An Overview of the new and improved OCO-3 ACOS V10.4 XCO$_2$ Data Product

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Introduction

Evaluating OCO-3's space-based measurements against independent data provides information about the quality, potential biases, and errors in the OCO-3 data. Here, we present comparisons of the new and improved OCO-3 V10.4 data version against ground-based measurements from the Total Carbon Column Observing Network (TCCON). We focus on comparisons over land in nadir, target, and SAM mode and use the latest TCCON GGG2020 data version in our analysis.

Collocation Criteria: The most direct comparisons between OCO-3 and TCCON are through OCO-3 target and SAM mode observations taken over TCCON sites. For nadir observations over land, we consider all OCO-3 soundings that fall within a 2.5° x 5.0° latitude-longitude box around a TCCON site as collocated. We calculate the median OCO-3 XCO$_2$ of all collocated soundings and compare it to the median TCCON XCO$_2$ within ±1h of the overpass time. We require a minimum of 50 good quality OCO-3 soundings per overpass.
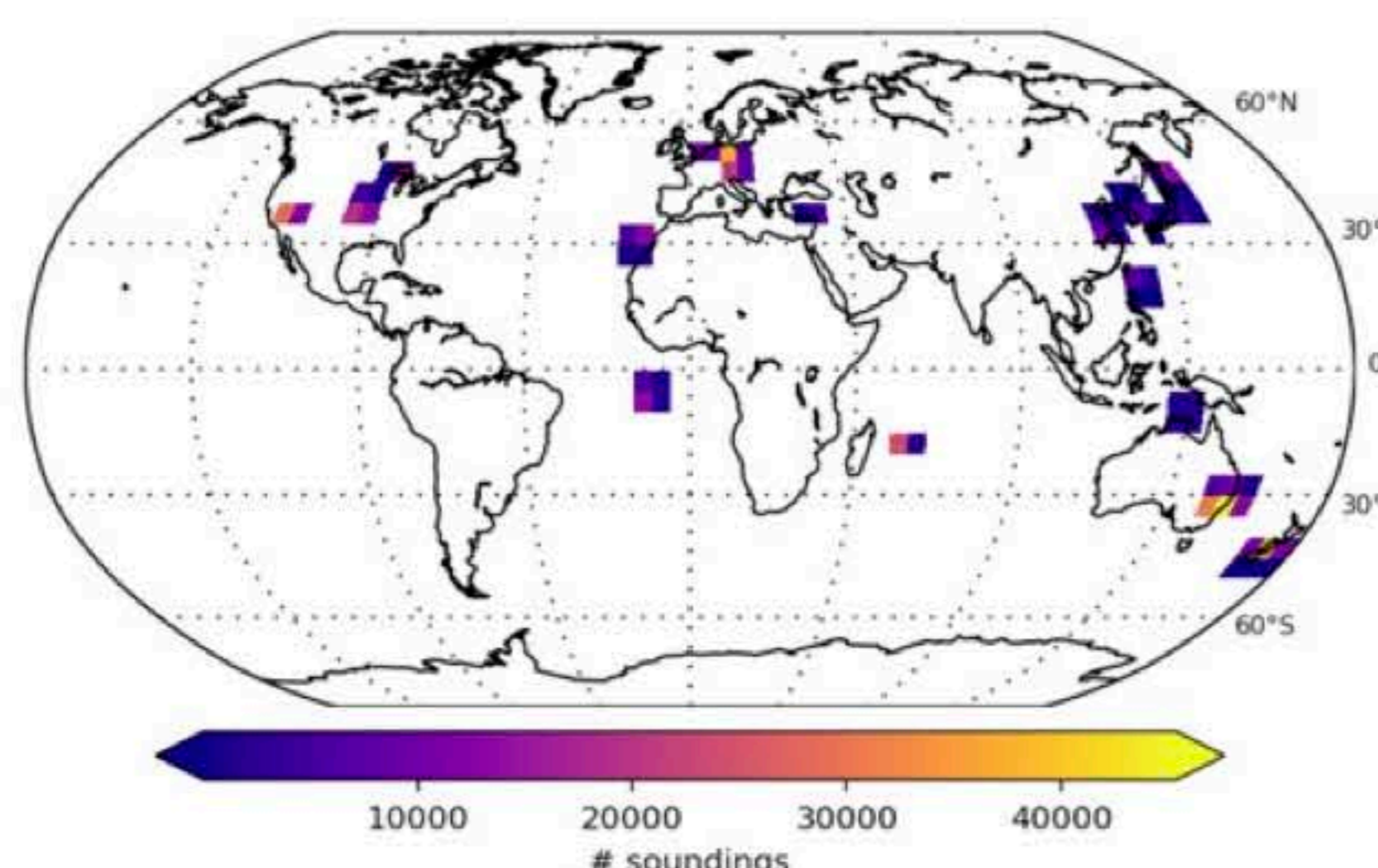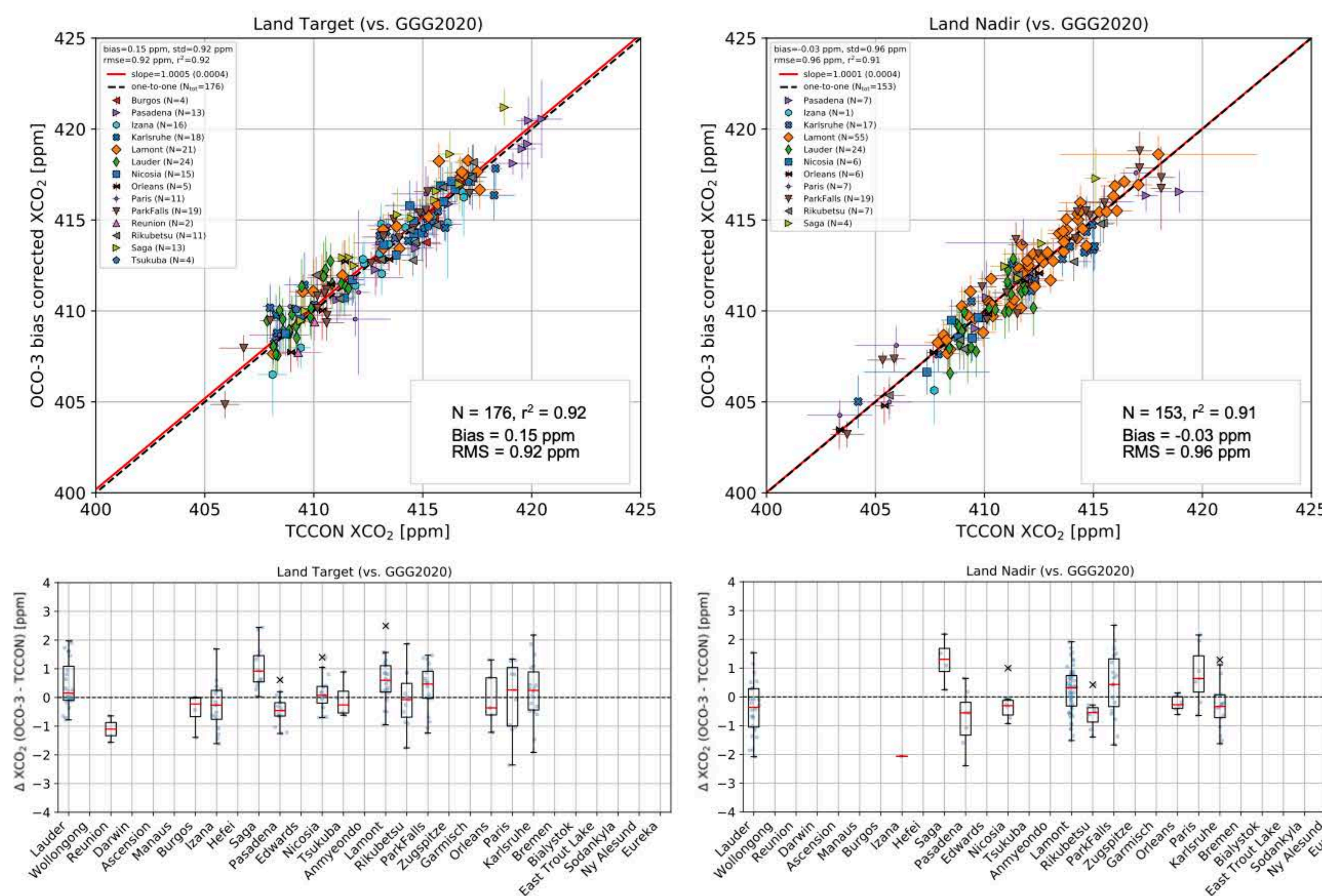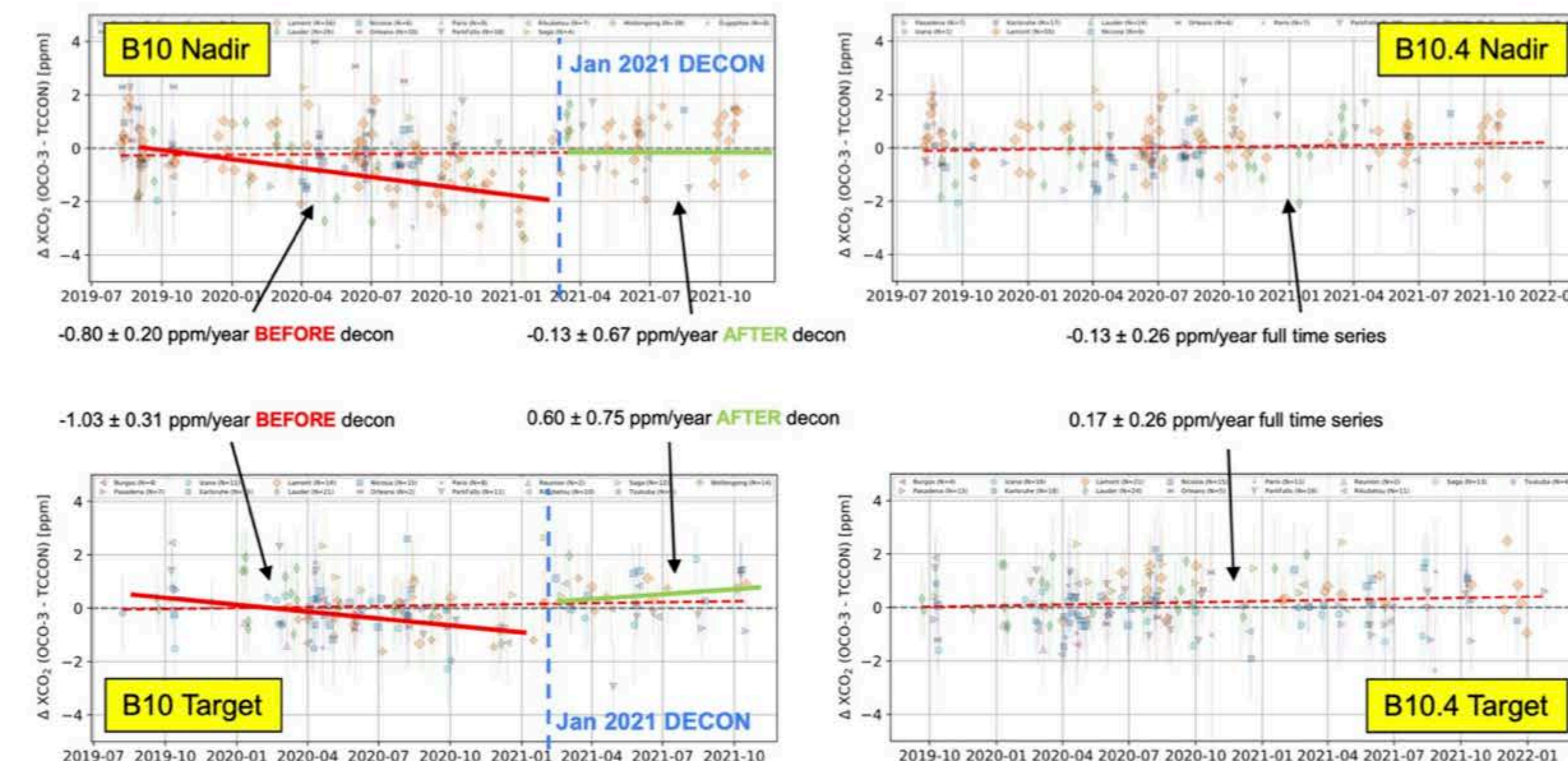

Fig: Number of good OCO-3 quality soundings over TCCON sites that meet the geometric collocation criteria. OCO-3 data used in this analysis spans from September 2019 to February 2022.
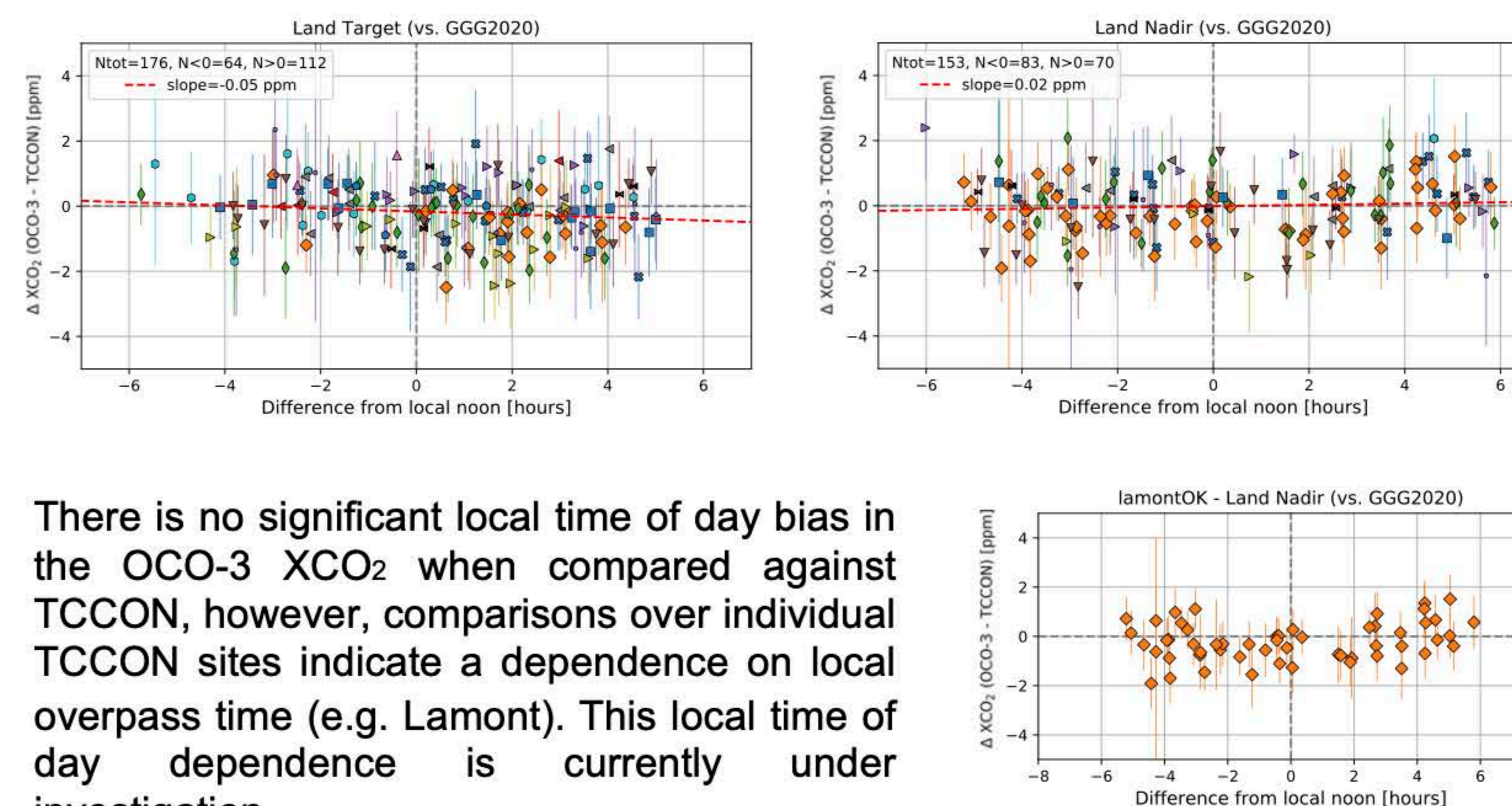
Comparison of Overpass Means

Temporal Dependence

The improved OCO-3 V10.4 data version reduces an XCO$_2$ time-dependent bias that was present in the previous data version (V10). The previous time-dependent bias has been traced to OCO-3 instrument icing and was highly correlated with the WCO2 spectral band Zero-Level-Offset, derived from sub-daily on-board calibration measurements. In V10.4, a correction was made to the XCO$_2$ to mitigate the diverging time trend.

Dependence on Local Overpass Time

Due to the precessing orbit of the International Space Station, overpasses do not occur at the same local time of day for a given point on Earth. On average, the ISS Equator crossing time occurs about 20 minutes earlier each day.
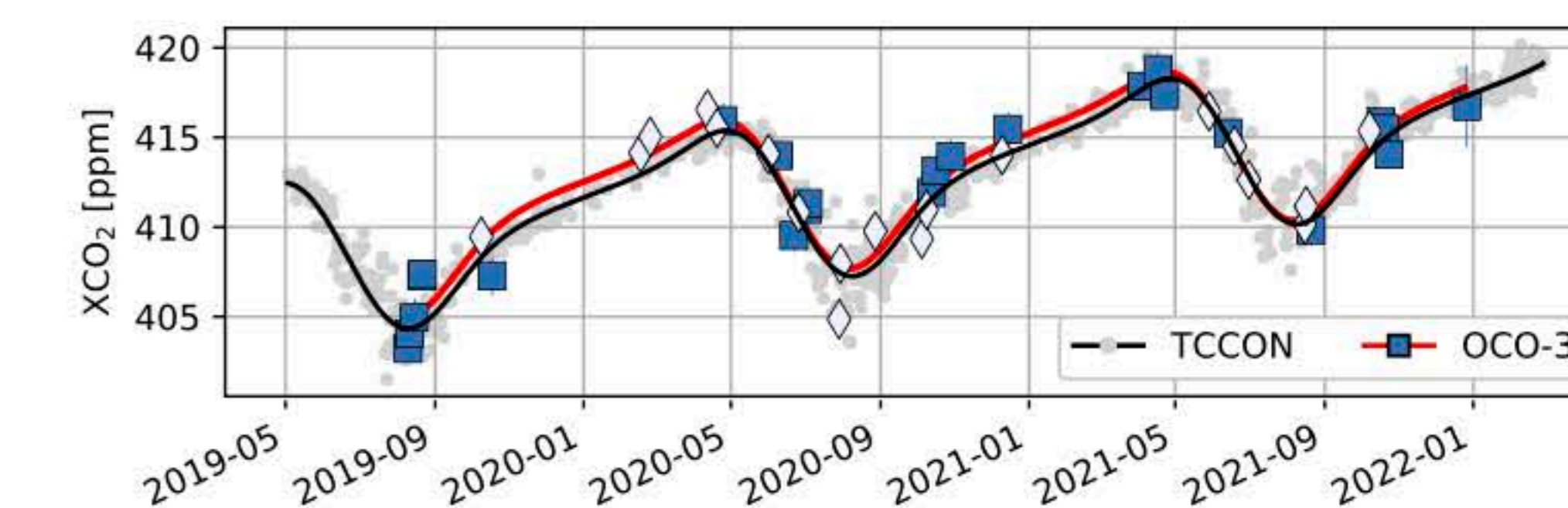

There is no significant local time of day bias in the OCO-3 XCO$_2$ when compared against TCCON, however, comparisons over individual TCCON sites indicate a dependence on local overpass time (e.g. Lamont). This local time of day dependence is currently under investigation.

Mean Seasonal Cycle Amplitude

Using a skewed sine wave approach (Lindqvist et al., 2015), we can quantify the peak-to-peak amplitude of the sine wave to define the XCO$_2$ seasonal cycle amplitude as seen by OCO-3 and TCCON over selected TCCON sites in the northern hemisphere. This method cannot be used to quantify interannual variability but it provides an average seasonal cycle amplitude conveniently.

Site	Mean Seasonal Cycle Amplitude	
	TCCON [ppm]	OCO-3 [ppm]
Pasadena	5.97 ± 0.12	5.56 ± 0.66
Nicosia	5.97 ± 0.13	6.63 ± 0.44
Izana	6.10 ± 0.07	6.74 ± 0.78
Karlsruhe	7.52 ± 0.24	6.63 ± 0.56
Lamont	5.24 ± 0.11	5.50 ± 0.48
Park Falls	8.97 ± 0.13	9.08 ± 0.66
Saga	6.04 ± 0.18	6.98 ± 0.89

Fig: Fit of the mean seasonal cycle using a skewed sine wave approach for based on OCO-3 and TCCON measurements over Lamont.

Los Angeles Snapshot Area Map (SAM) Comparisons

The OCO-3 instrument also collects data in SAM mode over several TCCON sites. SAM observations cover a much larger area (~ 80 x 80 km^2) compared to target mode observations and are more likely to capture local XCO$_2$ enhancements. Therefore, stricter geometric collocation criteria should be applied to SAM observations when compared to TCCON data. This sensitivity study over Los Angeles shows how the bias and scatter between OCO-3 and TCCON is reduced when stricter collocation criteria are chosen.