www.bsc.es

Barcelona Supercomputing Center
Centro Nacional de Supercomputación

Dust Forecast Services

WMO SDS-WAS and Barcelona Dust Forecast Center

Francesco Benincasa

Teheran, 8th of November 2016


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Barcelona
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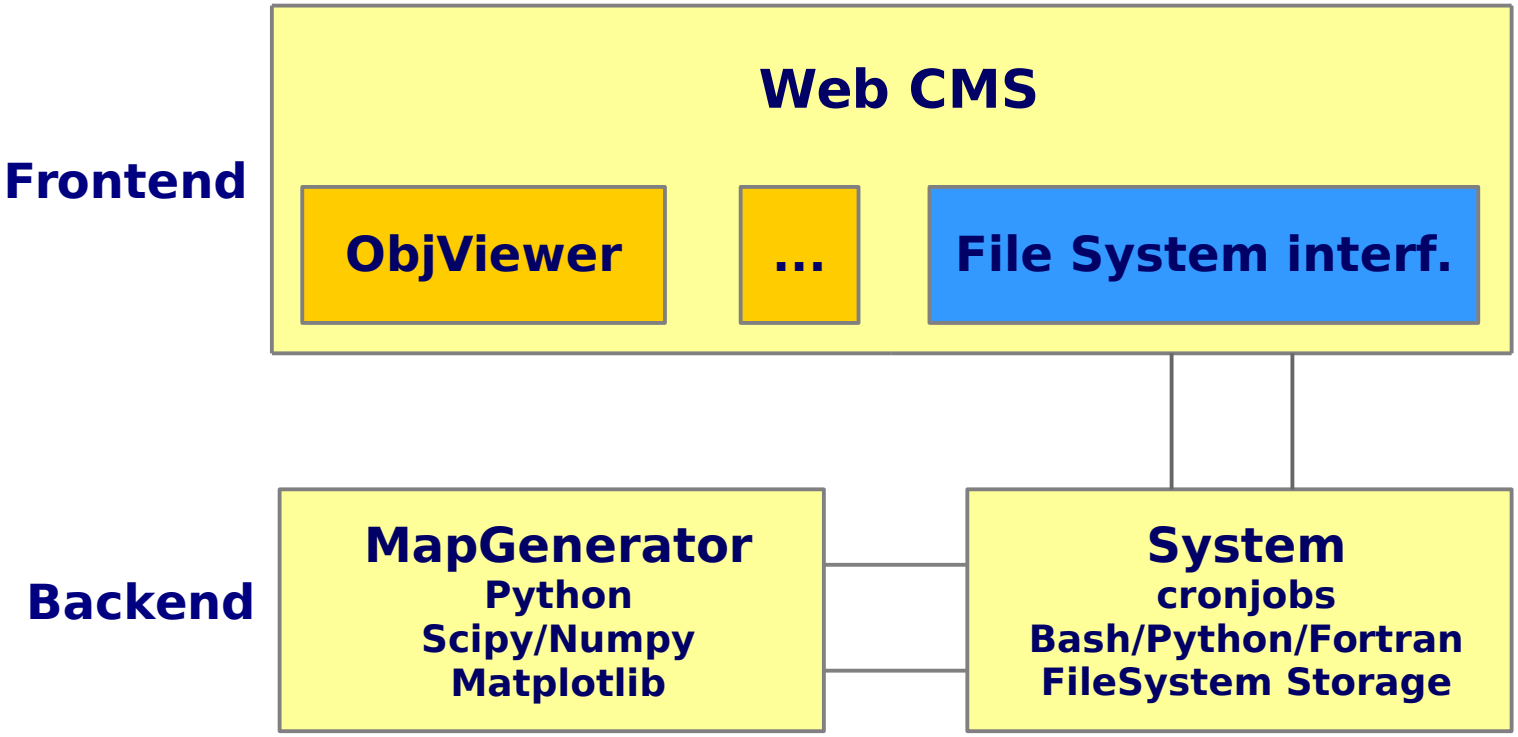
OUTLINE

OUTLINE

- WMO SDS-WAS NA-ME-E Regional Center
- Barcelona Dust Forecast Center
- Data visualization
- Data manipulation

Current Architecture



System

- Bash: scheduled download of
  - Forecast data (12 models for SDS, 1 for BDFC)
  - Forecast images (UK MetOffice, ...)
  - Observation data (txt, csv, xml, ...)
  - Observation images (UK MetOffice, EUMETSAT, ...)
- Python:
  - Normalize data to local standard (NetCDF regular lat lon)
  - Export to other formats (GRIB1/2, ...)
  - Communications between frontend and backend
- Fortran:
  - Regrid to a common resolution
  - Calculate evaluation scores (BIAS, RMSE, ...)

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WMO SDS-WAS NA-ME-E Regional Center

WMO SDS-WAS NA-ME-E Regional Center

Log in Register

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

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Latest News

Workshop on Meteorology, Sand and Dust Storm, Combating Desertification and Erosion: Presentations and Pictures

Nov 12, 2013

Workshop on Meteorology, Sand and Dust Storm (SDS), Combating Desertification and Erosion held in Istanbul, Turkey

Nov 08, 2013

Establishing a WMO SDS-WAS Regional Node for West Asia: Current Capabilities and Needs

You are here: Home

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

by Francesco Benincasa — last modified May 29, 2012 03:33 PM

Outstanding

Barcelona will host the first WMO Regional Meteorological Center specialized on Atmospheric Sand and Dust Forecast

Training events in Muscat, Oman

Files Download

Compared dust forecasts

Subscribe to the Public Newsletter!

To be informed about our activities, news and events related to dust. Frequency is almost monthly.

Full Name

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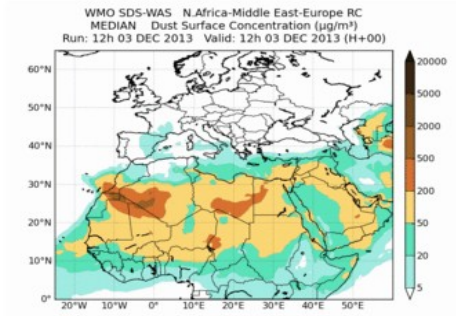
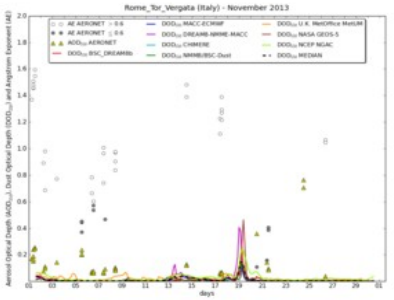
Dust forecasts

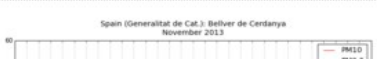


Compared Dust Forecasts



Forecast Evaluation

Dust observations



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WMO SDS-WAS NA-ME-E Regional Center

Retrieving

- Data models from 12 contributions of 11 institutions of 9 countries (Spain, UK, Serbia, US, Egypt, Italy, Greece, Norway, Netherlands) with 2 variables (SCONC_DUST, OD550_DUST)
- Data observations (AERONET, MODIS, MODIS DB, ...)
- External observationals products (MSG RGB EUMETSAT, MSG UK MetOffice, Debra-Dust)

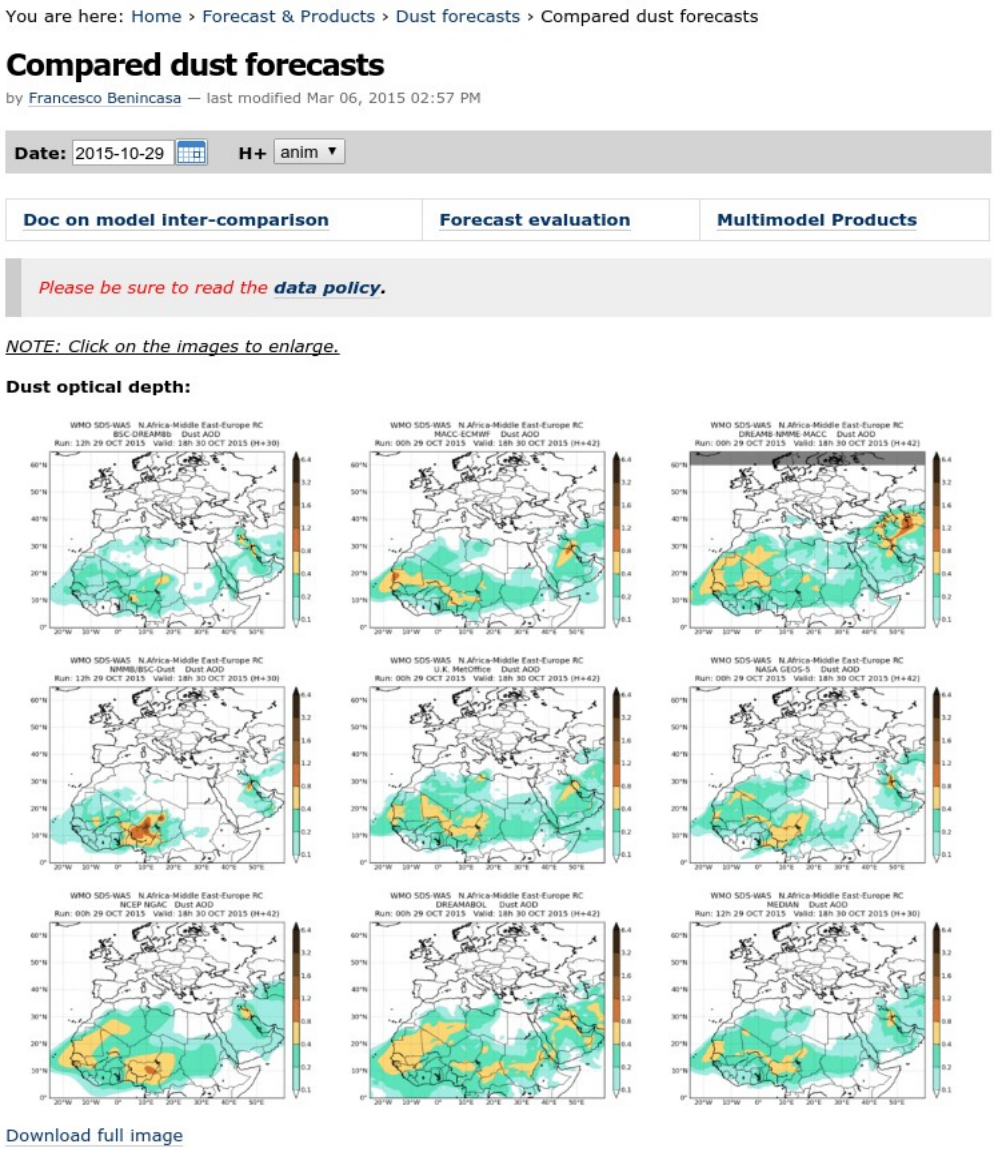
WMO SDS-WAS NA-ME-E Regional Center

Producing

- Dust forecasts of 2 variables (Surface concentration and Aerosol optical depth) of numerical models + 4 multi-model products
- Models evaluation against observations
- Guidance for forecasters
- Time averaged values
- Studies of dust episodes
- Workshops, training courses and seminars (with materials)

WMO SDS-WAS NA-ME-E Regional Center

- http://sds-was.aemet.es
  - ***Browsable*** images
    - Forecast



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WMO SDS-WAS NA-ME-E Regional Center

- http://sds-was.aemet.es
  - ***Browsable*** images
    - Forecast
    - Multimodel

You are here: Home › Forecast & Products › Dust forecasts › Multimodel Products

Multimodel Products

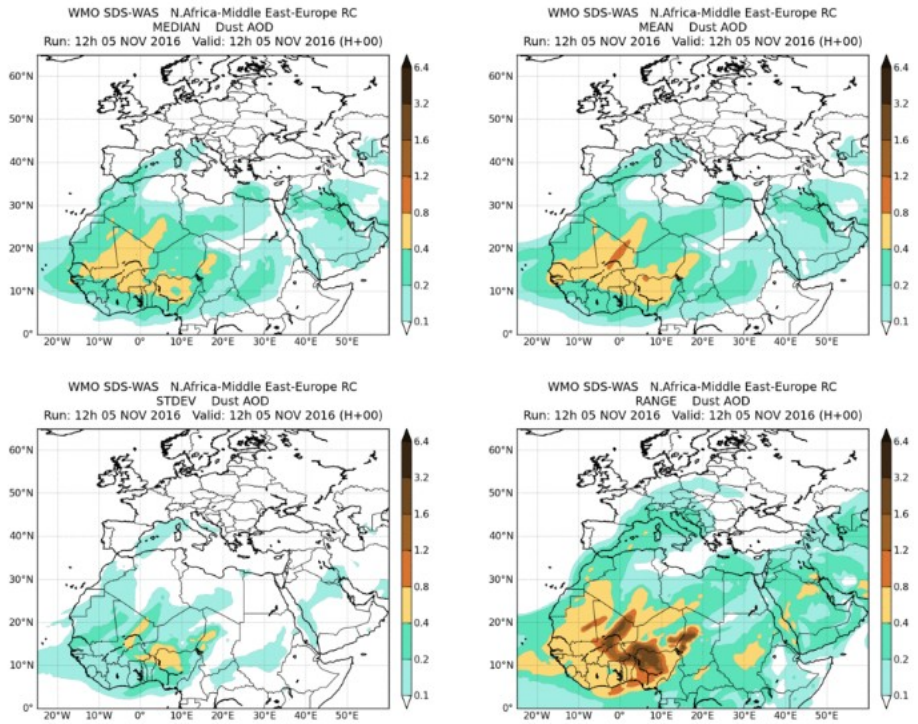
by Francesco Benincasa — last modified Oct 14, 2014 12:30

Date: 2016-11-05 **H+** anim

Compared dust forecasts
Evaluation of the multi-model median

NOTE: Click on the images to enlarge.

Dust optical depth:



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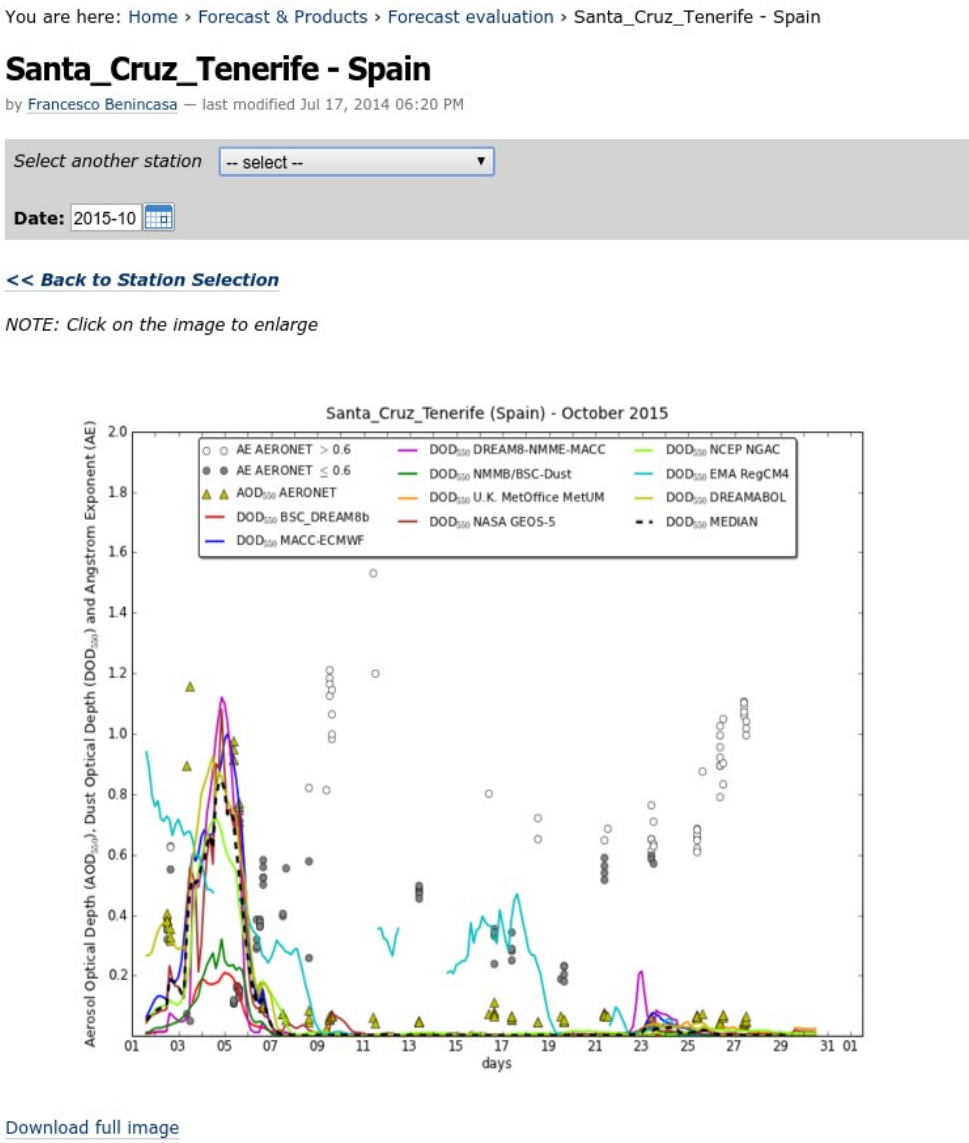
- http://sds-was.aemet.es
  - ***Browsable*** images
    - Forecast
    - Multimodel
    - Evaluation
      - AERONET



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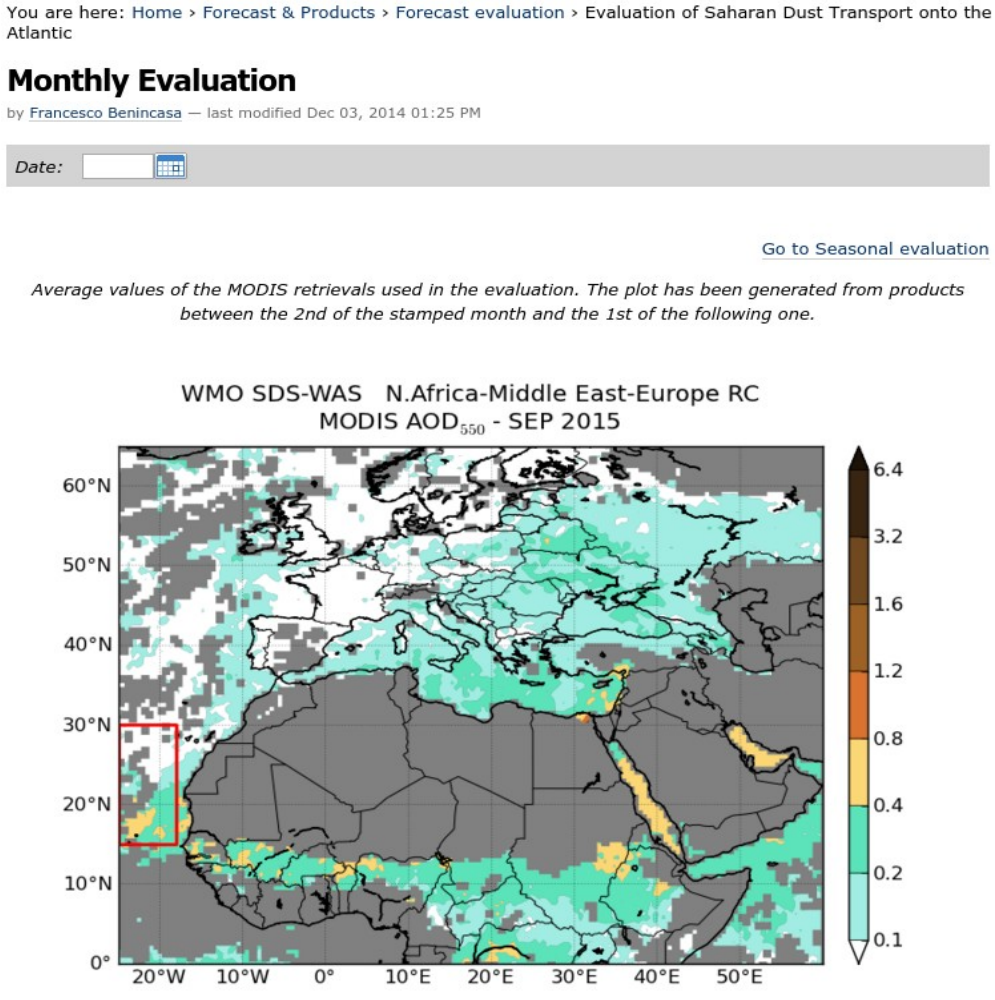
  - ***Browsable*** images
    - Forecast
    - Multimodel
    - Evaluation
      - AERONET
      - MODIS



	BIAS	ROOT MEAN SQUARE ERROR	CORRELATION COEFFICIENT	FRACTIONAL GROSS ERROR	NUMBER OF CASES
BSC_ DREAM8b	**-0.15**	**0.19**	**0.80**	**1.14**	**1239**

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- http://sds-was.aemet.es
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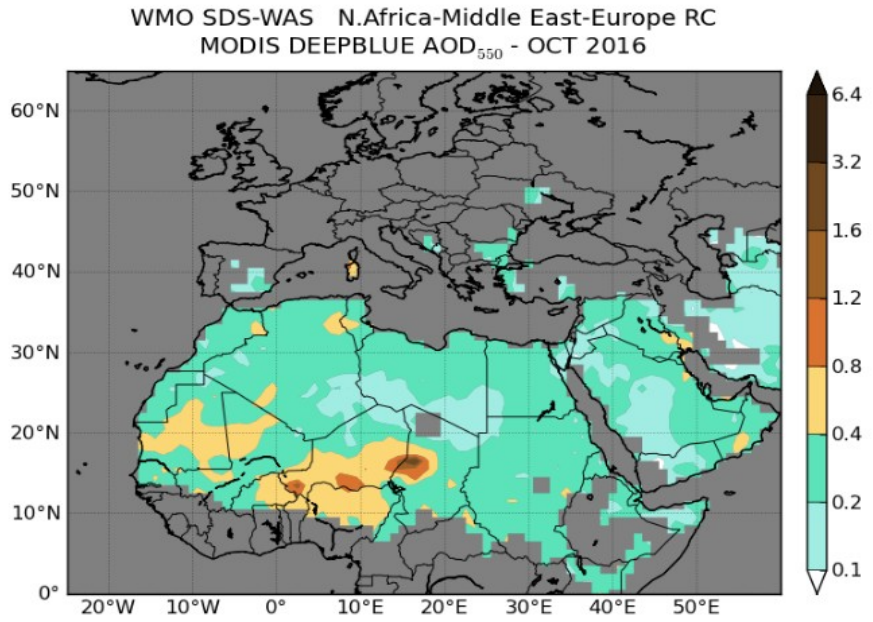
    - Forecast
    - Multimodel
    - Evaluation
      - AERONET
      - MODIS
      - MODIS DB

Monthly Evaluation

by Francesco Benincasa — last modified Jul 29, 2014 06:50

Date:

Average values of the MODIS retrievals used in the evaluation (data with an Angstrom exponent above 1.0 have not been considered).The plot has been generated from products between the 2nd of the stamped month and the 1st of the following one.



Download full image

	BIAS	ROOT MEAN SQUARE ERROR	CORRELATION COEFFICIENT	FRACTIONAL GROSS ERROR	NUMBER OF CASES
BSC_ DREAM8b	**-0.13**	**0.23**	**0.45**	**0.67**	**17766**

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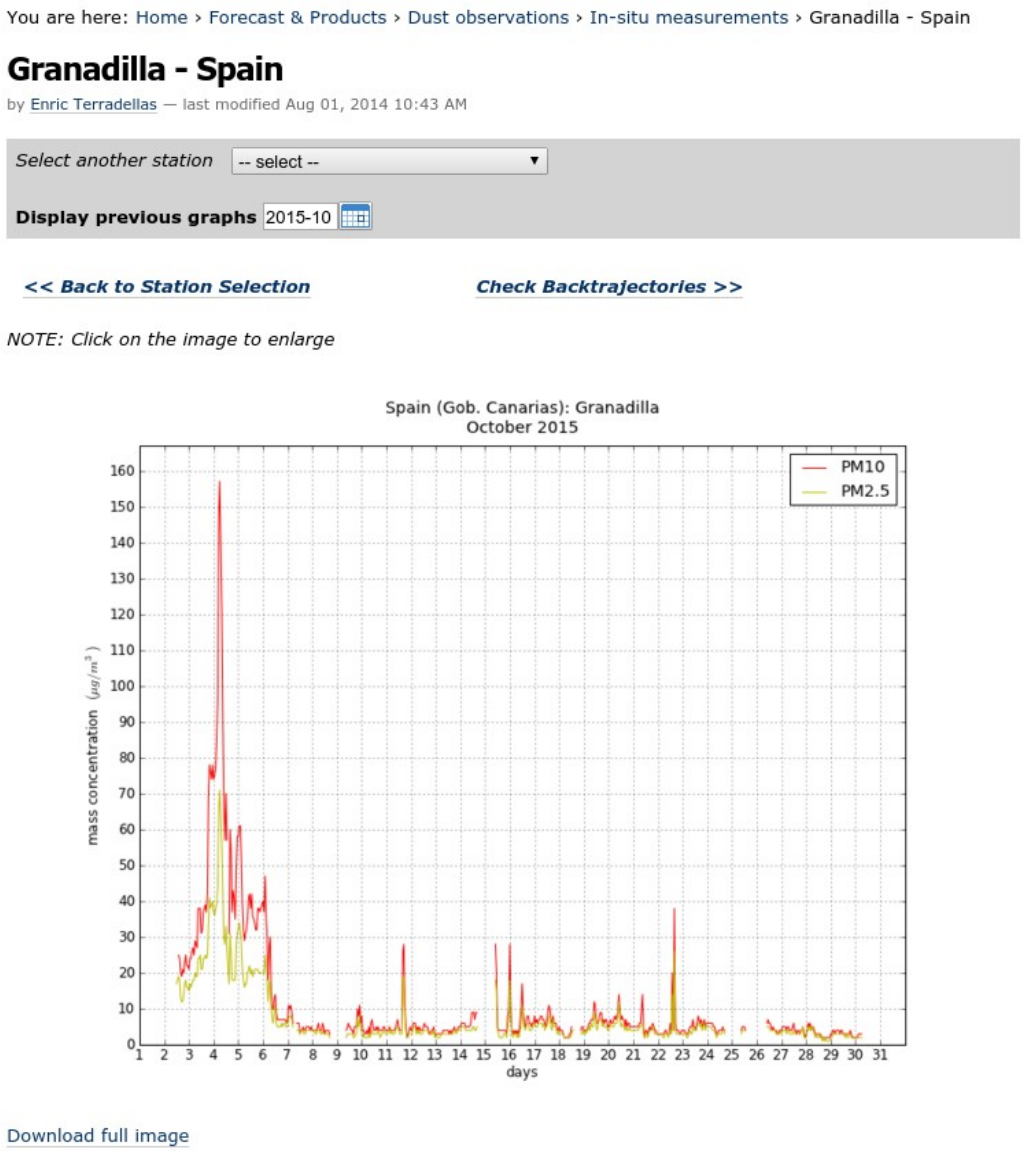
- http://sds-was.aemet.es
  - ***Browsable*** images
    - Observacions
      - In situ



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- http://sds-was.aemet.es
  - ***Browsable*** images
    - Observacions
      - In situ
      - MSG UK MO

You are here: Home › Forecast & Products › Dust observations › MSG – U.K. Met Office

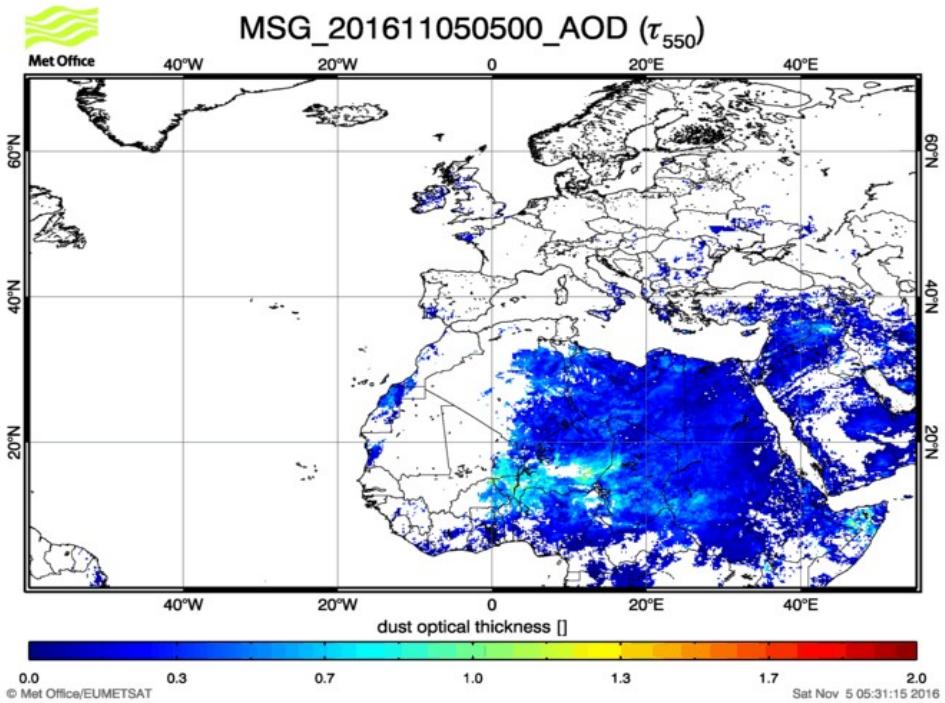
MSG – U.K. Met Office

by Francesco Benincasa — last modified Feb 12, 2013 02:03

Date: 2016-11-05 anim

The U.K. Met Office MSG dust product shows an estimation of the dust optical thickness retrieved from empirical relationship between SEVIRI infrared (10.8 μm) radiance and aerosol optical depth at 550nm. It is generated by transforming original retrievals to regularly-spaced grids (0.18 degree) using simple average method.

WARNING: Some level of cloud contamination may exist in the MSGAOD product due to the lack of temporal differencing scheme in the cloud processing. These artefacts are predominant over the Sahel and southern latitudes.



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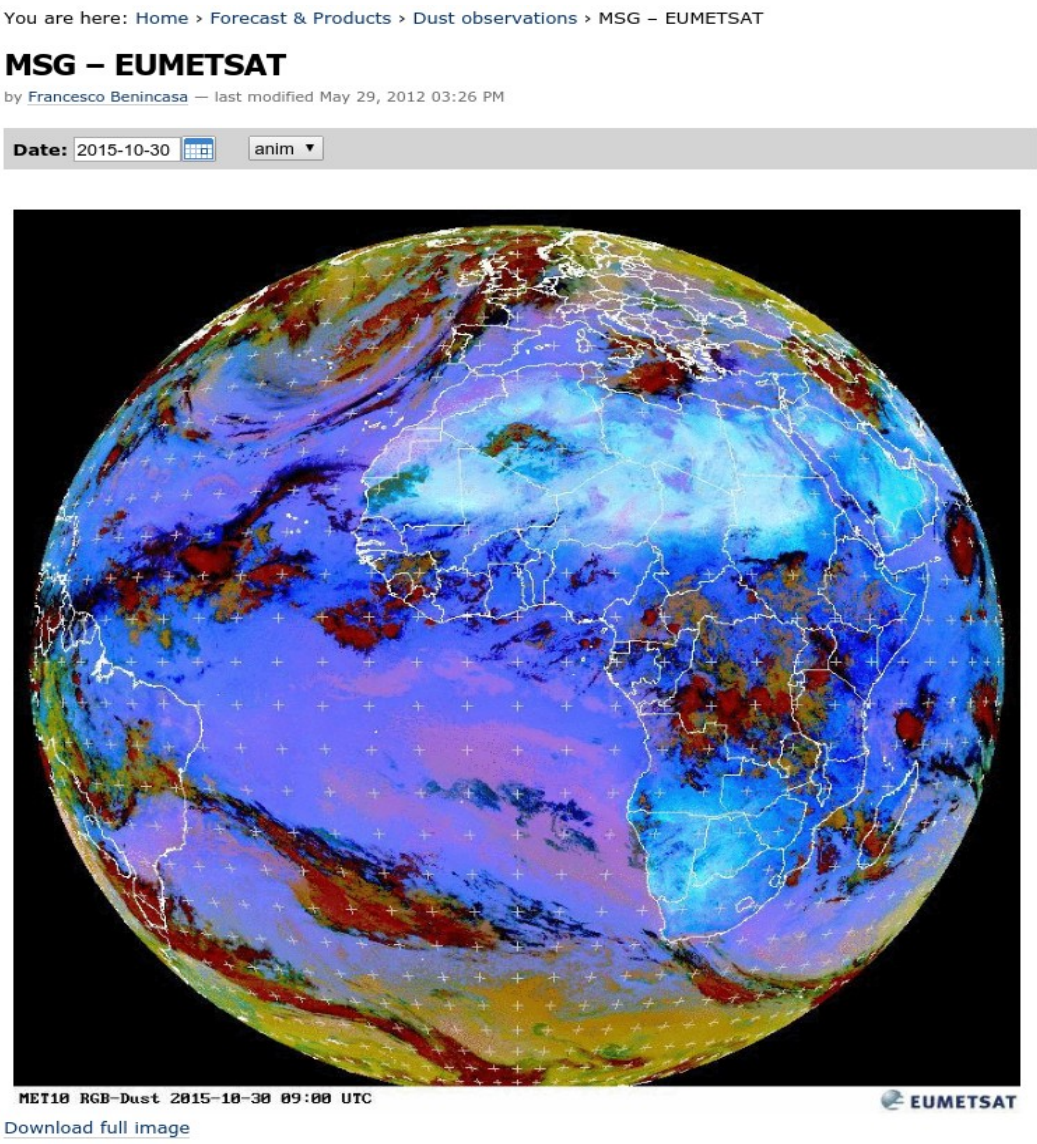
      - MSG UK MO
      - MSG EUMETSAT



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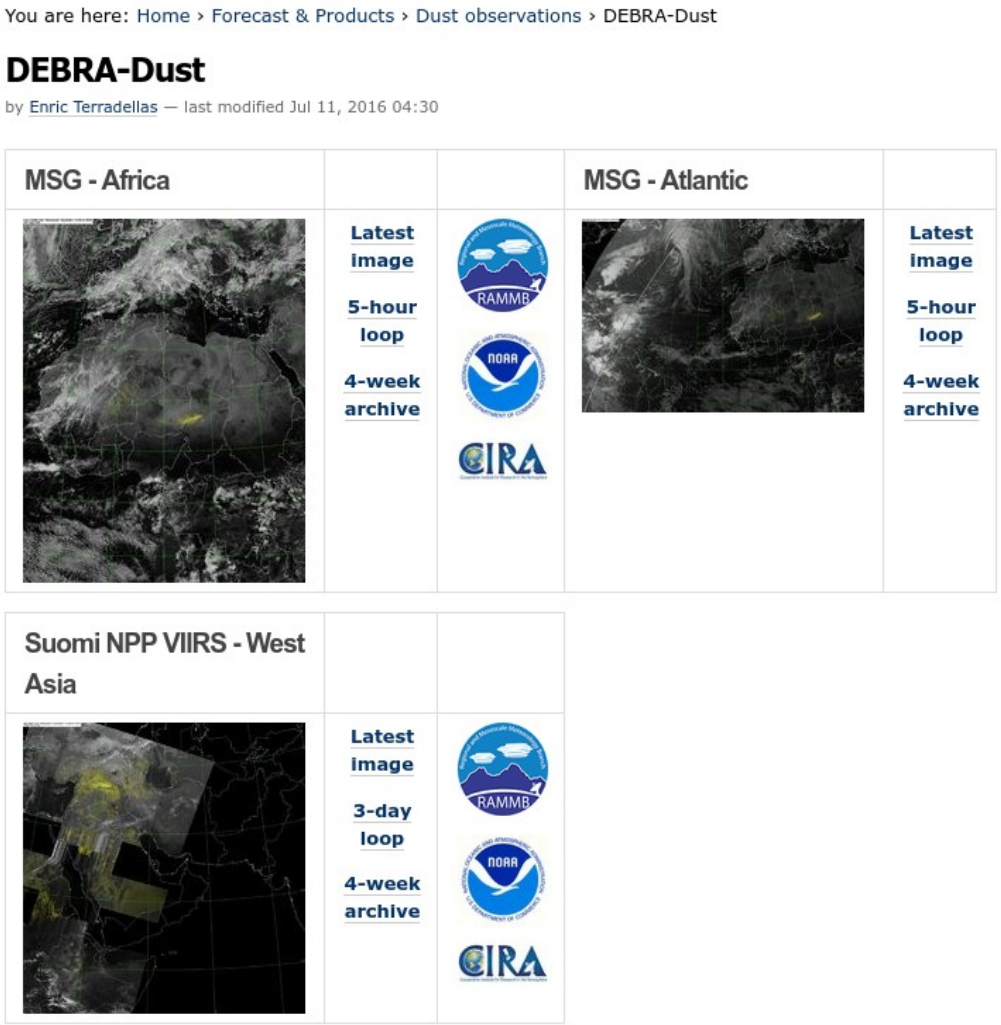
  - ***Browsable*** images
    - Observacions
      - In situ
      - MSG UK MO
      - MSG EUMETSAT
      - Debra-Dust



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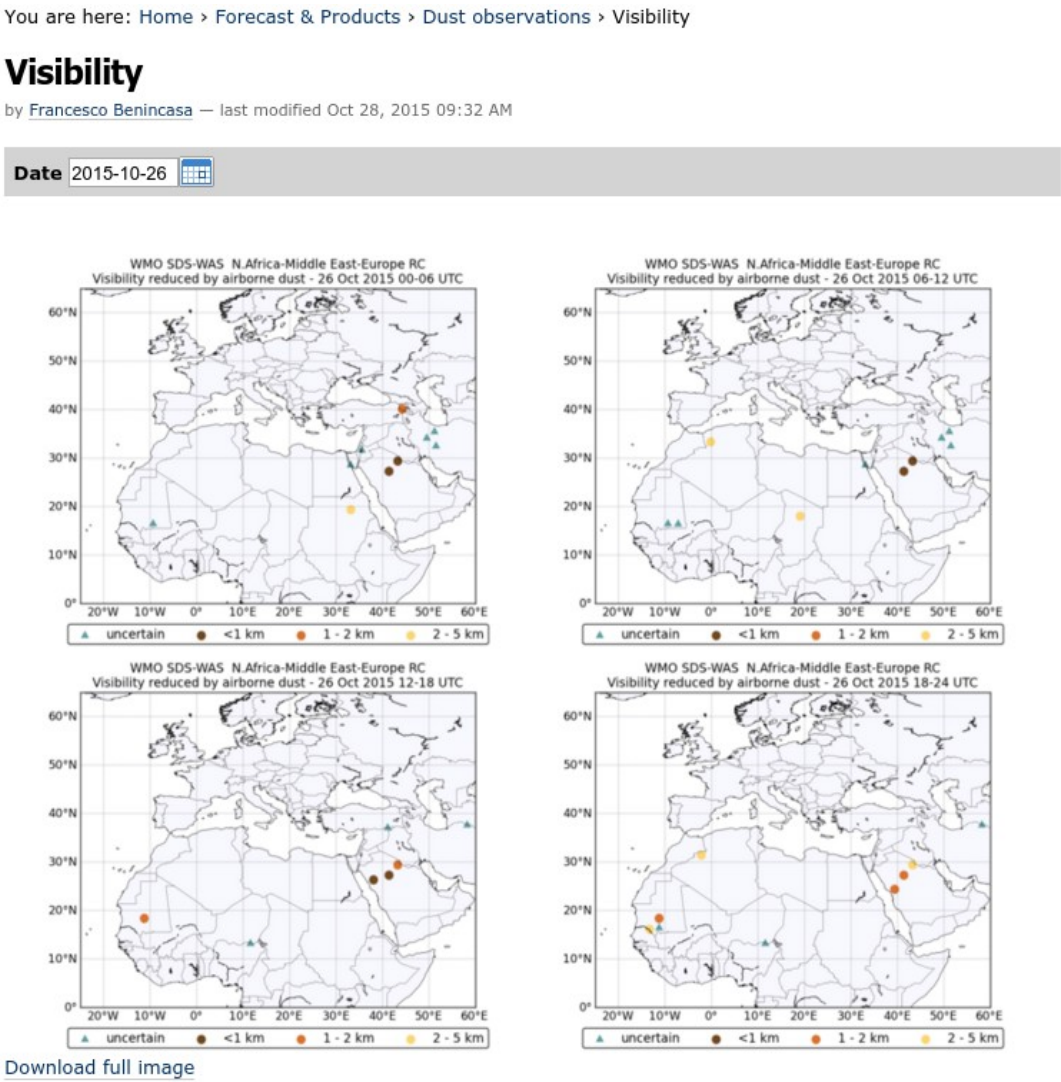
    - Observacions
      - In situ
      - MSG UK MO
      - MSG EUMETSAT
      - Debra-Dust
      - Visibility



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- http://sds-was.aemet.es
  - Numerical evaluation scores archive

Monthly scores

by Francesco Benincasa — last modified Nov 27, 2014 11:51 AM

Date:

Sep 2015. Dust Optical Depth.
Threshold Angstrom Exponent = 0.600

BIAS

	BSC_ DREAM8b	MACC-ECMWF	DREAM8-NMME-MACC	NMMB/BSC-Dust	U.K. Met Office	NASA GEOS-5	NCEP NGAC	EMA RegCM4	DREAM ABOL	MEDIAN
Sahel/Sahara show stations	**-0.28**	**-0.16**	**-0.12**	**-0.32**	**N/A**	**-0.20**	**-0.09**	**-0.05**	**0.02**	**-0.17**
Middle East show stations	**-0.28**	**-0.24**	**-0.22**	**-0.46**	**N/A**	**-0.27**	**-0.36**	**-0.23**	**0.02**	**-0.27**
Mediterranean show stations	**-0.31**	**-0.24**	**-0.23**	**-0.36**	**N/A**	**-0.25**	**-0.22**	**-0.20**	**-0.16**	**-0.26**
TOTAL	**-0.30**	**-0.20**	**-0.18**	**-0.35**	**N/A**	**-0.23**	**-0.17**	**-0.13**	**-0.06**	**-0.22**

ROOT MEAN SQUARE ERROR

	BSC_ DREAM8b	MACC-ECMWF	DREAM8-NMME-MACC	NMMB/BSC-Dust	U.K. Met Office	NASA GEOS-5	NCEP NGAC	EMA RegCM4	DREAM ABOL	MEDIAN
Sahel/Sahara hide stations	**0.48**	**0.42**	**0.41**	**0.50**	**N/A**	**0.43**	**0.40**	**0.49**	**0.42**	**0.42**
Capo_Verde	0.27	0.12	0.17	0.31	N/A	0.19	0.16	0.30	0.17	0.16
Dakar	0.60	0.48	0.44	0.65	N/A	0.51	0.43	0.51	0.43	0.48
IER_Cinzana	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Banizoumbou	0.67	0.60	0.56	0.68	N/A	0.60	0.56	0.59	0.54	0.58
Zinder_Airport	0.23	0.19	0.14	0.26	N/A	0.21	0.15	0.34	0.28	0.17
Santa_Cruz_ Tenerife	0.10	0.12	0.13	0.14	N/A	0.10	0.10	0.25	0.17	0.11
Zouerate-Fennec	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Tamanrasset_ INM	0.35	0.20	0.24	0.37	N/A	0.25	0.23	0.34	0.37	0.22

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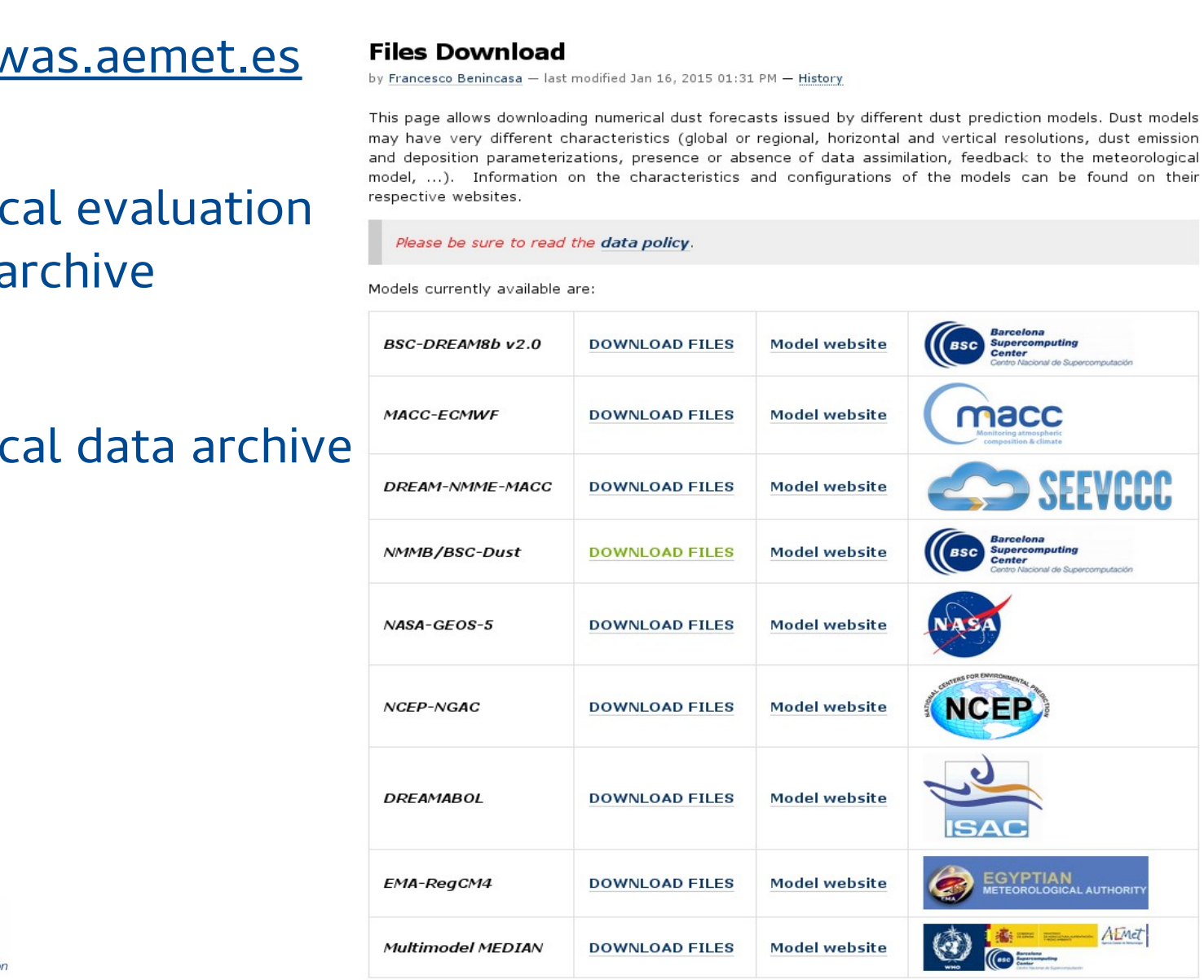
- http://sds-was.aemet.es
  - Numerical evaluation scores archive
  - Numerical data archive



Files Download

by Francesco Benincasa — last modified Jan 16, 2015 01:31 PM — History

This page allows downloading numerical dust forecasts issued by different dust prediction models. Dust models may have very different characteristics (global or regional, horizontal and vertical resolutions, dust emission and deposition parameterizations, presence or absence of data assimilation, feedback to the meteorological model, ...). Information on the characteristics and configurations of the models can be found on their respective websites.

*Please be sure to read the **data policy**.*

Models currently available are:

BSC-DREAM8b v2.0	DOWNLOAD FILES	Model website	Barcelona Supercomputing Center
MACC-ECMWF	DOWNLOAD FILES	Model website	macc
DREAM-NMME-MACC	DOWNLOAD FILES	Model website	SEEVCCC
NMMB/BSC-Dust	DOWNLOAD FILES	Model website	Barcelona Supercomputing Center
NASA-GEOS-5	DOWNLOAD FILES	Model website	NASA
NCEP-NGAC	DOWNLOAD FILES	Model website	NCEP
DREAMABOL	DOWNLOAD FILES	Model website	ISAC
EMA-RegCM4	DOWNLOAD FILES	Model website	EGYPTIAN METEOROLOGICAL AUTHORITY
Multimodel MEDIAN	DOWNLOAD FILES	Model website	

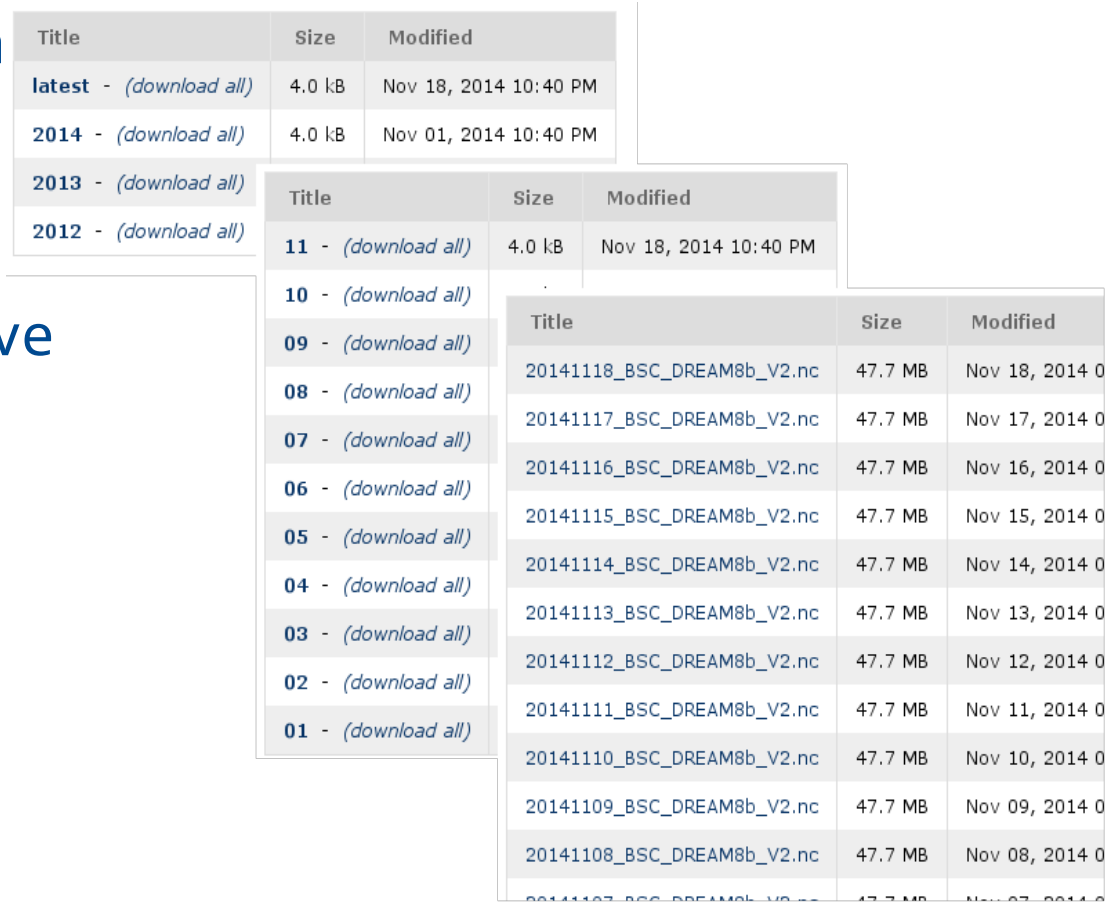
WMO SDS-WAS NA-ME-E Regional Center

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

  - Numerical evaluation scores archive

  - Numerical data archive

  - Data download



Title	Size	Modified
latest - *(download all)*	4.0 kB	Nov 18, 2014 10:40 PM
2014 - *(download all)*	4.0 kB	Nov 01, 2014 10:40 PM
2013 - *(download all)*		
2012 - *(download all)*		

Title	Size	Modified
11 - *(download all)*	4.0 kB	Nov 18, 2014 10:40 PM
10 - *(download all)*		
09 - *(download all)*		
08 - *(download all)*		
07 - *(download all)*		
06 - *(download all)*		
05 - *(download all)*		
04 - *(download all)*		
03 - *(download all)*		
02 - *(download all)*		
01 - *(download all)*		

Title	Size	Modified
20141118_BSC_DREAM8b_V2.nc	47.7 MB	Nov 18, 2014 0
20141117_BSC_DREAM8b_V2.nc	47.7 MB	Nov 17, 2014 0
20141116_BSC_DREAM8b_V2.nc	47.7 MB	Nov 16, 2014 0
20141115_BSC_DREAM8b_V2.nc	47.7 MB	Nov 15, 2014 0
20141114_BSC_DREAM8b_V2.nc	47.7 MB	Nov 14, 2014 0
20141113_BSC_DREAM8b_V2.nc	47.7 MB	Nov 13, 2014 0
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20141108_BSC_DREAM8b_V2.nc	47.7 MB	Nov 08, 2014 0

WMO SDS-WAS NA-ME-E Regional Center

- Data files download

  First step: REGISTER to the portal (go to home page and click on the top-right link – temporally suspended, send and email to sdswas@aemet.es)

  Go to data download page and download manually: follow model link and choose year, month and/or day …

WMO SDS-WAS NA-ME-E Regional Center

- Data files download

  ... or download automatically with a program (i.e. WGET):

  a single file:

```
wget --http-user="YOUR_REGISTRATION_EMAIL" --http-password="YOUR_REGISTRATION_PASSWORD"
     --auth-no-challenge http://MODEL_REPOSITORY_URL/YYYY/MM/YYYYMMDDMODEL_NAME.nc
```

  an entire month/year:

```
wget --http-user="YOUR_REGISTRATION_EMAIL" --http-password="YOUR_REGISTRATION_PASSWORD"
     --auth-no-challenge http://MODEL_REPOSITORY_URL/YYYY/MM/@@download -O FILENAME.zip
```

  the latest file:

```
wget --http-user="YOUR_REGISTRATION_EMAIL" --http-password="YOUR_REGISTRATION_PASSWORD"
     --auth-no-challenge http://MODEL_REPOSITORY_URL/latest/@@download -O FILENAME.zip
```

WMO SDS-WAS NA-ME-E Regional Center

Materials

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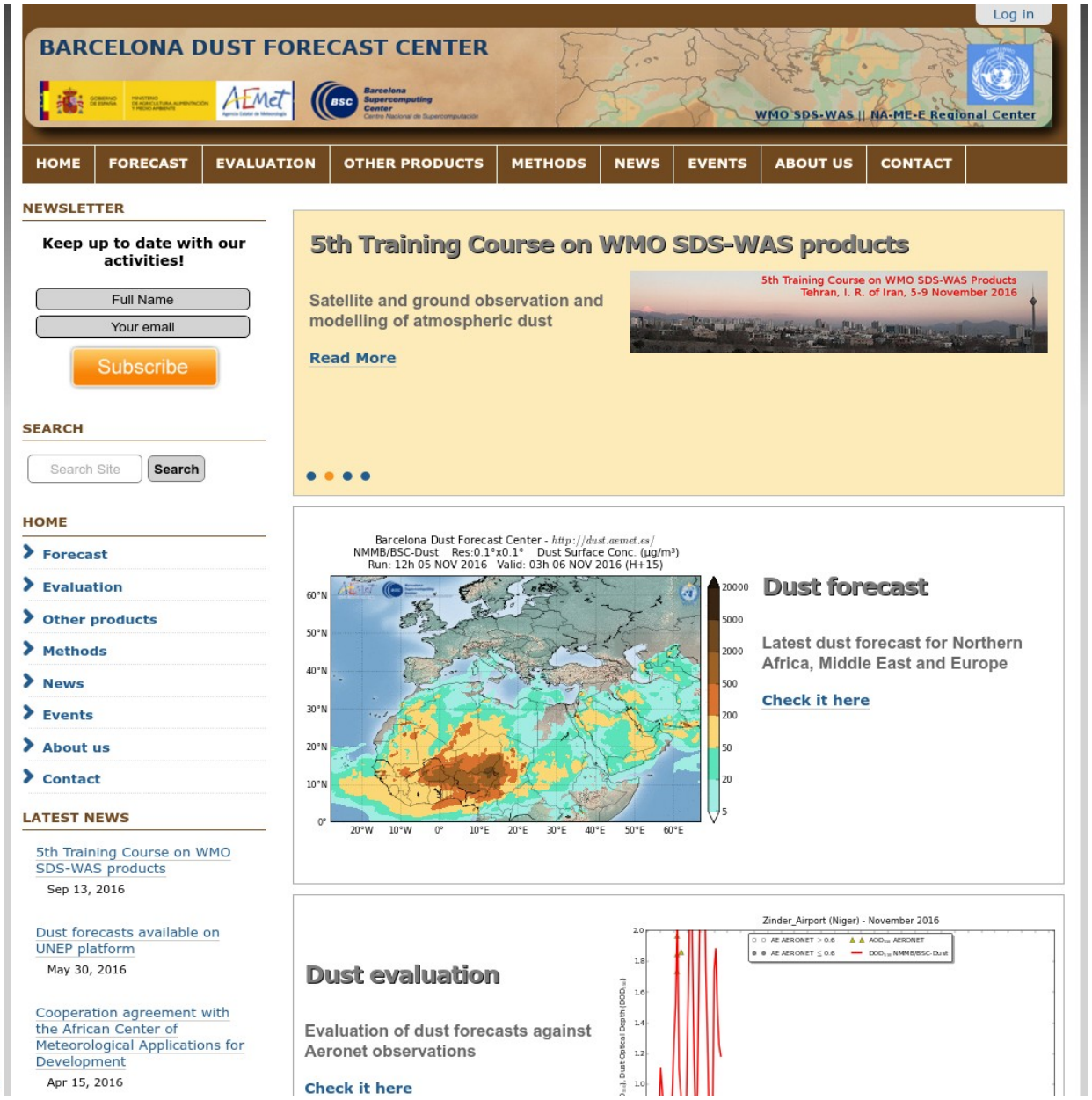


Barcelona Dust Forecast Center

- Operational center
  - Operated by BSC and AEMET
  - Officially recognized by the WMO
  - 72 hours forecast (3-hourly) model developed at BSC
  - 6 variables (Optical depth, Dry and Wet deposition, Load, Surface concentration, Surface extinction)

Barcelona Dust Forecast Center

- http://dust.aemet.es

- Products
  - Forecast images
  - Google Earth integration (KML/KMZ files)
  - Averaged values images
  - Zoomed area forecast images (Spain, Burkina Faso, ...)

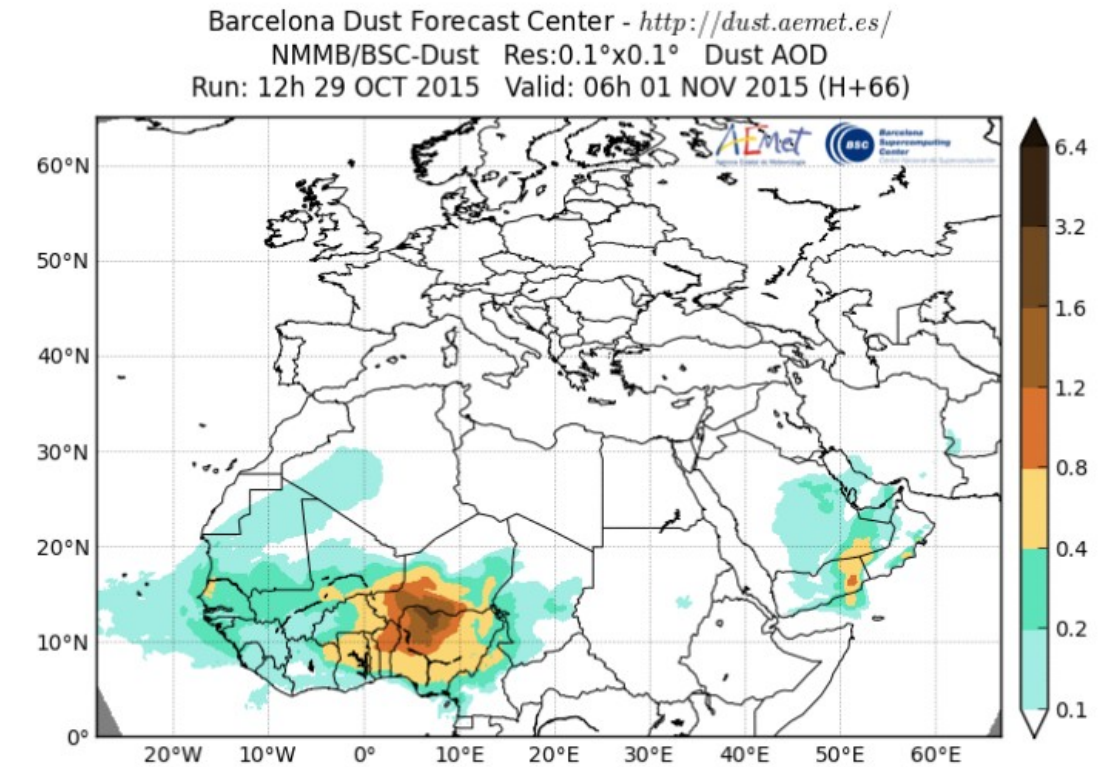
Barcelona Dust Forecast Center

You are here: Home / Forecast

Dust Optical Depth

Date 2015-10-29 H+ anim Variable Dust Optical Depth

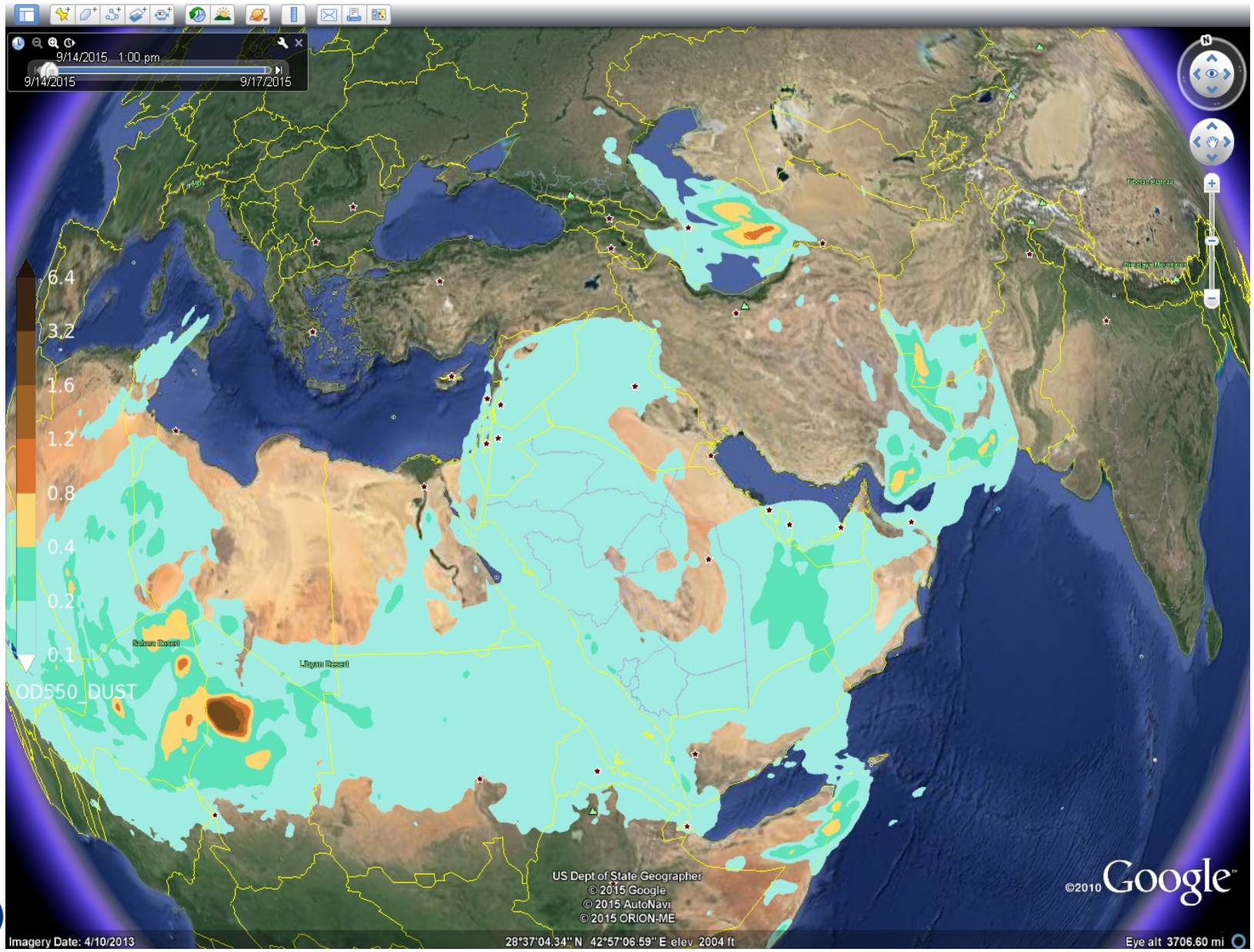
The NMMB/BSC-Dust model



▶ Download image ▶ KML - Online ▶ KMZ - Offline

What are KML/KMZ files?

Barcelona Dust Forecast Center



Barcelona Dust Forecast Center

You are here: Home / Other products / Averaged values

Monthly averaged values

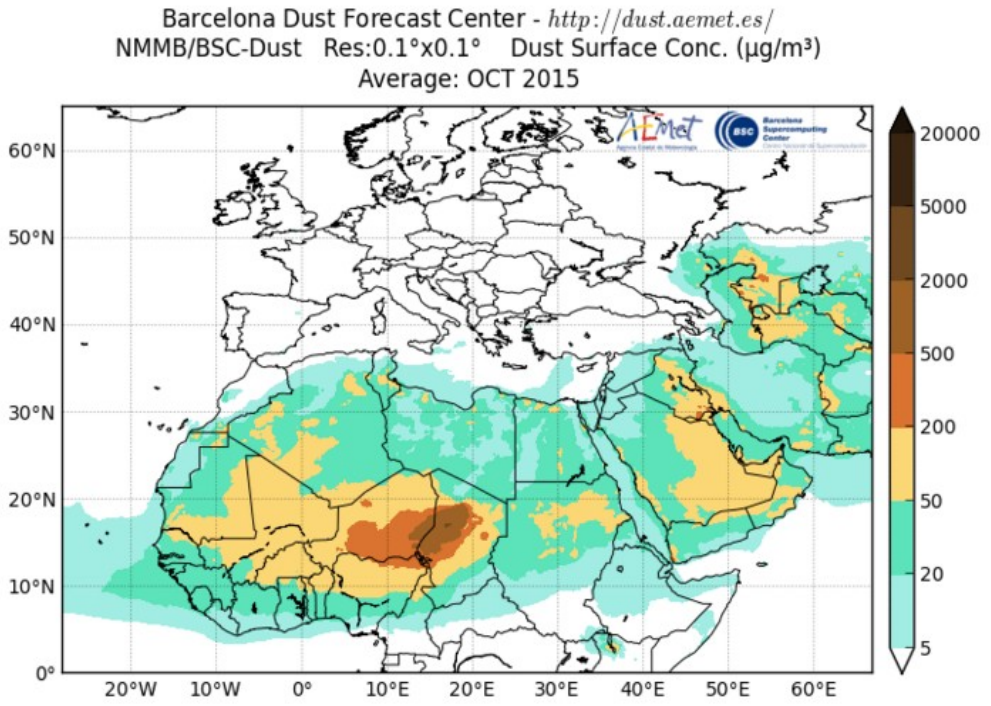
Monthly averaged values of dust surface concentration and dust load computed from the daily runs of the NMMB/BSC-Dust model.

Date 2015-10

Methods: Time-averaged values

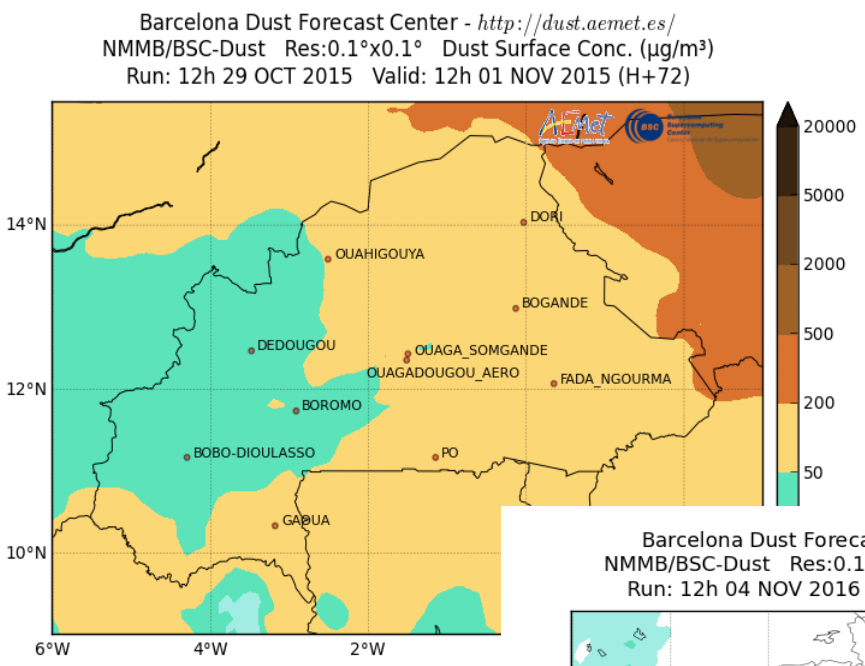
NOTE: Click on the images to enlarge

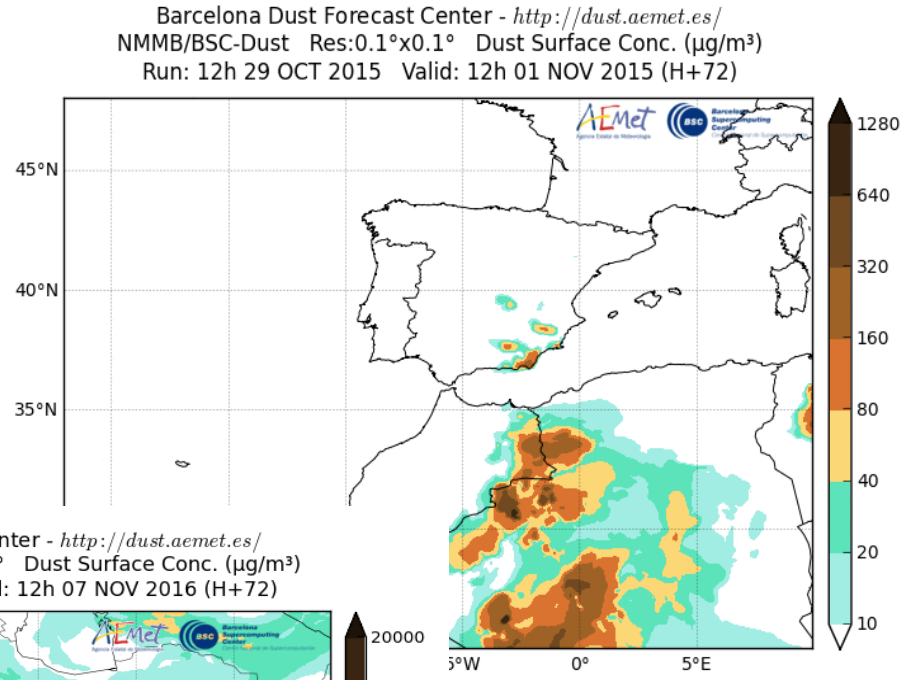
Monthly Averaged Dust Surface Concentration (µm/m³)

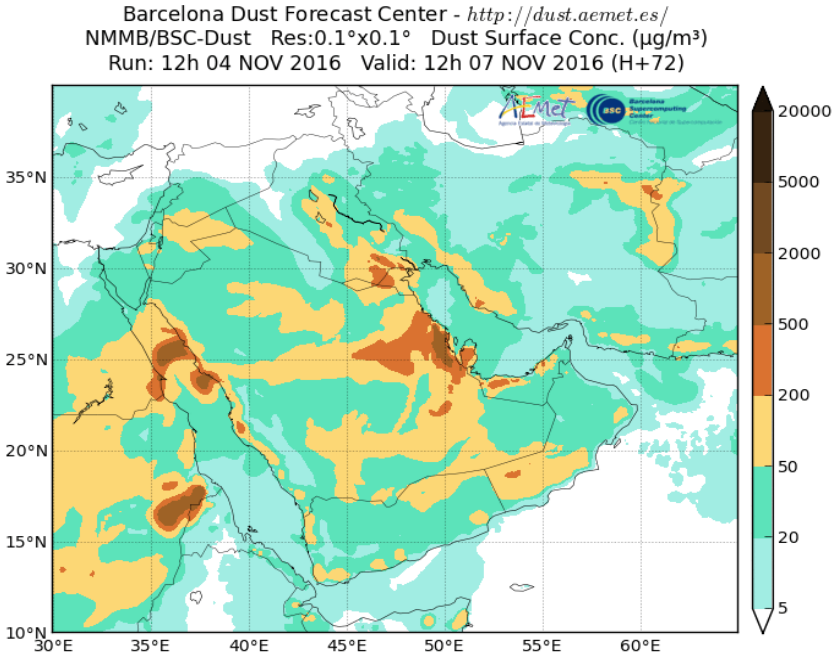


▶ Download image

Barcelona Dust Forecast Center







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Barcelona Dust Forecast Center

- Services
  - Forecast images dissemination
    - WMO GTS (Global Telecommunication System)
    - EUMETCast (EUMETSAT's primary dissemination mechanism)
    - UNEPlive
  - News & Events, Newsletter

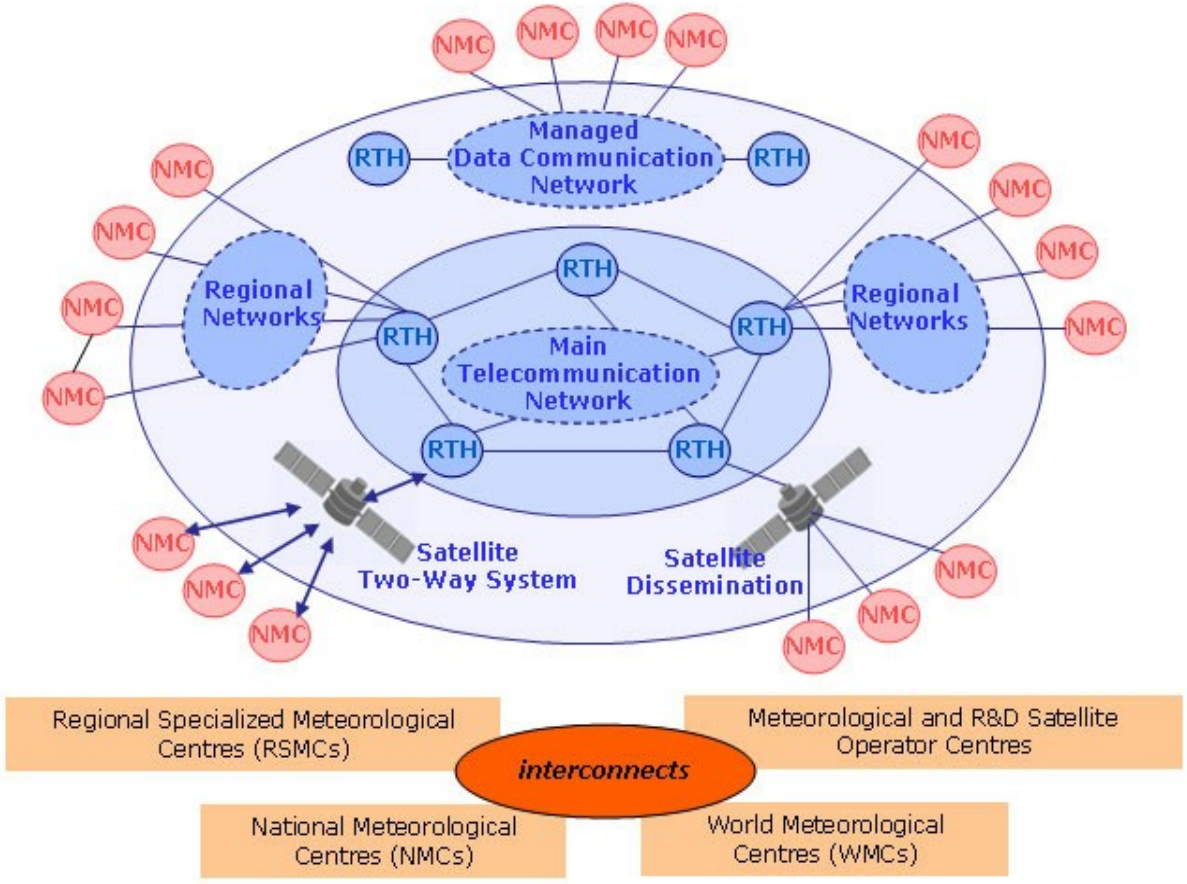
Barcelona Dust Forecast Center

WMO GTS

- Global network for transmission of meteorological data
- Data proceeding from weather stations, satellites and NWP centres
- Implemented and operated by
  - National meteorological services
  - Other international organizations (ECMWF, EUMETSAT, ...)

Barcelona Dust Forecast Center

WMO GTS



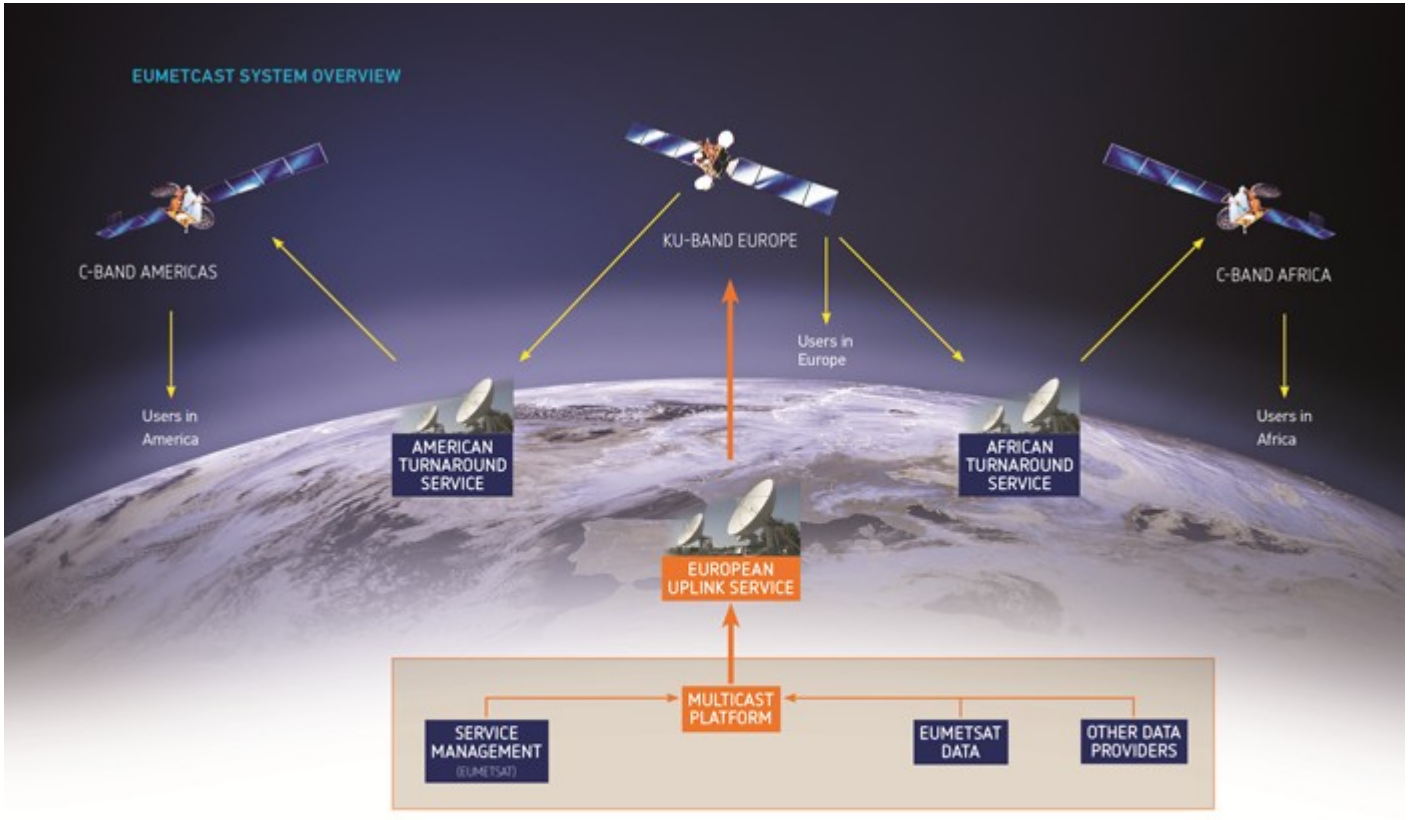
Barcelona Dust Forecast Center

EUMETCast

- Multi-service dissemination system based on standard Digital Video Broadcast (DVB) technology
- It uses commercial telecommunication geostationary satellites
- Multi-cast files (data and products) to a wide user community
- From 15th of October 2015 **BDFC** products are distributed over Europe and Africa

Barcelona Dust Forecast Center

EUMETCast



Barcelona Supercomputing Center
Centro Nacional de Supercomputación

Data visualization

Data visualization

- Grid Analysis and Display System (GrADS)
- Ncview
- McIDAS
- ECMWF MetView
- Panoply data viewer
- MapGenerator (Python-based, home-made)

Data visualization – MapGenerator

- Problem
  - Need to show results with high quality plots for an operational system
  - Handling a huge quantity of data with tons of scripts can be very frustrating
  - Hard to
    - Debug
    - Maintain
    - Add features, bug fixing, etc ...
- Solution
  - Develop an easy to use general-purpose software system able to generate plots
- Software Stack: python/numpy/scipy/OpenGrADS

Data visualization – MapGenerator

- Various formats support (NetCDF, GRIB, HDF, ...)
- Configuration through configuration file(s), no need to touch the code!

```
[General]
aspect = False
drawopts = 'coastlines', 'countries',
area_thresh = 100
resolution = 'l'
anim = True
indir = '/home/dream/ETA_DREAM_v2/ASIA/OPER8N/eta.1.a/grads'
outdir = '/home/sdswas/dream-images/data/images'
lat = 5., 60., 10.
lon = 58., 130., 10.
total = 13
freq = 6
interval = 1
gap = 1,
srcfile = 'CSFC.ctl',
xsize = 1
ysize = 0.9
dpi = 56
joint_template = '%(date)s-JOINT-%(step)s'
```

```
[DREAM_asia_aod]
title = """BSC-DREAM8b Dust Opt. Depth 550nm and 3000m Wind
%(step)sh forecast for %(simhh)sUTC %(day)s %(MONTH)s %(year)s
$http://www.bsc.es/projects/earthscience/BSC-DREAM/$
"""
bounds = 0.02, 0.15, 0.4, 0.8, 1.6, 3.2, 6.4
boundaries = 0, 10
lat = 5., 60., 10.
lon = 45., 130., 10.
total = 13
freq = 6
interval = 1
gap = 1,
colors = '#A1EDE3', '#5DE3BB', '#53BD9D', '#FCCA26', '#E5724C', '#944038',
over = '#AB025C'
under = '#ffffff'
var = 'dod',
srcfile = 'CSFC.ctl',
wind = 'DUST.ctl'
windopts = 'u.2', 'v.2', '6'
xsize = 1
ysize = 0.9
dpi = 300
img_template = '%(date)s_image_%(step)s'
```

Data visualization – MapGenerator/Use cases

- WMO Dust Centers
- CALIOPE Air quality forecast system: www.bsc.es/caliope
- NMMB/BSC-Dust Forecast on BSC website
- BSC-DREAM8b v2.0 Atmospheric Dust Forecast System on BSC website
- Used by some researchers in the department to plot maps for articles, posters or presentations

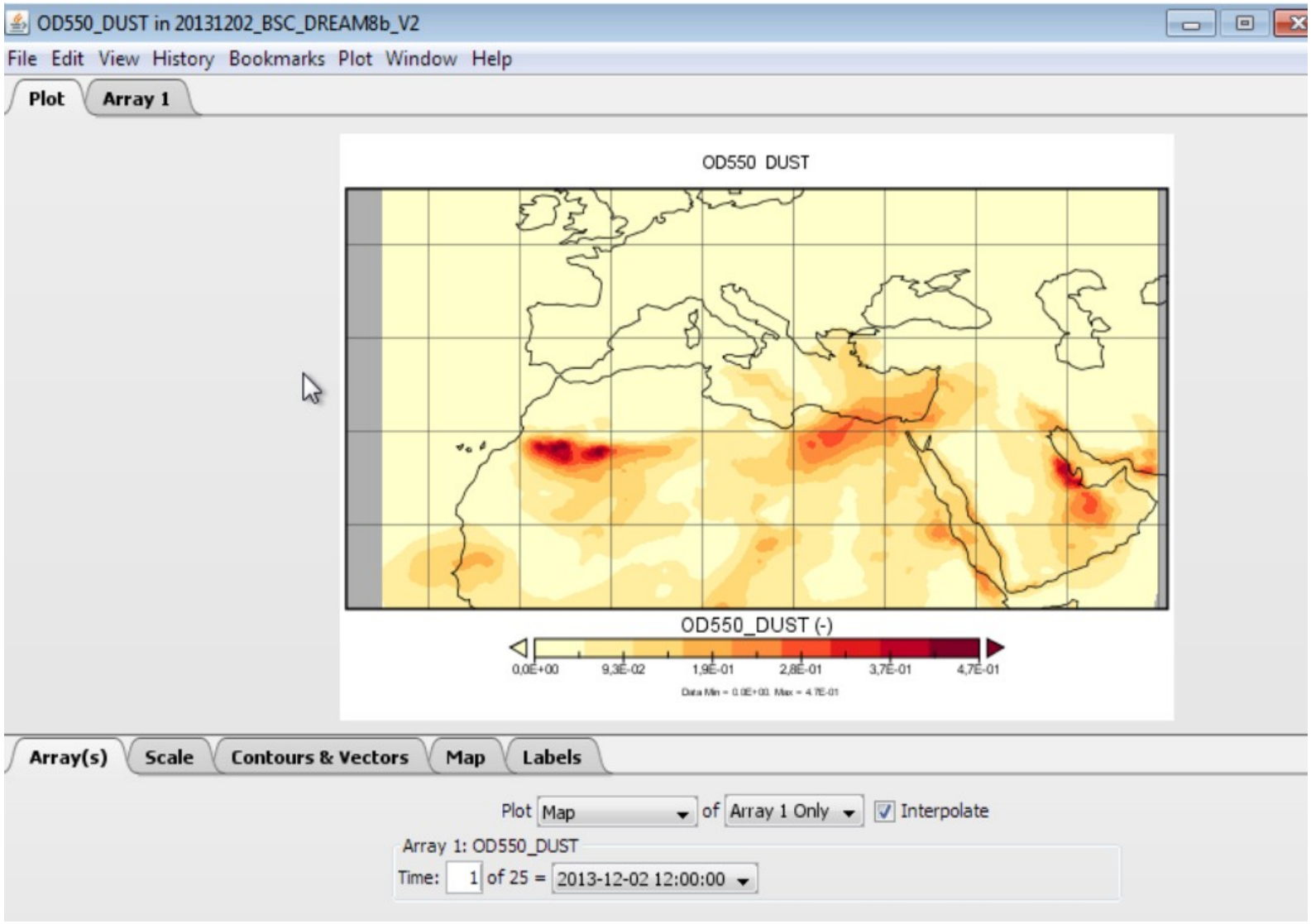
Data visualization – Panoply

Installation

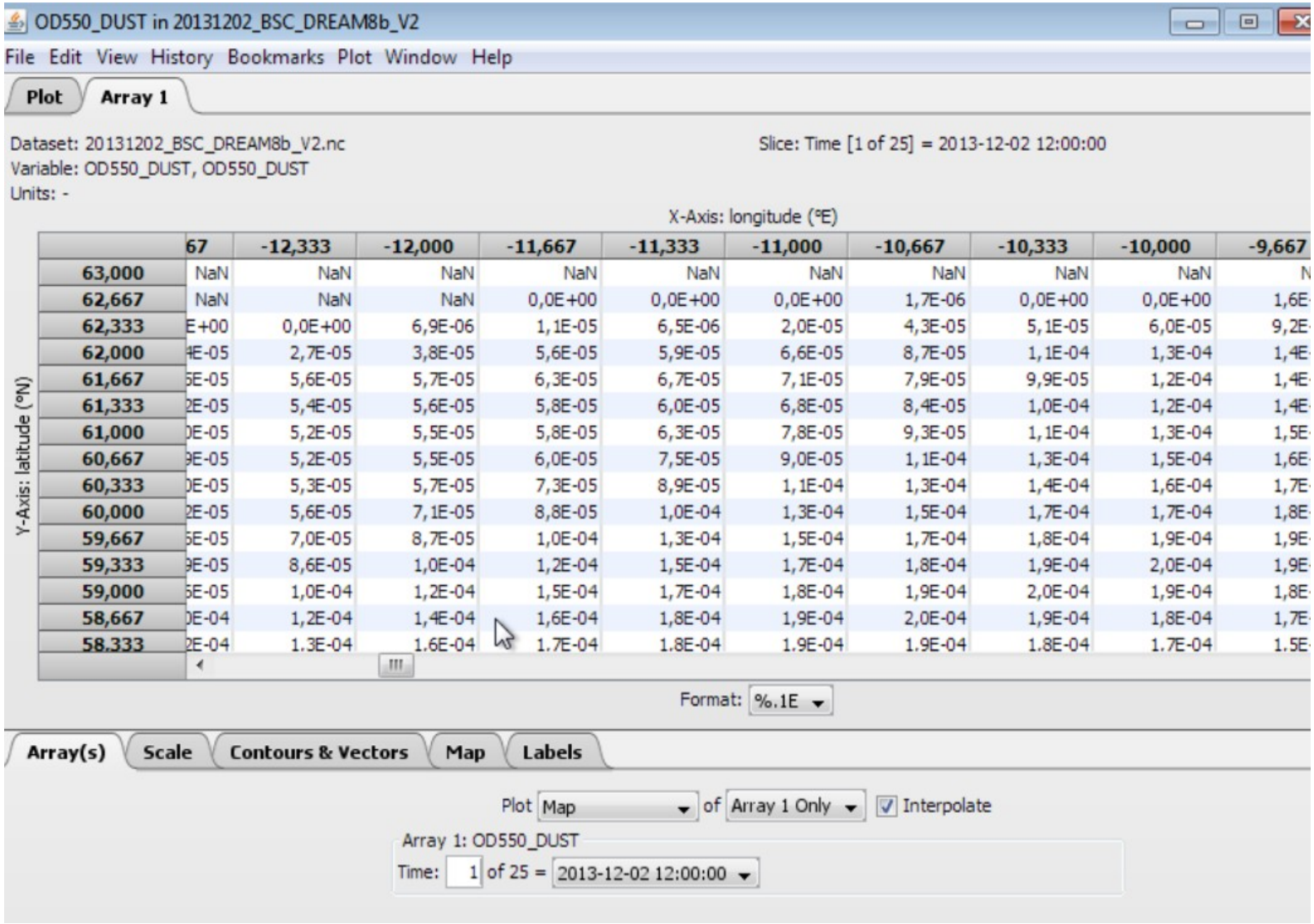
- Java: www.java.com
- Panoply: www.giss.nasa.gov/tools/panoply/
- In case of memory problems, launch manually:

```
C:\> "C:\Program Files\Java\jre\bin\java" -Xmx1g -jar
"C:\Program Files\PanoplyWin\jars\Panoply.jar"
```

Data visualization – Panoply



Data visualization – Panoply



	67	-12,333	-12,000	-11,667	-11,333	-11,000	-10,667	-10,333	-10,000	-9,667
63,000	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	N
62,667	NaN	NaN	NaN	0,0E+00	0,0E+00	0,0E+00	1,7E-06	0,0E+00	0,0E+00	1,6E
62,333	E+00	0,0E+00	6,9E-06	1,1E-05	6,5E-06	2,0E-05	4,3E-05	5,1E-05	6,0E-05	9,2E
62,000	4E-05	2,7E-05	3,8E-05	5,6E-05	5,9E-05	6,6E-05	8,7E-05	1,1E-04	1,3E-04	1,4E
61,667	5E-05	5,6E-05	5,7E-05	6,3E-05	6,7E-05	7,1E-05	7,9E-05	9,9E-05	1,2E-04	1,4E
61,333	2E-05	5,4E-05	5,6E-05	5,8E-05	6,0E-05	6,8E-05	8,4E-05	1,0E-04	1,2E-04	1,4E
61,000	0E-05	5,2E-05	5,5E-05	5,8E-05	6,3E-05	7,8E-05	9,3E-05	1,1E-04	1,3E-04	1,5E
60,667	9E-05	5,2E-05	5,5E-05	6,0E-05	7,5E-05	9,0E-05	1,1E-04	1,3E-04	1,5E-04	1,6E
60,333	0E-05	5,3E-05	5,7E-05	7,3E-05	8,9E-05	1,1E-04	1,3E-04	1,4E-04	1,6E-04	1,7E
60,000	2E-05	5,6E-05	7,1E-05	8,8E-05	1,0E-04	1,3E-04	1,5E-04	1,7E-04	1,7E-04	1,8E
59,667	5E-05	7,0E-05	8,7E-05	1,0E-04	1,3E-04	1,5E-04	1,7E-04	1,8E-04	1,9E-04	1,9E
59,333	9E-05	8,6E-05	1,0E-04	1,2E-04	1,5E-04	1,7E-04	1,8E-04	1,9E-04	2,0E-04	1,9E
59,000	5E-05	1,0E-04	1,2E-04	1,5E-04	1,7E-04	1,8E-04	1,9E-04	2,0E-04	1,9E-04	1,8E
58,667	0E-04	1,2E-04	1,4E-04	1,6E-04	1,8E-04	1,9E-04	2,0E-04	1,9E-04	1,8E-04	1,7E
58,333	2E-04	1.3E-04	1.6E-04	1.7E-04	1.8E-04	1.9E-04	1.9E-04	1.8E-04	1.7E-04	1.5E

Data manipulation

Data manipulation

- Formats: NetCDF
  - Numerical data format
  - Developed and maintained at Unidata (UCAR)
  - Well documented with complete technical information
  - With a large list of supporting software

Data manipulation

- A NetCDF dataset contains
  - Dimensions

```
lon = 289 ; // longitude, number of points in the X axis
lat = 211 ; // latitude, number of points in the Y axis
time = 25 ; // number of timesteps
```

  - Variables

```
float sconc_dust(time, lat, lon) ;
    sconc_dust:long_name = "dust 10m concentration" ;
    sconc_dust:units = "kg m-3" ;
    sconc_dust:title = "dust 10m concentration" ;
    sconc_dust:_FillValue = -9.e+33f ;
```

  - And, of course, **numerical values**!

Data manipulation

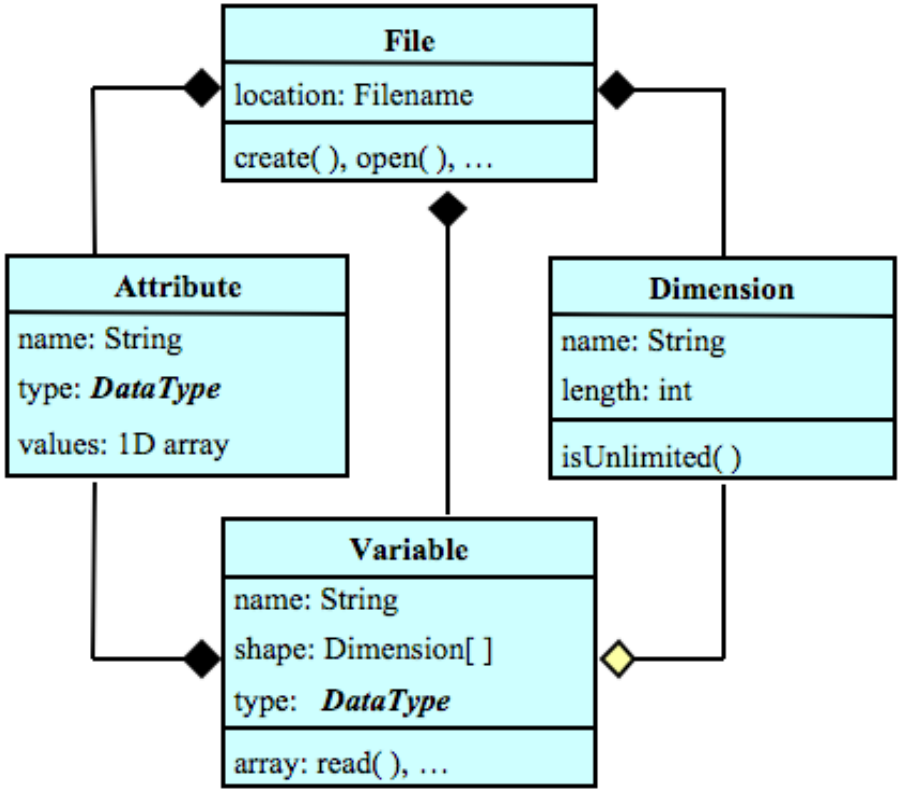
- Metadata!
  - Data must be understandable: migrograms and kilograms are not the same!
  - Follow standards
  - Numerical metadata
    - Time units

```
int time(time) ;
        time:units = "hours since 2015-02-23 12:00:00.0" ;
        time:description = "time forecast" ;
```

    - Missing value

```
SCONC_DUST:missing_value = -999.f
SCONC_DUST:_FillValue = -999.f
```

NetCDF3 “classic” diagram



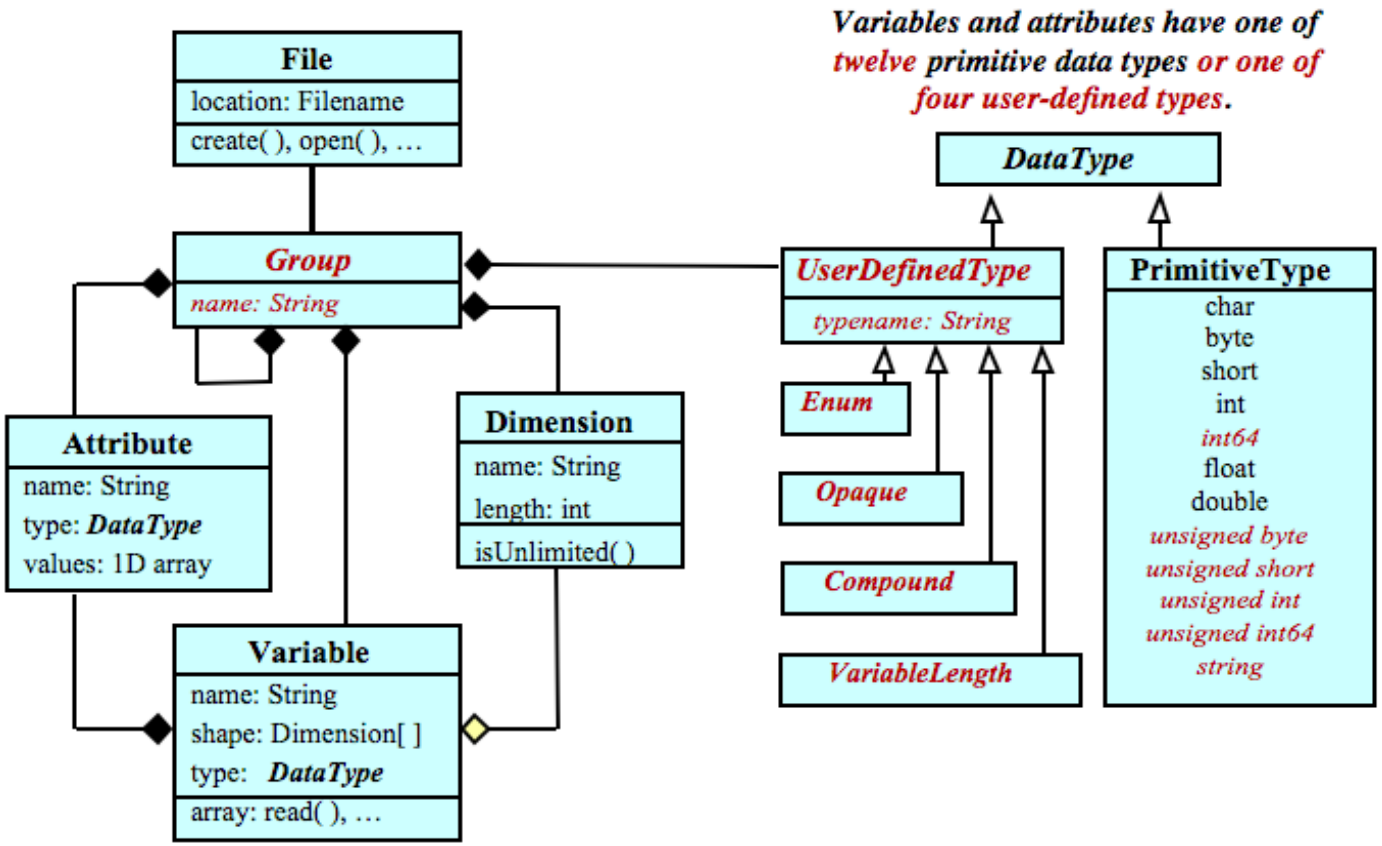
Variables and attributes have one of six primitive data types.

DataType
char
byte
short
int
float
double

A file has named variables, dimensions, and attributes. Variables also have attributes. Variables may share dimensions, indicating a common grid. One dimension may be of unlimited length.

From Unidata's NetCDF Data Model: http://www.unidata.ucar.edu/software/netcdf/docs/netcdf_data_model.html

NetCDF4 enhanced data model



A file has a top-level unnamed group. Each group may contain one or more named subgroups, user-defined types, variables, dimensions, and attributes. Variables also have attributes. Variables may share dimensions, indicating a common grid. One or more dimensions may be of unlimited length.

From Unidata's NetCDF Data Model: http://www.unidata.ucar.edu/software/netcdf/docs/netcdf_data_model.html

Data manipulation

- NetCDF Operator (NCO)
- Climate Data Operators (CDO)
- Programming languages like R or Python

Data manipulation – NCO

- Download the installer and execute it
- Put the NCO directory in the PATH:

> *1. Right-click on "My computer" -> Properties -> Advanced -> Environment Variables*
>
> *2. In "System variables" chose "Path" variable and click the "Edit" button.*
>
> *3. Append the NCO path after a semicolon, e.g.: ORIGINAL_PATH;C:\nco*

- Read the documentation!

Data manipulation – NCO/NCKS

- Append content

```
ncks -A FILEIN.nc FILEOUT.nc
```

- Isolate variable

```
ncks -v VAR FILEFROM.nc FILETO.nc
```

- Select an area

```
ncks -d longitude,260, 20150223_BSC_DREAM8b_V2.nc
20150223_BSC_DREAM8b_V2_cutted.nc
```

Data manipulation – NCO/Others

- Ncap2, the arithmetic processor

```
ncap2 -O -s 'SCONC_DUST=0.00347949*(exp(lnsp)/t)*(aermr04+aermr05+aermr06)' IN.nc OUT.nc
```

- Ncatted, the attribute editor

```
ncatted -a long_name,T,o,c,temperature IN.nc
```

- Ncrename

```
ncrename -h -O -v duaod550,OD550_DUST IN.nc OUT.nc
```

Data manipulation – CDO

- Download and unzip the compressed file
- Put the CDO directory where you like in you filesystem and add the PATH to system one (like NCO)
- Read the documentation!

Data manipulation – CDO/Examples

- File info

```
cdo sinfov FILENAME.nc
```

- Select area

```
cdo sellonlatbox,25,60,10,30 FILEIN.nc FILEOUT.nc
```

- Time mean

```
cdo timmean FILEIN.nc FILEOUT.nc
```

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Thank you!

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