

Aerosol Activities at ECMWF



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With contributions from:

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Luke Jones



OUTLINE

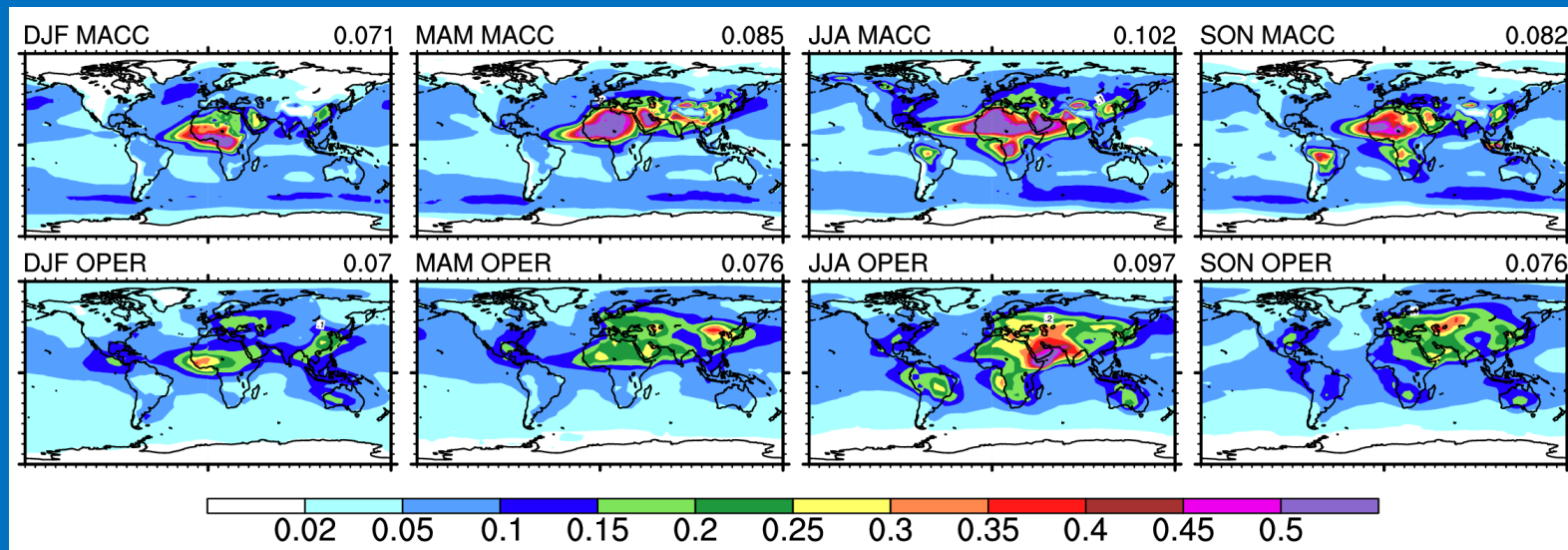
- Copernicus Atmosphere Monitoring Service (CAMS) updates
- Aerosol impacts on the NWP system:
 - medium-range.
 - monthly/seasonal range.
 - 4D-Var radiance assimilation.



AEROSOL IMPACTS ON NUMERICAL WEATHER PREDICTION

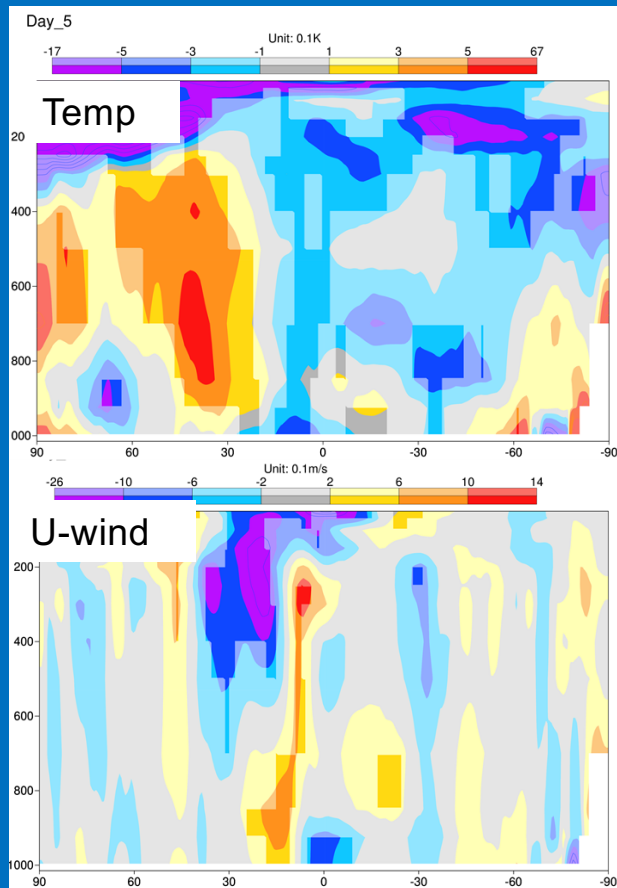
Climatological AOD 550nm distribution MACC vs Tegen et al 1997 (OPER)

Credits: Alessio Bozzo

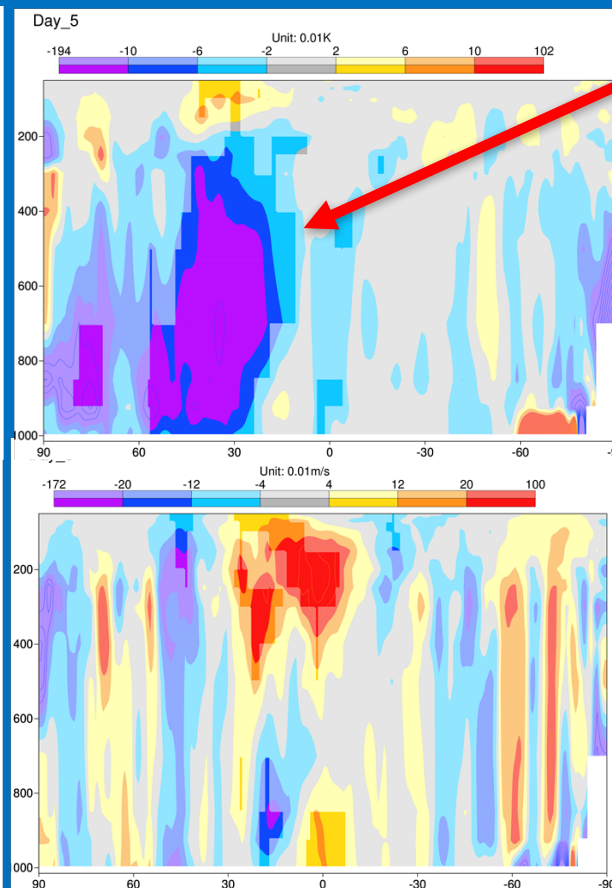


- MACC run (2003-2012): sources of biomass burning from GFAS, sulphate aerosol precursor from EDGAR 4.1, prognostic for sea salt and dust, revised dust model
- Optical properties recomputed for RRTM spectral bands and for each aerosol type/size bin. Mass mixing ratio as input to radiation
- Vertical distribution following an exponential decay with scale height derived from the MACC model for each aerosol type. Monthly varying for dust.

Impacts on forecast errors



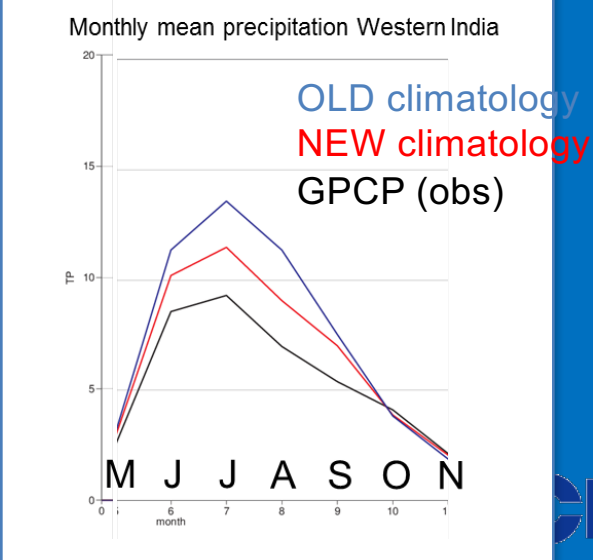
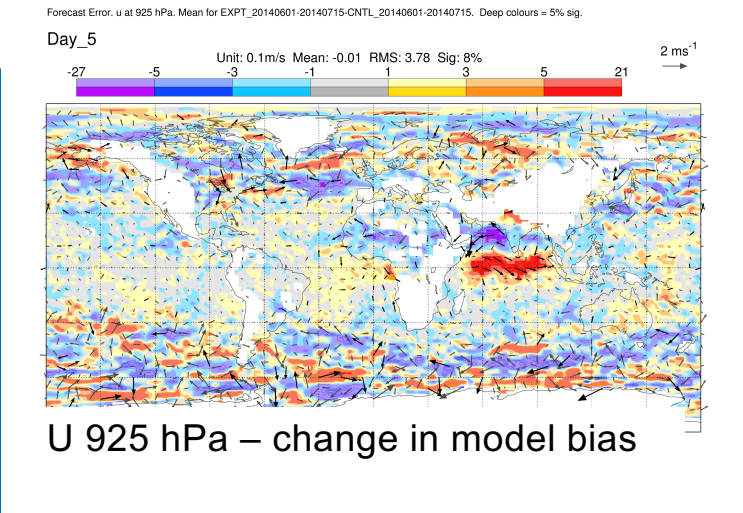
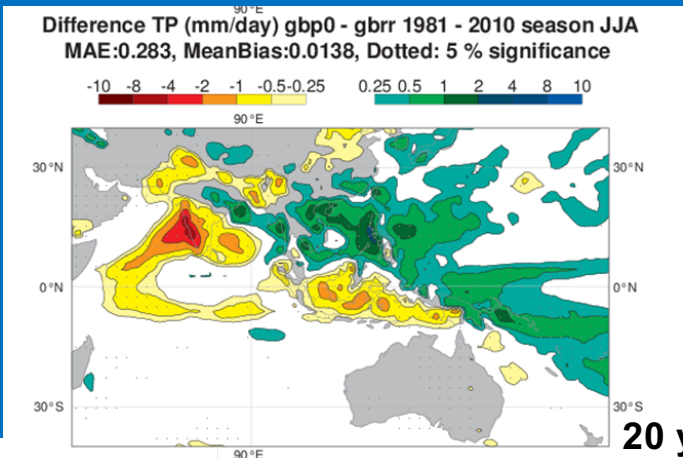
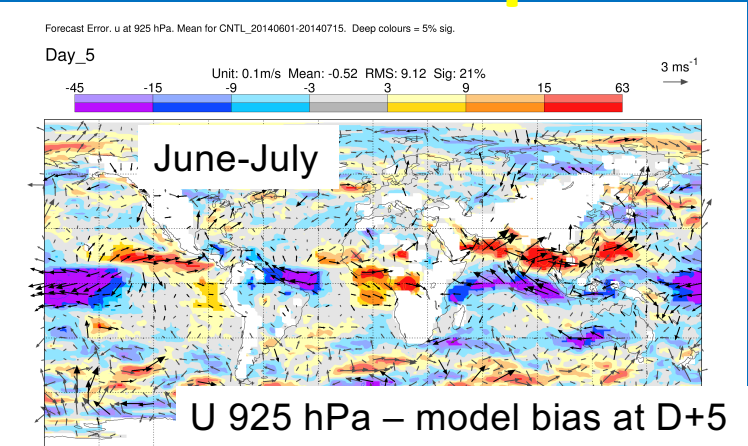
June-July
Model FC error d+5



June-July
Change in FC error d+5

- Change in mass distribution and optical properties -> reduction in SW absorption -> reduction in temperature (positive)
- This is of the order of 0.1K for a bias of the order of 0.3K – it explains at least ~30% of the temperature error.
- Similar for winds at upper levels

Impacts on FC errors



Credits: Alessio Bozzo, Linus Magnusson



WMO Working Group on Numerical Experimentation (WGNE)

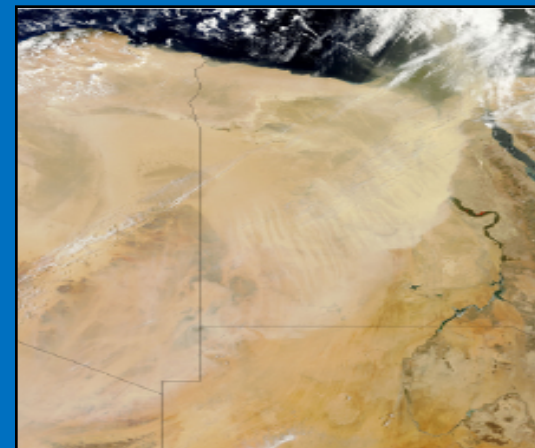
This inter-comparison aims to evaluate the impact of aerosols on Numerical Weather Prediction

Three situations were proposed :

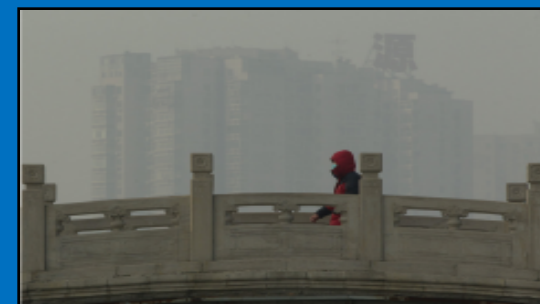
- Dust storm over Egypt on 18th of April 2012
- Extreme pollution over Beijing, 12-16th of January 2013
- Extreme biomass burning over Brazil in September 2012 during the SAMBBA field campaign

Participants : Météo-France, Met-Office, JMA, ECMWF, NOAA, NASA, CPTEC (Brazil)

Credits: Samuel Rémy



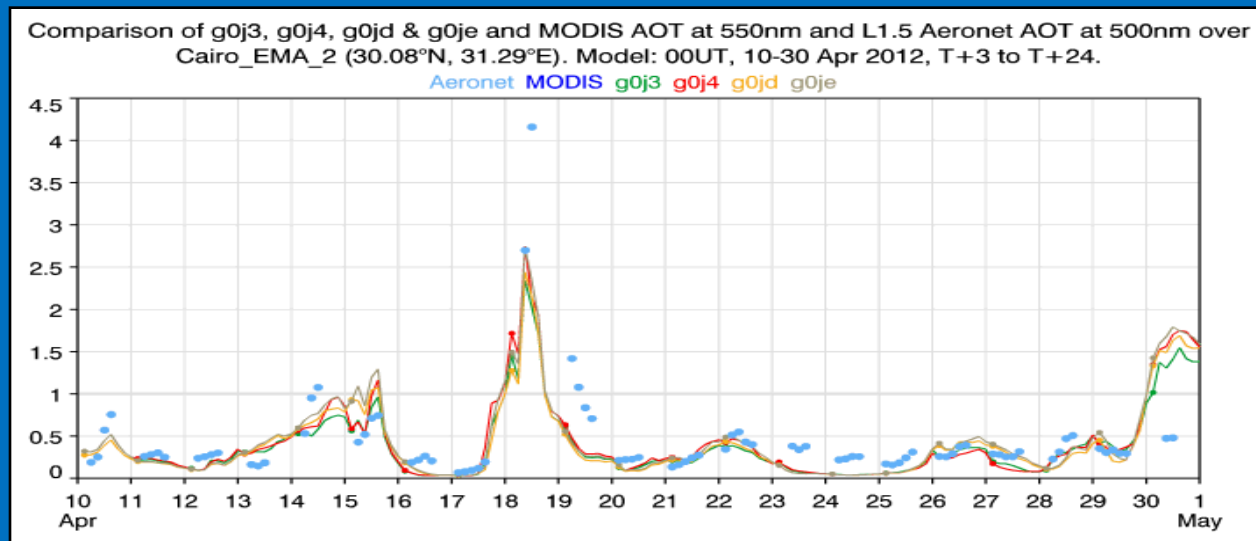
MODIS imagery, 18/4/2012



Beijing , 14/1/2013

Dust case of April 2012 – AOD forecasts

- Cycling forecast with the MACC global system, with aerosol direct effect from climatology or prognostic aerosols at T511, L60
- Dust bins : 0.03 – 0.55 – 0.9 – 20 μm
- AOD peak of 18th of April well timed but underestimated
- End of the event forecast too soon



Dust case of April 2012 – Impact on temperature, winds and dust production

Table 2. 2m temperature, RMSE of REF_ASSIM and TOTAL_ASSIM for forecast times 0, 12, 24, 36 and 48h, average for the period of 10th to 25th of April 2012. Stations considered are Hurguada, Luxor, Kosseir, Siwa, Wadi el Natroon, Cairo, Port Said and Ras Sedr in Egypt, and Ben Gurion airport close to Tel Aviv in Israel.

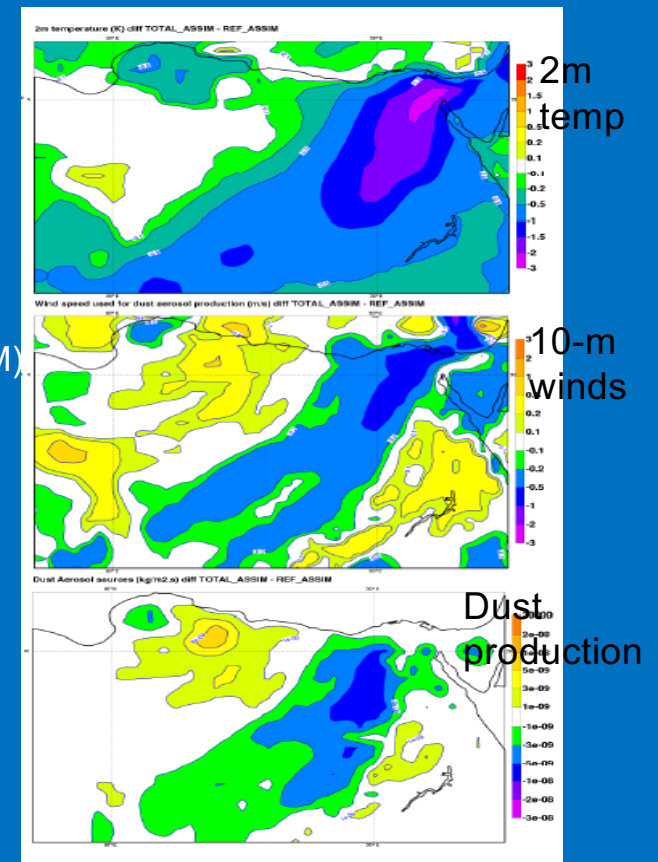
Forecast time	0h	12h	24h	36h	48h
REF_ASSIM	1.46	1.48	1.5	1.62	1.53
TOTAL_ASSIM	1.32	1.49	1.43	1.6	1.58

Table 3. 2m temperature, bias of REF_ASSIM and TOTAL_ASSIM for forecast times 0, 12, 24, 36 and 48h, average for the period of 10th to 25th of April 2012 over the same selection of weather stations as table 2.

Forecast time	0h	12h	24h	36h	48h
REF_ASSIM	-0.87	-0.05	-0.73	0.48	-0.47
TOTAL_ASSIM	-0.65	-0.18	-0.58	0.2	0.26

Difference between run with interactive aerosols (TOTAL_ASSIM) and reference run (REF_ASSIM), 36 hour forecast (valid on April 18th at 12UTC)

- Reduced 2m temperature
- Increased surface winds
- Increased dust production

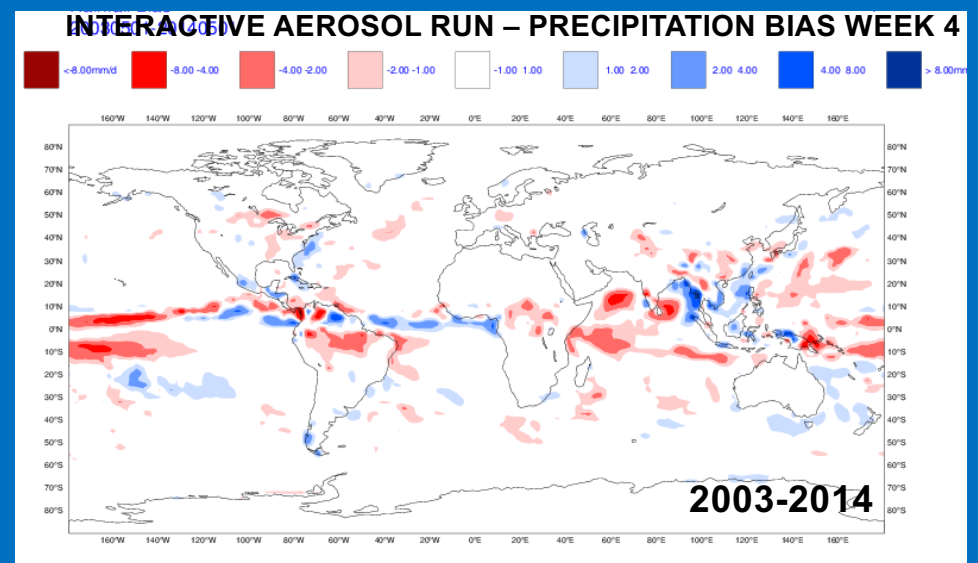
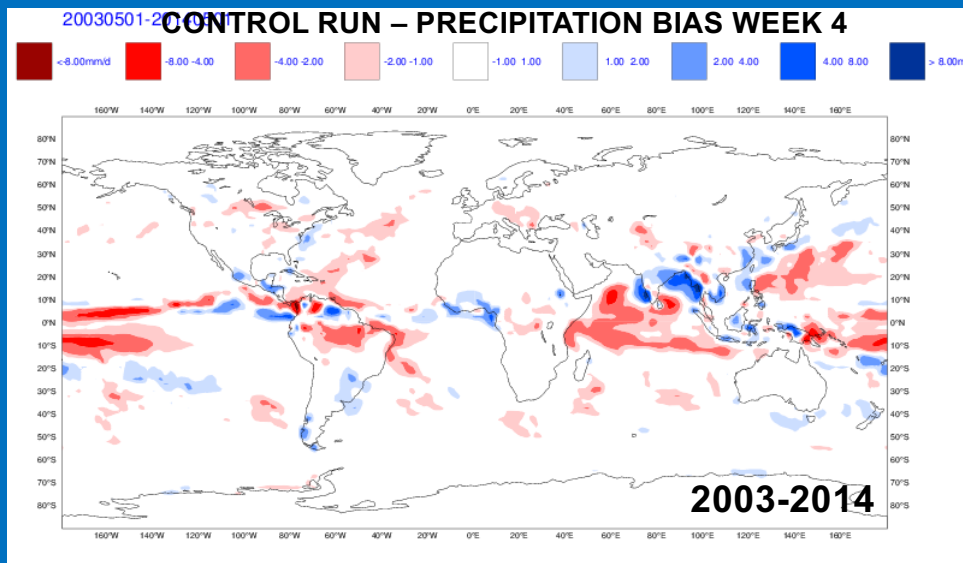


Monthly EPS coupled runs

- Work on activating aerosols in the monthly coupled EPS system started in November 2015
- Several changes were required to run the aerosol module (acquisition of emissions, and initial conditions) – cost is approximately 50% higher
- Control run for the period 2003-2015 uses standard Tegen et al 1997 climatology
- Interactive aerosol run covers the same period and uses fully prognostic aerosols in the radiation scheme
- Focus is summer season (June-July)
- Ensemble size is 10 members – augmented with running 5 different start dates around May 1 (50 members in total)

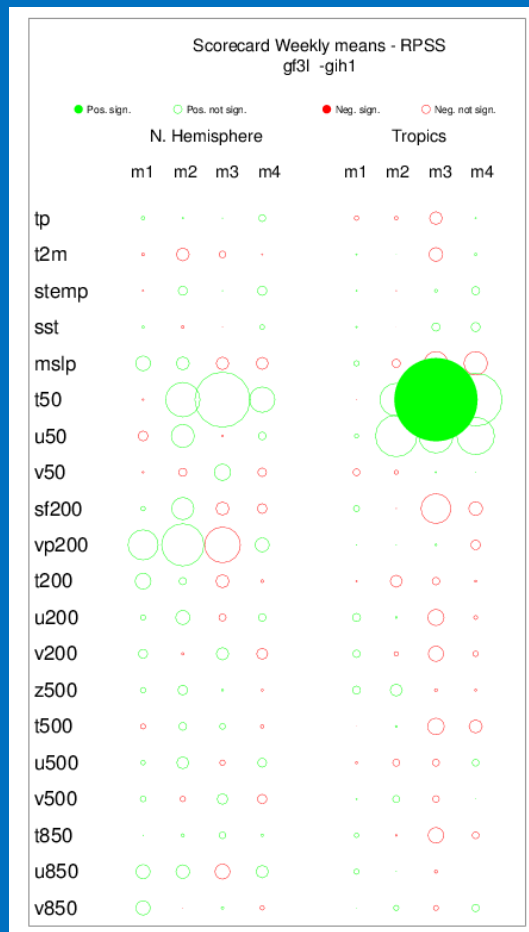
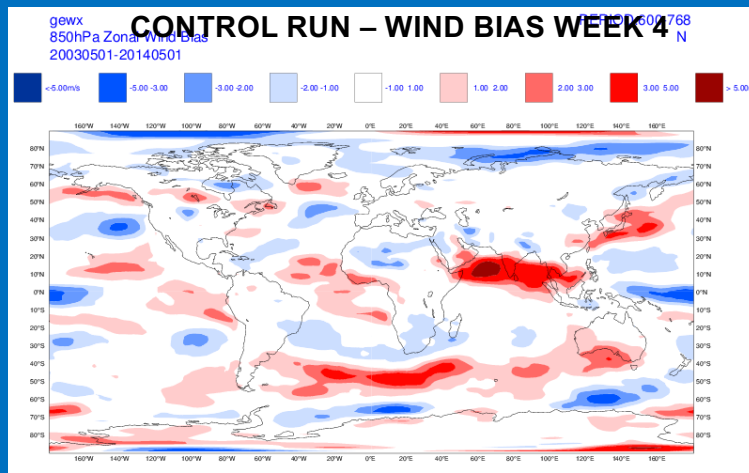
Aerosol impacts on monthly forecasts (I)

- Preliminary results confirm the positive impact (reduction in bias) of the interactive aerosols on meteorological fields (winds and precipitation)
- More prominent (positive) impact over the Indian Ocean and to a lesser extent in other areas
- Aerosol fields will be evaluated too by comparing with the MACC/CAMS reanalysis (BONUS: aerosol seasonal prediction!)



In collaboration with: Frédéric Vitart (ECMWF)

Aerosol impacts on monthly forecasts (II)

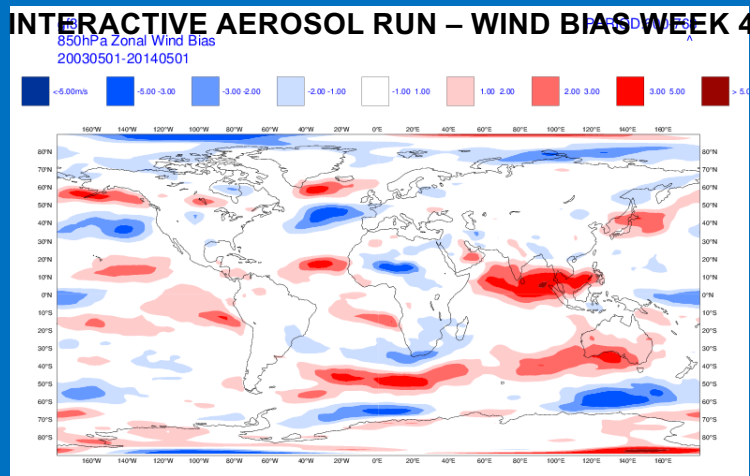


- Scorecards measures performance of interactive aerosol experiment with respect to a control run for several parameters.

- Green circles indicate positive impact

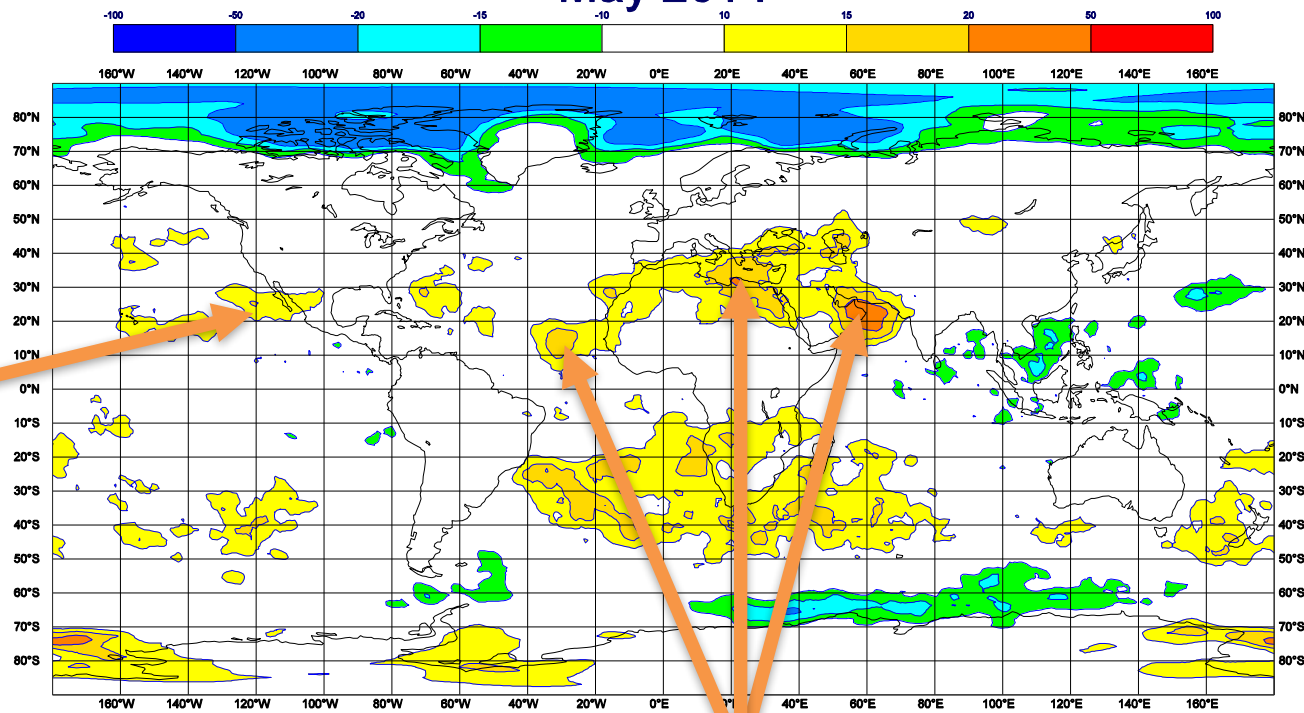
- Solid circles indicate significant impact

- Upper-level temperature is greatly improved on the seasonal scale (month 2-3) in the interactive aerosol run



Importance of aerosol in observations

Diff on Z500 between CTRL and w/o IR
May 2014

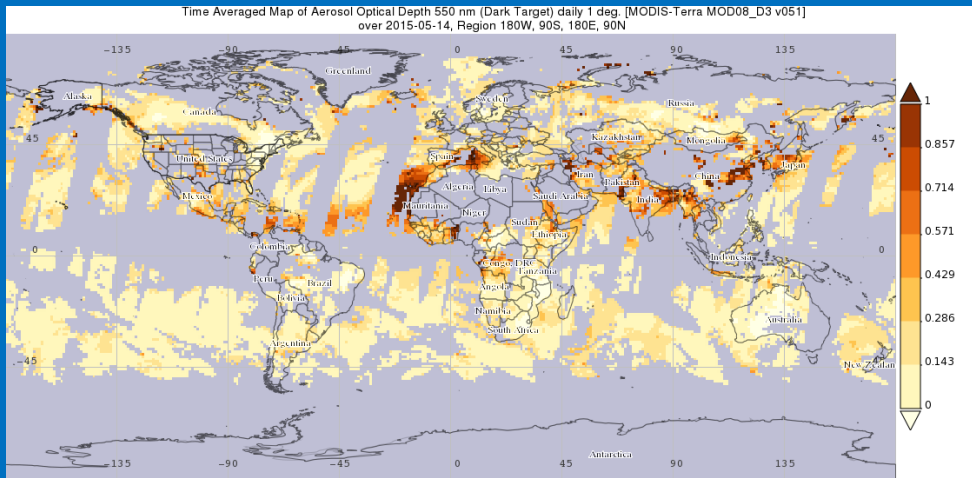


Smoke?

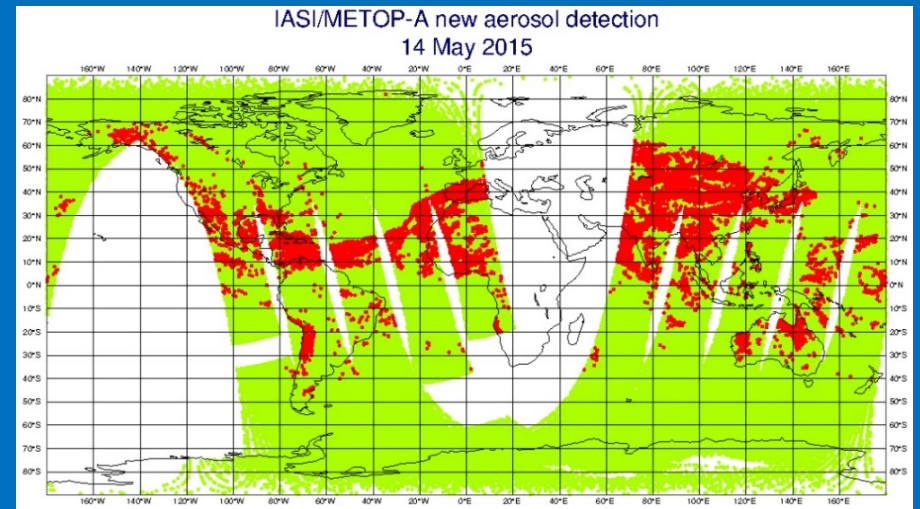
Dust?



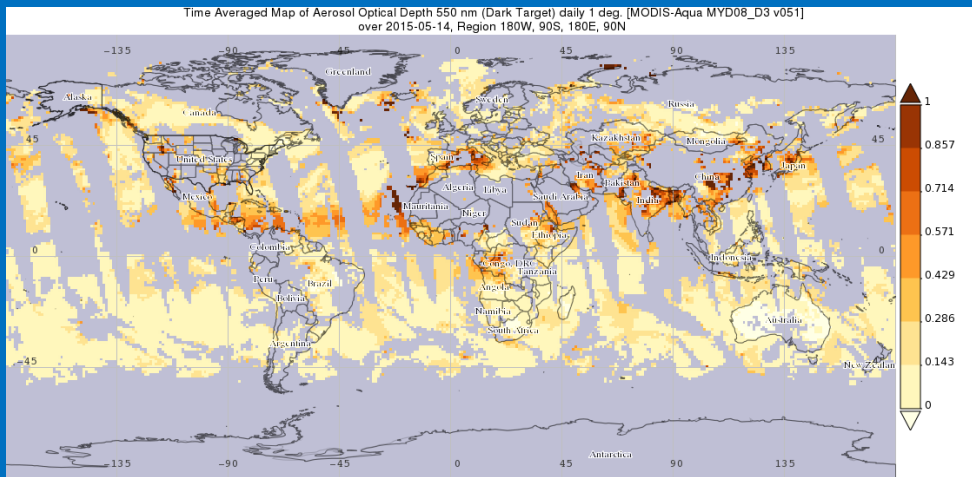
Agreement between IASI detection and MODIS AOD



MODIS TERRA



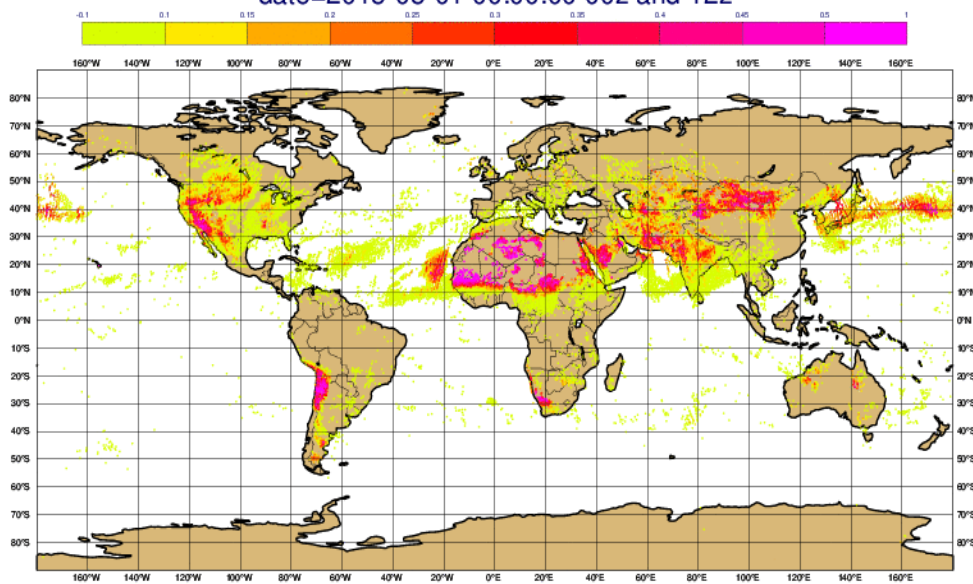
MODIS AQUA



IASI METOP-A

AOD and Altitude estimation for IASI (preliminary results)

Total Aerosol Optical Depth (ECMWF OPS) METOP-A/B IASI
date=2015-05-01 00:00:00 00z and 12z



O-B spectrum in function of AOD

