

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



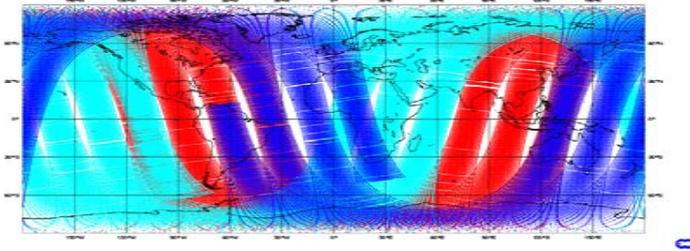
Overview

- 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

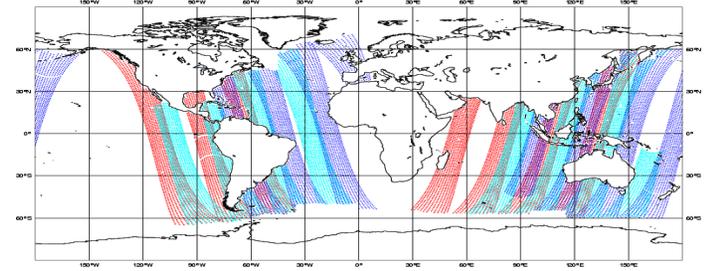


Why is there a Challenge? – Satellite Data Coverage at ECMWF

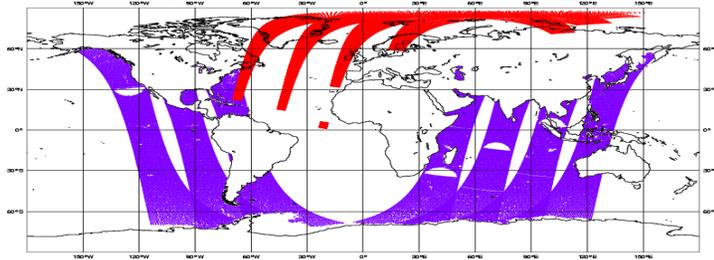
NOAA AMSUA/B HIRS, AQUA AIRS



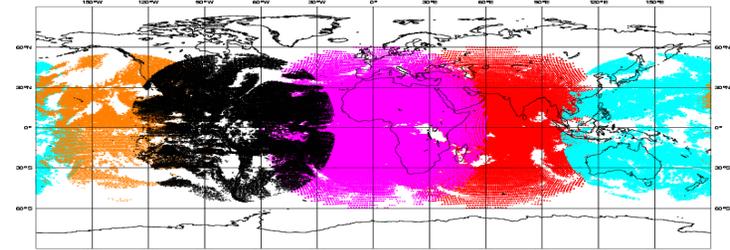
DMSP SSM/I



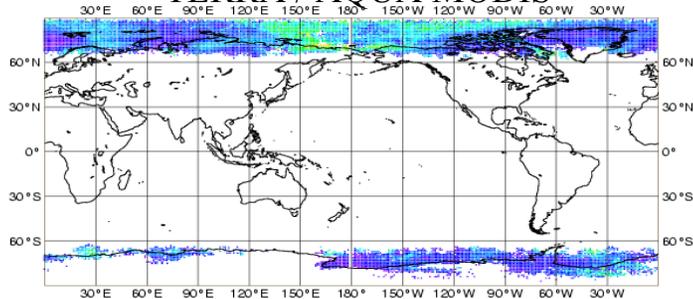
SCATTEROMETERS



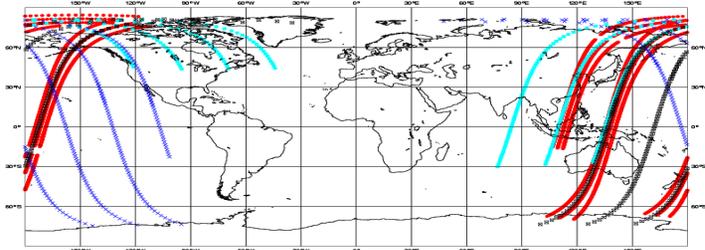
GEOS



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	

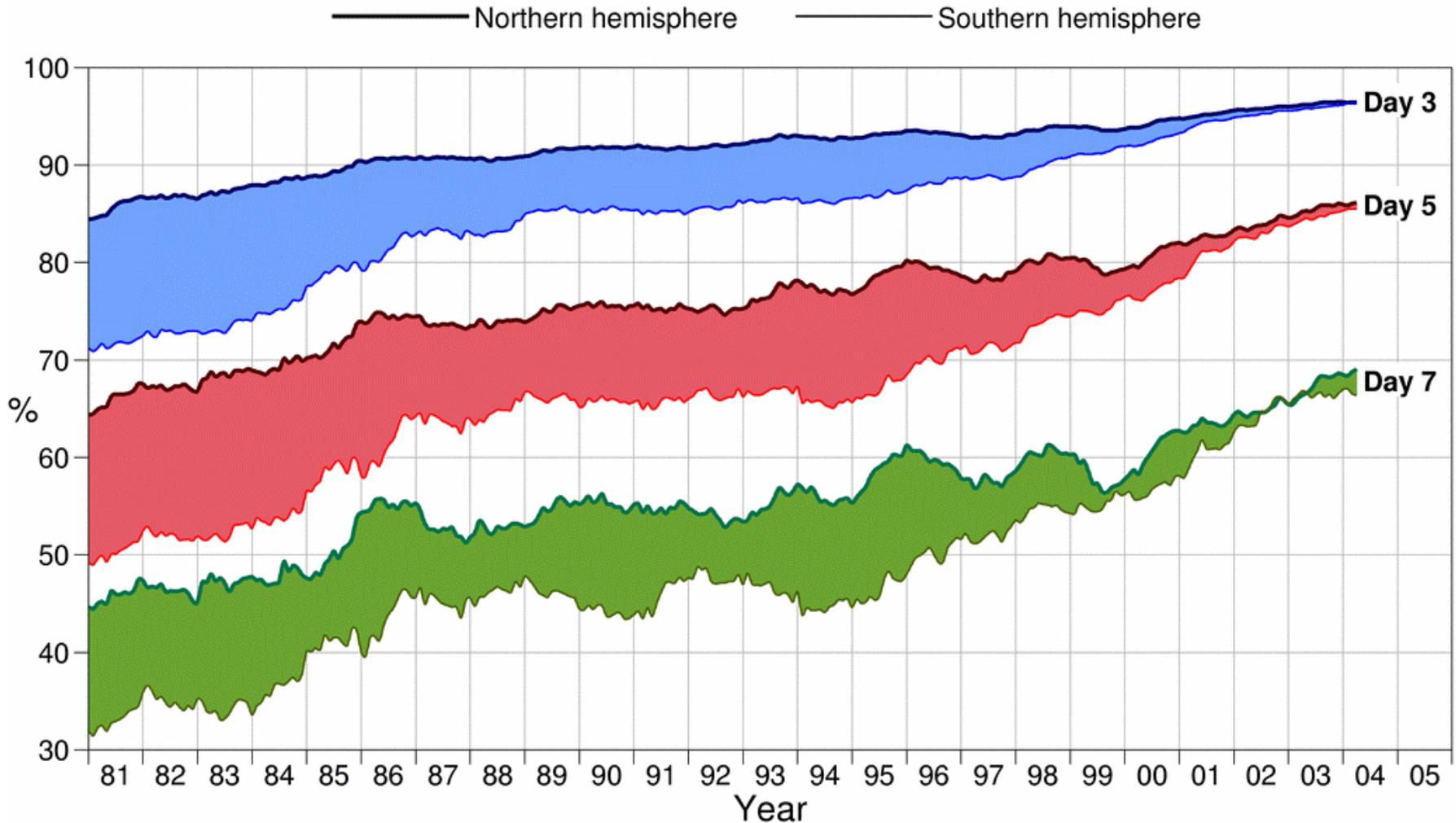
~ 99% of screened data come from satellites

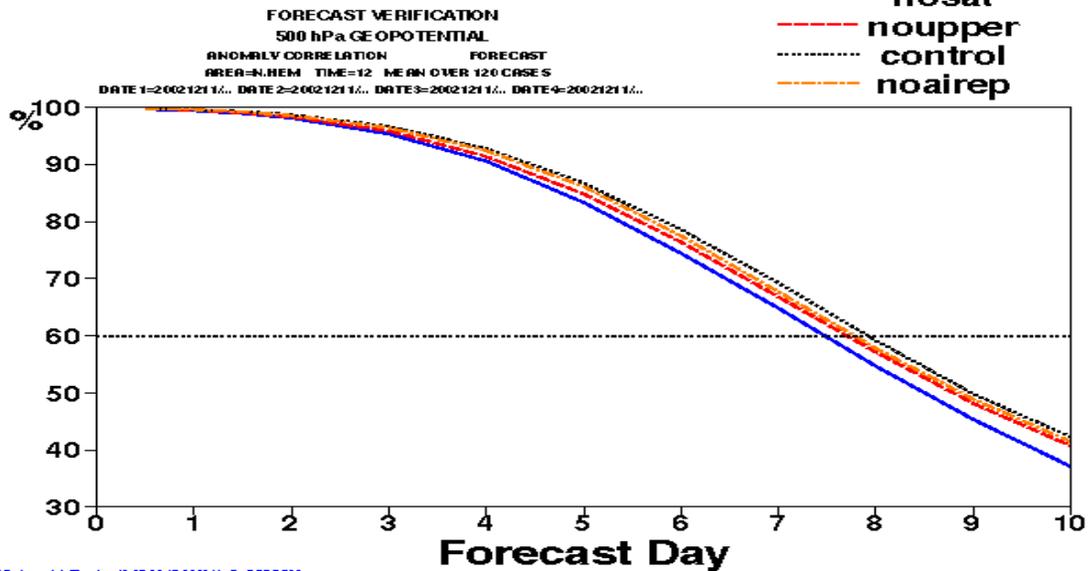
~ 85% of assimilated data come from satellites



Why is there a Challenge? – Importance of Satellite Data

Anomaly correlation of 500hPa height forecasts

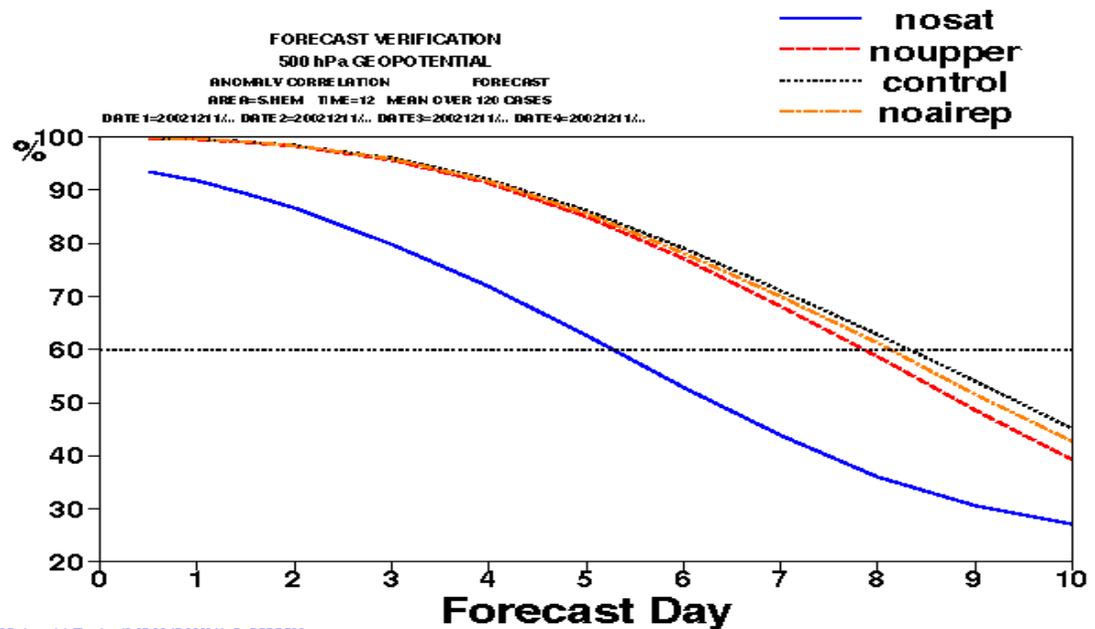




MAGICS-67 stjx - dak Thu Apr 10 07:39:47 2003 Verify S00COM

©

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



MAGICS-67 stjx - dak Thu Apr 10 07:39:47 2003 Verify S00COM



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.



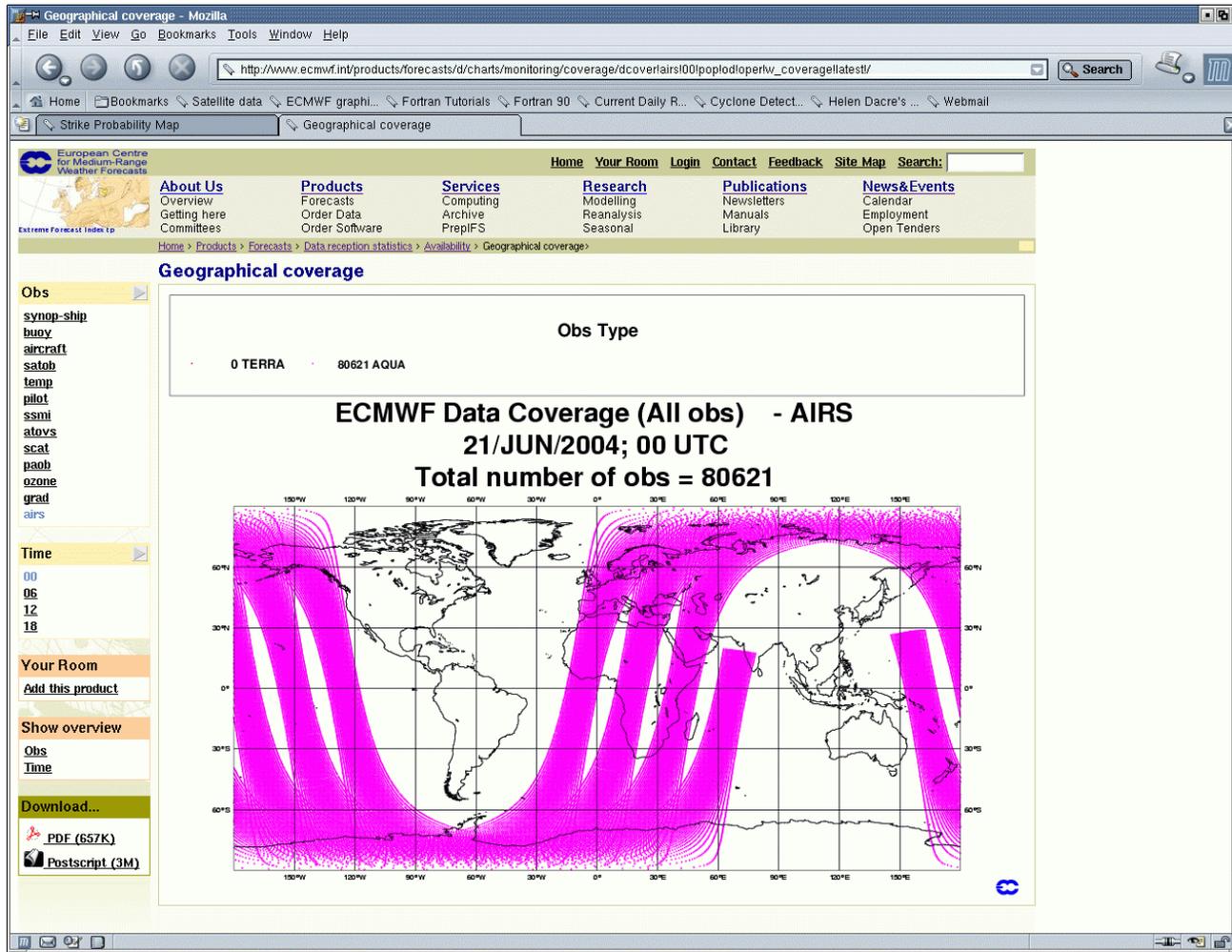
Overview

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 - » Importance of satellite data
- **How is this challenge tackled?**
 - » **Non-Real time monitoring**
 - » **Some examples**
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Tackling this Challenge – Monitoring Products on the Web

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



Coverage maps for recently received data.



June 28 – 1 July

ECMWF Workshop on Assimilation of high spectral resolution sounders in NWP

Slide 10

Tackling this Challenge – Monitoring Products on the Web

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

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Satellite data

Other charts

- [Data monitoring](#)
- [Monitoring of GUAN stations](#)
- [Radiances](#)
- [Satellite data](#)

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These pages show monitoring statistics for a variety of satellite data, mostly radiances. A large part of the data is "active", i.e. used in the operational data assimilation. All other data is monitored passively.

- [High resolution Infrared Radiation Sounder \(HIRS\)](#)
- [Advanced Microwave Sounding Unit A \(AMSU-A\)](#)
- [Advanced Microwave Sounding Unit B \(AMSU-B\)](#)
- [Special Sensor Microwave Imager \(SSM/I\)](#)
- [Atmospheric InfraRed Sounder \(AIRS\)](#)
- [Solar Backscatter UltraViolet radiometer \(SBUV/2\)](#)
- [Atmospheric Motion Vectors \(AMV\)](#)
- [ENVISAT monitoring](#)
- [ERS-2 monitoring](#)
- [Geostationary RADiances \(GRAD\)](#)
- [Quikscat monitoring](#)

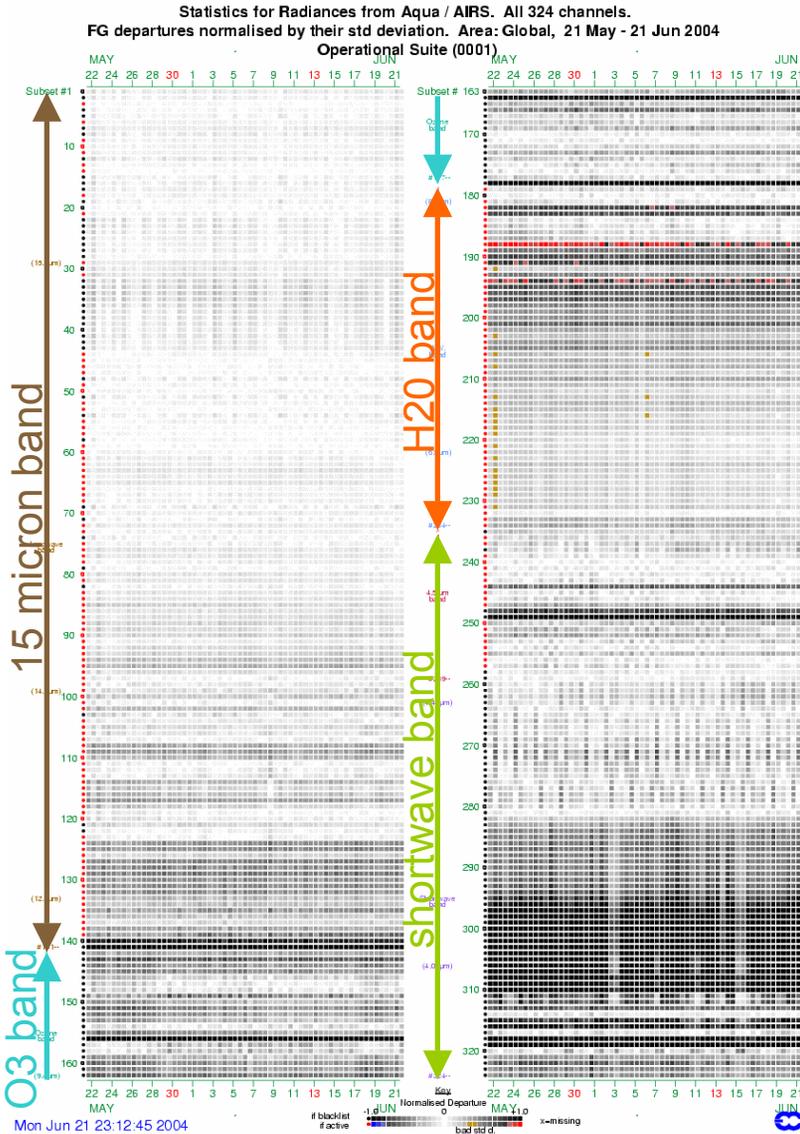
05-04-2004 meteorological_support@ecmwf.int © ECMWF

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!



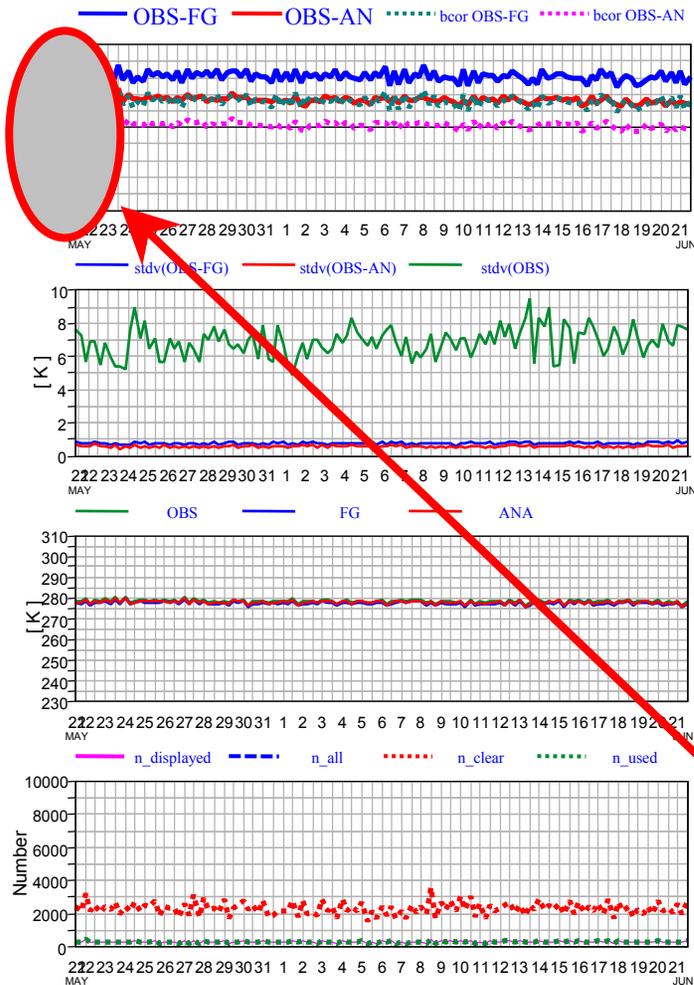
Tackling this Challenge – Monitoring Products on the Web

Statistics for Radiances from Aqua / AIRS

Channel = 1449, Used Data

Area: lon_w= 0.0, lon_e= 360.0, lat_n= 90.0, lat_s= -90.0 (over sea)

EXP = 0001



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.



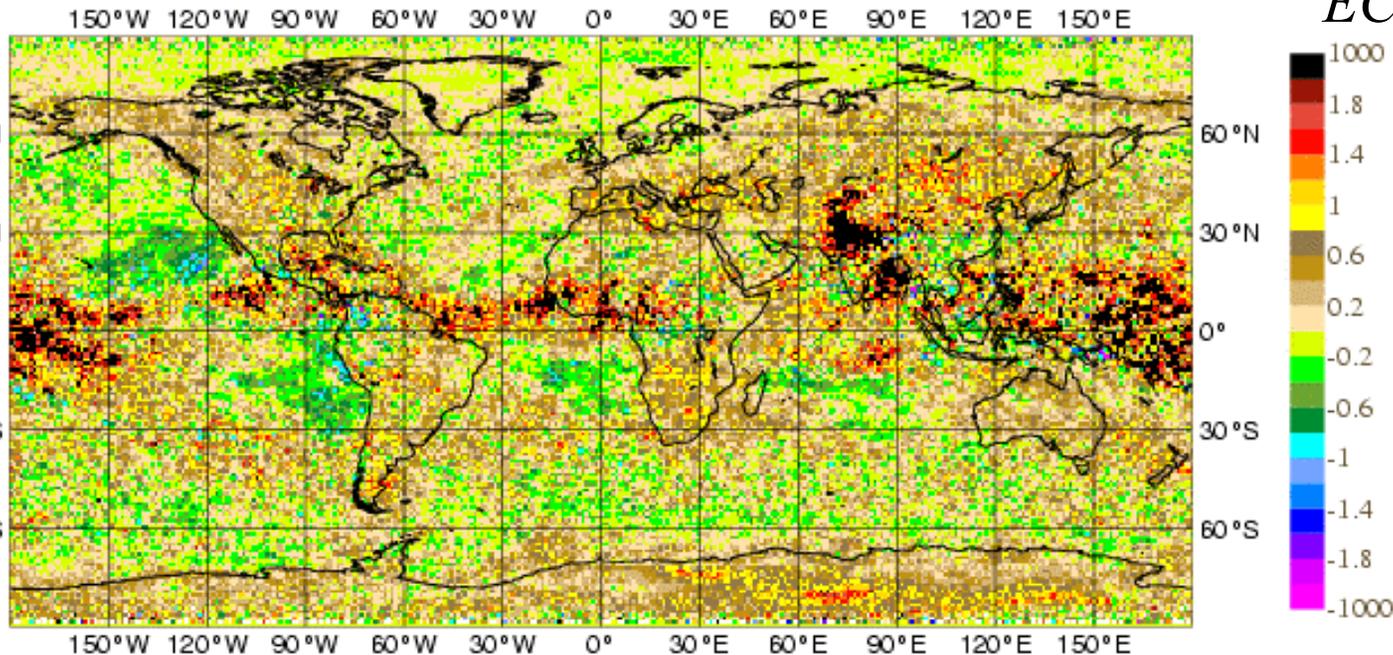
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Channel specific time averaged geo-plots

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

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

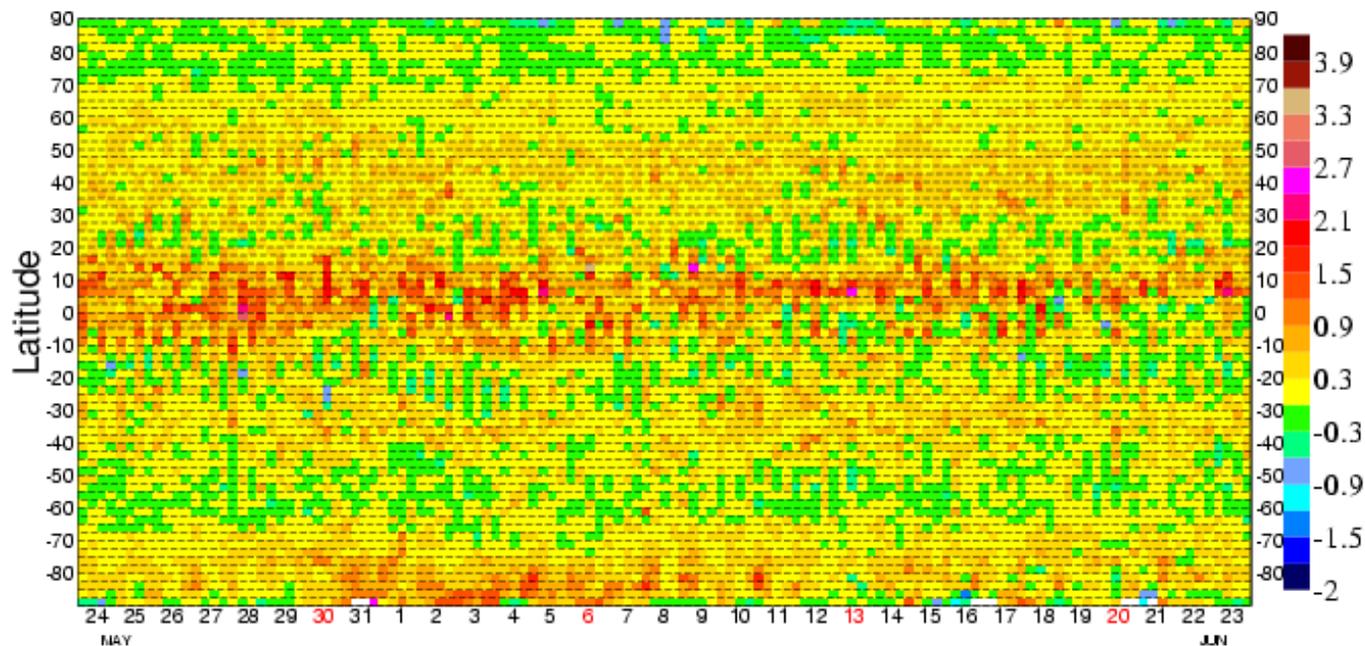


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Channel specific Hovmöller diagrams

STATISTICS FOR RADIANCES FROM AQUA / AIRS
BIAS CORR. ZONAL MEAN FIRST GUESS DEPARTURE (OBS-FG) [K] (
CHANNEL = 1783
EXP = 0001
Min: -1.4077 Max: 3.4545 Mean: 0.257477

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



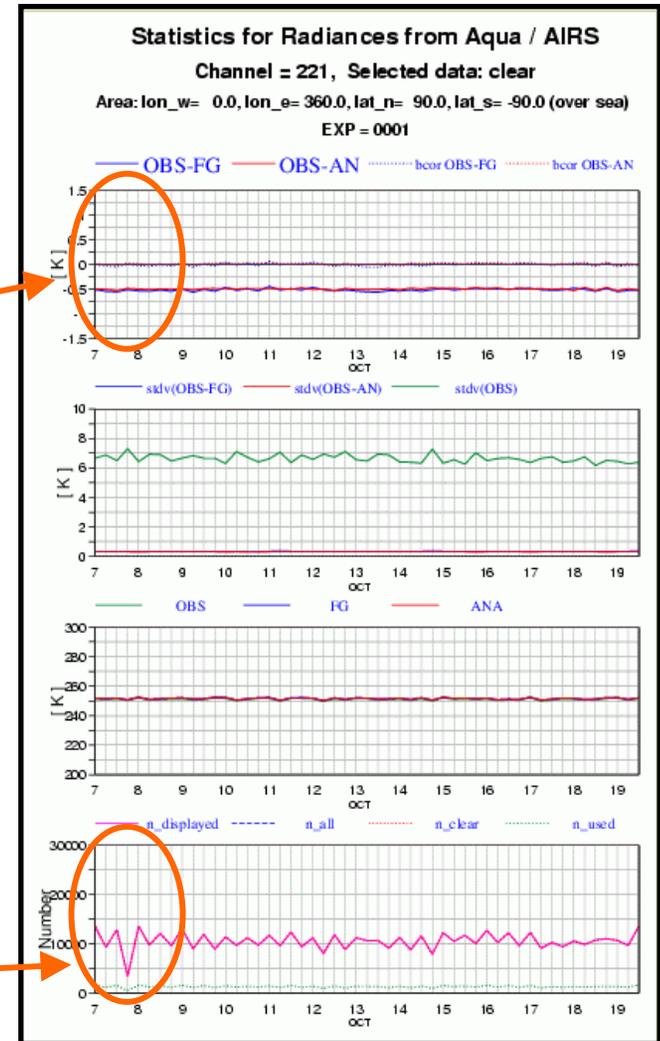
Tackling this Challenge – Example

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

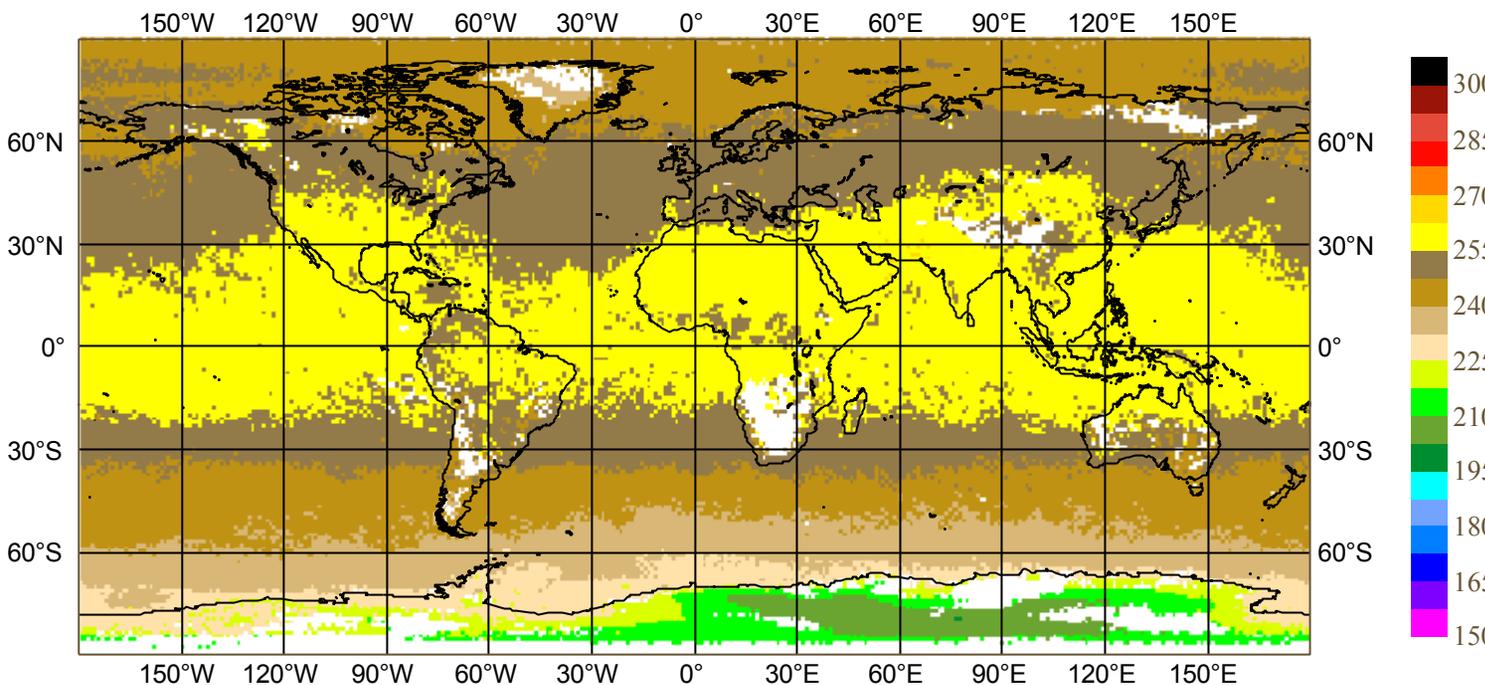


Tackling this Challenge – Comparing with Similar Instruments

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

STATISTICS FOR RADIANCES FROM NOAA-15 / AMSU-A - 05
MEAN OBSERVATION (CLEAR)
DATA PERIOD = 2004053118 - 2004061912 , HOUR = ALL
EXP = 0001
Min: 202.25 Max: 264.44 Mean: 249.18

compare the statistics with a similar but independent satellite instrument.

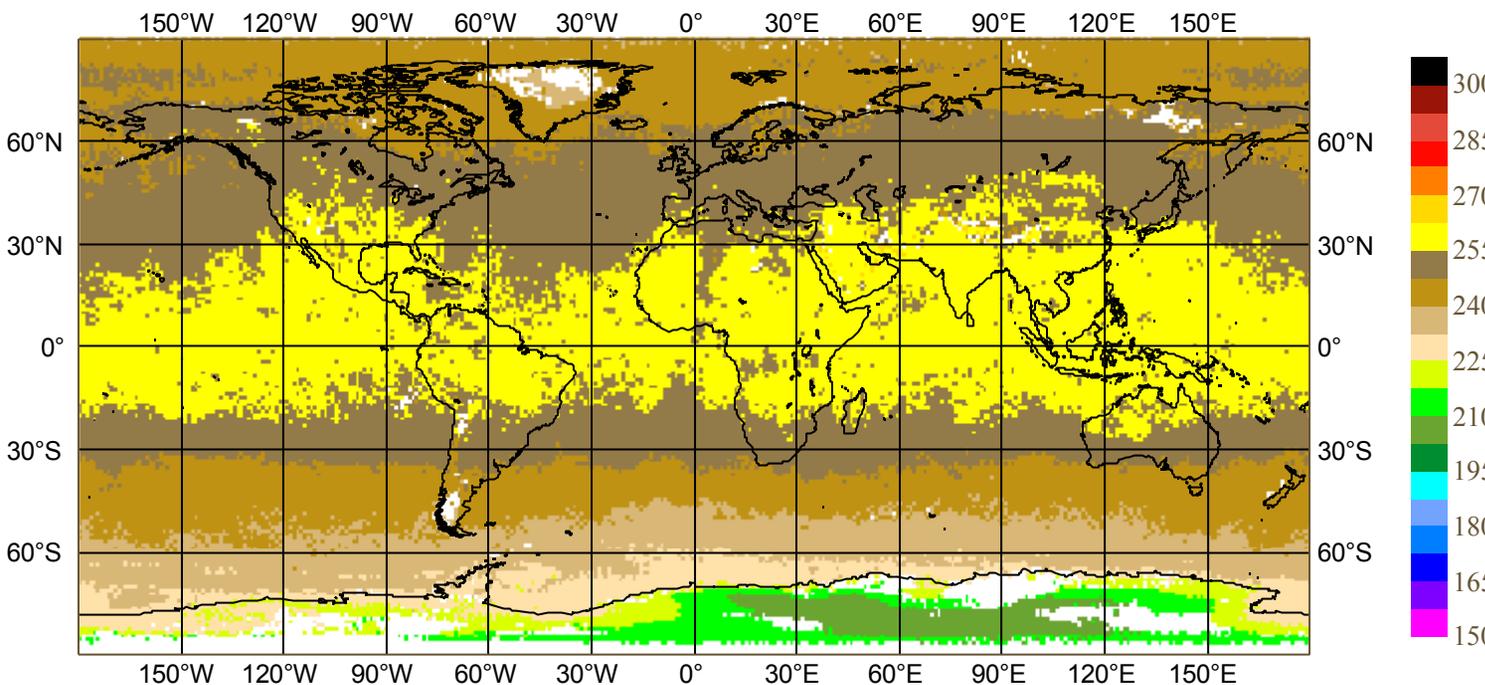


Tackling this Challenge – Comparing with Similar Instruments

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

STATISTICS FOR RADIANCES FROM NOAA-16 / AMSU-A - 05
MEAN OBSERVATION (CLEAR)
DATA PERIOD = 2004053118 - 2004061912 , HOUR = ALL
EXP = 0001
Min: 202.6 Max: 268.2 Mean: 248.58

compare the statistics with a similar but independent satellite instrument.

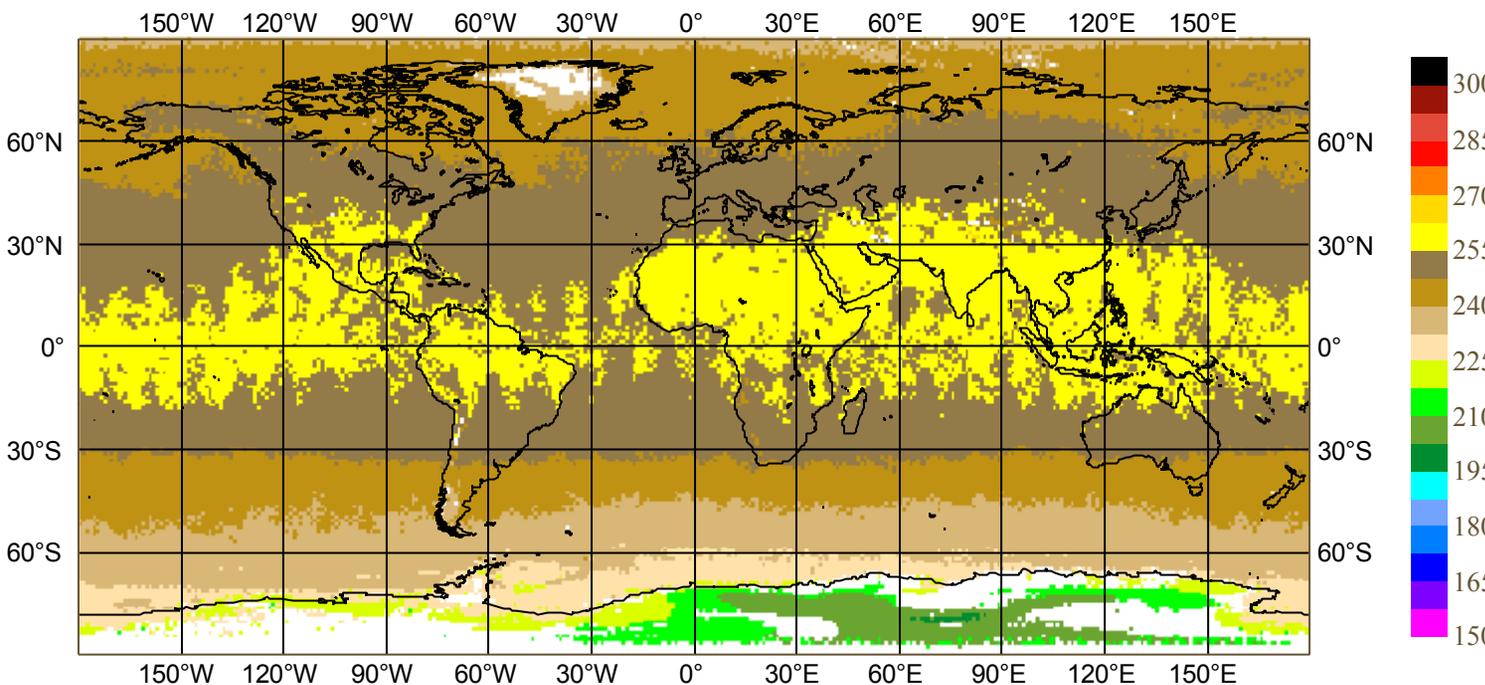


Tackling this Challenge – Comparing with Similar Instruments

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

STATISTICS FOR RADIANCES FROM AQUA / AMSU-A - 05
MEAN OBSERVATION (CLEAR)
DATA PERIOD = 2004053118 - 2004061912 , HOUR = ALL
EXP = 0001
Min: 201.48 Max: 269.6 Mean: 248.06

compare the statistics with a similar but independent satellite instrument.



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

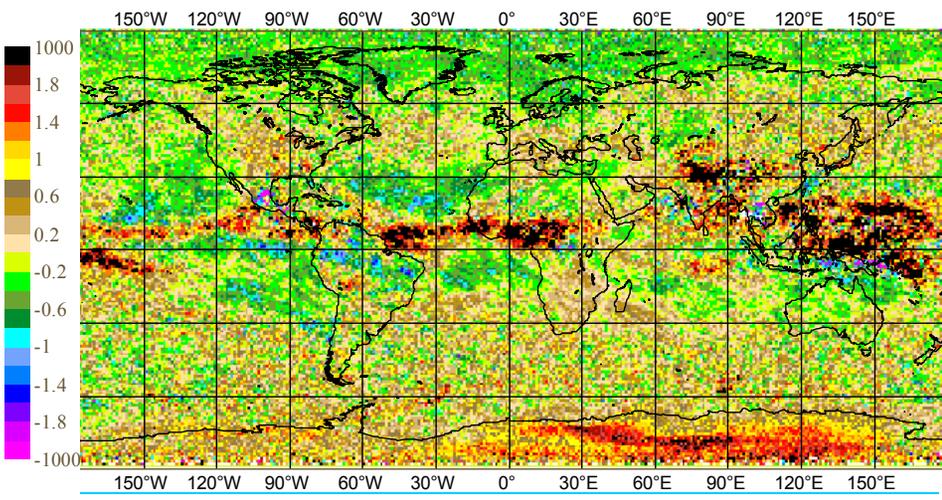
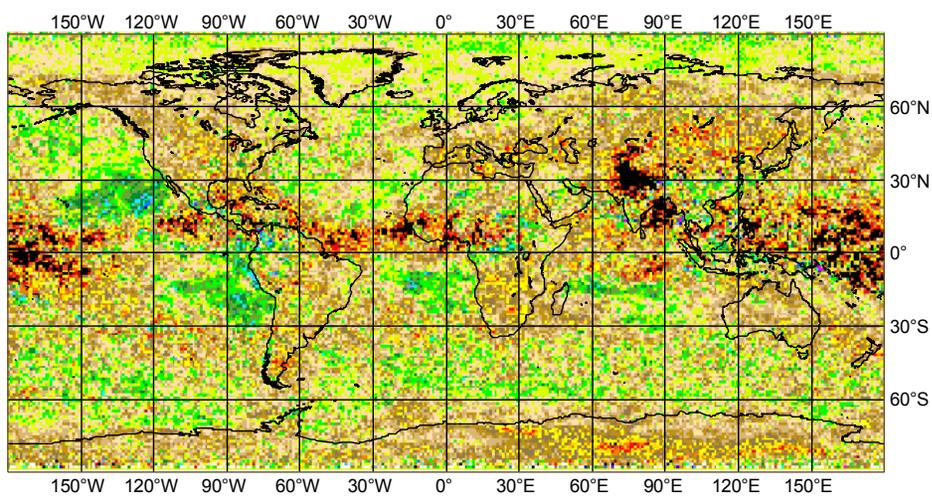
AIRS 1783 (6 micron)



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



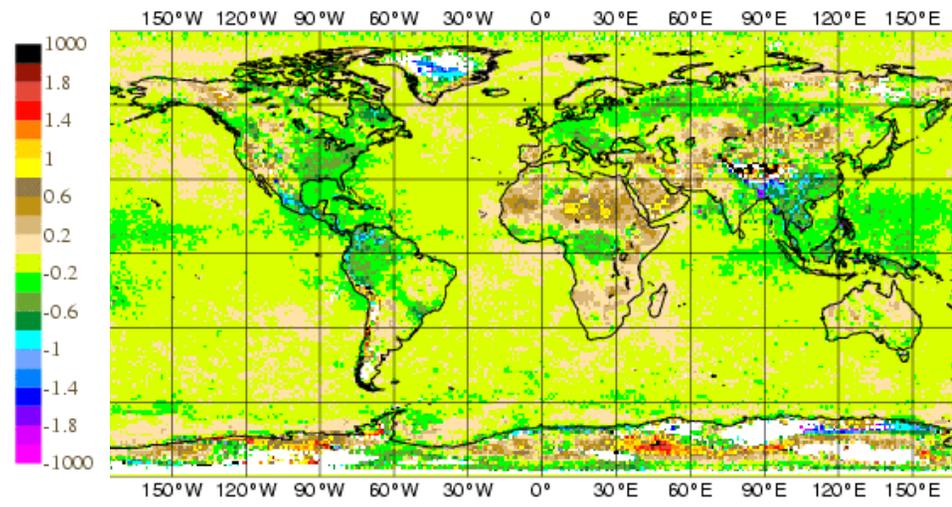
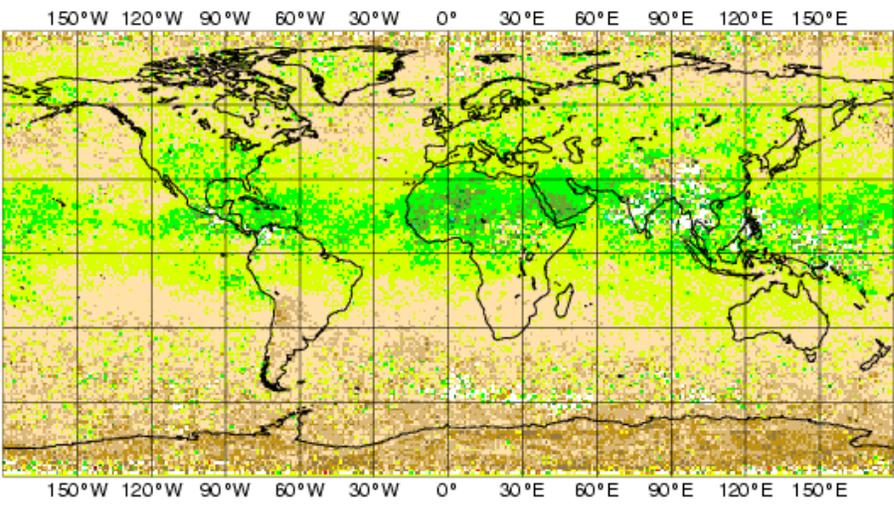
Tackling this Challenge – Comparing with Similar Instruments

Mid Tropospheric Temperature

AIRS 221 (14 micron) ↔ **AMSU-A 5**

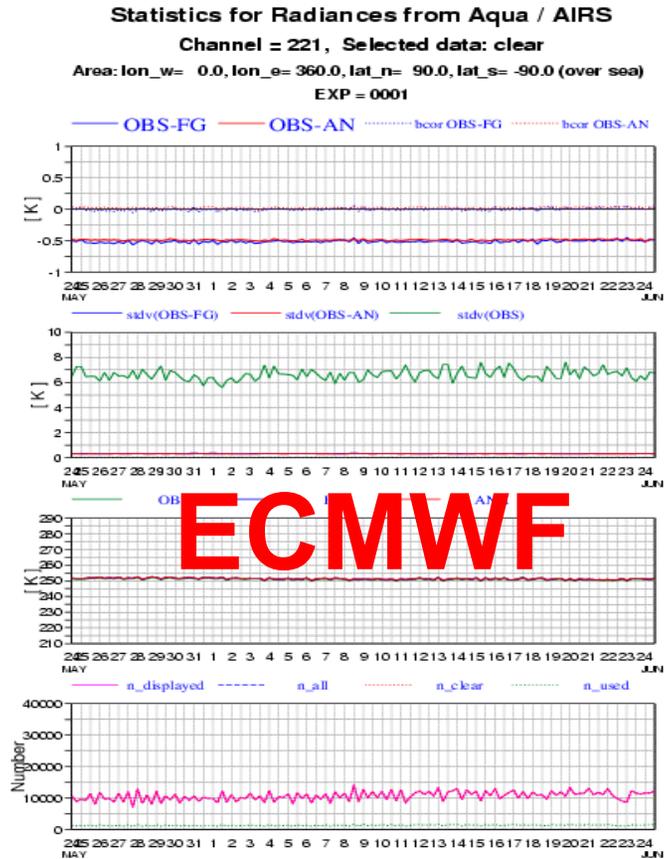
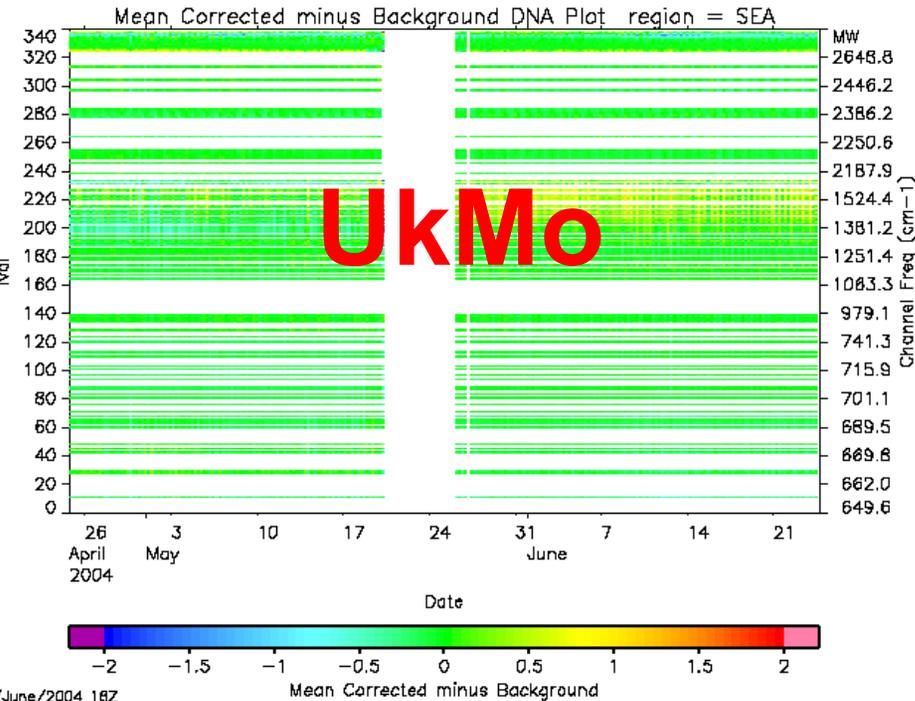
STATISTICS FOR RADIANCES FROM AQUA / AIRS - 221
MEAN FIRST GUESS DEPARTURE (OBS-FG) (BCORR.) ()
DATA PERIOD = 2004053118 - 2004061912 , HOUR = ALL
EXP = 0001
Min: -1.1857 Max: 2.9905 Mean: 0.014410

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.



ECMWF

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



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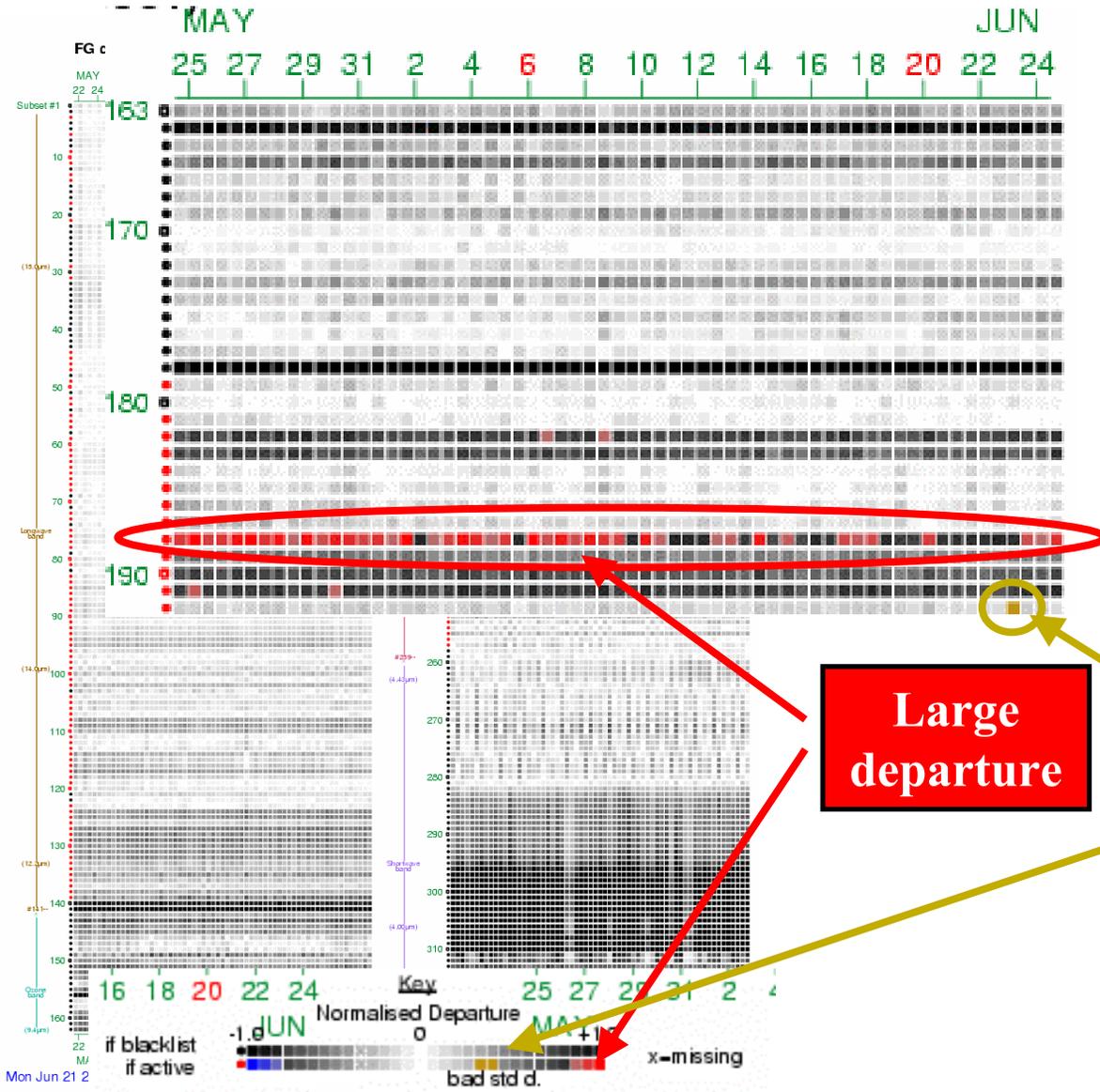
Future Plans – Automatic Alerts

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

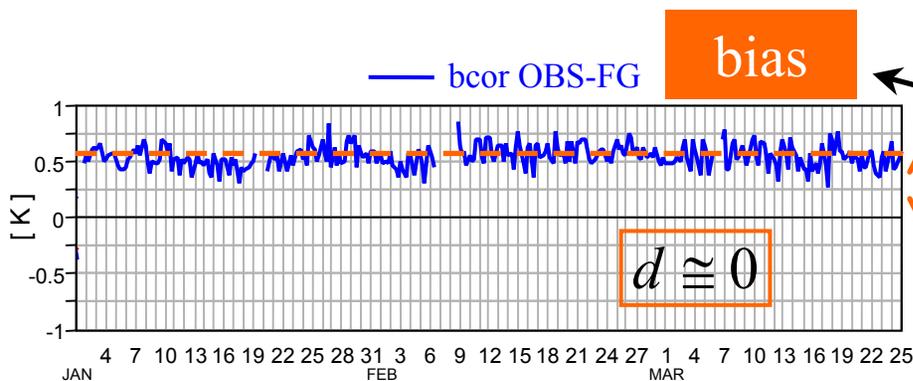
Sudden change in standard deviation



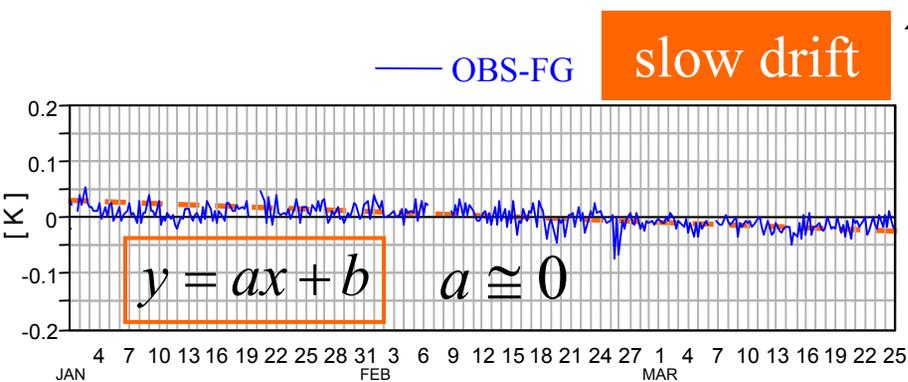
Future Plans – Automatic Alerts

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



extreme values

