

Algorithm and Theoretical Basis Document (ATBD)

NOAA Oceansat-3 (EOS-06) Scatterometer Data Products

Prepared by:

NOAA/NESDIS/STAR Ocean Surface Winds Science Team
Seubson Soisuvarn (UCAR), Zorana Jelenak (UCAR), Paul S. Chang (NOAA/NESDIS/STAR)

Version: 1.1

Date: October 2025

Table of Contents

1. INTRODUCTION	2
2. OSCAT-3 DATA PRODUCTS	2
3. LEVEL-2A (L2A) ALGORITHM	3
4. LEVEL-2B (L2B) ALGORITHM	3
5. RAIN IMPACT AND QUALITY CONTROL	5
6. NEAR REAL-TIME (NRT) DATA MONITORING	7
7. REFERENCES	8

- **Rain Rate Product:** A machine learning-based estimation included as supplementary information in the L2B NetCDF data product to identify rain-impacted wind retrievals.
- **NRT Data Monitoring:**

3. LEVEL-2A (L2A) ALGORITHM

3.1. Grid Cell Generation

The L2A processing transforms L1B scan-by-scan data into a gridded swath format. The algorithm uses satellite state vectors to interpolate position and velocity for each pulse. Grid cell indices (row and column) are computed by calculating relative distances parallel and perpendicular to the orbit based on the Space Oblique Mercator transformation. For a 12.5 km grid, there are 3,248 cells in a full orbit along-track and 152 cells across-swath.

3.2. Sigma0 Grouping (Compositing)

Sigma0 measurements are grouped per beam, pulse, and grid cell. Composite parameters, including latitude, longitude, sigma0 (σ^0), and brightness temperature (T_B), are calculated using a weighted average based on the X-factor. This results in "four flavors" of sigma0 for each WVC: fore-look VV, aft-look VV, fore-look HH, and aft-look HH.

4. LEVEL-2B (L2B) ALGORITHM

4.1. Preprocessing and Calibration

Before wind inversion, sigma0 values are corrected for two-way atmospheric attenuation using a global monthly climatology. Calibration offsets are applied to account for sensor drift and version updates from ISRO's L1B data. Table 1 summarizes the calibration period for each polarization [2].

Table 1: Sigma0 Calibration Values

Calibration Period	VV	HH	Note
Sept 2023 (Initial)	0.0 dB	-0.65 dB	10 days period
Aug 2024 (updated)	-0.22 dB	-0.88 dB	10 days period
May-July 2025 (updated)	0.21 dB	-0.47 dB	v1.0.4
Oct–Nov 2025 (current)	0.19 dB	-0.49 dB	v1.0.5

4.2. Wind Inversion and Solution Ranking

Wind speed and direction are determined through Maximum Likelihood Estimation (MLE), minimizing the difference between measured sigma0 and predicted values from the NOAA SCATSAT-1 GMF [3]. The process steps through wind directions increments to identify up to four local maxima, or ambiguities.

4.3. Ambiguity Removal

To select a unique, meteorologically consistent wind vector, NOAA utilizes a combination of the Multi-Solution Scheme (MSS), Direction Interval Retrieval with Thresholded Nudging (DIRTH) [4], and Variational Data Assimilation (VAR). The Numerical Weather Prediction (NWP) model winds is used as a "first guess" to guide the selection of the most likely vector.

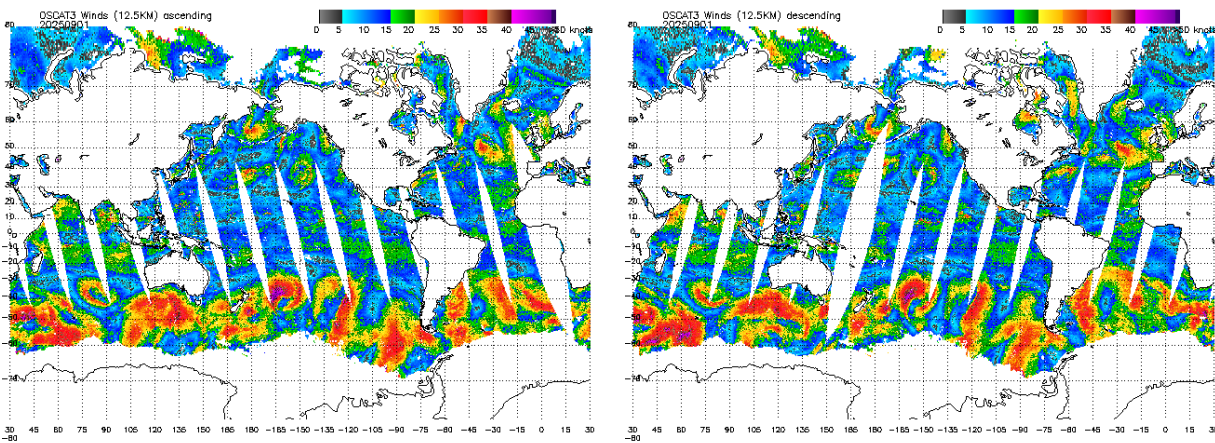


Figure 2: Near Real-Time OSCAT3 Display.

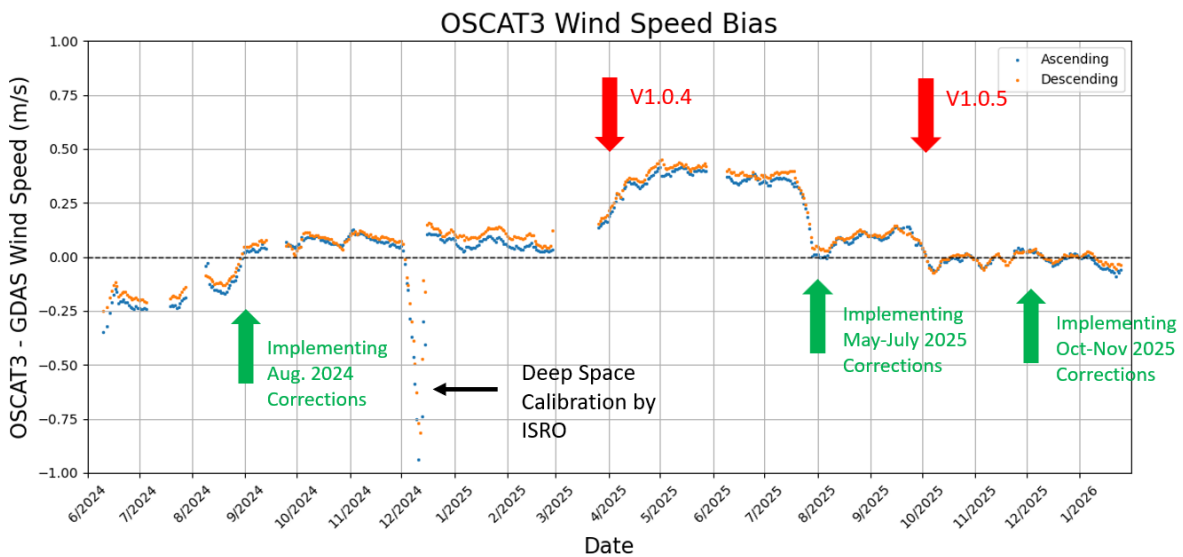


Figure 3: OSCAT3 wind speed biases before/after implementing calibration corrections.

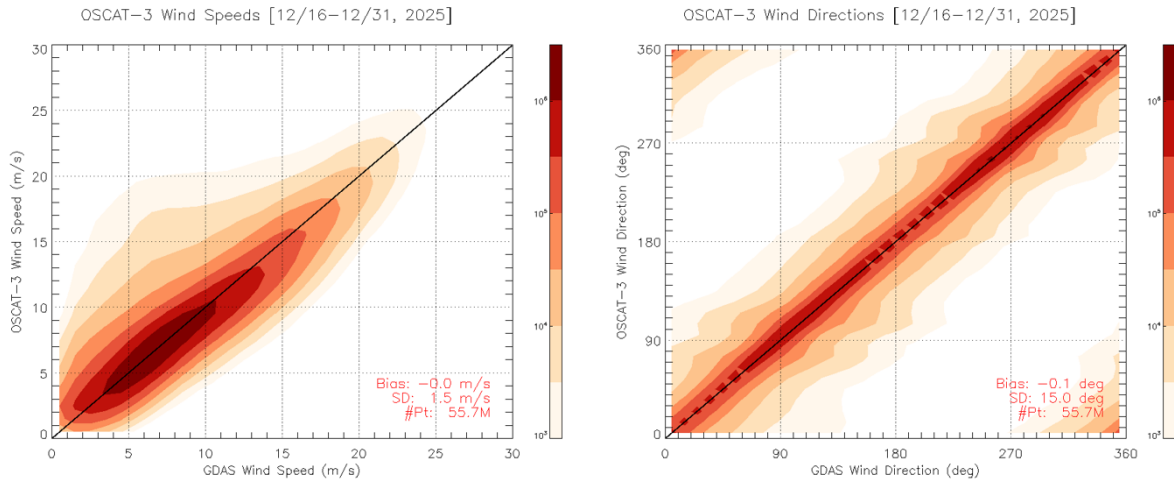


Figure 4: OSCAT3 Wind Vectors Validation.

5. RAIN IMPACT AND QUALITY CONTROL

5.1. Machine Learning Rain Estimation

OSCAT-3 rain rates are estimated using a Support Vector Machine (SVM) algorithm. The model is trained on brightness temperature T_B , NWP sea surface temperature (SST), and OSCAT-3 retrieved wind speeds [5]. Significant drifts in T_B measurements observed in late 2023 required the implementation of correction offsets to maintain accuracy. Table 2 summarizes the update T_B offset for each period [2].

Table 2: T_B Offset Values

Calibration Period	VV	HH	Note
Sept 2023 (Initial)	0.0 K	0.0 K	10 days period
Aug 2024 (updated)	-32.8 K	-30.7 K	10 days period
May-July 2025 (updated)	21.9 K	17.4 K	v1.0.4
Oct-Nov 2025 (current)	-9.6 K	-7.5 K	v1.0.5

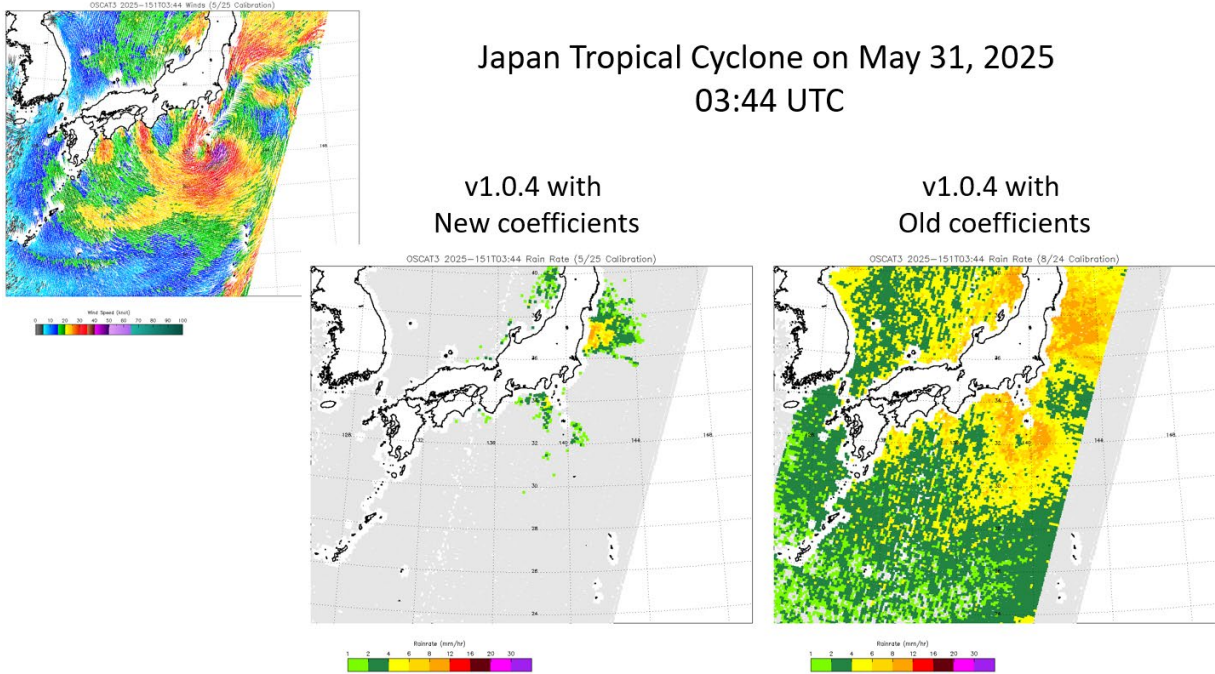


Figure 5: OSCAT3 Rain Rate before and after updated brightness temperature offset in v1.0.4.

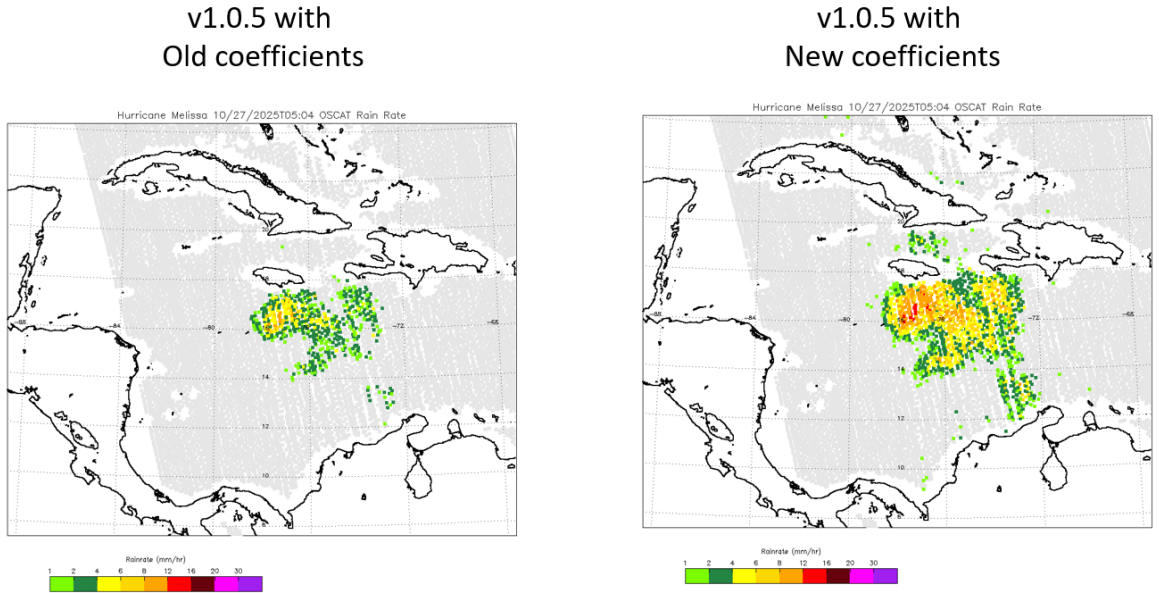


Figure 6: OSCAT3 Rain Rate before and after updated brightness temperature offset in v1.0.5.

5.2. Quality Control and Rain Flagging

The L2B product includes several quality flags to identify valid ocean data and contamination.

- **Rain Flag:** Activated when the estimated rain rate exceeds 1.5 mm/hr.
- **NOAA Overall Flag:** Summarizes multiple QC factors, including invalid sigma0, land/ice contamination, and unsuccessful inversion.

The L2B quality control flags are summarized in Table 3

Table 3: L2B Quality Flags Definition

Bit No.	Meaning if Equal to 0	Meaning if Equal to 1
0	Sigma0 is valid	Sigma0 is invalid
1	Model winds are valid	Model winds are invalid
2	Land model is not detected	Land model is detected
3	Ice model is not detected	Ice model is detected
4	Usable sigma0 detected	No usable sigma0 detected
5	Land contamination not detected	Land contamination detected
6	Ice contamination not detected	Ice contamination detected
7	More than two azimuth look	Two or less azimuth look
8	Wind inversion is successful	Wind inversion is not successful
9	NOAA overall quality flag is not detected	NOAA overall quality flag is detected
10	Wind inversion is not attempt	Wind inversion is attempt
11	Rain flag is not usable	Rain flag is usable
12	Rain is not detected	Rain is detected

6. NEAR REAL-TIME (NRT) DATA MONITORING

To mitigate the impact of unannounced version changes from the data provider, NOAA has implemented dedicated NRT monitoring. This system allows the team to rapidly re-calibrate coefficients, ensuring wind and rain product stability for operational users.

- **Sigma0 Monitoring:** Continuous daily tracking of measured versus simulated sigma0 to detect sensor drift or abrupt jumps caused by ground system updates (e.g., transitions to v1.0.4 and v1.0.5).
- **TB Monitoring:** Ongoing monitoring of brightness temperature values to identify shifts that would lead to erroneous rain rate estimations.

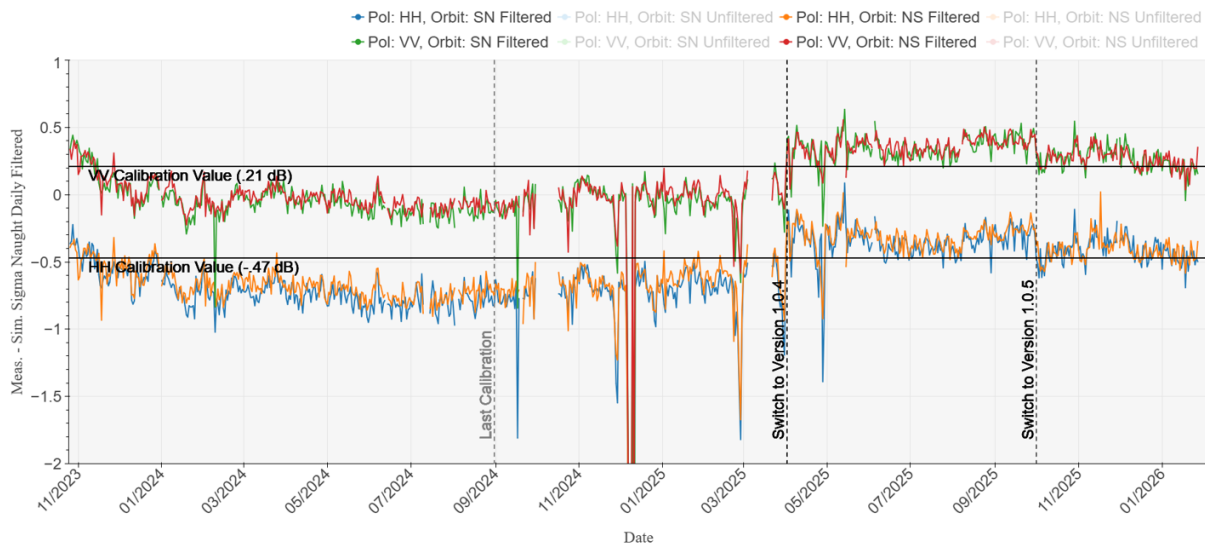


Figure 7: OSCAT3 Daily Sigma0 Biases Monitoring.

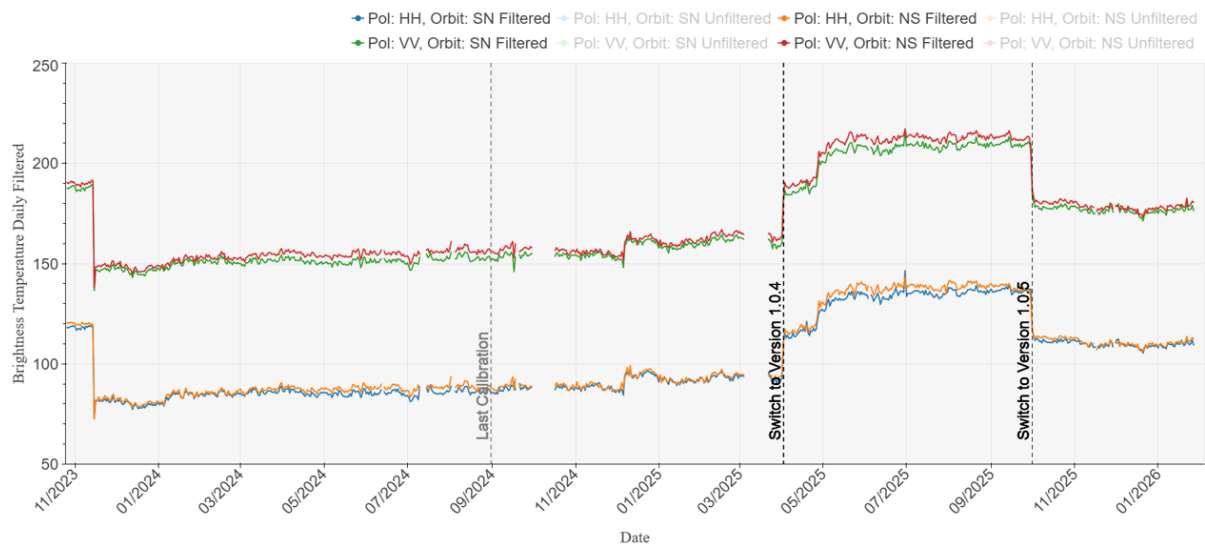


Figure 7: OSCAT3 Daily Brightness Temperature Monitoring.

7. REFERENCES

1. Microwave Data Processing Division, Signal and Image Processing Group, Space Applications Center, Ahmedabad, "Formats for EOS-06 Scatterometer Data Products," E06/SCAT/DP-FORMAT-DOC/1.0/SEP2022, September 2022.
2. S. Soisuvarn, Z. Jelenak, P. S. Chang and Q. Zhu, "Calibration and Validation of NOAA Oceansat-3 Scatterometer Wind Data Products," *IGARSS 2025 - 2025 IEEE International*

Geoscience and Remote Sensing Symposium, Brisbane, Australia, 2025, pp. 4772-4776, doi: 10.1109/IGARSS55030.2025.11314028.

3. Soisuvarn, S.; Jelenak, Z.; Chang, P.; Park, J.; Zhu, Q.; Sapp, J.; Said, F. "Scatsat-1 High Winds Geophysical Model Function and its Winds Application in Operational Marine Forecasting and Warning," in *IEEE International Geoscience and Remote Sensing Symposium (IGARSS)*, 2020, pp. 5794-5797, doi: 10.1109/IGARSS39084.2020.9324328.
4. B. W. Stiles, B. D. Pollard and R. S. Dunbar, "Direction interval retrieval with thresholded nudging: a method for improving the accuracy of QuikSCAT winds," in *IEEE Transactions on Geoscience and Remote Sensing*, vol. 40, no. 1, pp. 79-89, Jan. 2002, doi: 10.1109/36.981351.
5. S. Soisuvarn, Z. Jelenak, P. S. Chang and Q. Zhu, "A Machine Learning-Based Rain Rate Estimation from the OceanSat-3 Scatterometer Measurements," *IGARSS 2024 - 2024 IEEE International Geoscience and Remote Sensing Symposium*, Athens, Greece, 2024, pp. 5827-5830, doi: 10.1109/IGARSS53475.2024.10641001.