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# EARLY STATISTICAL ANALYSIS OF SHIP EMISSIONS INVENTORIES IN THE ISTANBUL AREA

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## ABSTRACT

Ship emissions contribute substantially to air pollution. The Bosphorus, as one of the busiest straits in the world, has been influenced by the emissions of marine traffic. However, one of the main uncertainties in air quality assessments for coastal areas is ship emission inventories. In this study, the Ship Traffic Emission Assessment Model (STEAM) is applied to the Automatic Identification System (AIS) data from the Bosphorus Strait. In addition to AIS data, a ship database containing technical details of each and every vessel found in AIS data must be at hand. This database is a composite from many data sources, most significantly IHS Fairplay, ship owners and engine manufacturers. In case all the vessel details are not available for a specific ship, the model applies educated guesses to generate a reasonable estimate of emissions for that vessel. As a result, vessel specific emission inventories are generated; when the process is repeated for all vessels in an area, an emission inventory is obtained. However, vessels without the AIS equipment onboard will not be covered in the inventory. A snapshot of emissions from shipping is obtained in addition to detailed statistics of vessel traffic in the area. Pollutants which are currently covered consist of $NO_x$, $SO_x$, CO, $CO_2$ and PM, which is further divided to EC, OC, ash and hydrated $SO_4$. If dry PM mass is preferred then the water can be left out.

**Key Words:** Ship emissions, AIS, STEAM model, Bosphorus

## 1. INTRODUCTION

Emissions from ships have recently received more attention since they have become a significant concern for air quality in harbors and port cities (Schrooten et al. 2009). Sea transportation increases every day and causes air pollution, which has a negative impact on the environment and human populations. The issue of controlling air pollution form ships was discussed in the International Convention for the Prevention of Marine Pollution (MARPOL) in the 1973. However, it was decided not to include regulations concerning air pollution at the time. Long and short distance shipping plays important roles in facilitating international trade transportation over the world. Cargo transport by ships is about 70 percent of all trade between the European Union (EU) and the rest of the world (Harrison et al., 2004; Derwent et al., 2004; Jaffe et al., 2003; ENTEC 2005; Qinbin et al., 2002; Davies et al. 2000). Environmental and Engineering Consultancy (ENTEC) has studied ship emissions of SO2, NOx, CO2 and hydrocarbons in the North Sea, Irish Sea, English Channel, Baltic Sea, Black Sea and Mediterranean to determine these emissions for all vessels as well as separately for each vessel type and flag state (ENTEC, 2002). Ships are fast becoming the biggest source of air pollution in the EU. According to the Commission of the European Communities (CEC) unless more action is taken they are set to emit more $SO_x$ than all land sources combined by 2020 (CEC, 2005). The International Maritime Organization (IMO) notes in their study of

greenhouse emissions from ships, there is an increasing awareness of the impacts of shipping emissions on onshore air quality. An estimated 85 percent of international shipping traffic occurs in the northern hemisphere, and 70 percent of that is within 400 km of land. Much of the shipping activity and associated emissions occur near major urban areas, many of which are already struggling with air quality problems (IMO, 2000; ENTEC, 2005; Acid News, 2006).

The ships passing from the Bosphorus contribute sea, air, noise pollution and other environmental risks like maritime accidents. The number of ships passing between İstanbul and Çanakkale has increased and these shipping activities contribute significantly to the air pollution in the Bosphorus. In this study, the STEAM emission model is applied to the Automatic Identification System from the Bosphorus Strait.The results of this study may help environmental scientists and policy makers, (Toros and Deniz, 2006).

## 2. DATA AND METHODOLGY

The Bosphorus is one of the most beautiful, historical and picturesque stretches of water in the world, which is a geological strait separating the European and the Asian parts of Istanbul and it lies between the Black Sea and the Sea of Marmara. Emissions from ships in transit through the Bosphorus have an impact on the air quality of densely populated areas. The Strait of Istanbul is approximately 31 kilometers long average depth 35 meters average width 1.5 km at the narrowest point is about 700 meters. The length of the strait of the Çanakkale is about 70 kilometers with a general width ranging 1-2 kilometers, (Toros and Deniz, 2006).The Strait of Istanbul through the Black, Marmara, Aegean and Mediterranean Sea, are unique in many respects in the world.

The Bosphorus is a significant and growing source of air pollution and one of the biggest problems in air quality studies is emission inventories. The use of Automatic Identification System (AIS) has given opportunity to a more accurate calculation of ship emission inventories. This system needs international and interdisciplinary collaboration between institutes and organizations. In this study, the ship emission inventories for the Bosphorus Strait will be produced using the AIS and Ship Traffic Emission Assessment Model (Jalkanen et al. 2009; 2012) as well as vessel specific emissions of NOx, SOx, CO, CO2 and PM.

The input data for STEAM consists of the activity data (AIS), ship technical specifications of every vessel (IHS Fairplay) and possible fuel requirements in the study area. The STEAM model structure is outlined in Fig 1. The effect of various emission abatement techniques are taken into account. The model determines the vessel resistance as a function of vessel speed. Engine power levels are estimated taking propeller, power transmission losses and vessel operational mode into account. For example, power requirements of onboard systems are very different in a case of an oil tanker than those of a large cruise vessel. Environmental effects, like waves and marine currents can be taken into account if specific datasets for these are available. Pollutants included in the model are NOx, SOx, CO, CO2 and PM, which is further subdivided into EC, OC, Ash and hydrated SO4 (Jalkanen et al. 2012).

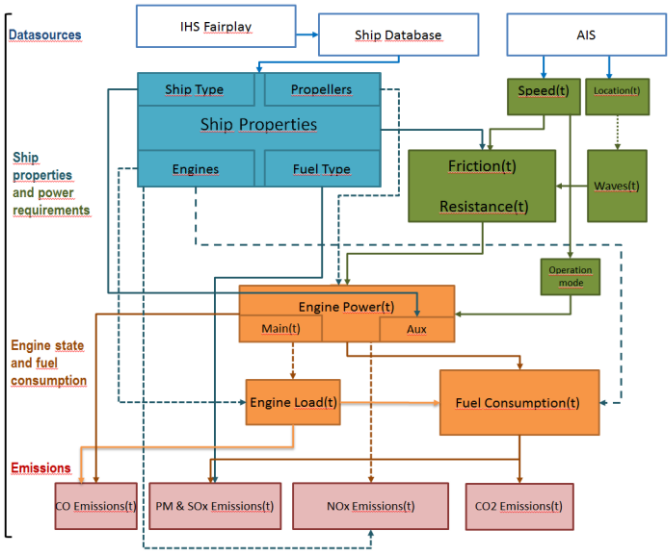


Fig 1. Schematic presentation of the STEAM model (Jalkanen et al., ACP 12, 2641-2659, 2012).

## 3. CONCLUSION

Preliminary runs indicate that there are areas of significant emissions north and south of the Bosphorus, where ships are waiting and loading/unloading. A summary of the results is given in Table 1. For this example, grid cell size of 100 by 100 meters was used. Air quality studies of the Bosphorus will determine the impact of ship emissions to the dense human population in the area. As seen Table 1, one month total emission of NOx, SOx, CO, CO2, PM is 860, 220, 250, 44.000 and 58 tons emitted in the Bosphorus sequentially. One of pollution result shown in Fig. 2 as a ship NOx emissions in the Bosphorus area during March 2012 based on AIS data and STEAM model.

Table 1. Ship emissions in the Bosphorus during March 2012 (in tons). The rightmost column shows the projected (assuming no seasonal variation) annual emissions based on one month of AIS data.

| **Pollutant** | **March 2012, tons** | **Projection, 12 months, tons** |
|---|---|---|
| **$NO_x$** | 860 | 10 300 |
| **$SO_x$** | 220 | 2 680 |
| **CO** | 250 | 3 000 |
| **$CO_2$** | 44 000 | 530 000 |
| **Total PM,** | 58 | 700 |
| *of which* | | |
| *EC* | 6 | 70 |
| *OC* | 16 | 189 |
| *Ash* | 4 | 51 |
| *Hydr. SO4* | 32 | 391 |
| **Fuel** | 14 500 | 174 000 |


Fig 2: Ship NOx emissions in the Bosphorus area during March 2012 based on AIS data and STEAM model. The scale indicates the total ship emissions in kilograms inside 100 by 100 meter cells.

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