Comparison of ground-based remote sensing and in-situ observations of CO, CH_4 and O_3, accounting for representativeness uncertainty

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2) Institute of Astrophysics and Geophysics, University of Liège, Belgium
3) Institute for Meteorology and Climate Research (IMK), Karlsruhe Institute of Technology (KIT), Germany
4) Izaña Atmospheric Research Center, Agencia Estatal de Meteorología (AEMET), Spain

Demonstration Network Of ground-based Remote Sensing Observations in support of the Copernicus Atmospheric Service

- **EU FP7 project**
- **Start**: Nov. 1, 2011
- **Duration**: 33 months
- **Lead**: Martine De Mazière, BIRA

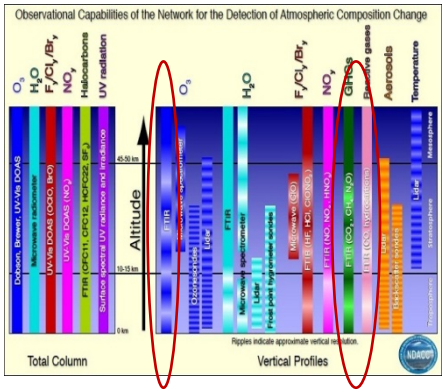
http://nors.aeronomie.be

- **Objective:**
  - **Perform the required research and developments for optimizing the NDACC data for the purpose of supporting the quality assessments of the future Copernicus** *"The programme formerly known as GMES"* **Atmospheric Service (GAS ⇔ MACC-II)**

- **WP5: Integration of tropospheric products**
  - **Extensive characterisation/validation of NDACC tropospheric products using surface in-situ observations at two demonstration sites**
  - **Instruments: FTIR, DOAS, MAXDOAS**
  - **Parameters: CO, CH_4, O_3, NO_2**

FTIR & Surface In-situ

- **Solar Fourier Transform InfraRed spectroscopy**
  - High resolution allows observation of **pressure broadening**
  - Possible to retrieve **vertical profiles** using optimal estimation and radiative transfer code
  - **Validation** using traceable in-situ measurements
    - Aircraft, balloon soundings, UAS, surface



- **Surface in-situ**
  - Very good **accuracy**, since **traceable** to standards
  - Often **collocated** with FTIR
- **Difficulties of comparison**
  - **Representativeness**
  - Lowest FTIR partial column not independent from profile
  - ➢ Apply **averaging kernel** (AVK) to reference profile

FTIR & Surface In-situ

- **Sola**
  - H
  - P
    ra
  - **V**
- **Surf**
  - V
  - O
- **Diff**
  - **R**
  - L
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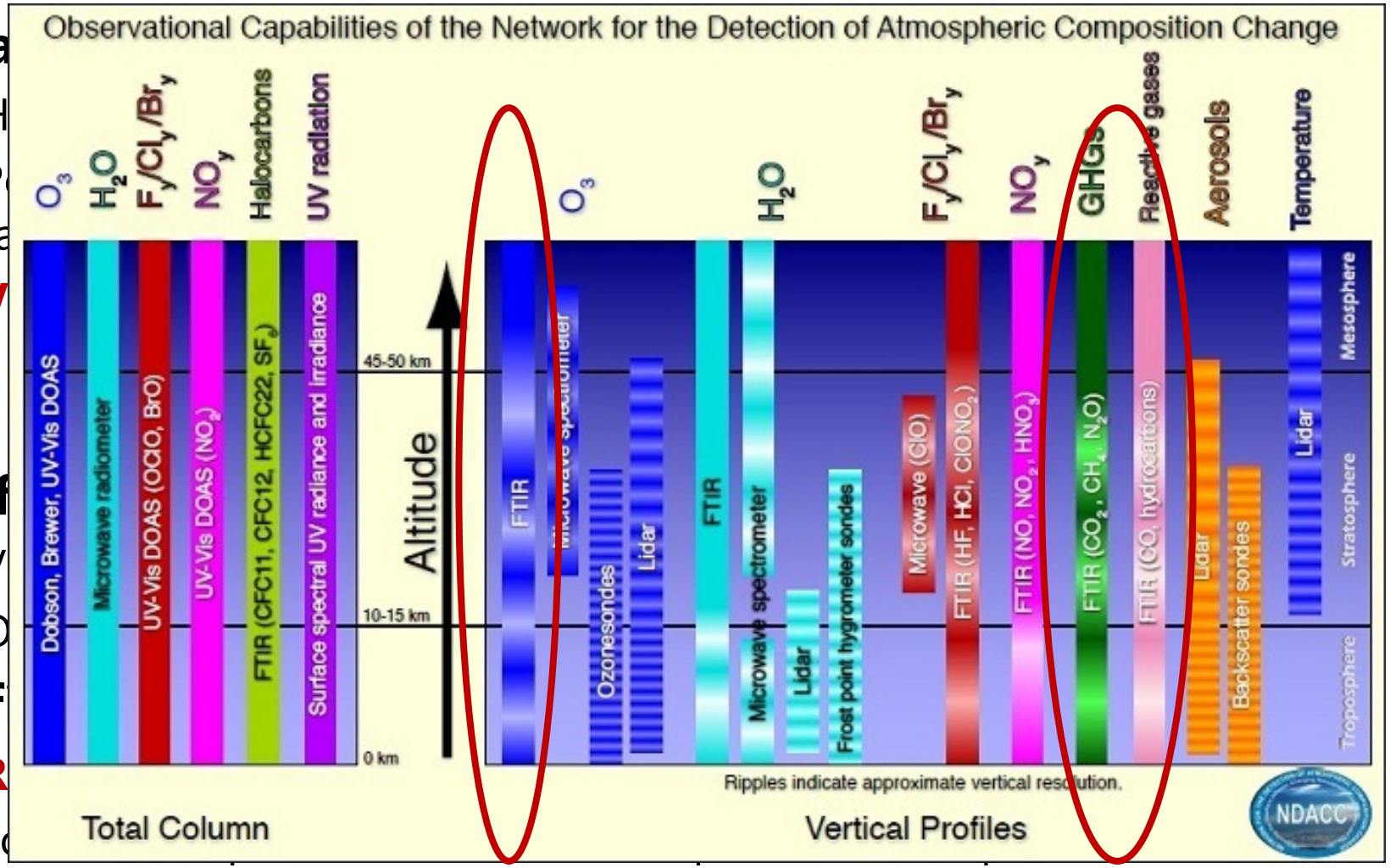

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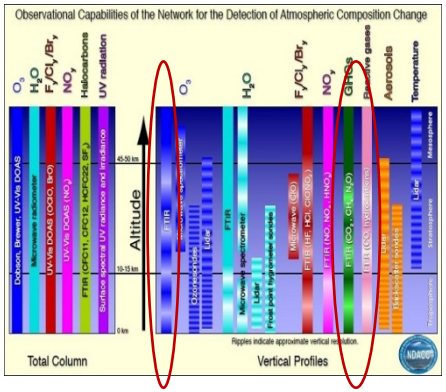

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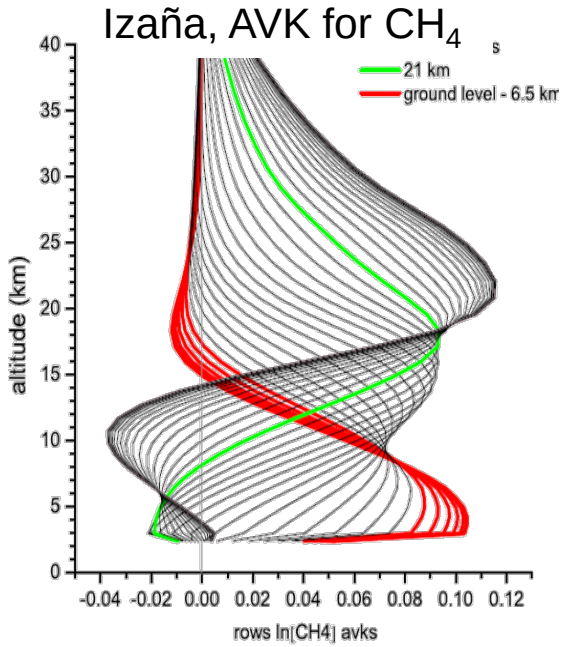
Approach

- **Previous studies**
  - Take observations from sites that are considered to be **representative** for **lower free troposphere (LFT)**
  - **Average FTIR** data up to the level where one independent piece of information is obtained



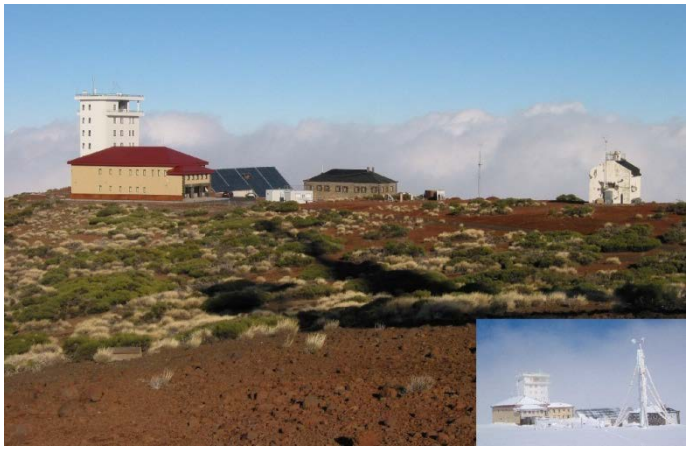
Sepúlveda et al., 2012, AMT

- **This study**
  - **Characterise representativeness** of different sampled air masses
  - Extract cases for which surface fulfills **LFT criterion**
  - Construct **"in-situ profiles"** by blending surface observation with model profiles

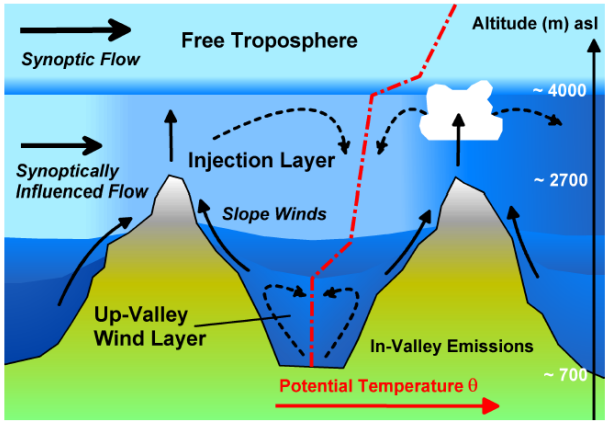
Demonstration Sites

Jungfraujoch, 3580 m asl

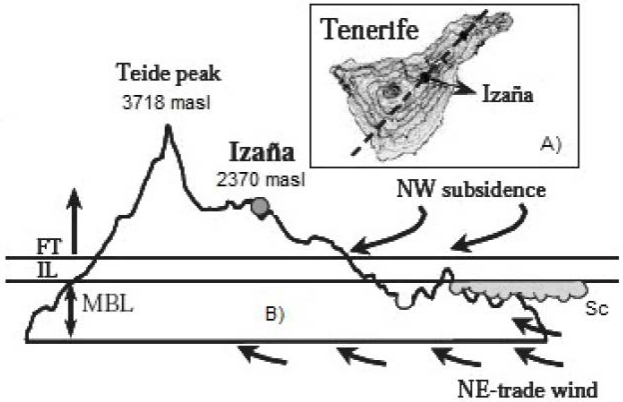
Izaña, 2370 m asl



Day-time influence from up-slope winds



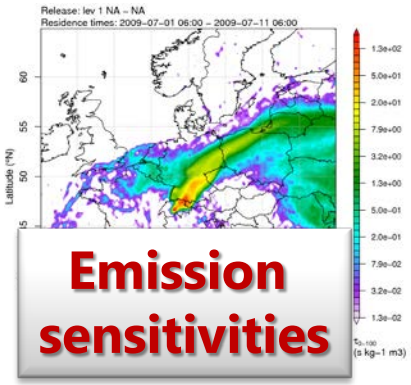
Henne et al., 2004, ACP



Sepúlveda et al., 2012, AMT

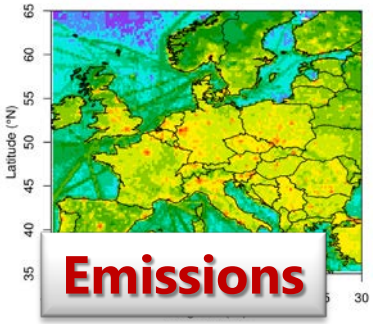
Characterisation of Sampled Air Volumes

- Run **backward** Lagrangian Particle Dispersion (**LPDM**) calculations for all **different sampled air volumes**
- Derive recent (10 days) **emission influence**
- Simulate **mole fractions** for **long lived** tracers (CH_4, CO)
- Analysis of **representativeness** (comparison of recent influence) for filtering and in-situ extrapolation



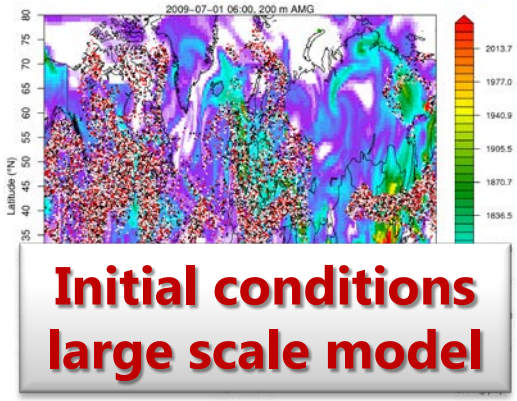
FLEXPART

X



Switzerland: MeteoTest
Europe: TNO/MACC
Global: EDGAR/GFED

+



MACC Re-analysis
FLEXPART-CTM
NCEP-MOZART
TM5

Concentration Simulations with FLEXPART LPDM

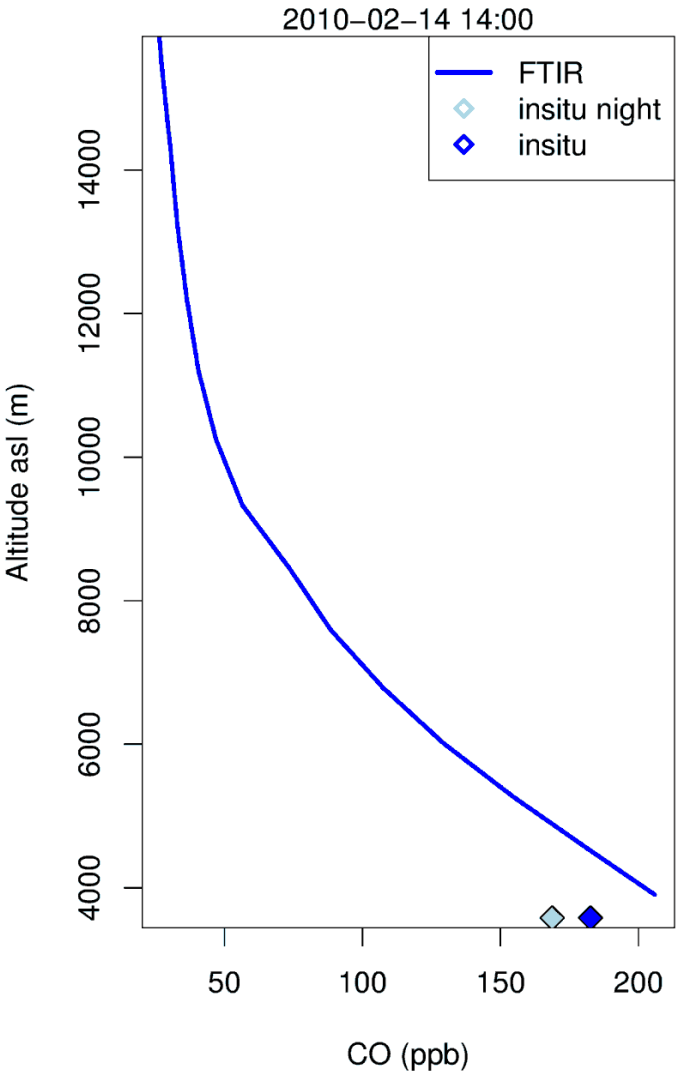
- **FLEXPART** (ECMWF IFS + MeteoSwiss COSMO)
  - **Presentation on FLEXPART-COSMO: Friday, B15, 14:30–14:45**

- Mean, turbulent and convective transport of **air parcels**
- Advecting **passive tracer**
- Run in **backward** mode (10 d) yielding **emission sensitivities**

- Input meteorology
  - **2 km x 2 km** MeteoSwiss COSMO Alps; 7 km x 7 km W. Europe
  - 0.2° x 0.2° ECMWF-IFS W. Europe, Canary Islands, 1° x 1° globally

- Particle **releases** (50'000 each)
  - In-situ observation: point source
  - FTIR partial columns (< 16 km): volume according to viewing geometry

Example CO Vertical Column JFJ



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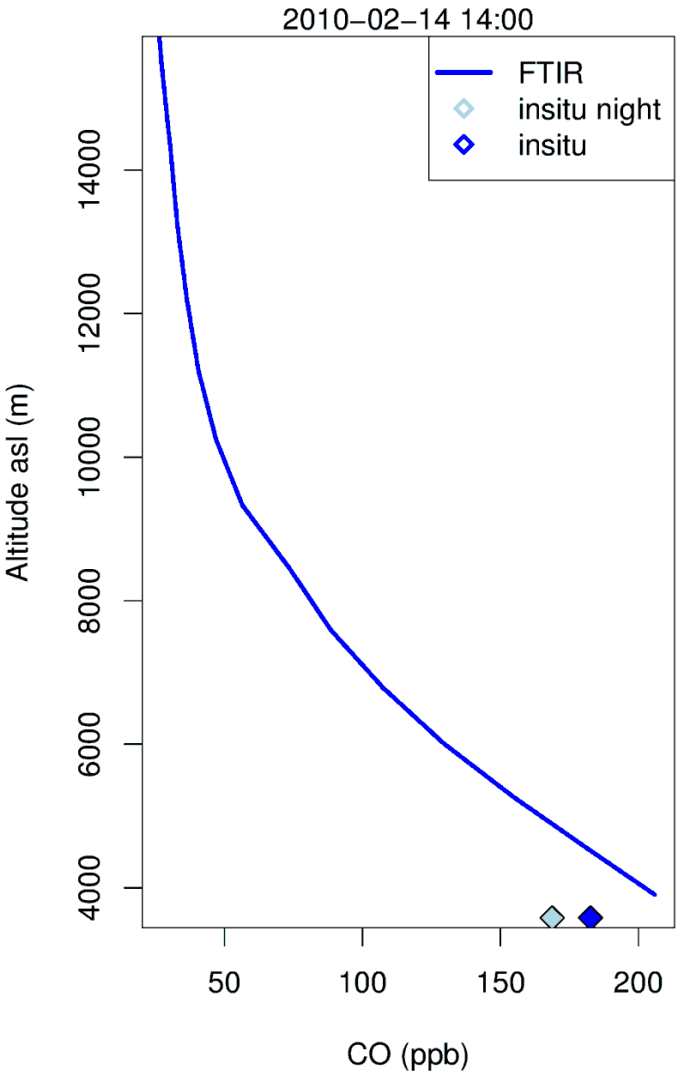

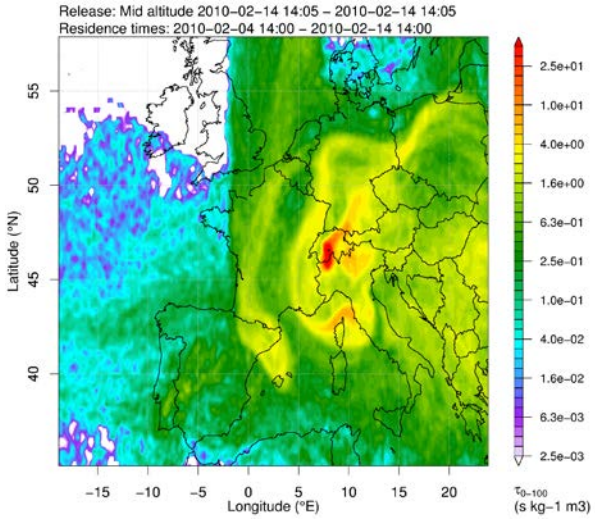

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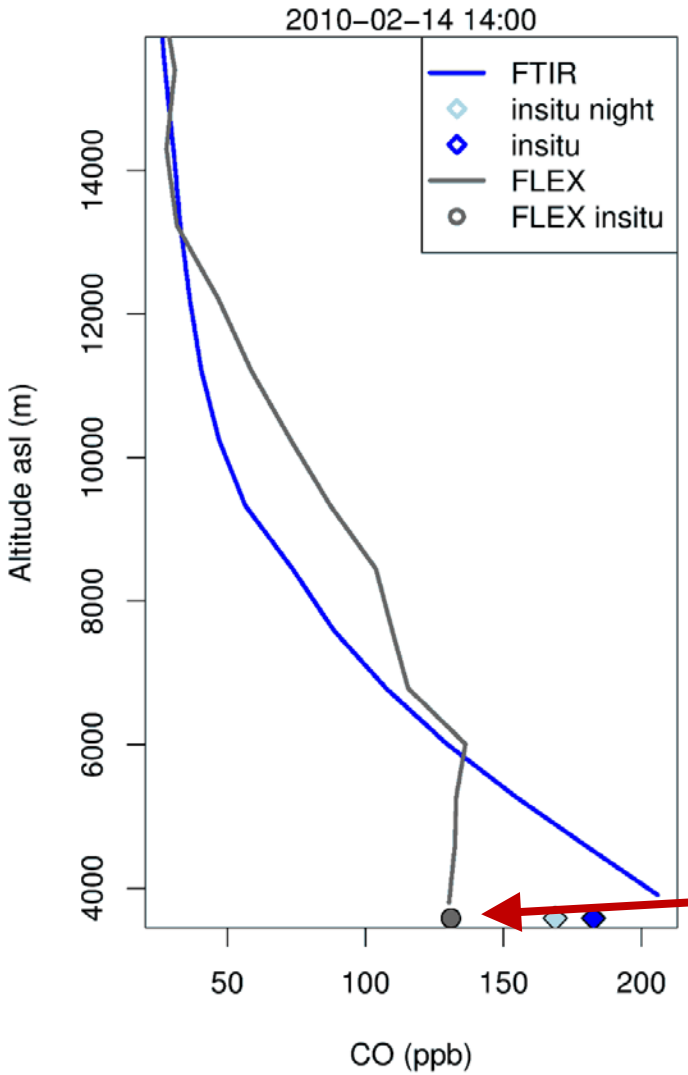

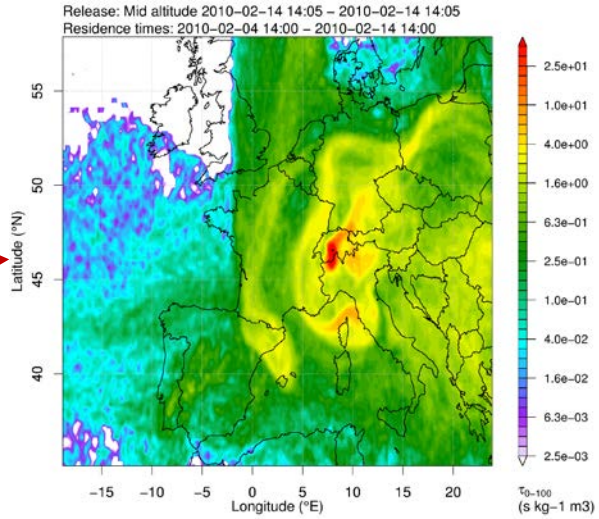

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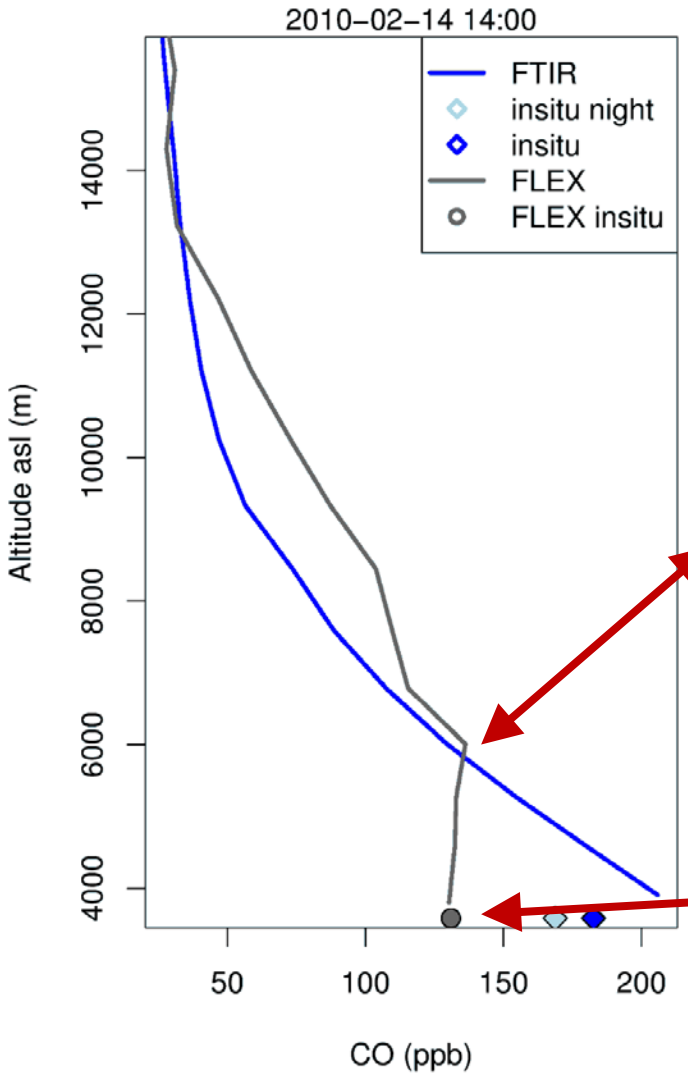

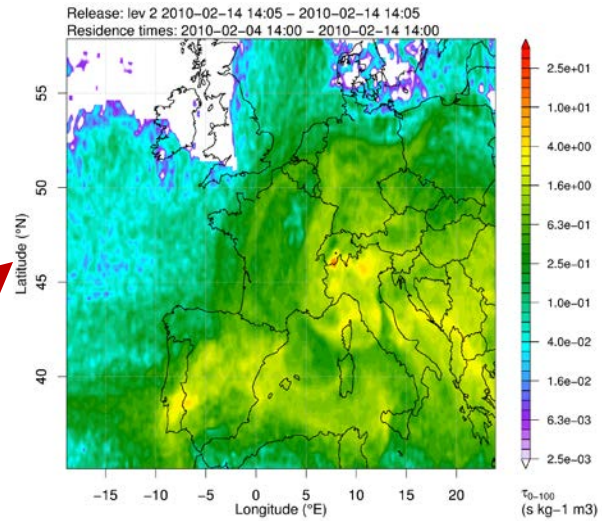

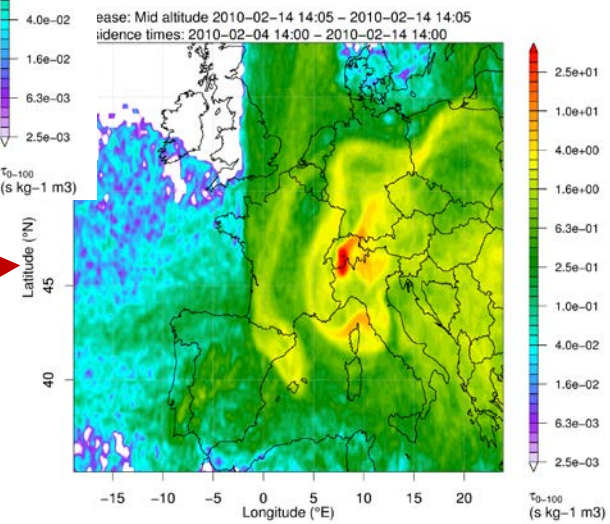

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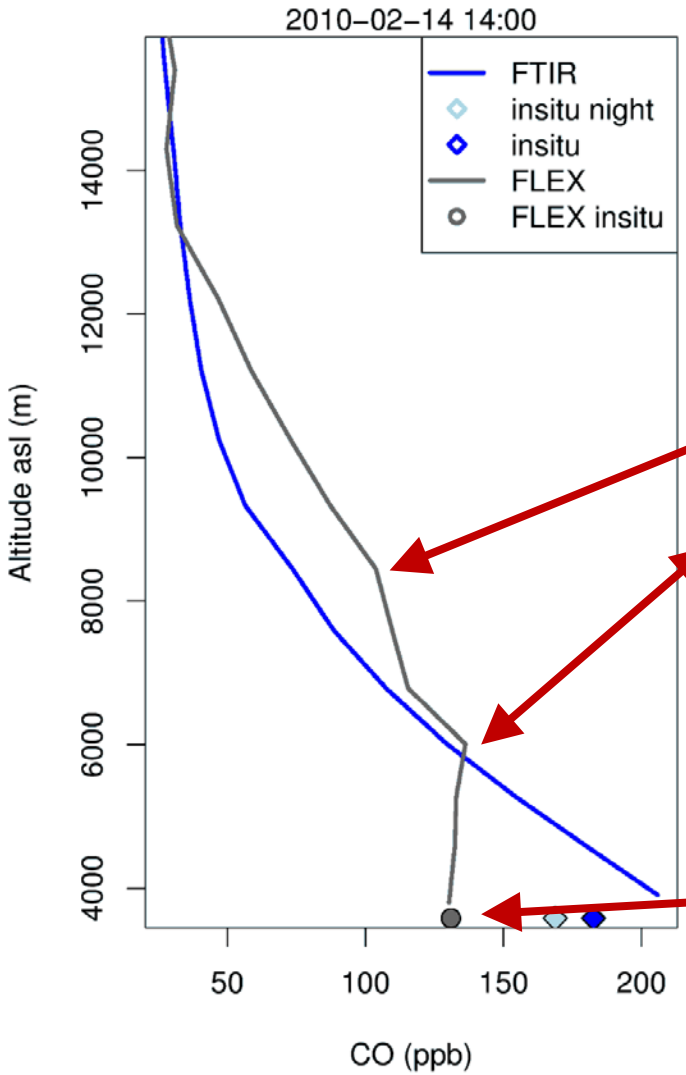
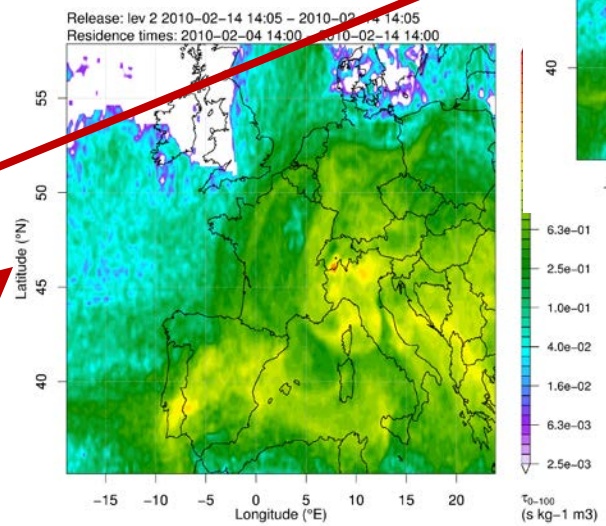
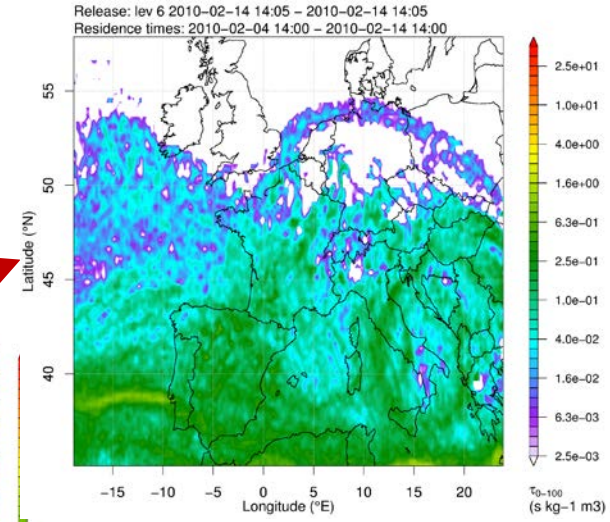
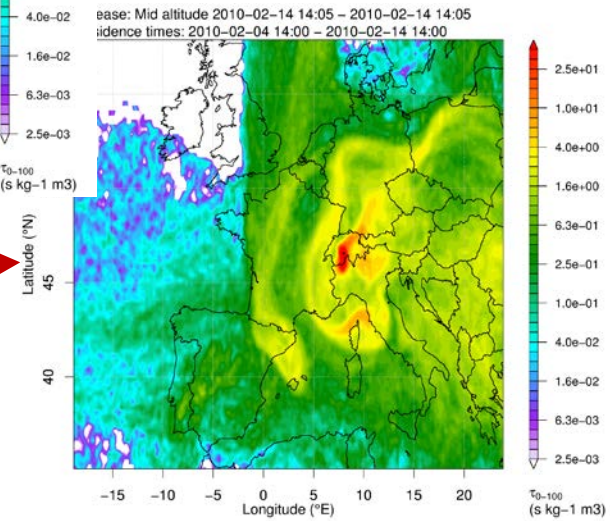
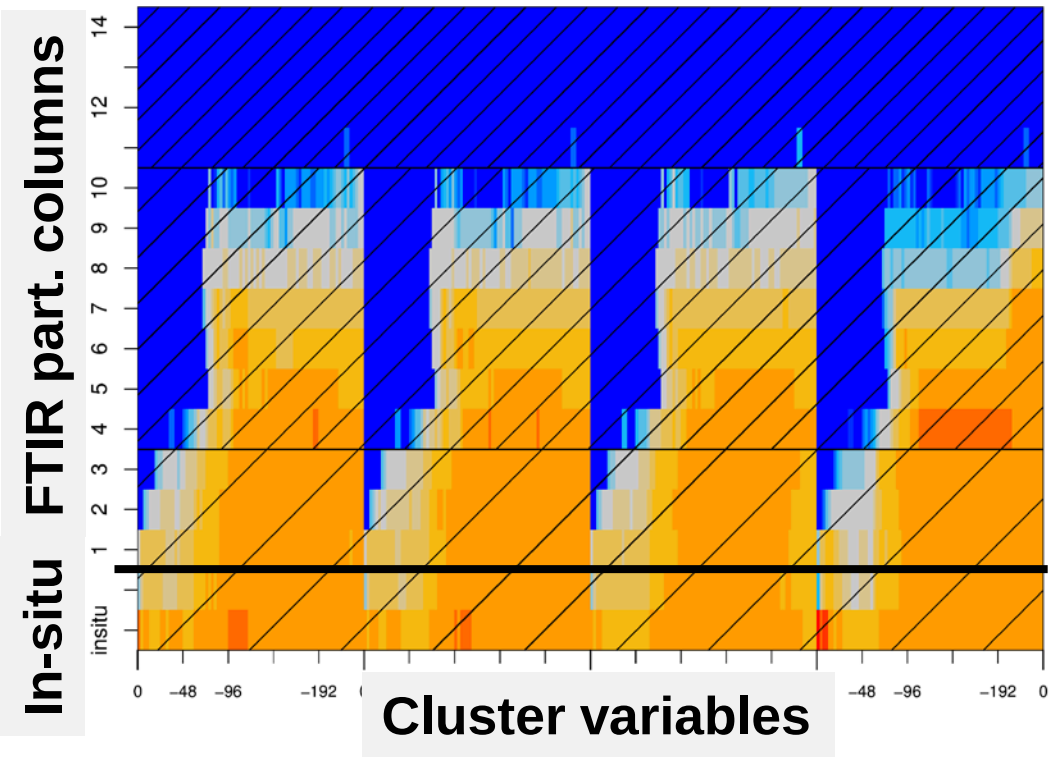


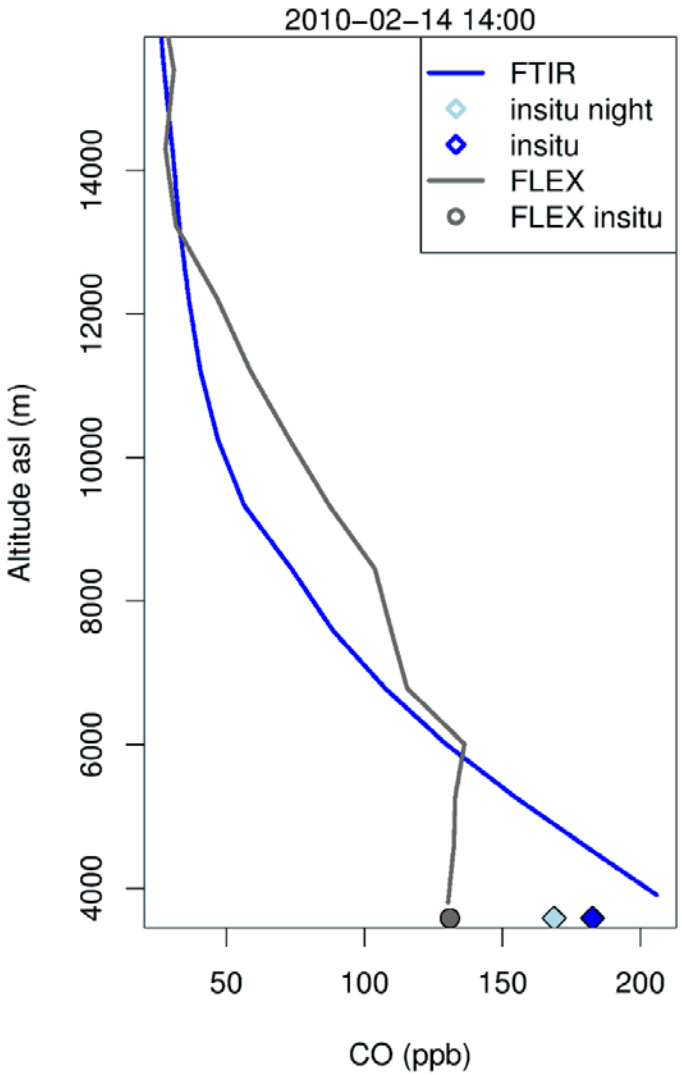






Extension of Surface In-situ





Clustering of FLEXPART results

- Surface residence time and emission uptake before arrival
- Ward Clustering
- Number of clusters obtained from inter-cluster variance

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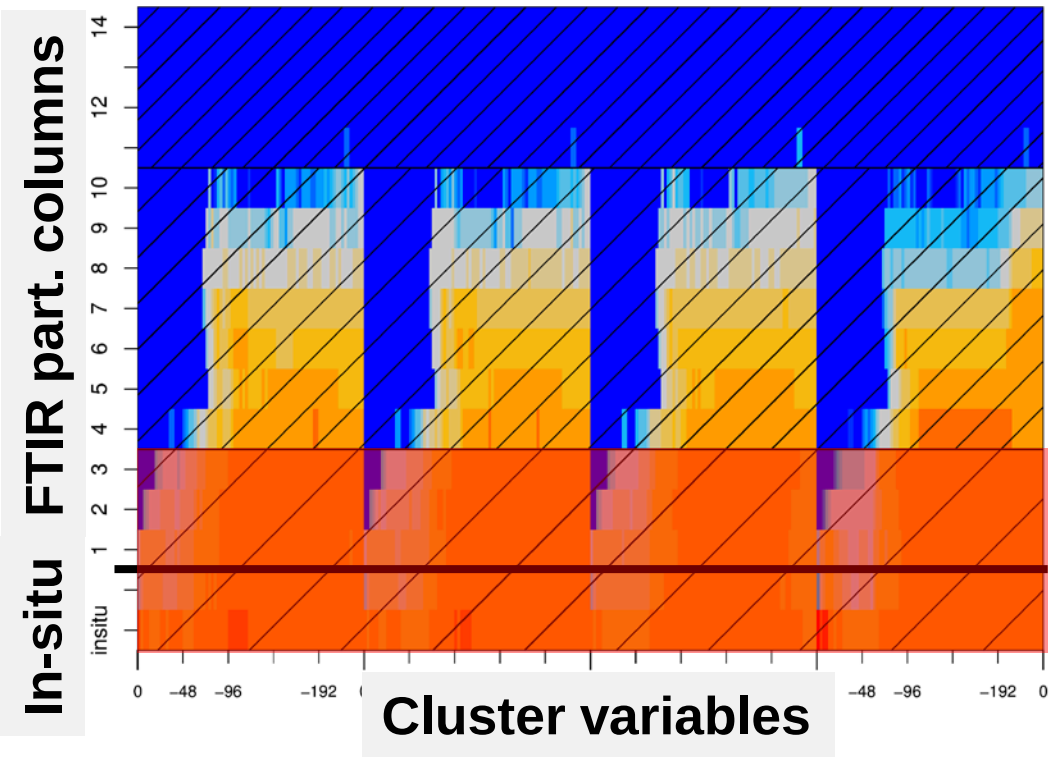

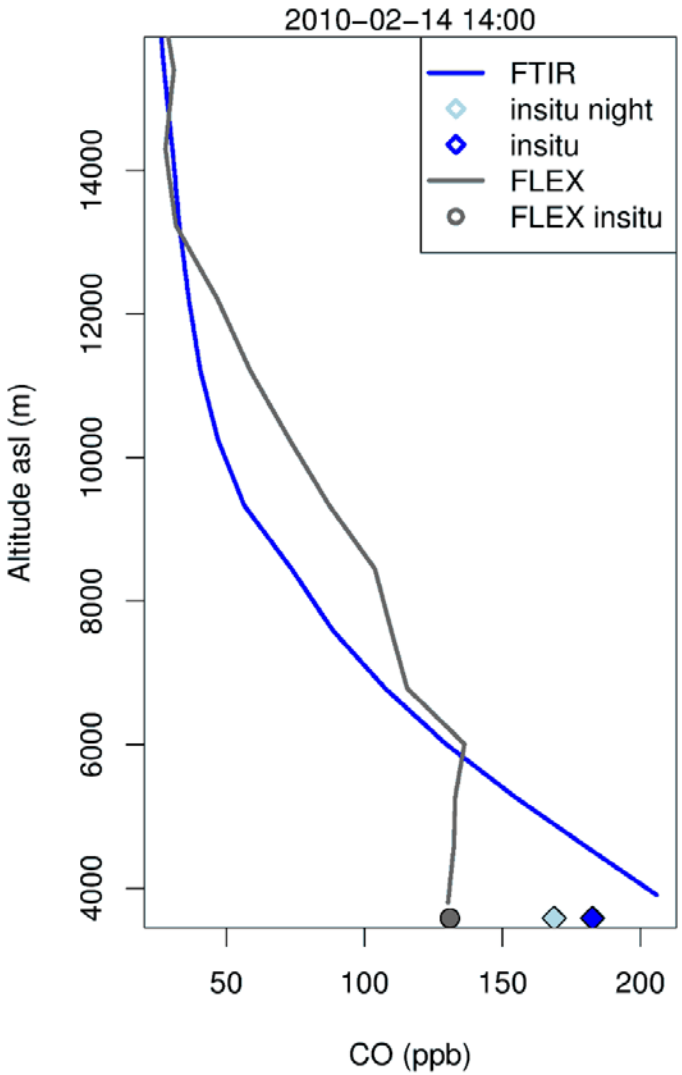

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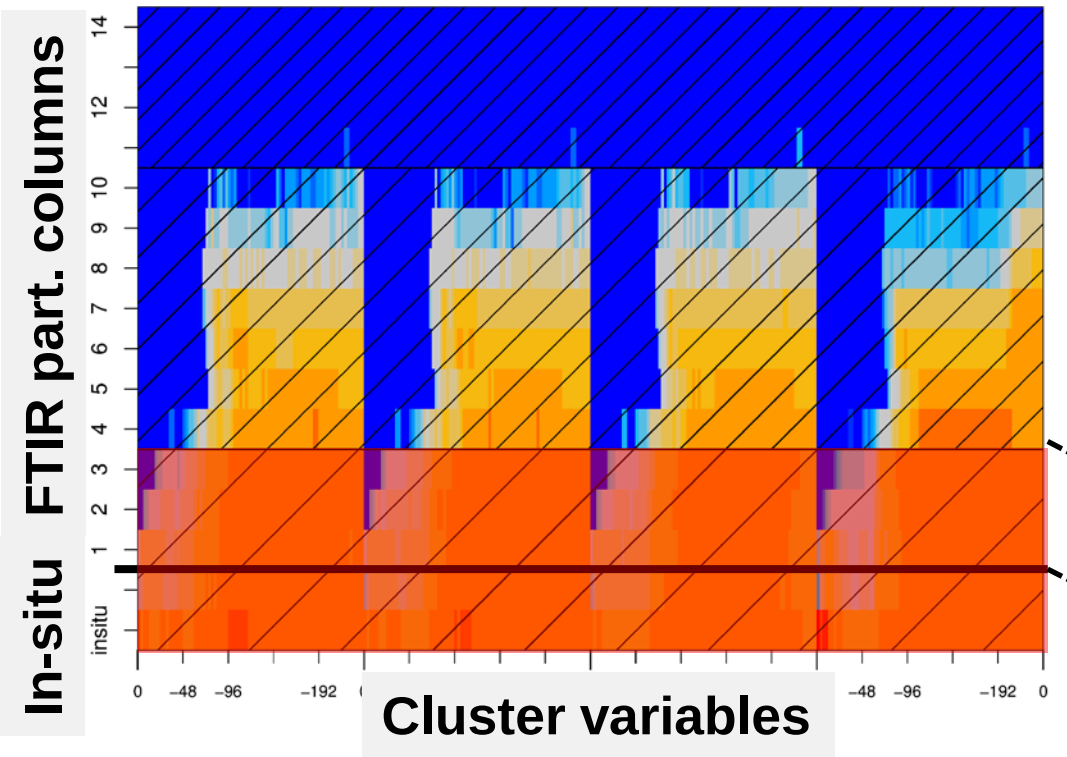

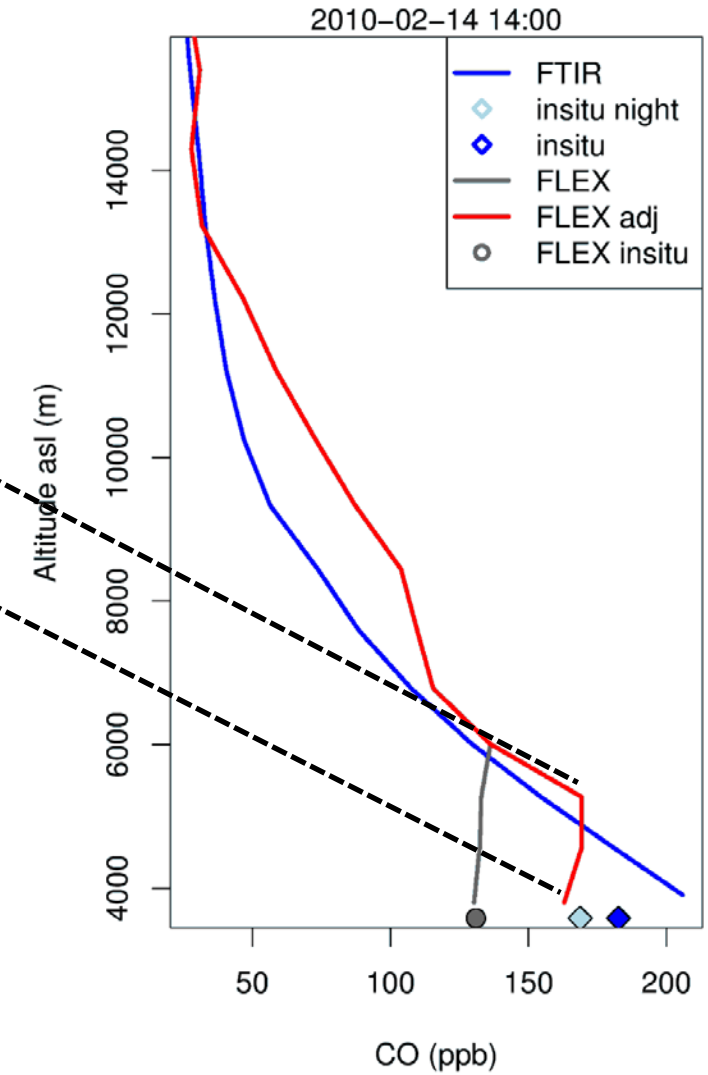

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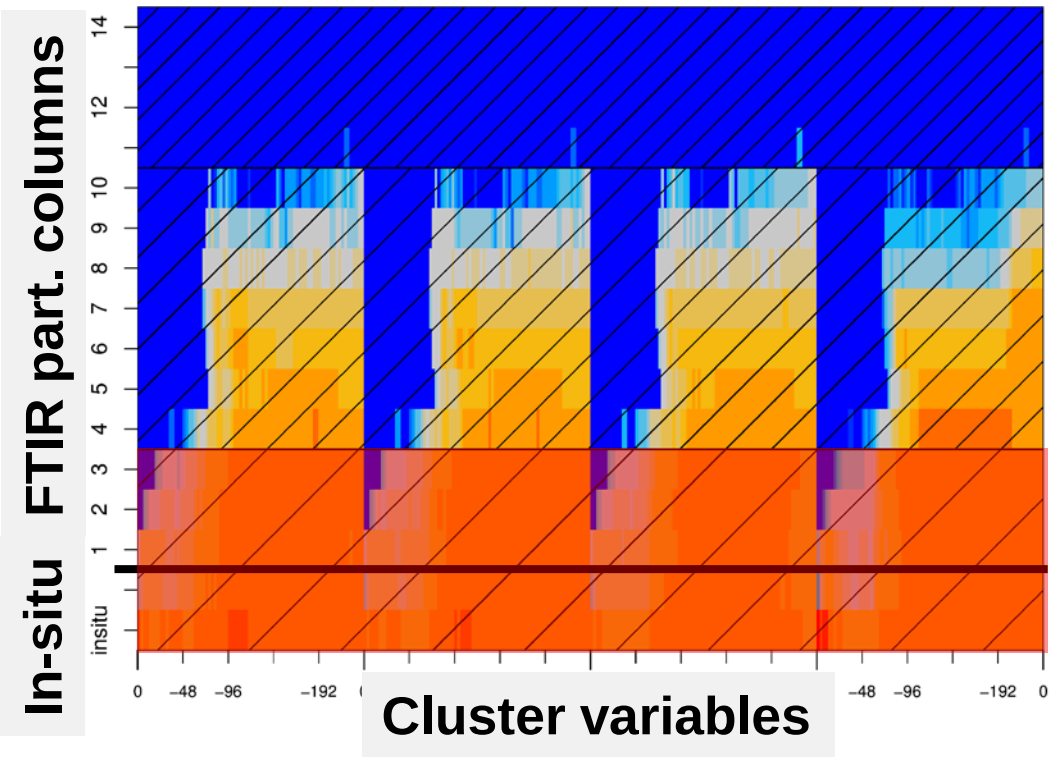

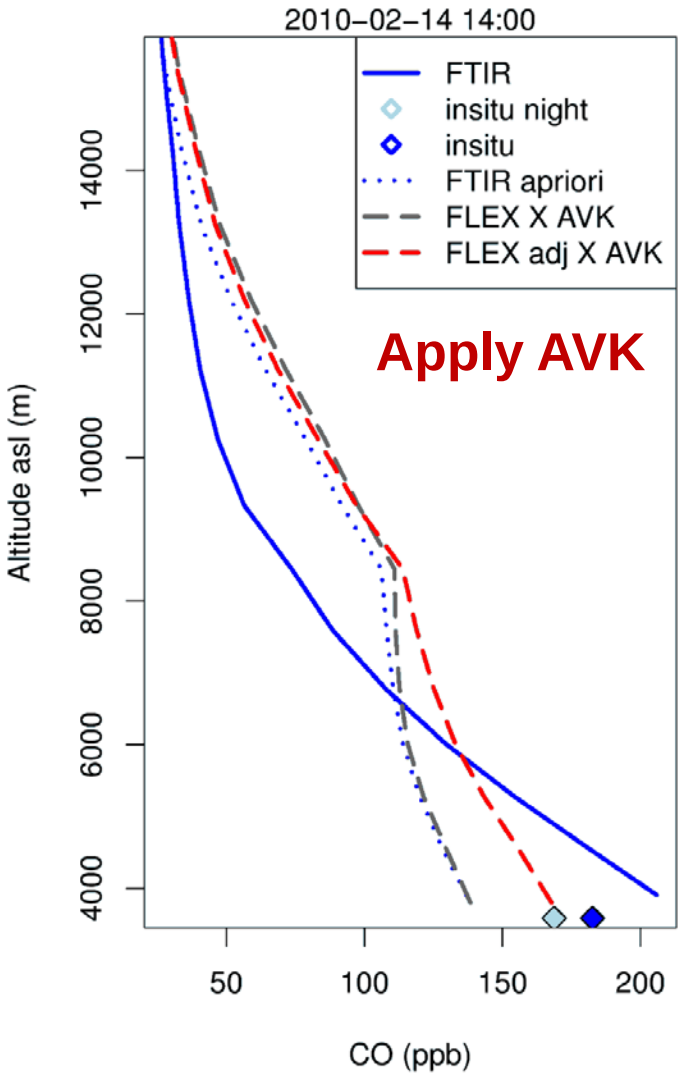

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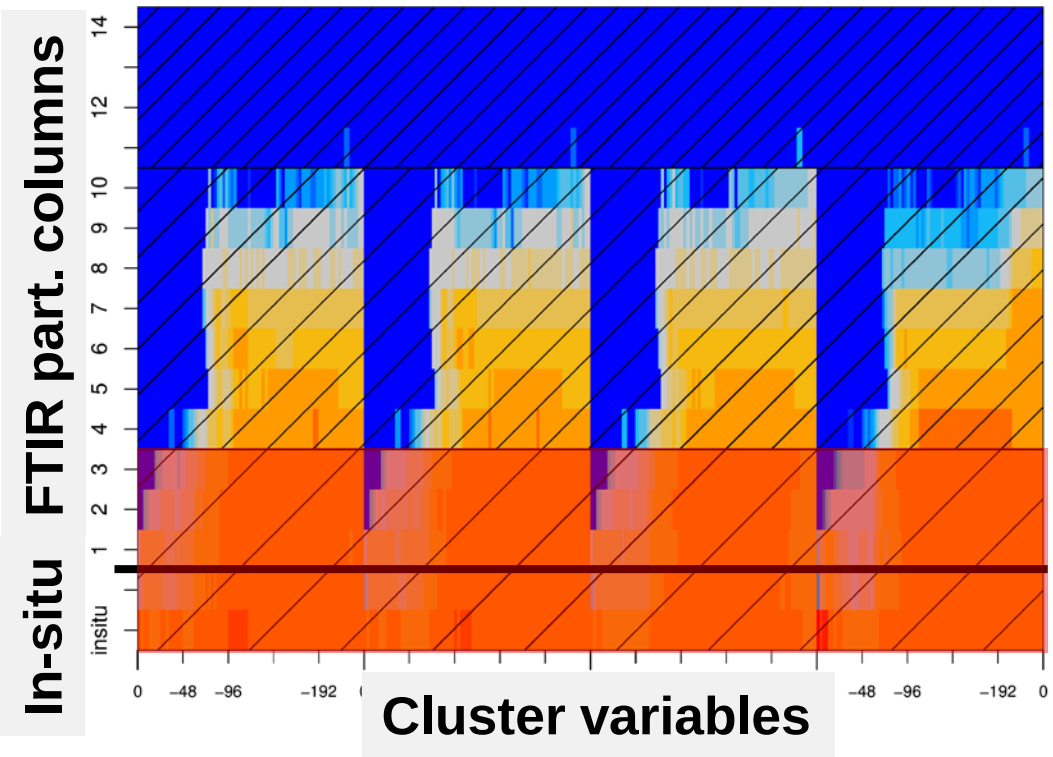

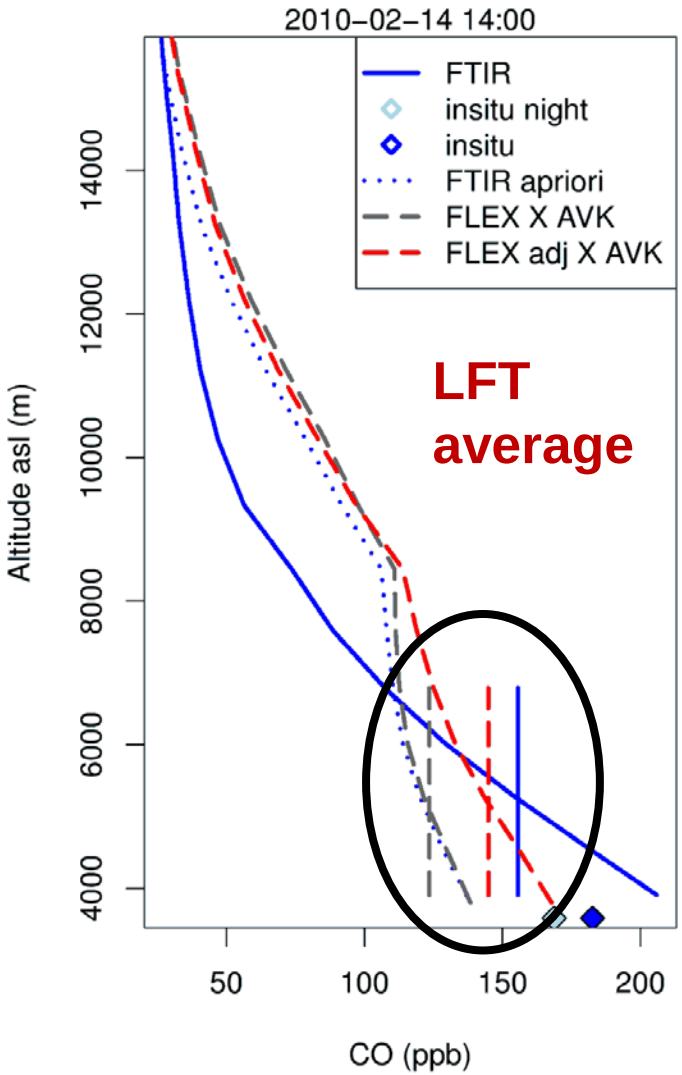

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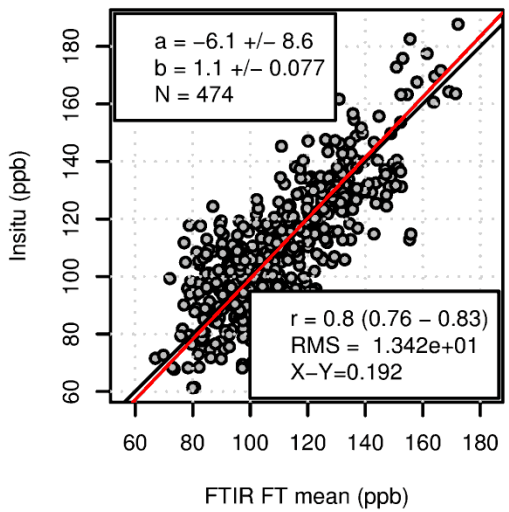
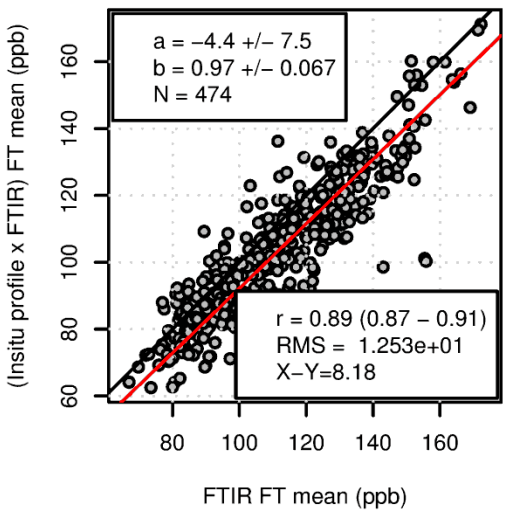
Preliminary Results: Jungfraujoch CO

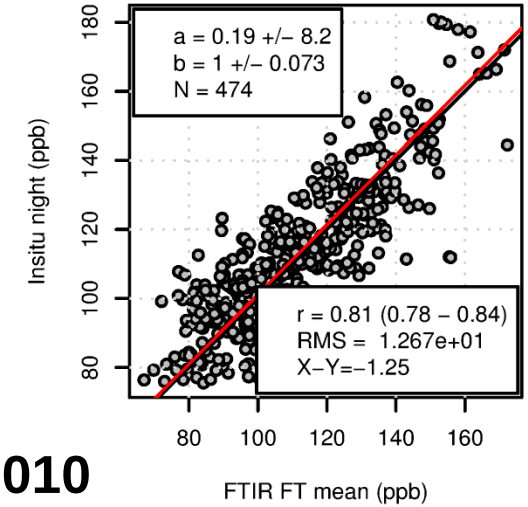
Direct comparison





In-situ profile LFT mean

In-situ night-time



Period 2009-2010
Hourly aggregates

FTIR LFT mean

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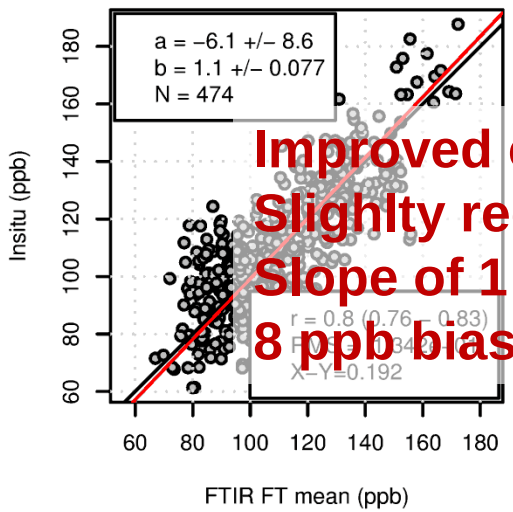
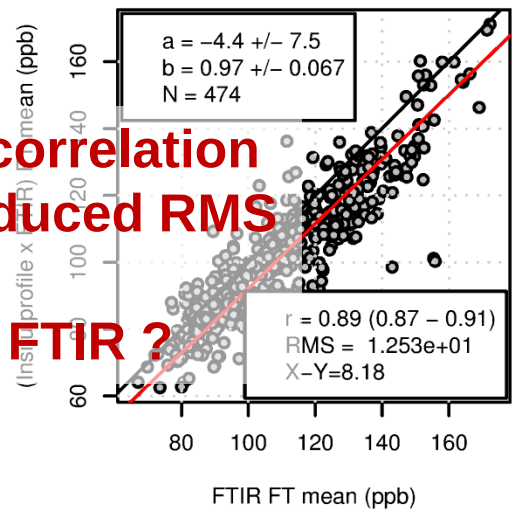
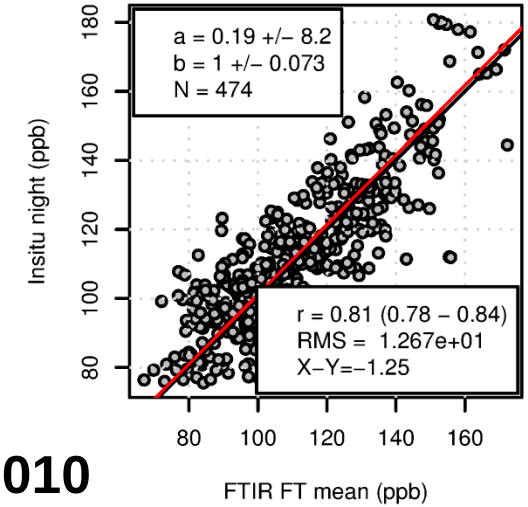




In-situ profile LFT mean

Improved correlation
Slighlty reduced RMS
Slope of 1
8 ppb bias FTIR ?

In-situ night-time



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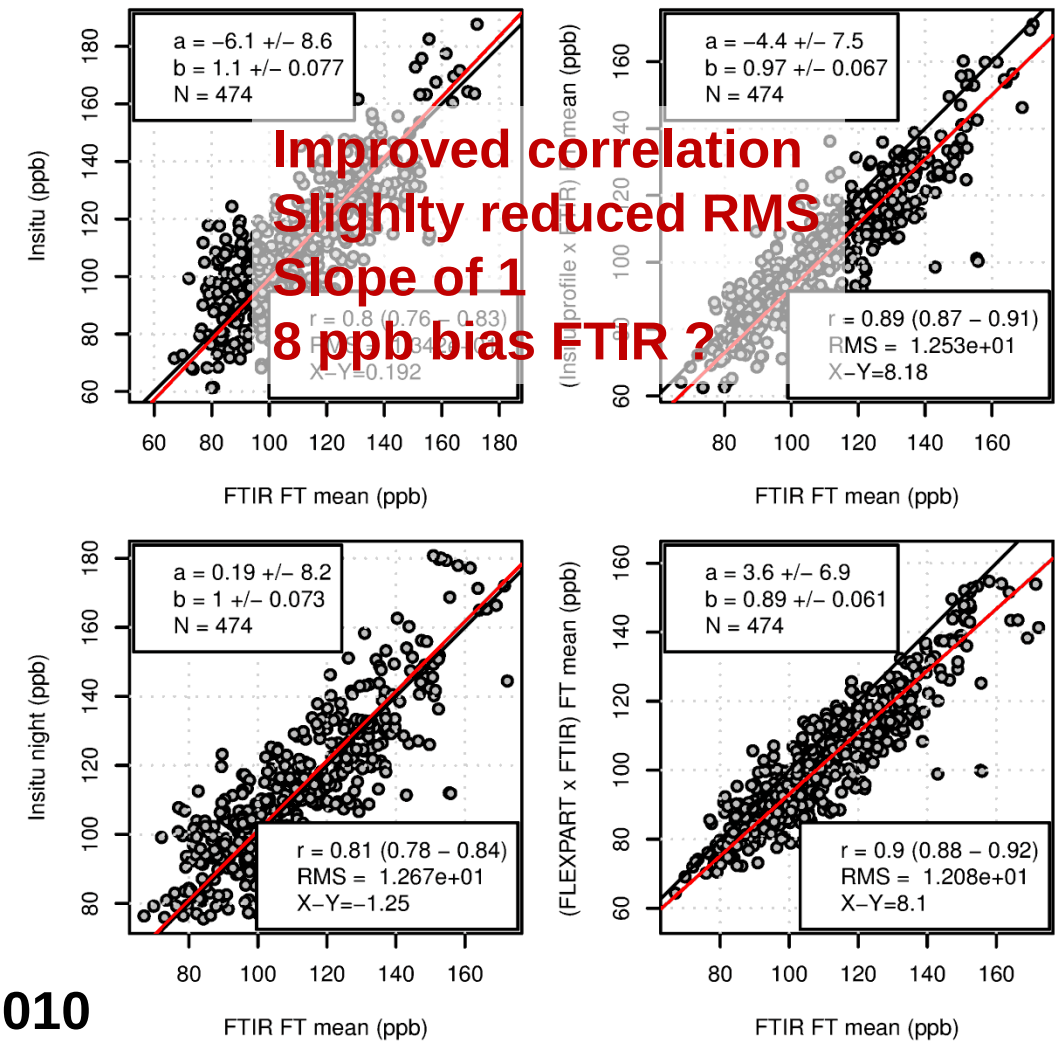
Model LFT mean



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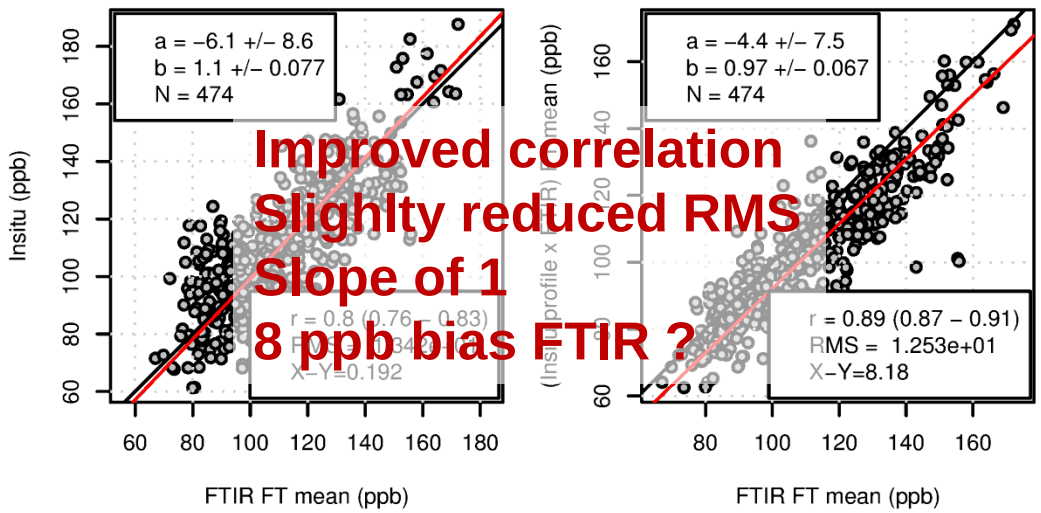

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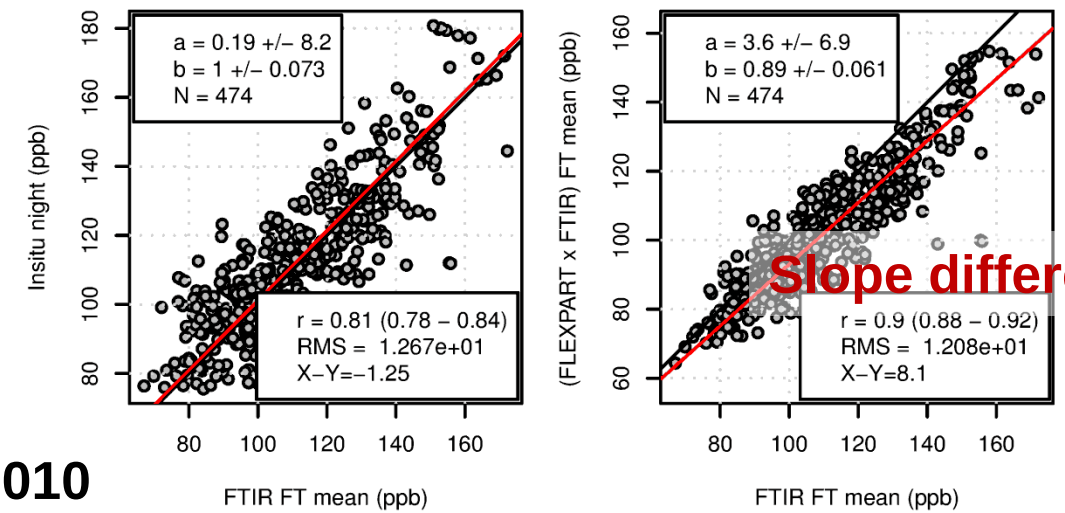


Slope different 1

Period 2009-2010
Hourly aggregates

FTIR LFT mean

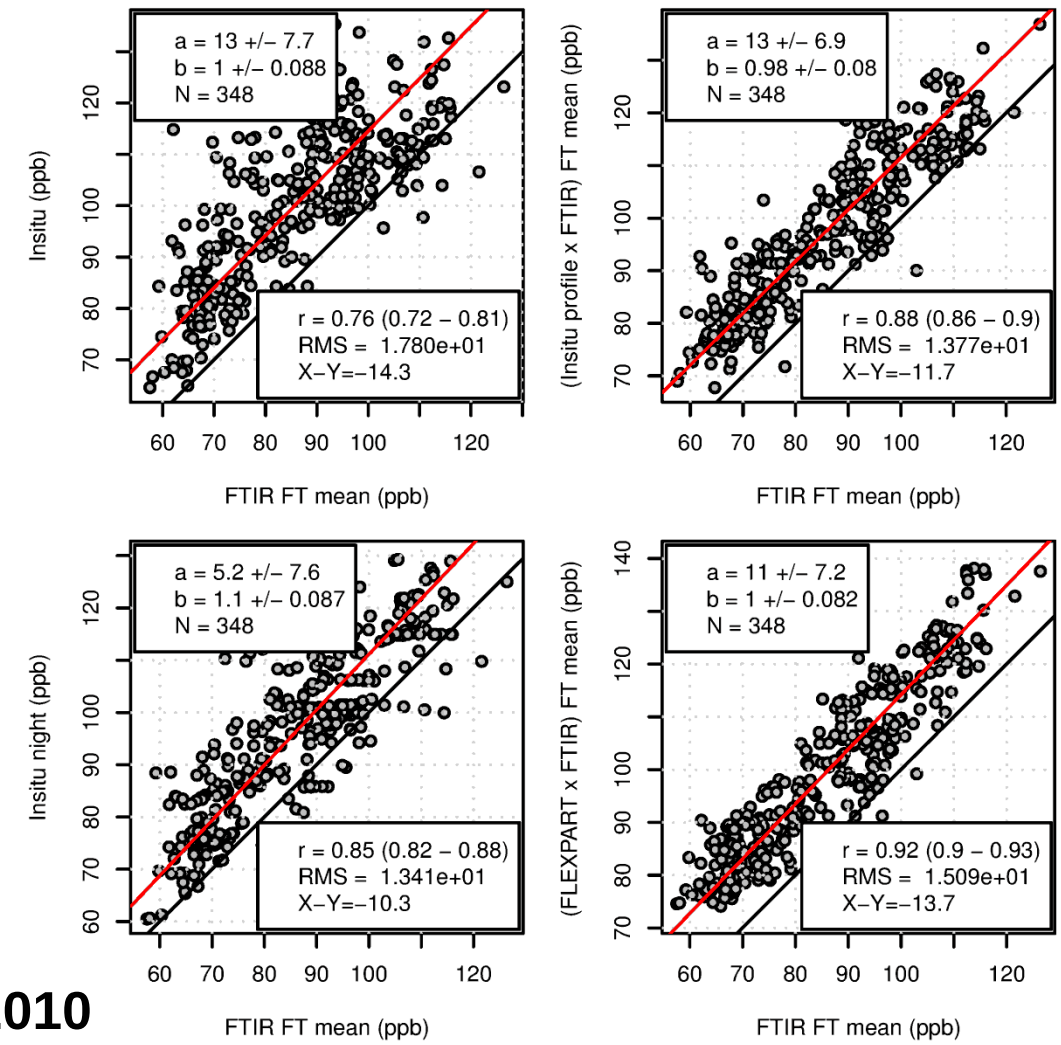
Preliminary Results: Izaña CO

Direct comparison

In-situ profile LFT mean

In-situ night-time

Model LFT mean



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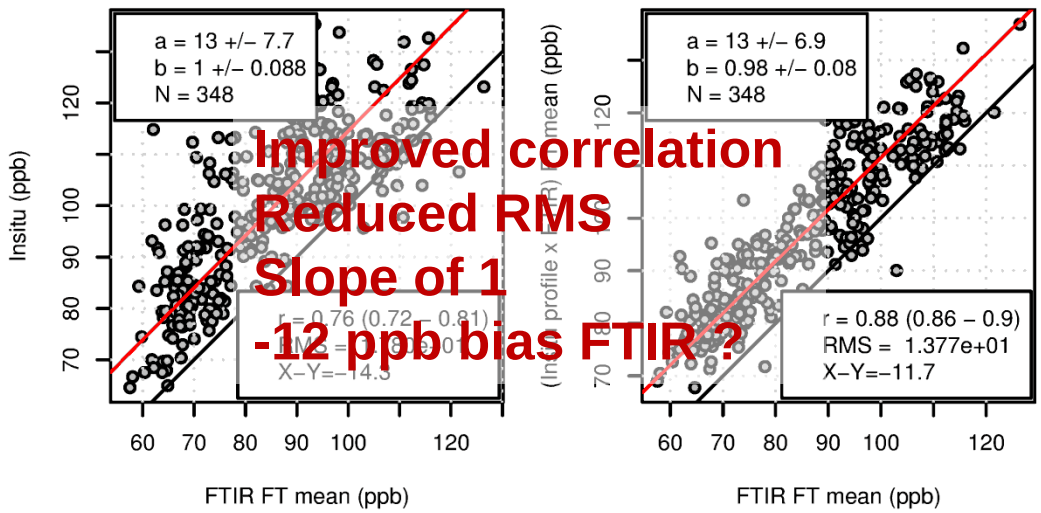

Improved correlation
Reduced RMS
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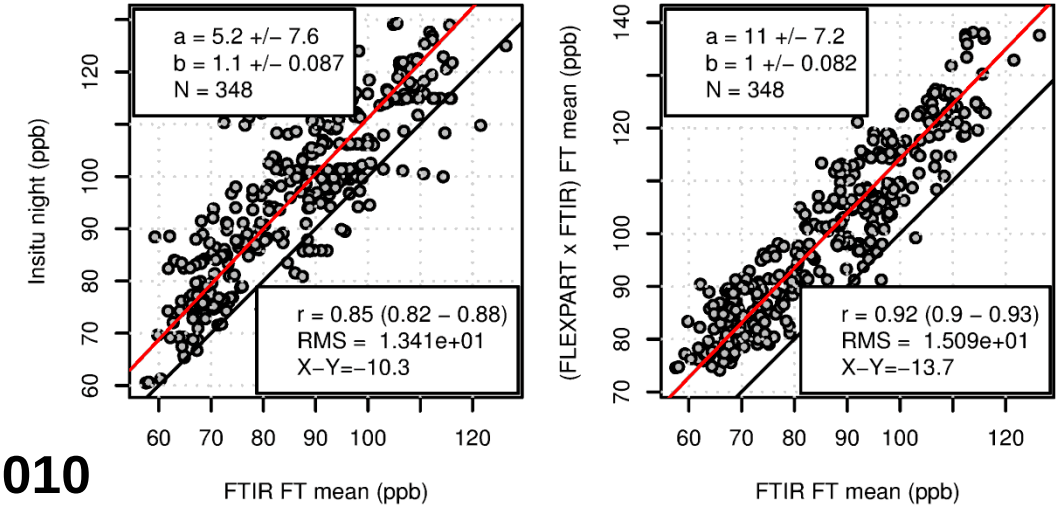
-12 ppb bias FTIR ?

In-situ night-time

Model LFT mean



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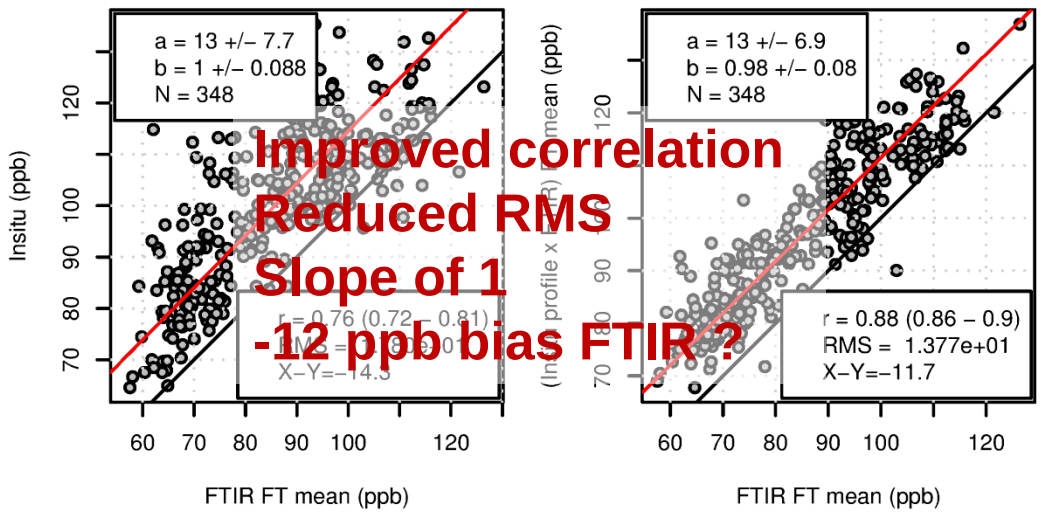

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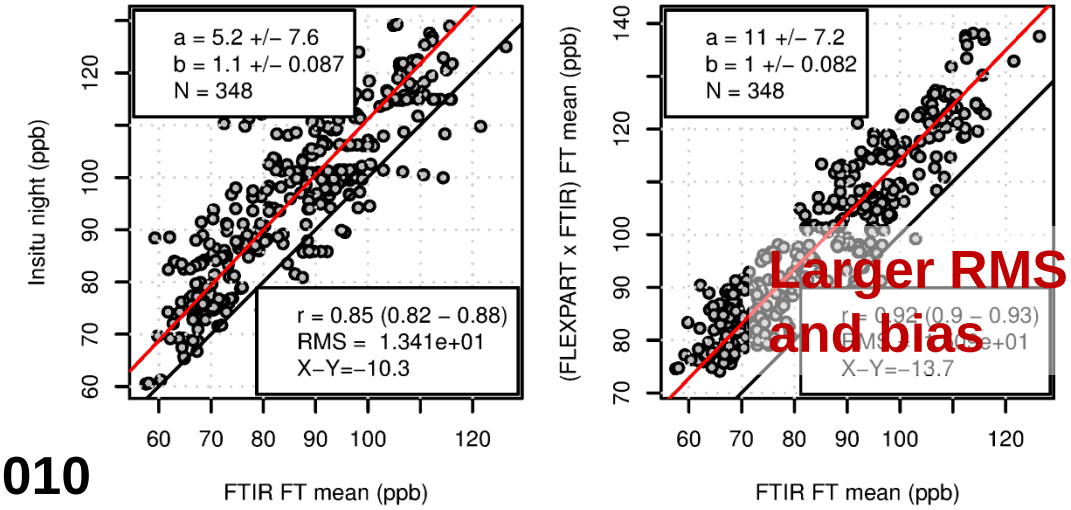
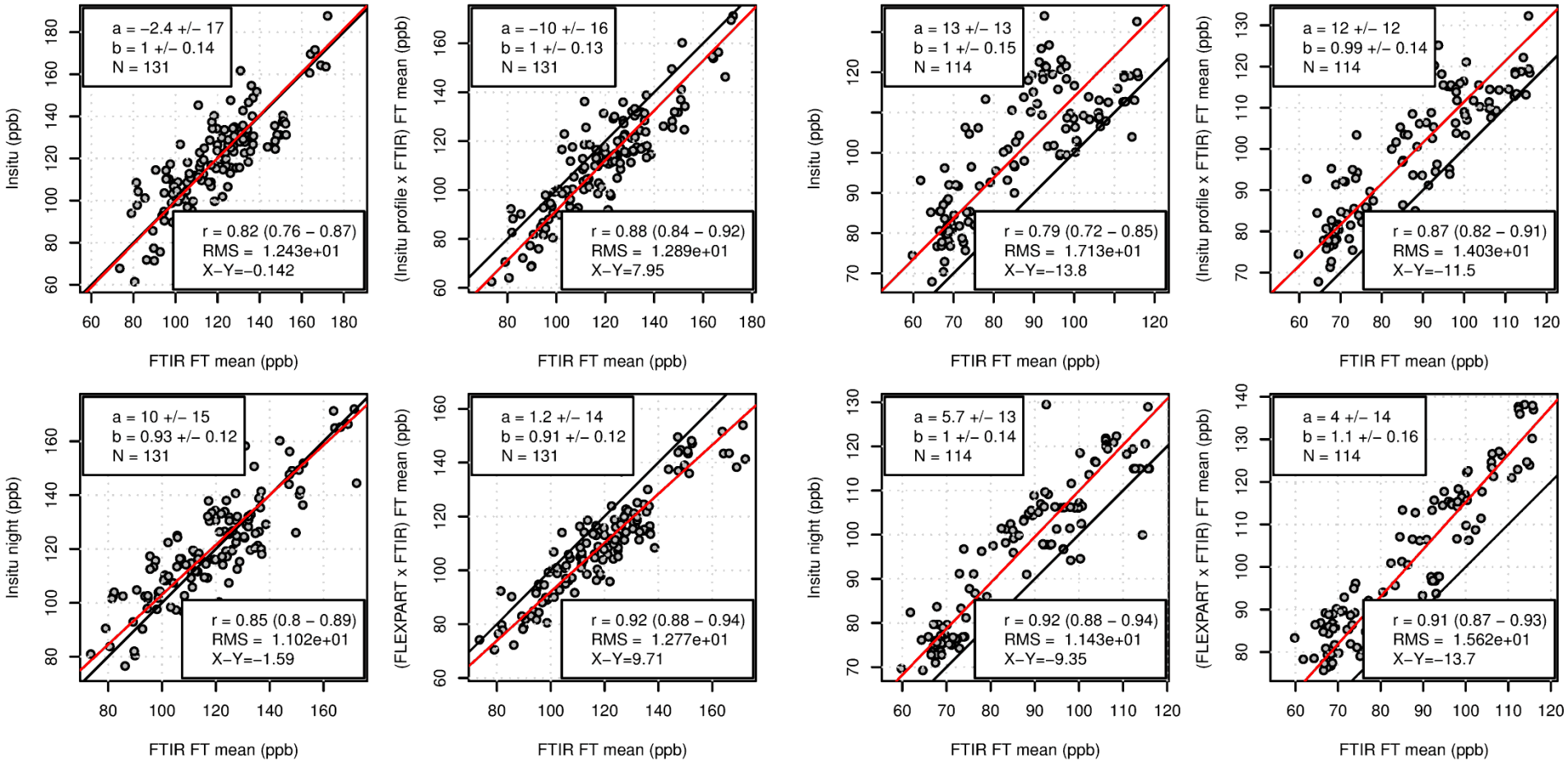


Larger RMS and bias

Period 2009-2010
Hourly aggregates

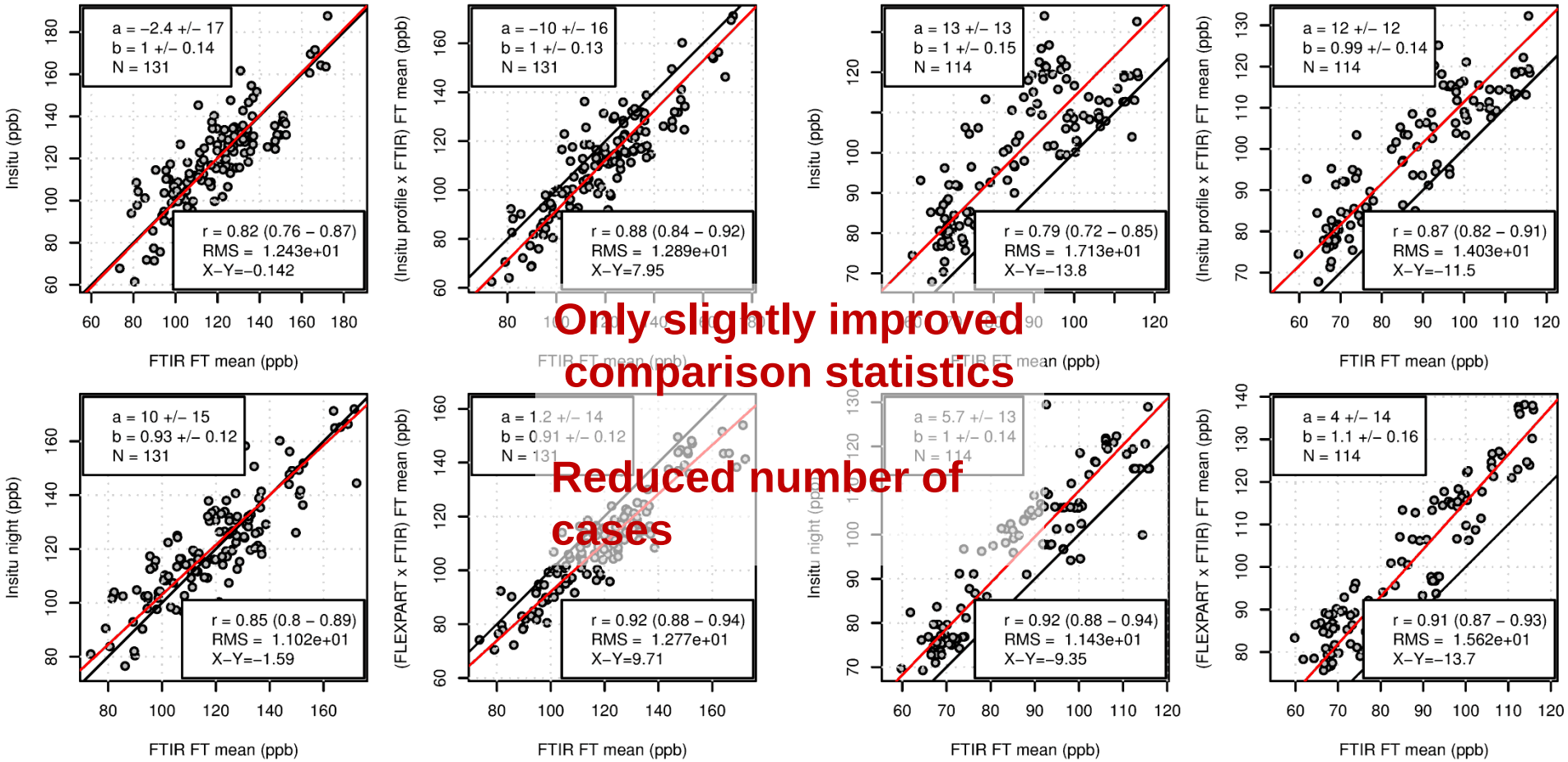
FTIR LFT mean

Results LFT Conditions



Jungfraujoch **Izaña**

Results LFT Conditions



Only slightly improved comparison statistics

Reduced number of cases

Jungfraujoch **Izaña**

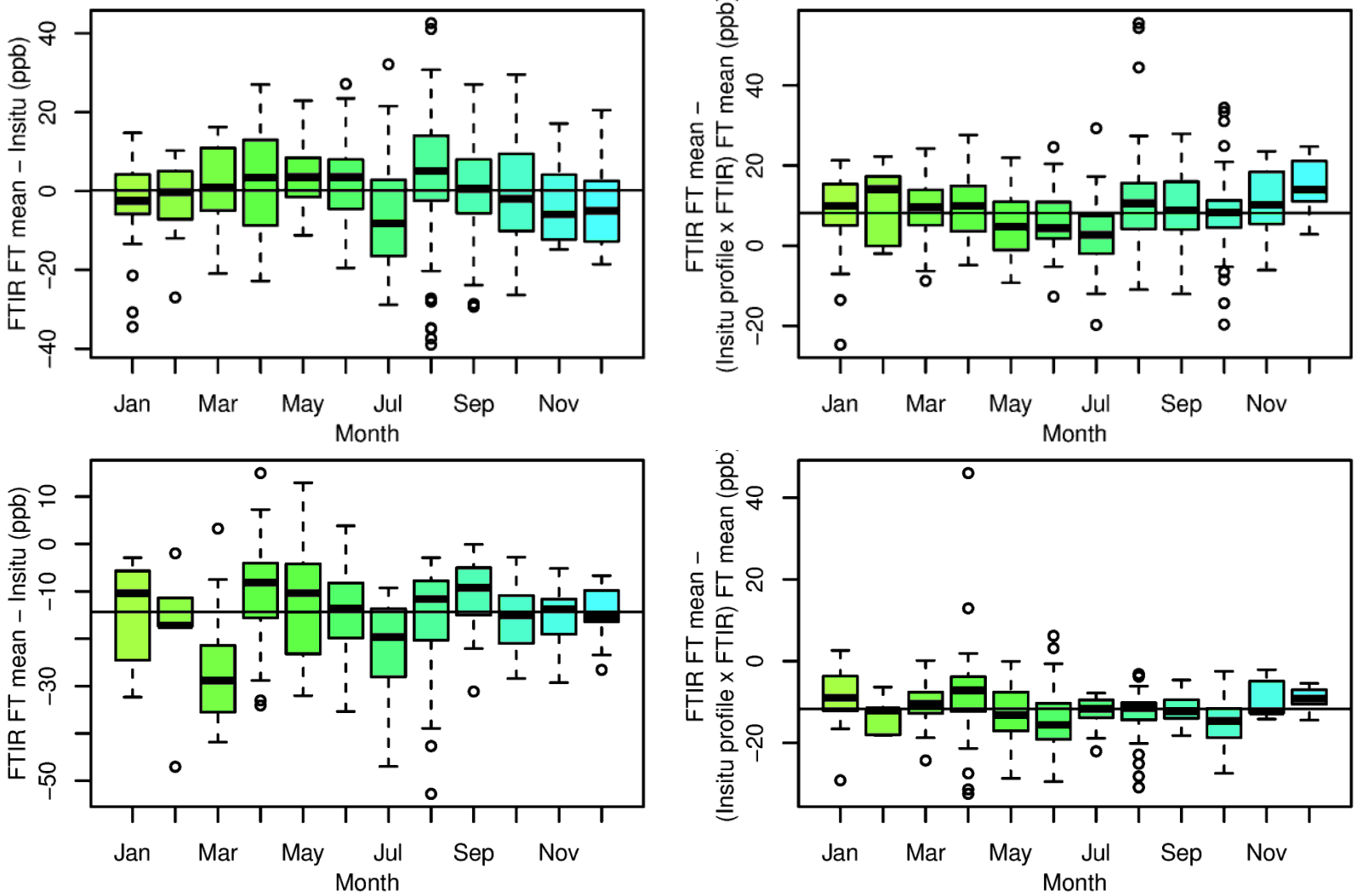
CO Annual Cycle

FTIR - In-situ

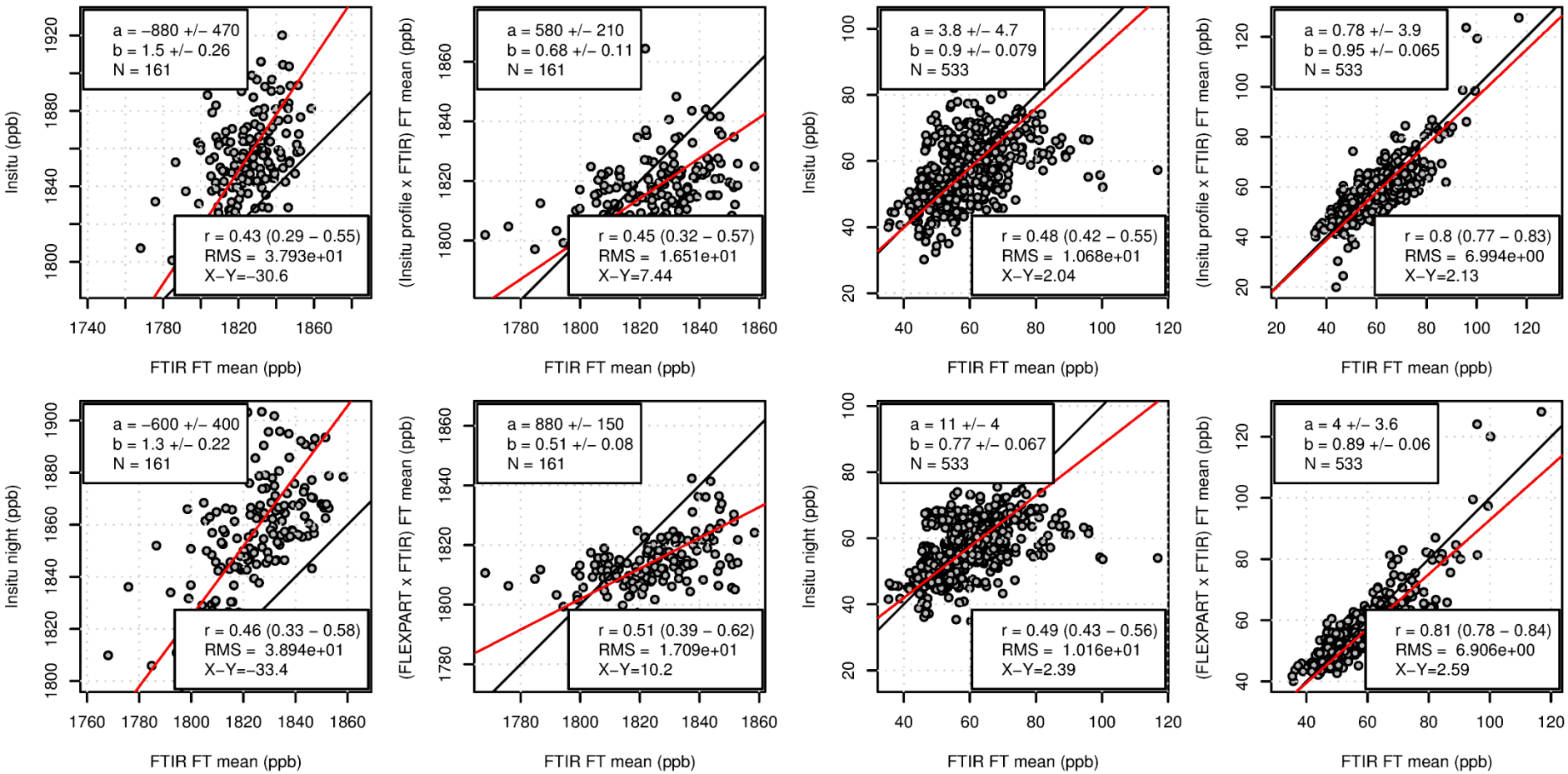
FTIR – "In-situ profile"

Jungfraujoch

Izaña

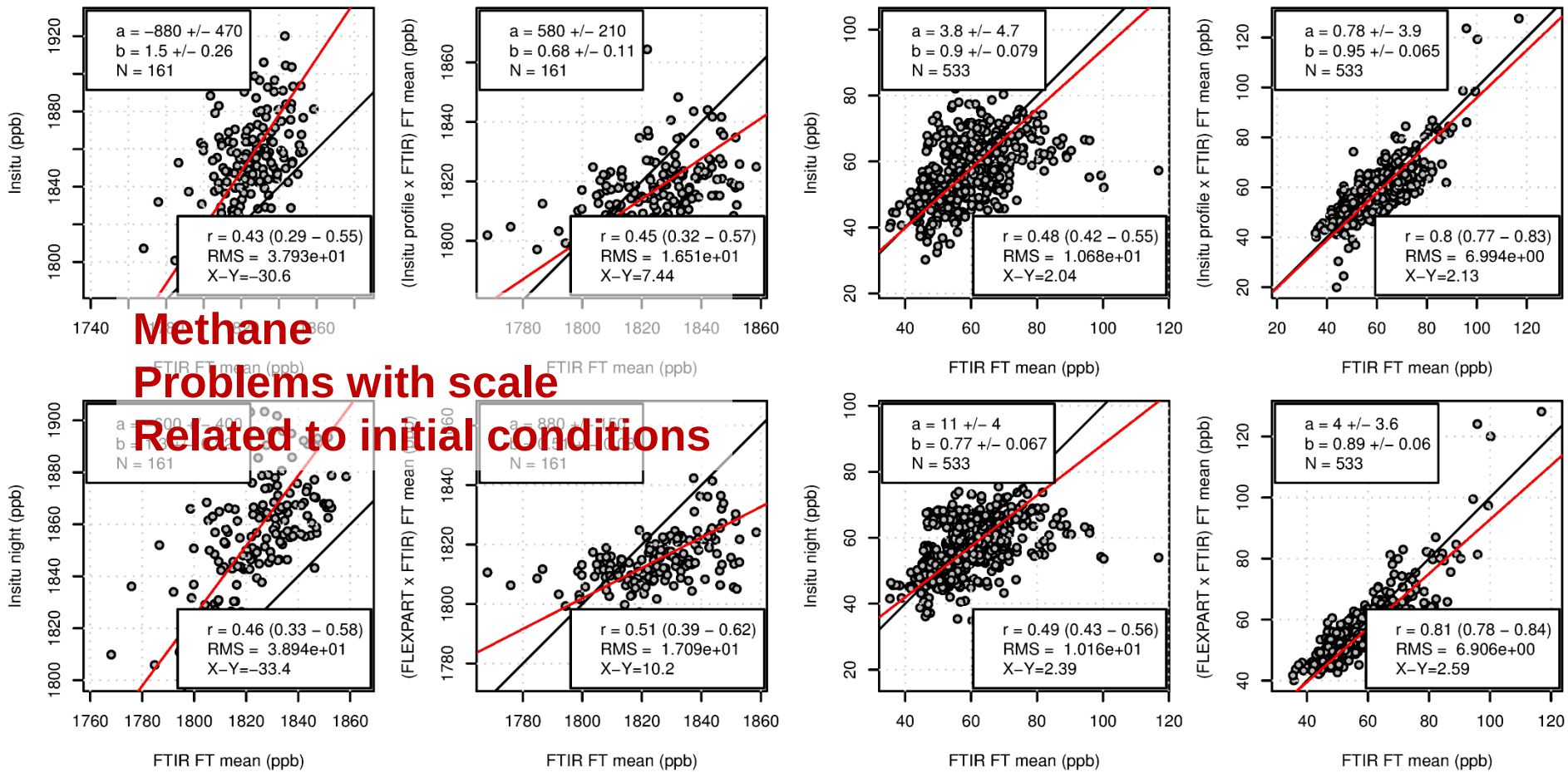


Jungfraujoch: CH_4 and O_3



Period 2009-2010
Hourly aggregates

Jungfraujoch: CH_4 and O_3



Methane

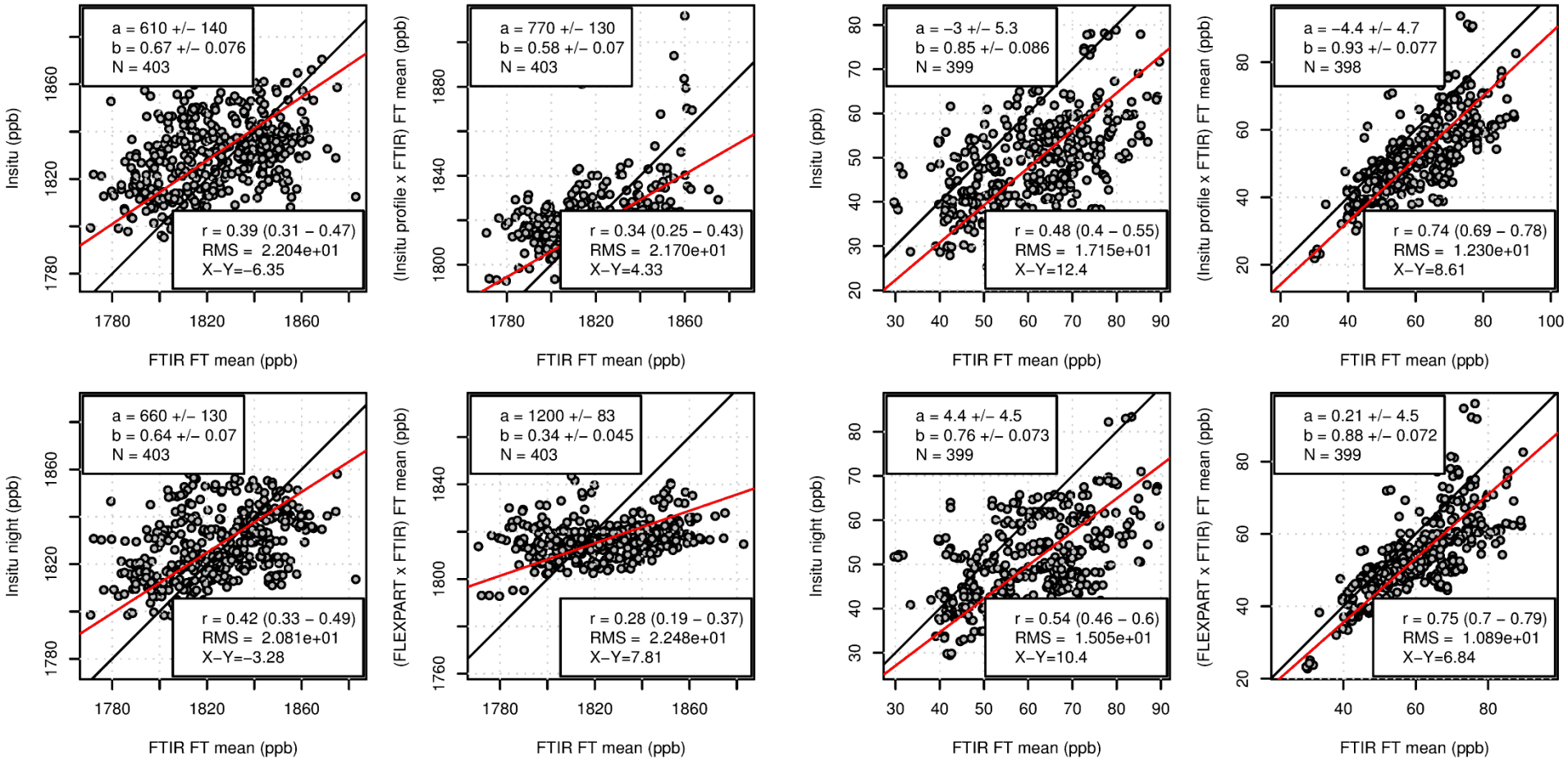
Problems with scale

Related to initial conditions

Period 2009-2010

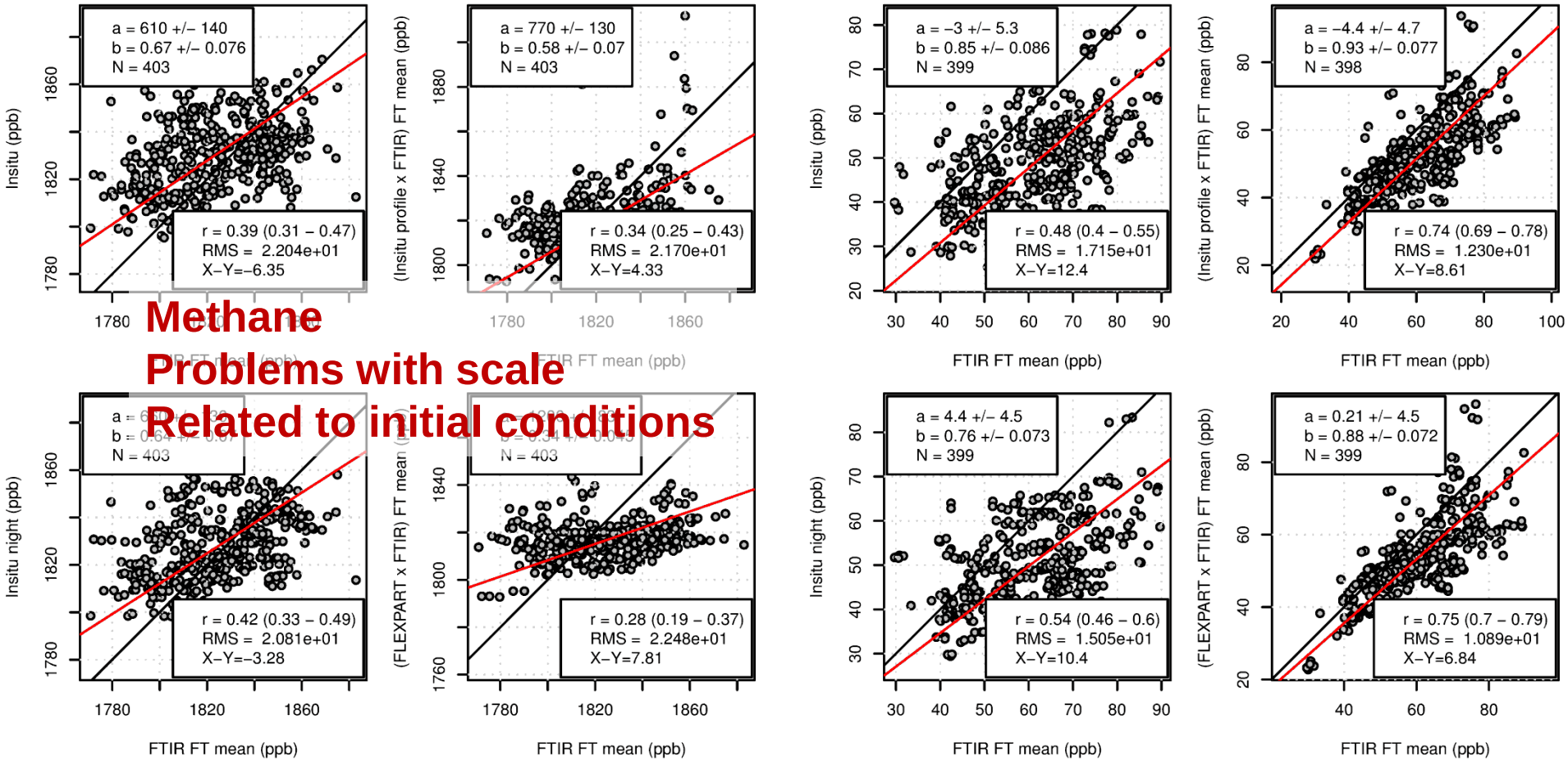
Hourly aggregates

Izaña: CH_4 and O_3



Period 2009-2010
Hourly aggregates

Izaña: CH_4 and O_3



Methane

Problems with scale

Related to initial conditions

Period 2009-2010

Hourly aggregates

Conclusions & Outlook

- Method for vertical extrapolation of surface in-situ data and subsequent comparison to FTIR profile data taking representativeness and AVK into account
- FTIR tropospheric products well correlated with surface observations
- Blending of surface in-situ and model data improves comparability to FTIR
  - Improved correlations, reduced RMS, excellent scale
  - Possible bias between FTIR and «in-situ» profile might be due to model initial conditions
- Future developments
  - Refinement of extrapolation method
  - Application of different initial model conditions
  - Analysis of uncertainties

Acknowledgements

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