Karlsruhe Institute of Technology

CO2 CCON
esa
Collaborative Carbon
Column Observing Network

The COCCON Travel Standard for TCCON sites: Results from Tsukuba, ETL and Wollongong

TCCON-NDACC-COCCON Meeting in Spa

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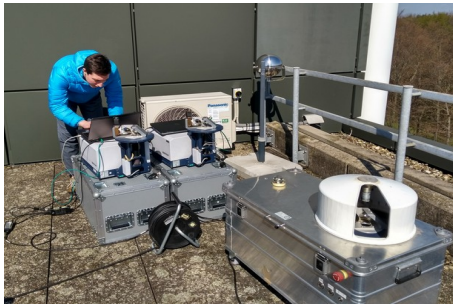
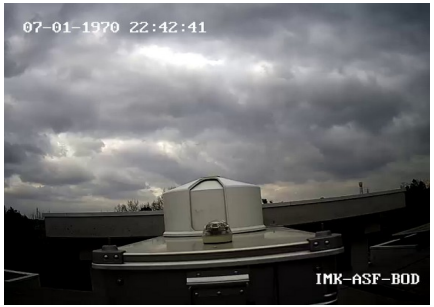
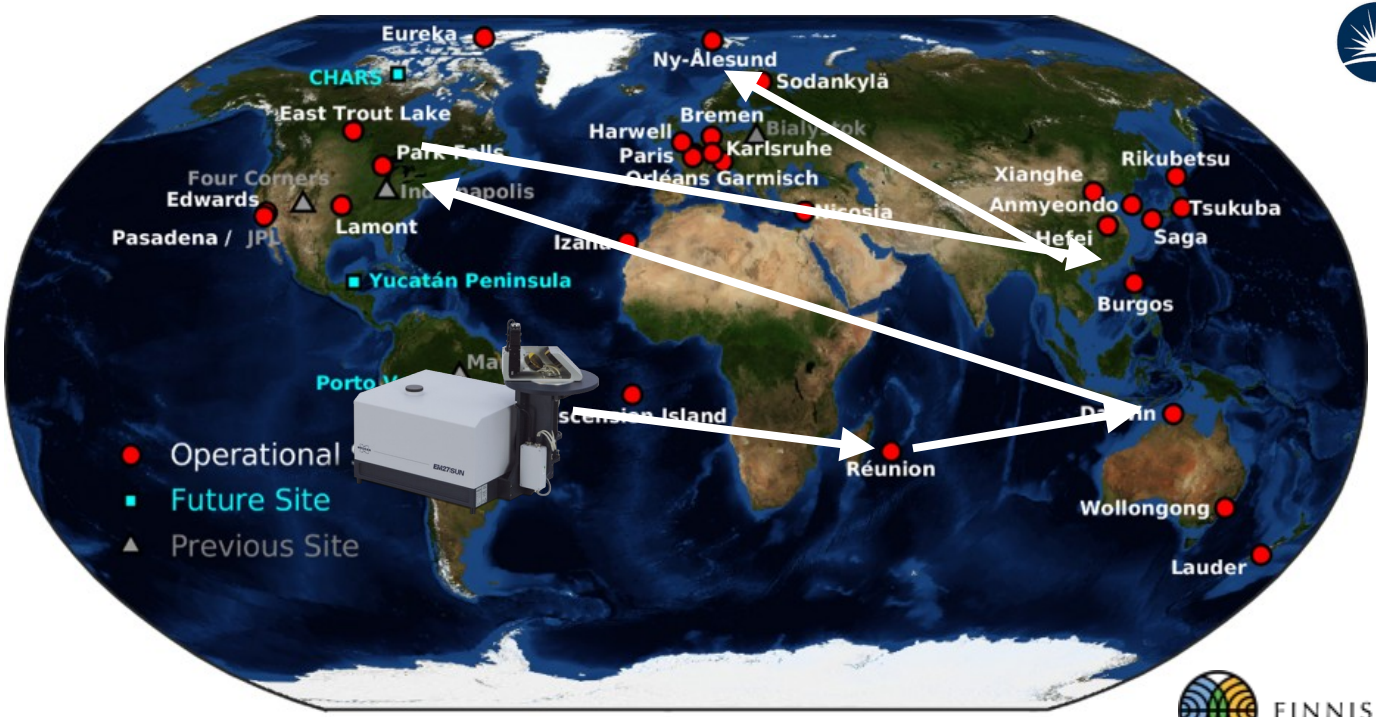




Outline

- Idea and Realization of Travel Standard (TS)
- Calibration of (TS) between the Campaigns
- Results of Tsukuba (TK), East Trout Lake (ETL), and Wollongong (WG)
- Systematic Noise analysis
- Quantiative XGas comparison

The COCCON Travel Standard: Idea

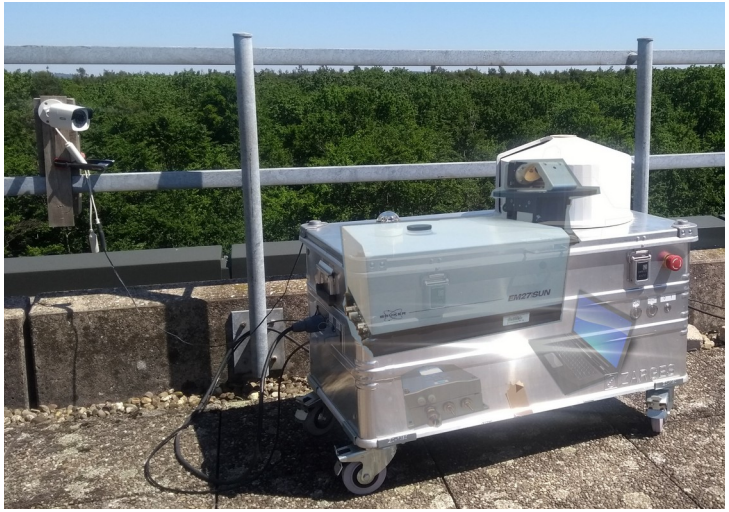


Introduction: Realization

- Calibration in KA **before and after** a campaign shipping to a TCCON-site: $K_{TS}^{KA\text{-}TCCON}$

- At each site:
  - Travel Standard:
    - 0.5 cm^{-1}
  - TCCON Site record alternating
    - low-res (LR, 0.5 cm^{-1})
    - high-res (HR, 0.002 cm^{-1})

- Process LR data with PROFFAST2 and HR data with GGG2020

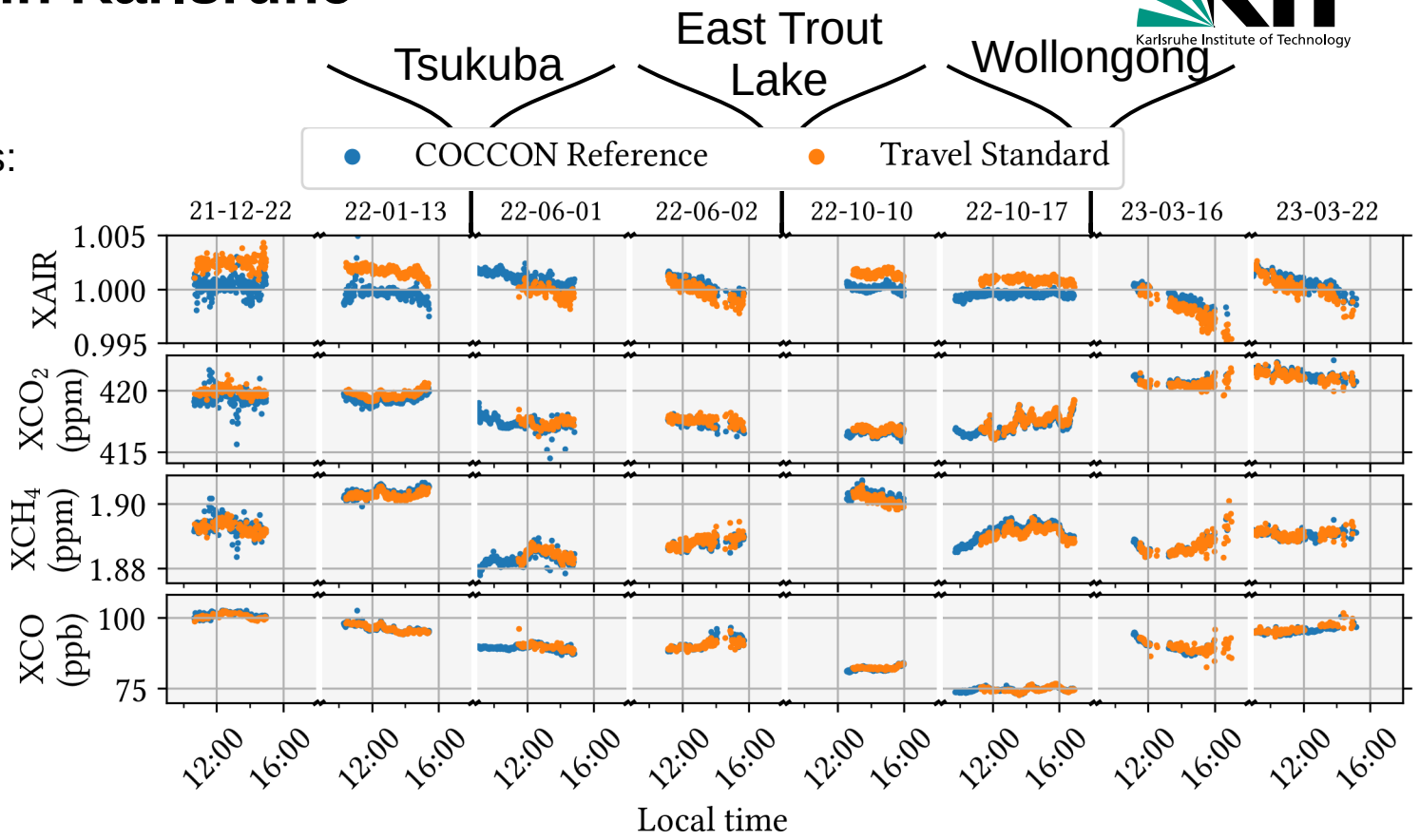


Calibration in KA between the Campaigns.

Calibration in Karlsruhe

Maximum deviation between campaigns:

- 0.31 ppm for XCO_2
- 0.0019 ppm for XCH_4
- −0.51 ppb for XCO

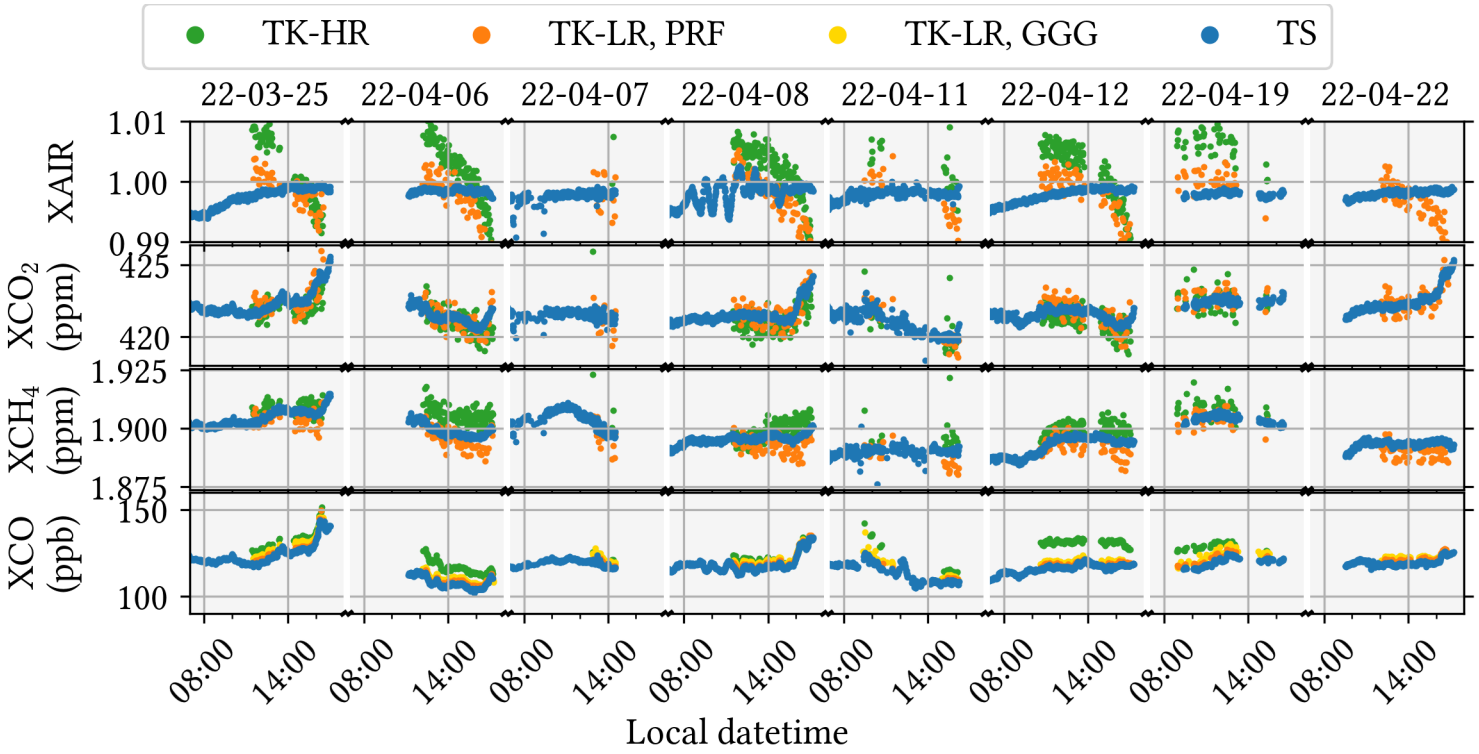


Results of the Campaigns in Tsukuba (TK) East Trout Lake (ETL) Wollongong (WG)

Results of the Campaigns in
Tsukuba (TK)
East Trout Lake (ETL)
Wollongong (WG)

Results of Tsukuba, Japan

Stayed ~1 Month in Tsukuba, 8 good measurement days



- Good overall agreement
- Resolution based effects in XCO
- High Noise-level
- XAIR: Air mass dependency → Timing error

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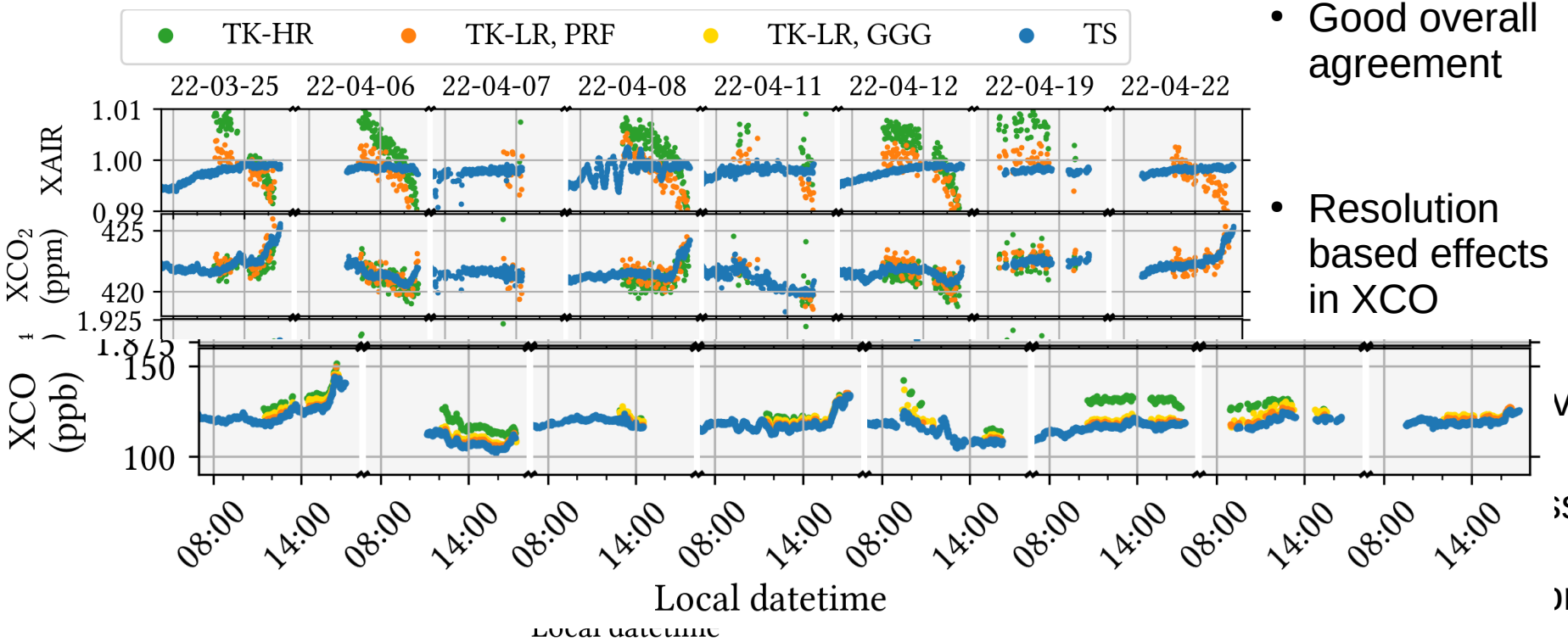

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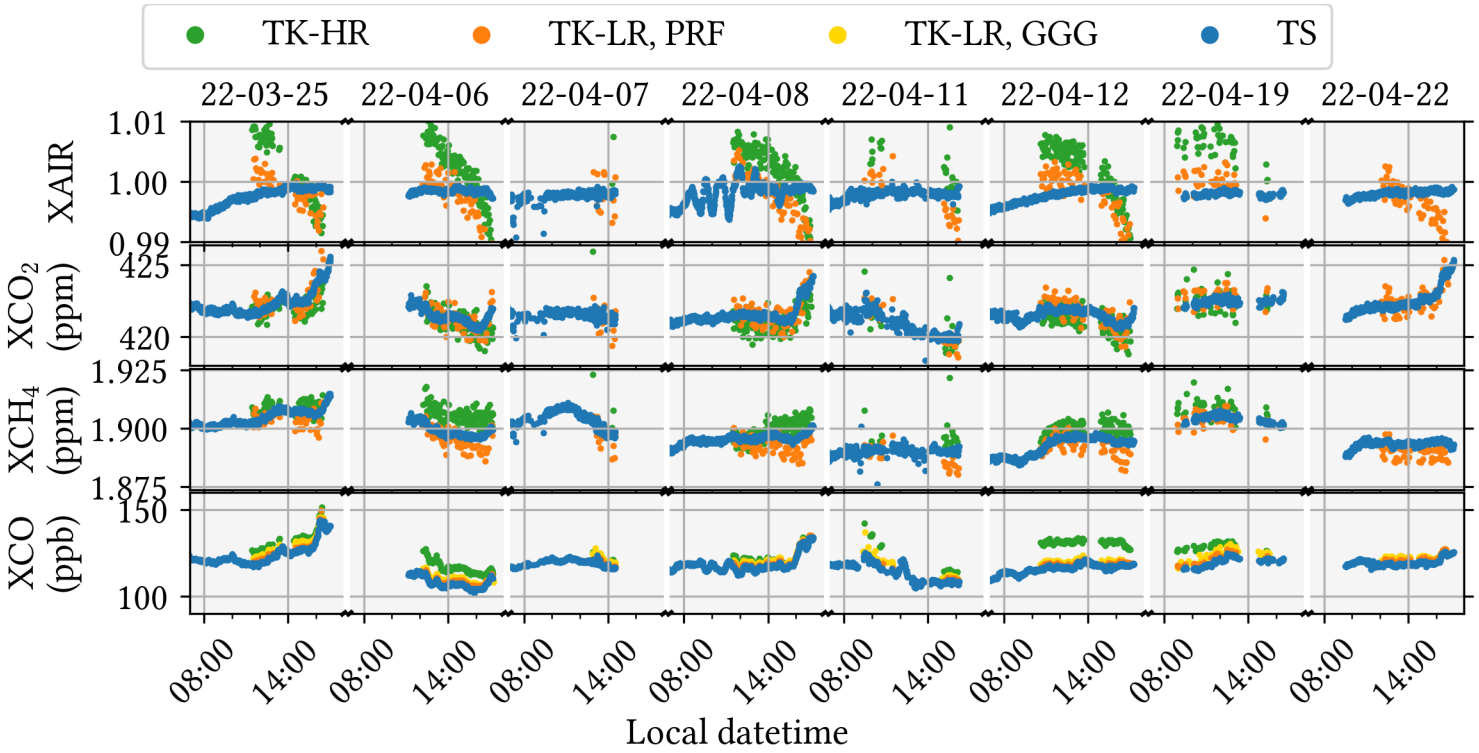

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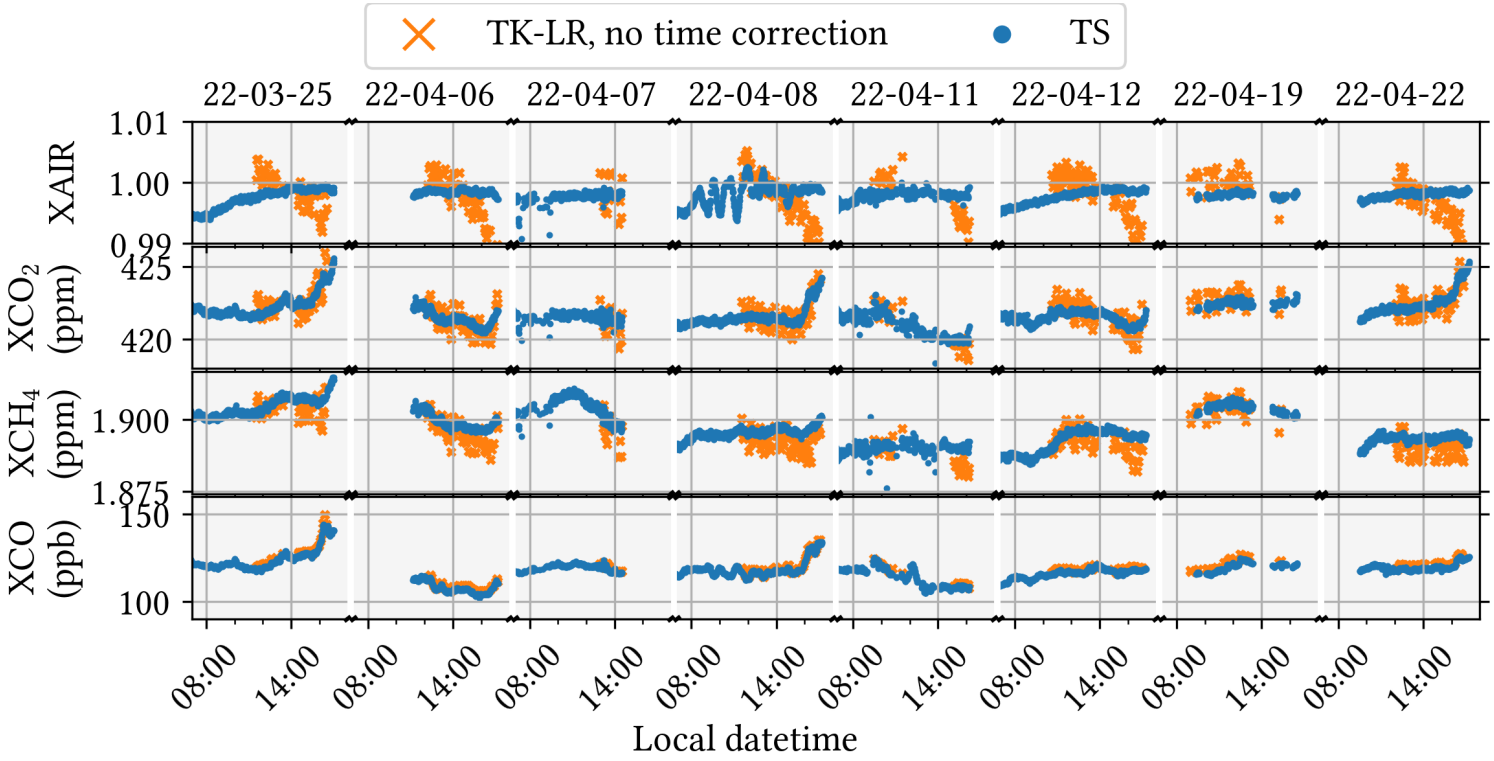

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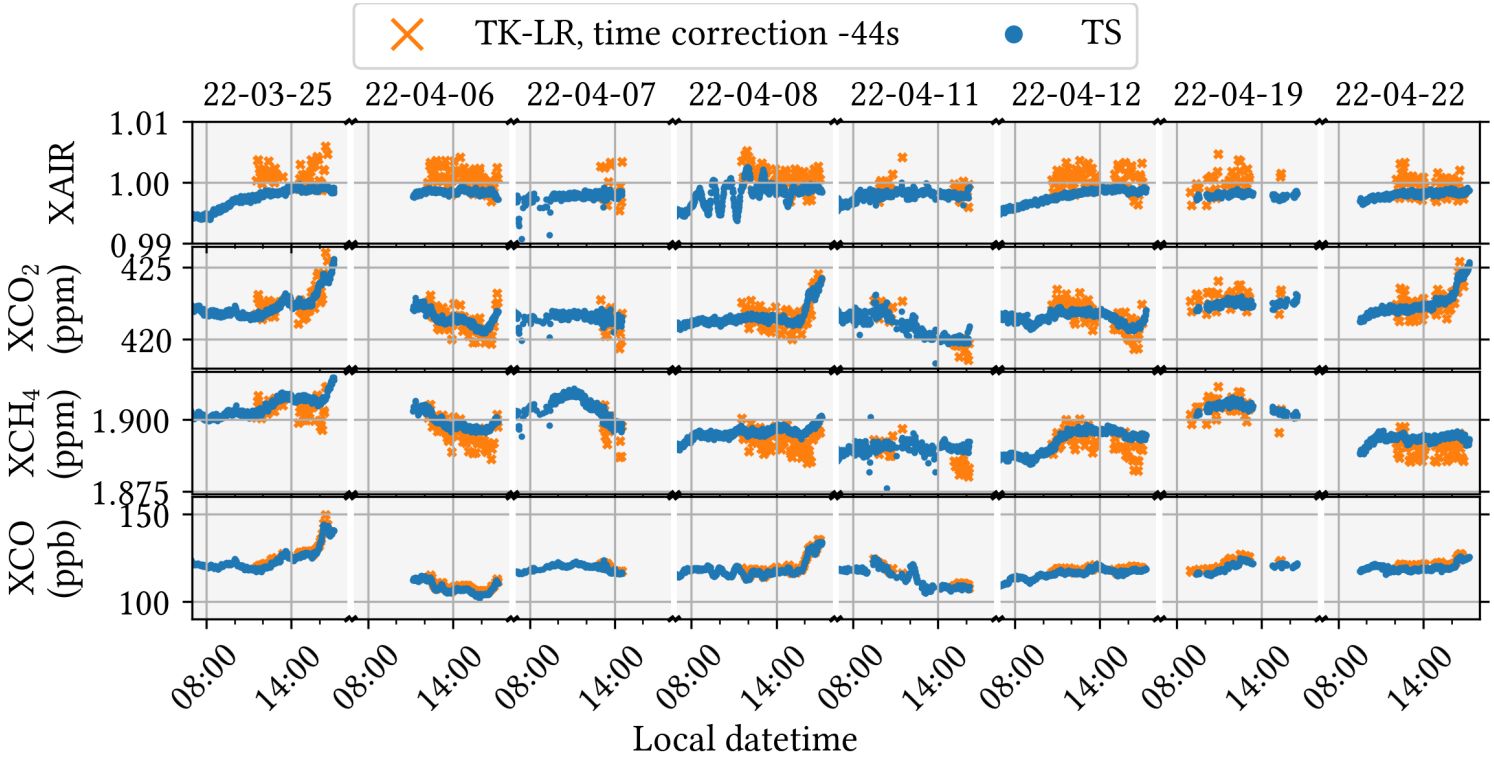

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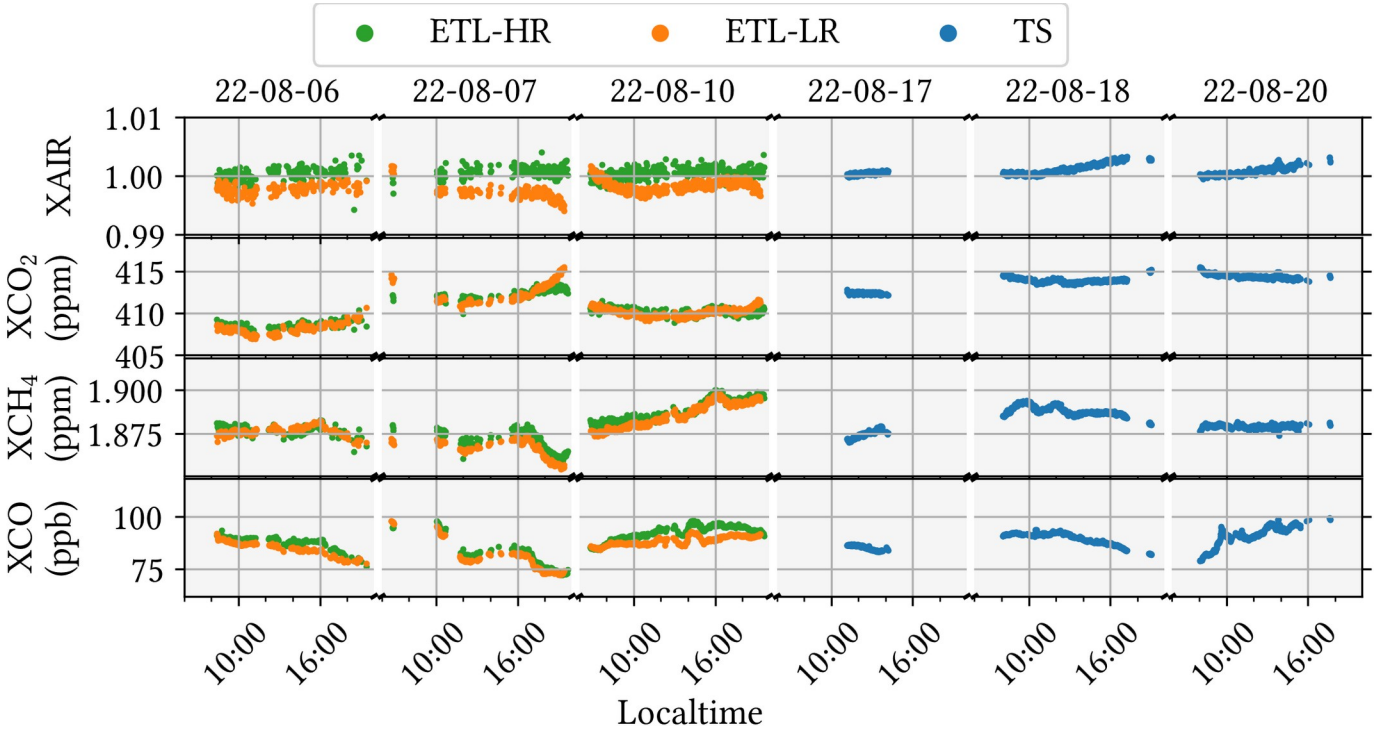
Results of the Campaigns in Tsukuba (TK) **East Trout Lake (ETL)** Wollongong (WG)

Results of East-Trout-Lake (ETL), Canada

No side-by-side measurements due to laser failure of TCCON instrument

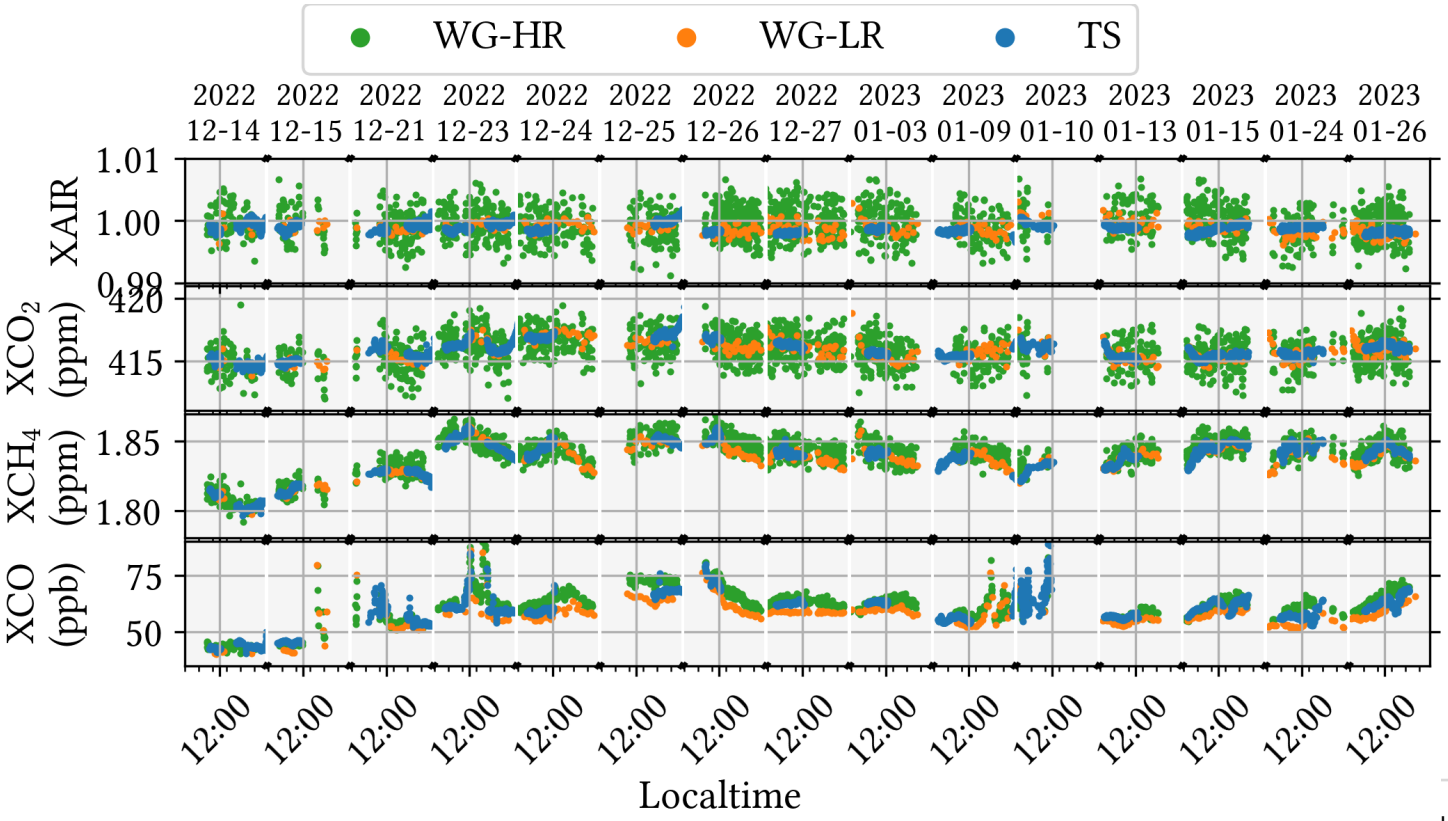


- Less noise, compared to Tsukuba
- No instrumental issues detected
- Plan for evaluation:
  - Use adjusted **model data** to extrapolate data
  - Use an other EM27/SUN as proxy

Results of the Campaigns in Tsukuba (TK) East Trout Lake (ETL) **Wollongong (WG)**

Results of Wollongong, Australia

Stayed ~ 1.5 month in WG, 15 days of side-by-side measurements



- High noise level
  - Difference between HR and LR data
- Less significant CO dependency
- No timing error

Noise Analysis

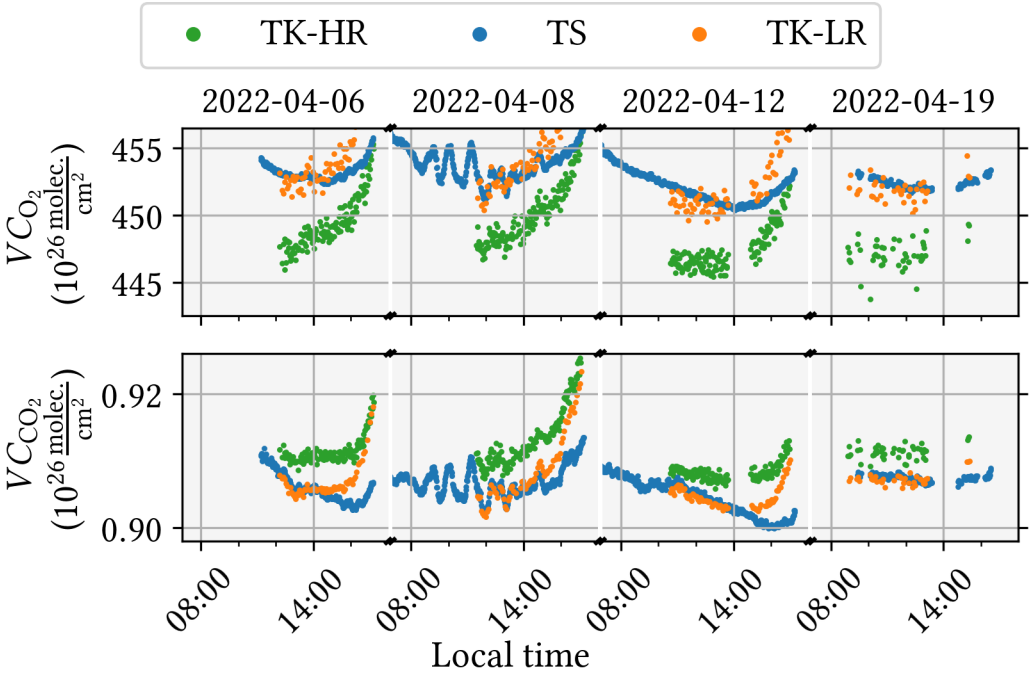
Noise Analysis

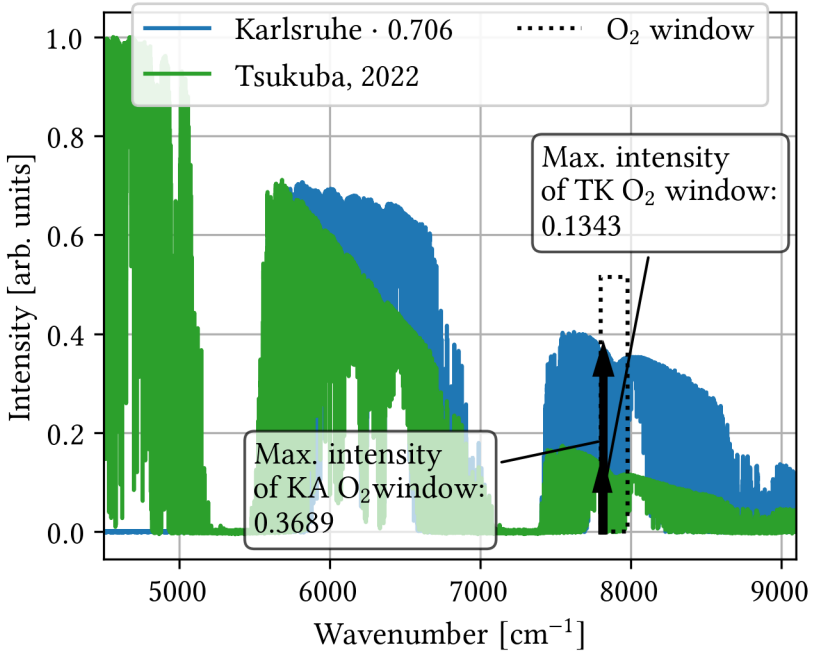
1) Reason for noise in Xgas in TK and WG data

2) Systematic network-wide evaluation using internal TCCON engineering data

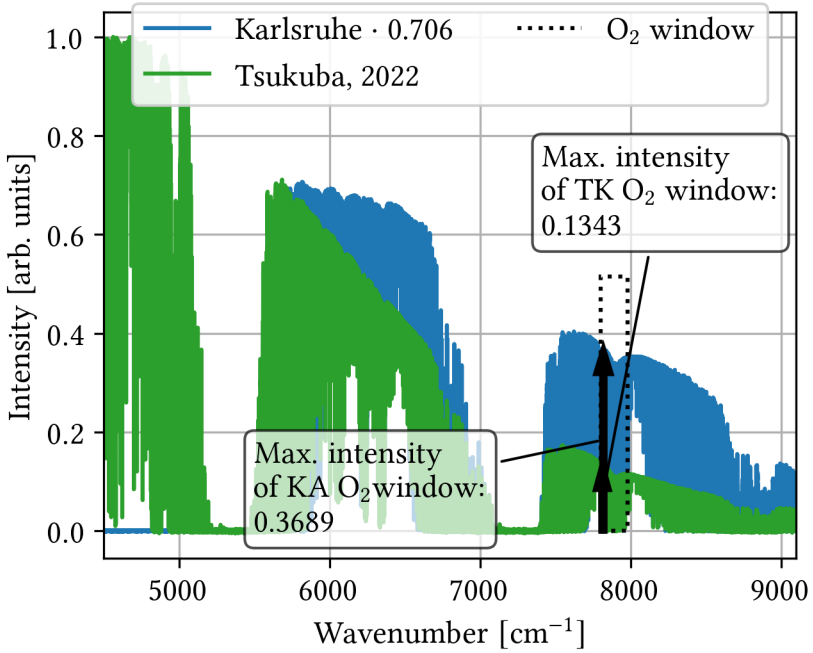
Noise Analysis: reason for noise in TK and WG data

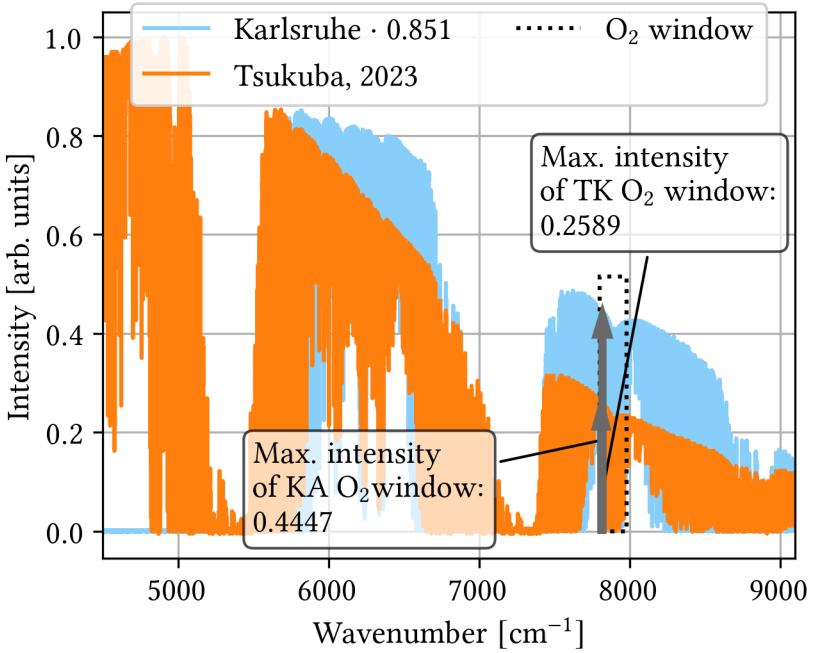
$$\mathrm{XGas} = \frac{VC_{\mathrm{Gas}}}{VC_{\mathrm{O_2}}} \cdot 0.209059$$





Noise Analysis: reason for noise in TK and WG data





Network-wide noise analysis

Question:

Noise in Spectrum $\xrightarrow{?}$ **Noise in Xgas time Series**

using GGG engineering data > 2021

SSQ (Spectral Signal Quality):

$$SSQ = \frac{1}{\frac{1}{N}\sum_{\text{wn}} \text{gas\_wn\_rmscol}} \propto \text{SNR}$$

σ_{XGas}**: Noise in Xgas time series**
standard deviation of detrended XGas values

Network-wide noise analysis

σ_{XCO_2} **: Noise in XCO_2 time series**

standard deviation of smoothed Xgas values

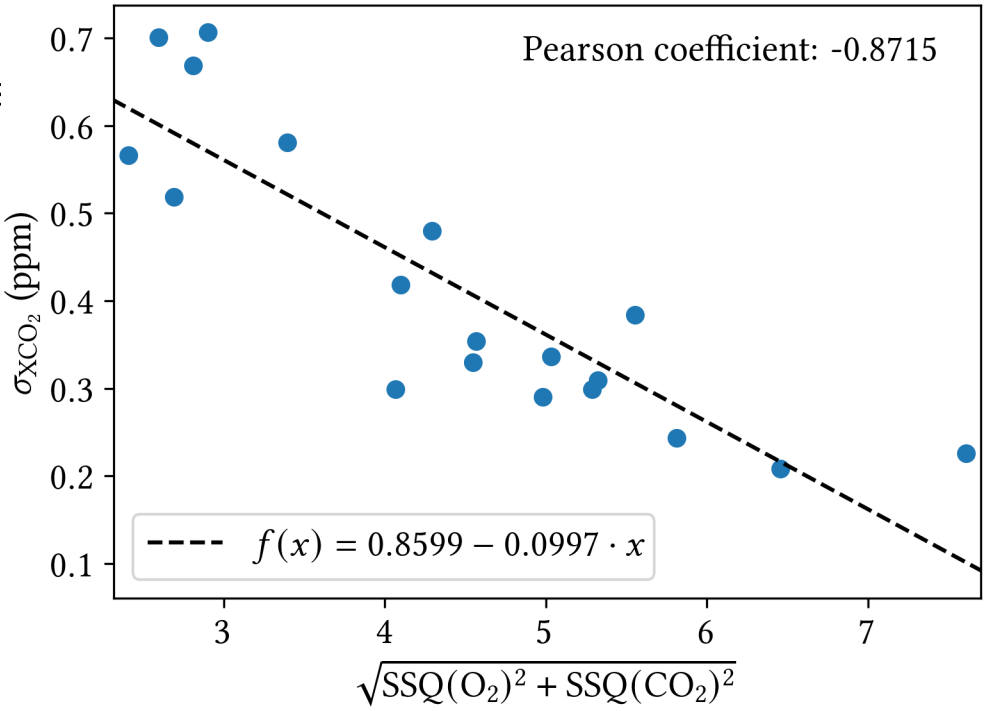
SSQ (Spectral Signal Quality):

$$SSQ = \frac{1}{\frac{1}{N}\sum_{xxxx} \text{gas\_xxxx\_rmscol}}$$

$$\propto \text{SNR}$$

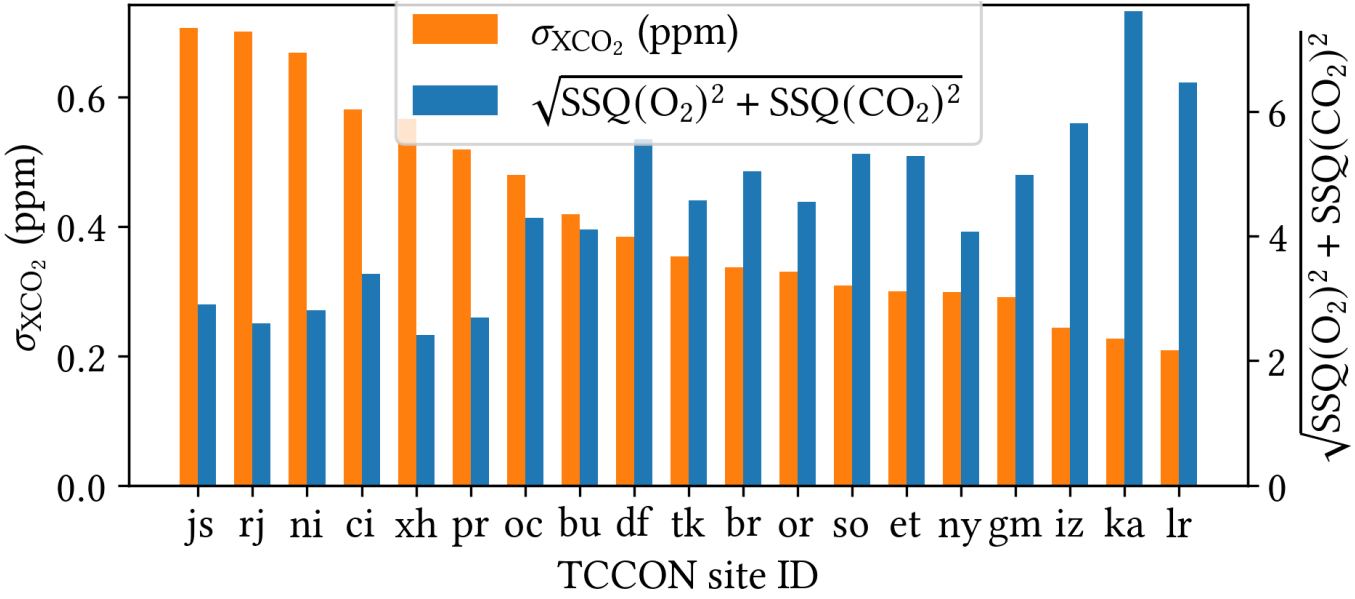
species_window:

- "co2_6220" and "co2_6339"



Network-wide noise analysis

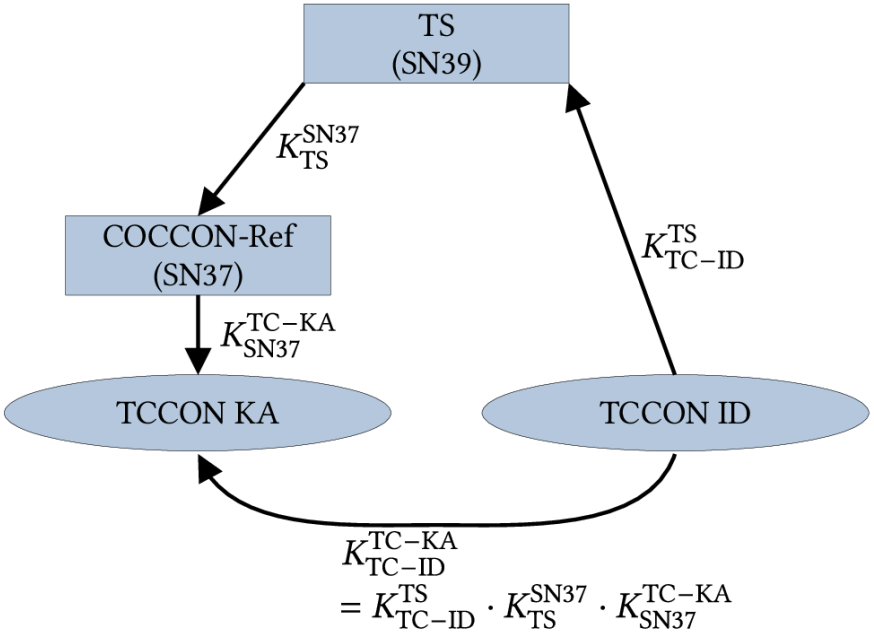
Noise in XGas:
- max: 0.71 ppm (js)
- min: 0.21 ppm (lr)



Interesting:
- Karlsruhe (ka): Exceptional high SNR due to different setting (small band detector)
- Edwards (df): higher noise in XGas (0.38 ppm) but also high SSQ (5.55)

Quantitative XGas Analysis

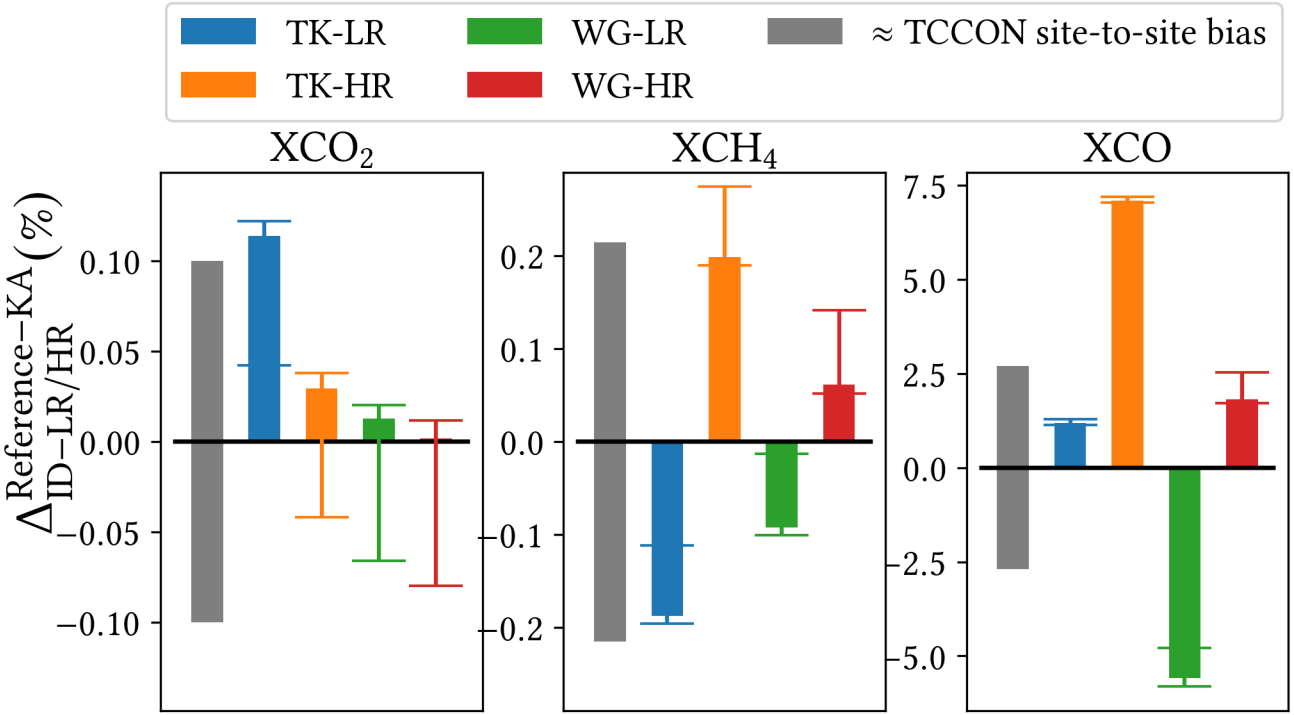
Quantitative Comparison of XGas values



Calculate a deviation in % of the visited TCCON sites to the Karlsruhe site as a reference.

Quantitative Comparison of XGas values

- Good results for XCO_2 and XCH_4
- Problems for XCO:
  - *Tsukuba:*
    Wrong a priori in combination with resolution based effects
  - *Wollongong:*
    - Low measurement rate for WG-LR measurements



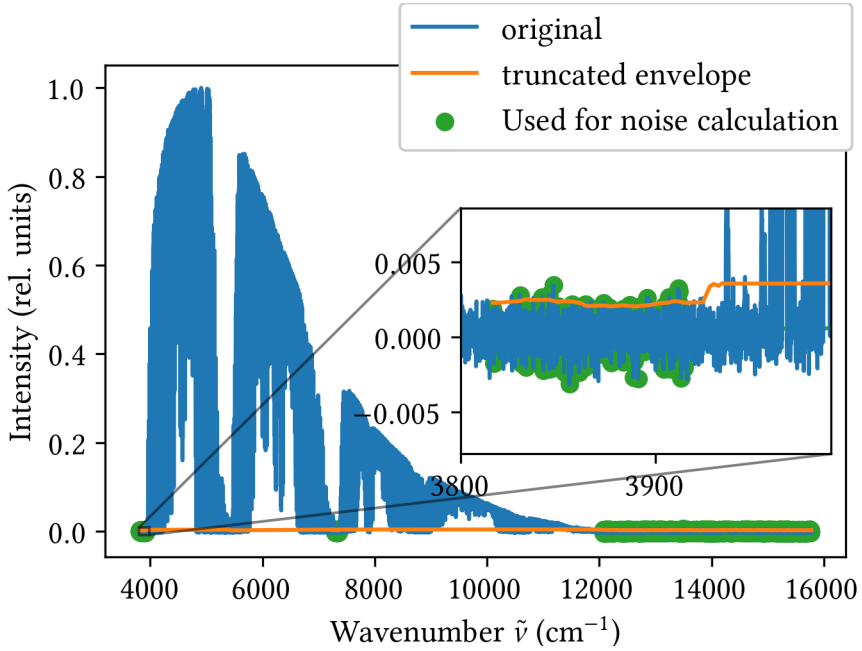
Conclusion

- **Successfully demonstrated** application of COCCON **Travel Standard** on a international scale
- Found **instrumental issues**:
  - **Noise** issue in TK and WG
  - **Timing error** in Tsukuba
- Implemented a **new tool for** systematic analysis of **spectral quality** in the **TCCON**
- Good agreement for XCO2 and XCH4

Thank you for your attention!

Network-wide analysis using spectra

Site	max_{O_2}	SNRs for O_2
Rikubetsu	0.3075	271.2298
Burgos	0.3395	392.7592
Izaña	0.3052	212.2268
Wollongong, new	0.5692	274.7110
Wollongong, old	0.1510	49.8372
Lauder, old	0.3097	272.7060
Lauder, new	0.6145	306.8384
Ny-Alesund	0.2775	101.6041
Anmyeondo	0.2968	163.7335
Karlsruhe	0.5212	901.7539
Tsukuba	0.1348	95.6686
Tsukuba, realigned	0.2585	220.1736
East Trout Lake	0.2881	197.2654
Garmisch	0.5086	223.6055
Zugspitze	0.0963	63.1467



Network-wide analysis using GGG engineering data > 2021

Noise:
- Max: 3.5 ppb (js)
- min: 1.0 ppb (lr)

$\sqrt{\mathrm{SNR}(\mathrm{O_2})^2 + \mathrm{SNR}(\mathrm{CH_4})^2}$:
- max: 6.90 (ka)
- min: 2.48 (xh)

- Similar behavior as for XCO_2