AirCore, aircraft, and FTS measurement campaigns at Sodankylä

Huilin Chen
University of Groningen

FMI:
Rigel Kivi, Pauli Heikkinen, Juha Hatakka, Tuomas Laurila
RUG-CIO:
Bert Kers, Marcel de Vries
NOAA/ESRL:
Jack Higgs, Tim Newberge, Colm Sweeney, Pieter Tans

InGOS TNA team:

BIRA: Martine De Maziere, Mahesh Kumar Sha, Minqiang Zhou
Reev River: Florin Mingireanu, Aurel Chirila
Lund: Jutta Holst

AirCore measurements

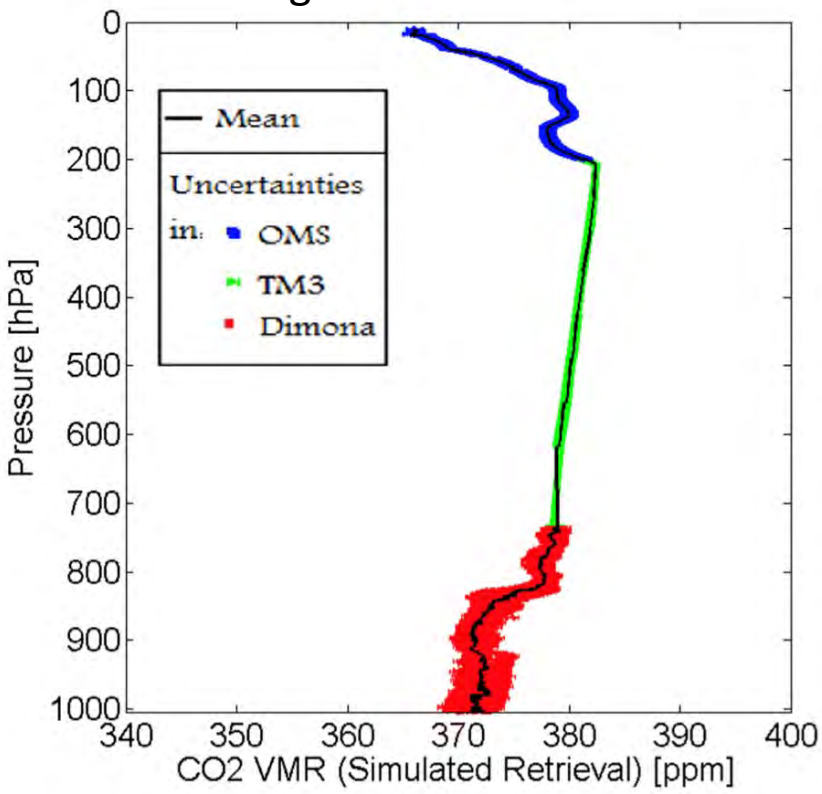
The AirCore with magnesium perchlorate driers and shut-off valves attached on each end, 152 m long, 7 kg *[Karion et al. 2010]*

Summary of recent AirCore development

- CO as a tracer for diffusion (fill air with 10,000 ppb CO)
- AirCore weight and vertical resolution optimization (1/4” + 1/8”)
- Automatic shut-off valve (preventing lost of air samples on the ground)
- Improving the accuracy of AirCore profiles (corrections for non-equilibrium)

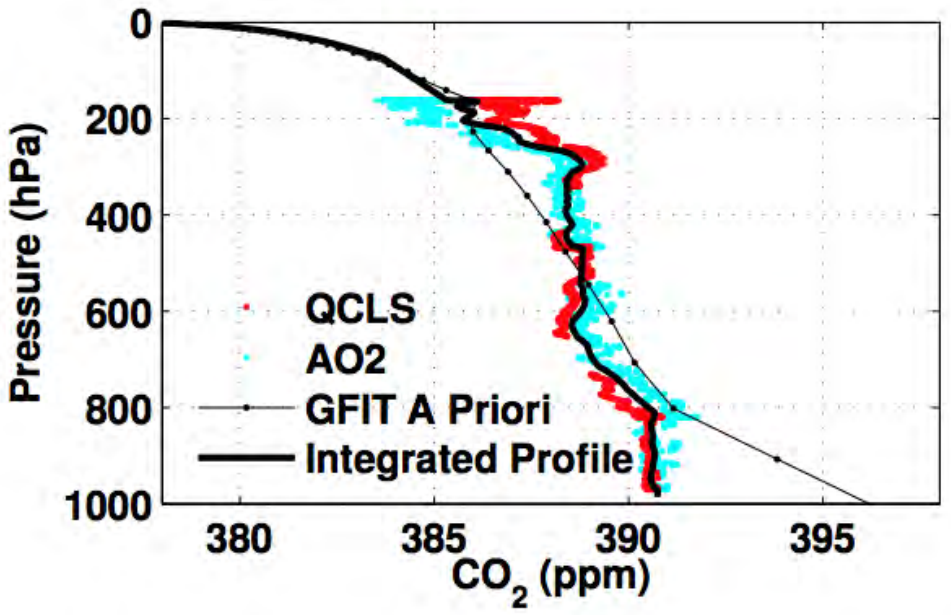
Calibrations of FTS Retrievals

Using low-altitude aircraft



Macatangay et al., 2008

Using high-altitude aircraft



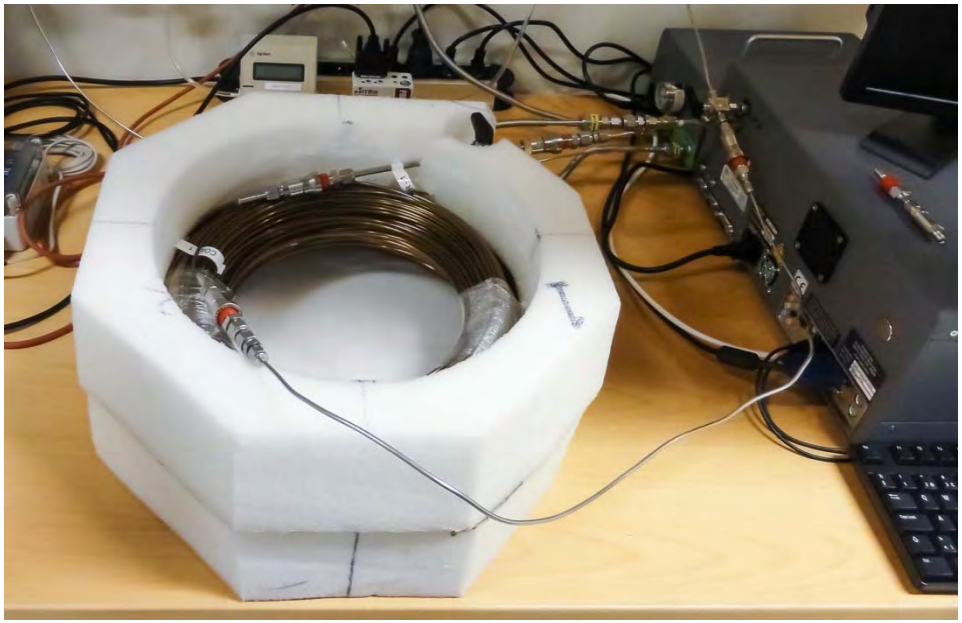
Wunch et al., 2010

IMECC in Europe

Messerschmidt et al. 2011

Geibel et al. 2012

AirCore measurements over Sodankyla



TCCON station

Location 67° North

AirCore: 40 m 1/4” + 60 m 1/8”

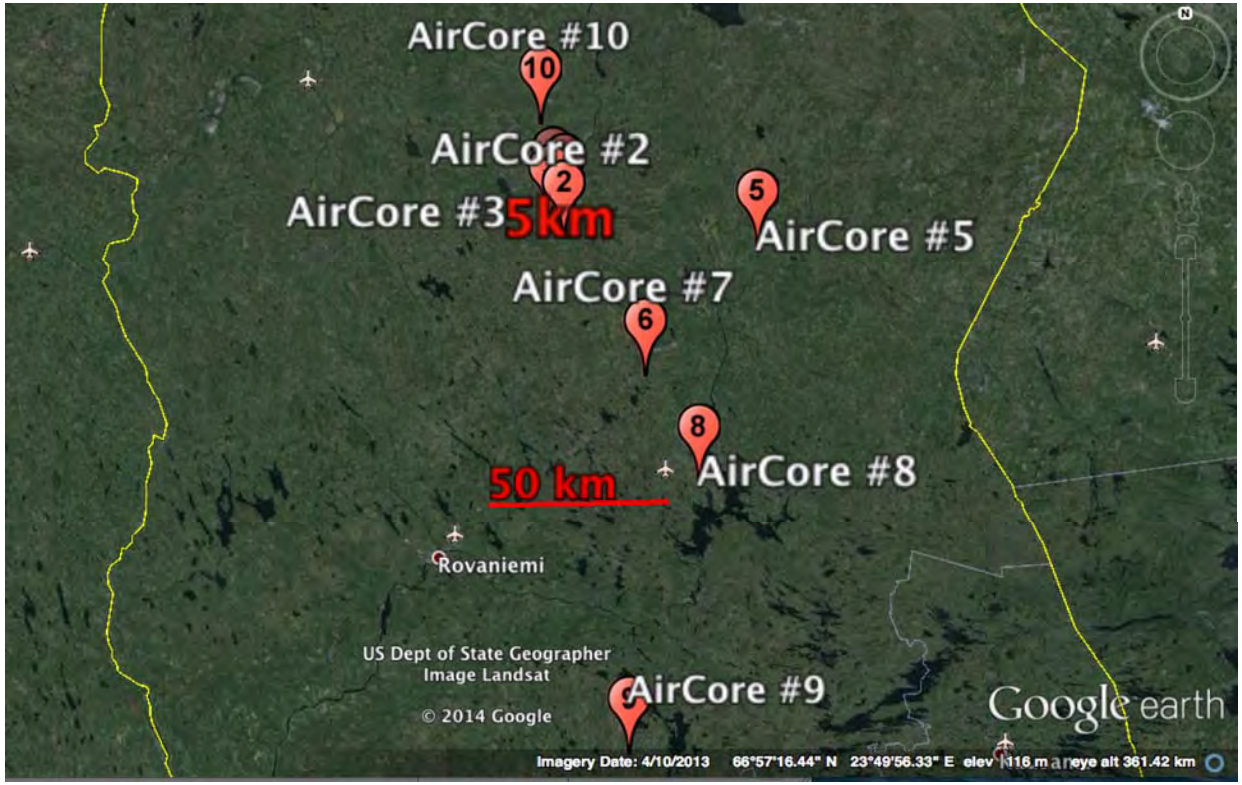
Coils: 2.8 kg

Total package: 3.6 kg

Analysis: Picarro $CO_2/CH_4/CO$

AirCore flights 2013 & 2014

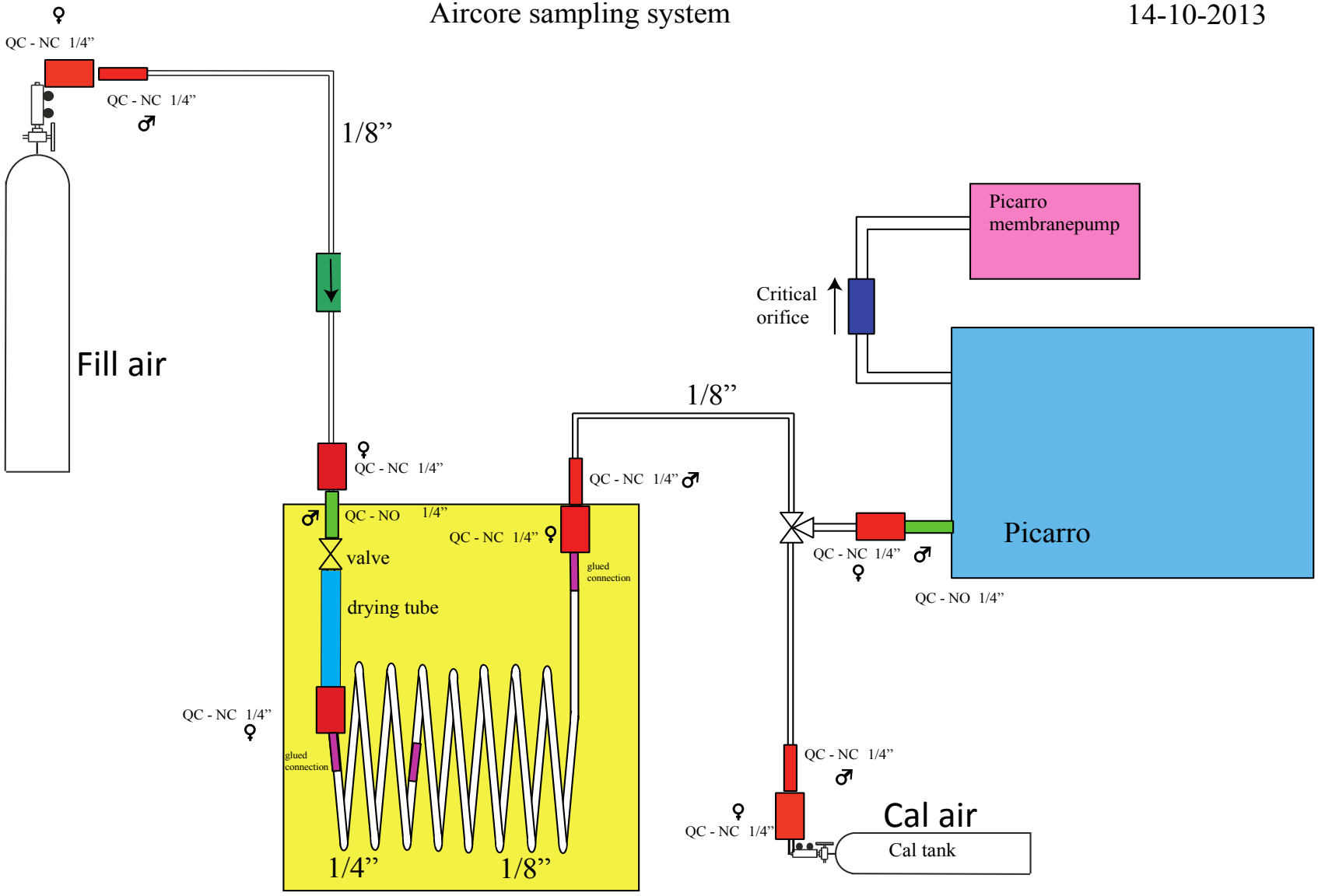
Landing sites



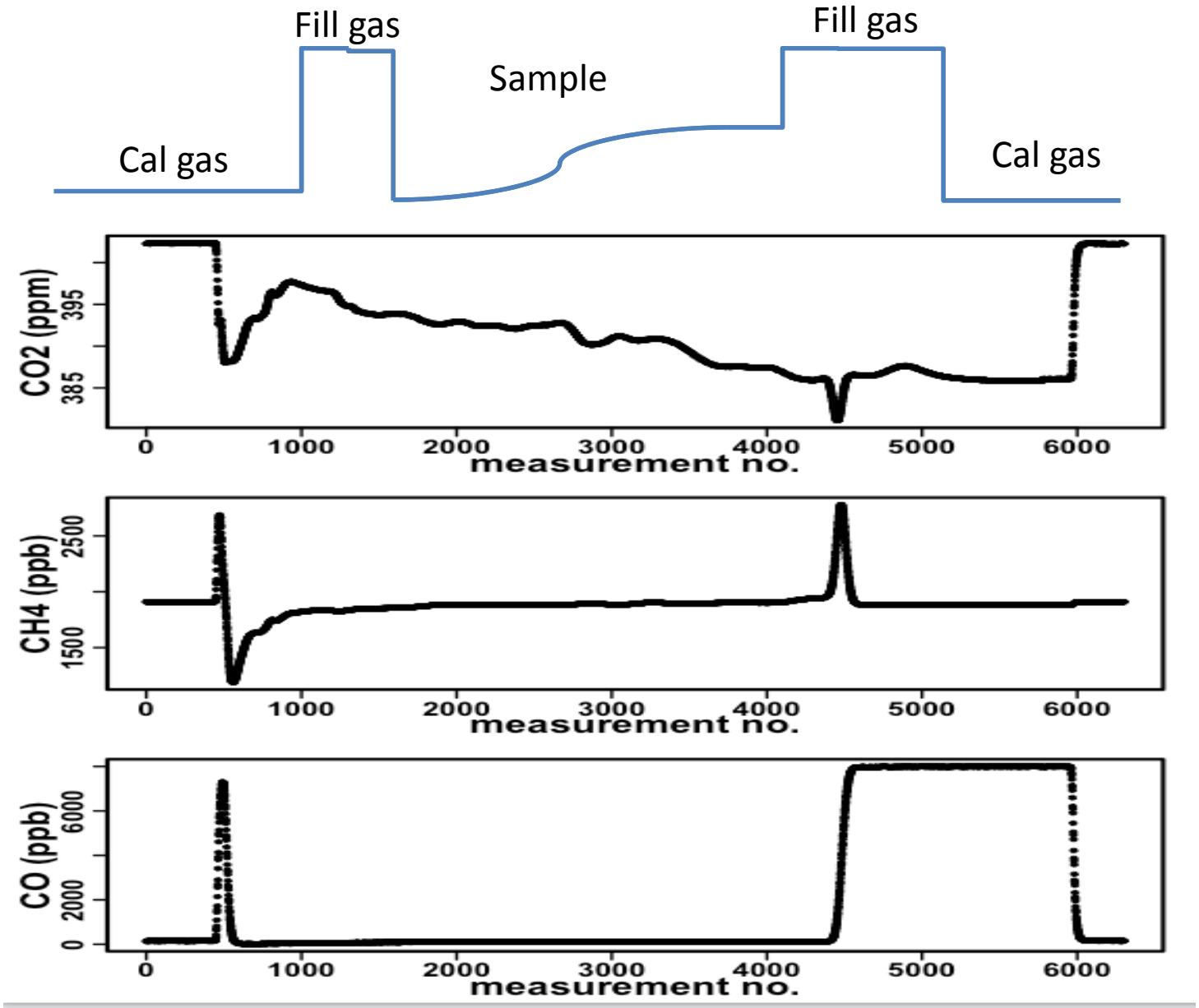
Summary:

- **Distance from TCCON: 7 – 115 km**
- **Column coverage: 85-95 %**

AirCore Prep & Analysis System



Analysis of AirCore sample



To the vertical profiles

Assuming

1. Temperature variations negligible
2. Steady status during flight

PV = nRT

P: air pressure
V: AirCore volume
n: number of moles
T: AirCore temperature
R: gas constant

Equal ΔP → Equal Δn the same air mass

During analysis:

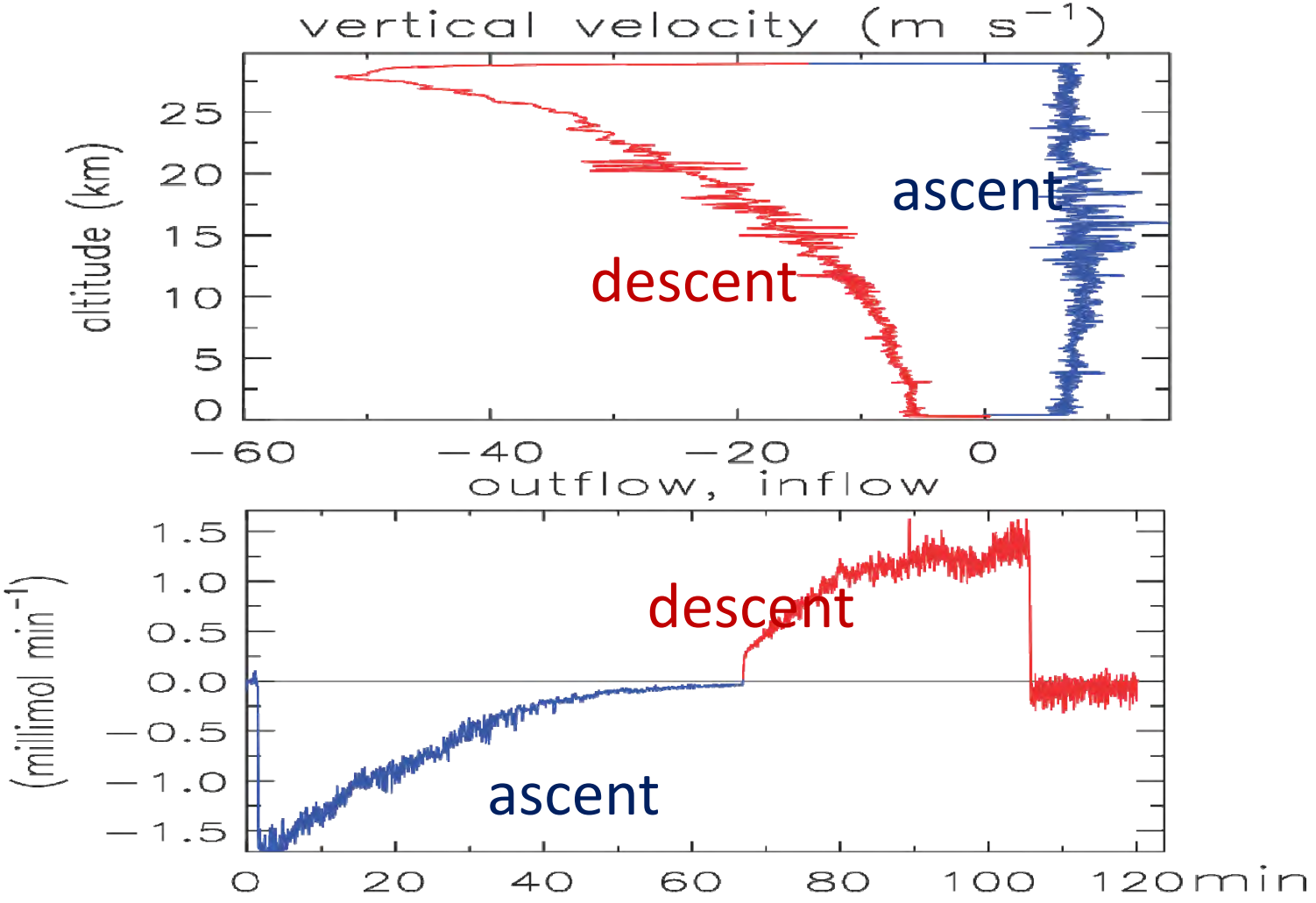
Equal Δtime → Equal Δn the same air mass

→ **Δtime → ΔP**

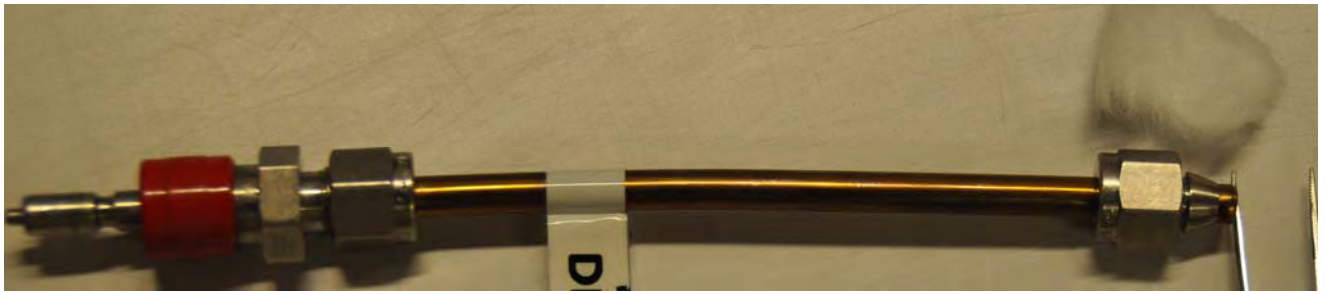
To the vertical profiles

Assuming

1. Temperature variations negligible
2. Steady status during flight

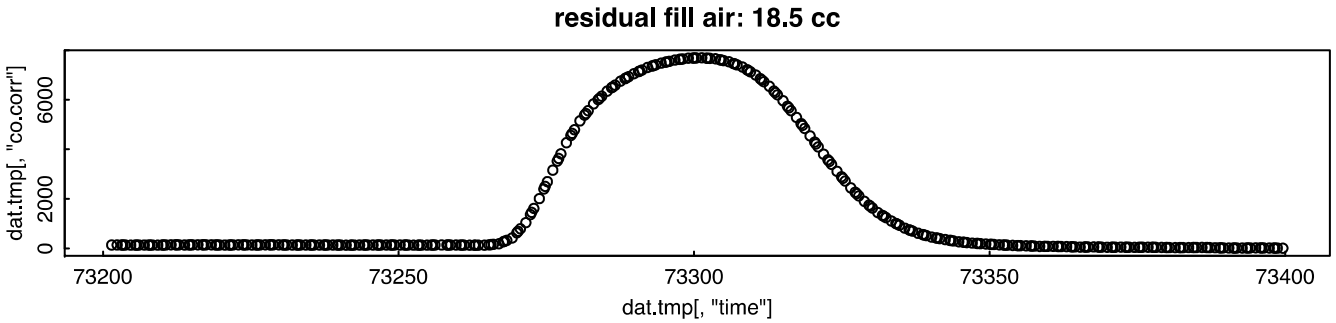


What more?

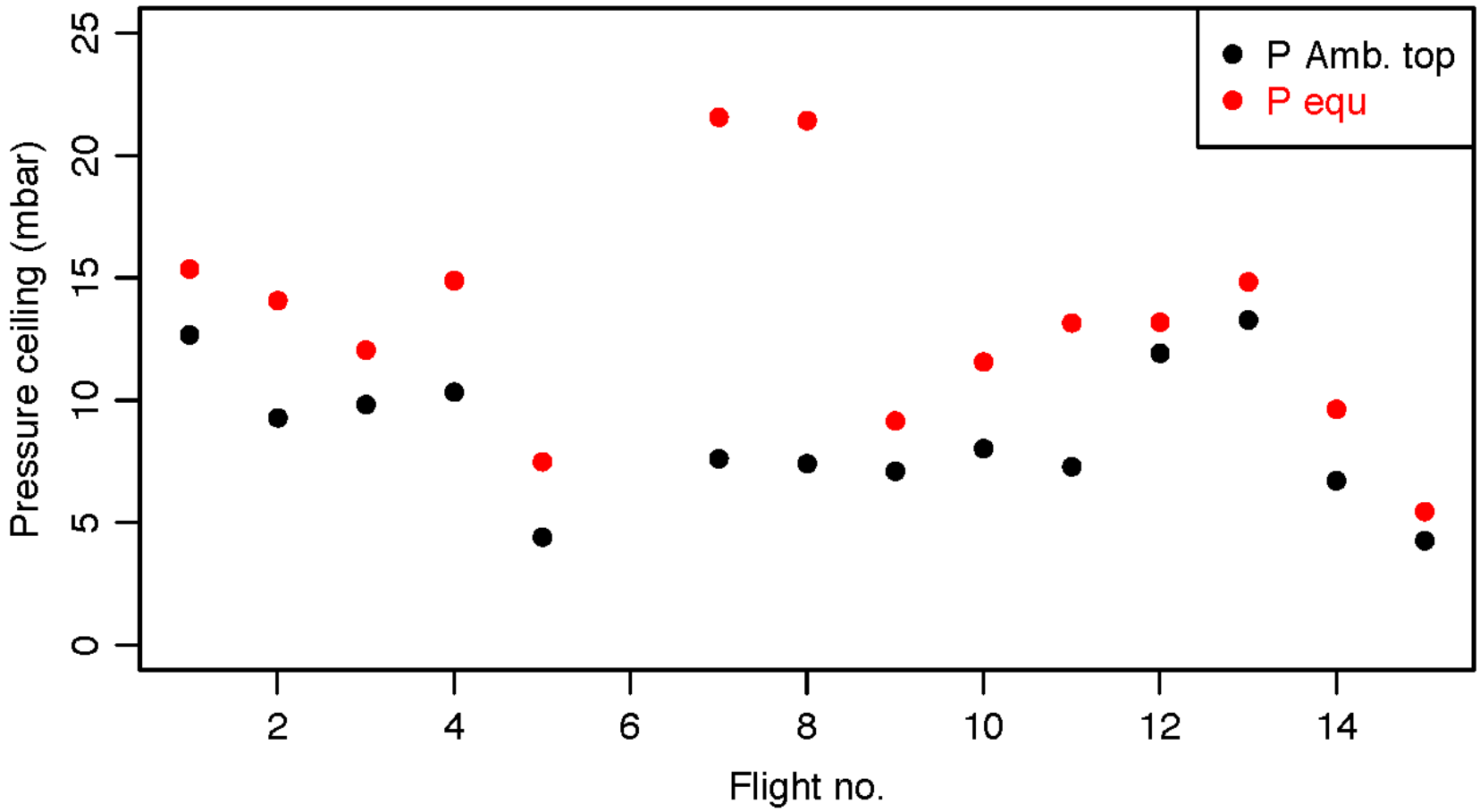


- Flow restrictor:
- Varies from flight to flight

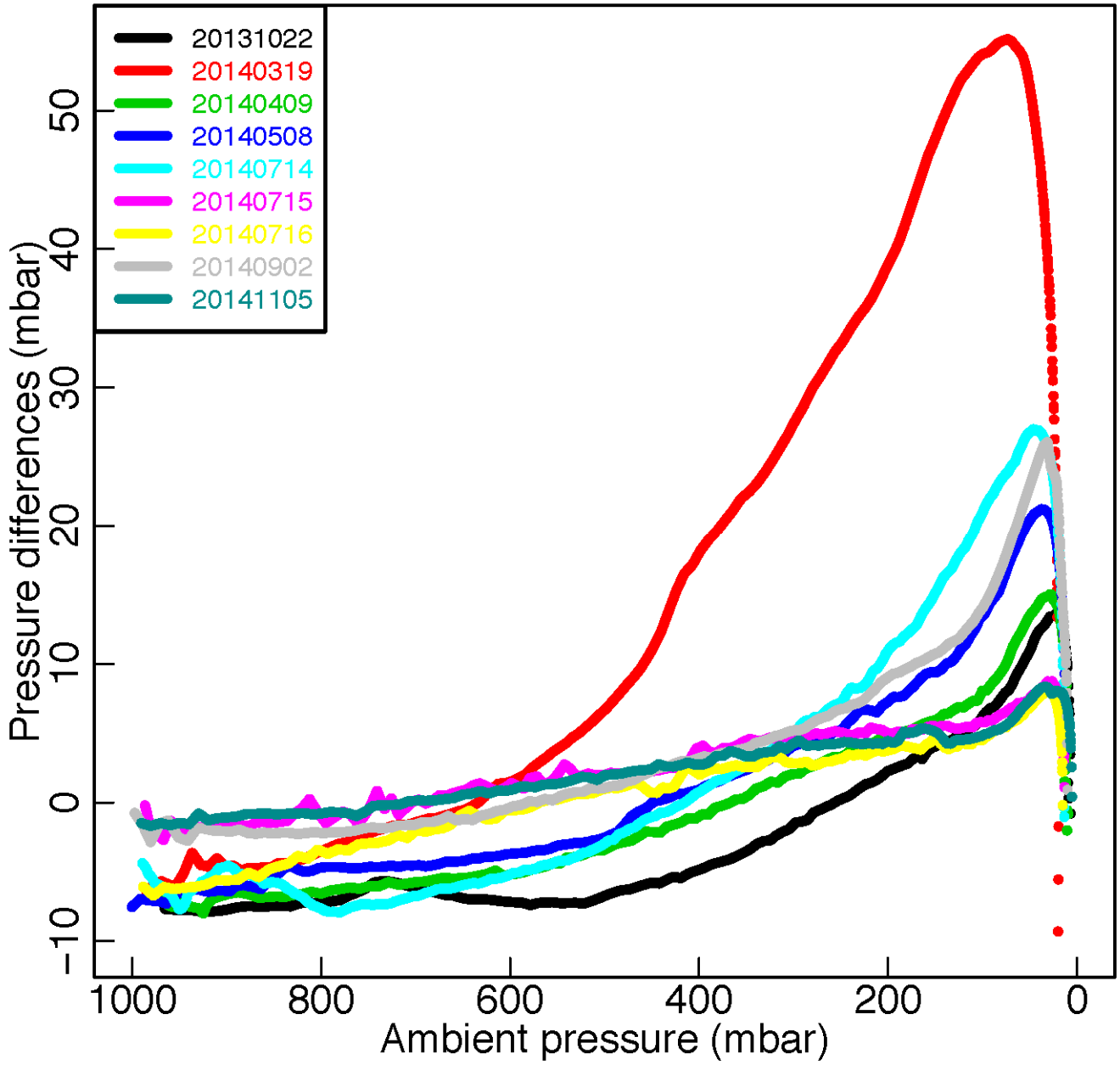
- Can be determined from residual fill gas



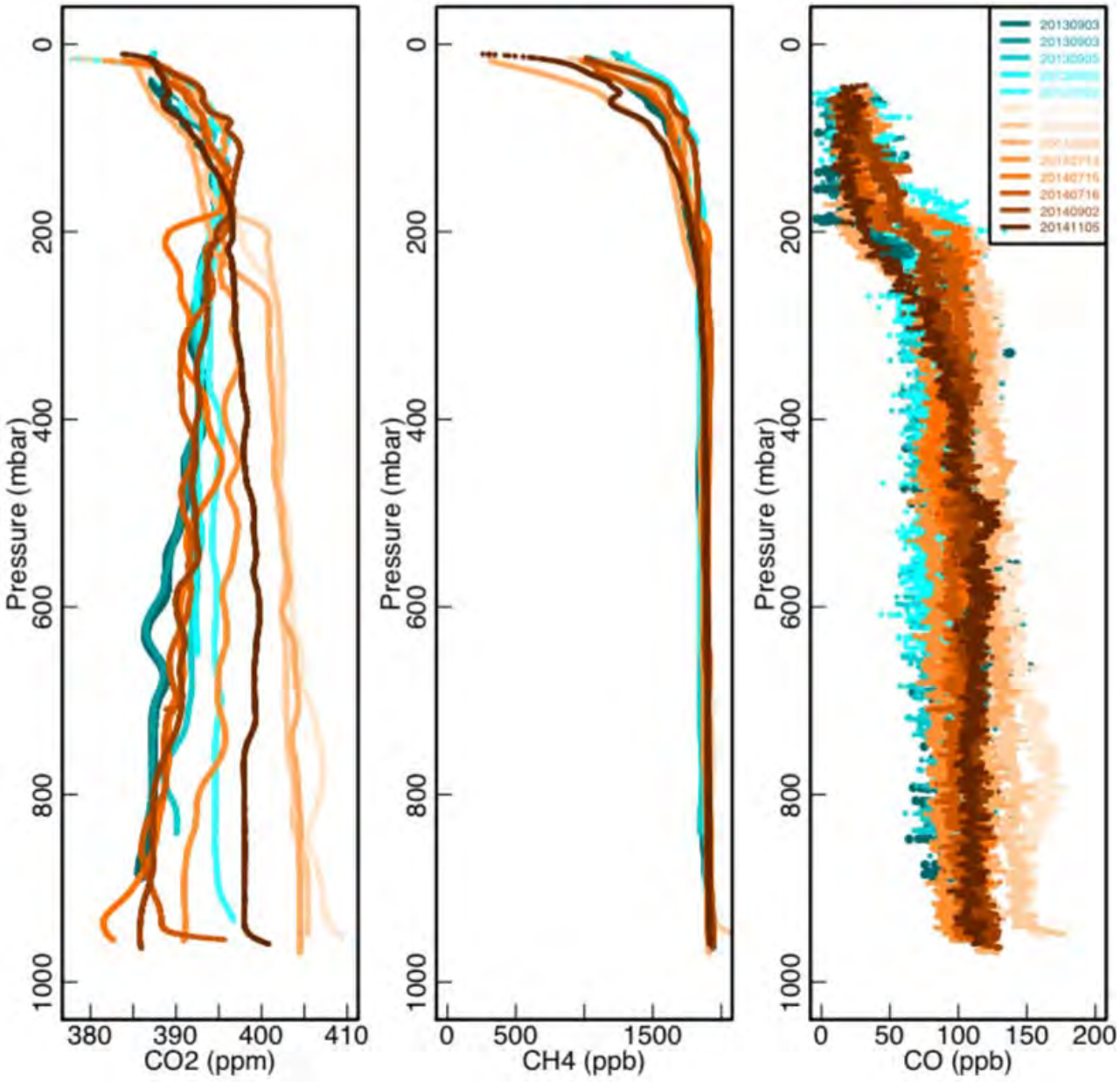
Pressure drop across the tubing and dryers



Non-equilibrium corrections

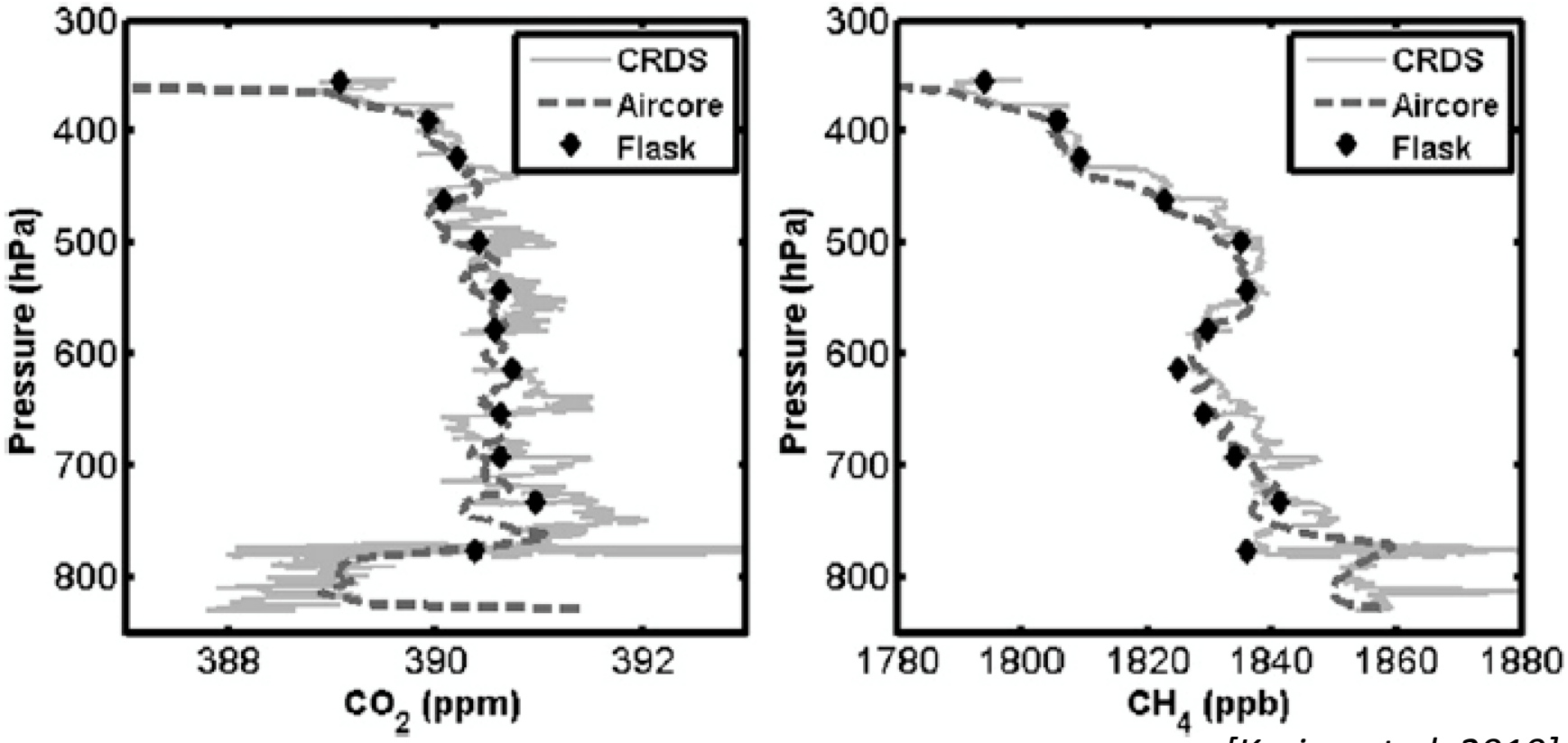


AirCore Sodankyla profiels version 1.0



Would like to use the AirCore profiles?
Huilin.Chen@rug.nl &
Rigel.Kivi@fmi.fi

Validation of AirCore measurements



[Karion et al. 2010]

Aboard light aircraft

- Up to an altitude of 8 km
- Slow descent rate

Aboard large balloons Canada

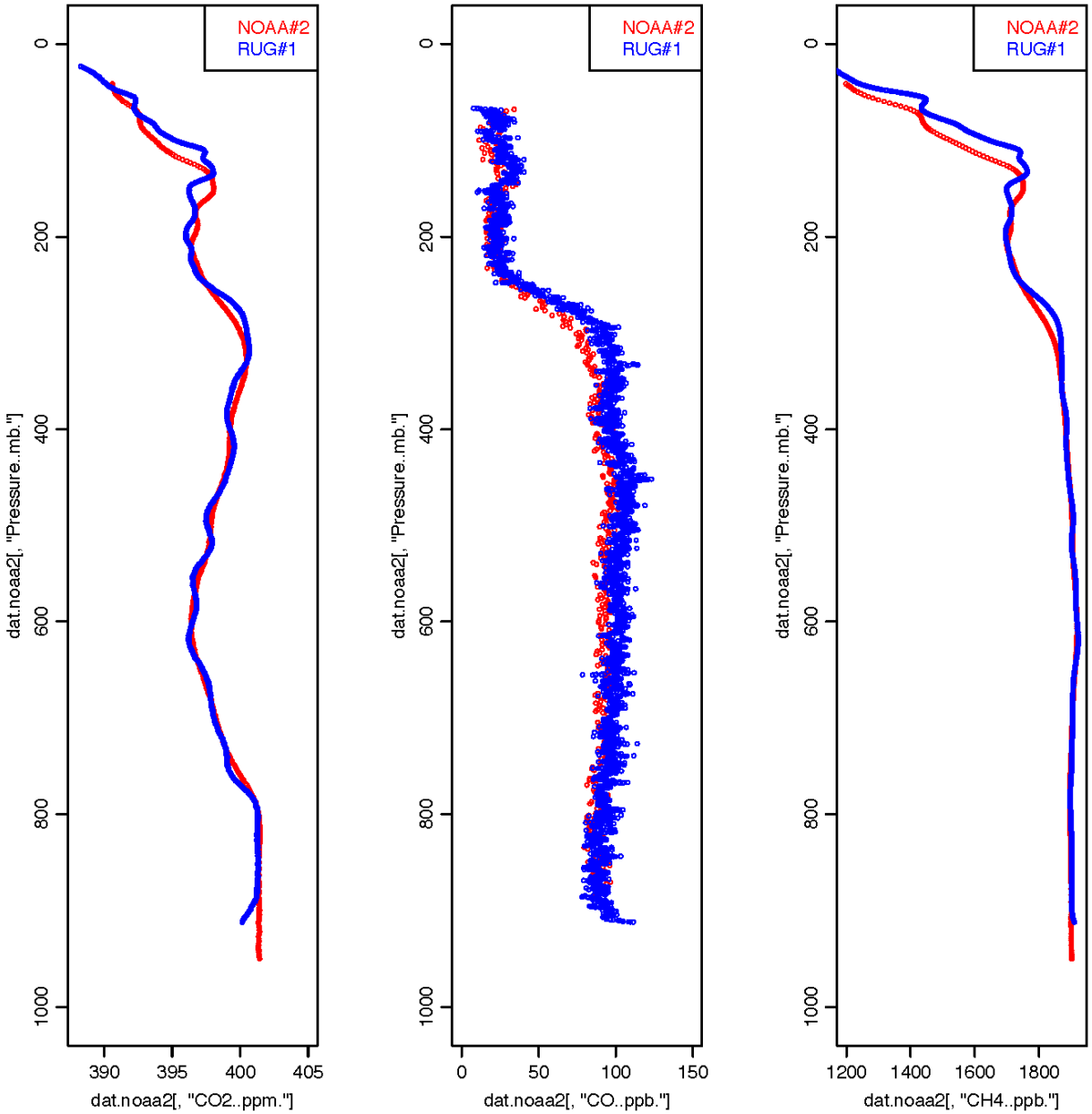
- Up to an altitude of 30 km
- Slow descent rate
- In situ measurements not accurate

Andreas Engel & Cyril Crevoisier

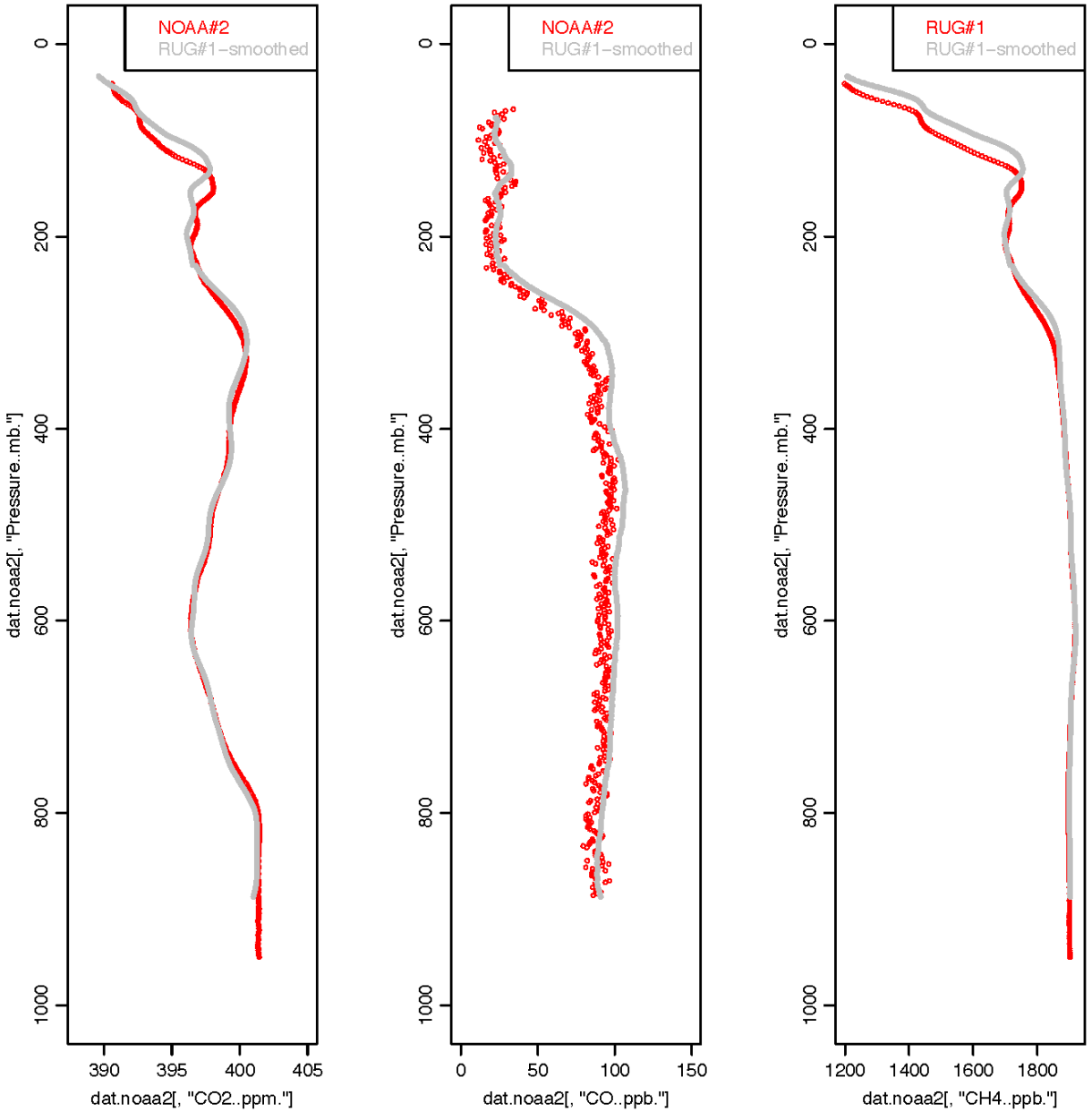
InGOS campaign activities

Date	AirCores	Weight
June 20	RUG01	4.3 kg
	NOAA02&03	5.0 kg
June 21	RUG01&NOAA02	7kg
June 22	RUG01&NOAA02	7 kg
	RUG03	3.5kg
June 23	RUG01&RUG04	8kg

AirCore-AirCore comparisons



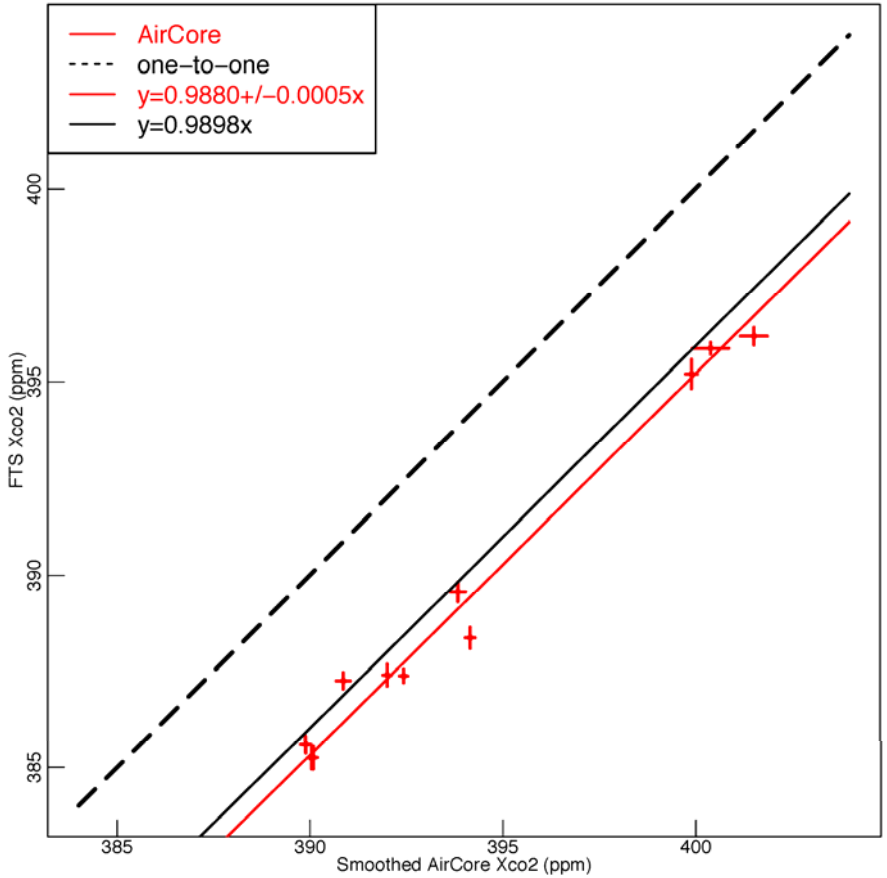
AirCore-AirCore comparisons

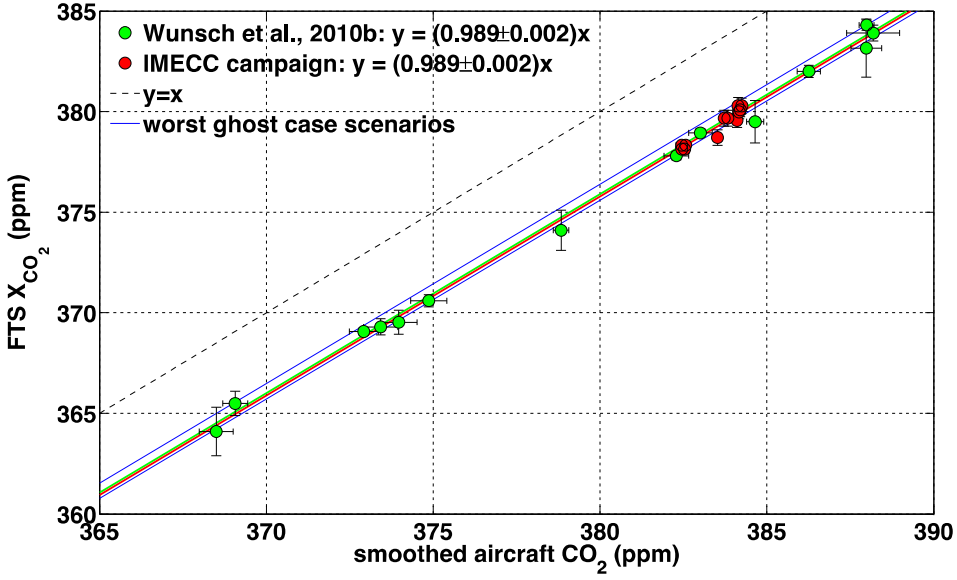


Coming up:

- Feb 2016: Geophysica flights up to 21km
- mid 2016: Large balloon flights up to 30 km
- April/May 2017: HALO flights up to 15 km

Correction factors Sodankyla – CO_2





[Messerschmidt et al. 2011]

Uncertainty of the smoothed aircraft:

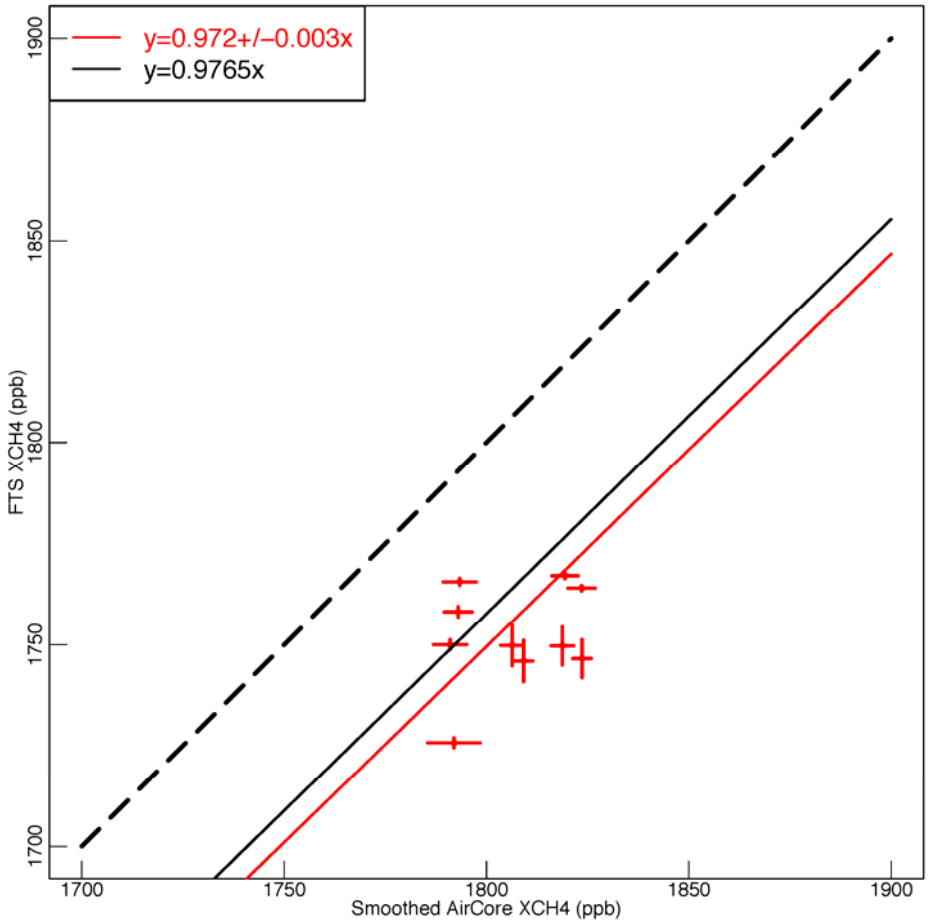
- Missing bottom & distance; (largest CO2)
- Missing top; (largest CH4)
- Measurement accuracy; (largest CO)

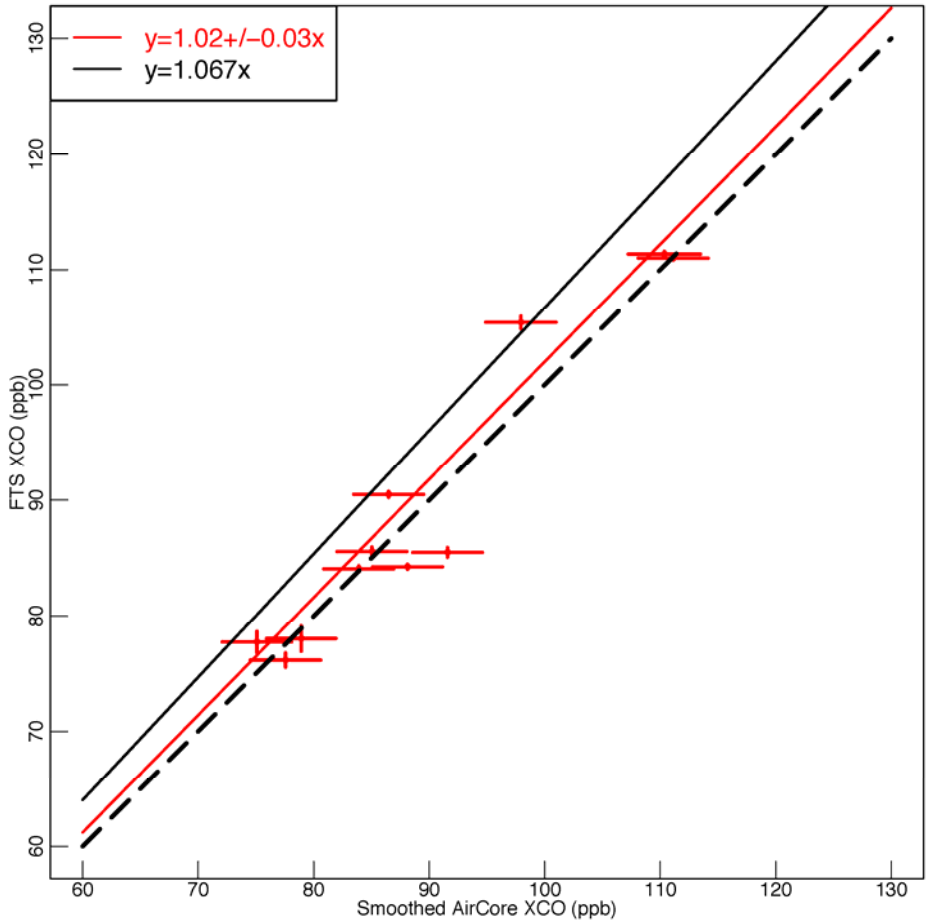
Uncertainty of the FTS:

- Standard deviation of measurements within 1- 3 hours

Linear fit with uncertainties on both axes York et al. 2004

Correction factors Sodankyla - CH_4 and CO





Chen et al. tbs

Correction factors overview

Gas	Wunch et al. 2010	GGG2014	AirCore
CO_2	0.989± 0.001	0.989 8	0.9884± 0.0005
CH_4	0.978± 0.002	0.976 5	0.972± 0.003
CO	0.98± 0.02	1.067 2	1.02± 0.03

Correction factors overview

Gas	Wunch et al. 2010	GGG2014	AirCore	AirCore no pres drop corr.	AirCore no strat.
CO_2	0.989± 0.001	0.989 8	0.9884± 0.0005	0.9877± 0.0005	0.9877± 0.0011
CH_4	0.978± 0.002	0.976 5	0.972± 0.003	0.962 ± 0.005	0.960 ± 0.020
CO	0.98± 0.02	1.067 2	1.02± 0.03	0.99 ± 0.03	0.98 ± 0.06

Conclusions & Future work

1. Regular AirCore profile measurements in Sodankylä, Finland (67° North)

2. CO_2, CH_4, CO site-specific corrections factors for Sodankyla, contributing to the TCCON network

3. Development of light-weight AirCore (<1kg)

4. Isotopes for stratospheric air samples