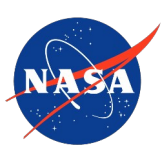

Remote Sensing Systems

Evaluation of COWVR as a Cost-Effective Sensor for Providing Climate Data Records of Ocean Vector Winds and Other Air-Sea Variables

IOVWST 2025 Meeting

2025-05-06

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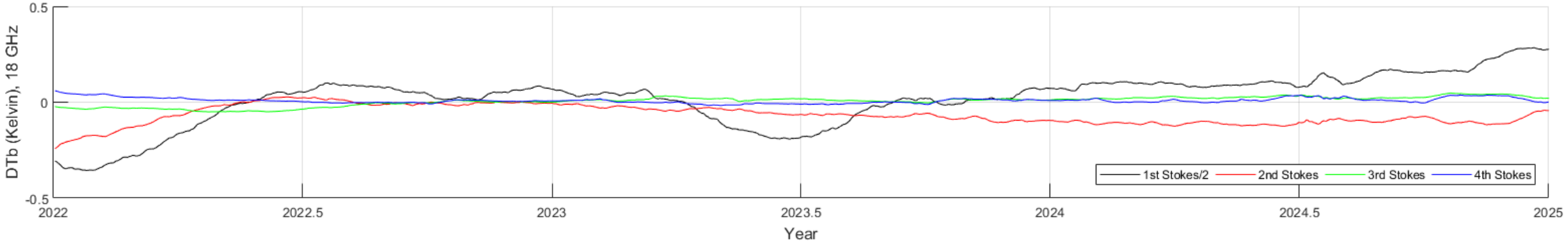
COWVR

- COWVR is a polarimetric microwave radiometer operating on the ISS since 2022-01-08
- The TB observations at 18.7, 23.8 and 33.9 GHz are used to retrieve ocean surface wind vectors, atmospheric water vapor, liquid cloud content, and rain rate
- For a climate data record, the retrievals of vector winds and other variables rely on an accurate TB calibration which is stable over time

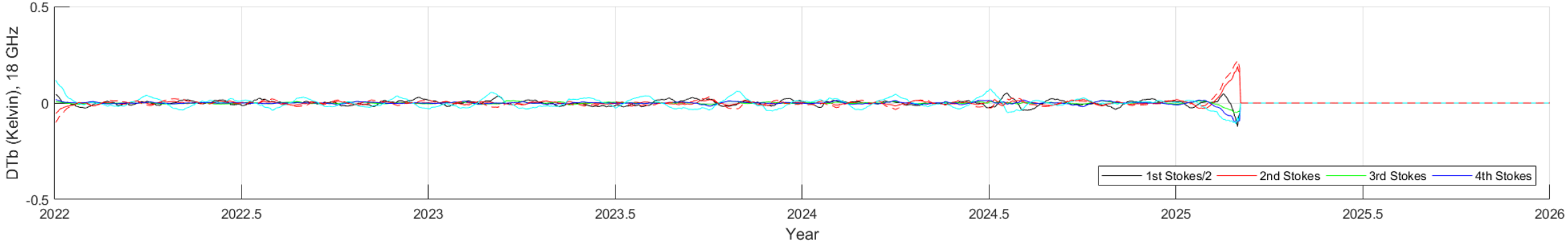
TB calibration and stability

- The COWVR TBs, from the JPL-produced TSDR files, are calibrated using the internal noise diodes and opportunistic cold sky observations.
- We apply an *additional* set of changes to ensure stability by tying the TBs from COWVR with TBs from GMI, an absolutely calibrated microwave radiometer.
  - COWVR TB bias offset is addressed with modified antenna spillover coefficients
  - Along-scan TB biases are removed
  - Time-varying TB biases are addressed using a ±30-day window comparing COWVR/GMI TBs

TB calibration and stability



Unmodified COWVR – RTM TBs for 18.7 GHz over the ocean, all polarizations

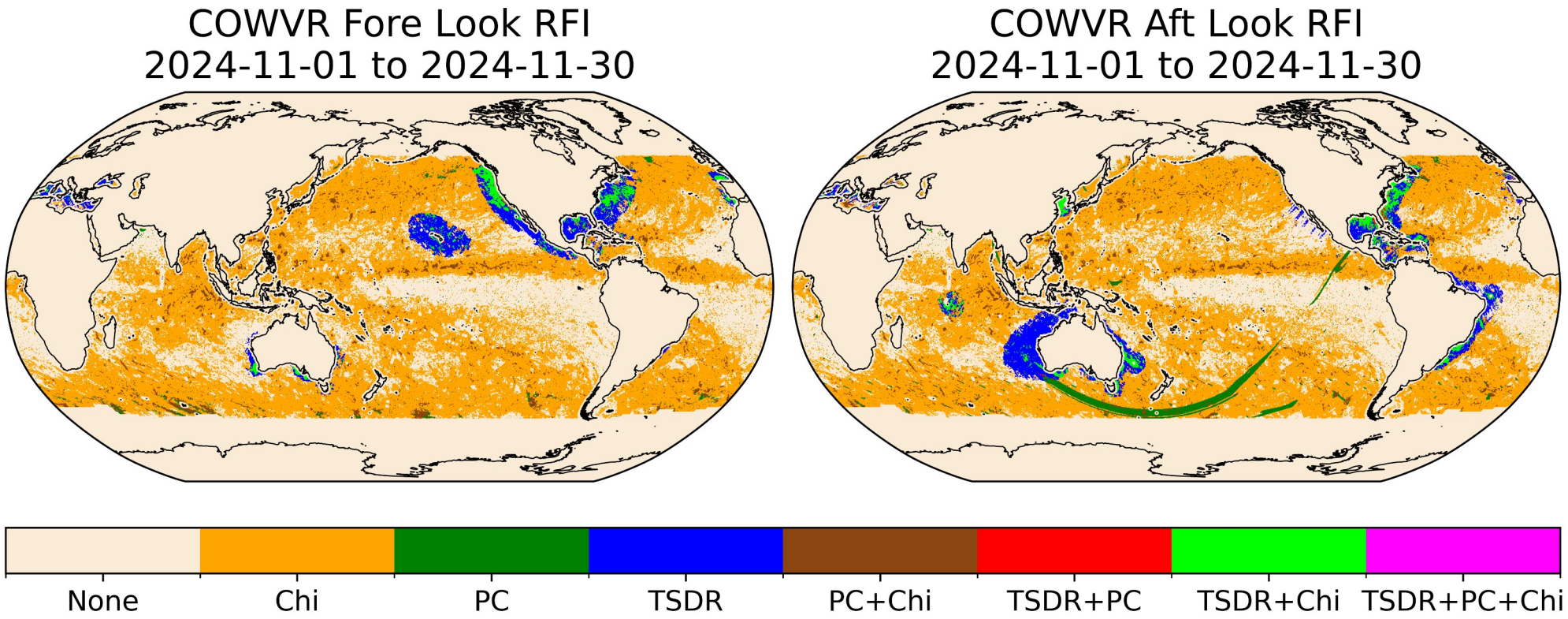


Modified COWVR – RTM TBs for 18.7 GHz over the ocean, all polarizations
(Note that the time ranges differ)

Flagging of RFI and other issues

- The JPL-produced TSDR product already flags most of the RFI and other degraded conditions. We apply additional checks to filter out suspect data:
  - Outliers are detected after a principal component (PC) transformation: the thresholds are set using 99.9% of the data
  - After wind retrieval, large values in the wind error term, χ^2, indicate undetected RFI, rain, or other error sources

Flagging of RFI and other issues



Flags for the fore look (left) and the aft look (right) showing the maximum value in November 2024.

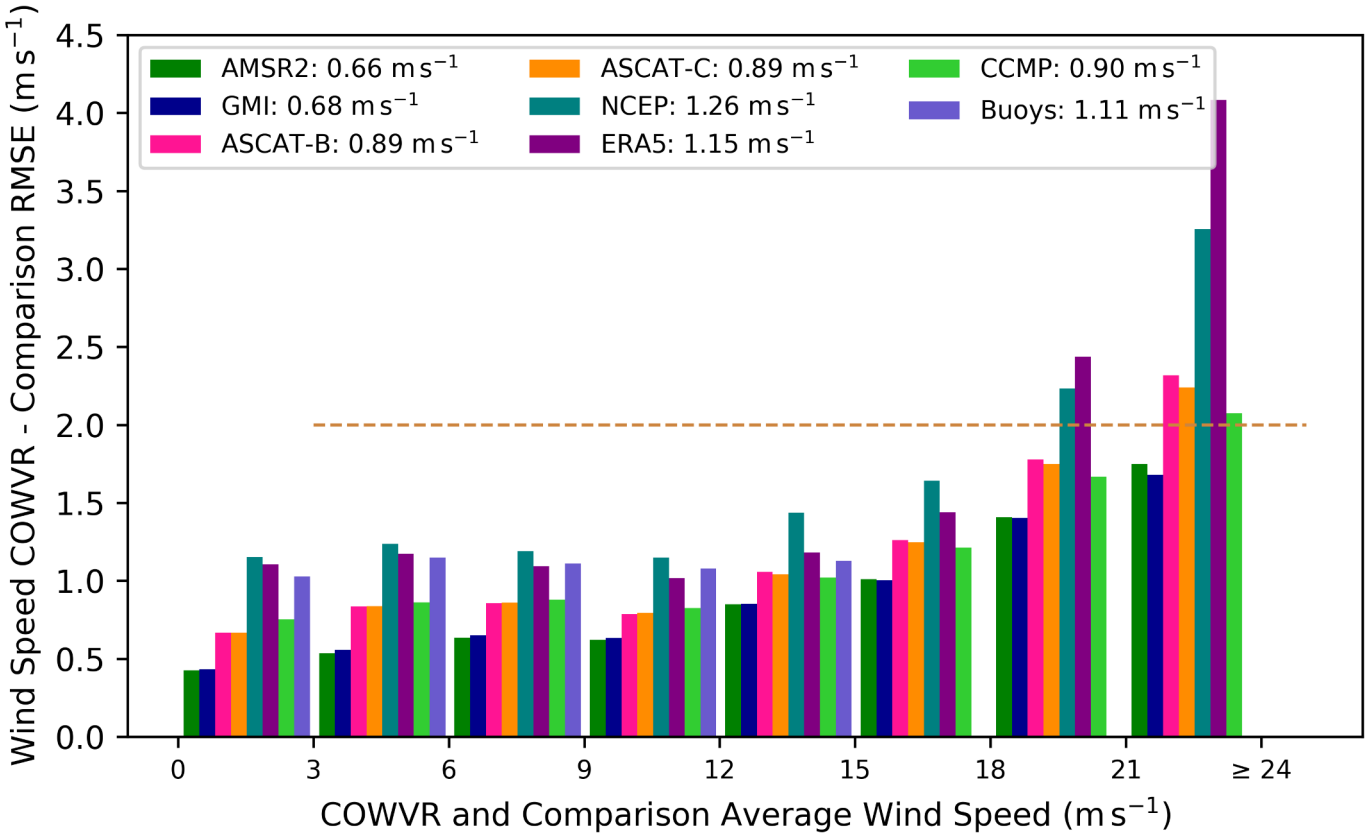
Chi/PC flags are set as described previously; the TSDR flag is from the JPL-produced data.

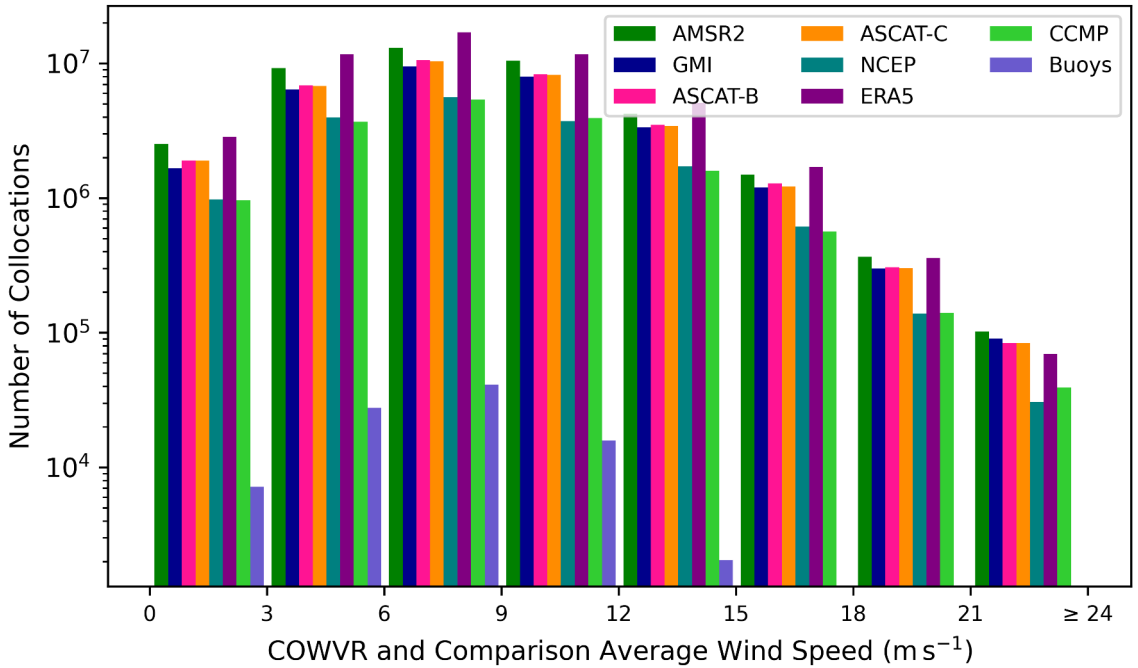
These flags were designed to flag RFI but in practice can also flag rain and bad scans.

COWVR wind validation

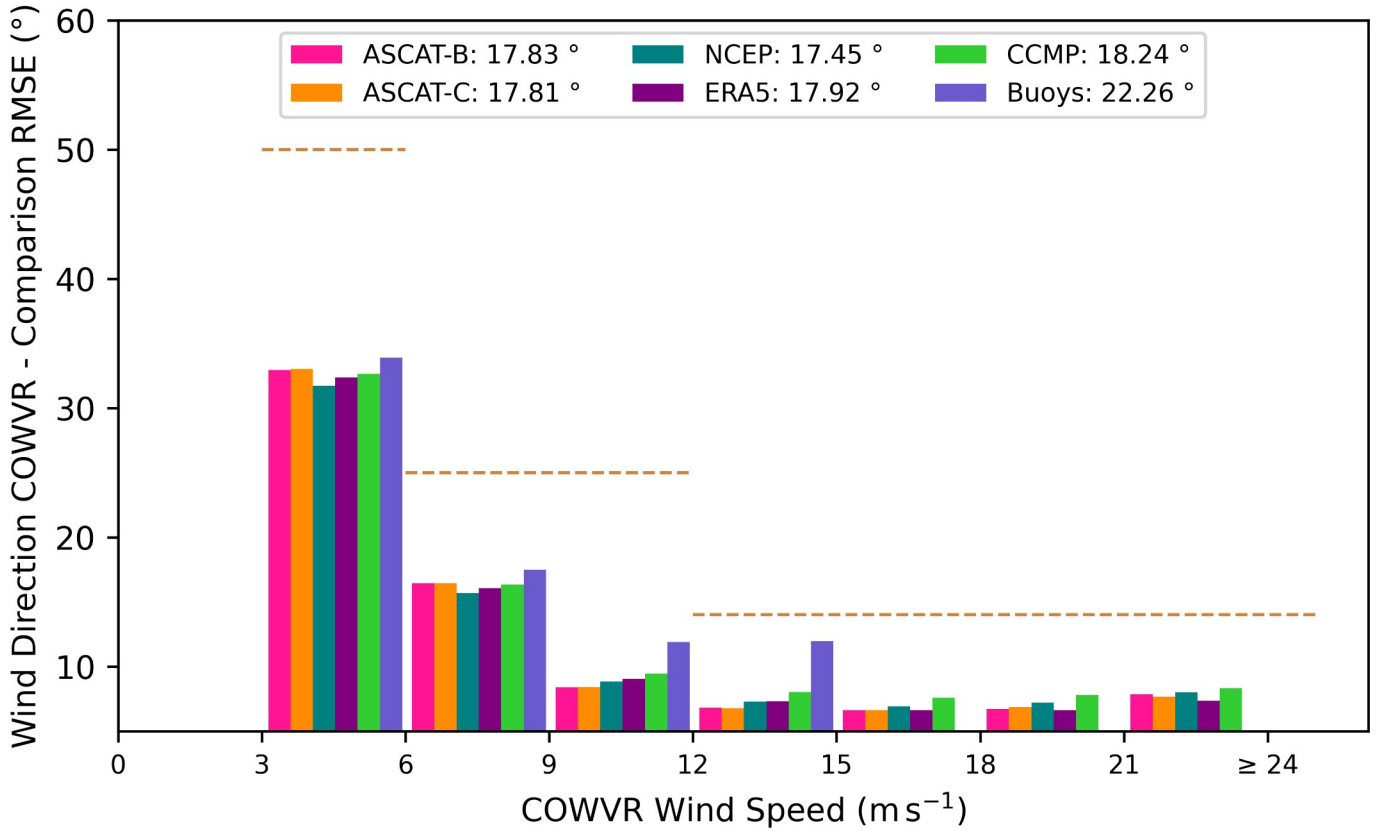
- The COWVR winds are compared against multiple sources:
  - Models: CCMP, ERA5, NCEP
  - Satellites: AMSR2, ASCAT-B, ASCAT-C, GMI
  - Buoys
- See appendix for matchup criteria

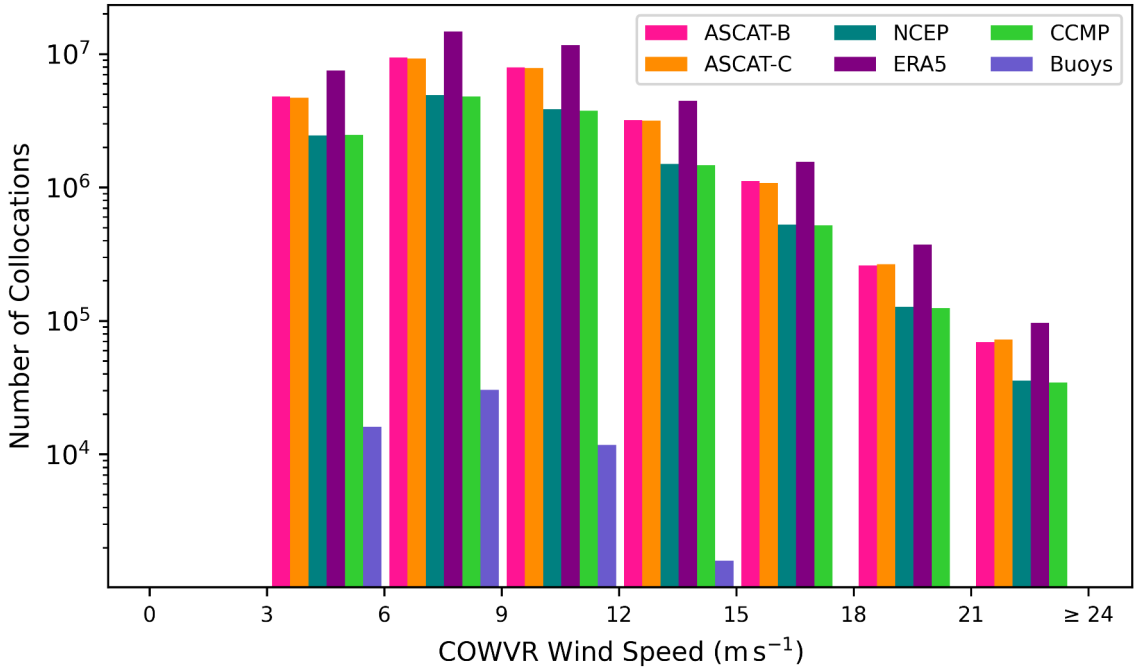
COWVR wind speed performance





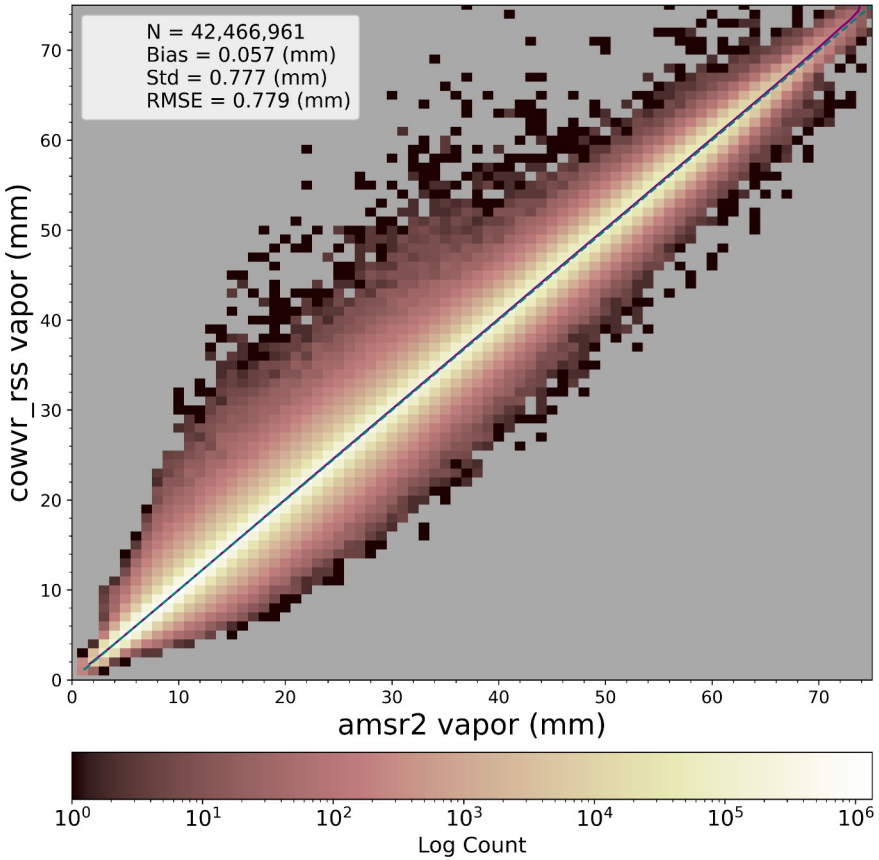
COWVR wind direction performance

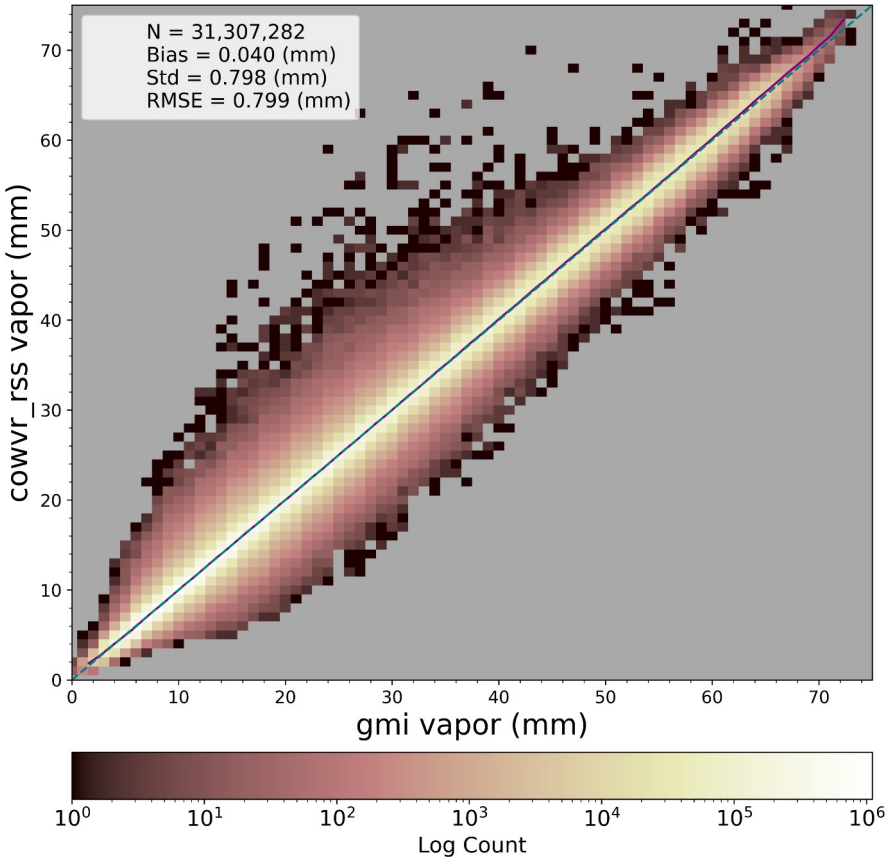




COWVR performance of air-sea variables

- The COWVR retrievals of columnar water vapor and cloud liquid water compare favorably with those from GMI and AMSR2.

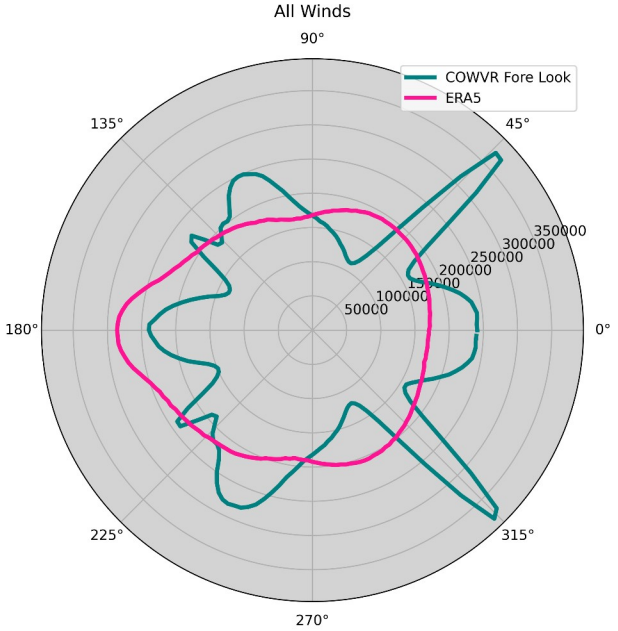




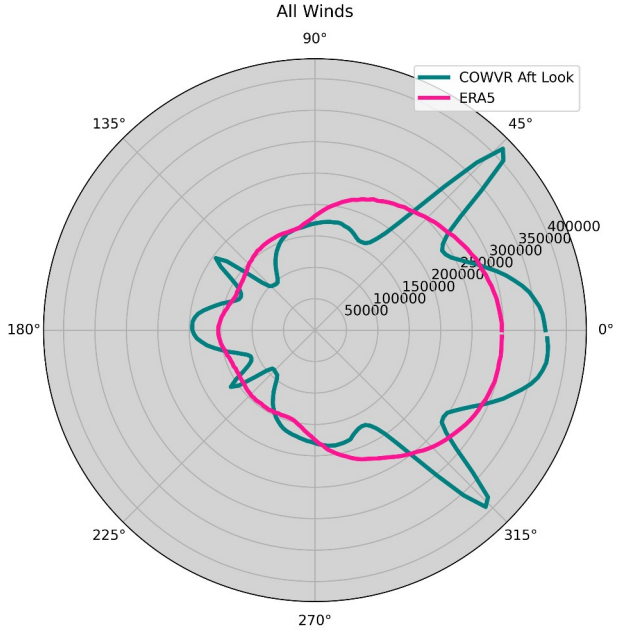
Wind directions using single or dual looks

- COWVR measures over the entire 360° scan angle range to observe the ocean surface at both fore and aft looks. (Data at swath edges is obscured from external blockages.) The dual-look geometry improves the wind direction performance.

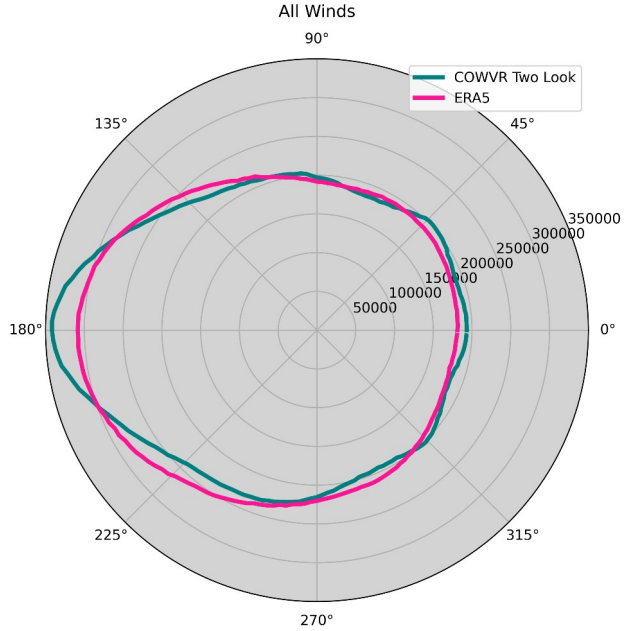
Fore-only relative wind directions



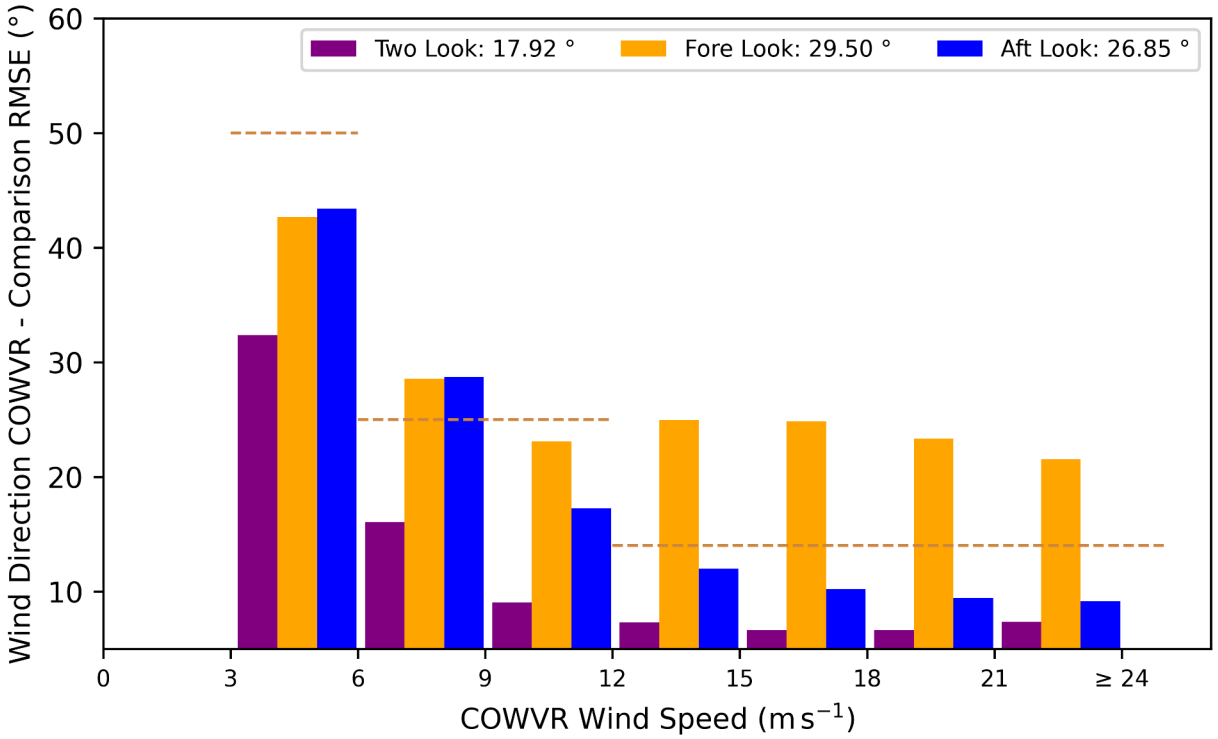
Aft-only relative wind directions



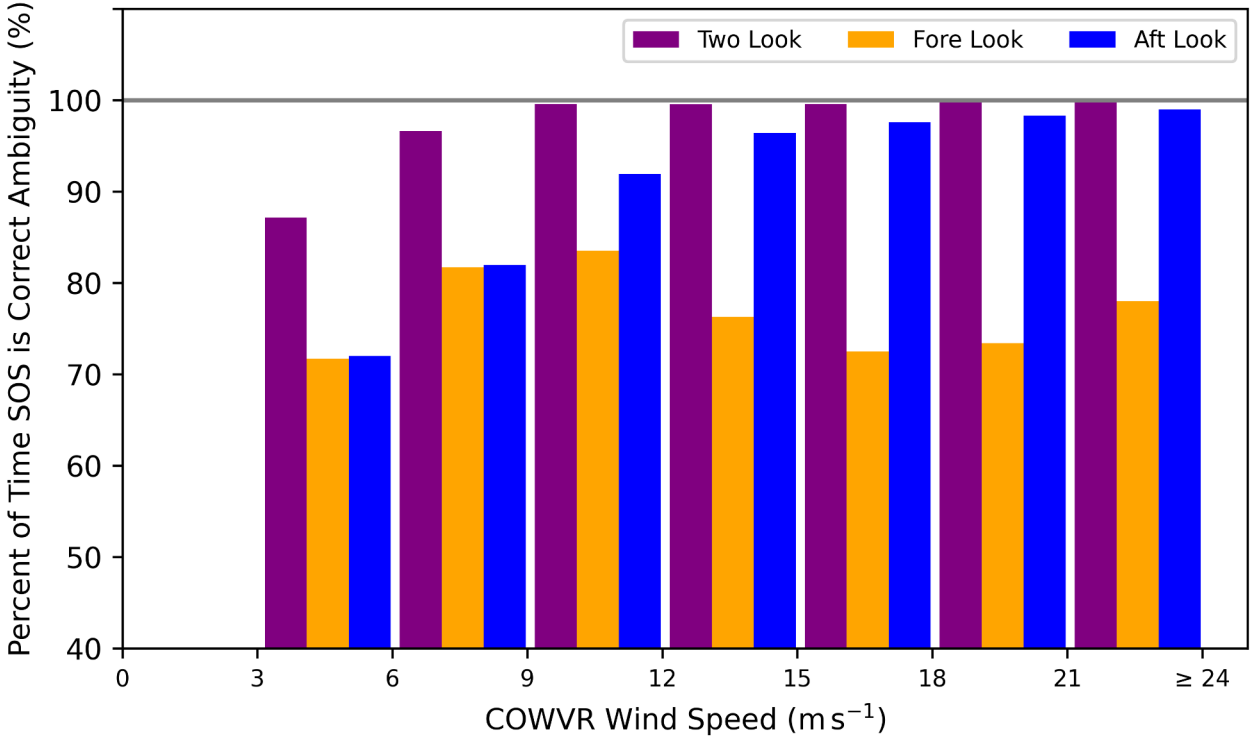
Dual-look relative wind directions



Wind directions using single or dual looks



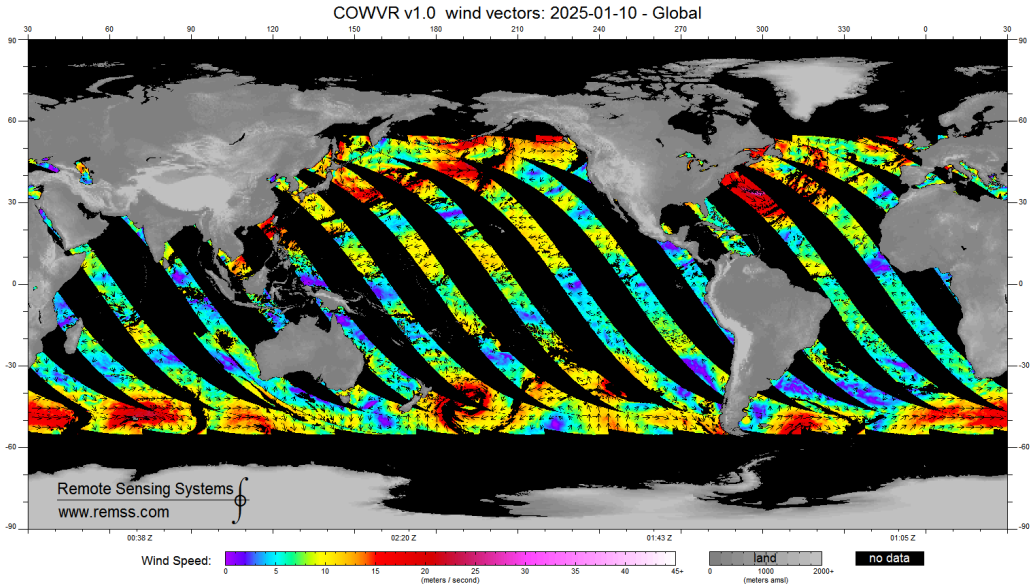
COWVR wind direction RMS error is lower when using both looks



The ambiguity skill (fraction of cases where the lowest-error ambiguity is the correct choice) increases when using both looks

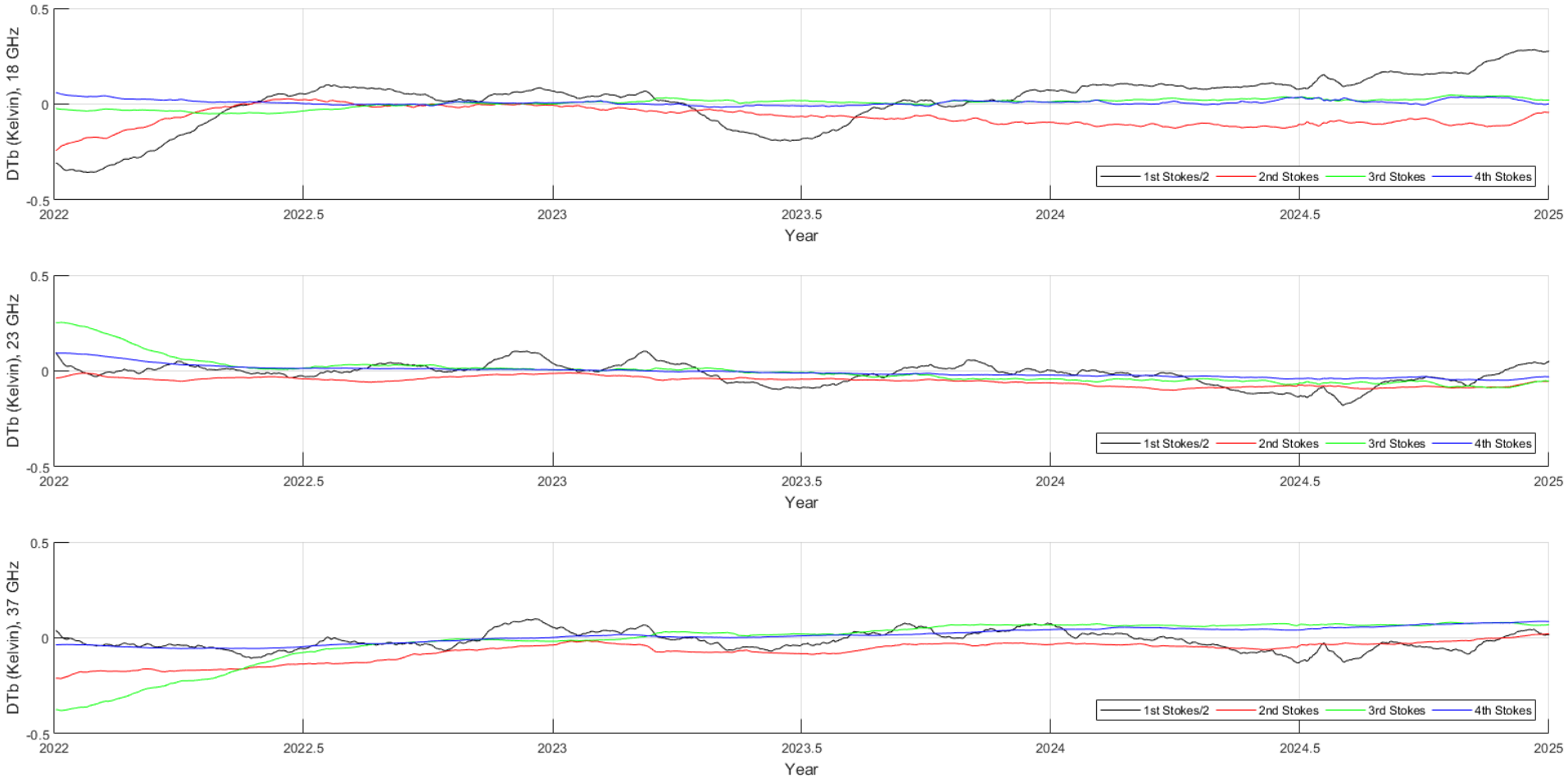
Data availability

- The RSS-produced data are available to the public
  - https://www.remss.com/missions/cowvr/
  - https://doi.org/10.56236/RSS-bu
- The data are in CF-compliant netCDF format on an Earth-oriented grid in daily and multi-day averages.



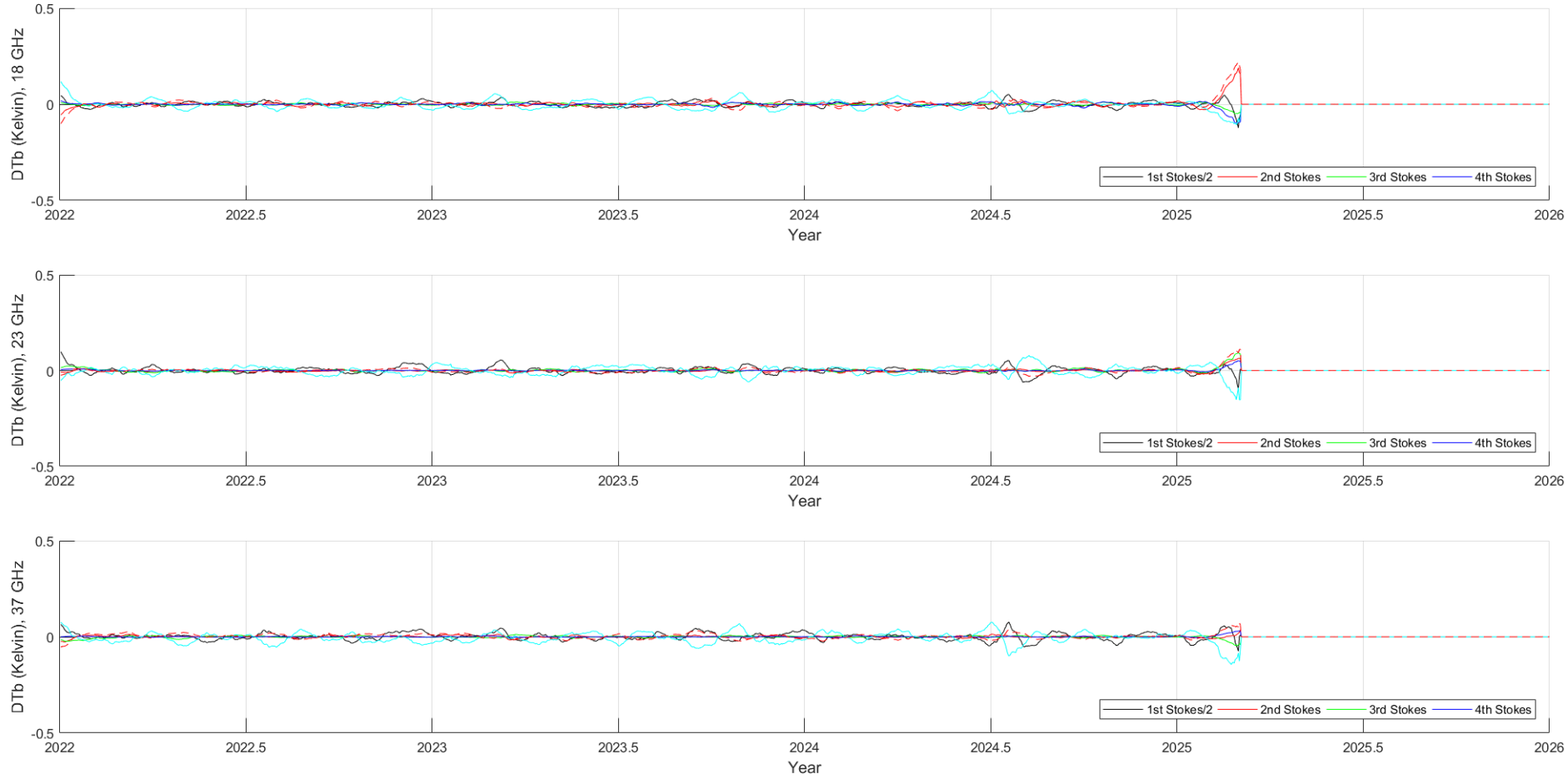
Appendix: extra slides

TB calibration and stability



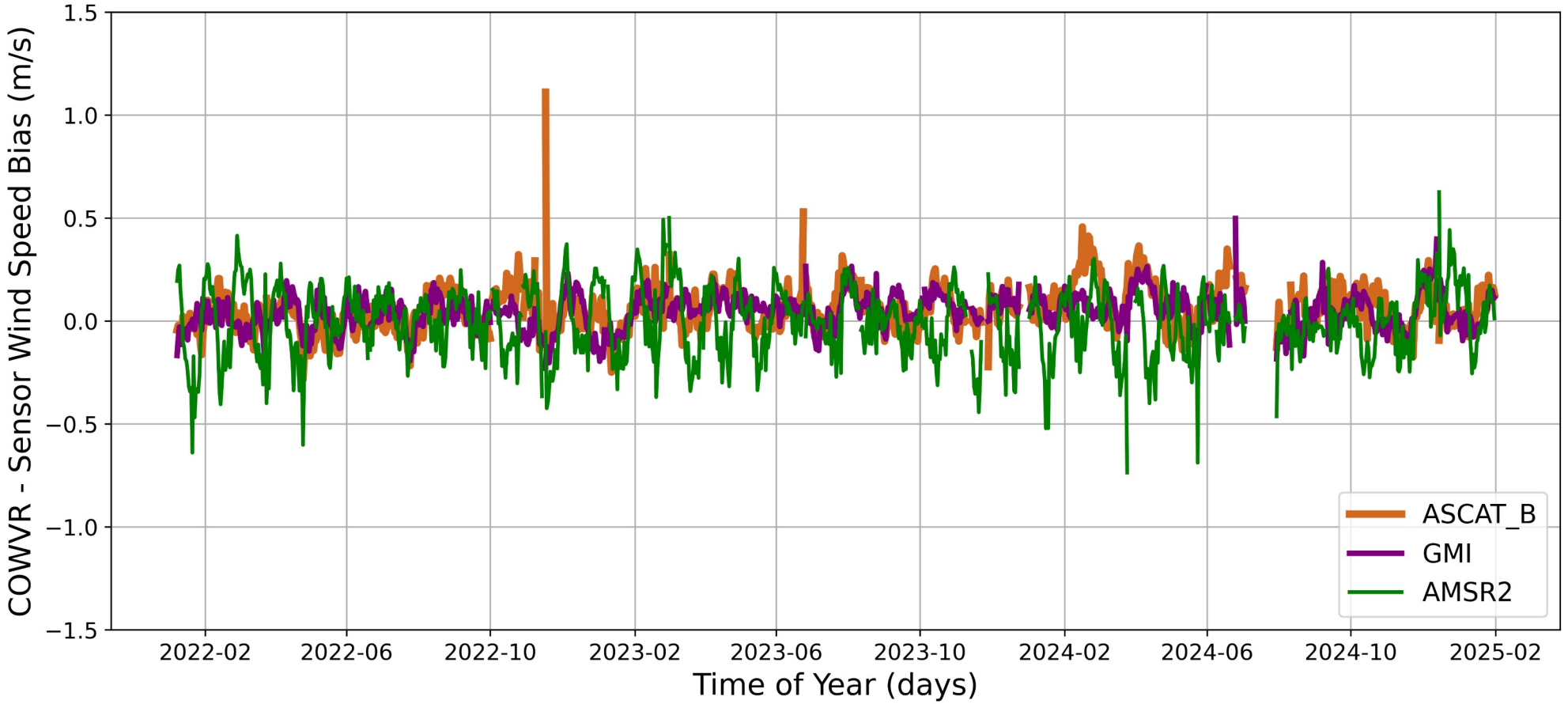
COWVR TB calibration over the ocean as a function of time. The panels show COWVR minus RTM TBs without any adjustment to the COWVR TBs. The first panel is 19 GHz, second is 24 GHz, and third is 34 GHz. The lines are the 0.5*1st Stokes (black), 2nd Stokes (red), 3rd Stokes (green), 4th Stokes (blue).

TB calibration and stability



COWVR TB calibration over the ocean as a function of time after the data has been adjusted to match GMI TBs. The panels show COWVR minus RTM TBs. The first panel is 19 GHz, second is 24 GHz, and third is 34 GHz. The lines are the 0.5*1st Stokes (black), 2nd Stokes (red), 3rd Stokes (green), 4th Stokes (blue).

Stability of wind retrievals

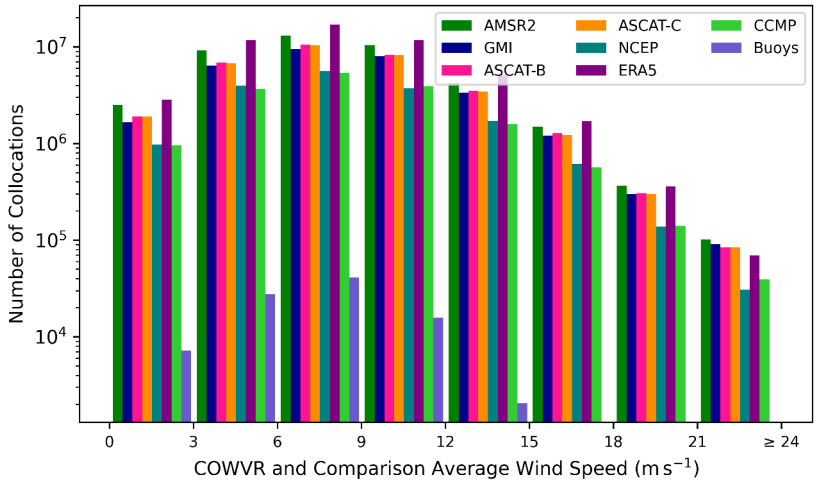


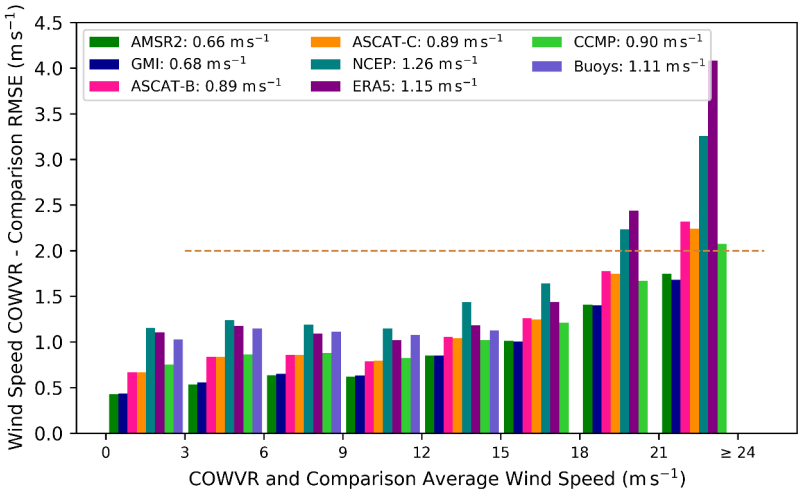
COWVR minus ASCAT-B, AMSR2, and GMI daily wind speed biases. Collocations are within 1 hour of the comparison datasets. The time range for the collocations extends from 2022-01-08 to 2025-01-31.

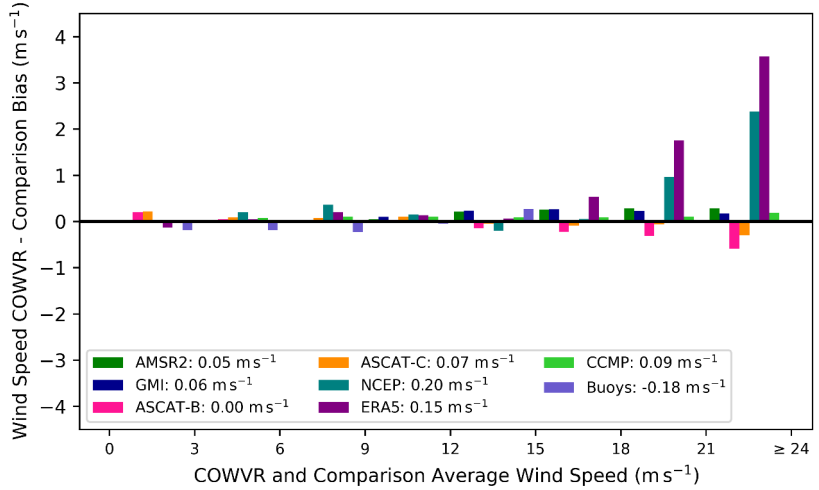
COWVR wind validation details

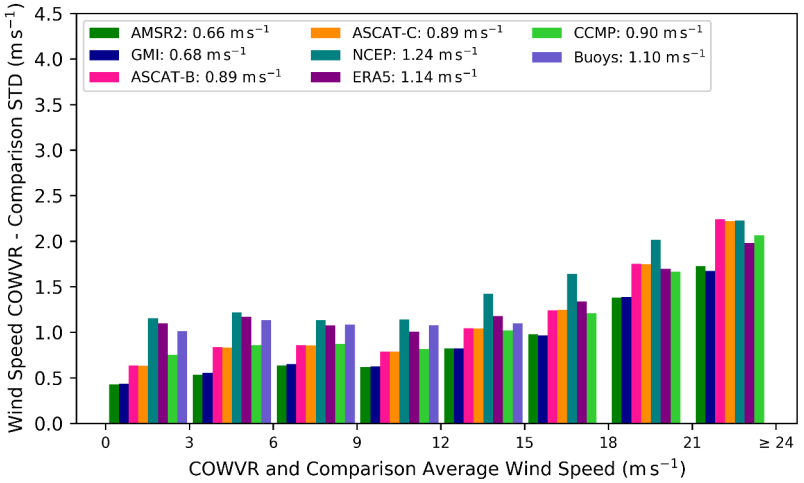
- Comparison sources
  - Models: CCMP v3.1, ERA5, NCEP 0.25°
  - Satellites: AMSR2, ASCAT-B, ASCAT-C, GMI (in all cases, the RSS-produced daily data)
  - Buoys: TAO, PIRATA, RAMA, MEDS buoy arrays
- Date range: 2022-01-08 through 2025-01-31
- Maximum time difference: 1 h
- Results are aggregated across wind speed bins every 3 m/s.
  - For wind speed plots: the binned wind speed is the *mean* of the COWVR wind speed and the comparison wind speed. (Equivalent to binning orthogonally to the 1:1 line.)
  - For wind direction results: the binned wind speed is the COWVR wind speed
- COWVR wind direction ambiguities: the ambiguity with the lowest χ^2 value is selected, and data removed where the wind direction difference > 90°
- Wind direction comparisons exclude data with wind speed < 3 m/s

COWVR wind speed performance

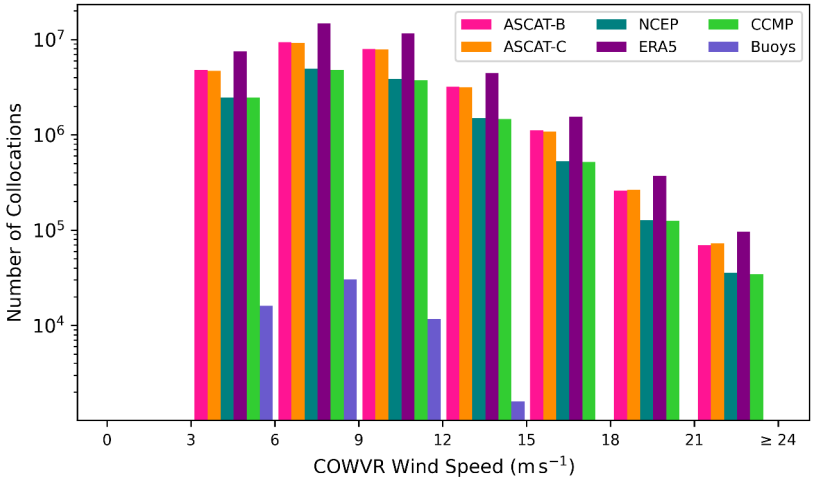


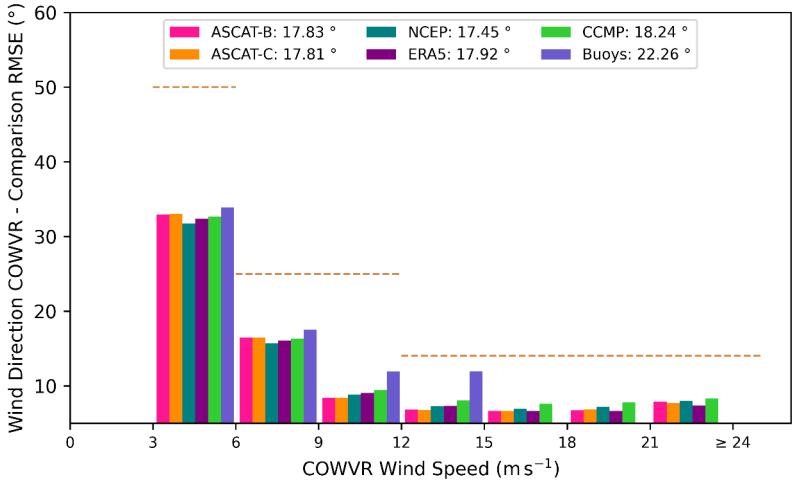


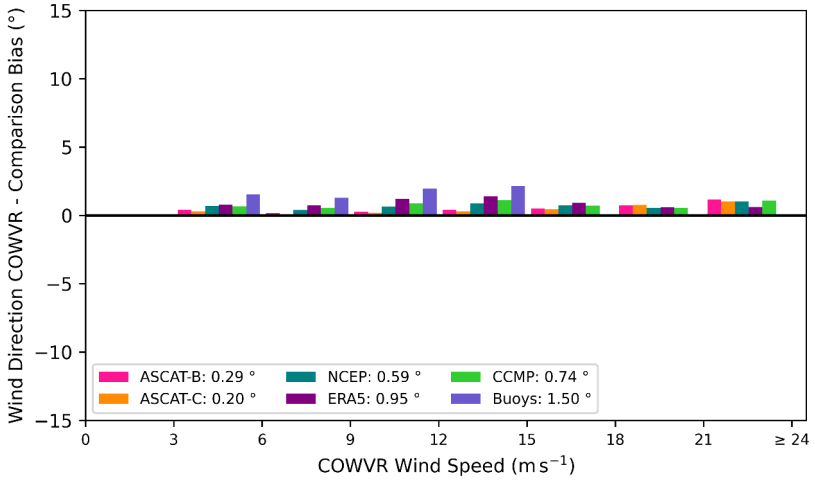


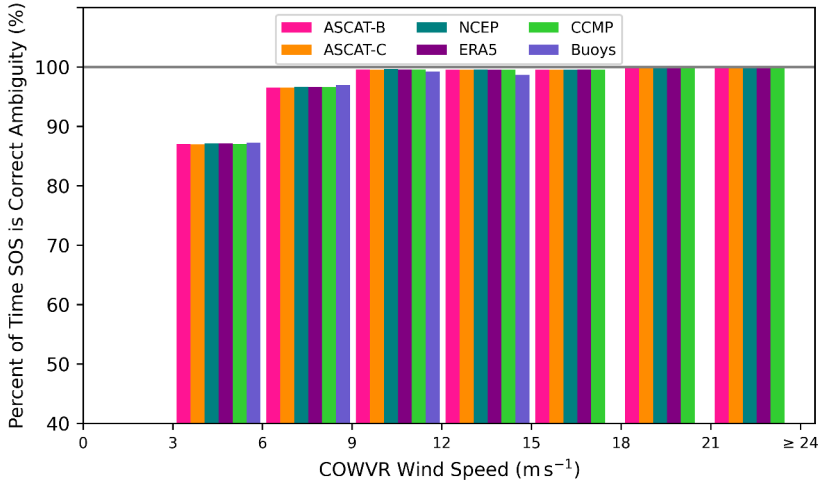


COWVR wind direction performance



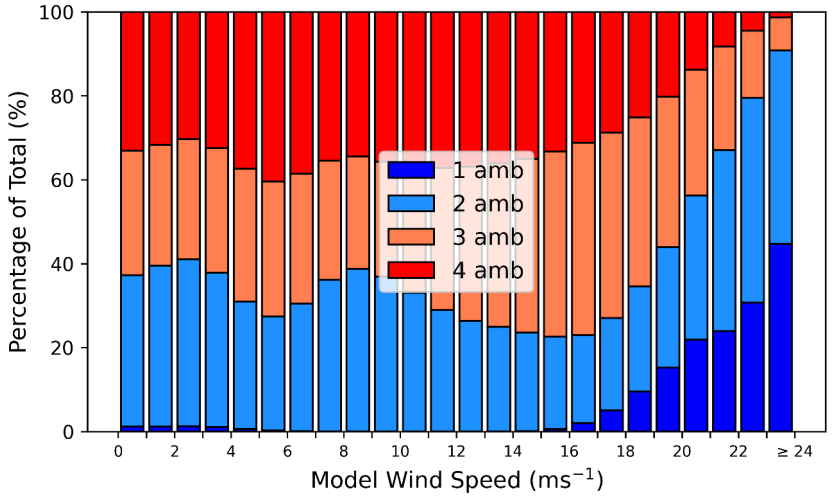




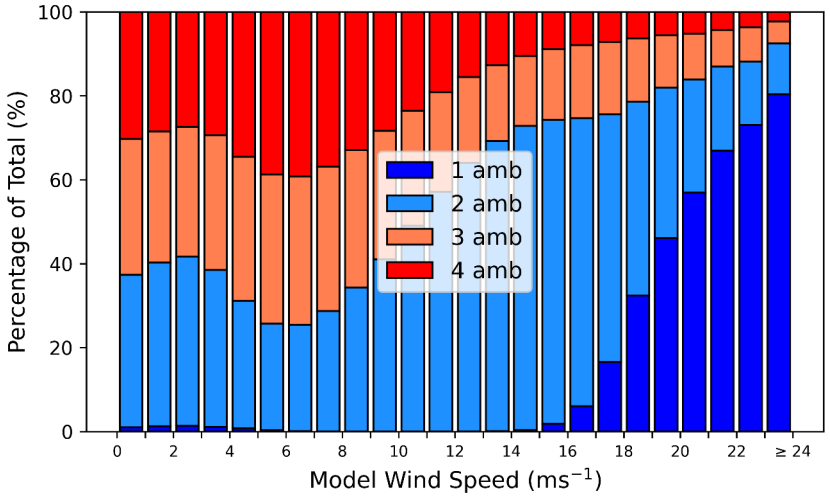


Wind directions using single or dual looks

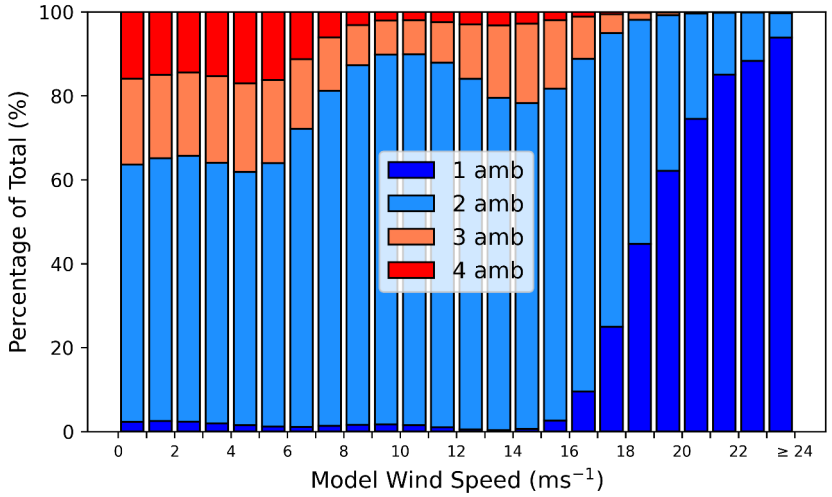
Fore-only



Aft-only



Dual-look



The number of wind ambiguities *decreases* when using both look directions