ACOMET

GOBIERNO DE ESPAÑA MINISTERIO DE MEDIO AMBIENTE Y MEDIO RURAL Y MARINO

AEMet Agencia Estatal de Meteorología

IV Seminario de ACOMET

Polvo mineral
El Sistema de alerta de tormentas de polvo y arena

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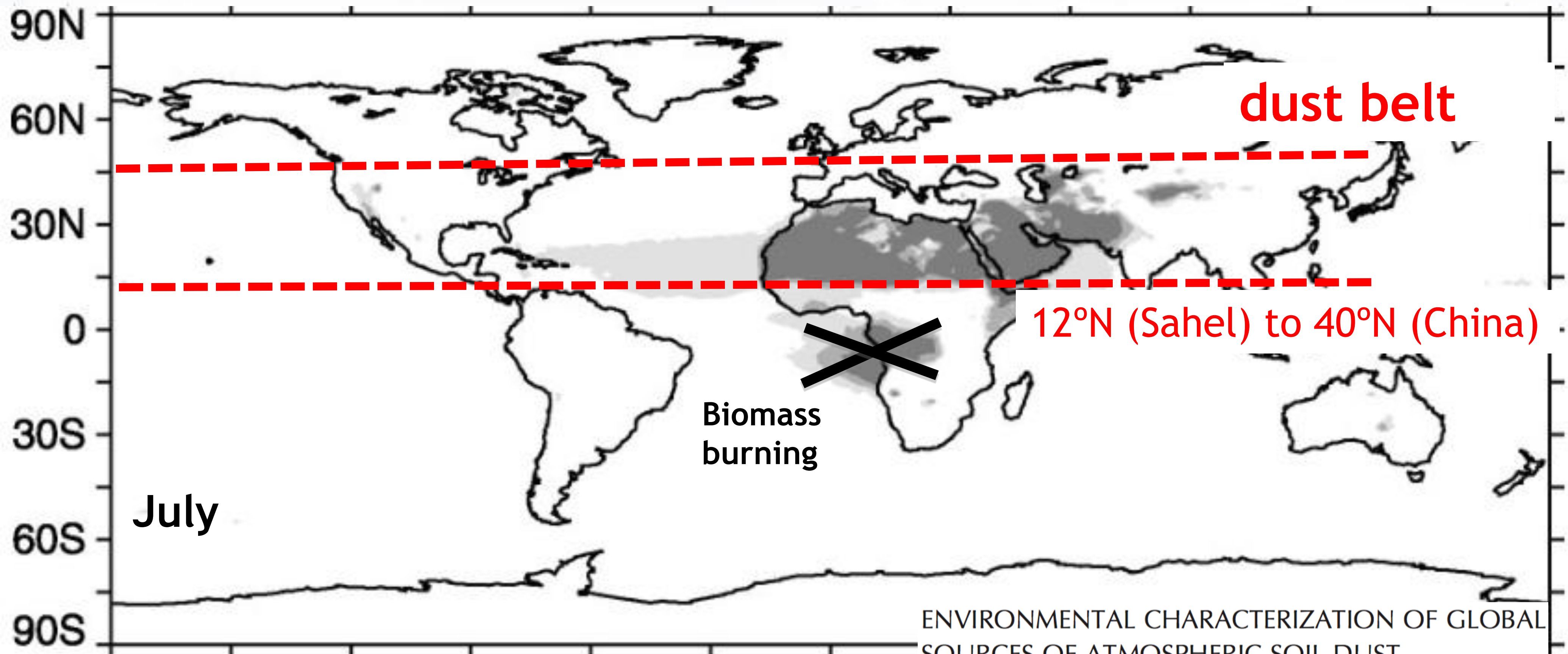
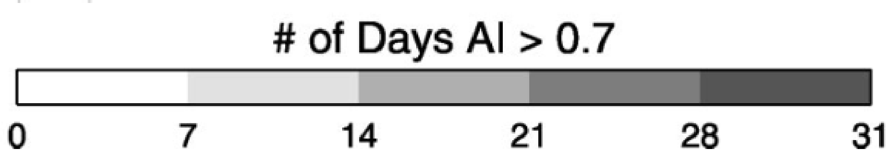
Centro de Investigación Atmosférica de Izaña
AEMET

UV absorbing aerosols - dust
Satelite





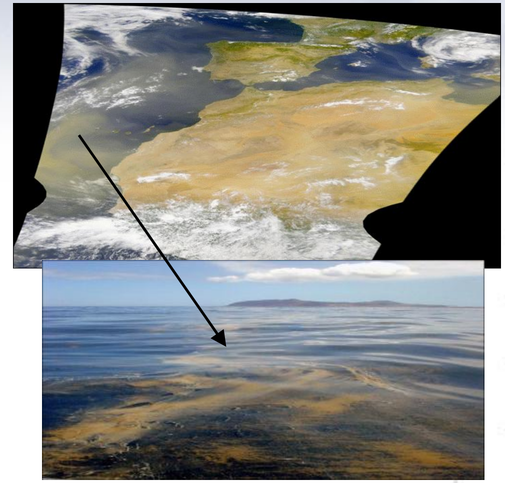
ENVIRONMENTAL CHARACTERIZATION OF GLOBAL SOURCES OF ATMOSPHERIC SOIL DUST IDENTIFIED WITH THE NIMBUS 7 TOTAL OZONE MAPPING SPECTROMETER (TOMS) ABSORBING AEROSOL PRODUCT

Joseph M. Prospero,[1] Paul Ginoux,[2] Omar Torres,[3] Sharon E. Nicholson,[4] and Thomas E. Gill[5]

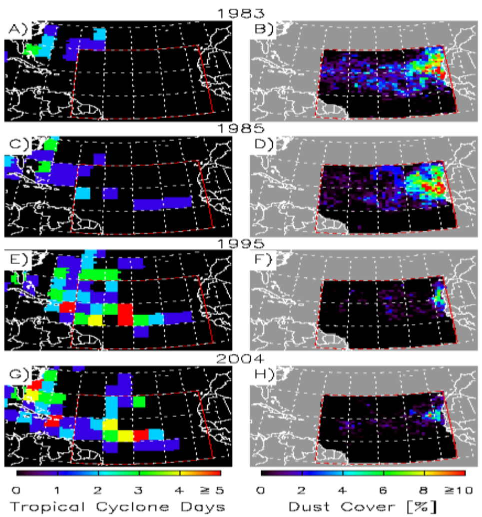
Impacts of Sand and Dust

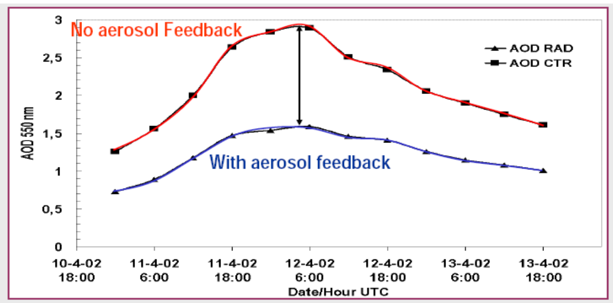
Human Health (Asthma, infections, Meningitis in Africa, Valley Fever in the America's)

Agriculture (negative & positive impacts)



Marine productivity (negative & positive impacts)





Improved **Weather** and **Seasonal Climate prediction**

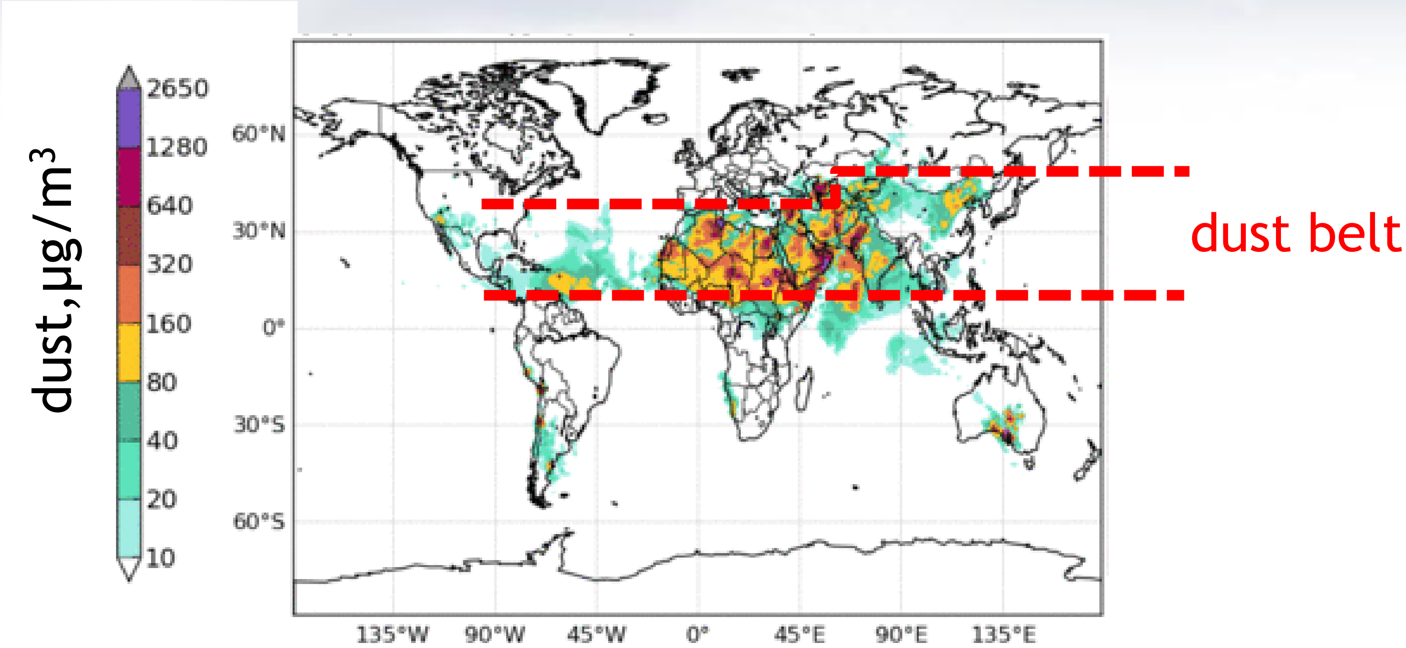
Industry (Semi-conductor, etc.)

Energy (Thermal solar energy)

Aviation (air disasters)

Ground Transportation (high speed rail)

SDS-WAS and health



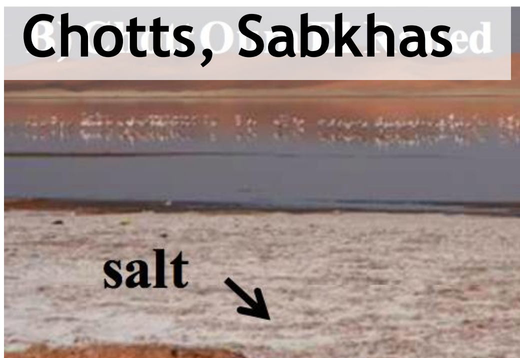
1000 mill North Africa to West Asia
1300 mill India
1300 mill China
40 mill Caribbean

3650 mill population

50% of global population
is exposed to dust concentrations
100 – 1000 µg/m^3

There are several types of sources, but the mayor dust sources are associate with <u>dry lakes/rivers beds</u>

chotts, sabkhas, wadis, salt flats

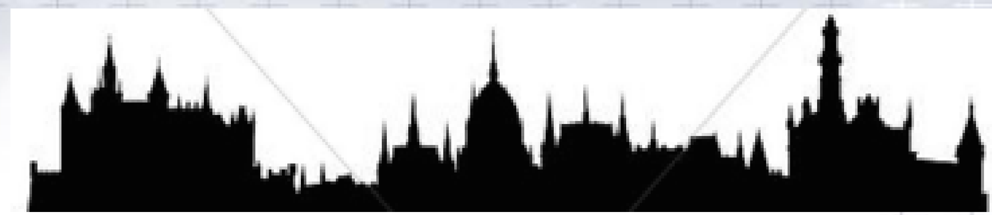


aerosols, a cocktail of chemicals:

- dust
- sulphate
- nitrate
- organic mater
- black carbon (soot)
- metals (Ni, As, Cd, V, Co...)
- sea salt

size: 1 nm (10^{-9} m) to 20 µm (10^{-6} m)

human hair: 70 µm

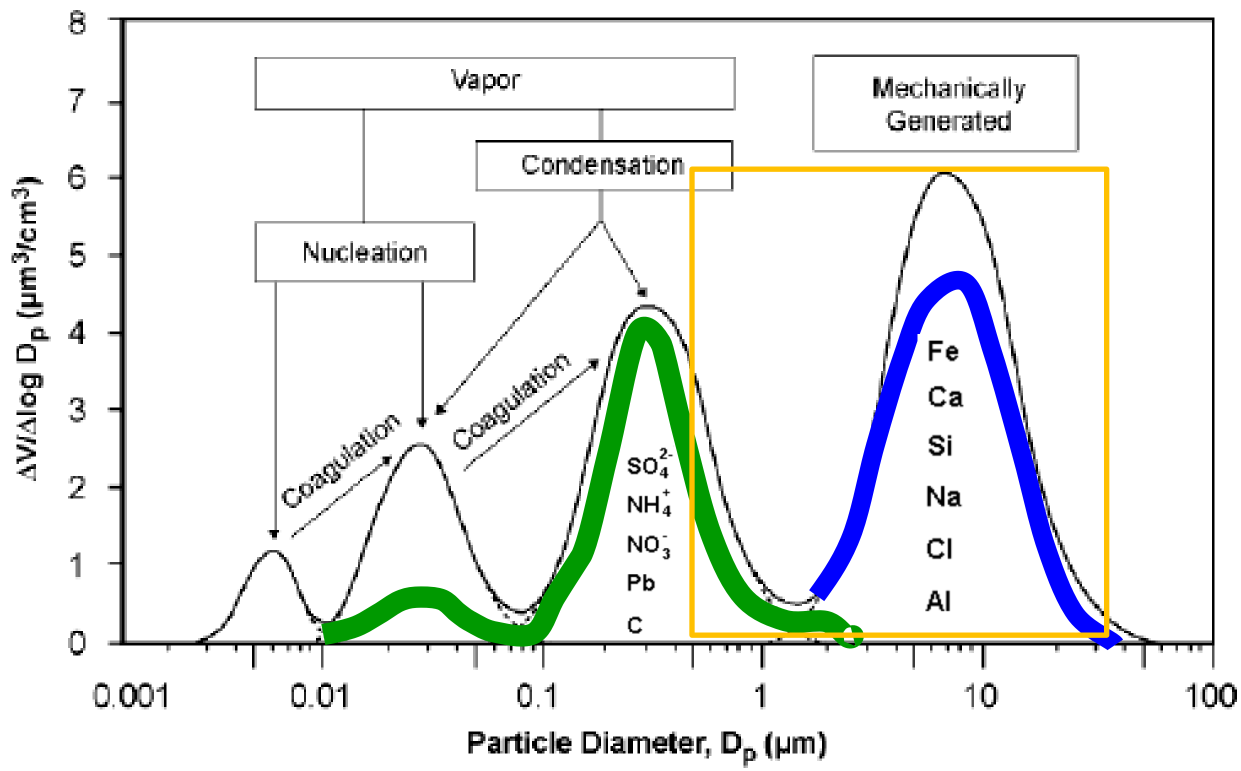


people live in cities and breath a cocktail dust + pollutants

PM_{10} (diameter <10 microm)

$PM_{2.5}$

$PM_{2.5-10}$



ultrafine <0.1 μm

accumulation 0.1 – 1 μm

Coarse 1 - 10 μm

Mineral dust :

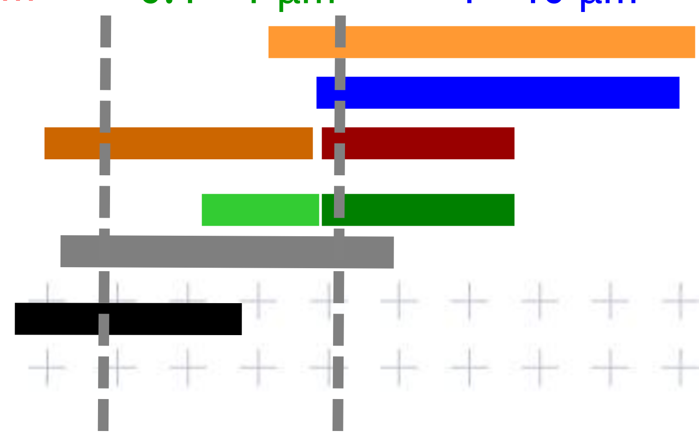
Marine salt:

Sulfate:

Nitrate:

Organic aerosol:

black carbon:

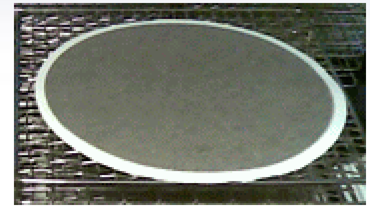


bulk chemical composition

PM samples:
- fine + coarse (TSP, PM_{10})
- fine ($PM_{2.5}$, PM_1)

Saharan dust

Urban particles



PM ($\mu g/m^3$)= **dust** + trace elements + **ions ($SO_4^{=}$, NO_3^-, NH_4^+, Na^+, Cl-)** + OC + EC

Elemental Composition:

Major elements (Al, Si, Ca, K, Na, Mg) + trace elements (P, Li , Be , Sc , Ti , V , Cr , Mn , Co , Ni , Cu , Zn , Ga , Ge , As , Se , Rb , Sr , Y , Zr , Nb , Mo, Cd , Sn , Sb, Cs , Ba , La , Ce , Pr , Nd , Sm , Eu , Gd , Tb , Dy , Ho , Er , Tm , Yb , Lu , Hf , Ta, W, Tl , Pb , Bi , Th , U)

Inductively coupled plasma
Atomic Emission Spectroscopy
ICP-AES

Inductively coupled plasma
Mass spectroscopy
ICP-MS

Destructive techniques

Ions: $SO_4^{=}$, NO_3^-, NH_4^+, Na^+, Cl^-

Ion Chromatography, ICP-AES, ICP-MS, selective electrodes and colorimetry

Destructive techniques

Thermal/optical reflectance (TOR) and/or thermal/optical transmission (TOT)

destructive techniques

XRF, PIXE, INAA : none destructive techniques

In-situ estimations

WMO - visibility

The greatest distance that a black object of "suitable dimensions," situated near the ground, can be seen and recognized when observed.

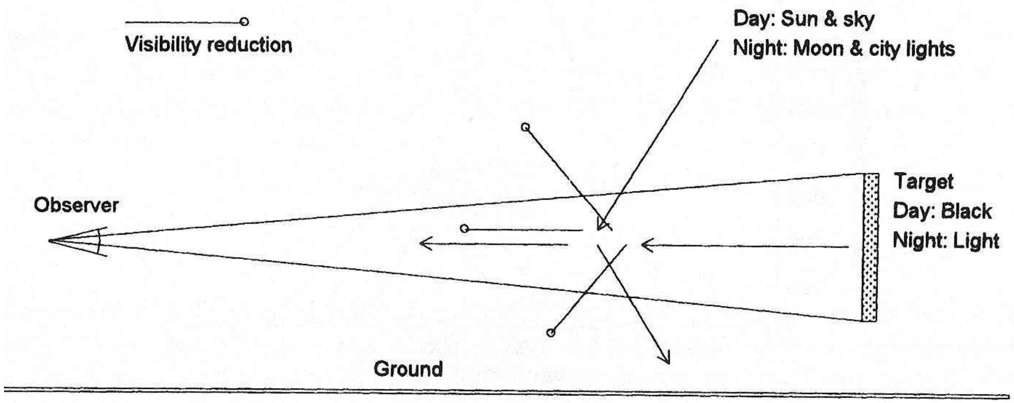


Fig. 11-1 Visibility reduction by scattering.

aerosols are the main cause of visibility reduction

- **Operational surface synoptic weather station reports from Global Telecommunication System (GTS)**
- **Station reports include past & present weather, visibility (km), temperature (° C), dew point temperature (° C), wind direction (°), and speed (knots)**

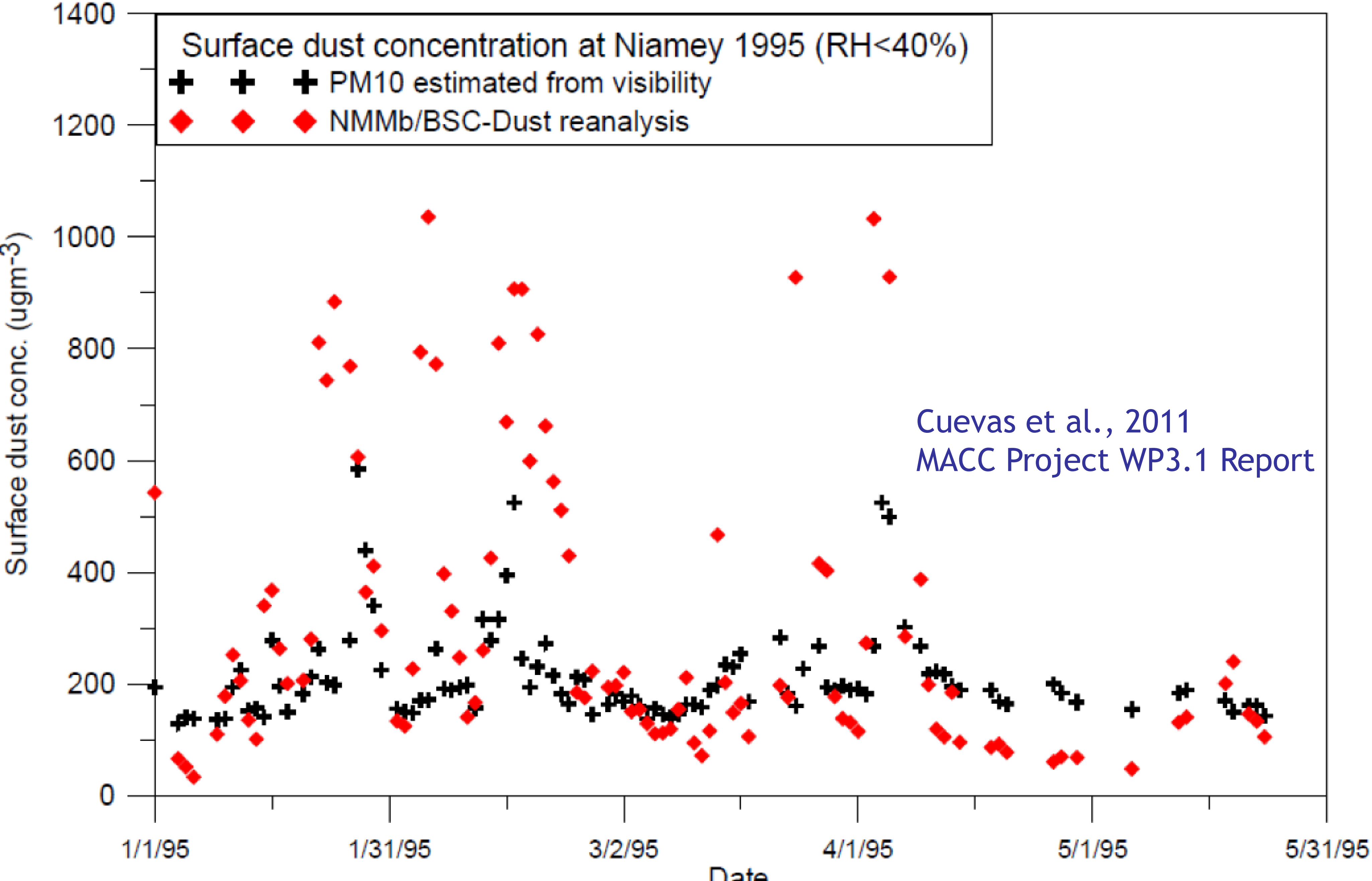
62733	15.32	35.60	02040818	Dust, not at time of obs.		6	0	18	22	320	2	35.5
62733	15.32	35.60	02041015	Dust, raised at time of obs.		7	0	99.	30	320	6	34.5
62733	15.32	35.60	02041121	-9	-9	-9	-9	20	23	320	2	26.0
62733	15.32	35.60	02041212	-9	-9	-9	-9	20	34	340	3	37.5

C. Camino et al. / Aeolian Research 16 (2015) 55-68

Empirical equations to estimate dust concentration (PM10 or TSP in lg/m3) using visibility (V in km) obtained by several authors within the dust belt.

Authors	Code	Empirical equation	Dust concentrations and visibility data reported from SYNOP station
D'Almeida (1986)	DA-Eq	$PM_{10} = 914.0\ V^{-0.73} + 19.03$	Turbidity network of eleven stations set up over the Sahara and the Sahelian belt PM_{10} field campaign at Agadez (Niger) with visibility ranges from 0.2 to 40 km
Ben Mohamed et al. (1992)	BM-Eq	$TSP = 1339.84\ V^{-0.67}$	TSP field campaign at Niamey (Niger) with visibility ranges from 0.1 to 20 km
Shao and Wang (2003)	SH-Eq	$TSP = 3802.29\ V^{-0.84};\ V < 3.5$ km $TSP = e^{-0.11V+7.62};\ V \geq 3.5$ km	TSP measured at twelve monitoring sites located in China, Japan and Korea Visibility data disaggregated in weak dust events and strong dust events
Dayan et al. (2008)	DAY-Eq	$PM_{10} = -505\ln(V) + 2264$	PM_{10} monitoring site located at Negev Desert. Visibility ranges from 1 to 5 km at Hazerim airport (Israel)
Jugder et al. (2014)	JU-Eq	$PM_{10} = 485.67V^{-0.776}$	PM_{10} and visibility data were observed at Zamyn-Uud site in the Gobi desert. $PM_{10} \geqslant 50\ \mu g/m^3$ threshold was established for hazy atmospheric conditions Visibility MOR sensors have a maximum measurement range of 20 km

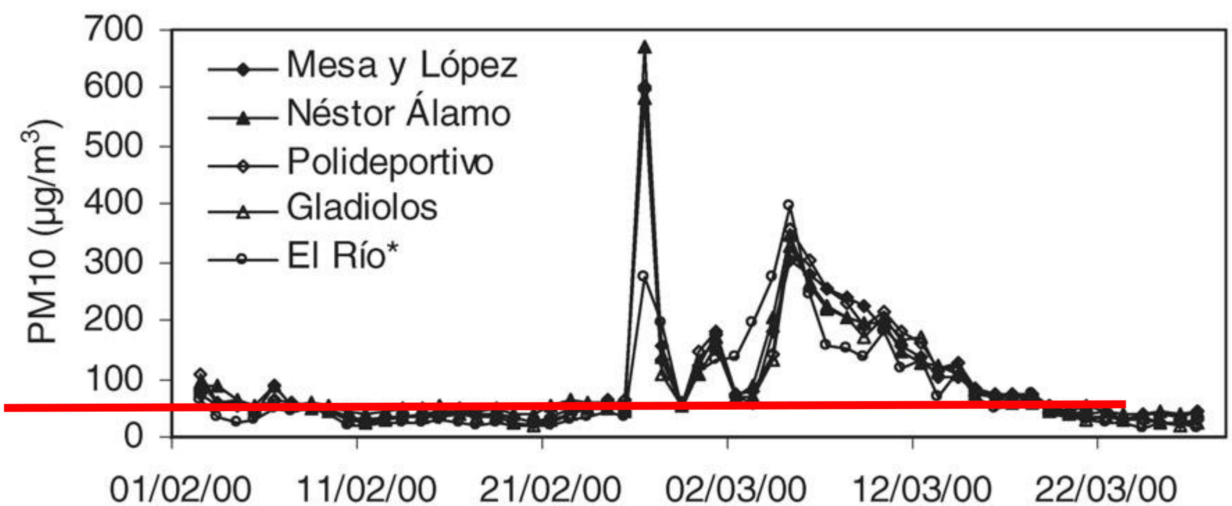
In-situ estimations



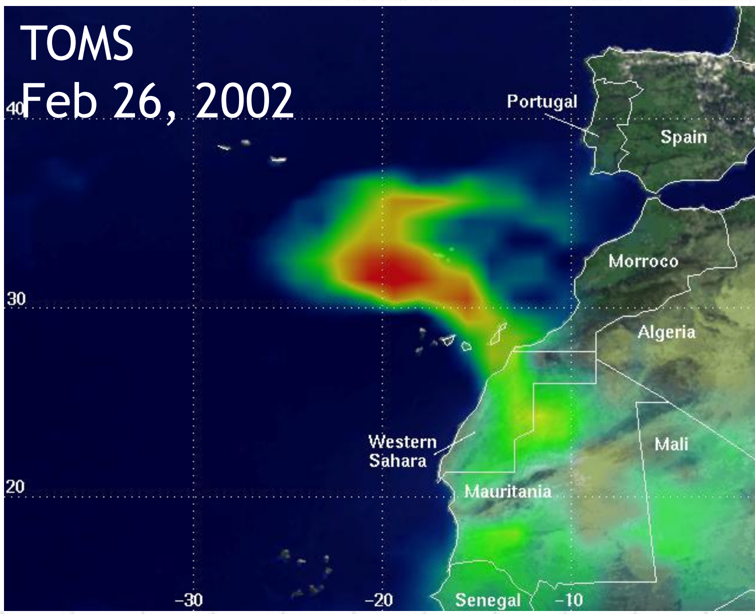
Cuevas et al., 2011
MACC Project WP3.1 Report

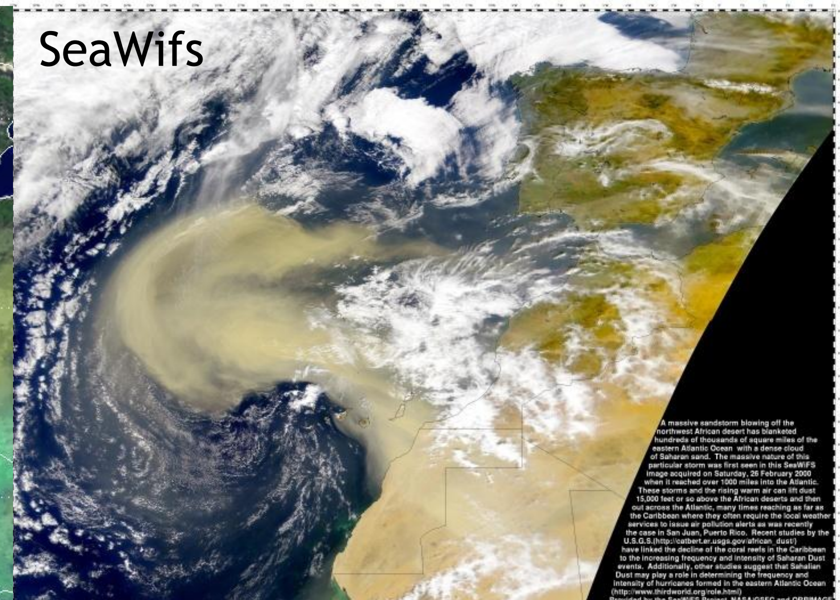
In-situ dust characterization

Air quality stations at Tenerife Island



EC recommend PM_{10} (24-h) do not exceed 50 μg/m³

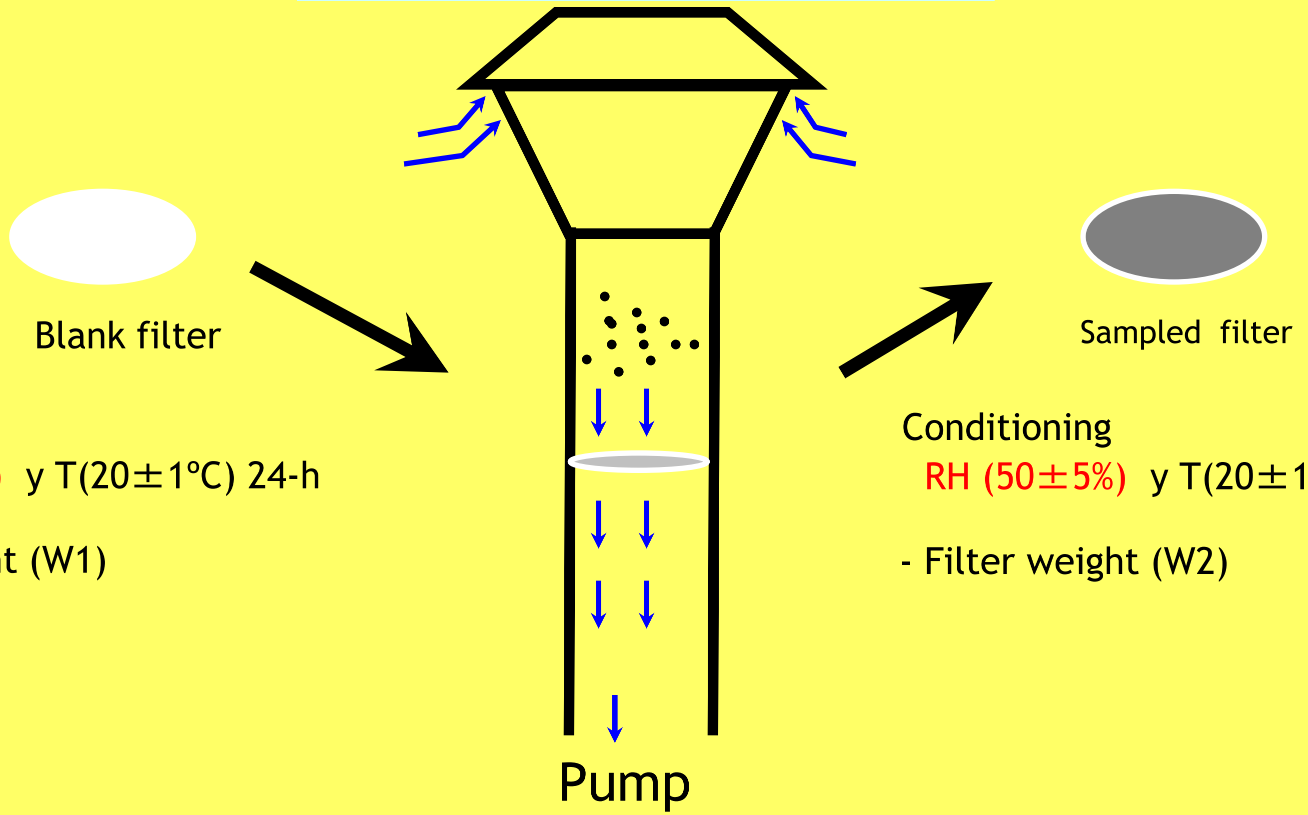




Viana et al., Atmospheric Environment , 2002

-method-01: reference - manual gravimetry

$$PM = \frac{(W2-W1)}{Volume} \; \mu g/m^3$$



Conditioning
RH (50±5%) y T(20±1°C) 24-h

- Filter weight (W1)

Conditioning
RH (50±5%) y T(20±1°C) 24-h

- Filter weight (W2)

Room for weighting the filters: RH =50% (30 %) and 20ºC

balance, LVS resolution >= 5 digits (0.00001g)
balance, HVS resolution >= 6 digits (0.000001g)

-we recommend you use a specific normalised method (e.g. EN12341:2014)

PM$_{10}$ Blank filter

PM$_{10}$ sample urban air

PM$_{10}$ sample in dust days

-we recommend you use a specific normalised method (e.g. EN12341:2014)

Filters: Quartz, Teflon, Cellulose

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Low Volume Sampler | High Volume Sampler

LVS: 2.3 m^3/h | HVS: 68 m^3/h | HVS: 30 m^3/h

-we recommend you use a specific normalised method (e.g. EN12341:2014). Ask to the distributor if the sampler is designed to any standards

Inlets, airflows....

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-method-02: automatic

The most extended method and the most robust for dusty regions

beta

there are other methods, but are less robust for dusty regions

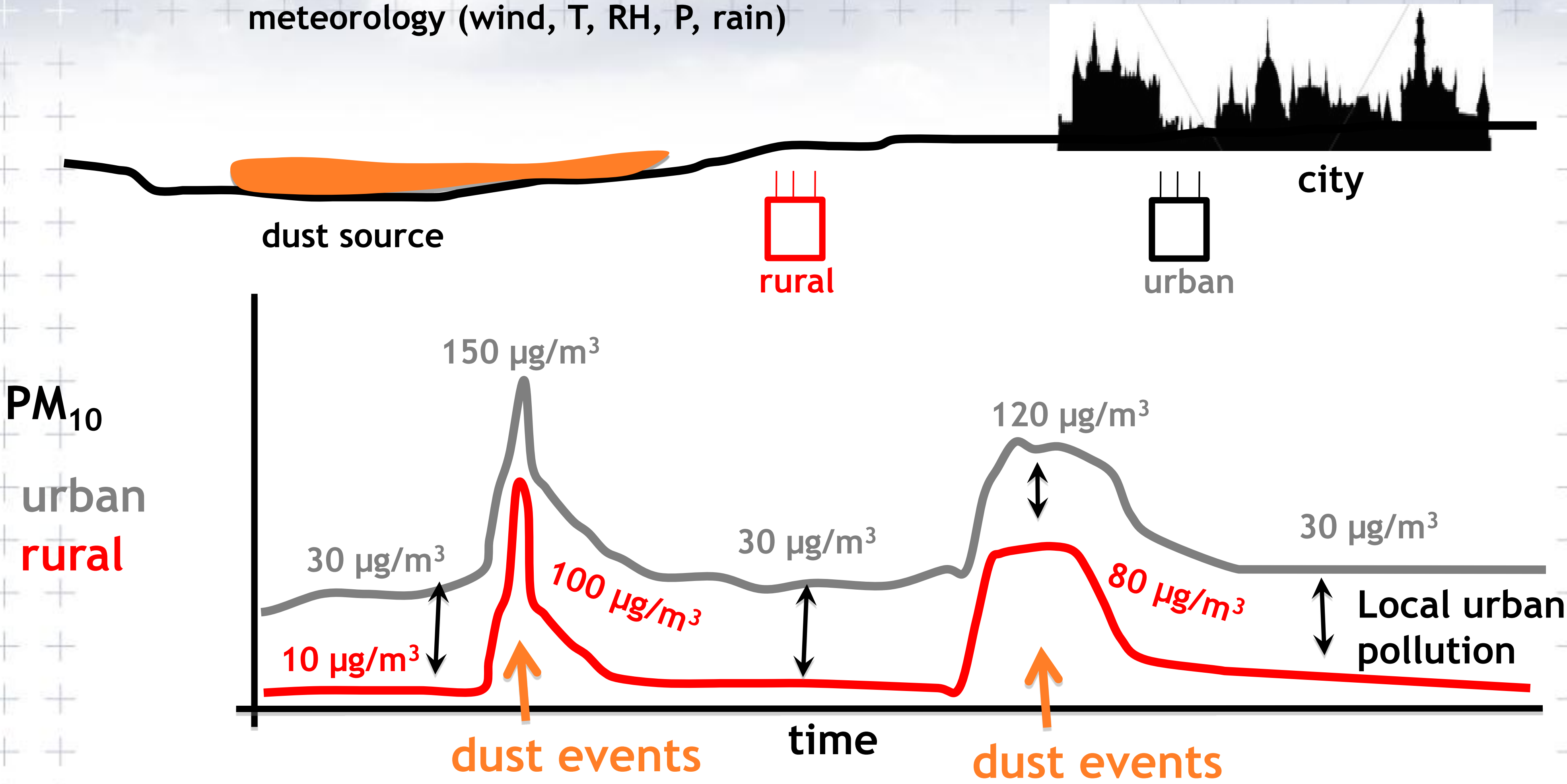
Tapered Oscillating Microbalance
TEOM
Manual change of the filter

Optical Particle Counters

cleaning of optics
laser maintenance

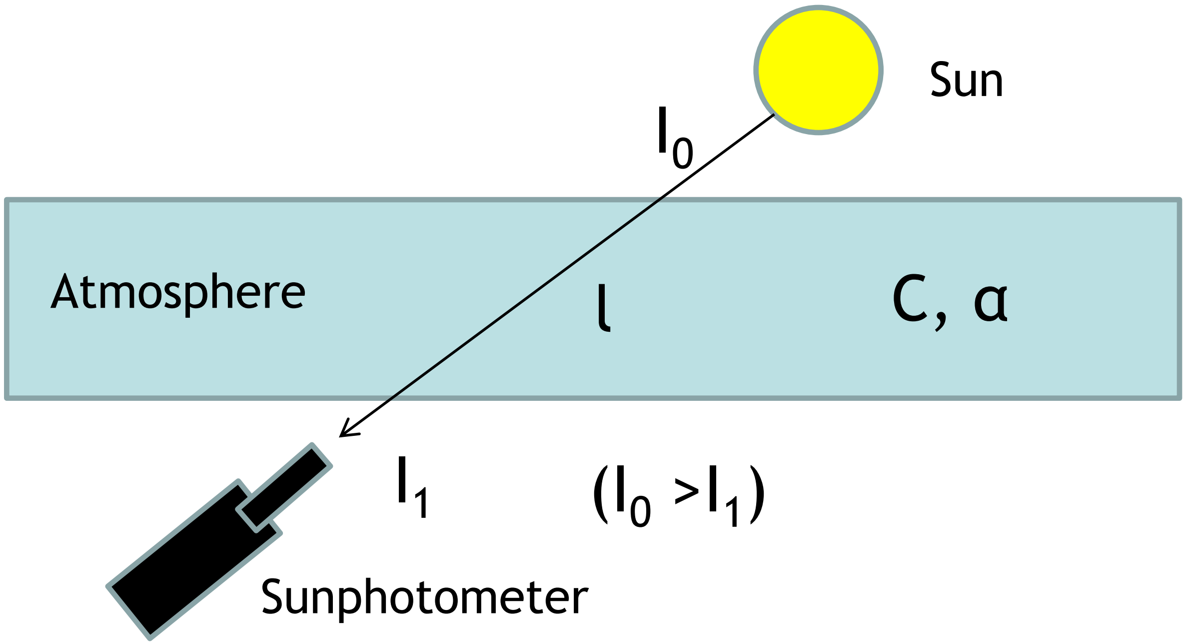
Level 1

PM_{10} and $PM_{2.5}$ - automatic methods
meteorology (wind, T, RH, P, rain)



Ground-based remote sensing

The intensity of sunlight at the top of the earth's atmosphere is constant. While the sunlight travels through the atmosphere, aerosols can dissipate the energy by scattering (Rayleigh and Mie) and absorbing the light. More aerosols in the atmosphere cause more scattering and less energy transmitted to the surface.



Beer's Law

$$I = I_o \cdot e^{-\sigma_{ext} \cdot L}$$

Transmissivity (T)

Extinction coefficient (σext): εC

path length (L)

molar absorptivity of the absorber (ε)

concentration of absorbing species in the material (C)

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ASSESSMENT OF OBSERVATIONS CONSISTENCY

Langely plot calibration (I00 determination for each wavelenght):

$$I = I_o \cdot e^{-\sigma_{ext} \cdot L}$$

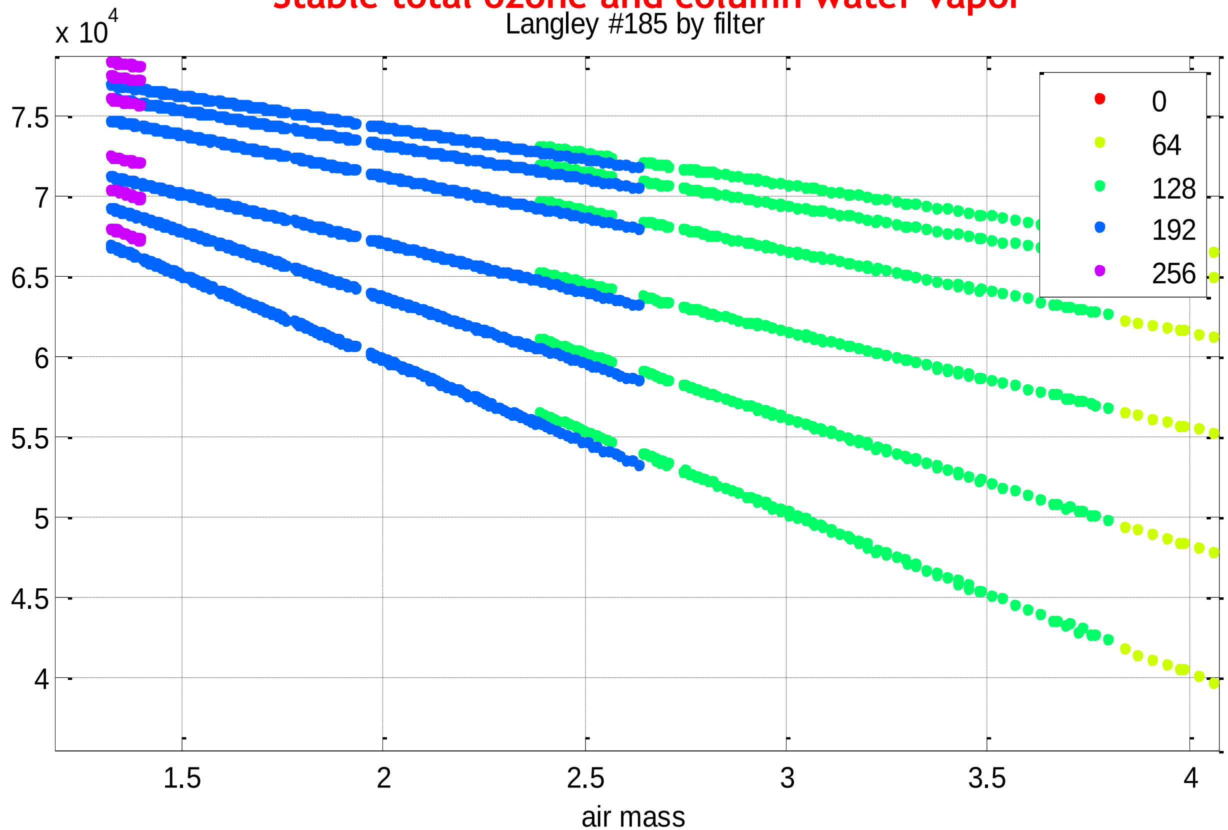
$$\ln I = \ln I_o - \sigma_{ext} L$$

If σ_{ext} is constant during the observation → We can determine I_o

Pristine conditions (very low and constant aerosol load)

No clouds

Stable total ozone and column water vapor



CONCEPTS:

Aerosol Optical Depth (or Thickness)

"Aerosol Optical Depth" (AOD) is the degree to which aerosols prevent the transmission of light. The aerosol optical depth or optical thickness (τ) is defined as the integrated extinction coefficient over a vertical column of unit cross section.

$$AOD = \int_{z=0}^{z=toa} \sigma_{ext}(z)dz$$

Angstrom Exponent (α)

An exponent that expresses the spectral dependence of Aerosol Optical Depth (τ) with the wavelength of incident light (λ). The spectral dependence of aerosol optical thickness can be approximated (depending on size distribution) by:

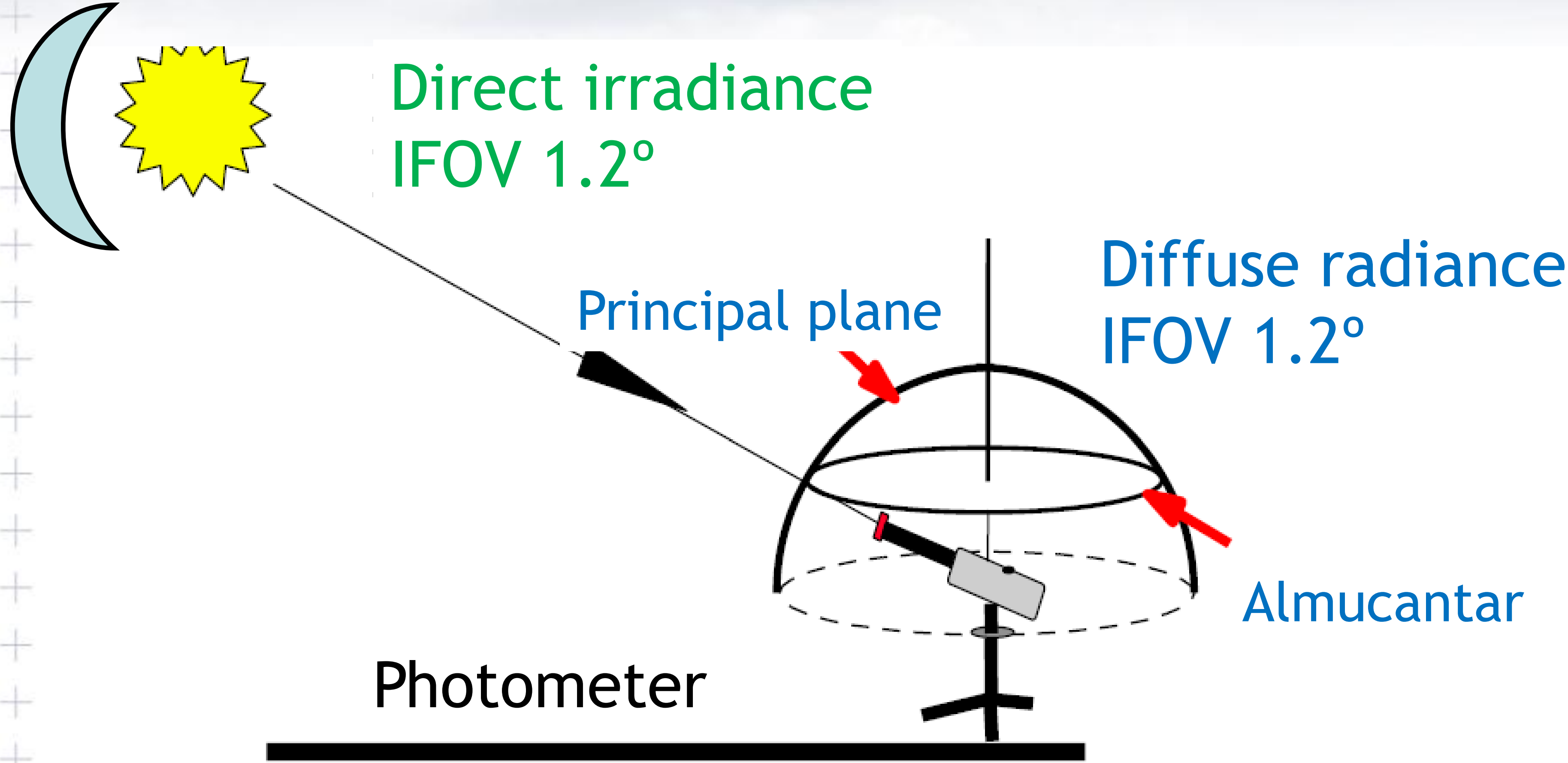
$$AOD = \beta\, \lambda^{\alpha}$$

α >> 0.9 FINE particles

α << 0.7 COARSE particles

where α is the Angstrom exponent (β = aerosol optical depth at 1 μm)

i.e. If AOD >~ 0.2 and $\alpha<0.7$ then we are observing dust (aprox.)



Sun/moon measurements
Sky measurements

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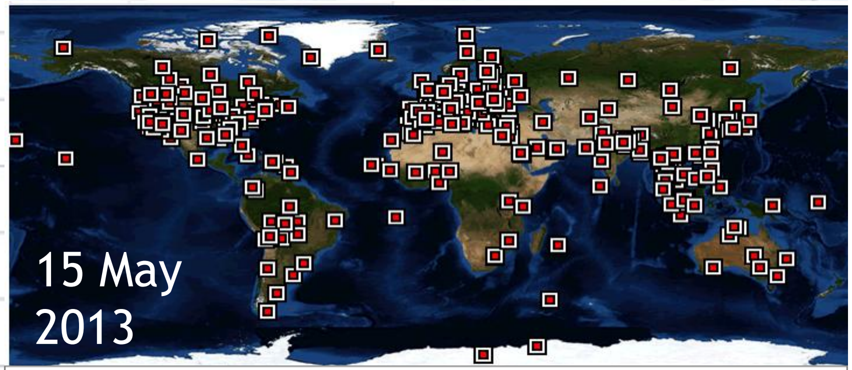
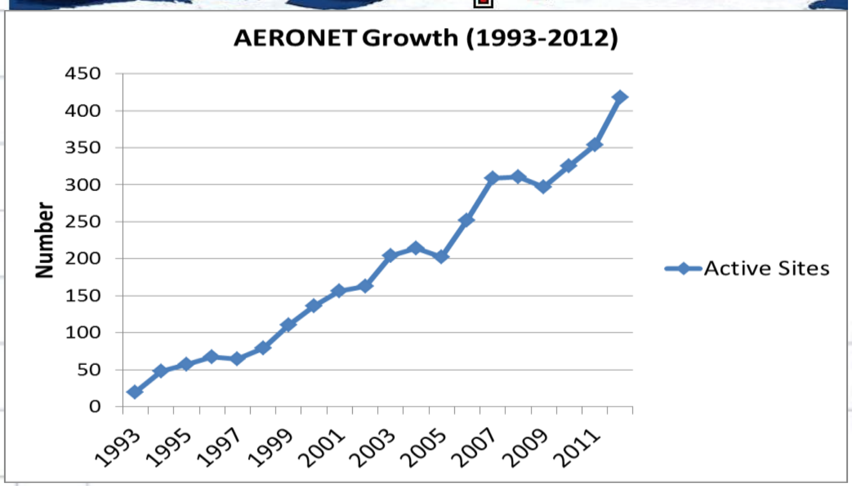
AERONET Aerosol Robotic Network-Twenty Years of Observations and Research





The AERONET program is a federation of ground-based remote sensing aerosol networks established by NASA and LOA-PHOTONS (CNRS) and has been expanded by collaborators from international agencies, institutes, universities, individual scientists and partners.

- >7000 citations
- >400 sites
- Over 80 countries
- http://aeronet.gsfc.nasa.gov

AERONET provides a long-term, continuous public database of aerosol optical, microphysical, and radiative properties for aerosol research and characterization, validation of satellite measurements, and synergism with other databases.

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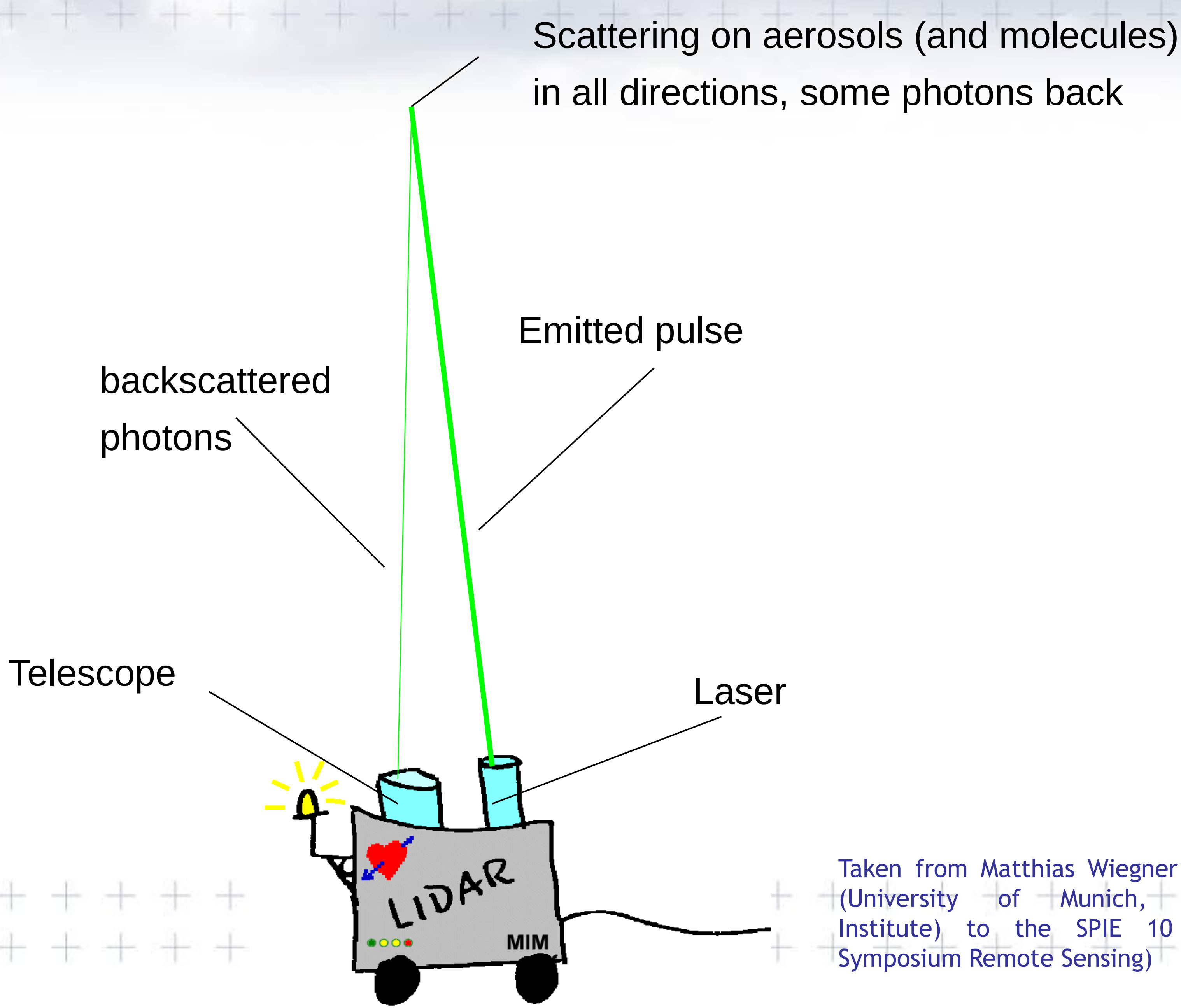


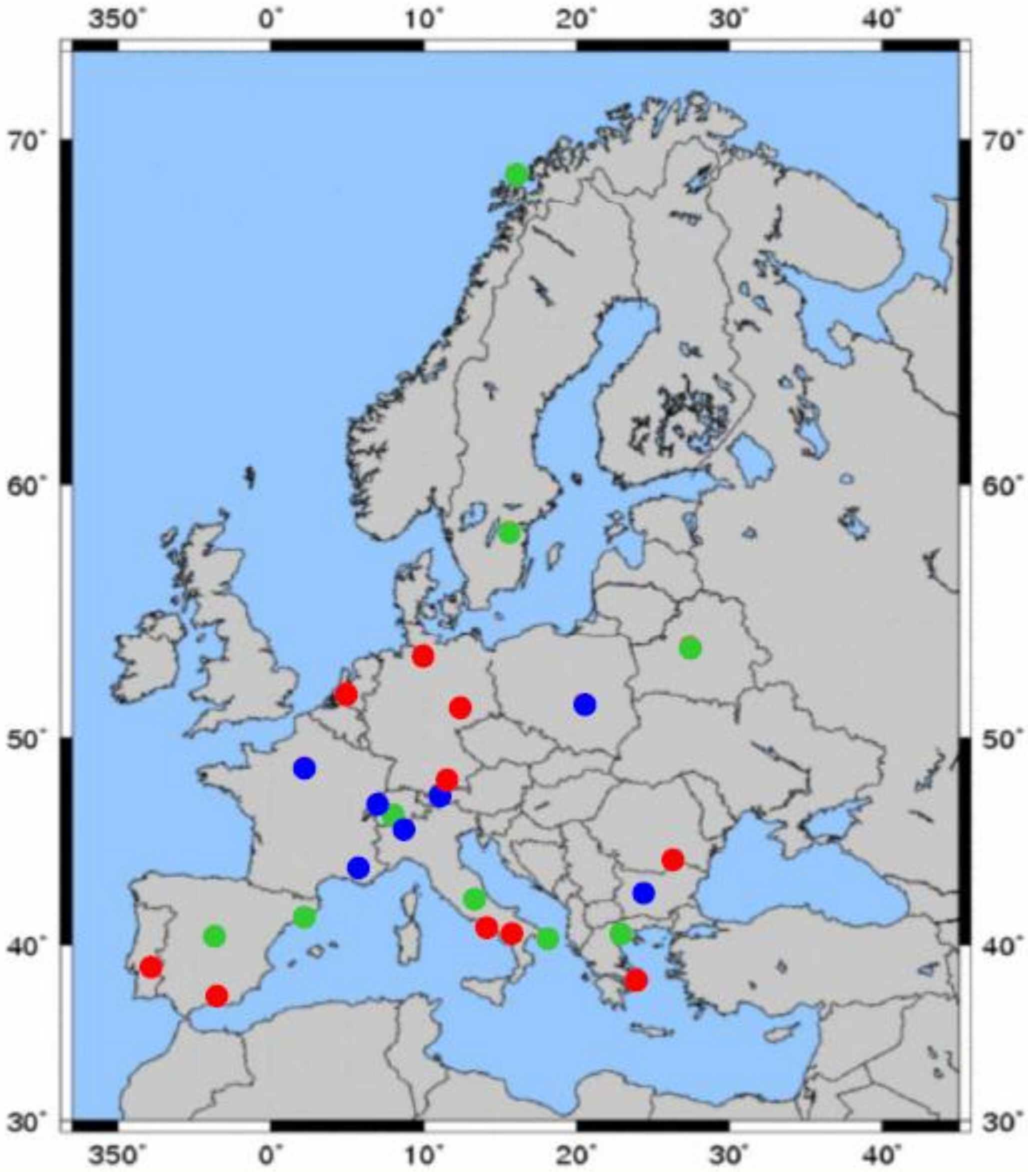
Taken from Matthias Wiegner's presentation (University of Munich, Meteorological Institute) to the SPIE 10 (International Symposium Remote Sensing)

Ground-based remote sensing

Lidar-Barcelona (UPC)
Raman Lidar
EARLINET-SPALINET

Lidar-Tenerife (INTA-AEMET); Elastic lidar
MPLNET

EARLINET



EARLINET (**European Aerosol Research LIdar NETwork**) is a network of advanced lidar stations distributed over Europe with the main goal to provide a comprehensive, quantitative, and statistically significant data base for the aerosol distribution on a continental scale. EARLINET provides independent measurements of aerosol extinction and backscatter, and retrieval of aerosol microphysical properties.

10 EARLINET stations are equipped also with sunphotometers (they are part of AERONET).

26 lidar stations

- 10 multiwavelength Raman lidar stations

backscatter (355, 532 and 1064 nm) + extinction (355 and 532 nm) + depol ratio (532 nm)

- 9 Raman lidar stations

- 7 single backscatter lidar stations

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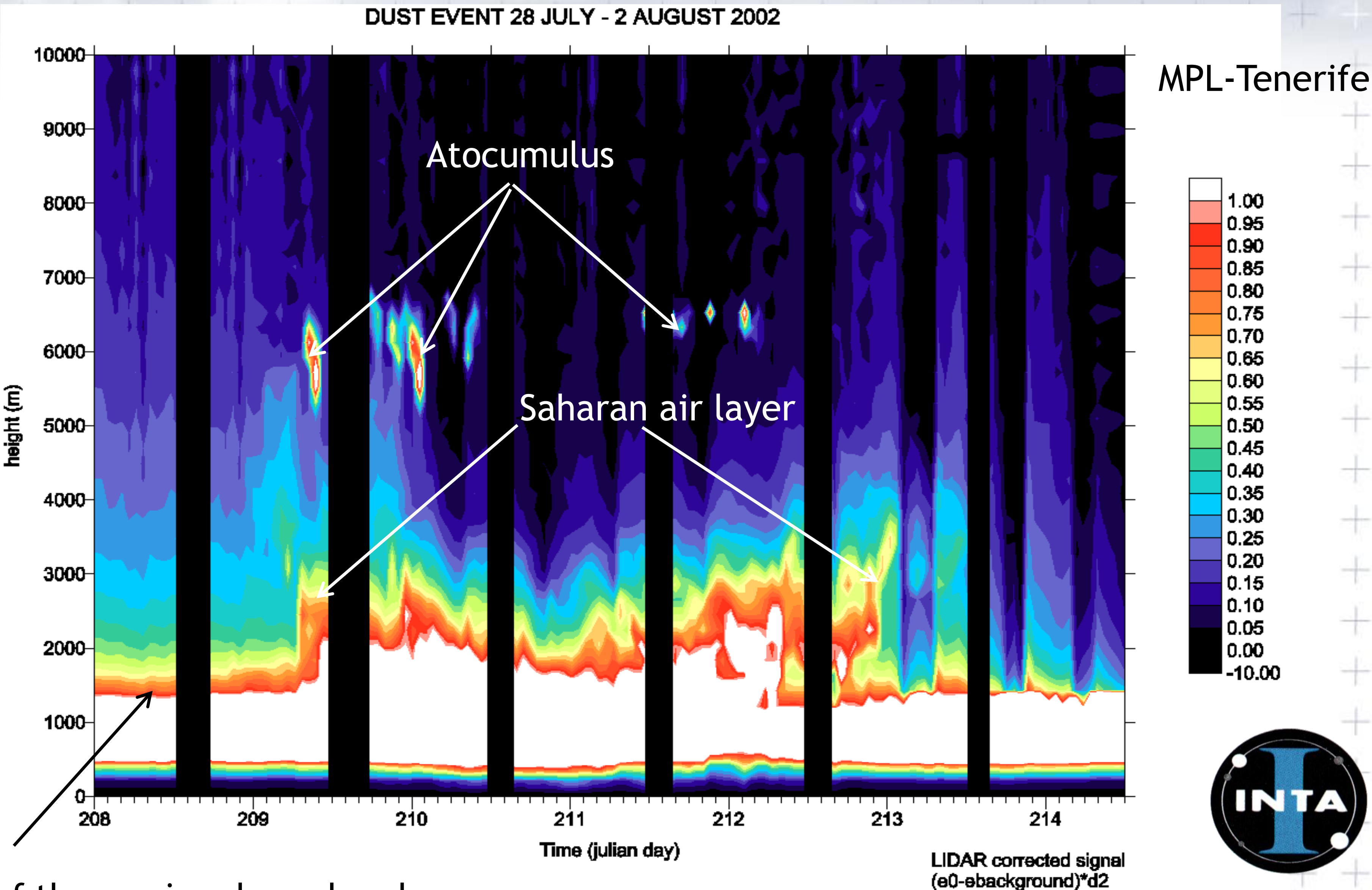
Aerosol lidar (MPLNet)

http://mplnet.gsfc.nasa.gov/

523 nm MPLNET
Automatized since July 2005

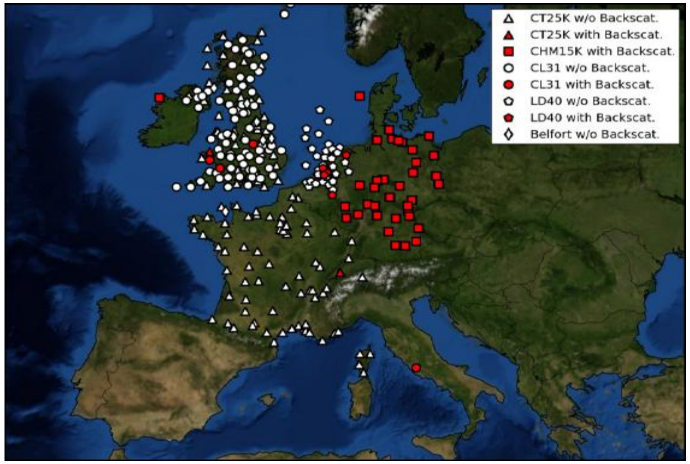
Ground-based remote sensing

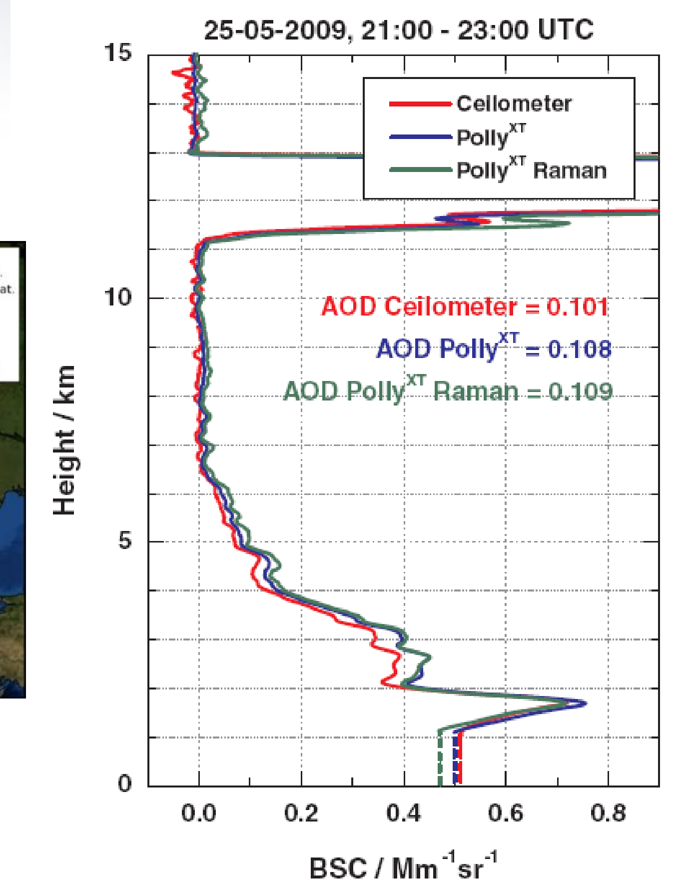


Top of the marine boundary layer

Ceilometer network

Met Services are replacing **cloud-base** ceilometer networks by **aerosol backscatter profiling ceilometers** (**IR wavelenght**).
Objective: **To monitor MLD (Mixing Layer Depth)** based on **several hundred profiling ceilometers (100km sampling)**

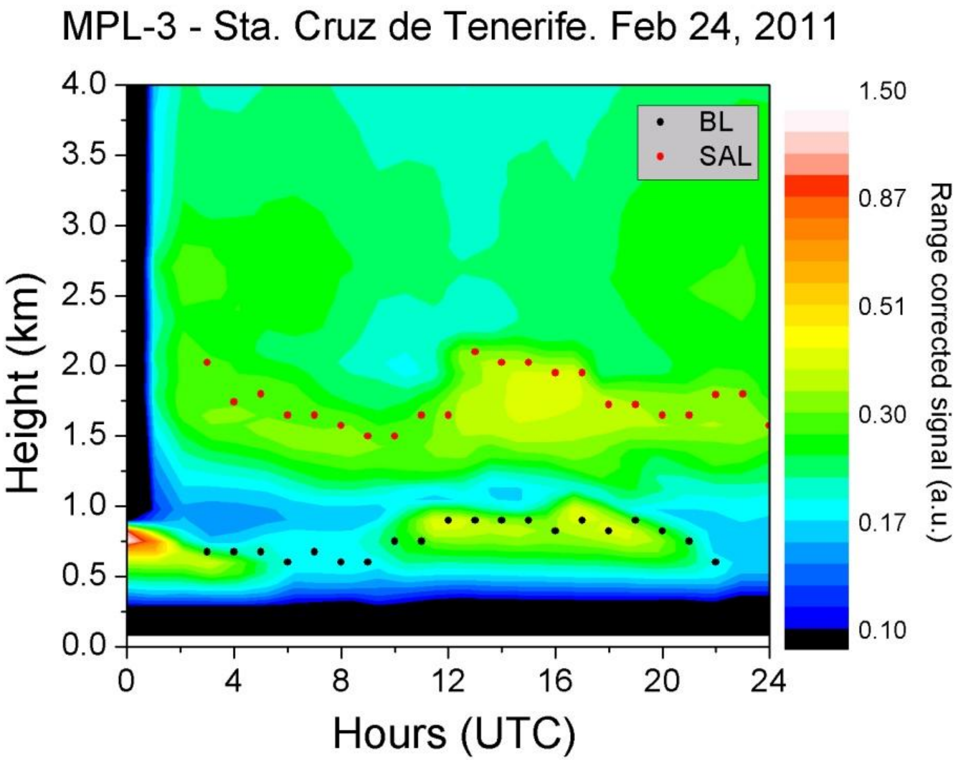


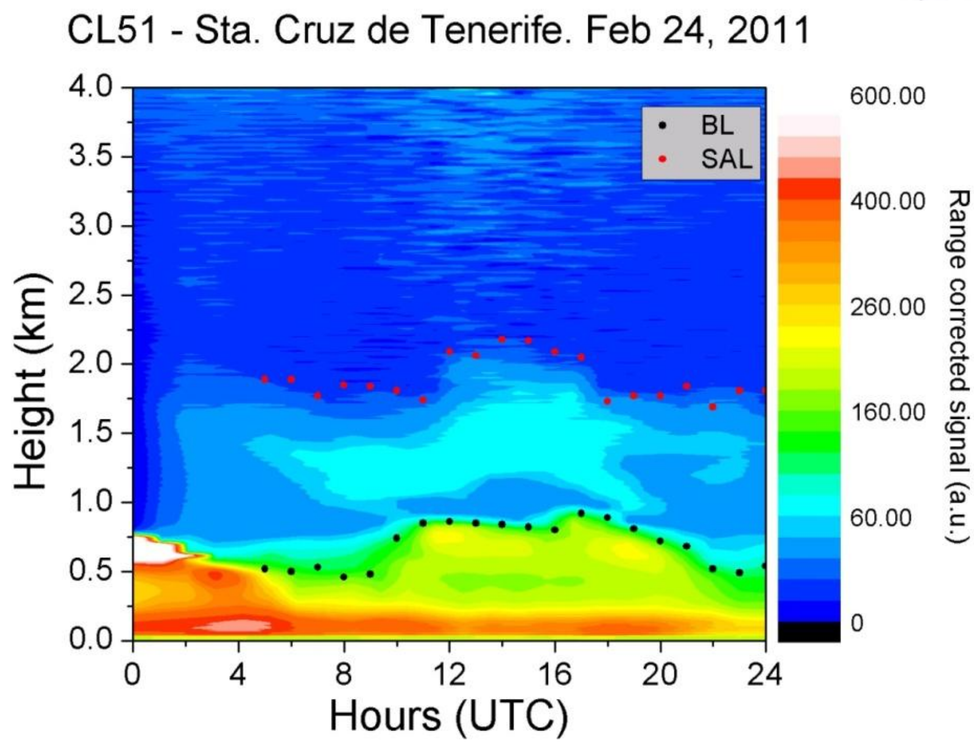


Heese et al., Atmos. Mes. Tech. 2010, Ceilometer-lidar inter-comparison: backscatter coefficient retrieval and signal-to-noise ratio determination

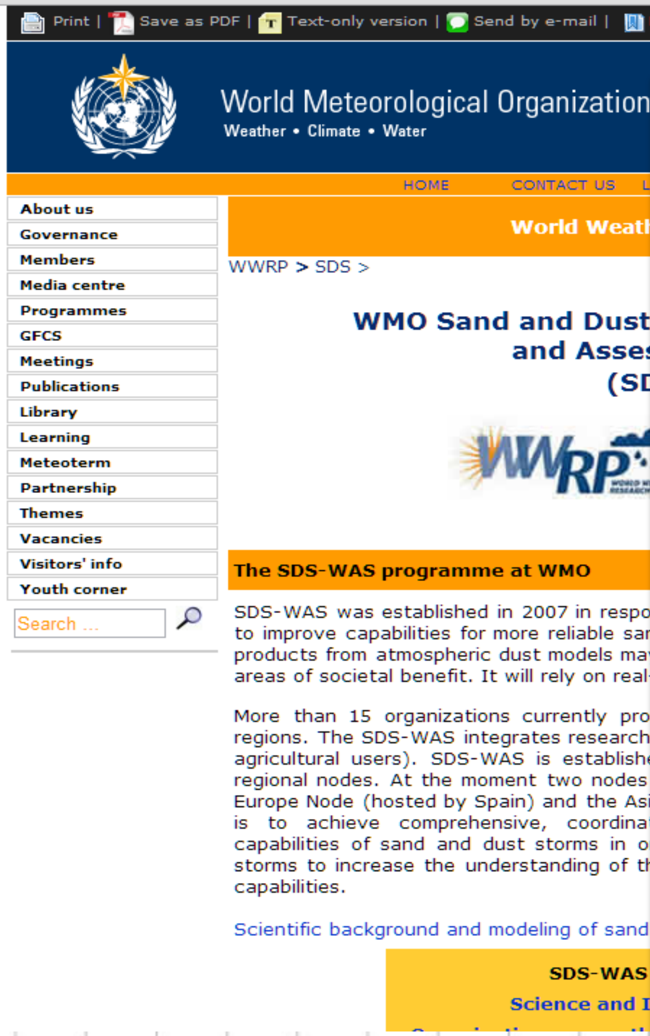
Optimal for desert regions !!

Ground-based remote sensing





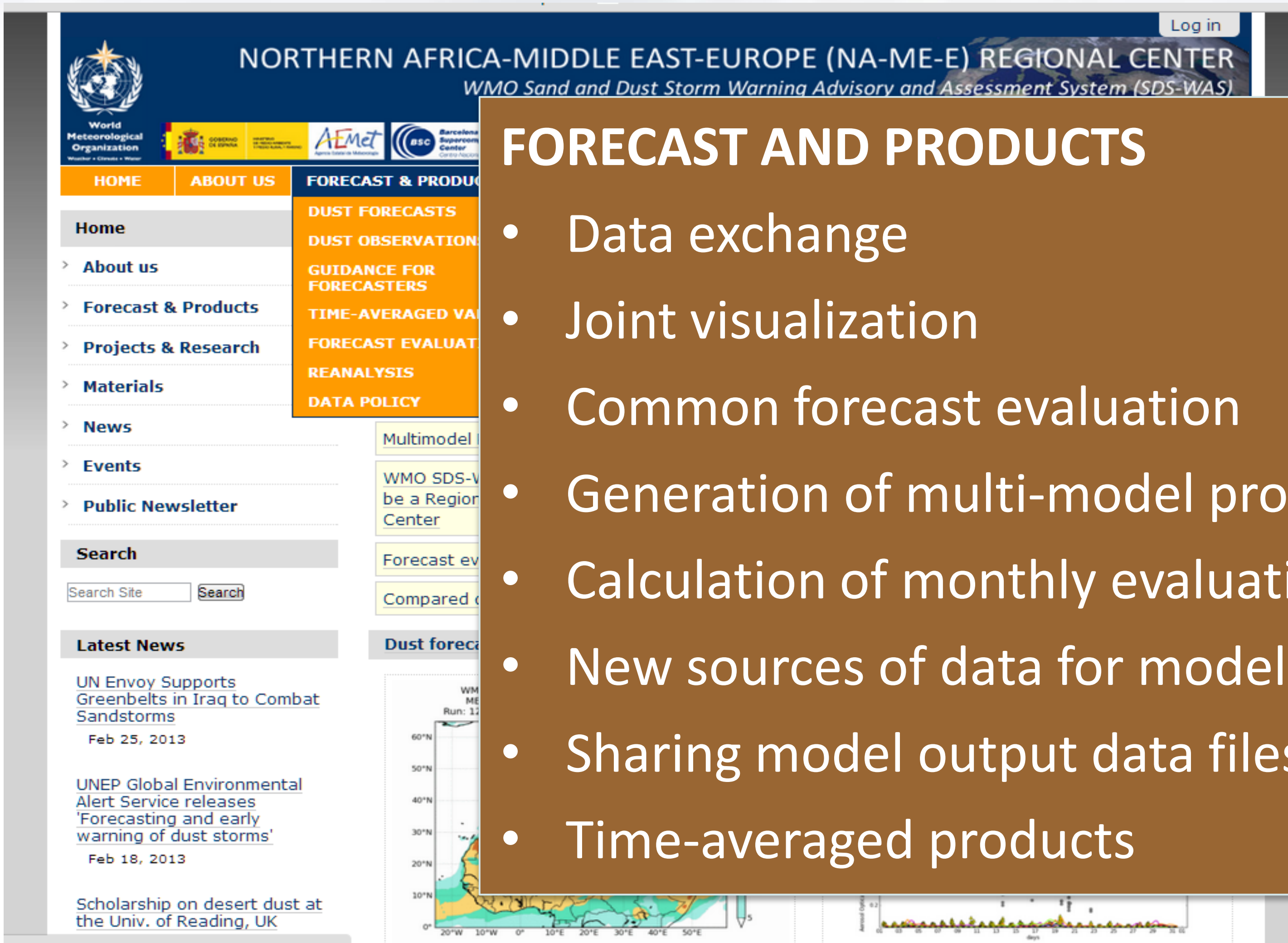
SDS-WAS (http://www.wmo.int/sdswas)



OBJECTIVES:

- Identify and improve products to monitor and predict atmospheric 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 by the WMO SDS-WAS project

SDS-WAS (http://www.wmo.int/sdswas)



FORECAST AND PRODUCTS

- Data exchange
- Joint visualization
- Common forecast evaluation
- Generation of multi-model products
- Calculation of monthly evaluation metrics
- New sources of data for model evaluation
- Sharing model output data files
- Time-averaged products

sdswas@aemet.es

Dust Forecasts

Dust prediction models provide 72 hours (at 3-hourly basis) of dust forecast (AOD at 550nm and surface concentration) covering the NAMEE region.

MODEL	RUN TIME	DOMAIN	DATA ASSIMILATION
BSC-DREAM8b v2.0	12	Regional	No
CHIMERE	00	Regional	No
LMDzT-INCA	00	Global	No
CAMS-ECMWF	00	Global	MODIS AOD
DREAM8-NMME	00	Regional	CAMS analysis
NMMB/BSC-Dust	12	Regional	No
MetUM	00	Global	MODIS AOD
GEOS-5	00	Global	MODIS reflectances
NGAC	00	Global	No
EMA REG CM4	12	Regional	No
DREAMABOL	12	Regional	No
NOA WRF-CHEM	12	Regional	No
FMI-SILAM	12	Global	No

DOD joint visualization

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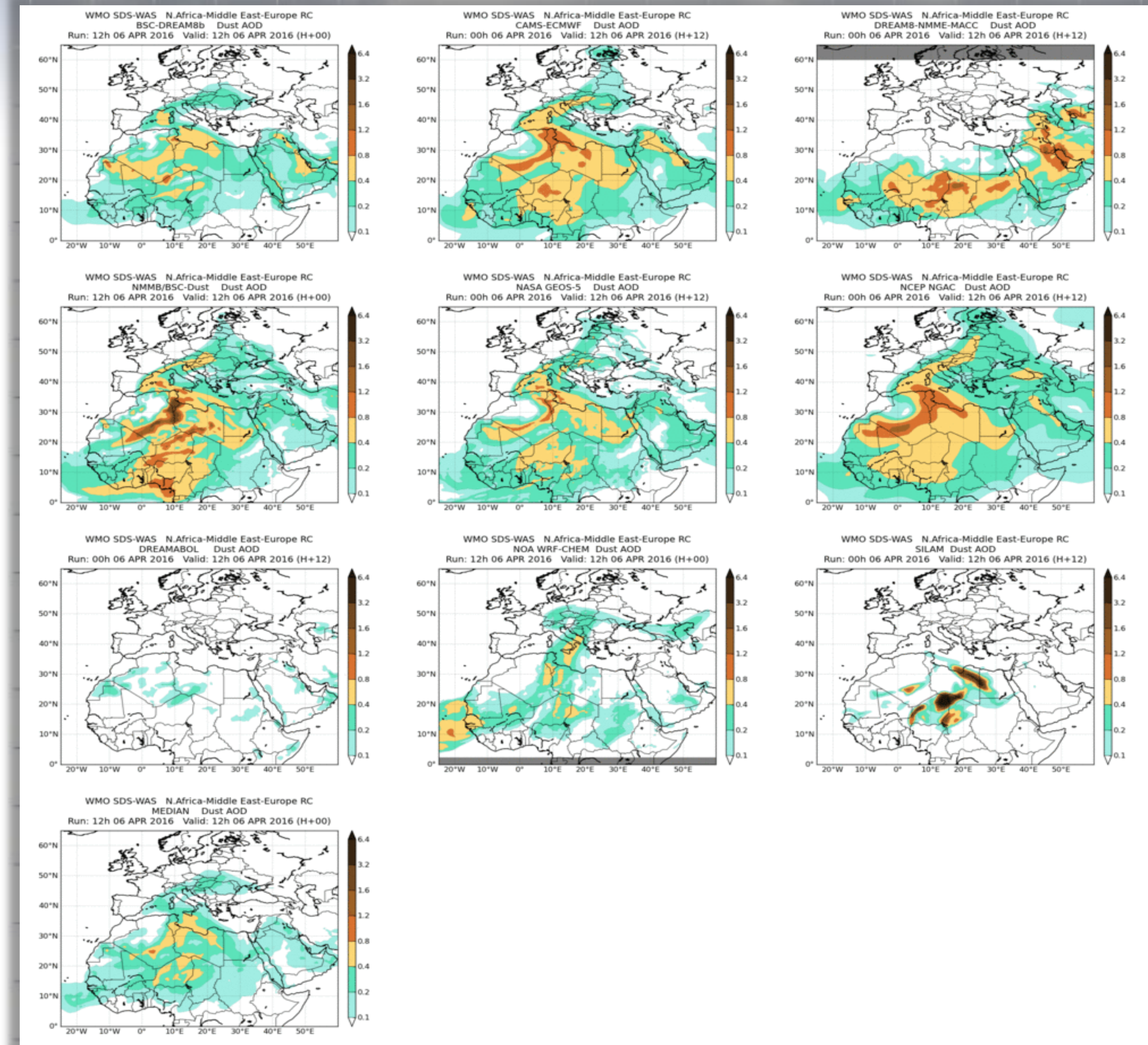
AOD at 550nm from 6-Apr-2016 12:00 to 9-Apr-2016 00:00



http://sds-was.aemet.es/forecast-products/dust-forecasts/compared-dust-forecasts

SDS-WAS in UNEP

Log in

BARCELONA DUST FORECAST CENTER

WMO SDS-WAS || NA-ME-E Regional Center

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- **Dust forecasts available on UNEP platform**

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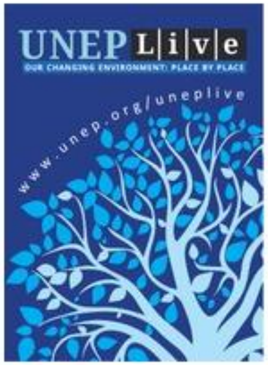


Dust forecasts produced by the WMO SDS-WAS Regional Center for Northern Africa, Middle East and Europe and the Barcelona Dust Forecast Center are available on UNEPLive, a platform managed by the United Nations Environment Program.

The aim of UNEP Live is to facilitate the exchange and sharing of latest data, information, assessments and knowledge amongst member countries, research networks, communities of practice, indigenous peoples and society, in order to keep the environment and emerging issues under review.

Direct links:

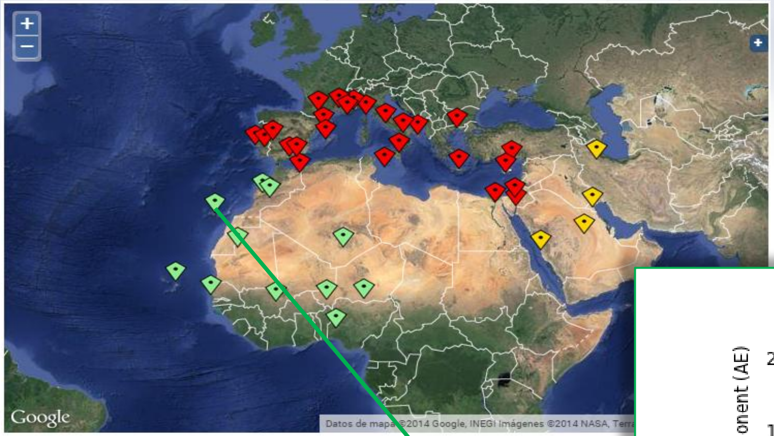
Africa: http://uneplive.unep.org/region/index/AF#data_tab

West Asia: http://uneplive.unep.org/region/index/WS#data_tab

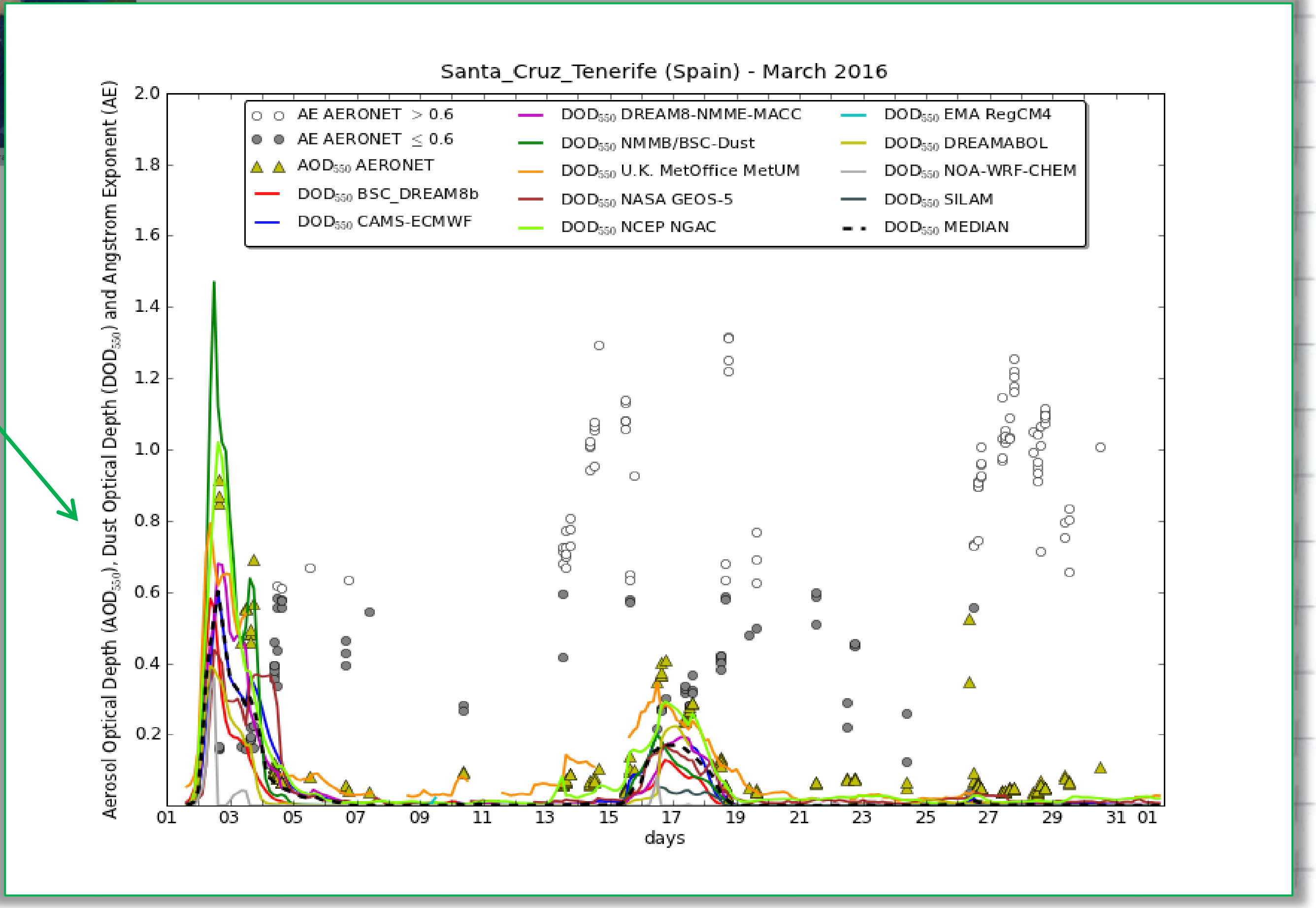
Filed under: Outstanding

http://dust.aemet.es/

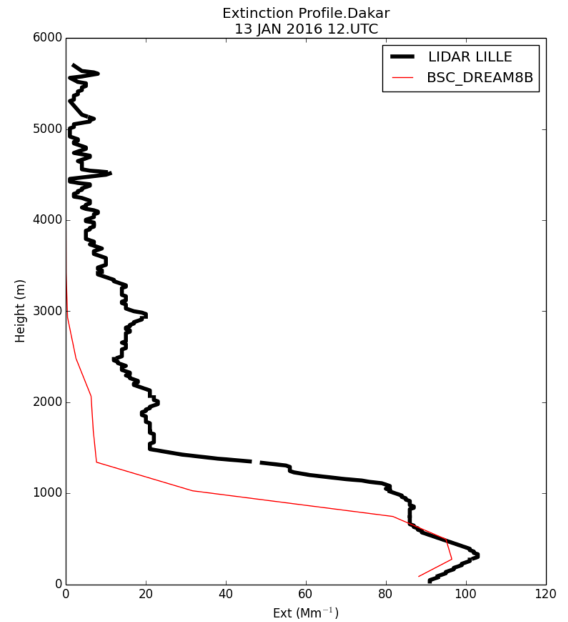
Evaluation with AERONET data

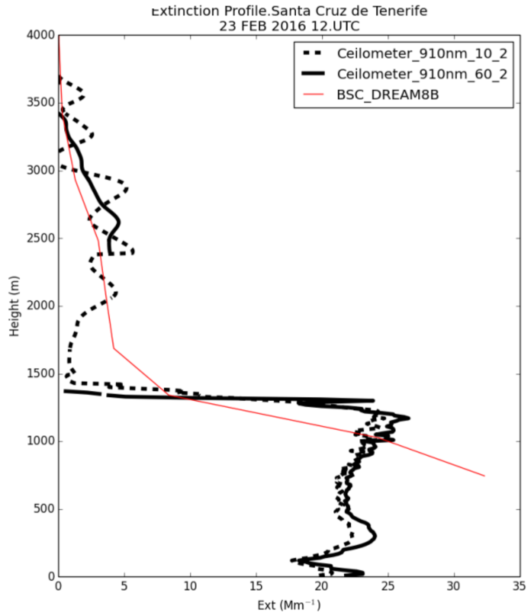


http://actris2.nilu.no/DataServices/InstrumentCalibration/AERONET.aspx



Evaluation of vertical profiles (extinction)



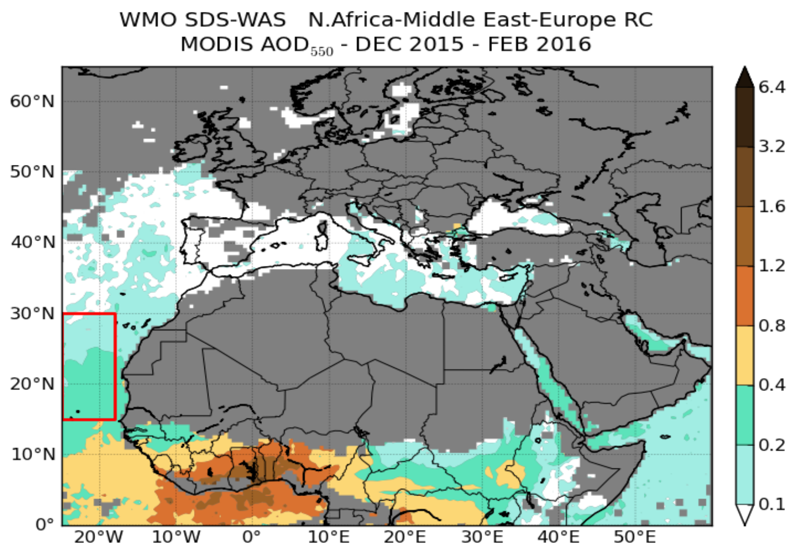


Université de Lille 1 Sciences et Technologies

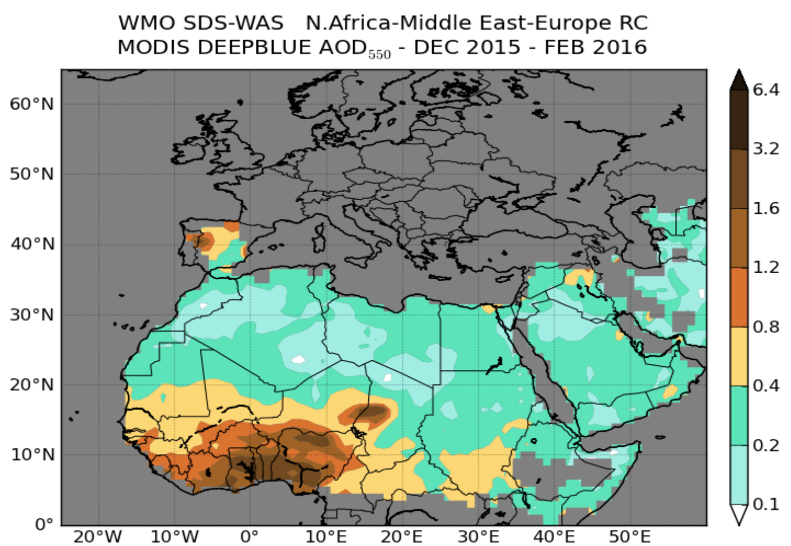
Barcelona Supercomputing Center
Centro Nacional de Supercomputación

Gobierno de España
Ministerio de Medio Ambiente y Medio Rural y Marino
AEMet Agencia Estatal de Meteorología

Evaluation with MODIS



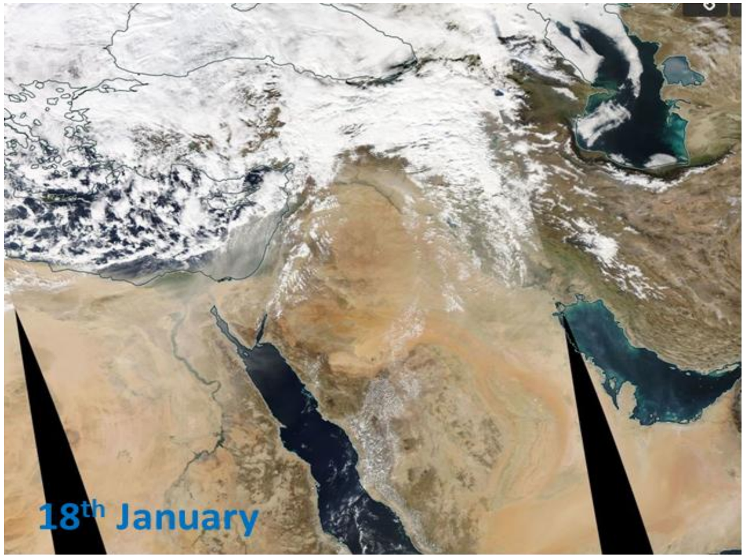
	BIAS	ROOT MEAN SQUARE ERROR	CORRELATION COEFFICIENT	FRACTIONAL GROSS ERROR	NUMBER OF CASES
BSC_DREAM8b	-0.24	0.43	0.63	1.07	207012
NMMB/BSC-Dust	-0.10	0.29	0.78	0.98	201353
NCEP NGAC	-0.12	0.32	0.68	0.71	207012
EMA RegCM4	0.11	0.54	0.29	0.94	39231
DREAMABOL	-0.21	0.44	0.36	0.96	198954
NOA-WRF-CHEM	-0.19	0.41	0.46	1.04	198463

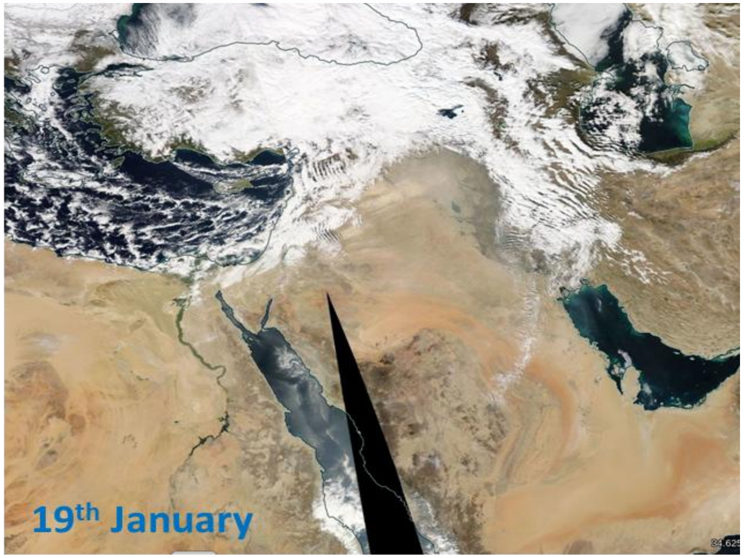


	BIAS	ROOT MEAN SQUARE ERROR	CORRELATION COEFFICIENT	FRACTIONAL GROSS ERROR	NUMBER OF CASES
BSC_DREAM8b	-0.23	0.44	0.45	0.89	51308
NMMB/BSC-Dust	-0.11	0.34	0.78	1.03	47494
NCEP NGAC	-0.14	0.34	0.69	0.66	48659
EMA RegCM4	0.17	0.59	0.35	0.82	12050
DREAMABOL	-0.25	0.46	0.41	0.91	48036
NOA-WRF-CHEM	-0.22	0.43	0.48	1.03	51220

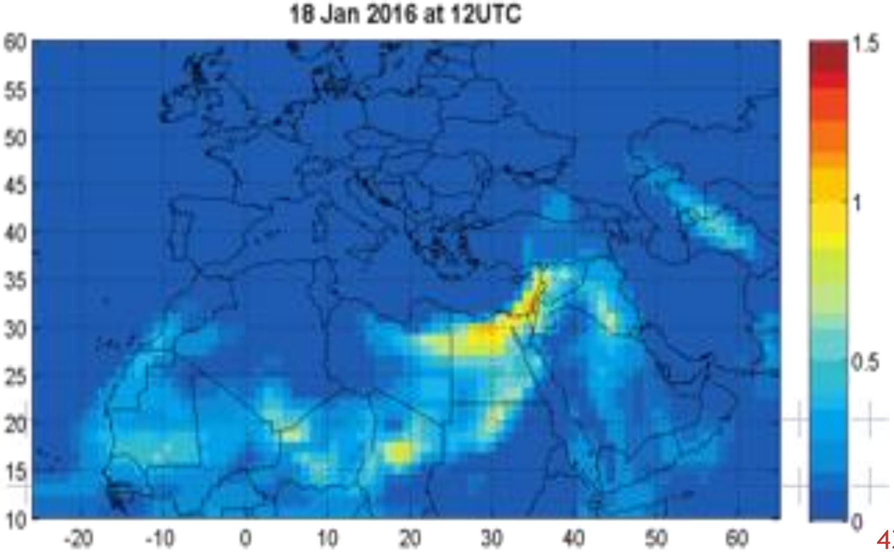
Events: Eastern Med. And Middle East dust event on Jan 2016

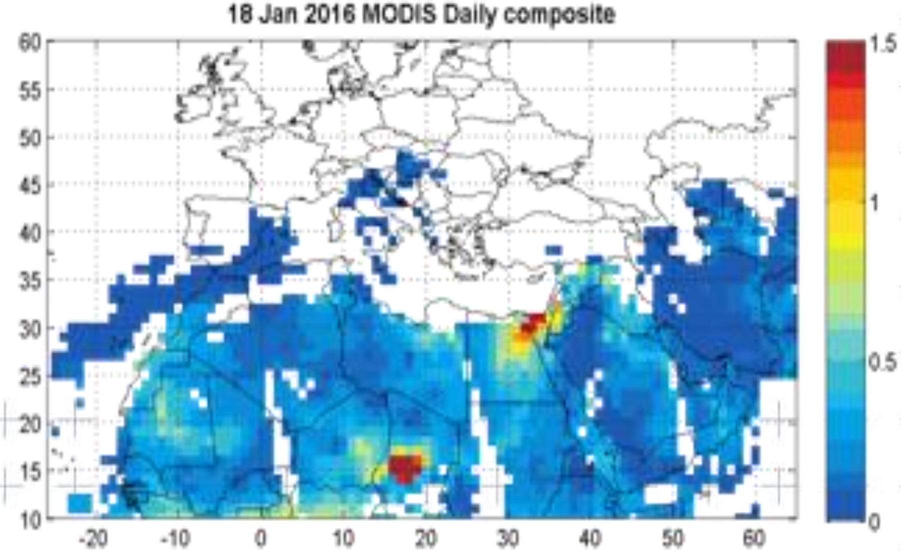
MODIS/Aqua



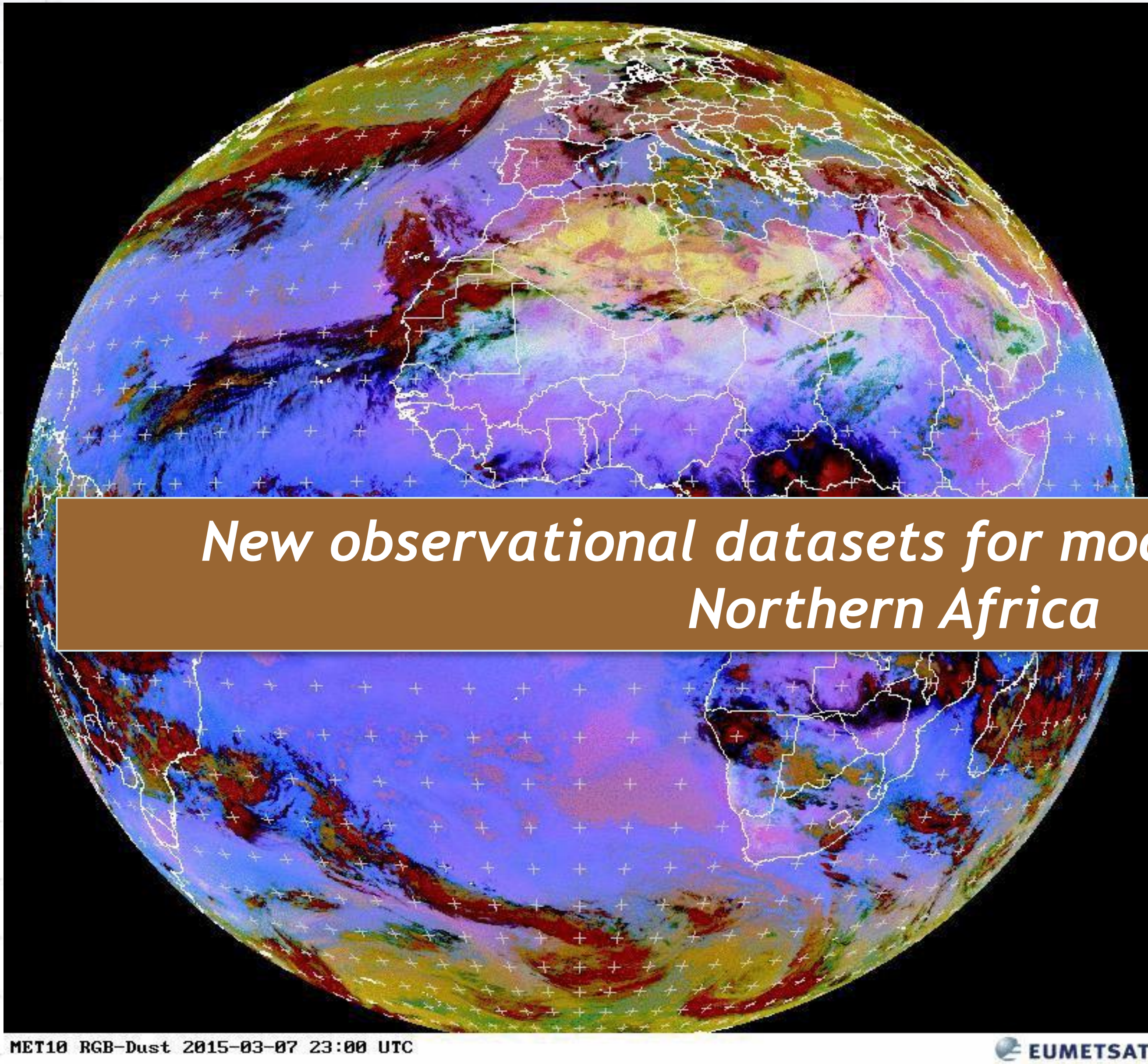


Collection 6





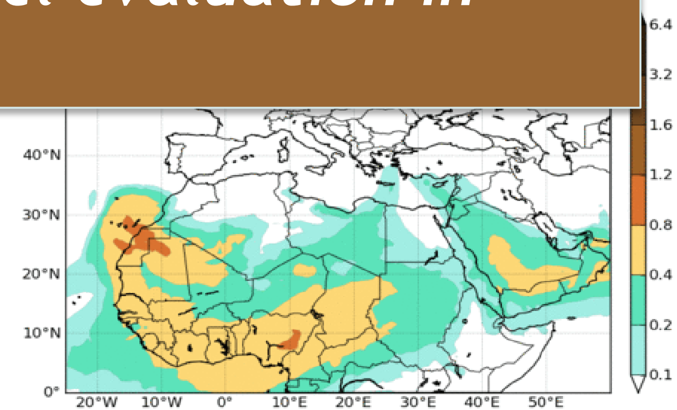
NRT Evaluation using satellite aerosol products



EUMETSAT

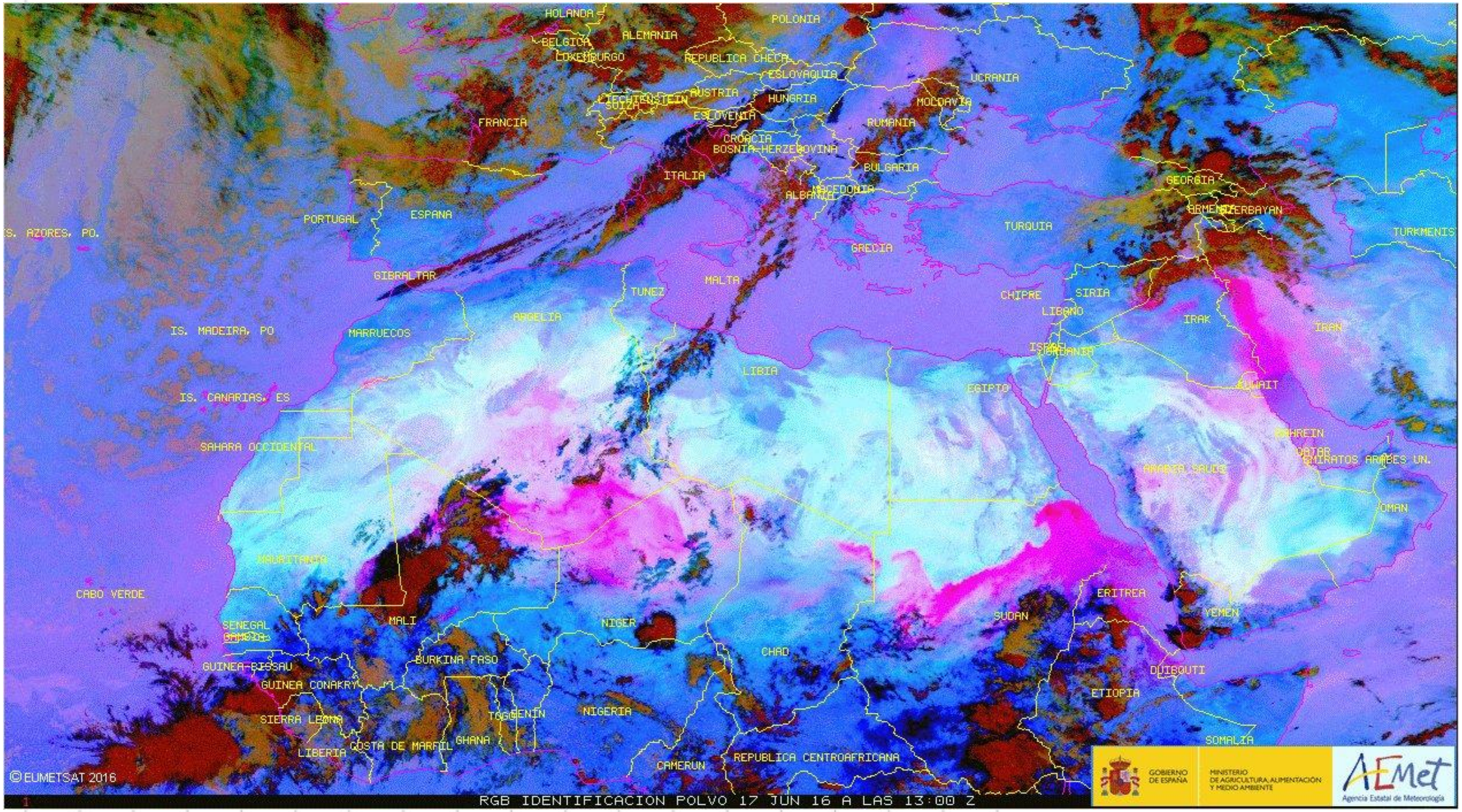
7 March 2015

New observational datasets for model evaluation in Northern Africa



NRT Evaluation using satellite aerosol products

http://sds-was.aemet.es/forecast-products/dust-observations/msg-2013-eumetsat



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Agencia Estatal de Meteorología

Gracias