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

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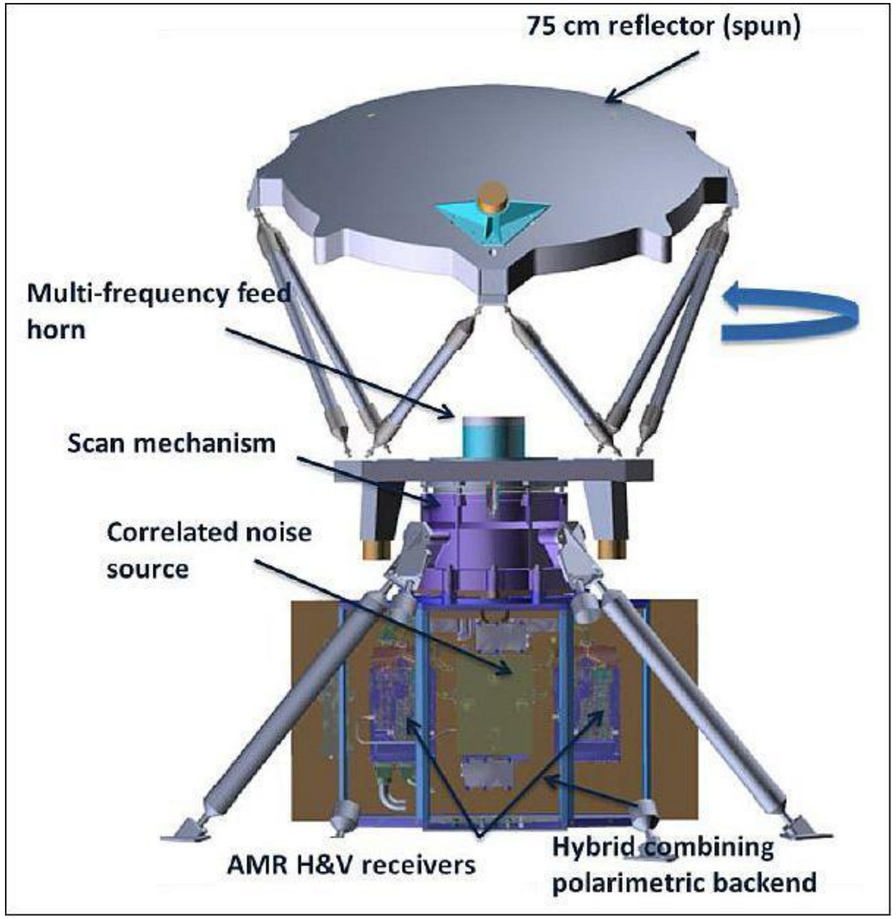
Outline

I. What is COWVR
   A. The Basics
   B. Advantages
   C. Risks
II. What does RSS plan to do with it?
   A. Adapt the WindSat Analysis Package to COWVR
   B. Evaluate COWVR wind vectors relative to WindSat, Scatterometers and moored buoys.
   C. Evaluate COWVR wind wpeed relative to conventional radiometers

COWVR (Compact Ocean Wind Vector Radiometer)



PI – Shannon Brown, JPL
Funder – US Air Force

Fully Polarimetric Radiometer at 18.7, 23.8 and 33.9 GHz

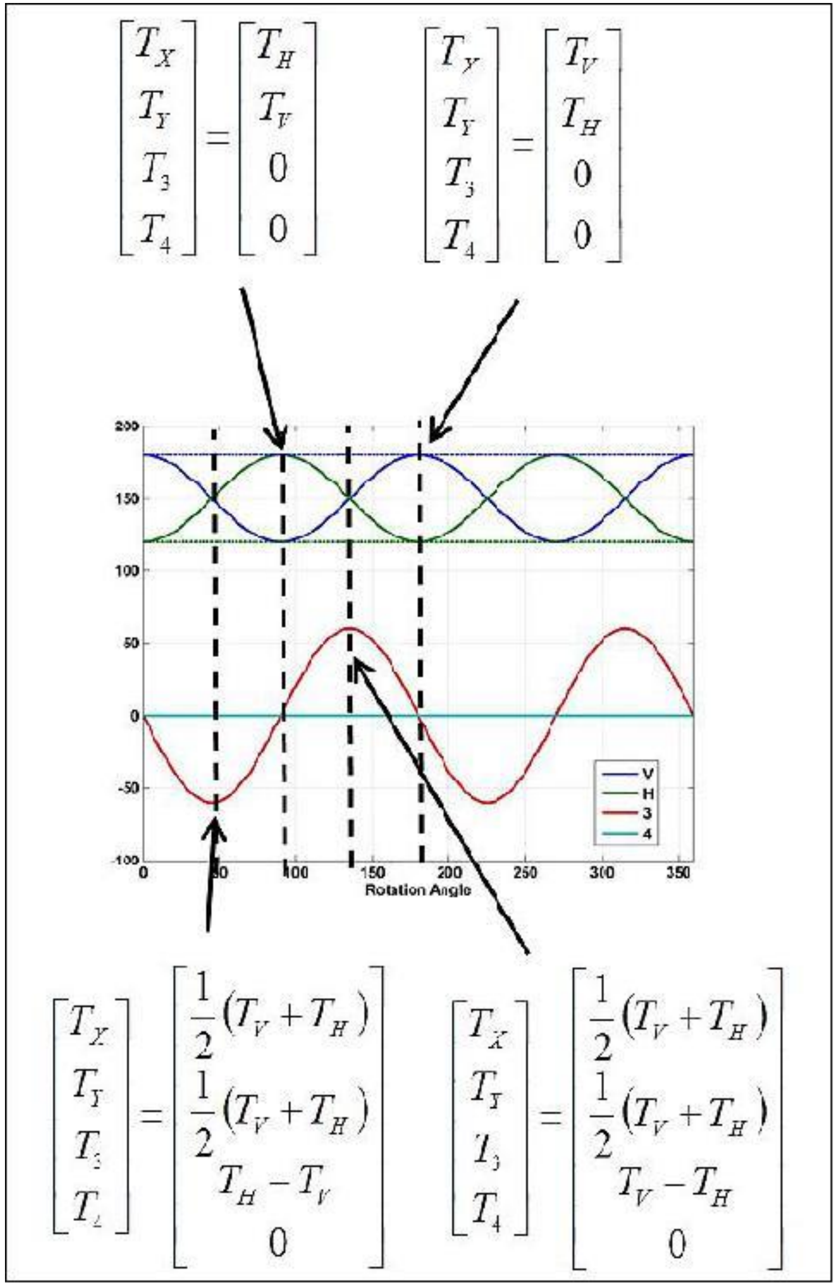
Single feed horn for all 3 frequencies

Only the reflector rotates – the receiver is fixed to the spacecraft – No BAPTA – spinning angular momentum almost 50 times less than WindSat

No External Calibration Loads -- Internally Calibrated Using PIN Diodes and correlated noise sources.

Implications of these features:

1. Polarizations are mixed as the reflector rotates
   - But receiver is fully polarimetric, which allows the polarization state to be deduced even when basis is rotated.
   - Technology has been demonstrated in the lab and for airborne radiometers.
   - Requires a close match for the antenna patterns for the various components of the Stokes vector (or at least, a detailed understanding of the differences).



Implications of these features:

2. Lack of External Calibration Targets Allows for an Almost Uninterrupted 360 degree scan.

- Each location is observed twice at different azimuth angles.
- This is very good!
- WindSat had such “2-look” capability for part of the scan.
- RSS and others have shown that wind vectors are substantially improved by 2 looks.

Implications of these features:

3. Internal calibration sources can be tricky.
   - Radiance may vary slowly over time due to changes in source or PIN diode switches.
   - Need to use innovative cal-val methods to ensure that any such drifts are characterized and removed.
   - Aquarius, SMAP and GMI* all use internal calibration sources.
   - Aquarius had drifts issues, but SMAP is much improved.

*GMI has traditional calibration targets too.

Launch + Launch Vehicle

- Launch was scheduled for July 2018 but is now delayed until ????

Original Launch Plan.

- “Commercial Rideshare” launch shared with numerous other, mostly smaller satellites
- COWVR project doesn’t get to choose the exact orbit or launch window, but….
- The approach leads to substantial cost savings (25% to 50%) relative to a dedicated launch vehicle.

RSS Activities Related to COWVR

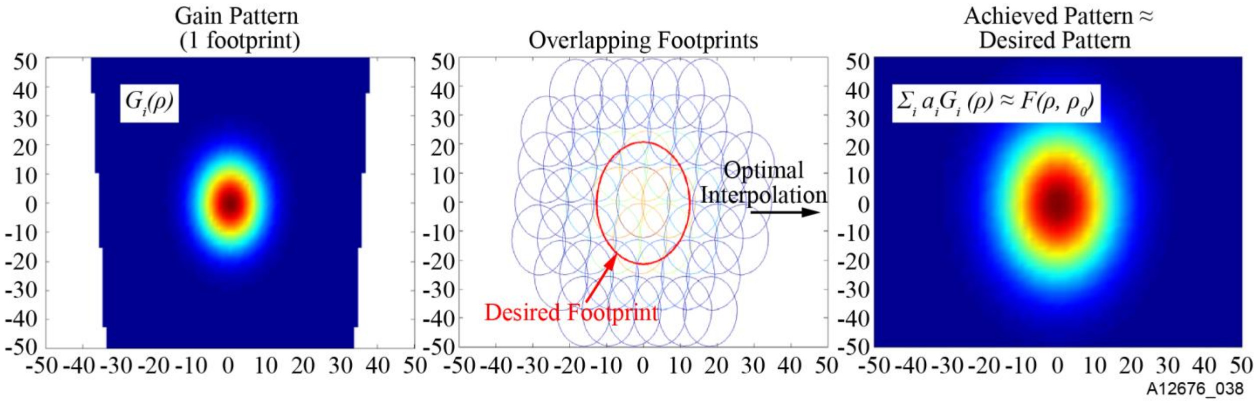
- Pre-launch Simulations
- Geolocation
- Footprint Resampling
- Calibration
- Vector Wind Algorithm
- Vapor, Cloud and Rain Algorithm

Prelaunch Simulation

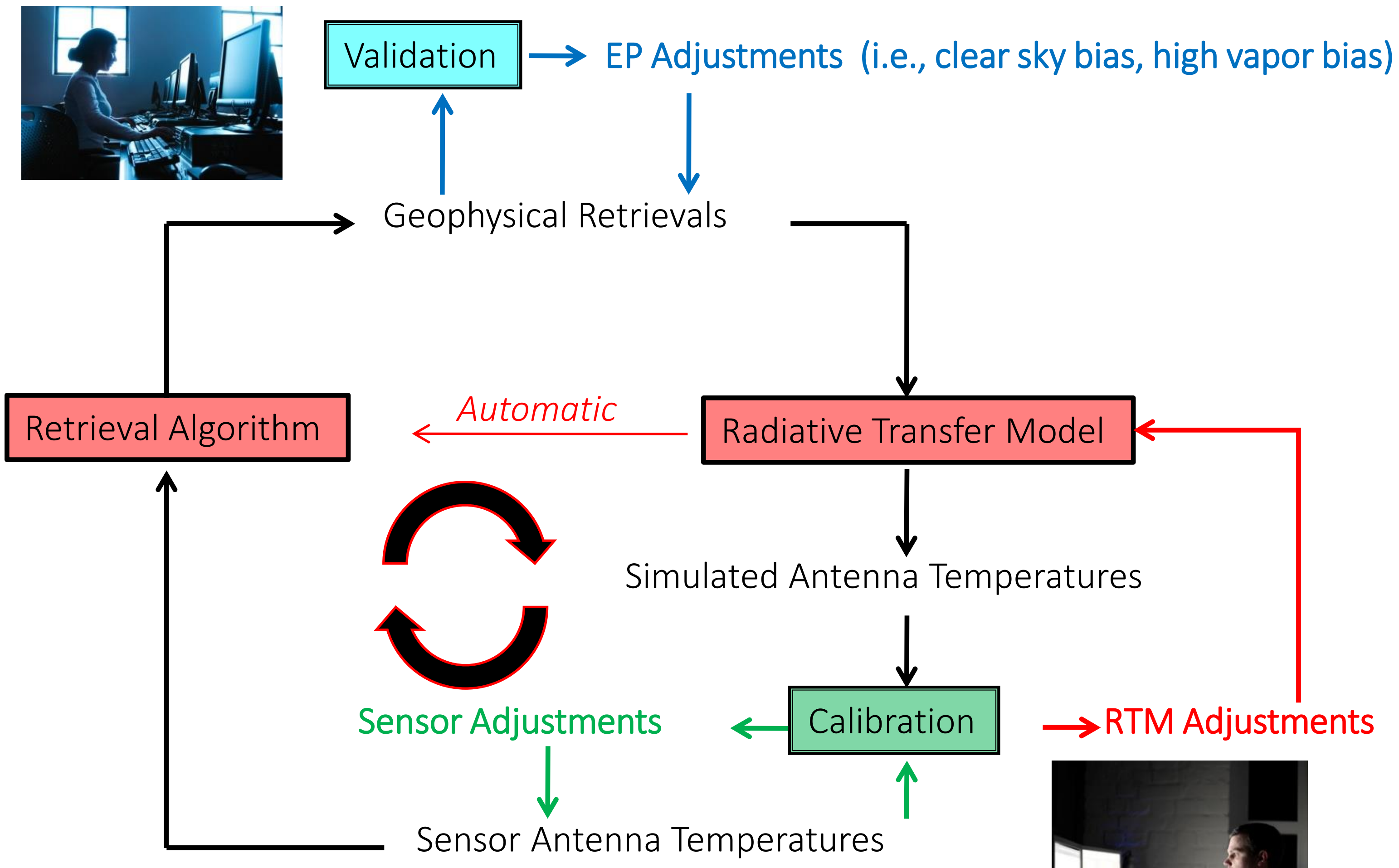
- End-to-End Satellite Simulator
  - Environmental Conditions for NWP output
    - Wind, SST, Salinity, Profiles of Temperature, Vapor, Clouds and Rain + Total electron content in the ionosphere.
  - RTM used to calculate top-of-the-atmosphere Tb
  - T_B converted to T_A using antenna spill-over, cross-pol and geometrical polarization rotation.
  - Noise is added to T_A to account for receiver noise
- Simulated T_A is then used to develop and test retrieval algorithms
- Results from retrievals can be compared to known conditions at the input to evaluate algorithm performance.

Geolocation and Resampling

- Geolocation
  - Satellite Location and Attitude used to compute footprint location on ground, as well as incidence angle, sun location, etc.
  - For real COWVR data, the locations of coastlines and similar features can be used to evaluate. Often Antenna Boresights need to be adjusted by a few 10ths of a degree. This can depend on the polarization under study.
- Footprint Resampling to Common Footprint
  - Optimum interpolation



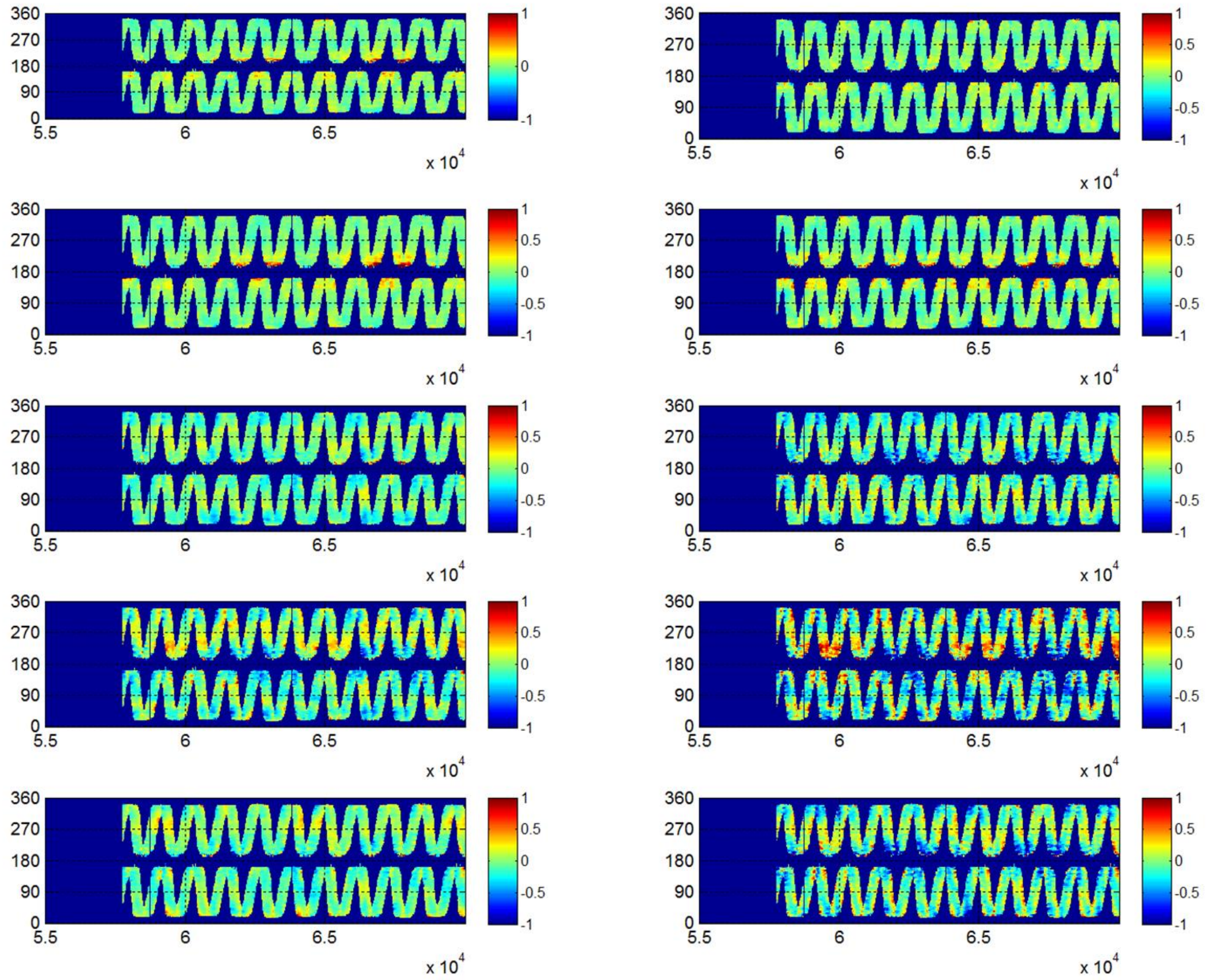
The RSS Calibration and Retrieval System



- Start with Satellite Radiometer Counts
- Use same RTM for calibrating all satellites
- Use RTM^{-1} for same retrieval algorithm for all satellites

Radiometric Calibration

- Primary Method is comparison to GMI.
  - GMI is absolutely calibrated (Wentz and Draper, 2016)
  - GMI radiances converted to COWVR radiances using a RTM over the oceans.
  - Receiver linearity can be investigated by adding comparisons over the Amazon rainforest.
- Needs to be monitored over entire mission to guard against drifts.



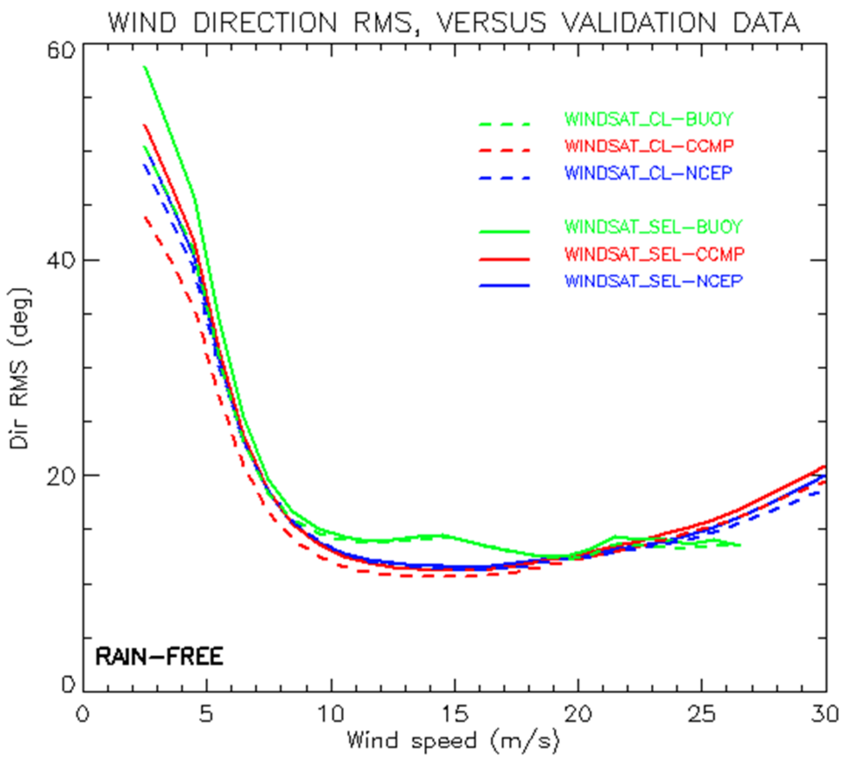
Wind Algorithm

- Adapt our WindSat Algorithm to COWVR
  - Changes include
    - Lack of low frequency channels
    - De-rotating polarizations due to rotating antenna
    - "back look" available for all swath positions – should lead to good direction retrievals
    - Simplified footprint geometry – only one feed horn!
  - Step 1 – Find wind speed using a multistep regression algorithm (The regression is trained using the simulated data)
  - Step 2 – Find direction ambiguities by minimizing sum-of-squares for all channels
  - Step 3– Choose direction ambiguity using median filter method
  - (these are all proven methods for multi-look radiometers)

Wind Validation

- Compare to:
  - Buoys
  - NWP output
  - CCMP

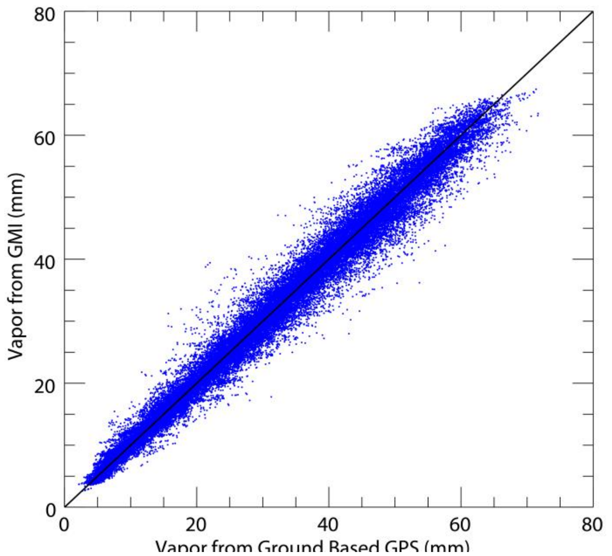
  Using binned wind speed differences, binned direction differences, Ebuchi plots, overall means and std. devs.

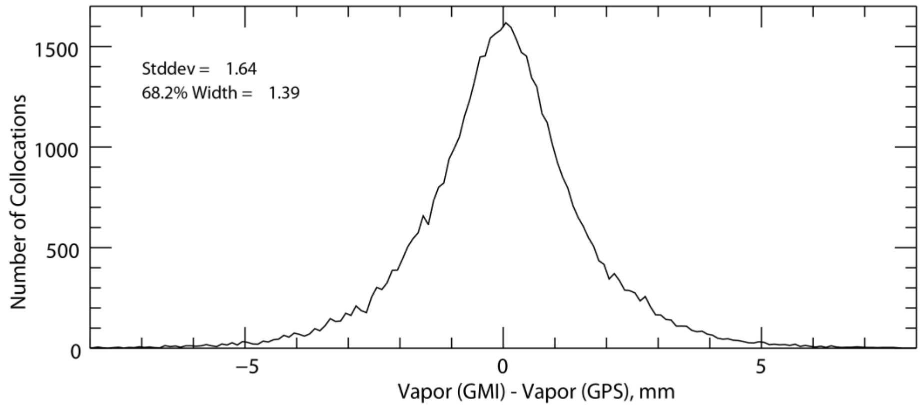


Vapor, Clouds and Rain

- These are retrieved simultaneously with wind speed by the multistep regression algorithm.
- Vapor can be validated via comparison with ground-based GPS results from small islands.

Example from GMI





Conclusions

- We are excited about COWVR
  - It could be a (relatively) low cost way to get ocean vector winds in the future (especially if future COWVR's include 11 GHz).
  - Low-cost satellites could make it possible to have more satellites operating at same time – better coverage, better assimilation into NWP, possible to study diurnal variability.
  - Two-look capability should produce good direction retrievals than "classic" WindSat products.