

1. Abstract

C and Ku-band scatterometer wind estimates deteriorate when rain is present. A longer wavelength (like L-Band) has reduced sensitivity to rain. The Soil Moisture Active/Passive (SMAP) mission included a quad-polarization L-Band scatterometer, though it was only active 3 months, limiting the characterization of L-band wind retrieval. It has been believed σ^0 at L-Band has minimal dependence on wind direction; however, using SMAP data, we find this is not true by making Geophysical Model Functions, performing a compass simulation, wind retrieval, and analyzing tropical storm data..

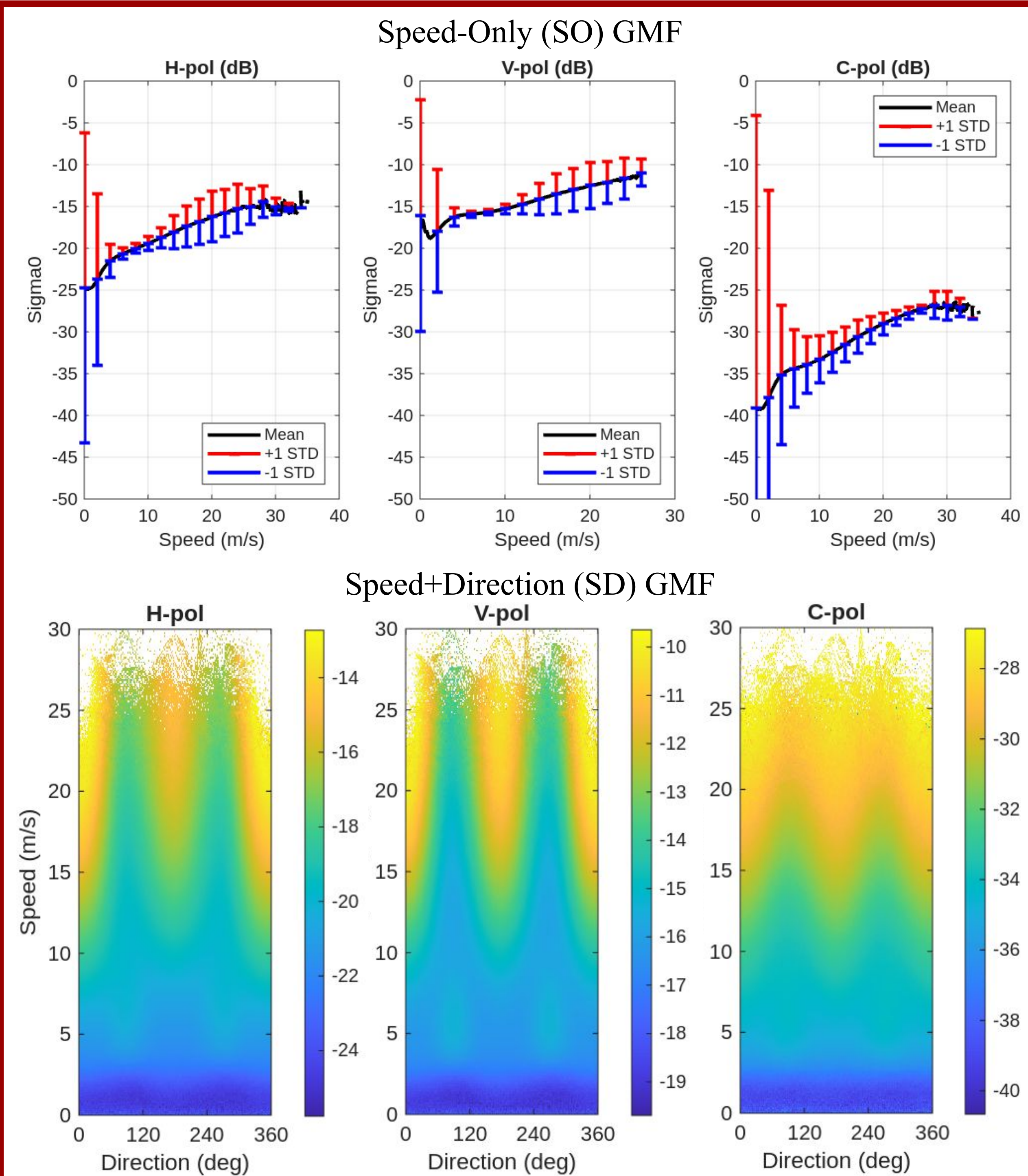
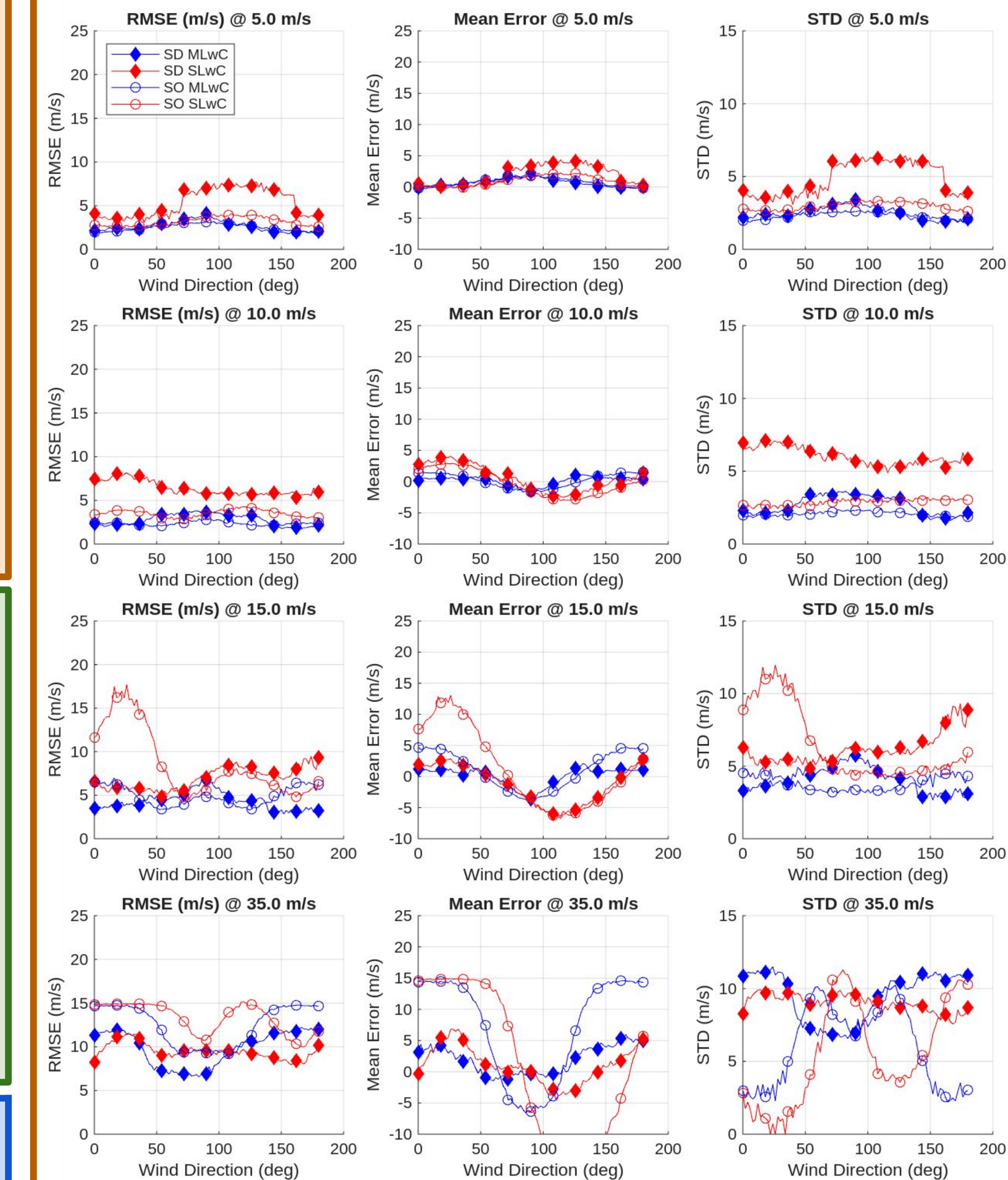
2. Geophysical Model Functions

- Two new multi-polarized Geophysical Model Functions (GMF) developed using Freilich and Dunbar approach:
 - **SO**: Speed-Only
 - **SD**: Speed+Direction
- Polarizations:
 - Horizontal (HH or H-pol)
 - Vertical (VV or V-pol)
 - Cross (VH/HV, X-pol, or C-pol)
- SO and SD GMFs have similar speed trends
- SD GMF has significant direction dependence
- C-pol has much lower σ^0 magnitude compared to H-pol and V-pol
 - Lower SNR means lower utility of data in wind retrieval at non-storm speeds

3. Compass Simulation Results

- Accuracy Metrics:
 - Root Mean Square Error (RMSE)
 - Mean Error
 - Standard Deviation
- Simulated noise based on observed data
- Evaluate wind direction dependence importance:
 - SO against SD compared results
 - Multiple against Single azimuth look directions
 - Importance of C-pol data
- Four cases:
 - **MLwC**: Multiple Looks with C-pol
 - **MLwoC**: Multiple Looks without C-pol
 - **SLwC**: Single Look with C-pol
 - **SLwoC**: Single Look without C-pol
- Compass Simulations Results:
 - Estimate accurate at low wind speeds
 - Accuracy decreases with increasing wind speed
 - SD estimates are more accurate than SO

Comparison of Wind Speed Compass Simulation Results



4. Wind Retrieval Results

- Same used Four Cases as Compass Simulation
- Figures show SO and SD wind speed estimates compared to the European Centre for Medium-Range Weather Forecasts (ECMWF) wind speeds
 - For both SO and SD estimates, C-pol has minimal influence on estimate accuracy
 - SO estimates have a higher variance, and overestimate high wind speeds compared to SD
 - SD estimates have less variance, generally good estimation of high wind speeds compared to SO
- Align with the compass simulation analysis
- SD reduces estimate RMSE compared to SO by roughly 0.75 m/s (see table)

5. Tropical Storm Analysis

- BYU Ultra-High Resolution (UHR) SMAP σ^0 used to analyze 2015 tropical storms
 - UHR enhances σ^0 spatial resolution using spatial response function and image reconstruction over conventional σ^0 values
 - 25 x 25 km to 2.5 x 2.5 km enhancement
 - Can detect hurricane eye in UHR σ^0 images
 - **Trade-off**: UHR conveys more features compared to conventional resolutions but has some artifacts and higher noise level
 - Hurricane wind retrieval is performed
 - C-pol results have highest speed accuracy
 - Compare estimates near hurricanes to HURDAT2

6. Conclusion

We find the L-Band SD GMF better models the wind and σ^0 relationship than the SO GMF, and there is a non-negligible σ^0 wind direction dependence for non-tropical storm intense winds. There are three takeaways, the first is C-pol measurements adds minimal information to wind retrieval accuracy at low to moderate wind speeds due to low SNR and the differences between the estimate distributions which include and omit C-pol are minor. Second, SO results tend to overestimate the wind speed compared to SD.

Third, the variance for wind speed estimates is much greater for SO compared to SD.

Current work is focusing on analysis of SMAP effectiveness during tropical storm intensity winds. Dissimilarly to nominal wind retrieval conditions, C-pol data has proven useful. Compared to H-pol and V-pol (which both exhibit a significant direction dependence and are saturated at high wind speeds), C-pol data are less directionally sensitive and remain unsaturated at intense wind speed. L-band C-pol data open the possibility of accurate wind estimation in tropical storm level wind speeds intensities.

Wind Speed Retrieval RMSE (m/s)

	MLwC	MLwoC	SLwC	SLwoC
SO	2.52	2.52	2.74	2.72
SD	2.04	2.04	2.64	2.72

