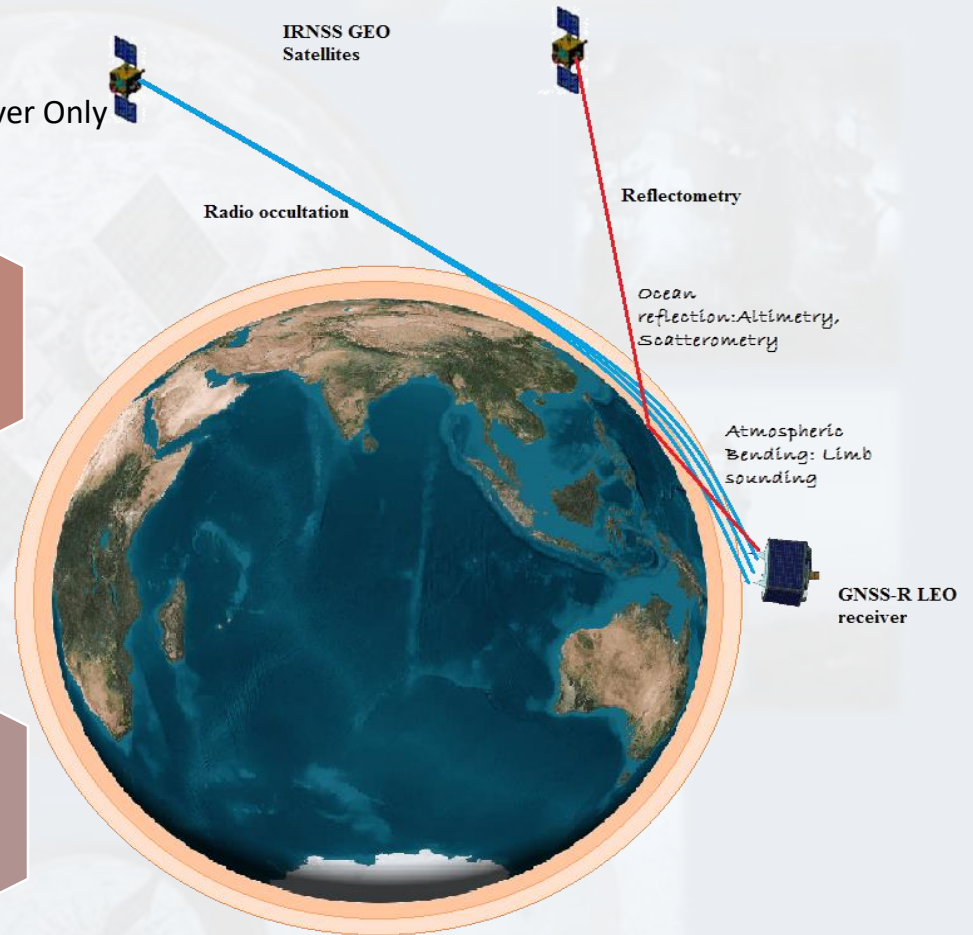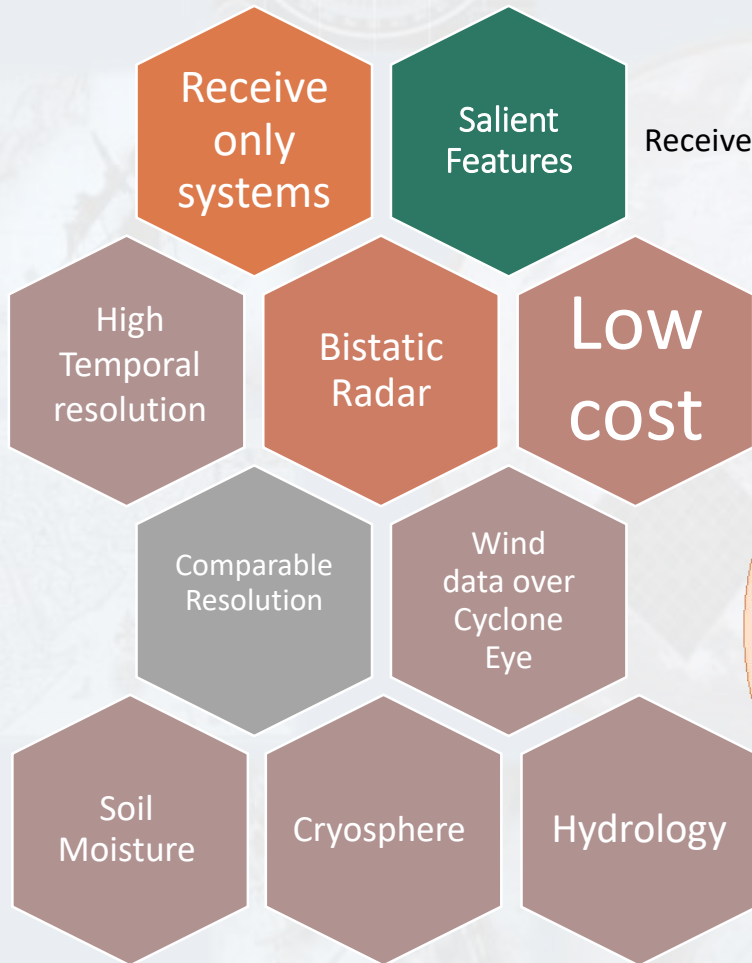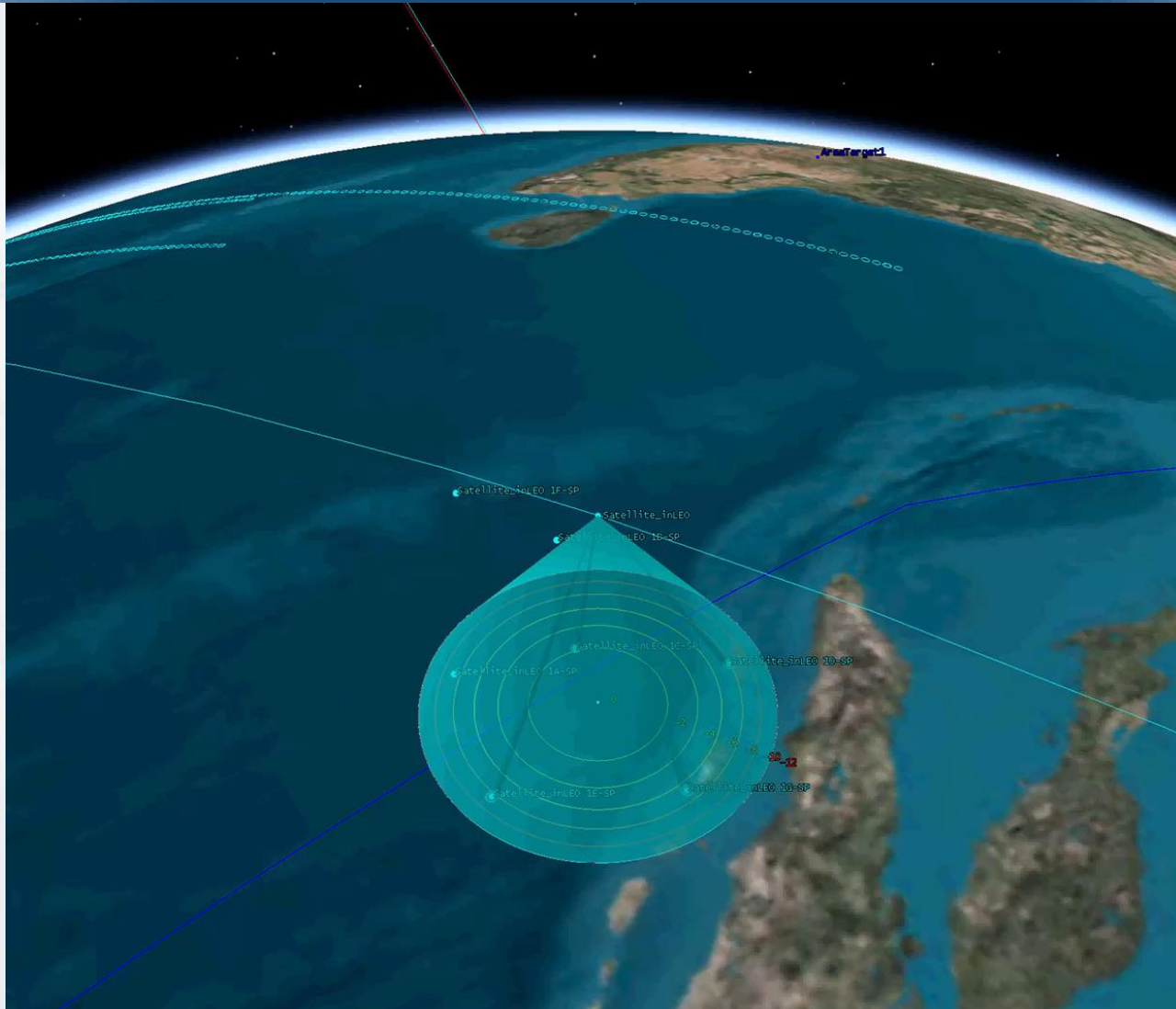# GNSS Reflectometry systems with NavIC

Ananya Ray
Space Applications Centre/ISRO

- Brief of GNSS-Reflectometry
- Need for GNSS-Reflectometry for Remote sensing
- Unique opportunities in remote sensing with NavIC signals
- Ground based GNSS- reflectometry Systems
- Space based GNSS-Reflectometry Systems
- Application Aims
- Constellation of GNSS-Reflectometry Systems

Receive only systems

Salient Features

High Temporal resolution

Bistatic Radar

Low cost

Comparable Resolution

Wind data over Cyclone Eye

Soil Moisture

Cryosphere

Hydrology

Receiver Only

IRNSS GEO Satellites

Reflectometry

Radio occultation

Ocean reflection:Altimetry, Scatterometry

Atmospheric Bending: Limb sounding

GNSS-R LEO receiver

Concept of data acquisition

Why do we need GNSS-Reflectometry

More data — Better monitoring and prediction

Constellation — High temporal resolution

Less Rain Attenuation — Data availability in heavy rain

High contrast signals in Land/Water boundaries — High resolution inland water body detection/ flood inundation map generation

L band penetrates Dry ICE or soil — Can be used for Ice layer detection and change monitoring over Polar regions

Unique opportunities in remote sensing with NavIC signals

| Experiment	Global Configuration	Gaps filling/ new scope	Application advantage
Reflectometry	LHCP receive in L1 Band	LHCP S band (New scope)	Wind detection: Better roughness sensitivity and lesser time to respond to dynamic wind conditions
		LHCP-RHCP dual pol L/S band (gap filling)	Polarization in Dual frequency provides more information on target properties. Differential detection of biomass, soil moisture

Ground Based Reflectometry System

Feature	Specification
Band	L1-GPS (1.57542 GHz +/- 1.25MHz), L5 (1.17645 MHz ± 1.25 MHz) ,S (2.492028 GHz +/- 1.25MHz)
Rx chains	(2 x 3) channels- Reflectometry (2 channels for each frequency) 3 channel- Direct reception PVT
Antenna	Direct- Hemispherical Active RHCP; Down looking- H/V and LHCP/RHCP dual pol; HPBW- 66 deg
NF	<2dB for L1, L5, <2.5 for S band Reflectometry chains
$\Delta\sigma_0$ (NBRCS)	< 0.45dB
Data capture	Data captured at the USB Storage. No user intervention needed. • 5-bit ADC IF data gets saved for Reflectometry and Direct chains • PVT solutions, Temperatures, Satellite info data gets saved from Direct channel
Power	10 W

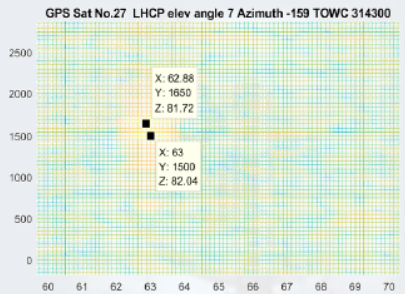**Usage: Soil moisture, Ice layer detection, Crop height trend estimation**
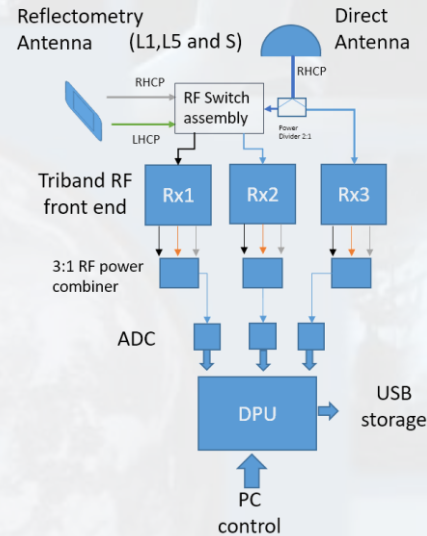
System Blocks for Triband Configuration
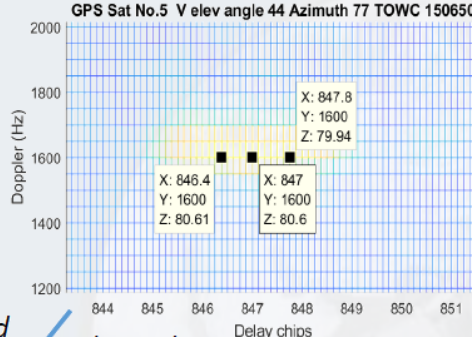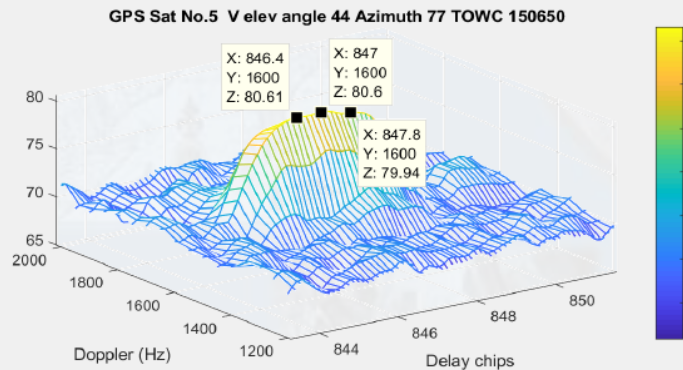
Prototype Single band System
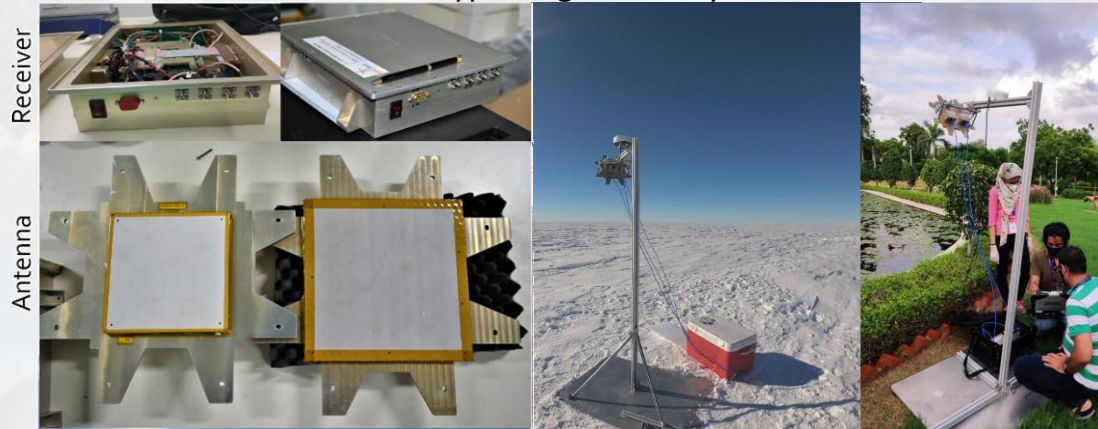
Reflected chain (LV and LHCP) data from multi layer Ice reflection at Antarctica
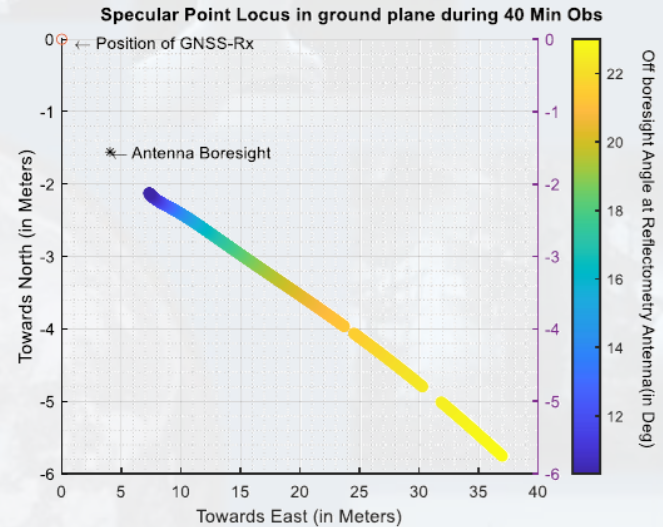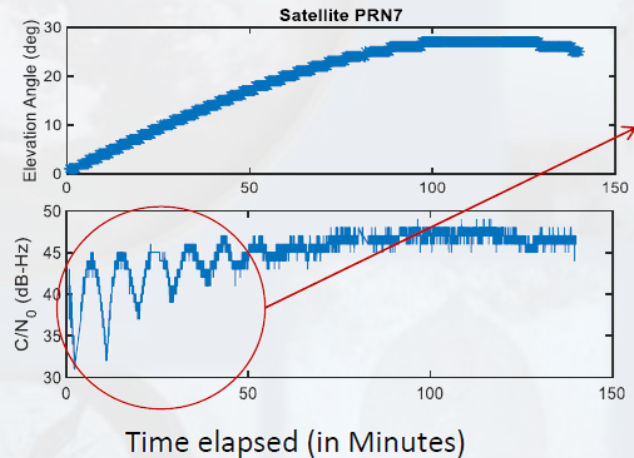
These two points are separated by 36 m (slant range)

These three points are separated by 179 m and 239 m (slant range)
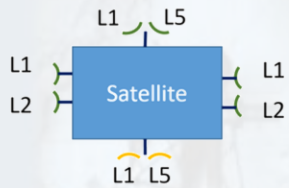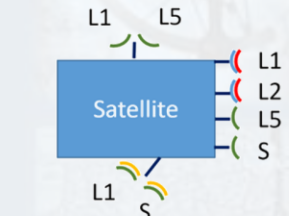
Delay Doppler Maps of Ice Reflected GPS L1 signals

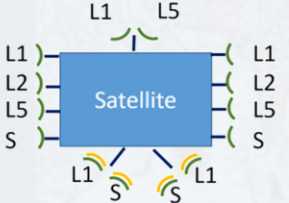Specular Point Locus in ground plane during 40 Min Obs

Direct antenna data from Antarctica

Amplitude of the Interference pattern detected in direct path for Rising GPS satellite is *proportional to the Dielectric coefficient* of the surrounding surface

Space Borne GNSS-Reflectometry

Configuration plan

Sl No	Layout	No of RF channels	No of Digital Channels	Power	Mass	Data Rate
1	L1 L5 / L1 L1 / L2 L2 / L1 L5 (Satellite)	8	POD: 8x2 RO: 6x4 Reflectometry: 4x2	~30 W	~8kg (including antenna)	0.43 Mbps
2	L1 L5 / L1 / L2 / L5 / S / L1 S (Satellite)	12	POD: 8x2 RO: 6x6 Reflectometry: 4x4	~55 W	~10.5 kg (including antenna)	0.73 Mbps
3	L1 L5 / L1 L1 / L2 L2 / L5 L5 / S S / L1 S L1 S (Satellite)	18	POD: 8x2 RO: 6x8 Reflectometry: 4x8	~80 W	~14 kg * (including antenna)	1.17 Mbps

Satellite Velocity → Earth View

) RHCP (H
) LHCP (V

*Assuming use of up-screened COTS component RF

Specification	Reflectometry
Frequency of operation	L5,L1,S
Bandwidth	2 MHz
Targeted (min) Detectable NBRCS (σ_0)	7 dB
Accuracy of σ_0	<0.5 dB
Min C/N_0	NA
Antenna gain	12.1 dBi
Antenna Boresight pointing	36 degree off nadir
Polarization	LHCP/RHCP
3 dB beam width (degrees)	32
Resolution	5km , 25 km, ~1.1 km (over inland water bodies)
ADC sampling	Continuous mode: 5Msps Raw Data mode : 10 Msps

Resolution for Space based platform

Under Incoherent reflection scenario
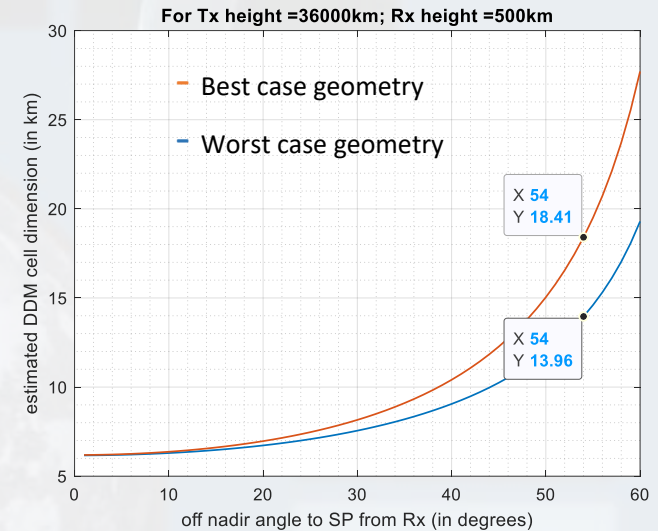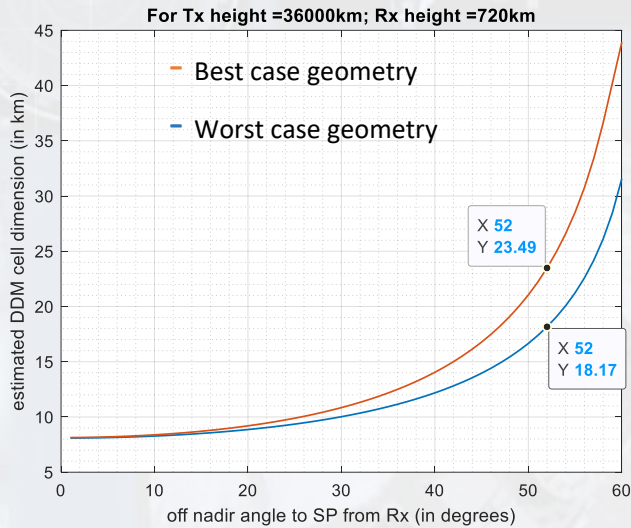
Under Coherent reflection scenario

# Application Aims
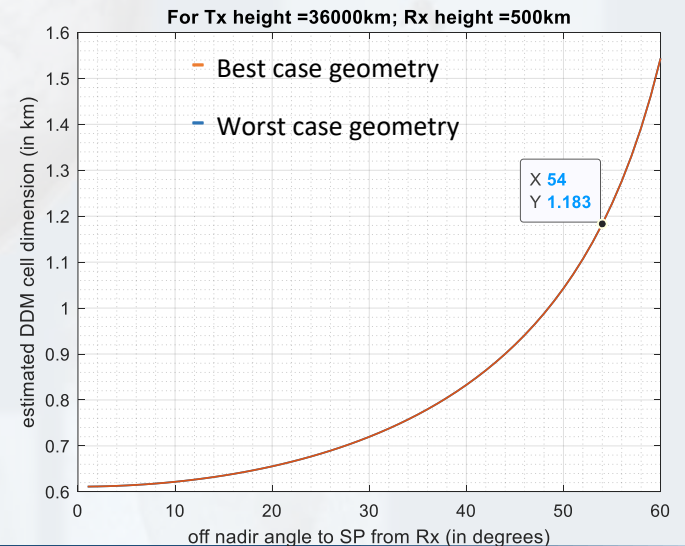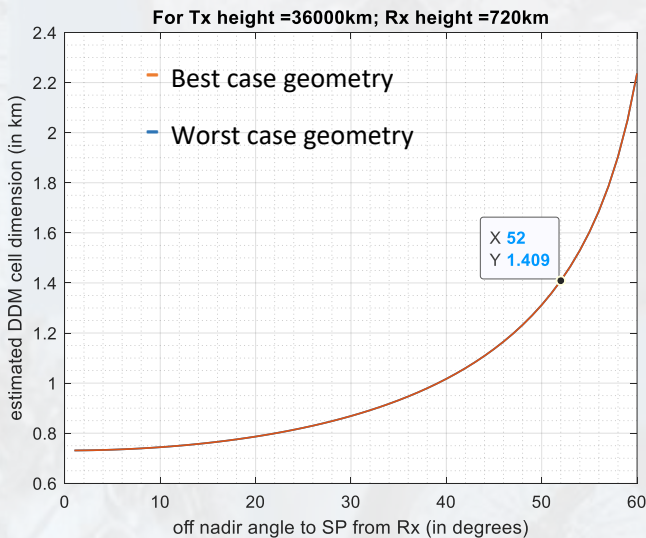
- ## Ocean Winds:
  - 3-35 (50 target) m/s wind speed detection within the accuracy of 2m/Sec or 10% of actual wind speed (whichever is higher)
  - Wind detection till 100 mm/hr (typical) rainfall (can go up to 150mm/hr)
  - Continuous On-board processing resolution: 25 km x 25 km
  - Tropical cyclone intersection mode (Raw data mode) resolution: 5 km x 5 km

- ## Land reflections:
  - Measurement up to -30 dB reflection coefficient in LHCP polarisation.
  - Resolution targeted up to 0.7 km over inland water bodies
  - Soil moisture, flood inundation, inland waterbody detection.

- ## Cryosphere:
  - Measurement up to -30dB reflection coefficient in LHCP polarisation.
  - Sea ice, dry ice detection and monitoring

Constellation and coverage using NavIC
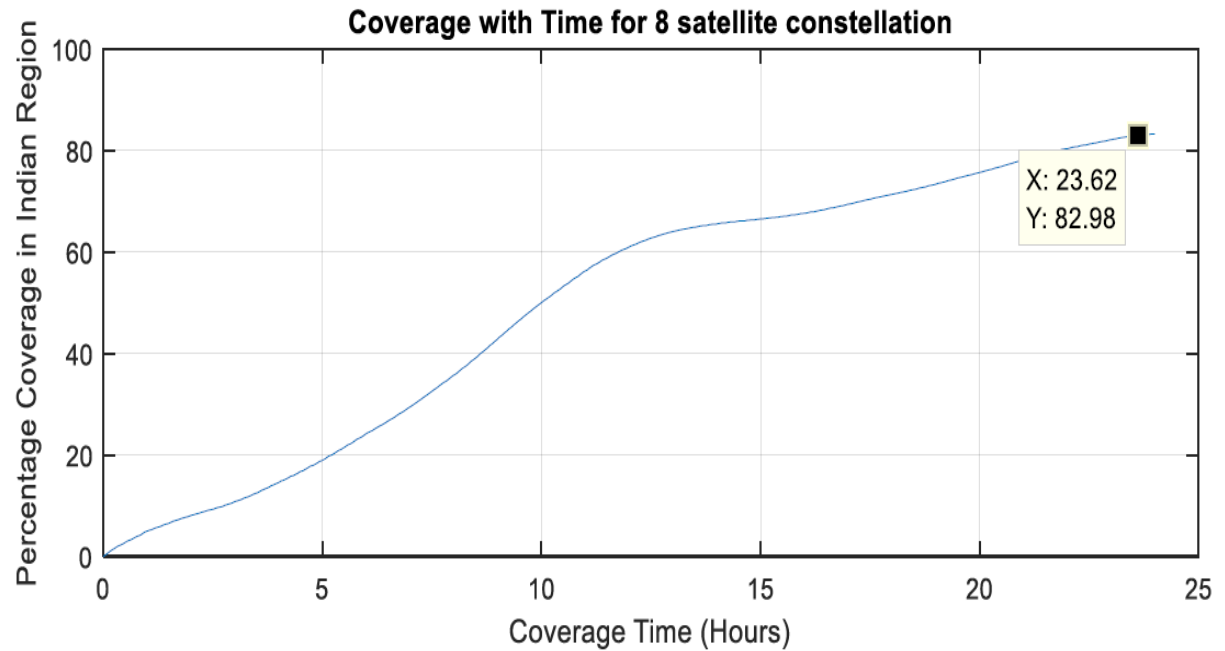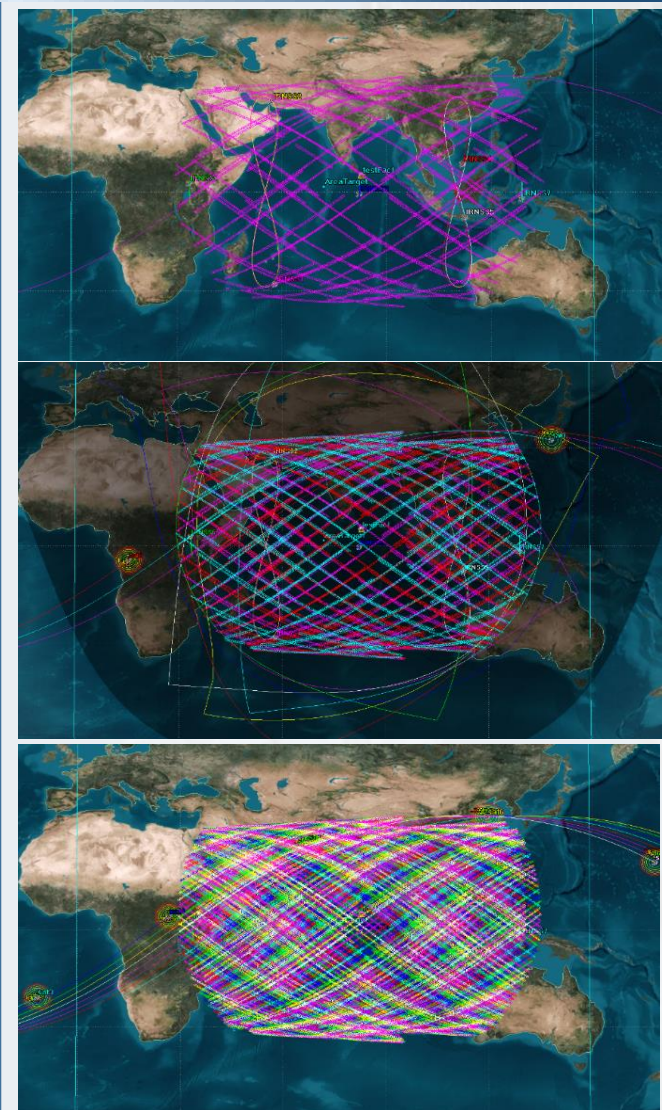
Footprint of valid specular point tracking for a single day: a) using 1 LEO reflectometry receiver b) using 3 LEO reflectometry Receiver c) using 8 LEO receivers
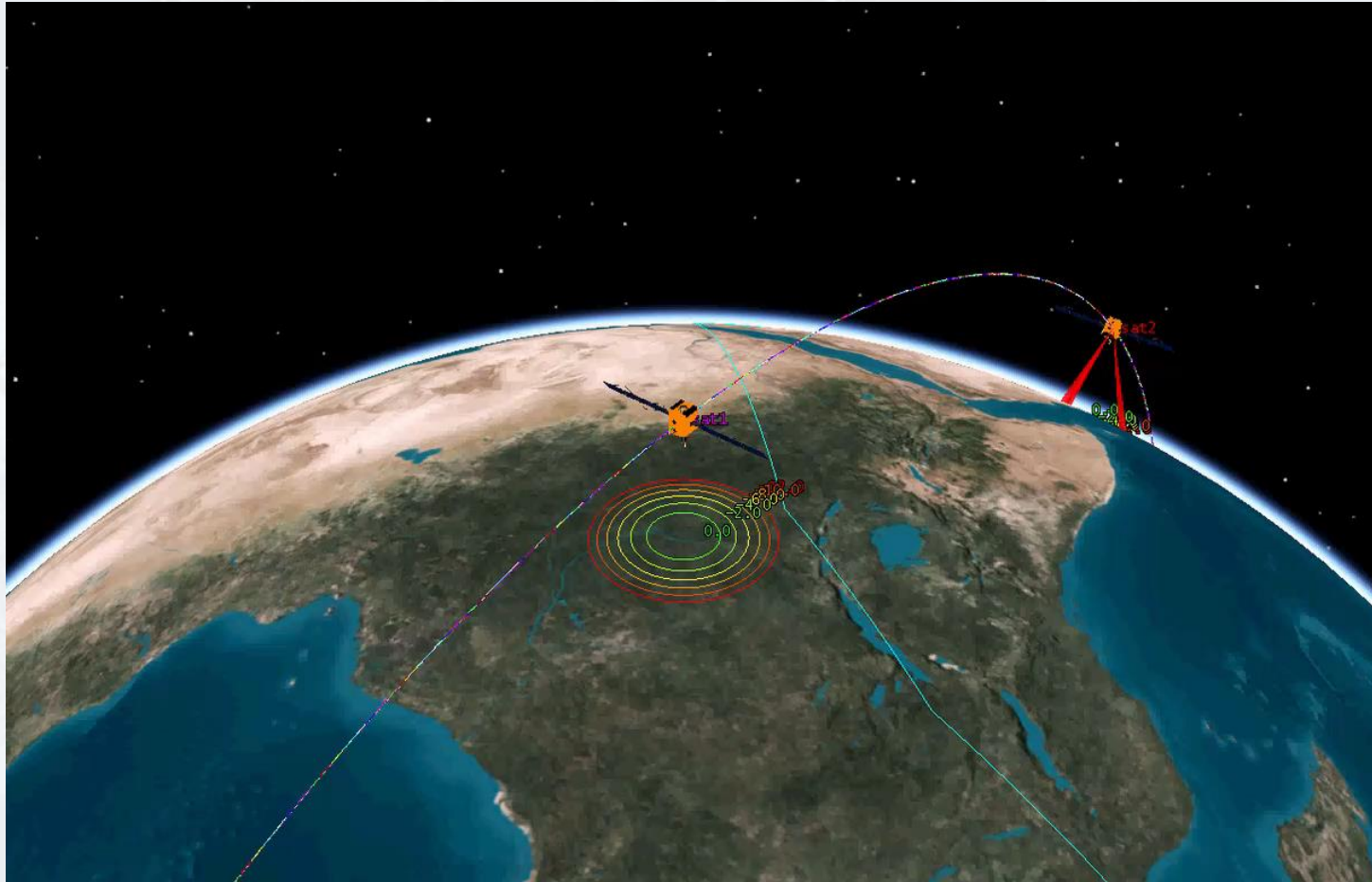
Contact mail id: a_roy1660@sac.isro.gov.in

Thank You