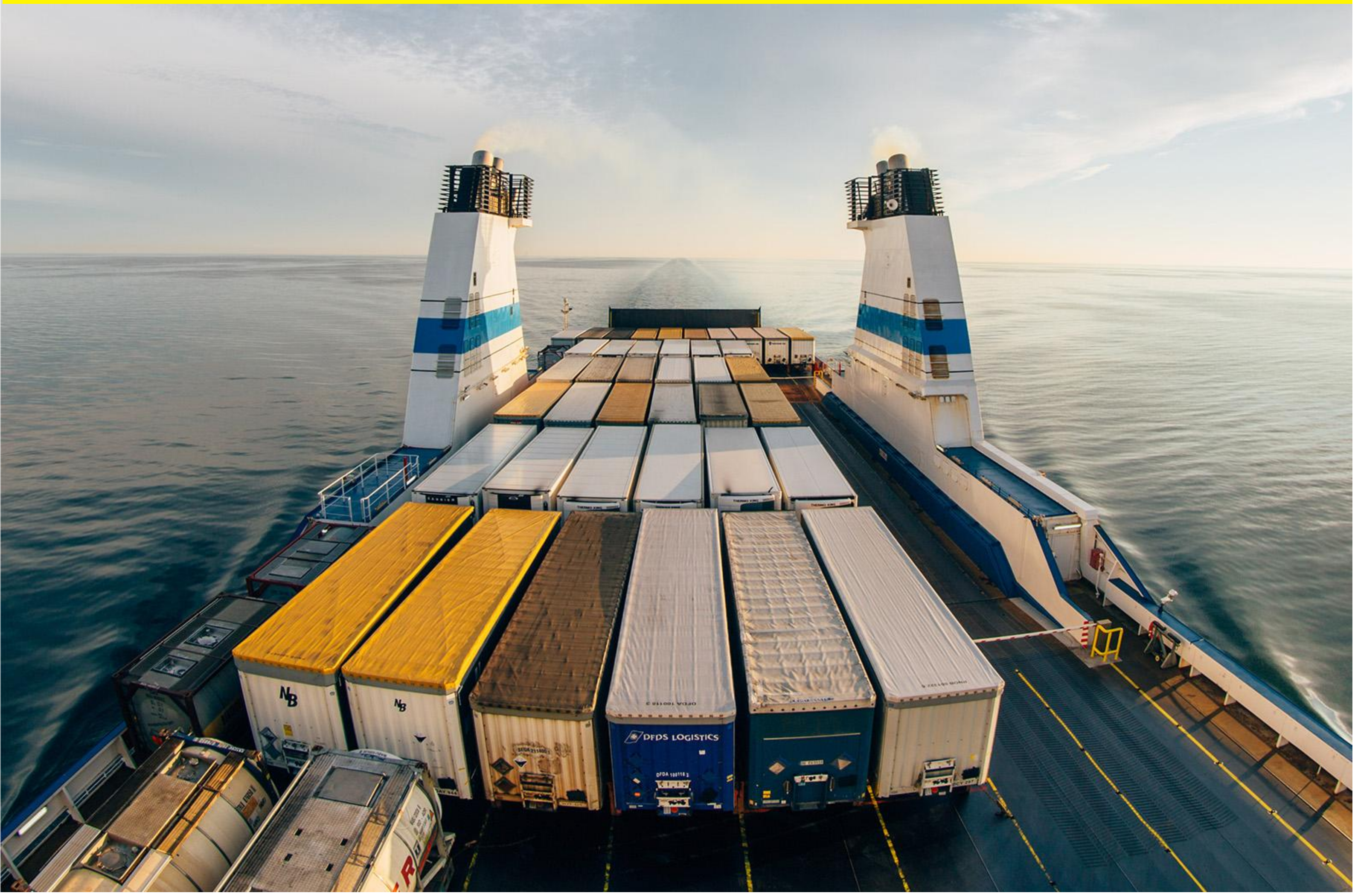
CompMon

Compliance monitoring pilot for Marpol Annex



Sub-activity 4.2 Piloting of the emission estimate application

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Compliance monitoring pilot for Marpol Annex VI

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Abstract

Coarse graining of candidates for closer inspection for marine fuel sulphur content can be done by combining emission modeling and optical measurements. In this case, the emission modeling results will indicate the mass flow of CO2 from ships whereas the optical measurements will yield mass flow of SO2 in exhaust gases. Combination of measured SO2 and modeled CO2 will enable a rough estimate whether there is a reasonable doubt for closer inspection by a flyby and sniffer measurements. This method has been applied previously in the English Channel area, during a measurement campaign of JRC and it has been reported in scientific literature. The accuracy of the combined measurement/modeling tool is limited, but it will allow fast preliminary determination of fuel sulphur content. This first estimate could be used to determine whether a more detailed measurement, or fuel sampling, might be necessary.

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1 General description of the approach

By default, the Ship Traffic Emission Assessment Model (STEAM) combines activity data from the Automatic Identification System (AIS) with the vessel technical description and produces predictions of instantaneous emissions and fuel consumption (Jalkanen et al., 2009, 2012; Johansson et al., 2013). Based on the previous experience with compliance monitoring efforts using the DOAS (Differential Optical Absorption Spectroscopy) equipment (Berg et al., 2012) STEAM is required to produce an estimate of the instantaneous mass flux of CO_2 in the ship exhaust. The DOAS result will indicate the mass flow of SO_2 in the exhaust, but measurement of CO_2 with this setup is not possible. Through the combination of the measured SO_2 result from DOAS and CO_2 output from emission modelling it is possible to determine a rough SO_2/CO_2 ratio, which could be used as a preliminary indication whether there is a reason to conduct a flyby and more accurate sniffing measurement from the exhaust plume

2 Materials and methods

For the purpose described above and from the modelling point of view, geographical location or the time of the release of CO_2 emission becomes irrelevant because the CO_2 emission is calculated as a function of ship speed. The minimum data required to compute an estimate of ship's instantaneous fuel consumption consists of vessel identity (IMO number) and speed entry. Based on the IMO number, vessel identity is defined and technical data needed by emission model can be extracted from relevant databases. The speed entry will be used to calculate vessel resistance and power needed to travel the indicated speed. Use of auxiliary engines will be estimated based on vessel type, cargo capacity and operating mode (Jalkanen et al., 2012; Johansson et al., 2013). By default, STEAM outputs fuel consumption and pollutant emissions as mass flux (in grams/second). This data can be calculated beforehand for the whole global fleet over various speed entries and made available for compliance monitoring purposes.

During the DOAS measurement, ship identity and speed are determined from AIS data and corresponding modelling result can be looked up in the precalculated table of emission results which correspond to that vessel speed and identity. Regardless of the location or the time of the measurement, same vessel is always modelled to require same amount of engine power and produce same amount of emissions when it travels at same speed. The emissions and fuel consumption are only impacted by vessel speed and identity, which do not require the use of AIS data during the actual emission modelling phase. Precalculated values for the ship fleet as a function of vessel speed need to be produced and delivered to DOAS measurement crew.

The technical data used in the emission modelling consists of commercial ship database (IHS Fairplay) which has been augmented with additional data from other classification societies (ClassNK, ABS, DNV-GL, Bureau Veritas, Russian Register of Shipping, Korean Register of Shipping), engine and equipment manufacturers. The STEAM model assigns fuel type (residual/distillate) for marine engines based on engine crankshaft revolutions, installed power and stroke type according to (Kuiken K., 2008). Engine load dependency of specific fuel oil consumption is included (Jalkanen et al., 2012) and the base value for each engine is determined from engine specifications and the 2nd IMO GHG study (Buhaug et al., 2009).

The flow of data is illustrated in Figure 1.

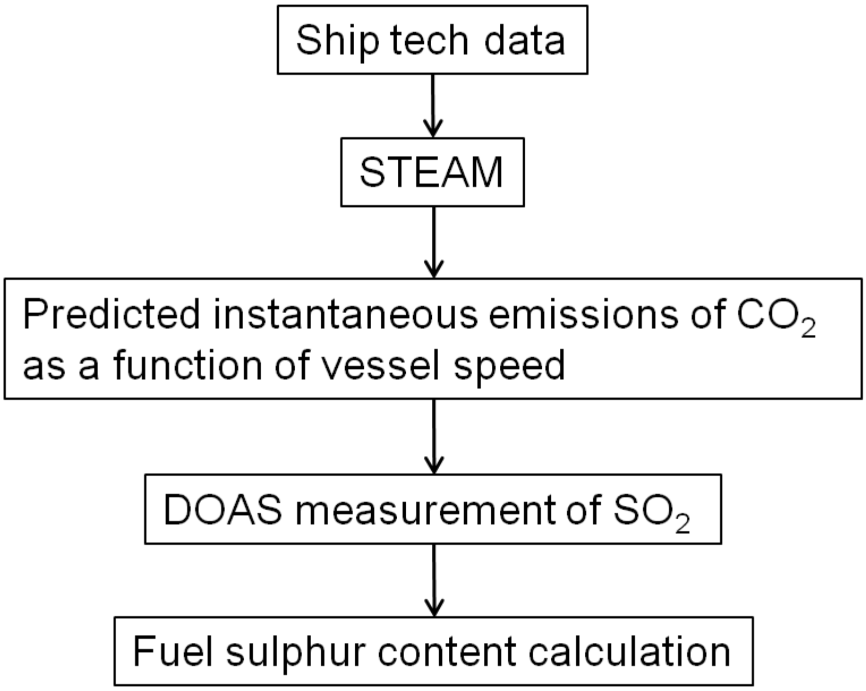

Figure 1 Flow of data concerning the targeting

The CO_2 data needed for targeting the airborne compliance monitoring with DOAS will be generated for the global fleet of ships as ship specific entries and as a function of vessel speed (third box from the top in Figure 1). This table will include one row of data for each vessel in the global fleet and one column for each speed entry. For the global fleet, a table with 95 000 rows and some 250 columns will suffice to describe the CO_2 output. This table needs to be updated at regular intervals, for example twice a year, because there is no mechanism to include new vessels which were built after the emission calculation took place.

3 Outputs

Example output from STEAM will be in ASCII text file with semicolon (;) separating the data columns. The size of this data table (Table 1) in text format is 30 megabytes. This format is directly readable as Excel spreadsheet and search for a specific IMO number will help to find a correct data row for any vessel.

Table 1. An example of a precalculated emission table for one vessel. The first columns identifies the vessel and consecutive columns list the CO_2 emission flux as a function of vessel speed. The emissions are listed up to design speeds + 2 knots of each vessel using 0.2 knot intervals.

IMO number	m(CO_2, g/sec),v=0 kn	m(CO_2, g/sec),v=0.2 kn	...	m(CO_2, g/sec),v=design speed+2 kn
1234567	123	124	...	1428
Repeated over the global fleet of ships				

This data table will include predicted CO_2 output as a function of ship speed for all the vessels in the global fleet. This data table will need to be updated with regular intervals as new ships enter the fleet each year. The accuracy of the predictions is directly dependent on the completeness of the technical data used in modelling the power and performance. The accuracy of monthly CO_2 emission predictions is usually 10-15% when all necessary data is available. Larger discrepancies are possible with instantaneous values or if there are significant data gaps in the technical description of ships. It should be noted that the predicted fuel consumption represents the theoretical situation without contributions of wind, waves, currents, sea ice or fouling. The data table describing the CO_2 output of the global fleet as a function of speed was delivered to Chalmers Technical University, Sweden, in December 2016.

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