New Results from GOSAT and GOSAT-2 FOCAL Retrievals

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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

**Pre-Processing**
- Collects all input data required for processing
- Performs basic filtering (e.g. for clouds)
- **NEW:** Relaxed limits: Max. SZA/lat 90°; SLIM a-priori

**Processing**
- Read pre-processed data
- Runs FOCAL retrieval for each measurement
- **NEW:** FOCUS with isotropic scattering; 3rd order background polynomial

**Post-Processing**
- Read processed data
- Additional filtering
- Bias correction
- **NEW:** Improved filtering and bias correction; optimised settings for each product

SLIM = Simple cLImatological Model for CO2 and CH4; based on CarbonTracker CO2 / TM5 CH4 data
Post-Processing Filters

→ Basic filter:
  → Convergence
  → Residual to noise ratio filter

→ Filtering out low quality data:

1. SZA filter (< 75°); 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 XCO\textsubscript{2} bias/scatter

0.51/2.19 ppm (GOSAT)
0.88/2.04 ppm (GOSAT-2)
Methane (XCH4): Map & TCCON Validation (FP & Proxy)

TCCON validation results:

→ FOCAL v3.0 XCH$_4$ 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)
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
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