RETRIEVAL AND APPLICATIONS OF ATMOSPHERIC MOTION VECTORS USING INSAT-3D/3DR DATA : ISRO STATUS

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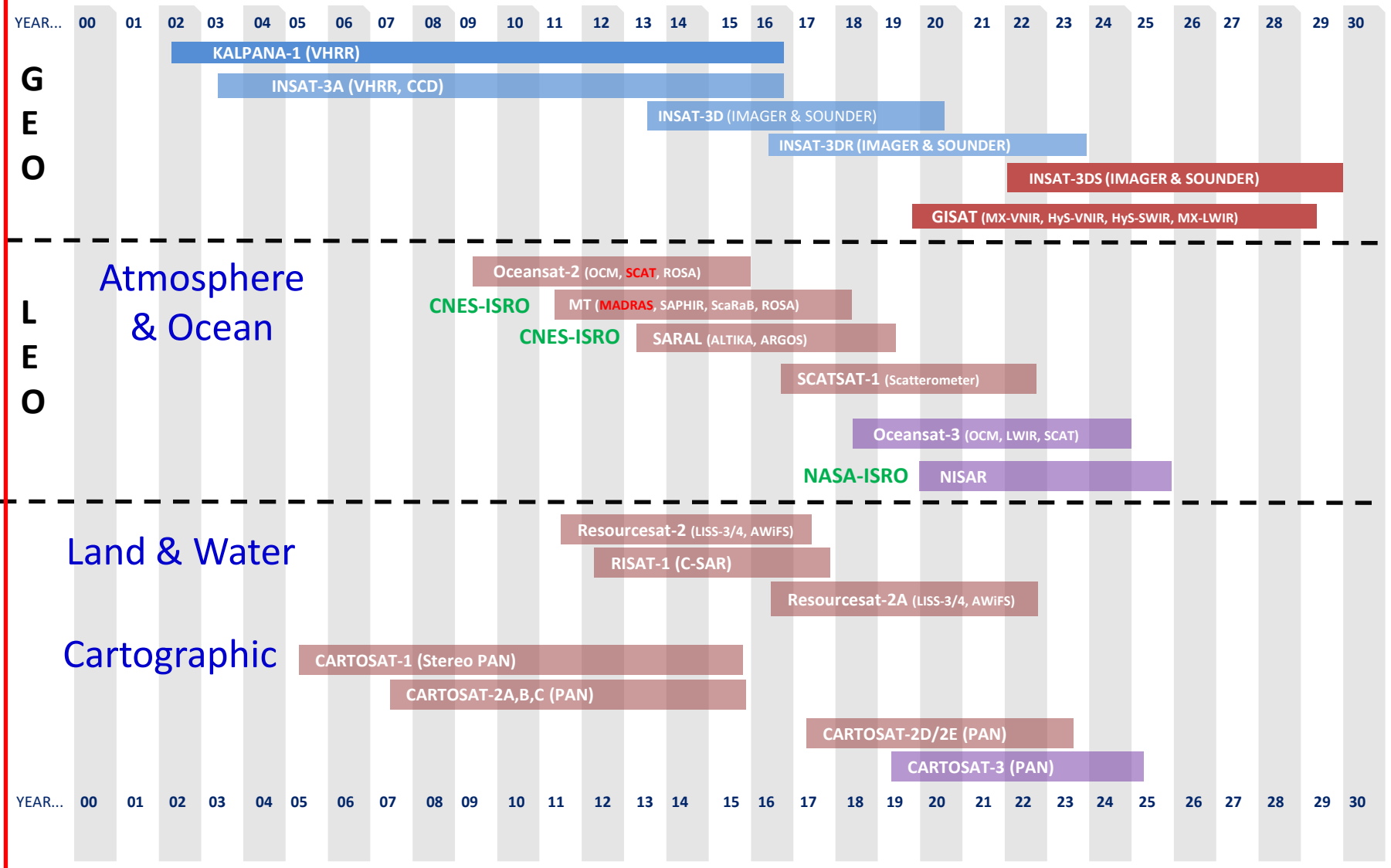
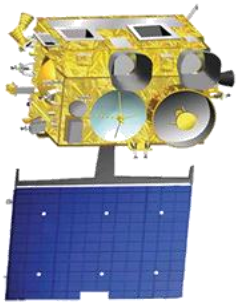
Contents:

1. Current and future Indian Geo/LEO satellites.
2. ISRO AMV retrieval activities.
3. Present AMV accuracy status.
4. NWP applications.
5. Derived products from INSAT-3D/3DR AMVs
6. Concluding remarks and future scopes

ISRO Current satellites for Earth Observations

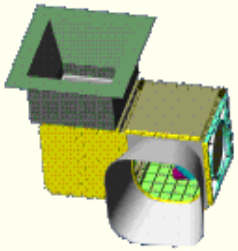


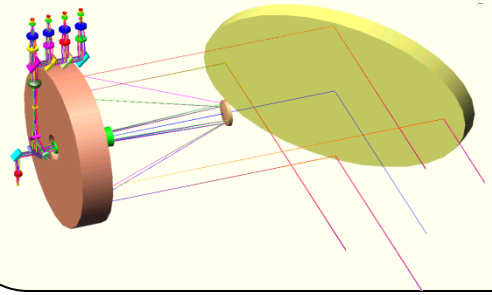
Meteorological GEO SATELLITES: INSAT – 3D/3DR/3DS



LAUNCH:
2013/2016
2022

6 Channel IMAGER



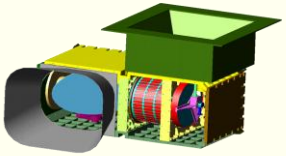


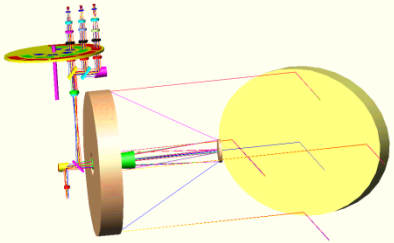
- Spectral Bands (µm)

Visible	: 0.55	- 0.75
Short Wave Infra Red	: 1.55	- 1.70
Mid Wave Infra Red	: 3.70	- 3.95
Water Vapour	: 6.50	- 7.10
Thermal Infra Red – 1	: 10.30	- 11.30
Thermal Infra Red – 2	: 11.30	- 12.50

- Resolution : 1 km for Vis & SWIR
  4 km for MIR & TIR
  8 km for WV

19 Channel SOUNDER





- Spectral Bands (µm)

Short Wave Infra Red	:	Six bands
Mid Wave Infra Red	:	Five Bands
Long Wave Infra Red	:	Seven Bands
Visible	:	One Band

- Resolution (km) : 10 X 10 for all bands
- No of simultaneous : 4 sounding per band

FUTURE GEO SATELLITES: (GISAT)

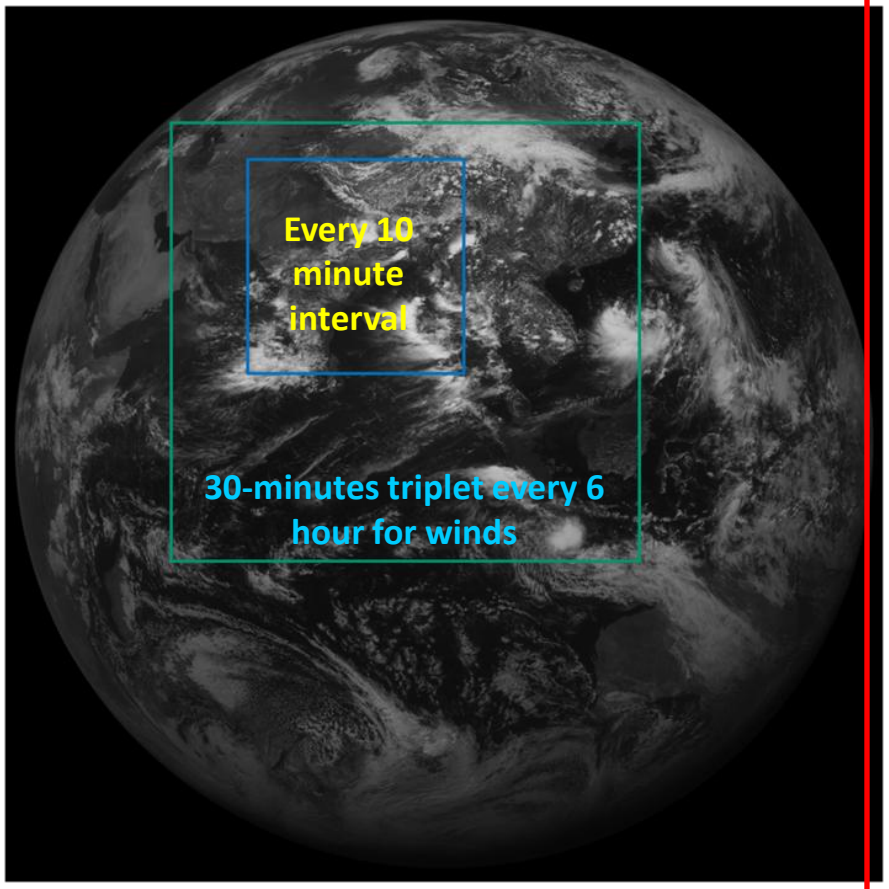
Launch Schedule: 2019, Geostationary orbit, 83E

MX-VNIR: Multispectral - Visible Near Infrared, HySI-VNIR: Hyperspectral Imager - Visible Near Infrared, HySI-SWIR: Hyperspectral Imager - Short Wave Infrared, MX-LWIR: Multispectral - Long Wave Infrared.

Band	Ch	SNR/ NEdT	IFOV (m)	Range (μm)	Channels (μm)
MX-VNIR	4	> 200	50	0.45 - 0.875	B1: 0.45-0.52 B2: 0.52-0.59 B3: 0.62-0.68 B4: 0.77-0.86 B5N: 0.71-0.74 B6N: 0.845-0.875
HyS-VNIR	60	> 400	500	0.375 - 1.0	$\Delta\lambda$ < 10 nm
HyS-SWIR	150	> 400	500	0.9 - 2.5	$\Delta\lambda$ < 10 nm
MX-LWIR	6	NEdT < 0.15K	1500	7.0 – 13.5	CH1: 7.1-7.6 CH2: 8.3-8.7 CH3: 9.4-9.8 CH4: 10.3-11.3 CH5:11.5-12.5 CH6: 13.0-13.5

GISAT Scan scenario

Scan area for two scan scenario (5° & 10 °)



Changes since IWWG13

1. INSAT-3DR launched in September 2016 (INSAT-3D operational since July 2014)
2. Operationalization of AMVs algorithm for INSAT-3DR at SAC ISRO.

   (Now 3D and 3DR providing AMVs at 15 minutes interval, www.mosdac.gov.in).
3. Operationalization of Staggering TIR1 AMV algorithm using 3D/3DR at SAC ISRO (Available at www.mosdac.gov.in since Feb-2017)
4. Though INSAT-3DR is operational at ISRO, however it is not yet declare operational at IMD, so not available in GTS.
5. Operationalization of AMV derived products (3D/3DR)
6. Full disc AMV using INSAT-3DR data (yet to be implemented)

AMV ALGORITHM FLOWCHART

Geostationary Satellite Observations
Level 1B data IR/WV/VIS/MIR Channels

Target Selection – Local Anomaly Method (Deb et. al 2008, Kishtawal et. a 2009)

$$a_{i,j} = \sum_{i=1}^{20}\sum_{j=1}^{20}[I_{i,j} - \bar{I}]$$

Target Tracking- Nash Sutclifffe Coefficient (Deb et. al 2008)

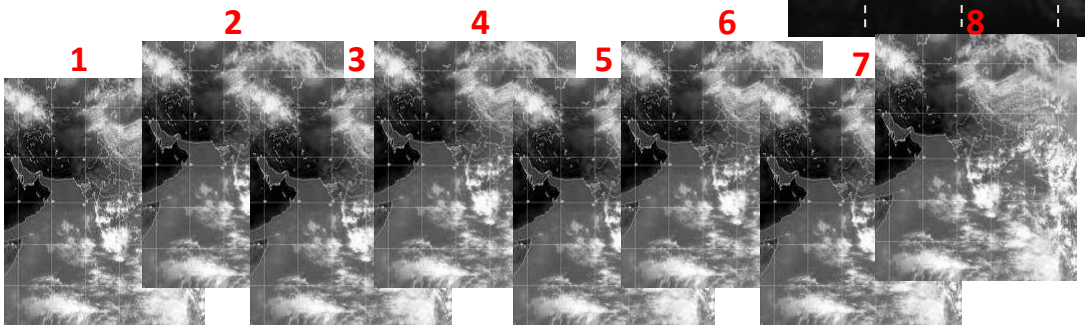
$$E = 1 - \frac{\sum_{i=1}^{n}(I_t - I_s)^2}{\sum_{i=1}^{n}(I_t - \bar{I}_t)^2}$$

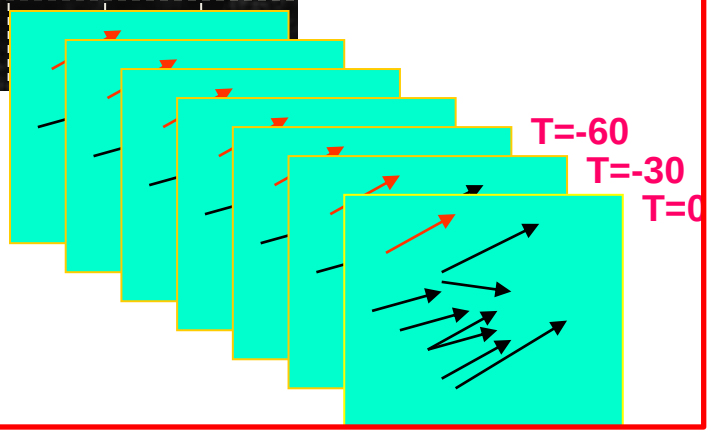
BUFFER GENERATION + QUALITY CONTROL
(Deb et al 2013, Holmlund 1998)

Tracer Height Assignment

IR WINDOW Technique → **H_2O Intercept** (Neiman et. al 1993) → **CLOUD BASE method** (Marshall et al. 1997)

FINAL OUTPUT





Strategy use for staggering AMVs

Data: INSAT-3D and INSAT-3DR images

INSAT-3D: AMV at 1200 UTC

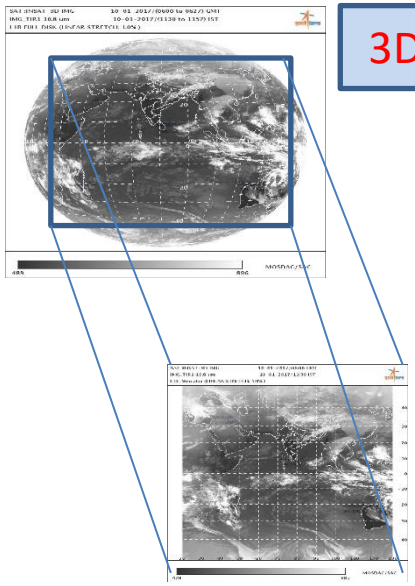
…….1100, 1130, 1200

4 Km horizontal resolution

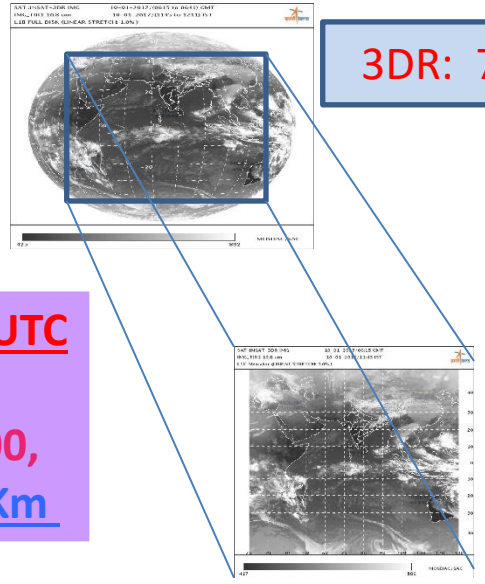
INSAT-3DR: AMV at 1215 UTC

……. 1115, 1145, 1215

4 Km horizontal resolution



3D: 82.5E



3DR: 74E

In staggering mode: AMV at 1200 UTC

…….1100, 1115, 1130, 1145, 1200,

Both 3D and 3DR images are in 4 Km

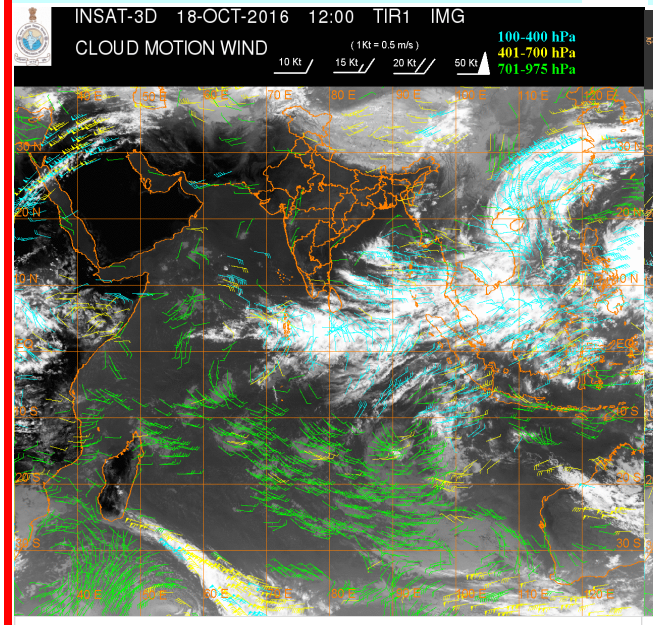
In staggering mode: **1. Before tracer selection and tracking INSAT-3DR images are calibrated using INSAT-3D**

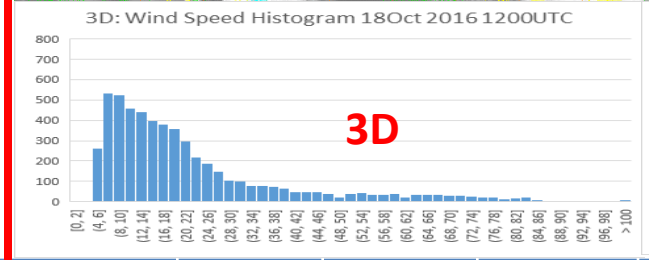
2. Height Assignment is done using INSAT-3DR images

Atmospheric Motion Vectors
(Staggering mode)

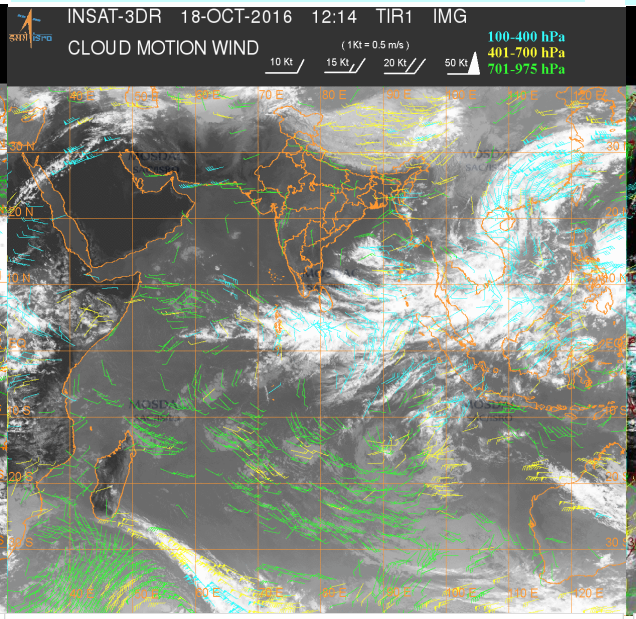
Period: 18 Oct 2016 - 31 Oct2016
Total sample: 56 Sets
Type: Infrared AMVs (TIR1)

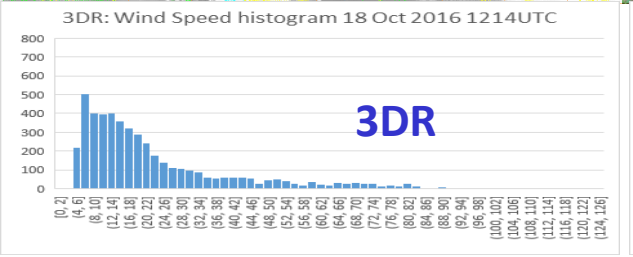
18 Oct 2016 1200 UTC: 3D



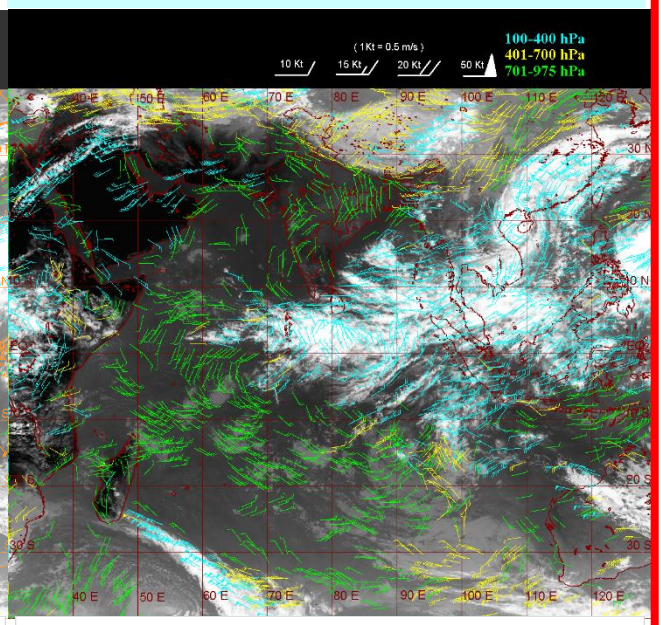


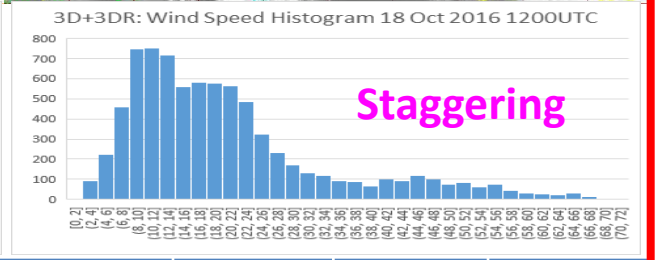
18 Oct 2016 1214 UTC: 3R





18 Oct 2016 1200 UTC: STAG



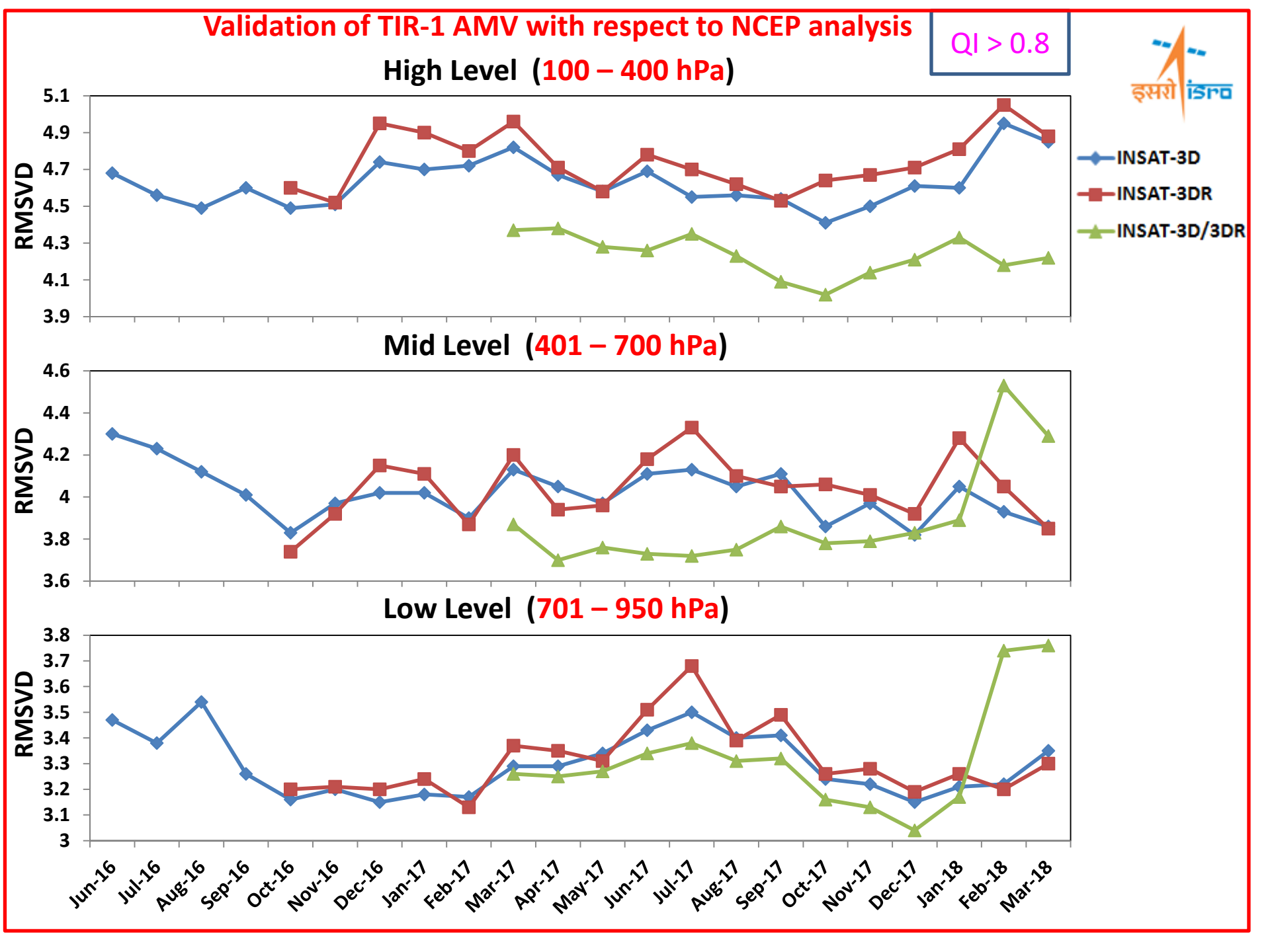


	High	Mid	Low		High	Mid	Low		High	Mid	Low
RMSVD	5.26	5.28	4.10	RMSVD	5.47	4.84	4.14	RMSVD	5.50	4.74	3.95
BIAS	-0.10	0.47	0.24	BIAS	-0.35	-0.17	0.38	BIAS	-0.23	-0.06	0.73

In the mid and low-level staggering AMVs are more accurate with higher numbers of retrievals

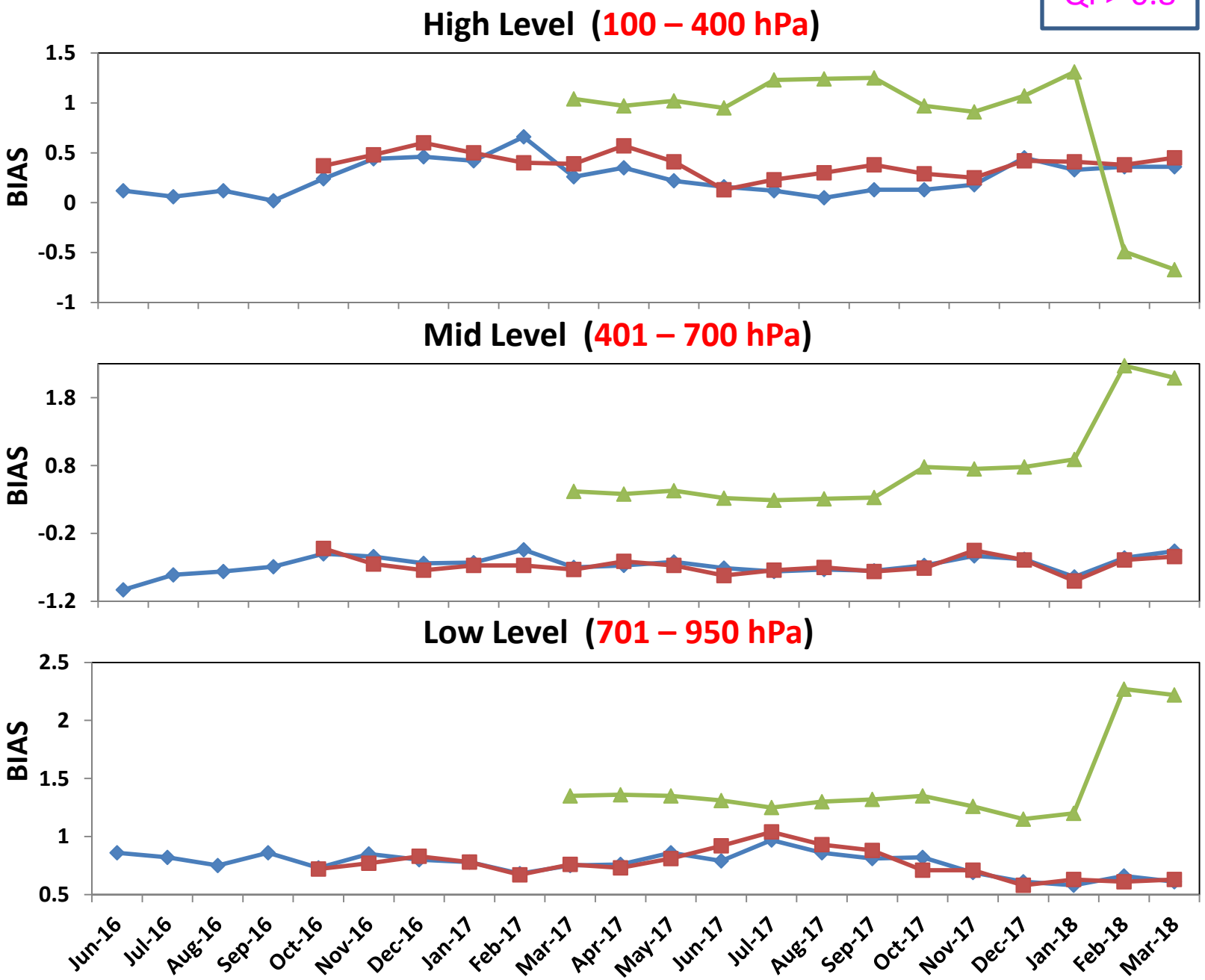
Validation of TIR-1 AMV with respect to NCEP analysis

QI > 0.8



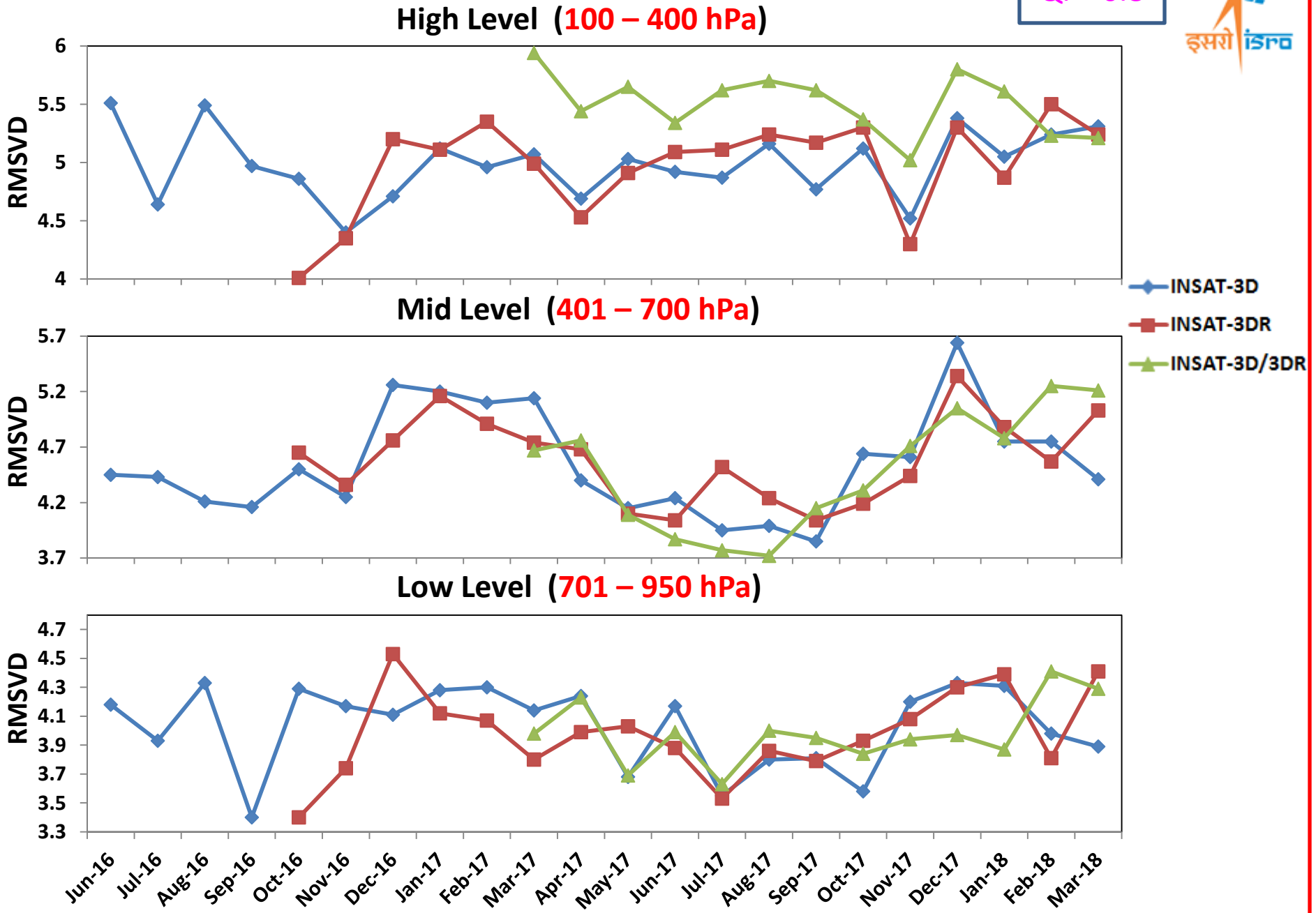
Validation of TIR-1 AMV with respect to NCEP analysis

QI > 0.8



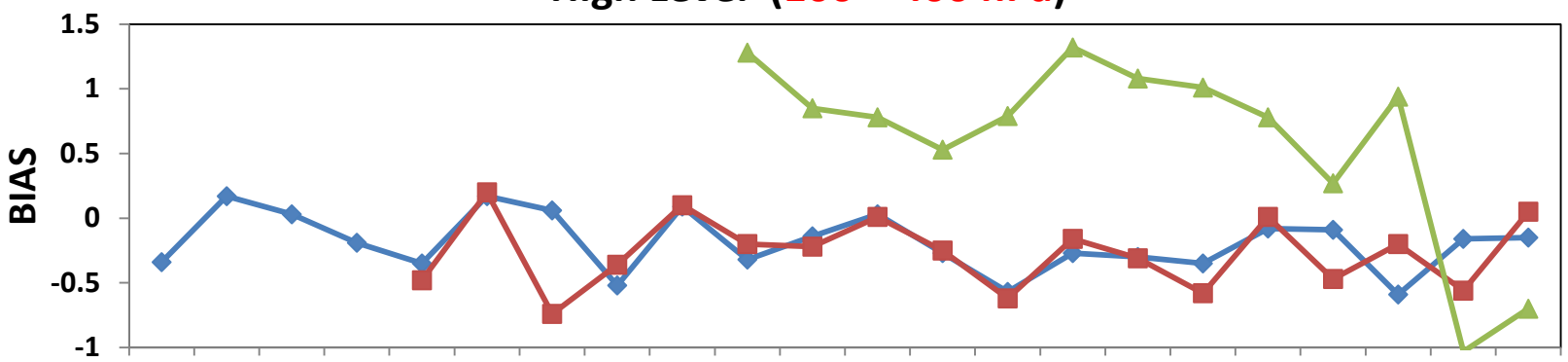
Validation of TIR-1 AMV with respect to Radiosonde data

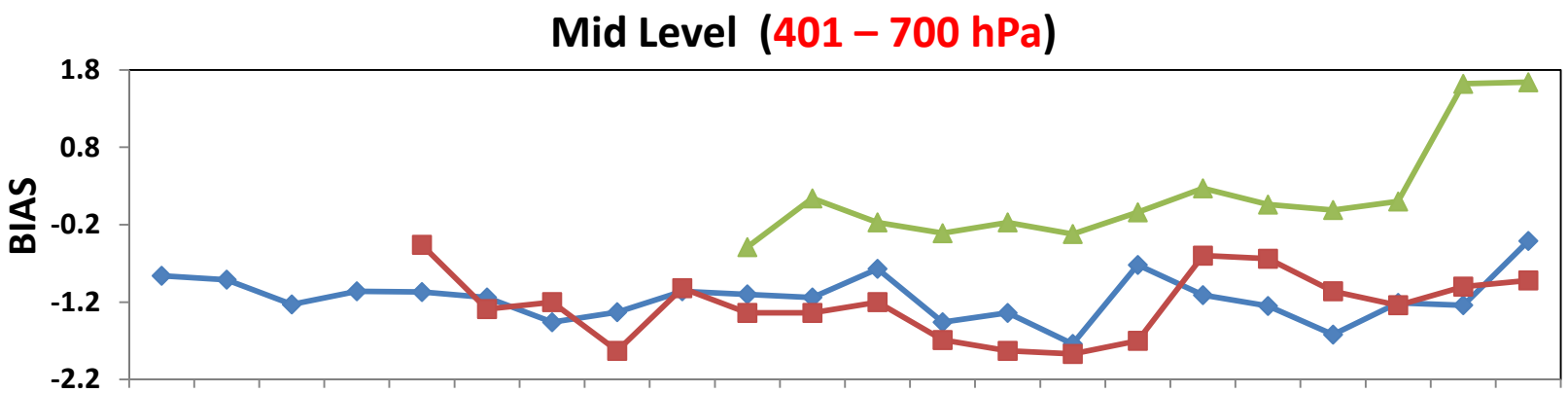
QI > 0.8

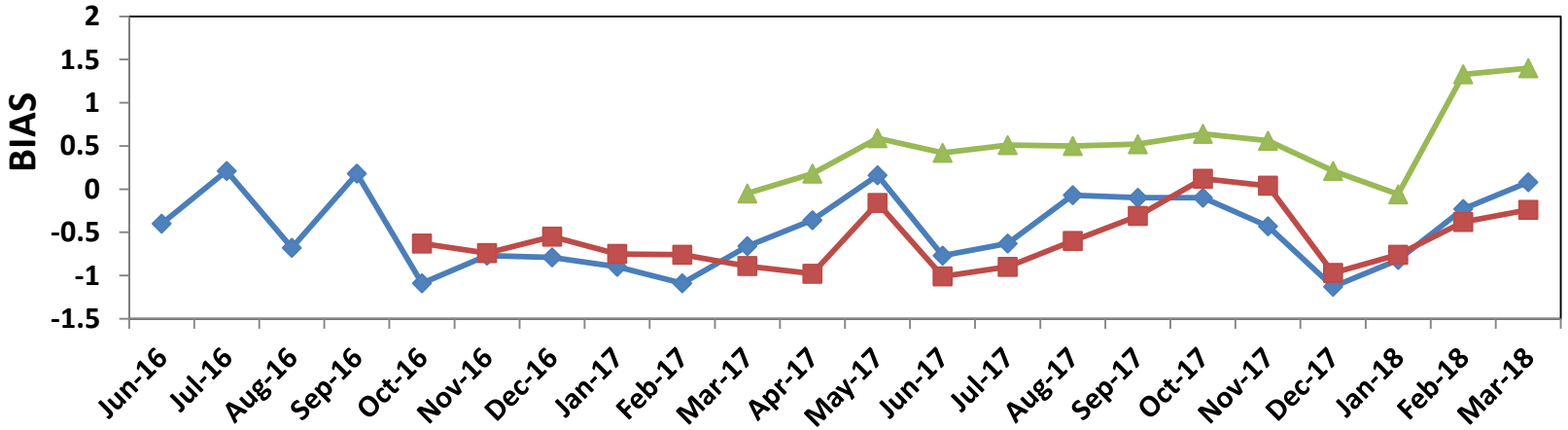


Validation of TIR-1 AMV with respect to Radiosonde data

QI > 0.8

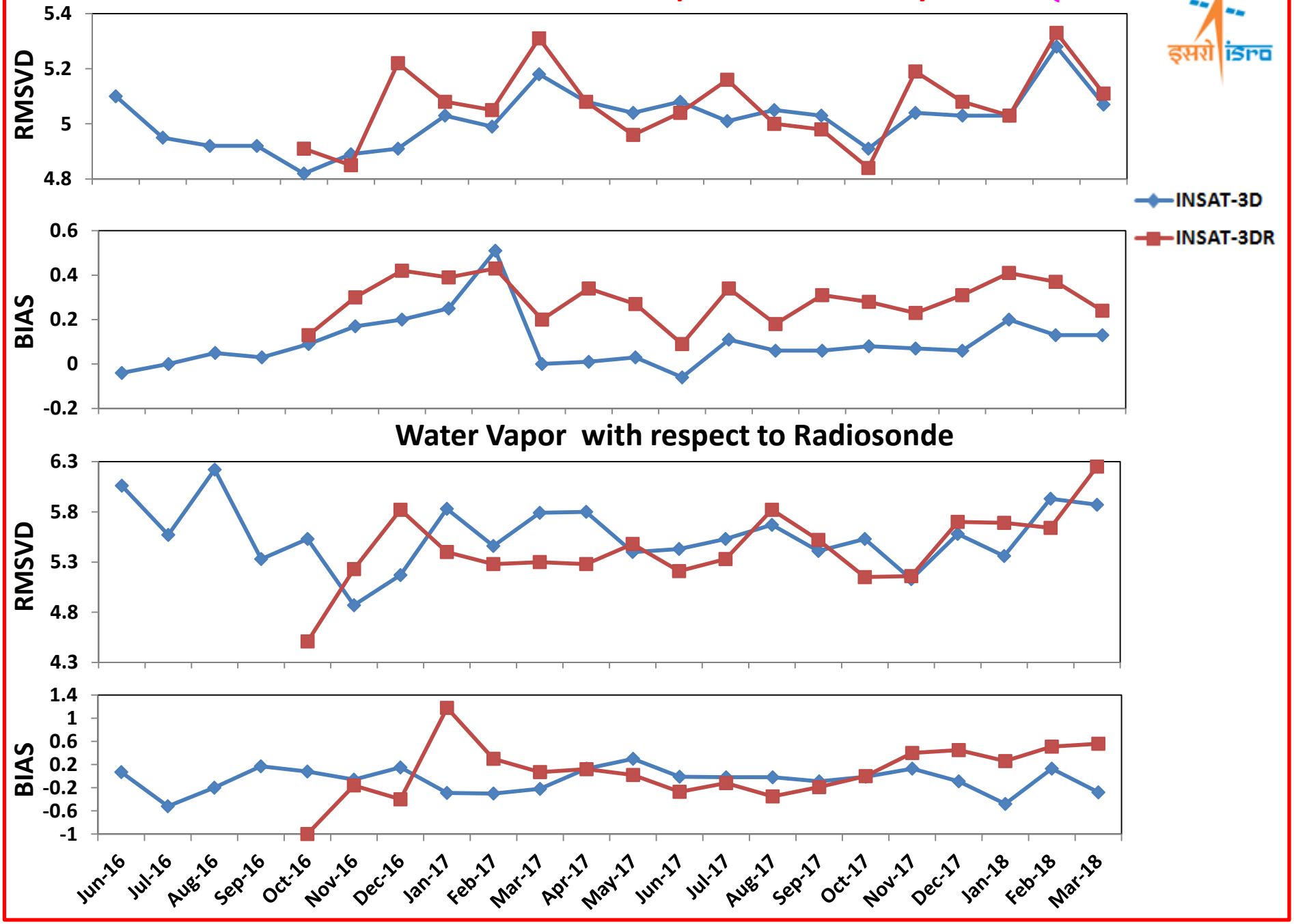


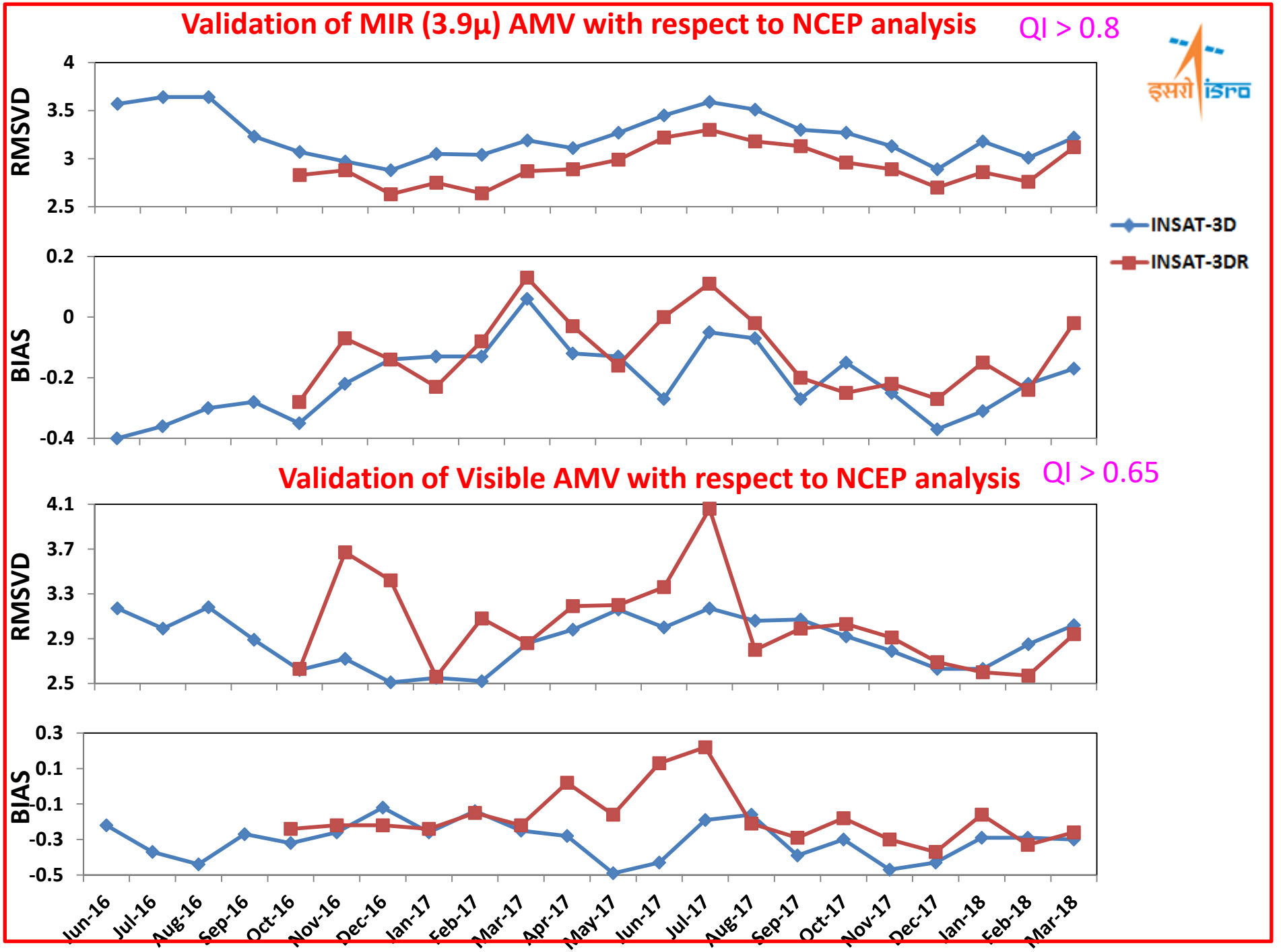




Validation of WV AMVs with respect to NCEP analysis

QI > 0.8



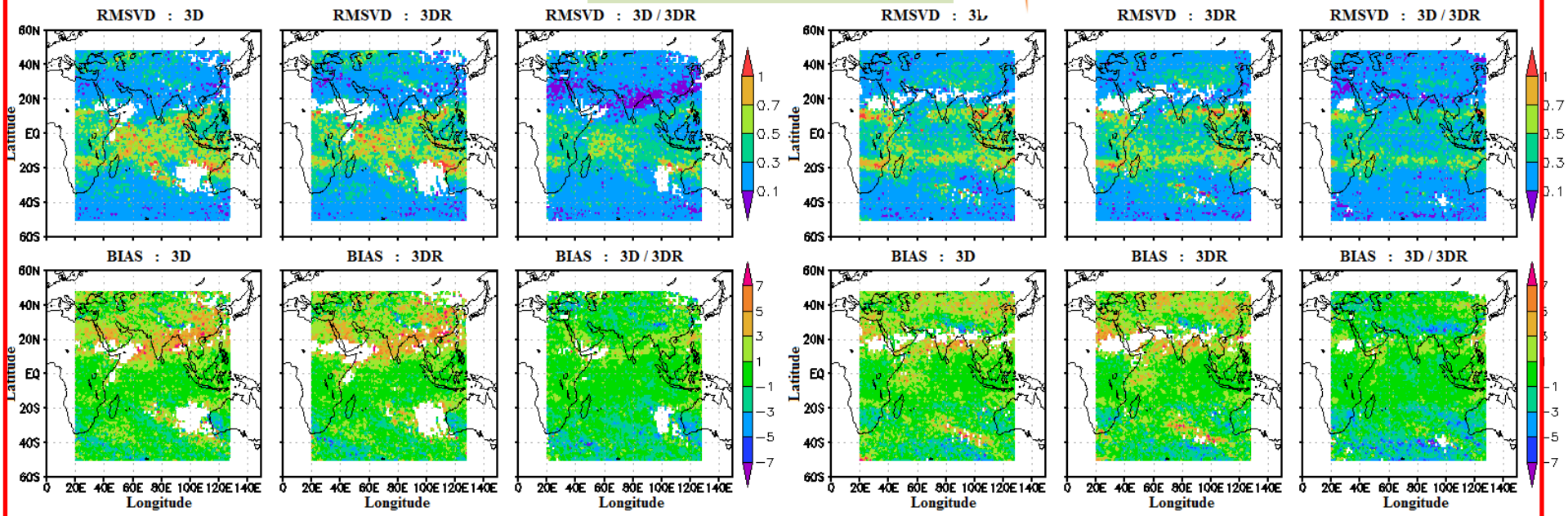

Validation of MIR (3.9µ) AMV with respect to NCEP analysis
QI > 0.8
RMSVD
BIAS
INSAT-3D
INSAT-3DR
Validation of Visible AMV with respect to NCEP analysis
QI > 0.65
RMSVD
BIAS
Jun-16
Jul-16
Aug-16
Sep-16
Oct-16
Nov-16
Dec-16
Jan-17
Feb-17
Mar-17
Apr-17
May-17
Jun-17
Jul-17
Aug-17
Sep-17
Oct-17
Nov-17
Dec-17
Jan-18
Feb-18
Mar-18

Spatial Variation

TIR-1

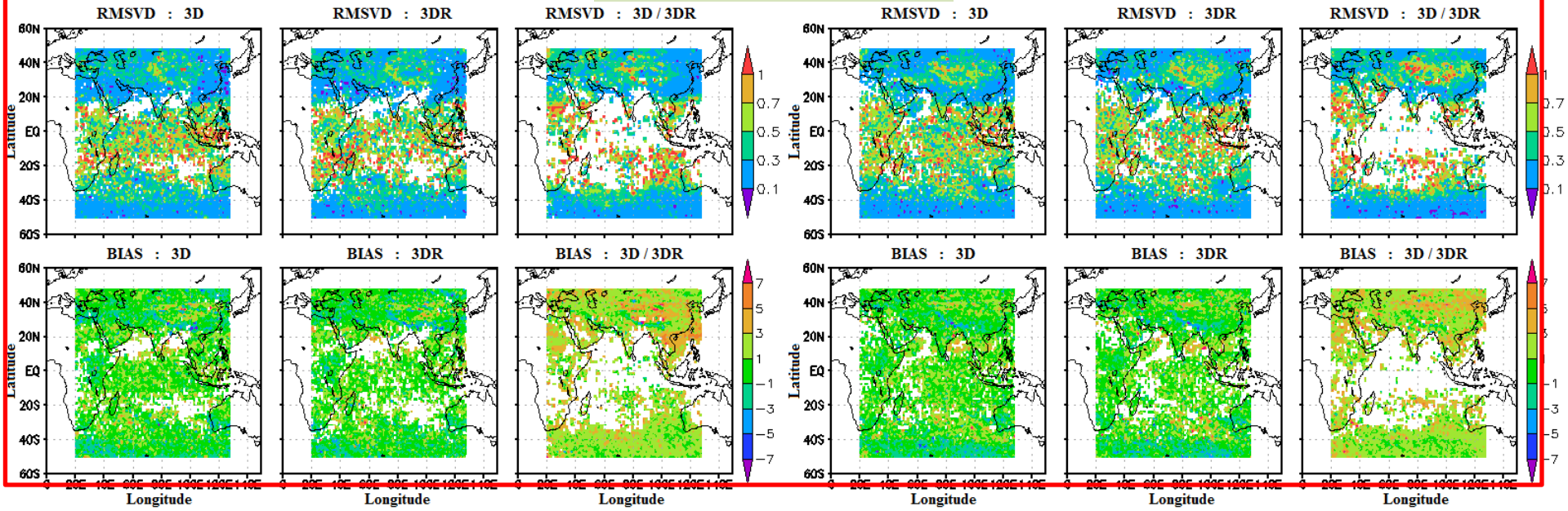
High Level (100 – 400 hPa)

FEB - 2018 | MAR - 2018



Mid Level (401 – 700 hPa)

FEB - 2018 | MAR - 2018



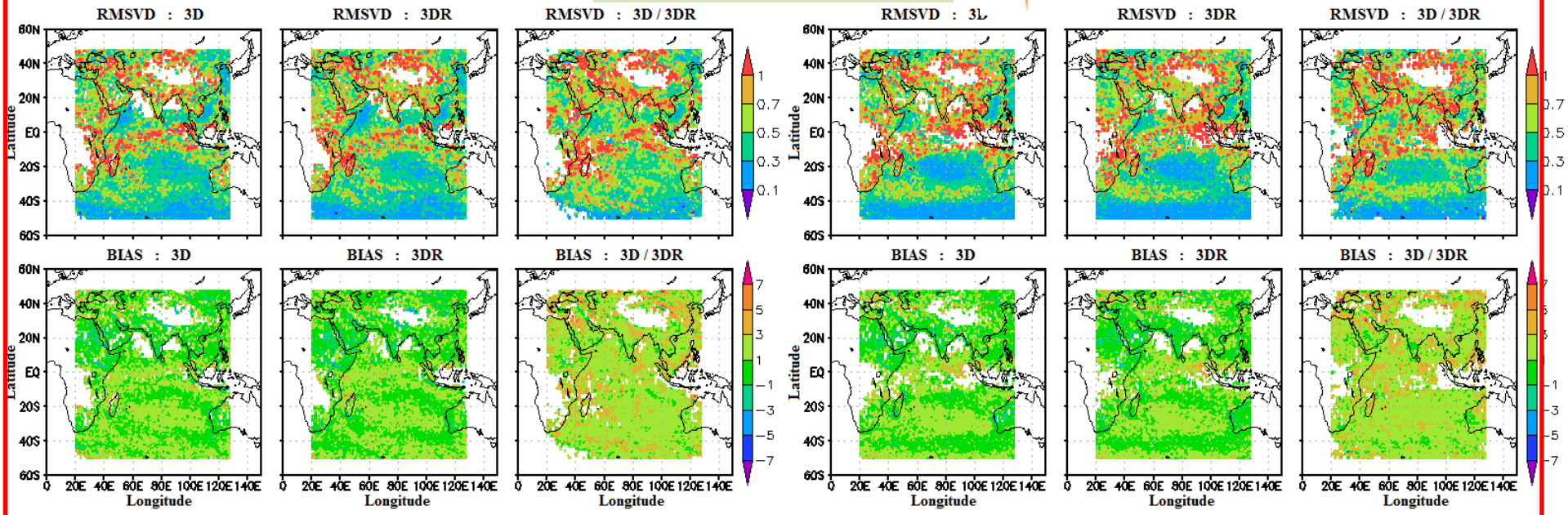
Spatial Variation

FEB - 2018

Low Level (701 – 950 hPa)

MAR - 2018

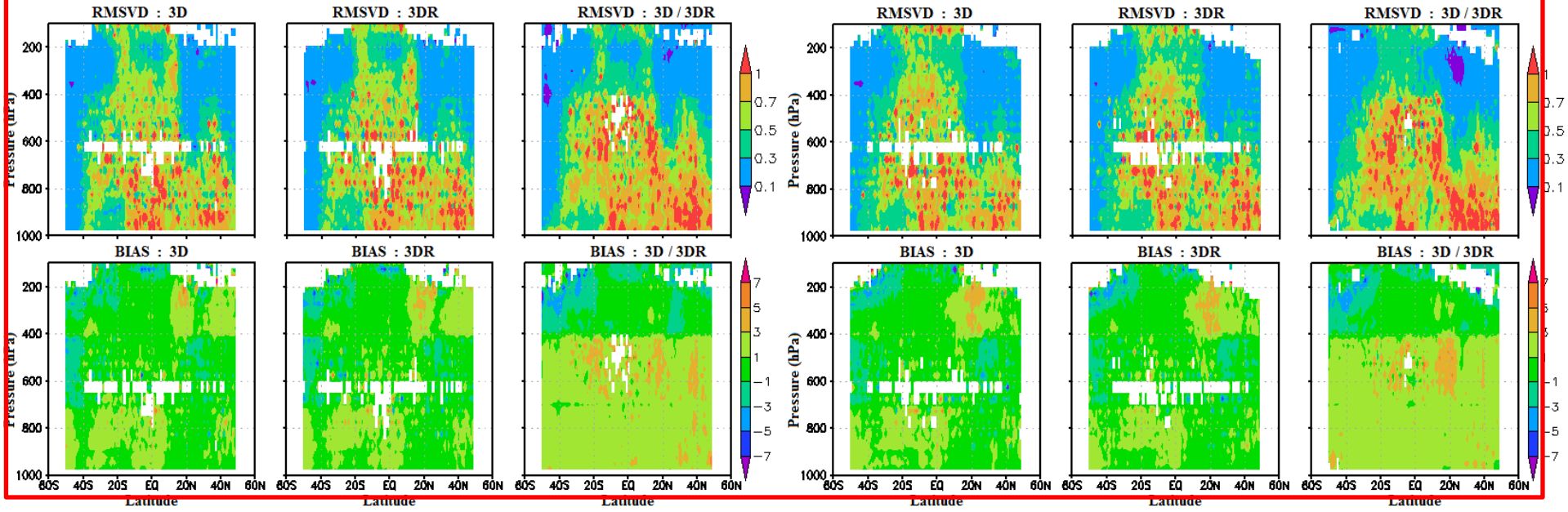
TIR-1



Vertical Plot

FEB - 2018

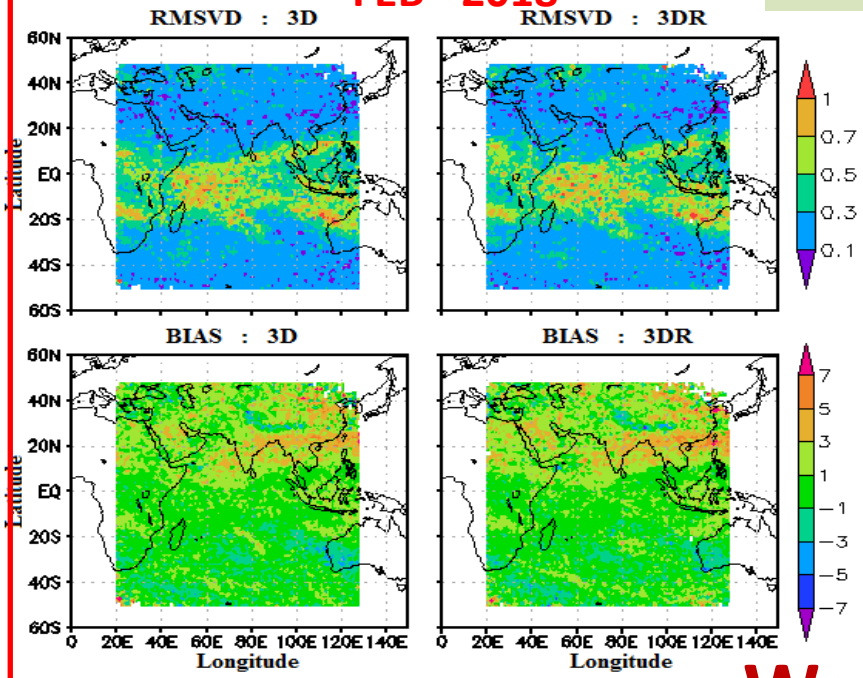
MAR - 2018



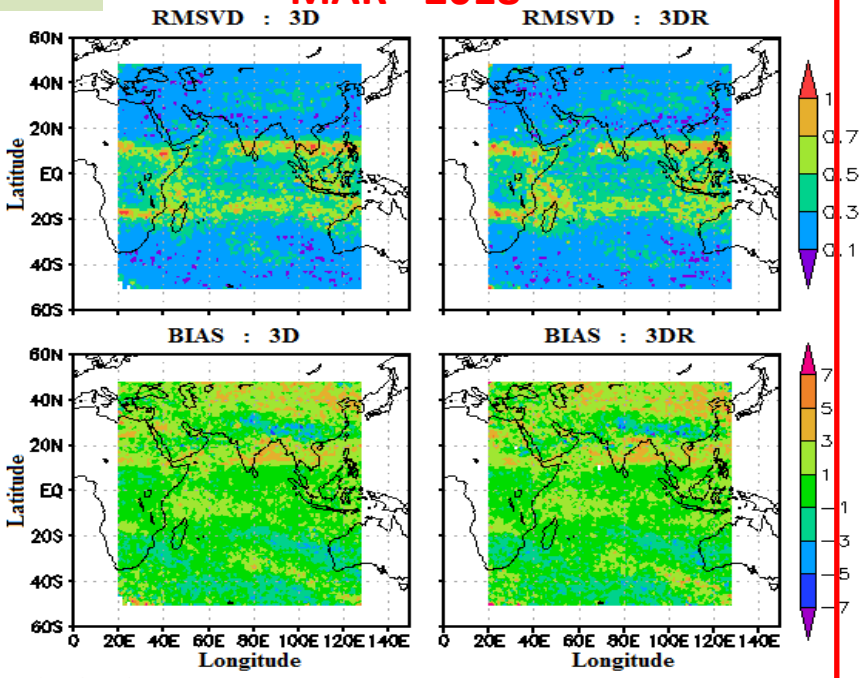
Water Vapor

High Level (100 – 400 hPa)

FEB - 2018

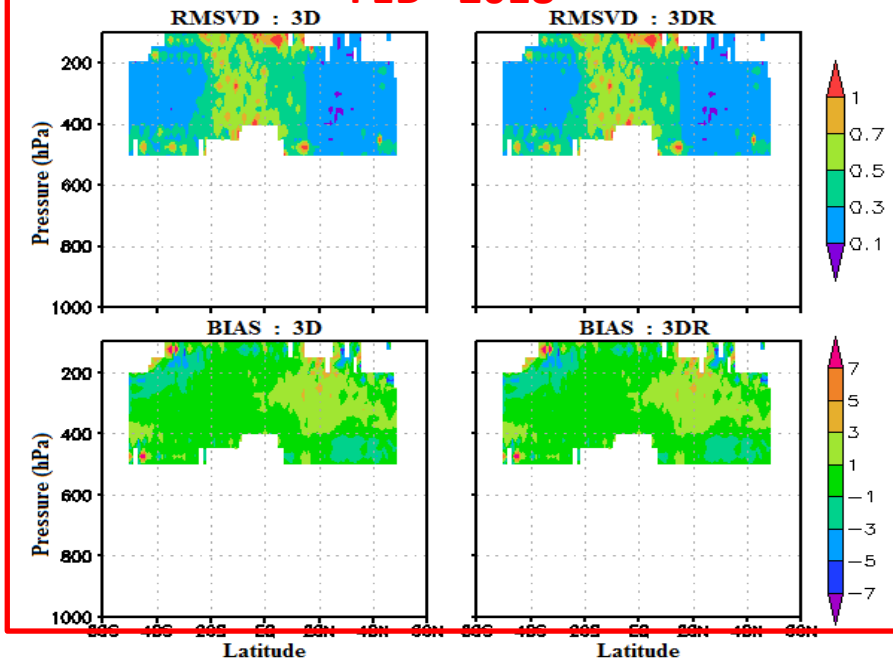


MAR - 2018

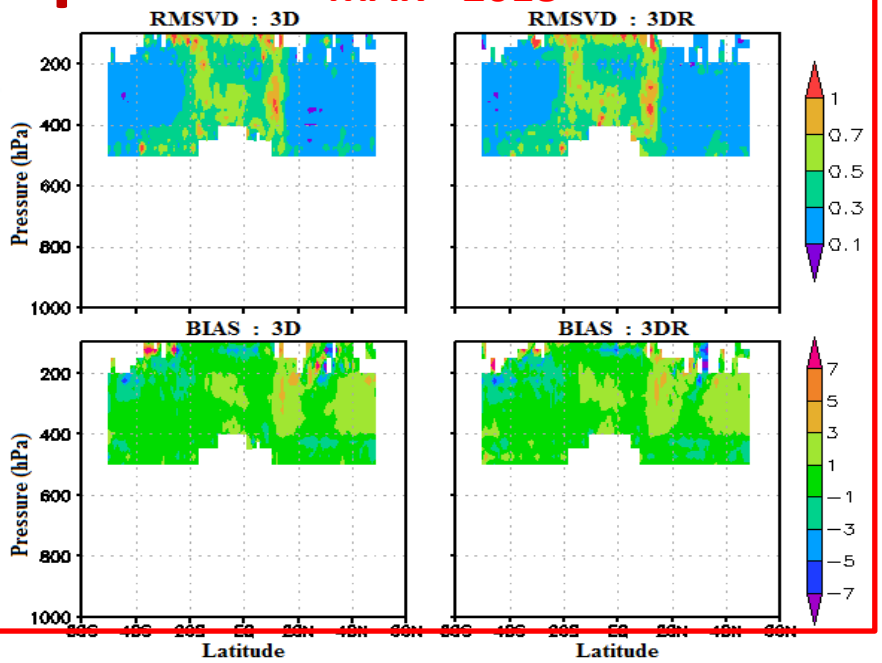


Vertical Plot

FEB - 2018



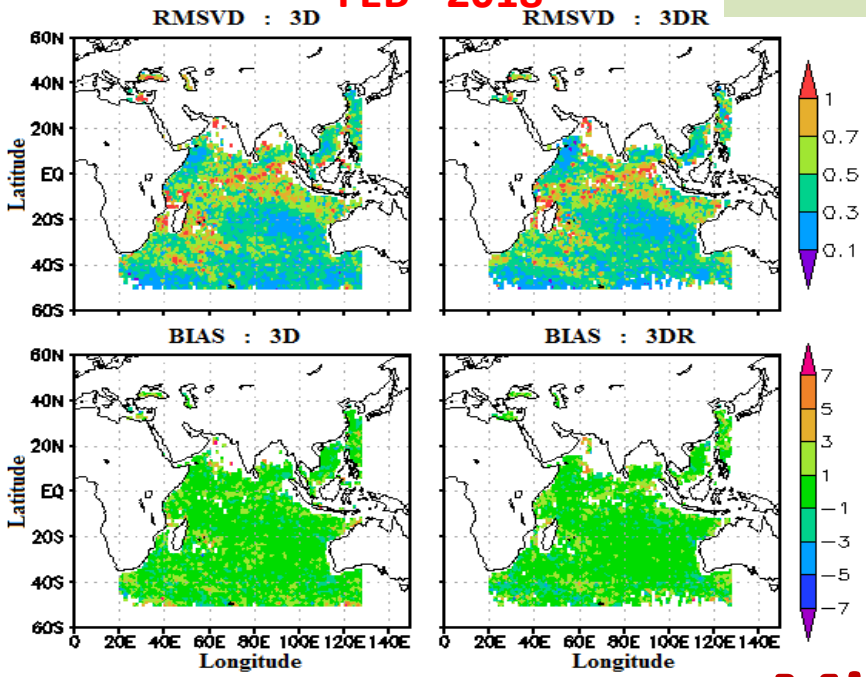
MAR - 2018



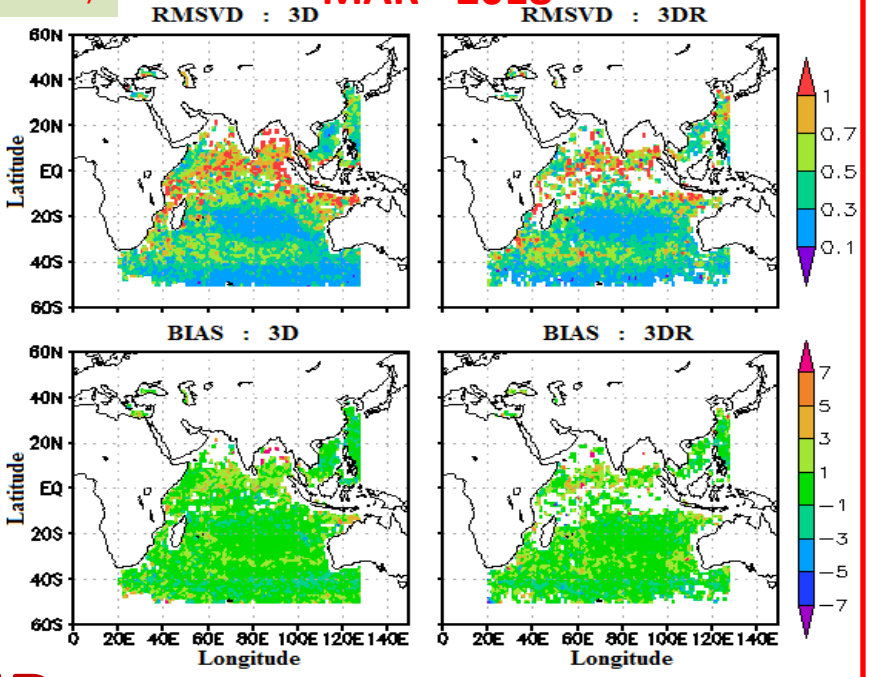
Mid - IR

Low Level (701 – 950 hPa)

FEB - 2018



MAR - 2018



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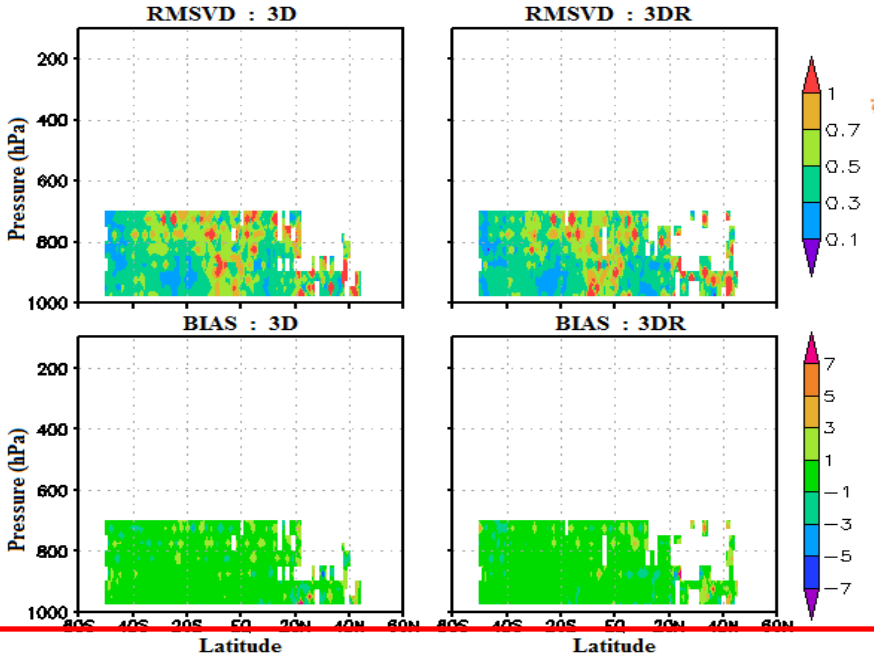
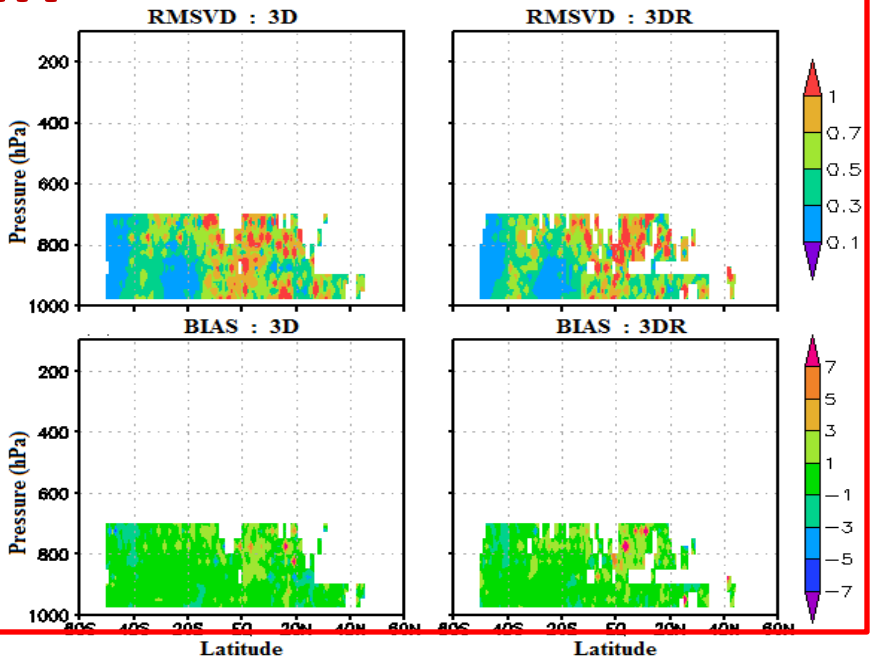
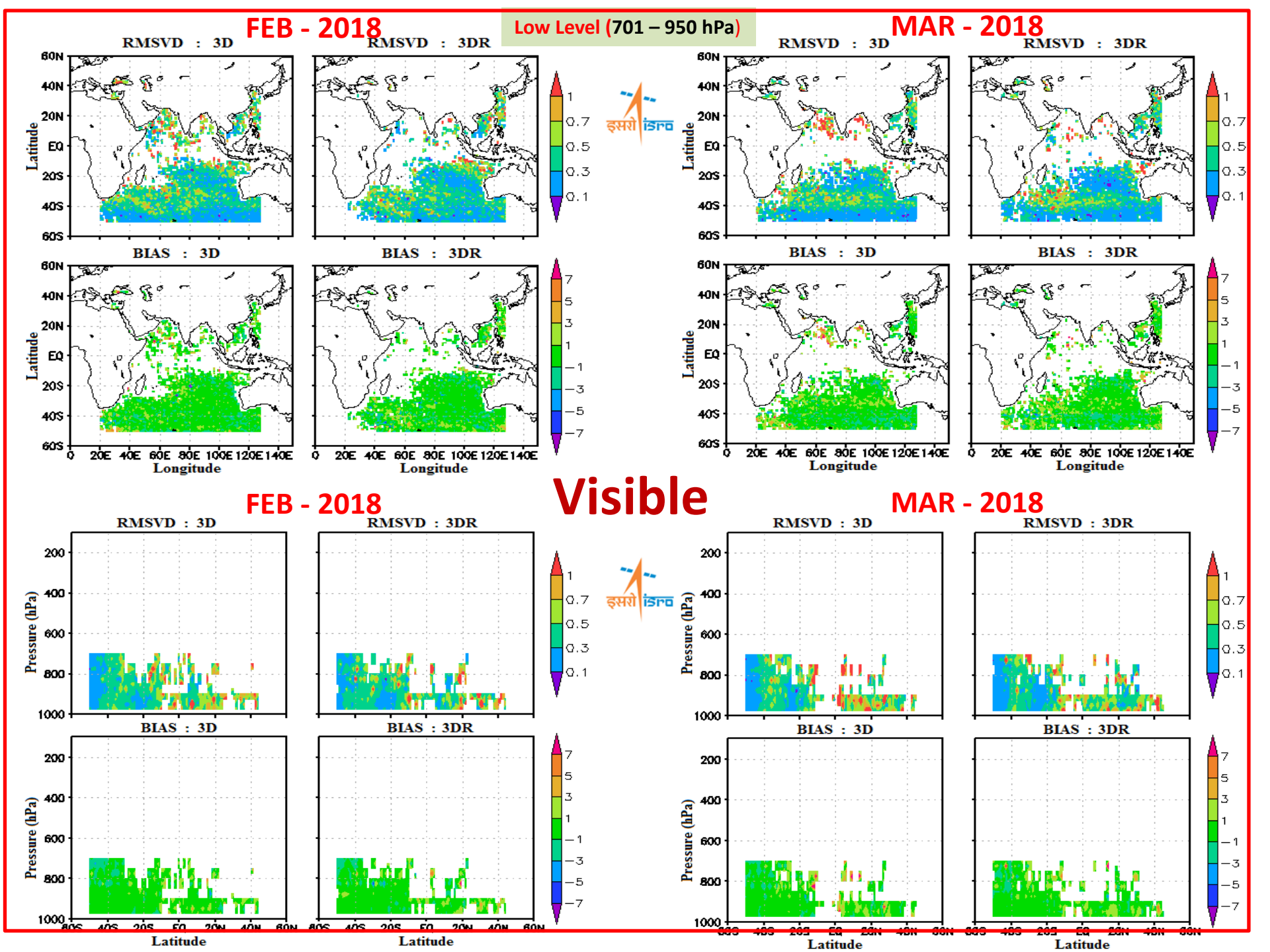


MAR - 2018

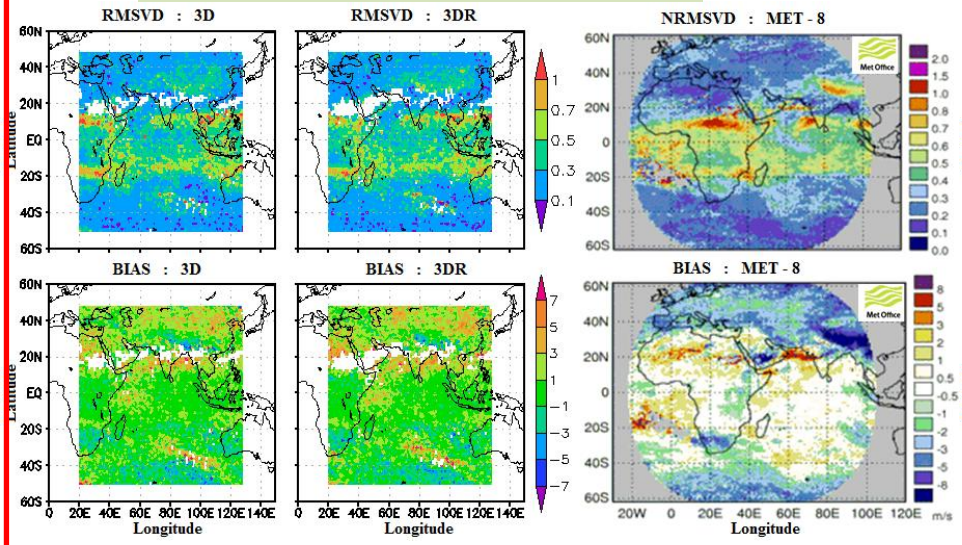



FEB - 2018
Low Level (701 – 950 hPa)
MAR - 2018
RMSVD : 3D
RMSVD : 3DR
BIAS : 3D
BIAS : 3DR
Latitude
Longitude
60N
40N
20N
EQ
20S
40S
60S
0 20E 40E 60E 80E 100E 120E 140E
1
0.7
0.5
0.3
0.1
7
5
3
1
−1
−3
−5
−7
इसरो isro
Visible
FEB - 2018
MAR - 2018
Pressure (hPa)
200
400
600
800
1000
80S 40S 20S EQ 20N 40N 60N

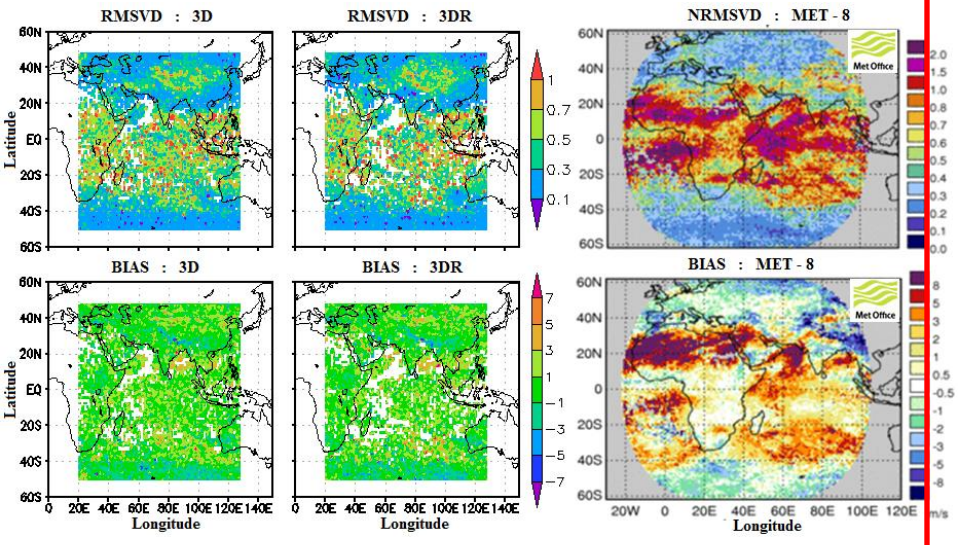
TIR-1 AMV

MAR - 2018

High Level (100 – 400 hPa)

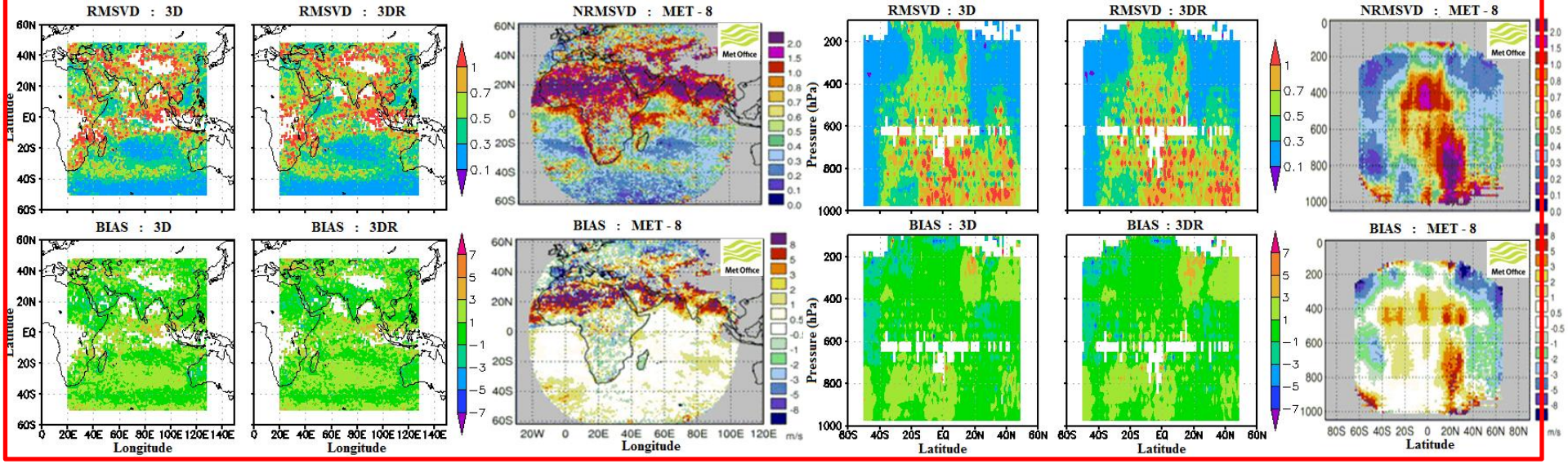


Mid Level (401 – 700 hPa)



https://nwpsaf.eu/monitoring/AMV

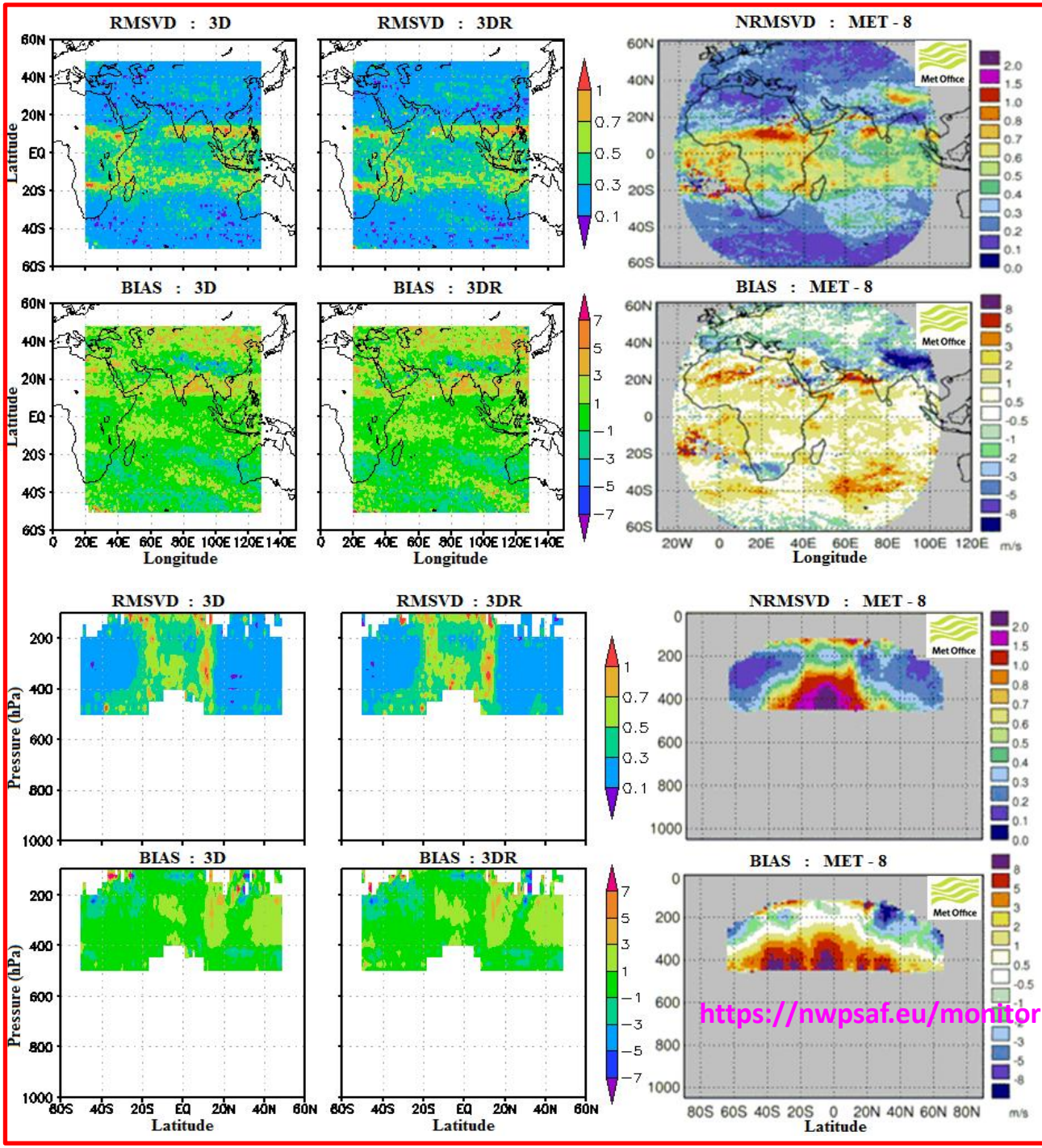
Low Level (701 – 950 hPa)



MAR - 2018

Water Vapor AMV

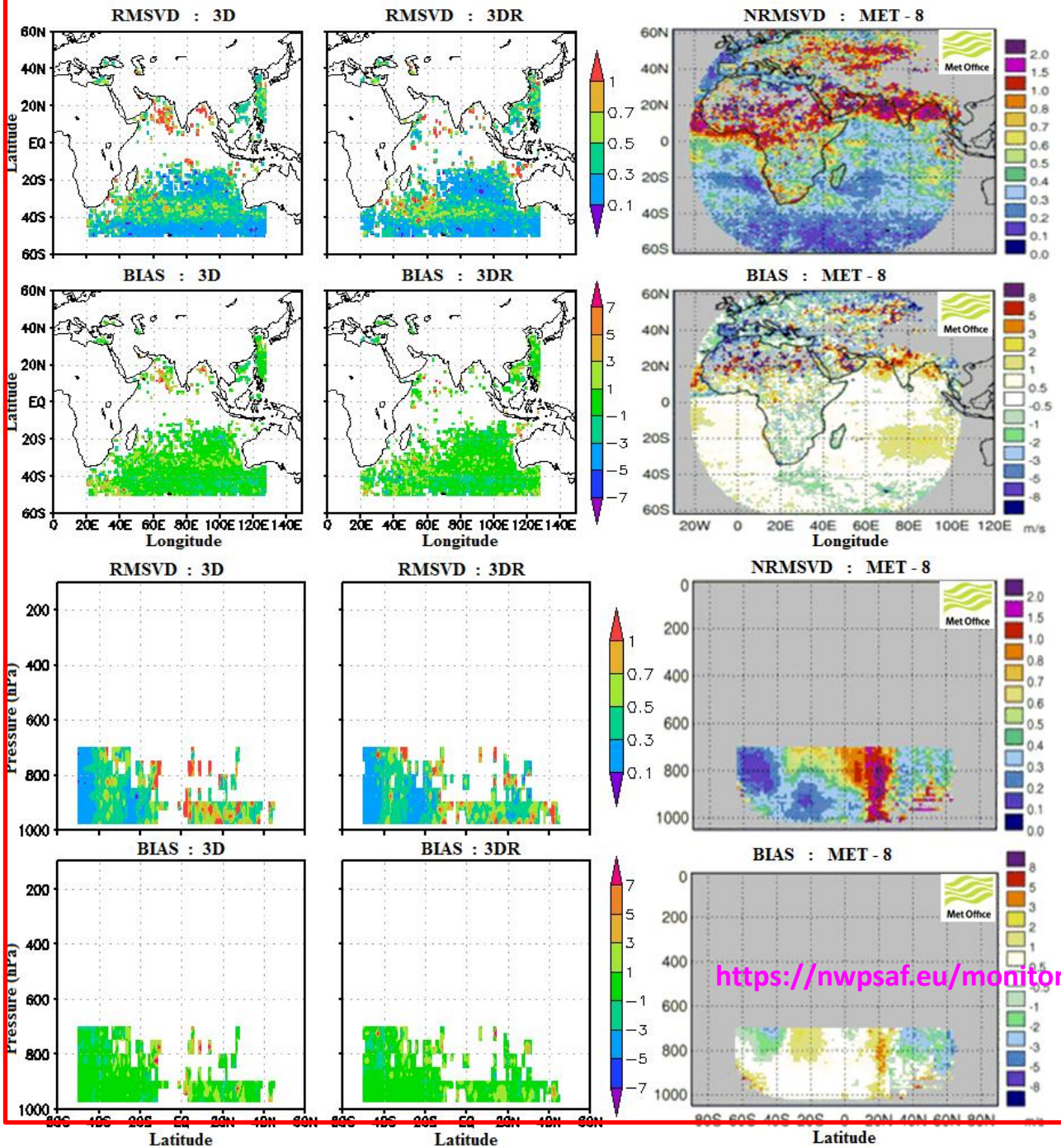
High Level (100 – 400 hPa)



MAR - 2018

Visible AMV

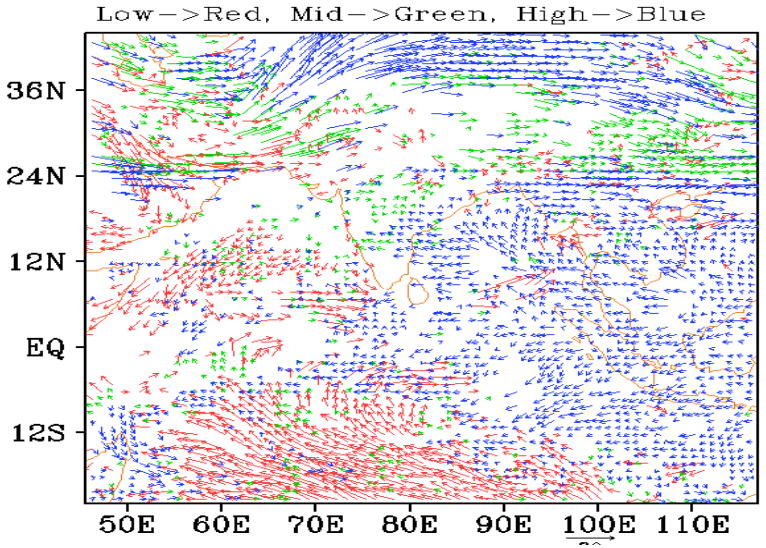
Low Level (701 – 950 hPa)

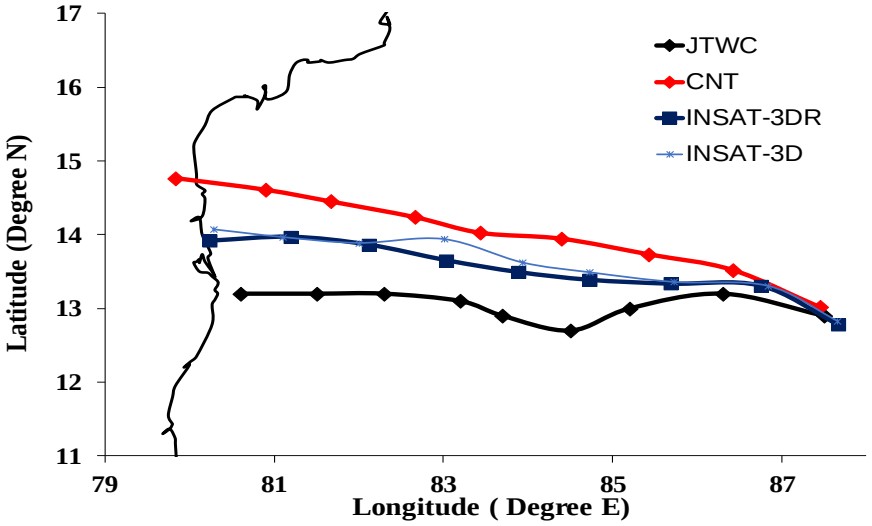


https://nwpsaf.eu/monitoring/AMV

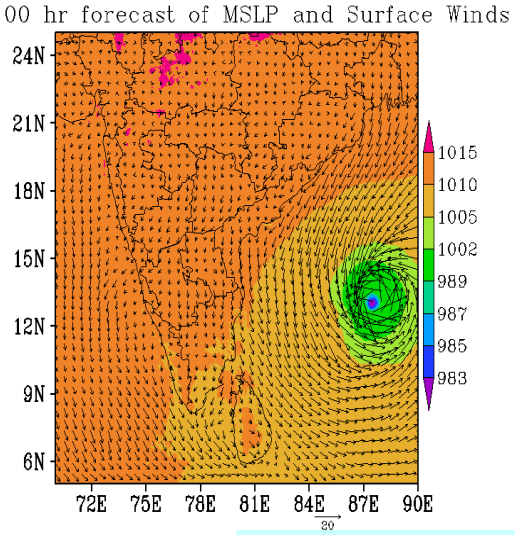
INSAT-3DR AMVs used for Assimilation

Vardha Cyclone: 10-12 Dec 2016

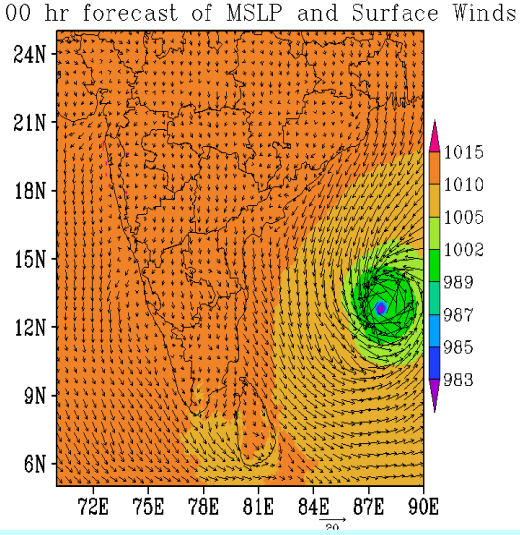




CNT



INSAT-3R



Model : WRF

Assimilation technique: 3DVAR

StartTime: 00 UTC 10 Dec 2016

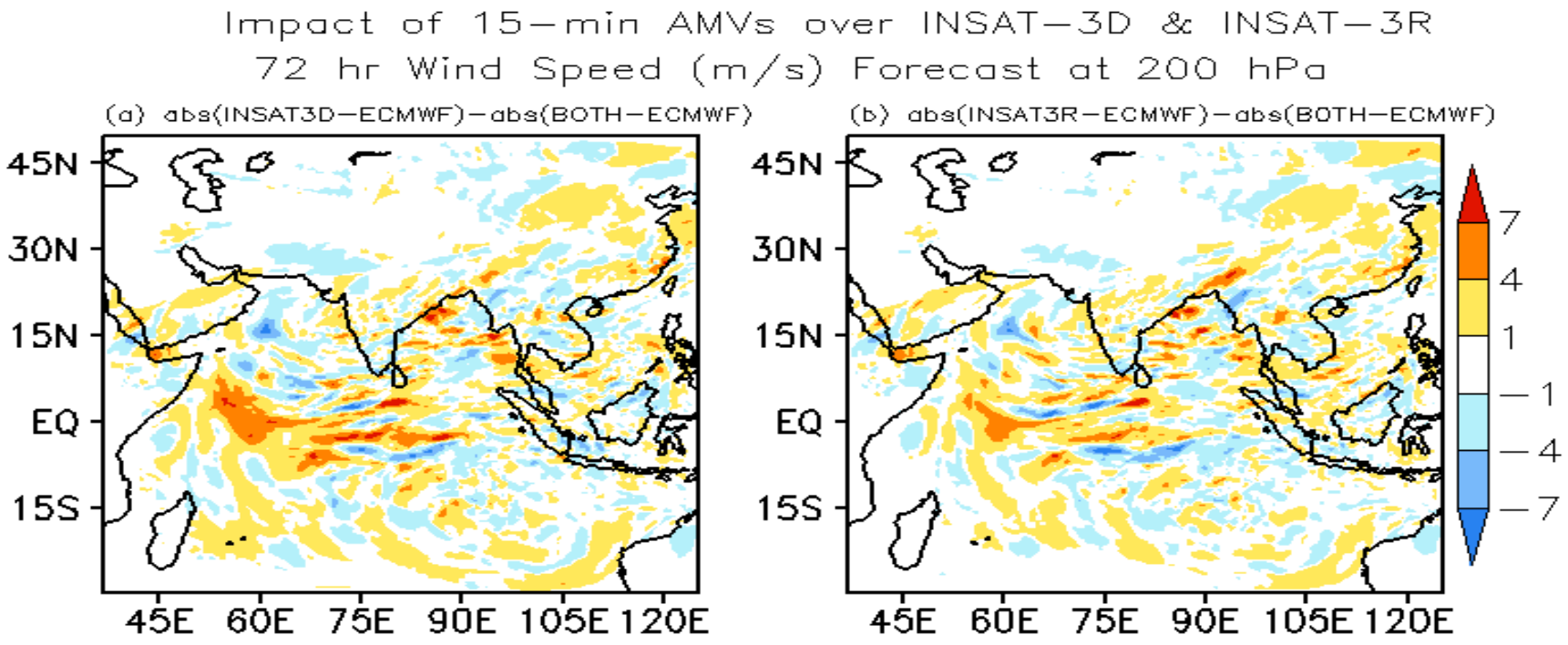
Winds used: 5000 winds (appx)

Int. time : 66 Hours

Track forecast improved after INSAT-3DR AMV Assimilation

Assimilation of INSAT 3D/3DR staggering AMVs

EXP1: INSAT3D (3D AMVs), **EXP2: INSAT3R (3R AMVs)**, **EXP3: BOTH (3D/3R STG AMVs)**



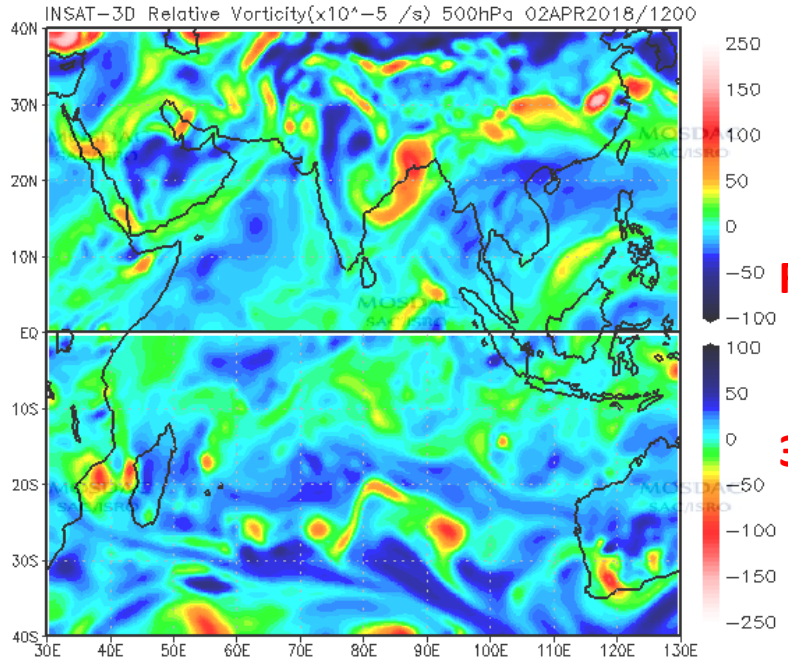
Model :WRF
Assimilation technique: 4DVAR
Time : 06 UTC 19 Oct 2016
AMV used : 50000 winds (approx) for staggering
25000 winds for individual 3D/3DR
Integration time : 72 Hours

72 hrs wind speed forecast has improved after assimilation of staggering AMVs

www.mosdac.gov.in

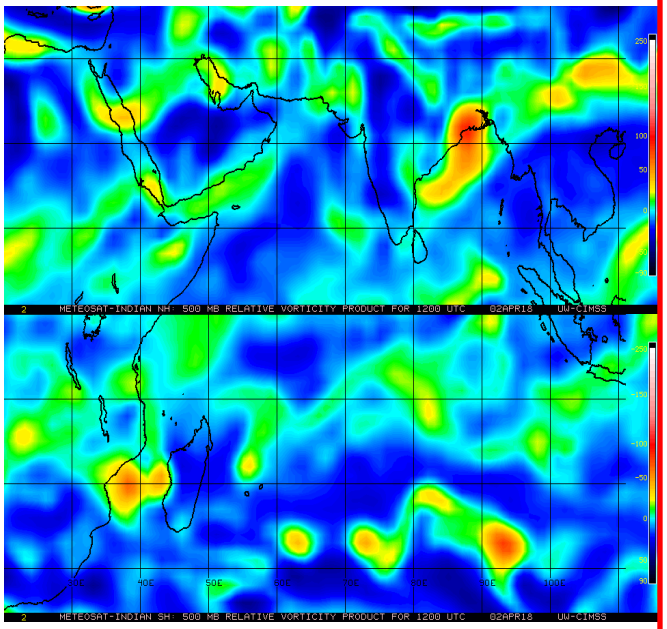
AMV derived product

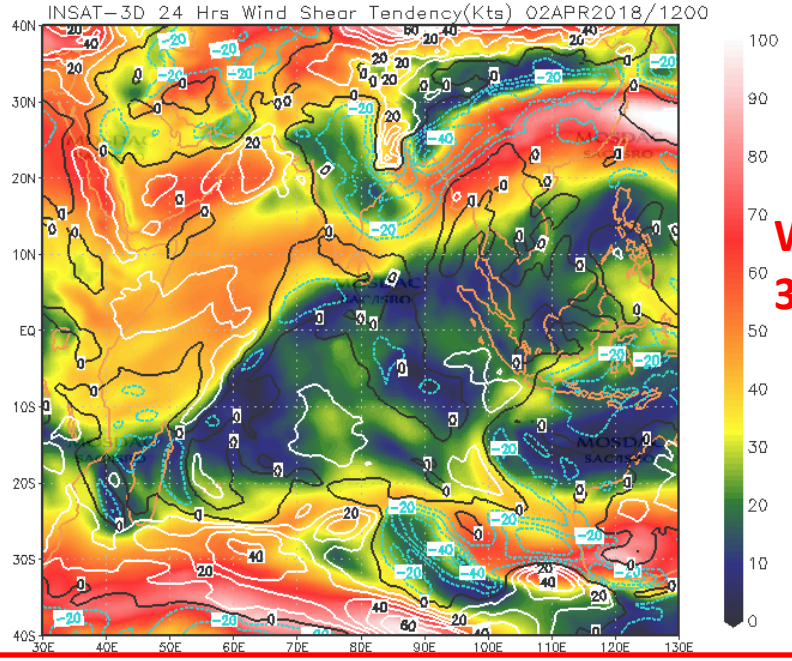
www.tropic.ssec.wisc.edu



Relative Vorticity at 500 hPa

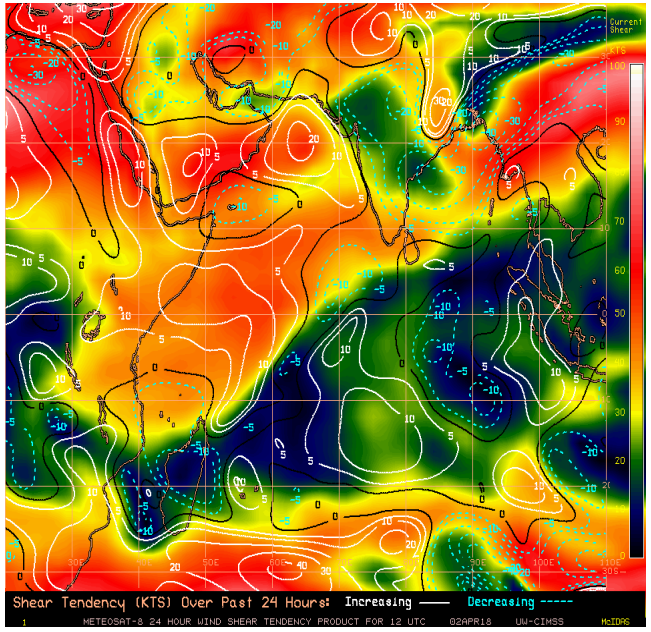
3D MET8





Wind shear tendency

3D MET8



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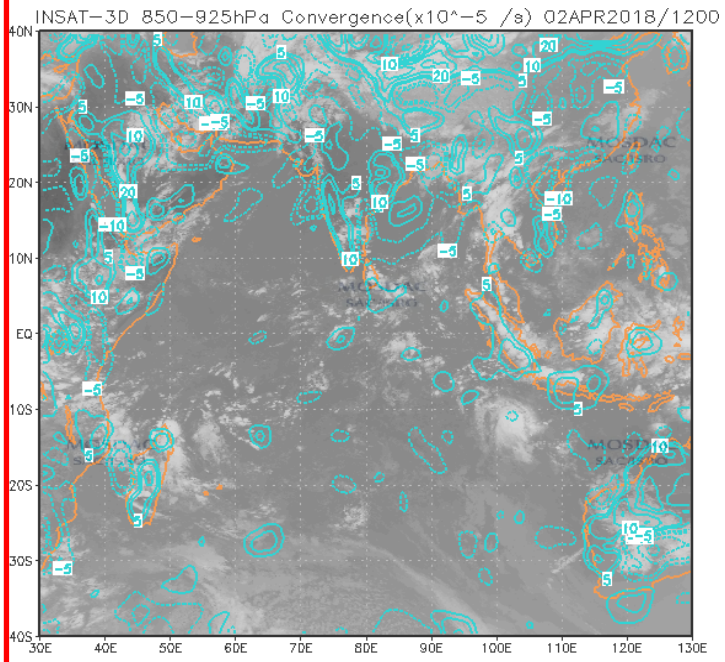
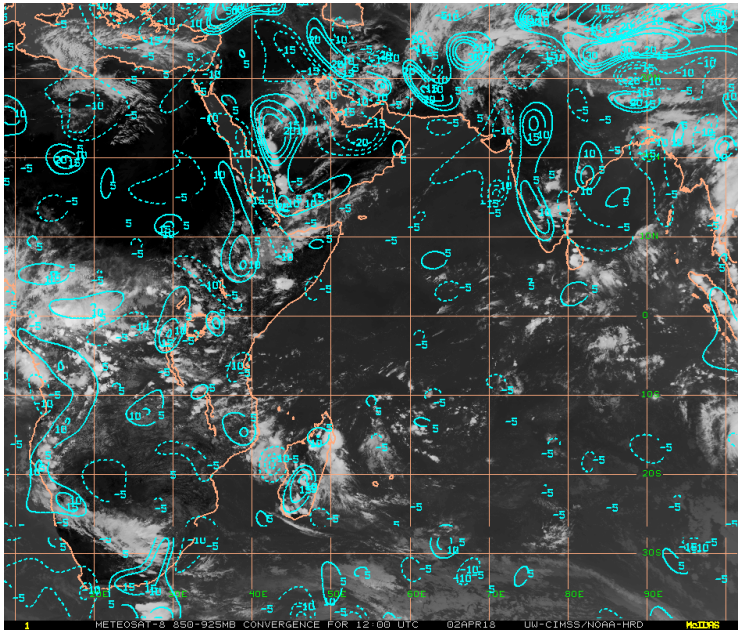


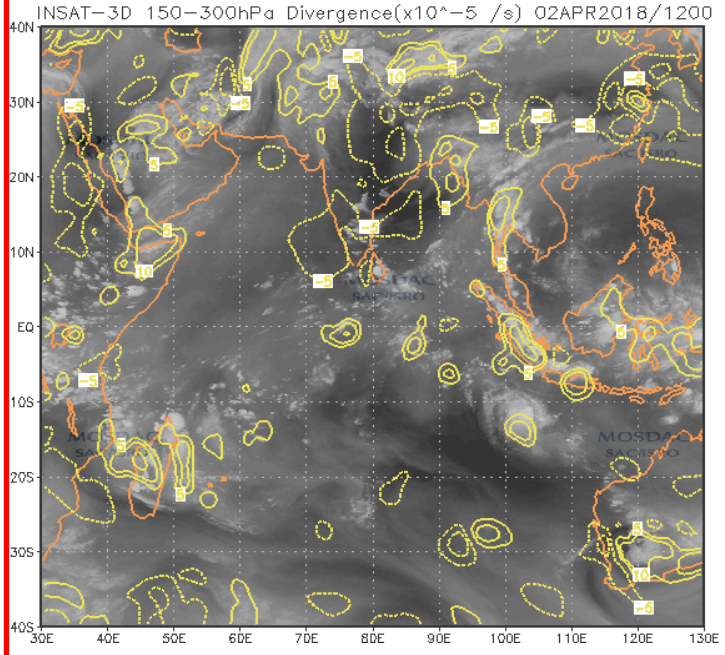
Lower-level convergence

3D

www.tropic.ssec.wisc.edu

MET8

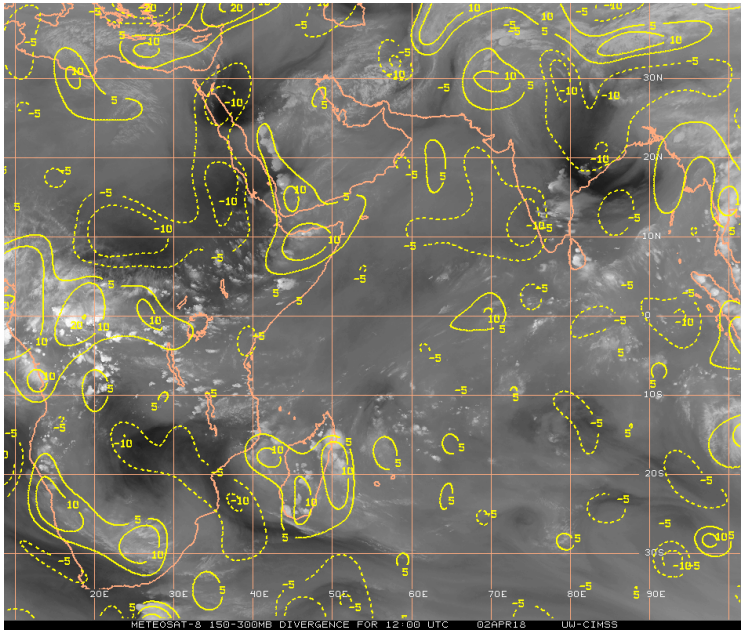




Upper-level divergence

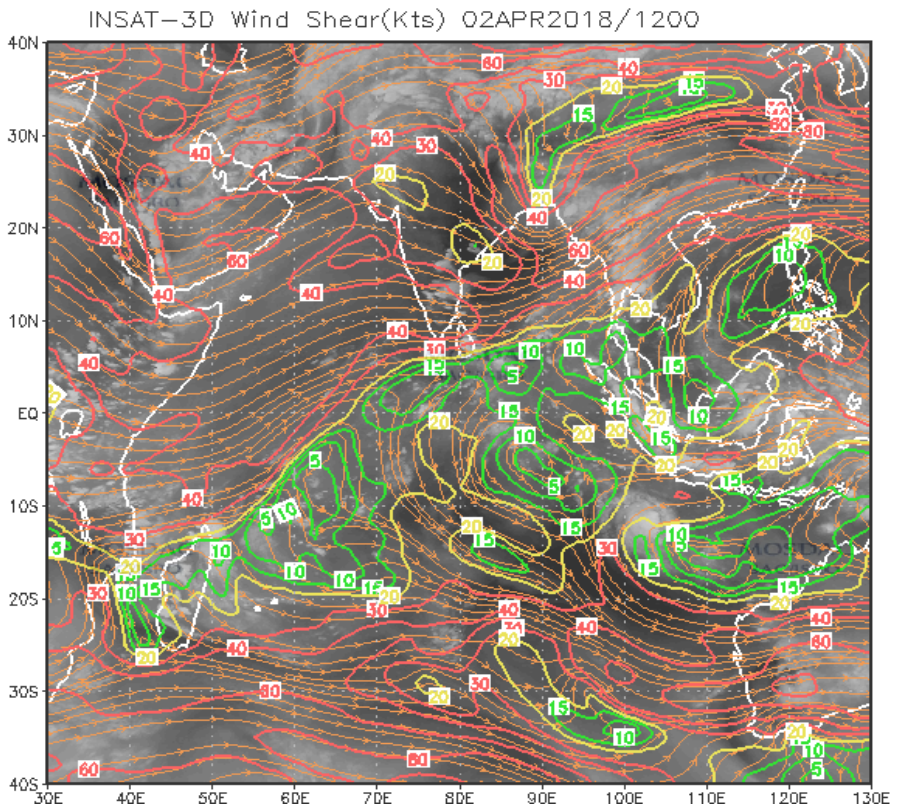
3D

MET8



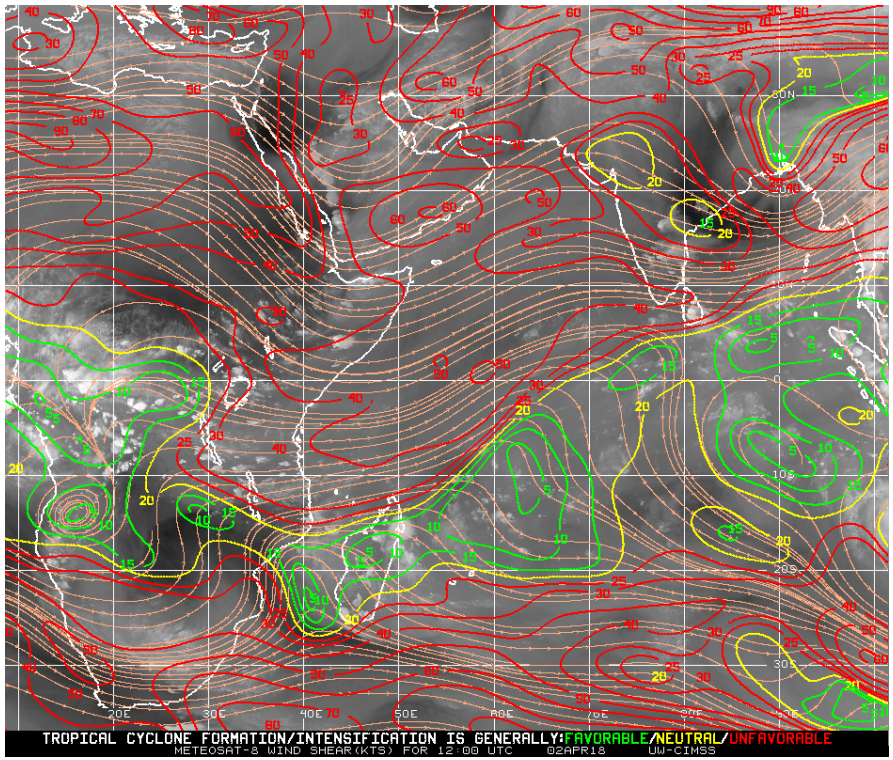
Wind shear

3D



www.mosdac.gov.in

MET8



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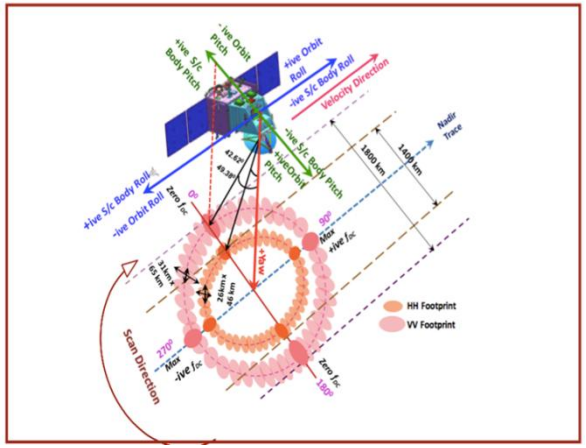
SCATSAT-1 Ocean Surface winds

Scatsat-1 Measurement Geometry



Mission Specifications

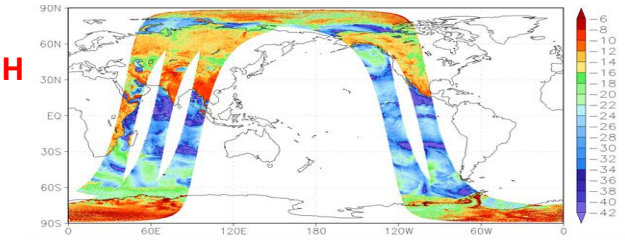
Spacecraft Altitude	720 Km (Nominal)
Inclination	98°
Orbit	Polar Non Sun-Synchronous at Injection with Ascending-Node time 9:30 am; to be made Sun-synchronous at 8 am local time after ~150 days
Frequency	13.515625 GHz
Polarization	HH for inner and VV for Outer beams
Swath	1400 Km (both HH and VV beams available) 1400-1800 km (only VV beam available)
Wind Speed Range	3-30ms/s
Wind Direction Range	0° to 360°
Wind Speed Accuracy	1.8 m/s rms or 10% whichever is higher
Wind Direction Accuracy	20^0 rms
Wind Vector Cell (grid) Size	25 Km x 25 Km Grid

Types of products

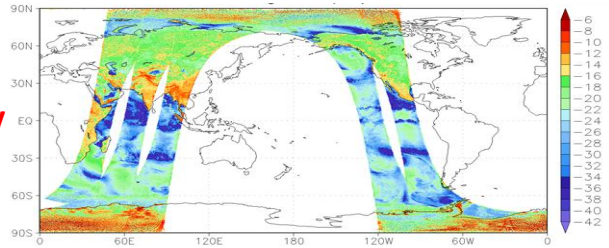
S.No	Level of product	Description	Format
1	Level 1B	Scan mode Sigma – 0	HDF 5
2	Level 2A	Swath grid mode sigma – 0	HDF 5
3	Level 2B	Swath grid Wind product	HDF 5
4	Level 3W	Global wind product	HDF 5
5	Level 3S	Global Sigma – 0 product	HDF 5

Scatsat-1 L2A Sigma0 (db) October 3, 2016

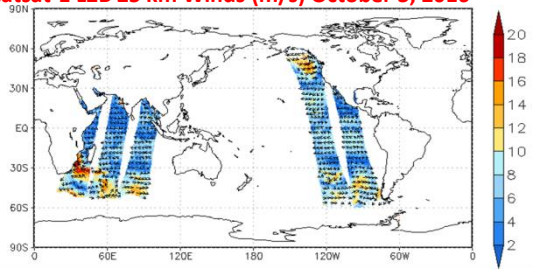
HH

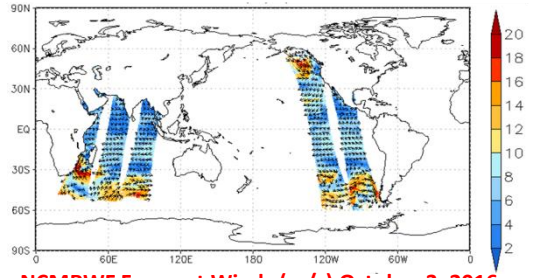


VV



Scatsat-1 L2B 25 km Winds (m/s) October 3, 2016

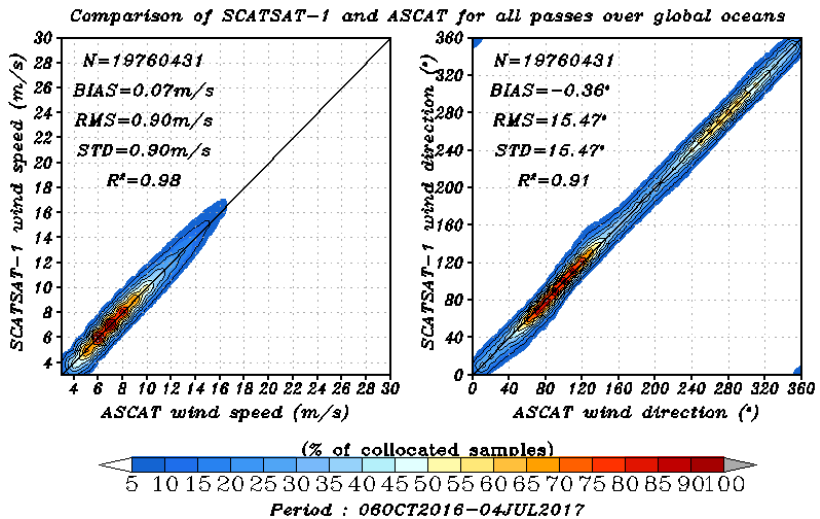


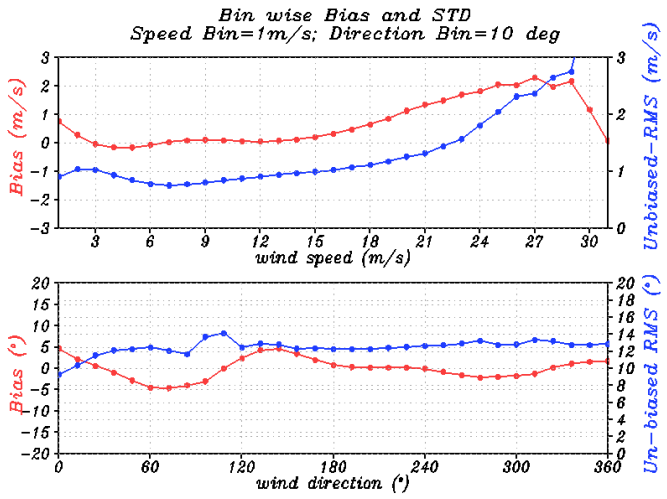


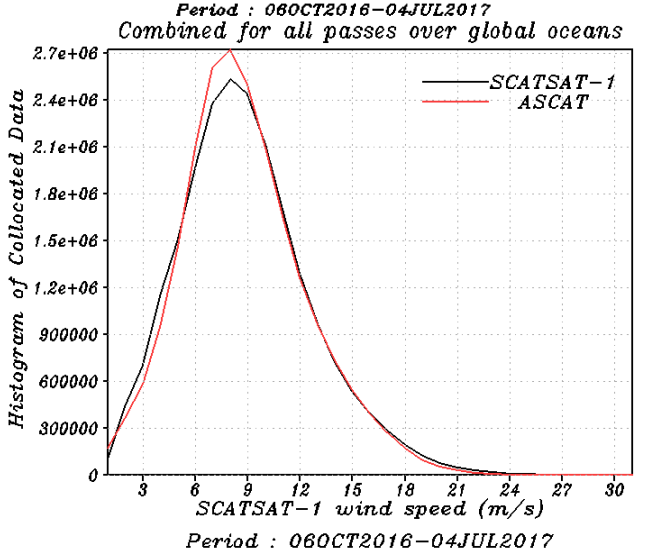
NCMRWF Forecast Winds (m/s) October 3, 2016

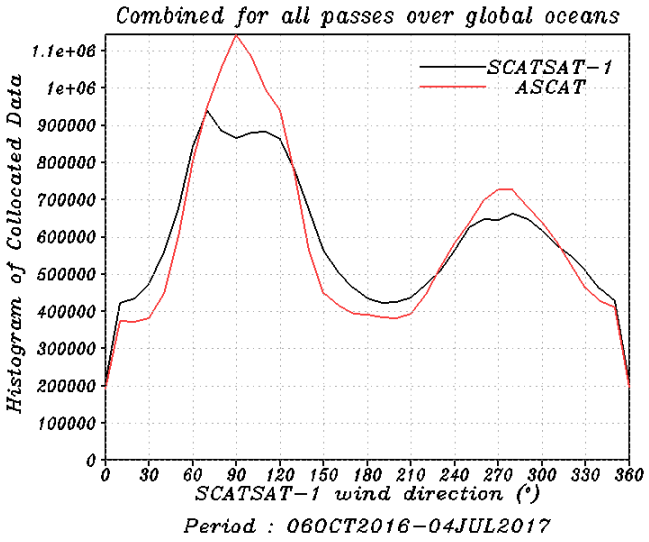
SCATSAT Wind Validation

Comparison of SCATSAT-1 V1.1.3C with ASCAT
Period : 06 October 2016 – 04 July 2017



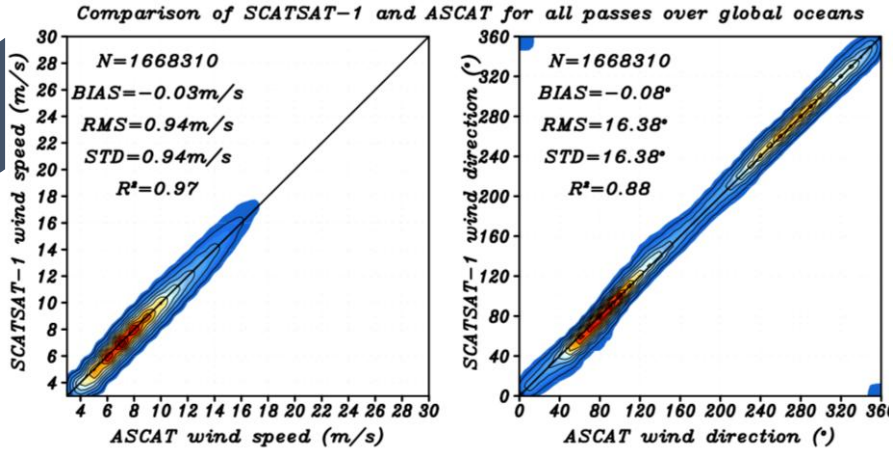




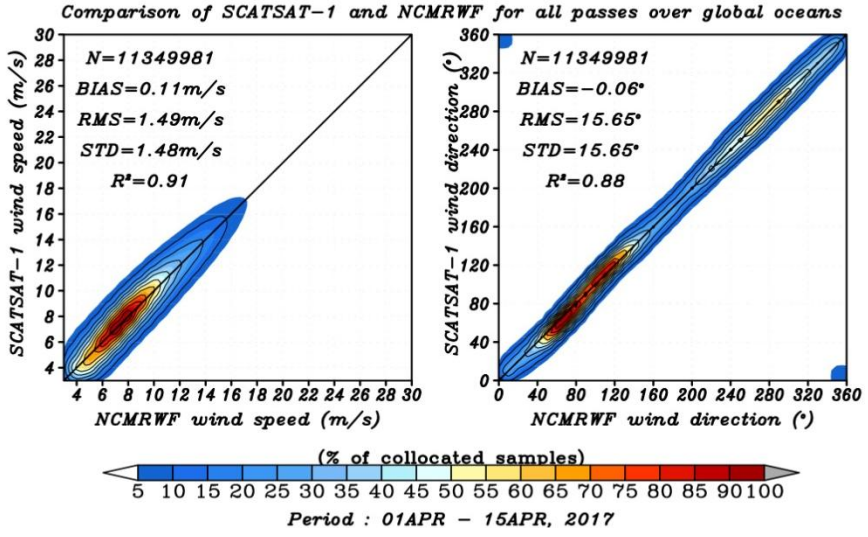


SCATSAT Wind Validation

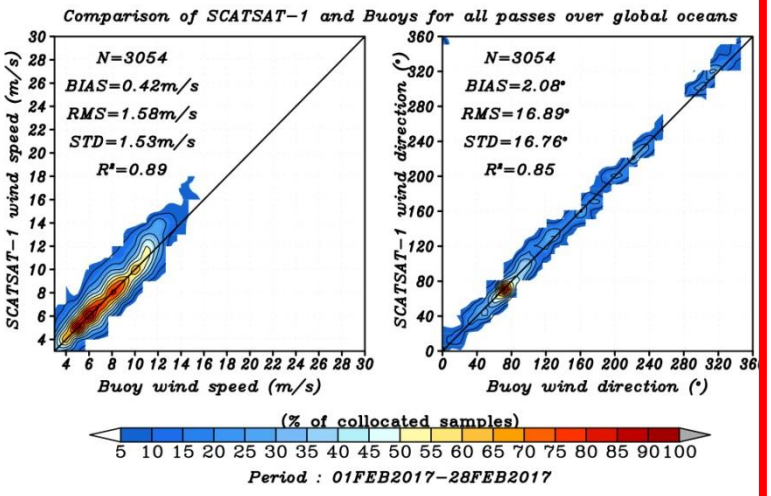
Validation with ASCAT



Validation with NCMRWF



Accuracy of the wind in currently operational version (25 km)

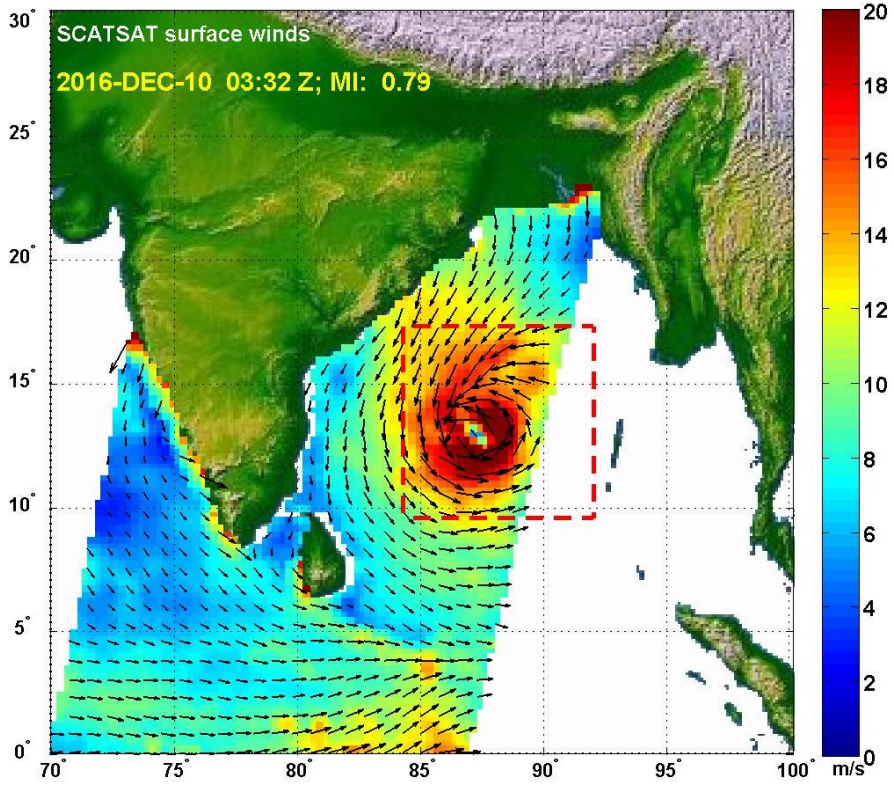


Validation with Buoy

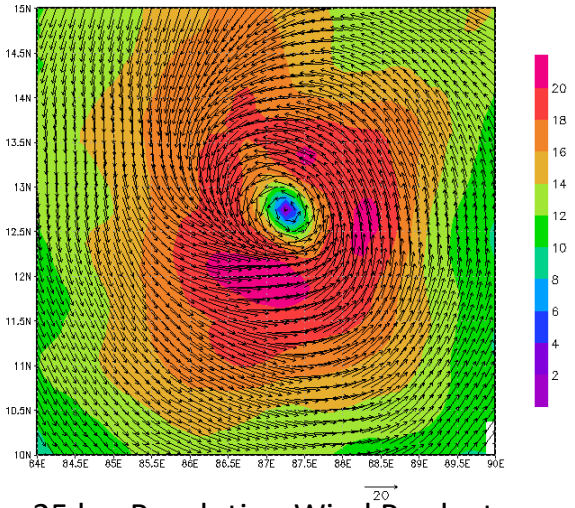
SCATSAT-1 winds Applications

Tropical Cyclone VARDAH

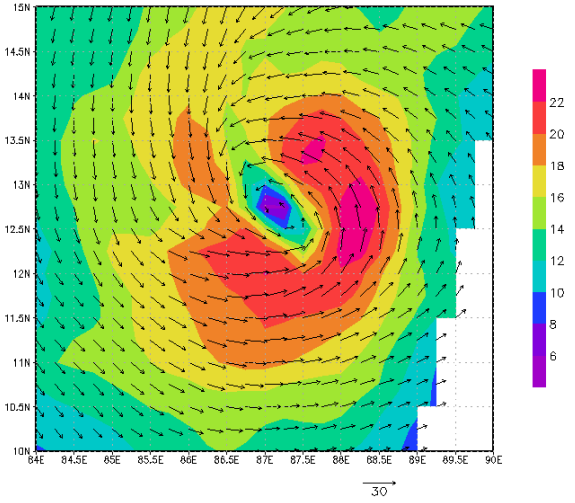
03:30 UTC 10 December, 2016



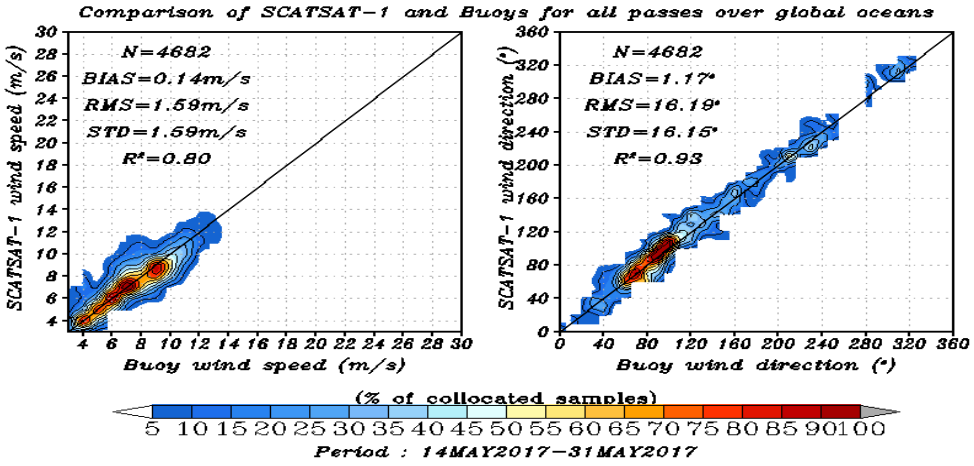
High Resolution Wind Product

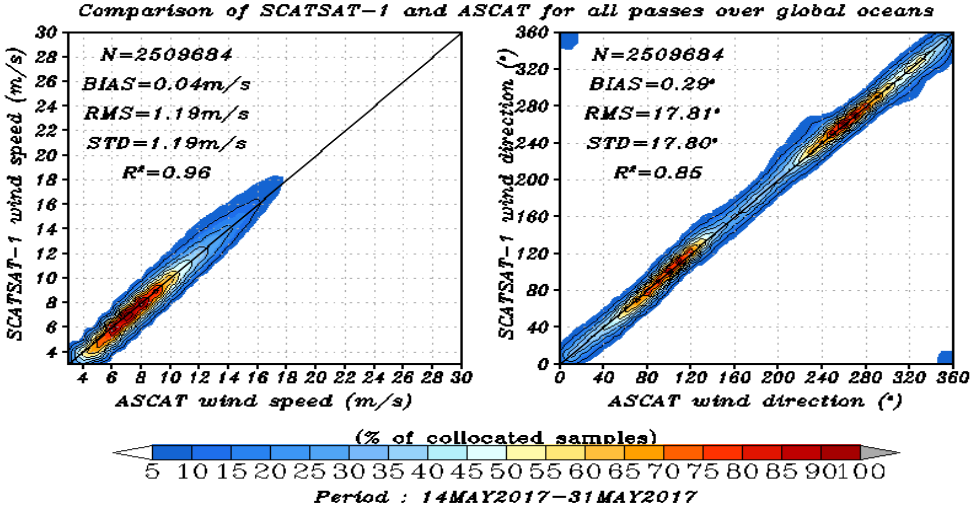


25 km Resolution Wind Product

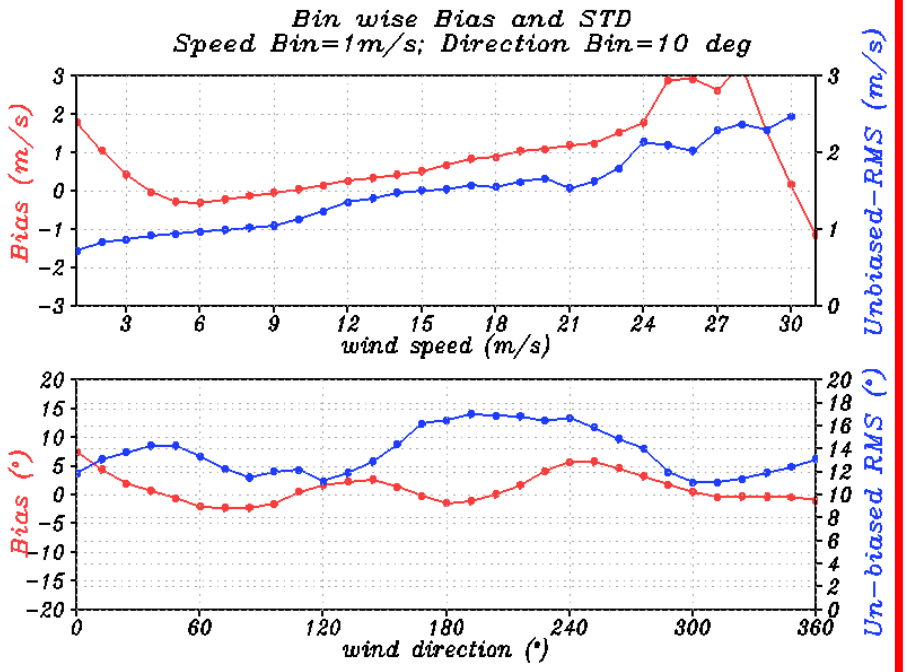


Analysis of special high resolution products of SCATSAT-1 (HAHB)

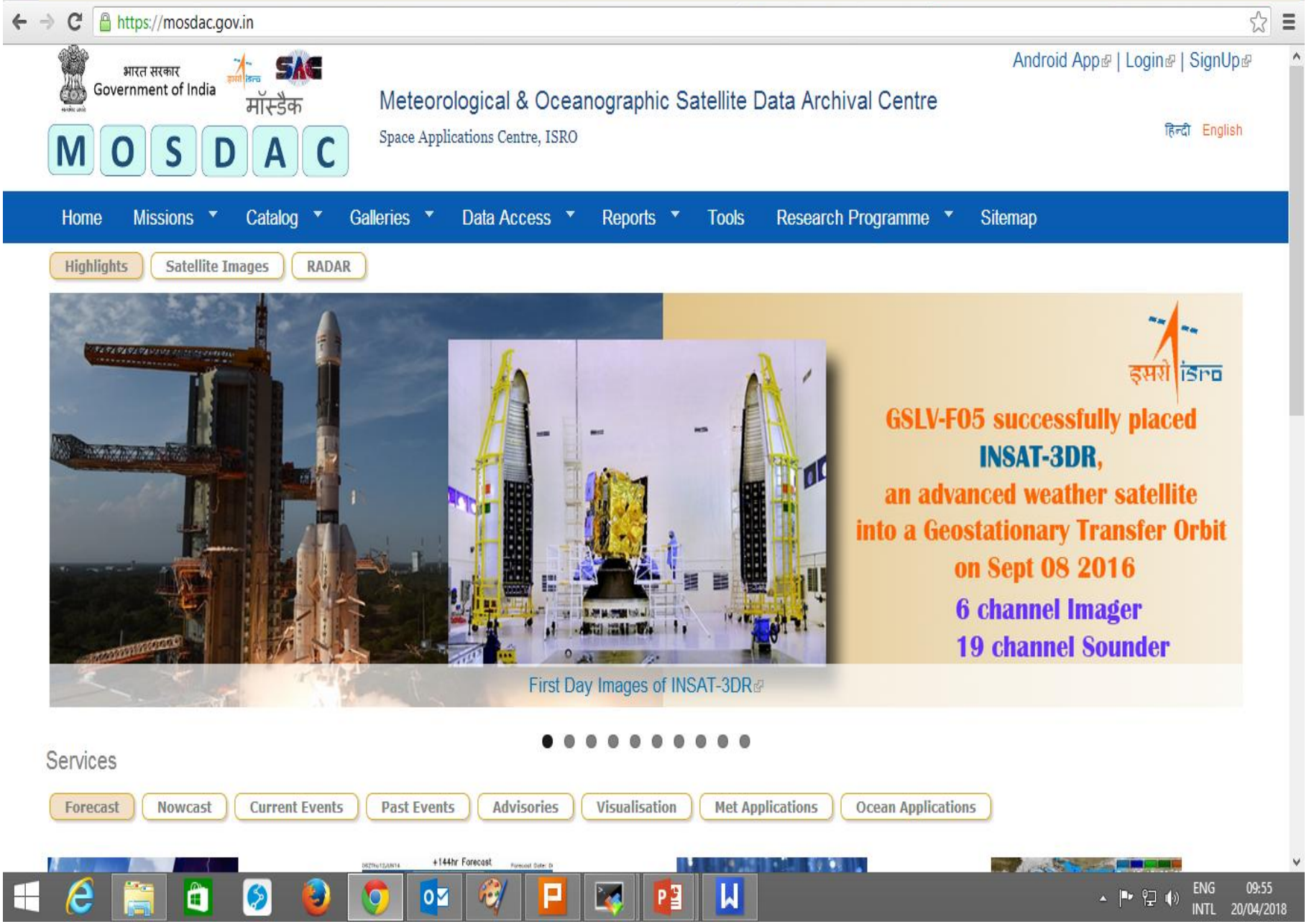




HAHB



ISRO's Meteorological and Oceanographic Data Archival Centre (www.mosdac.gov.in)



Concluding remarks:

AMV retrieval algorithm for INSAT-3D and INSAT-3DR is operational at SAC and accuracy for both the satellites are comparable.

The demonstration of algorithm for the derivation of AMV using the imager data from INSAT-3D and INSAT-3DR in staggering mode at higher temporal sampling has been done.

The average percentage improvement in the winds retrieved using infrared imager data from INSAT-3D and INSAT-3DR in staggering mode is 4-5% in the mid and low-levels when compared with radiosonde for individual INSAT-3D and INSAT-3DR winds.

The availability of staggering mode AMVs at every 15 minute interval operationally has enhanced the quality of wind information, which eventually leads the forecast improvement over the Indian Ocean region.

ACKNOWLEDGEMENT: IWWG Co-Chairs , WMO
ISRO Chairman, Director SAC