

Quantification and Evaluation of OCO-2 measured XCO₂ against COCCON

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OBJECTIVE

Satellite measurements of column-averaged dry-air mole fraction of CO₂ (X_{CO2}) from the Orbiting Carbon Observatory-2 (OCO-2) are compared against the ground-based COllaborative Carbon Column Observing Network (COCCON) measurements to identify potential biases and errors.

DATA and METHODOLOGY

- □ The new and improved Version 11.1 (V11.1) of OCO-2 data (Aug 2015 – Dec 2022) and the COCCON data products have been used in this work.
- □ V11.1 uses a digital elevation map that improves the retrievals, particularly at high latitudes. V11.1 Lite files will be publicly available in May 2023.
- **Coincidence Criteria**:
- $\pm 2.5^{\circ} \text{ x} \pm 5^{\circ}$ latitude-longitude boxes around COCCON sites
- Minimum of 100 good quality OCO-2 soundings required
- III. COCCON X_{CO2} (median) ±1h of overpass time



Figure 1. Operational and Campaign COCCON sites.

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observations.



over Karlsruhe.

The standard deviation values for land and ocean glint over Gobabeb are under 0.6 ppm, but higher for Karlsruhe for the target mode.

SUMMARY and **IMPORTANCE**

References:

Frey, M., Sha, M.K., Hase, F., Kiel, M., Blumenstock, T., Harig, R., Surawicz, G., Deutscher, N.M., Shiomi, K., Franklin, J.E. and Bösch, H., 2019. Building the COllaborative Carbon Column Observing Network (COCCON) long-term stability and ensemble performance of the EM27/SUN Fourier transform spectrometer. Atmospheric Measurement Techniques, 12(3), pp.1513-1530. Crisp, D., Miller, C. E., and DeCola, P. L.: NASA Orbiting Carbon Observatory: measuring the column averaged carbon dioxide mole fraction from space, J. Appl. Remote Sens., 2, 23508, https://doi.org/10.1117/1.2898457 Hase, F., Frey, M., Kiel, M., Blumenstock, T., Harig, R., Keens, A. and Orphal, J., 2016. Addition of a channel for XCO observations to a portable FTIR spectrometer for greenhouse gas measurements. Atmospheric

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One-to-One Comparison and Difference Time Series



RESULTS



Figure 2. Left columns indicate the OCO-2 one-to-one plot against COCCON, middle columns indicate the time series of the differences, and the right columns show the statistical parameters. 'N' and 'r²' indicate the number of points on the graph and the coefficient of determination, respectively. The absolute average biases are less than 0.6 ppm for Land Nadir/Glint, and Target mode observations, but are higher for Ocean Glint

Diagnostic Plots for Specific Sites



Aggregated OCO-2 X_{CO2} estimates filtered with xco2_quality_flag = 0 typically compare well with coincident COCCON data at global scales, with absolute average biases less than 0.6 ppm for Land Nadir/Glint, and Target mode observations.

This study bridges the gap between satellite and ground-based X_{CO2} measurements, and aids the improvement of the OCO-2 X_{CO2} data product.





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Figure 4. Site-to-site differences between OCO-2 and COCCON, separated by observation modes for sites for which 10 coincident measurements are available. The bottom and top edges of the box indicate the 25 and 75 percentile limits; whiskers represent the full range of the data, excluding the outliers indicated by '+' markers. The grey shaded area shows the ±0.4 ppm uncertainty in the **COCCON** values.

• Overall, site-to-site comparisons between OCO-2 and COCCON suggest reasonable agreement between the datasets, considering the uncertainty and the limited number of coincident measurements.



Figure 5. Left columns indicate the OCO-3 one-to-one plot against COCCON, middle columns indicate the time series of the differences, and the right columns show the statistical parameters. 'N' and 'r²' indicate the number of points on the graph and the coefficient of determination, respectively

Figure 6. Site-to-site differences between OCO-3 and COCCON, separated by observation modes for sites for which 10 or more coincident measurements are available. The bottom and top edges of the box indicate the 25 and 75 percentile limits; whiskers represent the full range of the data, excluding the outliers indicated by '+' markers. The grey shaded area shows the ±0.4 ppm uncertainty in the COCCON values.

- □ The absolute average biases are less than 0.7 ppm for Land Nadir/Glint, and Target observations, but higher for Ocean Glint observations.
- Site-to-site comparisons indicate that, overall, for all conditions, OCO-3 V10.4 performs well against COCCON, given the limited number of coincidences.

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Site-to-Site Differences