SDS Forecast Products for Northern African Countries: Workshop Cabo Verde

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MAC2/3.5b/254
Online, 3 February 2023

Outline

- MAC-CLIMA INTERREG & CREWS
- Introduction: SDS-WAS
- Operational Model and multimodel Products
- Warning Advisory System
- Warning Advisory System: Evaluation
- Summay SDS forecast products

- Activity 2.1.2 Increase the technical and human training of actors responsible for meteorological and oceanographic observation of the phenomenon of climate change in the cooperation area, framed in the MAC-CLIMA Project (MAC2/3.5b/254) approved in the framework of the INTERREG VA-Madeira-Azores-Canary Islands (MAC) territorial cooperation program 2014-2020, 85 % co-financed with ERDF funds

MAC-CLIMA INTERREG

- MAC: Madeira, Açores, Canarias
- Sénégal, Cabo Verde, Mauritanie

CREWS - WMO

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

Tasks (2020-2023)

- Proposal: Expansion of the Burkina Faso WAS
- Online Training Workshops
- Installation PM sensors and Sunphotometers → Evaluation WAS

Outline

History and Objectives

- Impacts on health, transport, industry, climatology, ...
- SDS-WAS WMO system (2004-2007)
- Sand and Dust Storm Warning Advisory and Assessment System
- Improvement of Sand and Dust Storm Observation and Forecast
- Difusion of knowledge and products
- Regional Centers: Beijin (Asia 2008), Barcelona (NAMEE 2010), Barbados (America 2016-2017)

- SDS-WAS NAMEE RC (2010)
- Barcelona Dust Regional Center (RSMC-ASDF 2014)
- AEMET & BSC (Barcelona Supercomputing Center)

Marenostrum 4: BSC

Cirrus-Atos: AEMET

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Operational model and forecast: 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 Depth (Dust AOD) [–]
- Dry Deposition [mg/m2]
- Wet Deposition [mg/m2]

Multimodel products (Link: Technical report multimodel)

Model	Institution	Domain	Data Assimilation
BSC-DREAM8b_c2 (End 2022)	BSC-CNS	Regional	NO
CAMS-ECMWF	ECMWF	Global	MODIS-AOD
DREAM8-NMME-CAMS	SEEVCCC	Regional	ECMWF dust-analysis
NMMB/MONARCH	BSC-CNS	Regional	NO
MetUM	Met Office	Global	MODIS/Aqua
GEOS-5	NASA	Global	MODIS
GEFS	NCEP	Global	NO
EMA REG CM4	EMA	Regional	NO
NOA-WRF-CHEM	NOA	Regional	NO
WRF-NEMO	NOA	Regional	NO
SILAM	FMI	Global	NO
LOTOS-EUROS	TNO	Regional	NO
ALADIN-DUST	ONM-Algeria ALADIN Consortium	Regional	NO
ICON-ART	DWD	Regional/Global	NO
ZAMG-WRF-CHEM	ZAMG	Regional	NO
MOCAGE	MétéoFrance	Global	MODIS and VIIRS

- 15 models
- Median → Multimodel!
- Probability maps, Warning System
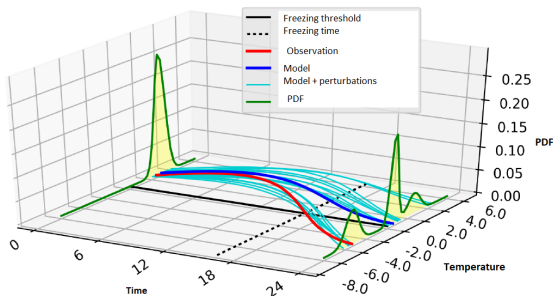- Evaluation: AERONET & MODIS
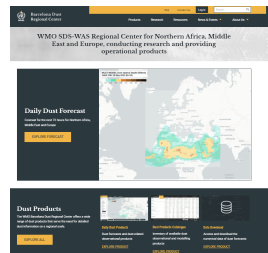
Dust Optical Depth (AOD) & Surface Concentration
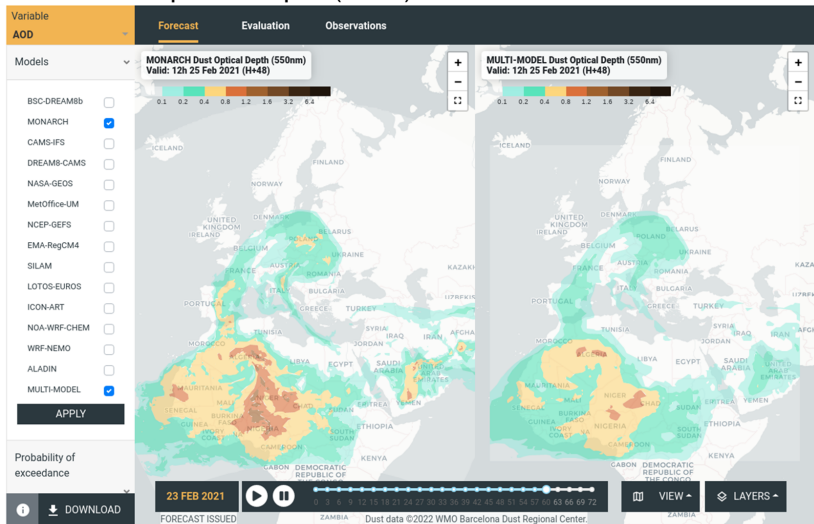
Ensemble Prediction System (EPS)

- Chaotic system → limited predictability
- Sensitivity to initial conditions
- Uncertainties: emission schemes, physics, parametrizations,....
- Median → Reference
- Best verification but... best prediction?

Source: Física del caos en la predicción meteorológica, Carlos Santos et al.

Ensemble Prediction System (EPS)

Parameters available

- Dust Surface concentration
- Dust Aerosol Optical Depth (AOD)

Goals

- Ensemble forecasts are built with the models available in the BDRC (member of the ensemble) → **Poor man's ensemble**
- Condenses all forecasts into a simpler product
- Objective probability of the weather situation

Probability Maps

- These maps indicate the probability of a certain event
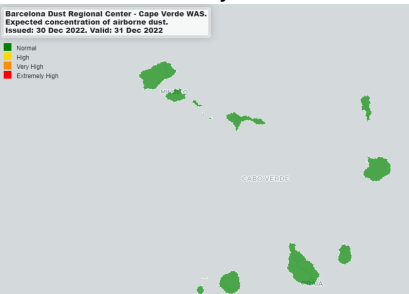- This probability can help users in their decision making

Outline
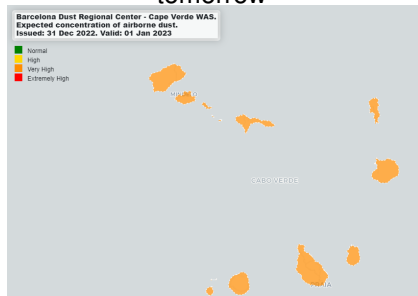
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Cabo Verde WAS: Warning Maps

today

Barcelona Dust Regional Center - Cape Verde WAS.
Expected concentration of airborne dust.
Issued: 30 Dec 2022. Valid: 31 Dec 2022

Normal
High
Very High
Extremely High

tomorrow

Barcelona Dust Regional Center - Cape Verde WAS.
Expected concentration of airborne dust.
Issued: 31 Dec 2022. Valid: 01 Jan 2023

Normal
High
Very High
Extremely High

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

- A third day before summer!!

INMG
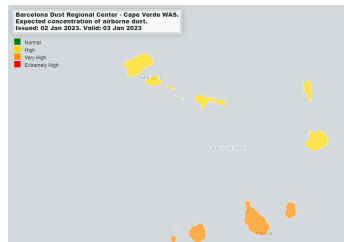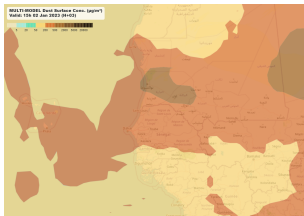INSTITUTO NACIONAL DE
METEOROLOGIA E GEOFÍSICA

Cabo Verde Thresholds μgm^{-3}: 01/11/2017-30/04/2021			
Warning colors	Percentiles	Barlavento	Sotavento
median	50 %	74	78
yellow	80 %	189	199
orange	90 %	277	275
red	97.5 %	435	444

- 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

Cabo Verde Thresholds μgm⁻³: 01/11/2017-30/04/2021			
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- 6000m GVBA, 5000m GVNP
- 5000m GVAC, 7000m GVSV

- Comparison of the median prediction with the thresholds calculated with the time series
- No probability
- **Qualitative surface dust concentration forecast**

**Outline**

WAS Evaluation

Data and methodology

- Visibility, present weather and relative humidity SYNOP & METAR

- Data filtering:
  - Relative humidity < 70 %
  - Daily mean visibility < 8000 m
  - Daily Minimum Visibility

- Time Series Visibility $\rightarrow$ Thresholds: yellow, orange, red

- Evaluation: Comparison of visibility warnings with WAS warnings for each province/region
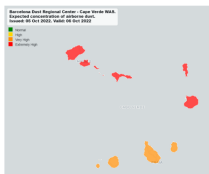
Visibility Verification from METAR/SYNOP bulletins by Stations
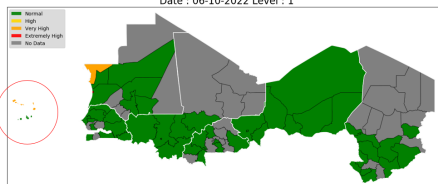Date : 06-10-2022
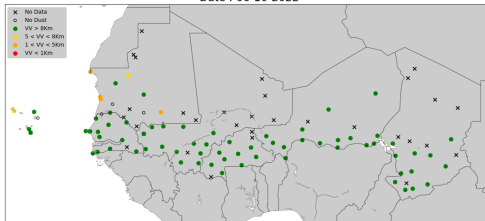
Filter **METAR** & **SYNOP**:
- **RH < 70 %**
- **Present Weather (Dust)**
- **VIS daily mean < 8000 m**

WAS from METAR/SYNOP bulletins THRESHOLD: Dry season 2017-2021
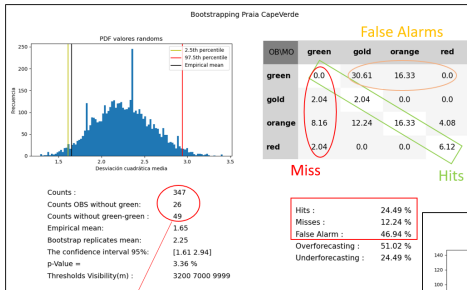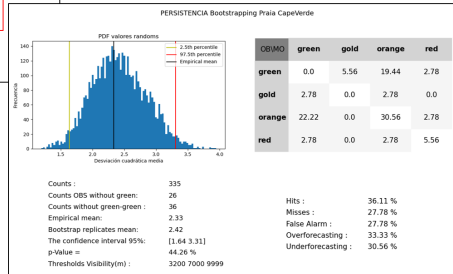Date : 06-10-2022 Level : 1

Warning from Models

Warning from Observations

Bootstrapping Praia CapeVerde

PDF valores randoms

False Alarms

OB/MO	green	gold	orange	red
green	0.0	30.61	16.33	0.0
gold	2.04	2.04	0.0	0.0
orange	8.16	12.24	16.33	4.08
red	2.04	0.0	0.0	6.12

Miss

Hits

- Contingency table
- Define Index for evaluation
- No Green-Green days
- Bootstrapping
- Comparison with Persistence

Counts	347
Counts OBS without green	26
Counts without green-green :	49
Empirical mean:	1.65
Bootstrap replicates mean:	2.25
The confidence interval 95%:	[1.61 2.94]
p-Value =	3.36 %
Thresholds Visibility(m) :	3200 7000 9999

Hits :	24.49 %
Misses :	12.24 %
False Alarm :	46.94 %
Overforecasting :	51.02 %
Underforecasting :	24.49 %

WAS Evaluation 2021

Persistence Evaluation 2021

PERSISTENCIA Bootstrapping Praia CapeVerde

PDF valores randoms

OB/MO	green	gold	orange	red
green	0.0	5.56	19.44	2.78
gold	2.78	0.0	2.78	0.0
orange	22.22	0.0	30.56	2.78
red	2.78	0.0	2.78	5.56

Counts	335
Counts OBS without green	26
Counts without green-green :	36
Empirical mean:	2.33
Bootstrap replicates mean:	2.42
The confidence interval 95%:	[1.64 3.31]
p-Value =	44.26 %
Thresholds Visibility(m) :	3200 7000 9999

Hits :	36.11 %
Misses :	27.78 %
False Alarm :	27.78 %
Overforecasting :	33.33 %
Underforecasting :	30.56 %

|	
Total days:	347
Days with dust event:	26
Days with warning observed or predicted:	49

Warning Advisory System: Evaluation

Conclusions

- Limitation: not enough SYNOP & METAR
- Qualitative evaluation $\rightarrow$ no PM data
- Visibility good proxy for regions near the dust sources
- Not so good for regions relatively far away
- Dust homogeneous regions instead of Administrative divisions
- Better than Persistence $\rightarrow$ WAS forecasts better when a situation starts or ends
- Objective evaluation $\rightarrow$ WAS updates

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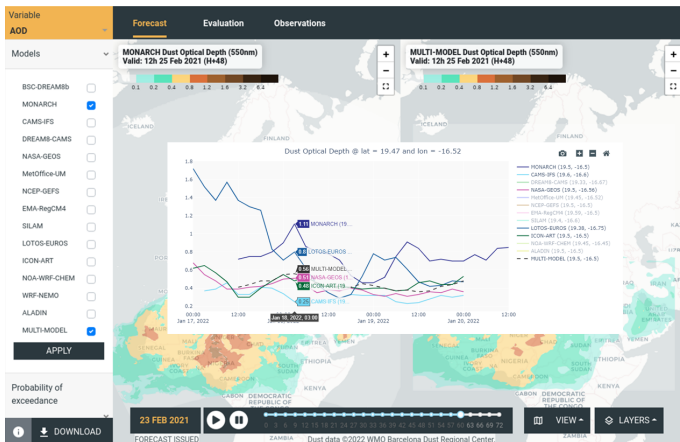
Summay SDS forecast products (I)
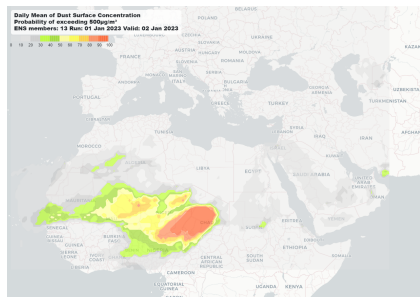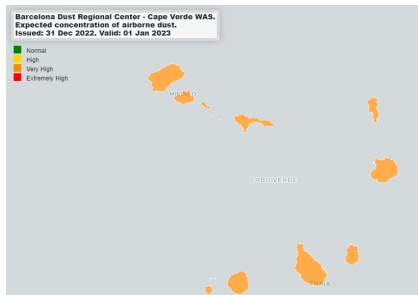
- Warning system → Qualitative forecast (daily maximum)
- Probability maps → Quantitative forecast (daily mean) & Several thresholds
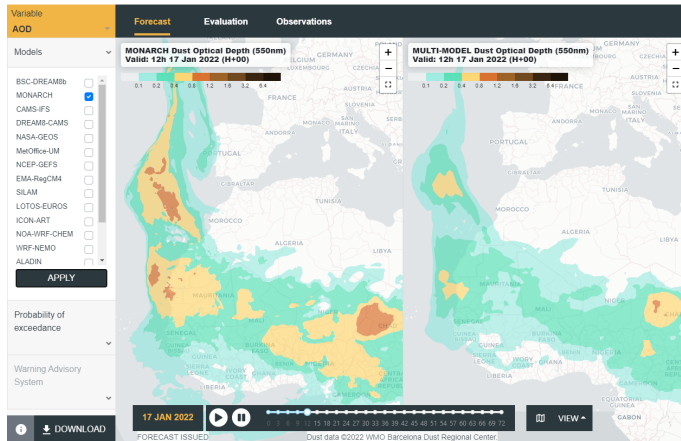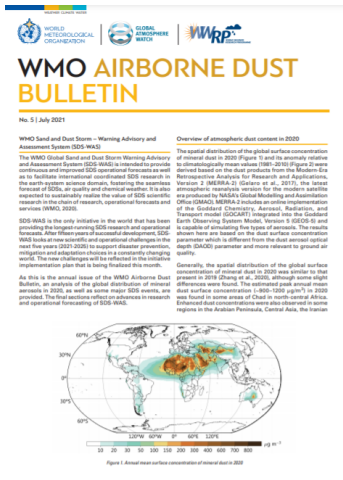
- Comparison of models and median of the multimodel
- Operational model → Multiple parameters and 72 hour forecast

One-point comparison of models and median of multi-model

The work presented here is possible thanks to the collaboration of the active members of the **WMO SDS-WAS** and in particular the partners of the regional node NA-MEE.

My thanks to the colleagues of **BSC** and **AEMET**.

Thanks also to the associated researchers from **NASA** (i.e. AERO-NET, MODIS) and EUMESAT as well as the **inDust** and **DustClim** networks.

Thank you for your attention!