Study of biomass burning emissions with MetOp-A/IASI

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Biomass burning and greenhouse gases

General Characteristics of fires:

Annual emissions = 2,0 GtC*
Tropics = 80%* emissions
Africa = 52 %* ; South America = 15 %*

90% CO$_2$ (flamming phase),
9% CO (smoldering phase),
<1% CH$_4$, and other trace gases

* GFEDv3 averaged over 1997-2009,
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Fire Carbon emissions*

* GFEDv3 averaged over 1997-2009, van der Werf et al., 2010

Growth rate of the gases at the surface

(Langenfelds et al., 2002)

Strong correlations between CO₂, CH₄ and CO related to fire events.

→ Limitation of the surface network.

Use of observations of CO₂, CH₄ and CO from space.

Here, we focus on Thermal IR sounders.

TOVS CO₂  AIRS CO₂ & CO  IASI CO₂, CH₄ & CO

Chédin et al.,2003  Crevoisier et al.,2004  Crevoisier et al.,2009a/b
Thonat et al., in prep.  Thonat et al., in prep.
Daily Tropospheric Excess of CO₂

TIR sounders onboard polar satellites overpass every point twice a day

- NOAA-10 observes CO₂ during day (7h30) and night (19h30)
- Study of the night minus day difference of retrieved CO₂

DTE: *Daily Tropospheric Excess*  
*Chédin et al., 2005, 2008*

### Diurnal cycle of fires

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

### Convection of fires emissions in the troposphere

- Simulation of CO₂ fire plumes emissions

- Freitas et al., 2007, find similar patterns

**Giglio, 2006**
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**Giglio, 2006**

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Results: IASI CO₂

Averaged seasonal cycle (night+day) of CO₂ over [0-20N]

Trend of +2 ppm yr⁻¹ in 2003-2010
Results: IASI CO₂

Averaged seasonal cycle (night+day) of CO₂ over [0-20N]

Night-day CO₂

DTE of CO₂

MODIS fire pixels count

Trend of +2 ppm.yr⁻¹ in 2003-2010
The fire signature on CO$_2$ and CH$_4$ is quite weak because of the high background level of CO$_2$ and the weak amount of CH$_4$ emitted by fires.

CO is a well-known proxy of fire emissions.

Therefore, we retrieve CO to study the diurnal cycle of fire emissions.
Contribution of IASI to the study of GHG

Sensitivities of 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)

Simultaneous observations:
- CO₂, CH₄, CO
- H₂O (20%)
- O₃ (10%)
- CO (10%)
- Tsurf (1 K)
- Emi (5%)

Scott et Chédin, 1981
http://www.noveltis.fr/4AOP/

Jacquinet-Husson et al., 2008
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Objective: to find couples of channels which have the same sensitivities to every atmospheric and surface parameter, except for CO.

Retrieval method – Sélection of CO channels

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Mean TIGR sensibility in the tropics

CO (10%)  T (1K)  H$_2$O (20%)  Tsurf (1 K)  Emi (5%)

Variations of the BT (K)

Wave number (cm$^{-1}$)

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Description of the retrieval method

Channels selection

Method based on 3 differences of 2 IASI channels:
- Channel 1: sensitive to CO
- Channel 2: not sensitive to CO

ERA-INTERIM Reanalyses:
- T, H₂O and O₃ profiles

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

Estimation of Ts with the 2501.75 cm⁻¹ channel

Péquignot, private comm.

4A simulations of BT and Jacobians

∆BT = (BT⁴A − BTIASI)_{chan1} − (BT⁴A − BTIASI)_{chan2}

∆qCO = ∆BT (K) / (Sens.ₐₙ₁ − Sens.ₐₙ₂) (K/ppbv)

qCO

Clear sky detection

IASI Observations

From Ether Centre, via Eumetcast

Precision: 3.5 ppbv (~3.5 %)
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\[ \Delta qCO = \Delta BT \frac{(K)}{(Sens._{\text{chan1}} - Sens._{\text{chan2}}) \ (K/\text{ppbv})} \]

Clear sky detection
IASI Observations

From Ether Centre, via Eumetcast

CO weighting function

Precision: 3.5 ppbv (~3.5 %)
Results: Monthly means of IASI CO (2008)

Day

Night

Jan

Feb

Mar

Apr

May

Jun

Jul

Aug

Sep

Oct

Nov

Dec

Precision ~ 3.5 %
Monthly means of daily IASI CO vs. MODIS BA (2008)

Day-night CO Burned Area Day-night CO Burned Area
Jan Feb Mar Apr May Jun Jul Aug Sep Nov Dec
-20 -10  0  10  20  30 (ppbv) 0  0.1  0.2  (%) 0  0.1  0.2  (%)
Spatio-temporal evolution averaged over SAf

Monthly variations of CO
(January 2008 to December 2010, averaged over Southern Africa)

ppbv

CO day
CO night

BA MODIS: Roy et al., 2008; GFEDv3: van der Werf et al., 2010
Monthly variations of \textit{CO} and fire products
(January 2008 to December 2010, averaged over Southern Africa)

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Spatio-temporal evolution averaged over Amazonia

Day-night CO (ppbv)

- Jul-Nov 2008
- Jul-Nov 2009
- Jul-Nov 2010
Spatio-temporal evolution averaged over Amazonia

Monthly variations of CO and fires

Day-night CO (ppbv)

- MODIS Fire pixels count
- CO day - night

Jul-Nov 2008
Jul-Nov 2009
Jul-Nov 2010
Spatio-temporal evolution averaged over Amazonia

Monthly variations of CO, CO$_2$ and fires

July-Novembre 2010

MODIS Fire pixels count
CO day - night
CO$_2$ night - day

ppbv ppmv

2008 2009 2010

MODIS fires

night-day CO$_2$

day-night CO
Spatio-temporal evolution averaged over Amazonia

Monthly variations of CO, CO₂ and fires

These diurnal cycles are of opposite signs: more CO for the daytime observation; more CO₂ for the nighttime observation. This might be due to the different combustion phases (smoldering vs. flaming), and to the different parts of the troposphere seen for each gas.
We have used the IASI/MetOp observations to retrieve tropospheric CO and CO$_2$ mixing ratios and to study the link between CO, CO$_2$ and biomass burning.

These results have highlighted:
- the diurnal cycle of tropospheric CO and CO$_2$ over Southern Africa and Amazonia
- a temporal and spatial variation of this signal, in agreement with fire activity

However, these diurnal cycles are of opposite signs.

Perspectives of this work:
- study of the vertical transport of gases emitted by fires
- study of the correlations between CO$_2$, CO and CH$_4$