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Fachbereich 1
Physik/Elektrotechnik

New Results from GOSAT and GOSAT-2 FOCAL Retrievals

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ATMOS 2021

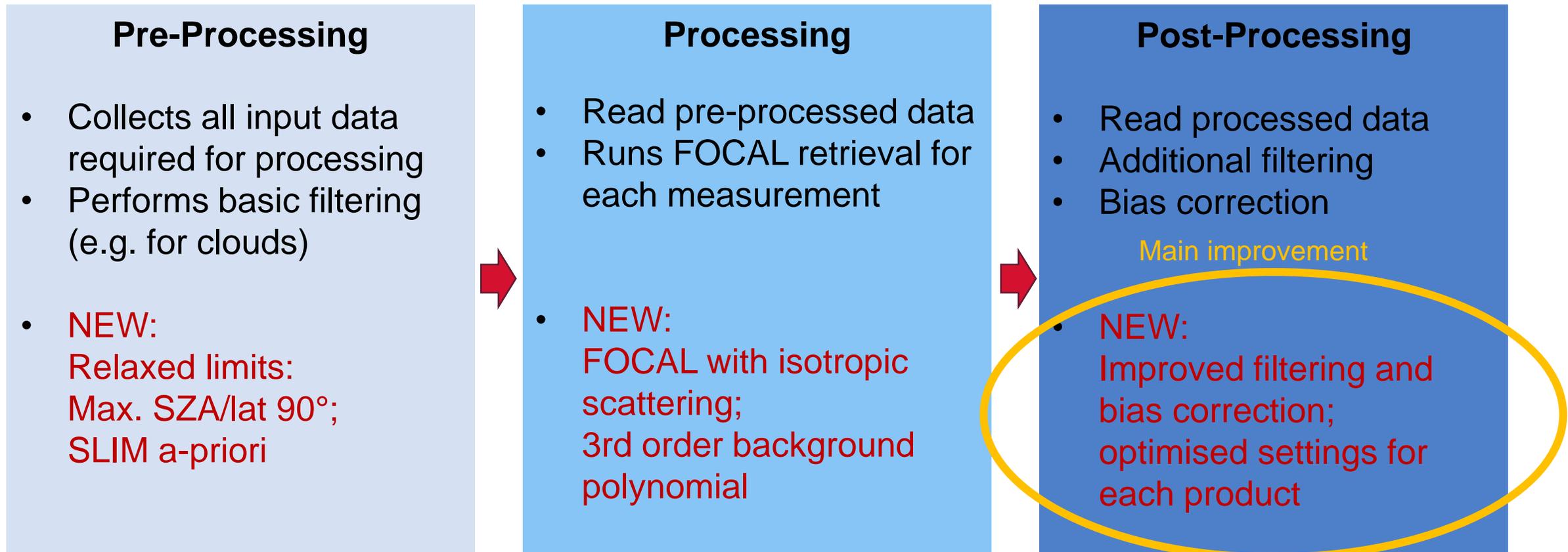


Introduction

- Noël et al. (AMT 2021) presented a first application of the Fast atmospheric trace gas retrieval (FOCAL) method to GOSAT and GOSAT-2 measurements (only XCO₂, v1.0)
- FOCAL was first applied to OCO-2 (Reuter et al., 2017):
 - Fast and accurate method suited for large data sets (e.g. forthcoming CO2M)
 - Full physics retrieval based on optimal estimation
 - Scattering is approximated by single scattering layer
- GOSAT/GOSAT-2 retrieval method has been further improved:
 - Updated XCO₂ and also results for other gases available (v3.0):
XCH₄ (+Proxy), XH₂O, HDO (delta D) and for GOSAT-2 also XCO and XN₂O
- All data until end of 2020 processed and validated with TCCON
 - GOSAT-2 validation preliminary (only ~2 years)

FOCAL Retrieval

→ 3 main steps: pre-processing, processing, post-processing



Post-Processing Filters

→ Basic filter:

→ Convergence

→ Residual to noise ratio filter

→ Filtering out low quality data:

1. SZA filter ($< 75^\circ$); not applied to XH₂O
2. Variance filter as for OCO-2, using deviation relative to local median as reference:
Determine best parameter limits to reduce local variance to a prescribed limit
 - a) For retrieved optical depth of scattering layer only; not for XCH₄ Proxy and XH₂O
 - b) For full list of possible variables (largely reduced compared to v1; esp. no CO₂ gradient used)

→ Only input: Percentage of data to be filtered out (optimized for each product)

→ Almost automatic determination of filters

Bias Correction

→ Applied only to XCO₂ and XCH₄ data

→ Method: Random forest regression

→ Same method as in Noël et al. (2021)

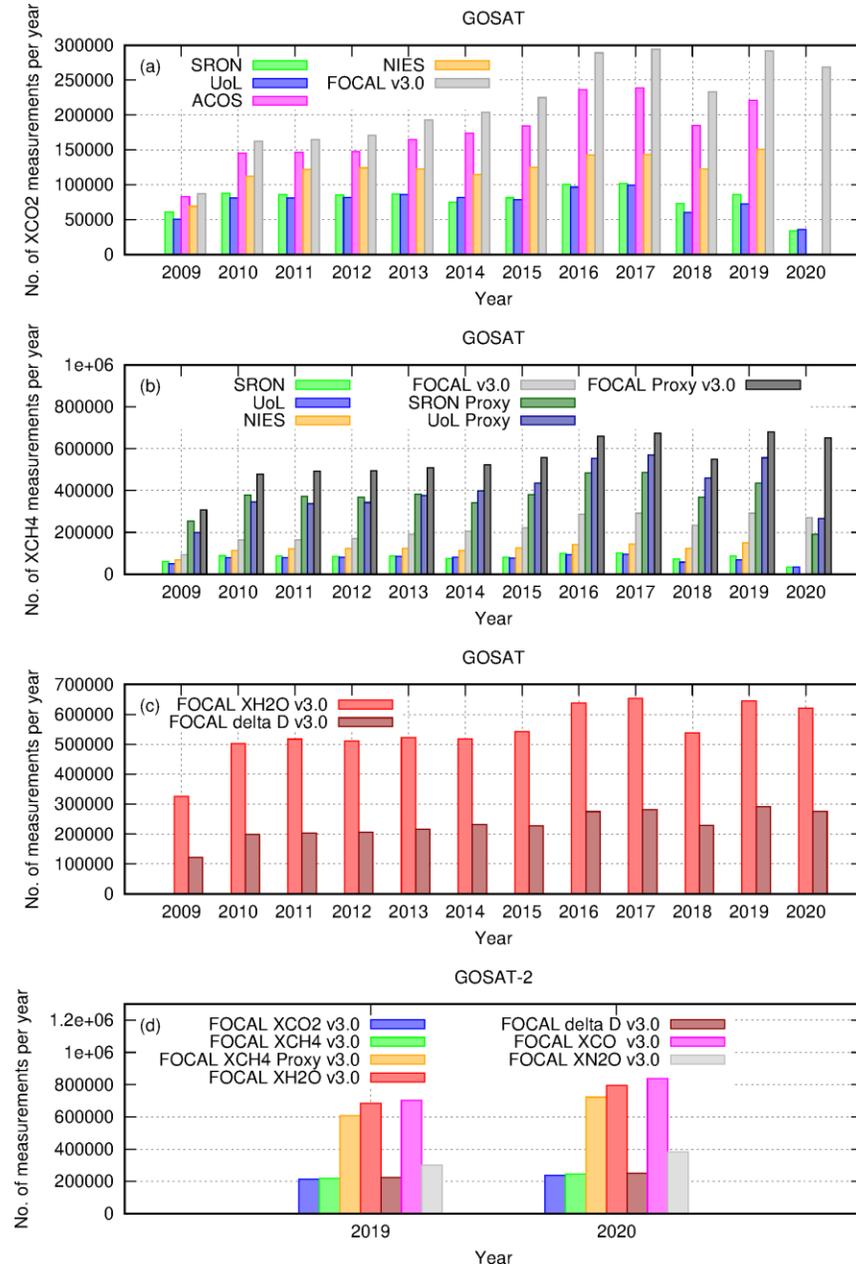
→ Reference for the bias correction:

Data base derived from a subset of SLIM data for 2019, confirmed by TCCON

→ Reduced set of possible variables/features (e.g. no gradients)

No. of valid data

- Data yield largely improved in v3.0
- More valid data than other available GOSAT products
- NASA ACOS XCO₂ v9r
- SRON XCO₂/XCH₄ FP v238, XCH₄ Proxy v239
- UoL XCO₂/XCH₄ FP v73, XCH₄ Proxy v90
- NIES XCO₂/XCH₄ v029x (bias corrected)
- About 2-3x more data in FOCAL XCH₄ Proxy, XH₂O and XCO due to relaxed filtering compared to FP XCO₂, XCH₄, XN₂O and delta D



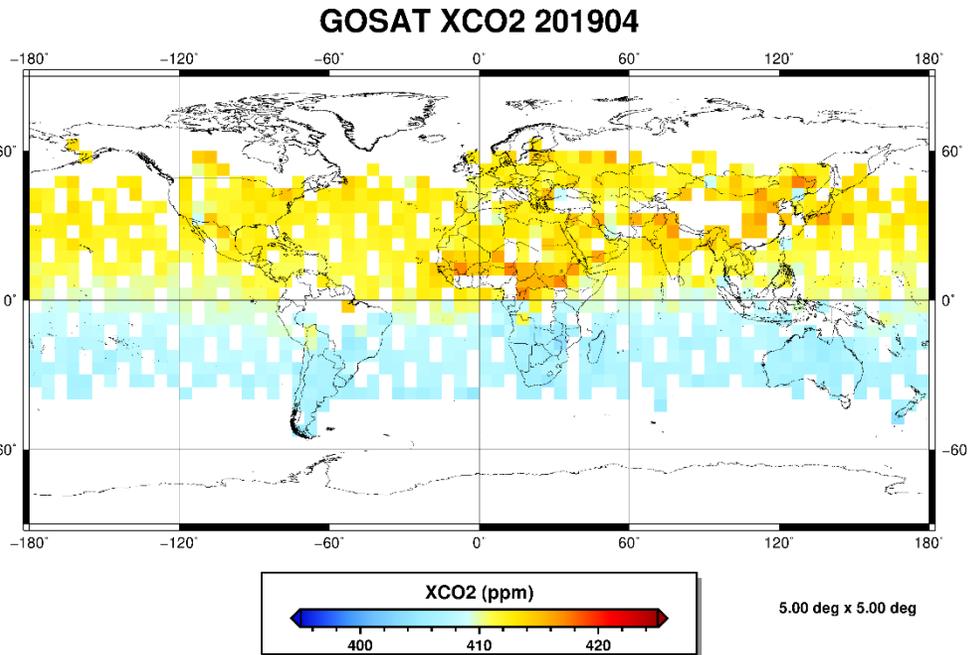
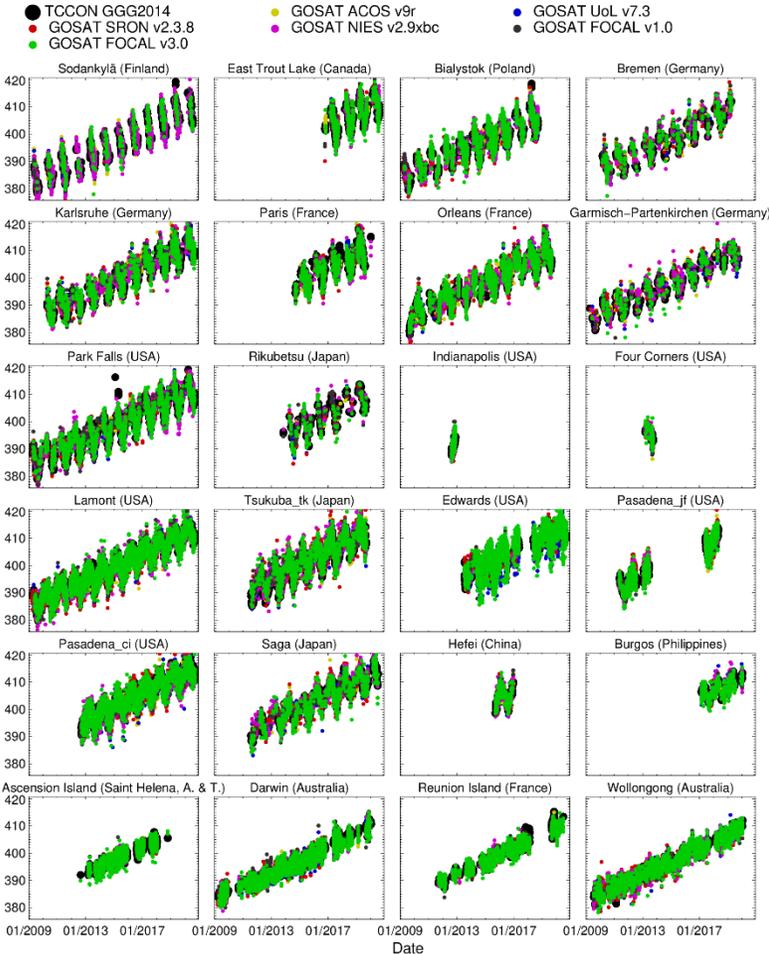
Carbon Dioxide (XCO₂): Map & TCCON Validation

TCCON validation results:

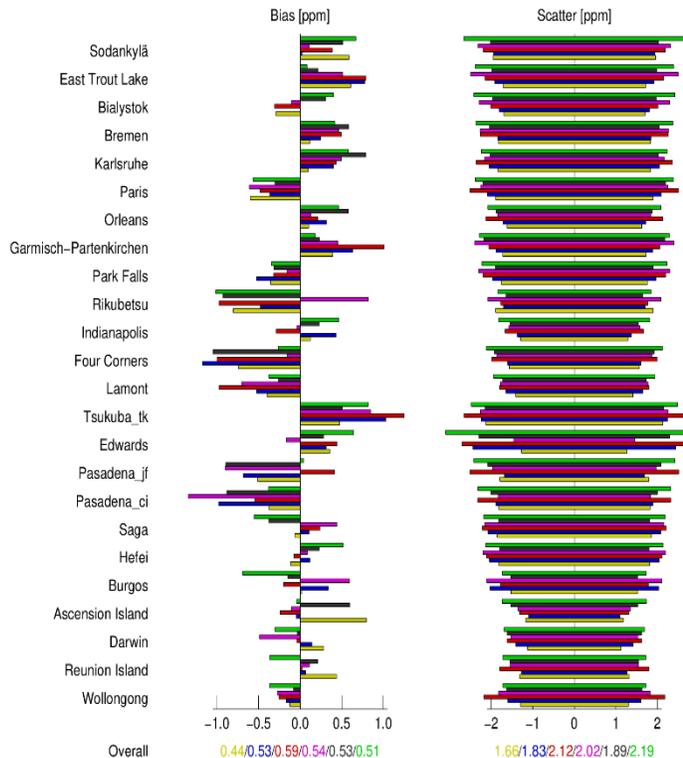
→ FOCAL v3.0 XCO₂ bias/scatter

0.51/2.19 ppm (GOSAT)

0.88/2.04 ppm (GOSAT-2)



- ACOS v9r
- SRON v2.3.8
- FOCAL v1.0
- UoL v7.3
- NIES v2.9xbc
- FOCAL v3.0

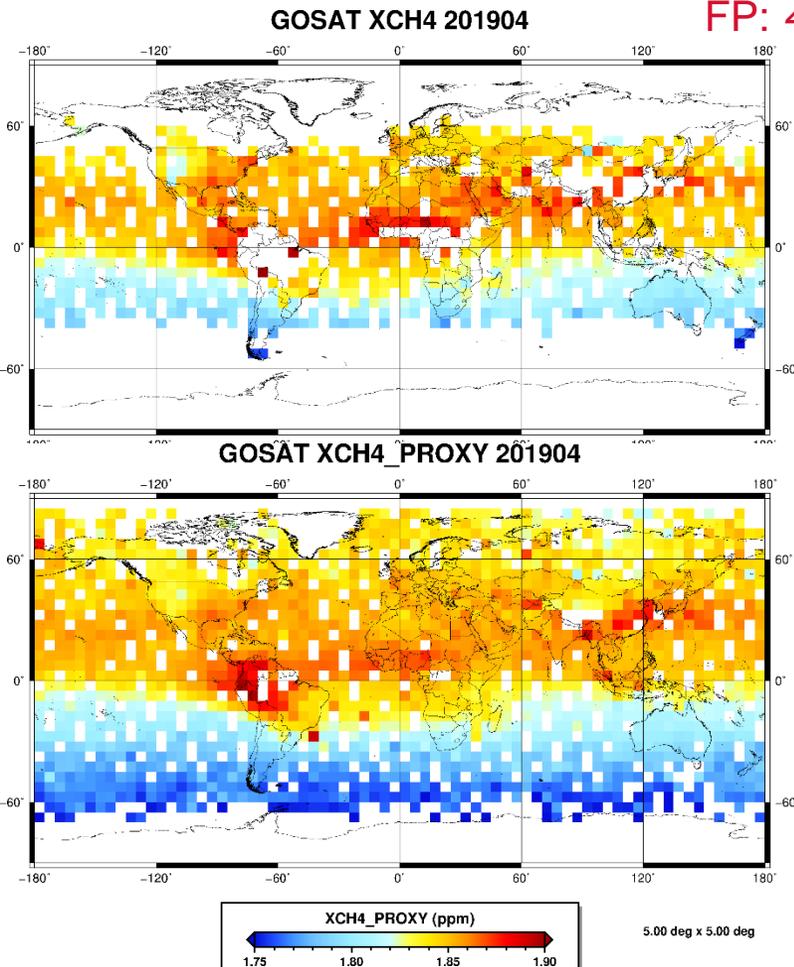


Methane (XCH₄): Map & TCCON Validation (FP & Proxy)

TCCON validation results:

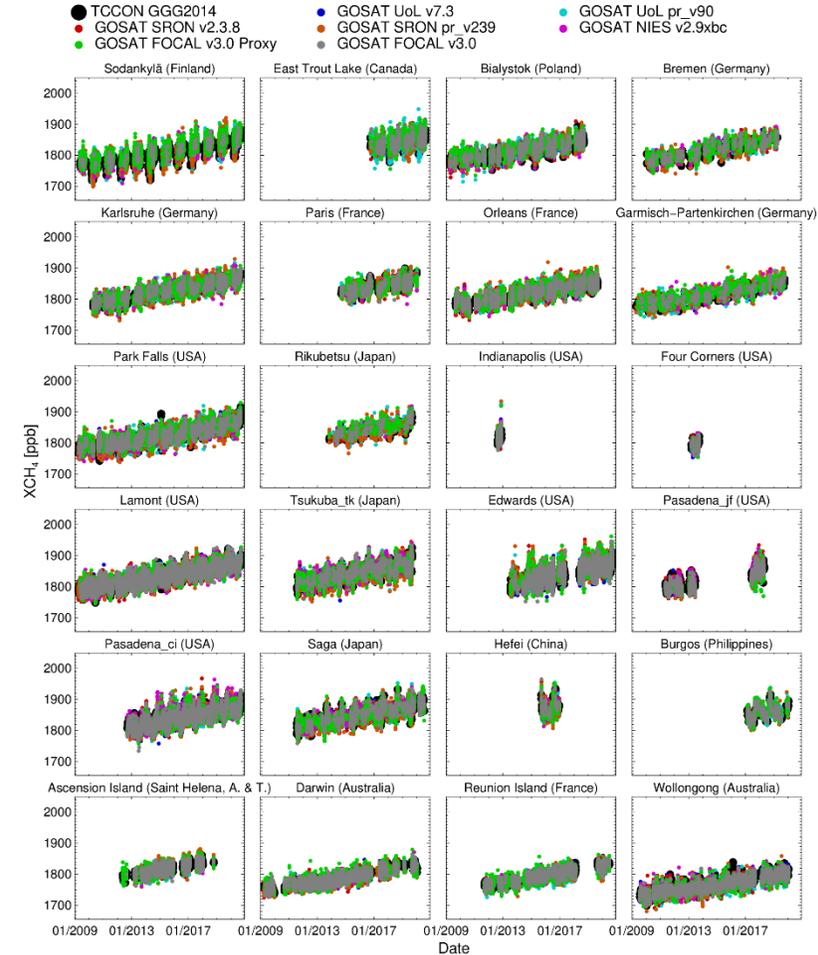
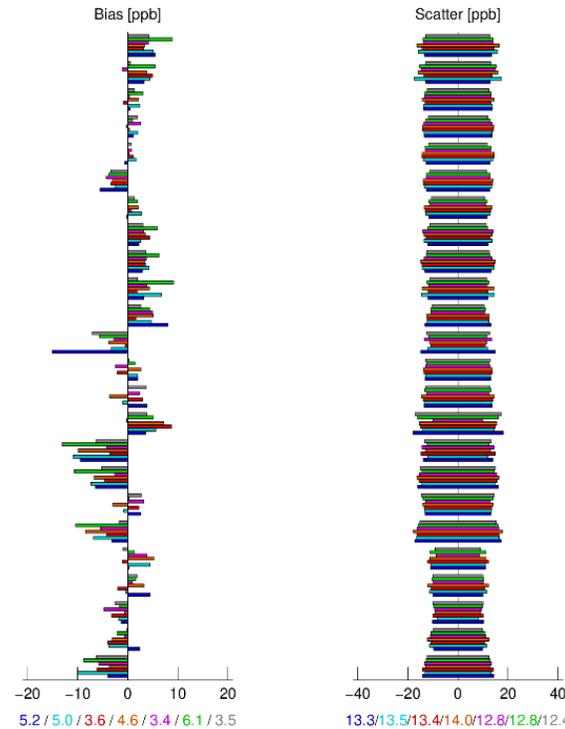
→ FOCAL v3.0 XCH₄ bias/scatter FP: 4.3/12.4 ppb
FP: 4.5/11.9 ppb

Proxy: 6.1/12.8 ppb (GOSAT)
Proxy: 6.4/11.5 (GOSAT-2)



- UoL v7.3
- SRON v2.3.8
- NIES v2.9xbc
- FOCAL v3.0
- UoL pr_v90
- SRON pr_v239
- FOCAL v3.0 Proxy

- Sodankylä
- East Trout Lake
- Bialystok
- Bremen
- Karlsruhe
- Paris
- Orleans
- Garmisch-Partenkirchen
- Park Falls
- Rikubetsu
- Indianapolis
- Four Corners
- Lamont
- Tsukuba_tk
- Edwards
- Pasadena_jf
- Pasadena_ci
- Saga
- Hefei
- Burgos
- Ascension Island
- Darwin
- Reunion Island
- Wollongong



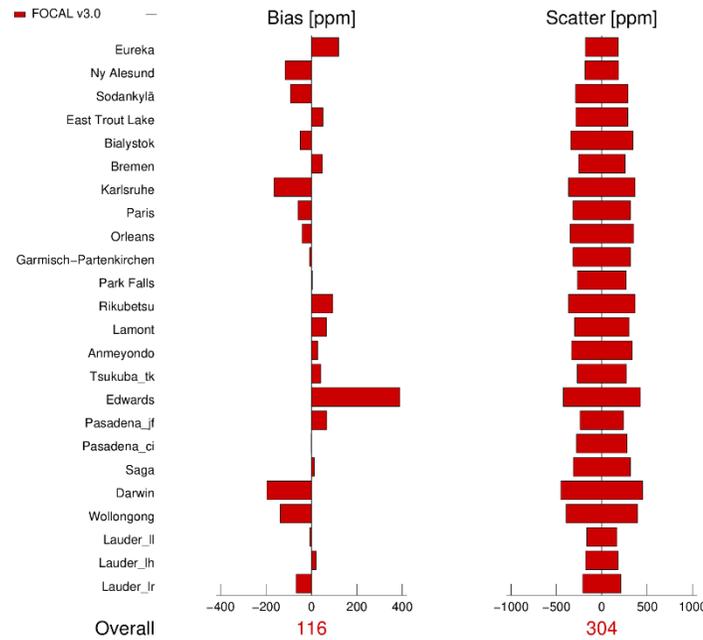
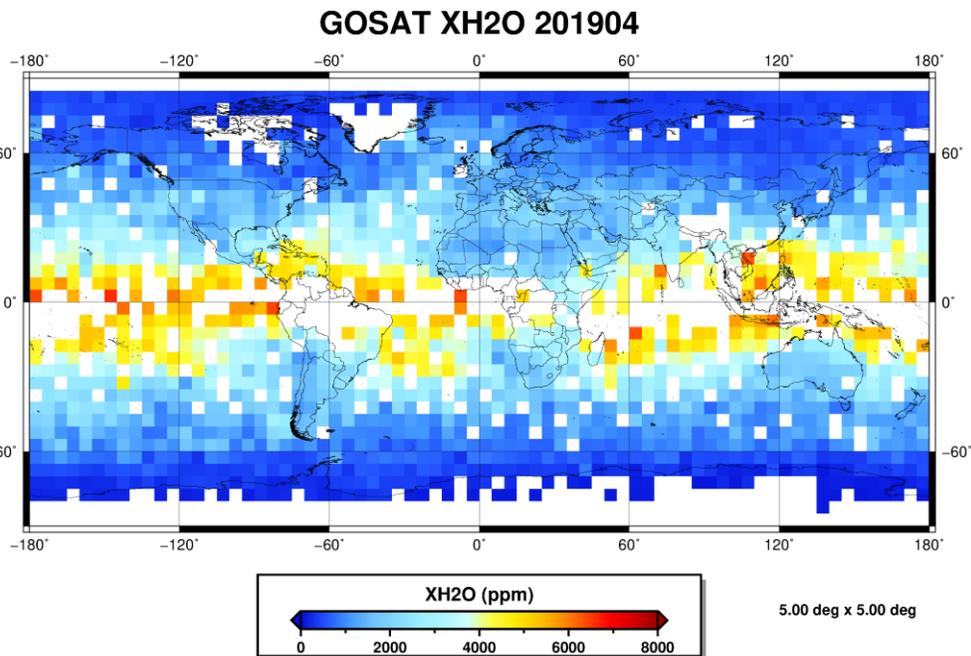
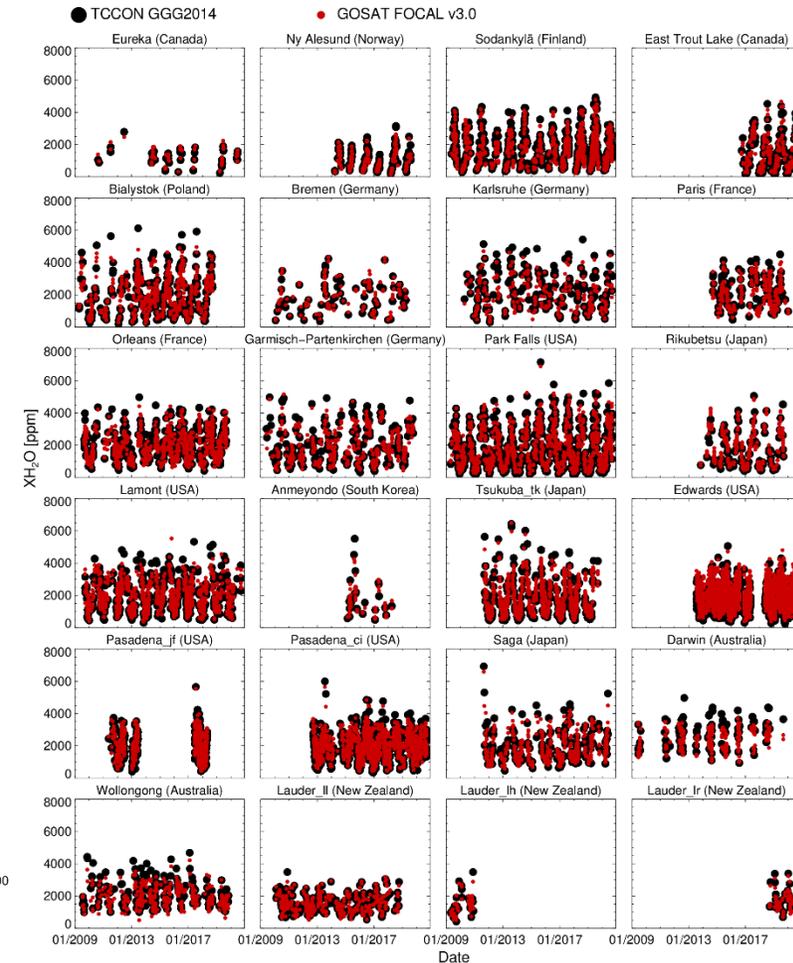
Water Vapour (XH₂O): Map & TCCON Validation

TCCON validation results:

→ FOCAL v3.0 XH₂O bias/scatter

116/304 ppm (GOSAT)

162/293 ppm (GOSAT-2)

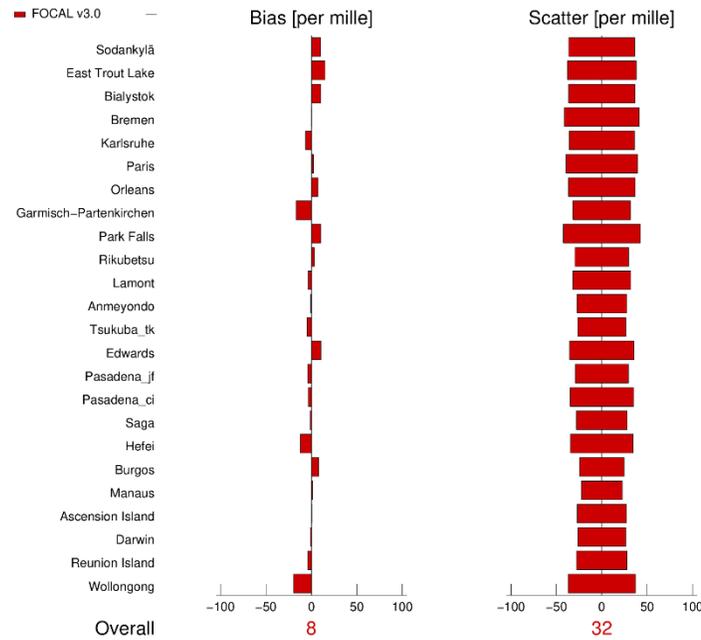
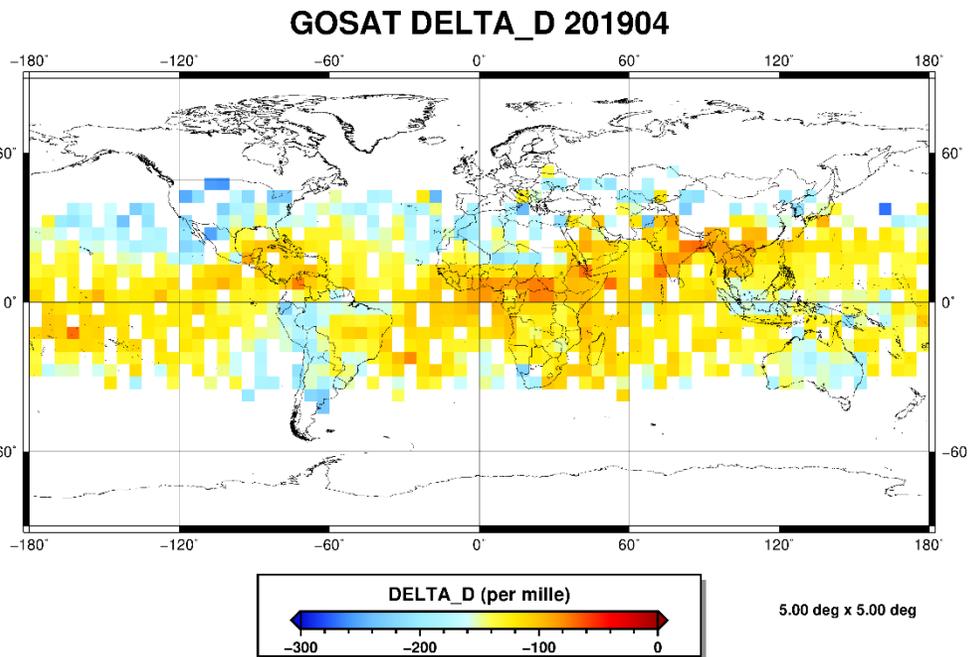
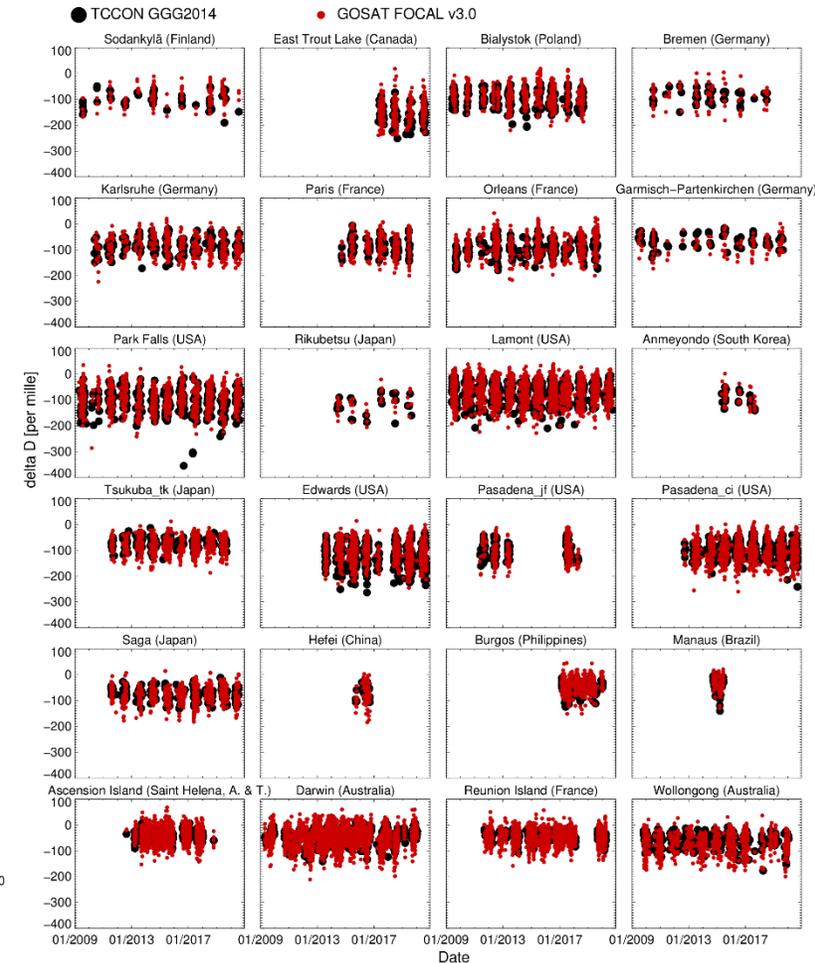


HDO (delta D): Map & TCCON Validation

TCCON validation results:

→ FOCAL v3.0 delta D bias/scatter

8/32 per mille (GOSAT)
8/32 per mille (GOSAT-2)

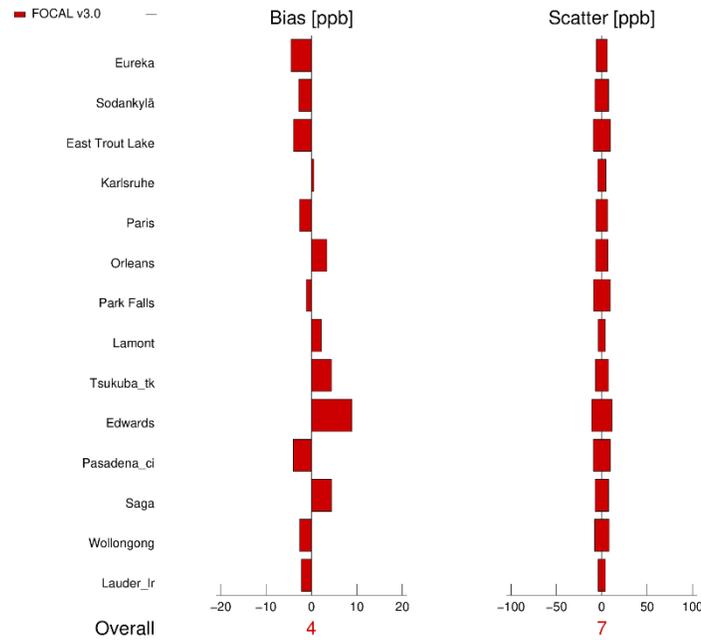
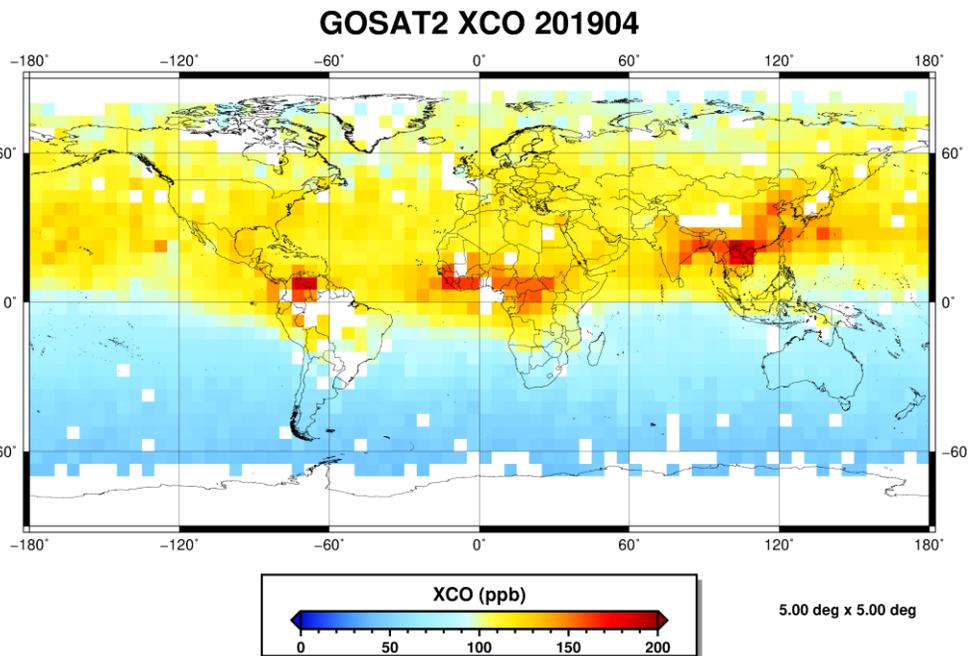
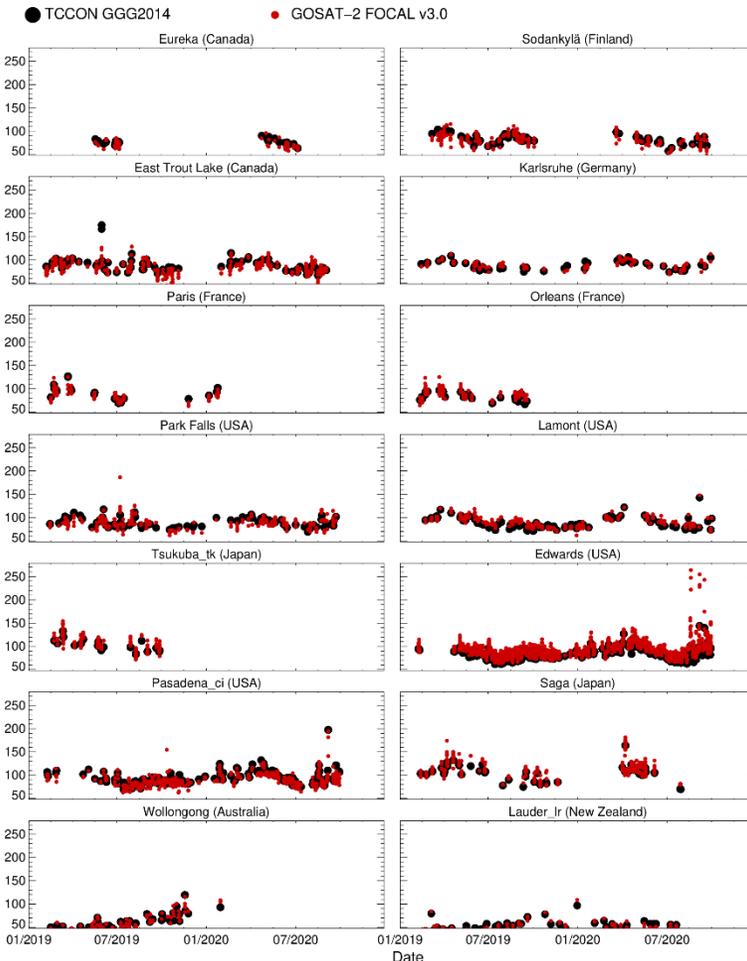


Carbon Monoxide (XCO): Map & TCCON Validation

TCCON validation results:

→ FOCAL v3.0 XCO bias/scatter

4.1/7.4 ppb (GOSAT-2)

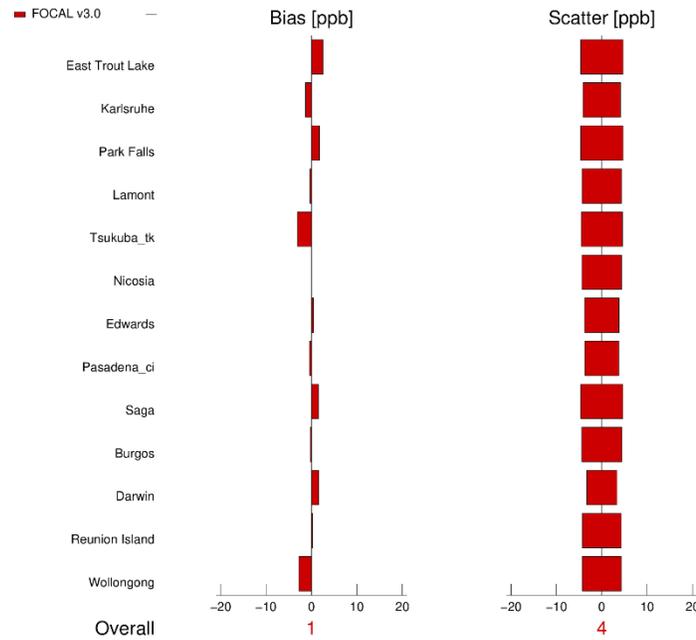
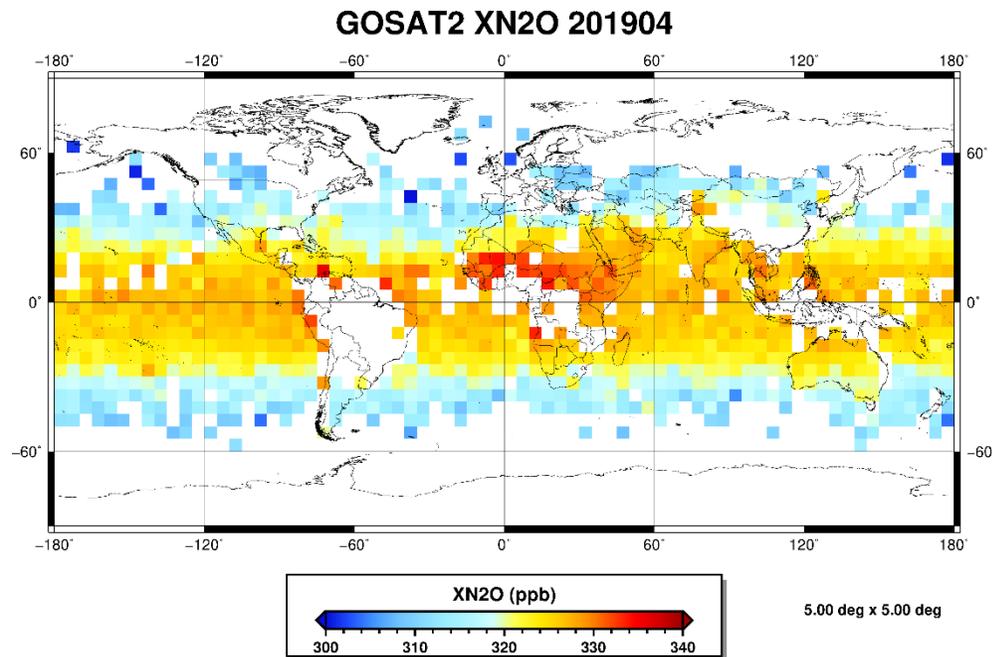
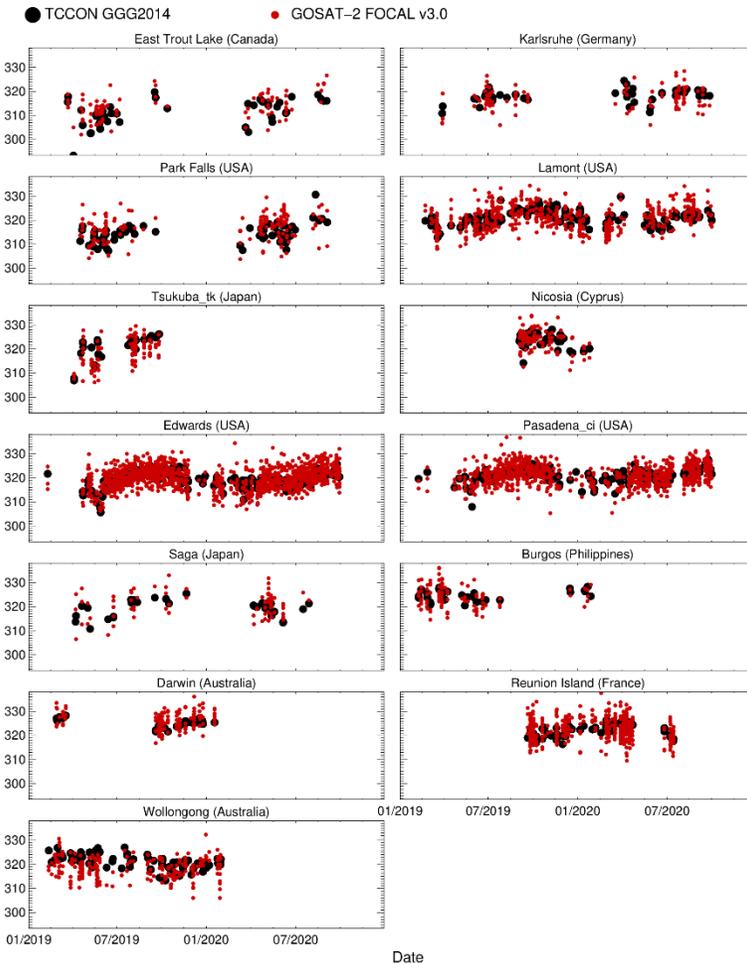


Nitrous Oxide (XN₂O): Map & TCCON Validation

TCCON validation results:

→ FOCAL v3.0 XN₂O bias/scatter

1.7/4.3 ppb (GOSAT-2)



Conclusions

- New v3.0 of GOSAT/GOSAT-2 FOCAL products is available (data until 2020)
- Especially updated post-processing
- Data yield improved
- Additional products (to XCO₂):
 - XCH₄ (FP + Proxy), XH₂O, HDO (delta D); XCO, XN₂O (GOSAT-2)
- TCCON validation shows good results
- Publication in preparation

- FOCAL is well suited for processing of e.g. future CO₂M data
- GOSAT-FOCAL will be baseline for future CAMS XCO₂ products from IUP

Acknowledgements

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THANK YOU FOR YOUR ATTENTION!