Recent Developments in the Use of Satellite Observations at ECMWF

European Centre for Medium Range Weather Forecasts

Tony McNally

ITSC-XV

October 2006

Acknowledgements

Satellite Section ECMWF

OUTLINE

- **Upgrades to the operational forecasting / assimilation system**
- **New satellite data availability**
- **Environmental Monitoring (GEMS)**
- **Developments in Re-Analysis (ERA-40 > interim > ERA-65)**

Upgrades to the operational forecasting / assimilation system

Upgrades to the operational forecasting / assimilation system

- **system version 29R2 (28 June 2005)**
- **system version 30R1 (1 Feb 2006)**
- **system version 31R1 (12 Sep 2006)**

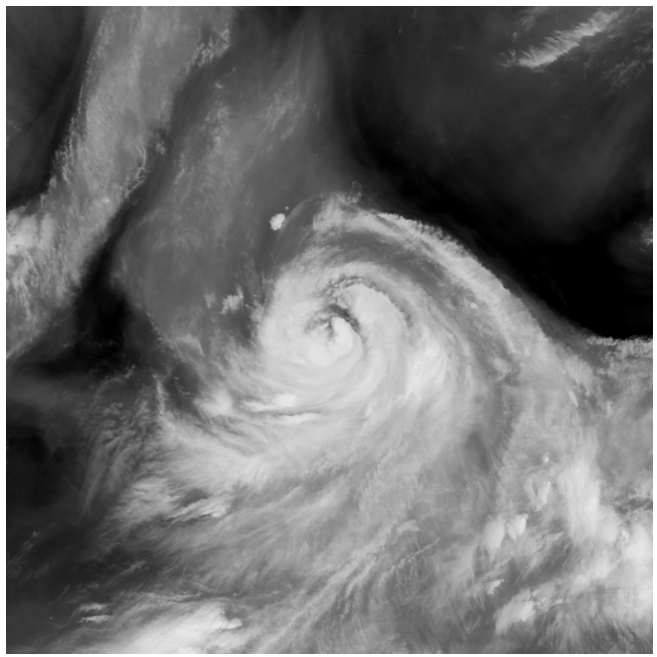
System version 29R2 (28 June 2005)

- **Initial 1D-Var+4D-Var use of SSM/I rain affected radiances**
- **extended AIRS assimilation**
- *Introduction of Meteosat-8 (MSG) winds*
- *New Jb stats (from recent ensemble of data assimilation)*
- *Modifications to humidity analysis (less increments in areas with high CAPE, reduced spinup)*
- *Modifications to convection scheme (bugfix for negative mass flux, implicit momentum+tracer transport)*
- *Revision of the initial perturbations for the EPS*
- *Introduction of SMHI Baltic sea ice*

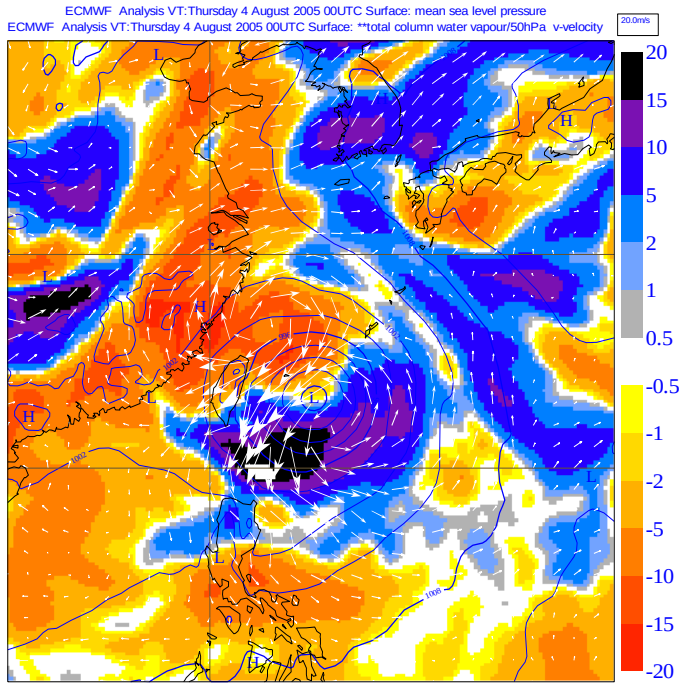
System version 29R2 (28 June 2005)

... rainy radiance assimilation ...

Typhoon Matsa (04/08/2005 00 UTC)



4DVar wind and TCWV increments from SSM/I

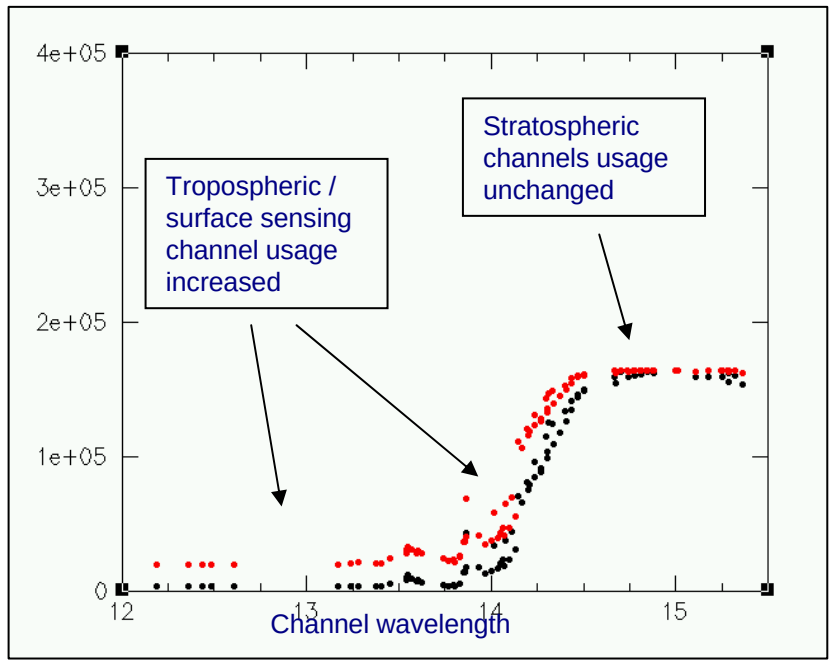


…see poster by Alan Geer on rain assimilation…

System version 29R2 (28 June 2005)

... extended AIRS assimilation ...

- Warmest FOV selection
- new surface emissivity model
- intelligent thinning of AIRS data
- new observation errors (down to 0.4K)
- VIS / NIR cloud information
- VARBC / bias technical changes

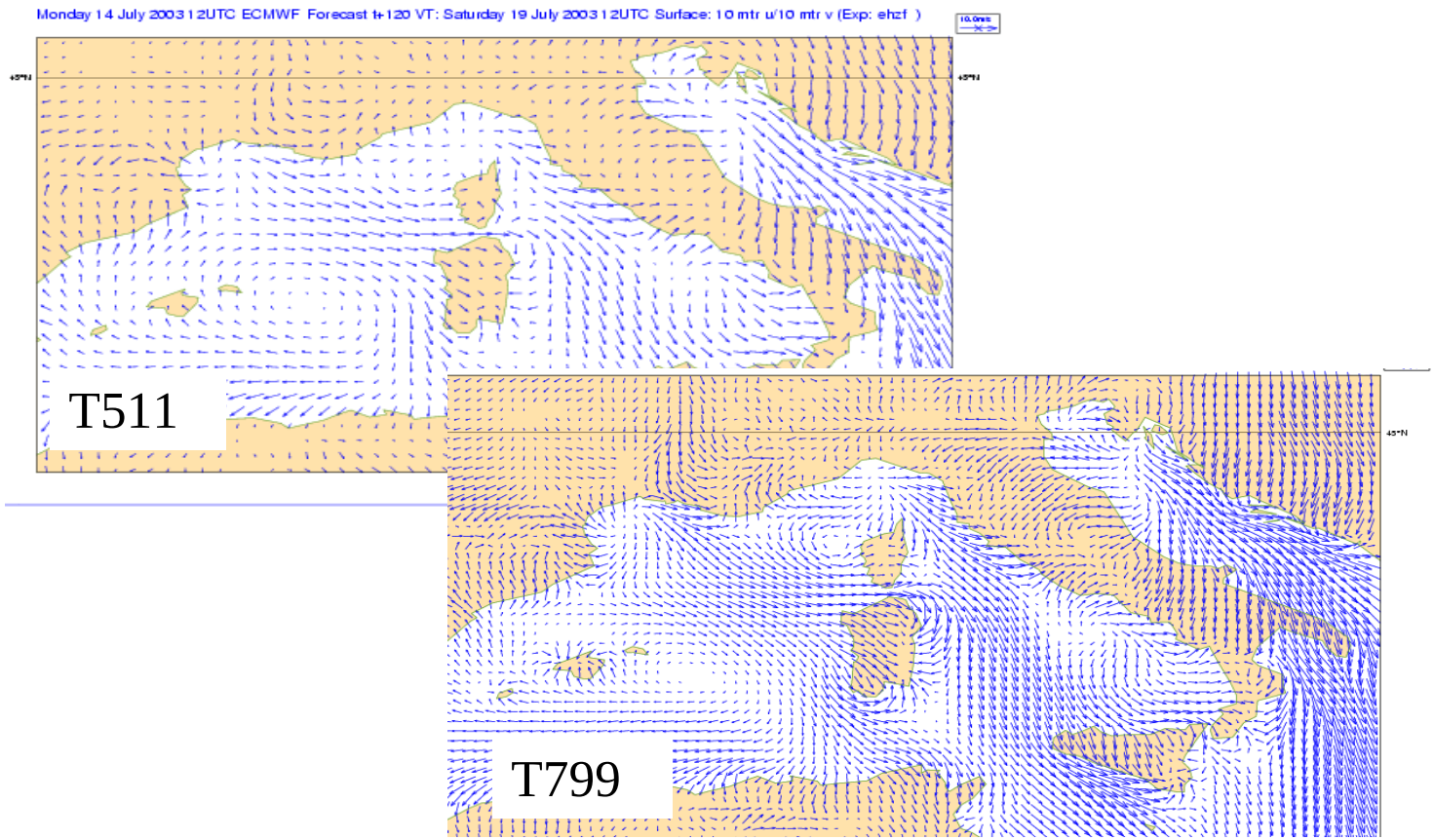


...see talk by Andrew Collard on AIRS assimilation...

System version 30R1 (01 Feb 2006)

- **T799 horizontal resolution (12min time step)**
- **4D-Var increments at T255 (30min time step)**
- **Vertical resolution increased to 91 levels**
- **Model top raised to 0.01hPa**
- ***Grid-point humidity and ozone in 4D-Var***
- ***Changes to the wave model***
  - ***Resolution increased from 0.5° to 0.36°***
  - ***Use of Jason altimeter wave height data and ENVISAT ASAR spectra in the wave model assimilation. ERS-2 SAR spectra no longer assimilated.***

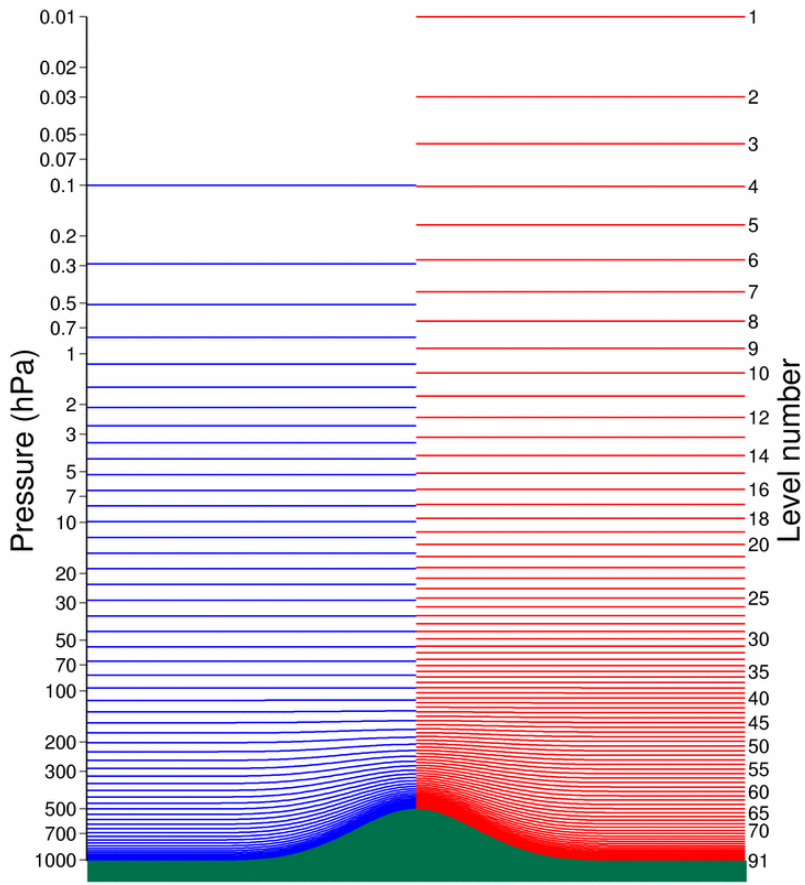
System version 30R1 (01 Feb 2006)



…a new profile dataset will be available from this model…

System version 30R1 (01 Feb 2006)

L60 vs L91



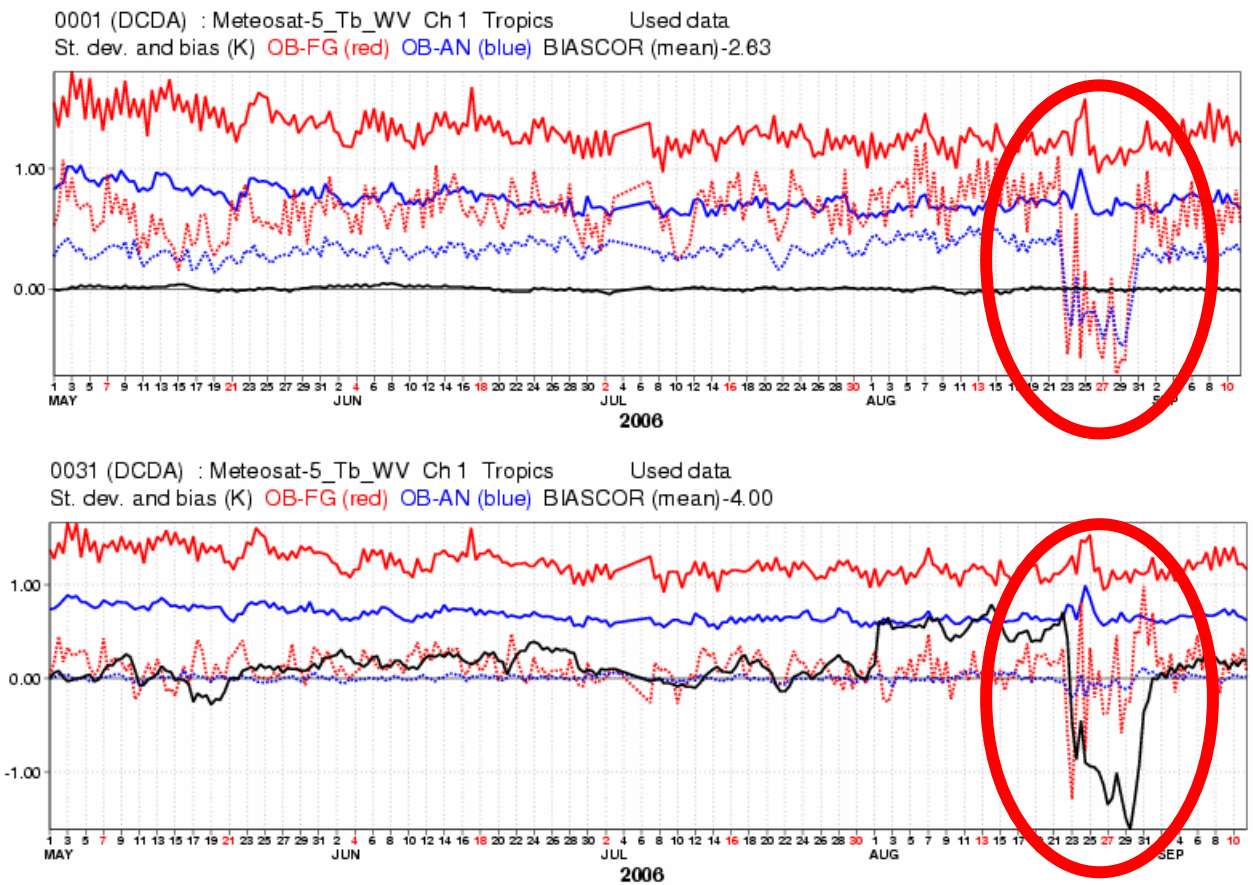
…a new profile dataset will be available from this model…

System version 31R1 (12 Sep 2006)

- **Introduction of adaptive bias correction VarBC**
- *Improved QC of SSM/I rain affected radiances*
- *Revised use of low level aircraft observations*
- *Modifications to humidity*
- *Modifications to convection scheme*

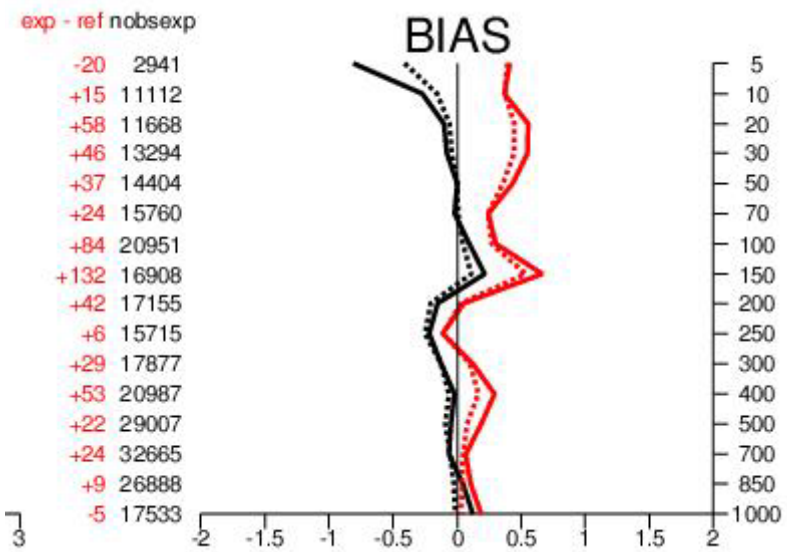
System version 31R1 (12 Sep 2006)

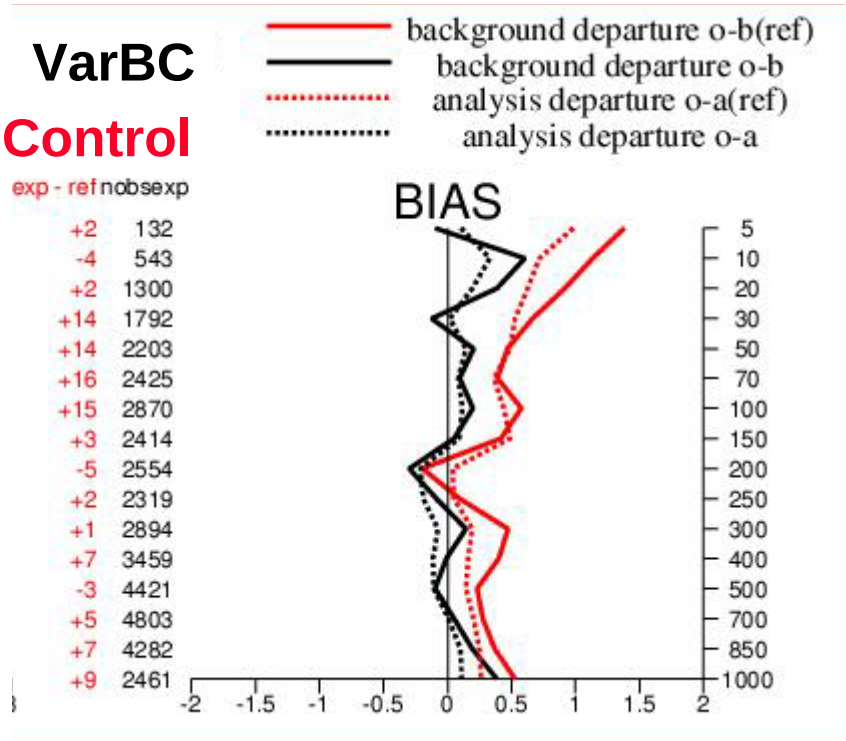
...introduction of adaptive bias correction VarBC ...



System version 31R1 (12 Sep 2006)

...introduction of adaptive bias correction VarBC ...





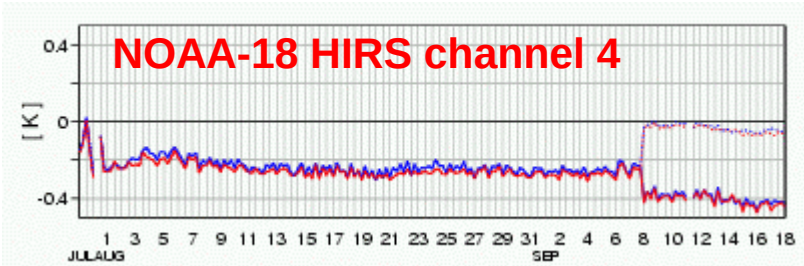
...see talk by Thomas Auligne on VarBC...

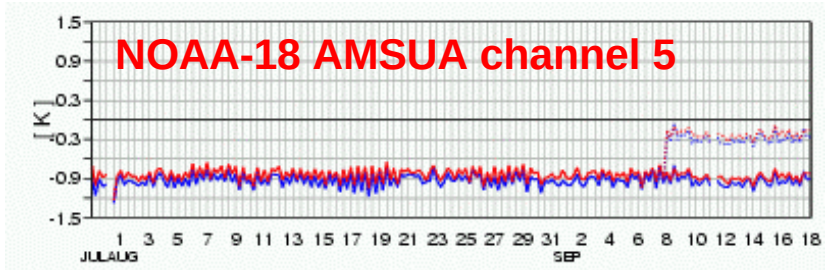
New Satellite data availability

New Satellite data availability

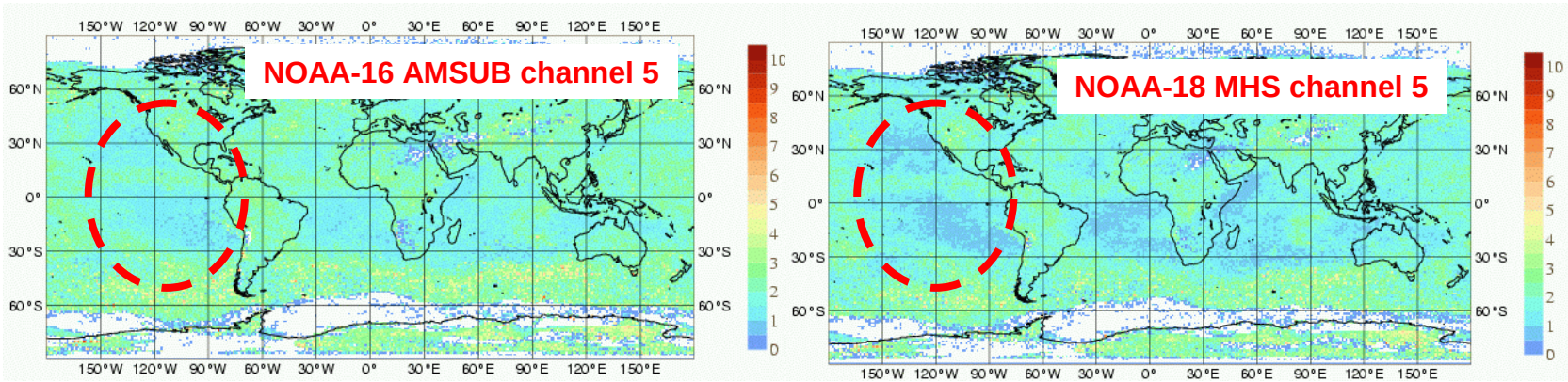
- **NOAA-18 (HIRS, AMSUA, MHS)**
- **MTSAT**
- **DMSP-F16 / AQUA (SSM/IS, AMSRE)**
- **GPS (CHAMP, COSMIC, GRACE)**
- *METEOSAT-9, GOES-11*

NOAA-18 HIRS / AMSUA / MHS



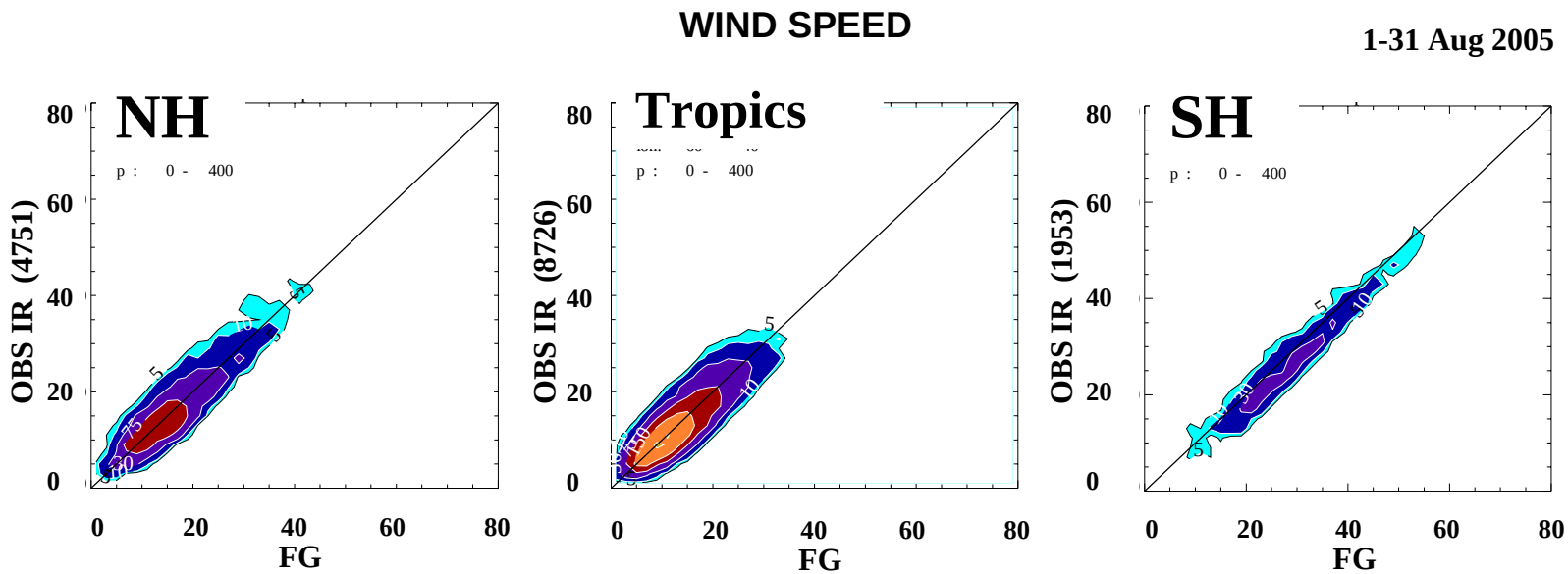


Monitoring of the NOAA-18 MHS show that the radiances are **less noisy** than those from the AMSU-B (confirming improved instrument design for METOP)



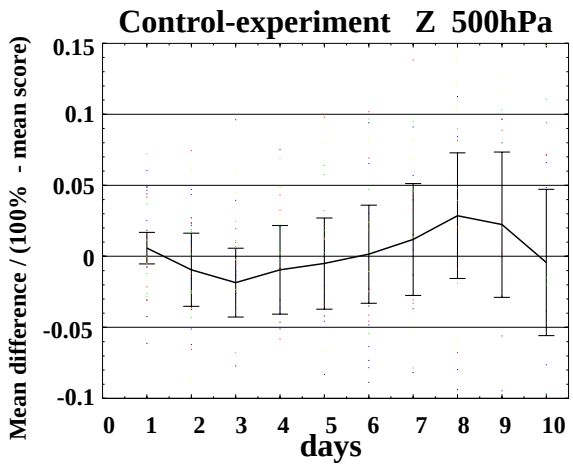
MTSAT - AMVs

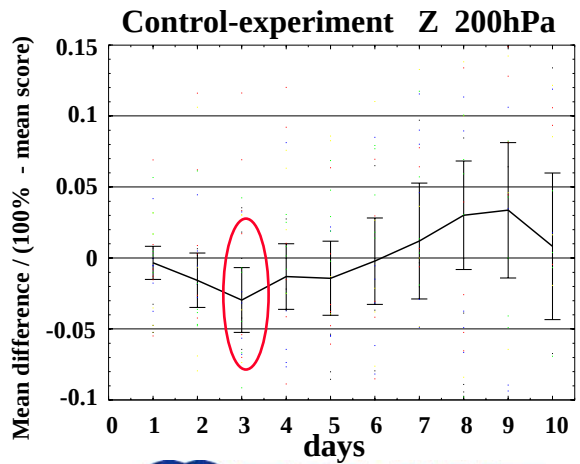
Active data



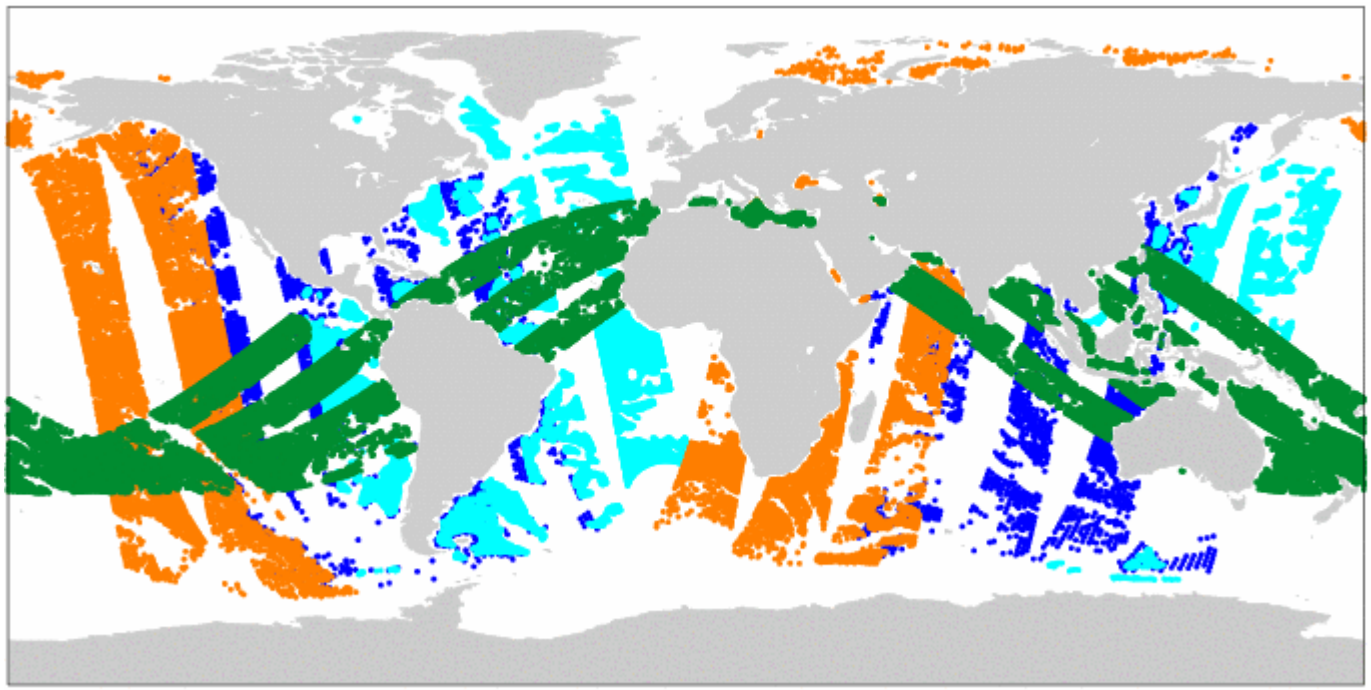
Z anomaly correlation scores:

OVERALL NEUTRAL impact.
Only significantly positive result: NH 200hPa – day 3.





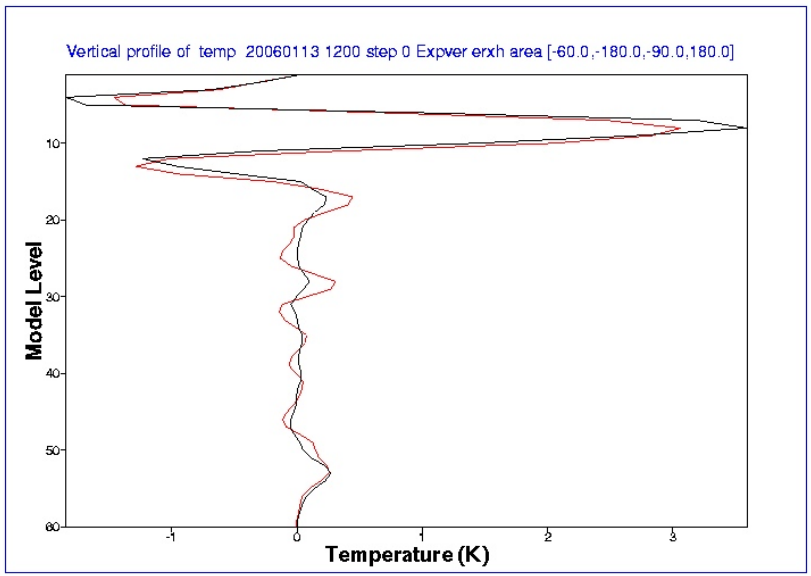
SSM/IS and AMSR-E



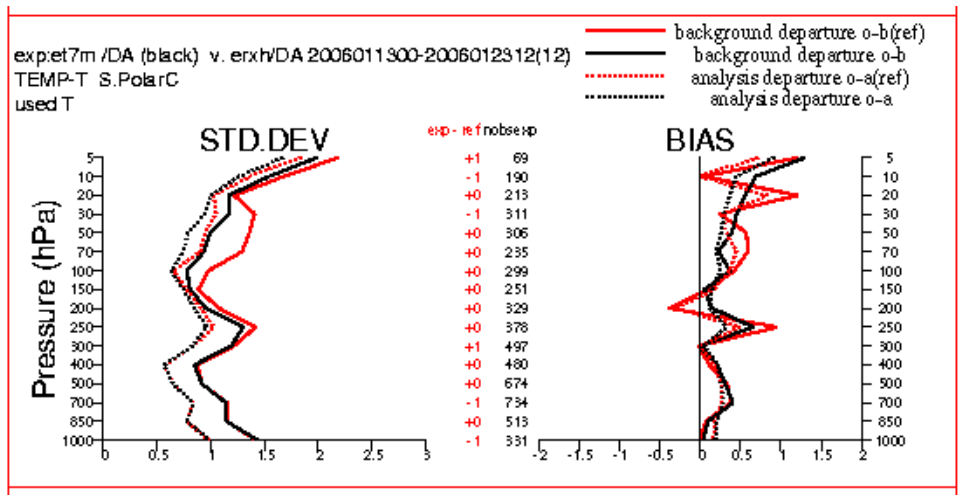
…see talk by Niels Bormann on MW assimilation…

GPS RO (CHAMP)

MEAN TEMPERTAURE INCREMENTS

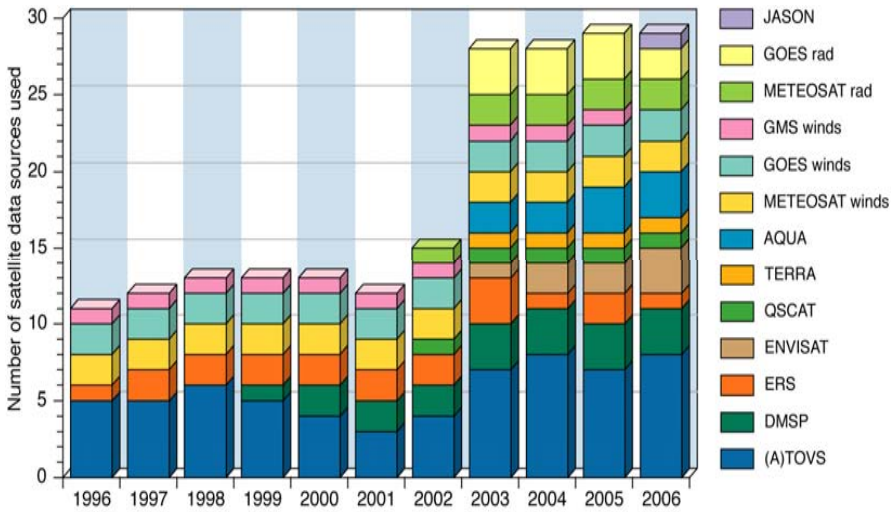


IMPROVED FIT TO RADIOSONDE T DATA



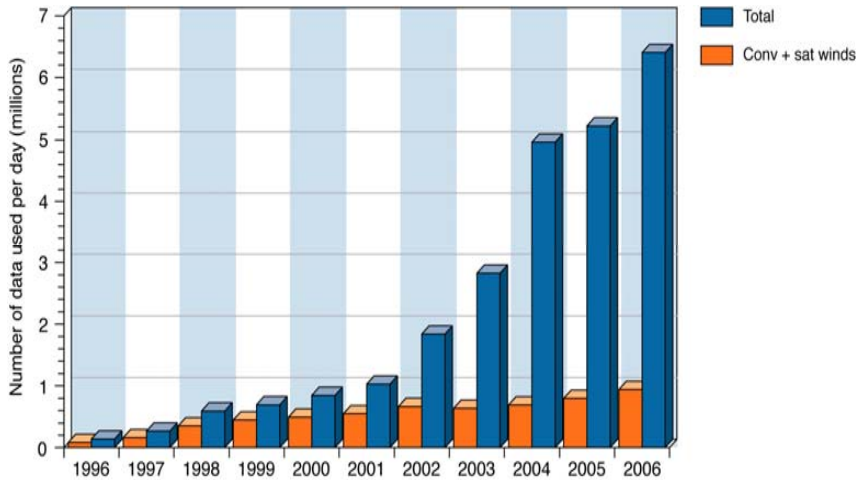
…see poster by Niels Bormann on MIPAS assimilation…

The impact of Satellite data



Large increase in number of data used daily

Data from twenty-nine sources used daily !



Observation data count for one 12h 4D-Var cycle 0900-2100UTC 26 March 2006

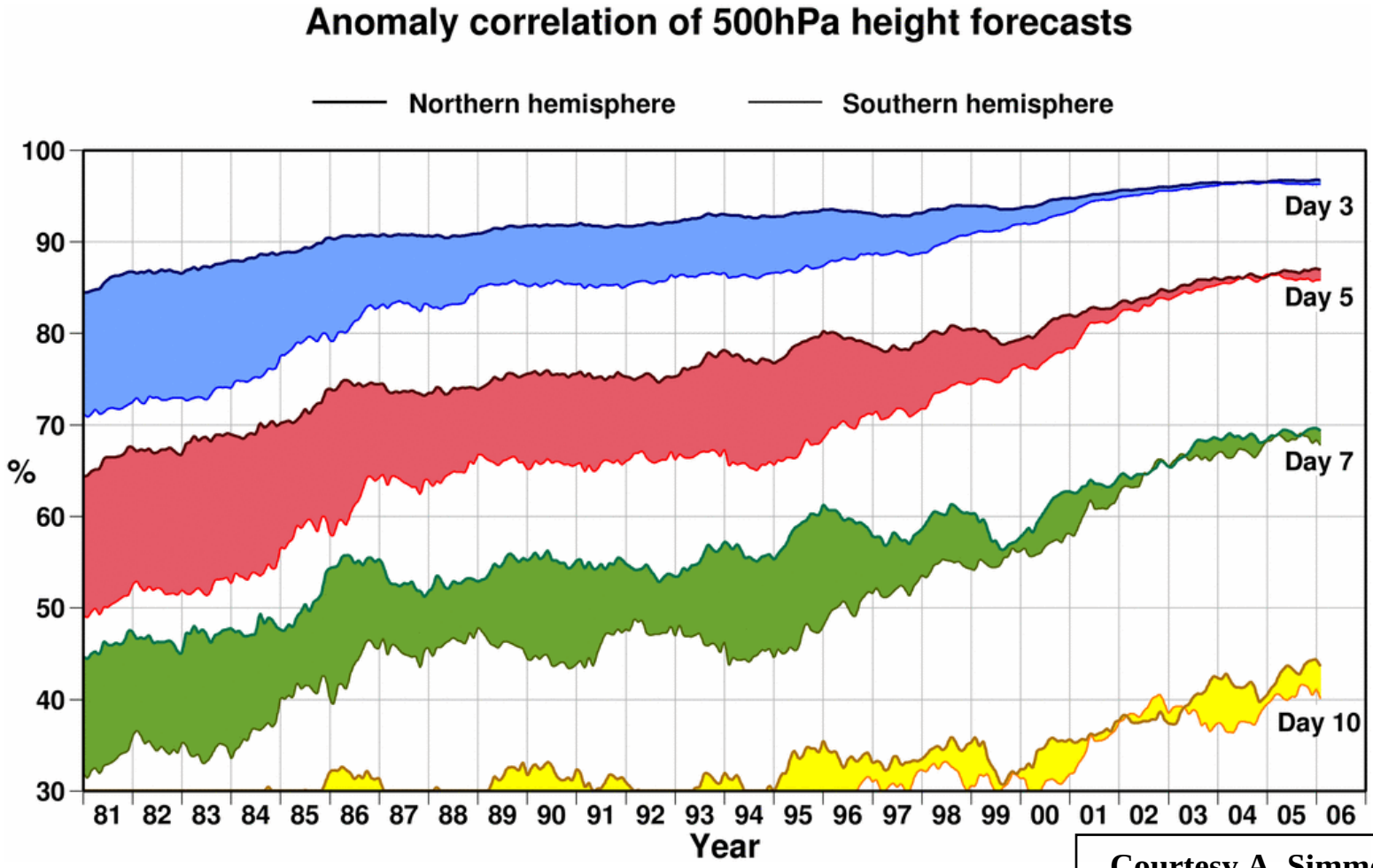
Screened			Assimilated		
Synop:	389.000	(0.49%)	Synop:	60.000	(1.84%)
Aircraft:	362.000	(0.46%)	Aircraft:	179.000	(5.50%)
Dribu:	20.000	(0.03%)	Dribu:	5.600	(0.17%)
Temp:	135.000	(0.17%)	Temp:	67.000	(2.06%)
Pilot:	108.000	(0.14%)	Pilot:	48.000	(1.48%)
AMV's:	2.811.000	(3.56%)	AMV's:	127.000	(3.90%)
Radiance data:	74.825.000	(94.81%)	Radiance data:	2.646.000	(81.34%)
Scat:	269.000	(0.34%)	Scat:	122.000	(3.75%)
TOTAL:	78.918.000	(100.00%)	TOTAL:	3.253.000	(100.00%)

99% of screened data is from satellites

89% of assimilated data from satellites

Gap reduction between S.Hem and N.Hem:

- satellite data signature

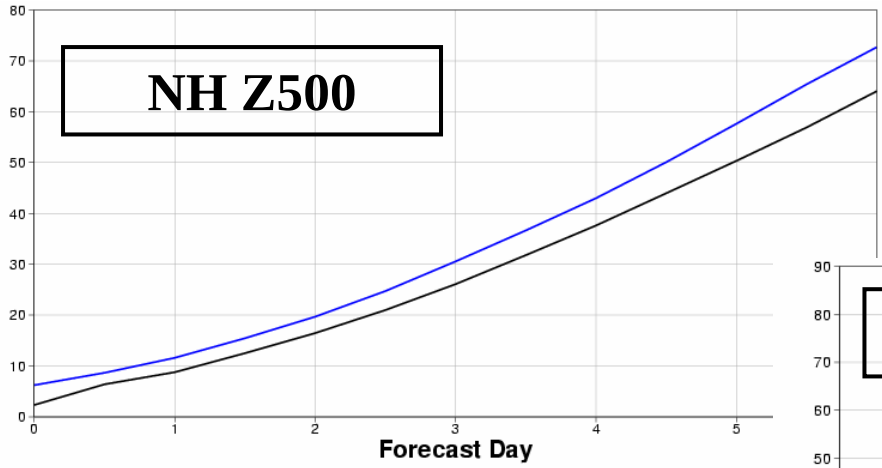


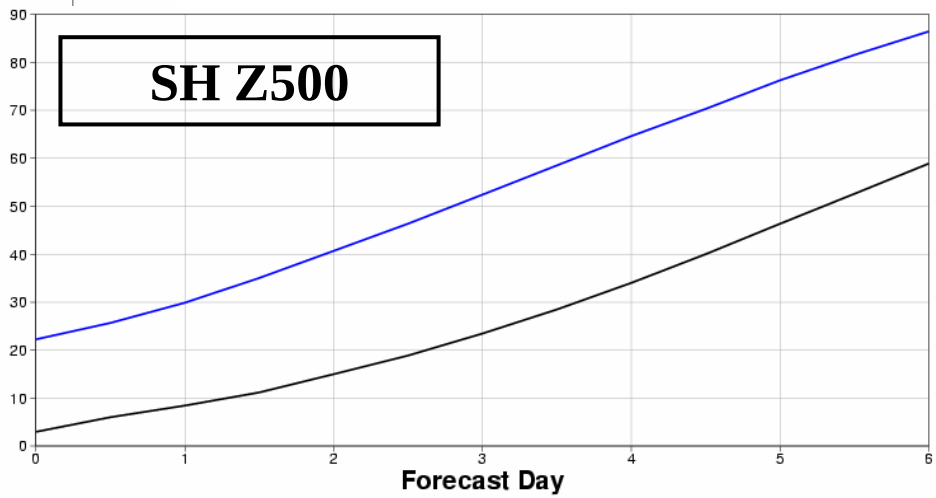
Courtesy A. Simmons

ECMWF

IMPACT STUDIES at ECMWF

…SAT vs NOSAT





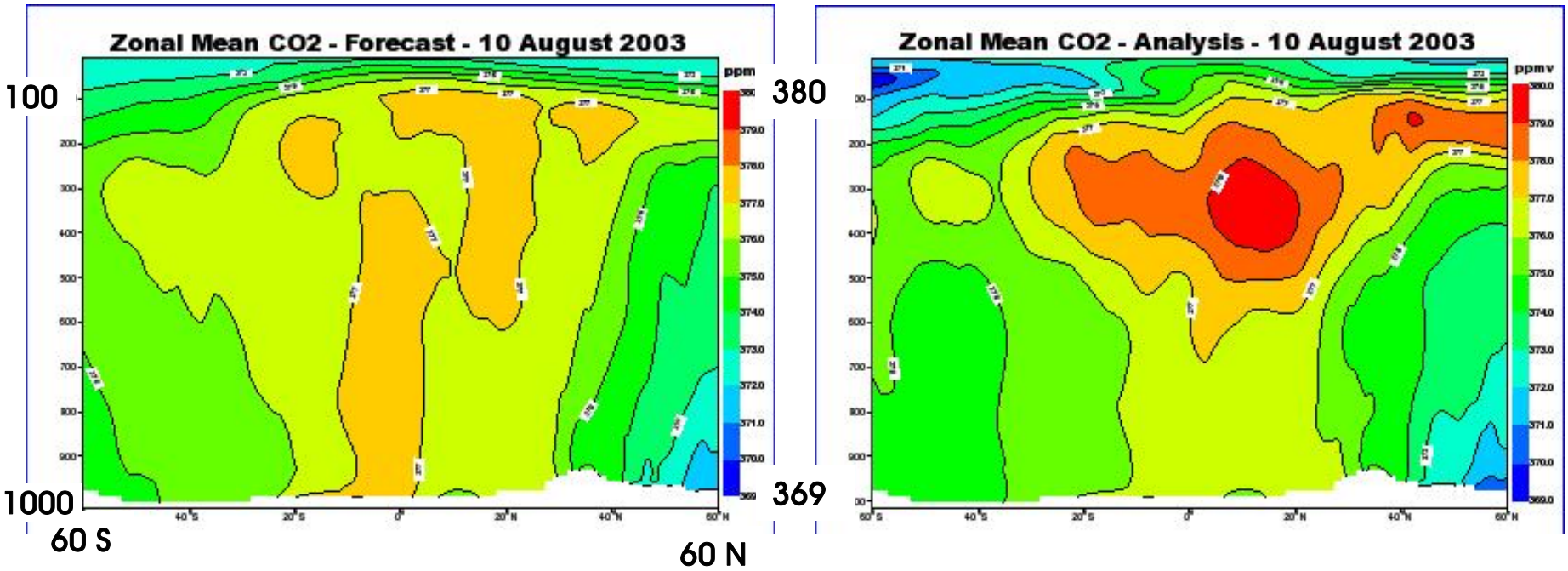
…see talk by Graeme Kelly on impact studies…

Environmental monitoring (GEMS)

The GEMS project has started

- **Funded by European Commission under Framework Programme 6 (one of the GMES IPs)**
- **ECMWF and 25 partner institutes in Europe**
- **Deliverables:**
  - **An operational capability for global analyses and forecasts of greenhouse gases (CO2, CH4, N2O), reactive gases (O3, NO2,SO2, CO, HCHO) and aerosols (5 categories initially)**
  - **A reanalysis of the recent period and validation against in situ measurements**
  - **Use as much satellite and in situ data as possible**
  - **Provide boundary conditions for regional air quality models and organize a European-size inter-comparison between regional air quality models**

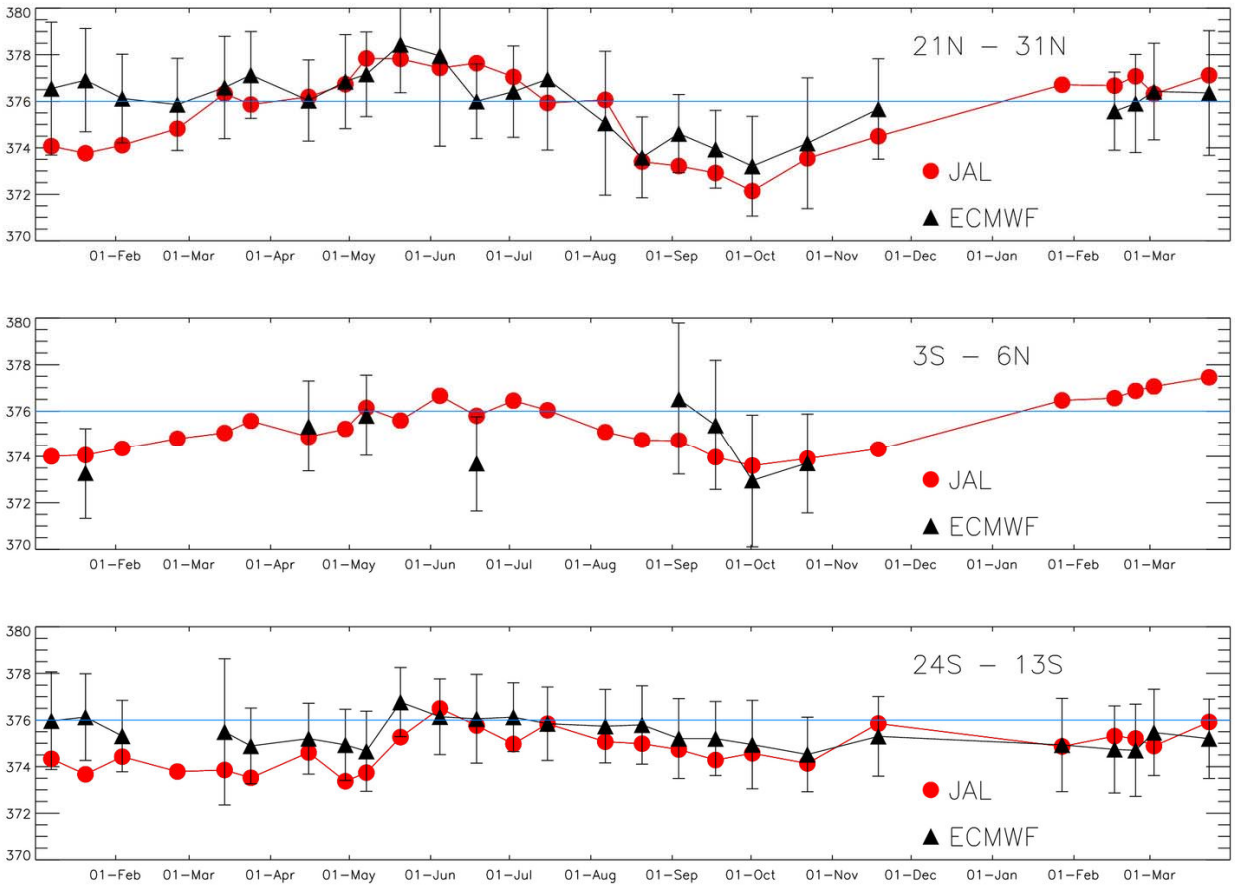
Zonal mean CO_2 distributions



The effect of assimilating AIRS radiances is mainly to increase CO_2 mixing ratios in the upper troposphere.

The lower troposphere is largely unaffected, because vertical error correlations are narrow and the adjoint of convection is still missing.

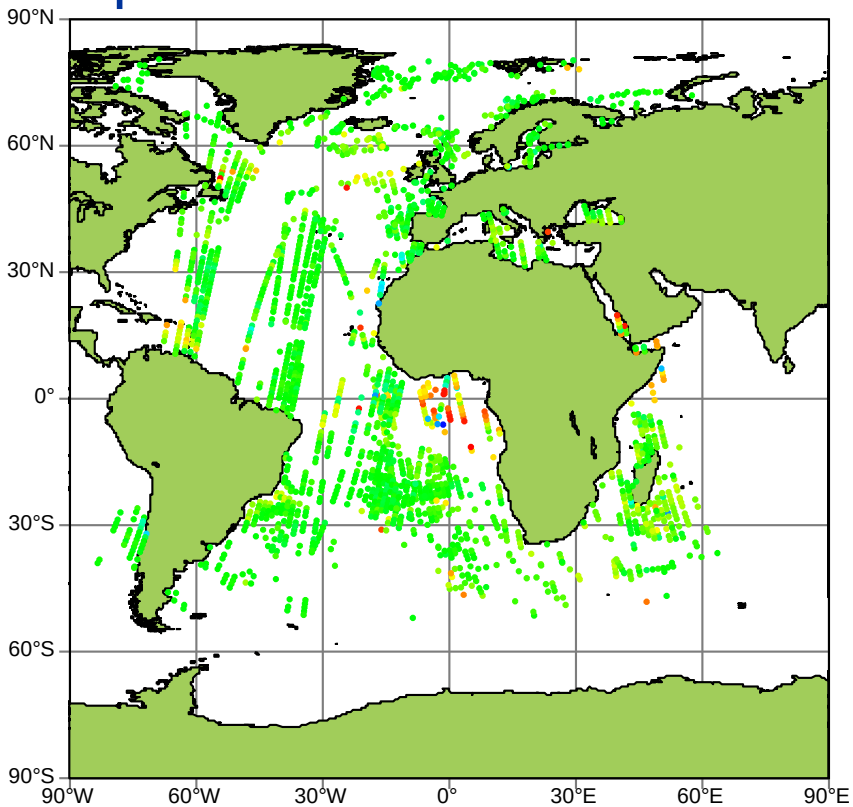
CO_2 Comparison with flight data from Japan Air Lines

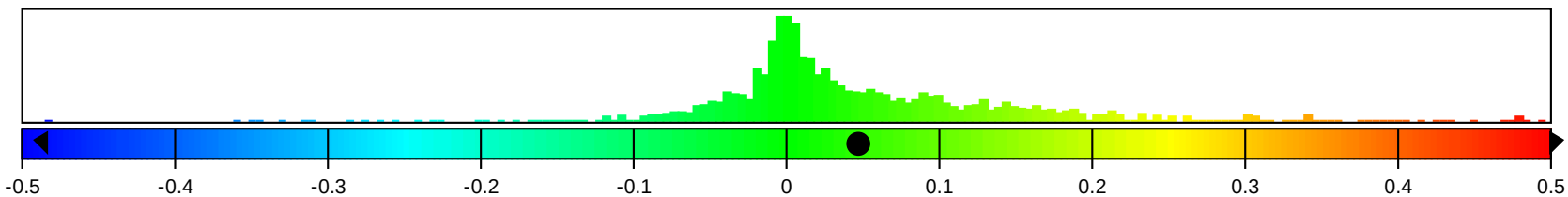


Flight data kindly provided by H. Matsueda, MRI/JMA

Analysis departures for MODIS Aerosol Optical Depth at 0.55 microns

Analysis departures are observations minus model analysis.



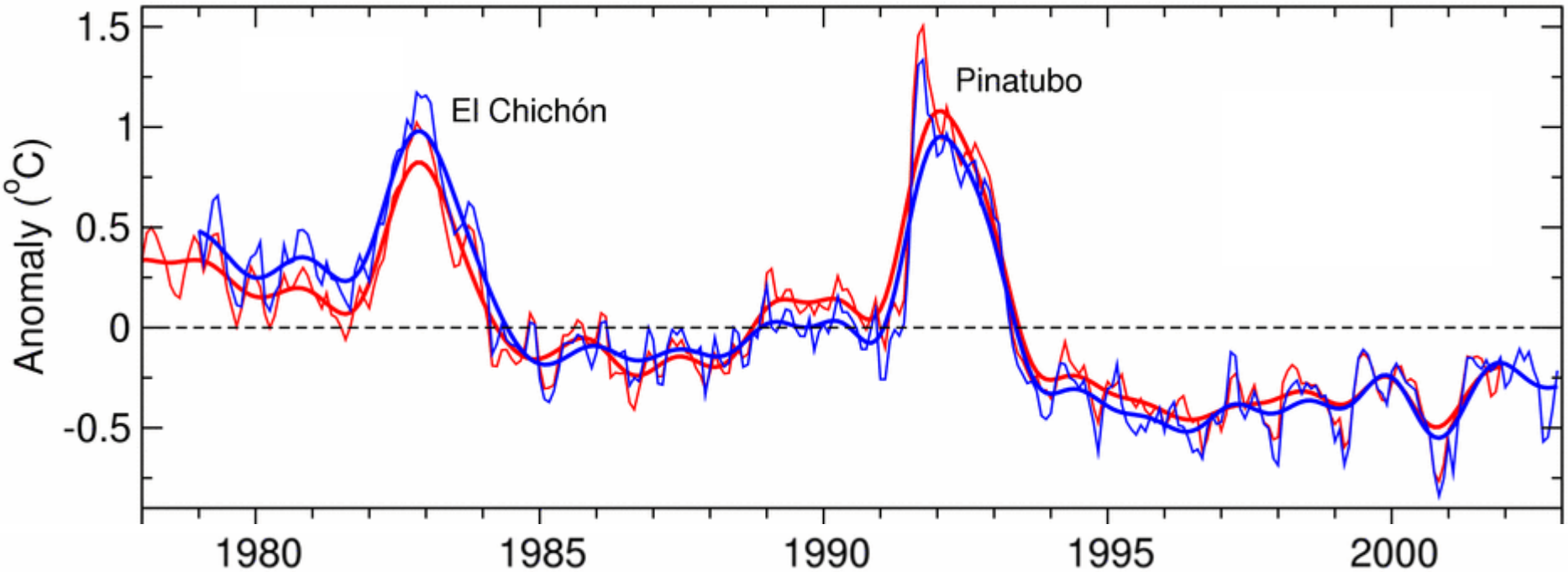


ECMWF Re-analysis (ERA)

ECMWF plans for reanalysis

- **The interim reanalysis**
  - Has started with T255L60(91), 4D-Var and cycle 31r1
  - will run from 1989 onwards, and be continued in close to real time
  - will use mostly same pre-2002 data as ERA-40, but will include
    - **reprocessed winds from EUMETSAT**
    - **reprocessed ERS altimeter data**
    - **GOME profile data from RAL**
    - **improved radiosonde bias corrections**
  - Will use VarBC
- **European Regional Reanalysis (EURRA)**
  - potential for a European regional reanalysis project (EURRA) is being explored with NMSs and EEA
- **A new major reanalysis (ERA-65 or -75) in due course**
  - funding has to be secured

Trend and variability in lower stratospheric temperature



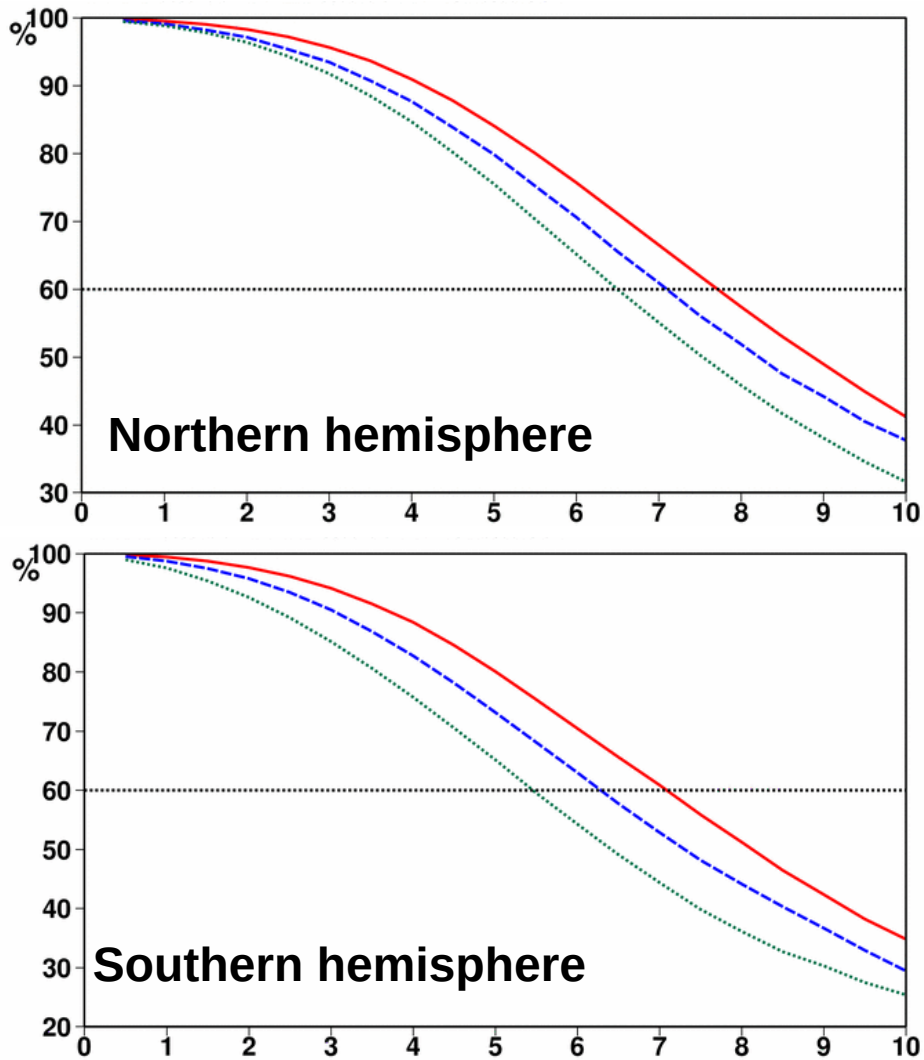
MSU-4 data analyzed by Mears et al. (2003)

ERA-40 equivalent from Ben Santer

Linear trend:		
	MSU-4	**- 0.39°C/decade**
	ERA-40	**- 0.30°C/decade**
	NCEP	**- 0.82°C/decade**

Using 4DVAR in the next reanalysis

Improved anomaly correlation of 500hPa height, averaged for 12UTC forecasts from 1 January to 31 December 1989



ERA-new
ERA-40
Operations

END