Baltic Marine Environment Protection Commission

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Background

Ship traffic is one of contributors to the total input of nutrients into the Baltic Sea. A certain amount of nitrogen is contributed by both Baltic Sea ship traffic and ships in the North Sea. The data on deposition of nitrogen on the Baltic Sea area are annually provided by EMEP MSC-W center. The annual dataset includes evaluation of deposition from different sources including ship traffic. MSC-W uses emissions inventoried by the EMEP Centre on Emission Inventories and Projections (CEIP).

Independently, the Finnish Meteorological Institute (FMI) has developed its own ship emission data set based on real ship movements (Automatic Identification System, AIS data).

The Baltic Sea Pollution Load Compilation (PLC) utilizes data on deposition of nitrogen provided by EMEP. The last assessment of the progress towards country-wise allocated reduction targets (CART) indicated constant growth of ship traffic contribution into the total nitrogen input to the Baltic Sea. At the same time, the FMI's data reveal rather constant trend of emissions from ship traffic in the period from 2006 to 2014 with even a slight tendency towards reduction.

In order to resolve the inconsistence between CEIP and FMI emission data, MSC-W together with FMI prepared a joint paper which gives a brief overview of the basic assumptions underlying these two data sets.

Action requested

The Meeting is invited to take note the information and utilize it, as appropriate, in further work on assessment of nitrogen input to the Baltic Sea.

Note to HELCOM: data on emissions from international shipping used in EMEP MSC-W modelling

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1 Introduction

Emissions from shipping activities are an important source of air pollution in Europe. For air pollution modelling and assessments it is therefore important to have as accurate ship emission data as possible.

For modelling air concentrations and depositions (reported to UN CLRTAP, HELCOM, etc.) the EMEP Centre MSC-W uses emissions provided by the EMEP Centre on Emission Inventories and Projections (CEIP). Until 2014, CEIP provided international shipping emissions data based on ENTEC and IIASA estimates. Since 2015 (i.e. the EMEP status report for the year 2013) CEIP has used the *TNO-MACC* inventory, which was developed by TNO within the EU H2020 project MACC-III for international shipping in different European Seas (European part of the North Atlantic, Baltic Sea, Black Sea, Mediterranean Sea, North Sea and Caspian Sea).

The TNO-MACC data set extends until the year 2011. Therefore, CEIP and EMEP MSC-W have used the same emissions in their reports for the years 2011, 2012 and 2013. Also in this year's reporting (i.e the EMEP status report for the year 2014) EMEP MSC-W uses TNO-MACC data for 2011, as this is assumed to be the most accurate data on international shipping that is currently available to EMEP MSC-W modelling.

Independently, the Finnish Meteorological Institute (FMI) has developed its own ship emission data set based on real ship movements (Automatic Identification System, AIS data). For the Baltic Sea, the FMI data set extends until 2014. EMEP MSC-W has applied FMI data sets in various research projects (BSR Innoship, EnviSuM, North Sea NECA work).

FMI has reported its ship emission data to HELCOM, which has led to questions regarding the differences compared to the CEIP (TNO-MACC) data. The present note explains the differences between the FMI and TNO-MACC emission data sets and discusses possible ways forward, with regard to EMEP MSC-W modelling for UN CLRTAP and HELCOM.

2 Data on emissions from international shipping

In order to better understand the differences between CEIP and FMI emission data, this section gives a brief overview of the basic assumptions underlying these two data sets.

2.1 TNO-MACC

Improved data on emissions and trends for international sea shipping were developed by TNO within the EU MACC projects based on reviews of existing information and expert knowledge. One of the assumptions is that, at sea, mainly HFO (heavy fuel oil) is used, while diesel is used around and in ports. In-port emissions were included based on TNO expert judgement.

TNO-MACC takes into account different influences on ship emission trends:

- Economic growth of the sector per year
- SECA – Sulphur emission control areas North Sea and Baltic Sea
- Economic crisis: slow steaming to save fuel (costs); less emission per mile
- Trend towards bigger ships – economics of size

According to this data set international shipping emissions were increasing after 2000 with a trend change in 2006-2007. Related to the stepwise reductions in marine fuel sulphur content by SECA regulations (in the Baltic Sea area; May 2006, July 2010, January 2015) and EU sulphur directive requirements for low sulphur fuel use in EU port areas (January 2010), there has been a significant drop in SOx emissions from 2006 to 2010, and then again from 2010 to 2011.

The TNO-MACC data are available for the period of 2000-2011. To complete the emission trend for the earlier years 1990 to 1999, extrapolation was done by CEIP assuming a growth rate of 2.5% per year during that period. Due to the lack of expert estimates of international shipping emissions for 2012-2014, the emission data has been kept constant after 2011.

The TNO-MACC data for international shipping are, in general, lower than the ones that were used by CEIP until 2014 (see EMEP status report 1/2015, their Figure 3.5).

2.2 FMI

The FMI data set is a bottom-up inventory based on AIS data (real ship movements) and the STEAM model (Jalkanen et al., 2016, doi:10.5194/acp-16-71-2016). FMI combines ship movements with vessel specific technical data and predicts the fuel usage and emissions based on modeling of individual ships. As a result, the emission data sets fully reflect the changes of ship activity (route and speed changes) and the variability of ship building and powering options. The benefits of this approach include for example:

- Realistic description of ship traffic and ship emissions in the Baltic Sea region
- Possibility to validate ship specific emission predictions with ship stack measurements
- Conservation of geographical and temporal variability of emissions instead of reporting flat annual emission totals and static emission maps
- Classification of emissions according to various criteria, like vessel type, flag state and age
- Methodological compatibility with the latest IMO GHG study

There are some drawbacks, however:

- The earliest possible year for FMI emission inventory is year 2006 in the Baltic Sea area, because the AIS system became mandatory only during 2005. The coverage of AIS signals in year 2005 was low.
- Availability of AIS data from relevant organizations: In this regard, HELCOM has set an excellent example for others by facilitating access to AIS data for research purposes. The continuation of AIS

data delivery for ship emission studies for areas beyond the Baltic Sea is not guaranteed, because besides HELCOM, relevant organizations have not been as forthcoming with their AIS data.

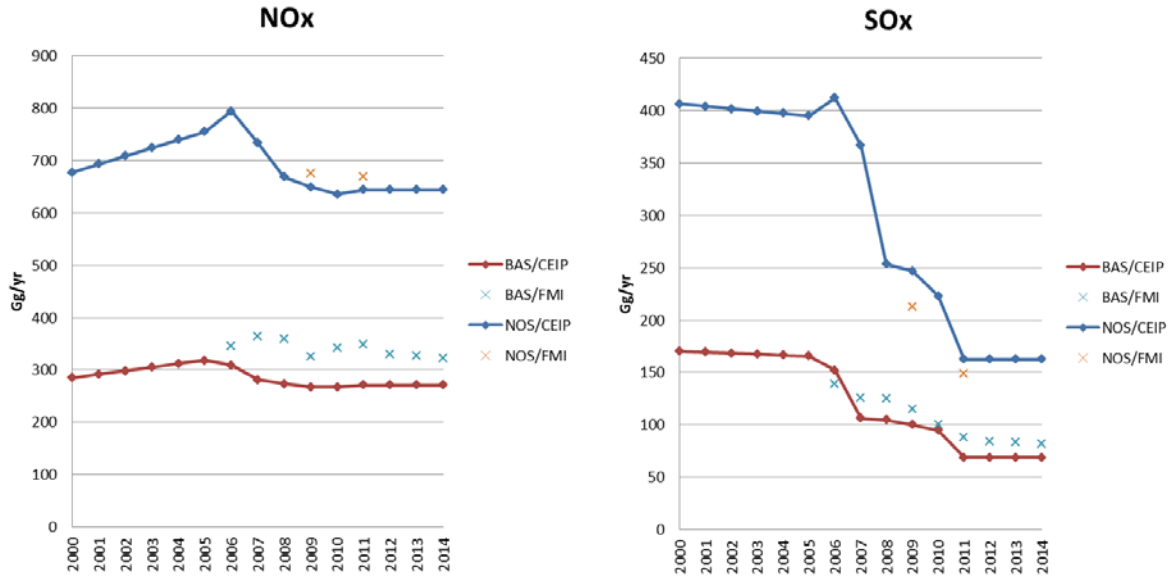
2.3 Comparison of data sets

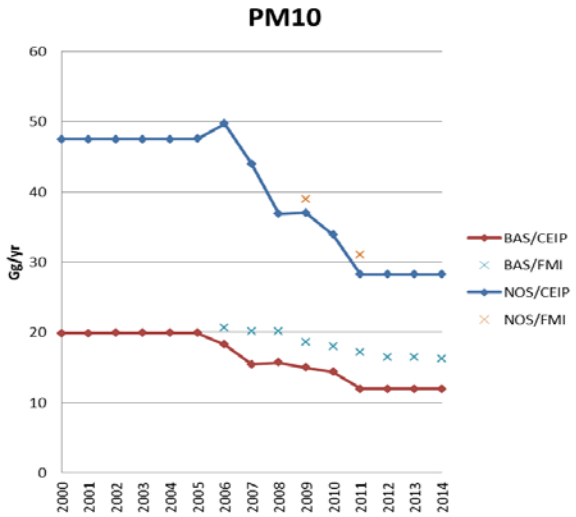
The figure below shows trends in ship emissions of NOx, SOx and PM_{10} for the Baltic Sea and the North Sea, according to the CEIP (TNO-MACC) and FMI data sets. In general, the FMI data is somewhat higher than the CEIP data (except for North Sea SOx).

During the North Sea NECA background studies TNO concluded that differences in the North Sea could be due to the fact that TNO handles ship auxiliary engine emissions differently from FMI. There are no ready-made models for vessel energy consumption with regard to auxiliary engines. The situation is better with regard to propulsion engines, because there are existing models for vessel resistance prediction as a function of speed. Differences between the data sets in the Baltic Sea are larger, and probably related to different assumptions on activity growth and slow steaming.

Nevertheless, the trends until 2011 in TNO-MACC and FMI are rather similar. After 2011, FMI has a small downward trend in shipping emissions in the Baltic Sea, probably because of economic downturn and the decrease of vessel activity, while CEIP has no trend (as TNO-MACC data are only available until 2011).

In the context of EMEP MSC-W modelling it is worth noting that, in regard to emissions in the Mediterranean (not shown), FMI suggests much higher values than CEIP (TNO-MACC). However, for the Mediterranean only one data point (2011) is available from FMI, so that trends cannot be compared.





CEIP data (TNO-MACC) and FMI data (based on AIS/STEAM) on annual emissions from international shipping in the Baltic Sea ('BAS') and North Sea ('NOS') from 2000 to 2014. Upper left: NOx, upper right: SOx, left: particulate matter (PM_{10}).

3 Conclusions and the way forward

For obvious reasons, accurate data should be used for air quality and deposition modelling. However, the judgement on which emission data set is fittest for purpose is not a straightforward task because measurements to constrain the emission estimates are sparse. Uncertainties derive from total fuel use, actual ship movements (spatial distribution of emissions), and emission factors (exhaust per kg of fuel burnt).

The fact that the FMI data are based on real ship movements (AIS) and extend to 2014 in the Baltic Sea, with 2015 data becoming available soon, makes their use an interesting option for EMEP MSC-W modelling and their reports to HELCOM. However, the availability of data until year 2014/15 only applies to the Baltic Sea. Data for other seas in the EMEP domain are only available until 2011 (e.g. North Sea and Mediterranean), or not at all (North Atlantic, Caspian Sea). From a technical point of view, annual updates of global ship emissions are fully feasible using the FMI approach, as was demonstrated in the 3rd IMO GHG study, and 2015 emission data will become available once the global calculation (with global AIS data) is finished by FMI. However, these emission calculations require access to global AIS data, which are currently only available from commercial data providers, i.e. require funding. For European sea areas, AIS data is already collected by EU maritime authorities, but the question whether these data can be made available for ship emission research is still open.

For these reasons, the use of FMI data is currently not an option for EMEP MSC-W modelling. However, discussions are ongoing to improve the situation with respect to restrictions on the use of FMI ship emission data. Also, further research is needed on emission factors, which differ between the FMI and TNO-MACC sets. The question of emission factors for international shipping will thus be revisited prior to the modelling in 2017 (i.e. for the status in 2015).

In conclusion, we note that for this year's EMEP MSC-W modelling (status of 2014 and trends), the trend in international ship emissions is assumed to be zero after 2011. Although data beyond 2011 do exist, their access is restricted for use in the EMEP MSC-W model. However, since the trends after 2011 in the FMI data are very small for the Baltic Sea, it is assumed that the error introduced by assuming a zero trend is also small and well within meteorological variability or uncertainties in other input data and in the modelling. It is expected that the recovery of economy will influence vessel activity, which will inevitably have an impact on Baltic Sea ship emissions. These issues will be clearly mentioned in the EMEP report to HELCOM in 2016.

In addition, a dedicated chapter on ship emissions (with focus on the Baltic Sea, North Sea and the Mediterranean Sea) has been written for this year's EMEP status report 1/2016, to be published in September 2016 at www.emep.int.