ITSC-19
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Processing of Aqua/AIRS and Metop-A/IASI to study Essential Climate Variables

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GCOS Essential Climate Variables

In 2010: GCOS created a list of 50 Essential Climate Variables (ECVs) required to support the work of the UNFCCC and the IPCC.

Atmospheric (over land, sea and ice)	**Surface:**	Air temperature, **precipitation**, air pressure, surface radiation budget, wind speed and direction, water vapour.
	Upper air:	**Earth radiation budget (including solar irradiance), upper air temperature (including MSU radiances), wind speed and direction, water vapour, cloud properties.**
	Composition:	**Carbon dioxide**, methane, **ozone**, other long-lived greenhouse gases, **aerosol properties.**

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Atmospheric (over land, sea and ice)	Surface:	Air temperature, precipitation, air pressure, surface radiation budget, wind speed and direction, water vapour.
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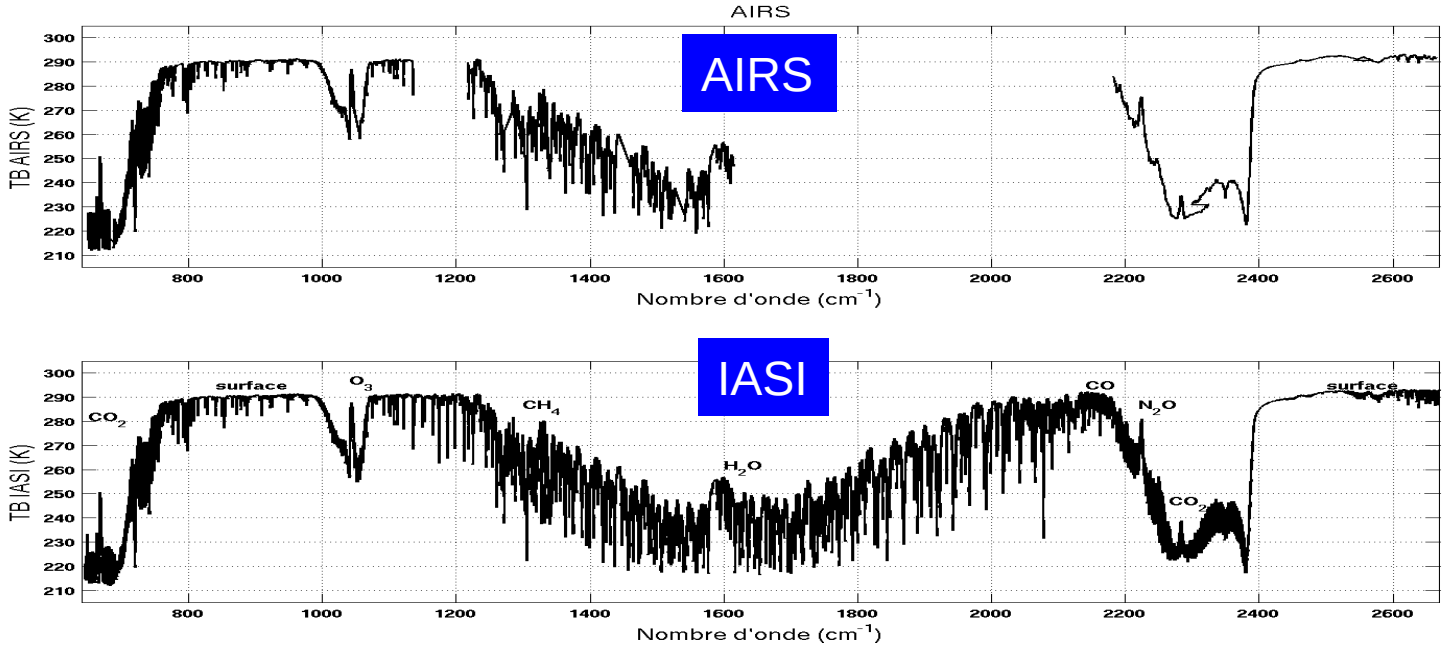
	Composition:	Carbon dioxide, methane, ozone, other long-lived greenhouse gases, aerosol properties.

Most of the atmospheric ECVs are available from hyperspectral IR sounders.

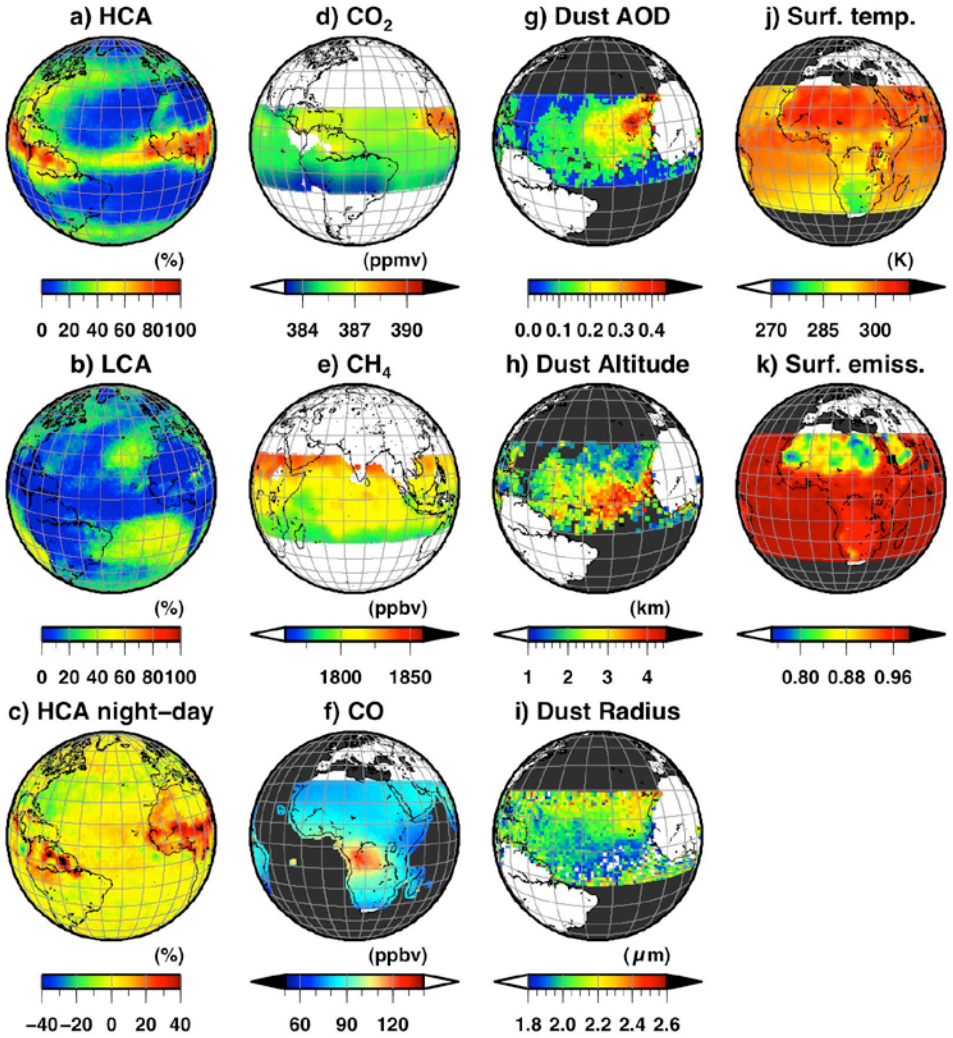


11 years from AIRS, 6 years from IASI/Metop-A, 1 year from IASI/Metop-B.

Focus on 4 Essential Climate Variables

Clouds | GHG | Aerosols | Surface

2007 ← Climatologies of Climate Variables from IASI → 2014



For details on the retrievals and main results, please see the posters by:

- Stubenrauch et al. (#9p.08)
- Crevoisier et al. (#13p.02)
- Capelle et al. (#13p.04)

Focus of this presentation: what can we learn about climate and climate processes from these ECVs?

1. Clouds: physical and microphysical properties

•**Objective**: to understand cloud formation in combination with upper tropospheric relative humidity and aerosols and cloud radiative budget.

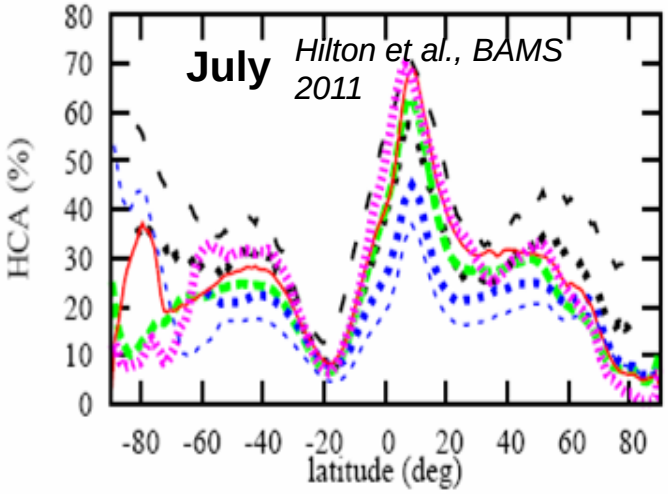
•**AIRS & IASI contribution**: retrieval of cloud pressure, temperature, emissivity of all clouds; ice water path, effective particle size and indication of particle shape of semi-transparent cirrus, day and night.

•**Methods**: weighted χ^2 method using CO_2 absorption band (Stubenrauch et al.).

→ Contribution to the GEWEX Cloud Assessment
(co-chairs: C. Stubenrauch & S. kinne)

GEWEX Cloud Assessment

comparison of 12 global cloud datasets

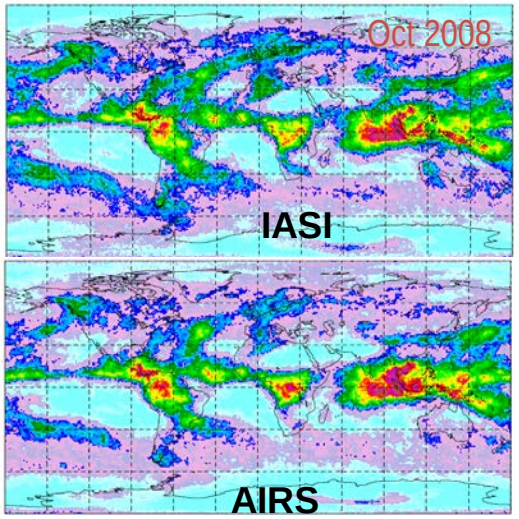


IASI cloud climatology

IASI-LMD
AIRS-LMD
TOVS-B

CALIPSO — **incl subvis Ci**, **excl subvis Ci**

ISCCP — **day**, **day + night**



Vertical sounders are sensitive to cirrus properties (also for multi-layered cloud systems by day & night)

2. Dust aerosol optical depth, altitude and radius

•**Objective:** retrieval of the dust optical properties, vertical distribution, size and analysis of their interaction with the climate system

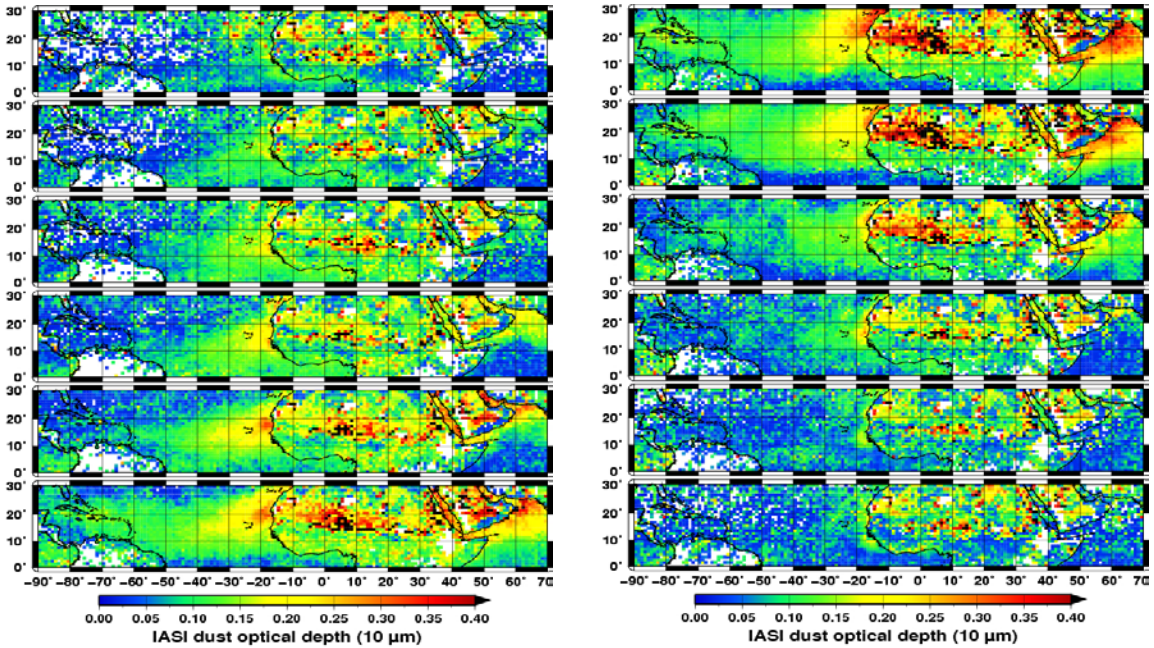
•**AIRS & IASI contribution:**

- Observations available **daytime** and **nighttime**, over **ocean** and over **land**
- Access to the **mean aerosol layer altitude** and to **the particle size.**
- 10 µm : preferential detection of **dust aerosol coarse mode**

•**Method:** proximity recognition in brightness temperature within Look Up Tables.

10µm coarse mode optical depth

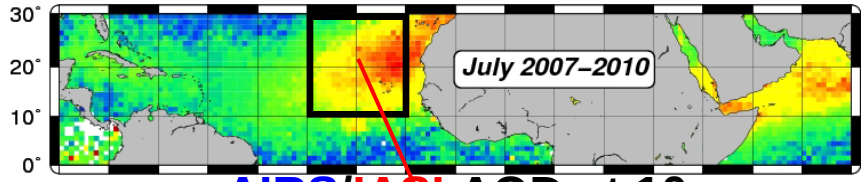
Climatology over the IASI period (2007-2011)



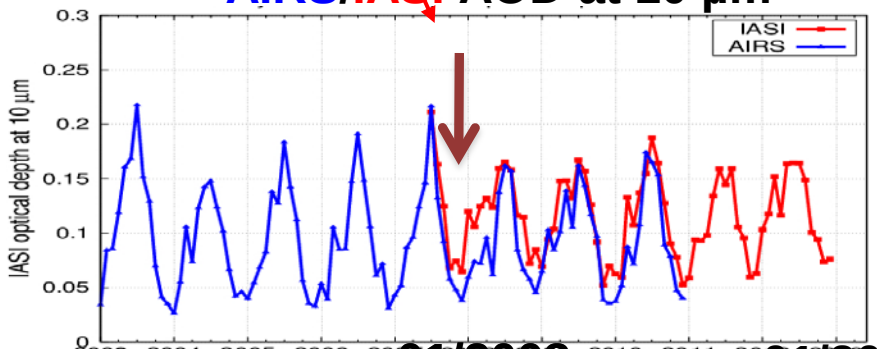
Pierangelo et al., ACP, 2004 ; Peyridieu et al., ACP, 2012 ; Capelle et al., ACPD, 2014

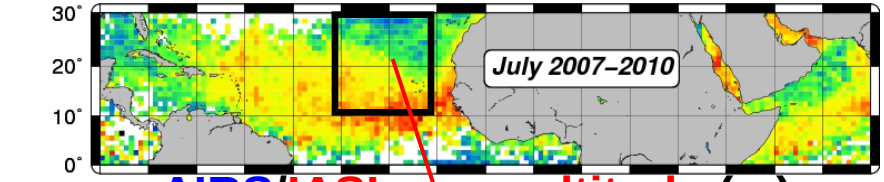
2. Dust aerosol optical depth, altitude and radius

10 years of dust aerosols properties: analysis of long-term evolution

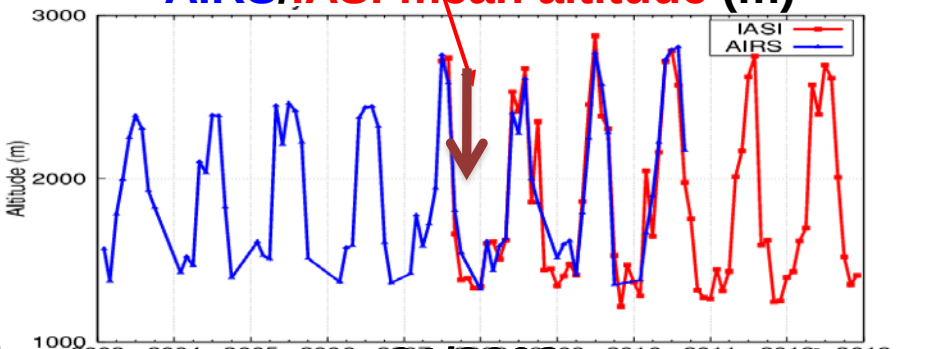


AIRS/IASI AOD at 10 µm





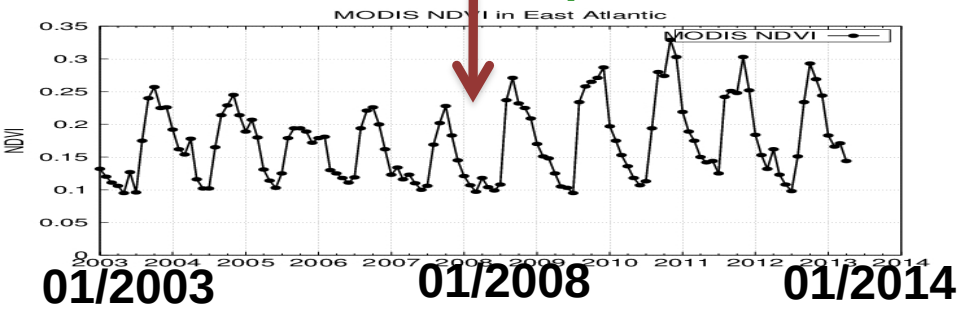
AIRS/IASI mean altitude (m)



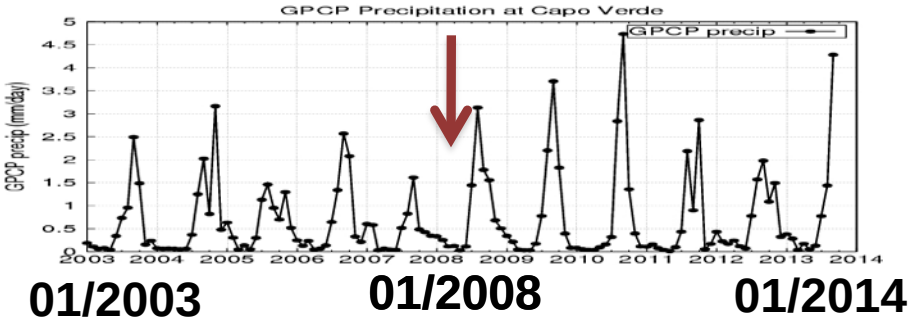
→In 2007/2008, a change in both AOD (with a lower amplitude of the seasonal cycle) and altitude (with a higher amplitude) is seen on AIRS and IASI during summer.

→A similar change is observed on vegetation (NDVI) and precipitation

MODIS NDVI at Capo Verde



Precipitations at Capo Verde



3. Land surface properties: temperature and emissivity

•**Objective**: Obtain an accurate estimation of spectral emissivity (often considered as constant) and surface temperature in order to improve the retrieval of tropospheric properties and to estimate the radiative budget.

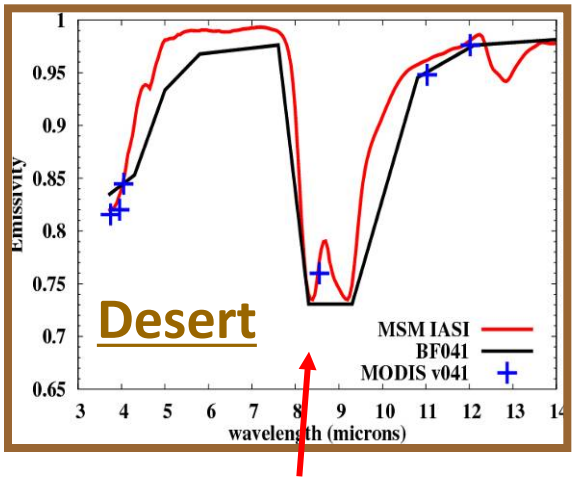
•**AIRS & IASI contribution**: Surface temperature and emissivity continuous spectrum at 0.05 µm resolution between 3.7 and 14.0 µm for monthly grid (1° X 1°) or for each IASI spots.

•**Method**: Physical inversion of the RTE using a fast RT model based on the TIGR atmospheric dataset (Péquignot et al., JAMC, 2008; Capelle et al., JAMC, 2012)

IASI

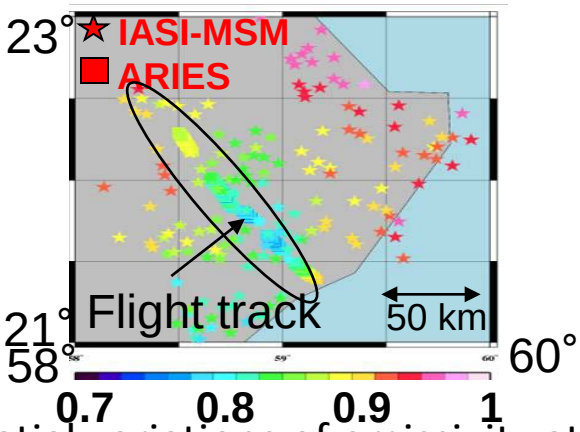
MODIS-Baseline Fit

MODIS



Local maximum at 8.65 µm

Comparison between IASI emissivity and ARIES "in-situ" emissivity at 9 µm (May 2009)

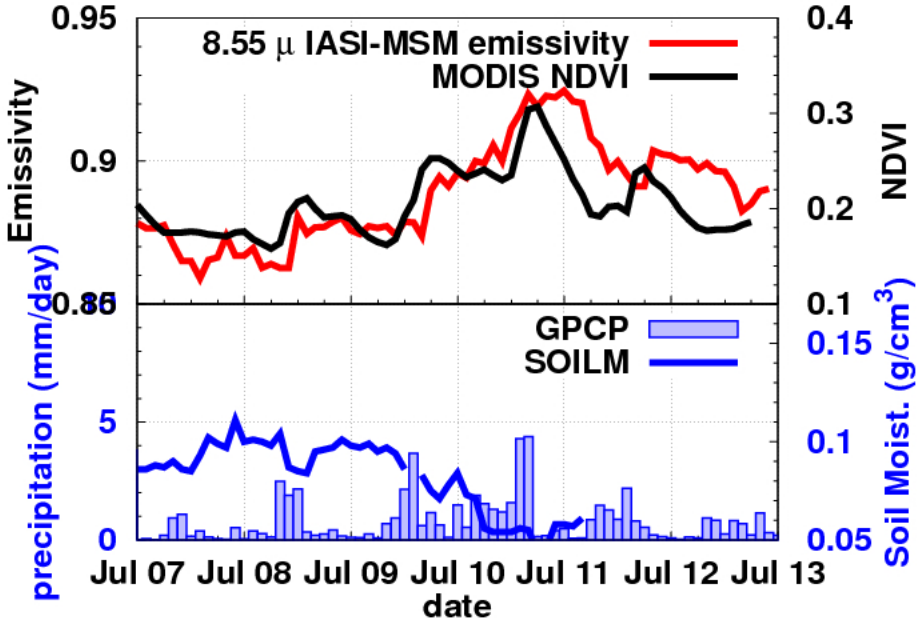


→large spatial variations of emissivity at very local scales consistent (10% variation for an area < 0.5°

3. Land surface properties: temperature and emissivity

Time series of IASI-derived emissivity at 8.55 µm over Australia from July 2007 to July 2013

Comparison with:
MODIS NDVI
precipitation (TRMM)
soil moisture (AMSRE)



⇒A drought period is clearly seen until 2009, followed by 3 strong rain episodes in 2009, 2010 and 2011.

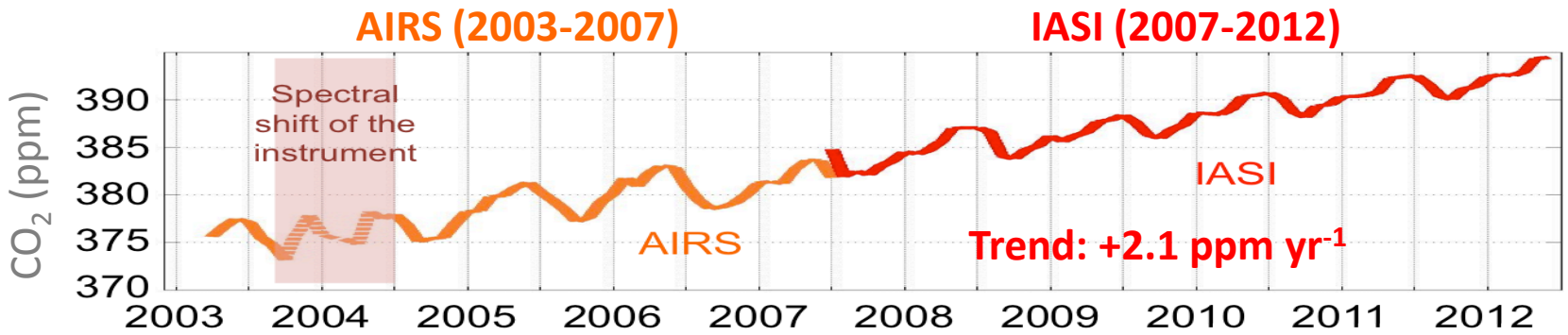
⇒The emissivity follows the evolution of vegetation induced by these dry/wet conditions (increase of both vegetation and emissivity at 8.55 µm from January 2010 to end of 2011)

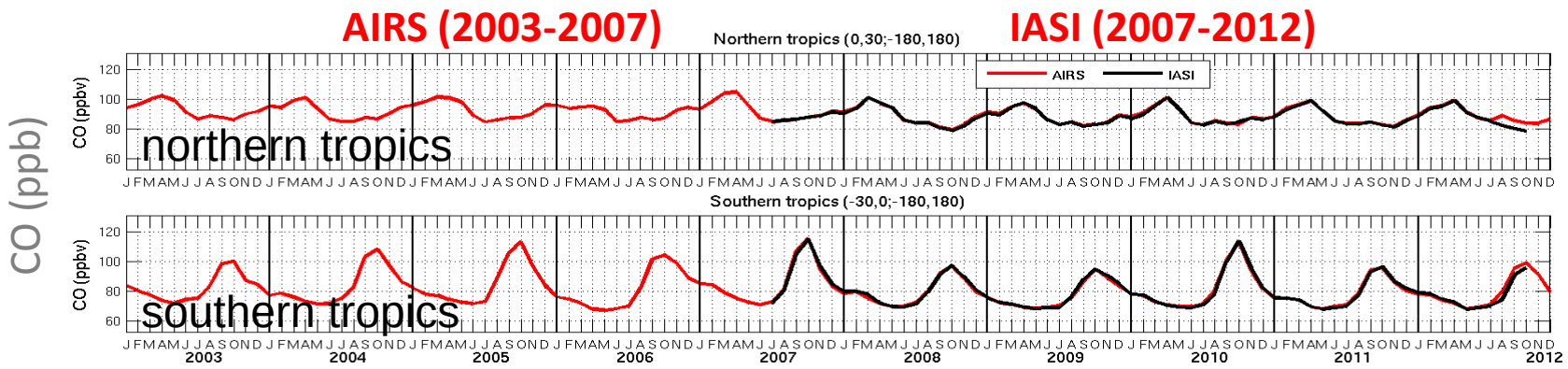
4. Greenhouse gases: CO_2 and CH_4 and CO

Objective: to better understand surface sources and sinks of greenhouse gases and the related processes (transport, flux).

AIRS & IASI contribution: mid-tropospheric integrated contents of CO_2, CH_4 and CO over both land and sea, day and night.

Methods: non linear inference scheme for CO_2 and CH_4 and spectral double differential approach for CO.

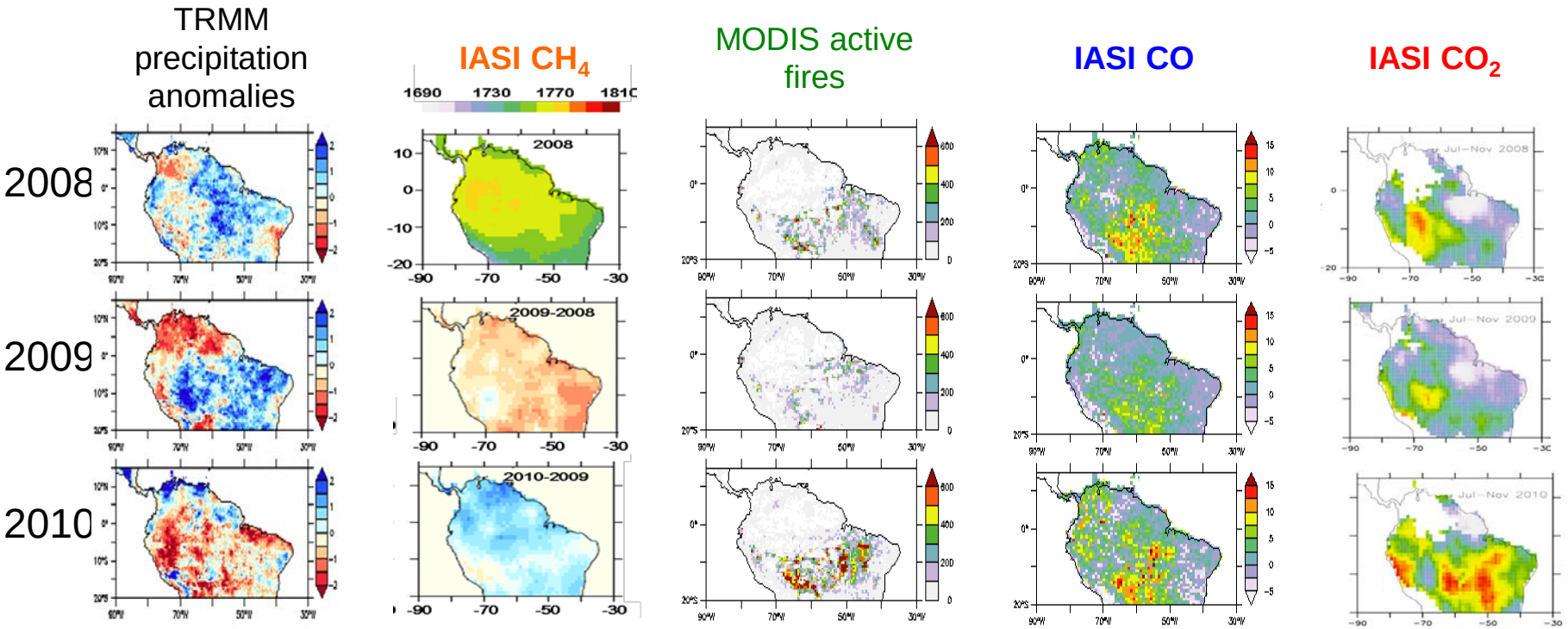




Chédin et al., 2003; Crevoisier et al., GRL, 2004; ACP 2009; ACP 2012; Thonat et al., AMT, 2013

4. Greenhouse gases: CO_2 and CH_4 and CO

Focus on Amazonia: Severe drought from mid-2009 to the end of 2010 originating from the combination of El Niño conditions during the wet season followed by a warming of the tropical North Atlantic during the dry season .



→ Decrease of CH_4 seen by IASI in 2010: due to decrease of wetland emission

→ Increase of fires seen by MODIS (especially over the arc of deforestation).

→ Increase of **CO** and **CO_2** due to fire emissions.

IASI multi-species observation allows the characterisation of regional climate events.

Summary

•AIRS & IASI allow monitoring several ECVs and provides their characteristics in the thermal IR.

•Thanks to their great stability in terms of radiometric and spectral characteristics (IASI is the reference for the GSICS activities), it is now possible to follow trends and interannual variations of the ECVs.

•Climate signatures are clearly embedded in the observations and correlation between ECVs and climate indexes need to be further studied.

•This relies on properly documented and well calibrated observations, as well as on constant improvement of key elements of the processing chains (spectroscopy, radiative transfer modeling, inverse modeling).

•Most of the databases (GEISA, ARSA, aerosols, surface) are available at:

http://ara.abct.lmd.polytechnique.fr