



**Barcelona
Supercomputing
Center**
Centro Nacional de Supercomputación



Modelling and forecasting Sand and Dust Storms - Model evaluation

Sara Basart (sara.basart@bsc.es)

*Earth Sciences Department,
Barcelona Supercomputing Center (BSC)*

Outlook

Session 1. Introduction to desert dust

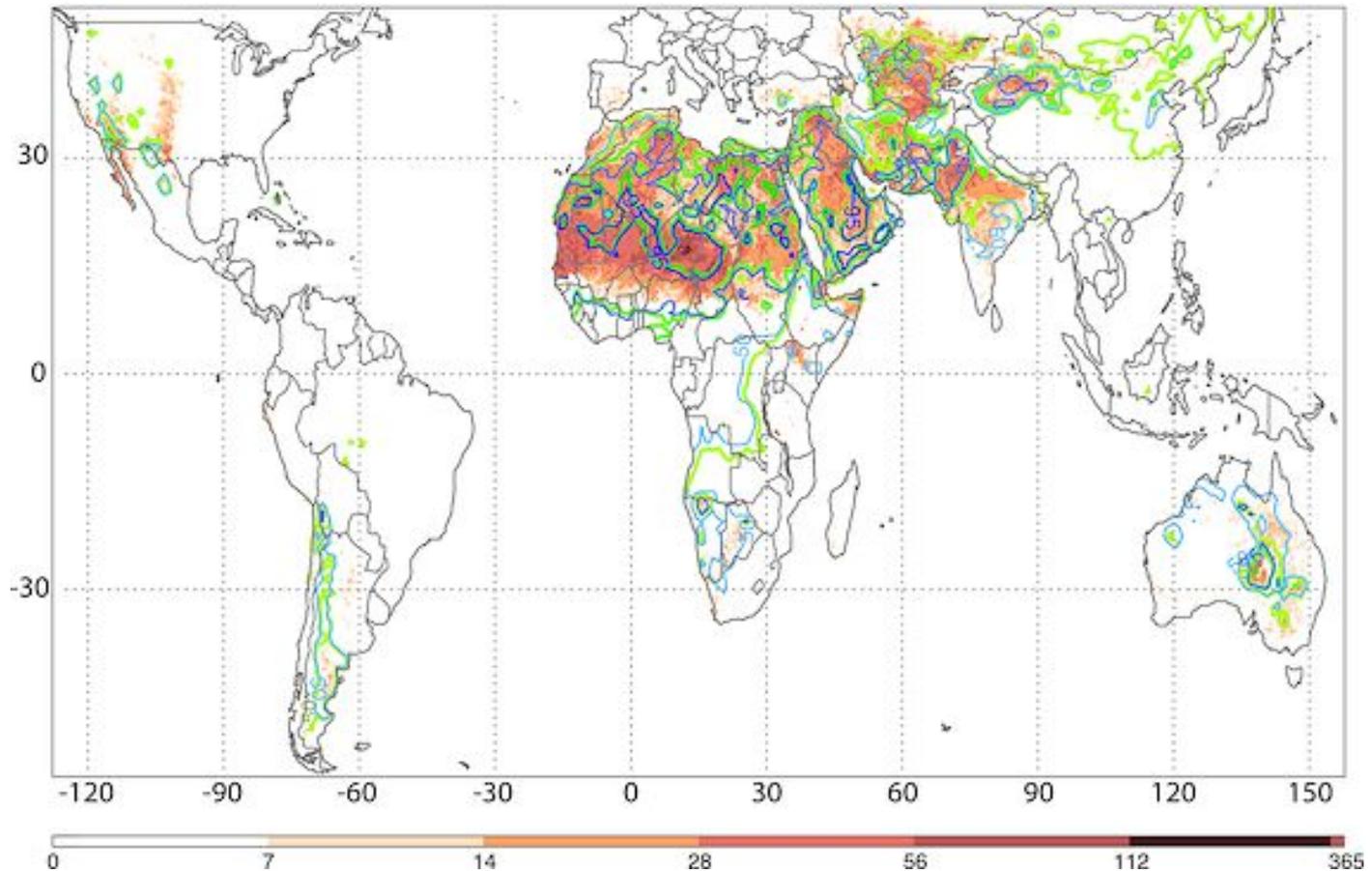
- *Atmospheric aerosols*
- *Desert dust and its cycle*
- *Types of sand and dust storms*
- *Dust global climatology*

Session 2. Evaluating models

- *Dust forecasting models*
- *Model evaluation:*
 - *NRT verification vs. long-term assessment*
 - *Dust-filtered satellite products*

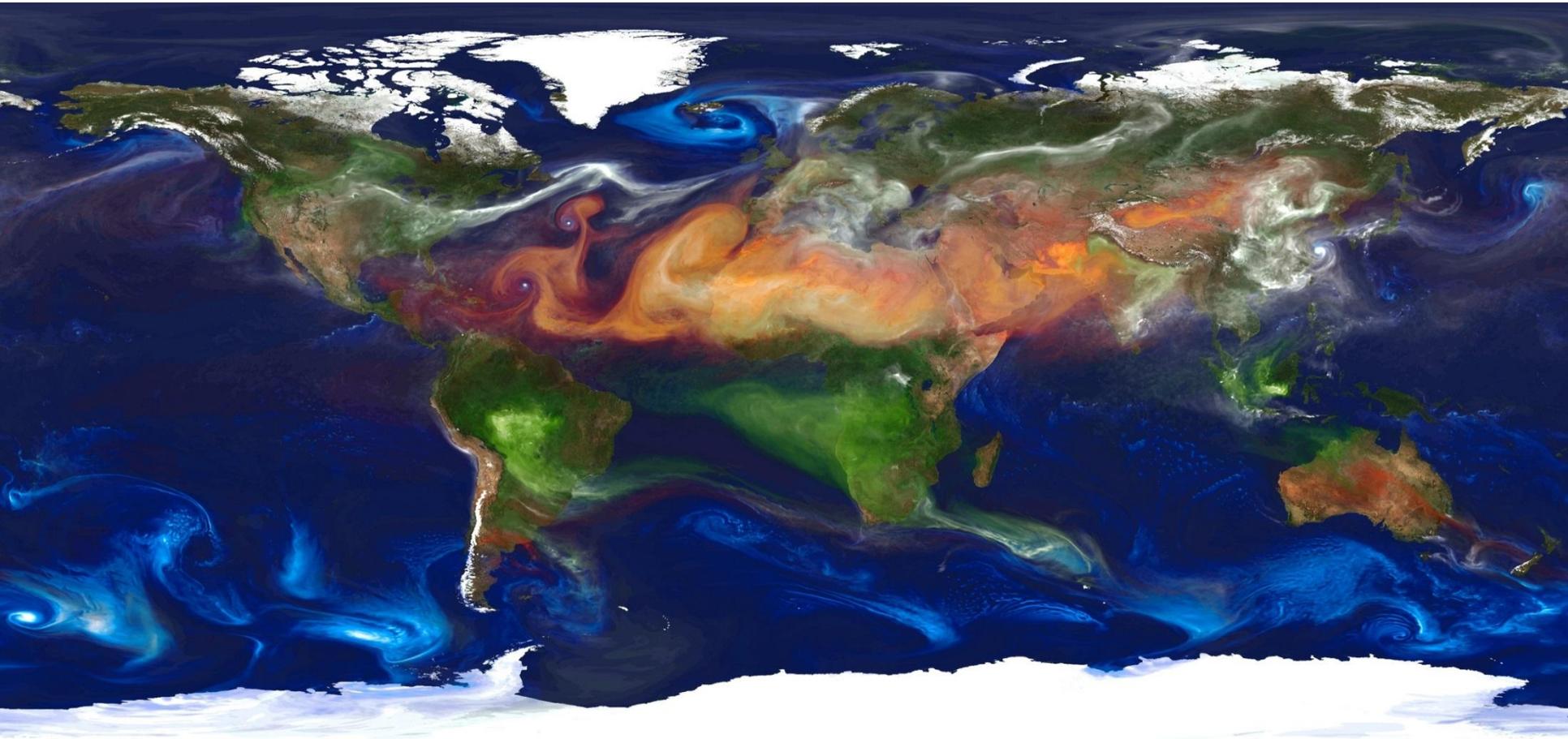
Dust impacts and its extension

Dust global distribution



Global-scale attribution of anthropogenic and natural dust sources and their emission rates based on MODIS Deep Blue aerosol products by Ginoux et al. (2012)

Dust impacts and its extension



Organic Carbon + Elemental carbon

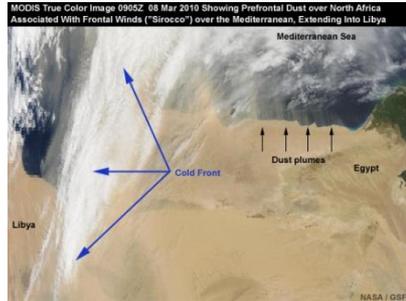
Dust

Sulfate

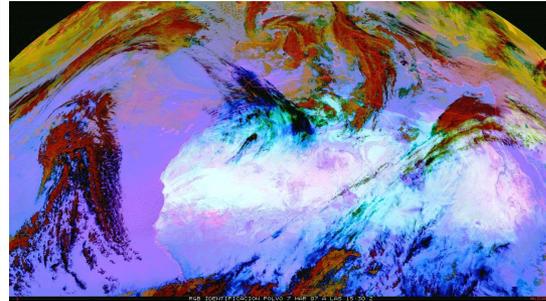
Sea salt

Dust cycle and associated processes

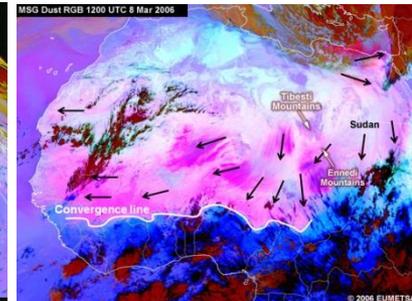
Synoptic dust storms (large scale weather systems)



Pre-frontal winds

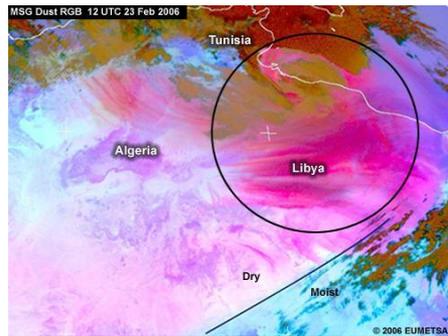


Post-frontal winds

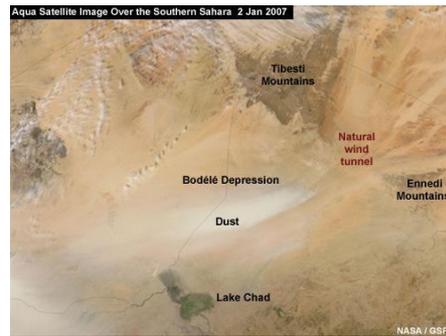


Large-scale trade winds

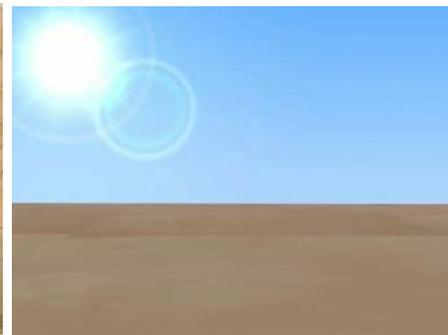
Mesoscale dust storms



Downslope winds



Gap flow



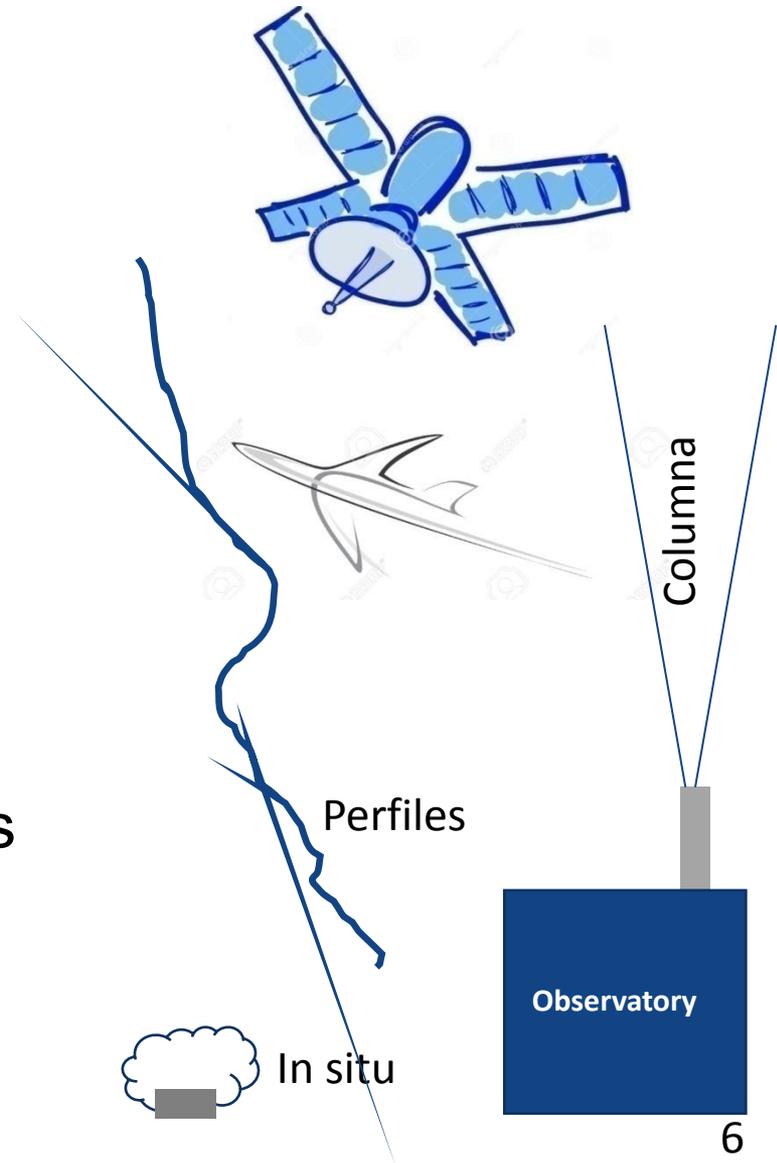
Dust devils



Haboobs

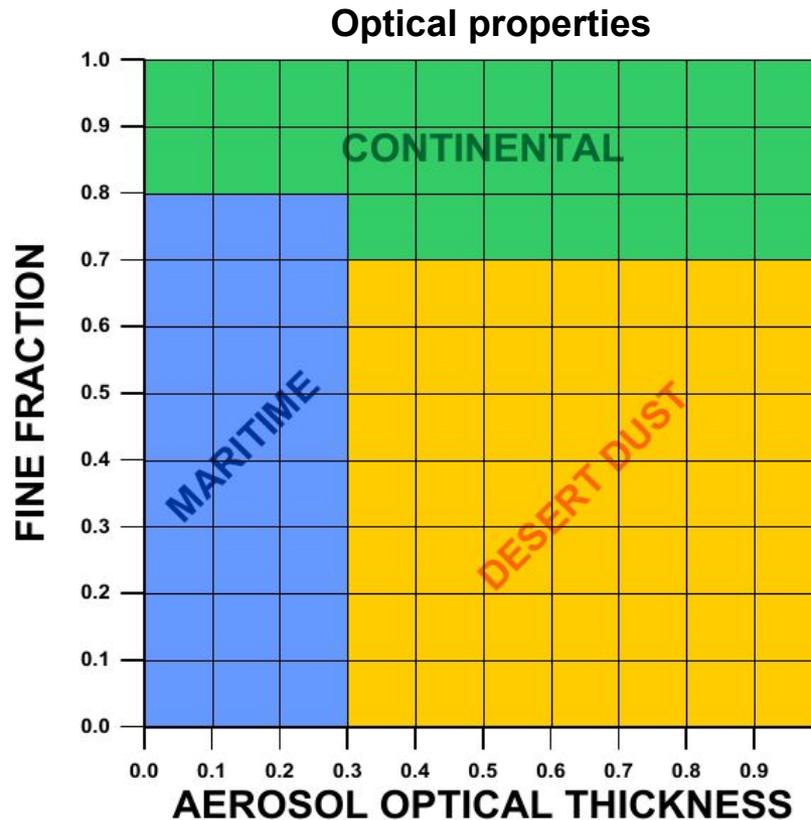
How we can characterize the state of the atmosphere?

- Satellite measurements
- Ground based remote sensing
- Near surface characterization
- Measurement campaigns
 - *Development of new methods*
- Climate and forecasting models



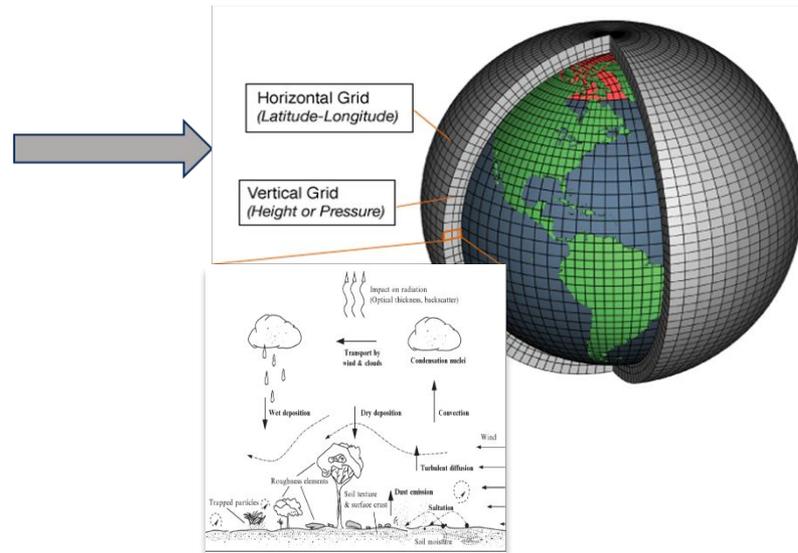
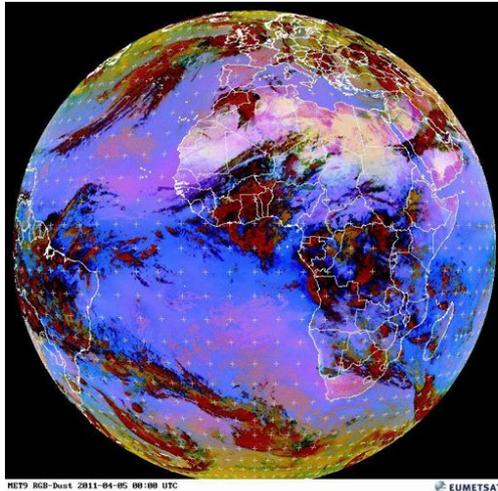
Atmospheric aerosols

Desert dust can be characterised by its coarser size, irregular shape and large absorption.



Dust forecasting models

Dust models are a **mathematical representation** of atmospheric dust cycle.



- ✓ *To complement dust-related observations, filling the temporal and spatial gaps of the measurements.*
- ✓ *To help us to understand the dust processes and their interaction with climate and ecosystems.*
- ✓ *To predict the impact of dust on surface level concentrations*

Dust forecasting models

Dust forecasting models do **NOT** take account dust **resuspension** and other anthropogenic sources

Cattle herds, Chad



Mining, Ohio valley

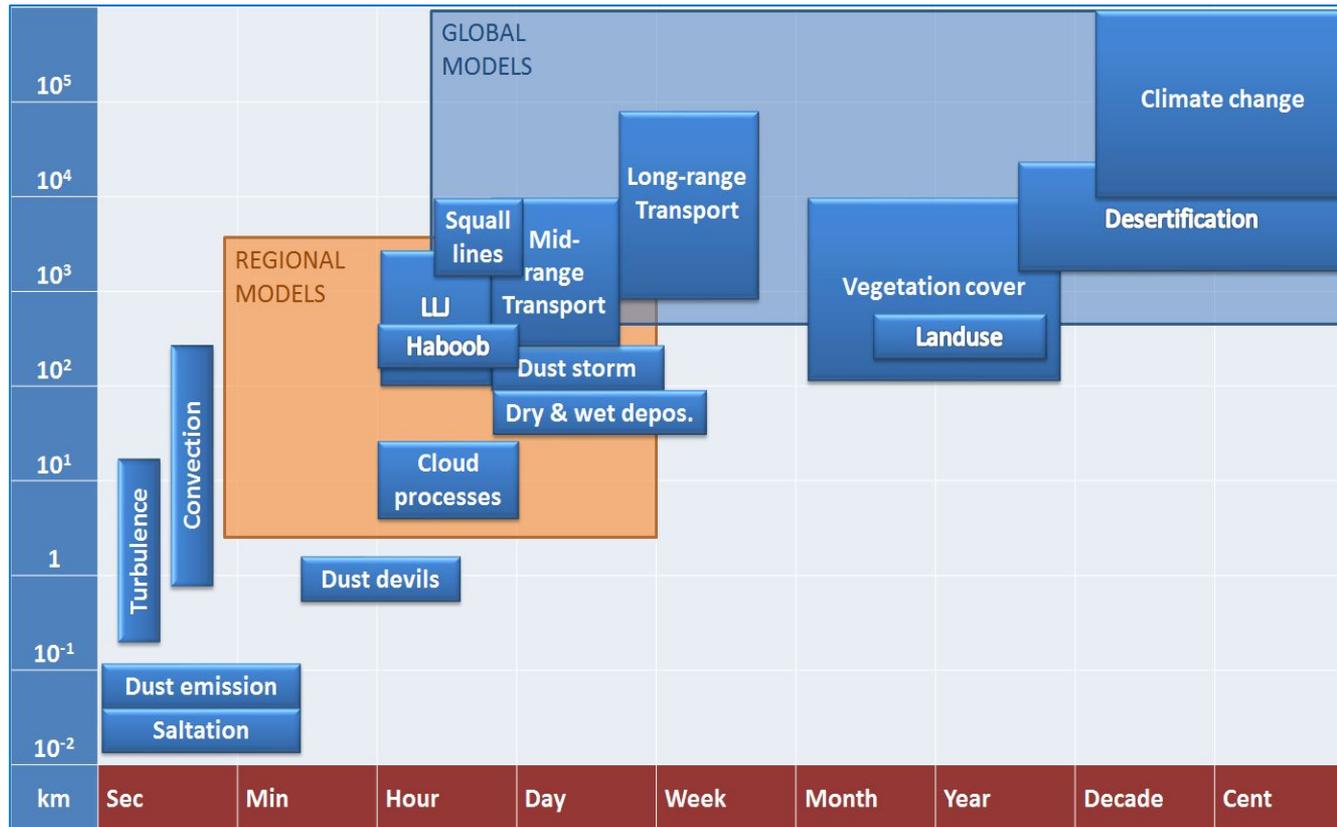


Dust from dry sea bed, Aral sea (Uzbekistan)



Kathmandu, Nepal, March 2017

Dust forecasting models



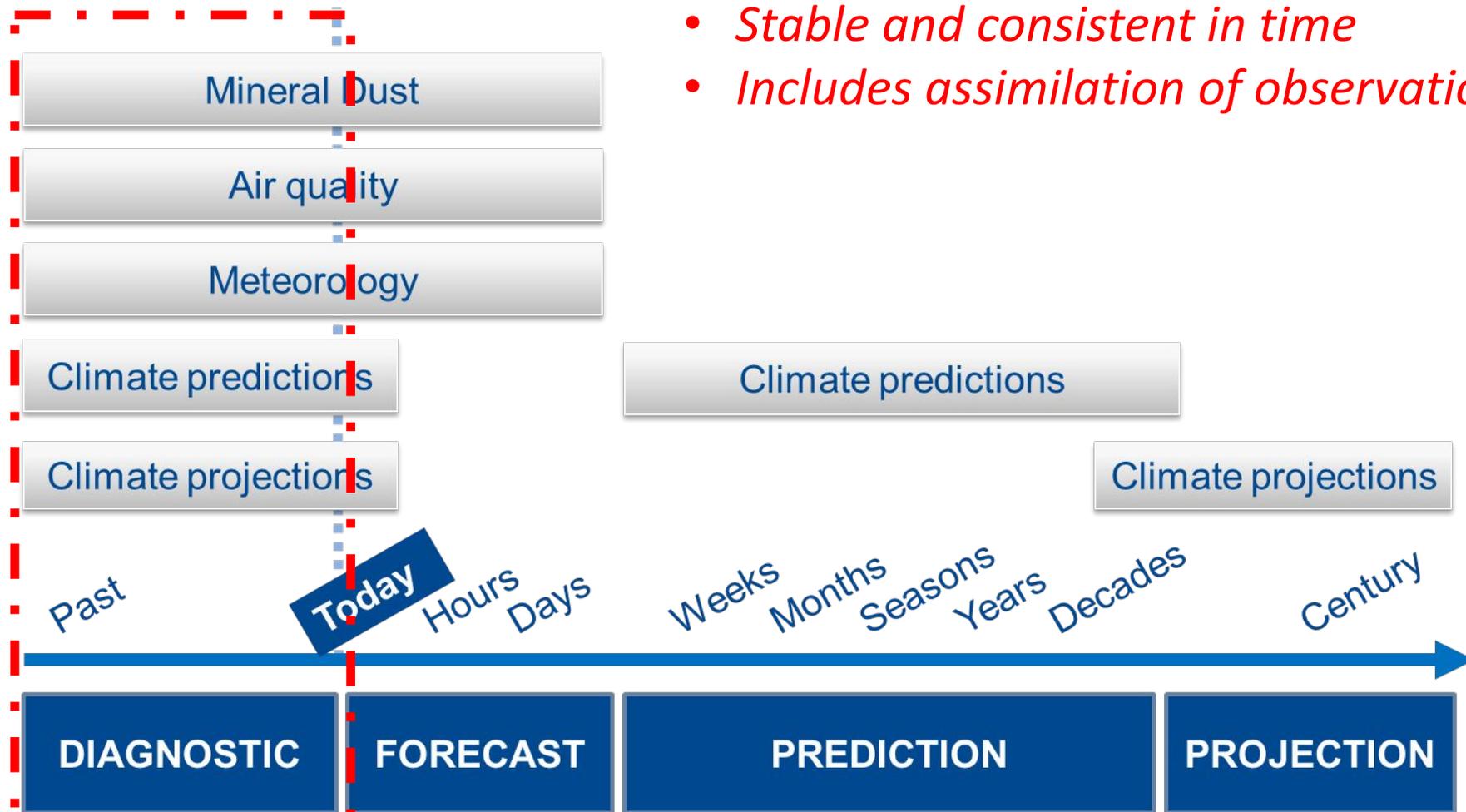
Dust processes span over five orders of magnitude in space and time. **Dust transport** is a global phenomenon. However, **dust emission** is a threshold phenomenon, sporadic and spatially heterogeneous, that is locally controlled on small spatial and temporal scales.

Accurate representation of dust sources and sinks is critical for providing realistic magnitudes and patterns of atmospheric dust fields.

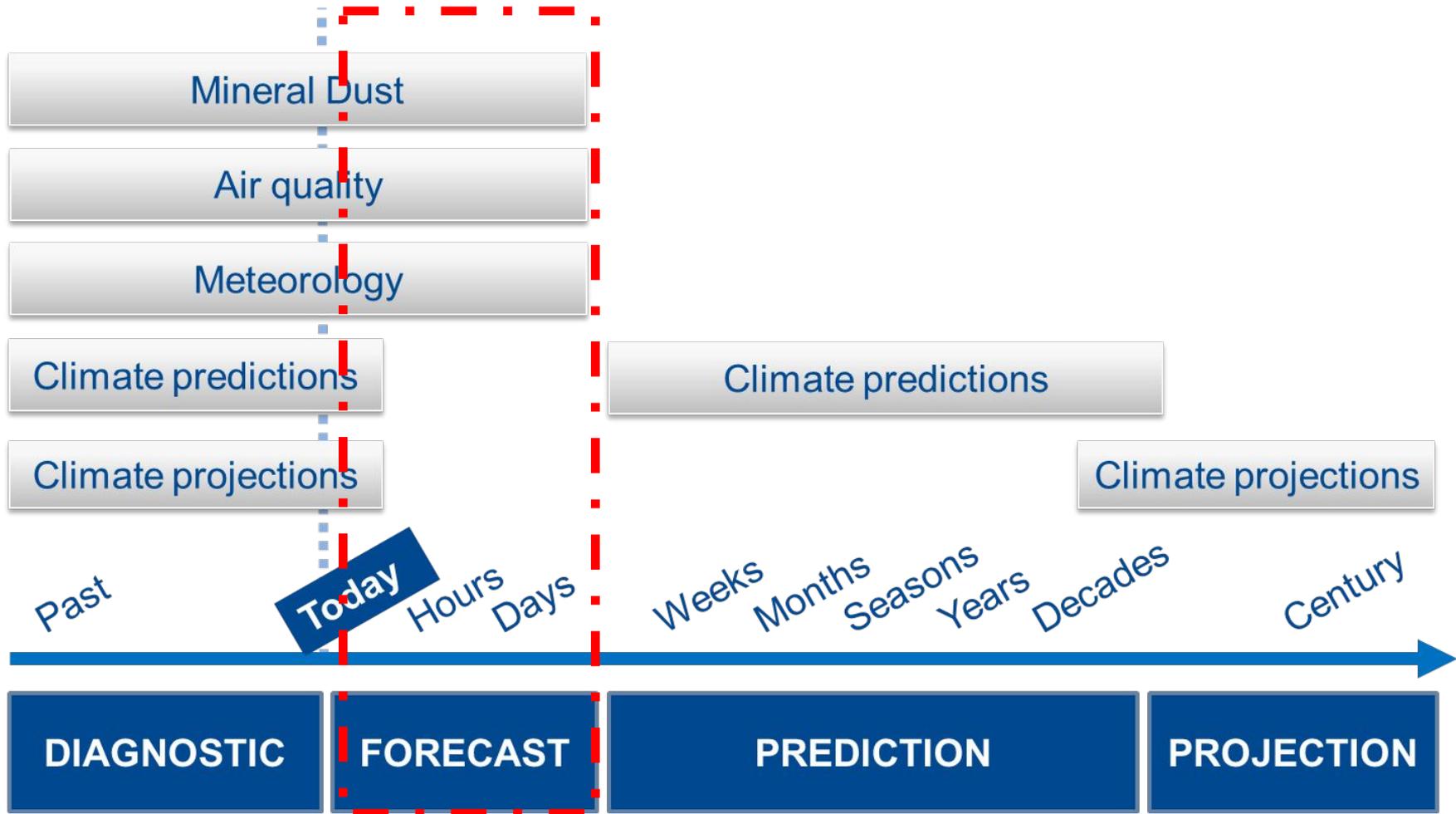
Modelling scales

Reanalysis →

- *Long-term dataset*
- *Stable and consistent in time*
- *Includes assimilation of observations*



Modelling scales



Modelling evaluation

Atmos. Chem. Phys., 14, 11753–11773, 2014
www.atmos-chem-phys.net/14/11753/2014/
doi:10.5194/acp-14-11753-2014
© Author(s) 2014. CC Attribution 3.0 License.

Atmospheric
Chemistry
and Physics
Open Access

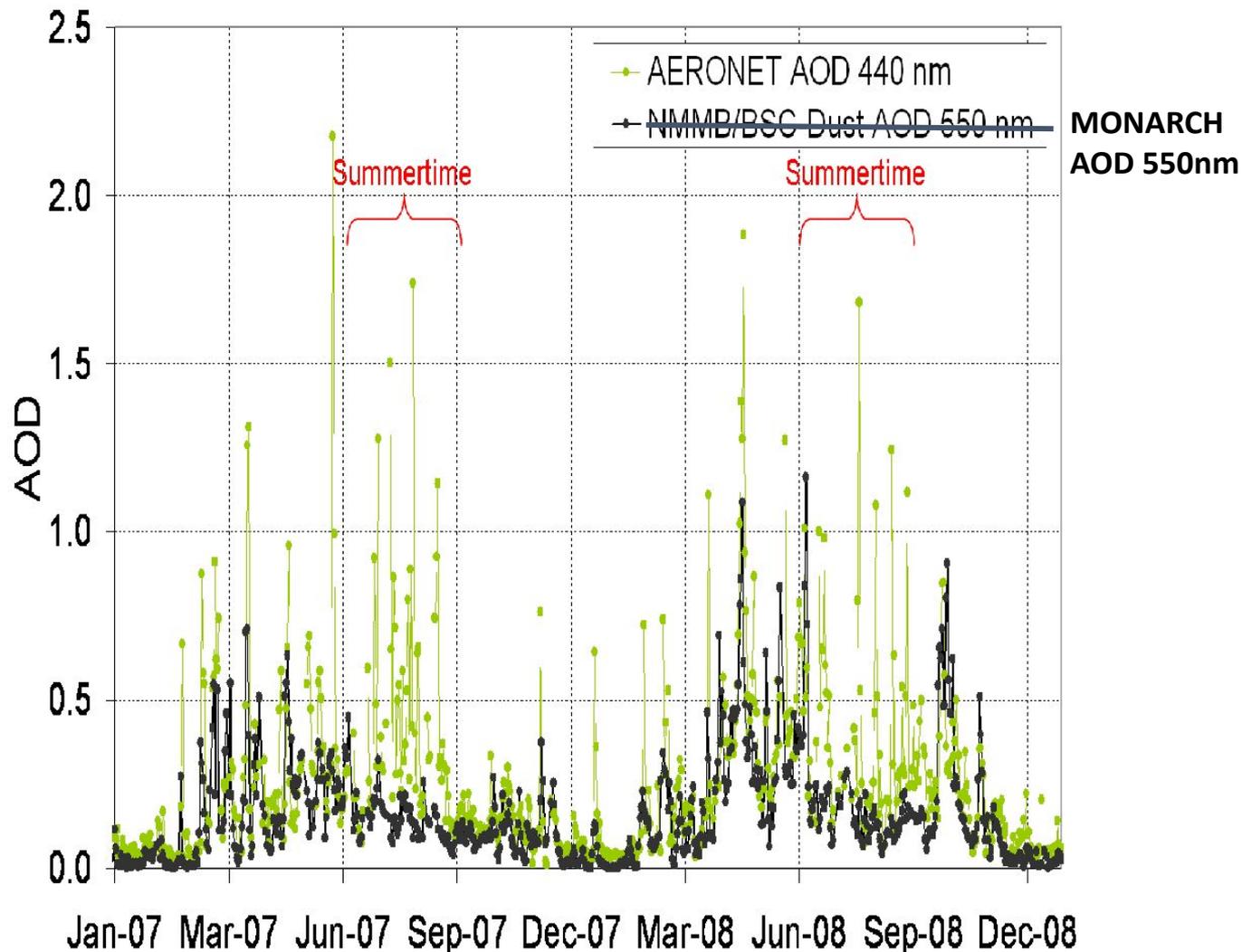


Aerosol characterization at the Saharan AERONET site Tamanrasset

C. Guirado^{1,2}, E. Cuevas², V. E. Cachorro¹, C. Toledano¹, S. Alonso-Pérez^{2,3,4}, J. J. Bustos², S. Basart³,
P. M. Romero², C. Camino², M. Mimoumi⁶, L. Zeudmi⁶, P. Goloub⁷, J. M. Baldasano^{5,8}, and A. M. de Frutos¹



Model evaluation



Extracted from Guirado et al. (2014, ACP)
Time series from Tamanrasset, Algeria

A piece of SDS history

- **Late 80's:**
 - First demonstration that SDS dynamic simulations are possible
- **90's:**
 - First satellite products capable to detect SDS
 - First successful daily SDS forecast test
 - First long-term daily SDS forecasts
- **2000's:**
 - Fast growth in dust observations and forecasting models
- **2010's:**
 - Fast growth in user-oriented applications



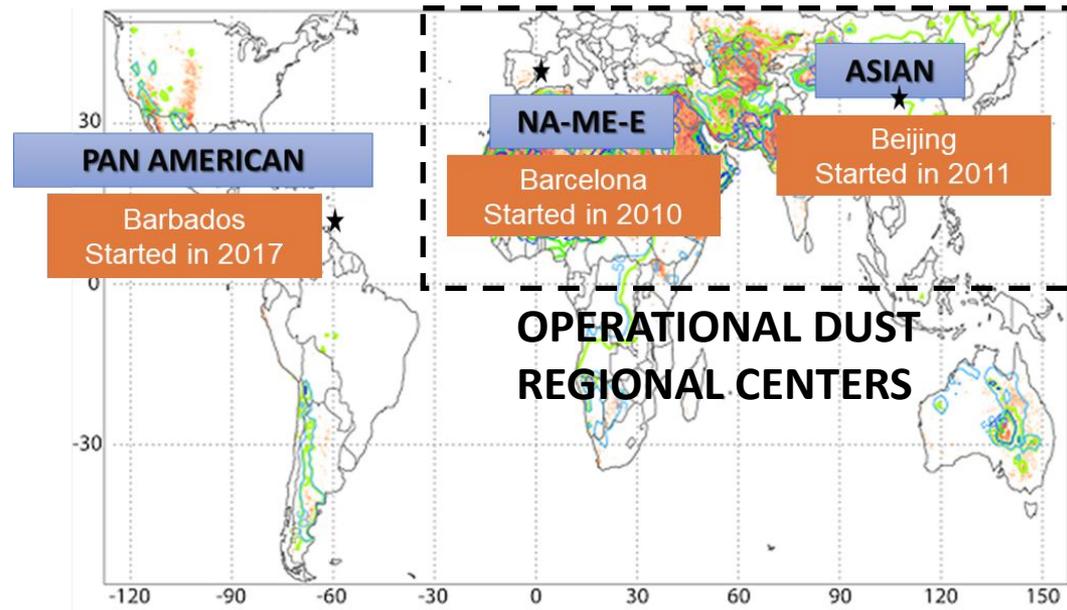
WE ARE **NOW** READY
TO PROVIDE
ADDED-VALUE
DUST INFORMATION !

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

Objectives:

- Identify and improve **products to monitor and predict dust** by working with research and operational organizations, as well as with users.
- Facilitate **user access** to information.
- Strengthen the **capacity of countries to use** the observations, analysis and predictions provided.

Regional Nodes and Centers



WMO Barcelona Dust Regional Center

The **WMO Barcelona Dust Regional Center** (includes operations and R&D) is coordinating the activities of the NAMEE node and participating in ongoing research projects that search to produce **dust services**.



@Dust_Barcelona

Barcelona Dust Forecast Center Operations

<http://dust.aemet.es>



SDS-WAS

R&D

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



Multi-model ensemble

15 Global – Regional models (from ~ 100 to 10 km)



PROBABILISTIC products can provide better information during extreme events

WMO Barcelona Dust Regional Center

- **SDS-WAS Regional Center.** Sand and Dust Storm Warning Advisory and Assessment System. Starting in 2010 – **Research**

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

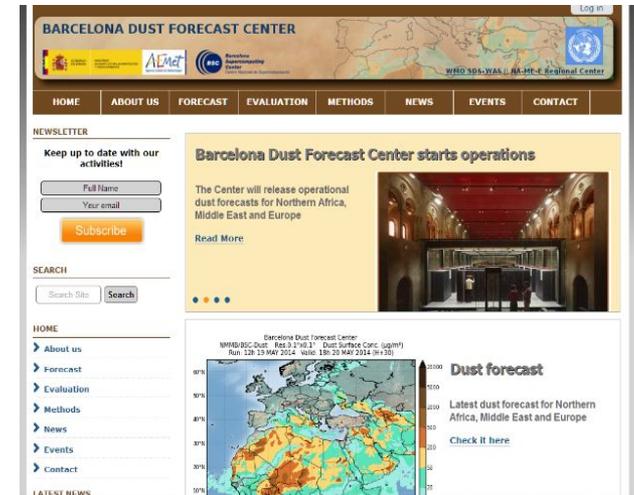
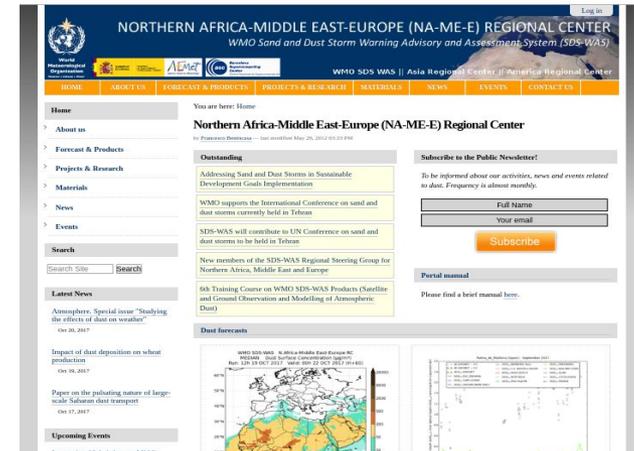
It includes a multi-model ensemble
PROBABILISTIC products

- **Barcelona Dust Forecast Center (RSMC-ASDF).** First Regional Specialized Meteorological Center with activity specialization on Atmospheric Sand and Dust Forecast. Starting in 2014 - **Operational**

- <http://dust.aemet.es>

- @Dust_Barcelona

MONARCH is the reference model and it contributes to the SDS-WAS ensemble



Barcelona Dust Regional Center



AEMet
Agencia Estatal de Meteorología



Barcelona Dust

@Dust_Barcelona Te sigue

The Barcelona Dust Forecast Center is a WMO RSMC-ASDF center that produces and distributes dust forecasts for Northern Africa, Middle East and Europe.

[Traducir la biografía](#)

Barcelona (Spain) dust.aemet.es Se unió en noviembre

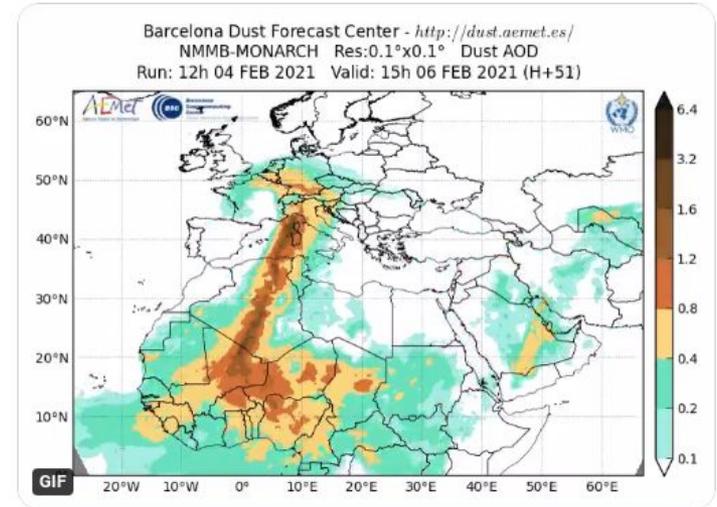
139 Siguiendo **3.393 Seguidores**



Barcelona Dust @Dust_Barcelona · 5 feb.

Follow the current Saharan dust intrusion over the Mediterranean and Europe.
Find our forecast products here: dust.aemet.es/forecast/nmmb-... and probability maps: sds-was.aemet.es/forecast-produ...

[@WMO](#) [@AEMET_Esp](#) [@BSC_CNS](#) [@UNCCD](#)



119



133



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AEMet
Agencia Estatal de Meteorología



Operational Dust Forecast

Reference model **MONARCH**

72-hours forecasts of:

- Dust Optical Depth at 550nm
- Dust Dry and Wet Deposition
- Dust Load
- Dust Surface Concentration
- Dust Surface Extinction at 550nm

Downloadable forecast products

- Maps (FRAME or GIF)
- GoogleEarth (KMZ or KML)

Evaluation with AERONET

The screenshot shows the Barcelona Dust Forecast Center website. At the top, there is a navigation menu with links for HOME, FORECAST, EVALUATION, OTHER PRODUCTS, METHODS, NEWS, EVENTS, ABOUT US, and CONTACT. Below the menu, there is a 'NEWSLETTER' section with a 'Subscribe' button. A 'SEARCH' section is also present. The main content area displays the 'Dust Optical Depth' forecast for the date 2021-02-06. The forecast is based on the NMMB/MONARCH model, with a resolution of 0.1°x0.1°. The map shows dust optical depth values over Europe and the Mediterranean, with a color scale ranging from 0.1 (light green) to 6.4 (dark brown). The map is titled 'Barcelona Dust Forecast Center - http://dust.aemet.es/ NMMB-MONARCH Res:0.1°x0.1° Dust AOD Run: 12h 06 FEB 2021 Valid: 12h 06 FEB 2021 (H+00)'. Below the map, there are links to 'Download image', 'KML - Online', and 'KML - Offline'. A small calendar for November 2021 is also visible, with the 11th highlighted.

Multi-model ensemble

15 Global and Regional models

72-hours forecasts of:

- Dust Optical Depth at 550nm
- Dust Surface Concentration

Downloadable forecasts products

- Maps (FRAME or GIF)
- GoogleEarth (KMZ or KML)
- Numerical data

Evaluation with AERONET and MODIS

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 Regional Center || America Regional Center

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

You are here: Home

Northern Africa-Middle East-Europe (NA-ME-E) Regional Center
by Francesco Benincasa — last modified Jul 18, 2018 02:11 PM

Outstanding

- New Forecast Product: Icelandic Dust
- Operational dissemination of dust forecast in numerical form through EUMETCast
- Warning Advisory System for Sand and Dust Storm in Burkina Faso
- Status and future of numerical atmospheric aerosol prediction with a focus on data requirements
- 7th Training course on WMO SDS-WAS Products

Dust forecasts

WMO SDS-WAS N. Africa-Middle East-Europe RC
MEDIAN Dust Surface Concentration (µg/m³)
Run: 12h 10 NOV 2021 Valid: 18h 12 NOV 2021 (H+54)

Compared Dust Forecasts

Forecast Evaluation

Dust observations

WMO SDS-WAS N. Africa-Middle East-Europe RC
Visibility reduced by airborne dust - 11 Nov 2021 06-12 UTC

Visibility

EUMETSAT RGB-Dust

« November 2021 »

Su	Mo	Tu	We	Th	Fr	Sa
	1	2	3	4	5	6
7	8	9	10	11	12	13
14	15	16	17	18	19	20
21	22	23	24	25	26	27
28	29	30				

Print this

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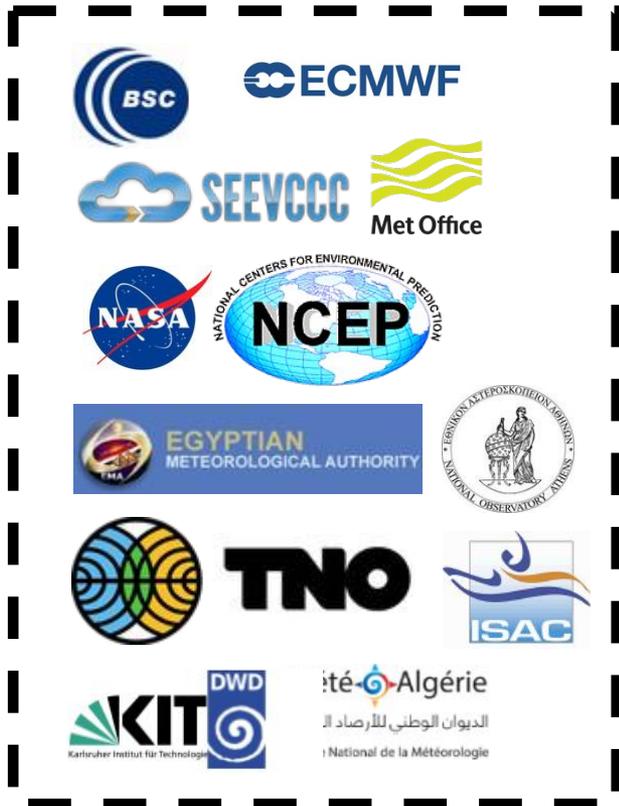
Powered by Plone & Python

Si @Dust_Barcelona

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

Multi-model ensemble

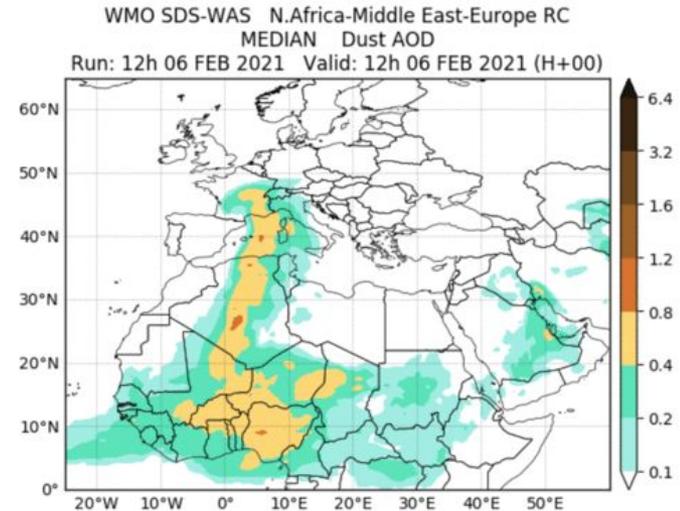
Model ensemble



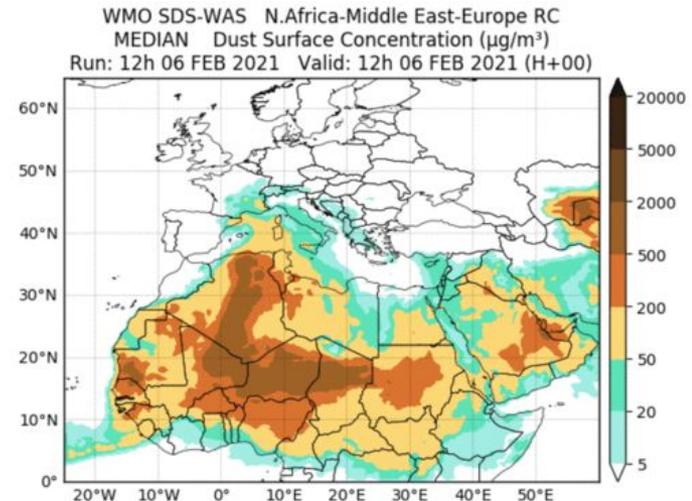
15 Global – Regional models
(from ~ 100 to 10 km)

PROBABILISTIC products can provide better information during extreme events

Dust column-load, DOD



Surface concentration



Saharan outbreak over Europe on 5-7 Feb 2021

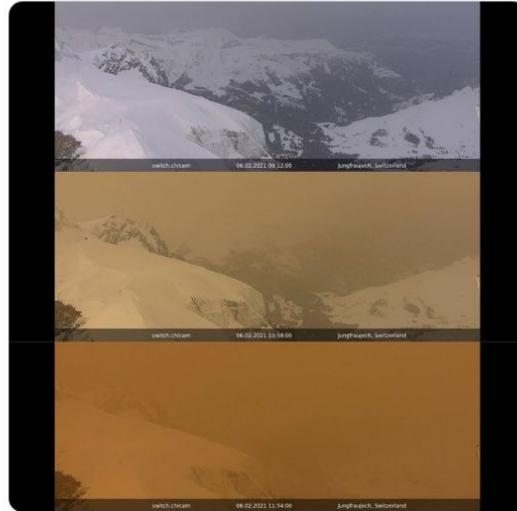
Sara Basart @SaraBasart · 6 feb.
Saharan dust is giving an amazing reddish touch to the Pyrenees today!
[@Dust_Barcelona](#) forecast captured! [@m_parrington](#) [@cp_garcia_pando](#)
[@SanGasso](#) [@PavlaDagsson](#) [@CALIOPE_BSC](#)

Dani Mora @meteobenas · 6 feb.
Nos llegan espectaculares fotos de la lluvia de
[@llanoshospital](#)



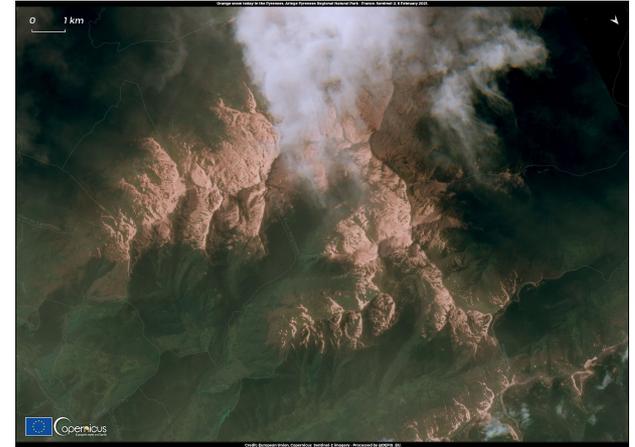
2 21 48

Claudia Mignani @ClaudiaMignani
Today's Saharan dust event captured by SWITCH at Jungfrauoch, Switzerland, 3571 meters (11716 feet) above sea level.



12:08 a. m. · 7 feb. 2021 · Twitter for iPhone

66 Retweets 9 Tweets citados 212 Me gusta



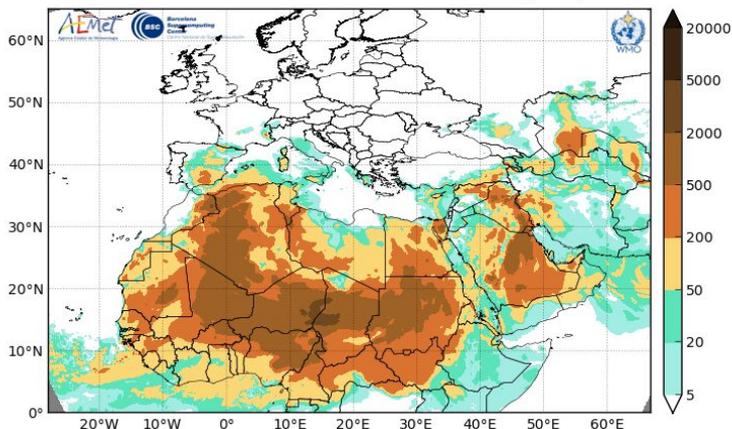
Geneva, Switzerland, 6th February 2021
From Oksana Tarasova



Saharan outbreak over Europe on 5-7 Feb 2021

Operational Dust Forecast

Barcelona Dust Forecast Center - <http://dust.aemet.es/>
NMMB-MONARCH Res:0.1°x0.1° Dust Surface Conc. ($\mu\text{g}/\text{m}^3$)
Run: 12h 05 FEB 2021 Valid: 12h 05 FEB 2021 (H+00)



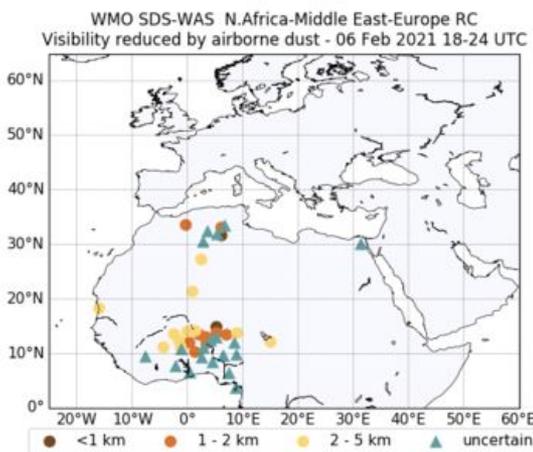
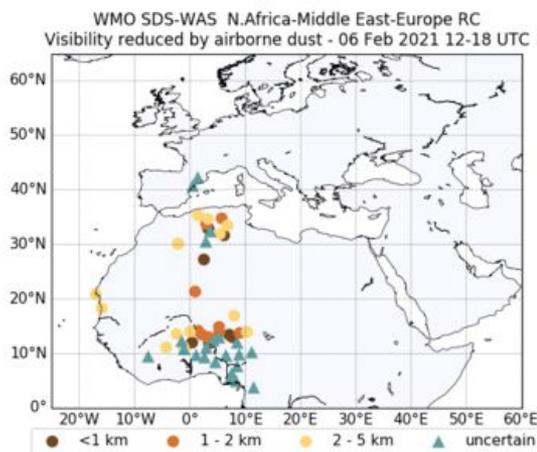
The reference dust forecast is based on **MONARCH**

Six dust variables are available:

- Surface concentration
- Surface extinction (related with visibility)
- Dust optical depth at 550nm
- Dust load
- Wet deposition
- Dry deposition

<http://dust.aemet.es>

VISIBILITY OBSERVATIONS 6 February 2021

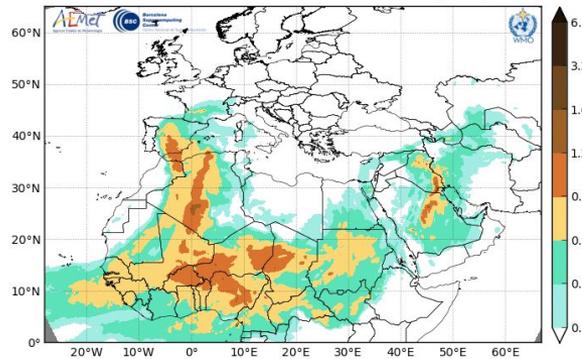


The observed reductions of **visibility** achieved few meters (< 800m) in North Algeria where it is localised the origin of this event. Some stations in Western Mediterranean informed on reductions of visibility during the afternoon.

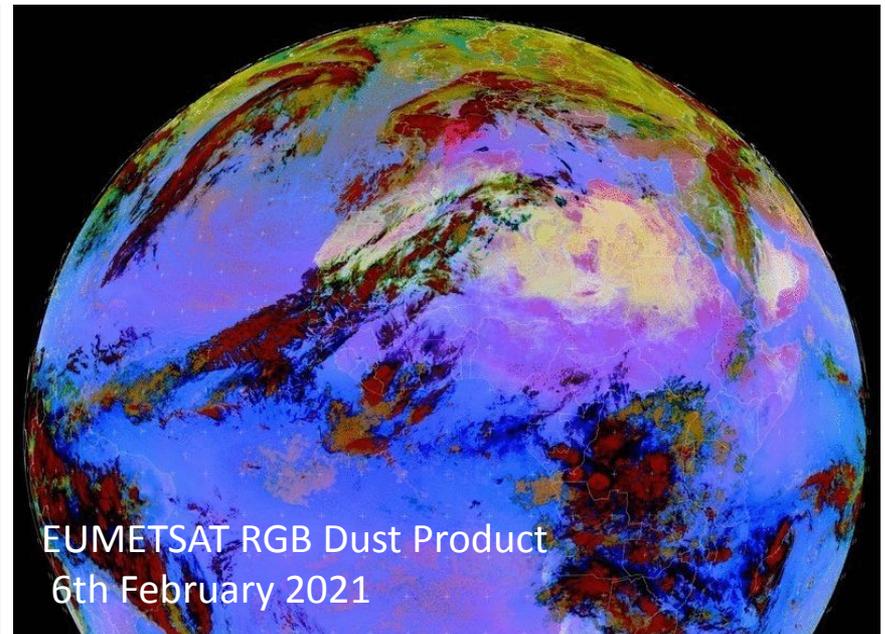
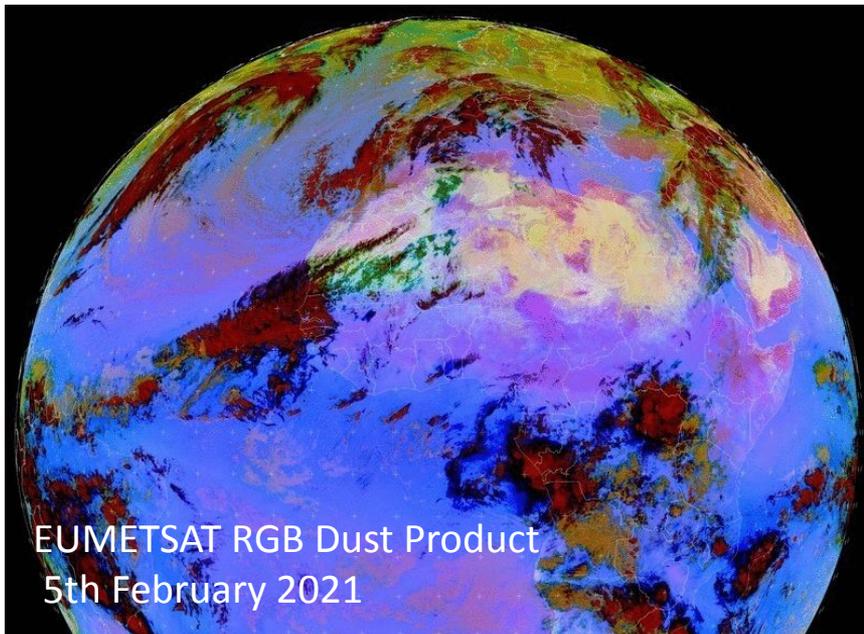
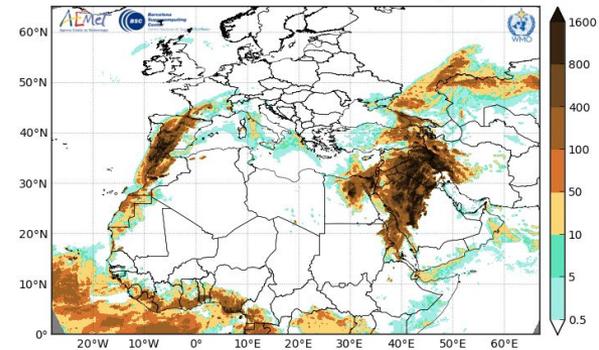
Saharan outbreak over Europe on 5-7 Feb 2021

Operational Dust Forecast

Barcelona Dust Forecast Center - <http://dust.aemet.es/>
NMMB-MONARCH Res:0.1°x0.1° Dust AOD
Run: 12h 05 FEB 2021 Valid: 12h 05 FEB 2021 (H+00)



Barcelona Dust Forecast Center - <http://dust.aemet.es/>
NMMB-MONARCH Res:0.1°x0.1° 3h Acc. Dust Wet Depos. (mg/m²)
Run: 12h 05 FEB 2021 Valid: 12h 05 FEB 2021 (H+00)



<http://dust.aemet.es>

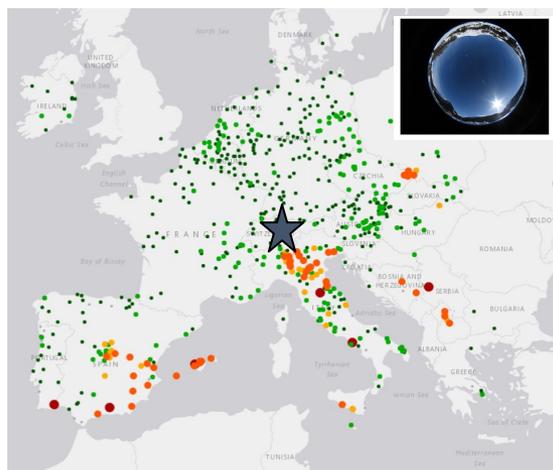
<https://sds-was.aemet.es/forecast-products/dust-observations/msg-2013-eumetsat>

Saharan outbreak over Europe on 5-7 Feb 2021

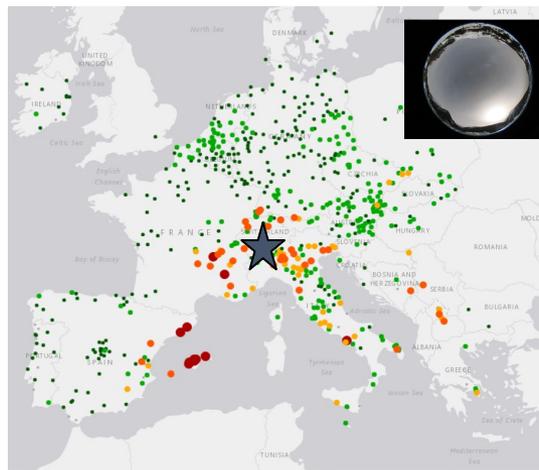


*Davos, Switzerland, 6th February
WMO-GAW PFR station
Courtesy of Stelios Kazadzis*

5 February 2021



6 February 2021

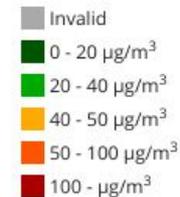


7 February 2021



<https://www.eea.europa.eu/data-and-maps/explore-interactive-maps/up-to-date-air-quality-data>

Particulate matter (PM10)

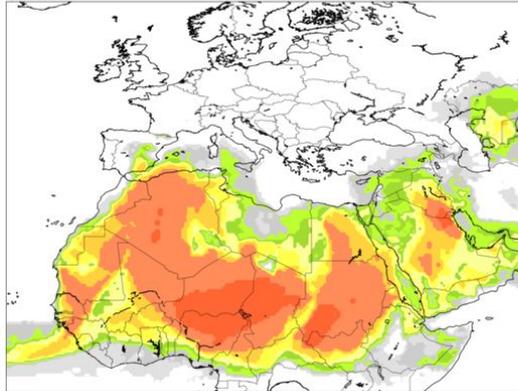


Saharan outbreak over Europe on 5-7 Feb 2021

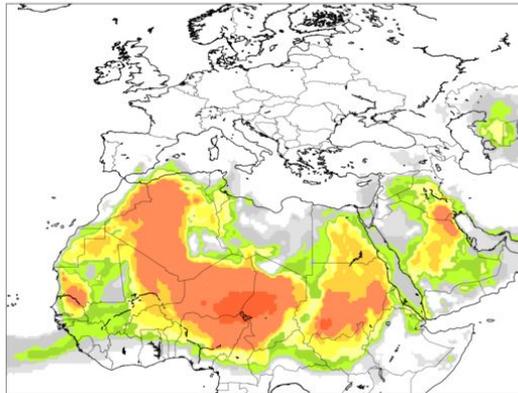
Multi-model ensemble: Probability maps

5 Feb (24h forecasts)

Daily Mean of **Dust SFC Concentration**
Probability of exceeding **50 $\mu\text{g}/\text{m}^3$**
ENS members: **9** Run: 04/02/2021 Valid for: **05/02/2021**

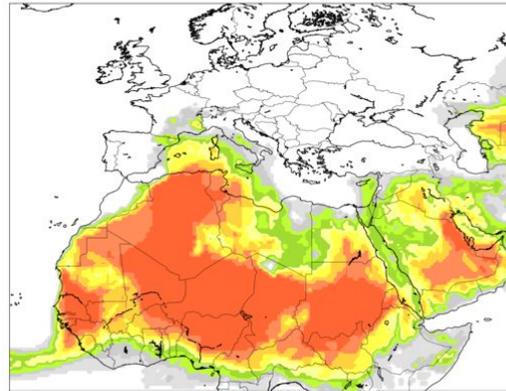


Daily Mean of **Dust SFC Concentration**
Probability of exceeding **100 $\mu\text{g}/\text{m}^3$**
ENS members: **9** Run: 04/02/2021 Valid for: **05/02/2021**

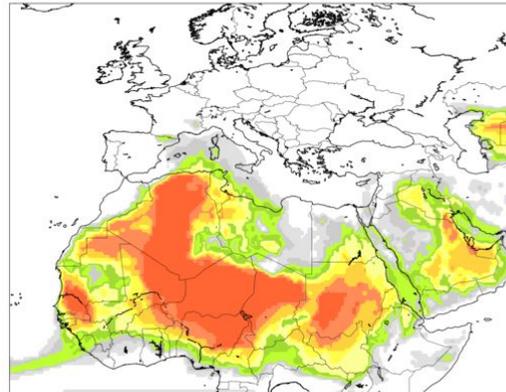


6 Feb (24h forecasts)

Daily Mean of **Dust SFC Concentration**
Probability of exceeding **50 $\mu\text{g}/\text{m}^3$**
ENS members: **11** Run: 05/02/2021 Valid for: **06/02/2021**

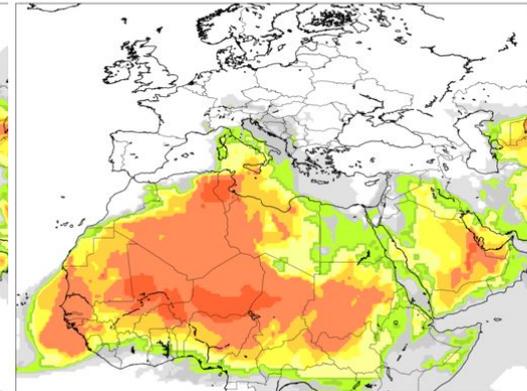


Daily Mean of **Dust SFC Concentration**
Probability of exceeding **100 $\mu\text{g}/\text{m}^3$**
ENS members: **11** Run: 05/02/2021 Valid for: **06/02/2021**

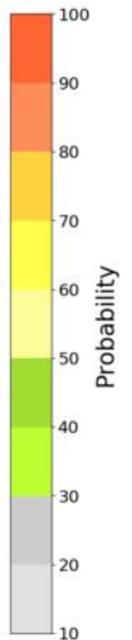
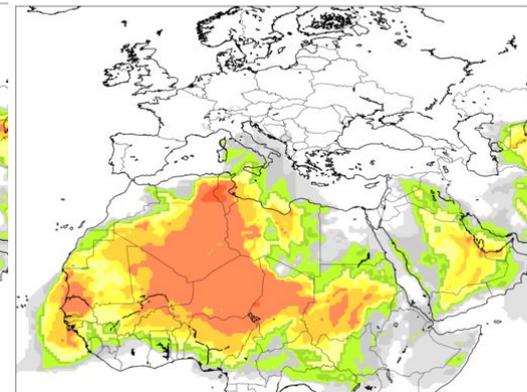


7 Feb (24h forecasts)

Daily Mean of **Dust SFC Concentration**
Probability of exceeding **50 $\mu\text{g}/\text{m}^3$**
ENS members: **8** Run: 06/02/2021 Valid for: **07/02/2021**

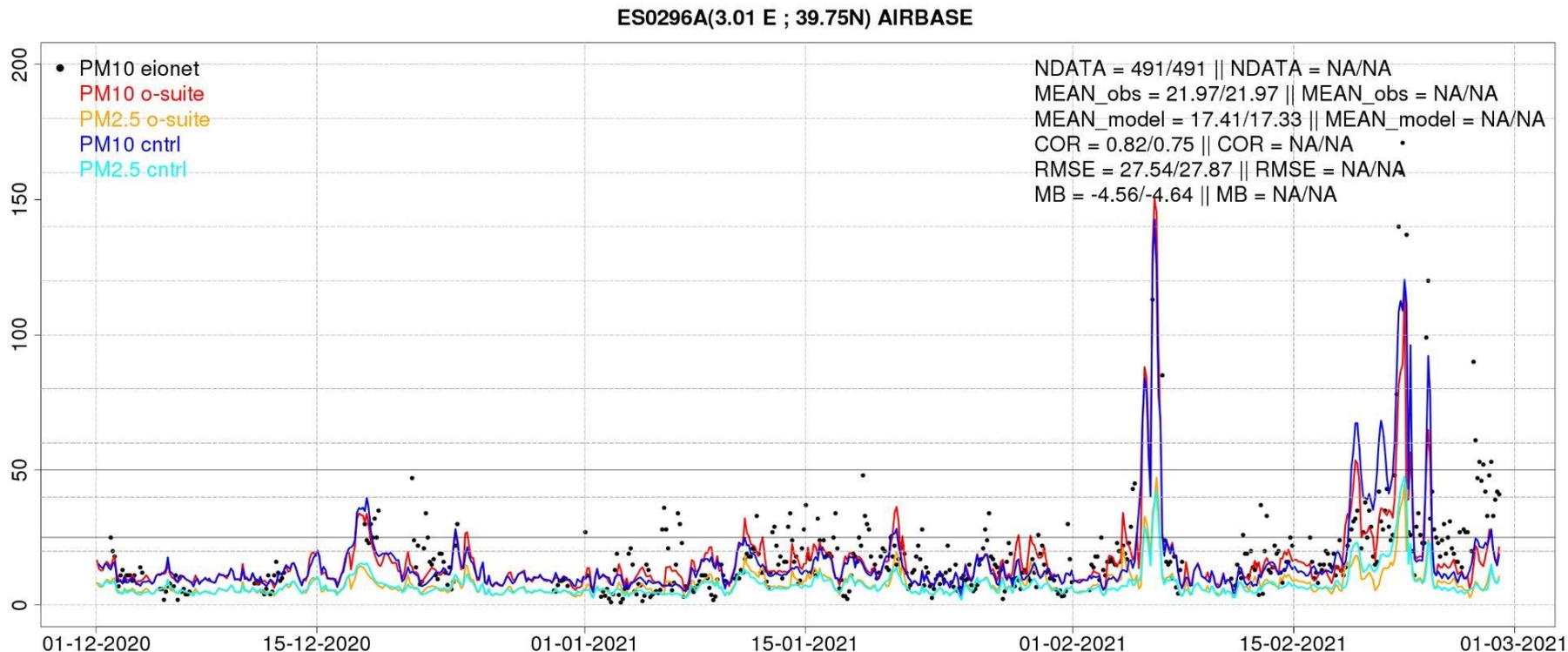


Daily Mean of **Dust SFC Concentration**
Probability of exceeding **100 $\mu\text{g}/\text{m}^3$**
ENS members: **8** Run: 06/02/2021 Valid for: **07/02/2021**



Saharan outbreak over Europe on 5-7 Feb 2021

Comparison PM of CAMS and EIONET



Extracted from CAMS Validation NRT report
(Schulz et al., 2021, doi:10.24380/f540-kb09)

Saharan outbreak over Europe on 5-7 Feb 2021

Comparison with AERONET



The dust-filtering of the AERONET observations is considering dust (i.e. DOD = AOD) when the Angstrom Exponent < 0.6

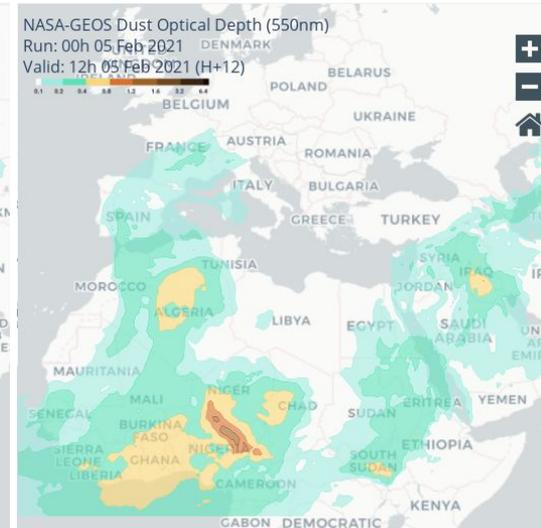
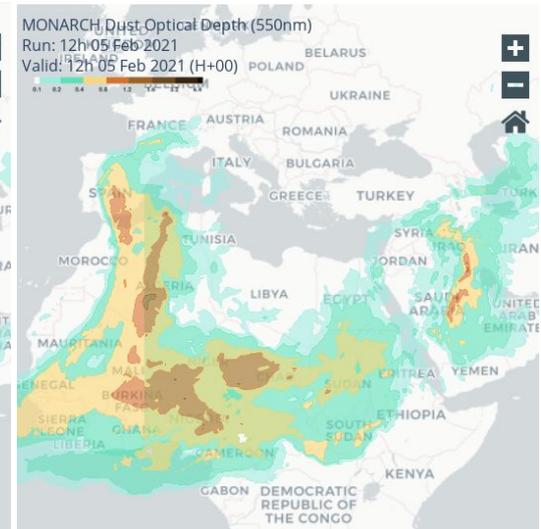
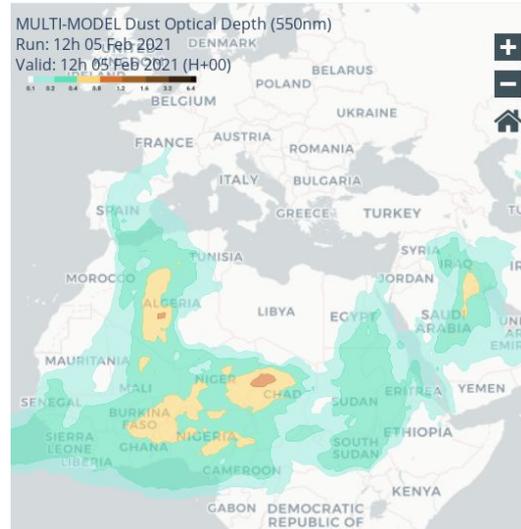
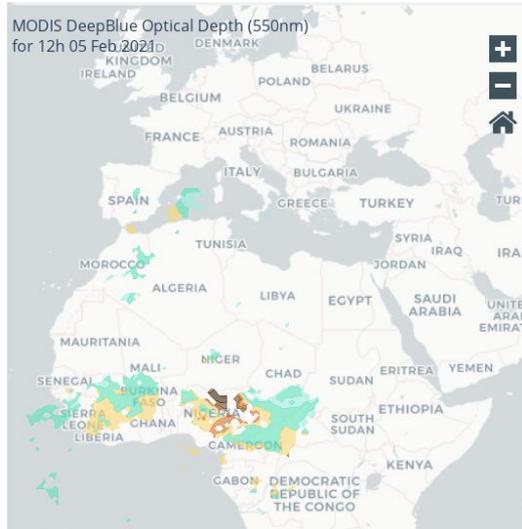
- *This is associated to coarse particles*



New WMO Barcelona Regional Center interactive visualisation tool
To be launched

Saharan outbreak over Europe on 5-7 Feb 2021

Comparison with MODIS Deep Blue AOD



Canary Islands – February 2020

Tourists stranded in Canary Islands after Saharan sandstorm blows in

Dozens of flights cancelled due to poor visibility, leaving holidaymakers stuck at airports **The Guardian**

In pictures: Canary Islands sandstorm leaves tourists stranded



Maxima sandstorm en las Islas Canarias - video

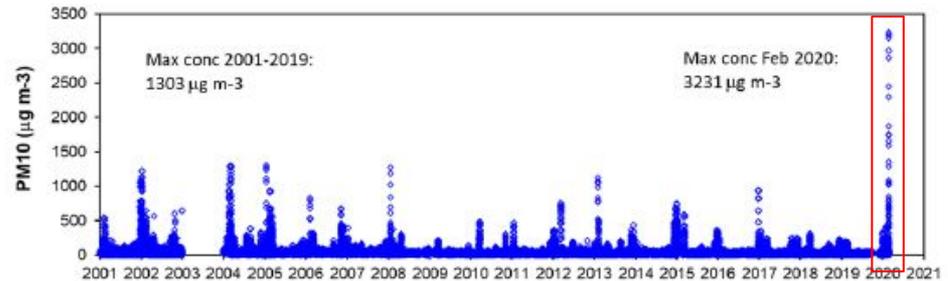
26 febbraio 2020 ore 17:02

METEO cronaca DIRETTA : potente tempesta di CALIMA investe le Canarie, paesaggio MARZIANO - VIDEO

CORRIERE DELLA SERA



22-23 February is an exceptional event: it is the most intense event in Canary Islands in the last 20 years records (from 2000s)



Impacts in the archipelago:

- Increase of the number of hospitalisations (3 times more)
- 745 flight cancellations and 84 diverted flights
- Solar PV energy production fell > 50%

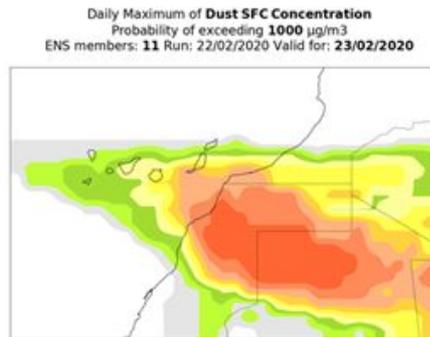
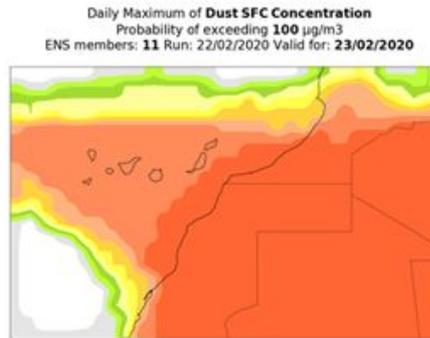
Canary Islands – February 2020

Probability maps based on the SDS-WAS ensemble

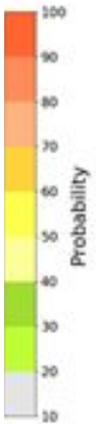
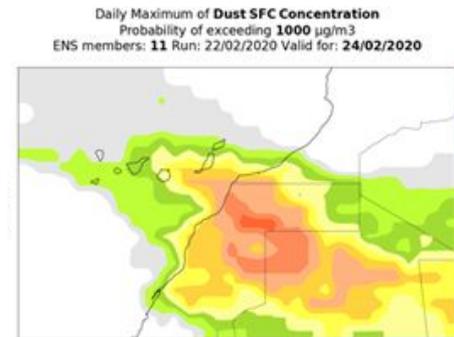
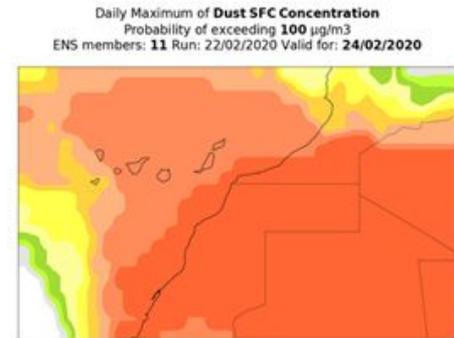
<http://sds-was.aemet.es/>

More than 40% of the SDS-WAS models predicted surface concentrations > **1000 $\mu\text{g}/\text{m}^3$**

23 Feb (24h forecasts)



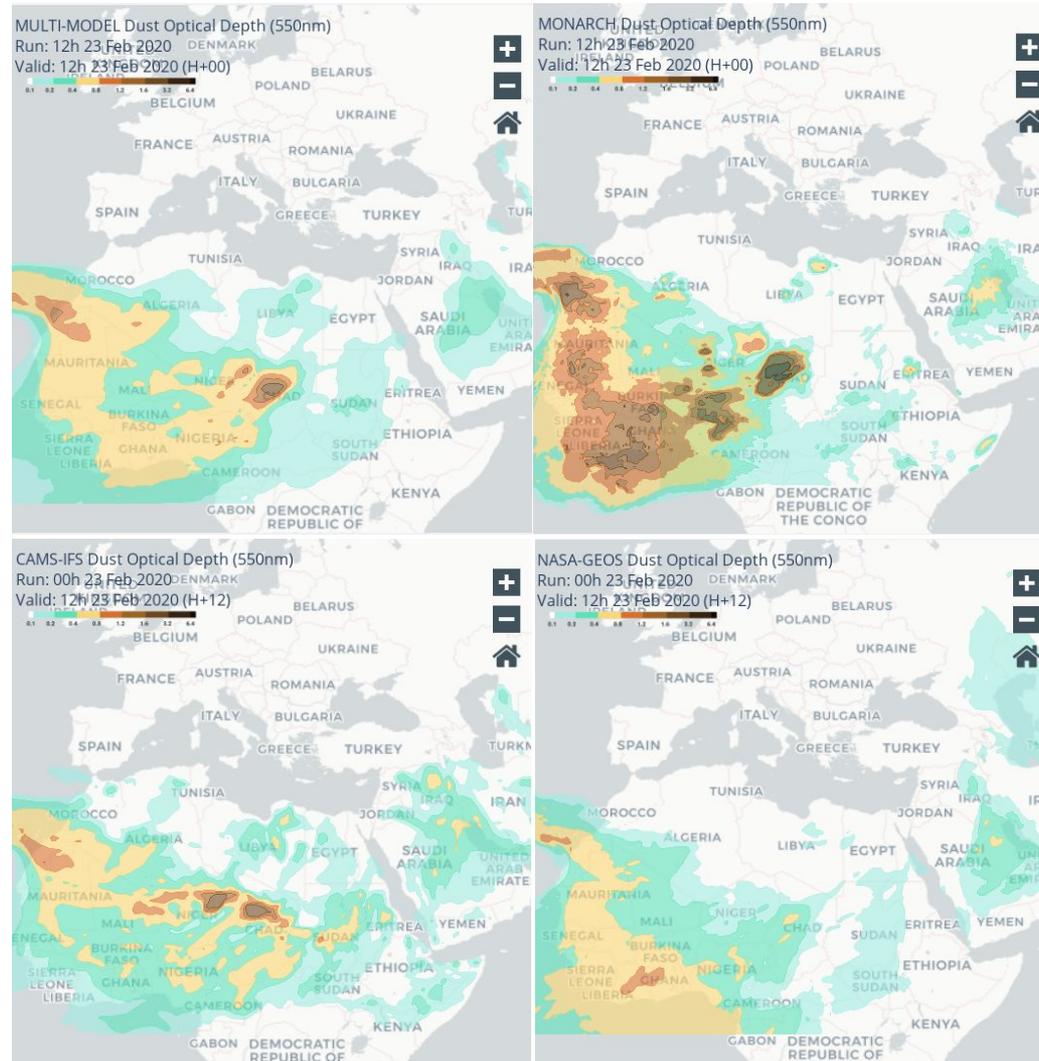
24 Feb (48h forecasts)



MODIS/Aqua images



Canary Islands – February 2020 Comparison with MODIS Visible



Canary Islands – February 2020 CAMS results

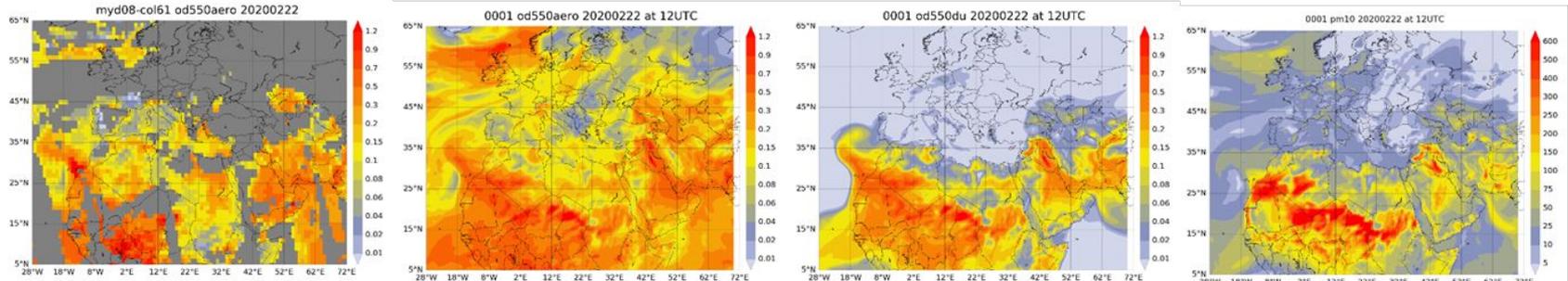
MODIS AOD

CAMS AOD

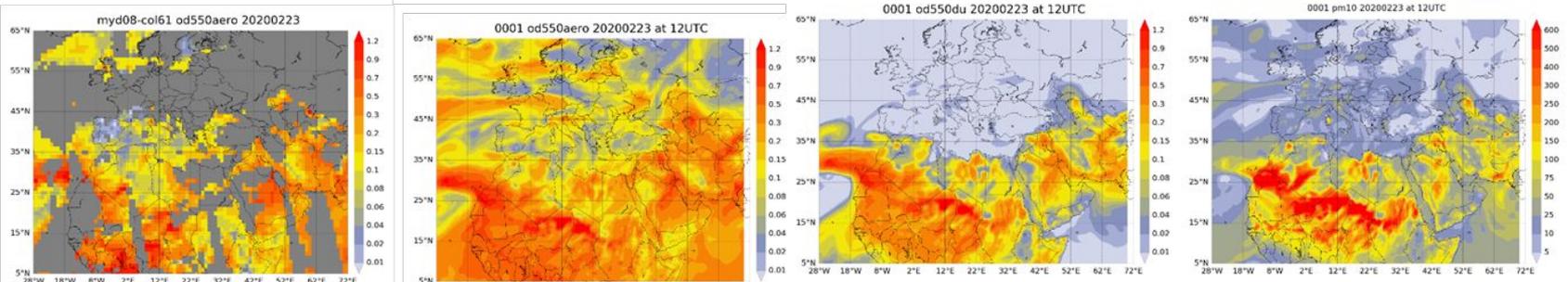
CAMS DOD

CAMS PM10

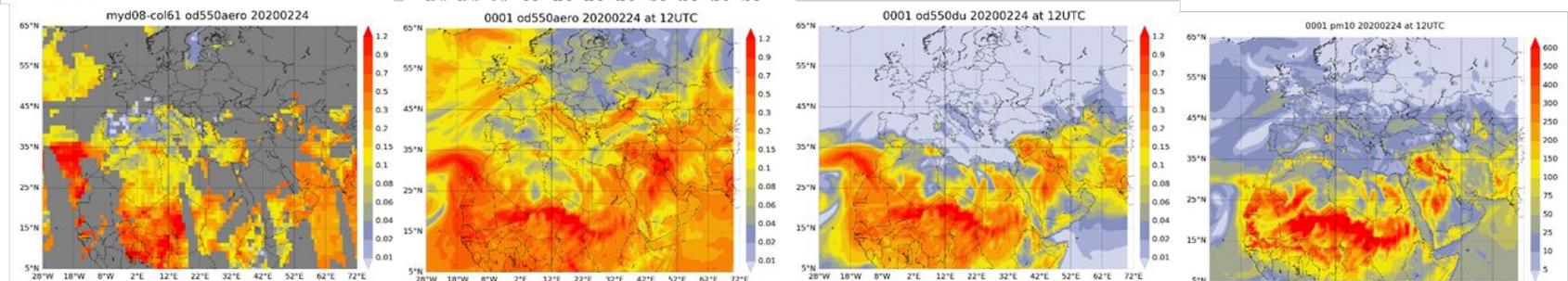
22 Feb



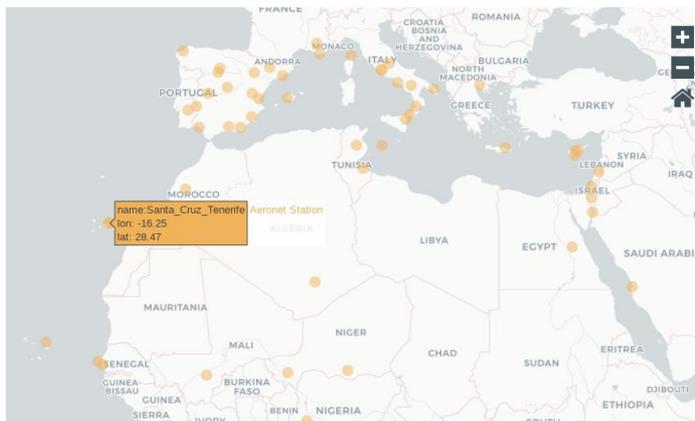
23 Feb



24 Feb

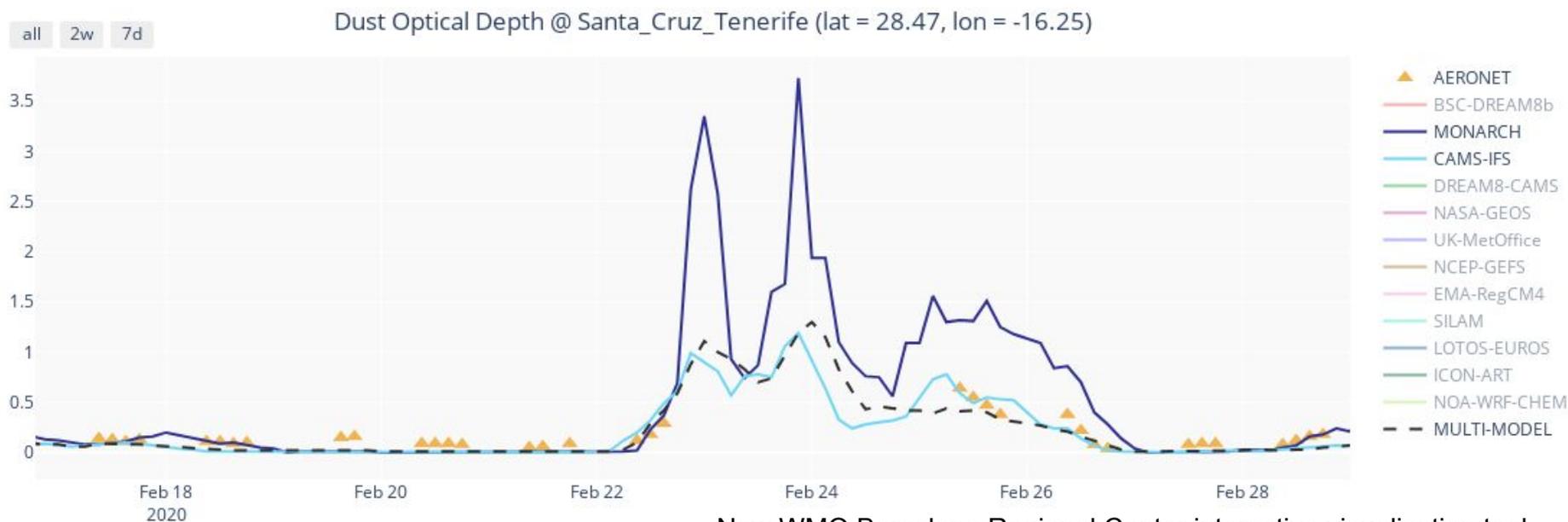


Canary Islands – February 2020 Comparison with AERONET



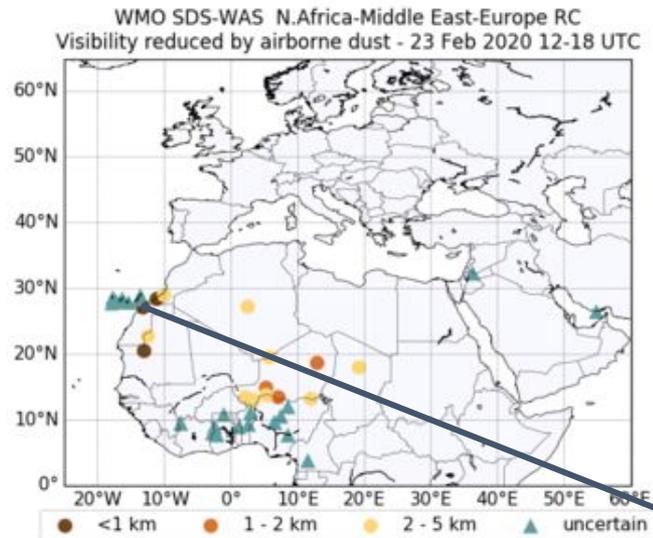
The dust-filtering of the AERONET observations is considering dust (i.e. $DOD = AOD$) when the Angstrom Exponent < 0.6

- This is associated to coarse particles



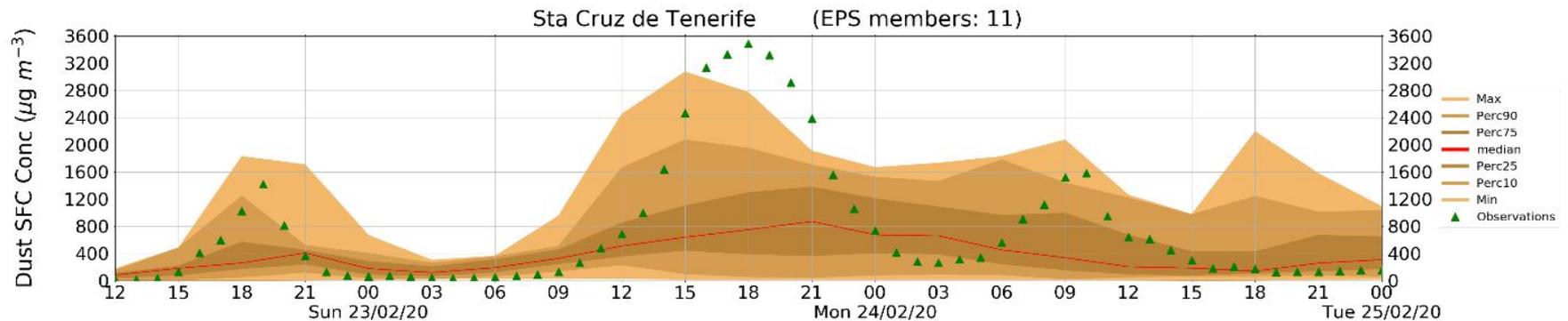
Canary Islands – 22-23 February 2020

OBSERVATIONS



The observed reductions of **visibility** achieved few meters (< **800m**) in the Canary Islands

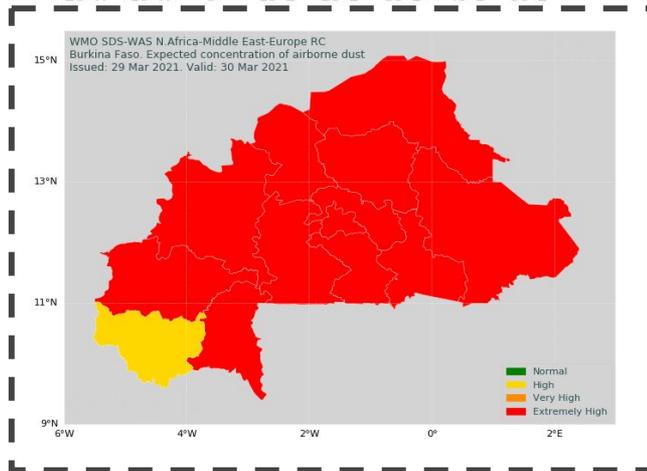
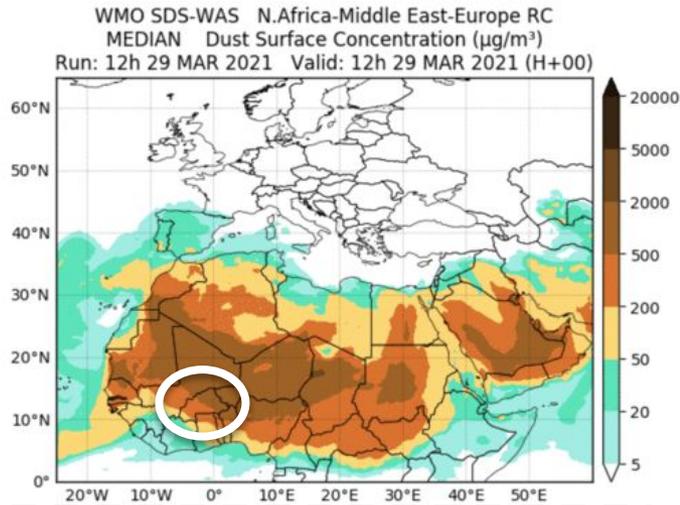
More than 50% of the SDS-WAS models predicted surface concentrations > 1000 $\mu\text{g}/\text{m}^3$ with some models predicting surface concentrations > **3000 $\mu\text{g}/\text{m}^3$**



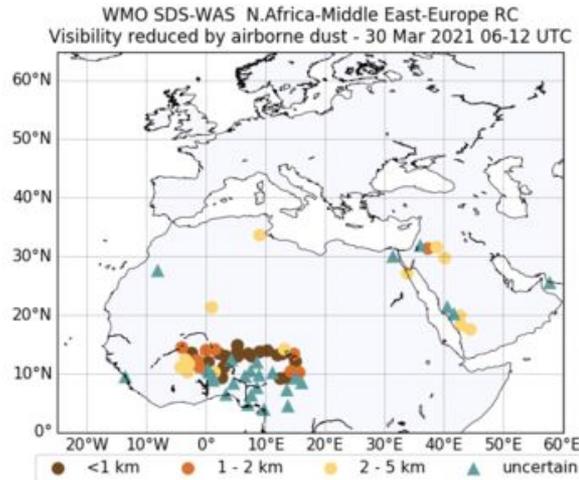
Warning System for Burkina Faso

30th March 2020

FORECASTS



VISIBILITY OBSERVATIONS



Why models? Burkina Faso does not have any Air Quality observational network



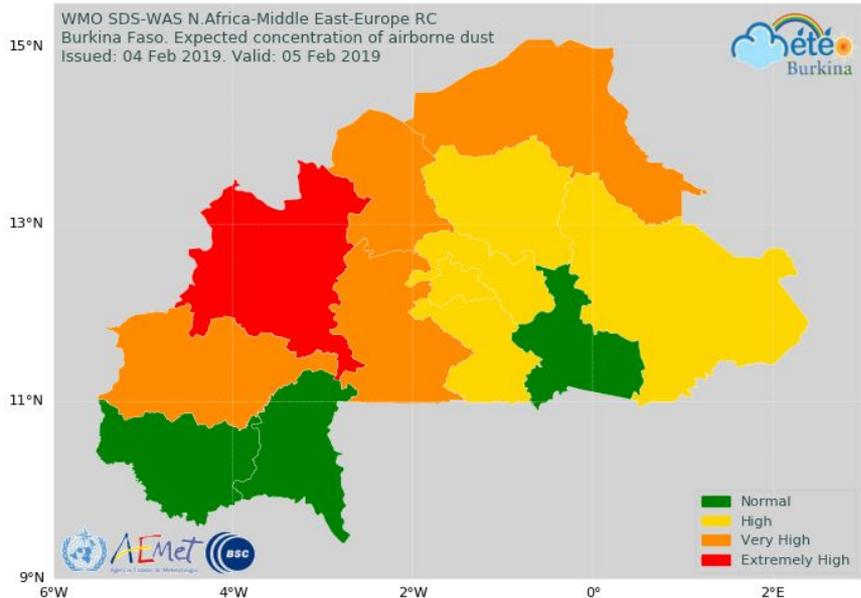
<http://sds-was.aemet.es/>

Warning System for Burkina Faso

Warnings for the next two days over Burkina Faso targeting on civil protection

Traffic light system based on the **dust surface concentration** information provided by the WMO multi-model ensemble.

Thresholds of each category are defined based on the percentiles obtained from more than **10-years** dust surface concentration **multi-model ensemble**.



Warning System for Burkina Faso

Extension to other countries in the Sahelian region SOON!



80th percentile
90th percentile
97.5th percentile



AEMet
Agencia Estatal de Meteorología

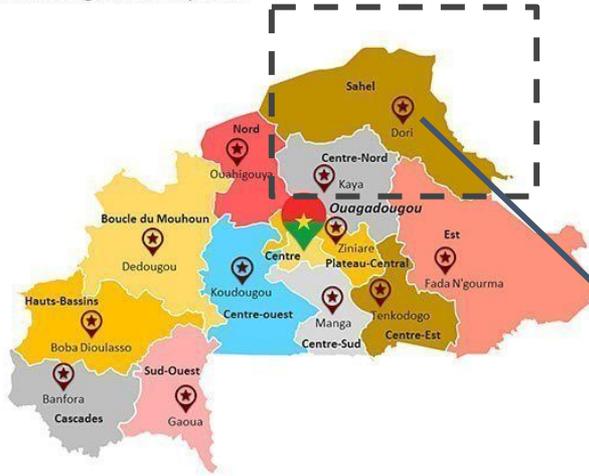
<http://sds-was.aemet.es/>



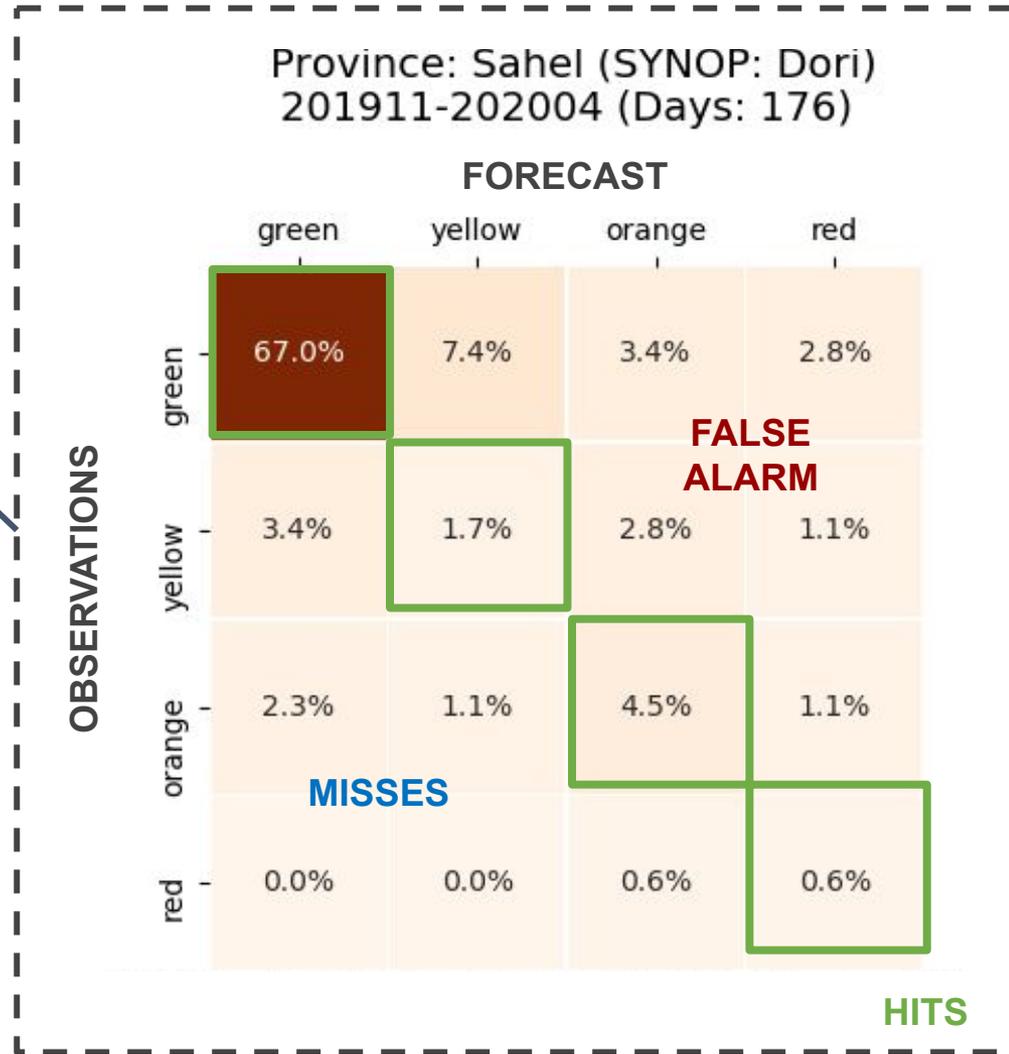
Warning System for Burkina Faso

Burkina Faso

National and Regional Capitals



Verification with **VISIBILITY observations**
(NO surface concentration observations)



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



NRT Dust Profiles Evaluation Exchange protocol



OBSERVATIONS

Extinction profiles at 12UTC available in a window of 24 hours



3 ceilometers
1 lidar



SDS-WAS MODELS

- BSC-DREAM8b
- ~~NMMB/BSC Dust~~ MONARCH
- CAMS
- DREAM8-NMME
-

```
2016040512_3H_BSC_DREAM8B_profiles {
  dimensions:
    time = 73;
    station = 67;
    lev = 24;
```

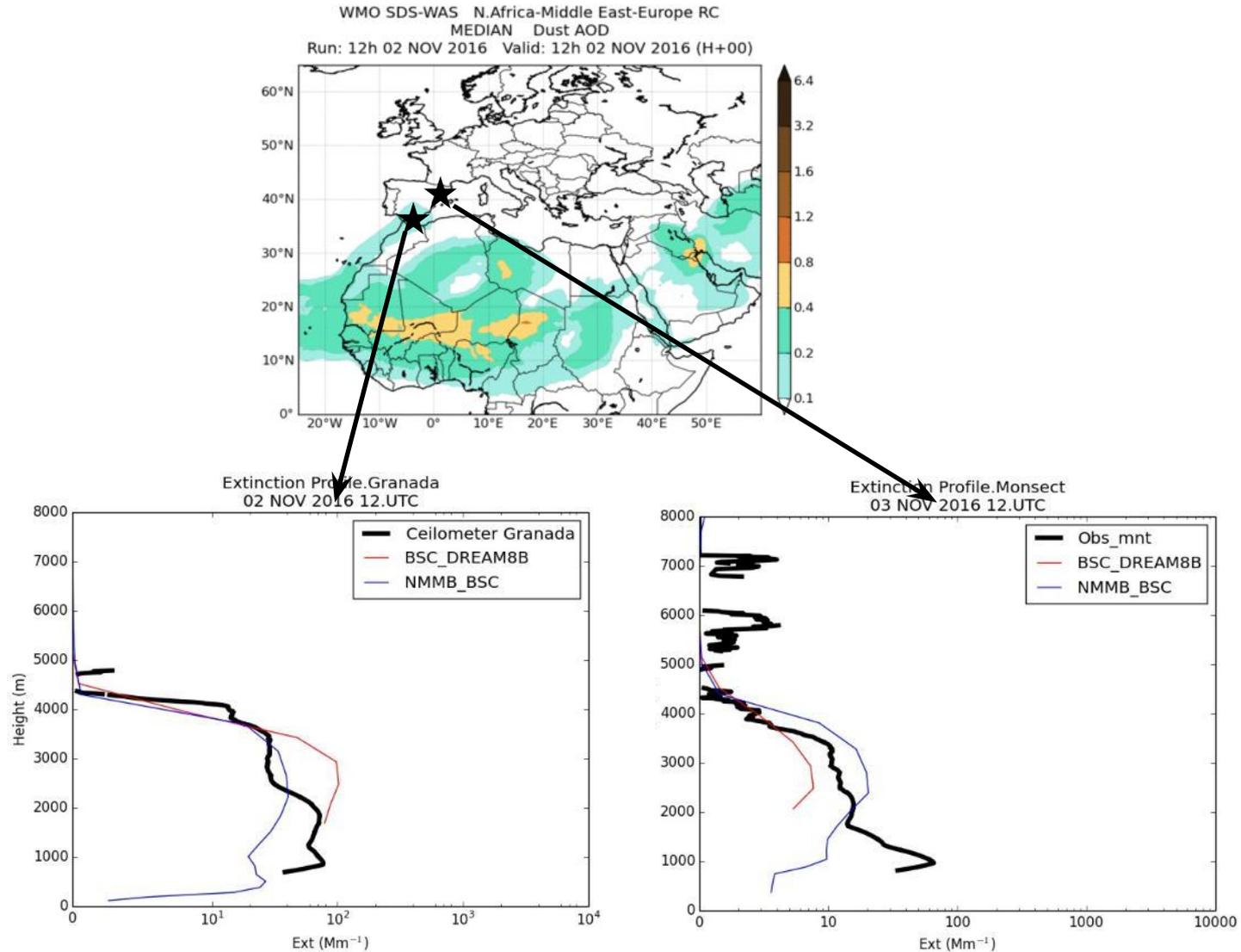
Data format
Exchange operational protocol includes 72 hours forecasts

```
char station_name(station, strlen);
  station_name:missing_value = -9999.;
  station_name:long_name = "station long name";
  station_name:units = ".";
char station_code(station, codlen);
  station_code:missing_value = -9999.;
  station_code:long_name = "station code";
  station_code:units = ".";
double time(time);
```

<http://sds-was.aemet.es/projects-research/evaluation-of-model-derived-dust-vertical-profiles>

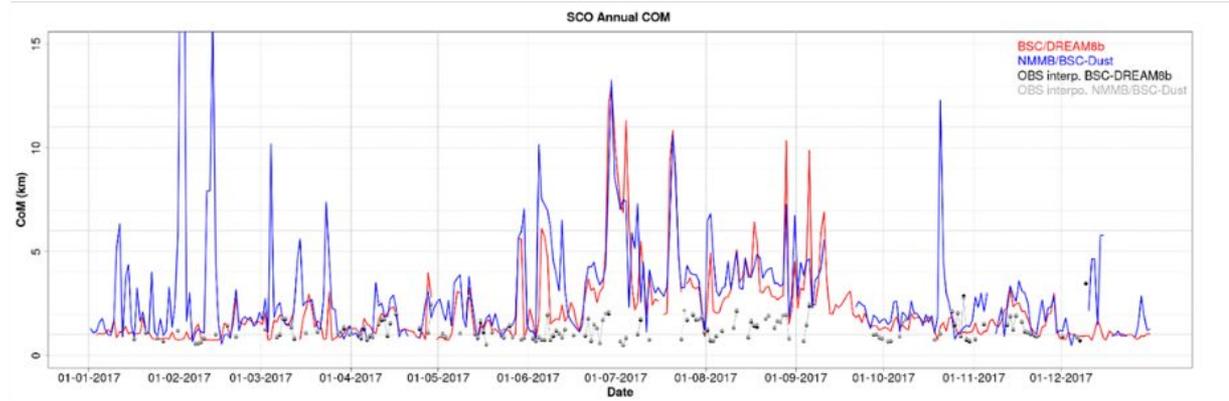
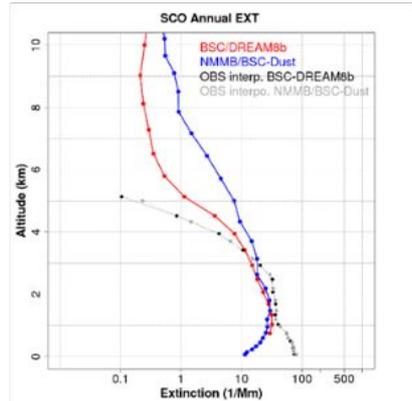
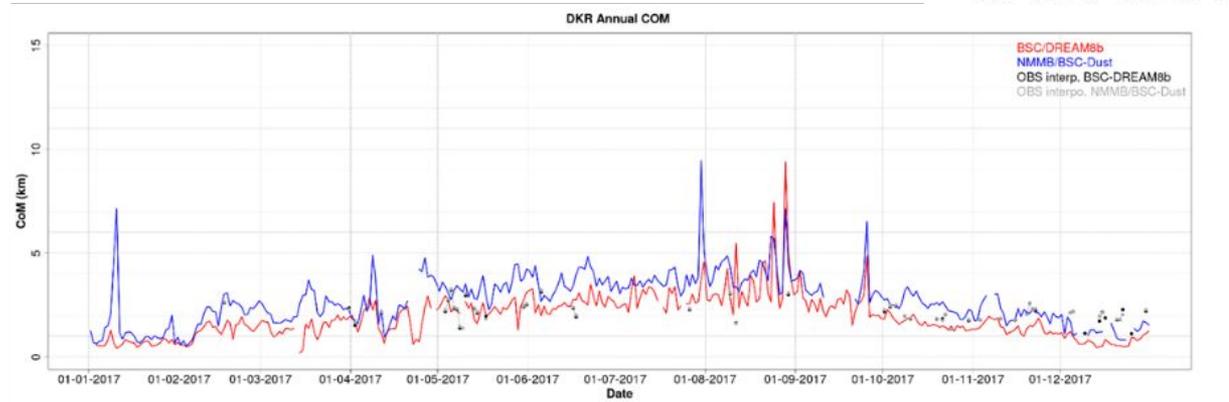
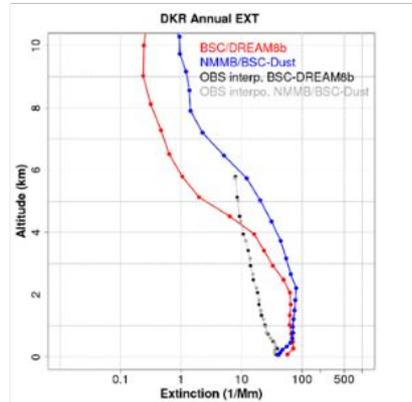
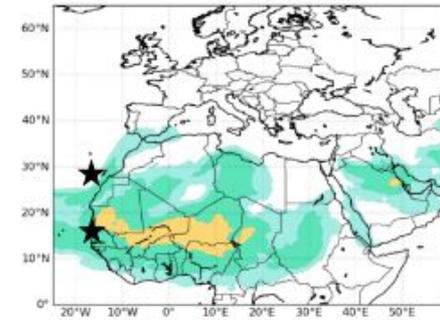
NRT Dust Profiles Evaluation

Atlantic dust event: 2 - 5 November 2016



NRT Dust Profiles Evaluation

Evaluation results for 2017



<http://sds-was.aemet.es/projects-research/evaluation-of-model-derived-dust-vertical-profiles>

NRT Dust Profiles Evaluation

Ceilometers are potential instruments for NRT “verification” of vertical dust forecasts.

- Skills score calculation:
 - *Definition of a common vertical reference profile for the participating models → Vertical interpolation is sensible to the original model and observations vertical resolution. The most standard product is based on pressure levels.*
 - *Center of Mass (CoM), Top and Base of the dust layer present some challenges*
 - *PBL and/or maritime boundary layer*
 - *multiple dust layers*
 - *laser signal*

CAMS Global Products catalogue



Global Services

EVALUATION AND QUALITY ASSURANCE REPORTS | QUALITY MONITORING GRAPHICS

Filters

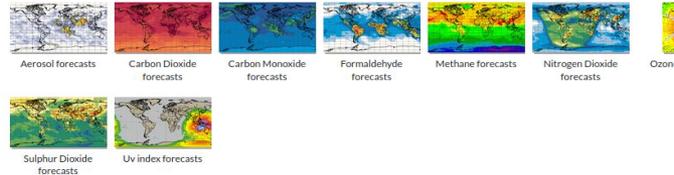
Filter

Family

- Aerosols (2)
- Fires (1)
- Greenhouse gases (2)
- Reactive gases (5)
- Solar radiation (1)

170 filters applied

Forecasts



Analyses



Home / [Help & Support](#) / [Quality assurance](#) / [Validation panel](#)

Global Services

EVALUATION AND QUALITY ASSURANCE REPORTS | QUALITY MONITORING GRAPHICS

Evaluation and Quality Assurance reports

The global forecasting system is continually being evaluated to ensure the output meets the expected requirements. Comprehensive Evaluation and Quality Assurance (EQQA) reports are produced on a quarterly basis. Before each update of the global forecasting system, the new system is tested and evaluated, and a so-called "in-house EQQA report" is produced. The CAMS global forecasts are evaluated daily by production teams resulting in several EQQA reports. All reports are available through the link below.

Access Evaluation and Quality Assurance reports

Quality monitoring graphics

CAMS uses a multitude of independent data sets to routinely monitor its global forecasts. It works with various data providers, acquiring the observations with appropriate frequency and geographical grids that show the difference between the forecasts and the independent observations.

Global evaluation server

CAMS has been providing information from its routine evaluation of the global forecasts through the various links below. To better harmonize the evaluation, a central server is being developed that will provide access to all the monitoring graphics based on the various observation data sets. For now, only evaluation based on observations from the NDACC network is available through this server.

WMO-GAW surface observations

Surface ozone and carbon monoxide mixing ratios from the CAMS global mid-time analysis and forecast system are routinely verified against data from some of the measurement stations of the World Meteorological Organization (WMO) Global Atmospheric Watch (GAW) programme.

IGOS aircraft observations

Ozone and carbon monoxide from the CAMS global mid-time analysis and forecast system as well as the MADC meteorology are validated at its profiles from IGOS/NDACC aircraft. These series of the difference between model and observations are presented for each available year, along with profiles at individual airports, and the observed climatologies.

NOAA-ESRL and EMEP surface observations

This evaluation service contains the following elements:

1. Surface ozone from the CAMS global mid-time analysis and forecast system are compared to ozone data from NOAA Earth System Research Laboratory (ESRL) stations.
2. Surface ozone from the MADC meteorology (2015) are verified against observations from the European EMEP network.

NDACC ground-based remote-sensing observations

This service provides quality assessment of the CAMS products using ground-based remote-sensing data from the global Network for the Detection of Atmospheric Composition Change (NDACC). This includes verification plots using NDACC remote sensing data from ground-based lidar, microwave interferometry, Fourier transform infrared and differential absorption lidar (DIAL) CAMS products, carbon monoxide (CO), methane (CH₄), ozone (O₃), nitrogen dioxide (NO₂), formaldehyde (HCHO) and aerosol extinction (total column abundance and/or vertical profiles). This service is now fully integrated to the CAMS global evaluation server.

AERONET ground-based remote-sensing observations

The aerosol analysis/forecasting system is operationally verified against AERONET observations. The aerosol verification plots show comparisons of aerosol optical depth (AOD) values from the CAMS analysis component to the various AERONET station observations. The verification plots also show the individual aerosol types as modelled by the CAMS system. This allows for constant monitoring of the quality of the CAMS aerosol analysis/forecasting system.

MORITT satellite observations

This service provides evaluation of CAMS simulations against MORITT carbon monoxide data. Measurement of Pollution in the Troposphere (MPROT) is an instrument designed to enhance our knowledge of the lower atmosphere and to observe how it interacts with the land and ocean biogeochemistry.

GOME-2 satellite observations

Tropospheric nitrogen dioxide (NO₂) and formaldehyde (FCHO) columns as well as stratospheric nitrogen dioxide from the near-real-time forecasting/analysis systems and the MADC meteorology are operationally verified against independent data from GOME-2 (Global Ozone Monitoring by Earth Search) and GOME-2B (Sentinel). The verification plots include comparisons of monthly averages on maps and comparison of time series over selected regions, allowing for constant monitoring of the CAMS forecasting/analysis system.

Stratospheric ozone evaluation

Validation of CAMS stratospheric ozone (and related species) is performed with respect to independent satellite data (DMSR-IP ACE, ice-saturated level 2 ozone data) and independent model results (MOCIE, TM2009). Model evaluations are done through change logs, with a focus on changes observed for stratospheric ozone. This service also allows some monitoring of the seasonal ozone hole evolution above the poles. Change log reports look at monthly comparisons of stratospheric ozone as well as some meteorological parameters (temperature, zonal wind) forecasts (TPO).

Aerocom evaluation

The performance of the aerosol model in CAMS is double checked by evaluation plots which are made available through the Aerocom web interface. This service is a check on the observation of total Aerosol Optical Depth (AOD) and the model analysis and the four-line forecast of total AOD as well as the AOD for the various aerosol species. Time series of the observed and modelled AERocom reports are also available. It is more in depth analysis of the CAMS aerosol forecasts available [here](#).

WMO Sand and Dust Storm Warning Advisory and Assessment System

The CAMS aerosol forecasts contribute to the WMO Sand and Dust Storm Warning Advisory and Assessment System (SDS-WAS). The forecasts are verified with near-real-time AERONET data. Evaluation metrics are available on a monthly and seasonal basis. A near-real-time model comparison of contributing dust models is available.

Quality Assurance

Back to top

WMO Sand and Dust Storm Warning Advisory and Assessment System

The CAMS aerosol forecasts contribute to the WMO Sand and Dust Storm Warning Advisory and Assessment System (SDS-WAS). The forecasts are verified with near-real-time AERONET data. Evaluation metrics are available on a monthly and seasonal basis. A near-real-time model comparison of contributing dust models is available.



<https://atmosphere.copernicus.eu/global-services>

Dust Products catalogue

Dust Catalogue
Admin Login

Filters
Contribute

Parameter

Satellite

Instrument

Spectral Range

Unit

Active/Passive

Temporal Resolution

Spatial Resolution

		Data Availability											
Parameter	Satellite	Instrument	From	To	Spectral Ra...	Unit	Active/Pass...	Temporal R...	Spatial Res...	Vertical Res...	Coverage	Open Data	F
Absorption ...	PARASOL	POLDER	2005-03-01	2013-11-30	443, 490, 5...	Unitless	Passive	Seasonal	0.1 deg x 0...	Columnar	Global	Yes	L
Absorption ...	PARASOL	POLDER	2005-01-01	2013-12-31	443, 490, 5...	Unitless	Passive	Yearly	0.1 deg x 0...	Columnar	Global	Yes	L
Absorption ...	PARASOL	POLDER	2005-03-22	2013-10-11	443, 490, 5...	Unitless	Passive	Daily	1 deg x 1 deg	Columnar	Global	Yes	L
Absorption ...	PARASOL	POLDER	2005-03-01	2013-10-31	443, 490, 5...	Unitless	Passive	Monthly	1 deg x 1 deg	Columnar	Global	Yes	L
Absorption ...	PARASOL	POLDER	2005-03-01	2013-11-30	443, 490, 5...	Unitless	Passive	Seasonal	1 deg x 1 deg	Columnar	Global	Yes	L
Absorption ...	PARASOL	POLDER	2005-01-01	2013-12-31	443, 490, 5...	Unitless	Passive	Yearly	1 deg x 1 deg	Columnar	Global	Yes	L
Absorption ...	Aura	OMI	2004-10-01	Present	354, 388, 500	Unitless	Passive	Sub-daily	13 km x 24 ...	Columnar	Global	Yes	L
Absorption ...	ERS-2	ATSR-2	1995-06-01	2003-06-30	550	Unitless	Passive	Monthly	1 deg x 1 deg	Columnar	Global	Yes	L
Absorption ...	ERS-2	ATSR-2	1995-06-01	2003-06-30	550	Unitless	Passive	Monthly	1 deg x 1 deg	Columnar	Global	Yes	L
Absorption ...	ENVISAT	AATSR	2002-05-01	2012-04-30	550	Unitless	Passive	Monthly	1 deg x 1 deg	Columnar	Global	Yes	L
Absorption ...	ENVISAT	AATSR	2002-05-01	2012-04-30	550	Unitless	Passive	Monthly	1 deg x 1 deg	Columnar	Global	Yes	L
Absorption ...	Terra	MISR	2000-02-24	Present	550	Unitless	Passive	Sub-daily	4.4 km x 4...	Columnar	Global	Yes	L
Absorption ...	Terra	MISR	2000-02-25	Present	446, 558, 6...	Unitless	Passive	Daily	0.5 deg x 0...	Columnar	Global	Yes	L
Absorption ...	Terra	MISR	2000-02-25	Present	550	Unitless	Passive	Daily	0.5 deg x 0...	Columnar	Global	Yes	L
Absorption ...	ERS-2	ATSR-2	1995-06-01	2003-06-22	550	Unitless	Passive	Sub-daily	10 km x 10 ...	Columnar	Global	Yes	L
Absorption ...	ERS-2	ATSR-2	1995-06-01	2003-06-22	550	Unitless	Passive	Daily	1 deg x 1 deg	Columnar	Global	Yes	L

< 1 2 3 4 5 ... 30 >
20 / page v

International Network to Encourage the Use of Monitoring and Forecasting Dust Products (inDust) - COST Action CA16204
 Developed by ReACT, IAASARS, National Observatory of Athens

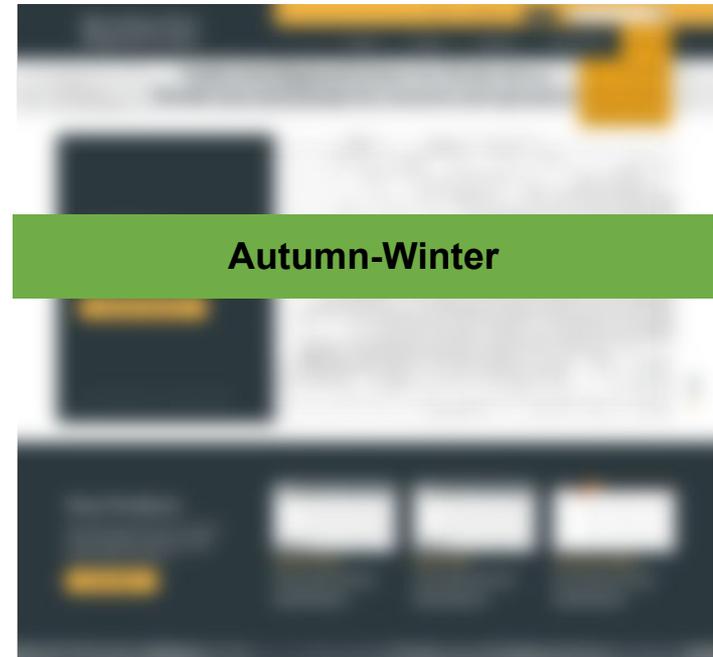
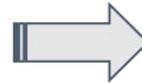
WMO Barcelona Dust Regional Center

The **WMO Barcelona Dust Regional Center** is coordinating and active in the ongoing research projects that search to produce **dust services**. Our activities are taking as a reference by the **UN SDS initiatives** that searches to help on the **mitigation of dust impacts**.

Barcelona Dust Forecast Center Operations
<http://dust.aemet.es>



SDS-WAS
R&D and operations
<http://sds-was.aemet.es>



Autumn-Winter

<http://dust.aemet.es>
[@Dust_Barcelona](#)

The work presented here it is possible thanks to the support of collaboration of the active members of the WMO SDS-WAS NAMEE Regional Node and associated researchers from NASA (i.e. AERONET, MODIS) as well as the inDust networks.

Upcoming event

WEBINAR SERIES

17 NOVEMBER 2021
15:00 - 16:00 CET

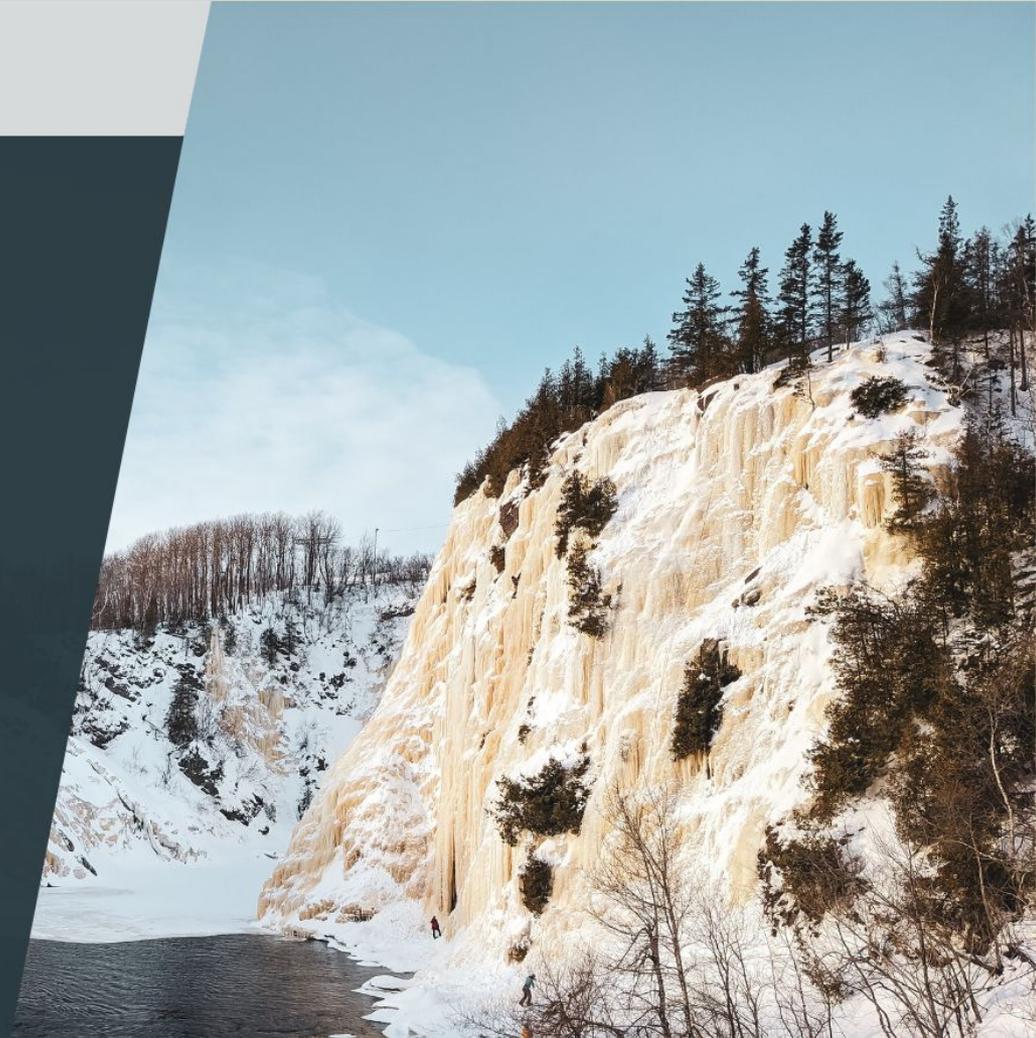
DUST IMPACTS ON SNOW

Marie Dumont
UMR CNRS & Météo-France



Barcelona Dust
Regional Center

inDust



Registrations and upcoming events: <https://cost-indust.eu/events/indust-events>

 @Dust_Barcelona





**Barcelona
Supercomputing
Center**
Centro Nacional de Supercomputación



AXA
Research Fund



Copernicus
Europe's eyes on Earth



**Atmosphere
Monitoring Service**

AEMet
Agencia Estatal de Meteorología



inDust

Thank you

Acknowledge to Carlos Pérez García-Pando, Emilio Cuevas, Slodoban Nickovic, Francesco Benincasa, Enza DiTomaso, Oriol Jorba, Paul Ginoux as well as AERONET, MODIS, U.K. Met Office MSG, MSG Eumetsat and EOSDIS World Viewer principal investigators and scientists for establishing and maintaining data used in the present contribution. Also special thank to all researchers, data providers and collaborators of the WMO SDS-WAS NA-ME-E Regional Node and CAMS-84 global validation team.

The source of some of the movies and information in this presentation is the COMET® Website at <http://meted.ucar.edu/> of the University Corporation for Atmospheric Research (UCAR), sponsored in part through cooperative agreement(s) with the National Oceanic and Atmospheric Administration (NOAA), U.S. Department of Commerce (DOC) © 2007-2011 University Corporation for Atmospheric Research. All Rights Reserved.

sara.basart@bsc.es