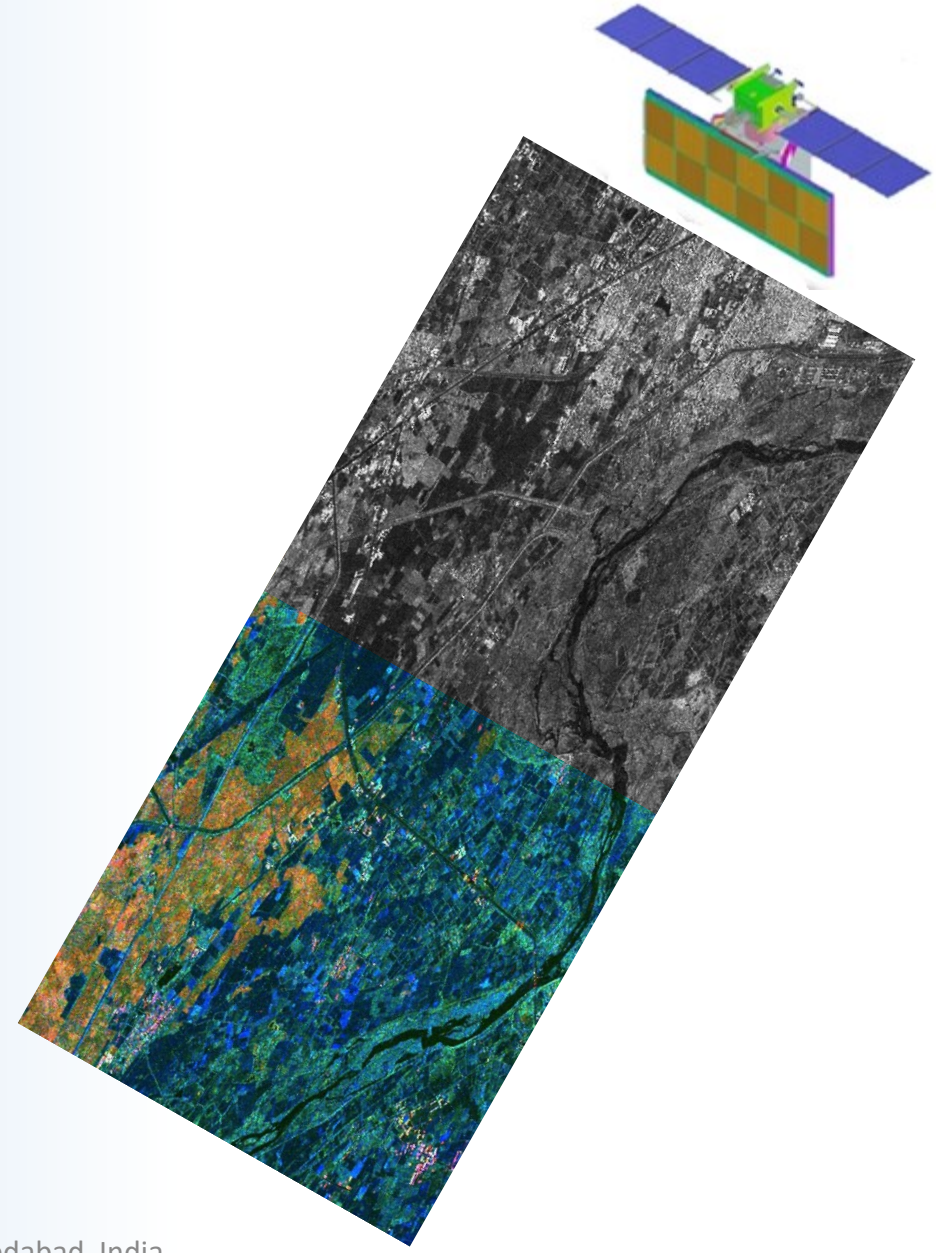
Data Quality Assessment of EOS-04 SAR Analysis Ready Data using in house developed Data quality Evaluation Software

Committee On Earth Observation Satellites
SAR Cal & VAL Workshop - 2024



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Outline

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  - Data, Level of Products, Specifications
- Level-2B ARD Data
- Geometric Evaluation Method & Parameters & Results
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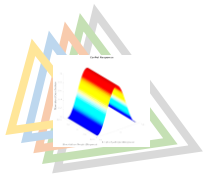


EOS-04 Mission, Specifications and Data Products

EOS-04 is a follow on mission of RISAT-1 with

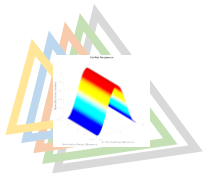
- Imaging Modes STRIPMAP, SCANSAR and SPOTLIGHT.
- Fine Resolution Stripmap-2 (FRS-2) mode replaced by Full-polarization FRS-2 mode.
- All basic Level-0, Level-1 and Level-2 are same
- Level-1C and Level-3A as Polarimetric value added products (VADs)
- MOSAIC VADS and
- **Level-2B products as Analysis Ready Data Products**

System Specification

Parameters	Value
Altitude	536 Kms
Inclination	97.552 deg.
Look Angle	11.3 deg. to 49.4 deg.
Incidence Angle	12.0 deg. to 55.0 deg.
Polarization	Single/Dual/Hybrid/Full
Frequency of operation	5.35 GHz
Doppler Bandwidth	2500 Hz
PRF	2800 Hz – 3700 Hz
Pulse Width	10 µs – 20 µs
Peak Power/ TRM	10 W
Antenna Size	6.0 m X 2.0 m
Antenna Gain	43.1 dB
Antenna Beam-width	2.18^0 – 1.47^0 (el) , 0.47^0 (Az)

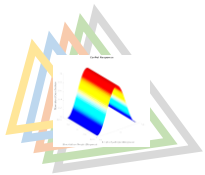
Mission Specification

SNO	Parameter	Coarse Resolution ScanSAR Mode	Medium Resolution ScanSAR Mode	Stripmap Mode
1	Altitude	536.38km	536.38km	536.38km
2	Inclination	97.554 °	97.554 °	97.554 °
3	Repeat Cycle	181 orbits in 12 Days	377 orbits in 25 Days	2096 orbits in 139 Days
4	Orbit Period (min)	95.4907	95.4907	95.4907
5	Path to Path Distance	212.6	106.3	19.12
6	Swath	223	115	25
7	Local time 6:00 Hrs +/-5 min			



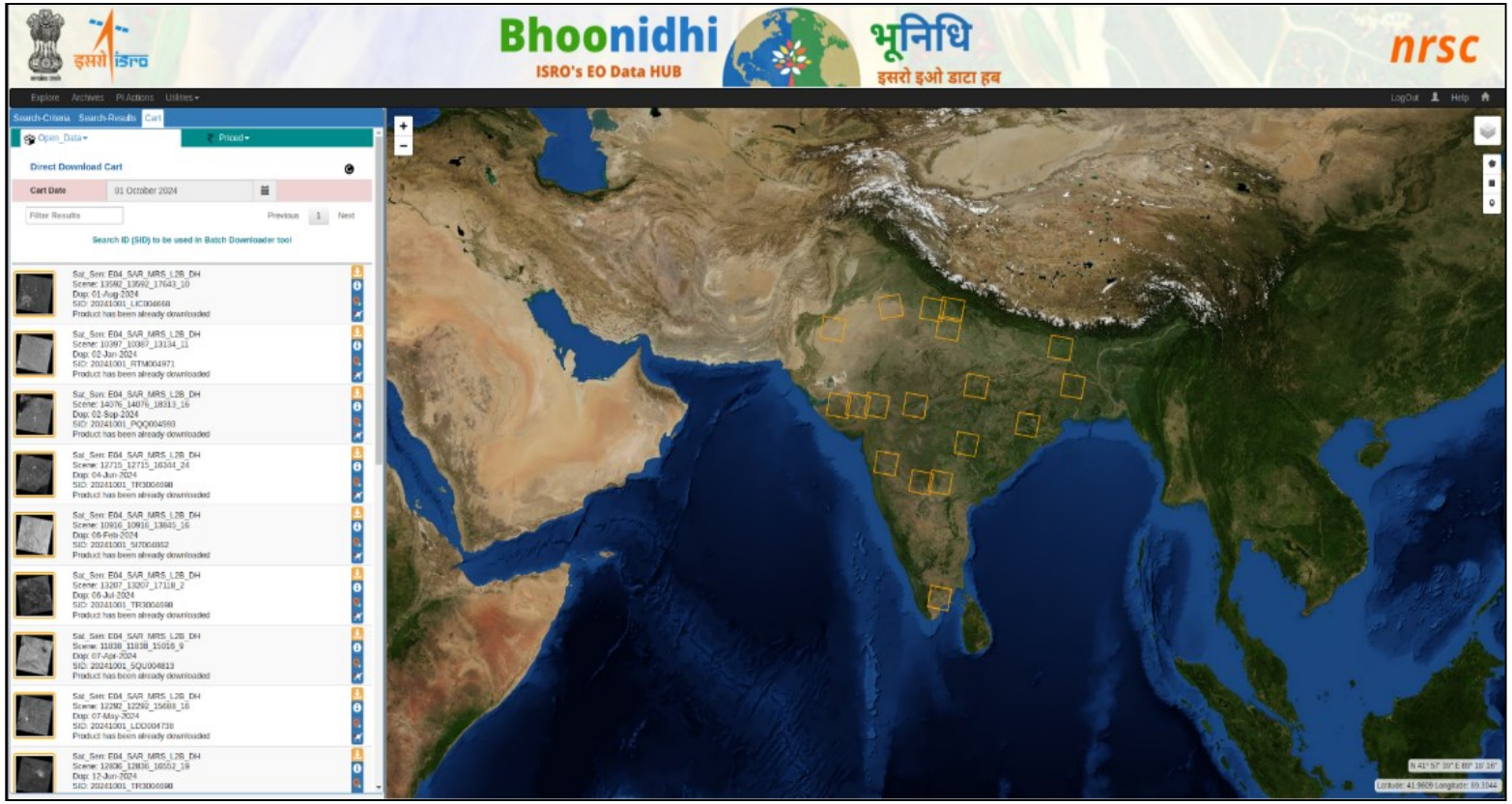
Level-2B ARD Data

- EOS-04 is the first ISRO's SAR mission disseminating the Analysis Ready Data (ARD) as Terrain **Normalized Radar Backscattered (NRB)** products in ScanSAR Mode as **Level-2B (**L2B) Data Products.
- Products are in **Gamma-Naught backscatter convention** with Geocoding and ortho-rectification process.
- Currently, EOS-04 Level-2B data products are available only for ScanSAR (MRS and CRS) mode acquisitions.
- The product will be in compliance with CEOS CARD4L-NRB product family and allows user for immediate analysis with a minimum additional effort
- As it is the user products, the Radiometric and Geometric quality aspects is essential



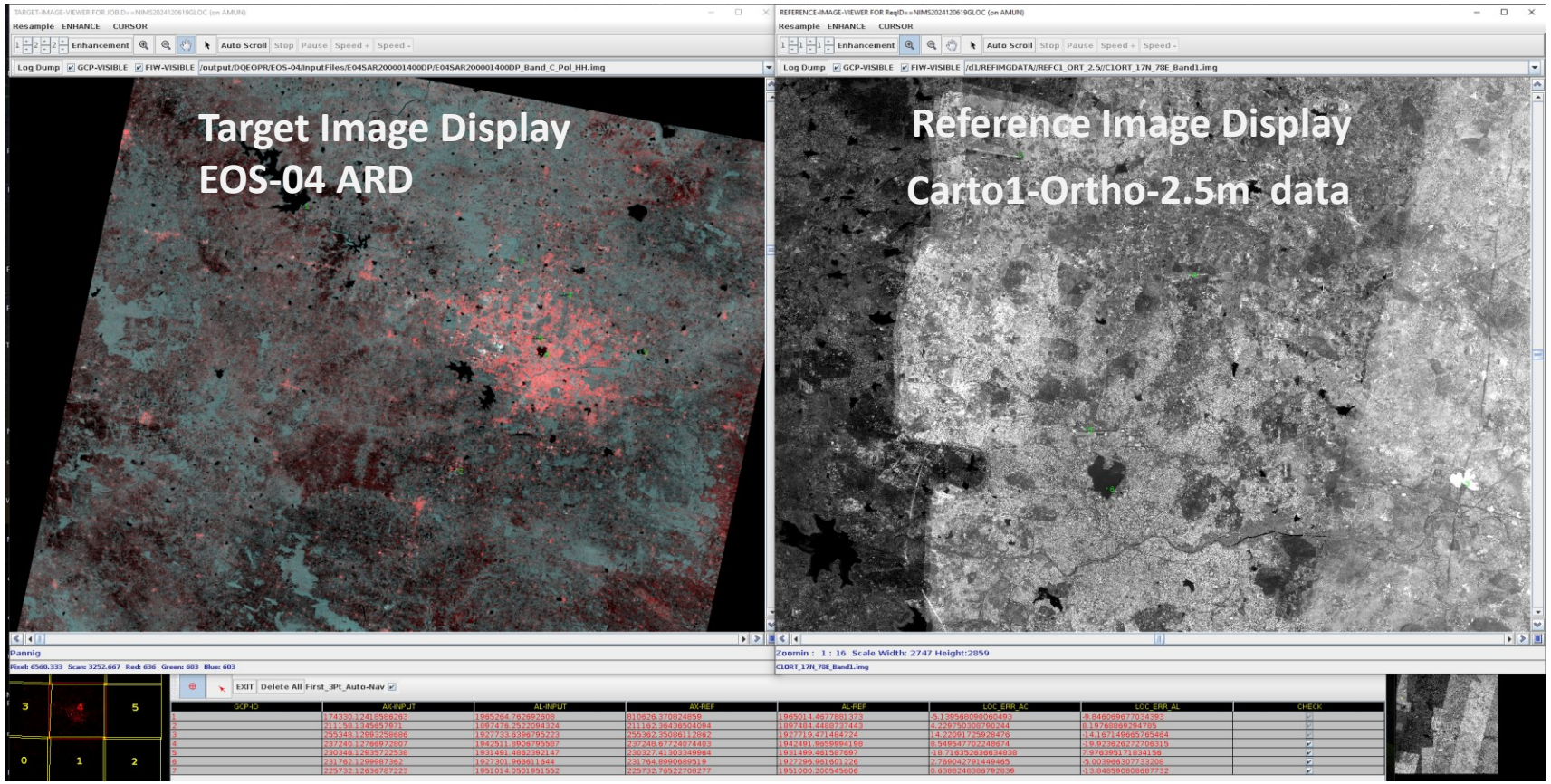
Geometric Evaluation

- The Geometric parameters are evaluated using in-house designed and developed Data Quality Evaluation Software (DQES) system consisting of pre-processing, reference selection, control point identification for the said scene, resulting into geometric error statistics.
- Here the data we have taken is over Indian Region using Bhoonidhi portal with around 20 scenes as shown in image.
- Usually urban area in MRS-8 Beam (HH/HV) acquired in Descending/Ascending, Right look direction.
- **Geometric Data Quality Evaluation parameters involves RMS and Mean Geolocation error, Circular Error 90 and scale.**
- The reference is Carto1-Ortho-2.5m data.



Geometric Data Quality Evaluation

Hyderabad, Telangana

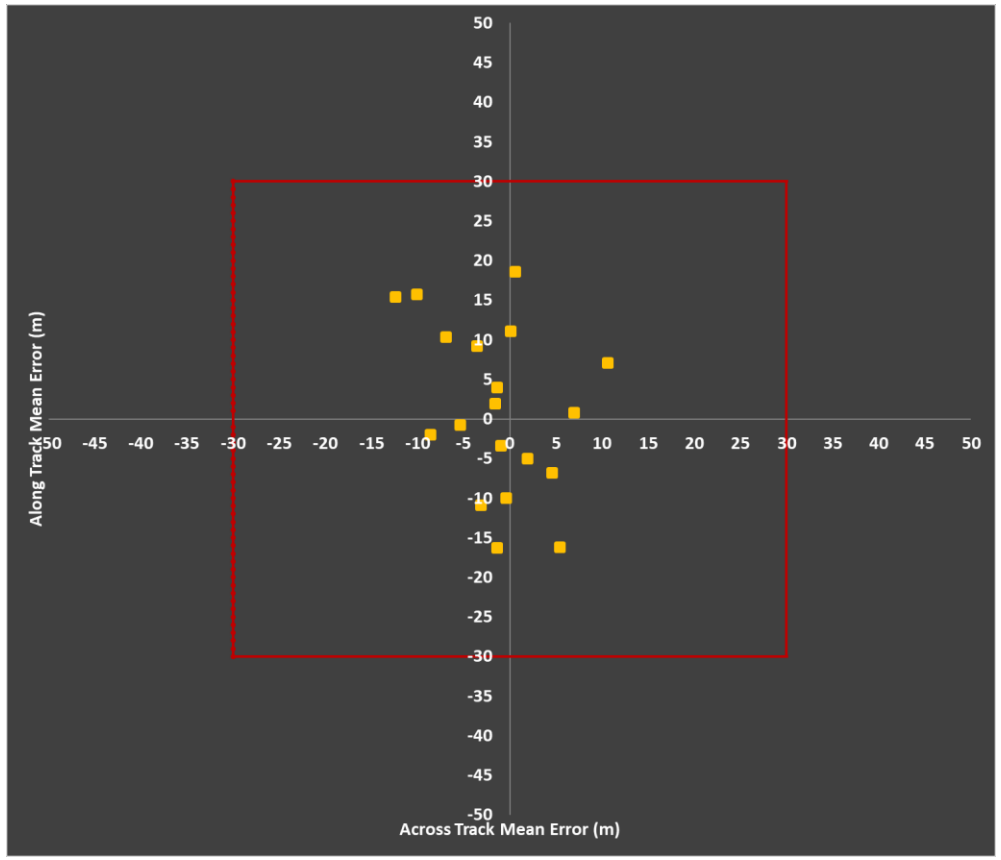


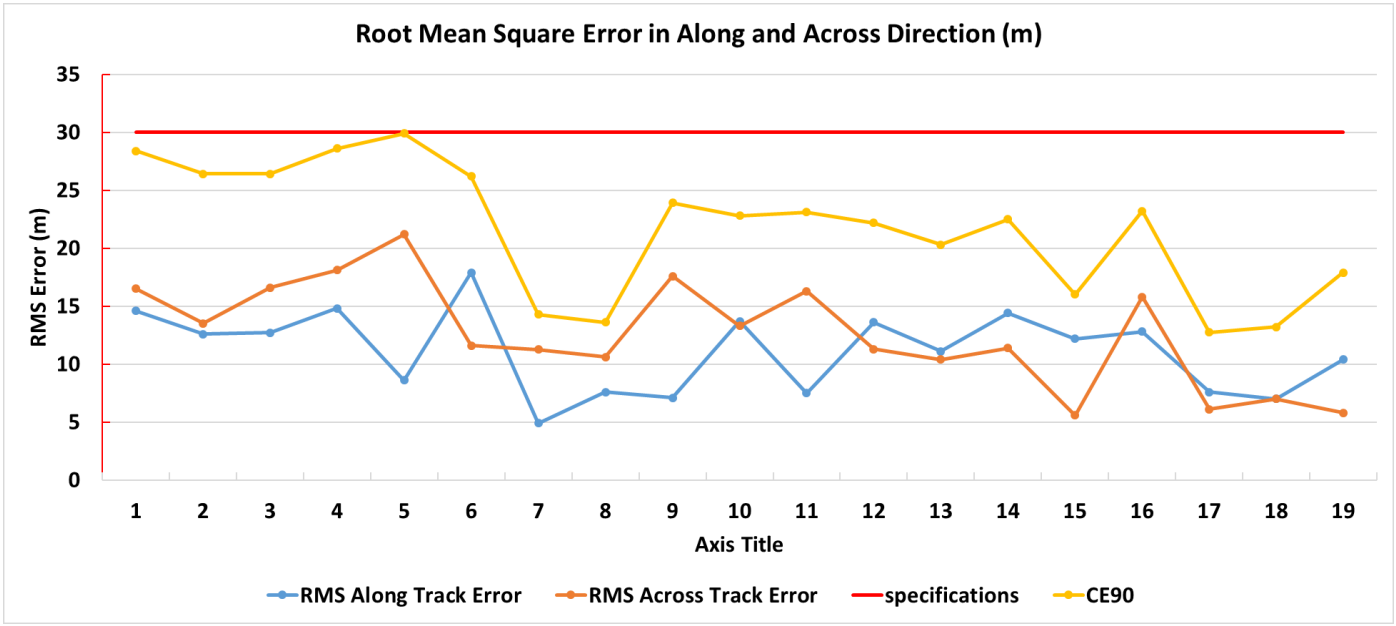
GCP Error Table

Geo-location error takes extracted data product in form of image, ancillary information, geometric references, and control points identified on target & reference images as input. The processes for this activity involves is:

1. **Computation of GCP scan/pix, Lat/Lon and projected (map) coordinates for target as well as reference in common projection space**
2. **Based on map-coordinates of control points, estimation of location accuracy, scale is computed**

EOS-04 ARD Geometric Evaluation Results



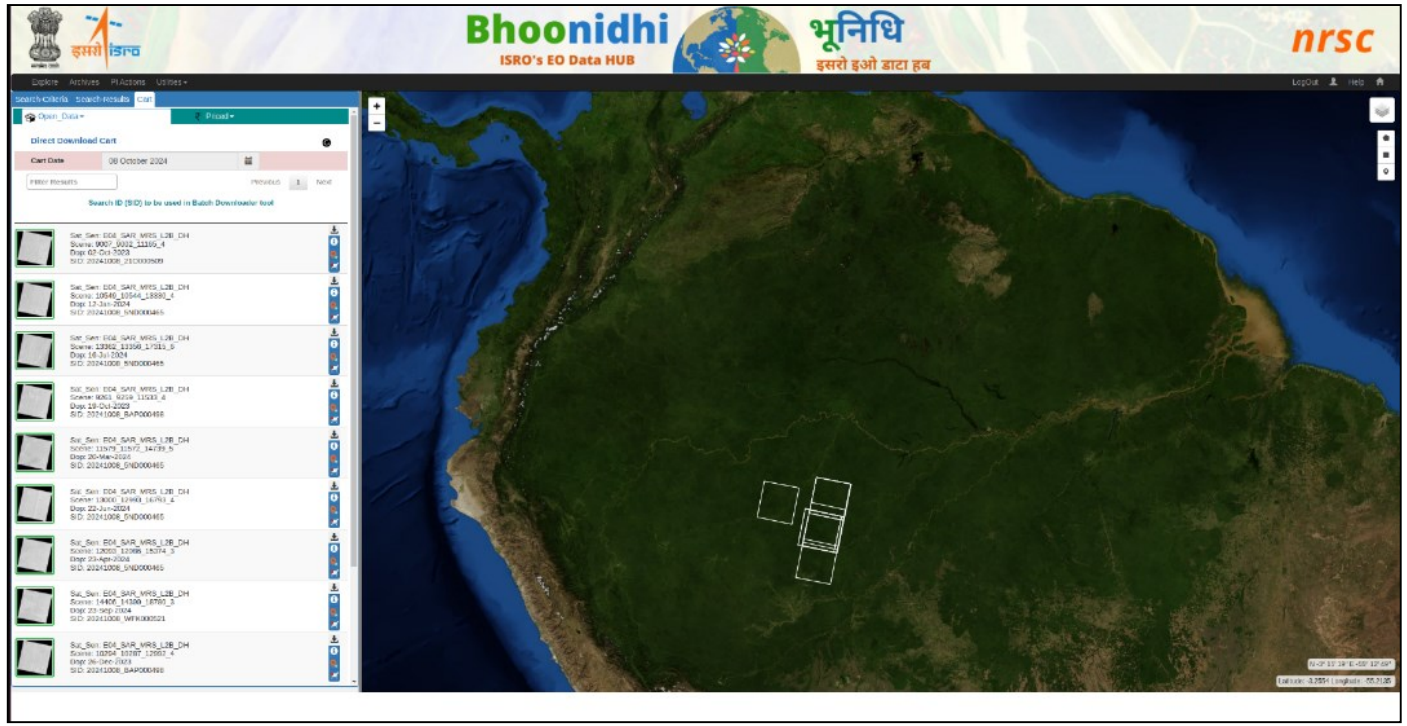


- **RMS Along: 11.1 m**
- **RMS Across: 12.6 m**
- **CE90: 21.6 m**
- **Scale: 17.97 m**


Mean Error Along and Across
Mean Along Error
Mean Across Error
Mean Error in across and Along (m)
50
40
30
20
10
0
-10
-20
-30
-40
-50
0
2
4
6
8
10
12
14
16
18
20
Sample Number

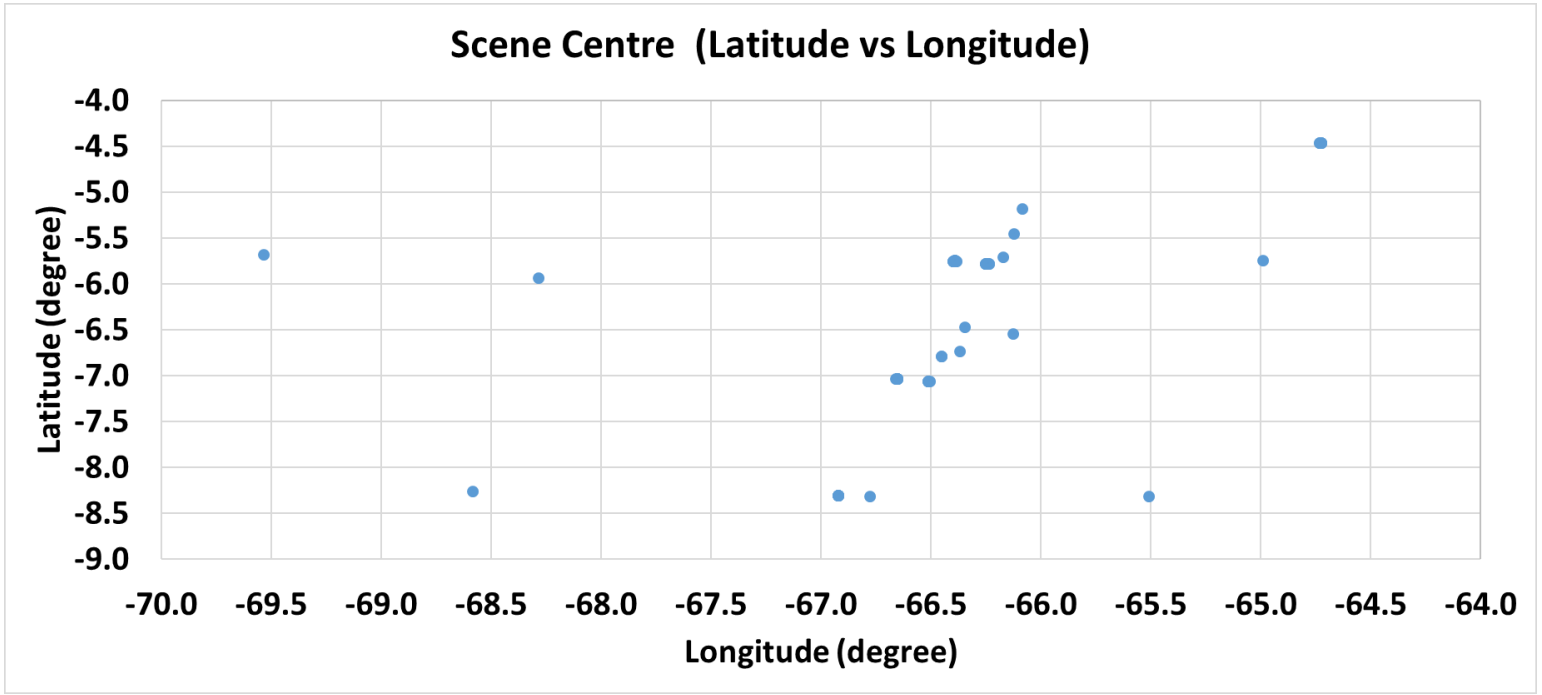
Radiometric Data quality Evaluation Tool

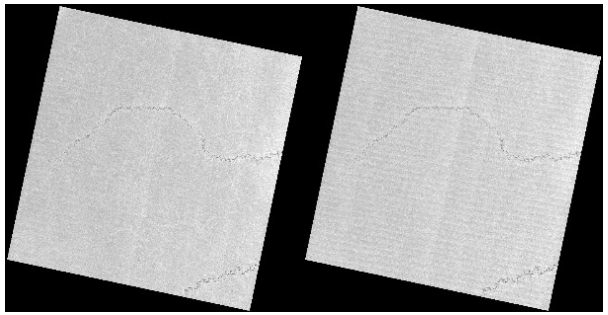
- The radiometric data quality is carried out using the Radiometric Data Quality Analysis tool in house developed for SAR missions consisting of preprocessing, computation of parameters and the statistics.
- **Radiometry is observed using Gamma-naught over extended homogeneous site i.e. Amazon Rain Forest.** Data over Amazon rain Forest, since launch till date, using Bhoonidhi portal (V1.1.03) with around 60 scenes in the defined window.
- All data sets have RTC Apply Flag as 1 i.e. Radar Terrain Correction applied.
- Data is in MRS-8 Beam (HH/HV) acquired in Descending/Ascending, Right look direction for analysis.



$$\gamma^0(\text{dB}) = 20.0 \times \log_{10}(DN_p - NoiseFactor) - K_{cal\_dB}$$

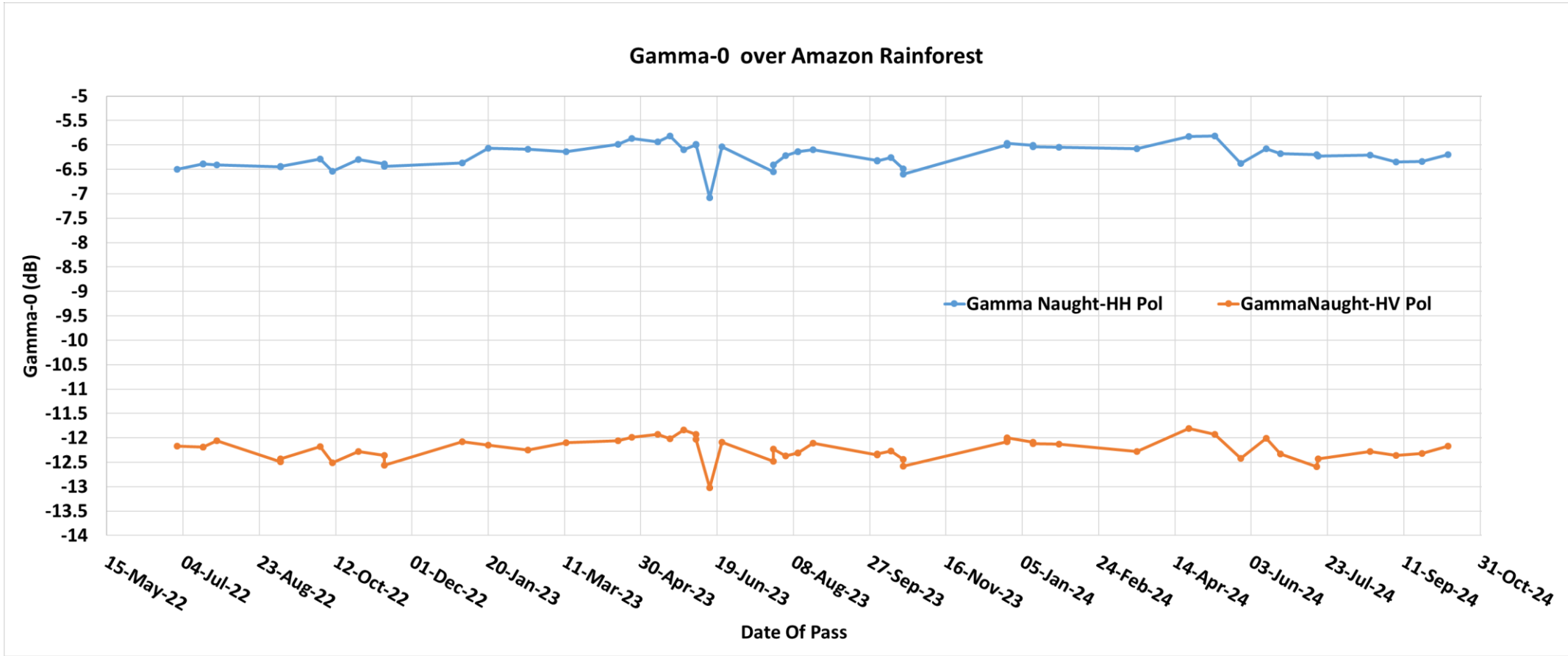
Kcal_dB is **Calibration_Constant**


Scene Centre (Latitude vs Longitude)
Latitude (degree)
-4.0
-4.5
-5.0
-5.5
-6.0
-6.5
-7.0
-7.5
-8.0
-8.5
-9.0
-70.0
-69.5
-69.0
-68.5
-68.0
-67.5
-67.0
-66.5
-66.0
-65.5
-65.0
-64.5
-64.0
Longitude (degree)



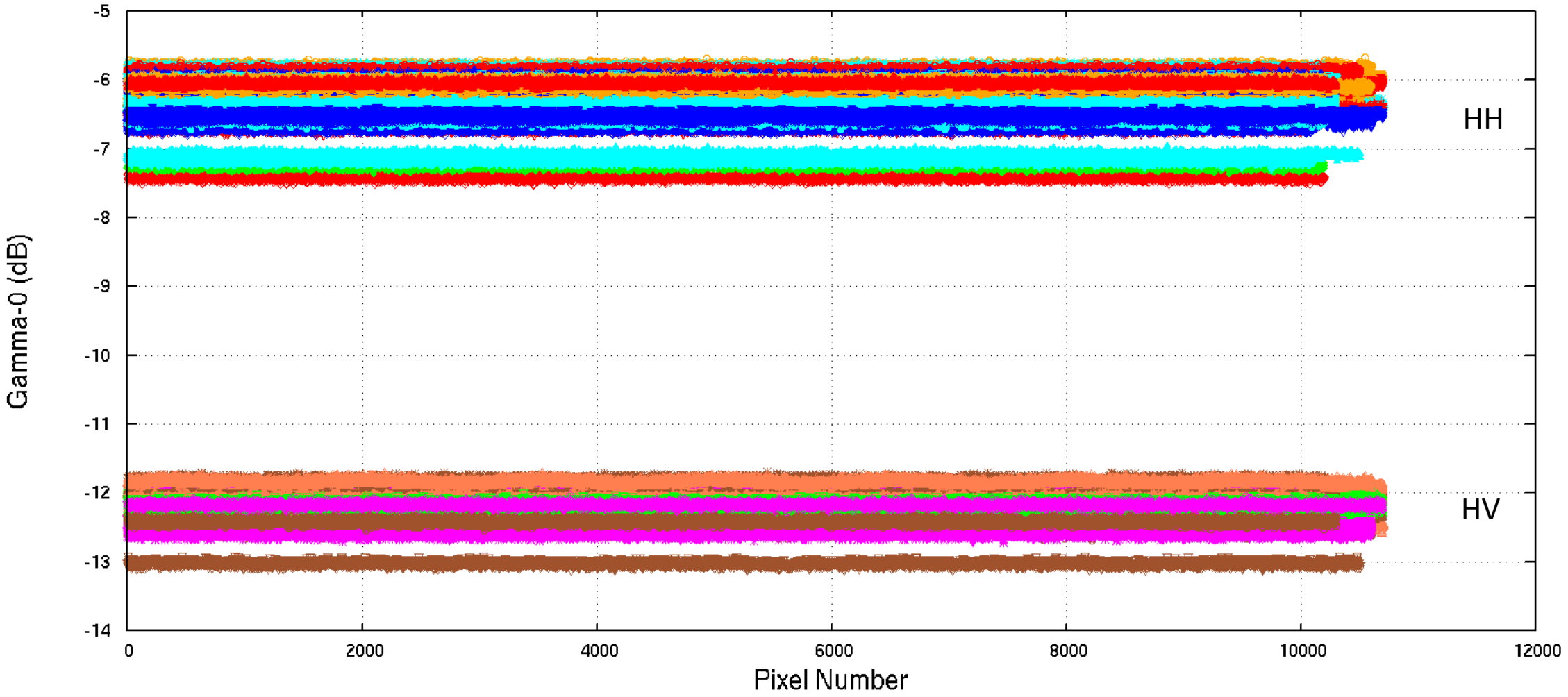
HH HV

Radiometric Evaluation Results



Parameters	Gamma-0 Mean HH	Gamma-0 Std Dev HH	Gamma-0 Mean HV	Gamma-0 Std Dev HV
Obs. Values	-6.21	0.24	-12.23	0.23

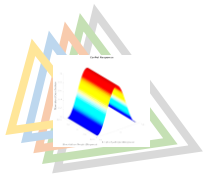
Gamma-0 (dB) over the swath in HH and HV Pol



conclusion

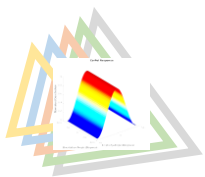
- EOS-04's Level-2B data is analysed for Geometry and Radiometry
- The RMS geo-location error was observed as 11.1m N-S and 12.6 m E-W
- Scale is around 18 (m) in both across and along.
- The CE90 in ARD 21.6 (m)
- This concludes that all sources of error were taken care in the L2B product and the error are within a pixel
- Gamma-0 computed over different DOP data is around -6.21 dB in Co-pol (HH) and -12.23 dB in Crosspol(HV) which is within the specifications.
- Variation across swath is within ±1 dB for both polarizations.

This independent assessment of L2B ARD product suggests that the data is improved in terms of geolocation error and Gamma-0 meets defined specifications over Amazon Rainforest and this Data is useful for scientific applications.

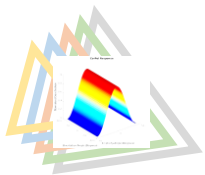


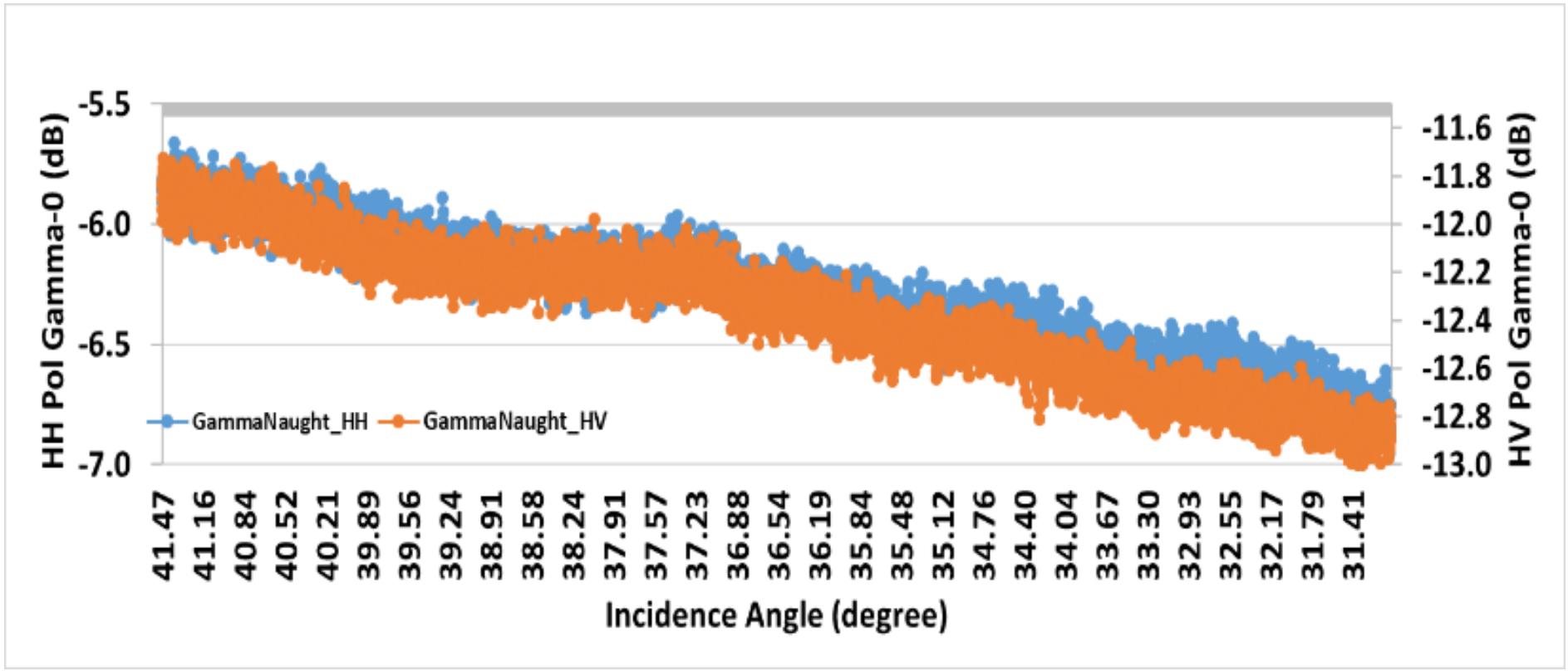
References

(1) EOS-04 Data Products Formats (July 2023); Version1.2.4; SAC/SIPG/MDPD/EOS-04/SAR/DP/2021/TN-05/Sep, 2021
(2) CEOS, ARD for SAR PFS Version 1.0; October 2023



Thankyou




HH Pol Gamma-0 (dB)
-5.5
-6.0
-6.5
-7.0
HV Pol Gamma-0 (dB)
-11.6
-11.8
-12.0
-12.2
-12.4
-12.6
-12.8
-13.0
GammaNaught_HH
GammaNaught_HV
41.47
41.16
40.84
40.52
40.21
39.89
39.56
39.24
38.91
38.58
38.24
37.91
37.57
37.23
36.88
36.54
36.19
35.84
35.48
35.12
34.76
34.40
34.04
33.67
33.30
32.93
32.55
32.17
31.79
31.41
Incidence Angle (degree)