UPDATES ON THE AEROSOL ASSIMILATION ACTIVITIES AT ECMWF

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With thanks to: Jean-Jacques Morcrette, Luke Jones, Johannes W. Kaiser, and Miha Razinger

Progress since last ICAP meeting

- A dual control variable (fine mode and coarse mode aerosol mixing ratio) to assimilate MODIS total and fine mode AOD is being tested in **NRT mode (up and running since June 2011)**.

- Assimilation of aerosol lidar backscattering is on its way – trial runs with CALIPSO Level 1.5 data

- MACC aerosol reanalysis in BAMS State of Climate

- Work in collaboration with Jean-Jacques Morcrette, Johannes Kaiser and Sarah Lu (NCEP) to implement a **volcanic ash prediction system.** Results of initial efforts are summarized in ECMWF Tech Memo **653 (not shown here).**

Fine and coarse mode control variable

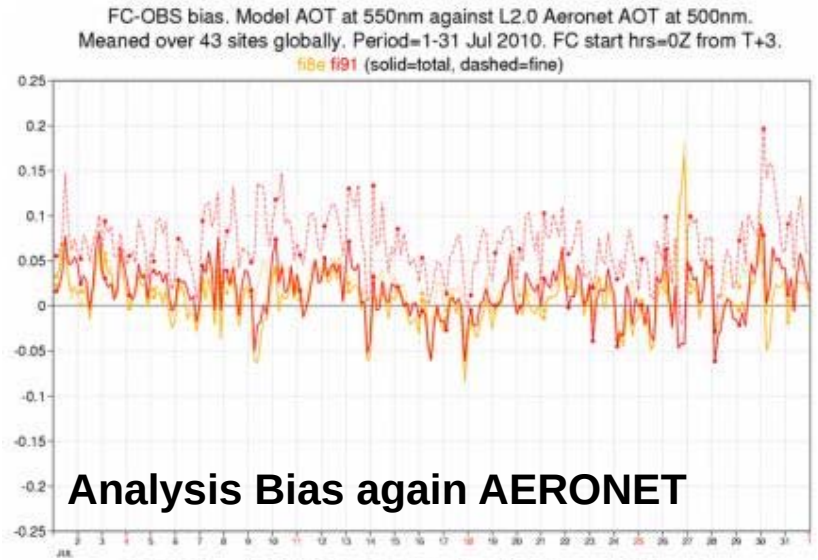
Aerosol control variables are the fine and coarse mode aerosol mixing ratio. Analysis increments are repartitioned into the single species according to their fractional contribution to the fine/coarse mode mixing ratio.

Background error statistics have been computed using forecasts errors as in the NMC method (48h-24h forecast differences).

Assimilated observations are the 550nm MODIS Aerosol Optical Depths (AODs) over land and ocean and the fine mode AODs over ocean.

Observation errors are prescribed fixed values. Global bias corrections are applied to both total and fine mode AOD using the variational bias estimation scheme (VAR-BC) implemented operationally at ECMWF.

Improvements are especially seen in fine mode AOD



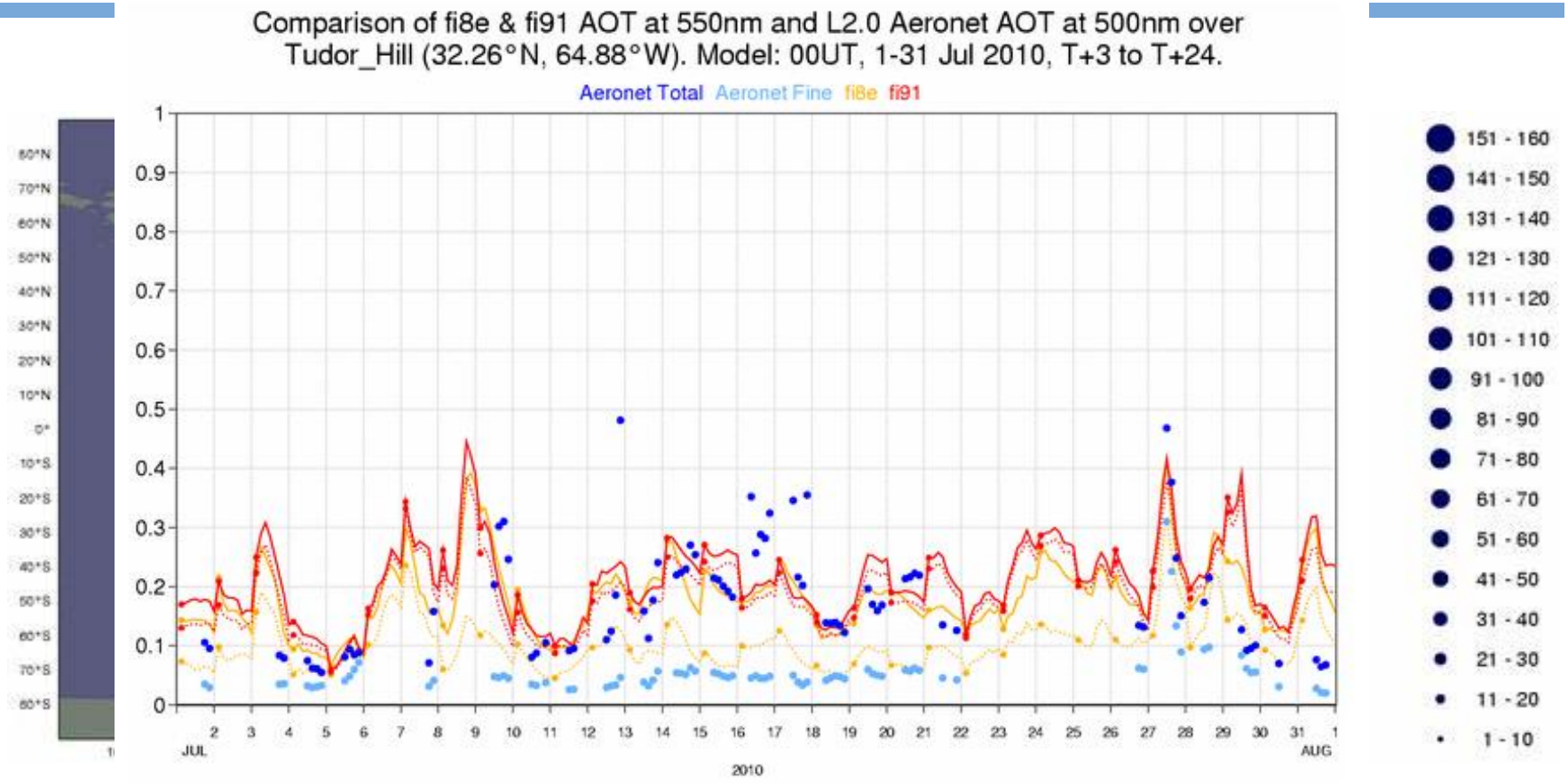
Single CV TOTAL AOD

Single CV Fine Mode AOD

Dual CV TOTAL AOD

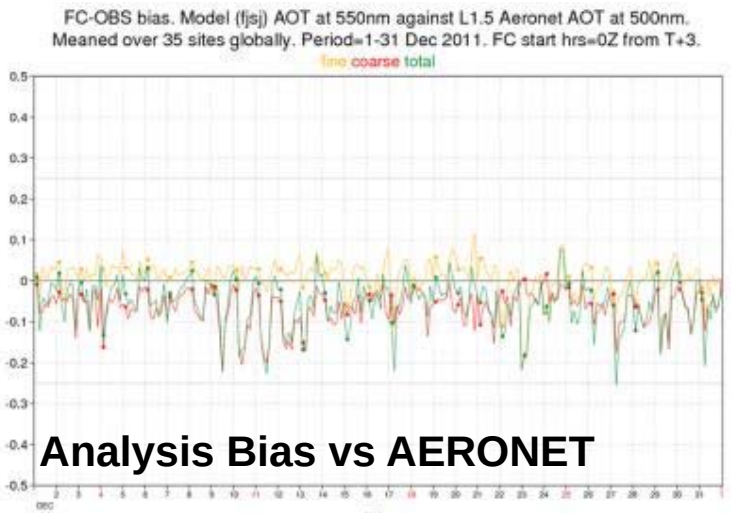
Dual CV Fine Mode AOD

Fine and coarse mode control variables - verification

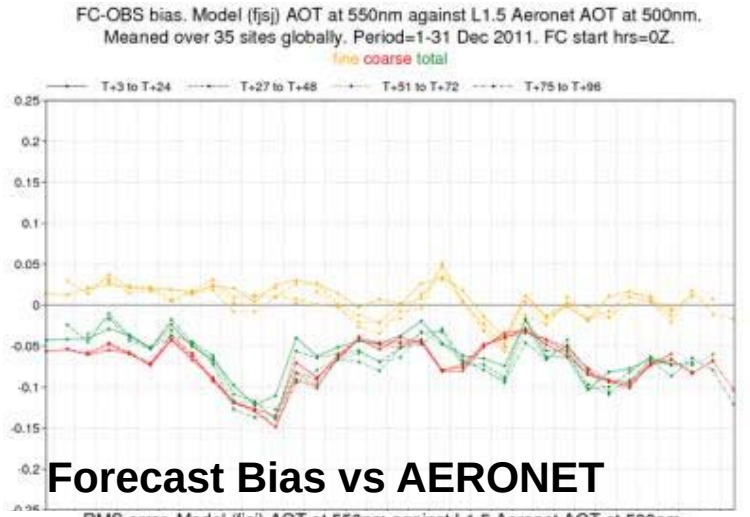


- Close to dust source (i.e. **La Laguna**) the fine mode AOD is improved greatly but still overestimated
- Away from the dust source (i.e. **Tudor Hill**) the relative magnitude of total and fine mode is well captured using the dual control variable formulation (and the extra MODIS observations!)
- Ongoing model improvements to correct for the large amount of fine mode dust aerosols will help considerably (see Jean-Jacques' presentation)

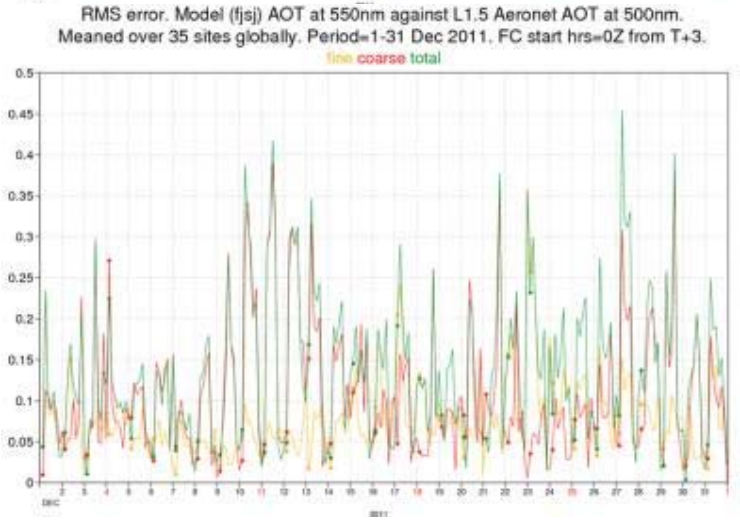
Fine and coarse mode control variables – NRT verification (Dec 2011)



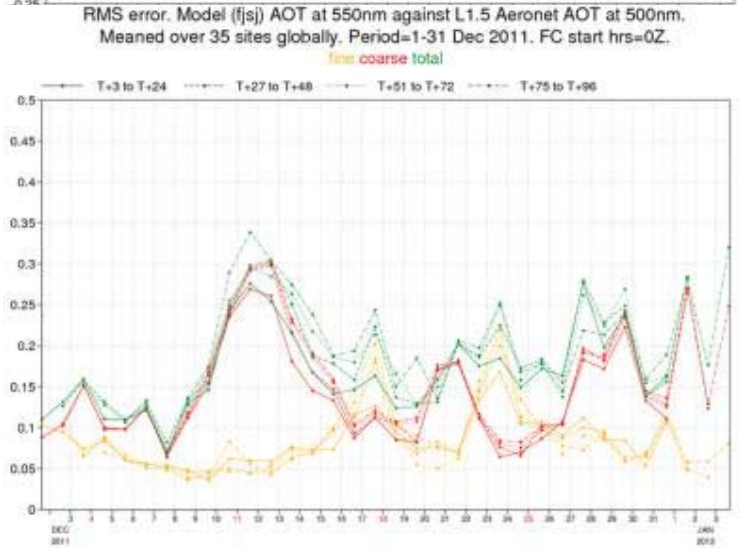
Analysis Bias vs AERONET



Forecast Bias vs AERONET



Analysis RMS vs AERONET



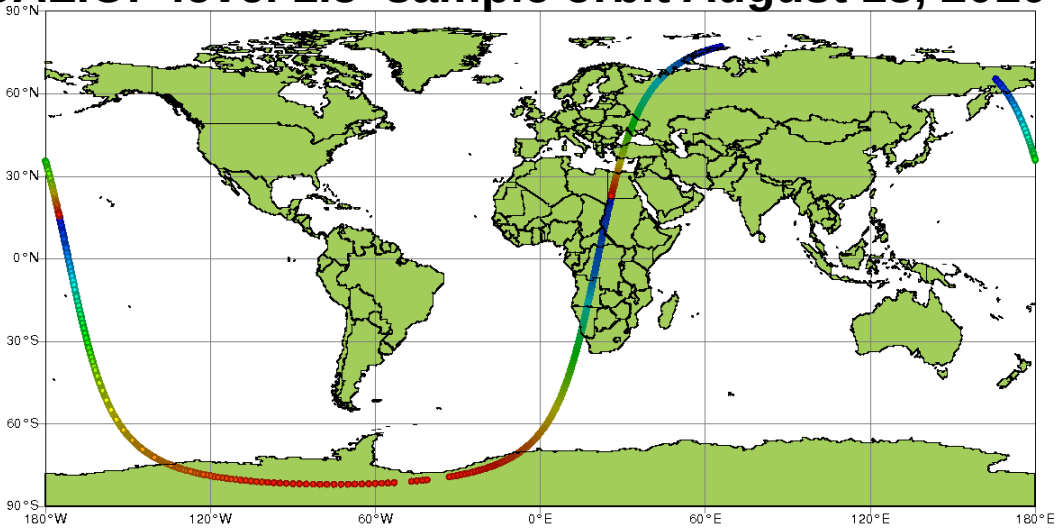
Forecast RMS vs AERONET

NRT CALIOP data for preliminary assimilation tests

- Mean and Median Attenuated aerosol backscatter at 532 nm
-Standard deviation
-cloud-cleared at 1km resolution
-averaged at 20 km horizontal resolution
-60m vertical resolution
-Feature mask
-Some indication of aerosol typing

This product has been custom-made for NRT provision and assimilation at operational centres.

CALIOP level 1.5 sample orbit August 18, 2010

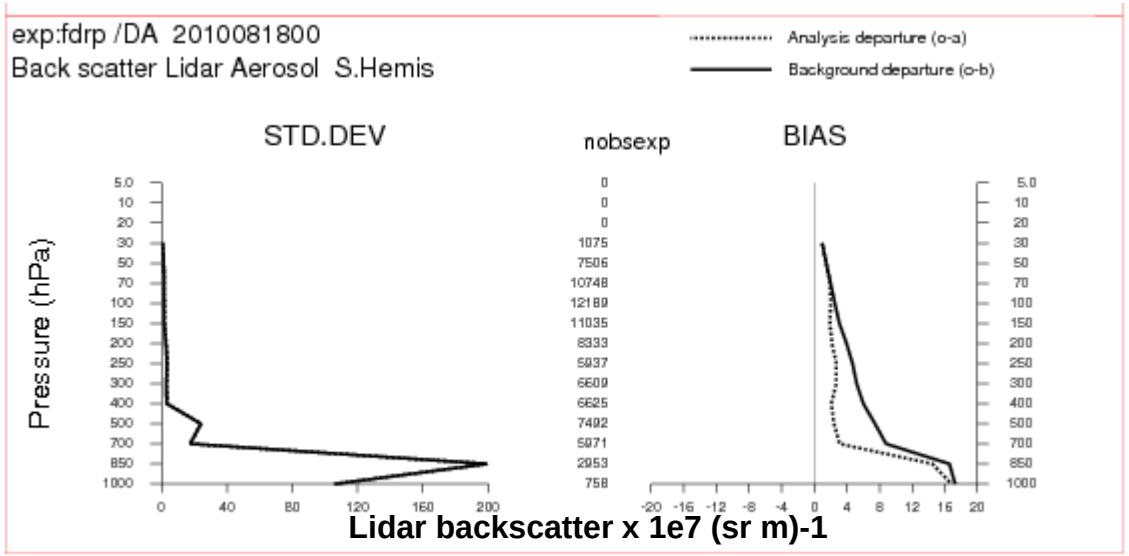


- Thinned to 900 profiles (originally 1800)
- 345 vertical levels
- ~200000 backscatter observations actively assimilated over the 4DVAR 12-hour window

Acknowledgements:
NASA LarC CALIPSOTeam (Dave Winker, Chip Trepte, Jason Tuckett)

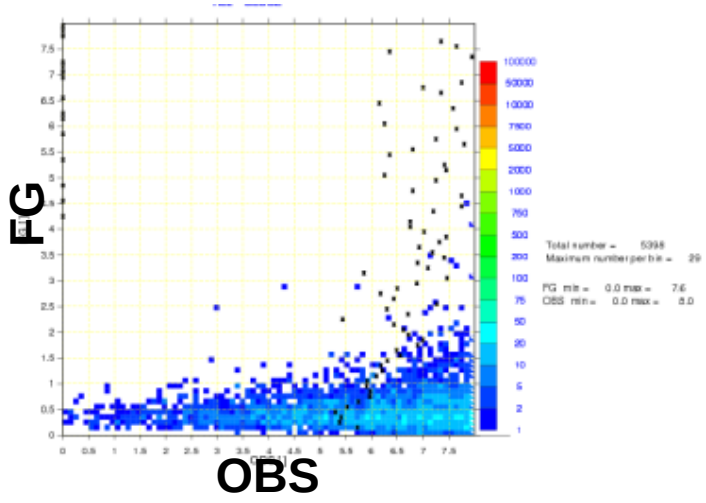
Preliminary lidar assimilation results (one orbit, no other data)

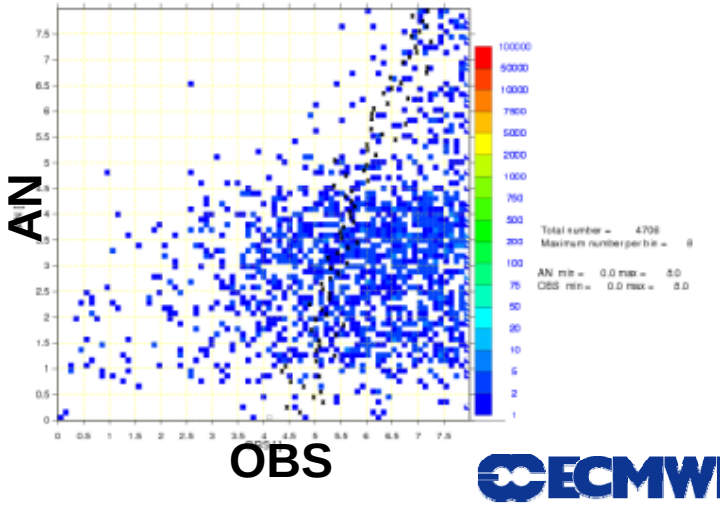
Experiment 1: original observation value and standard deviation



Only the bias wrt observations is corrected – this is indicative of a large first guess bias!

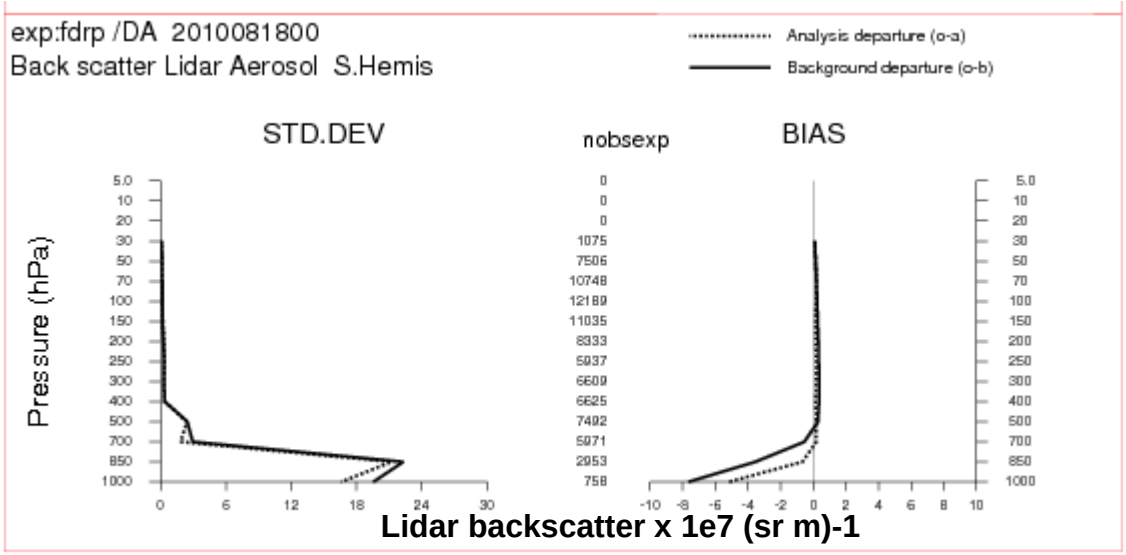
Scatterplot for layer 600-775 hPa





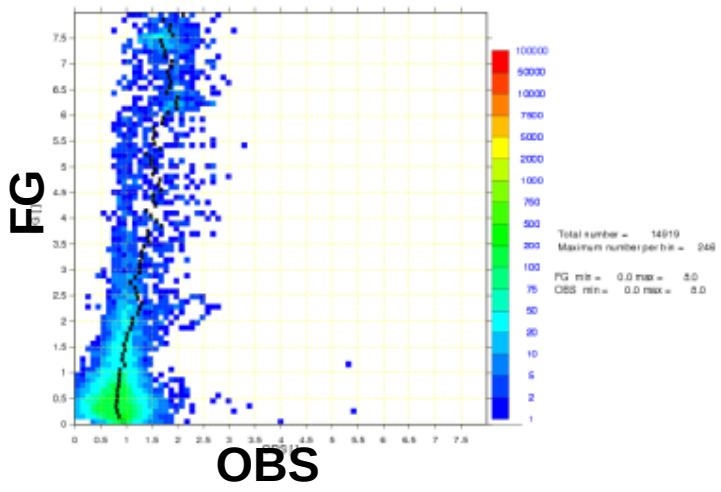
Preliminary lidar assimilation results (one orbit, no other data)

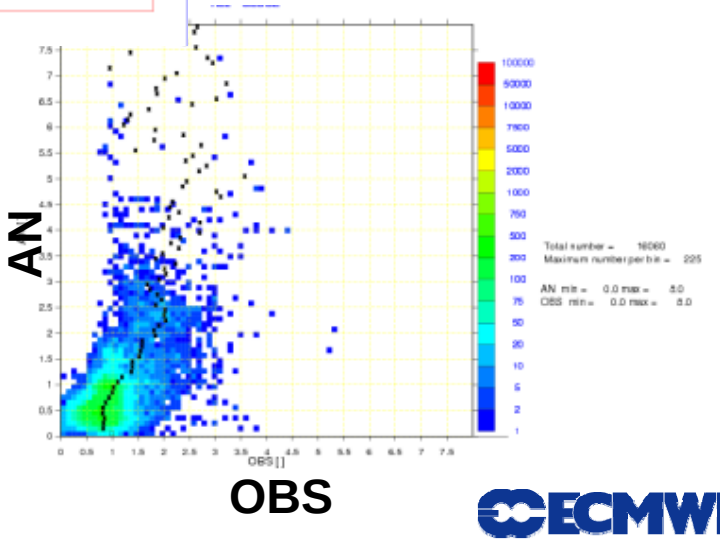
Experiment 2: modified observation values and errors to reduce first guess bias



Analysis departures show a lower bias and standard deviation than first guess departures. We need to address the first guess bias.

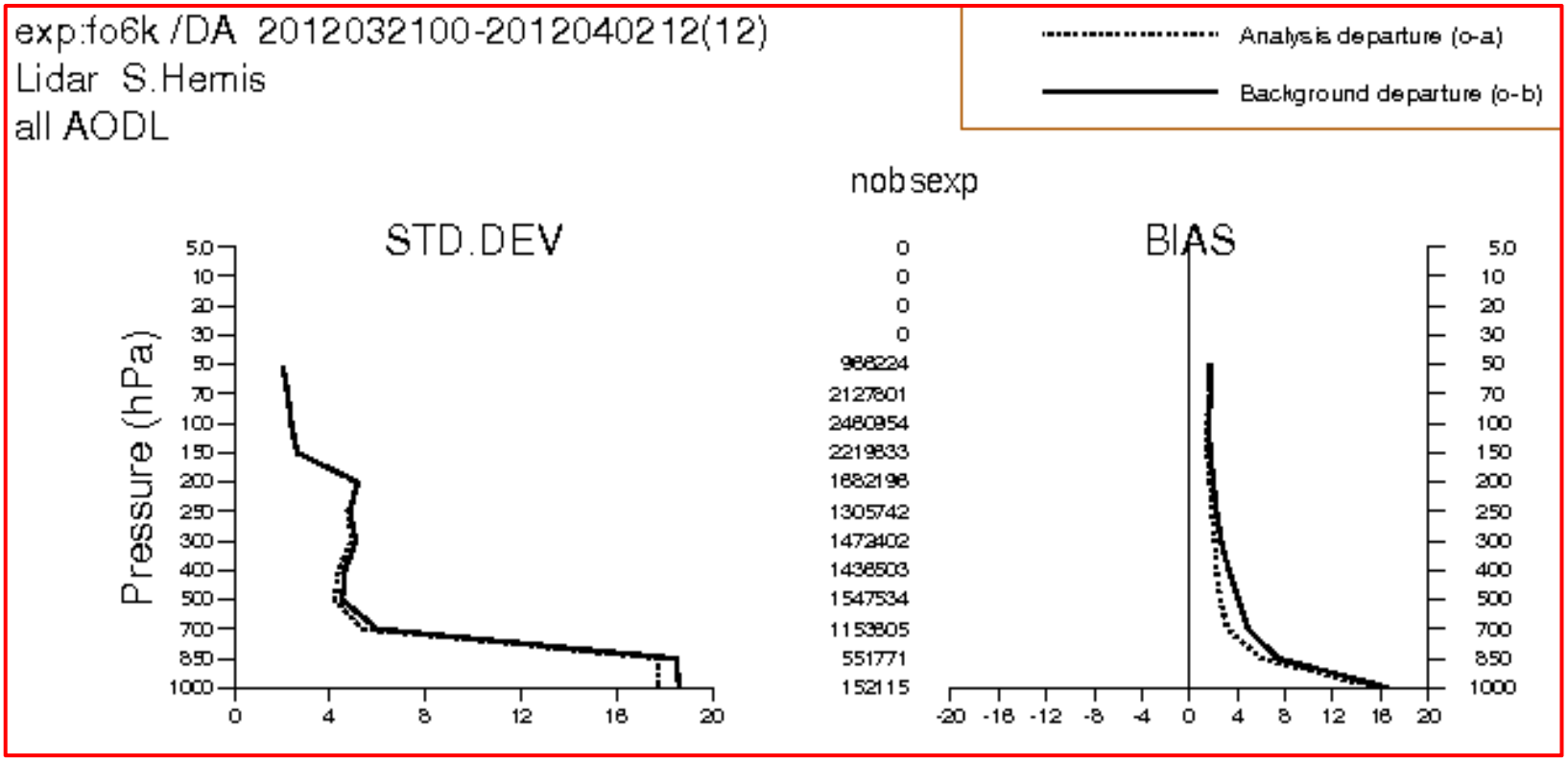
Scatterplot for layer 600-775 hPa





Cycling experiments with lidar data

Period: March 21- April 2, 2012
Data: all operational data plus MODIS AOD and CALIPSO Level 1.5 backscatter



Lidar backscatter x 1e7 (sr m)-1

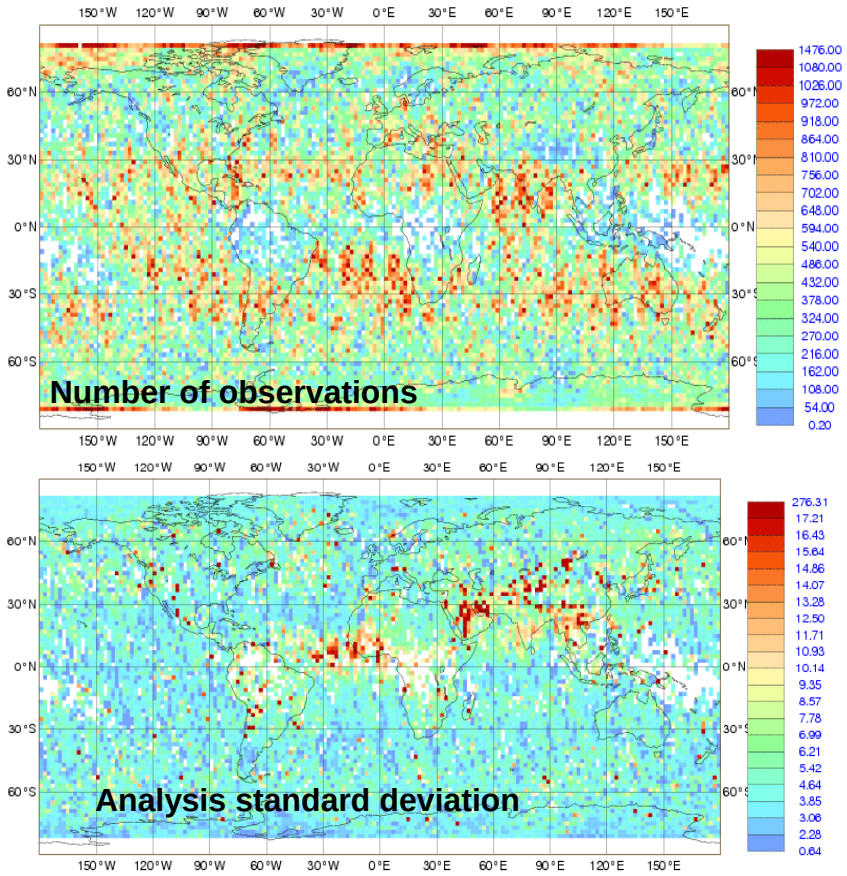
STD DEV not reduced enough – large first guess bias!

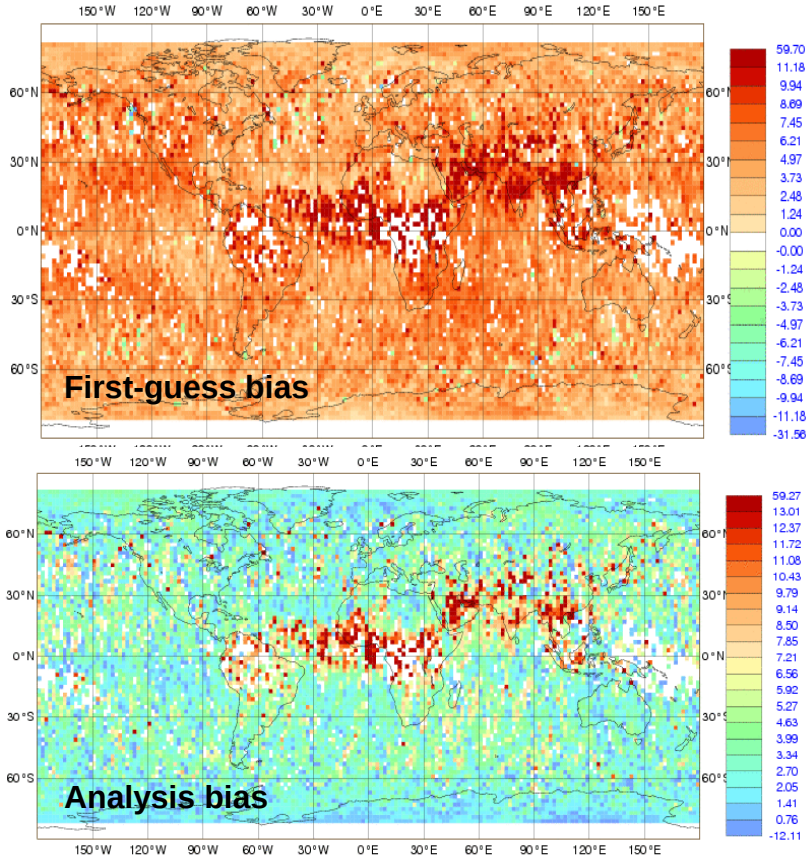
Cycling experiments with lidar data

Period: March 21- April 2, 2012

Data: all operational data plus MODIS AOD and CALIPSO Level 1.5 backscatter

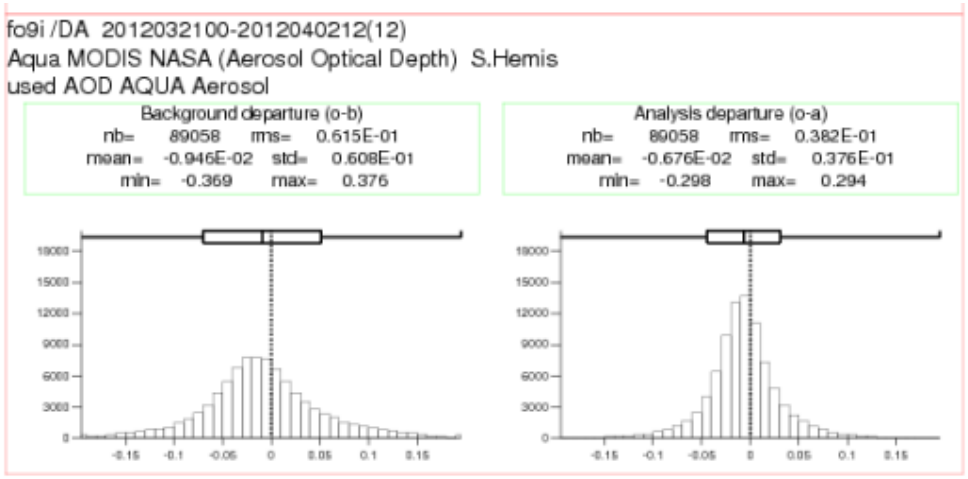
Statistics for level 500-800 hPa



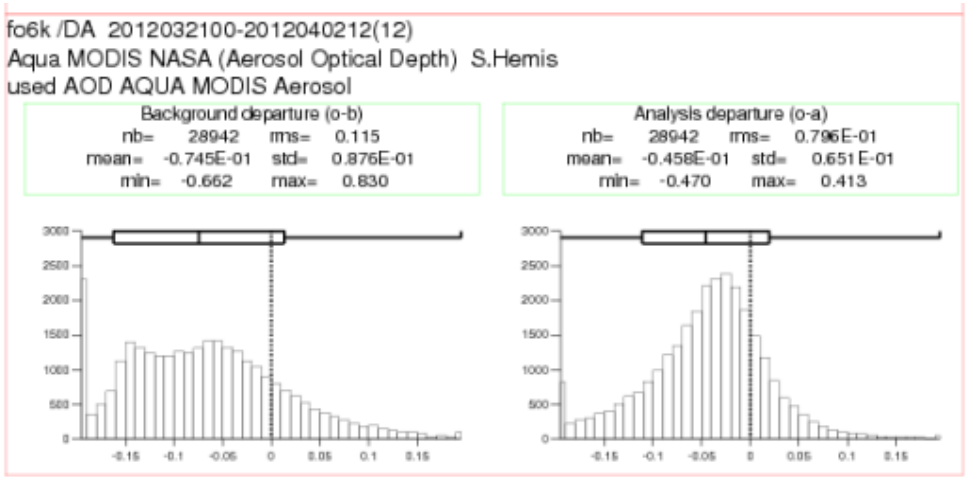


Cycling experiments with lidar data

Impact of lidar on AOD fit to MODIS observations

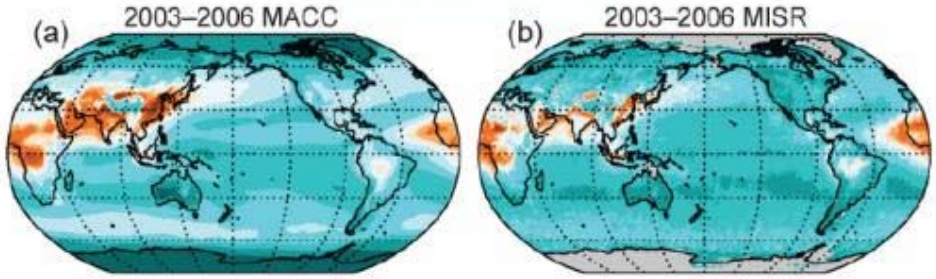


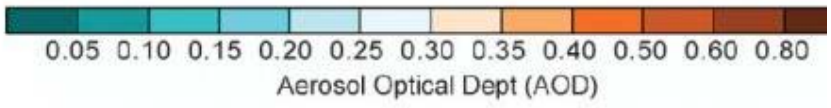
MODIS only (current NRT):
Nice Gaussian departures
and low bias both in first guess and analysis.



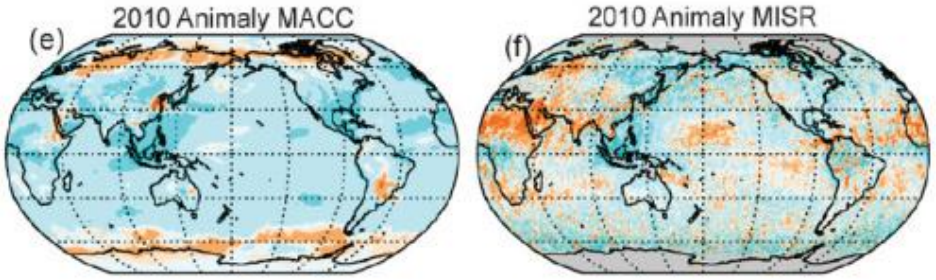
MODIS and CALIOP:
Non-Gaussian first-guess departures and larger
bias in the analysis departures

MACC Reanalysis activities – contribution to BAMS State of Climate 2010





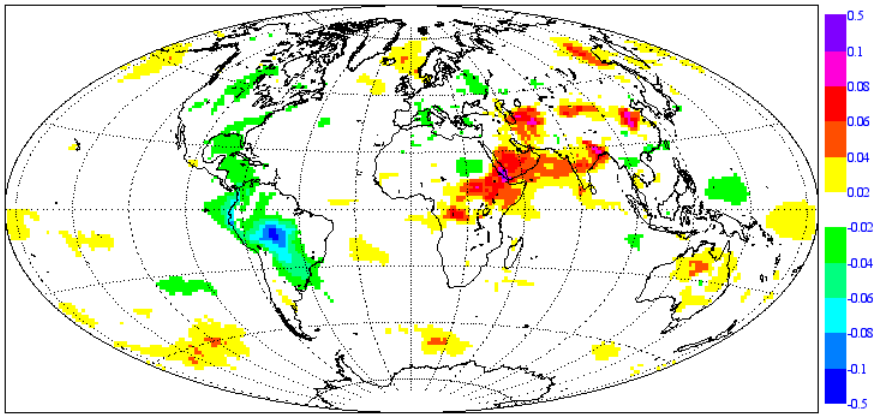
- Good agreement between MACC AOD climatology and (independent) MISR observations
- Known problems with underestimation of dust, but biomass burning 2010 anomalies are picked up by the MACC system (Russian, Siberian and South American lively fire activity and and low fire activity in Indonesia)
- East Asia pollution signal also evident

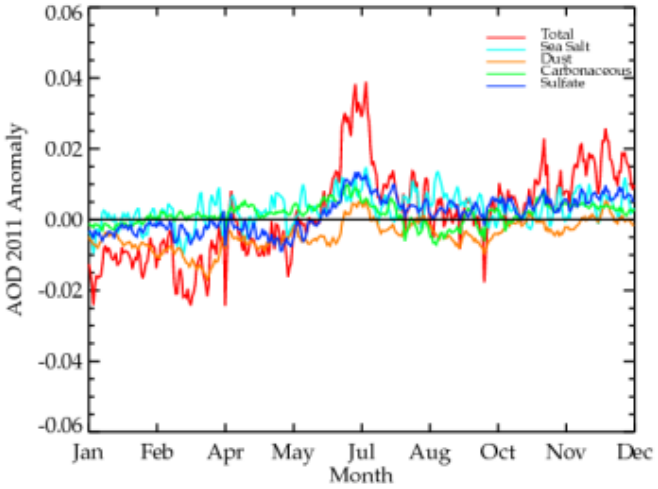


A. Benedetti, J. W. Kaiser, and J.-J. Morcrette. [Global Climate] Aerosols [in "State of the Climate in 2010"]. BAMS, 92(6):S65–S67, 2011.

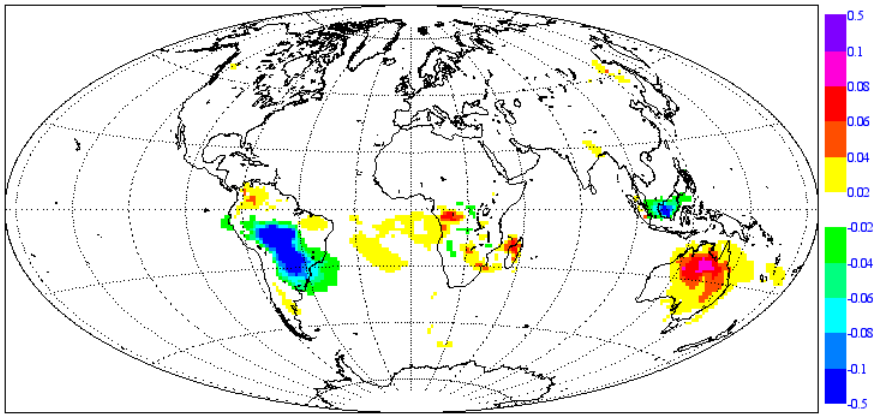
MACC Reanalysis activities – contribution to BAMS State of Climate 2011 (submitted)

Total AOD anomaly for 2011 with respect to 2003-2010 average



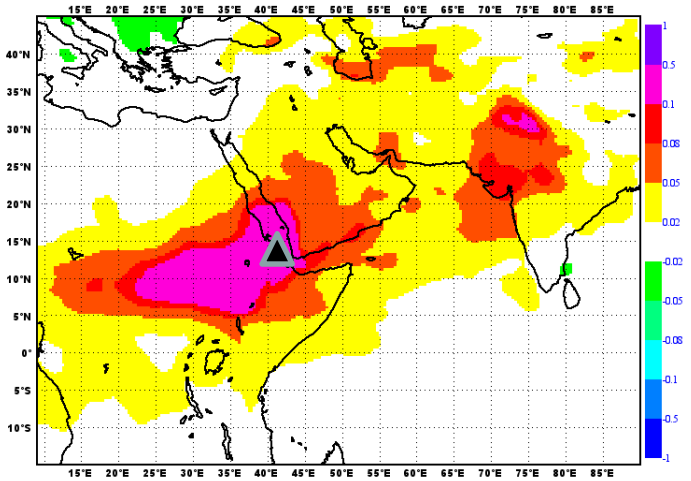


Carbonaceous aerosol anomaly for SON



Low fire activity in South America, intense fire activity in Australia

Sulfate anomaly for JJA-
volcanic eruption of Nabro (black triangle)



MWF