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# Contribution of desert dust transport to daily $PM_{10}$ concentrations in Aksaray, Istanbul: A long term study

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Dust sources and their impacts in Middle East
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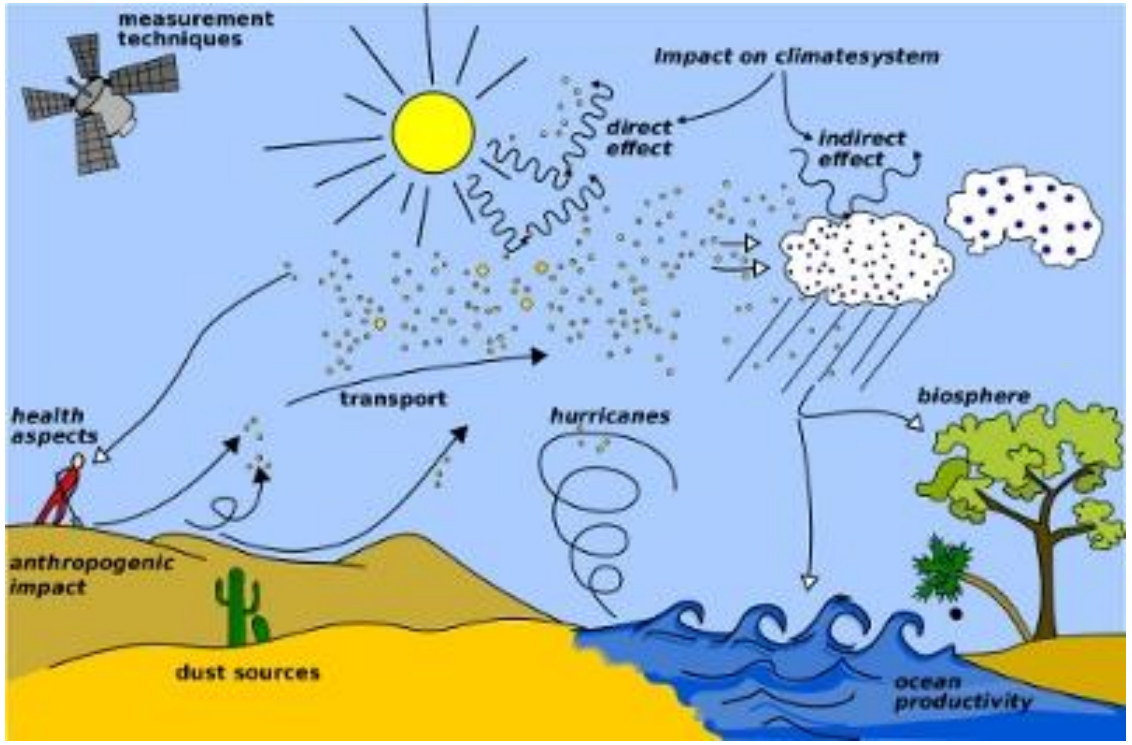
# Atmospheric Dust process

- Distribution of the source and activation
- Atmospheric stability
- Wash-out processes




WMO, 2017a

# Desert Dust sources

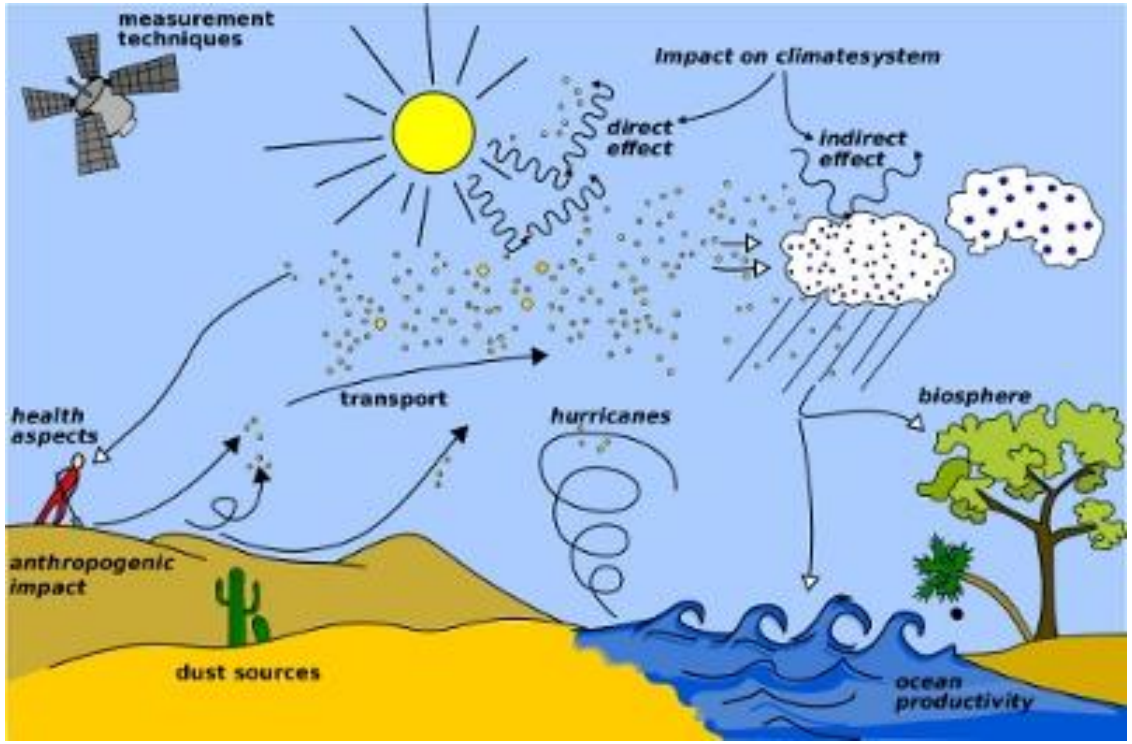
- Two of the major source regions of desert dust are in Africa (Sahara Desert) and Eastern Asia (Gobi and Taklamakan deserts). Both contributing to ~700 and 250 Tg dust/yr.

- Both sources have similar size distribution and elemental composition, therefore, similar dust dynamics is expected.

Laurent et al., 2006, 2008; Scheuvens and Kandfer, 2014

# Effects

- Climate change – radiative forcing
  - Mineral fraction absorbs radiation
  - Ageing and mixing during transport
- Ecosystems
  - Ocean productivity and carbon cycle
- Human health
  - Transmission of pathogens
  - Respiratory issues
  - Cardiovascular diseases
  - Eye infections
  - Silicosis or asbestosis
  - Other endemic diseases such as fever and meningitis

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# Study Area: Istanbul

- 15 million people
- 5460 km$^2$
- Air quality standards
- Sources of pollutants
- Long-range transport

# Background

- Im and Kanakidou (2012):

Long range transport > regional anthropogenic emissions

- Theodosi et al., (2010)

PM10 concentrations due to: 27% natural sources, 22% traffic/industrial, 16% fuel oil combustion, 10% secondary, and 7% ammonium sulfate

- Kabatas et al., (2014)

Estimated 96.6% PM10 during an episode in April 2008 due to desert dust; AOD = 0.87, negative radiative effect of -61.9 W m-2 at the surface, dust load> 700 mg m-2.

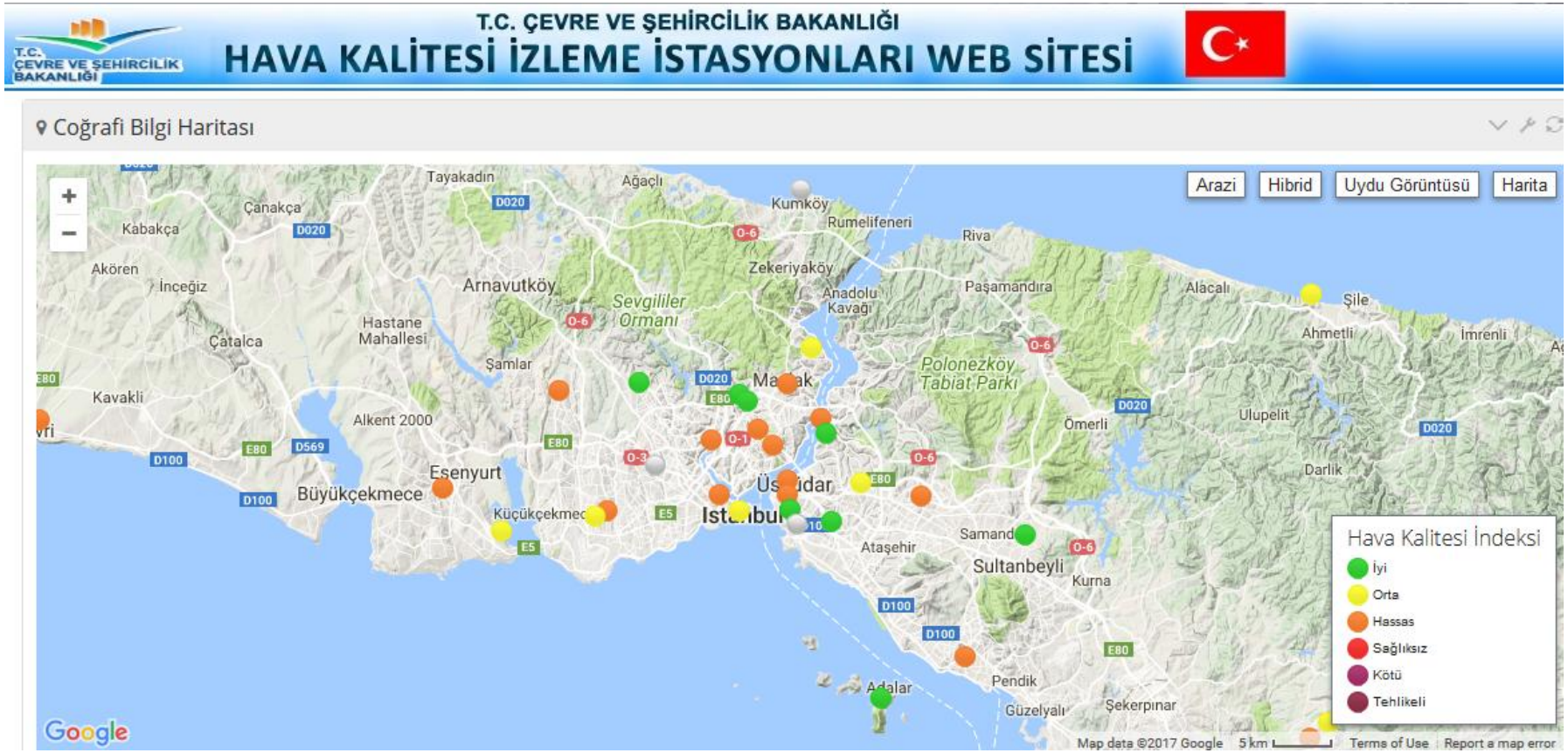
# Research Objectives

- Understand the impact of desert dust transport on PM10 concentrations

1. PM10 variations over the last 8 years in a traffic-influenced area
2. Air mass trajectories, occurrence, height, and associated PM10
3. Impacts of desert dust on local PM10 concentrations
4. Quantification of desert dust transport events and net dust load

# Methods

- 1. PM10 concentrations: Turkish Ministry of Environment and Urbanization – National air pollution monitoring network



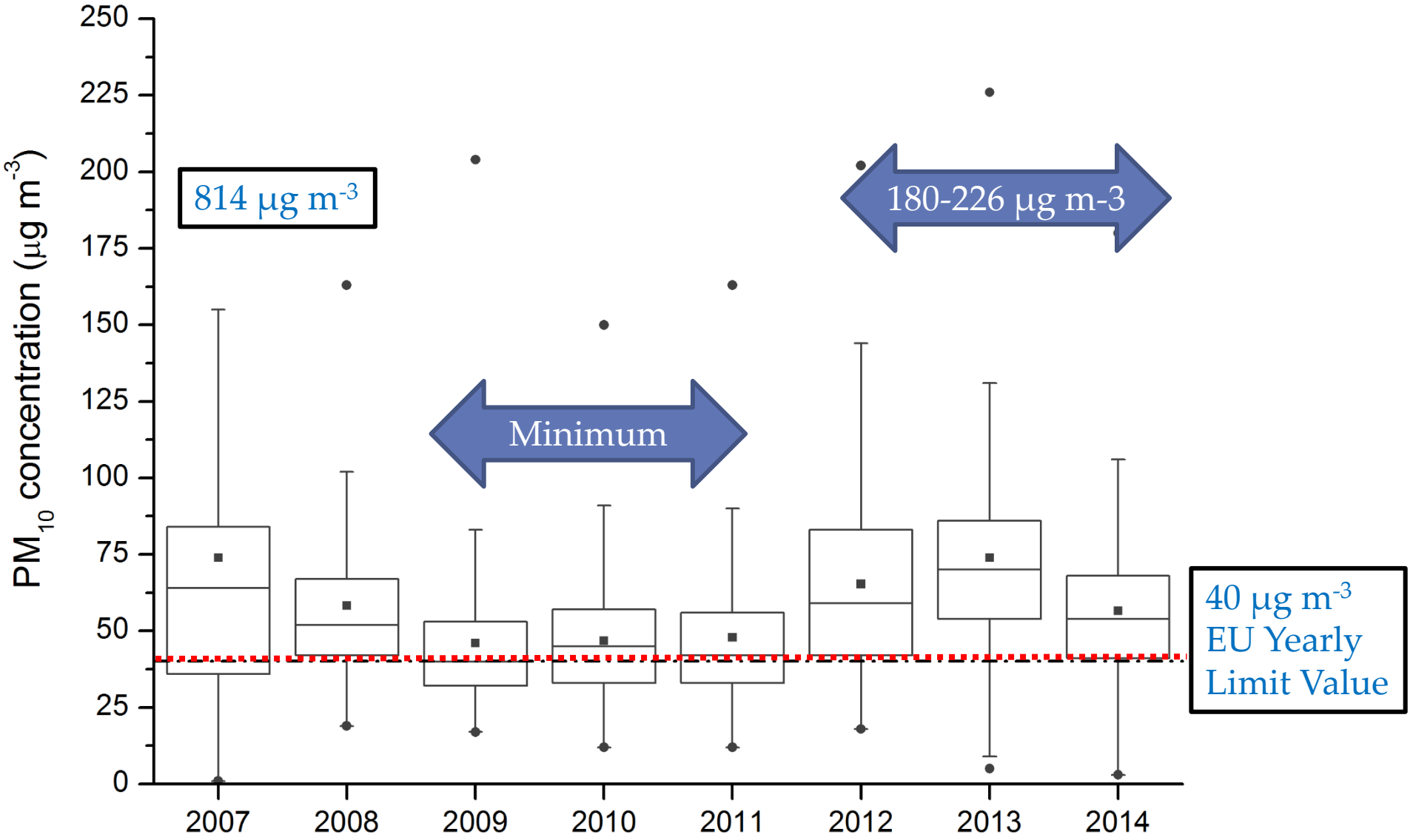
# Methods

- 2. Air mass backward trajectories and cluster analysis
  - NOAA – HYSPLIT 4 ending in Aksaray at 500 m and 3000 m

- 3. Quantification of mineral dust influence on PM10 concentrations
  - EU reference method (2008/50/EC)
  - A) background PM10 concentrations at urban background station (Sariyer) on days with no dust transport
  - B) PM10 due to desert dust = PM10 on days with desert dust advection – PM10 background
  - C) PM10 non-desert = Total PM10 concentration at urban station – PM10, dust

- 4. Net desert dust load and number of transport events
  - BSC-DREAM8b v2.0
  - Hourly forecast dust load (g m-2) was integrated to obtain total daily net dust load
  - Desert dust transport event:  Dust load > 0.25 g m-2
  - Net desert dust load (g): Dust load × surface area of Istanbul

The yearly-averaged EU air quality standard was exceeded all years



The daily-averaged EU air quality standard was exceeded 51% of days.

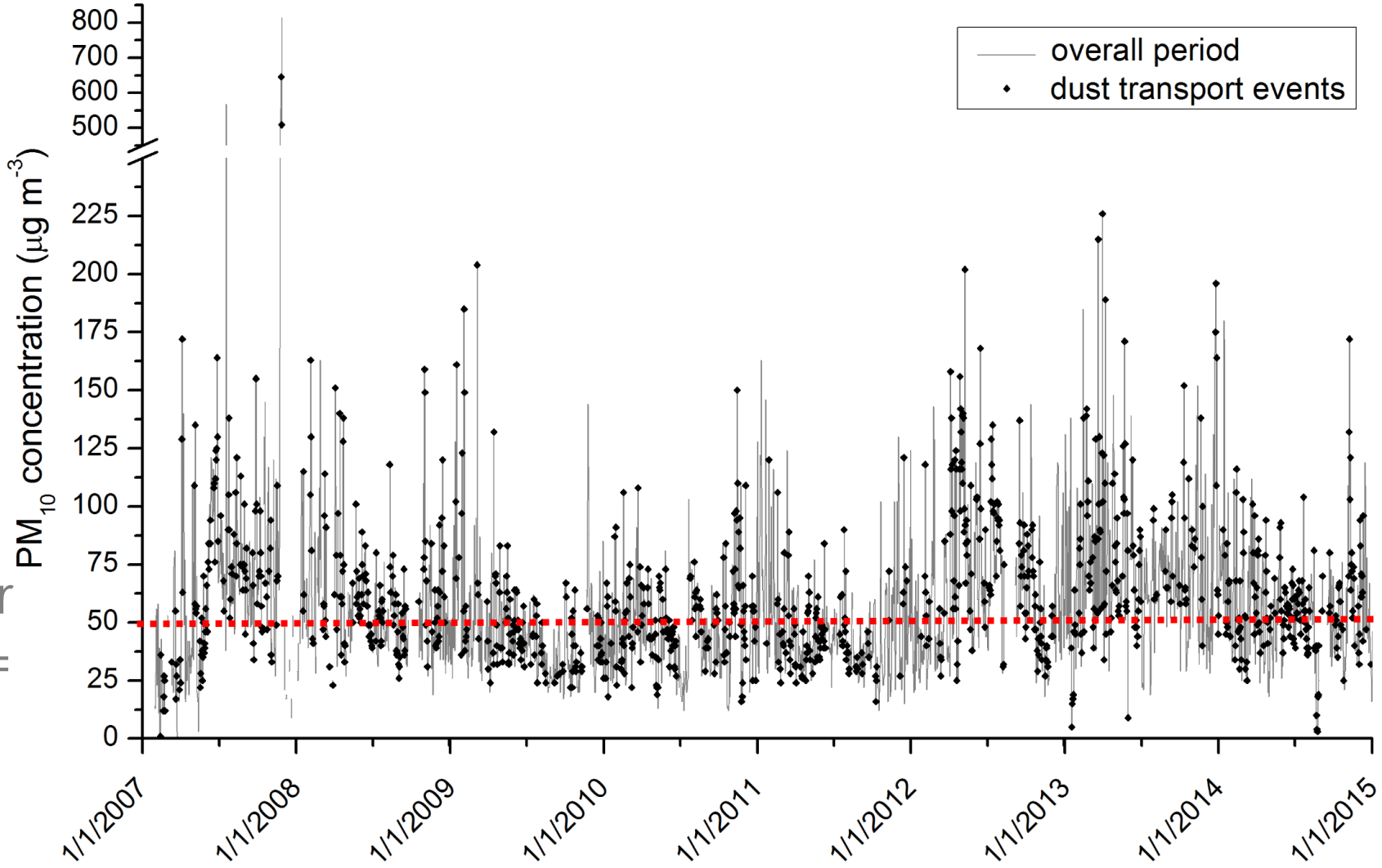
2007- 62%

2013 – 78%

N= 100-283/ year

N spring/winter = 322-329

N summer/fall = 272-278

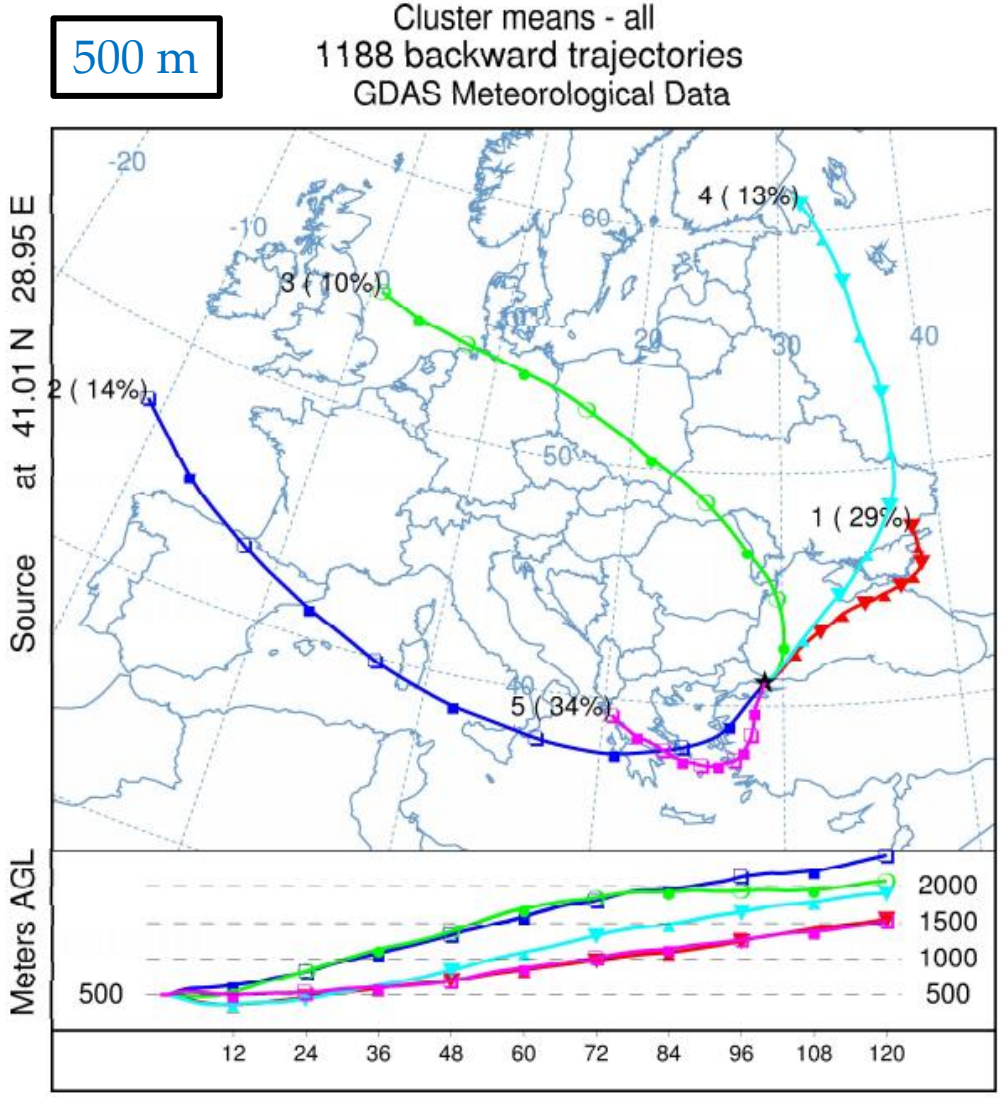



50 µg m$^{-3}$ EU Daily Limit Value

N<35 times/yr

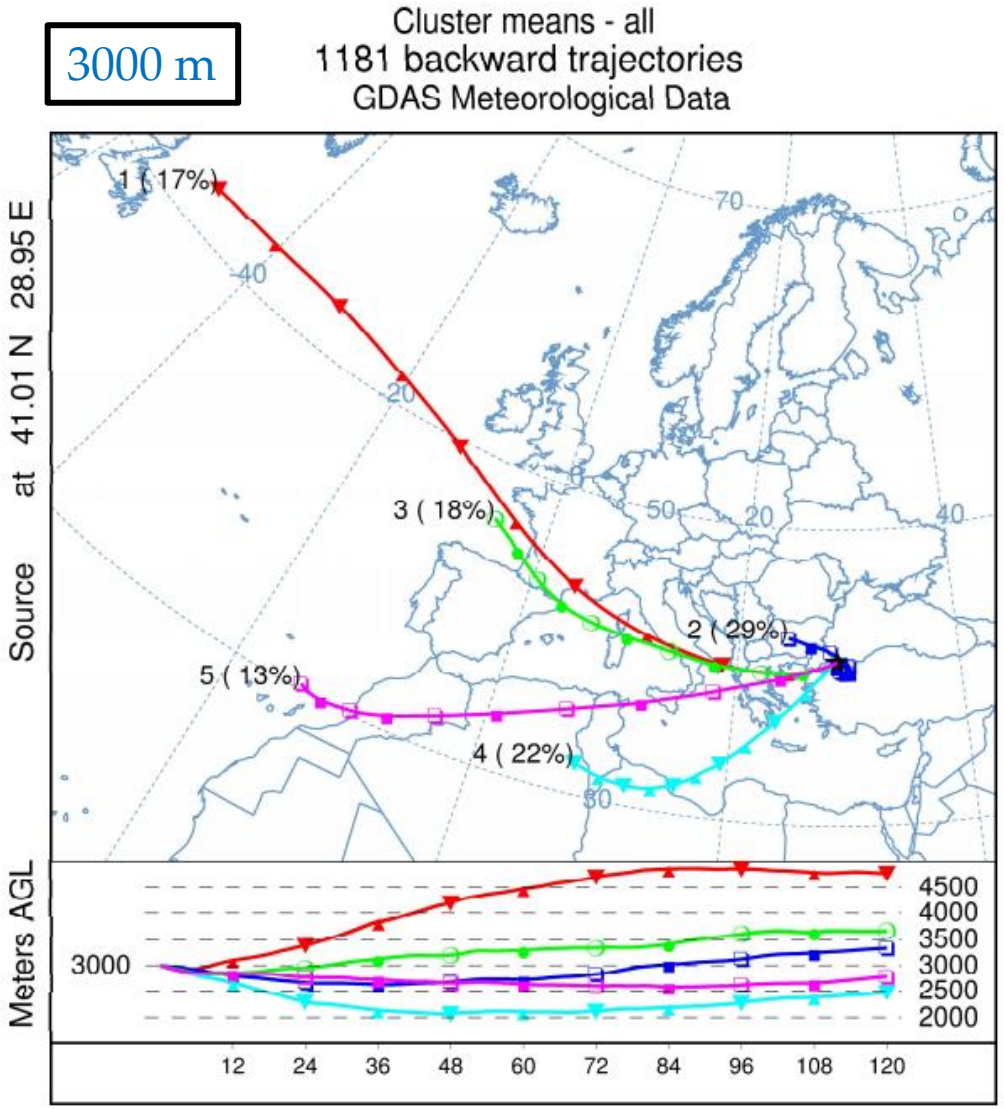
# Cluster analysis

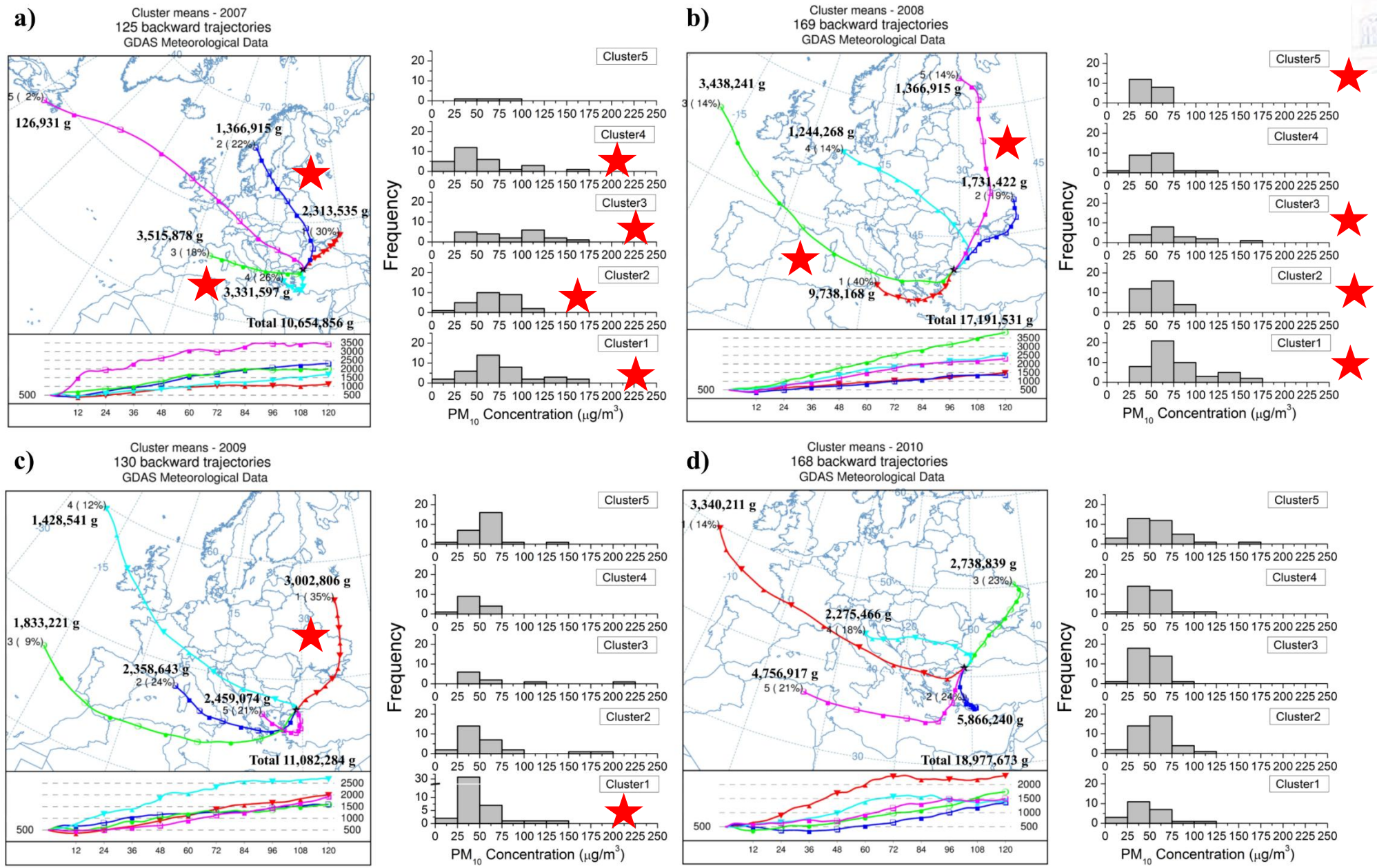
- Five clusters resolved over 82% of the variance on all years
- Northerly winds: Europe (2-29%), Ukraine/Finland/Black Sea (10-40%), Russia/Black Sea (6-35%).
- Southerly winds: Western Mediterranean (14-24%), African desert (7-21%), Short trajectories from Greece/Aegean sea (21-40%)
- 2011 – short trajectory Bulgaria 21%
- 2014 – Short trajectory Black Sea 22%

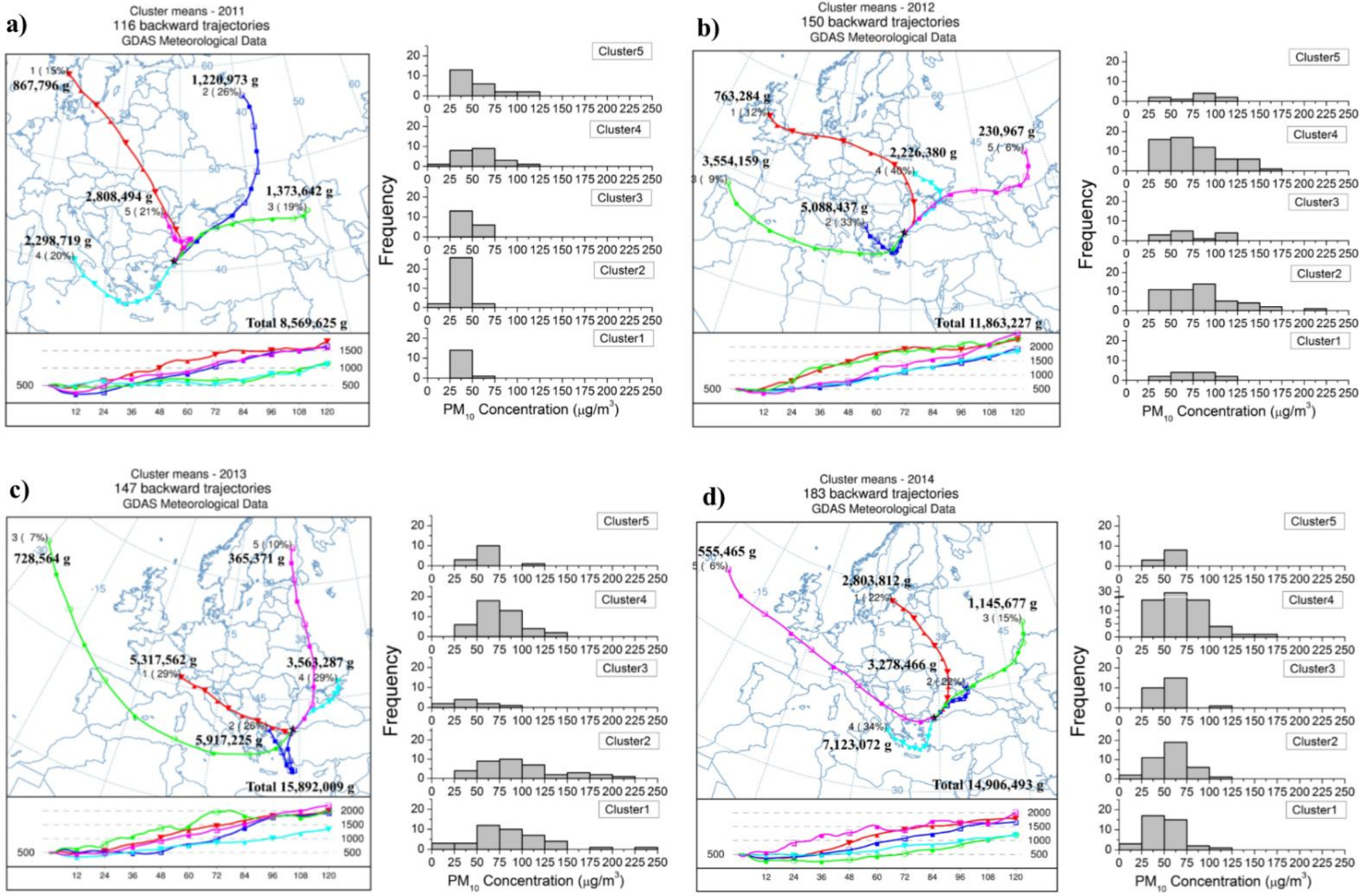


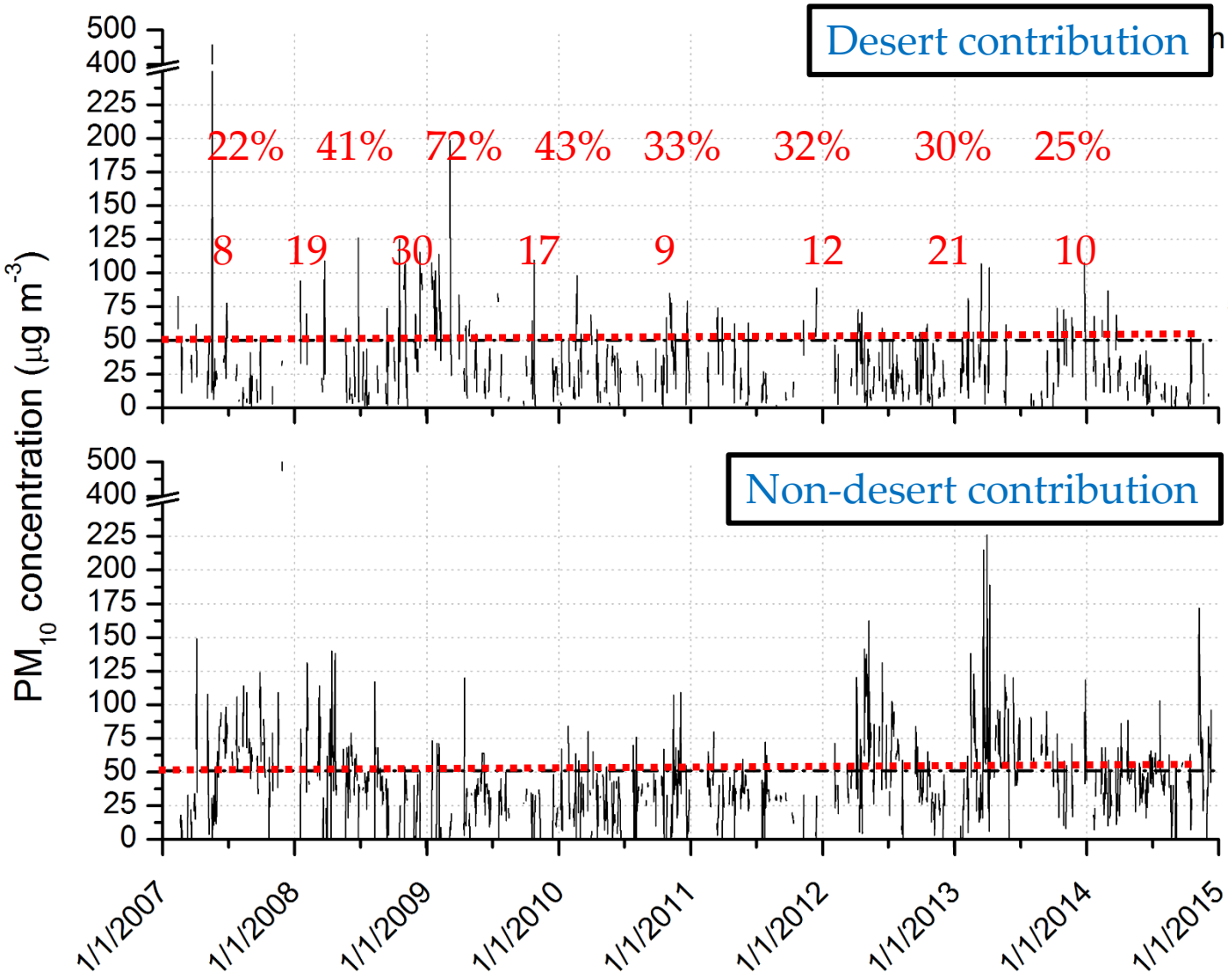
# Cluster analysis

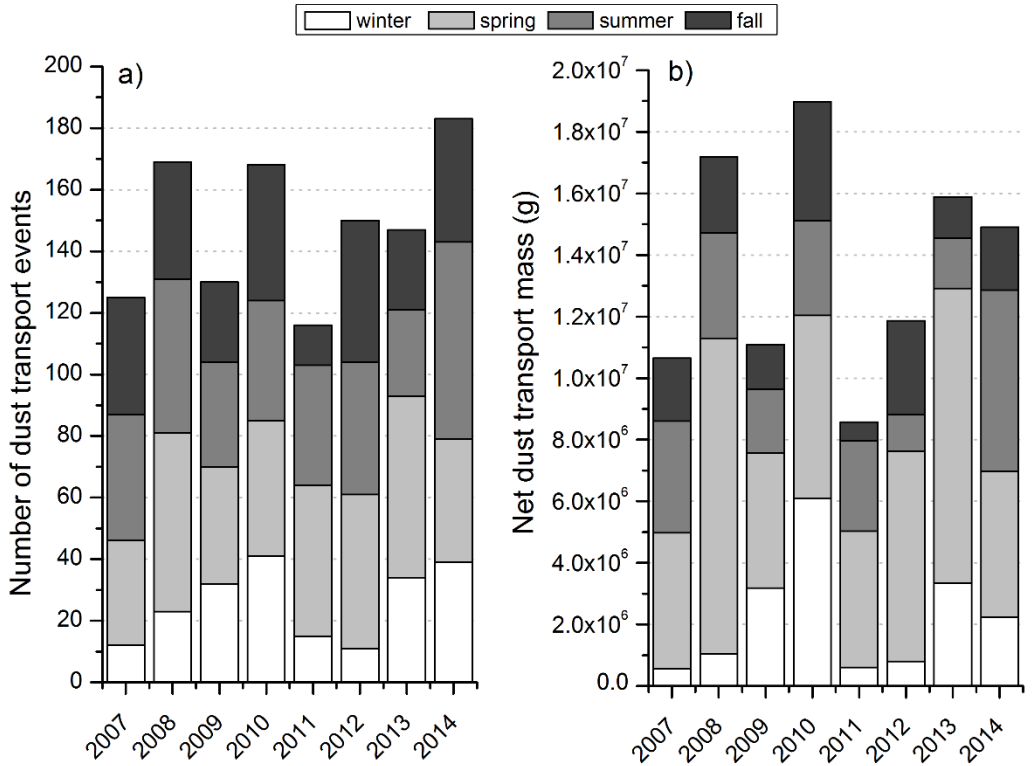
- Two southern trajectories originate from the African desert at 2500-3000 m.a.g.l. with total 35% frequency
- Trajectory 5 (13% frequency) may be associated with the highest amount of dust transport to Istanbul since it originates in the Grand Erg Occidental.
- Trajectory 4 (22%) may be associated to lower dust transport due to wet deposition or in-cloud scavenging processes occurring when air masses pass through the mountains (2500 m) in Southern Turkey.




a)
Cluster means - 2007
125 backward trajectories
GDAS Meteorological Data
5 ( 2%)
126,931 g
1,366,915 g
2 ( 22%)
2,313,535 g
1 ( 30%)
3,515,878 g
3 ( 18%)
4 ( 26%)
3,331,597 g
Total 10,654,856 g
b)
Cluster means - 2008
169 backward trajectories
GDAS Meteorological Data
3,438,241 g
3 ( 14%)
5 ( 14%)
1,366,915 g
1,244,268 g
4 ( 14%)
1,731,422 g
2 ( 19%)
1 ( 40%)
9,738,168 g
Total 17,191,531 g
c)
Cluster means - 2009
130 backward trajectories
GDAS Meteorological Data
4 ( 12%)
1,428,541 g
3,002,806 g
1 ( 35%)
1,833,221 g
3 ( 9%)
2,358,643 g
2 ( 24%)
2,459,074 g
5 ( 21%)
Total 11,082,284 g
d)
Cluster means - 2010
168 backward trajectories
GDAS Meteorological Data
3,340,211 g
2,738,839 g
3 ( 23%)
2,275,466 g
4 ( 18%)
4,756,917 g
5 ( 21%)
2 ( 24%)
5,866,240 g
Total 18,977,673 g
Cluster5
Cluster4
Cluster3
Cluster2
Cluster1
Frequency
PM10 Concentration (µg/m3)


a)
Cluster means - 2011
116 backward trajectories
GDAS Meteorological Data
1 ( 15%)
867,796 g
1,220,973 g
2 ( 26%)
2,808,494 g
5 ( 21%)
1,373,642 g
3 ( 19%)
2,298,719 g
4 ( 20%)
Total 8,569,625 g
Cluster5
Cluster4
Cluster3
Cluster2
Cluster1
Frequency
PM10 Concentration (µg/m3)
b)
Cluster means - 2012
150 backward trajectories
GDAS Meteorological Data
763,284 g
1 ( 12%)
230,967 g
5 ( 6%)
3,554,159 g
2,226,380 g
4 ( 40%)
3 ( 9%)
5,088,437 g
2 ( 33%)
Total 11,863,227 g
c)
Cluster means - 2013
147 backward trajectories
GDAS Meteorological Data
3 ( 7%)
728,564 g
5 ( 10%)
365,371 g
5,317,562 g
1 ( 29%)
3,563,287 g
4 ( 29%)
2 ( 26%)
5,917,225 g
Total 15,892,009 g
d)
Cluster means - 2014
183 backward trajectories
GDAS Meteorological Data
555,465 g
( 6%)
2,803,812 g
1 ( 22%)
1,145,677 g
3 ( 15%)
3,278,466 g
2 ( 22%)
4 ( 34%)
7,123,072 g
Total 14,906,493 g




- 50-86% of net dust loading occurs in spring and summer.
- 40-60% solely in spring

# Summary - Conclusions

- EU annual average air quality standard was exceeded all years between 2007-2014. The daily-averaged air quality standard was exceeded 51% of the time.
- At 500m, northern and southern air masses are approximately equally distributed. At 3000m, approximately 70% of the air masses follow southerly trajectories.
- 40-60% of the net dust load occurs in spring. Therefore, temporary air quality standards may be implemented to control local anthropogenic emissions.
- Important contributions of desert dust transport to surface PM10 concentrations were found, particularly in 2008-2011 with 41-72% of the yearly-averaged concentration.

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# Thank You


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- Turkish ministry of environment and urbanization- PM10 concentrations
- Turkish state meteorological service
- BSC – DREAM8b model
- NOAA –HYSPLIT
- NASA – remote sensing observations


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