

Dust and air quality from ground physical and chemical properties

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Rationale

Desert dust and sand storms (SDS):

- Impact on Air Quality; increase PM levels and modify PM composition.
- SDS may have an impact on health

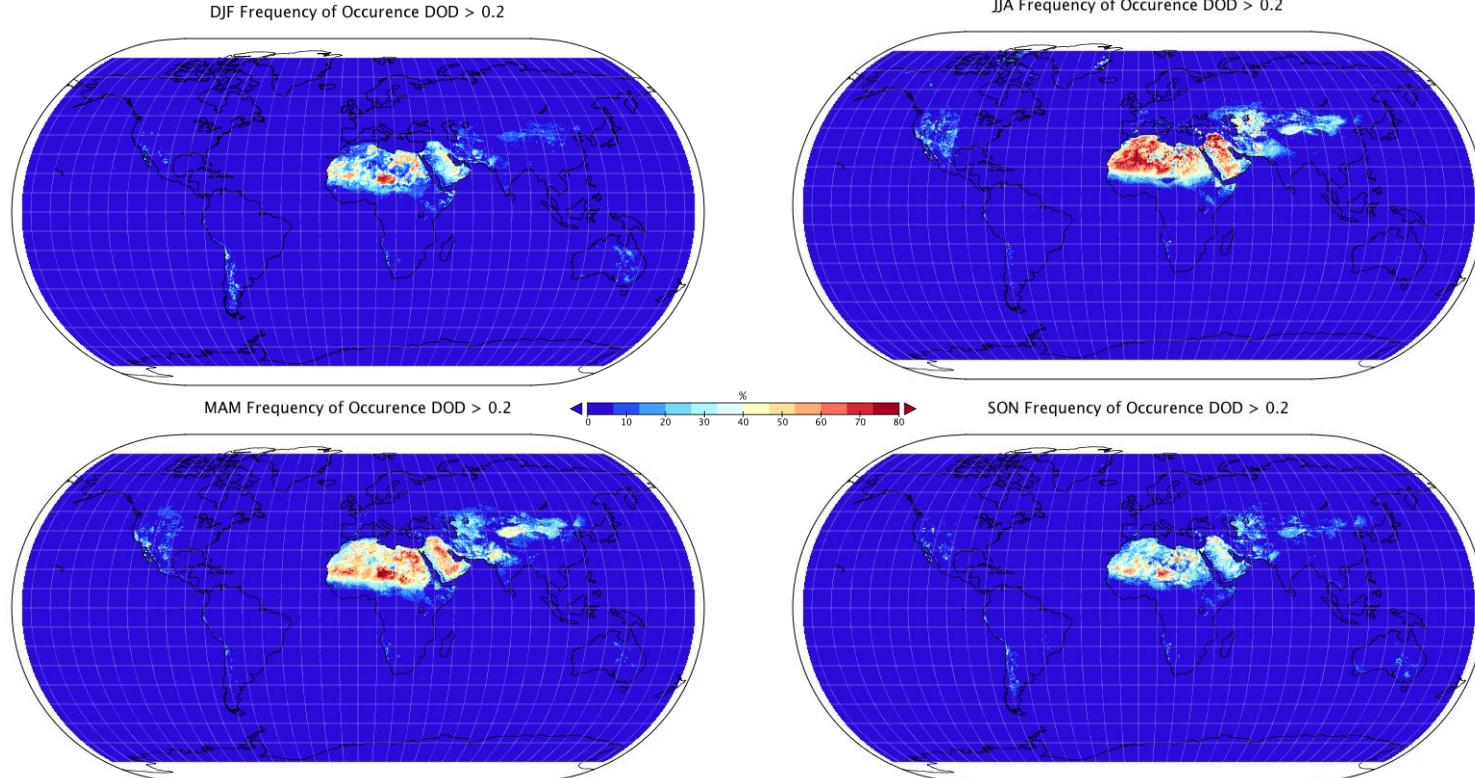
WHO 2021:

- insufficient evidence on quantitative and qualitative health risk-related characteristics of SDS to formulate AQG levels
- decision to formulate good practice statements:
 - (i) **strengthening and/or establishing the air quality management programs;**
 - (ii) **measuring PM components for the purpose of source apportionment;**
 - (iii) **conducting research on health impacts and epidemiological studies;**
 - (iv) Implement wind erosion control through the carefully planned expansion of green spaces;
 - (v) cleaning up road dust on streets

Outline

- **What is desert dust?**
- **Desert dust outbreaks, relevant patterns for AQ & health studies**
- **Procedure for the detection and quantification of natural dust contributions to PM**
- **Examples of applications of the method**
- **Concluding remarks**

Dust sources, emissions and transport



Ginoux P. et al., 2012. Rev Geophys 50:1–36.

Dust sources, emissions and transport

Global MASS of mineral dust aerosols:

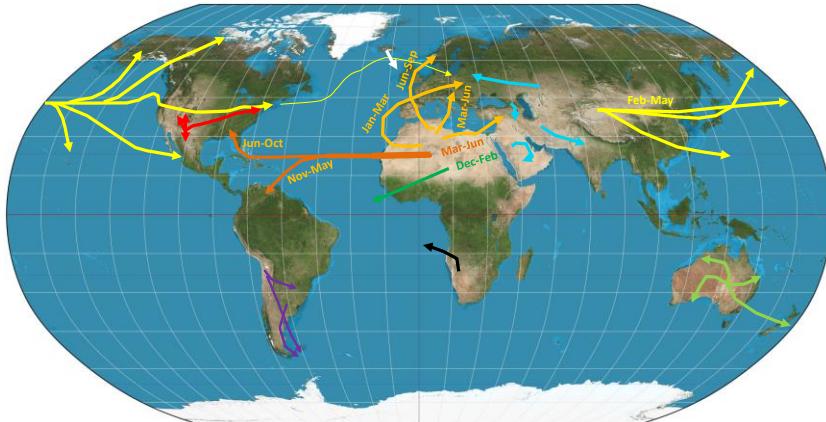
16 Mega (10^6)-tons

Emissions

- N-Africa 790-840 Mt/yr
- Gobi 140-220 Mt/yr
- C. Asia, E. Australia, Atacama and South Africa 10- 60 Mt/yr each
- S. US-N. Mexico 2- 60 Mt/yr

Prospero J.M., 2002. Rev. Geophys 40(1):1002
Huneeus N. et al., 2011. Atmos Chem Phys 11(15):7781–816
Ginoux P. et al., 2012. Rev Geophys 50:1–36
Ginoux P. et al., 2010. J Geophys Res Atmos 2010;115(5):1–10
Washington R. et al., 2003. Ann Assoc Am Geogr 93(2):297–313
Varga G., 2012. Hungarian Geogr Bull 61(4):275–98

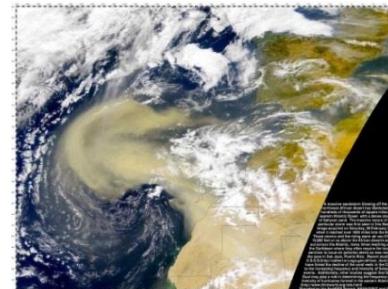
Atmospheric transport



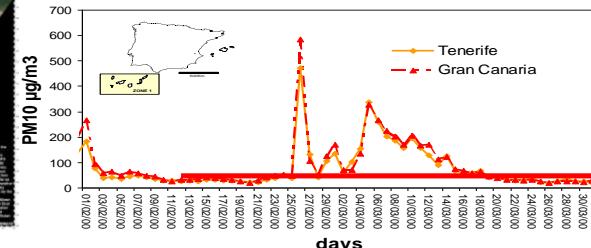
Modified from Griffin DW., 2007. Clin Microbiol Rev;20(3):459–77.

Duration

Atmospheric life time, hours- weeks



25/02 to 17/03/2000
Exceeding the PM10 DLV



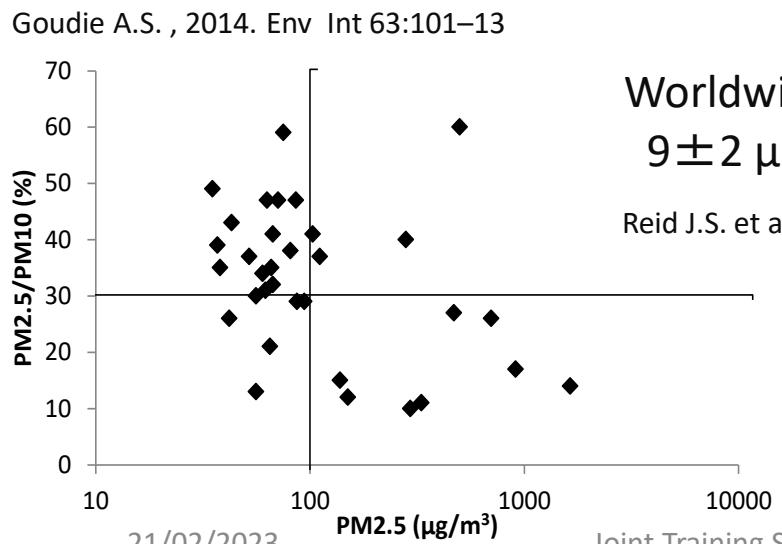
PM levels and size

- PM10 and PM2.5 vary widely during desert dust episodes according the regions and episodes in the same region
- PM size might also vary a lot

Mori et al., 2003 (TSP)	up to 6700 $\mu\text{g}/\text{m}^3$	8h	Inner Mongolia (China)
	up to 1500 $\mu\text{g}/\text{m}^3$	6h	Beijing (China) 95% coarse
	up to 230 $\mu\text{g}/\text{m}^3$	24h	Japan remote island 64% coarse
Aryal R, 2012 (PM10)	up to 11800 $\mu\text{g}/\text{m}^3$	1h	Sydney, Australia
Krasnov H, et al., 2014 (PM10)	up to 2000 $\mu\text{g}/\text{m}^3$	24h	Beer-Sheva, Negev, Israel
Viana et al., 2002 (PM10)	up to 675 $\mu\text{g}/\text{m}^3$	24h	Canary Islands, Spain
Sotoudeheian et al., 2016 (PM10)	up to 650 $\mu\text{g}/\text{m}^3$	24h	Central Iran cities
Achilleos et al., 2014 (PM10)	up to 470 $\mu\text{g}/\text{m}^3$	24h	Nicosia, Cyprus
Querol et al., 2009 (PM10)	up to 250 $\mu\text{g}/\text{m}^3$	24h	Mainland Spain remote sites
Querol et al., 2009; Pey et al., 2011: Mediterranean region	17 to 37% of the days are affected by dust transport 9 to 43% of the annual ambient PM10 levels at remote sites 1 to 8 $\mu\text{g}/\text{m}^3$ of the annual PM10 averages 25-30%. of dust days receive daily dust of 25 $\mu\text{g}/\text{m}^3$ in PM10 10% in Northwestern Mediterranean		
Krasnov H, et al., 2014: Beer Sheva, Israel	10% of the dust days exceed 71 $\mu\text{g}/\text{m}^3$ PM10 122 $\mu\text{g}/\text{m}^3$ PM10 daily net dust to PM10 during dust days		
Prospero et al., 2005: Barbados	35 days recorded dust contributions >50 $\mu\text{g}/\text{m}^3$, 7 days >100 $\mu\text{g}/\text{m}^3$.		

PM levels and size

	PM10 mg/m³	PM2.5 mg/m³	PM2.5/10 (%)
Region			
Southern Europe	150-2,500	43-86	43-47
Eastern Asia	134-3,006	63-700	11-61
Australia	266-15,366		
Western Africa	312-5,000	42-1,368	13-40
North America	123-65,112		
Midde the East	700-5,619		

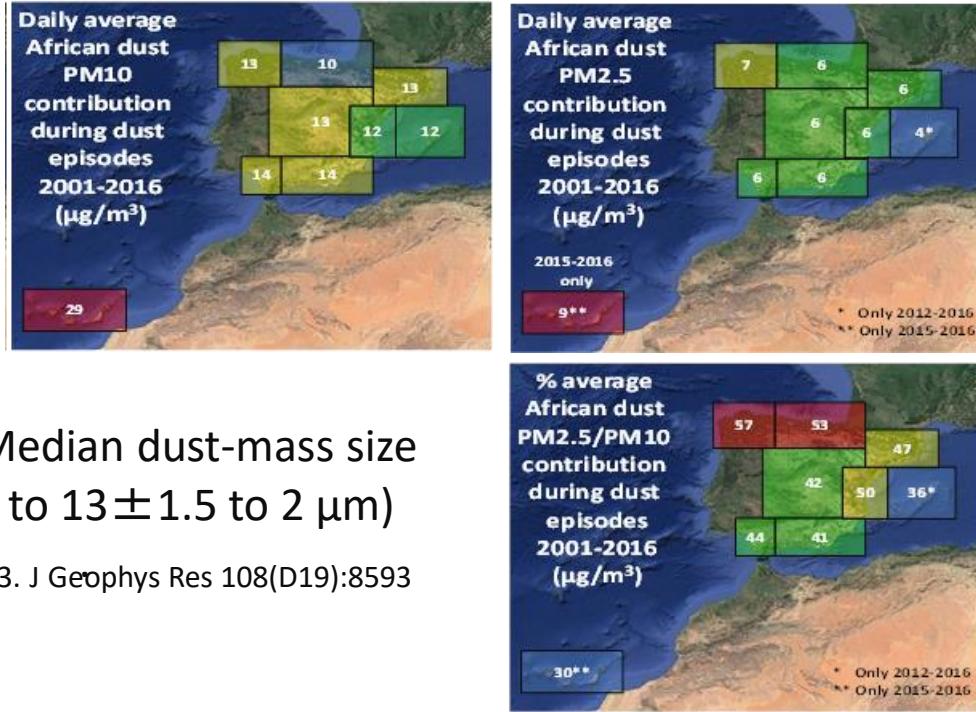


Worldwide Median dust-mass size
 $9 \pm 2 \mu\text{m}$ (5 to 13 ± 1.5 to 2 μm)

Reid J.S. et al., 2003. J Geophys Res 108(D19):8593

Data obtained from:

- Goudie A.S., 2014; max. conc. over the world,
 - Jayaratne et al. (79) dust storm in Brisbane,
 - Engelbrecht et al. (73) annual mean conc. Middle East



Querol et al., 2019 Sci. Tot. Env.,
686 737-752

Spatial variability

Titos et al. J. Geophys. Res. Atmos., 122, 4052–4069, doi:10.1002/2016JD026252.

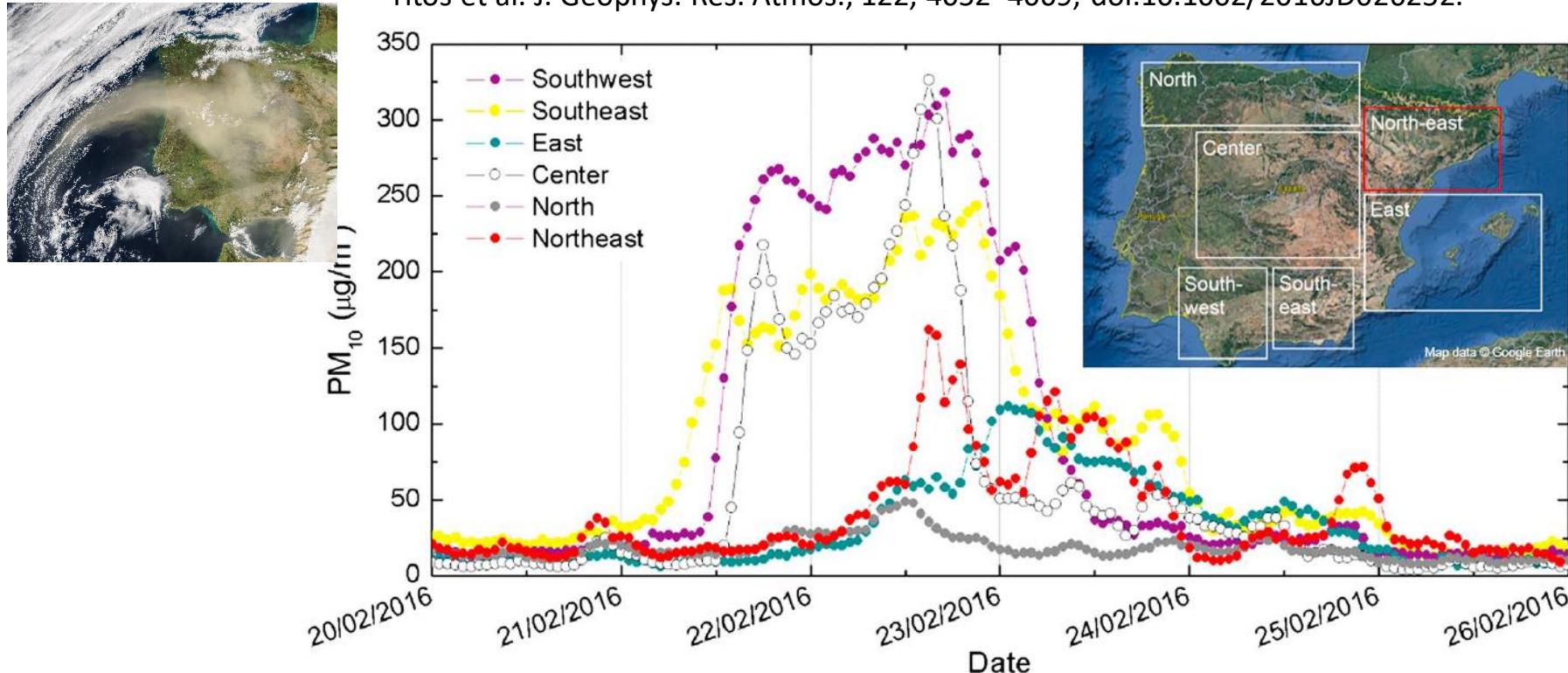


Figure 2. Hourly PM₁₀ concentrations (median values) corresponding with the different regions (inset map).

Spatial variability

Titos et al. J. Geophys. Res. Atmos., 122, 4052–4069, doi:10.1002/2016JD026252.

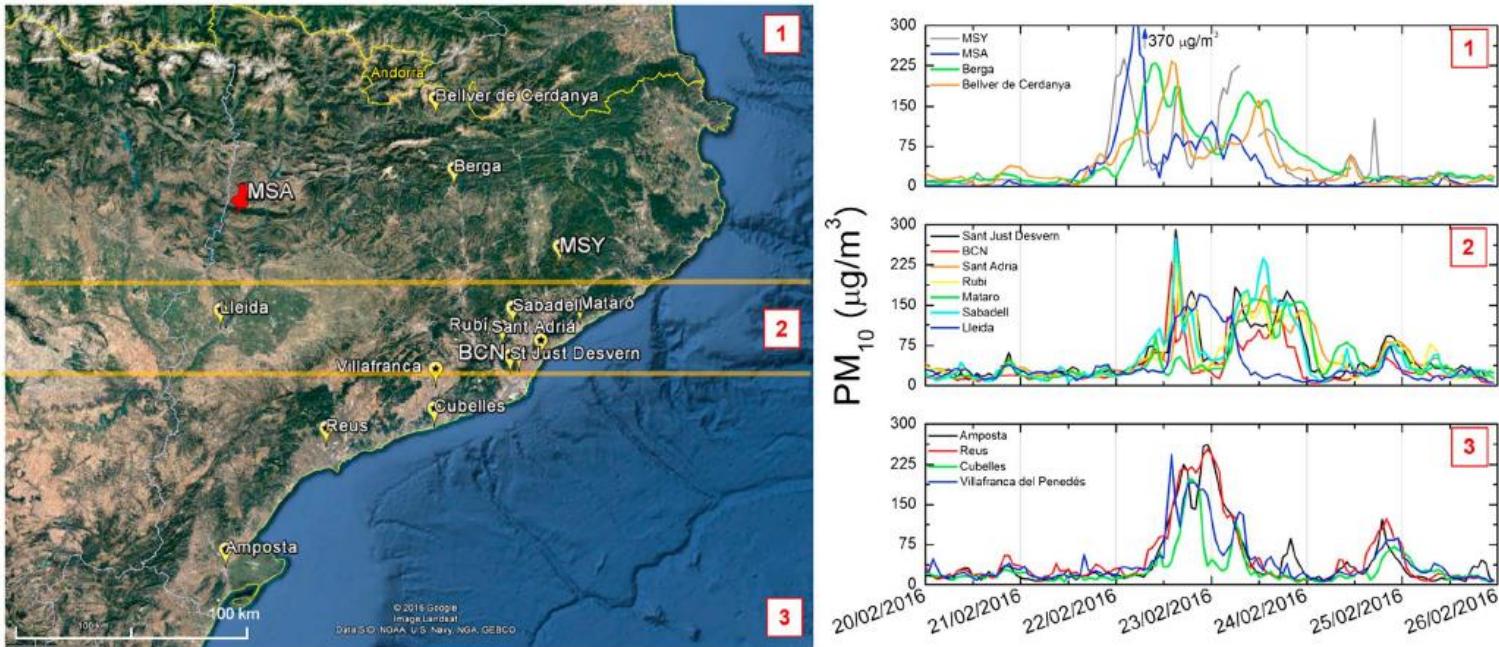


Figure 3. North-easternmost part of the Iberian Peninsula (Catalonia region) with the air quality stations marked and split into three sectors (1 = north, 2 = center, and 3 = south) and hourly PM_{10} mass concentrations at each station.

Vertical variability

Titos et al. J. Geophys. Res. Atmos., 122, 4052–4069, doi:10.1002/2016JD026252.

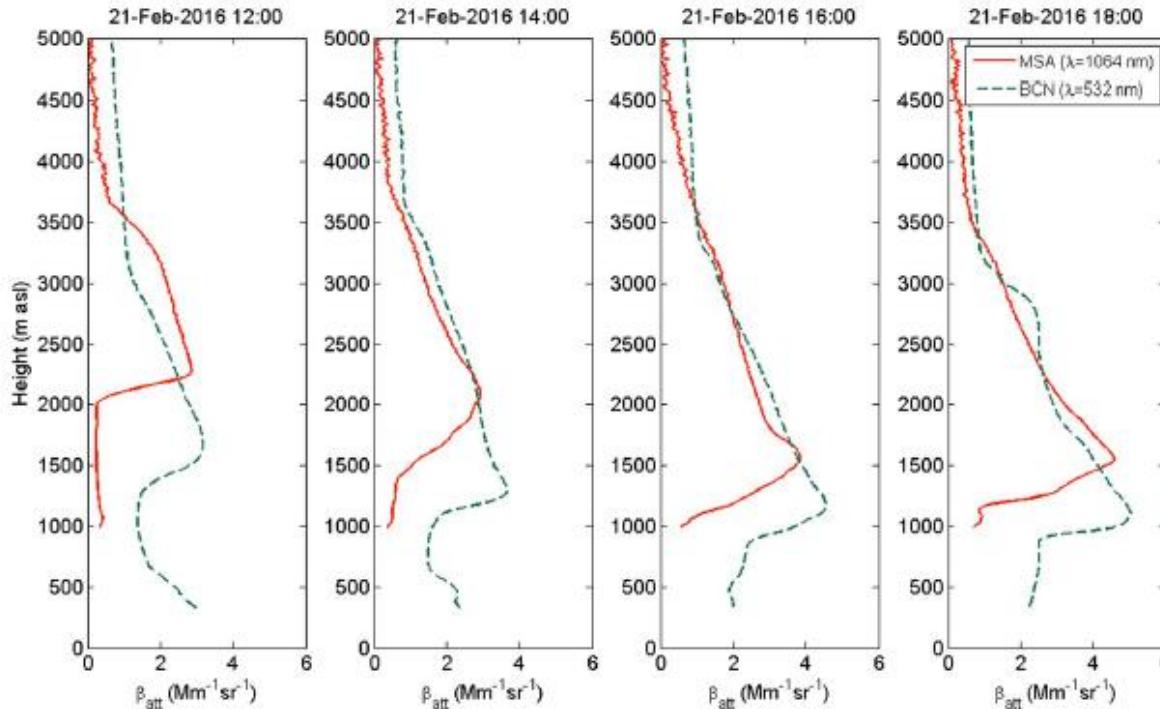


Figure 4. Vertical and temporal evolution of the attenuated backscatter coefficient, $\beta_{\text{att}}(\lambda)$, measured with ceilometer at MSA and micropulsed lidar at BCN (1 h average). Time refers to UTC.

PM composition of dust

Silicates & aluminium-silicates	Silicates	Quartz	SiO_2 (mineral grains or diatomea fragments)	*****
	Clay minerals	Kaolinite	$\text{Al}_2\text{Si}_2\text{O}_5(\text{OH})_4$	****
		Illite	$(\text{K},\text{H}_3\text{O})(\text{Al},\text{Mg},\text{Fe})_2(\text{Si},\text{Al})_4\text{O}_{10}[(\text{OH})_2,(\text{H}_2\text{O})]$	****
		Chlorite	$((\text{Mg}\text{Fe})_5\text{Al})(\text{AlSi}_3)\text{O}_{10}(\text{OH})_8$	***
		Palygorskite	$(\text{Mg},\text{Al})_2\text{Si}_4\text{O}_{10}(\text{OH}) \cdot 4(\text{H}_2\text{O})$	***
		Montmorillonite	$(\text{Na},\text{Ca})_{0.33}(\text{Al},\text{Mg})_2(\text{Si}_4\text{O}_{10})(\text{OH})_2 \cdot \text{nH}_2\text{O}$	***
	Feldspars	Albite	$\text{NaAlSi}_3\text{O}_8$	**
		Anorthite	$\text{CaAl}_2\text{Si}_2\text{O}_8$	**
		Microcline/orthocl.	KAISi_3O_8	**
	Other silicate	Zircon	ZrSiO_4	*
		Hornblende	$\text{Ca}_2(\text{Mg},\text{Fe},\text{Al})_5(\text{Al},\text{Si})_8\text{O}_{22}(\text{OH})_2$	*
Carbonates	Ca & Mg Carb.	Calcite	CaCO_3	* / ***
		Dolomite	$(\text{CaMg})_2\text{CO}_3$	**
Oxides	Iron oxides	Hematite	Fe_2O_3	**
		Magnetite	Fe_3O_4	*
		Goethite	$\alpha\text{-FeO(OH)}$	**
	Other oxides	Anatase & rutile	TiO_2	*
Salts	Chlorides	Halite	NaCl	*
	Sulphates	Gypsum	$\text{CaSO}_4 \cdot 2\text{H}_2\text{O}$	**
		Thenardite	Na_2SO_4	*
		Epsomite	MgSO_4	*
Phosphates		Apatite	$\text{Ca}_5(\text{PO}_4)_3(\text{F},\text{Cl},\text{OH})$	*

PM composition of dust

- **Saharan** dust: quartz, illite, calcite, montmorillonite, palygorskite, feldspars(Claquin et al., 1999)
- **Sahel** dust: quartz, kaolinite, hematite, feldspars (Claquin et al., 1999)
- **North-eastern China** desert dust: illite, kaolinite (47-52%), quartz (25-27%), feldspar and plagioclase (6-7%), calcite and dolomite (13-18%), traces of gypsum, hornblende (an Al-silicate), and halite (NaCl) (Shen et al., 2009)
- **Middle East-Central Asia** dust: higher Ca-Mg carbonates; lower SiO₂, Fe- and Mn-oxides (Goudie and Middleton, 2006 and Labban et al., 2004)
- **Australian** desert dust: quartz, anatase (TiO₂), calcite, feldspars, halite, hematite, and clays (kaolinite, illite and montmorillonite) (Aryal, 2012).

Accordingly

Major oxides SiO₂, Al₂O₃, CaO, Fe₂O₃, K₂O, MgO, Na₂O, TiO₂, MnO and P₂O₅.

Relatively high contents of Ti, Mn, Rb, V, Cr, Li, Sc, Be, Rare Earth Elements compared with non-dust days

PM composition during dust episodes

Sampling and monitoring of PM and dust



Chemical characterisation of environmental samples: atmospheric filters

Filter conditioning before and after sampling (20°C and 25%RH)

Filter weighing before and after 24 sampling

Acid Digestion

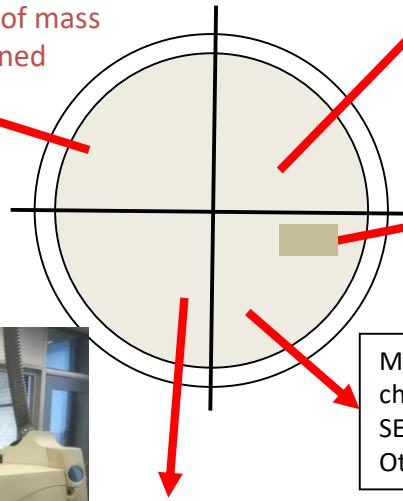
Major and trace elements

ICP-AES: Al, Ca, Fe, Mg, Na, K, Ti, P and S, among others

ICP-MS: Li, Be, V, Cr, Co, Ni, Mn, Cu, Zn, As, Se, Rb, Sr, Y, Zr, Hf, Cd, Sn, Ba, Rare Earths, Pb, Bi, Th and U, among others



70-85% of mass determined



Water leachate

Ion chromatography:

SO_4^{2-} , NO_3^- , Cl^- , NH_4^+



OC-EC Sunset / EUSAAR2
OC/EC



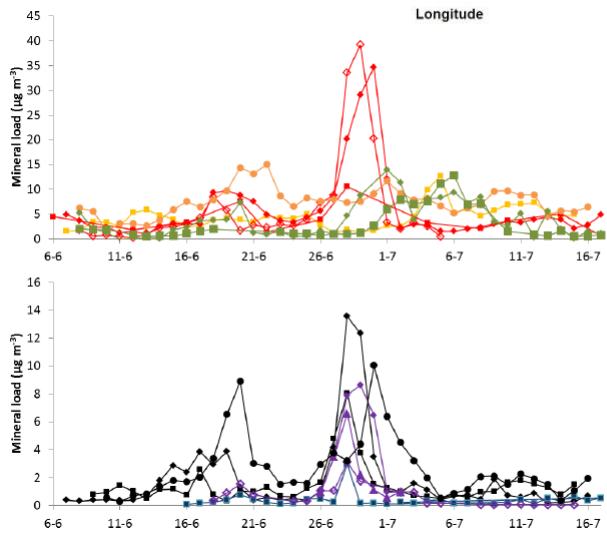
Mineralogical characterization XRD
SEM
Others



Organic speciation
Sugars, PAHs, Alkanes,
.....

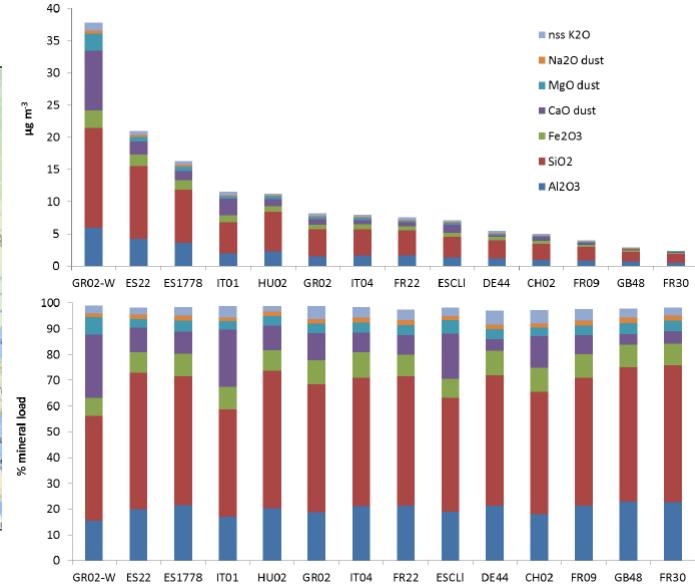
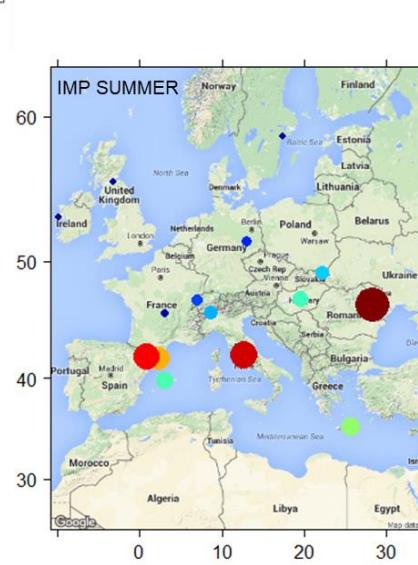


PM composition during dust episodes

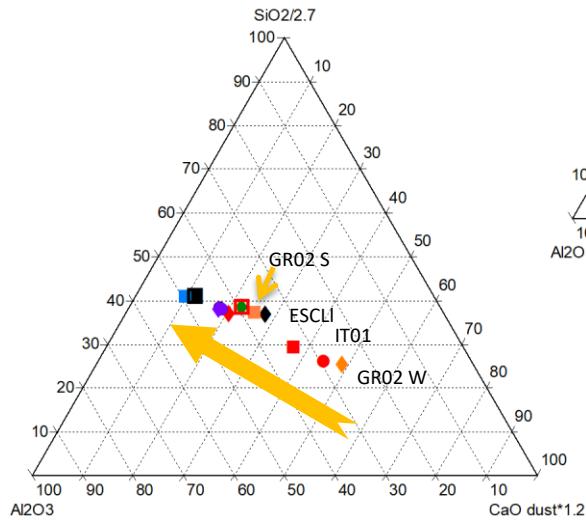
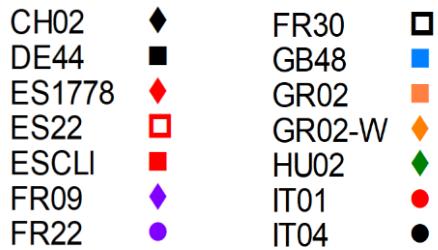


Alastuey et al. Atmos. Chem. Phys., 16(10), 6107–6129

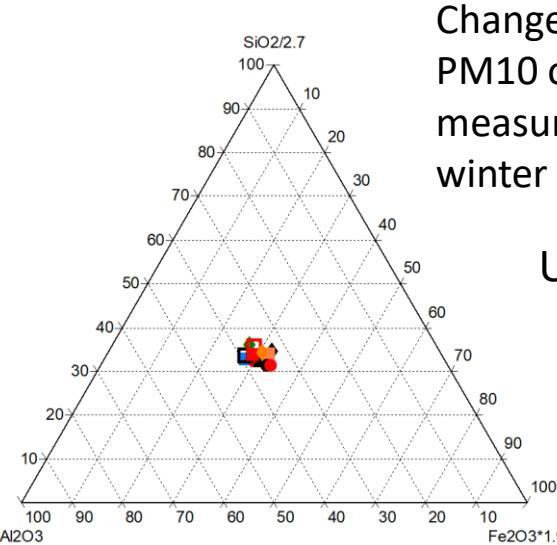
Changes during transport: geochemistry of PM10 over Europe during the EMEP intensive measurement periods in summer 2012 and winter 2013,



PM composition during dust episodes

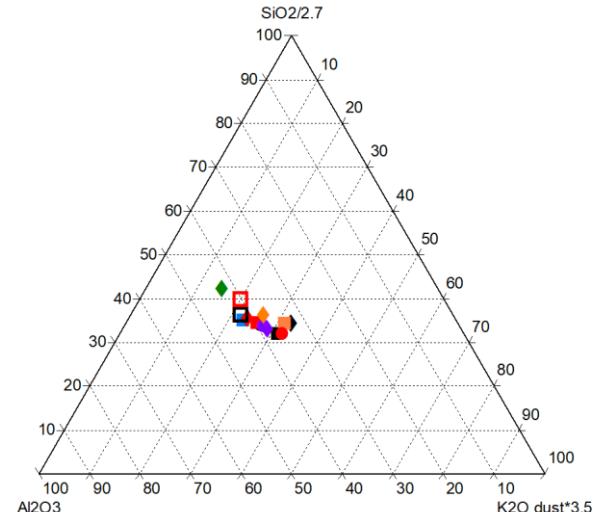


CaO
Source area
Local influence
Transport sorting

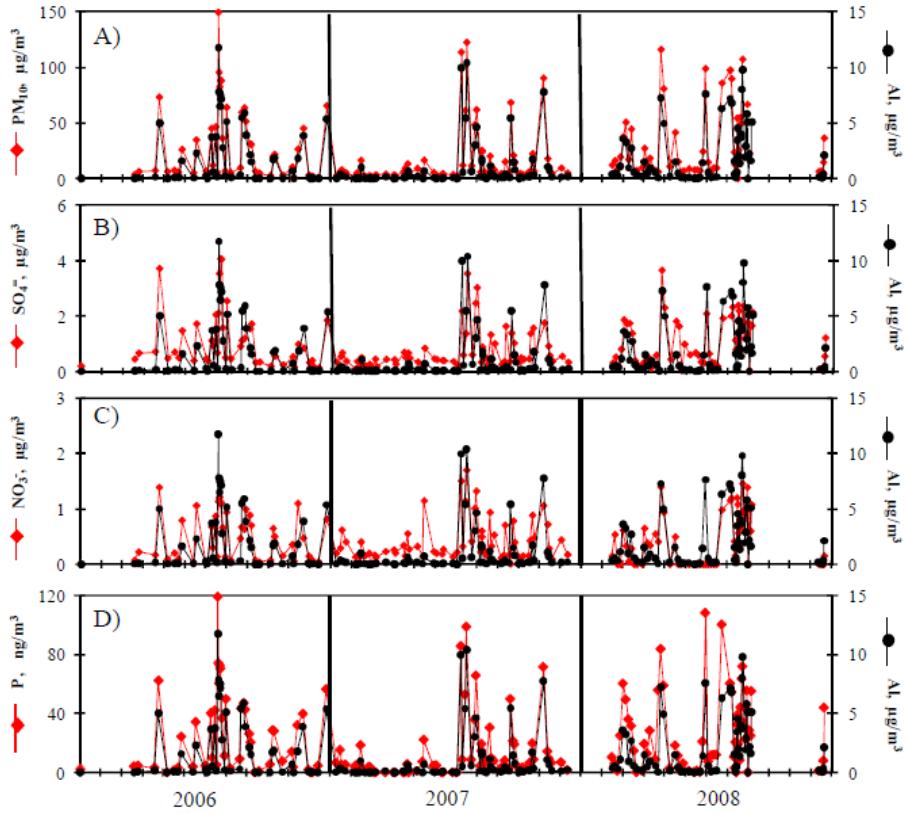


Changes during transport: geochemistry of PM10 over Europe during the EMEP intensive measurement periods in summer 2012 and winter 2013

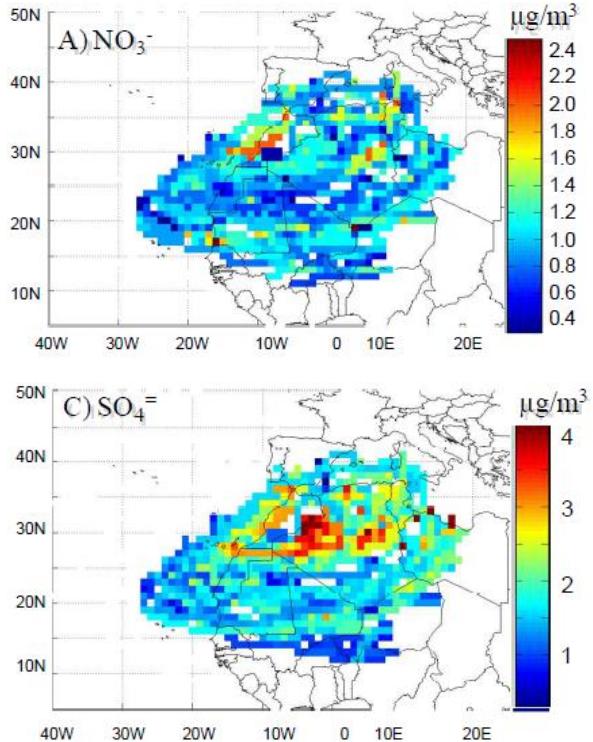
Uniform composition



PM composition during dust episodes



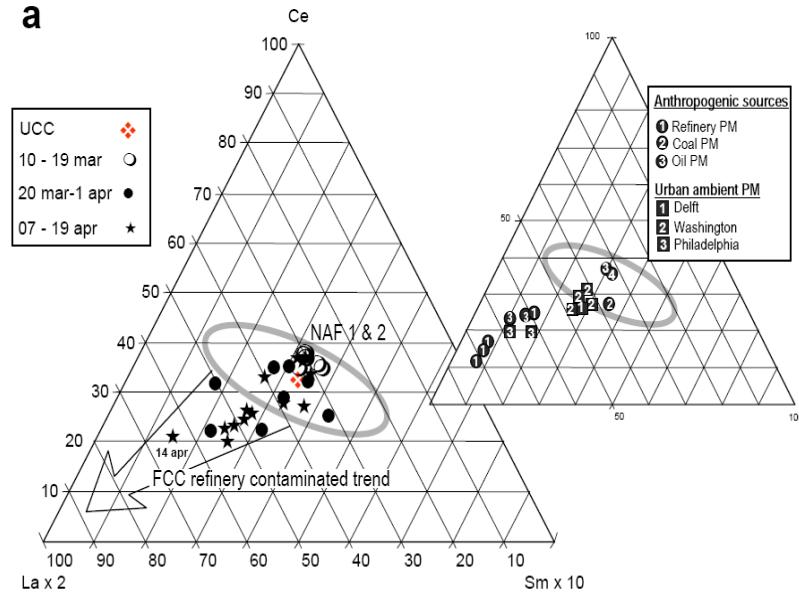
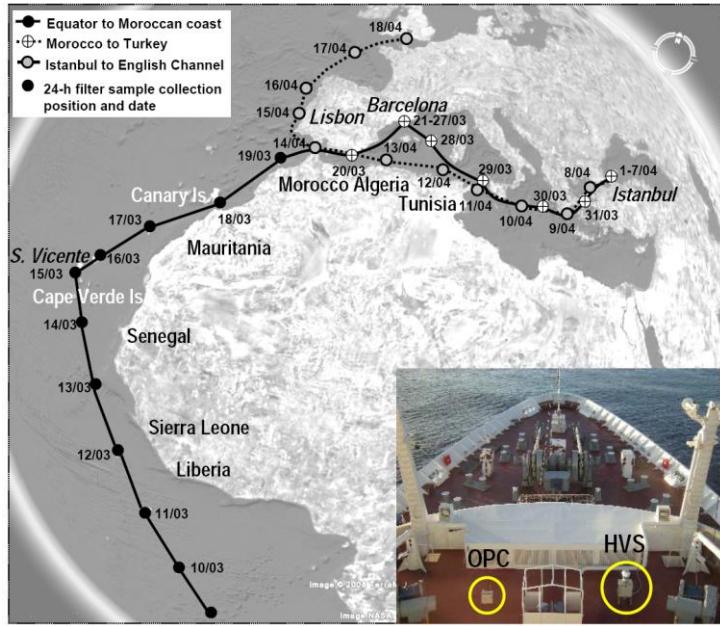
Transport of desert dust mixed with North African industrial pollutants in the subtropical Saharan Air Layer



Rodríguez, S., et al. *Atmos. Chem. Phys.*, 11, 6663–6685, 2011

PM composition during dust episodes

Interaction with anthropogenic pollution during transport
Identification of FCC refinery atmospheric pollution events
using lanthanoid- and vanadium-bearing aerosols



Moreno et al., 2008, Atmospheric Environment, 42, 7851-7861

PM composition during dust episodes

1996-1997, Fungi and bacteria from Africa
to the Caribbean with soil dust
Prospero et al.,
2005,
Aerobiologia

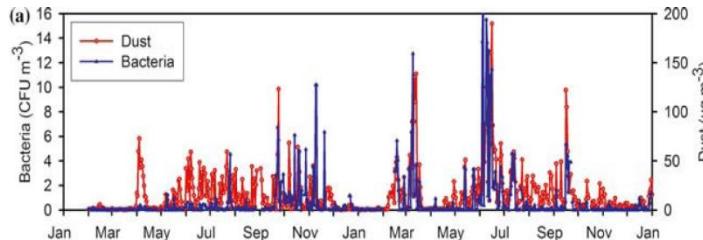
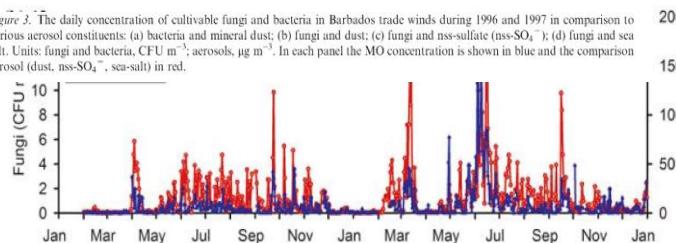


Figure 3. The daily concentration of cultivable fungi and bacteria in Barbados trade winds during 1996 and 1997 in comparison to various aerosol constituents: (a) bacteria and mineral dust; (b) fungi and dust; (c) fungi and nss-sulfate (nss-SO_4^{2-}); (d) fungi and sea salt. Units fungi and bacteria, CFU m^{-3} ; aerosols, $\mu\text{g m}^{-3}$. In each panel the MO concentration is shown in blue and the comparison aerosol (dust, nss-SO_4^{2-} , sea-salt) in red.



Microorganisms and pathogens from Africa
to the Eastern Mediterranean, 24-26/02/2006
Polymenakou P.N. et al., 2008,
Environmental Health Perspectives

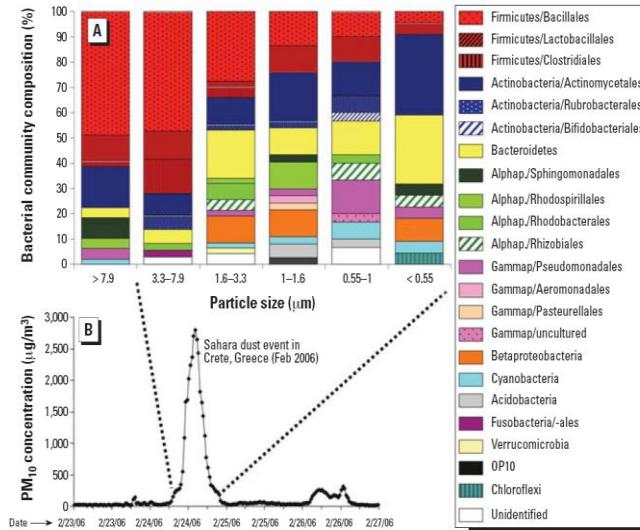
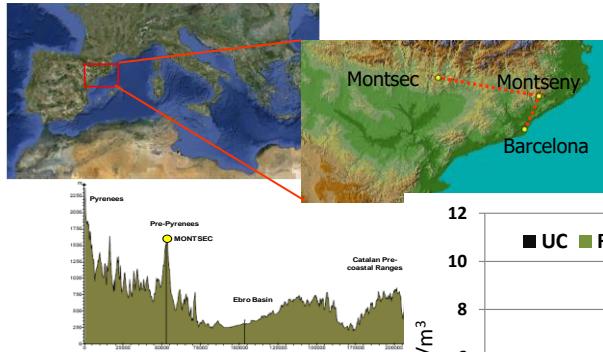


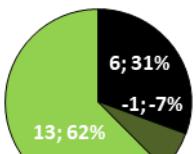
Figure 2. Analysis of dust particles from the Sahara dust event by bacterial community composition and by PM₁₀ concentration at different time points. (A) Bacterial community composition in particles of different sizes. (B) PM₁₀ concentrations during the Sahara dust event. Abbreviations: Alphap., Alphaproteobacteria; Gammap, Gammaproteobacteria.

PM composition during dust episodes

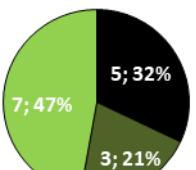


Barcelona, NE Spain 2009-2016

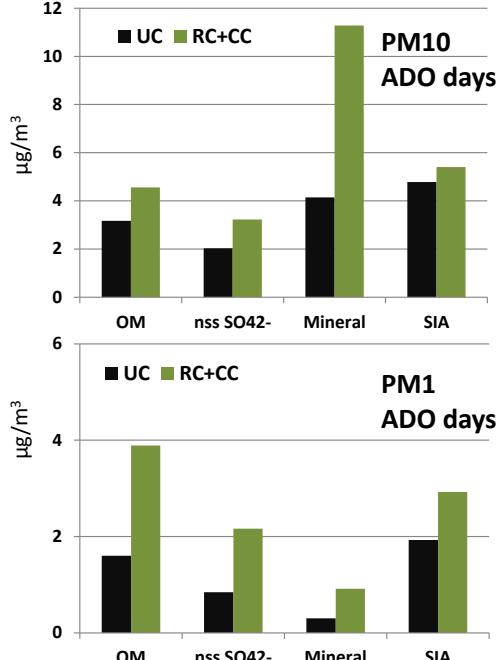
ADO-PM1-10



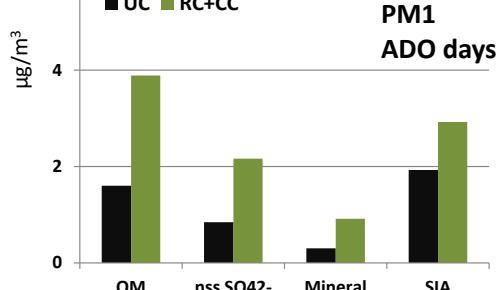
ADO-PM1



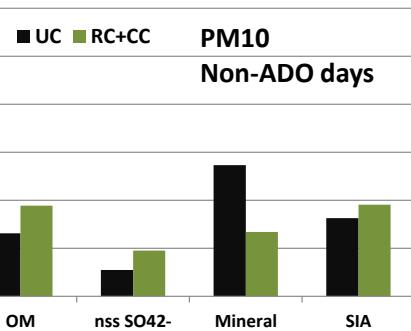
21/02/2023



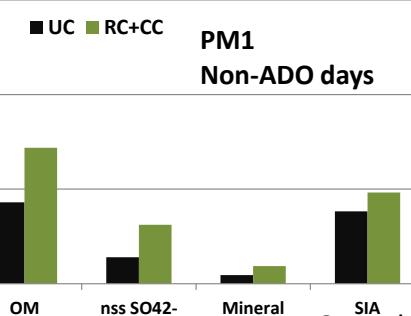
PM10
ADO days



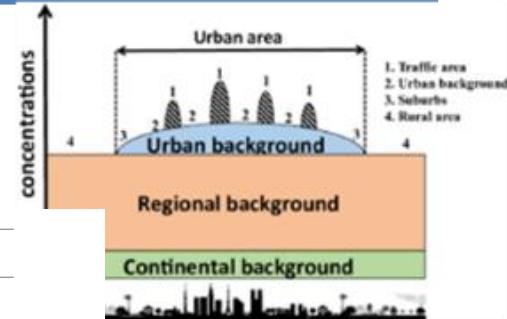
PM1
ADO days



PM10
Non-ADO days

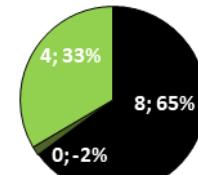


PM1
Non-ADO days

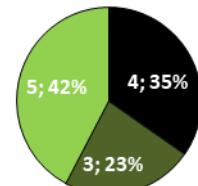


Lenschow et al., 2001. Atmos. Environ., 35 (2001), pp. 123-133

Non-ADO-PM1-10



Non-ADO-PM1



Querol et al., 2019

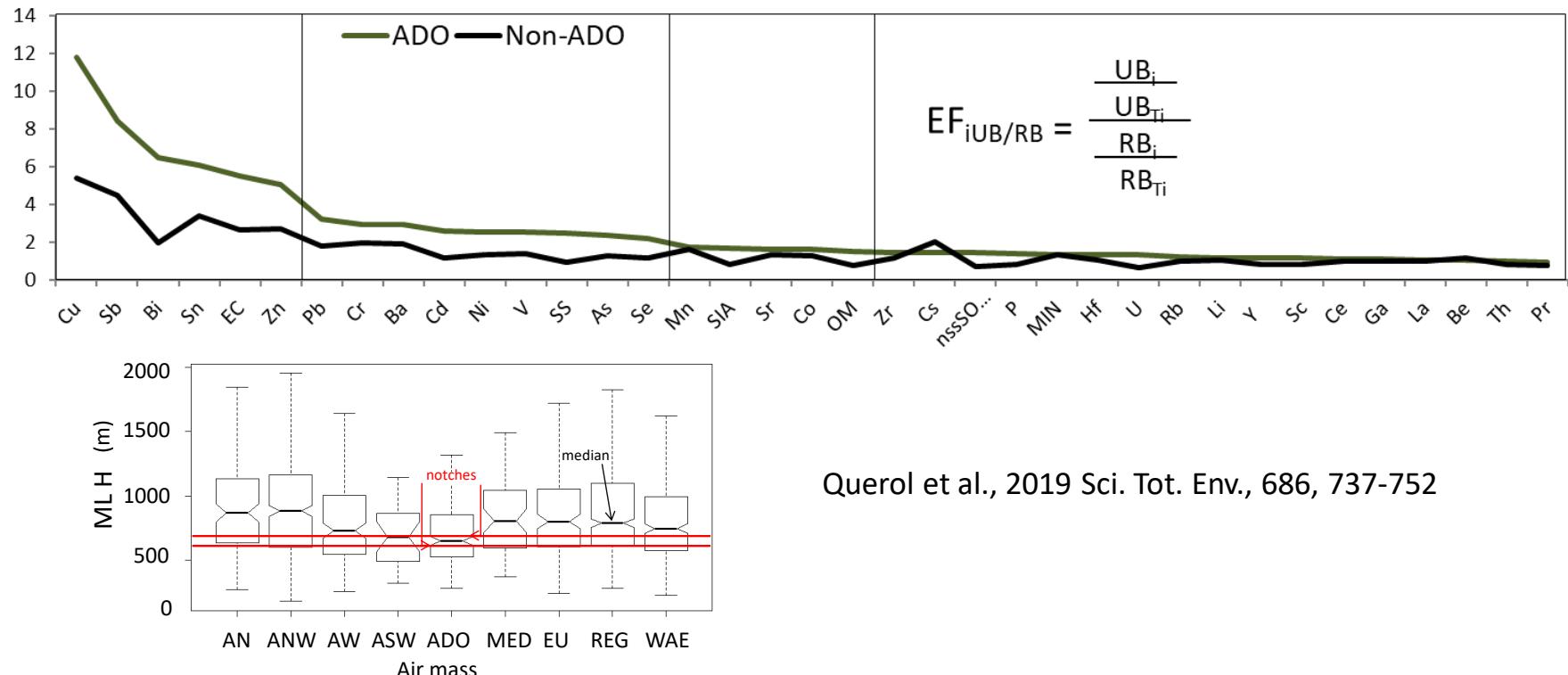
Sci. Tot. Env., 686, 737-752

Joint Training School & Workshop on Dust Aerosol

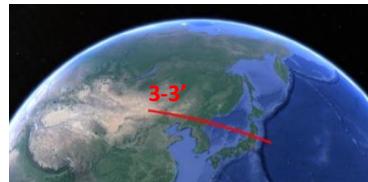
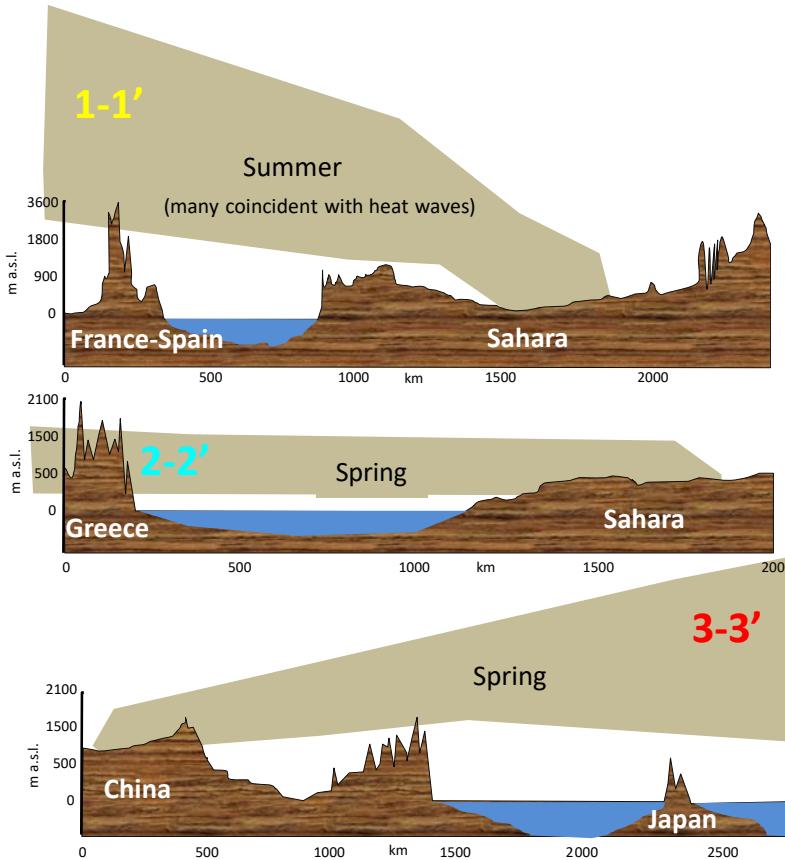
PM composition during dust episodes

Barcelona, NE Spain 2009-2016

Enrichment of PM components in the urban background compared with the regional background
during ADOs compared with non-ADOs



PM and atmospheric relevant patterns



PM and atmospheric relevant patterns

Increased PM concentrations during ADOs are caused by:

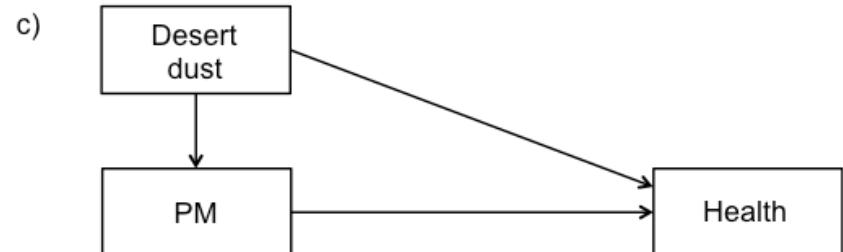
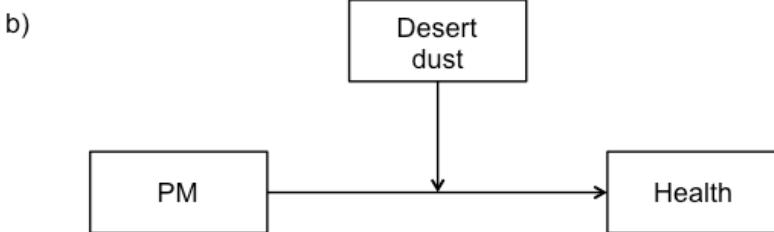
1. Obviously the transport of mineral matter from desert dust
2. The co-transport of anthropogenic pollutants with dust, both emitted at the source areas or entrained during dust transport
3. The accumulation of locally emitted anthropogenic PM pollutants by:
 - 3.1. A relatively low mixing layer height accumulate local pollutants
 - 3.2. Dust favouring the formation of secondary pollutants (such as nssSO_4^{2-})
 - 3.3. If ADOs frequency is higher in spring/summer: higher secondary PM pollutants

PM and atmospheric relevant patterns

- Patterns of PM during ADOs that might influence human health are very complex
- These might strongly vary from one region to other
- Not only PM_x levels have to be quantitatively contrasted with potential health effects
- ADOs also favour the occurrence of individual or synergistic effects that might involve:
 - Meteorology
 - Anthropogenic co-pollutants
- The impact of this complex mix of PM compounds on human health should be assessed in health assessment analysis of ADOs, if possible independently for anthropogenic and mineral dust loads
- It is not only mineral dust that matters for air quality during dust episodes

Design of epidemiology studies

- What should be monitored in dust events to evaluate health effects?
 - Dust load of PMx
 - Anthropogenic load of PMx
 - Meteorological parameters
- Dust and PM parameters to be used in epidemiological (time-series) studies
 - PMx
 - PMx (dust)
 - PMx (non-dust)



Procedure for the detection and quantification of natural dust contributions to PM

Dust-air quality evaluation system (EU)

http://ec.europa.eu/environment/air/quality/legislation/pdf/sec_2011_0208.pdf



EUROPEAN COMMISSION

Brussels, 15.02.2011
SEC(2011) 208 final

COMMISSION STAFF WORKING PAPER

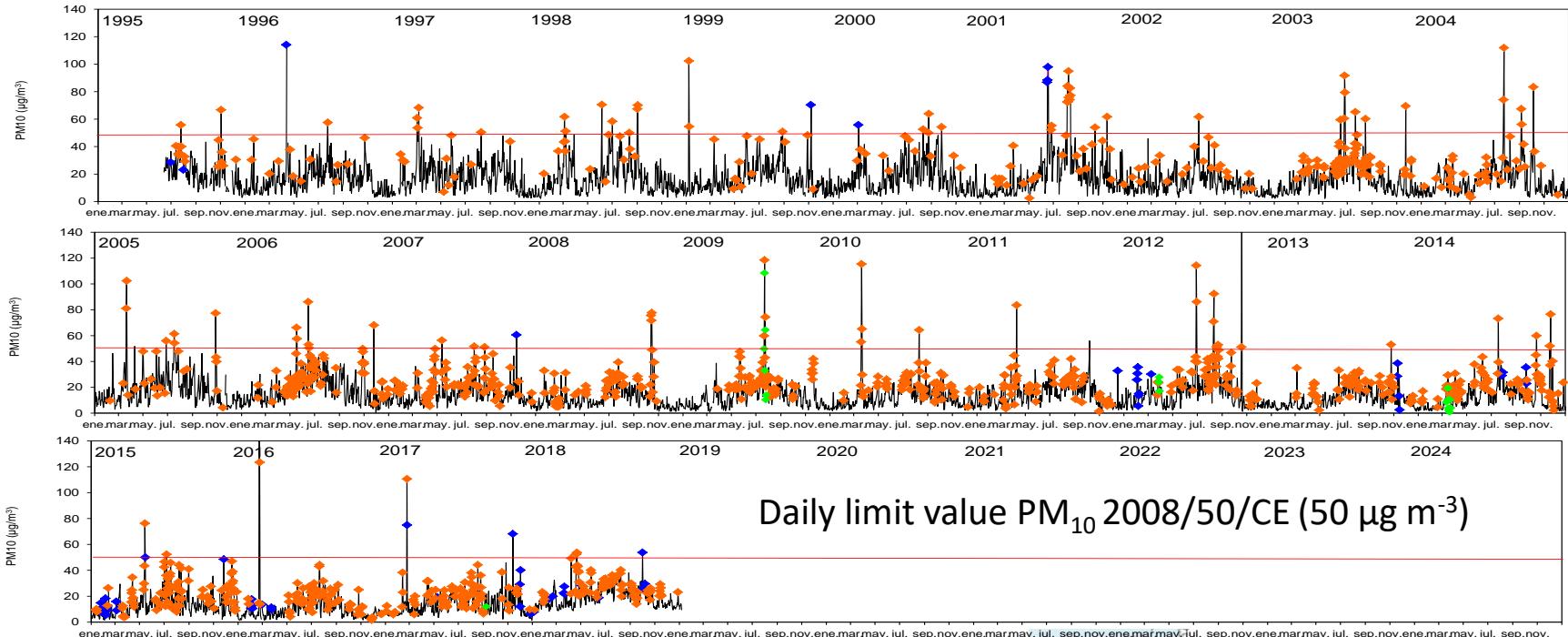
establishing guidelines for demonstration and subtraction of exceedances attributable to natural sources under the Directive 2008/50/EC on ambient air quality and cleaner air for Europe

4.1. Methodology for the determination of re-suspended and transported Saharan dust

The following describes a procedure to determine the African origin of the exceedances of the daily mean concentration of $50\mu\text{g}/\text{m}^3$. The procedure is based on a method developed in Spain and Portugal (Querol et al., 2006) for application in both countries¹⁰. It focuses on the daily limit value; discounting the contributions by re-suspended and transported natural Saharan dust episodes in the calculation of the annual average of PM_{10} may however also have a

Dust-air quality evaluation system (EU)

African dust, regional background NE Spain



87 out of 96 exceedances registered in 21.5 years are caused by African dust outbreaks



- ◆ African dust outbreaks
 - ◆ Local dust from Monegros
 - ◆ Forest fires 30

Dust-air quality evaluation system (EU)

The percentile method

AFRICAN DUST, IDENTIFICATION OF EPISODES

Modelling
Aerosol maps

Backtrajectories

Satellite

+

Evaluation of PM concentrations at RB sites

YES

NO

QUANTIFICATION OF DAILY CONTRIBUTIONS TO PM_x

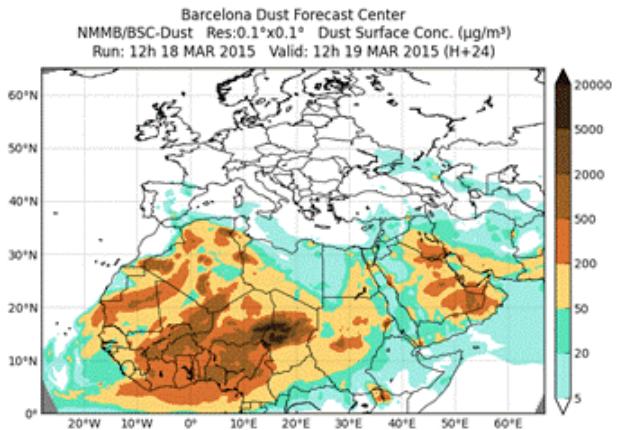
Dust-air quality evaluation system (EU)

1. Reporting on the detection of episodes and measurement PM10 levels in EMEP-type sites:
 - 1.1. Model outputs, meteo and satellite imagery tools
 - 1.2. Daily evaluation of PM ambient concentrations recorded in a specific regional background monitoring network made of around 25 remote monitoring sites (Spain and Portugal)
 - 1.3. Reporting on detected episodes and daily levels of PM10 for each station of the regional background network
 - 1.4. Three months after the end of the year, a report to scientifically support the occurrence of each episode included in the list

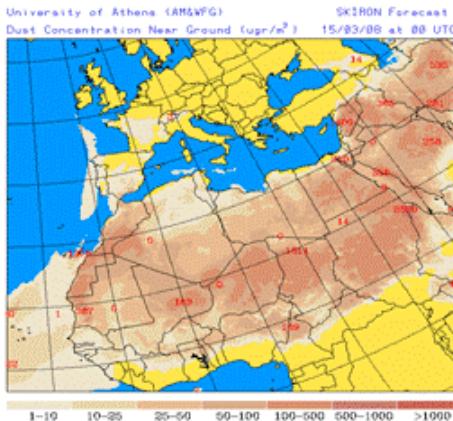
Dust-air quality evaluation system (EU)

Identification of Saharan dust outbreaks

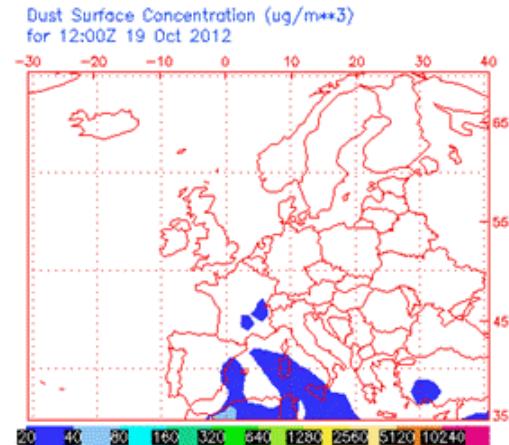
MMMB-BSC-
dust



SKIRON
simulations



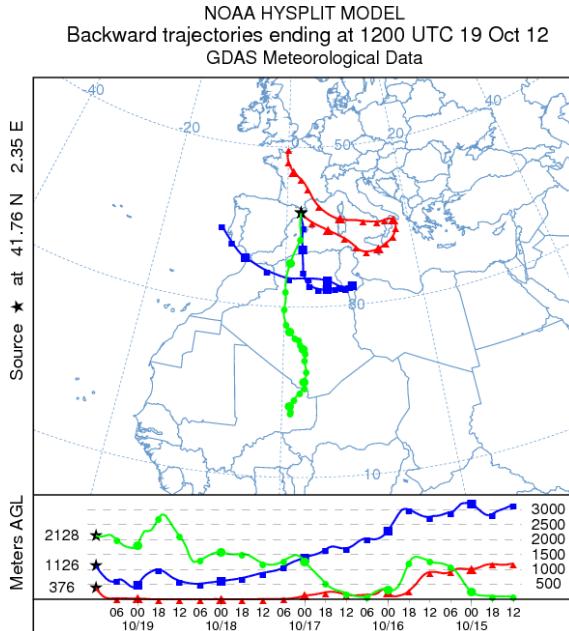
NAAPS - NRL



Dust-air quality evaluation system (EU)

Identification of Saharan dust outbreaks HYSPLIT back-trajectories

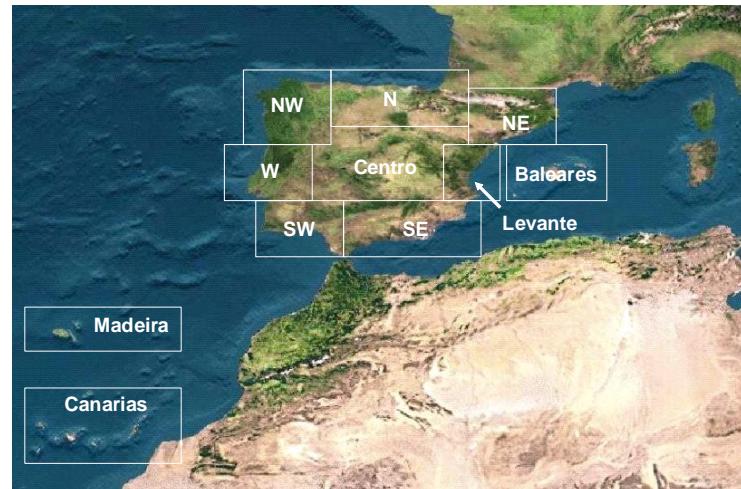
Calculated for 120 hours at 3 heights: 750, 1500 and 2500 m a.s.l.



Dust-air quality evaluation system (EU)

Reporting on episodes

Impact on surface PMx concentrations: experimental



Dust-air quality evaluation system (EU)



Dirección General de
Calidad y Evaluación
Ambiental

Reporting on episodes

ENERO 2008

ENERO 2008									
	CANARIAS	SUROESTE	SURESTE	LEVANTE	CENTRO	NOROESTE	NORTE	NORESTE	BALEARES
COMBUSTIÓN BIOMASA									
EUROPEO SULFATOS									
AFRICANOS	19-29	23	23	22-23	22-24	22-23	22-24	22-24	22-23

FEBRERO 2008

FEBRERO 2008									
	CANARIAS	SUROESTE	SURESTE	LEVANTE	CENTRO	NOROESTE	NORTE	NORESTE	BALEARES
COMBUSTIÓN BIOMASA									
EUROPEO SULFATOS									
AFRICANOS	6-12 21-23 27-29	12-19 22-28	13-20 22-28	14-20 24-29	14-17 26-27	14-17 23-26	15-17 24-26	15-17 24-29	14-16 19-20 24-29

MAYO 2008

MAYO 2008									
	CANARIAS	SUROESTE	SURESTE	LEVANTE	CENTRO	NOROESTE	NORTE	NORESTE	BALEARES
COMBUSTIÓN BIOMASA									
EUROPEO SULFATOS									
AFRICANOS		2-6	2-6	3-6	2-6	3-6	3-6	2-6	2-6

MARZO 2008

MARZO 2008									
	CANARIAS	SUROESTE	SURESTE	LEVANTE	CENTRO	NOROESTE	NORTE	NORESTE	BALEARES
COMBUSTIÓN BIOMASA									
EUROPEO SULFATOS									
AFRICANOS	5 13-16	2-3 15	1-3 14-16	1-3 14-15	14-15			15	1-3

ABRIL 2008

ABRIL 2008									
	CANARIAS	SUROESTE	SURESTE	LEVANTE	CENTRO	NOROESTE	NORTE	NORESTE	BALEARES
COMBUSTIÓN BIOMASA									
EUROPEO SULFATOS									
AFRICANOS	2-5 14-15 24-29	7 16-17	7 16	7 16	7 16	7 16	16	16-17 27-28	16-17 28

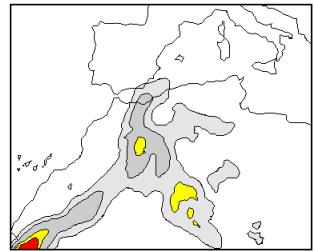
MAYO 2008

MAYO 2008									
	CANARIAS	SUROESTE	SURESTE	LEVANTE	CENTRO	NOROESTE	NORTE	NORESTE	BALEARES
COMBUSTIÓN BIOMASA									
EUROPEO SULFATOS									
AFRICANOS		2-6	2-6	3-6	2-6	3-6	3-6	2-6	2-6

Dust-air quality evaluation system (EU)

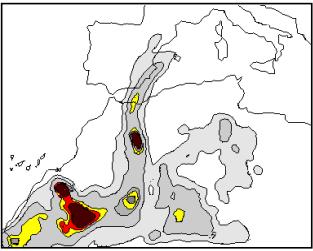
Example of detection and support information in reporting

21-Jan'97



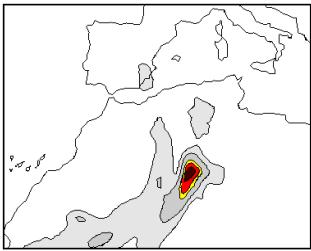
00:00 UTC 21 January 1997

22-Jan'97

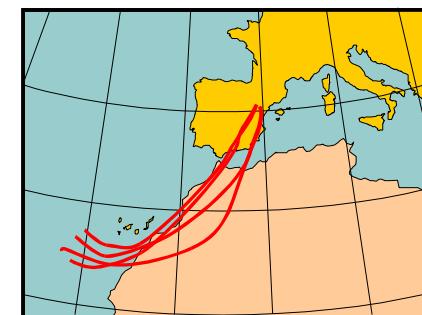
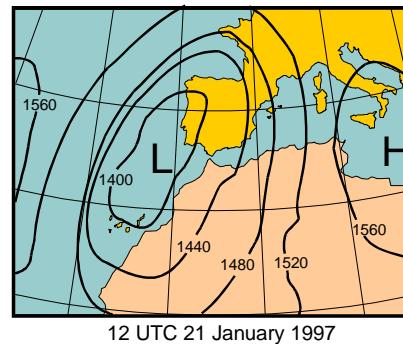
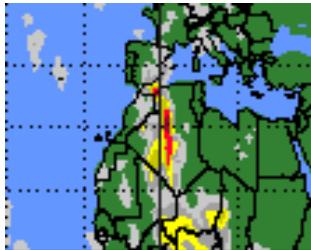
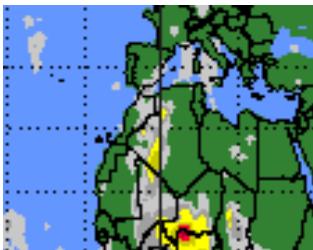
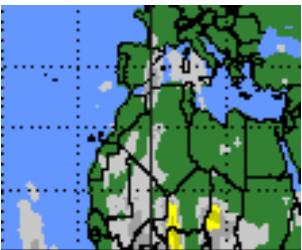


18:00 UTC 22 January 1997

23-Jan'97

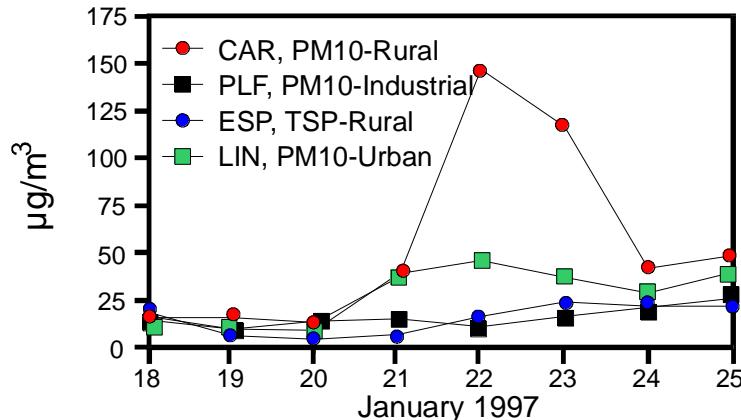
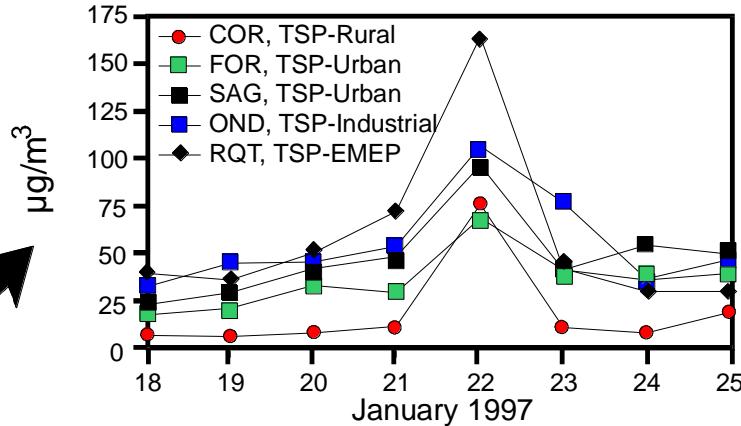
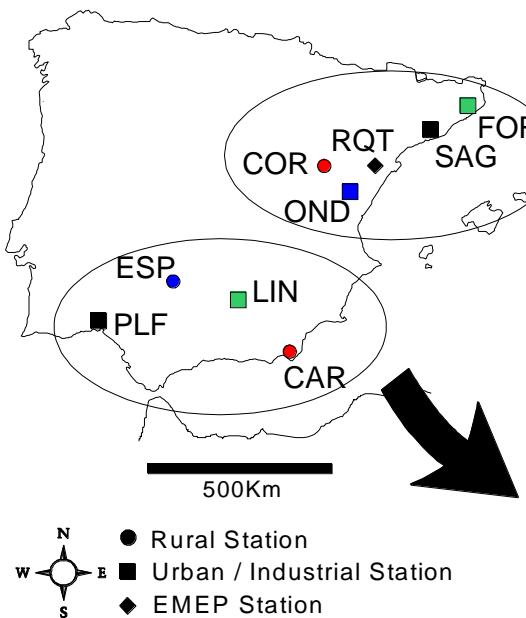


06:00 UTC 23 January 1997



Dust-air quality evaluation system (EU)

Reporting on episodes



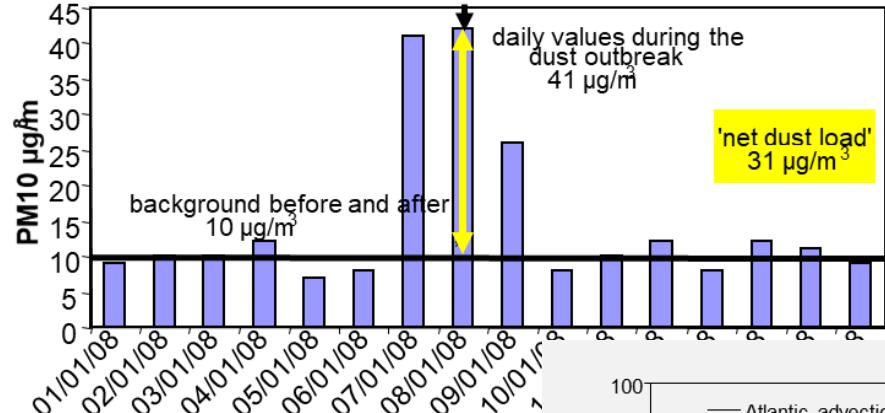
Dust-air quality evaluation system (EU)

The quantitative approach

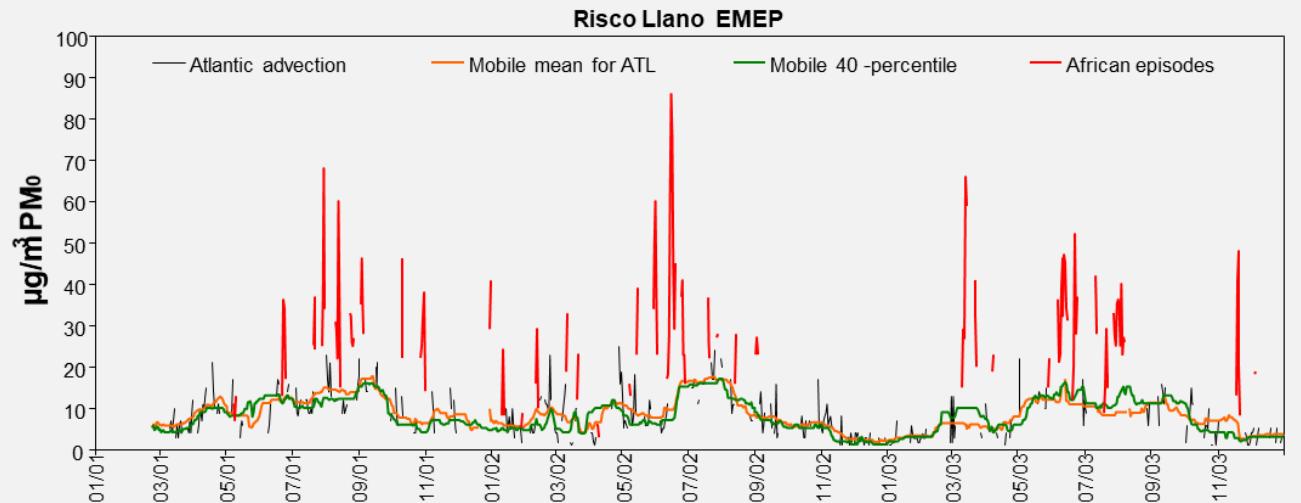
Procedure for the quantification of natural contribution to ambient levels of PM

2. Determining the natural contribution 'net dust load' for each day of the list of African episodes
 - 2.1. Local-regional PM₁₀ contribution (LRC, without African origin) determined to be subtracted to the bulk PM₁₀ levels during the episode
 - 2.2. LRC daily calculated from monthly mobile 40 percentile (centring the considered day in the middle of the month period) of the PM₁₀ levels excluding the African days
 - 2.3. Then 'net dust load' for a given day with African dust influence in one regional background station is determined: PM₁₀-LRC
 - 2.4. A list of 'net dust load' values for each day and regional background station is produced to be used to subtract the natural dust contribution to PM₁₀ during days with exceedances of the DLV recorded at the AQ monitoring sites close to this specific regional background station.
The list is produced by the Ministries of the Environment from Portugal and Spain

Dust-air quality evaluation system (EU)



The quantitative approach



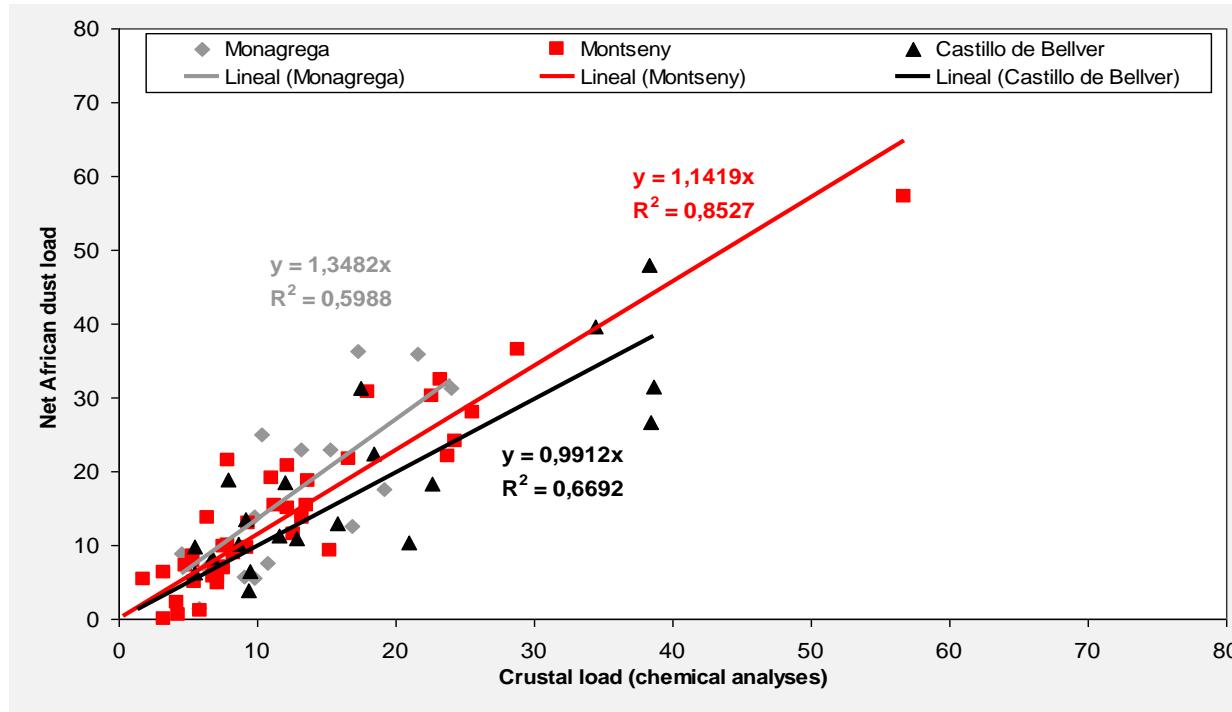
Dust-air quality evaluation system (EU)

Quantification of Saharan dust

A	B	C	D	E	F	G	H	I	J	K	L	M
	España FR Bellver	España EMEP Mahón	SIN NAF Bellver	SIN NAF Mahón			PERC 40 Bellver	PERC 40 Mahón		Belver Descuentos	Mahón Descuentos	N
3836	01/07/2011	22	15	22	15		17	14				
3837	02/07/2011	15	11	15	11		17	14				
3838	03/07/2011	20	16				17	14		3	2	
3839	04/07/2011	32	20				17	14		15	6	
3840	05/07/2011	22	15	22	15		17	14				
3841	06/07/2011	26	16	26	16		17	14				
3842	07/07/2011	22	21	22	21		17	14				
3843	08/07/2011	28	19	28	19		16	14				
3844	09/07/2011	26	16	26	16		16	14				
3845	10/07/2011	22	20				15	13		7	7	
3846	11/07/2011	31	25				15	13		16	12	
3847	12/07/2011	45	26				15	13		30	13	
3848	13/07/2011	24	17				14	13		10	4	
3849	14/07/2011	17	17	17	17		13	13				
3850	15/07/2011	17	10	17	10		13	11				
3851	16/07/2011	13	11	13	11		13	11				
3852	17/07/2011	21	14	21	14		13	10				
3853	18/07/2011	17	14	17	14		13	11				
3854	19/07/2011	20	19	20	19		13	11				
3855	20/07/2011	11	13	11	13		13	10				
3856	21/07/2011	13	9	13	9		13	10				
3857	22/07/2011	13	13	13	13		13	10				
3858	23/07/2011	14	14	14	14		13	10				
3859	24/07/2011	13	15	13	15		12	10				
3860	25/07/2011	11	10	11	10		12	10				

Dust-air quality evaluation system (EU)

Validation of the procedure by chemical analysis of PM10



Dust-air quality evaluation system (EU)

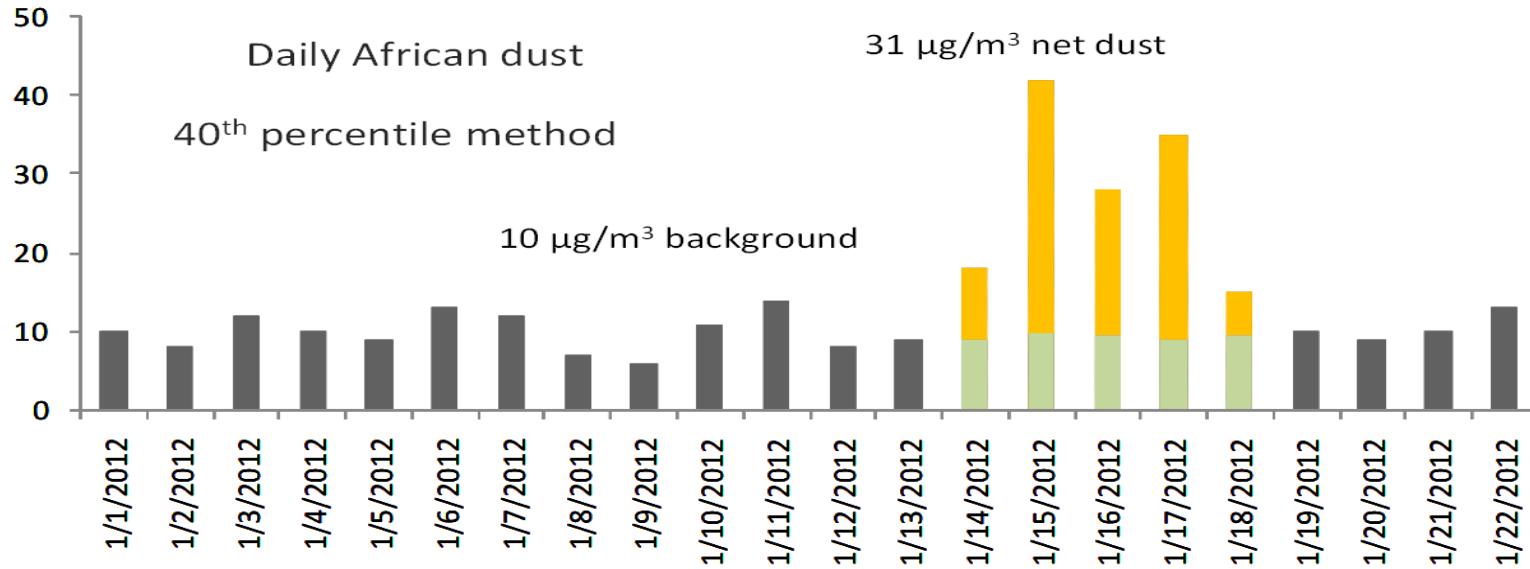
The quantitative approach

Determining the anthropogenic and natural contributions to PM in an urban site

3. **The AQ monitoring networks** compile a list of dates with exceedances of the DLV coinciding with the African dust outbreaks from the report by the **Ministry of the Environment**.
4. The ‘net PM₁₀ dust contribution’ for the closest regional background site is subtracted from the PM₁₀ levels of list produced in task 3 to discount the natural contribution
5. If after subtraction, the PM₁₀ levels are < DLV (50 µg/m³) then the exceedance will be attributed to the natural contribution, otherwise will be attributed to anthropogenic causes
6. PM10 levels of the days where the exceedances was attributed to natural contributions are not included in the annual average.
7. The AQ monitoring networks reports on:
 - 7.1. Mean average and total number of exceedances
 - 7.2. List of exceedances attributed to natural contributions (exceedances are not deleted!!!)
 - 7.3. Calculated dust contribution to the annual mean (from the difference of the annual mean-annual mean with the subtractions of the calculated daily net dust loads).

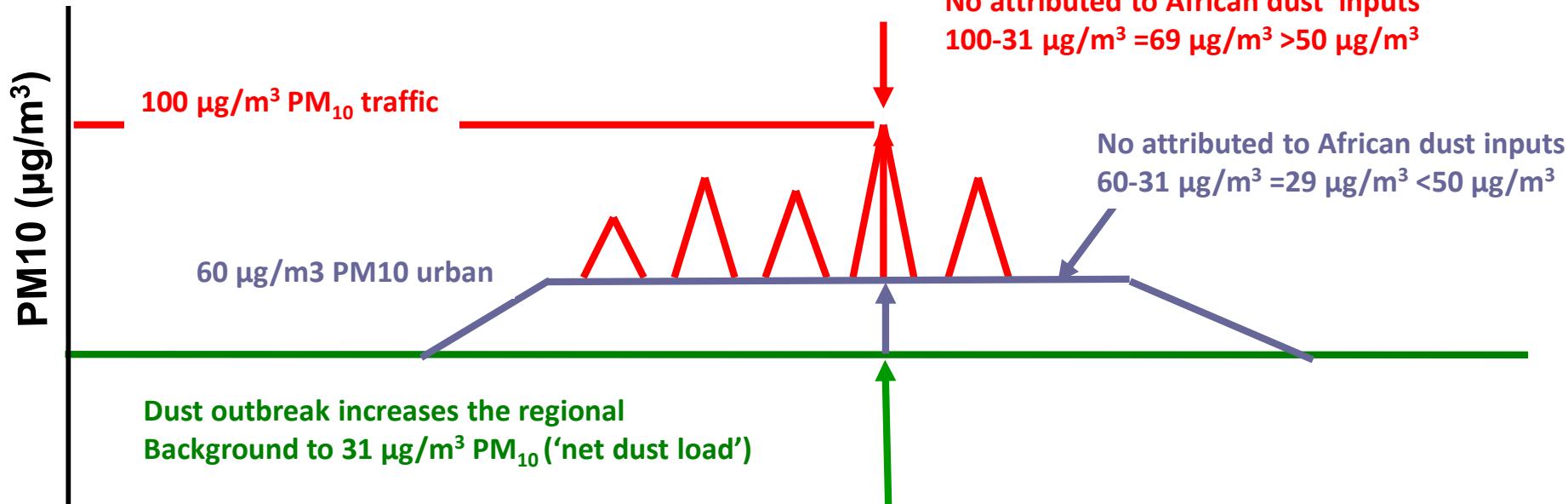
Dust-air quality evaluation system (EU)

Determining the anthropogenic and natural contributions to PM at an urban site



Dust-air quality evaluation system (EU)

Determining the anthropogenic and natural contributions to PM in an urban site

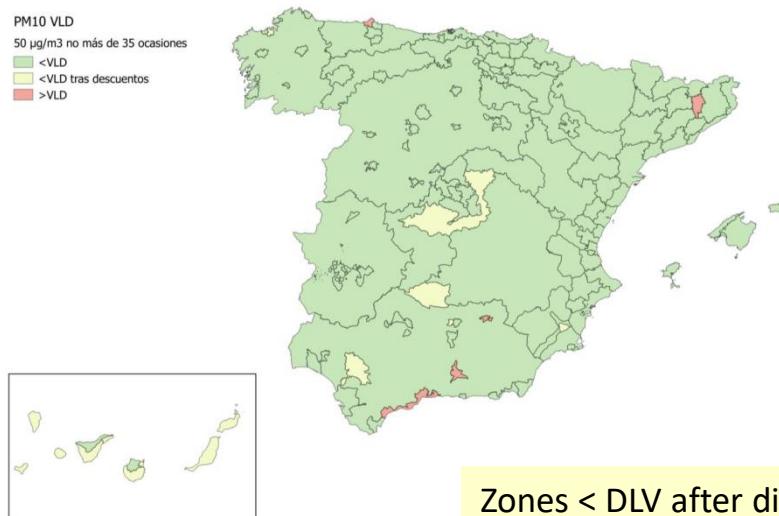


Examples of applications

Dust contribution in Spain: exceedances of the DLV

2017: zones exceeding the daily limit value - DLV

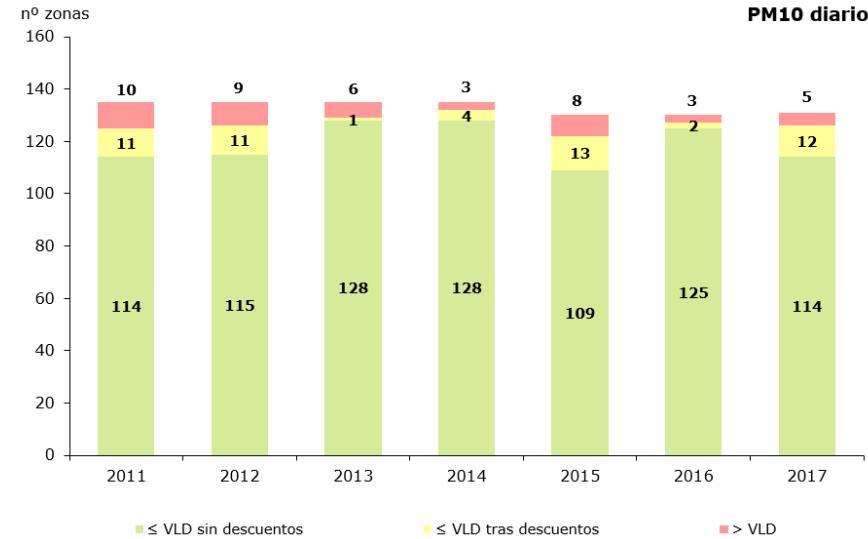
PM10 VLD
50 µg/m³ no más de 35 ocasiones
■ <VLD
■ <VLD tras descuentos
■ >VLD



Zones >DLV 2017

- Granada y Área Metropolitana
- Málaga y Costa del Sol
- Zona Villanueva del Arzobispo
- Avilés
- Plana de Vic

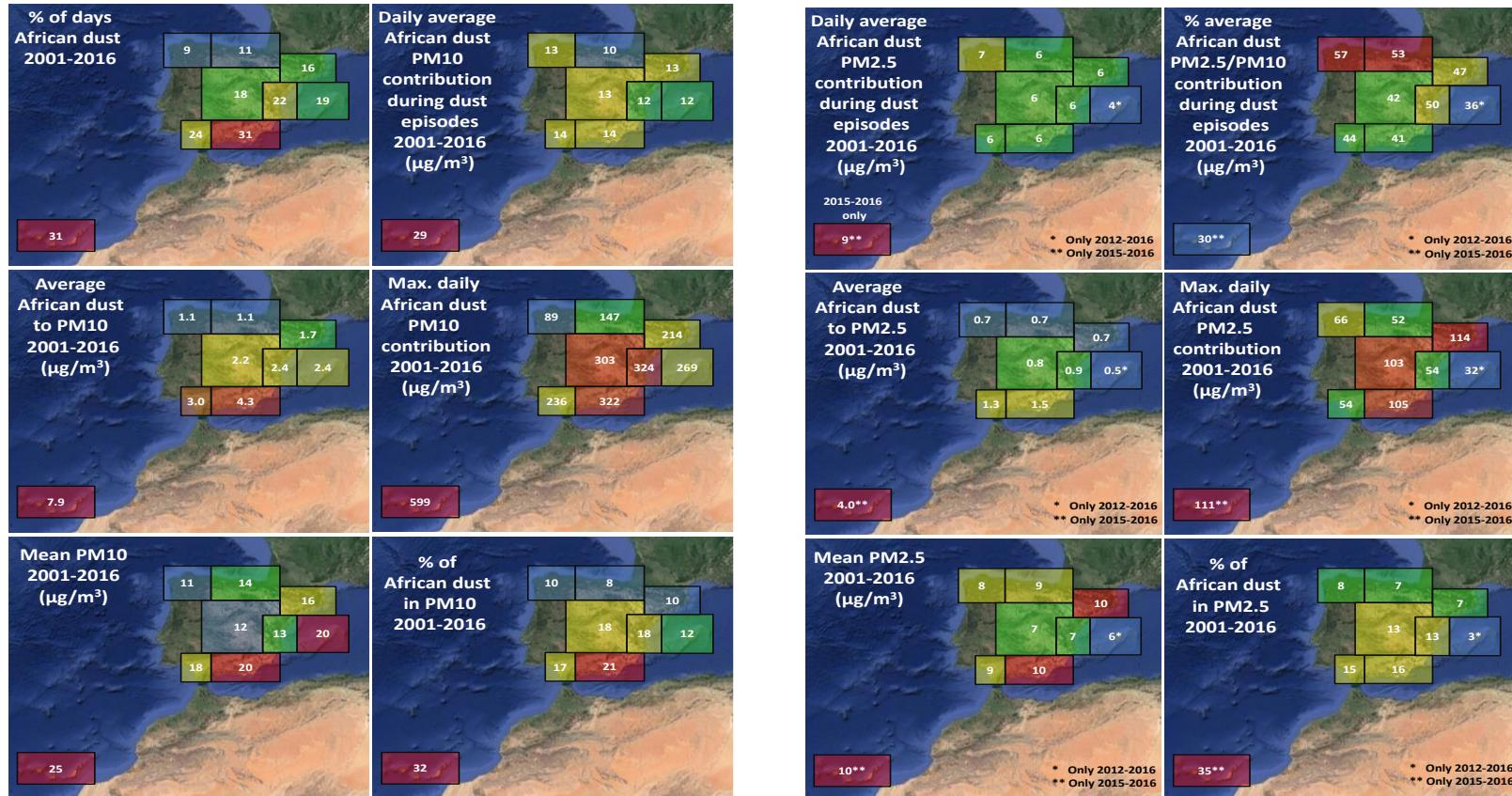
- Zones < DLV after discounting of net dust
- Islas Canarias (5 zonas)
 - Zona industrial Bailén
 - Nueva zona Sevilla y Área Metropolitana
 - Comarca de Puertollano
 - Zona industrial del Norte
 - A Coruña + Área Metropolitana
 - Ciudad de Murcia



Evaluación de la calidad del aire en España 2017



Dust contribution in Spain: 2001-2016



Querol et al., 2019 Sci. Tot. Env., 686, 737-752

Dust contribution in Spain: 2001-2016

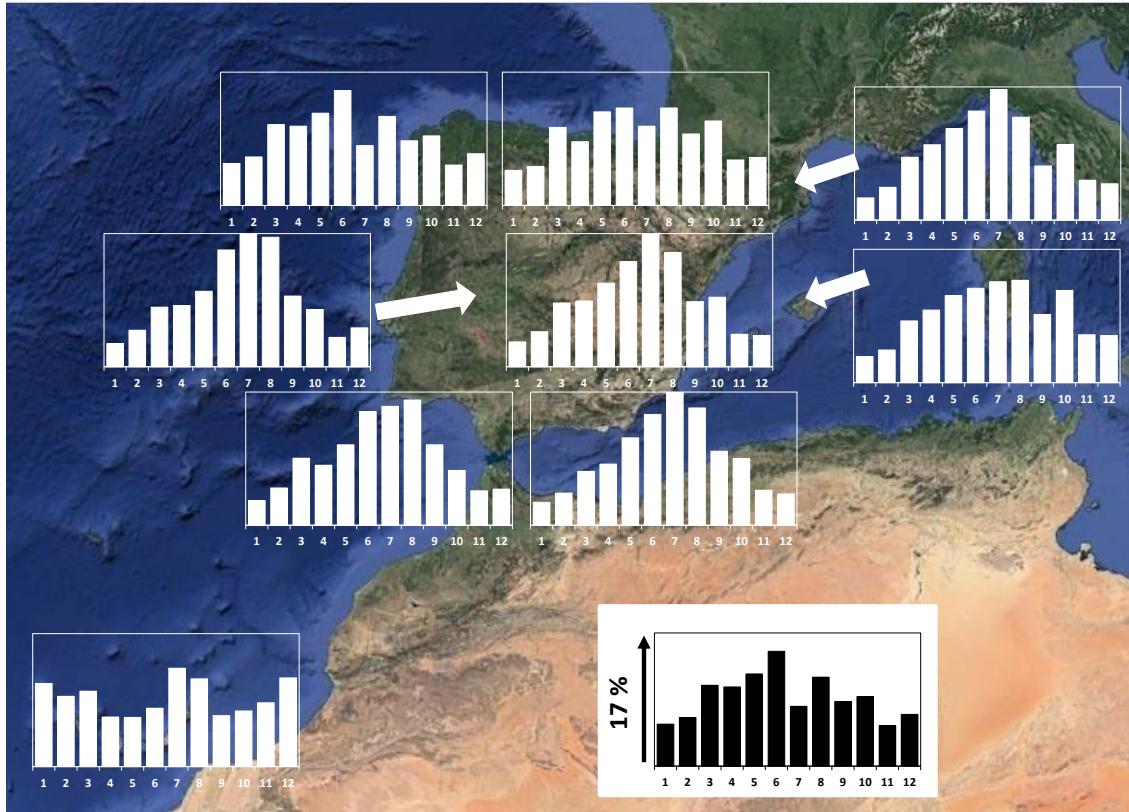
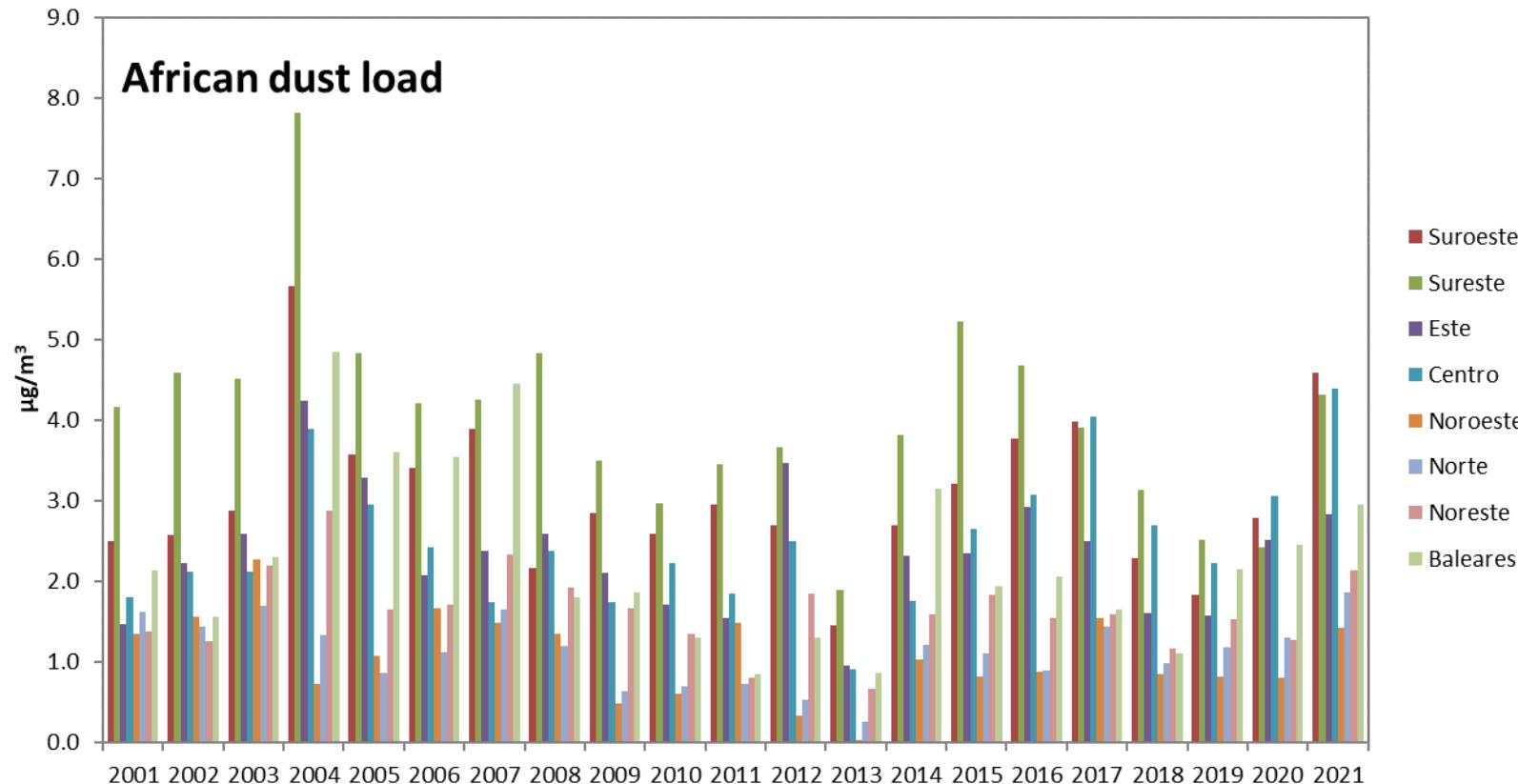


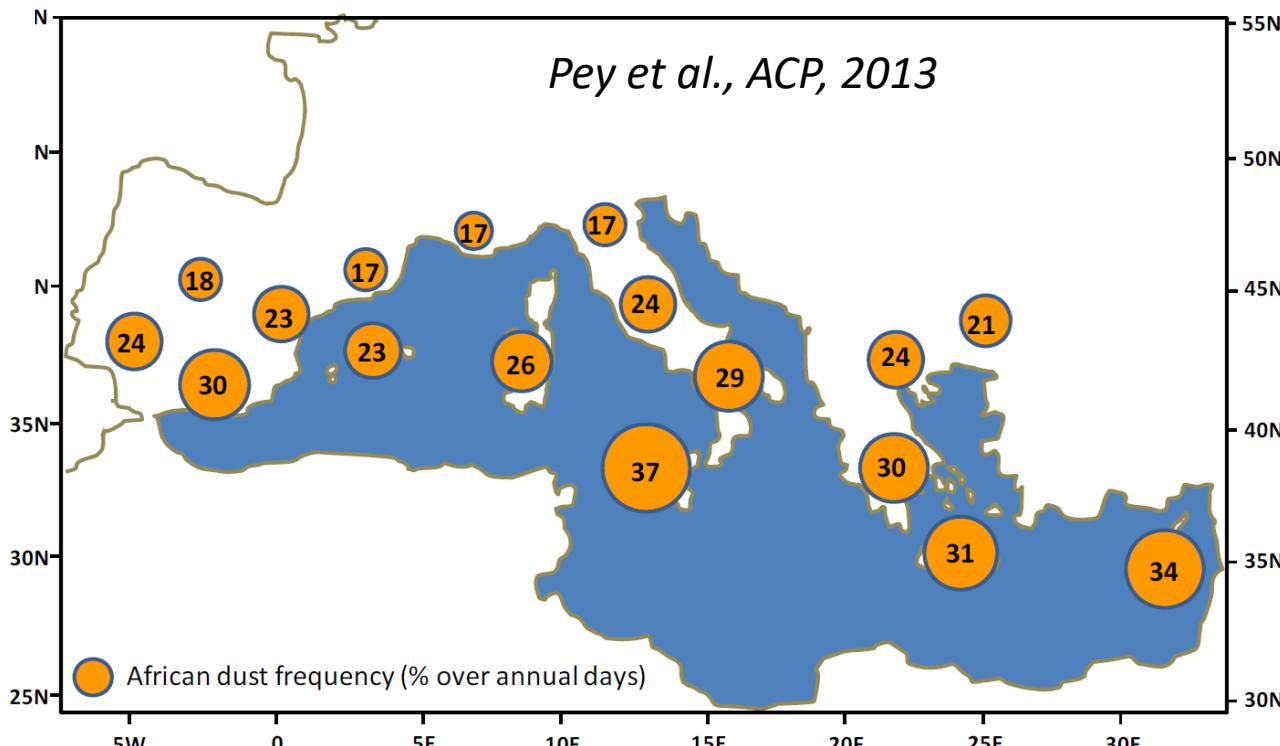
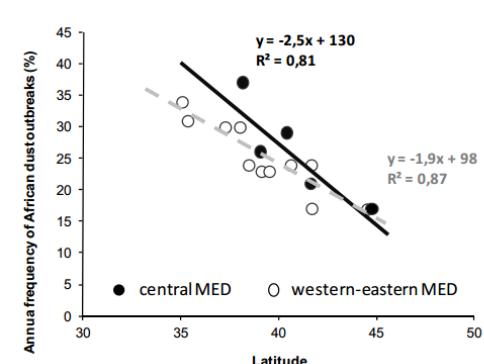
Figure 4. Percent seasonal average occurrence of ADOs over Spain for the period 2001-2016.

Querol et al., 2019 Stoten, 686, 737-752

Dust contribution in Spain: 2001-2016

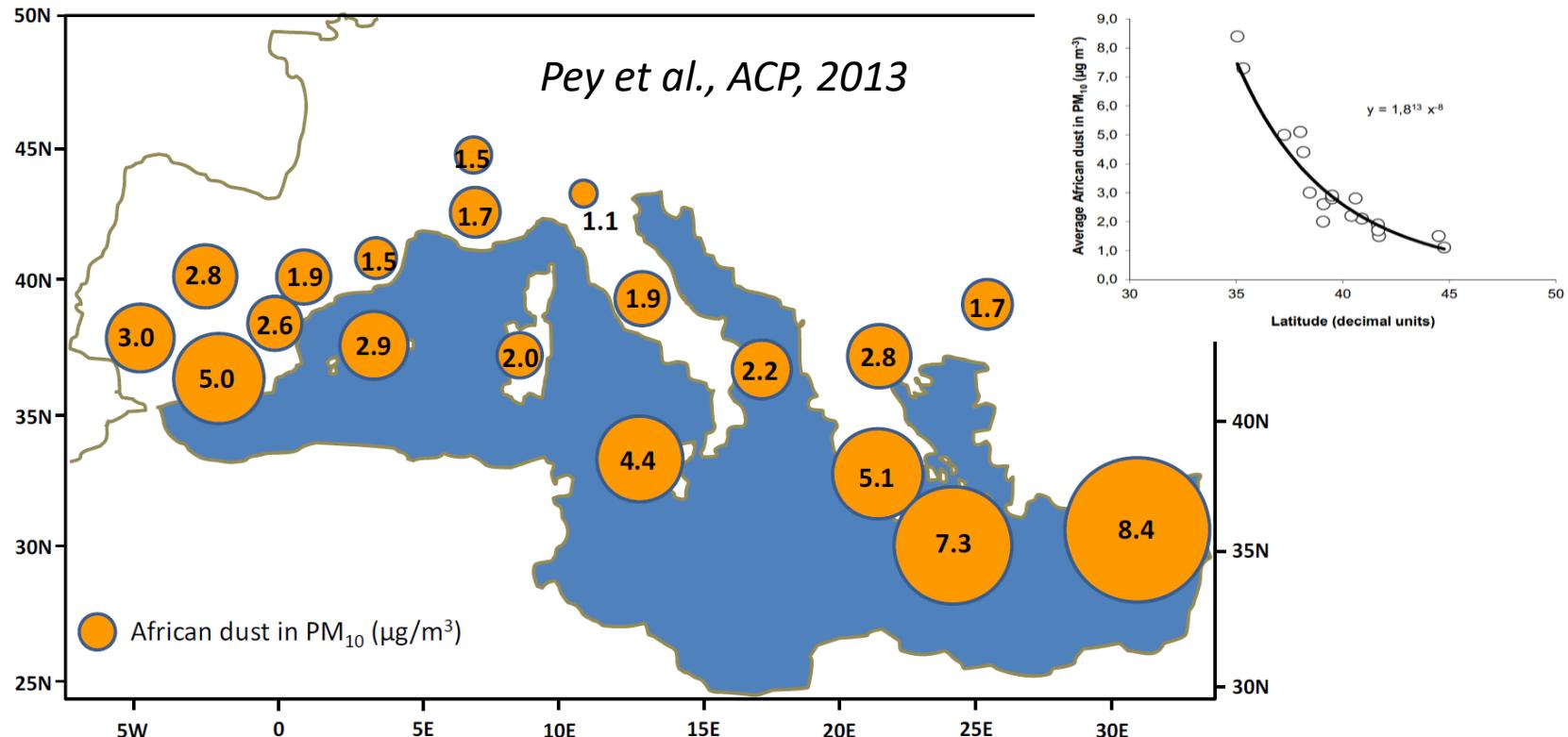


Dust contribution in the Mediterranean



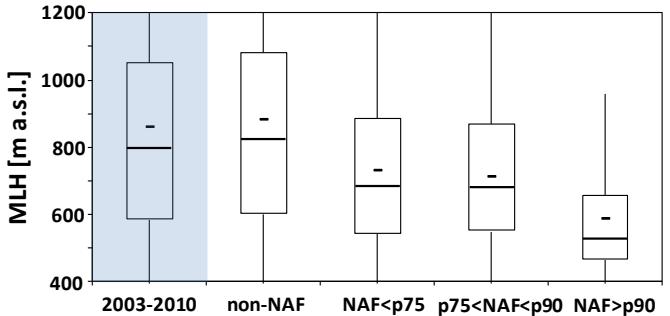
Dust contribution in the Mediterranean

African dust contribution to PM₁₀ in REGIONAL BACKGROUND sites



Examples of applications: Effects on MLH

BARCELONA 2003 – 2010: 2513 MLH days from radiosounding at 12:00 UTC

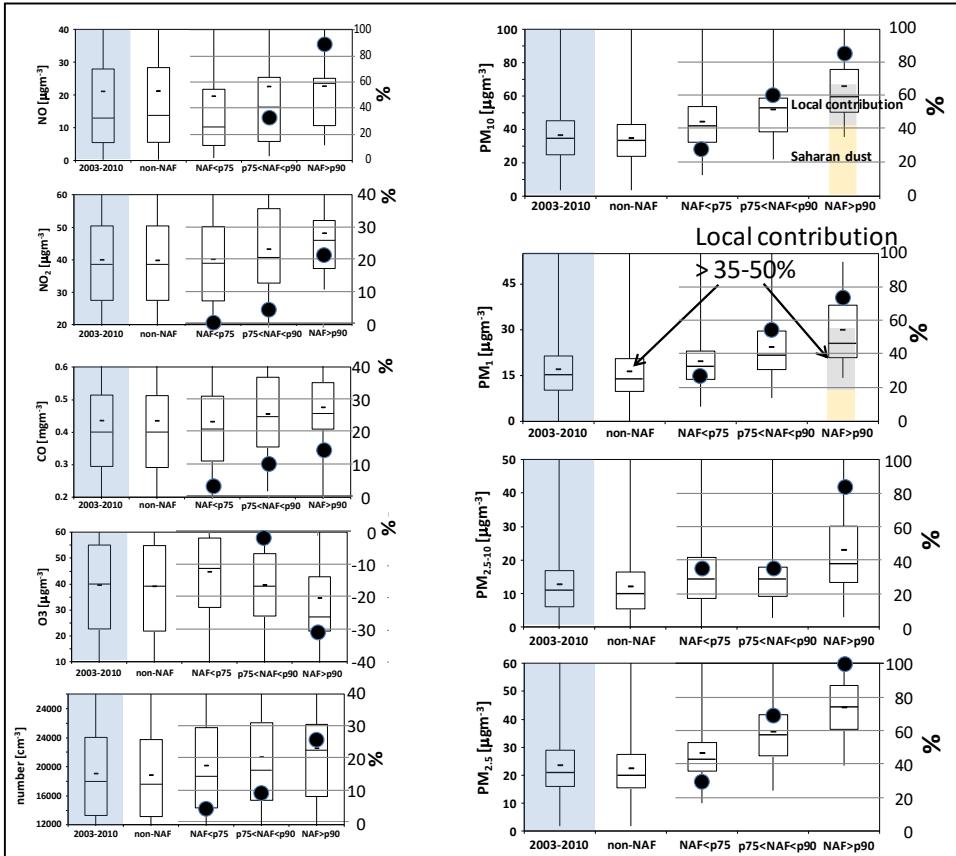


Effects of Saharan dust outbreaks on the Mixing layer Height (MLH)

Effects of MLH oscillation on air quality during Saharan dust outbreaks

- Effects depend on intensity of ADO
- MLH thinning favored the accumulation of pollutants
- Locally generated/formed PM₁ particles markedly increased during NAF > p90 in Barcelona

M. Pandolfi et al., 2014 STOTEN 494–495, 283–289

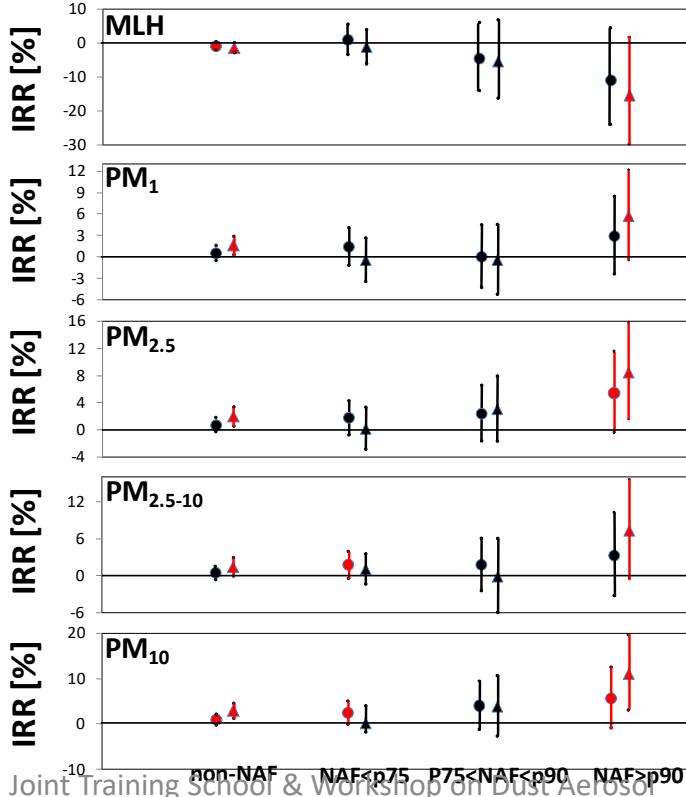


Examples of applications: effects on health

BARCELONA 2003 – 2010

Effect of MLH oscillations on health during Saharan dust outbreaks

- 2003 - 2010
- ▲ 2003 - 2007



Pandolfi et al., 2014, STOTEN

Concluding remarks

- EC Guidelines in natural dust: is a conservative method (tends to underestimate the natural contribution), relatively easy to apply, and based on real PM time series recorded at AQ networks
- Permits to obtain information on spatial and temporal variation of ADOs impact on PM by using and harmonized and comparable method
- High spatial and vertical variability of dust outbreaks: selection of regional background site is crucial
- Quantification based on regional background sites: minimizes the interference of secondary / local pollutants formed in UB during ADOs

Thank you!

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noemi.perez@idaea.csic.es

xavier.querol@idaea.csic.es

21/02/2023

Fotografía: Alfons Puertas, Observatori Fabra

Acknowledgements

Ministry of the Environment of Spain
Joint Training School & Workshop on
Dust Aerosol



GOBIERNO
DE ESPAÑA
MINISTERIO
PARA LA TRANSICIÓN ECOLÓGICA