Overview of Data Assimilation in Operational Forecast at NCMRWF

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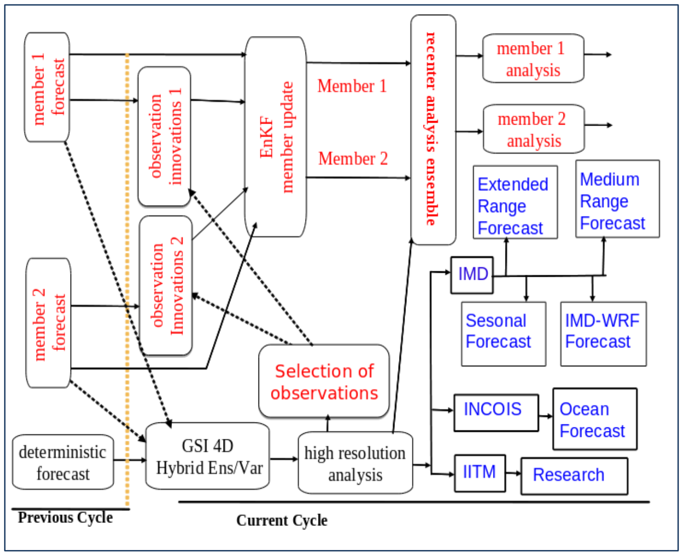
Outline

1. NCMRWF Assimilation Systems: Overview
2. Observation Reception at NCMRWF
3. Conventional Observations and Observing System Experiments (OSEs)
   Surface, Upper Air, Aircraft
4. Satellite Observations and OSEs
   Radiances, winds, GPSRO
5. Operational use of Indian satellite data at NCMRWF (R2O)
   Megha-Tropiques, Microsat-2B, INSAT-3 series, Oceansat
7. Observation Gap Areas

Operational NWP Suites Ministry of Earth Sciences (MoES) International Partnerships

Data Assimilation for IMD-GFS & GEFS Systems



IMD-GFS Global Prediction System (12 km)
(10 Days forecasts based on 00 UTC)

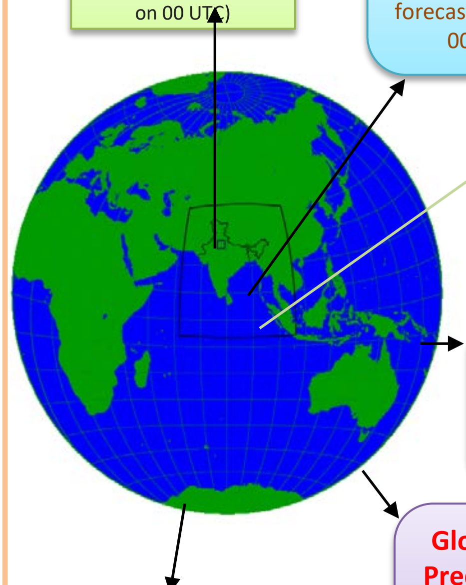
GEFS Global Ensemble Prediction System (12 km)
80 members
(10 Days forecasts based on 00 UTC)

NCUM and Data Assimilation System

330 m Delhi Fog Model
(36 hrs forecast based on 00 UTC)

1.5 km Regional Model
(48 hours forecasts based on 00 UTC)

4 km Regional Model
(72 hours forecasts based on 00 UTC)

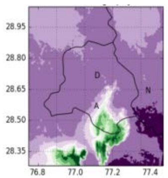
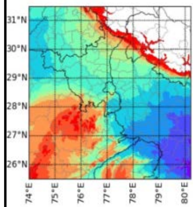
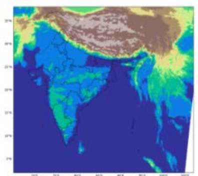
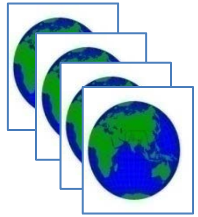
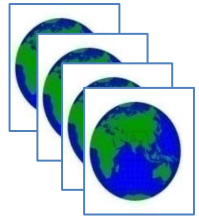


12 km Global Model
(10 Days forecasts based on 00 UTC)

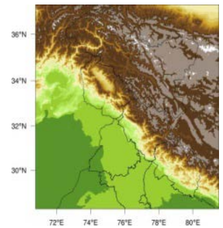
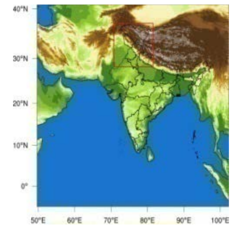
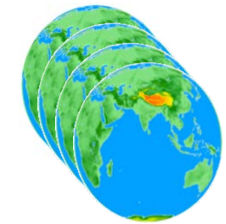
Global Ensemble Prediction System (NEPS) – 12 km
23 members
(10 Days forecasts based on 00 UTC)

60km Global Coupled Model
(NCUM+JULES+NEMO+CICE)
(One Month forecast)

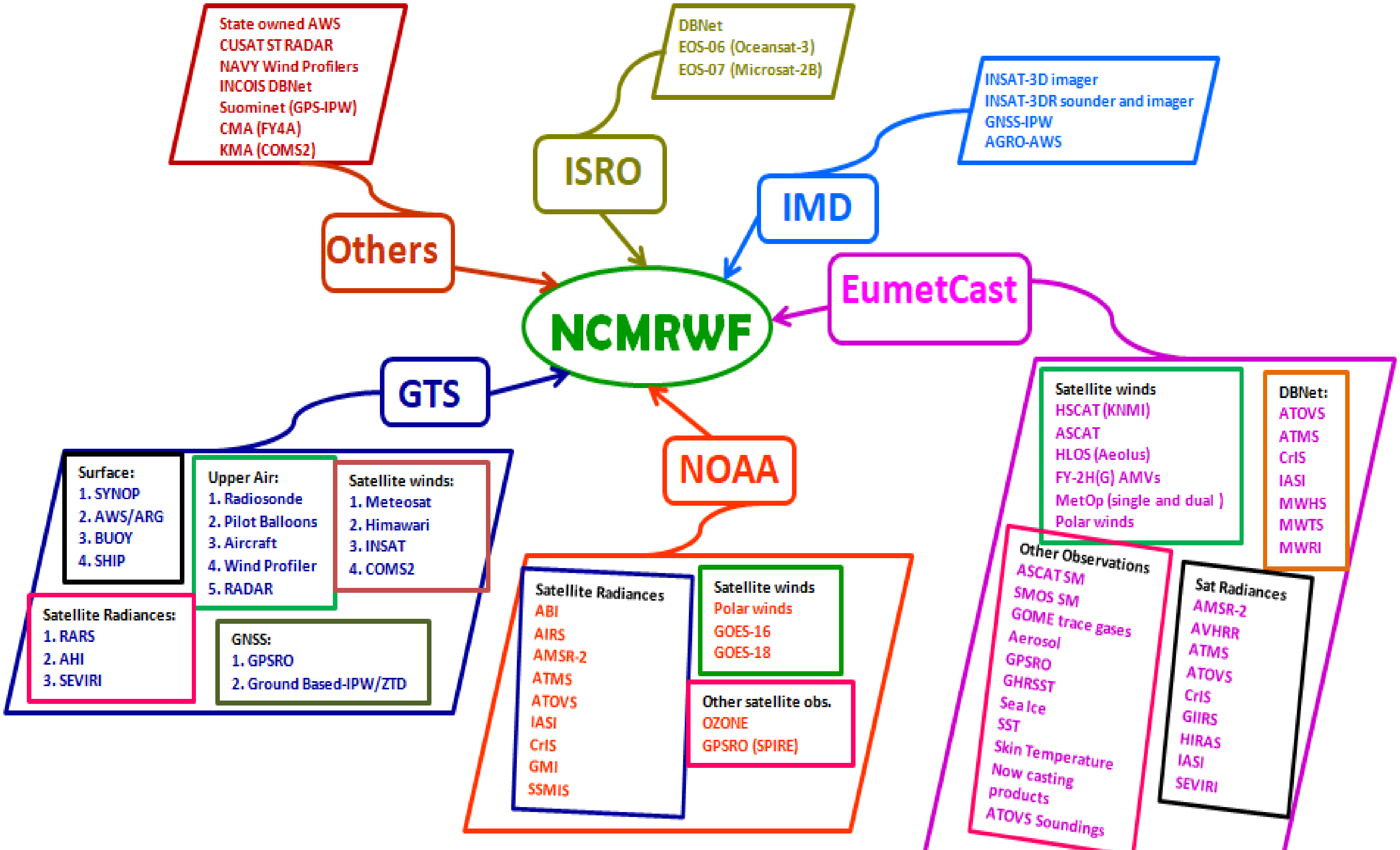
Operational NWP models at NCMRWF

	Urban Model (DM-Chem)	Meso-scale Model (1.5 km)	Regional UM (NCUM-R) (4km)	Global UM (NCUM-G) (12km)	Global EPS (NEPS) (12km)	Coupled UM (CNCUM) (60km)
Domain						
Horizontal resolution	330m	1.5km	4.4 km	12km	12km	Atmosphere: approx. 60 km Ocean: approx. 25 km
Fcst length (IC)	48 hours	48 hours	75 hours(00UTC & 12UTC)	10 days (00,12 UTC)	10 days (00,12 UTC)	1 month (ERP) 3 /4 months (Seasonal)
Ensemble size	1	1	1	1	23	ERP:16 Seasonal: 55 (Only atmosphere)
Initial conditions	Downscaled IC from 1.5km domain	Downscaled IC From NCUM-G	Regional DA (4-D Var)	Global DA (Hybrid 4-D Var)	Global DA Pert: ETKF+SKEB+SP	Atmosphere: Global DA Pert: SKEB Ocean: NEMOVAR
SST Conditions	Downscaled	Downscaled	OSTIA SST Analysis (EKF)	OSTIA SST Analysis (EKF)	OSTIA SST Analysis (EKF)	Predicted SST in the fully coupled model
Main Products	Visibility/fog AQI Surface weather	Visibility/Fog AQI Surface weather	Precipitation Lightning Wind gust Surface weather	Precipitation Wind TC track and intensity Severe weather	Precipitation Wind TC track and intensity EFI	Anomalies (Precipitation, wind, SST), monsoon, El Nino

Operational GFS based NWP models at NCMRWF

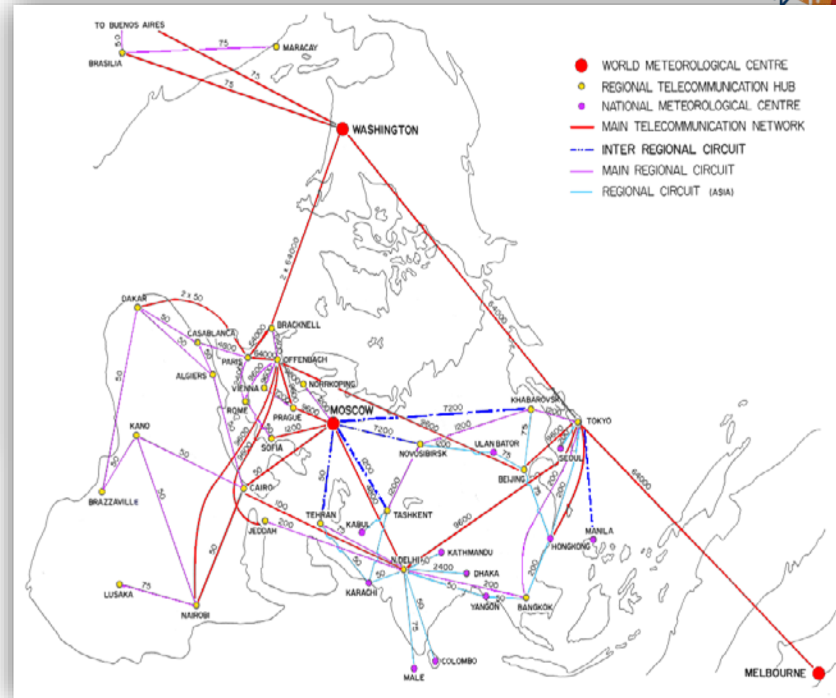
	HRRR	HWRF	Global Spectral Model (IMD-GFS)	Global EPS (GEFS)
Domain				
Horizontal resolution	1 km	5 km	~ 12 km	~ 12 km
Forecast Length (IC)	27 hours (00UTC) 18 hours (every hour)	120 hours (00UTC)	10 days (00,12 UTC)	10 days (00,12 UTC)
Ensemble size	1	1	1	20
Initial Conditions	3D-Var	Atmosphere: 3D-Var Ocean: HYCOM + Climatological Profile	Hybrid 4DEnVar	Global Analysis + EnKF
SST Conditions	GFS SST	HYCOM	Near-surface Sea Temperature (NSST)	Near-surface Sea Temperature (NSST)
Main Products	Heavy Rainfall Episodes, Thunderstorm Prediction	Cyclone Forecast	Daily Weather Forecast (Heavy Rainfall Forecast, TC Forecast, IC for Fog Forecast, Agro-Advisory, IC for Solar and Wind Energy Forecasting, etc.)	Weather Forecast (Daily Rainfall, Max-Min Temperature, TC Forecast, etc.)

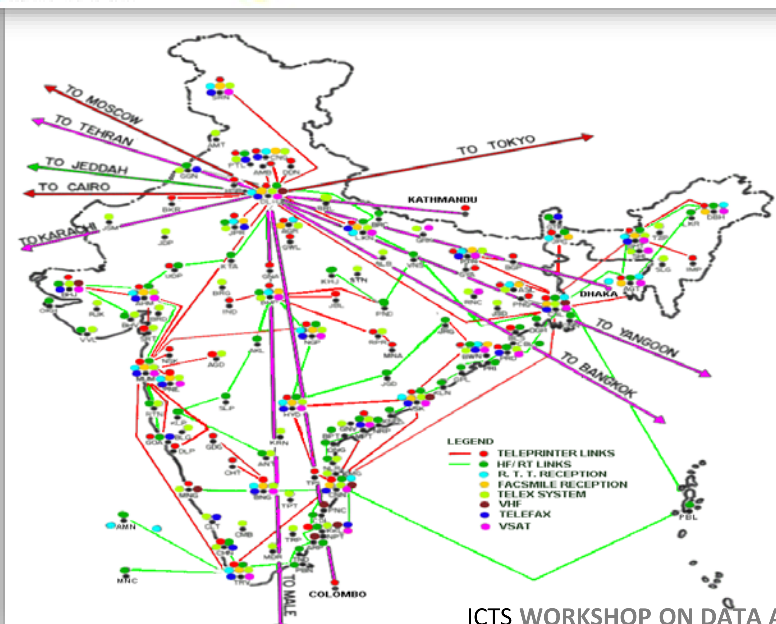
Meteorological and Oceanic Observation Reception at NCMRWF



WMO Regional Associations

Global Telecommunication System (GTS) Network





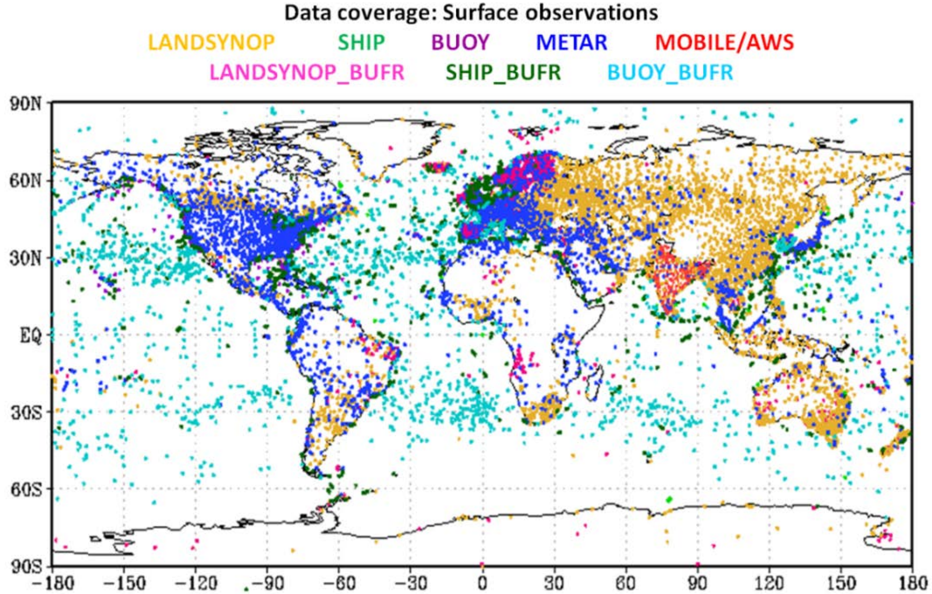
GTS Network: India

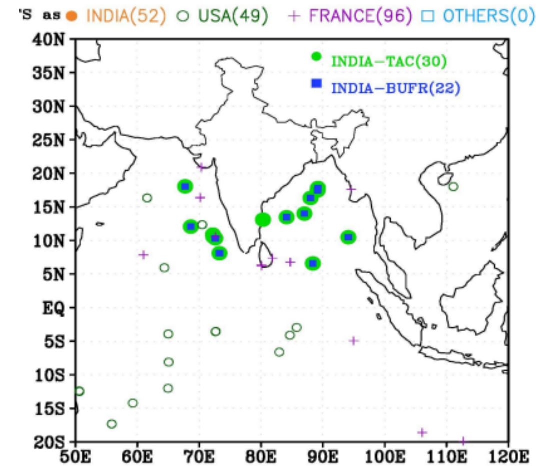
Observations Assimilated in the NCMRWF Global DA System

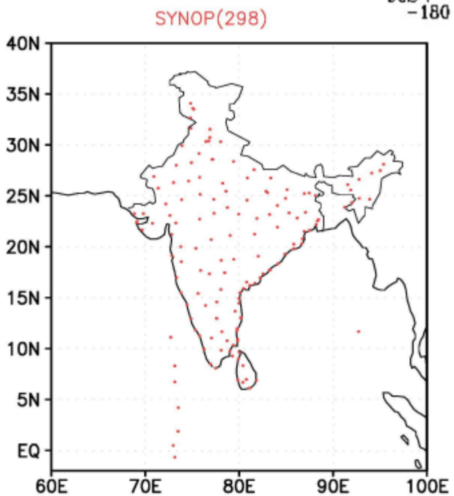
Conventional Observations	Surface (GTS)			**LAND SYNOP (TAC, BUFR), SHIP (TAC, BUFR), BUOY (TAC, BUFR), METAR, TC BOGUS, AWS**
	Upper Air (GTS)			**PILOT, RS/RW (TAC and BUFR) , Wind Profiler, Drop sonde, Indian DWR VAD Winds**
	Aircraft (GTS)			**AMDAR, AIREP**
Satellite Observations	HLOS Wind		LEO	**ALADIN (Aeolus) (Mie Cloudy and Rayleigh Clear)**
	Satellite Winds	AMVs	GEO	**INSAT-3D & 3DR, Meteosat-9 , Meteosat-11, Himawari-9, GOES-16, GOES-18**
			LEO	**MetOp-B & C, NOAA-18, NOAA-19, SNPP, NOAA-20, AQUA, TERRA, Dual MetOp**
		Scatterometer winds	LEO	**ASCAT (MetOp-B), ASCAT (MetOp-C), OSCAT-3 (Oceansat-3)**
	Satellite radiances	IR	GEO	**INSAT-3D Imager, INSAT-3DR Sounder, SEVERI (Metosat-9 & 11), AHI (Himawari-9), ABI (GOES-16 & 18)**
		IR (Hyper Spectral)	LEO	**IASI (MetOp-B, C), AIRS (AQUA), CrIS (SNPP & NOAA-20)**
		MW	Sounder	**AMSU-A (MetOp-B, -C, NOAA-15, 18, 19) , MHS (MetOp-B, C, NOAA-19), ATMS (SNPP & NOAA20) SSMIS (DMSP-F17), MWHS-2 (FY3-C, D), MWTS-2 (FY3-C,D), Microsat-2B (EOS-07)**
			Imager	**AMSR-2 (GCOM-W1), MWRI (FY3D), GMI (GPM)**
	GPSRO	Bending angle	LEO	**GRAS-(B & C), TanDEM-X, TerraSAR-X, FY-3D, COSMIC-2, Spire, PAZ, KOMPSAT-5, GeOptics, GRACE (C & D), PlanetIQ, Sentinel-6**

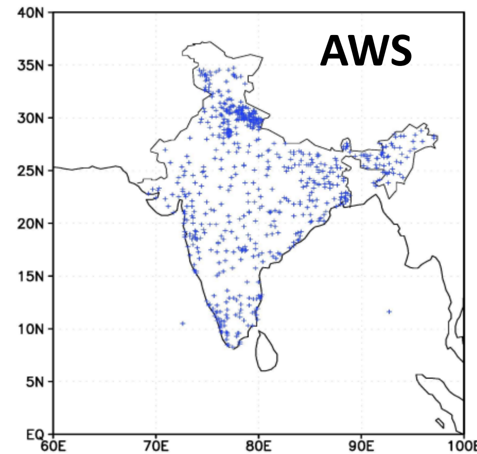
Conventional Observations

1. Surface





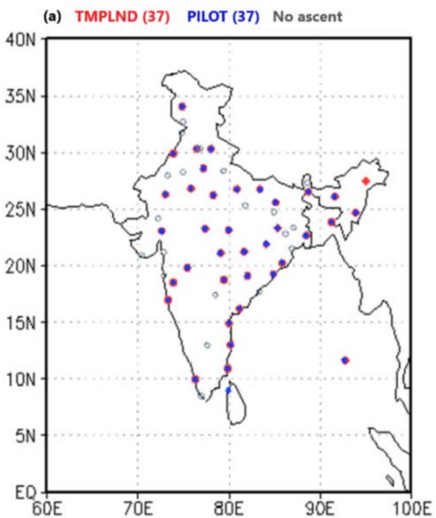


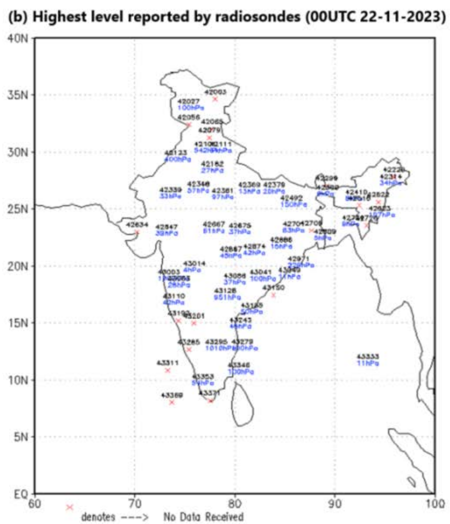


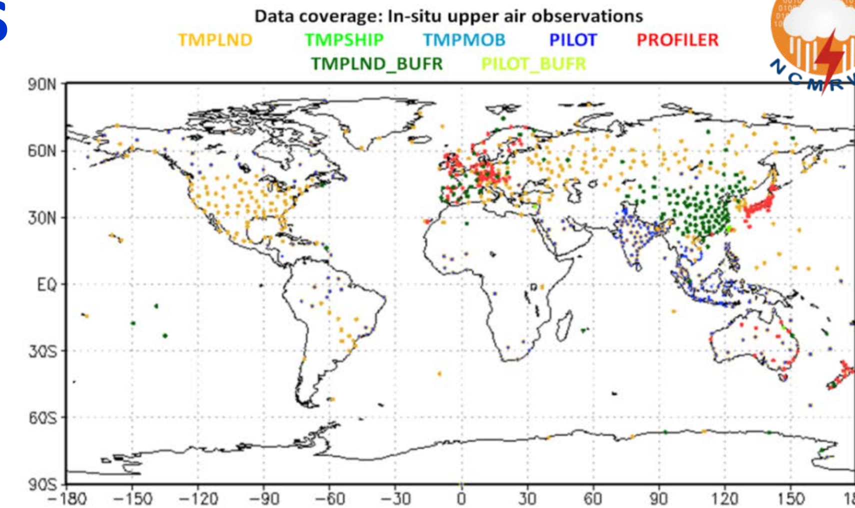
Conventional Observations

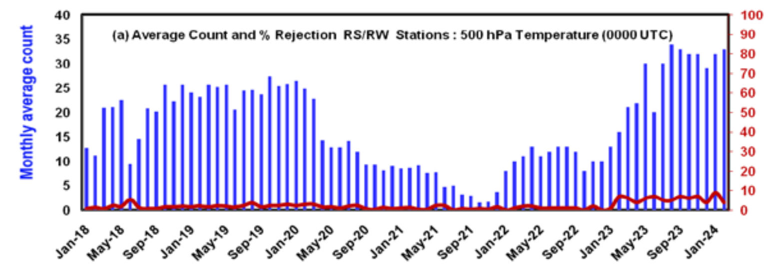
1. Surface

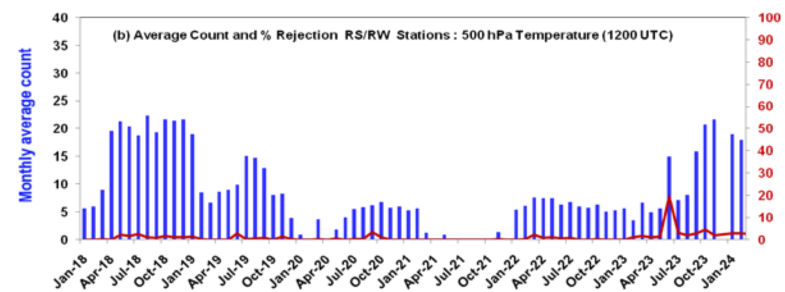
2. Upper Air









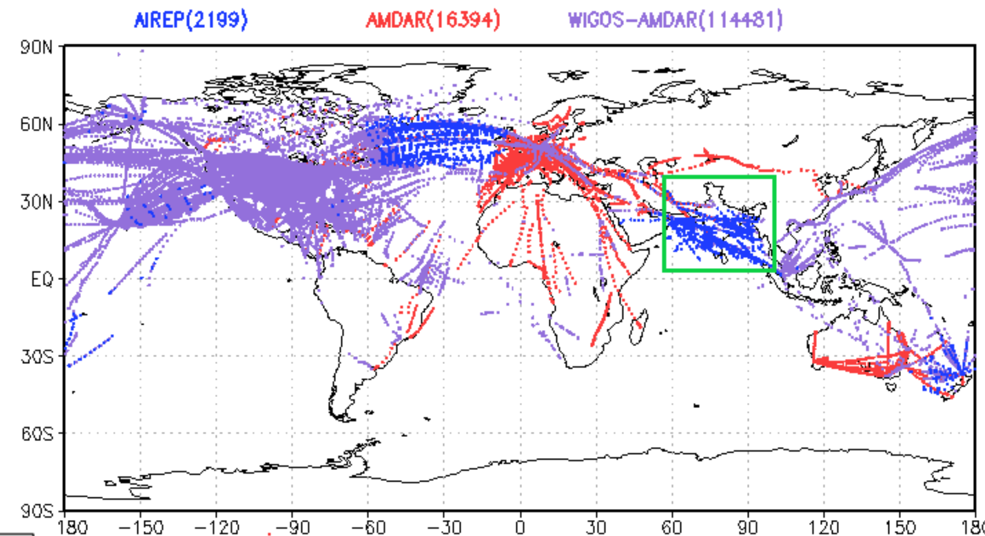


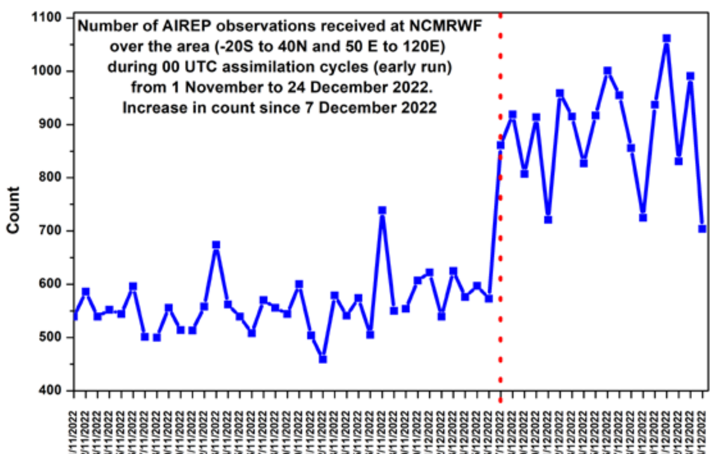
Conventional Observations

1. Surface

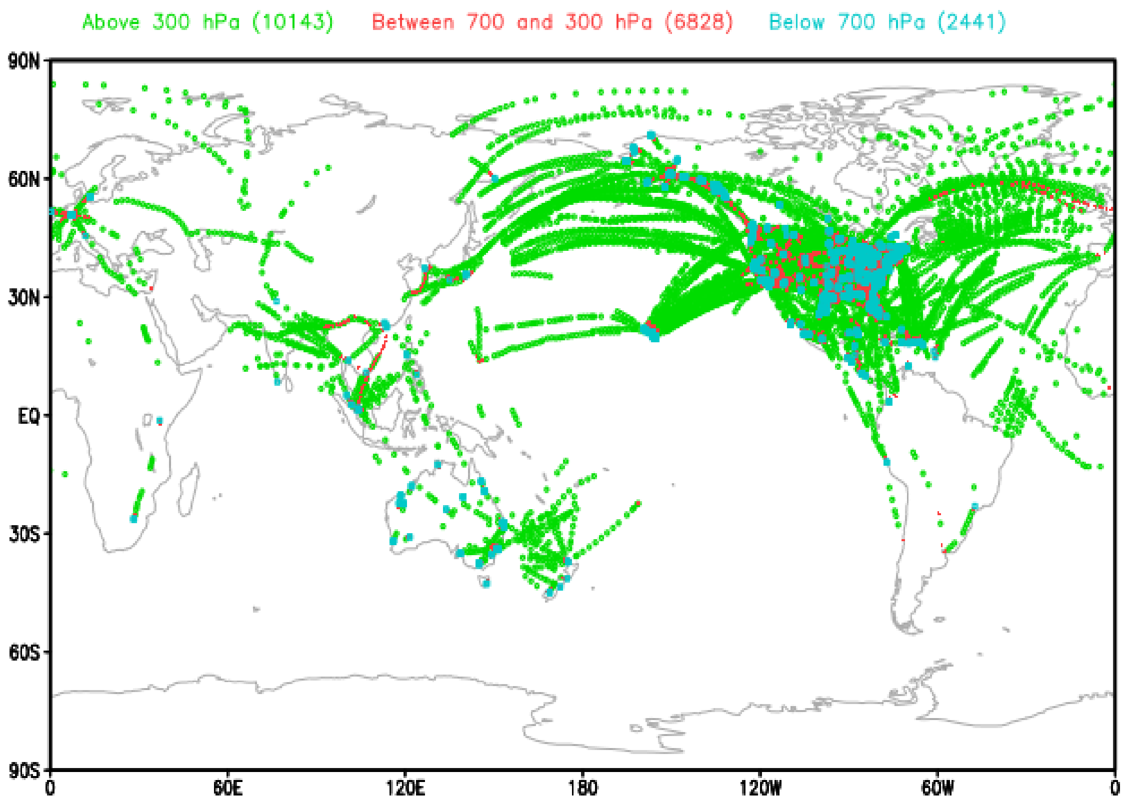
2. Upper Air

3. Aircraft





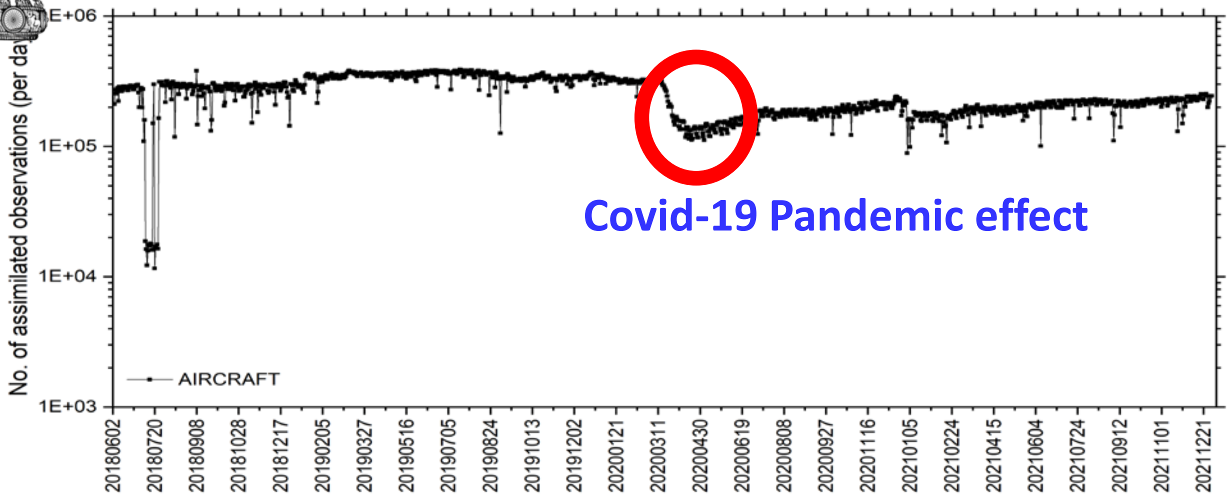
Bifurcation of Aircraft Observations at different regions in the vertical
For a typical 00z assimilation cycle



High level: Above 300 hPa
Middle level: Between 700 and 300 hPa
Low level: Below 700 hPa

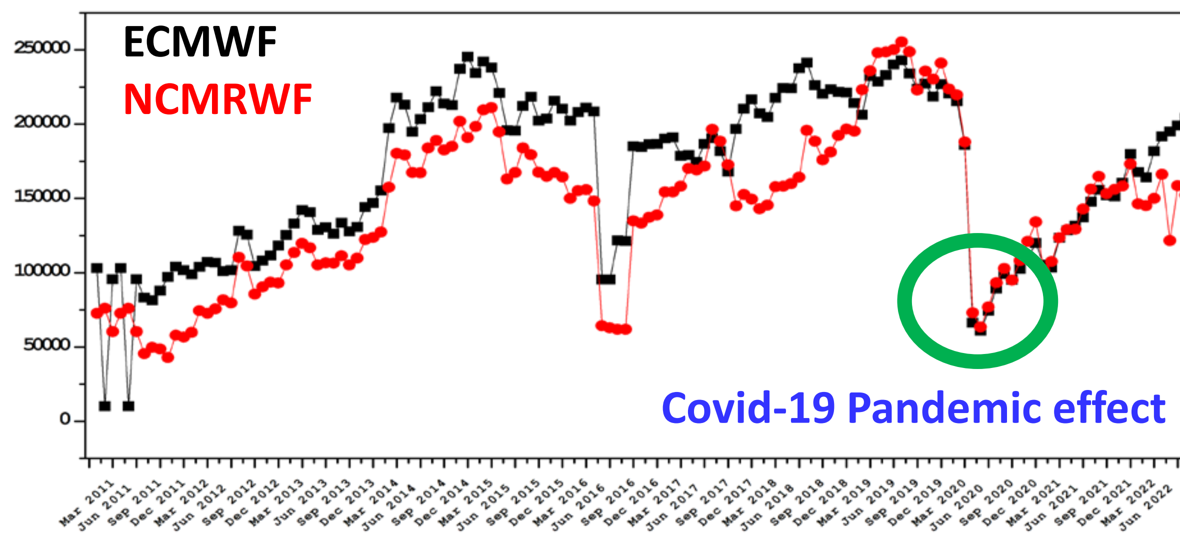
- **Majority of the aircraft observations received are at cruise level**
- **Very few or nil low level (take off and landing) and middle level observations over the Indian region**
- **Low and middle level aircraft observations are confined mainly over the U.S. and some part of Europe.**
- **Aircraft take off landing observations are of high vertical resolution and are equivalent to radiosonde profiles (Lacks over the Indian latitudes)**

Number of Aircraft observations assimilated per day (since June 2018)



Comparison of Aircraft data reception between **ECMWF** and **NCMRWF**

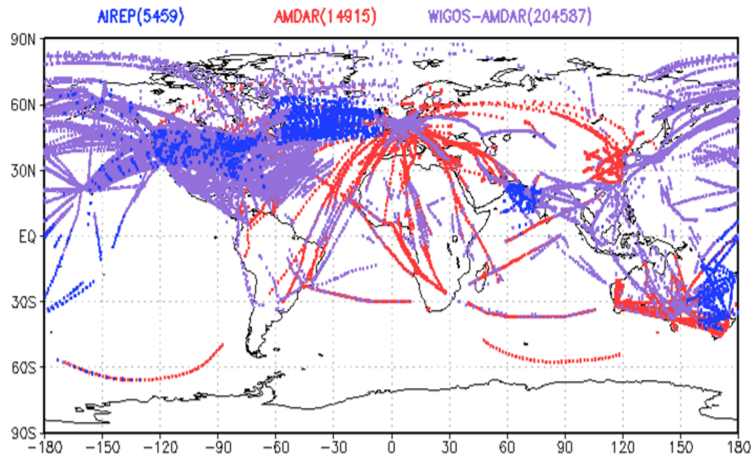
NCMRWF receives slightly less number of Aircraft observations than ECMWF



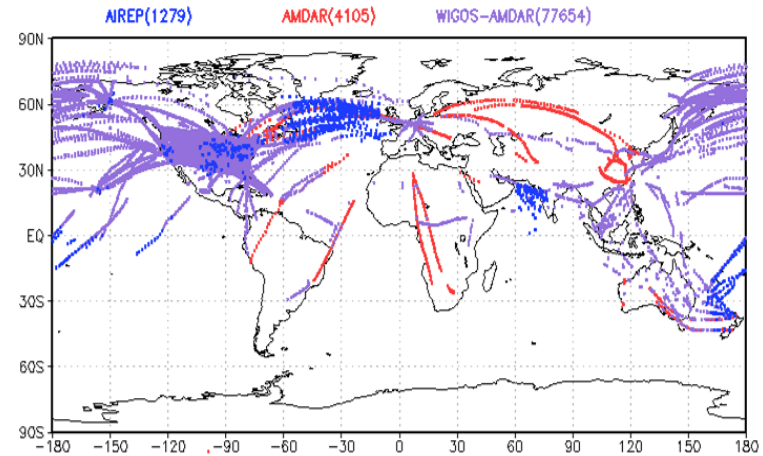
Aircraft Observation coverage received at NCMRWF

Global

(a) 10 April 2019 00Z

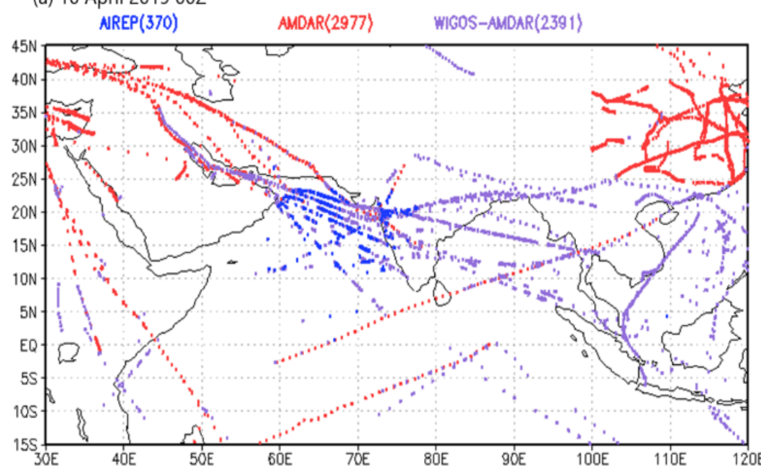


(b) 10 April 2020 00Z

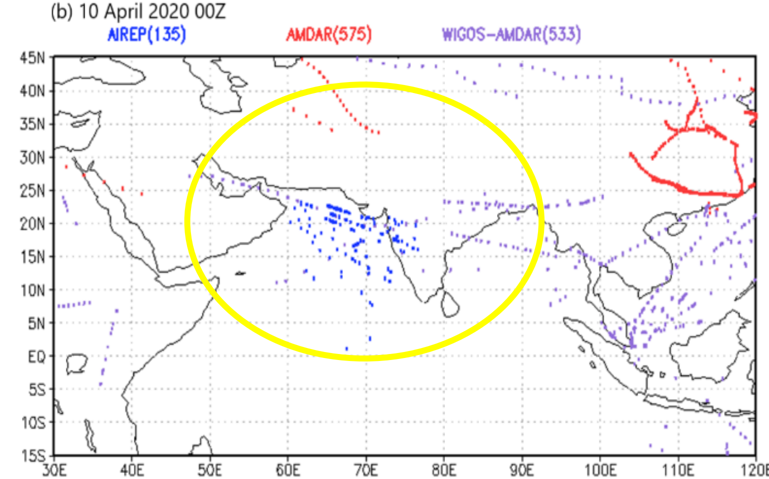


India and surrounding regions

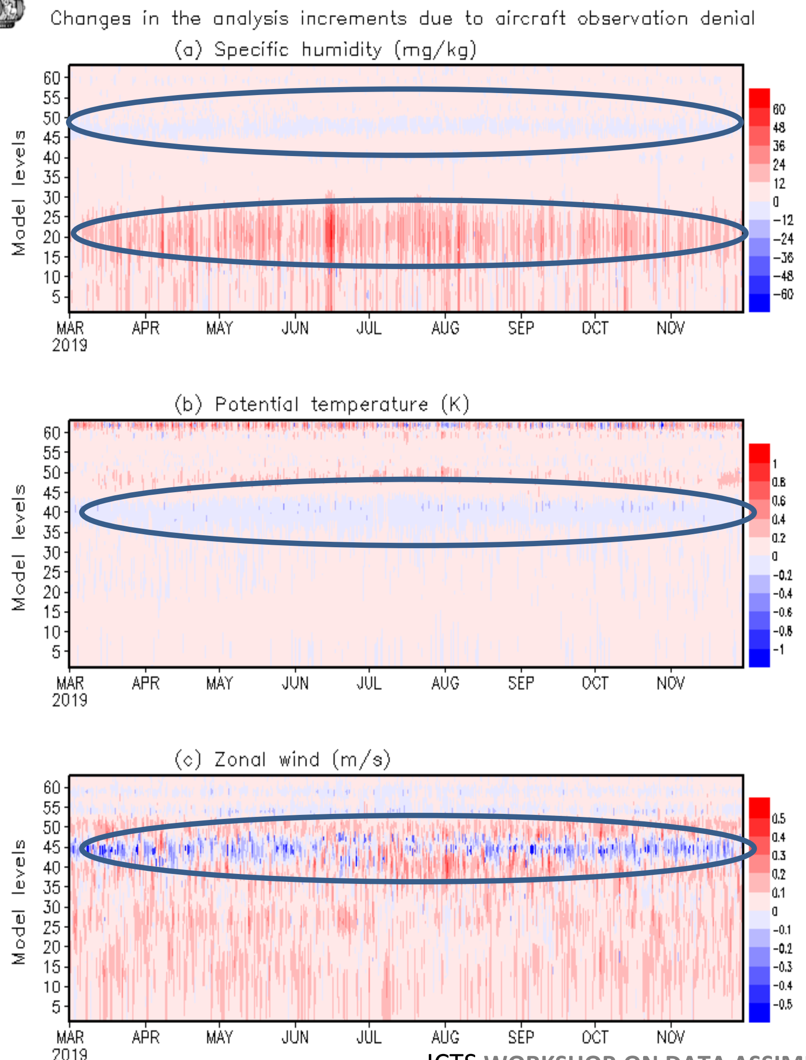
(a) 10 April 2019 00Z



(b) 10 April 2020 00Z



Aircraft Observation assimilation Impact: Analysis increment



Differences in the monthly average of domain mean of analysis increment profiles for (a) Specific Humidity (mg/kg), (b) Potential Temperature (K), and (c) zonal wind (m/s). The model levels 15, 30, and 45 respectively represent approximate heights of 1.5 km, 6 km, and 14 km.

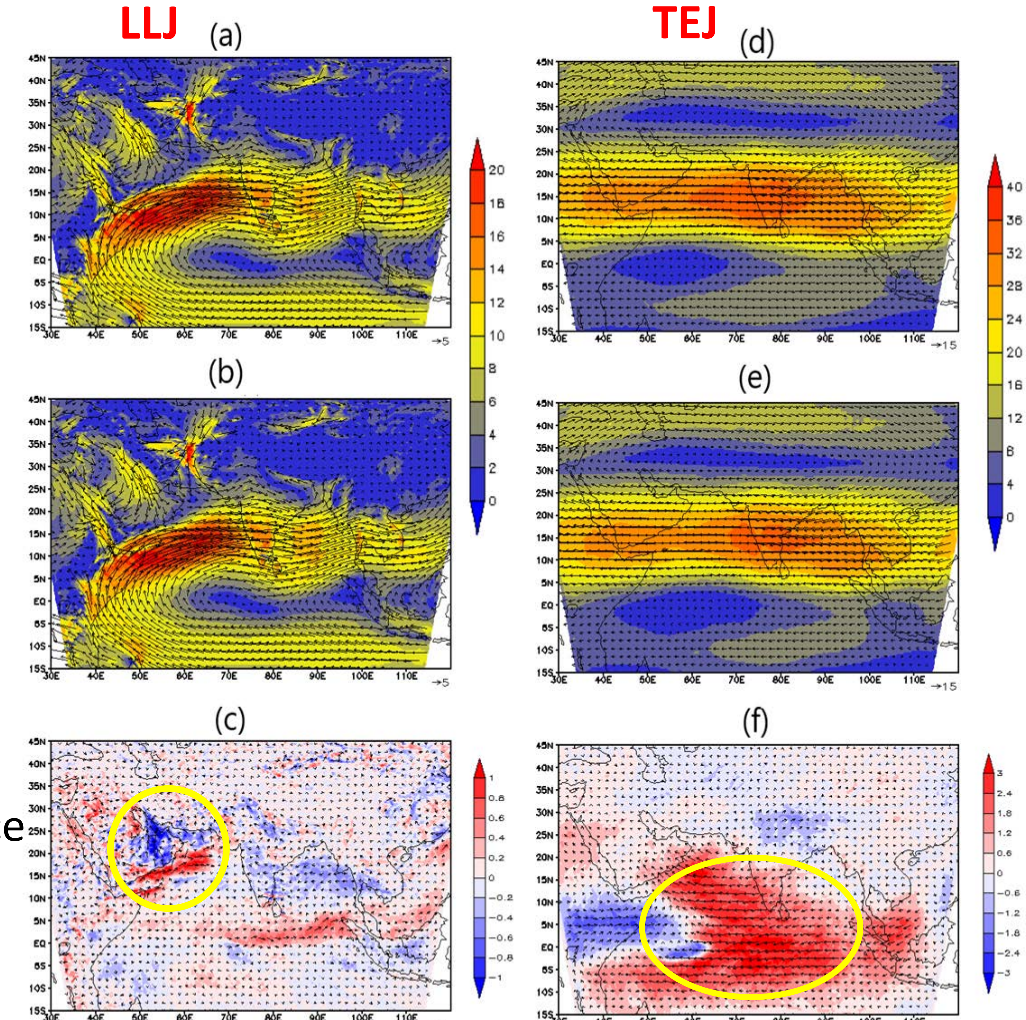
ABO assimilation impact is mainly confined over the higher altitudes

Aircraft Observation assimilation Impact: Forecast

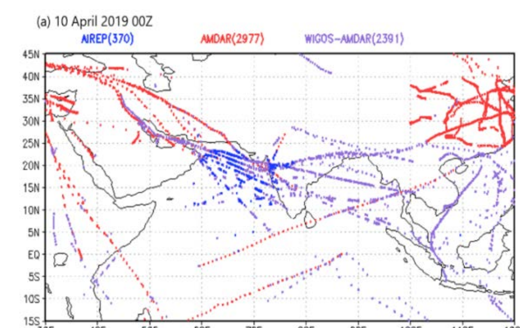
With Aircraft

Data Denial

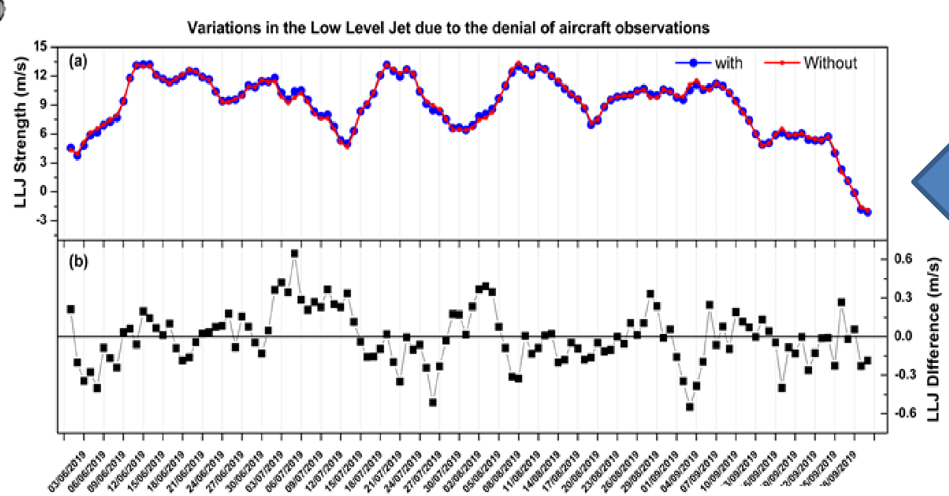
Difference



Impact of ABO assimilation noticed over the relatively heavy air traffic area and the neighboring region



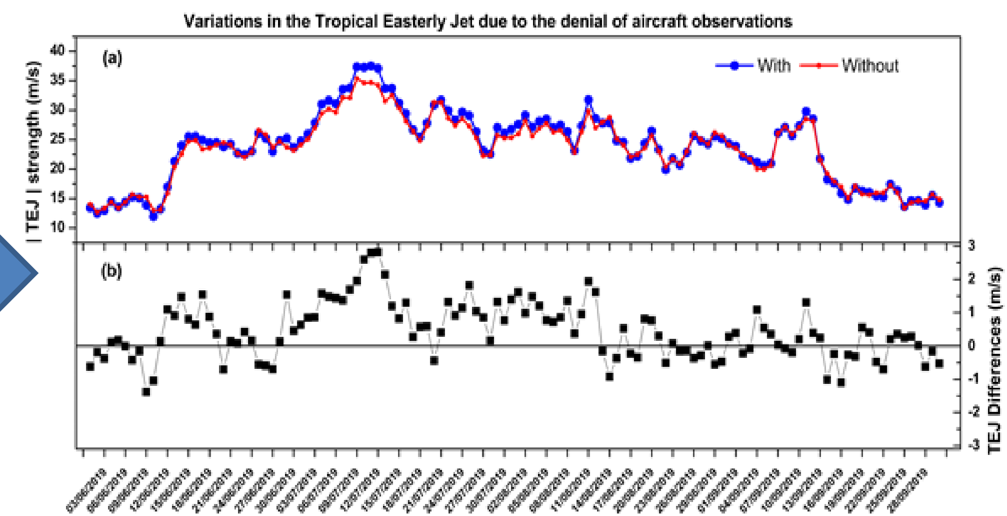
Aircraft Observation assimilation Impact: Forecast



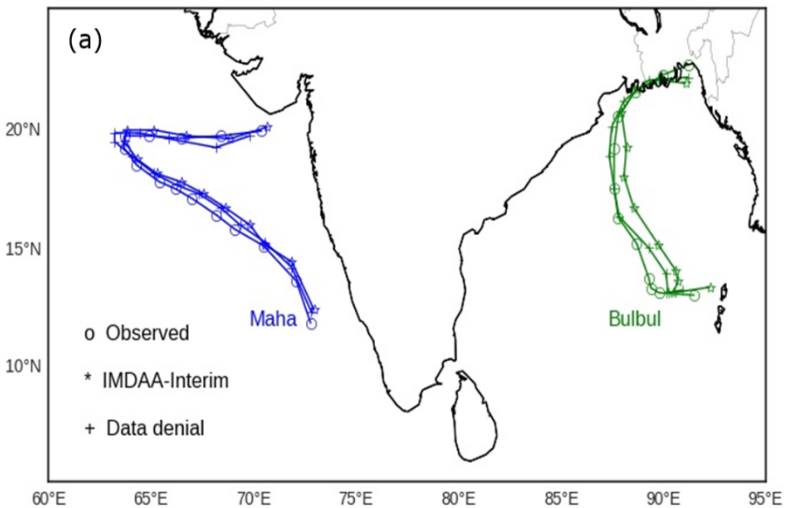
LLJ

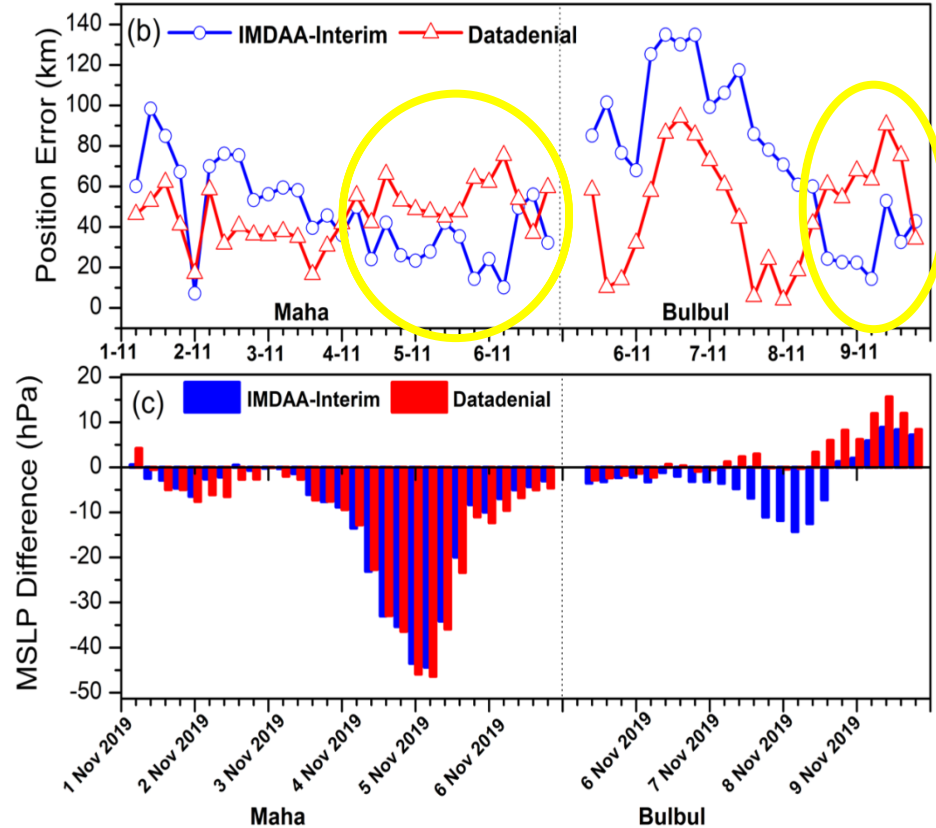
Assimilation of ABOs simulated strong LLJ and stronger TEJ

TEJ



Impact of ABO assimilation in the simulation of cyclones





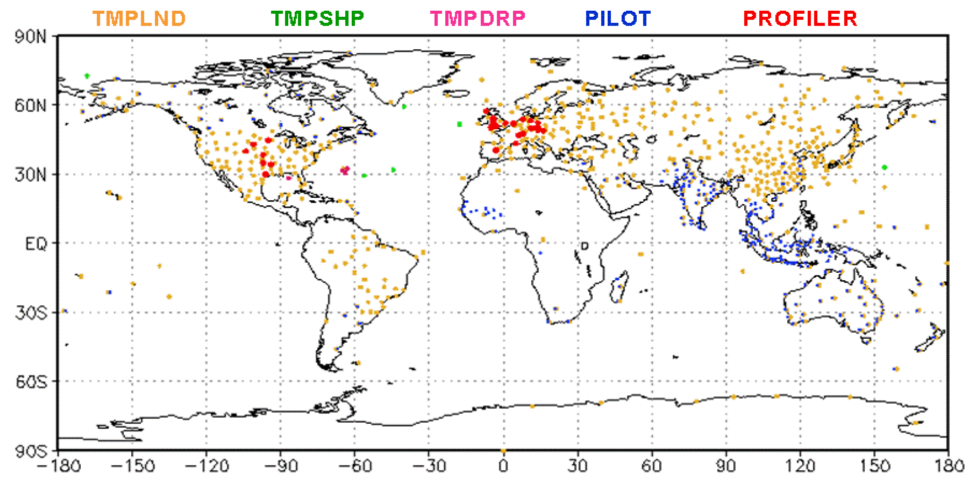
Assimilation of ABO simulates better track and intensity of the cyclones when they are in the category of "severe" storms.

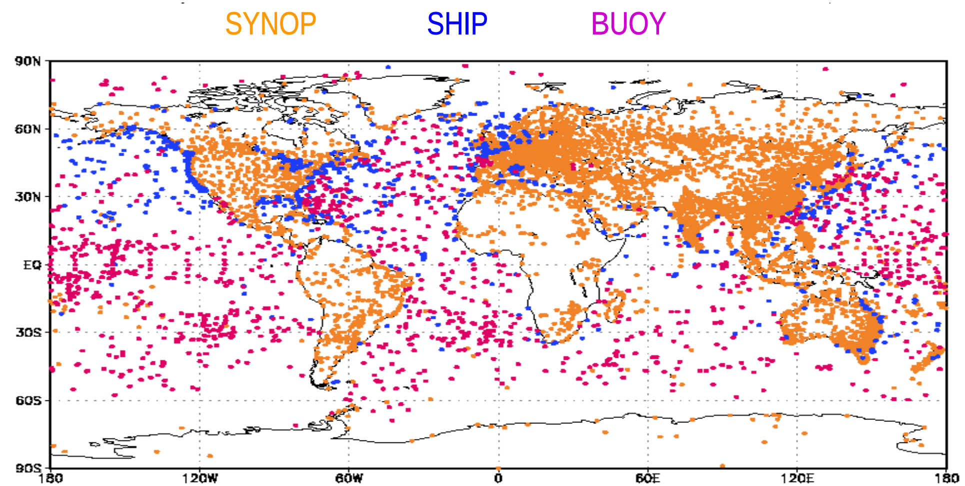
Need for Satellite Data

Conventional observations of temperature, wind, and moisture profiles are confined over the Northern Hemisphere land area

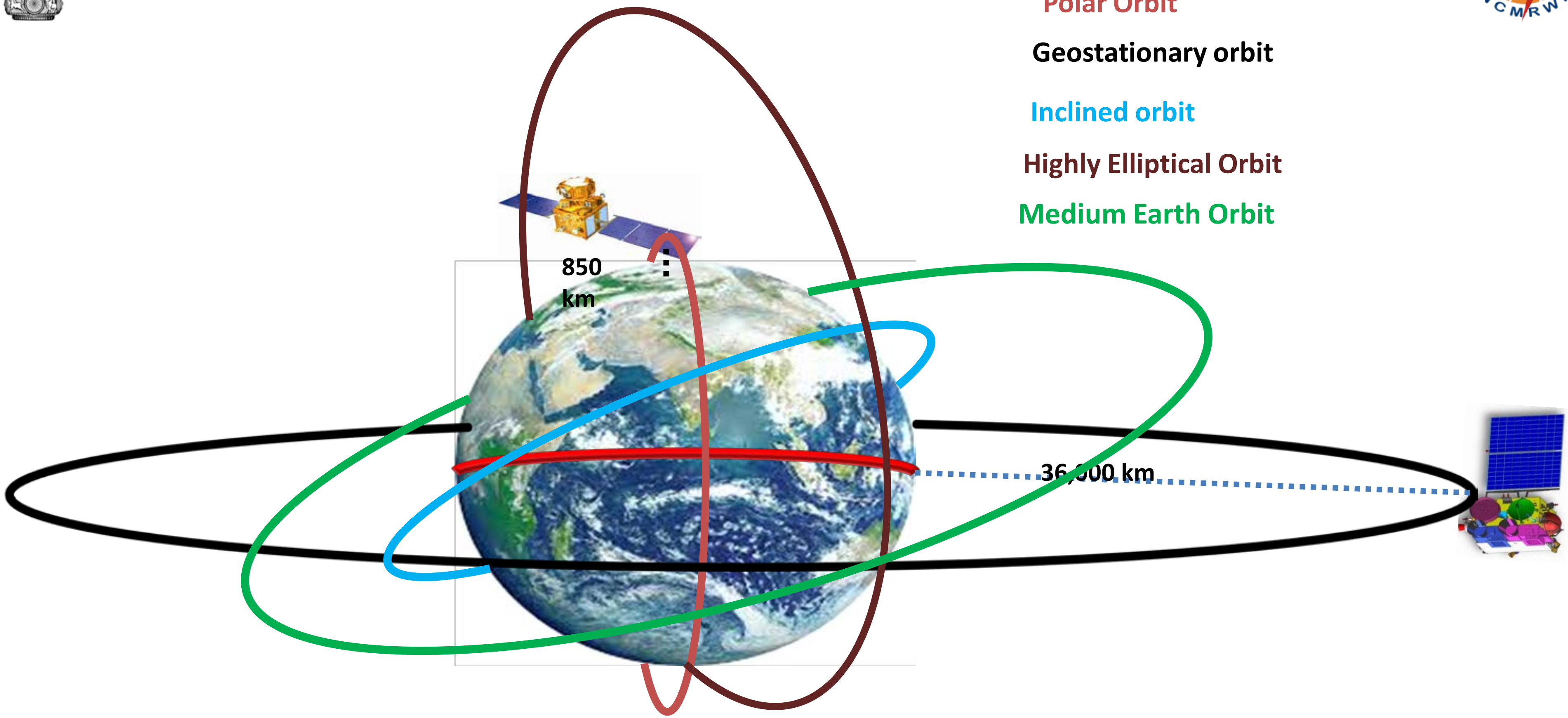
Over the ocean, conventional observations are primarily limited to single level data provided by aircraft, ships, and buoys.

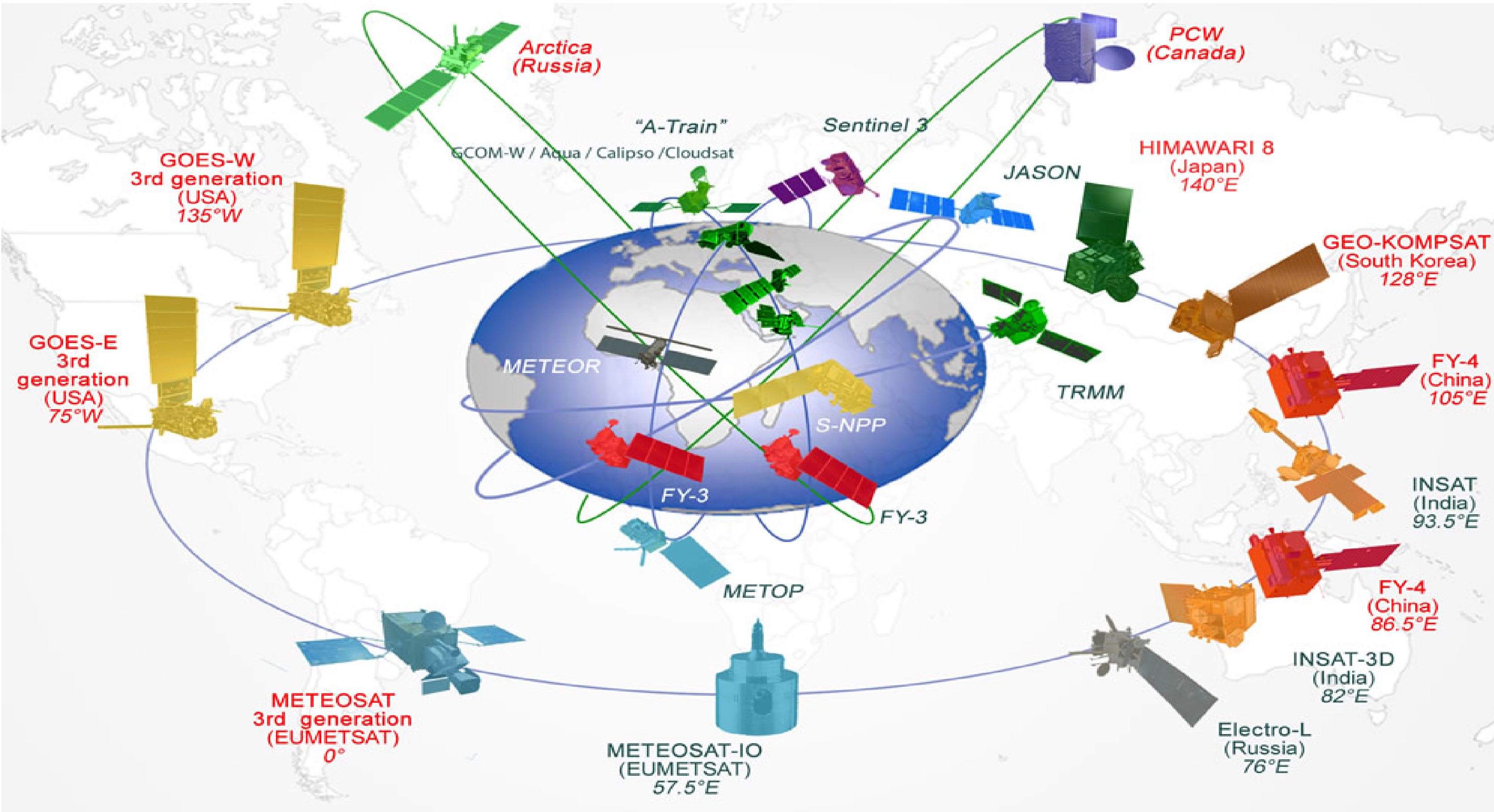
The coverage of these and other ground based observing systems is not sufficient for global atmosphere and ocean research or weather prediction.





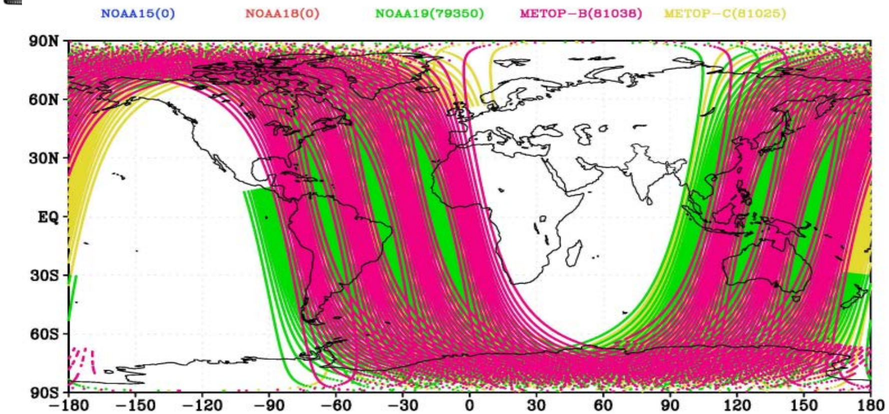
Types of satellite orbits




Arctica
(Russia)
PCW
(Canada)
"A-Train"
GCOM-W / Aqua / Calipso /Cloudsat
Sentinel 3
HIMAWARI 8
(Japan)
140°E
JASON
GOES-W
3rd generation
(USA)
135°W
GEO-KOMPSAT
(South Korea)
128°E
GOES-E
3rd
generation
(USA)
75°W
METEOR
FY-4
(China)
105°E
TRMM
S-NPP
INSAT
(India)
93.5°E
FY-3
FY-3
METOP
FY-4
(China)
86.5°E
INSAT-3D
(India)
82°E
METEOSAT
3rd generation
(EUMETSAT)
0°
METEOSAT-IO
(EUMETSAT)
57.5°E
Electro-L
(Russia)
76°E

Some of the main Satellite data currently using at NCMRWF

Radiances (Low Earth Orbit)



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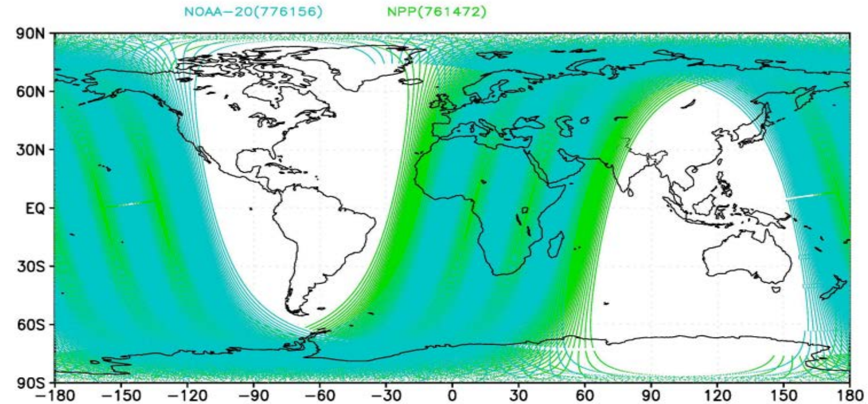
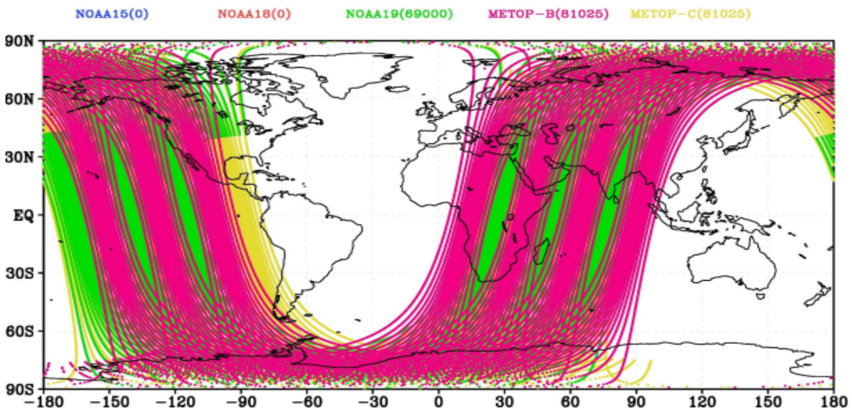
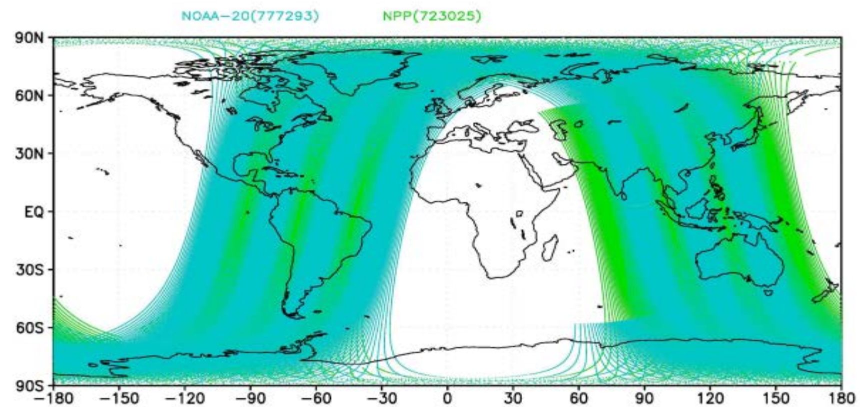


7. AIRS: Atmospheric Infra-Red Sounder (AQUA)

frare





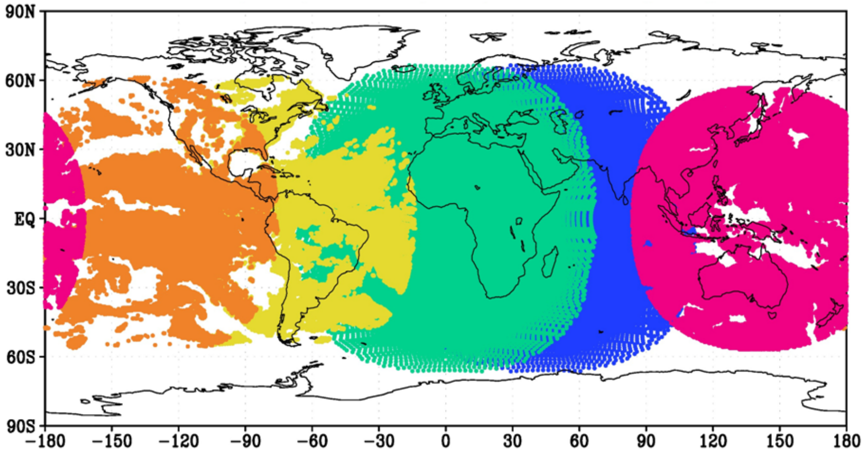
Some of the main Satellite data currently using at NCMRWF

Radiances (Geostationary)

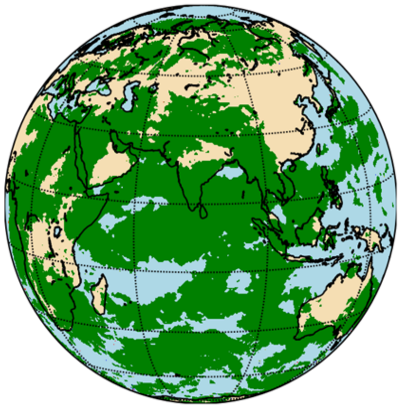
1. INSAT-3D(R) Imager and Sounder (4 instruments)
2. SEVIRI: Spinning Enhanced Visible and Infra-Red imager (Meteosat series) (2 instruments)
3. AHI: Advanced Himawari Imager (Himawari)
4. ABI: Advanced Baseline Imager (GOES) (2 intruments)

Multispectral GEO

(a) GOES-18 GOES-16 Meteosat-10 Meteosat-9 Himawari-9



(b) INSAT-3D/3DR



Some of the main Satellite data currently using at NCMRWF

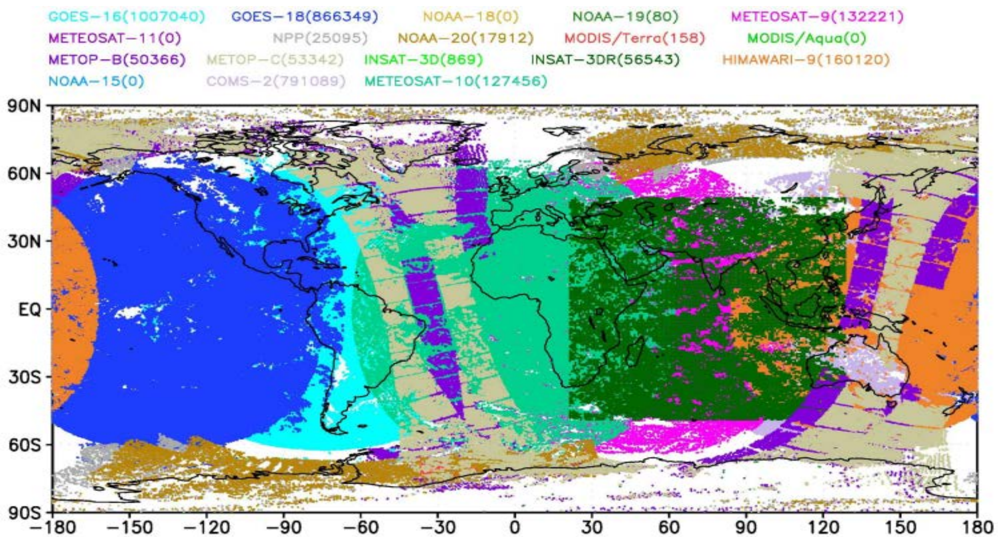
Satellite Winds

Atmospheric Motion Vectors

Geostationary: (INSAT-3D/3DR. Meteosat-9, 10, Himawari, GOES-16, 18, Geo-Kompsat)

Polar: (NOAA Series, MetOp series, Aqua/Teraa)

Dual winds: MetOp



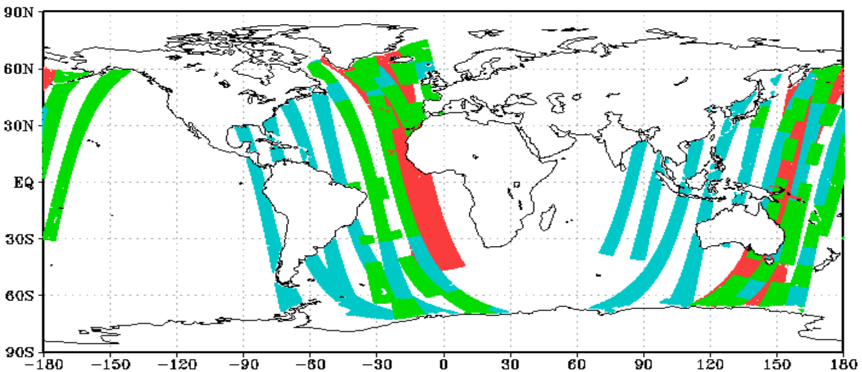
Some of the main Satellite data currently using at NCMRWF

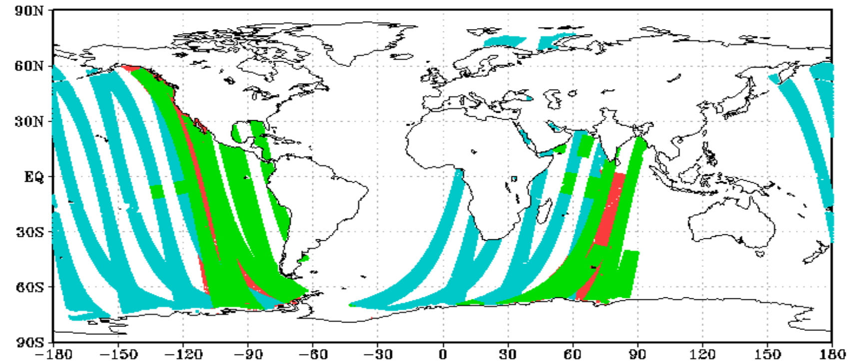
Satellite Winds

Scatterometer Sea Surface Winds

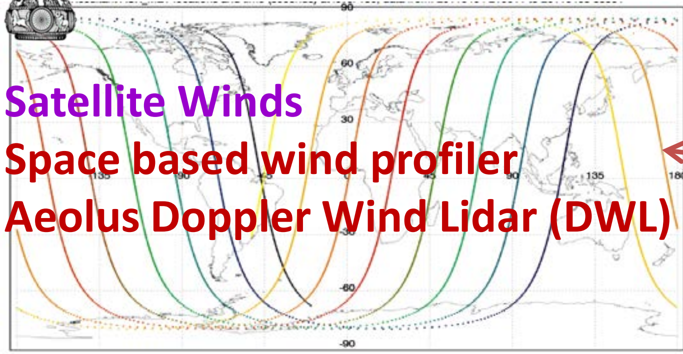
MetOp (ASCAT-B and C), Oceansat-3

Oceansat-3 **ASCAT-B** **ASCAT-C**





Some of the main Satellite data currently using at NCMRWF



Satellite Winds

Space based wind profiler

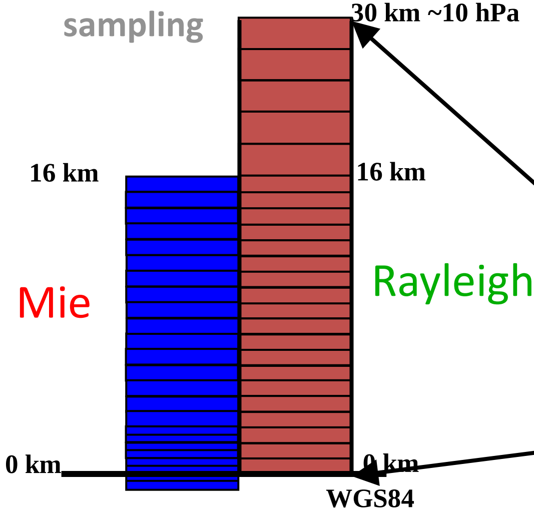
Aeolus Doppler Wind Lidar (DWL)

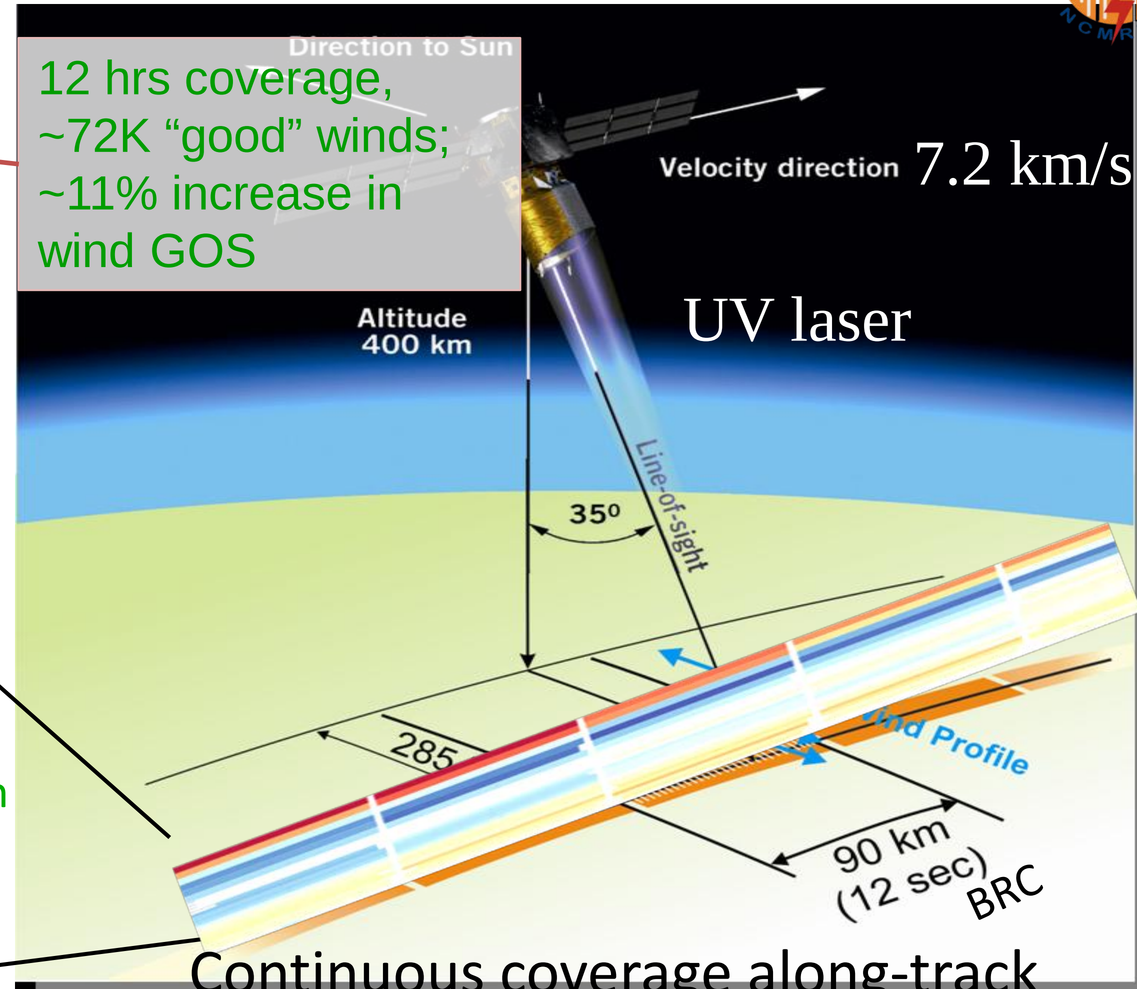
Mostly zonal component of wind

Coverage up to 83 °N/S

12 hrs coverage, ~72K "good" winds; ~11% increase in wind GOS

Example of Aeolus vertical sampling





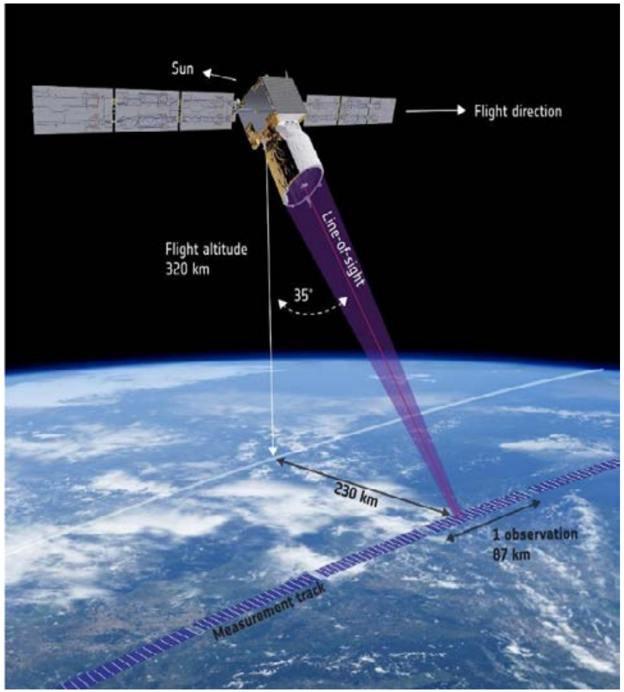
Continuous coverage along-track

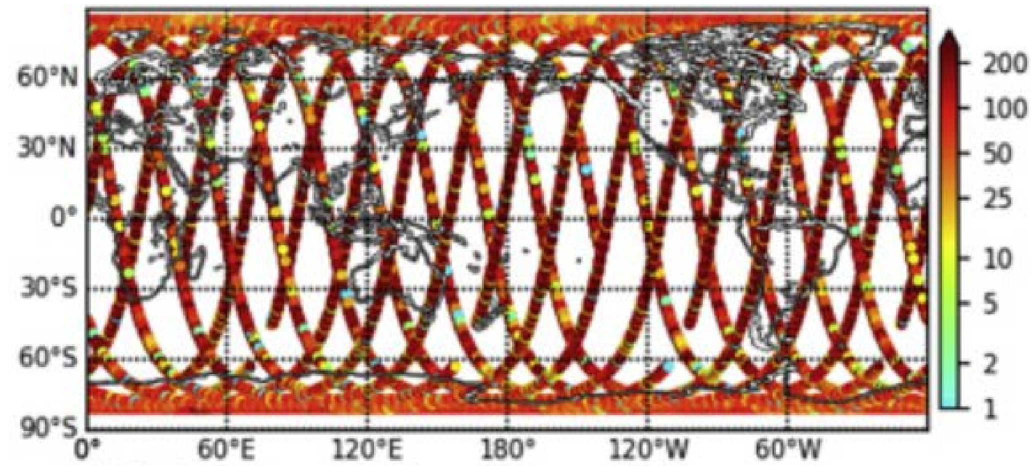
Some of the main Satellite data currently using at NCMRWF

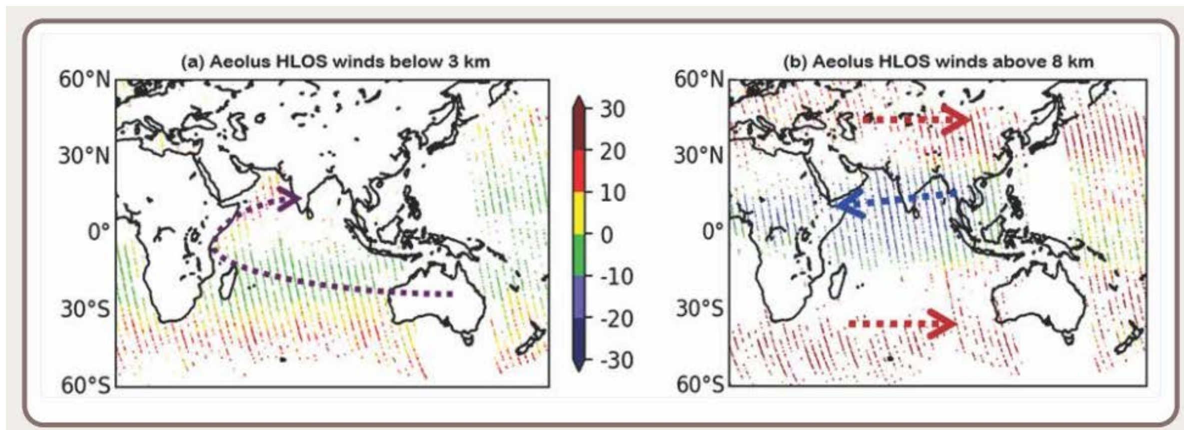
Satellite Winds

Space based wind profiler

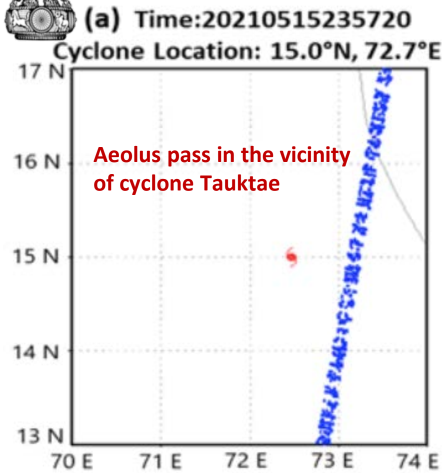
Aeolus Doppler Wind Lidar (DWL)



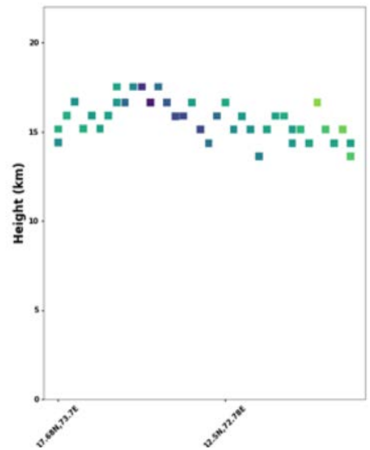




Aeolus wind assimilation and impact in the NCUM analysis and forecast system



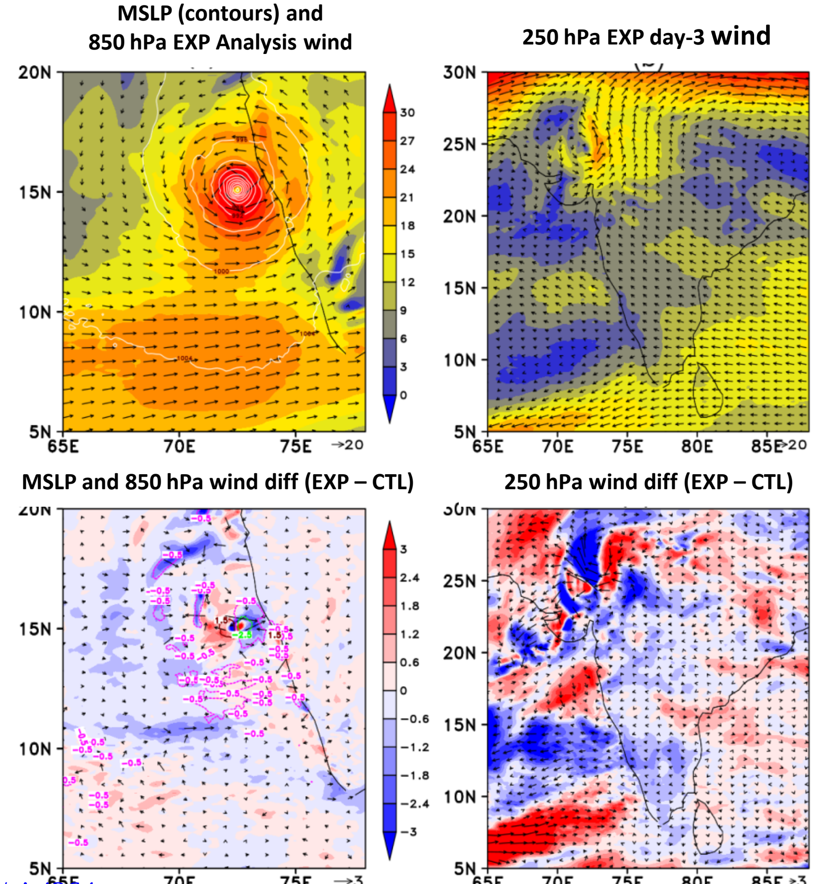
Assimilated Mie-cloudy winds



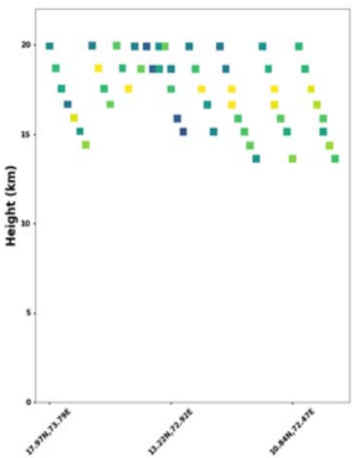
Cyclone Tauktae formed over the Arabian Sea

IC: 16 May 2021 00 UTC , ***CTL – No Aeolus winds assimilation***

EXP – With Aeolus winds assimilation



Assimilated Rayleigh-clear winds



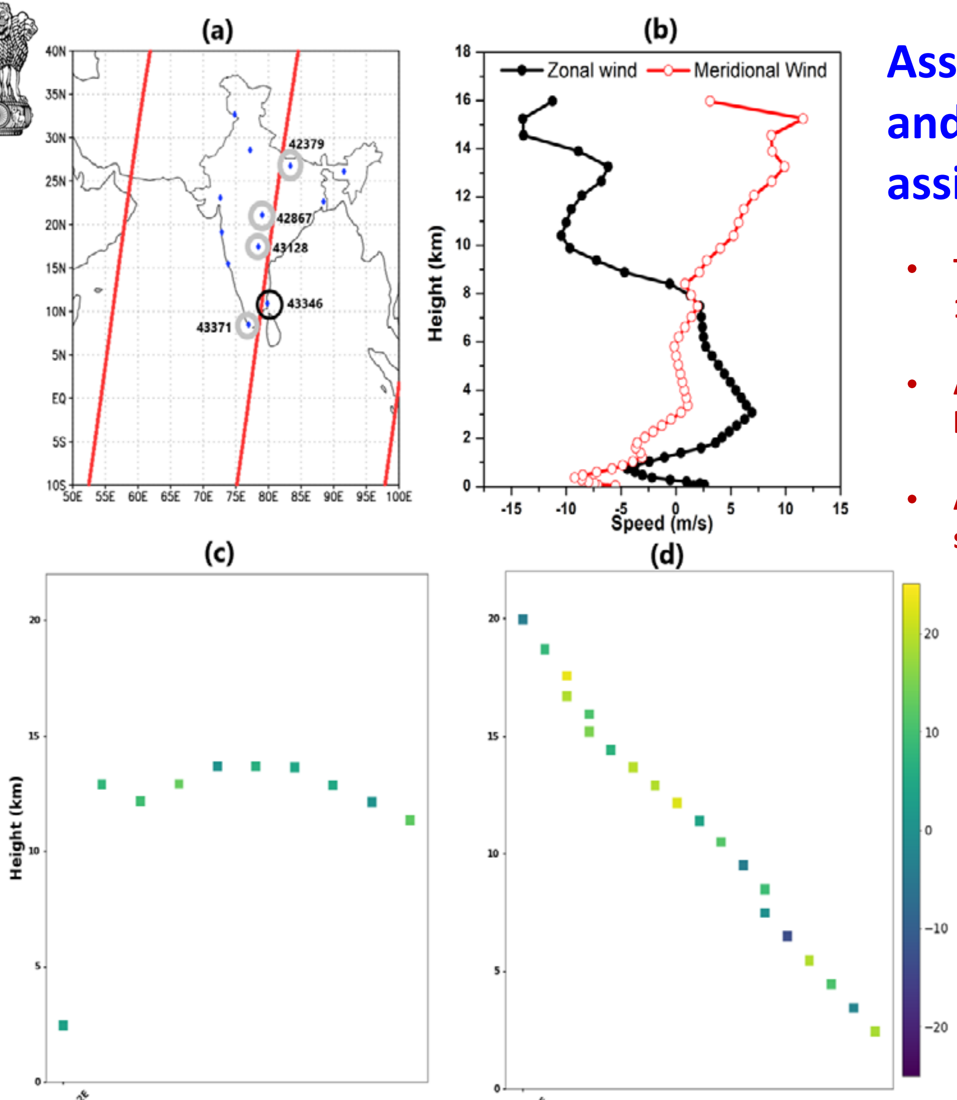
During *Taukte* cyclone both Mie-cloudy and Rayleigh-clear winds were assimilated above 10 km.

Since there were a lot of clouds around the cyclone, few Rayleigh-clear winds were available near the cyclone and the Mie-cloudy winds were available only at cloud top levels

Slight improvement in the lower and upper level cyclone features were detected due to the assimilation of Aeolus winds in the vicinity of the cyclone.

https://doi.org/10.1002/qj.4264

Assimilation of collocated radiosonde and Aeolus profiles: Single profile assimilation experiment



- The selected radiosonde location (43346 KARAIKAL, 10.92°N,79.83°E) is circled in black in Figure a.
- Assimilated u and v radiosonde profiles from the selected location are shown in Figure b
- Assimilated collocated Mie-cloudy and Rayleigh clear winds are shown in Figures c and d

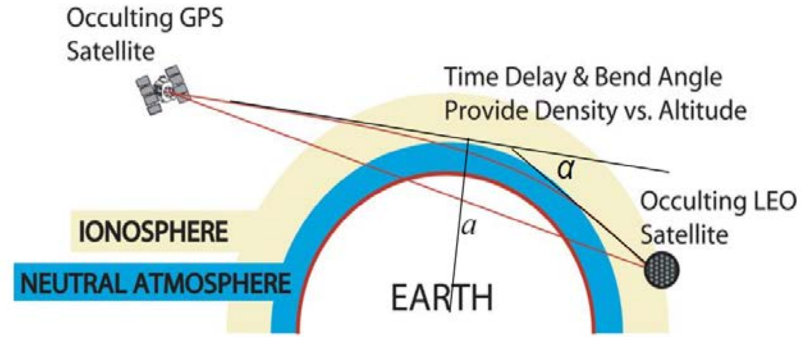
Single profile assimilation experiments with collocated Aeolus HLOS and radiosonde over the Indian landmass suggest that Rayleigh-clear profiles produce similar effects of radiosonde winds with an added value over the stratosphere.

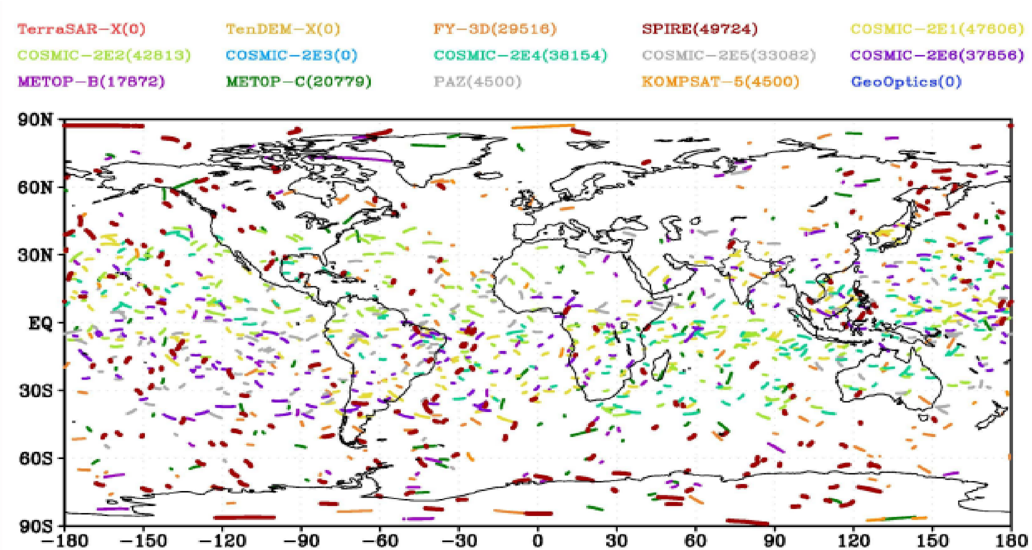
Assessing the quality of Novel Aeolus winds for NWP applications at NCMRWF, ***Q J R M. S.,*** https://doi.org/10.1002/qj.4264

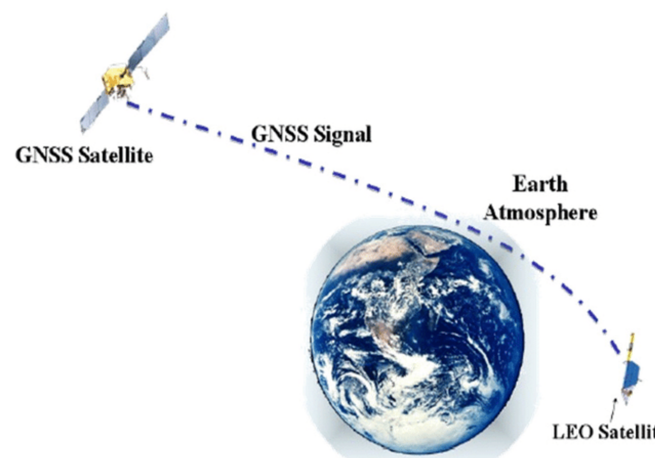
Some of the main Satellite data currently using at NCMRWF

GNSS-RO

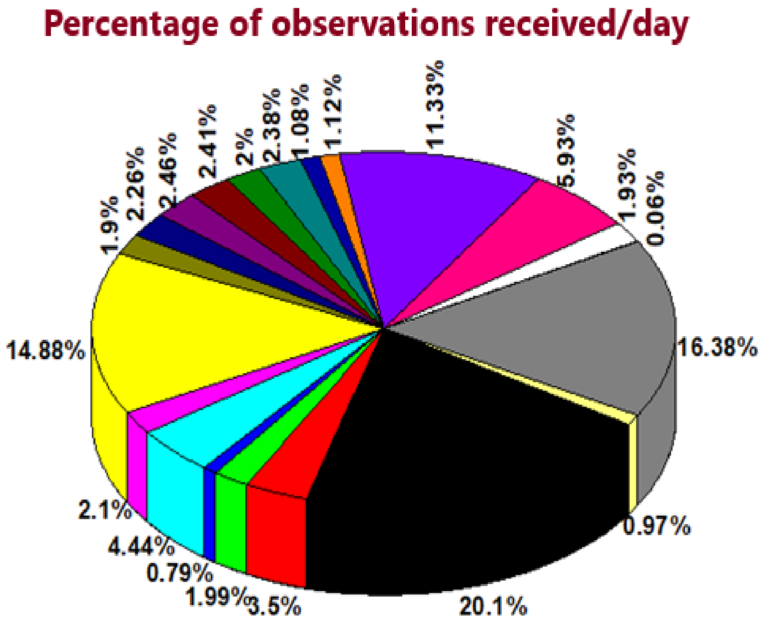
- Gradients in refractivity cause bending of a signal path between GPS and LEO satellite.
- Refractivity is a function of temperature, humidity and pressure.
- Bending angle derived from measures of phase delay.

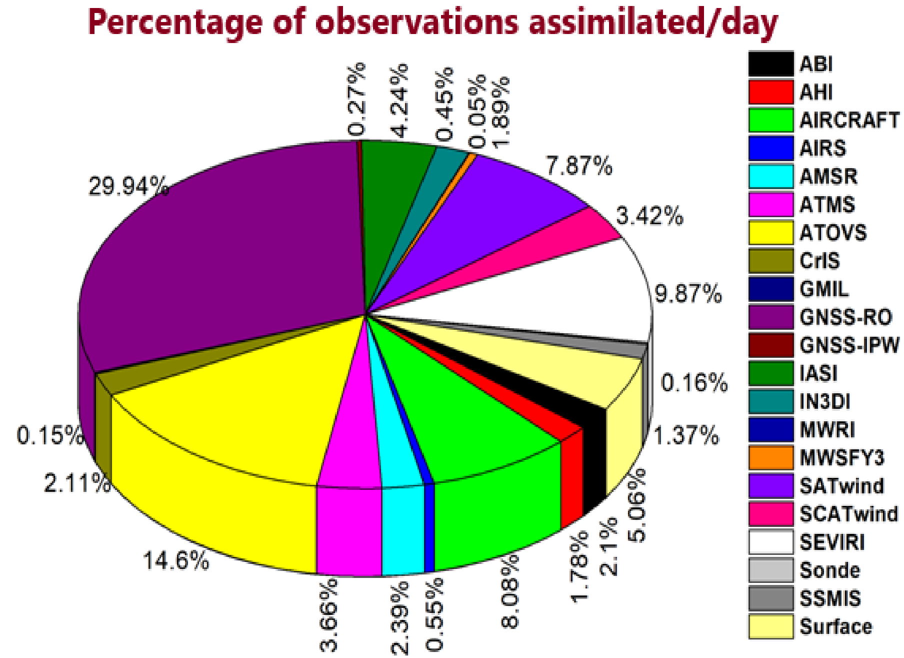




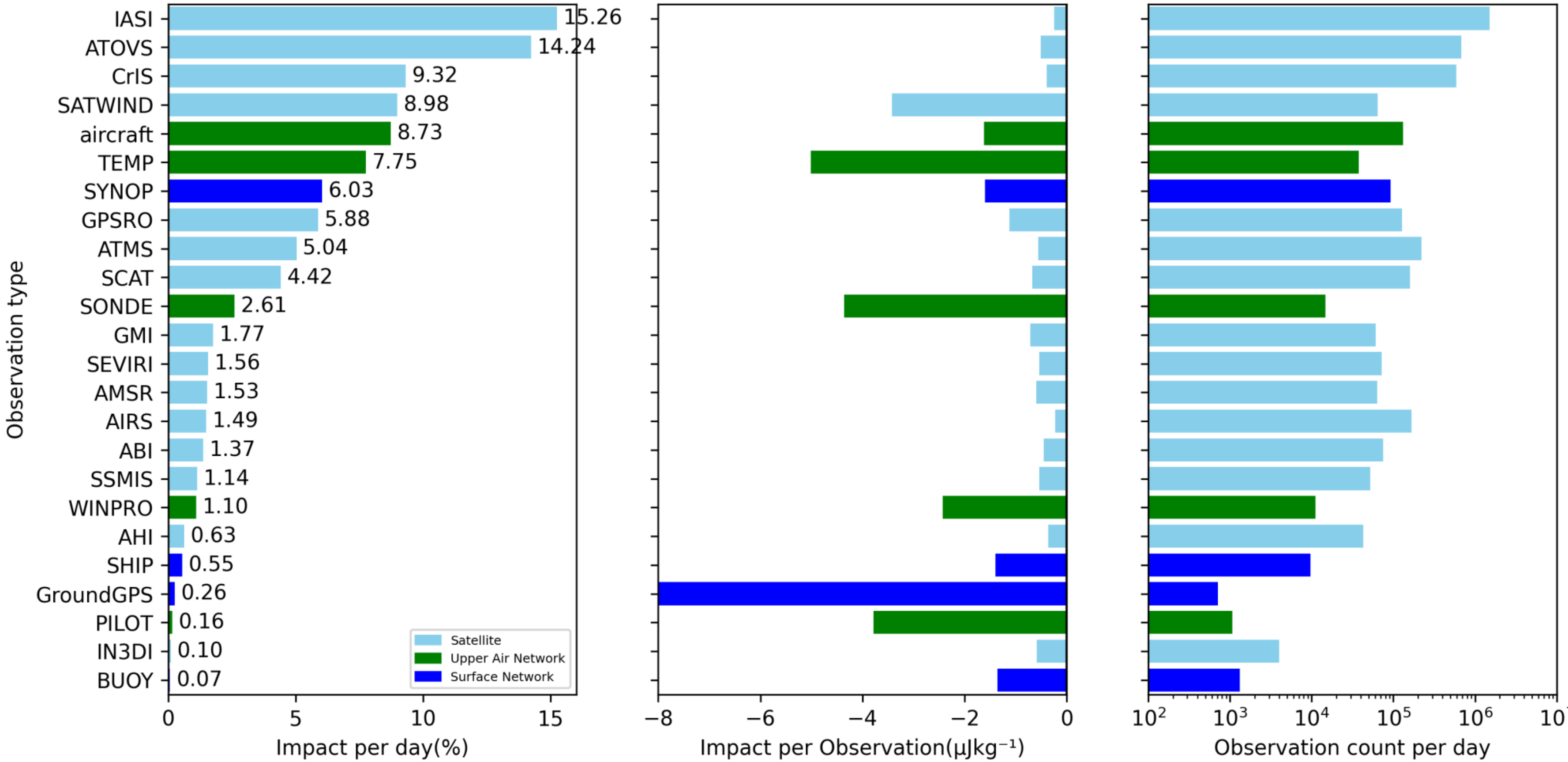


Observations Received / Assimilated at NCMRWF





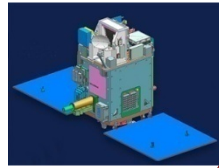
Forecast Sensitivity to Observation Impact



Indian Satellite Data added to the NCMRWF NWP system: Timeline

Microsat-2B (2023 expt)

Prasad et al., (2023)
Rani et al., (2023)
Gupta et al., (2023)



INSAT-3DR AMVs (2017)

Sharma et al., (2021)

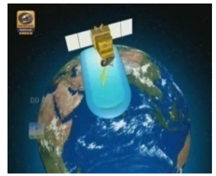
Oceansat-3 (2023)

Sankhala et al., (2023)
Srinivas et al., (2023)

Megha-Tropiques (2014)

SAPHIR: Singh et al., (2015), Rani et al., (2016), Doherty et al., (2018), Kumar et al., (2018)

ROSA: Johny et al., (2018)

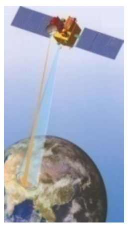


Scatsat-1 (2017)

Johny et al., (2019)
Bushair et al., (2021)

INSAT-3D radiances (Imager & Sounder) and AMVs (2013-2014)

Prasad et al.,(2014),
Rani et al., (2016, 2019)
Sharma et al., (2021)

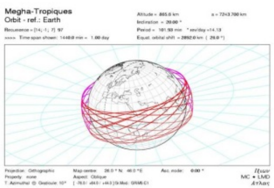


Oceansat-2 (2012)

Prasad et al., (2013), Rani and Das Gupta (2013)
Rani et al., (2014)

Kalpana AMVs (2009-2010)

Das Gupta and Rani (2013)
Rani and Das Gupta (2013)



Megha-Tropiques SAPHIR

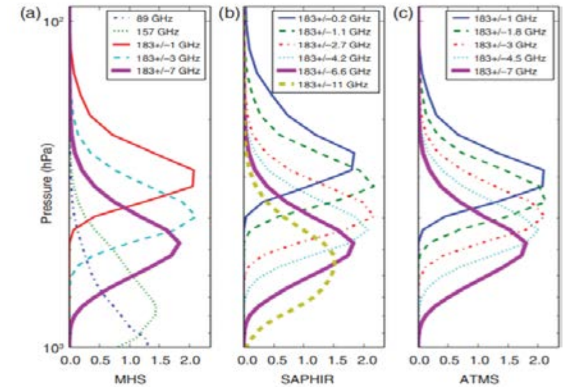
The Megha Tropiques (MT), a joint Indo-French satellite, was launched by the Indian launch vehicle, PSLV-C18 on 12 October 2011.

MT is positioned in a highly inclined equatorial plane of 20°at a height of 867 km above the Earth so as to orbit the tropical region (30°Sto 30°N) nearly 14–15 times per day.

The four payloads on-board MT consisting of a microwave radiometer(MADRAS), a microwave humidity sounder (SAPHIR), a radiation budget instrument (SCARAB) and a radio-occultation sounder (ROSA) are important for the study of tropical convective systems and hydrological cycle

SAPHIR and SCARAB have across-track scanning, MADRAS has conical scanning. SAPHIR and SCARAB images are distorted at the Edge of the Swath, MADRAS images are not.

Weighting functions (SAPHIR, MHS, ATMS)

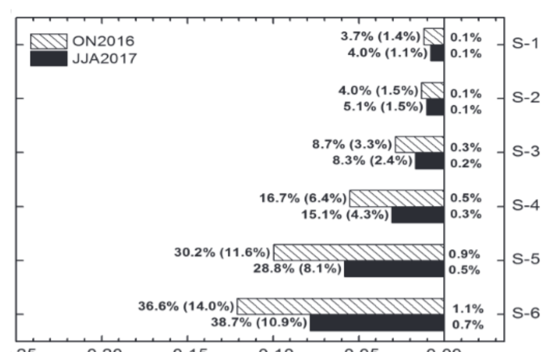


SAPHIR channel-6 (183±11 GHz) is unique and showed highest impact in the NWP system in the initial periods of the mission

SAPHIR Like channels available in the current missions

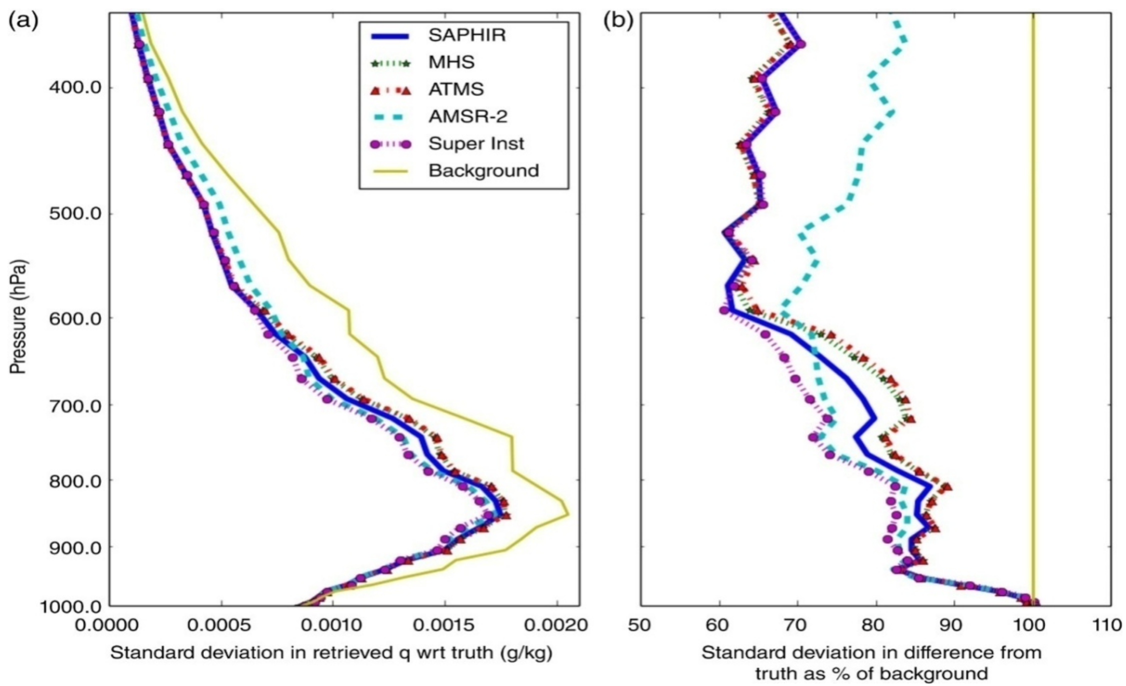
TABLE 1 Channel frequencies of all existing satellite radiometer channels around the 183 GHz water vapour line

Instrument	Channel number										
chan freq offset from 183.31 GHz	*±0.2*	*±1.0*	*±1.1*	*±1.8*	*±2.7*	*±3*	*±4.2*	*±4.5*	*±6.6*	*±7.0*	*±11.0*
AMSU-B/MHS		3				4				5	
SSMIS		11				10			9		
MWHS1		3				4				5	
ATMS		22		21		20		19		18	
MWHS2		11		12		13		14		15	
GPM-GMI						12				13	
SAPHIR	1		2		3		4		5		6



Demonstration of Super Instrument: Combination of SAPHIR and AMSR-2

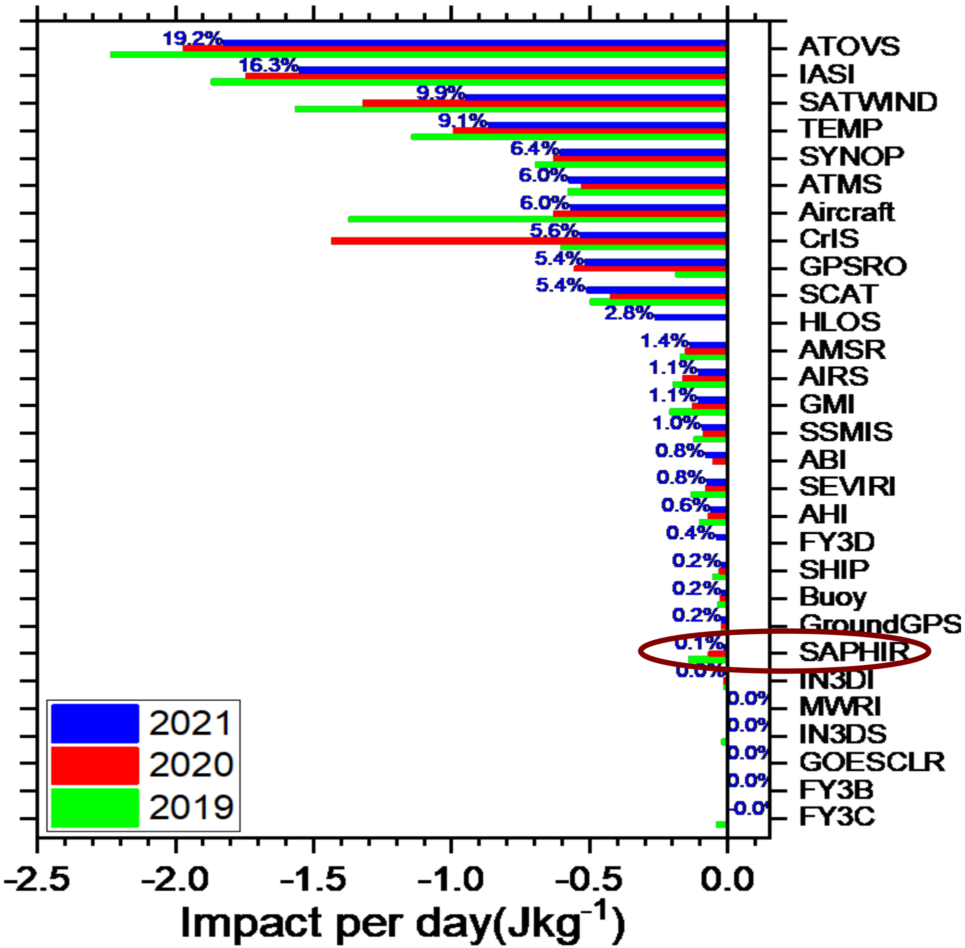
https://rmets.onlinelibrary.wiley.com/doi/full/10.1002/qj.3258

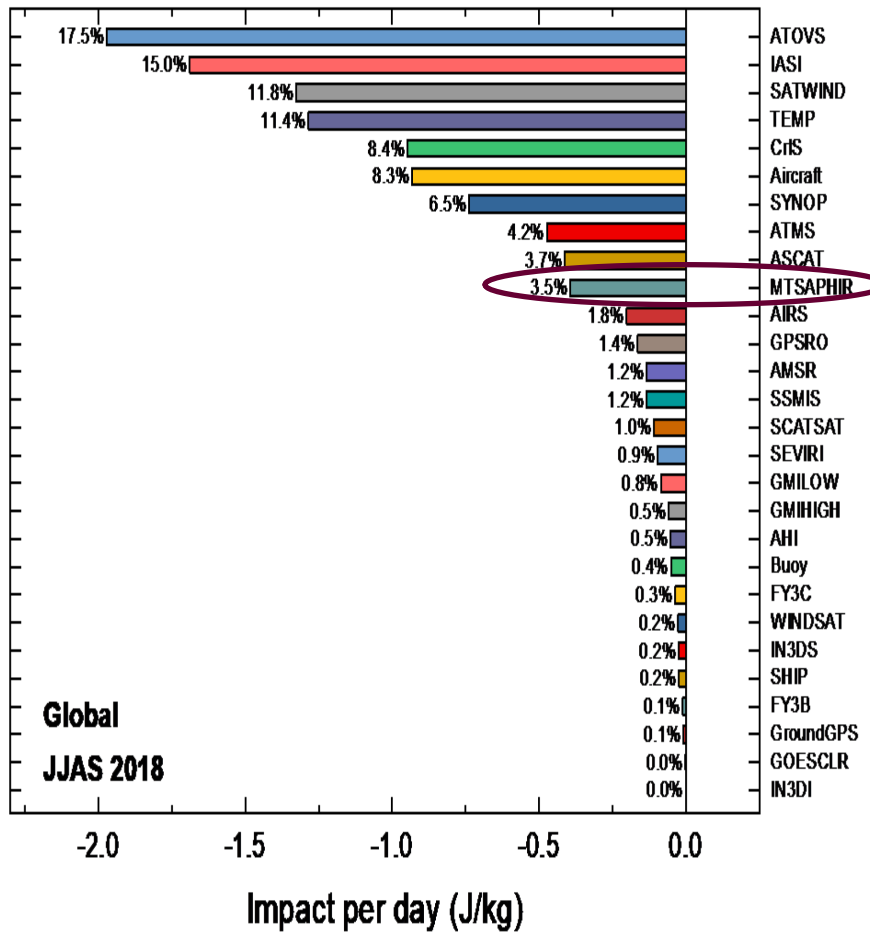


Considering first the humidity sounders: ATMS, MHS and SAPHIR perform similarly; SAPHIR notably outperforms the other instruments between 650 and 1000 hPa.

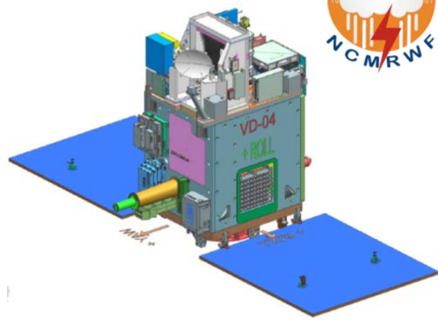
Secondly consider the performance of AMSR-2 and SAPHIR and their combined impact in the super instrument. AMSR-2 has the lowest errors in specific humidity at lower levels (below ~600 hPa), while SAPHIR performs best at higher altitudes. The difference between the super instrument and AMSR-2 demonstrates the additional information SAPHIR provides over AMSR-2 alone

SAPHIR Impact





Mm Wave Humidity Sounder (Microsat-2B) on SSLV-D2



- Experimental mission
- 3-D humidity profiling from surface to 12km; follow-on to SAPHIR.
- Vertical resolution < 2km and spatial resolution of 10 km @nadir.
- Analysis of the diurnal cycle of water vapour distribution.
- To aid in improving operational forecasts including Tropical cyclone.

Mm Wave Humidity Sounder (MHS) on MICROSAT-2B

Parameter	Specifications
Orbit	Circular, 37° inclination
Altitude	450 km
Swath	1050 km
Frequency band	183.31±16.25 GHz
Spatial resolution @ Nadir, Swath Edge	10 km, 20 km
Dwell/ Integration time	4msec
Scan Rate	50 rpm
Mission Life	12 months

MHS Channel Specifications

No.	Frequency (in GHz)	Noise (dB)	risation	BW (in MHz)	NEDT (K) at 300 K at 4ms
1	183.31±0.96	7	QH	300	1.5
2	183.31±2.8	6	QH	600	0.85
3	183.31±4.5	7	QH	1000	0.85
4	183.31±5.8	7	QH	700	1
5	183.31±11.56	8	QH	900	1
6	183.31±15.75	6.8	QH	1000	0.8

Slide courtesy: ISRO

Microsat-2B radiance assimilation at NCMRWF

FASTEM coefficient generation

- In-house computation, testing and implementation of CRTM Coefficients
- RTTOV coefficients are generated in collaboration with NWP-SAF (UK Met Office)
- Shared with SAC and they are using both the coefficients

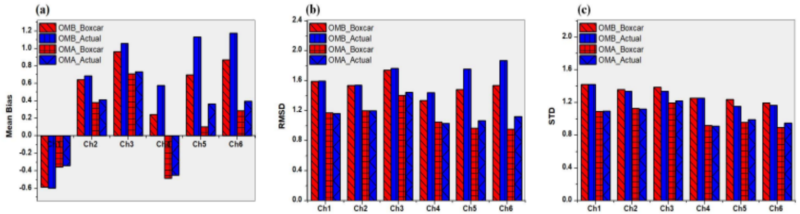
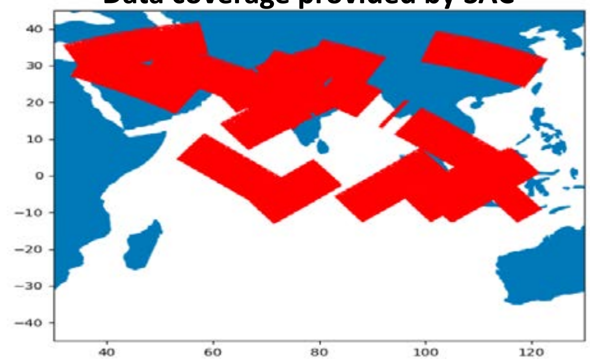
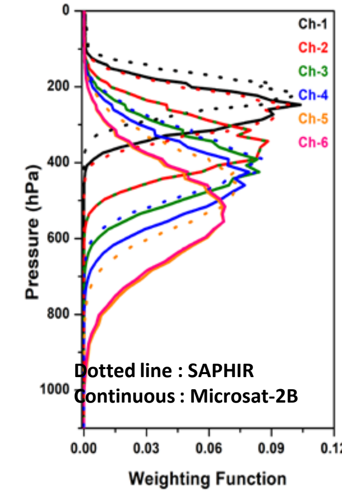


Figure 2. (a) Mean bias, (b) RMSD, and (c) Standard deviation calculated from OMB and OMA from the two assimilation experiments.

Data coverage provided by SAC





- Assimilation of MHS Microsat-2B data in the NGFS and NCUM assimilation systems leads to the reduction of mean bias, RMSD, and standard deviation of analysis innovation of all six channels.

- This indicates that the assimilation of microsat-2B data improves the model initial conditions.

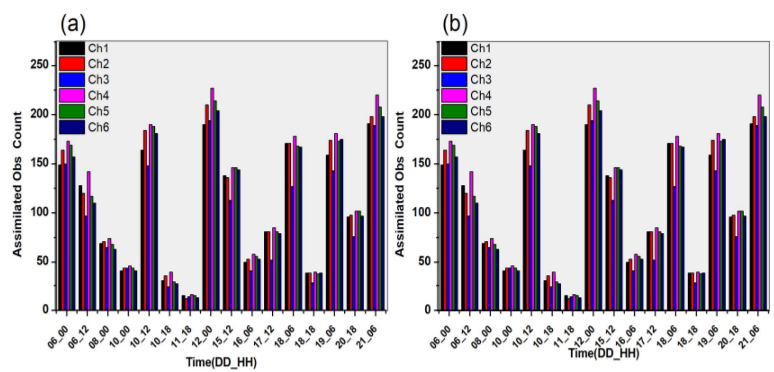
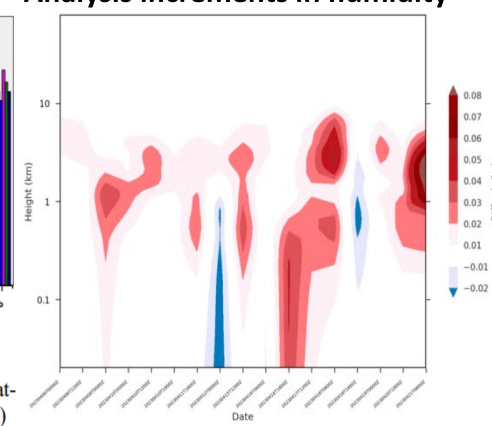
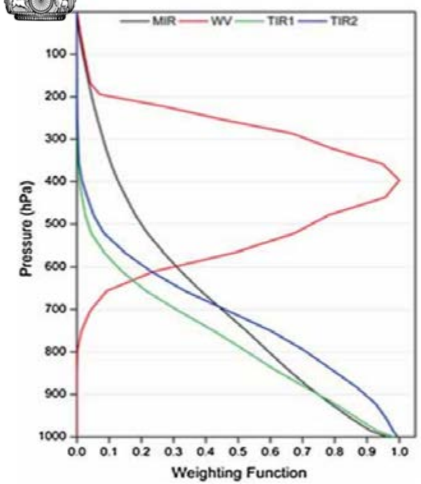


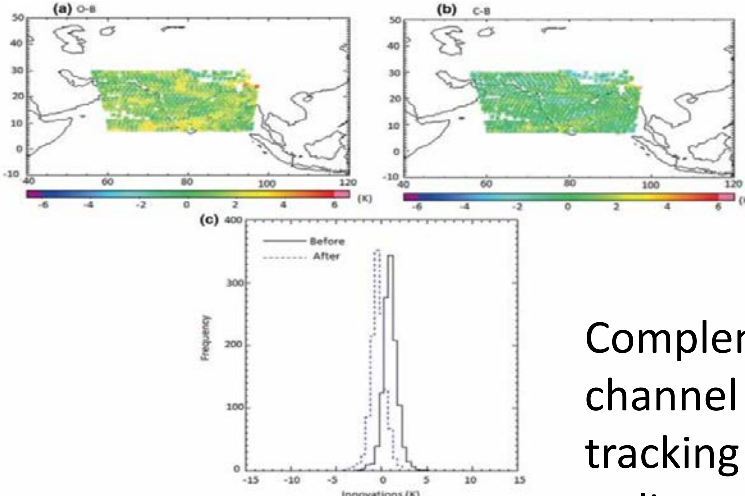
Figure 1. The counts of observations assimilated in GSI from each channel of MHS Microsat-2B using spectral and transmittance coefficient files prepared from (a) boxcar SRFs and (b) actual SRFs.

Analysis increments in humidity



INSAT-3D/3DR Sounder and Imager radiance assimilation





Issues:

No full disc data: Navigation problem

Sun glint: Can't use data between ~ 14 – 21 UTC

Complementarity of AMVs and WV channel radiances above 500 hPa (Cloud tracking wind vectors and clear sky WV radiances)

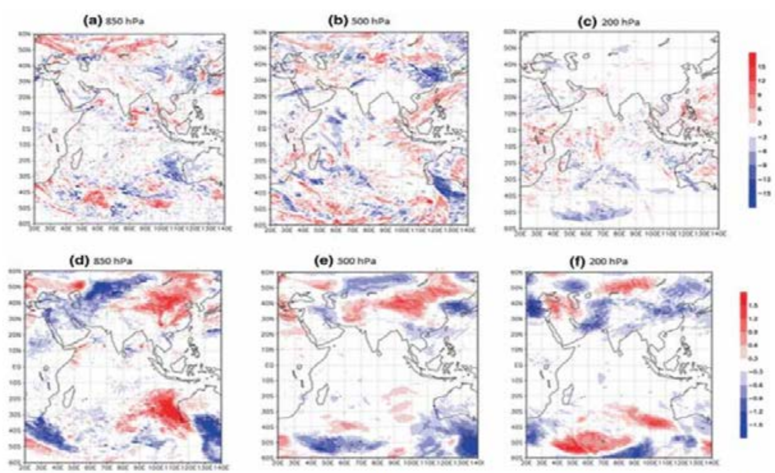


Figure 9. Day-1 forecast difference between EXP and CNTL, relative humidity (%) in the upper panel (at (a) 850 hPa, (b) 500 hPa, and (c) 200 hPa), and temperature (K) in the lower panel (at (d) 850 hPa, (e) 500 hPa and (f) 200 hPa).

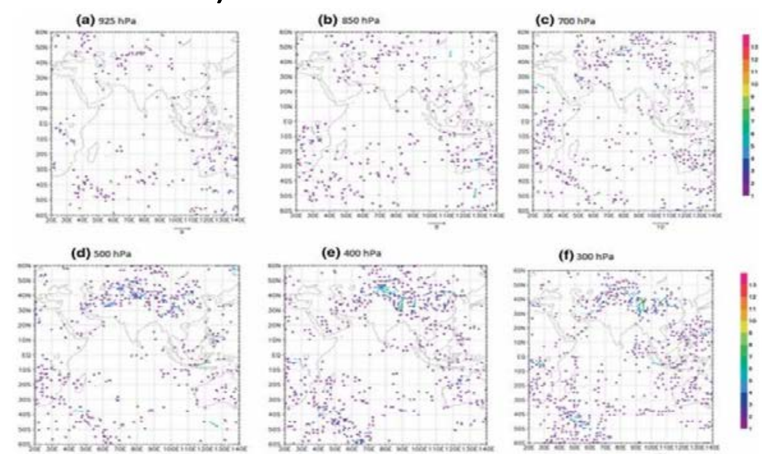


Figure 11. Day-1 forecast difference in wind vectors between EXP and CNTL at different model levels: (a) 925 hPa, (b) 850 hPa, (c) 700 hPa, (d) 500 hPa, (e) 400 hPa and (f) 300 hPa.

INSAT-3D/3DR Atmospheric Motion Vector assimilation

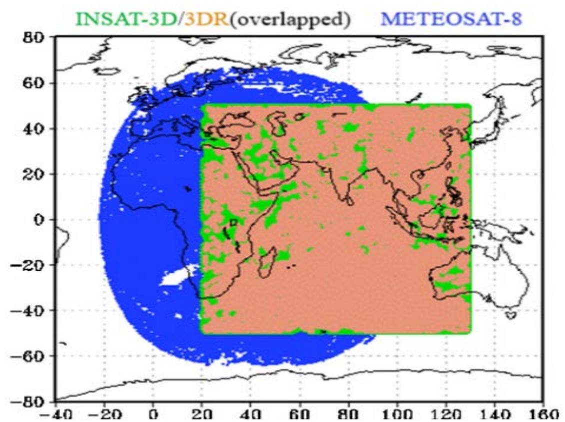
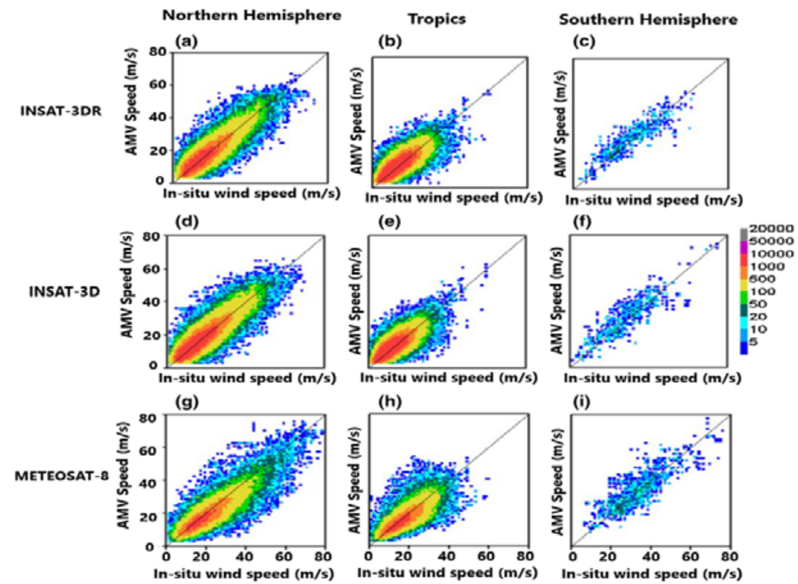
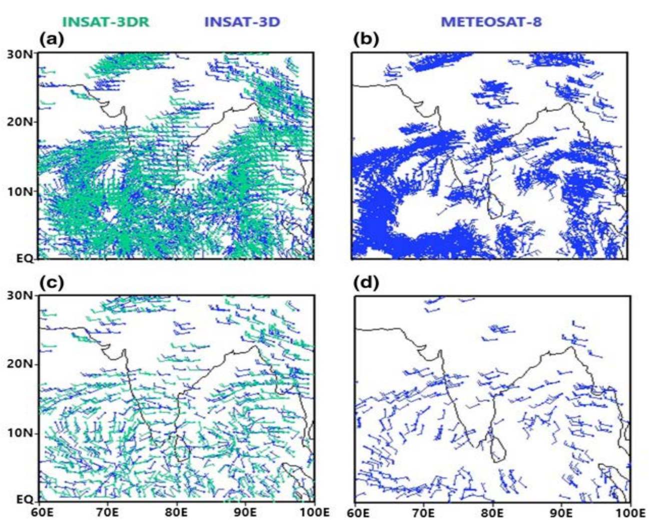
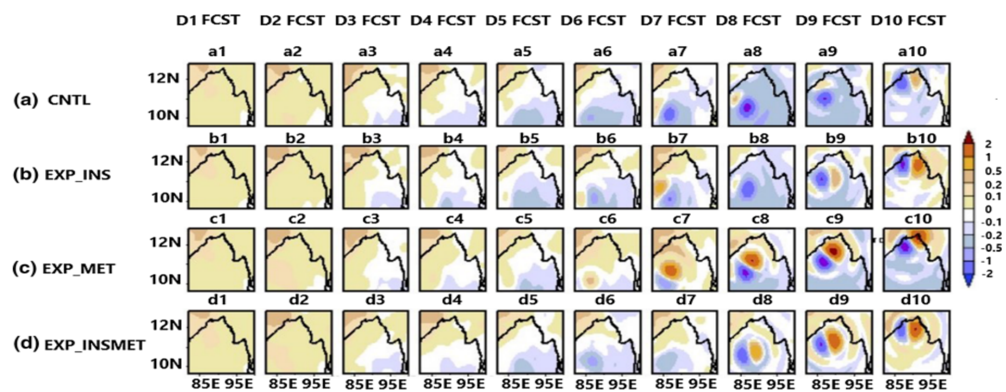


Figure 1. Spatial coverage of AMVs from INSAT-3D/3DR and Meteosat-8 satellites receiving at NCMRWF.





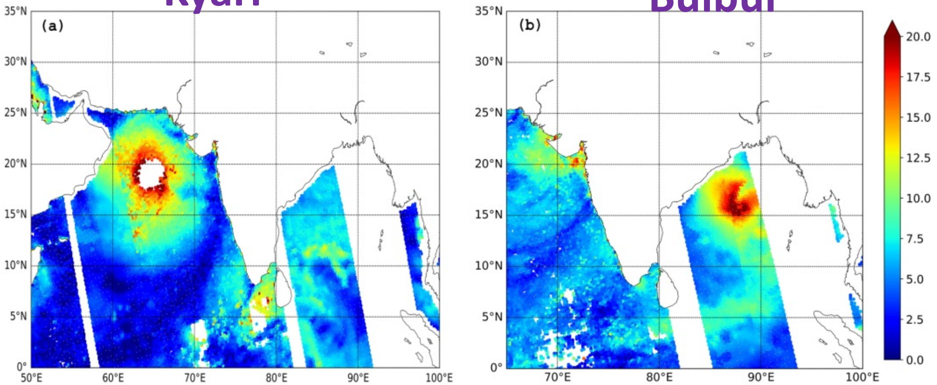


INSAT AMV quality is on par with that of Meteosat-IODC

Scatterometer wind assimilation and impact in the NCUM analysis and forecast system

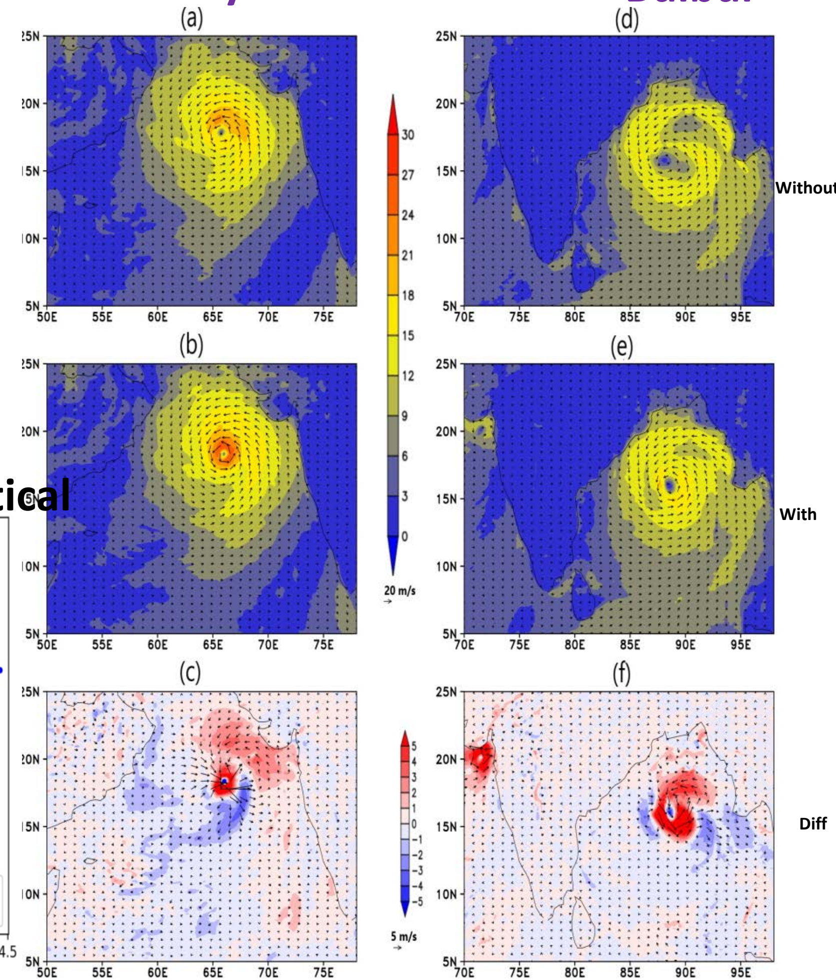
Observed sea scatterometer winds (ASCAT and Scatsat-1)

Kyarr Bulbul

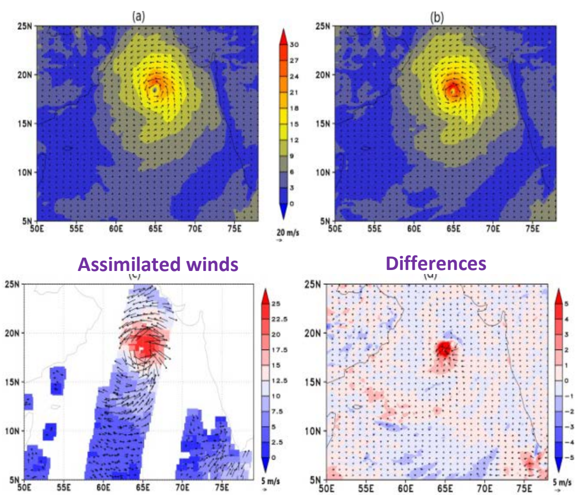


Day-1 forecast

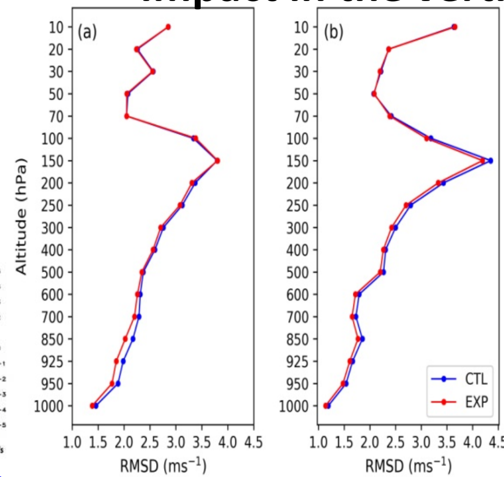
Kyarr Bulbul



Impact of Scatterometer wind assimilation in the 850 hPa wind analysis (Kyarr)



Impact in the vertical

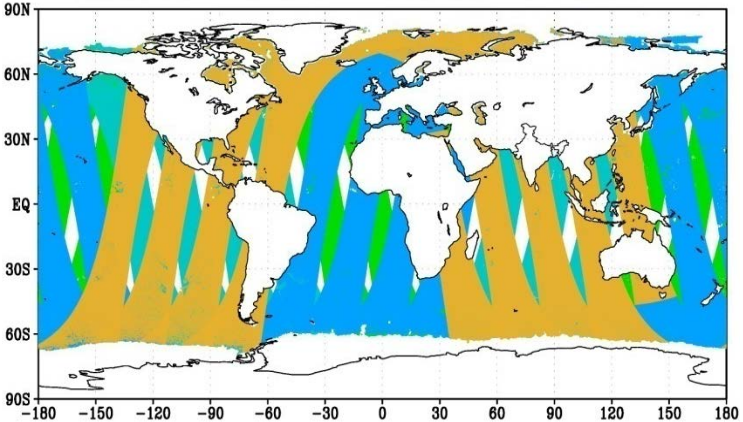


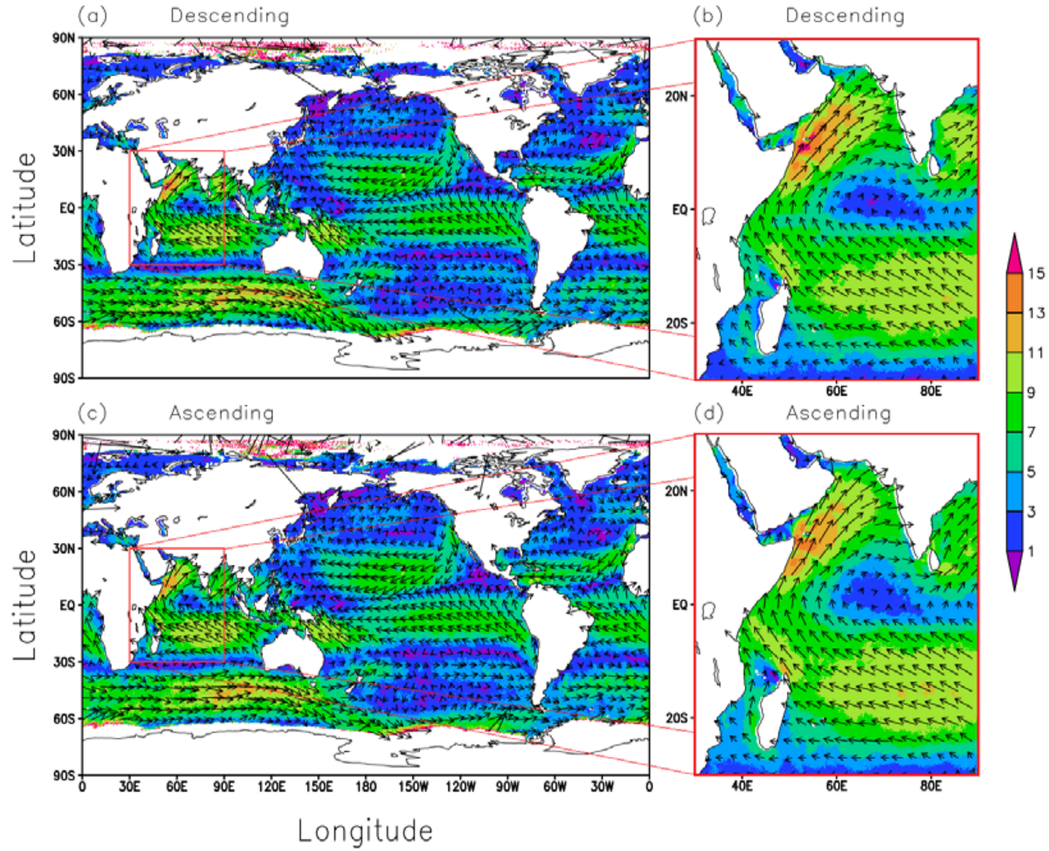
Zonal wind Meridional wind

https://doi.org/10.1007/s00024-021-02890-0

Oceansat-3 validation and assimilation

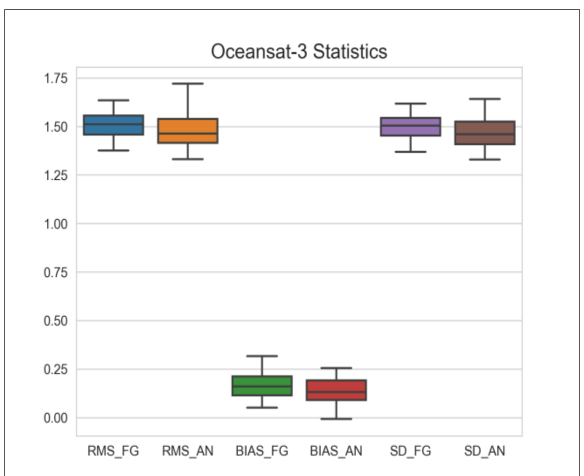
00 (1814842) 06 (1764793) 12 (2361455) 18 (1636271)





FG : First Guess

AN: Analysis



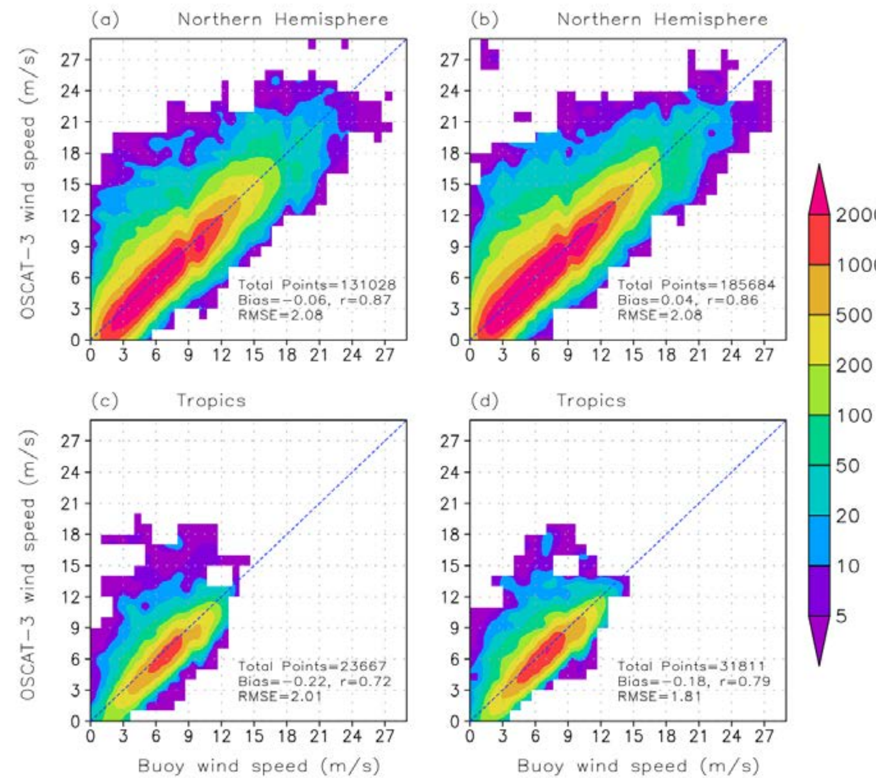
Validation and assimilation of Oceansat-3 sea surface winds

Data sets:
Oceansat-3 wind
BUOY wind
NCUM 10 m wind
GFS 10 m wind

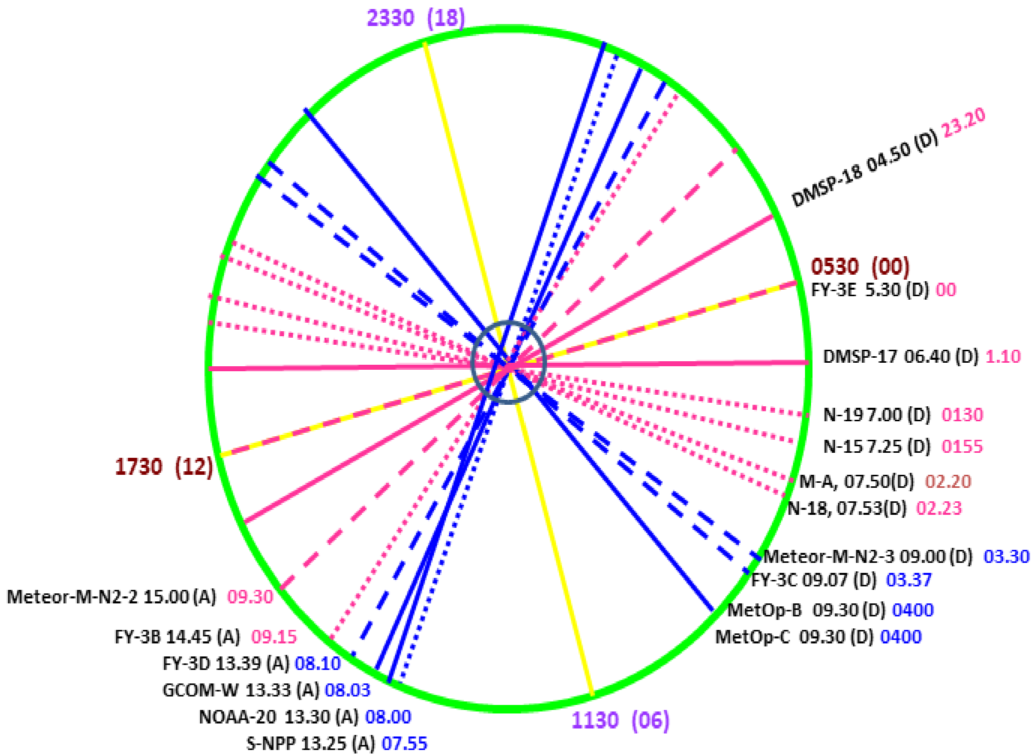
Criteria for validation with buoy data sets
Spatial: 12 × 12 (for 12 km wind)
25 × 25 (for 25 km wind)
Temporal : 20 Minutes

Criteria for validation with Model
Spatial: at Model resolution
Temporal : 60 Minutes

Parameter	12 Km		25 Km	
	Global	Tropics	Global	Tropics
	NCUM			
RMSVD	2.38	2.39	2.45	2.29
BIAS	-0.02	-0.24	-0.07	-0.33
	GFS			
RMSVD	2.46	2.28	2.49	2.30
BIAS	-0.10	-0.23	-0.16	-0.35

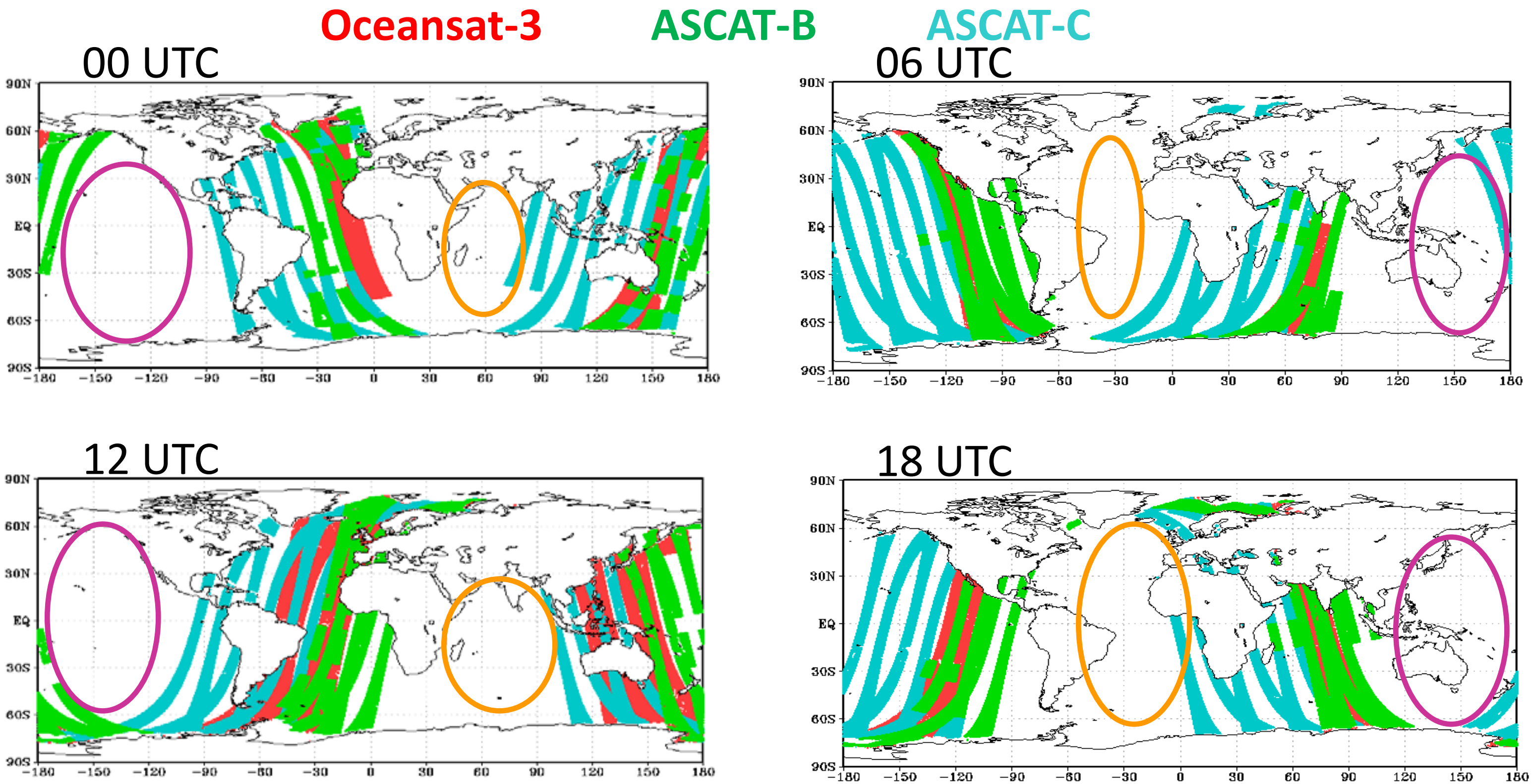


Gap Area: Microwave Radiances



Satellite	LECT (A)	LECT (D)	Assimilation cycle
DMSP-F18	16.50	04.50	00,12
FY-3E	17.30	05.30	00,12
DMSP-F17	18.40	06.40	00,12
N-19	19.00	07.00	00,12
N-15	19.25	07.25	00,12
M-A	19.50	07.50	00,12
N-18	19.53	07.53	00,12
FY-3B	14.45	02.45	00,12
Meteor-M-N2-2	15.00	03.00	00,12
S-NPP	13.25	01.25	06, 18
N-20	13.30	01.30	06,18
FY-3D	13.39	01.39	06,18
Meteor-M-N2-3	21.00	09.00	06,18
FY-3C	21.07	09.07	06, 18
M-B	21.30	09.30	06,18
M-C	21.30	09.30	06,18
GCOM-W	13.33	01.33	06,18

Gap Area: Scatterometer sea surface wind



During 00 and 12 UTC assimilation cycles, there is no scatterometer coverage over the Indian Ocean region (area of interest) and West Pacific Ocean.

During 06 and 18 UTC data sparse region over East Pacific and Atlantic Oceans

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Thank You