Aerosol Assimilation

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Ispra, Italy

MATCH Model with MODIS AOD Assimilation has been prepared for AEROCOM

Years 2000 and 2001

How does AOD assimilation work?

Assimilation adjusts model aerosol mass so that model AOD more closely matches satellite observed AOD.

$$\tau_\lambda = \Sigma_s \Sigma_k [\Delta p_k / g \quad k_\lambda(RH)] q_{sk}$$

Single wavelength assimilation scales aerosol mass mixing ratios independent of vertical level and species

$q_{sk} \Rightarrow \alpha\, q_{sk}$ through *Optimal Interpolation*, with a spatial correlation length of ~ 100 km .

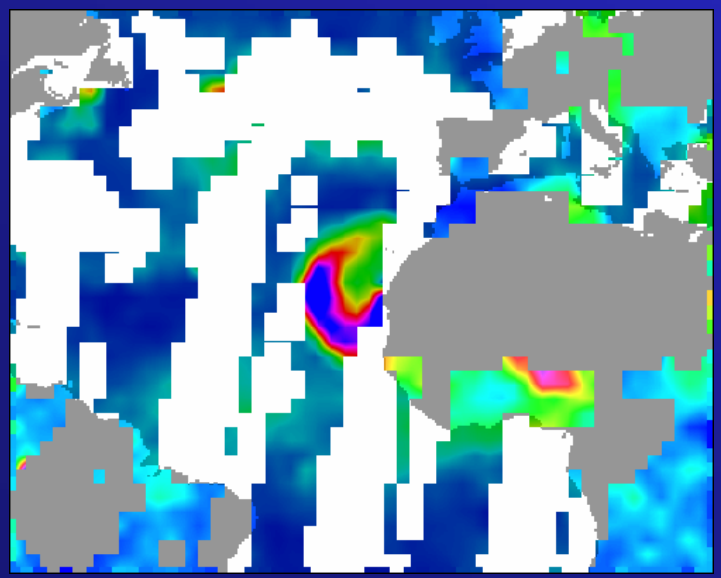
An example illustrates the subsequent model propagation of this mass correction …

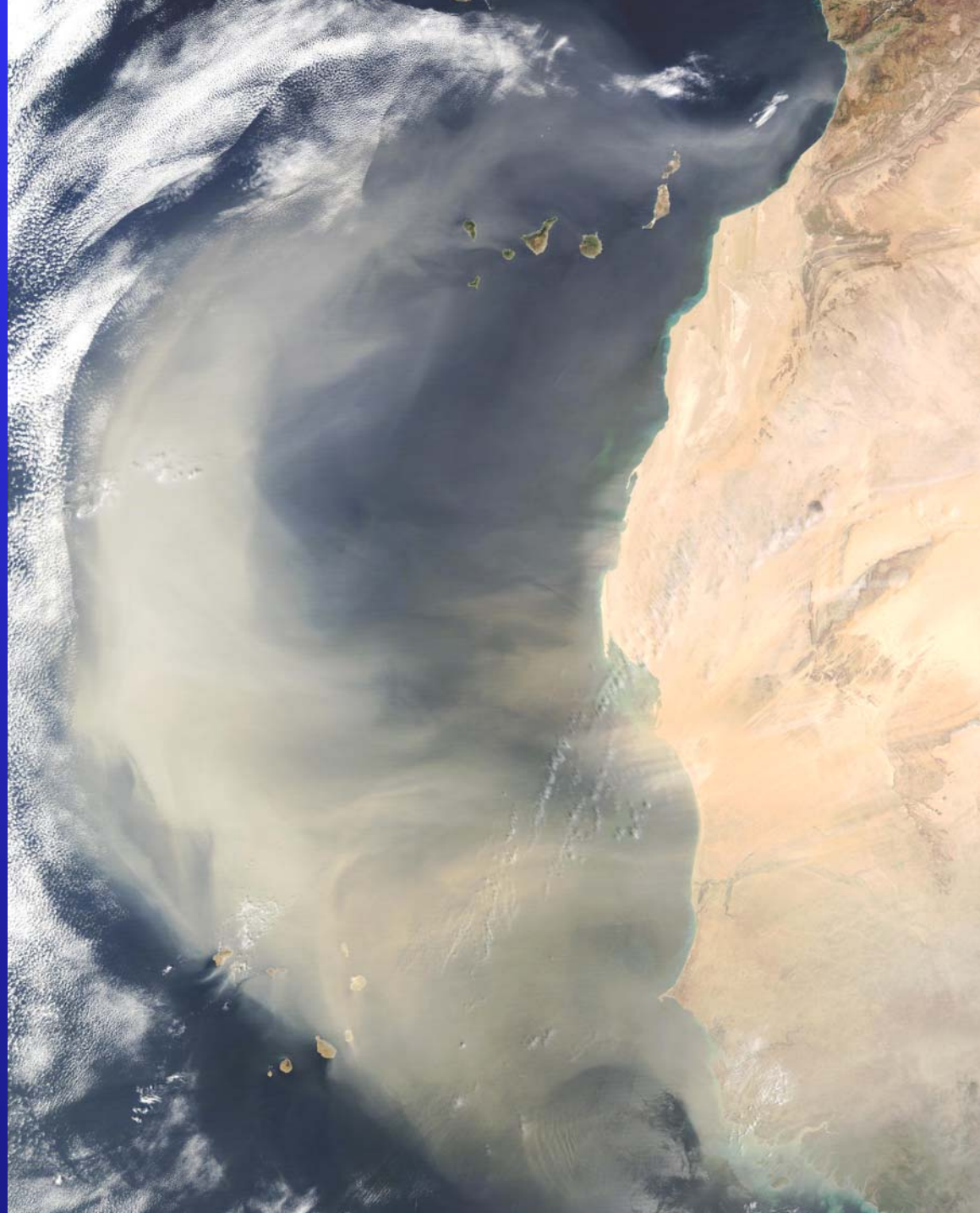
Aerosol Assimilation Example

Saharan Dust Storm March 2, 2003

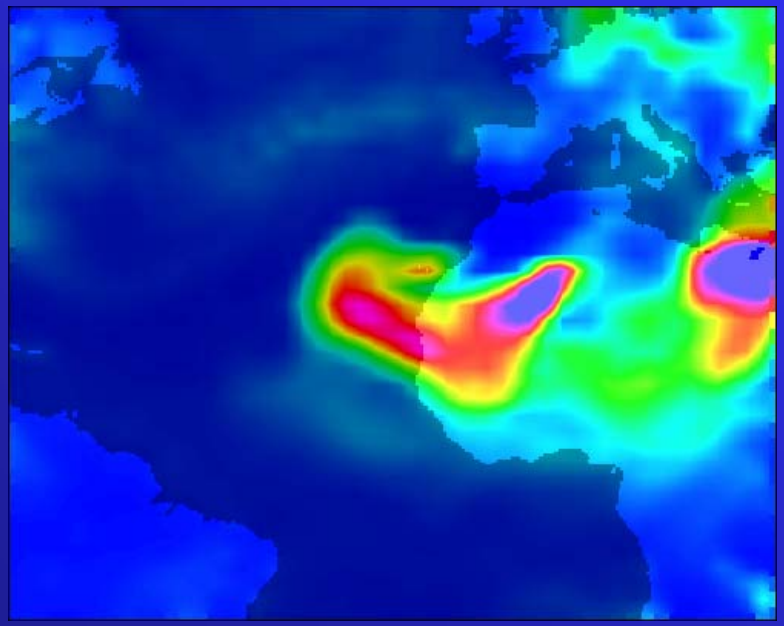
MODIS AOD at MATCH 1.9° resolution

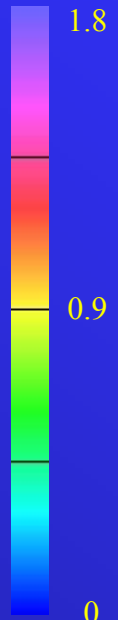
0 0.9 1.8



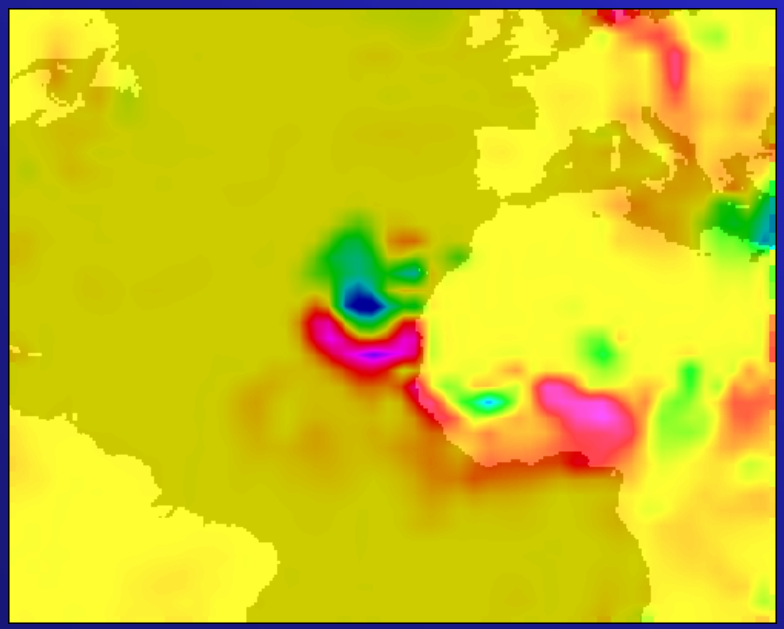


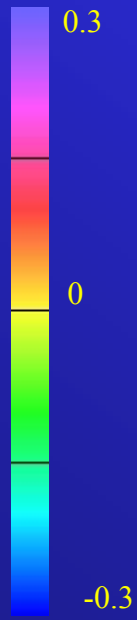
March 2





MATCH AOD





AOD Difference

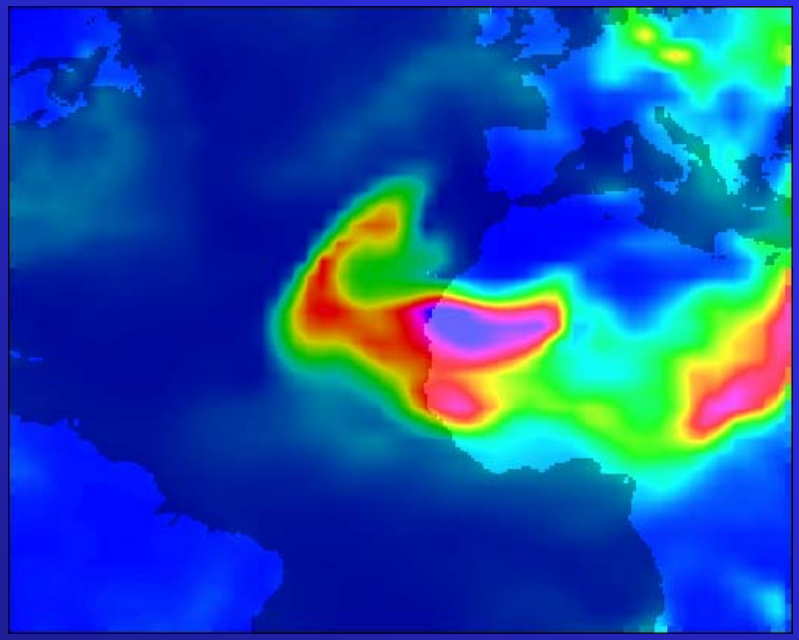
MATCH with
MODIS Assimilation
(on March 2 only)

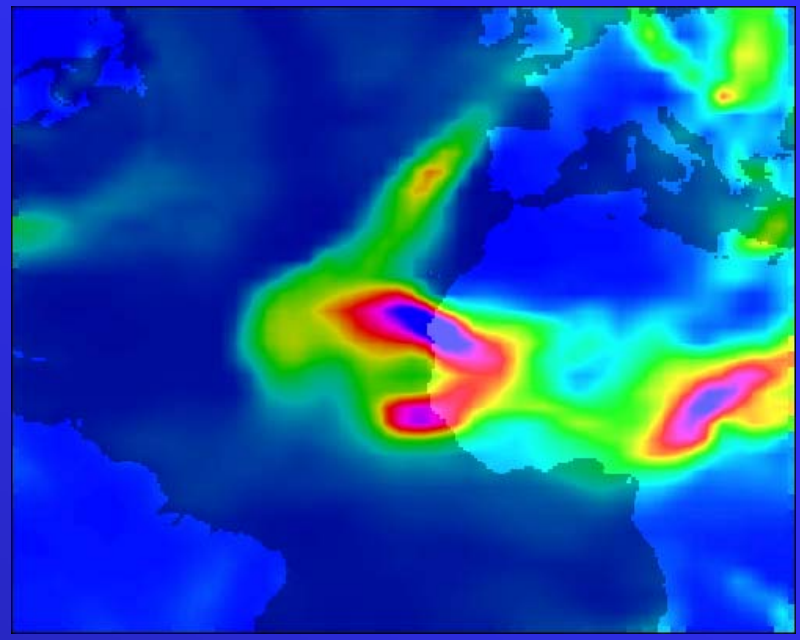
-

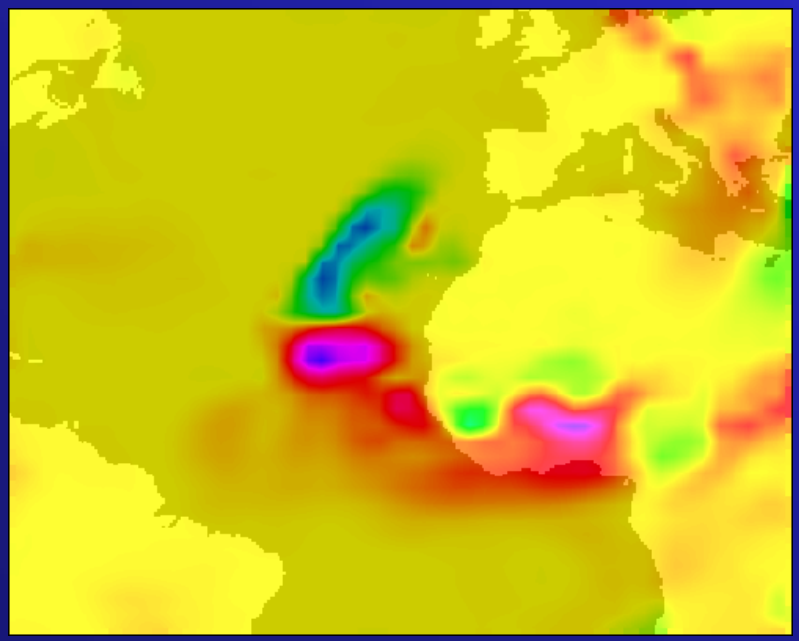
MATCH

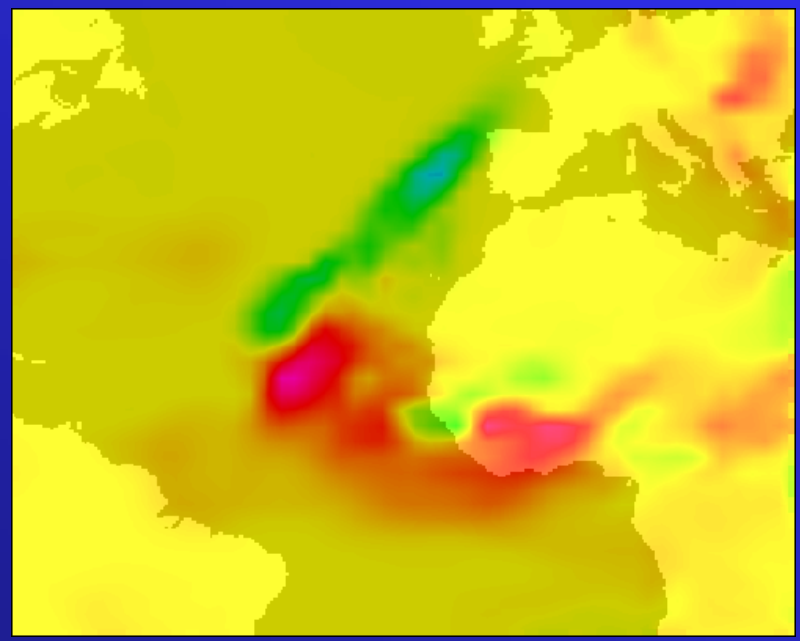
March 3

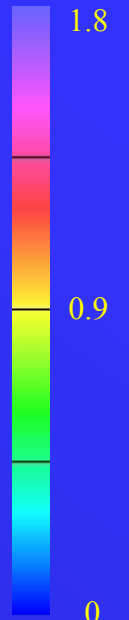
March 4

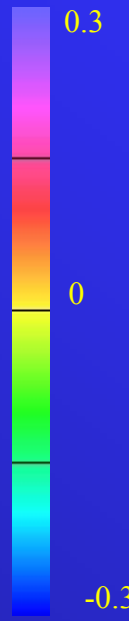






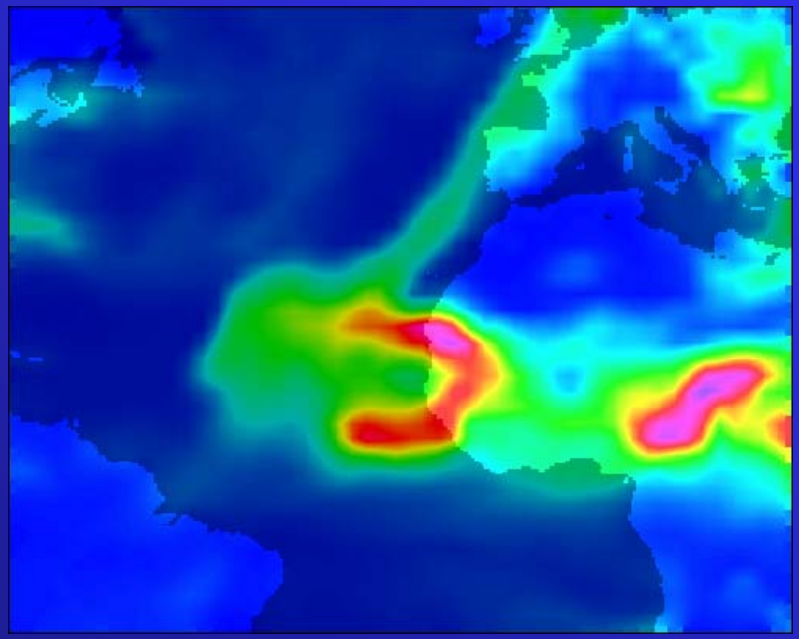


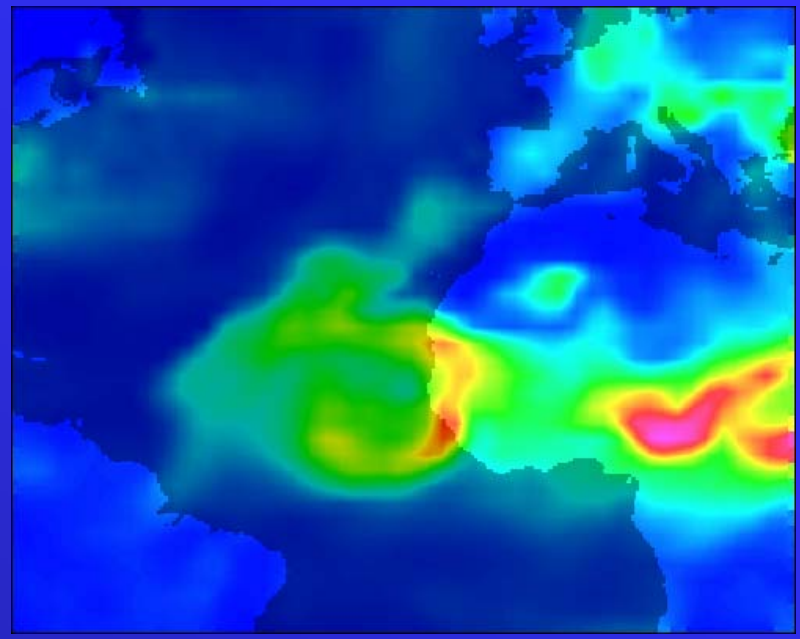


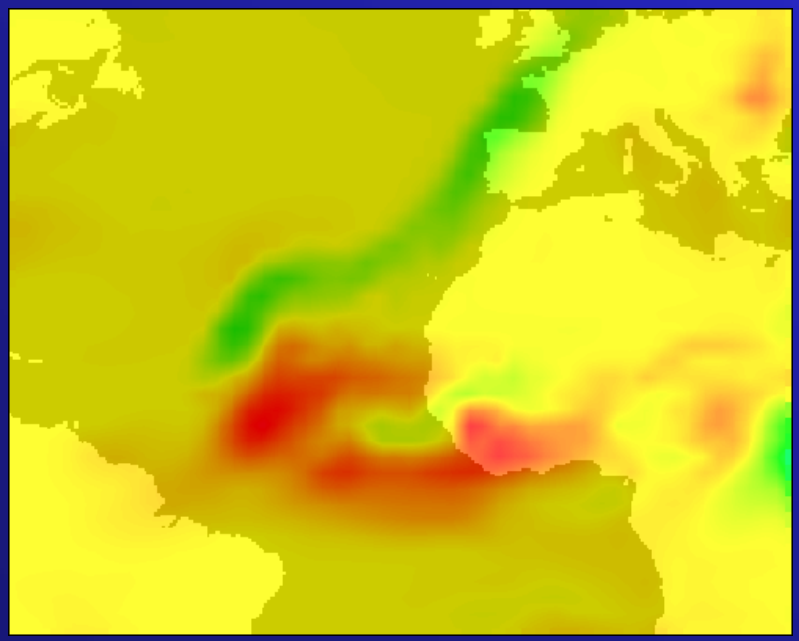


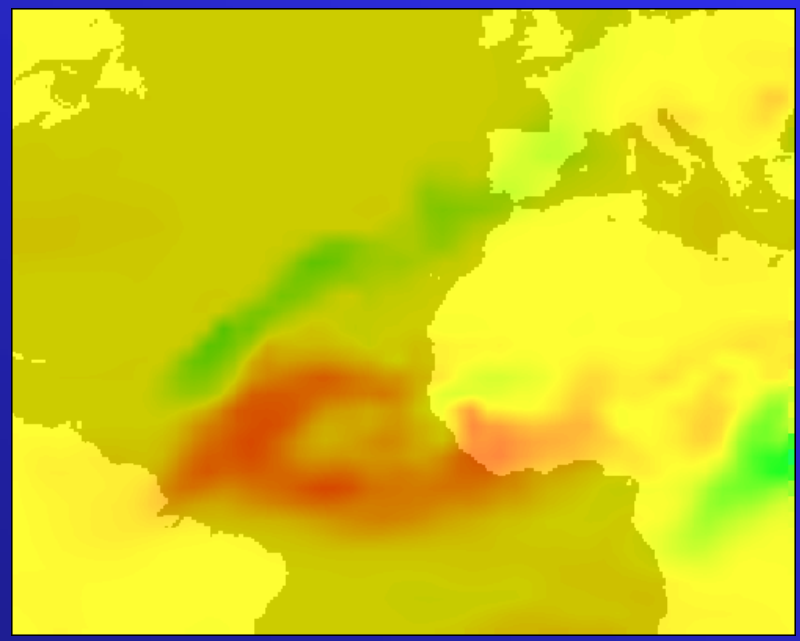
March 5

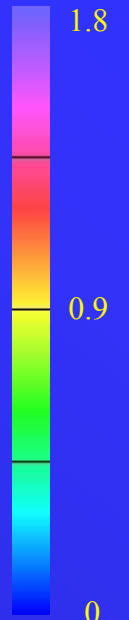
March 6

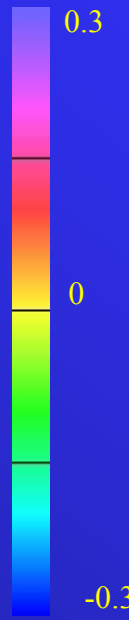




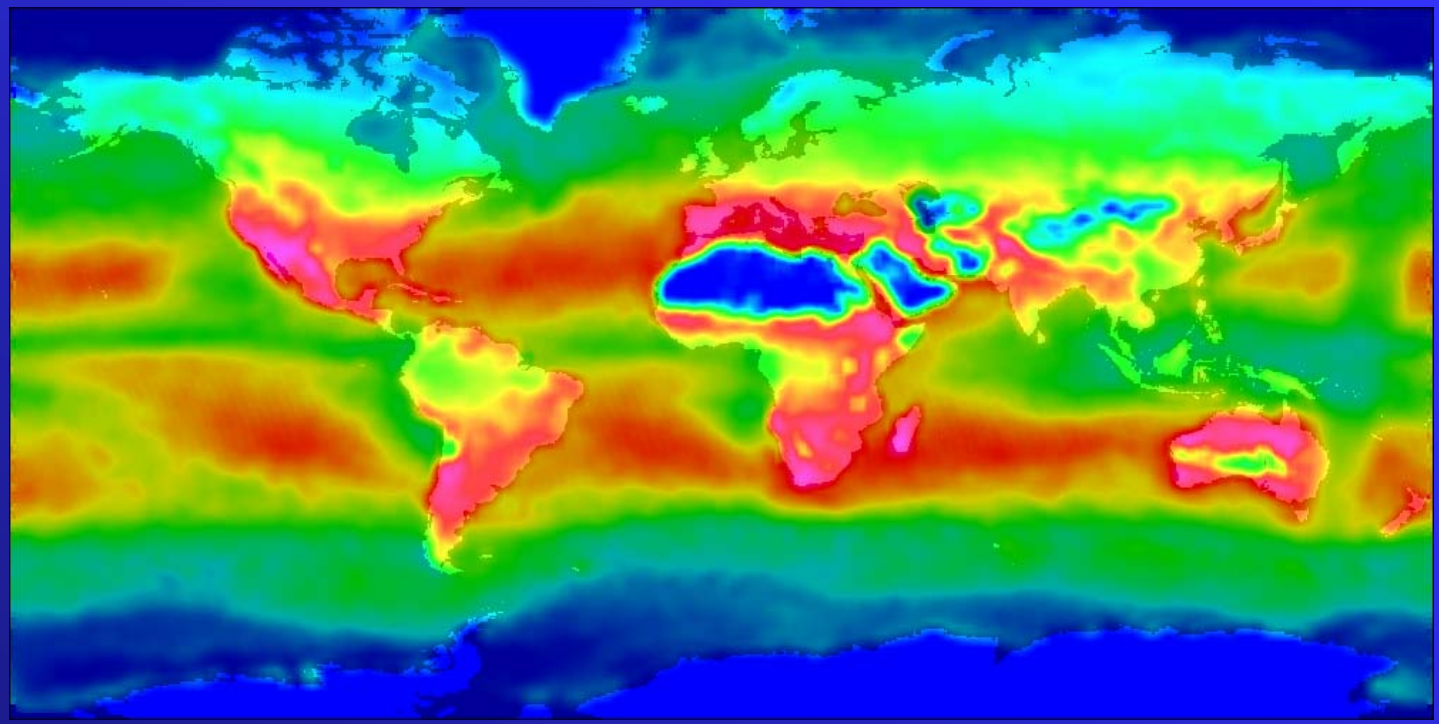








MODIS Sampling 2001



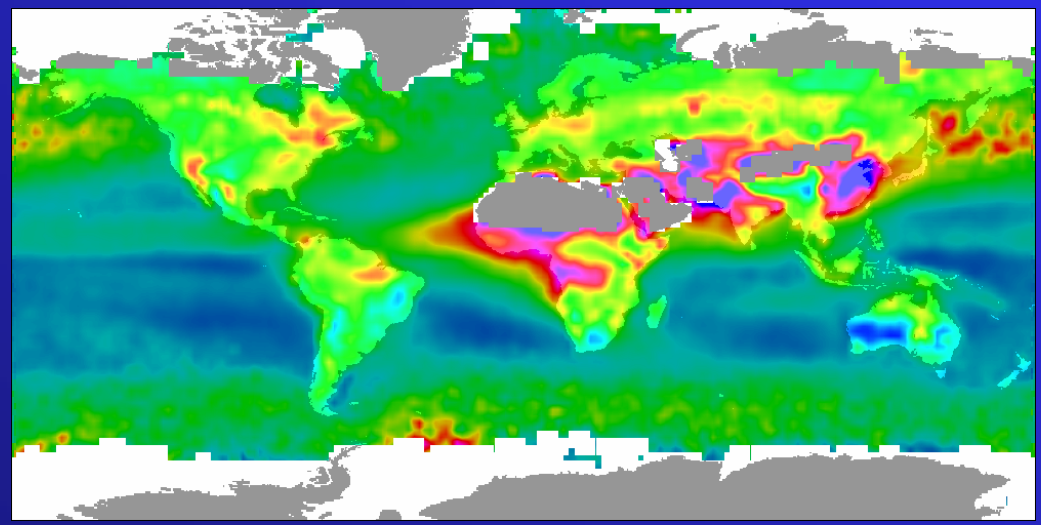
1.0

0.5

0

fraction of days with MODIS AOD measurement

MODIS AOD 2001

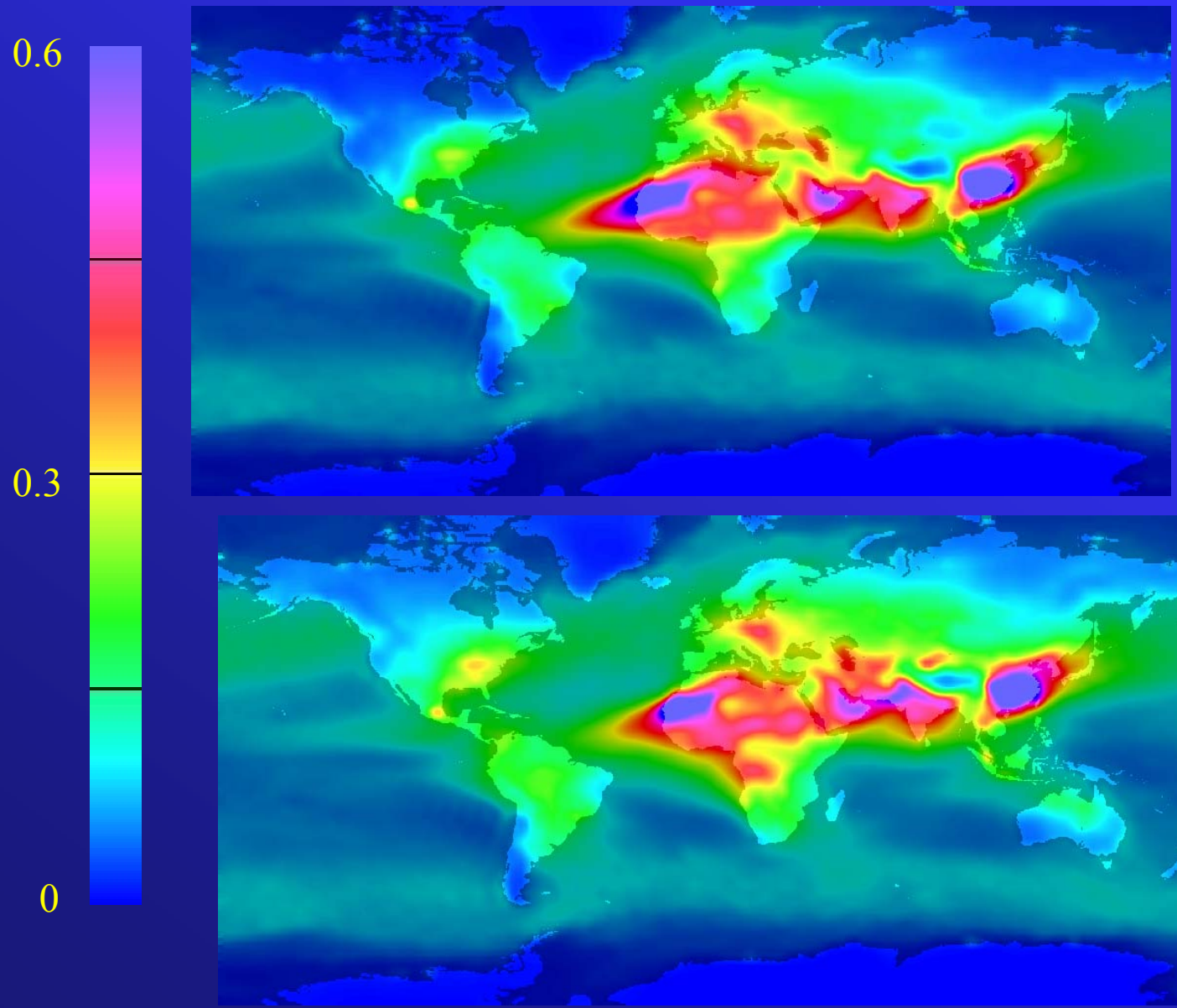


0.6

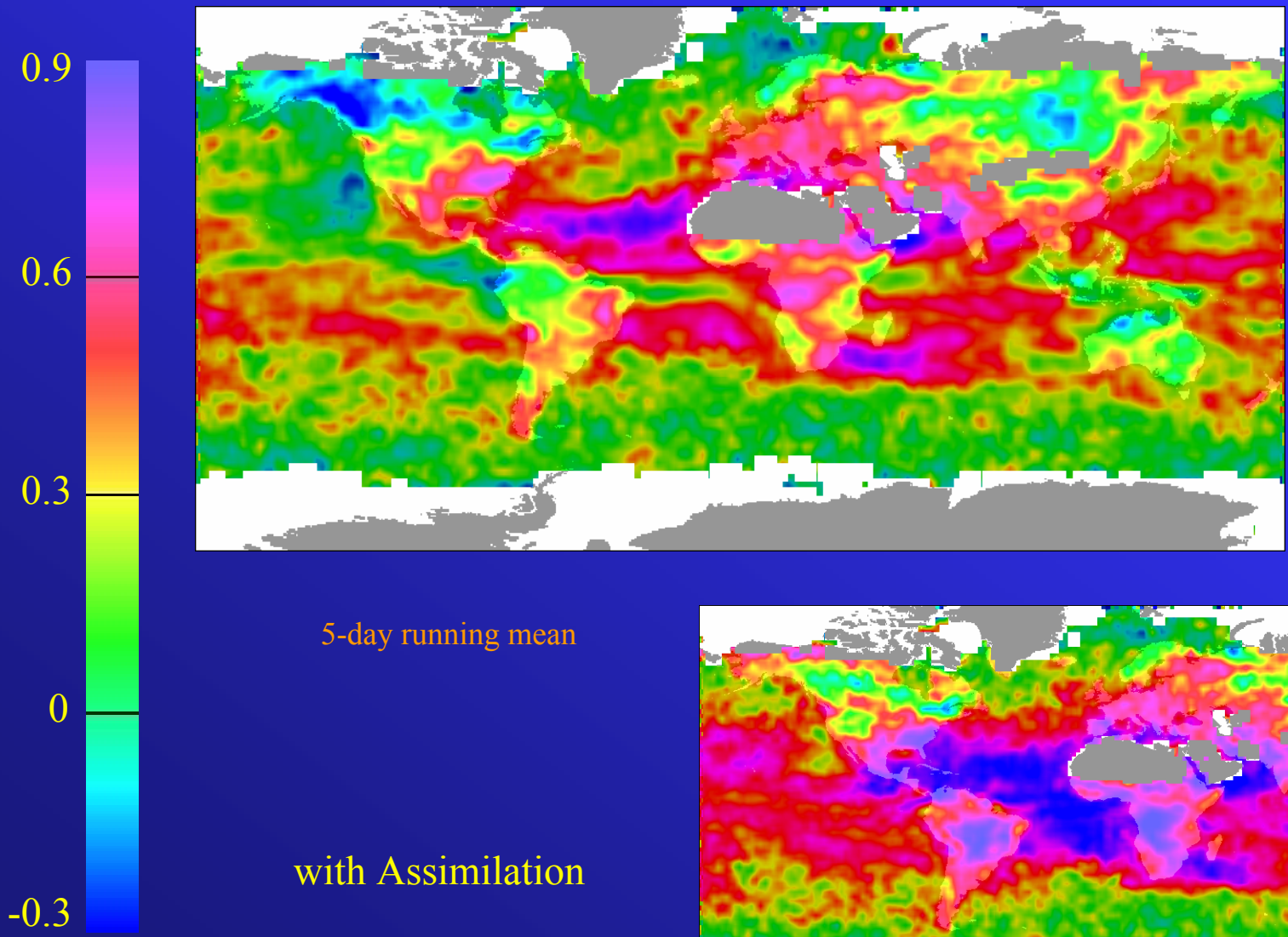
0.3

0

Aerosol Optical Depth 2001



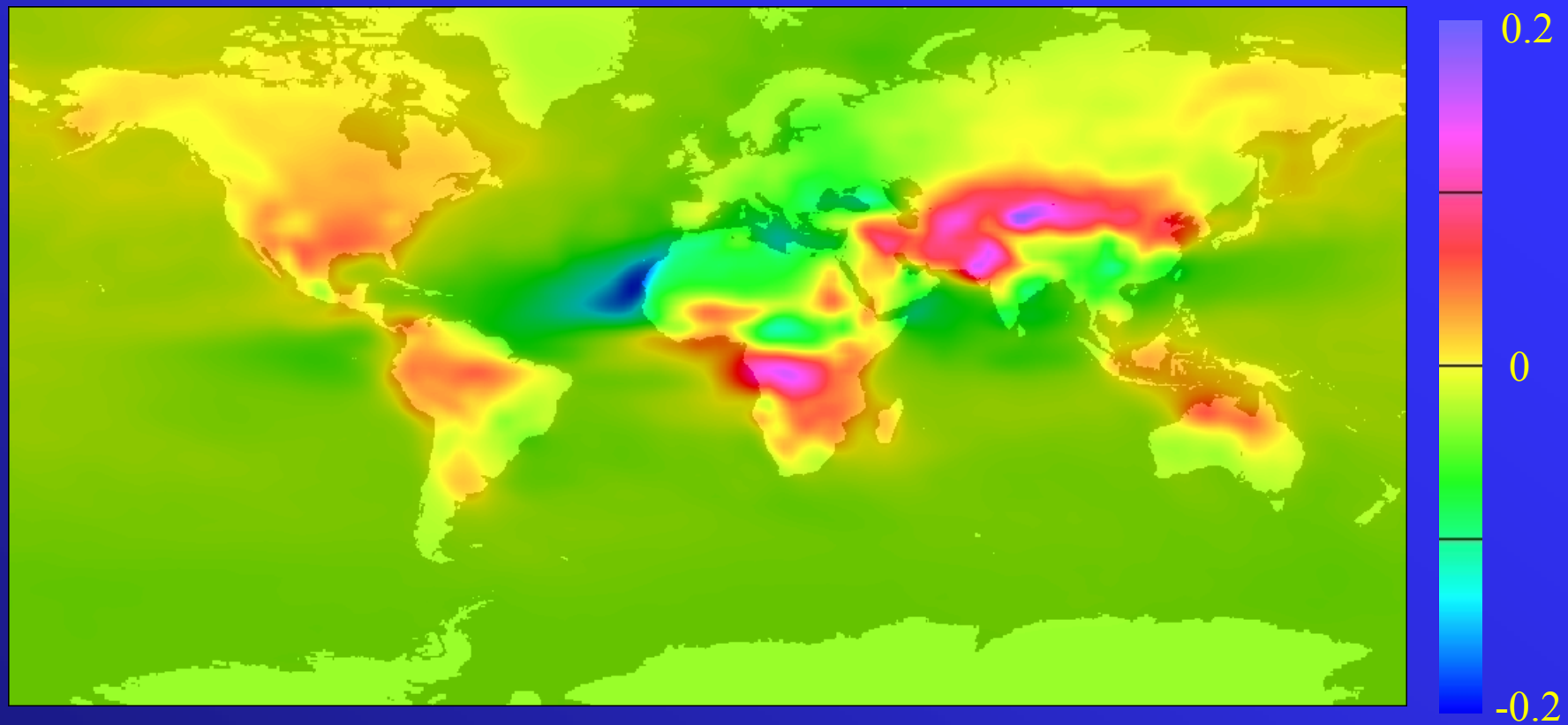
Aerosol Optical Depth MATCH/MODIS Correlation 2001



5-day running mean

with Assimilation

AOD Assimilation Correction 2001



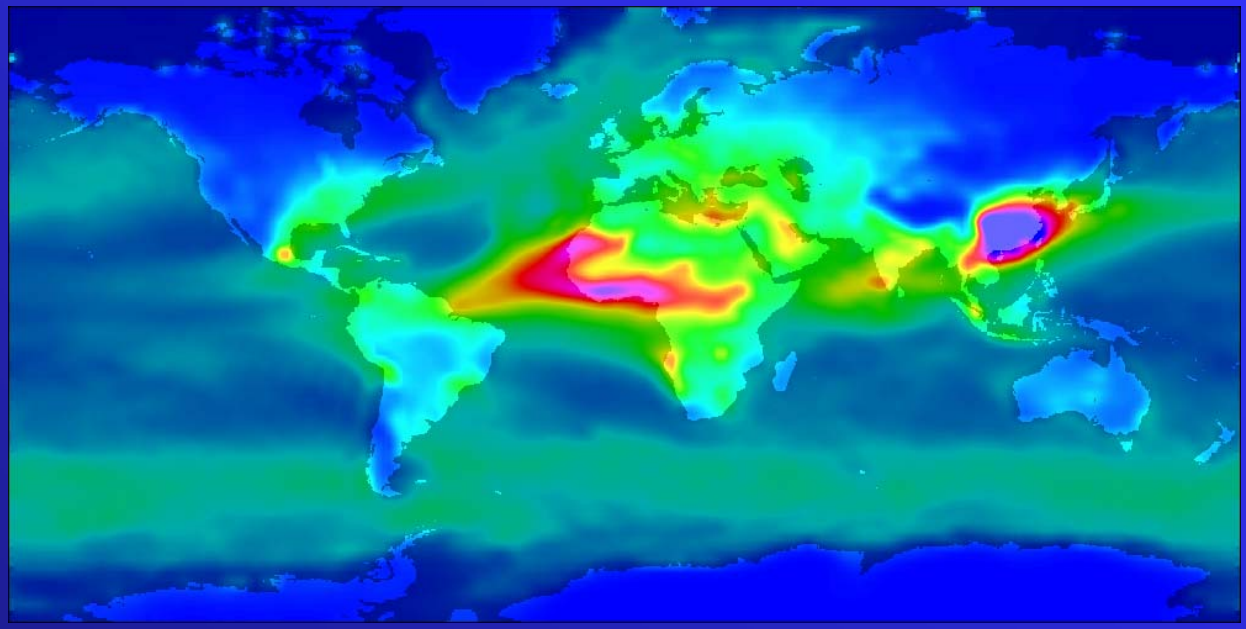
AOD Difference

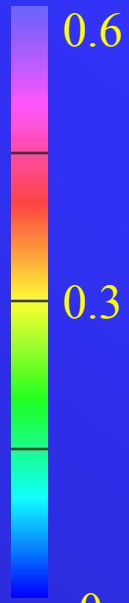
MATCH with MODIS Assimilation

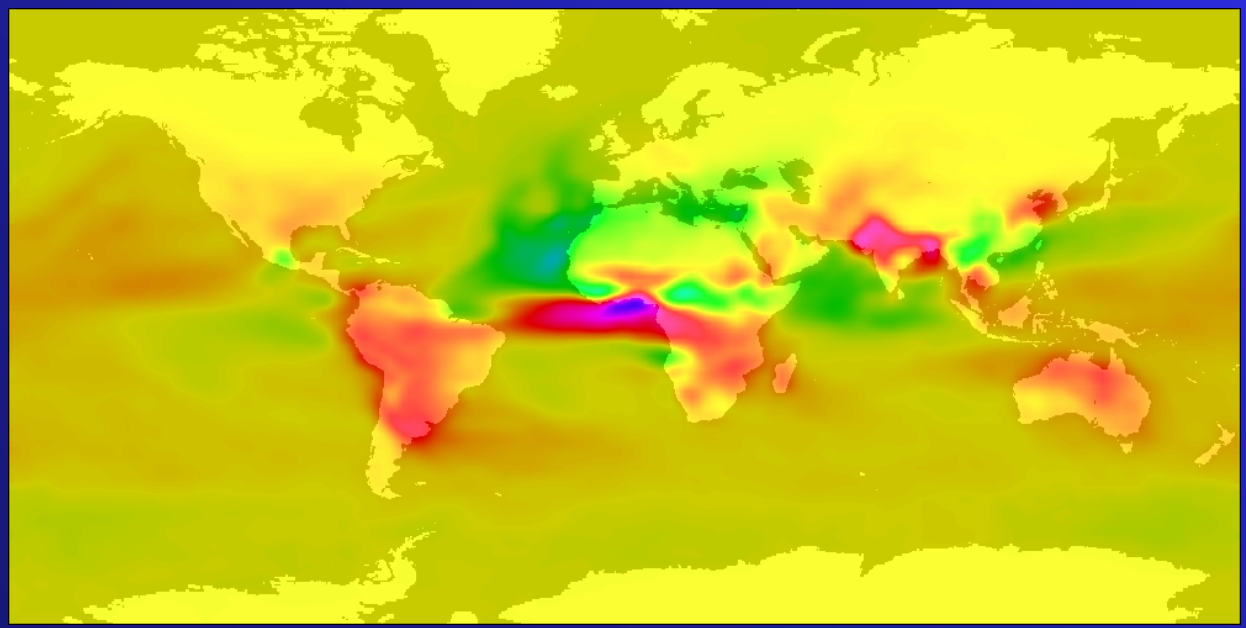
-

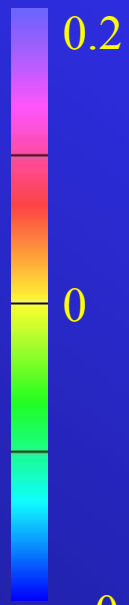
MATCH

December - January - February 2001

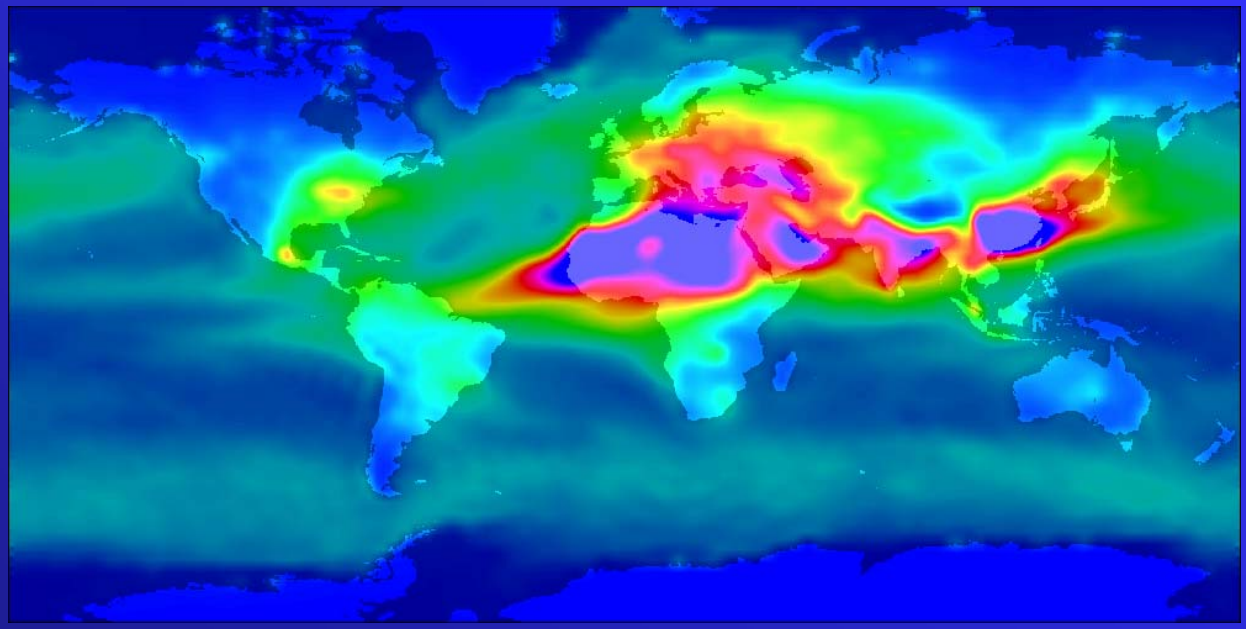


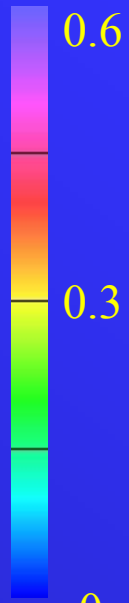


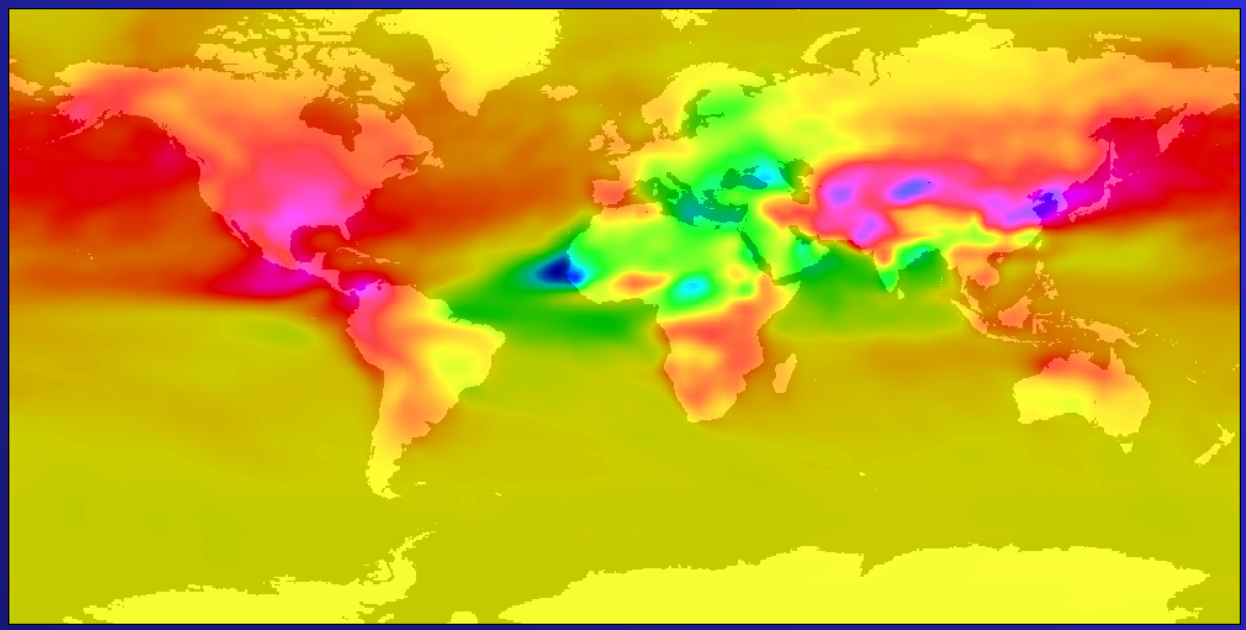


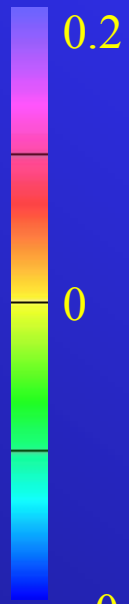


March - April - May 2001

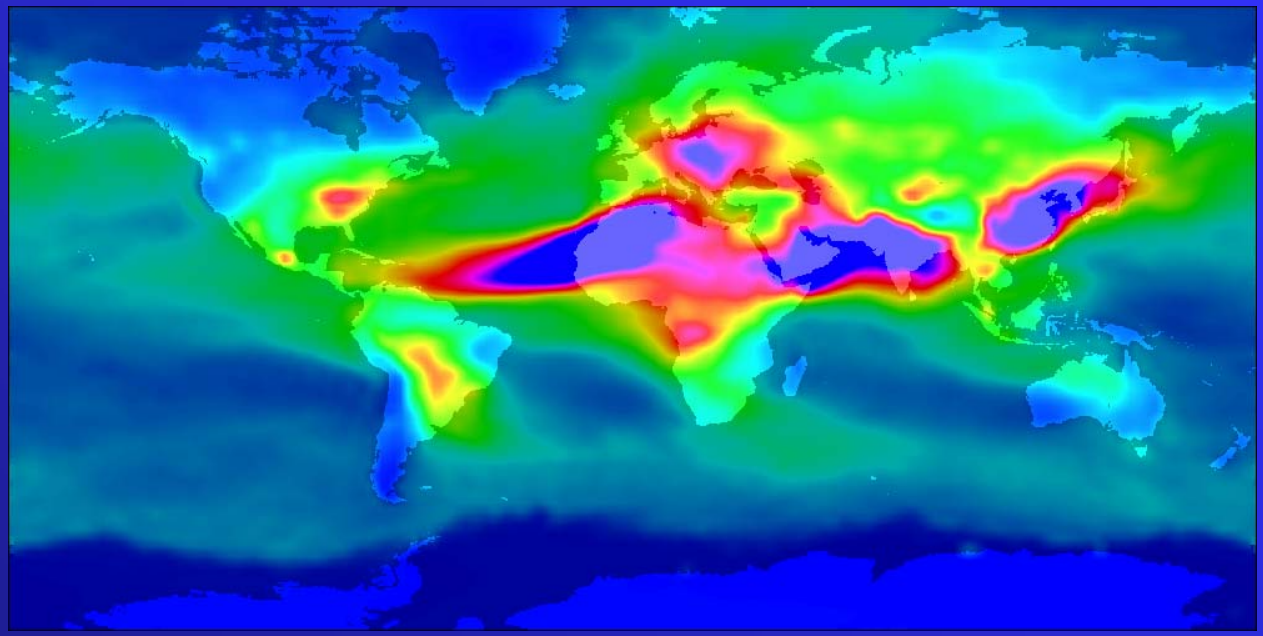


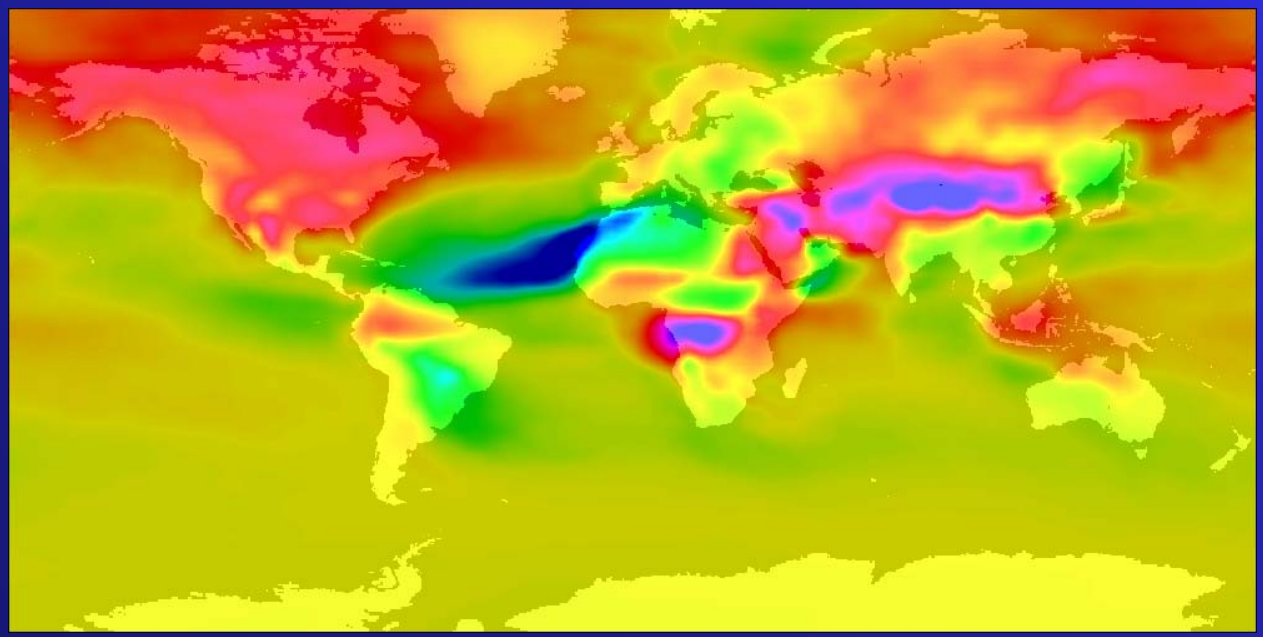


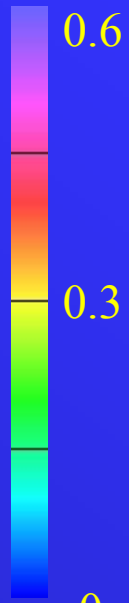




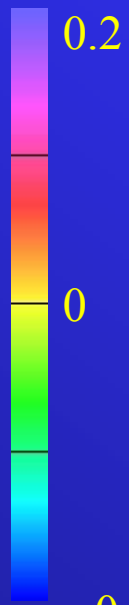
June - July - August 2001





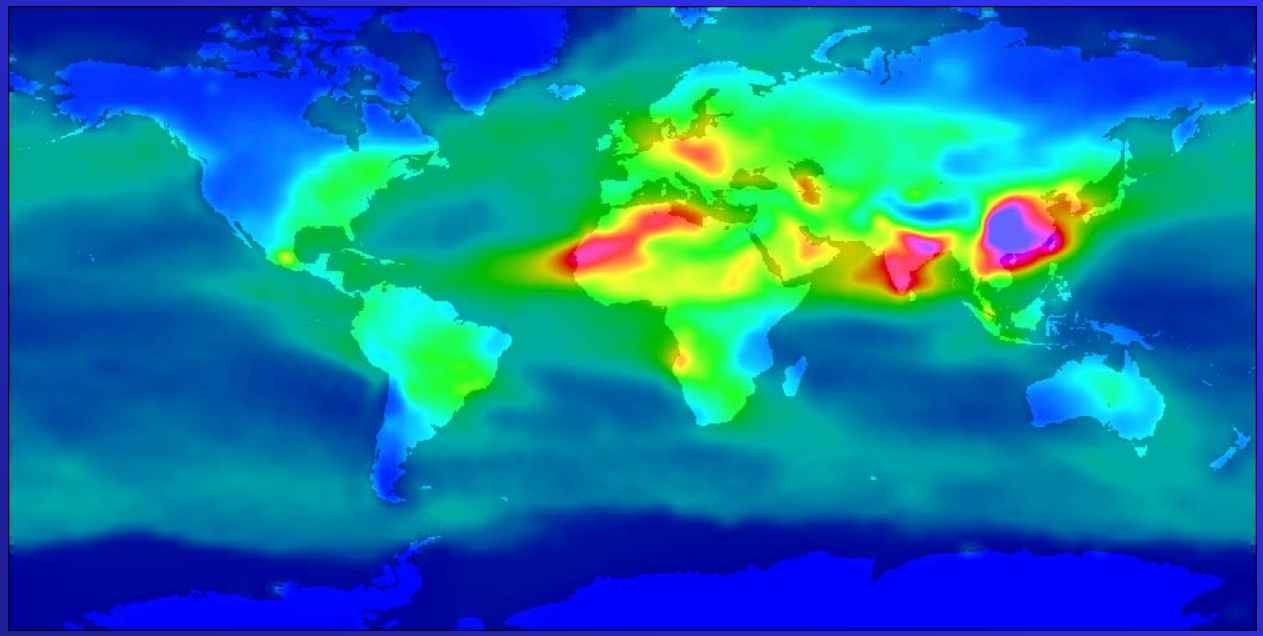


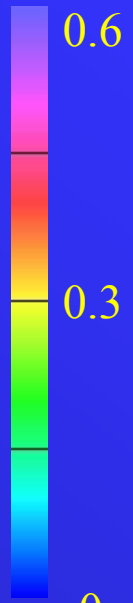
MATCH AOD



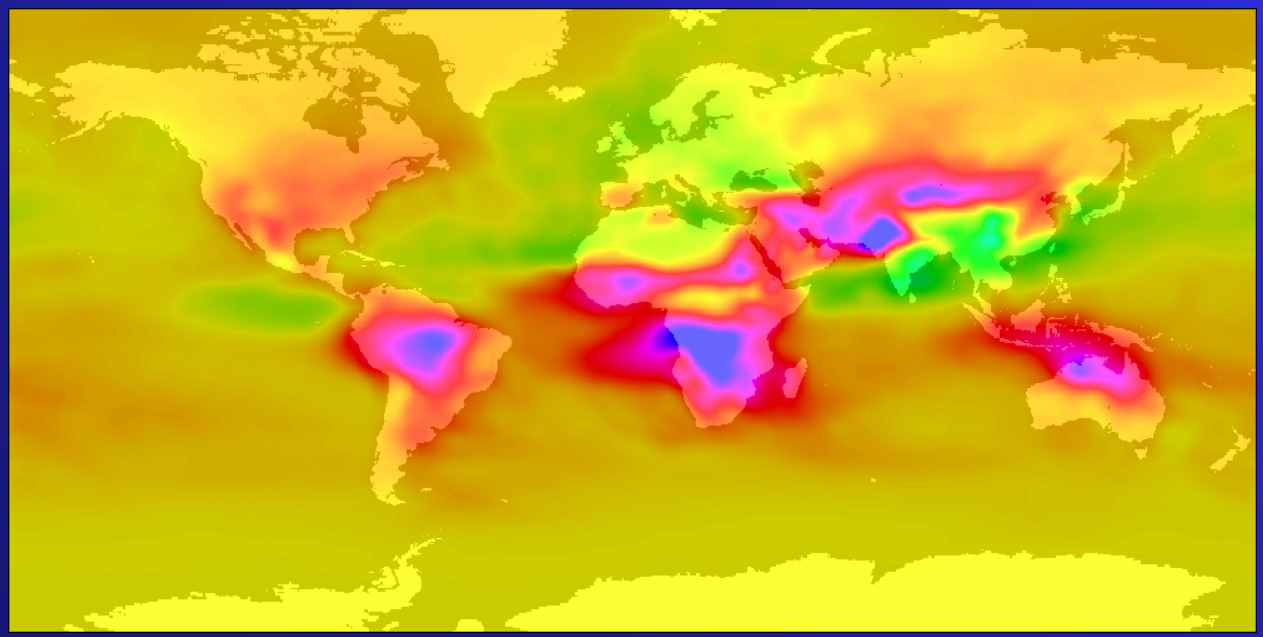
Assimilation Correction

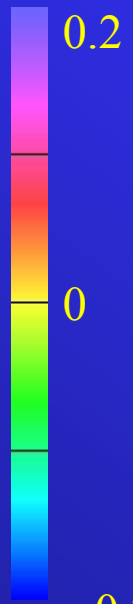
September - October - November 2001





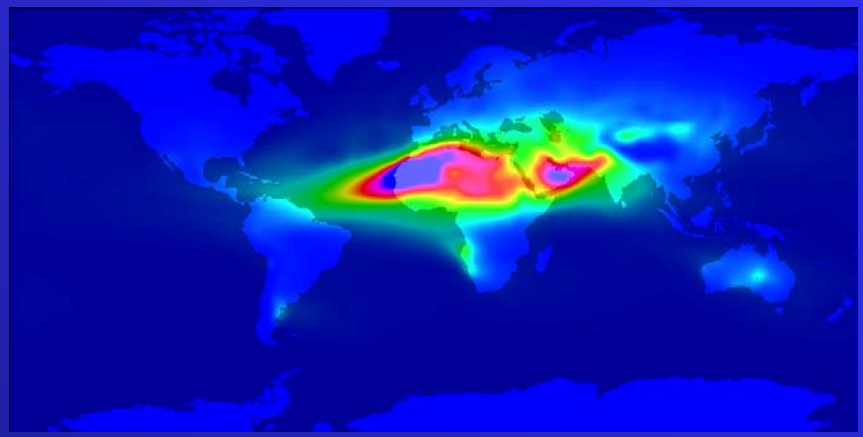
MATCH AOD





Assimilation Correction

Dust Mass Budget

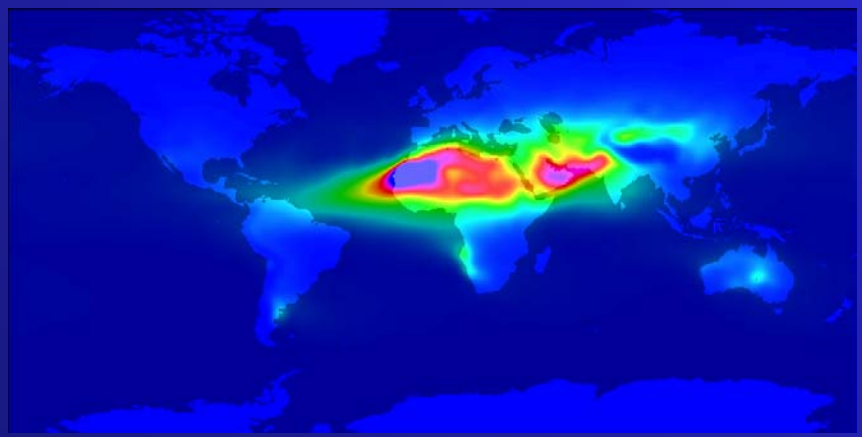


MATCH

Mass ~ 18.6 Tg
Emissions ~ 2.7 Tg day^{-1}
Dry Deposition ~ 1.2 Tg day^{-1}
Wet Deposition ~ 1.5 Tg day^{-1}

τ ~ 7.0 days

MATCH with MODIS Assimilation



Mass ~ 16.8 Tg
Emissions ~ 2.7 Tg day^{-1}
Assimilation ~ - 0.3 Tg day^{-1}
Dry Deposition ~ 1.1 Tg day^{-1}
Wet Deposition ~ 1.3 Tg day^{-1}

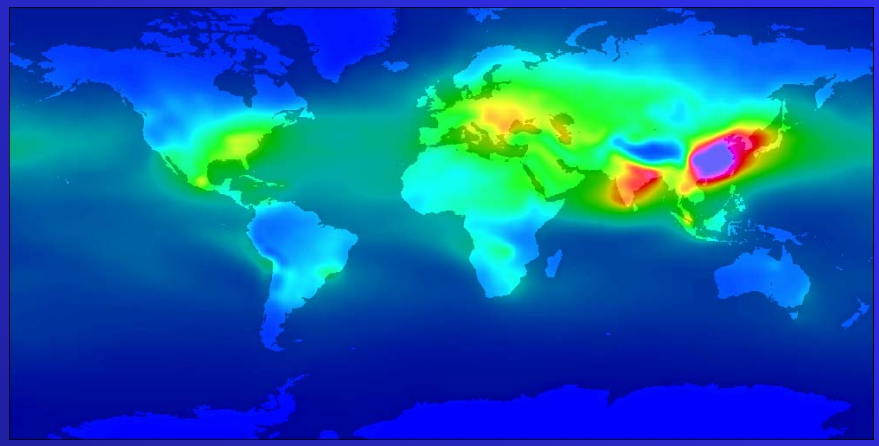
τ ~ 7.0 days

Dust Mass

0 0.5

g m^{-2}

Sulfate Mass Budget

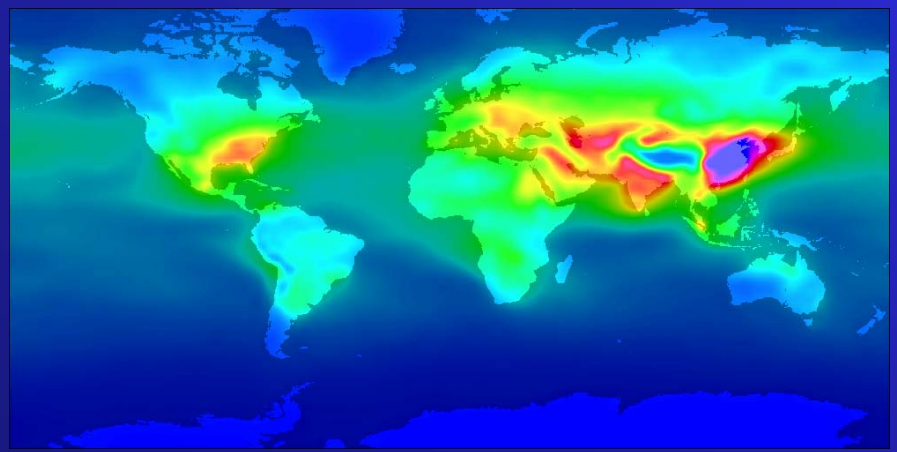


MATCH

Mass ~ 0.6 Tg(S)
Emissions ~ 0.005 Tg(S) day^{-1}
Gas Phase ~ 0.02 Tg(S)
Aqueous Phase ~ 0.125 Tg(S)
Dry Deposition ~ 0.02 Tg(S) day^{-1}
Wet Deposition ~ 0.13 Tg(S) day^{-1}

$\tau \sim 3.9$ days

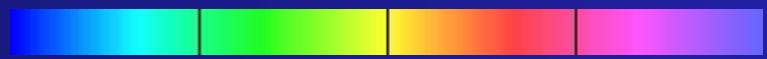
MATCH with MODIS Assimilation



Mass ~ 0.73 Tg(S)
Emissions ~ 0.005 Tg(S) day^{-1}
Gas Phase ~ 0.02 Tg(S)
Aqueous Phase ~ 0.125 Tg(S)
Assimilation ~ 0.02 Tg day^{-1}
Dry Deposition ~ 0.025 Tg(S) day^{-1}
Wet Deposition ~ 0.145 Tg(S) day^{-1}

$\tau \sim 4.3$ days

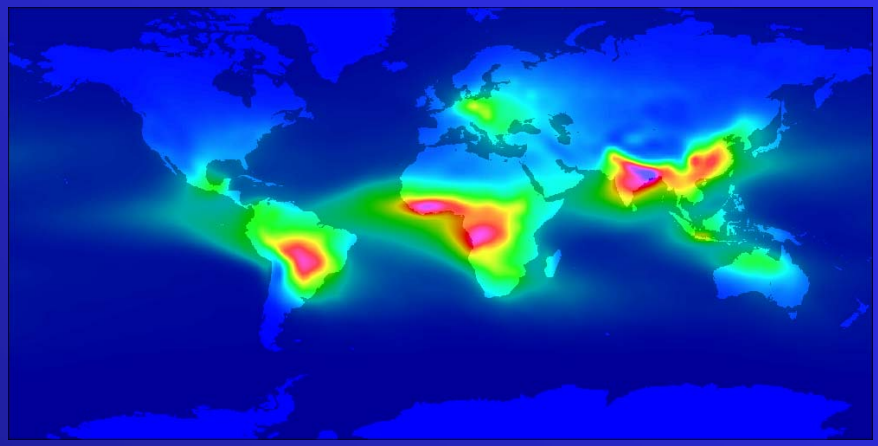
Sulfate Mass



0 0.008

g (S) m^{-2}

Organic Carbon Mass Budget

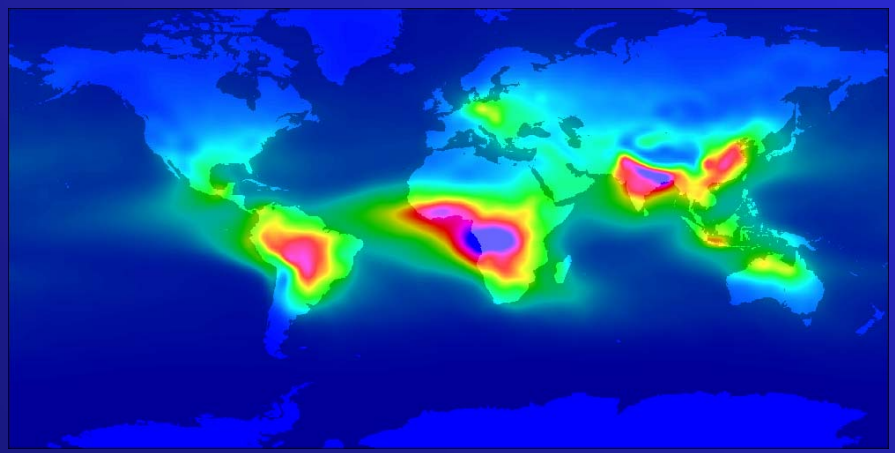


MATCH

Mass ~ 1.7 Tg
Emissions ~ 0.24 Tg day^{-1}
Dry Deposition ~ 0.06 Tg day^{-1}
Wet Deposition ~ 0.18 Tg day^{-1}

τ ~ 7.2 days

MATCH with MODIS Assimilation



Mass ~ 2.2 Tg
Emissions ~ 0.24 Tg day^{-1}
Assimilation ~ 0.04 Tg day^{-1}
Dry Deposition ~ 0.06 Tg day^{-1}
Wet Deposition ~ 0.22 Tg day^{-1}

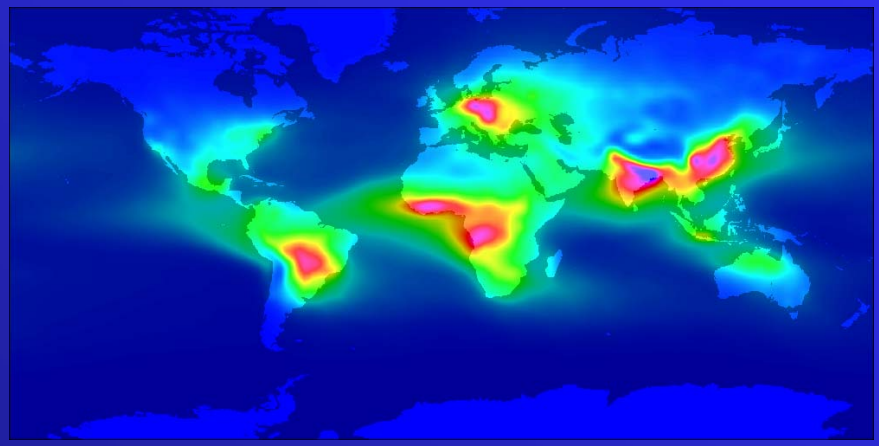
τ ~ 7.6 days

Organic Carbon Mass

0 0.03

g m^{-2}

Black Carbon Mass Budget

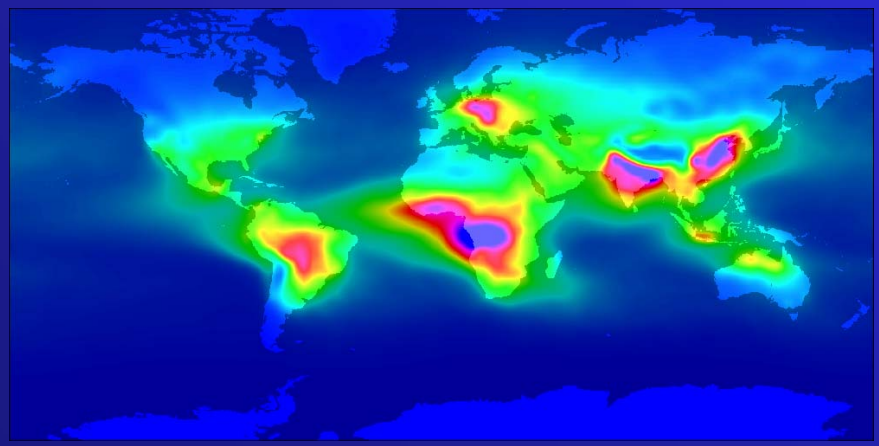


MATCH

Mass ~ 0.19 Tg
Emissions ~ 0.03 Tg day^{-1}
Dry Deposition ~ 0.01 Tg day^{-1}
Wet Deposition ~ 0.02 Tg day^{-1}

τ ~ 6.6 days

MATCH with MODIS Assimilation



Mass ~ 0.25 Tg
Emissions ~ 0.03 Tg day^{-1}
Assimilation ~ 0.005 Tg day^{-1}
Dry Deposition ~ 0.01 Tg day^{-1}
Wet Deposition ~ 0.025 Tg day^{-1}

τ ~ 7.1 days

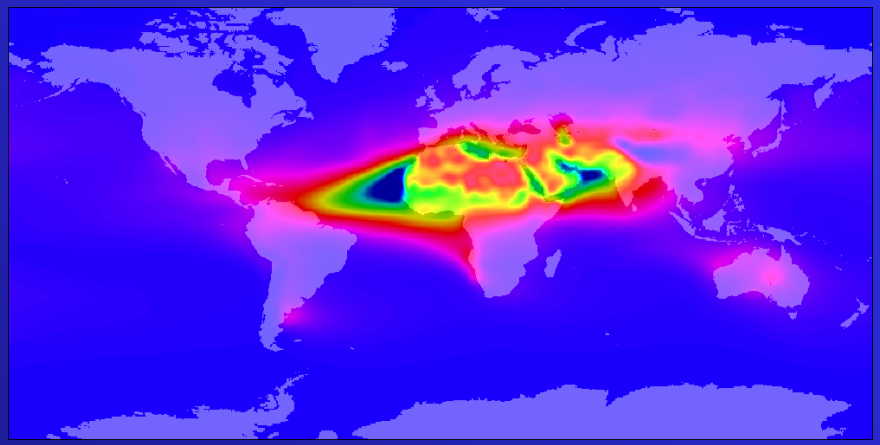
Black Carbon Mass

0 0.003

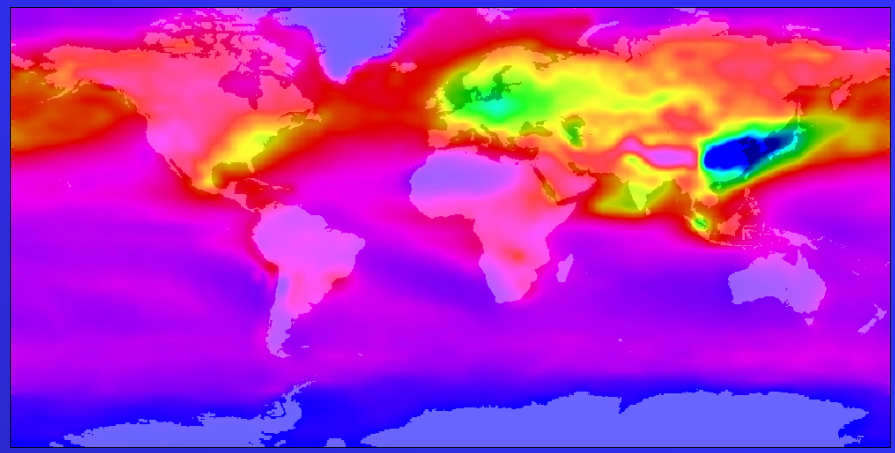
g m^{-2}

Aerosol TOA SW Radiative Forcing (Clear-Sky)

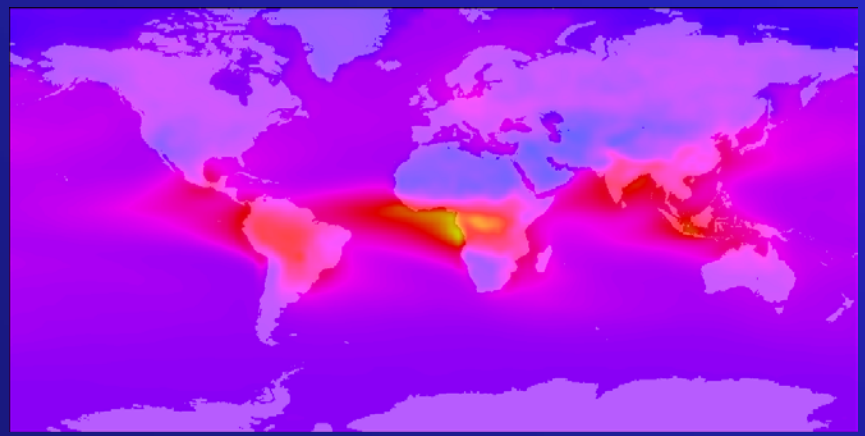
from CAM with MATCH/MODIS Aerosol Climatology



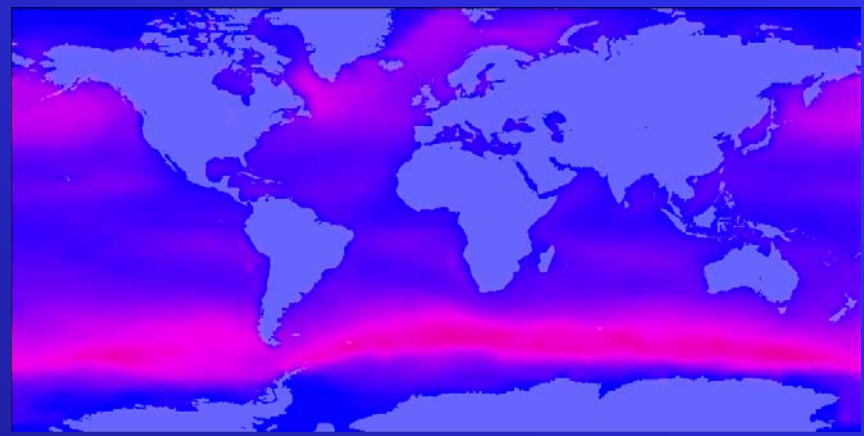
Dust



Sulfate

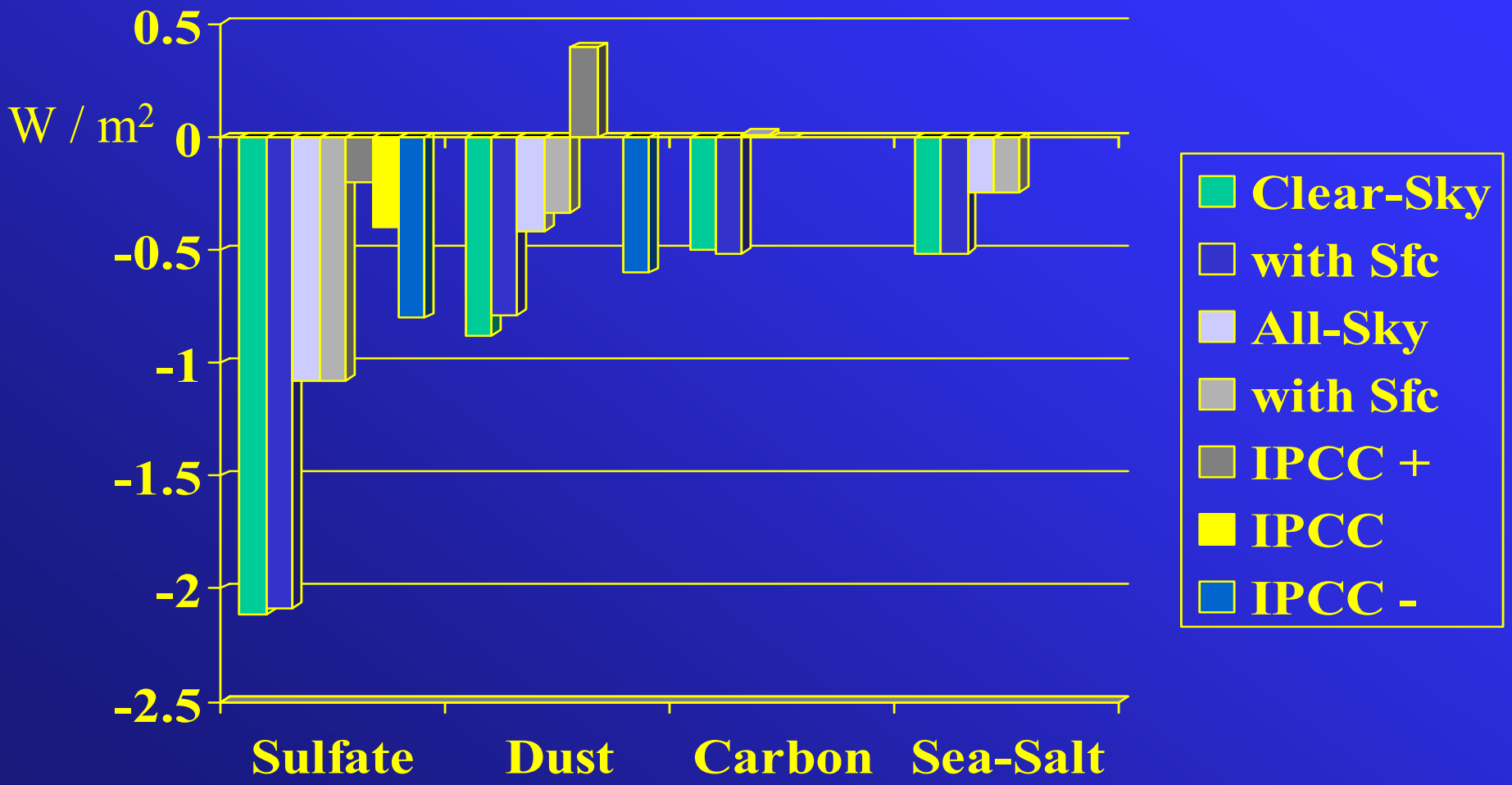


Carbon



Sea-Salt

Global Mean TOA Aerosol Forcing



Conclusions

- Aerosol assimilation constrains the model with satellite observations and may thus lead to more accurate estimates of direct radiative forcing.

- A multi-wavelength assimilation can in principal adjust the relative speciation of aerosols. However this inversion is ill-conditioned, which limits the number of groups of species that can be adjusted (~ 2), and is highly sensitive to the spectral dependence of the underlying optical models.

- A new MATCH/MISR assimilation dataset is being developed…