<ISRO>
Report on Cal/Val Activities

Arundhati Misra

ISRO

Agenda Item #

WGCV # 44,

EUMETSAT,DARMSDAT,GERMANY

28-31August, 2018

6. Agency updates

- **Agency reporting**
- **ISRO – Dr. Arundhati Misra**
- **Updates on the Calibration and Validation activities in ISRO**
  - **TOPICS**
    - **SAR / MW**
    - **AVIRIS-NG**
    - **Insat 3D**

Work Done in MW Calibration

- Design, development of perforated detachable Corner Reflector of 2m and testing using L band HH airborne data of SAC
- Study of Amrapur site in Gujarat as potential SAR calibration site (February 2018, Sentinel-1 image)
- Study of the response of SAC developed Active Radar Calibrator and comparison with CR Responses from Sentinel-1 VV Polarization (19th July 2018, Sentinel-1 image)
- Development of cal - val network for SAR calibration, across India

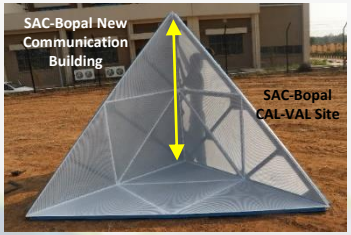
MOU between SAC and institutes are being done, and CR deployment, and cal experiments are being conducted.

- Design and development of CR for the deployment in Antarctica.

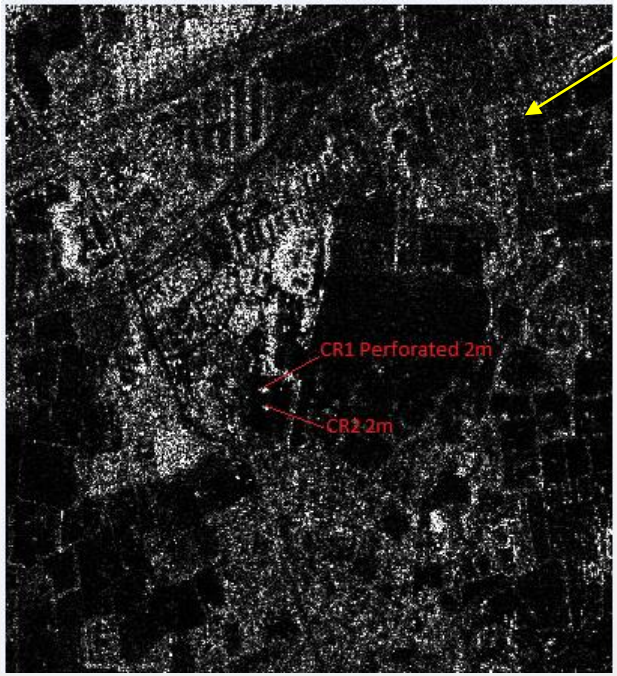
Design, development and testing of Calibration targets

Detachable Panels

Assembled 2m Perforated CR



Perpendicularity Check



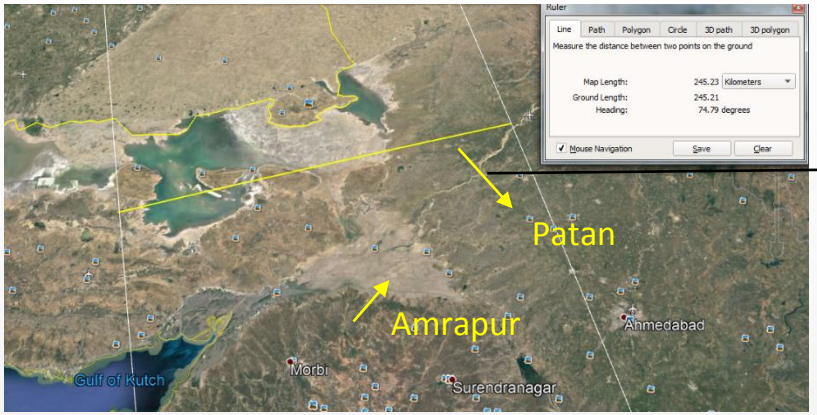
Response of perforated CR in L-band airborne image of 14th February 2018

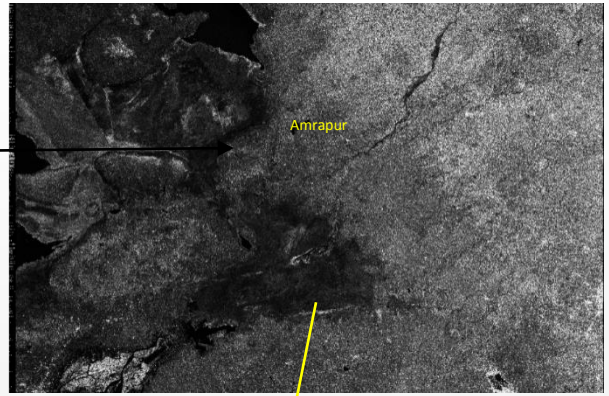
Deployed Perforated CR

		Date-14-Feb-18		
		L Band-SLC		
CR No.	CR Type	Polarisation	Cal. Constant (in dB)	SCR(in dB)
CR1	TTCR (2mPerf.)	HH	46.883	42.0869
CR2	TTCR (2m)	HH	47.39	42.901
CR1	TTCR (2mPerf.)	VV	49.154	41.99
CR2	TTCR (2m)	VV	48.33	44.35

- Development of perforated detachable CR of 2m

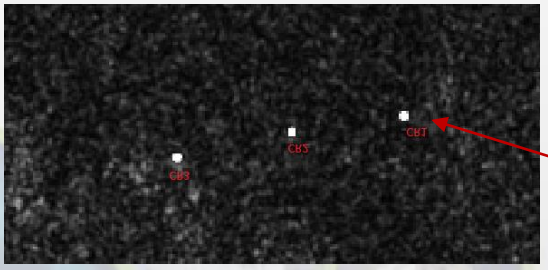
Study of Amrapur site in Gujarat as potential SAR calibration site

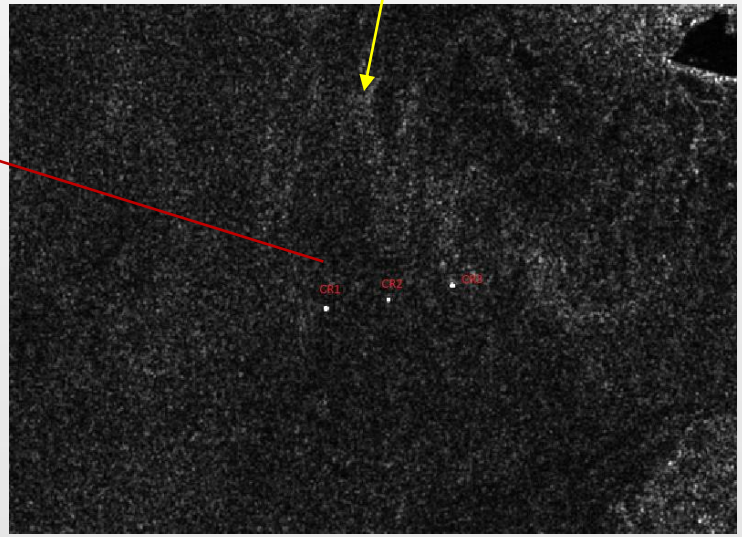




Sentinel-1 image of Amrapur site (6th February 2018)

Amrapur site as seen in Google Earth image

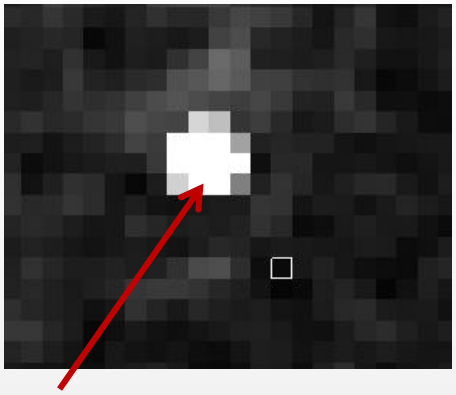




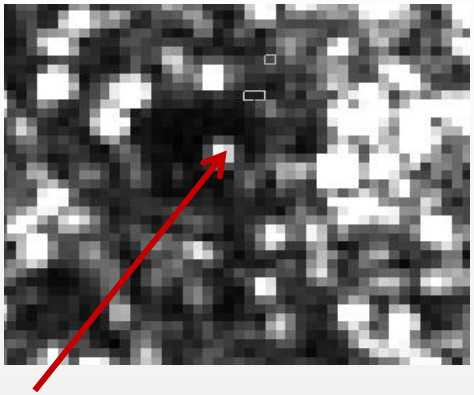
Ground Photo Amrapur

		Date:6-Feb-18			
		Site : Amrapur			
CR. No.	CR Type	Polarisation	Calc. RCS (in dB)	Theor. RCS (in dB)	Diff.(in dB)
1	TT(0.9m)	VV	29.10	29.51	0.41
2	TT(0.9m)	VV	26.75	29.51	2.76
3	TT(0.9m)	VV	28.74	29.51	0.77

Study of the response of SAC developed Active Radar Calibrator and comparison with CR Responses with Sentinel-1 VV Polarization

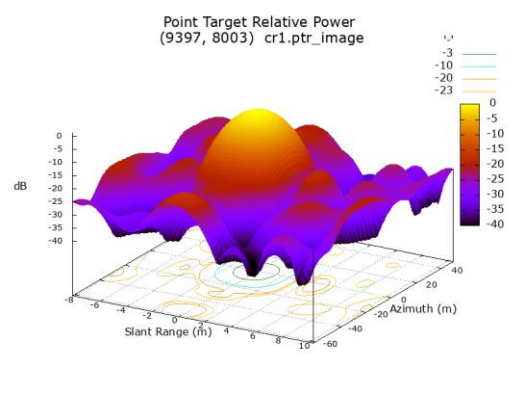


Response of CR as seen in Sentinel-1 GRD image (6th Feb 2018) Amrapur



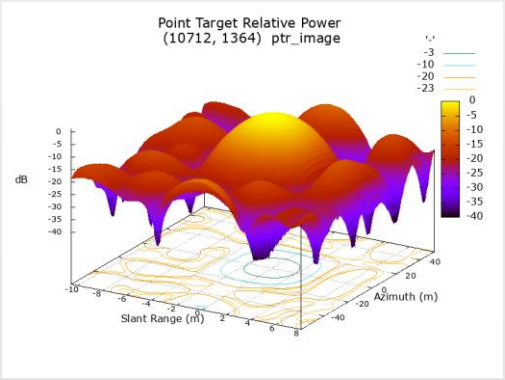
Response of ARC as seen in Sentinel-1 GRD image (19th July 2018) SRC ground

CR



Impulse Response Function

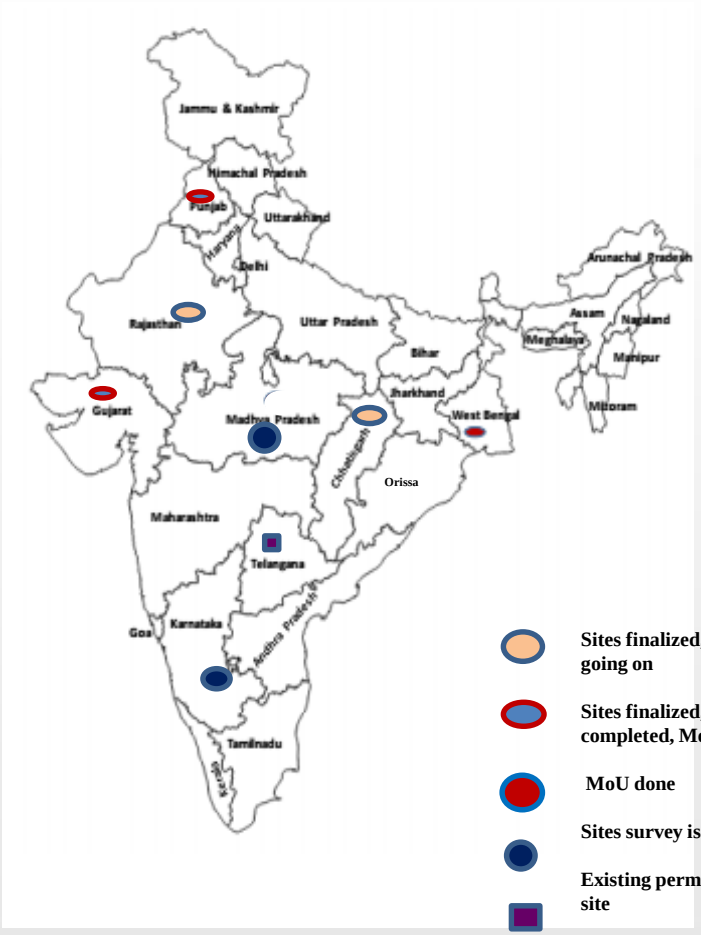
ARC



Development of CAL VAL NETWORK

Indian Sites

- It is planned to permanently deploy different types and sizes of corner reflectors at additional sites (educational institutes, regional remote sensing centres) in each state of India to cover all the beams of S-band.
- In the first phase, permanent deployment of CRs in six Indian states (Gujarat, West Bengal, Rajasthan, Chhatisgarh, Karnataka and Madhya Pradesh) has been initiated. MOU has been signed with most institutes.
- For L-band beams, campaign modes will be carried out in various Indian sites in joint-mode with S-band for the external calibration.



International Sites

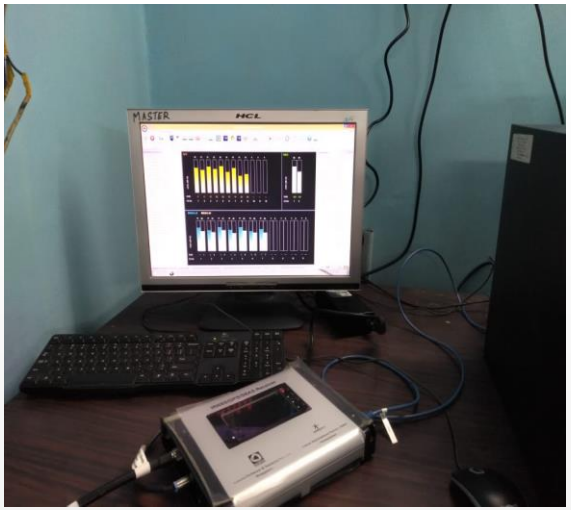
- It is planned to develop point target site at Antarctica (near Indian stations at Bharti and Maitri).

NAVIC Installation


NaVIC antenna
Mining, IITKGP


NaVIC antenna
KCSTC, IITKGP


NaVIC antenna, JU




NaVIC installation team at JU

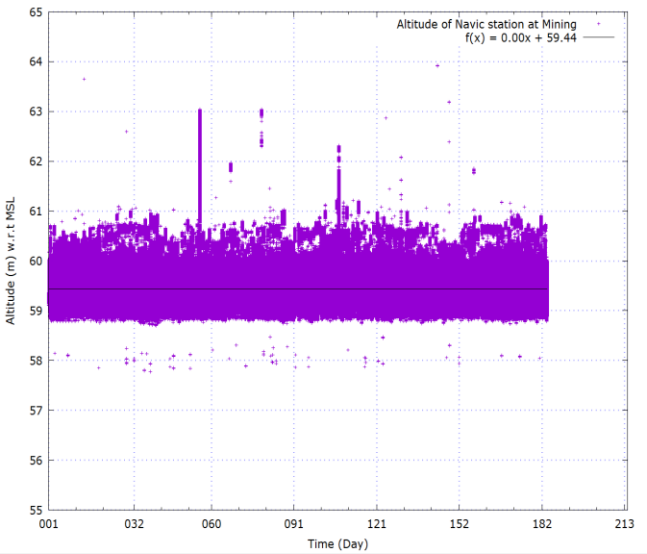

NaVIC proposed site
at IITKgp Kolkata
guest house

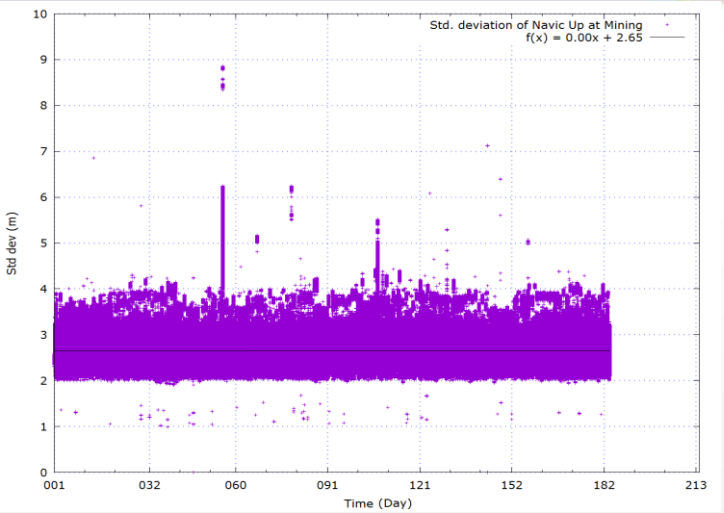

NaVIC proposed site
at TDG college,
Raniganj

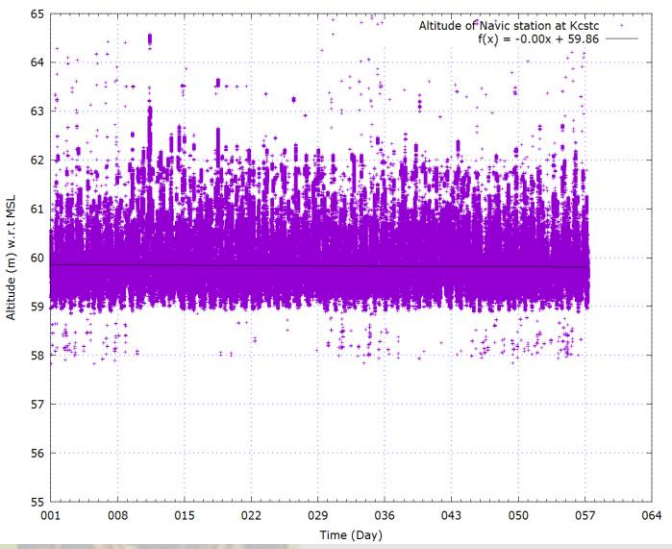
NAVIC Installation

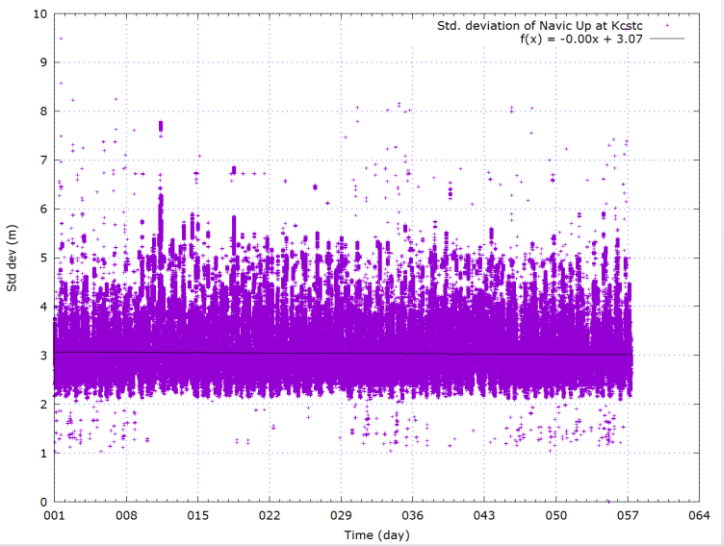
NaVIC installation team at JU

MSL height & its standard deviation plot of NAVIC at Mining Department & KCSCT, IITKGP

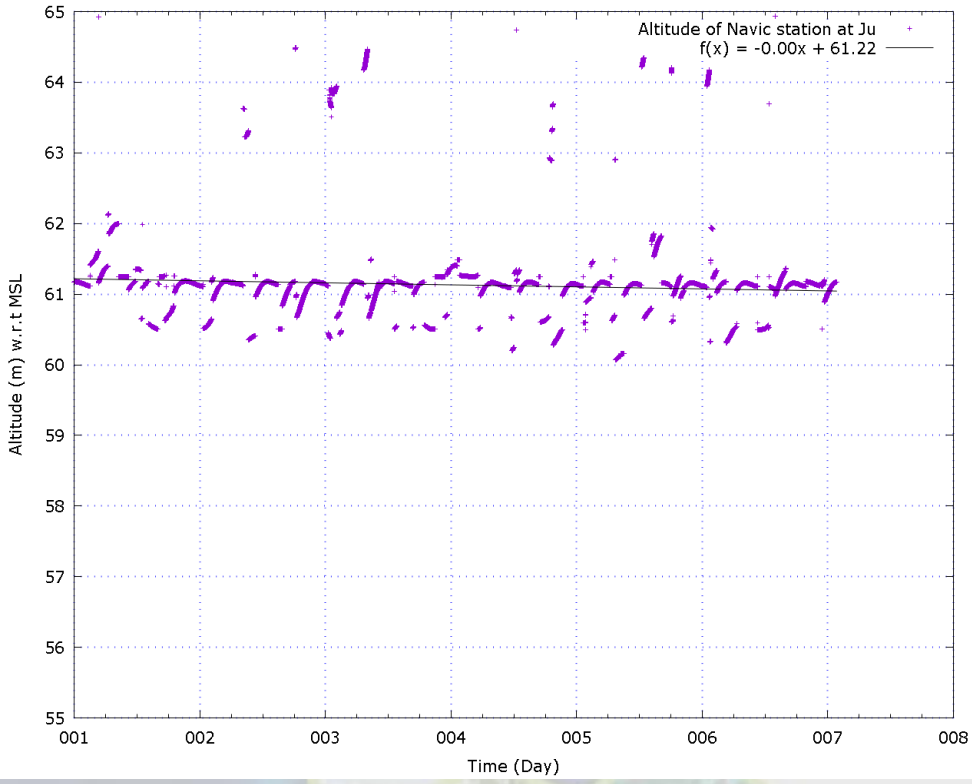


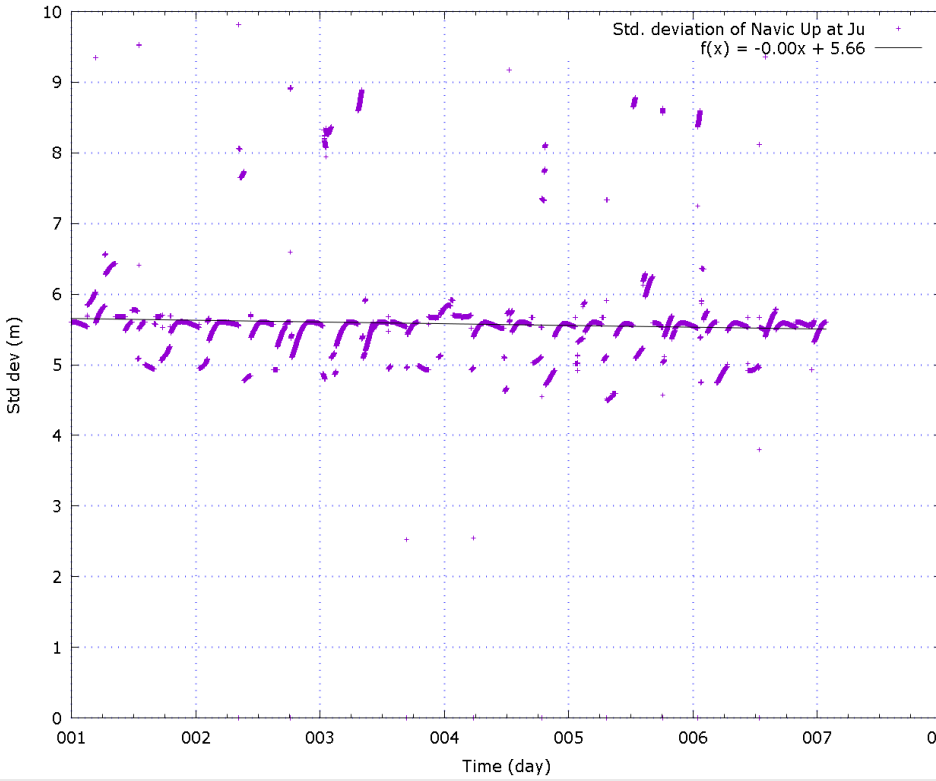






MSL height & its standard deviation plot of NAVIC at Jadavpur University





Analysis of NAVIC data from the stations

NAVIC Station name	MSL height (m)	Std-dev of height (m)	Std-dev of North (m)	Std-dev of East (m)
Mining Dept.	59.44	2.65	1.27	1.01
KCSTC	59.86	3.07	1.38	1.09
JU	61.22	5.66	1.75	3.88

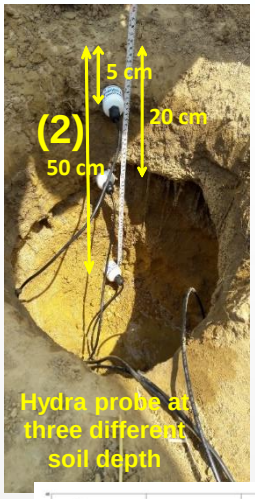
Hydra probe station installation in Agricultural Farm, IIT Kharagpur

- **Installation of Automated Hydra probe station at Agricultural Farm in IIT Kharagpur campus on 5th April, 2018**

Selected Site for Hydra Probe station at Agricultural Farm (IIT KGP)

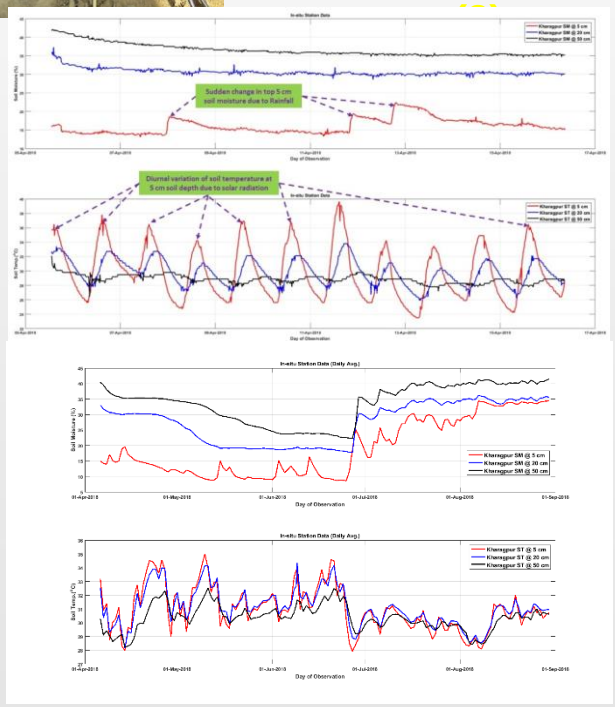
IIT Kharagpur and SAC team with operational fully installed Hydra probe station

- **Soil moisture, soil temperature and electrical conductivity at 5, 20 and 50 cm soil depth (at 15 min interval) are measured simultaneously and disseminated to IIT KGP and SAC email server through GSM services.**
- **Top plot shows temporal dynamics of Soil Moisture (SM) at 5 cm, 20 cm and 50 cm soil depth and bottom plot shows the Soil Temperature (ST) at 5 cm, 20 cm and 50 cm soil depth from hydra station at IIT Kharagpur campus.**



Hydra probe at three different soil depth

Fully installed Hydra probe at testing and data verification phase



Hydra probe station installation in Jaisalmer

- **Installation of Automated Hydra probe station at Chandan experimental farm of Central Arid Zone Research Institute on 27th June, 2018.**

(1)

Site preparation for Hydra Probe station installation at Chandan Farm (CAZRI, Jaisalmer)

(2)

(3)

Field view of grassland at Site

- **Soil moisture, soil temperature and electrical conductivity at 5, 20 and 50 cm soil depth (at 15 min interval) are measured simultaneously and disseminated to SAC email server through GSM services.**

(4)

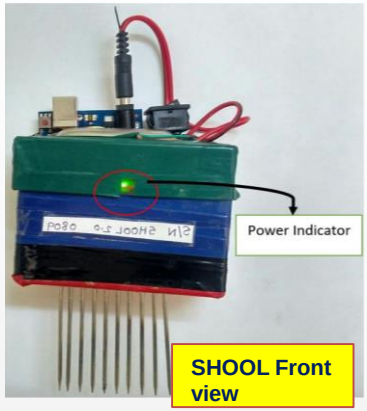
Fully installed Hydra probe at testing and data verification phase

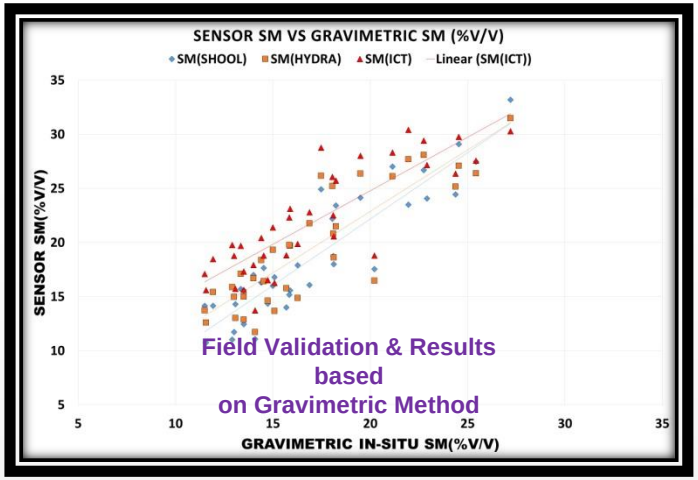
Design and Development of In-situ soil sensor for validation of satellite derived soil moisture products by SAC-ISRO

SAC In-house developed

Salient features and Functionality

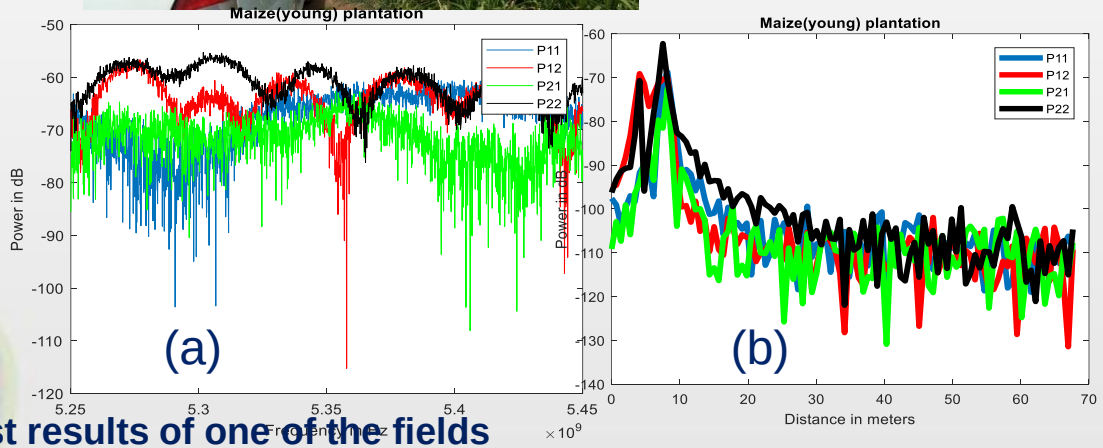
- Directly measure dielectric constant, soil moisture, temperature, EC and salinity.
- In-built DC power; Single charge to last one month.
- Integrated Bluetooth module and Temperature sensor.
- Data logging, viewing and sharing in .CSV format.
- Multi-port capability for data logging (through USB, Laptop etc.)





VNA based Ground-Scatterometer: Design, Development and Tests carried out

- Development aimed at multi-frequency measurements in all four polarization combinations (HH, HV, VV, VH) using handheld 1-14GHz VNA
- Proof-of-concept tests carried out with C-band antennas; to be extended for other bands
- For other bands, only antennas have to be changed
- Calibration exercises carried out using corner reflector
- Evolved into vehicle-mounted configuration
- Preliminary backscatter measurements carried out at SAC campus and Anand Agriculture University, Gujarat
- Obtained encouraging results



Test results of one of the fields
(a) Frequency domain response in all four polarizations
(b) Corresponding time domain response; the peak value is used to derive sigma-naught

GPR test site developed

GPR test site (5m x 5m x 2m depth) developed at New Bopal Cal /Val site, SAC

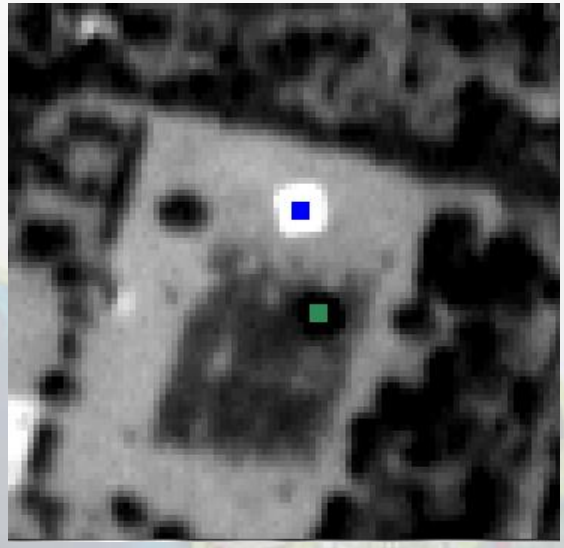
- Two layers (each 1m depth) with soils of different dielectric constants
- Pipes of varying thickness at different depths used
- GPR Measurements carried out.

GPR experiments carried out using 400MHz and 100MHz instruments

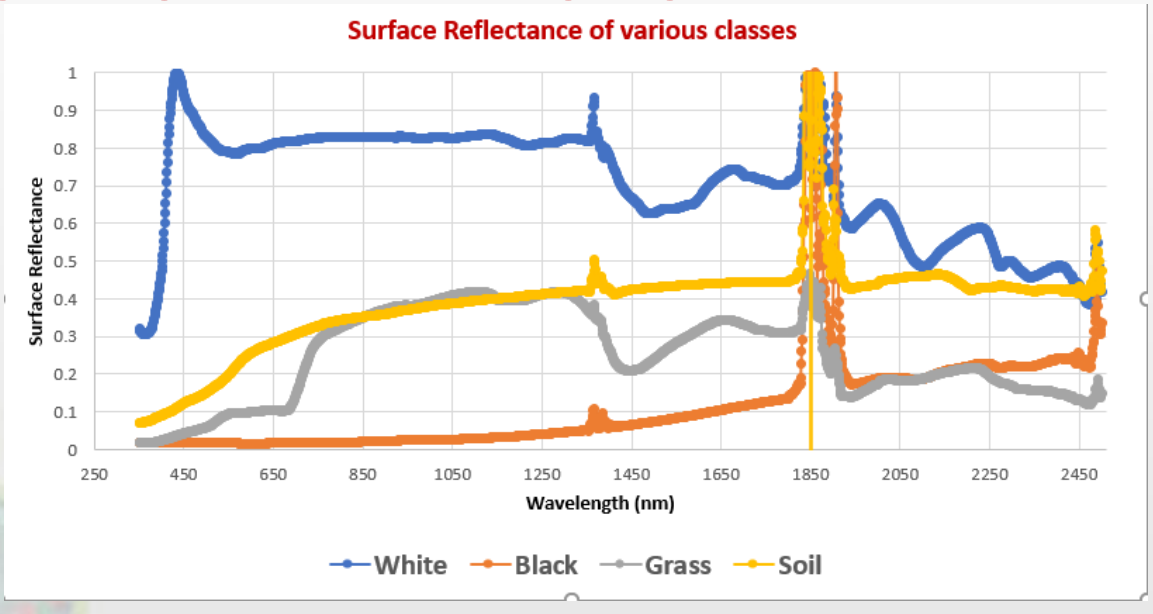
AVIRIS Cal/Val Campaign

- **Field data collection of surface reflectance and atmospheric parameters synchronous to AVIRIS-NG airborne campaign at Jodhpur on 31 March 2018 and Cartosat-1 image on 24th March 2018 for optical data calibration.**

➢ **Artificial targets were used (black and white cloth of 15m * 15m) to cover the dynamic range along with natural targets grass and soil.**



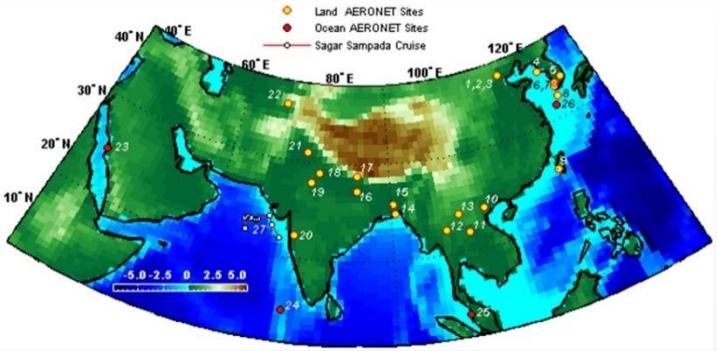
Response and area of interest of artificial targets (black and white cloth) on Cartosat-1 image of 24th March 2018



Field collected surface reflectance of various classes

Name of Activity	INSAT-3D Aerosol Optical Depth Algorithm:
1. Major Objective	Uncertainty and Validation
Study site	Indian Subcontinent and Adjoining Ocean
Data used	• INSAT-3D L1 visible channel radiance data (for AOD product). • AERONET in-situ data at around 26 sites and at 1 Sagar Sampada cruise. • >3800 and >800 in-situ data points corresponding to land and oceanic sites, respectively, have been used in this study, for validation, uncertainty and diurnal variation. • MODIS AOD product for 2013 to 2015 for generating climatology of background aerosol. • MODIS AOD for 2016 for inter-sensor AOD comparison. • Radiative transfer simulations, typical atmospheric, aerosol and surface conditions for theoretical uncertainty study.
Approach	Newly developed advanced clear composite algorithm (*see Mishra et al., 2018, JGR, 123(10), 5484*)
Output	• INSAT-3D AOD, a AOD retrieval algorithm is developed for the use of INSAT-3D visible band data. • Theoretical uncertainty study shows retrieval uncertainty of <45% over land and <30% over ocean. • Validation with AERONET covering >3500 data points show uncertainty within theoretical limit. • Diurnal variability of INSAT-3D and AERONET AOD in India and south-east Asia is presented. • Comparison with MODIS-aqua aerosol product show good agreement. • INSAT-AOD is operationally available at every 30-minute during daytime to the user community.
Other information	Large uncertainty of INSAT-3D AOD over land is due to the presence of only one single visible channel which limits us to use only one fixed aerosol model. Multi-spectral sensor with high SNR, narrow bandwidth and additional SWIR channels are required for faithful AOD retrieval.

1. Aerosol optical depth (AOD) from INSAT-3D



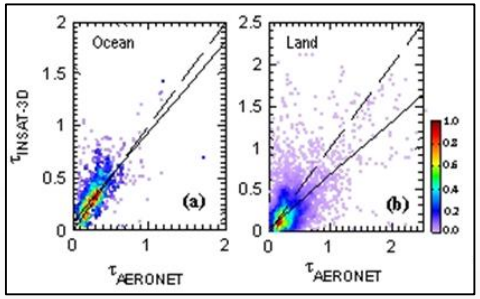


Figure. (a) and **(b)** Scatter plot of INSAT-3D & AERONET AOD over 5 ocean and 22 land sites, respectively. For land, the linear regression is $\tau_{INSAT\text{-}3D} = 0.61\tau_{AERONET} + 0.07$ ($r = 0.69, \sigma_\tau = 0.15$), while for ocean the linear regression is $\tau_{INSAT\text{-}3D} = 0.87\tau_{AERONET} + 0.08$ ($r = 0.77, \sigma_\tau =$) .

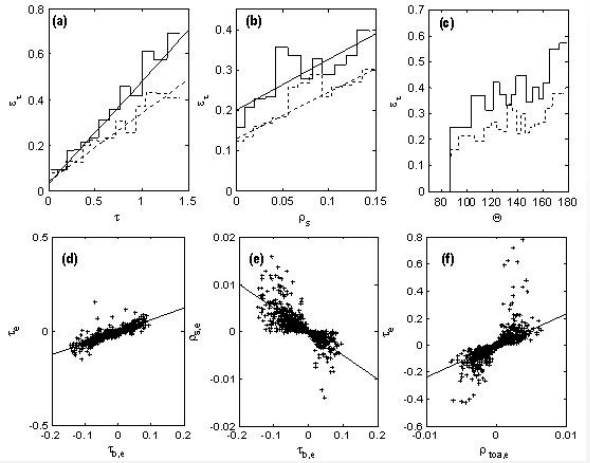


Figure. Results of uncertainty study.

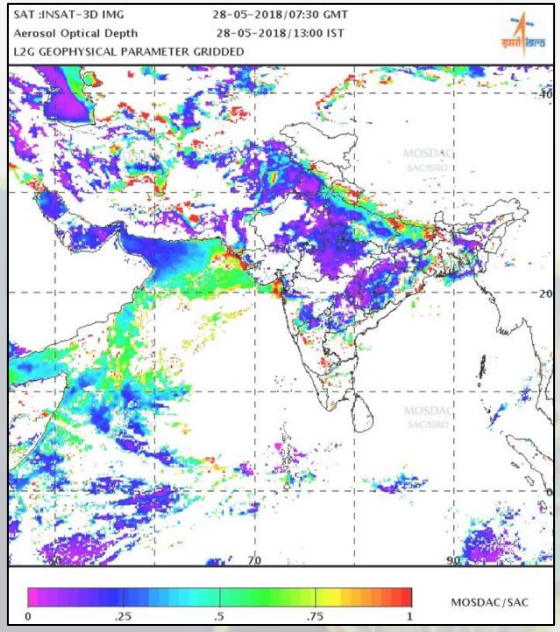


Figure. Operational INSAT-3D AOD product from MOSDAC/SAC, ISRO.

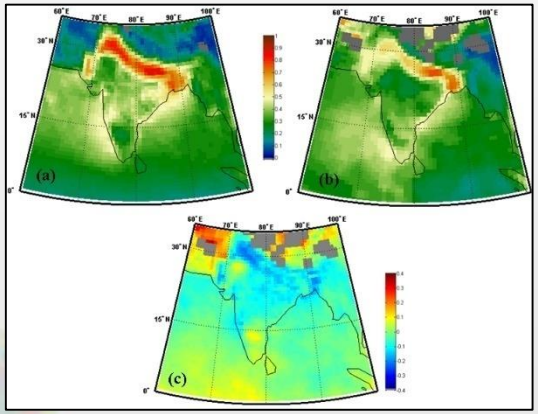
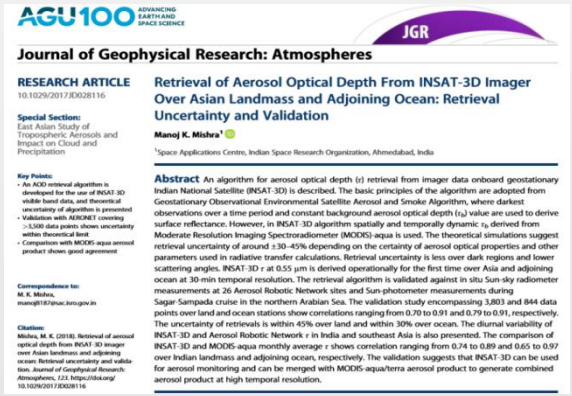


Figure. (a–c) Annual average map of MODIS-aqua AOD,INSAT-3D AOD, and the difference (INSAT3D AOD - MODIS AOD), respectively, over Indian landmass and adjoining ocean for year 2016. MODIS = Moderate Resolution Imaging Spectro-radiometer;; INSAT-3D = Indian National Satellite.



AGU100 ADVANCING EARTH AND SPACE SCIENCE

JGR

Journal of Geophysical Research: Atmospheres

RESEARCH ARTICLE

10.1029/2017JD028116

Special Section: East Asian Study of Tropospheric Aerosols and Impact on Cloud and Precipitation

Retrieval of Aerosol Optical Depth From INSAT-3D Imager Over Asian Landmass and Adjoining Ocean: Retrieval Uncertainty and Validation

Manoj K. Mishra[1]

[1]Space Applications Centre, Indian Space Research Organization, Ahmedabad, India

Key Points:
- An AOD retrieval algorithm is developed for the use of INSAT-3D visible band data, and theoretical uncertainty of algorithm is presented
- Validation with AERONET covering >3,500 data points shows uncertainty within theoretical limit
- Comparison with MODIS-aqua aerosol product shows good agreement

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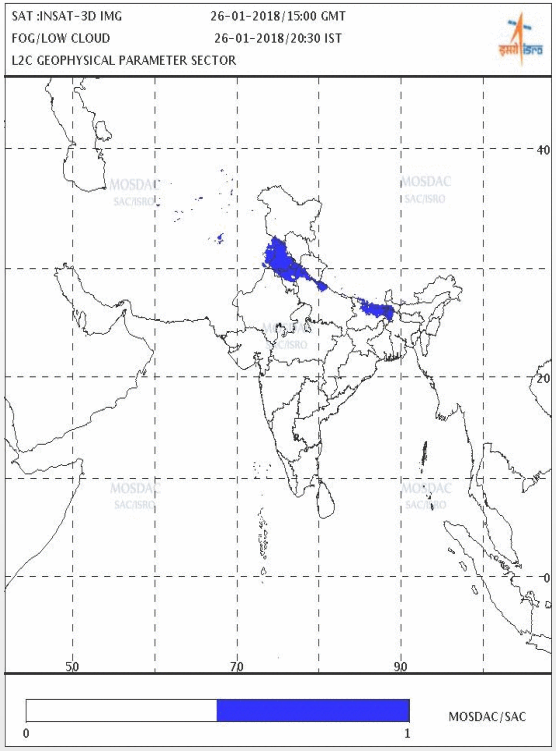
Citation:
Mishra, M. K. (2018). Retrieval of aerosol optical depth from INSAT-3D imager over Asian landmass and adjoining ocean: Retrieval uncertainty and validation. *Journal of Geophysical Research: Atmospheres, 123*. https://doi.org/10.1029/2017JD028116

Abstract An algorithm for aerosol optical depth (τ) retrieval from imager data onboard geostationary Indian National Satellite (INSAT-3D) is described. The basic principles of the algorithm are adopted from Geostationary Observational Environmental Satellite Aerosol and Smoke Algorithm, where darkest observations over a time period and constant background aerosol optical depth (τ_0) value are used to derive surface reflectance. However, in INSAT-3D algorithm spatially and temporally dynamic τ_0 derived from Moderate Resolution Imaging Spectroradiometer (MODIS)-aqua is used. The theoretical simulations suggest retrieval uncertainty of around ±30–45% depending on the certainty of aerosol optical properties and other parameters used in radiative transfer calculations. Retrieval uncertainty is less over dark regions and lower scattering angles. INSAT-3D τ at 0.55 μm is derived operationally for the first time over Asia and adjoining ocean at 30-min temporal resolution. The retrieval algorithm is validated against in situ Sun-sky radiometer measurements at 26 Aerosol Robotic Network sites and Sun-photometer measurements during Sagar-Sampada cruise in the northern Arabian Sea. The validation study encompassing 3,803 and 844 data points over land and ocean stations show correlations ranging from 0.70 to 0.91 and 0.79 to 0.91, respectively. The uncertainty of retrievals is within 45% over land and within 30% over ocean. The diurnal variability of INSAT-3D and Aerosol Robotic Network τ in India and southeast Asia is also presented. The comparison of INSAT-3D and MODIS-aqua monthly average τ shows correlation ranging from 0.74 to 0.89 and 0.65 to 0.97 over Indian landmass and adjoining ocean, respectively. The validation suggests that INSAT-3D can be used for aerosol monitoring and can be merged with MODIS-aqua/terra aerosol product to generate combined aerosol product at high temporal resolution.

Fog Product using INSAT 3D/3DR and its validation

- Fog product using INSAT-3D/3DR is generated since November 2014
- Operationally available at www.mosdac.gov.in and www.imd.gov.in
- Validation is regularly being carried out with visibility data at 5 Airports located in the Indo-Gangetic Plains.
- For all the years the percentage of detection (POD) ranges between 60-70%.
- Being visible and IR imager, is not able to detect fog beneath high cloud.
- Widely being used by aviation sector, railways and road transport services.



Temporal and spatial variation of Fog


THANK YOU