ATMS Geolocation Validation and Trending

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- **S-NPP ATMS Geolocation Calculation Flow Chart**
- **S-NPP ATMS Geolocation Accuracy Validation Methods**
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  - Land-sea Fraction Method (LFM)
- **S-NPP ATMS Geolocation Accuracy Validation Results**
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- **Path Forward**

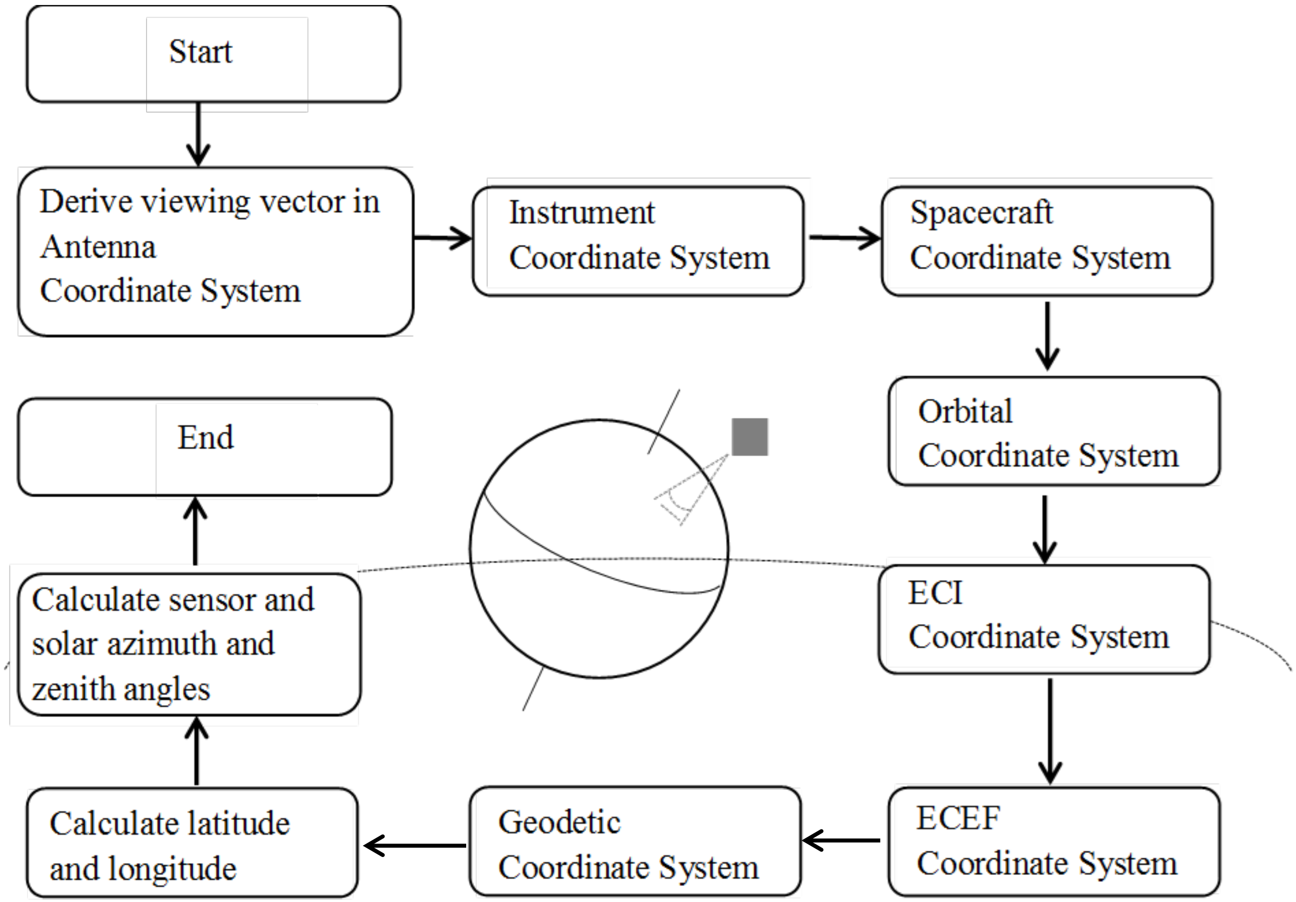
ATMS Geolocation Accuracy Requirement

- **Pointing Accuracy Definition**
  - At each beam position, in both the scan (crosstrack) and the spacecraft velocity (downtrack) directions, the beam pointing accuracy is defined as the difference between the intended and actual beam electrical boresight directions

- **Pointing Accuracy Requirement (S-NPP, AE-28100)**
  - +/-0.10 degrees for the 1.1 degrees beamwidth channels (G-band)
  - +/-0.15 degrees for the 2.2 degrees beamwidth channels (V/W-band)
  - +/-0.30 degrees for the 5.2 degrees beamwidth channels (K/Ka-band)

- **Pointing Accuracy Requirement (JPSS, AE-28300)**
  - For each position, the pre-launch static beam-pointing error shall be no greater than 0.50 degrees, 3 sigma, per axis for all channels

ATMS Geolocation Implementation Flow Chart

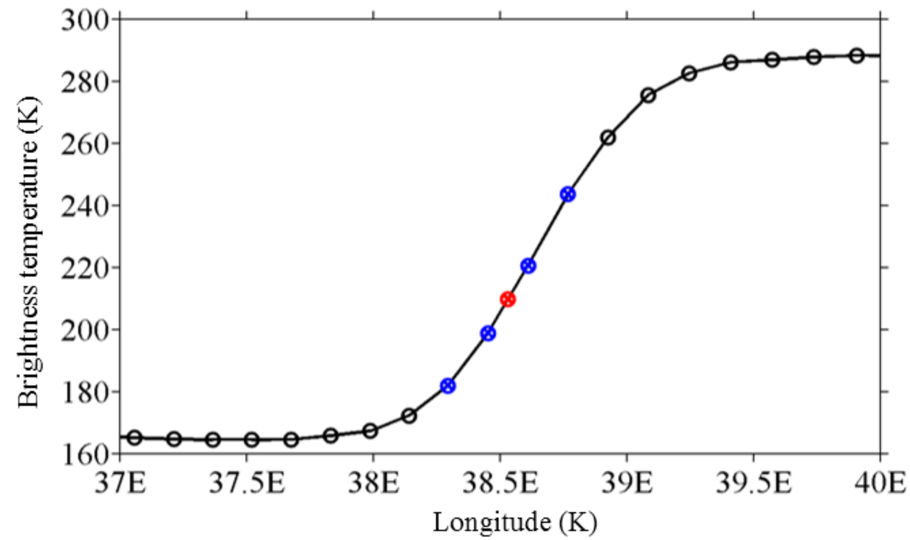


Coordinate system transformation from antenna coordinate to geodetic coordinate

ATMS Geolocation Accuracy Validation Method

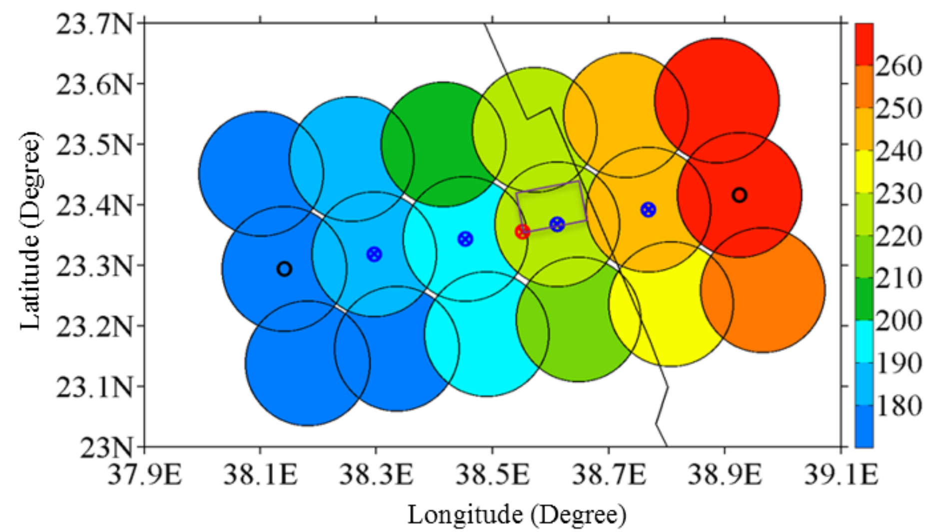
Coastline Detection Method (CDM)

a. Fit a cubic polynomial to brightness temperatures at four consecutive FOVs that cross a coastline
b. Find the coastline by calculating inflection point when preset conditions are satisfied
c. Obtain geolocation errors in latitude and longitude by computing the perpendicular distance between the inflection point and GSHHS database



Recommendation on scene selection,

1. High thermal contrast between land and water
2. Infrequent cloud cover
3. No unusual terrain features



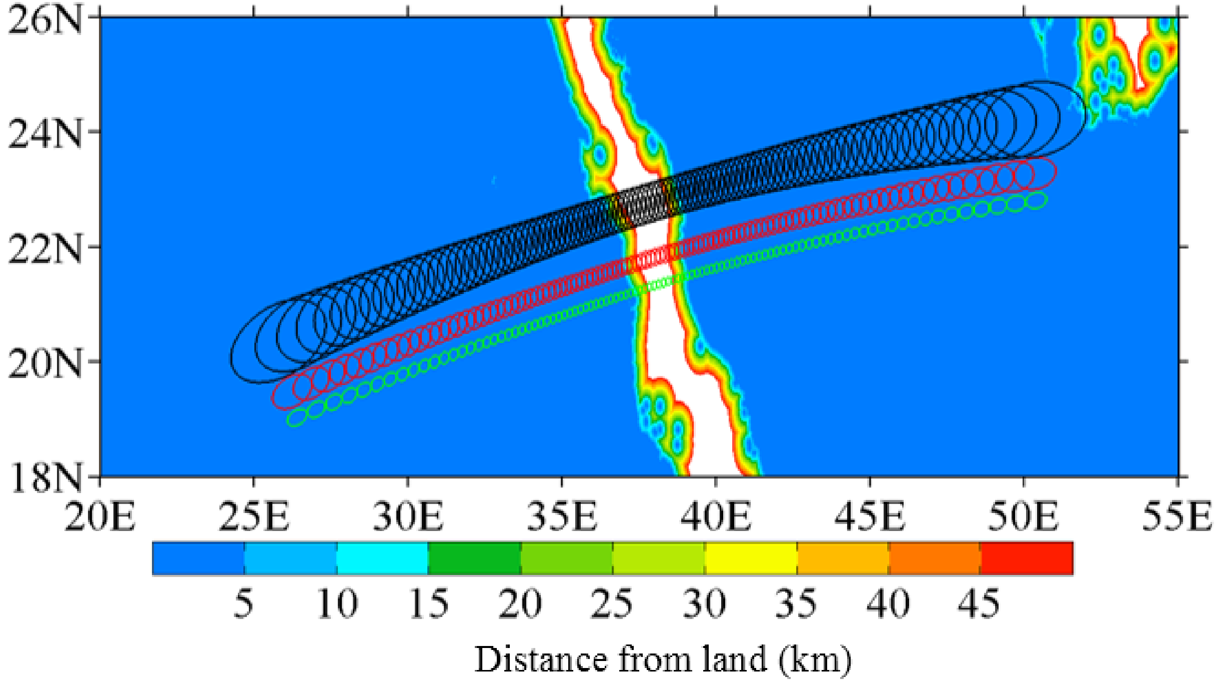
Selected coasts for validation,

a) North Africa western coast
b) Caspian Sea coast
c) Red Sea coast

ATMS Geolocation Accuracy Validation Method

Land-sea Fraction Method (LFM)

a. Collocate land sea mask within ATMS FOVs
b. Simulate brightness temperature with land sea mask datasets
c. Define cost functions by shifting the land sea mask in the along-track and cross-track directions
d. Detect geolocation accuracy by minimizing cost functions



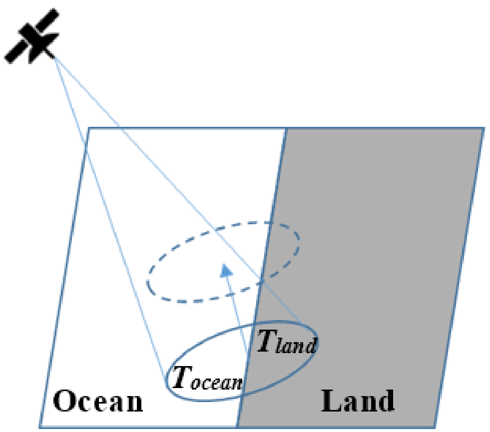
Collocating land sea mask datasets with ATMS FOVs at beam width of 5.2 (black), 2.2 (red), and 1.1 (green) degree

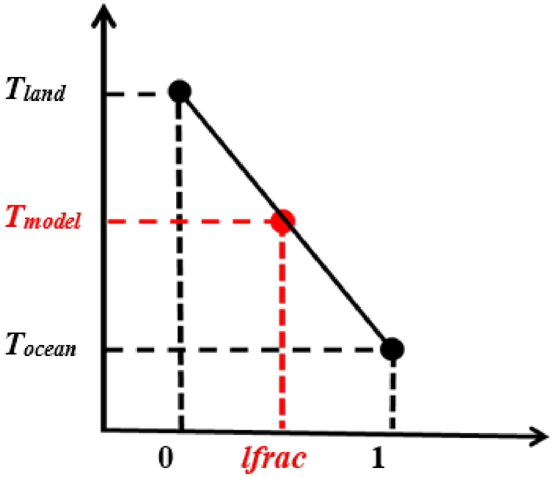
ATMS Geolocation Accuracy Validation Method

Construct brightness temperature simulation model according to statistical analysis of the scene measurements

$$T_{Model} = T_{sea} + lfrac \cdot (T_{land} - T_{sea})$$

$\boldsymbol{T_{land}}$ **and** $\boldsymbol{T_{ocean}}$ is the average brightness temperature in land and ocean, respectively. *lfrac* is the land-sea fraction in a satellite footprint, and $\boldsymbol{T_{model}}$ is the corresponding brightness temperatures





Minimize Chi-square function by shifting the land sea mask datasets in north-south and east-west directions to find the best matched land sea mask fractions

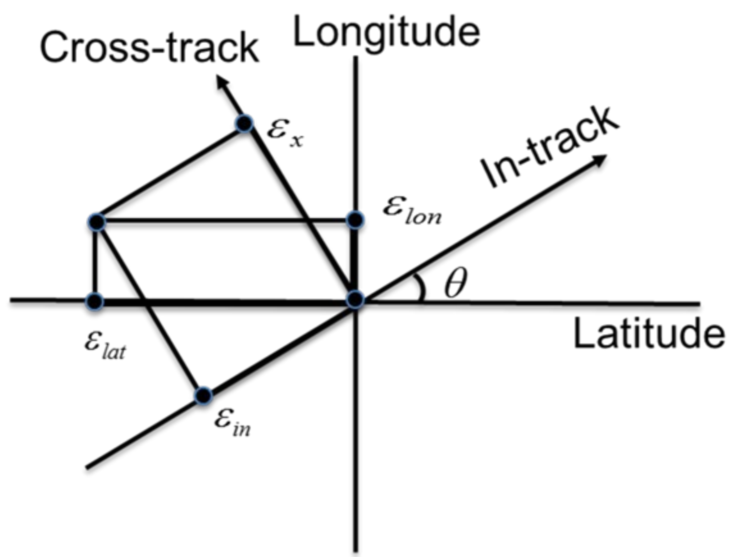
$$\chi^2 = \sum_{FOVs} (T_{OBS} - T_{Model})^2$$

ATMS Geolocation Accuracy Validation Method

Geolocation errors in latitude (ε_{lat}) and longitude (ε_{lon}) can be mapped to in-track (ε_{in}) and cross-track (ε_x) errors by the following equation, where θ is the spacecraft heading angle

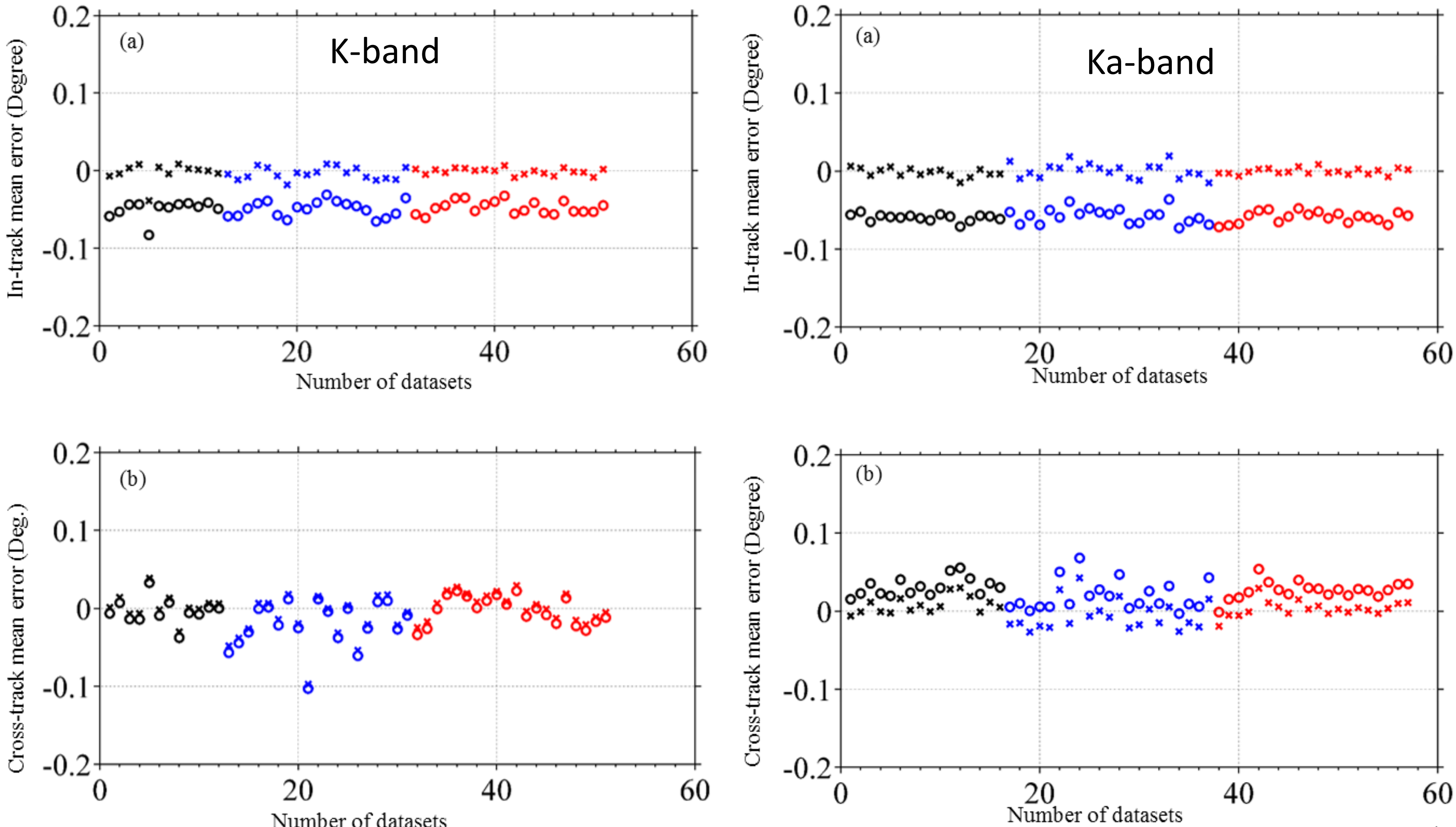
$$\begin{bmatrix} \varepsilon_x \\ \varepsilon_{in} \end{bmatrix} = \begin{bmatrix} \sin\theta & \cos\theta \\ \cos\theta & -\sin\theta \end{bmatrix} \begin{bmatrix} \varepsilon_{lat} \\ \varepsilon_{lon} \end{bmatrix}$$

Transformation from latitude and longitude to in-track and cross-track coordinate

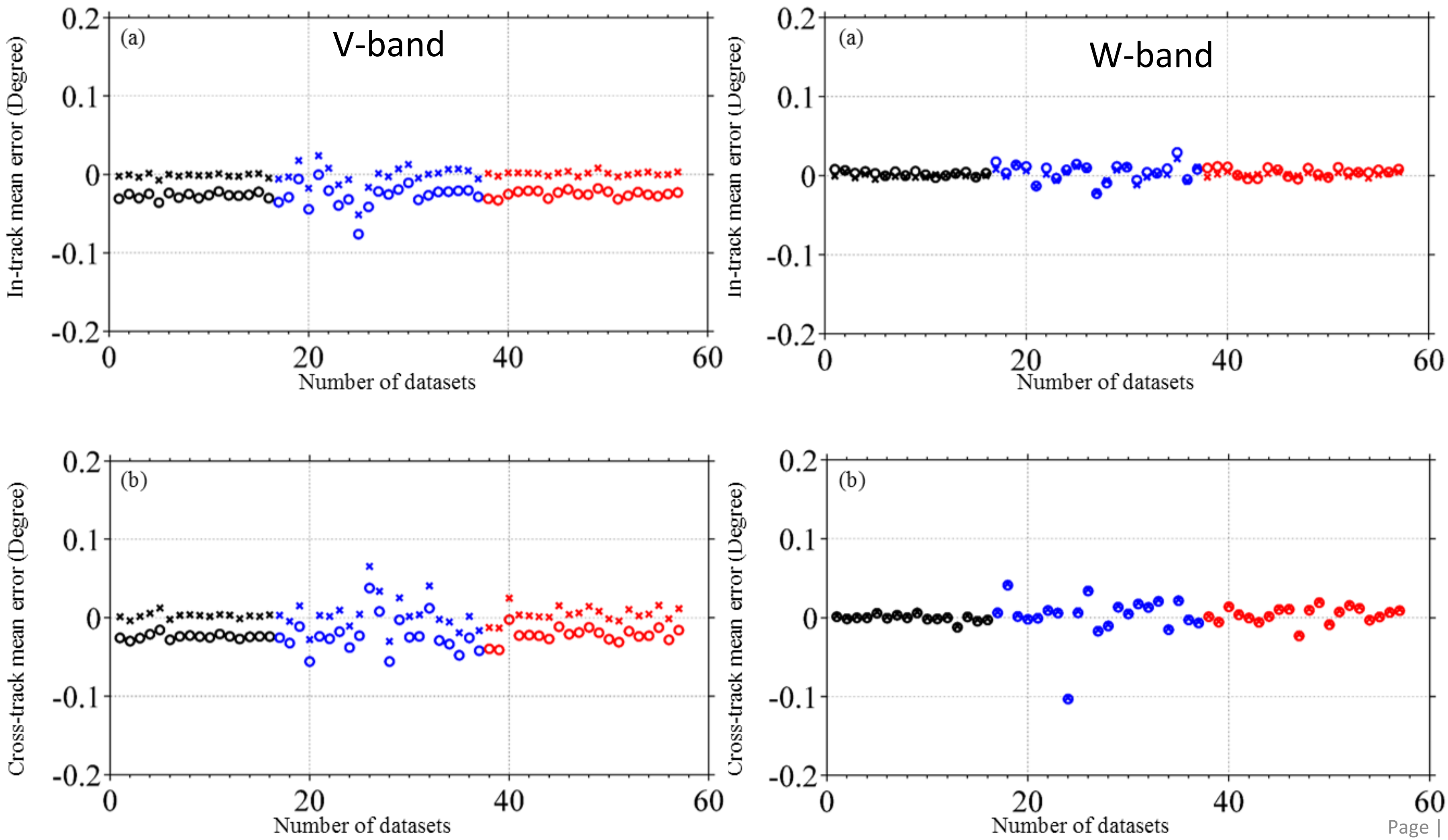


ATMS Geolocation Accuracy Validation Results (CDM)

In-track and cross-track mean errors over North Africa western coast (black), Caspian Sea (blue), and Red Sea (red) before (circle) and after (cross) geolocation error correction.

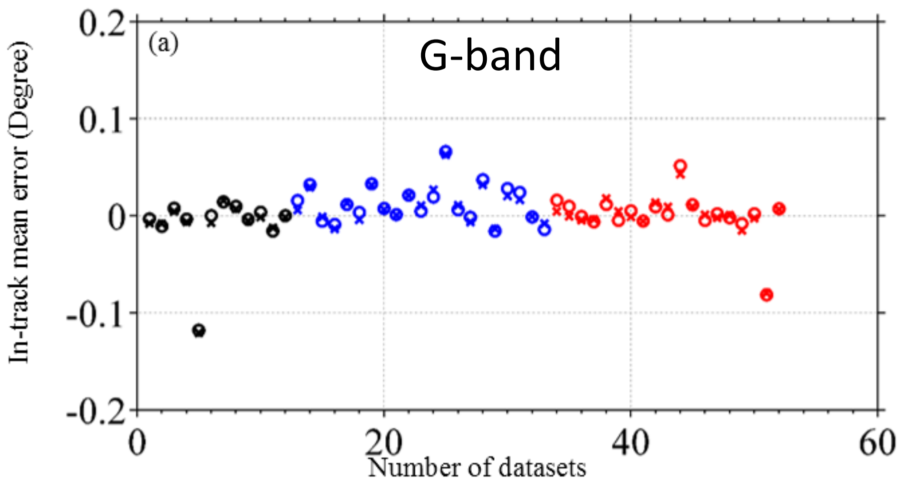


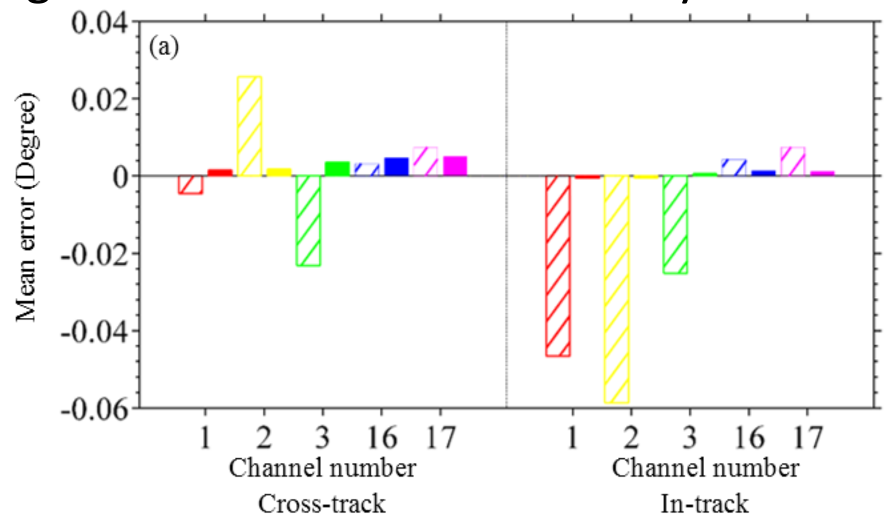
ATMS Geolocation Accuracy Validation Results (CDM)

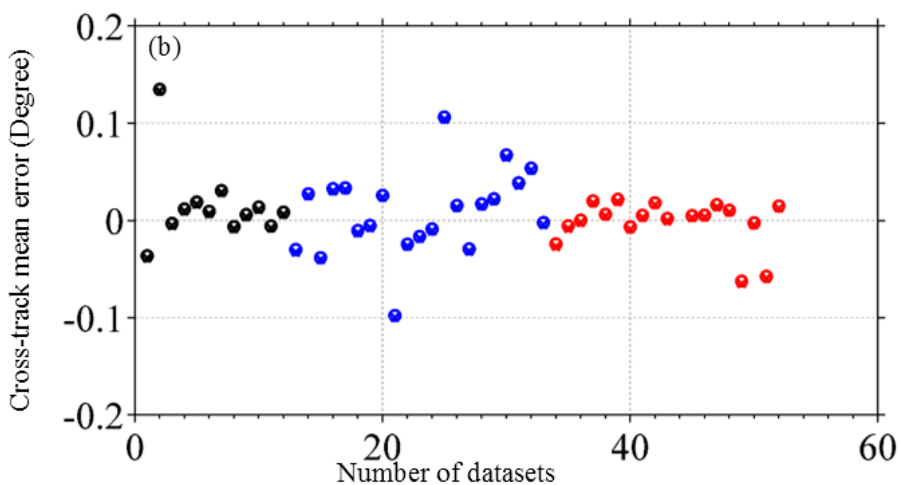


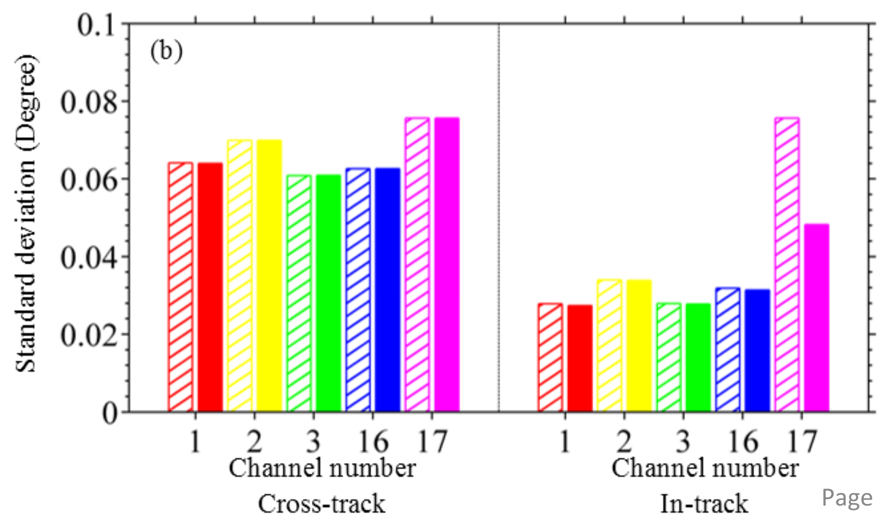
ATMS Geolocation Accuracy Validation Results (CDM)

In-track and cross-track mean errors and standard deviation before and after geolocation error correction by bands



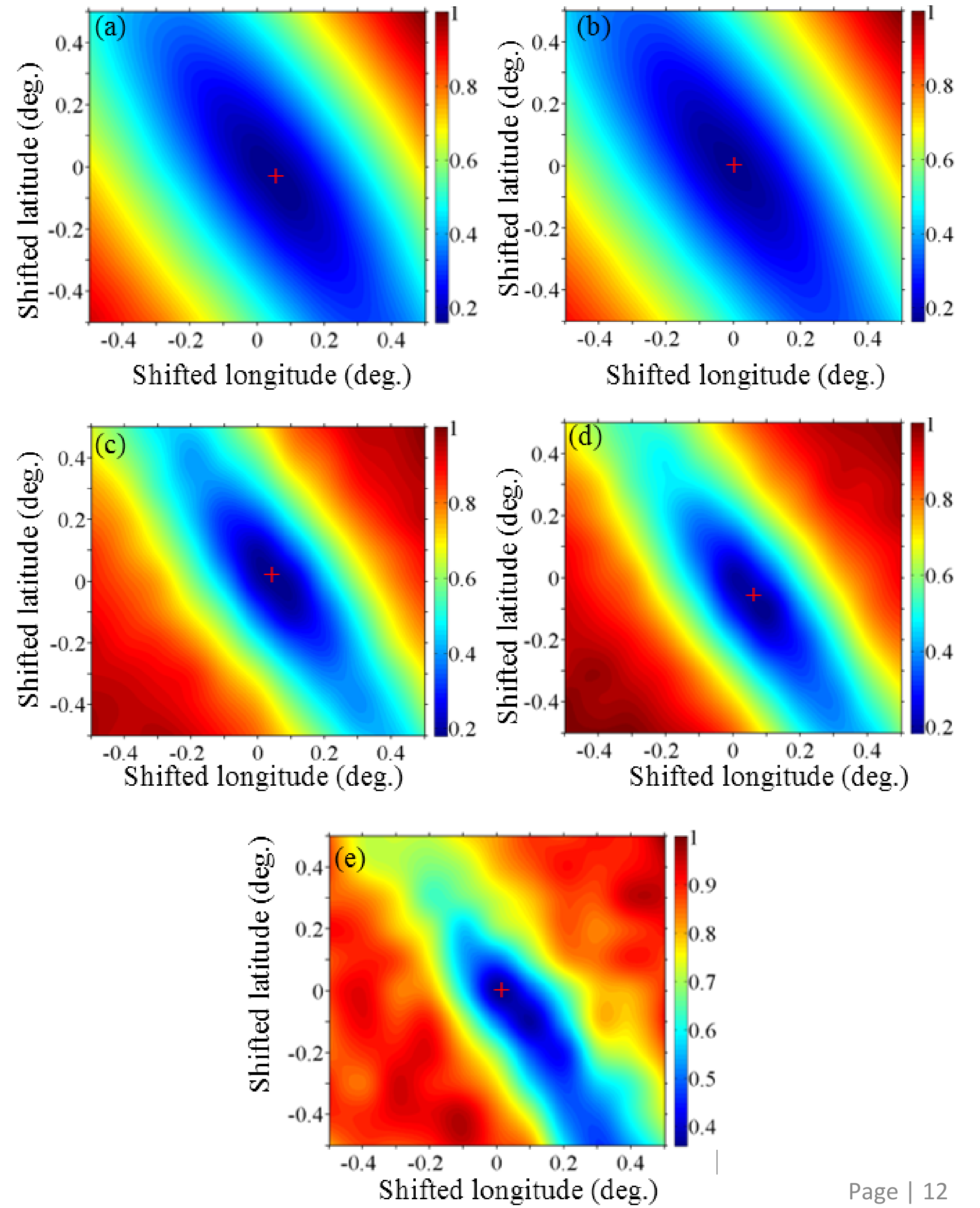






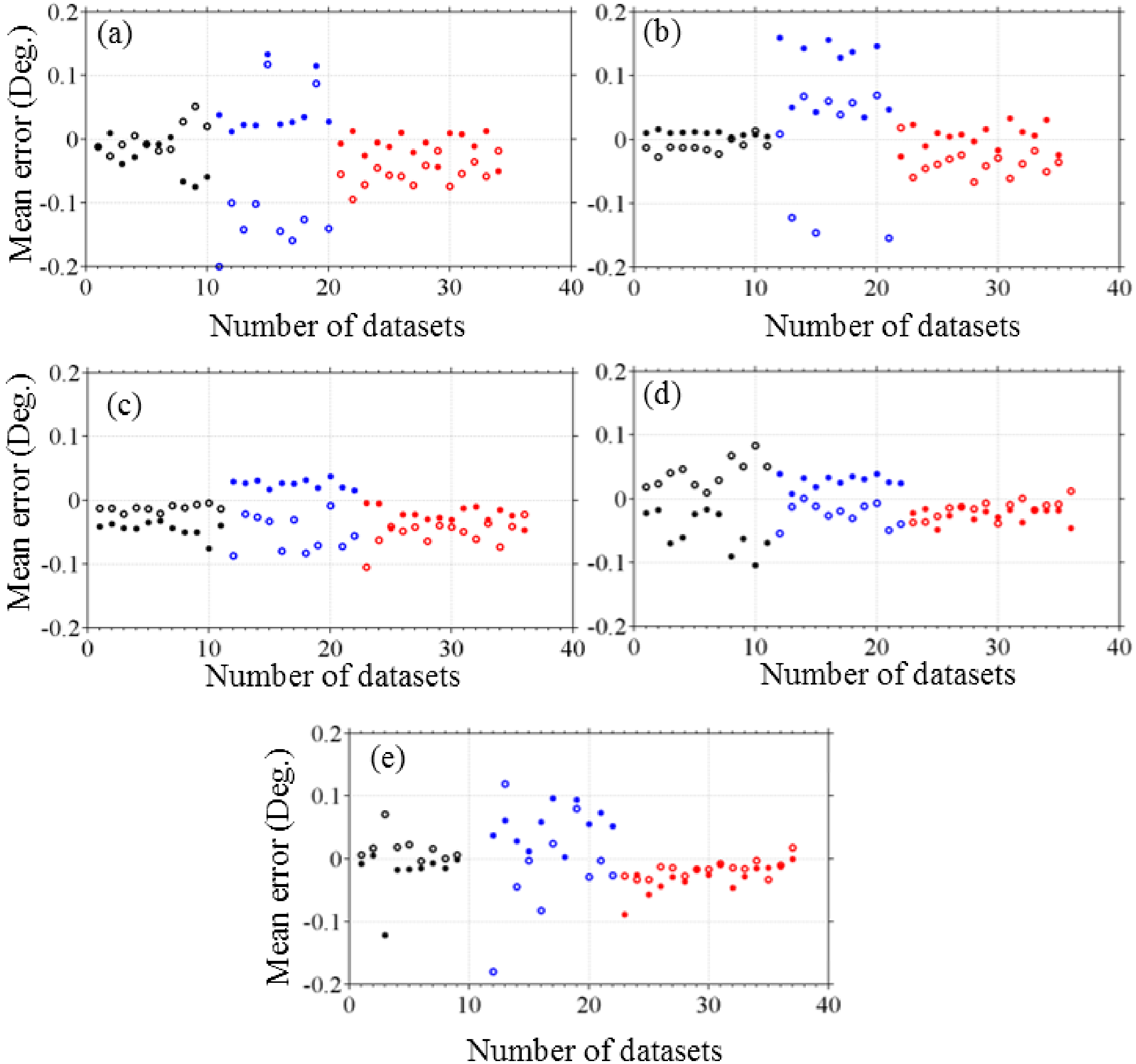
ATMS Geolocation Accuracy Validation Results (LFM)

Cost functions for ATMS K/Ka/V/W/G-band. The minimized coast functions is at (-0.074, 0.082), (-0.001, -0.002), (0.001, 0.0510), (-0.1010, 0.0880) and (-0.0010, 0.0110)



ATMS Geolocation Accuracy Validation Results (LFM)

In-track (solid circle) and cross-track (open circle) mean errors ATMS K/Ka/V/W/G-band over North Africa western coast (black), Caspian Sea (blue), and Red Sea (red)



ATMS Geolocation Correction

Latitude and longitude errors are recommended to be corrected in instrument alignment by pitch, roll and yaw angle adjustments

First transformation is from geodetic coordinate (ENU) to Earth spherical coordinate (IJK)

$$T_{IJK/ENU}^{loc} = \begin{bmatrix} -\sin\theta_{loc} & -\sin\varphi_{loc}\cos\theta_{loc} & \cos\varphi_{loc}\cos\theta_{loc} \\ \cos\theta_{loc} & -\sin\varphi_{loc}\sin\theta_{loc} & \cos\varphi_{loc}\sin\theta_{loc} \\ 0 & \cos\varphi_{loc} & \sin\varphi_{loc} \end{bmatrix}$$

Second transformation is from Earth spherical coordinate (IJK) to instrument coordinate (XYZ)

$$T_{XYZ/IJK}^{sat} = (T_{IJK/XYZ}^{sat})^T = \begin{bmatrix} \vec{x} & \vec{y} & \vec{z} \end{bmatrix}^T$$

The beam vector in instrument coordinate (XYZ) can be obtained from observed beam vectors in geodetic coordinate (ENU) by,

$$\vec{b}_{XYZ} = T_{XYZ/IJK}^{sat} T_{IJK/ENU}^{loc} \vec{b}_{ENU}$$

	K	Ka	V	W	G
Roll	-0.0525	0.1645	-0.1967	-0.0103	0.0186
Pitch	0.3538	0.4388	0.1992	-0.0219	-0.0132
Yaw	-0.0938	-0.0594	-0.0524	0.0682	-0.0954

Summary

- S-NPP ATMS in-track and cross-track geolocation errors meet the requirement

- According to this study, ATMS in-track and cross-track geolocation error is,
  - (-0.0466, -0.0046) for K-band
  - (-0.0587, 0.0257) for Ka-band
  - (-0.0251, -0.0232) for V-band
  - (0.0043, 0.0032) for W-band
  - (0.0023, 0.0075) for G-band

- A rotation correction matrix is derived based on the analysis to improve the geolocation accuracy

Path Forward

- STAR ICVS will add S-NPP ATMS geolocation accuracy long term trending parameters
- Attempt to implement geolocation correction in OPS
- Validate JPSS-1 ATMS mounting matrix