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

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1. Introduction

Fires emit annually more than 2 GtC in the atmosphere, an amount which represents about one third of anthropic emissions, and which plays a key role in the interannual variations of three major gases: CO2 (90% of the emissions), CO (9%) and CH4 (1%). To study fire emissions, we look at the concentrations of emitted gases and study the links between CO2, CO and CH4 in the troposphere. Spatial observations give access to a global coverage, which is especially needed in the tropics where 80% of the emissions are located and where ground measurements are sparse.

2. Contribution of IR sounders to the study of BB emissions

Infrared sounders onboard polar satellites overpass every point twice a day. NOAA-10 observes CO2 by day and by night, allowing to study the night minus day difference of retrieved CO2. We call this difference the Daily Tropospheric Excess (DTE) of CO2 (see below). It is quantitatively related to fire emissions (Chédin et al., 2005, 2008).

The 2 origins of the observation of the DTE:

- Diurnal cycle of fires
- Convexion of fire emissions in the troposphere

During the day, CO2 is emitted by fires and uplifted to the high-troposphere. When the satellite passes at night, it sees the accumulation of CO2 below the tropopause; when it passes the next morning, before fires start again, the emissions have been diluted by the general circulation.

Taking the difference between night and day allows to keep only the CO2 fire emissions signal. The retrieved signal, from 2 to 3 ppbv, is low compared to the amplitude of the CO2 seasonal cycle, which is of about 6 ppmv in the northern tropics. Moreover, this low signal is spatially very localized. On the contrary, CO is a well-known proxy of fire emissions, its temporal evolution being mostly driven by fires. That’s why there is a strong interest to retrieve CO available from AIRS and IASI sounders, to study the diurnal cycle of fire emissions.

3. Retrievals of CO2 and CO from AIRS and IASI

- IASI (Infrared Atmospheric Sounding Interferometer)
  - Launched in October 2006 onboard MetOp-A and operational since July 2007
  - 8461 channels between 645 and 2760 cm⁻¹ (15.5 - 3.63 µm);
  - spectral resolution of 0.5 cm⁻¹ after apodisation;
  - spectral sampling of 0.25 cm⁻¹.

- AIRS (Atmospheric Infrared Sounder)
  - Launched in May 2002 onboard Aqua and operational since September 2002
  - 2378 channels between 650 and 2665 cm⁻¹ (15.4 - 3.7 µm);
  - spectral resolution ranging from 0.5 cm⁻¹ to 2 cm⁻¹.

4. Diurnal cycle of CO and fires

IASI (9:30 am/pm) and AIRS (1:30 am/pm) give access to 4 CO retrievals a day, allowing to study the diurnal cycle of CO in the troposphere.

- Airs CO retrievals: IASI CO (ppbv) - day IASI CO (ppbv) - night
- Airs CO retrievals: AIRS CO (ppbv) - 9:30 IASI CO (ppbv) - 13:30
- Airs CO retrievals: AIRS CO (ppbv) - 21:30

5. Study of night vs. day CO

Although the evolution of tropospheric CO is mostly driven by fires, the excess of CO seen in the maps above, in day and night, are not exactly localized on the areas affected by fires. This discrepancy between CO and fires might be explained by the transport of the emissions and by the accumulation of CO emissions from previous months in the troposphere.

To have only a signal which is directly related to fires, we study the monthly mean of CO day minus night differences. There is a very good agreement between this diurnal signal and fire activity.

6. CO2, CO and fires (Amazonia)

The 2010 drought explains the sharp increase in fires and CO2 emissions.

Very good agreement between fires and diurnal signals of CO and CO2.

7. Conclusion

- Infrared sounders enable to monitor the diurnal evolution of gases emitted by fires. AIRS and IASI give access to 4 retrievals of CO2 and CO a day.
- Our study highlights the diurnal cycle of tropospheric CO and CO2 in southern Africa and in Amazonia, which is in good agreement with fire activity. However, these cycles are of opposite sides, which might be explained by the different phases of combustion (= flaming phase for CO2 and = smoldering for CO). The main perspective of this work is to study the vertical transport of fire emissions.

References


Jacquinet-Husson et al. (2011), The 2010 drought explains the sharp increase in fires and CO2 emissions.
