

Using the COllaborative Carbon Column Observing Network for validating space borne GHG sensors

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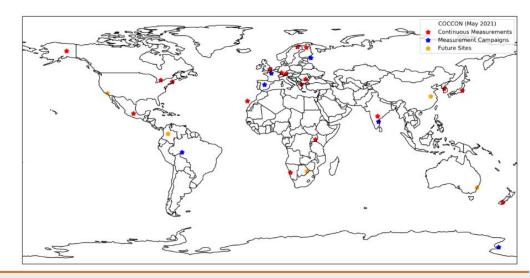
ROYAL BELGIAN INSTITUTE FOR SPACE AERONOMY



COllaborative Carbon Column Observing Network (COCCON)



- COCCON as the framework for EM27/SUN spectrometers; <u>https://www.imk-asf.kit.edu/english/COCCON.php</u>
- EM27/SUN are portable low-resolution (0.5 cm⁻¹) FTIR spectrometers operating with dual InGaAs detectors covering 4000 11000 cm⁻¹
- Simultaneous retrievals of column abundances of CO₂ (XCO₂), CH₄ (XCH₄), CO (XCO), H₂O (XH₂O), O₂
- **COCCON central facility** performs checks of new instruments (before delivery to customers) alignment checks and ILS measurements, side-by-side measurements with reference EM27/SUN and TCCON instrument at Karlsruhe to determine scaling factors for each target gas
- Retrievals performed using COCCON processing chain (PREPROCESS + PROFFAST) either by site PIs or by using COCCON central processing facility. Important to use the correct ILS and scaling factors → follow processing chain
- Tools available to store output stored as GEOMS HDF and provision of DOI via EVDC with prefix 10.48477
- Travelling standard for tying COCCON and TCCON calibration closer, diagnose TCCON station-to-station biases, support measures for further improving TCCON network consistency
- More than **50 EM27/SUNs** are operated around the world as campaign deployment or permanent stations
- Harmonised data product offering reference data from wide range of geophysical conditions for satellite and model data validation.
- BIRA-IASB is coordinating the validation activities
- **ESA support** for the COCCON central facility, future improvements, campaigns and validation work via projects COCCON PROCEEDS II & COCCON PROCEEDS III (in preparation), FRM4GHG & FRM4GHG-2.0 (in preparation), SVANTE, QA4EO, MPC
- Please contact us if you want further information on data processing, the central facility, creating GEOMS HDF output files and if you want to contribute to our study with your data.
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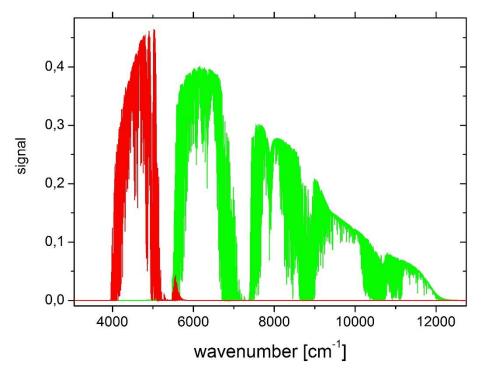




Validating space borne GHG sensors



- COCCON provides one measurement every minute. Good possibility to get data even in broken cloudy conditions.
- Simultaneous retrievals of column abundances of CO₂ (XCO₂), CH₄ (XCH₄), CO (XCO), H₂O (XH₂O) enable us to use the data for validation of several space borne sensors
- In this study we focus on using the COCCON XCO₂ product for validating OCO-2 XCO₂ data; XCH₄, XCO, XH₂O products for validating Sentinel 5 Precursor XCH₄, XCO (official), XH₂O (scientific) products
- See poster of Matthias M. Frey in session 2.2b for validation of **GOSAT** XCO₂, XCH₄ products using COCCON XCO₂ and XCH₄ data





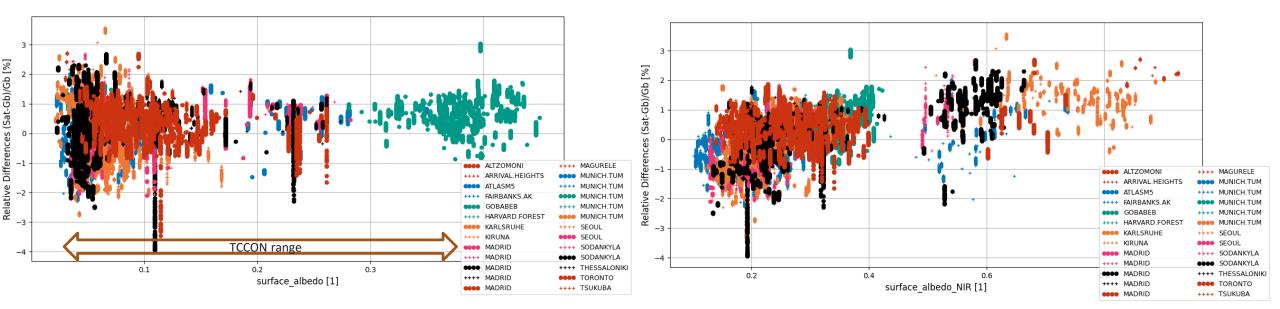
Solar spectrum measured by EM27/SUN using dual-channel covering 4000 – 11000 cm⁻¹

EM27/SUNs performing side-by-side measurements in Karlsruhe Picture source: Carlos Alberti



Validation of S-5P XCH₄ products

- CO CCON Collaborative Carbon Column Observing Network
- S-5P launched on 13th October 2017, ascending node equatorial crossing at 13:30, 16 days orbit cycle, wide swath of 2600 km on surface, spatial sampling of 7 x 7 km2, along track resolution increased to 5.5 km since 6th August 2019
- Methane requirements: 1.5% (systematic uncertainty), 1% (random uncertainty)
- Coincidence criteria: time delta = 1h, geo-distance delta (radius) = 100 km, qa_value>0.5, average of all coincident S-5P pixels is taken for each COCCON measurement
- S-5P prior is used as common prior (Rodgers, 2003), altitude correction done for each S-5P pixel to the GB station height
- Further validation details in Sha et al., 2021, https://doi.org/10.5194/amt-2021-36



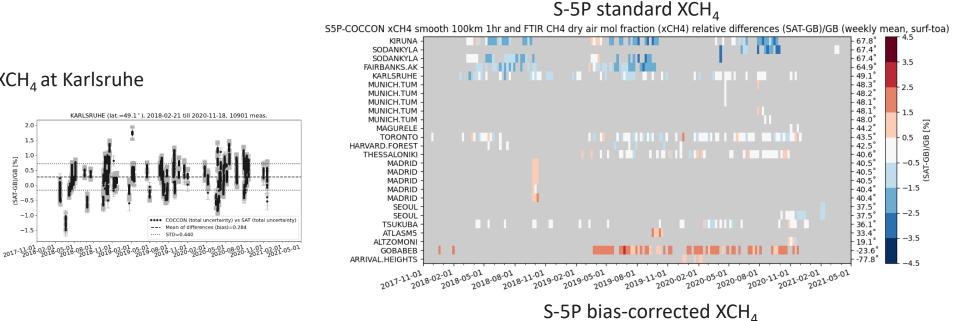
• Higher range of surface albedo with data from stations that contributed so far



Validation of S-5P XCH₄ products



5



S-5P bias-corrected XCH₄ at Karlsruhe

2.0

1.5

0.5

0.0

-0.5

-1.0

-1.5

30-

2 5

2.0

1.5 -

1.0

0.5

0.0

-0.5

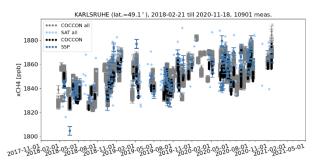
GOBABEB (lat.=-23.6°), 2017-12-18 till 2020-11-27, 14178 meas

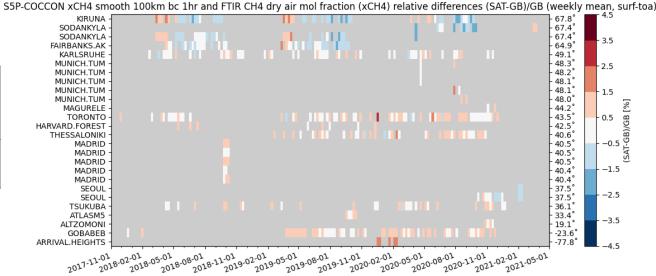
 $_{2017} - \frac{1.01}{7018} - \frac{02.01}{2018} - \frac{0.01}{2018} - \frac{0.01}{2018} - \frac{1.01}{2019} - \frac{02.01}{2019} - \frac{02.01}{2019} - \frac{02.01}{2019} - \frac{02.01}{2012} - \frac{02.01}{2012}$

•••• COCCON (total uncertainty) vs SAT (total uncertainty

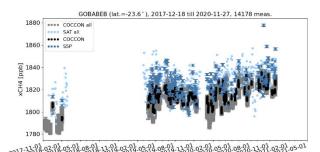
--- Mean of differences (bias)=0.607

STD=0.507





S-5P bias-corrected XCH₄ at Gobabeb



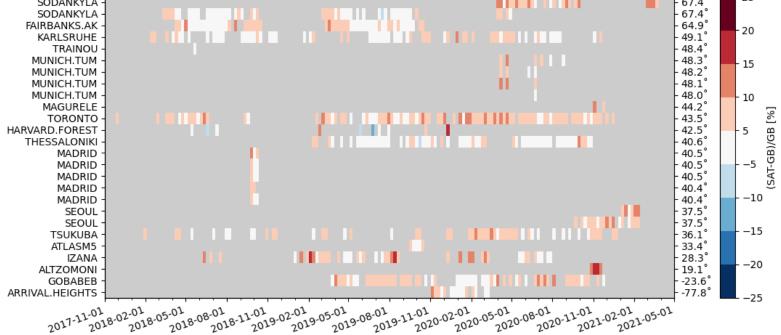


Validation of S-5P XCO product



- Carbon Monoxide requirements: 15% (systematic uncertainty), 10% (random uncertainty)
- Coincidence criteria: time delta = 1h, geo-distance delta (radius) = 50 km, qa_value>0.5, average of all coincident S-5P pixels is taken for each COCCON measurement
- S-5P prior is used as common prior (Rodgers, 2003), altitude correction done for each S-5P pixel to the GB station height
- Further validation details in Sha et al., 2021, https://doi.org/10.5194/amt-2021-36





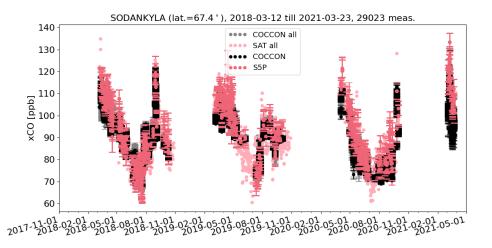
- Raw comparison performed for XCO without application of calibration factors
- Both campaign and long term measurements from sites are included in the validation plots
- Poor density at some sites is due to: (i) only test data submitted so far, (ii) manual operation (on sunny days)

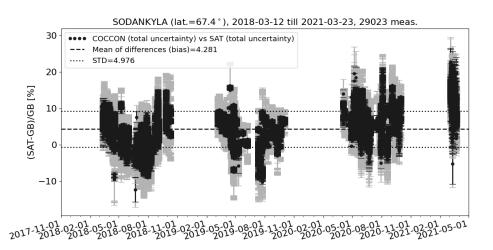


Validation of S-5P XCO product



Two EM27/SUNs operated in Sodankylä (2018 & 2019 – KIT039; 2020 onwards – FMI122)



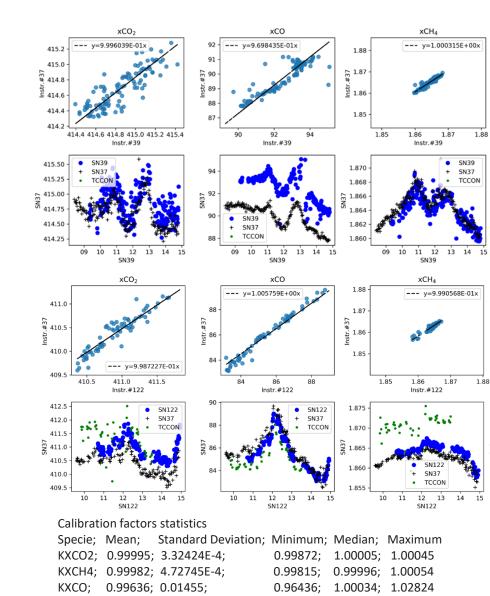


Calibration work performed at COCCON central facility (Carlos Alberti)

Raw data are plotted here

SN37 as the reference EM27/SUN

Note: Calibration factor for each species is important to link COCCON data to reference EM27/SUN and TCCON instrument

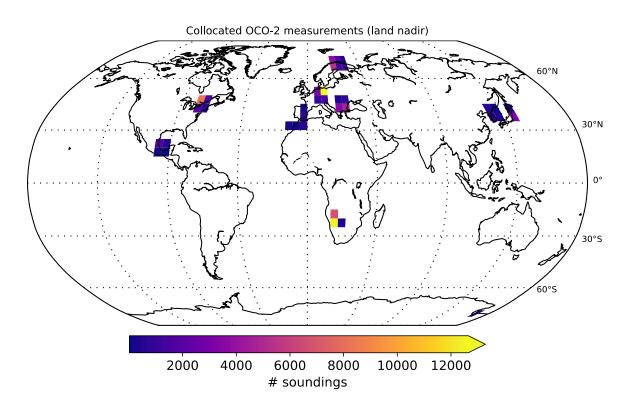


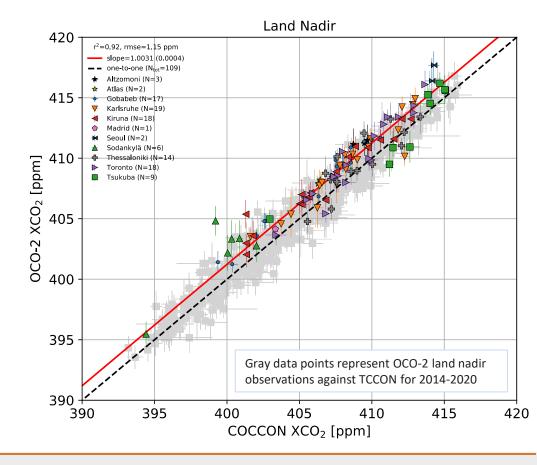


Validation of OCO-2 XCO₂ product (preliminary)



- Collocation criteria: (relaxed as compared to validation using TCCON) Geometric 5° latitude and longitude box, median COCCON XCO₂ within +/-2h of OCO-2 overpass, minimum of 50 "good" OCO-2 soundings required → validation done by Matthäus Kiel (NASA)
- Collocated data for 109 overpasses (11 sites total), OCO-2 biased high against COCCON (mean bias = 1.2 ppm), scatter comparable to TCCON (rms = 1.15 ppm)
- Results are indicative, further optimization of collocation criteria will be done soon, influence of different resolution







Validation of S-5P XH₂O product

CO Collaborative Carbon Collaborative Carbon Column Observing Network

Currently ongoing - stay tuned to see the results soon



Summary



COCCON is an emerging network, initiated by KIT, focusing on greenhouse gas measurements using portable EM27/SUN spectrometers.

Instruments follow common instrumental standards, and calibration and data analysis procedures. This ensures an unprecedented level of network homogeneity and comparability.

The spectrometers are ideal to be used as campaign instruments, observation of localised sources, as travel standard as well as for long-term deployment.

Validation results are promising and the stations offer an extension of ground-based reference total column data for wide range of surface albedo conditions, latitude bands and atmospheric conditions that are not fully covered by TCCON and NDACC-IRWG stations.

COCCON complements the TCCON and expands the global coverage of ground-based reference of the major greenhouse gases (CO₂, CH₄ and H₂O) and CO.

Please contact us if you want further information on data processing, the central facility, creating GEOMS HDF output files and want to contribute to our study with your data. Frank Hase <u>frank.hase@kit.edu</u>; Darko Dubravica <u>darko.dubravica@kit.edu</u> Mahesh Kumar Sha <u>mahesh.sha@aeronomie.be</u>

Thank you for your attention!