Overview and status of the IAGOS added-value products (L4 ancillary data)
Source-receptor links applications

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Added-value products: methodology

FLEXPART

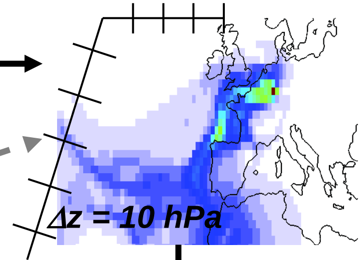
5-20 days of backward simulations

ECMWF

Operational analyses & forecasts

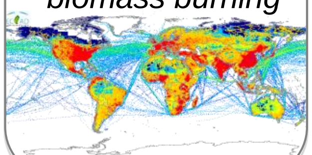
(0.5° res. / 50-137 vertical levels)

IAGOS



CO Emission inventories

anthropogenic and biomass burning



Coupling tool

(SOFT-IO)

$$Contribution = \frac{T_{resid} \times Emission}{\Delta z_{injection}}$$

Added-value products

A-Meteorological data (since 1994)

B-Residence time (since 1994)

Over 20 days

C-Trajectories (since 1994)

Over 5days, every 6h OR 3h

PV, P(PV=1pvu, 2pvu, …),lat, lon, fraction of each cluster →

D-SOFT-IO (since 2002)

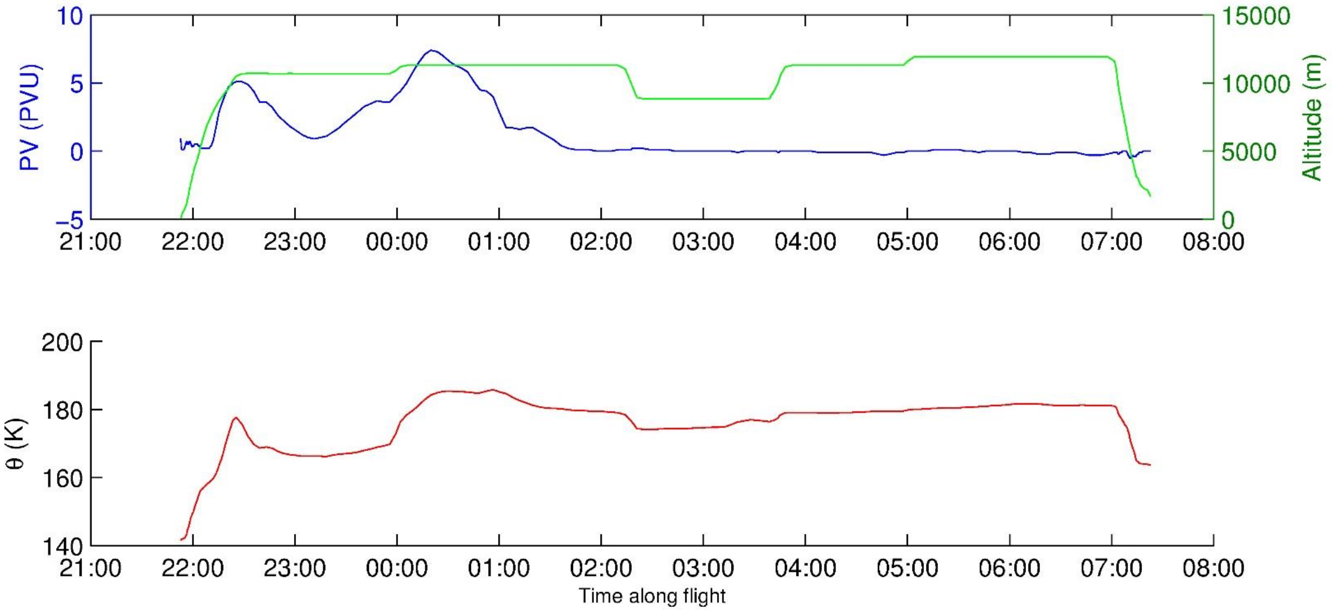
- **CO anthropogenic contributions (EDGAR & MACCITY)**
- **CO fire contributions (GFASv1.2 & GFED4)**

Over 20days & 14 regions

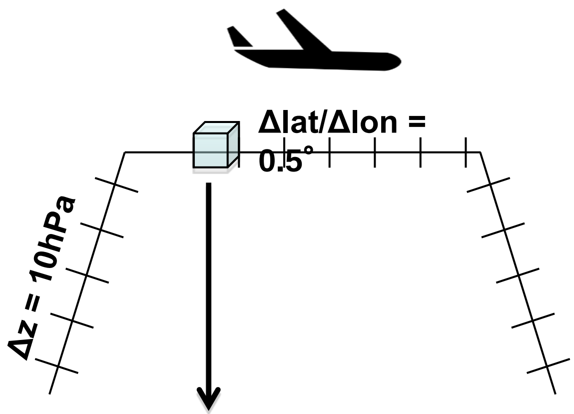
A-Meteorological data (Ancillary Parameters)

ECMWF meteorological analyses interpolation over flight tracks since 1994 :

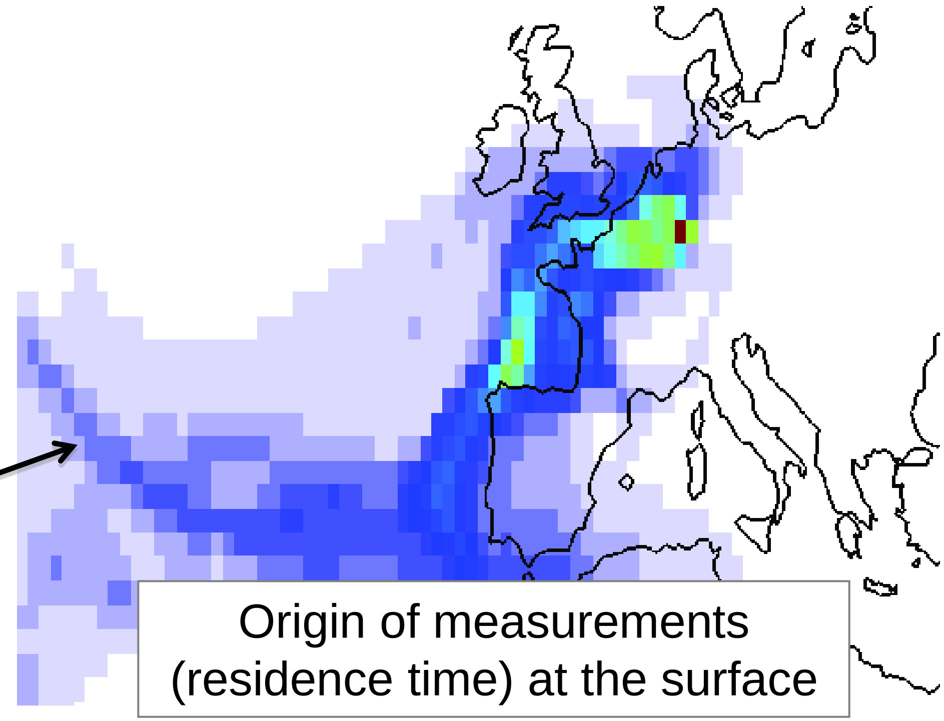
- Air potential temperature
- Geopotential height (@ 500hPa)
- Orography
- Pressure of PV=1.5; PV=2; PV=3; PV=4
- PV (ECMWF and calculated with FLEXPART)
- Surface pressure
- Vertical wind speed
- PBL height (ECMWF and calculated with FLEXPART)



B-FLEXPART added-value products: residence time



1000 particles initialized:
•every Δlat/Δlon = 0.5° during cruising
•every Δz = 10hPa during ascent/descent

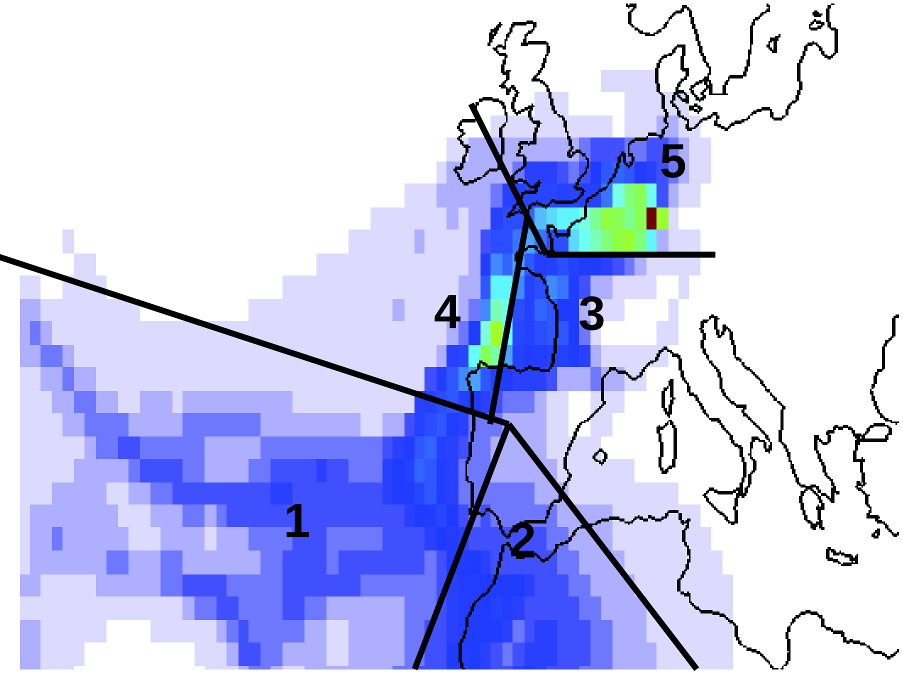


3D Lagrangian backward plumes (residence time) calculated up to 20 days before observation (every 3h)

➔ Global **origin of the IAGOS observations**

(1° lon/lat resolution; 1000m vertical resolution)

C-FLEXPART added-value products: backward trajectories

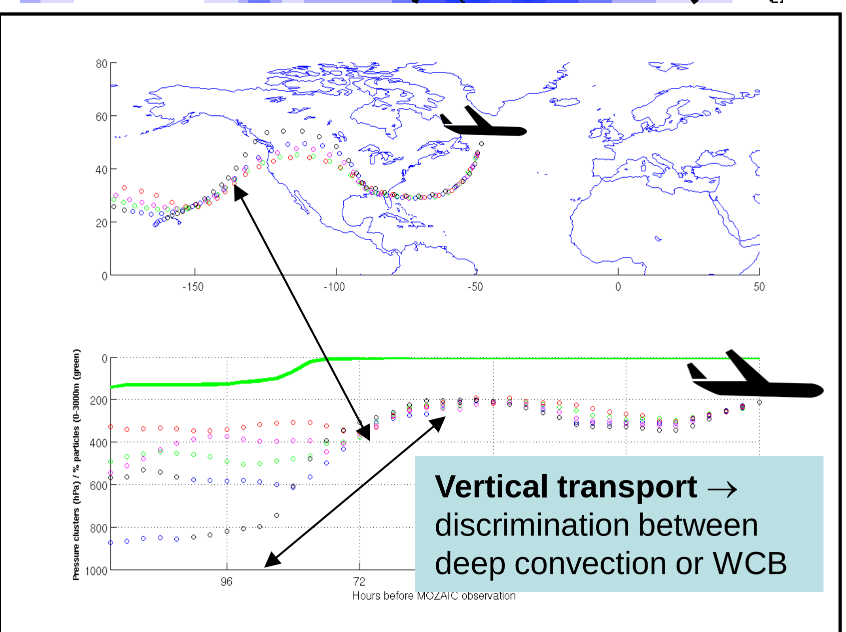


5 backward trajectories are calculated using *k-means* clustering of 3D FLEXPART residence time along each flight (every 0.5° or 10hPa)

For each of the 5 trajectories:

- **latitude**
- **longitude**
- **pressure**
- **PV**
- **% of particles**

are calculated every 3h during 5 days before IAGOS observations



➔ **Meteorological classification** of IAGOS measurements (STE, WCB, convection, etc)

➔ **CLIMATO project** (H2020) using new ERA5 reanalyses, along with LAGRANTO simulations)

D-Quantifying the source/receptor links for the IAGOS database: SOFT-IO software

Methodology:

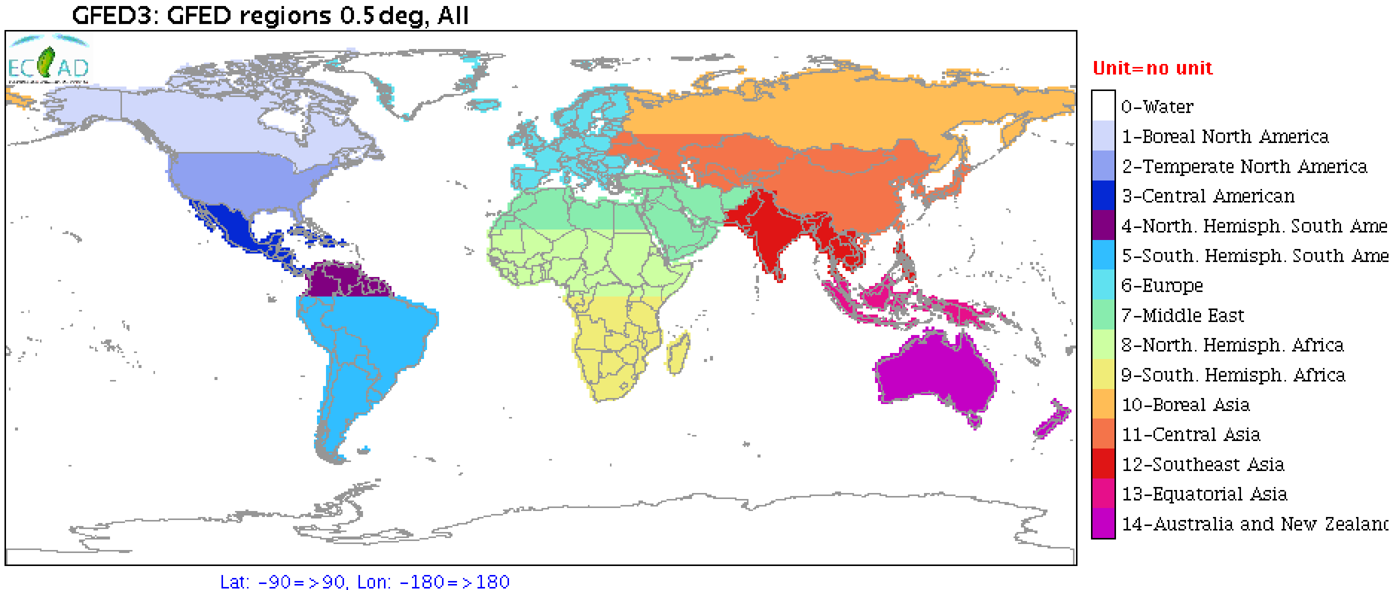
Coupling of **FLEXPART residence time** (over 20 days) + **CO emission inventories** (*MACCITY, EDGAR, GFAS v1.2, GFED4, fires vertical injection*)

→ **CO contributions (ppb)** (no background):

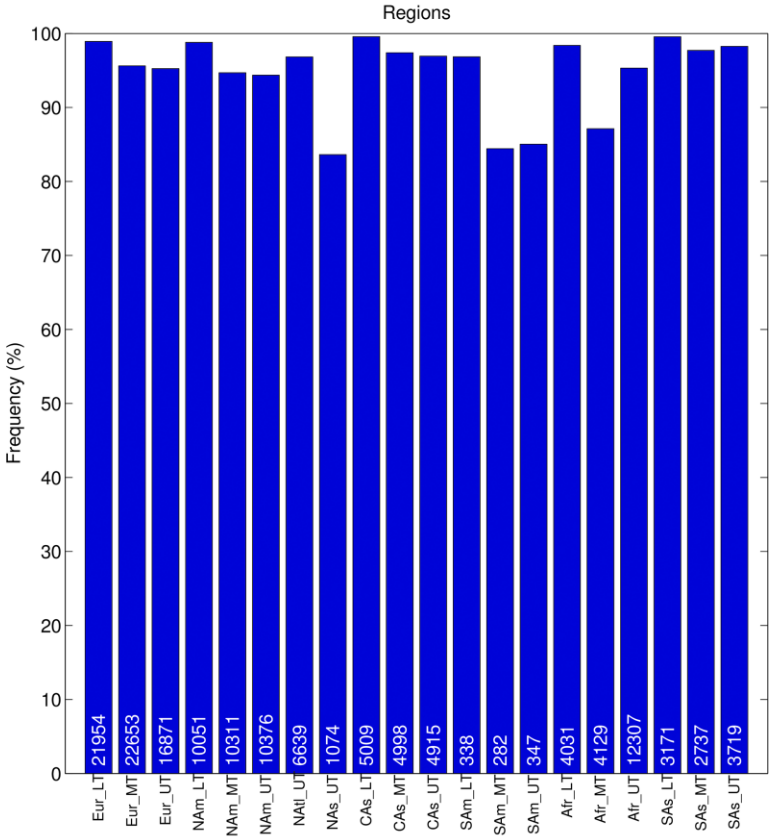
- of biomass burning,
- of anthropogenic emissions

And **14 regions**

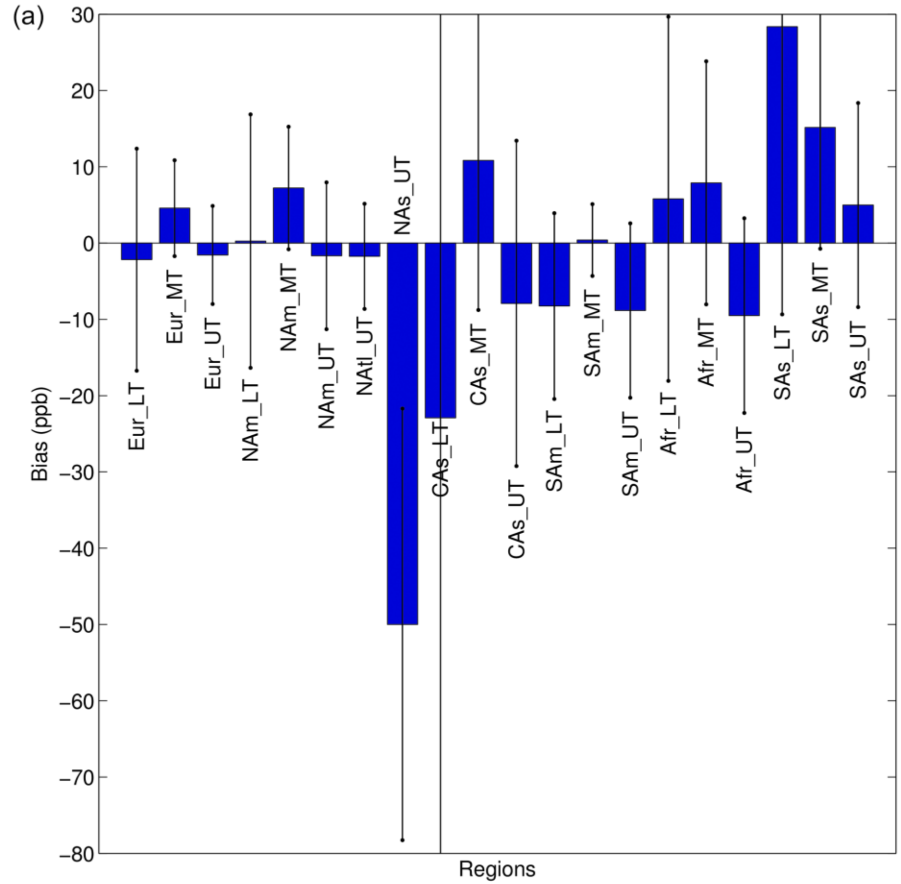
Geographical origin of CO sources in SOFT-IO *(Sauvage et al., ACP, 2017)*



D-Quantifying the source/receptor links for the IAGOS database: SOFT-IO software



Frequency of CO plumes detections



(Sauvage et al., ACP, 2017)

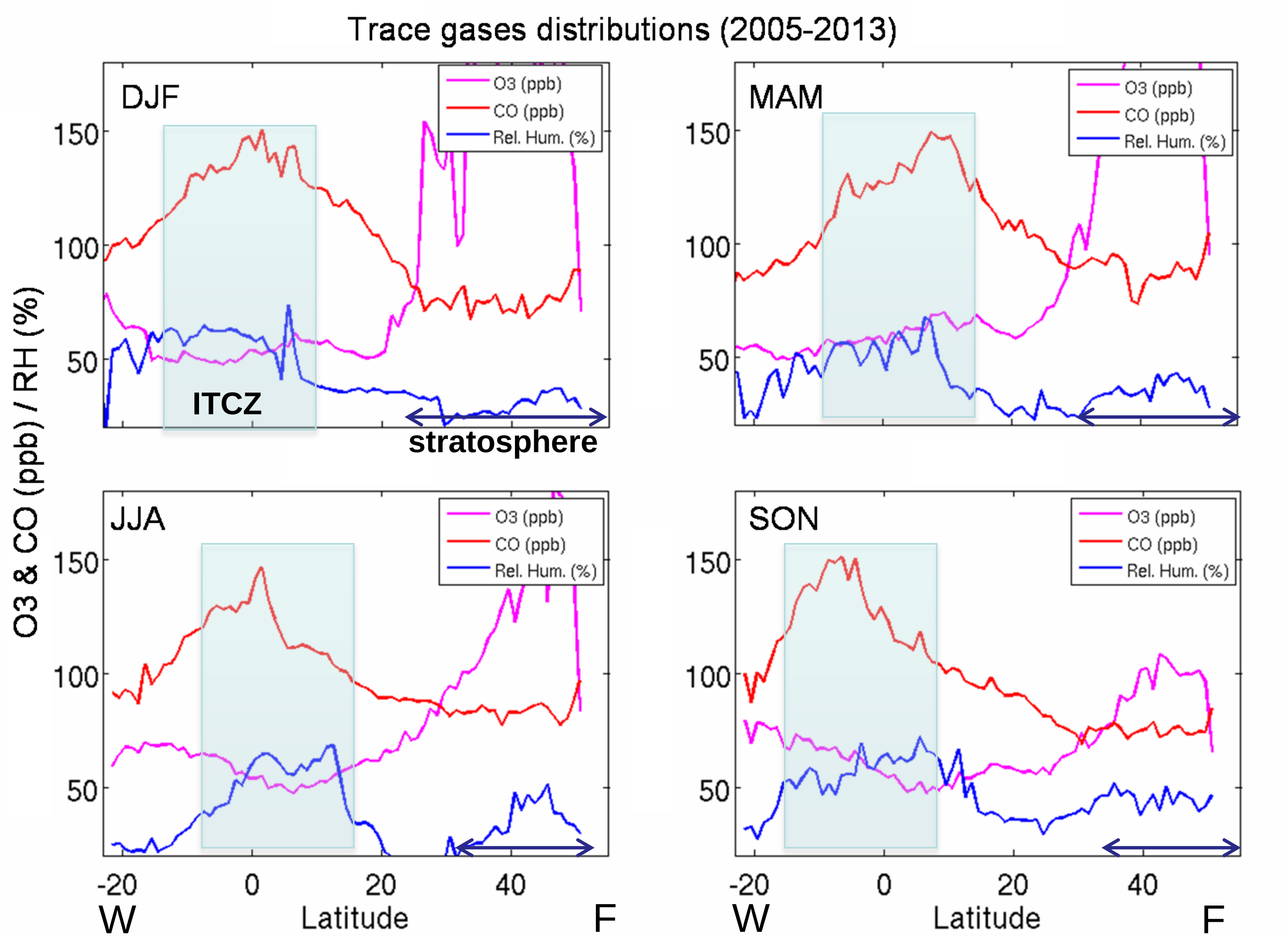
***Mean bias (blue) and mean standard deviation bias (black) between the modeled and observed CO anomalies*.**

Low biases (5 to 10ppb) for **the most documented regions** (Europe, North America, Africa, North Atlantic UT, central Asian MT and UT, South America, south Asian UT) → **high skill of SOFT-IO**

Highest biases are found **in the Asian LT**, suggesting misrepresentation of local emissions

The African upper troposphere

Daily flights between Frankfurt and Windhoek (Air Namibia) from 2005 to 2013
→ **Strong CO & RH** / **low O3** around the **ITCZ**; **meridional gradients poleward**

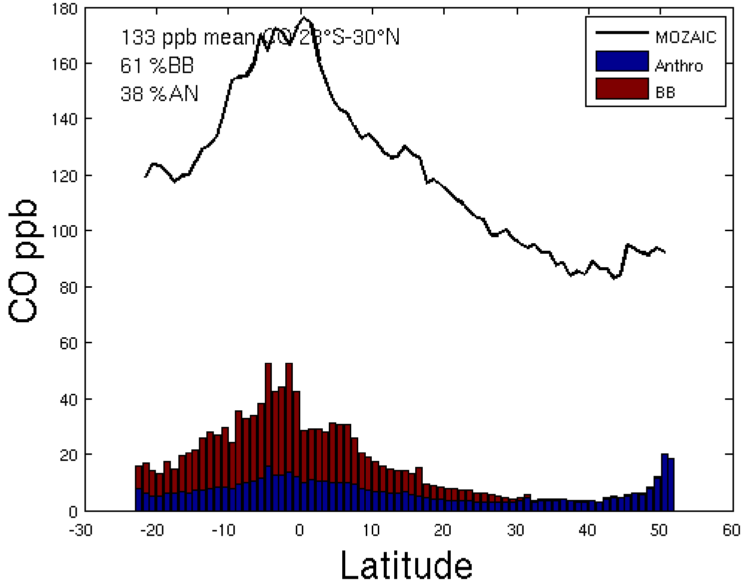


Sauvage et al., in preparation

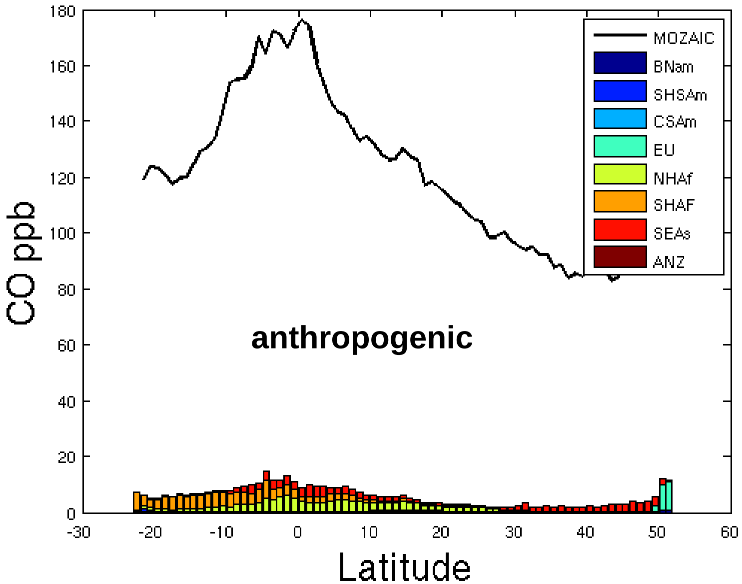
Origin of CO in the African upper troposphere

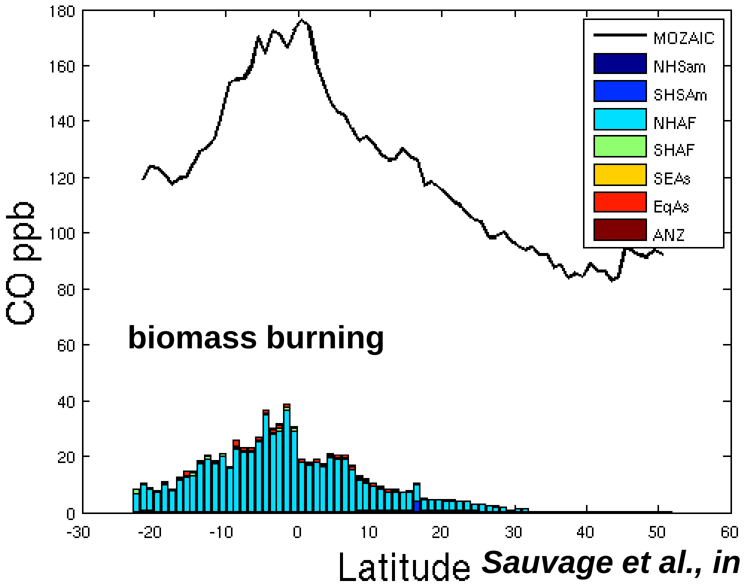
using SOFT-IO (DJF 2006)

Source origin



Geographical origin



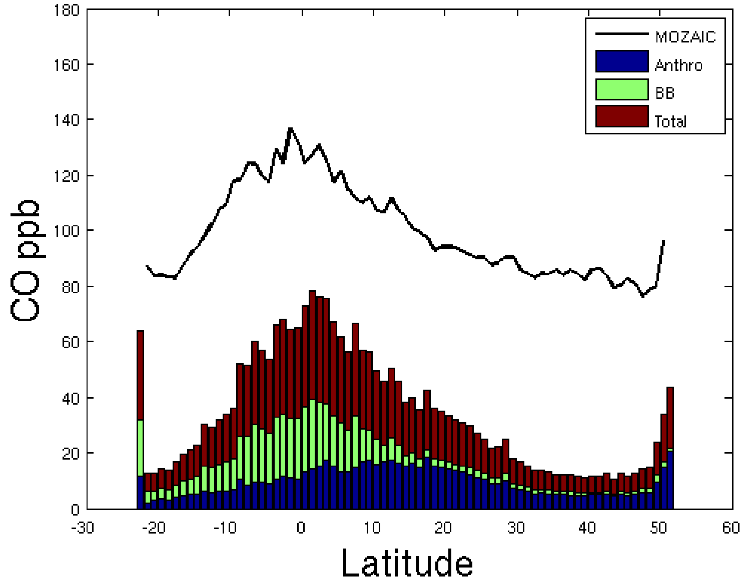


Sauvage et al., in preparation

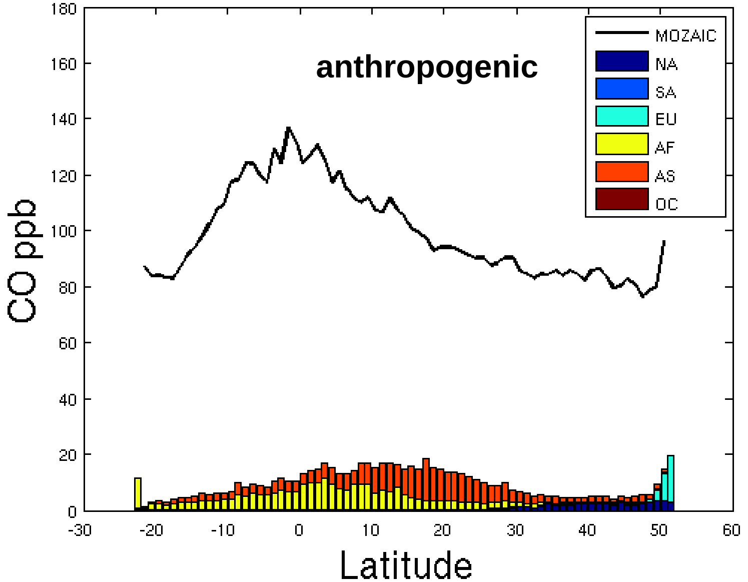
Origin of CO in the African upper troposphere

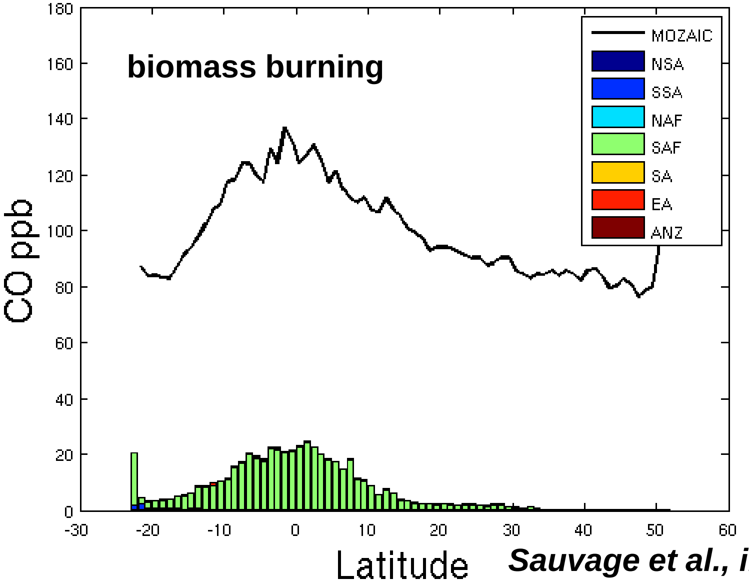
Source origin

JJA 2006



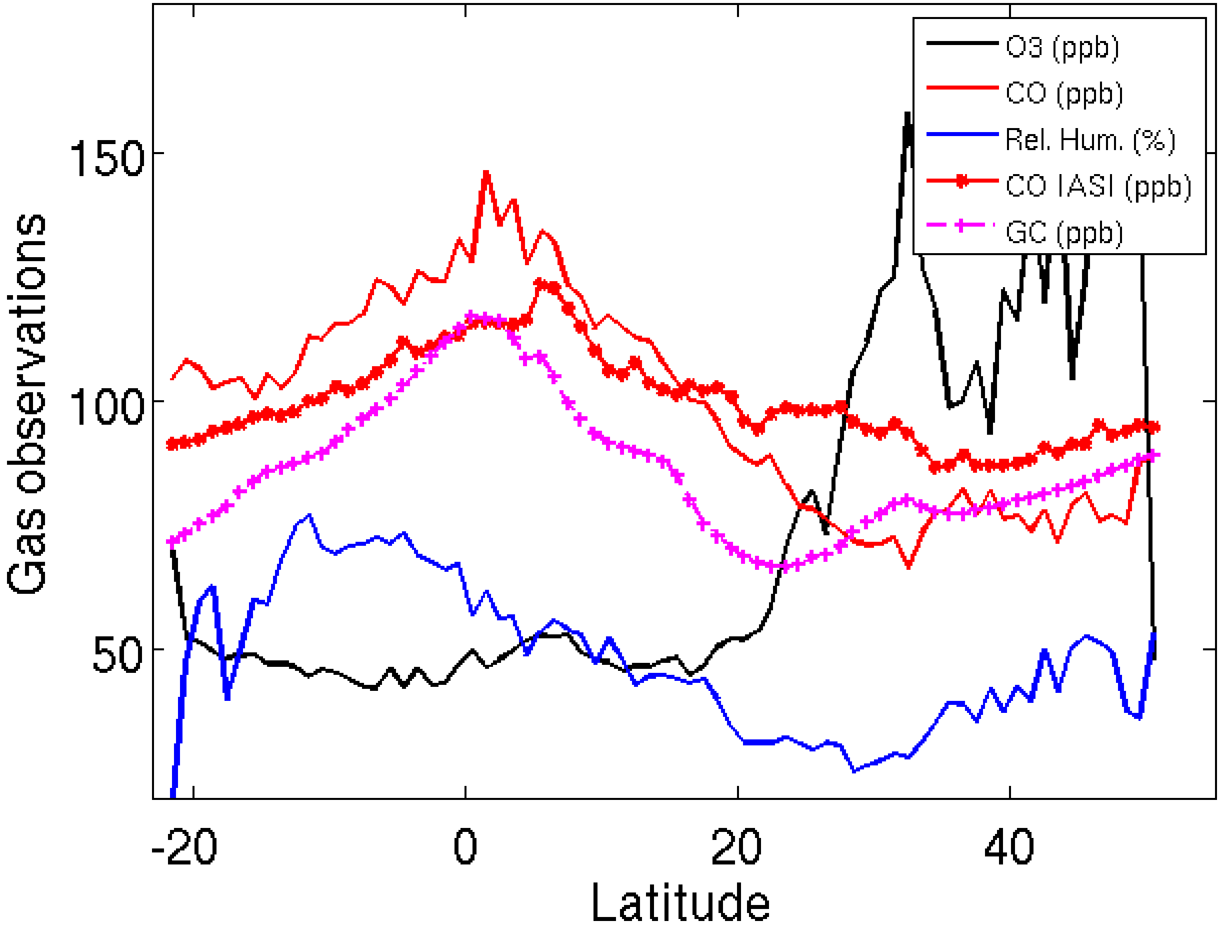
Geographical origin





Sauvage et al., in preparation

IAGOS vs IASI (satellite) vs GEOS-Chem (CTM)

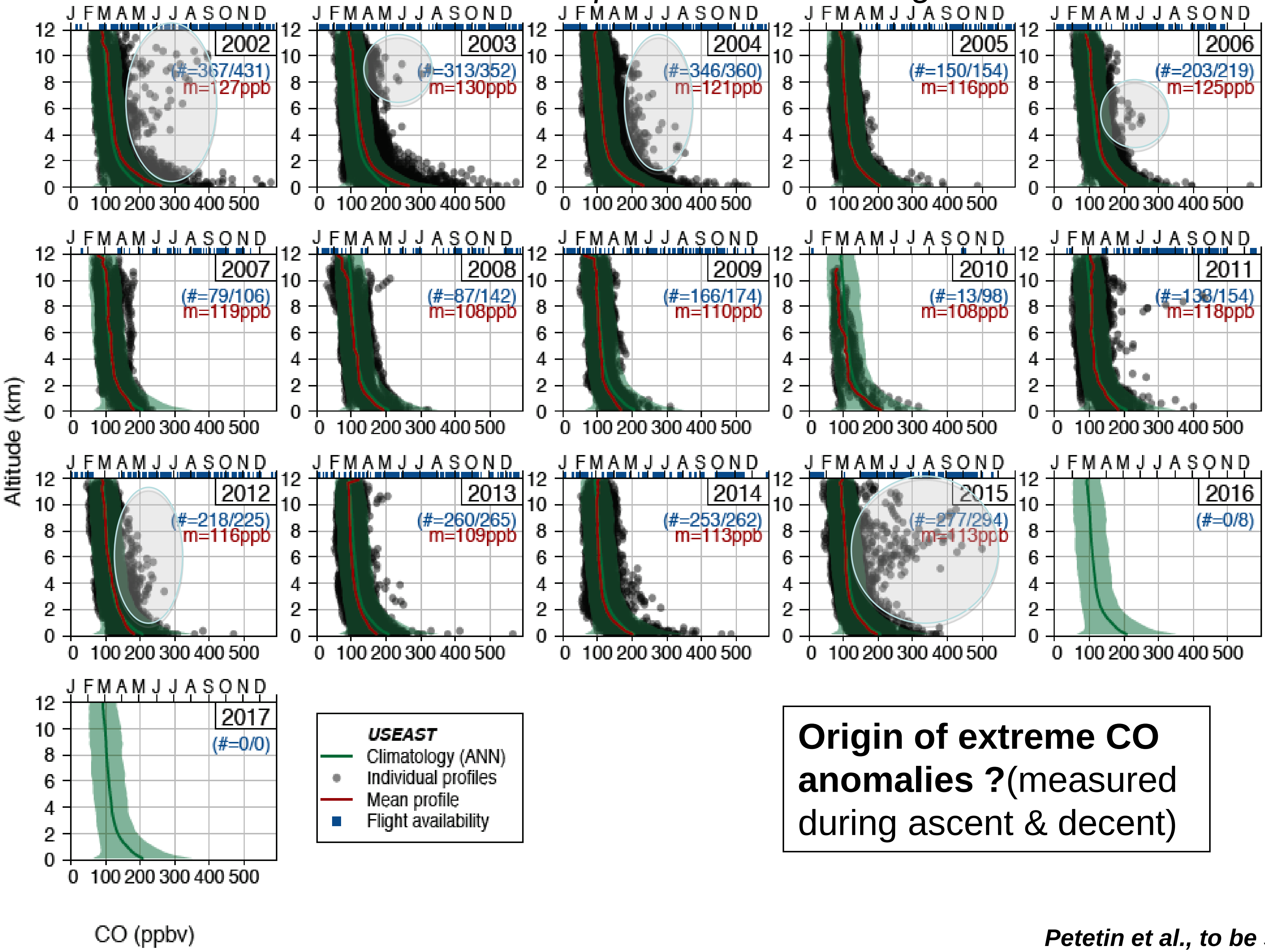


Correct reproduction (by IASI & GEOS-Chem) of the CO maxima and of the negative gradients poleward, with somehow underestimation by the model

➔Use IASI to complete IAGOS (after 2013 for **interannual variability & trends assessment**; over the Atlantic & the Indian Ocean for a **regional overview**
➔Use GEOS-Chem CTM for **chemical species budget** in the African UT (O3 & CO)

Origin of extreme CO anomalies

***Summertime** profiles in Useast region*

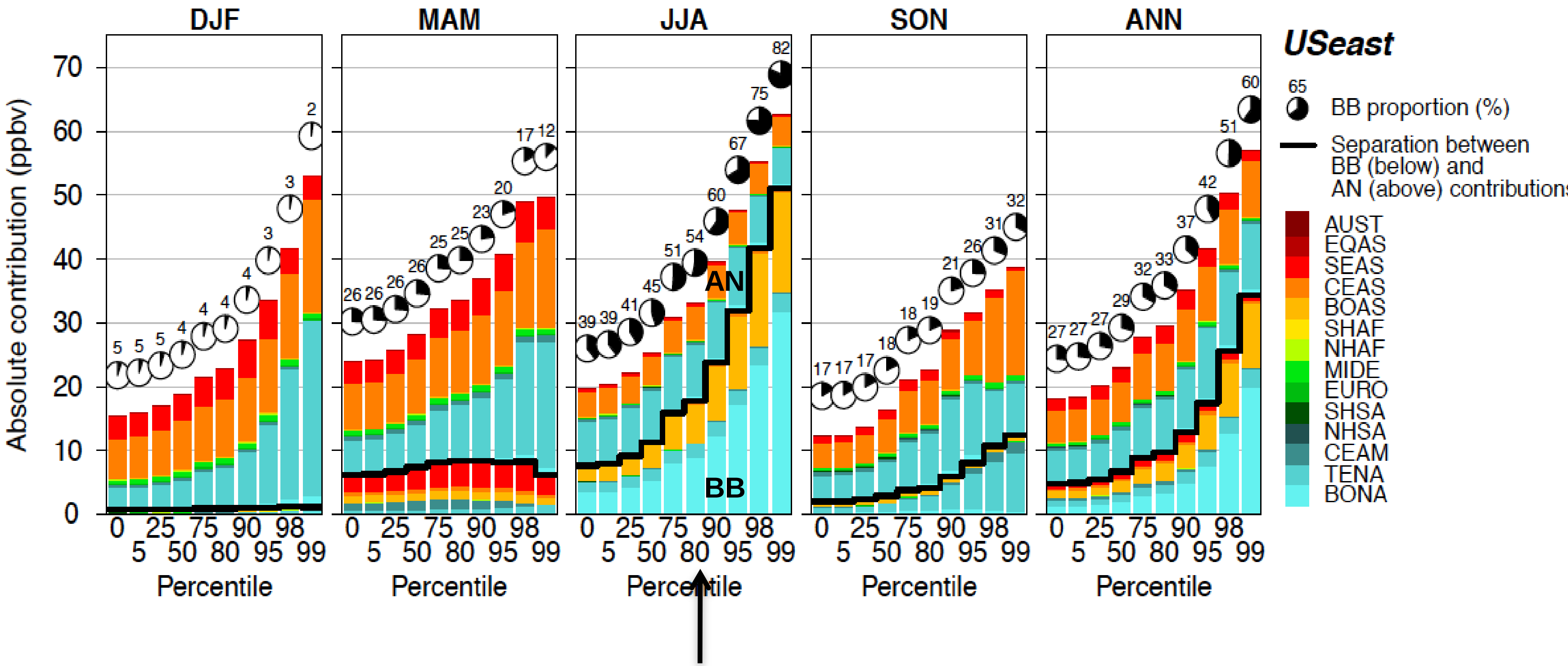


Origin of extreme CO anomalies ?(measured during ascent & decent)

Petetin et al., to be submitted

Origin of extreme CO anomalies

Mean AN and BB contributions to CO anomalies at the Useast airports cluster



Strongest CO anomalies (>75th percentile)

→ AN have a strong contribution for all seasons
→ BB have increasing contributions for the strongest CO anomalies (JJA, SON, ANN) and are dominant in JJA since the 75th percentile (with > 51% contribution to total CO)

Petetin et al., to be submitted

Perspectives

Backward trajectories:

New calculations with ERA5 reanalyzes (rather than operational analyses and forecasts)

$\rightarrow$ meteorological classification of IAGOS observations (CLIMATO H2020): STE, WCB, convection

SOFT-IO:

New simulations using meteorological analyses with higher horizontal resolution (0.1° /0.3°)

New simulations using ERA5 reanalysis (consistency for inter annual variability and climate studies)

Perspectives

New software for coupling IAGOS NOx and lightning observations (SOFT-IO-Li)

→ Systematic **FLEXPART** simulations from **IAGOS NOx** measurements, coupled with **lightning observations (**geostationary satellites **GLM, MTG-Li)** : proposal submitted to the French space agency (CNES) (Sauvage, Berkes, Defer et al., LA + Jülich)

→ Derive **LiNOx plumes metrics:**

- plumes age,
- NOx, O3, RH
- lightning numbers,
- IC/CG ratio,
- possibly space-based NO2 & HNO3 over sea,
- NOx concentrations at the just after emission using NOx e-folding