

Construction and Validation of the OCO-3 Version 11 XCO₂ Product

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OCO-3 & Version 11

Introduction

- OCO-3 has been operating on the International Space Station since August 2019. OCO-3 has been stowed since November 2023; it should resume operations in August 2024 (Fig 1).
- The latest operational version of OCO-3 XCO₂ data is V10.4, which is behind the latest version for OCO-2 (V11.2).

Version 11 Updates:

- Improved Calibration, including substantially improved pointing knowledge (Fig 2).
- Improved Algorithm: spectroscopy update to ABSCO 5.2, digital elevation map update to Copernicus DEM, prior meteorology update (GEOS-FPIT → GEOS-IT), other minor updates (see [1] for details).

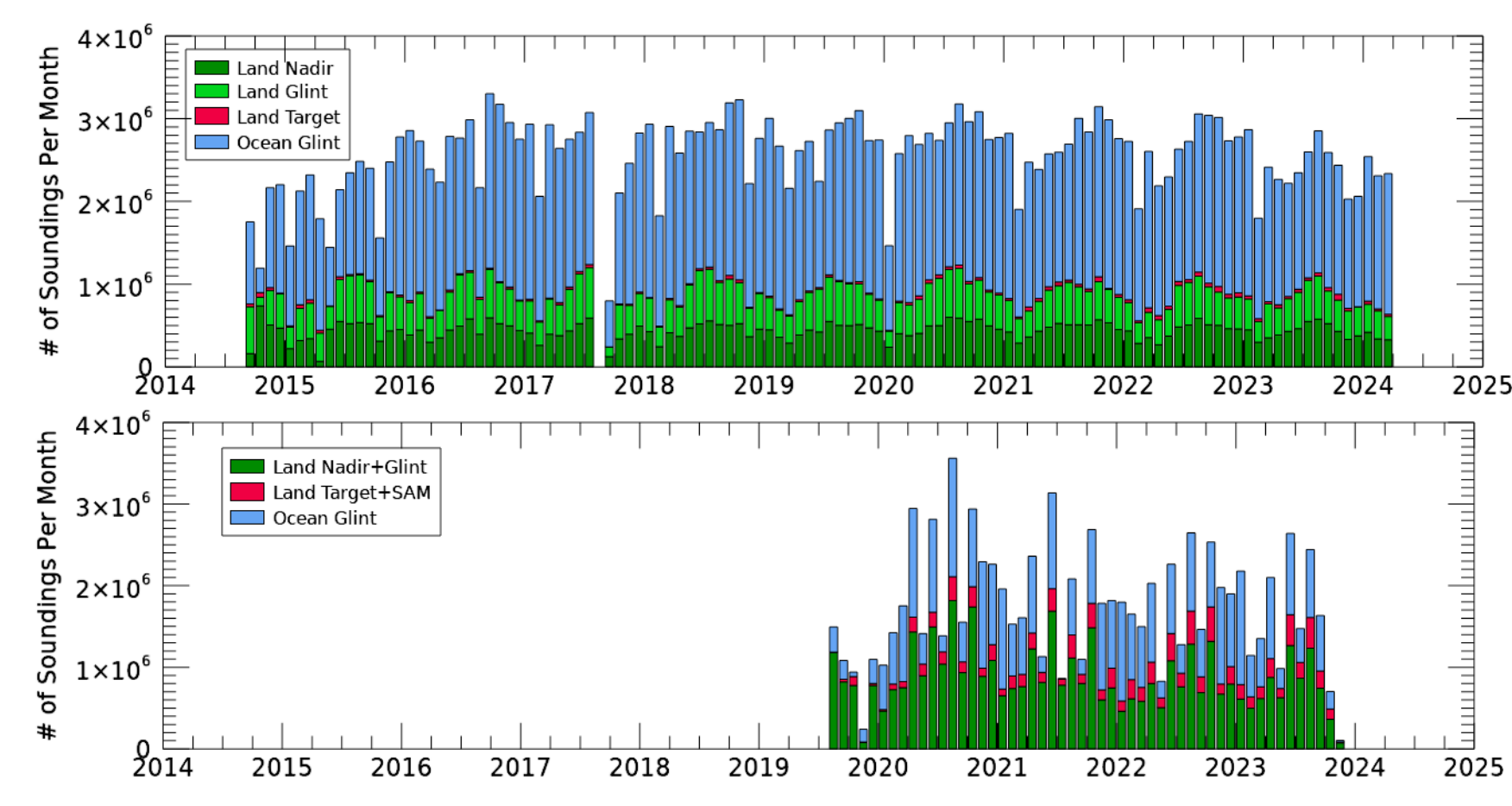


Fig 1: Time Series of OCO-2 & OCO-3 data

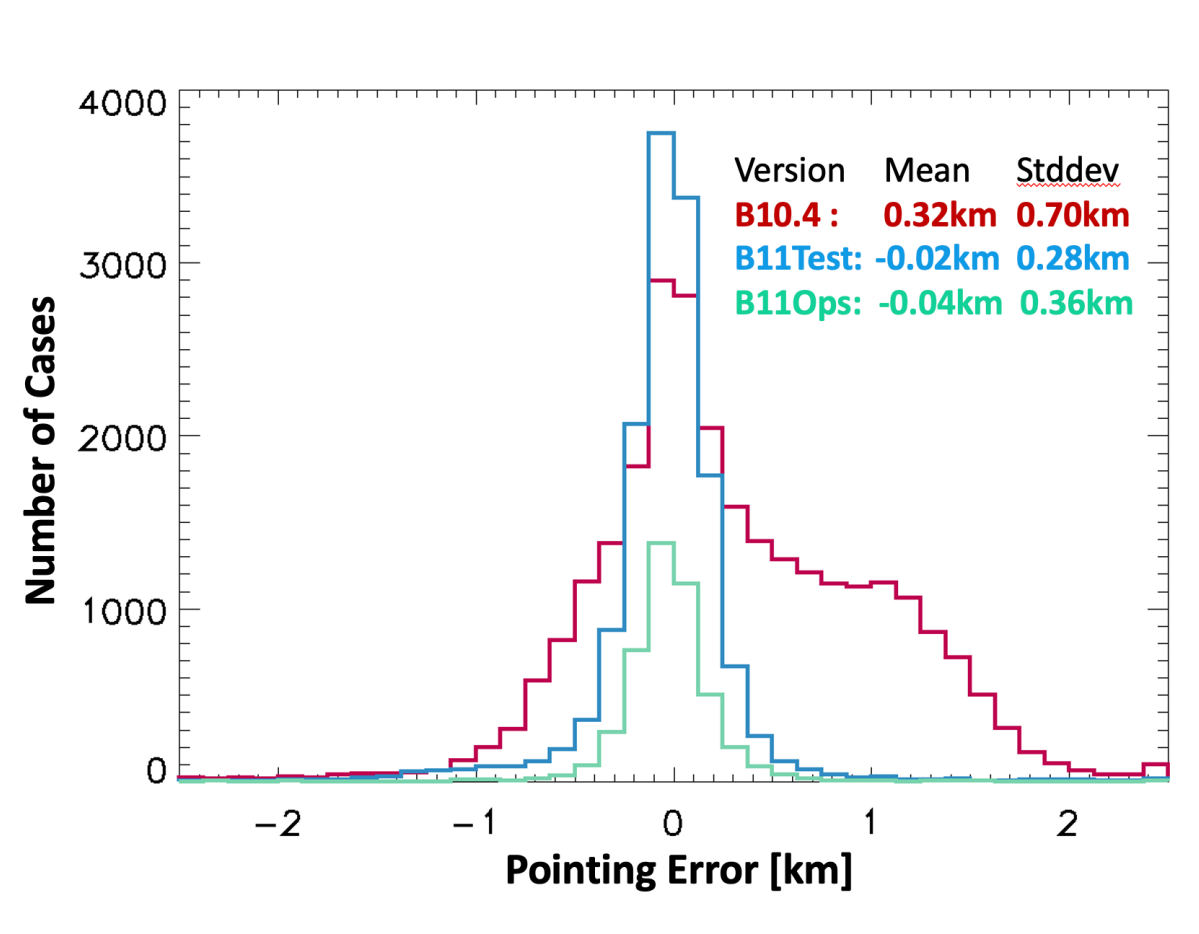


Fig 2: Pointing Improvements

OCO-3 Training Datasets

- We used 5 truth proxies for the OCO-3 Filtering & Bias Correction:
 - Multi-Model-Median
 - TCCON (GGG2020)
 - Small Area Approximation
 - OCO2 Colocations
 - Coastal Crossings

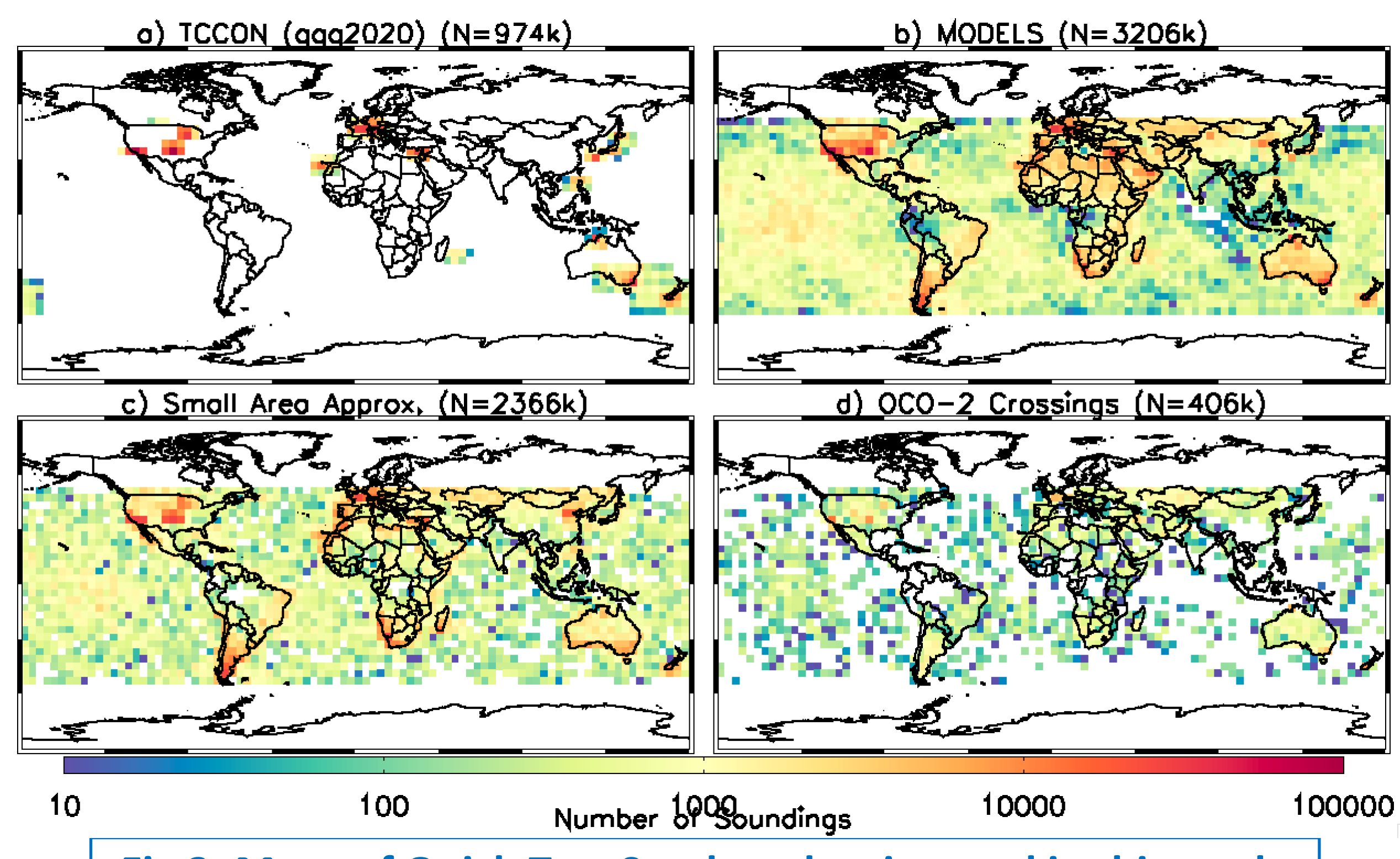
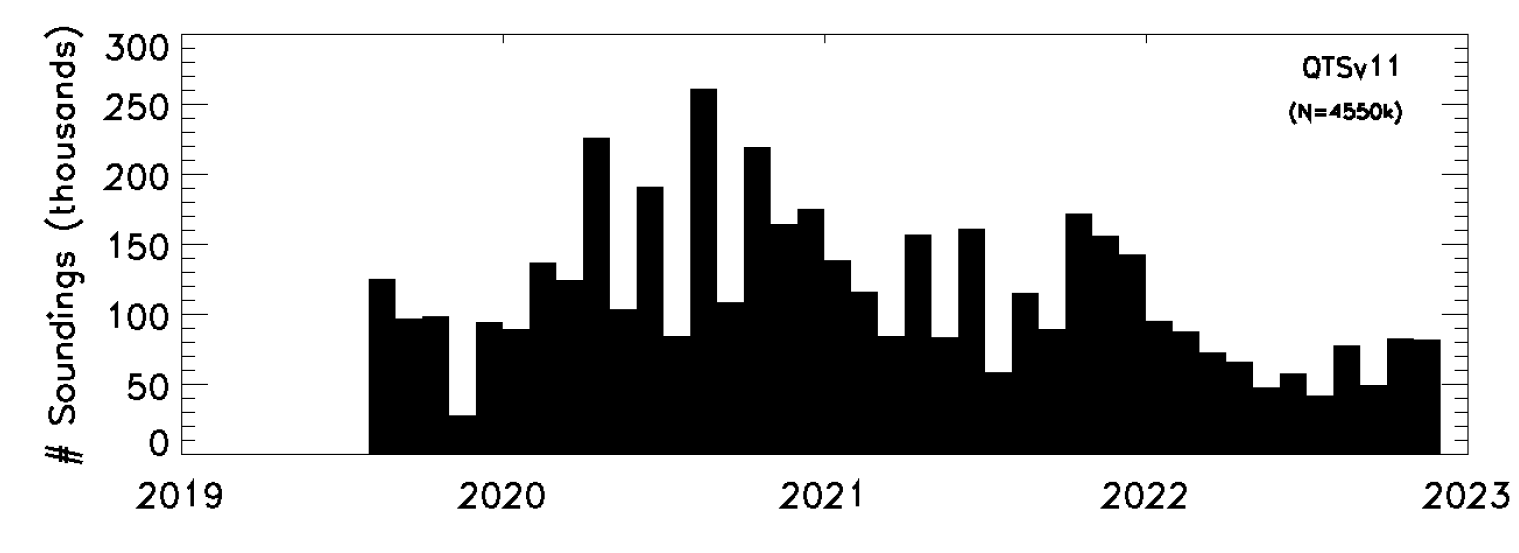


Fig 3: Maps of Quick-Test-Set data density used in this work.

Land Filtering & Bias Correction

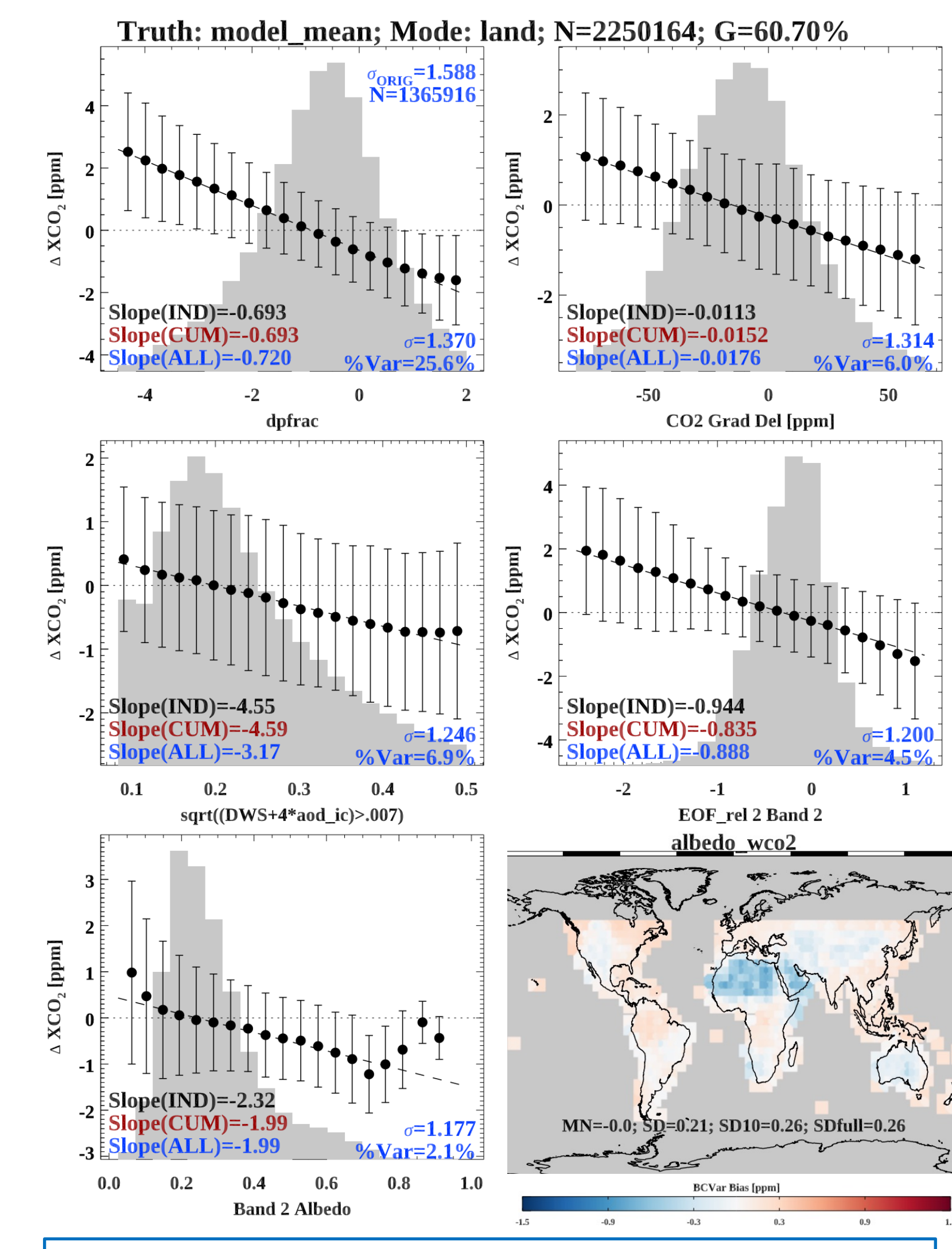


Fig 4: Bias correction parameters for land XCO₂. Weak CO₂ Albedo, although per-sounding is a weak correction (2% of variance), is important regionally and thus included.

- Used Methods of [2].
- Filtering used 23 variables, and was consistent with previous versions.
- The bias correction consisted of:
 - Parametric Bias Correction (5 vars)
 - Fixed Footprint Bias Correction
 - A bias linear in zero-level-offset, only affects data before Jan 12, 2021.
 - Global Scaling Factor tied to TCCON
- The BC coefficients were generally consistent among the truth proxies used. (Table 1)

Table 1: Bias correction coefficients over land from four truth proxies.

Truth	N	dPfrac	CO2GradDel	Sqrt(DWSI)	Eof2_rel	Alb_wco2
ModelMean	1366k	-0.72	-0.0176	-3.2	-0.89	-1.99
TCCON	569k	-0.71	-0.0180	-3.2	-0.89	-1.75
OCO2X	234k	-0.75	-0.0191	-4.2	-0.87	-0.78
Coastal	49k	-0.70	-0.0141	-3.4	-1.06	-1.89
Uncertainty		± 4%	± 13%	± 16%	± 9%	± 27%
OCO3 B11		-0.71	-0.0180	-3.4	-0.93	-1.8
OCO3 B10.4		-0.62	-0.0110	N/A	N/A	-2.5

Ocean Filtering & Bias Correction

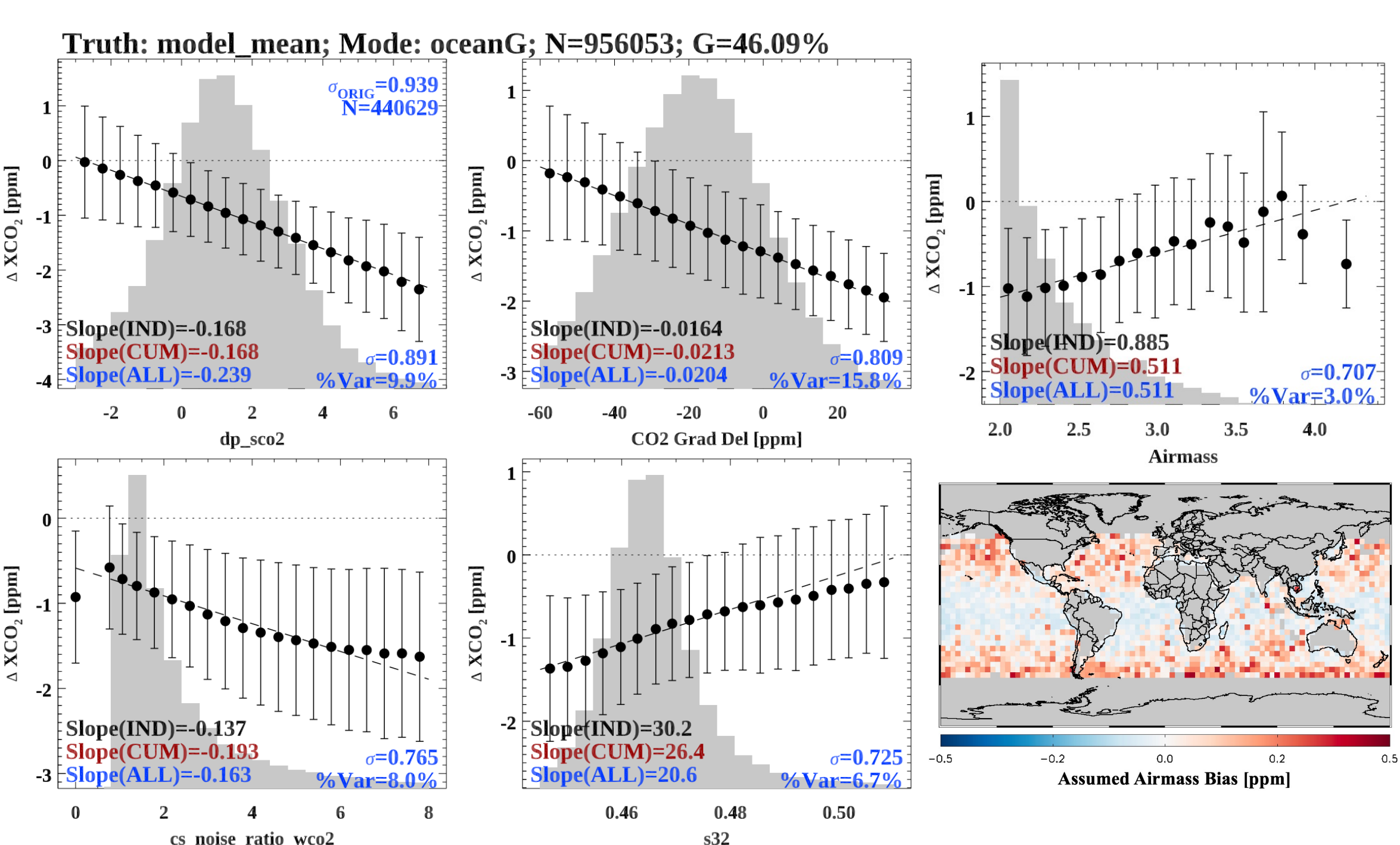
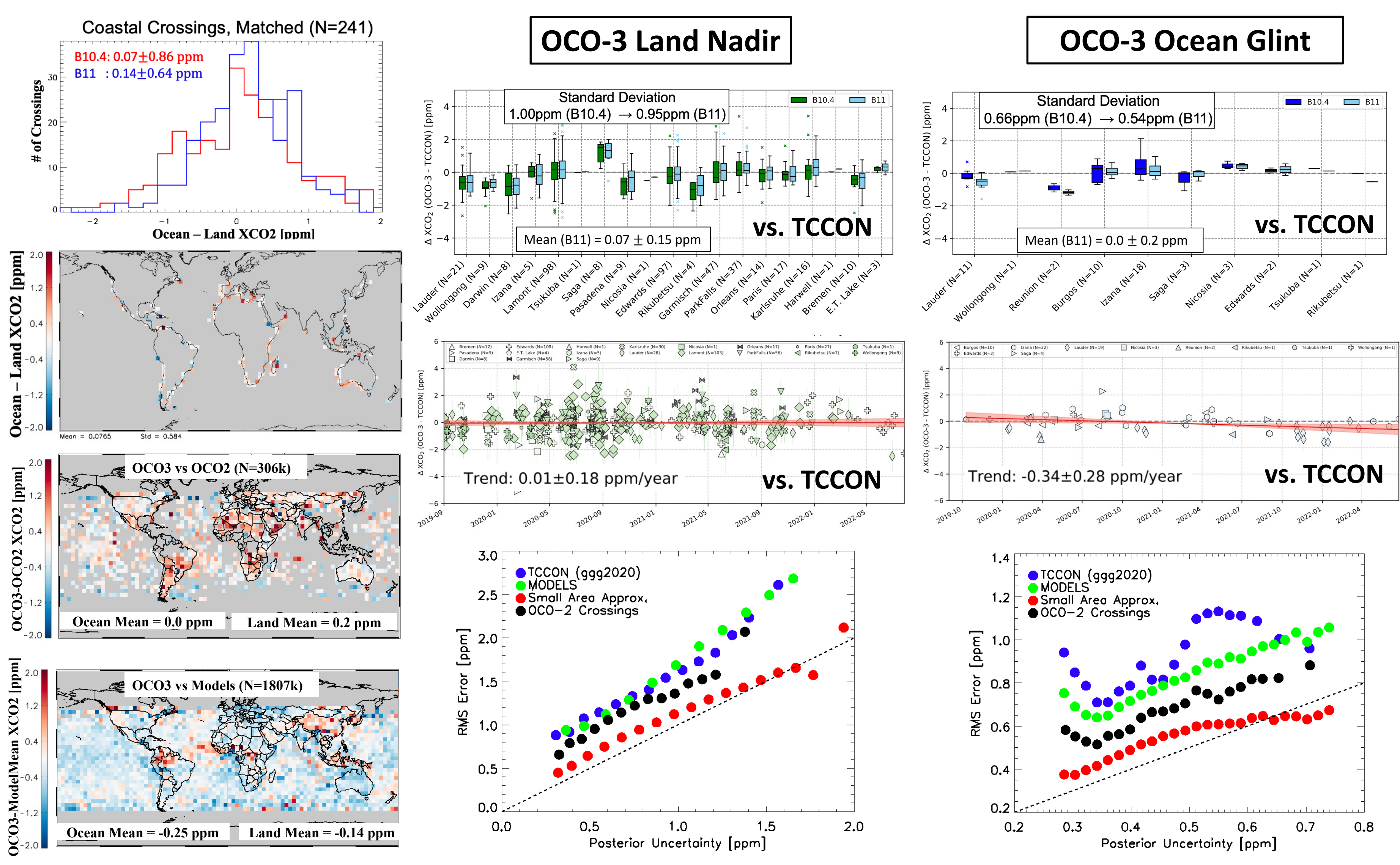


Fig 5: Bias correction parameters for ocean XCO₂. Airmass was included as a bias parameter as it was consistently chosen for TCCON, all the models, and OCO2 truth proxies.

Truth	N	dPscO2	CO2GradDel	CSNR_wco2	s32	Airmass
ModelMean	440k	-0.239	-0.0204	-0.163	20.6	0.51
TCCON	45k	-0.219	-0.0212	-0.172	33.7	0.45
OCO2X	73k	-0.176	-0.0220	-0.134	10.3	0.37
Coastal	30k	-0.256	-0.0208	-0.118	21.4	-0.37 ??
Uncertainty		± %	± %	± %	± %	± %
OCO3 B11		-0.215	-0.020	-0.135	21.5	0.40
OCO2 B10.4		-0.16	0.13	N/A	N/A	N/A

Table 2: Bias correction coefficients over water from four truth proxies.

Validation Plots



Summary

- A new version of OCO-3 XCO₂ data, V11, has been trained & validated, using five truth proxies (including OCO-2 colocations).
- XCO₂ has been scaled to have no global bias vs. TCCON; this creates global biases vs. models (~ -0.2 ppm). There is no apparent time trend.
- The V11 data has slightly better error statistics than V10.4 vs. TCCON – lower scatter and inter-station bias.
- Once OCO-3 becomes operational again, V11 data will be available soon thereafter (expected Aug-Sep 2023).
- Reprocessing the full 2019–2023 record is expected to complete in late 2024 – early 2025.

References: [1] Jacobs et al., 2024: “The importance of digital elevation model accuracy in XCO₂ retrievals: improving the OCO-2 ACOS version 11 retrieval product”, *Atmos Meas. Tech.*, 17, 1375-1401. [2] O’Dell et al., 2018: “Improved retrievals of carbon dioxide from OCO-2 with the version 8 ACOS algorithm”, *Atmos. Meas. Tech.*, 11, 6539–6576; [3] Taylor et al., 2023: “Evaluating the consistency of OCO-2 and OCO-3 XCO₂ estimates derived from the NASA ACOS version 10 retrieval algorithm”, *Atmos. Meas. Tech.*, 16, 3173-3209.