The contribution of port-related emissions and meteorology in the air quality of Igoumenitsa port

Dr. Ioannis Logothetis, Christina Antonopoulou,

Konstantinos Sfetsioris, Dr. Adamantios Mitsotakis, Dr. Panagiotis Grammelis

Correspondence: logothetis@certh.gr

2nd International Electronic Conference on Applied Sciences

15/10/2021 - 31/10/2021

Abstract: *The port-related emissions impact on climate risk affecting the air quality and human health in coastal regions (UNEP). The port of the city of Igoumenitsa is located in Western Greece and it is a trade bridge for Western Europe and the Balkans showing a heavy traffic of goods and passengers. This study aims to investigate the effect of shipping and port activity on the air quality in the port of Igoumenitsa comparing two representative seasons. For the analysis, a mobile air quality monitoring system is used. Results show that port-related emissions are associated with air quality degradation and emphasize the importance of green and sustainable management regarding the port operation.*

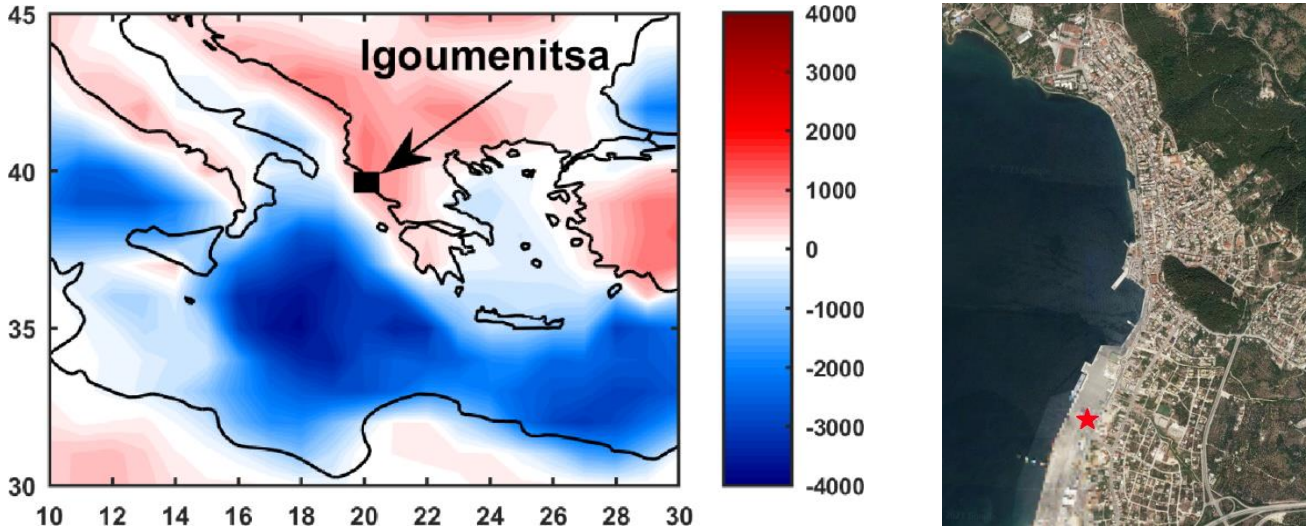

Figure 1. (a) Location of Igoumenitsa in Western Greece over the eastern Mediterranean (topography map). **(b)** Location of the mobile air quality monitoring station (red star).

- The analysis of the impact of shipping and port activity on air quality is based on the comparison between the two representative seasons of 2018:
  - **High port activity season** → from 25.8.2018 to 31.8.2018
  - **Low port activity season** → from 17.5.2018 to 25.5.2018.

- A mobile air quality monitoring station, equipped with ambient air pollution sensors (HORIBA sensors) was employed at the port of Igoumenitsa.

- The sensor recordings include:
  - ❖ gases (NOx; NO; NO2; O3; CO; SO2),
  - ❖ particle matters (PM1, PM2.5, PM4, PM10, PM_tot;) and
  - ❖ meteorological parameters (wind speed - WS; wind direction – Wdir; temperature – T; pressure - P; relative humidity - RH).

For the analysis:

- Spearman correlation are employed for both studied seasons.
- The hourly variation of meteorology parameters and concentration of pollutants are calculated to study the effect of hourly port activity during the two seasons.
- The PM2.5/PM10 ratio is calculated to investigate the impact of shipping and port activities on local air quality.

For the explanation of the differences of PM between high and low season in the air quality of the Igoumenitsa port are used:

- Satellite image form **MODIS** (*Moderate Resolution Imaging Spectroradiometer*), provided by the NASA's Worldview application (https://worldview.earthdata.nasa.gov)
- Results from **MERRA-2 model** (*Modern-Era Retrospective analysis for Research and Applications, Version 2; M2T1NXAER v5.12.4*) developed and maintained by the NASA Goddard Earth Sciences (GES) Data and Information Services Center (DISC) (https://giovanni.gsfc.nasa.gov/giovanni/).
- Figures provided by the **DREAM8b model**, operated by the Barcelona Supercomputing Center are shown (http://www.bsc.es/ess/bsc-dust-daily-forecast/)
- **HYSPLIT** (*Hybrid Single-Particle Lagrangian Integrated Trajectory*) back trajectories were simulated at different levels (https://www.ready.noaa.gov/HYSPLIT.php)

The Correlation analysis shows that:

- For the high season: The correlation analysis between wind speed and the concentration of pollutants shows that the wind speed is negatively associated with PM10, CO, NO2 and NOx, and not correlated with PM1, PM2.5 and PM4
- For the low season: The wind speeds are negatively correlated with the concentration of the pollutants except for the O3 (which shows positive correlation coefficient) and the PM1 (no correlation).
- For both seasons, O3 is positively correlated with temperature (due to photochemical reactions during the sunlight hours) and significantly negatively correlated with NO2 and NOx.

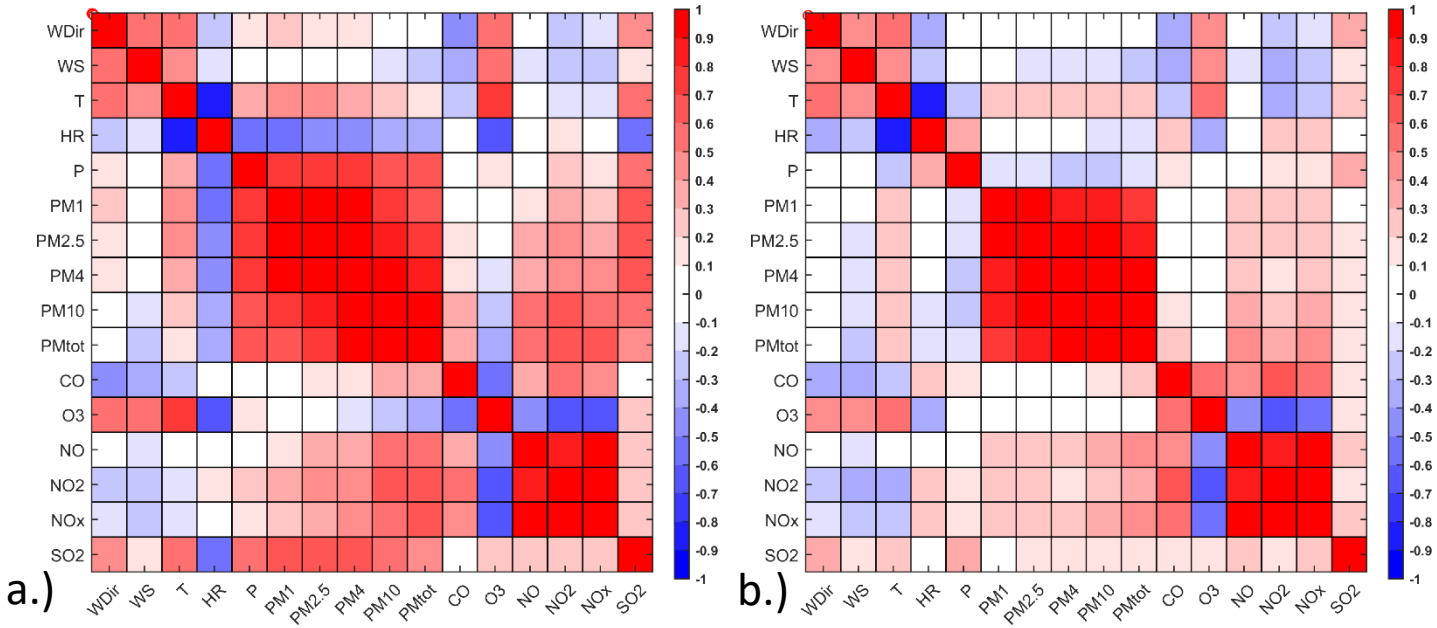

Figure 2. Correlation coefficients for air quality (pollutants) and meteorological parameters (a) for High port activity and (b) for Low port activity season

- The hourly variation of meteorological parameters and concentration of pollutants indicate that the concentration of pollutants is maximized during the hours with high shipping and port activity.

- Compared high with low season:

❖ the concentrations of O3 and NOx are increased by about 10 ppb

❖ the concentrations of NO2 and SO2 are increased by about 2.5 ppb

❖ the concentration of PM1 is increased by about 2.5 μg/m³ and the concentration of PM4, as well as PM10, is reduced by about 5.5 μg/m³

- To investigate the higher concentration of PM4 and PM10 during the high season compared to low season, the possible effect of synoptic atmospheric conditions (African dust transfer) in western Greece is also studied.

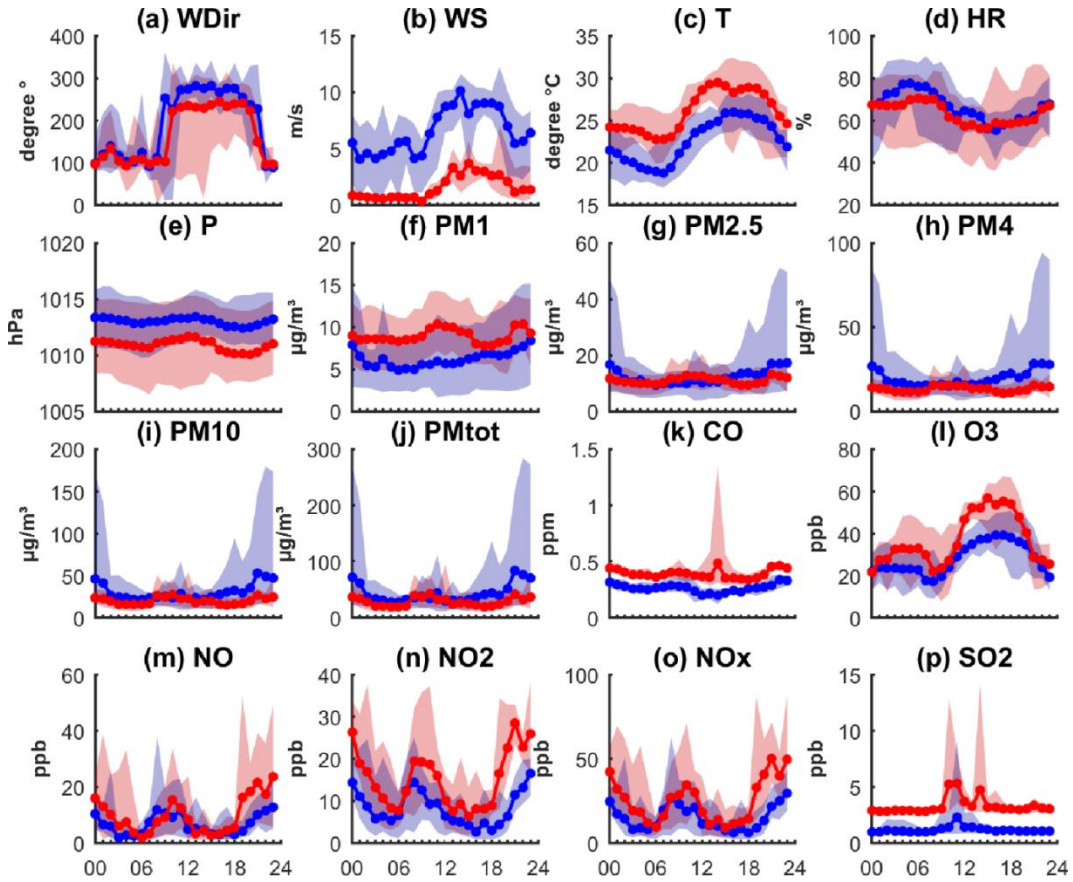

Figure 3. Hourly evolution of meteorology (a-e) and air quality parameters (f-p). The red/ blue lines indicate the high/ low port activity season. The shaded area indicates the range between lower and higher hourly variability during the two seasons studied (red for the high and blue for the low port activity season).

The following are used to investigate and verify the transfer of African dust:

- Results from BSC-DREAM8b (from 15.05.2018 to 24.05.2018, 06UTC; Figure 4)
- Satellite Imagery from MODIS (23.05.2018; Figure 5)
- Hysplit back trajectories (23.05.2018; Figure 6)
- Composite difference of mean dust column mass density (gr/m^2) between high and low season (Figure 7)

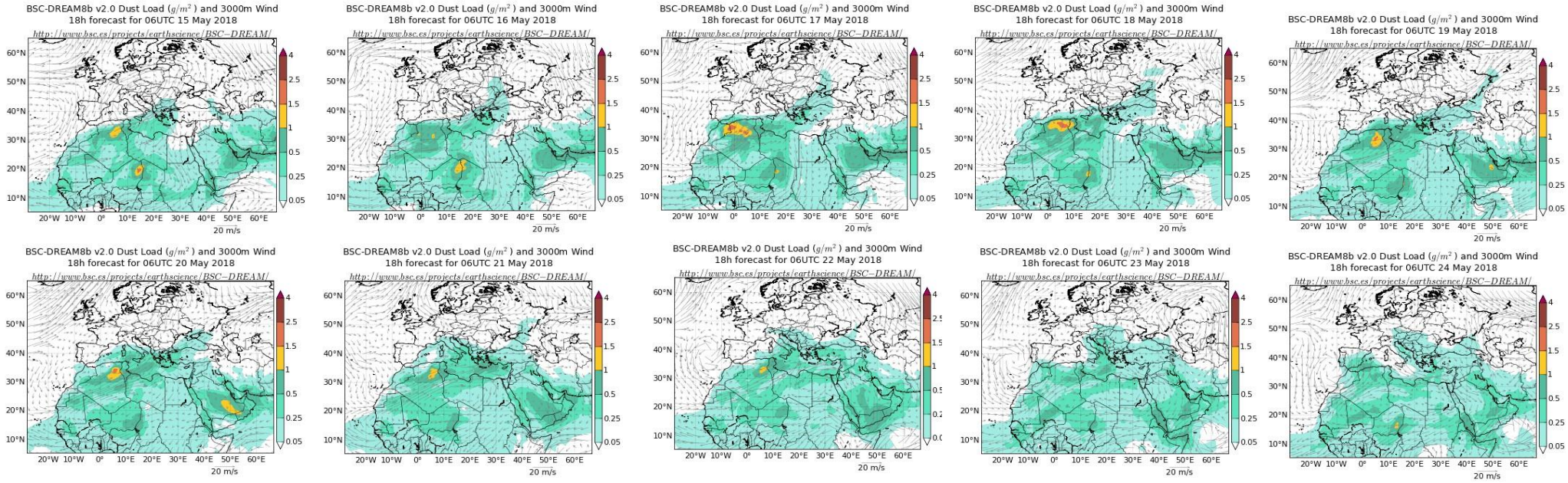

Figure 4. Dust load (gr/m^2) and 3000m wind speed from 15.05.2018 to 25.05.2018 (BSC-DREAM8b)

Figure 5. Image of the African dust transport in Greece on May 23, 2018 (MODIS visible imagery)

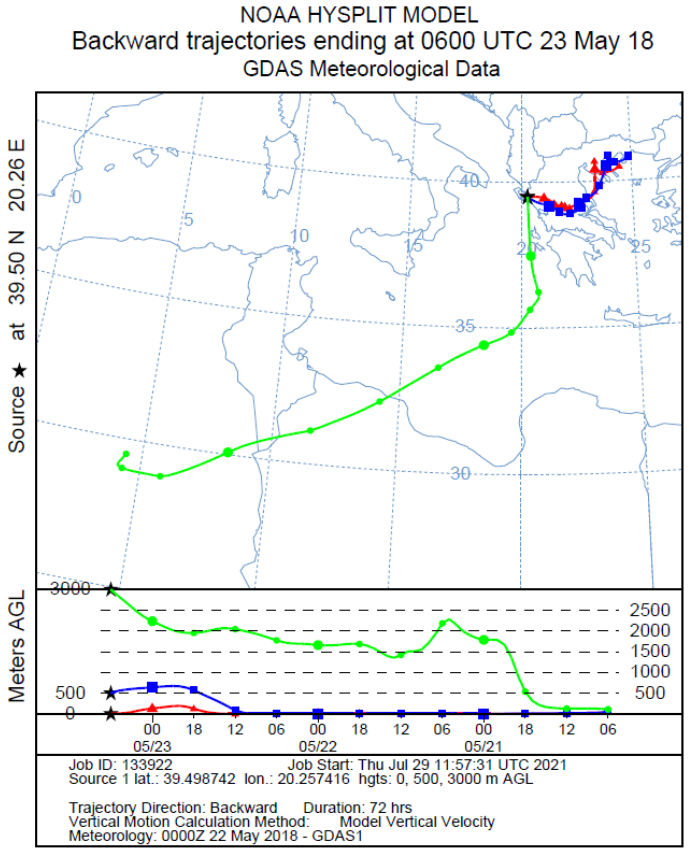

Figure 6. Back-trajectory simulations were performed for 0600 UTC 23 May 2018 using the HYSPLIT model

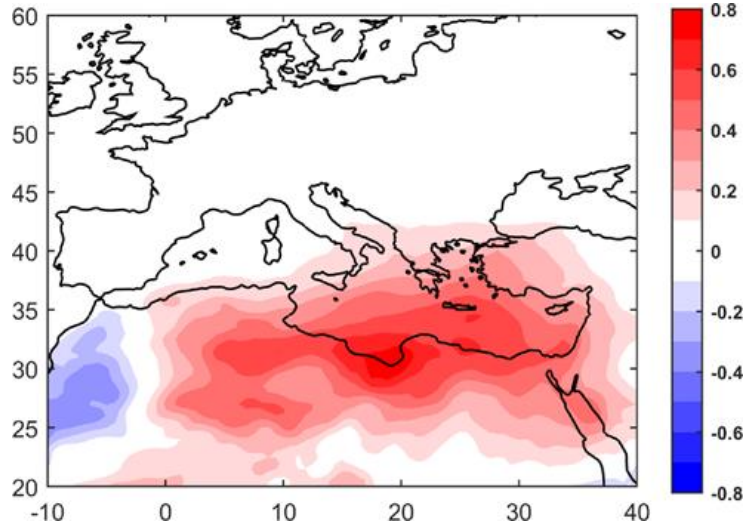

Figure 7. Composite difference of mean dust column mass density (gr/m^2) between low and high port activity season (MERRA2 model)

- The analysis shows that the higher concentrations of PM4 and PM10 during the high season are explained by an African dust transfer event occurs during the low season and affects Western Greece.

PM2.5/PM10 ratio:

- During the high port activity season, the PM2.5/PM10 ratio is about 0.13 higher compared to the low port activity season (Figure 8).

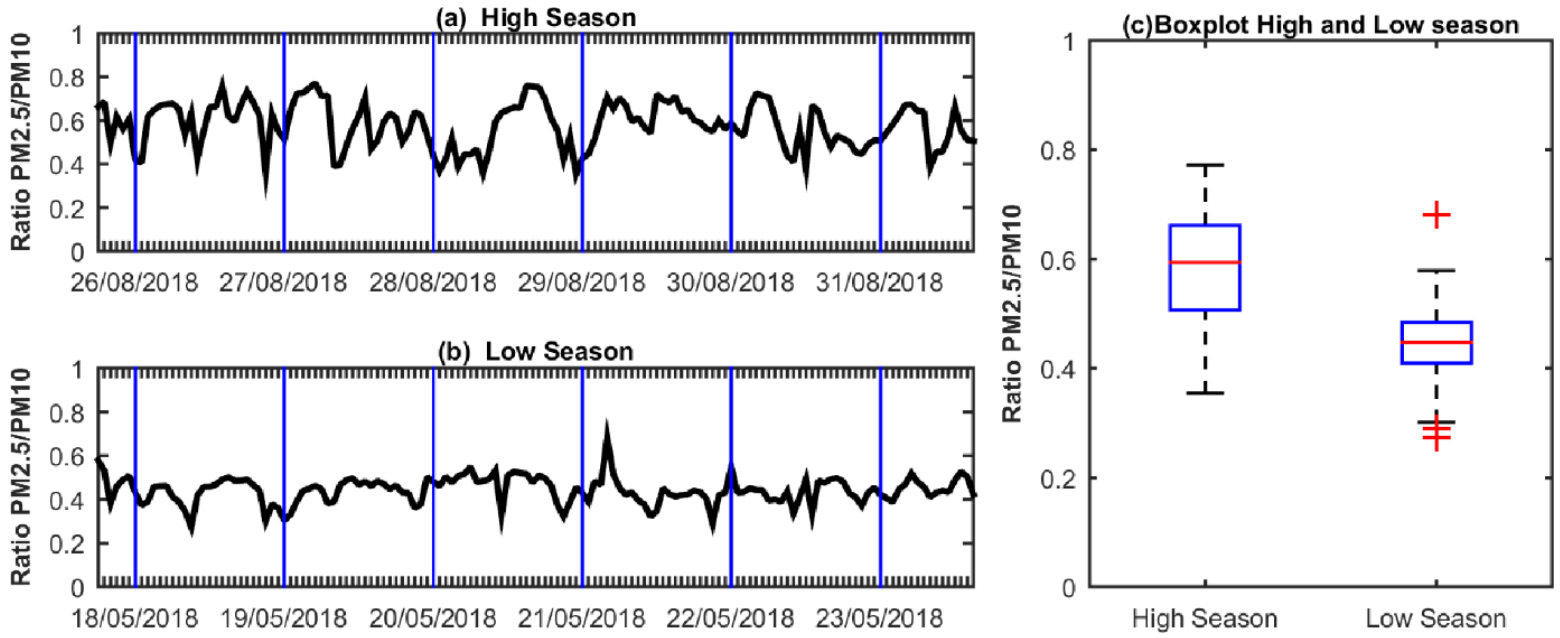

Figure 8. Timeseries of PM2.5/PM10 ratio for the (a) high port activity season and (b) low port activity season (c) boxplot of PM2.5/PM10 ratio for high and low port activity season.

➢ Shipping and port activities impact on air quality degradation of the port of Igoumenitsa

- The analysis shows that the meteorology affects the concentration of pollutants in the port of Igoumenitsa. In particular, wind speed is associated with lower pollution levels.
- For both studied seasons, the hours with high ship traffic show increased concentrations of pollutants compared to the other hours.
- Generally, the high port activity season shows increased concentration of pollutants compared to low port activity season.
- The higher concentrations of PM4 and PM10 during the low period (compared to the high one) are explained by the effect of African dust transfer (occurred during the low season) and affect Western Greece and Igoumenitsa port.
- The higher ratio of PM2.5/PM10 during the high season compared to the low season clearly shows the impact of shipping on the air quality degradation in the port of Igoumenitsa.

Thank you for your time

Funding: *This research was funded by the Connecting Europe Facility of the European Union, grant number 2014-EU-TM-0673-S and The APC was funded by Poseidon Med II Action No.2014-EU-TM-0673-S*

Acknowledgments: *The study received support by POSEIDON MEDII project which is co-financed by the Connecting Europe Facility (CEF) Transport Sector of the European Union. The authors would like to thank the DEPA Commercial S.A (project coordinator) and DESFA S.A. (project technical coordination). Also we would like to thank Igoumenitsa Port Authority S.A. and personnel for providing information regarding the port activity to guarantee the representative sampling of recordings for the analysis. We acknowledge the Envirosys Ltd. Environmental Ap-plications Technological Equipment, Athens, Greece, for the collaboration and the availability of the Horiba Ltd. Sensors. Also, the authors would like to acknowledge the (NMMB/BSC-Dust or BSC-DREAM8b) model, operated by the Barcelona Supercomputing Center (http://www.bsc.es/ess/bsc-dust-daily-forecast/) for provided image. We acknowledge the use of imagery from NASA's Worldview application (https://worldview.earthdata.nasa.gov), part of NASA's Earth Observing System Data and Information System (EOSDIS). Part of the analysis used in this study were produced with the Giovanni online data system, developed and main-tained by the NASA Goddard Earth Sciences (GES) Data and Information Services Center (DISC).*