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## Navigation in Greece: Developing a methodology for the spatial allocation of emissions

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Due to its complex topography (many islands) and extended coastline, Greece has numerous ports (about 200) which serve both commercial and touristic purposes. Almost 85 of them were in use in 2017. According to the FEI-GREGAA emissions inventory, navigation accounted for the 12% to the annual NO<sub>x</sub> emissions and by 3% to the PM<sub>10</sub> emissions in 2017. Consequently, it is an important source of emissions especially for areas which are close to major ports, such as the Athens basin; because it affects the local air quality (almost 32% of total NO<sub>x</sub> emissions in Athens for the year 2017 came from shipping).

In this study a comprehensive emissions inventory for the navigation sector was developed covering the period 2006 – 2017 and used as input to a photochemical model study. The shipping emissions were calculated for each Greek port and ship type based on the ship arrivals. The relevant data for each ship type were provided by Eurostat in seasonal basis. The methodology followed was the Tier 2 approach suggested by the EMEP/EAA emissions inventory guidebook. Harbour (hotelling and manoeuvring) and cruise emissions of both the main and auxiliary engine were calculated for the main pollutants (such as NO<sub>x</sub>, NMVOCs, CO, etc), particulates (PM<sub>10</sub>, PM<sub>2.5</sub>), heavy metals (e.g. Pb, As, Cr, Zn), PCB and HCB.

In Greece the movement of passenger ships is very frequent. Consequently the spatial disaggregation of emissions was carried out with two different methodologies. Emissions from passenger ships were distributed on the ferry lines, as these have been recorded by OpenStreetMap, in which the necessary completion was made in order to cover the itineraries of the ships in all the Greek islands. The emissions from the other ship categories were distributed in the coastal zones around the respective ports, considering the probability of being in the specific zones significant. Finally, a part of the total emissions (10%) was placed in the ports.

Results revealed that in 2017 NO<sub>x</sub> emissions (27.5 ktonnes) prevailed among other pollutants contributing by 69% to the total maritime emissions, while SO<sub>x</sub> emissions followed (16%). This is due to the use of diesel fuel. Concerning the annual variation of pollutants for the period 2006 – 2017, it was found that in 2011 there was a significant reduction of emissions compared to 2010 (9,921 ktonnes for NO<sub>x</sub> and 3,913 ktonnes for sulfur oxides - SO<sub>x</sub>) while the decrease was lower for the rest pollutants. From 2012 onwards, the results showed a stabilization trend. The majority

of pollutant emissions are attributed to the port of Piraeus (3704.7 ktonnes NOx emissions from passenger ships), which is the busiest passenger and commercial port in Greece (20228 passenger ships and 3168 container ships arrived in 2017).