REMOTE SENSING STUDY OF PARTICULATE MATTER AIR POLLUTION OVER NORTHERN ITALY

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Po valley, in the northern part of Italy, is the area with the most severe air pollution problems in the country as it is the largest industrial, trading and agricultural area with a high population density. The Alpine chain at the North and West sides of the valley, and the Apennines to the South, act as a barrier to winds blowing from Northern Europe and the Mediterranean, favoring the stagnation of pollutants. Ground-based observations represent local measurements and do not have the necessary coverage to map the distribution of aerosols all over the Po valley.

Aim of the work: investigate and study the relationship between the satellite remote sensing aerosol retrievals and the ground-based particulate matter measurements.
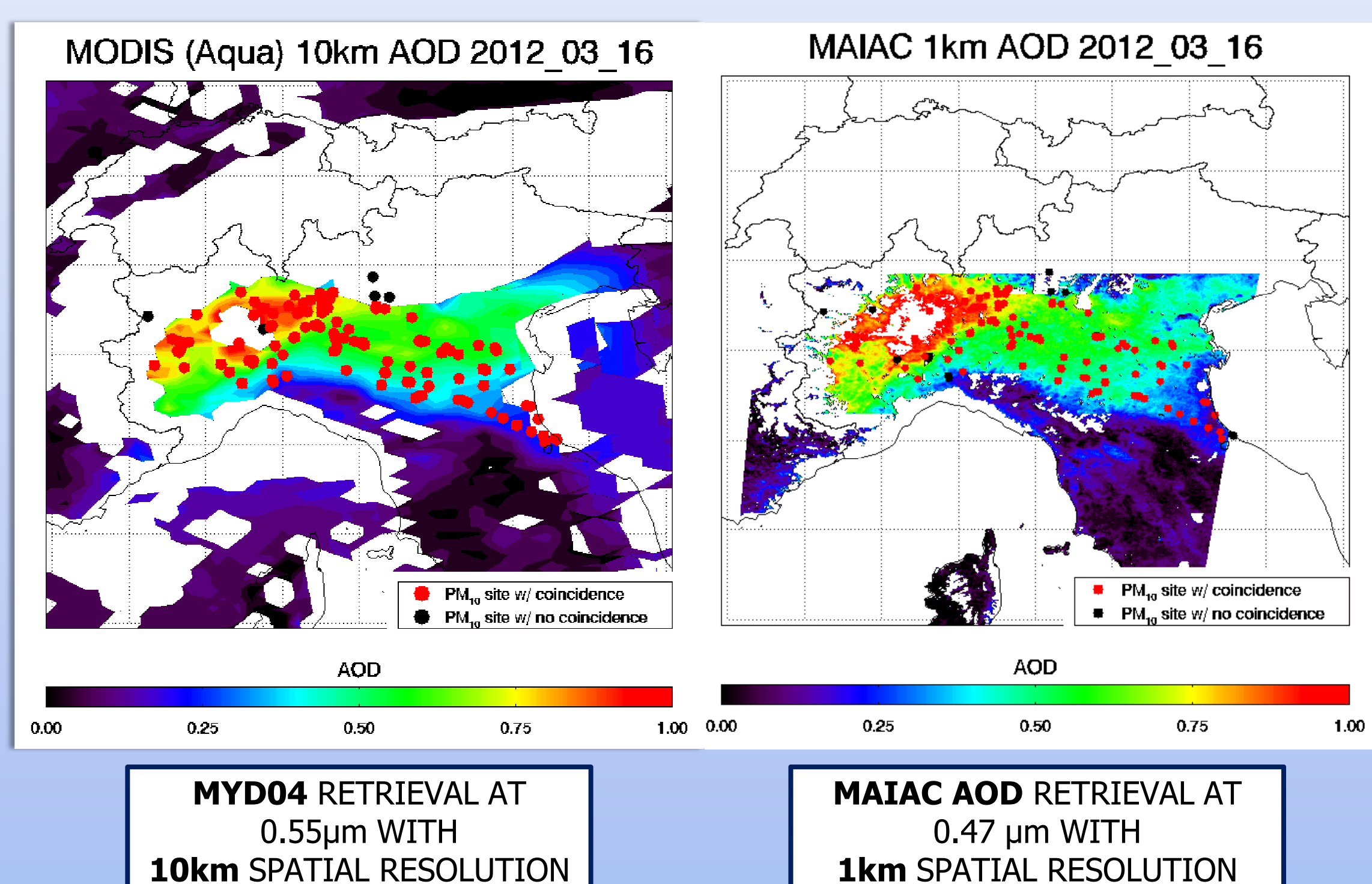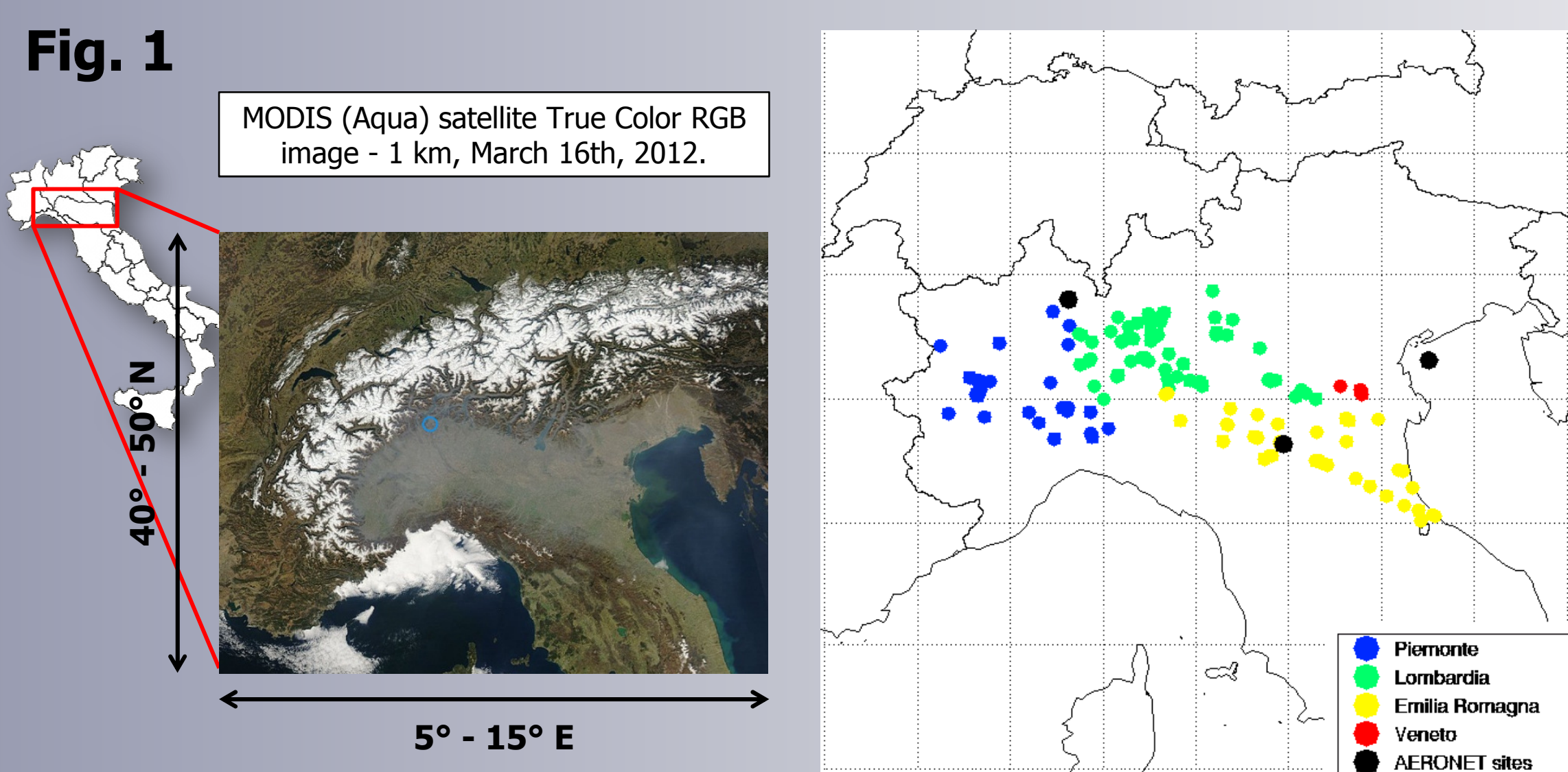
Fig. 1

MODIS (Aqua) satellite True Color RGB image - 1 km, March 16th, 2012.

- Piemonte
- Lombardia
- Emilia Romagna
- Veneto
- AERONET sites

METHODS

❑ **PM$_{10}$** in µgm^{-3}, was considered over 126 air quality monitoring stations of the ARPA (*Italian Regional Agency for Environmental Protection*) network, across four different administrative regions: Piemonte (27 stations), Lombardia (59 stations), Emilia Romagna (37 stations) and Veneto (3 stations); cf. **Figure 1**.

❑ **AOD** (*Aerosol Optical Depth*) measurements (**Figure 2**) from the NASA Aqua satellite were retrieved using two different methods:

  ❑ standard MODIS (*MODerate resolution Imaging Spectroradiometer*) Aqua Collection 5.1 level 2 (MYD04_L2) with a nominal spatial resolution of 10km at nadir that extends roughly four-fold to the edges of the swath;

  ❑ the new MAIAC aerosol retrieval algorithm (Multi-Angle Implementation of Atmospheric Correction) with a finer spatial resolution of 1km, developed by NASA and not publicly available yet (Lyapustin et al., 2011).

❑ One year (2012) of **coincidence data** of PM$_{10}$ concentration, MODIS AOD obtained over the Po valley was used to establish and study the relationship between the ground and the satellite aerosol retrieval.

AEROSOL VERTICAL DISTRIBUTION

❑ Since the majority of aerosol abundance resides in the boundary layer, the thickness of boundary layer has direct impacts on the correlation between AOD and PM. For this reason the PM$_{10}$ - AOD normalized by the *Planetary Boundary Layer* (PBL) height over the Po Valley has been under investigation correlation.

❑ As assumption: the aerosols are confined and mixed homogeneously within boundary layer only. So, the values of AOD normalized by PBL height (ZPBL) may be regarded as mean PBL extinction in km^{-1} (**Figure 3**).

Fig. 3

$$AOD = \int_{0}^{TOA} \sigma_{0.55\,\mu m}^{ext}(z)\,dz$$

Fig. 2

MODIS (Aqua) 10km AOD 2012_03_16 | MAIAC 1km AOD 2012_03_16

- PM$_{10}$ site w/ coincidence
- PM$_{10}$ site w/ no coincidence

MYD04 RETRIEVAL AT 0.55µm WITH **10km** SPATIAL RESOLUTION

MAIAC AOD RETRIEVAL AT 0.47 µm WITH **1km** SPATIAL RESOLUTION

The MYD04 aerosol product, MAIAC aerosol retrieval algorithm and the surface particulate matter PM$_{10}$, were collocated *in space* for a comparative and quantitative analysis (year 2012)

PM – AOD CORRELATION — Fig. 4

MODIS - 2012 | MAIAC - 2012

MODIS AOD/GFS ZPBL = 1.15* PM$_{10}$+0.04
R^2 = 0.98
stations: #126
N = 12536
Method Coincidence = NEAR NEIGHBOR
Rad Coincidence = 0.20

MAIAC AOD/GFS ZPBL = 0.98* PM$_{10}$+0.19
R^2 = 0.98
stations: #126
N = 16325
Method Coincidence = NEAR NEIGHBOR
Rad Coincidence = 0.02

❑ **Linear regression equation** derived by binning PM$_{10}$ (24Hrs) into 5 µgm^{-3} intervals (Gupta et al., 2006)

❑ Normalizing by ZPBL improves the PM$_{10}$ – AOD correlation for the whole Po valley domain (**Figure 4**).

❑ **R^2 = 0.98** for both MYD04 and MAIAC aerosol retrievals, showing a almost linear behavior with a slope close to 1.

❑ Robust estimate of the linear regression between the averaged PM$_{10}$ and the satellite AOD retrieval data.

TIME SERIES ANALYSIS — Fig. 5

PoValley

- PM (24Hrs) Mean Value in ug/m^3
- PM Monthly Mean in ug/m^3
- MODIS AOD/ZPBL Monthly Mean in 1/km
- MAIAC AOD/ZPBL Monthly Mean in 1/km

Method Coincidence = NEAR NEIGHBOR
Rad Coincidence = 0.20
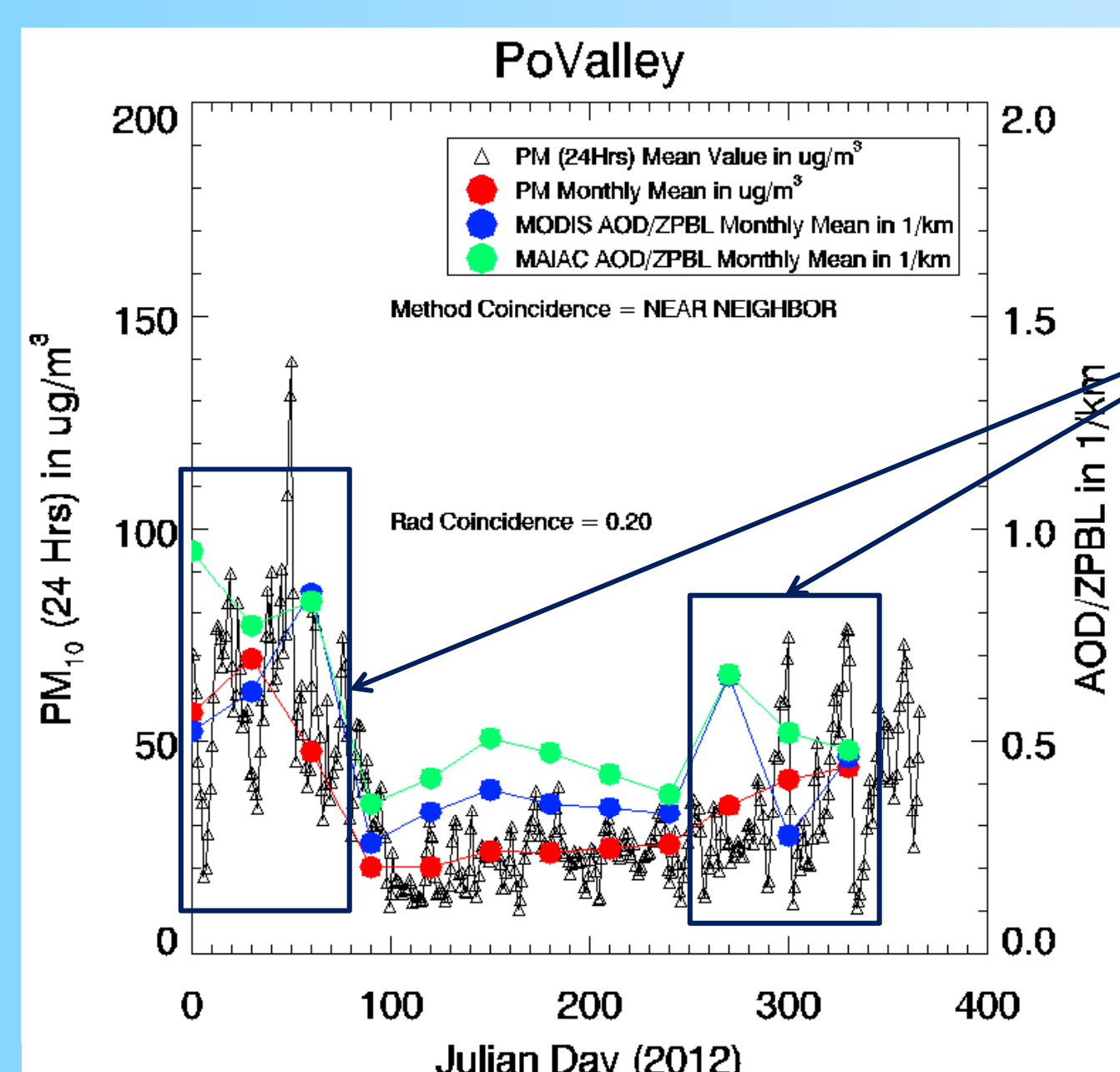
Trends more comparable for the fall/winter seasons

❑ MYD04 and MAIAC mean AOD values follow the PM trend throughout the year 2012; good agreement in the fall and in the winter period (**Figure 5**).

❑ The result is in agreement with the meteorological condition that characterize the Po valley domain:

  ❑ in the winter season, higher values of atmospheric air pollution particulate are recorded, due to meteorological conditions that favor the near-surface pollutants buildup.

IMAPP IDEA-International APPLICATION

❑ Terra/Aqua MODIS AOD retrievals are available daily.

❑ The use of these products by *Infusing satellite Data into Environmental Applications* (**IDEA**) - **International** software, open source and portable package, permits a near real-time air quality forecasts (Al-Saadi et al., 2005).

❑ AOD retrieval is used to initialize the trajectories which show where the aerosol will move in the next 48 Hrs, in 3 dimensions (**Figure 6**); the trajectories are predicted using the NASA Langley code, combining the GFS (Global Forecast System) data information.

MODIS AOD & AOD Trajectories on 2012-03-16 09Z

AERONET_Ispra.2012062.terra.1km

Pollution source

Predicted venting of aerosols to the Adriatic sea of the severe pollution from the Po valley on **March 2nd, 2012**

MODIS AOD & AOD Trajectories on 2012-03-03 00Z

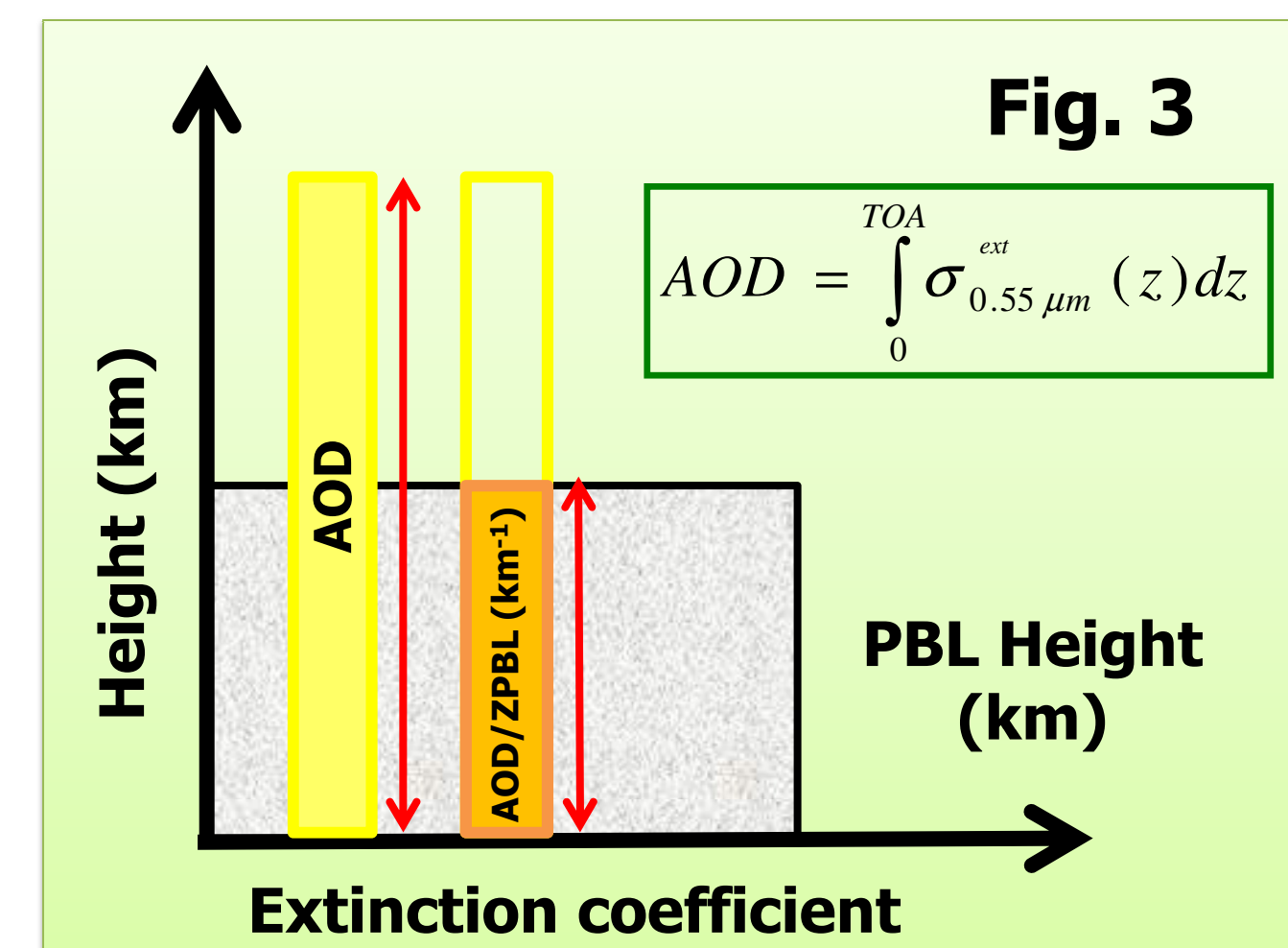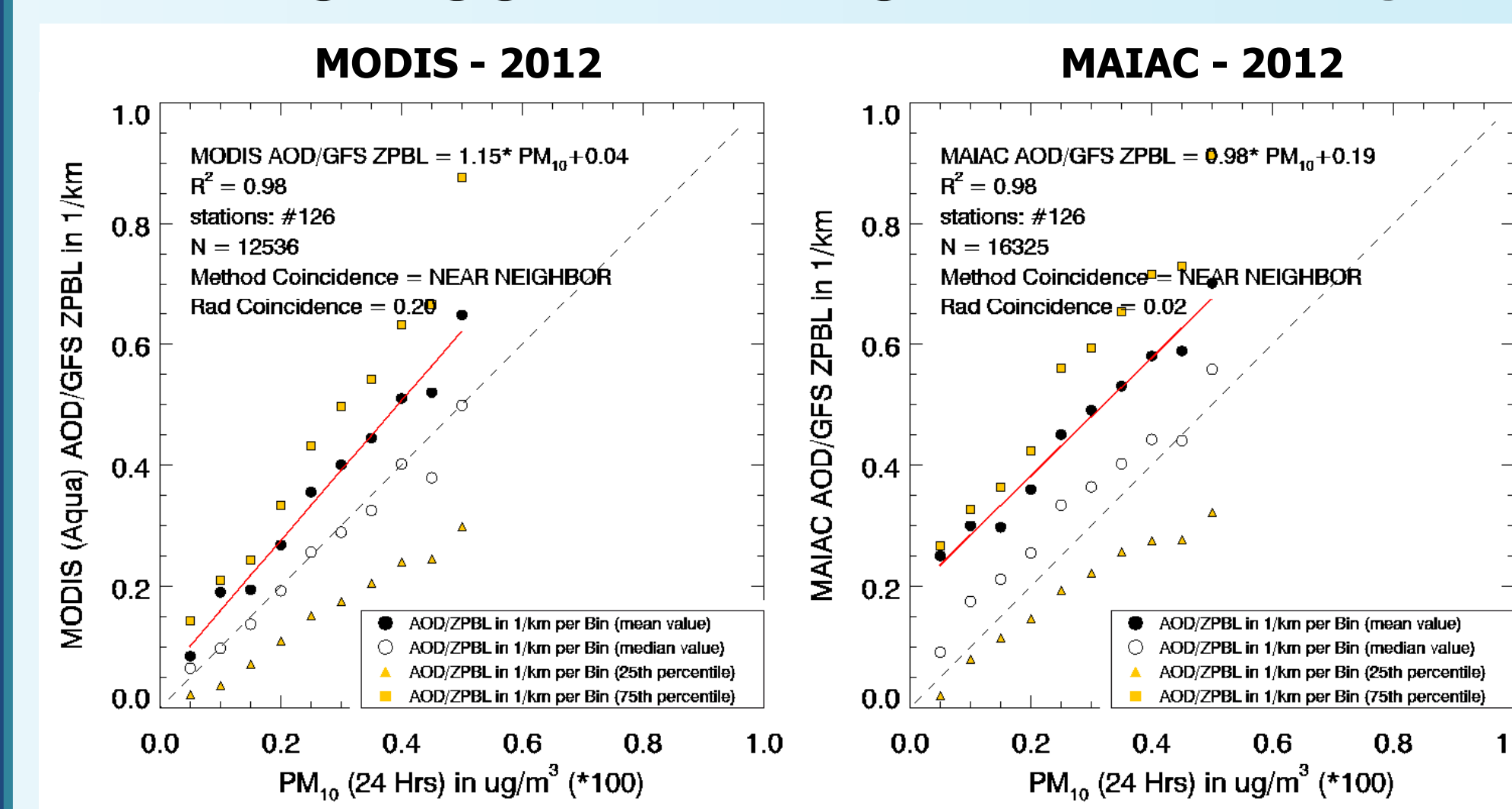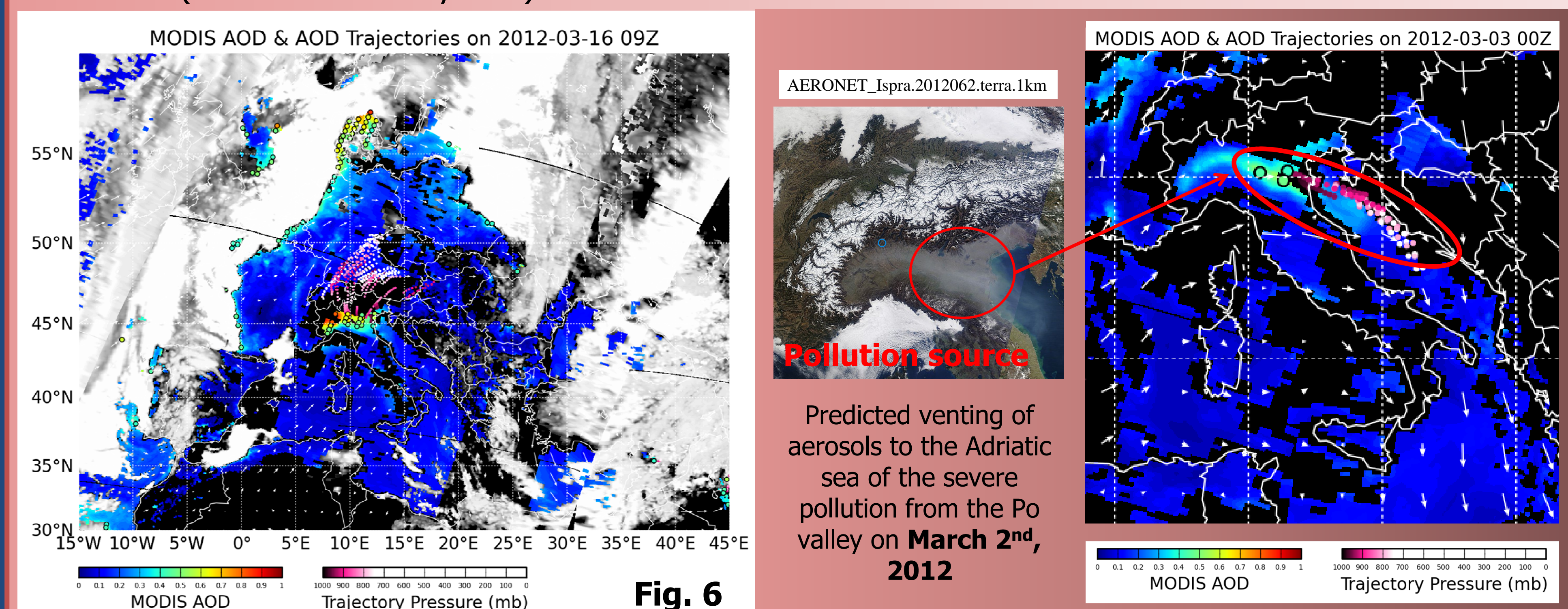MODIS AOD | Trajectory Pressure (mb)

Fig. 6

SUMMARY

❑ The good results obtained from the PM – AOD correlation suggests that the satellite remote sensing aerosol retrieval data may be a good substitute for the air quality assessment over northern Italy and obtained air quality indices where PM measurements are available.

❑ MAIAC 1km retrieval provides high resolution information on AOD within the highly industrialized study domain.

❑ The application of IMAPP IDEA-I aerosol forecasts heightens the comprehension of air quality within the Po valley area when meteorological data information are not available.

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