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Jet Propulsion Laboratory
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Compact Ocean Wind Vector Radiometer (COWVR) Mission: Current Calibration Status

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Abstract

Under the OVWST, the project team is responsible for supporting the COWVR project team in radiometric calibration and validation, in order to server the larger goals of the wind-vector community.

The COWVR radiometer design is unique, presenting unique calibration opportunities and challenges. COWVR does not use any external warm or cold loads for radiometer calibration and entirely relies on internal fully polarimetric calibration sources. Most importantly, the COWVR mechanical design allows the reflector antenna to spin around the feed axis, as opposed to needing to spin the whole radiometer assembly. This causes the input polarization basis viewed by the antenna feed to rotate with the rotation of the reflector, which is then compensated using Electronic Polarization Basis Rotation (EPBR). This unique architecture can cause systematic calibration effects between the two polarization channels, but also allow unique calibration behavior that can be taken advantage of.

Here we briefly describe the COWVR instrument and discusses the calibration challenges. We present initial calibration results with respect to pointing, polarimetric performance, as well as radiometric performance.

COWVR Introduction

Figure 1: COWVR in its pre-launch configuration during system-level testing

The Compact Ocean Wind Vector Radiometer (COWVR) mission COWVR was commissioned by the U.S. Air Force to address the expected ocean surface vector wind gap, provided by WindSat that has been recently decommissioned. The COWVR payload has been developed by the Jet Propulsion Laboratory (JPL).

COWVR is a three channel Ka/Ku polarimetric radiometer system with a single multi-frequency stationary feed. COWVR measurements are at 18/23/34 GHz. COWVR launched in December 2021, and was installed on the International Space Station. COWVR started collecting data in January 2022. It is currently in its cal/val phase.

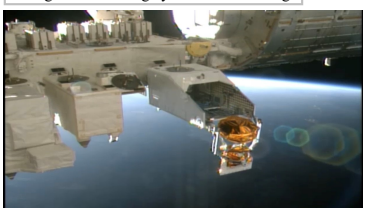
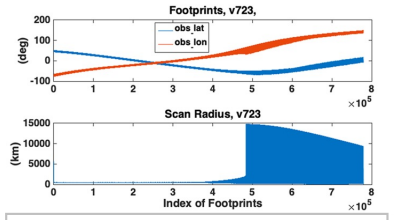


Figure 2: COWVR as installed on the International Space Station. The reflector and horn hoisted by two arms can be observed. The two arms result in blockage for parts of the instrument scan. The two arms each contain star-trackers for COWVR.

COWVR Pointing Calibration

The initial commissioning phase for COWVR involved detailed pointing calibration from the project team, with validation support from the associated science teams. COWVR dealt with some unique calibration issues as a consequence of being installed on the ISS.

Initial pointing data from COWVR in January is corrupted by the ISS robotic arm in front of the COWVR star trackers. COWVR has two star trackers on each arm of the system, and the software switches from one star tracker to another depending on the viewing geometry, location of the sun etc. Figure 3 below shows an initial anomaly detected by the team that showed erroneous geolocation (observed as a proxy through scan radius) during certain orbits. This was tracked to incorrect switching between the star trackers that was eventually corrected.



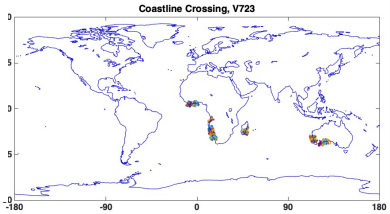
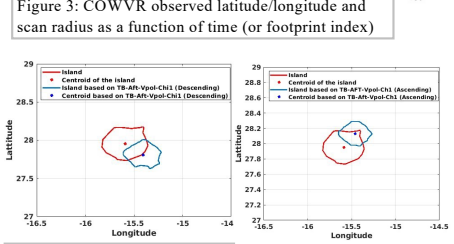


Figure 3: COWVR observed latitude/longitude and scan radius as a function of time (or footprint index)



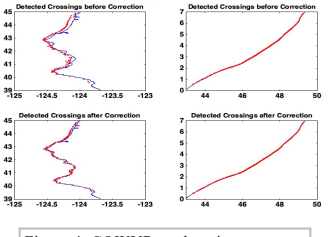
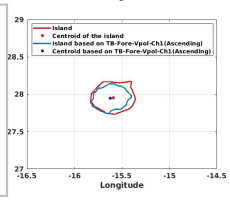


Figure 5: COWVR geolocation correction based of minimization of detected vs true islands. The top two figures show geolocation offset due to a timing error, the bottom figure shows geolocation accuracy after timing offset is corrected

Figure 4: COWVR geolocation correction based of coastal crossing minimization of detected vs true coasts. The top figure shows the various scan locations used to assess geolocation accuracy, the bottom figures show a few examples of geolocation before and after correction (W. Australia, Somalia)



COWVR geolocation was calculated using three different methods and independently verified with the project geolocation correction

1. The first method shown in figure 4, geolocation error is defined as shortest distance (scalar or vector) between the geolocation on the Earth's surface with largest gradient in TBs and a coastline when the antenna scan across the coastline. GSHHRS (Global Self-consistent Hierarchical High-Resolution Shoreline) used for Earth's coastline
2. The second method shown in figure 5 uses relatively small islands and calculates the centroid of the islands based on ascending and descending orbits
3. The third method uses 3/4 Stokes Tbs and detects coasts using the lowes Tb point

Corrections

-0.050 deg (look ang)
0.380 deg (roll)
-0.350 deg (pitch)
-0.090 deg (yaw)

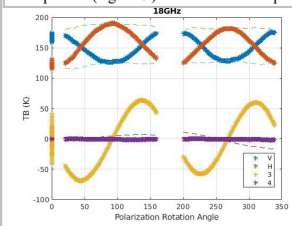
Antenna pointing error before → after correction

scalar error:
3.03 km → 1.48 km

vector error:
1.35 km → 0.08 km

COWVR Radiometric and Polarimetric Performance

Initial results from COWVR look promising, indicating a well calibrated instrument. The instrument Electronic Polarization Basis Rotation behaves as expected (figure 6 and 7). There is some residual polarization leakage, an example given in figure 8 which can now be fine tuned given the pointing calibration. Similarly, the brightness temperature behaves as expected (figure 9) with the next steps being absolute Tb calibration.



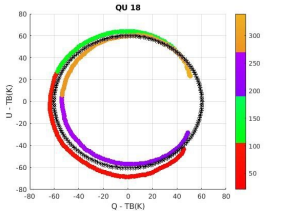
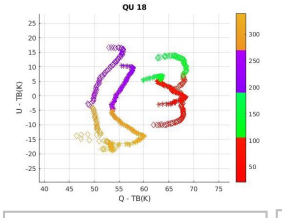


Figure 6: COWVR Tb before (*) and (--) after correction of the polarization rotation angle for all four stokes. The third stokes purple dashed line shows some residual pol leakage

Figure 7: COWVR Tb Q vs U. The theoretical is shown by the black * with measurement as a function of pol rotation shown with the colored dots. The deviation from theoretical is due to differing fore and aft incidence angles.



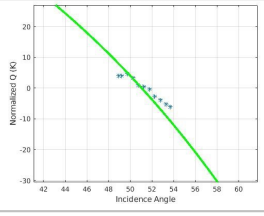


Figure 8: Q leakage into U after pol correction for two different ISS attitudes. Ideally U = 0 K

Figure 9: Normalized Q vs observation incidence angle (*) compared to model data (-). Initial results show consistent relative calibration.

Summary and Work to Go

COWVR is a well calibrated instrument, with the initial couple of months showing the unique challenges presented from an ISS installation. The variable behavior of the ISS on the other hand also presents calibration opportunities that the calibration team can take advantage of.

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