The assimilation of AIRS radiance data at ECMWF

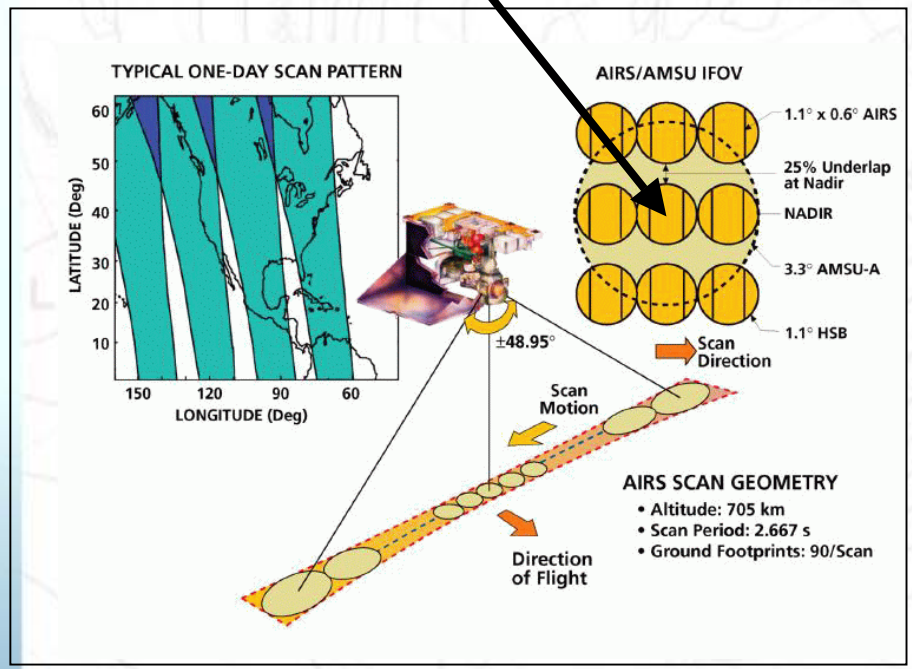
Tony McNally, Phil Watts,
Marco Matricardi, Jonathan Smith,
Jean-Noel Thepaut, Richard Engelen, G.Kelly

Current ECMWF operational satellite data

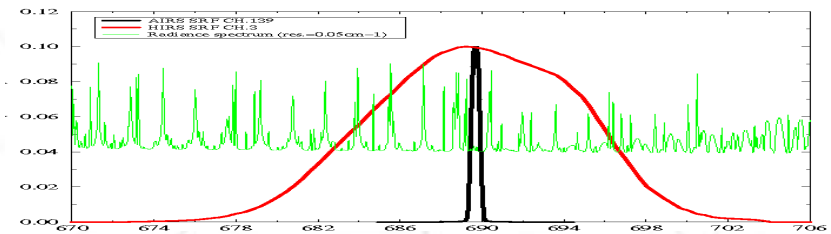
- **AQUA AIRS**
- 3xAMSUA (NOAA-15/16/17) + **AQUA AMSUA**
- 3 SSMI (F-13/14/15)
- 2xHIRS (NOAA-16/17)
- **2xAMSU-B (NOAA-16/17)**
- 5xGEOS (Meteosat-5/7 GOES-9/10/12)
- MODIS/TERRA winds
- QuiKSCAT
- ENVISAT Altimeter / ASAR
- SBUV
- **ENVISAT OZONE**

Atmospheric InfRared Sounder (AIRS)

1 spot out of 18



324 out of 2378 channels



Specifications

Infrared Spectral Coverage	3.74 - 4.61 μm 6.20 - 8.22 μm 8.80 - 15.4 μm
Spectral Response	
Spectral Resolution	ν/Dν>1200 nominal
Spectral Sampling	Dν/2
Integrated Response (95%)	±1 Dν
Wavelength Stability	0.05 Dν24 hours
Wavelength Knowledge	0.01 Dν
Spatial Coverage	
Scan Angle	±49.5° around nadir
IFOV	1.1°
Measurement Simultaneity	>99%
Sensitivity (NEDT)	0.14 K at 4.2 μm 0.20 K from 3.7 - 13.6 μm 0.35 K from 13.6 - 15.4 μm
Radiometric Calibration	± 3% absolute error
Power / Mass	256 W / 166 kg
Lifetime	5 years

Visible Spectral Coverage	0.41 - 0.44 μm 0.58 - 0.68 μm 0.71 - 0.92 μm 0.49 - 0.94 μm
Spatial Coverage	
Scan Angle	±49.5° around nadir
IFOV	0.185°
SNR @ Albedo = 0.4	>100
Polarization	<5%

Key elements of the AIRS assimilation system

Operational AIRS radiance usage in 4DVAR

- Input radiance data consists of **324** selected channels sampled **1 / 18** locations (from NASA / NESDIS-ORA in BUFR format)

- All channels flagged **clear** at a location are **assimilated** (excluding channels in the O3 band or 4.2 micron band and low level channels over land)

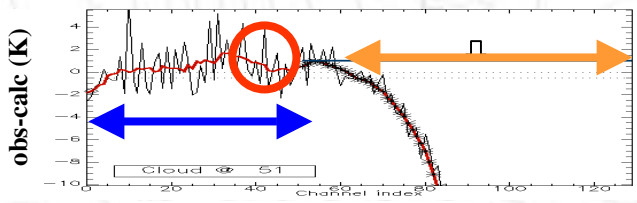
- **Flat bias correction** (single global number) used for each channel

- Very **simple** (and conservative) **observation error** assigned to each channel (varying between 0.6 / 1.0 / 2.0K)

Our initial emphasis is on a conservative use of the AIRS data (with simple observation error models and bias correction aiding diagnosis of the results)

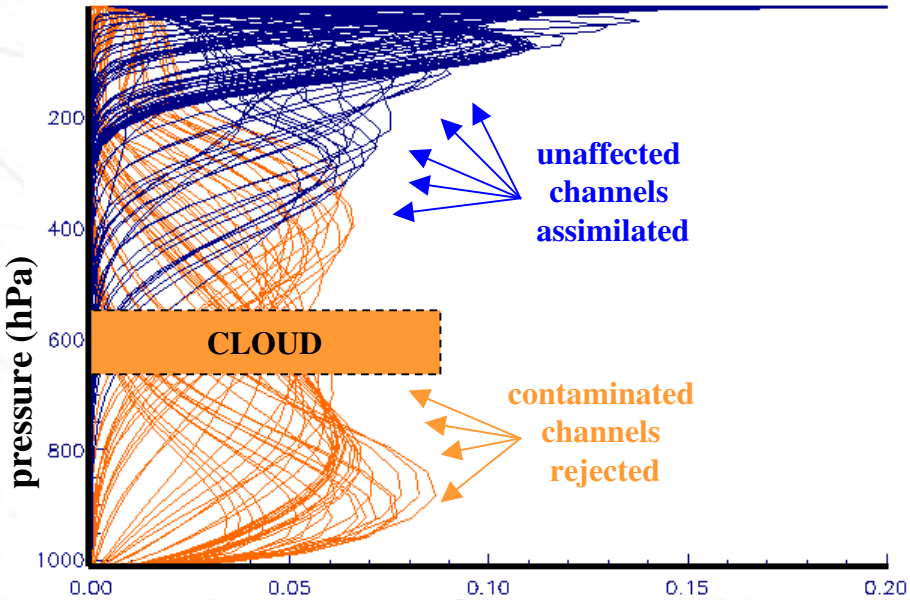
Cloud detection scheme for AIRS (IASI / CrIS)

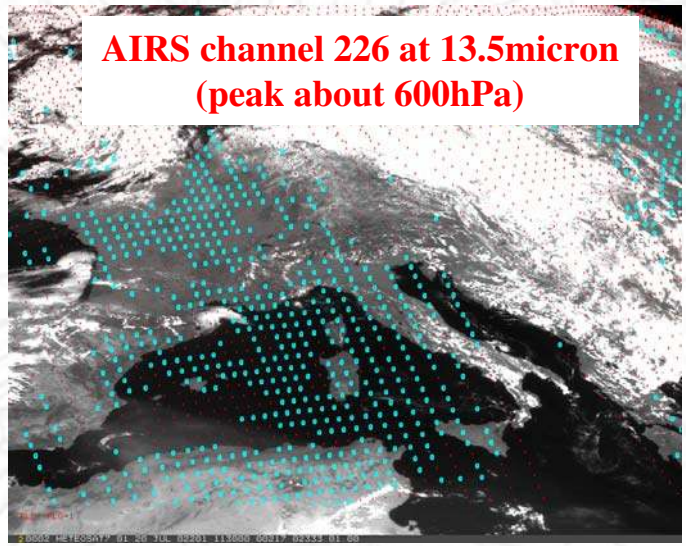
A non-linear pattern recognition algorithm is applied to departures of the observed radiance spectra from a computed clear-sky background spectra.

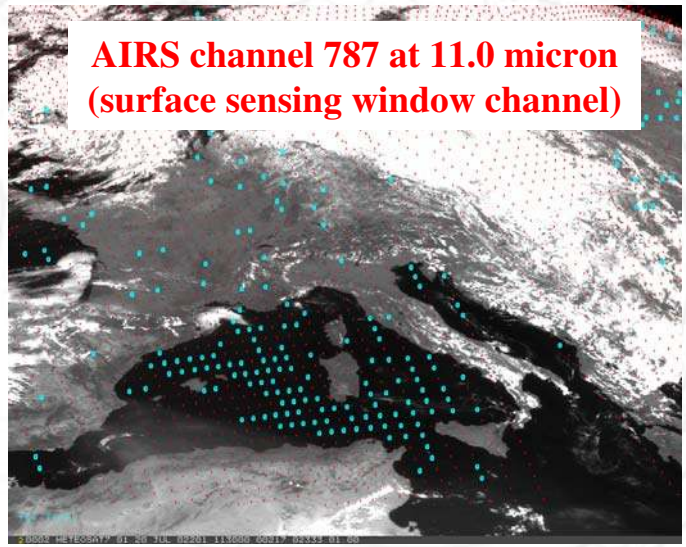


Vertically ranked channel index

This identifies the characteristic signal of cloud in the data and allows contaminated channels to be rejected

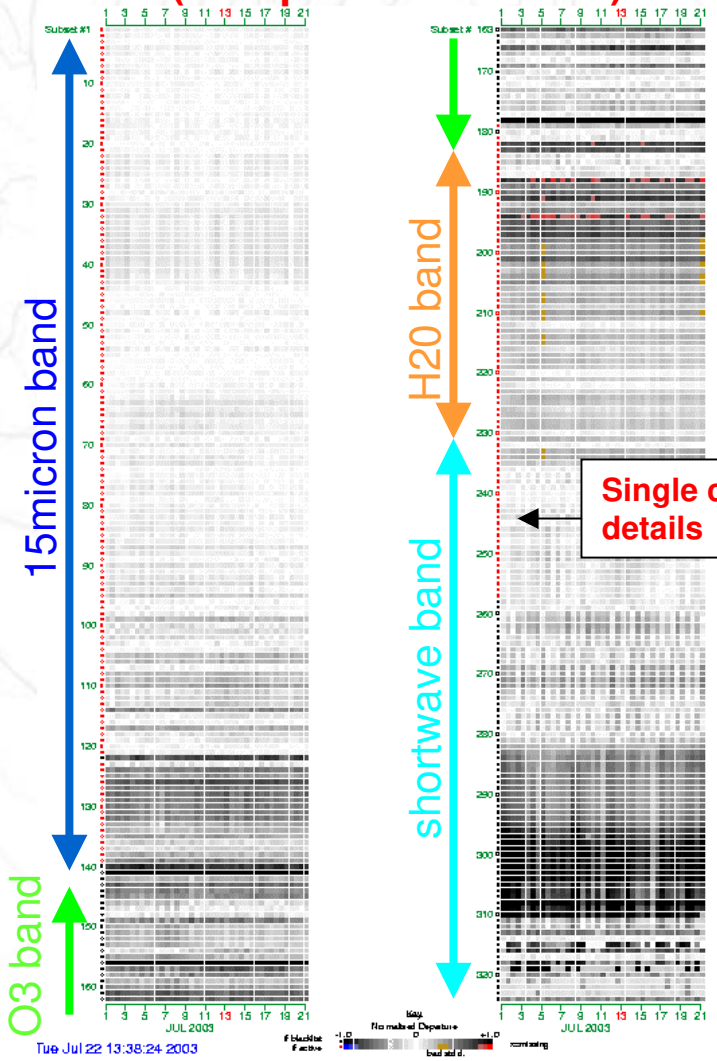






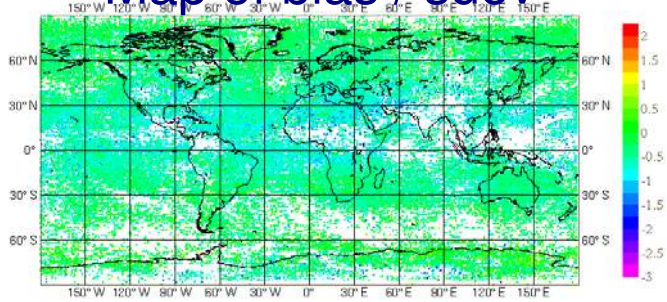
AIRS bias monitoring

All channels time series (for operational alerts)

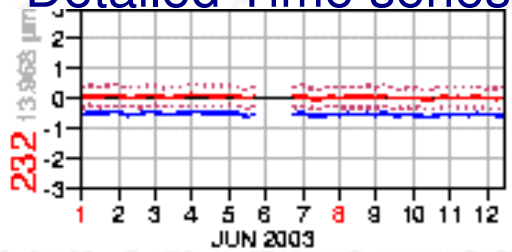


Single channel details

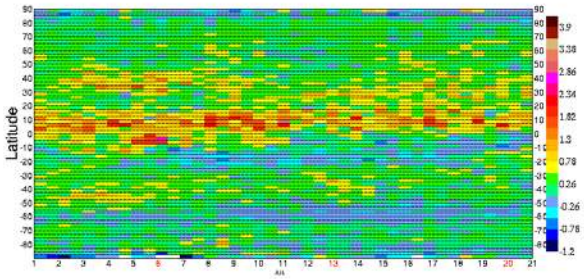
Map of bias / sdev



Detailed Time series

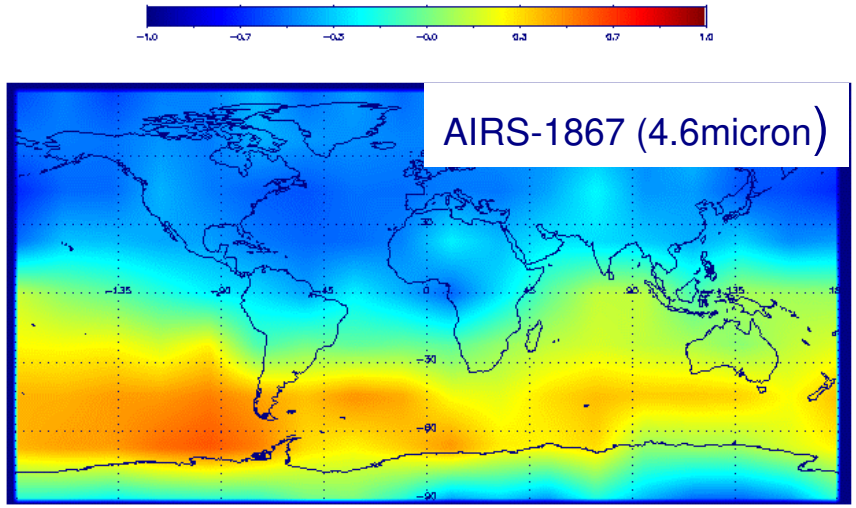


Hovmoller time series

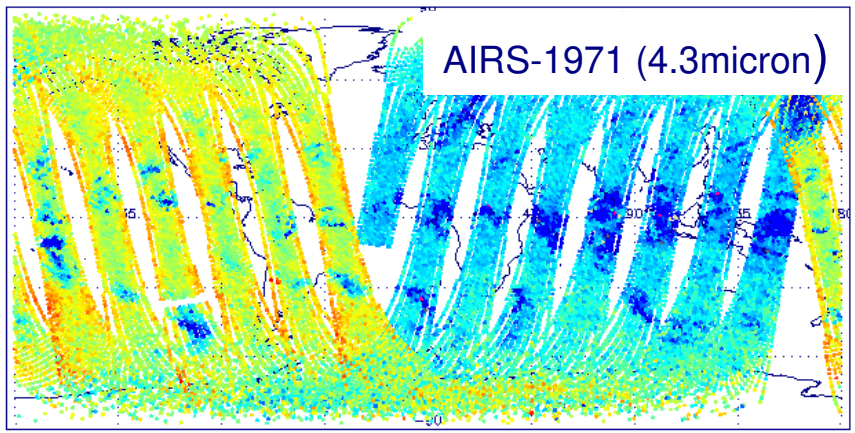


AIRS channels NOT used (i.e. blacklisted)

Channels with a strong air-mass dependent bias (e.g. due to gasses not well modelled in RT)



Channels with a strong day-night dependent bias (e.g. due to solar / non-LTE effects not modelled in RT)

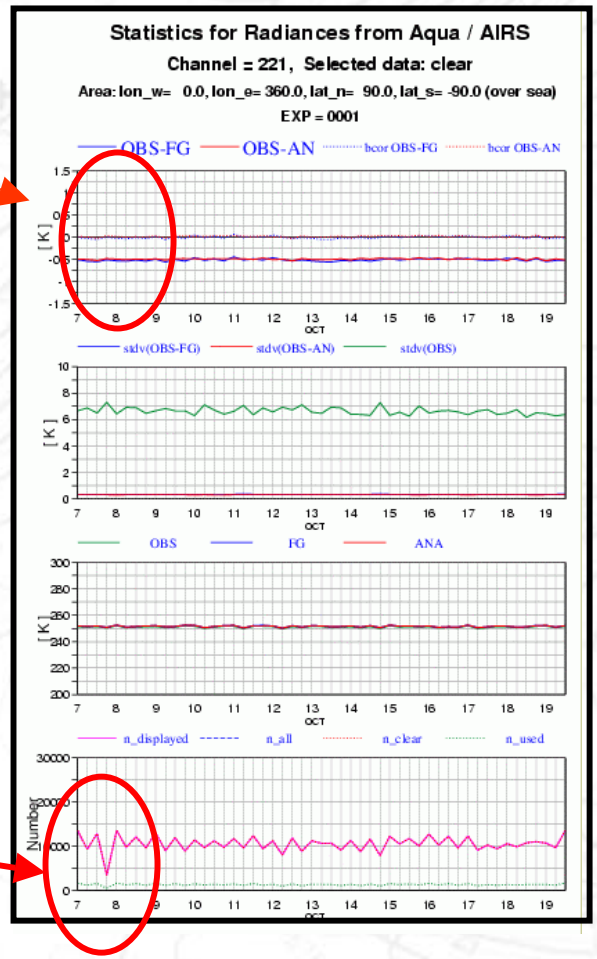


Good news about the AQUA Manoeuvre (7 October 2003)

no change in obs minus calc statistics

Following the shut-down of the AIRS no disruption or change to the radiance data quality has been observed

data lost



Filtering bias statistics in a vertically ranked space

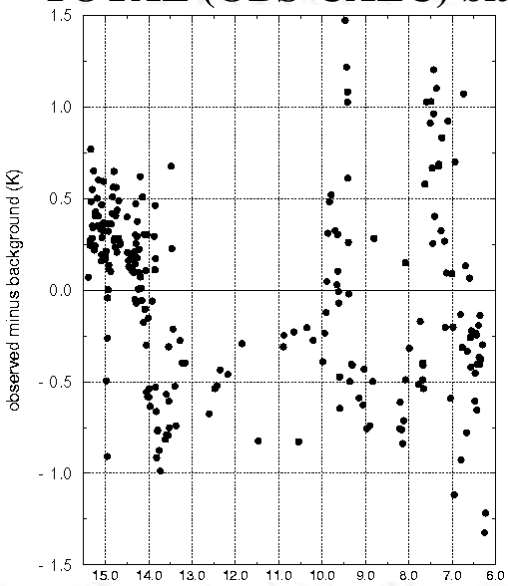
•Diagnosing biases in the AIRS data and / or RT model is complicated by the presence of systematic errors in the NWP estimate of the atmospheric state.

•However, we know that the NWP errors can only contribute to *slowly varying* modes in a vertically ranked channel space (such that used in the cloud detection scheme).

•Thus filtering the OBS-CALC statistics in a ranked space allows some separation of the different bias components.

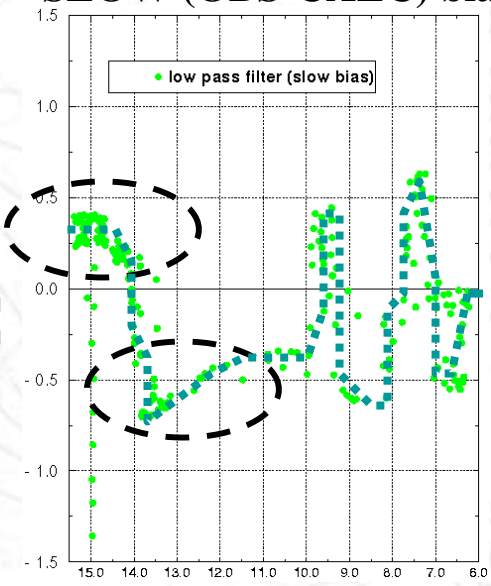
Filtering bias statistics in a vertically ranked space

TOTAL (OBS-CALC) bias



=

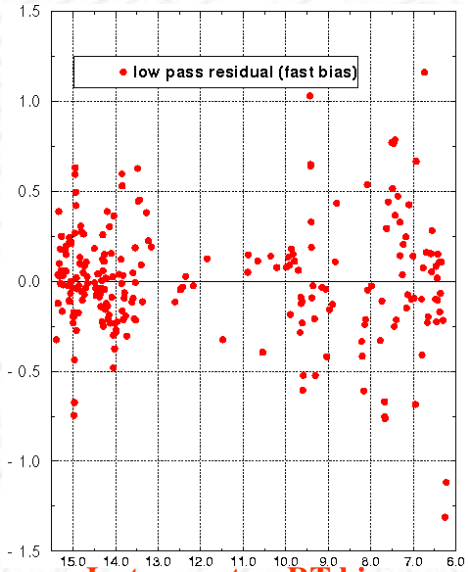
SLOW (OBS-CALC) bias



combination of NWP systematic error and slow RT bias

+

FAST (OBS-CALC) bias



Instrument or RT bias that MUST be corrected before assimilation

Filtering of bias statistics allows a much better cross checking of results with other sources (e.g. CAMEX and results from UMBC etc…)

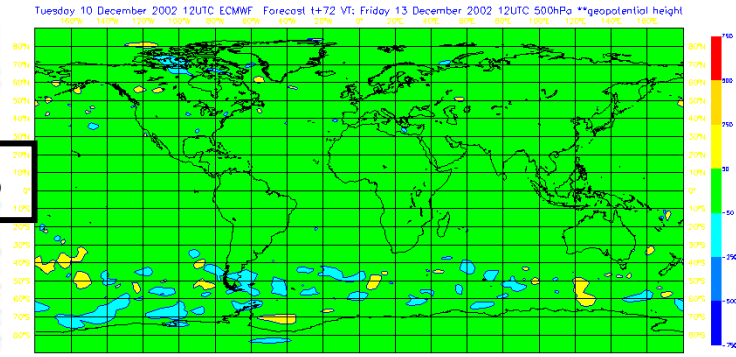
The impact of AIRS

AIRS impact on the analysis and forecast

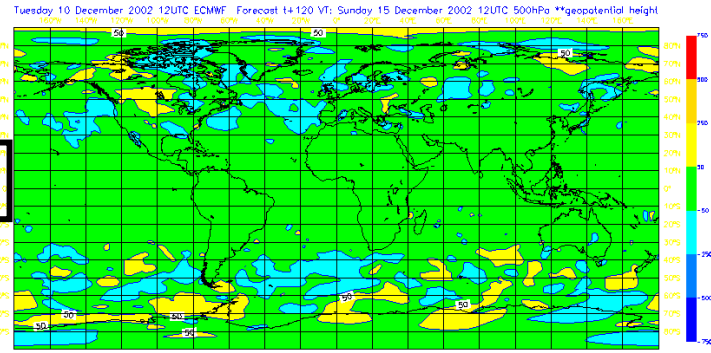
The assimilation of AIRS radiances shows a small but consistent positive impact on the analysis and forecast quality in all areas

RMS of 500hPa geopotential forecast error averaged over 40 days (Dec 02/ Jan 03)[AIRS error] minus [CTRL error]

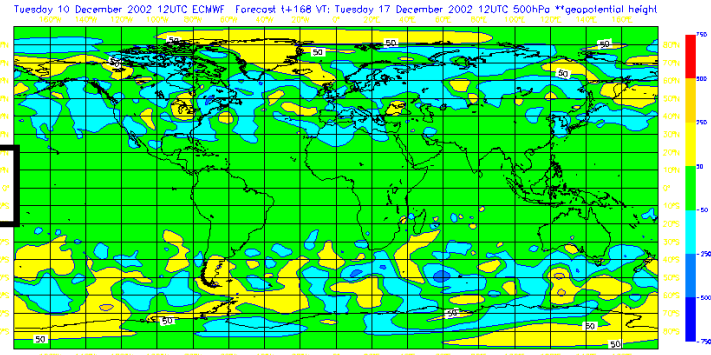
Day-3



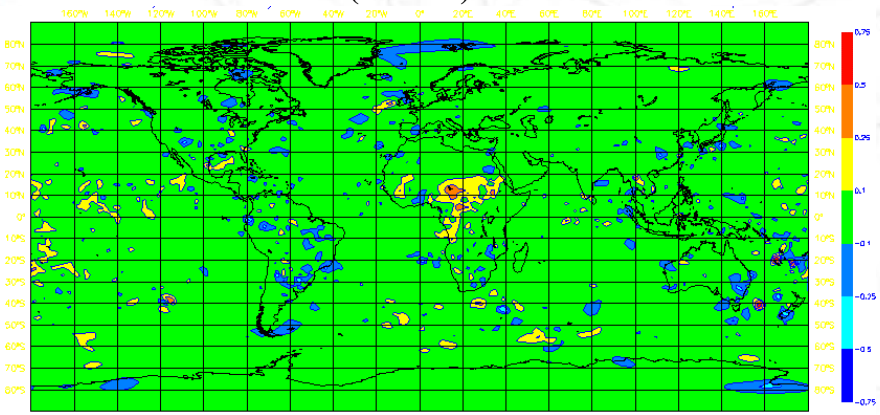
Day-5



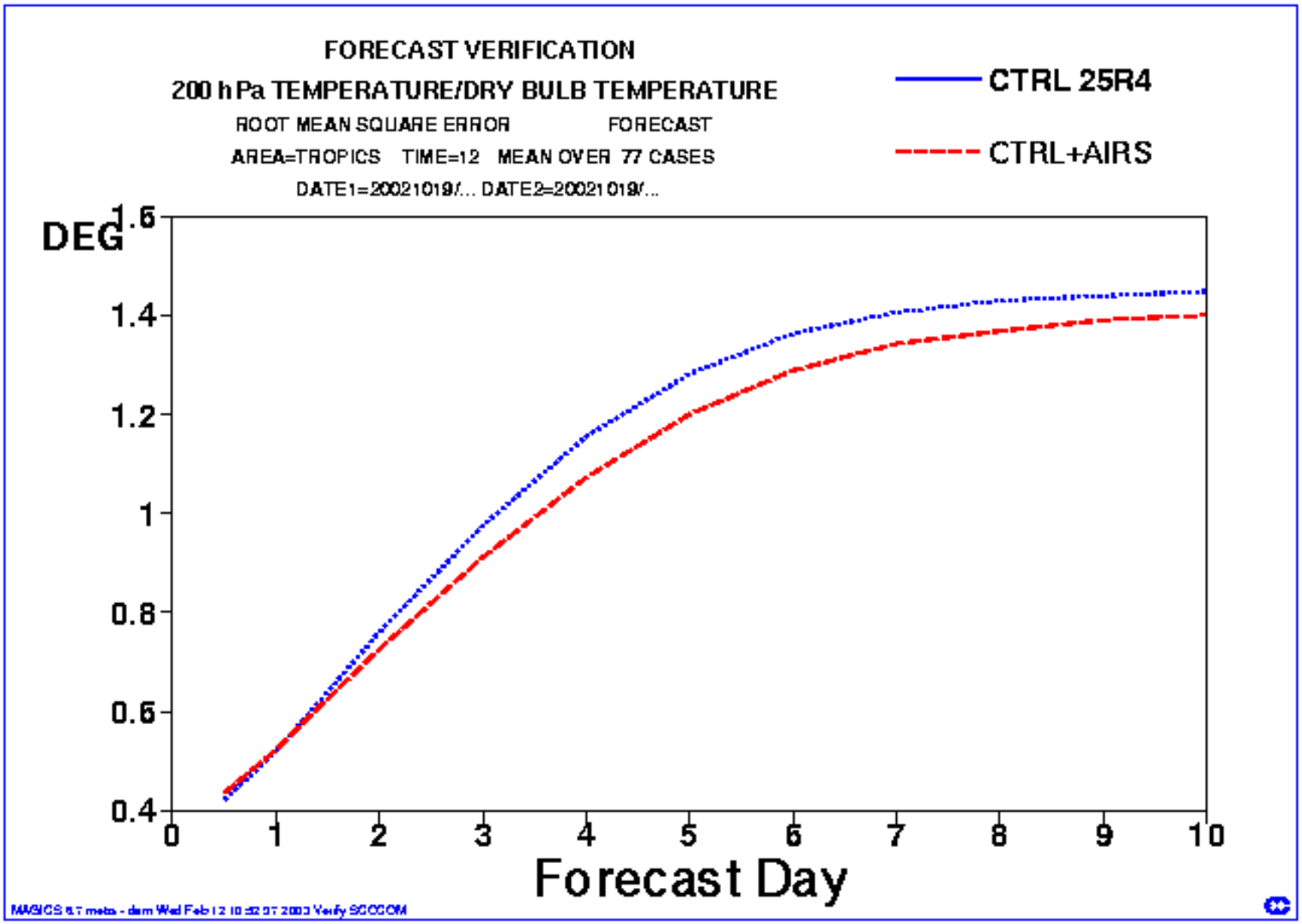
Day-7



RMS T increments (500hPa) at radiosonde locations



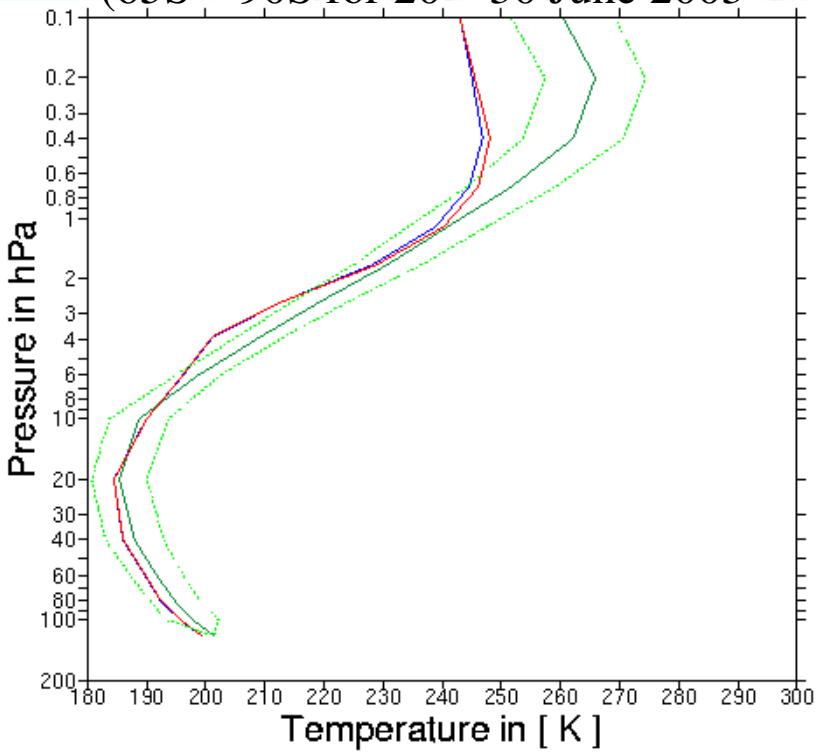
AIRS forecast impact in the Tropics



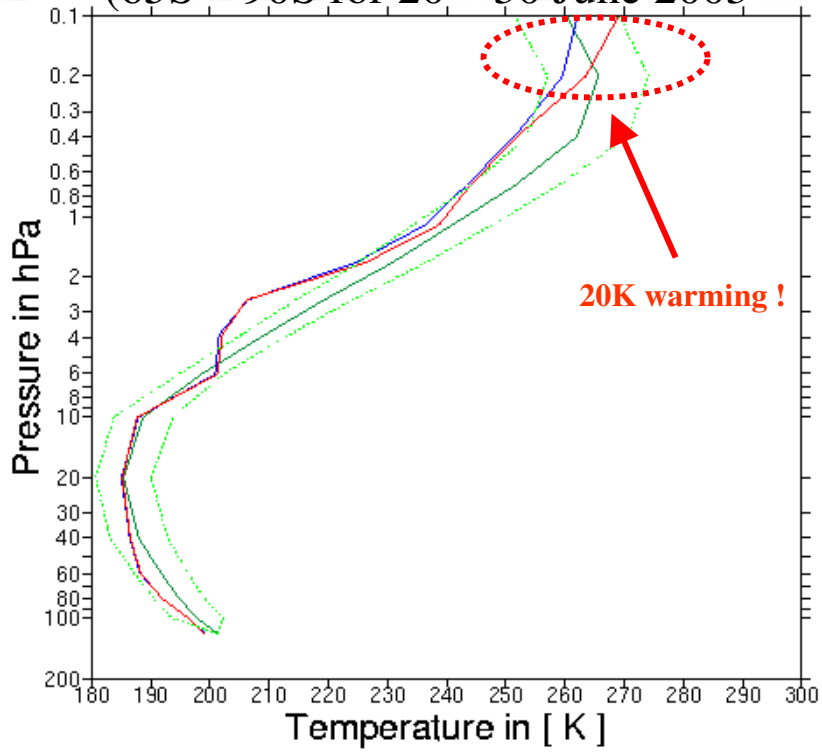
AIRS adjustments in the stratosphere / mesosphere

ECMWF analysis fit to MIPAS temperature retrievals (not assimilated)

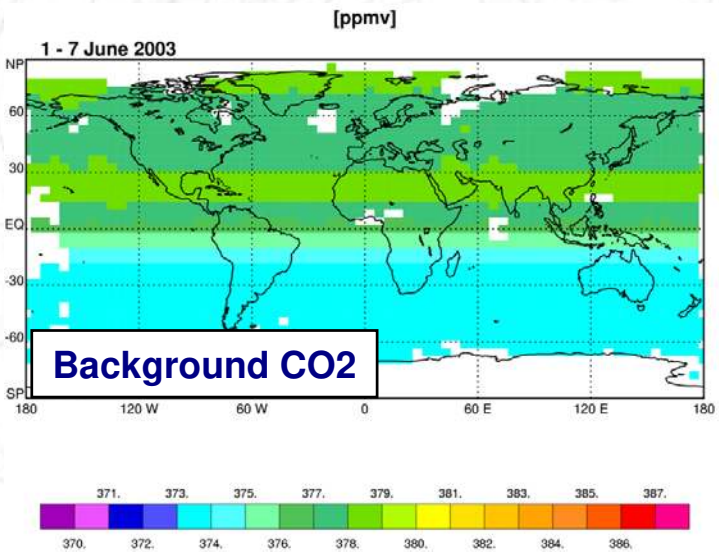
26R3 – **WITHOUT AIRS** radiances
(65S – 90S for 20 – 30 June 2003

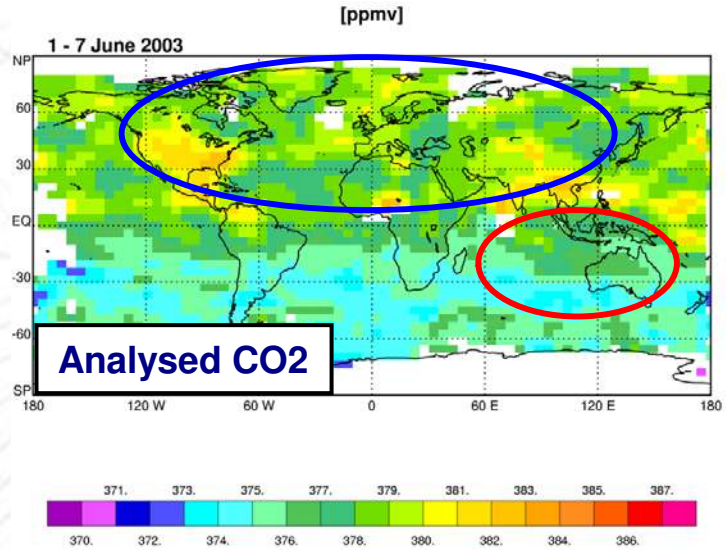


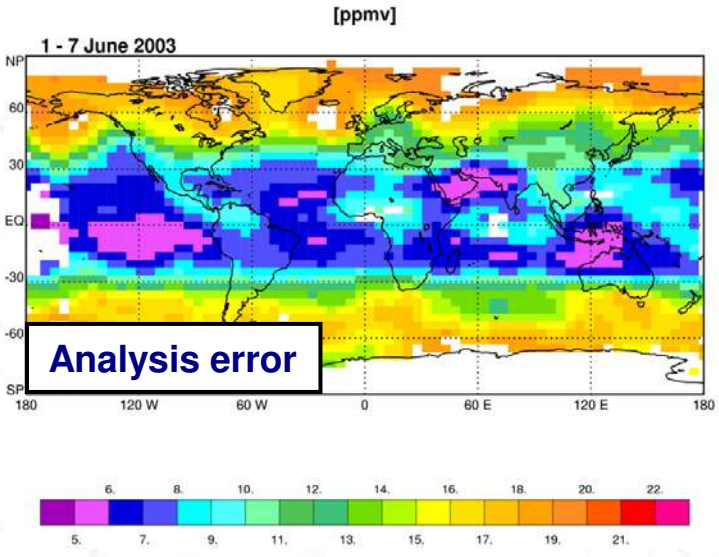
26R3 – **WITH AIRS** radiances
(65S – 90S for 20 – 30 June 2003

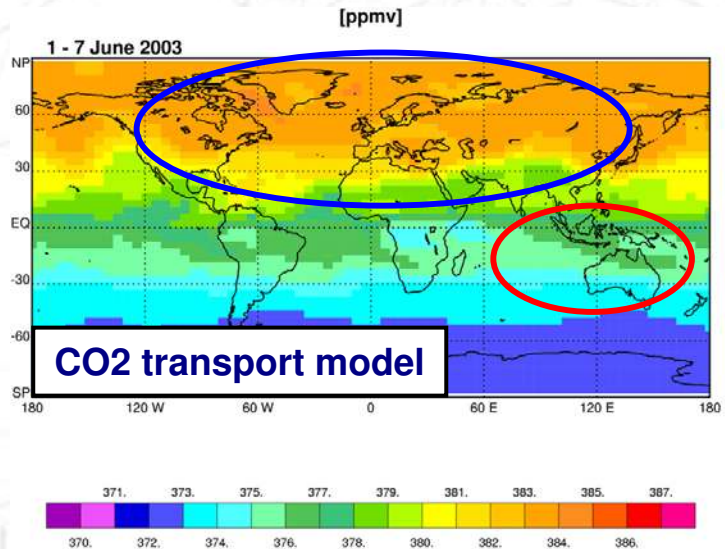


Column CO_2 estimates from AIRS assimilation









Summary and Plans

Summary of progress to date

The AIRS radiance assimilation system is currently conservatively tuned (in terms of observation errors and QC) and produces modest positive impacts on forecast skill in all areas.

The CONTROL system (ECMWF previous operations) was performing extremely well (3xAMSUA 3xSSMI 2xHIRS 5xGEOS) and we should not have expected large positive impacts from the addition of AIRS on the mean forecast skill.

The dream scenario of the assimilation of AIRS data fixing up many "failed forecasts" has not yet been found yet (lots of cloud / few busts) but we will keep looking!

Planned AIRS operational upgrades

Ready for end of year implementation

- New surface emissivity model
- Fix to stratospheric ringing
- Upgrade to bias correction
- Upgrade(s) cloud detection
- Technical modifications

Ready for mid 2004 implementation

- Review of observation error model
- Extra channels shortwave night / O3
- Routine CO2 estimation

Ready for end 2004 implementation

- Non LTE parameterization
- Use / assimilation of EOFs
- Use of cloudy data with sink variable

NWP Survey results

TABLE of RESULTS