ITSC XVI
Angra dos Reis, 7-13 May 2008

Midtropospheric CO_2 Concentration derived from infrared and microwave sounders. Application to the TOVS, AIRS/AMSU, and IASI/AMSU instruments.

Cyril Crevoisier, Alain Chédin, Noëlle A. Scott,
Gaelle Dufour, Raymond Armante and Virginie Capelle

Laboratoire de Météorologie Dynamique, CNRS, IPSL, Palaiseau

CO_2 from infrared/microwave sounders

NOAA10/HIRS/MSU
1987-1991

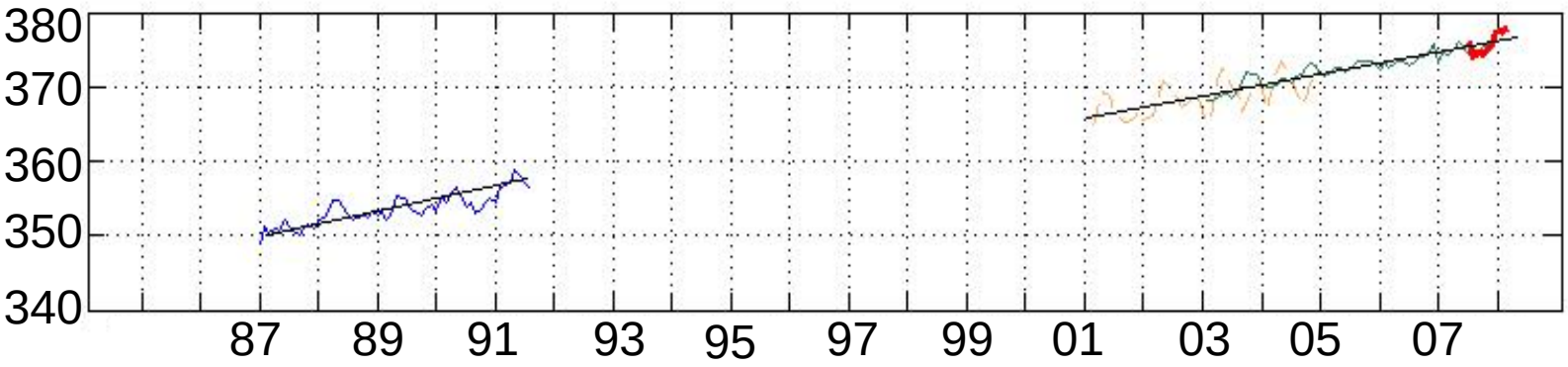
NOAAk/HIRS/AMSU
1999-2005

AIRS/AMSU
NASA/Aqua
Since 2002

IASI/AMSU
ESA/MetOp
Since 2006

	NOAA10 TOVS	NOAAk ATOVS	Aqua AIRS/AMSU	MetOp IASI/AMSU
Time coverage	1987-1991	1999-2005	May 2002-…	Oct. 2006-…
Spectral resolution			0.5 - 2 cm^{-1}	0.5 cm^{-1} (apodized)
# IR/MW channels	19/4	19/15	2378/15 **(324/15)**	8461/15 **(421/15)**
Local time	7.30	7.30	1.30	9.30

CO_2 seasonal cycle - Northern tropics [0-20°N]



NOAA10
TOVS

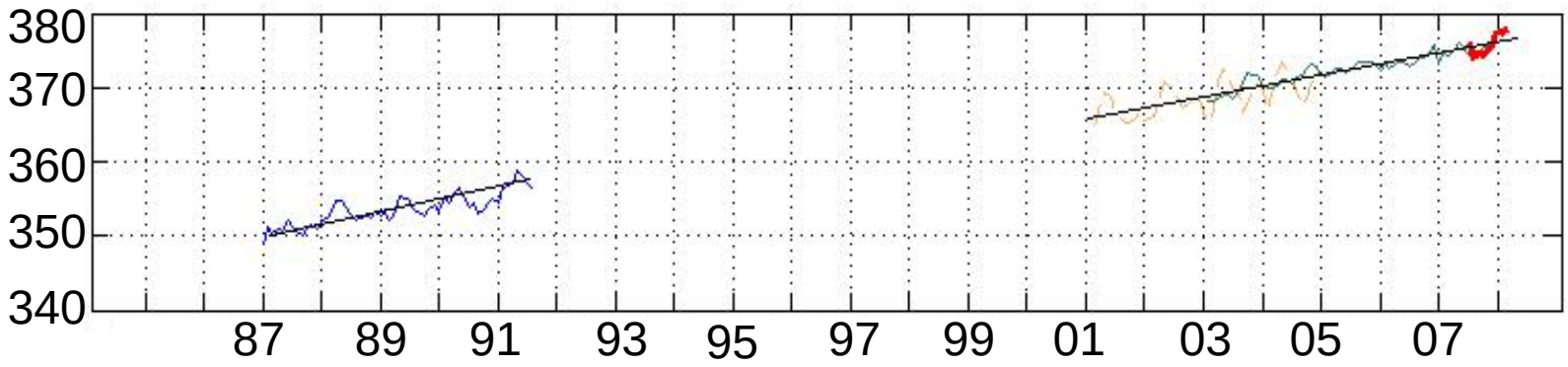
NOAA15
*ATOVS**

MetOp
IASI/AMSU

Aqua
AIRS/AMSU

- NOAA10: *Chédin* et al., JGR, 2003, 2008.
- NOAA15: Very preliminary results…
- AIRS: *Crevoisier* et al., GRL, 2004.

CO_2 seasonal cycle - Northern tropics [0-20°N]



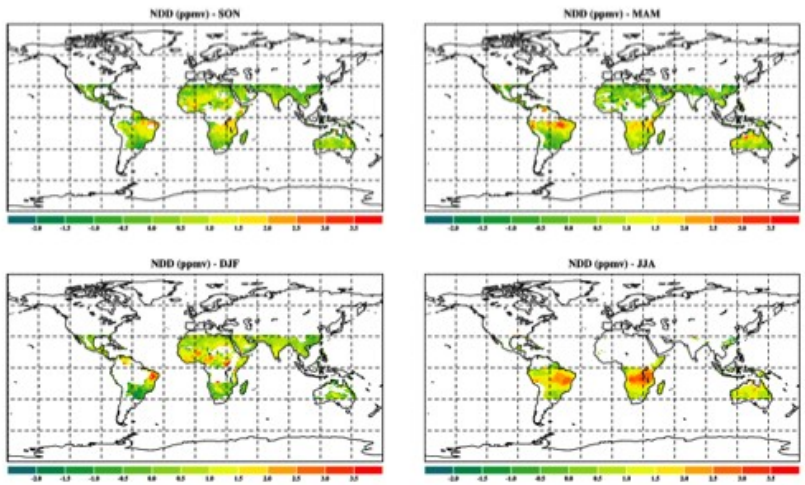
NOAA10
TOVS

NOAA15
*ATOVS**

MetOp
IASI/AMSU

Aqua
AIRS/AMSU

Difference between
7.30 am/pm observations

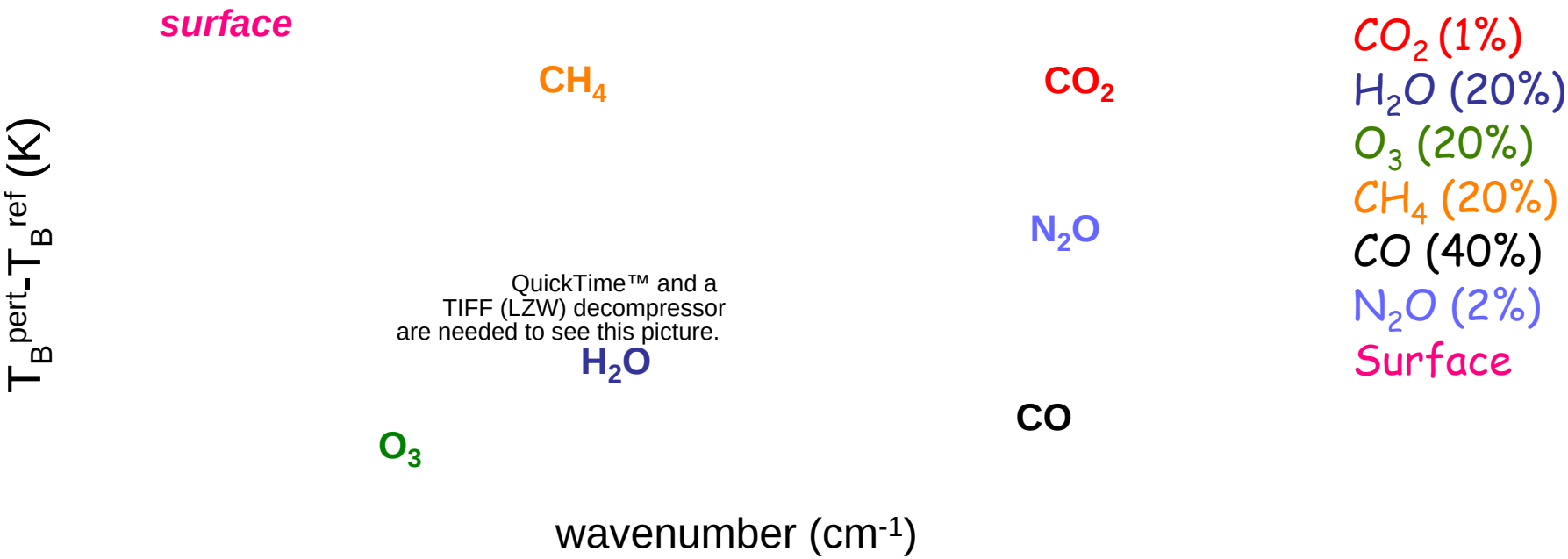


Diurnal Tropospheric Excess of CO_2
due to biomass burning emissions

See Poster B12 [*Chédin* et al.]

Spectrum and sensitivity to atmospheric components

Sensitivity of IASI T_B to variations of atmospheric and surface variables (simulations with the 4A RT model)



1 % of CO_2 variation $\rightarrow$ 0.04% of T_B variation

3ppmv $\rightarrow$ 0.3 K

$\Rightarrow$ The full information contained in the channels is needed to extract the CO_2 signal!

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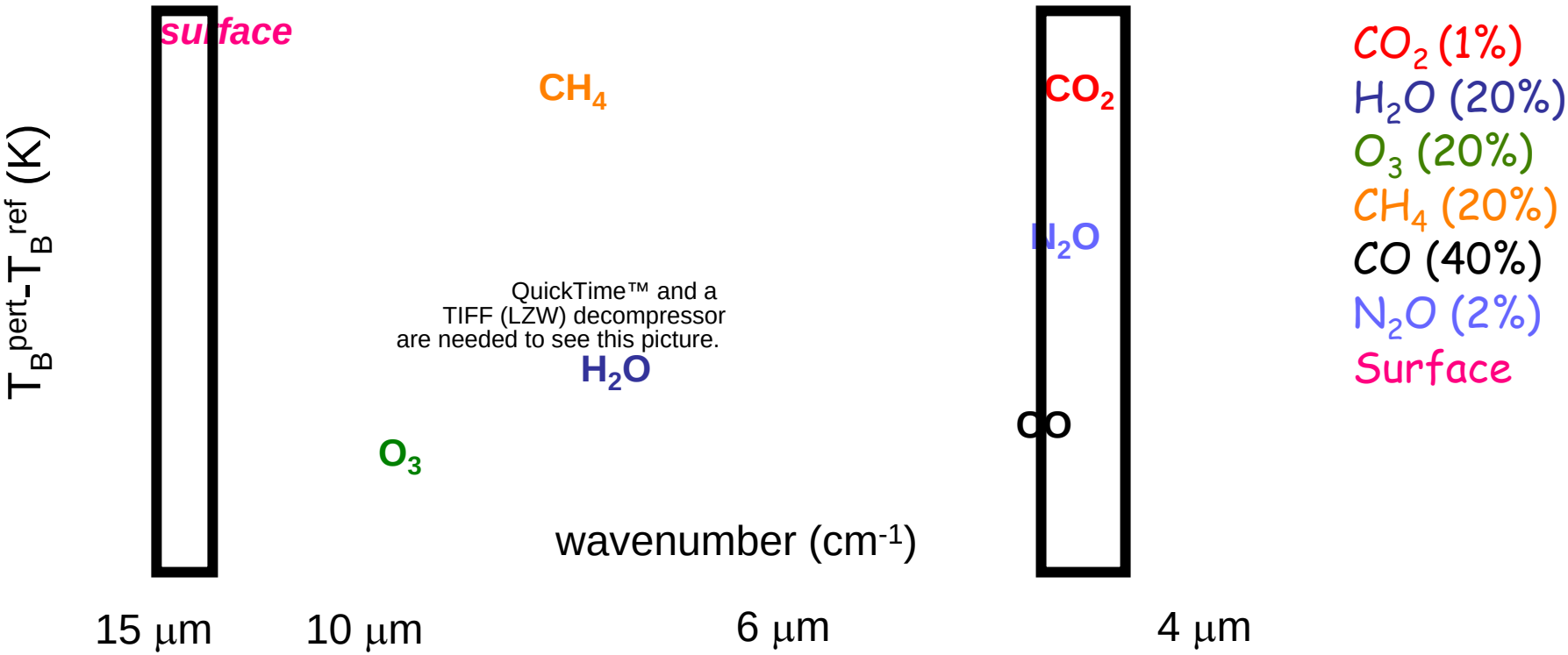


1 % of CO_2 variation → 0.04% of T_B variation

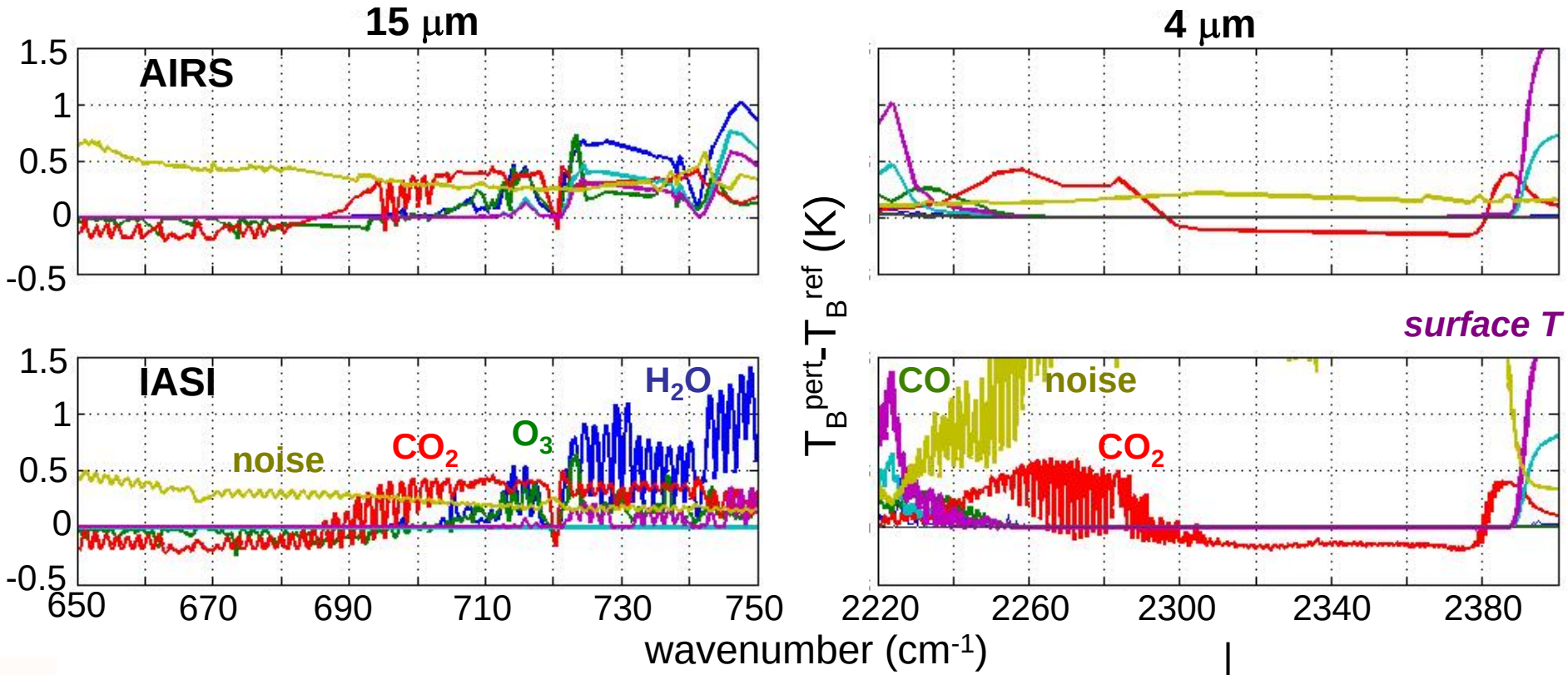
3ppmv → 0.3 K

⇒ The full information contained in the channels is needed to extract the CO_2 signal!

Spectrum and sensitivity to atmospheric components

Sensitivity of AIRS and IASI channels in the two CO_2 bands

(simulations with the 4A RT model)



CO_2 (1%)
H_2O (20%)
O_3 (20%)

CO (40%)
Surface T (1%)
Surf. emissivity (5%)

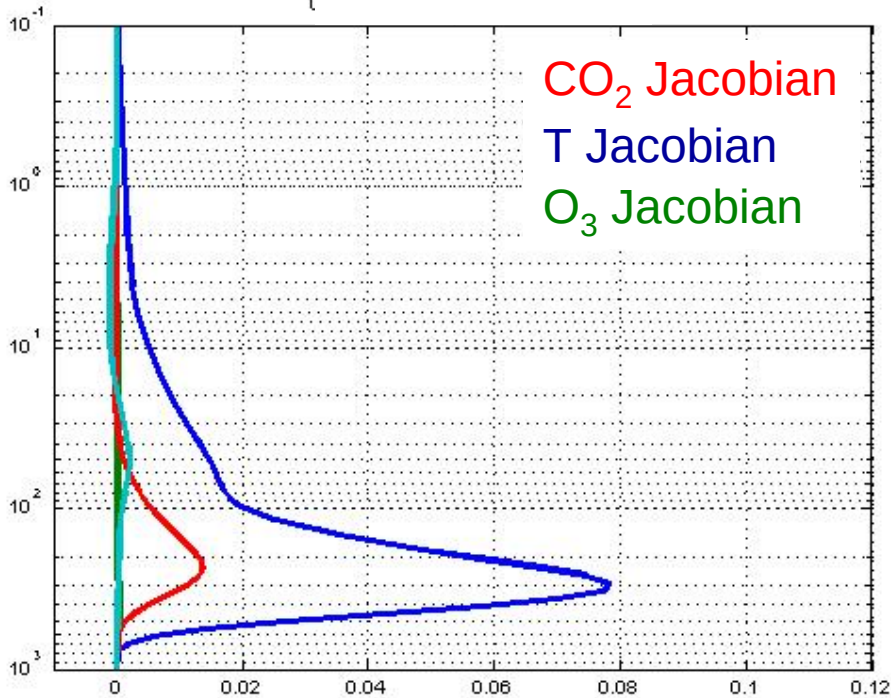
At 4 μm: Non-LTE

Only nightime retrieval

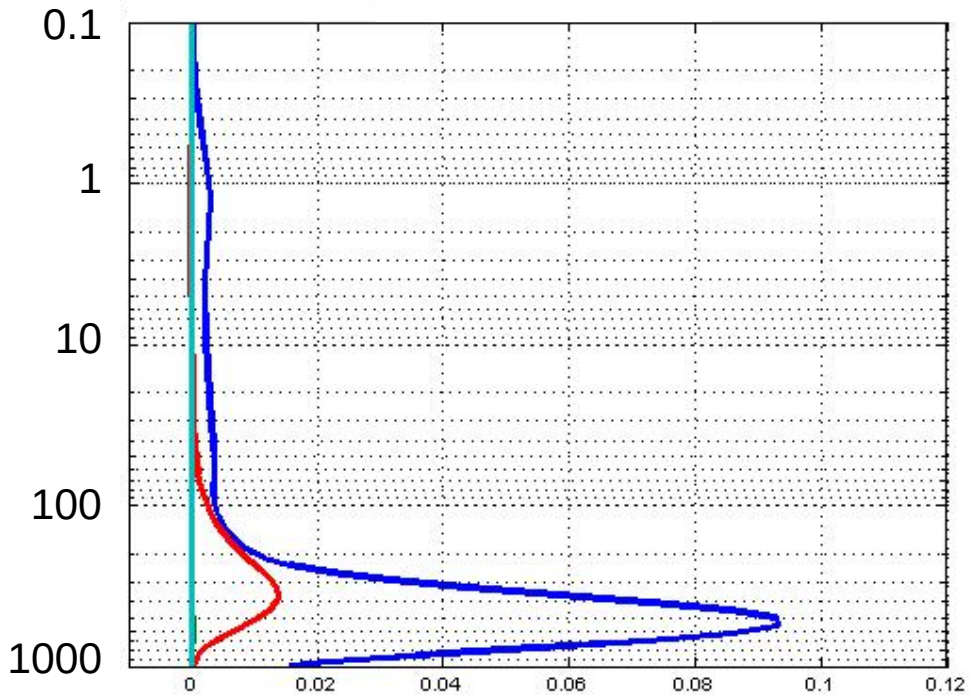
Spectrum and sensitivity to atmospheric components

Jacobians of two "CO_2" AIRS channels

Channel 80 - 15μm



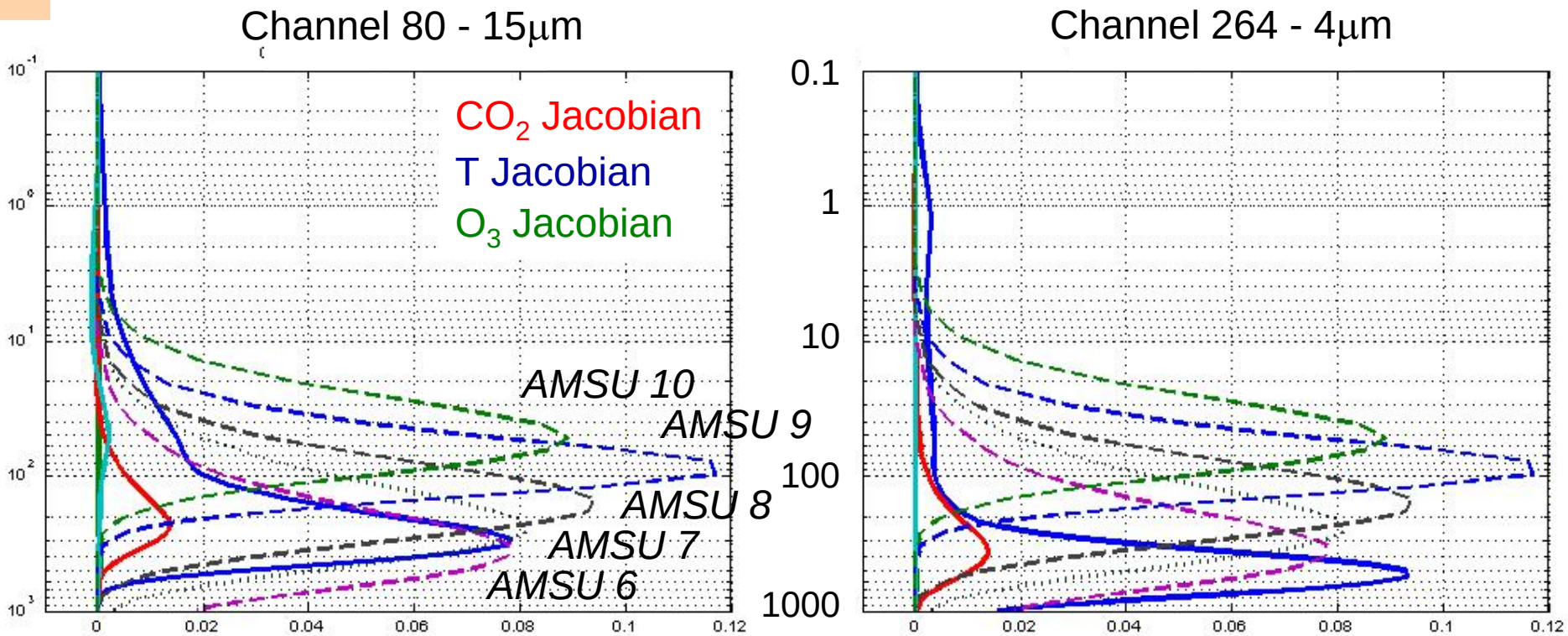
Channel 261 - 4μm



- Channels at 4μm peak lower in the atmosphere.

Spectrum and sensitivity to atmospheric components

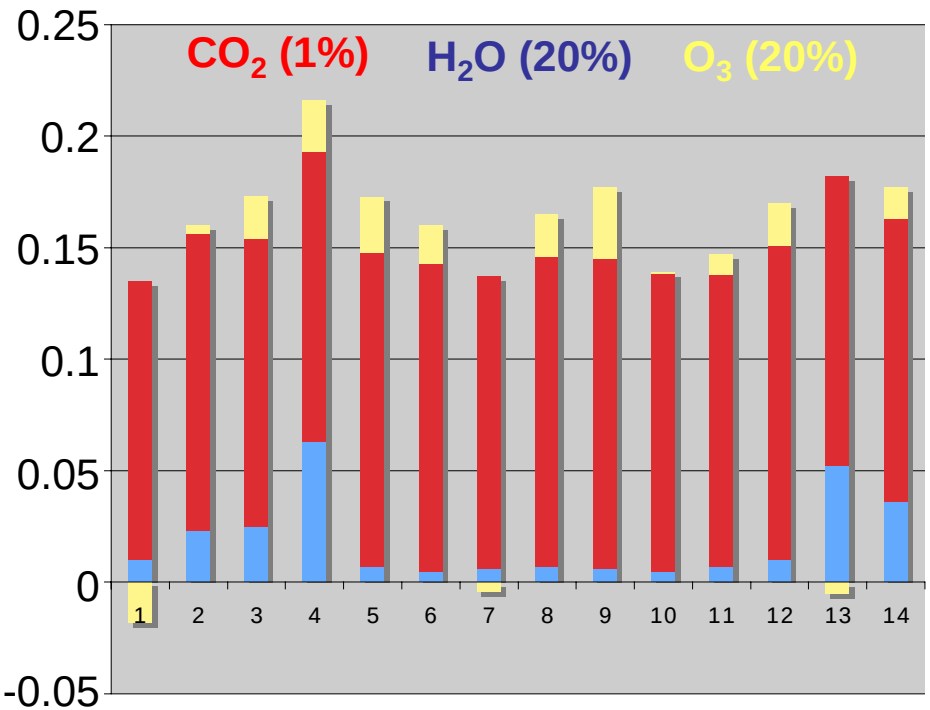
Jacobians of two "CO_2" AIRS channels and AMSU weighting functions

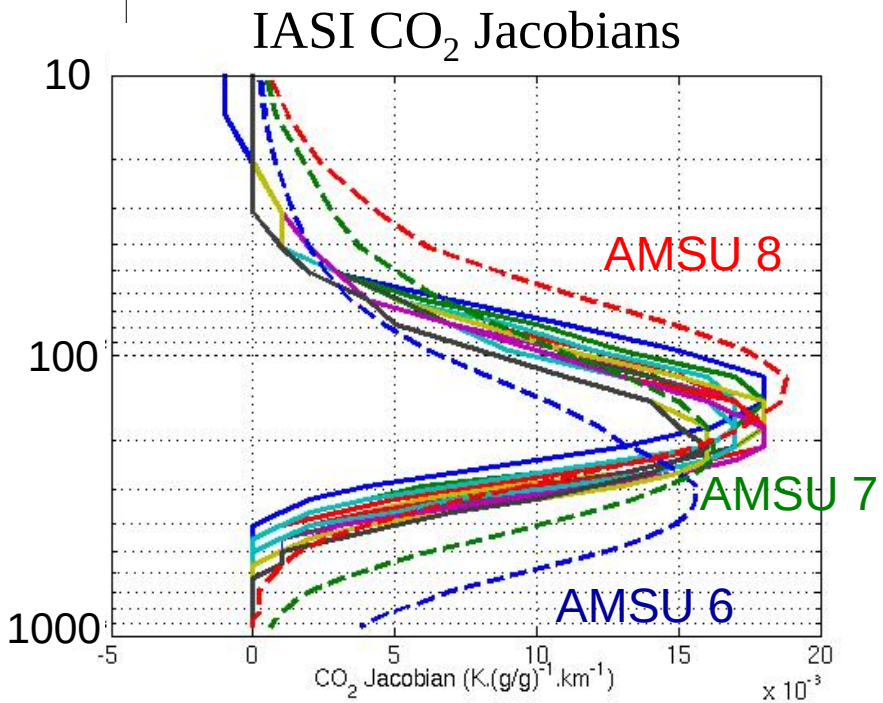


- Channels at 4μm peak lower in the atmosphere.
- AMSU channels bring the information on temperature.

CO_2 channel selection

- Aqua AIRS/AMSU:
  - -15 AIRS channels (8 in the 15 μm band - 7 in the 4 μm band).
  - -2 AMSU channels (6 and 8).
- MetOp IASI/AMSU:
  - -14 IASI channels (all in the 15 μm band).
  - -3 AMSU channels (6, 7, and 8).

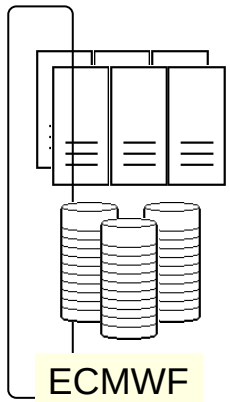




The level1b validation suite at LMD

See Poster B10 [Armante et al.]

Colocation of radiosoundings/re-analyses ERA40 with IR/MW observations



ECMWF

FTP

Radio-soundings /Reanalysis (ERA-40)

Quality control of the Radiosoundings
➔Inter/extrapolation UGAMP climatology

« Clean » Radio-soundings

Space and Time Colocation (100 Km, 3h)

RT model (Stransac, 4A)

Fixed CO_2=372 ppmv

Radiative biases between calculated and observed BT

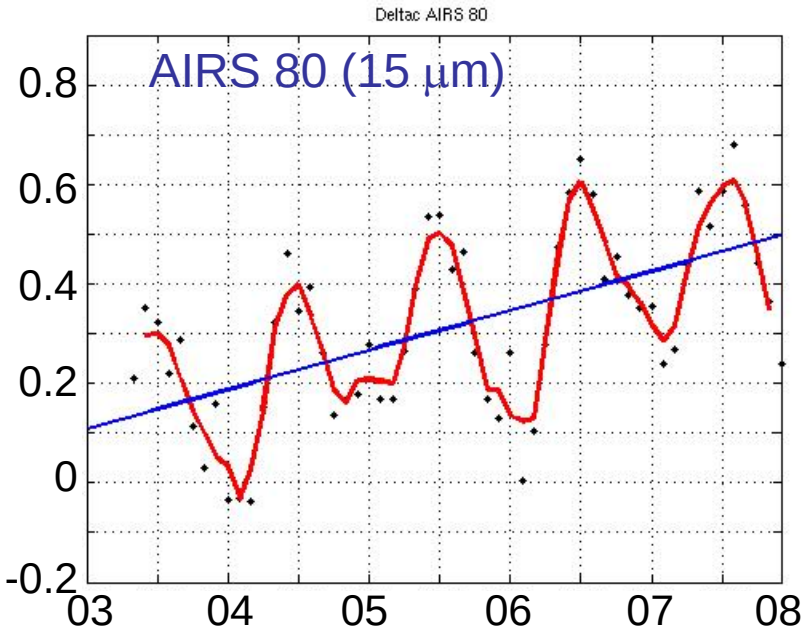
L1B Satellite Data (1979-2006)

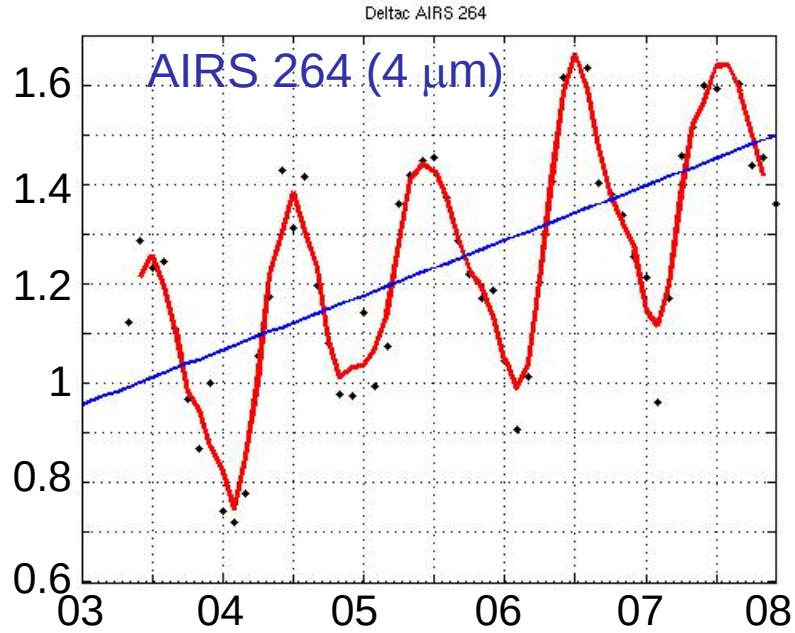
- Radiosoundings «ERA40 »
(23 Go from 1979 to 2007)
-Re-analyses ERA-40
(79 Mo / day, 2 days /month)

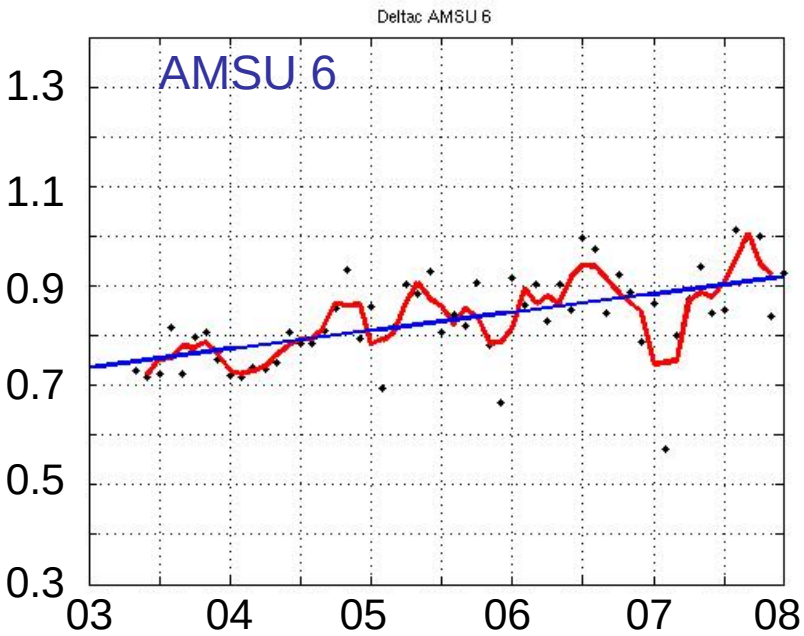
Example IASI/AMSU (MetOp)
Satellite data :14 orbits/day
900 Mo/day; 421 IR, 15 MW

AIRS Radiative biases: Monthly evolution (5 years over the tropics)

Calc.-Obs. (K)







~60 situations/month over sea
~30 situations/month over land

AIRS Radiative biases: Monthly evolution (5 years over the tropics)

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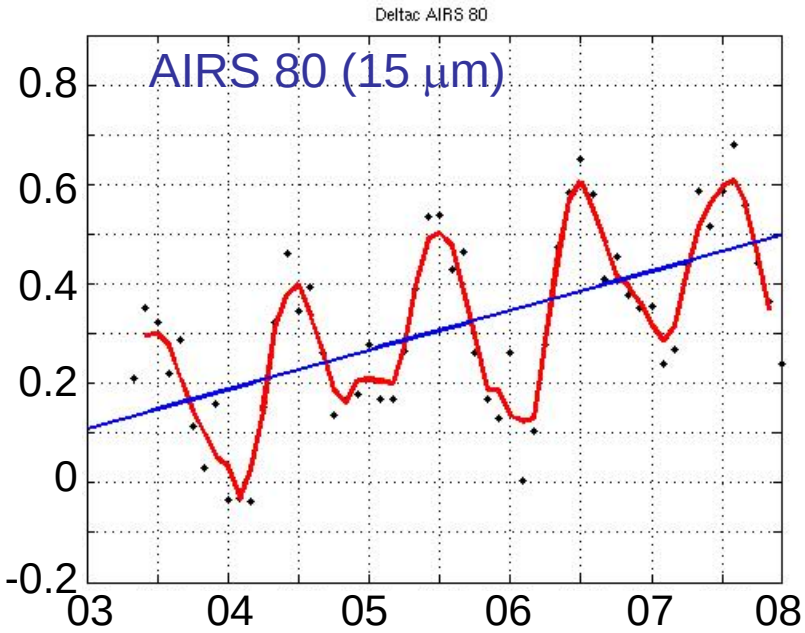
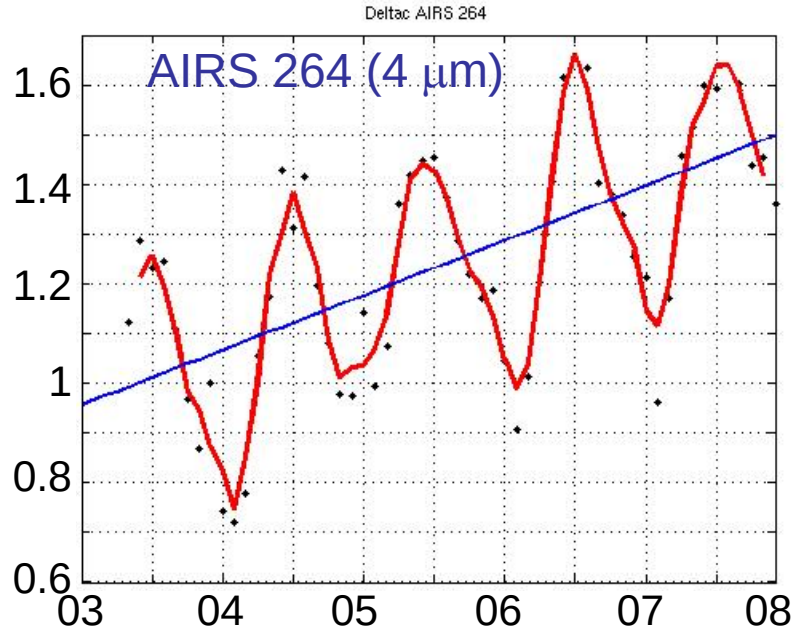




"CO_2" slopes (mean over 5 years):

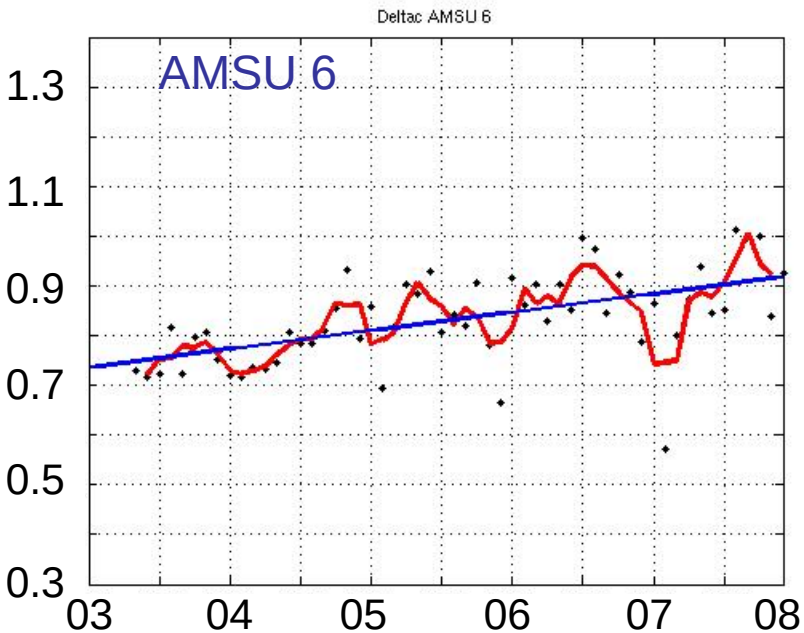
AIRS 80: 2.16 ppmv.yr^{-1}

AIRS 264: 2.39 ppmv.yr^{-1}

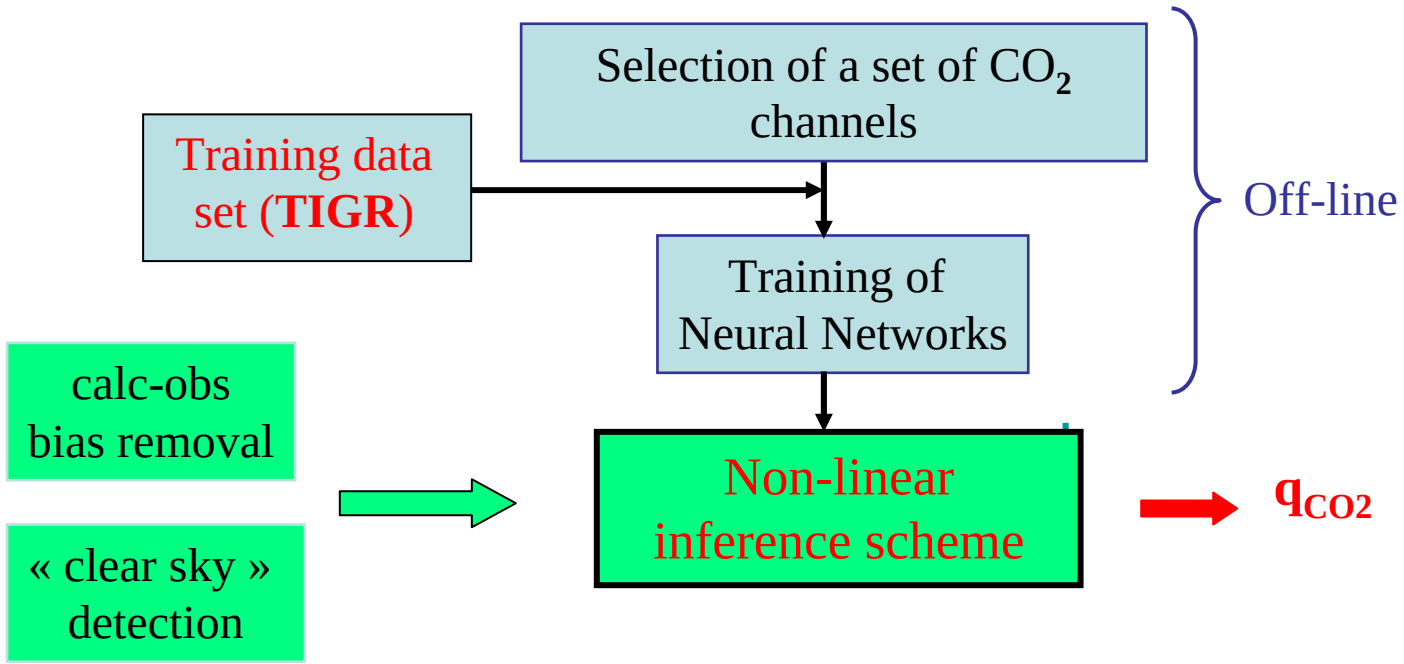
Mauna Loa: 2.05 ppmv.yr^{-1}

~60 situations/month over sea

~30 situations/month over land



General features of the CO_2 retrieval scheme : non-linear regressions



- Simultaneous use of IR and MW channels to decorrelate T/CO_2.

IASI AMSU

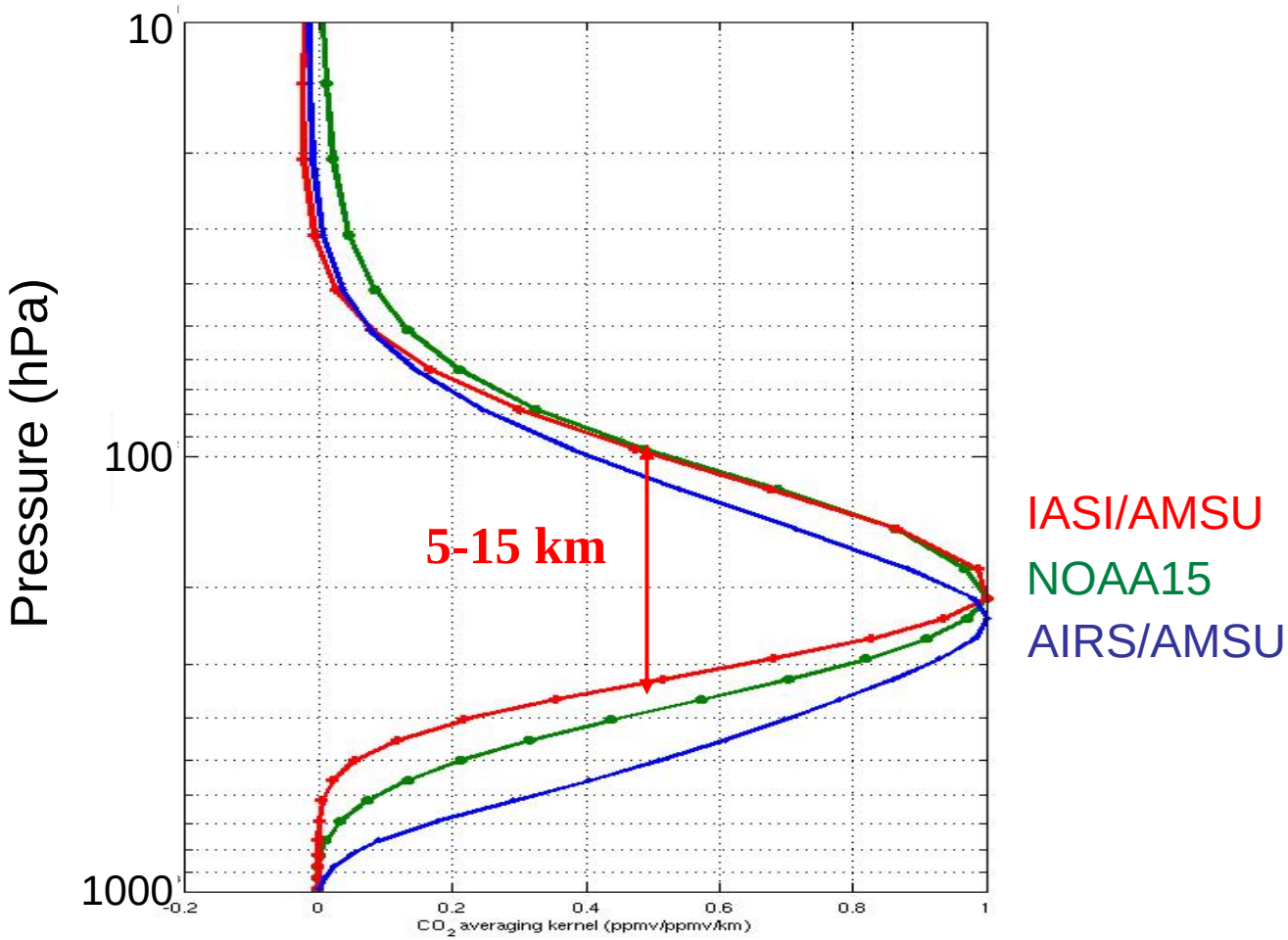
- Retrieval limited to the tropical region.

[*Chédin* et al., JGR, 2003; *Crevoisier* et al., GRL, 2004]

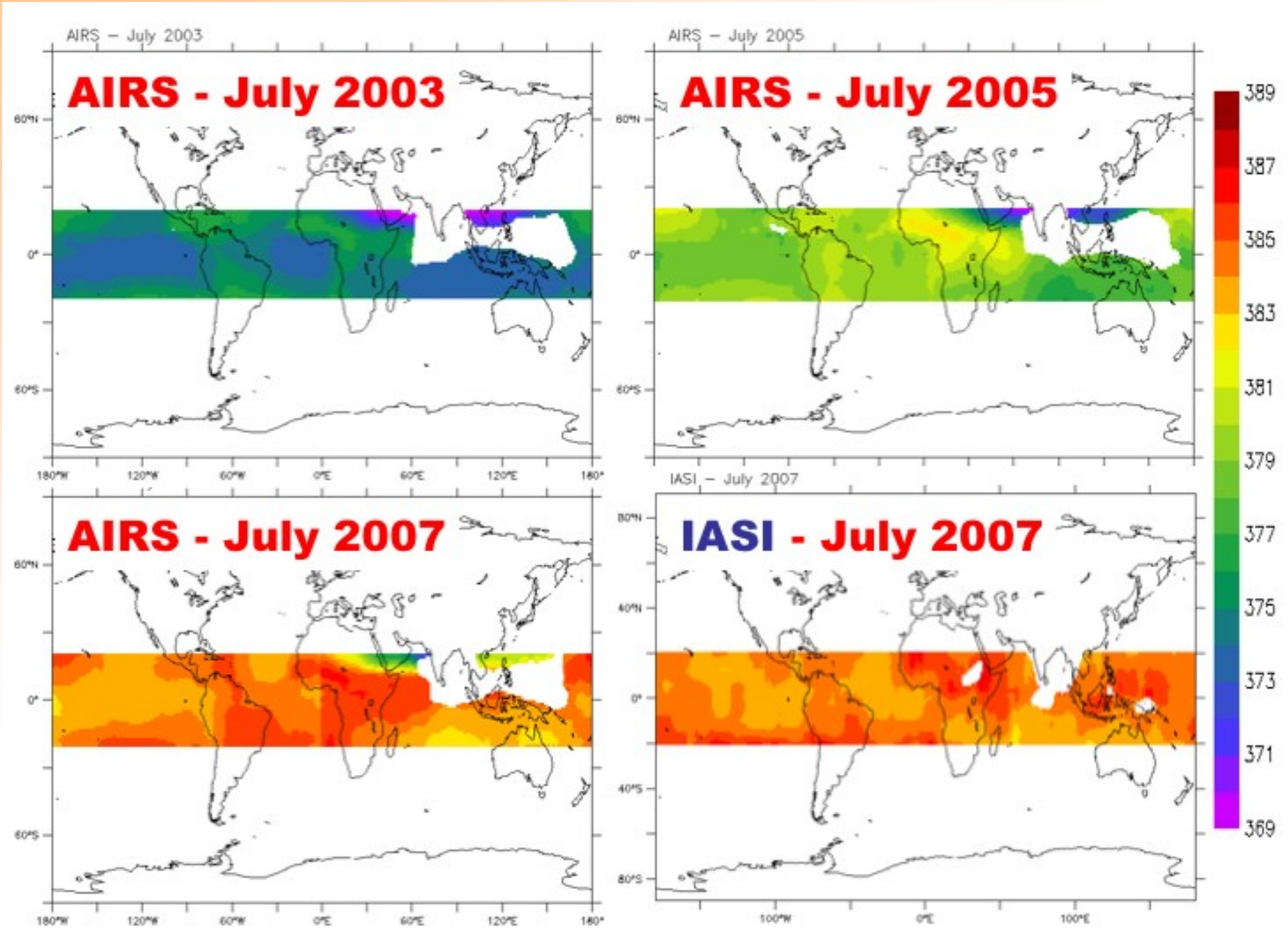
Evaluation of the inference scheme characteristics

We retrieve a mid-to-upper tropospheric integrated content of CO_2.

*Mean **CO_2 averaging kernel** over TIGR atmospheric dataset for nadir observation*

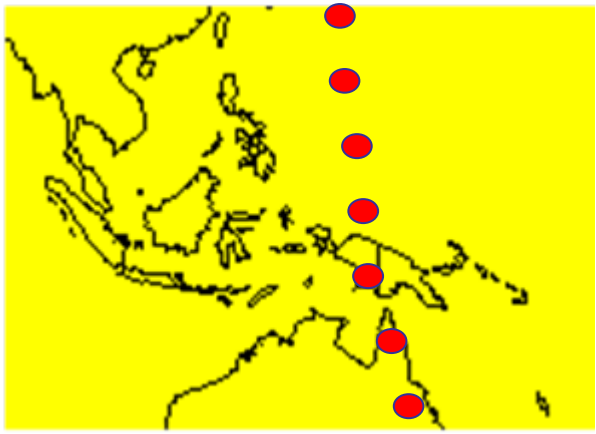


CO_2 distribution from AIRS and IASI - Monthly average

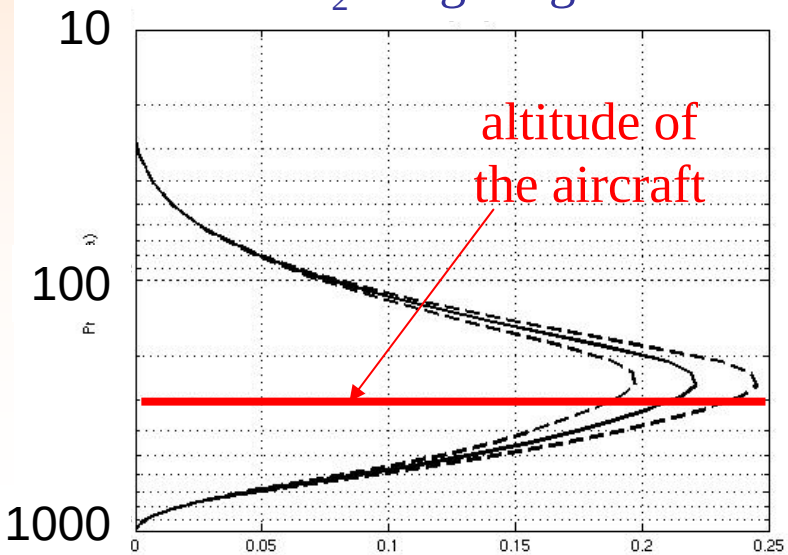


Evaluation of IASI CO_2

JAL commercial airliners
between Australia and Japan



IASI CO_2 weighting function

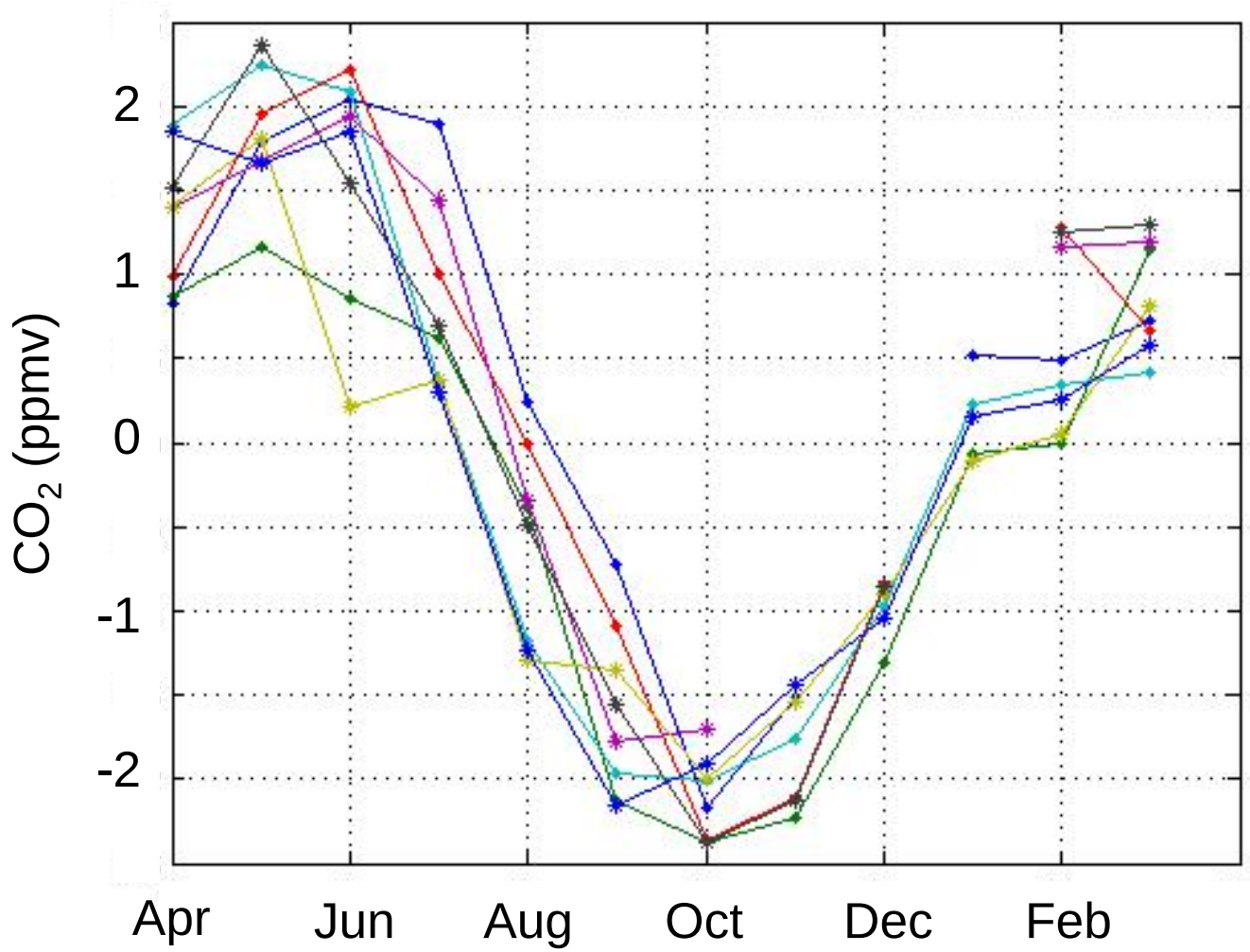


- Aircraft [Matsueda et al.]
  - -8-10 km
  - -1-2 points/month
  - -until March. 2007

- IASI CO_2
  - -integrated content 5-15 km
  - -monthly mean
  - -period: July 2007-March 2008

Seasonal cycle

Detrended CO_2 seasonal cycle as observed in situ by JAL aircraft for 2003-2006



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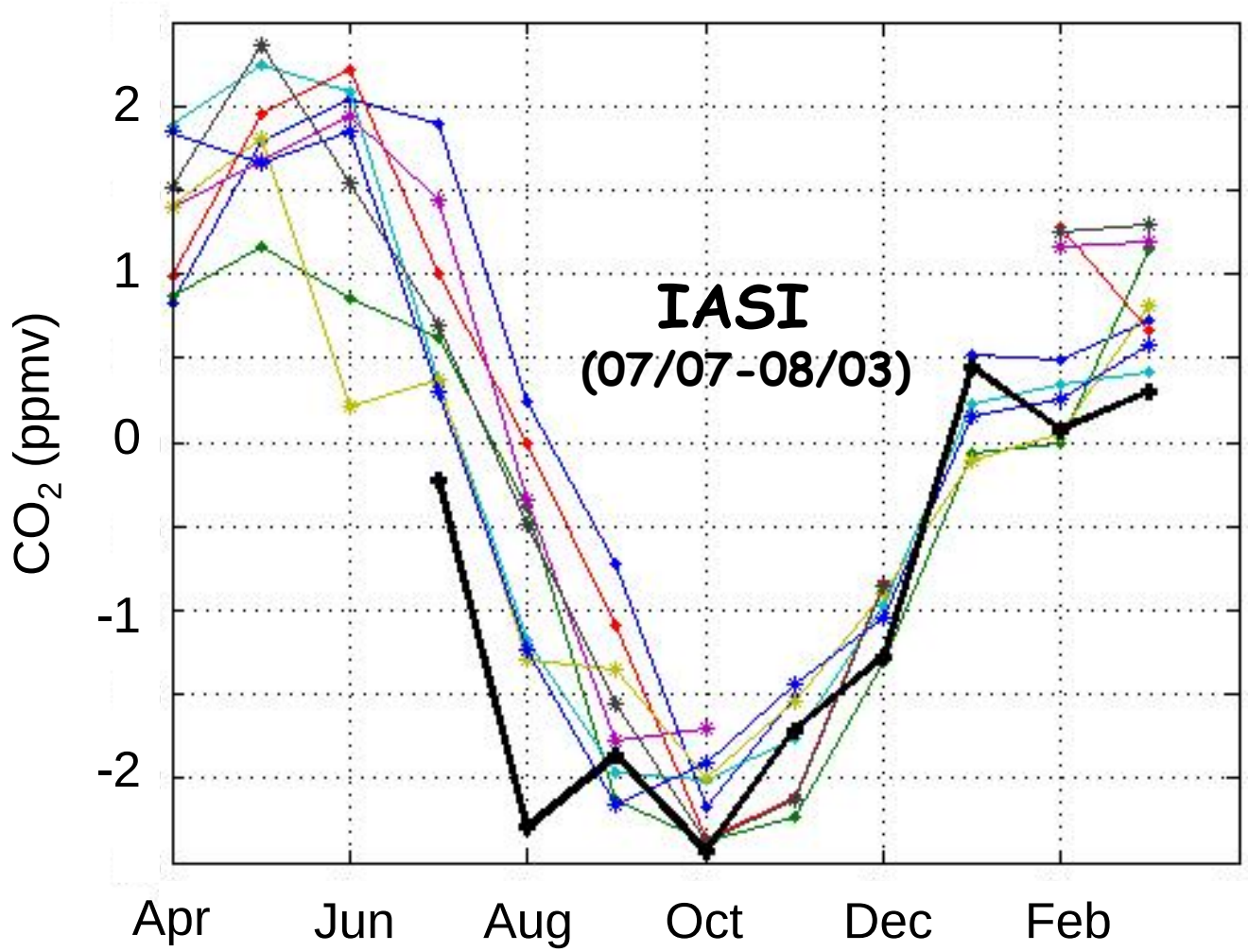
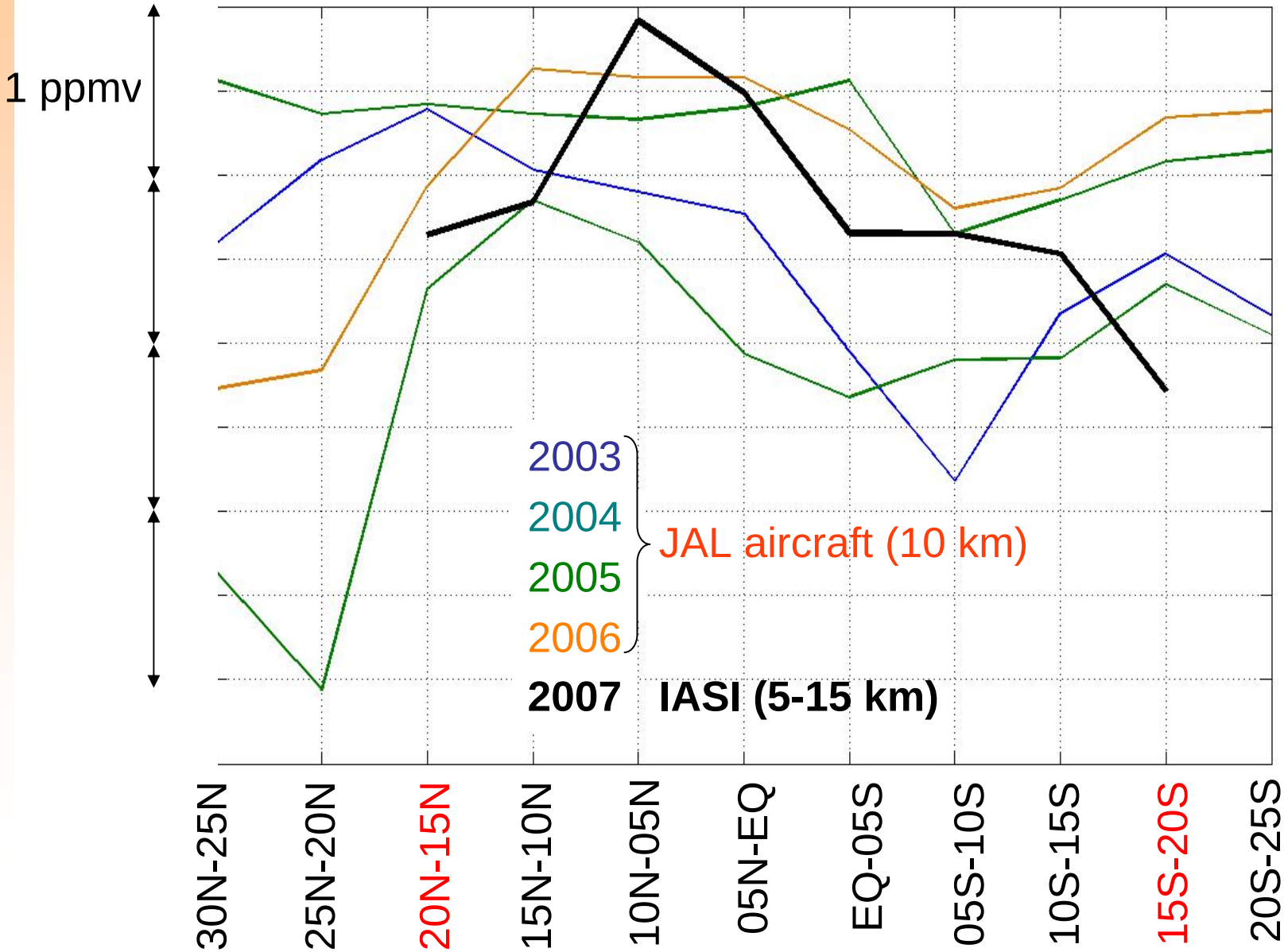


Latitudinal variation

CO_2 latitudinal variation in July



Conclusions

•We retrieve a mid-to-upper tropospheric integrated content of CO_2 from simultaneous IR/MW observations (TOVS, ATOVS, AIRS/AMSU, IASI/AMSU).

•The CO_2 signal is very low:

The full information contained in the channels is needed (that excludes using PCA-like data).

•Good agreement of CO_2 distribution between IASI and AIRS but lower variability/uncertainty with IASI:

-Reducing radiometric noise is as important as improving spectral resolution.

-A "good" AMSU instrument is important.

•General good agreement with in-situ observation in terms of seasonal cycle and latitudinal gradients.