



**Barcelona  
Supercomputing  
Center**

*Centro Nacional de Supercomputación*

## **BSC Data Assimilation Updates**

Enza Di Tomaso\*, Nick Schutgens, Oriol Jorba

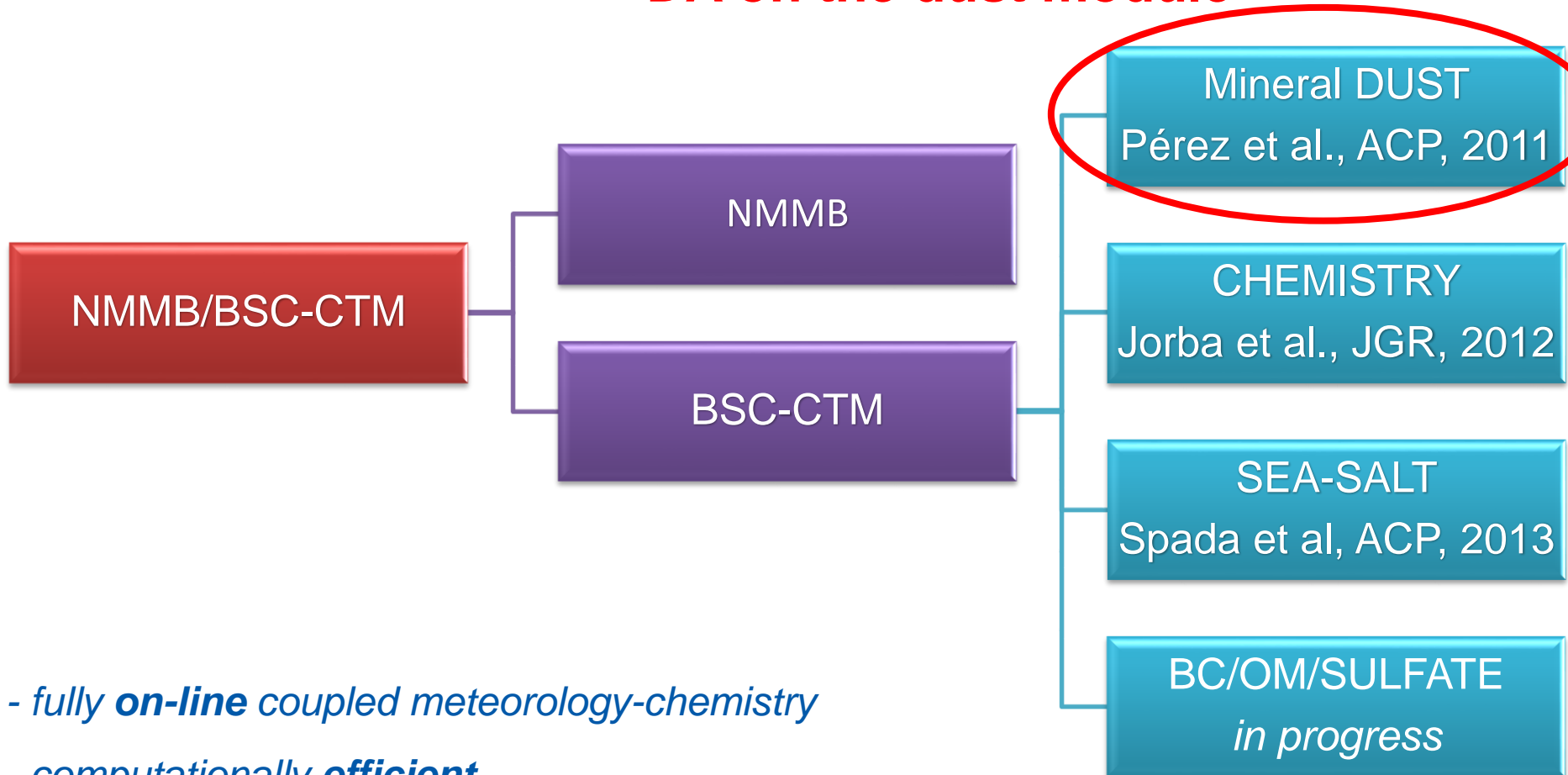
\*Severo Ochoa fellow  
Earth Sciences Department  
Barcelona Supercomputing Center



Special thanks to Francesco Benincasa @BSC

# The “Barcelona Model” in ICAP

## DA on the dust module

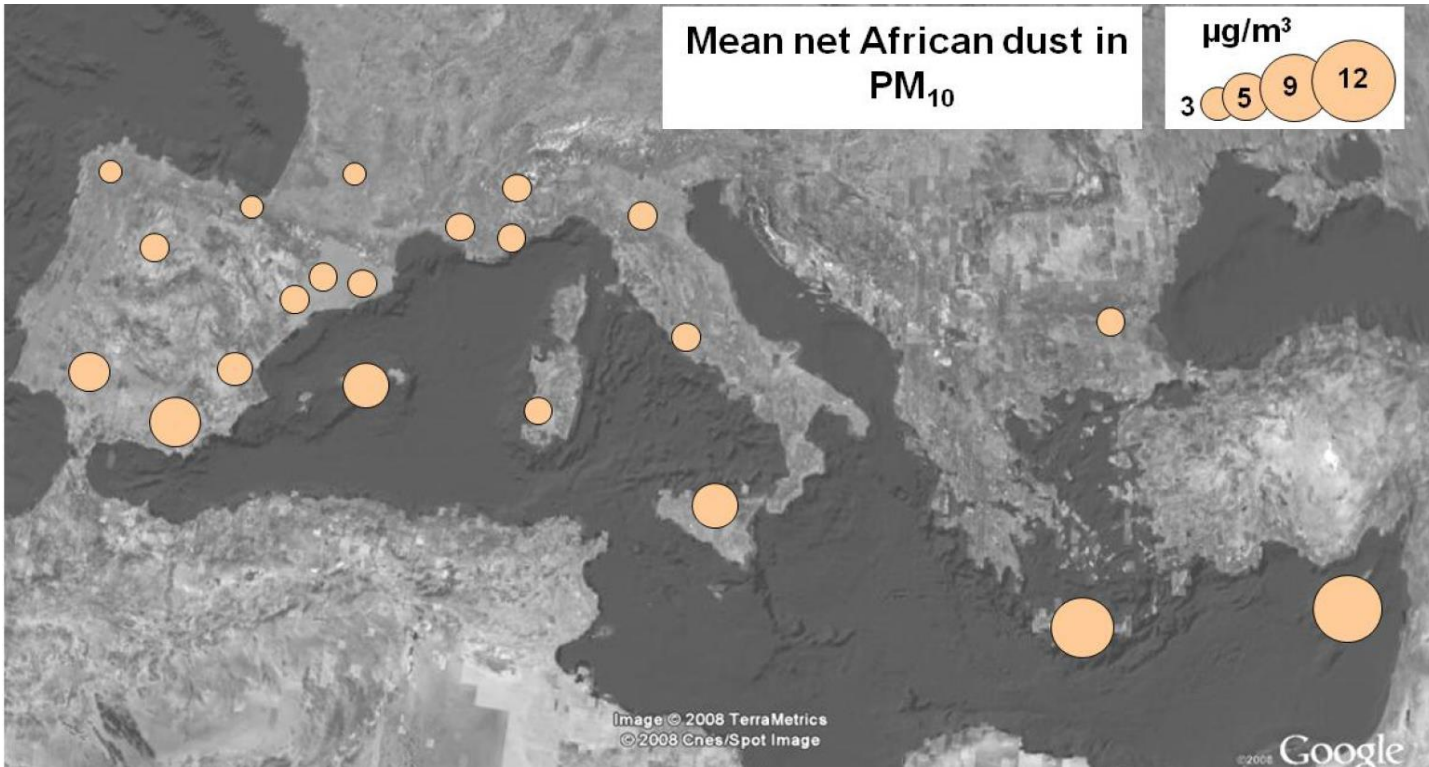


- fully **on-line** coupled meteorology-chemistry

- computationally **efficient**

- **multi-scale** thanks to its unified non-hydrostatic dynamical core

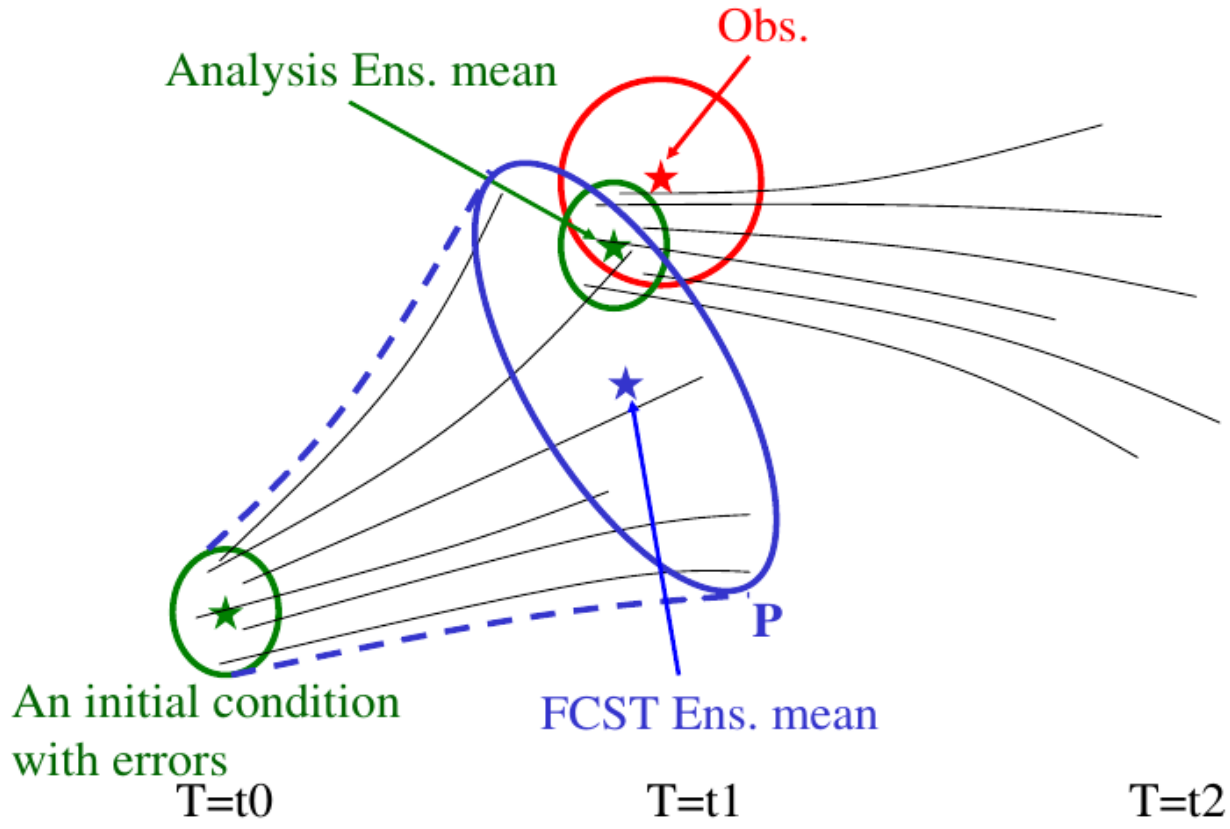
# Motivations for caring about mineral dust even where ICAP meetings are held!



Querol et al., 2009

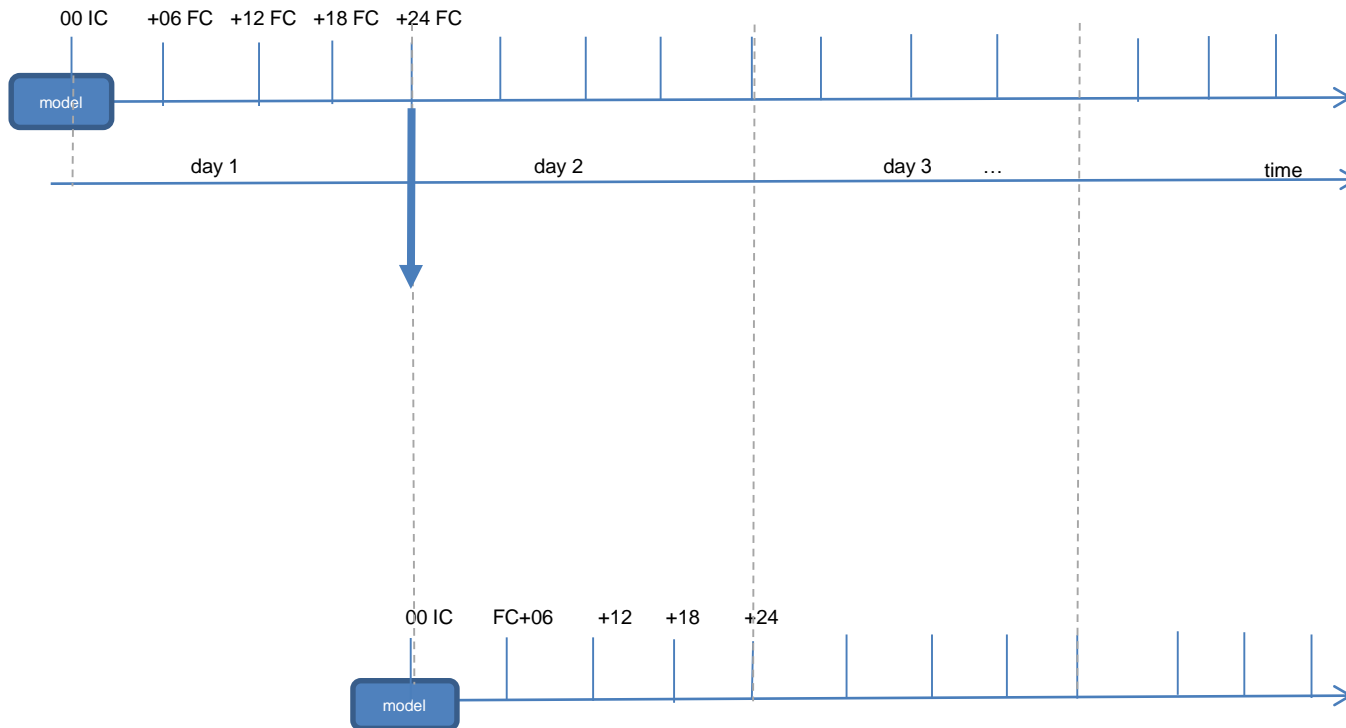
Studies performed with measurements taken in **Barcelona** show that Saharan dust outbreaks have **adverse health effects** (Perez et al. 2008, Pandolfi et al., 2014)

# Ensemble-Based DA Technique (LETKF)

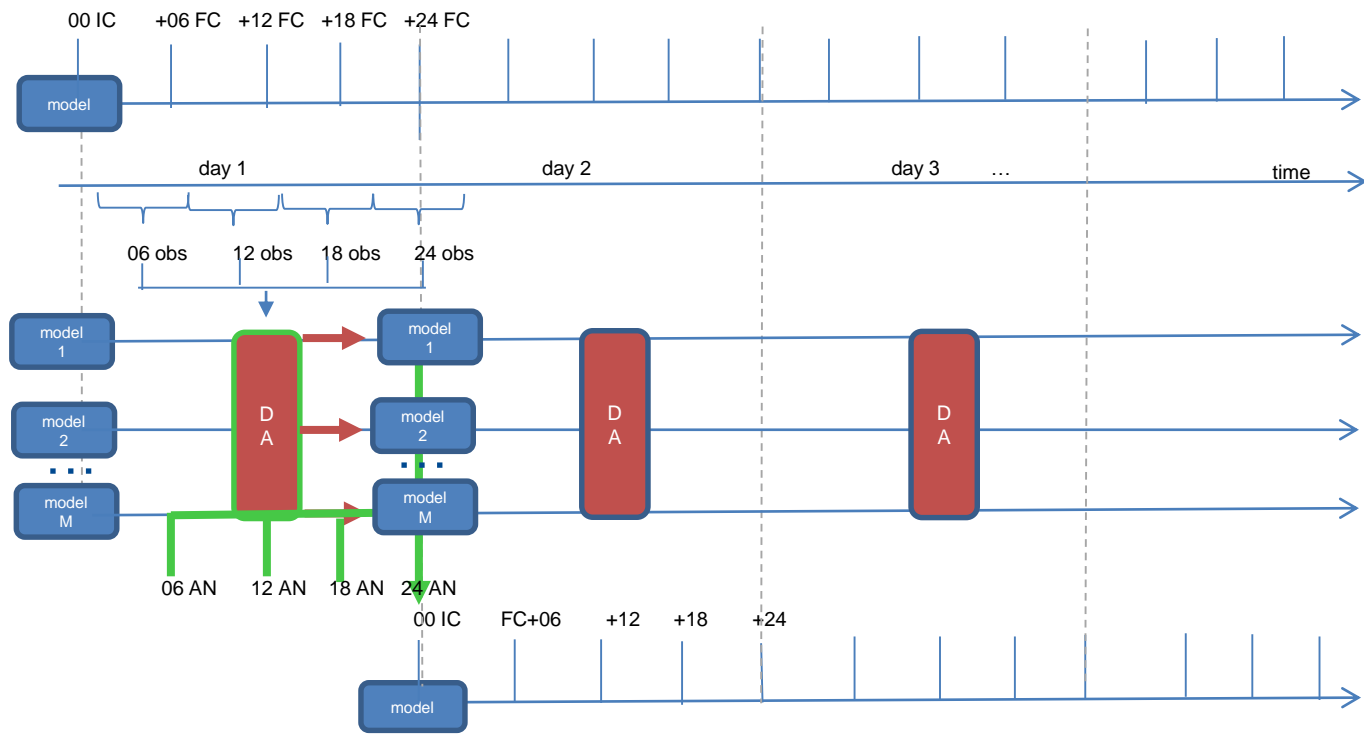


(courtesy of Takemasa Miyoshi)

# Current Operational Flow



# Data Assimilation Flow

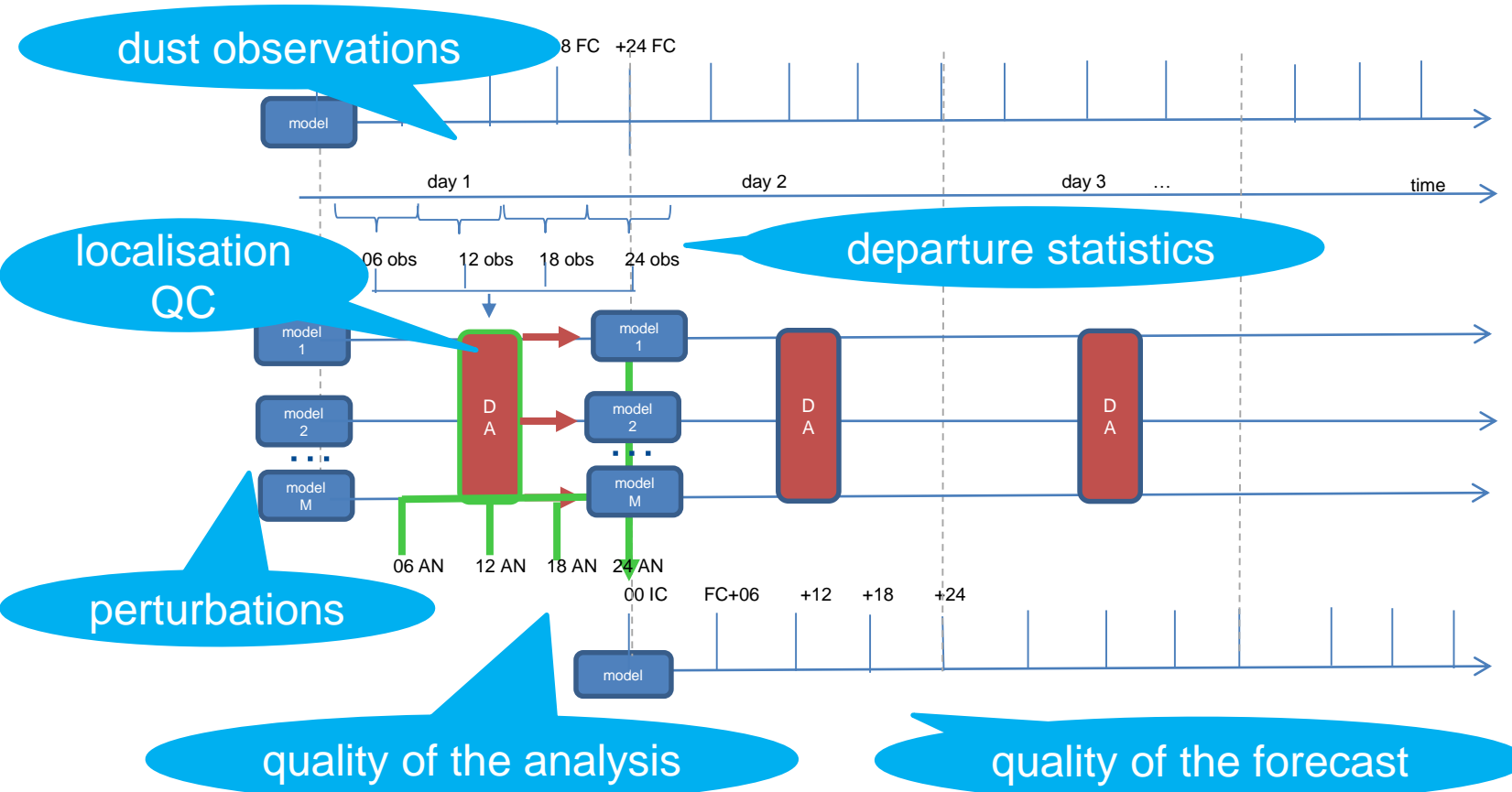


- aerosol treatment by Nick Schutgens (*Schutgens et al. 2010*)
- core function by Takemasa Miyoshi (*Ott et al. 2004, Hunt et al. 2005*)



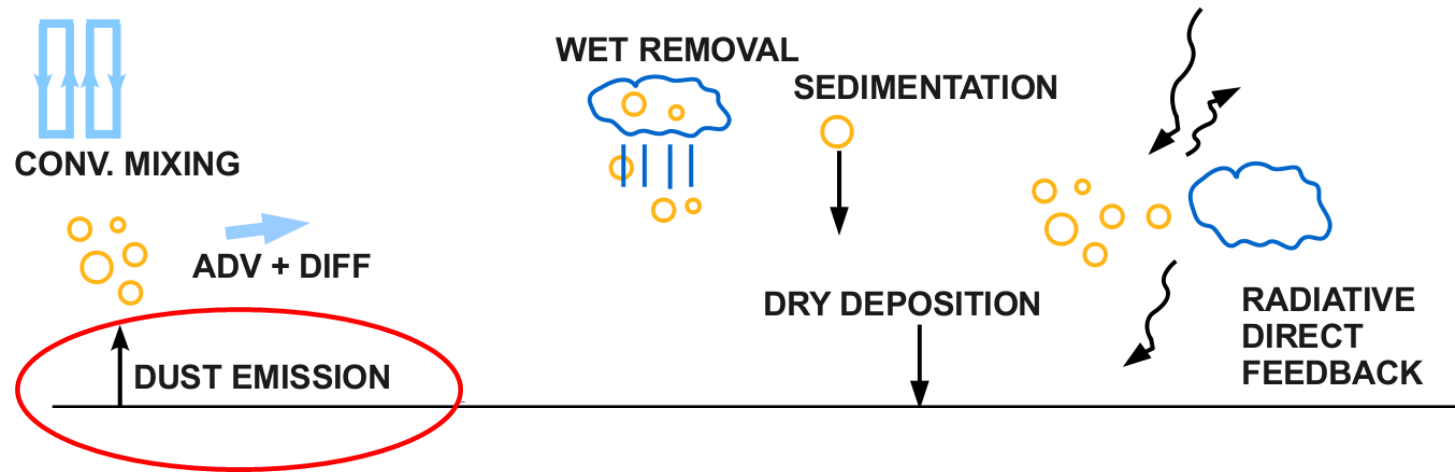
# Data Assimilation Flow

## Outline



- aerosol treatment by Nick Schutgens (*Schutgens et al. 2010*)
- core function by Takemasa Miyoshi (*Ott et al. 2004, Hunt et al. 2005*)

# Creation of the Ensemble



Vertical mass flux of dust into a transport bin  $k$

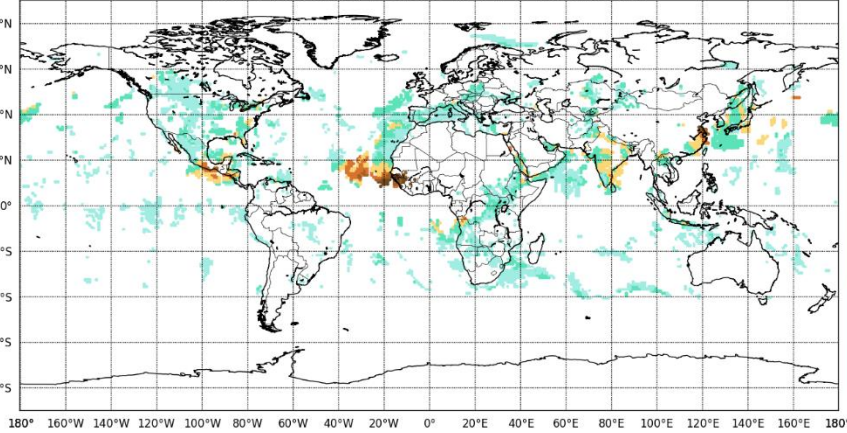
$$F_k = C S (1 - V) \alpha H \sum_{i=0}^3 m_i M_{i,k} \quad k = 1, \dots, 8$$



# NRL MODIS L3 Product

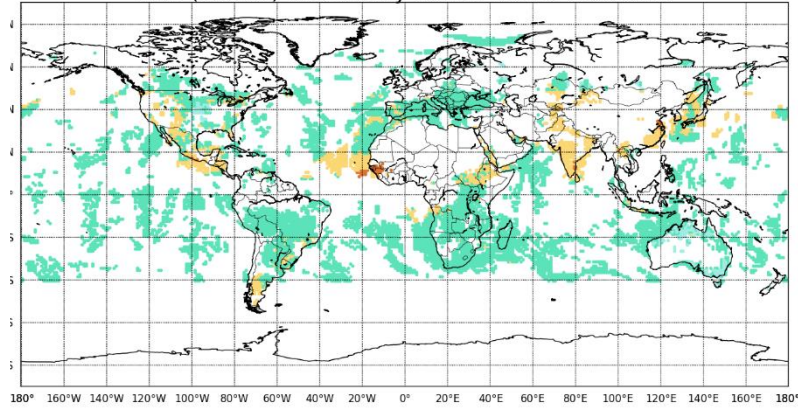
## Aerosol Optical Depth

AOD (550nm) MODIS NRL L3 20070511



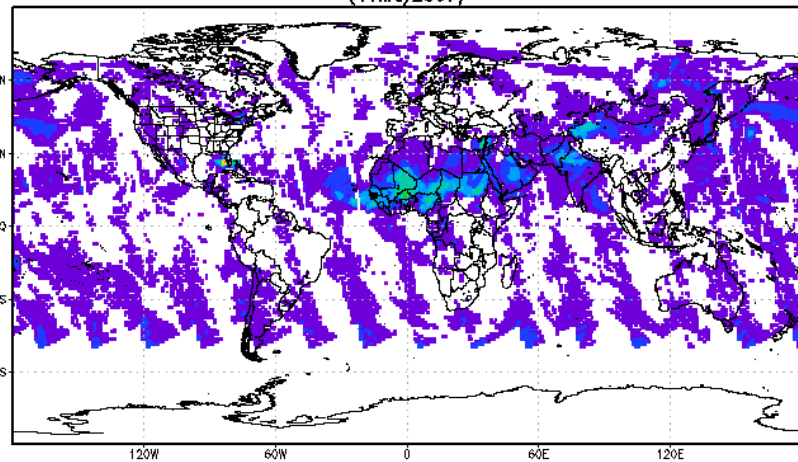
## Uncertainty

AOD (550nm) Uncertainty MODIS NRL L3 20070511



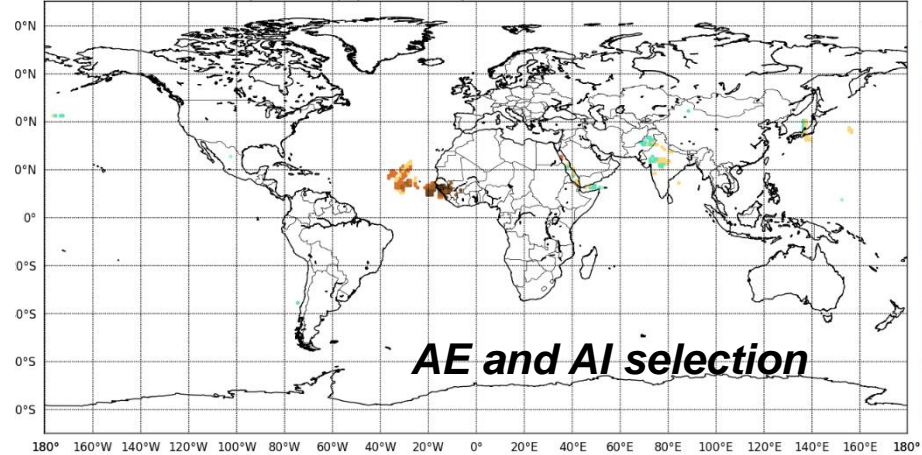
## OMI Aerosol Index

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



## Selected Aerosol Optical Depth

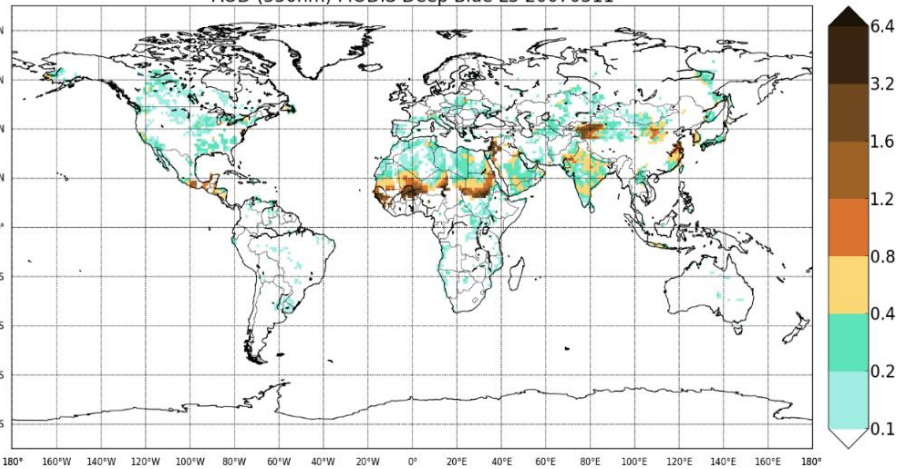
AOD (550nm) (selected) MODIS NRL L3 20070511



# MODIS Deep Blue L3 Product, Coll 6

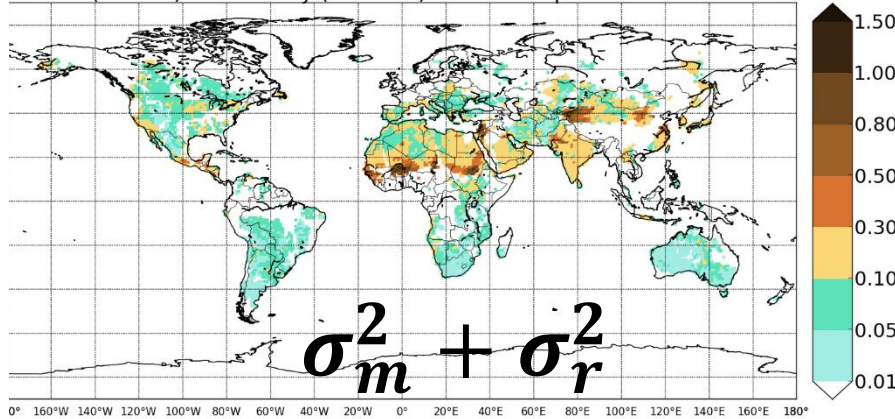
## Aerosol Optical Depth

AOD (550nm) MODIS Deep Blue L3 20070511



## Uncertainty

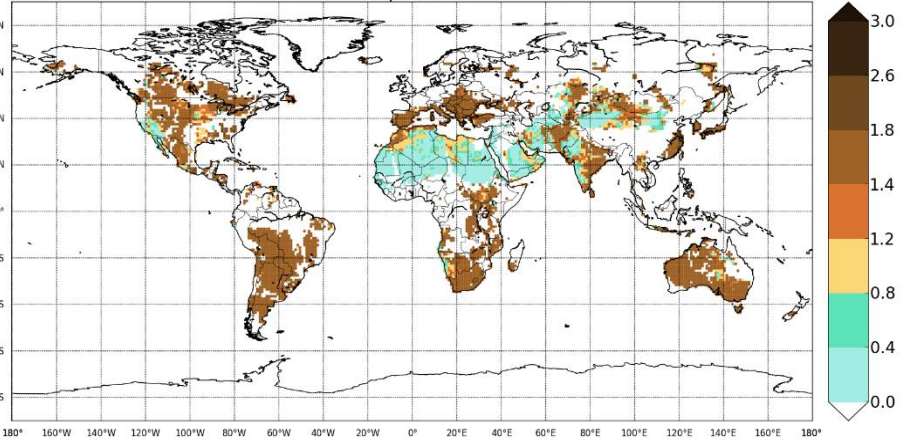
AOD (550nm) Uncertainty (selected) MODIS Deep Blue L3 20070511



$$\sigma_m^2 + \sigma_r^2$$

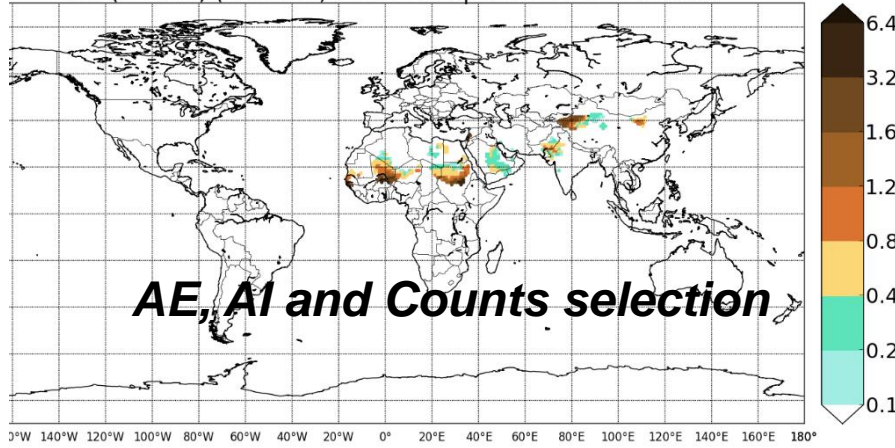
## Ångström Exponent

AE MODIS Deep Blue L3 20070511



## Selected Aerosol Optical Depth

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

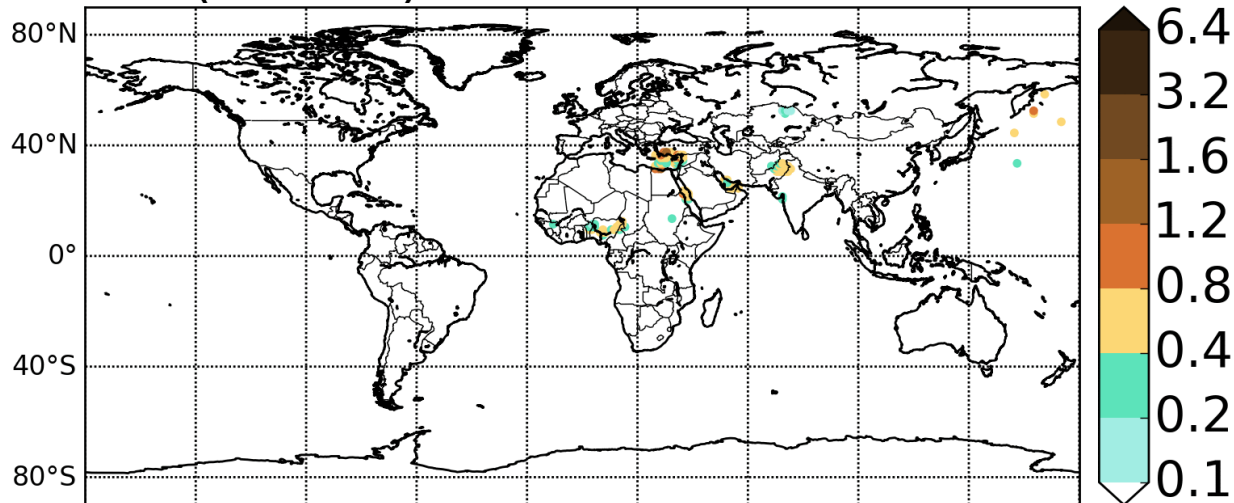


*AE, AI and Counts selection*



# Dust Selected Observations

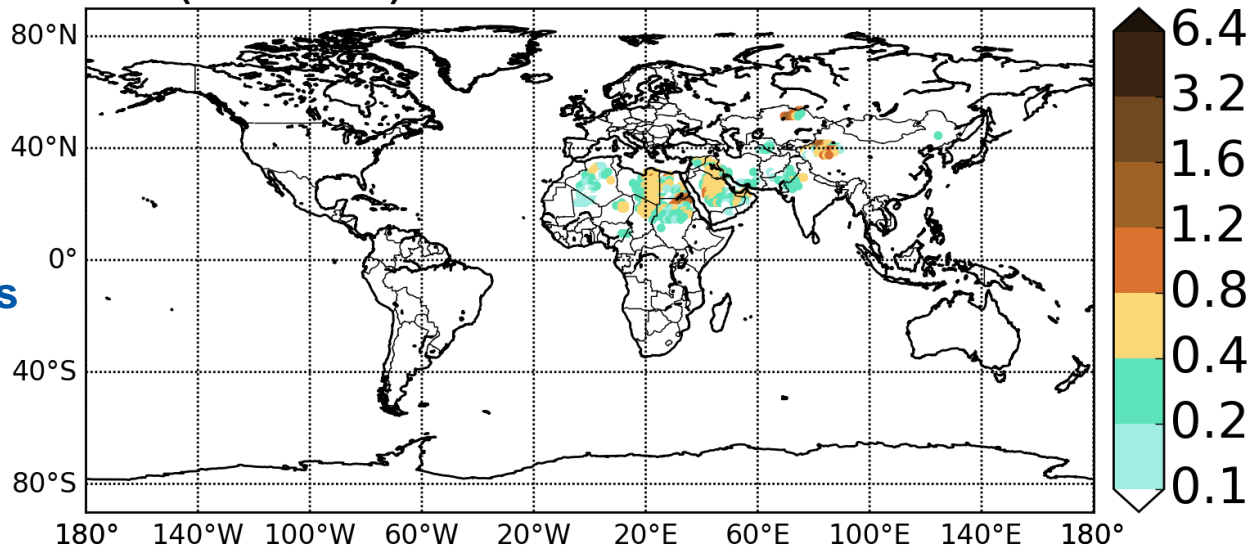
AOD (550nm) MODIS NRL L3 20070502



Selected  
NRL MODIS  
observations

*animation*

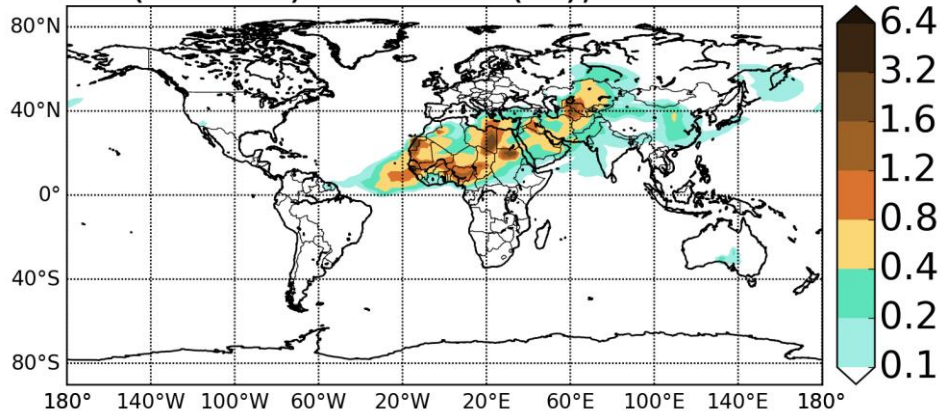
AOD (550nm) MODIS DB L3 2007050212



Selected  
MODIS DB  
observations

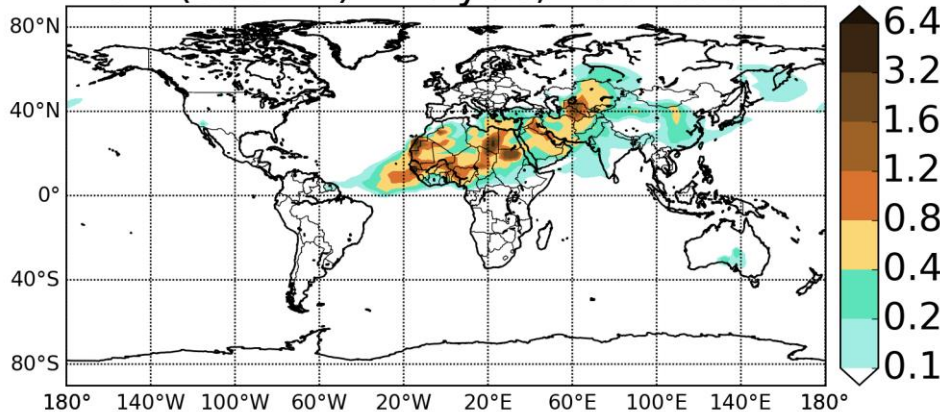
# Dust Analysis (NRL MODIS)

AOD (550nm) Free Run (IC), 2007050200

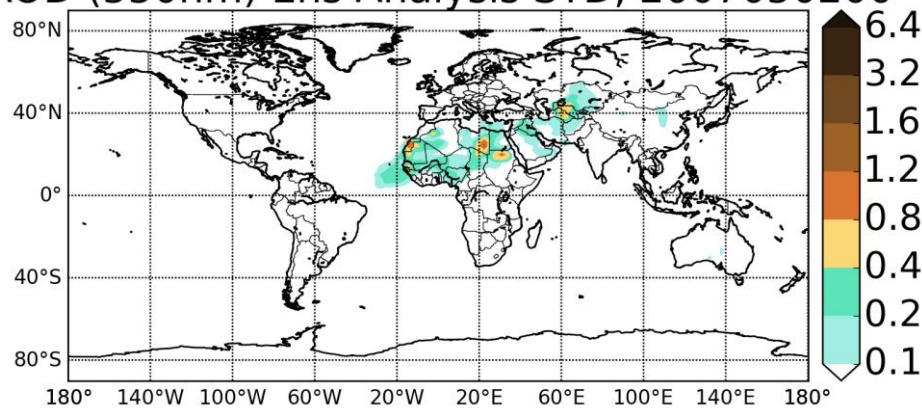


*animation*

AOD (550nm) Analysis, 2007050200

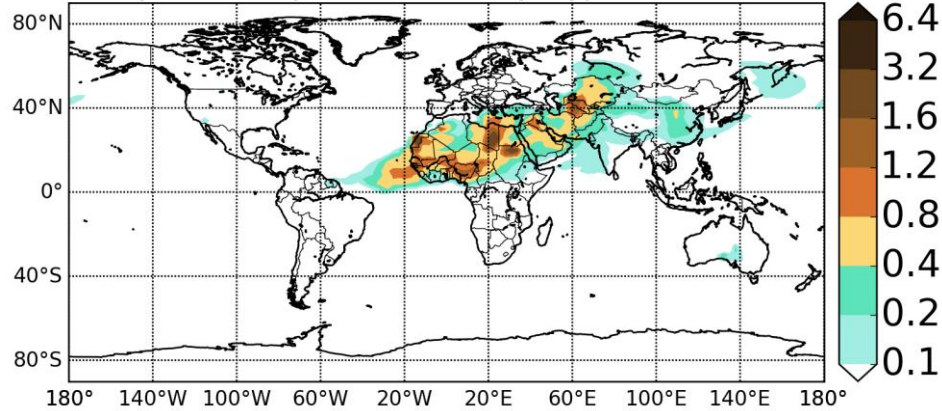


AOD (550nm) Ens Analysis STD, 2007050200



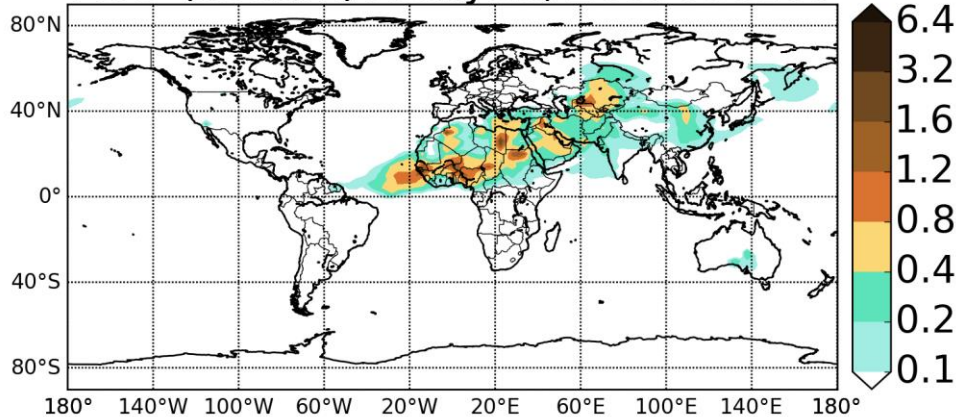
# Dust Analysis (NRL MODIS + DB)

AOD (550nm) Free Run (IC), 2007050200

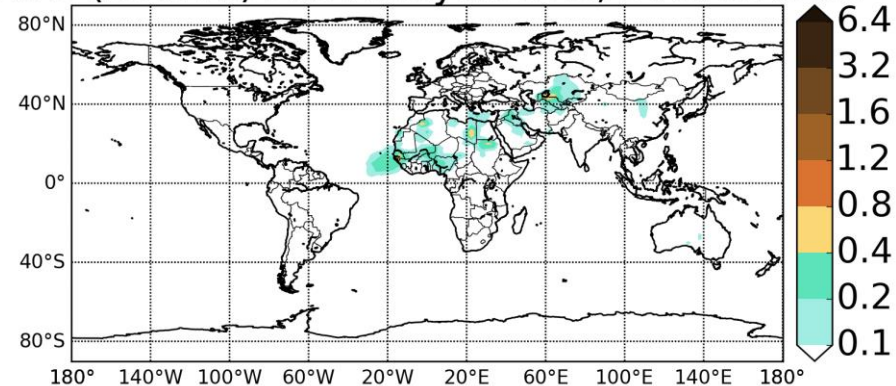


*animation*

AOD (550nm) Analysis, 2007050200

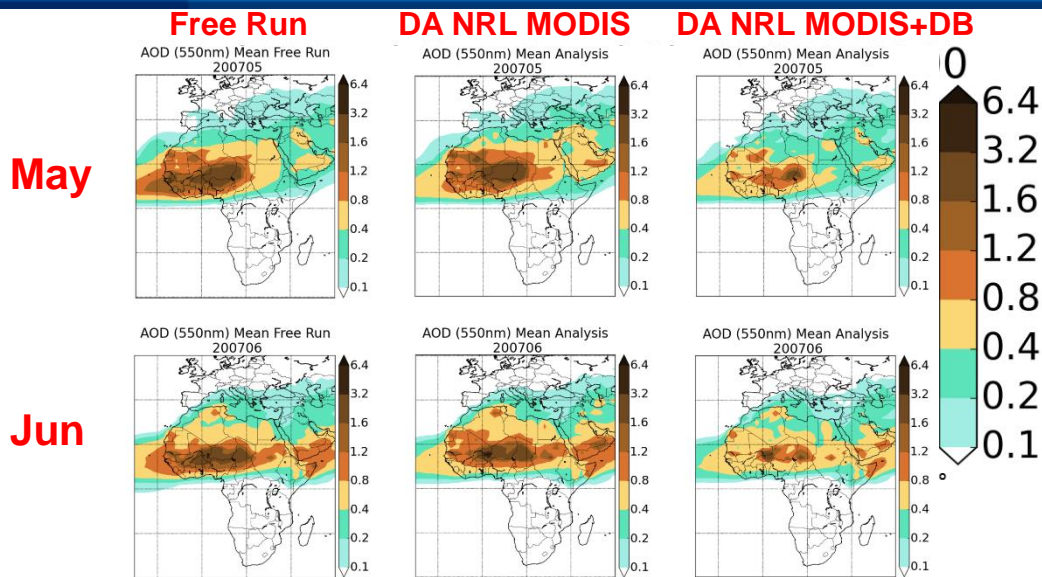


AOD (550nm) Ens Analysis STD, 2007050200

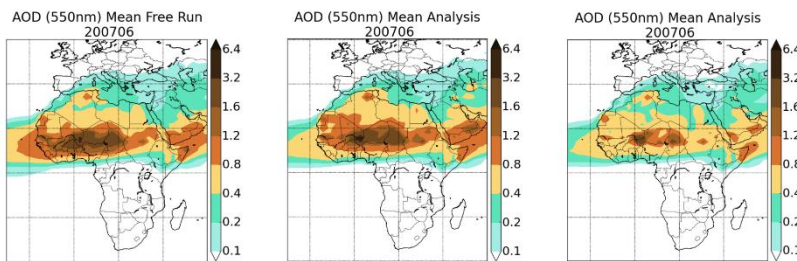




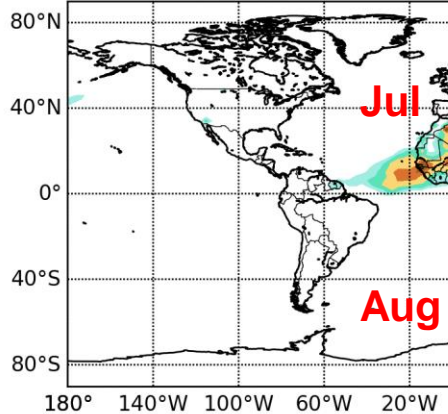
# Dust Analysis (NRL MODIS + DB)



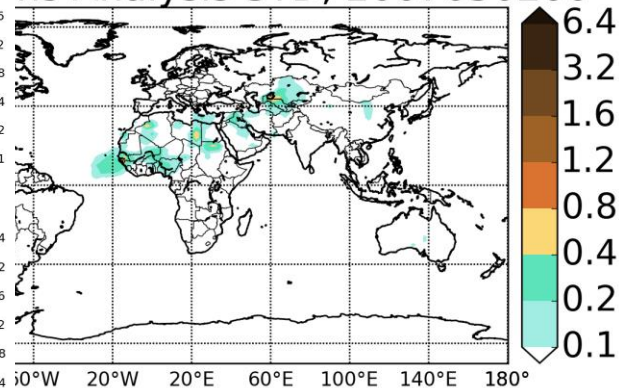
**Jun**



AOD (550nm) Ana

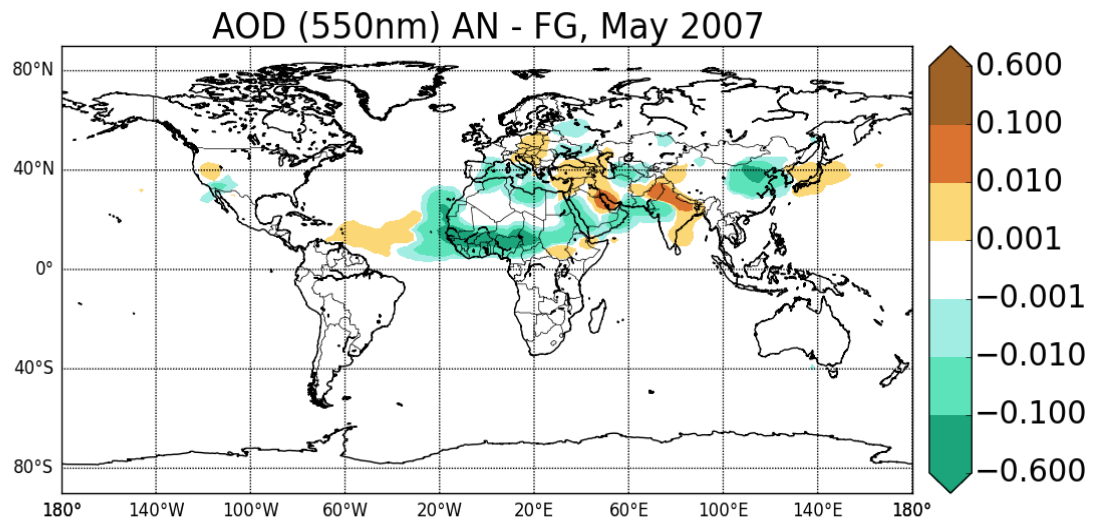


ns Analysis STD, 2007050200

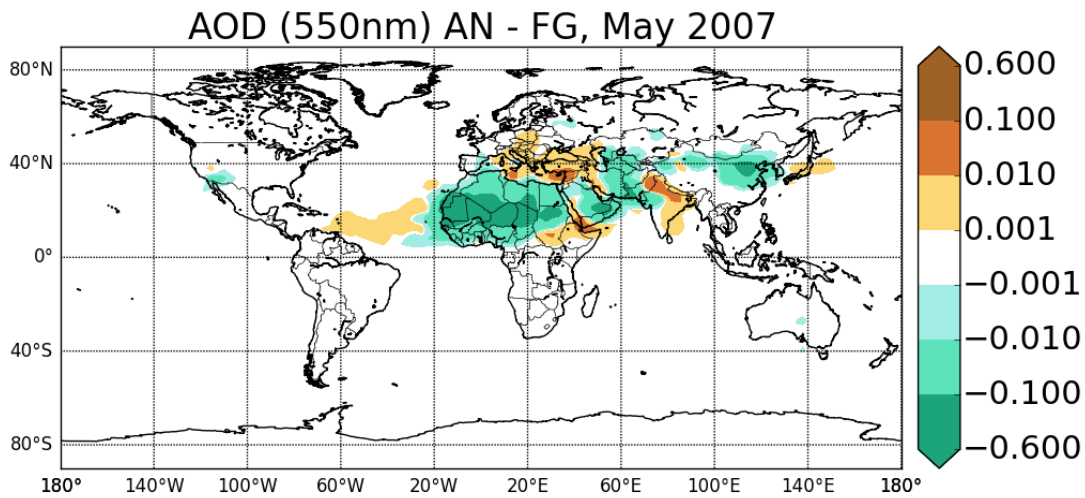


# Mean Increments

MODIS NRL



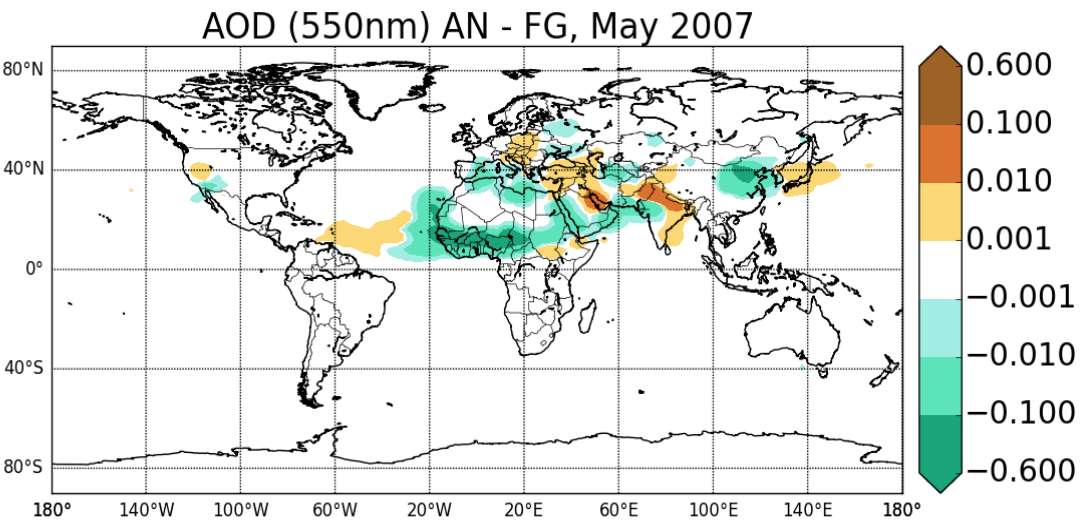
MODIS NRL +DB



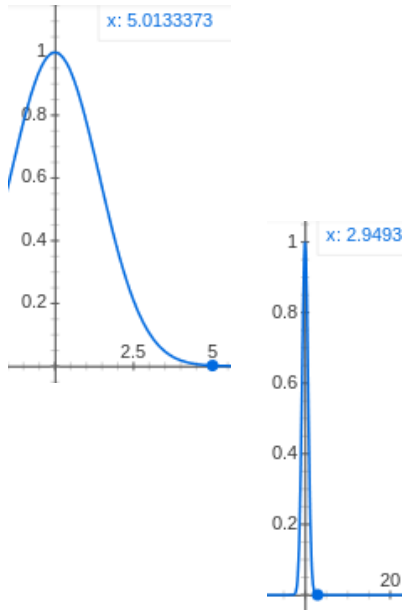


# Mean Increments

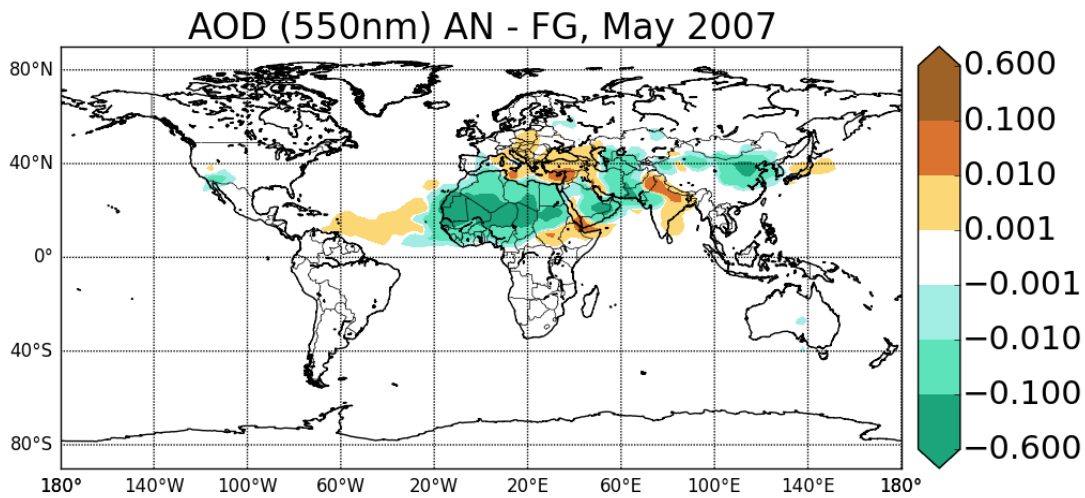
MODIS NRL



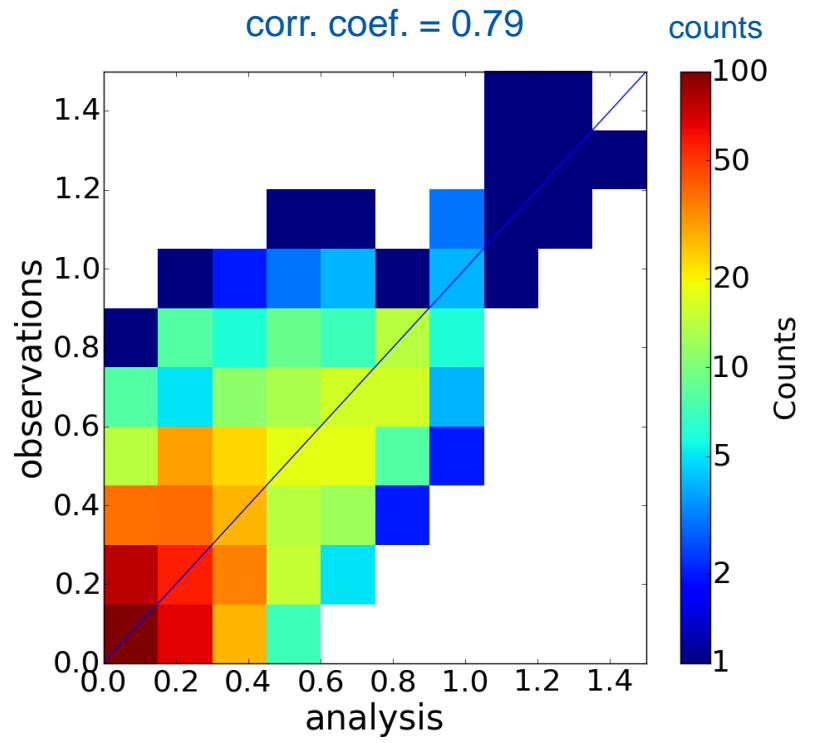
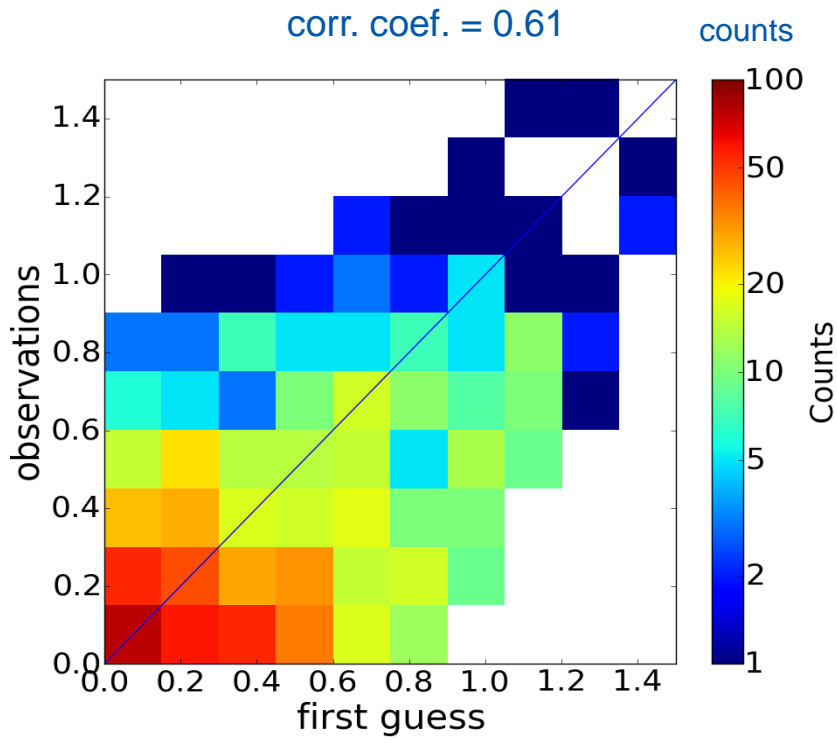
Localisation function



MODIS NRL +DB

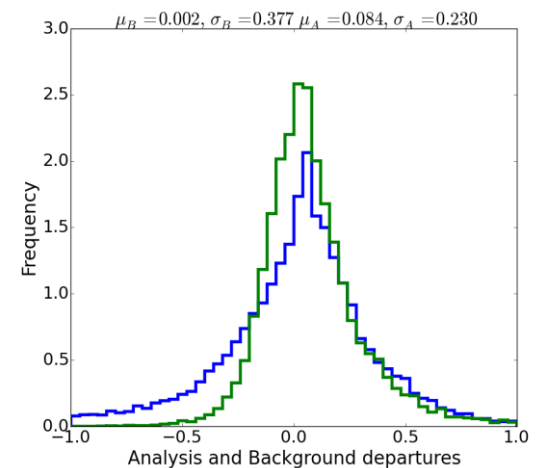


# Departure Statistics (assimilating NRL MODIS)

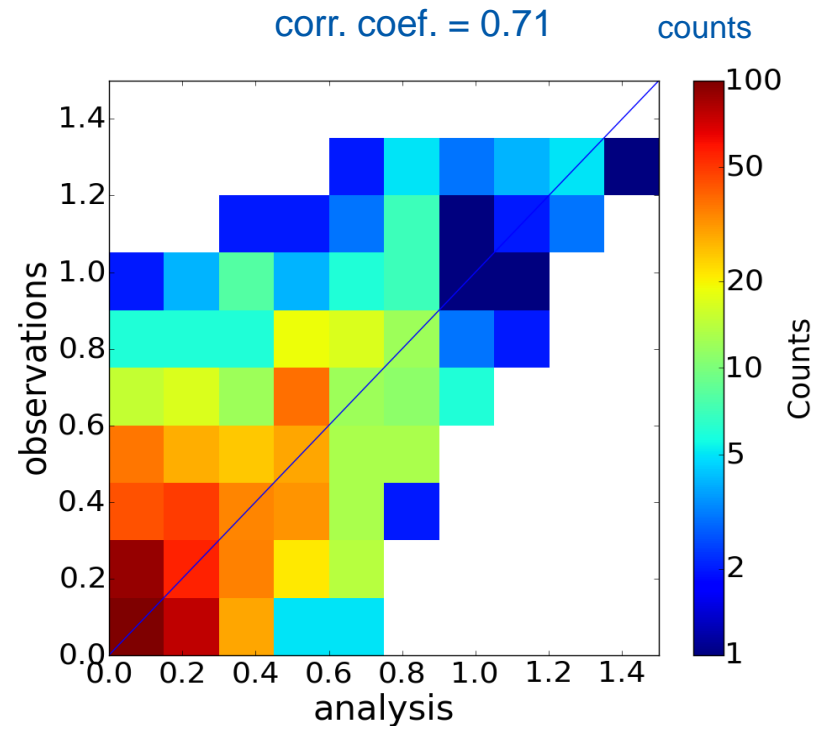
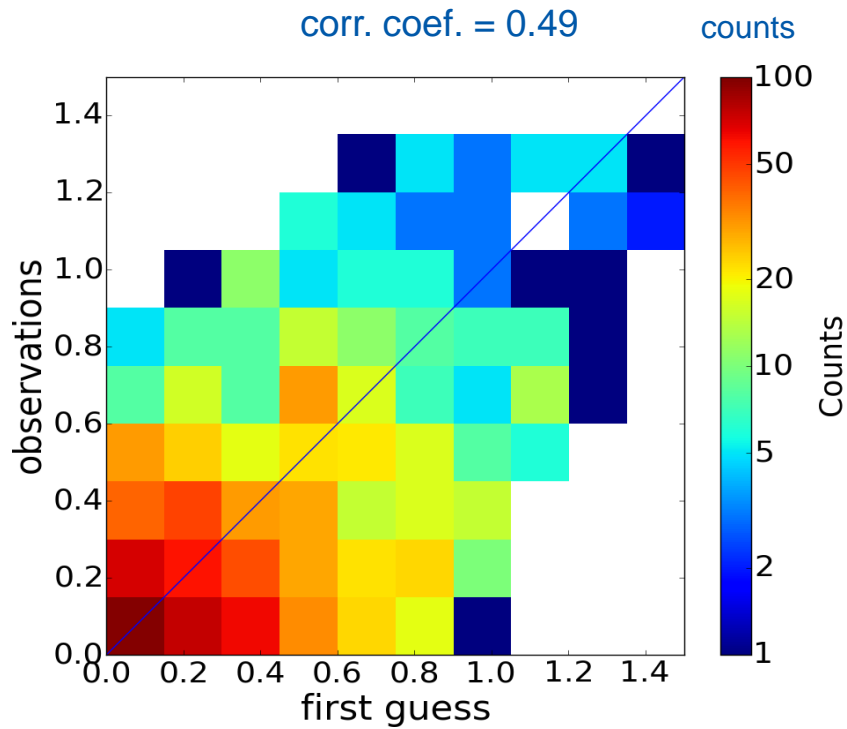


Scatter in the analysis is smaller than for the first guess;

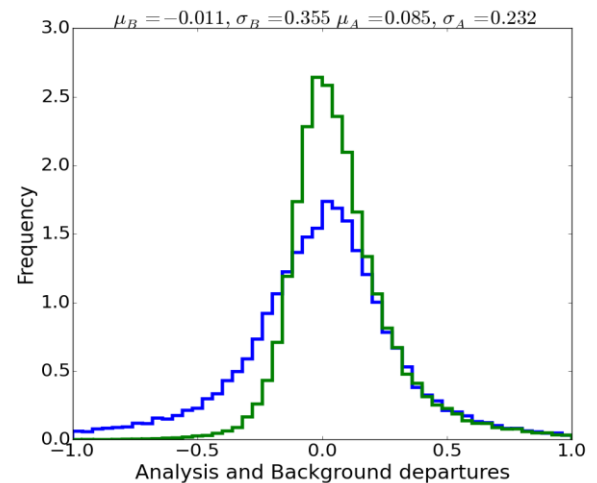
Analysis performs better in reducing too high value than increasing too low values



# Departure Statistics (assimilating NRL MODIS + DB)



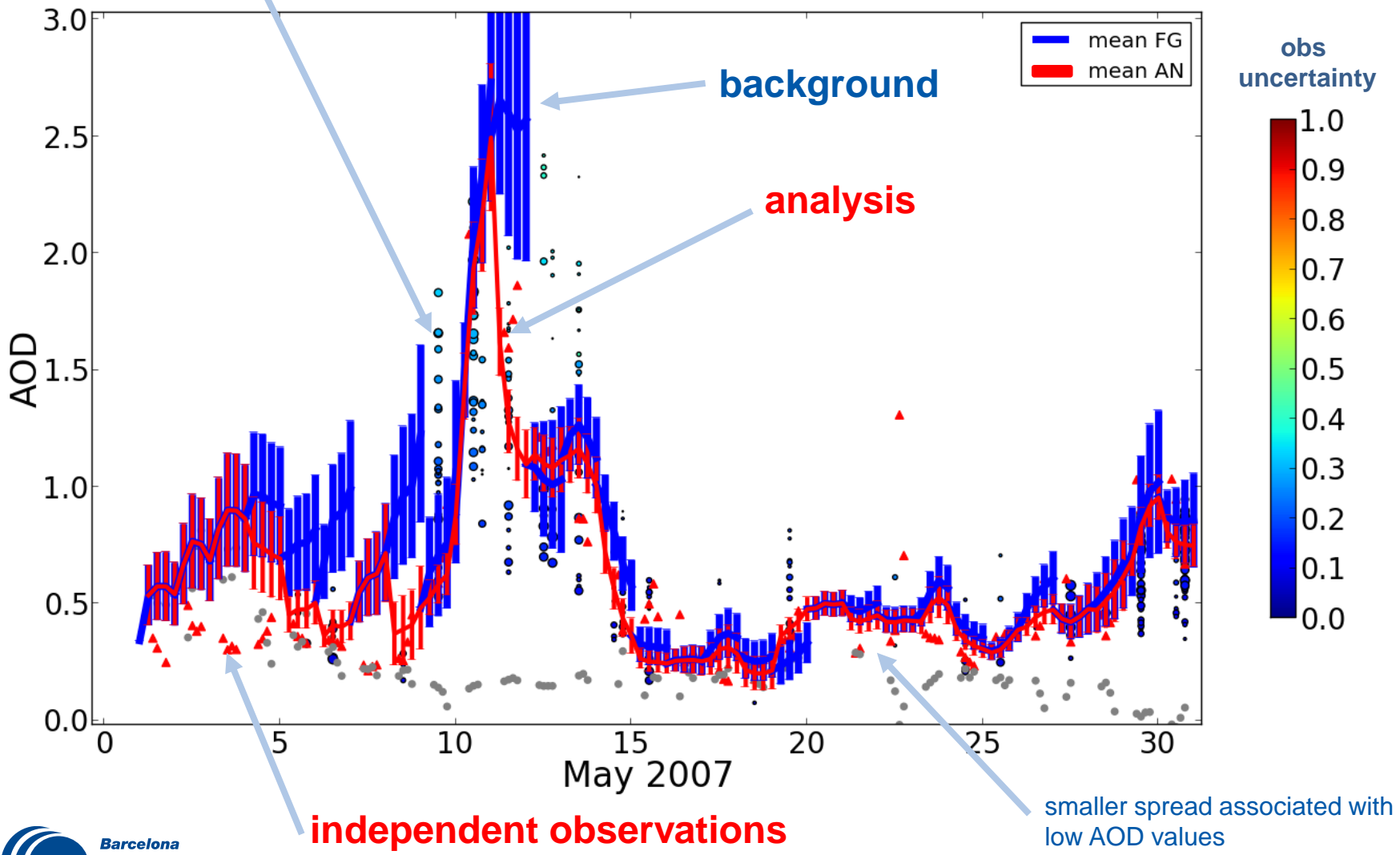
Departure statistics are improved after QC



# Inside the box

Dakar (Senegal)

assimilated observations

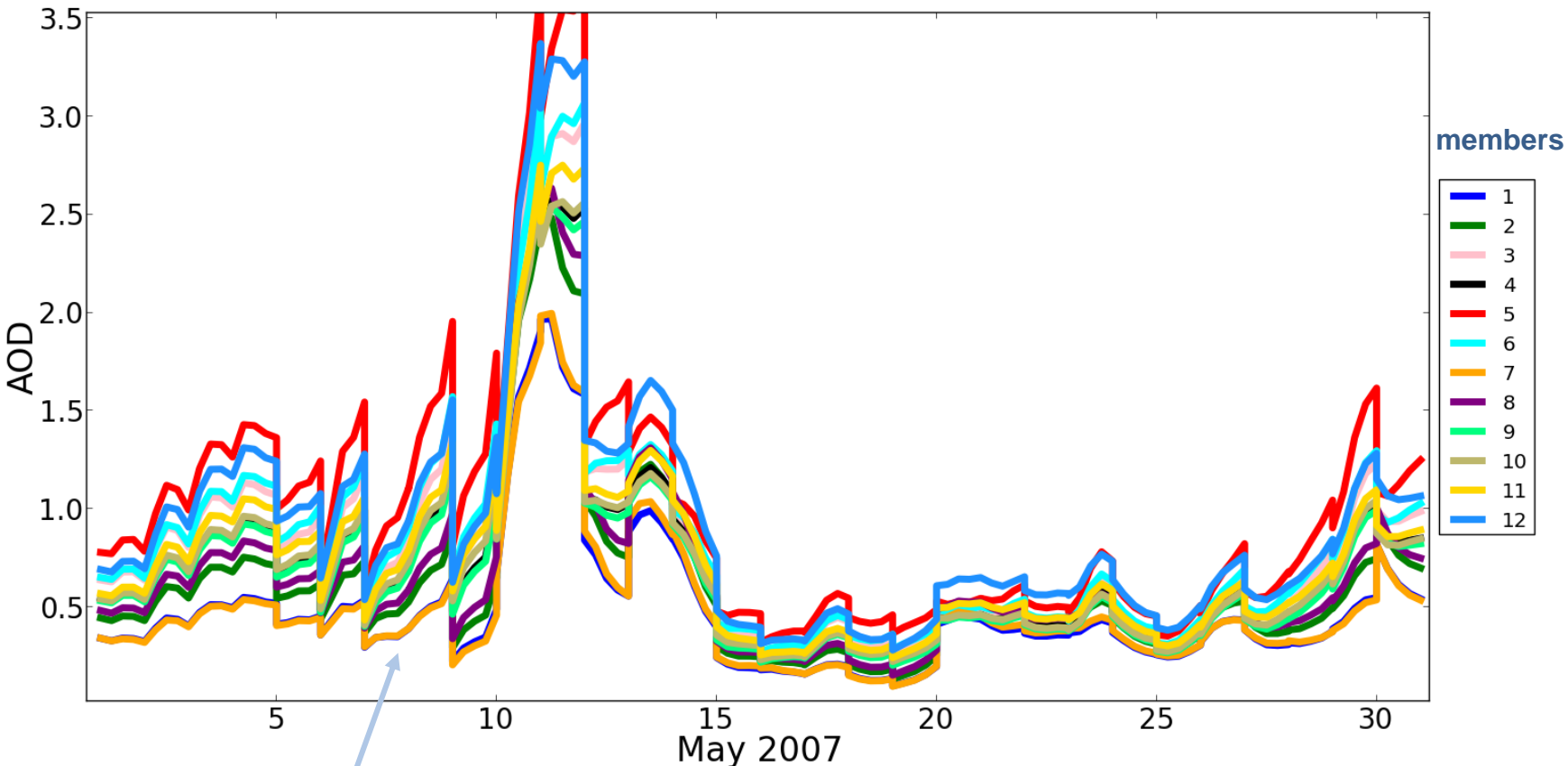


independent observations

smaller spread associated with low AOD values

# Background Ensemble (assimilating NRL MODIS)

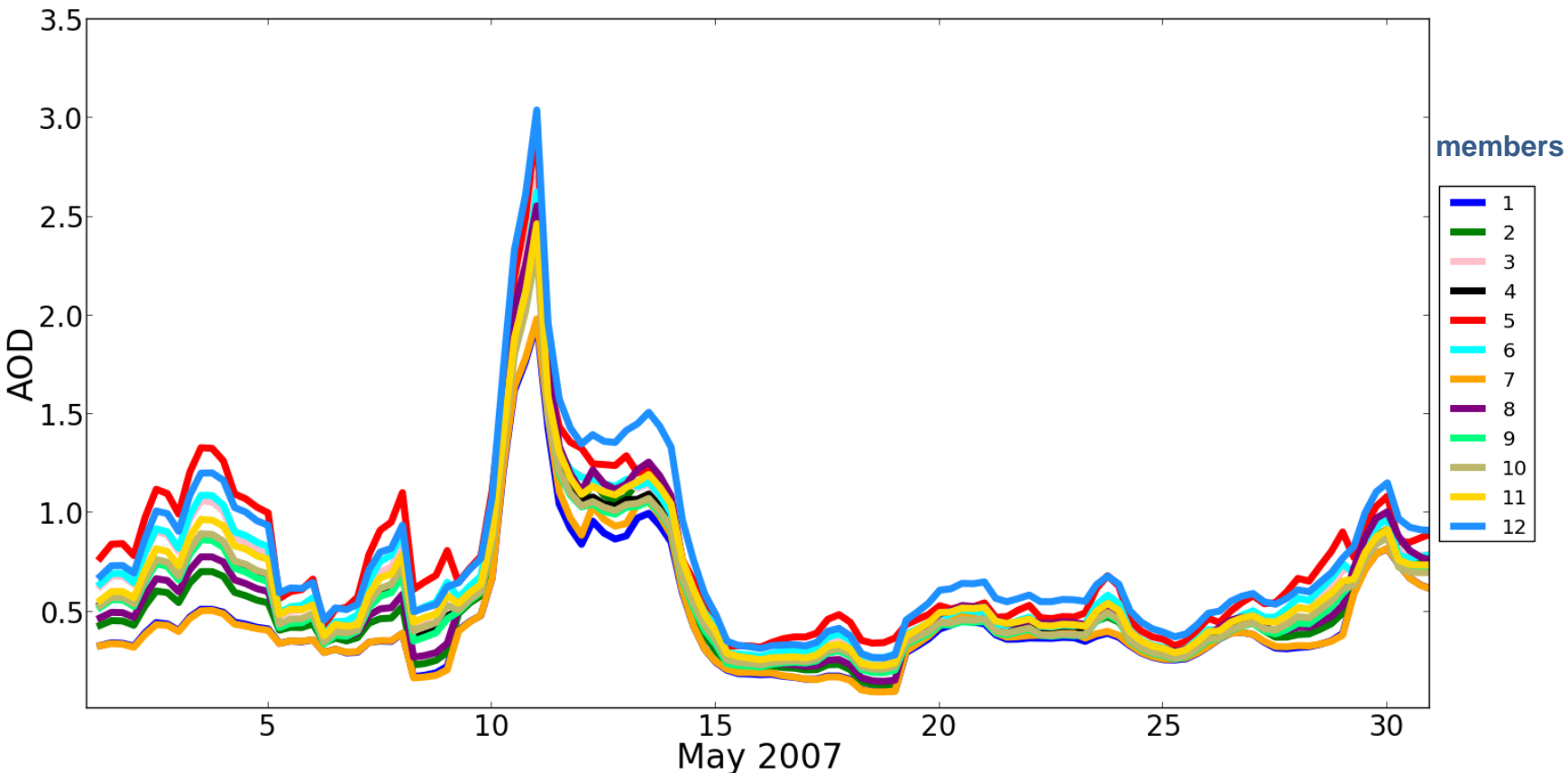
## Dakar (Senegal)



FG spread increases towards the end of the window

# Analysis Ensemble (assimilating NRL MODIS)

## Dakar (Senegal)

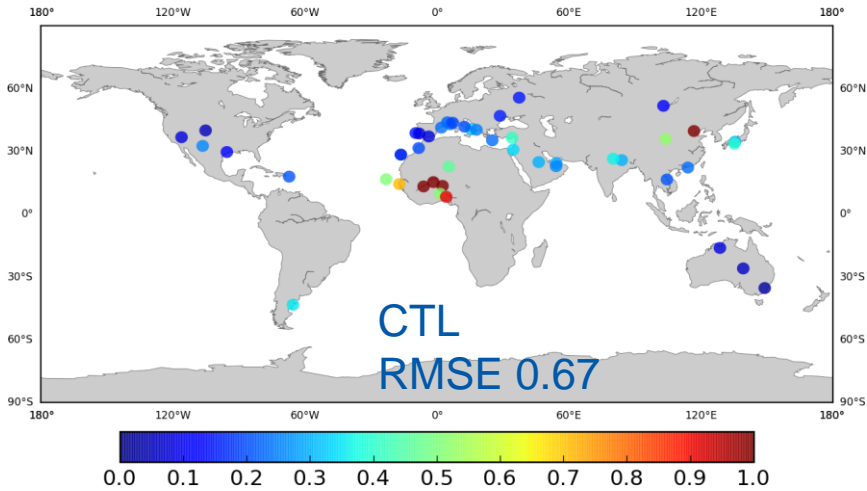


AN spread generally smaller than FG spread

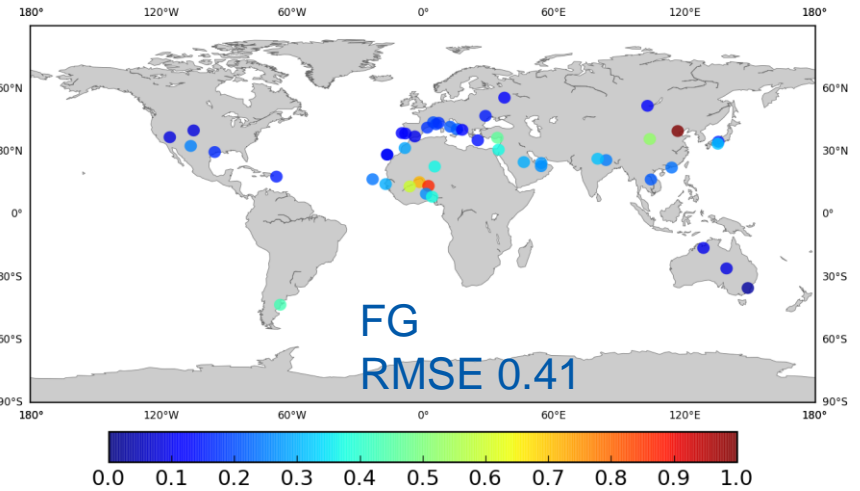
# Validation against Level 2 AERONET



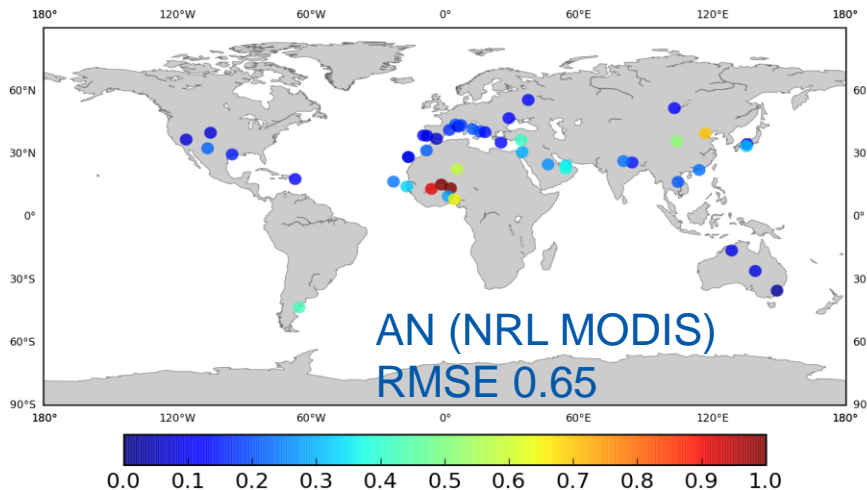
RMSE against AERONET



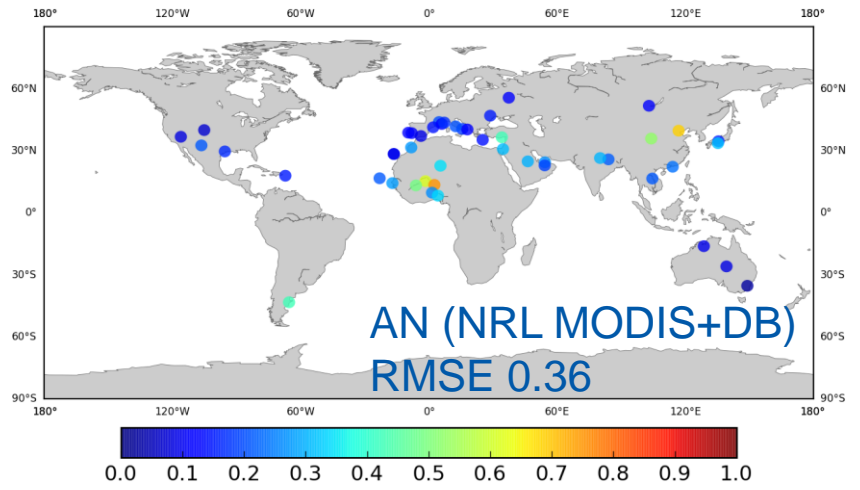
RMSE against AERONET



RMSE against AERONET



RMSE against AERONET

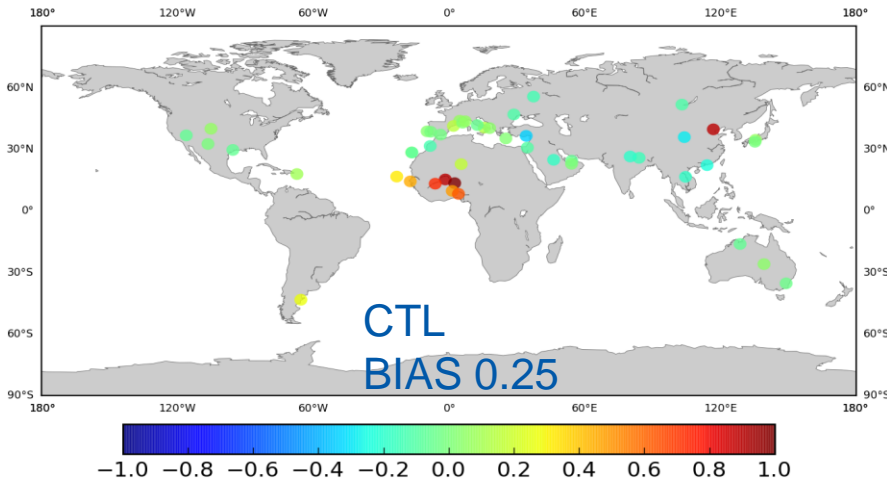




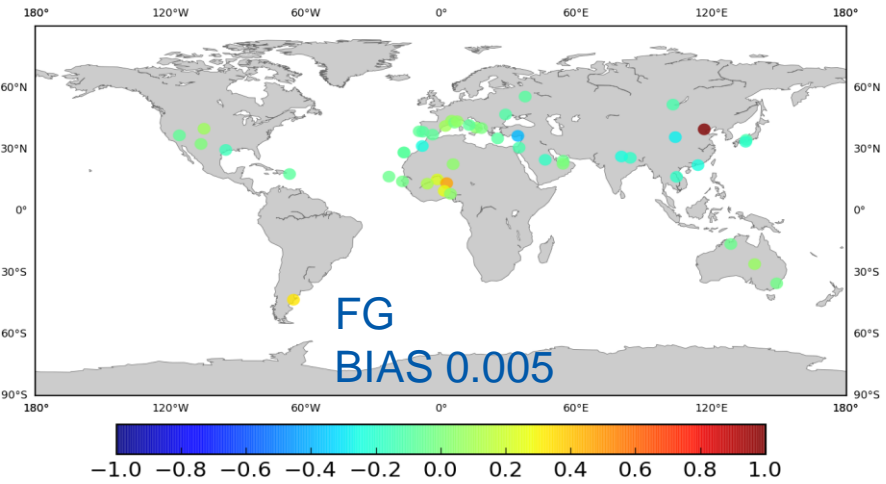
# Validation against Level 2 AERONET



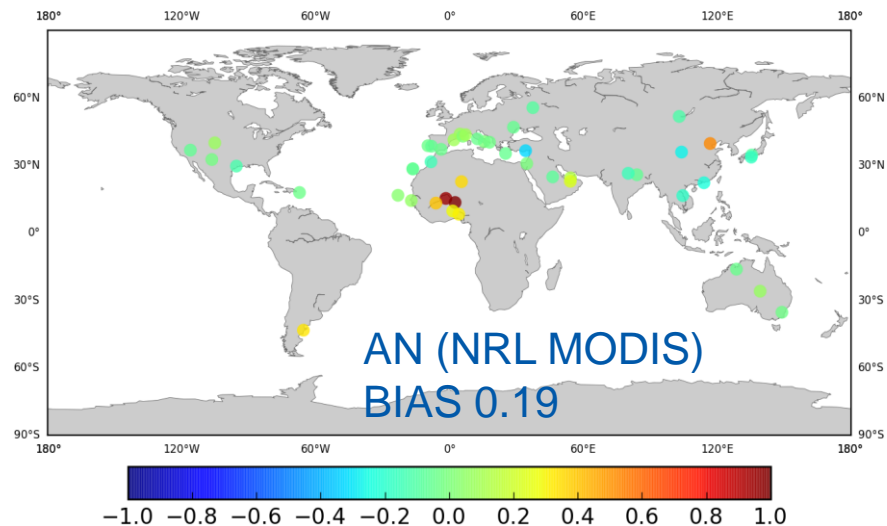
BIAS against AERONET



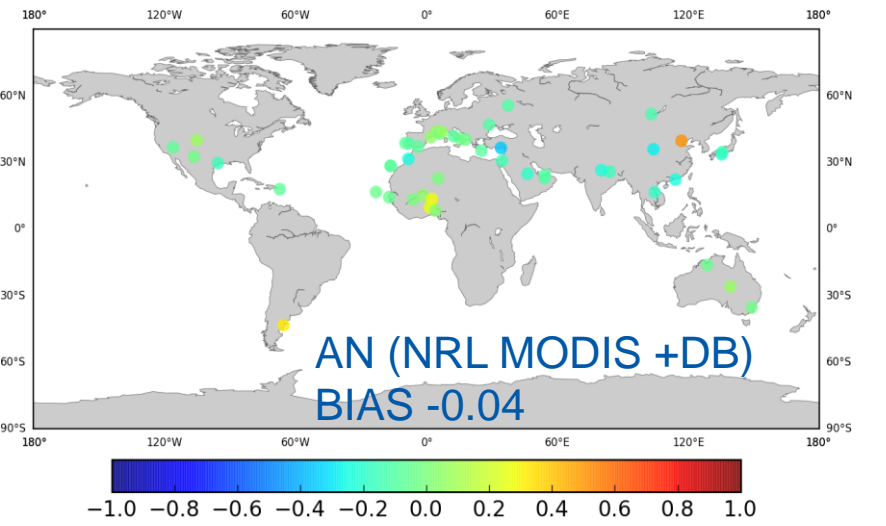
BIAS against AERONET



BIAS against AERONET

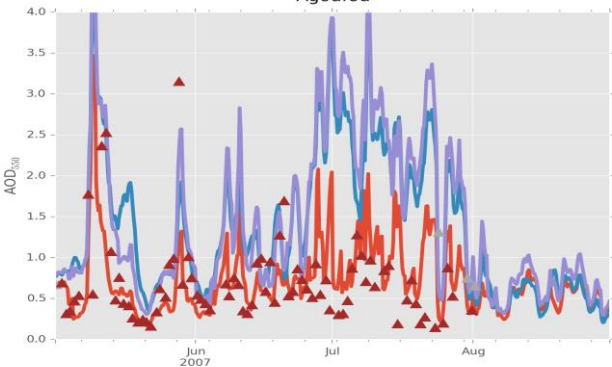


BIAS against AERONET

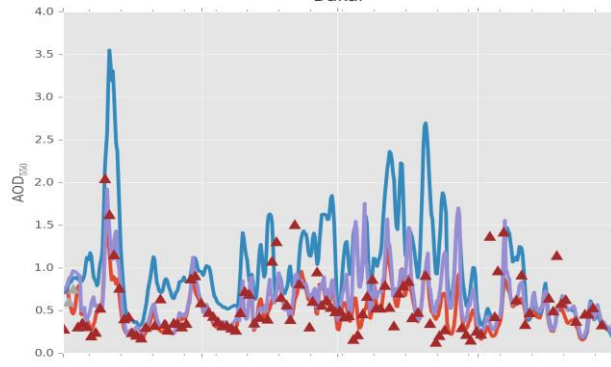


# Analysis versus AERONET

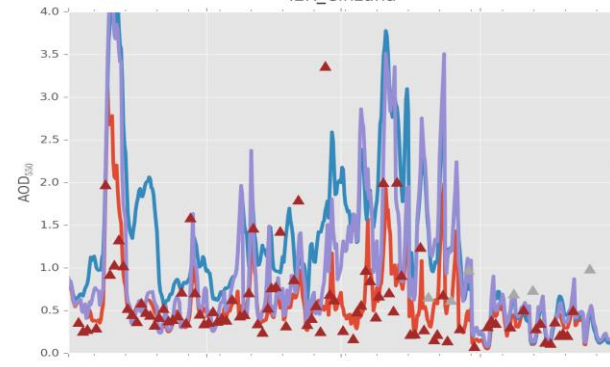
Agoufou



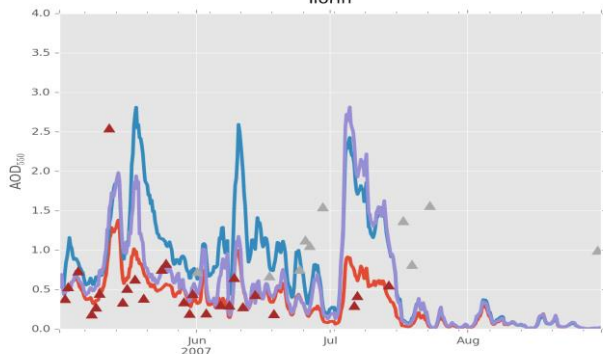
Dakar



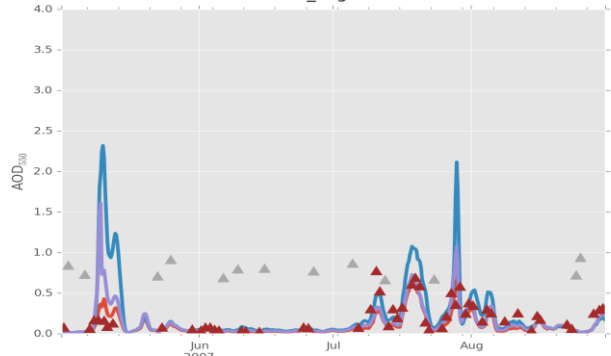
IER\_Cinzana



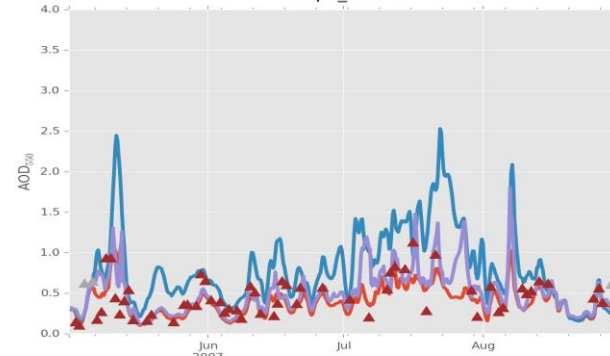
Ilorin



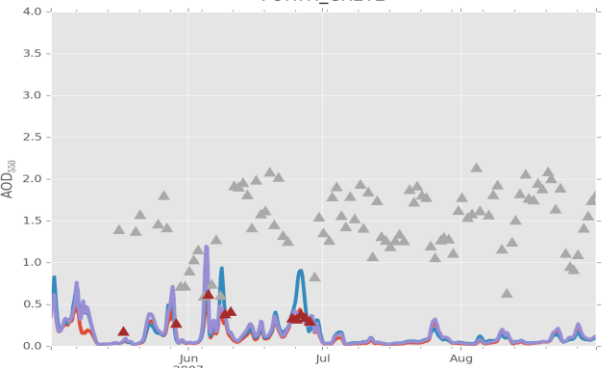
La\_Laguna



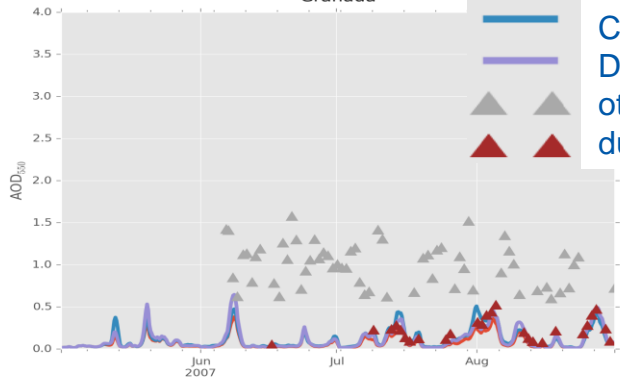
Capo\_Verde



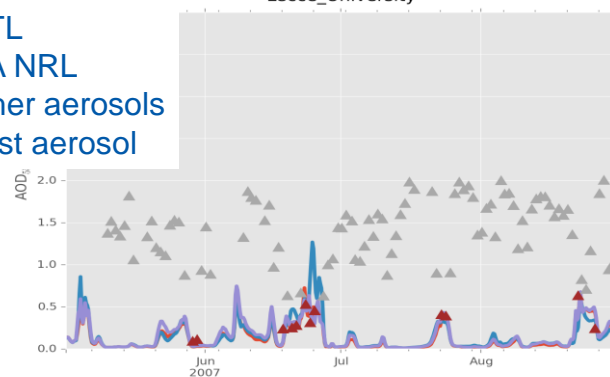
FORTH\_CRETE



Granada



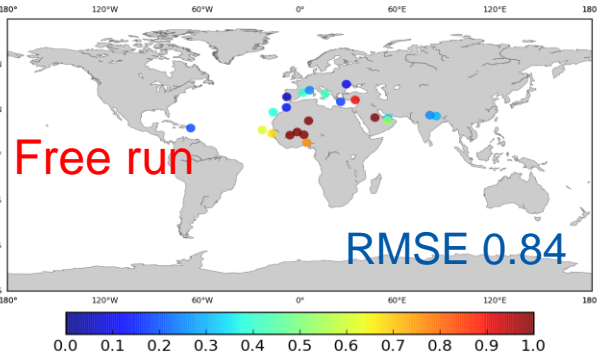
Lecce\_University



# Forecast versus AERONET

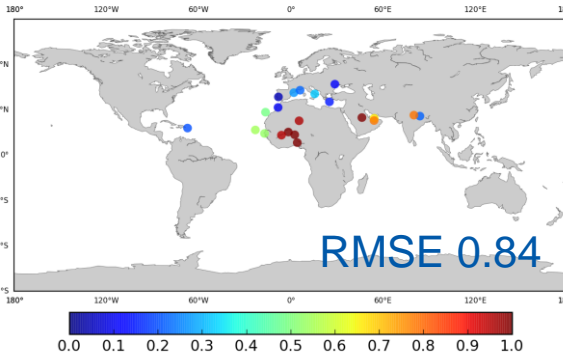
**FC+12**

RMSE against AERONET



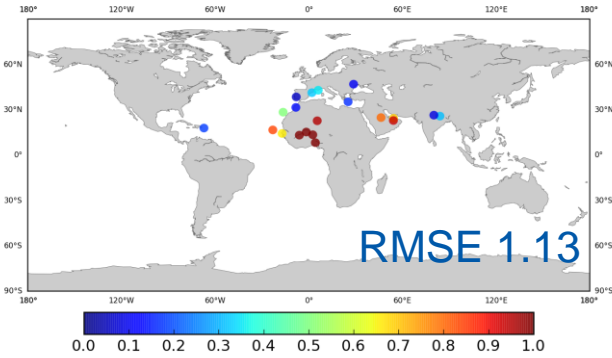
**FC+60**

RMSE against AERONET

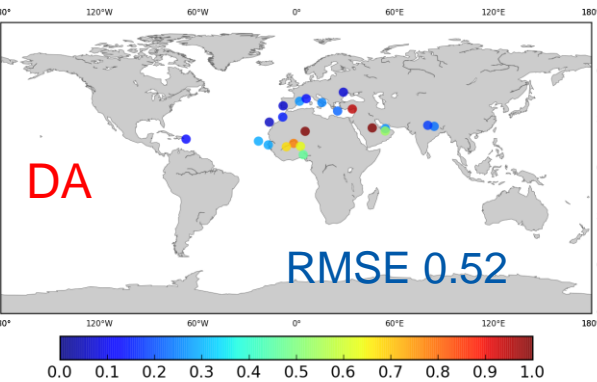


**FC+108**

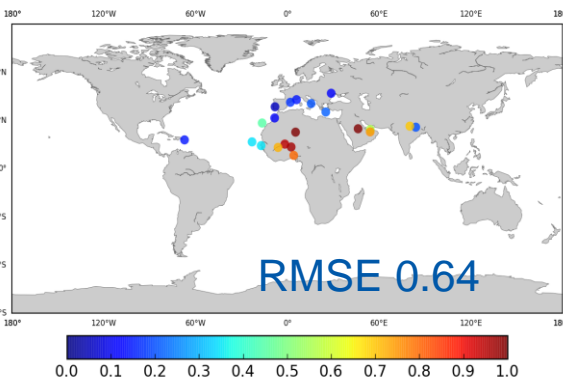
RMSE against AERONET



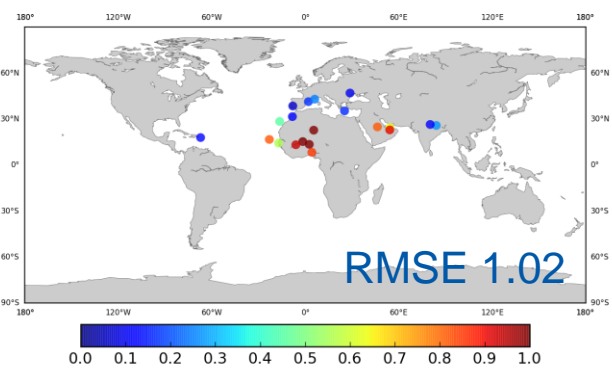
RMSE against AERONET



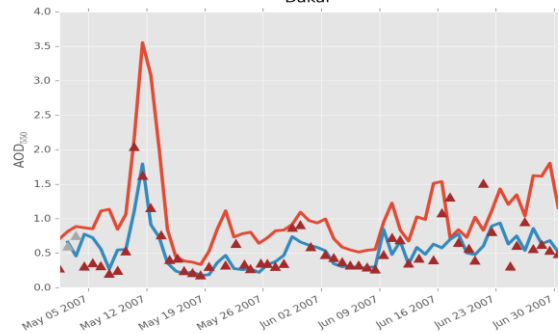
RMSE against AERONET



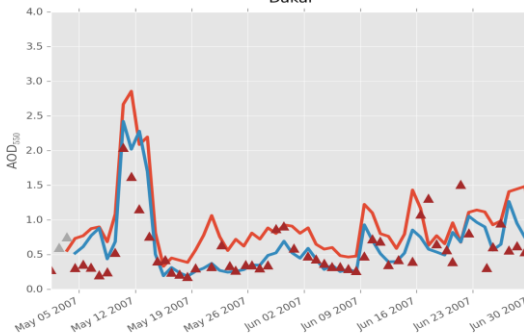
RMSE against AERONET



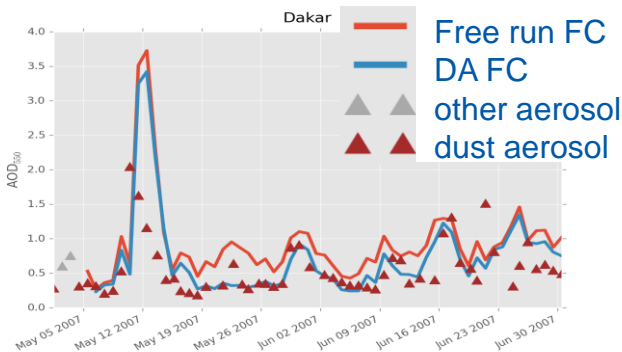
Dakar



Dakar



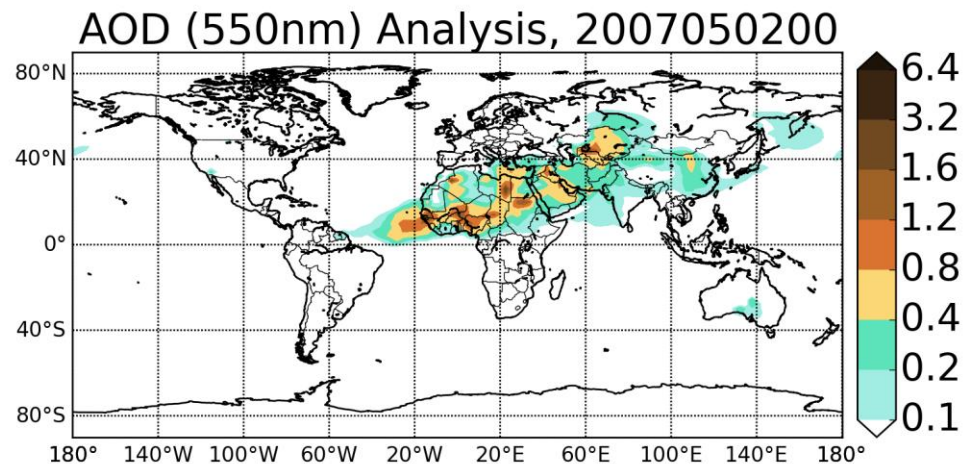
Dakar



# Conclusions

First foundations have been built for a DA capability for the “Barcelona model” participating in ICAP;

Not yet there to perform an operational forecast but more than ready to produce dust reanalysis.







**Barcelona  
Supercomputing  
Center**

*Centro Nacional de Supercomputación*

**Thank you!**

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