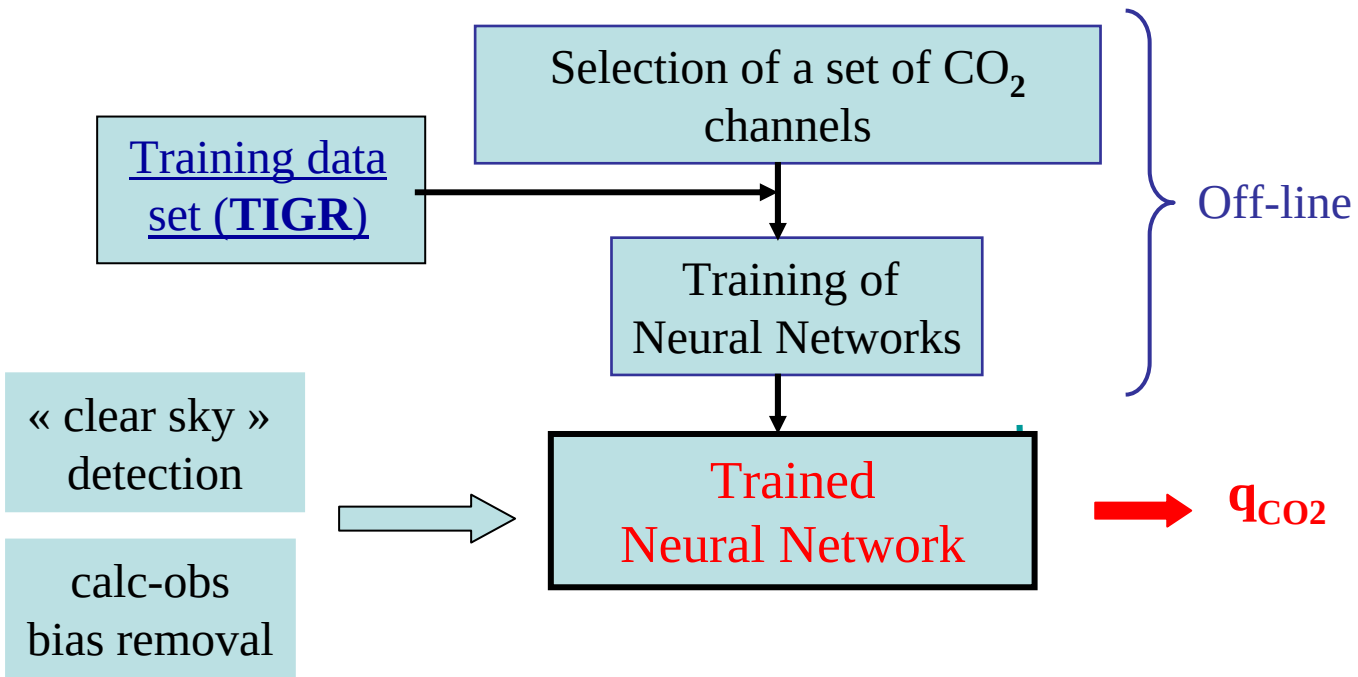
Retrieving mid to upper tropospheric CO_2 columns from AIRS revisited

LMD/IPSL/ARA, Ecole Polytechnique, France

GEMS, February 2006

General features of the CO2 retrieval scheme : non-linear regressions

CO_2 retrieval from AIRS observation



Since April 2003, LMD has stored AIRS/AMSU observations distributed by NOAA/NESDIS with the highest spatial resolution available.

Design of a new learning data base (TIGR)

« SAF »
tropical data set* (from one year of analyses at 60-levels): ~11,300 sit.
(F. Chevallier, priv. comm.)

Fast RT algo. to compute AIRS Tb's

Two years of daily observed AIRS Tb's

Proximity recognition and selection of the closests : ~2,000 sit.

Analysis of their distribution in time (monthly) and in space (15° L x 5° l)

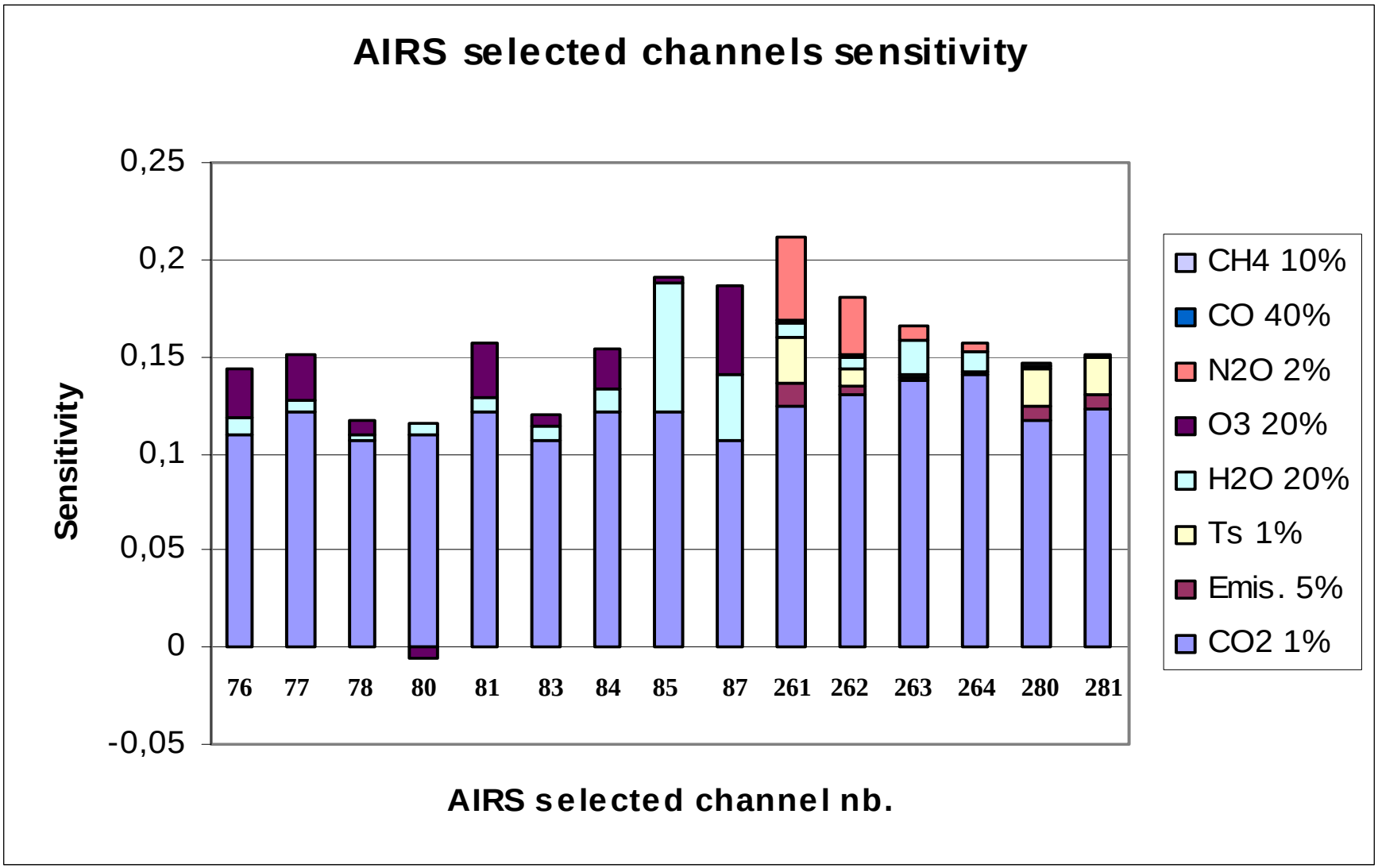
Final selection of ~ 800 situations

Done separately over land and over sea : two files of ~ 800 situations each

Improvements compared to TIGR:
- better time coverage (months, seasons)
- better space coverage (tropics)
- better coherence T(P), H2O(P), O3 (P)

To day: work completed over sea

Revised AIRS channels selection (15 Airs and 2 AMSU)



AIRS cloud and aerosol detection algorithm

Aim: detect clear columns (thin cirrus, low clouds and aerosols may contaminate observations)

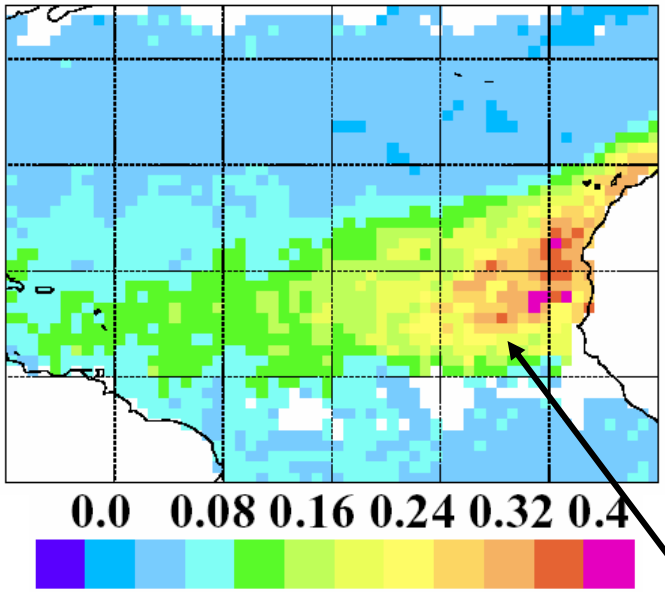
13 tests based on observed channel difference histograms

Thresholds determined from the observations

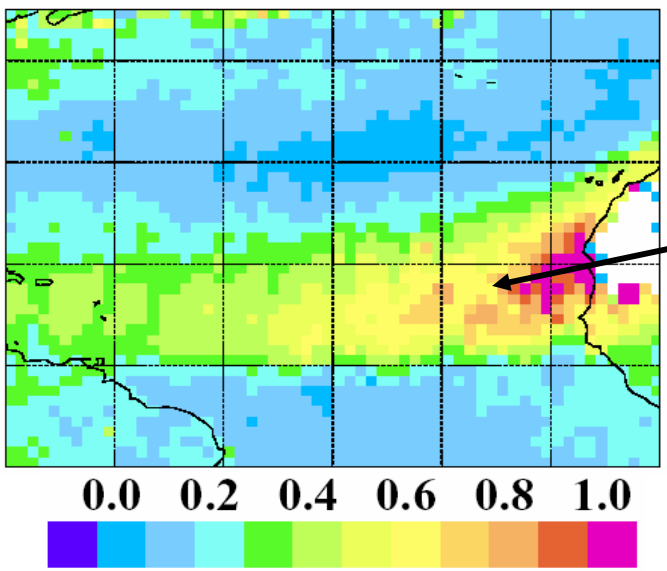
Dedicated tests for low clouds and/or aerosols (channels selected from simulations using "4A" and "DISORT"), mid clouds, and high clouds (cirrus)

"Validation" using MODIS: AIRS cloud cover should be significantly larger due to lower spatial resolution)

AIRS AODs (10 µm)



MODIS AODs (0.55 µm)



Undetected aerosols may contaminate CO_2 retrievals

Dedicated AIRS cloud tests allow separating aerosols from low clouds

Infrared (10 µm) aerosol optical depths and altitude may then be calculated [Pierangelo et al., 2004]

Top left figure shows results from AIRS for July 2003

Bottom left figure shows the results obtained from MODIS in the visible (0.55 µm)

Note the strong signature of dust aerosols crossing the Atlantic ocean

C. Pierangelo et al., 2005

AIRS cloud tests (night, sea, “version 8”)

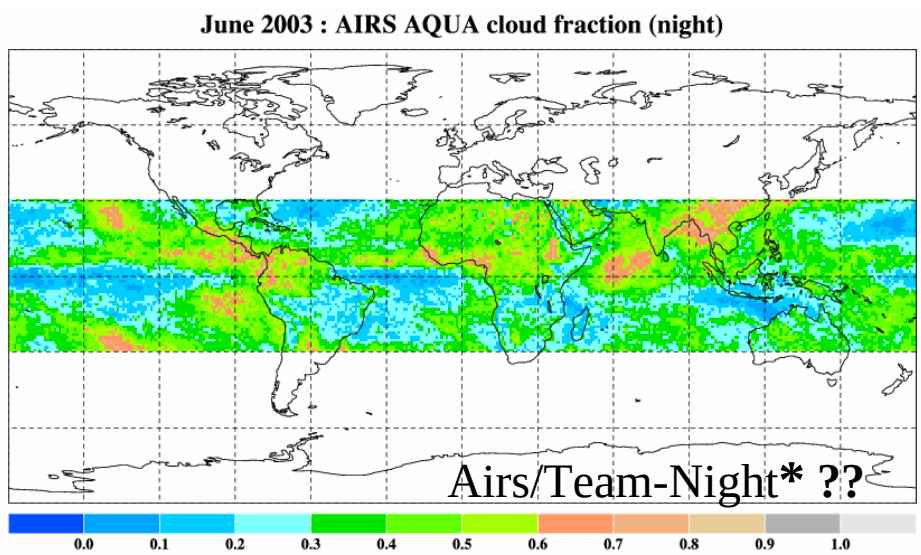
Test nb	Test*	Threshold (K)	W/F
1	|93 – A6| GT	1.0	high
2	|264 – A6| GT	1.0	high
3	|280 – A6| GT	1.0	high
5	|284 – A5| GT	1.0	mid
6	|284 – A6| GT	1.0	mid
7	|286 – A5| GT	1.0	low
8	|136 – 308| GT	2.0	surf
9	|136 – 315| GT	2.0	surf
10	315 – 140 LT	0.7	low clouds
11	315 – 140 GT	3.3	cirrus
12	313 – 177 GT	1.8	high clouds
13	313 – 177 LT	0.8	aerosols

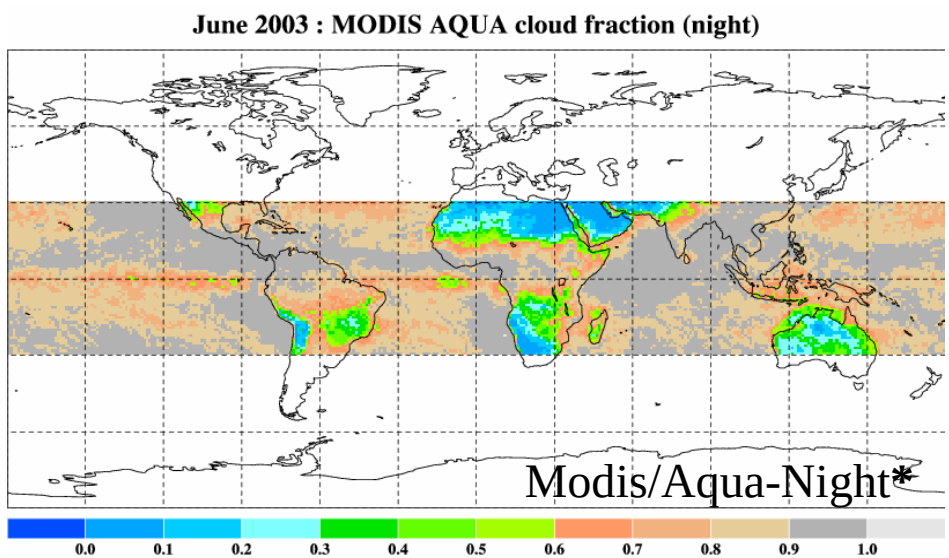
* n° on the 324 channel list ; A5-6 : AMSU channels

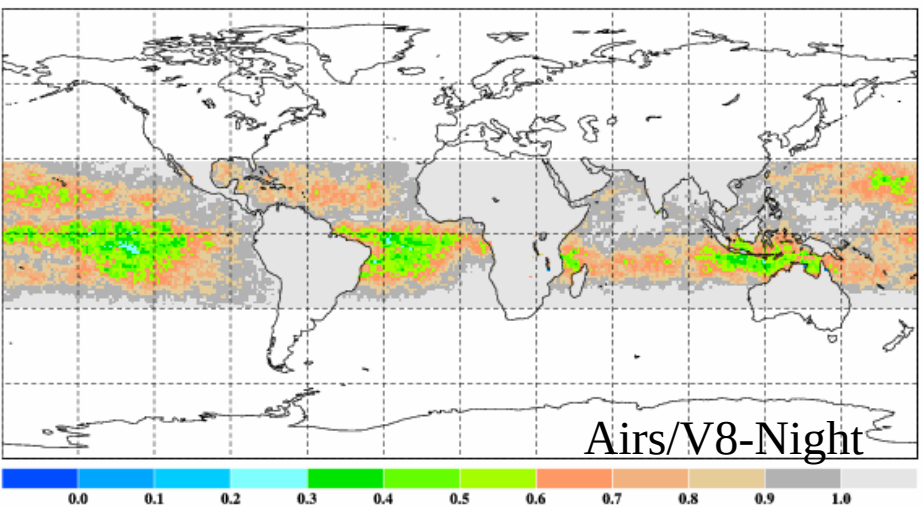
93	14.08
136	10.90
140	10.36
177	8.14
264	4.428
280	4.192
286	4.182
313	3.835
315	3.822

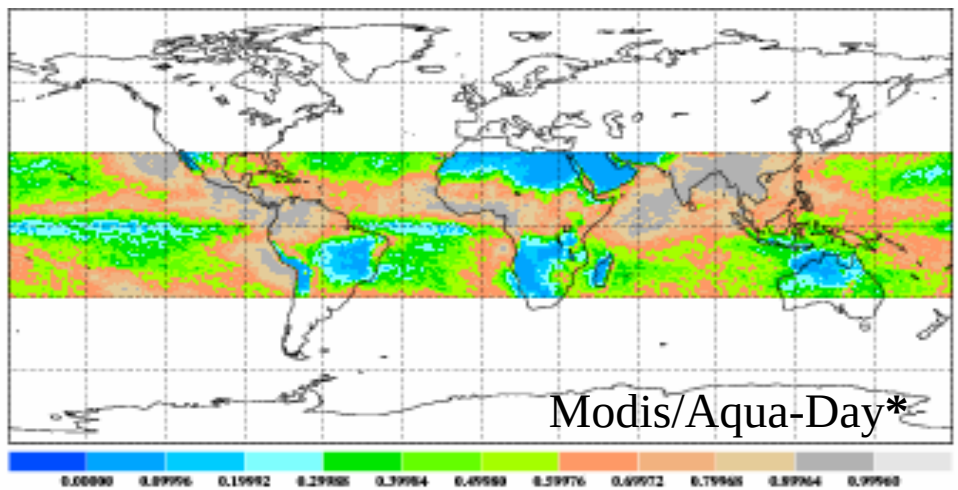
Wavelength of the channels used (µm)

Cloud masks (monthly) from Airs and Modis …





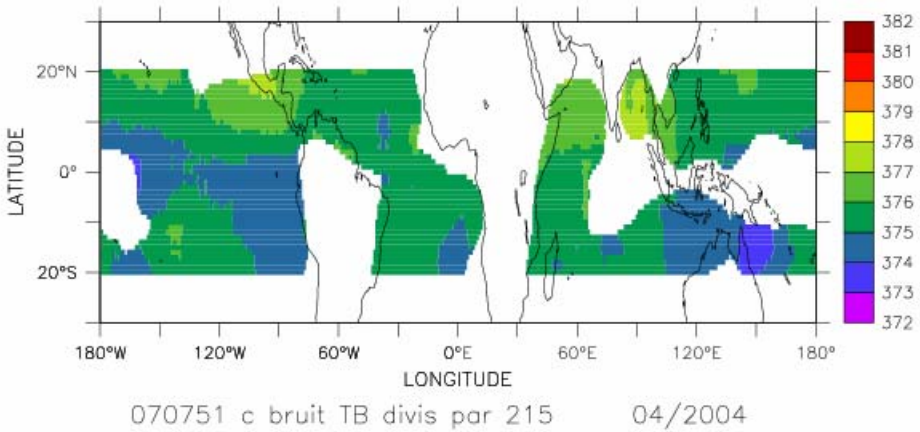


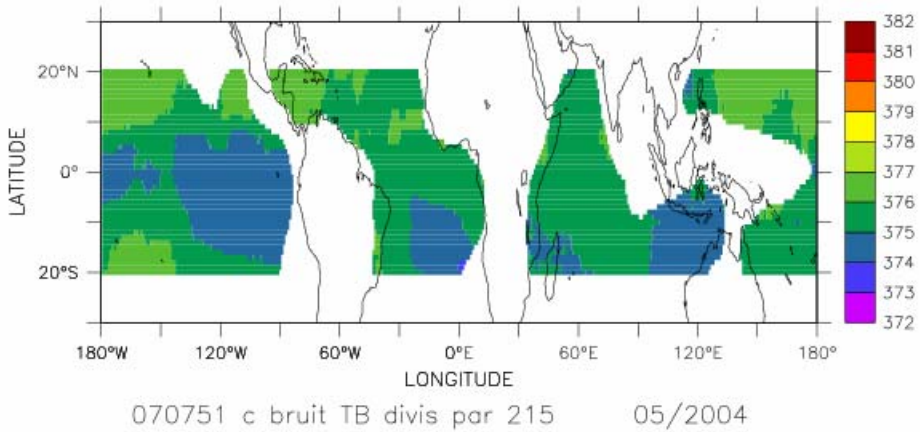


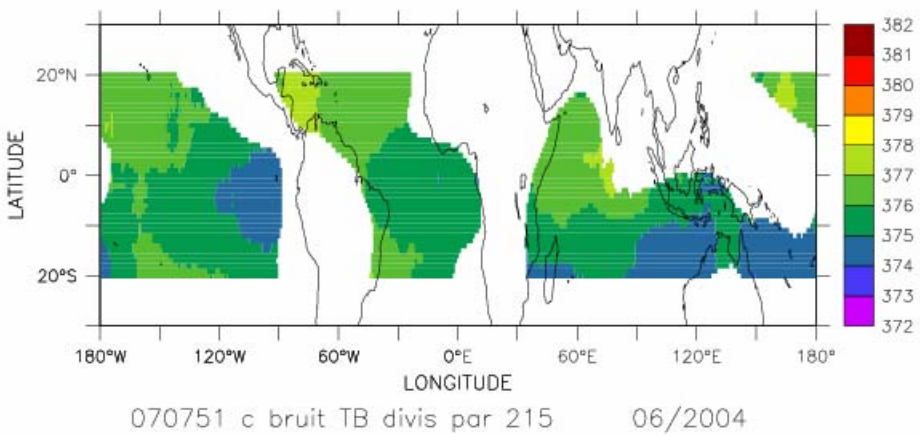
*http://daac.gsfc.nasa.gov/data/datapool/

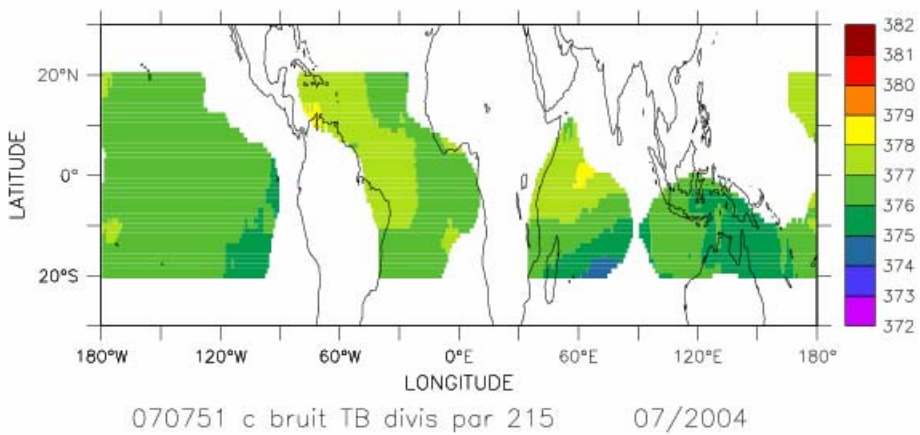
Example of AIRS CO2 fields

April – July 2004



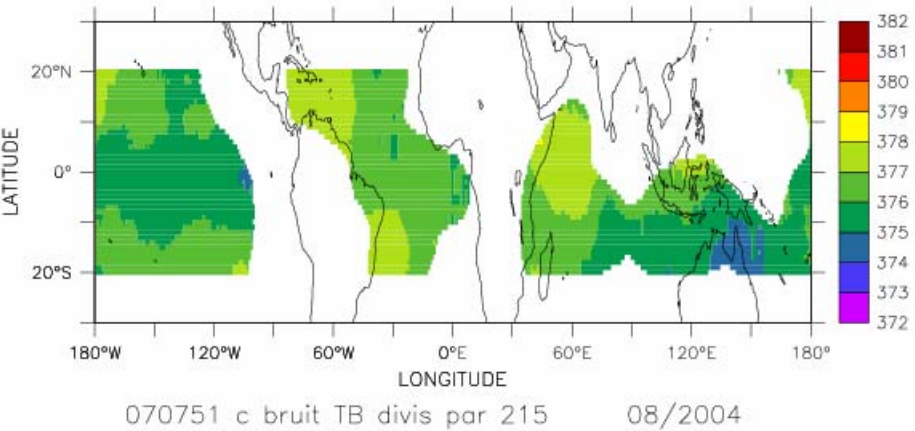


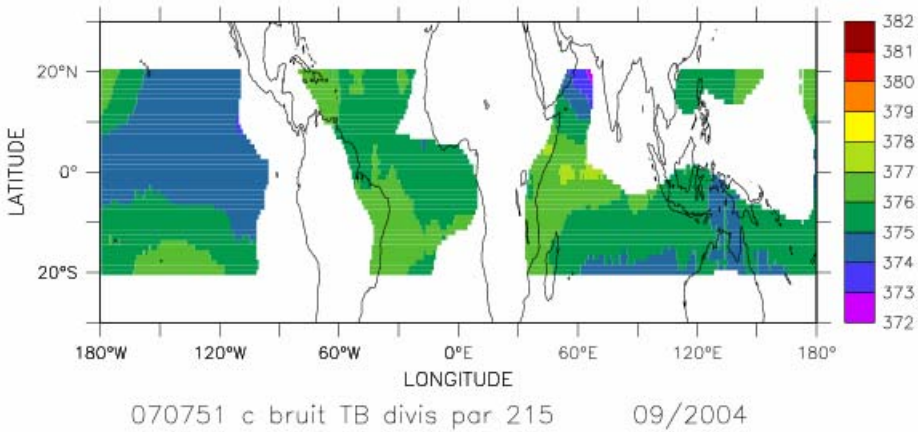


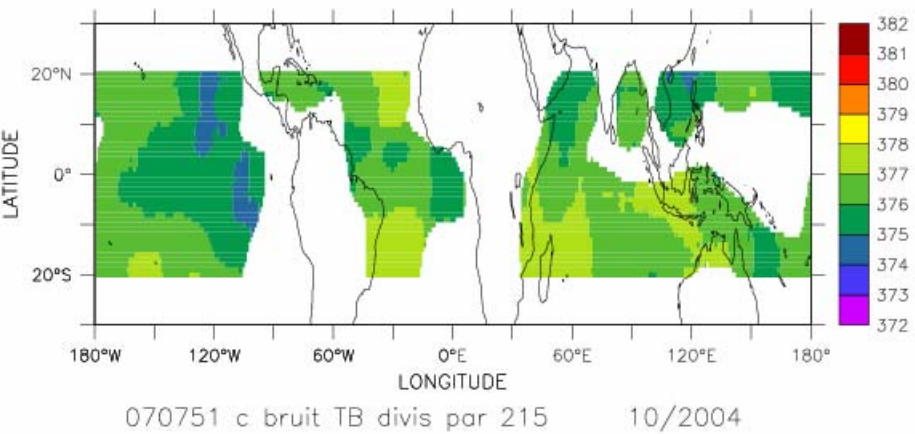


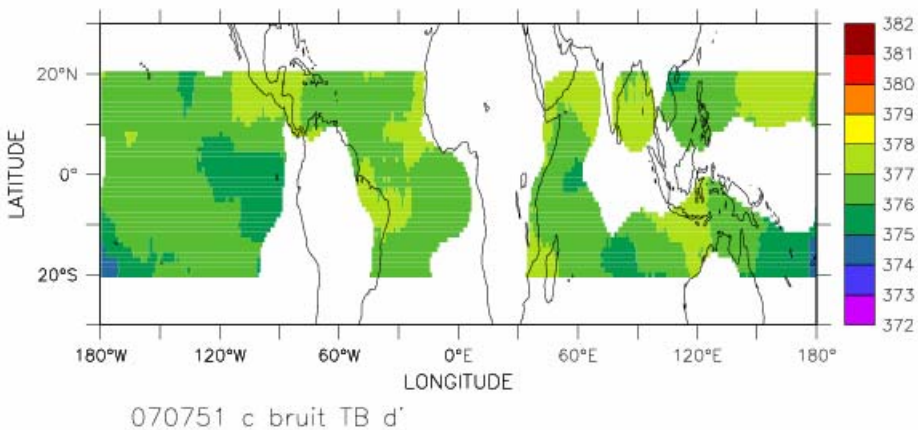
Example of AIRS CO2 fields

August – November 2004









Comparison with aircraft measurements* from April 2003 to March 2005 (Japan to Australia)

Limits of the comparison:

(a) satellite retrievals integrate the mid-to-high troposphere (max contribution between ~6-16 km) when the aircraft flies at 10-11 km

(b) only 2 aircraft measurements per month at variable dates

(c) the region is dominated by convection from the warm pool: large gaps due to clouds

(d) the number of individual (1°x1°) retrievals to be averaged may be too small : average done over the longitudes from 120° to 180° E for each 5° latitude band, when the aircraft flies at ~ 145° E

(e) the number of individual (1°x1°) retrievals to be averaged may however remain too small (see right ordinate)

***H. Matsueda, private comm., 2005**

Comparison Airs– Aircraft

Aircraft 1st part of the month

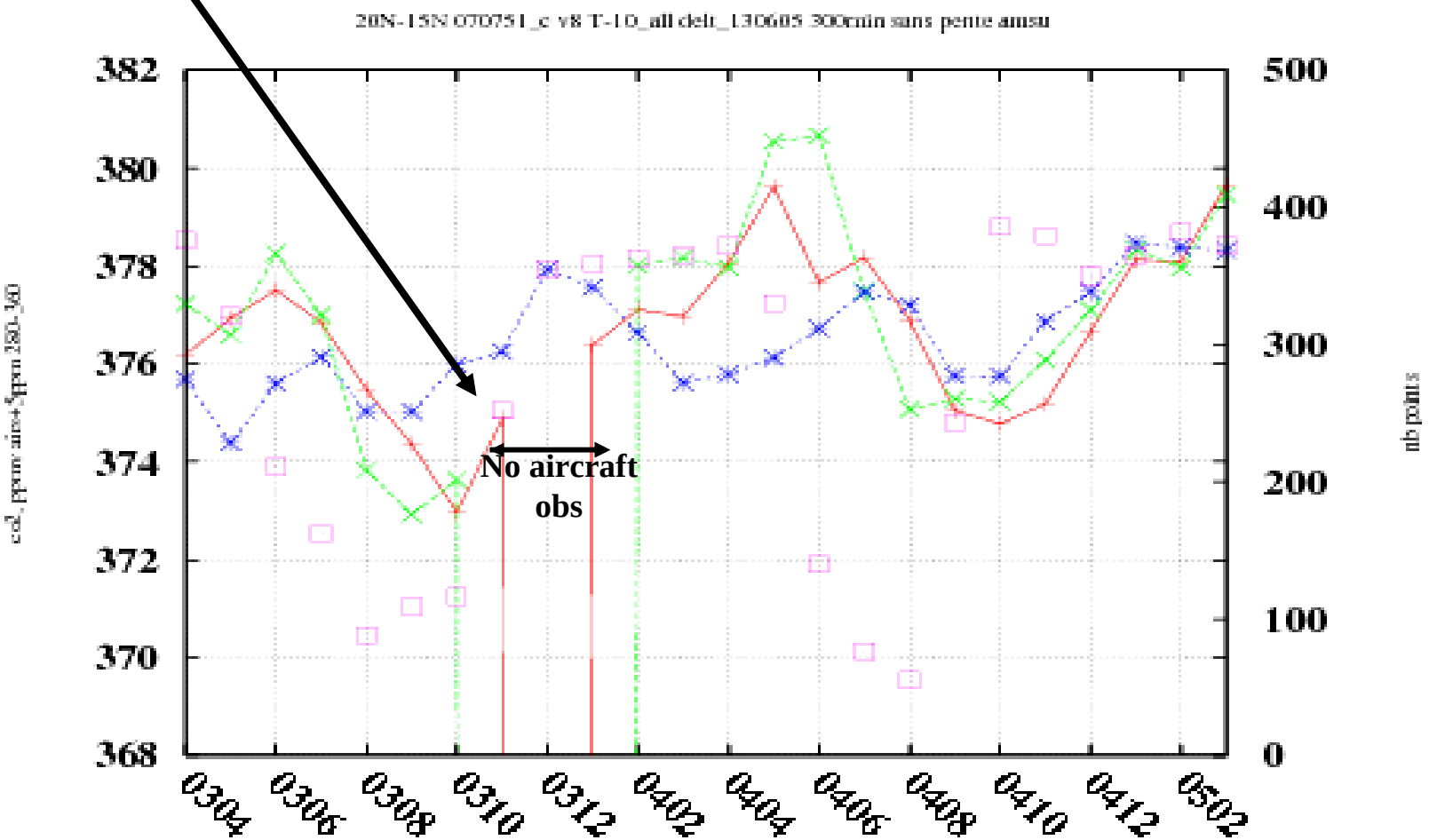
Aircraft 2nd part of the month

Airs

20N-15N

Number of 1°x1° retrievals

«AIRS icing »



Comparison Airs– Aircraft

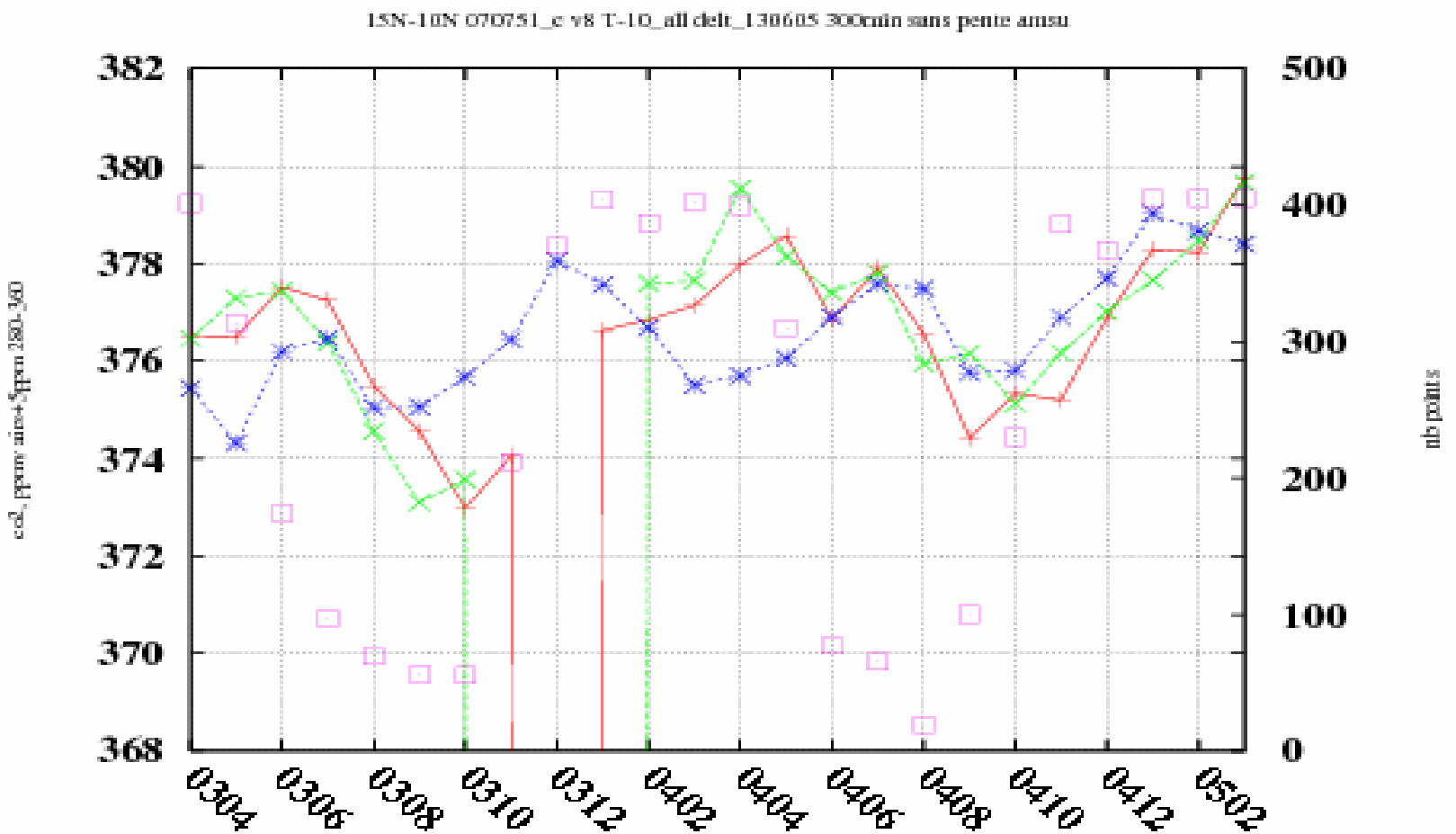
Aircraft 1st part of the month

Aircraft 2nd part of the month

Airs

15N-10N

Number of 1°x1° retrievals



Comparison Airs– Aircraft

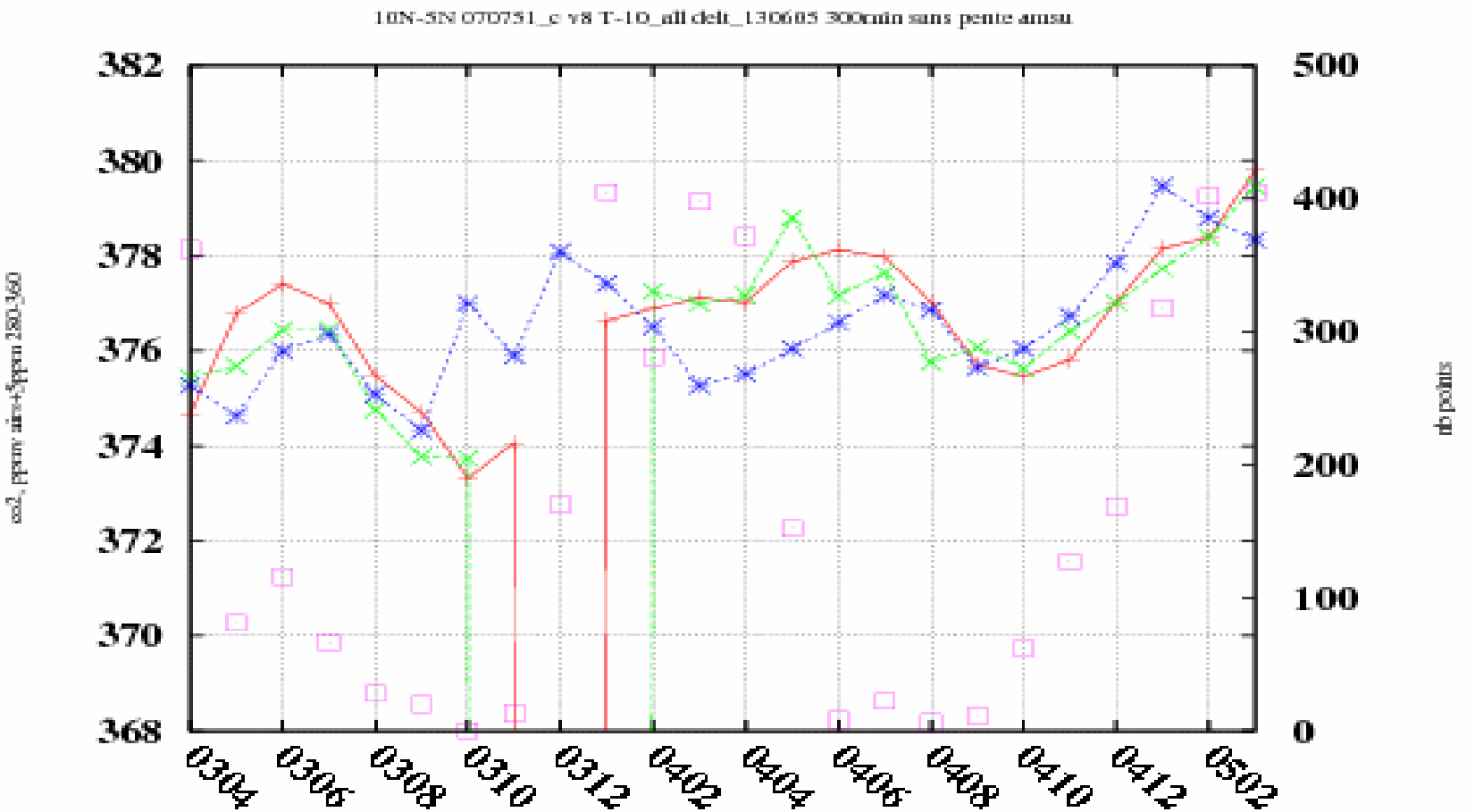
Aircraft 1st part of the month

Aircraft 2nd part of the month

Airs

10N-5N

Number of 1°x1° retrievals



Comparison Airs– Aircraft

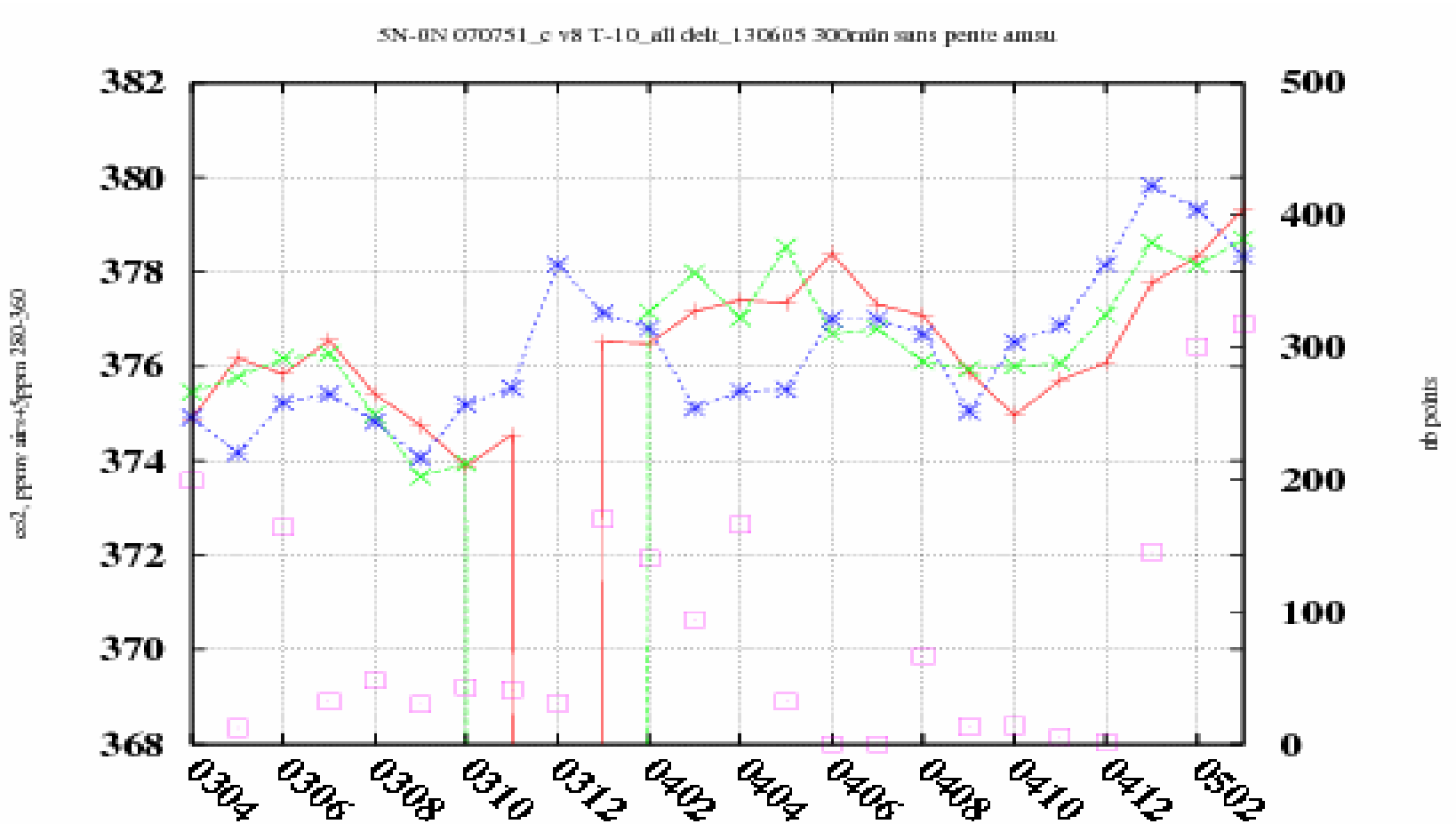
Aircraft 1st part of the month

Aircraft 2nd part of the month

Airs

5N-0N

Number of 1°x1° retrievals



Comparison Airs– Aircraft

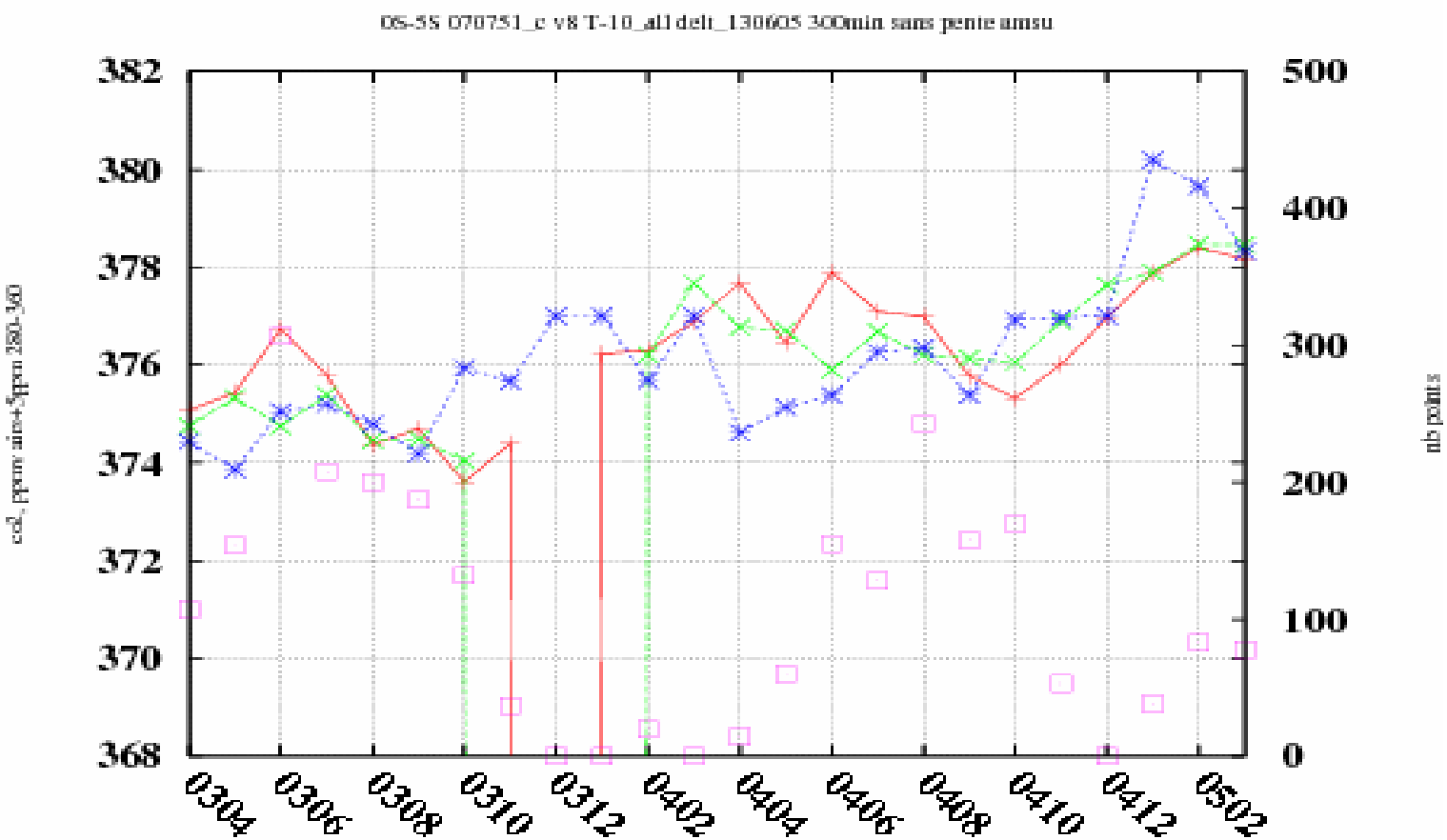
Aircraft 1st part of the month

Aircraft 2nd part of the month

Airs

0S-5S

Number of 1°x1° retrievals



Comparison Airs– Aircraft

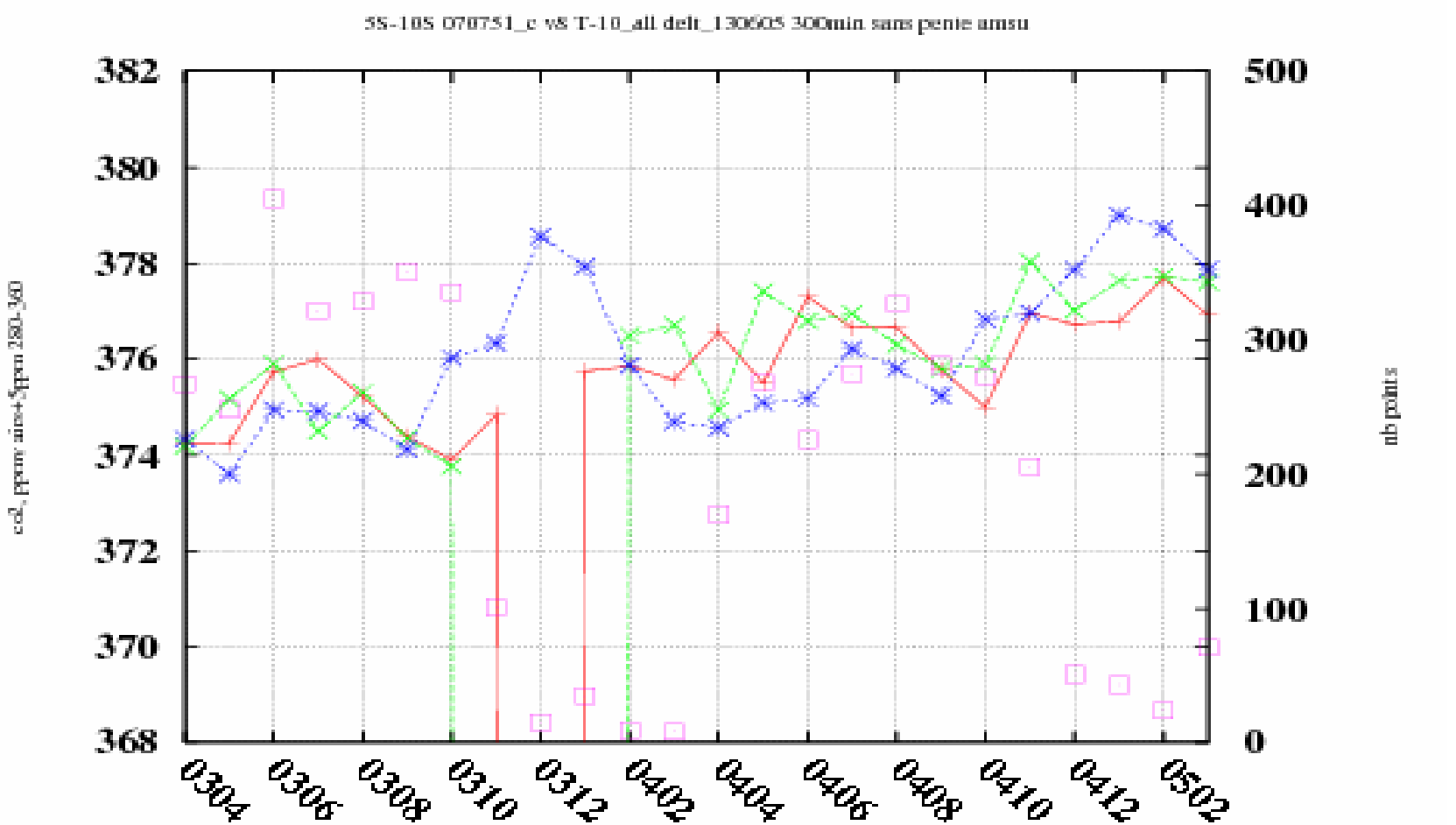
Aircraft 1st part of the month

Aircraft 2nd part of the month

Airs

5S-10S

Number of 1°x1° retrievals



Comparison Airs– Aircraft

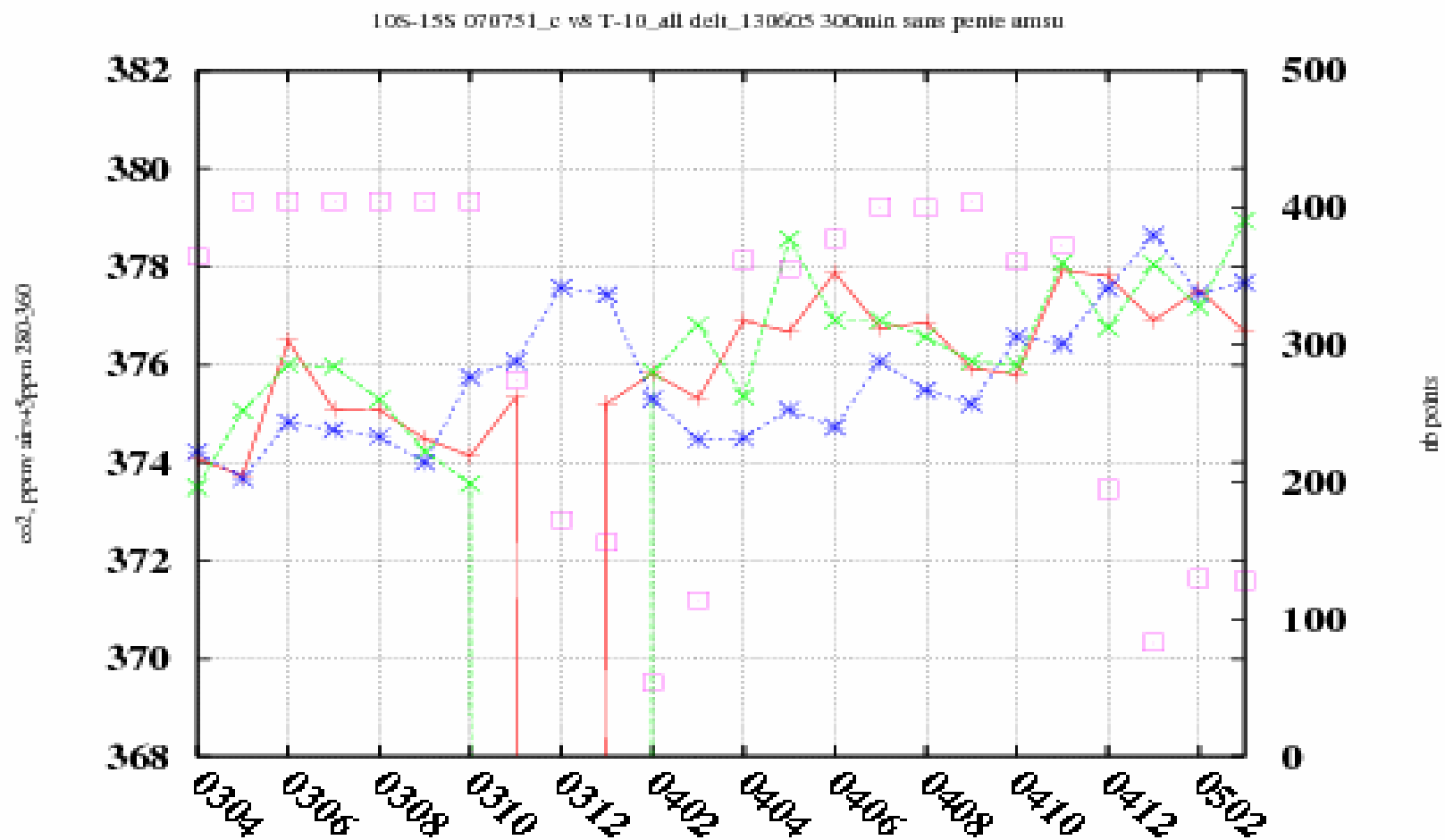
Aircraft 1st part of the month

Aircraft 2nd part of the month

Airs

10S-15S

Number of 1°x1° retrievals



Comparison Airs– Aircraft

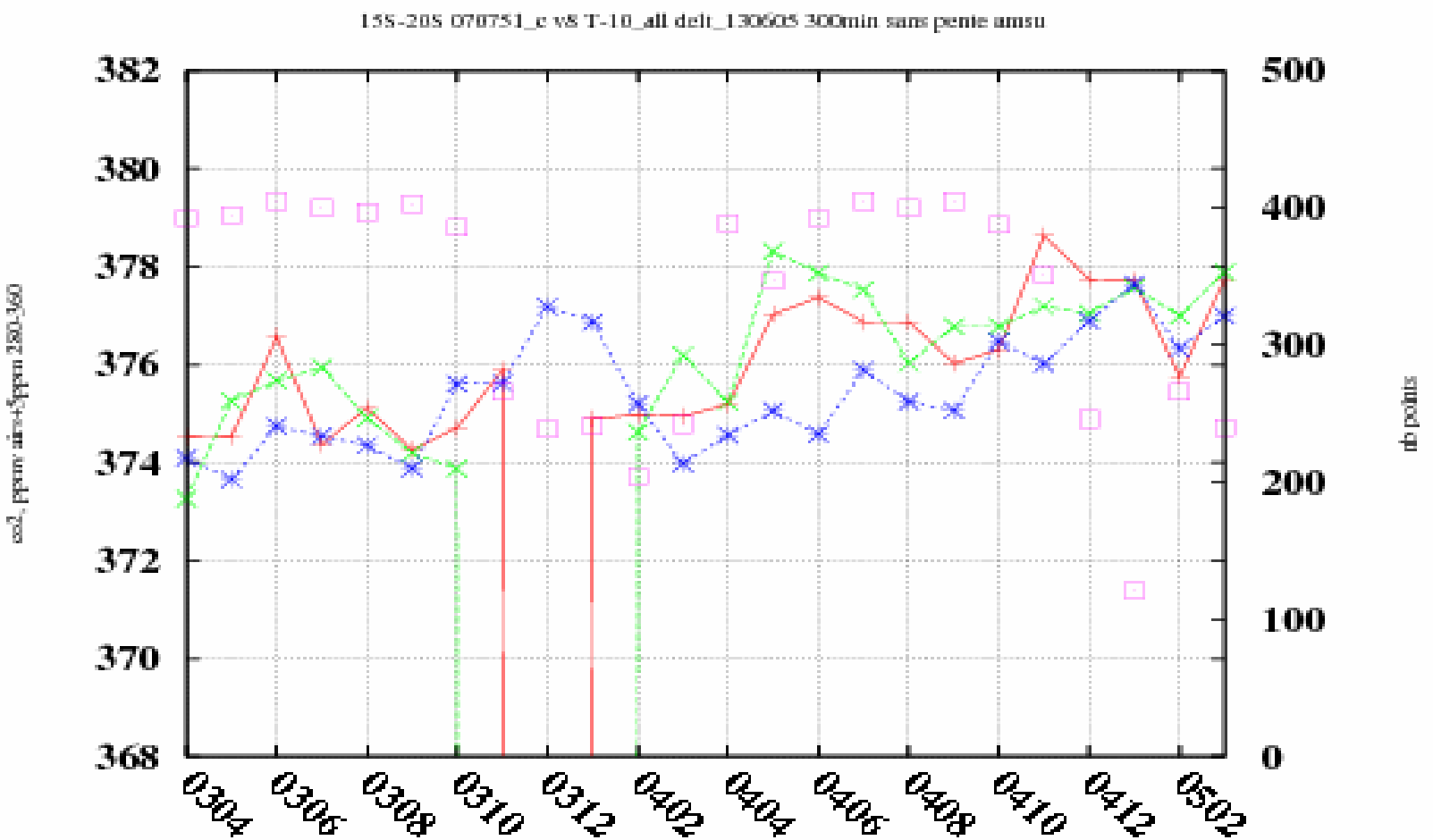
Aircraft 1st part of the month

Aircraft 2nd part of the month

Airs

15S-20S

Number of 1°x1° retrievals



Problems with AIRS

- **lack of AMSU-7 due to a very large noise: its weighting function almost exactly coincides with the CO_2 Jacobians. This very significantly degrades the quality of the decorrelation between CO2 and temperature**

- **AIRS noises degraded with respect to plans (now slightly larger than for IASI in the LW)**

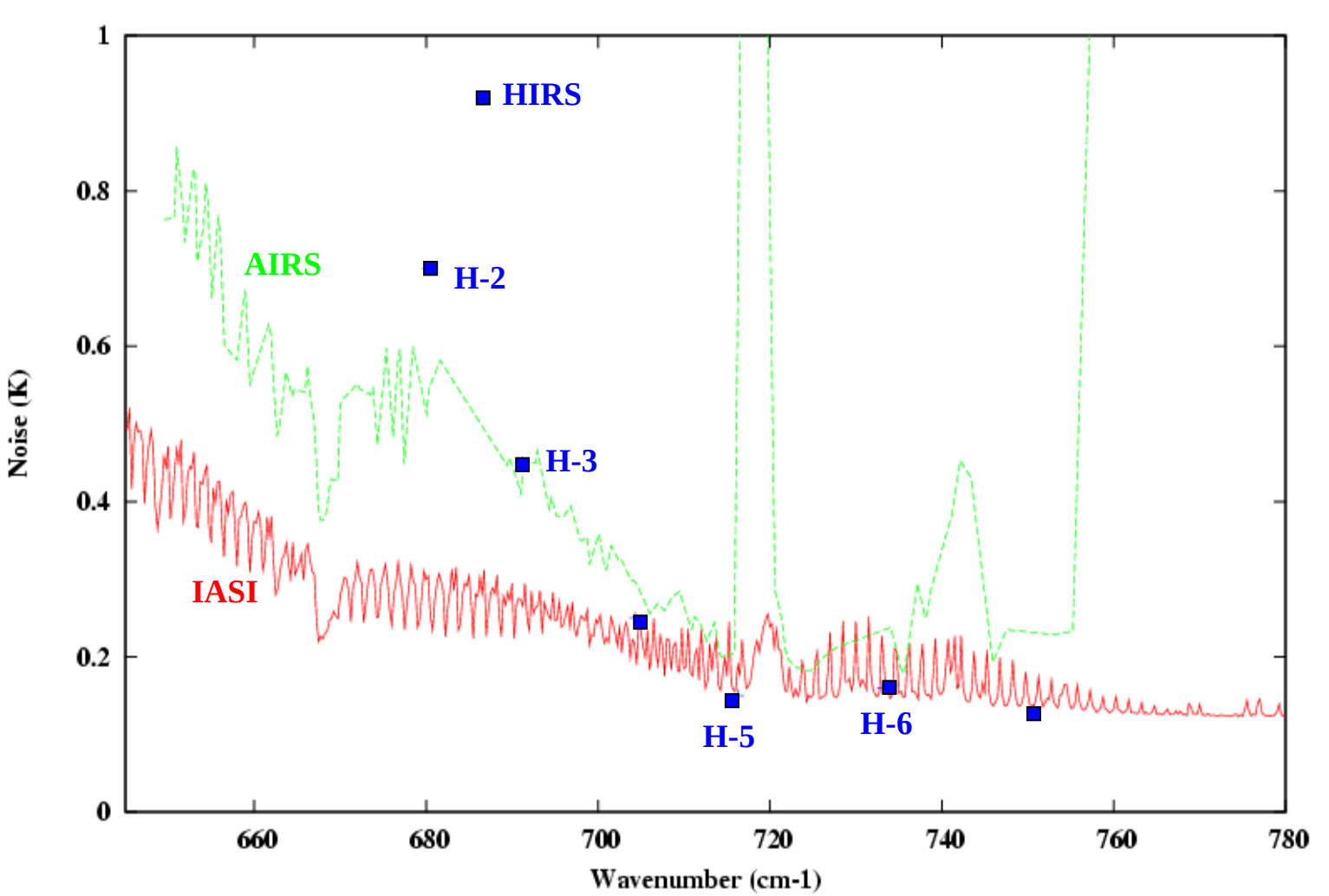
- **icing problems occurred in ~ October 2003. Seem to have lasted quite long (at least at the "CO2- accuracy" !), at least looking at our present results. However, not proven**

- **discontinuous 324 channel list (what IASI list will be available ?)**

- **one shot instrument (contrary to IASI)**

- **but good laboratory for IASI and eventual forthcoming passive instruments which key characteristics should be a very significantly better S/N ratio**

Noises at scene temperature* for HIRS, AIRS, and IASI



*Tropical atmosphere

Next 18-month major tasks and deliverables

Tasks

1. **Refinement of the cloud and aerosol mask (completed for AIRS over sea at night) having in mind that IASI offers much larger possibilities (thin cirrus, aerosols, for ex.)**

2. **Selection of IASI CO2-channels (first list, Jacobians, and sensitivities sent to ECMWF)**

3. **Selection of IASI CH4 channels (preliminary: at most, 6-8 acceptable channels around 7.7 µm)**

4. **New learning data set (from Frederic "SAF" data set) : partly done for AIRS, under development for TOVS, to be done for IASI**

5. **Reprocessing of AIRS observations (April 2003 – now …)**

6. **IASI retrieval simulations and performance comparisons against both TOVS and AIRS**

Deliverables

1. **Final list of IASI CO2 and CH4 channels with their Jacobians and sensitivities to thermodynamic and gas variables**
2. **Cloud mask (night, day, land, sea) for both AIRS and IASI. Processing of all AIRS observations available**
3. **Reprocessing of AIRS observations in terms of tropospheric CO2 concentrations : distribution of the results**
4. **Results of the performance comparisons between IASI and both AIRS and TOVS on the basis of simulations**