Challenges in Satellite Data Monitoring at ECMWF

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Thanks to the following persons who contributed in one way or the other to this presentation:

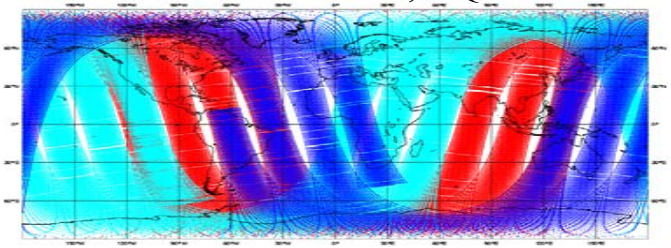
Jean-Noël Thépaut, Tony McNally, Graeme Kelly, Jonathan Smith

Overview

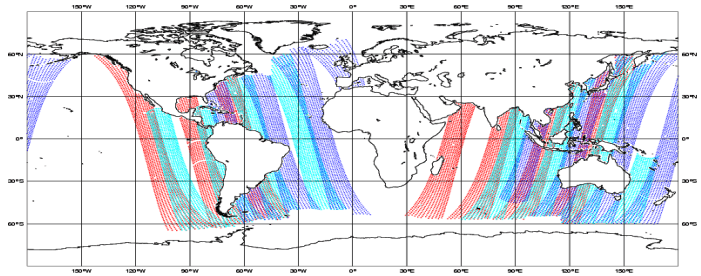
- Why is there a challenge?
  - » Summary of satellite data usage at ECMWF
  - » Importance of satellite data
- How is this challenge tackled?
  - » Summary of monitoring products
  - » Some Examples
- Future plans

Why is there a Challenge? – Satellite Data Coverage at ECMWF

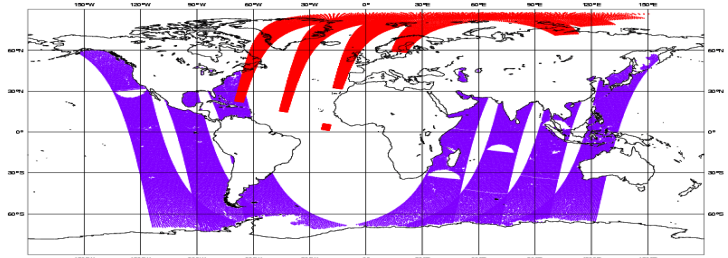
NOAA AMSUA/B HIRS, AQUA AIRS



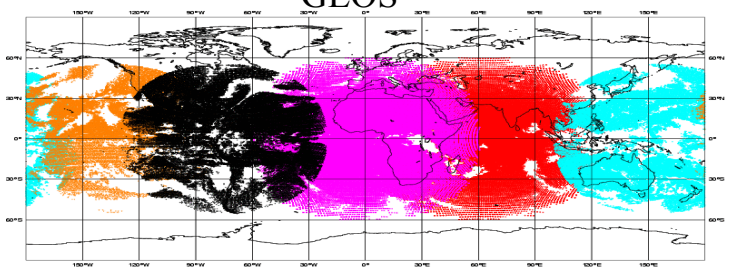
DMSP SSM/I



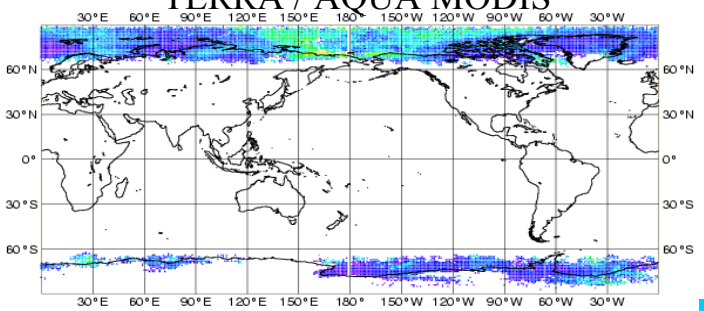
SCATTEROMETERS



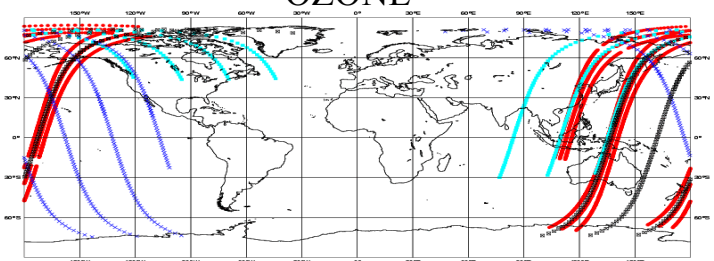
GEOS



TERRA / AQUA MODIS



OZONE



Why is there a Challenge? – Satellite Data Usage at ECMWF

- 1 x Airs (Aqua)
- 3 x AMSU-A (NOAA-15/16, AQUA)
- 2 x AMSU-B (NOAA-16/17)
- 1 x HIRS (NOAA-17)
- 3 x SSM/I (F-13/14/15)
- 5 x GRAD (GOES-9/10/12, MET-5/7)
- 1 x SBUV/2 (NOAA-16)
- 5 x AMV (GOES-10/12, MET-5/7, MODIS on Terra)
- QuikSCAT
- ENVISAT RA-2
- ERS-2 Scatterometer, RA-2, ASAR

Why is there a Challenge? – Current Data Counts

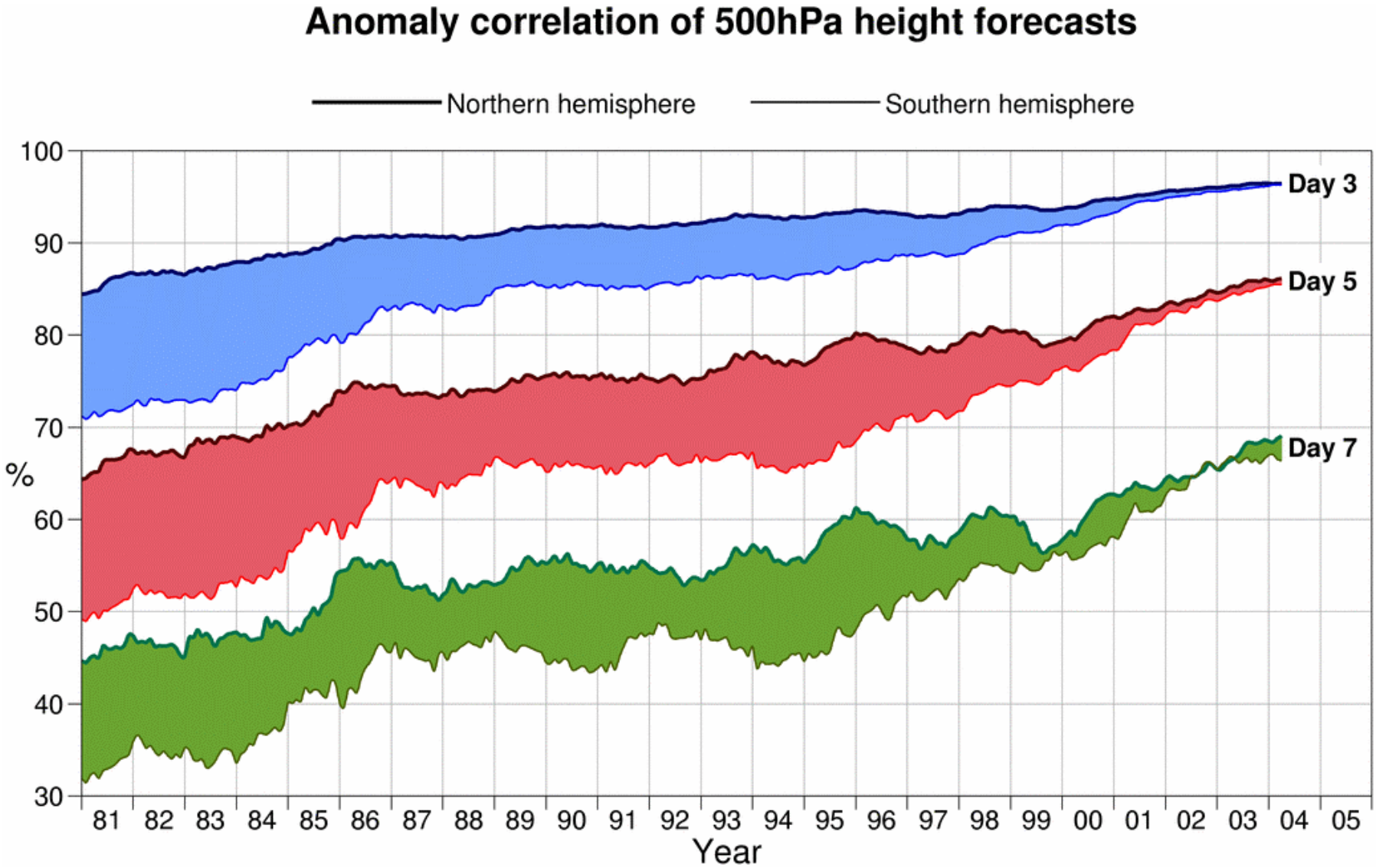
28R1 (25/06/04 00Z)

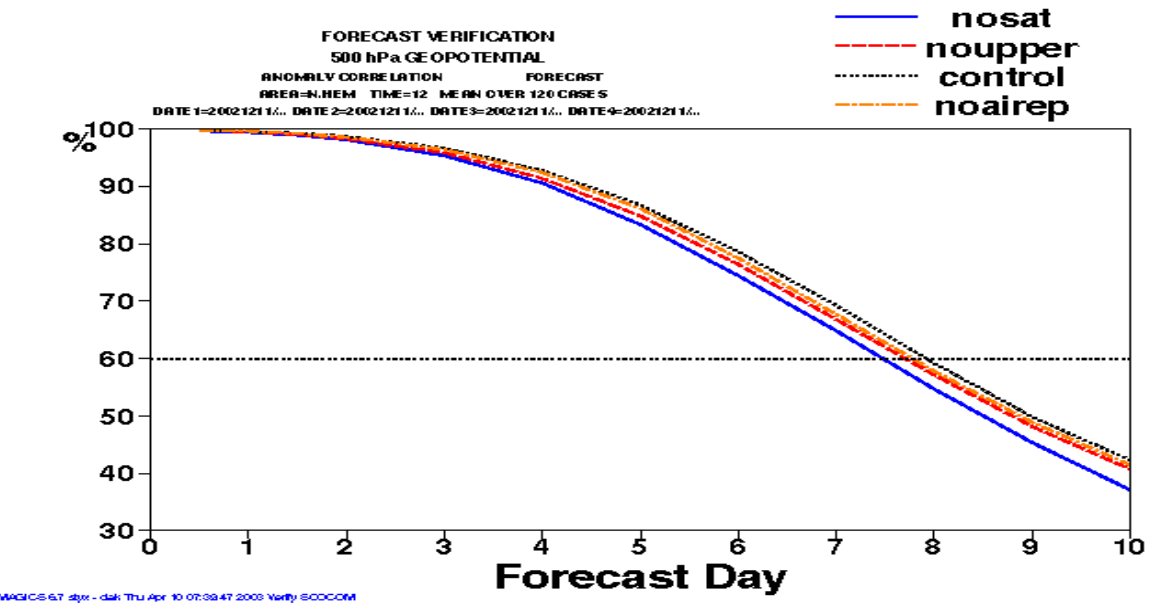
Screened			Assimilated		
• Synop:	276872	(0.39%)	• Synop:	39124	(1.51%)
• Aircraft:	229994	(0.32%)	• Aircraft:	156720	(6.03%)
• AMV's:	**1641042**	**(2.31%)**	**• AMV's:**	**77194**	**(2.97%)**
• Dribu:	11392	(0.02%)	• Dribu:	3622	(0.14%)
• Temp:	118240	(0.17%)	• Temp:	68181	(2.63%)
• Pilot:	103910	(0.15%)	• Pilot:	60320	(2.32%)
• UpperSat:	**68274801**	**(96.26%)**	**• UpperSat:**	**1983481**	**(76.37%)**
• PAOB:	550	(0.00%)	• PAOB:	191	(0.01%)
• Scat:	**249464**	**(0.35%)**	**• Scat:**	**118494**	**(4.56%)**
TOTAL:	70.926.265		TOTAL:	2.597.327	

~ 99% of screened data come from satellites

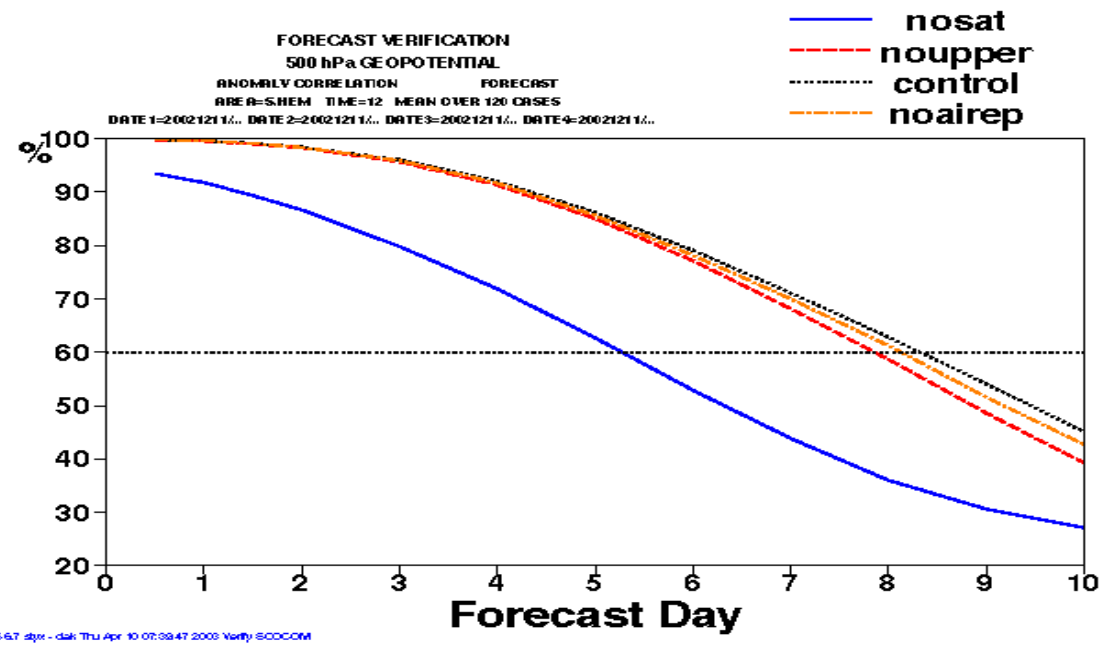
~ 85% of assimilated data come from satellites

Why is there a Challenge? – Importance of Satellite Data





Satellite data have a larger impact on forecast skill than conventional upper-air observations. Especially in the Southern-Hemisphere.



Why is there a Challenge?

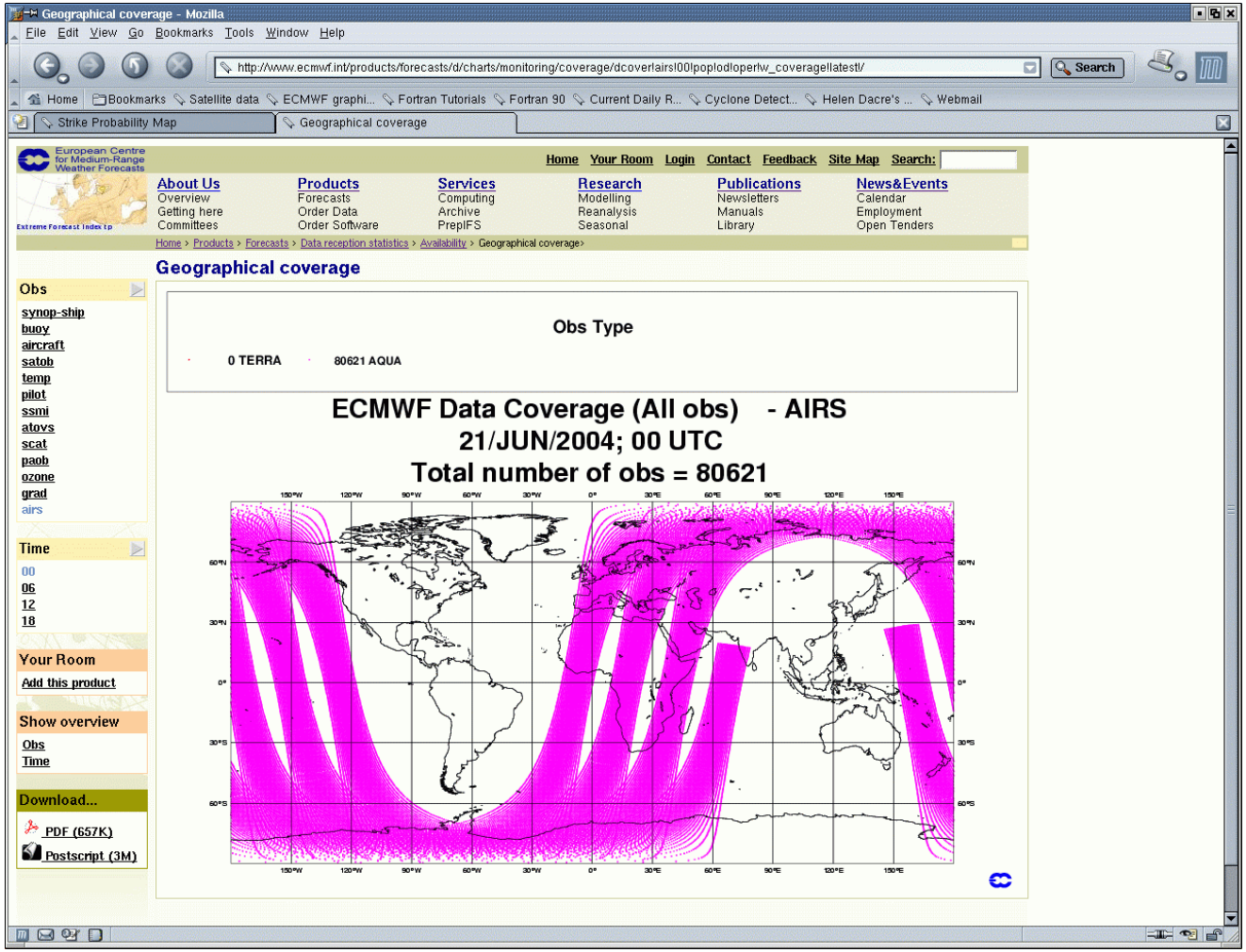
- Satellite data represent by far the **largest volume** of data (and associated computing cost) used in the ECMWF data assimilation system.
- Satellite data have progressively become an essential part of the observing system used at ECMWF. Satellite data have recently caught up with radiosondes in terms of **forecast skill impact** over NH.
- Satellite data monitoring is essential in order to safeguard the **quality** of the observations used and to detect any **systematic errors** in the ECMWF forecast system.
- The usage of **future hyper-spectral instruments** (e.g. IASI on METOP) will increase the importance of a (semi-) automatic satellite data monitoring.

Overview

- Why is there a challenge?
  - » Summary of satellite data usage at ECMWF
  - » Importance of satellite data
- **How is this challenge tackled?**
  - **» Non-Real time monitoring**
  - **» Some examples**
- Future plans

Tackling this Challenge – Monitoring Products on the Web

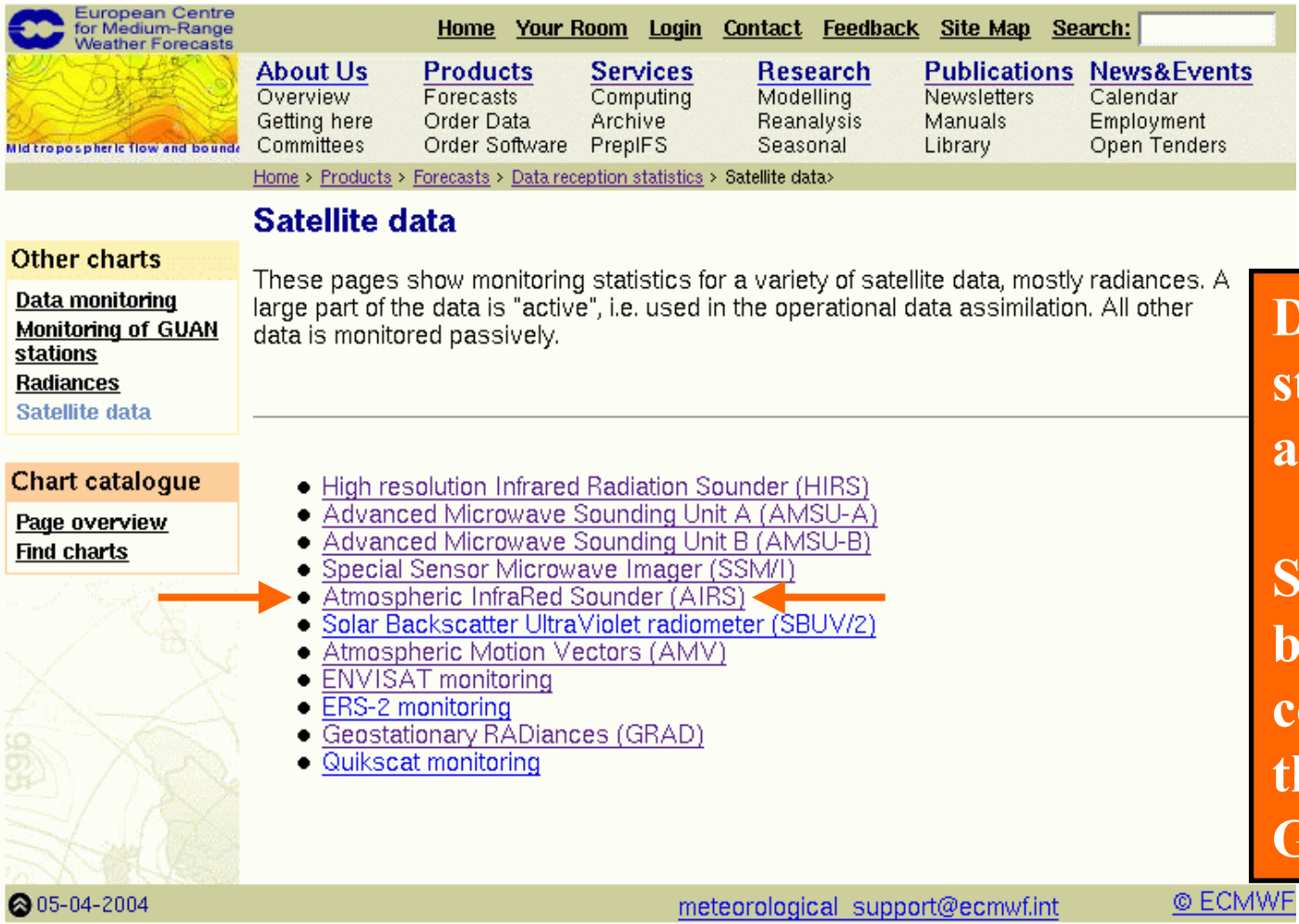
http://www.ecmwf.int/products/forecasts/d/charts/monitoring/coverage/



Coverage maps for recently received data.

Tackling this Challenge – Monitoring Products on the Web

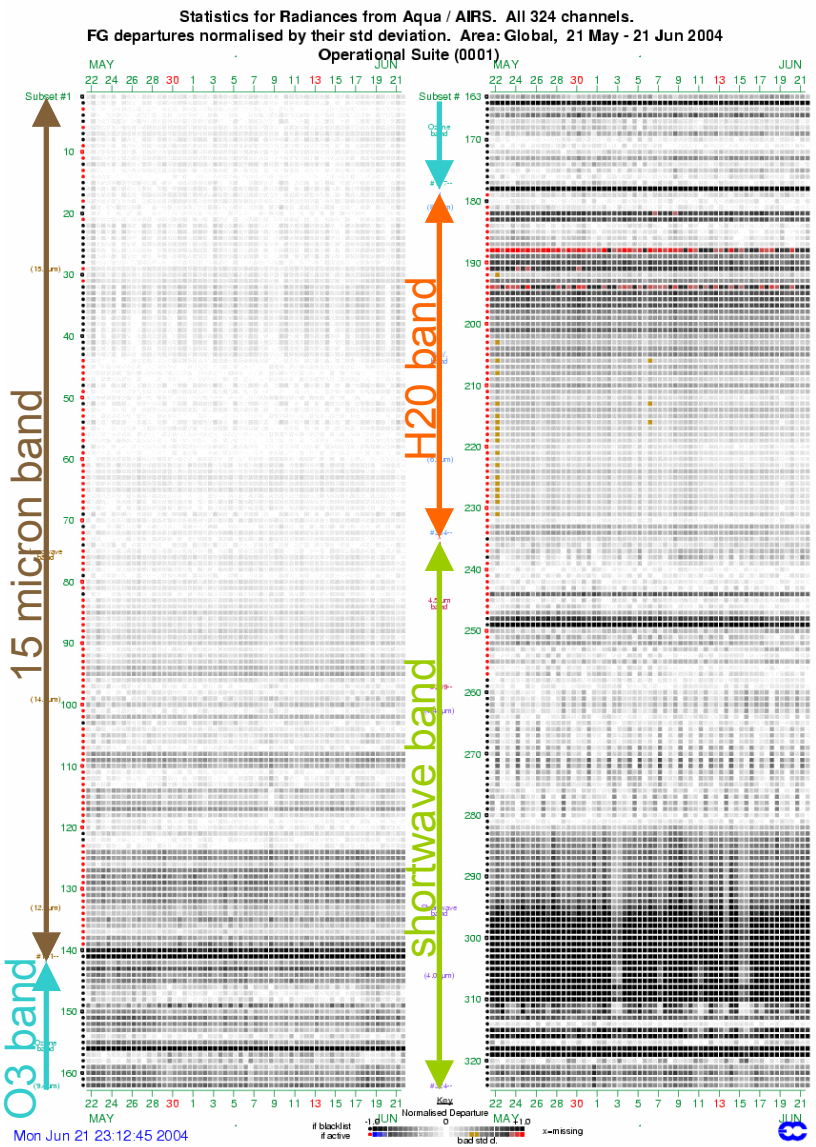
http://www.ecmwf.int/products/forecasts/d/charts/monitoring/satellite



Data monitoring statistics of active and passive data.

Statistics mainly based on comparison with the model First Guess.

Tackling this Challenge – Monitoring Products on the Web

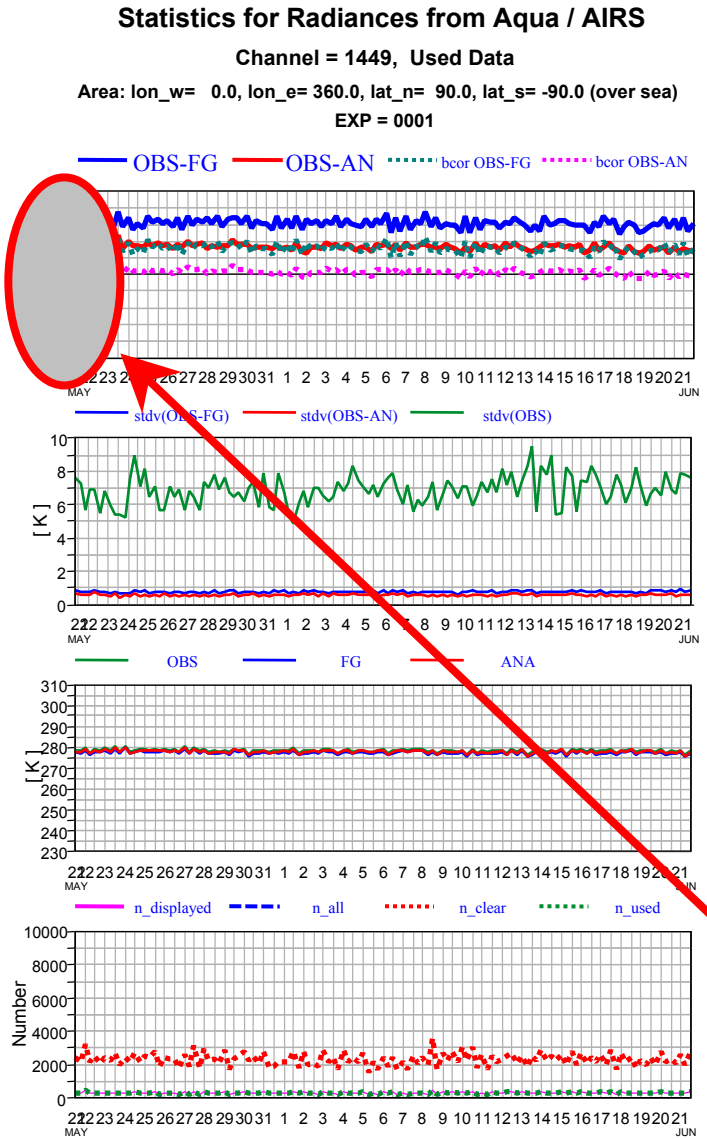


Summary maps

- *Time series of averaged AIRS T_b departures from the model first guess.*
- *Statistics for the complete subset of 324 channels.*
- *Quick assessment made 'easy' and therefore useful for operational alert.*

Note: Something else might be needed for IASI data!

Tackling this Challenge – Monitoring Products on the Web



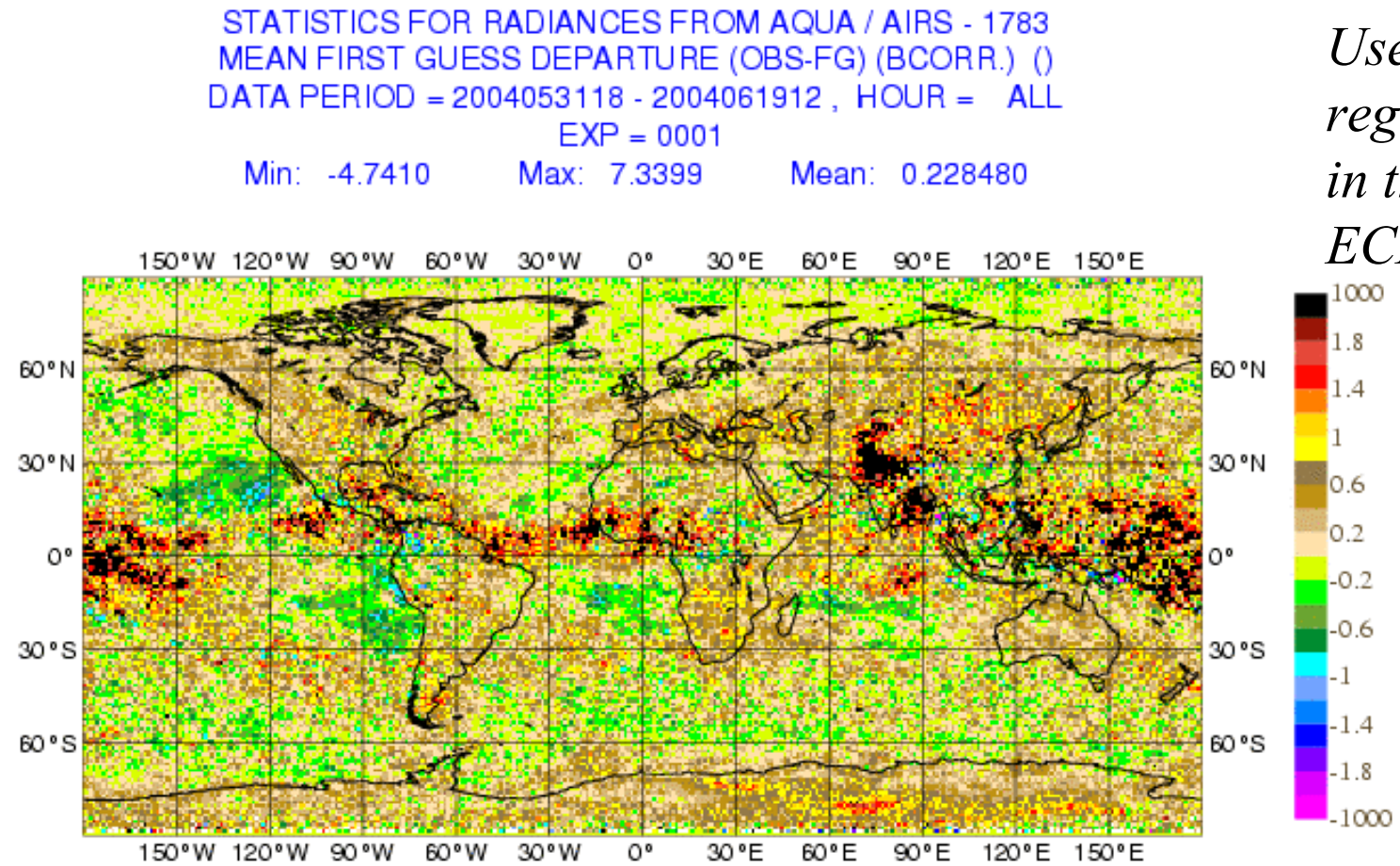
Channel specific time series of area averages.

- *For monitoring long-term evolution of departures and observations.*
- *In case of retrieval or calibration problems in the observation data or scientific changes in the ECMWF model they will show sudden jumps.*
- *Useful for detecting biases and slow drifts in the data.*

Accurate scaling allows for detailed monitoring.

Tackling this Challenge – Monitoring Products on the Web

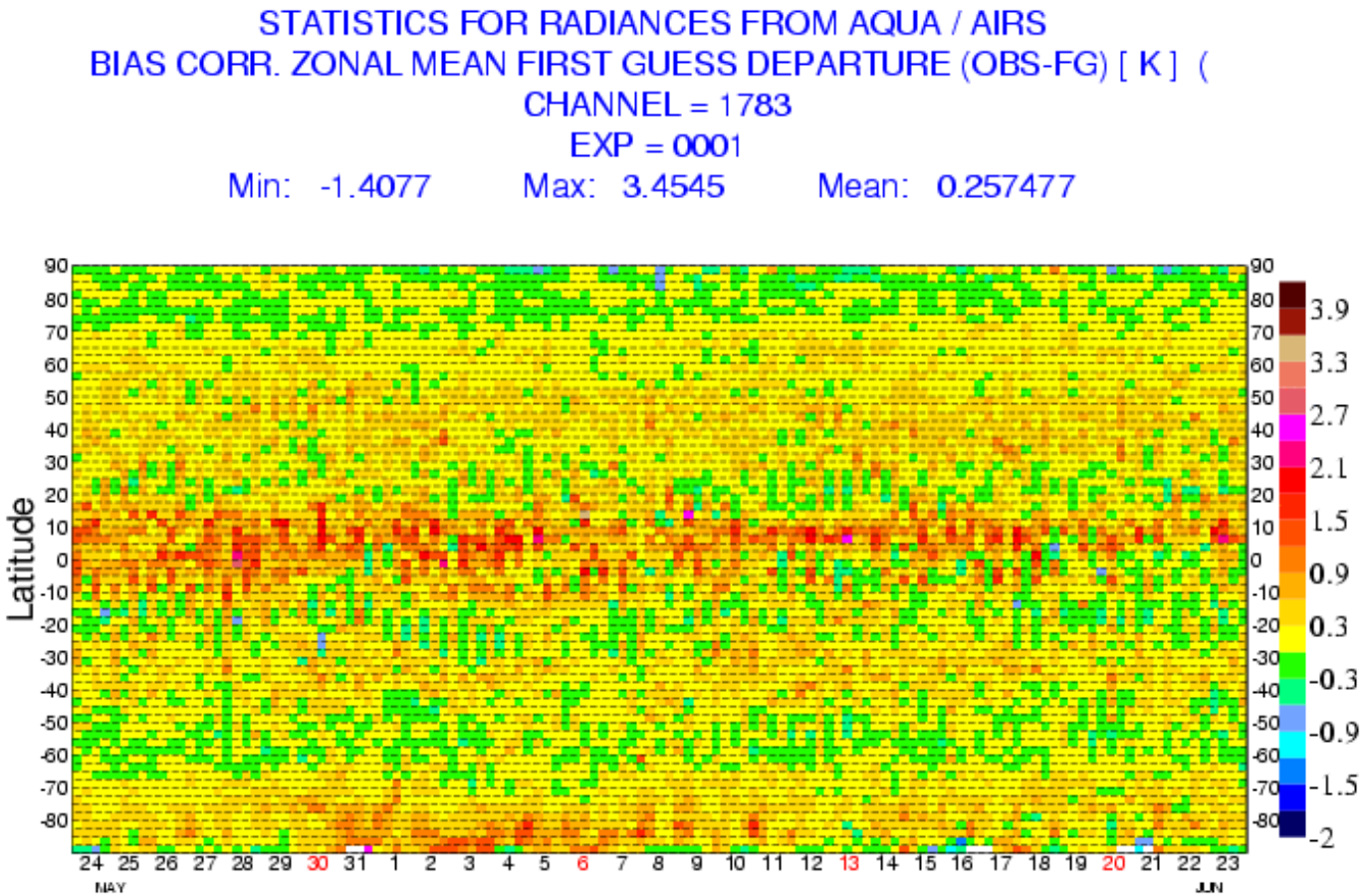
Channel specific time averaged geo-plots



Useful for detecting regional problems in the data or the ECMWF model.

Tackling this Challenge – Monitoring Products on the Web

Channel specific Hovmöller diagrams



- *Another way of looking at long-term behaviour of the data and the model.*
- *Show the time evolution of zonal mean data.*

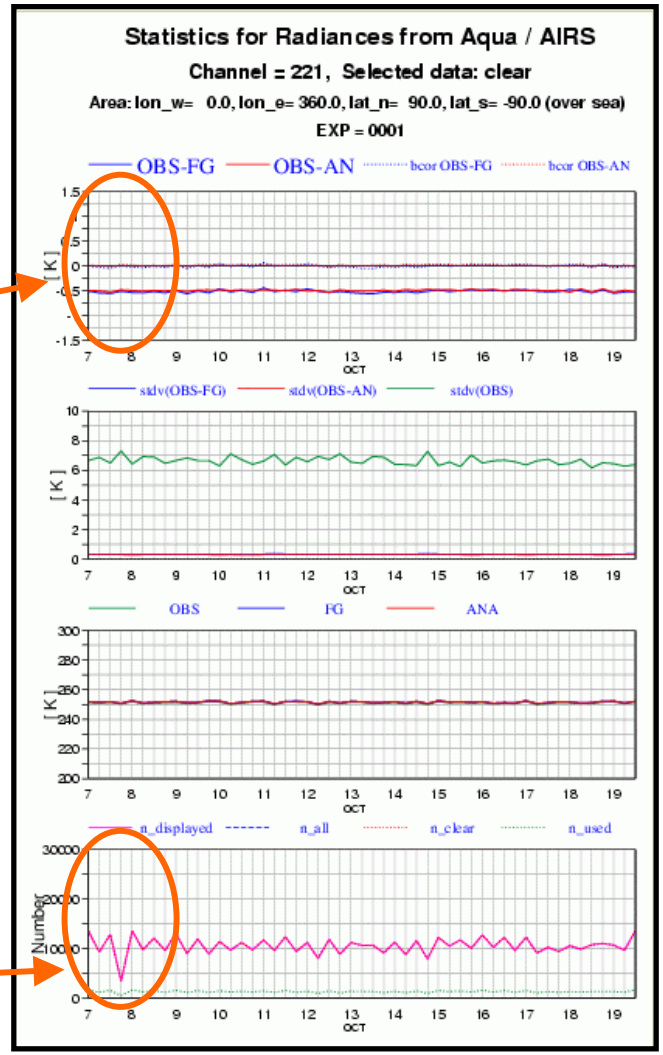
Tackling this Challenge – Example

Shortly after AIRS radiances were put into assimilation an AQUA manoeuvre was carried out (7 October 2003)

no change in obs minus calc statistics

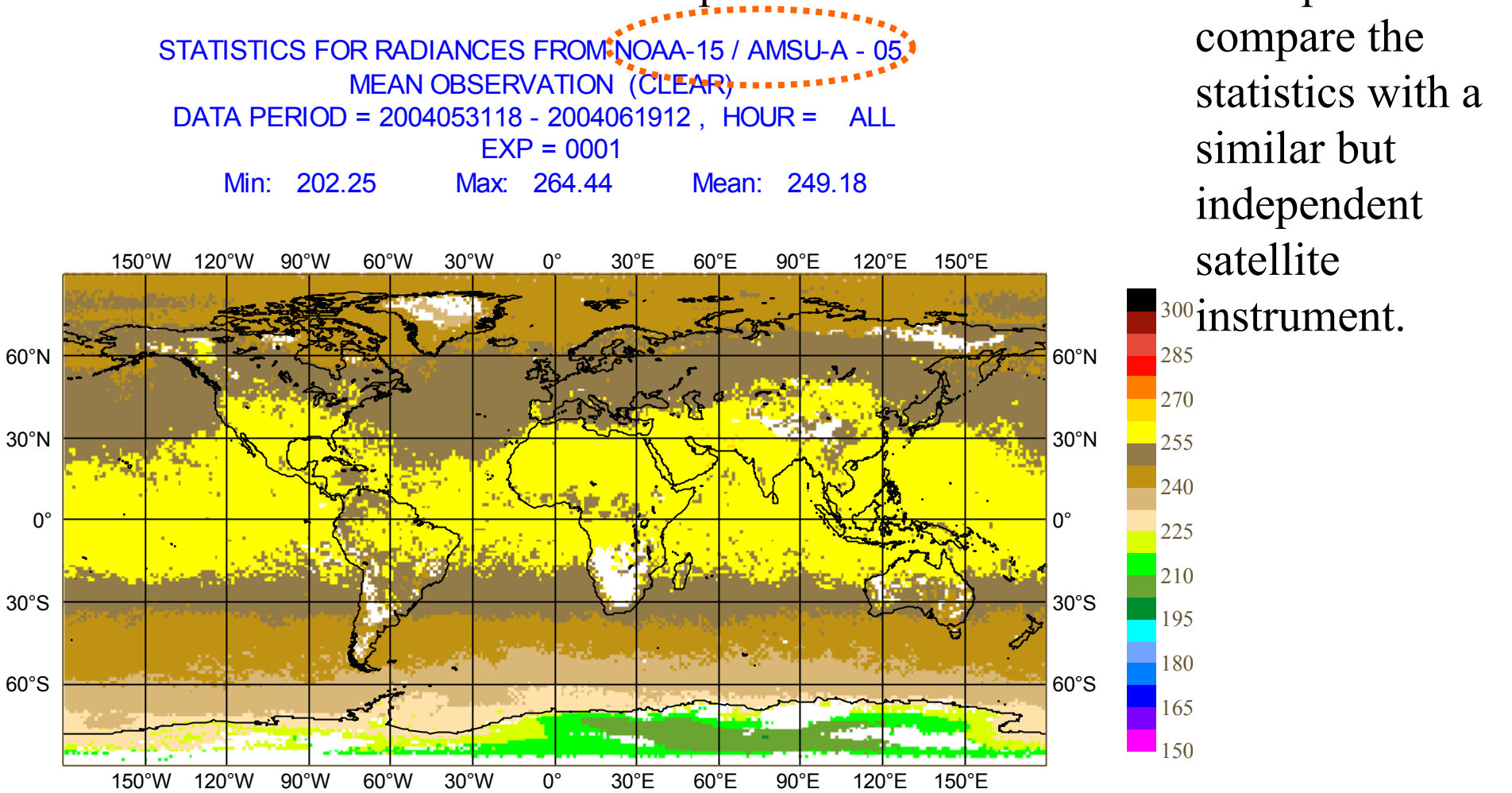
Following the shut-down of the AIRS no disruption or change to the radiance data quality has been observed

data lost



Tackling this Challenge – Comparing with Similar Instruments

Both the model and the observation contribute to the First Guess departure and neither of them is 'true'. To separate these two sources it is helpful to compare the statistics with a similar but independent satellite instrument.



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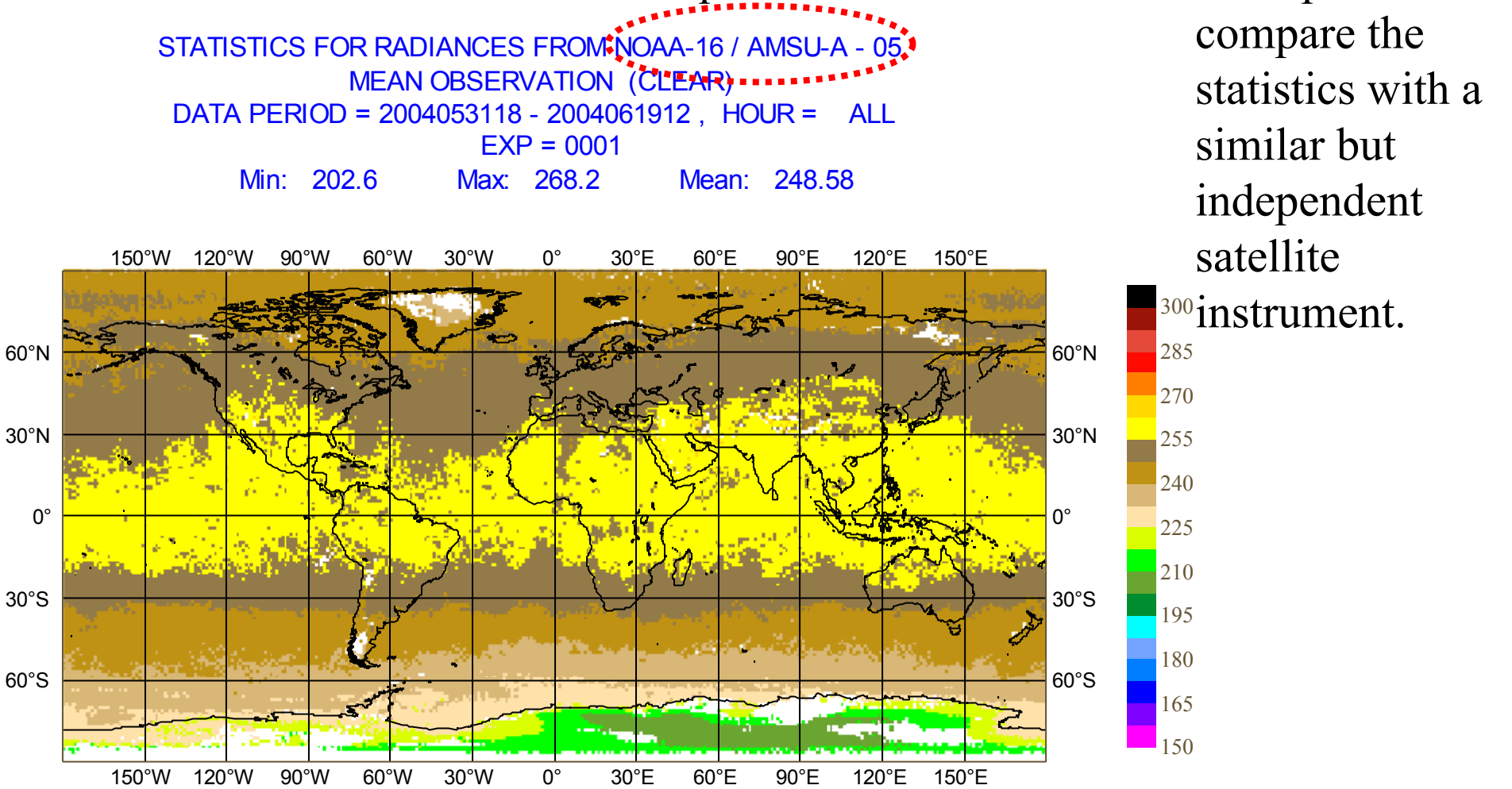

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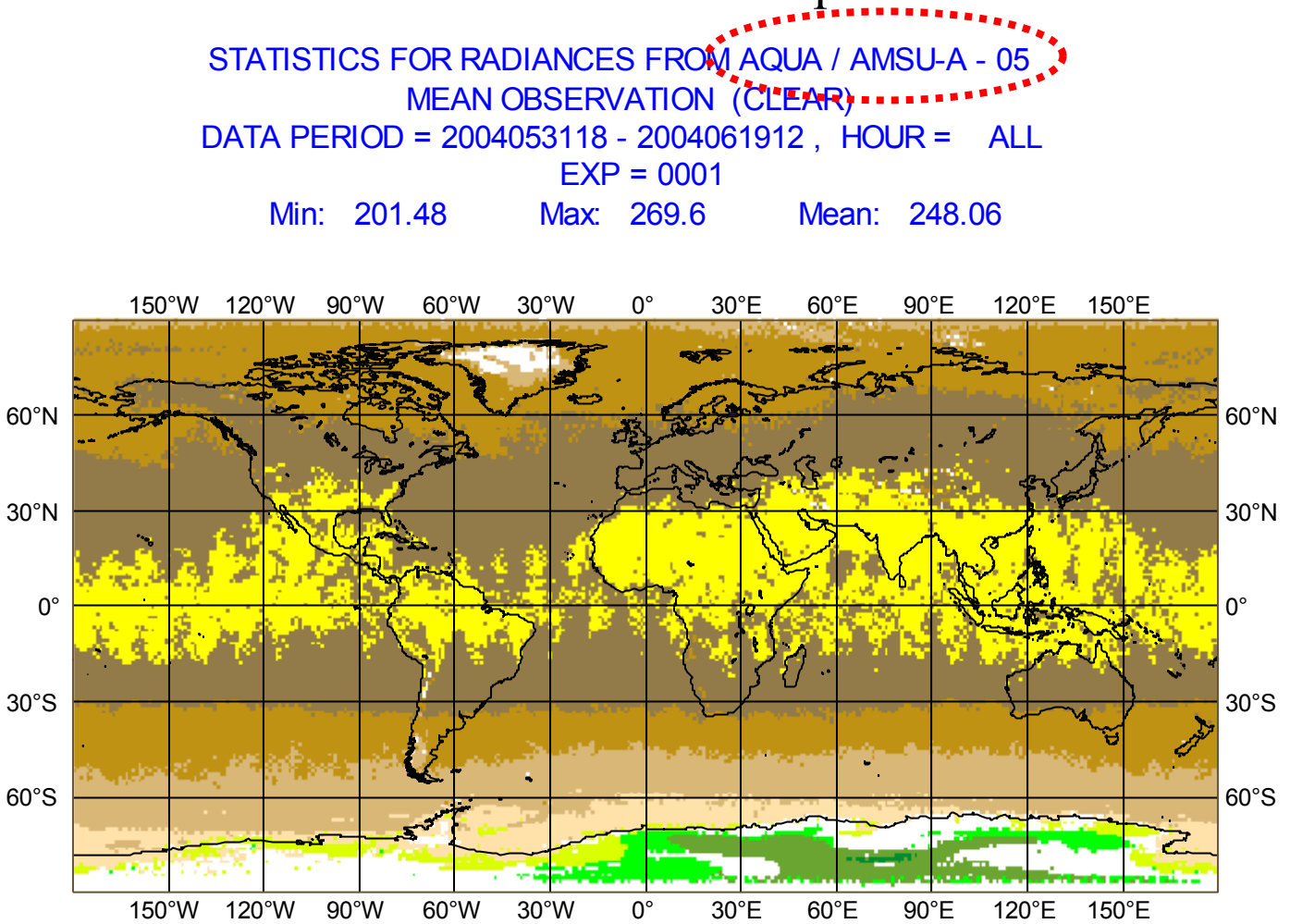


Tackling this Challenge – Comparing with Similar Instruments

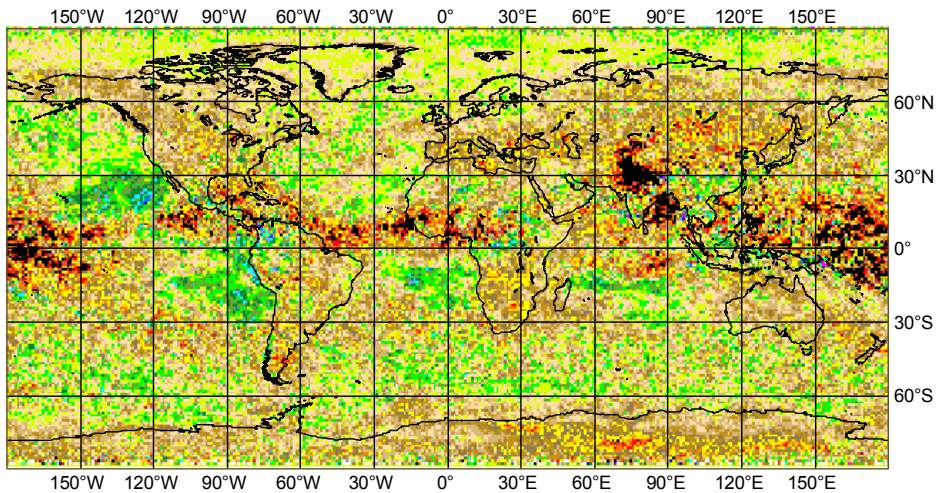
However, another high-spectral resolution infra-red sounder, similar to AIRS, is not available yet. This makes comparisons with similar independent observations not so straightforward.

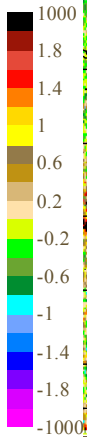
Comparing AIRS with channels on different instruments but with the same radiometric properties.

Upper Tropospheric Humidity

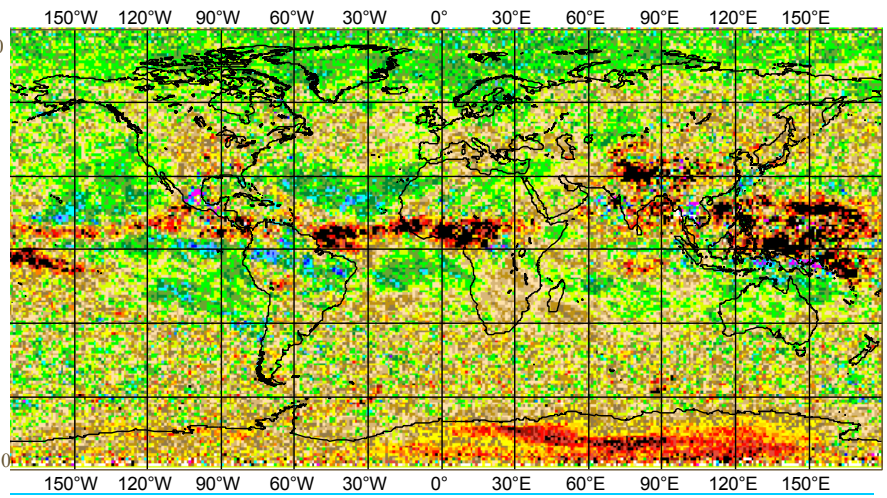
AIRS 1783 (6 micron) ⟷ HIRS 12

STATISTICS FOR RADIANCES FROM AQUA / AIRS - 1783
MEAN FIRST GUESS DEPARTURE (OBS-FG) (BCORR.) ()
DATA PERIOD = 2004053118 - 2004061912 , HOUR = ALL
EXP = 0001
Min: -4.7410 Max: 7.3399 Mean: 0.228480





STATISTICS FOR RADIANCES FROM NOAA-17 / HIRS - 12
MEAN FIRST GUESS DEPARTURE (OBS-FG) (BCORR.) (CLEAR)
DATA PERIOD = 2004053118 - 2004061912 , HOUR = ALL
EXP = 0001
Min: -10.35 Max: 7.9 Mean: 0.105079

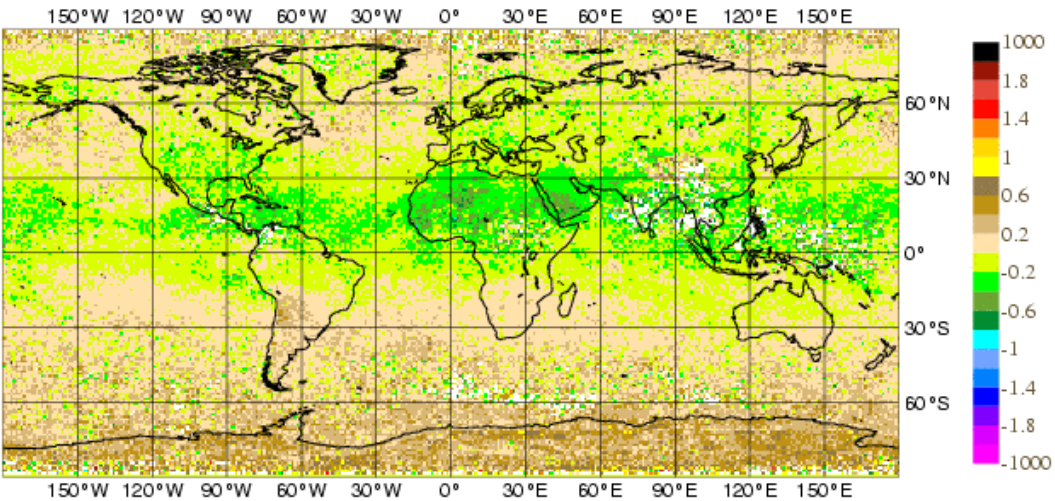


Tackling this Challenge – Comparing with Similar Instruments

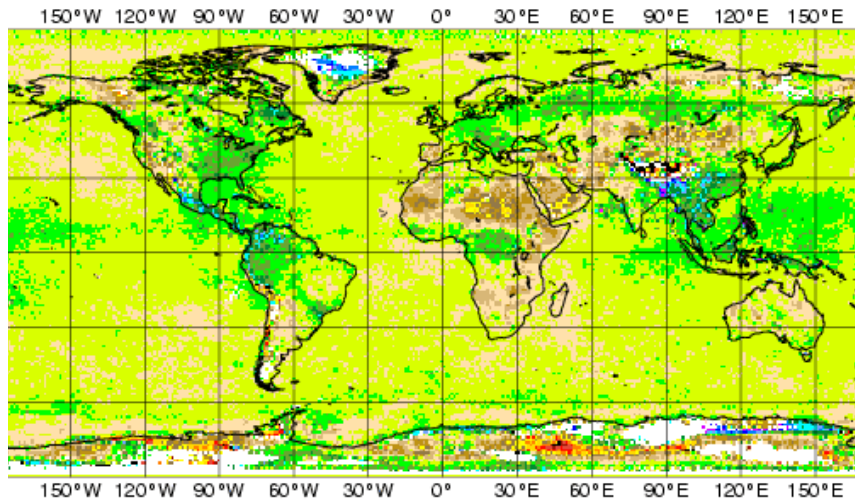
Mid Tropospheric Temperature

AIRS 221 (14 micron) ⟷ AMSU-A 5

STATISTICS FOR RADIANCES FROM AQUA / AIRS - 221
MEAN FIRST GUESS DEPARTURE (OBS-FG) (BCORR.) ()
DATA PERIOD = 2004053118 - 2004061912 , HOUR = ALL
EXP = 0001
Min: -1.1857 Max: 2.9905 Mean: 0.014410

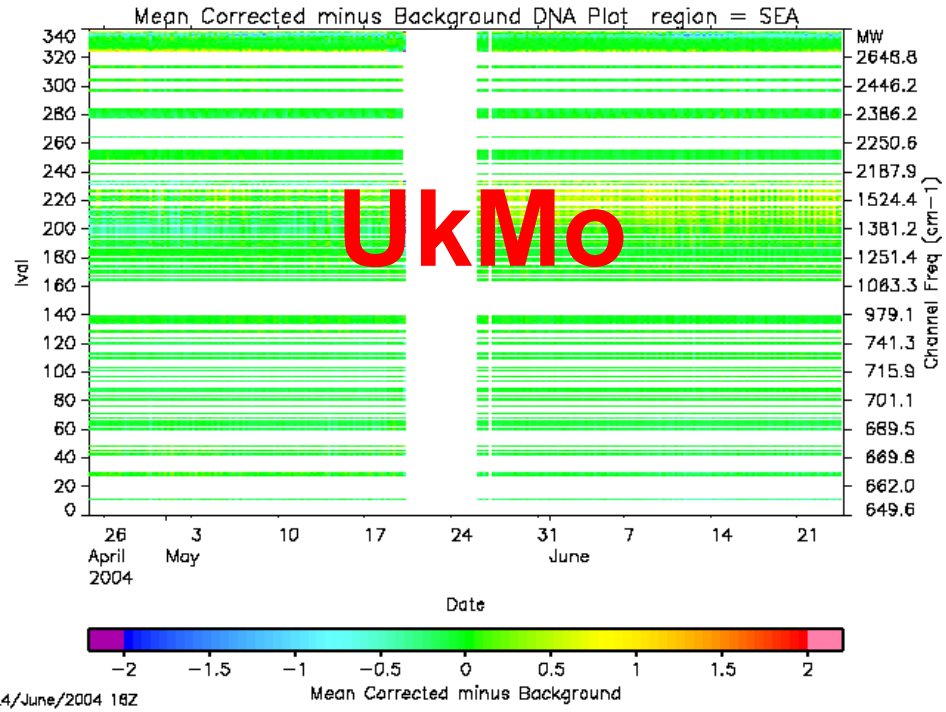


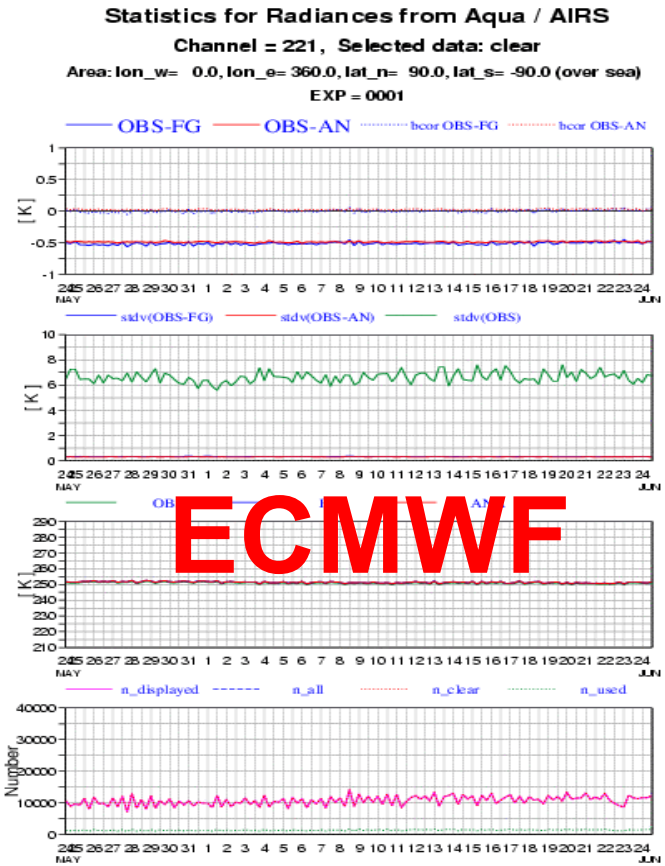
STATISTICS FOR RADIANCES FROM NOAA-16 / AMSU-A - 05
MEAN FIRST GUESS DEPARTURE (OBS-FG) (BCORR.) (CLEAR)
DATA PERIOD = 2004053118 - 2004061912 , HOUR = ALL
EXP = 0001
Min: -2.7 Max: 4.5667 Mean: -0.070707



Tackling this Challenge – Comparing with Other Centres

By comparing data monitoring statistics between different centres one can make an assessment of the contribution of the model error in the departures.





However, monitoring plots should be in the same format to allow for easy comparisons.

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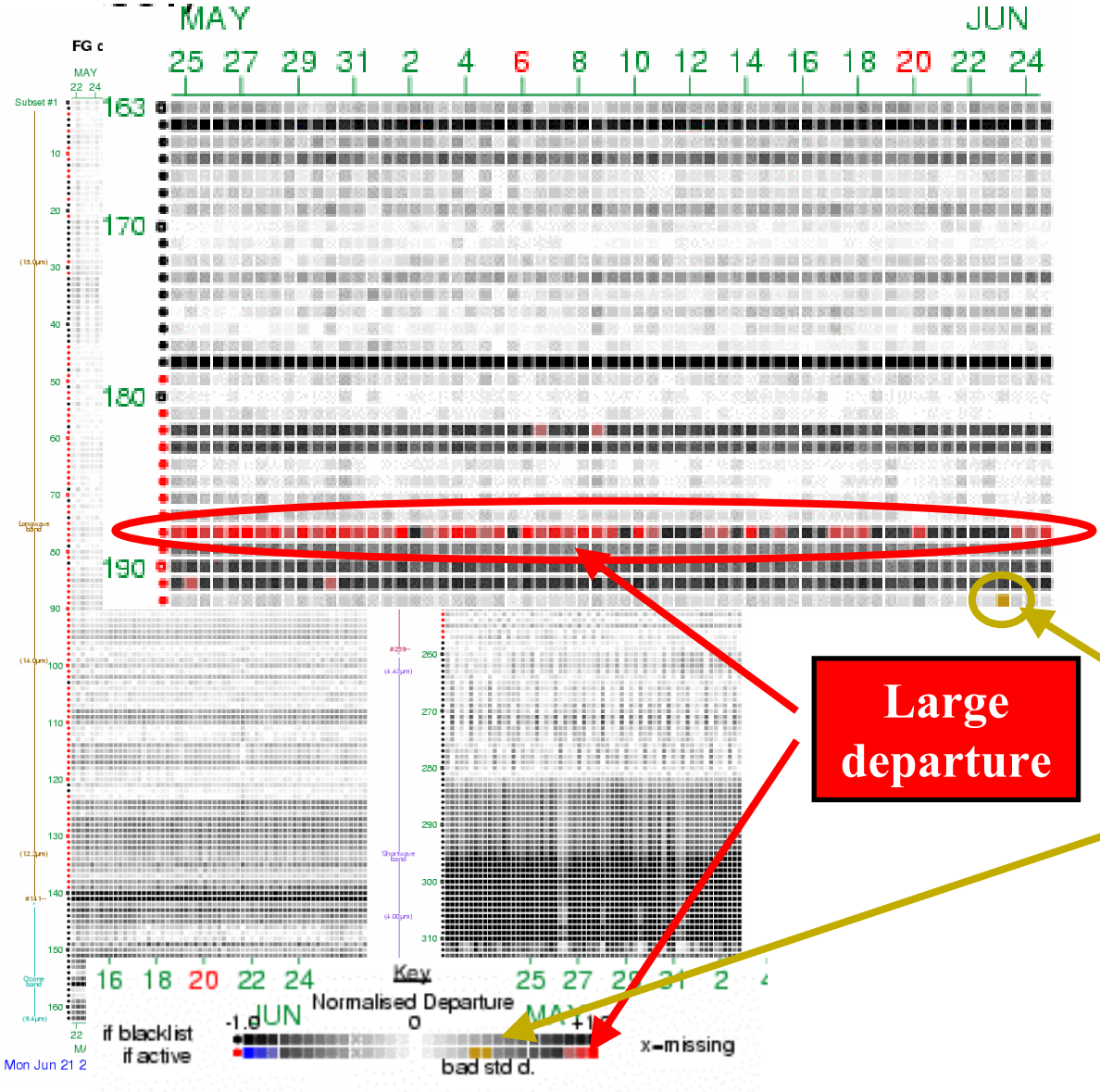
- How is this challenge tackled?
  - » Non-Real time monitoring
  - » Some examples
- **Future plans**

Future Plans – Automatic Alerts

More high-spectral resolution instruments are planned in the near future. As a result, thousands of more channels will be available for assimilation in NWP systems.

An automatic monitoring system will be essential to safeguard the quality of these data and to monitor the impact on the model.

Future Plans – Automatic Alerts



Summary maps already provide semi-automatic alerts.

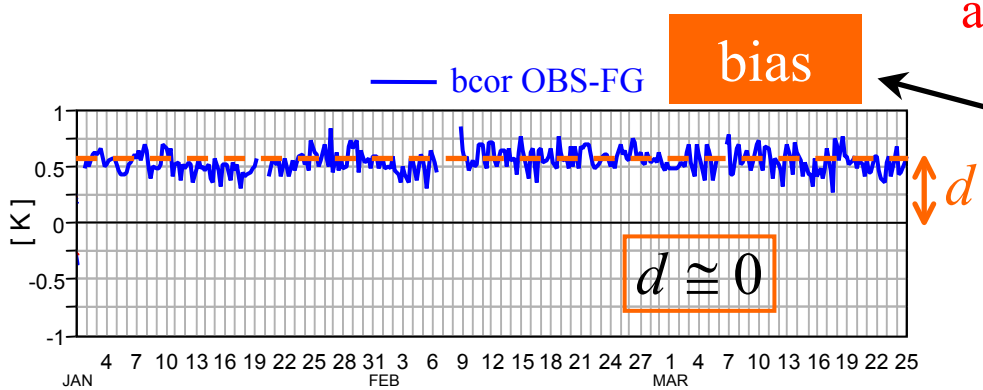
Large departure

Sudden change in standard deviation

Future Plans – Automatic Alerts

Signal detection based on statistics of past ~ 50 days

A variational bias correction technique is currently investigated at ECMWF. As such a system is designed to keep the bias close to zero one would also need to monitor the applied bias correction value itself.



Three types of signals