



Abstract: For the quantitative applications of the Suomi **National Polar-orbiting Partnership (SNPP) Advanced Technology Microwave Sounder (ATMS), the geolocation accuracy of its sensor** data records must be quantified during its on-orbit operation. In this study, a mathematical model is built up to relate the ground geolocation error to the boresight pointing error in terms of Euler angles defined in spacecraft coordinate system. A retrieval algorithm is developed to derive the boresight pointing Euler angles based on the established mathematical model and the refined coastline inflection point method. Numerical simulation results show that by using this method, the retrieval error can be reduced from 42% to 6%. The correction matrixes constructed by the retrieved Euler angles can be directly applied into the SNPP **ATMS on-orbit geolocation process. After correction, the absolute** on-orbit in-track/cross-track geolocation error at nadir is reduced to 0.5/0.4km at K band, 0.6/0.7 km at Ka band, 0.4/0.02km at V band, and 0.1/0.2 km at W band.

Geolocation Error Mathematical Model

The geolocation mathematical model is established in spacecraft coordinate system (SC). \overline{b}_{SC} and b'_{SC} are the beam vectors with and without geolocation bias respectively. ROT_{corr} is the correction matrix and its elements are defined by Euler angle ξ_r , ξ_p , and ξ_v .

 $ROT_{corr} = ROT_{v}(\xi_{v}) \cdot ROT_{r}(\xi_{r}) \cdot ROT_{p}(\xi_{p})$

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 $= |sin\xi_{\gamma}cos\xi_{p} + cos\xi_{\gamma}sin\xi_{r}sin\xi_{p} - cos\xi_{\gamma}cos\xi_{r}|$ $-\cos\xi_r\sin\xi_p$

 $sin\xi_r$

 $[cos\xi_y cos\xi_p - sin\xi_y sin\xi_r sin\xi_p - sin\xi_y cos\xi_r cos\xi_y sin\xi_p + sin\xi_y sin\xi_r cos\xi_p]$ $sin\xi_{v}sin\xi_{p} - cos\xi_{v}sin\xi_{r}cos\xi_{p}$ $cos\xi_r cos\xi_p$



SNPP ATMS On-orbit Geolocation Error

Evaluation and Correction Algorithm

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Sensitivity of Geolocation error to Euler angles

The sensitivity of in-track and cross-track geolocation errors to each Euler angle is studied by using the geolocation error mathematical model. For the FOV near sub-satellite point, in-track error is only sensitive to pitch angle and cross-track error is only sensitive to roll angle. For the FOV beyond nadir, yaw angle is much more sensitive to in-track error than cross-track error.



Retrieval Algorithm for ATMS Pointing Errors

The sensitivity study indicates possibility to retrieve roll, pitch and yaw independently. The cross-track and in-track error at nadir can be used to retrieve roll and pitch respectively while the in-track error beyond nadir can be used to retrieve yaw. Before retrieving yaw, the geolocation error in b_{SC} caused by roll and pitch need to be corrected first.

$$min\sum_{i=1}^{N} \left| \vec{b}'_{SC} - ROT_{j}(\xi_{j}) \cdot \vec{b}_{SC} \right|_{l_{2}}^{2}, -\frac{\pi}{2} \le \xi_{j} \le \frac{\pi}{2}, \ \mathbf{j}=\mathbf{r}, \mathbf{p}, \mathbf{y}$$

In equation above, N is the number of samples and ROT_i is the rotation matrix corresponding to roll, pitch, or yaw.

The improved coastline inflection point (CIP) method is applied to identify the samples of ground truth and observed coast point containing in-track or cross-track error. High resolution VIIRS cloud products are used to identify clear-sky observations. A total of 24 regions without islands are selected, each with a coastline along in-track or cross-track directions.

ATMS Geolocation Error Retrieval Result

ATMS observations in June-August, 2016 are used to retrieve the Euler angles of SNPP ATMS beam alignments.

	Ch.	Euler Angle (°) (Number of Samples)		
		Roll	Pitch	Yaw
	1	-0.034 (47)	0.229 (150)	-0.031 (6314)
	2	0.161 (46)	0.328 (152)	0.052 (6693)
	3	-0.207 (53)	0.128 (148)	-0.191 (5745)
	16	-0.069 (52)	-0.107 (151)	0.006 (6277)

Retrieval Accuracy Evaluation

Euler angles of misalignment is perturbed from -1° to 1° at 0.2 added into the intervals and observations. The retrieved Euler angles are compared with the simulated truth to assess the the retrieval accuracy ot algorithm.



On-orbit SNPP ATMS Geolocation Error Correction

Beam misalignment correction matrix for on-orbit SNPP ATMS geolocation can be rebuilt by the retrieved Euler angles. ATMS observations in June-August, 2014 are corrected with the updated correction matrix. As showed in the following figure, the reduction in the geolocation error near nadir and the in-track error beyond nadir indicates that the retrieved Euler angles are reliable. The insufficient correction to the cross-track error towards the end of scan line is due to the irregularity of the vertical coastlines.



A geolocation error mathematical model was established, which connects the beam misalignment in Euler angles to geolocation error. This mathematical model, combined with the improved coastline inflection point method, was used to develop a retrieval algorithm of Euler angles. This algorithm has an accuracy of 6%. SNPP ATMS Euler angles were retrieved and applied to rebuild the misalignment correction matrix for on-orbit geolocation correction. The geolocation error mathematical model and beam misalignment retrieval algorithm developed in this paper is not limited to ATMS. They can be applied to transparent window channel of spaceborne microwave any observations.

References

Zhou J., H. Yang, and F. Z. Weng, "SNPP ATMS On-orbit Geolocation Error Evaluation and Correction Algorithm", IEEE Trans. Geosci. Remote Sens., 2017, under the third round review. Han Y., F. Weng, X. Zou, H. Yang, and D. Scott, "Characterization of geolocation accuracy of Suomi NPP advanced technology microwave sounder measurements," J. Geophys. Res., 121, doi: 10.1002/2015JD024278, Apr. 2016. Tang F., X. Zou, H. Yang, and F. Weng, "Estimation and correction of geolocation errors in Feng Yun-3C microwave radiation imager data," IEEE Trans. Geosci. Remote Sens., vol. 54, no. 1, pp.407-420, Jan. 2016.







