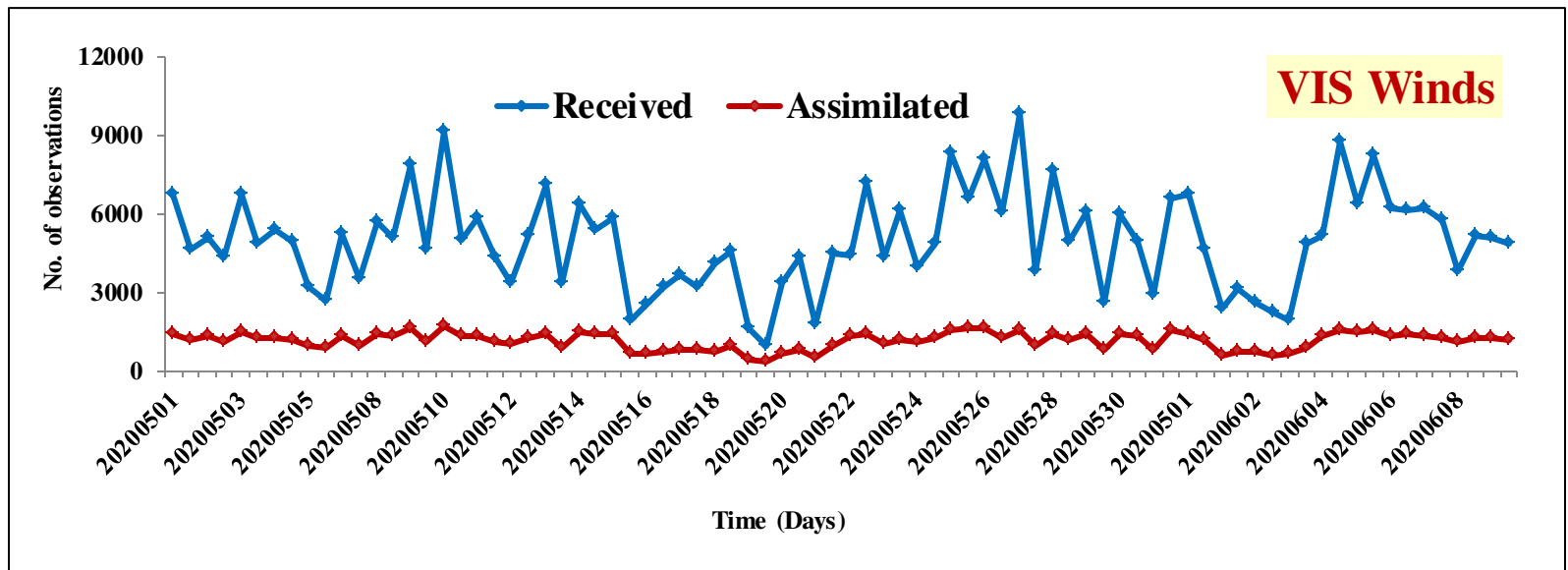
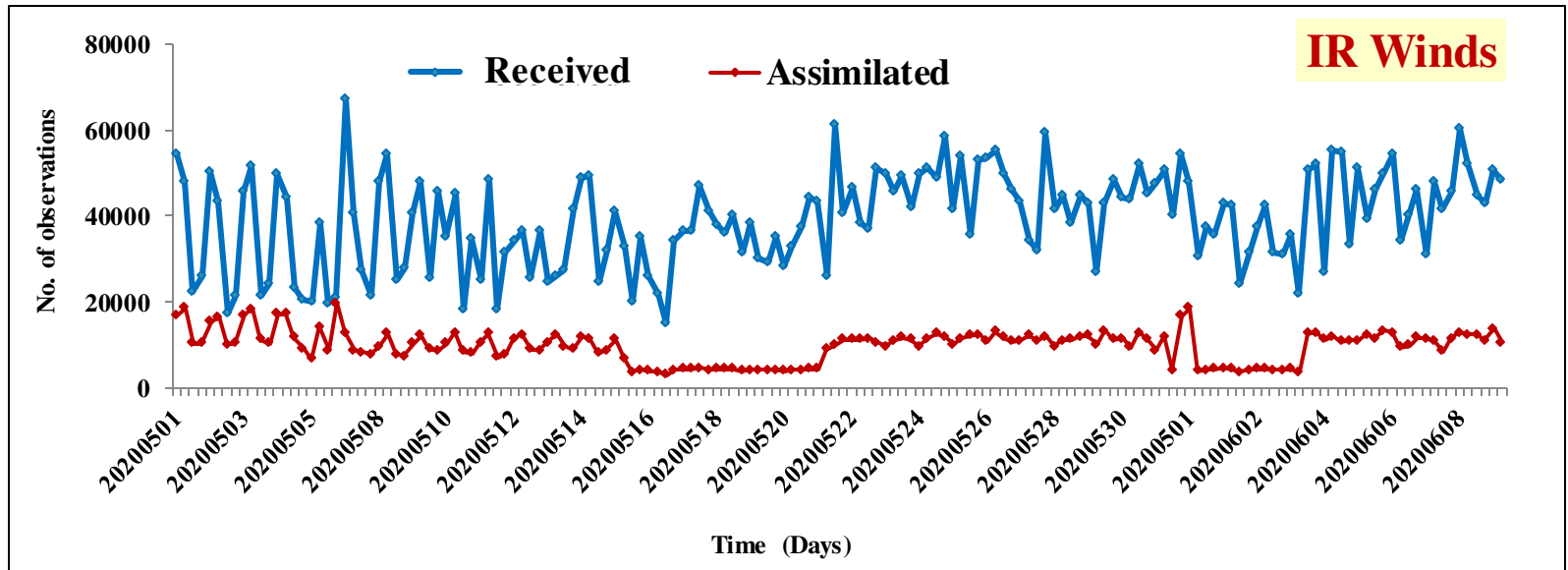


Assimilation of INSAT (3D & 3DR) AMVs



- OSE with INSAT (3D & 3DR) AMVs
- Thinning criteria:
horizontal - 200 km, vertical -100 hPa and temporal - 2 hrs
- Study period : 1 May to 10 June 2020
- NGFS 4D-VAR data assimilation system
- Control Run : Data from operational NCMRWF daily archive
- Experiment : Control data + INSAT (3D & 3DR) AMVs
- Simulation of Indian Sumer Monsoon onset features

INSAT(3D & 3DR) Winds received at NCMRWF and assimilated during the study period



Significant features during the study period



Onset over Bay of Bengal

- 1 - 25 May 2020
- “Amphan” cyclone formed over Bay of Bengal during 16 - 21 May 2020

Onset over Arabian Sea

- 25 May to 10 June 2020
- “Nisarga” cyclone formed over Arabian Sea from 1 - 4 June 2020
- Onset of Indian Sumer Monsoon

Onset over Bay of Bengal

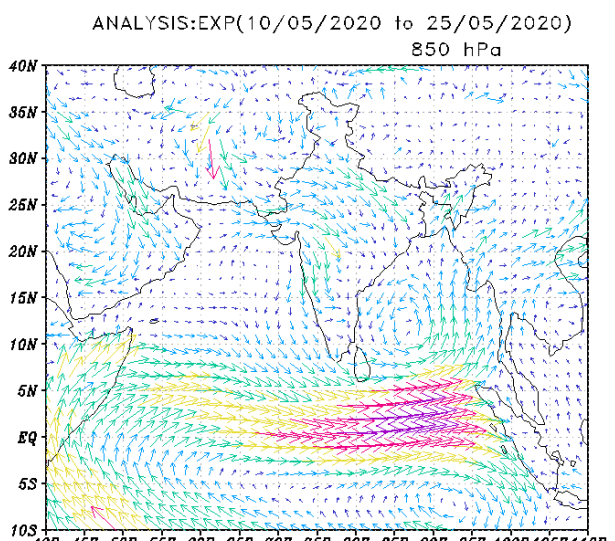
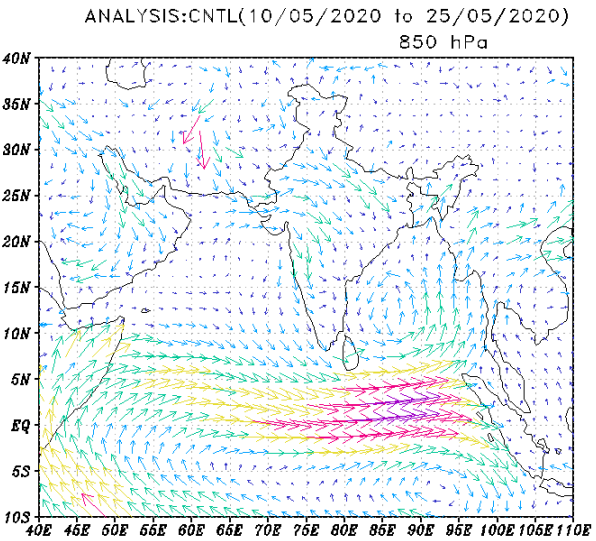
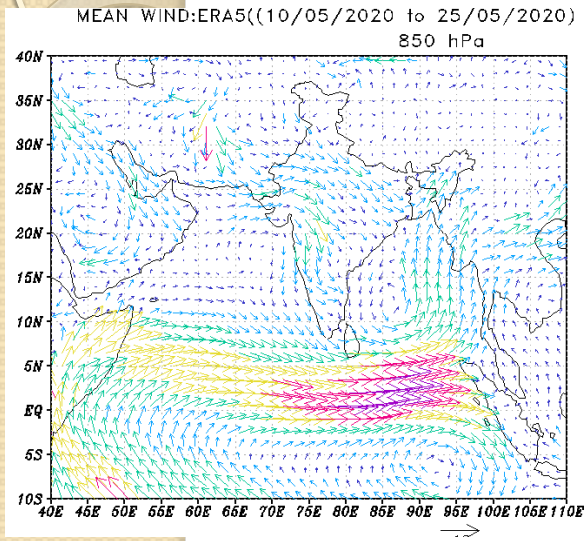
850 hPa Mean Wind Analysis



ERA5

CNTL

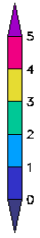
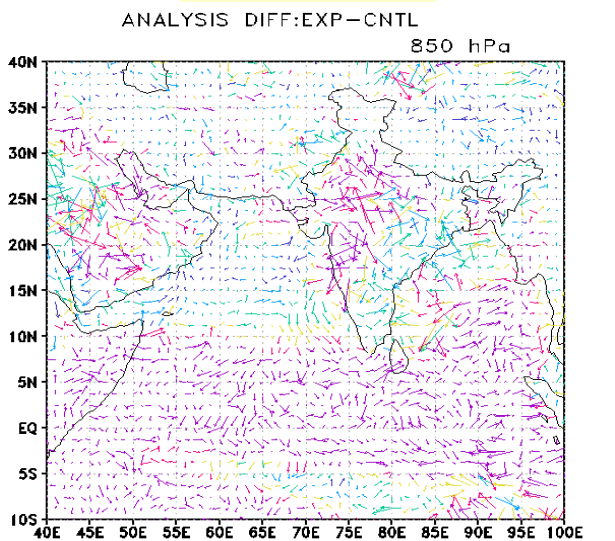
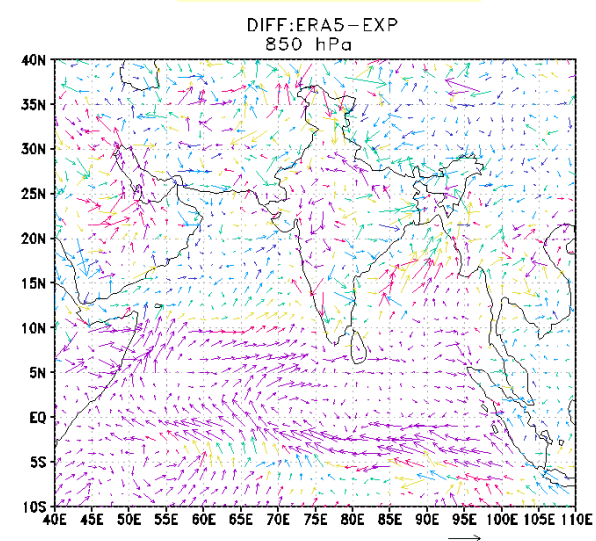
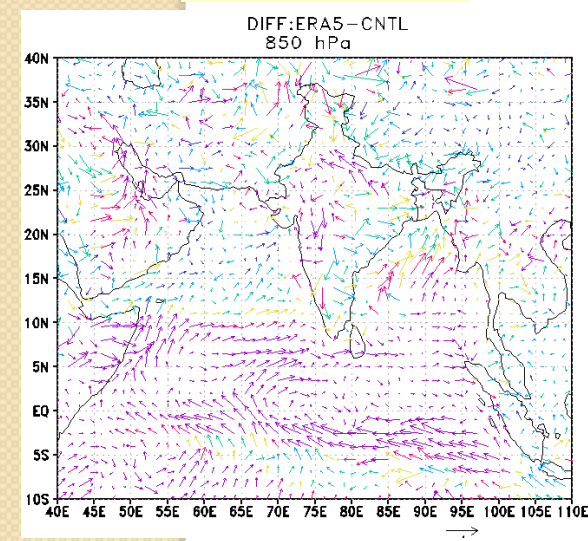
EXP



ERA5-CNTL

ERA5-EXP

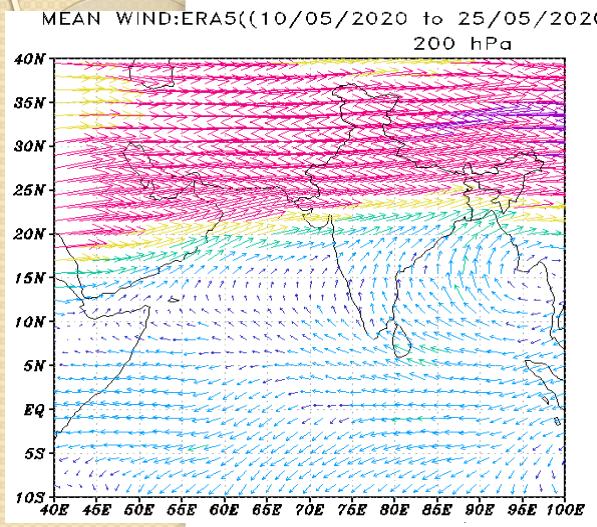
EXP-CNTL



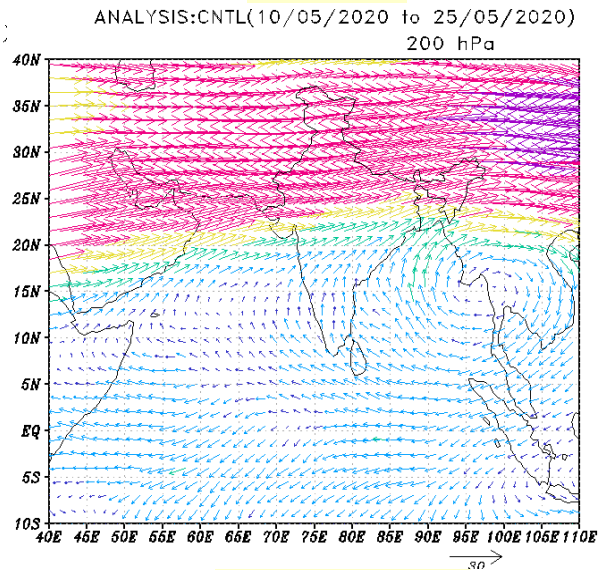
Onset over Bay of Bengal

200 hPa Mean Wind Analysis

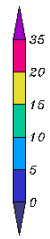
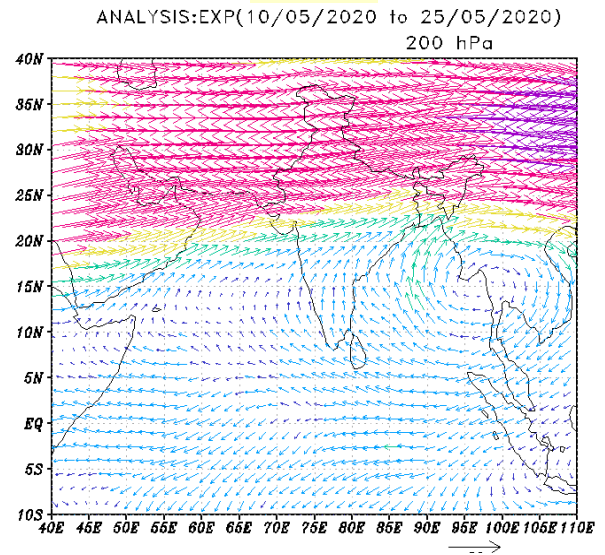
ERA5



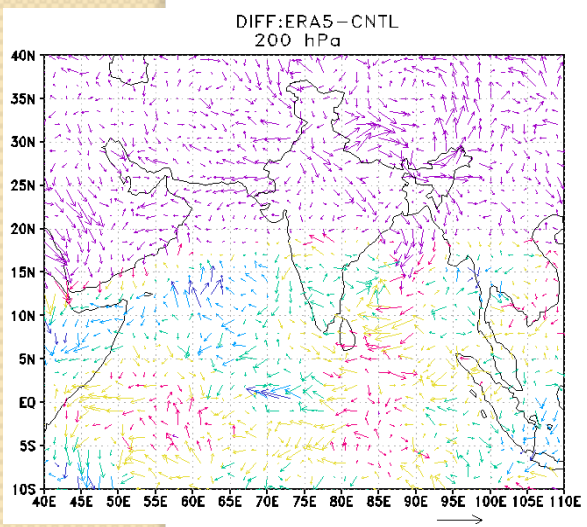
CNTL



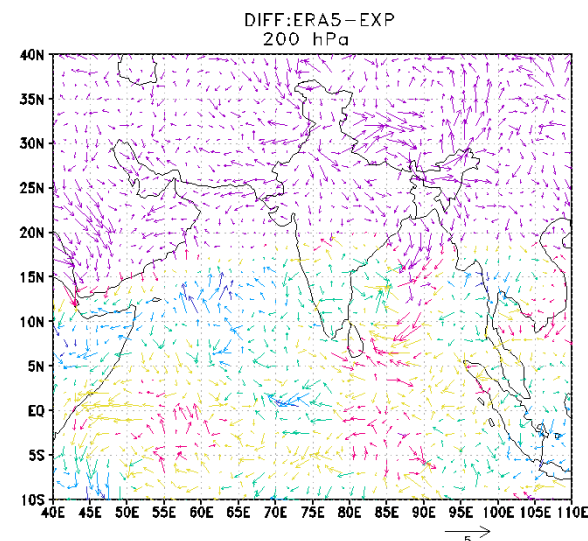
EXP



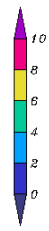
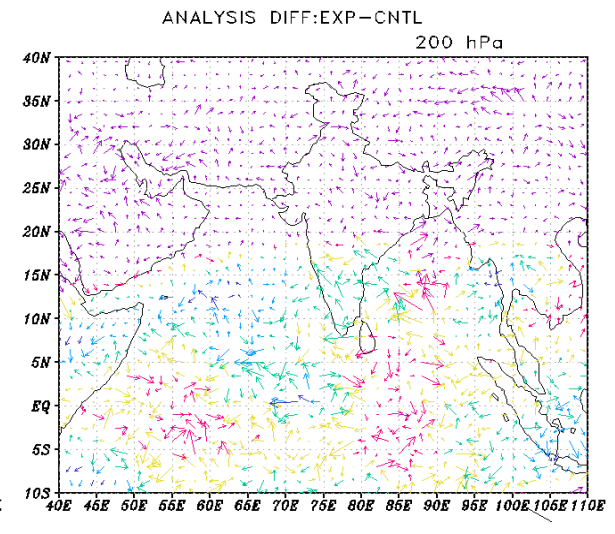
ERA5-CNTL



ERA5-EXP



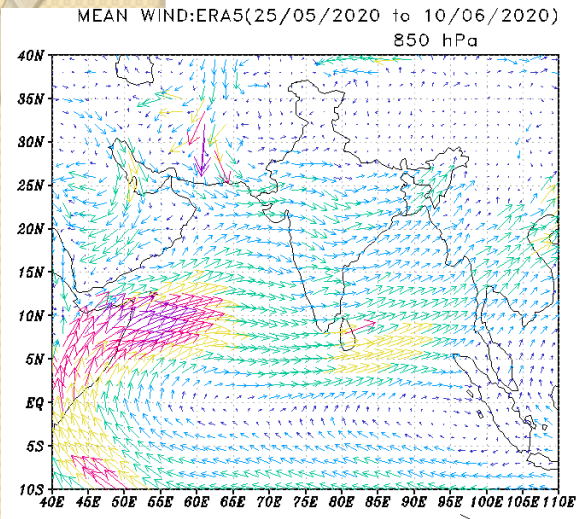
EXP-CNTL



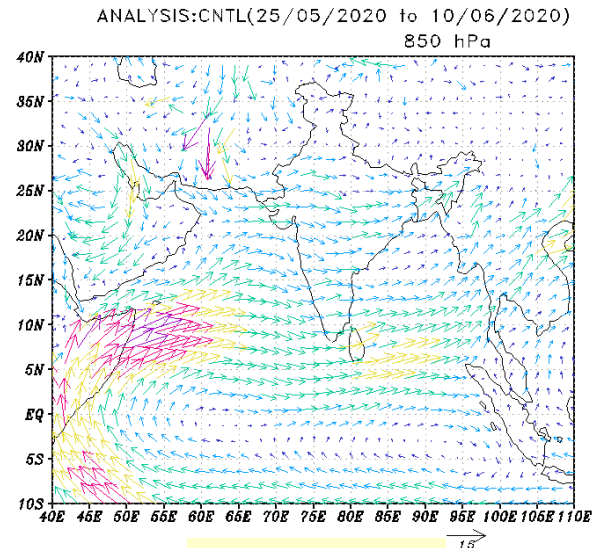
Onset over Arabian sea

850 hPa Mean Wind Analysis

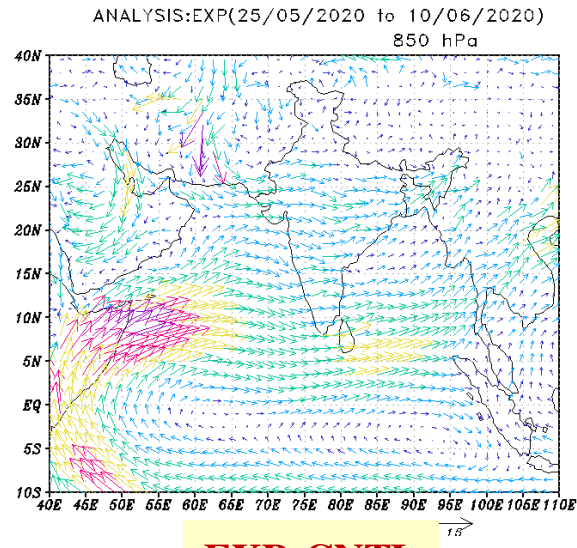
ERA5



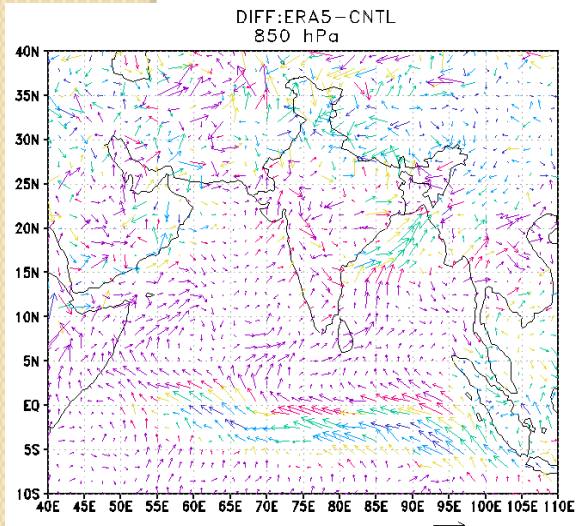
CNTL



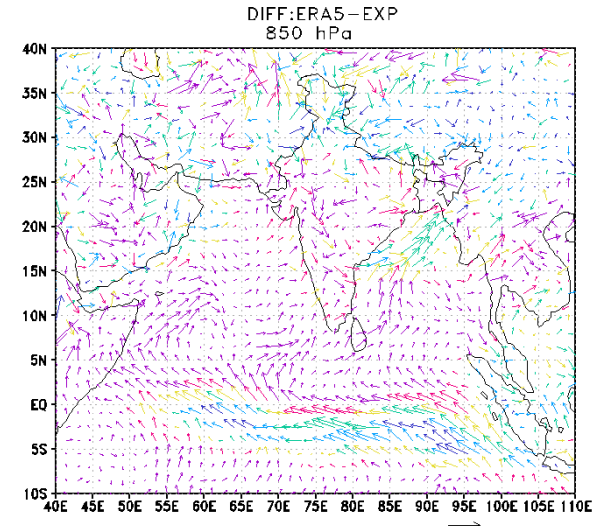
EXP



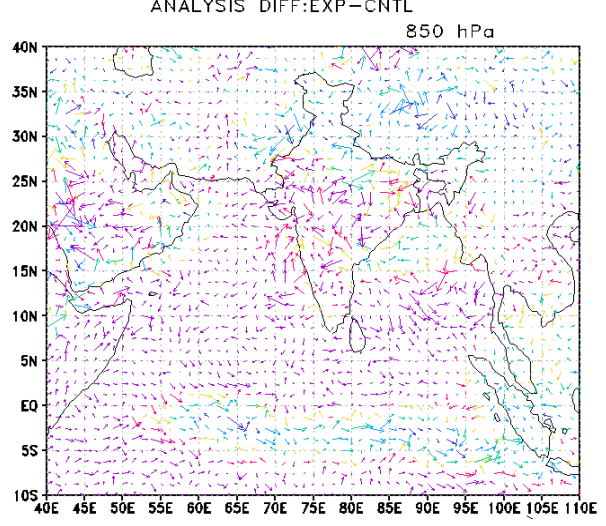
ERA5-CNTL



ERA5-EXP



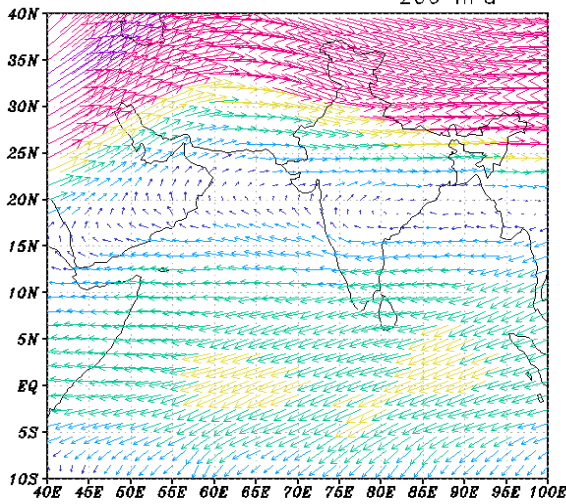
EXP-CNTL



200 hPa Mean Wind Analysis

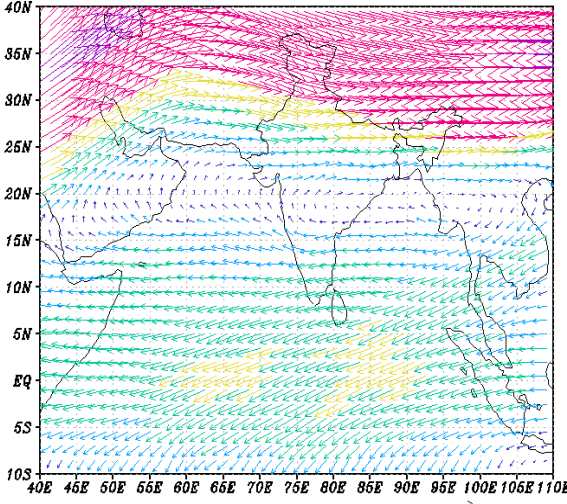
ERA5

MEAN WIND:ERA5(25/05/2020 to 10/06/2020)
200 hPa



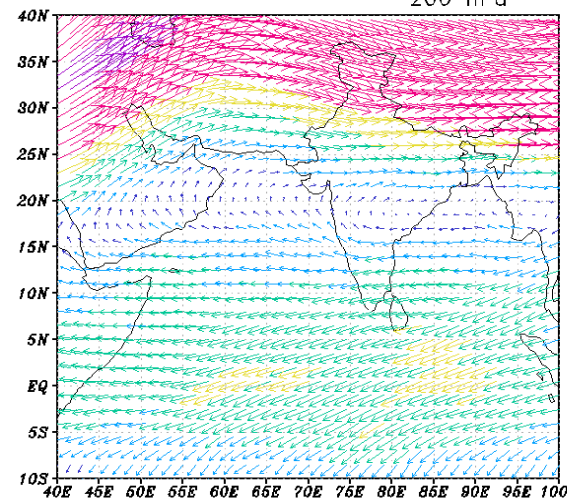
CNTL

ANALYSIS:CNTL(25/05/2020 to 10/06/2020)
200 hPa



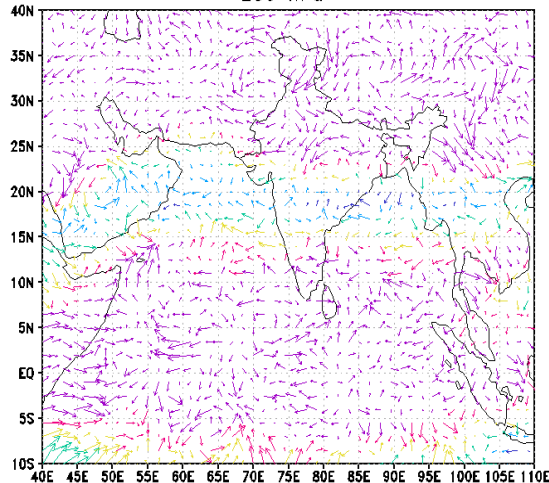
EXP

ANALYSIS:EXP(25/05/2020 to 10/06/2020)
200 hPa



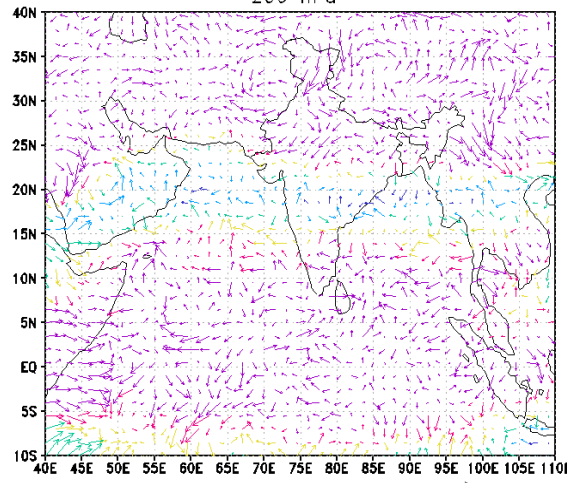
ERA5-CNTL

DIFF:ERA5-CNTL
200 hPa



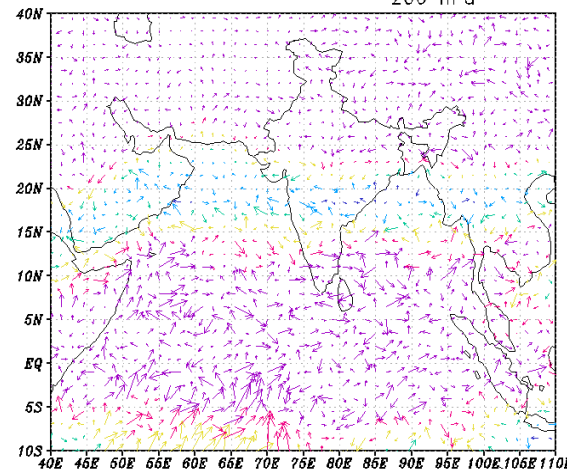
ERA5-EXP

DIFF:ERA5-EXP
200 hPa



EXP-CNTL

ANALYSIS DIFF:EXP-CNTL
200 hPa



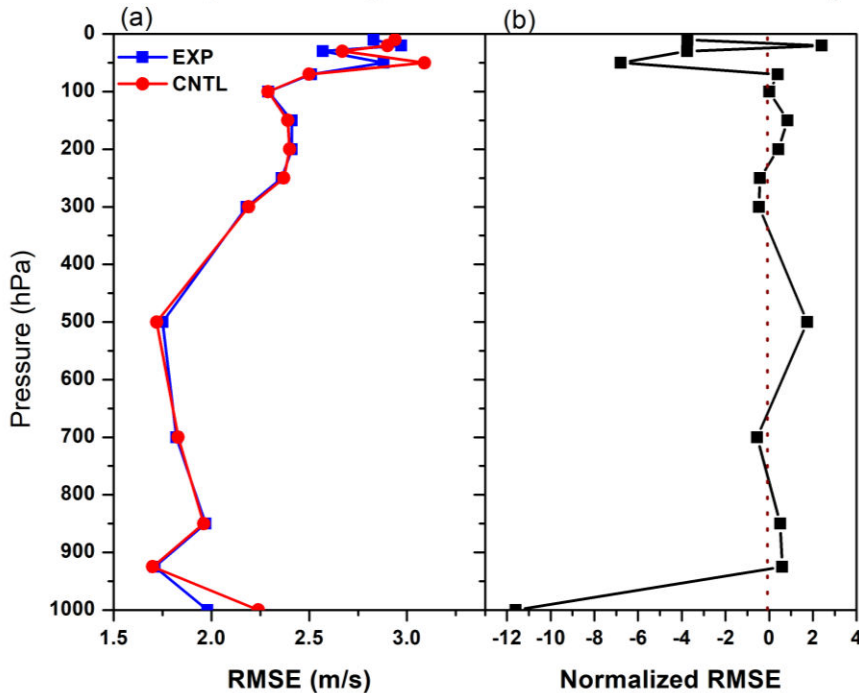
RMSE of analysed Zonal winds at various pressure level for EXP and CNTL



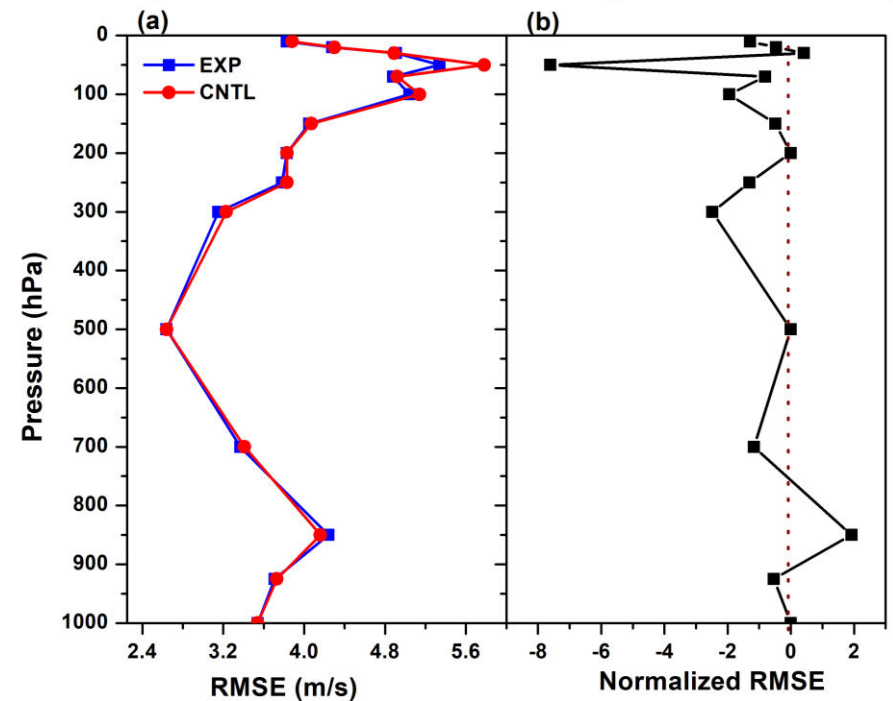
Global

Indian Region

Vertical profiles of global RMSE in Zonal wind Analysis



Vertical profiles of RMSE in Zonal wind Analysis over the Indian region



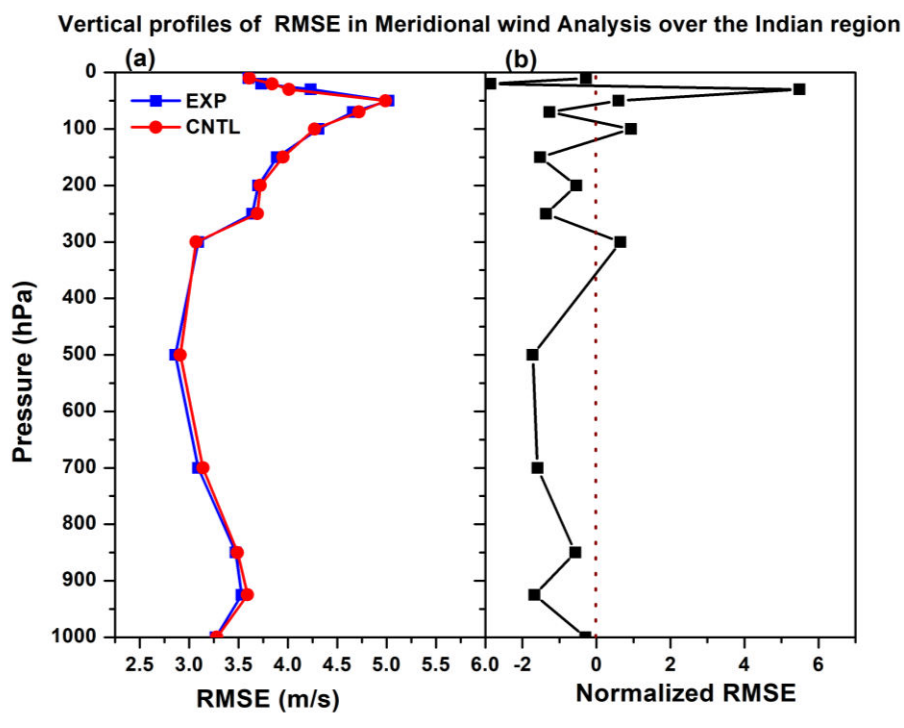
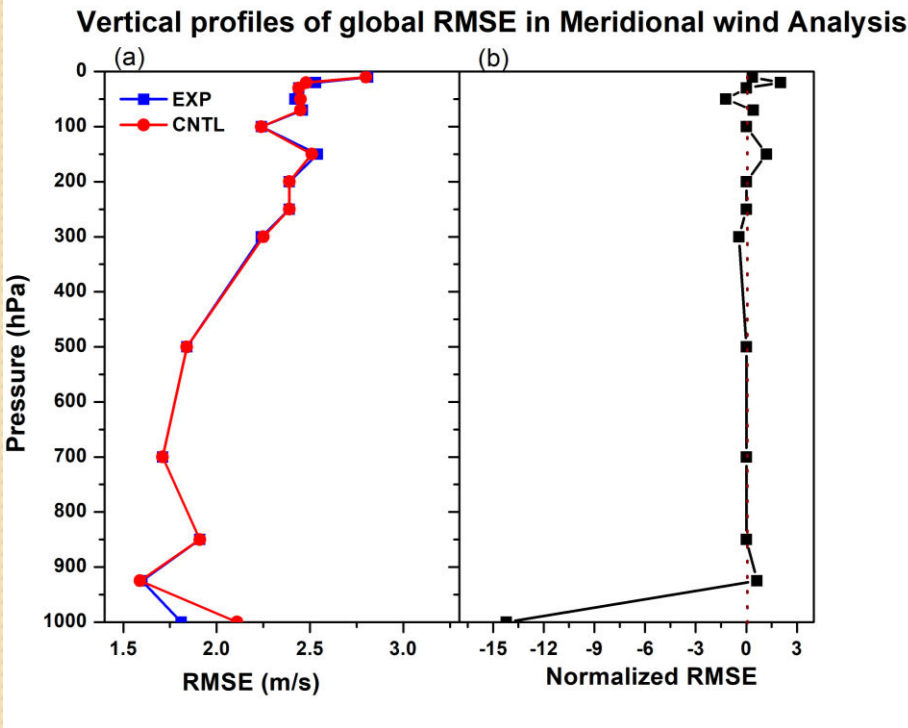
Averaged for 1 May 2020 to 10 June 2020

$$NormalizedRMSE = \frac{RMSE(EXP) - RMSE(CNTL)}{RMSE(CNTL)} \times 100$$

RMSE of analysed Meridional winds at various pressure level for EXP and CNTL

Global

Indian Region



Averaged for 1 May 2020 to 10 June 2020

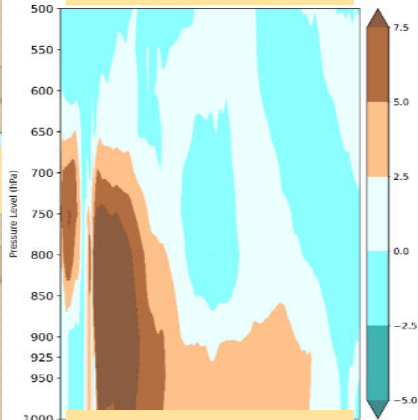
$$NormalizedRMSE = \frac{RMSE(EXP) - RMSE(CNTL)}{RMSE(CNTL)} \times 100$$

Meridional Component of Wind at Equator

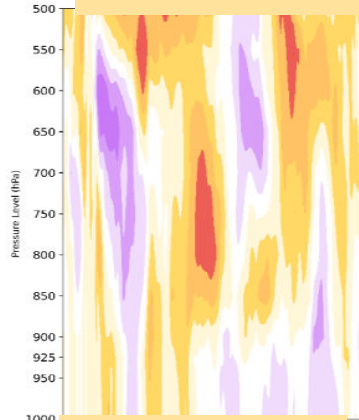


CNTL

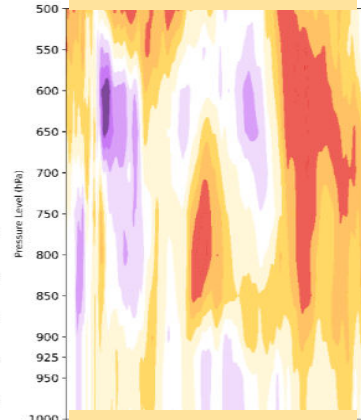
CNTL: Analysis



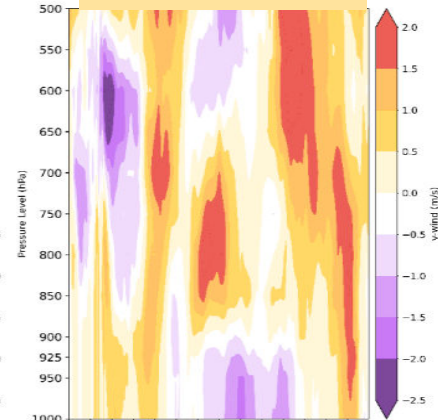
D3 FCST-ANAL



D5 FCST-ANAL

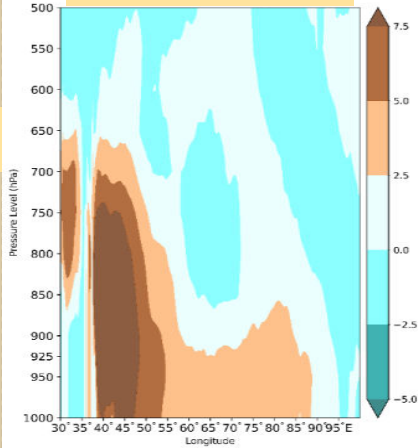


D7 FCST-ANAL

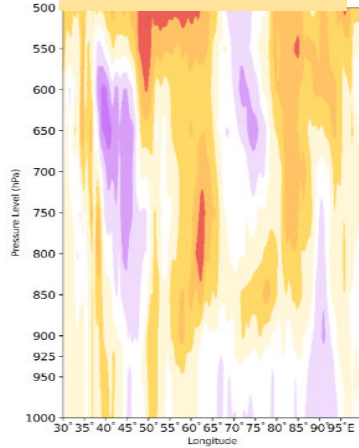


EXP

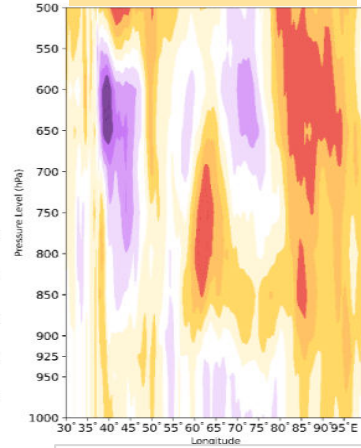
EXP: Analysis



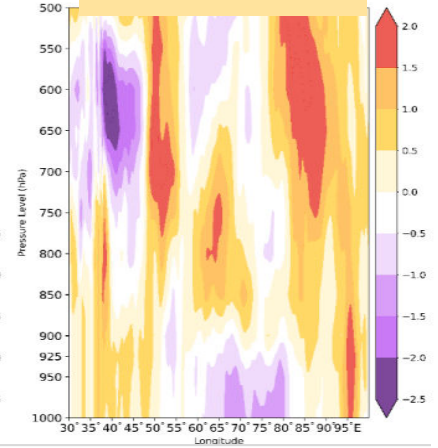
D3 FCST-ANAL



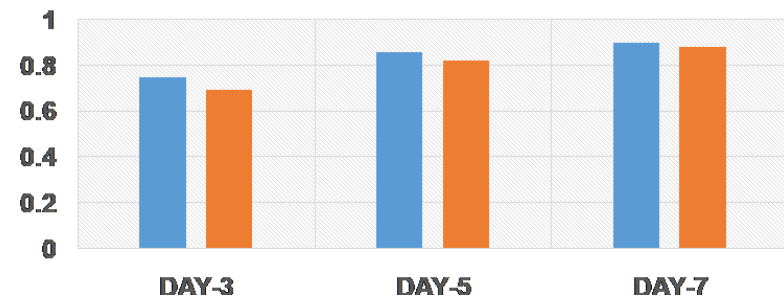
D5 FCST-ANAL



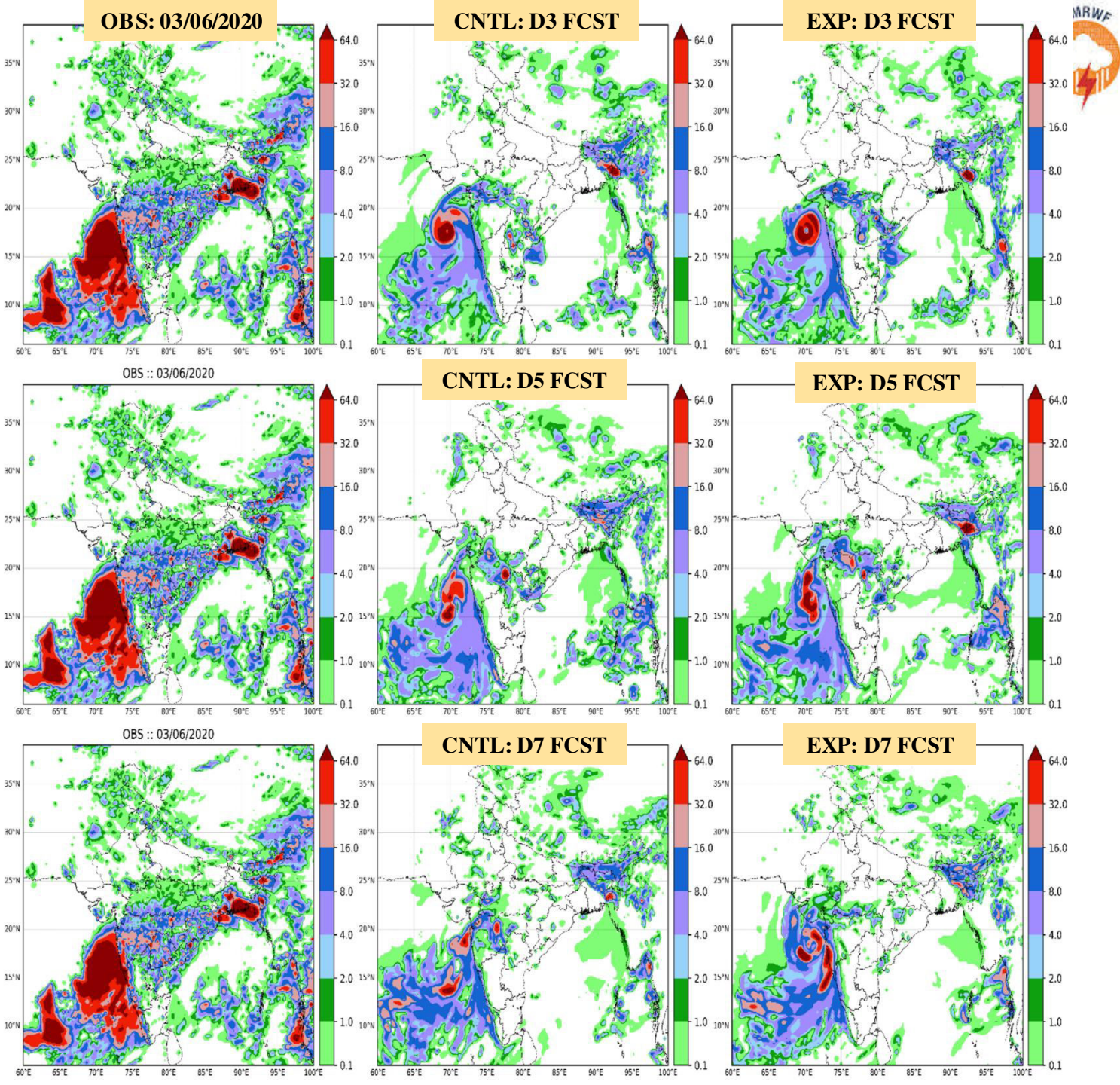
D7 FCST-ANAL



RMSE (v-wind at Equator) ■ CTRL ■ EXPT



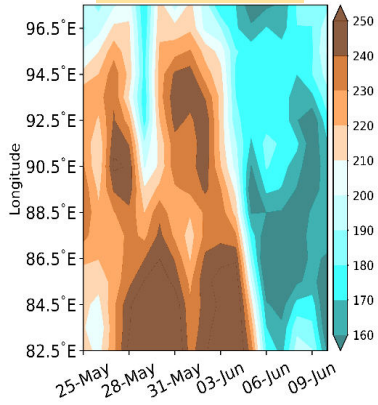
**Verification of
Rainfall on 03
Jun 2020
(Day-3,
Day-5, Day-7)
with
Merged Satellite
Rainfall
Observation**



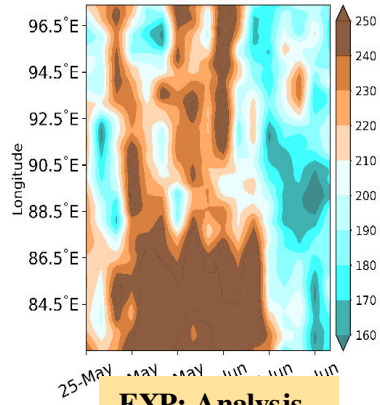
OLR over Bay of Bengal during Onset of ISM



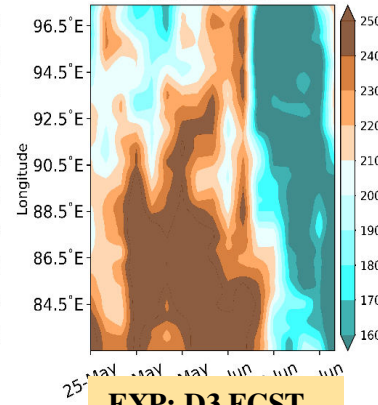
CDR: OLR



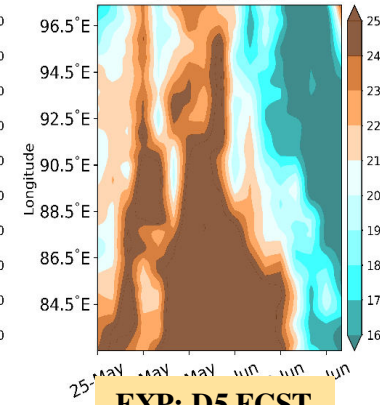
CNTL: Analysis



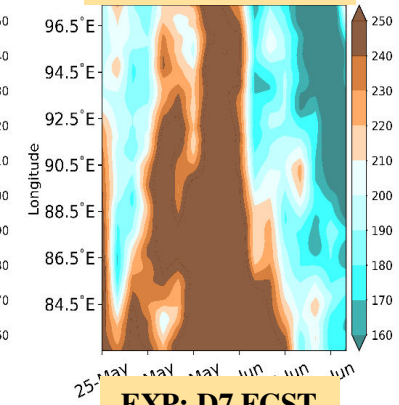
CNTL: D3 FCST



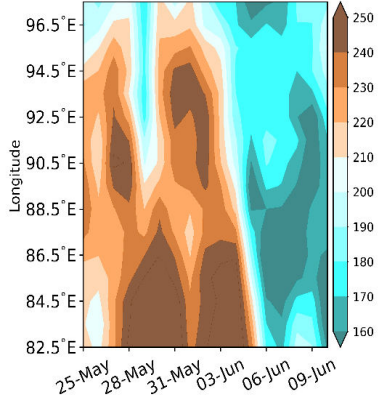
CNTL: D5 FCST



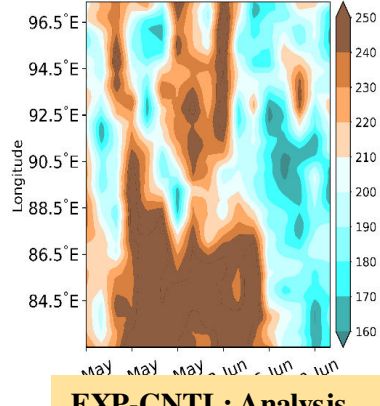
CNTL: D7 FCST



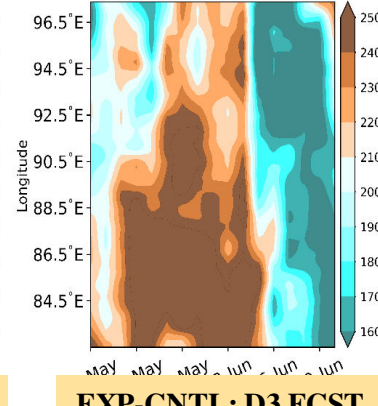
SATELLITE OLR from CDR



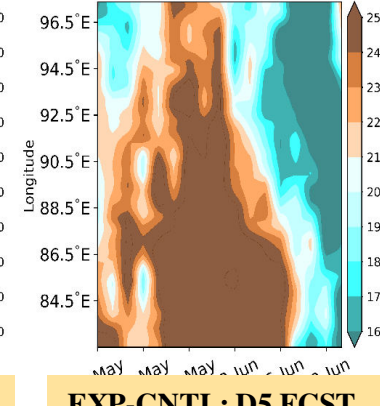
EXP: Analysis



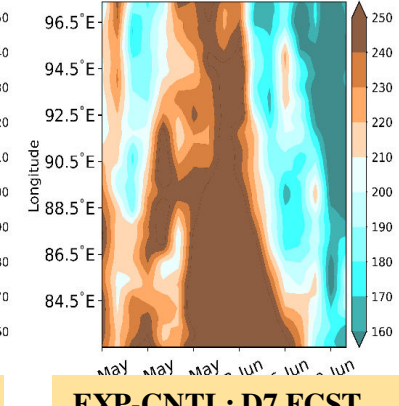
EXP: D3 FCST



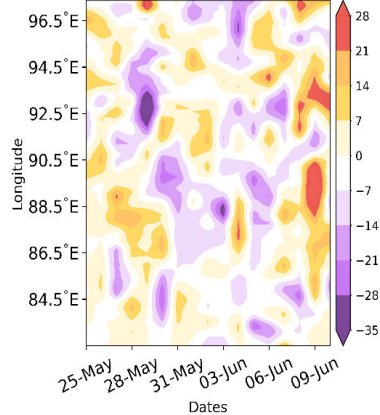
EXP: D5 FCST



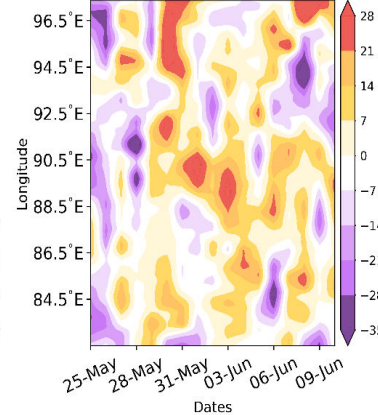
EXP: D7 FCST



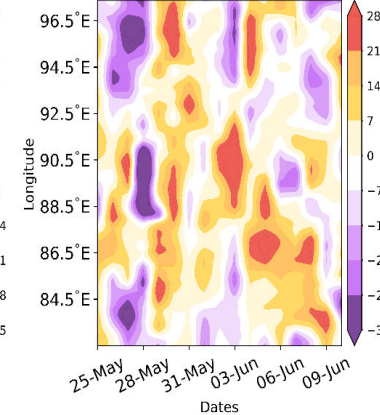
EXP-CNTL: Analysis



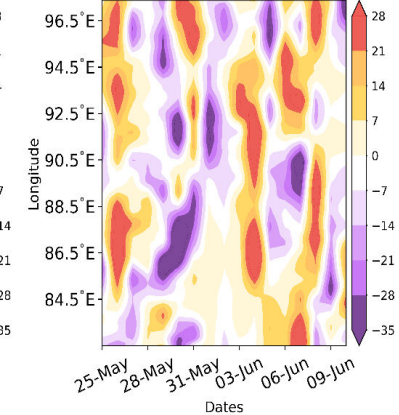
EXP-CNTL: D3 FCST



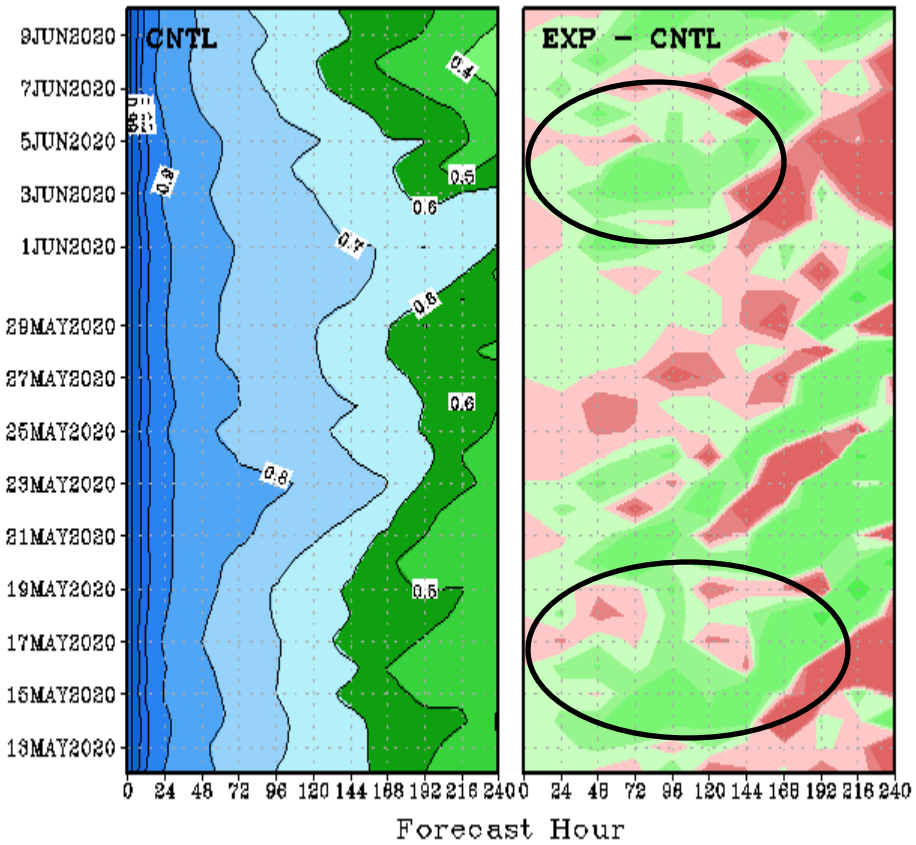
EXP-CNTL: D5 FCST



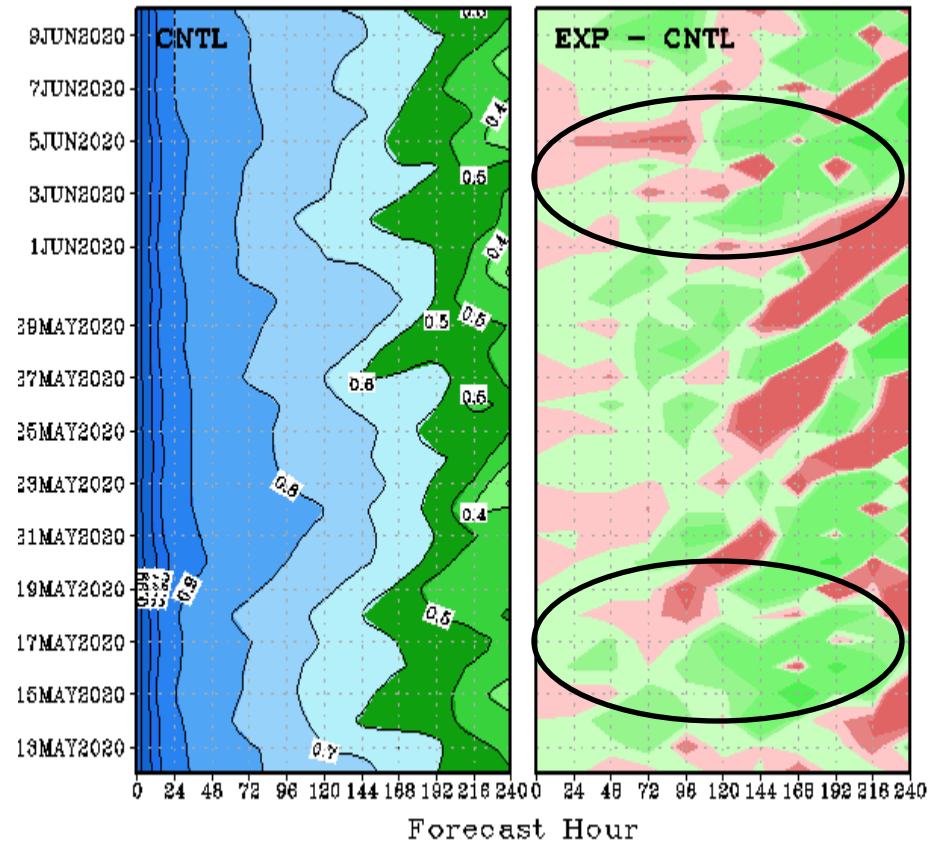
EXP-CNTL: D7 FCST



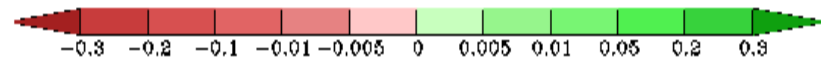
Anomaly Correlation in Wind at 250 hPa over Tropics



Anomaly Correlation: WIND P250 G3/TR0 00Z



Anomaly Correlation in Wind at 850 hPa over Tropics



Forecast Verification: Correlation in Wind Pattern

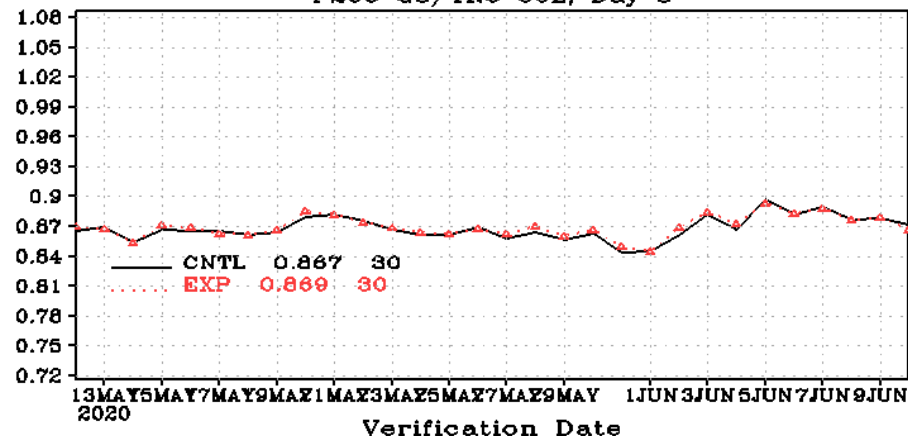
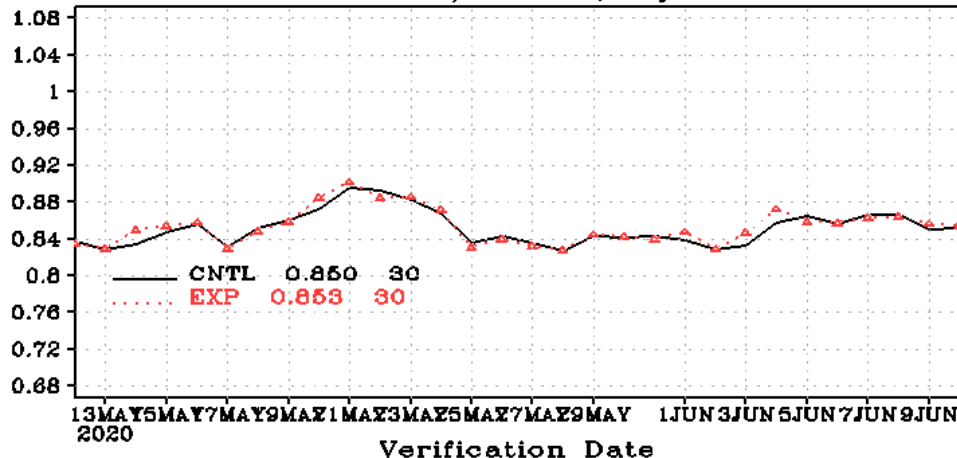


850 hPa

200 hPa

WIND: Pattern Correlation
P850 G3/TRO 00Z, Day 3

WIND: Pattern Correlation
P200 G3/TRO 00Z, Day 3



Forecast Lead Time	CNTL-850hPa	EXP-850hPa	CNTL-200hPa	EXP-200hPa
DAY 3	0.850	0.853	0.867	0.869
DAY 5	0.800	0.800	0.810	0.812
DAY 8	0.710	0.711	0.724	0.727

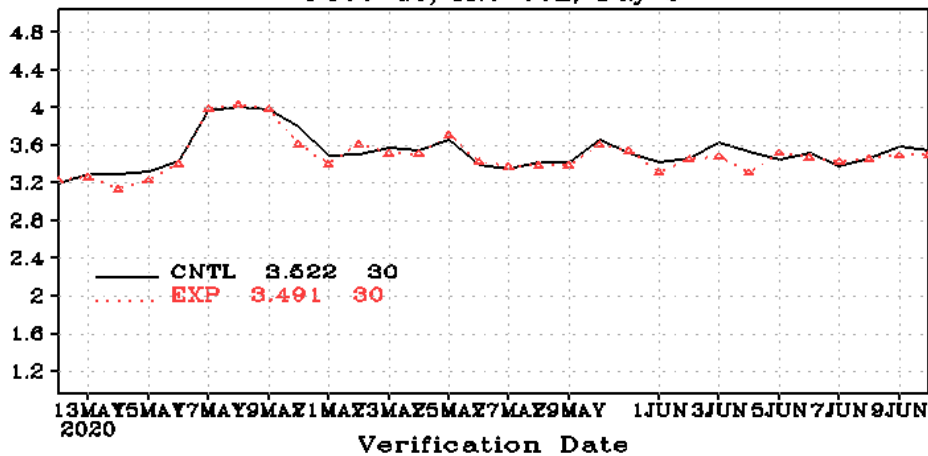
Forecast Verification : RMSE in Wind



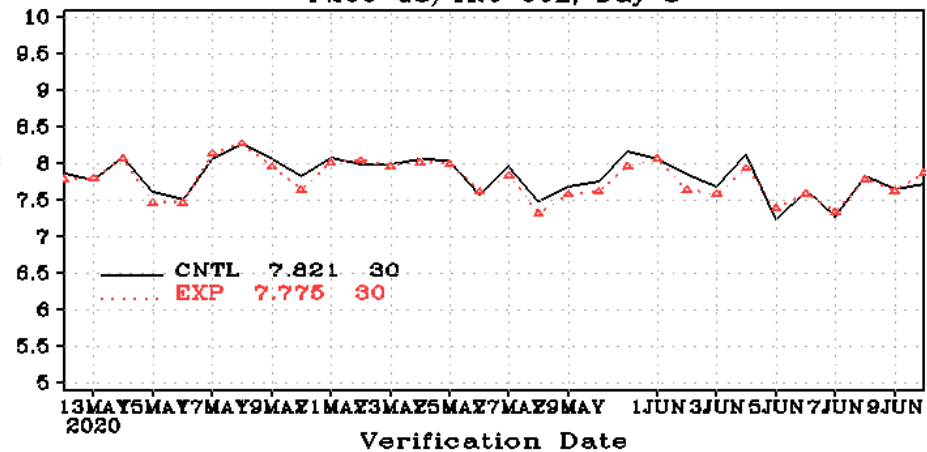
850 hPa

200 hPa

WIND: RMSE
P850 G3/TRO 00Z, Day 3



WIND: RMSE
P200 G3/TRO 00Z, Day 3

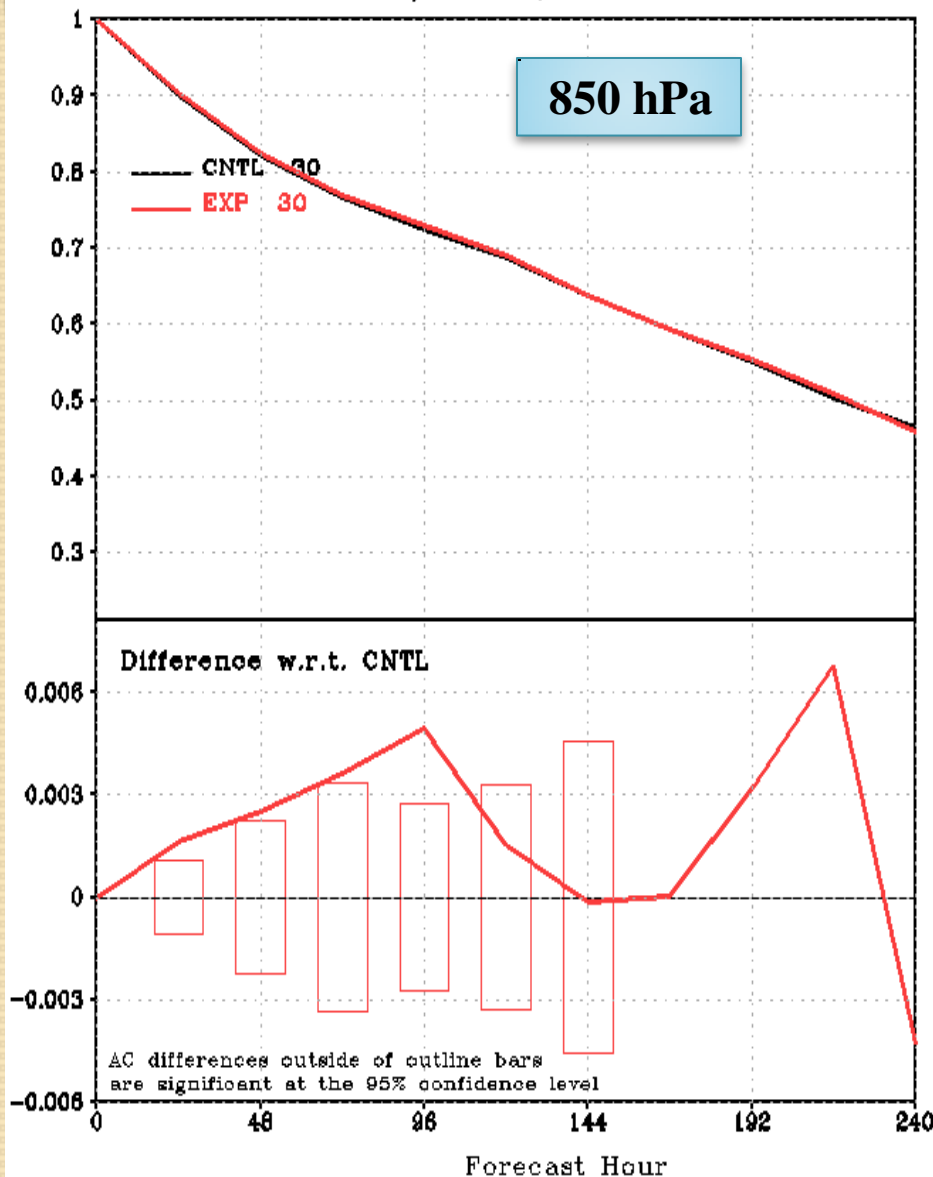


Forecast Lead Time	CNTL-850hPa	EXP-850hPa	CNTL-200hPa	EXP-200hPa
DAY 3	3.522	3.491	7.821	7.775
DAY 5	4.069	4.064	9.366	9.337
DAY 8	4.852	4.824	11.31	11.22

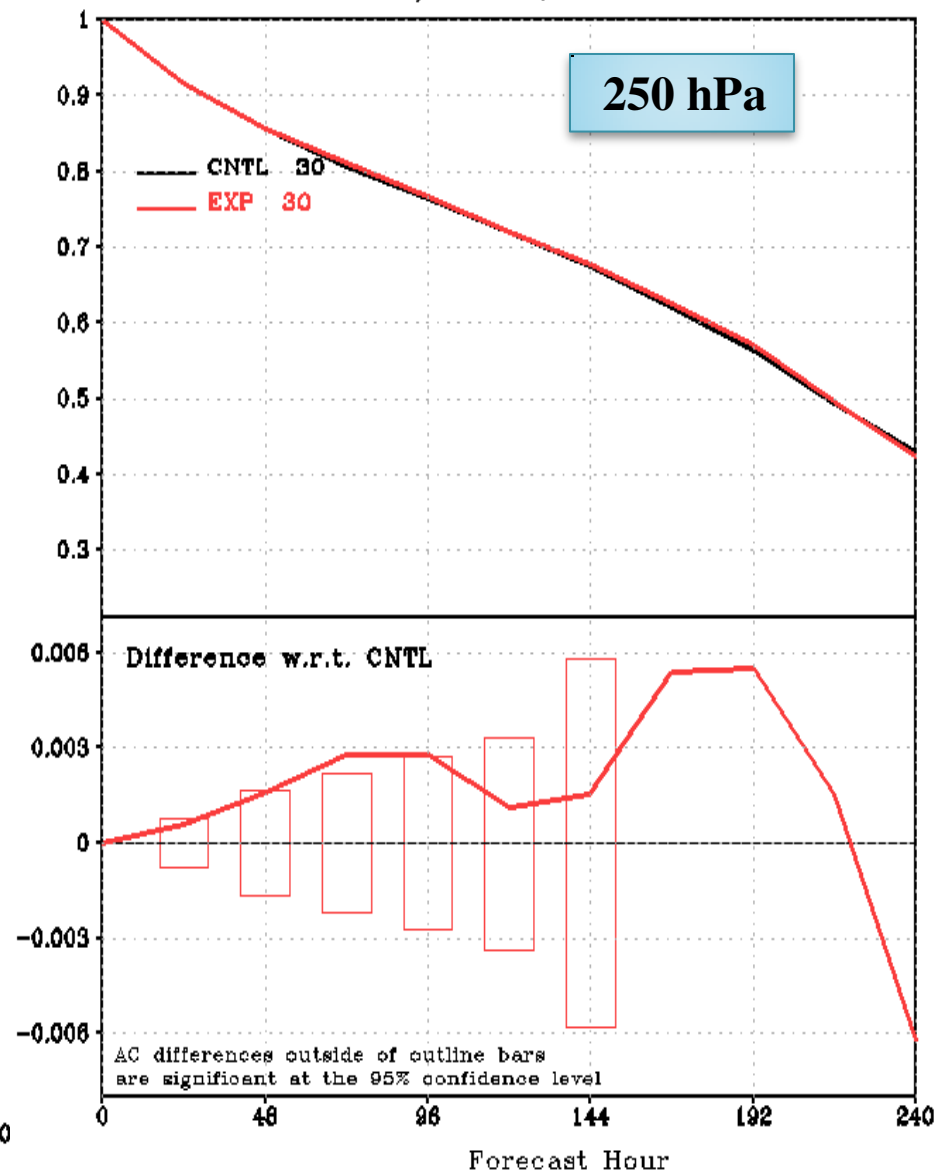
Anomaly Correlation in Winds with forecast lead time



AC: WIND P850 Q3/TRO 00Z, 20200512-20200610



AC: WIND P250 Q3/TRO 00Z, 20200512-20200610



Conclusions

- INSAT(3D & 3DR) AMVs are validated against NCMRWF NWP short forecast and in-situ observations.
- The quality of INSAT(3D & 3DR) AMVs is found to be comparable with AMVs from other satellites.
- Assimilation of INSAT(3D & 3DR) AMVs shows improvement in forecasting the Indian Summer Monsoon onset features compared to the baseline experiment.



Thanks