

Modeling the Dust Cycle – Implications for Climate and Air Quality

Michael Schulz *

* Norwegian Meteorological Institue, Norway

Overview

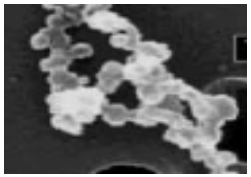
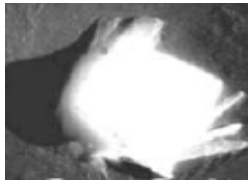
Characteristics of dust to be modelled

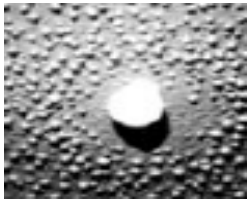
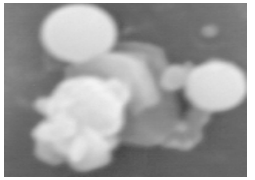
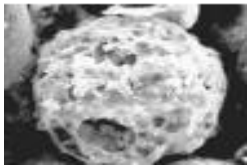
Radiative forcing of climate

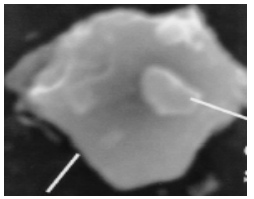
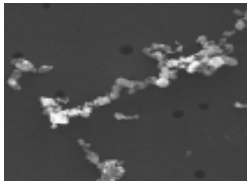
The past and today

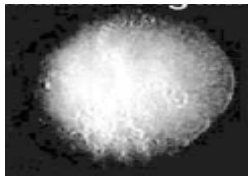
Characteristics of dust to be modelled

Typical Aerosol particles

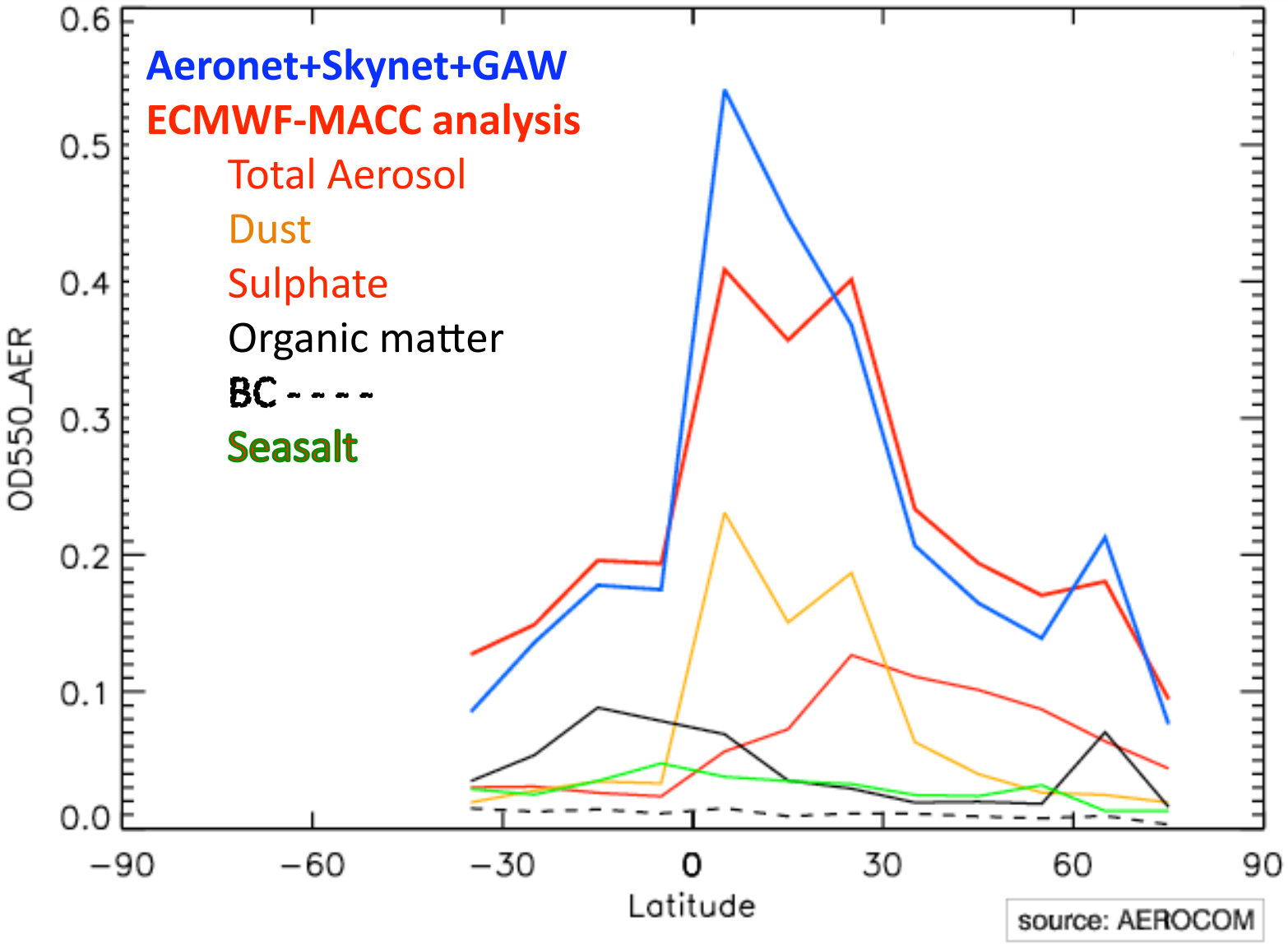



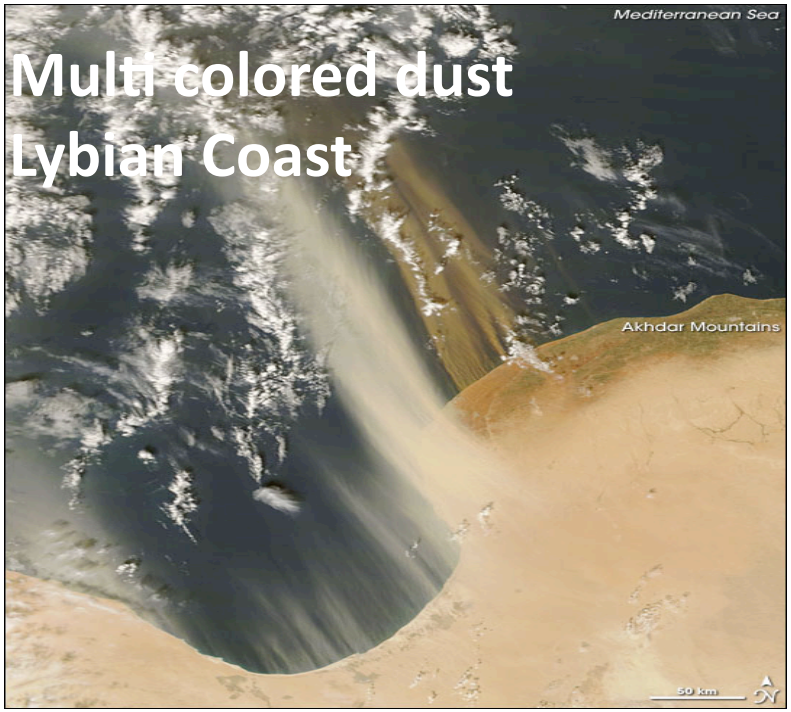




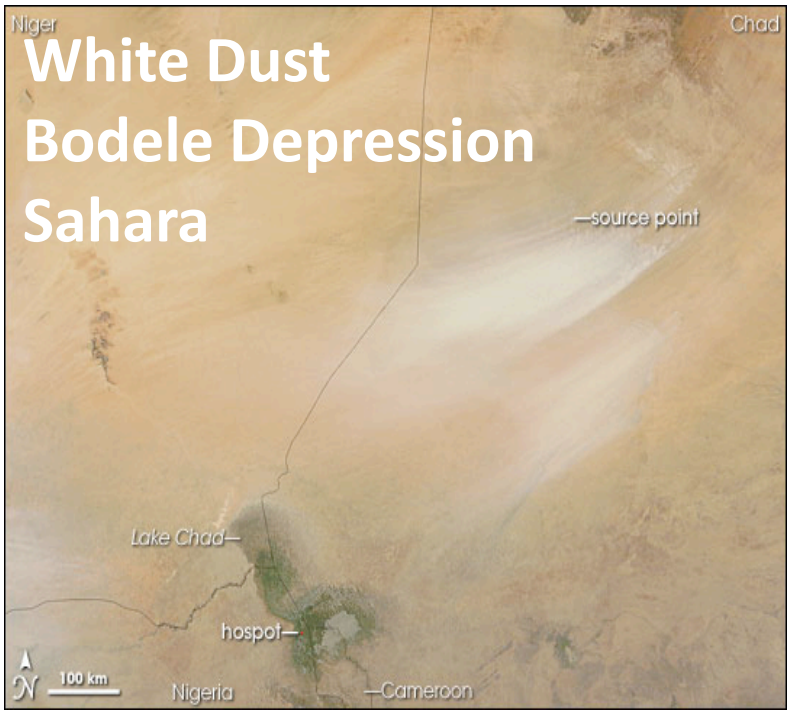


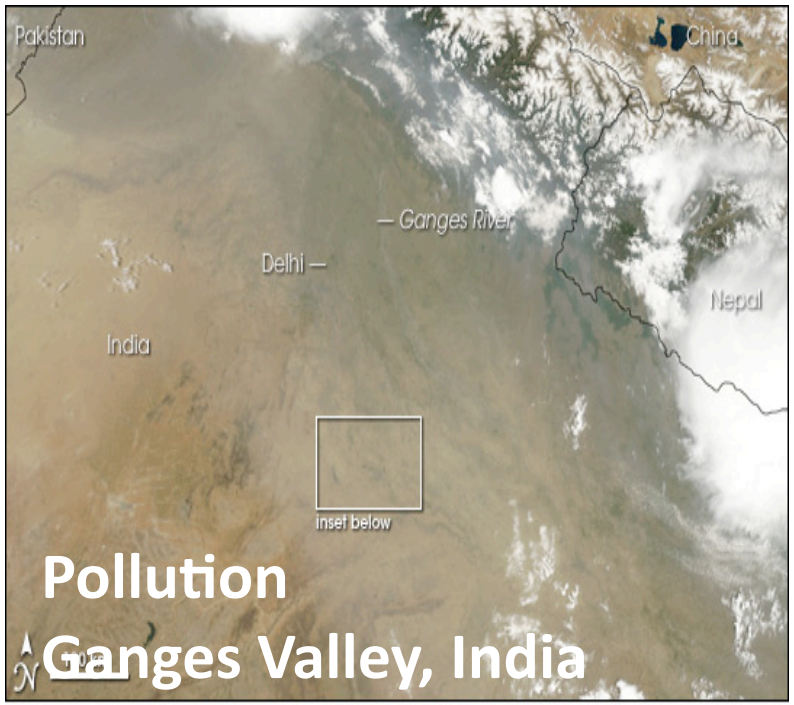
Latitudinal distribution of modeled and observed aerosol optical depth (ww aerosol mass of a column)



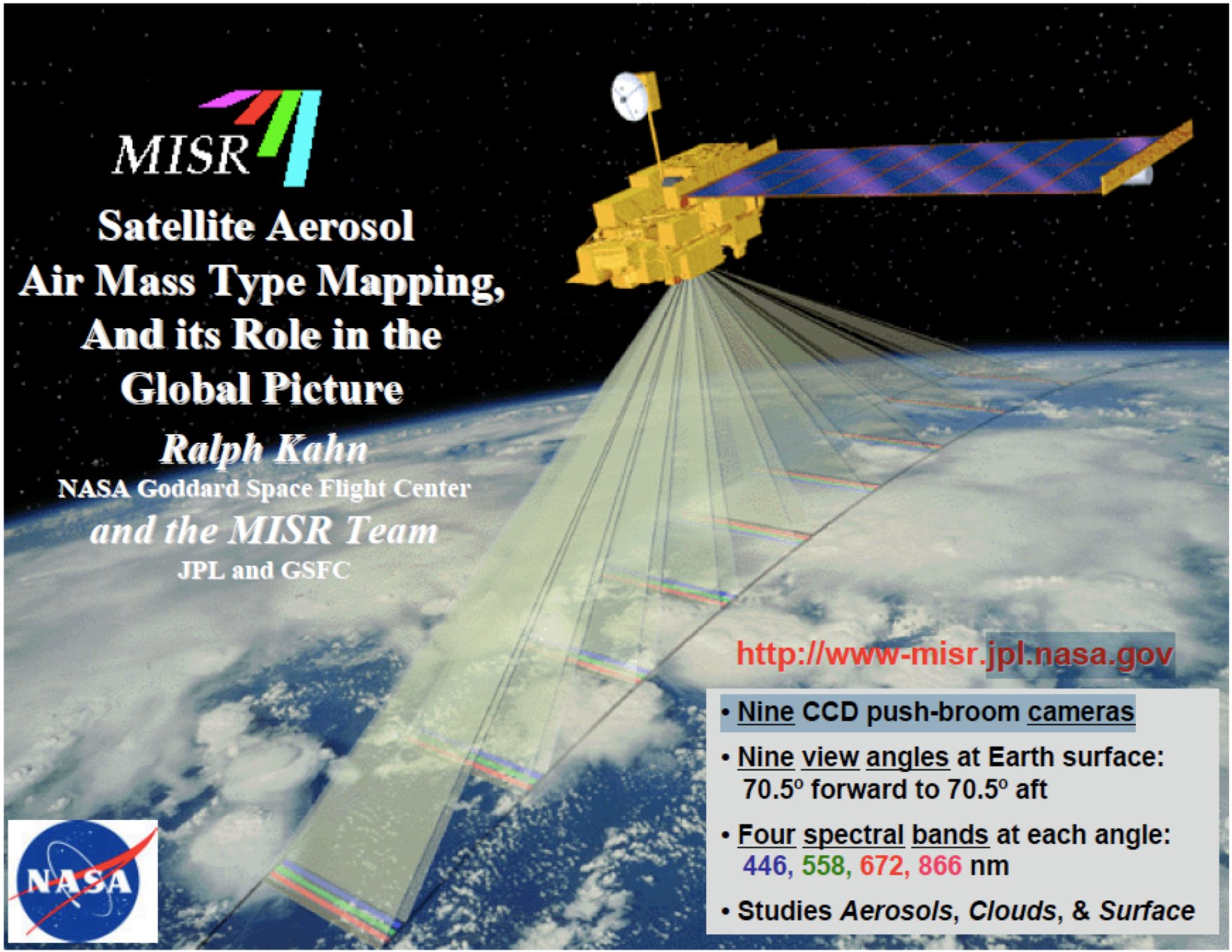

Mediterranean Sea
Multi colored dust
Lybian Coast
Akhdar Mountains
50 km


Greece
Athens
Fires, August 2007
Greece
Libya
100 km


Niger
Chad
White Dust
Bodele Depression
Sahara
—source point
Lake Chad—
hospot—
100 km
Nigeria
—Cameroon

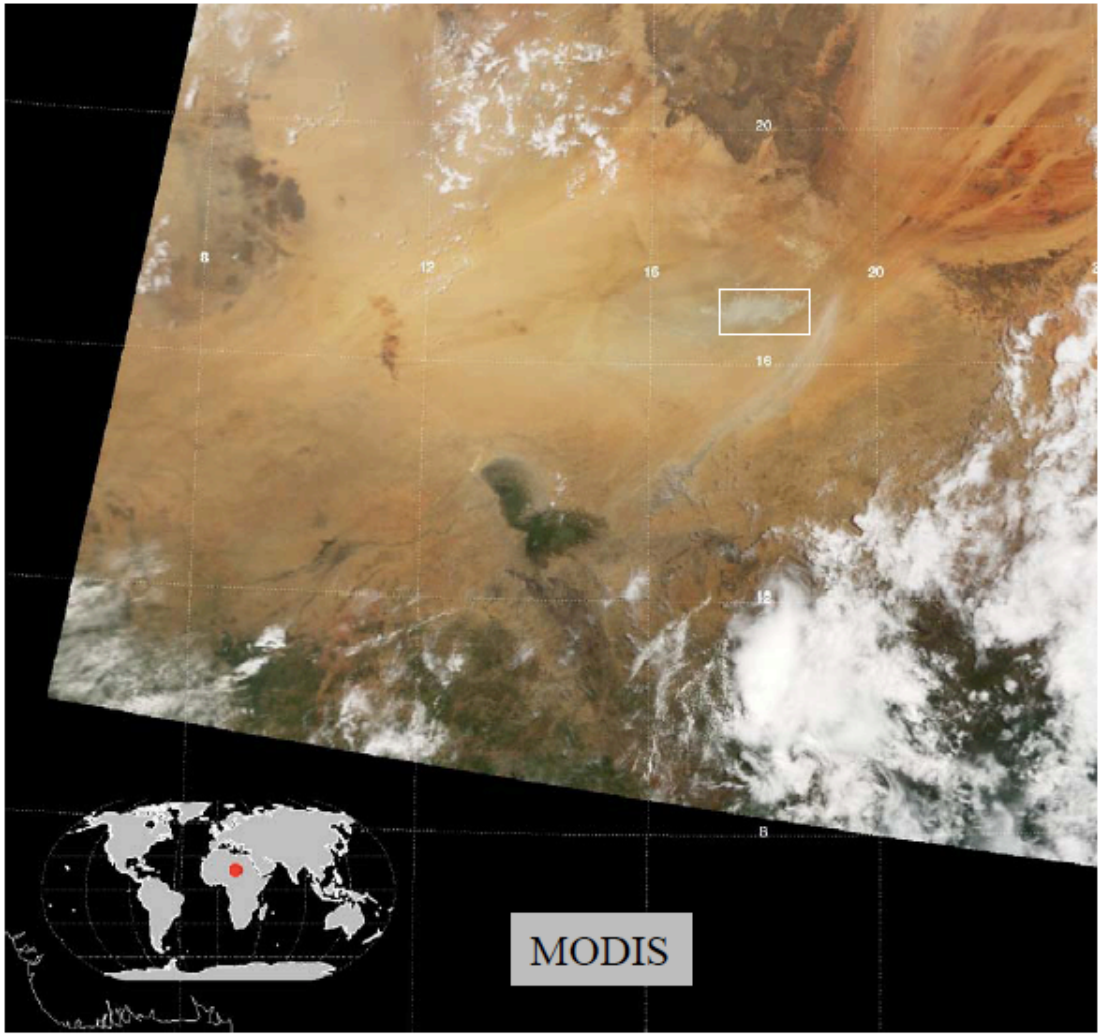

Pakistan
China
— Ganges River
Delhi —
Nepal
India
inset below
Pollution
Ganges Valley, India

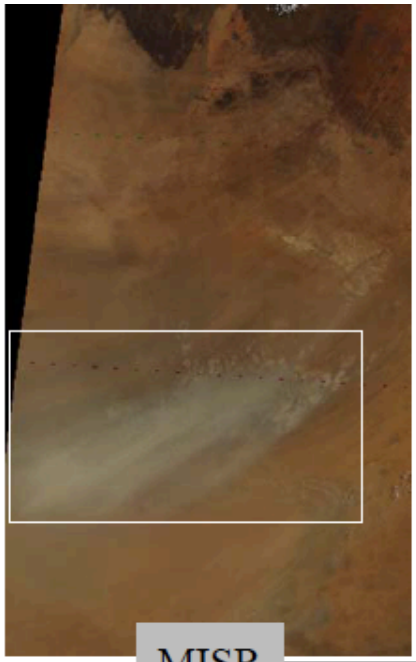
Source: NASA

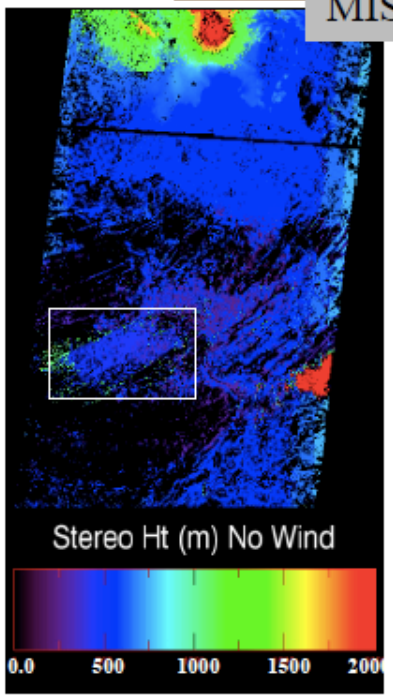

MISR
Satellite Aerosol
Air Mass Type Mapping,
And its Role in the
Global Picture
Ralph Kahn
NASA Goddard Space Flight Center
and the MISR Team
JPL and GSFC
http://www-misr.jpl.nasa.gov
• Nine CCD push-broom cameras
• Nine view angles at Earth surface:
70.5° forward to 70.5° aft
• Four spectral bands at each angle:
446, 558, 672, 866 nm
• Studies Aerosols, Clouds, & Surface
NASA

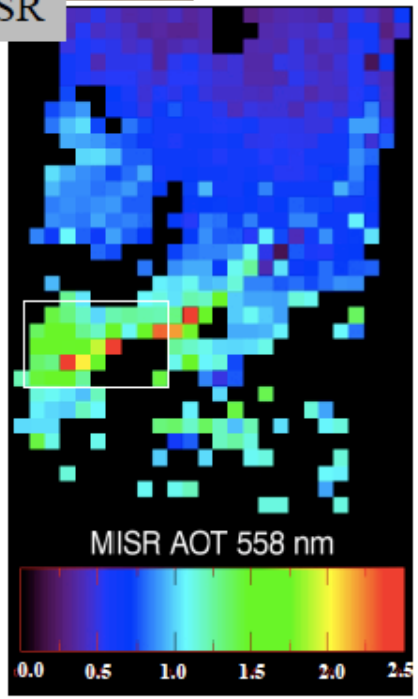
Saharan Dust Source Plume

Bodele Depression Chad June 3, 2005 Orbit 29038







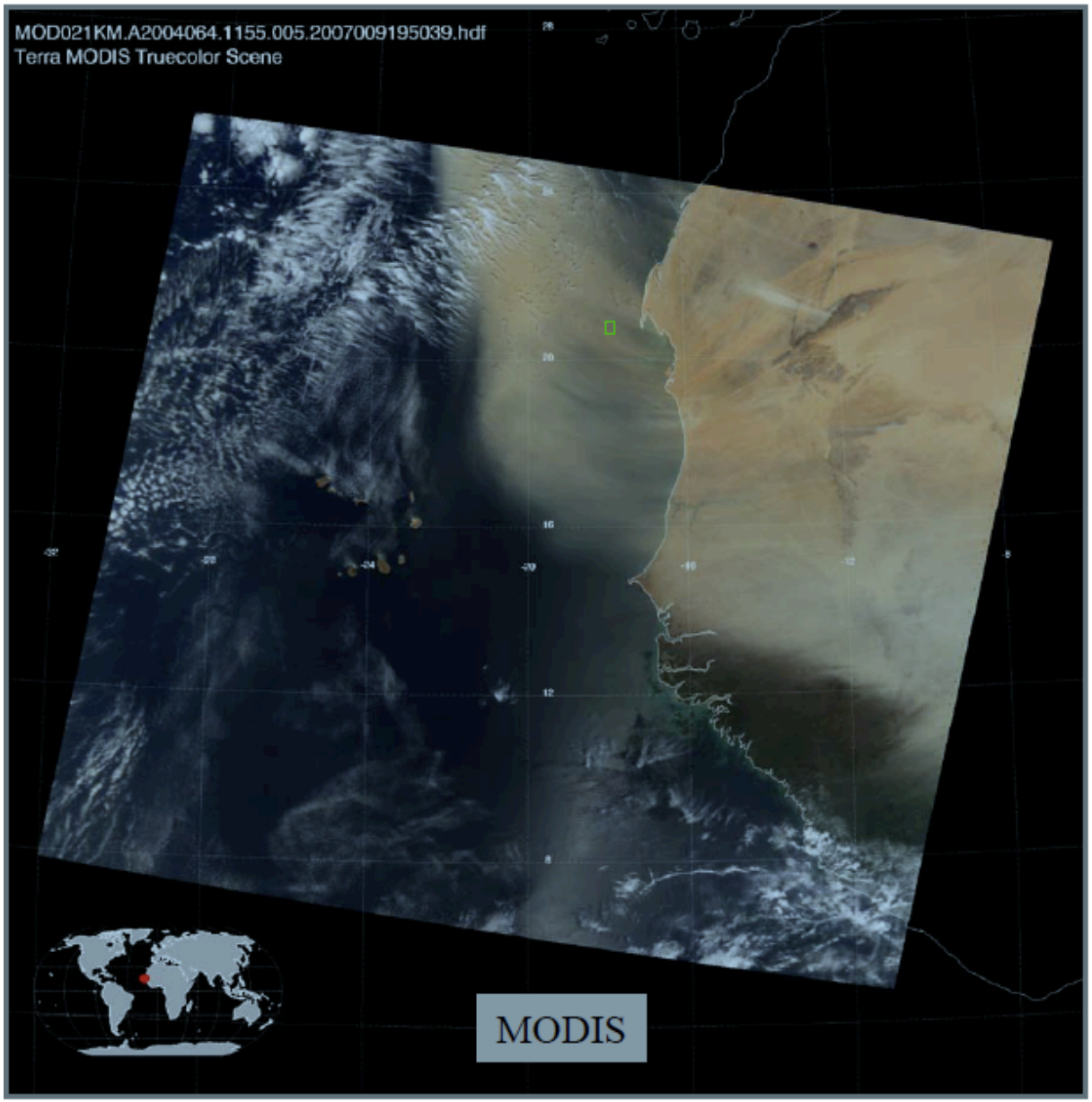


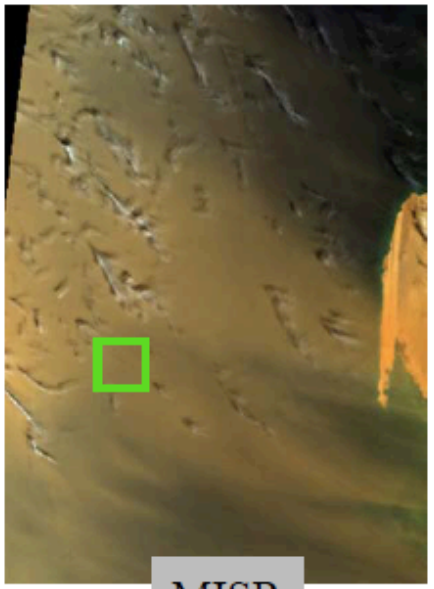
Dust is injected near-surface…

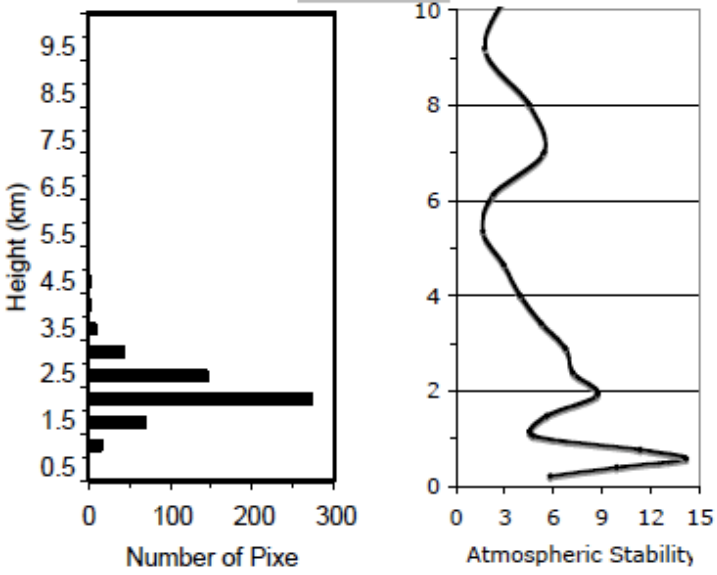
Kahn et al., JGR 2007

Transported Dust Plume

Atlantic, off Mauritania March 4, 2004 Orbit 22399







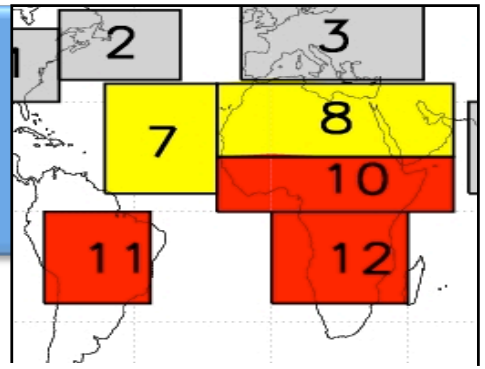
Transported dust finds elevated layer of relative stability… *Kahn et al.*, JGR 2007

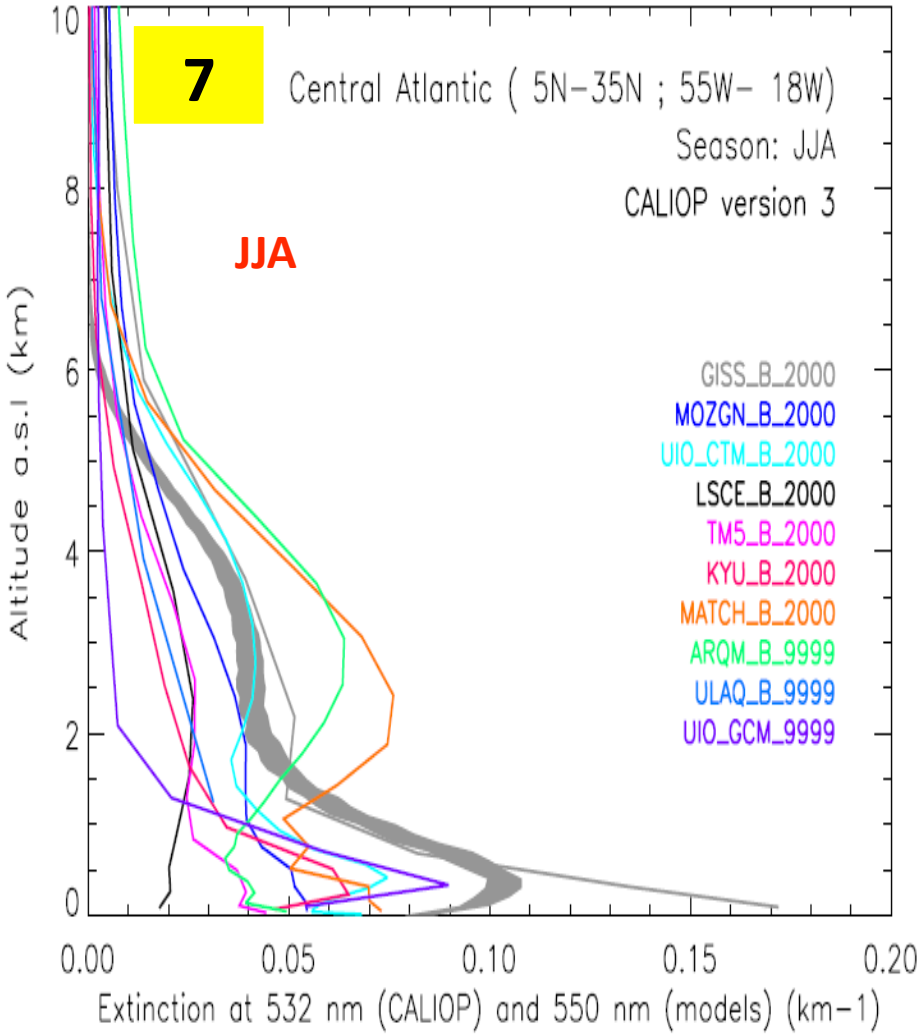
CALIPSO satellite
Lidar for observing vertical profiles of aerosols

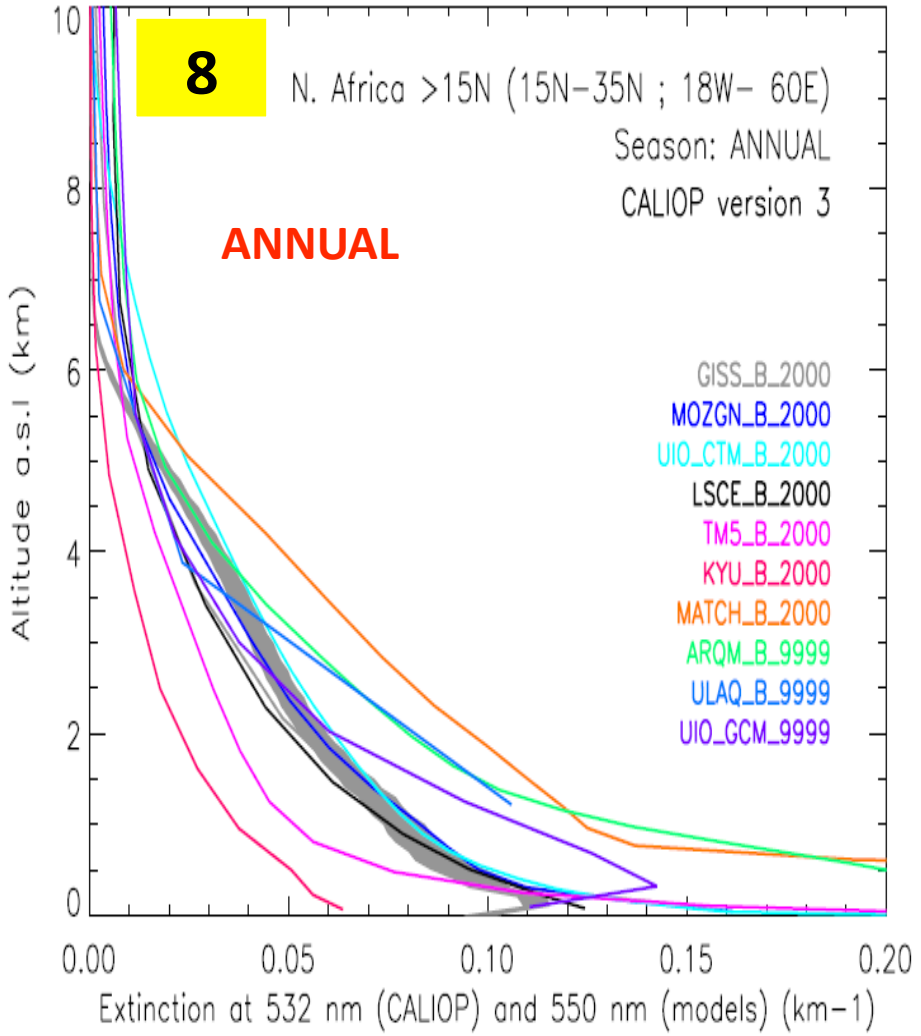


Dave Winker
and
Mark Vaughan, Ali Omar, Zhaoyan Liu, Yongxiang Hu,
Brian Getzewich, Ray Rogers and Jason Tackett
NASA and CNES team

Calipso (2007-2009) vs Aerocom models (00)
Northern Africa versus Central Atlantic

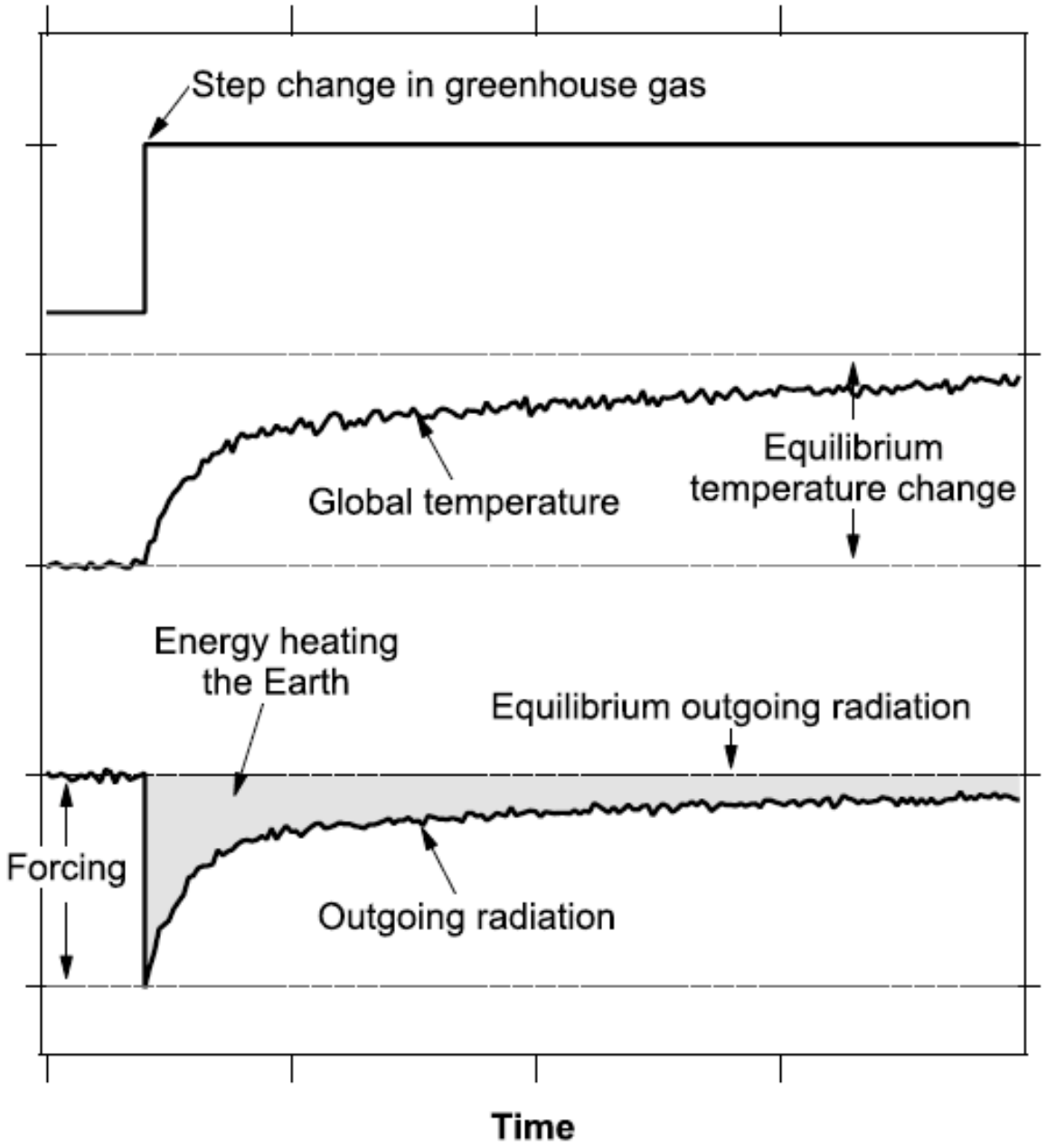






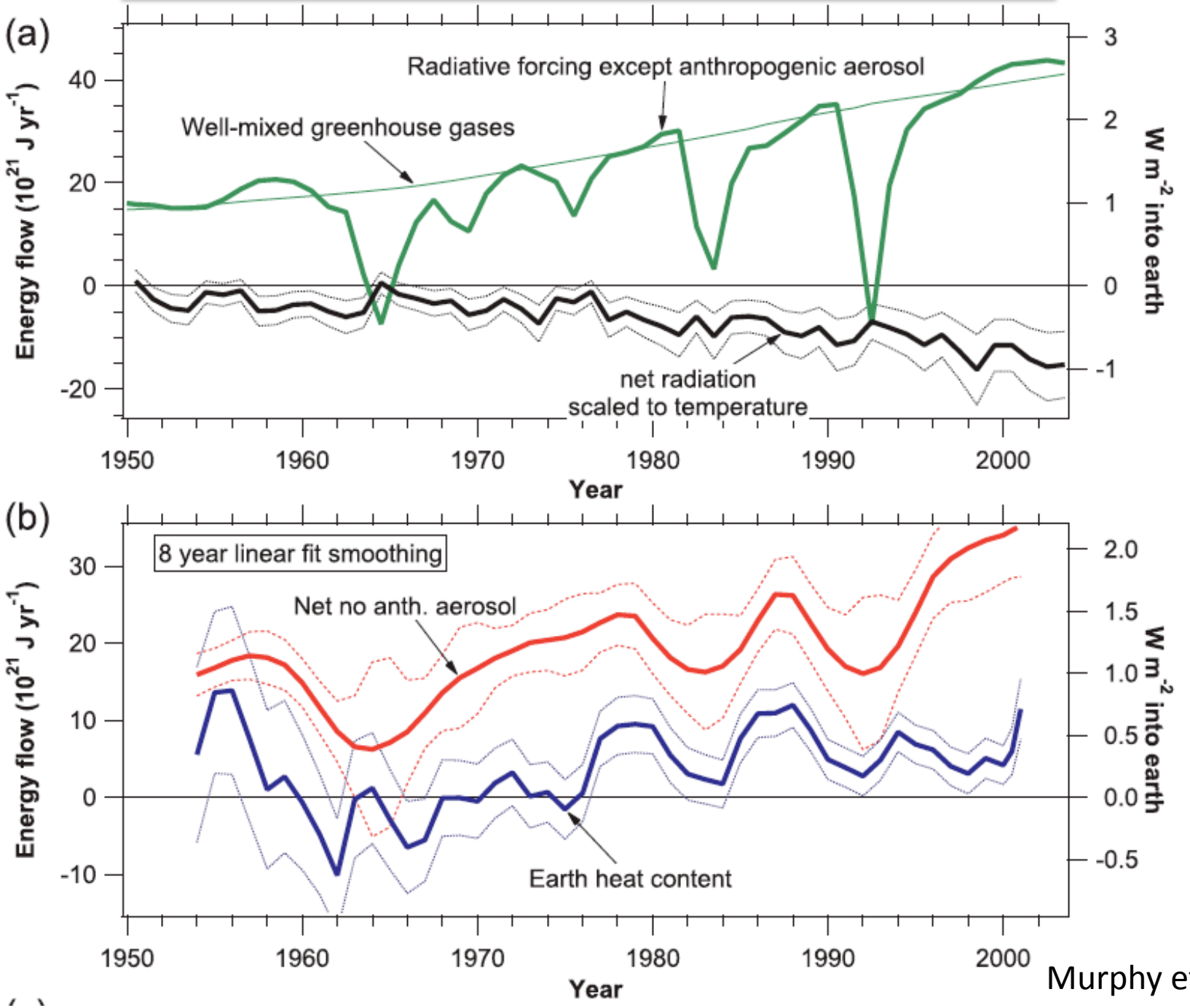
Radiative forcing of climate

What is radiative forcing and response of climate?



Murphy et al; 2009

Evolution of the Earth Radiative Budget



Murphy et al; 2009

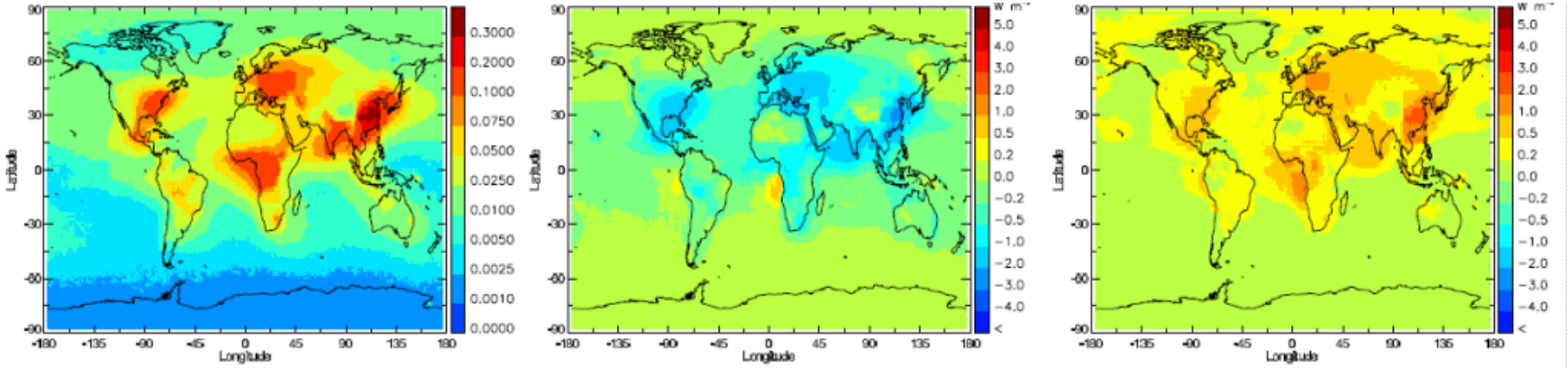
Direct Radiative Forcing components

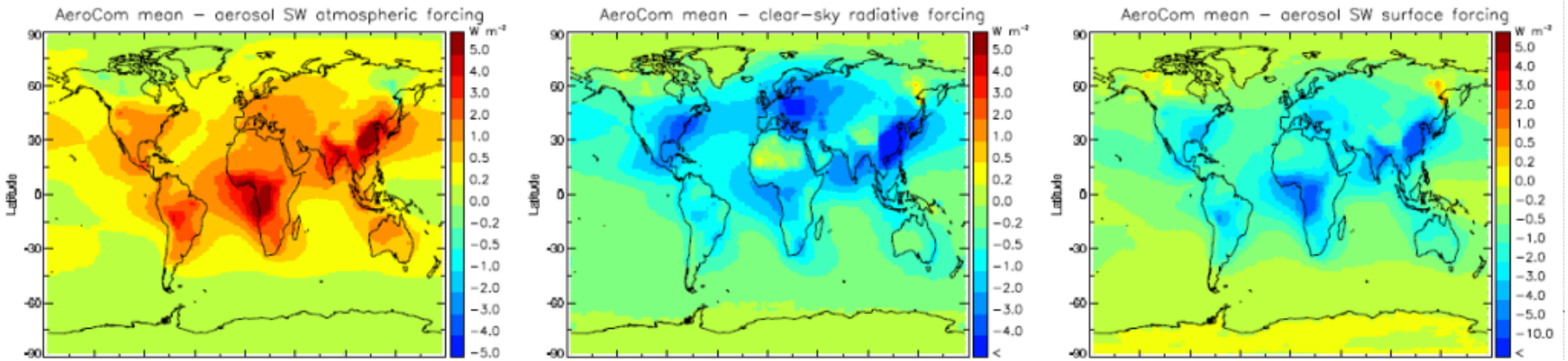
AeroCom

Aerosol Optical Depth

Aerosol Radiative forcing

Forcing Uncertainty From Models





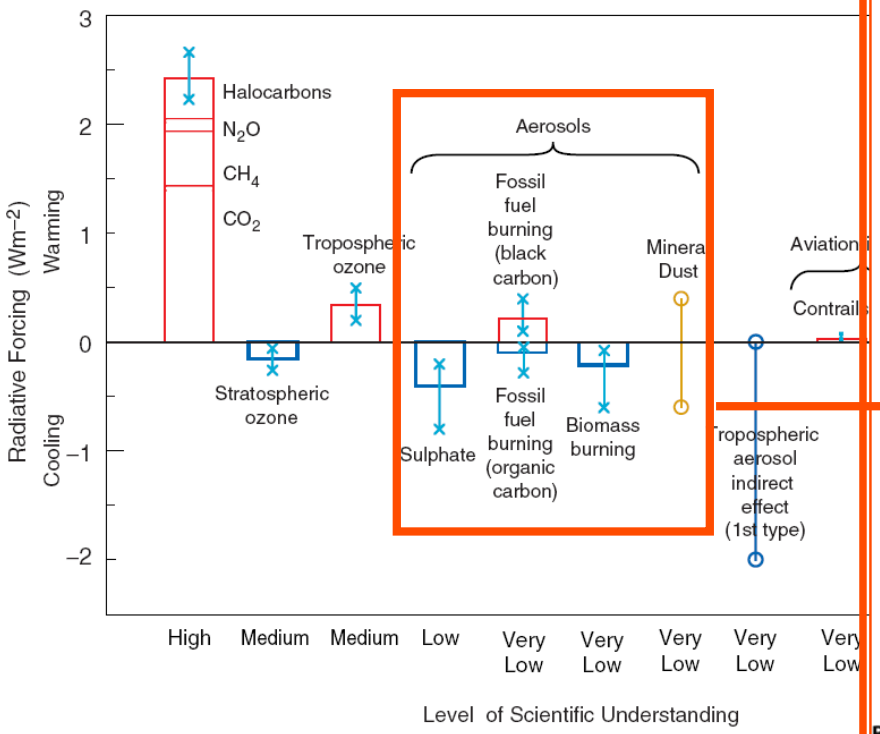
Atmospheric forcing

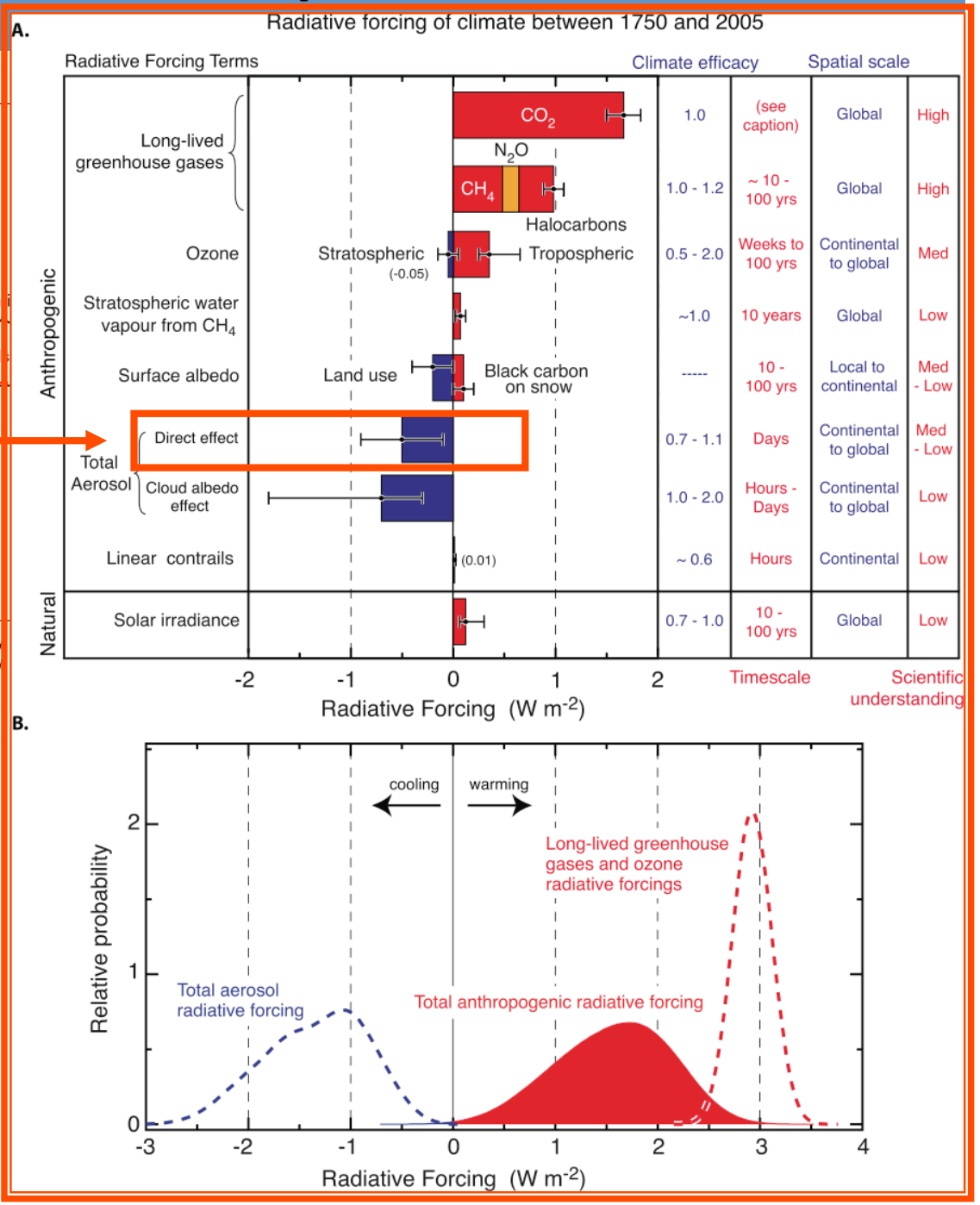
Forcing Clear-sky

Forcing at the surface

4AR IPCC chapter 2 / Schulz et al. ACP 2006

Radiative forcing bar chart IPCC reports 2001 => 2007





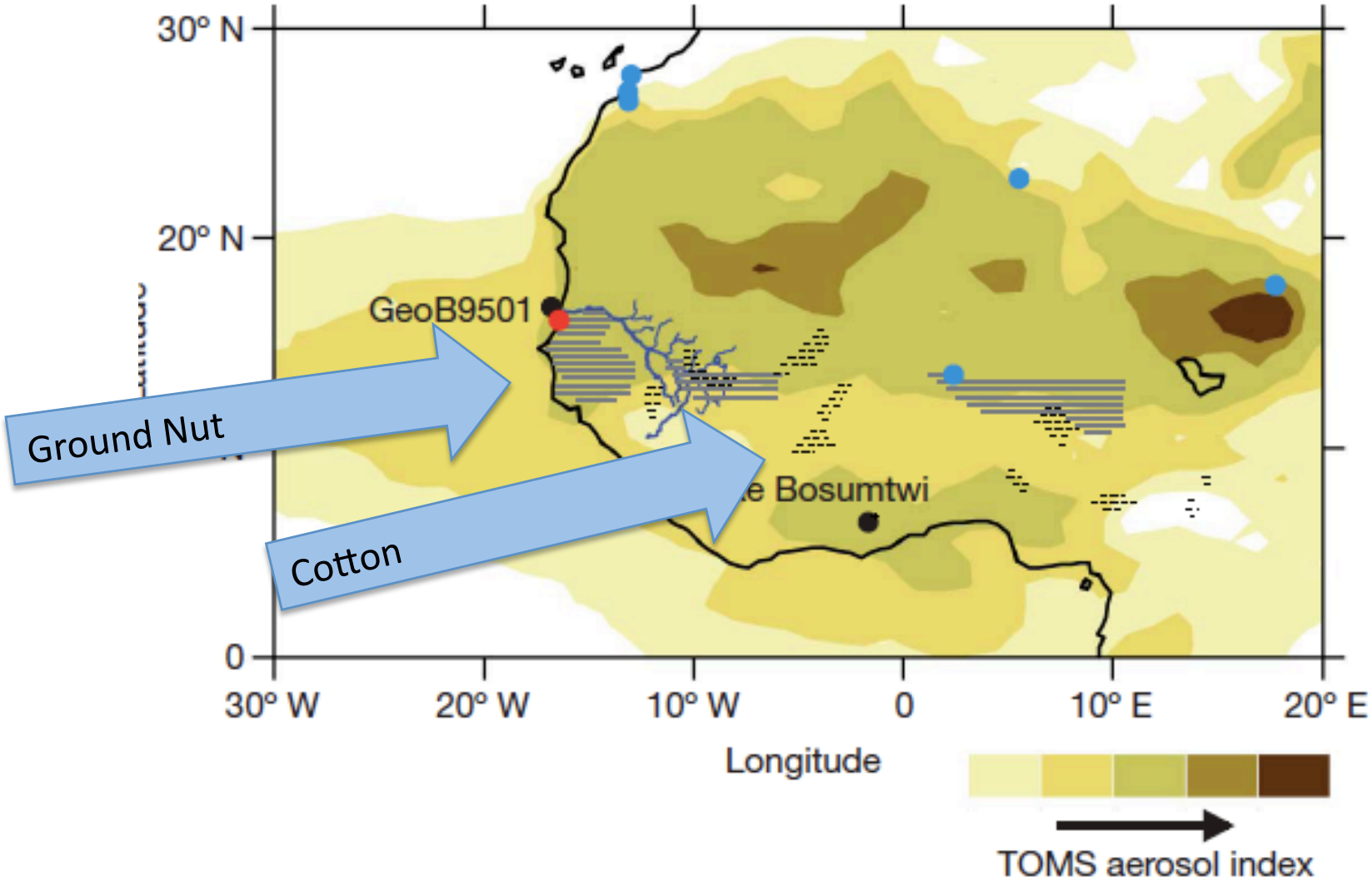
Understanding the past

Has there been a change in dust load in recent decades/centuries ?

Understanding the present

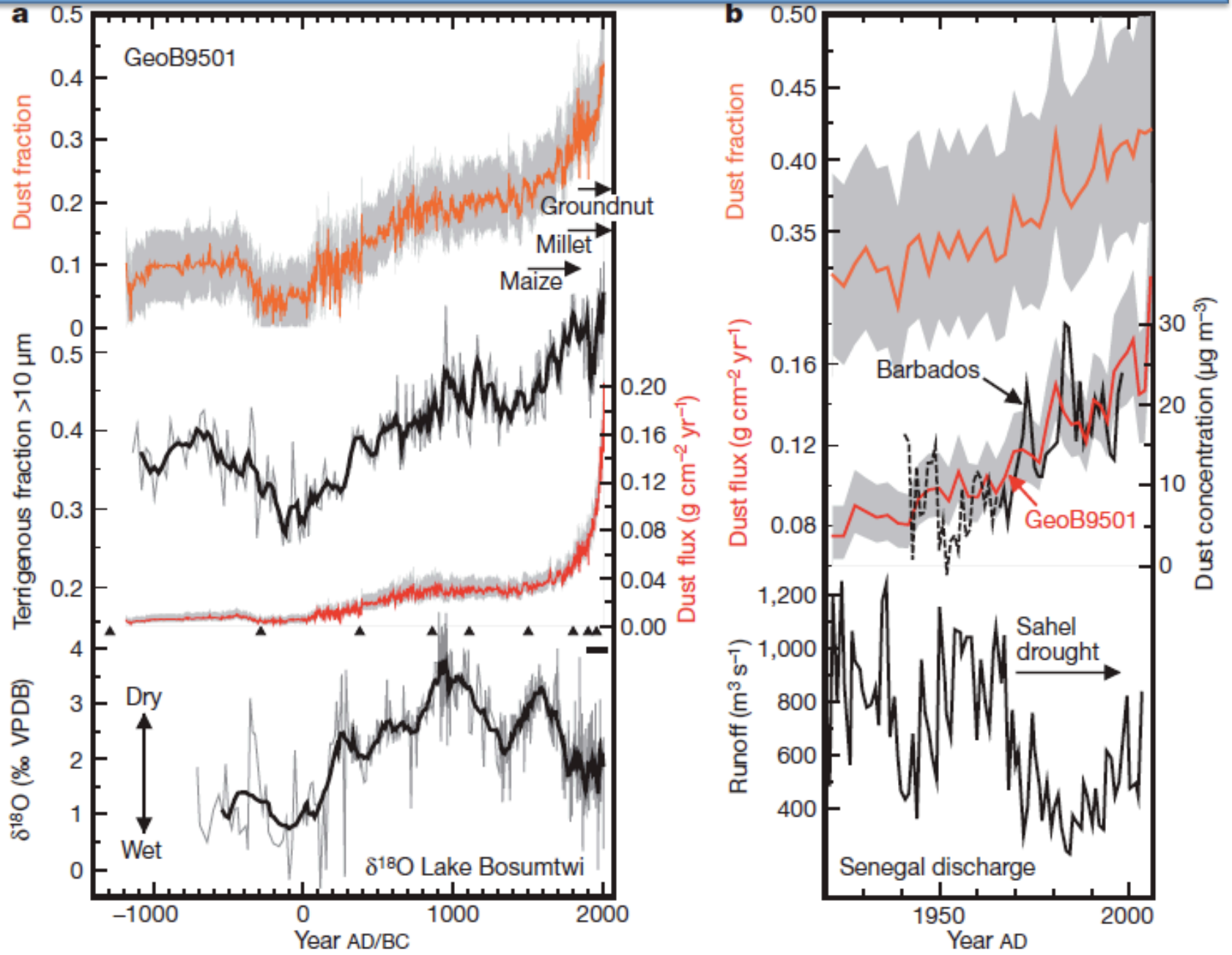
Can we predict and simulate dust events today?

Sampling of sediment cores and dust samples



Mulitza et al., Nature, 2010

Dust in sediment, drought, dust deposition in History



Mulitza et al., Nature, 2010

NORTHERN AFRICA-MIDDLE EAST-EUROPE (NA-ME-E) REGIONAL CENTER

WMO Sand and Dust Storm Warning Advisory and Assessment System (SDS-WAS)

WMO SDS WAS || Asia/Central Pacific Regional Center || North American Center

Home | About us | Forecasts & Products | Research | News & Events | Contact us

Products

- Dust forecasts
  - BSC-DREAM
  - ECMWF
  - LMDZT-INCA
  - CHIMERE
  - METEO-FRANCE
  - SKIRON
  - TAU-DREAM
- Near real time observations
  - AERONET
  - MODIS
  - OMI
  - SEAWIFS
  - CALIPSO
  - MSG
  - METAR
- Forecast Verification
- Reanalysis
- Data access

Visibility observations from Weather Services

sensors. So, visibility is available in airports with aeronautic meteorological offices every 30 minutes, and in synoptic weath
useful METAR visibility information for model verification is constrained to days with severe reductions of visibility (below 1
accurate visibility conditions using far off references. For both dust monitoring and model verification, only visibility data ov

This interface is courtesy of BSC.

AERONET Verification | MSG Verification | MODIS Real-Time | Visibility Real-Time

Map Reload

- < 50 m
- > 50 m And < 2 km
- > 2 km And < 4 km
- > 4 km And < 6 km
- > 6 km And < 8 km
- > 8 km And < 10 km
- > 10 km



NORTHERN AFRICA-MIDDLE EAST-EUROPE (NA-ME-E) REGIONAL CENTER

WMO Sand and Dust Storm Warning Advisory and Assessment System (SDS-WAS)

WMO SDS WAS || Asia/Central Pacific Regional Center || North American Center

Home | About us | Forecasts & Products | Research | News & Events | Contact us

Products

- Dust forecasts
  - BSC-DREAM
  - ECMWF
  - LMDZT-INCA
  - CHIMERE
  - METEO-FRANCE
  - SKIRON
  - TAU-DREAM
- Near real time observations
  - AERONET
  - MODIS
  - OMI
  - SEAWIFS
  - CALIPSO
  - MSG
  - METAR
- Forecast Verification
- Reanalysis
- Data access

ECMWF

Modelled dust and other aerosol distribution

Getting here | Order Data | Archive | Reanalysis | Manuals | Employment
Committees | Order Software | PrepIFS | Seasonal | Library | Open Tenders

ECMWF graphical product catalogue > Gems > Aerosol Products > Forecast of Aerosol Optical Depth > Forecast of Aerosol Optical Depth with Data Assimilation>

Forecast of Aerosol Optical Depth with Data Assimilation

Species: Total | Natural | Anthropogenic

Area: Global | Europe

Base time finder: Forecast base times with forecast valid for the displayed valid time: ***Mon 26 Oct 06UTC***

Sat 24 Oct 00UTC

Open in new window

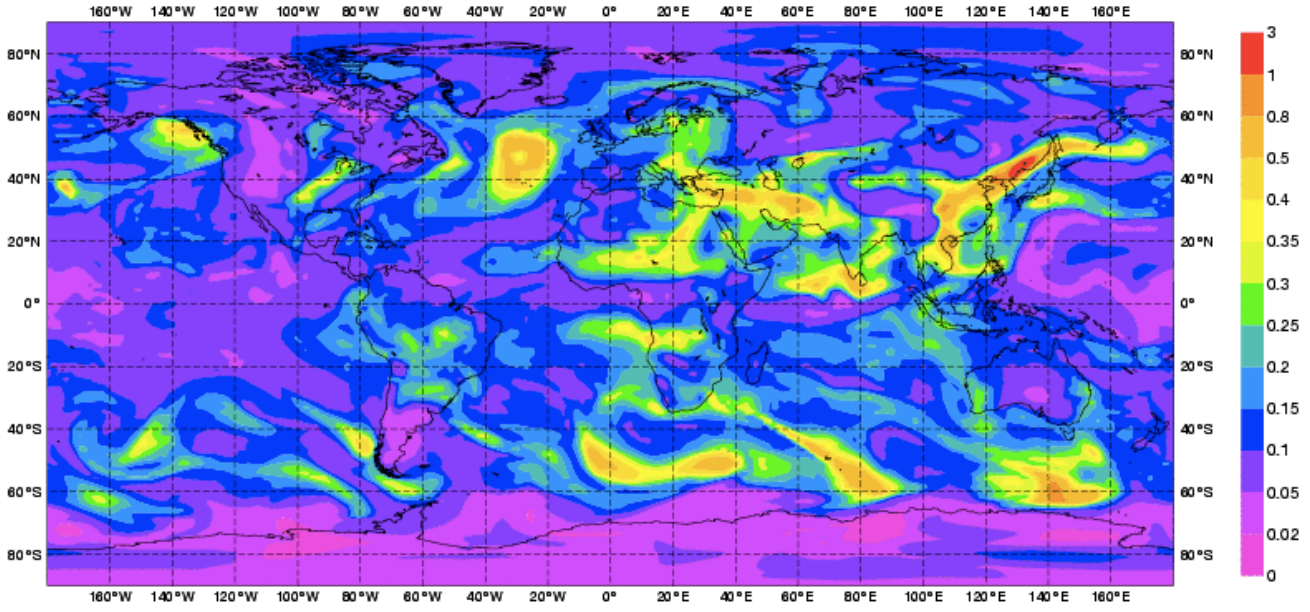
Your Room: Add this product

Show overview: Step (-> valid time)

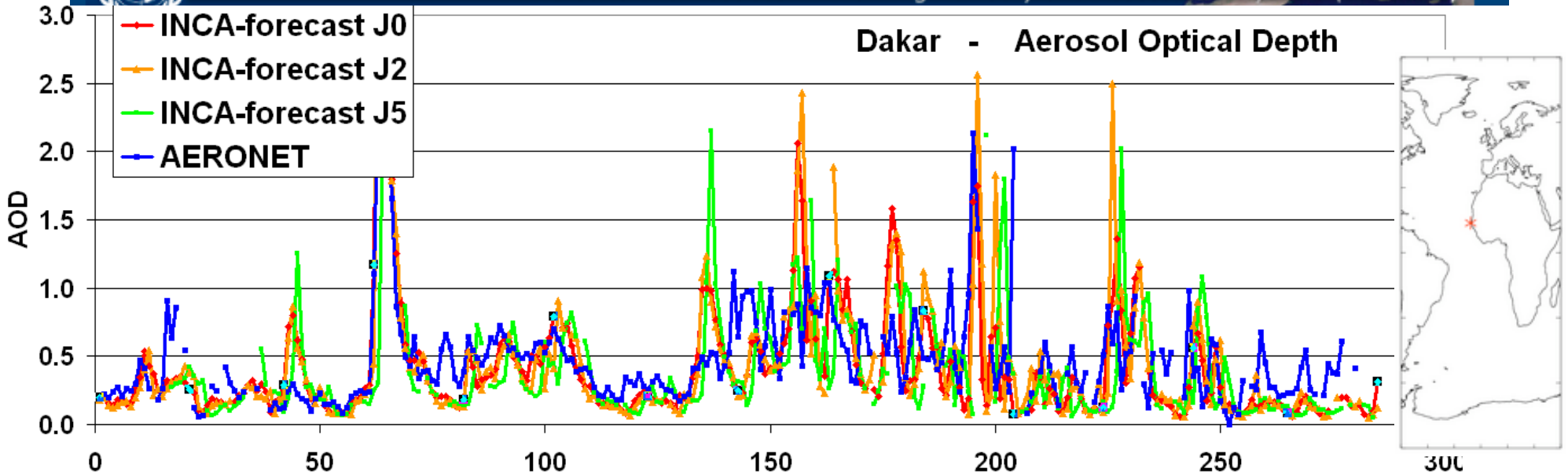
Step (-> valid time): 54 (Mon 26 Oct 2009 06UTC)

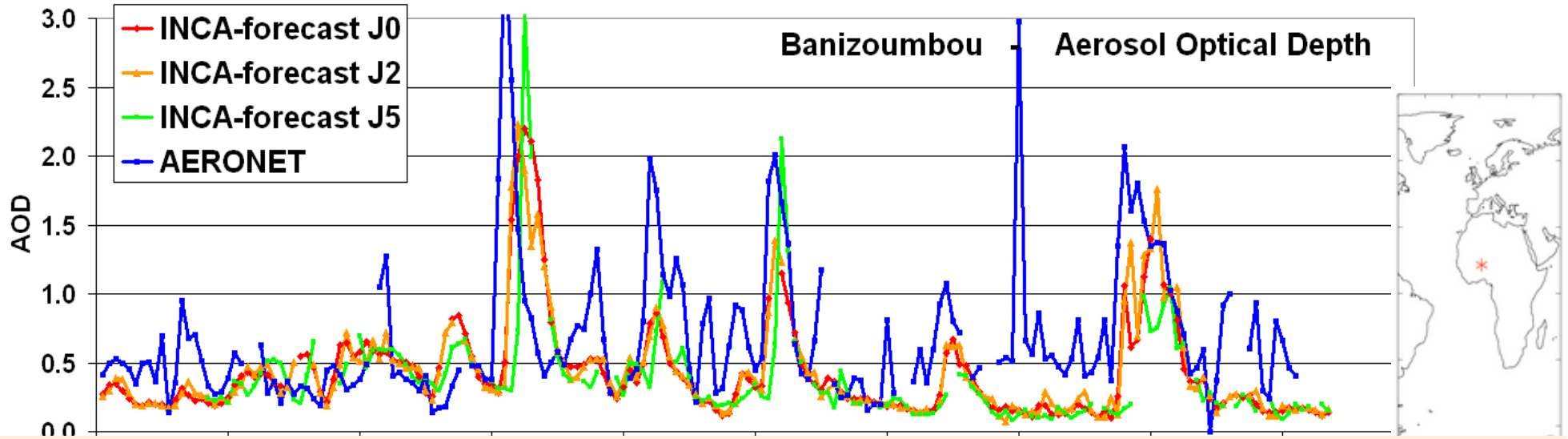
Forecast base time: Sat 24 Oct 2009 00UTC

Saturday 24 October 2009 00UTC ECMWF/GEMS Forecast t+054 VT: Monday 26 October 2009 06UTC
Total Aerosol Optical Depth at 550 nm



Comparison between model and sun photometer





Dust evaluation requires daily/hourly data and longterm investigations

Reliability of Modelled exceedance of dust load

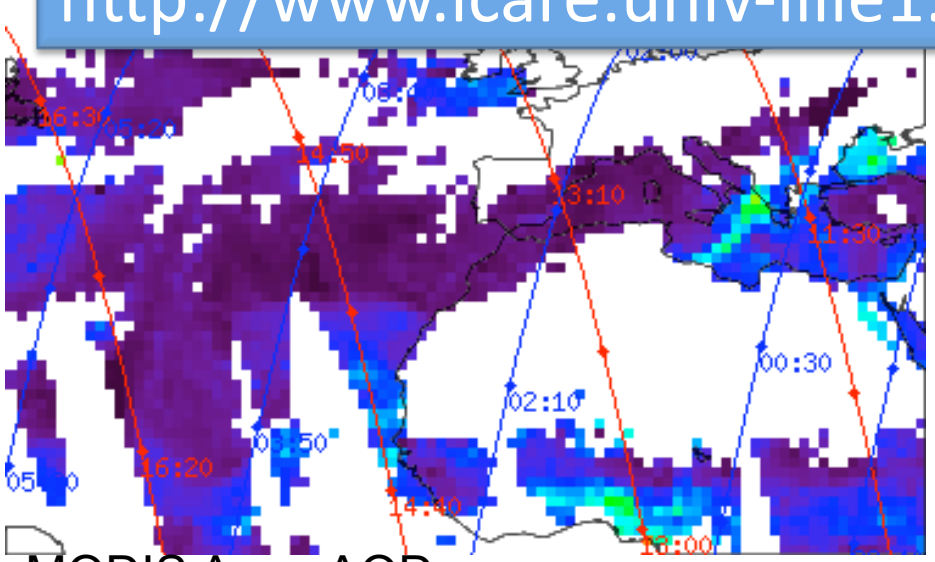
Example: Dust warning statistics
for one year of simulation of forecasts (2006)

LMDzT-INCA predicting high dust events
(AOD above 0.5 at Dakar)

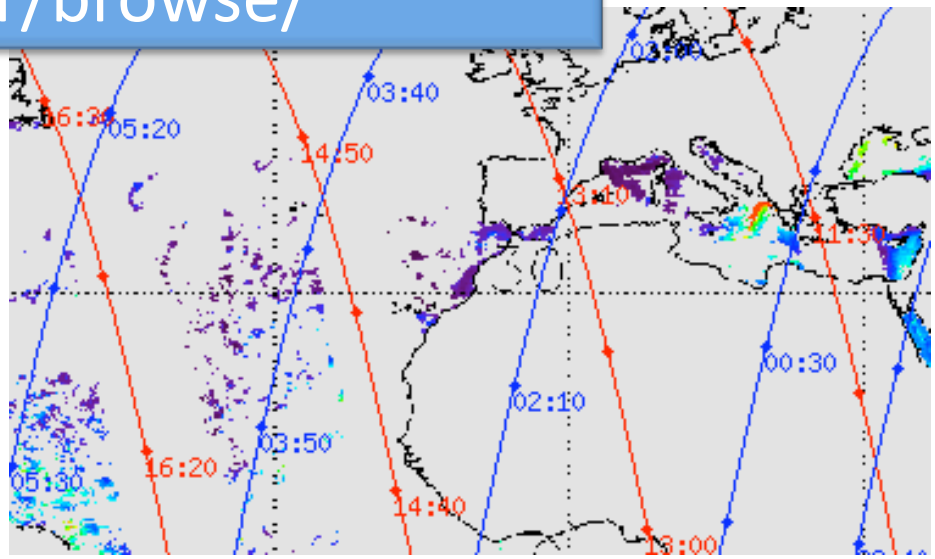
#	J0	J2	J5	ReAnalysis
missing warning	43	47	52	40
correct in no warning	118	116	114	124
correct warning	36	32	27	39
warning false	21	23	25	15

How successful is a SDS warning system ?
Which data make the biggest impact on quality?
Systematic Evaluation needs to be developed

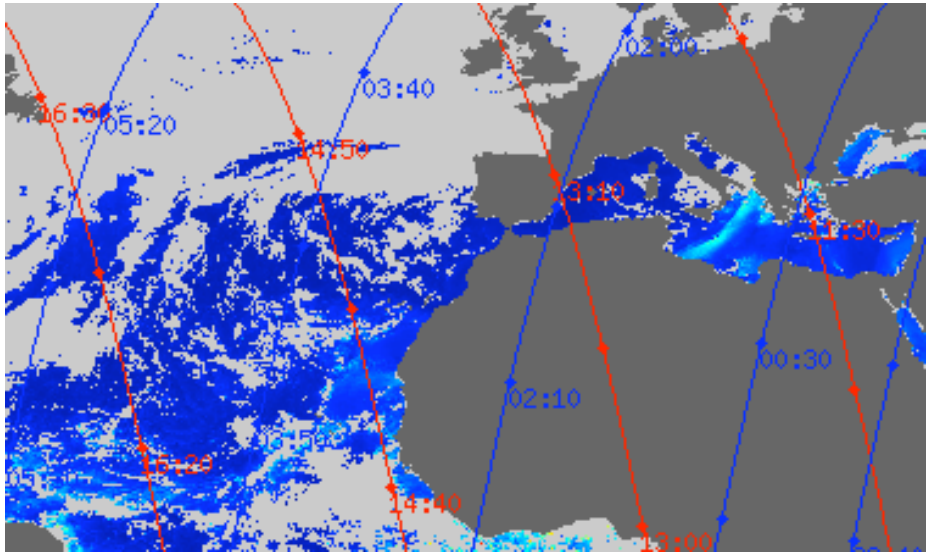
This Thursay noon 11.11.2010 dust information
http://www.icare.univ-lille1.fr/browse/



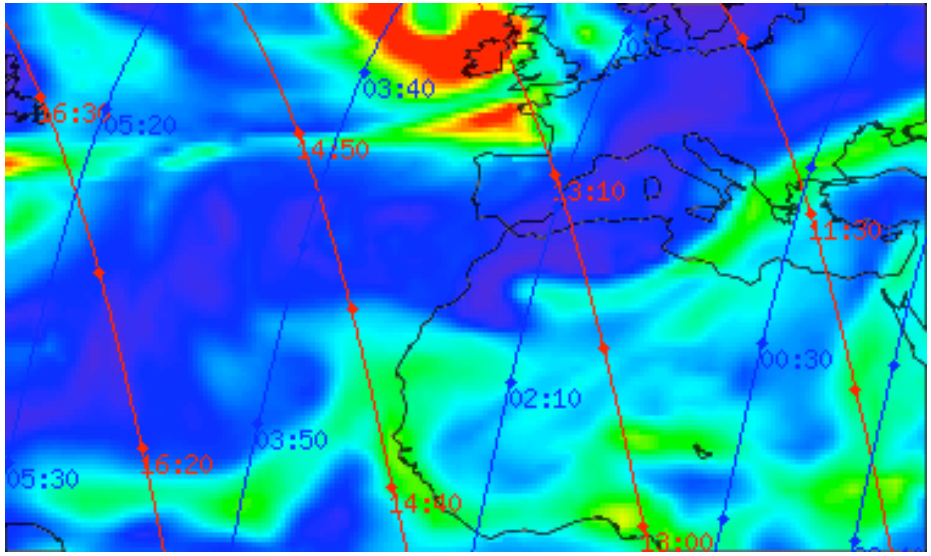
MODIS Aqua AOD



Parasol AOD

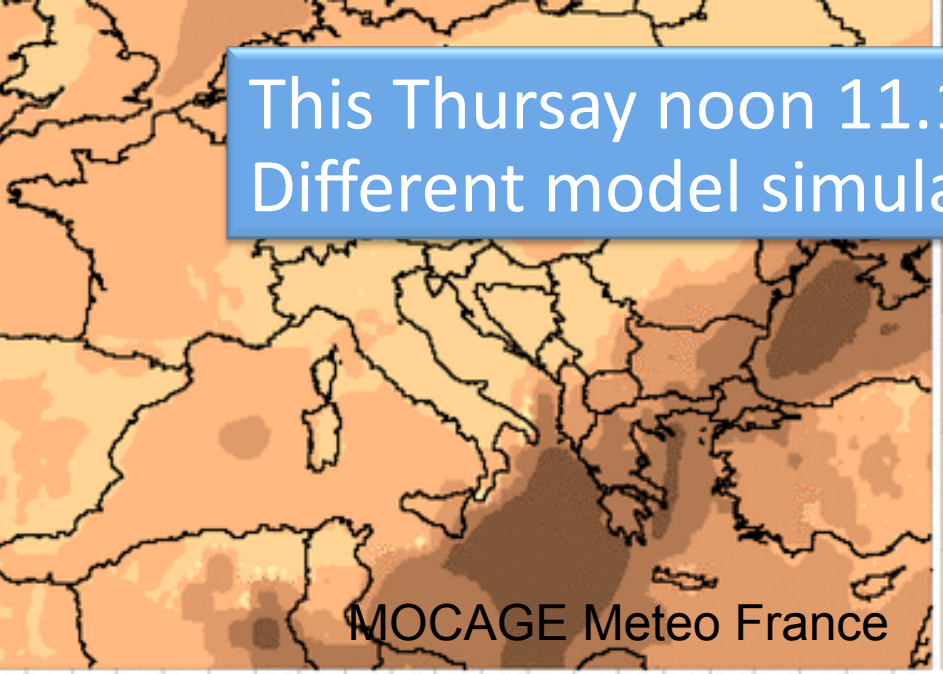


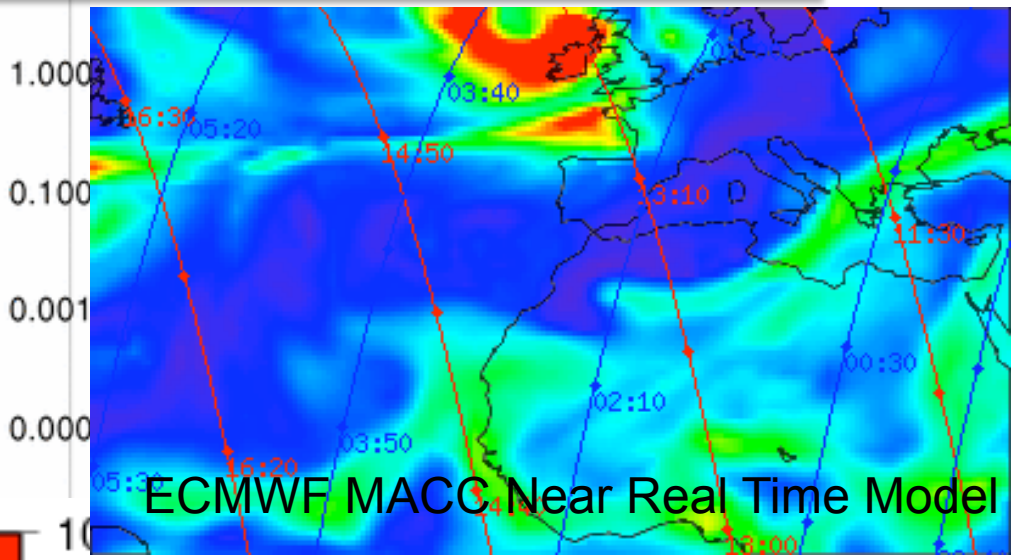
Seviri MSG AOD

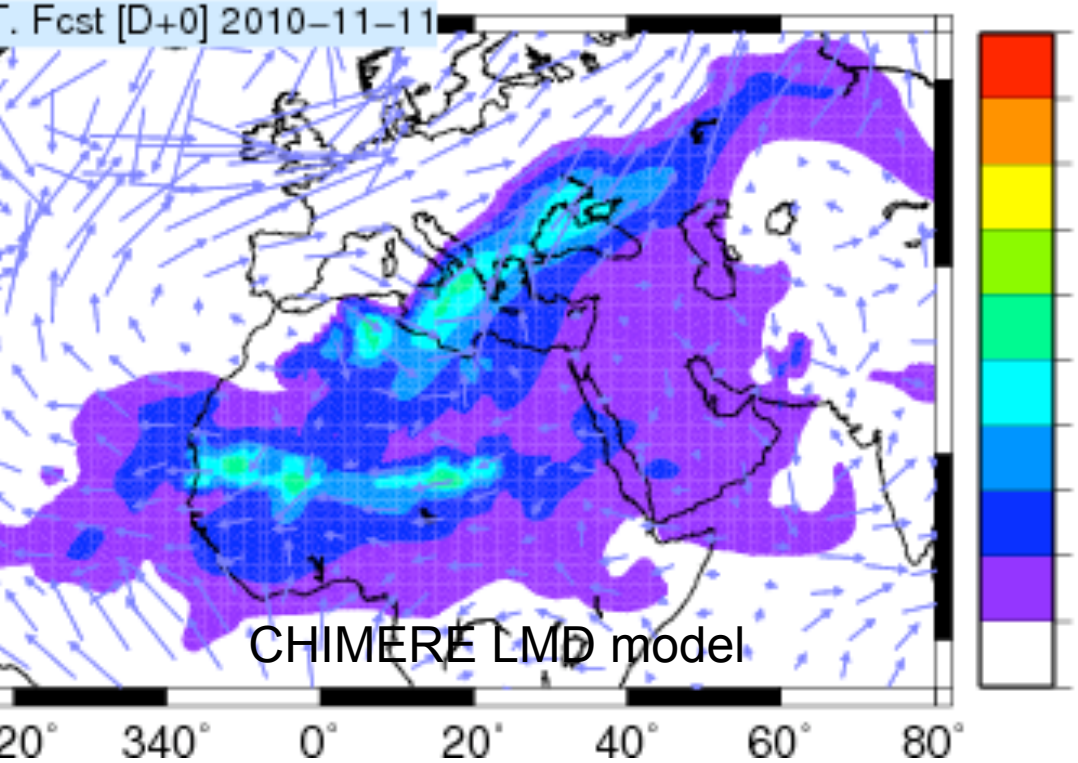


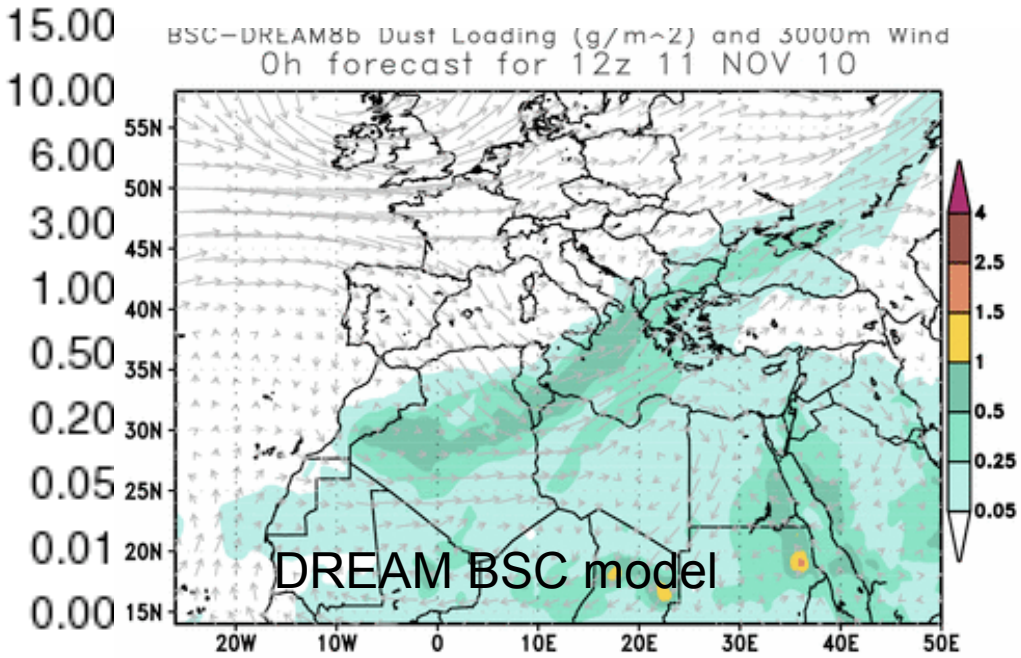
ECMWF MACC Near Real Time Model

This Thursay noon 11.11.2010 dust information
Different model simulations for the same moment

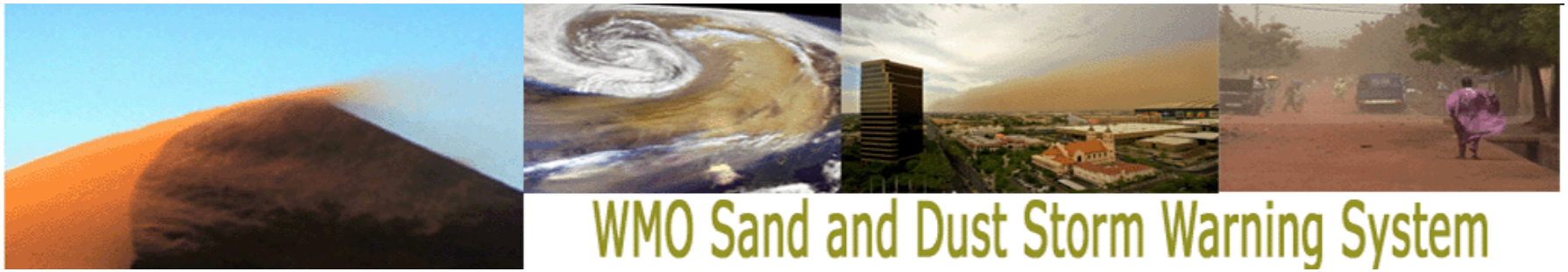








World Meteorological Organization
Weather • Climate • Water



WMO Sand and Dust Storm Warning System

Summary

Modelling of dust requires consideration of size, color, sources, transport&removal, radiative effects, on an almost hemispheric scale

Characteristics of dust transport involve transport up to 6 kilometer into the atmosphere, responsible for long range transport, radiative effects

Anthropogenic Dust may be an important climate forcer