

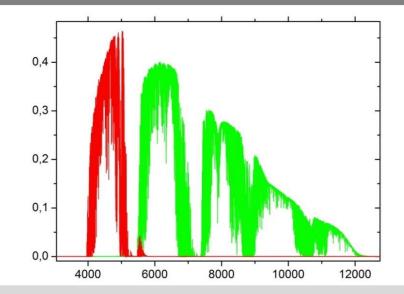


### The Collaborative Carbon Column Observing Network overview and current status

M. Frey and the COCCON team

Institute for Meteorology and Climate Research, Atmospheric Trace Gases and Remote Sensing (IMK-ASF, KIT)





# Outline

- Introduction
- EM27/SUN Spectrometer
  - Instrument Overview
  - ILS and Calibration
  - Long Term Stability
- Network COCCON
  - COCCON Service
  - Comparison to TCCON
  - Measurement Campaigns
  - COCCON-Proceeds
- Summary and Outlook





### Introduction

- Existing ground-based GHG networks
  - Validation of satelite measurements
  - NDACC: Network for the Detection of Atmospheric Composition Change
  - TCCON: Total Carbon Column Network (Near-IR)
    - Geographic coverage limited, instruments not portable
    - Good infrastructure and expert maintenance required
- New upcoming ground-based GHG network
  - COCCON: Collaborative Carbon Column Observing Network
  - EM27/SUN spectrometer network
    - Portable and easy to set up instrument
    - High instrumental stability and reliability
    - Low-cost interferometer (100 k€)
    - Low infrastructure requirements



Column Observing Network

Fig. source: TCCON network



Karlsruhe Institute of

# **EM27/SUN – Instrument Overview**

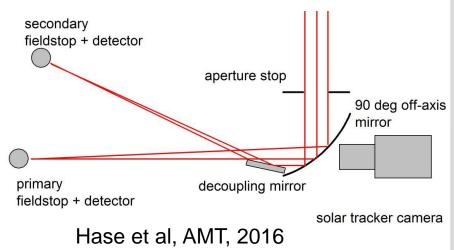


- 2 cube corners, CaF<sub>2</sub> beamsplitter
- Double sided interferograms
- Maximum OPD: 1.8 cm
- Resolution: 0.5 cm<sup>-1</sup>
- Dimensions: 35 x 40 x 27 cm
- Mass with tracker: ~25 kg
- Tracker unit & SW developed at KIT
  - Gisi and Hase et al, AMT, 2012
- InGaAs detector
  - Spectral range: 5000 11000 cm<sup>-1</sup>
- Second CO channel available

Spectral range: 4000 – 5500 cm<sup>-1</sup>





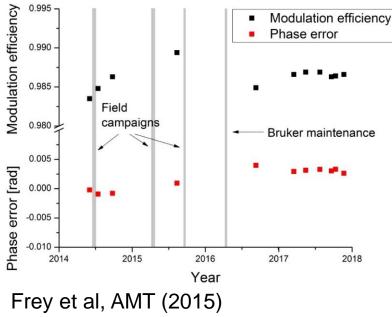


# **EM27/SUN – ILS and Stability**

- Instrumental Line Shape (ILS)
  - Accurate ILS knowledge of highest importance
    - 1%  $\Delta$ MEA at MOPD  $\rightarrow$  0.15%  $\Delta$ XCO<sub>2</sub>
  - Absorption lines of lab air water vapor
    - Externel source needed (50 W light bulb)
    - No gas cell necessary
- Long Term Stability (LTS)
  - Reference EM27/SUN spectrometer
  - Modulation Efficiency Amplitude (MEA)
    - $0.9862 \pm 0.0015 \rightarrow \Delta XCO_2 < 0.03\%$
  - Phase Error
    - 0.0019 ± 0.0018







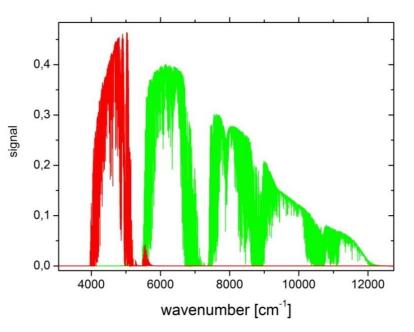
### **EM27/SUN – Calibration**



- Calibration measurements
  - Side-by-side calibration of instruments to common scale
  - Performed before and after several campaigns at IMK-ASF office building
- Additional pressure and temperature measurements
  - On site from tall tower at the KIT campus north
- More than 30 devices operated worldwide



#### IMK-ASF, KIT

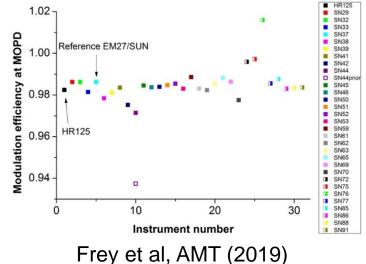


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# **COCCON** – Service



- COCCON: Collaborative Carbon Column Observing Network
- Framework for EM27/SUN spectrometers
- Check of new instruments at KIT (before delivery to customer)
  - Solar measurements together with reference EM27/SUN and co-located TCCON instrument
  - Alignment check and ILS measurements
  - ILS ensemble mean: 0.985 ± 0.008
  - $XCO_2$ ,  $XCH_4$ ,  $XH_2O$  and XCO scaling factors
- Loan of instruments possible for campaign deployment
- Retrieval algorithm available
  - PROFFIT and PROFFAST
  - Training at KIT possible
- Central facility for EM27/SUN spectra
  - Central processing facility
  - Central data handling facility
  - → COCCON-proceeds

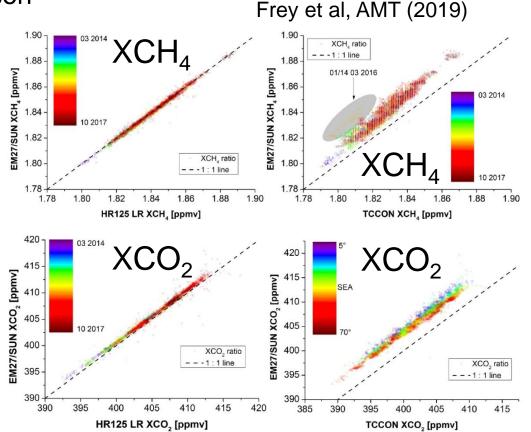


# **COCCON – Comparison to TCCON**

- High resolution spectrometer
  - Bruker IFS 125HR (KIT)
- Low resolution intercomparison
  - PROFFIT retrieval SW (same procedure for both data sets)
  - Excellent agreement
- Low versus high resolution
  - Different retrieval SW (PROFFIT vs. GFIT)
  - Different resolutions → Differing averaging kernels (0.5 cm<sup>-1</sup> vs 0.02 cm<sup>-1</sup>)
  - Seasonal variability
  - No significant long term drift



Column Observing Network

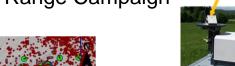


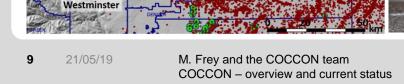
# Measurement campaigns with partner institutions

- Paris, Berlin, Boulder, Tokyo, etc.
- City emissions, fracking, dairy farms, coal mining, etc
- Poster Omaira Garcia
  - MEGEI-MAD Campaign
- Talk Matthias Frey

= cattle
 = dairy
 = ONG permit
 = fracking well

Colorado Front Range Campaign

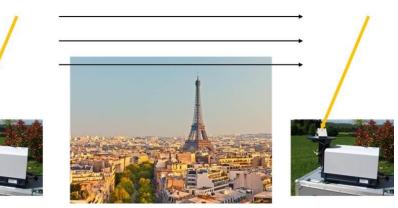




# **COCCON – Measurement Campaigns**









### **COCCON-Proceeds**

- COCCON Philosophy
  - Common standards for GHG measurements
    - Define and maintain an instrumental standard (EM27/SUN)
    - Verify performance of each device before delivery
    - Common way of data processing and analysis  $\rightarrow$  COCCON-proceeds
- COCCON-Proceeds (project funded by ESA)
  - Pre-processing (by the user community member)
    - Measured IFG  $\rightarrow$  Absorption spectra (binary files)
    - Quality checks (selection of good spectra)
  - Central processing and data handling facility
    - Upload pre-processed data
    - Analysis of absorption spectra
    - Data dissemination to user community

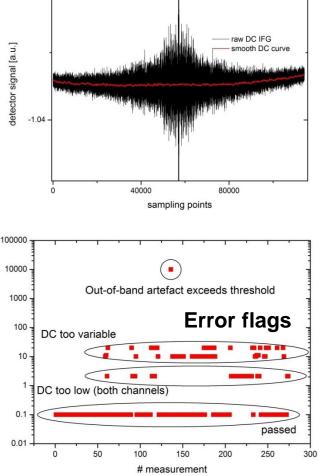


# **COCCON-Proceeds – Pre-processing**

- Calculation of Solar position
- Read IFG (OPUS format), DC correction
- IFG truncation to nominal resolution
- Numerical apodization function
- Perform FFT, phase correction and resampling
- Quality checks
  - Minimum DC value to available ADC range
  - Maximum variability of DC in IFG
  - Centerburst amplitudes of FWD/BWD scans
  - Centerburst location in the IFG
  - Relative amplitudes of out-of band artefacts
  - Slope, curvature, and change of curvature of phase spectrum
  - Spectral calibration based on cross-correlation of spectral structure wrt a reference spectrum







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# **COCCON-Proceeds – Retrieval algorithm**

- New retrieval algorithm PROFFAST designed for low resolution spectra
- Possibility to use TCCON map files as a priori profiles
- Internal postprocessing (airmass correction)
- 30 times faster than PROFFIT algorithm
- Software and code available via KIT website
- Preprocessing software and PROFFAST successfully used for the analysis of the MEGEI-MAD campaign measurements



### **COCCON-Proceeds – Central Facility**

- Central processing and data handling facility
  - Upload pre-processed binary files
  - Analysis of absorption spectra
  - Data dissemination to the user community
- Interface for data upload
  - Linux server system
  - Secure File Transfer Protocol (SFTP)
  - Login interface (e.g. Bitvise for Windows) (username, phassphrase, etc.)

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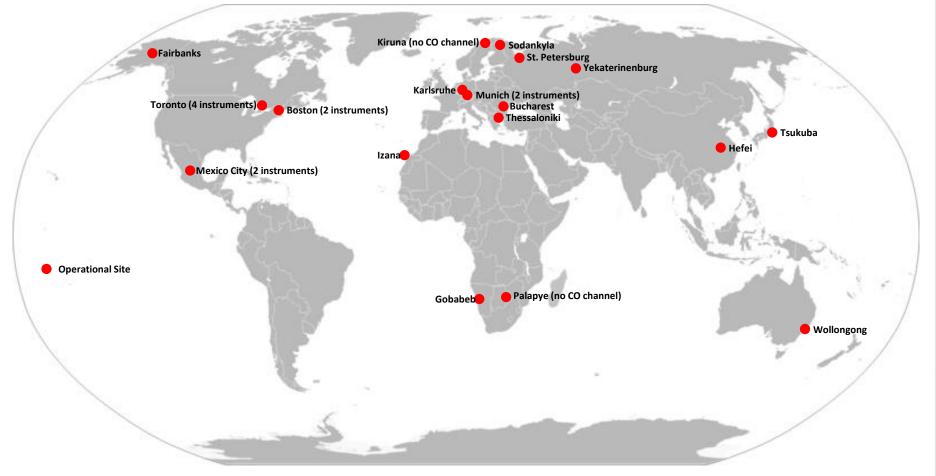
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Login interface (Bitvise)

### **COCCON – Next Step**







### **Summary and Outlook**

- EM27/SUN spectrometer
  - ILS, LTS and Calibration
- COCCON
  - Service, Comparison to TCCON and Campaigns
- COCCON-Proceeds
  - Pre-processing with quality checks
  - Central processing and data handling facility
- SW-distribution to external users
  - Pre-processing tool and PROFFAST
  - Extension to all members
- Future plan: Global EM27/SUN data set
- Acknowledgement: the COCCON-Proceeds project was funded by the ESA



Column Observing Network