Achievements in WP5

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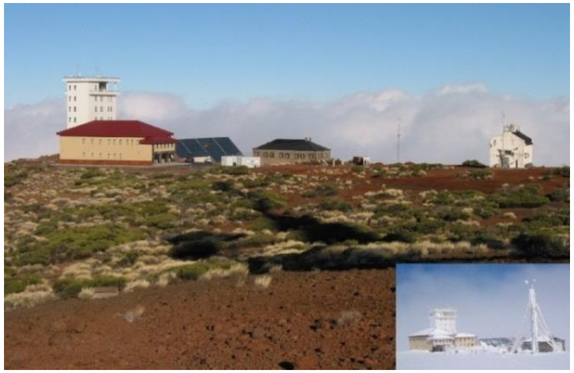
Contributions from BIRA-IASB, INTA, ULg, KIT, AEMET

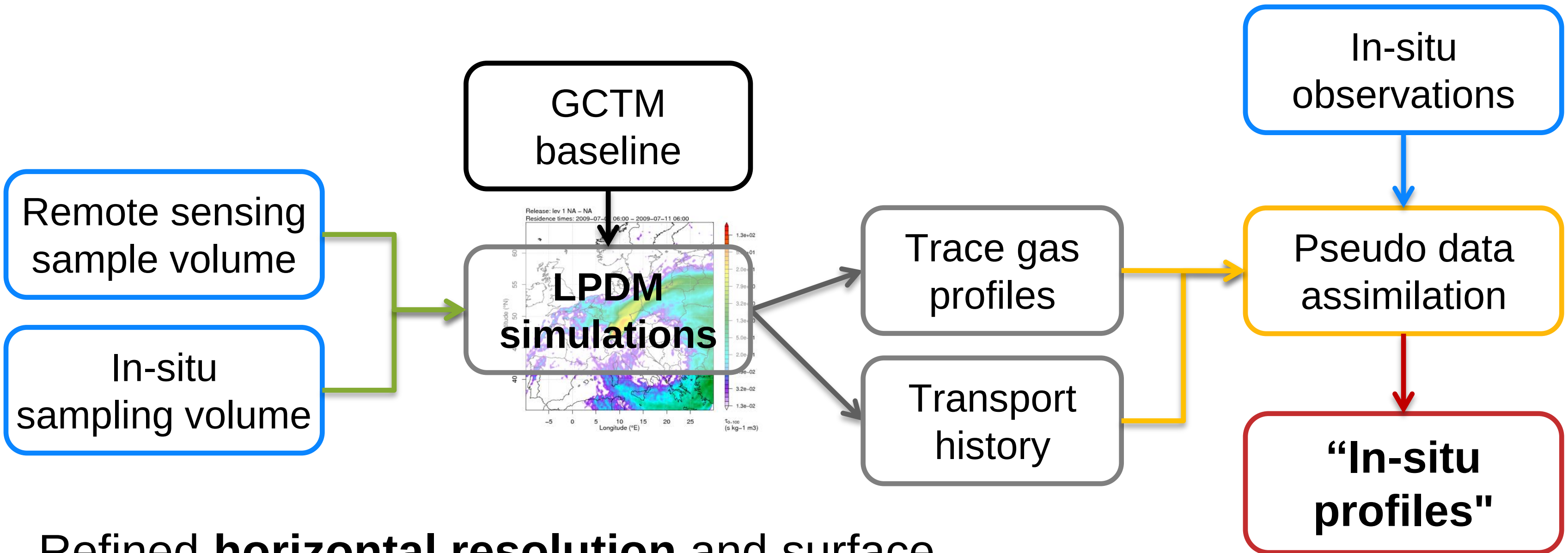
WP5: Validation and integration of tropospheric composition measurements

Main objective

- Further validate NORS products at two demonstration sites (**Jungfraujoch** and **Izaña**) by linking them to **surface in-situ** measurements
- **Surface in-situ**
  - Very good **accuracy**, **traceability (SI)**
  - **Collocated** with remote sensing sites
  - **Continuous** observations
- **Difficulties of comparison**
  - **Representativeness**
  - **Sensitivity of remote sensing**
  - Individual partial columns not independent
  - ➢ Apply **averaging kernel** (AVK)
- **NORS**
  - Characterise **representativeness** of different sampled air masses
  - Construct **calibrated "in-situ profiles"** by blending surface observations with model profiles



In-situ Profile vs. Direct Model Comparison



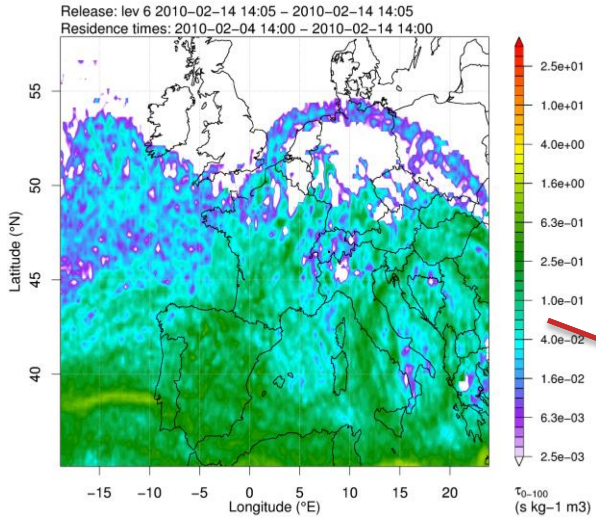
- Refined **horizontal resolution** and surface representation
- Refined transport to specific sampling volume: reducing the **representativeness error** that arises in grid box models
- **Transport history** accessible for each sub-column
- Separation into background and pollution contribution
- Direct relaxation towards surface data only for sub-columns with similar air mass history

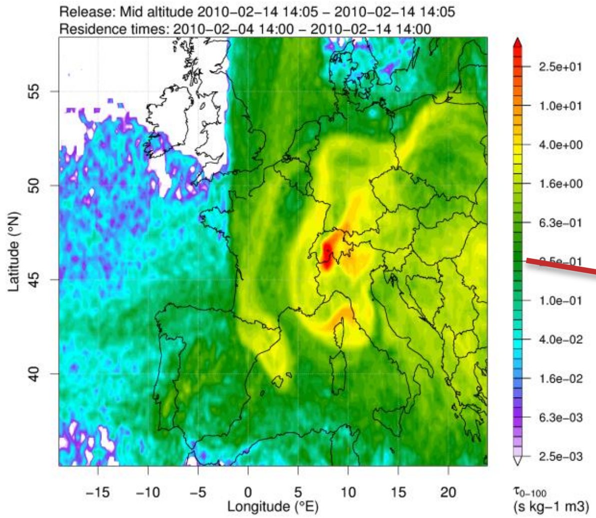
D5.1

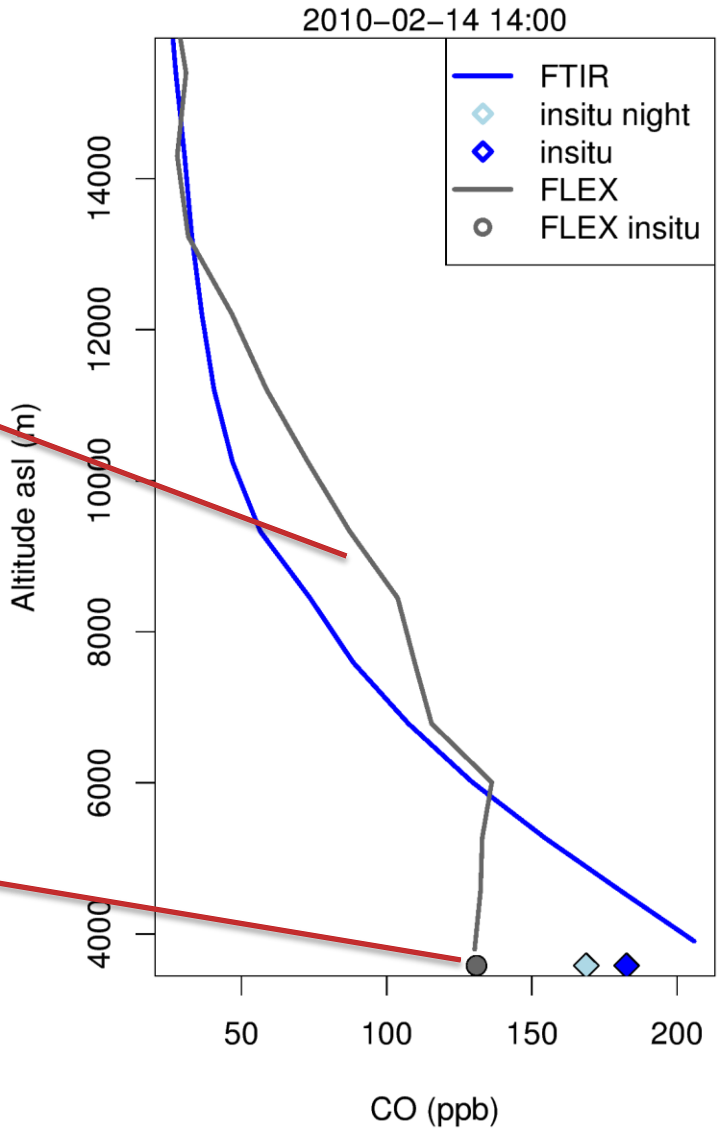
Limitations

- Method not based on a rigorous mathematical framework
- Currently, method does not include uncertainty propagation from surface in-situ to reference profile
- Method requires a model simulation that is locally not too biased
  - Model validation by independent observations required (surface + profile)
  - Model validation + surface correction vs. data assimilation
- Method best for passive tracers (as treated in the LPDM); for reactive species additional tuning may be required
- Validity of profile adjustment not validated

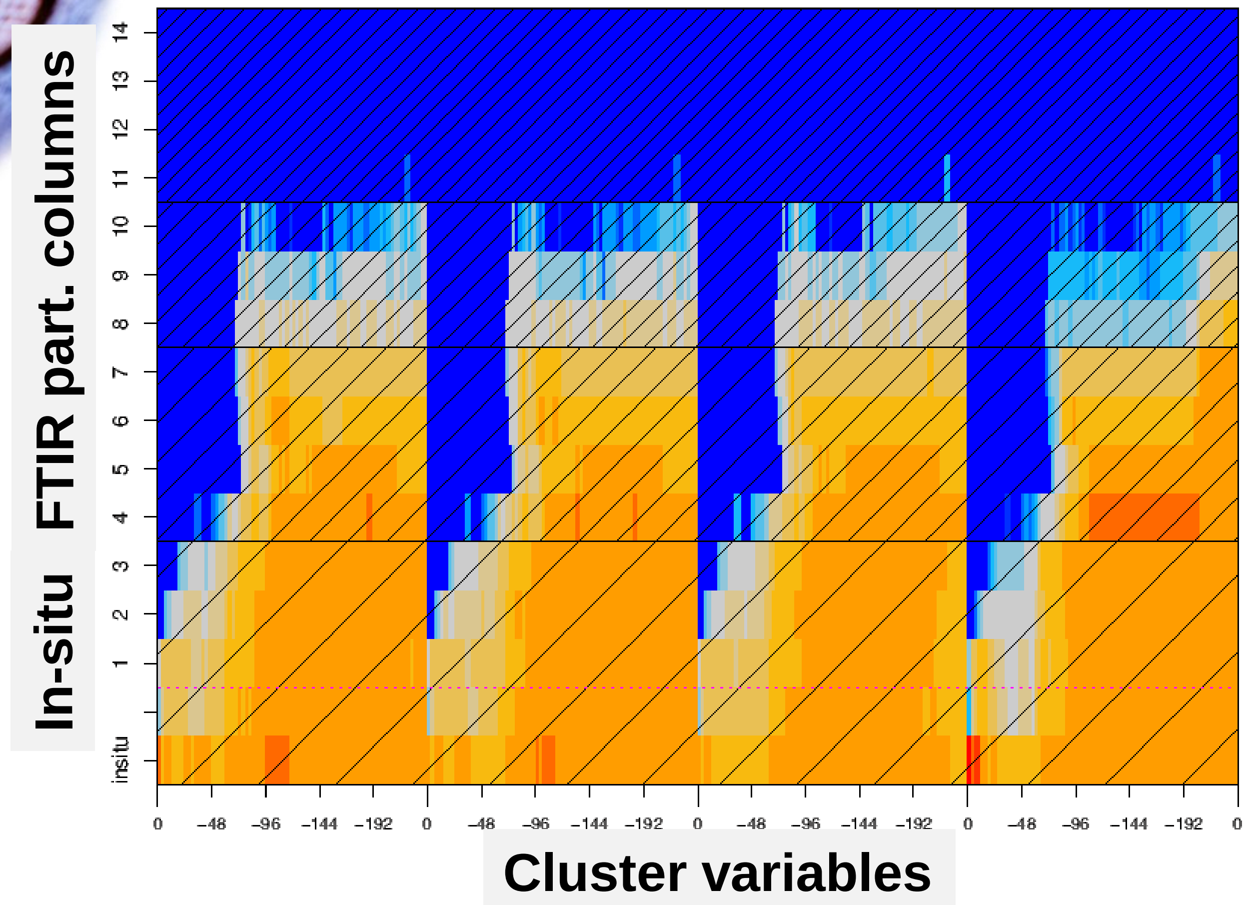
Example Profile: Jungfraujoch, CO 2012-02-14 14:00







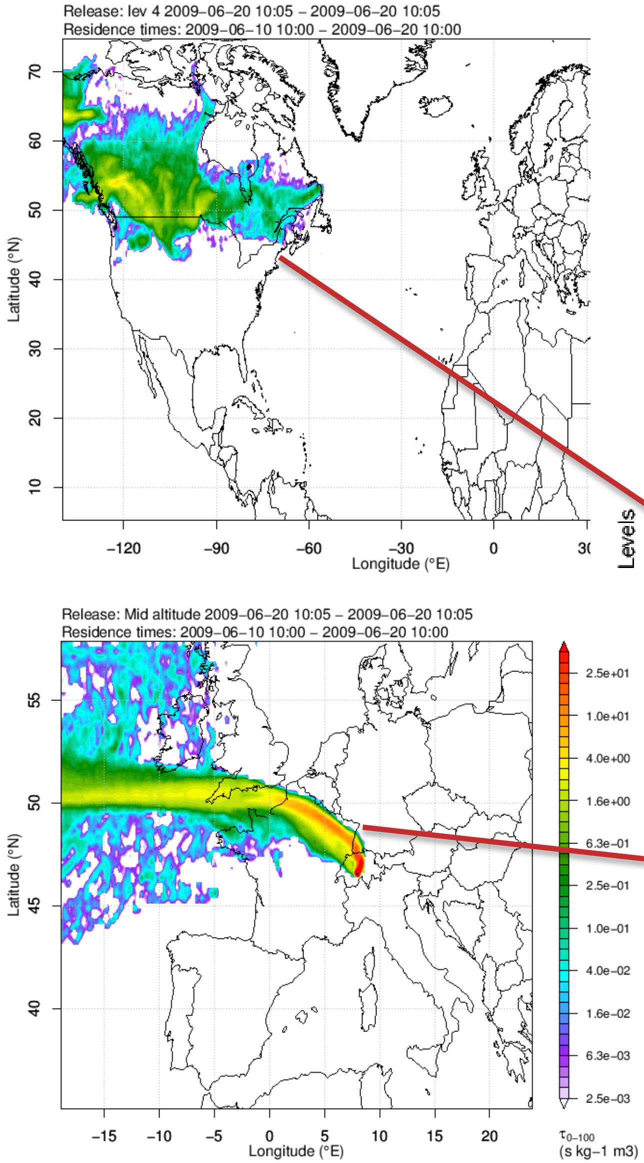
How to Distinguish Atmospheric Layers



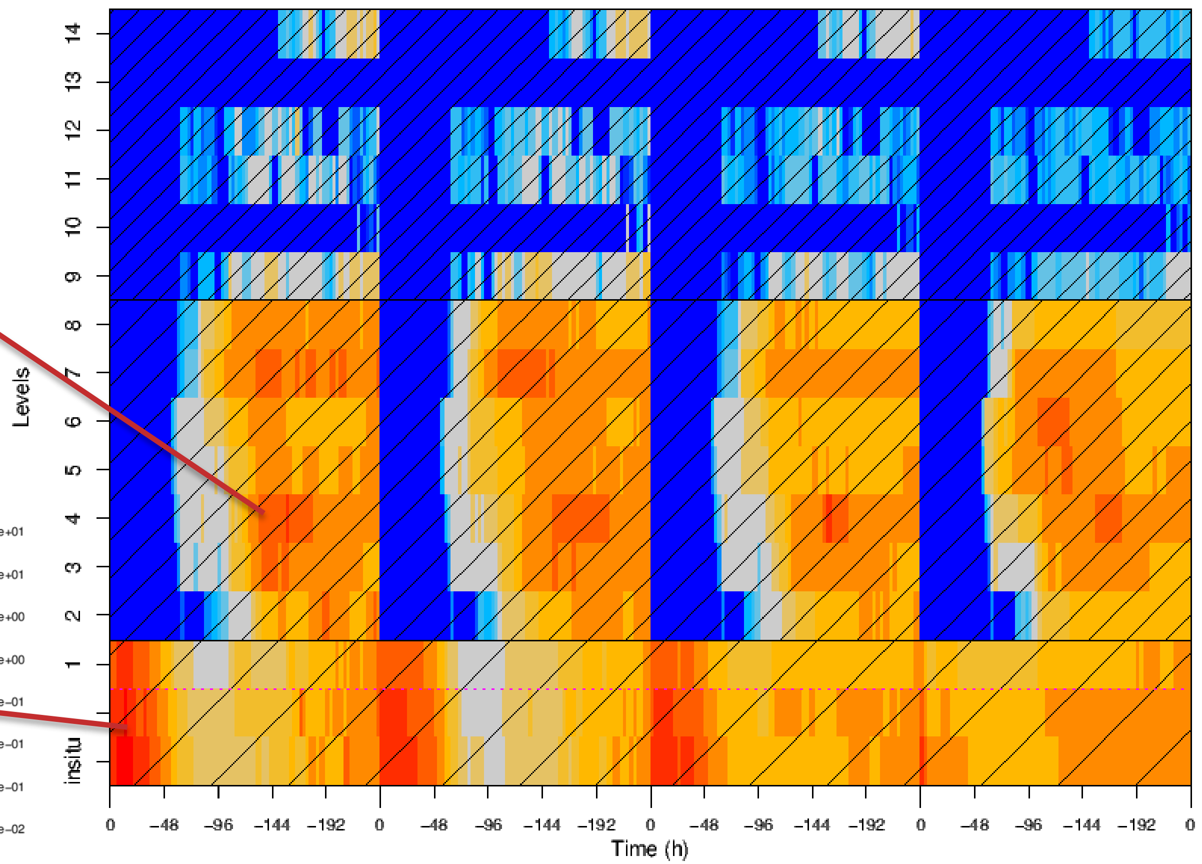
Clustering of FLEXPART footprints

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

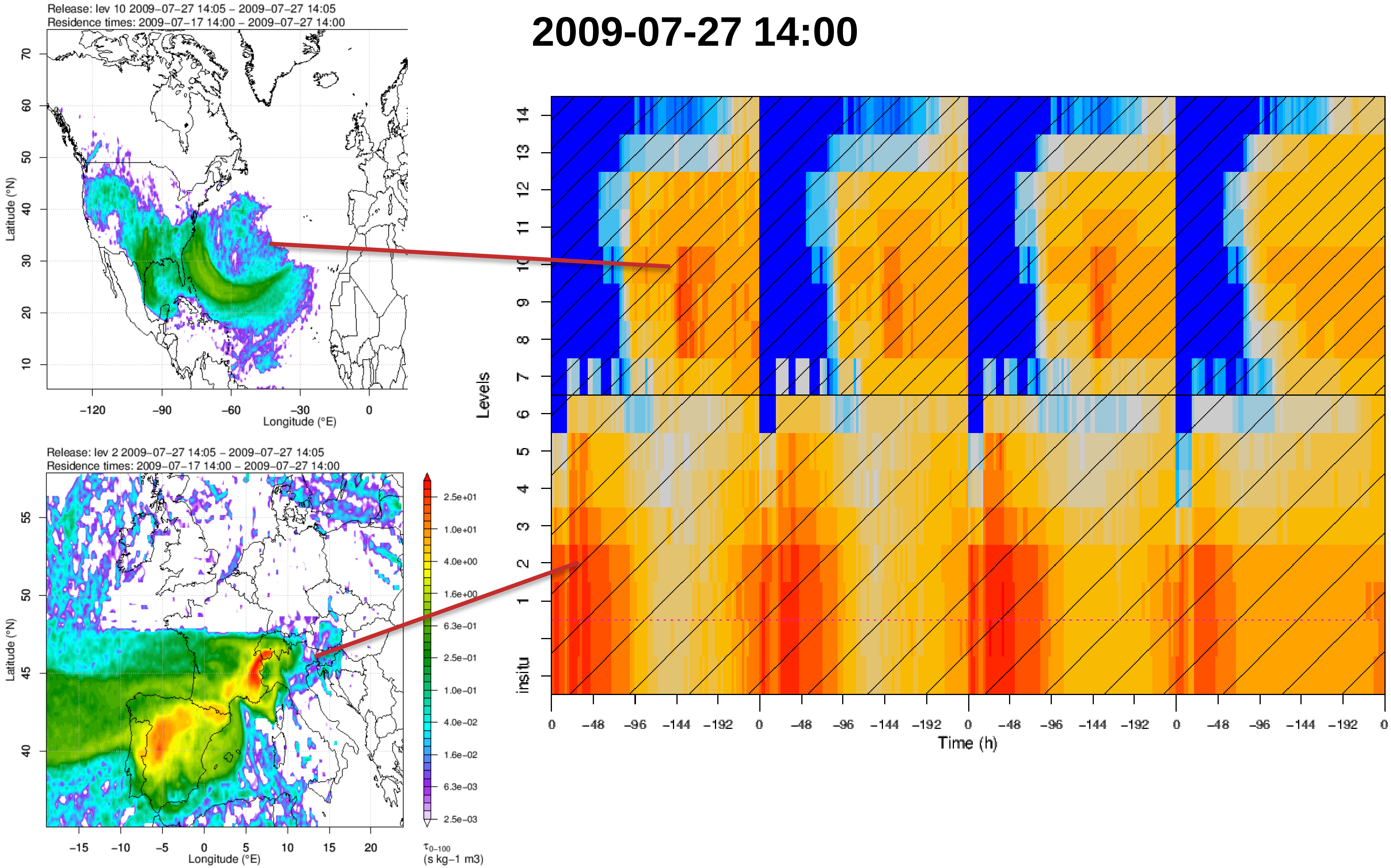
Footprint Clustering: Shallow in-situ Layer



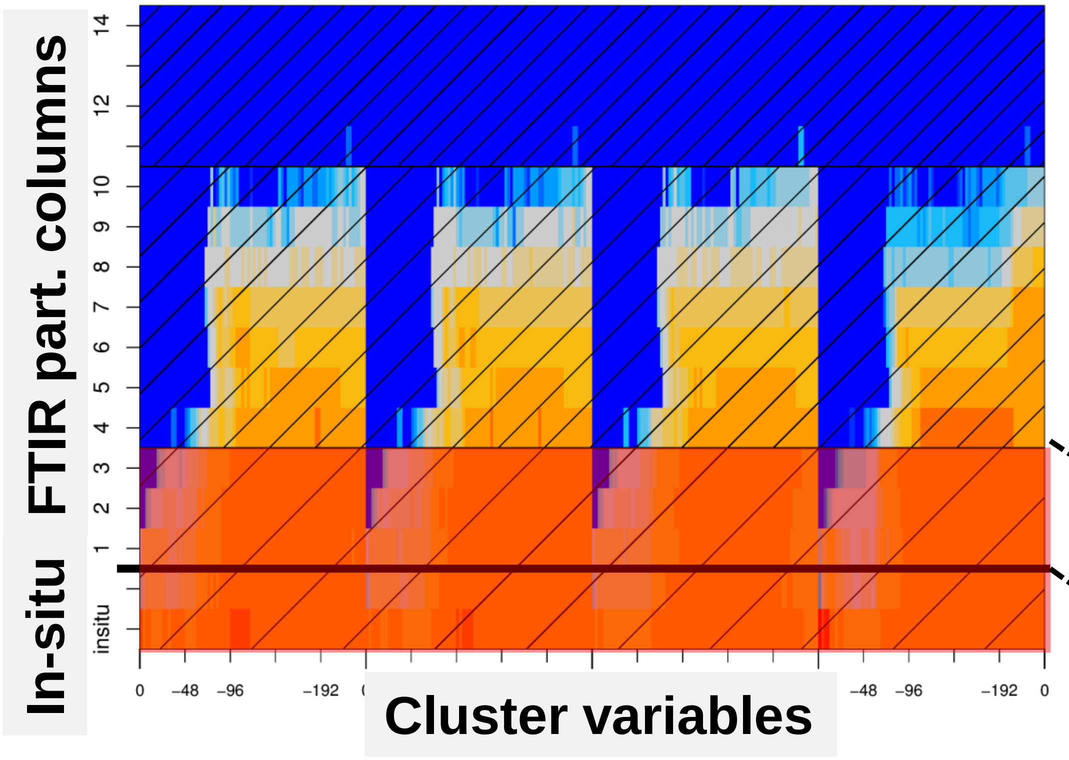
2009-06-20 10:00

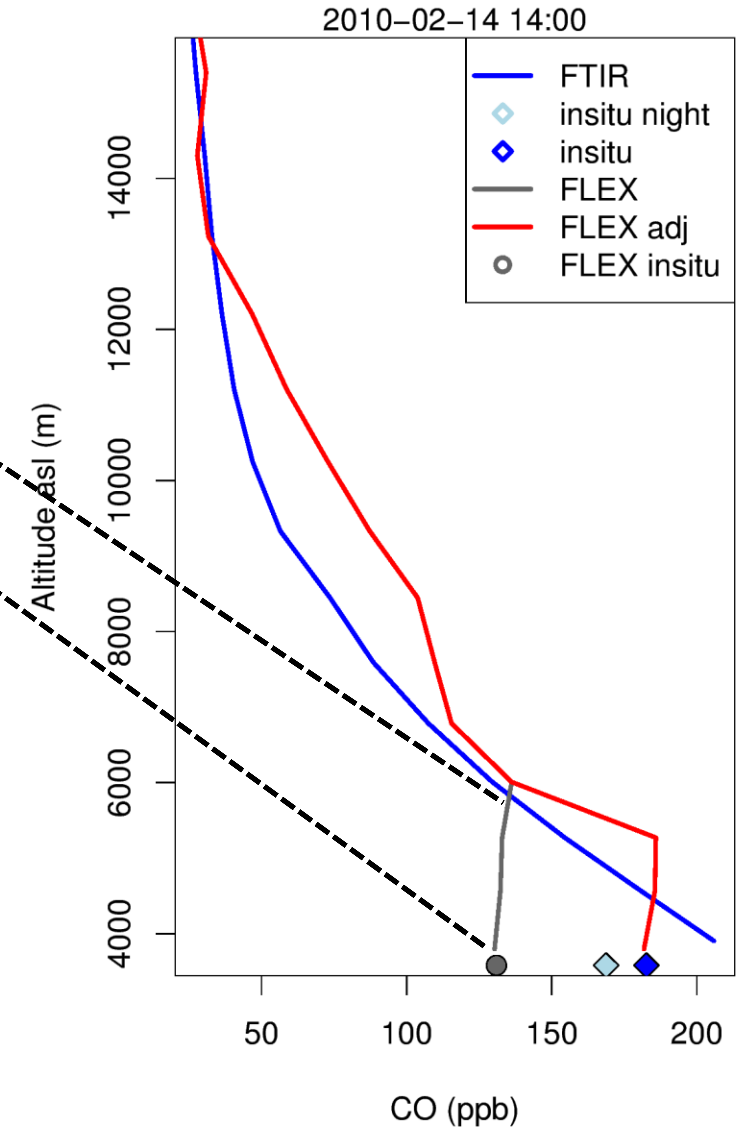


Footprint Clustering: Deep in-situ Layer



Adjustment of Model Profile

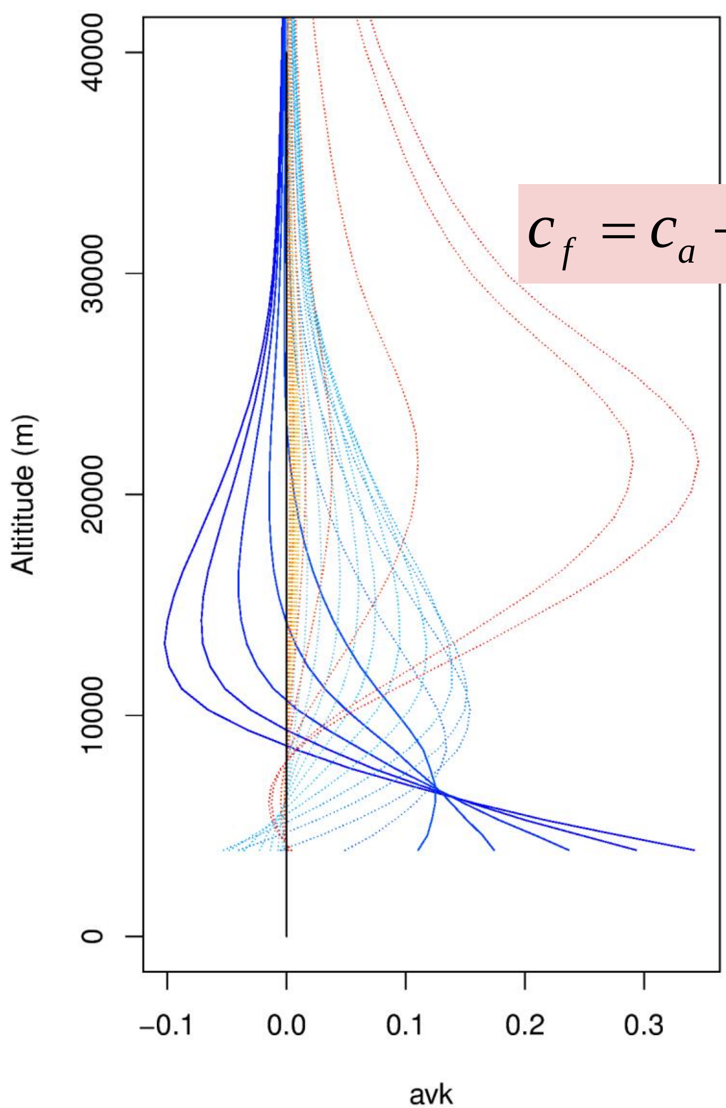




Adjustment

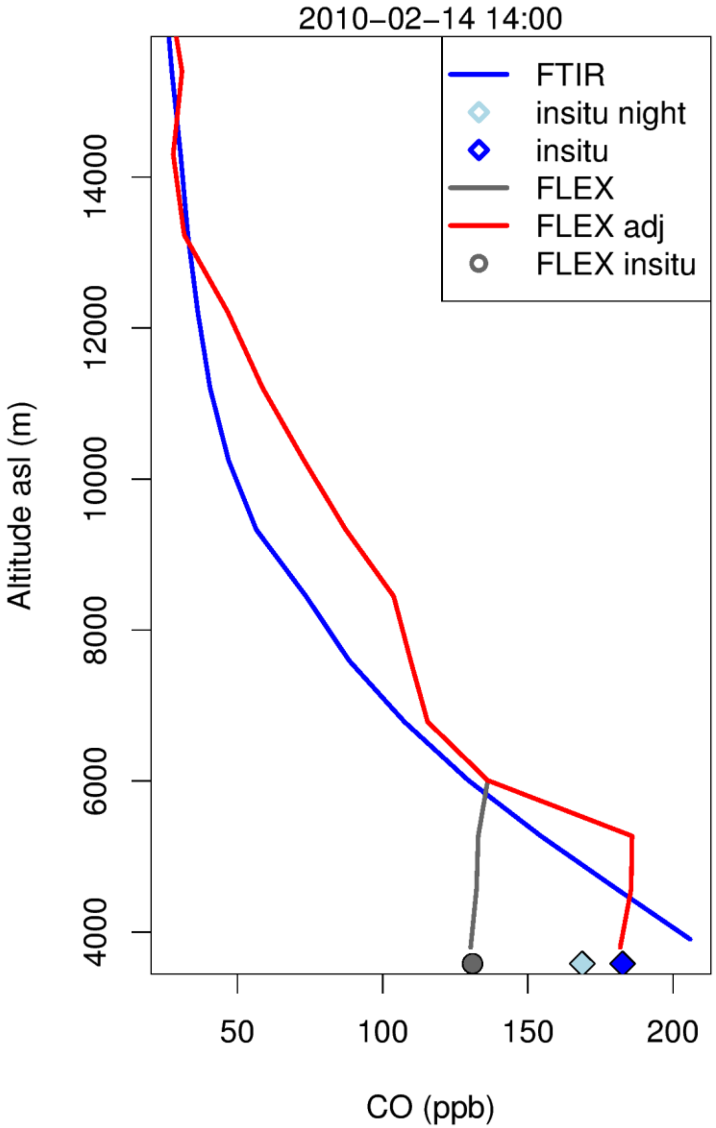
- Separating background and pollution
- Bias correction for background
- Factorial correction for pollution

Folding with Averaging Kernel and LFT Mean



$$c_f = c_a + A(c_m - c_a)$$

LFT mean

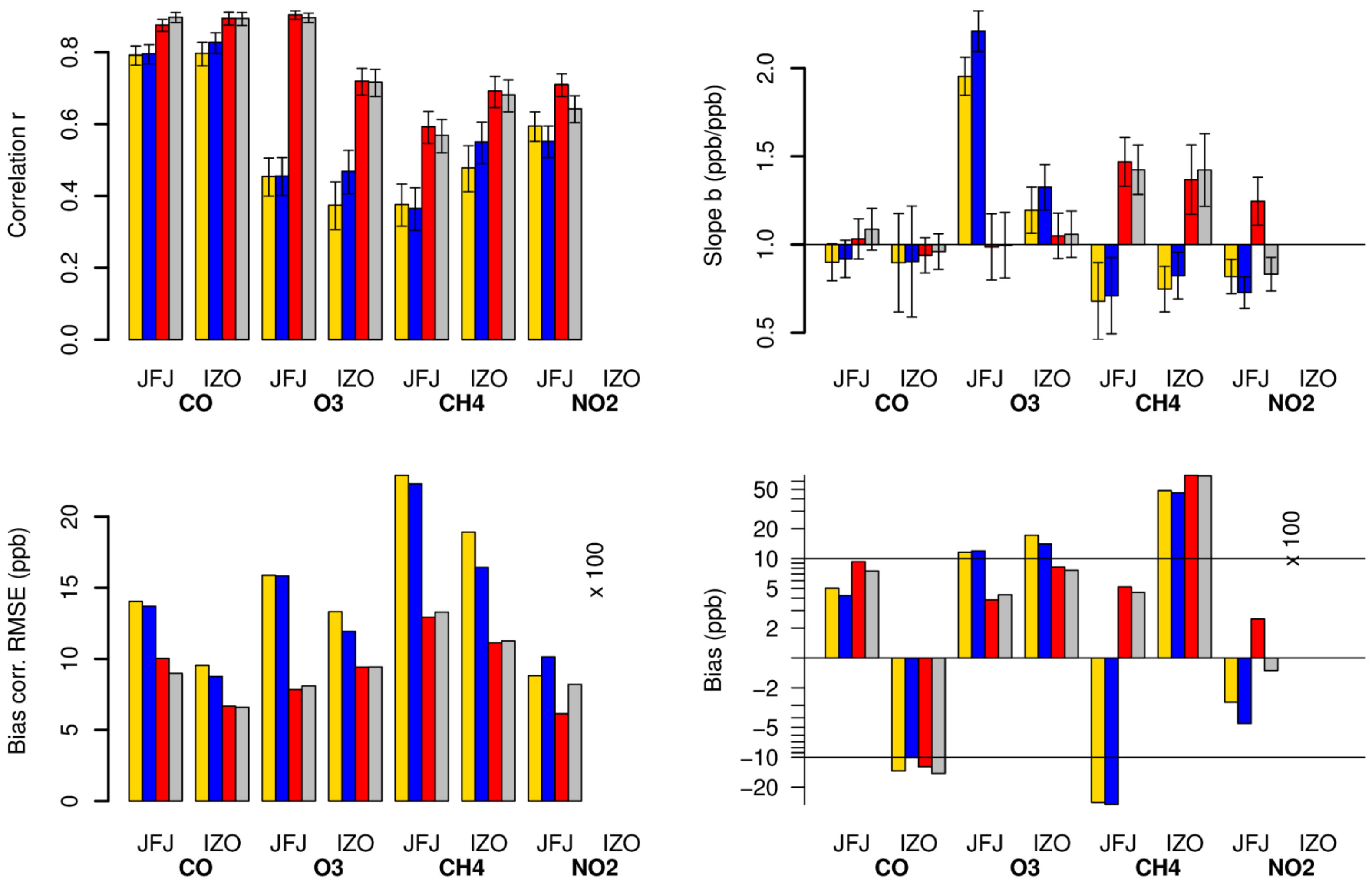


Comparison Datasets

Site	Parameter	Instrument	Retrival	Period	GCTMs
JFJ	CO	FTIR	Profile	2009-2011	FLEXCTM, MACC
JFJ	O_3	FTIR	Profile	2009-2011	MACC
JFJ	CH_4	FTIR	Profile	2009-2011	FLEXCTM, TM5, MACC
JFJ	NO_2	MAXDOAS	Profile	2011-2012	MACC
IZO	CO	FTIR	Profile	2009-2011	MACC, FLEXCTM
IZO	O_3	FTIR	Profile	2009-2011	MACC
IZO	CH_4	FTIR	Profile	2009-2011	FLEXCTM, TM5, MACC
IZO	O_3	MAXDOAS	MGA	2011-2012	MACC
IZO	NO_2	MAXDOAS	MGA	2011-2012	MACC

D5.2

Comparison Statistics: Tropospheric Column (DOF=1)

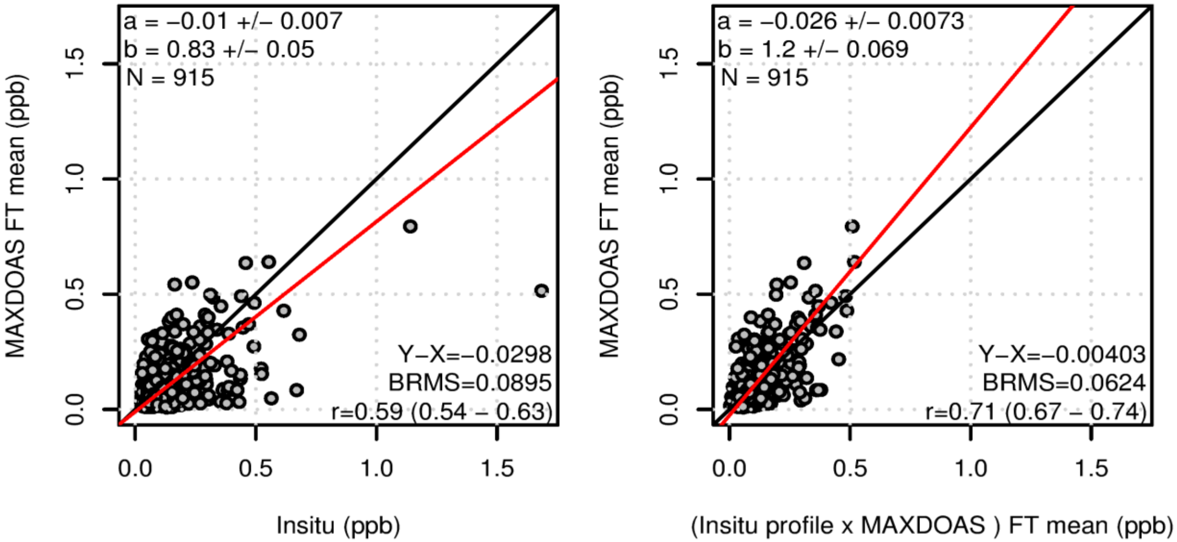


D5.3

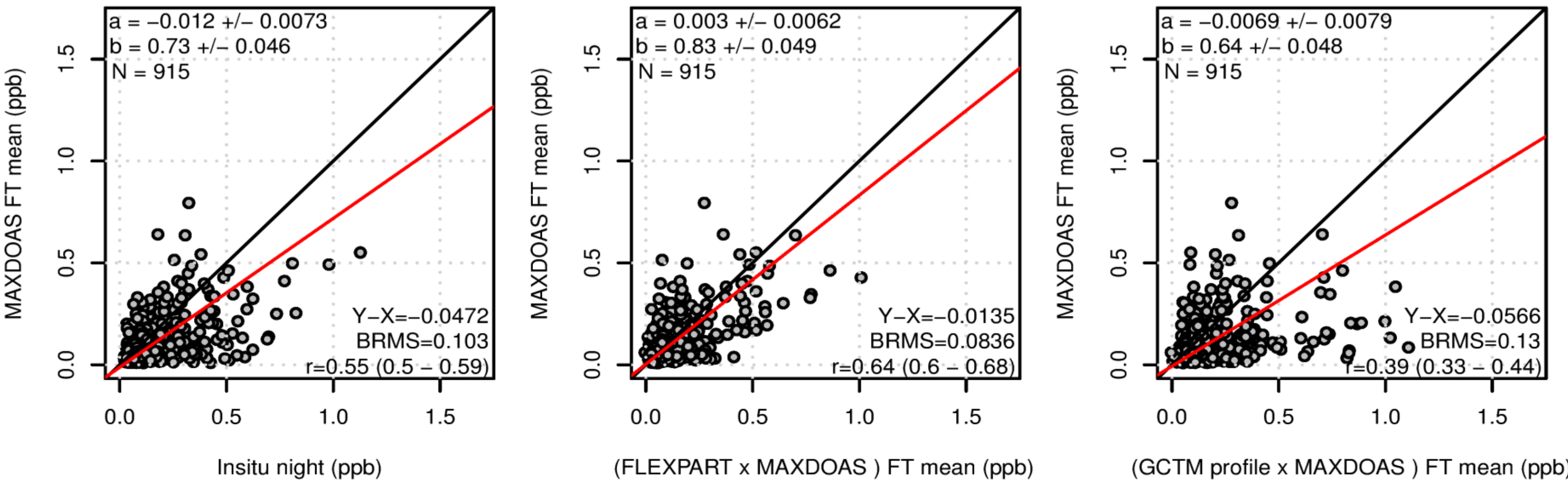
NO_2 MAXDOAS Jungfraujoch

in-situ comparisons

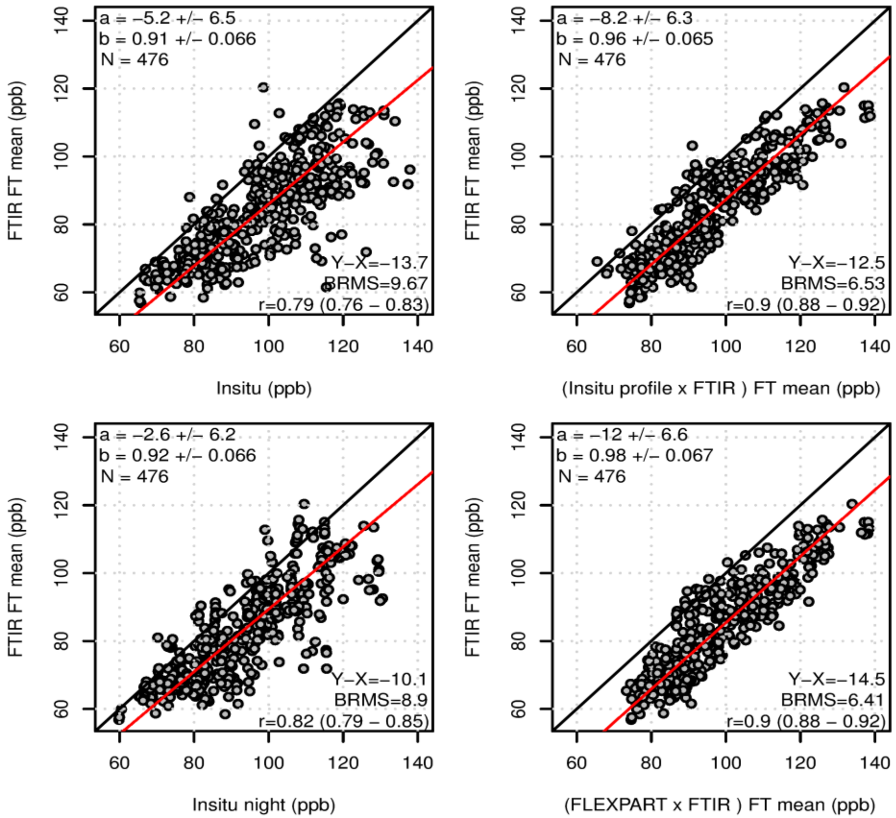
column comparisons

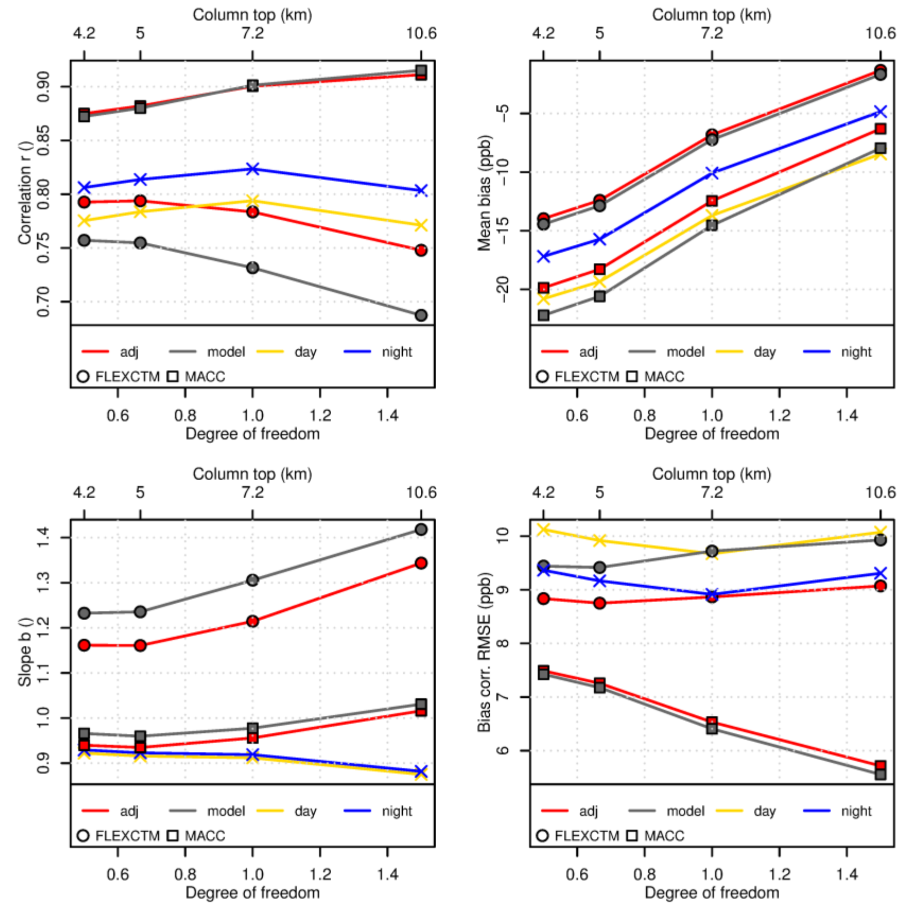


MAXDOAS column up to 4.06 km asl



CO FTIR Izaña





Tropospheric column up to 7.2 km asl

Dependence on column height

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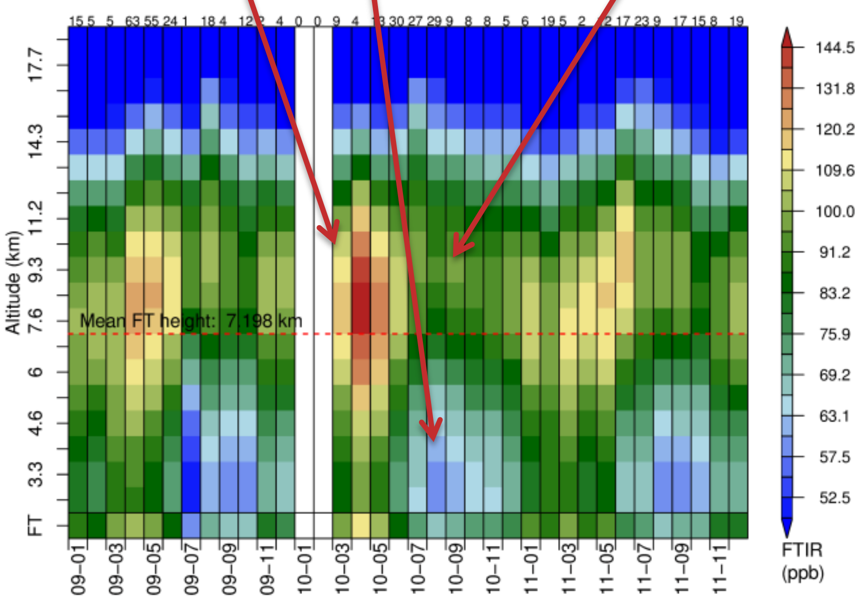
CO FTIR Izaña

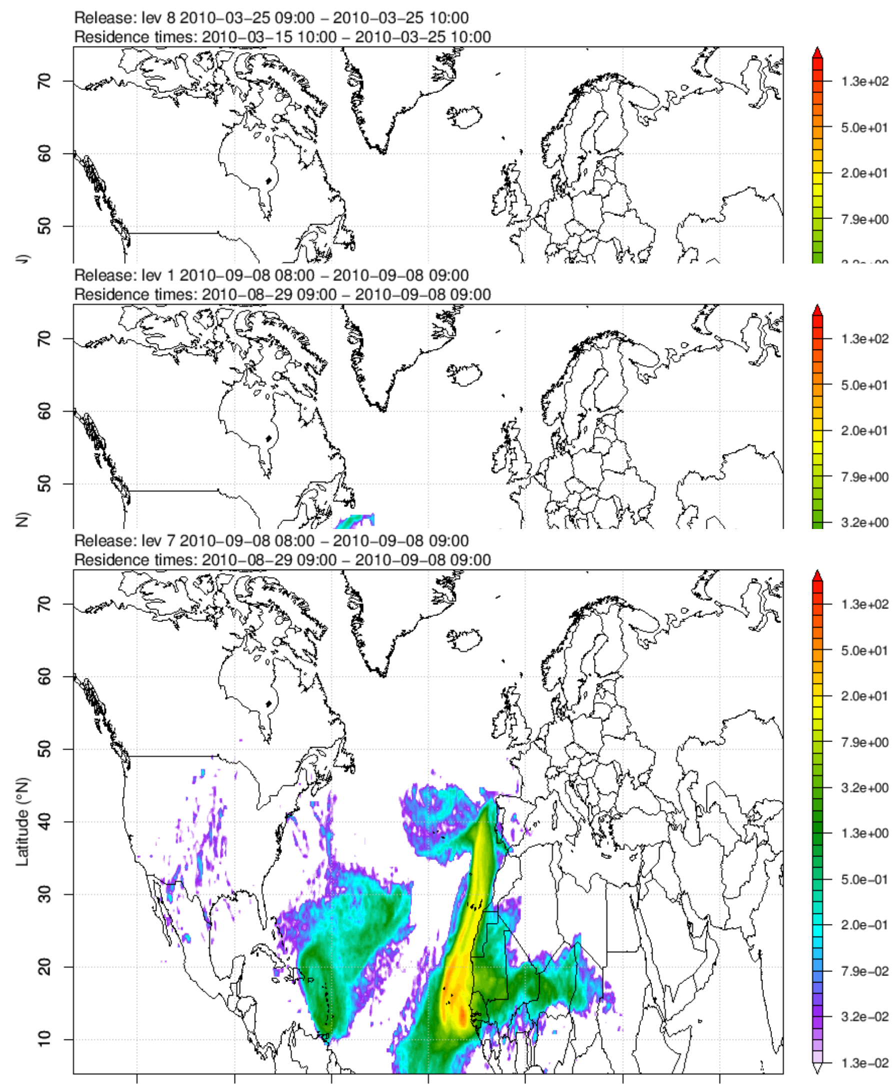
North American sources

Atlantic

North Africa

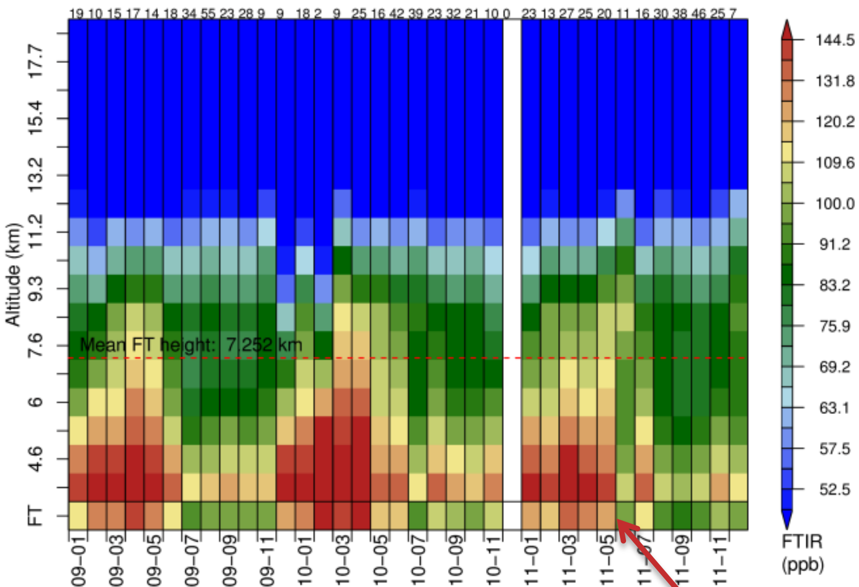


FTIR monthly mean concentrations

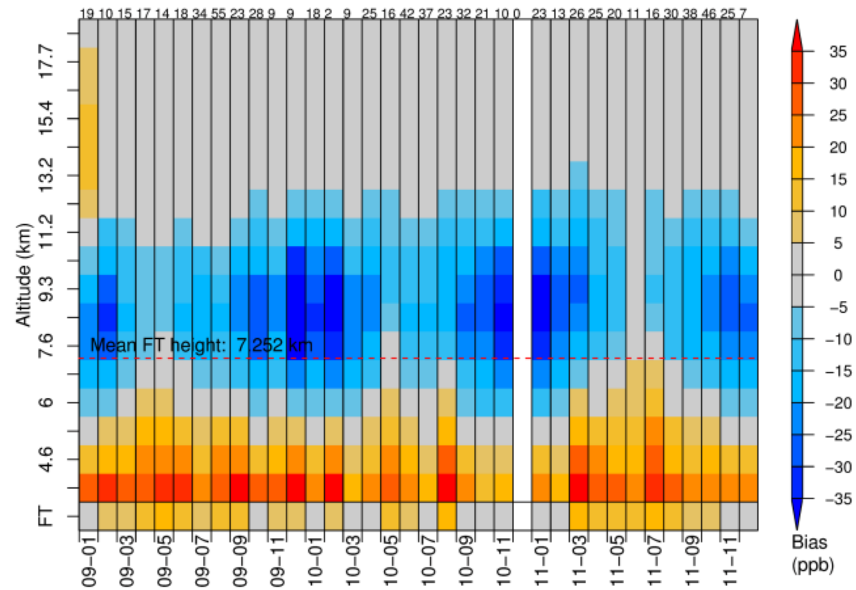


http://lagrange.empa.ch/NORS_browser/

CO FTIR Jungfraujoch



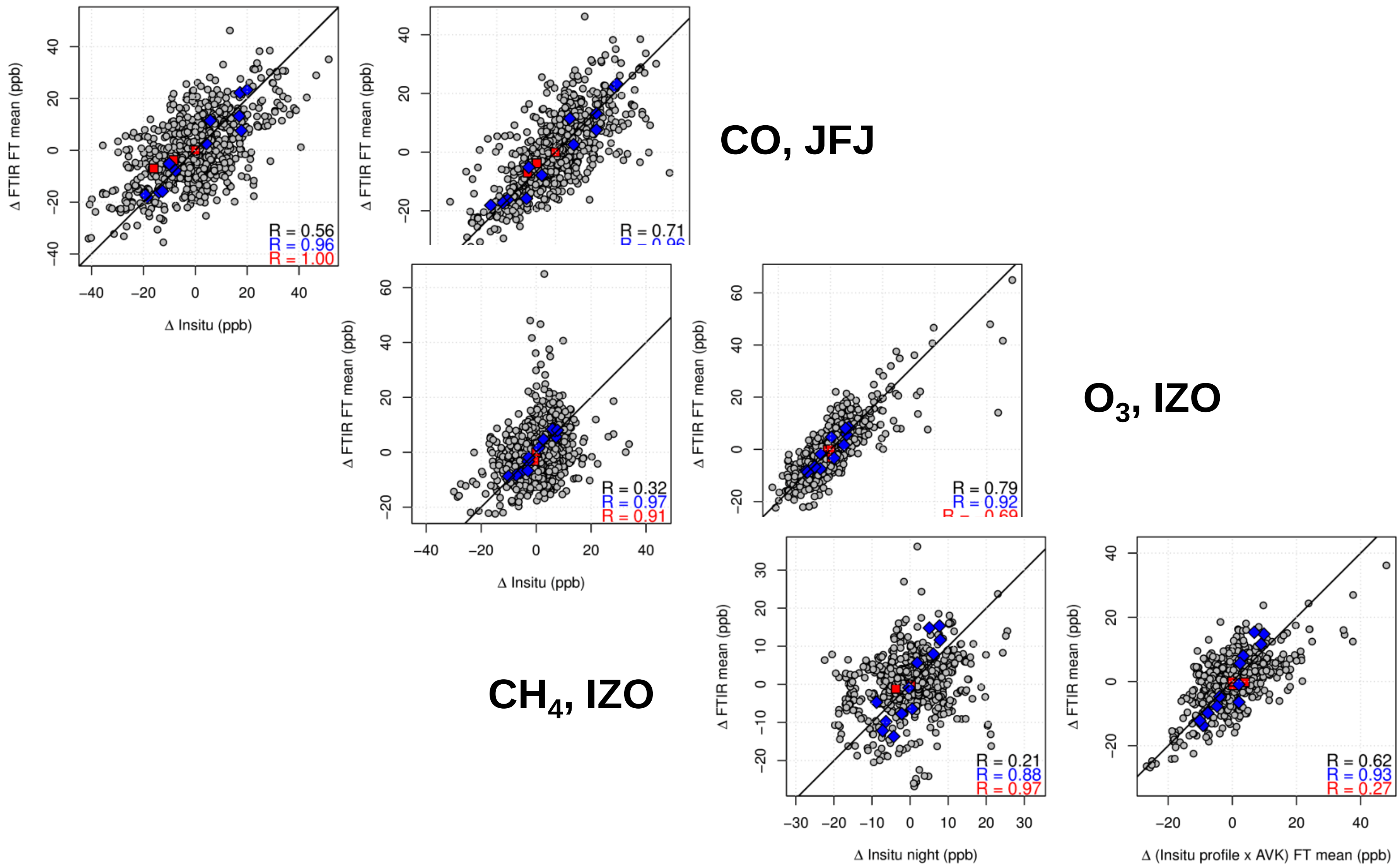
FTIR monthly mean concentrations



FTIR monthly mean bias

European PBL

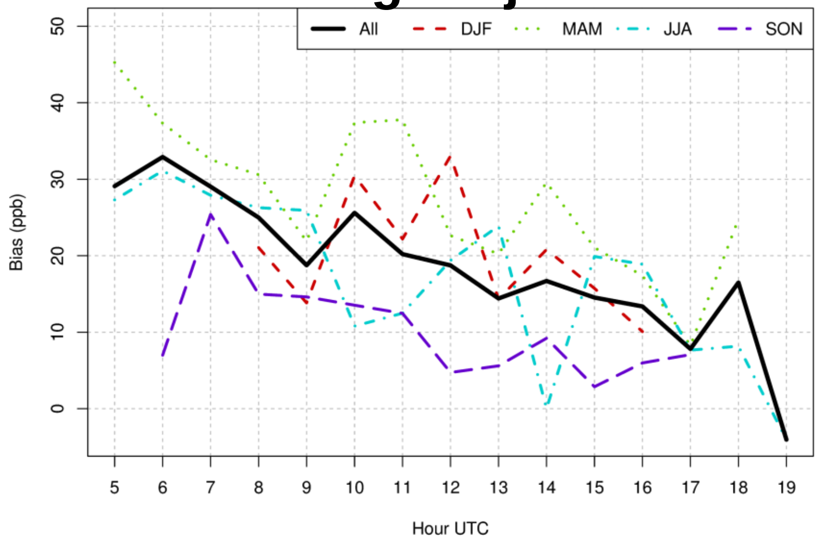
Temporal Variability

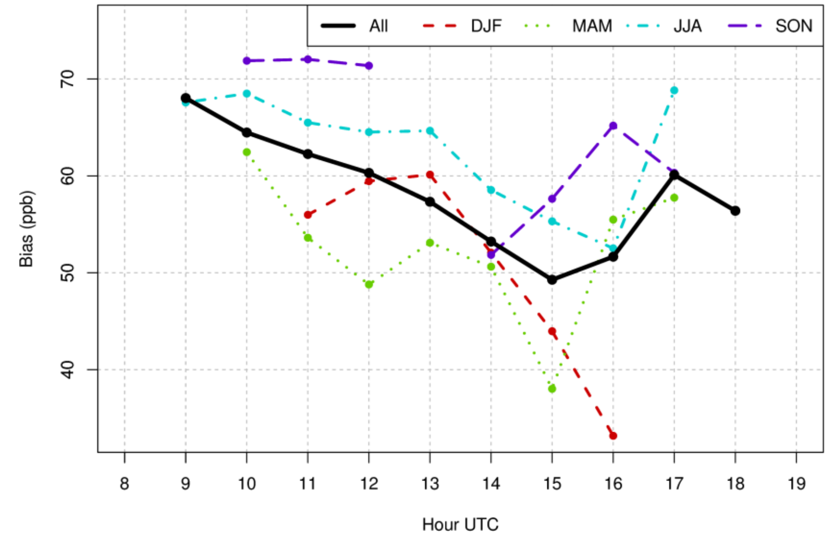


Diurnal Cycle of CH_4 Bias

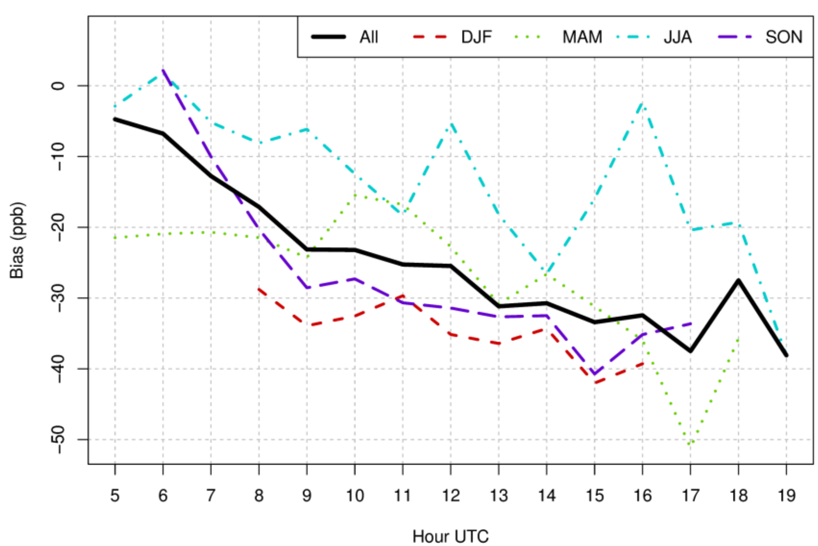
Jungfraujoch | Izaña

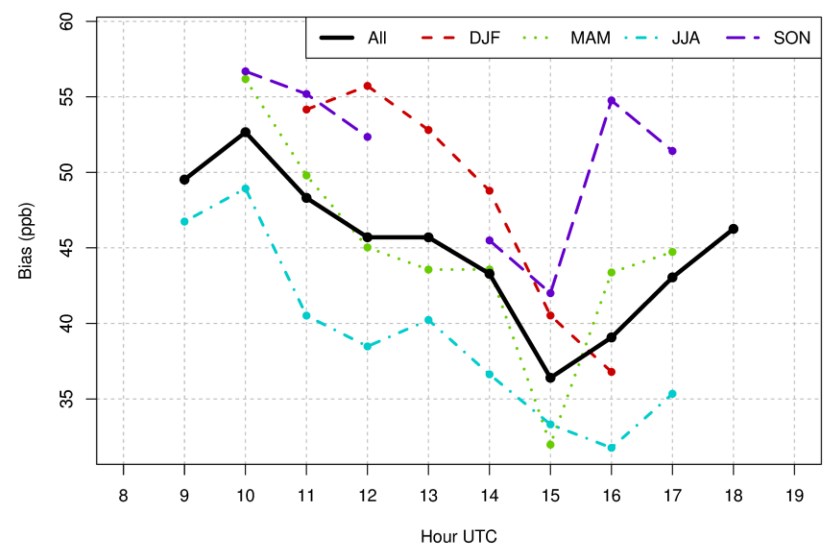
In-situ



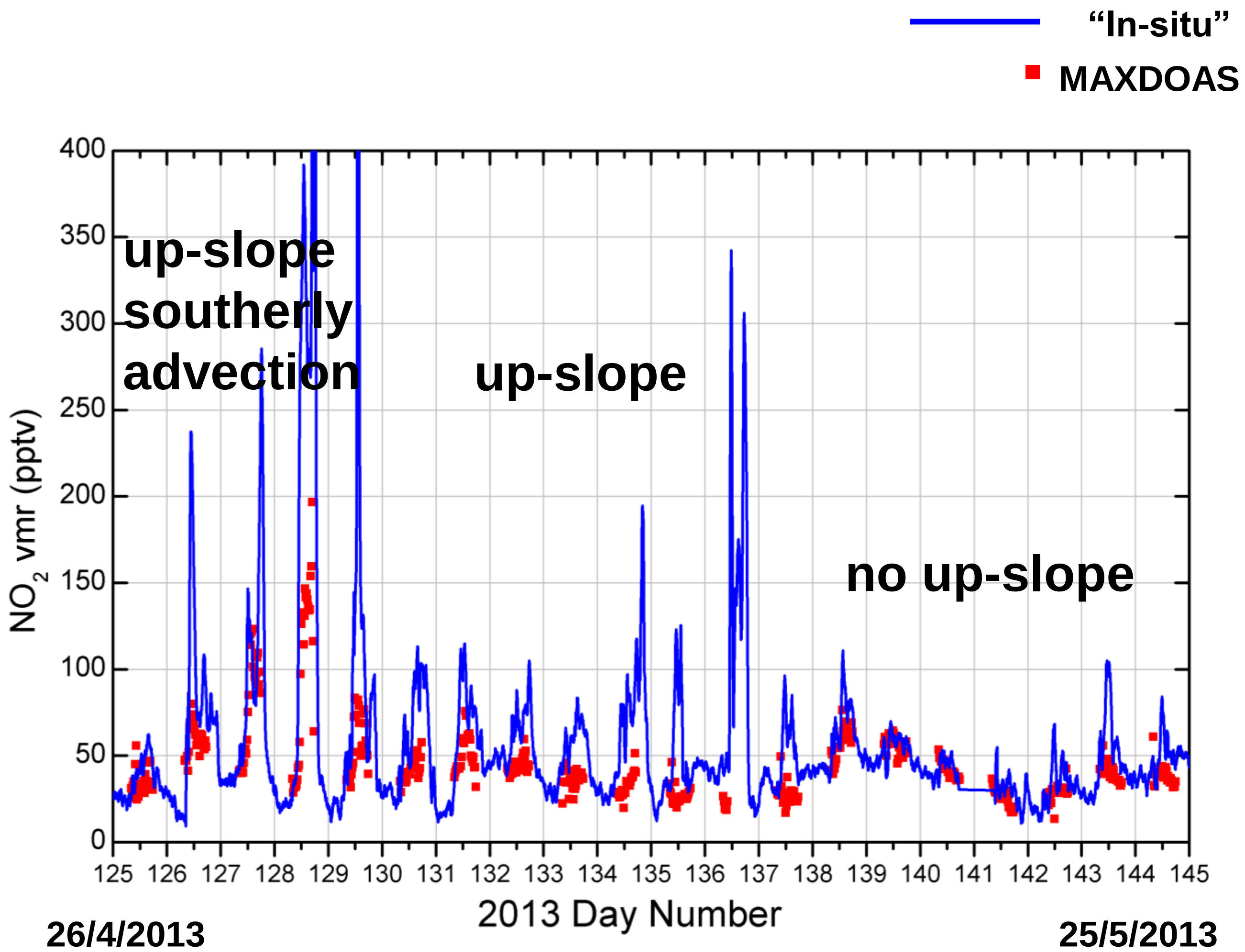


In-situ column

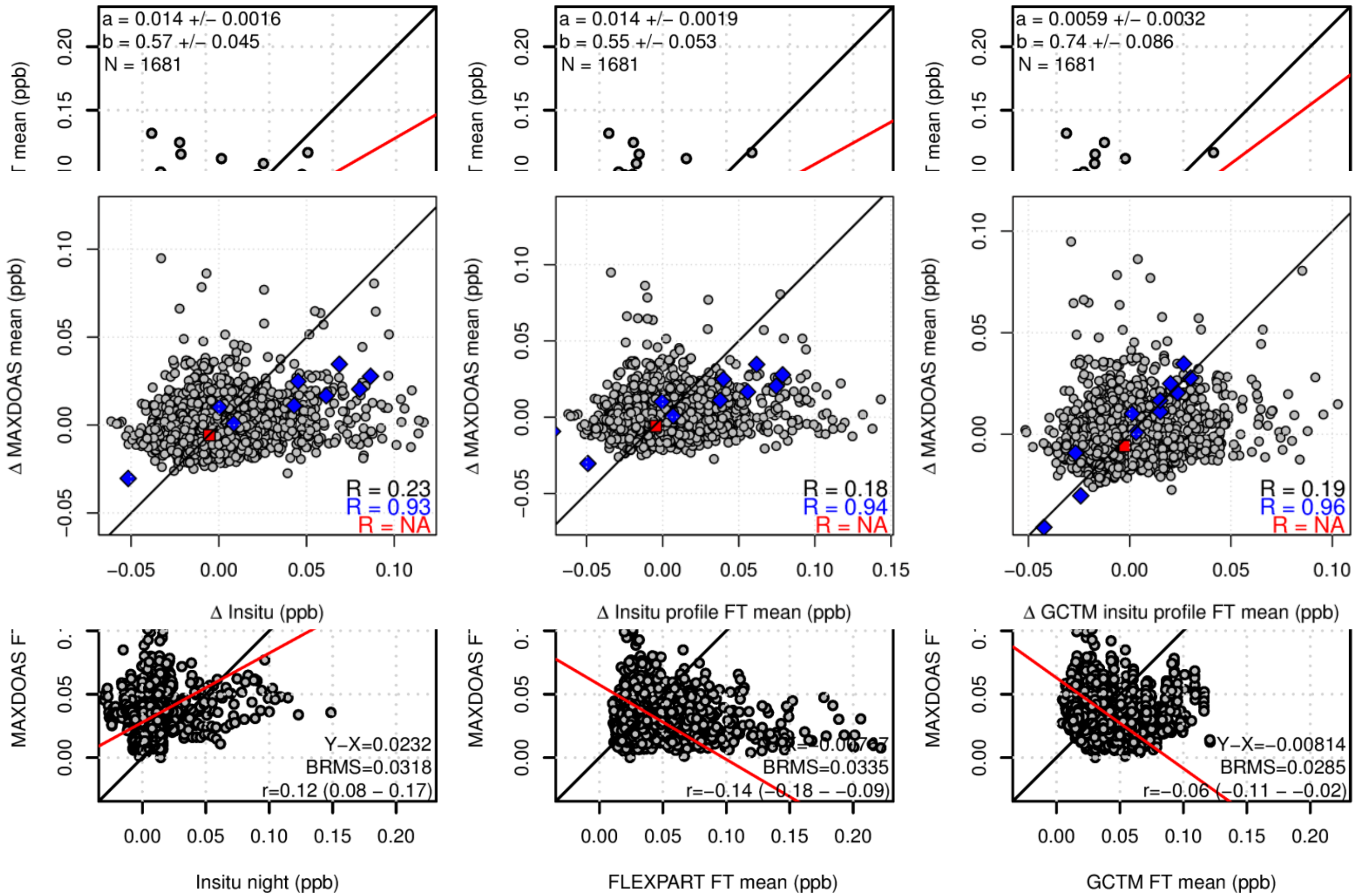




NO_2 MAXDOAS MGA Izaña

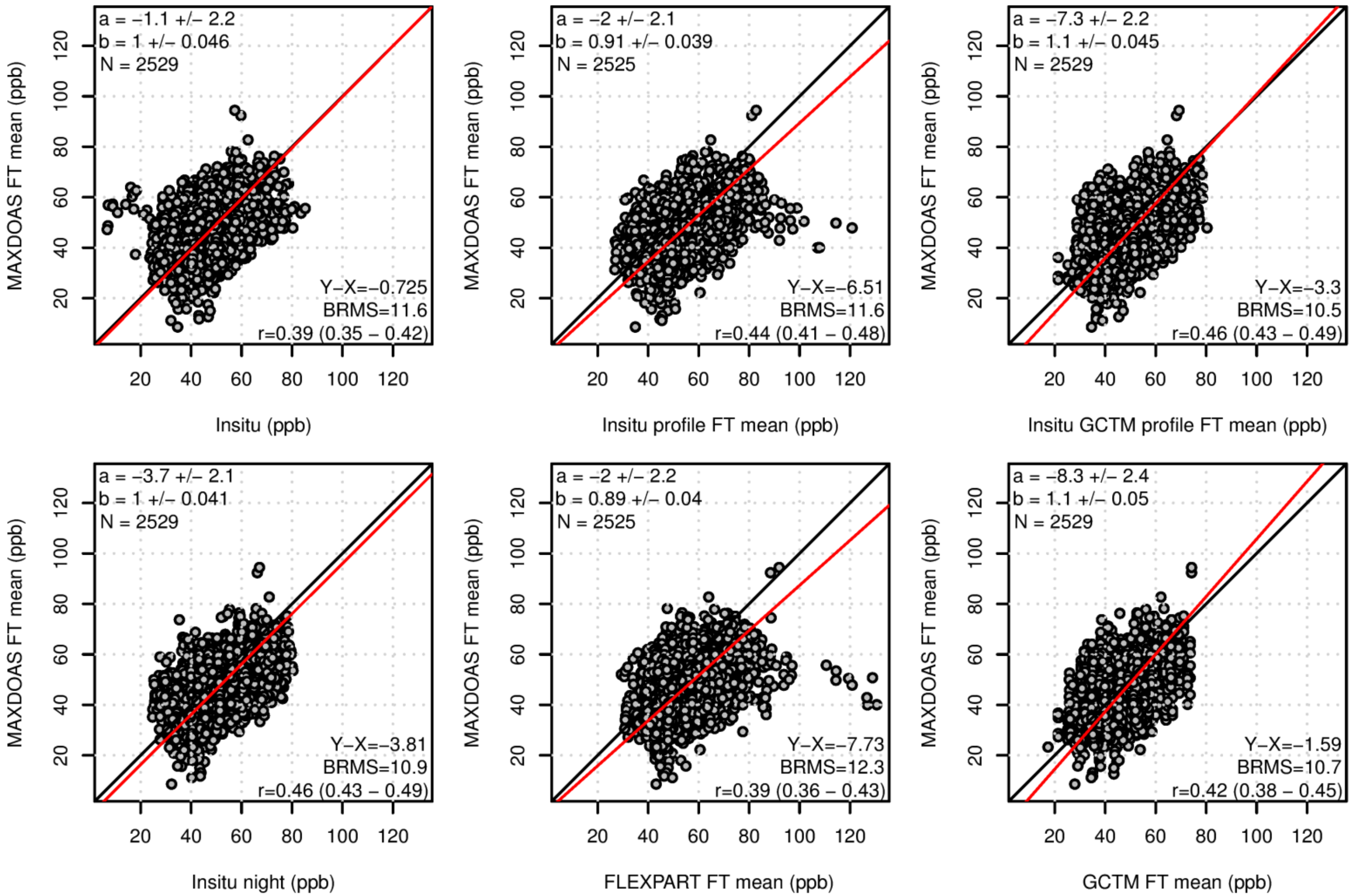


NO_2 MAXDOAS MGA Izaña



In-situ not suited for validation: local infulence, detection limit

O_3 MAXDOAS MGA Izaña



In-situ columns do not improve comparision: little representativeness of in-situ

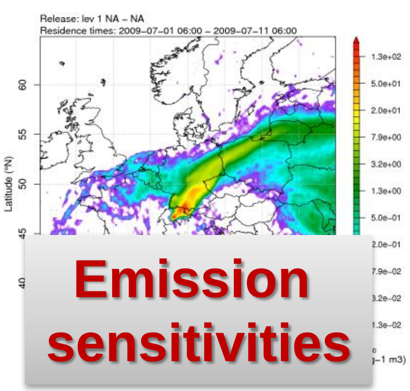
Conclusions

- WP5 mainly focussed on the development of a method to derive reference profiles from surface-in observations and independent model profiles
- Method offers a possibility to **quantitatively** validate remote sensing tropospheric products using surface in-situ observations
- It goes beyond a mere model to remote sensing comparison in that it incorporates dedicated transport simulations and an analysis of representativeness of the surface in-situ observation and transfers their information in the vertical (calibrating the model profile)
- Successfully applied to FTIR and MAXDOAS profile retrievals.
  - **Comparability enhanced** with in-situ profiles in contrast to in-situ only
    - increased correlation
    - decreased scatter
    - regression slopes close to unity for FTIR CO and O_3
    - reduced biases for all observations, but CH_4 at IZO
- Method reveals good ability of remote sensing techniques to detect **day-to-day variability**

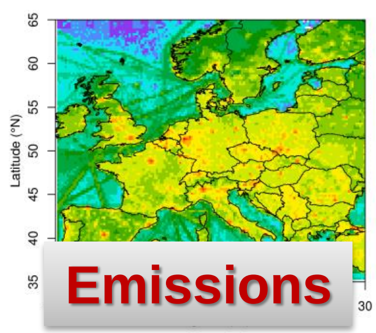
LPDM Simulations

- Run **backward** Lagrangian Particle Dispersion (**LPDM**) calculations for all **different sampled air volumes**
- Derive recent (10 days) **emission influence**
- Simulate **mole fractions** for tracers (CH_4, CO, O_3)
- Analysis of **representativeness** (comparison of recent influence) for filtering and in-situ extrapolation

C =



X



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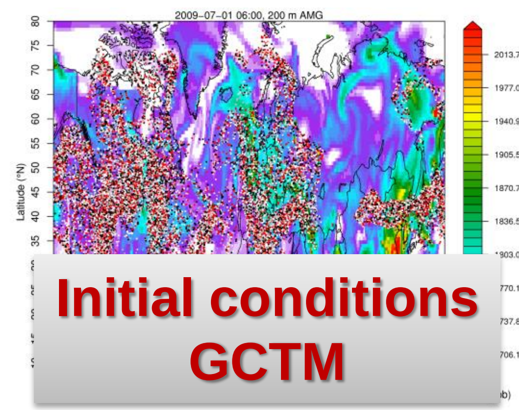


FLEXPART-LPDM

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

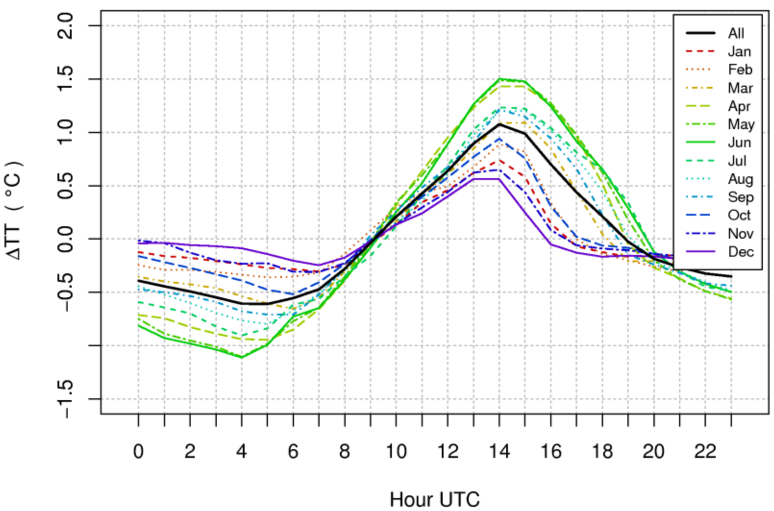
MACC Re-analysis
FLEXCTM
TM5

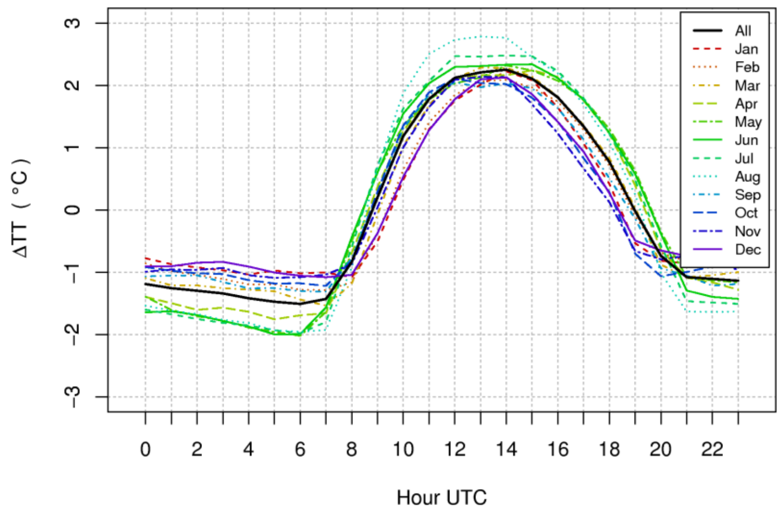
In-situ Diurnal Cycle

Jungfraujoch, 3580 m asl

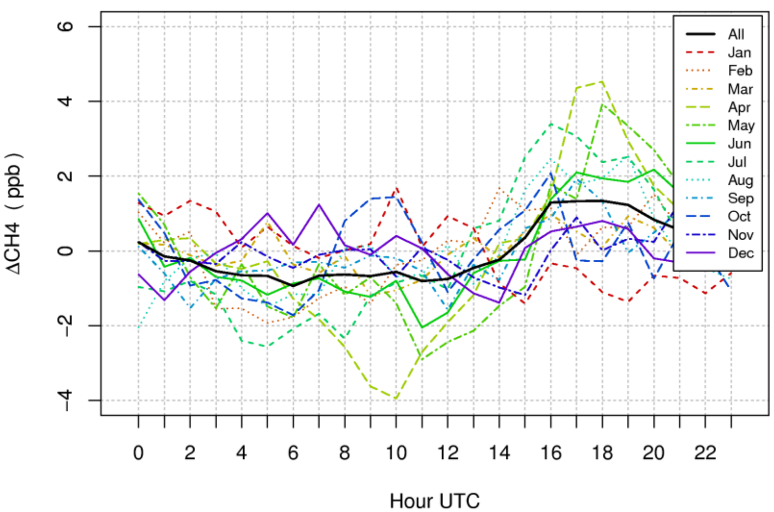
Izaña, 2370 m asl

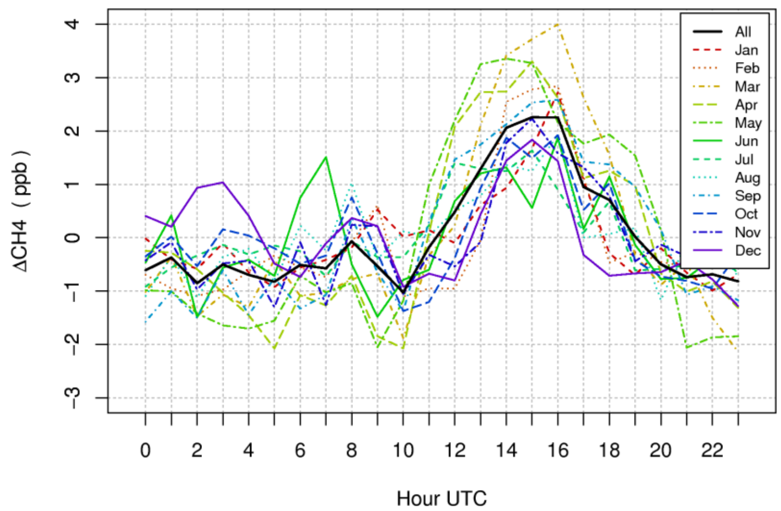
Temperature





Methane





In-situ Diurnal Cycle

Jungfraujoch, 3580 m asl

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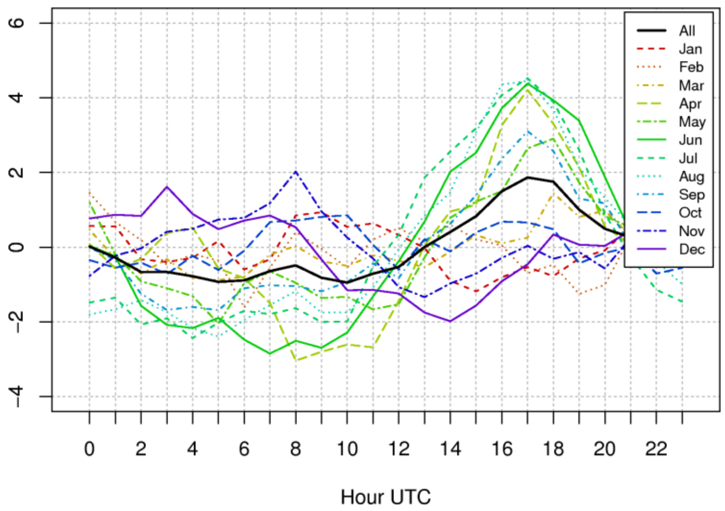
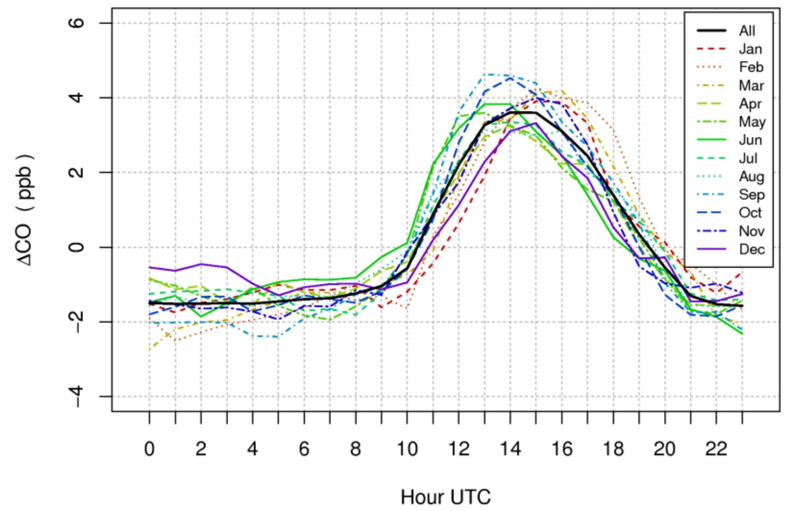
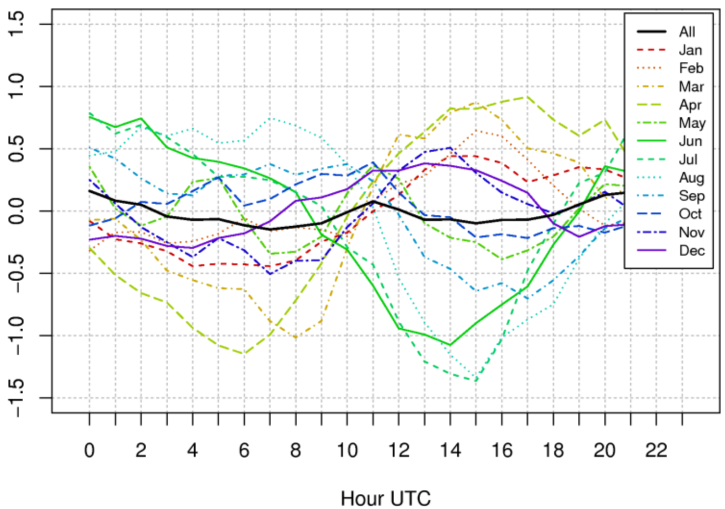
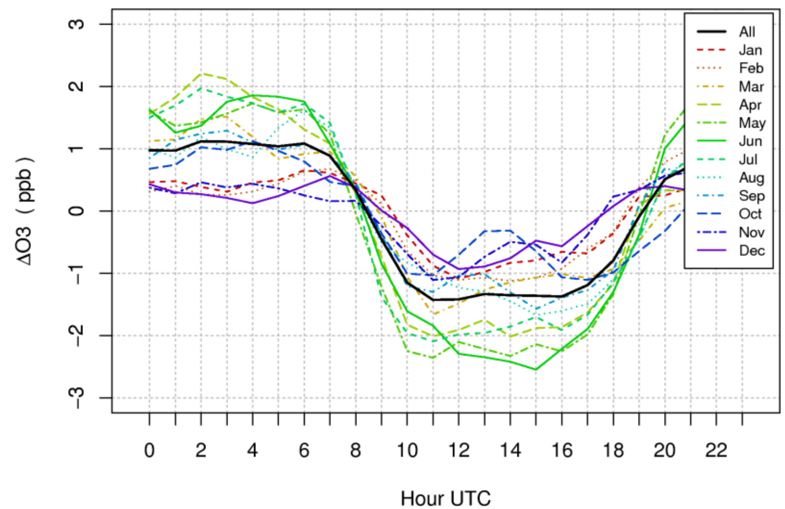
Carbon Monoxide



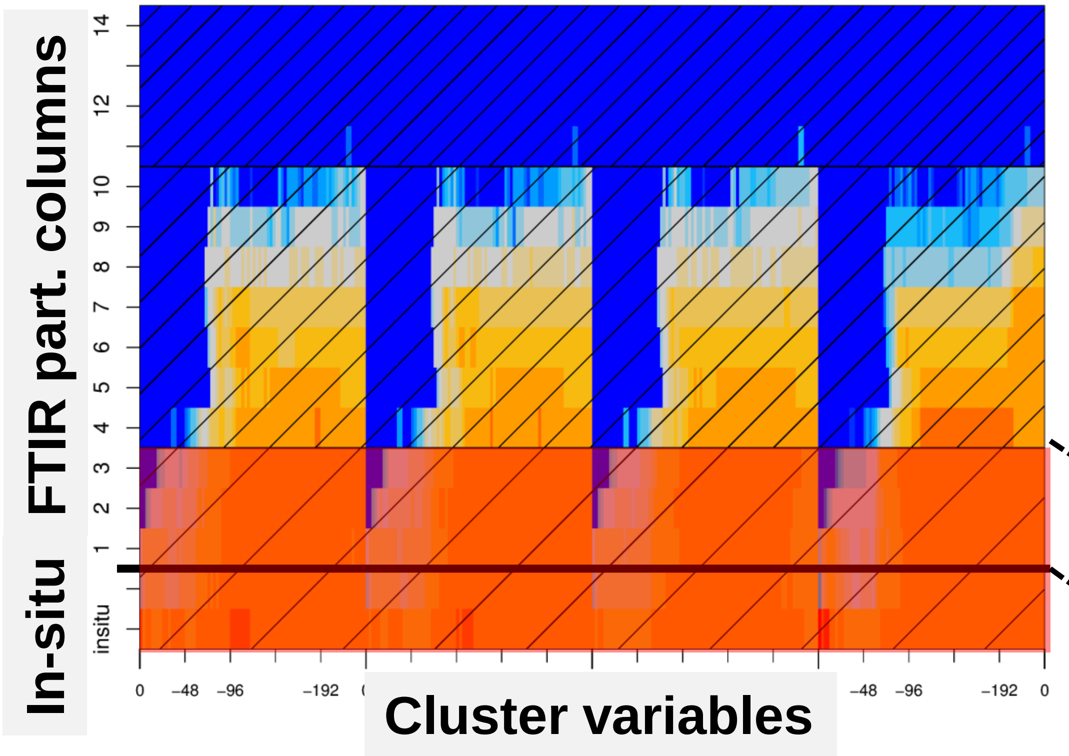


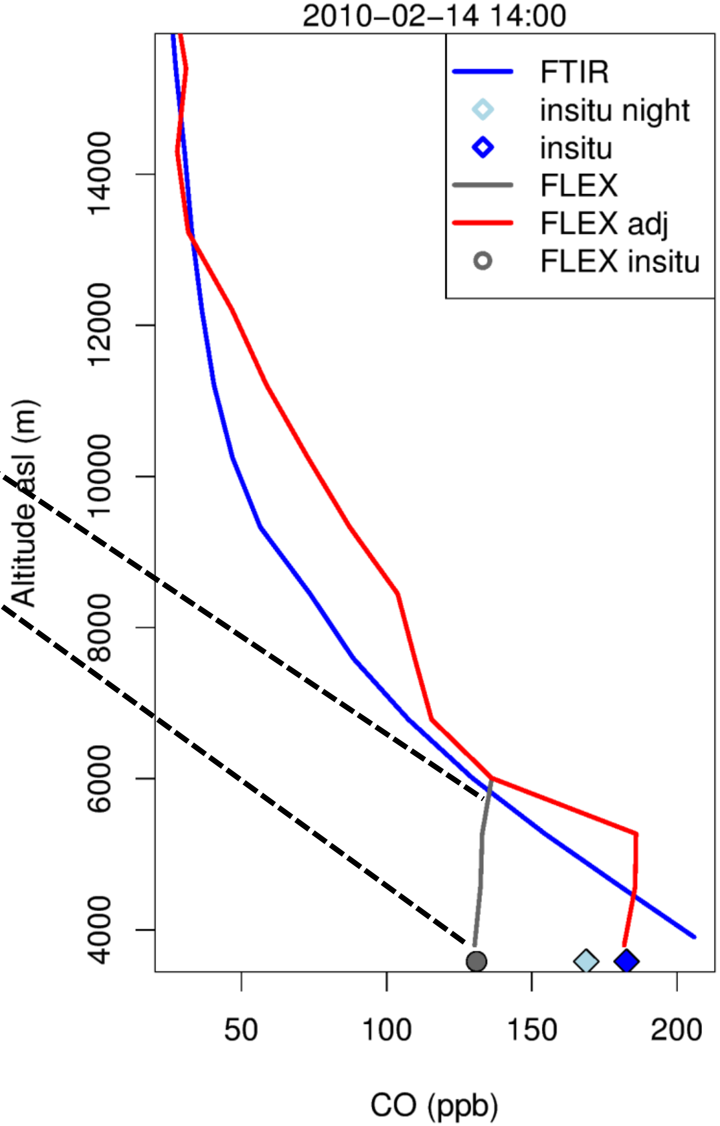
Ozone





"In-situ Data Assimilation"





Adjustment of FLEPXART profile

- Separating background and pollution
- Bias correction for background
- Factorial correction for pollution