

Evaluating aerosol impacts on Numerical Weather Prediction in an extreme dust event

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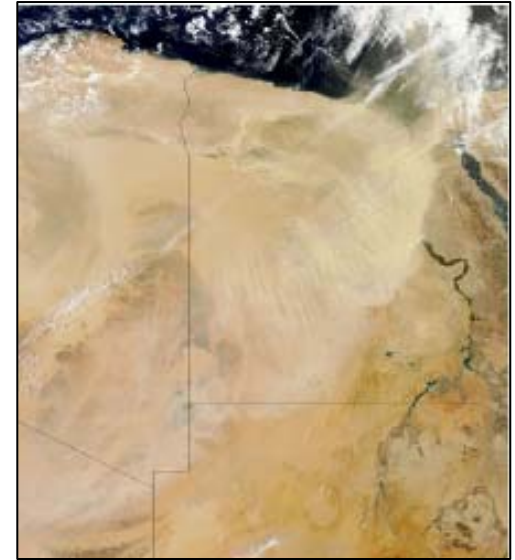
WGNE intercomparison

This intercomparison aims to evaluate the impact of aerosols on Numerical Weather Prediction – deadline : March 2014

Three situations are 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)



MODIS imagery, 18/4/2012

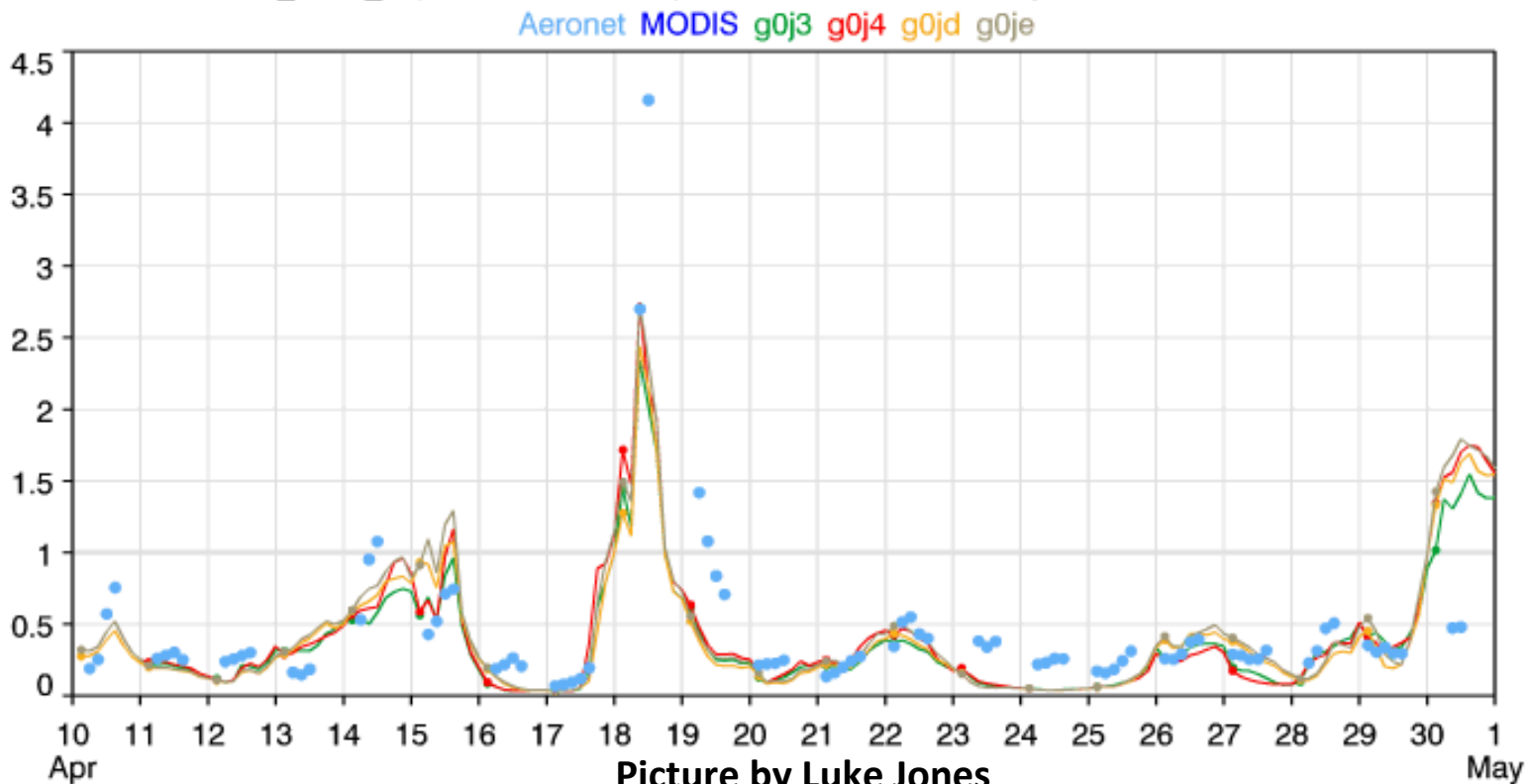


Beijing « airpocalypse », 14/1/2013

Dust case of April 2012 – AOD forecasts

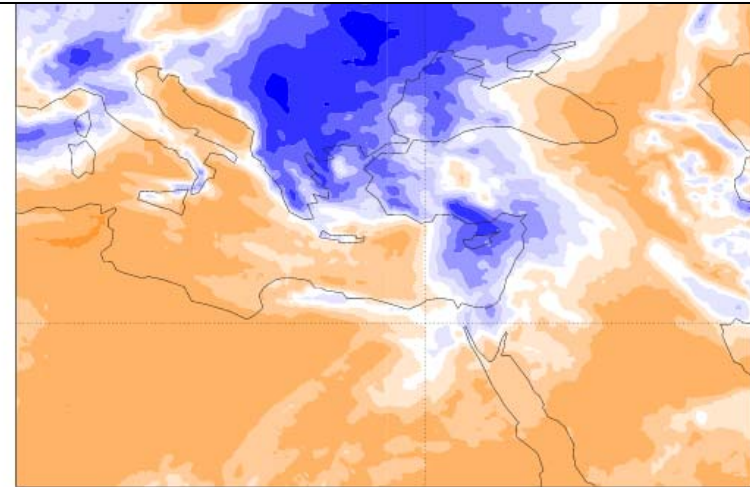
- Cycling forecast with the MACC global system, with (g0j4) / without (g0j3) aerosol direct effect, T511, L60
- Dust bins : 0.03 – 0.55 – 0.9 – 20 μm
- AOD peak of 18th of April well timed – underestimated
- End of the event forecasted too soon

Comparison of g0j3, g0j4, g0jd & g0je and MODIS AOT at 550nm and L1.5 Aeronet AOT at 500nm over Cairo_EMA_2 (30.08°N, 31.29°E). Model: 00UT, 10-30 Apr 2012, T+3 to T+24.



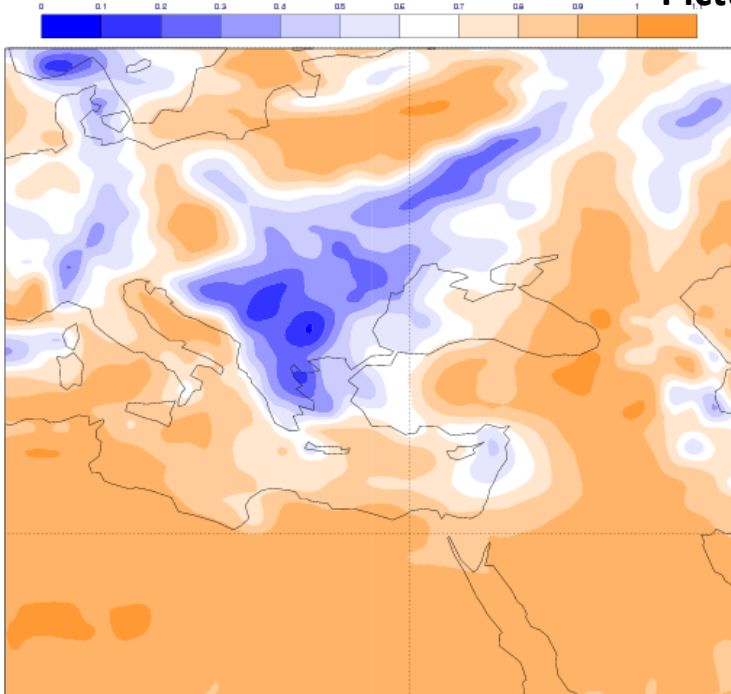
Radiative Impact of aerosols – SW

Comparison of SW downward radiative fluxes on 18/4/2012, normalized by clear-sky value



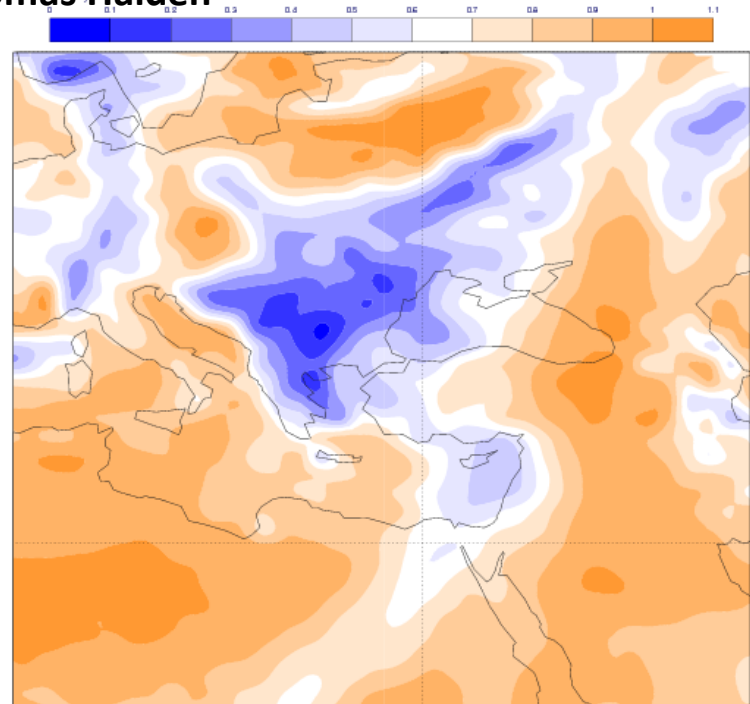
Observations

sis, fcst, 20120418



Without direct effect

Pictures by Thomas Haiden

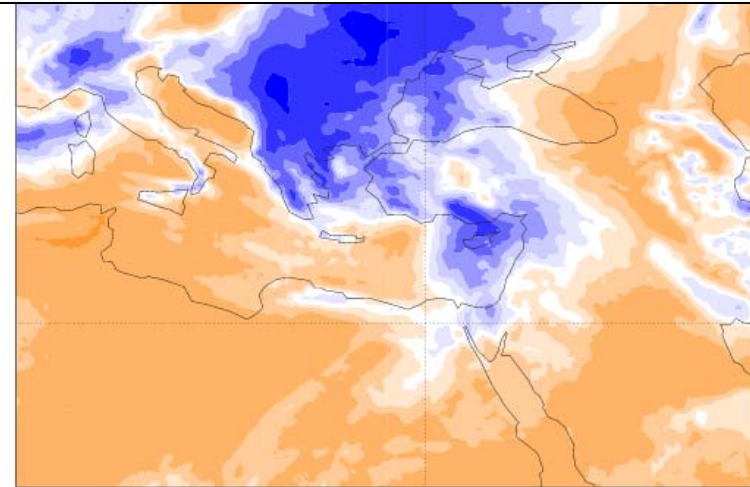


With direct effect

Radiative Impact of aerosols – SW

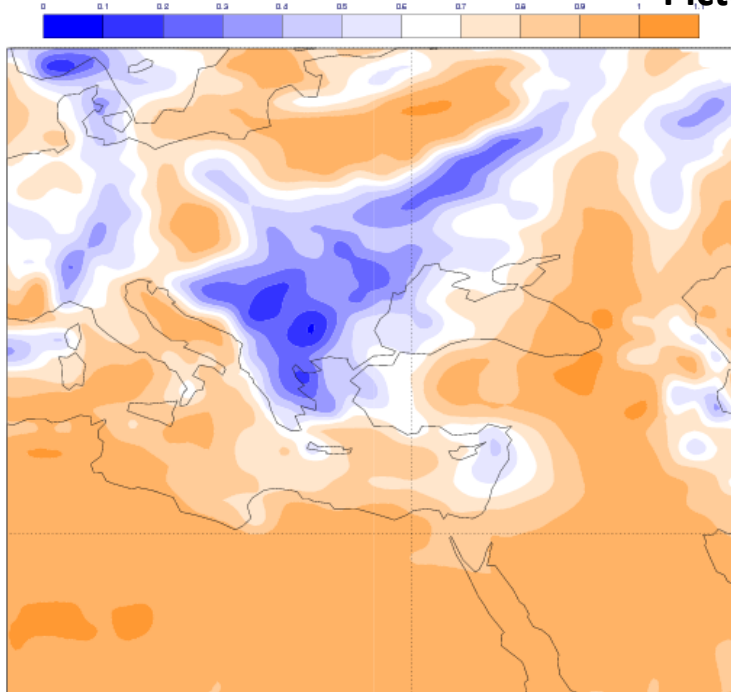
Comparison of SW downward radiative fluxes on 18/4/2012, normalized by clear-sky value

Aerosol direct effect provokes a 15-20% decrease in SW radiation



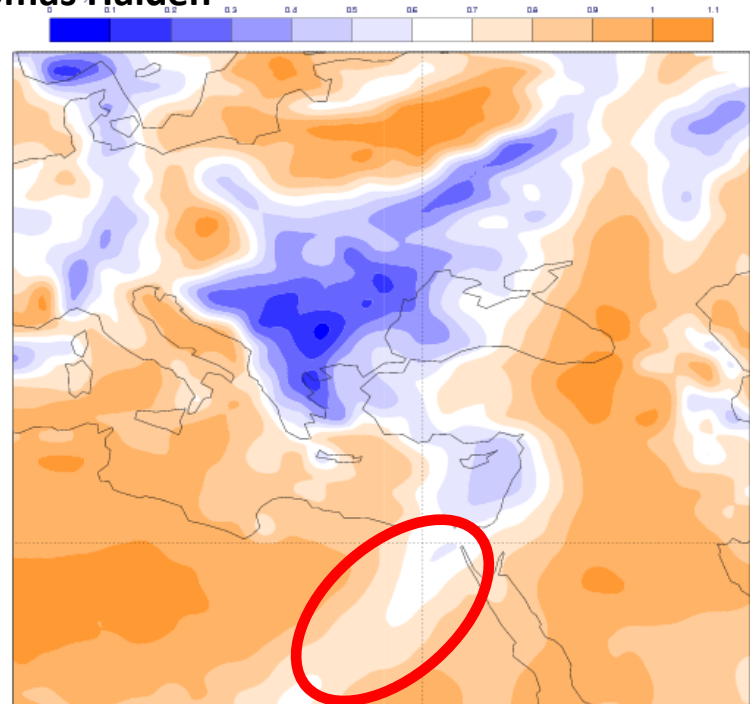
Observations

sis, fcst, 20120418



Without direct effect

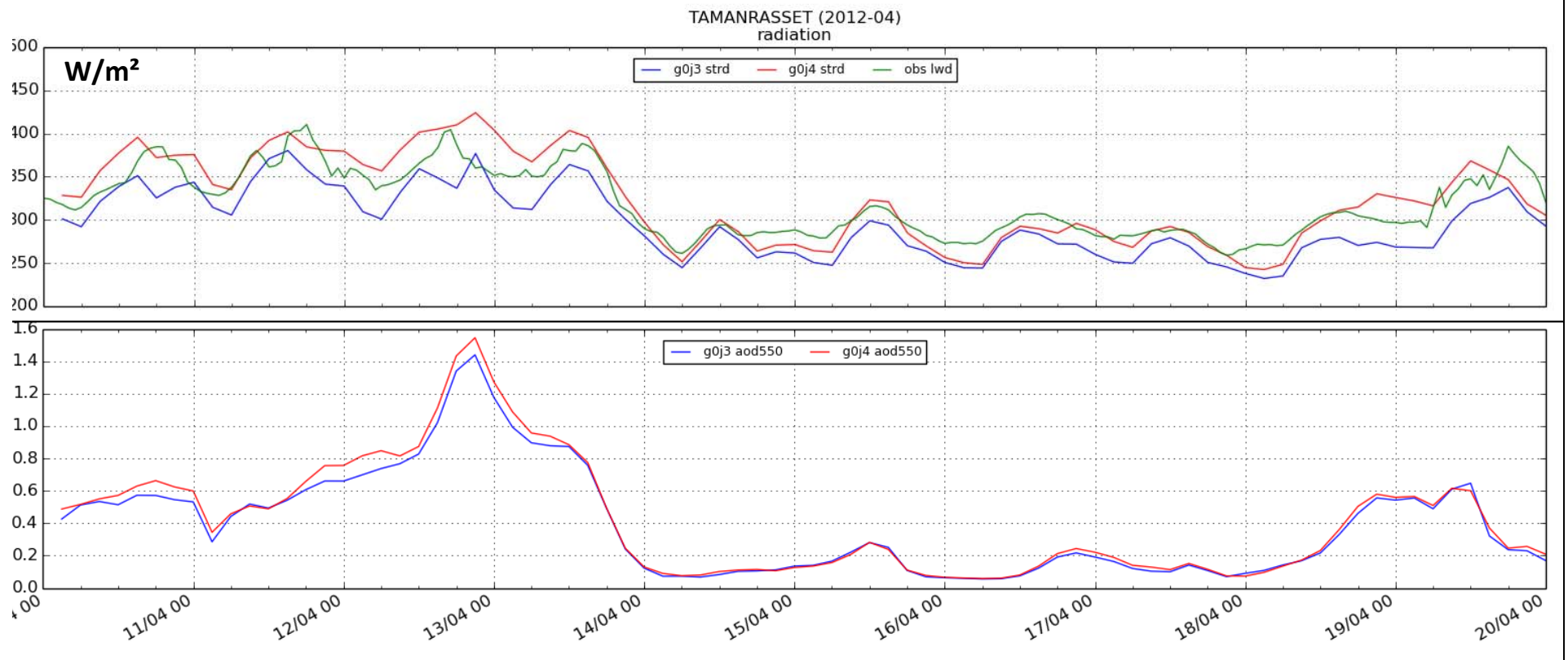
Pictures by Thomas Haiden



With direct effect

Radiative Impact of aerosols – LW

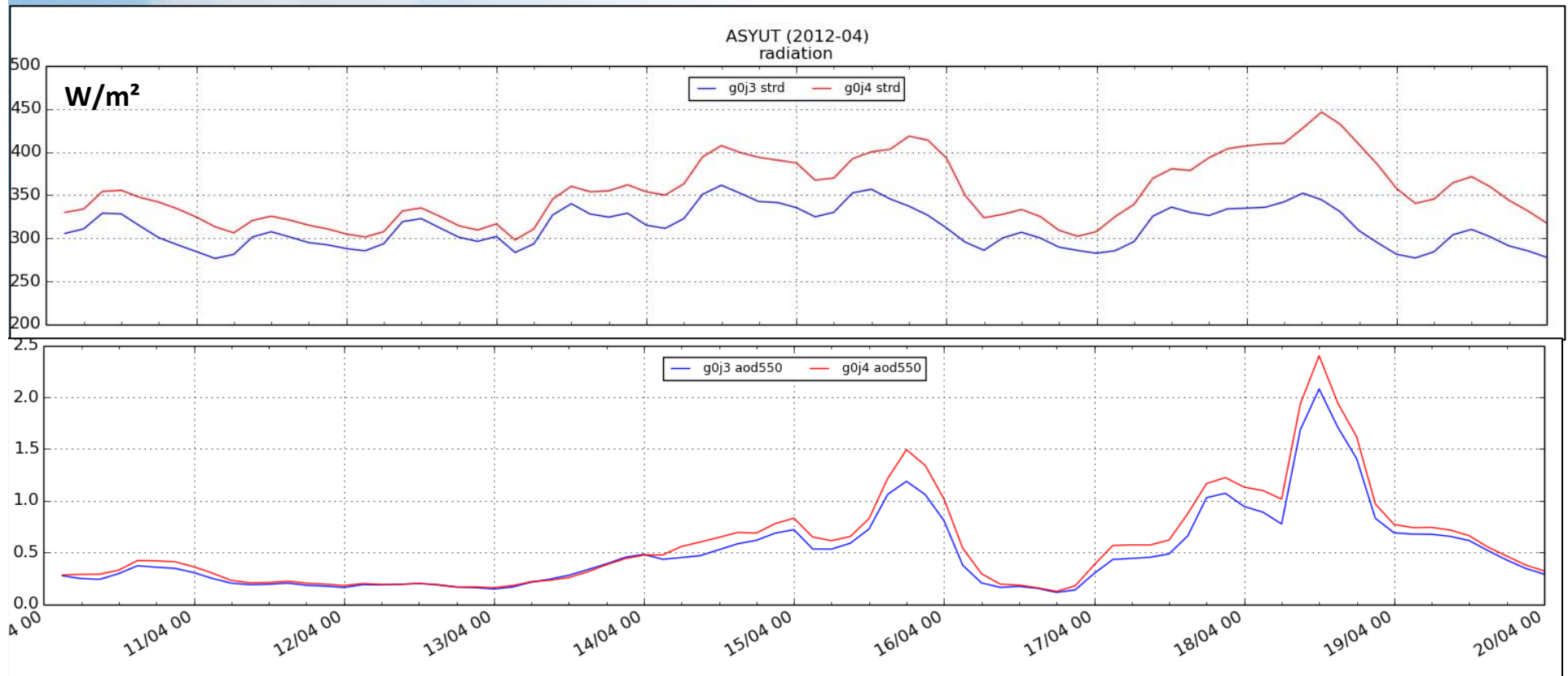
Forecasted (blue = no direct effect, red = direct effect) and observed downward LW radiation at Tamanrasset (Algeria), plus forecasted AOD :



Clear correlation between AOD and the difference between LW fluxes

Radiative Impact of aerosols – LW

Forecasted (blue = no direct effect, red = direct effect) at Asyut (Egypt), plus forecasted AOD :

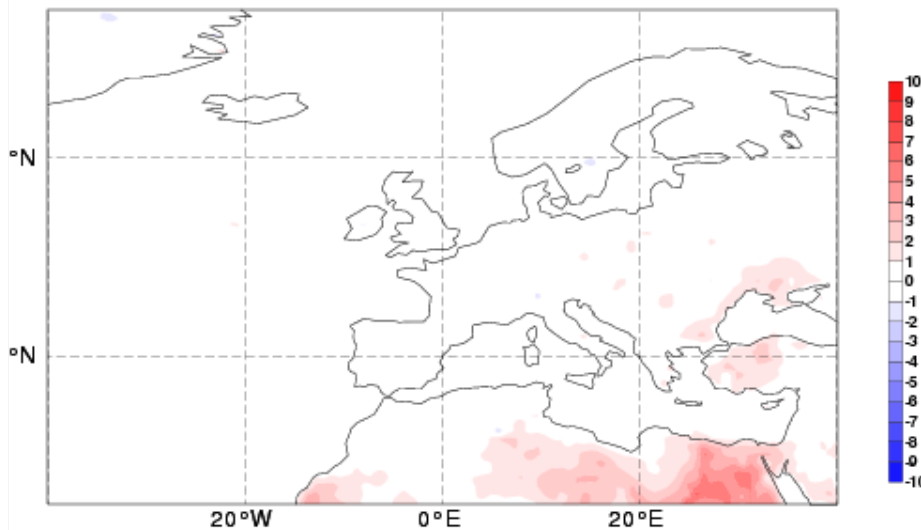


Clear correlation between AOD and the difference between LW fluxes

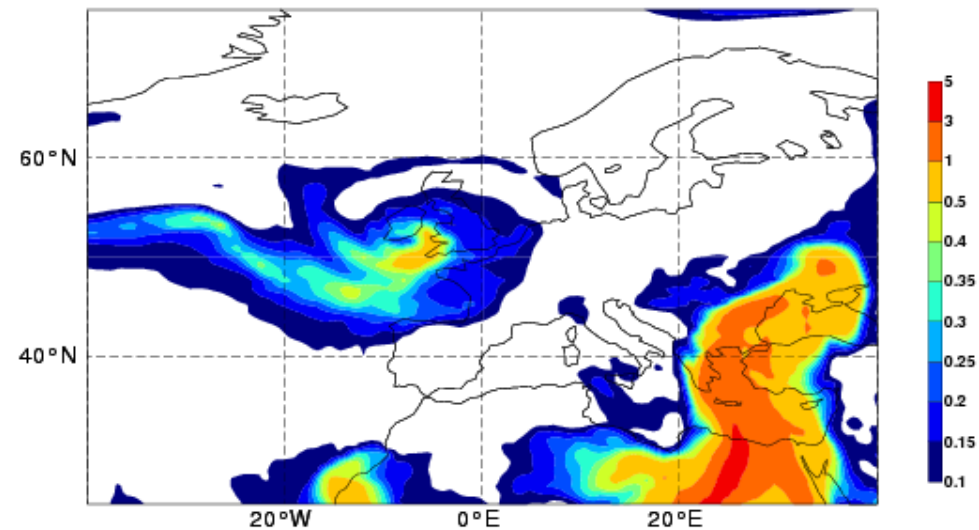
Impact of direct effect on minimum temperatures

- Taking into account the direct effect brings warmer night-time temperatures over land, by up to 4 degrees
- Near-perfect collocation with AOD patterns
- For most stations in desertic area, it reduces a cold bias at night during the 11th to 20th of April 2012 period :
 - Cairo : mean bias from -1 to -0,6K
 - Asyut : mean bias from -0.6K to 0.3K

T2m g0j4-g0j3 VT: 2012-04-18 00UTC



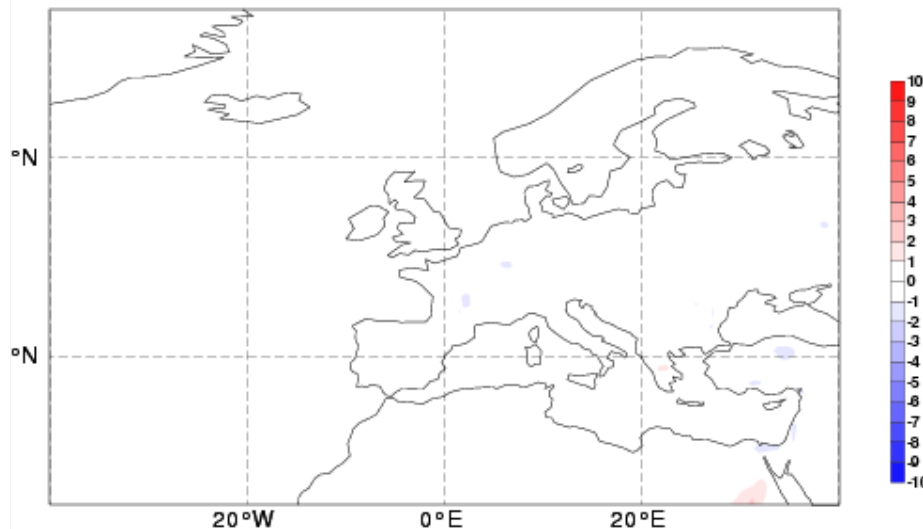
AOD550 g0j4 VT: 2012-04-18 00UTC



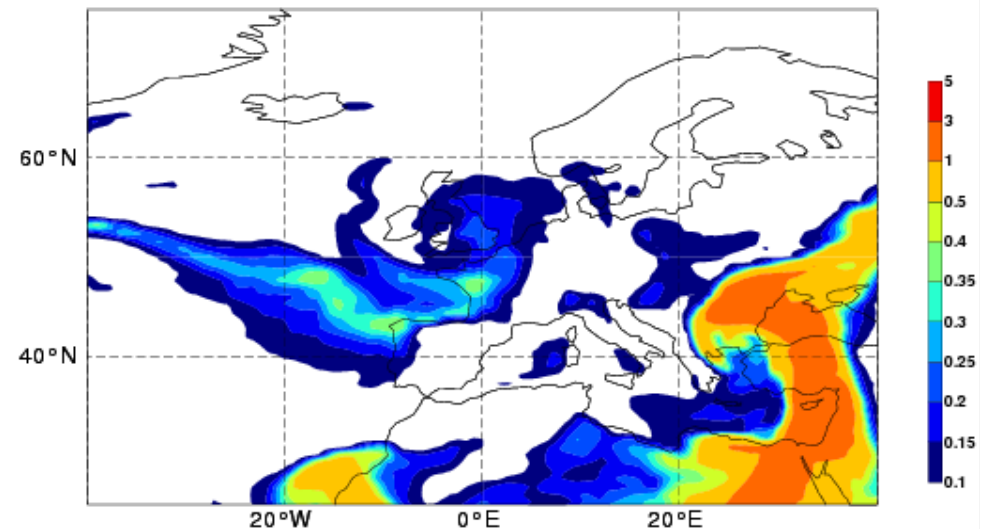
Impact of direct effect on maximum temperatures

- Not much impact of the reduced SW fluxes
- Probably hidden by the important warming of minimal temperatures caused by the larger downward LW fluxes

T2m g0j4-g0j3 VT: 2012-04-18 12UTC

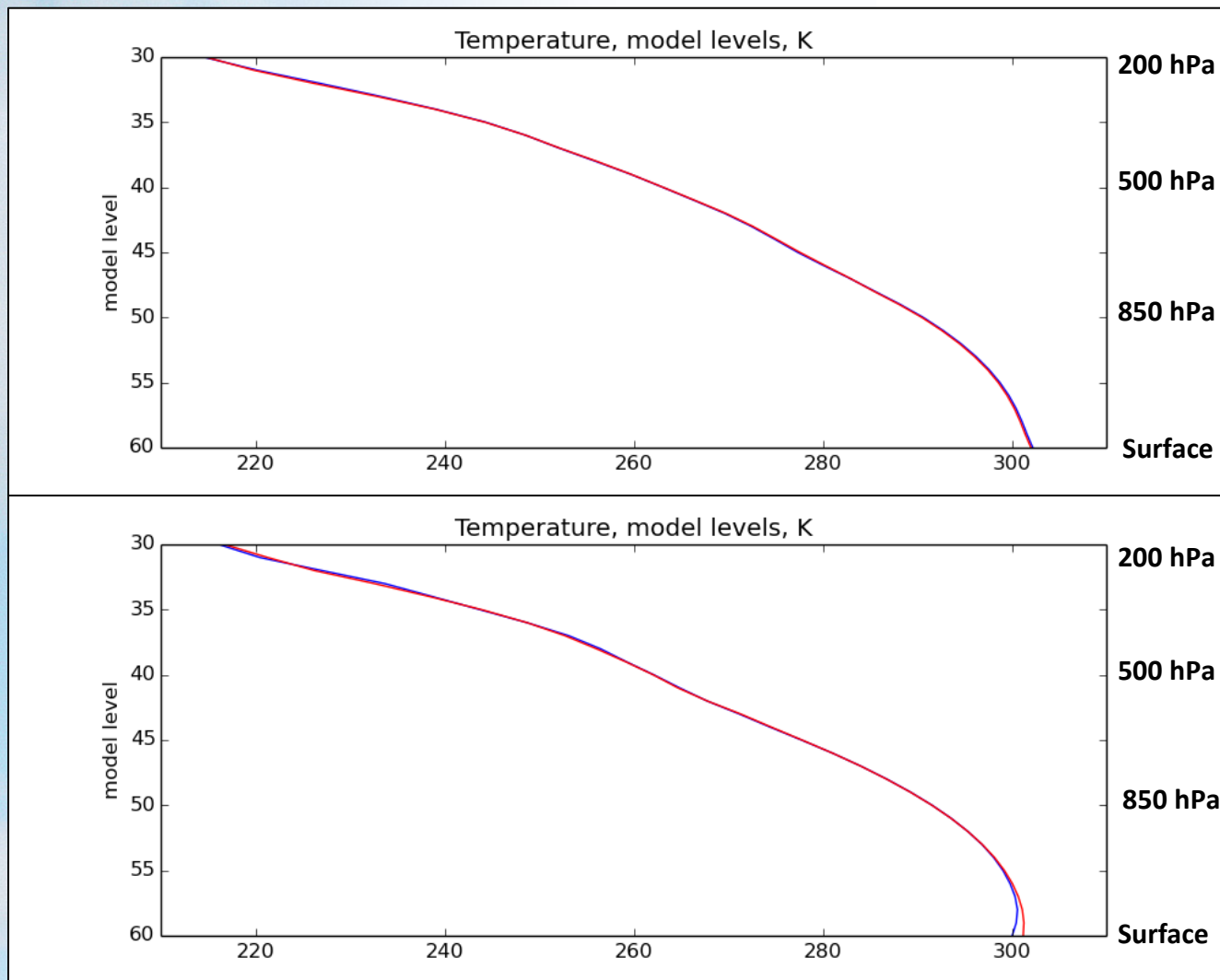


AOD550 g0j4 VT: 2012-04-18 12UTC



Impact of direct effect on temperature profiles

Forecasted (blue = no direct effect, red = direct effect) temperature profile at Tamanrasset (Algeria), 11/4/2012, 12UTC (top), 21UTC (bottom)



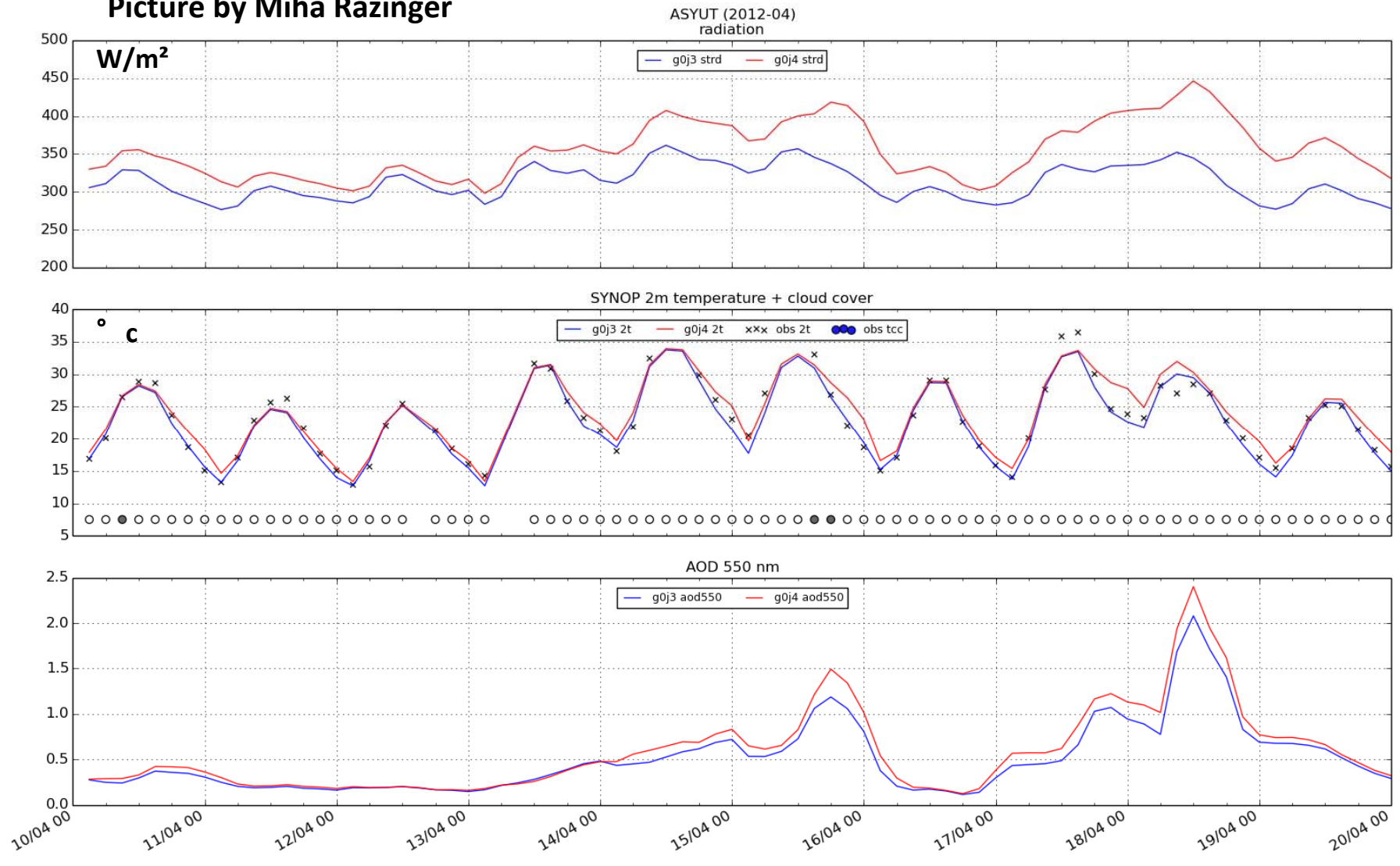
Impact mainly in the lower atmosphere

Aerosol – Meteorology feedback

blue = no direct effect, red = direct effect

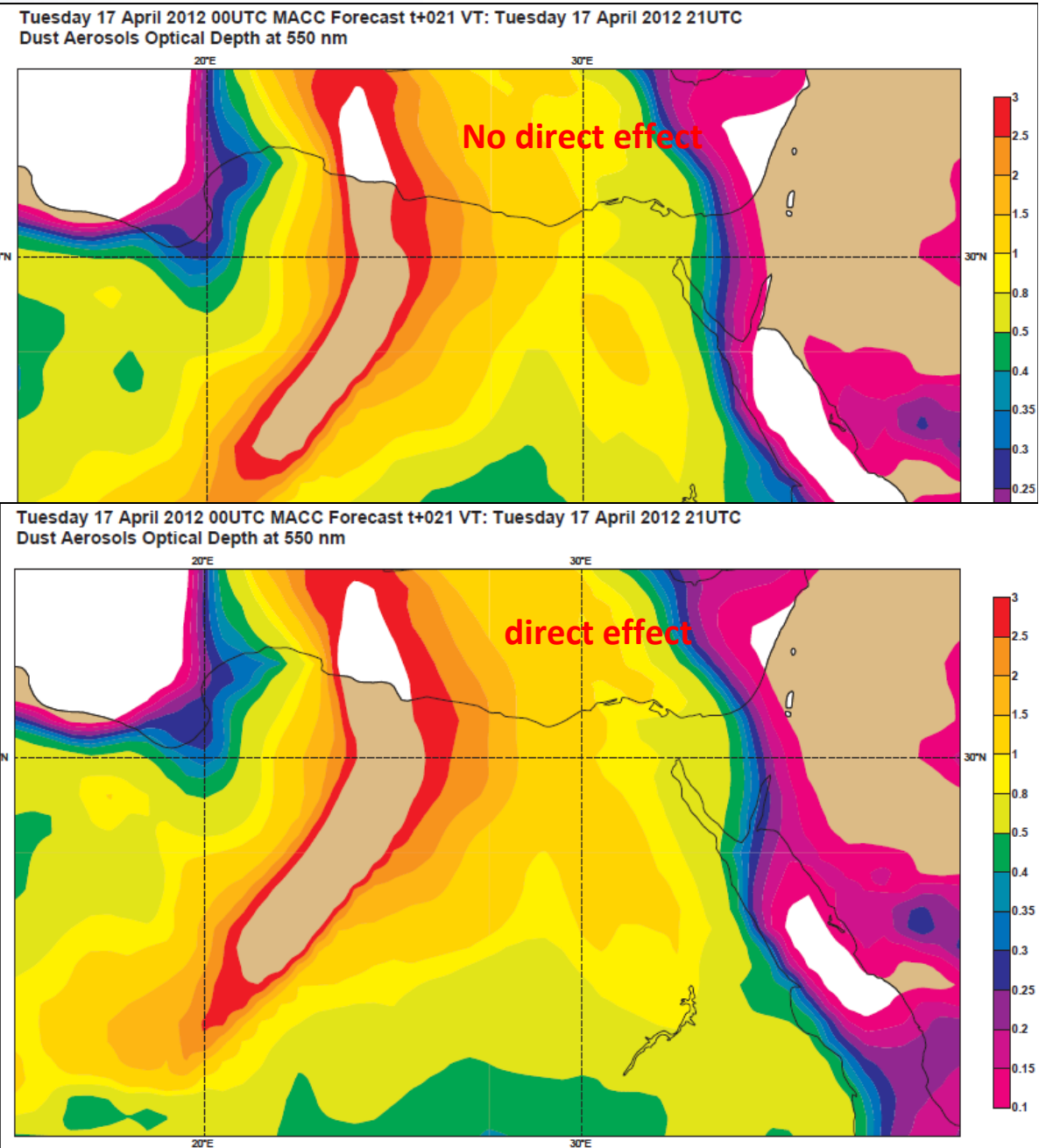
Taking into account the aerosol direct effect brings higher AOD – why?

Picture by Miha Razinger



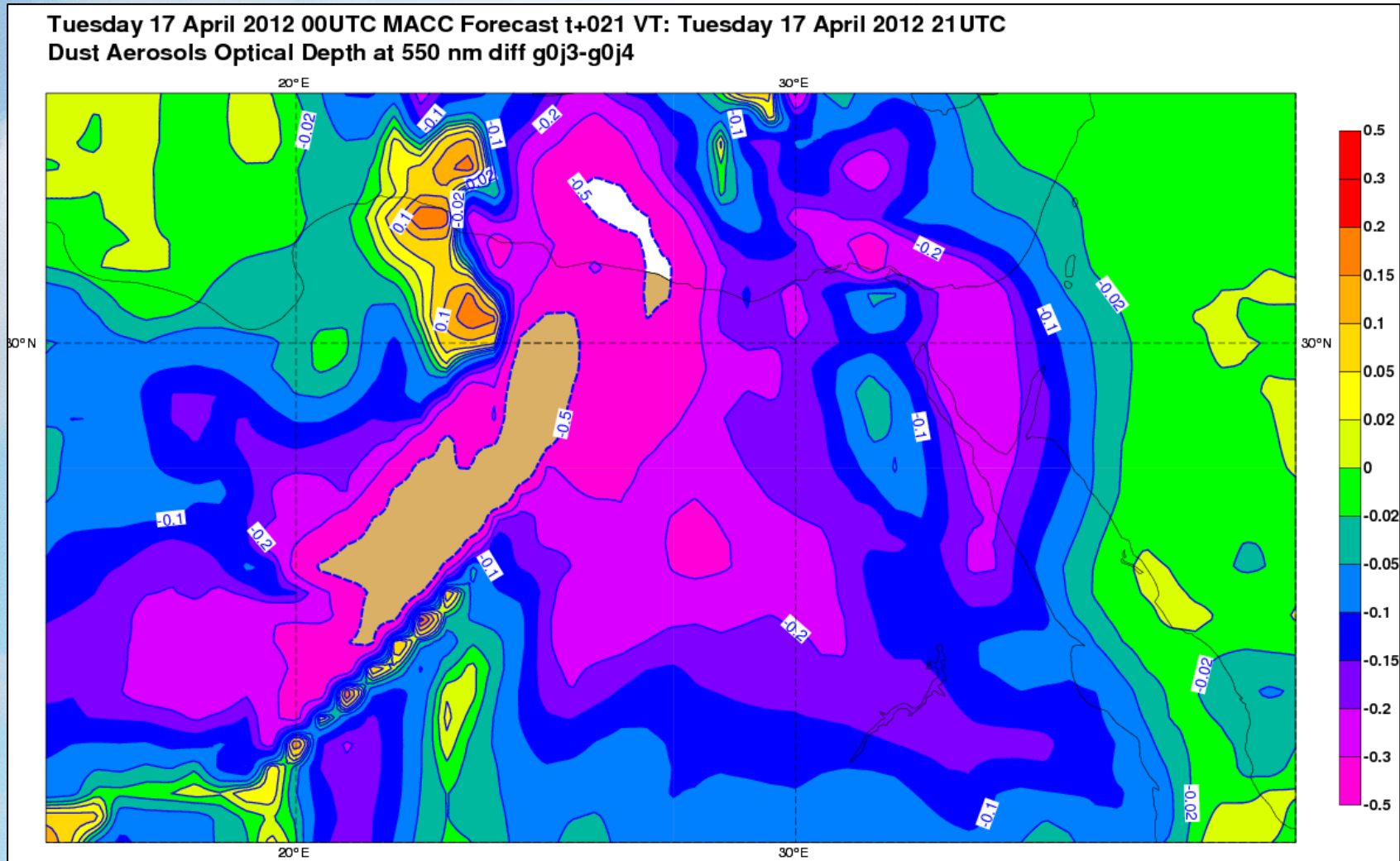
Comparison of the dust AOD

- Comparison on 17/4/2012 at 21UTC, simulation starting at 0UTC
- AODs are larger when taking into account the direct effect



Comparison of the dust AOD

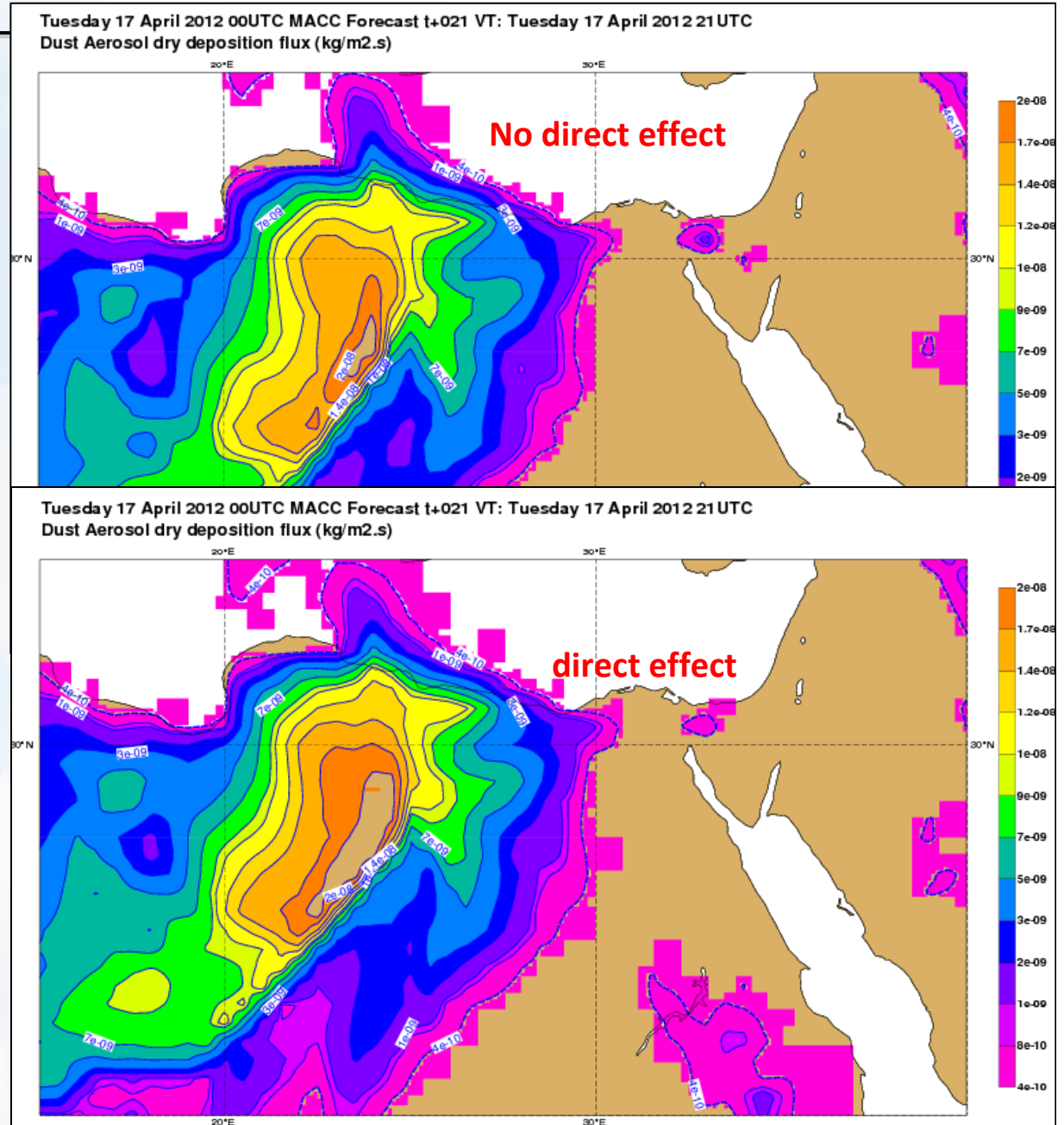
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AOD with no direct effect – AOD with direct effect

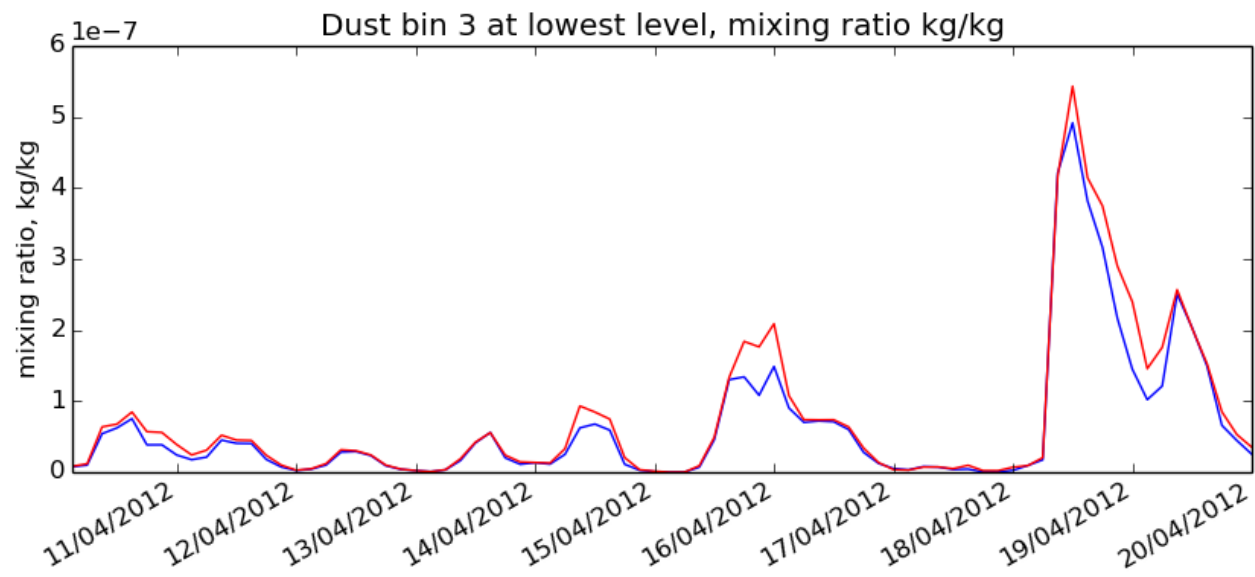
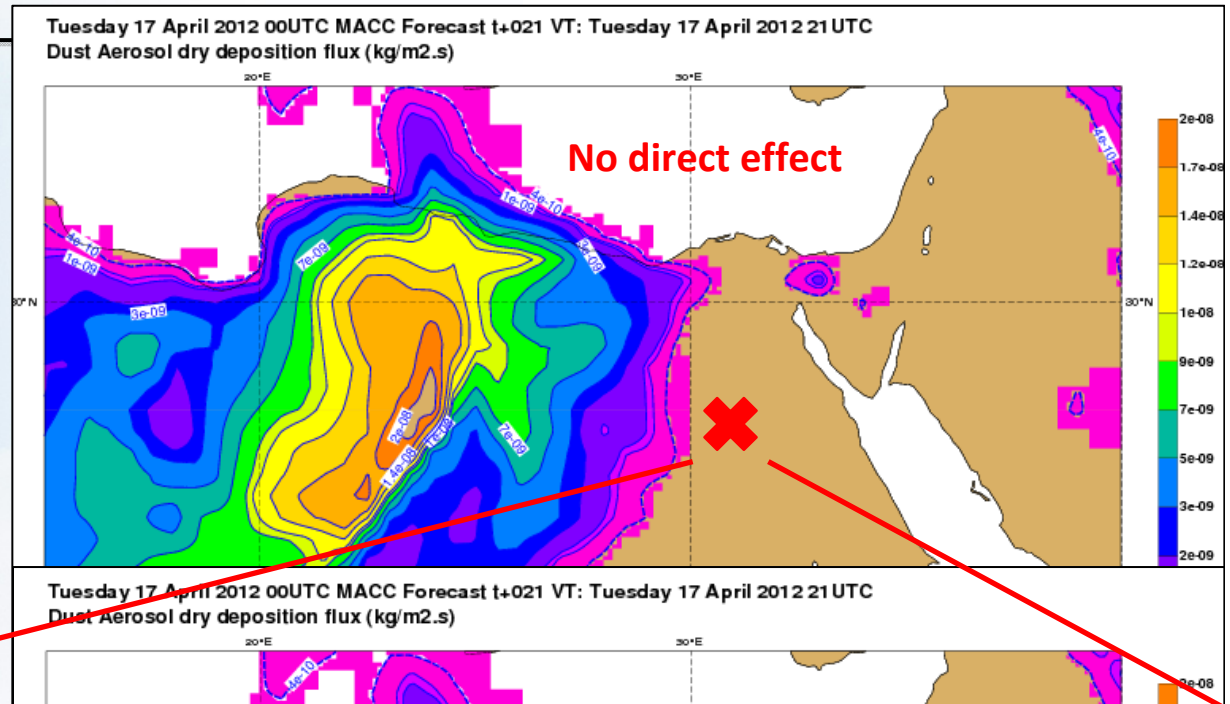
Comparison of the aerosol sinks

- Sedimentation is very small compared to dry deposition in this situation
- No scavenging (no rain)
- Dry deposition is larger when taking into account the direct effect



Comparison of the aerosol sinks

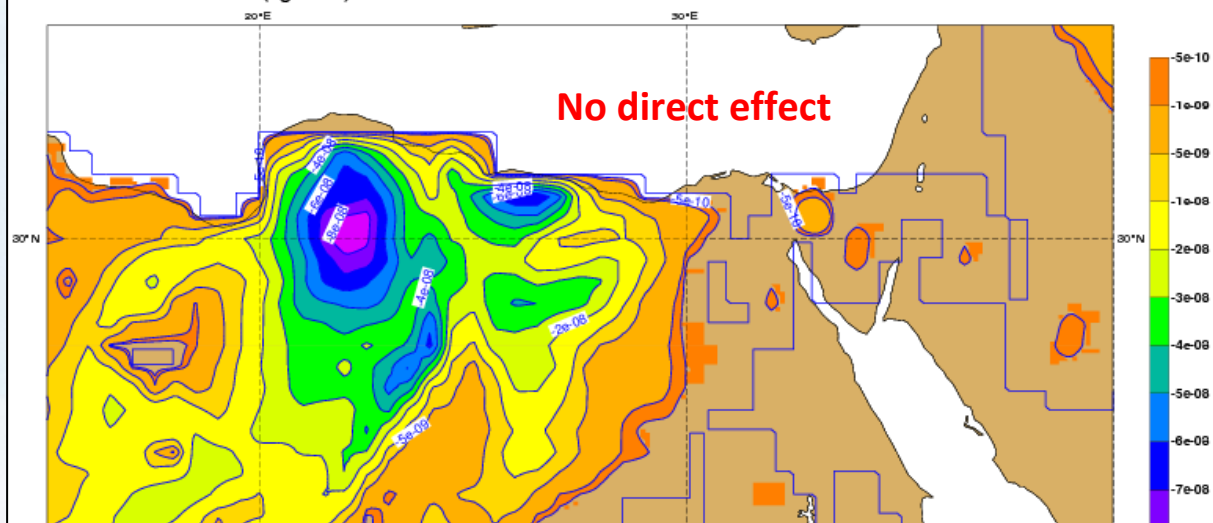
- Sedimentation is very small compared to dry deposition in this situation
- No scavenging (no rain)
- Dry deposition is larger when taking into account the direct effect **because dust mixing ratio at the lowest level is larger for the three bins**



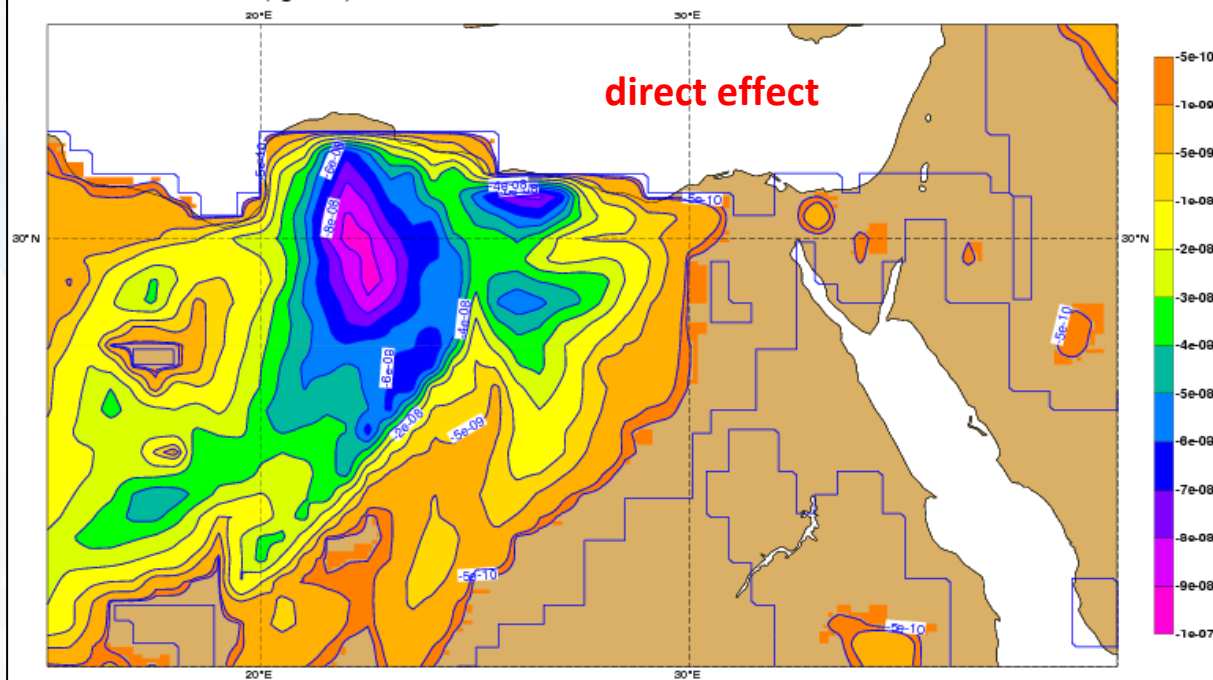
Comparison of the aerosol sources

Aerosol (ie dust) sources are much larger when taking into account the direct effect

Tuesday 17 April 2012 00UTC MACC Forecast t+021 VT: Tuesday 17 April 2012 21UTC
Dust Aerosol sources (kg/m².s)

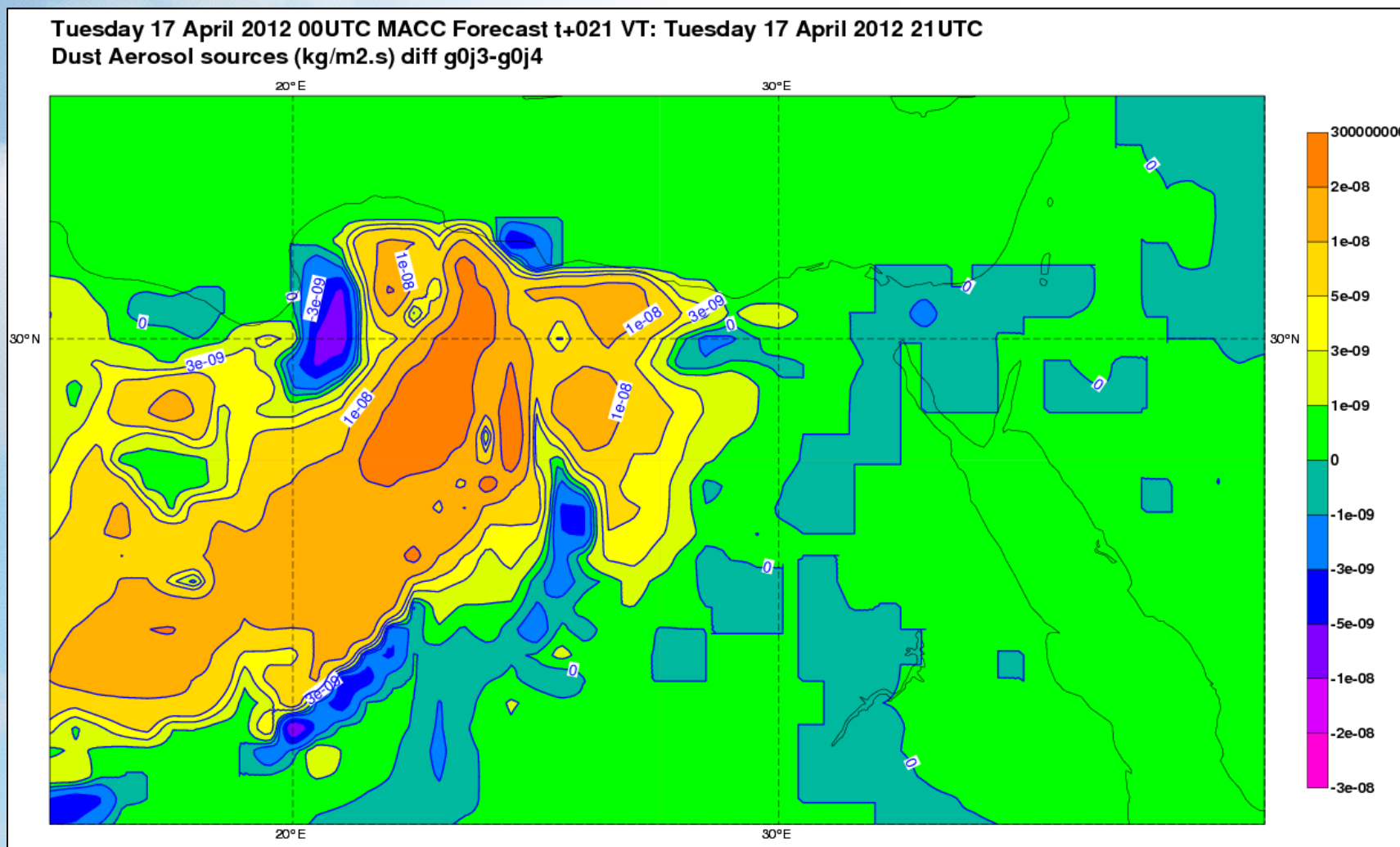


Tuesday 17 April 2012 00UTC MACC Forecast t+021 VT: Tuesday 17 April 2012 21UTC
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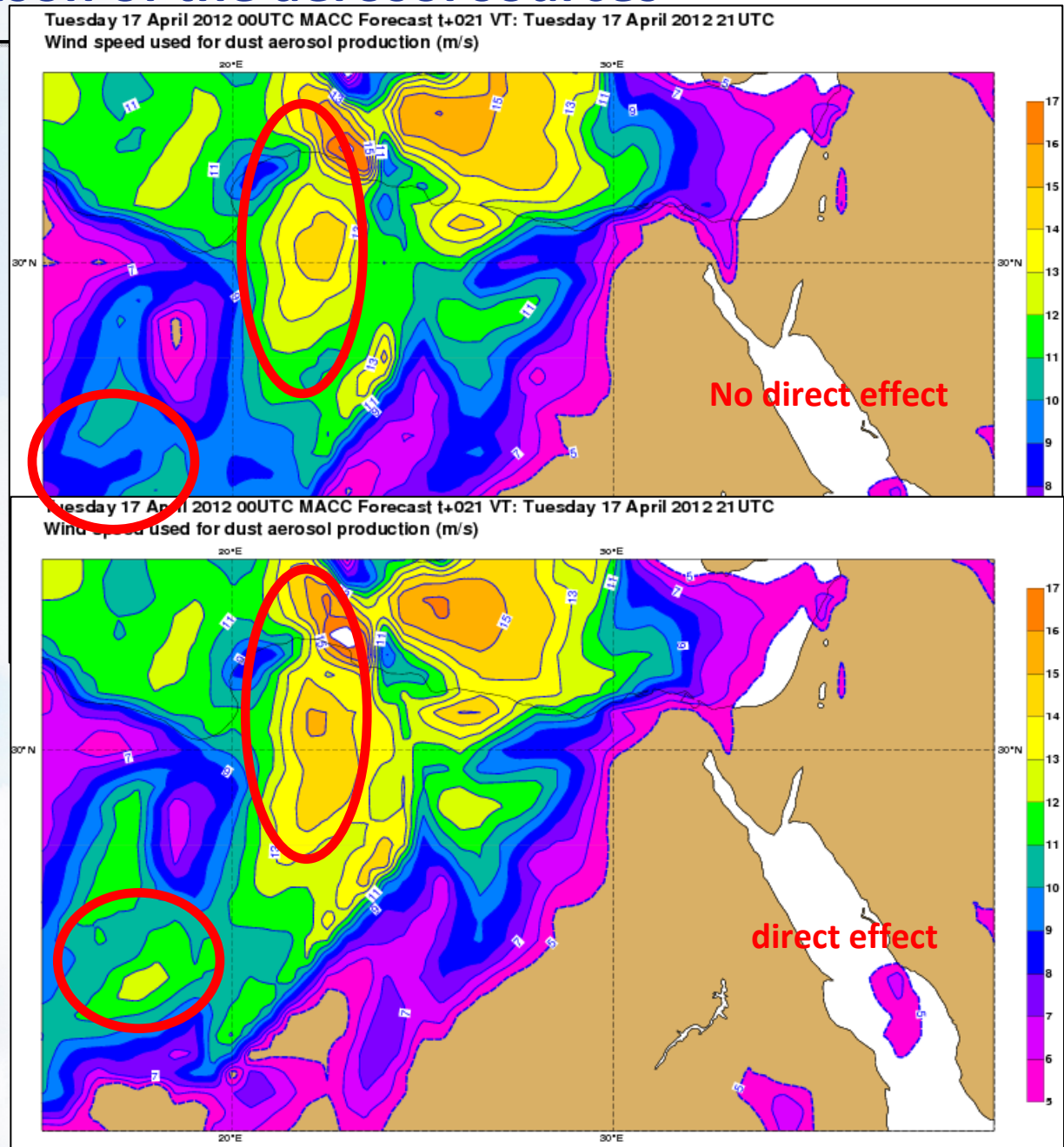


Dust sources with no direct effect – Dust sources with direct effect

Comparison of the aerosol sources

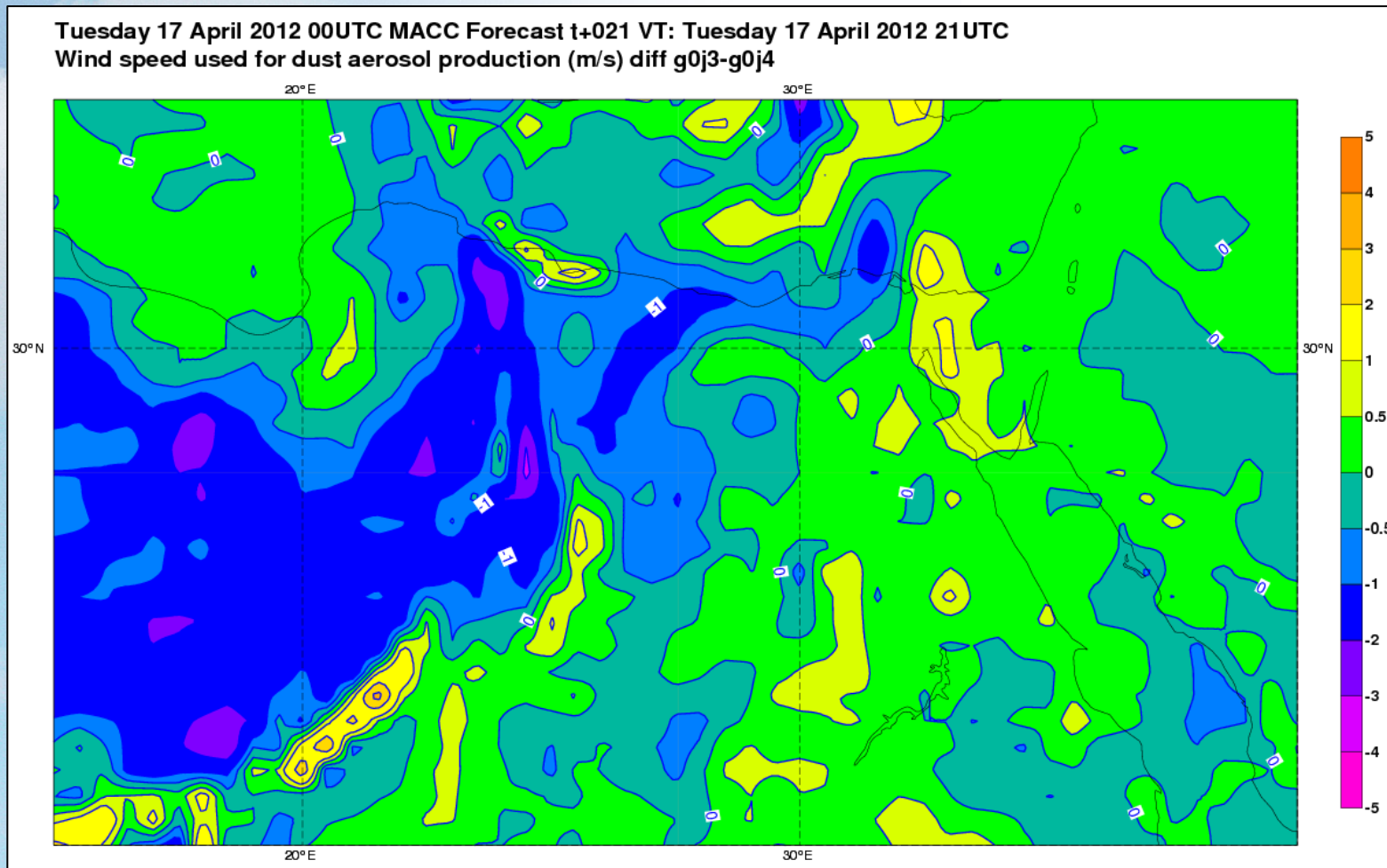
... Because 10m wind speed is larger when taking into account the direct effect

A small increase in 10m wind speed brings a large increase in dust aerosol production through saltation (power 3 dependency to 10m wind speed)



Comparison of the aerosol sources

... Because 10m wind speed is larger when taking into account the direct effect
A small increase in 10m wind speed brings a large increase in dust aerosol production through saltation (power 3 dependency to 10m wind speed)



10m wind speed with no direct effect – 10m wind speed with direct effect

Comparison of sea-level pressure

Heat low is slightly deeper over land when taking into account the direct effect, probably because of higher night-time temperatures

