

A novel portable FTIR spectrometer for the observation of CH₄ and CO₂ sources

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Institute for Meteorology and Climate Research IMK-ASF



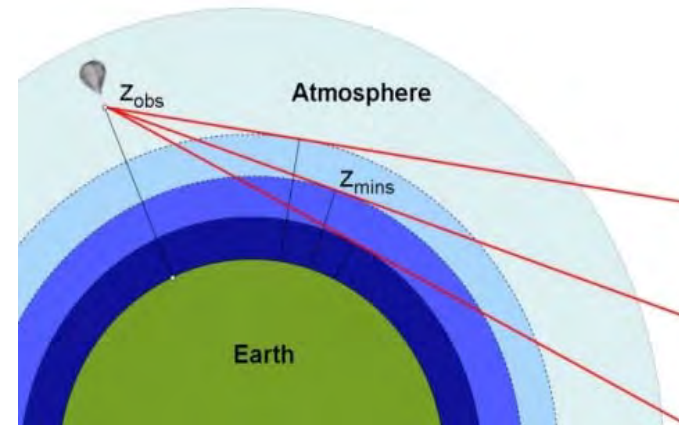
Contents

- A short profile of IMK-ASF
- Development of a tabletop FTIR spectrometer (observation of XCO₂ & XCH₄): EM27/SUN
- Performance
- Applications
- Summary

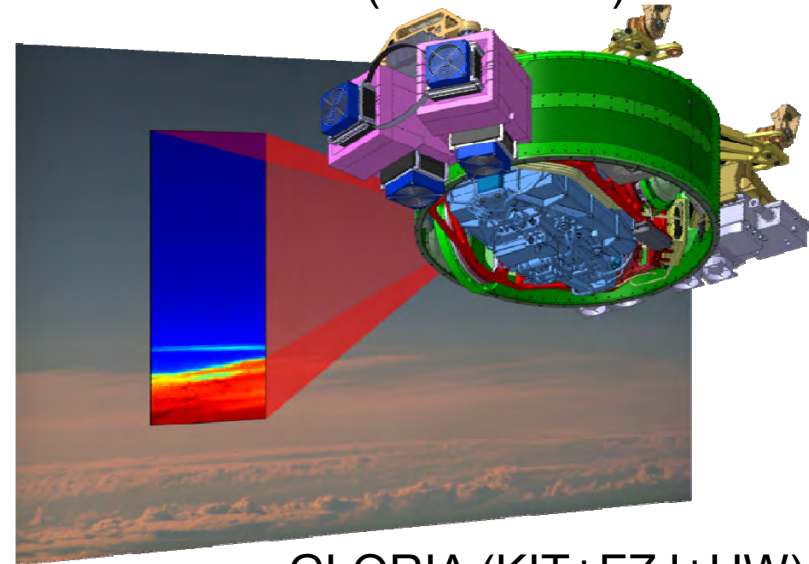


History of infrared remote sensing at IMK-ASF

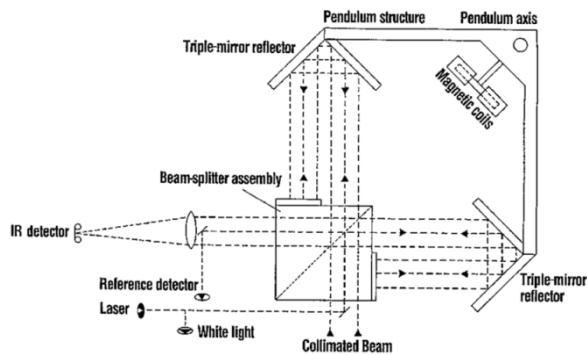
■ Develop & operate FTIR limb sounders



MIPAS-Envisat (2003-2012)

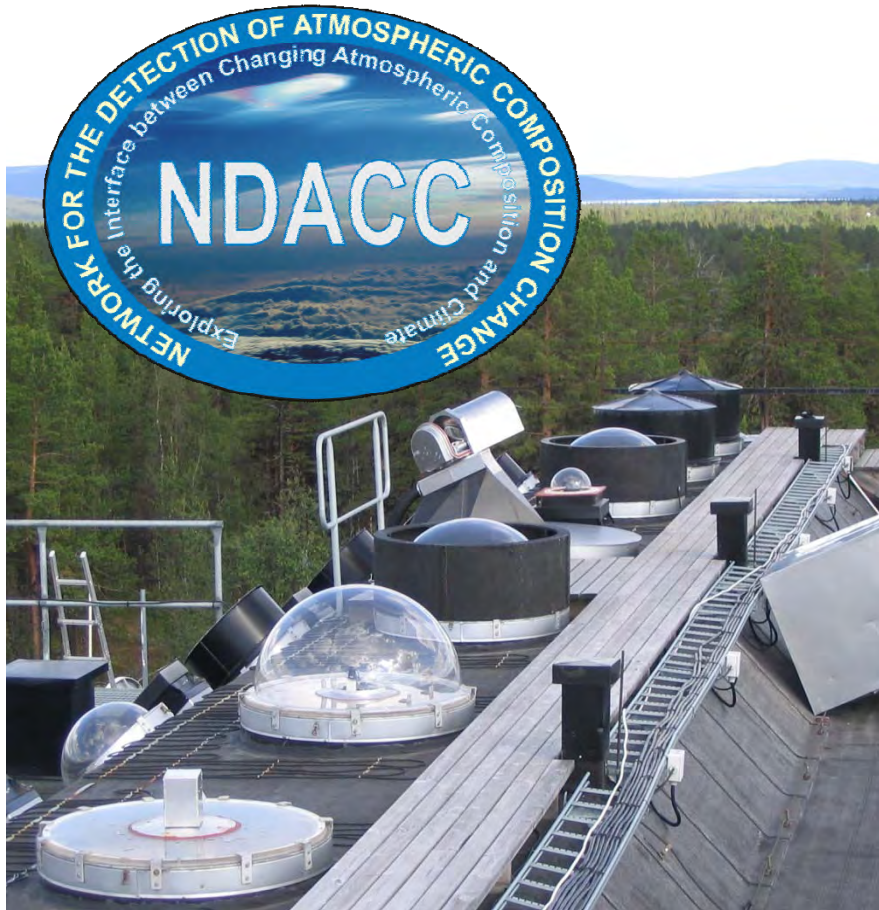


GLORIA (KIT+FZJ+UW)



History of infrared remote sensing at IMK-ASF

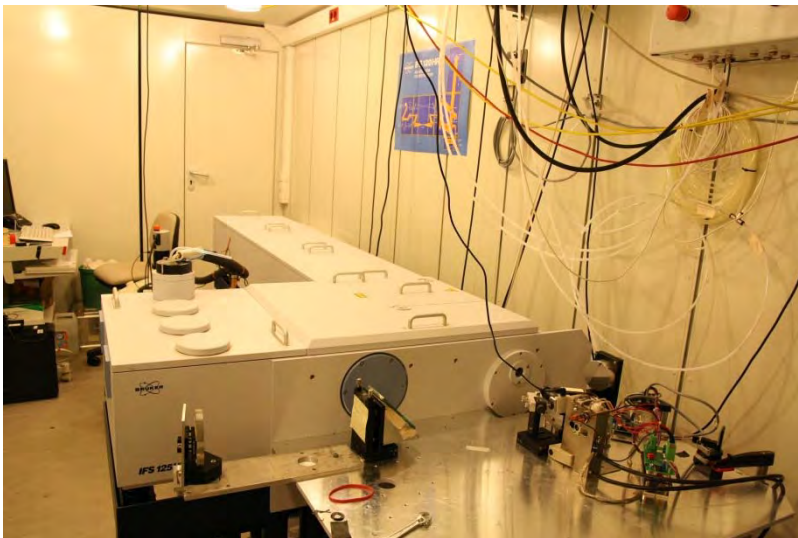
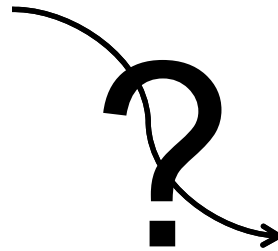
- Operate ground-based spectrometers (NDACC and TCCON)



TCCON – limitations



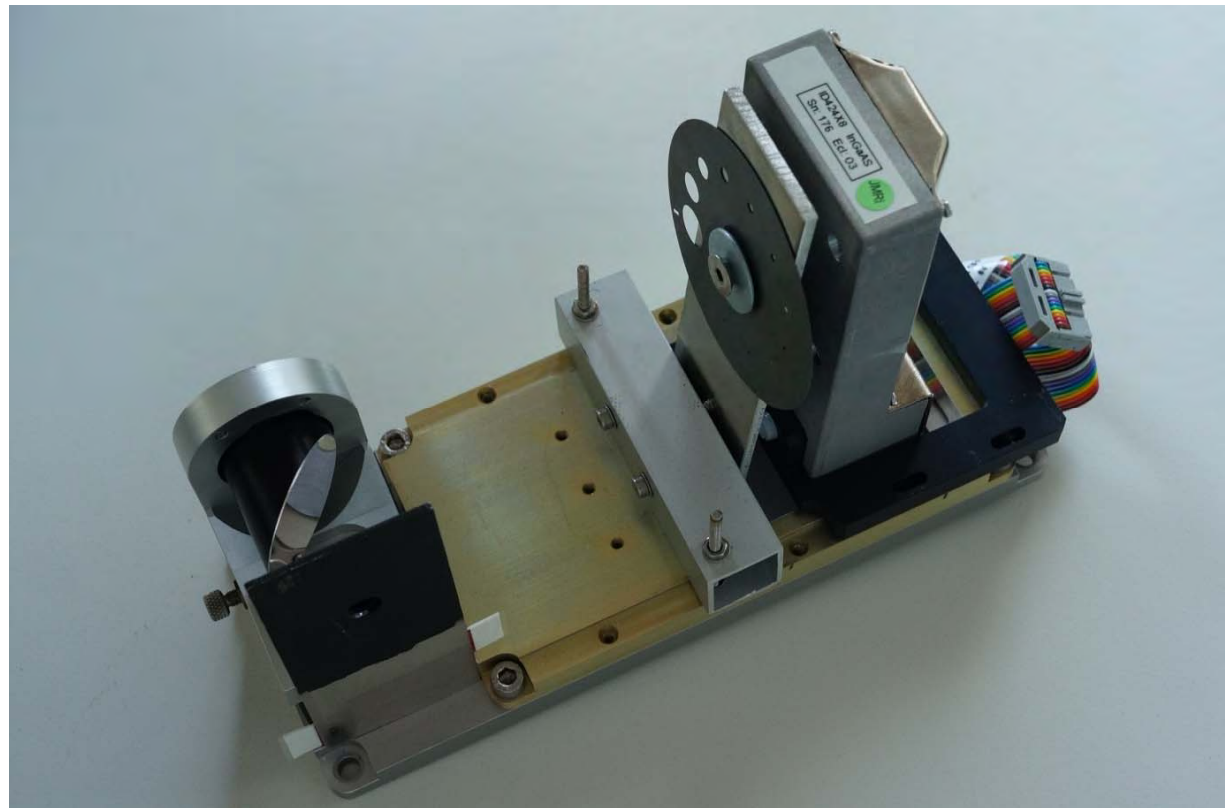
- Expensive
- Logistically demanding
- Requires continuing maintenance
- Not portable



Tabletop spectrometer for XCO₂ and XCH₄

KIT started in 2011 the development of a novel compact NIR-FTIR spectrometer for carbon cycle research. This venture was tackled in cooperation with Bruker Optik GmbH. We decided for the EM27 spectrometer as starting point.

Prototype



Tabletop spectrometer for XCO₂ and XCH₄

The spectrometer is now offered as a standard item from Bruker Optics, Germany (“EM27/SUN”). The serial production instrument is an upgrade of the prototype, e.g. uses a new acquisition electronics, offers wider spectral coverage and a redesigned tracker.

Das neue kompakte EM27/SUN Spektrometer für Atmosphärenmessungen

München, Deutschland, – April 2, 2014 – Die Bruker Corporation hat heute die erfolgreiche Einführung des neuen kompakten Spektrometers *EM27/SUN* für Atmosphärenmessungen durch solare Absorptionsspektroskopie bekannt gegeben.

Das *EM27/SUN* verfügt über ein neues CAMTracker-System, das eine weiterentwickelte Version des wohlbekannten Solar Tracker darstellt, wobei ein innovatives Kamera-basiertes Rückkopplungssystem der Sonne als Lichtquelle folgt. Die herausragende Akkuratheit bei der Verfolgung der Sonnenstrahlung ist die Grundlage für hoch präzise Quantifizierungen. Zusätzlich bietet das neue CAMTracker-System direkte Informationen über das Sichtfeld und ist gegenüber inhomogener Ausleuchtung unempfindlich. Aufgrund des sehr kompakten und robusten Aufbaus, des relativ geringen Gewichts und der intuitiven Benutzerführung ist das *EM27/SUN* leicht zu transportieren und somit auch ideal geeignet für Langzeitmesskampagnen an entlegenen Orten mit geringer Infrastruktur.



EM27/SUN

Performance of the EM27/SUN

- Longterm stability of the EM27/SUN $X_{CO_2} < 0.1\%$
- Side-by-side intercomparison



Performance of the EM27/SUN

XCO₂ calibration factors (Courtesy: M. Frey, KIT)

Drift of calibration factor spectrometer #2: 0.003% !!

Spectrometer #	Before campaign	after campaign
1	1.00000	1.00000
2	0.99924	0.99921
3	1.00015	1.00016
4	0.99987	0.99987
5	0.99960	0.99962



Performance of the EM27/SUN

XCH₄ calibration factors (Courtesy: M. Frey, KIT)

Drift of calibration factor spectrometer #3: 0.026% !!

Spectrometer #	Before campaign	after campaign
1	1.00000	1.00000
2	0.99927	0.99940
3	0.99971	0.99962
4	0.99856	0.99882
5	0.99892	0.99905



Calibration of the EM27/SUN to WMO scale

TCCON XCO₂ and XCH₄ data are calibrated wrt WMO scale using numerous aircraft profile measurements. It would be ambitious to aspire a similar independent effort for the EM27/SUN, instead: exploit portability, perform side-by-side calibration wrt TCCON spectrometer.

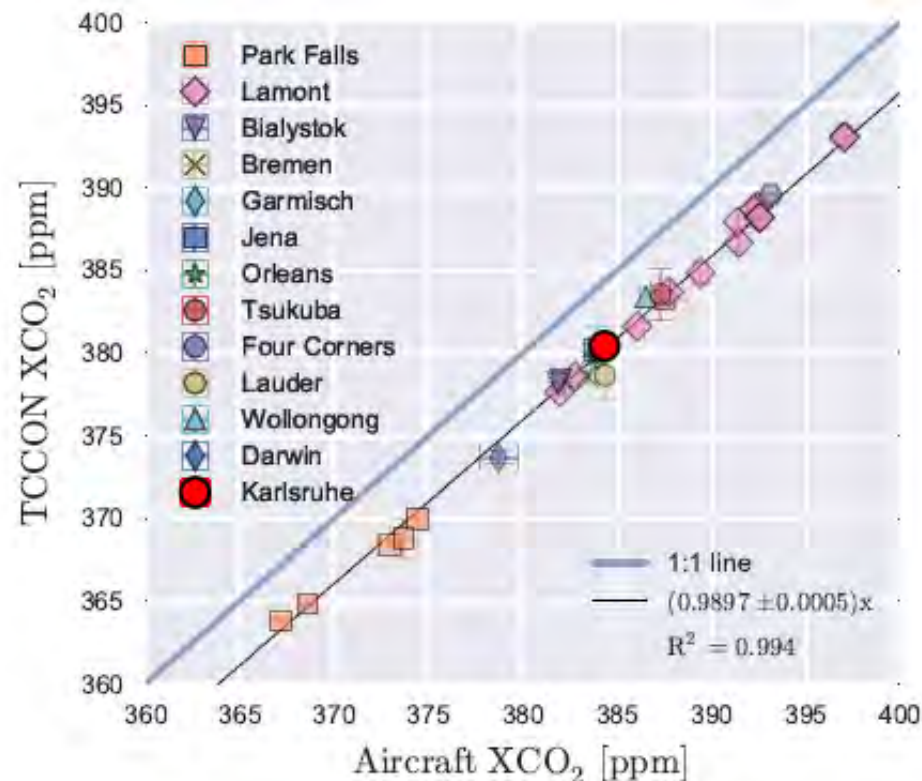


Figure courtesy of M. Kiel, D. Wunch

A TCCON supplement: COCCON



- Operate EM27/SUN spectrometers at remote sites



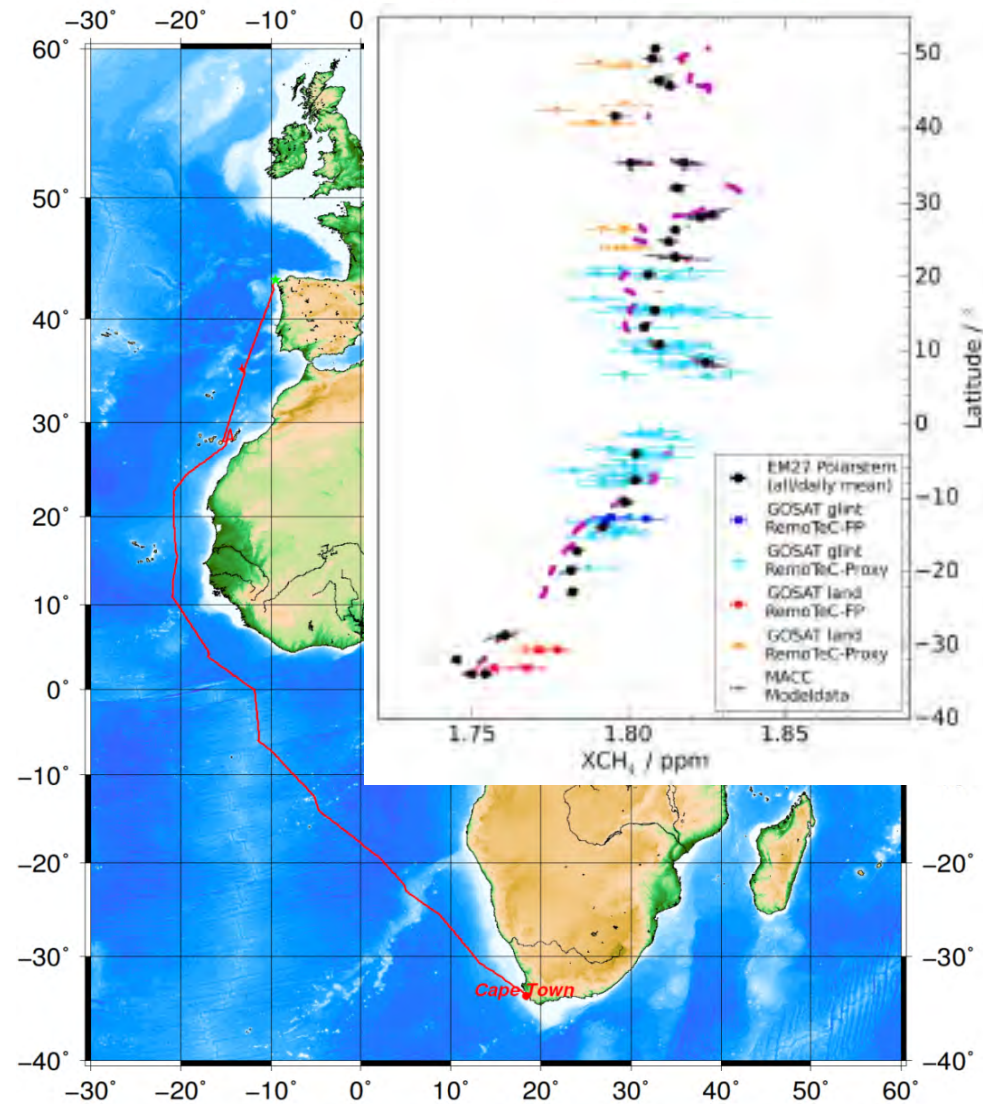
Local cooperations: Namibia / Brazil / Ethiopia / India

Mobile applications: Polarstern cruise

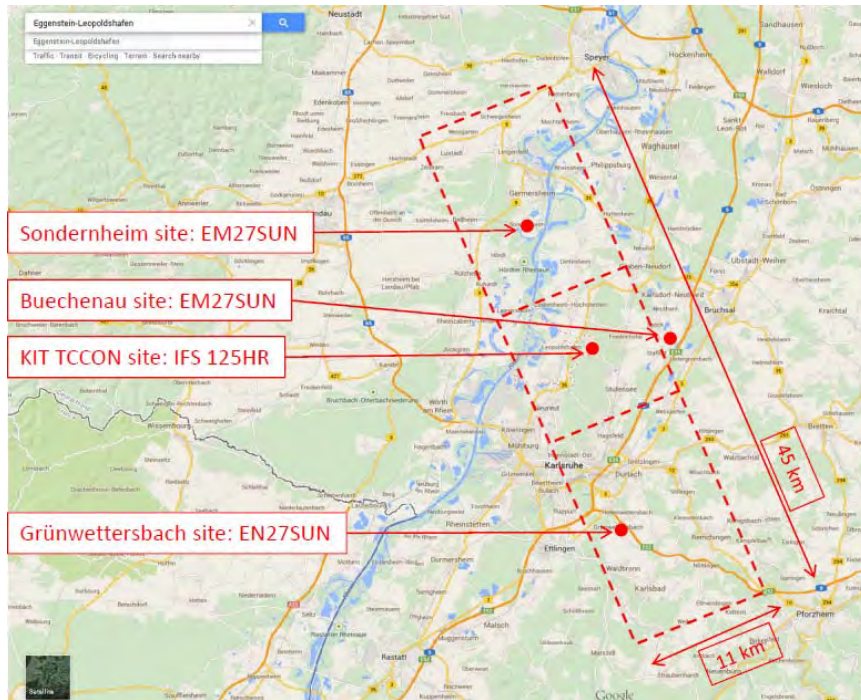


March + April
2014

Remote-C group: A. Butz
Klappenbach et al.: "Accurate mobile
remote sensing ... aboard a research vessel"
, AMT, 2015

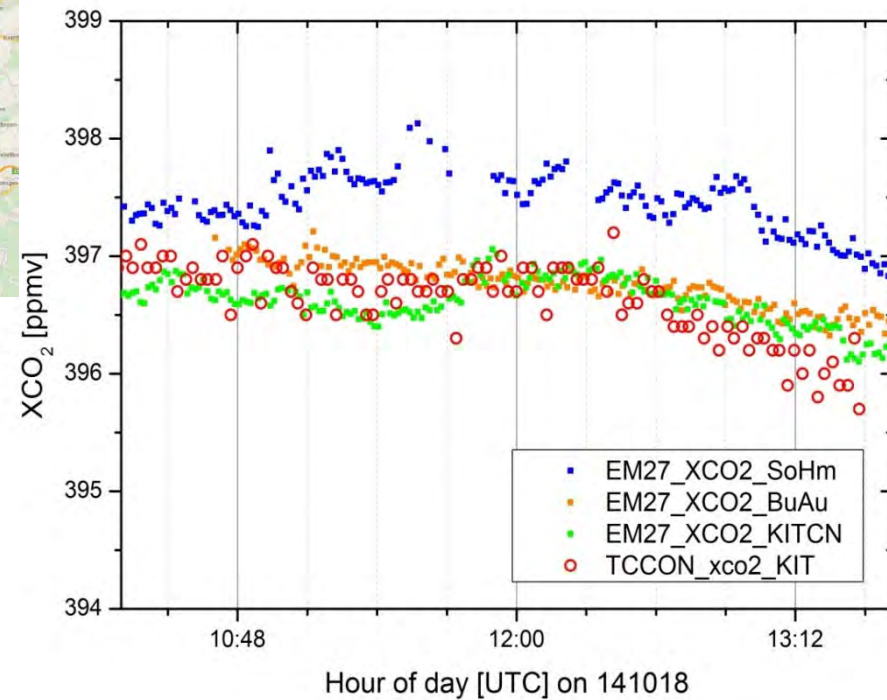


Gradient detection: OCO-II targets Karlsruhe

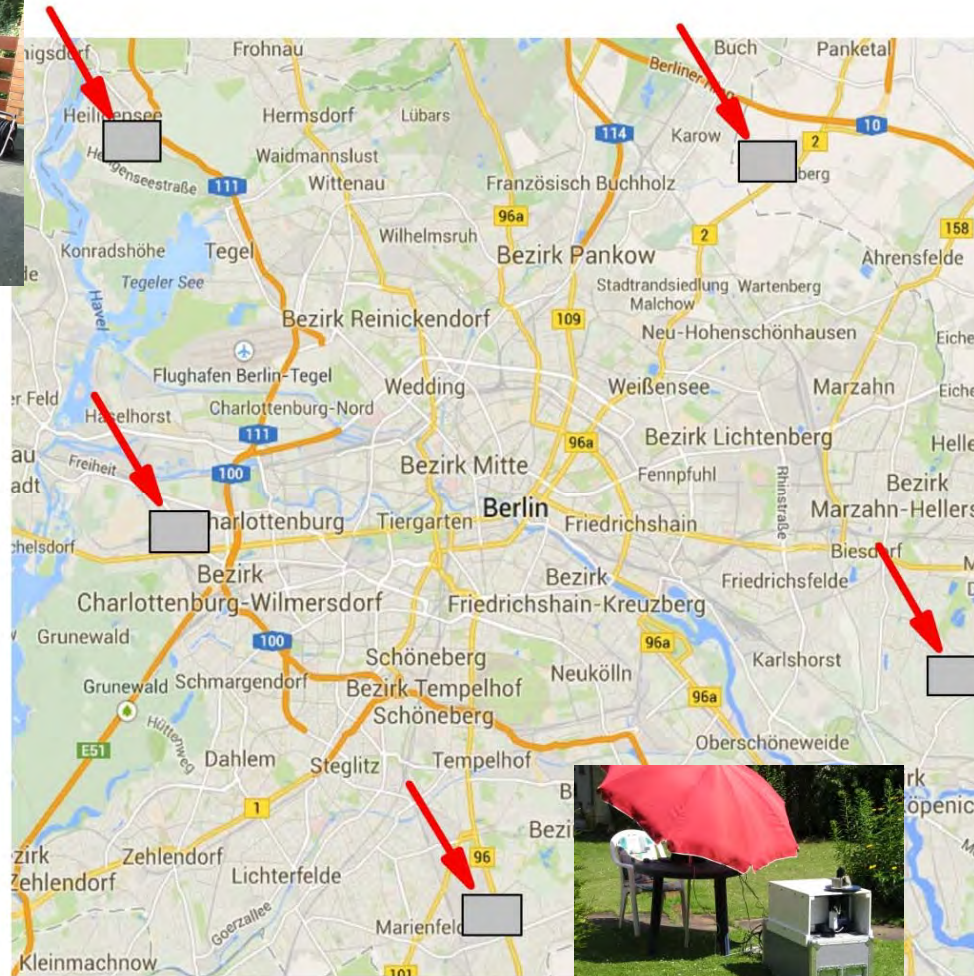


Note: XCO₂ gradient along OCO-II track of about 1 ppmv / 10 km

analysis TCCON spectra: S. Dohe
analysis COCCON spectra: M. Kumar Sha

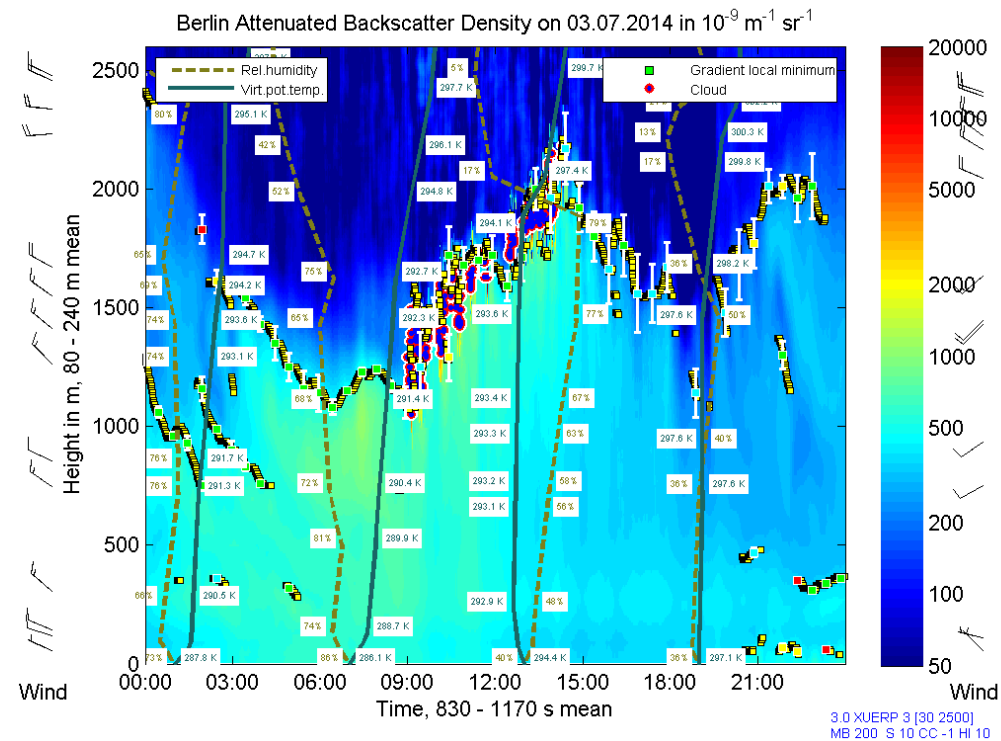


City emissions: Berlin (June / July 2014)



City emissions: Berlin

- Calibration of spectrometers before / after the campaign***
- Auxiliary meteorological information
 - ✓ Local pressure, T
 - ✓ Ceilometer measurements: BLH as fct of time*
 - ✓ COSMO winds**

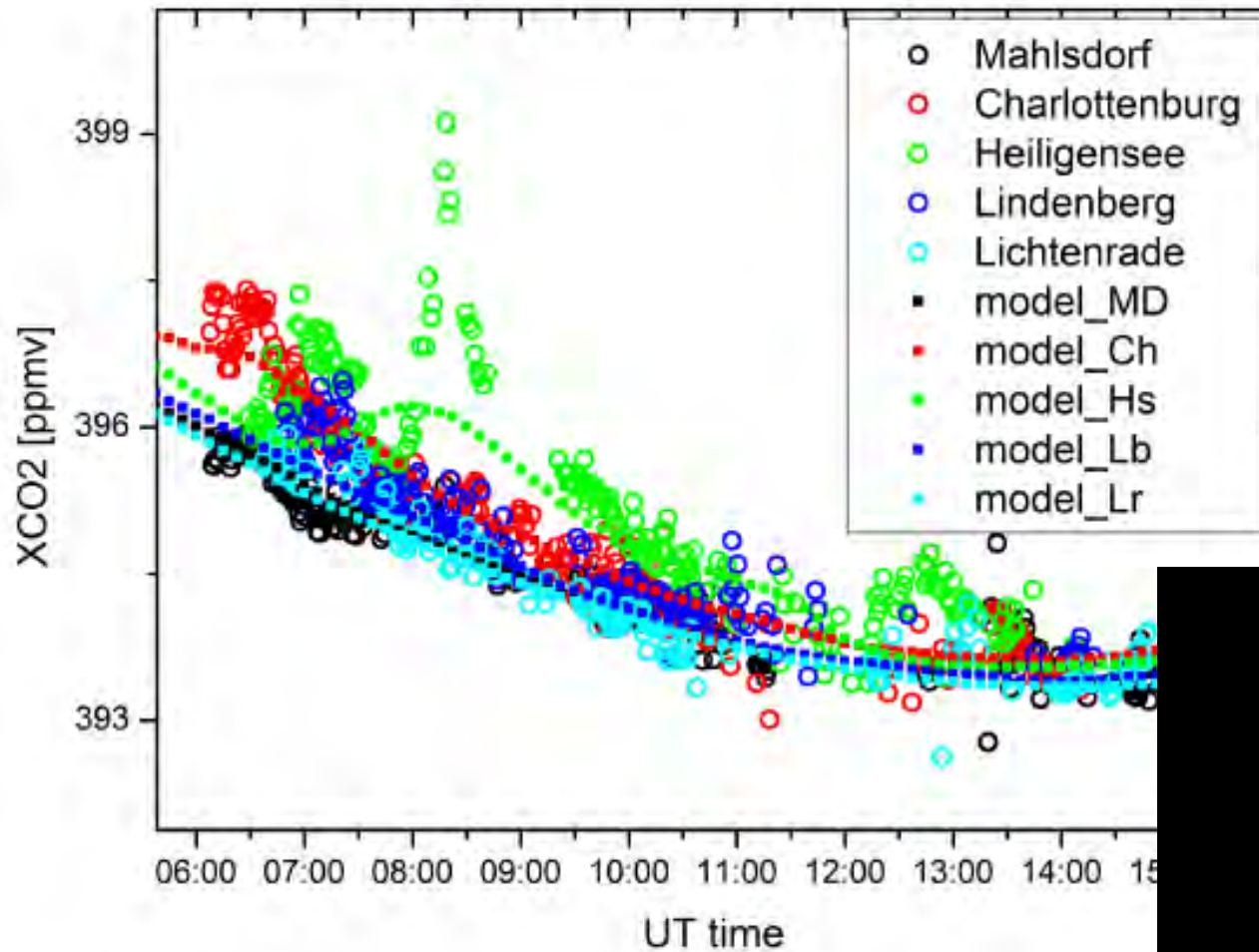


*: Prof. K. Schäfer, KIT, IMK-IFU

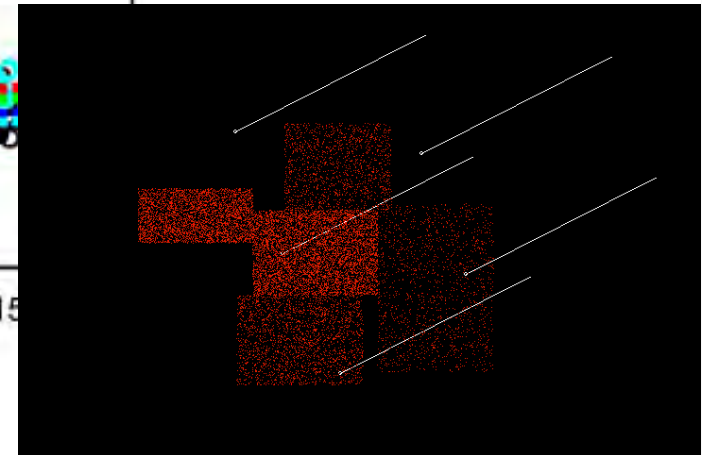
** : R. Kohlhepp, DWD

***: M Frey et al.: "Calibration ... of a set of portable FTIR spectrometers", AMT, 2015

City emissions: Berlin



Model source:
800 kg CO₂ / s



F. Hase et al.: "Application of portable FTIR spectrometers ..." AMT, 2015

City emissions: Paris (May 2015)



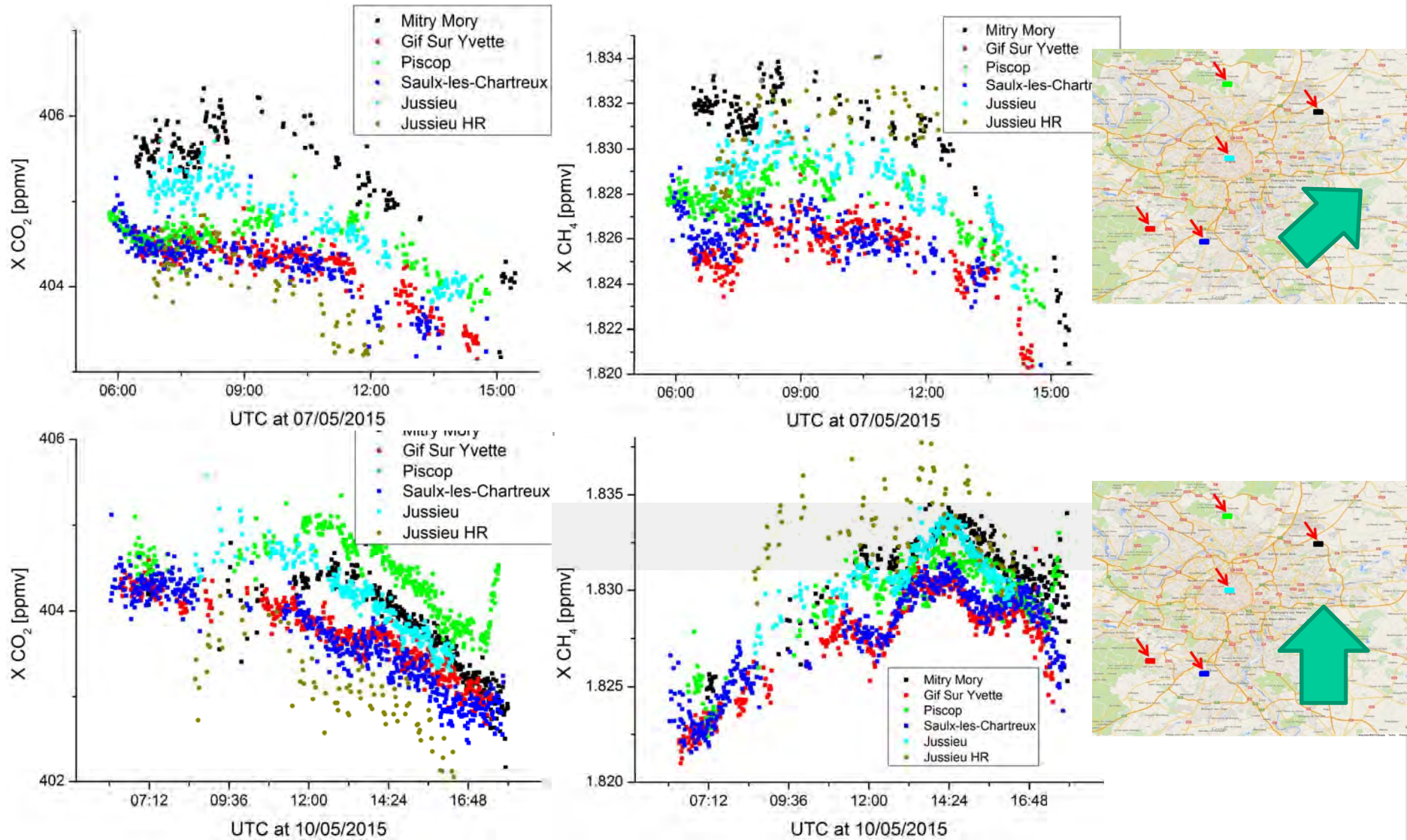
CO₂CCON
Collaborative Carbon
Column Observing Network

Paris
2015

The poster features a photograph of several white and grey portable FTIR spectrometers on a rooftop. The background of the poster is a blurred image of the Eiffel Tower. The text 'Paris 2015' is overlaid in large red letters.

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DU CLIMAT ET DE
L'ENVIRONNEMENT**  

Paris: XCO₂ and XCH₄ for individual days



Summary

- Successful development of a portable FTS for observing column-averaged greenhouse gases abundances.
- The spectrometer (Bruker EM27/SUN) is extremely stable.
- Wide range of applications:
 - ✓ Create TCCON periphery
 - ✓ Mobile measurements
 - ✓ Detect gradients in column-averaged abundances
 - ✓ Observe local sources using an array of spectrometers

THANKS FOR YOUR ATTENTION!!