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Focus

Environmental accounting for Arctic shipping – A framework building on ship tracking data from satellites

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ABSTRACT

Arctic shipping is on the rise, leading to increased concern over the potential environmental impacts. To better understand the magnitude of influence to the Arctic environment, detailed modelling of emissions and environmental risks are essential. This paper describes a framework for environmental accounting. A cornerstone in the framework is the use of Automatic Identification System (AIS) ship tracking data from satellites. When merged with ship registers and other data sources, it enables unprecedented accuracy in modelling and geographical allocation of emissions and discharges. This paper presents results using two of the models in the framework; emissions of black carbon (BC) in the Arctic, which is of particular concern for climate change, and; bunker fuels and wet bulk carriage in the Arctic, of particular concern for oil spill to the environment. Using the framework, a detailed footprint from Arctic shipping with regards to operational emissions and potential discharges is established.

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1. Introduction

The melting of Arctic sea-ice will effectively unlock greater parts of the Arctic Ocean, leaving it increasingly attractive to shipping and oil and gas related activities (e.g. Stephenson et al., 2011, 2013). A significant increase in the maritime activity in the Arctic waters is expected (e.g. AMSA, 2009; Paxian et al., 2010; Peters et al., 2011), leading to increased concern over the potential environmental impacts from this activity (e.g. Corbett et al., 2010; Browse et al., 2013; Dalsøren et al., 2007, 2013; Peters et al., 2011).

Accurate, up-to-date inventories of emissions and discharges from ships are essential for scientists quantifying the environmental impact of the shipping activities and for policy-makers to find cost effective regulative measures. Modelling studies have produced Arctic emission inventories, based on fleet and movement data (e.g. from AMSA in Corbett et al., 2010), as well as on ship observations in Arctic (e.g. Peters et al., 2011; Dalsøren et al., 2007). These data includes a range of assumptions and limitations (Endresen et al., 2003; Dalsøren et al., 2007; Corbett et al., 2010).

The Automatic Identification System (AIS) ship tracking data from satellites opens new possibilities for expedient and accurate environmental accounting for Arctic shipping. An AIS transponder, which is mandatory on board almost all ships above 300 gross tons, automatically transmits a unique ship identity code, a precise position reference, and the ship's heading and speed down to seconds intervals. AIS data coupled with ship registers and other databases, has already produced valuable insights into the operational risks (Eide et al., 2006, 2007, 2008; Brude et al., 2012), and the technical and environmental performance of ships (e.g. Endresen et al., 2007; Buhaug et al., 2009; Pitana et al., 2010; Jalkanen et al., 2009; Smith et al., 2013). Winther et al. (2014) were the first to publish in a journal an emission inventory for ships in the Arctic area based on AIS data. In addition, studies carried out on behalf of PAME (The Protection of the Arctic Marine Environment Working Group under the Arctic Council) and Norwegian authorities, presented in 2011 an inventory of ships carrying heavy fuel oil (HFO) in the Arctic (DNV, 2012). This paper describes a framework for environmental accounting for Arctic shipping based on AIS ship tracking data from satellites. Results from two cases are presented; Emissions of black carbon (BC) in the Arctic, and; Bunker fuels and wet bulk carriage in the Arctic.

2. The framework

An AIS-based modelling approach has been developed by DNV GL, which models the ship activities, emissions and potential discharges, and allocates the results geographically. The framework (outlined in Fig. 1) combines AIS data and ship particulars from ship registers, to form an activity basis for the Arctic fleet. The AIS-based modelling approach builds on the individual satellite

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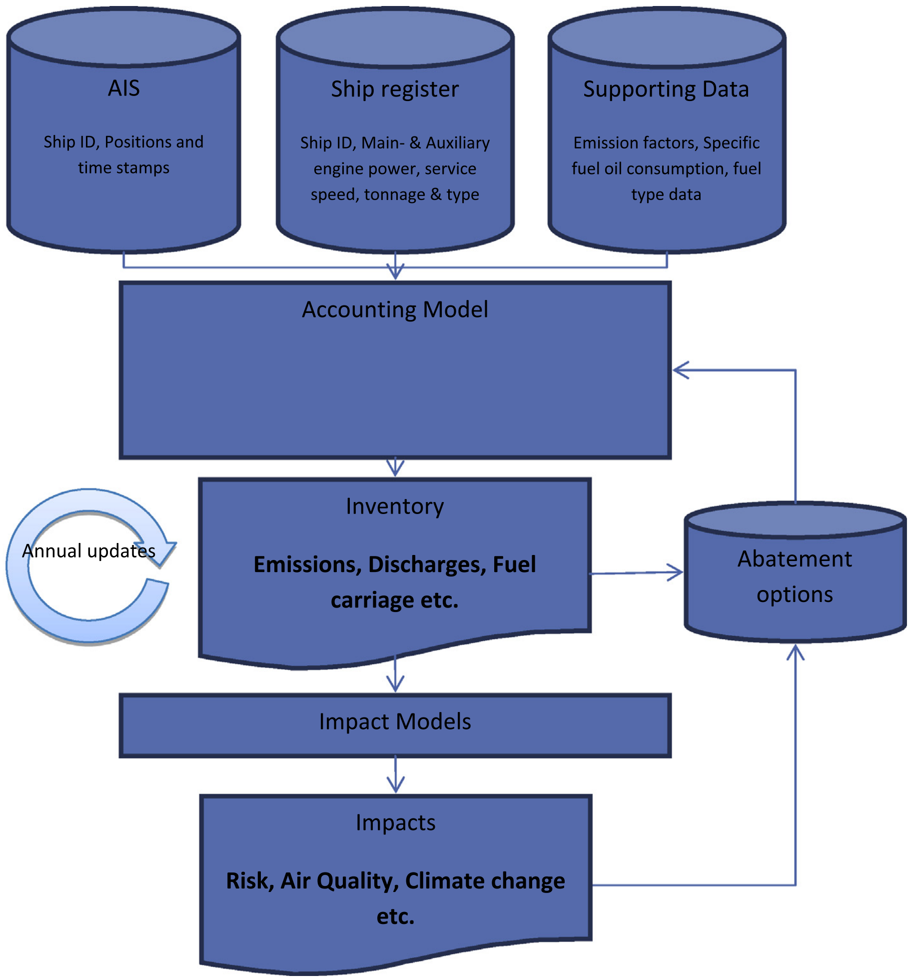

Fig. 1. Framework for AIS-based environmental accounting and impact modelling.

tracing of ships (each position record). In principle, any relevant quantity, Q, in a given area and time period, can be calculated in the model by applying the following formula;

$$Q = \sum_{i}\sum_{x} q_{i,x} \quad (1)$$

where $q_{i,x}$ denotes contribution from an individual ship i, in the time and space interval associated with an individual AIS position message x.

The quantification of $q_{i,x}$ is made by combining individual AIS satellite positions, vessel particulars and supporting data, see Fig. 1.

The calculated inventories based on Eq. (1) can be aggregated in groups based on ship characteristics, typically 13 ship types and 7 size segments. Results covering air emissions, potentially discharges to sea and voyage based risk are presented. The inventory is automatically updated, using a continuous download of AIS data, to track the development over time. Statistics are presented on different time scales (e.g. hourly, daily, monthly, yearly), and are integrated in an environmental accounting system, <www.havbase.no> which is operated by the Norwegian Coastal Administration (NCA). Spatial distribution is inherent in the AIS data, and can be aggregated at any relevant resolution, e.g. 10×10 km grids.

Having created an inventory, the concentration and impacts of the pollutant in question can be assessed using relevant atmospheric models or risk models (Fig. 1). Within the framework, databases of mitigation options can be linked to the inventory to assess the costs and effects of abatement options in "what-if" analysis. As an example, the effect of using alternative marine fuel such as Liquid Natural Gas (LNG) can be assessed, capturing the benefit from oil spill reductions, as well as the reduction in emissions such as CO_2, NO_X, SO_X and BC.

The AIS based modelling approach is by no means restricted to the Arctic, but may equally well be applied globally or to any specific region or area of interest. The framework has been used to model emissions to air, navigation risk and potential discharges to sea (grey water, black water, oils, etc.) and can be extended to other ship activity impacts including the risks related to invasive species from ballast water discharges. The high resolution of the inventories, combined with the ease of updating with new inputs (e.g. emission factors and emission reduction potentials from appropriate measures like Selective Catalytic Reduction (SCR), exhaust gas scrubbers, introduction of LNG/LPG, etc.), makes the framework ideally suited to providing policymakers and regulators, ship-owners and other stakeholders with the best possible decision basis.

3. Black carbon emissions in the Arctic

Emissions to air from shipping are of global concern. In the Arctic, particular focus has been on emissions of black carbon (BC) (e.g. Corbett et al., 2010; DNV, 2012; Winther et al., 2014).

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