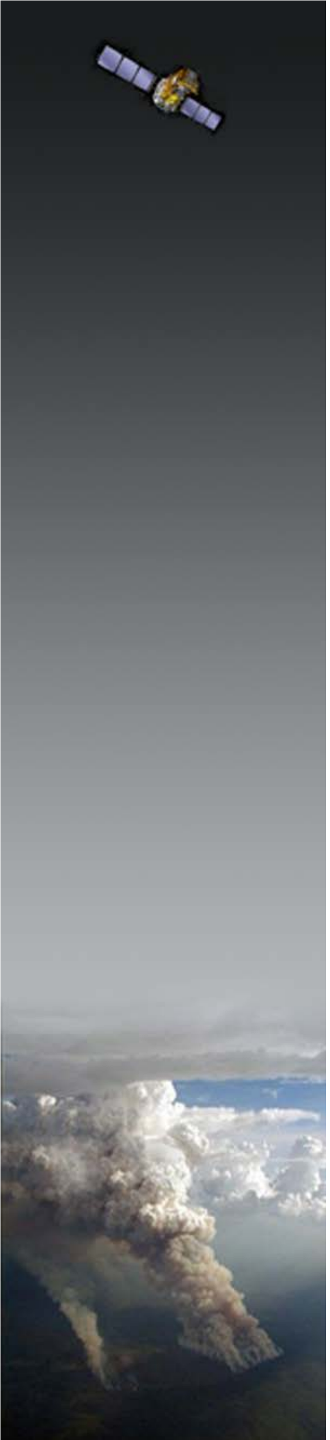

Study of biomass burning emissions with Aqua/AIRS and MetOp-A/IASI

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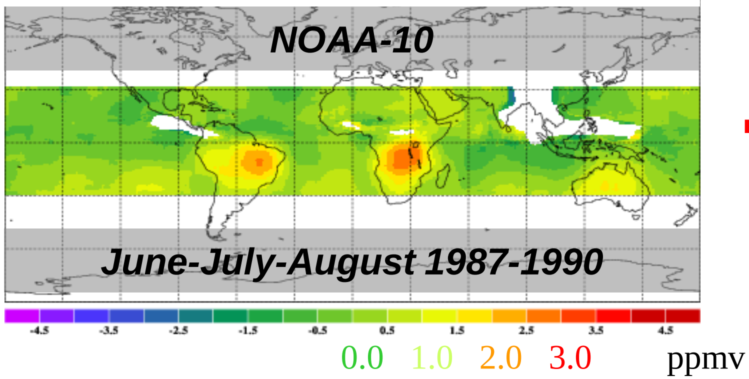
Contribution of IR sounders to the study of biomass burning emissions

Night-Day CO_2 from TOVS

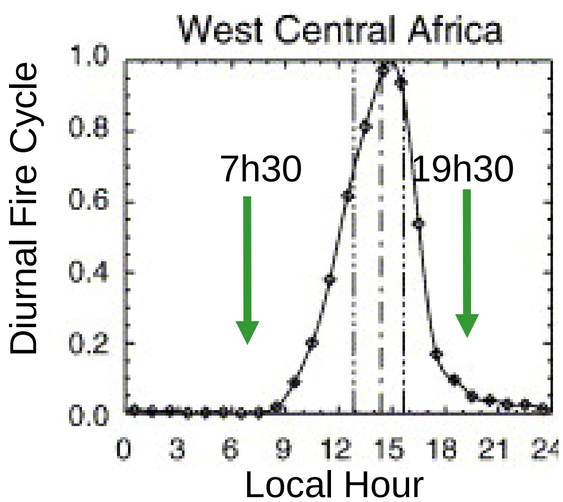


Daily Tropospheric Excess of CO_2

Chédin et al., 2005, 2008

Diurnal cycle of fires

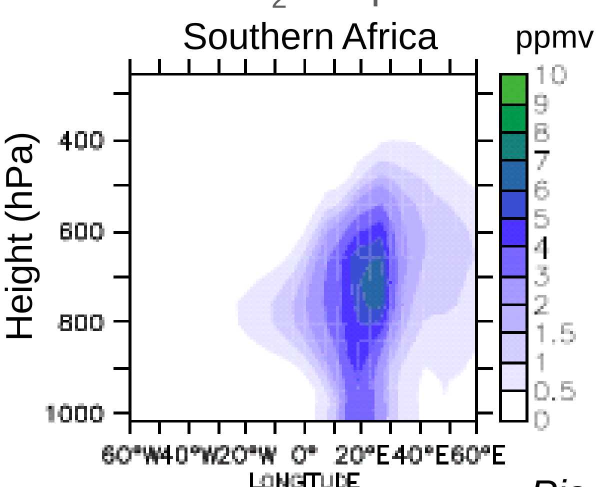
Diurnal cycle of fires in the surface and equator crosstime of NOAA-10



Giglio, 2006

Convection of fires emissions in the troposphere

Simulation of CO_2 fire plumes emissions



Rio et al., 2010

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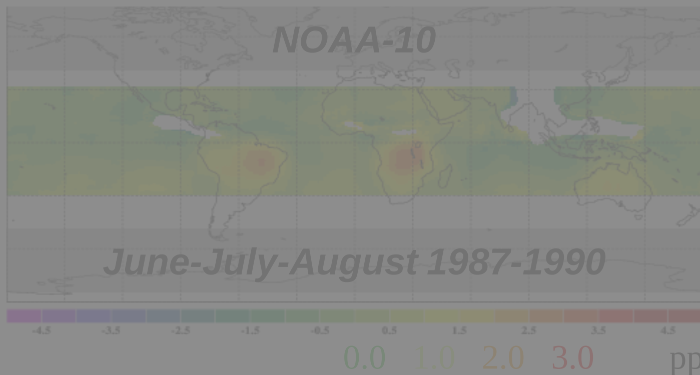

→ *Daily Tropospheric Excess of CO_2*

Chédin et al., 2005, 2008

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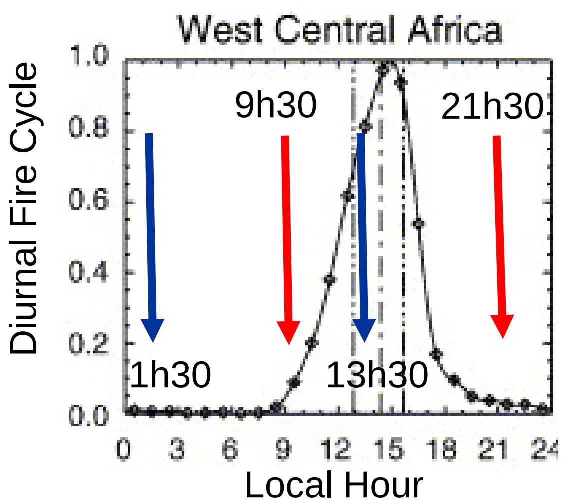
Diurnal cycle of fires in the surface and equator crosstime of IASI and AIRS



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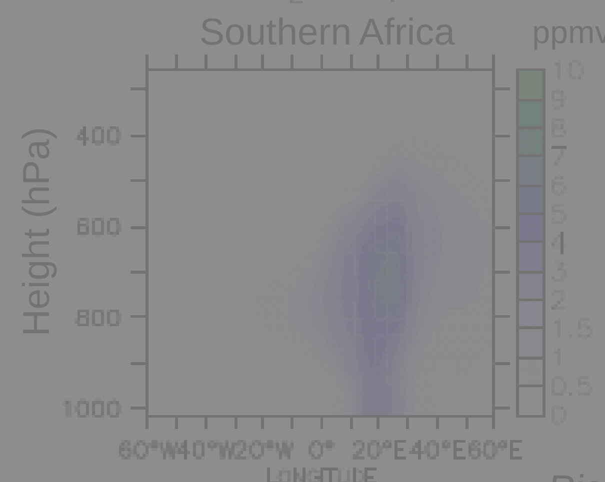


Rio et al., 2010

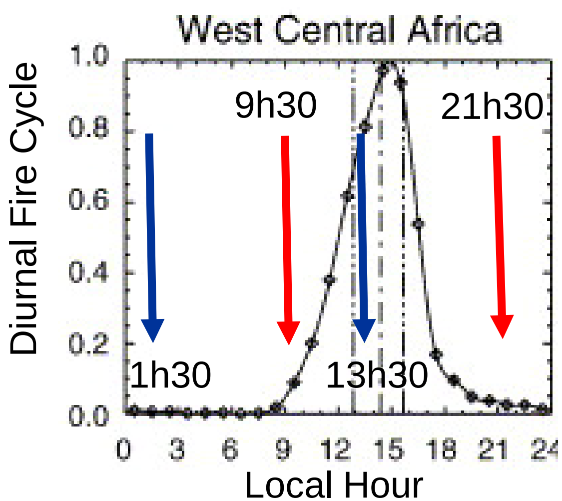
Contribution of AIRS and IASI to the study of biomass burning emissions

- Fire emissions :
  - •90% CO_2 (flamming phase),
  - •9% CO (smoldering phase),
  - •<1% CH_4, and other trace gases
- **At LMD, we retrieve CO_2 and CO from AIRS and IASI, and CH_4 from IASI**.
- AIRS and IASI give access to 4 points a day : 1:30, 9:30, 13:30, 21:30

→ Study of the **diurnal cycle of the emissions** and **the different phases of the combustion.**

Diurnal cycle of fires

Diurnal cycle of fires in the surface and equator crosstime of IASI and AIRS



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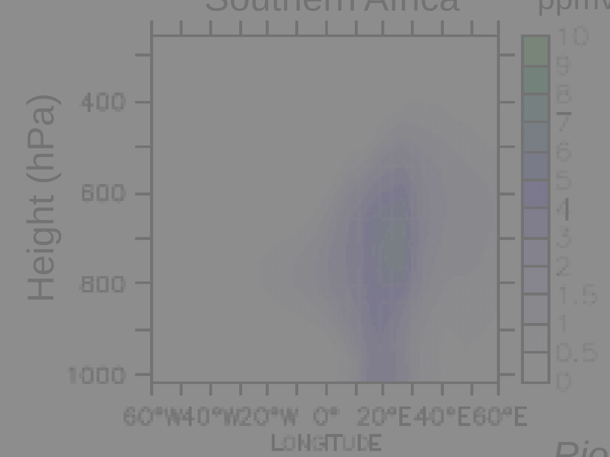

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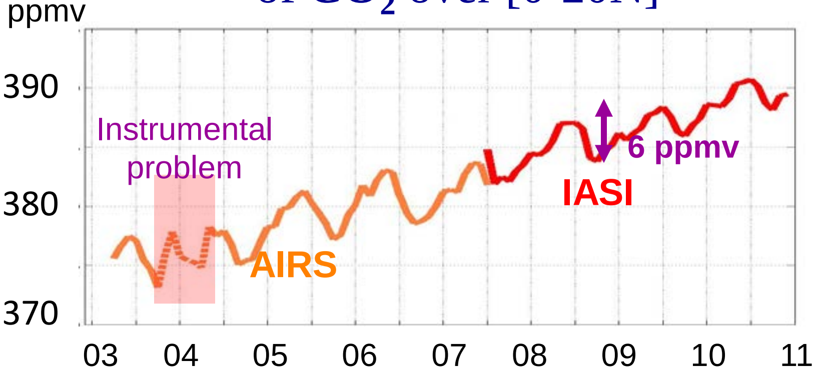
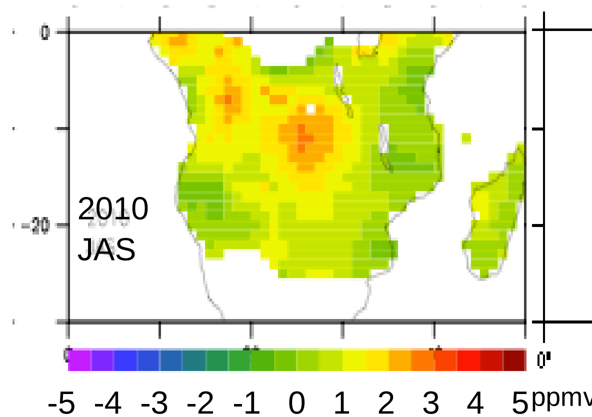
Averaged seasonal cycle (night+day) of **CO_2** over [0-20N]

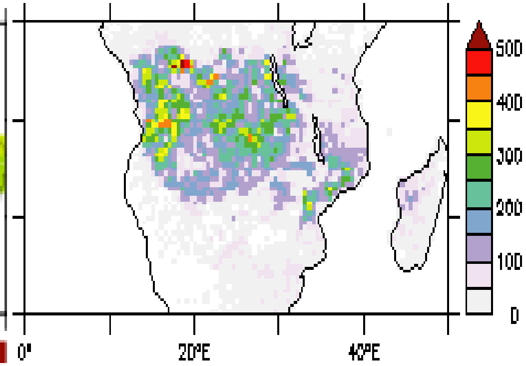


Trend of +2 ppm.yr^{-1} in 2003-2010

Night-day CO_2



MODIS fire pixels count



The fire signature on CO_2 and CH_4 is quite weak whereas CO is a well-known proxy of fire emissions. That's why we focus on CO to study the diurnal cycle of fire emissions.

Retrieval of CO, CO_2 and CH_4 from AIRS/IASI

■For **CO_2** (low signal) and for **CH_4** (interferences from other species), we use:

-Non linear inference scheme based on neural networks [*Crevoisier et al*., 2004, 2009a/b].

-CO_2/CH_4 and T(p) are intimately correlated in the IR.

→ Use of IR (IASI/AIRS) and MW (AMSU) observations to decorrelate T from gas variations.

-The decorrelation between T/GHG is easier to do in the tropics.

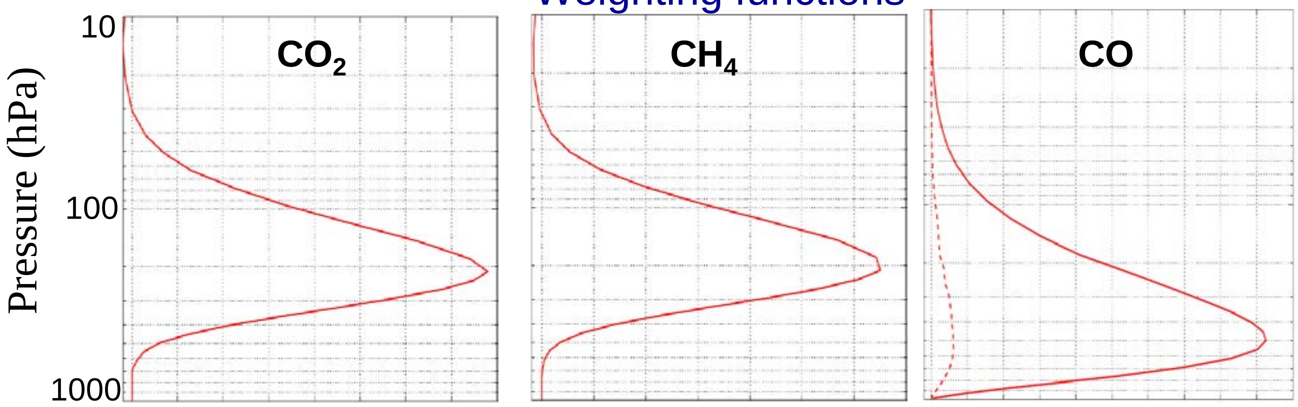
⇒ a better precision is expected there.

■For **CO**, we use a double differential approach [*Thonat et al*., sub.].

•We retrieve a mid or upper-tropospheric content:

- in clear sky only (no clouds, no aerosols)
- in day and night, over land and over sea

Weighting functions

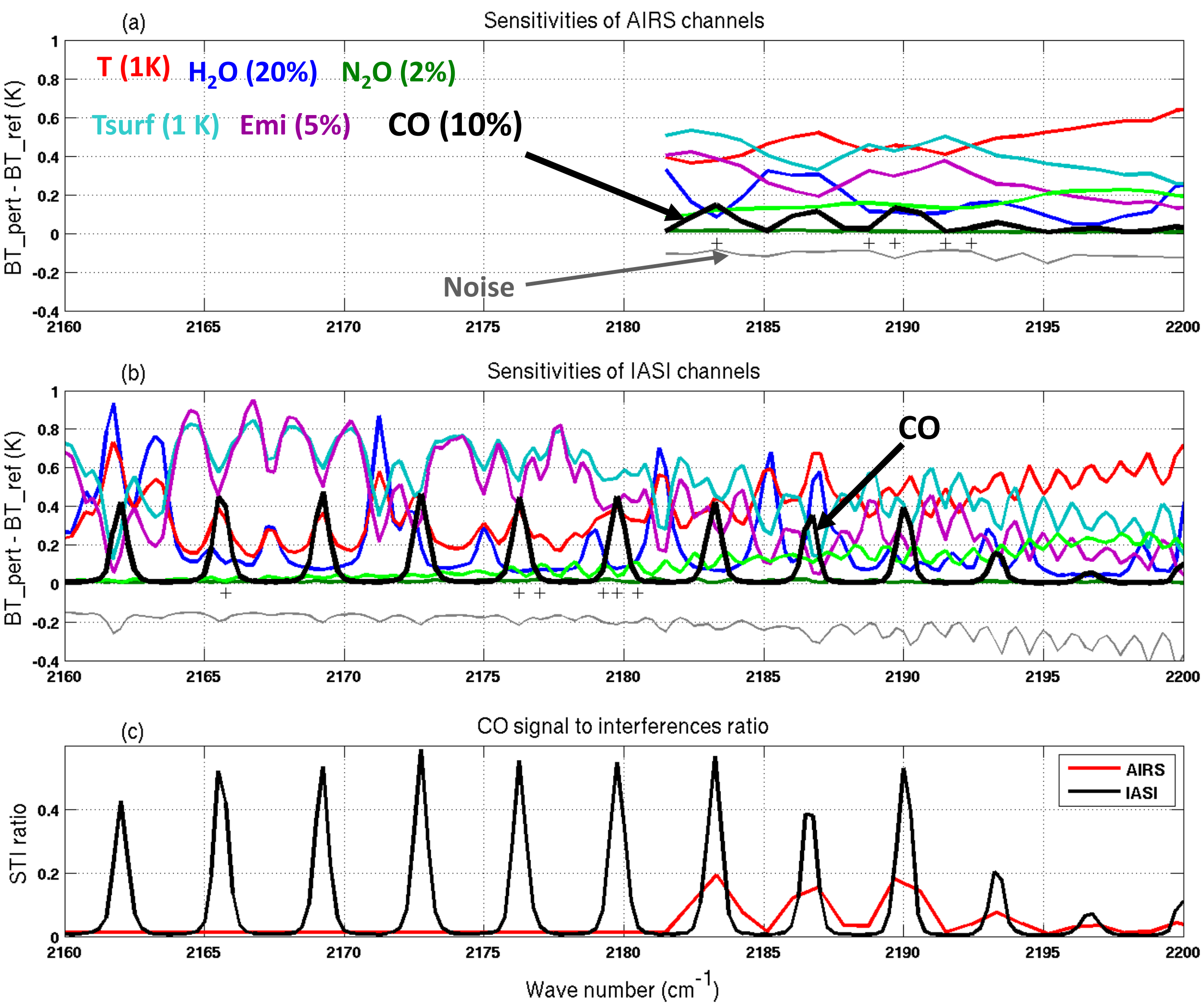


We have now ~4 years (July 2007-June 2011) of monthly averaged tropospheric integrated content of **CO_2, CO and CH_4** from **IASI**, and also **CO and CO_2** from **AIRS**.

AIRS and IASI characteristics - CO

Sensitivities of AIRS and IASI channels to atmospheric and surface perturbations

(*from LMD 4A radiative transfer model, based on the GEISA spectroscopic database and using the TIGR atmospheric dataset*)



-AIRS resolution: **1.8 cm^{-1}**

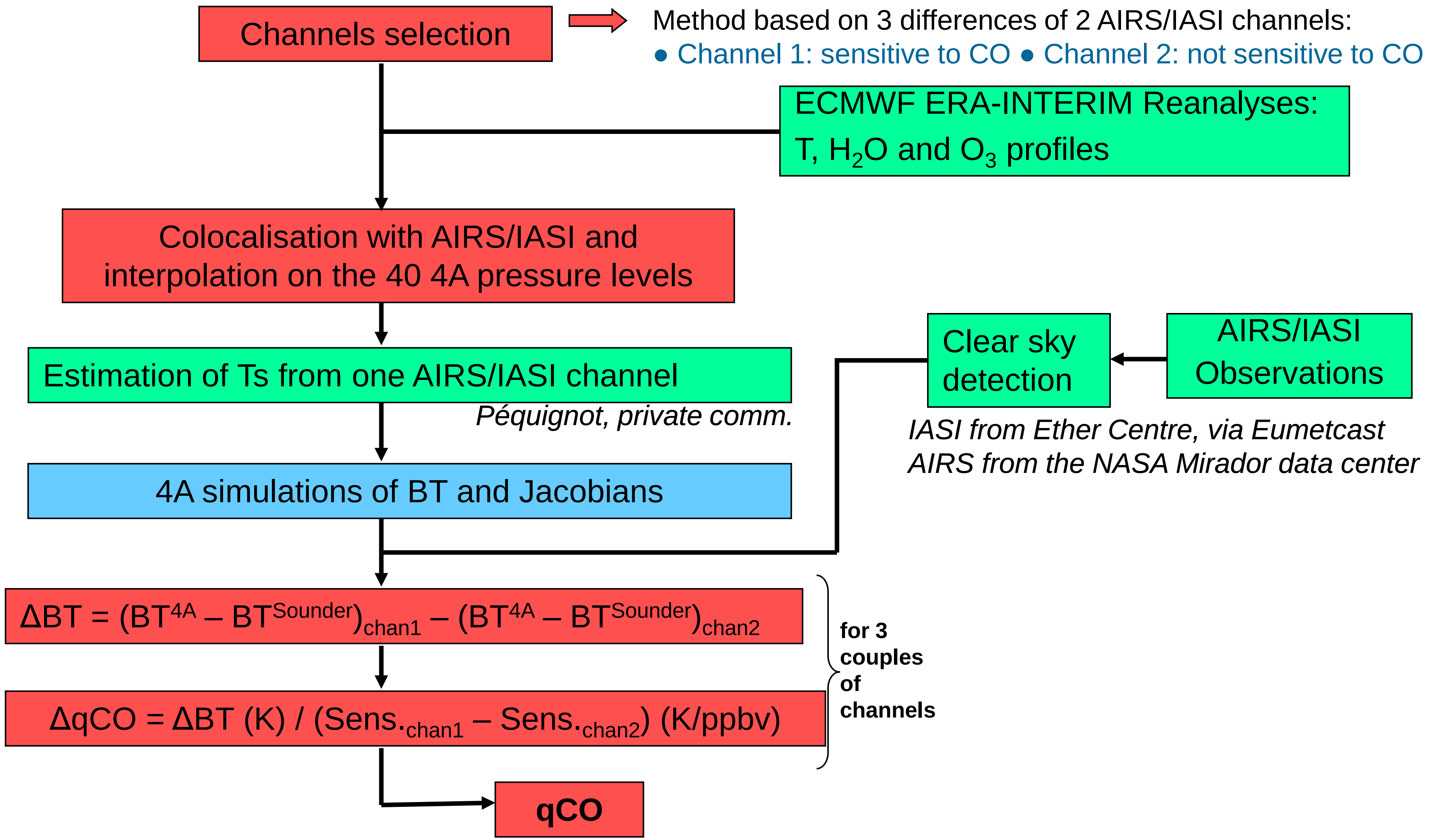
-Coverage of the **end** of the CO absorption band

-IASI resolution: **0.25 cm^{-1}**

-Coverage of the **whole** CO band

IASI has a 3 times higher signal-to-noise ratio

Description of the CO retrieval method



Precision: 2.5 ppbv (~3 %)

Description of the CO retrieval method

Channels selection → Method based on 3 differences of 2 AIRS/IASI channels:
● Channel 1: sensitive to CO ● Channel 2: not sensitive to CO

ECMWF ERA-INTERIM Reanalyses: T, H_2O and O_3 profiles

Colocalisation with AIRS/IASI and interpolation on the 40 4A pressure levels

Estimation of Ts from one AIRS/IASI channel

Péquignot, private comm.

AIRS/IASI Observations → Clear sky detection

IASI from Ether Centre, via Eumetcast
AIRS from the NASA Mirador data center

4A simulations of BT and Jacobians

$$\Delta BT = (BT^{4A} - BT^{Sounder})_{chan1} - (BT^{4A} - BT^{Sounder})_{chan2}$$

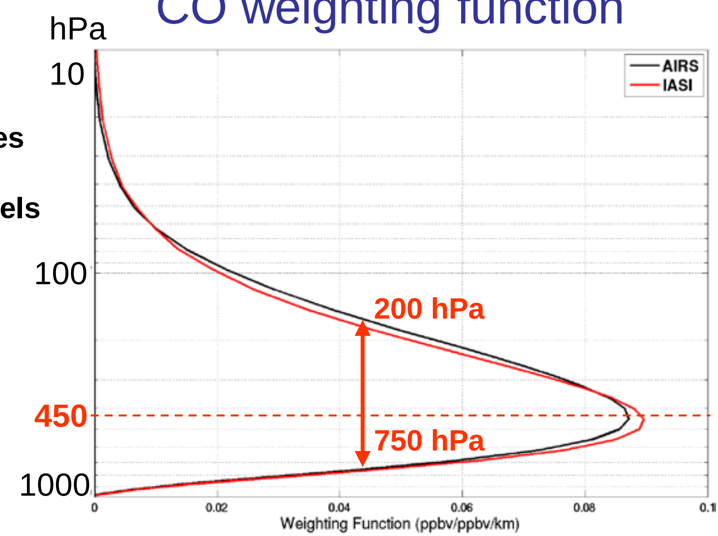
$$\Delta qCO = \Delta BT\ (K) / (Sens._{chan1} - Sens._{chan2})\ (K/ppbv)$$

for 3 couples of channels

qCO

Precision: 2.5 ppbv (~3 %)

CO weighting function



AIRS and IASI CO

Monthly means of mid-tropospheric CO (July 2007 – June 2011)

AIRS 1:30

IASI 9:30

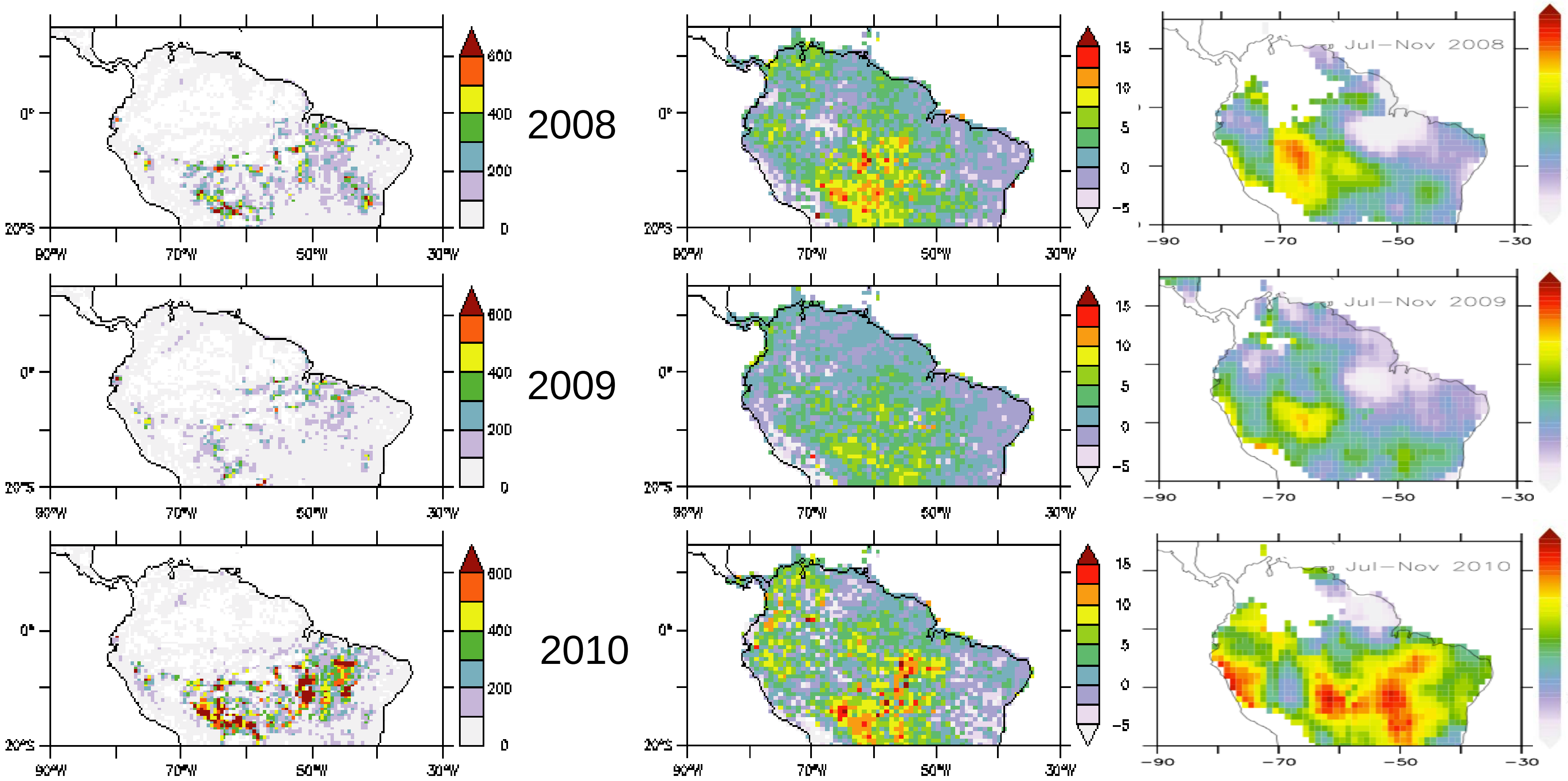
AIRS 13:30

IASI 21:30

Results from IASI over South America (2008-2010)

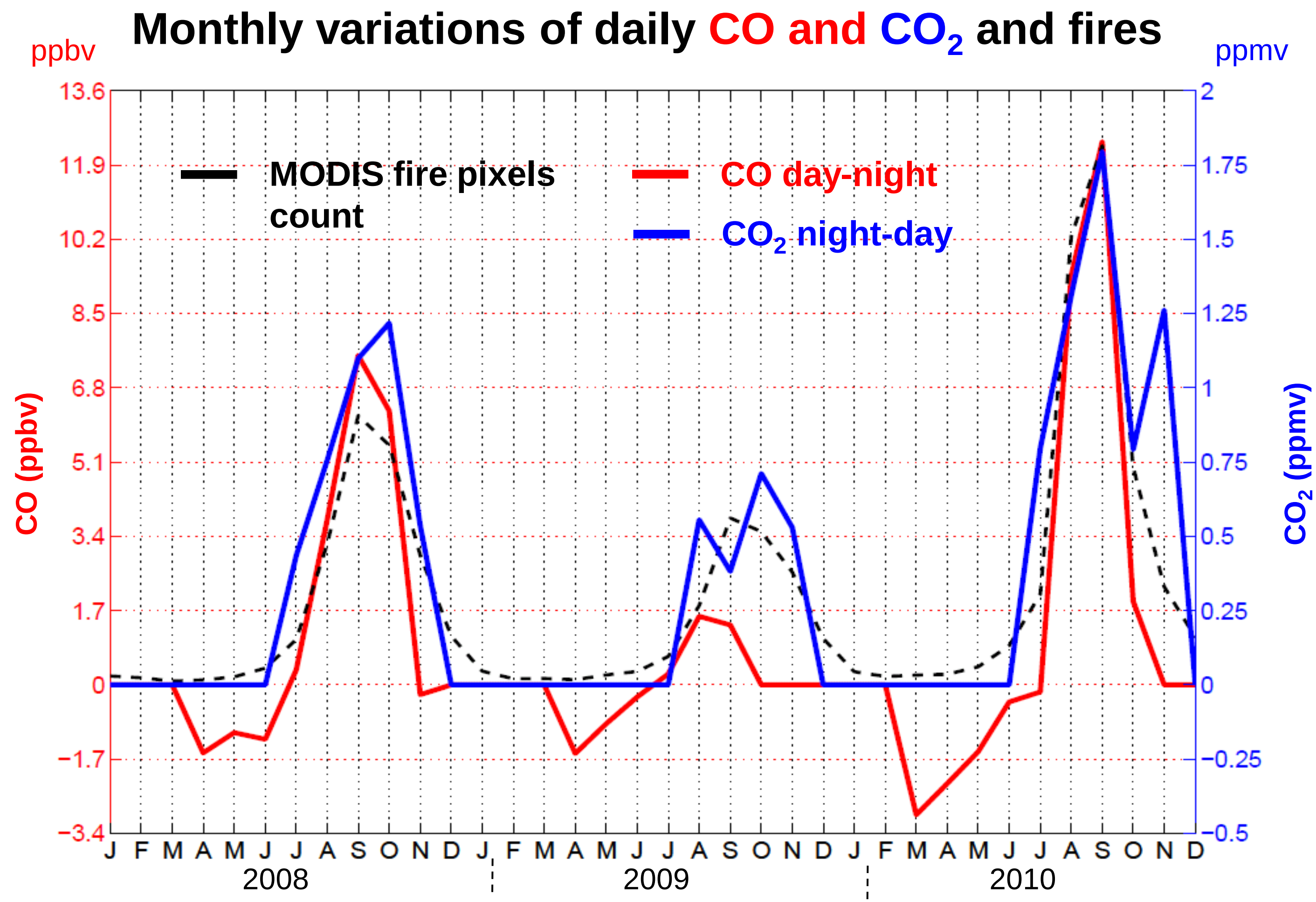
Fire season (July-Nov)

MODIS fire pixels count | Day-night CO (ppbv) | Night-day CO_2 (ppmv)



Effects on CO and CO_2 emissions of the 2010 severe drought in Amazonia

Spatio-temporal evolution averaged over Amazonia



- Very good agreement between the diurnal variations of CO and CO_2 and fires
- These diurnal cycles are of opposite signs: more **CO** for the daytime observation; more **CO_2** for the nighttime observation.
- This might be due to the different combustion phases (smoldering vs. flamming), and to the different parts of the troposphere seen for each gas.

Conclusion

We have retrieved tropospheric integrated content of CO_2, CO and CH_4 from MetOp-A/IASI and CO_2 and CO from Aqua/AIRS observations, from July 2007 to June 2011. We have used these retrievals to study the link between CO, CO_2 and biomass burning emissions.

These results have highlighted:

- the interest of coupling AIRS (1:30, 13:30) and IASI (9:30, 21:30) observations to study the diurnal cycle of CO and the interest of retrieving simultaneously CO, CO_2 and CH_4 from IASI.
- the diurnal cycle of tropospheric CO and CO_2 over the tropical regions
- a temporal and spatial variation of this signal, in agreement with fire activity
- however, the diurnal cycles of CO and CO_2 are of opposite signs, which gives complementary information on the phases of combustion.

Perspectives of this work:

- extension to NPP/CrIS and MetOp-B/IASI observations
- study of the vertical transport of gases emitted by fires
- further study of the correlations between CO_2, CO and CH_4

Annex

Daily Variations of CO

More CO seen by day than by night

CO is mainly emitted in the smoldering phase of combustion :

- low-temperature process
- burns the organic layer, after the aboveground biomass was consumed in the daytime releasing mostly CO_2
- conditions of higher moisture

CO is emitted mostly at night and trapped into the boundary layer until the next morning, and then uplifted by convection

Case of a wildland biomass fire in Alaska (*Ferguson et al*., 2003)