

20 & 21 October 2014
Athens, Greece

2nd South-Eastern Europe GEO Workshop
on Integrating Earth Observation Data
and Services for monitoring the
Environment, protecting the citizens and
stimulating the regional economic growth

Integrating aerosol observations and atmospheric-dust models: A way to further improve regional weather forecasts

Dr Slobodan Nickovic

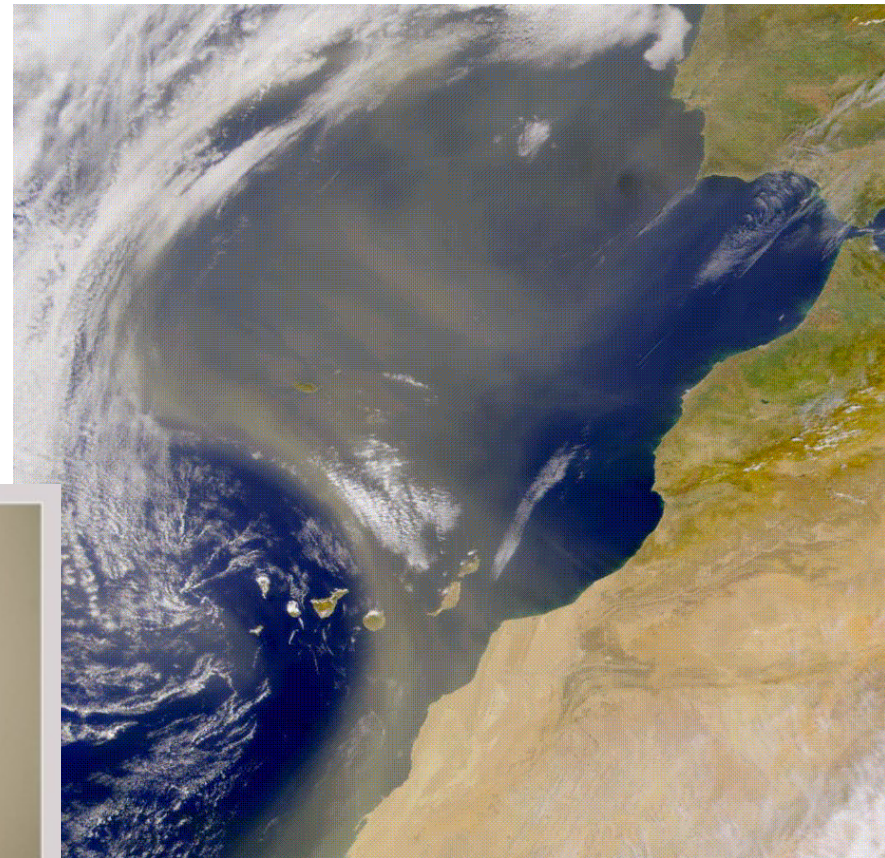
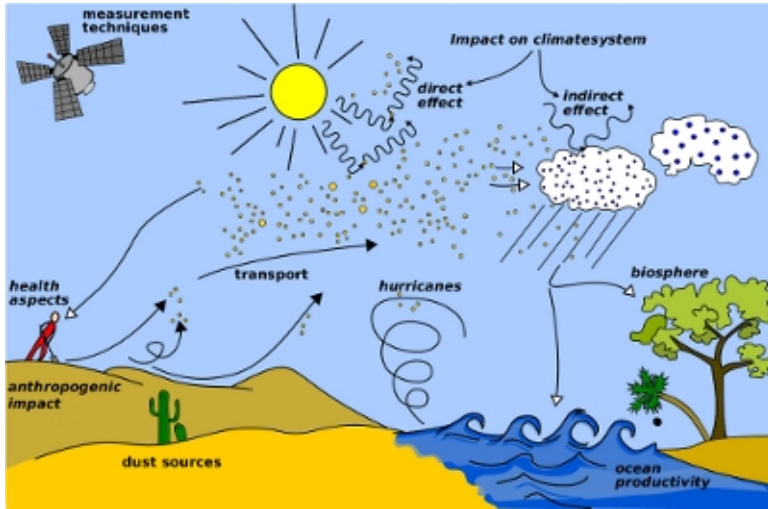
*Republic Hydrometeorological Service, Belgrade, Serbia
Institute of Physics, Belgrade, Serbia*



Could information on atmospheric dust (dust forecast/observations) improve weather predictions?

- Dust and atmosphere interact mutually
 - Dust is driven by the air
 - Atmosphere is modified by dust
 - By affecting radiation
 - By affecting clouds
- Both weather and climate are changed by dust
- Frequent question: why research on dust is important for Balkans?

Atmospheric dust process



Tehran – 2 June 2014, 1pm UTC

Atmospheric dust impacts

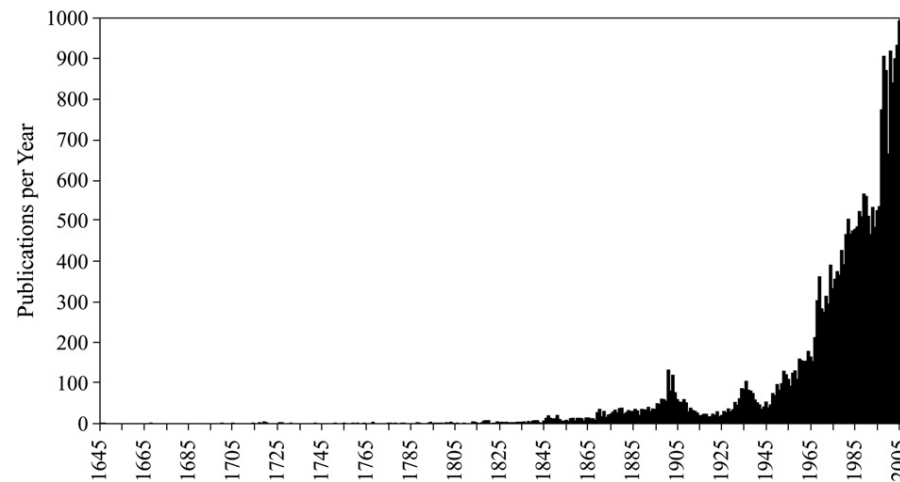
- Health
- Agriculture
- Marine productivity
- Improved weather and climate prediction
- Aviation; Ground transportation



Links to GEO - WMO Sand and Dust Storm Warning Advisory and Assessment System (SDS-WAS):

- SDS-WAS Mission: To enhance the ability of countries to deliver timely and quality sand and dust storm **forecasts, observations**, information and knowledge to **users** through an international partnership in **research and operations**
- **First WMO/GEO SDS-WAS Symposium (2007, Barcelona)**
- **GEO/WMO/WHO MERIT project**
 - **Meningitis outbreaks and dusty weather**

**Interest for dust
research:
Publications/year on
dust-related subjects
(Stout et al, 2008)** ⁵



SDS-WAS Activity Nodes and countries expressed interest to cooperate



<http://sds-was.aemet.es>

HOME ABOUT US FORECAST & PRODUCTS PROJECTS & RESEARCH MATERIALS NEWS EVENTS CONTACT US

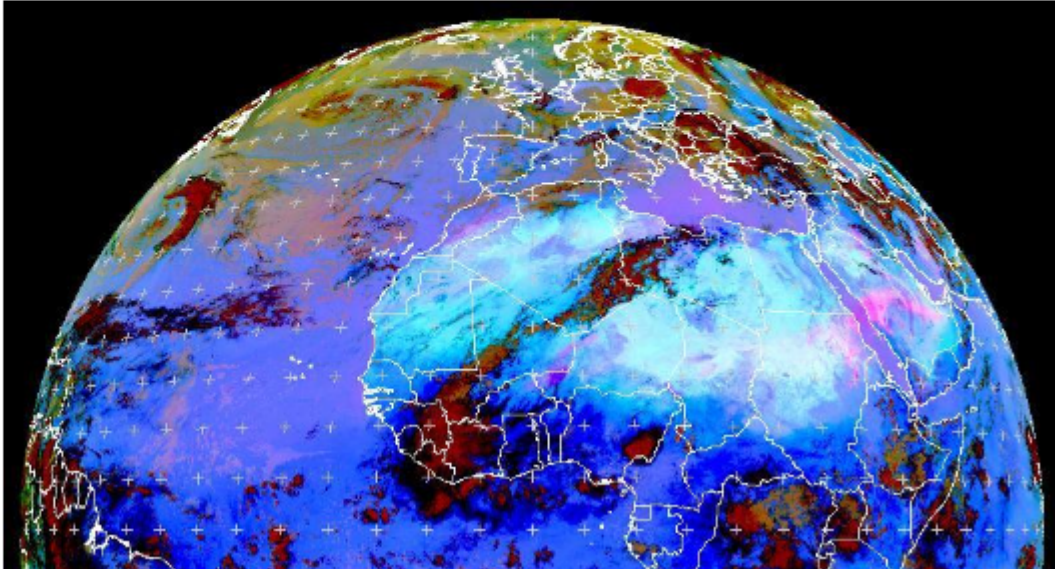
Home

You are here: Home

Northern Africa-Middle East-Europe (NA-ME-E) Regional Center

by [admin](#) — last modified Mar 14, 2011 06:05 PM

LATEST RGB dust image (courtesy of EUMETSAT)



Search

Search Site

Latest News

The U.K. Met Office dust product is available again
May 03, 2011

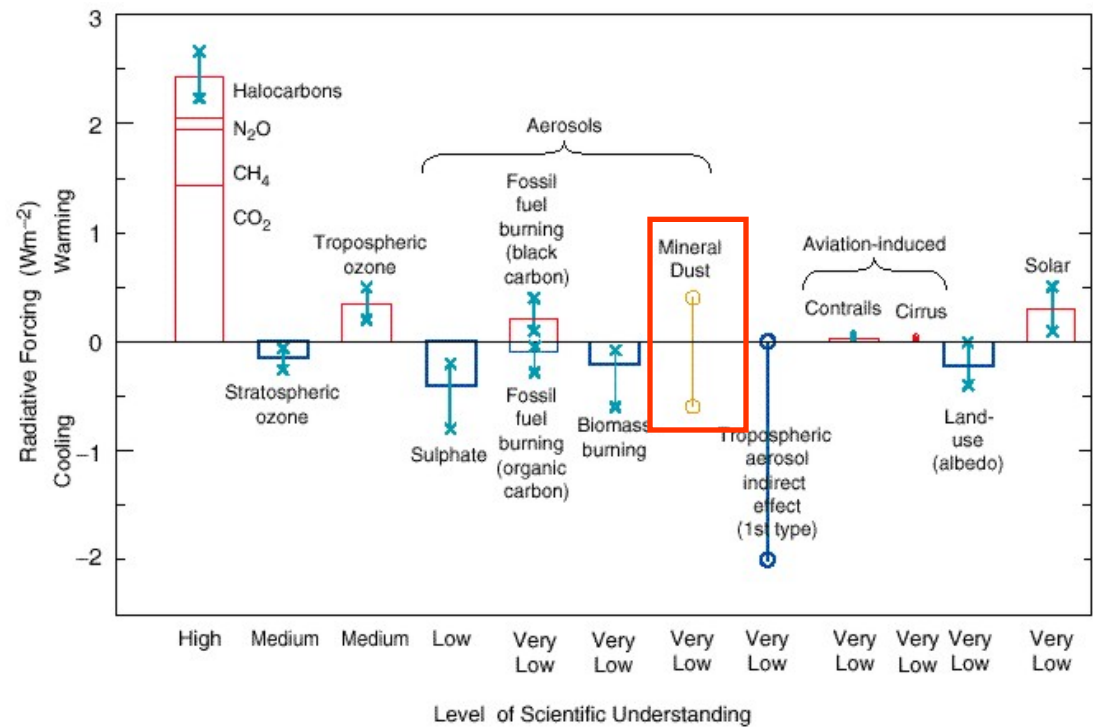
sdswas@aemet.es

2011

IPCC:

➤ Both the magnitude and the sign of the dust direct radiative forcing remain unresolved and depend on

- *_optical properties,*
- *vertical distribution,*
- *cloud cover*
- *albedo*



South East European Virtual Climate Change Center (SEEVCCC) (hosted by the Serbian Met Service)

 Earth Modeling System

 IPCC Scenarios Seasonal Ensemble Forecast downscaling in SEE

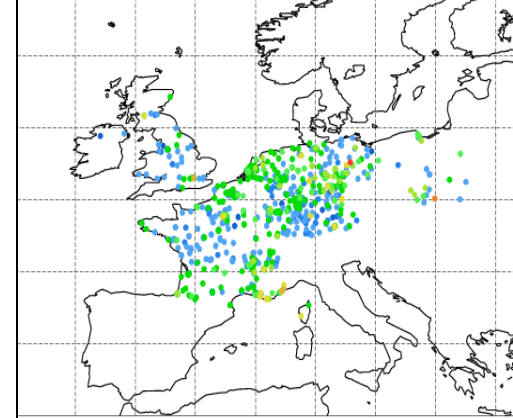
 DREAM model Dust/aerosol forecast

 HYPROM Hydrology Prediction Model

How our research fits into GEO?

- *GEO: (...coordinated, comprehensive and sustained Earth observations and information...)*
- Integrating dust observations from different geo-oriented observation sources
- Integrating into models (verification, assimilation)
- Providing the society with useful information (improvements of weather forecasts; predicting extreme dust storms)

Observations

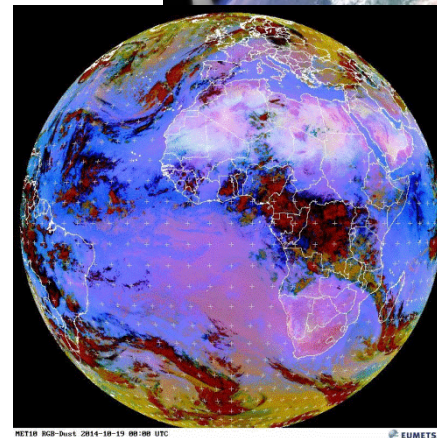
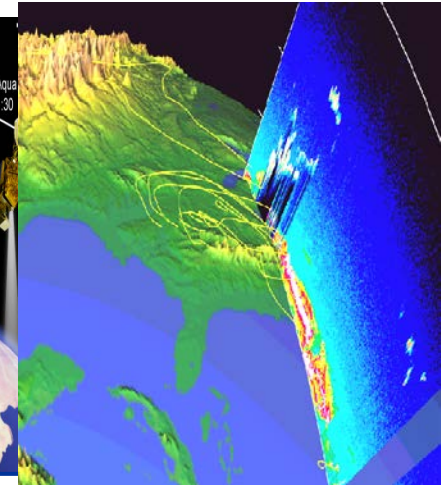
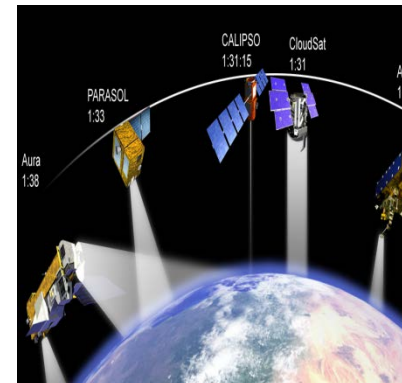


Particulate Matter concentration



Aerosol Optical Depth AOD from WMO GAW AERONET Contribution network of sun-photometers

sun-photometers

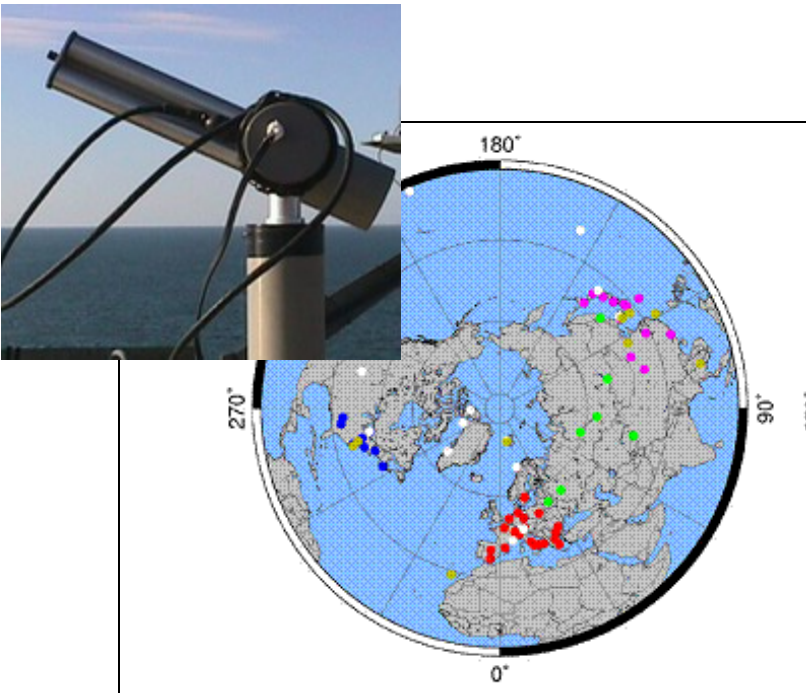


- **NASA A-Train
MODIS CALIPSO
& Geostationary
Satellite IR**
- **EUMETSAT MSG**

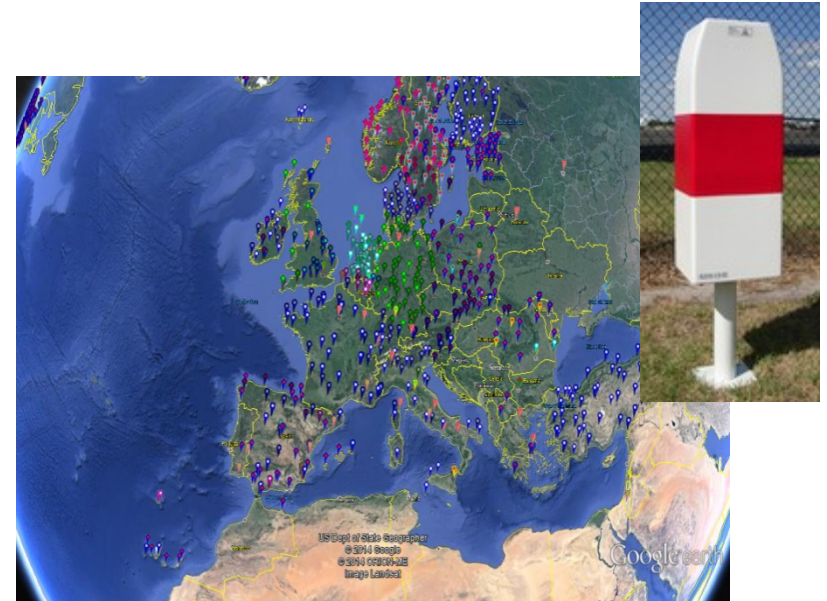
Observations

- GAW Aerosol Lidar Observation Network (**GALION**) data extensively used

- Inventory of **ceilometer global network** (WMO-DWD initiative) – big future source for aerosol profiling



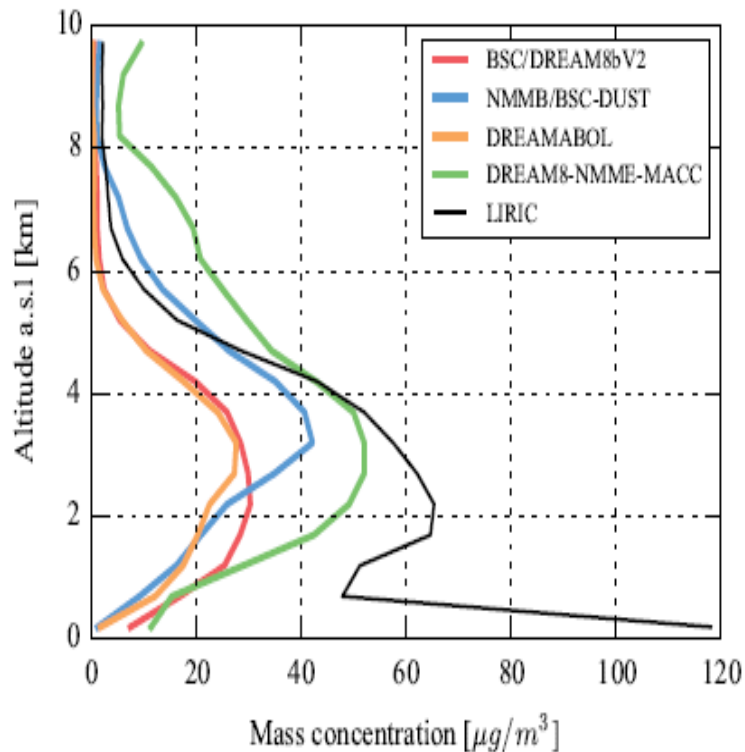
GAW Aerosol Lidar Observation Network (GALION)



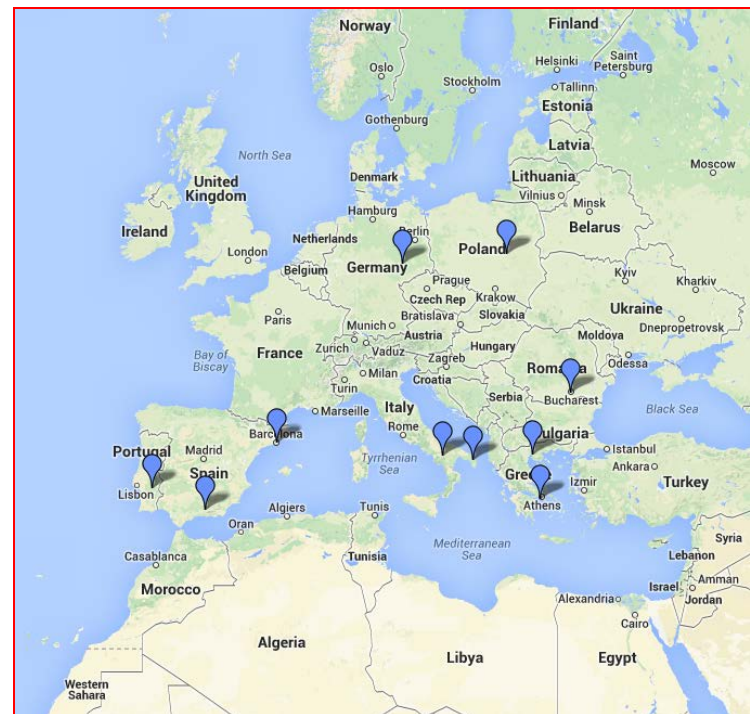
ceilometer global network

Lidars and ceilometers

LIRIC vs Models

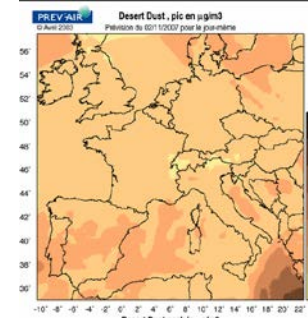


Average profiles

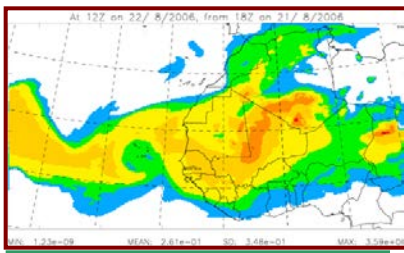


10 EARLINET / AERONET stations

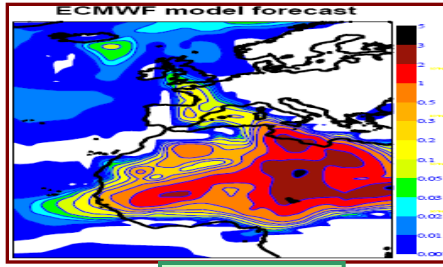
Binietoglou et al. 2014, National R&D Institute for Optoelectronics, Bucharest, Romania



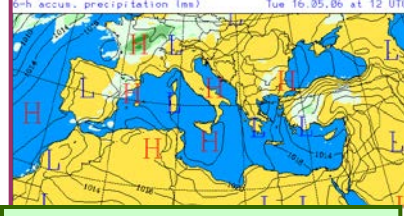
METEOFRANCE



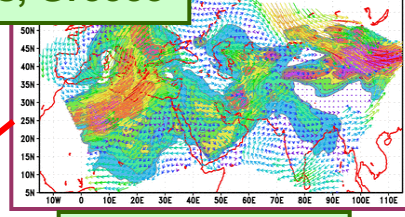
UK MET OFFICE



ECMWF

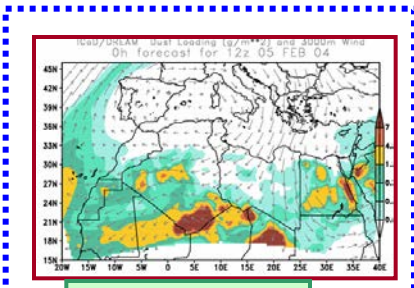


U of Athens, Greece

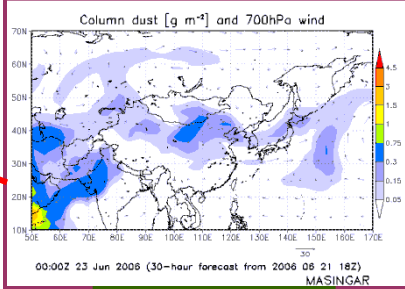


METU, Turkey

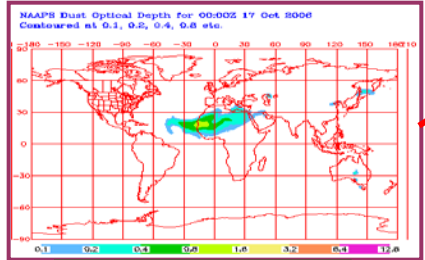
Dust models



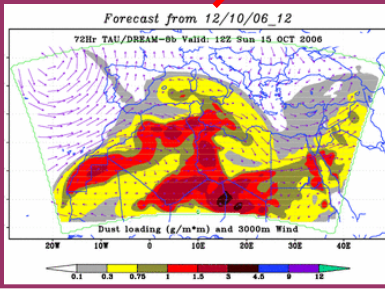
BSC, Spain



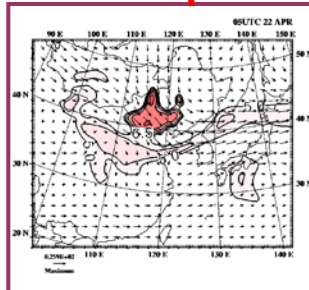
MRI, Japan



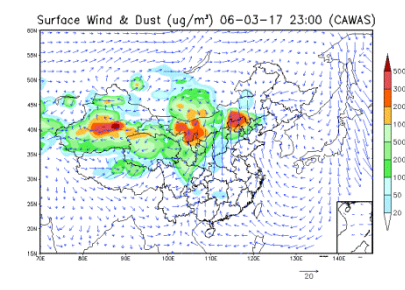
US Navy, USA



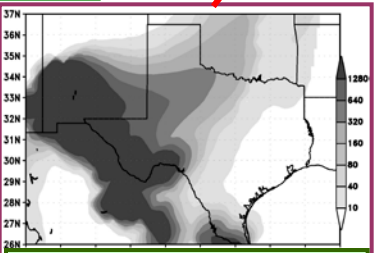
Tel Aviv U, Israel



KMA, S. Korea



CMA, China



U of Arizona, USA

Operational Research Dust Forecasting Centres

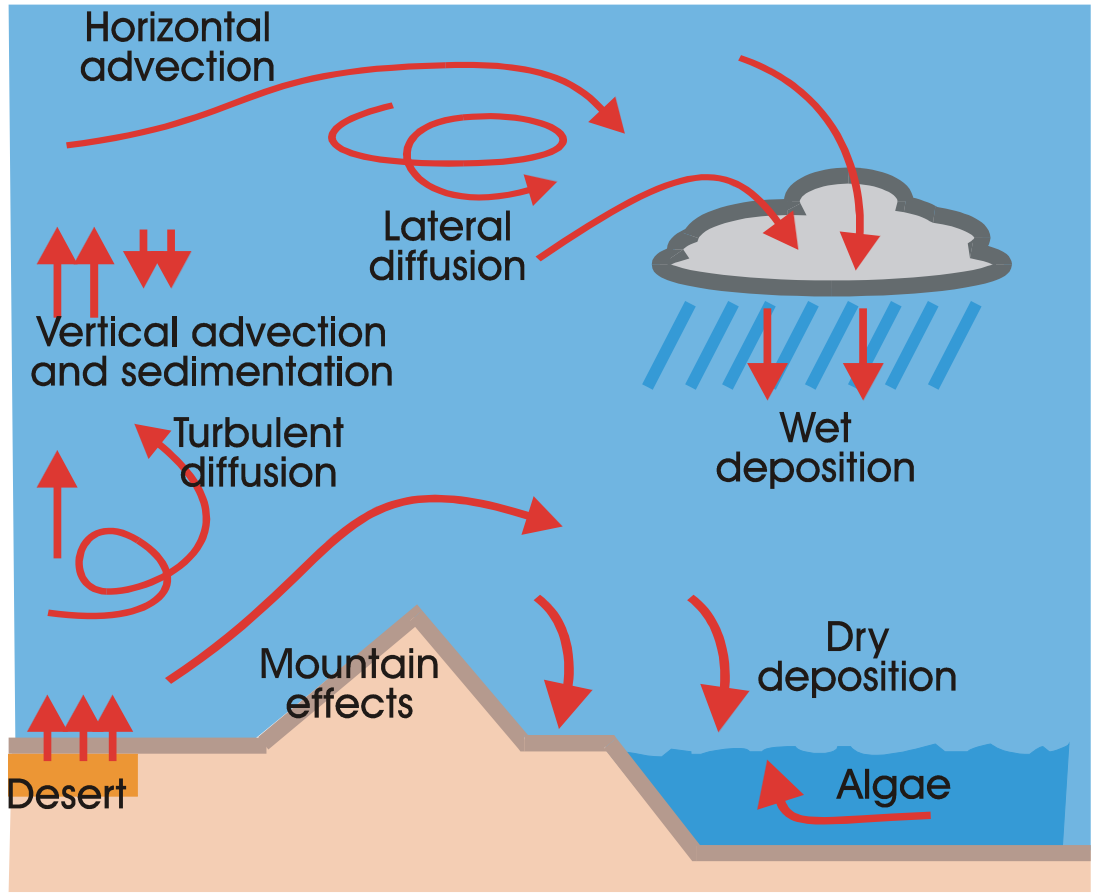
Dust Regional Atmospheric Model (DREAM)

Nickovic et al., 2001

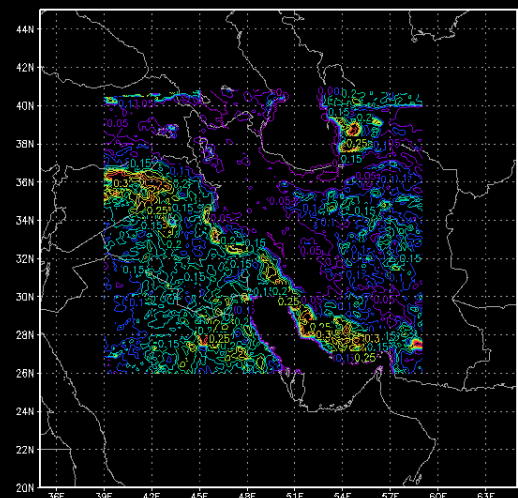
$$\frac{\partial C_k}{\partial t} = -u \frac{\partial C_k}{\partial x} - v \frac{\partial C_k}{\partial y} - (w - v_{gk}) \frac{\partial C_k}{\partial z} - \nabla \cdot (K_H \nabla C_k) - \frac{\partial}{\partial z} \left(K_z \frac{\partial C_k}{\partial z} \right) + \left(\frac{\partial C_k}{\partial t} \right)_{SOURCE} - \left(\frac{\partial C_k}{\partial t} \right)_{SINK}$$

Dust model – a set of numerical methods and parameterizations of physical processes solving a complex set of mathematical equations

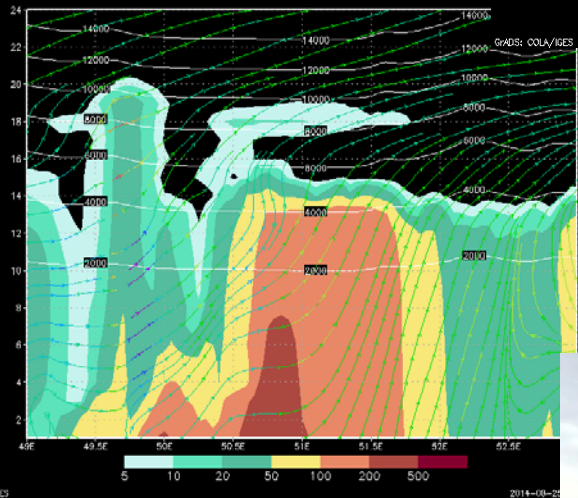
Simulates all major processes of the atmospheric dust cycle



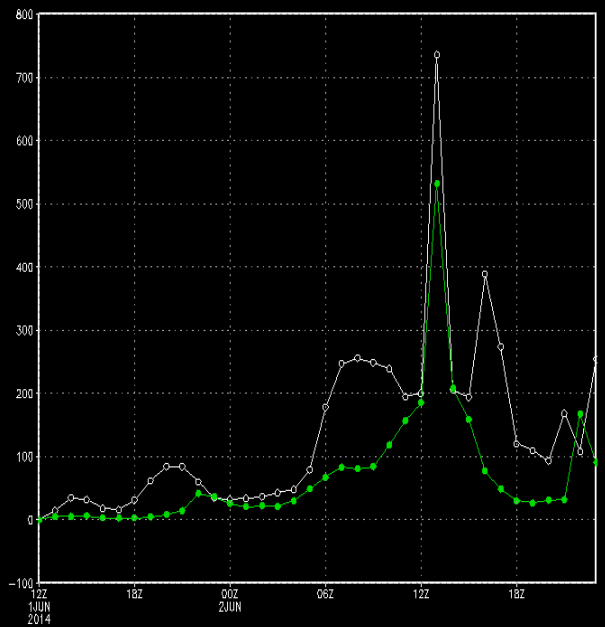
DREAM model simulation of the June 2014 Tehran dust storm *Preliminary analysis of results*



2014-07-11-08:13



2014-08-26



2014-08-26-12:03



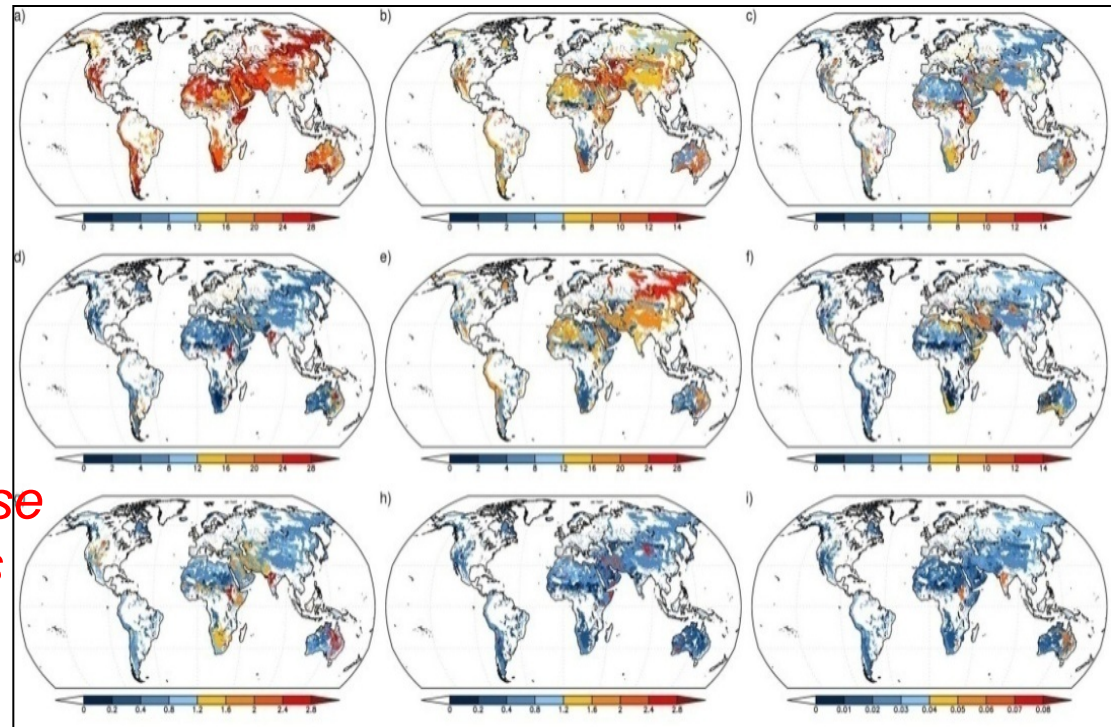
©TABNAK/Farzin Saleh

Importance of dust mineral composition

- radiation,
- dust-cloud interactions,
- health

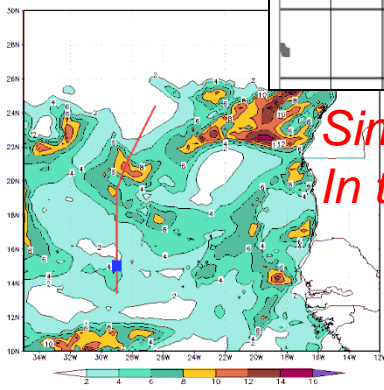
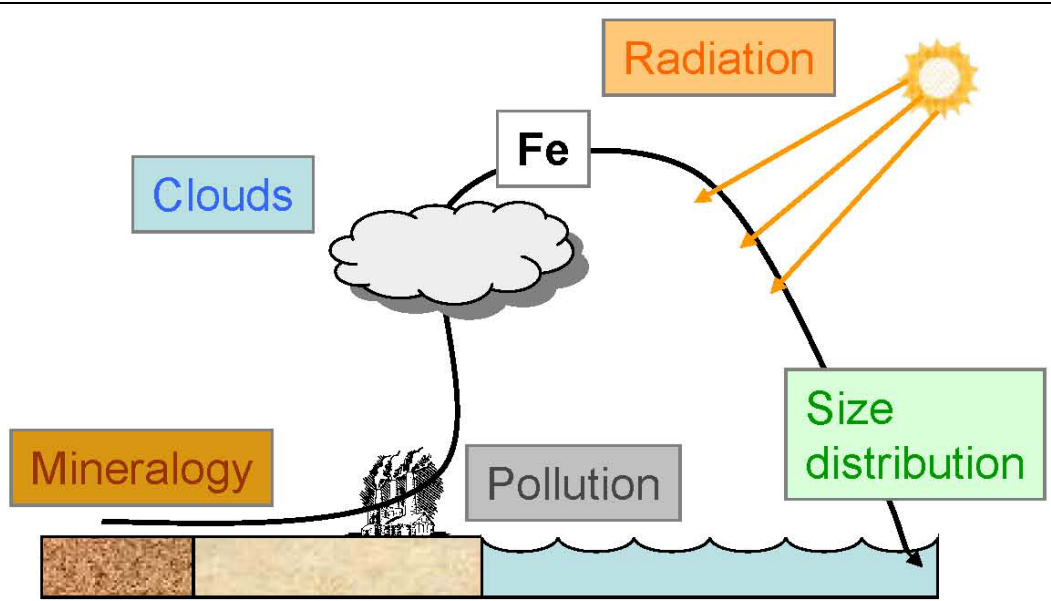
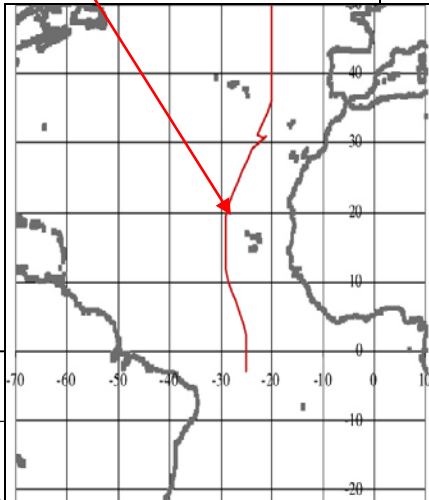
Impacting weather,
climate and
environment

- *Dust Mineralogy –hi-res database*
A data type fits to GEO structures
- *Publically available*



How dust impacts the marine environment: **Fe ATMOSPHERIC PROCESSING**

*cruise sector
dominated by dust*



*Simulated soluble Fe
In the Atlantic*

*Algae bloom in Canaries
2006 due to dust deposition*



Can desert dust explain the outgoing longwave radiation anomaly in the UK operational model over the Sahara?

Haywood, et al., JGR 2003

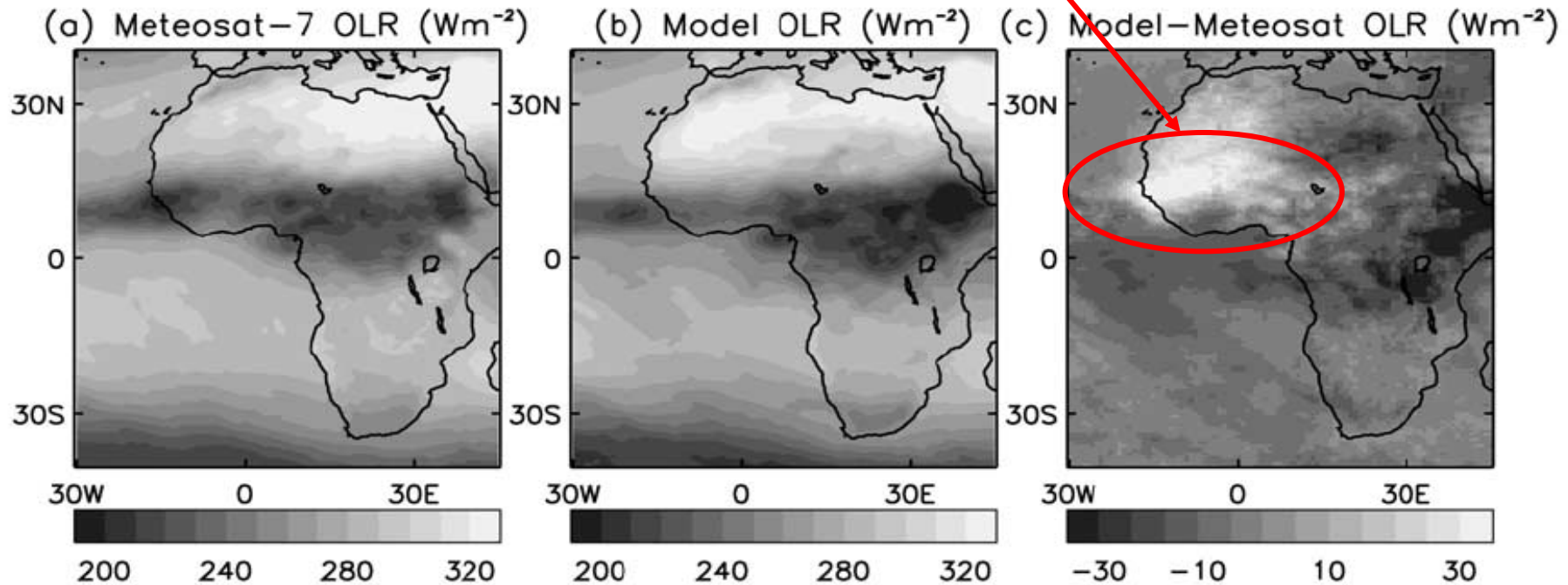
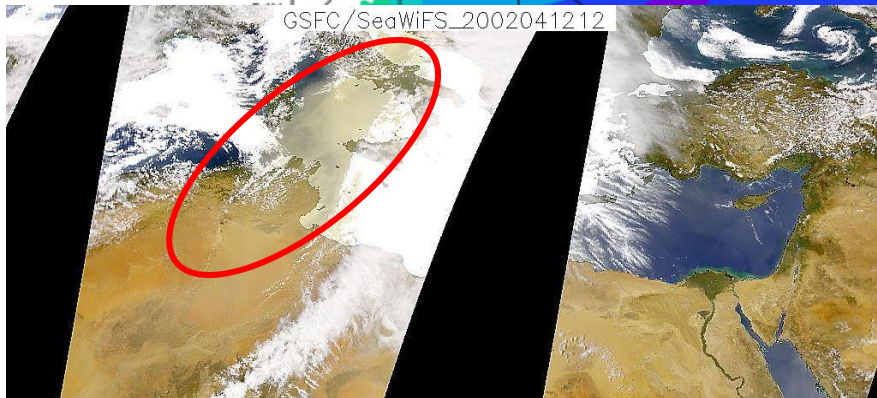
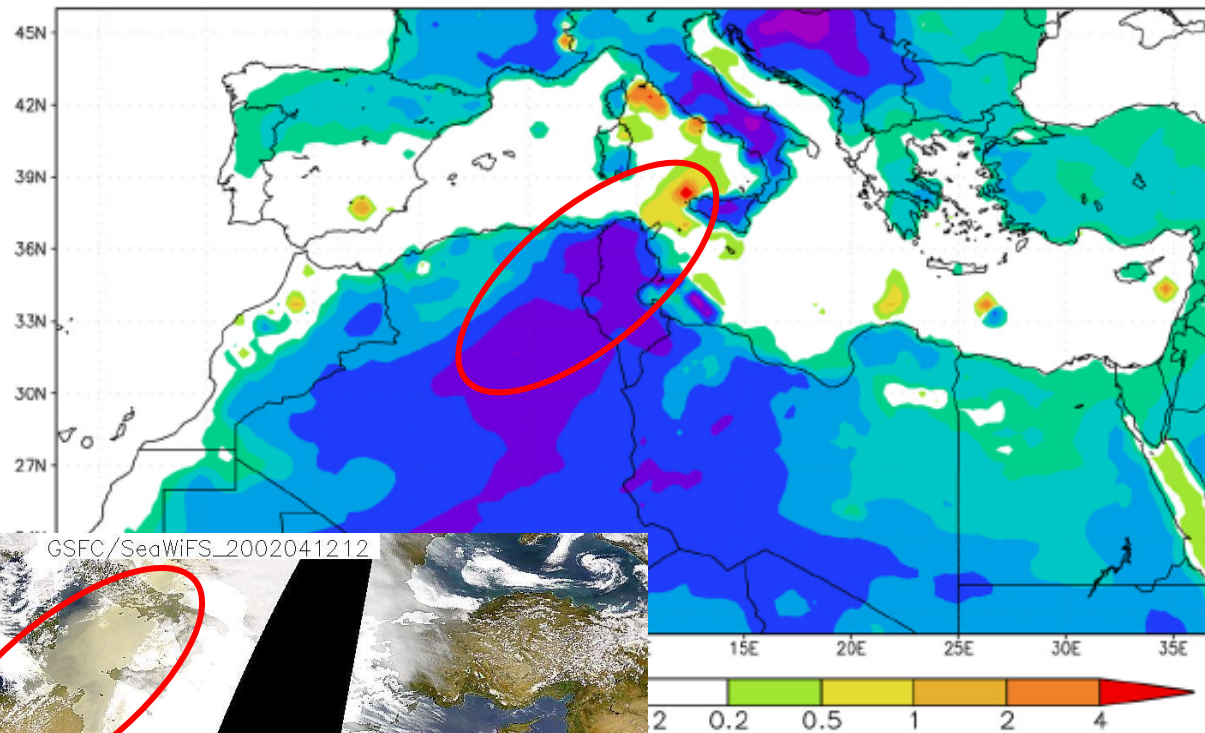


Figure 1. The July 2003 monthly mean for (a) OLR_{Met7} , (b) $\text{OLR}_{\text{model}}$, and (c) $\text{OLR}_{\text{model}} - \text{OLR}_{\text{Met7}}$. The monthly mean consists of the average of the monthly mean of the OLR diagnosed at 0000 UTC, 6000 UTC, 1200 UTC, and 1800 UTC. Units are Wm^{-2} . See color version of this figure in the HTML.

How dust impacts atmospheric radiation: Cooling surface temperature by $\sim 5^{\circ}\text{C}$

2m Temperature difference (k) RAD-CTR 12 April 2002 UTC



over the whole domain.

s 30°N and 40°N along longitude 12°E of (a) the
e atmospheric temperature difference between RAD
horizontal distribution of 2m temperature difference

Importance of assimilating vertical aerosol profiles:

Early ideas (Nickovic, 1996)

- Suggested analogy between TEMP reports and aerosol profile observations
- Recognizing that satellite column variables (e.g. AOD) are not sufficient for model assimilation
- Proposed blending the vertical profiling data (not available at that time) and model forecasts

**MODELING OF DUST PROCESS FOR THE SAHARAN AND
MEDITERRANEAN AREA**

S. NICKOVIC

*Department of Applied Physics, University of Athens,
Ippokratou St. 33, Athens, Greece*

How dust observations help improving dust forecasts?

Data assimilation issue

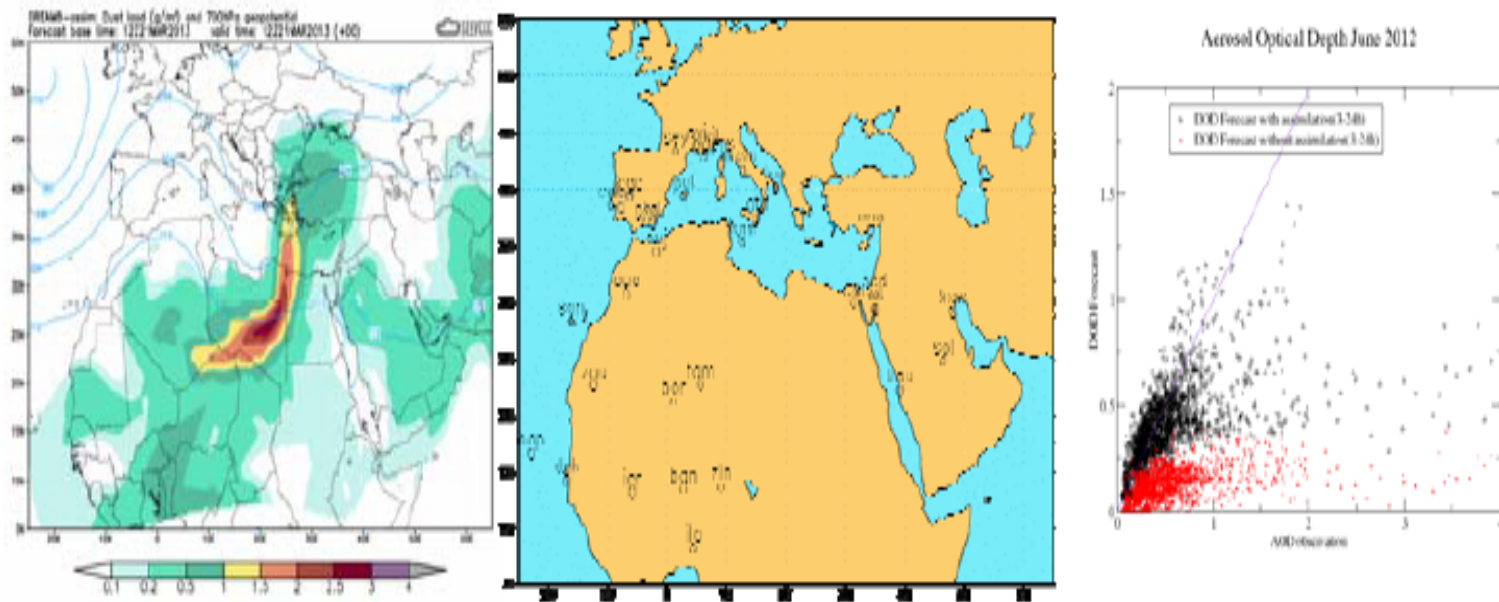
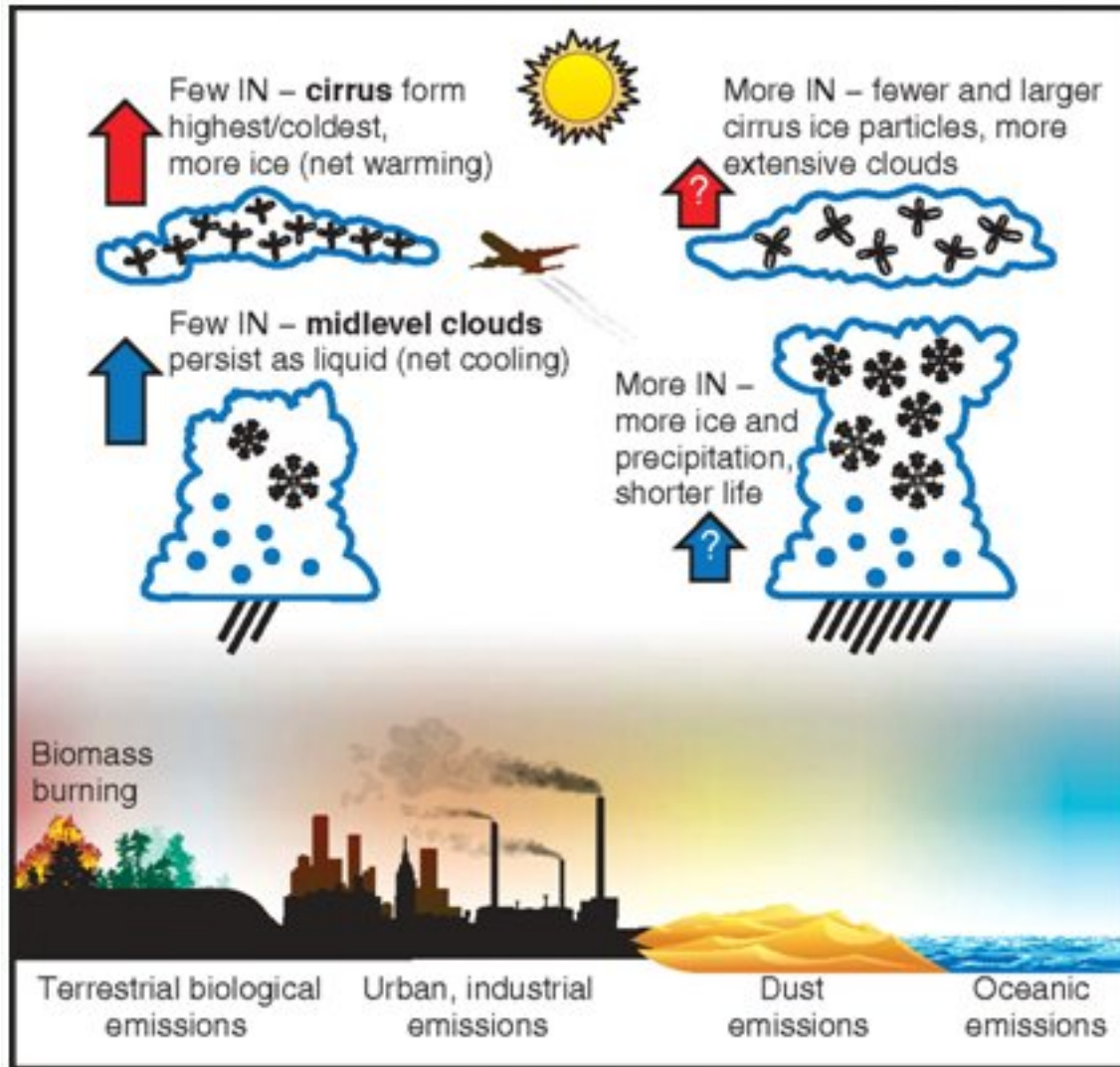


Figure 3 Left: Domain of the operational DREAM8-NMME dust forecasts with included MODIS AOD assimilation; Central: AERONET AOD observation sites Right: AOD scatter diagram with (black points) and without (red points) assimilation, when compared with the AERONET AOD in the region

Ice Nucleation process



Generation of cold clouds

How dust enhance cold-cloud generation?

- 2/3 of ice clouds formed due to pure dust and metalics
- Only small dust C needed
- Way of freezing – heterogeneous
- Feldspar – the most effective ice agent among dust mineral

Scienceexpress

Clarifying the Dominant Sources and Mechanisms of Cirrus Cloud Formation

Daniel J. Cziczo,^{1*} Karl D. Froyd,^{2,3} Corinna Hoose,⁴ Eric J. Jensen,⁵ Minghui Diao,⁶ Mark A. Zondlo,⁶ Jessica B. Smith,⁷ Cynthia H. Twohy,⁸ Daniel M. Murphy²

Cziczo et al, 2013

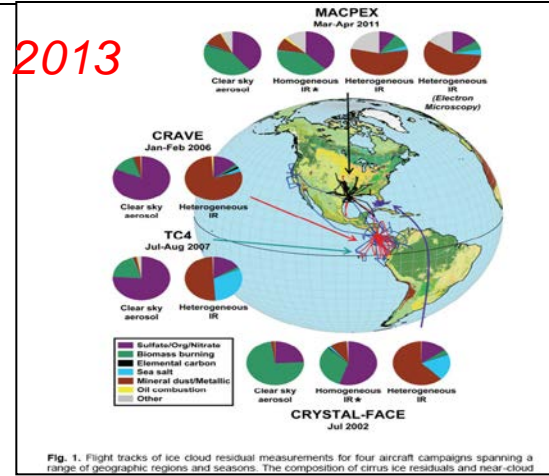
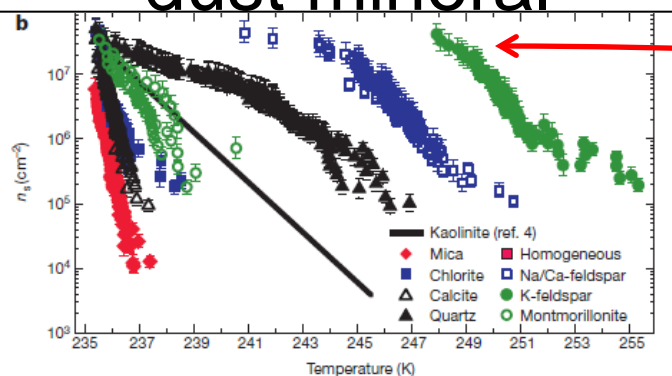


Fig. 1. Flight tracks of ice cloud residual measurements for four aircraft campaigns spanning a range of geographic regions and seasons. The composition of cirrus ice residuals and near-cloud



The importance of feldspar for ice nucleation by mineral dust in mixed-phase clouds

James D. Atkinson¹, Benjamin J. Murray¹, Matthew T. Woodhouse², Thomas F. Whale¹, Kelly J. Baustian¹, Kenneth S. Carslaw¹, Steven Dobbie¹, Daniel O'Sullivan¹ & Tamsin L. Malkin¹

Atkinson et al, 2013

DREAM model:

Ice Nuclei (IN) parameterization

- Based on the DREAM dust model
 - 50km horizontal resolution
 - effective radii: 0.15, 0.25, 0.45, 0.78, 1.3, 2.2 and 3.8 μm (PM10)
 - ice-active surface site density $n_s(T)$ and N of immersion freezing particles N_{imm} (Niemand et al, 2012):

$$n_s(T) = \exp[-0.517(T - 273.14) + 8.934] \text{ [m}^{-2}\text{]}$$

$$N_{imm} = n_s(T) S_{tot,dust}$$

Cloud radar and DREAM model IN: comparison

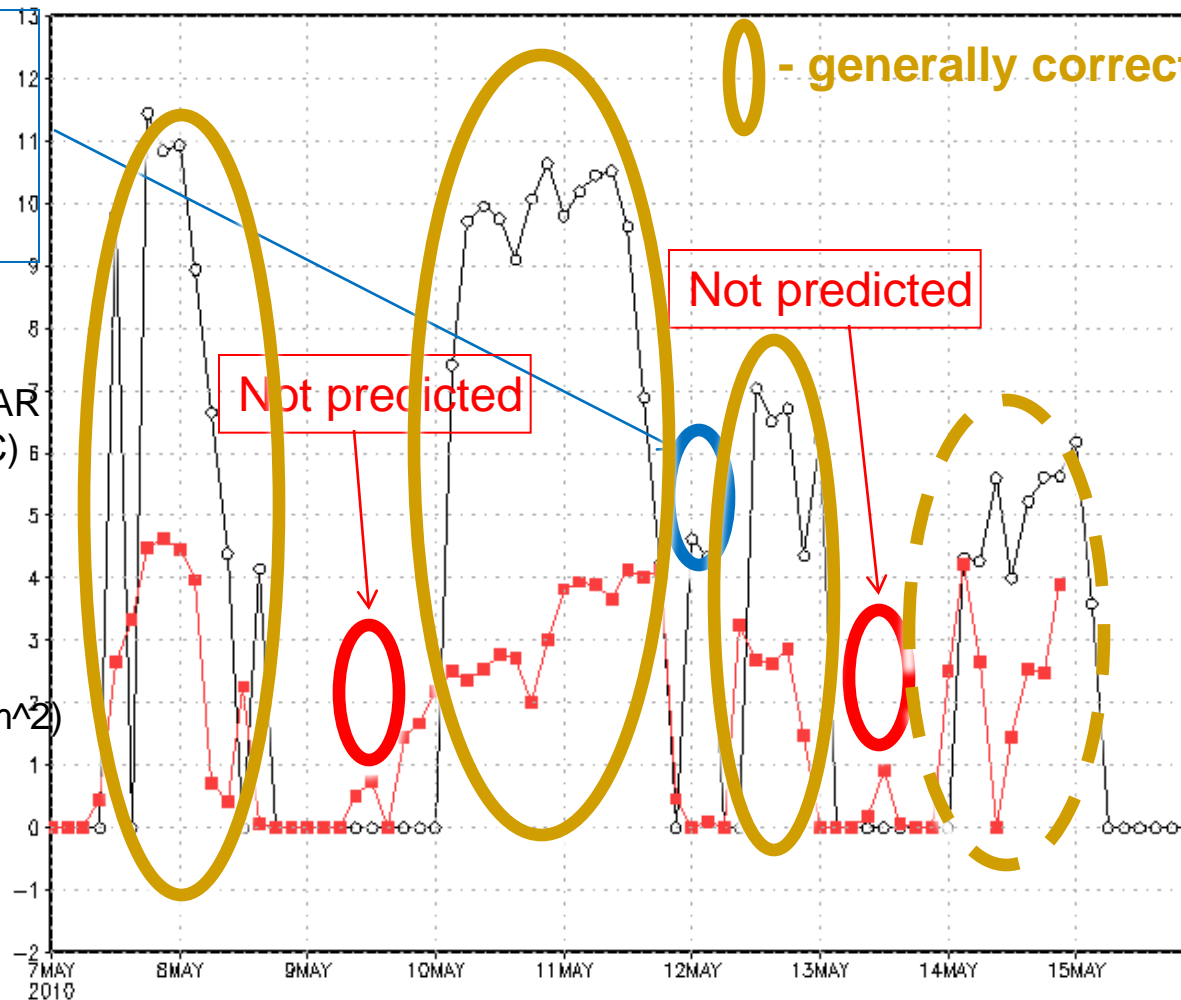
Potenza, $\log_{10}(\text{IN})$, fcst (b); $\log_{10}(\text{iwc} \cdot 1\text{e}6)$, obs MIRA55 (r)

Overpredicted
although
lidar shows some
high cloudiness
(next slide)

Tito Scalo MIRA-55 RADAR
LOG10 (Vertical load IWC)
(IWC – ice water content
[$1\text{e}+7 \cdot \text{kg}/\text{m}^2$])

RED

DREAM
LOG10(I Vertical load N/m^2)
BLACK



In conclusion:

- Contribution of the presented research corresponds to the GEO meeting objectives:
 - **Monitoring the environment** (aerosol; atmospheric drivers)
 - **Protecting the citizens** (dust forecasts during extensive dust storms)
 - **Regional economic growth** (improving weather forecasts where weather is impacted by aerosol)