



**Barcelona  
Supercomputing  
Center**

*Centro Nacional de Supercomputación*



EXCELENCIA  
SEVERO  
OCHOA

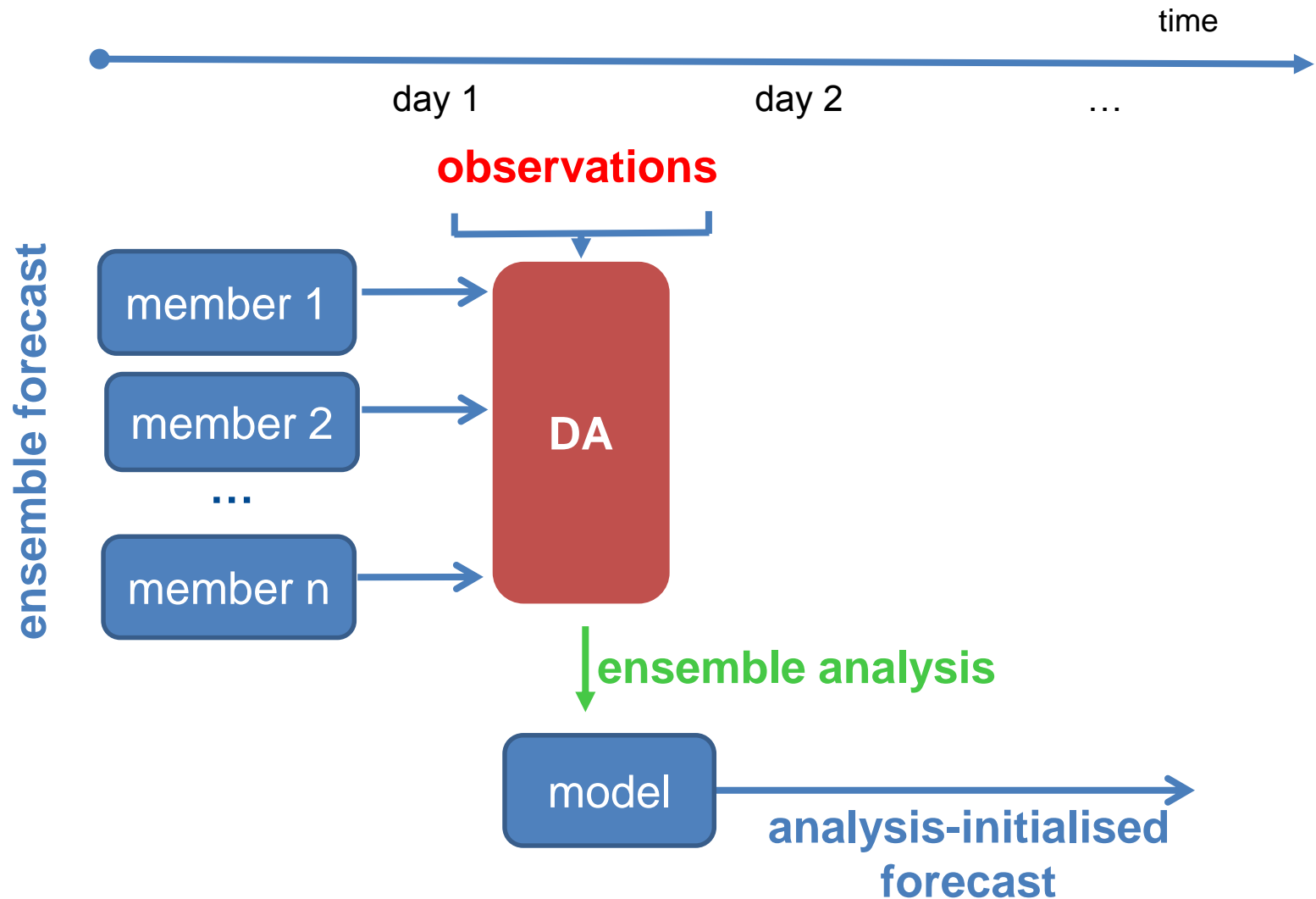
# Data assimilation in dust models

## Part 2: Practical example and diagnostic tools

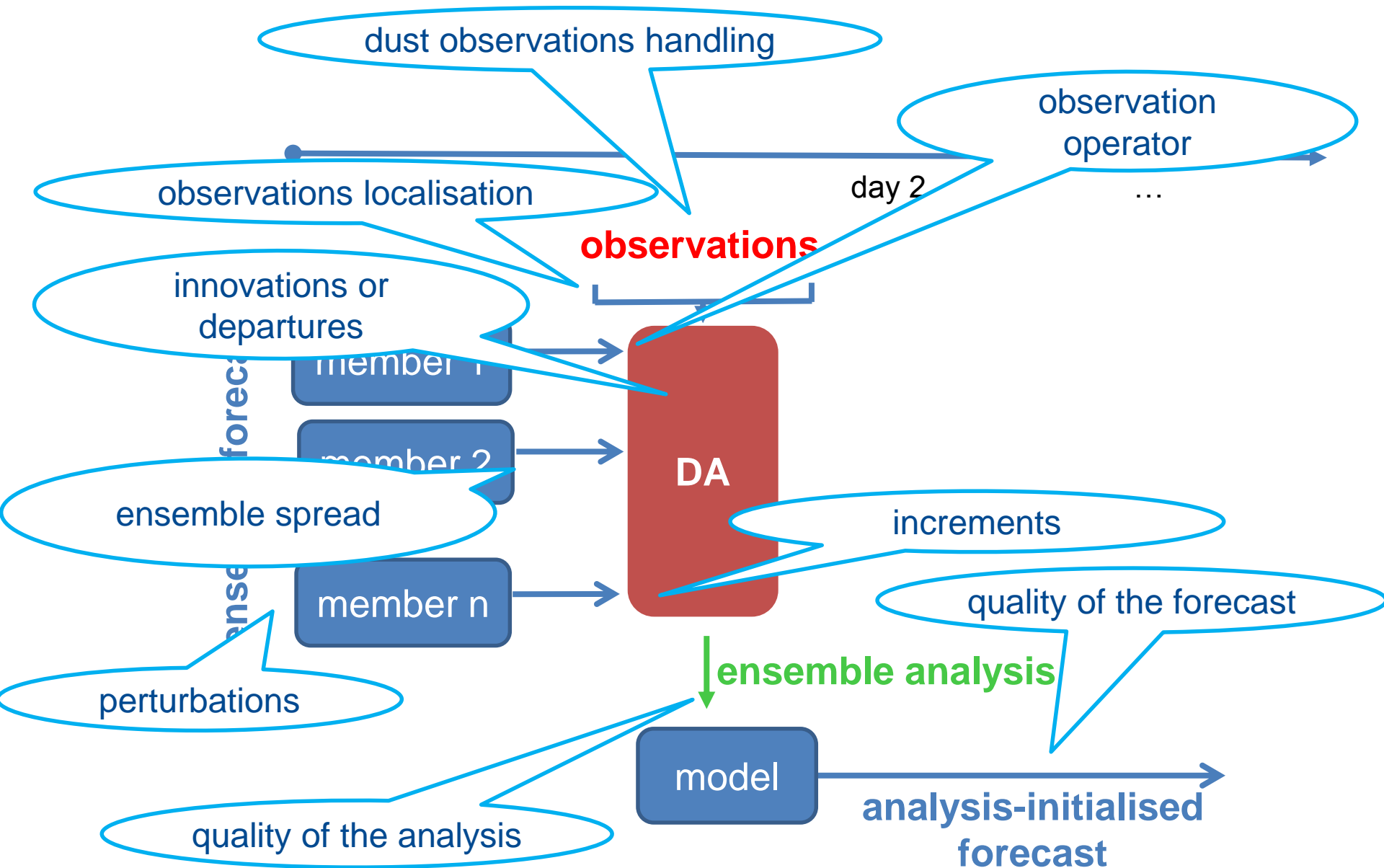
Enza Di Tomaso  
Earth Sciences Department



# Where we were



# A lot of new jargon





# A mineral dust application

# Recap: iterative approach

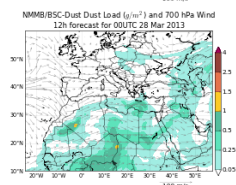
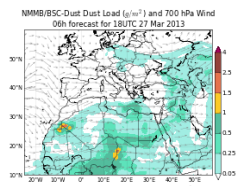
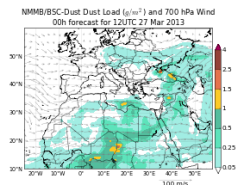
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day = 2

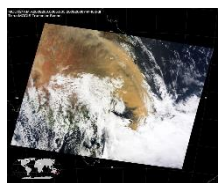
ensemble background  
(short-term forecast)

ensemble analysis  
(initial conditions)

ensemble background  
(short-term forecast)

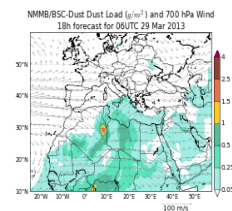
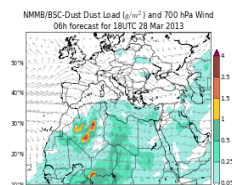
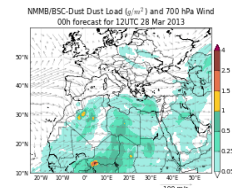


Observations

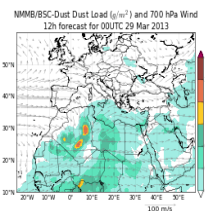


<http://modis-atmos.gsfc.nasa.gov/>

LETKF

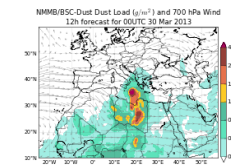
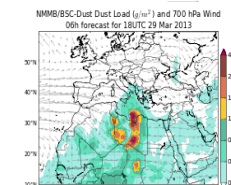
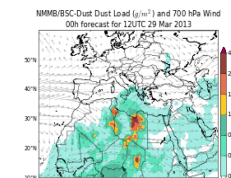


mean analysis  
(initial conditions)

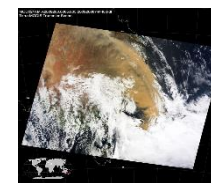


NMMB/BSC-Dust

NMMB/BSC-Dust



Observations

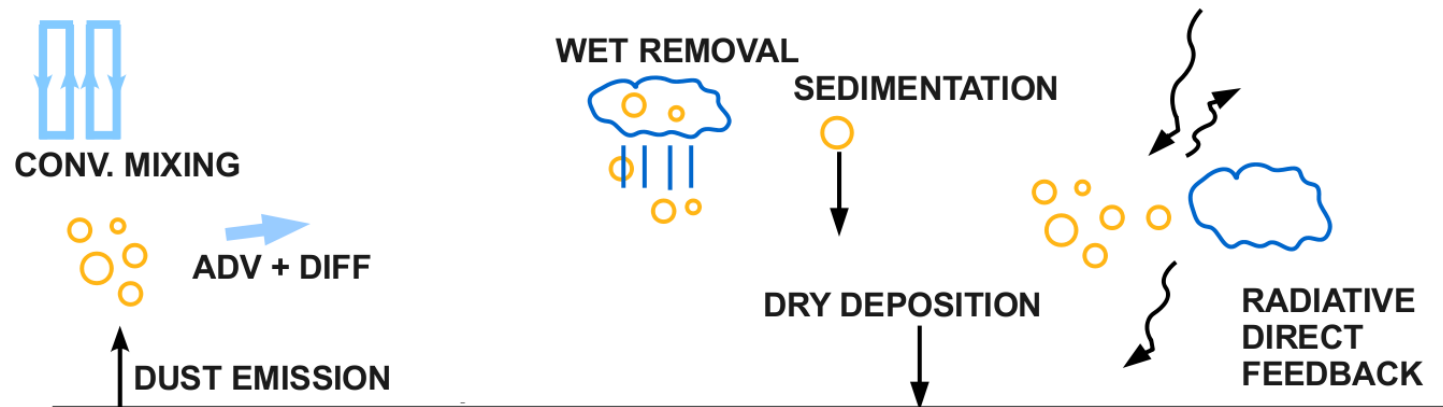


<http://modis-atmos.gsfc.nasa.gov/>

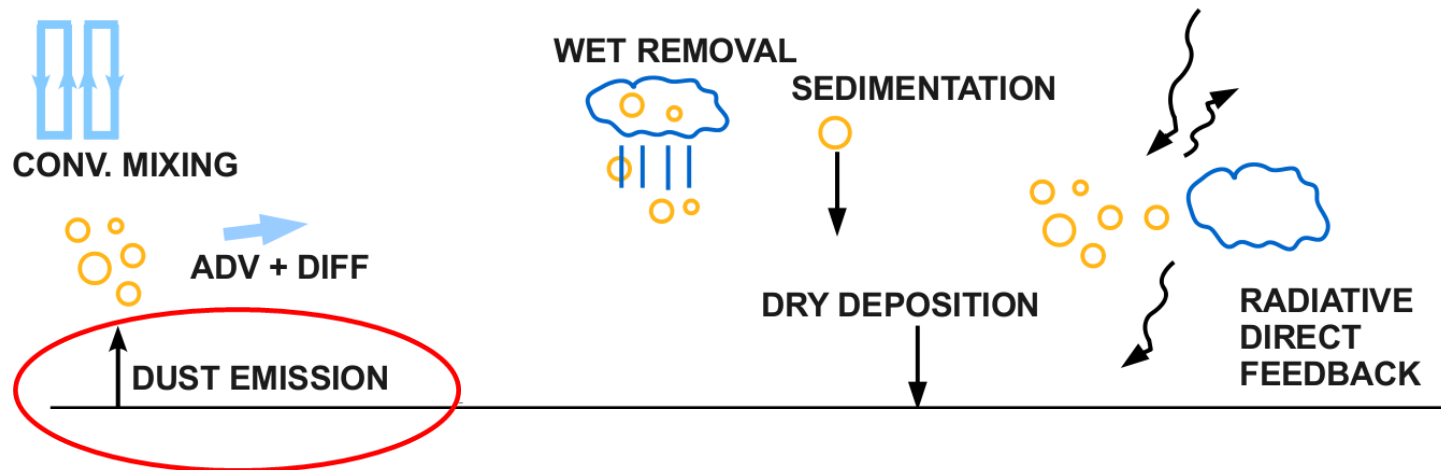
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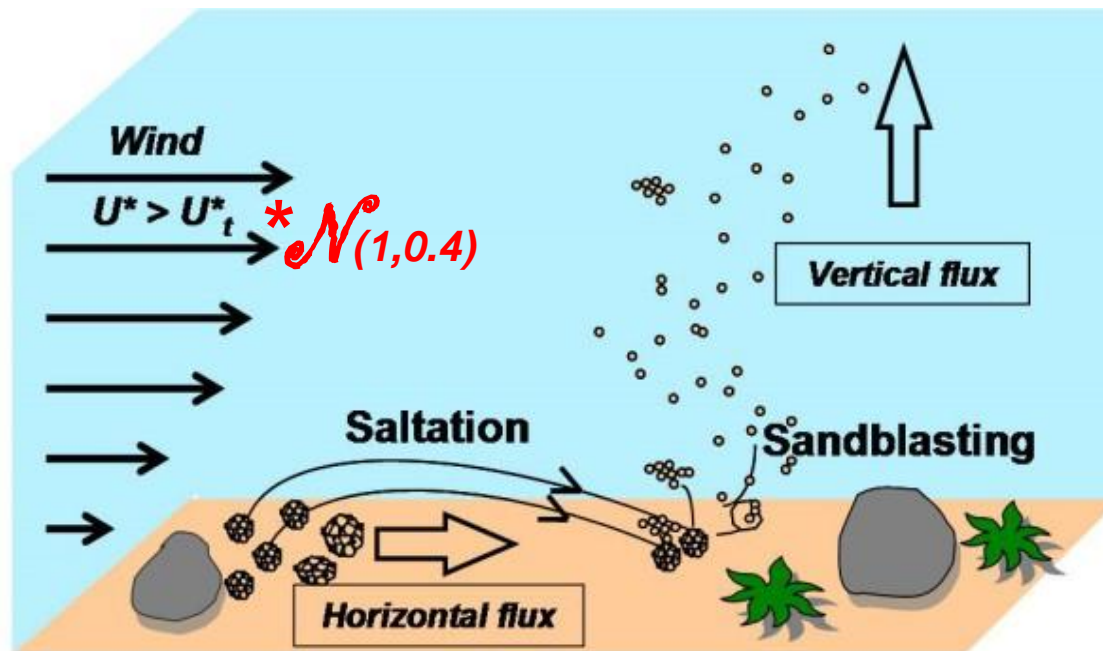
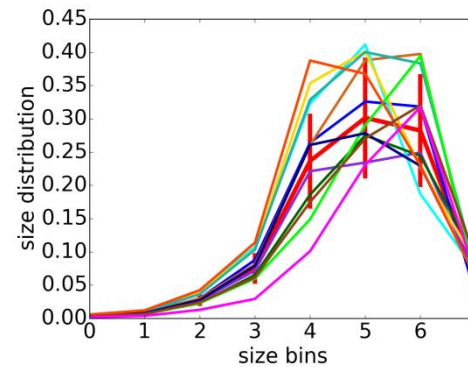
long-term dust forecast

The ensemble forecast is based on some known uncertainties in the dust emission scheme: vertical flux, size distribution at emission, threshold on friction velocity



The ensemble forecast is based on some known uncertainties in the dust emission scheme: vertical flux, size distribution at emission, threshold on friction velocity





(LISA website)

ensemble forecast

member 1

member 2

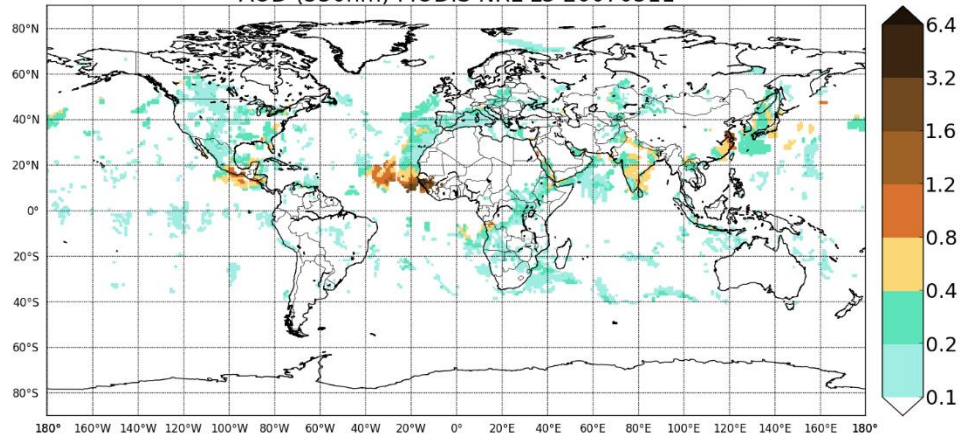
...

member n



## Aerosol Optical Depth

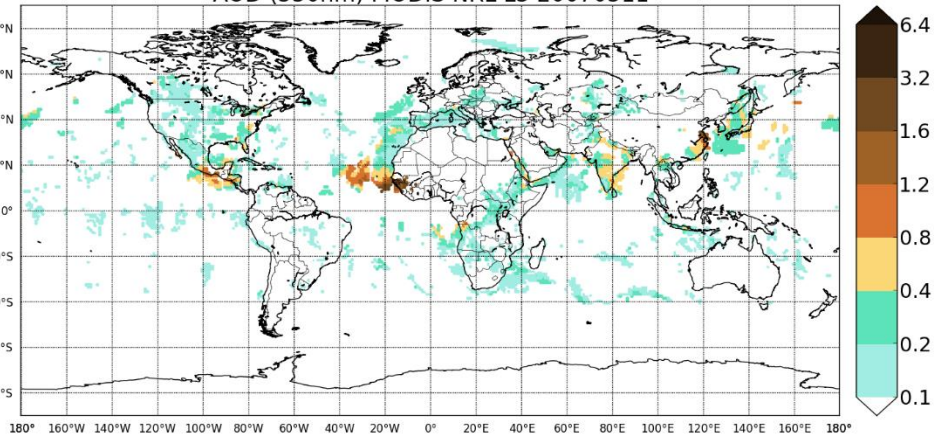
AOD (550nm) MODIS NRL L3 20070511



# Observations and uncertainty

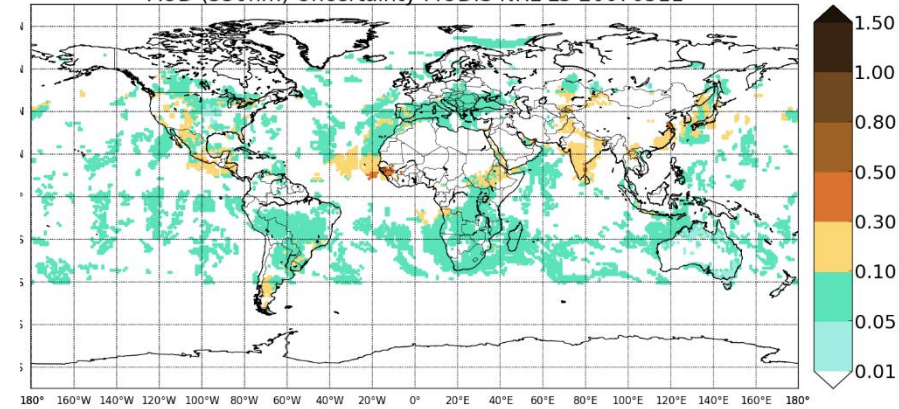
## Aerosol Optical Depth

AOD (550nm) MODIS NRL L3 20070511



## Uncertainty

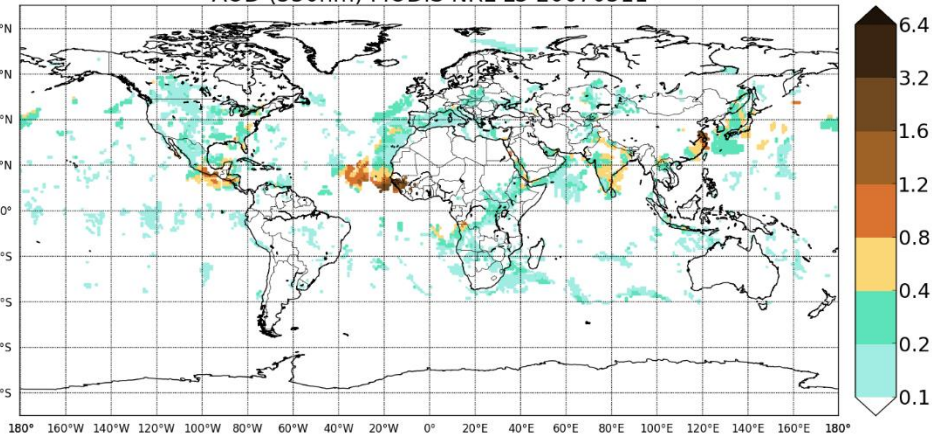
AOD (550nm) Uncertainty MODIS NRL L3 20070511



# Observations and uncertainty

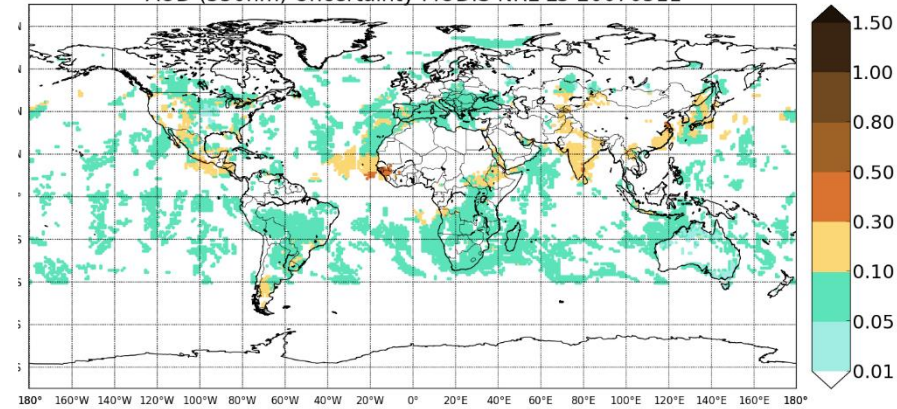
## Aerosol Optical Depth

AOD (550nm) MODIS NRL L3 20070511



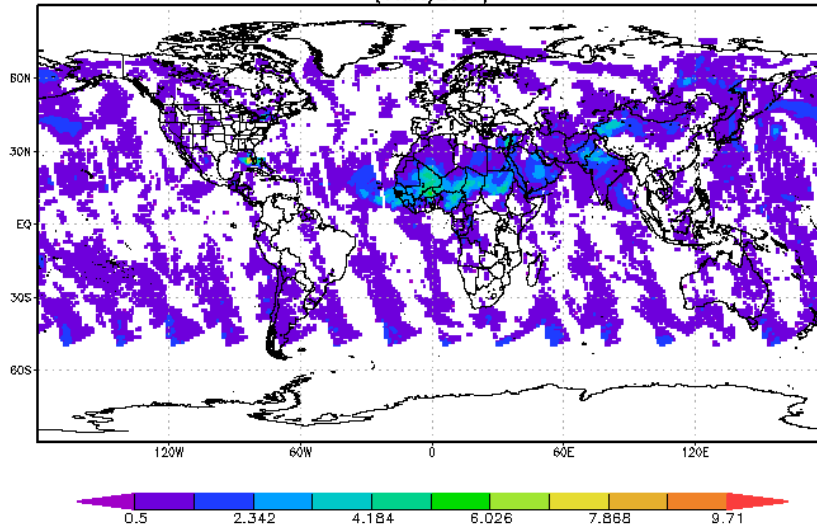
## Uncertainty

AOD (550nm) Uncertainty MODIS NRL L3 20070511



## OMI Aerosol Index

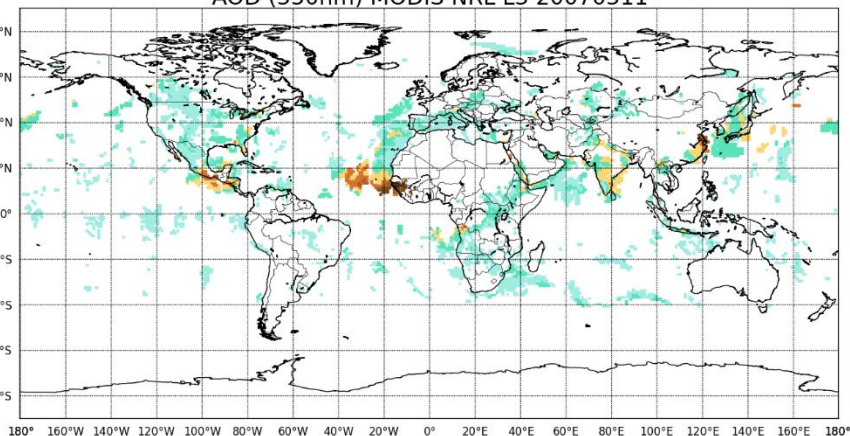
OMT03d.003 UV Aerosol Index [unitless]  
(11May2007)





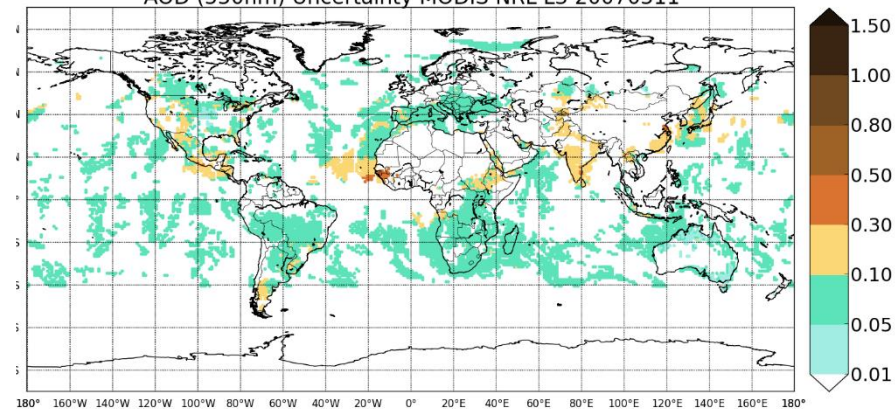
## Aerosol Optical Depth

AOD (550nm) MODIS NRL L3 20070511



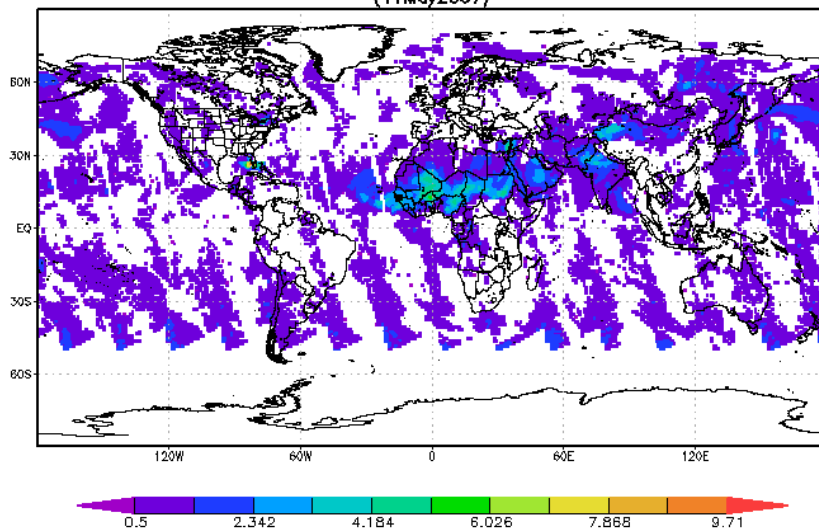
## Uncertainty

AOD (550nm) Uncertainty MODIS NRL L3 20070511



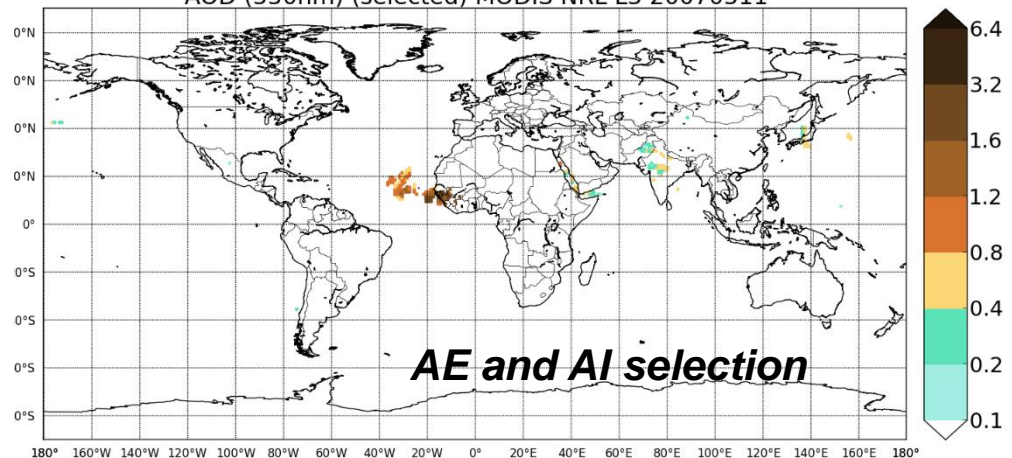
## OMI Aerosol Index

OMT03d.003 UV Aerosol Index [unitless]  
(11May2007)



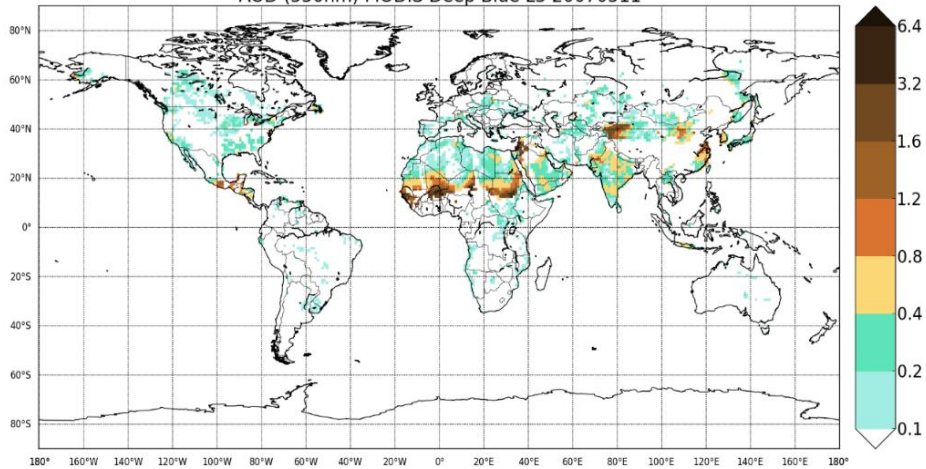
## Selected Aerosol Optical Depth

AOD (550nm) (selected) MODIS NRL L3 20070511



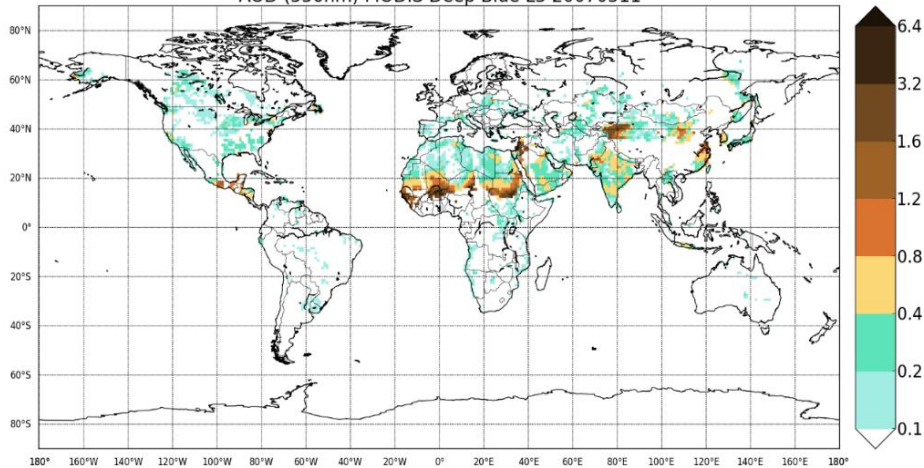
## Aerosol Optical Depth

AOD (550nm) MODIS Deep Blue L3 20070511



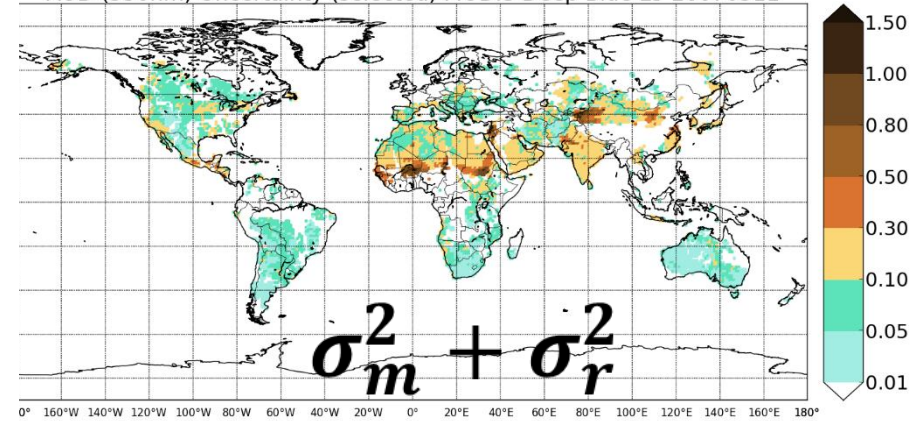
## Aerosol Optical Depth

AOD (550nm) MODIS Deep Blue L3 20070511



## Uncertainty

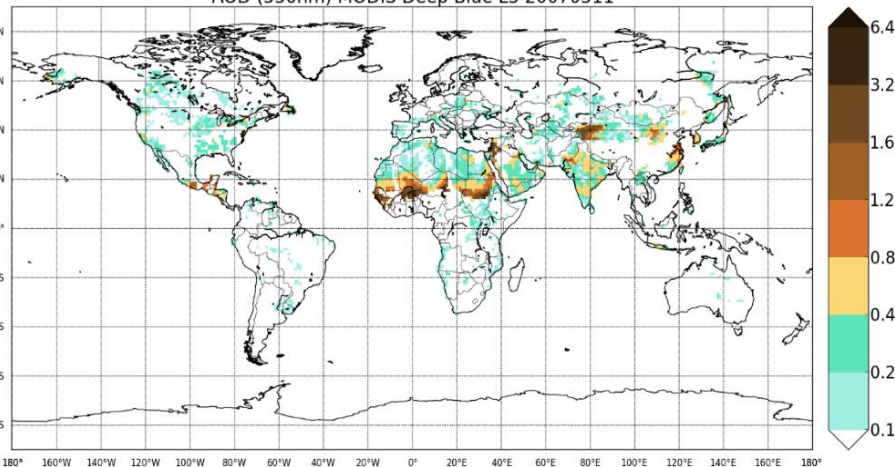
AOD (550nm) Uncertainty (selected) MODIS Deep Blue L3 20070511





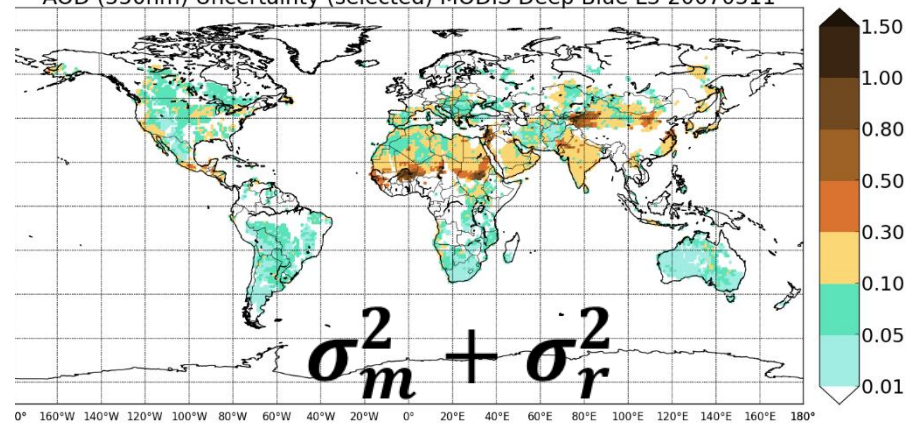
## Aerosol Optical Depth

AOD (550nm) MODIS Deep Blue L3 20070511



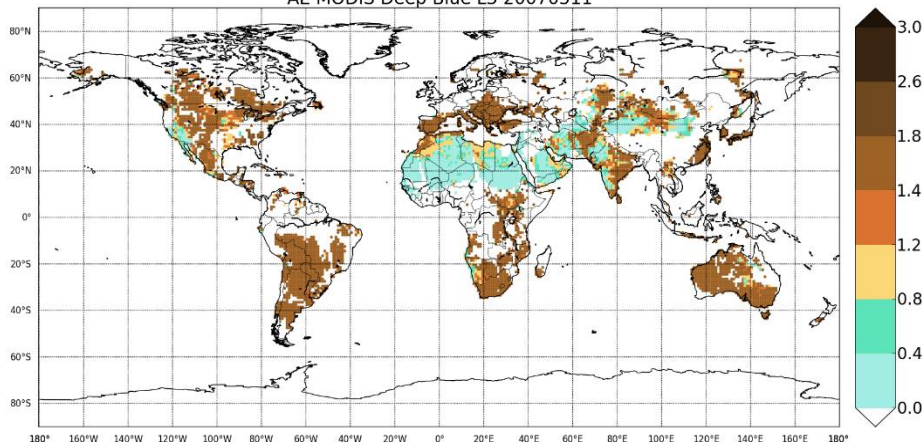
## Uncertainty

AOD (550nm) Uncertainty (selected) MODIS Deep Blue L3 20070511



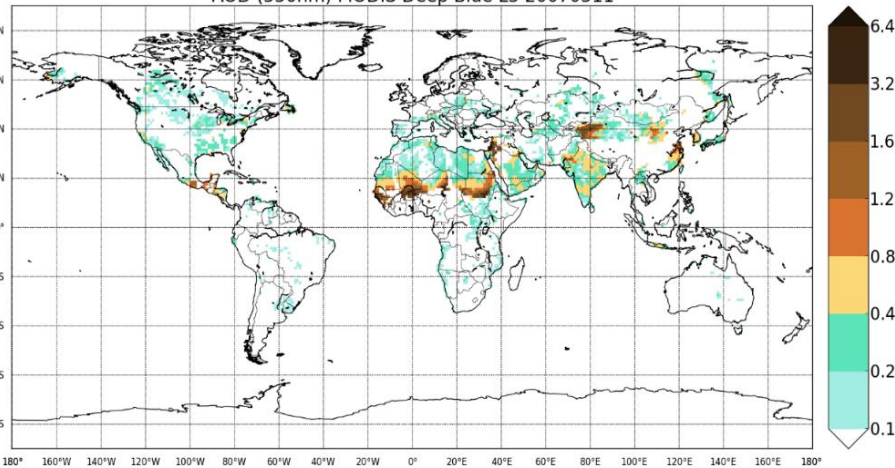
## Ångström Exponent

AE MODIS Deep Blue L3 20070511



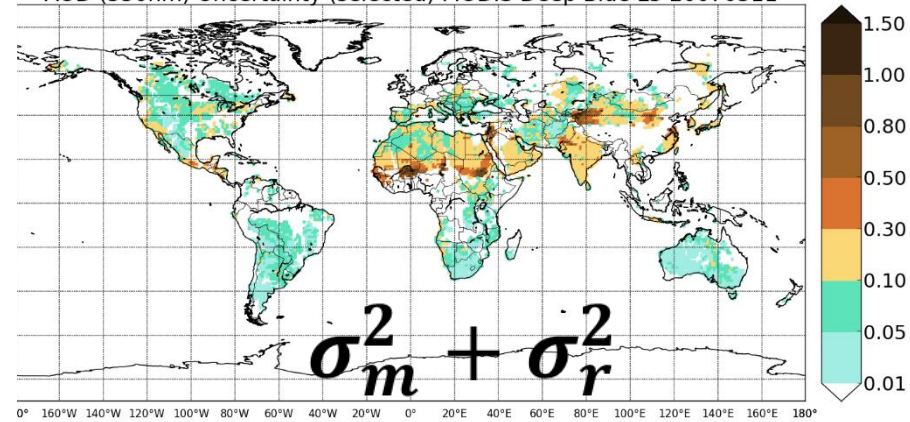
## Aerosol Optical Depth

AOD (550nm) MODIS Deep Blue L3 20070511



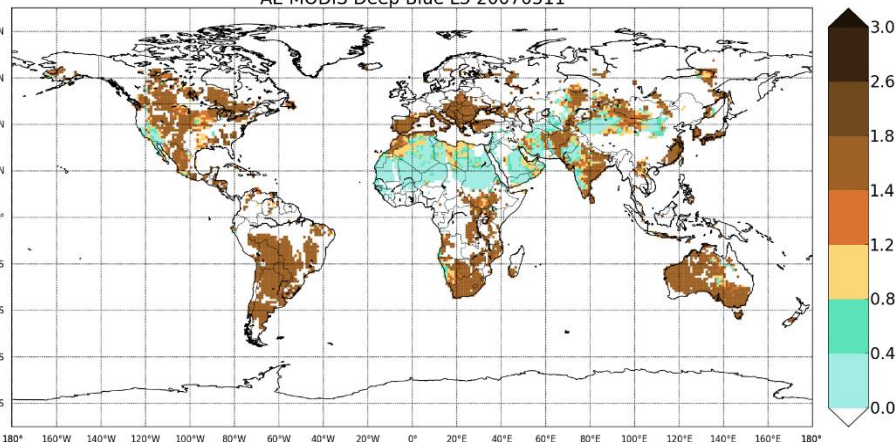
## Uncertainty

AOD (550nm) Uncertainty (selected) MODIS Deep Blue L3 20070511



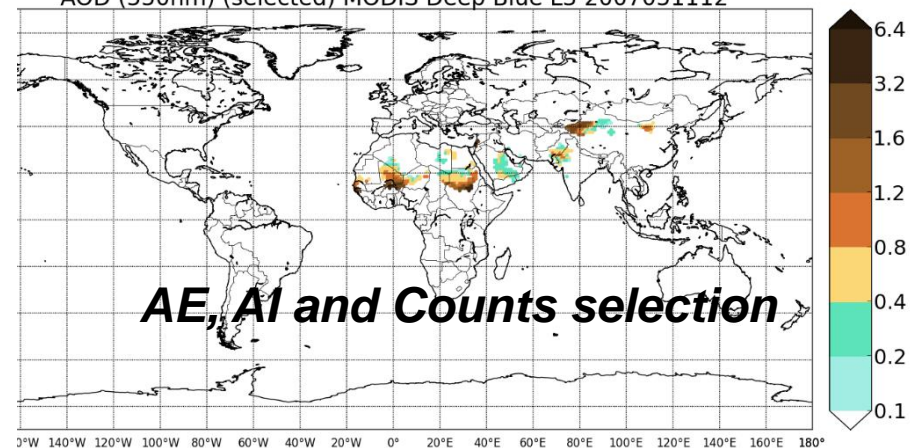
## Ångström Exponent

AE MODIS Deep Blue L3 20070511



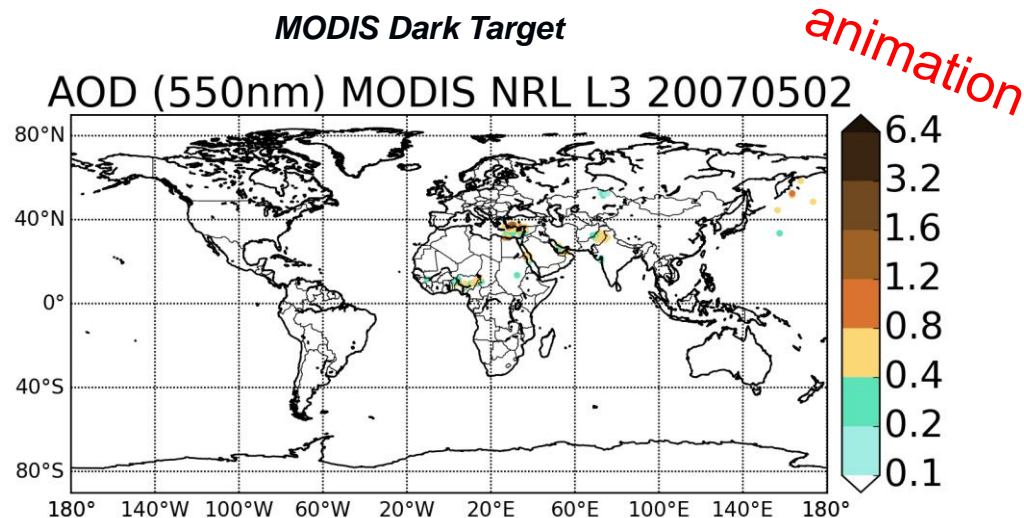
## Selected Aerosol Optical Depth

AOD (550nm) (selected) MODIS Deep Blue L3 2007051112

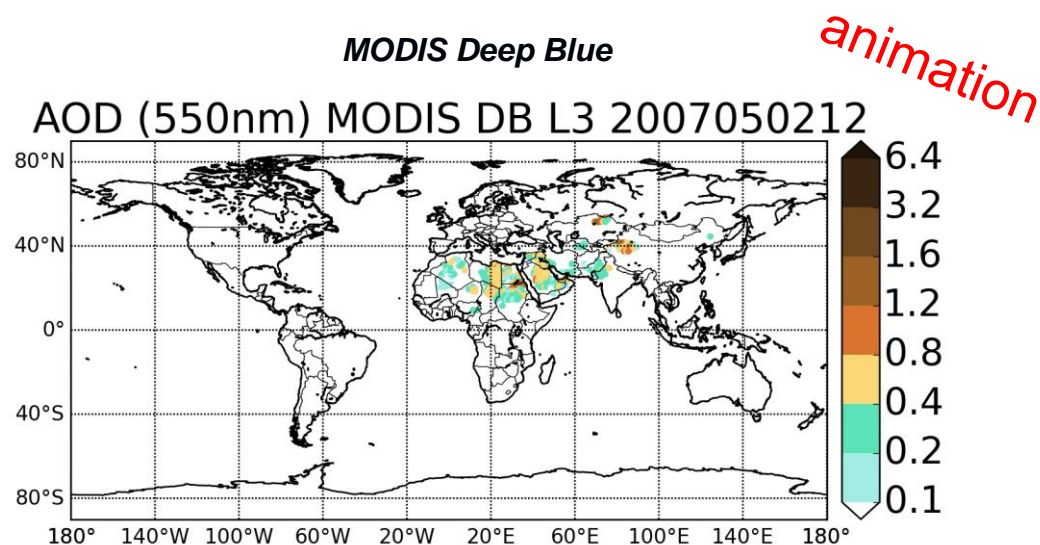




Selected  
NRL MODIS  
observations



Selected  
MODIS DB  
observations



# Observation operator



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**Observed**

**Modelled**

Observed

Modelled


$$AOD_{\lambda} = \sum_z \sum_i C_{ext,i}(\lambda) c_{z,i} \Delta z$$

Observed

Modelled


$$AOD_{\lambda} = \sum_z \sum_i C_{ext,i}(\lambda) c_{z,i} \Delta z$$

$c_{z,i}$  ensemble member mass concentrations for bin  $i$  [kg/m<sup>3</sup>]

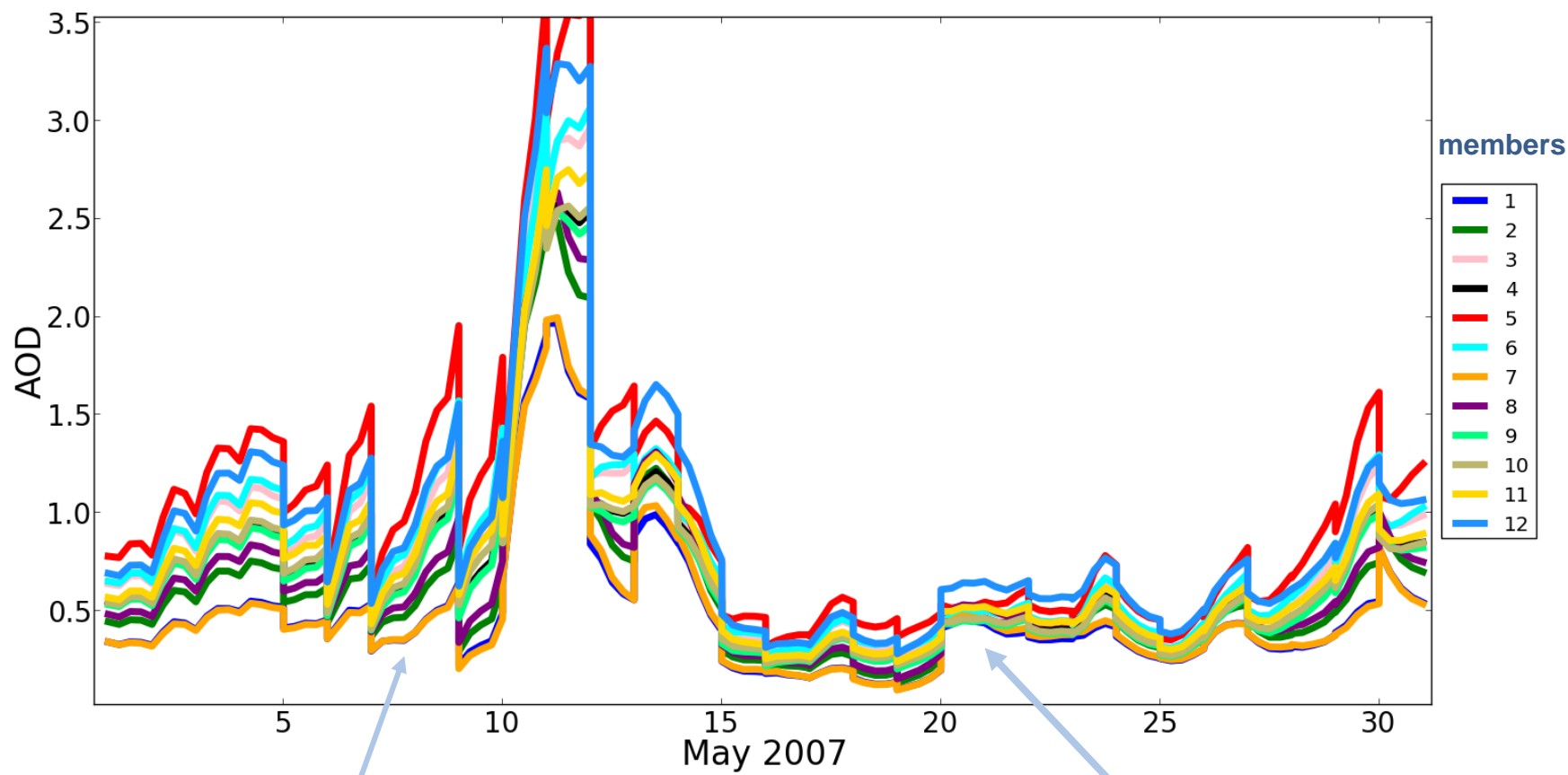
$C_{ext,i}(\lambda)$  mass extinction coefficients [m<sup>2</sup>/kg]

$\Delta z$  layer thickness [m]



# Diagnostic tools

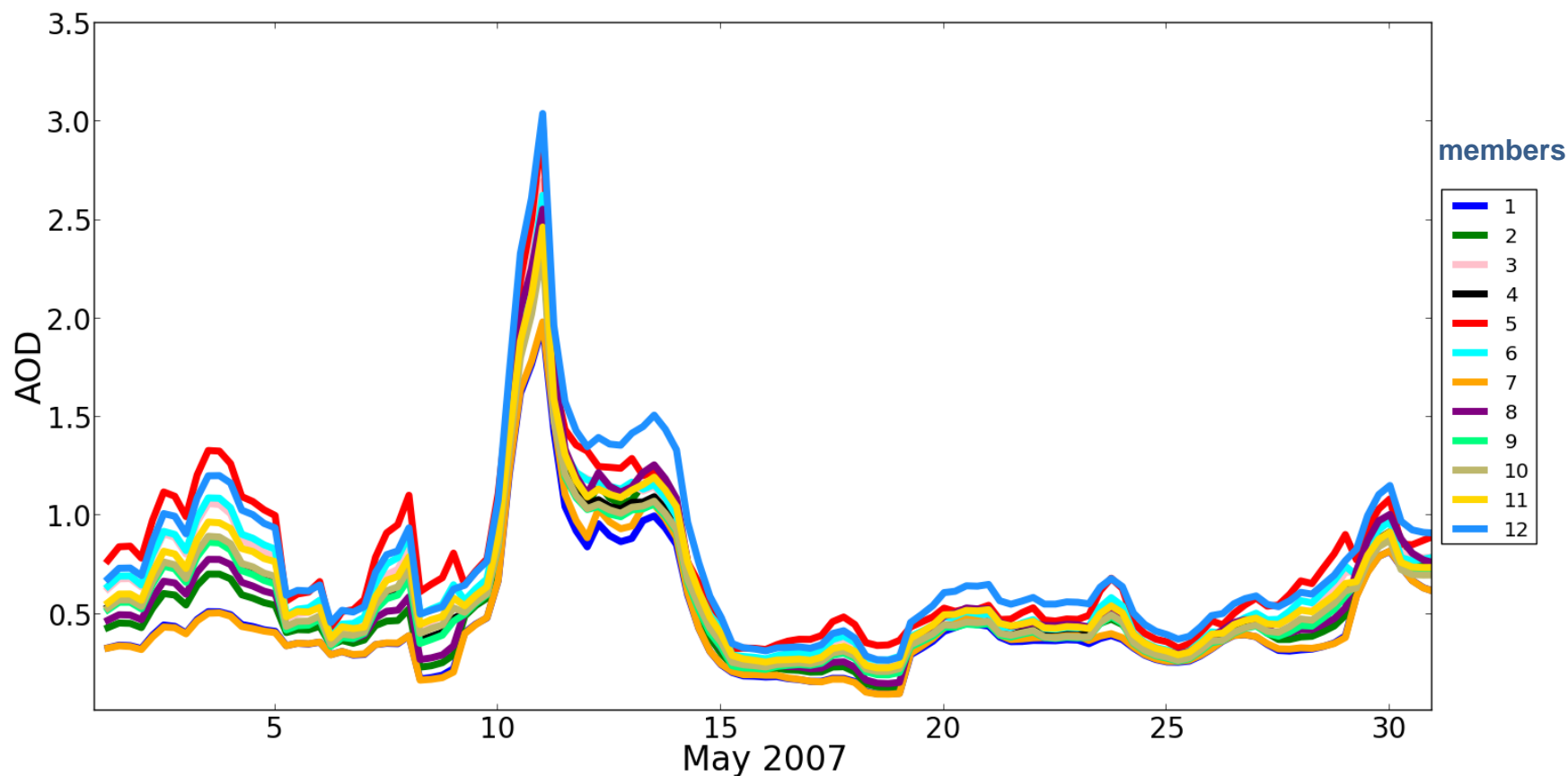
## Dakar (Senegal)



FG spread increases toward the end of the window

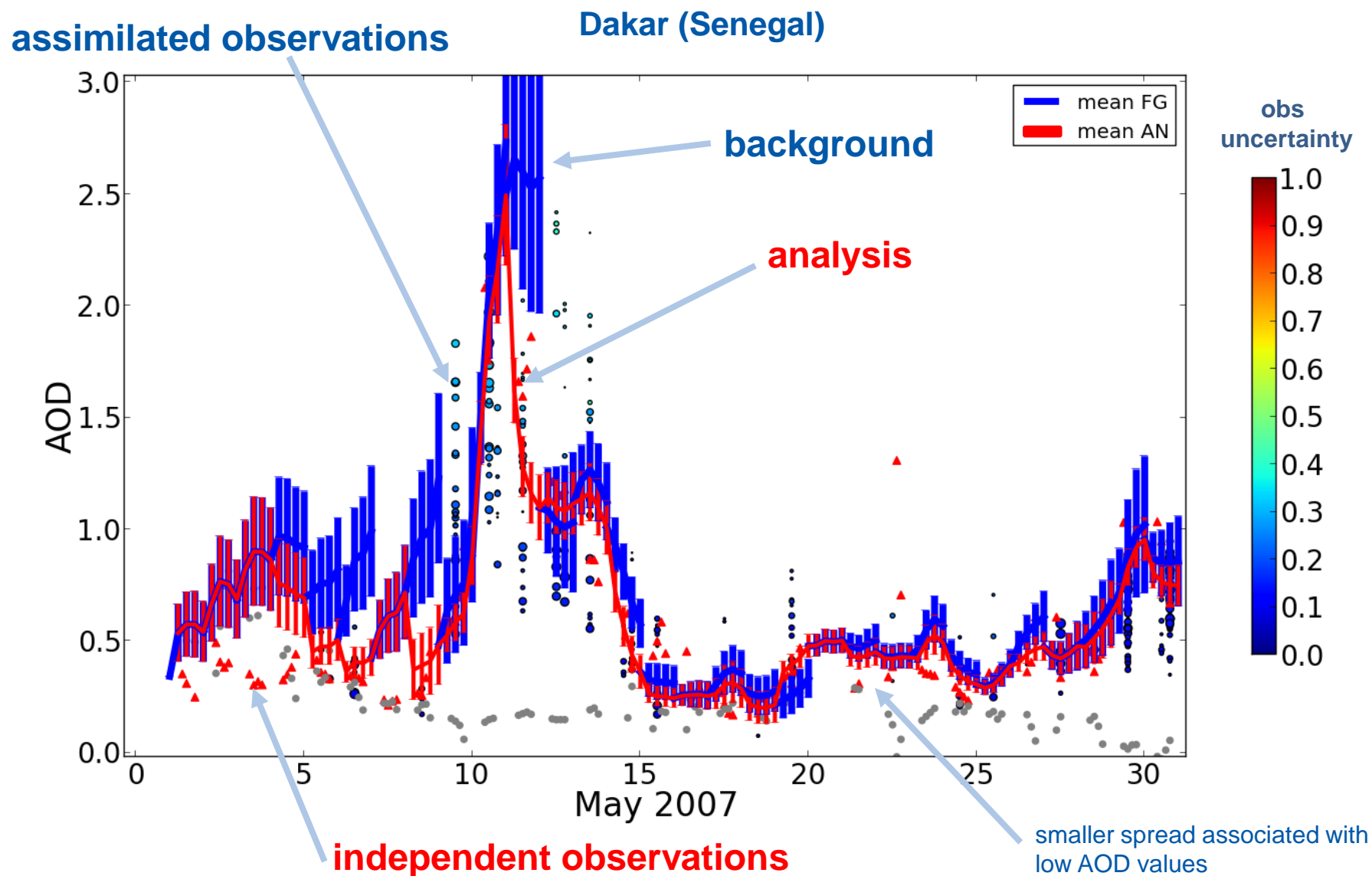
Smaller spread associated with low AOD values

## Dakar (Senegal)



AN spread generally smaller than FG spread

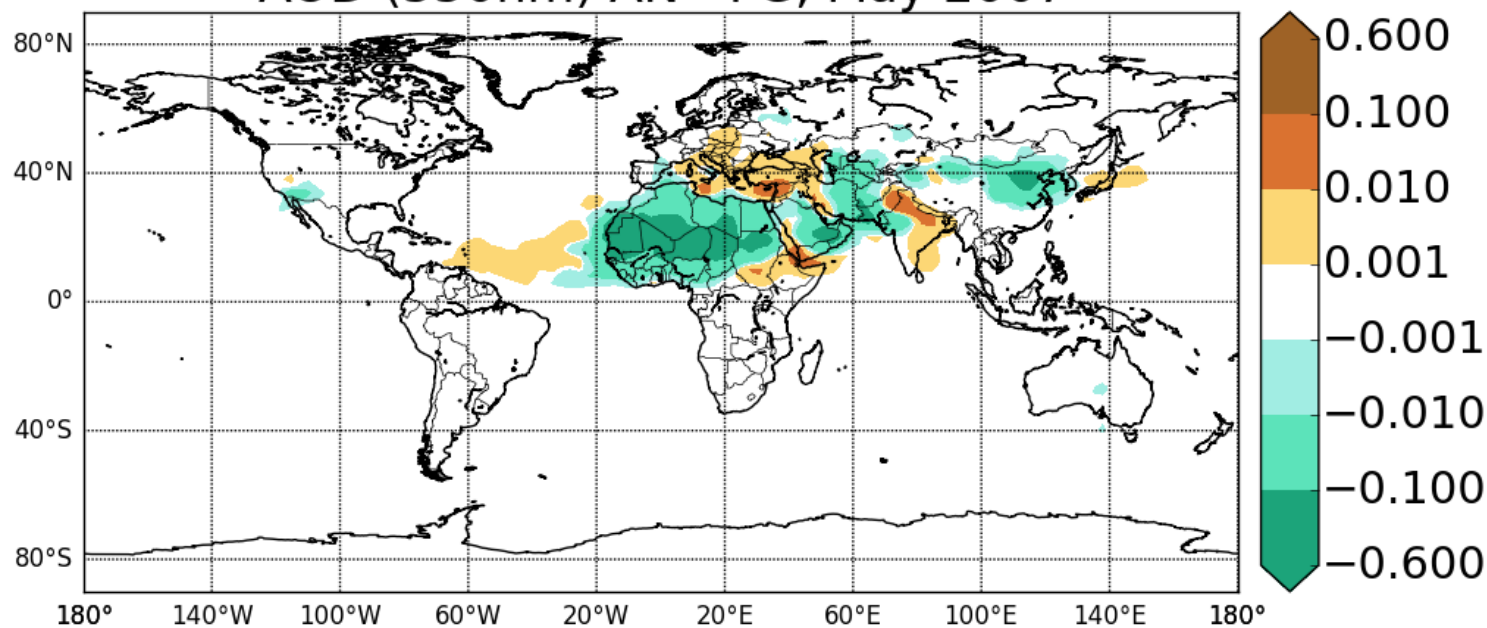
# Ensemble spread





## MODIS NRL +DB

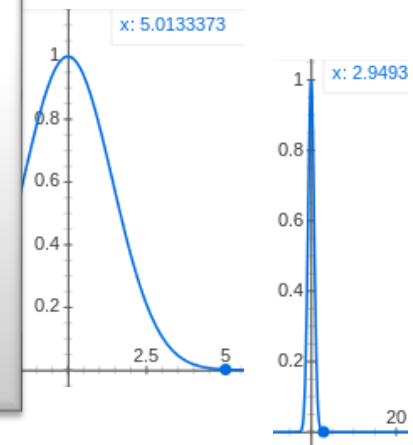
AOD (550nm) AN - FG, May 2007



## Observation-space localisation for AOD

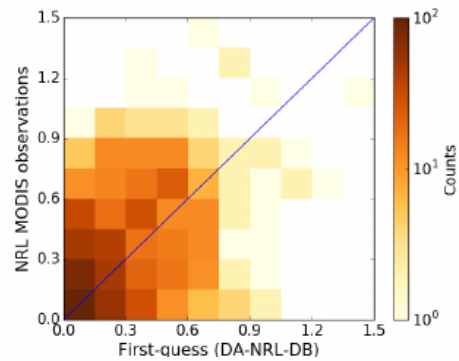
- observation error is divided by a distance-dependent function that decays to zero with increasing distance (horizontal localisation)

### Localisation functions

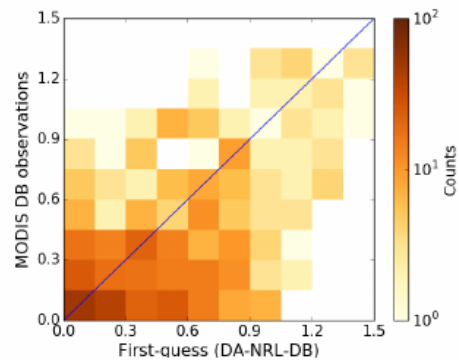


## First-guess

MODIS Dark Target  
(NRL)



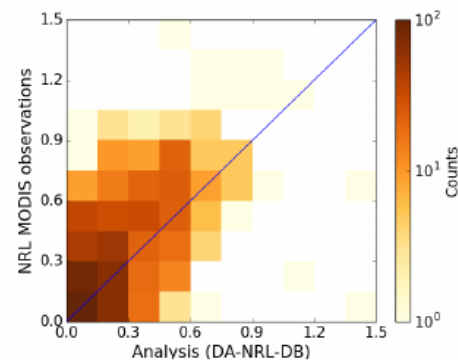
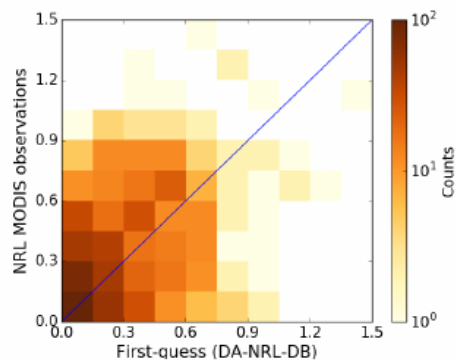
MODIS Deep Blue



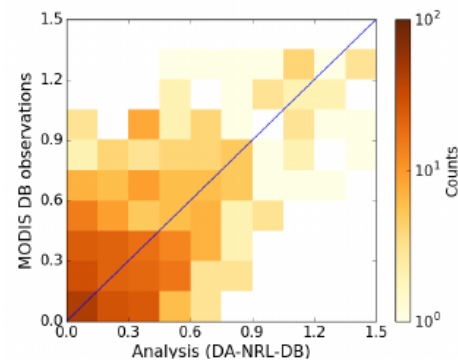
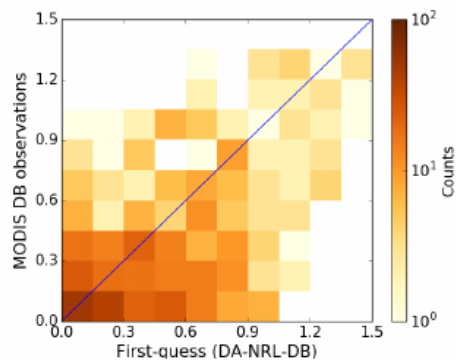
First-guess

Analysis

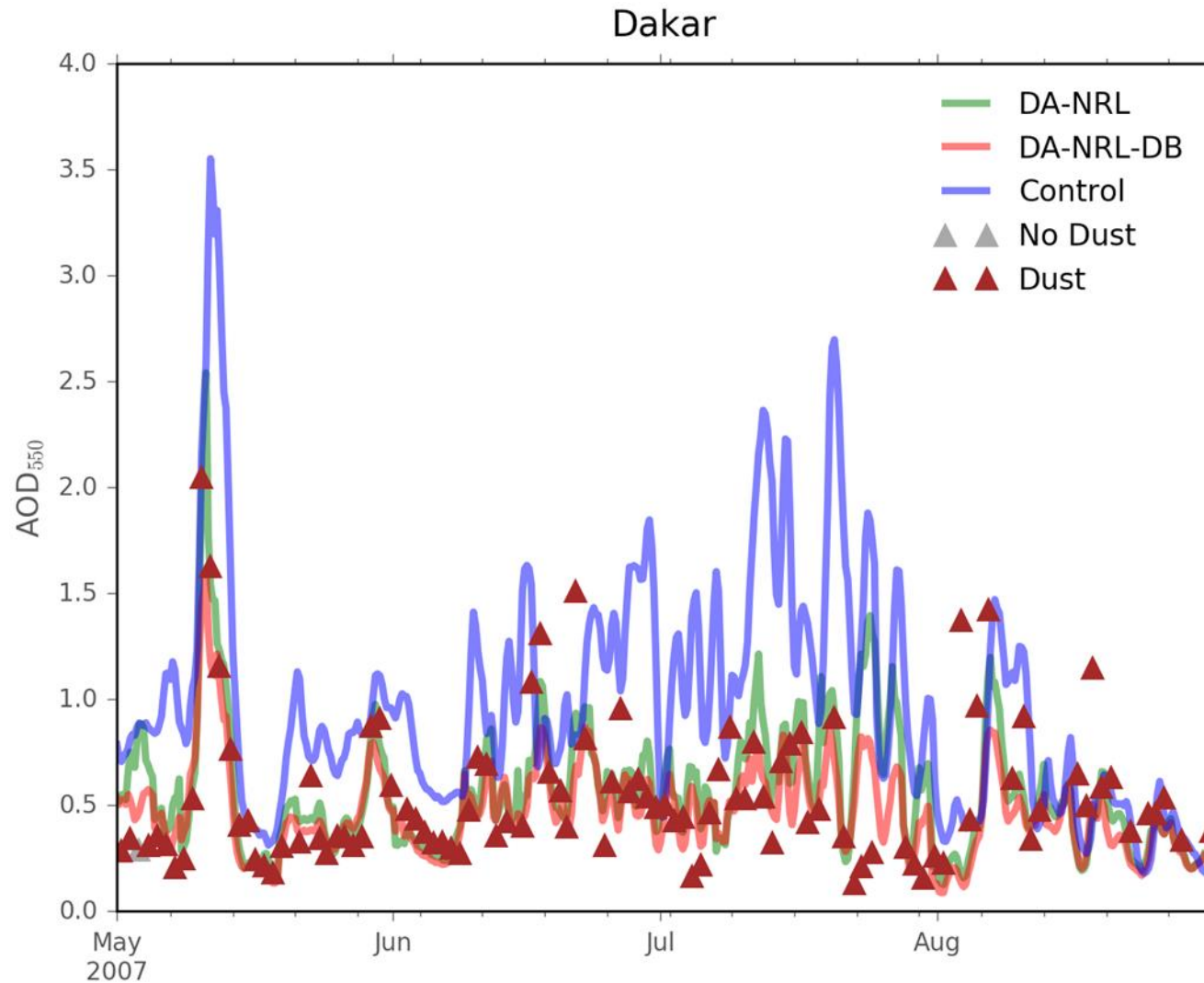
MODIS Dark Target  
(NRL)



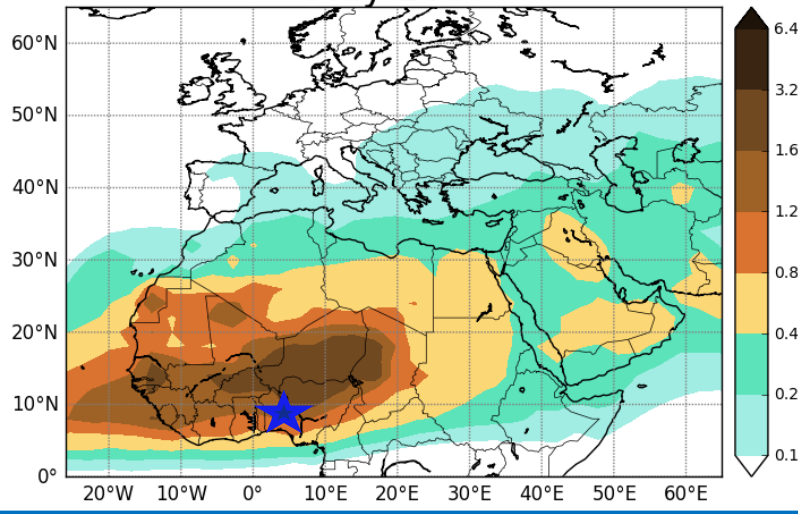
MODIS Deep Blue



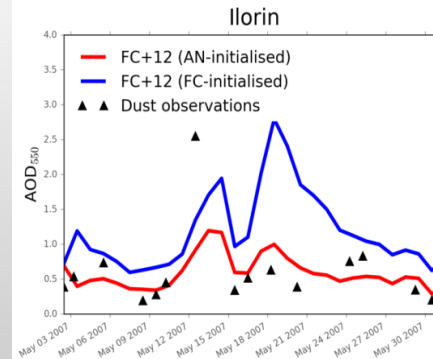
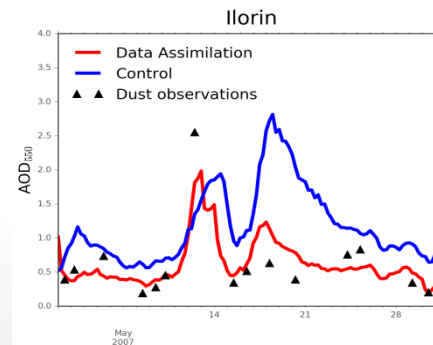
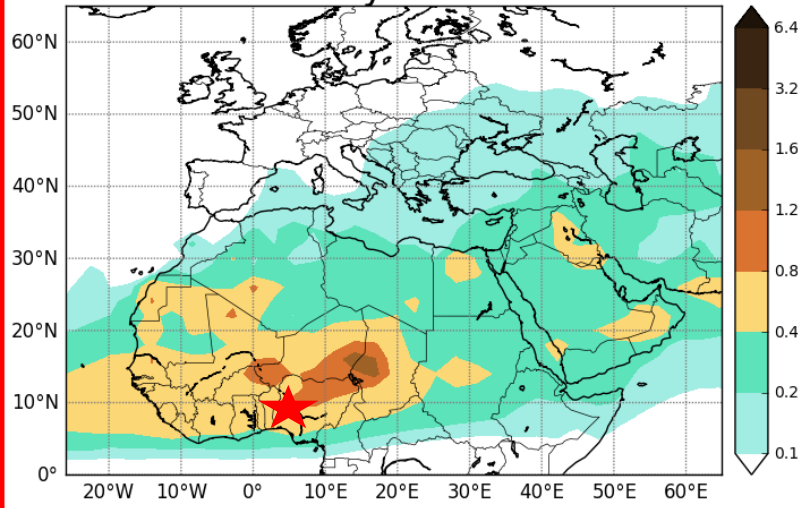
Dark Target  
+  
Deep Blue  
assimilation experiment



Dust AOD (550nm), Control Simulation  
May 2007

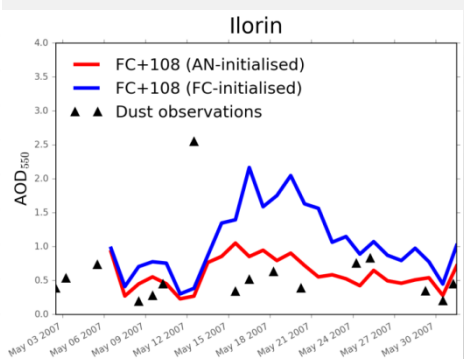


Dust AOD (550nm), DA Simulation  
May 2007



**Validation**

Better description of  
current and forecast  
conditions for dust  
with data assimilation



*AERONET site of independent sun photometer observations*



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Supercomputing  
Center**

*Centro Nacional de Supercomputación*



# Thank you!

For further information please contact  
[enza.ditomaso@bsc.es](mailto:enza.ditomaso@bsc.es)