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Port-city exhaust emission model: An application to cruise and ferry operations in Las Palmas Port

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ABSTRACT

Exhaust emissions cause air pollution and climate change. The exhausts of shipboard fuel combustion are equally damaging particularly, so close to the environmentally sensitive mainland and island coasts, as well as at ports due to their urbanized character. This paper estimates, for the first time, exhaust pollutants related to cruise and ferry operations in Las Palmas Port and, in an island context. Emission assessment is based on a full bottom-up model and messages transmitted by the Automatic Identification System during 2011. Results are described as a breakdown of NOx, SOx, $PM_{2.5}$, CO and CO_2, according to ship classes, operative type and time, providing valuable information to environmental policy makers in port-city areas and islands under similar conditions. It is generally concluded that vessel traffic and passenger shipping in particular are a source of air pollution in Las Palmas Port. Emission maps confirm location of hot spots in quays assigned for cruise and ferry operations. Policy recommendations encourage regular monitoring of exhaust emissions and market-based incentives supported by details on polluting and operative profiles. On the other hand, feasibility studies are suggested for automated mooring, LNG bunkering facilities and also shore-side energy services, prioritizing berthing of shipping sectors (or sub-sectors) with the highest share of exhaust emissions once their local effects have been confirmed by a dispersion, exposure and impact assessment.

1. Introduction

Ferry and cruise, share positive effects and economic benefits in ports and cities. However negative impacts, including air pollution, also relate to engine exhaust emissions while operating at port (Castells et al., 2014; Chang et al., 2014). Shipping activity and the propagation of exhaust gases resulting from the combustion of fuels have a significant impact on air quality in port-city areas. Most importantly, however, harmful ship emissions into the air have been addressed as a risk factor for cardiovascular, respiratory conditions or even human death (Corbett et al., 2007). As a result of this, compliance and enhancement of emission regulation in shipping has been pursued.

Policy makers need the support of methodologies which will reliably inform them on how much, where, how and who releases emissions in order to decide on an effective regulatory framework for the improvement of air quality and the reductions of greenhouse gases emissions. Data scarcity and uncertainty has led to a widespread use of methodologies for

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estimating the exhaust emissions in shipping. Still, the utilization of new technologies with reliable data retrieving capabilities on vessel traffic question usefulness of the methodologies proposed so far (Miola et al., 2010).

More specifically, AIS-assisted emission inventories can be effectively used to assess the impact of shipping in port areas (Ng et al., 2012). The challenge of identifying operative profiles of ships at berth (hotelling), manoeuvring and normal cruising navigation in conjunction with the emission dependency on engine load can be addressed with ship position records and databases containing ship technical and engine details, respectively. This offers the ability to model the geographical characterization of emissions through high-resolution maps in port-city areas. AIS-based methodologies have been already introduced to estimate shipping emissions (Jalkanen et al., 2008), but they have never been presented as an instrument to assist policy design and corrective measures of a specific shipping sector (passenger) and sub sectors (cruise and ferry) within an island context. Thus, the main contribution of this paper is to present evidence on the application of AIS-based methodologies to assess exhaust emissions of cruise and ferry services according to ship size classes, time and ship activity phases (i.e. hotelling, manoeuvring and cruising).

The results of this study aim at the improvement of the current environmental policy in Las Palmas Port, as well as in other island ports experiencing a similar shipping activity. The structure of this paper is as follows: Section 2 provides an overview on regulation and practices for the control of ship exhaust emissions in ports. Section 3 describes emission estimation in shipping to then present the full bottom-up Ship Traffic Assessment Model (STEAM) used in this case study. Section 4 presents results for emission estimation as a breakdown of ship activity phase, type and time and ship size classes. Also, the geographical characterization of results is described through a selection of high-resolution maps. Discussion and policy implications are presented in Section 5, followed by conclusions and future research recommendations in Section 6.

2. Regulation and practices for the control of ship exhaust emissions in ports

Current regulation seeks to reduce emissions from ships through the introduction of minimum fuel quality standards and the implementation of new abatement technologies. The International Maritime Organization (IMO) has addressed ship pollution under the MARPOL convention. The regulation of air pollution by ships was defined in MARPOL Annex VI, first adopted in 1997 and enforced in 2005 including a progressive reduction of SOx and NOx and indirectly Particulate Matter (PM) in Emission Control Areas (ECA). MARPOL Annex VI is the only global regime that clearly addresses the control of air emissions from ships.

The European Union (EU) has also expressed its concerns about the impact of transport on air quality through the Strategy for Sustainable Development published on its White Paper on Transport Policy (Gemeinschaften, 2001), leading to the establishment of stringent sulphur regulation for marine fuels through directives: 2012/33/EU, 2005/33 and 1999/32. According to these, all passenger ships operating on scheduled services to or from any EU port should not exceed 1.5% sulphur limit and all vessels calling at an EU port should use low sulphur fuel (less than 0.1%) or a shore-side electricity facility during port stays longer than two hours. In addition, with the framework of IMO regulations, MARPOL Annex VI sets a maximum 0.1% sulphur for all ship operations in ECAs from 2015, which with regard to European waters are currently limited to the Baltic Sea, the English Channel and the North Sea. It should be also noted that the expressed EU willingness to unilaterally widen the enforcement of sulphur restrictions to all European sea faces compliance constraints in relation to the United Nations Convention on the Law of the Sea 1982 (UNCLOS) to which the EU is signatory. There is currently no legal basis for the EU to exercise extra-territorial jurisdiction and this is likely to give non-EU states and industrial bodies grounds for challenging emissions reduction measures adopted by the EU for maritime transport (Miola et al., 2010).

As ports constitute the nodes of maritime transport where all shipping routes ultimately converge, they are particularly exposed to the burden of ship exhaust emissions. Therefore, in response to this problem and besides the provisions of the IMO and EU framework, they have been collectively or individually active in adopting voluntary measures, which aim at improving the air quality and achieving emission reductions of greenhouse gases (CO_2). These measures either take the form of offering economic incentives (i.e. environmentally differentiated port dues) or the undertaking of infrastructural investments, which encourage ship operators to make use of environment friendly services (i.e. shore-side electricity, LNG bunkering, automated mooring systems, and others). For further information on green ship promotion through major European ports and the use of environmental indices, the reader is referred to Gibbs et al. (2014).

At present, there is no preference for a specific environmentally differentiated port charging system, although it should be noted that the relevant EU proposal (COM/2013/295) in action 8 suggests that "to encourage a more consistent application of environmentally differentiated port infrastructure charges, the Commission will propose principles for environmental charging and promote the exchange of good practices by 2015" in order to abate air emissions and address the technological alternatives available for this.

With regard to infrastructural port facilities, shore-side LNG bunkering[1] is evident in Norway (i.e. Kristiansund, Mongstad, Bergen), Sweden (i.e. Stockholm), the Netherlands (i.e. Rotterdam, Antwerp, Amsterdam) and Belgium (i.e. Zeebruge) while the feasibility of providing shore-side electricity services has been studied in various locations (Tzannatos, 2010) and is already offered to ships in the west coast of the USA. In summary, a positive evolution of exhaust emissions related to shipping has

[1] World map with LNG bunkering activities in ports is accessible online at http://www.lngbunkering.org/. Website launched in 2014 by the International Association of Ports and Harbours.