inDust EXPERTS MEETING ON DUST EXPOSURE PRODUCTS AND HEALTH EFFECTS

QUANTIFYING THE SAHARAN DUST CONTRIBUTION TO PM_{10} LEVELS: SOME PROPOSED MODIFICATIONS TO THE CURRENT EUROPEAN COMMISSION GUIDELINES FROM THE EC-LIFE+ DIAPASON PROJECT EXPERIENCE IN ITALY

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Desert dust contribution to PM10 loads in Italy: Methods and recommendations addressing the relevant European Commission Guidelines in support to the Air Quality Directive 2008/50

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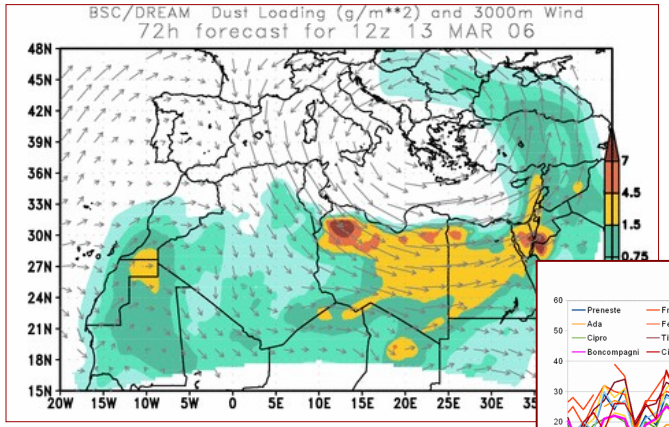
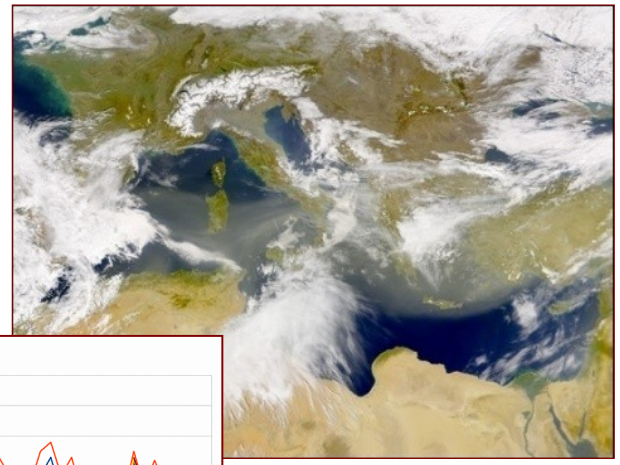
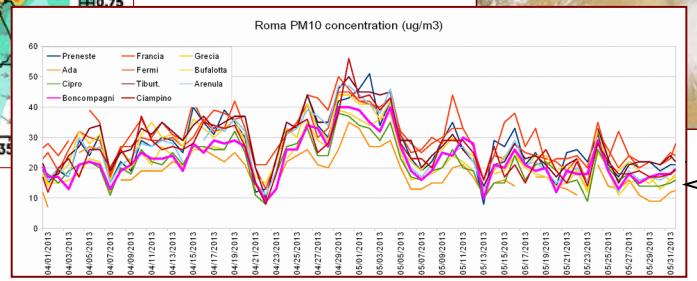
Barnaba et al., Atm. Env., 2017

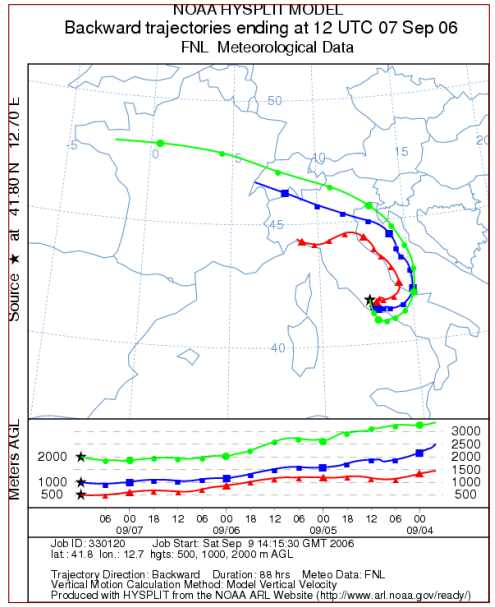
The **EC legislation allows for subtraction of natural aerosol contributions to PM_{10} concentrations** in urban air after assessing their origin and amount. The Methodology to implement such an assessment, largely based on the work by Escudero et al. (2007) and follow up on the basis of the Spanish experience, is given in specific **EC Guidelines (EC, 2011)** on the quantification of the contribution of natural sources under the Directive 2008/50/EC.

The EC Guidelines require visual inspection of **back-trajectories**, **dust model forecasts** and **satellite observations** to select/flag 'dust days'









and couple this information to **ground PM_{10} data** to **estimate the dust content**

The quantitative estimation of the dust load also:

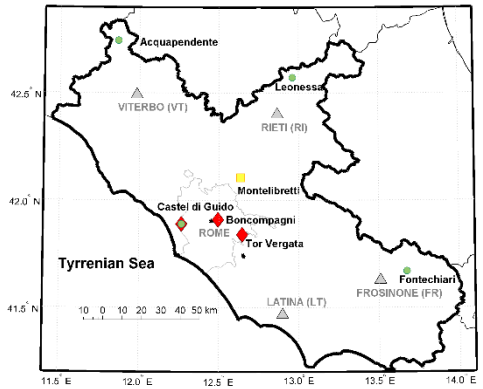
- **Requires selection of a Regional Background site for a given area**
- **Is obtained through direct comparison of the PM10 values 'in dust' with those recorded in an 'out-of-dust' reference (background) period of ±15 days ($PM10_{dust}$ = ΔPM = $PM10_{dustday}$ - $PM10_{nodustbackground}$)**

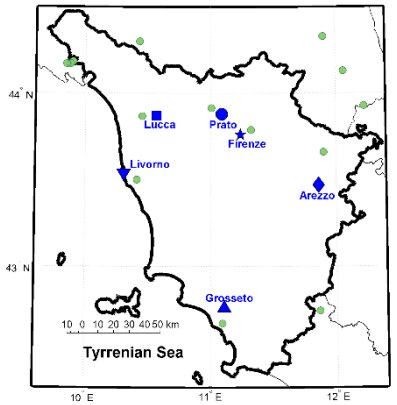
1. Description of the method to identify dust events and/or to measure/model local/natural sources.

DIAPASON built on the capabilities of the current **EC-Guidelines Method**,
and proposed **modifications to optimize the applicability in the Italian context**

	DIAPASON	PATOS1
Region	Lazio	Toscana
Period	2009, 2012-2014	2005-2006

DATASET





Main points of the EC Method investigated within DIAPASON

1st: the choice of a ±15 days out-of-dust reference period

The dust load in the Regional Background is computed in an out-of-dust period of ±15 days, is this the optimal choice?

2nd: the required selection of a Regional Background site

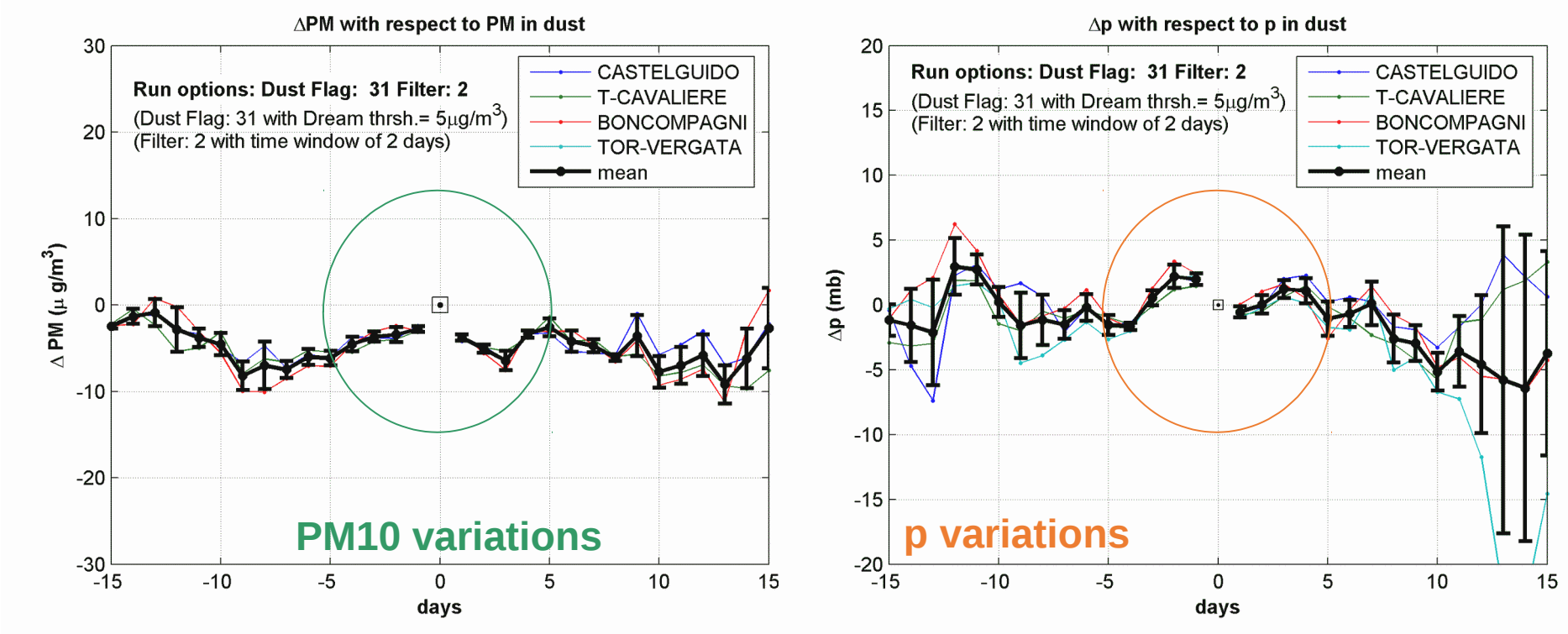
Desert dust load in all the monitoring sites of a given region are set equal to that derived in the Regional Background site

How to select it? What if there is no site in a region with RB characteristics?

Is this choice really necessary?

1st - About the choice of a ±15 days out-of-dust averaging period in the EC Guidelines

THERE ARE IMPORTANT METEOROLOGICAL VARIATIONS OVER A 30-DAYS PERIOD TO CONSIDER THIS AS AN EFFECTIVE 'BACKGROUND PERIOD'



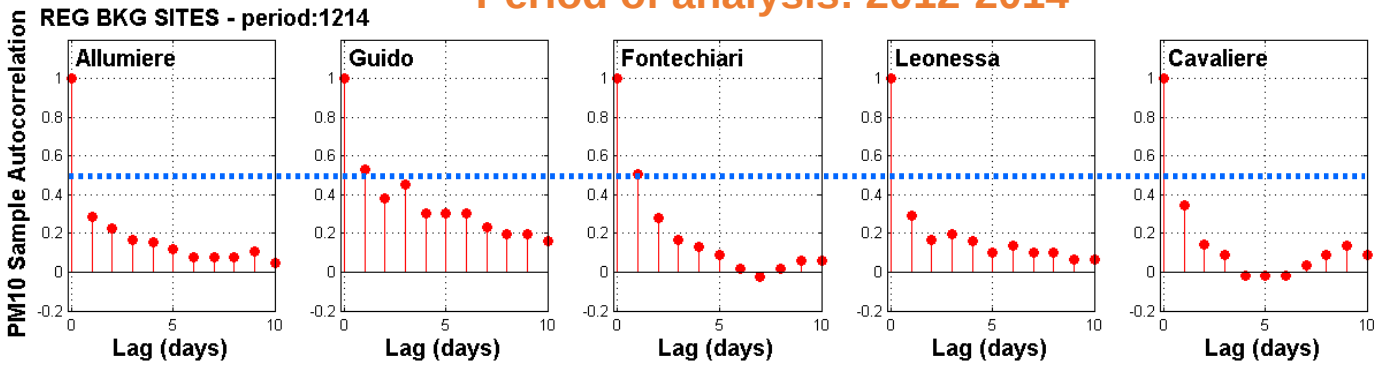
Daily, relative variations of PM10 and Pressure with respect to the 'in dust' condition over the ±15 days period from the dust event

day = 0 includes the whole dust event, regardless of its duration

1st - About the choice of a ±15 days out-of-dust averaging period in the EC Guidelines

AUTO-CORRELATION FUNCTION (ACF) OF PM10 SERIES :
- LOW (<0.5) AFTER 1-to-3 days of time lag even at 'BACKGROUND SITES'

Period of analysis: 2012-2014



Regional Background sites

These (and other) evaluations indicate that the closer the background period to the dust event the better this represent the 'real' background the dust event builds on…

THE CHOSEN APPROACH to compute the PM10nodustbackground IS TO USE THE SHORTEST, SYMMETRICAL OUT-OF-DUST BACKGROUND PERIOD WHICH ALSO ALLOWS TO AVOID POSSIBLE WEEKLY CYCLES ⇒ *± 3 days*

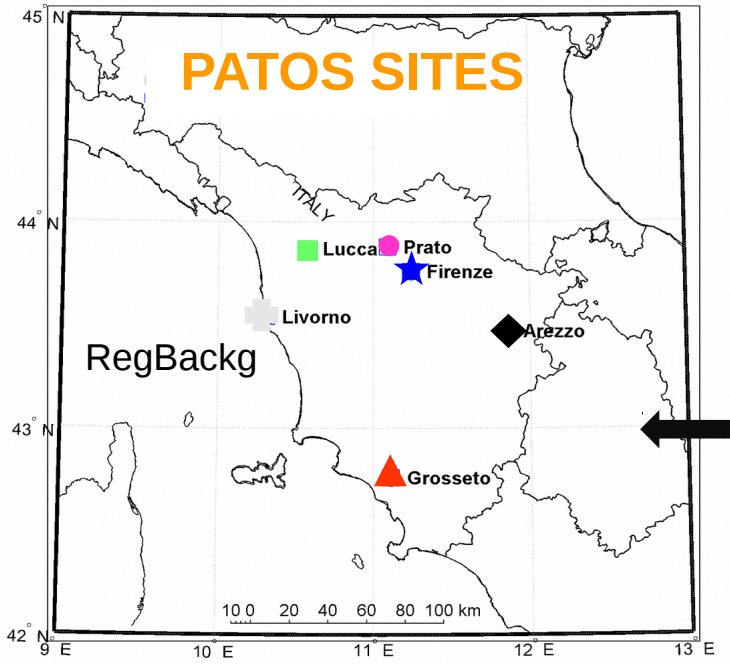
2nd - About the need for & selection of a Regional Background

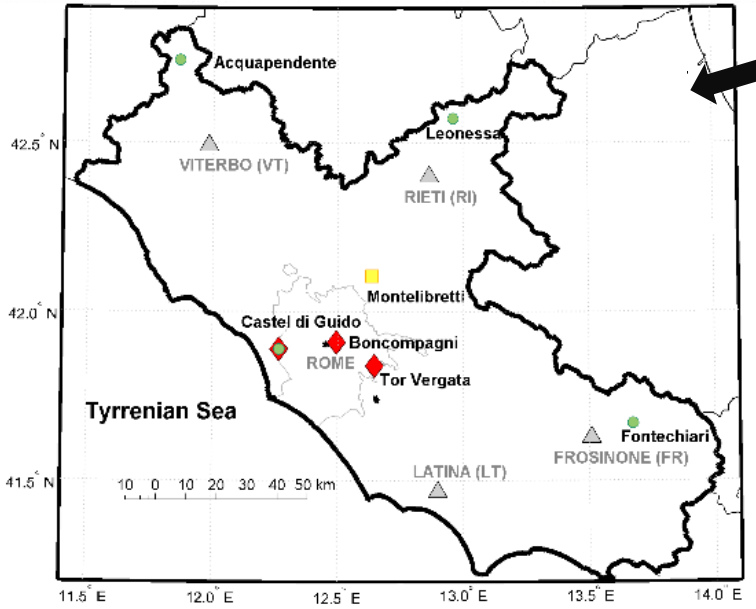
Saharan Dust Load from direct PIXE Analysis of PM10 samples

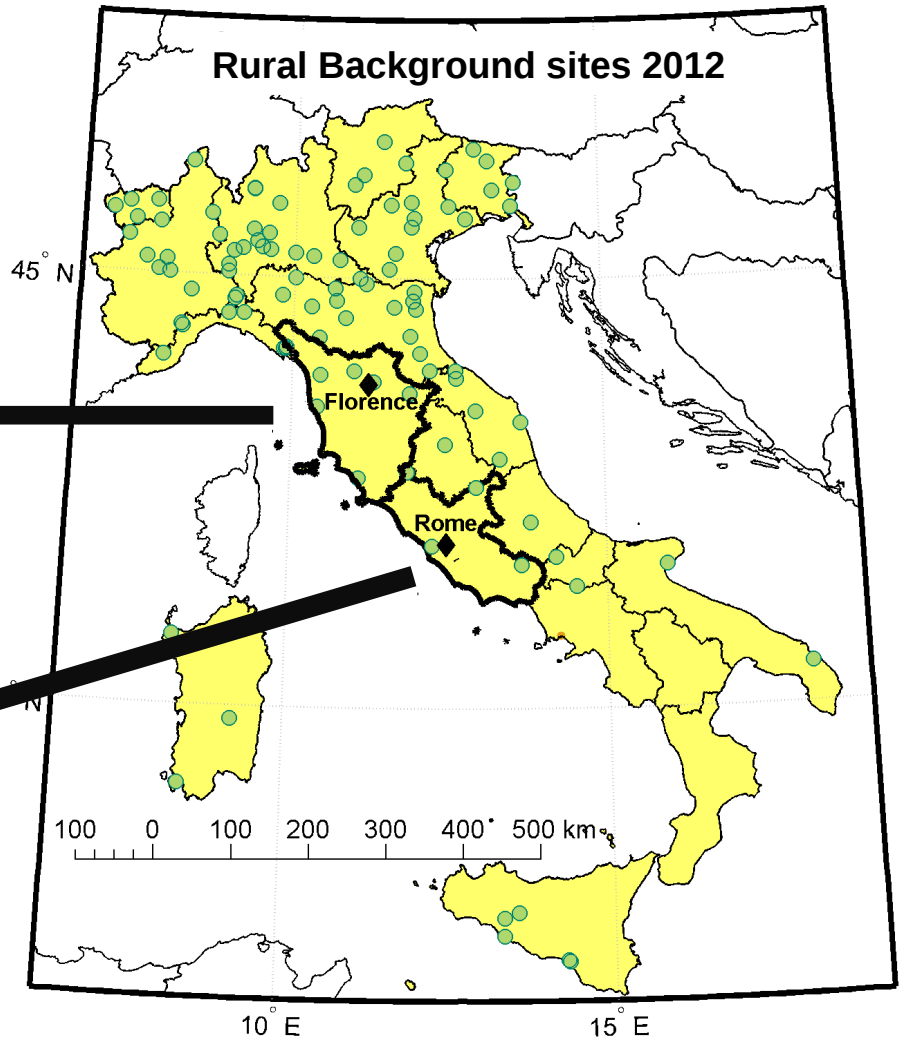
Typical Differences of 5-10 μg/m3

PATOS PIXE data (Lucarelli & Nava, INFN , FI)

Using different RGB sites we get typical absolute differences of estimated dust load of the order of 10±20 μg/m³, with maximum differences > 50 μg/m³



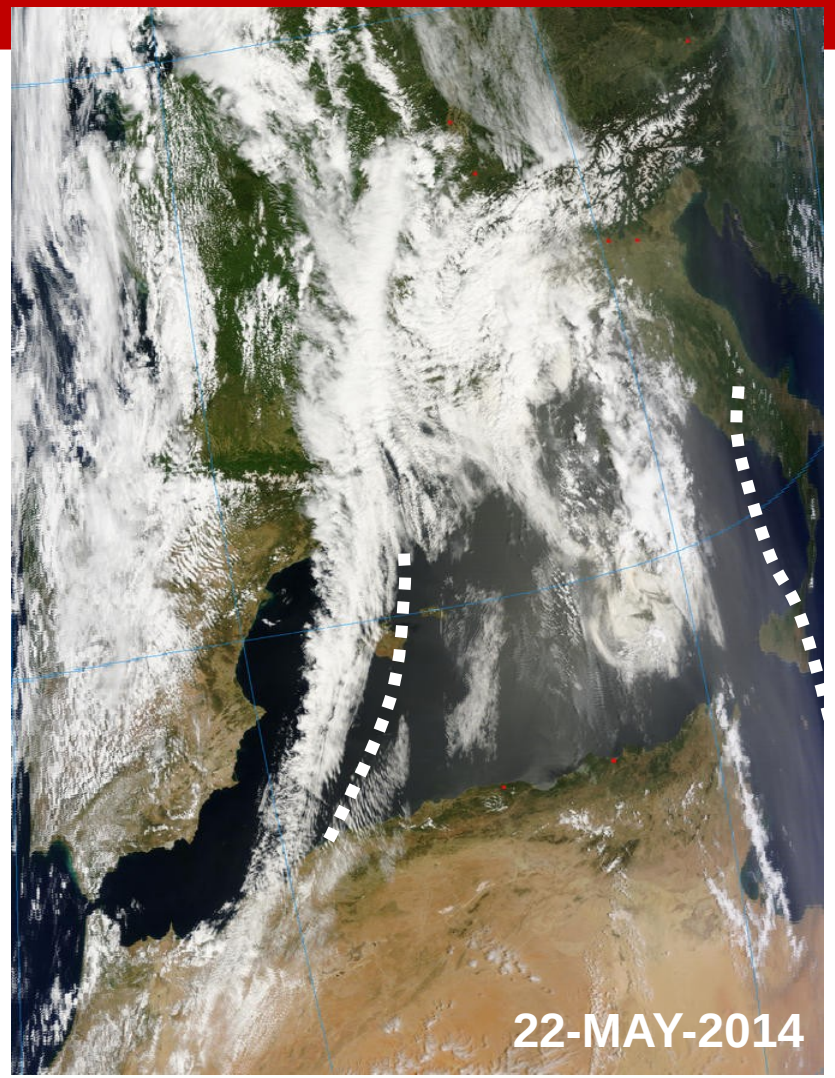




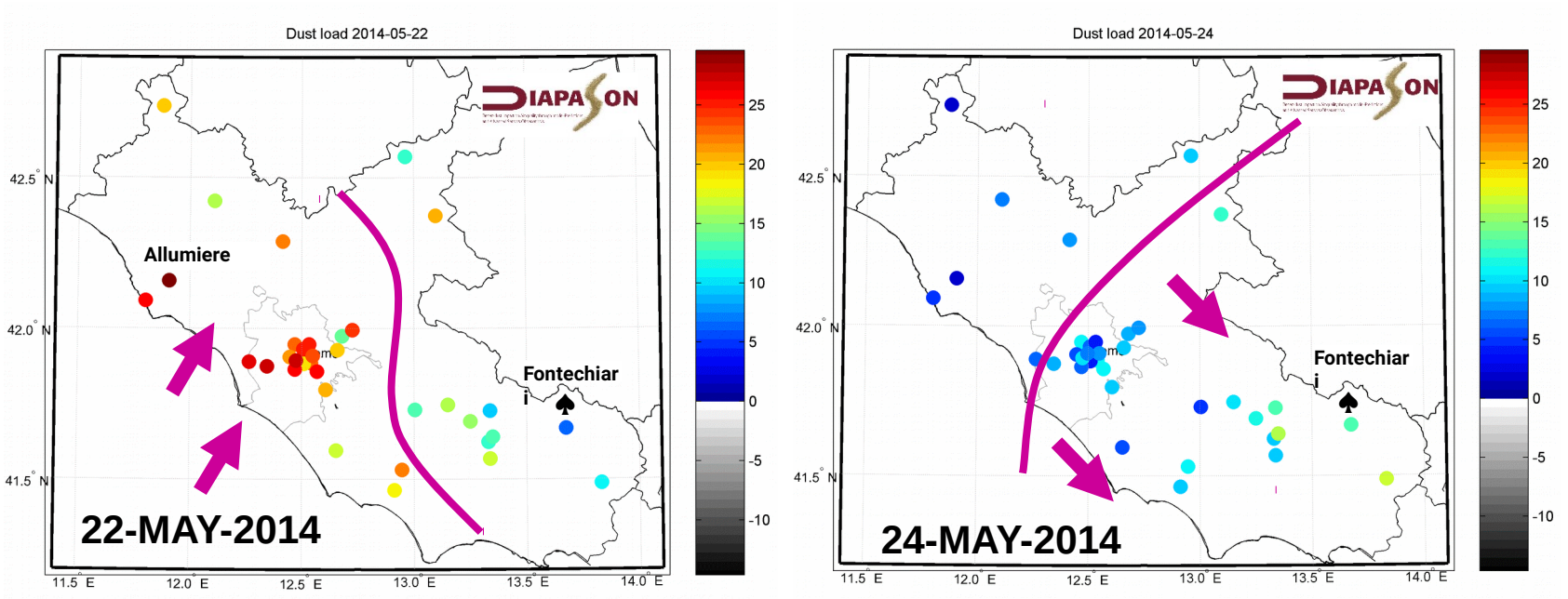
In some Italian regions there is no site with RB characteristics

2nd - About the need for & selection of a Regional Background

This indicates that the need for, selection of, and use of a Regional Background site is limitative, particularly considering that estimates of the dust load are mostly important at urban sites…



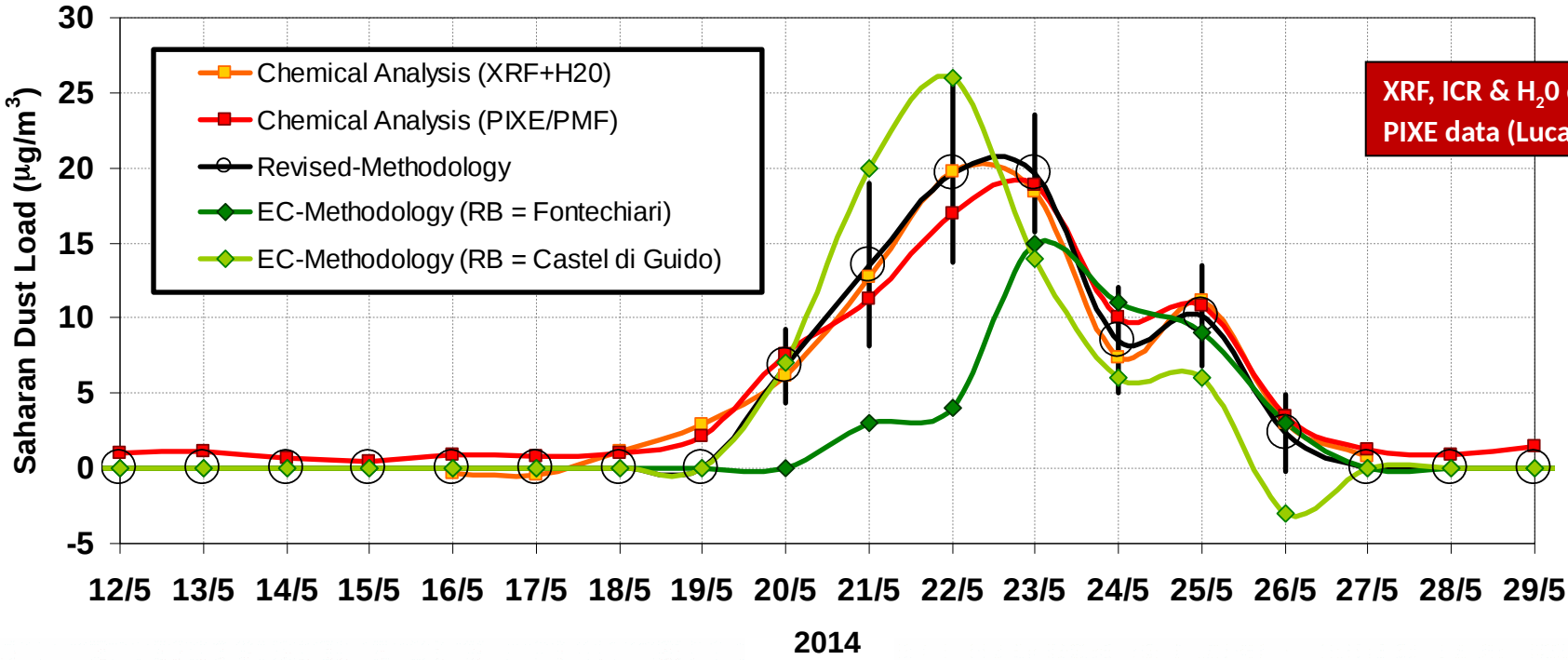
THE DIAPASON CHOSEN APPROACH IS TO USE EACH SINGLE SITE AS A REFERENCE BACKGROUND FOR ITS OWN PM10 RECORD



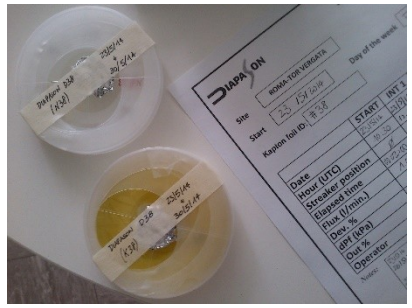
PM10 (µg/m3)

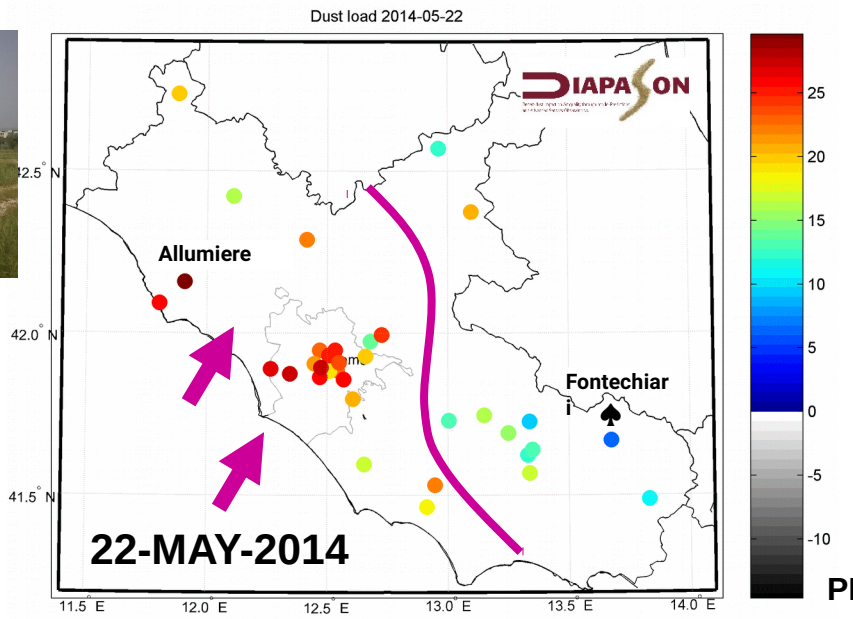
Quantitative Evaluation of the DIAPASON Method outcome (DIAPASON IOP2)

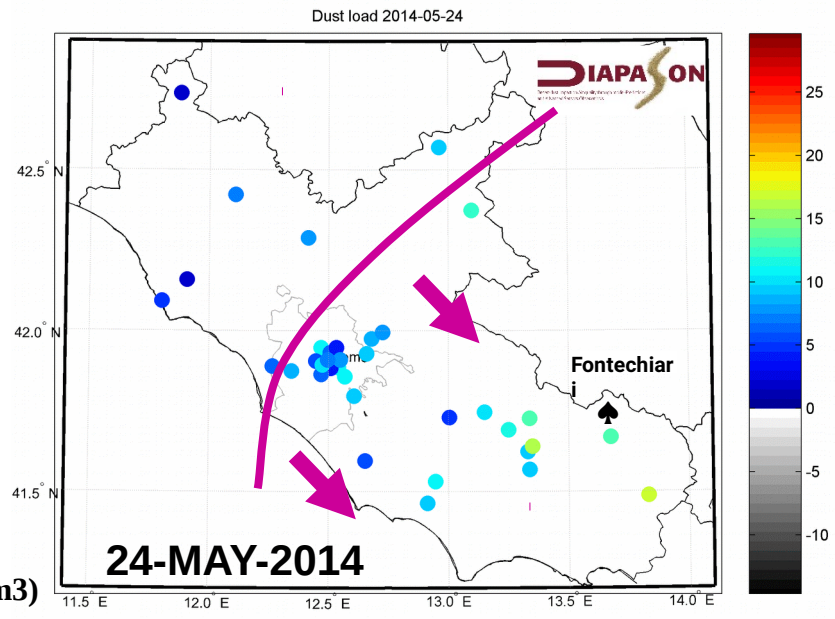
DIAPASON IOP2 MAY 2014



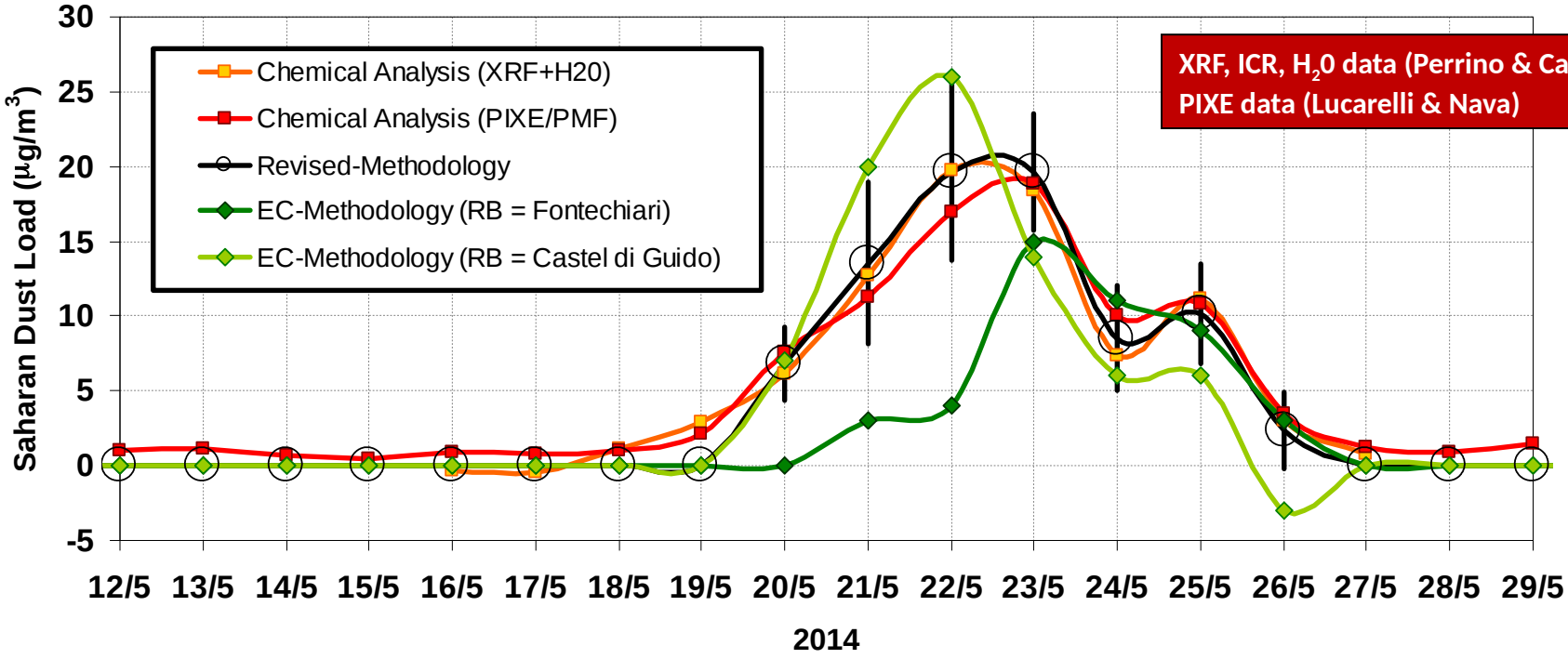
XRF, ICR & H_20 data (Perrino & Canepari, IIA, RM)
PIXE data (Lucarelli & Nava, INFN , FI)





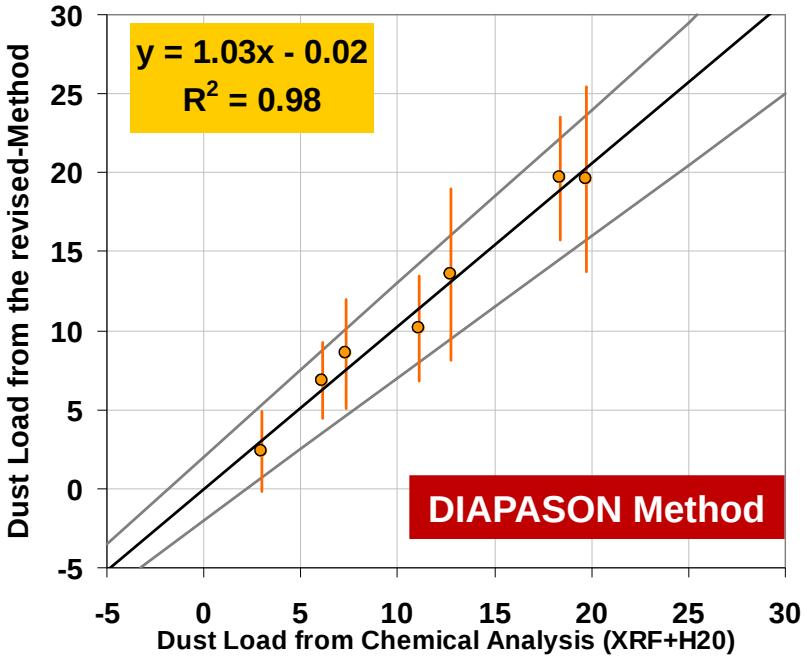


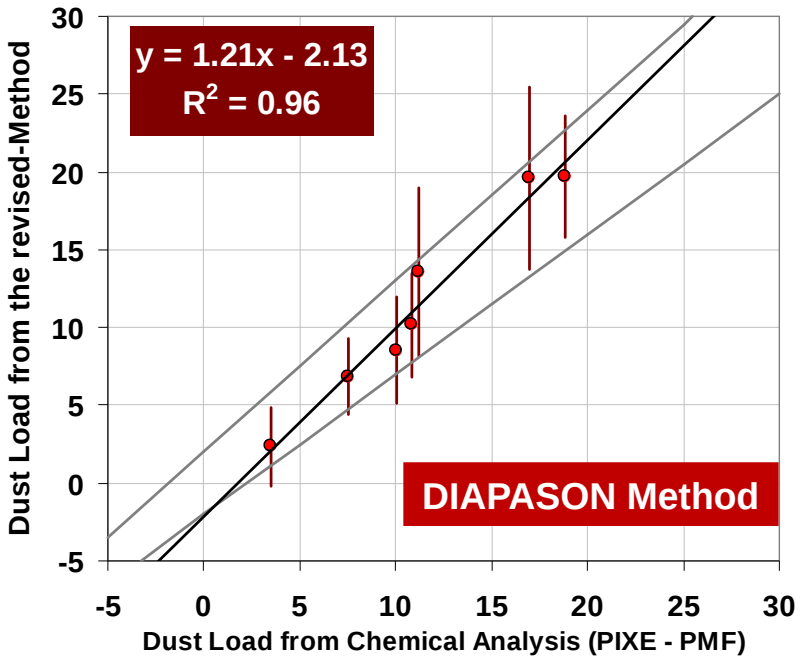
PM10 (µg/m3)

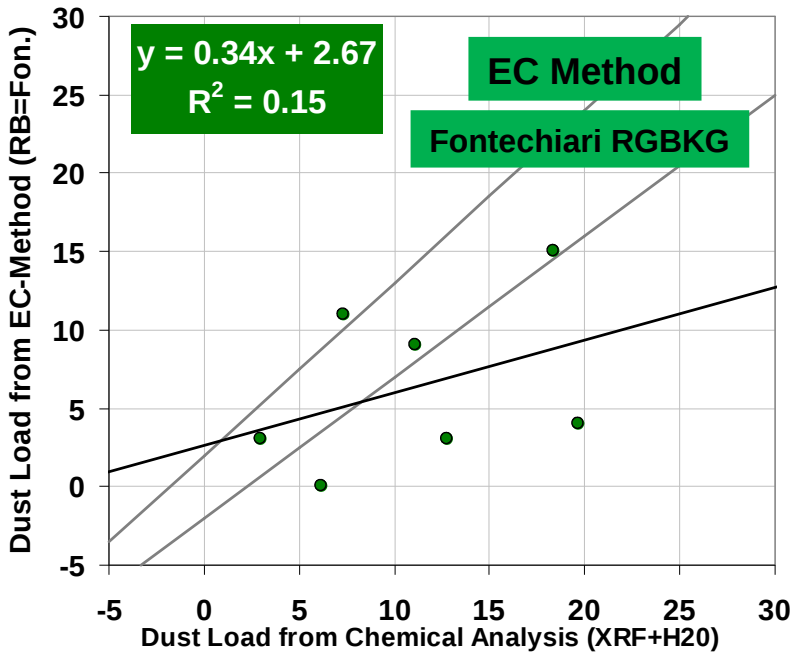


XRF, ICR, H_20 data (Perrino & Canepari)
PIXE data (Lucarelli & Nava)

DIAPASON IOP2 MAY 2014



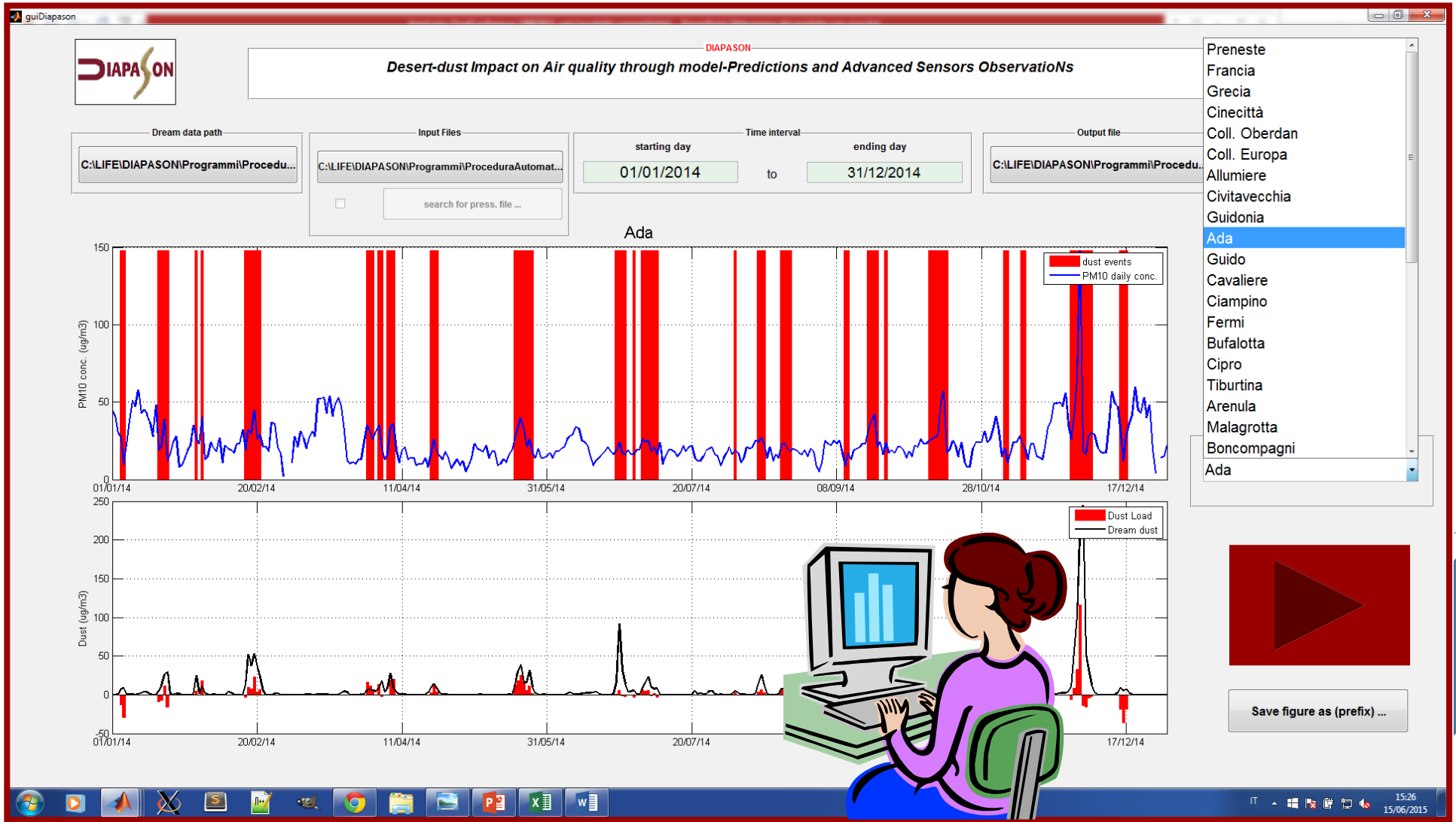




- A further limit of the EC Guidelines is that the selection of episodes is subjective (visual inspection) and requires much effort in collection of all the needed resources

…the DIAPASON approach has been turned into an automatic user-independent software as strongly requested by the Project Stakeholder Community

FREELY AVAILABLE TOOL



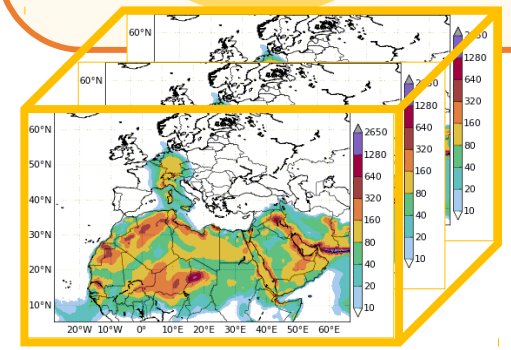
FREELY AVAILABLE TOOL

Overall scheme

STEP 1: Desert dust dates identification

model dust-PM10 from BSC-DREAM8b v2 numerical data

daily & 0.3°resolved

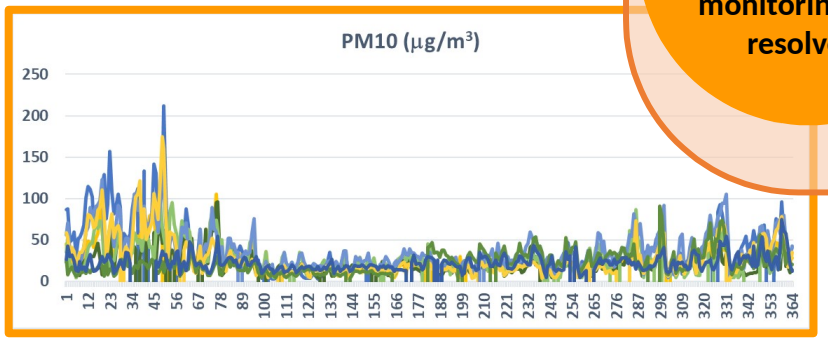


dust-FLAG (yes/no) from DREAM Model

yes if > 5 µg/m³

daily & 0.3°resolved

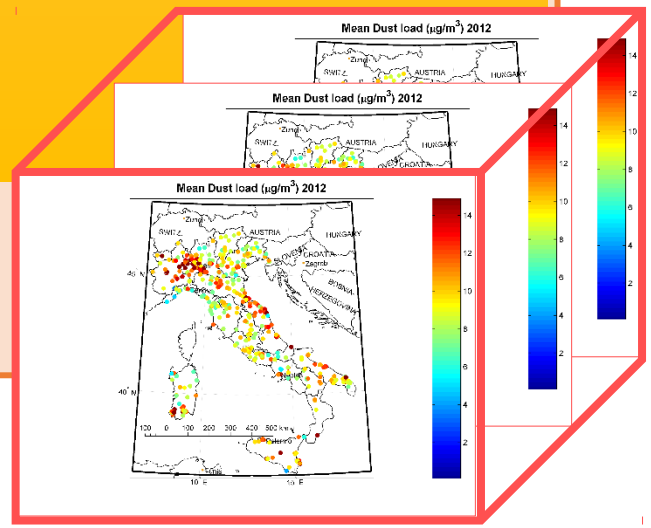
Time series of PM10 data (daily & monitoring site - resolved)



STEP 2: Dust-PM10 quantification

$$\text{Dust-PM10} = PM10_{observed\_ij} - PM10_{bckg\_ij}$$

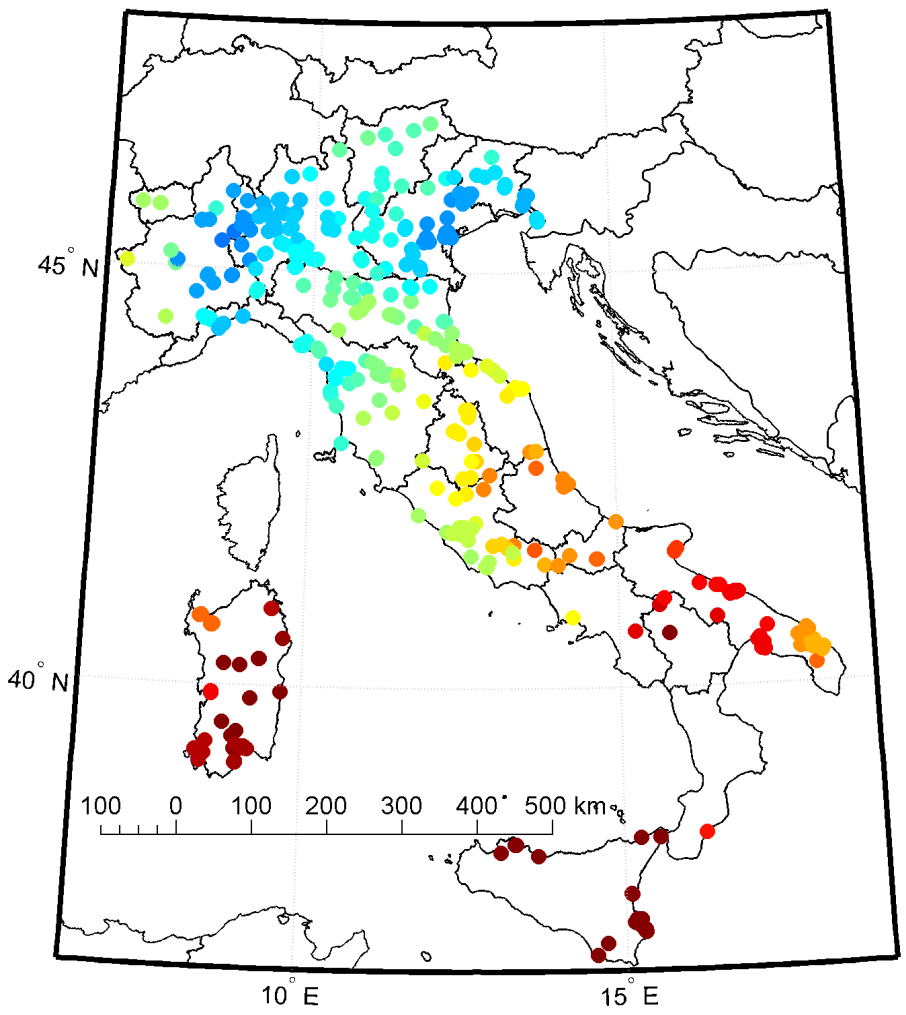
day (i)- & monitoring site (j)–resolved

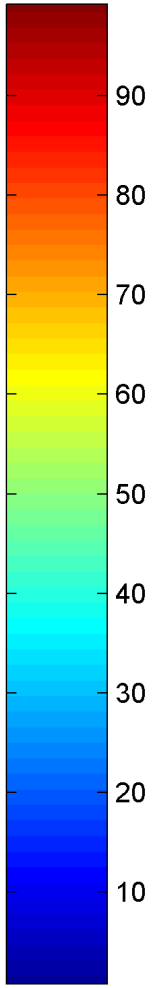


2. Summary of the main results you found to identify dust event exposures.

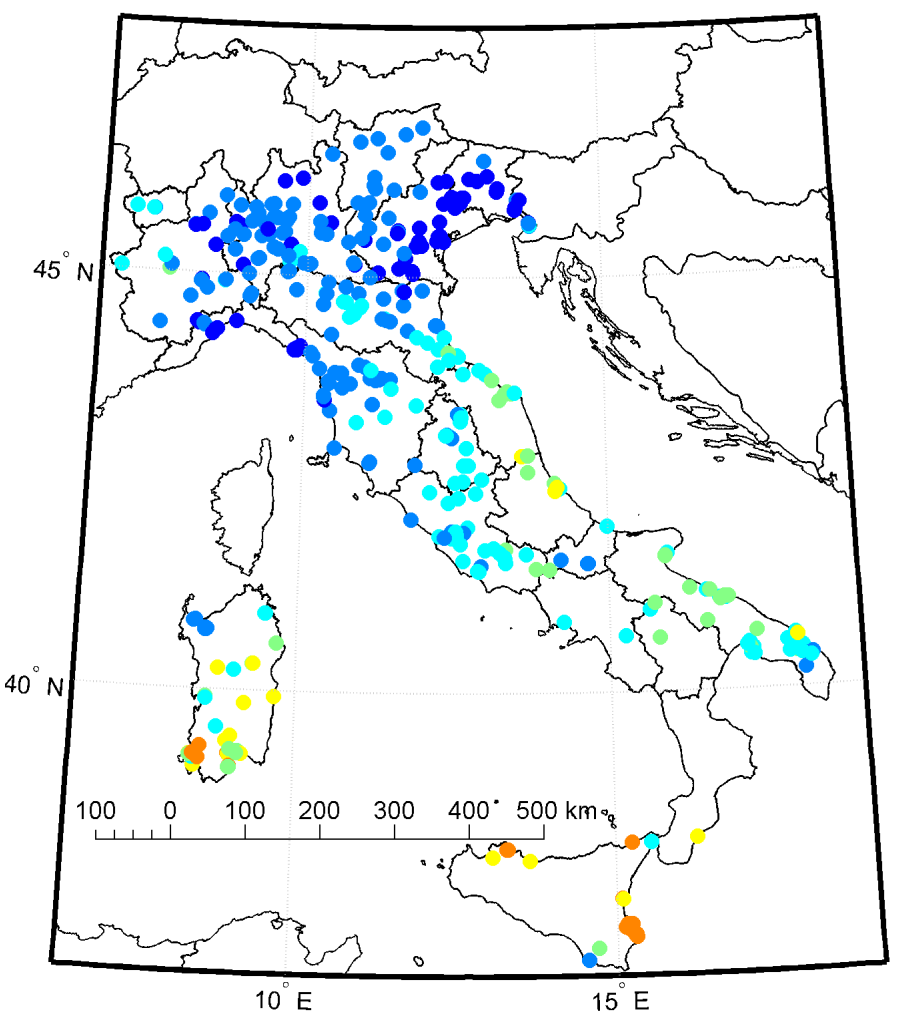
Results for the year 2012 (a)

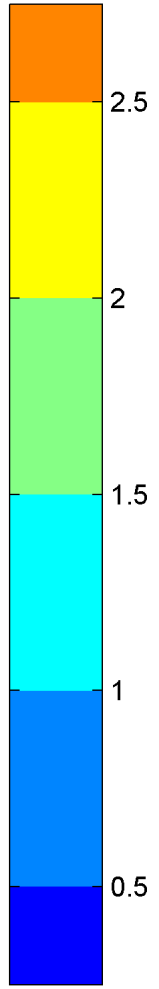
Number of dust days 2012





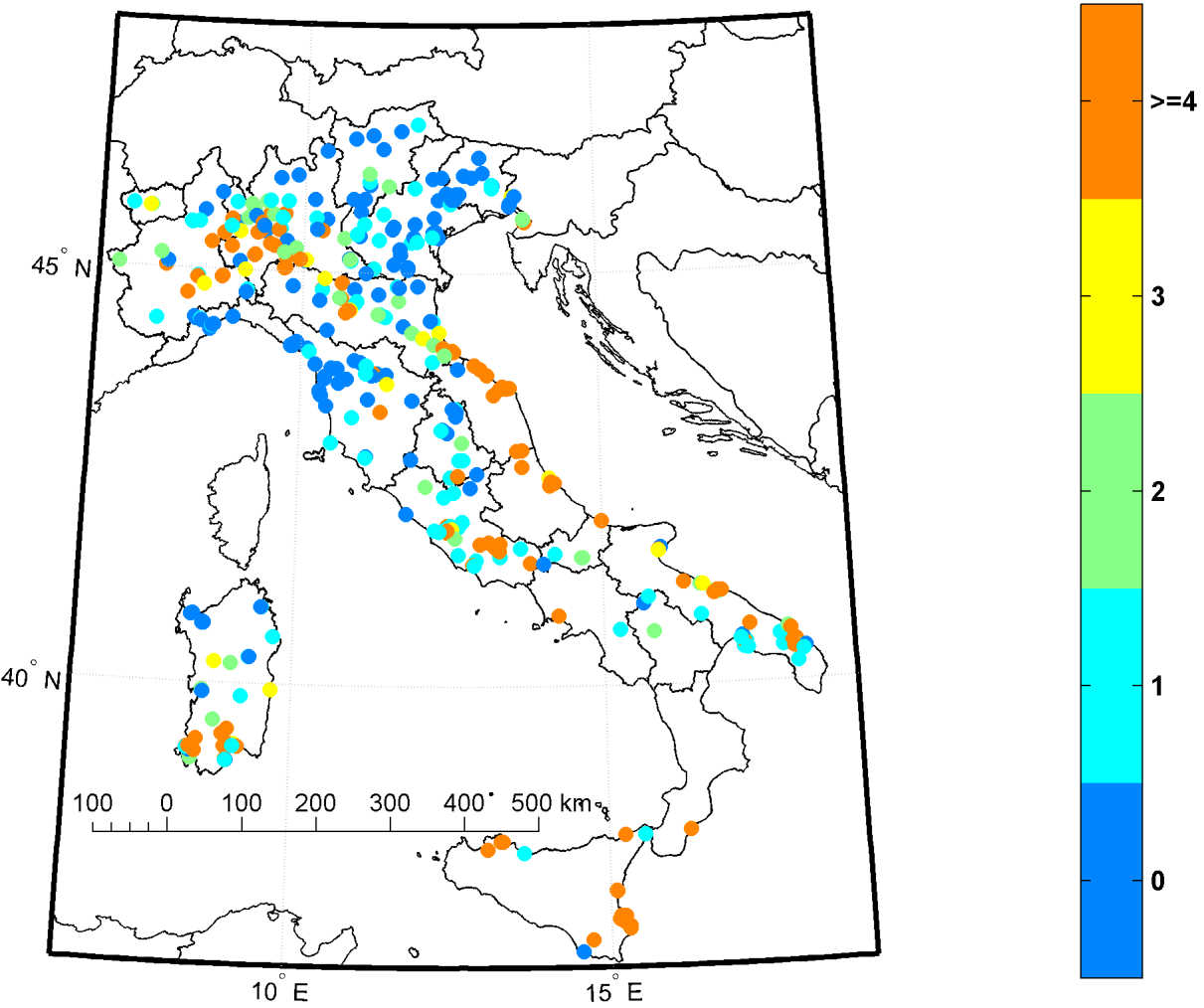
Dust Impact on Yearly Average PM10 (μg/m^3) 2012



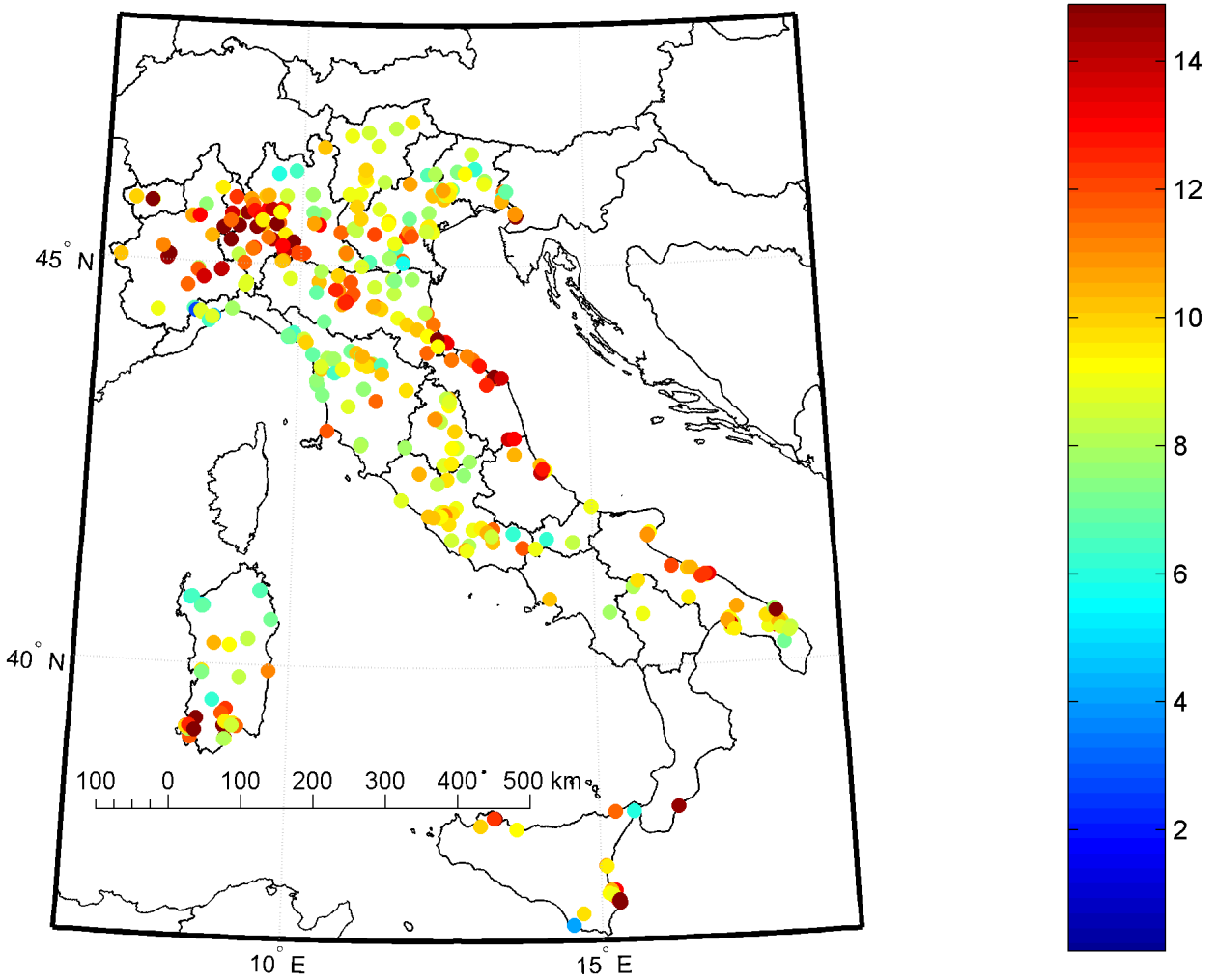


Results for the year 2012 (b)

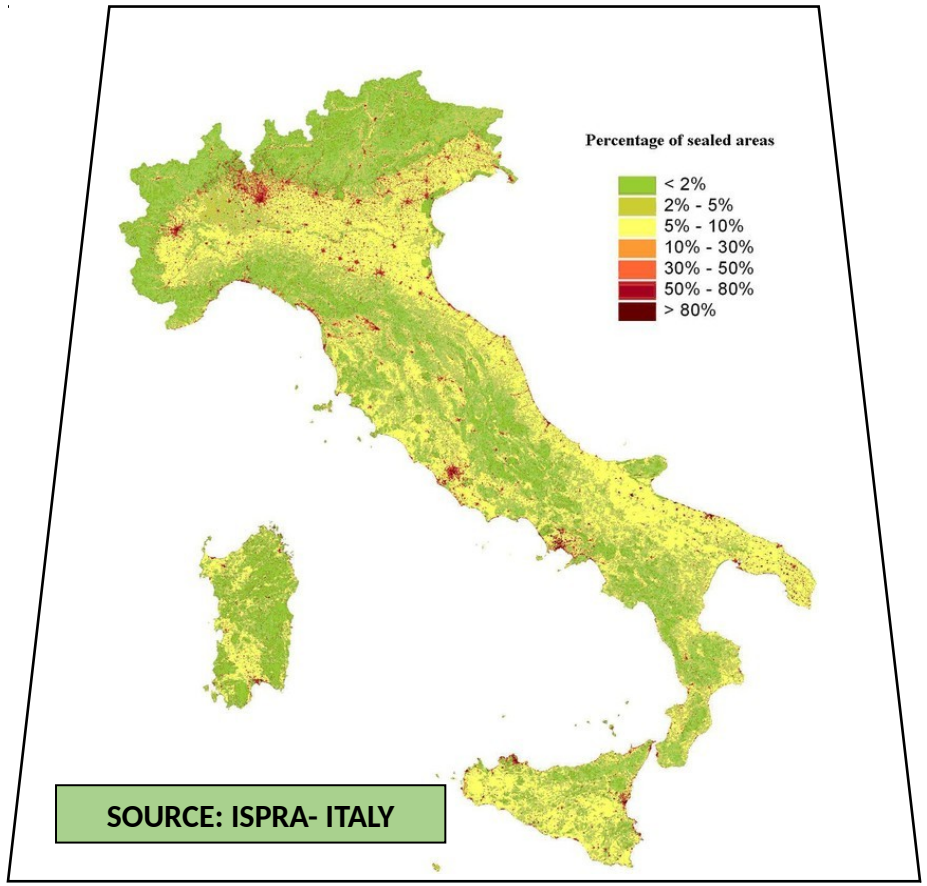
Number of Exceedances due to dust 2012

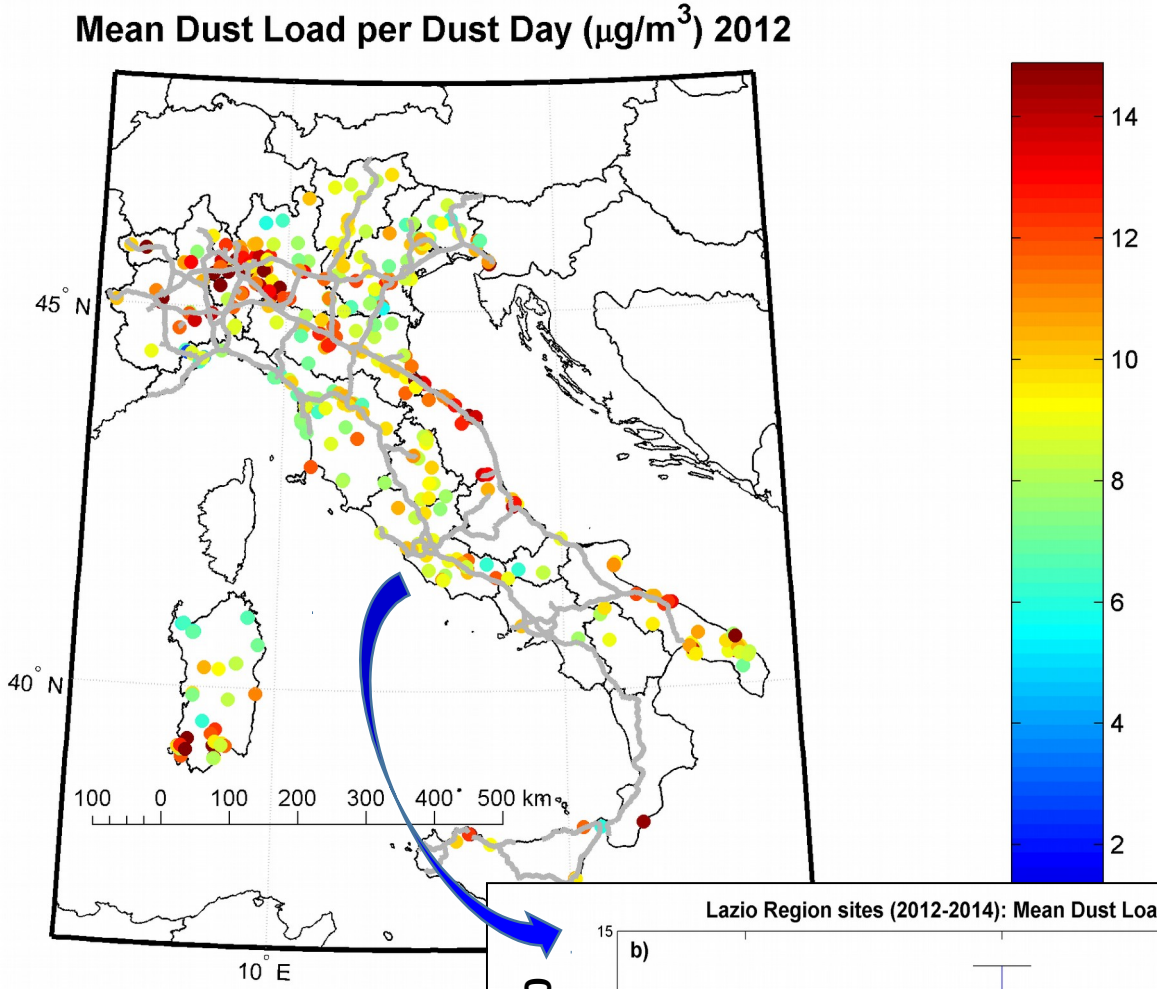


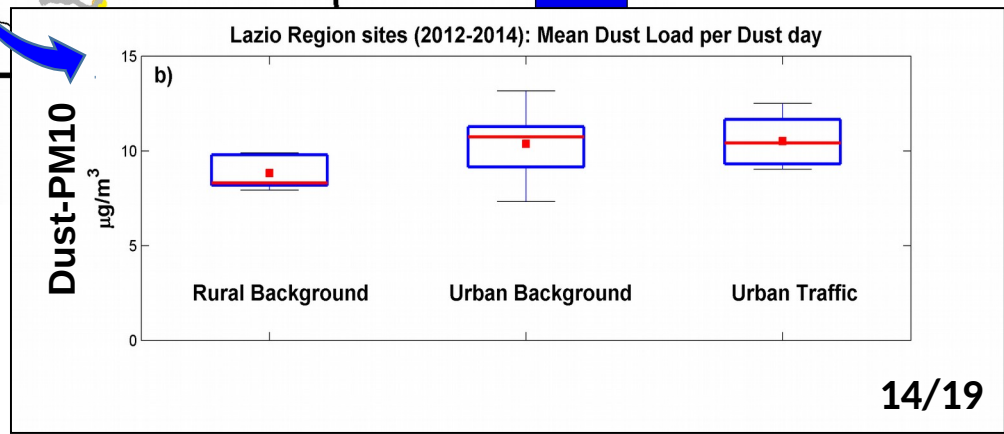
Mean Dust Load per Dust Day (μg/m^3) 2012



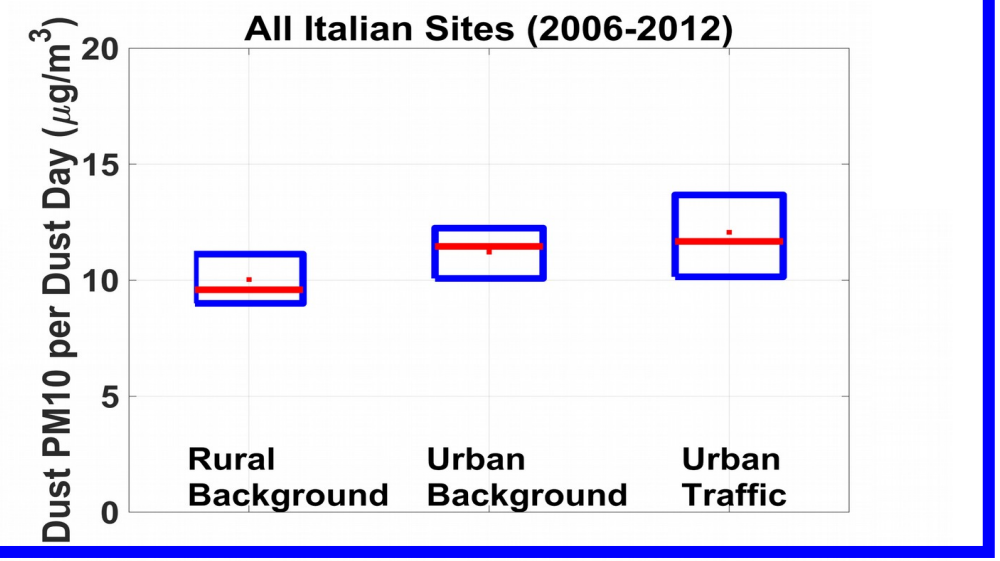
Results for the year 2012 (c)

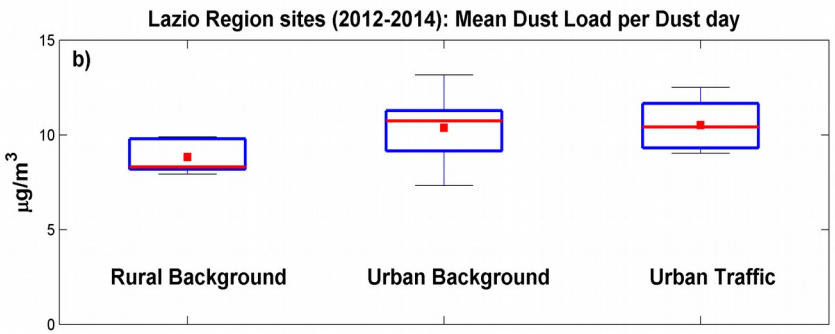






Follow up with an extended period: 7 years (2006-2012)

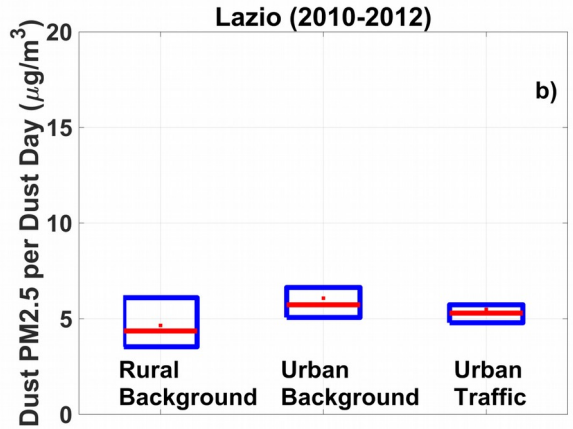




Barnaba et al., 2017

dust-PM10 (µg/m3)

dust-PM2.5 (µg/m3)



Barnaba et al., in preparation 2019

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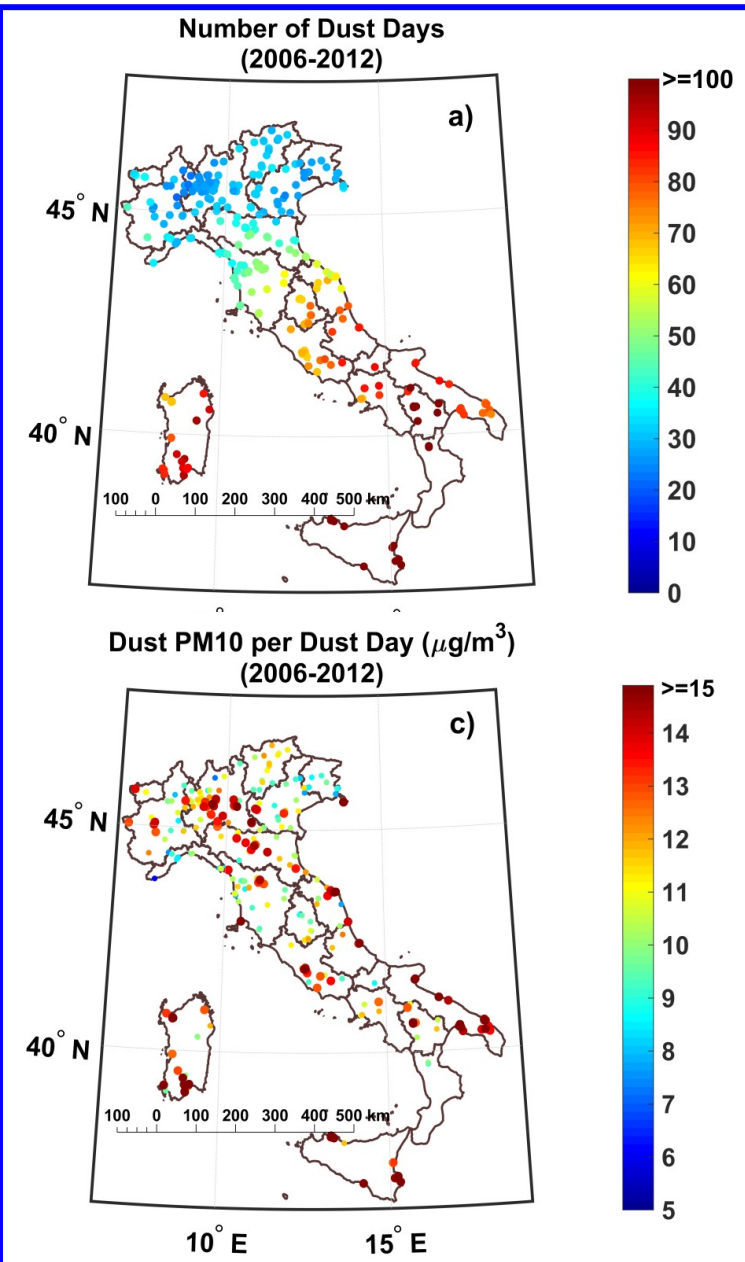
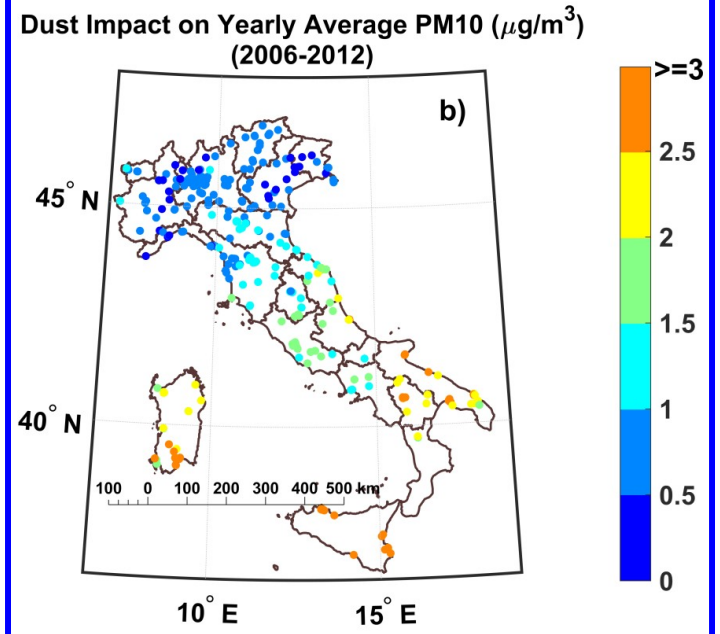
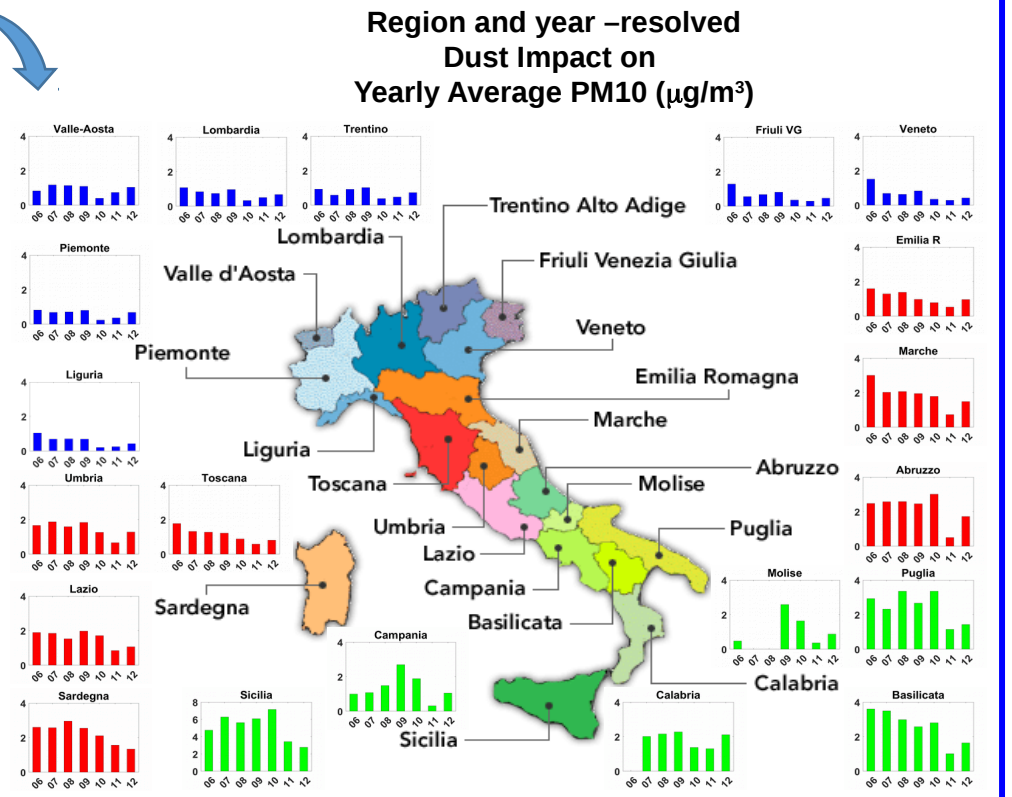
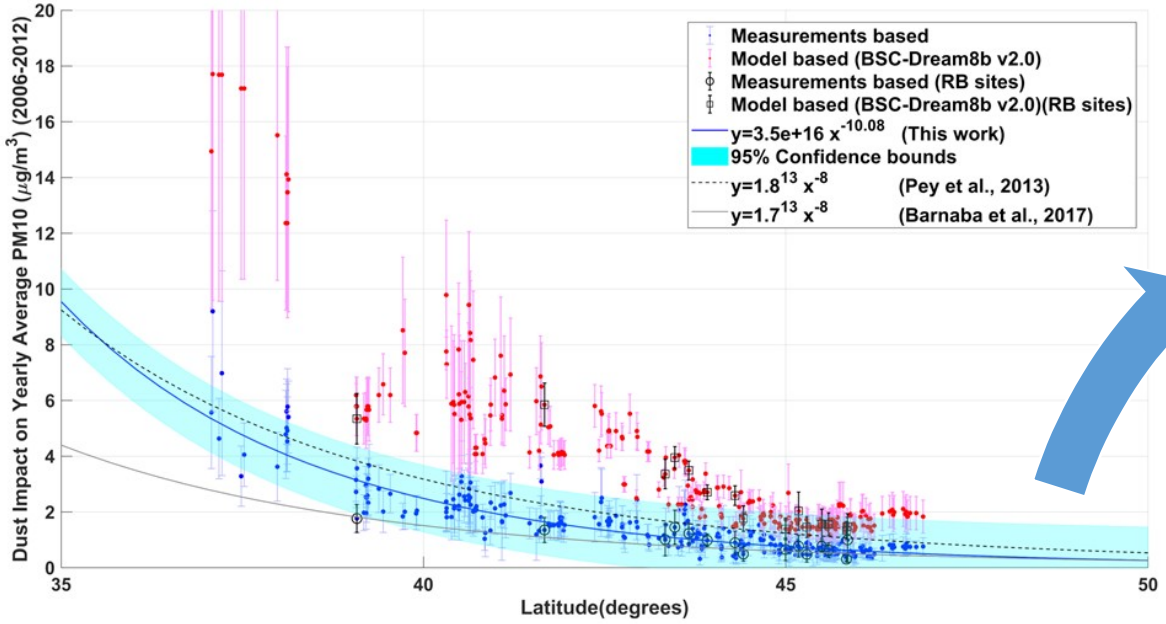
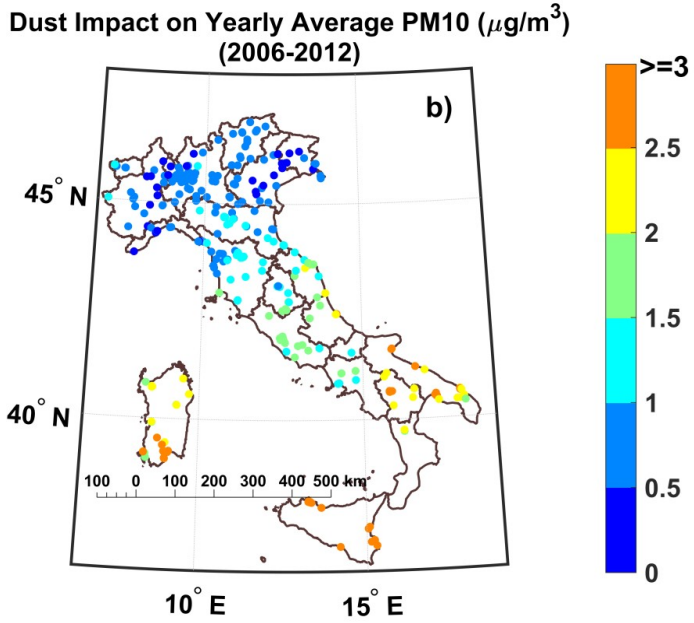


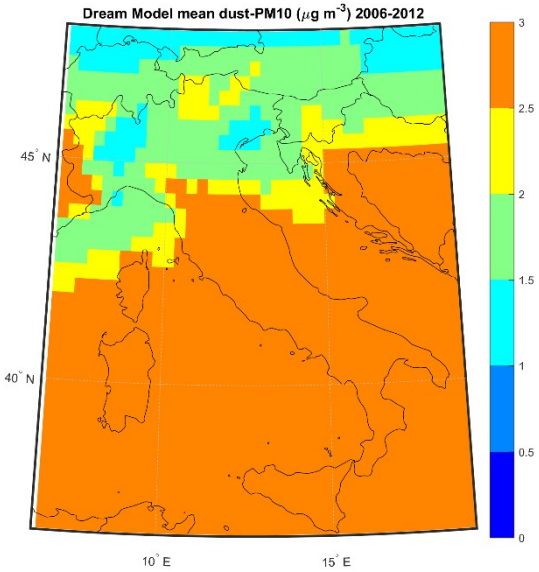


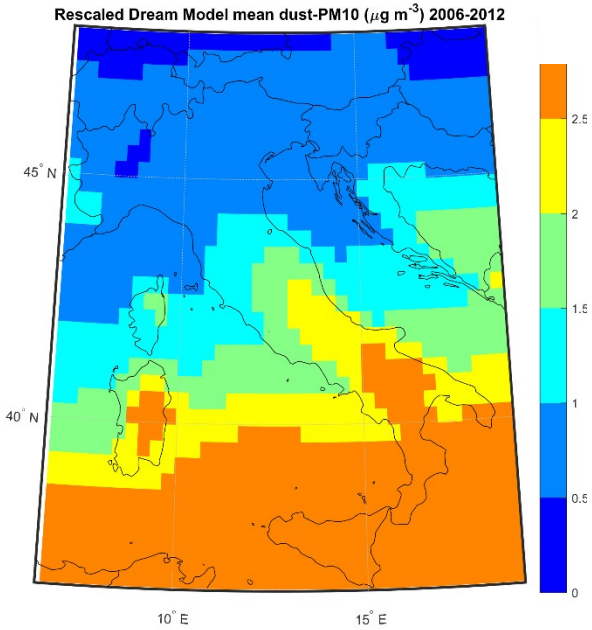


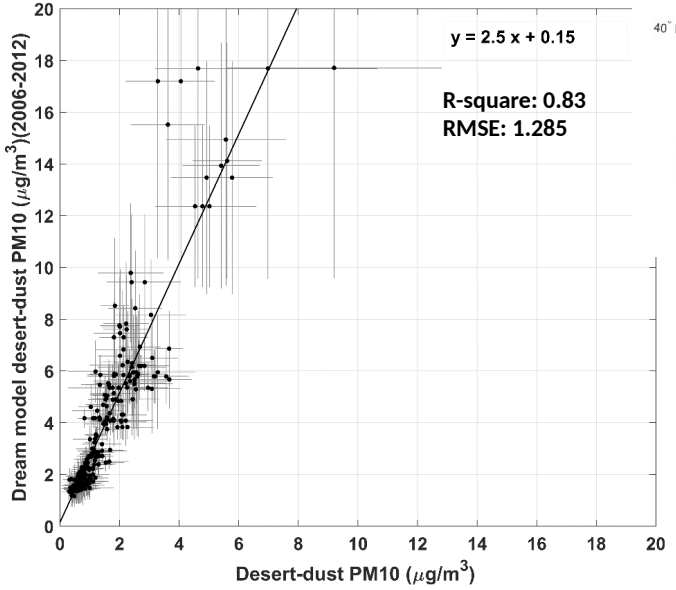
Barnaba et al., in preparation 2019











1. ***Agreement level between methods based on monitored data and model predictions.***
2. ***Recommendations to identify dust event exposures in hot spot geographical areas without monitored data available.***

Barnaba et al., in preparation 2019

3. Strengths and limitations of the method

Strengths:

1. Builds (intentionally) on EC-Guidelines, and is a reasoned upgrade of these
2. Automatic and user-friendly
3. Objective and quantitative
4. Can be used to quantify the impact of an event starting few days after it took place..
5. Can be run over large areas and several years very quickly (few minutes for a 1-year evaluation over Italy).

Limits:

6. Does not take into account rain effects (same as in EC-Guidelines) This can lead to some negative dust-PM10 estimates (in Rome about 30% of the events is associated to rain)
7. Estimates in high-traffic sites are (obviously) more uncertain (can be screened out but this may hide 'real' effects)
8. Need for tests in other countries and in general further validation exercises
9. Model-related problems (important in the dust-flag phase): Which model? Why? definition of 'surface PM10' from a model point of view, sensitivity of the model dust mass to all the factors influencing the dust cycle…
10. Associated error can be large: being x the 'real' dust load our estimate y is $y = x \pm \Delta$, where $\Delta = 2\ \mu g/m^3 \pm 0.1\ x$ (derived from the DIAPASON validation exercises). It should be noted however that even the most sophisticated experimental – chemistry based - estimations of the 'advected dust' fraction within PM10 have several drawbacks

Wish list:

- Test of the ‘DIAPASON’ approach over different regions (ideally Spain having a long ‘reference’ record there)
- Experimental verification of the enhanced resuspension during desert dust episodes in major urban centers
- Additional work on dust-pollution interactions at the chemical level (and 3D meteo and aerosol fields)

THANKS

(Some) Issues for dust- related health impacts:

- Is advected dust increasing the health risk? if yes why? (role of composition, e.g. metals content, role of associated ‘meteorology’, e.g. effects on MLH)
- Can we evaluate the role of dust mixing with other pollutants? (e.g. site-type dependent ‘dust-only’ health effects)
- Can we evaluate the role of resuspension if any (e.g. response visible even after the end of main events)