

Evaluating the atmospheric columns of CH₄ retrieved from space using vertical profiles from aircraft and stratospheric balloon campaigns

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IASI Atmospheric CH₄ observations

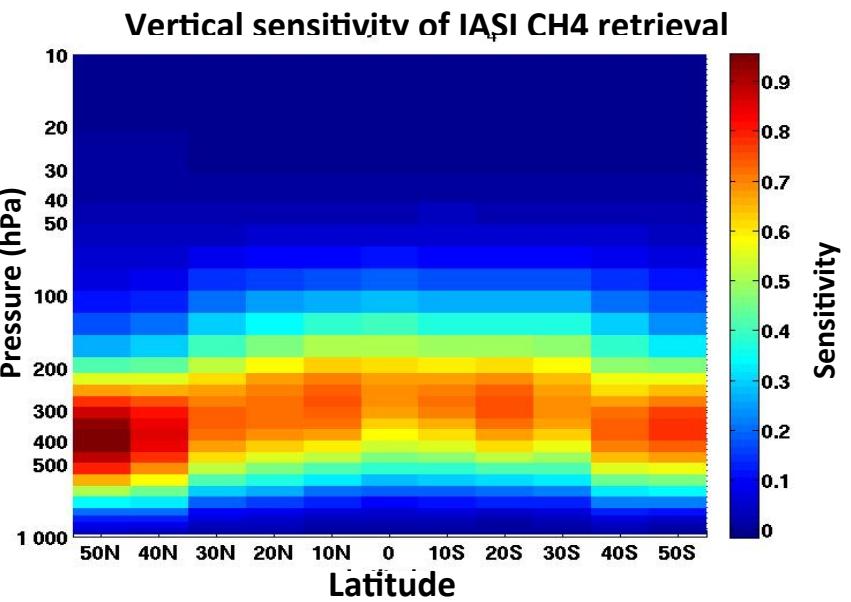
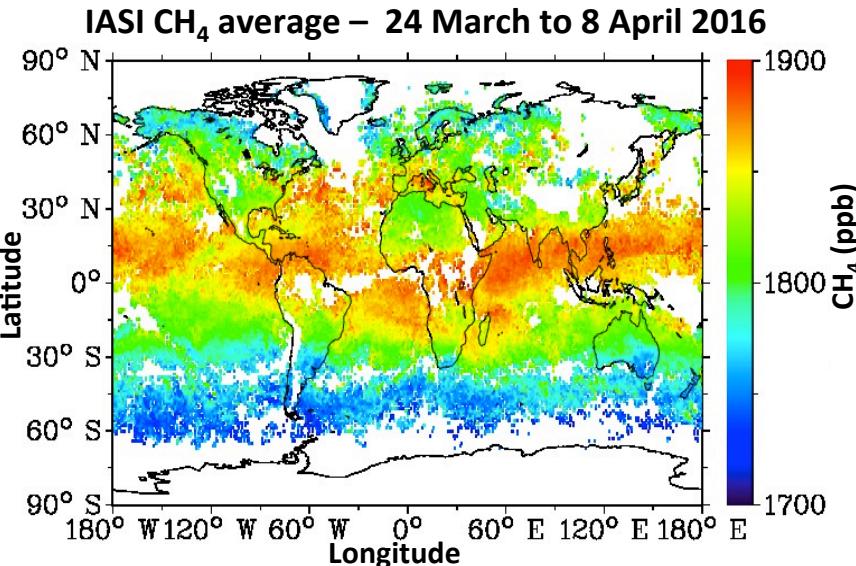


Focus on **validation** of CH₄ mid-tropospheric columns retrieved from IASI.

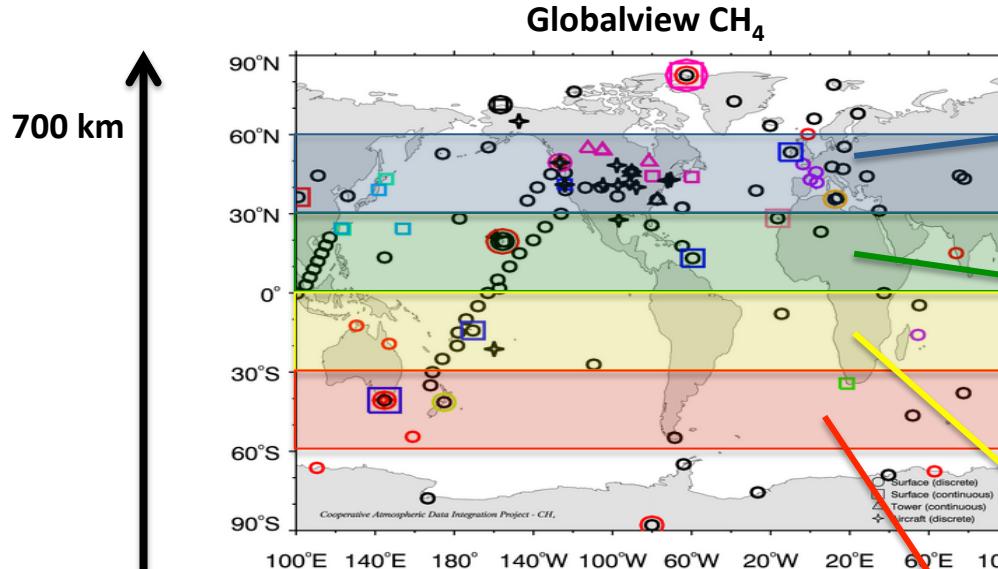
Retrieval procedure: non-linear inference scheme (Crevoisier et al., 2013)

- Use of IASI channels around **7.7 μm**.
- Based on the **4A** RT code and the latest edition of the **GEISA** database.
- Radiative biases are computed using the **ARSA** database.
- Version V8.3: global, day/night, **vertical sensitivity provided for each retrieval**.

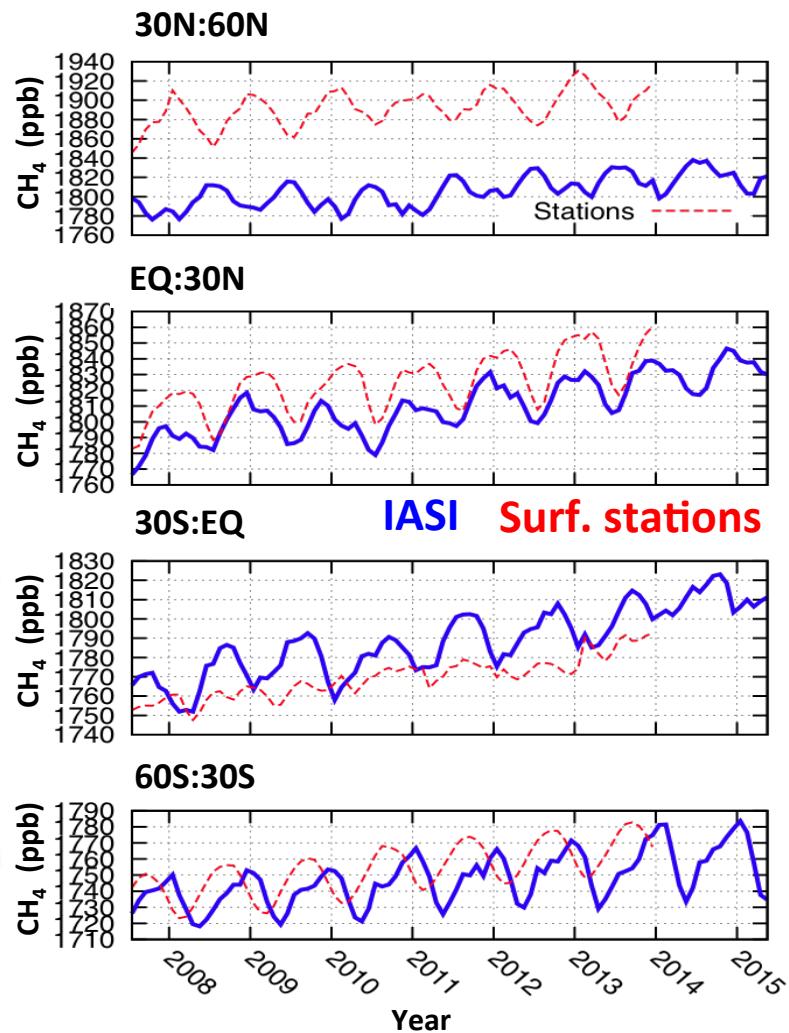
Tropics: max at 12 km.
Mid-lat: max at 8 km.



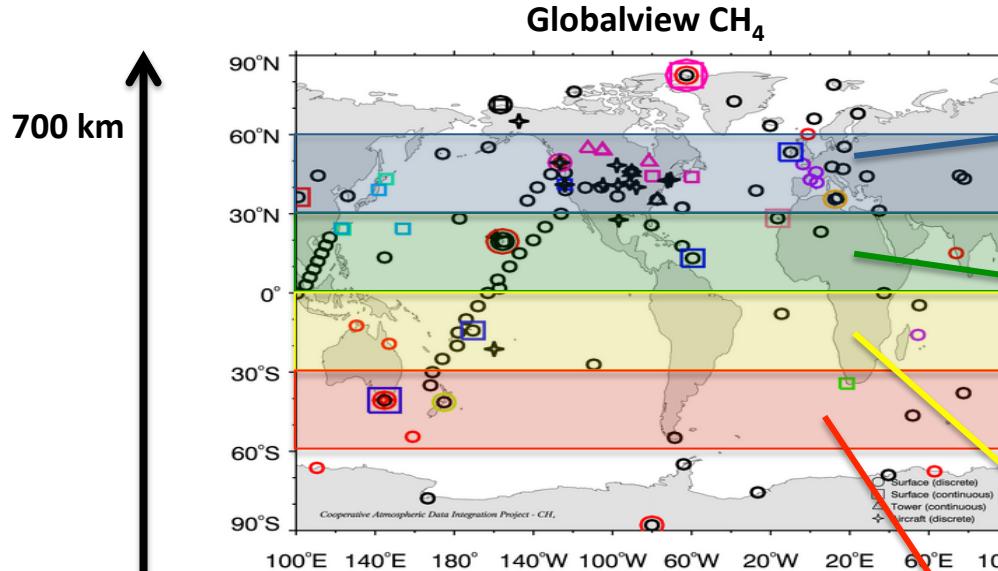
Comparisons with measurements from surface networks



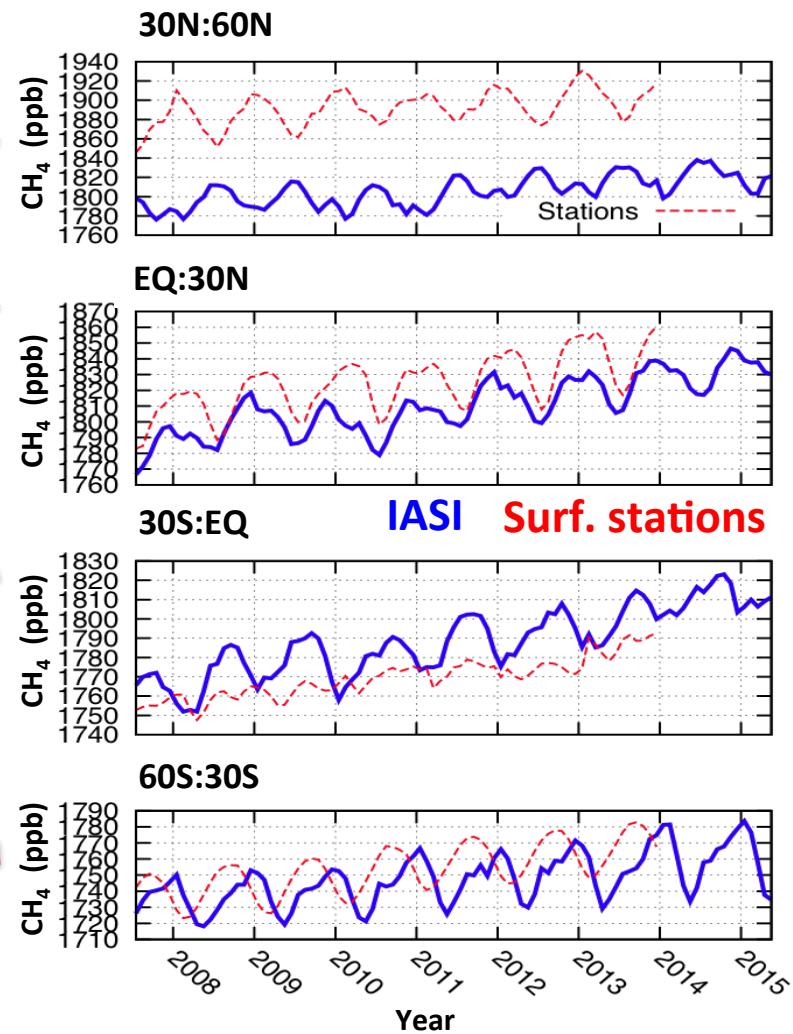
- **Tropics (N&S):**
→ seasonality and amplitude OK.
 - **Southern hemisphere:**
→ 2-month shift, very few stations
 - **Northern hemisphere:**
→ Strong differences!!
→ Large bias and shift in seasonality.
- surface



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Not appropriate due to vertical sensitivity of IASI and large variation of CH₄ along the vertical.

Validation with aircraft measurements



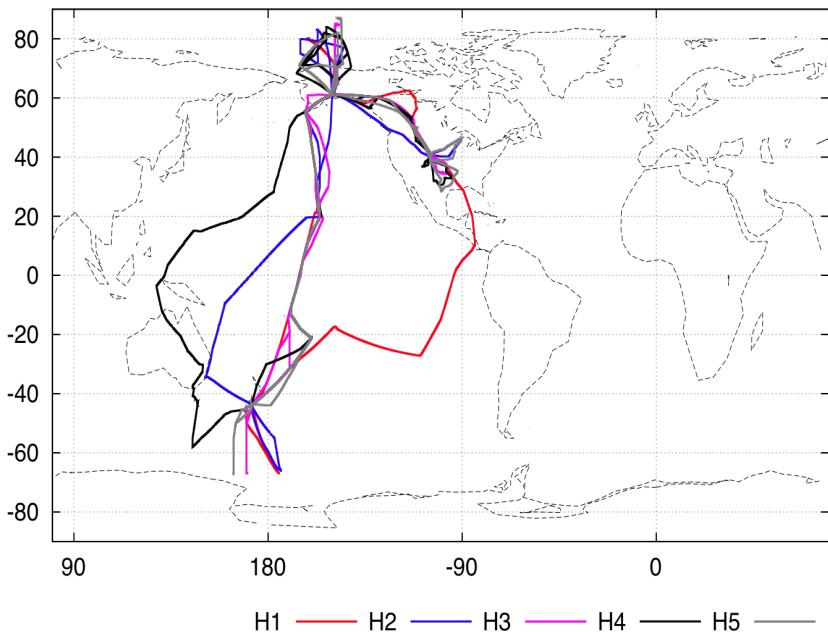
700 km

- Use of **HIPPO flights**.
- 5 campaigns (H1...H5).
- Along each flight: **profile measurement of several trace gases including CH₄**.

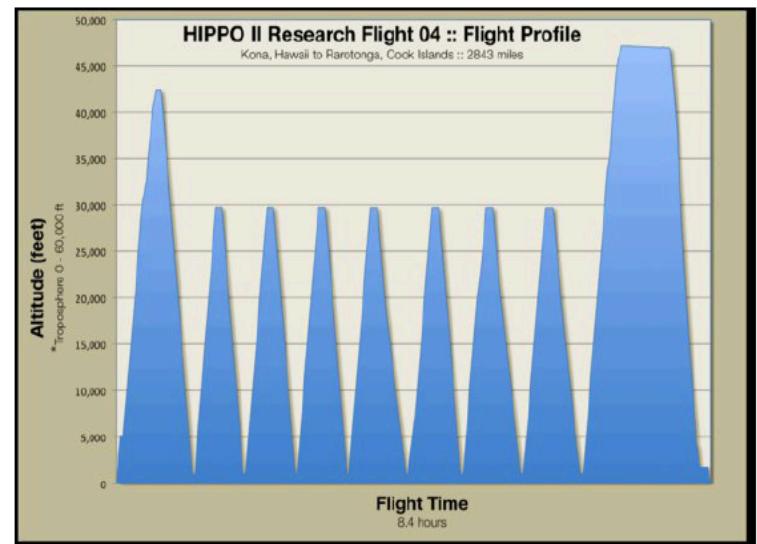


HIPPO Flight Trajectories

14 km



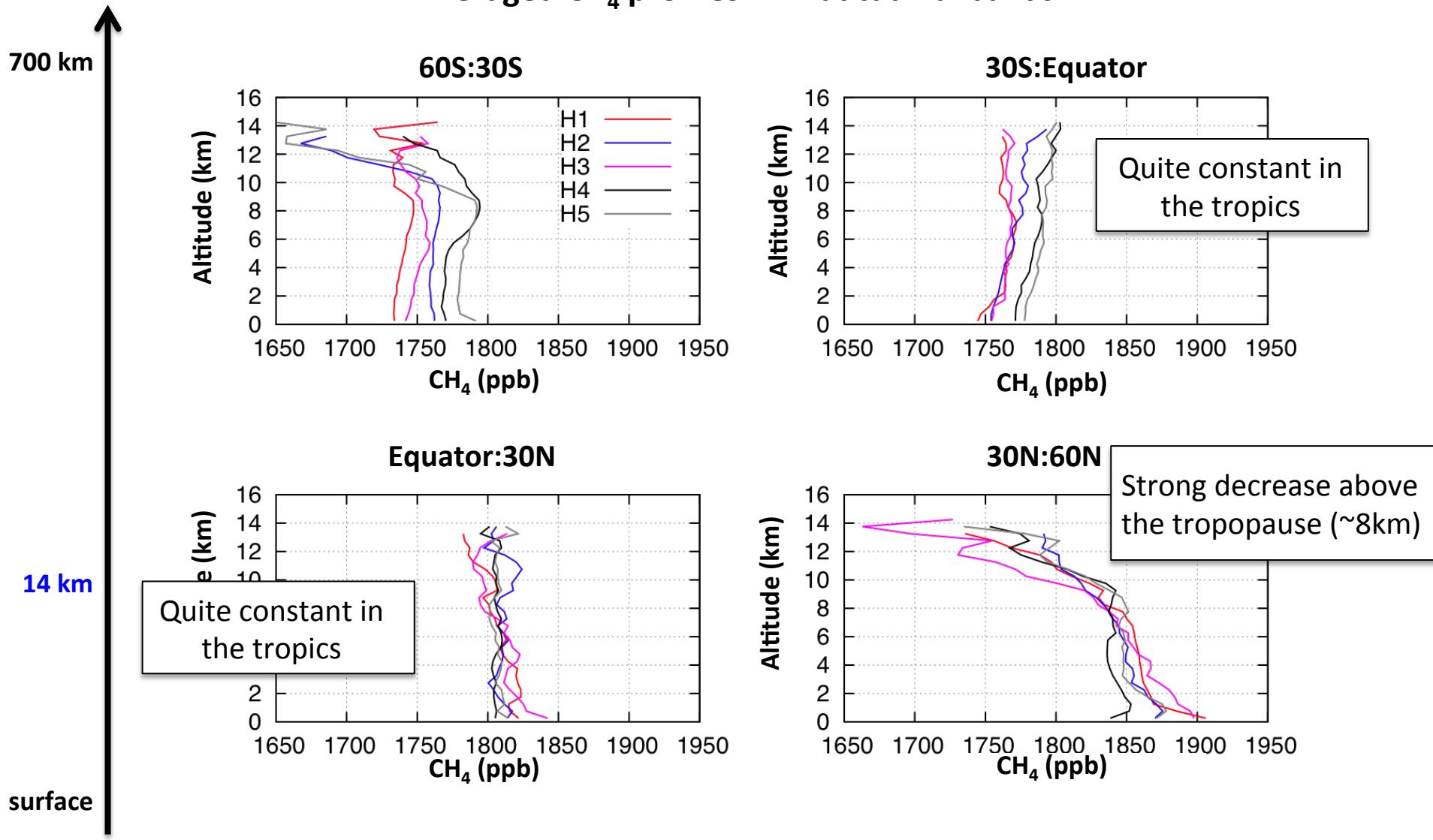
Altitude of the Plane along trajectory 4



<http://www.eol.ucar.edu/projects/hippo>

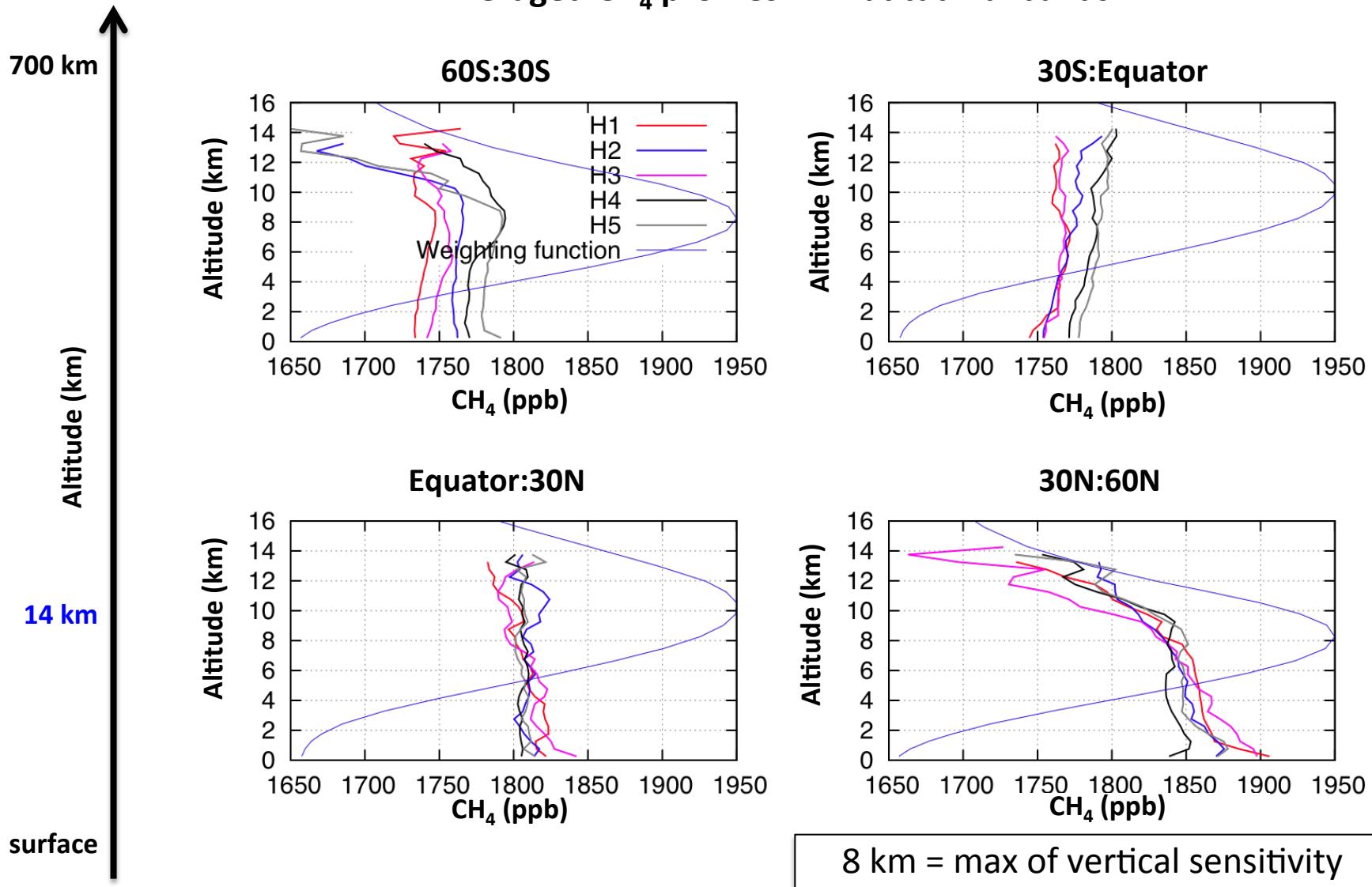
Validation with HIPPO aircraft measurements

Averaged CH₄ profiles in 4 latitudinal bands

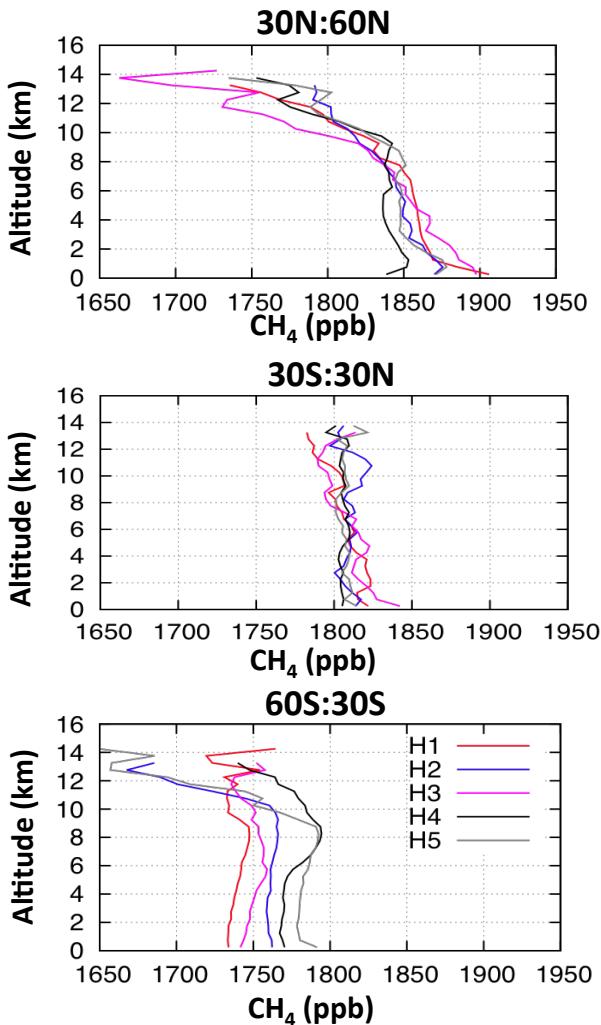
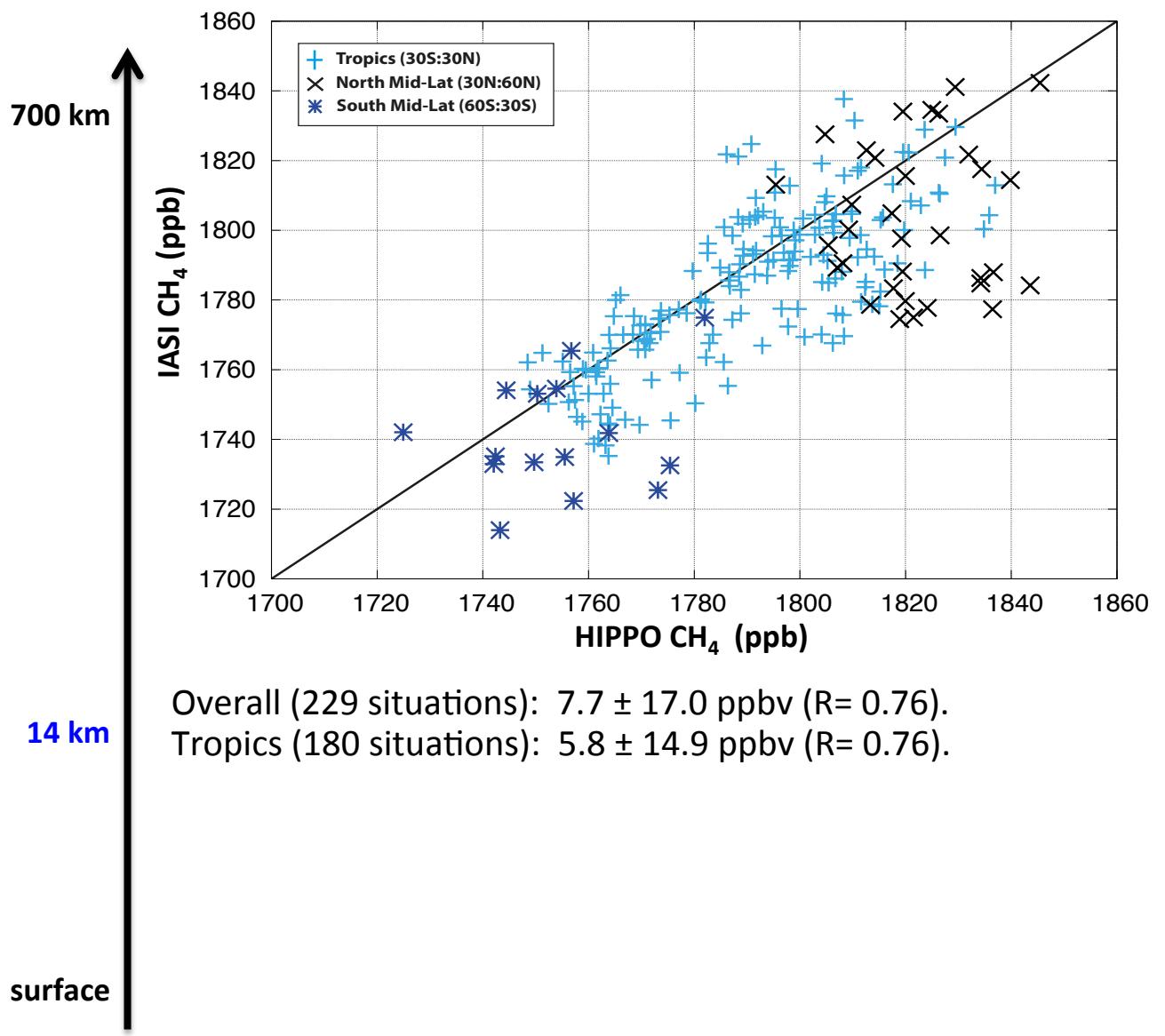


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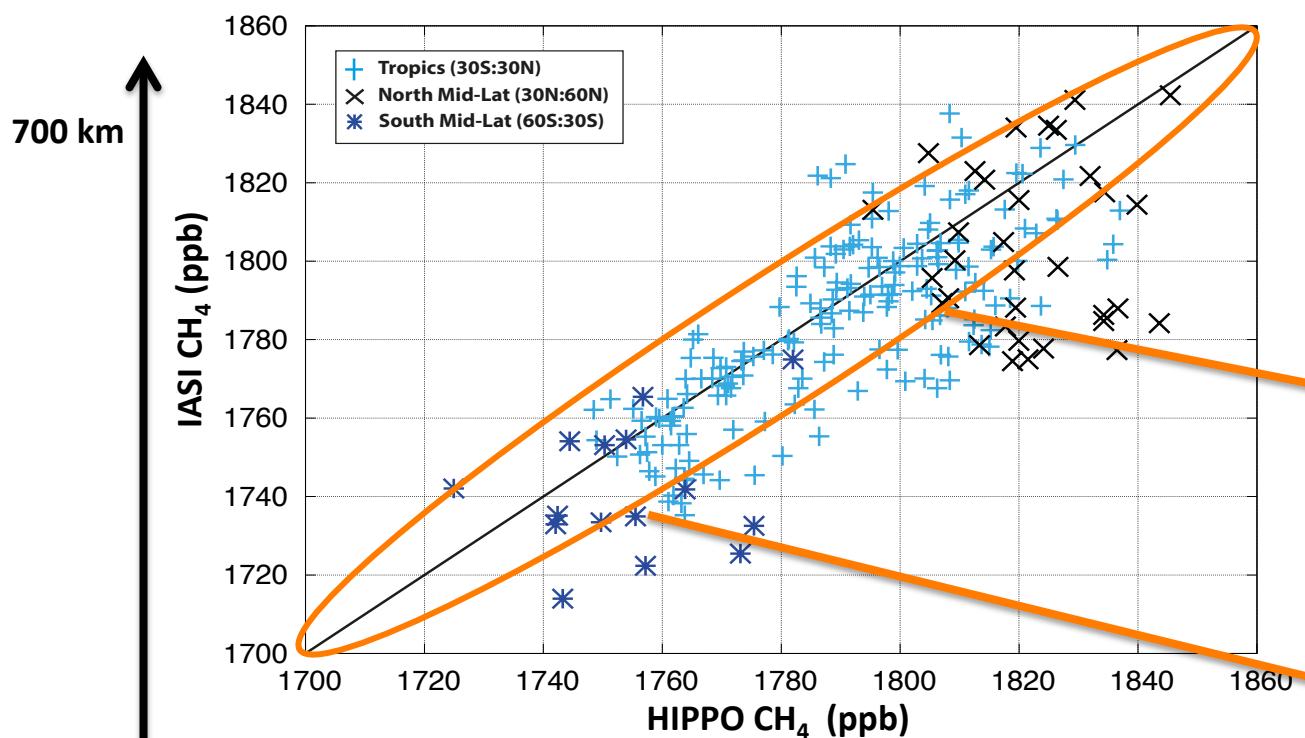
Averaged CH₄ profiles in 4 latitudinal bands



Validation with HIPPO aircraft measurements



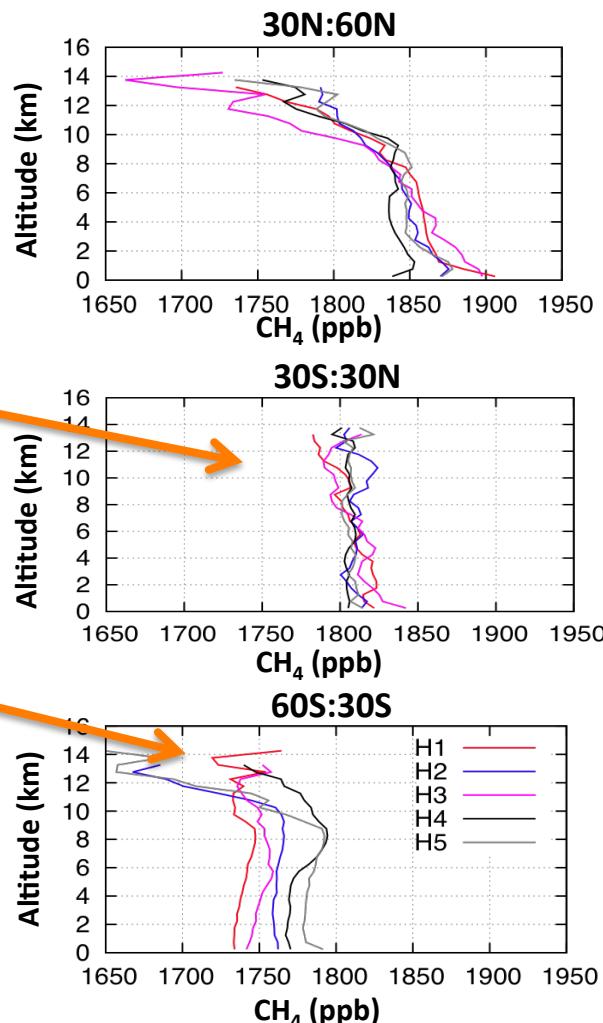
Validation with HIPPO aircraft measurements



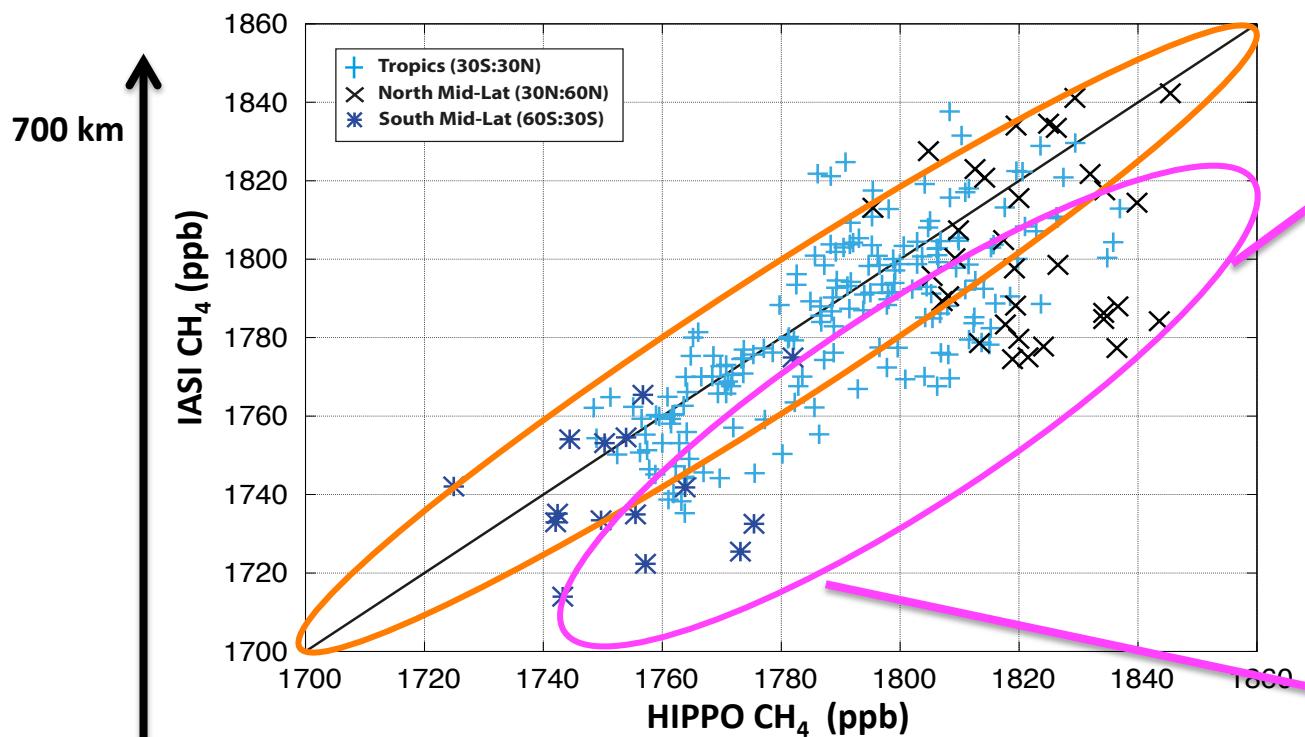
Overall (229 situations): $7.7 \pm 17.0 \text{ ppbv}$ ($R= 0.76$).

Tropics (180 situations): $5.8 \pm 14.9 \text{ ppbv}$ ($R= 0.76$).

Small bias and std for straight profiles.



Validation with HIPPO aircraft measurements

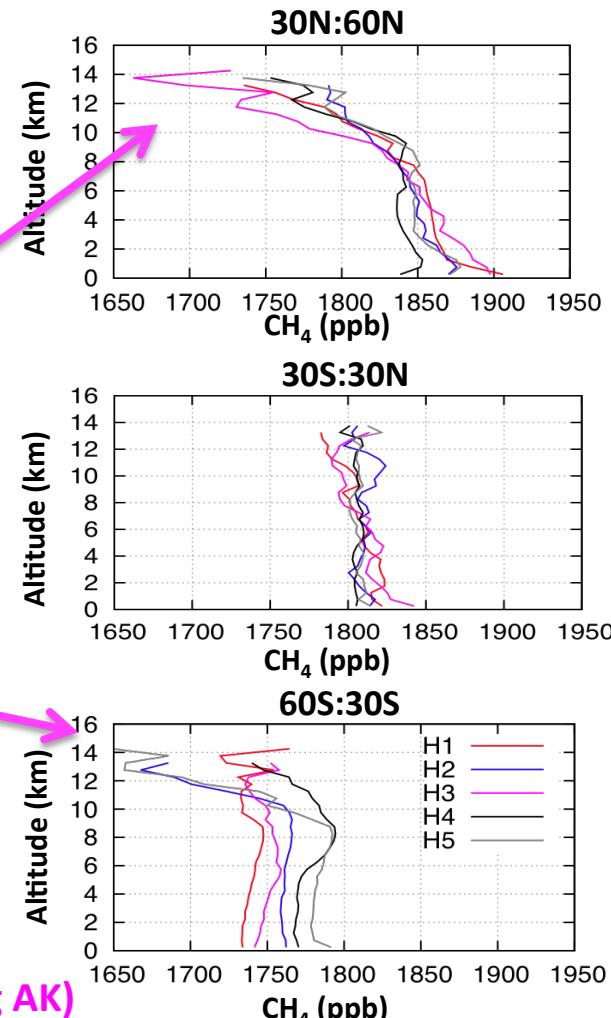


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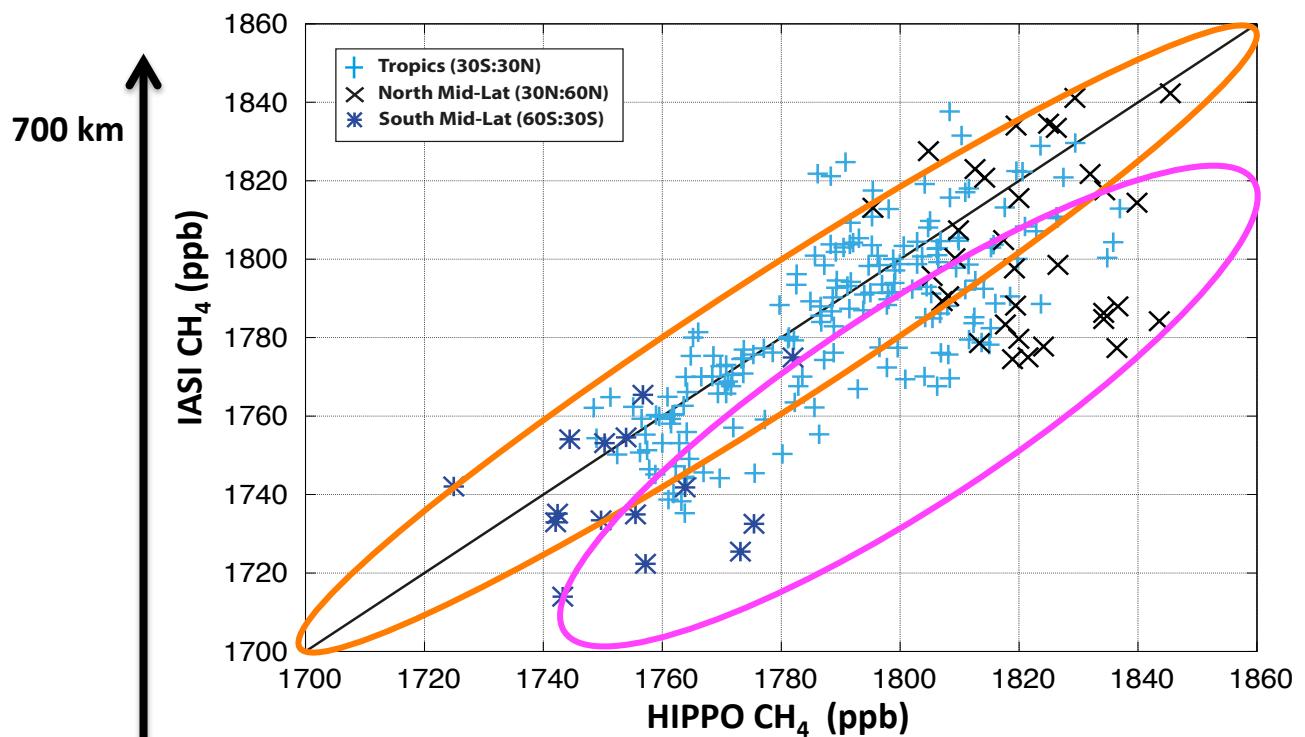
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Large bias and std when strong slope (missing data for applying AK)



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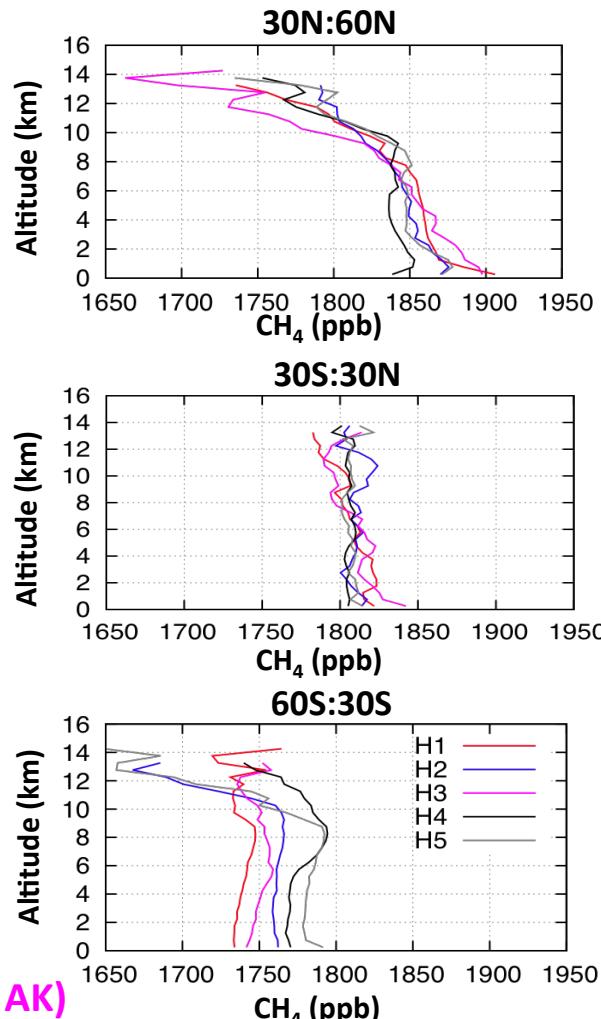


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Using a proper characterization of stratospheric CH_4 is mandatory to fully validate the retrievals.
Sources: models or balloons.

What's an AirCore ?

AirCore = an **atmospheric sampling system** that allows **greenhouse gas measurements**



NOAA AirCore © Karion et al. 2010

AirCore in 3 key points:

- Stems from an original Idea from P.Tans at NOAA
- **Long stainless steel tube** : treated with Suflinert® coating to avoid interaction with water vapor
- Magnesium Perchlorate dryer at inlet



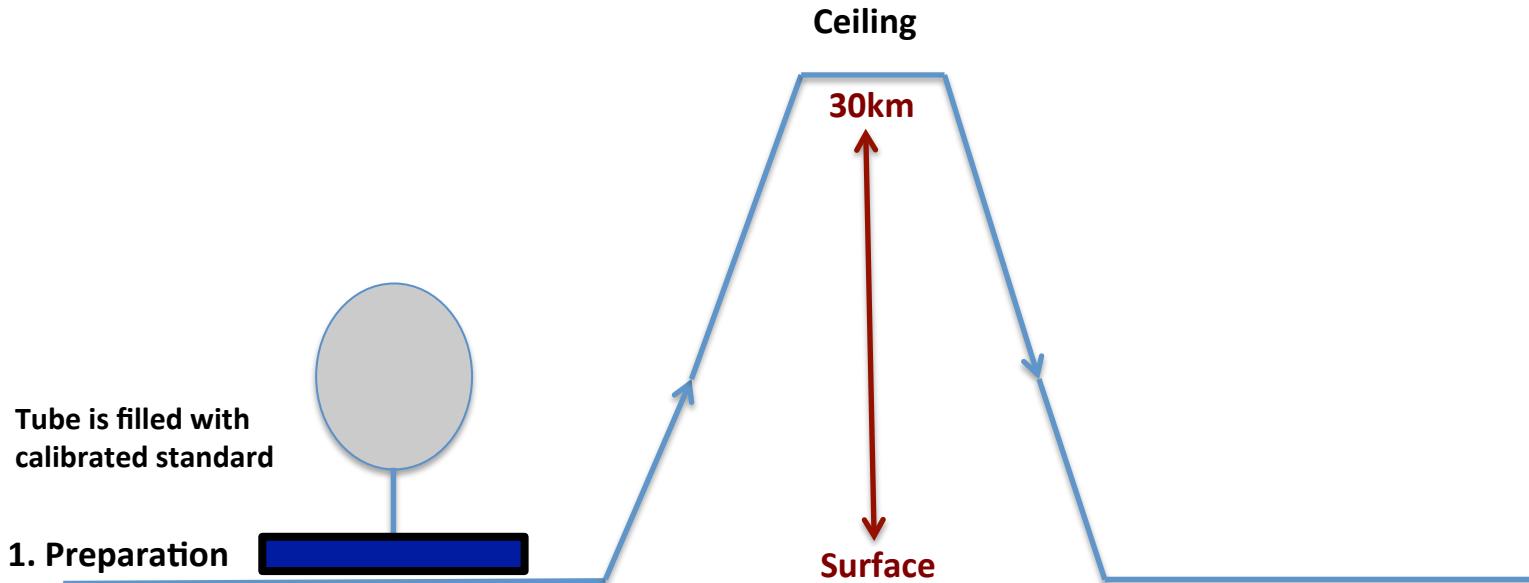
Electronic data
package

Required flight parameters:

- Pressure probe(s) (Ambient P)
- Temperature probe(s) (Ambient T, Coil Temperature)
- GPS data...
- Relative humidity...

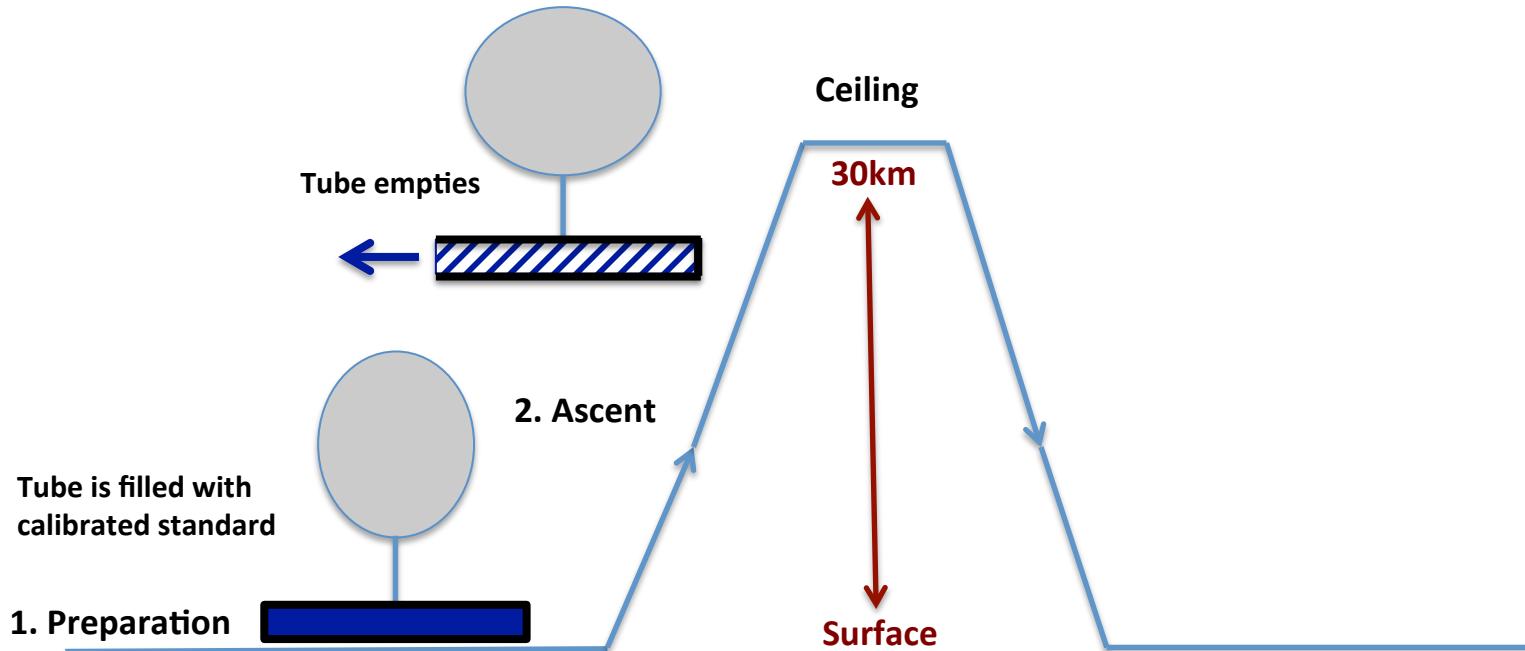
What's an AirCore ? – sampling method

AirCore = an atmospheric sampling system that allows greenhouse gas measurements



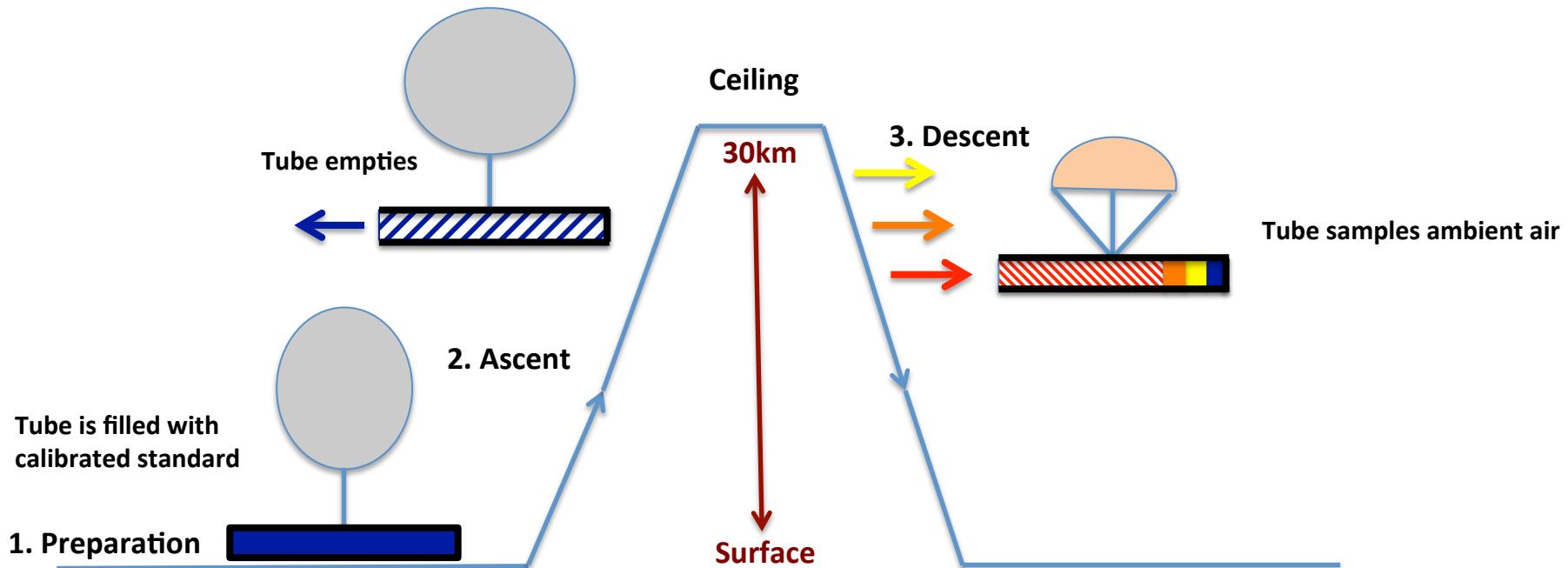
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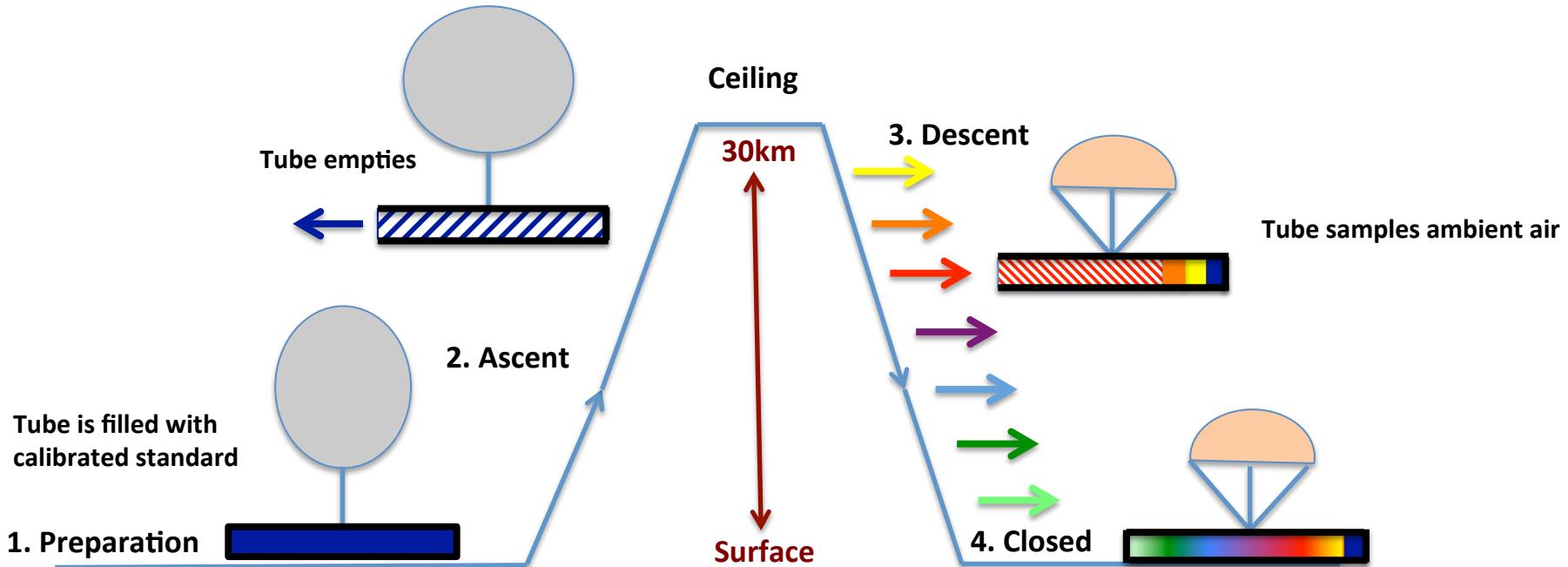
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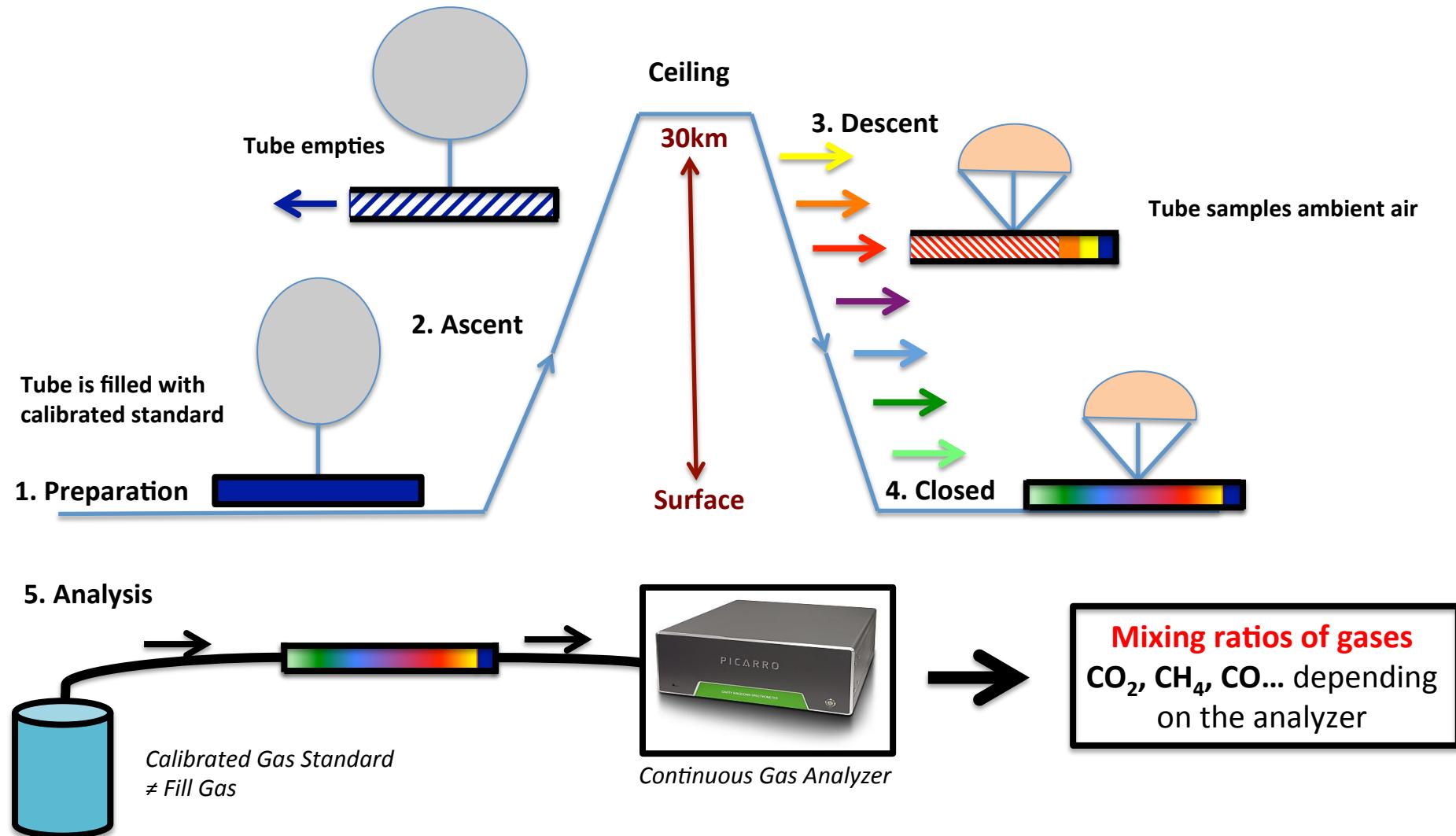
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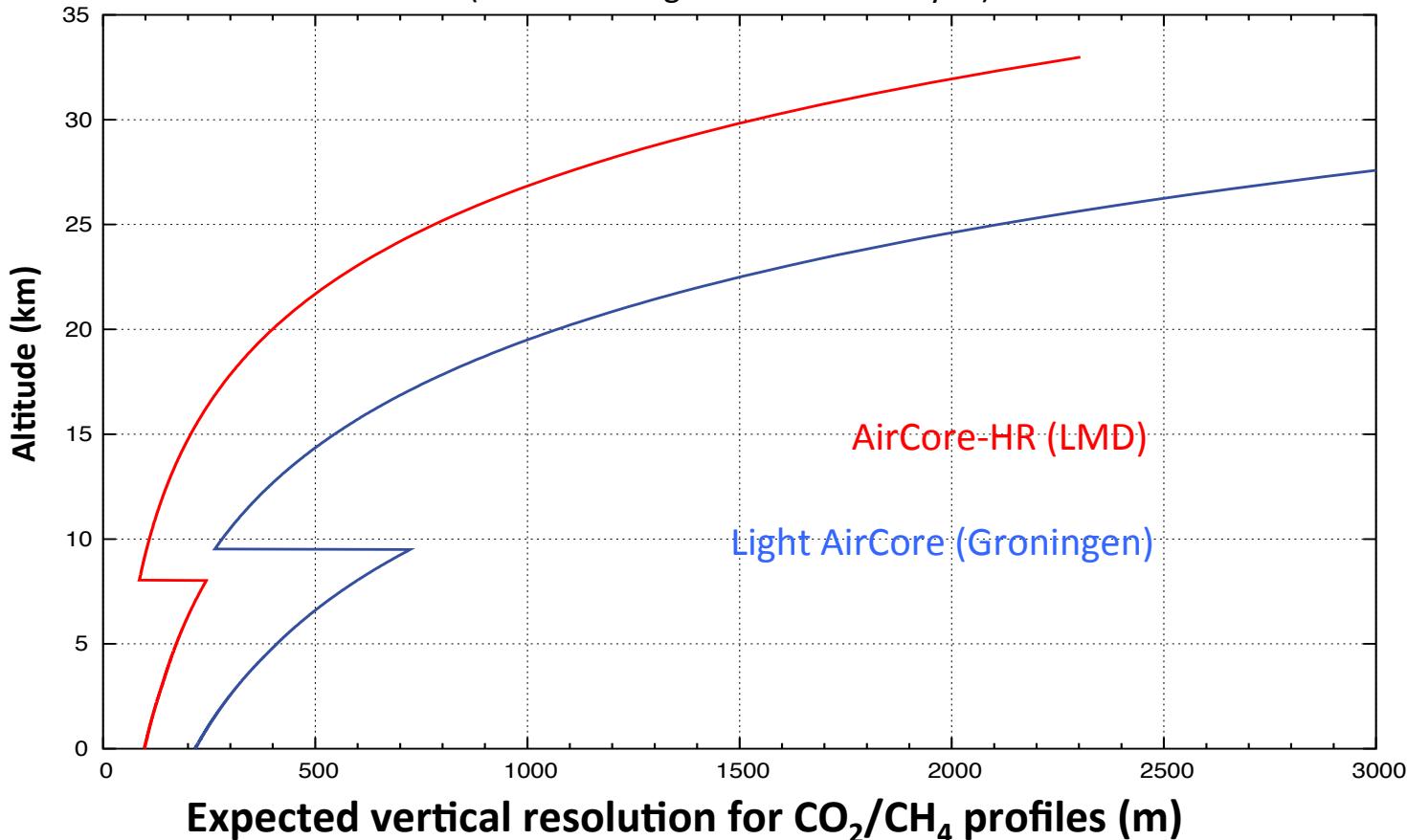
What's an AirCore ? – Vertical Resolution

Vertical resolution can be estimated thanks to:

- Molecular Diffusion
- Taylor Dispersion

and is directly affected by (**Length, diameter**)

Expected vertical resolution for air sampled at different altitudes
(for 3h waiting time before analysis)



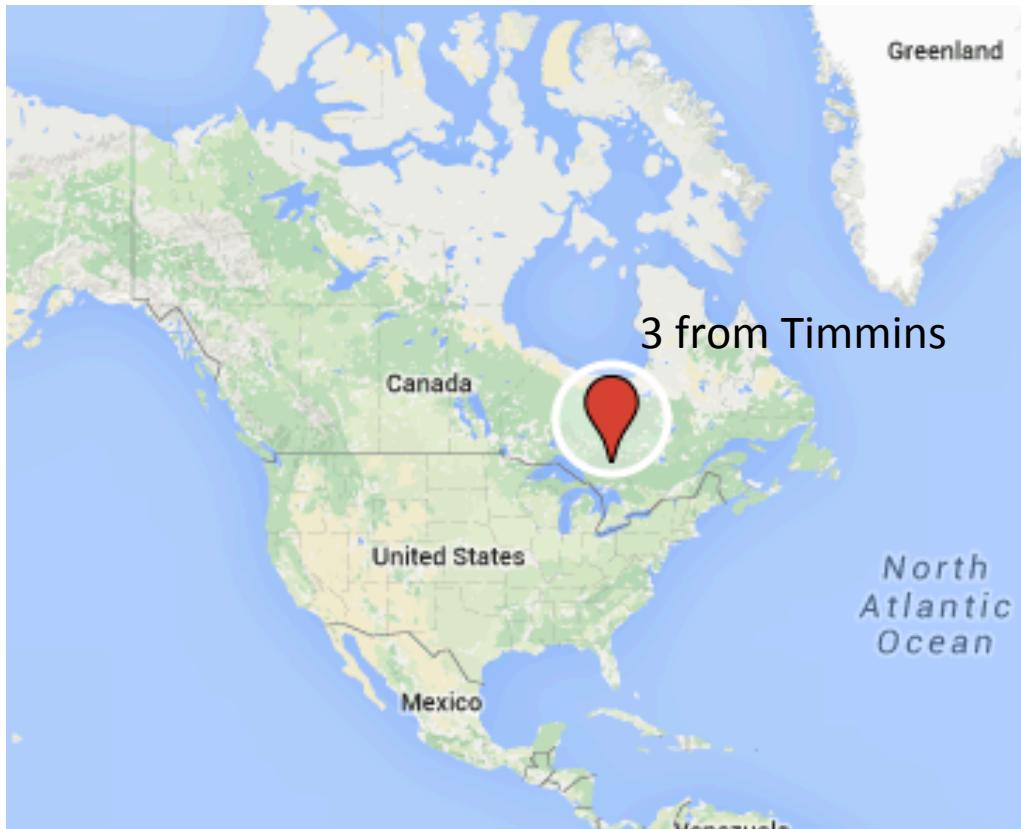
Overview of AirCore Data



LMD AirCores flown during the annual Stratoscience campaigns from CNES (in partnership with CSA)



15 independent flights from Summer 2013 to 2015



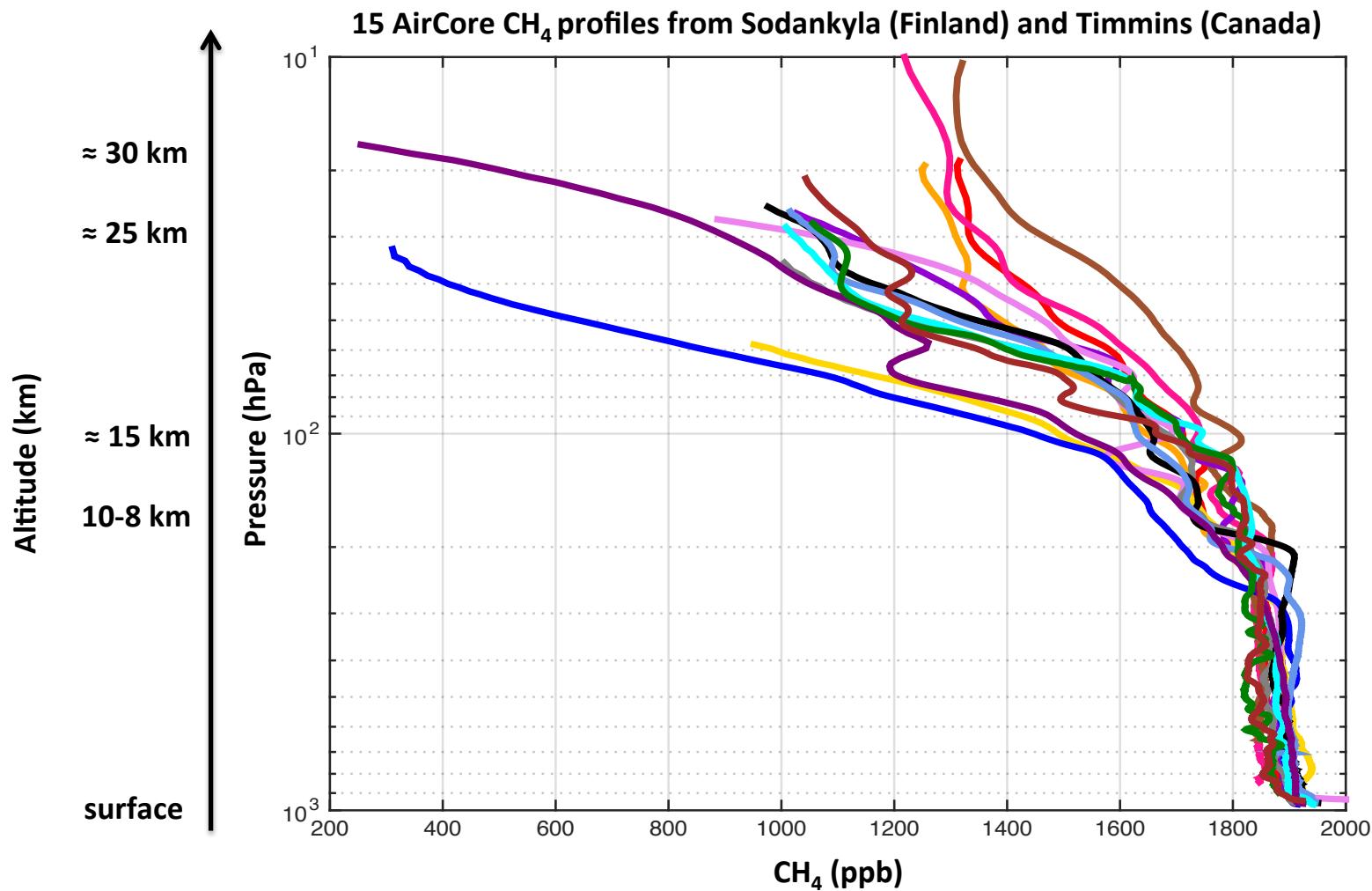
Regular flight from Sodankyla
University of Groningen / Finnish Meteorological Institute



FINNISH METEOROLOGICAL
INSTITUTE

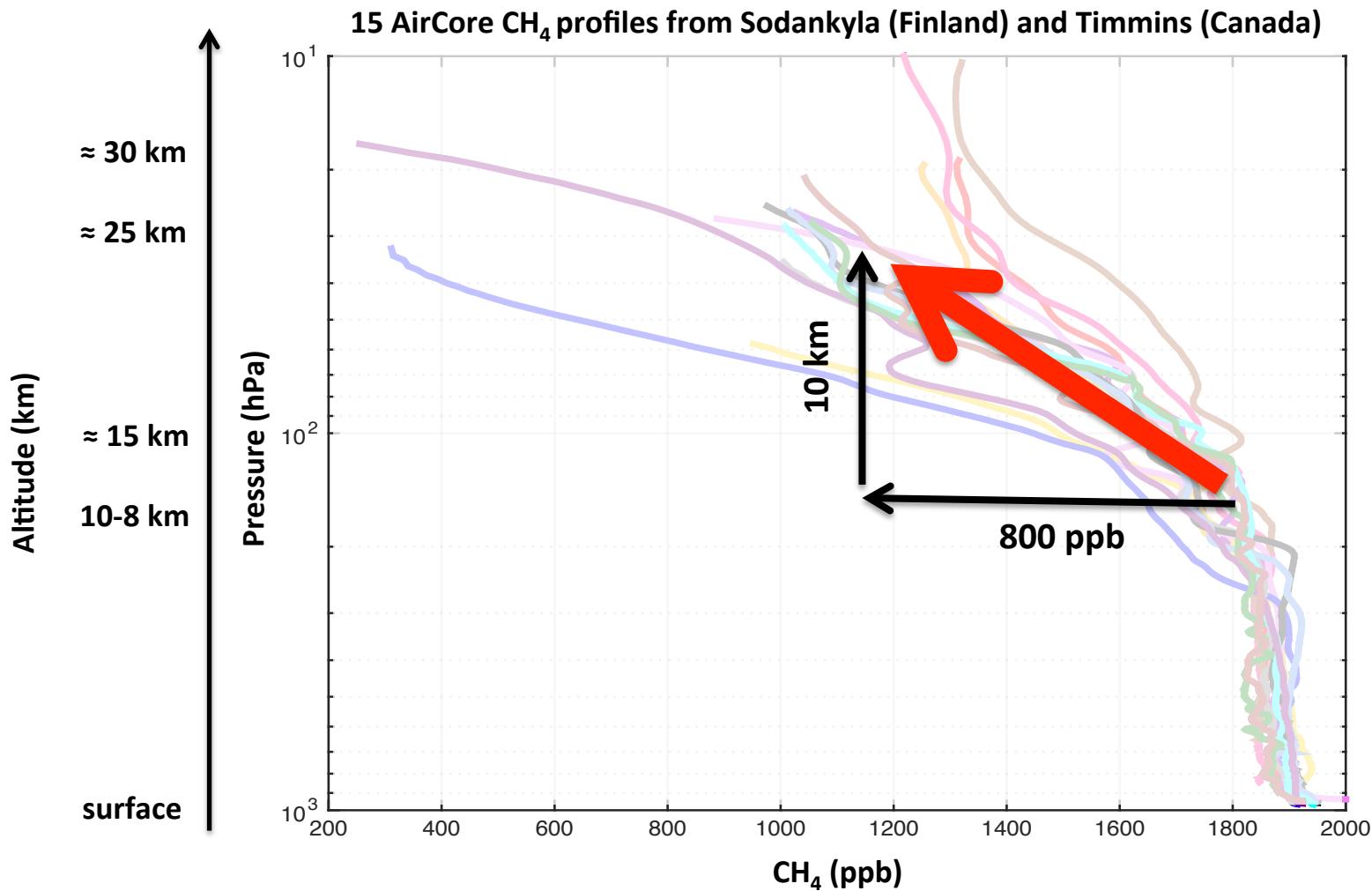


The AirCore Profiles



- Troposphere is quite stable (with respect to seasonal and regional variation)
- Strong decrease in the stratosphere (on average **800 ppb gradient between 120 hPa and 30 hPa**)

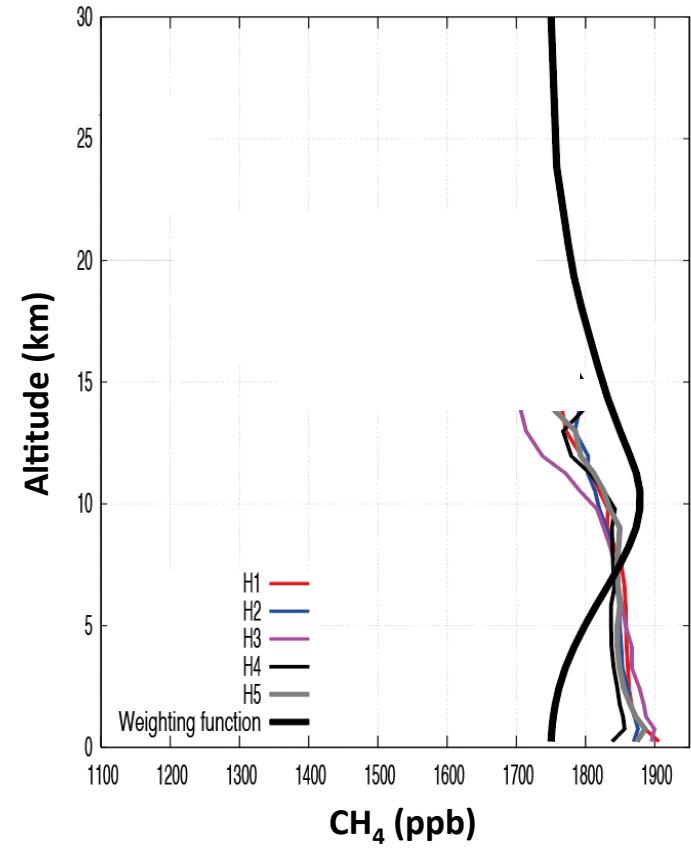
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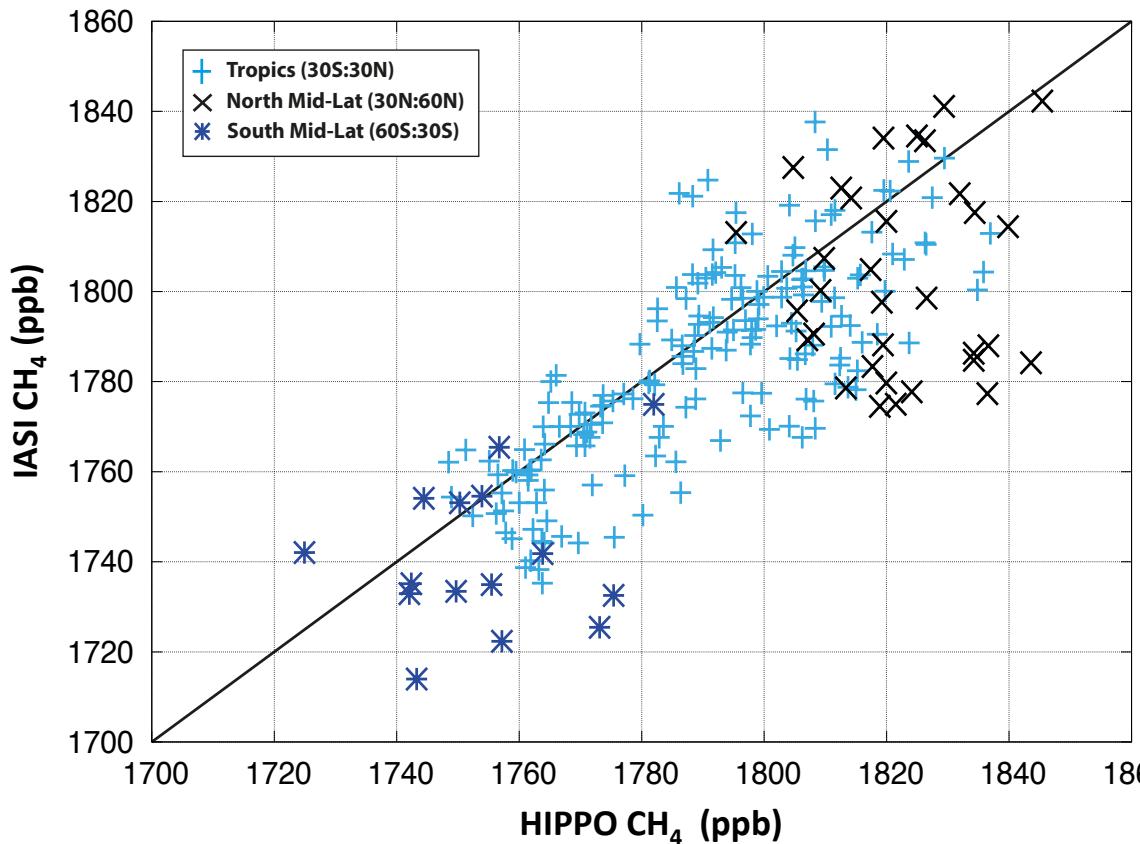
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Completing HIPPO profiles with Stratospheric Information from AirCores

HIPPO profiles in the North Mid-Lat



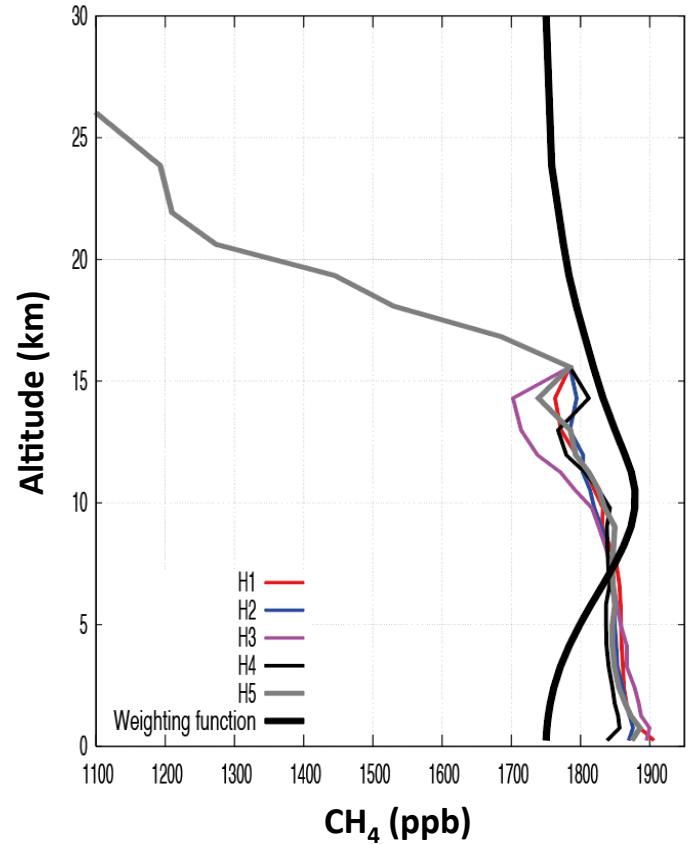
Comparison of IASI mid-tropospheric CH_4 with HIPPO CH_4



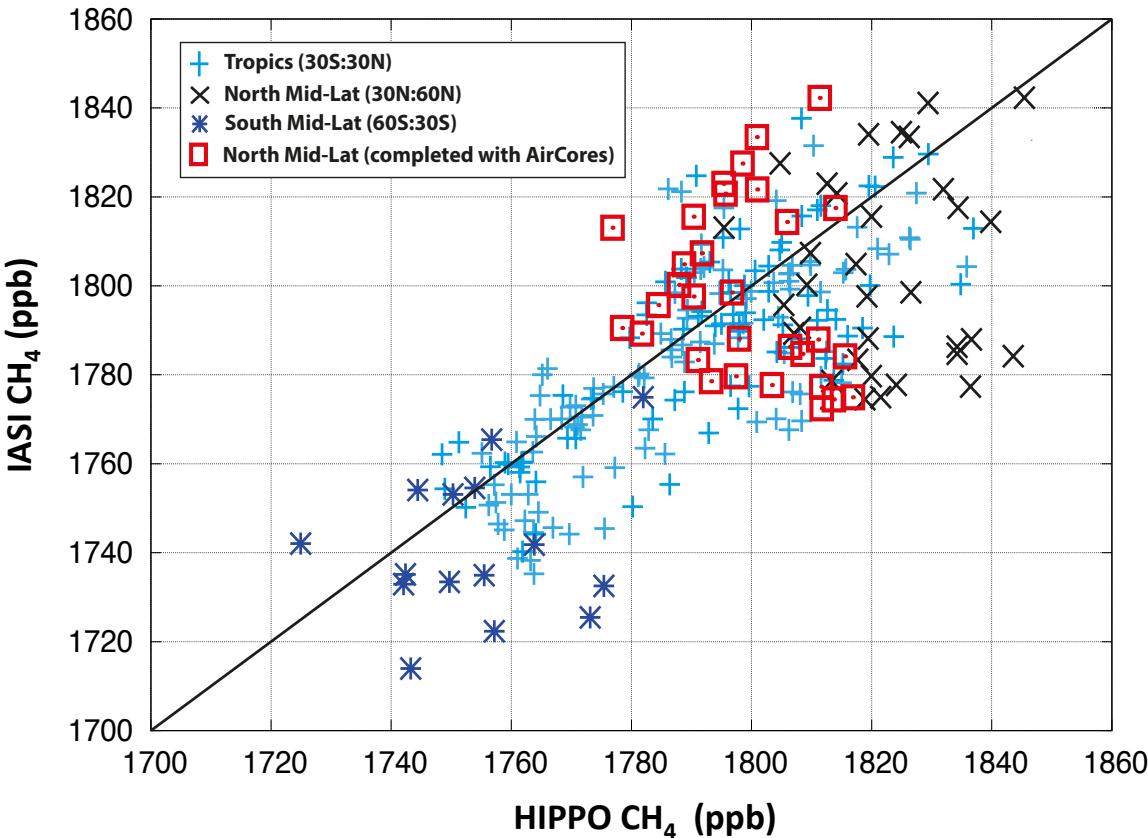
North Mid-Lat (33 situations): 18,8 ppb

Completing HIPPO profiles with Stratospheric Information from AirCores

HIPPO profiles completed with AirCores



Comparison of IASI mid-tropospheric CH₄ with HIPPO CH₄

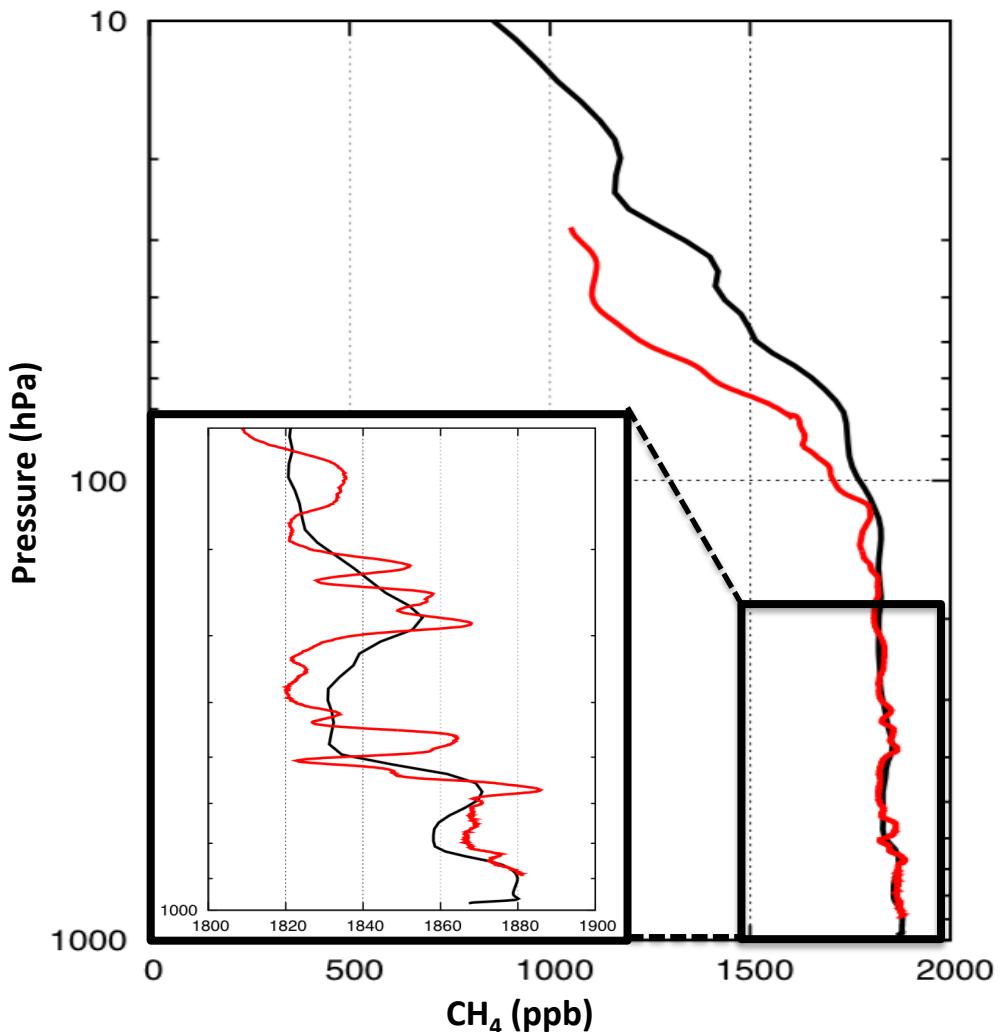


North Mid-Lat (33 situations): 18,8 ppb → 6,1 ppb

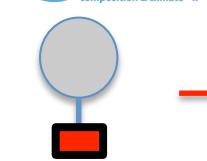
- Bias between HIPPO and IASI is corrected when taking into account **realistic stratospheric behavior**.
- Large dispersion due to unappropriate stratospheric correction.
- **Need for collocated in-situ measurements**

Comparison of AirCore profiles with models

CH₄ Profiles from AirCore-HR and forecast from ECWMF



Legend



- CH₄ IFS/MACC (137 levels)
(29/08/2014 12UTC)
- CH₄ AirCore-HR (29/08/2014)

- Excellent **agreement in the troposphere** (signatures)
- Not satisfactory above the tropopause

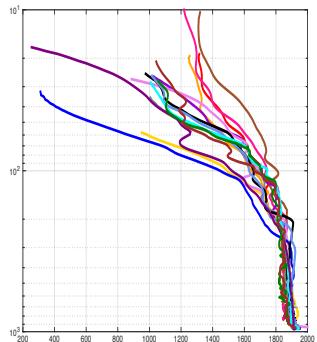
Impact on **integrated columns** when comparing to integrated CH₄:

IFS CH₄ = + 13 ppb

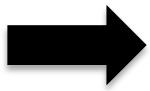
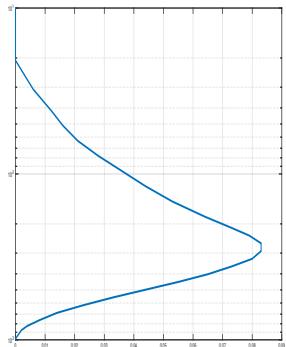
IFS Data : Courtesy of S.Massart & A.Augusti-Panareda

Validation of IASI CH_4 Data with AirCores

15 AirCore Profiles



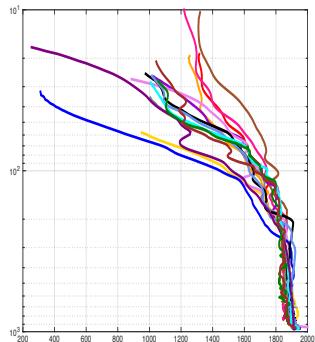
IASI CH_4
Weighting Function



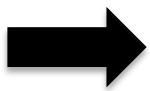
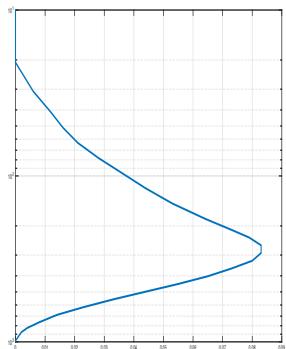
qAirCore CH_4

Validation of IASI CH₄ Data with AirCores

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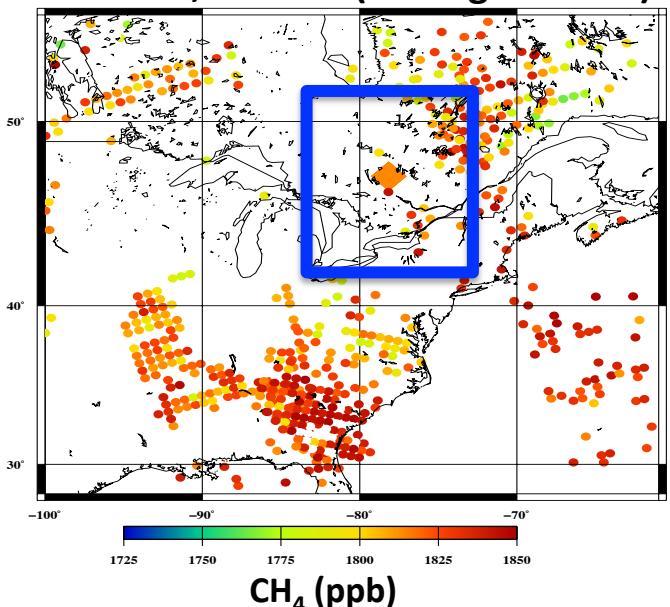


IASI CH₄
Weighting Function



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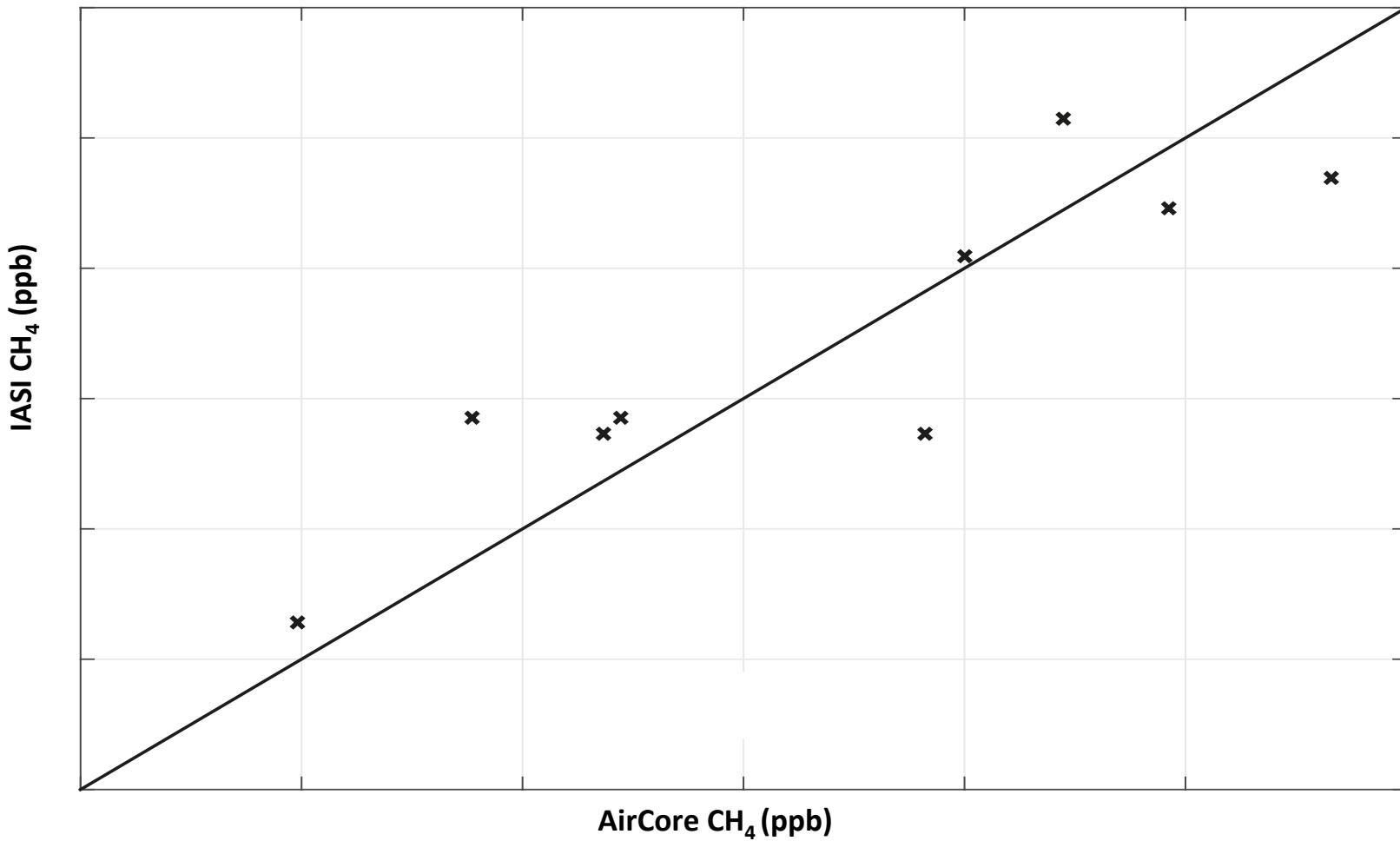
Collocation with LMD AirCore-HR
Timmins, Canada (29 August 2014)



- To get enough statistics **averaging is done over a 10°x10° box on 1 day.**

Validation of IASI CH₄ Data with AirCores

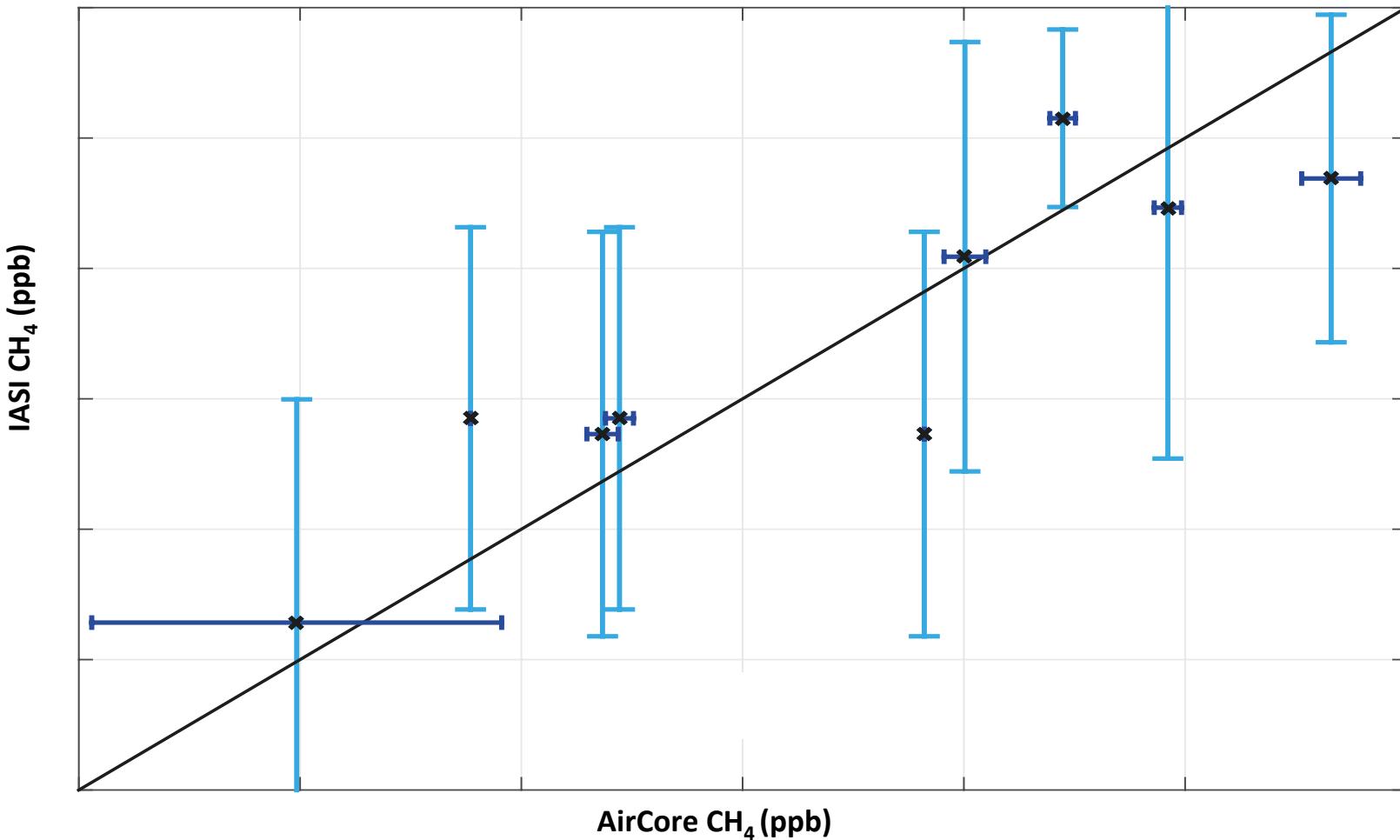
Comparison of IASI mid-tropospheric CH₄ with AirCore CH₄



Overall (10 cases) : 2.56 ± 15.08 ppb (R = 0.88).

Validation of IASI CH₄ Data with AirCores

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Use of AirCore Balloon Data

- CH₄ validation in the Northern Hemisphere
- Possibility to extend this study to CO₂ and CO
- Other gasses could be studied with AirCores

Future Campaigns

Aire-sur-Adour, France (2016),

- AirCore-light (Wheater Balloon), **regular flights**, starting from June

Trainou (Orléans), France (2016),

- **multi-instrument campaign: on ICOS/TCCON site**, AMULSE laser diode spectrometers, Lidar, AirCraft campaign, AirCore-light (Wheater Balloon)

Validation plans for IASI-NG, Merlin CH₄ and MicroCarb CO₂

- opportunities for **intensive balloon campaigns** together with aircraft flights

Remaining Questions

- What vertical resolution is needed ?
- Assessment of temporal and spatial variability of the profiles



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