Model products to assess the health impact of airborne dust

Enric Terradellas eterradellasj@aemet.es
Ernest Werner ewernerh@aemet.es
AEMET, Barcelona
WMO SDS-WAS

SDS-WAS / InDust Meeting on the Health Impact of Dust, Barcelona, 10-11 January 2019

Summary

- Introduction
- Dust modeling
- WMO SDS-WAS. Products
- Other products

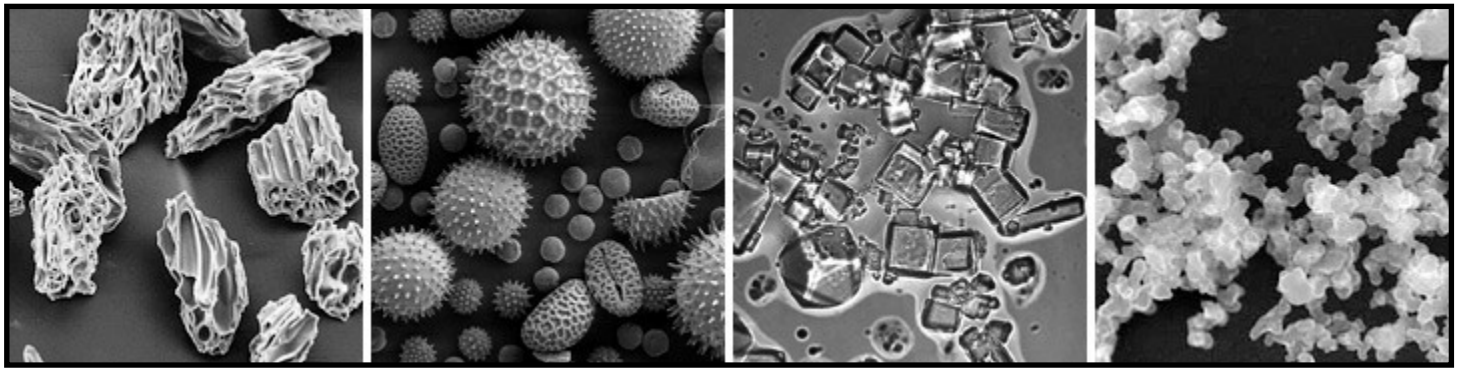
Summary

- Introduction
- Dust modeling
- WMO SDS-WAS. Products
- Other products

Atmospheric aerosol

Solid or liquid particles suspended in the air

- Types: primary / secondary particles, natural / anthropic particles
- Size: diameter between 0.001 µm (1 nm) and 100 µm approx.
- Chemical and mineralogical composition: diverse
- Optical properties (absorption, scattering): diverse

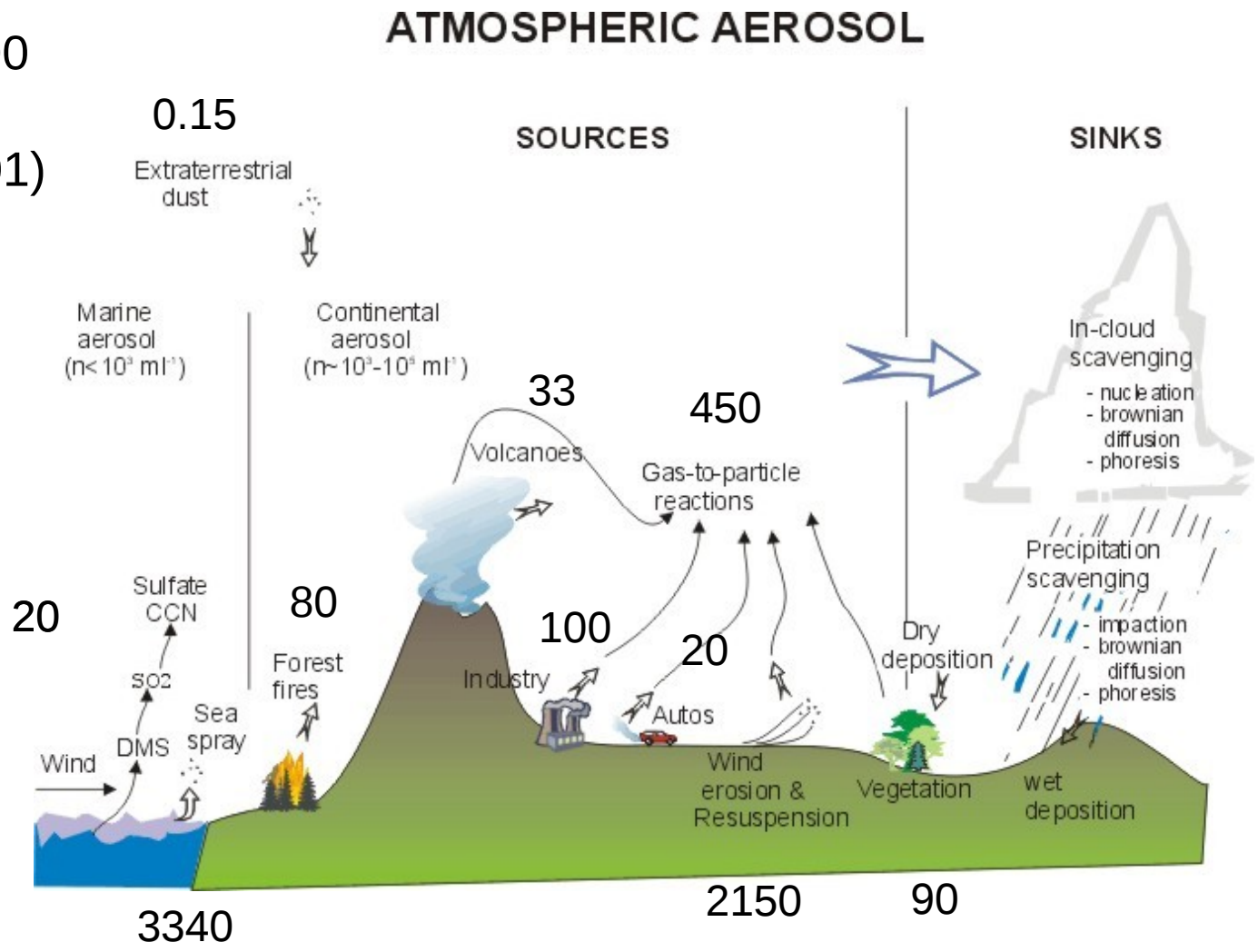


USGS science for a changing world

ASU Arizona State University

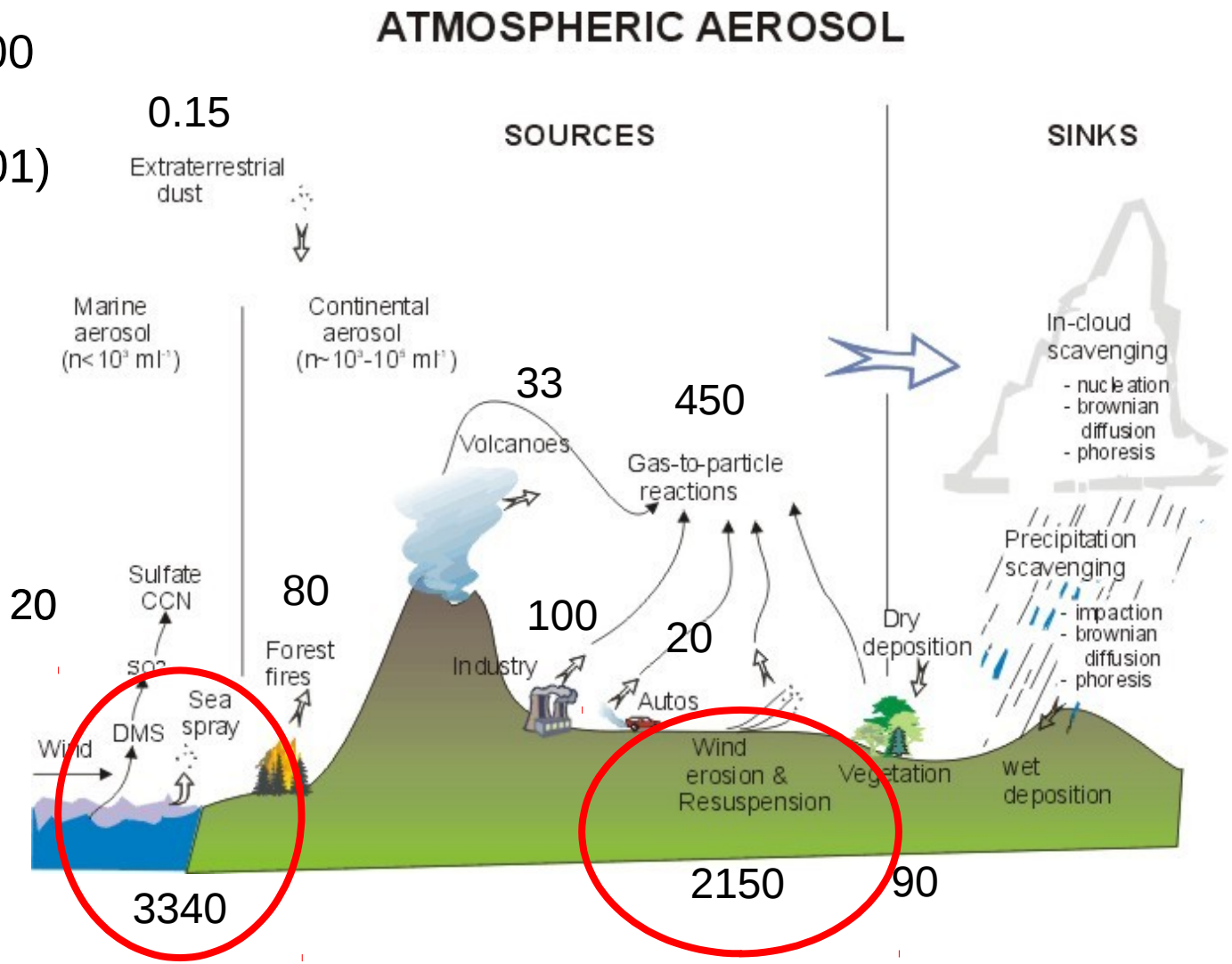
Sources of atmospheric aerosol

Year 2000
(Tg)
IPCC (2001)



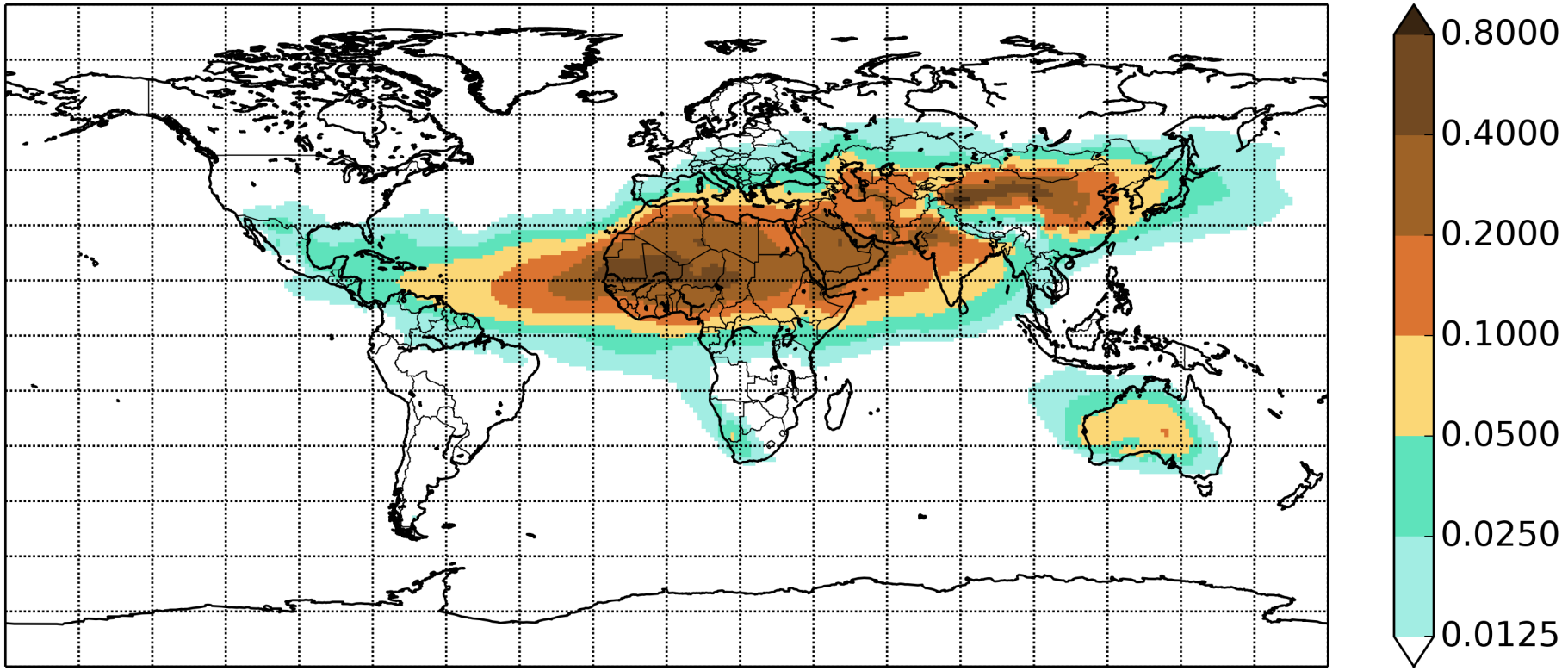
Sources of atmospheric aerosol

Year 2000
(Tg)
IPCC (2001)



Grographical distribution of dust

Dust optical depth at 550 nm. Average value 2003-2015



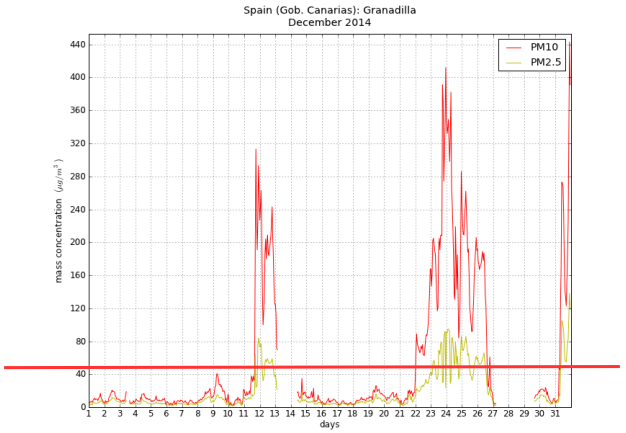
Data: CAMS reanalysis
Picture: WMO SDS-WAS

WMO AIRBORNE DUST BULLETIN
Sand and Dust Storm Warning Advisory and Assessment System

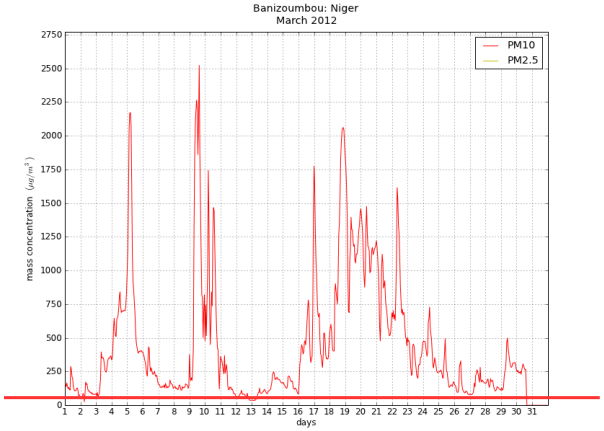
Episodic nature of the dust problem

European Commission

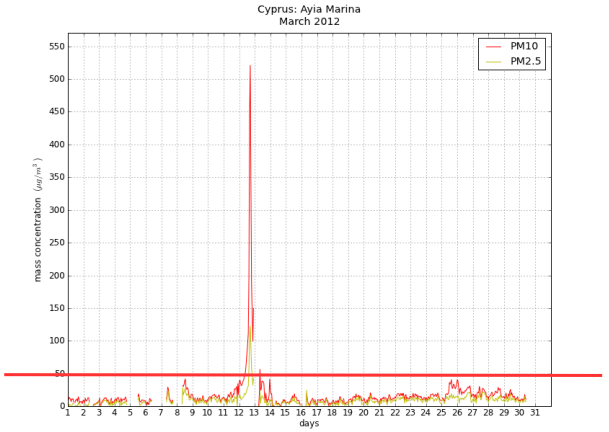
PM10	24-h avg.	50 µg/3	35 exceed.
	Year avg.	40 µg/m3	-
PM2.5	Year avg.	25 µg/m3	-



Granadilla, Spain
Dec 2014



Banizoumbou, Niger
Mar 2012

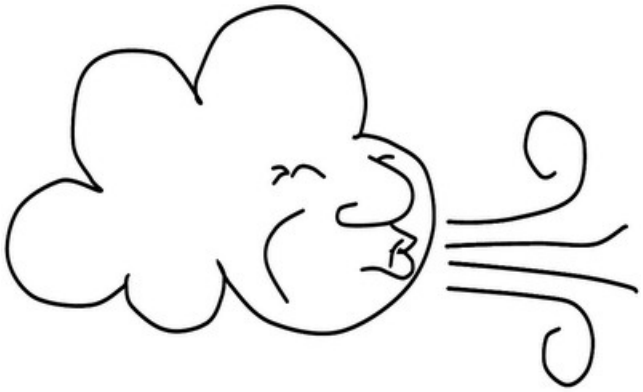


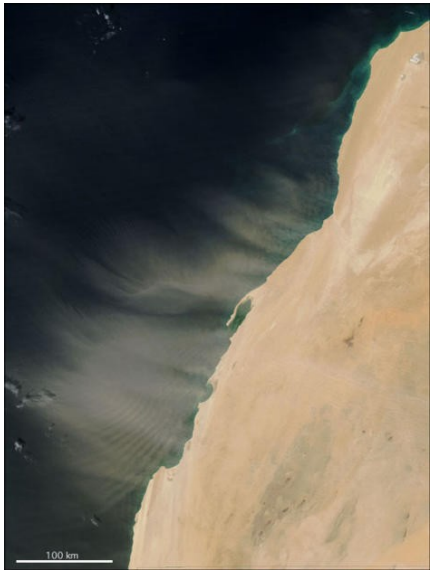
Ayia Marina, Cyprus
Mar 2012

Summary

- Atmospheric aerosol
- Dust modeling
- WMO SDS-WAS. Products
- Other products

The dust cycle





Dust prediction models

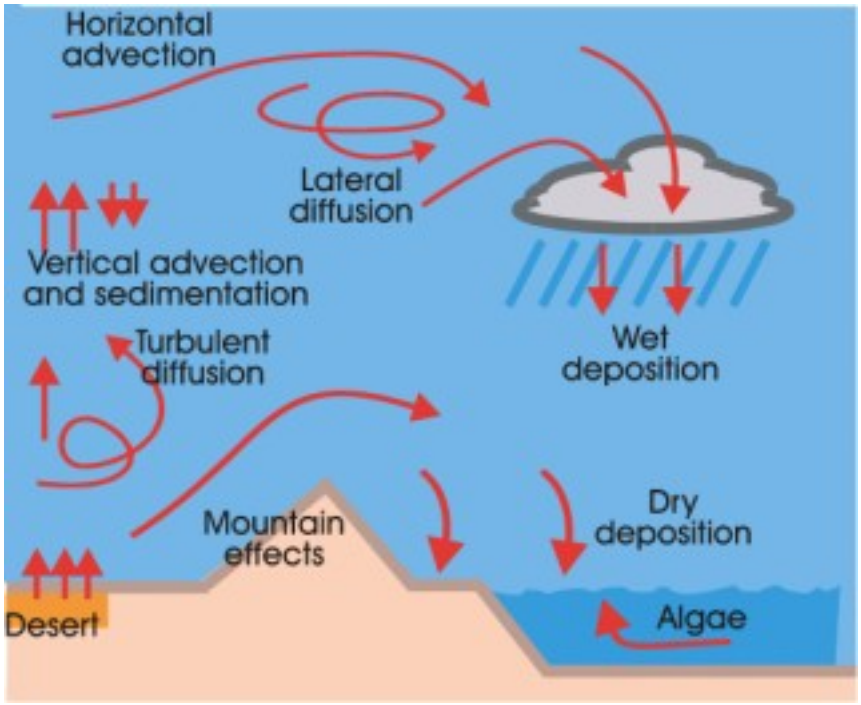
Numerical Weather Prediction model

+

Parameterization of the dust cycle

=

Dust prediction model



- Emission
- Transport (diffusion, convection, advection)
- Dry / wet deposition
- ...
- Interaction with radiation
- Interaction with cloud droplets
- Ice nucleation
- Atmospheric chemistry
- …

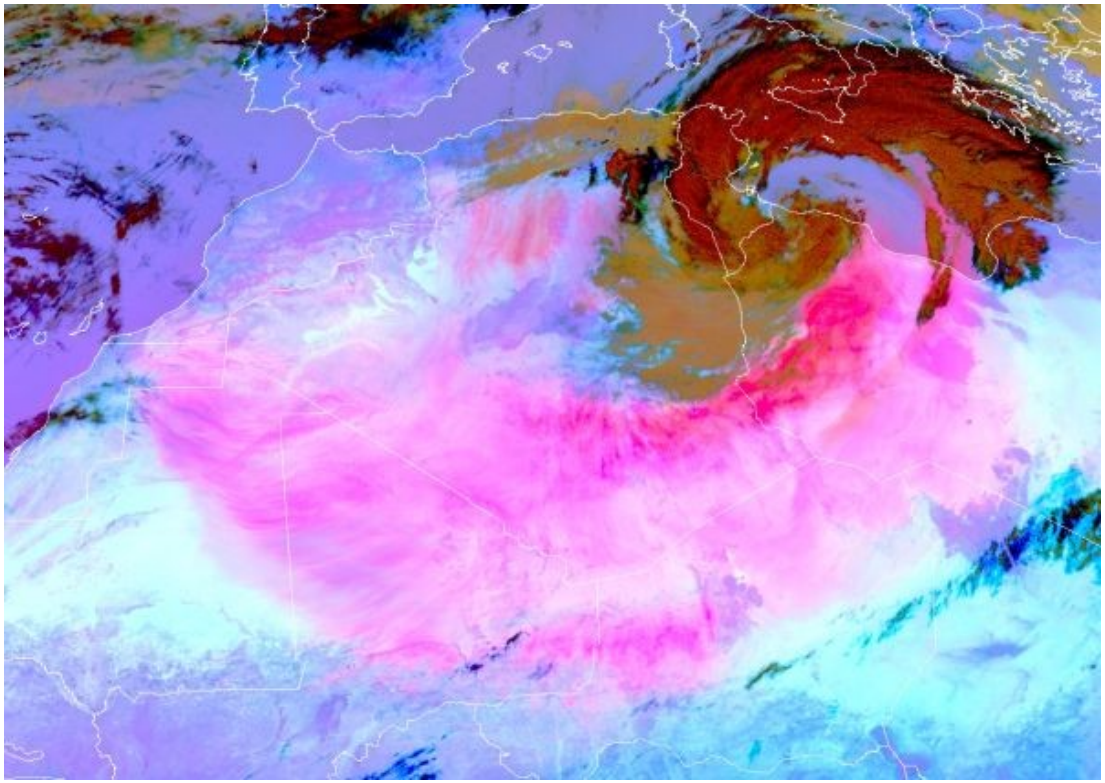
Dust models. Main problems

- Incomplete knowledge of the physical processes involved in the dust cycle
- Processes of very diverse scale
- Incomplete information of soil state and nature
- Need for a very accurate wind forecast
- Lack of adequate observations for assimilation and verification

Dust models. Main problems

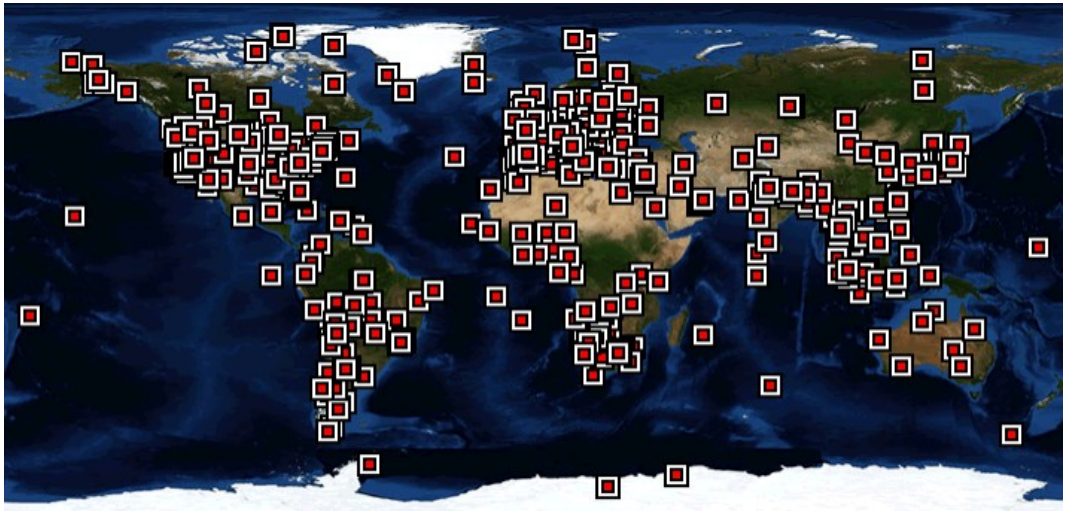
- Incomplete knowledge of the physical processes involved in the dust cycle
- **Processes of very diverse scale**
- Incomplete information of soil state and nature
- Need for a very accurate wind forecast
- **Lack of adequate observations for assimilation and verification**

Processes of diverse scale



State-of-the-art models are able to predict synoptic-scale or meso-alfa scale (> 200 km) dust events, but they suffer when emission happens at smaller scales (meso-gamma and microscale: < 20 km)

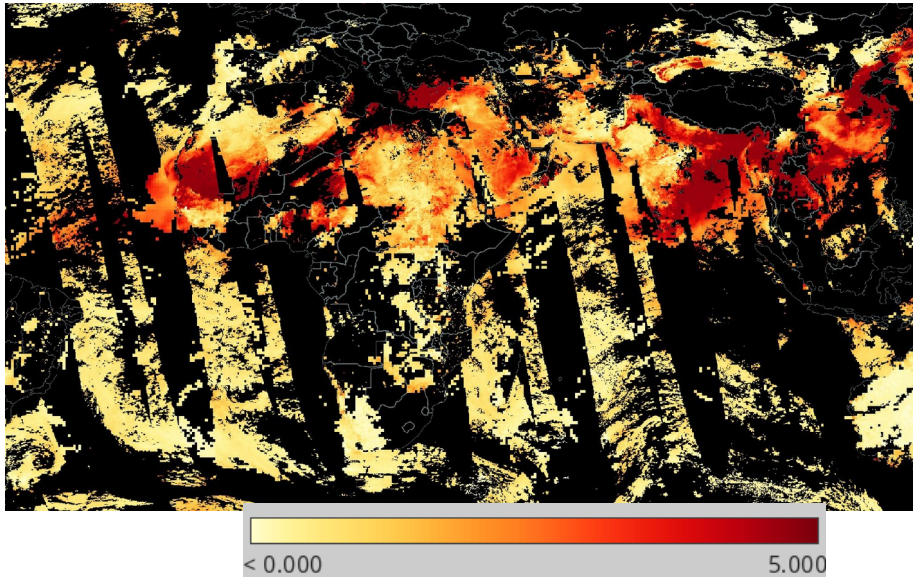
Lack of adequate observations



AERONET
AEROSOL ROBOTIC NETWORK

Active stations in 2018

AERONET data (columnar) are typically used in forecast verification

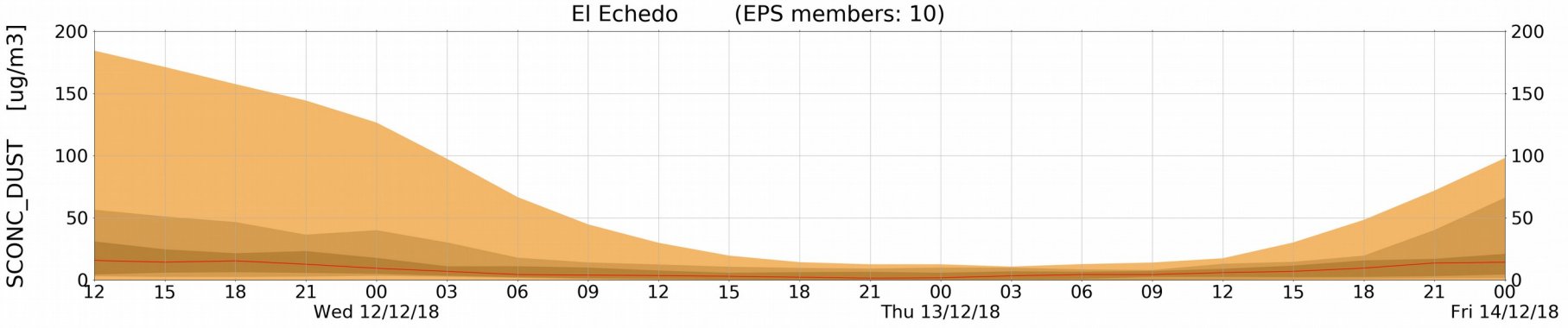


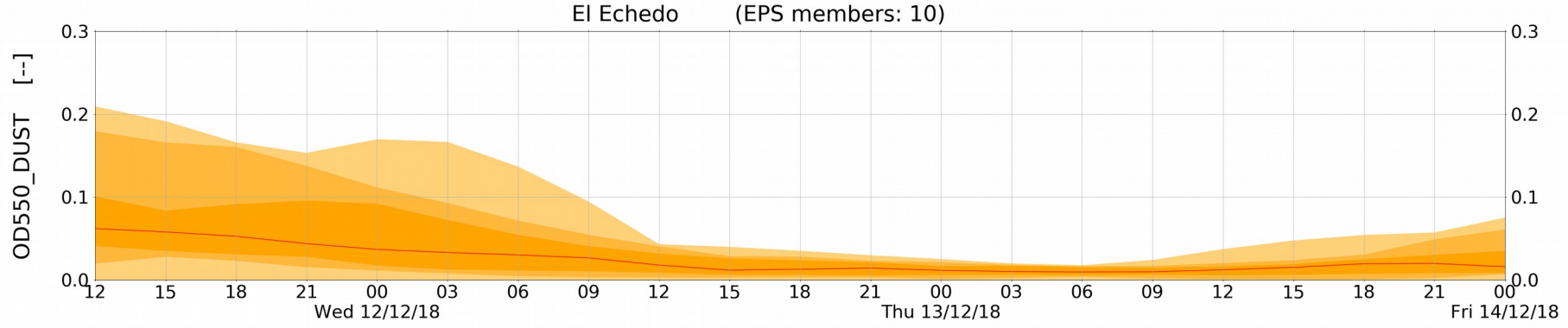
NASA MODIS
MODERATE RESOLUTION IMAGING SPECTRORADIOMETER

Daily AOD product

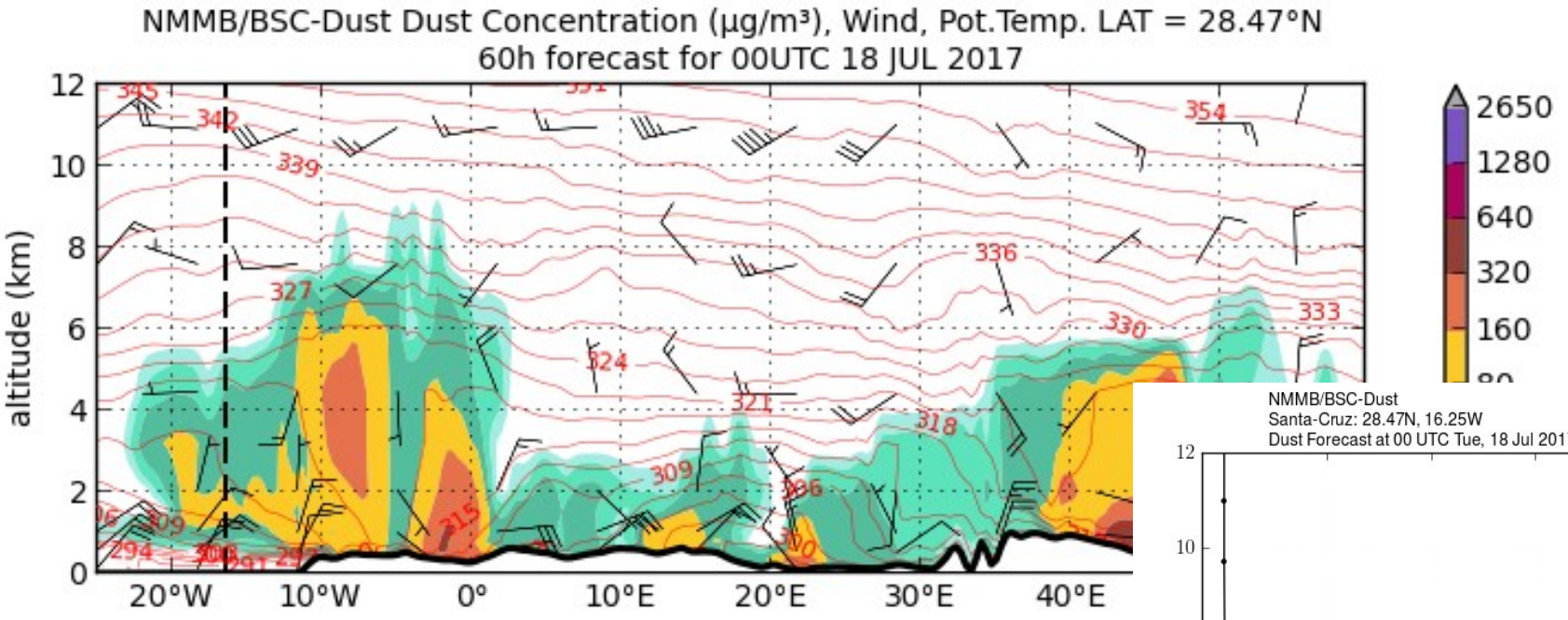
MODIS retrievals (columnar) are typically used in data assimilation

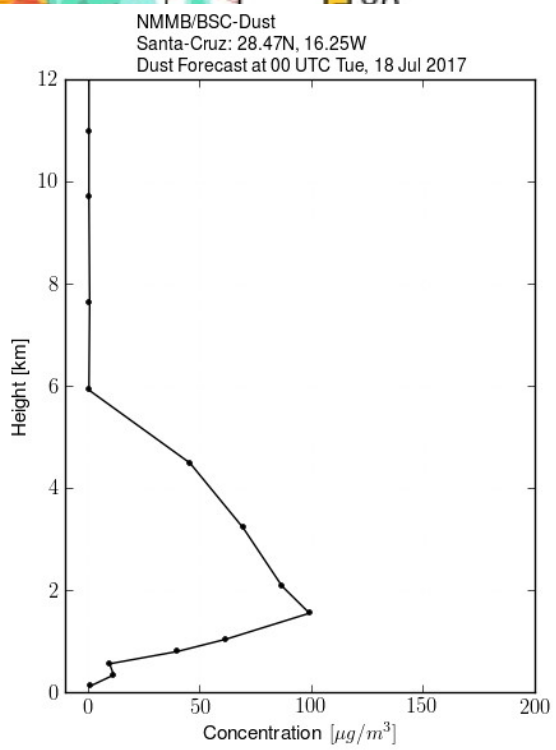
More dispersion in surface concentration than in optical depth (total column)





Columnar values useless for health applications





In summer, it is common for Saharan dust to reach the Canary Islands at high levels of the atmosphere, while below 400, 600 or 800 m ASL trade winds keep on blowing and bringing clean, fresh air. In those cases, the dust optical depth is high, but the dust concentration at sea level can be very low.

Summary

- Introduction
- Dust modeling
- WMO SDS-WAS. Products
- Other products

Dust impacts

- Air quality & health
- Weather & climate
- Transportation
- Energy
- Agriculture, fisheries
- …

WMO SDS-WAS

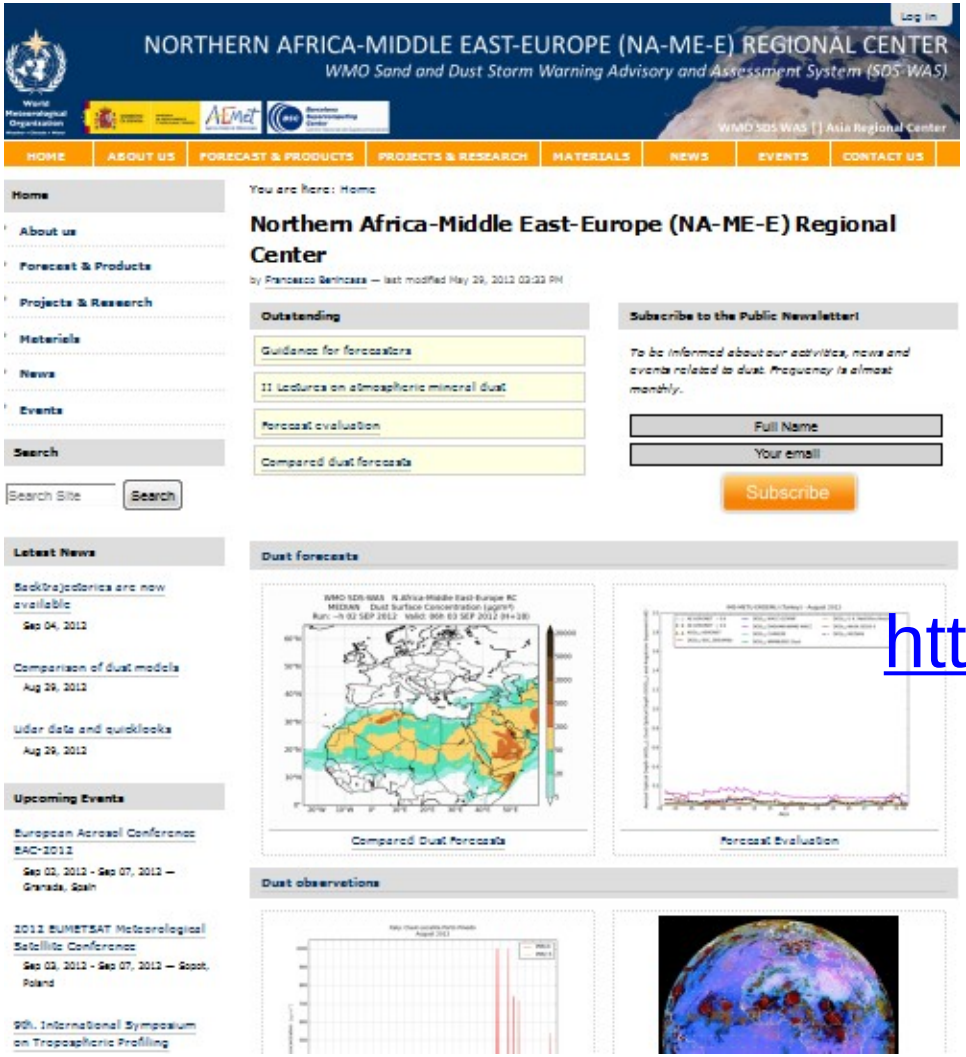
Mission:

Enhance the capacity of countries to generate and distribute to end-users dust observations, forecasts, information and knowledge

Structure:

- Regional Center for Northern Africa, Middle East and Europe, Barcelona
- Regional Center for Asia, Beijing
- Regional Center for Pan-America, Bridgetown
- Regional Center for West Asia (??)

SDS-WAS Regional Center NAMEE

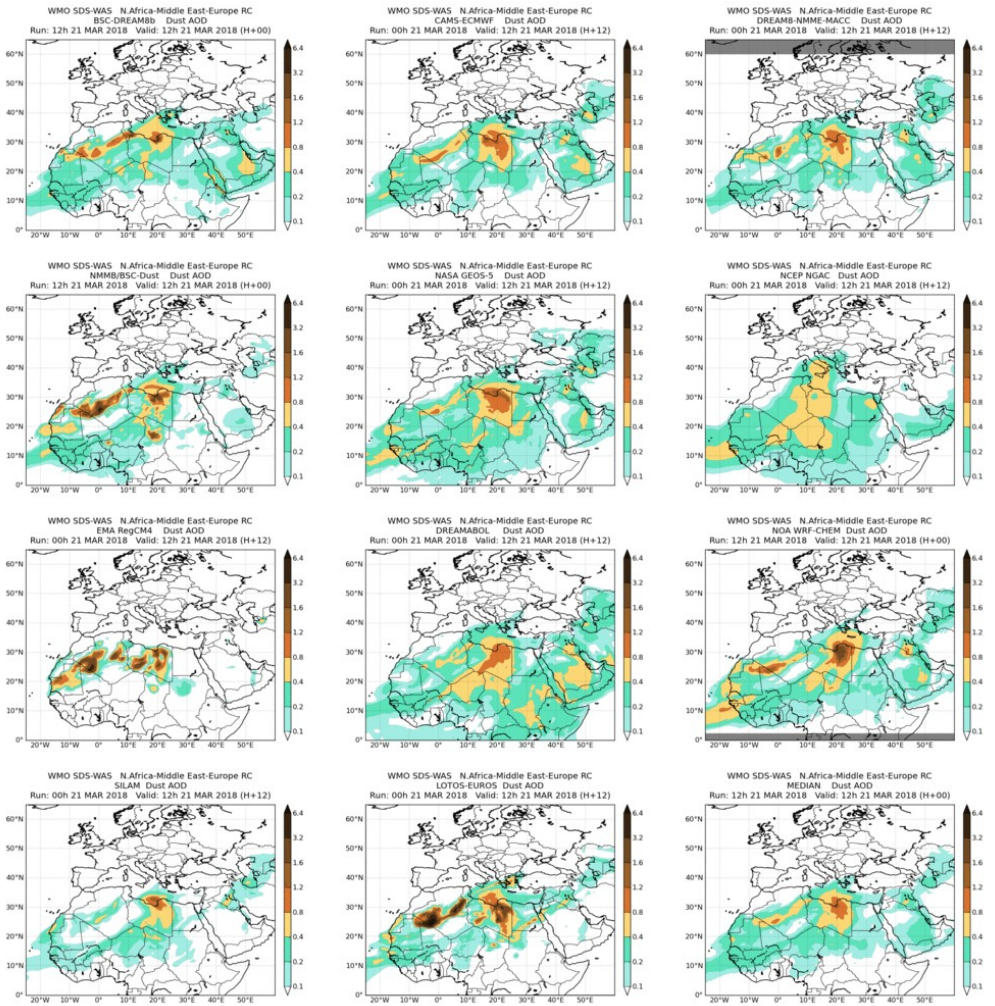


https://sds-was.aemet.es

sdswas@aemet.es

Forecast intercomparison

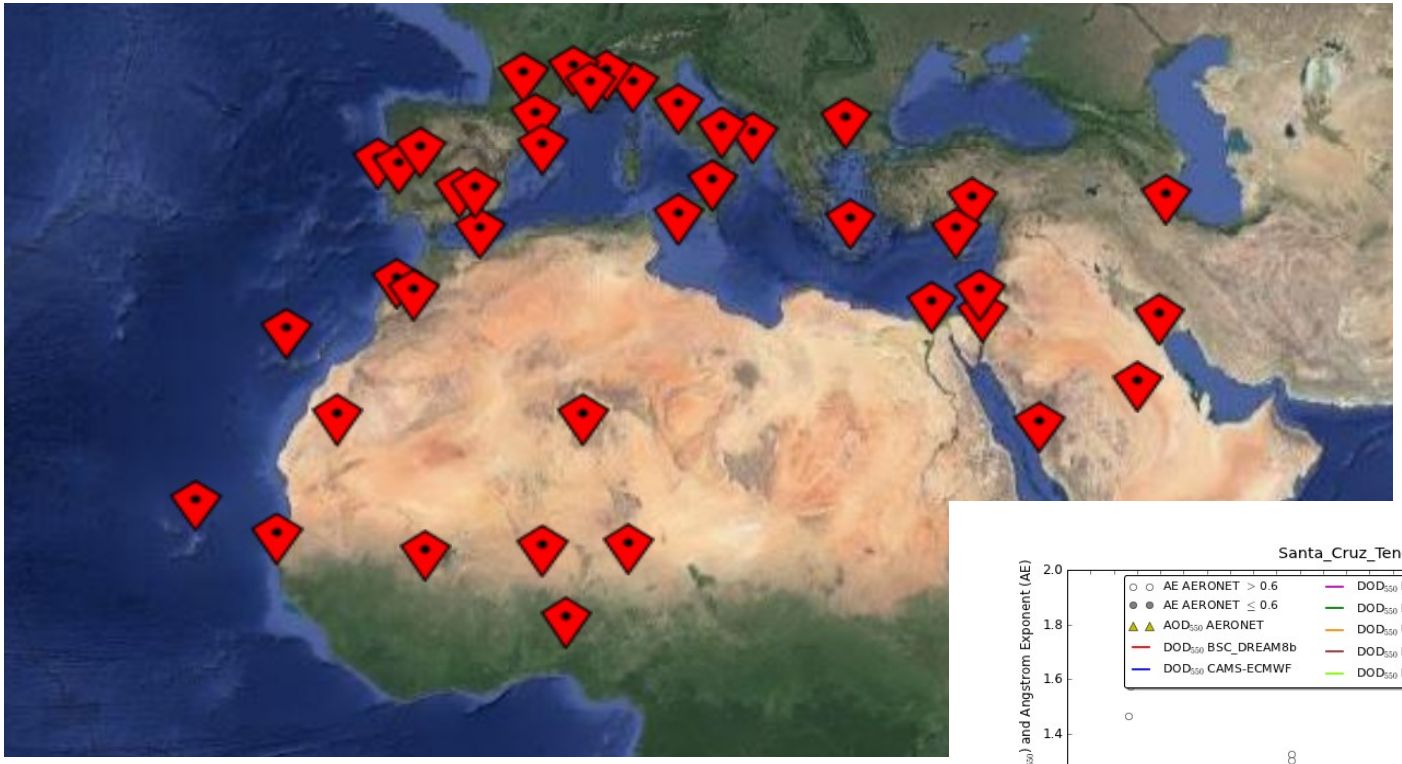
MODEL	INSTITUTION	DOMAIN
BSC-DREAM8b	BSC	Regional
CAMS	ECMWF	Global
DREAM-NMME-MACC	SEEVCCC	Regional
NMMB/BSC-Dust	BSC	Regional
MetUM	Met Office	Global
GEOS-5	NASA	Global
NGAC	NCEP	Global
RegCM4	EMA	Regional
DREAMABOL	CNR	Regional
NOA WRF-CHEM	NOA	Regional
SILAM	FMI	Regional
LOTOS-EUROS	TNO	Regional



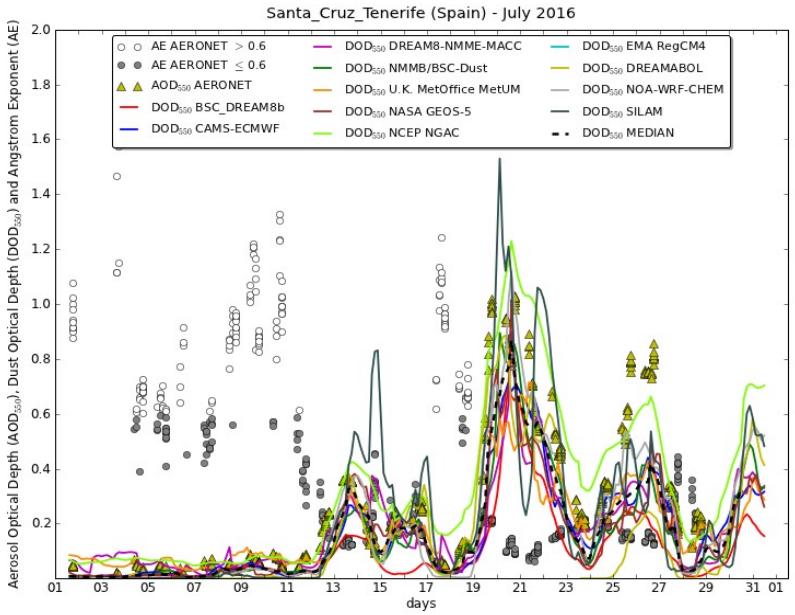
Forecasts of dust surface concentration and optical depth at 550 nm until 72 hours

21 Mar 2018

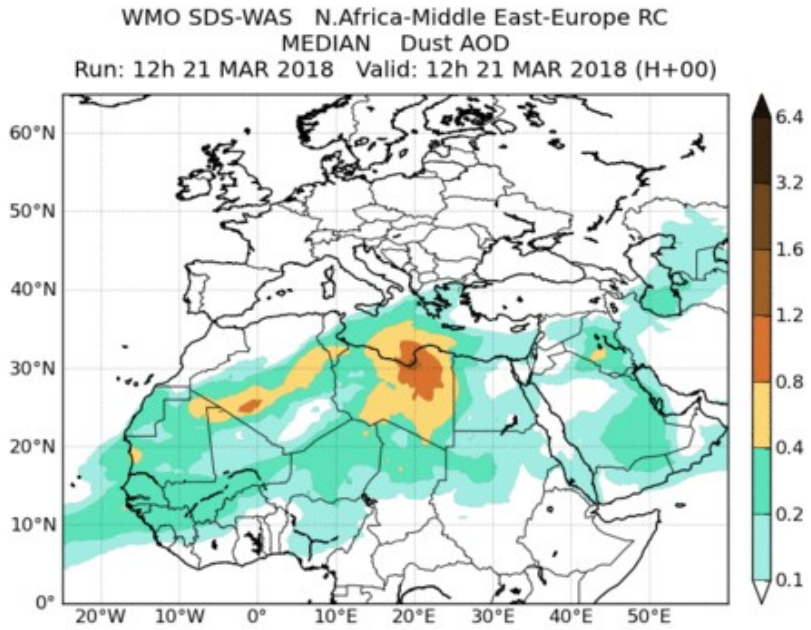
Verification

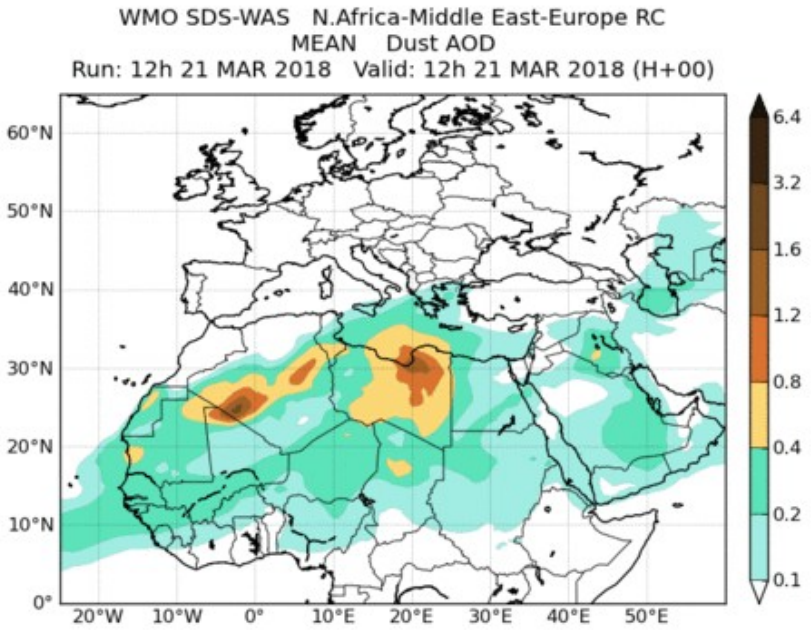


Santa Cruz de Tenerife
July 2016



Multi-model ensemble





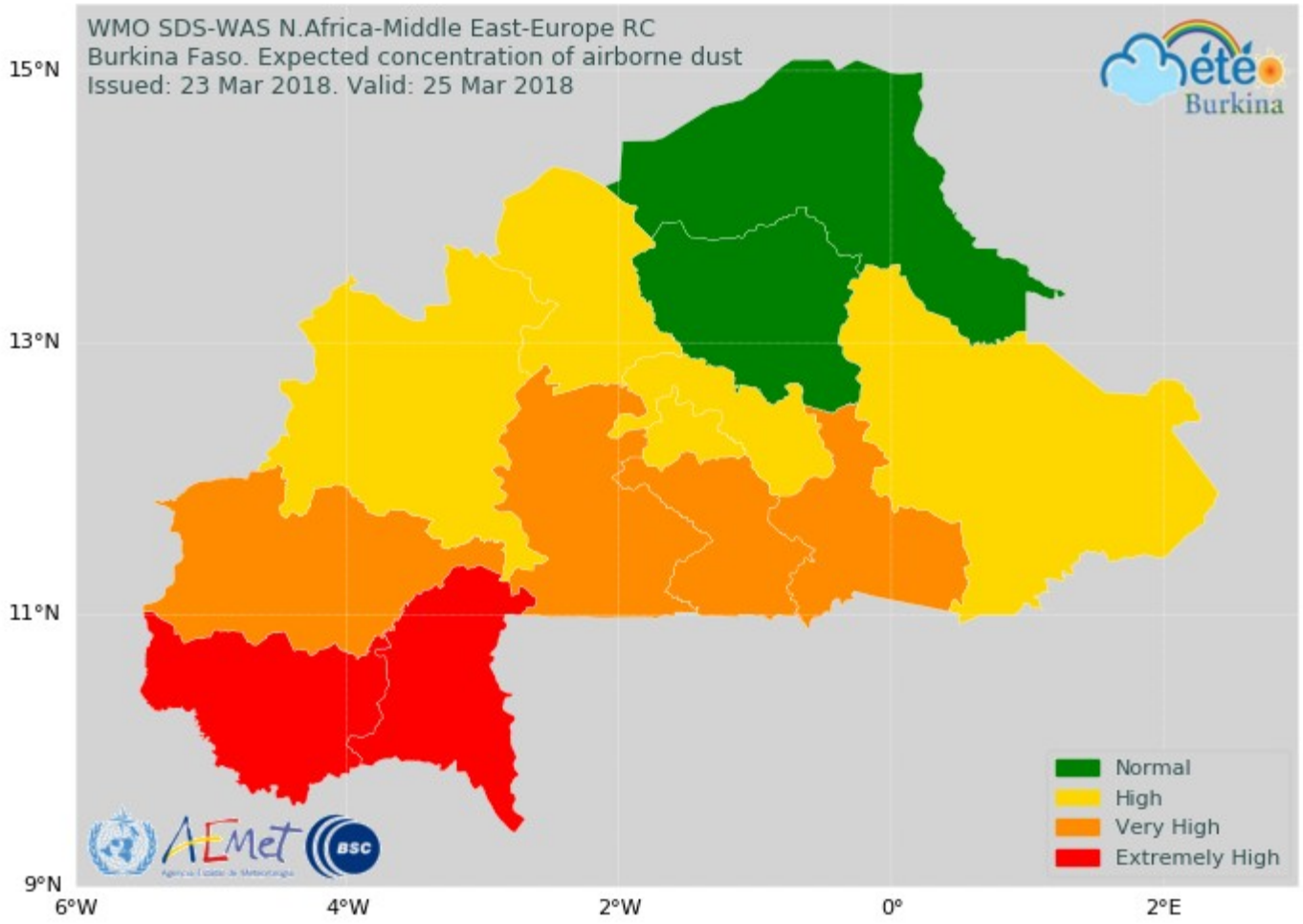
- Forecasts of 12 models are daily interpolated to a common grid mesh. Then ensemble multi-model products are generated.
- Multi-model median yields better verification scores than any individual model

21 Mar 2018

GOBIERNO DE ESPAÑA
MINISTERIO DE AGRICULTURA Y PESCA, ALIMENTACIÓN Y MEDIO AMBIENTE
AEMet Agencia Estatal de Meteorología

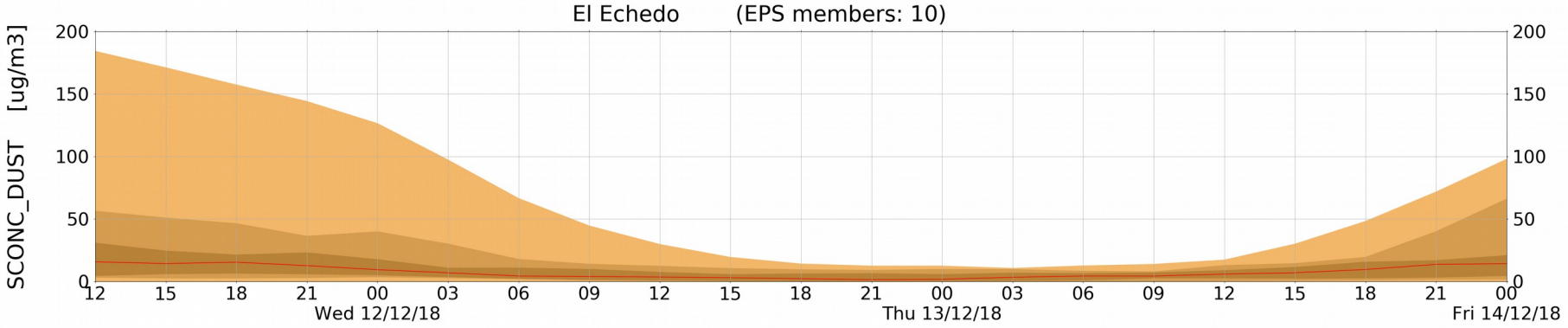
BSC Barcelona Supercomputing Center
Centro Nacional de Supercomputación

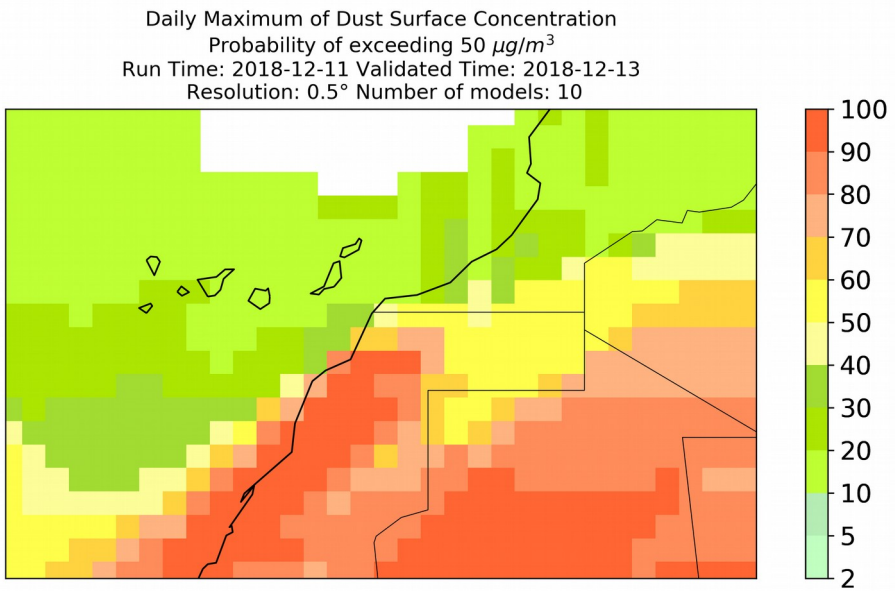
Application of SDS-WAS median

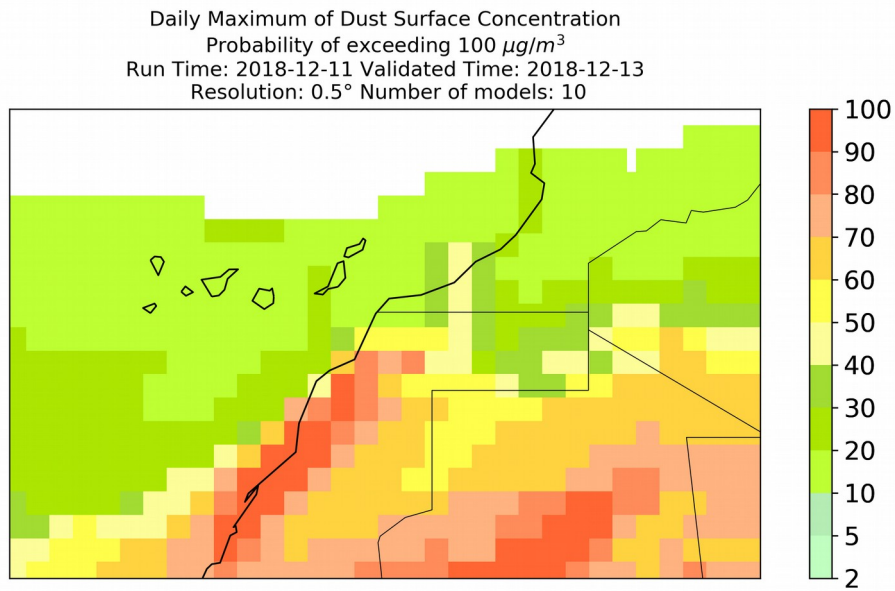


Warning advisory system for sand and dust storm in Burkina Faso

Probabilistic products







Dust forecast system in the Canary Islands

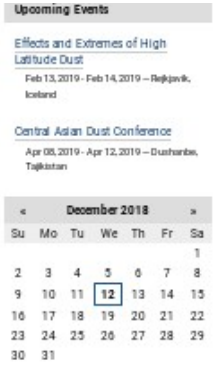
Models contributing to the EPS

Changes in the list of available models, temporal or eventual unavailability, changes in model configuration, sometimes (often) without any notice make the timeseries lack the necessary homogeneity.

One strategy could be to restrict the number of models and use only those that ensure a minimum level of quality and continuity

Files download

- Need credentials
- Daily datafiles since 2012
- Almost all models available
- NetCDF format
- Surface concentration & dust AOD
- Tri-hourly forecasts up to 72 hours



BSC-DREAM8b v2.0	PUBLIC Files RESTRICTED Files	Model website	
CAMS-ECMWF	PUBLIC Files RESTRICTED Files	Model website	opernicus
DREAM-NMME-MACC	PUBLIC Files RESTRICTED Files	Model website	SEEVCCC
NMMB/BSC-Dust	PUBLIC Files RESTRICTED Files	Model website	
NASA-GEOS-5	PUBLIC Files RESTRICTED Files	Model website	
NCEP-NGAC	PUBLIC Files RESTRICTED Files	Model website	NCEP
DREAMABOL	PUBLIC Files RESTRICTED Files	Model website	ISAC
EMA-RegCM4	PUBLIC Files RESTRICTED Files	Model website	EGYPTIAN METEOROLOGICAL AUTHORITY
NOA-WRF-CHEM	PUBLIC Files RESTRICTED Files	Model website	
SILAM	PUBLIC Files RESTRICTED Files	Model website	FMI
LOTUS EUROS	PUBLIC Files RESTRICTED Files	Model website	TNO innovation for life
Multimodel MEDIAN	PUBLIC Files RESTRICTED Files	Model website	

HOW TO DOWNLOAD FILES?

Before downloading files, please register either by clicking on the "Register" link on top-right of the web page or going here. Automatic registration is temporally suspended. Please, email to sdswas@aemet.es to request your user id.

After registering, you can log into the portal and enter all repositories following the links above. In each repository you can find daily files, sorted by year and month. You may download a file by clicking on it, or files of a entire month or year (zipped) by clicking on the '(download all)' link on the right of the month or year.

Barcelona Dust Forecast Center

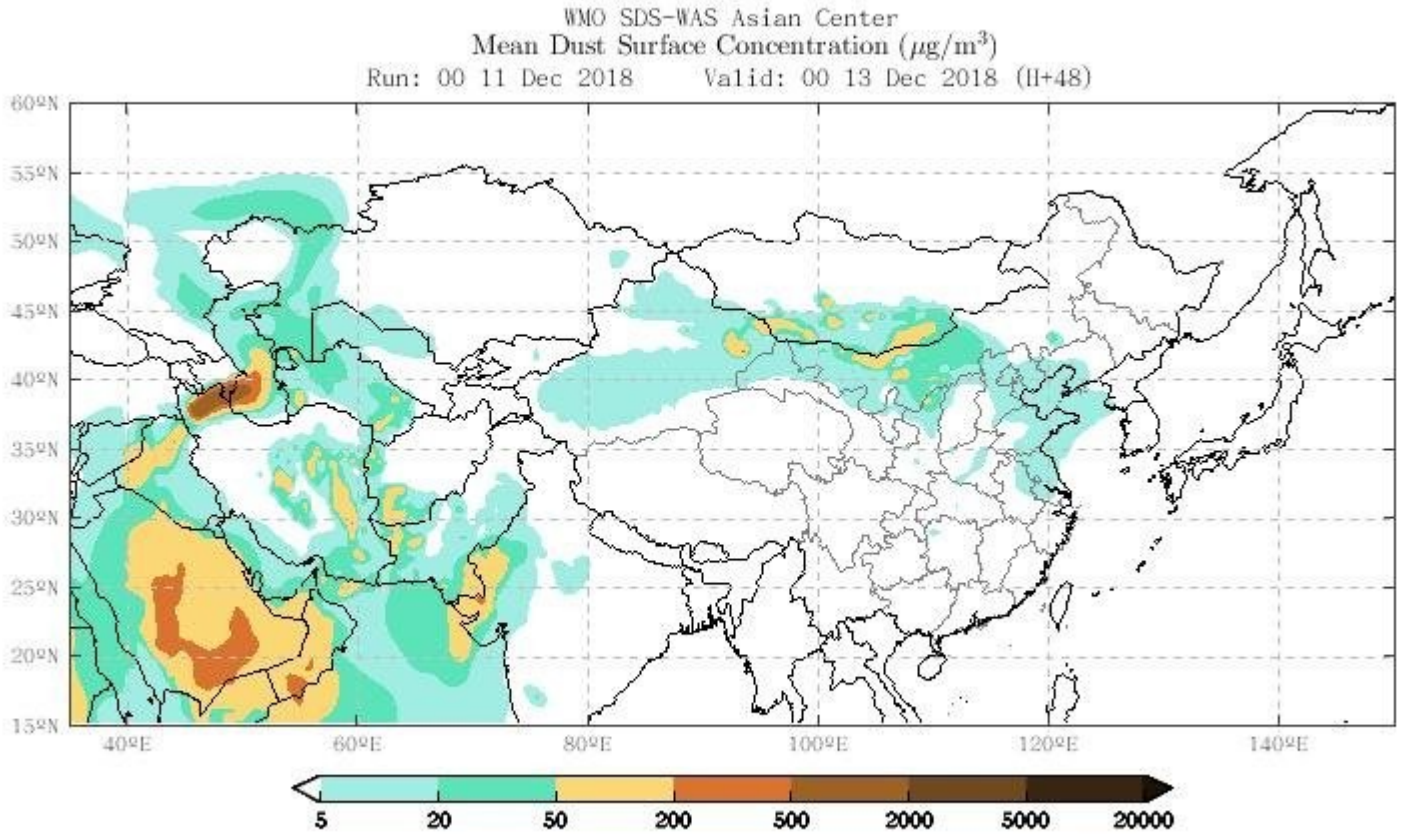
https://dust.aemet.es

dust.aemet.es

Summary

- Introduction
- Dust modeling
- WMO SDS-WAS. Products
- Other products

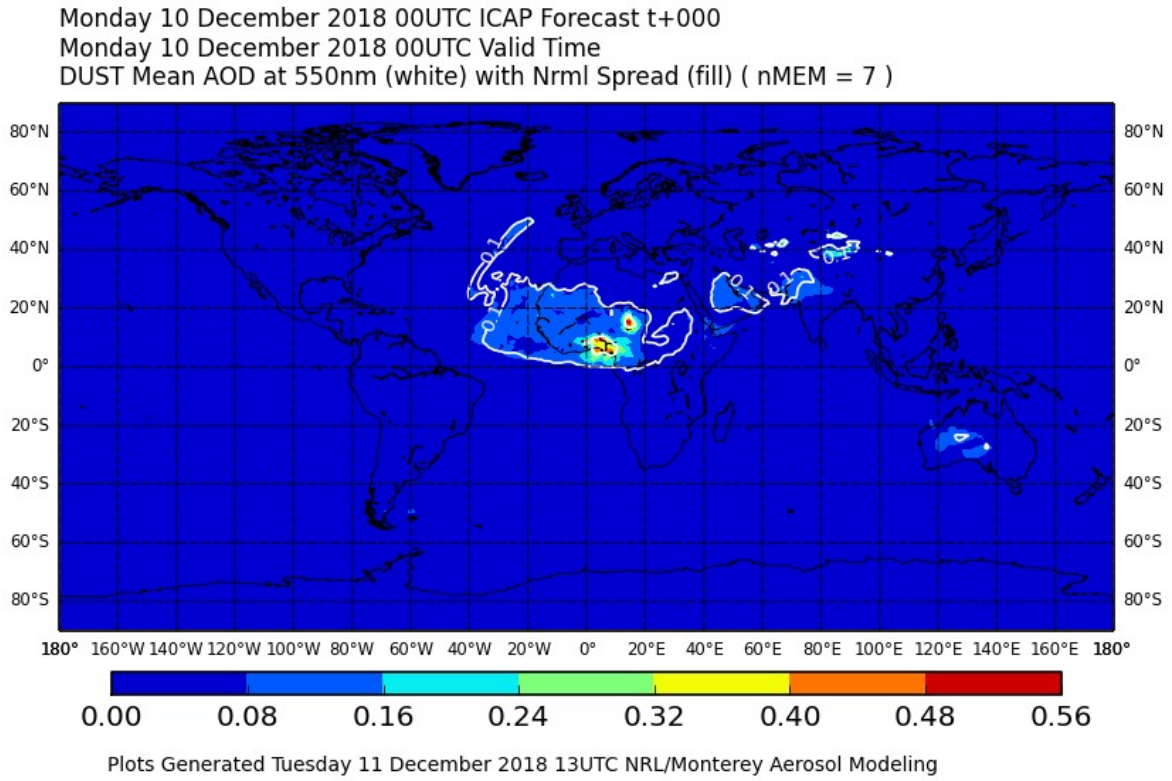
Other products. Asia



http://eng.nmc.cn/sds_was.asian_rc/

Multi-model mean generated by the WMO SDS-WAS Regional Center for Asia using 6 models (run by CMA, KMA, JMA, FMI, NCEP and ECMWF)
Lead time: up to 72 h

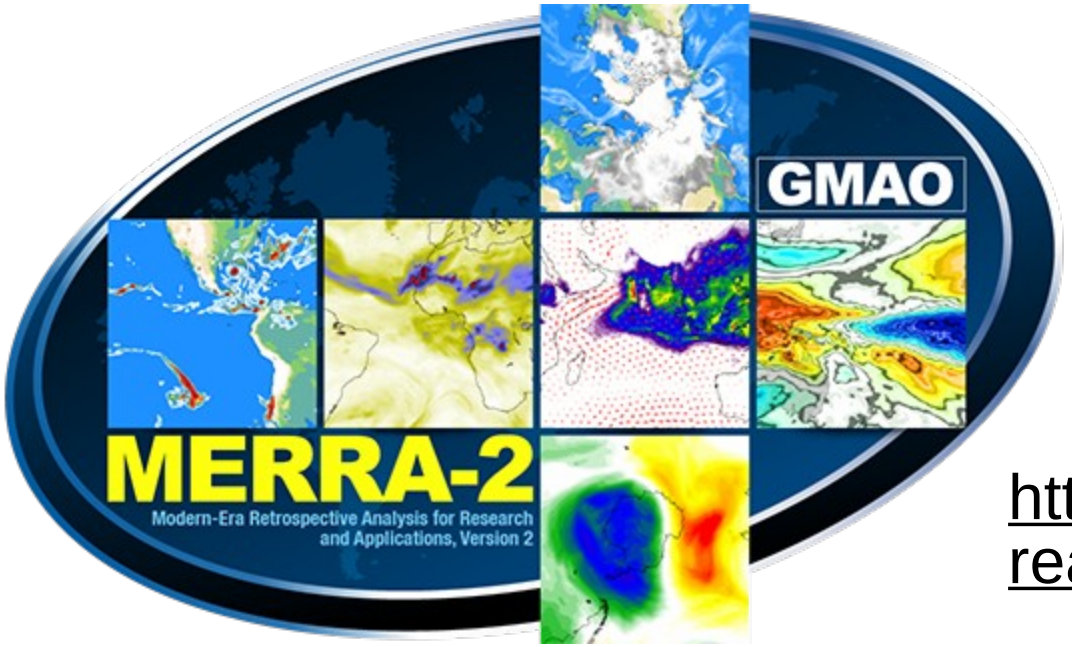
ICAP: a global EPS (only AOD)



https://www.nrlmry.navy.mil/aerosol/icap.1135.php

Multi-model mean generated by ICAP using 7 models (run by US Navy, BSC, NASA, Copernicus, JMA, NCEP and UKMO)
Lead time: up to 120 h. **Only for dust AOD**

Global reanalyses



https://gmao.gsfc.nasa.gov/reanalysis/MERRA-2/

Copernicus
Europe's eyes on Earth

https://apps.ecmwf.int/data-catalogues/cams-reanalysis/?class=mc&expver=eac4

Global models

iNSTITUTION	MODEL NAME
NCEP	NGAC
NASA	GEOS-5
US Navy	NAAPS
UK Met Office	MetUM
CAMS	CAMS
JMA	MASINGAR
BSC	MONARCH

Conclusions

- Dust surface concentration (DSC) is the parameter that should be used for health impact assessment
- Models yield very different values for DSC
- We consider the SDS-WAS multi-model median as the best option for Northern Africa, Middle East and Europe
- The SDS-WAS ensemble for Asia is also an option
- An option for global products is the use of reanalyses (NASA's MERRA-2 and CAMS'), although they are based on a single model