Total Column Water Vapor from OCO-2

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Introduction

- Measurements of atmospheric water vapor provide useful information for a wide range of applications including hydrological cycle studies, radiation budget studies, weather forecasting, and climate change studies.
- While many existing ground-based networks provide highly precise and accurate measurements of water vapor, the large temporal and spatial variability of water vapor results in the need for additional information on a global scale.
- In this work, **we investigate the accuracy of Orbiting Carbon Observatory-2 (OCO-2) total column water vapor (TCWV) measurements by comparing them to observations from SuomiNet, the AErosol RObotic NETwork (AERONET), and the Advanced Microwave Scanning Radiometer-2 (AMSR-2).**

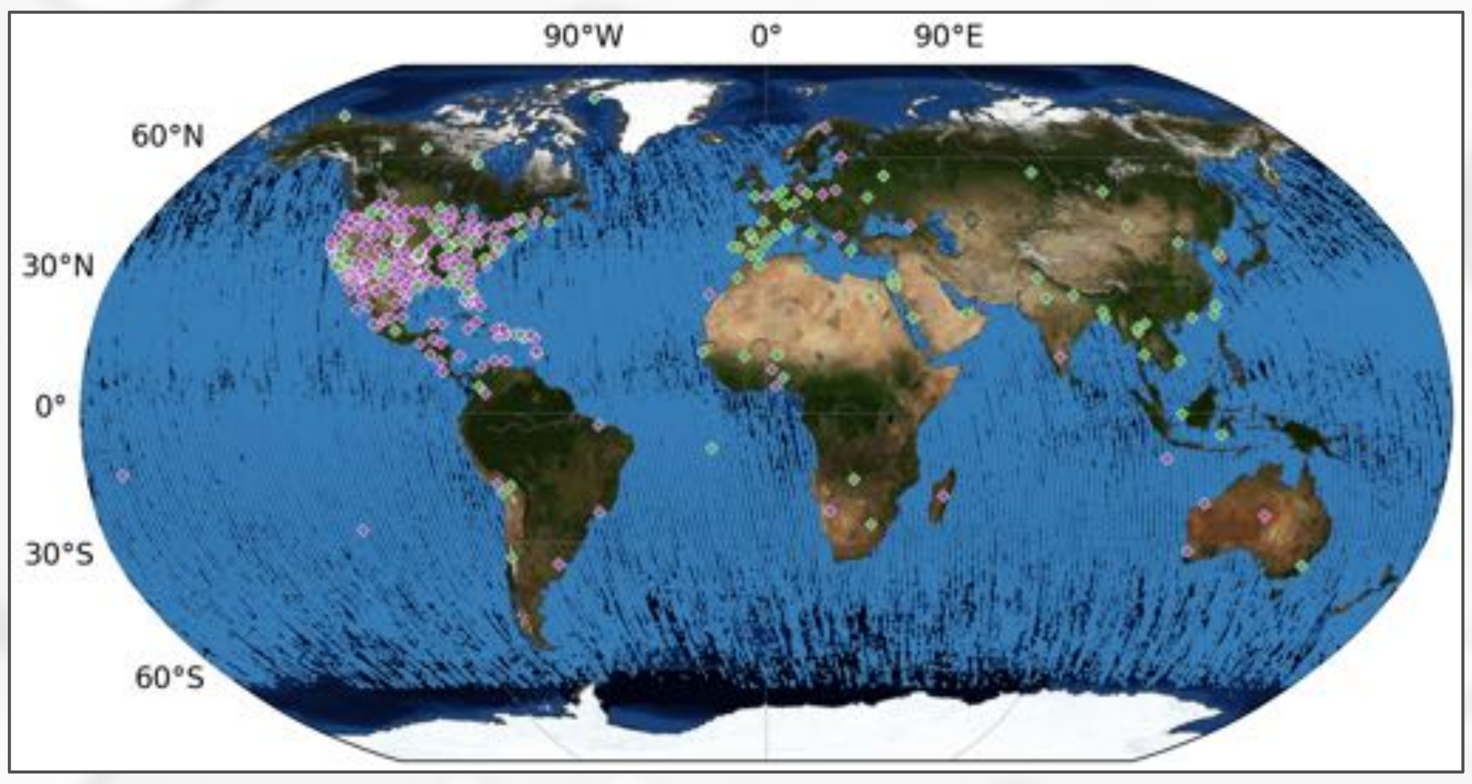

Figure 1. Location of SuomiNet sites (purple), AERONET sites (green), and AMSR-2 grid cells (blue) that have a valid OCO-2 meas. co-located in time & space from 6 Sep. 2014 to 10 Feb. 2016.

Data & Methodology

- Though OCO-2's primary mission is to measure the total column of atmospheric carbon dioxide (X_{CO_2}), it also measures total column water vapor with the NASA Atmospheric CO2 Observations from Space (ACOS) X_{CO_2} retrieval algorithm[1,2] using information contained in two near-infrared absorption bands at 1.6 and 2.05 μm (Fig. 2).
- SuomiNet measures TCWV at over 300 locations, mostly in North America, using phase delays in GPS signals[3]. AERONET is a collection of several hundred sun photometers[4]. Both networks have reported accuracies of better than 2.0 mm.
- AMSR-2 is a polar-orbiting microwave radiometer that measures TCWV over water using emissions from the surface and atmosphere[5].
- OCO-2 measurements from 6 Sep. 2014 to 10 Feb. 2016 were co-located with the other measurements to within 0.1° and 30 minutes. Co-located measurements over land with large differences in surface pressure were removed to ensure the same column of air was being compared.

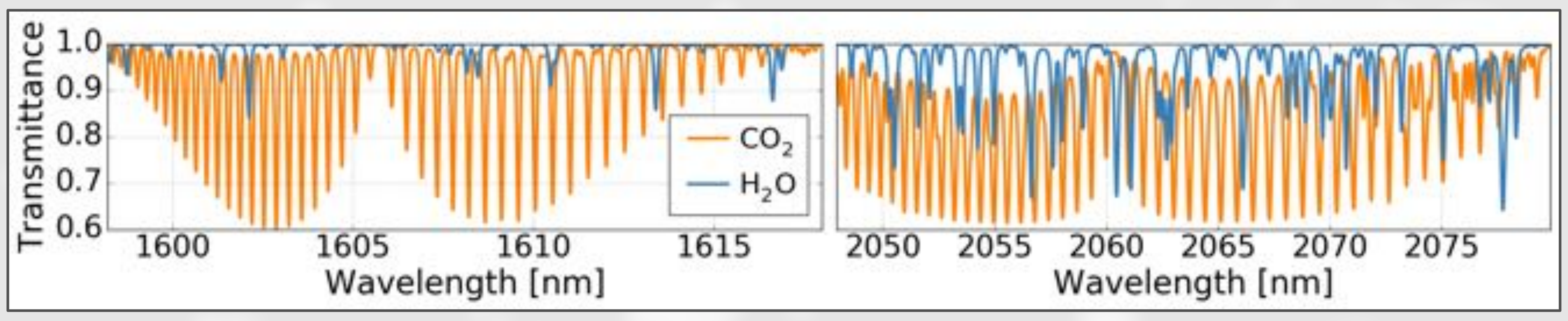

Figure 2. Example of OCO-2 weak CO_2 band (left panel) and strong CO_2 band (right panel) spectra demonstrating the prevalence of water vapor absorption features (blue lines).

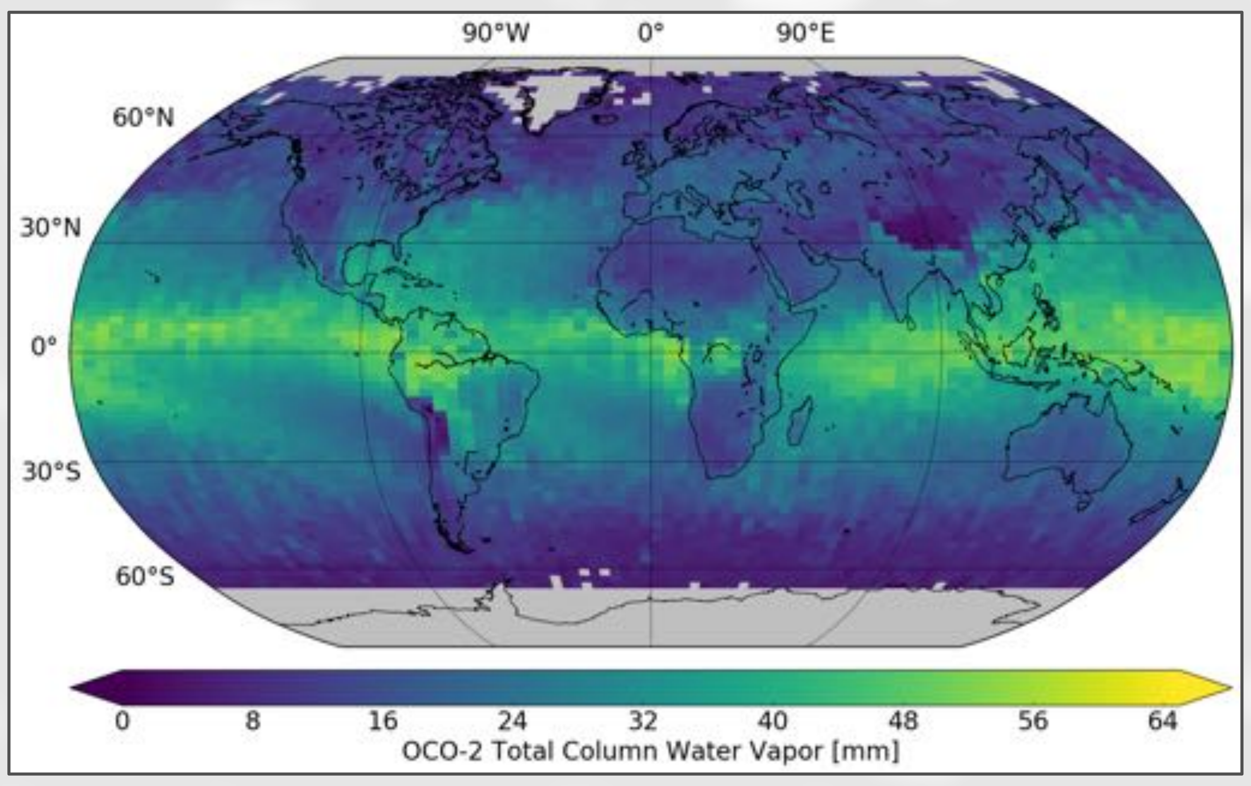

Figure 3. Binned retrieved OCO-2 total column water vapor for 2015. Extremely large values are not seen, as OCO-2 only measures in clear-sky conditions.

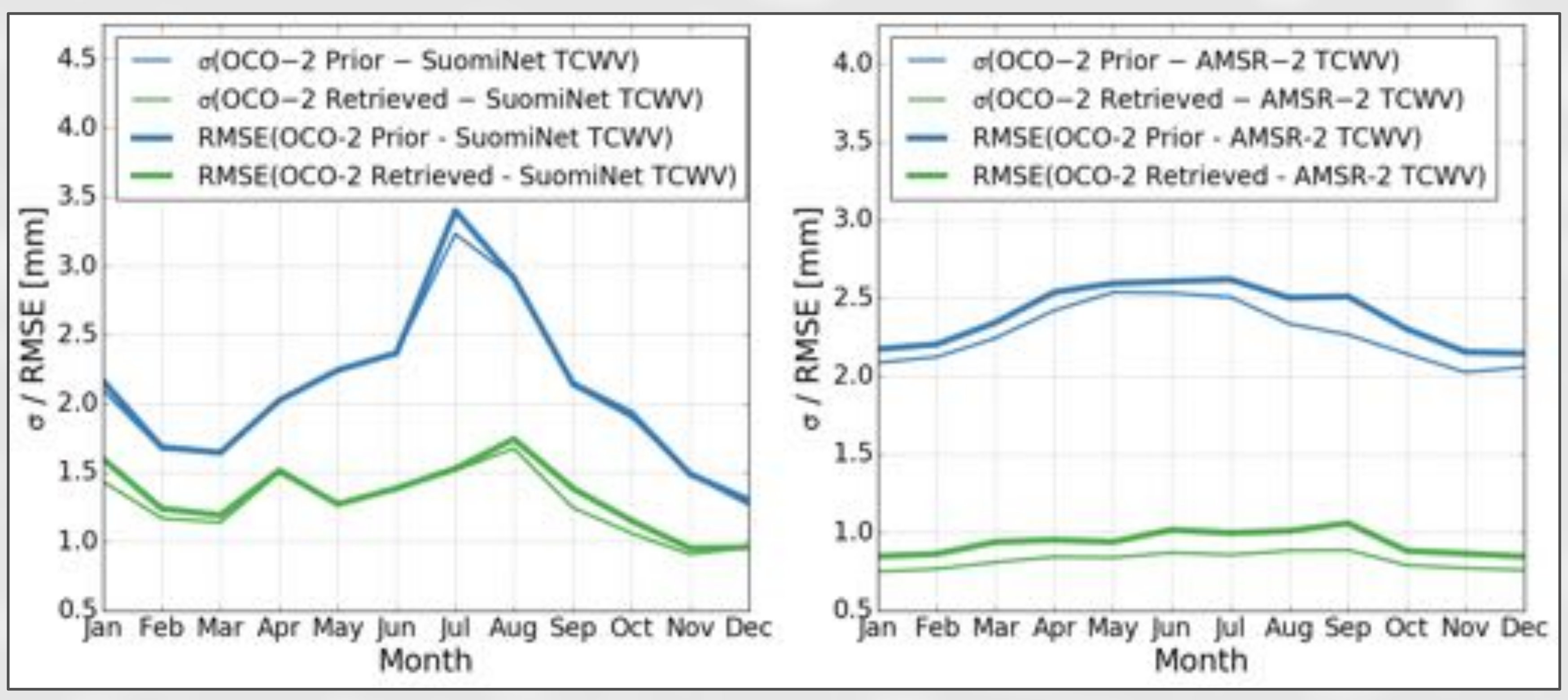

Figure 4. Standard deviation of the differences (thin line) and RMSE (thick line) of the prior OCO-2 TCWV (blue) and the retrieved OCO-2 TCWV (green) relative to SuomiNet (left) and AMSR-2 (right).

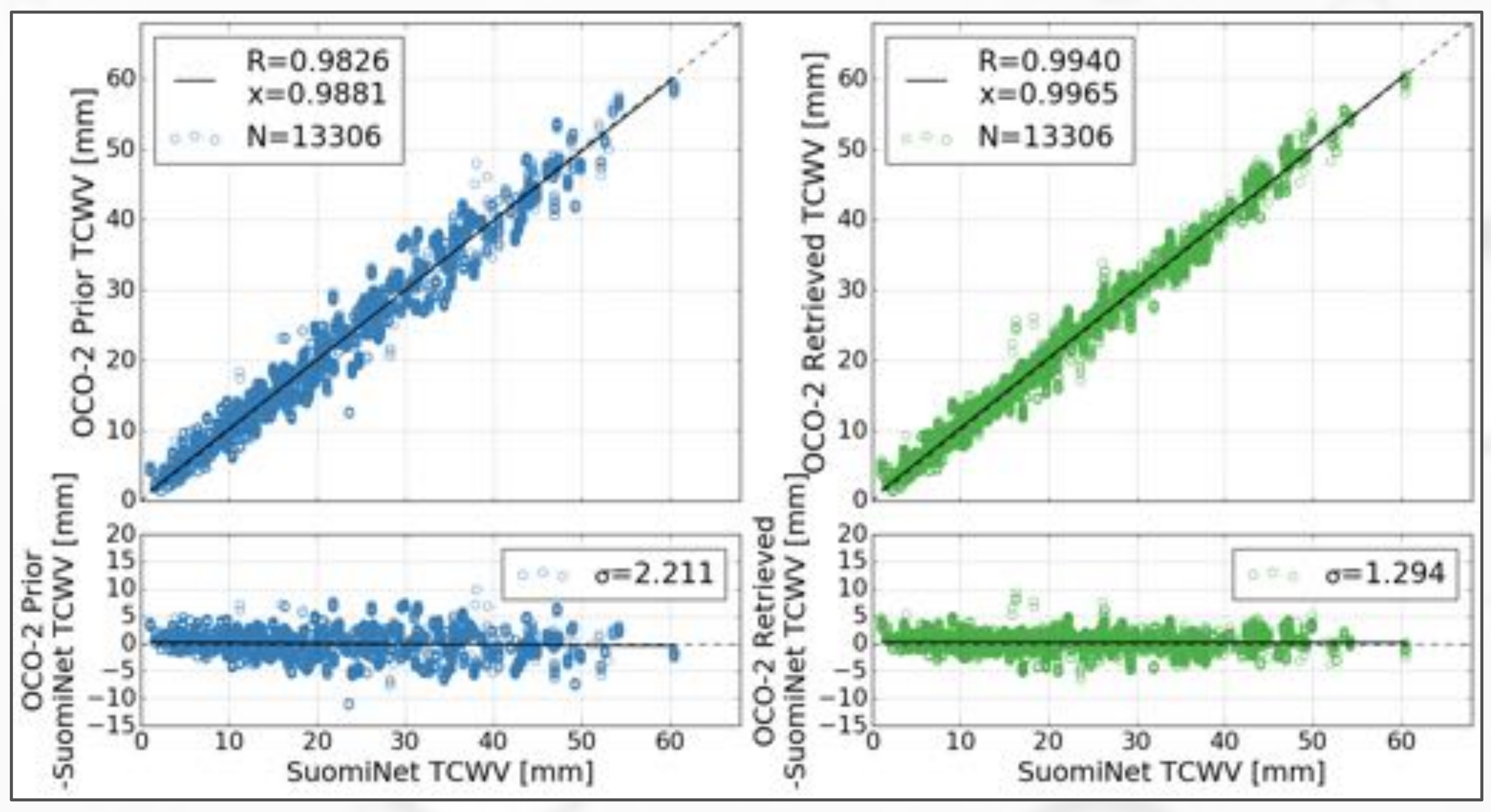

Figure 5. Left: prior OCO-2 TCWV (via the European Centre for Medium-Range Weather Forecasts Integrated Forecast System (ECMWF IFS[6]) vs. SuomiNet TCWV. Top: x-y comparison. Bottom: differences (prior OCO-2 TCWV - SuomiNet TCWV) vs. SuomiNet TCWV. Right: same but for retrieved OCO-2 TCWV.

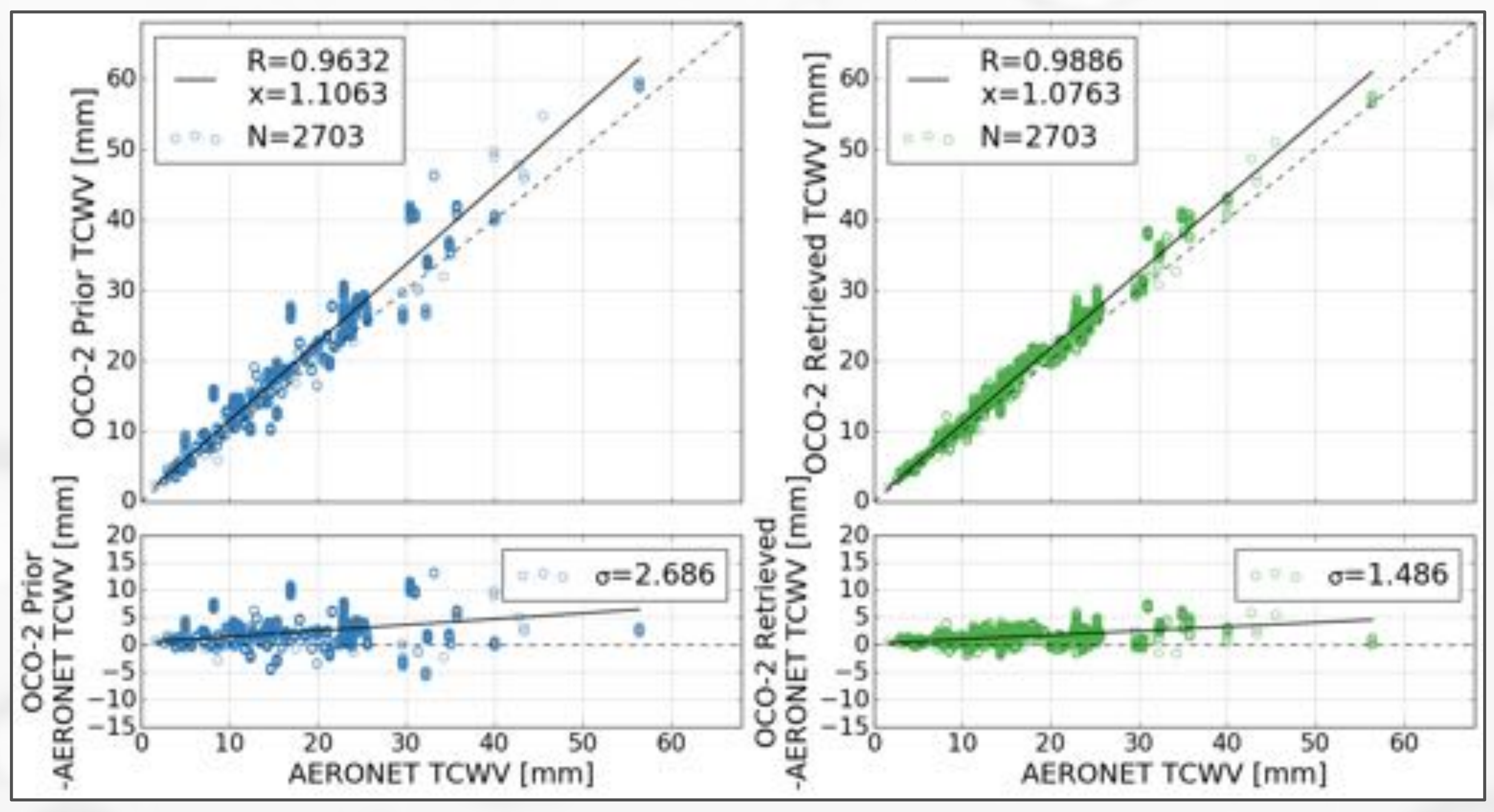

Figure 6. Same as Fig. 5, but with AERONET TCWV measurements.

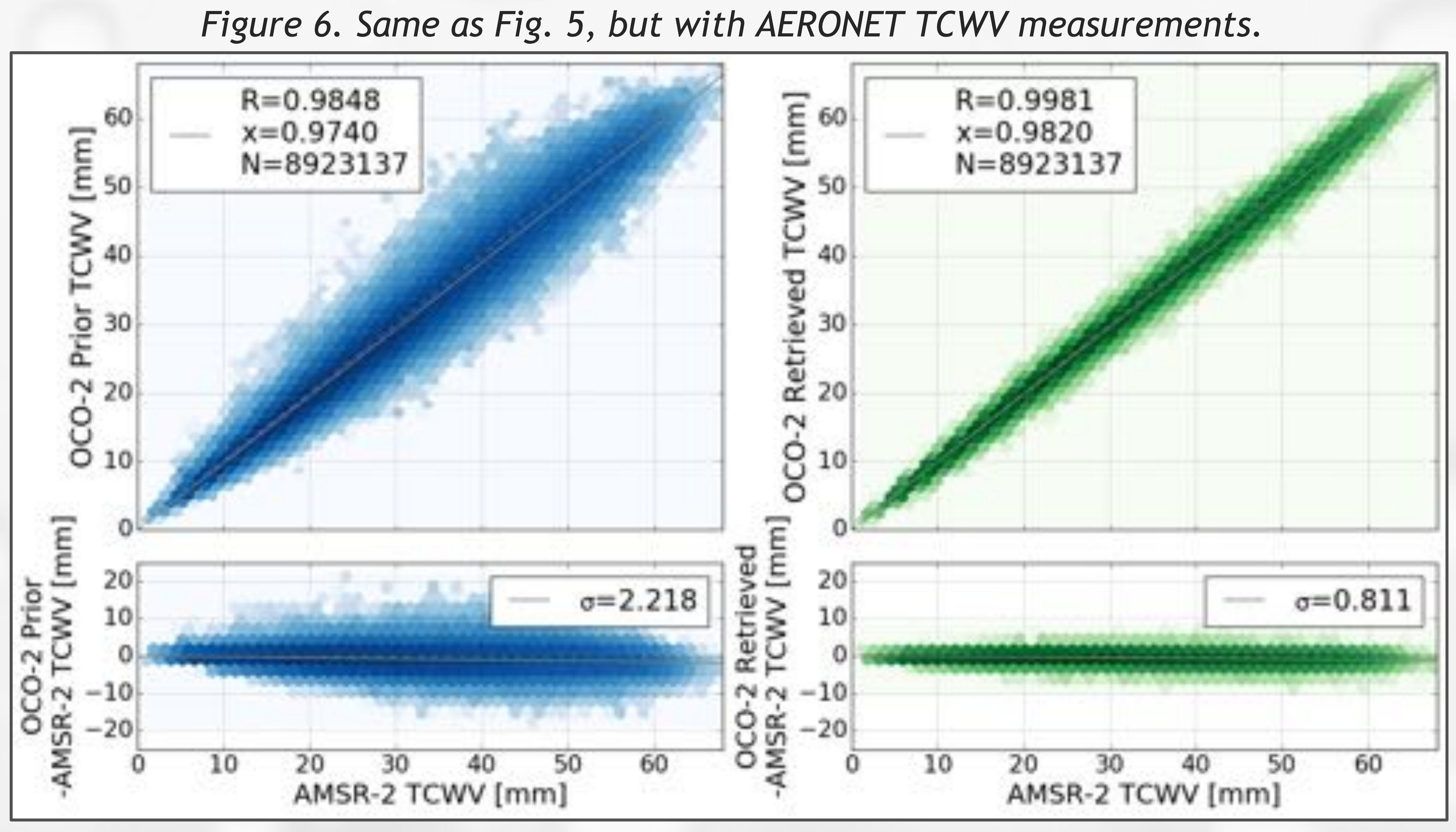

Figure 7. Same as Figs. 5 & 6, but with AMSR-2 measurements and log(N) bins.

Results

- The prior OCO-2 TCWV (taken from the ECMWF IFS) differences relative to SuomiNet and AMSR-2 have a consistent standard deviation of 2.2 mm. The retrieved OCO-2 TCWV is able to reduce the scatter down to 1.4 mm relative to SuomiNet (Fig. 5) and 0.8 mm relative to AMSR-2 (Fig. 7). This represents **a 67% reduction in the variance relative to the prior (compared to SuomiNet) and an 87% reduction relative to the prior (compared to AMSR-2).**
- The mean prior bias against SuomiNet is 1.6% while the mean retrieved bias is 3.5%. For AERONET the prior bias is 12.5% and the retrieved bias is 9.3% (likely due to low number statistics or a bias in AERONET itself). For AMSR-2 the prior bias is -2.7% and the retrieved bias is -1.5%.
- The retrieved OCO-2 TCWV differences are less temporally sensitive than the prior differences relative to both SuomiNet & AMSR-2 (Fig. 4).
- These results are not significantly dependent on our co-location criteria.

Conclusions

- OCO-2 is able to accurately measure total column water vapor, with an **RMSE of 1.3 mm relative to SuomiNet and an RMSE of 0.8 mm relative to AMSR-2.**
- OCO-2 is able to **reduce the variance in the TCWV differences by 67% (vs. SuomiNet) and 87% (vs. AMSR-2)**, compared to the ECMWF IFS prior.
- Future work includes investigating the source of the differences between the OCO-2 TCWV measurements and the SuomiNet and AMSR-2 measurements, including co-location and retrieval errors.

References

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