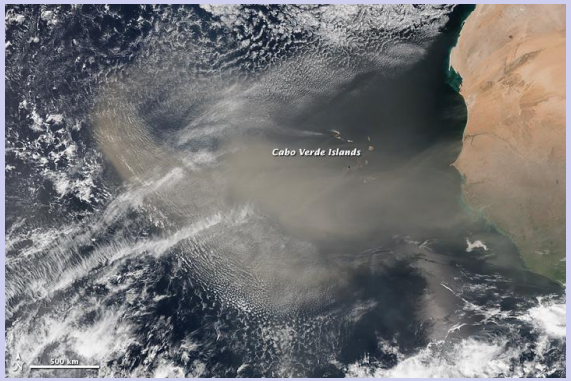
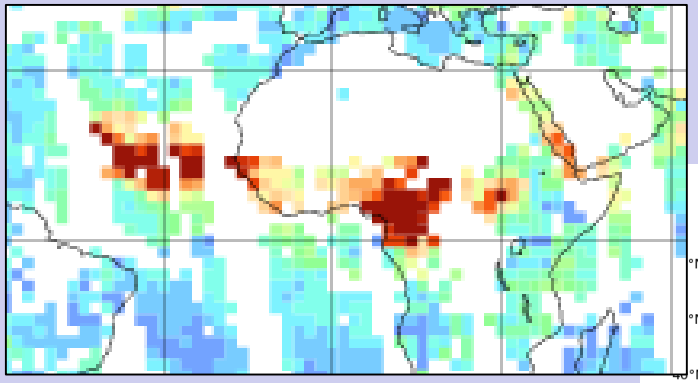
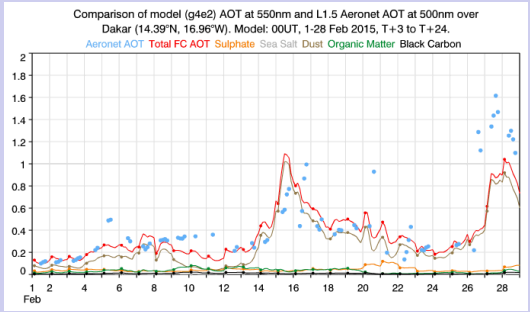
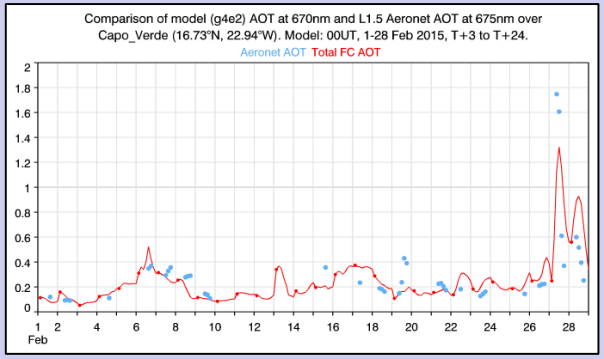
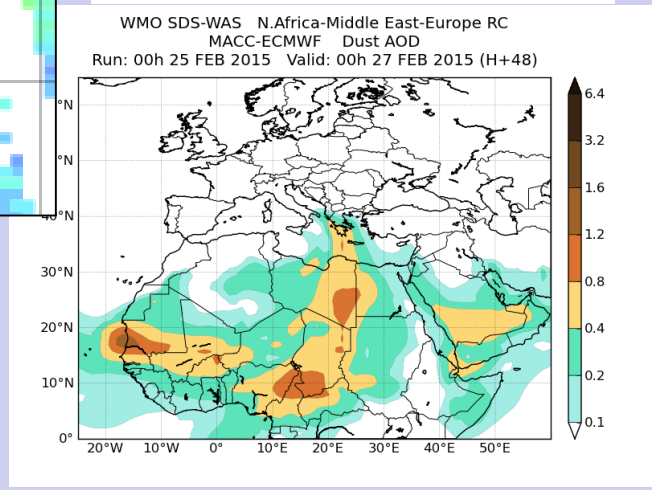
AEROSOL ASSIMILATION UPDATES











Angela Benedetti
ECMWF

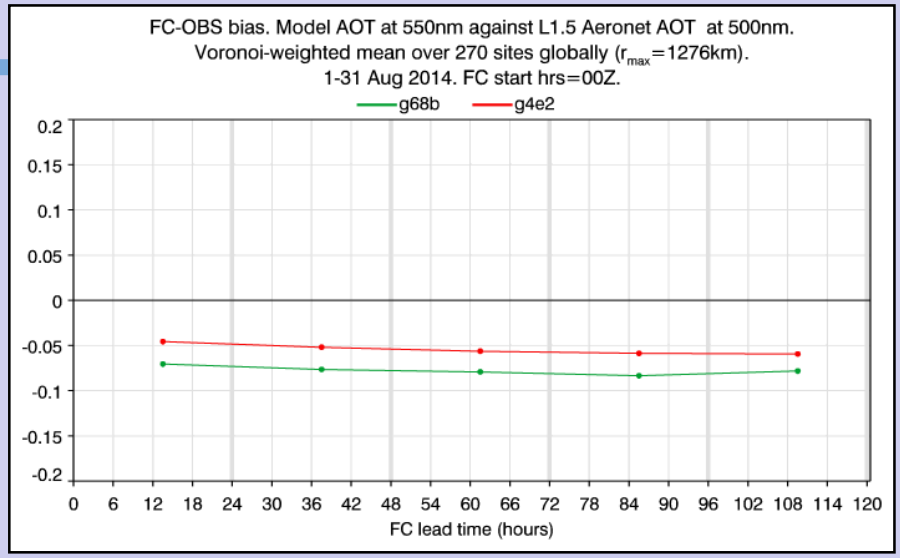
In collaboration with: Antje Inness, Johannes Flemming, Sebastien Massart, Marijana Crepulja, Martin Suttie, Mohamed Daouhi and Luke Jones

Progress since last ICAP

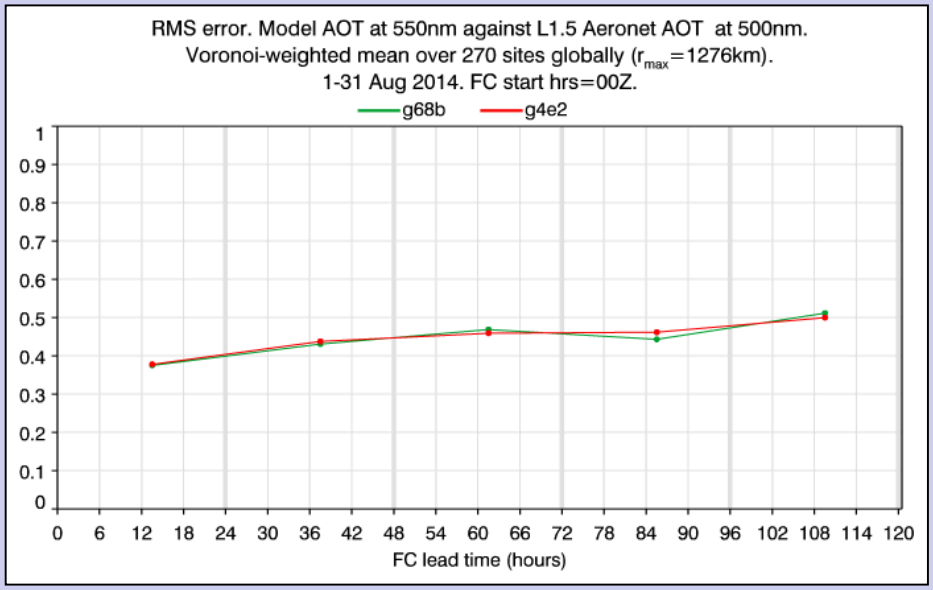
- MODIS Deep Blue data are included passively in the NRT CAMS run – will be switched on to active in the next upgrade
- SEVIRI AOD assimilation test performed
- CALIPSO assimilation improvements (activated variational bias correction)
- Evaluation of CALIPSO assimilation with HSRL
- Development of TL for AOD assimilation with GLOMAP

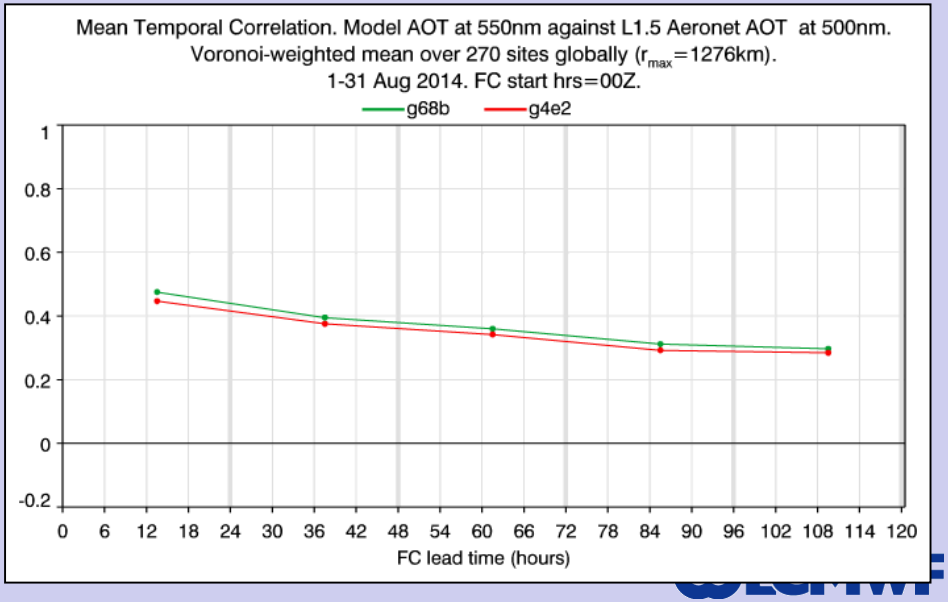
Impact of MODIS Deep Blue AOD data

- Tested in the o-suite (g4e2) configuration of C-IFS for three months (Jun-Aug-Sept 2014)
- Impact on bias is slightly negative
- Impact on rms is neutral
- Correlations are improved, possibly due to better constraining the AOD close to the dust sources



O-suite run (MODIS DT)
MODIS DT + DB run



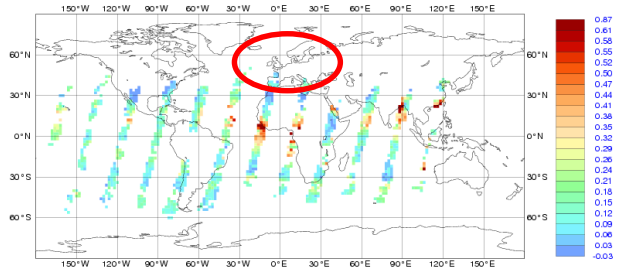


Aerosol Optical Depth coverage from various sensors

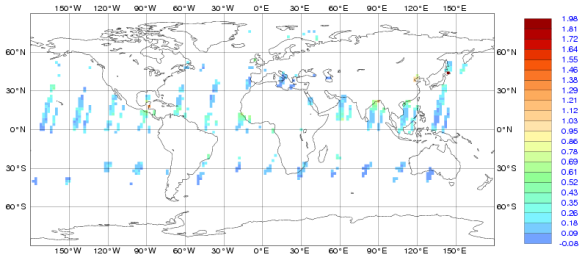
AATSR: data over deserts but narrow swath & one instrument

PMAP: for now, only data over ocean were tested at ECMWF. Two platforms (more resilient), multi-sensor (more points of failure).

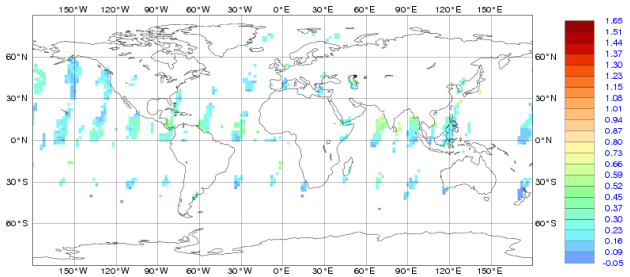
STATISTICS FOR AEROSOL FROM FROM ENVISAT/SSMI/S
MEAN OBSERVATION (USED)
DATA PERIOD = 2007-12-31 21 - 2008-01-01 21
EXP = G4FW, LEVEL = 0.00 - 1013.25 HPA
Min: 0.000 Max: 0.842 Mean: 0.153
GRID: 2.00x 2.00



STATISTICS FOR AEROSOL FROM FROM METOP-A/GOME-2
MEAN OBSERVATION (ALL)
DATA PERIOD = 2014-04-29 21 - 2014-04-30 21
EXP = G4UN, CHANNEL = 1
Min: 0.004 Max: 1.893 Mean: 0.201
GRID: 2.00x 2.00



STATISTICS FOR AEROSOL FROM FROM METOP-B/GOME-2
MEAN OBSERVATION (ALL)
DATA PERIOD = 2014-04-29 21 - 2014-04-30 21
EXP = G4UN, CHANNEL = 1
Min: 0.020 Max: 1.580 Mean: 0.240
GRID: 2.00x 2.00



SEVIRI: geo-stationary, high data volume, partial coverage

MODIS: two platforms, global coverage.
Data also over bright surfaces when Deep Blue is used.

STATISTICS FOR AEROSOL FROM METEOSAT-9/SEVIRI_O3
MEAN OBSERVATION (USED)
DATA PERIOD = 2014-02-01 21 - 2014-02-02 21
EXP = G6JR, LEVEL = 0.00 - 1013.25 HPA
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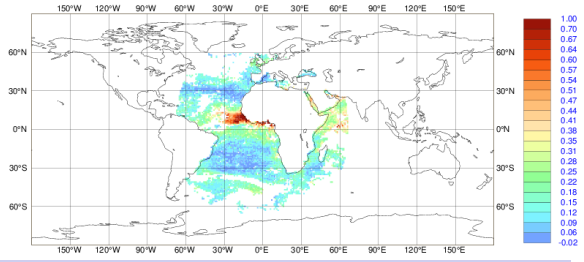
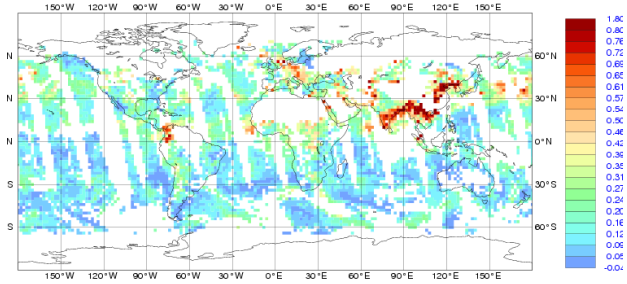


STATISTICS FOR AEROSOL FROM FROM AQUA/389
MEAN OBSERVATION (USED)
DATA PERIOD = 2014-03-31 21 - 2014-04-01 21
EXP = G4E2, LEVEL = 0.00 - 1013.25 HPA
Min: 0.002 Max: 1.760 Mean: 0.163
GRID: 2.00x 2.00



STATISTICS FOR AEROSOL FROM FROM TERRA/389
MEAN OBSERVATION (USED)
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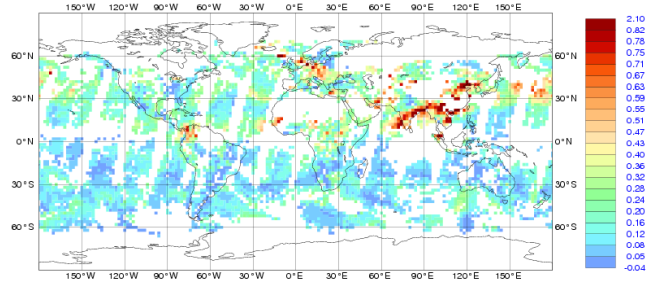
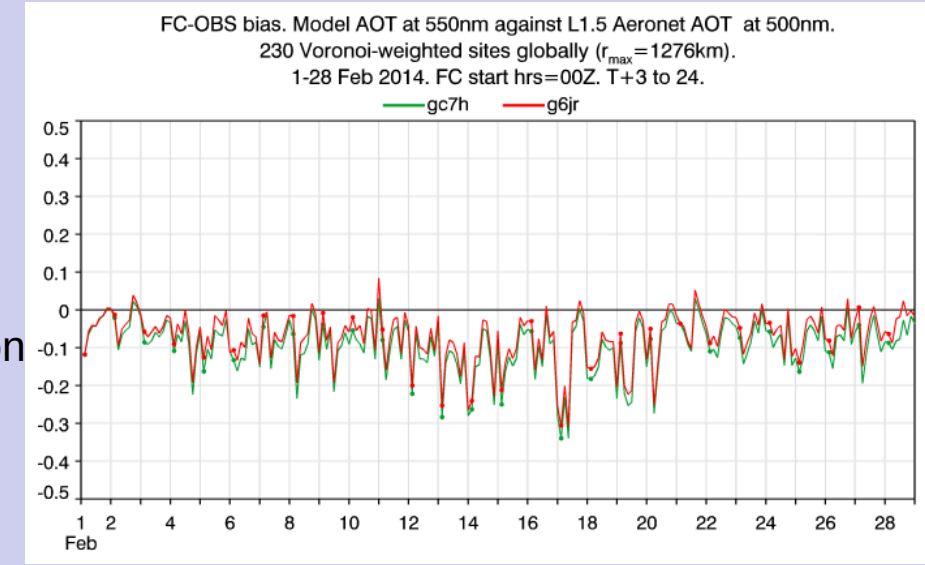
Min: 0.000 Max: 2.060 Mean: 0.166
GRID: 2.00x 2.00

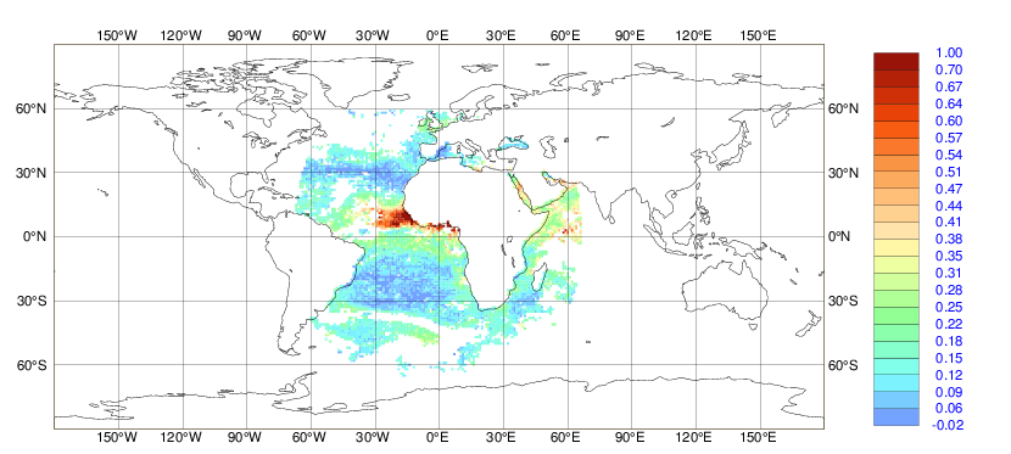


SEVIRI Aerosol Optical Depth (ocean-only)

- Produced in NRT at ICARE (http://www.icare.univ-lille1.fr/msg/)
- Based on an algorithm by Thieuleux et al., 2005
- Small but detectable impact on global bias (negligible in RMS)
- European/African coverage
- Of interest for European regional data assimilation
- Huge data volume (thinning needed)
- Other products under consideration



Data coverage over 24h



SEVIRI + MODIS run

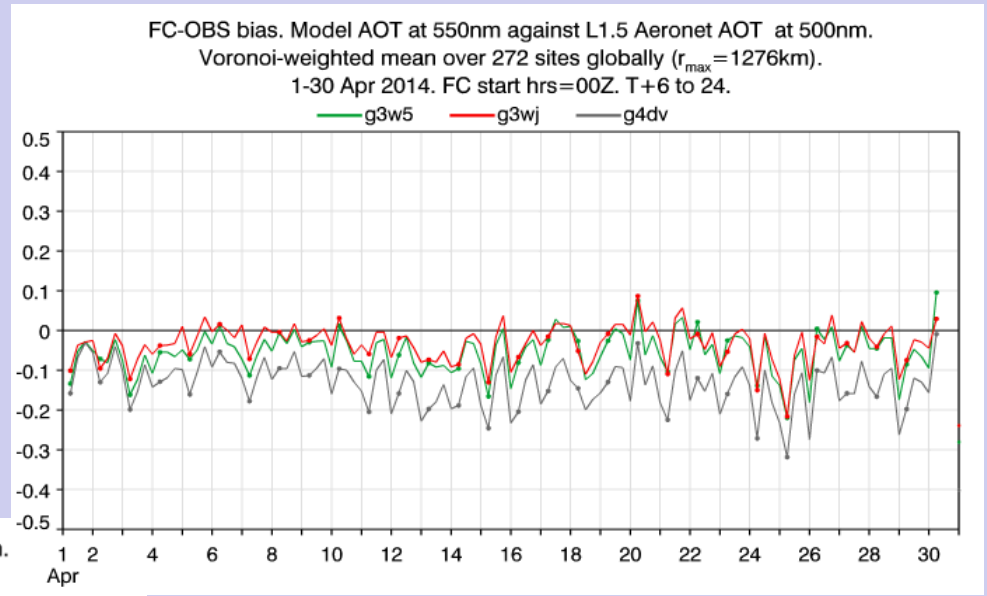
MODIS-only run

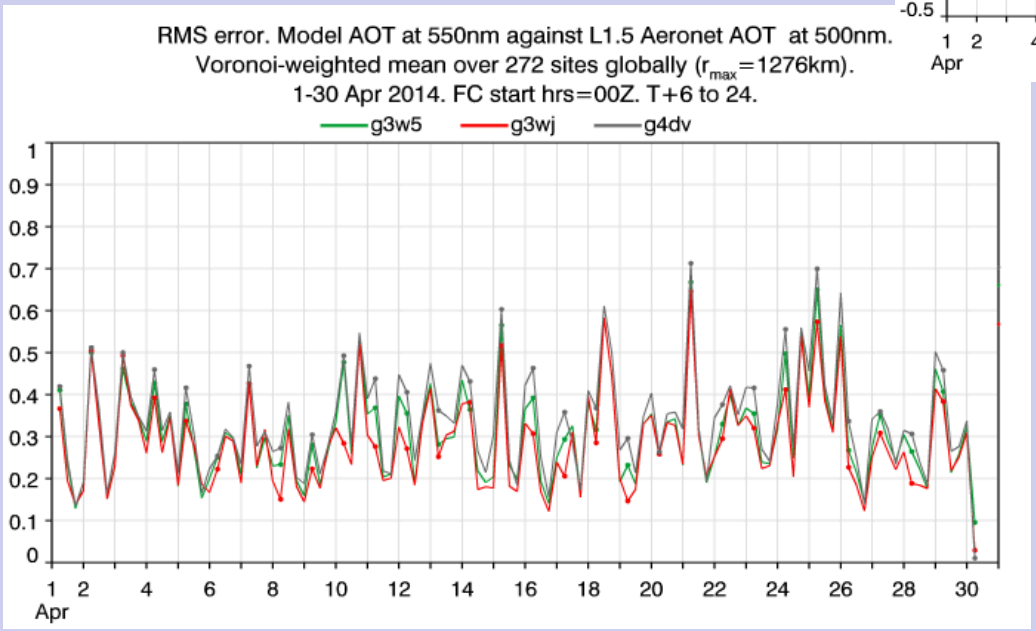
- ECWMF is actively pursuing monitoring/assimilation of SEVIRI products

PMAP Aerosol Optical Depth

Produced pre-operationally by EUMETSAT based on GOME2, AVHRR and IASI data. Similarly to AATSR data:

- Adds value to forecast-only run as shown by comparison with AERONET data
- Comparable impact with MODIS due to global coverage
- Good back-up (as it will be NRT from METOPA and METOPB) if MODIS stops working





Forecast-only run

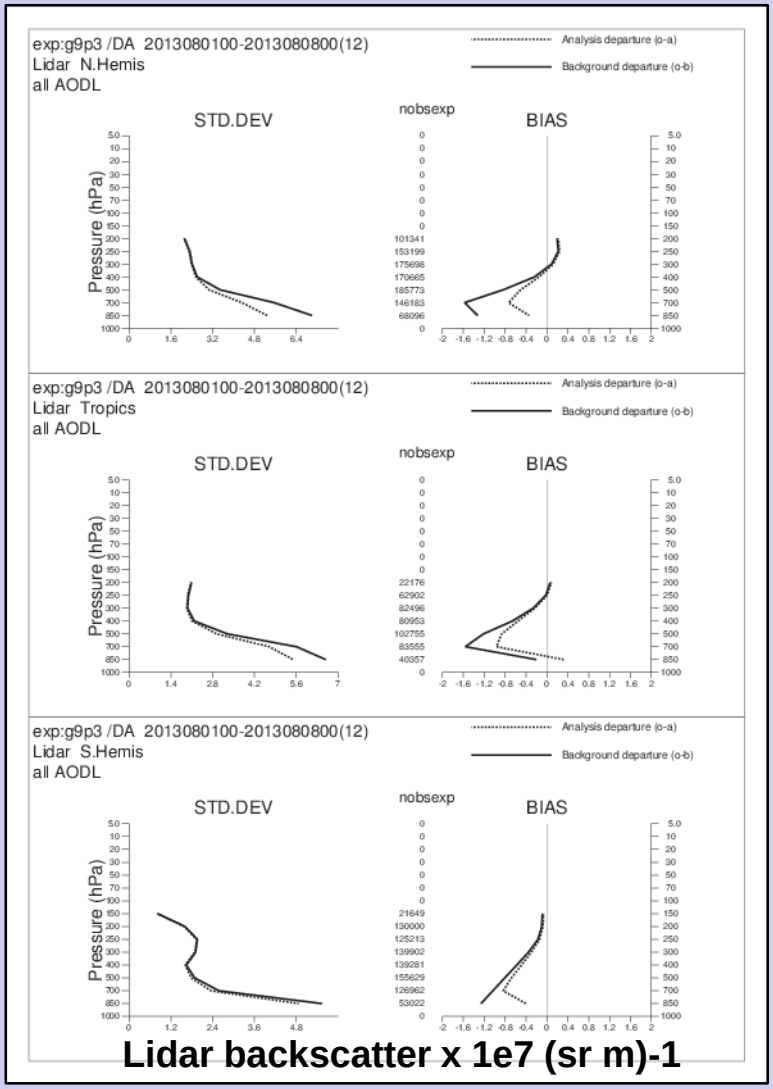
PMAP-only run

MODIS-only run

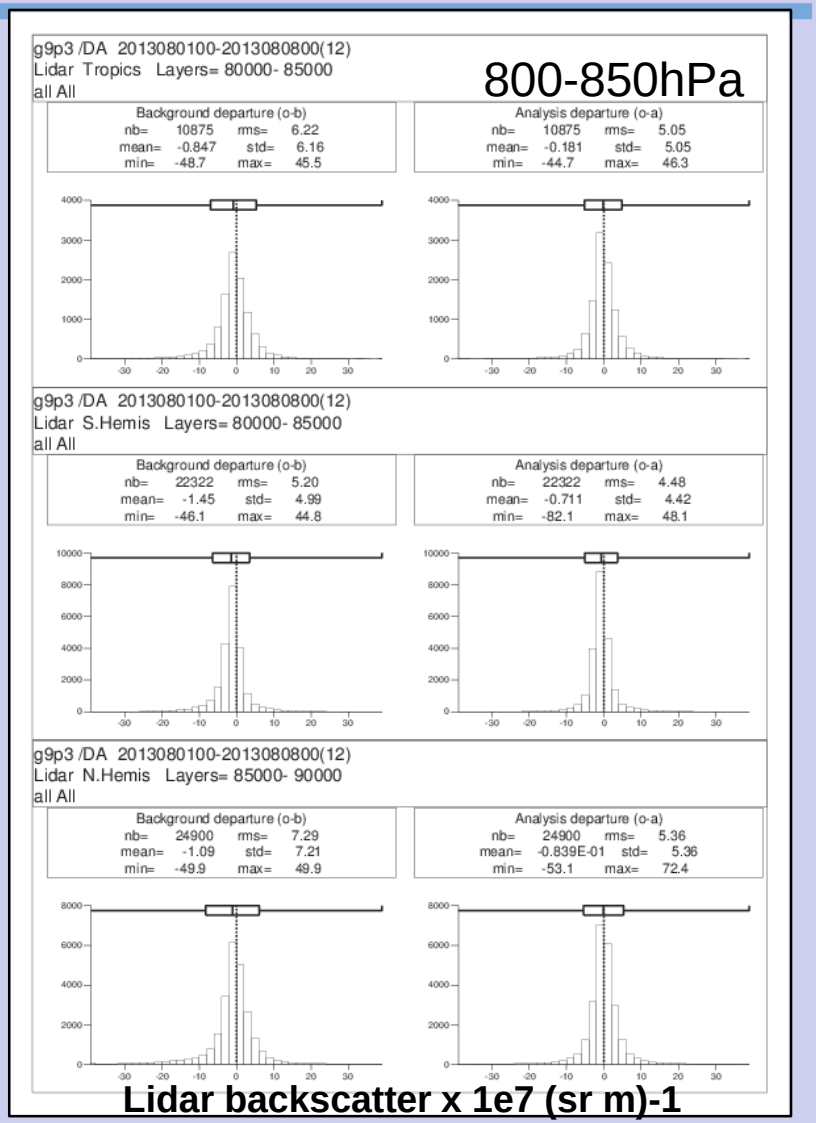
- Monitoring, and eventually assimilation, of PMAP data begin soon

Assimilation of lidar signal

CY40R2 (NRT cycle)



Lidar backscatter x 1e7 (sr m)-1

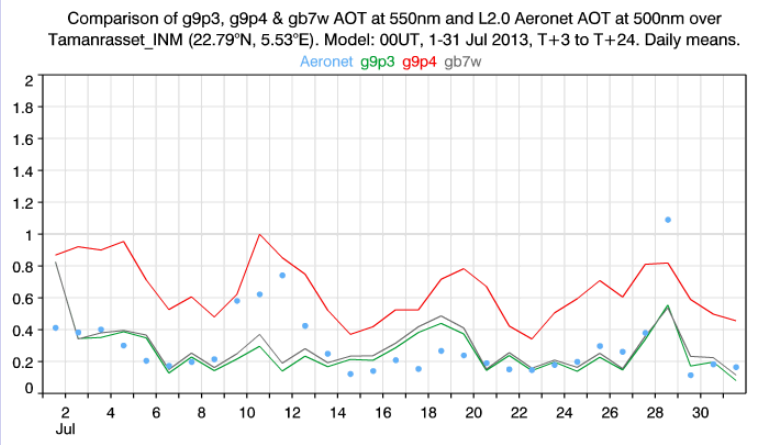


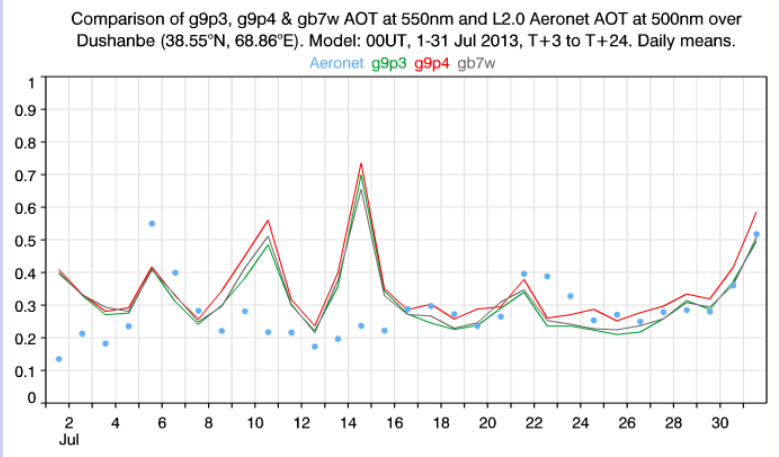
Lidar backscatter x 1e7 (sr m)-1

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

Verification of lidar assimilation experiments

AERONET verification shows good performance of lidar assimilation locally or at least not worse than the MODIS Dark Target-only run….

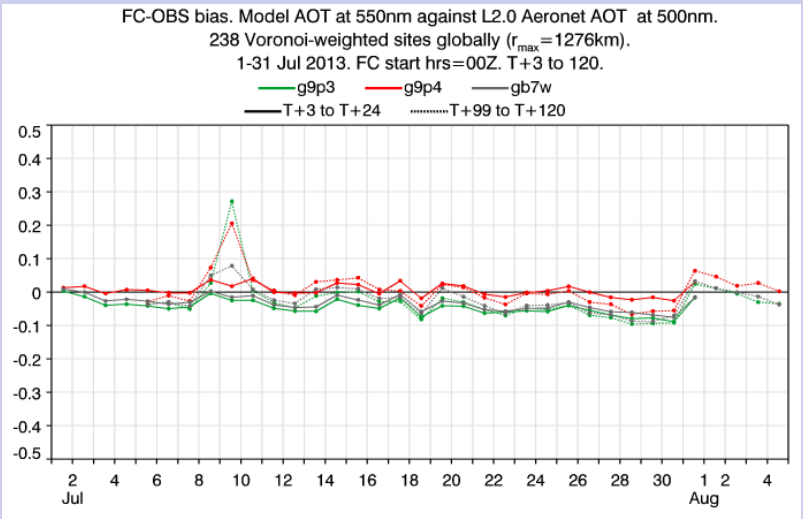




MODIS only

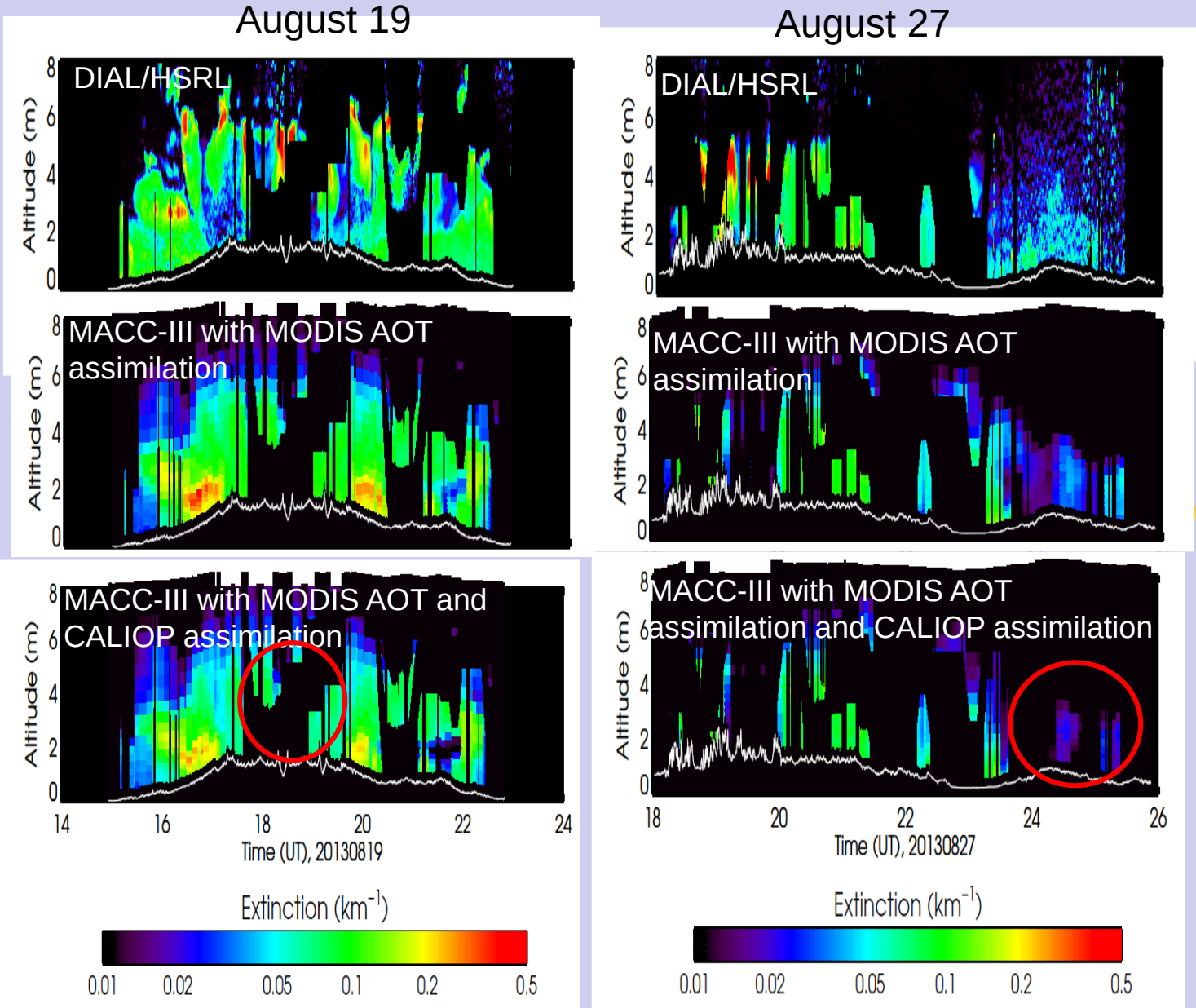
CALIOP+ MODIS

CALIOP + MODIS (both bias corrected)



…but globally the MODIS-only run is still on the lead.

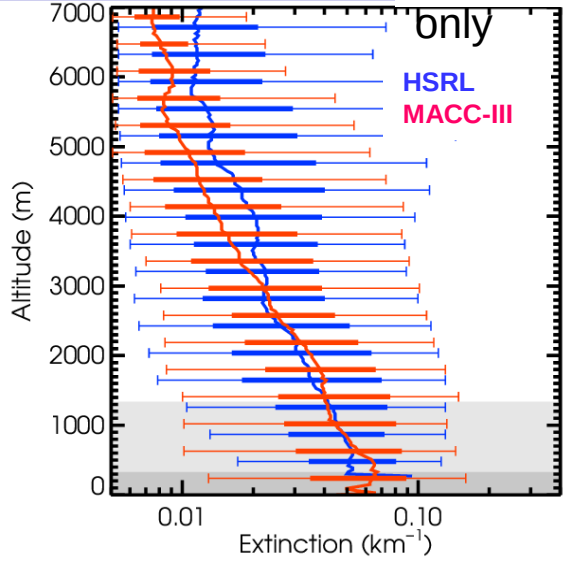
More on evaluation of the impacts of CALIOP profile assimilation

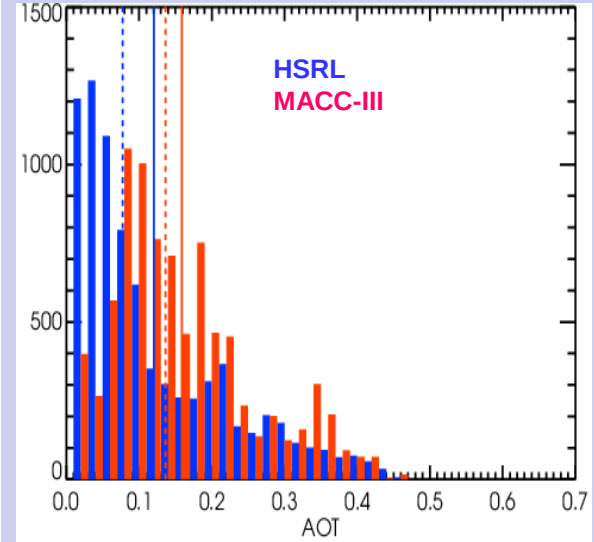


- Assimilation of CALIOP profiles slightly reduces extinction profiles in some locations; largest extinction values remain near surface
- Depending on location, these reductions can improve or worsen agreement with HSRL

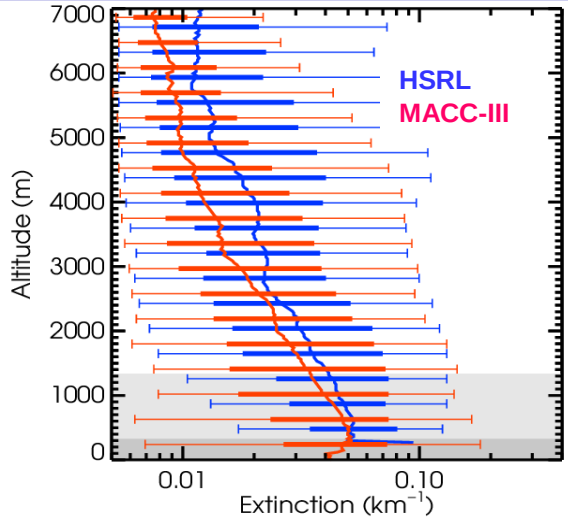
Comparison of Median Profiles with and without CALIOP assimilation

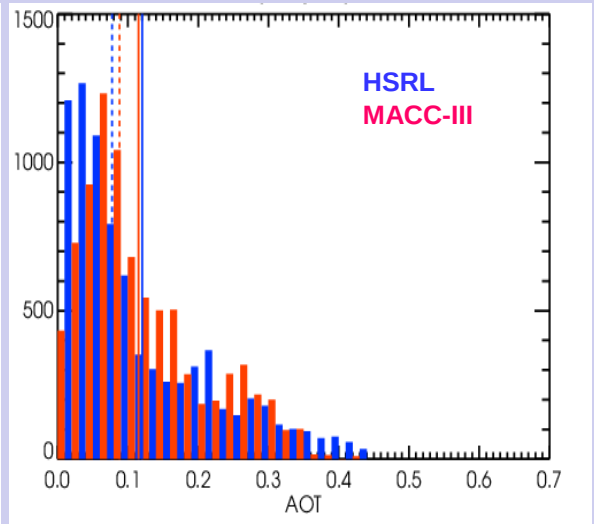
MODIS assimilation only





MODIS and CALIOP assimilation

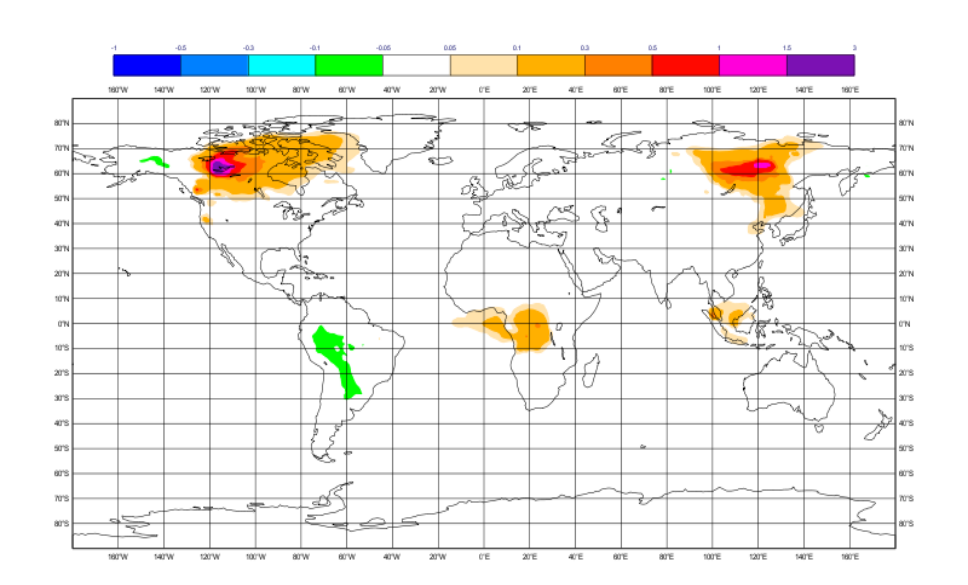




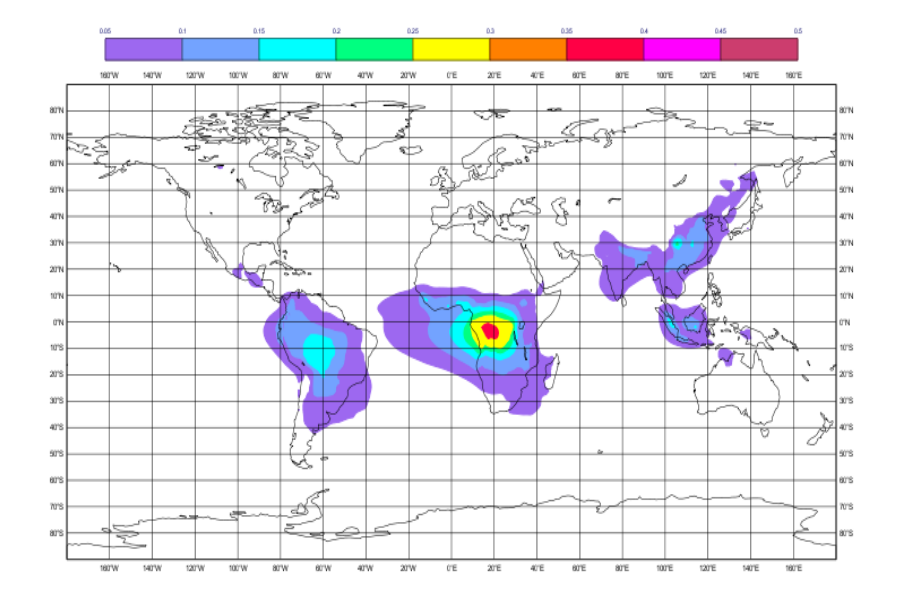
- Median profiles in good agreement with MODIS AOT assimilation
- Adding CALIOP:
  - produces relatively minor effects on median profiles
  - tends to lower the AOT with respect to runs that assimilate only MODIS AOT – slightly better agreement with HSRL

REANALYSIS RUNS

BAMS State of Climate 2014



Biomass burning AOD anomaly for JJA 2014



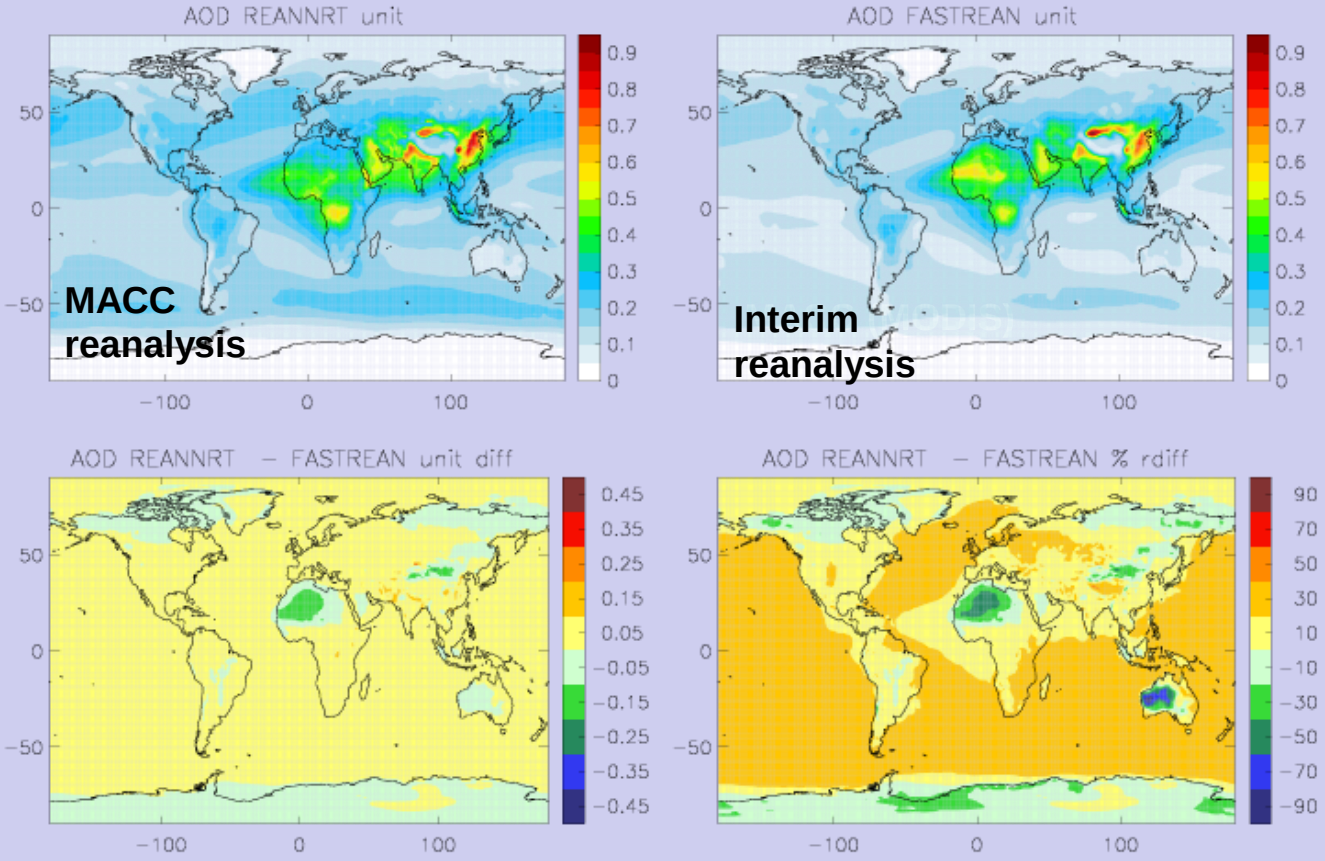
Carbonaceous Aerosol Optical Depth (2003-2012)

- Only anomalies in biomass burning aerosols could be plotted as the reanalysis for 2014 had to be run with a different cycle from that used for the MACC reanalysis
- These were shown to be consistent with fire emissions and CO anomalies

Benedetti, A. and S. Rémy, 2015: [Global climate] Aerosols [in "State of the Climate in 2014"]. To appear in Bull. Amer. Meteor. Soc.

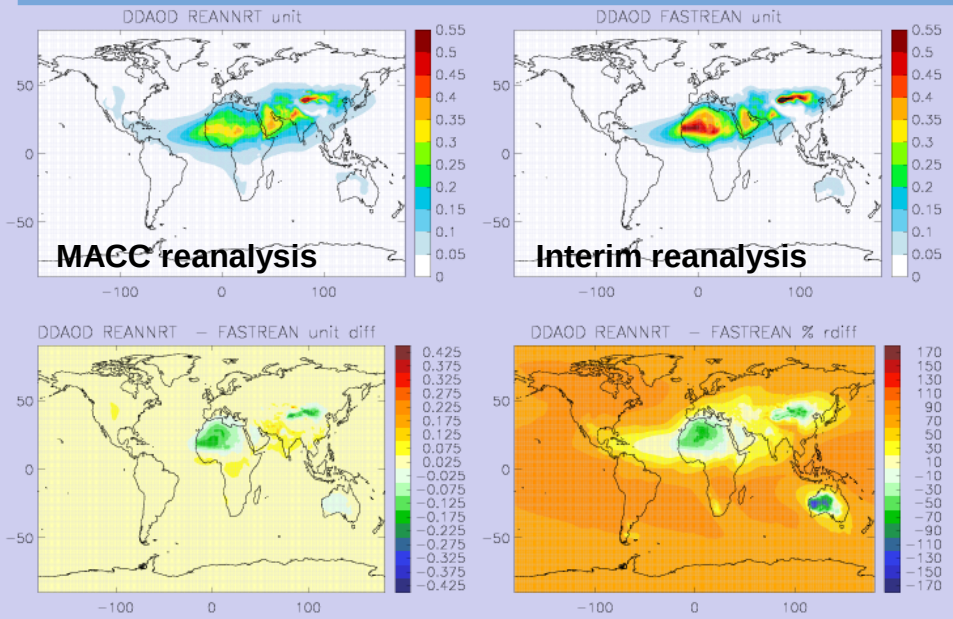
REANALYSIS RUNS

- New “interim” reanalysis from 2003-2014 has been run in parallel mode (literally) for fast turnaround
- Limited number of archived fields
- Reduced number of meteorological datasets
- Still under evaluation

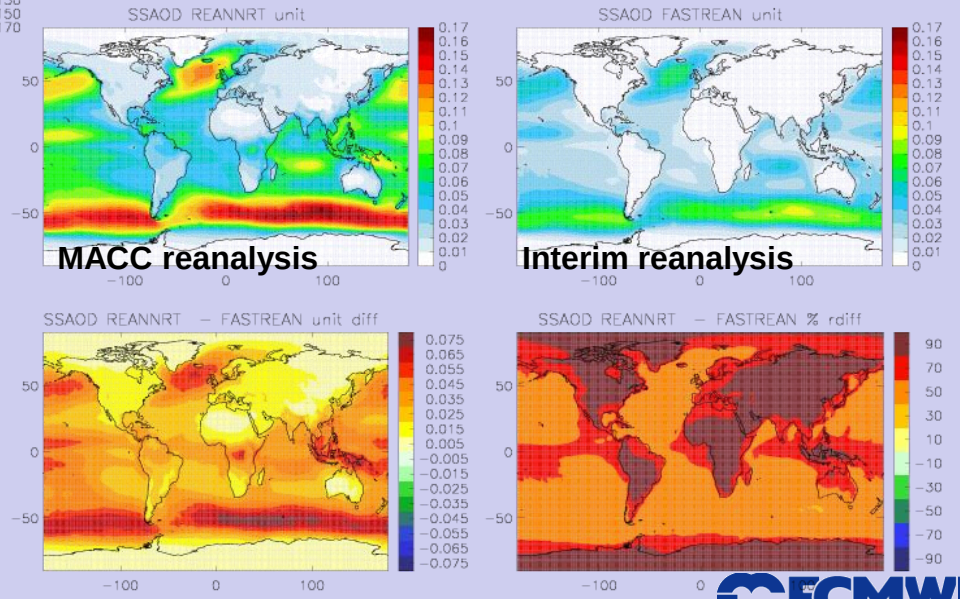


In collaboration with: Johannes Flemming and Antje Inness

REANALYSIS RUNS



- Main differences in AOD are down to model changes as the “interim” reanalysis uses MODIS Dark Target as the MACC reanalysis
- Increase in dust (particularly close to the source areas)
- Perhaps now too much dust but this is being corrected for the next reanalysis



- Striking differences in sea salt are attributable to model changes (big impact)
- Bias correction for MODIS data includes also surface wind speed as predictor (smaller impact)

In collaboration with: Johannes Flemming and Antje Inness

Data used in CAMS NRT system (2015)

Instrument	Satellite	Satellite operator	Data provider	Species	Status
MODIS	Terra	NASA	NASA/NOAA	**Aerosol, fires**	**Active**
MODIS	Aqua	NASA	NASA/NOAA	**Aerosol, fires**	**Active**
SEVIRI	Meteosat-9	EUMETSAT	IM	**Fires**	**Active**
Imager	GOES-11, 12	NOAA	NOAA	**Fires**	**Passive**
Imager	MTSAT-2	JMA	JMA	**Fires**	Planned
MLS	Aura	NASA	NASA	**O_3**	**Active**
OMI	Aura	NASA	NASA	**O_3**	**Active**
SBUV-2	NOAA-16,19	NOAA	NOAA	**O_3**	**Active**
SCIAMACHY	Envisat	ESA	KNMI	**O_3**	**Died**
GOME-2	Metop-A	EUMETSAT	DLR	**O_3**	**Active**
GOME-2	Metop-B	EUMETSAT	DLR	**O_3**	**Active**
OMPS	SNPP	NOAA	EUMETCast	**O3**	**Tests**
IASI	Metop-A	EUMETSAT	LATMOS/ULB	**CO**	**Active**
IASI	Metop-B	EUMETSAT	LATMOS/ULB	**CO**	**Active**
MOPITT	Terra	NASA	NCAR	**CO**	**Active**
GOME-2	Metop-A	EUMETSAT	DLR	**NO_2**	**Passive/Tests**
GOME-2	Metop-B	EUMETSAT	DLR	**NO_2**	**Passive/Tests**
OMI	Aura	NASA	KNMI	**NO_2**	**Active**
OMI	Aura	NASA	NASA	**SO_2**	**Active**
GOME-2	Metop-A	EUMETSAT	DLR	**SO_2**	**Active**
GOME-2	Metop-A	EUMETSAT	DLR	**SO_2**	**Active**
GOME-2	Metop-B	EUMETSAT	DLR	**HCHO**	**Passive**
TANSO-FTS	GOSAT	JAXA/NIES	UoB	**CO2**	**Active**
TANSO-FTS	GOSAT	JAXA/NIES	SRON	**CH4**	**Active**
Offline tests:					
IASI	Metop-A	EUMETSAT	LATMOS/ULB	**O3**	**Tests**

CAMS DATA USAGE PERSPECTIVES

- CAMS is a data-hungry beast
- At the moment ~20 different datasets are used, mostly related to O3 and other chemical species
- Only two aerosol-related datasets are used in the NRT analysis and forecast suite (MODIS Terra and Aqua, including Deep Blue)
- More datasets are in the pipeline
- Radiance assimilation is still far into the future, products such as optical depth or lidar backscatter/extinction are still the main observation type
- Aerosol assimilation depends heavily on products from space agencies
- Assimilation of profiling data from lidars is on its way, but still requires a lot of R&D (on both sides: agencies, and developers)