Multimodel Products

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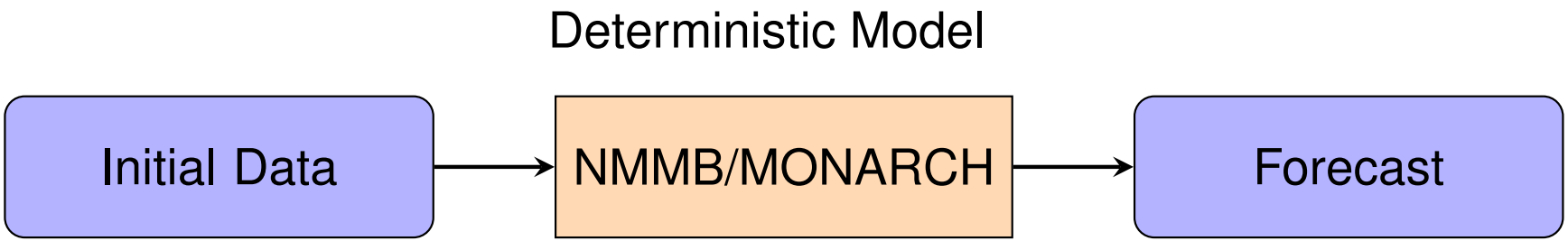
Workshop on Dust Products Northern and Western Africa
Dakar, Senegal 9-11 Dec 2019

Outline

Outline

Deterministic Model



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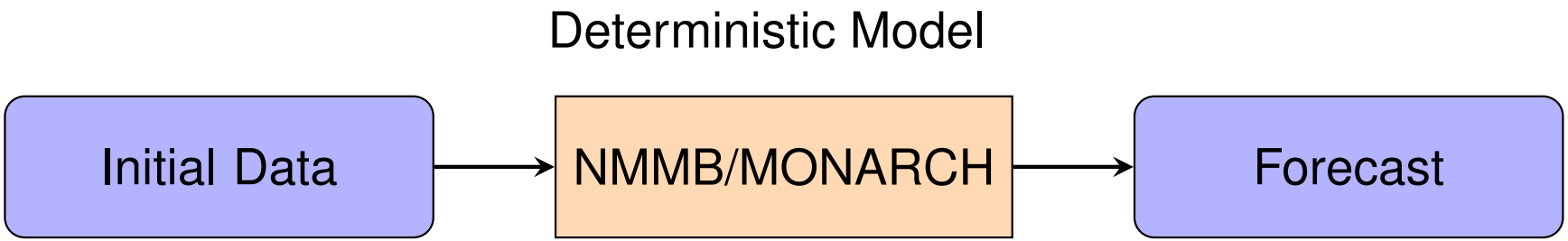
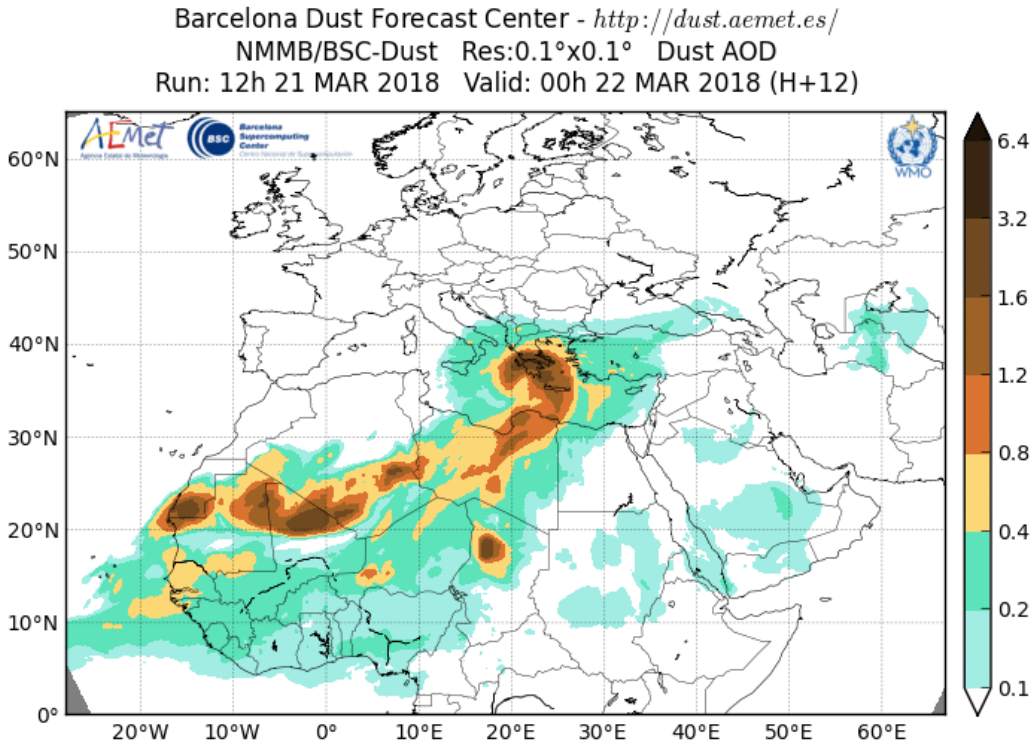
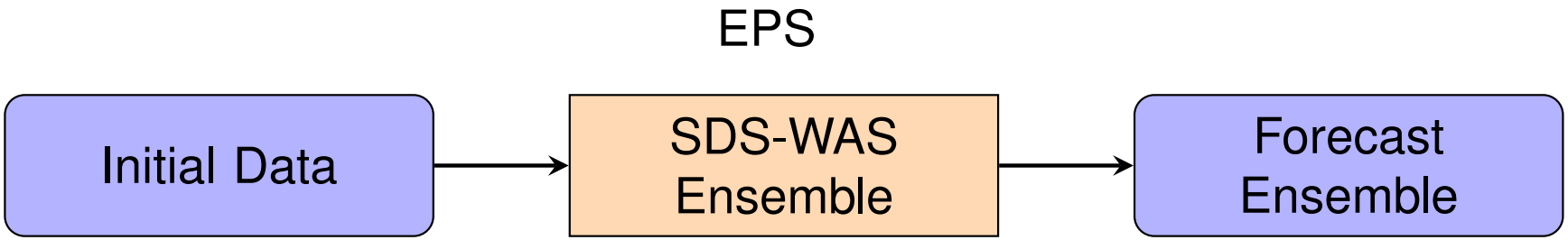




Ensemble Prediction System: EPS



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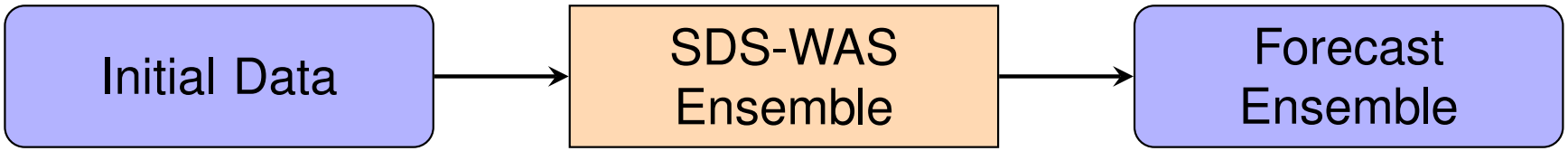
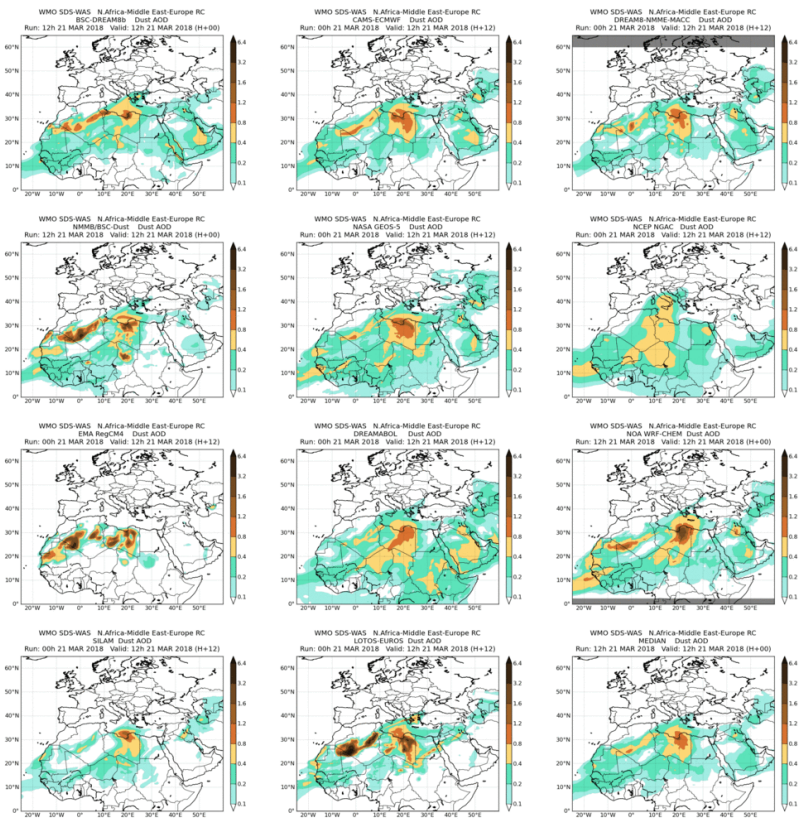
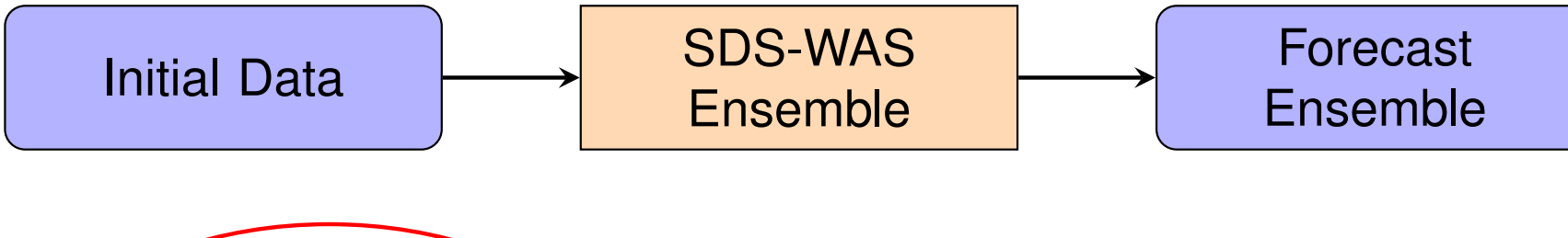


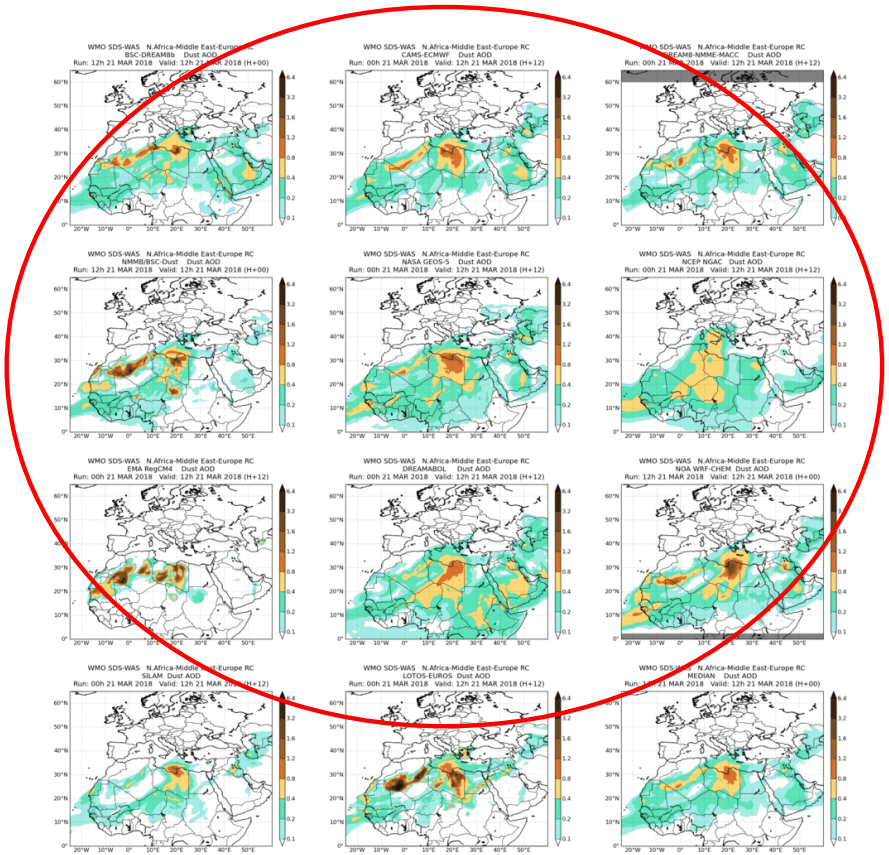


Set of 12 different forecasts

Ensemble Prediction System: EPS → Objective Probability = 75 %

EPS





9 members forecast a SDS
3 don't →
75 % (objective) probability of that event to happen

Deterministic forecast vs Ensemble forescast: summary

Deterministic Model

- One model
- One forecast
- No **objective** probabilistic information

EPS: Ensemble Prediction System

- Set of Deterministic Models (members)
- Each member is equiprobable $\rightarrow$ Calibration
- Ensemble of forecasts

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EPS: Ensemble Prediction System

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- **Probabilistic & Multimodel products**

Outline

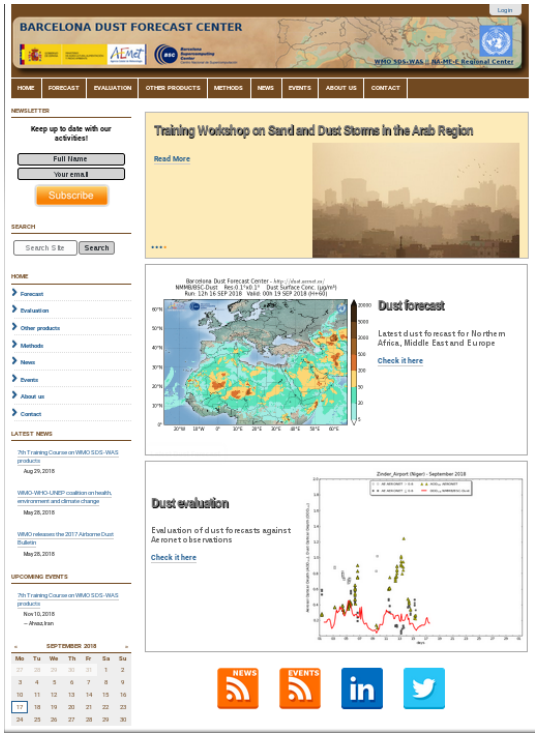
Operational forecast: NMMB/MONARCH (https://dust.aemet.es)

Features

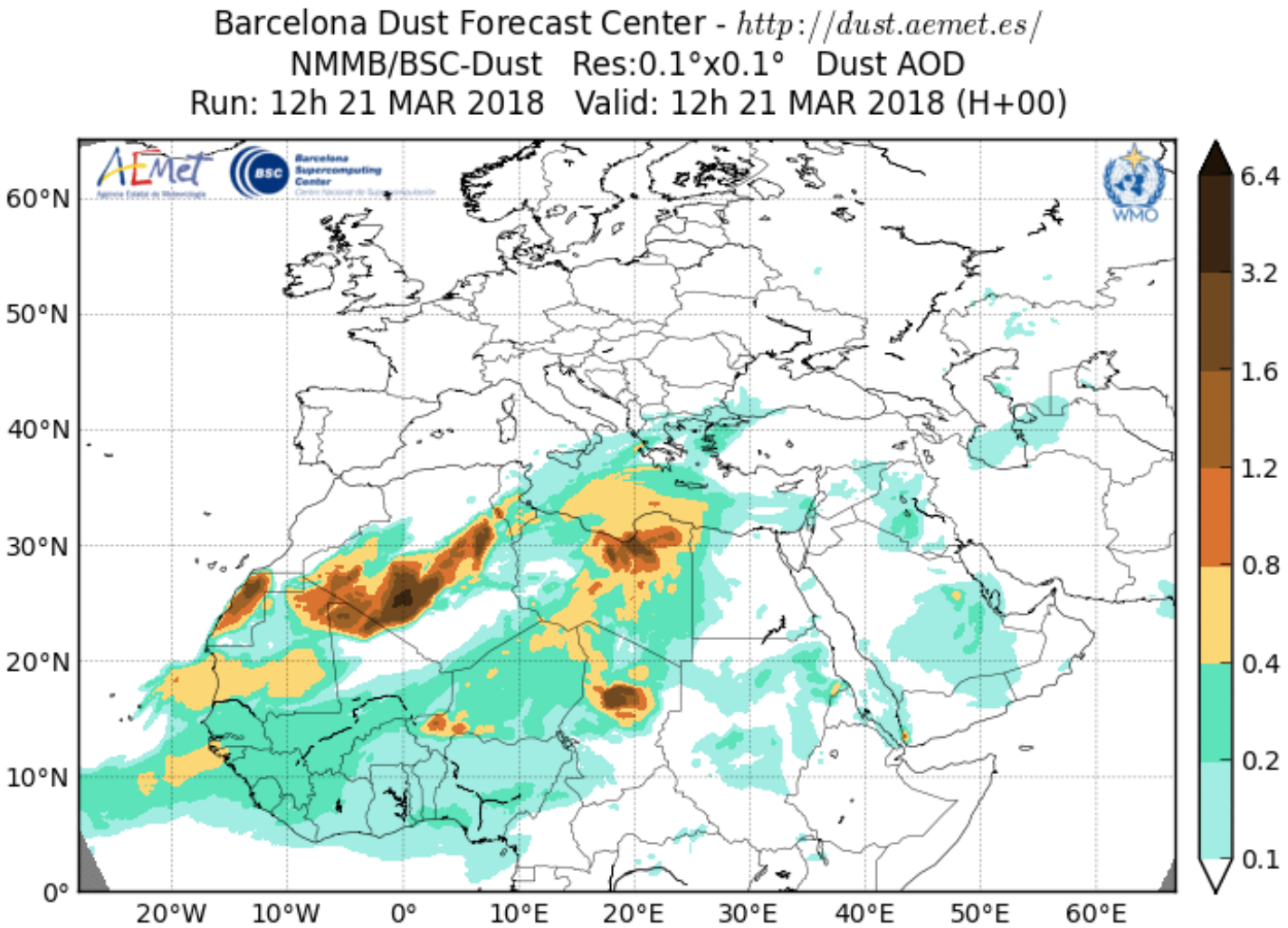
- Daily forecast: 12 UTC run, 72 h forecast, 3 h step
- Resolution: 0.1° x 0.1°
- Domain: NA-ME-E

Parameters

- Dust Surface Concentration [μg/m3]
- Extinction [M/m]
- Dust Load [g/m2]
- Dust Optical Depht (Dust AOD) [–]
- Dry Deposition [mg/m2]
- Wet Deposition [mg/m2]

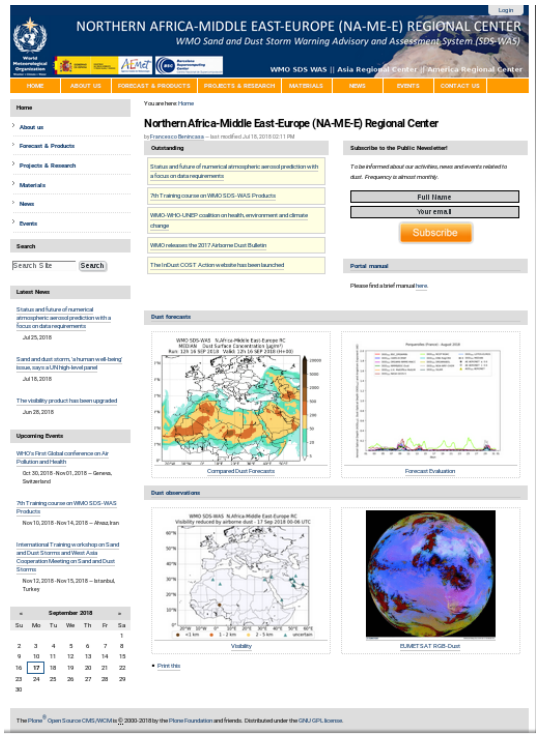


Operational forecast: NMMB/MONARCH



Multimodel (12 members): Dust AOD & Dust Surface Concentration

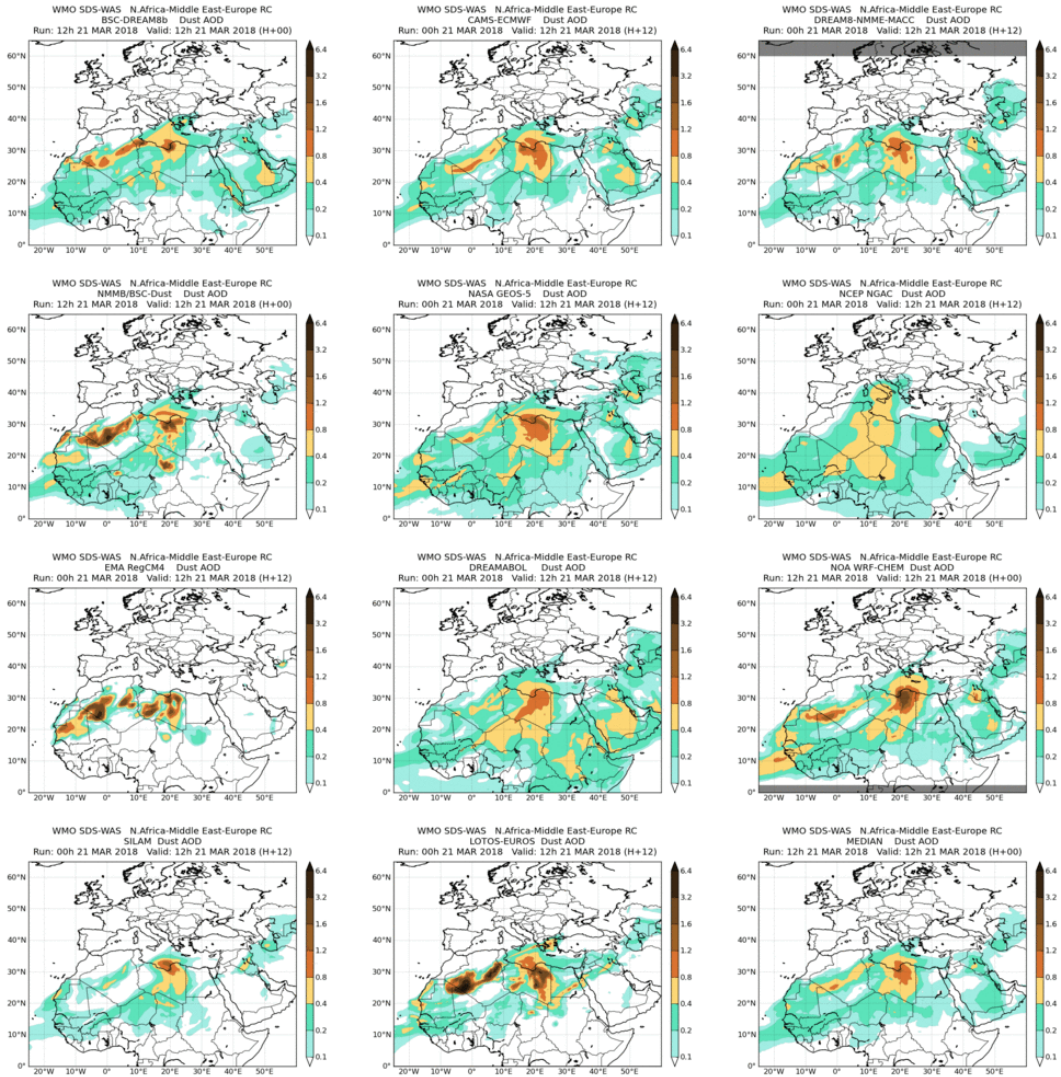
Model	Institution	Domain	Data Asimilation
BSC-DREAM8b_c2	BSC-CNS	Regional	MODIS-AOD
CAMS-ECMWF	ECMWF	Global	NO
DREAM-NMME-MACC	SEEVCCC	Regional	NO
NMMB/BSC-Dust	BSC-CNS	Regional	NO
MetUM	Met Office	Global	MODIS-AOD
GEOS-5	NASA	Global	MODIS
NGAC	NCEP	Global	NO
EMA REG CM4	EMA	Regional	NO
WRF-CHEM	NOA	Regional	NO
SILAM	FMI	Global	NO
LOTOS-EUROS	TNO	Regional	MODIS-AOD
ICON-ART	DWD	Regional	NO



New arrivals: NMM-DREAM-MSG (NOA), ALADIN-DUST (Algeria)

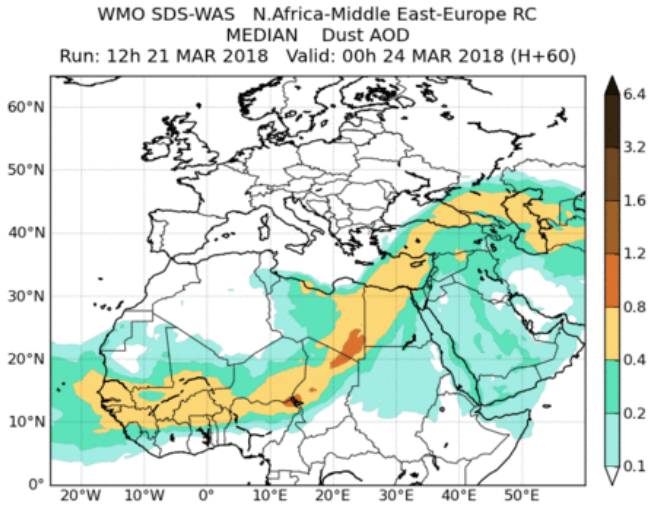
Dust model inter-comparison

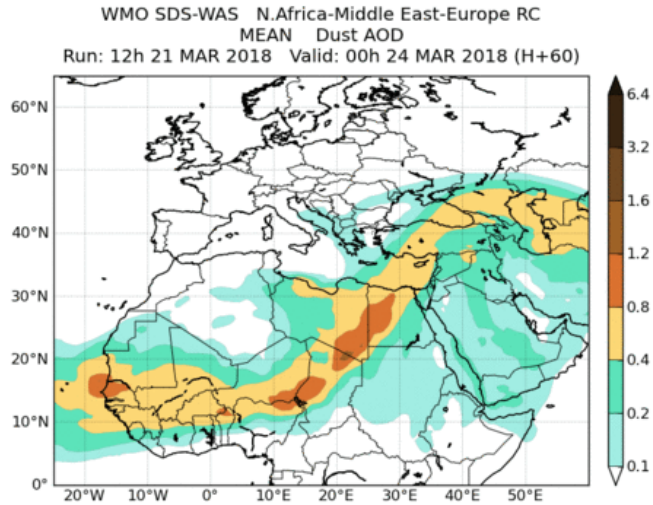
Dust Optical Depth 550 nm. Models runtime: 21 Mar 2018

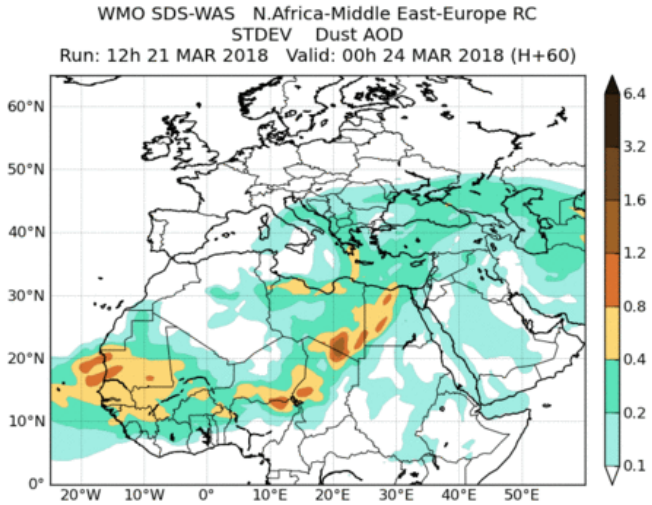


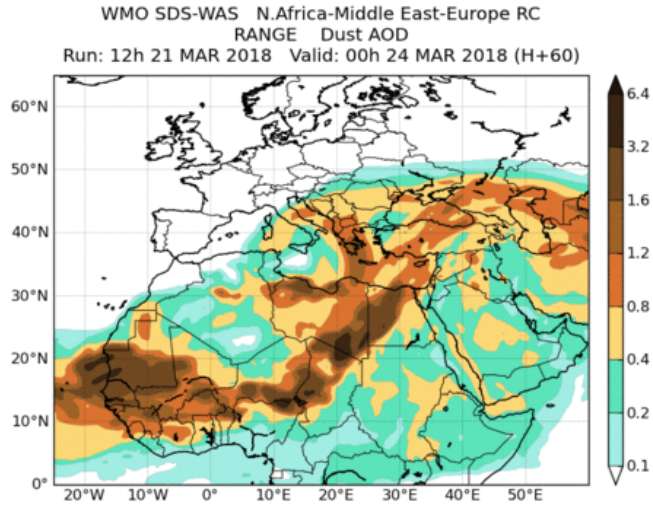
Multimodel Products: Median, Mean, STDEV & Range

Dust Optical Depth 550 nm. Models runtime: 21 Mar 2018









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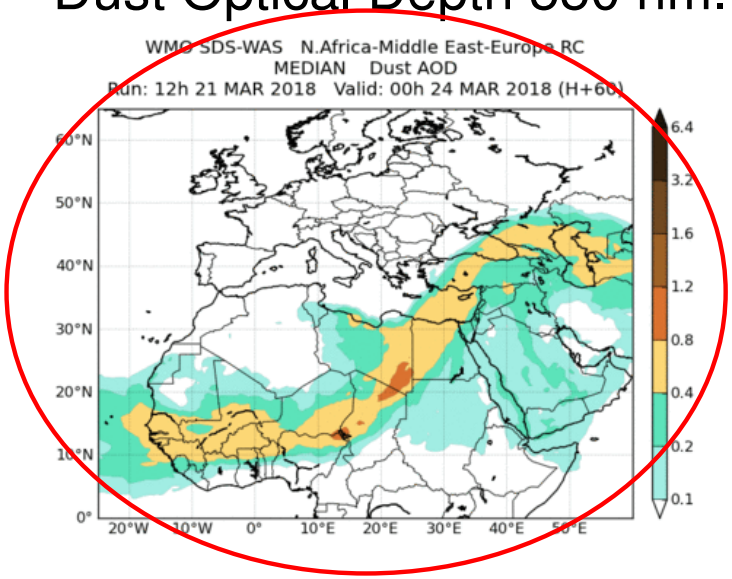
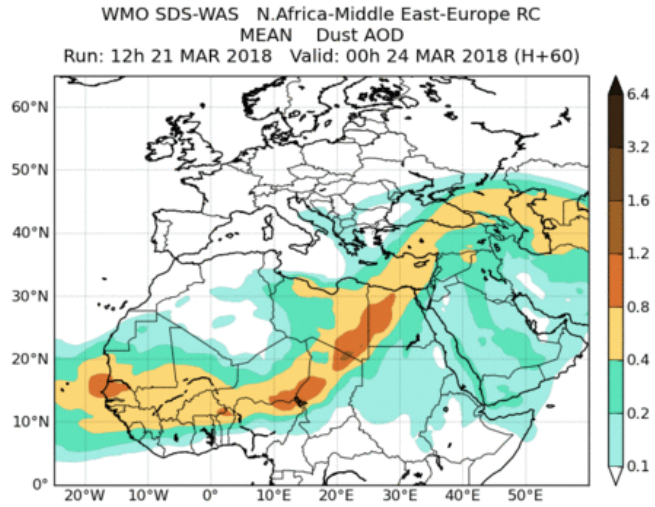
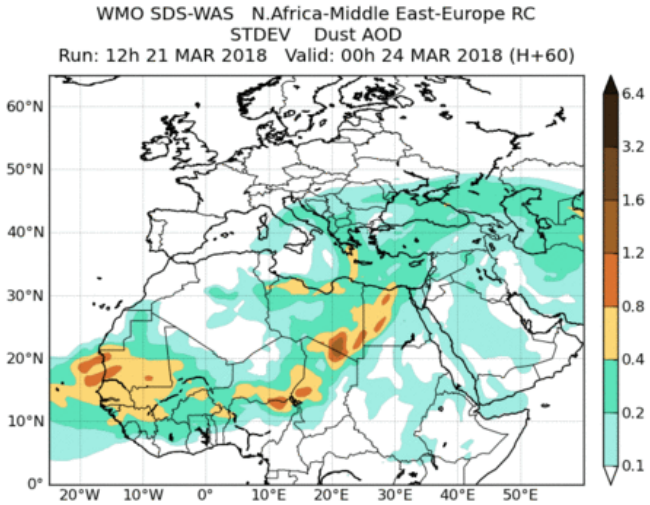
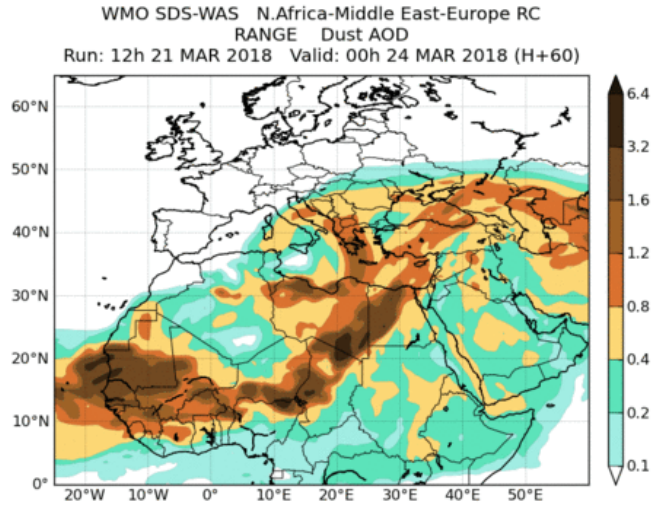








Multimodel Products: Median, Mean, STDEV & Range

Median versus Mean

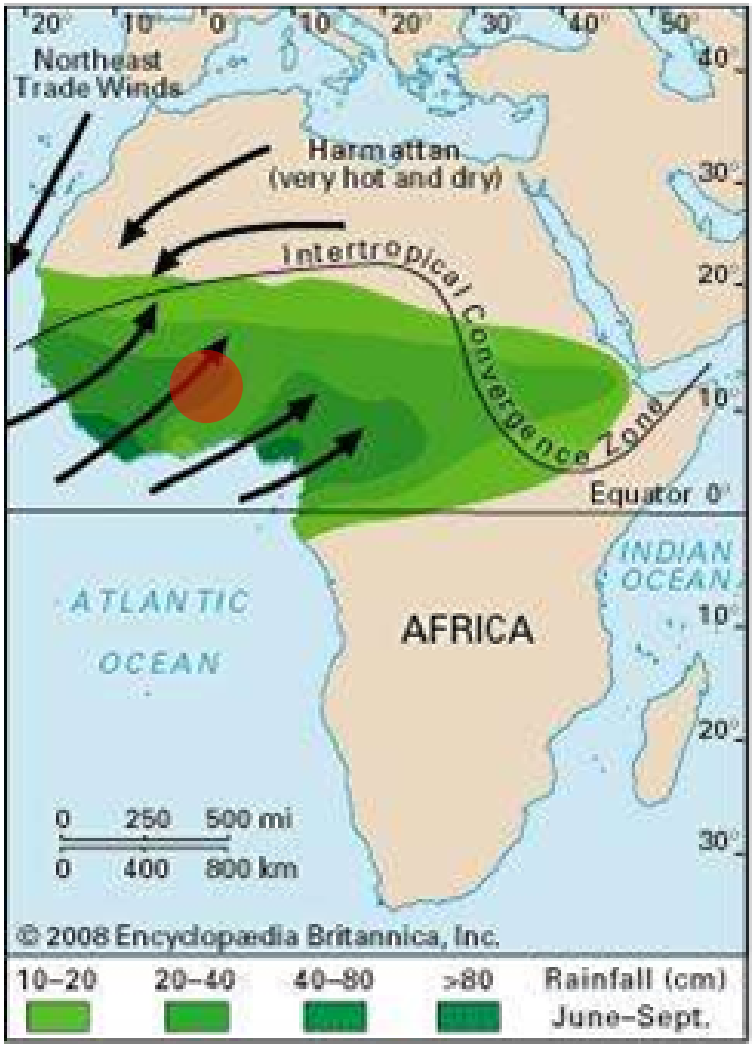
- Mean: The sum of all the data entries divided by the number of entries
- Mean is largerly influence by extreme values (outliers)
- Some models can forecast too highvalues $\rightarrow$ specially for Dust Surface Concentration
- Median: The value that lies in the middle of the data when the data set is ordered
- Median is not affected by the values of the extrems
- Median better evaluation than models taken individually
- **Median $\rightarrow$ reference forecast**

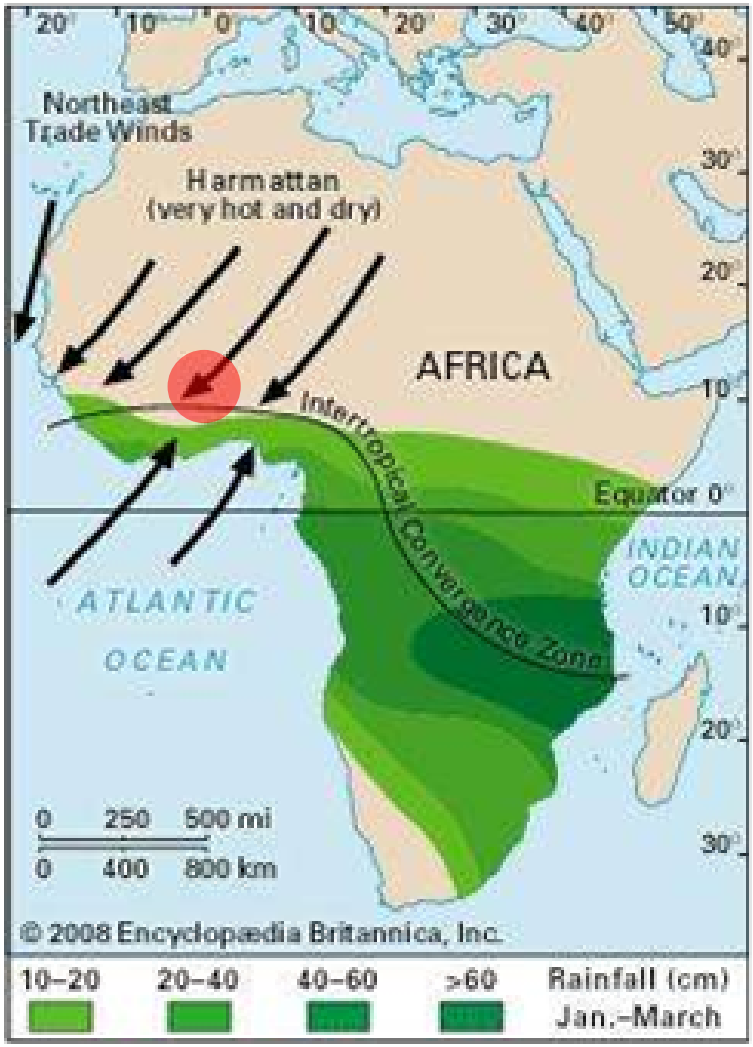
Percentile, Standard Deviation & Range

- Percentile: The n-percentile of a data set is the data value at which n-percent of the value in the data set are less than or equal to this value $\rightarrow$ media is the 50 % percentile
- STDEV: How much the members of a data set differ from the mean
- Range: Difference between the maximum and minimum of the data set

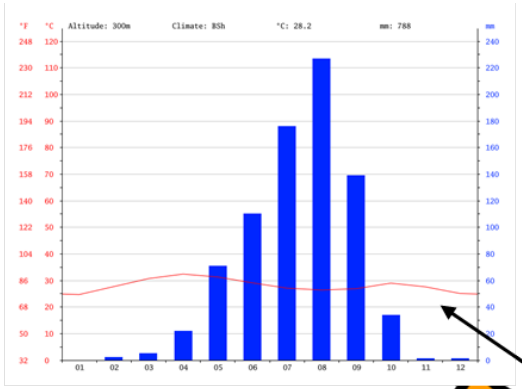
Outline

Burkina Faso WAS: Climate





Burkina Faso WAS: Precipitation



< 600 mm / year

600-900 mm / year

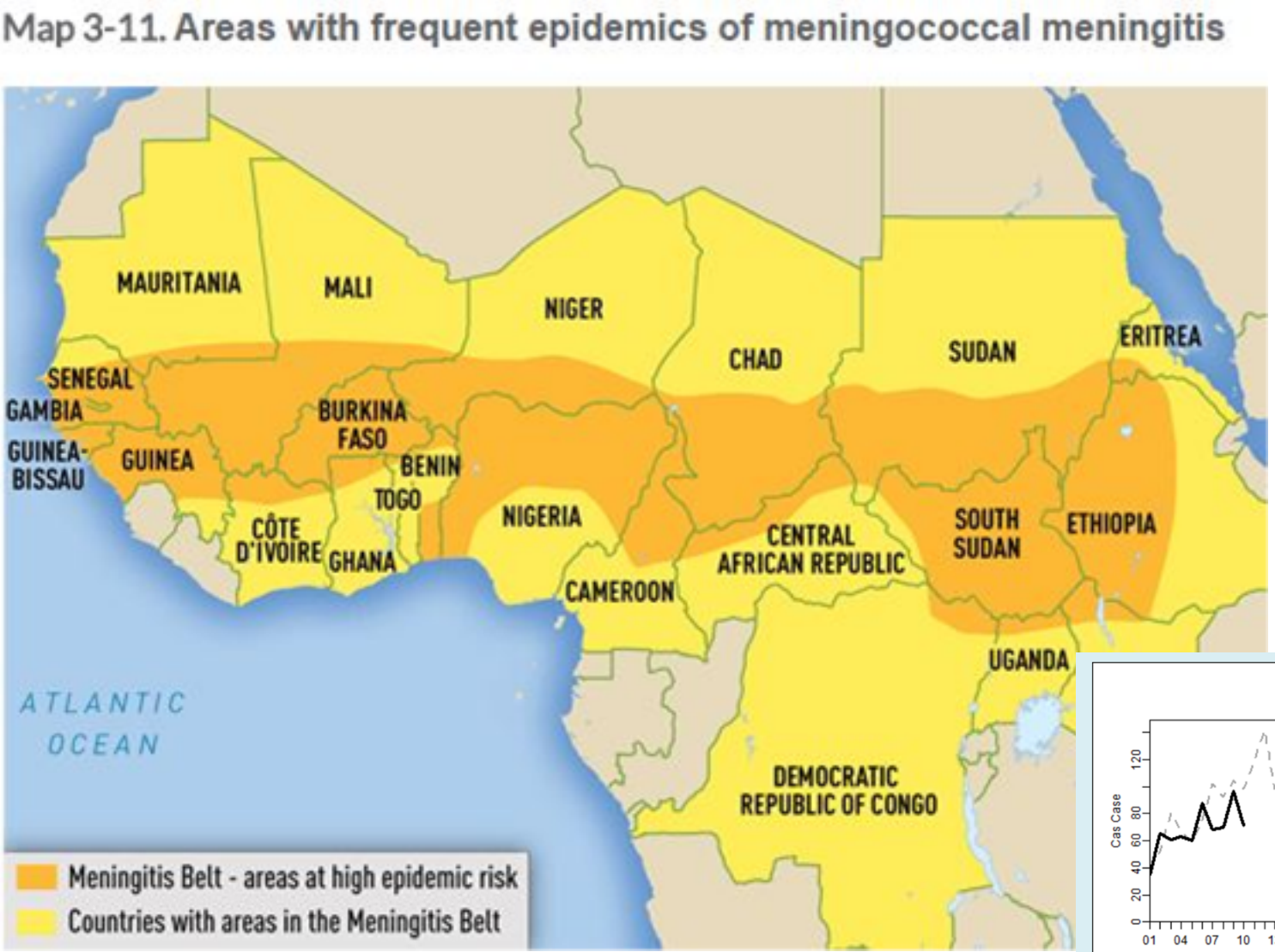
> 900 mm / year

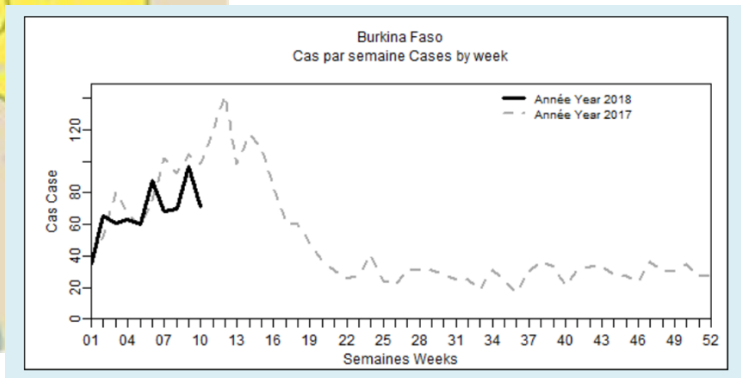
Warm desert climate (BWh)

Warm semi-arid climate (BSh)

Tropical savanna climate (Aw)

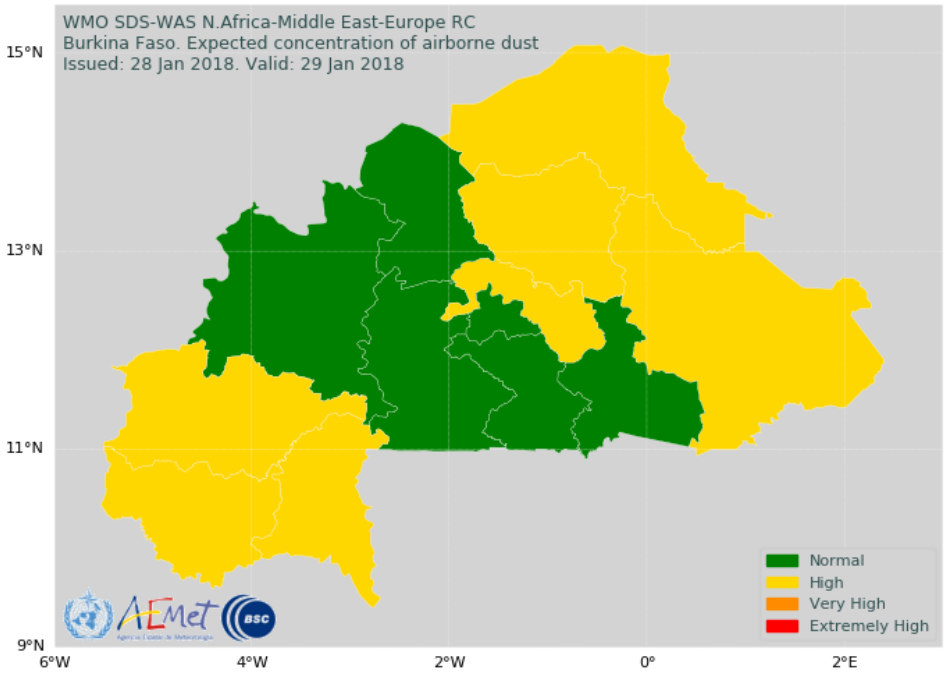
Burkina Faso WAS: Health Impact (Meningitis Belt)



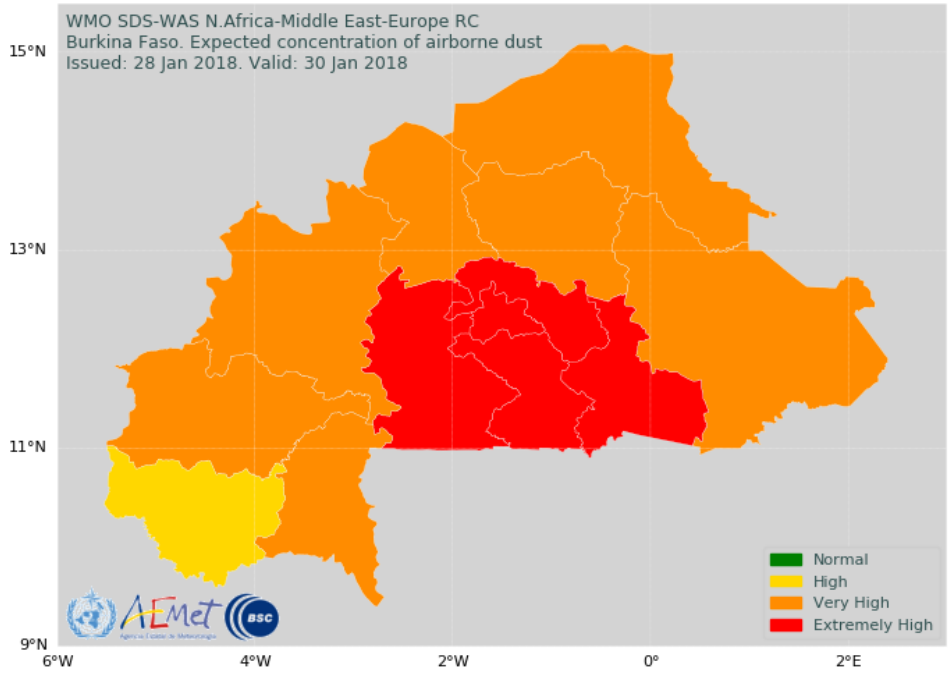


Burkina Faso WAS: Warning maps

Today

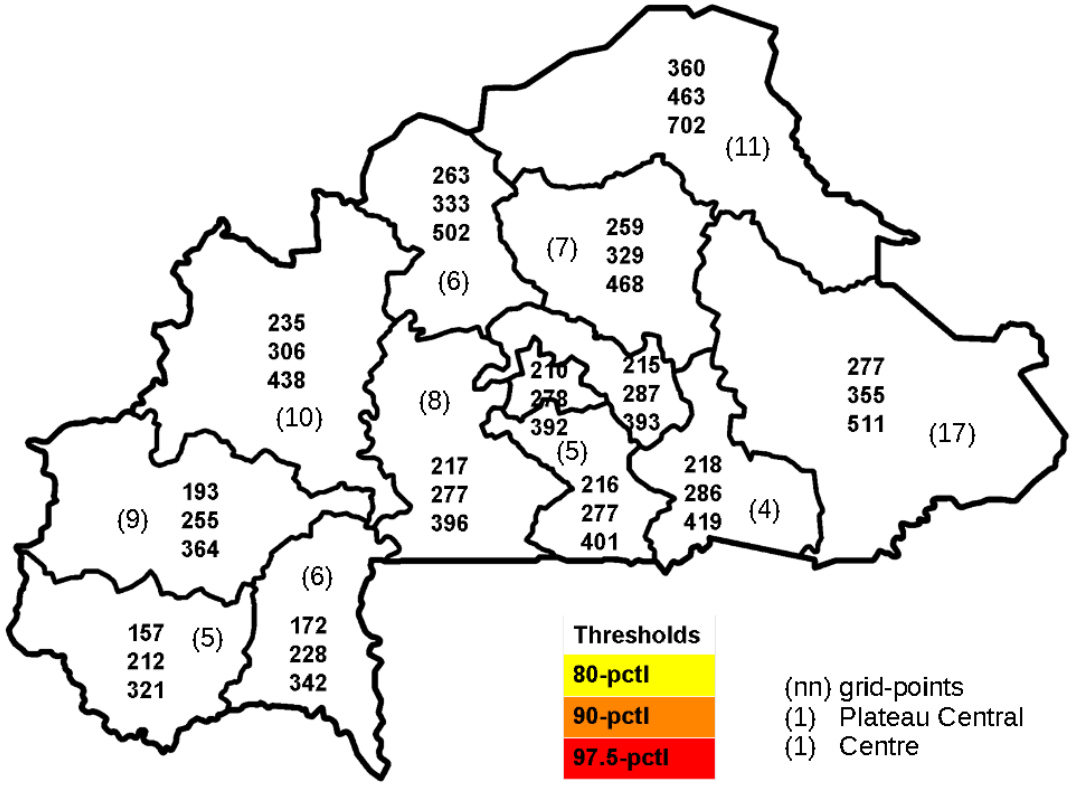


Tomorrow



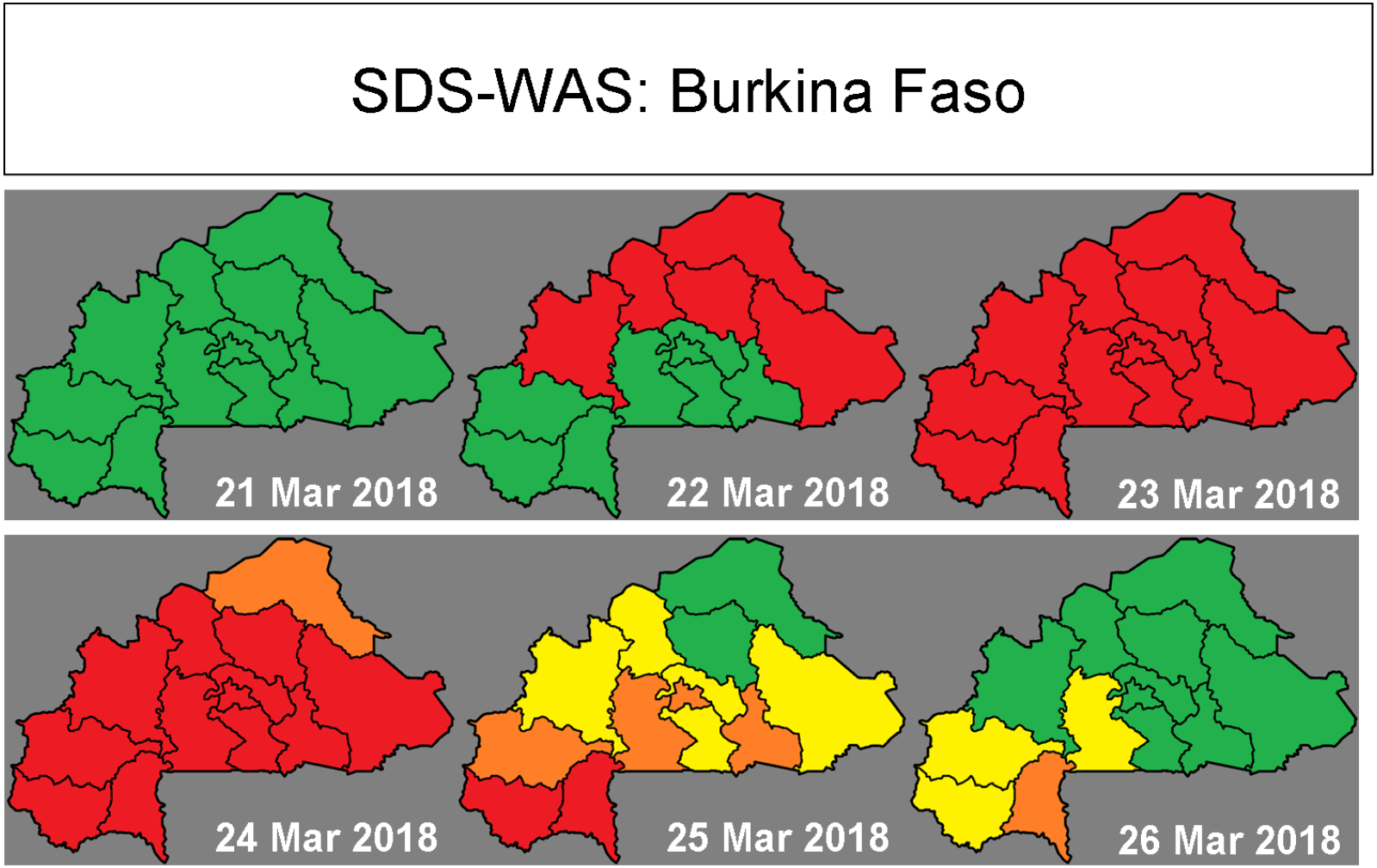
- Warning for Today and Tomorrow
- One color for each province
- Green: Normal Dust SFC Concentration
  Yellow: High
  Orange: Very High
  Red: Extremely High

Burkina Faso WAS: Grid-points and province thresholds [μg/m3]

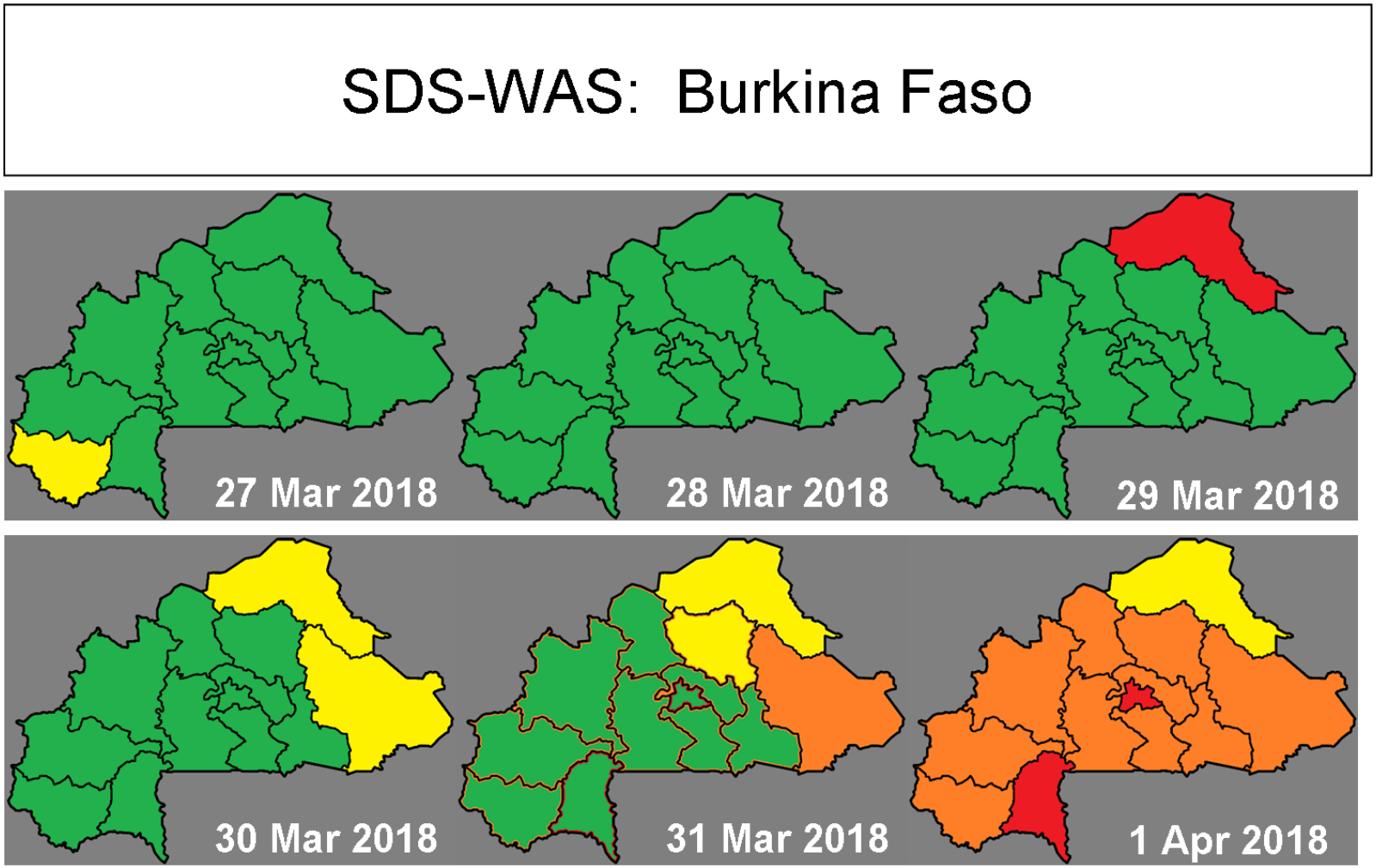


- Time series of the multimodel median (5 years)
- Daily maximum value of Dust Surface Concentration
- Considered all the grid points in each province
- Threshold [μg/m3] based on the percentiles
- Compare median forecast with the thresholds to assign a color

Burkina Faso WAS: Example



Burkina Faso WAS: Example



Outline

WAS Evaluation: Feedback from Météo Burkina

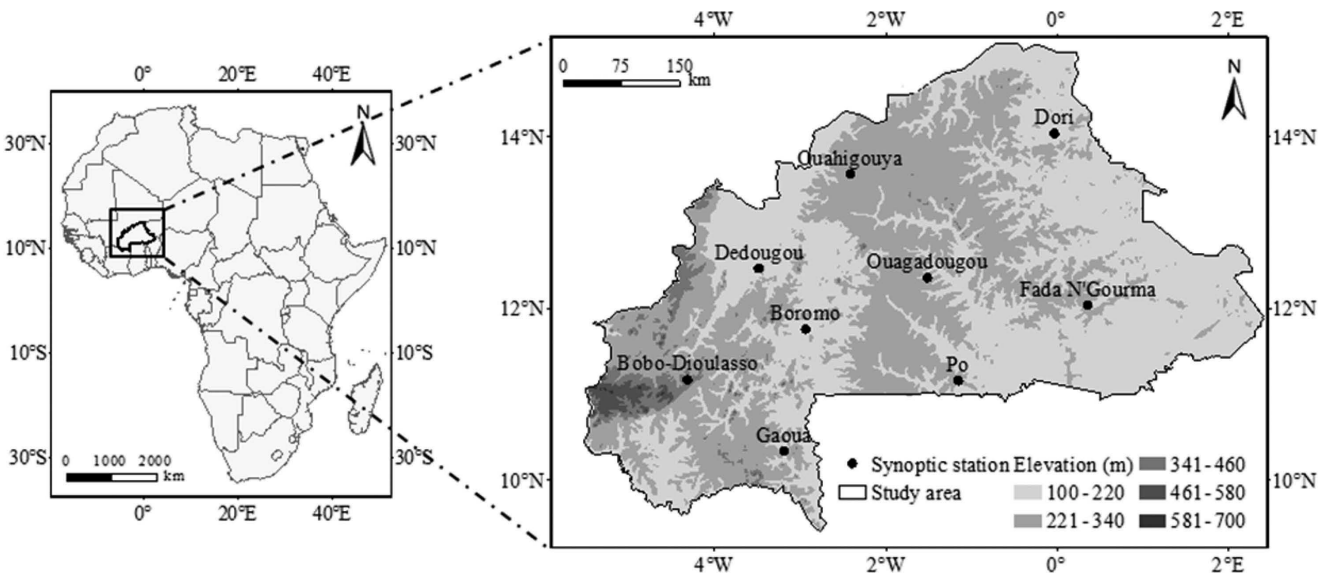
First feedback

- Useful tool → weather forecasters
- Qualitative forecast → Lack of PM10 observations
- Daily work routine
- Too many warnings
- Adjust thresholds → Higher percentiles
- More detailed information about Dust Events → WAS evaluation

Feedback for Dust Events: web form example

- SDS Event Duration
- Local SDS, transport, resuspension, ...
- Visibility reduction: max & when
- Wind speed, gust, direction
- Deposition: dry, wet, ...
- Impacts: Agriculture, AQ, Health, warnings, mesures taken,...
- Others: Photograh of the SDS $\rightarrow$ GLOBE app by NASA

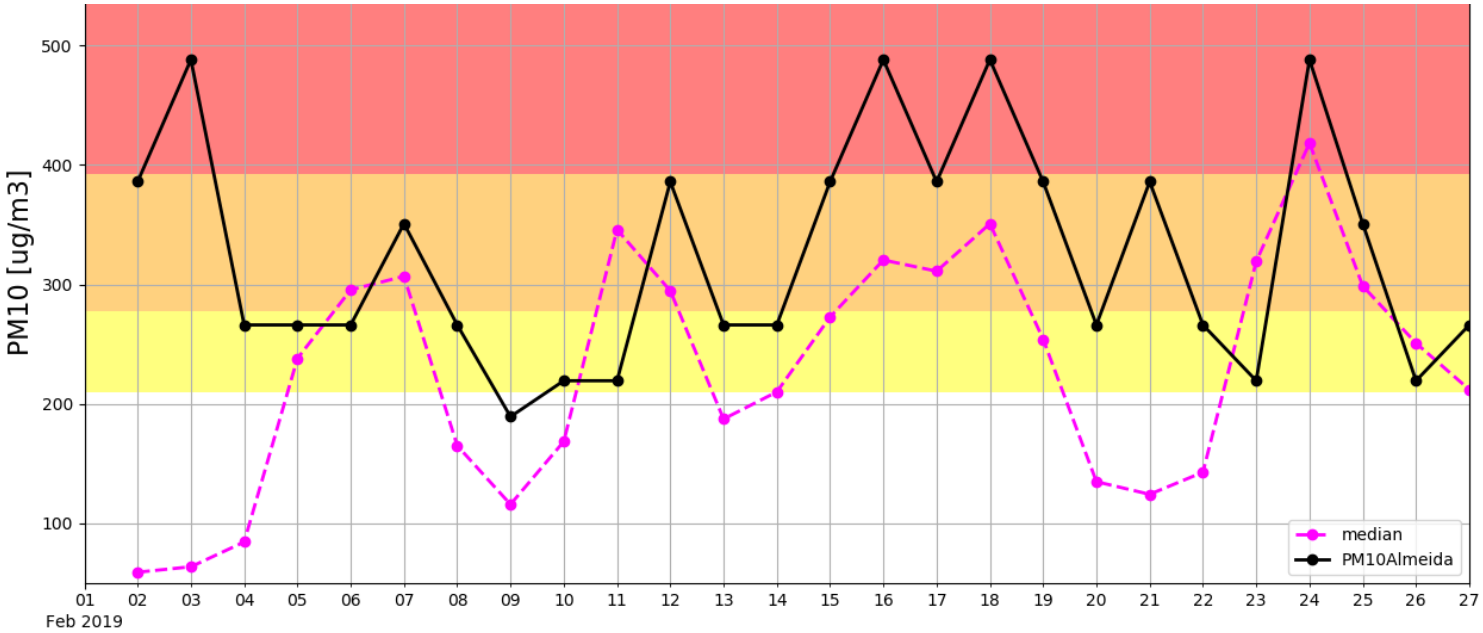
WAS Evaluation: SYNOP and METAR Burkina Faso



Source: Moctar Dembélé & Sander J. Zwart (2016)

Source: Google Maps

WAS Evaluation (first attempt): METAR Ougadougou airport



D'Almeida (1986) Equation: → VIS & PM10 Agadez (Niger)

- PM10 = 914.0 VIS $^{-0.73}$ +19.03

Next steps

- Another eq: Camino (2014) Canary Islands, Ben Mohamed (1992) Niamey (Niger), ...
- METAR & SYNOP Visibility → **Categorize Dust Events**
- Microscale phenomena, local dust sources & resuspension

MAC-CLIMA INTERREG & CREWS

MAC-CLIMA INTERREG

- MAC: Madeira, Açores, Canarias
- Senegal, Cabo Verde, Mauritania

CREWS

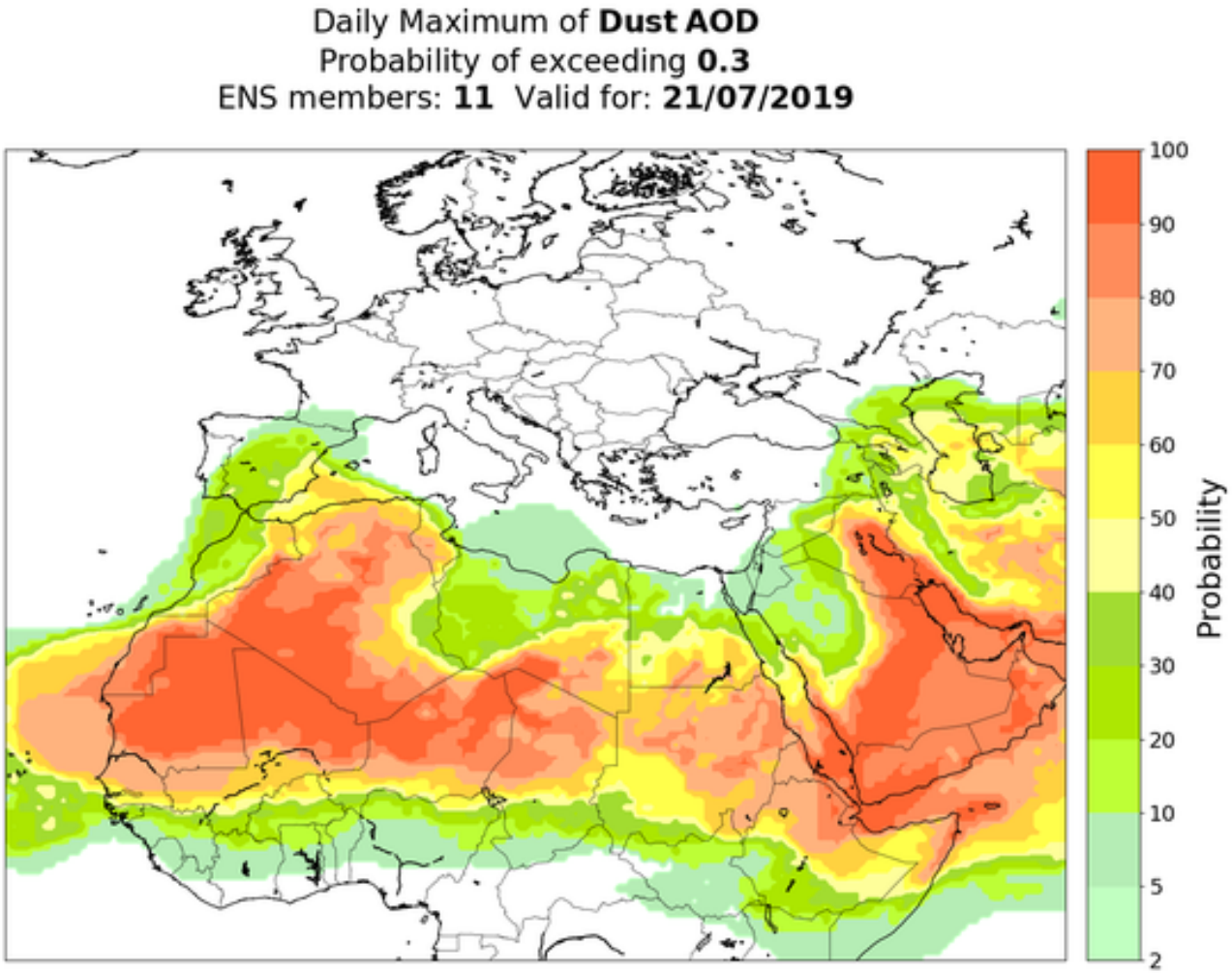
- Climate Risk and Early Warning Systems
- Burkina Faso, Chad, Mali, Niger, Togo

Proposed actions (2020-2022)

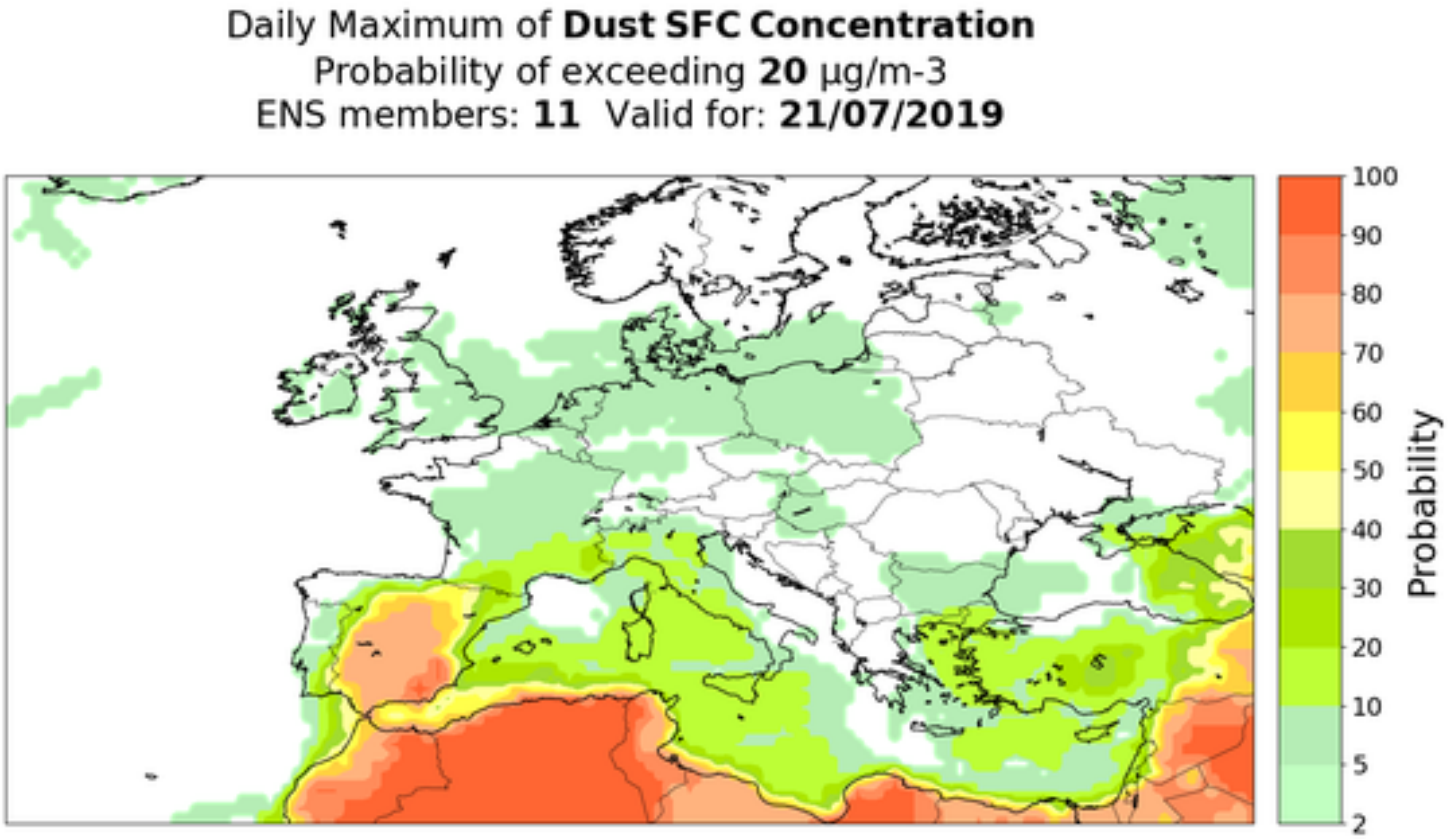
- Proposal: Expansion of the Burkina Faso WAS
- Training Workshops
- Installation PM stations $\rightarrow$ evaluation WAS

Outline

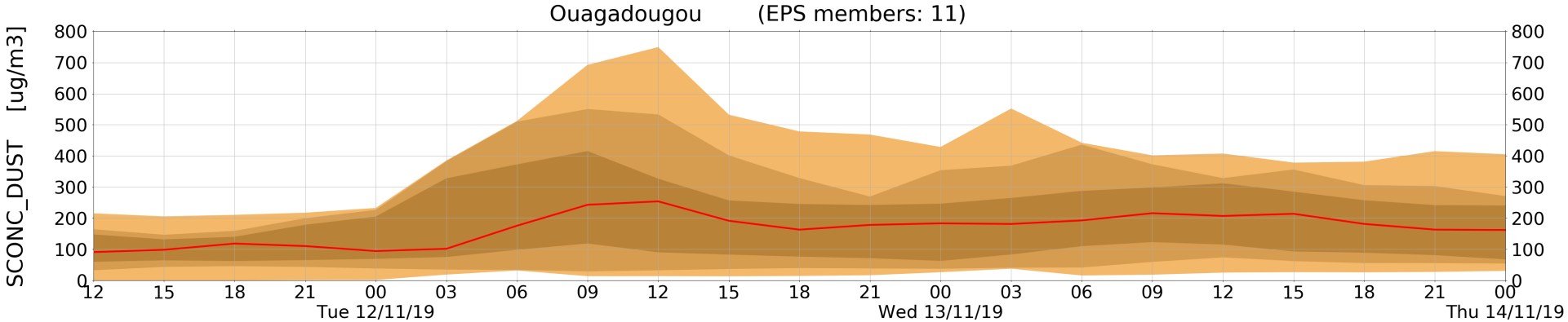
Probability maps: Dust AOD Regional

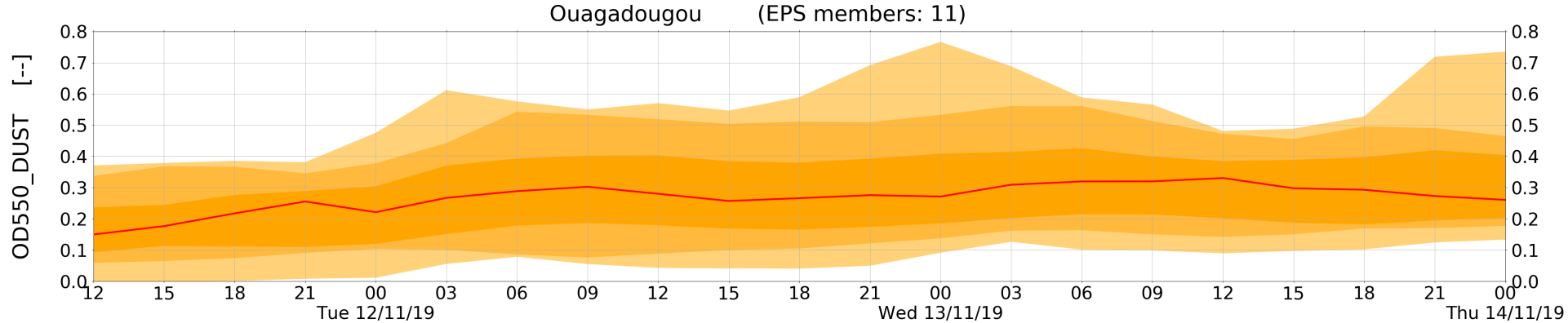


Probability maps: Dust Surface Concentration Europe



AOD and Dust SFC Concentration EPSgrams





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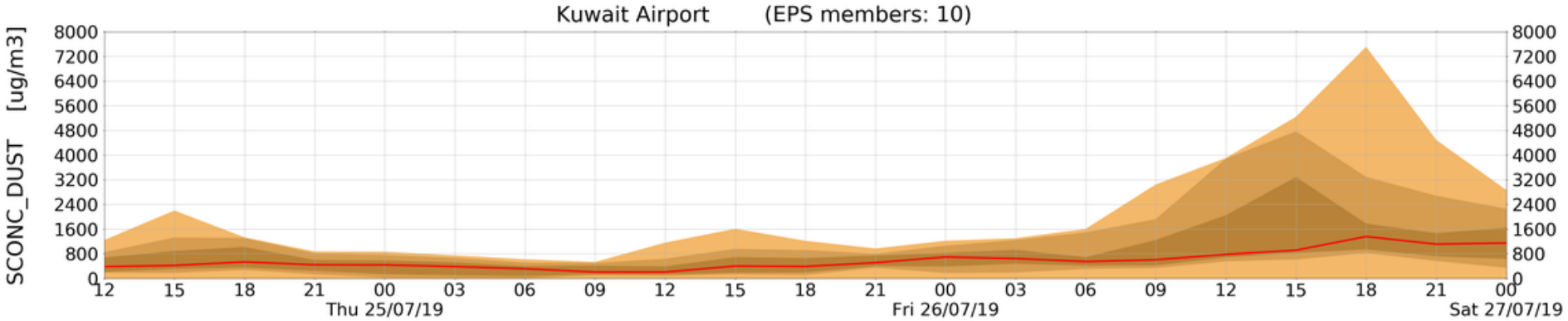

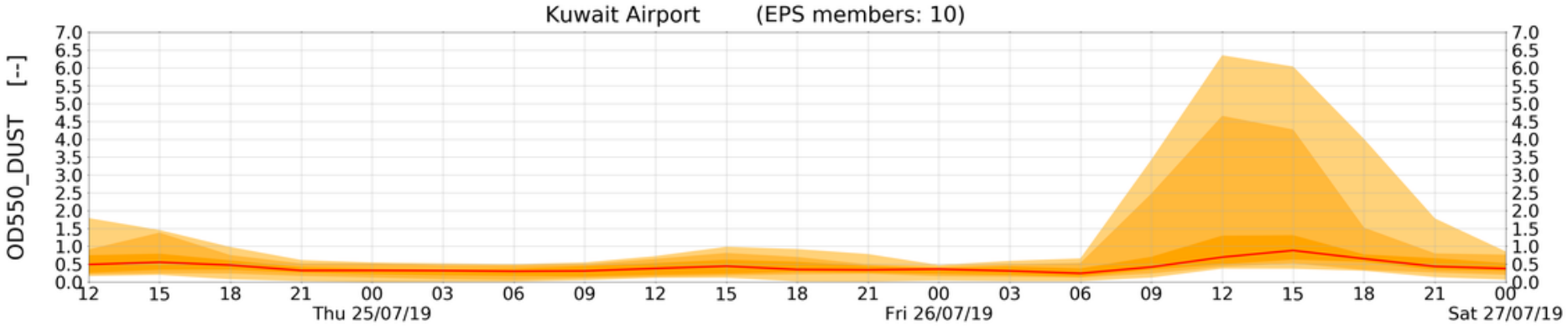

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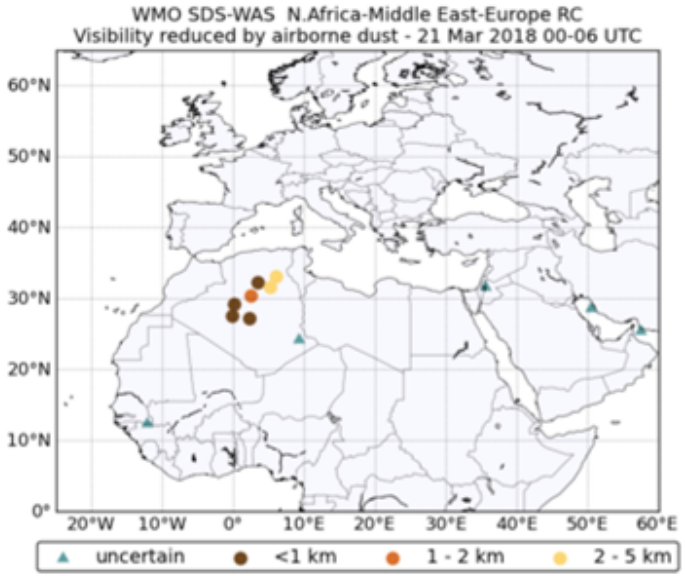
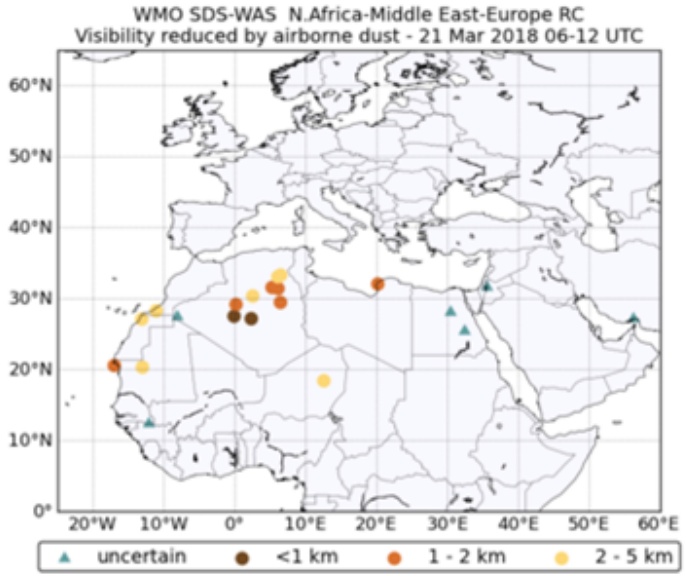
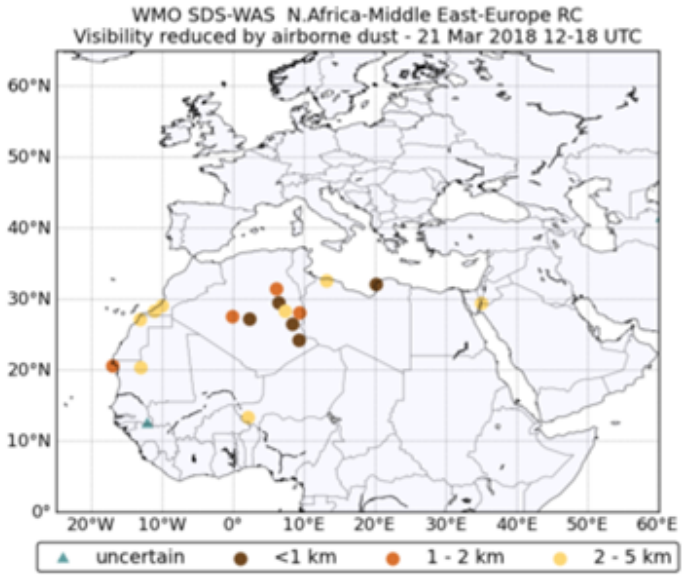
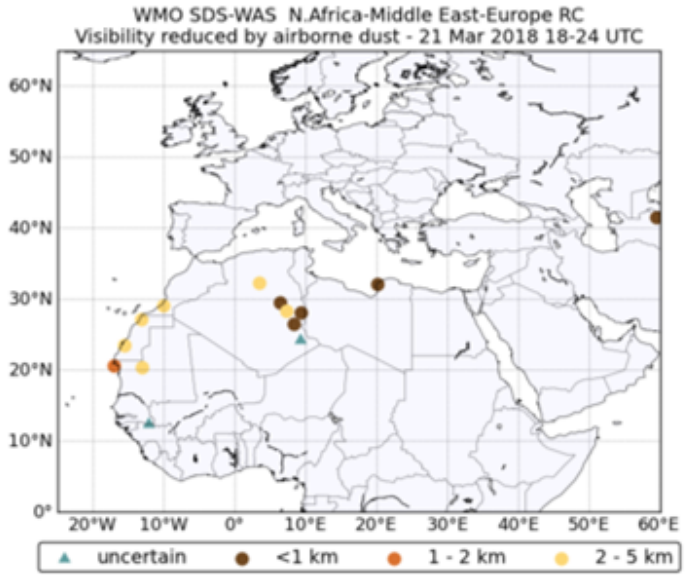
Visibility: METARS and SYNOPS









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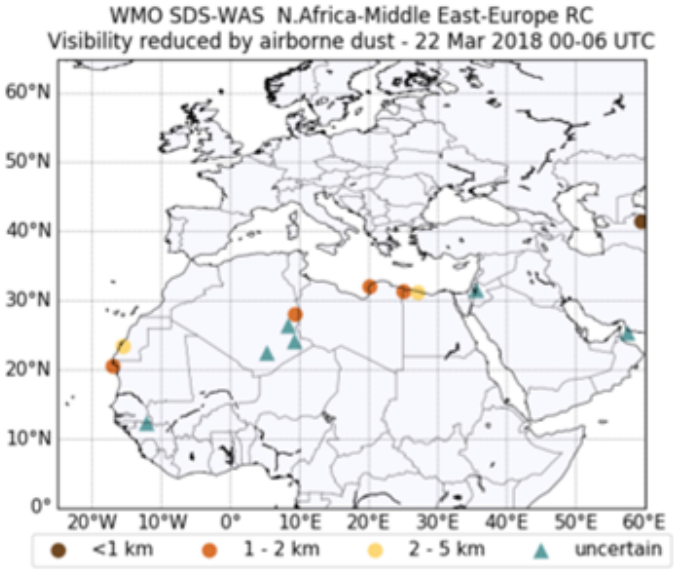

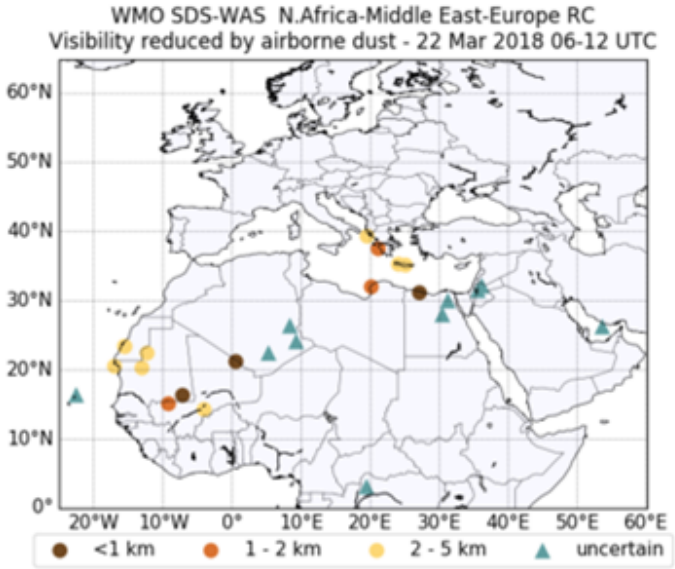

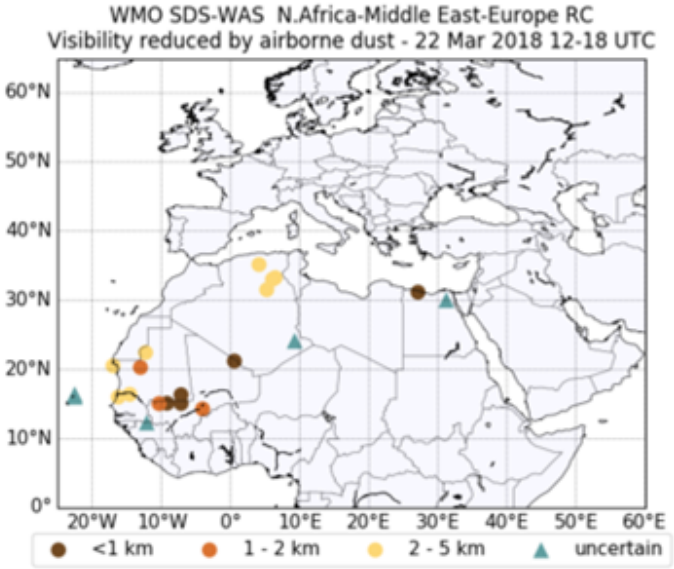

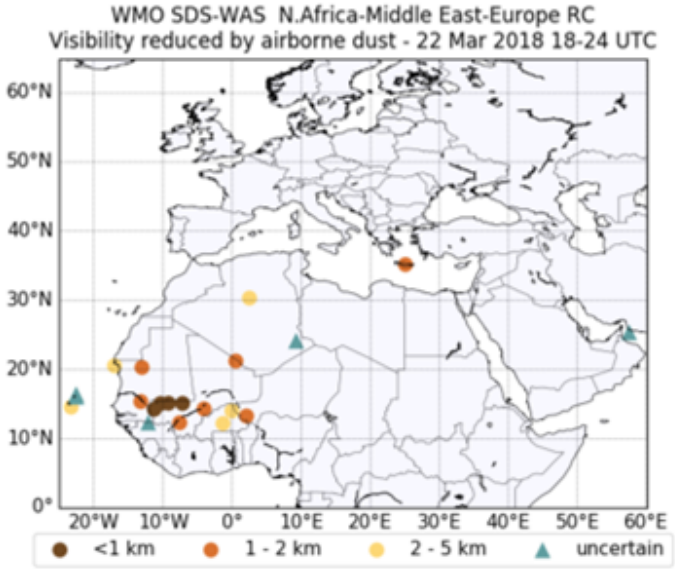

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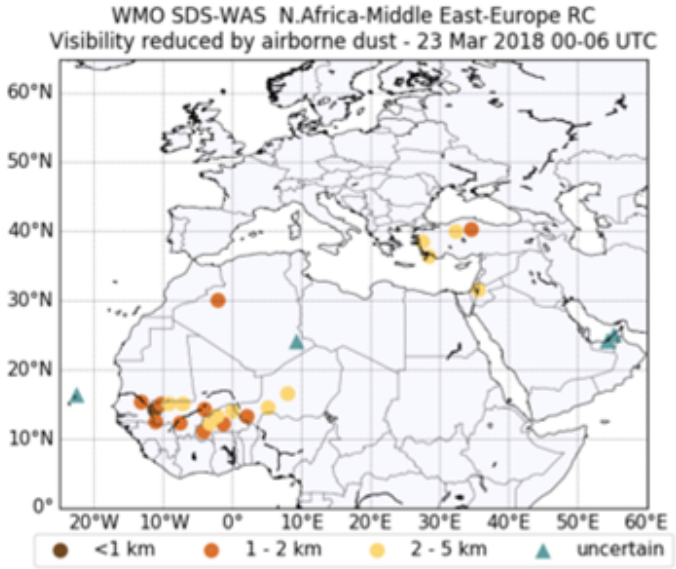
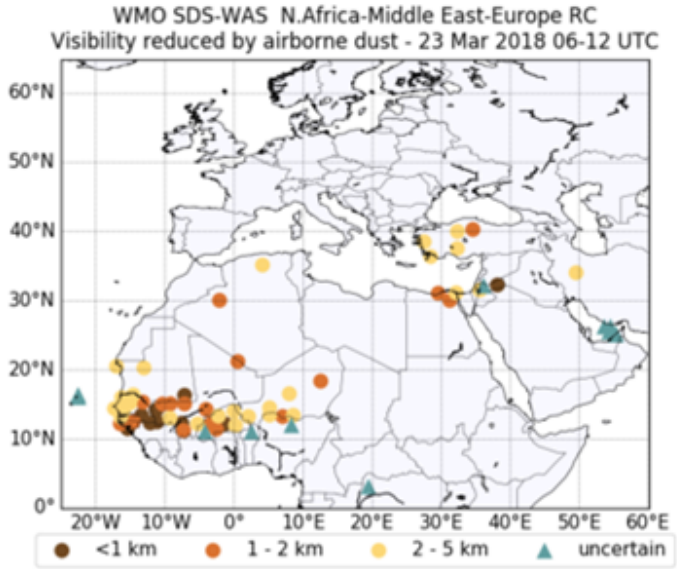
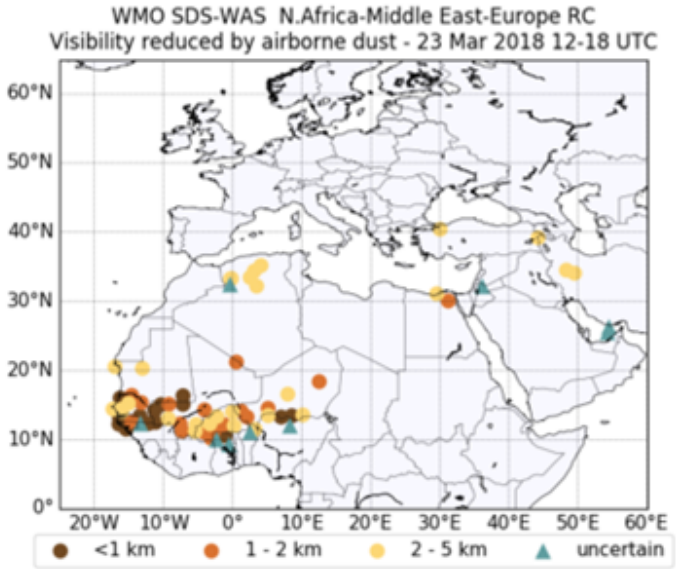
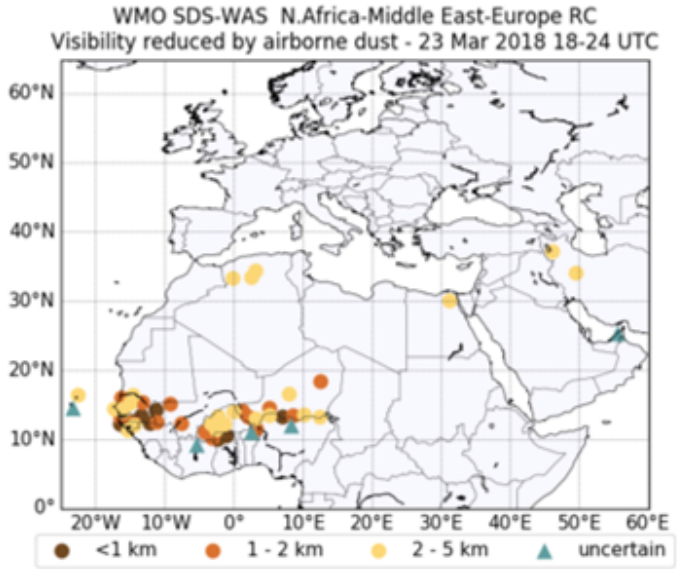
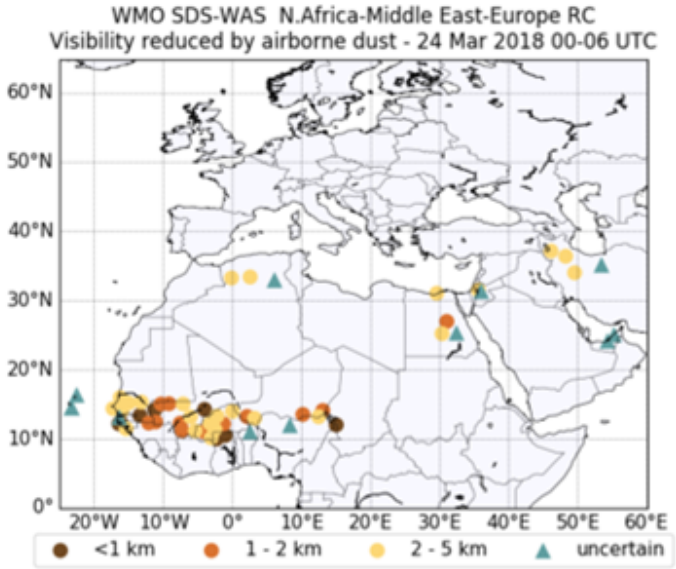


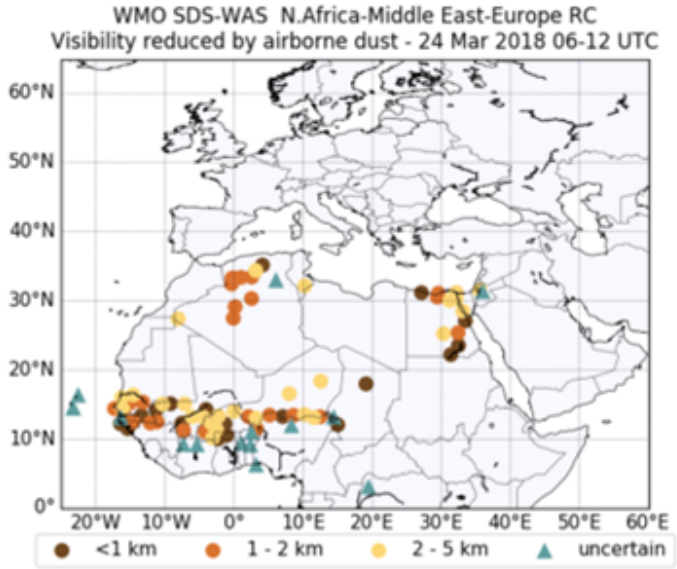


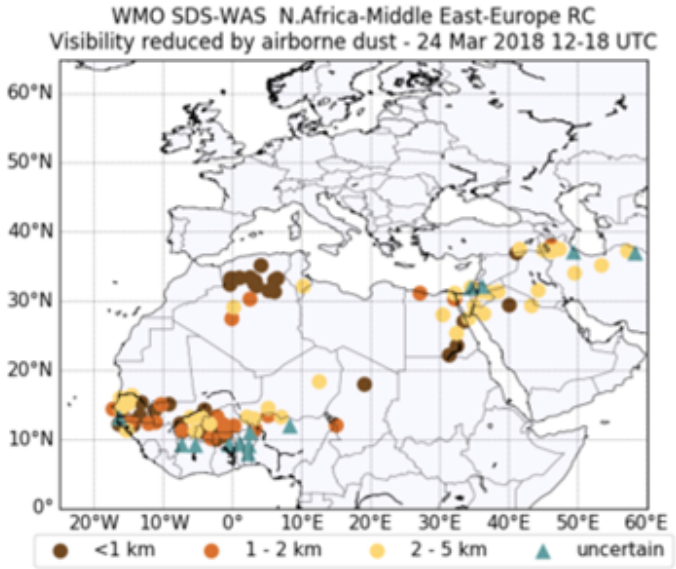


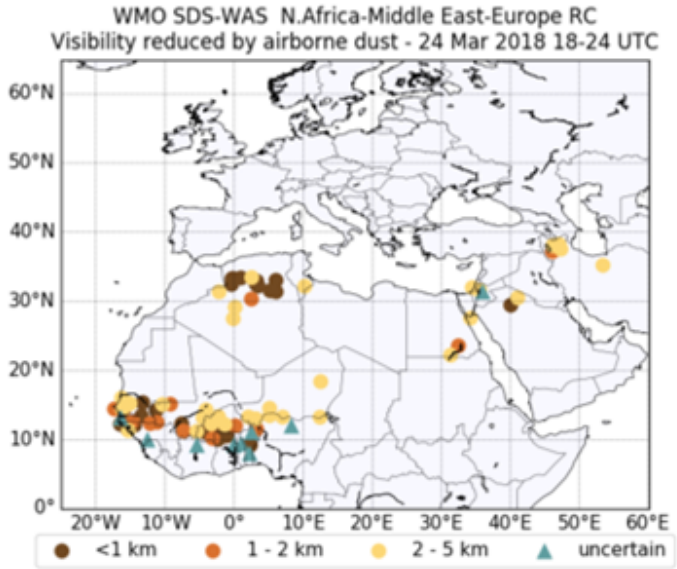


Visibility: METARS and SYNOPS

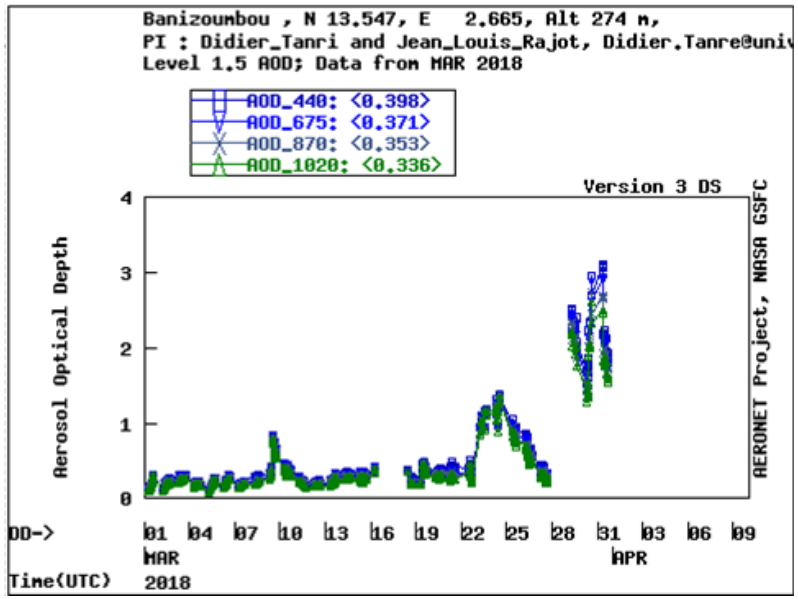


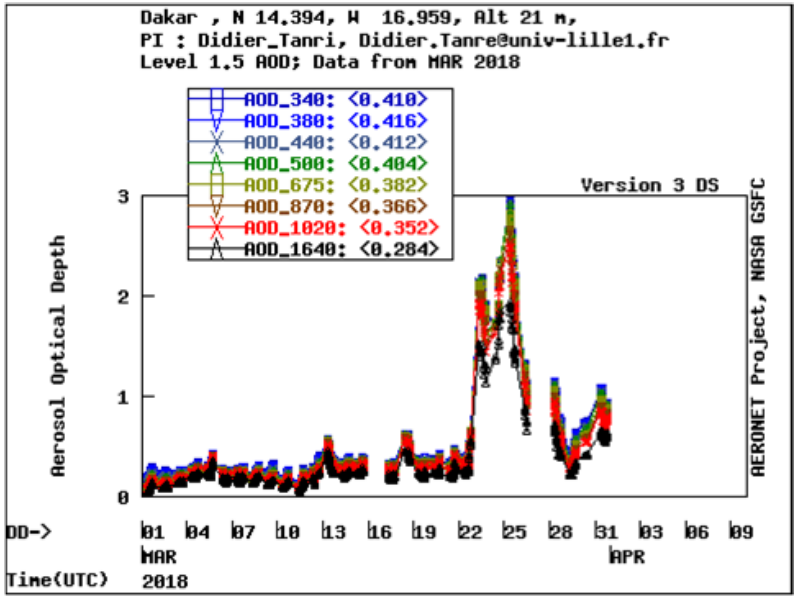




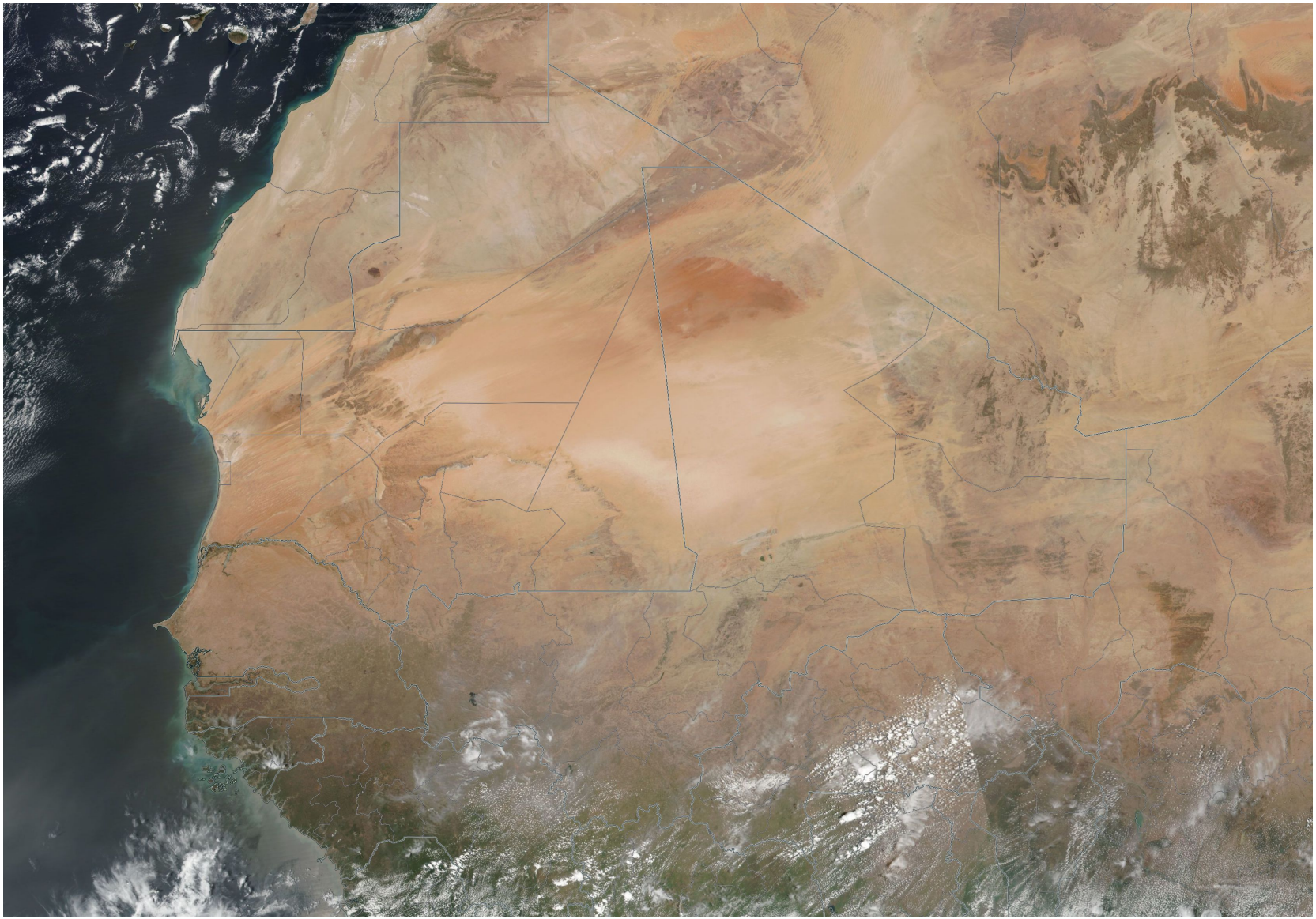


AERONET: Banizoumbou and Dakar





Satellite: Suomi 20/03/2018



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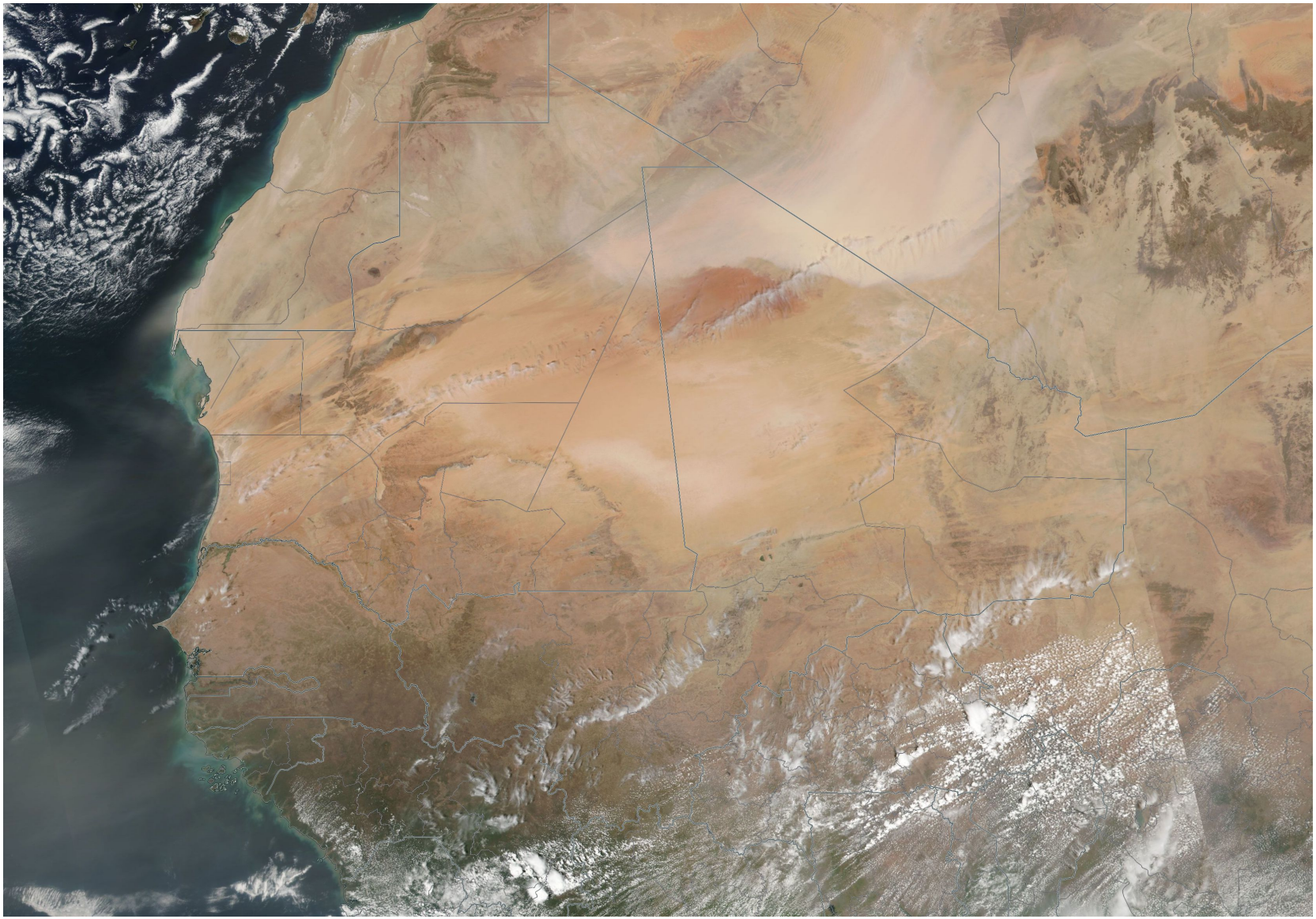
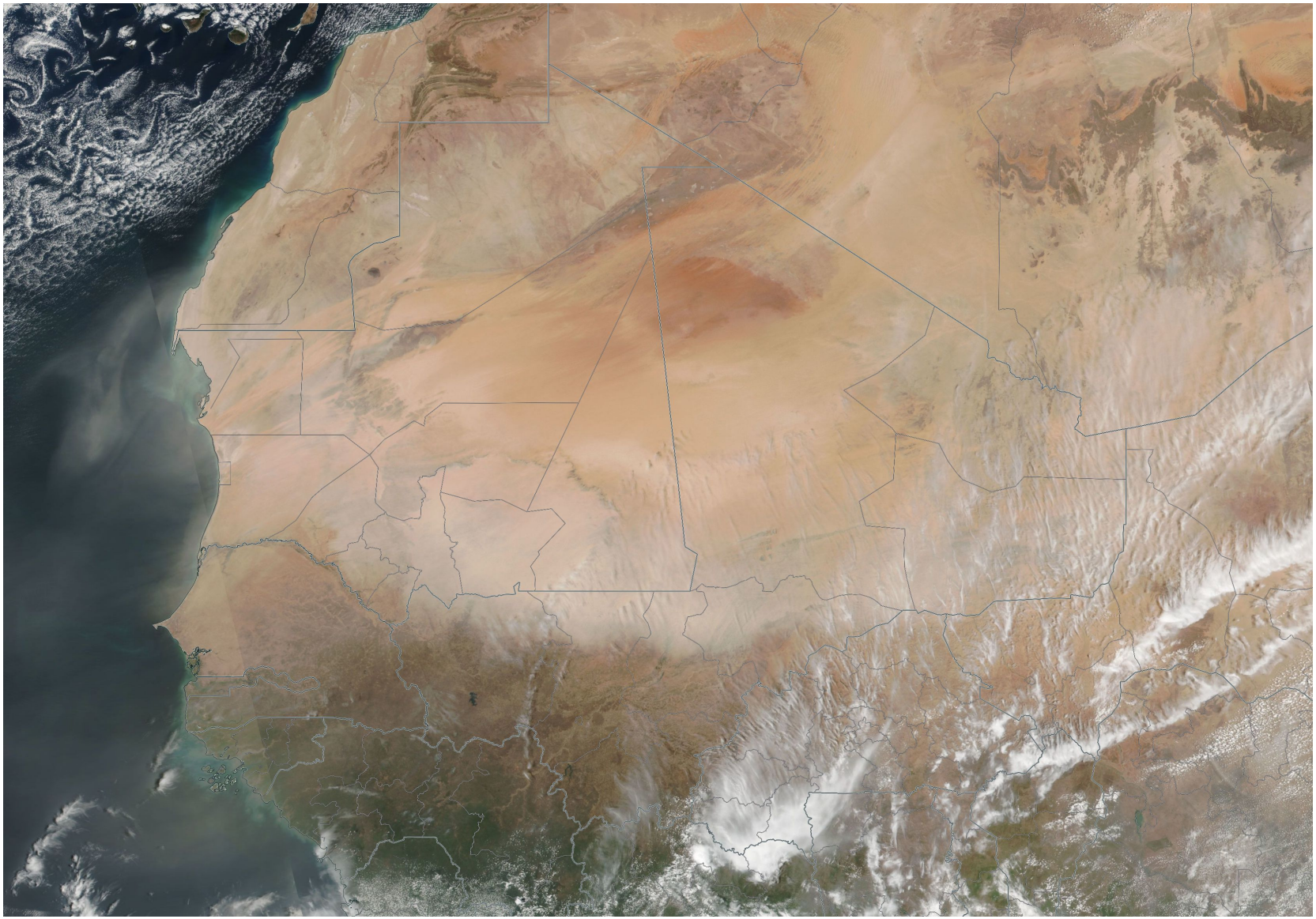
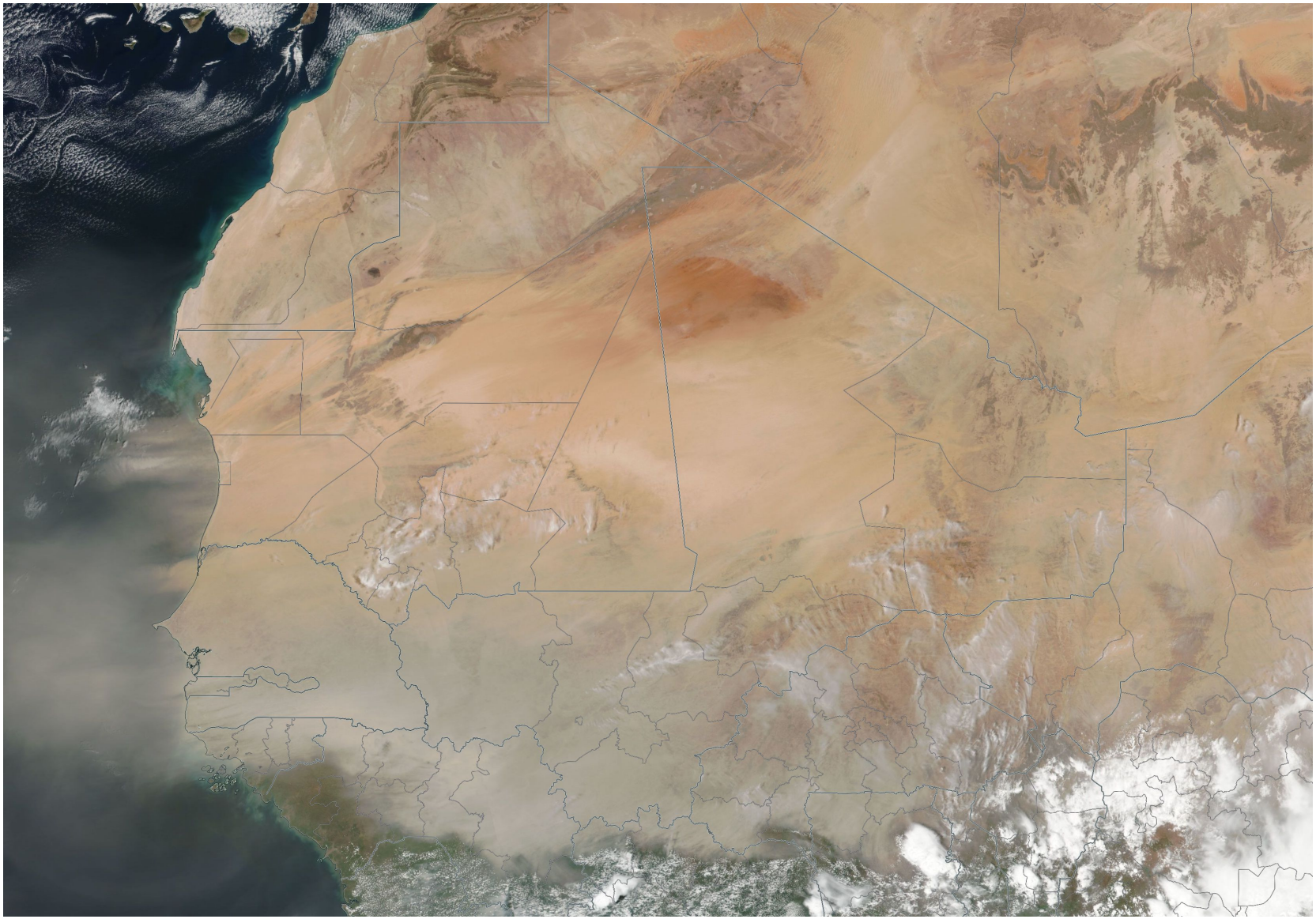


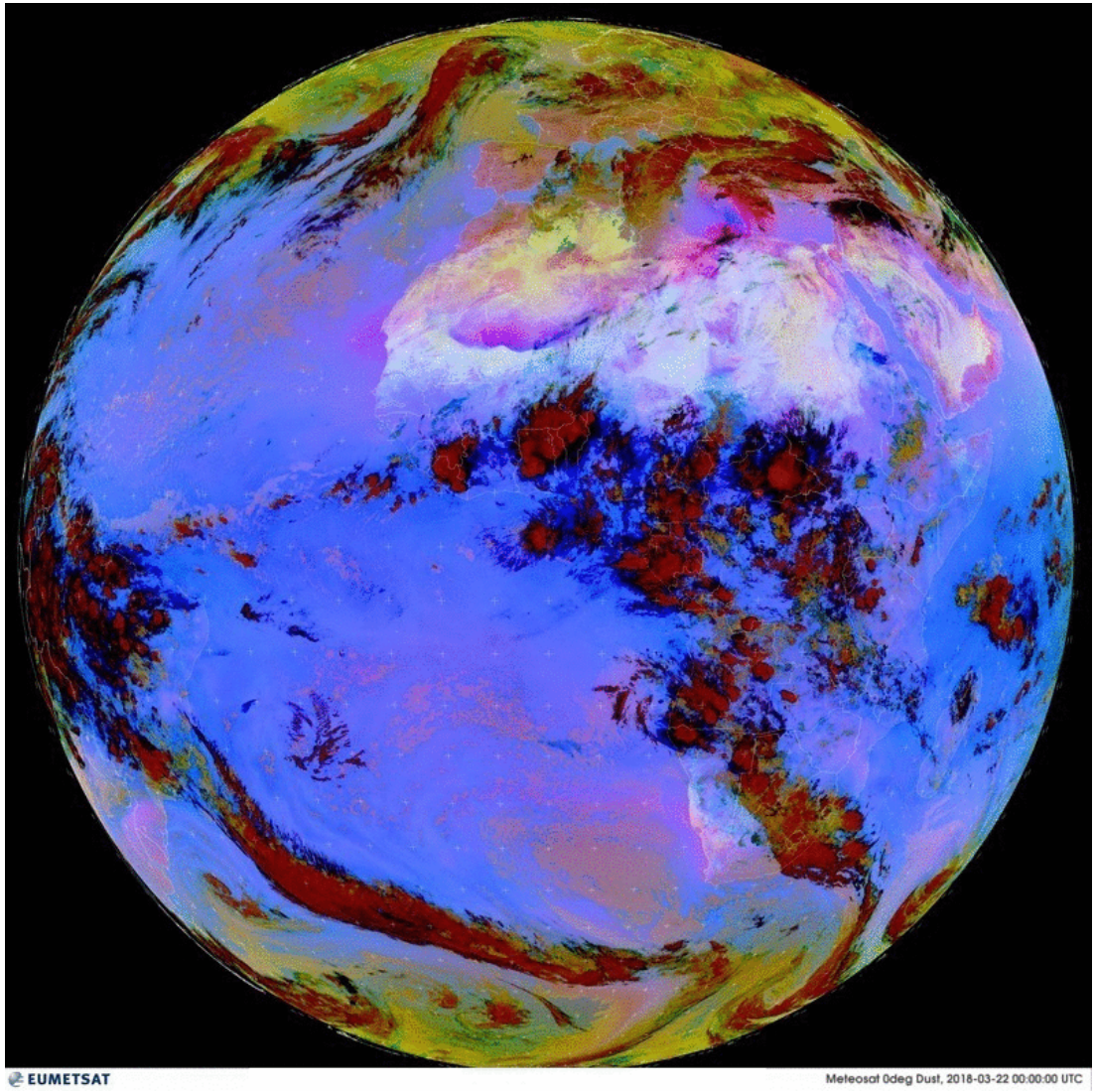
Satellite: Suomi 22/03/2018



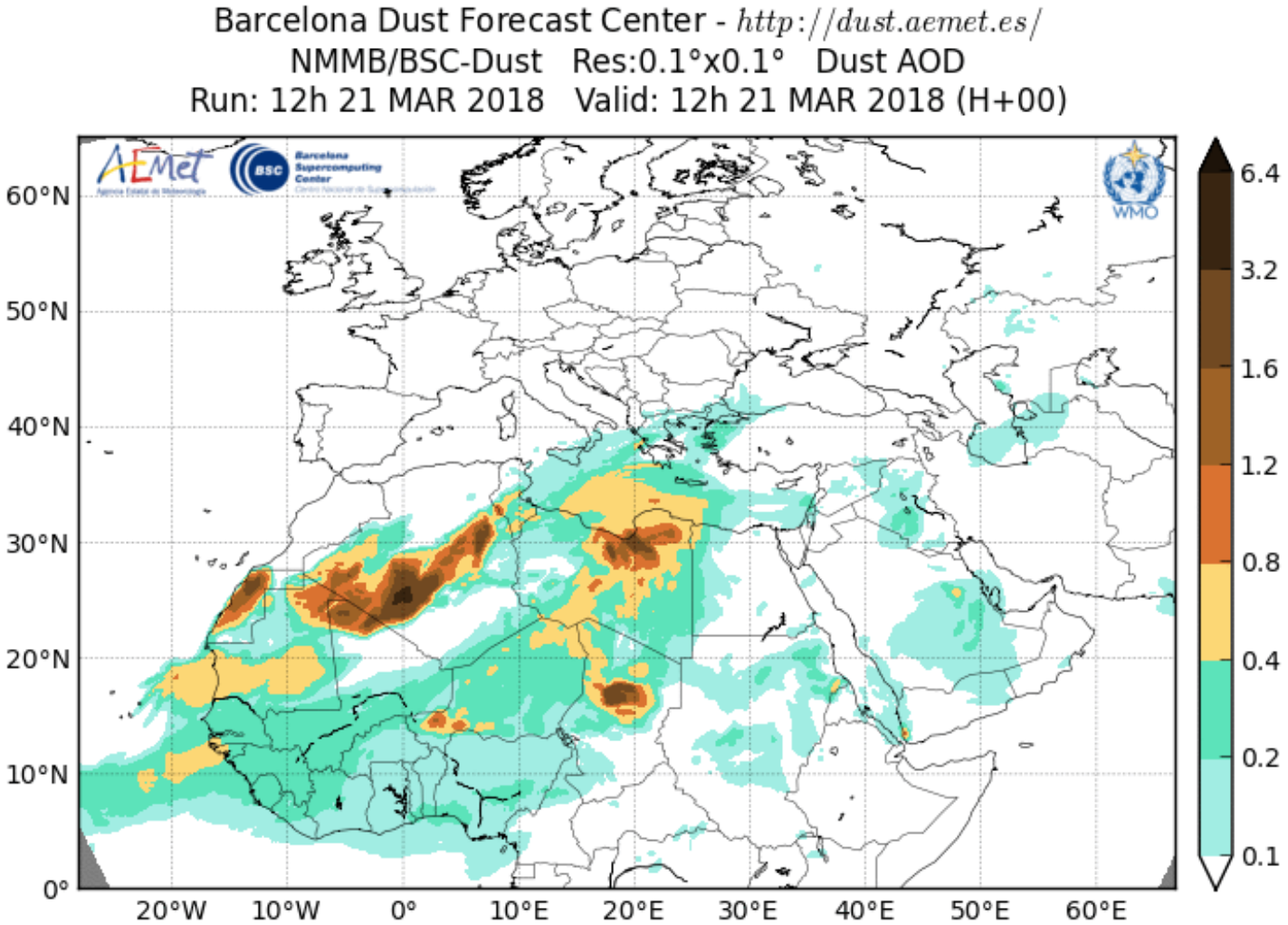
Satellite: Suomi 23/03/2018



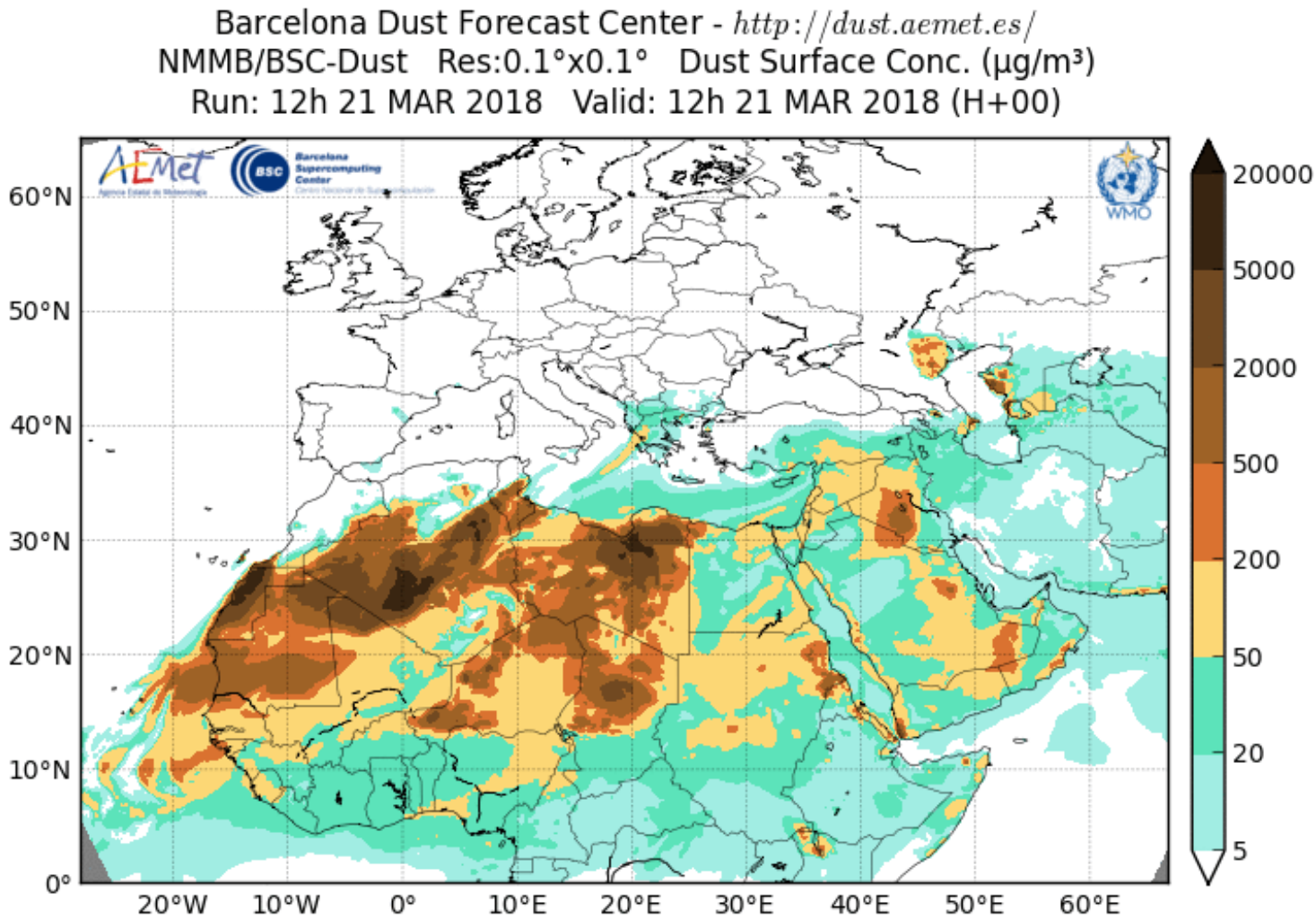
METEOSAT RGB 22/03/2018



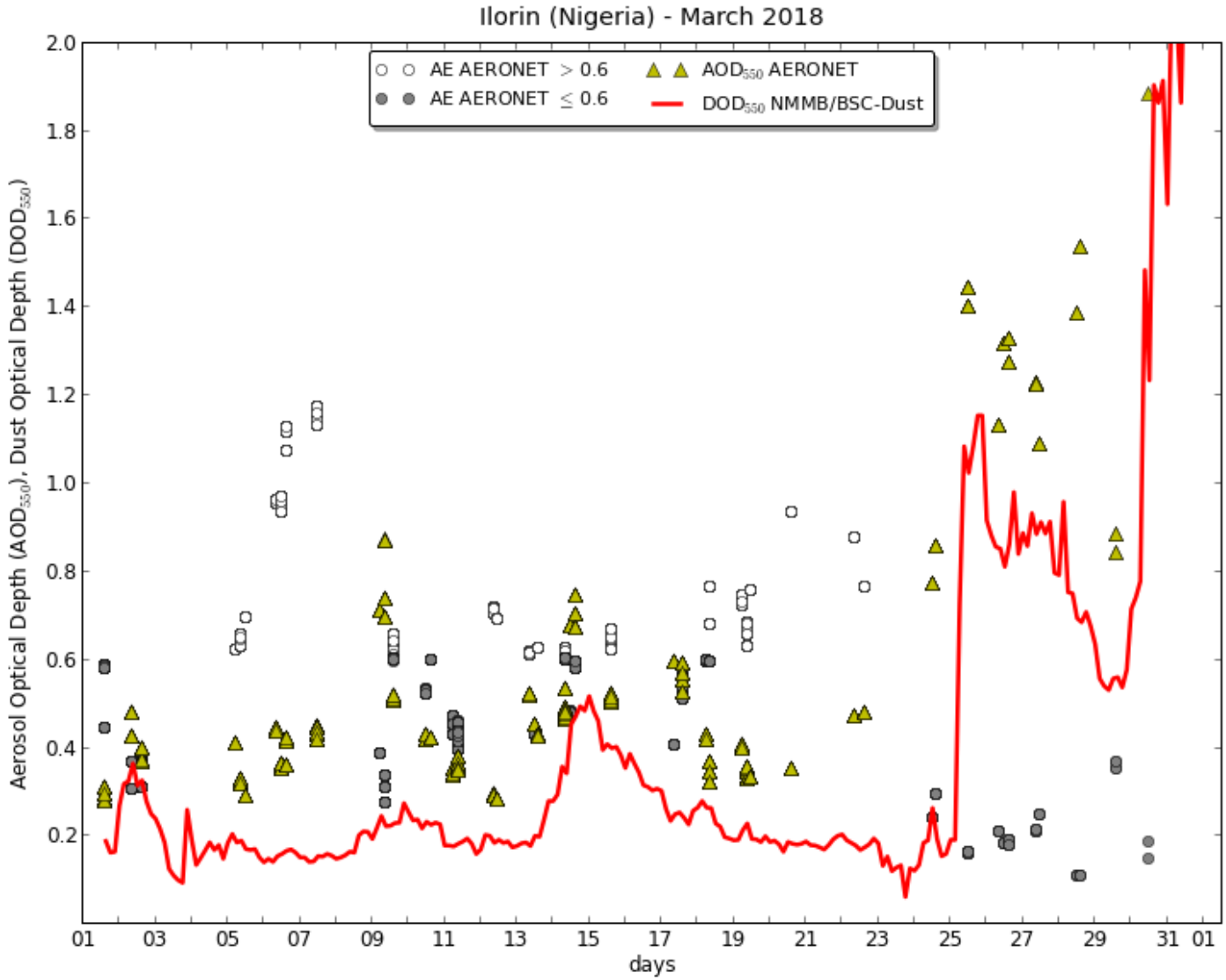
Operational Model: AOD



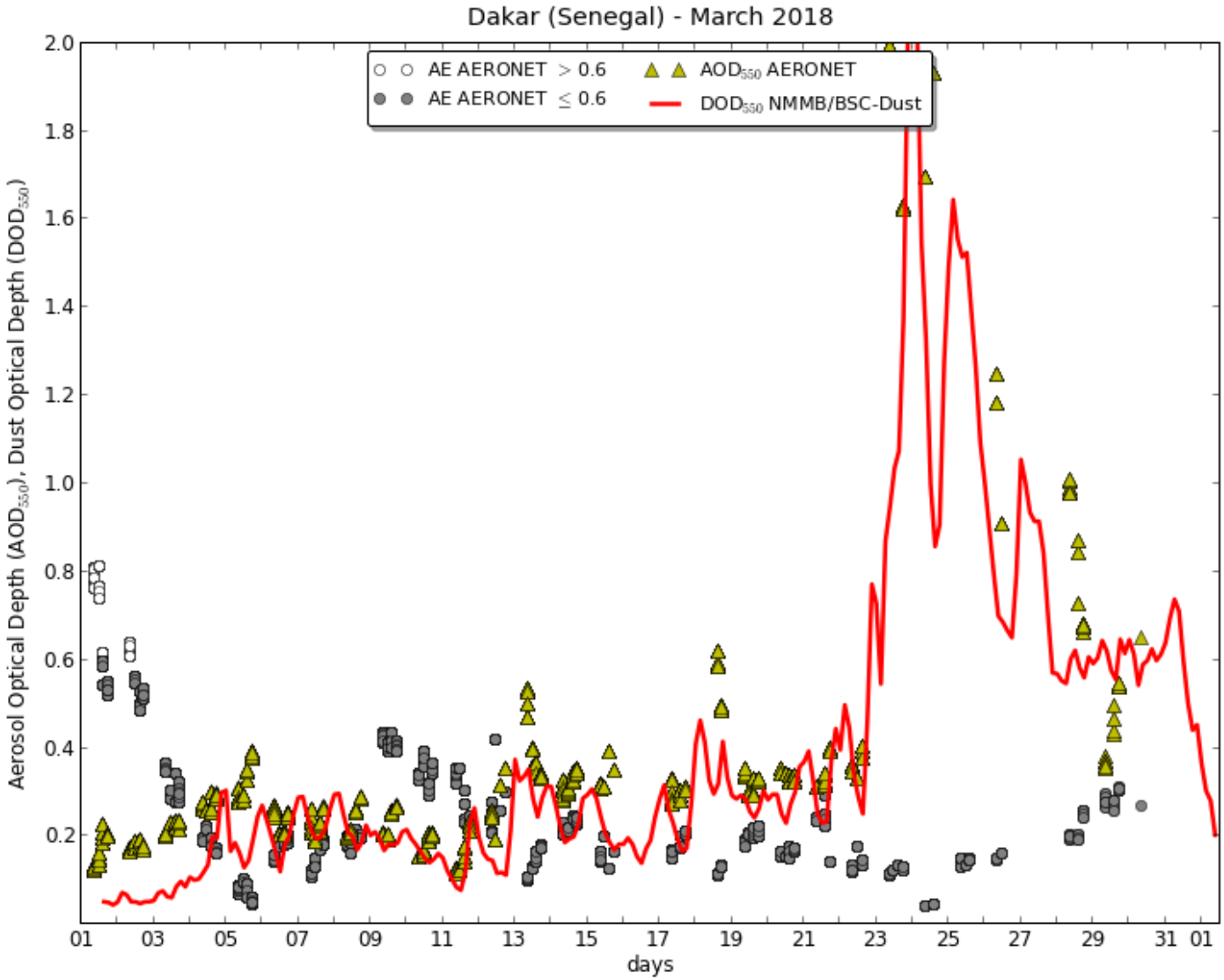
Operational Model: Dust Surface Concentration



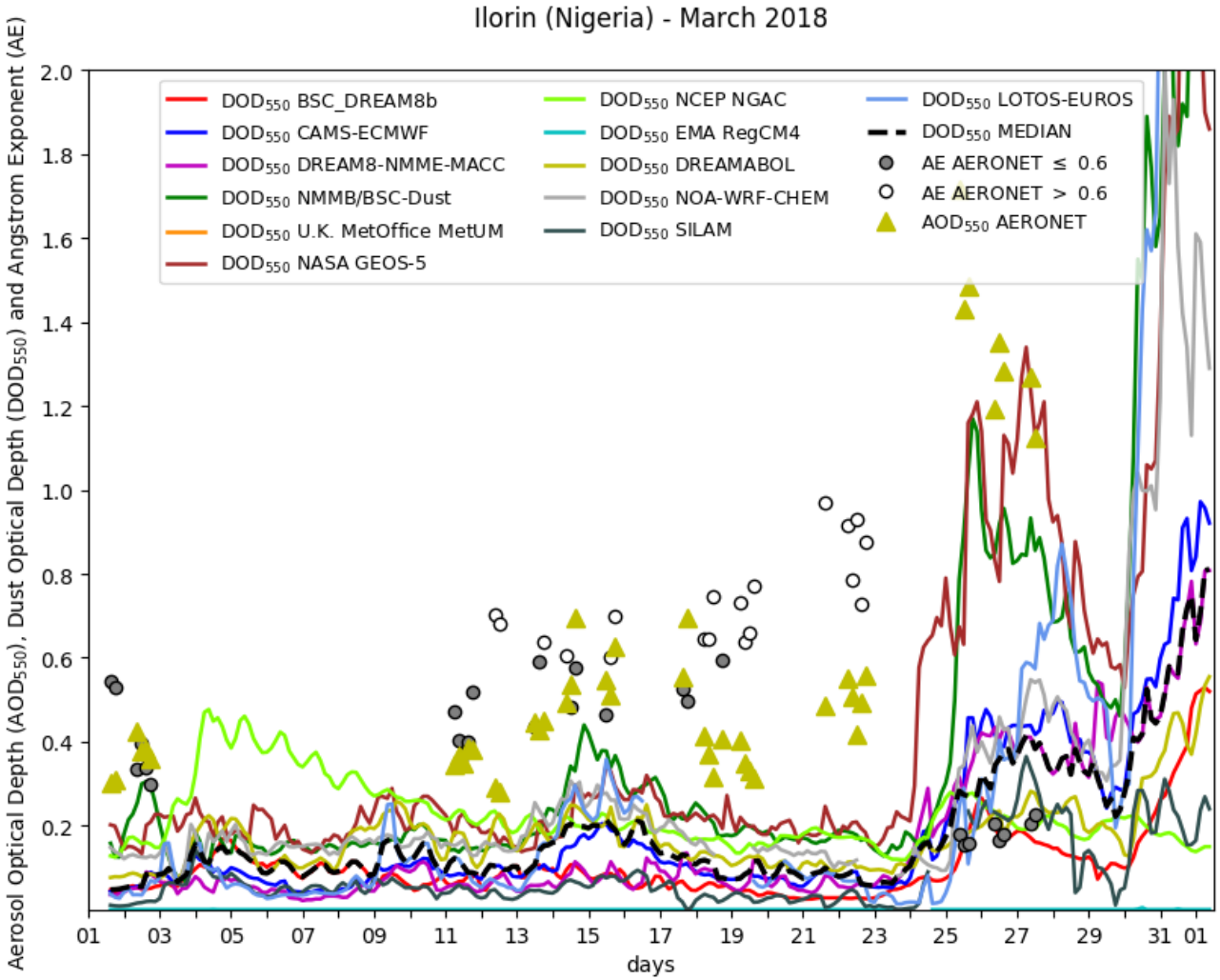
Operational Model: Validation AERONET Ilorin



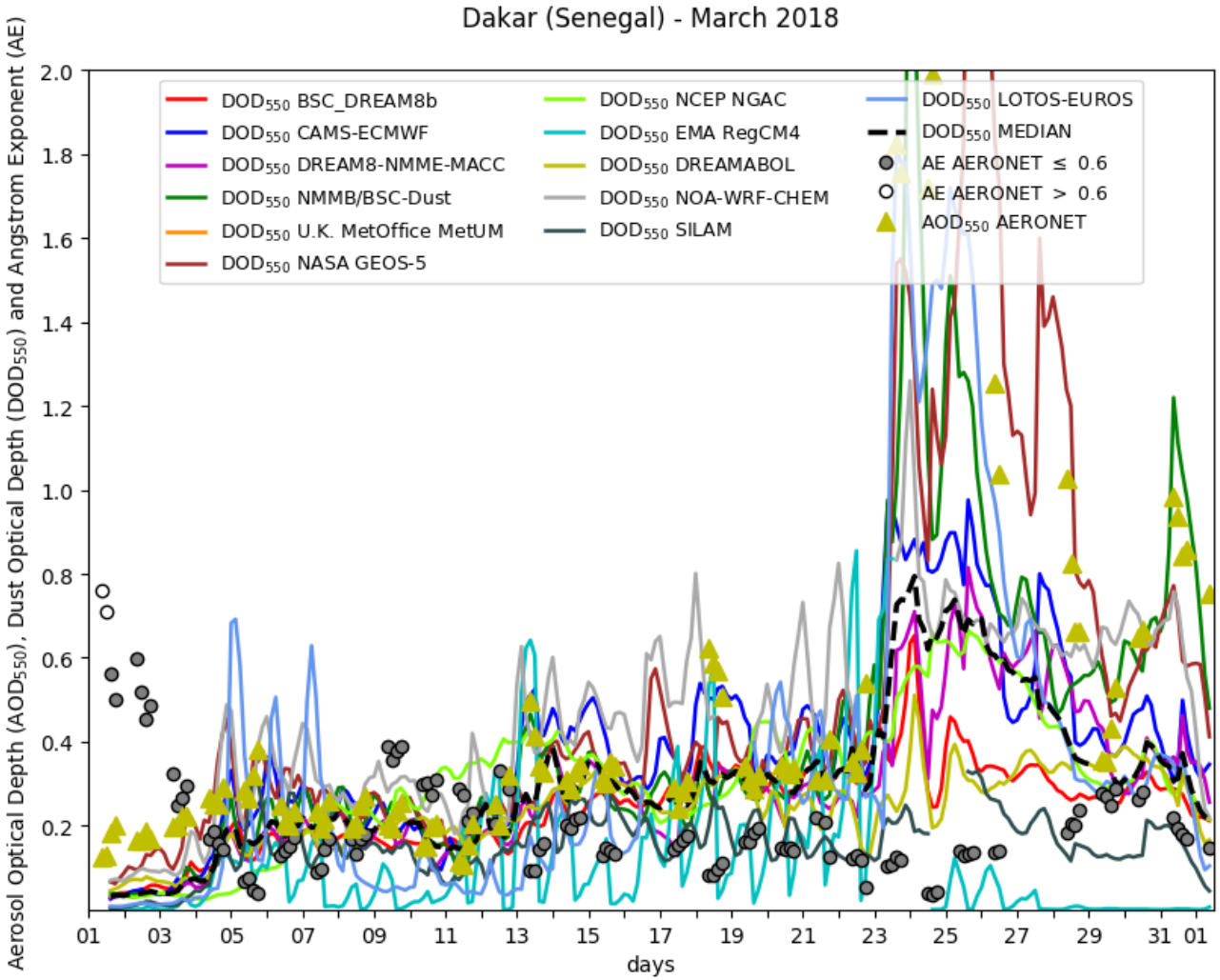
Operational Model: Validation AERONET Dakar



Multimodel: Validation AERONE Ilorin



Multimodel: Validation AERONE Dakar



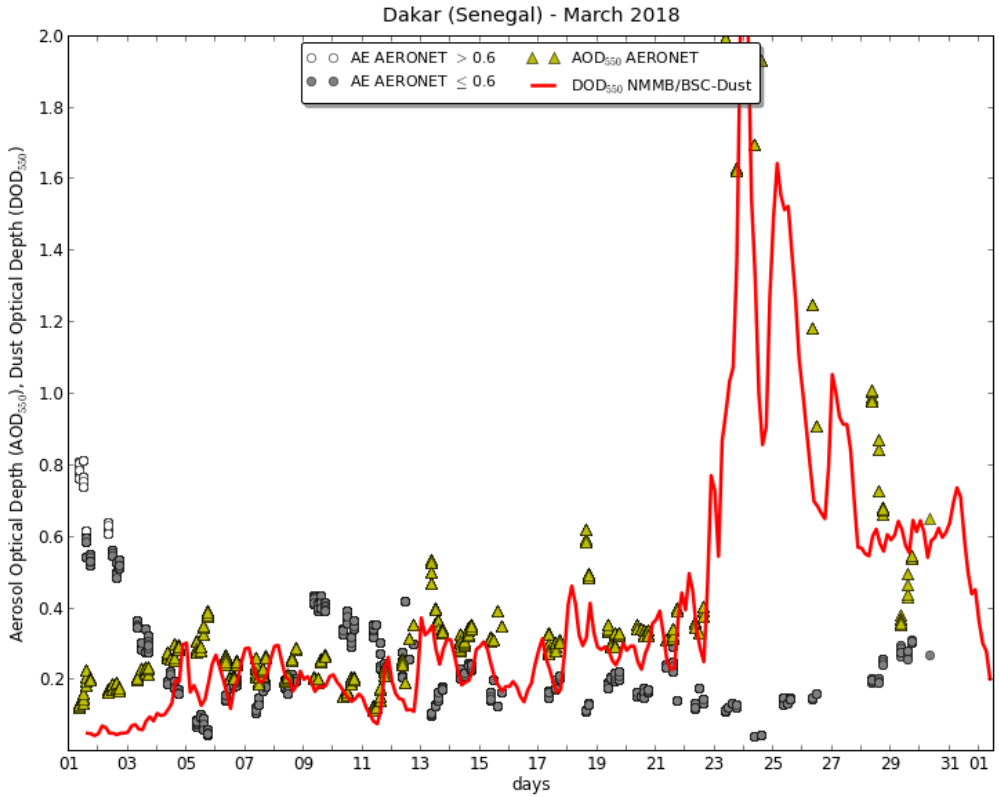
Outline

Dust AOD

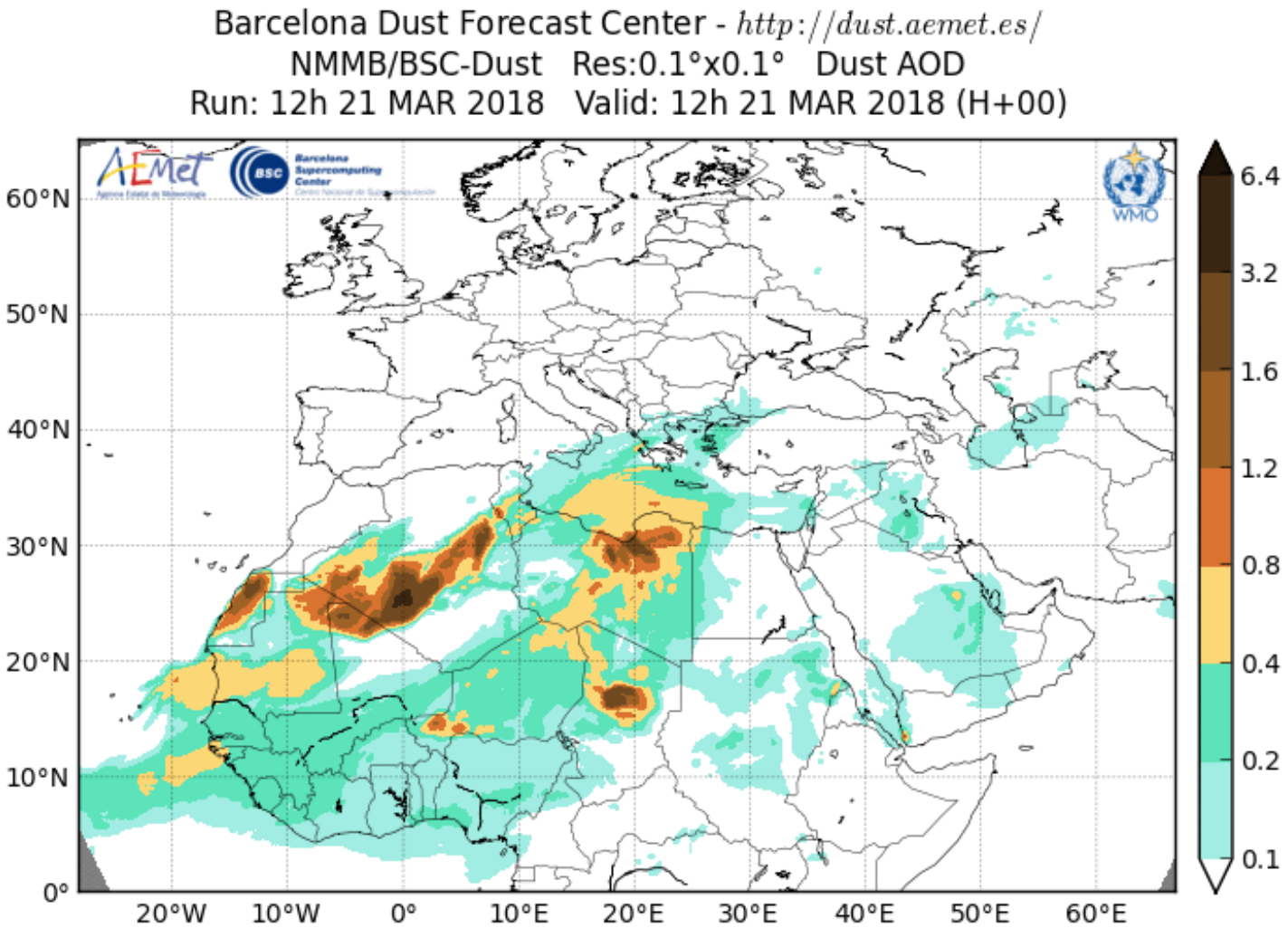
- Dust Aerosol Optical Depth: τ (atmospheric turbidity)
- Optical properties of the atmosphere
- Sunphotometers $\rightarrow$ AERONET, Calitoo, MODIS,...
- Describes the exponential attenuation of incoming solar radiation through the atmosphere by particles
- Lambert-Beer law $\rightarrow$ $I(\lambda)=I_0(\lambda)\ e^{-\tau(\lambda)}$
- $I_0(\lambda)$ and $I(\lambda)$ $\rightarrow$ intensities of incoming radiation on top of the atmosphere and on ground at wavelengthλ
- Columnar value: **total amount of dust in the atmoshpere**
- Dimensionless parameter
- Easier to forecast than Dust SFC Conc

Dust AOD

- Angstrom exponent α: $\tau / \tau_0 = (\lambda/\lambda_0)^{-\alpha}$
- α is inversely related to the average size of the particles in the aerosol: the smaller the particles, the larger the exponent.
- $\alpha < 0.6 \rightarrow$ Dust



Dust AOD

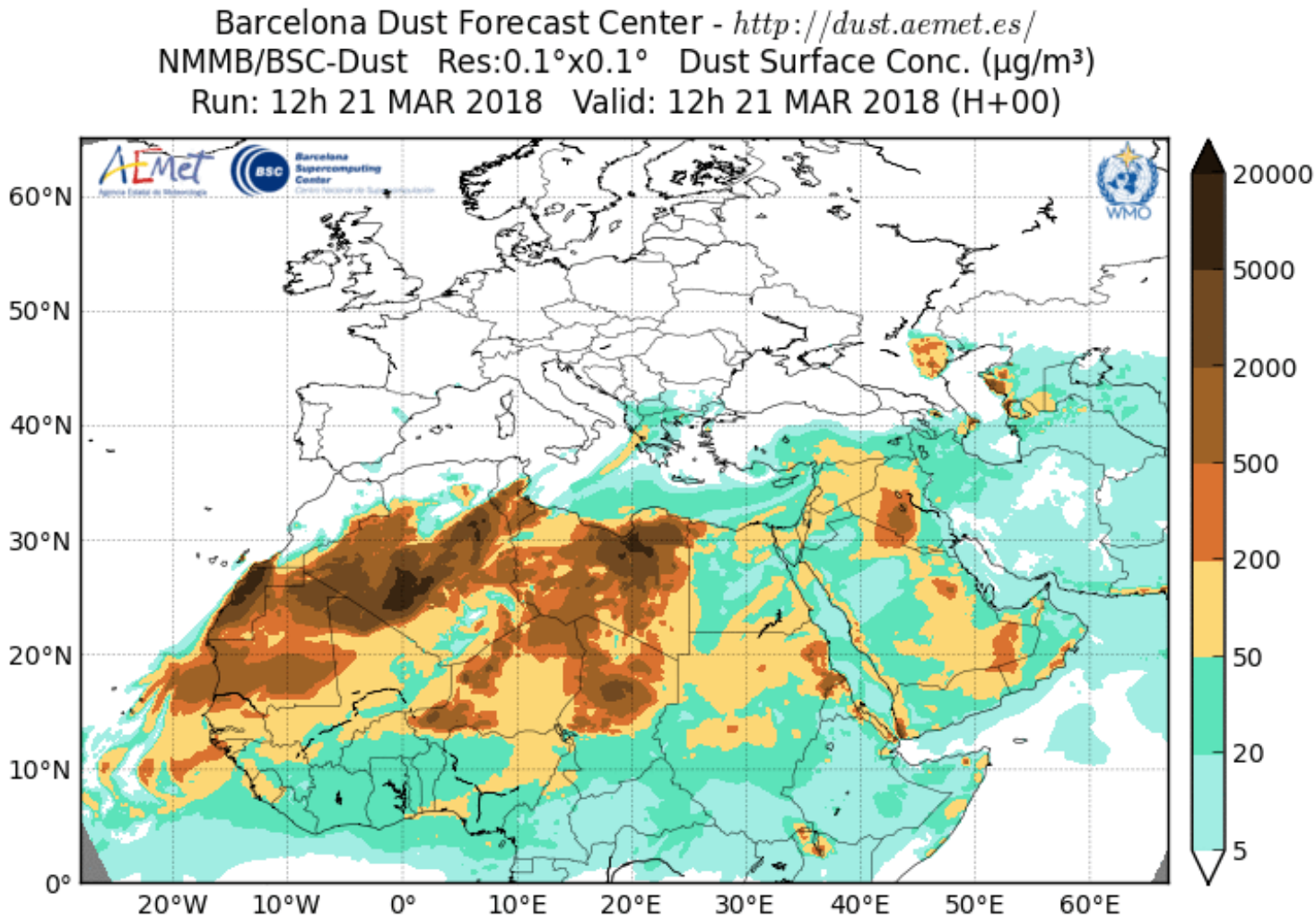

Barcelona Dust Forecast Center - http://dust.aemet.es/
NMMB/BSC-Dust Res:0.1°x0.1° Dust AOD
Run: 12h 21 MAR 2018 Valid: 12h 21 MAR 2018 (H+00)
60°N
50°N
40°N
30°N
20°N
10°N
0°
20°W
10°W
0°
10°E
20°E
30°E
40°E
50°E
60°E
6.4
3.2
1.6
1.2
0.8
0.4
0.2
0.1

Outline

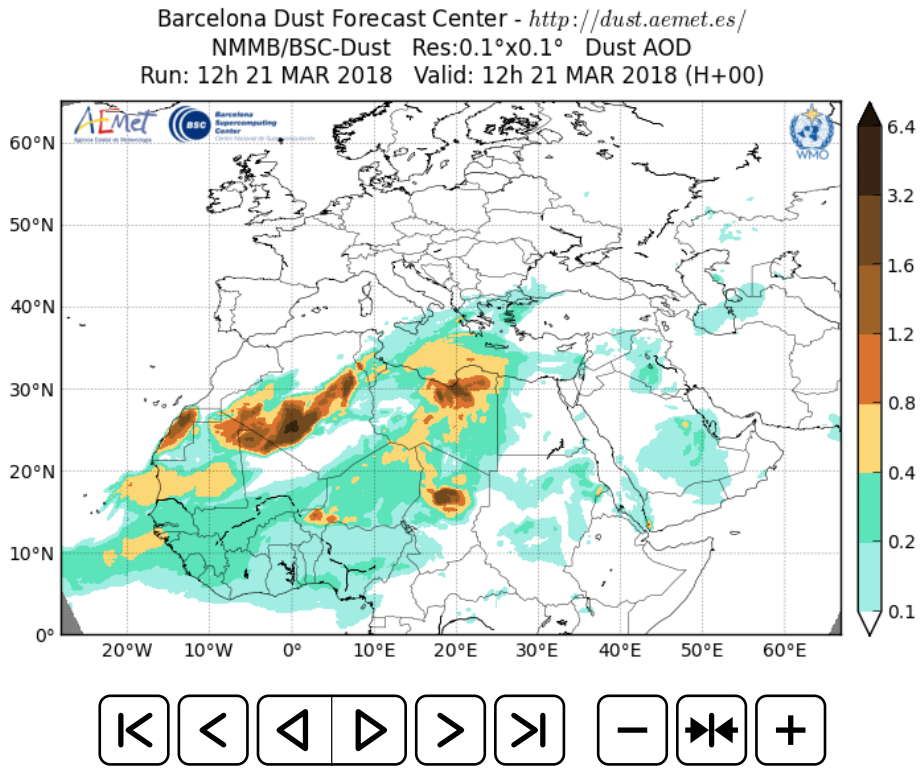
Dust Surface Concentration

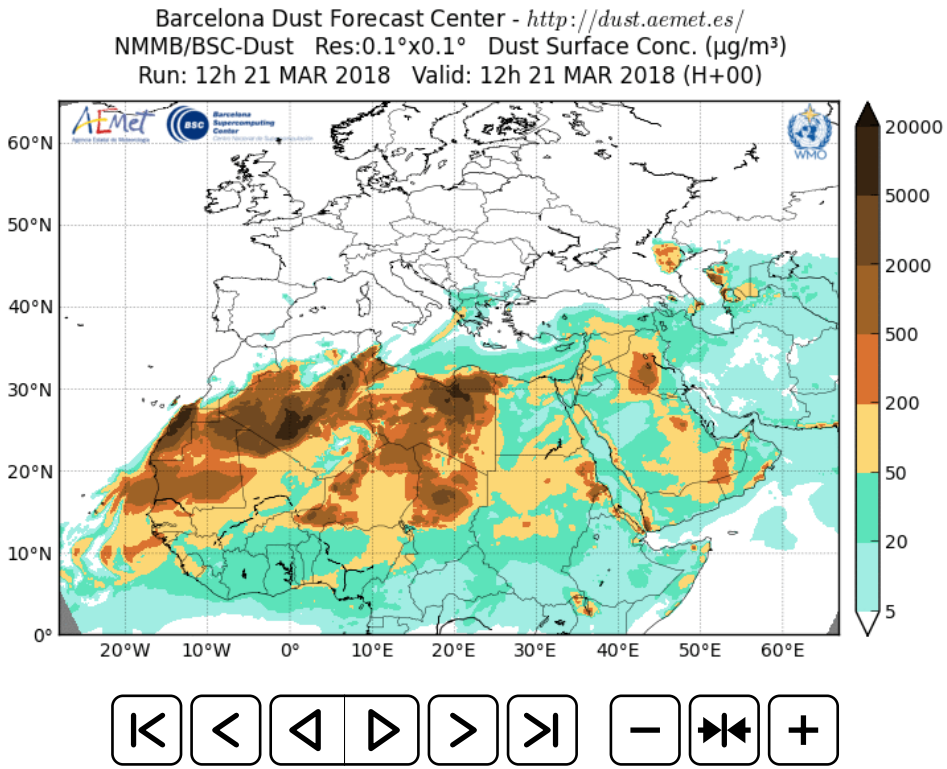
- Dust Surface Concentration [μg/m^3]
- European annual mean max: 40 μg/m^3
- Average annual [PM10] in Nouakchott (Mauritania): 108 μm
- in-situ measurements (AQ monitoring stations)
- PM10 Particulate matter aerodynamic diameter $\leq$10 μm
- PM2.5 Fine fraction $\leq$ 2.5 μm
- PM1 Ultrafine fraction $\leq$ 1 μm
- PM10 - PM2.5 coarse fraccion
- PM10 can be inhale

Dust Surface Concentration



Dust AOD versus Dust SFC Concentration

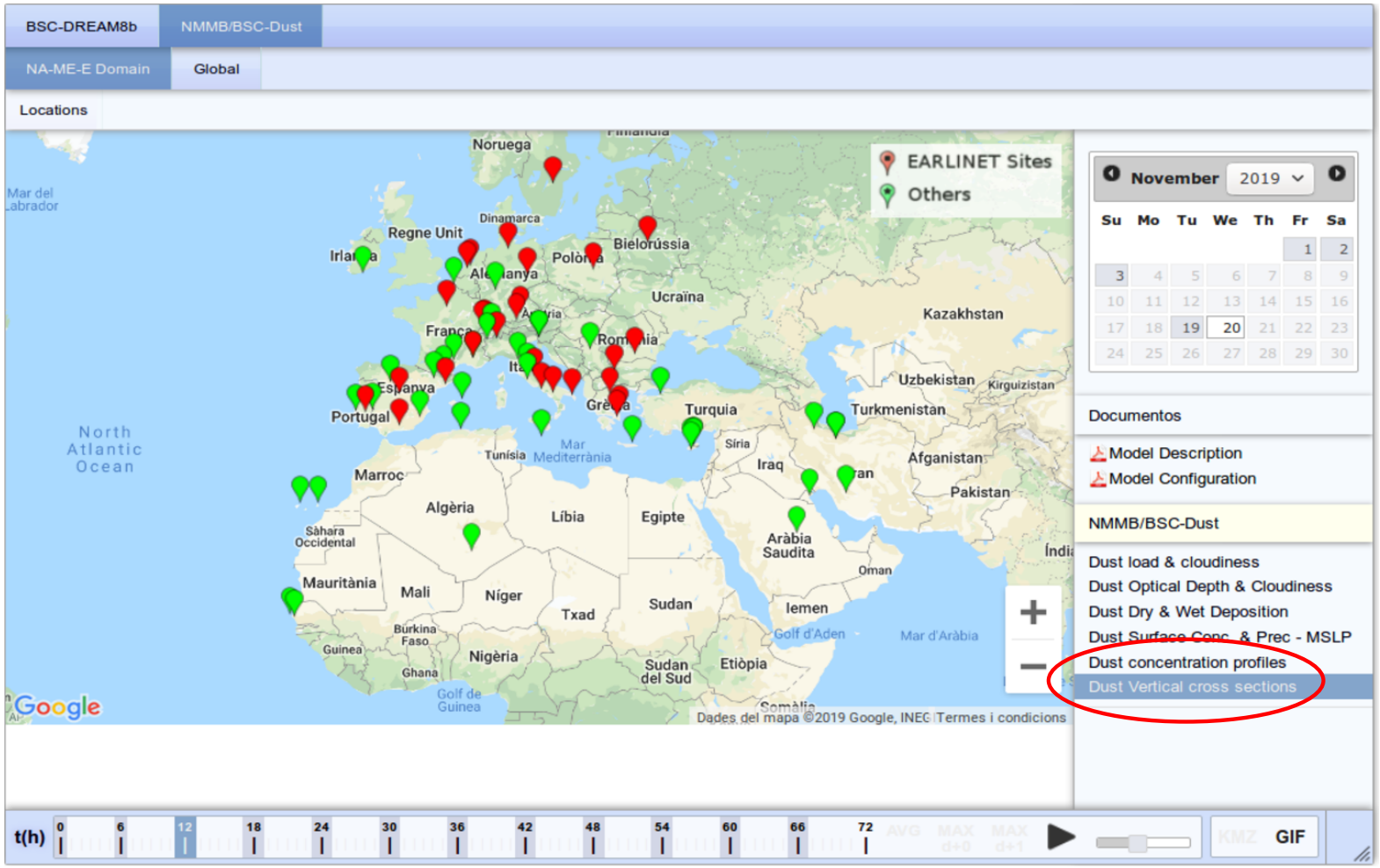




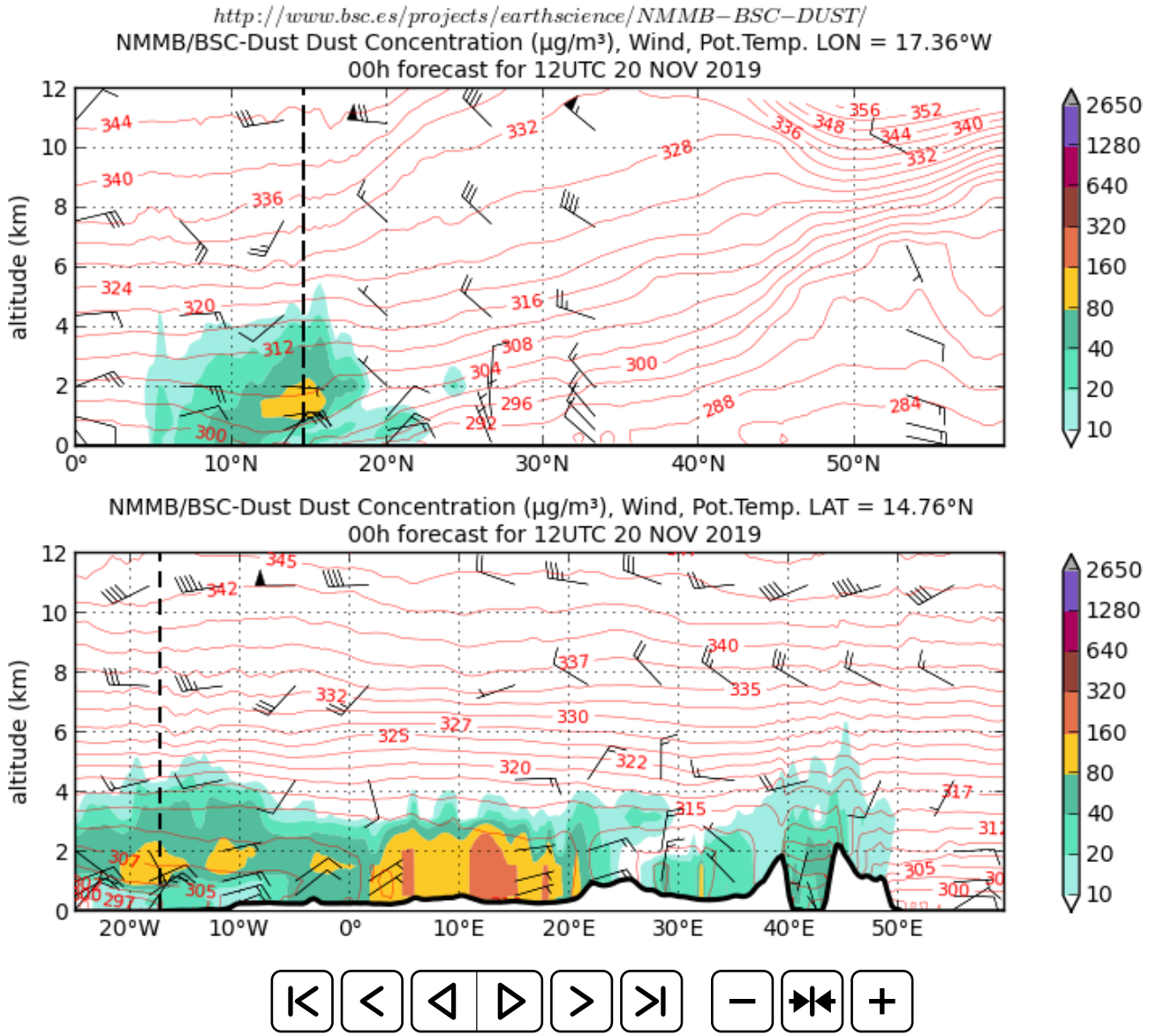
Outline

Dust Concentration: Vertical Structure

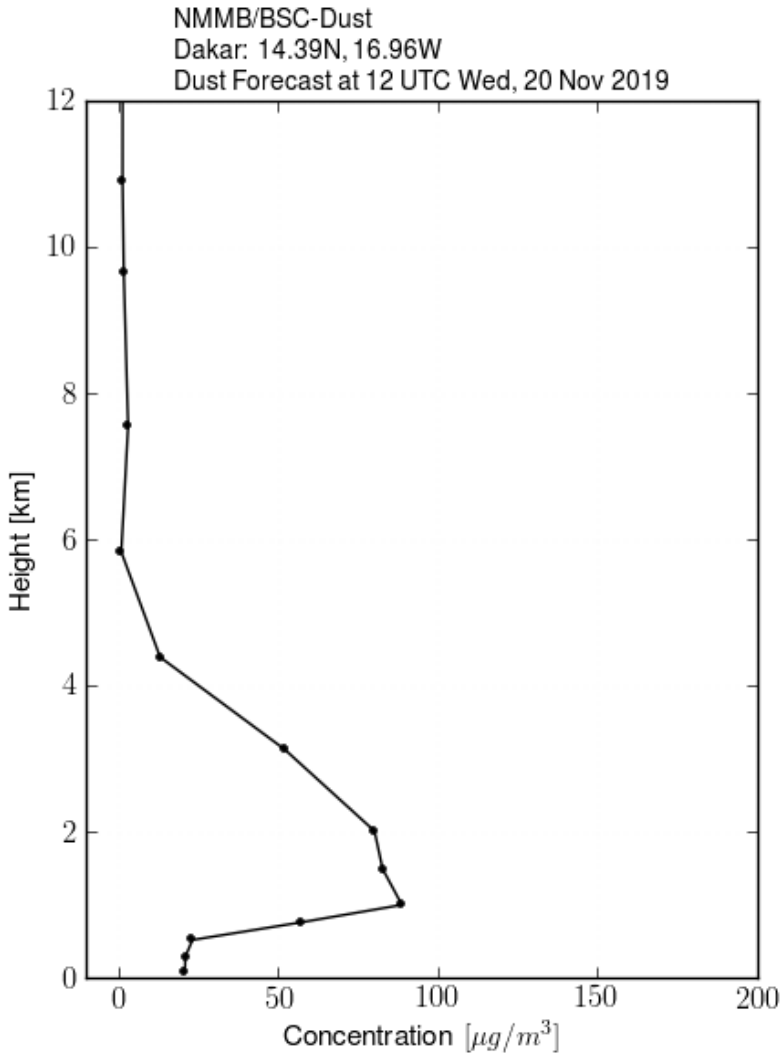
- Cross Section
- Vertical Profile



Dust Concentration: Cross Section



Dust Concentration: Vertical Profile



Outline

Model Download

- Link to SDS-WAS NAMEE RC models download → netCDF files
- netcdf files extension → .nc
- Link to Panoply dowload → netCDF data viewer
- CDO & NCO → manipulate and analyse netCDF files

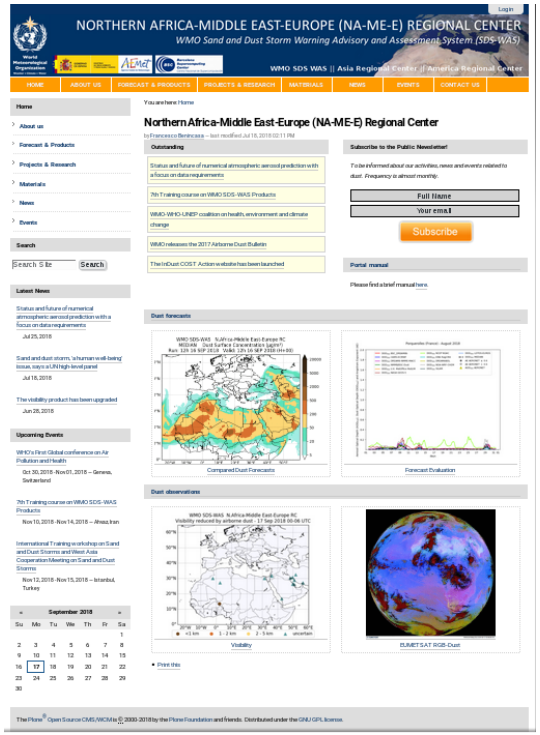
Outline

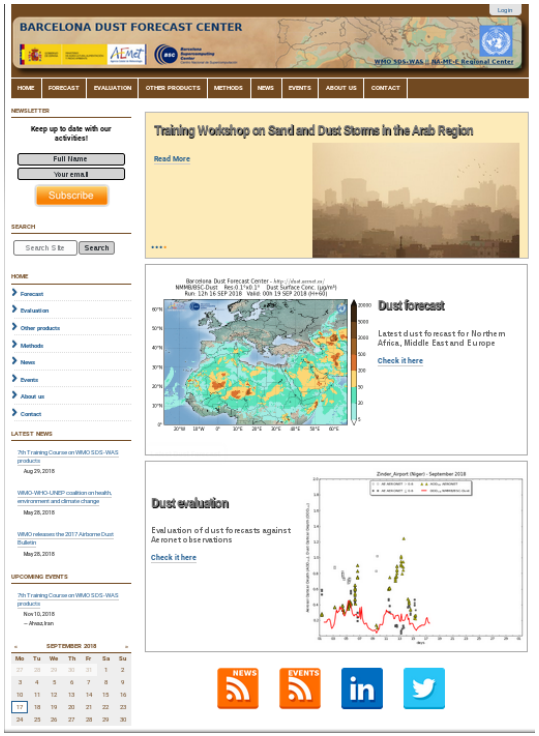
Links: Observations

- → Worldview NASA (Polar Satellites)
- → Meteosat RGB
- → Photometers network

Thank you for your attention

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





sdswas@aemet.es