Continuous and high precision Greenhouse Gas Observations onboard Commercial Airliner within IAGOS-ERI

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Motivation: Using mixing ratios of greenhouse gases from monitoring networks consisting of near-surface stations and tall tower observatories for estimating surface-atmosphere exchange fluxes of those gases is severely compromised by **uncertainties** associated with simulating **vertical mixing in transport models** as obvious from the TransCom studies [Law et al., 1996, Denning et al., 1996, Law et al., 2008], and from comparison of mixing heights in models with hose from observations [Gerbig et al., 2008]. Direct comparison of the vertical tracer distribution to **vertical profile observations** provides a strong additional constraint on flux distributions [Stephens et al., 2007], which suggests that when using profile information such as available from airborne sampling programs in inversions, the impact of uncertainty in vertical transport is largely reduced.

Validation of remotely sensed columns of CO_2 and CH_4, both from ground (e.g. FTS) and from space (e.g. GOSAT), requires regular in-situ profile observations with sufficient accuracy. Last, but not least, measurements of long lived trace gases in the upper troposphere and lower stratosphere (UTLS) provide a strong **constraint on troposphere-stratosphere exchange** processes [c.f. Boering et al., 1996].

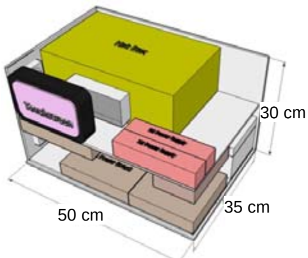
The preparatory phase for the EU infrastructure project "In-service Aircraft for a Global Observing System – European Research Infrastructure" (**IAGOS-ERI**), builds upon the experience gathered during MOZAIC (Measurements of OZone, water vapour , carbon monoxide and nitrogen oxides by in-service AIrbus airCraft) over the last decade [Marenco et al., 1998], and aims at increasing the number of parameters measured by adding to the currently covered chemistry related gases also more climate related components, including the greenhouse gases CO_2 and CH_4 as well as aerosols. The target is a comprehensive suite of measurements onboard in-service Airbus A340 and A330 aircraft, distributed globally with vertical coverage of nearly the full troposphere.

IAGOS Approach

- Continuous measurements onboard a fleet of Airbus longhaul aircraft
- Permanent integration in avionics bay
- Multiple species: O_3, H_2O, CO, NO_y, NO_x, CO_2, CH_4, Aerosols, cloud particles
- Multiple science communities:
  - Climate change
  - Air quality
  - Carbon cycle
  - Impact of aviation

Method

- Simultaneous measurement of CO_2, CH_4, and H_2O
- Cavity Ring-Down Spectroscopy (CRDS, Picarro)
- Calibration system using two 3L composite cylinders
- Standard gases traceable to WMO scale
- No drying system, correction to dry air mixing ratio using measured H_2O
- Online data transmission to database via Satcom



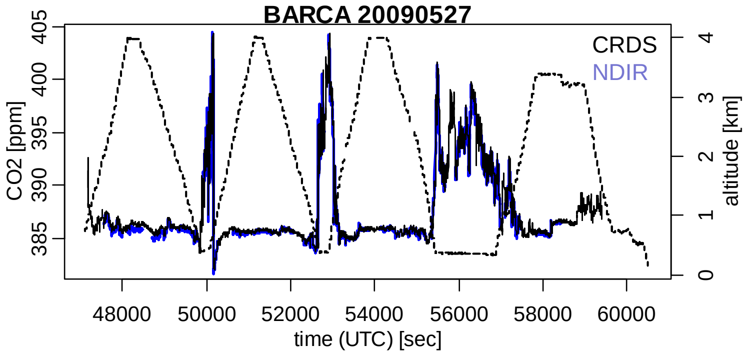
Instrument design (courtesy of Eric Crosson, Picarro)

Specifications of IAGOS CRDS instrument	
CO_2 Precision@1 s	0.1 ppm
CO_2 accuracy	0.1 ppm
CH_4 Precision@1 s	1 ppb
CH_4 accuracy	2 ppb
Dimensions	30x35x55 cm³
Weight incl. calibration unit	<30 kg
Power consumption	<300 W @ 28VDC

Calibration system using certified composite cylinders

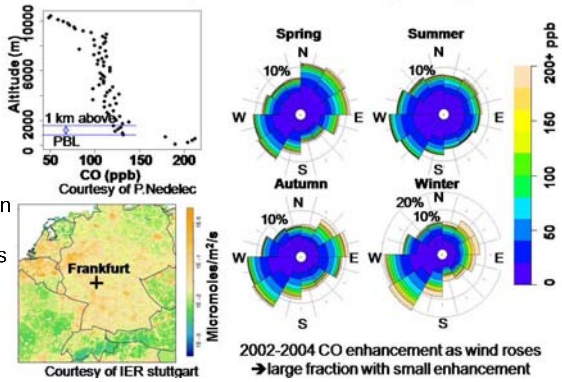
Prototype results

- Laboratory tests prove working correction of dilution and broadening from H_2O mixing ratios up to 6% with residuals smaller than 0.05 ppm and 0.5 ppb for CO_2 and CH_4, respectively
- CRDS flown side-by-side during BARCA campaign with pressure and temperature controlled Licor 6062 (NDIR) equipped with in-flight calibration system and sample dryer
- Excellent agreement:
  flight-to-flight variations CRDS-NDIR < 0.06 ppm
  within-flight variations CRDS-NDIR (0.3 Hz) < 0.25 ppm



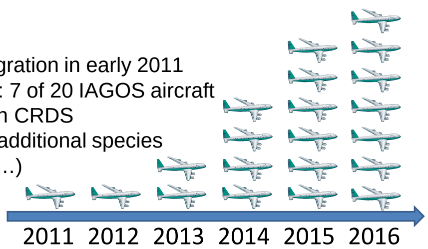
Are profiles over airports representative?

Assessment using MOZAIC profiles for CO over Frankfurt => Enhancement in PBL shows regional rather than local representativeness



Schedule

- The first integration in early 2011
- After 5 years: 7 of 20 IAGOS aircraft equipped with CRDS
- Potential for additional species (N_2O, COS, …)



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