Impact of shipping to atmospheric pollutants in four Adriatic-Ionian port-cities

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Within the Mediterranean Sea, the Adriatic-Ionian region is one of the most congested, both for international ship traffic and for short sea shipping routes. Therefore, shipping has several potential effects on environment and health especially at local scale. Because of that, several studies quantified the contribution of shipping on air quality degradation in coastal cities, focusing on ship releases of gaseous pollutants (NO_X, SO_X, O_3) and particulate matter (PM). Inter-comparison of shipping impacts in different areas requires a homogenization of the evaluation approach in order to obtain comparable results and to facilitate the planning of future mitigation strategies.

This work focuses on an inter-comparison analysis of the impact of shipping to atmospheric PM concentrations in four important Adriatic-Ionian port-cities: Brindisi and Venice (Italy), Rijeka (Croatia) and Patras (Greece). A comparable state-of-the-art methodology based on an approach that integrates emission inventories, dispersion modelling and experimental measurements (at low and high temporal resolution) was used.

Emission inventories (at Municipality level) confirmed that shipping sector represents a non-negligible emission source in all port-cities compared to other transport modes (e.g. road traffic), especially for NO_X (range 9.2-54.8% for the maritime sector and 8.0-36.8% for road transport) and $PM_{2.5}$ (range 11.2-31.0% for maritime sector and 14.8-29.0% for road transport). Internal harbour logistics and typology significantly influence emissions and impacts. The cruise ports (Venice and Patras) had higher emissions from passenger ships with respect to Brindisi and Rijeka (commercial harbours) with cargo and containers ships as greater emitters. At regional scale (Central and Eastern Mediterranean), the anthropogenic source sectorial contribution to pollutant emissions confirmed the comparability between maritime and road sector. A seasonality of emissions was clear, with the maximum in summer for NO_X (28%), SO_X (17%), CO (6%), PM_{10} (10%), and $PM_{2.5}$ (13%).

WRF-CAM_X simulations were performed on the Central and Eastern Mediterranean, with the zero-out method (i.e. including and omitting ship emissions). In the summer period (July 2012) NO_X and SO_2 exceeded 90% in relative impact along the main international shipping routes, over 70% for NO_X and 60% for SO_2. Regarding to PM10 and PM2.5 concentrations, shipping impact decreased from 15% and 13% respectively at larger scale and to 5% and 3% in the Adriatic area. Experimental data were processed by two methods: PMF (Positive Matrix Factorization) receptor model for PM data; statistical treatment of high temporal resolution data for gaseous and PM concentrations. Source apportionment by PMF showed a factor/source characterized by Ni and V, with V/Ni ratio between 1.4 and 4.2 at the different sites, indicating a common industrial and heavy oil combustion source with local differences in the chemical profiles. The contribution of ship emissions to primary $PM_{2.5}$ was calculated based on V concentrations and it ranged from 0.5% (Rijeka) to 2.8% (Brindisi). The analysis of high temporal resolution data (Contini et al., 2011; Donateo et al., 2014) showed that gaseous pollutants (NO_X, SO_2) impacted 3-5 times more than PM. Impacts to particles number concentrations (PNC) are larger (3-5 times) than those to mass concentrations, PNC could be more appropriate to investigate this source with respect to PM_{10} or $PM_{2.5}$.

In Venice and Rijeka, inter-annual analysis demonstrated the declining impact of ships on PM concentrations at local scale but a very limited effect on PAHs, metals, nitrogen oxides due to the implementation of the European Directive 2005/33/EC (Gregoris et al., 2015) and voluntary agreements (Venice Blue Flag).

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