The Collaborative Carbon Column Observing Network COCCON: Recent Progress

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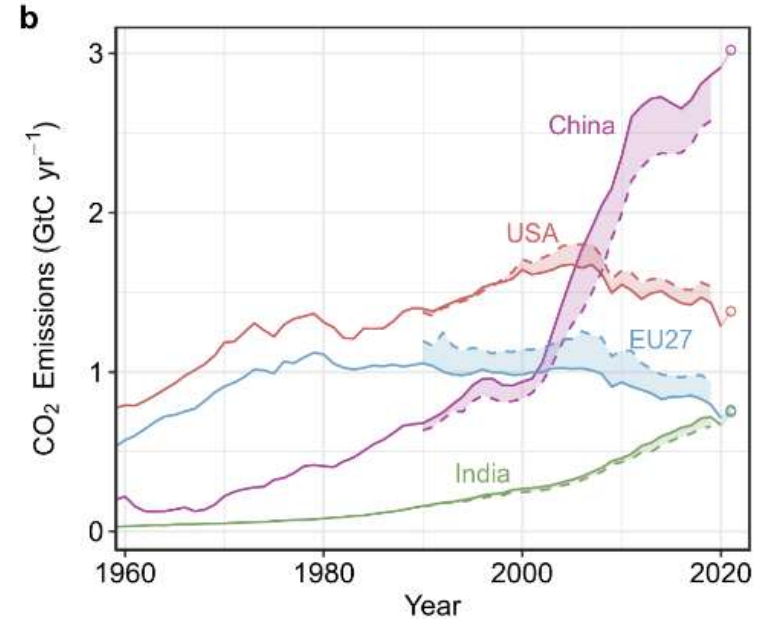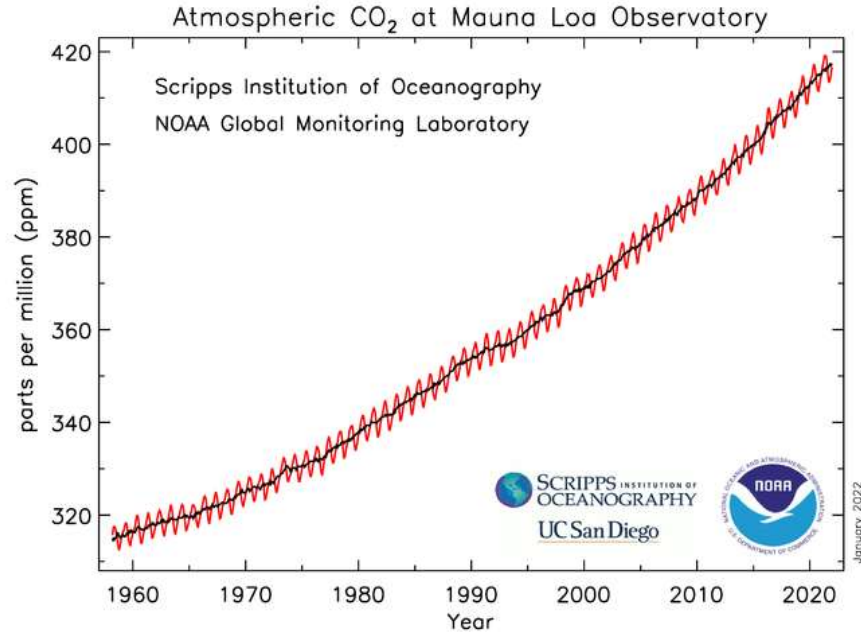
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GHGs and anthropogenic climate change

Anthropogenic GHG emissions are the main driver of climate change!

https://gml.noaa.gov/ccgg/trends   //   Global Carbon Budget 2021, Friedlingstein et al., ESSD, 2021.
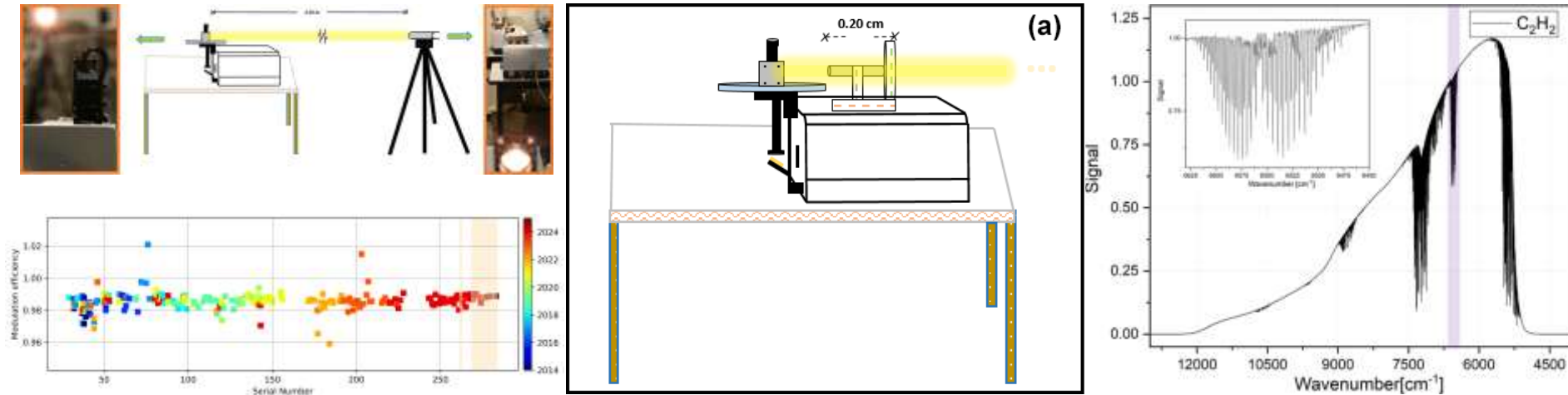
Collaborative Carbon Column Observing Network

Frey et al.: Building the COllaborative Carbon Column Observing Network (COCCON): long-term stability and ensemble performance of the EM27/SUN Fourier transform spectrometer, AMT, 2019.

✓ Centralized calibration & QC methods (performed at KIT, cooperation with Bruker)
✓ Common software standards, community telecons
✓ Centralized data processing, data provision via EVDC
✓ Travel standard COCCON spectrometer

COCCON: Centralized calibration and QC

Frey, M., Hase, F., Blumenstock, T., Groß, J., Kiel, M., Mengistu Tsidu, G., Schäfer, K., Sha, M. K., and Orphal, J.: Calibration and instrumental line shape characterization of a set of portable FTIR spectrometers for detecting greenhouse gas emissions, AMT, 2015.

Alberti, C., Hase, F., Frey, M., Dubravica, D., Blumenstock, T., Dehn, A., Surawicz, G., Harig, R., Orphal, J., & EM27/SUN-partners team: Improved calibration procedures for the EM27/SUN spectrometers of the COllaborative Carbon Column Observing Network (COCCON), AMT, 2022.

COCCON: Centralized calibration and QC

- Side-by-side measurements with new instruments together with a dedicated reference EM27/SUN and co-located TCCON instrument
- Until now, 163 COCCON spectrometers checked at KIT
- Facilitated by proximity to the manufacturer of the EM27/SUN
- Although very rare, sometimes oversights of the manufacturer are found and corrected

COCCON: Data processing

- PROFFAST
  - Retrieval software
  - Current version 2.4
- PROFFASTpylot
  - Python user interface
  - Current version 1.3

- Feature update to be distributed
  - Mobile observations supported
  - Additional diagnostic output
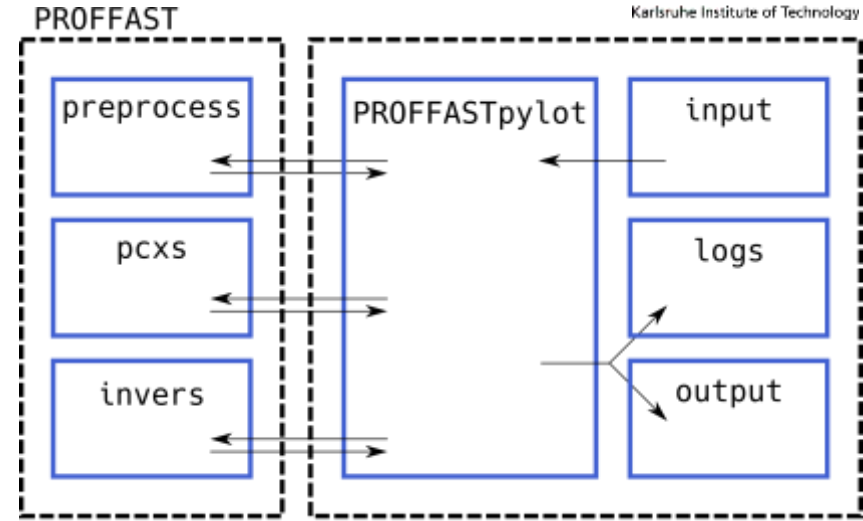
Feld, L., Herkommer, B., Vestner, J., Dubravica, D., Alberti, C., and Hase, F.: PROFFASTpylot: Running PROFFAST with Python, JOSS, 2024.

Hase, F., Castracane, P., Dehn, A., Garcia, O. E., Griffith, D. W. T., Heizmann, L., Jones, N. B., Karpinnen, T., Kivi, R. Maziere, M., Notholt, J., and Sha, M. K.: Implementation and application of an improved phase spectrum determination scheme for Fourier transform spectroscopy, AMT, 2025.

COCCON: Centralized data dissemination

- Option of centralized data processing is available at KIT
- Data is published via ESA data validation centre (EVDC)
- Currently reprocessing all COCCON data with PROFFAST2.4
  - Several sites already available
- Old revisions of COCCON data accessible via secondary data archive

COCCON Version 4 dataset from atmospheric observatory of Karlsruhe available at the EVDC Data Handling Facilities covering start date Mar 27th 2014 to end date Aug 22nd 2024

COCCON satellite validation [4.05_Sha, 4.02_Das]

- First publication using a global COCCON dataset (27 stations) for satellite (Sentinel-5 Precursor, OCO-2, GOSAT) validation by Sha et al. February 2025
- Follow up study for OCO-2/3 validation by Das et al. in preparation

COCCON stations
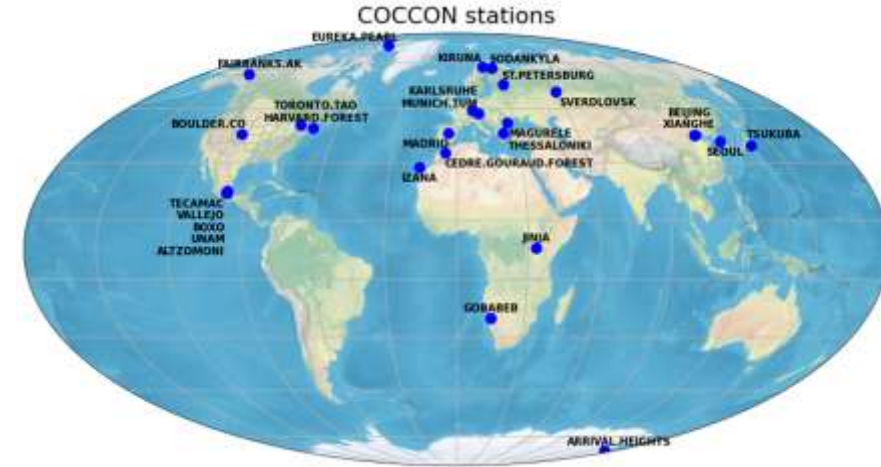
Sha, M.K., Das, S., Frey, M.M., Dubravica, D., Alberti, C., Baier, B.C., Balis, D., Benazilla, A., Blumenstock, T., Boesch, H., Notholt, J., et al..:Fiducial Reference Measurements for Greenhouse Gases (FRM4GHG): Validation of Satellite (Sentinel-5 Precursor, OCO-2, and GOSAT) Missions Using the Collaborative Carbon Column Observing Network (COCCON), Remote Sens., 2025.

COCCON-Japan [4.06_Morino, 4.17_Ohyama]

COCCON-Spain [6.21_Sepulveda]

Lack of GHG observations + (AQG) -> Nationwide station network supported by Next Generation EU Mechanism (€6.5M by 2023-2026)

Acción C5.I3: "implementation of a system for modeling and monitoring greenhouse gas emissions, including installation of measurement instruments in the main cities"
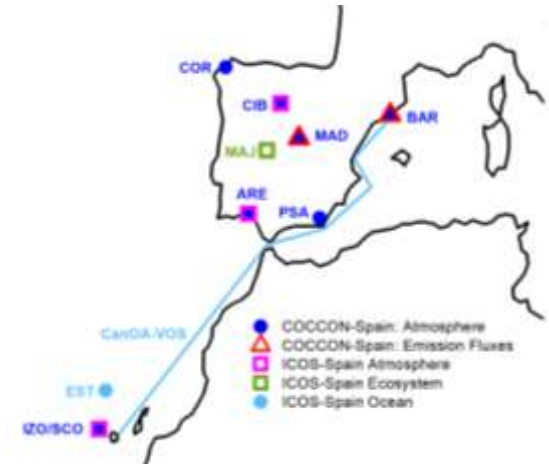
COCCON – Spain: 14 stations

COCCON products (**CO_2, CH_4**, H_2O, CO, HCl, HF,…) + Air Quatily (NO_x, SO_2, CH_2O, …)

Izaña Observatory as reference + KIT (ESA) support

Inter-comparison & Implementation of Stations
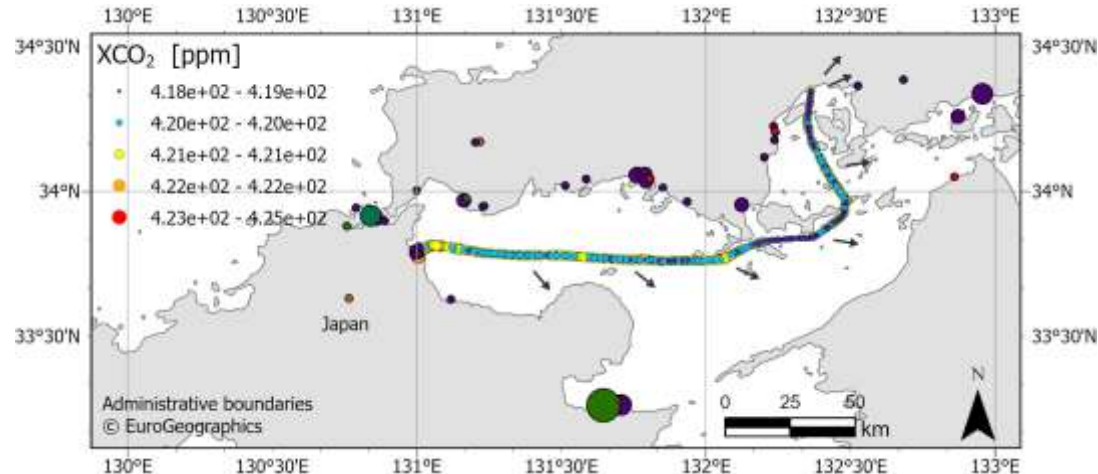
Mobile observations [7.02_Mueller]

- Operational cargo-ship observations using a custom-built EM27/SUN + Mini-DOAS setup
- Ship track along the Japanese coastline
- Beta-testing the new PROFFAST and Pylot version

Instrument viewing direction

Power plant
Steel factory
Oil/gas refinery
Cement industry

CO_2 emissions [Mt/Oct 2023]

< 0.10 Mt/Oct
< 0.30 Mt/Oct
< 0.59 Mt/Oct
< 1.01 Mt/Oct
< 1.90 Mt/Oct

(source: Climate TRACE (2023)

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