Characterizing Atmospheric Particulate Matters in Tehran by Use of LiDAR, Atmospheric Models and Satellite Data

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5th Training course on WMO SDS-WAS Product

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1 Physics Department Remote Sensing Laboratory (PDRSL)

1-1 Stations


36.7 ° N, 48.5 ° E
1800 AMSL
35.7 ° N, 51.3 ° E
1430 AMSL
UZBEKISTAN
AZERBAIJAN
ARMENIA
TURKEY
SYRIA
TURKMENISTAN
GARAGUM
AFGHANISTAN
PAKISTAN
BALUCHISTAN
DASHT-E LŪT
KERMĀN
KORDESTĀN
SEMNĀN
OSTĀN-E KHORĀSĀN
YAZD
SĪSTĀN VA BALŪCHESTĀN
HORMOZGĀN
Baku
Tehrān
Mashhad
Zanjān
Qazvin
Karaj
Semnān
Qom
Kāshān
Arāk
Hamadān
Sanandaj
Kermānshāh
Ilām
Urmia
Mosul
Herāt
Kermān
Zāhedān
Bandar-e 'Abbās

1 PDRSL

1-2 Objectives

- Monitoring APM in Northwest and central parts of Iran.
- Determining APM'S sources that are affecting the Iran Plateau.
- Studding the APM'S annual behavior
- Specifying the physical and optical properties of APM as well as their dominant type in this region.

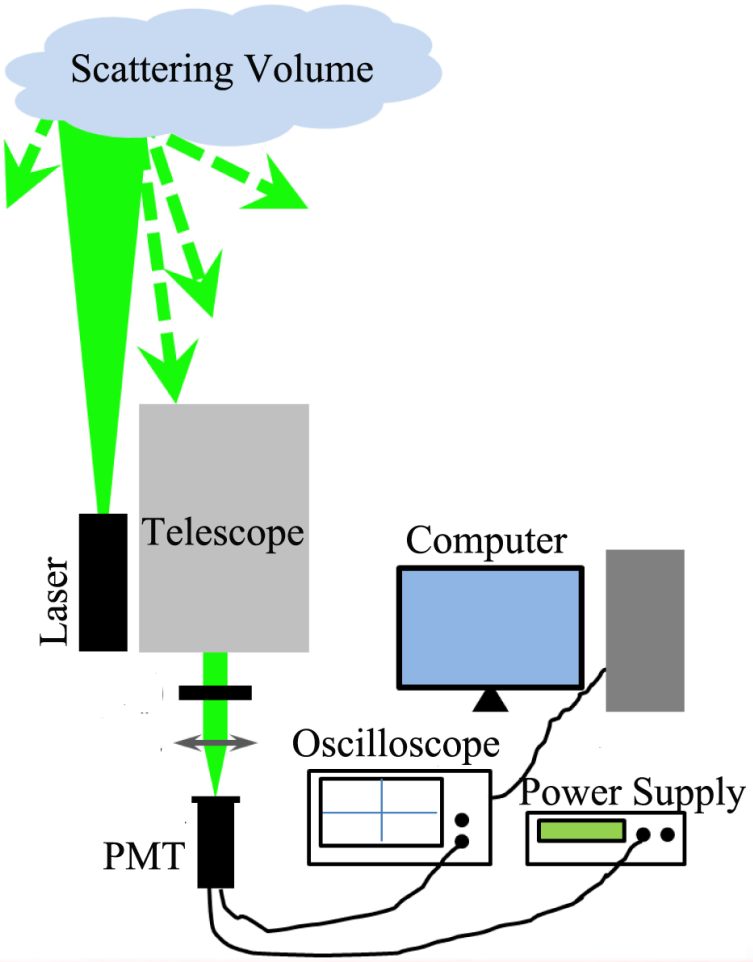
2 PDRSL

2-3 Methods

- GBM
- AQCC (PM, NO_2)
- HYSPLITE (BT, FT)
- SATELLITE DATA (CALIPSO, MODIS, OMI)
- WYOMING DATA (PT, PRESSURE, RELH, HV)
- NMMB/BSC-Dust Forecast

2 Lidar and Atmosphere

2-1 Remote Sensing Techniques



EBDL

lidar equation

$$P(R) = K\, G(R)\, \beta(R)\, T(R)$$

$$\beta(R) = \beta_{aer}(R,\lambda) + \beta_{mol}(R,\lambda)$$

$$T(R) = \exp\left[-2\int_0^R \alpha(r,\lambda)dr\right]$$

$$\alpha(R,\lambda) = \alpha_{mol,abs}(R,\lambda) + \alpha_{mol,sca}(R,\lambda) + \alpha_{aer,abs}(R,\lambda) + \alpha_{aer,sca}(R,\lambda)$$

3 EBDL

$$P(R) = P_0 \frac{c\tau}{2} A\eta \frac{O(R)}{R^2} [\beta_{aer}(R,\lambda) + \beta_{mol}(R,\lambda)]$$
$$\exp\left[-2\int_0^R [\alpha_{aer}(r,\lambda) + \alpha_{mol}(r,\lambda)]dr\right]$$

Known quantity: $\beta_{mol}(R,\lambda), \alpha_{mol}(r,\lambda)$

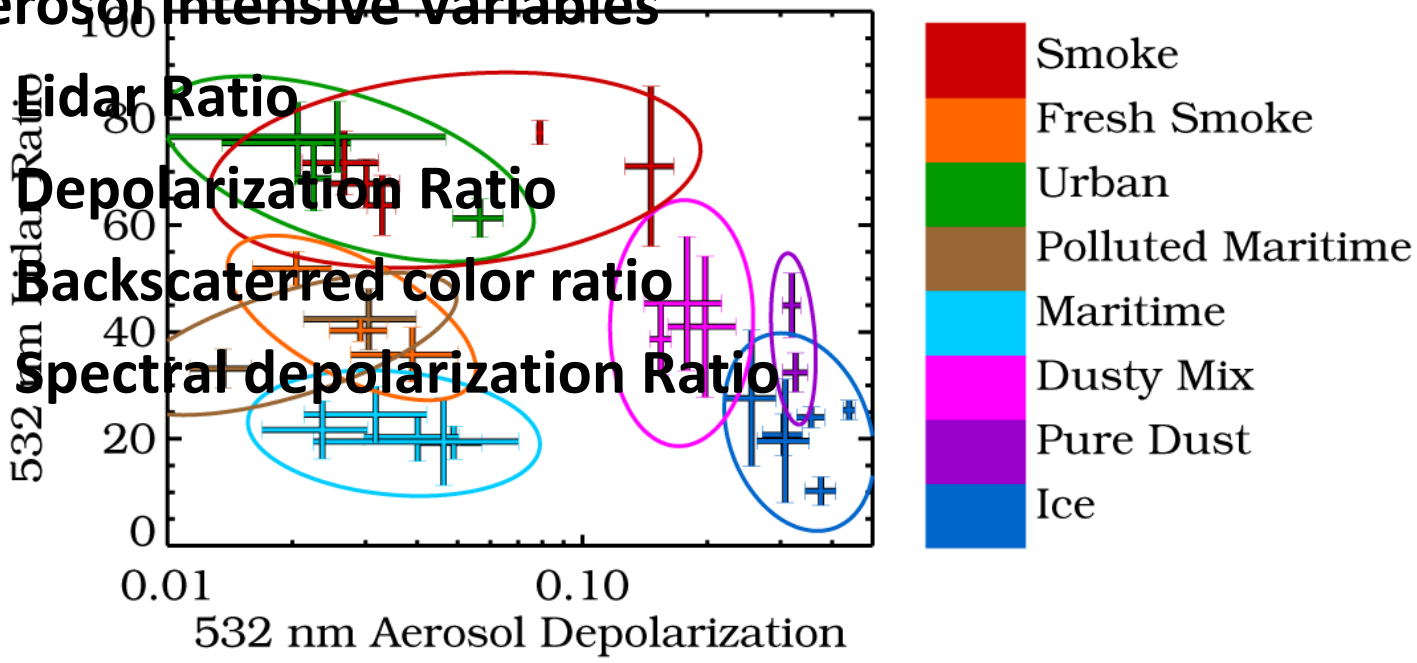
Unknown quantity: $\beta_{aer}(R,\lambda), \alpha_{aer}(r,\lambda)$

2 Lidar and Atmosphere

1-2 Aerosol Types

Aerosol Intensive Variables

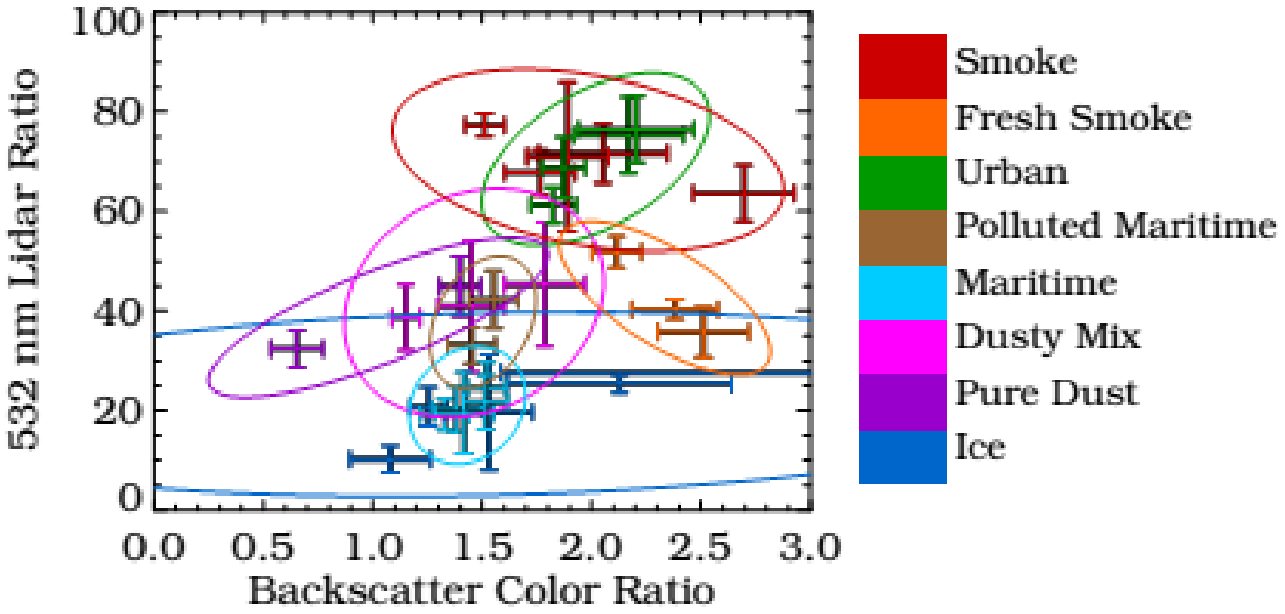
- **Lidar Ratio**
- **Depolarization Ratio**
- **Backscaterred color ratio**
- **Spectral depolarization Ratio**



Burton, S. P. et al. Aerosol classification using airborne high spectral resolution lidar measurements – methodology and examples. Atmos. Meas. Tech. 2012

2 Lidar and Atmosphere

1-2 Aerosol Types

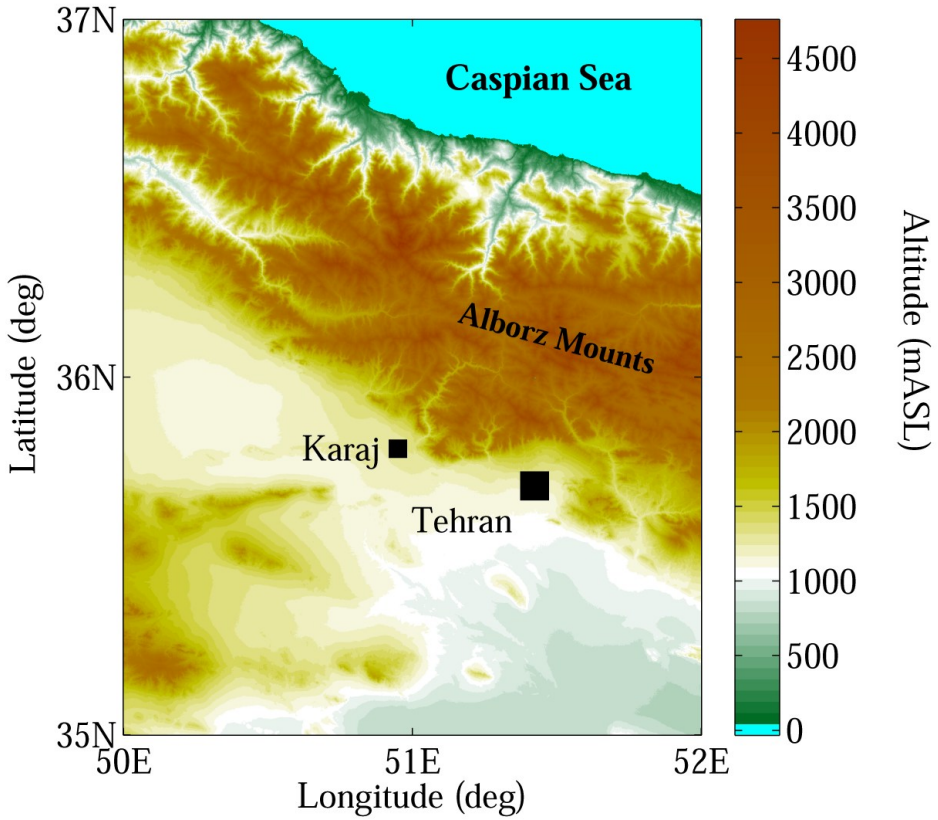


Burton, S. P. et al. Aerosol classification using airborne high spectral resolution lidar measurements – methodology and examples. Atmos. Meas. Tech. 2012

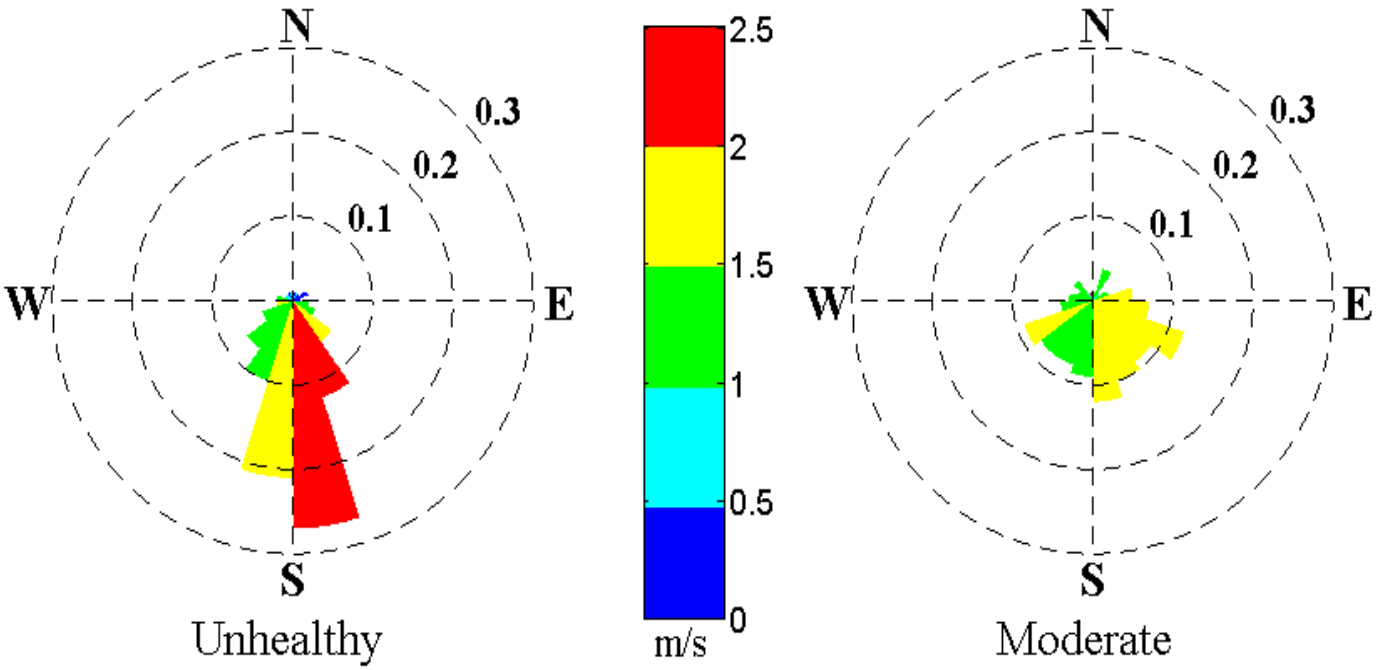
4 Case Studies

Tehran

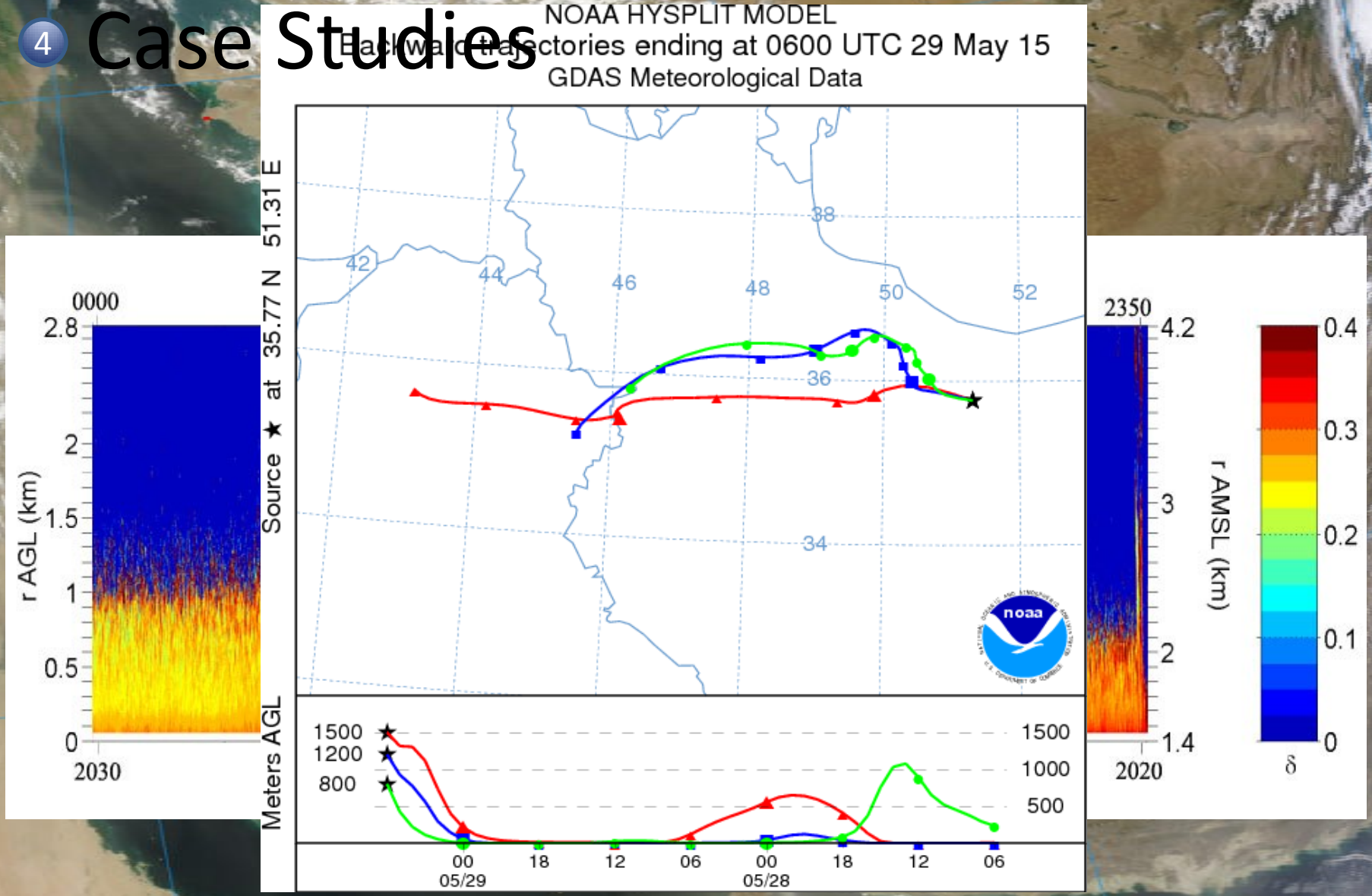
- population(2015)~12 millions
- Area: 22 km North-South,
  35 km East-West
- Elevation: 1,200 to 1,900 m
- Moving Vehicles ~ 3 millions
- Gas consumption:
  11.5 MLi/day



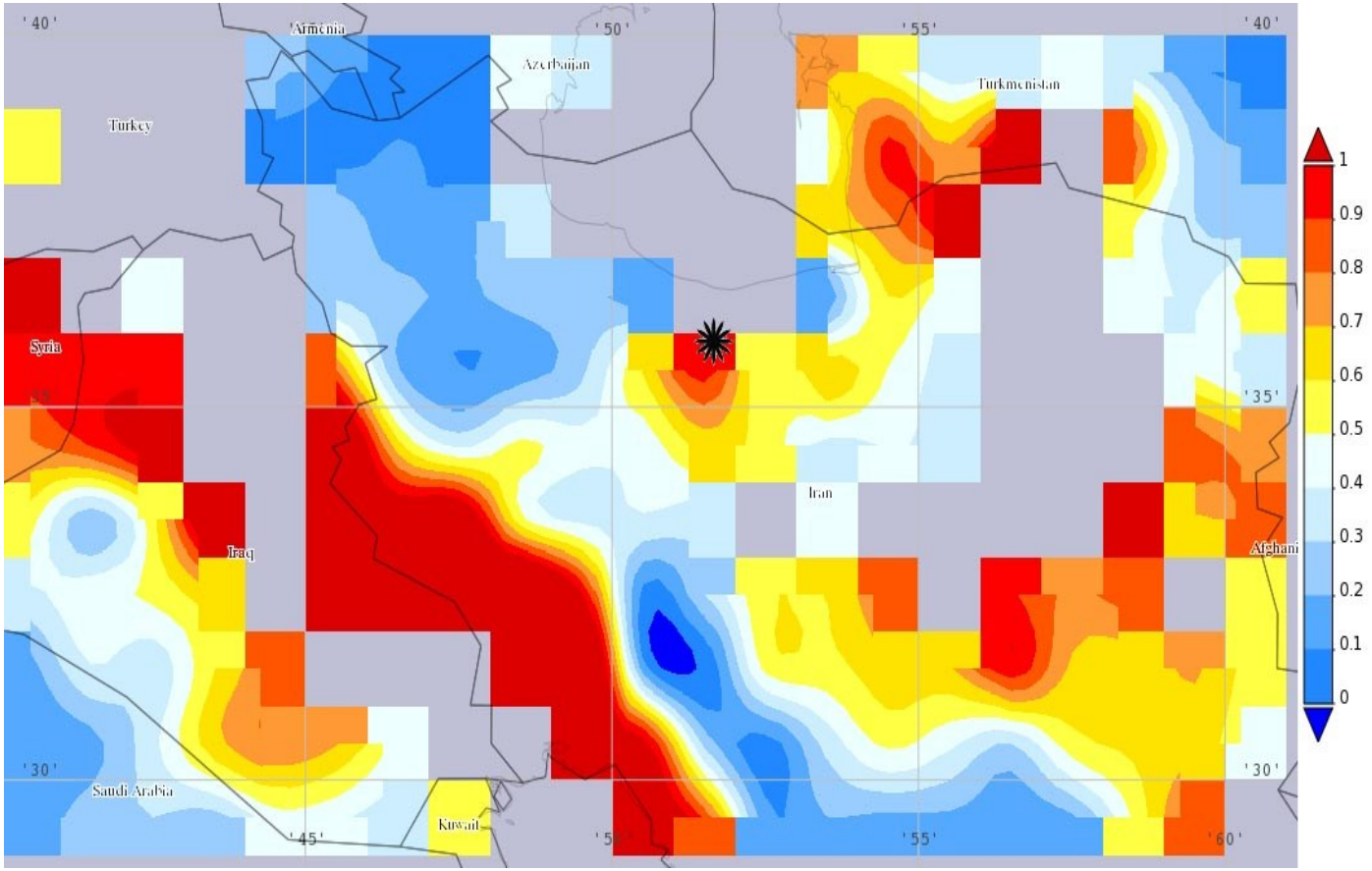
4 Case Studies



4 Case Studies

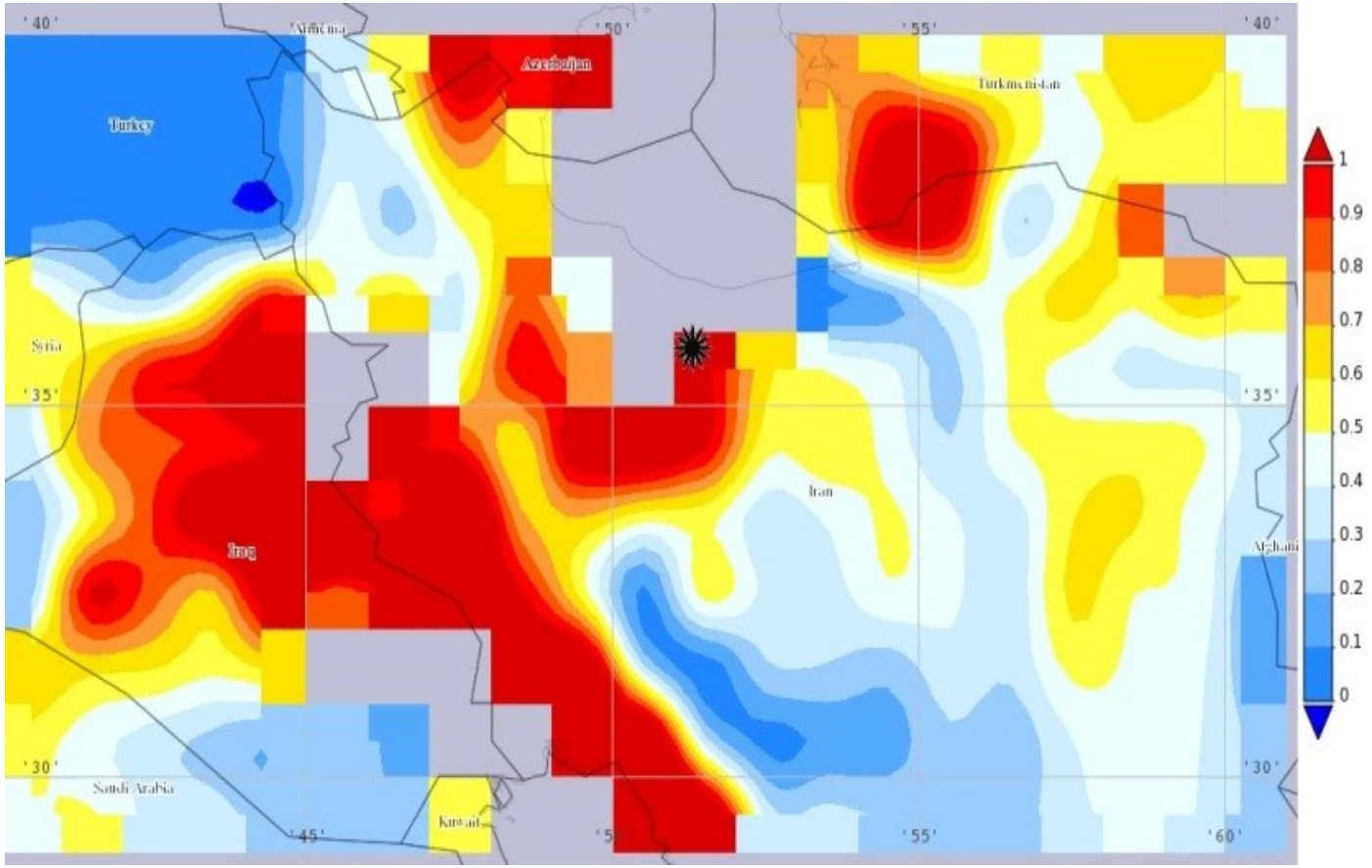


4 Case Studies



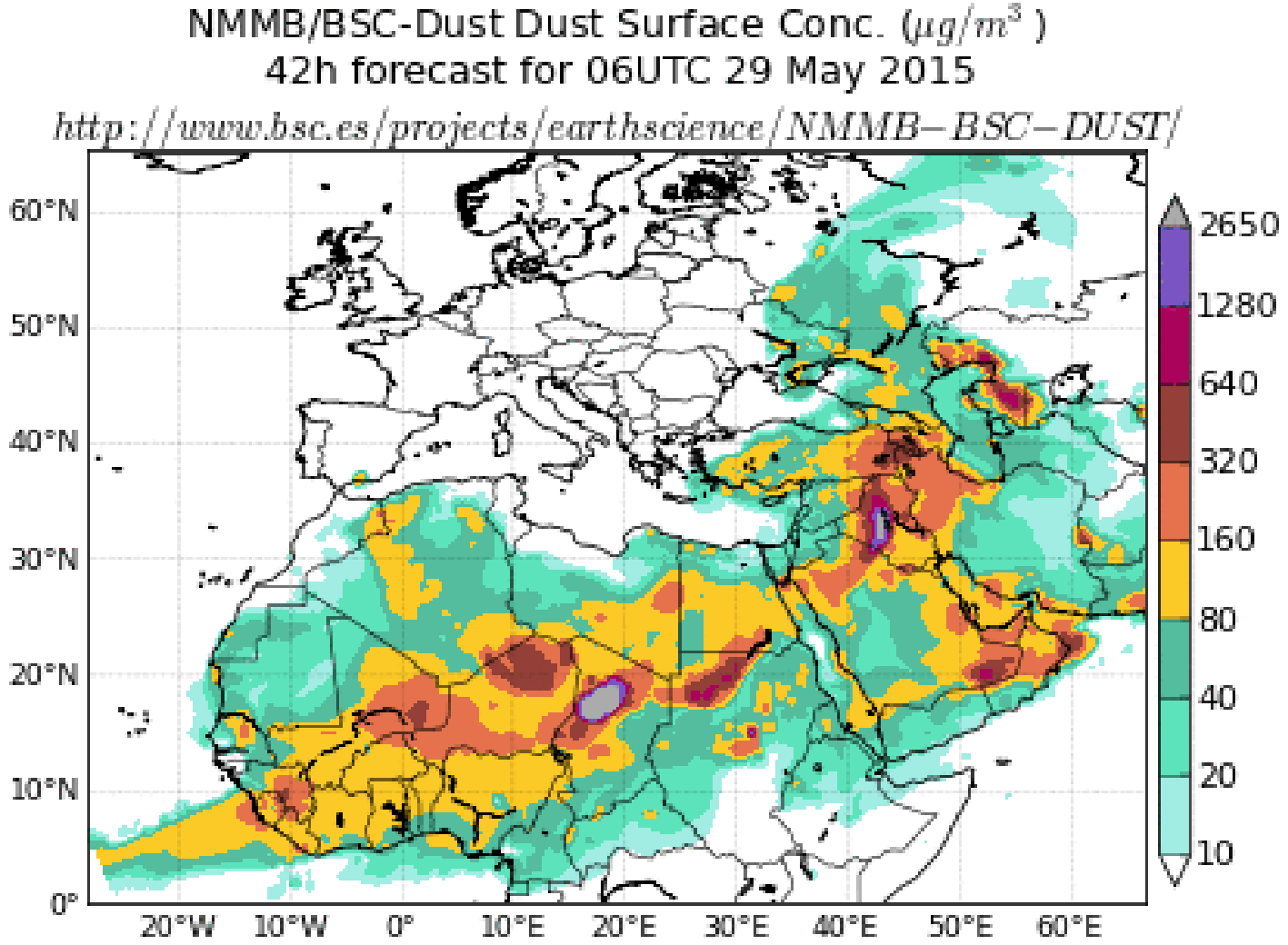
MODIS Deep Blue AOD map, May 27, 2015

4 Case Studies



MODIS Deep Blue AOD map, May 29, 2015

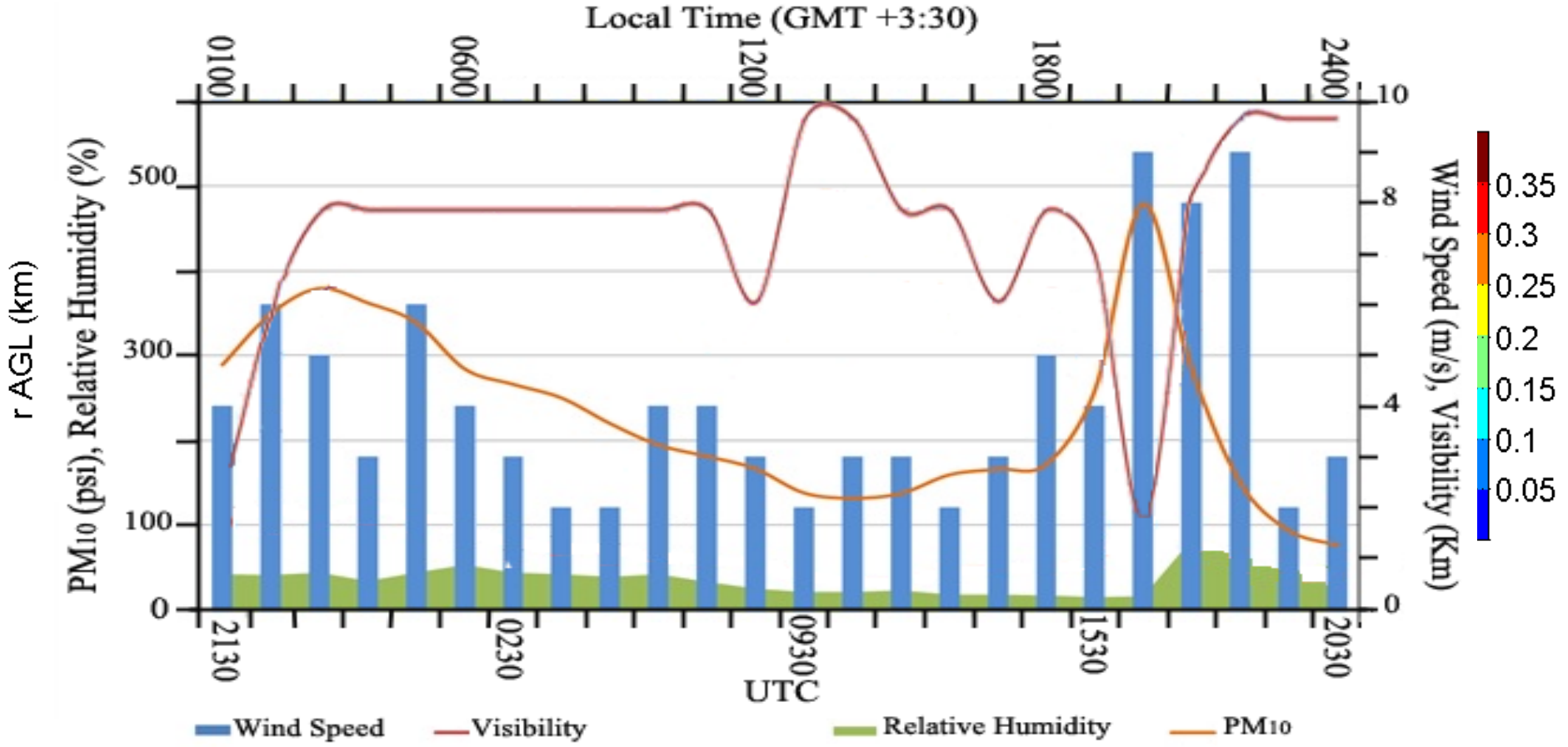
4 Case Studies



4 Case Studies

Dust event 19 Jul 2015

(PM_{10}: 185, $PM_{2.5}$: 161, NO_2: 54)



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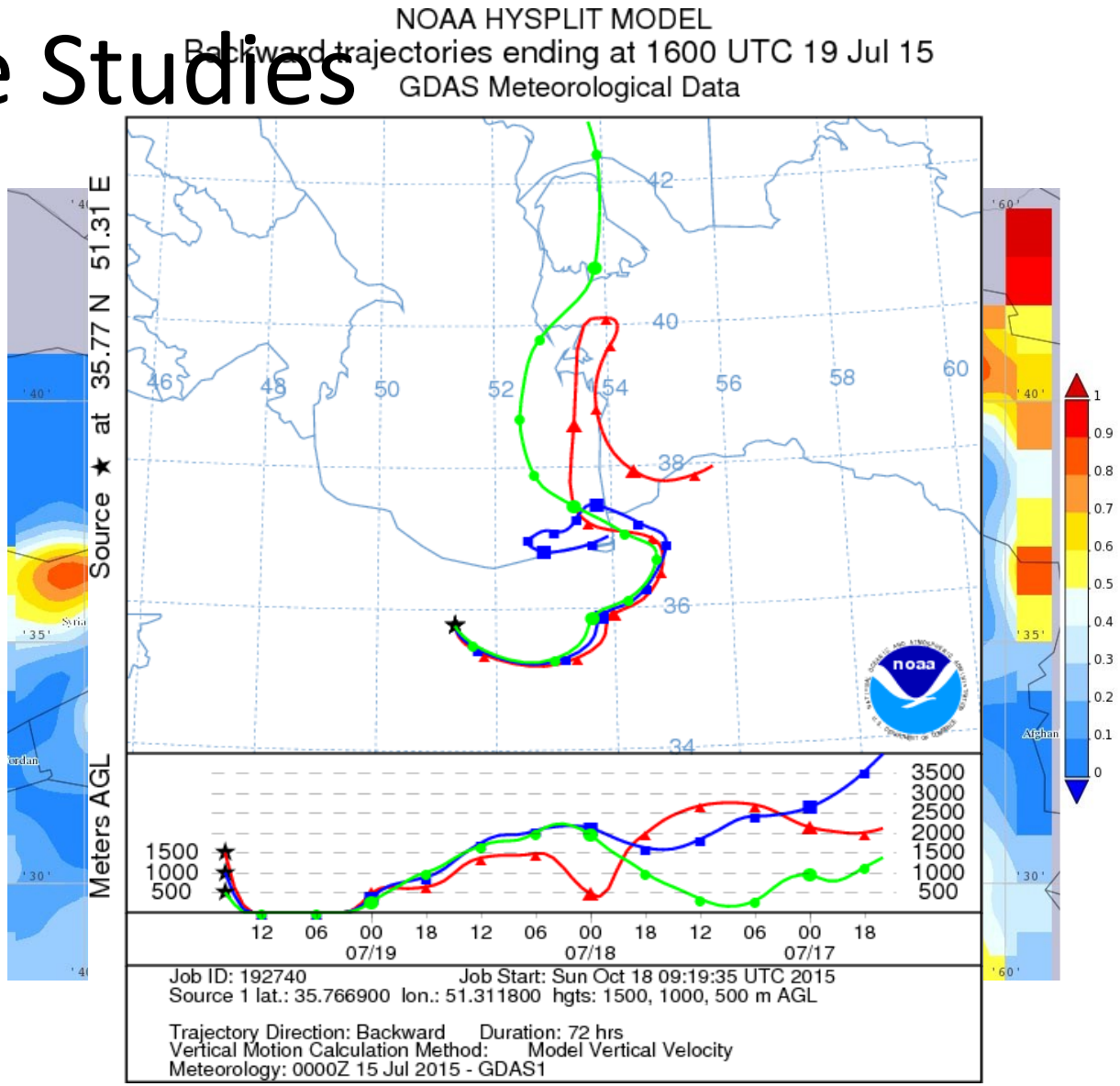
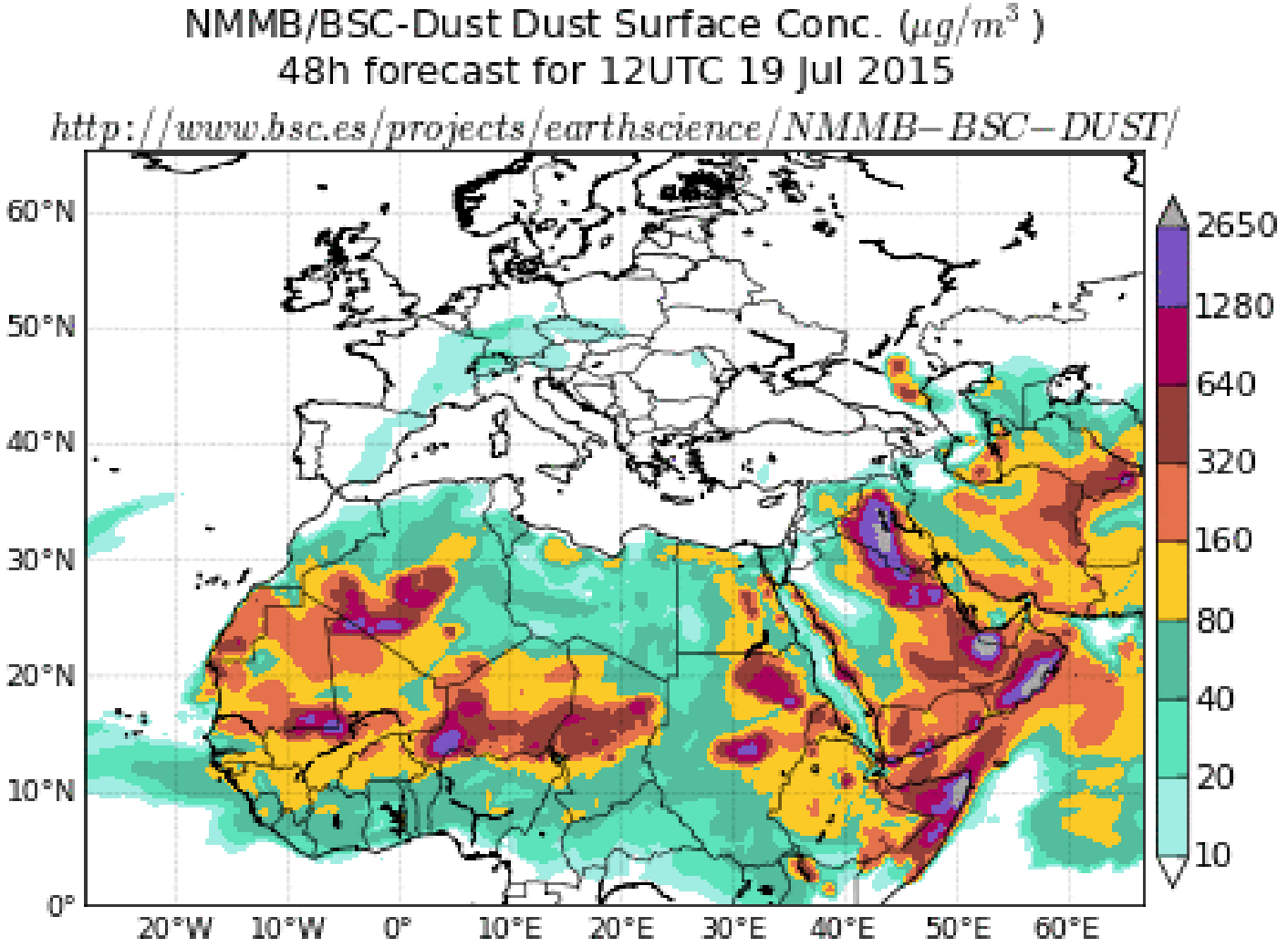
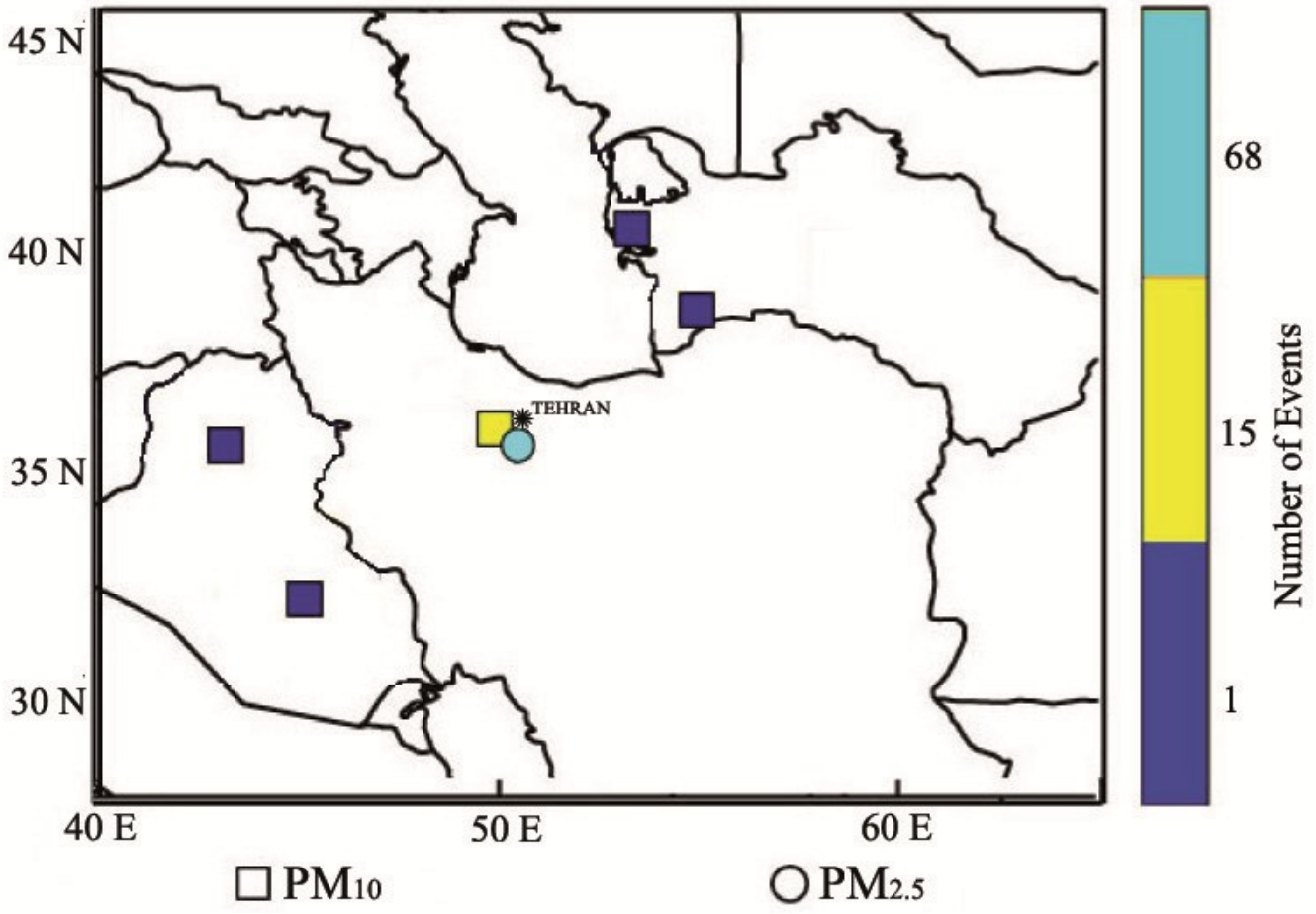



NMMB/BSC-Dust Dust Surface Conc. ($\mu g/m^3$)
48h forecast for 12UTC 19 Jul 2015
http://www.bsc.es/projects/earthscience/NMMB-BSC-DUST/
60°N
50°N
40°N
30°N
20°N
10°N
0°
20°W
10°W
0°
10°E
20°E
30°E
40°E
50°E
60°E
2650
1280
640
320
160
80
40
20
10

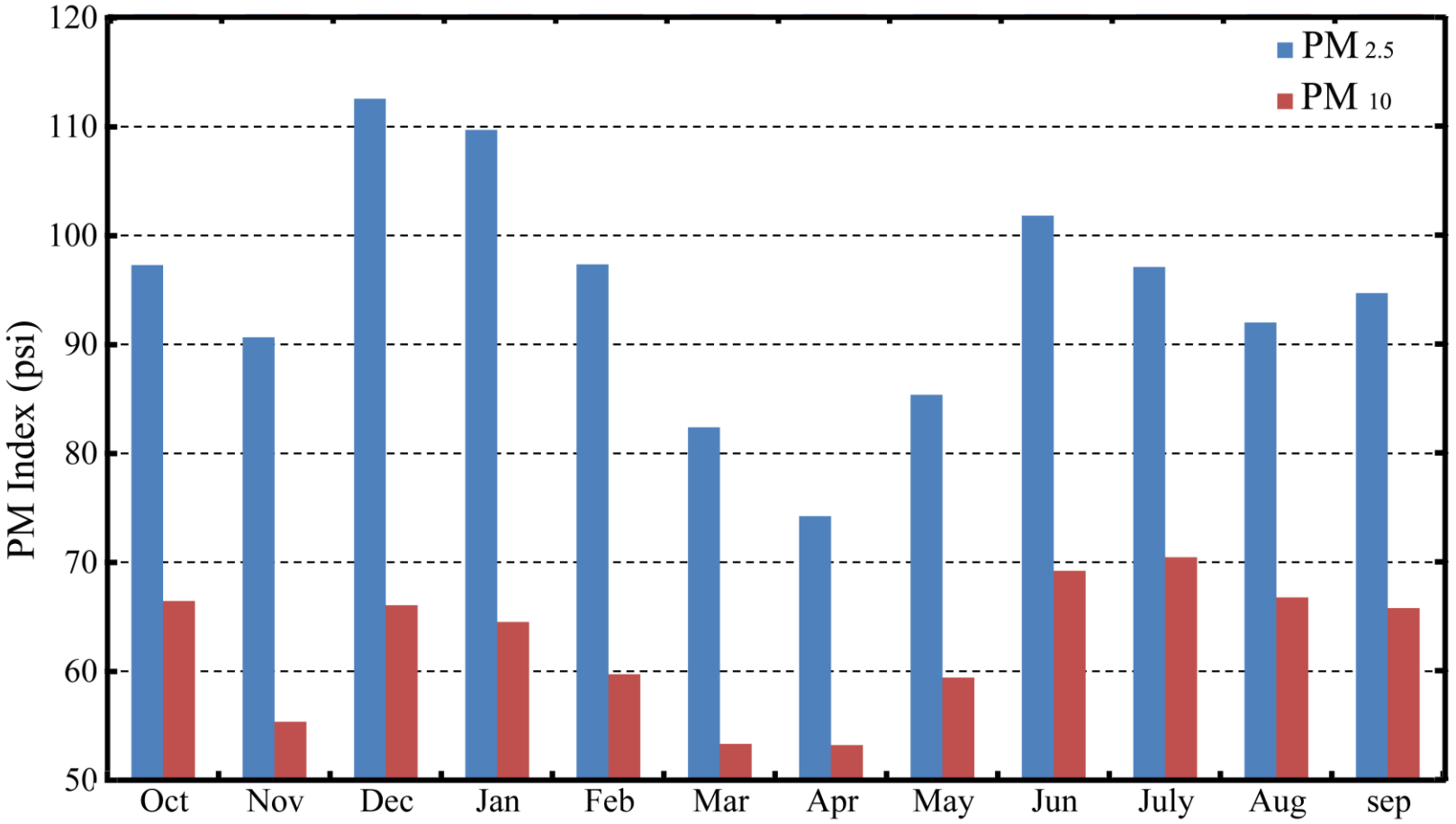
5 Conclusion

Sources of the events



5 Conclusion

Temporal variations of dust and pollution outbreaks



Monthly average values of PM_{10} and $PM_{2.5}$
Oct 2011 to Sept 2015, ref: AQCC

5 Conclusion

- Iran plateau is located on the Earth dust belt and surrounded by intense dust sources.

- Both dust and anthropogenic particles are contaminating the Tehran atmosphere.

- Most polluted days with anthropogenic aerosols are in winter times due to temperature inversions and low wind speed (< 3m/s).

- Most of the dust events are happening in late spring and summer times.

Gracias