INTERNATIONAL MARITIME ORGANIZATION

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AIR POLLUTION AND ENERGY EFFICIENCY

Emissions of Black Carbon from shipping inside and outside the Arctic

Submitted by Norway

SUMMARY	
Executive summary:	This document presents new emission data of Black Carbon (BC) from shipping within the Arctic, and from shipping north of 50 degrees north. The document also provides information on the importance of Black Carbon emissions in the Arctic.
Strategic direction:	7.3
High-level action:	7.3.2
Planned output:	7.3.2.1
Action to be taken:	Paragraph 21
Related documents:	None

Background

1 The purpose of this document is to provide information which may assist the Committee in further consideration of the impact on the Arctic of emissions of Black Carbon (BC) from international shipping. This document presents information on emissions of BC from shipping within the Arctic, as well as information on emissions of BC north of 50 degrees north. Emissions data are fed into a spreading model in order to evaluate whether emissions outside the Arctic are significant. Furthermore, reference is made to other studies which investigates the importance of emissions outside and inside the Arctic.

Methods for calculating Black Carbon from shipping in the Arctic

2 Emissions in this document are calculated on the basis of shipping activity combined with ship specific information. The AIS based environmental accounting system requires information from several data sources and that they are gathered and merged in a dedicated database. Calculation of fuel consumption and emissions to air are made for single ships applying the model as shown below and aggregated.

3 Based on the collected information, the calculations of fuel consumption, emissions to air and discharges to sea are made. The two main data sources for the environmental accounting system are the AIS ship movement data and the ship register. However, the system will require supporting data when making calculations not directly linked to information in the ship register or when the two data sources contain incomplete data.

4 The AIS data have several fields giving specific information on ship identification and ship particulars. However, the ship particulars presented in the AIS source are limited and a link with a comprehensive ship register is required for improving the data quality and for including additional information. The link between the AIS data and the ship register will then enable in-depth analysis and calculations, e.g. environmental accounting, risk analysis, analysis of voyage performance, Energy Efficiency Operational Indicator (EEOI), etc. Based on this, the vessels fuel consumption is calculated between each registration interval which again represents the basis for the emission calculations performed.

Gas component	Emission factors for engines (kg/ton fuel)		
	Slow Speed Engine RPM < 200	Medium Speed 200 < Engine RPM< 750	High Speed Engine RPM > 750
BC_EmFactor (kg/ton fuel)	0.18	0.18	0.18

Table 1: Gas Compentent. Source: DNV, 2013

Combining three data set

5 To be able to generate a full picture of BC emission over a full year, it has been essential to compile three different data sets:

.1 the IMO Arctic region: Emission density from shipping within the IMO definition of the Arctic is based on satellite tracking from April 2011 – April 2012;

.2 50 to 60 degrees: Emission density from shipping based on satellite based world-wide data from April 2012 – January 2013. From the world-wide data set, the data from 50-60 degrees north was selected and also the "missing area" in the Norwegian and Barents Sea was filled in using this data set. In order to represent a full year compatible with the data set for the Arctic, it was decided to let January and February to be represented by December and March and April represented by May. The variation between these months for the 50-60 degree region is assumed to be moderate and hence the approximation should not significantly affect the results; and

.3 for the Norwegian, North, Barents and the Baltic Sea, the current AIS satellite is a great instrument for collecting ship data, but it also has a limitation when the traffic density is at the highest. In the North Sea and the Baltic Sea, hardly any ship movements are recorded. To compensate for this huge influence to the overall emission picture, Norway has included data from our HELCOM (land-based – not satellite) data set.

6 Combining these three data sets on a 1x1 degree raster, the BC emission density is calculated and plotted as shown in figure 1. This data is then sent to the Norwegian Meteorological Institute for dispersion analysis.

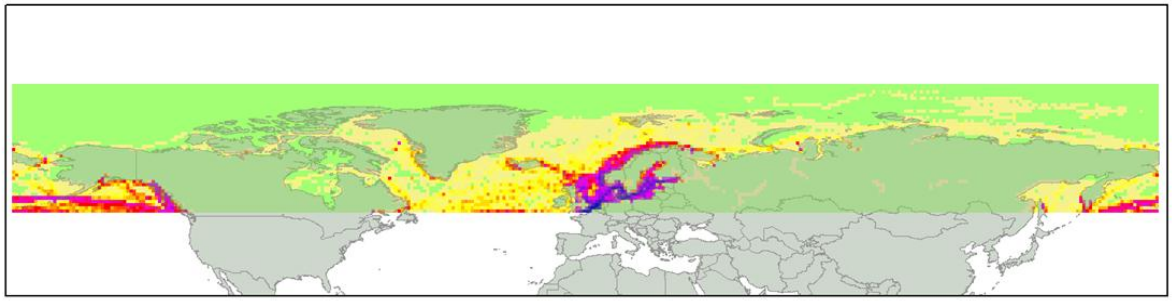


Figure 1: BC Emission density from shipping (September 2012) (Blue-high, yellow-low)

Dispersion analysis

7 The EMEP model is a chemical tracer model that can be run on domains ranging from global to local scales for calculations of air quality, depositions and air quality and deposition derived environmental indicators. The EMEP model is a public domain chemical tracer model available from https://wiki.met.no/emep/page1/unimodopensource2011

8 In the EMEP model, BC is calculated based on the emissions, followed by advection in the atmosphere. Sinks for BC are wet and dry depositions.

9 Here the EMEP model has been run for a full year in global mode with a 1x1 degree resolution. There are 20 vertical terrain following layers between the surface and 100hPa. The model has been run with meteorological input data for the year 2009.

10 The additional near surface air concentrations of BC are derived subtracting the results from model calculations with the BC emissions provided by DNV included from a model calculation including these emissions. The model calculations have been made in two steps. In the first step, the effects of ship emissions within the IMO Arctic region have been calculated. In the second step, the effects of ship emissions bordered by 50 degrees north and the IMO polar region have been made. Finally, the data is superimposed to represent the total emissions which are plotted in the figures below.

Formation of Black Carbon in the Arctic

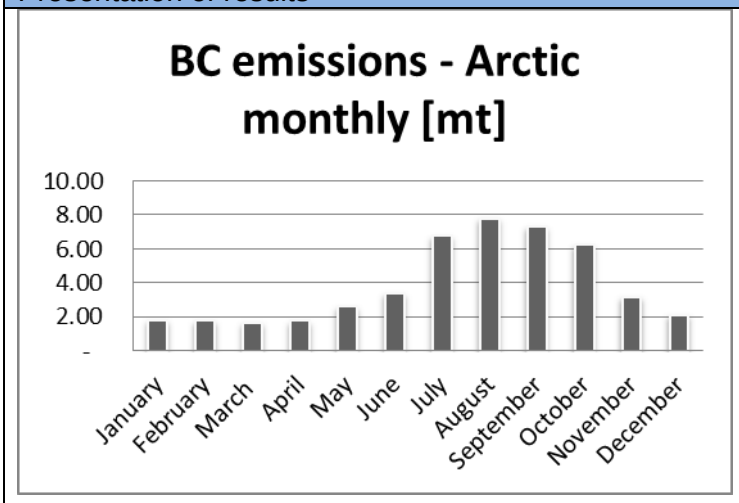
11 According to the article by The International Global Atmospheric Chemistry (IGAC) Project, *Bounding the role of BC in the climate system: A scientific assessment* (2013), there is a very high probability that BC emissions, have a lagrer forcing and warming effect on climate globally. Further, this study presents that short-lived climate forces are more dominant than in previous studies.

12 It is assumed that marine shipping contributes about 2 per cent of global BC emissions, but may constitute a larger fraction of direct BC emissions in remote regions. BC is a distinct type of carbonaceous material, formed only in flames during combustion of carbon-based fuels. It is distinguishable from other forms of carbon and carbon compounds contained in atmospheric aerosol because it has a unique combination of strong absorbation of solar radiation, refractory nature (stability at high temperatures), and insolubility in water.

13 BC particles emitted by fossil fuel and biomass combustion, transported in and to the Arctic and deposited in the snow and ice reduce the albedo of the surface and thus contributes to a warming of the climate.

Results

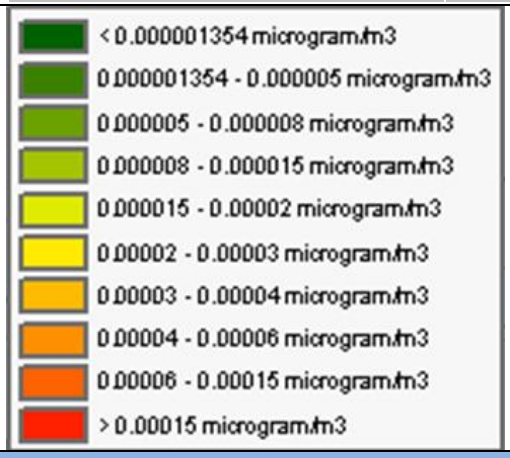
Presentation of results



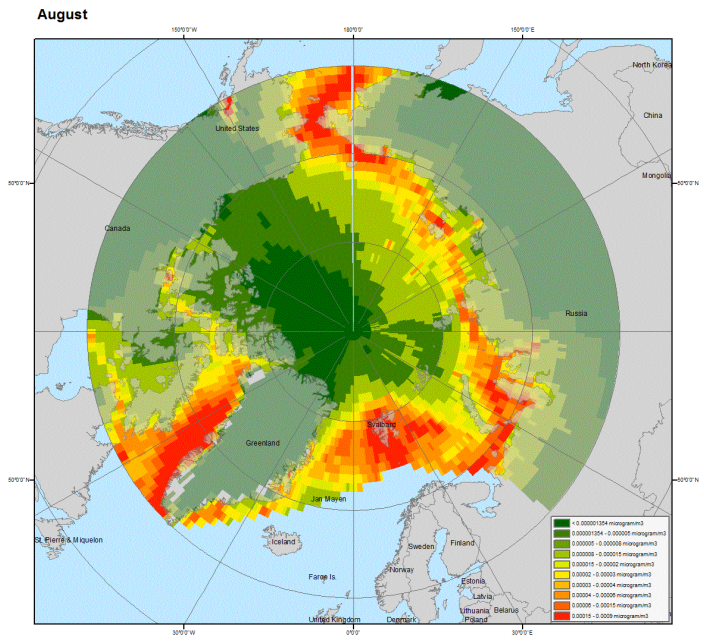
Vessel Category (one year)	BC [mt]
Other Activities	15.81
Other offshore vessels	0.79
Bulk ship	6.13
Fishing vessels	20.31
Gas tankers	0.00
Product tankers	4.04
Reefers	1.48
Container vessels	13.90
Offshore supply vessels	7.02
Oil tankers	10.75
Passenger vessels	7.71
General cargo	4.24
Unknown	-
Total (one year)	92,17

The results of the analysis are presented as contour plots with 1°x1° resolution illustrating the BC concentration at 2 m altitude.

Note that the scale is extremely low (maximum 0.15*10-6 g/m3) in order to represent the contours in the Arctic region. Consequently the results south of the Arctic are grossly overexposed. Note also that these are emissions from shipping only, but the interaction with land based emissions is accounted for in the dispersion analysis.



BC concentration from shipping within the Arctic



BC concentration from shipping above 50°

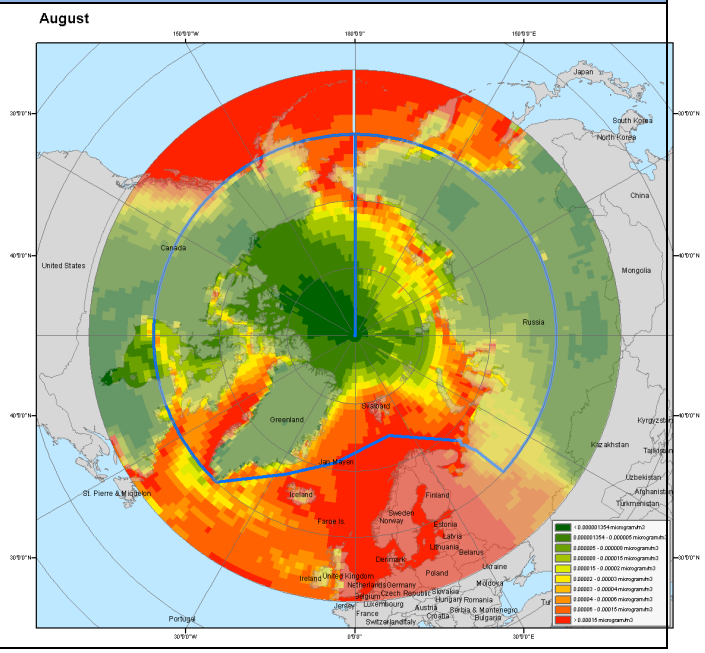


Figure 2: Presentation of the results. Source: DNV, 2013.

14 In figure 2 the bottom left column presents BC concentrations from shipping within the Arctic only. The right bottom hand column includes ship emissions down to 50°North. These two plots show the emissions in August which has the highest shipping activity. As can be seen in the density plots above, the BC concentration for the central Arctic is largely affected by Arctic shipping. The effect of the much heavier traffic in the adjacent regions is limited though a marked effect may be detected towards Scandinavia and slightly less so – also towards the Aleuts.

Discussion

15 The Arctic Monitoring and Assessment Programme (AMAP) is one of five Working Groups of the Arctic Council, which is Canada, Denmark, Finland, Iceland, Norway, Russian Federation, Sweeden and the United States of America. In 2009 AMAP established an Expert Group on Short-Lived Climate Forces (SLCF). The AMAP Technical Report No.4 (2011) *The Impact of Black Carbon on Arctic Climate* is a result of a work by the Expert Group on SLCF.

16 The report/analysis by AMAP is focused on Arctic impacts of BC with the Arctic defined as all regions north of 60 degrees North. As shown in figure 3 the the normalized net forcing (atmospheric direct forcing due to BC and BC snow/ice forcing) due to emissions form Arctic Council nations, compared to latitude bands, and global and within Arctic shipping. The comparison emphasizes the significance of close-to-Arctic and within Arctic sources to relativte more distant scources on a forcing per unit emission basis.

17 Within-Arctic BC sources (e.g. shipping, flaring) have a large impact on low-altitude BC concentrations and BC deposition in the Arctic, and thus, are likley to have a large forcing *per unit emission.*

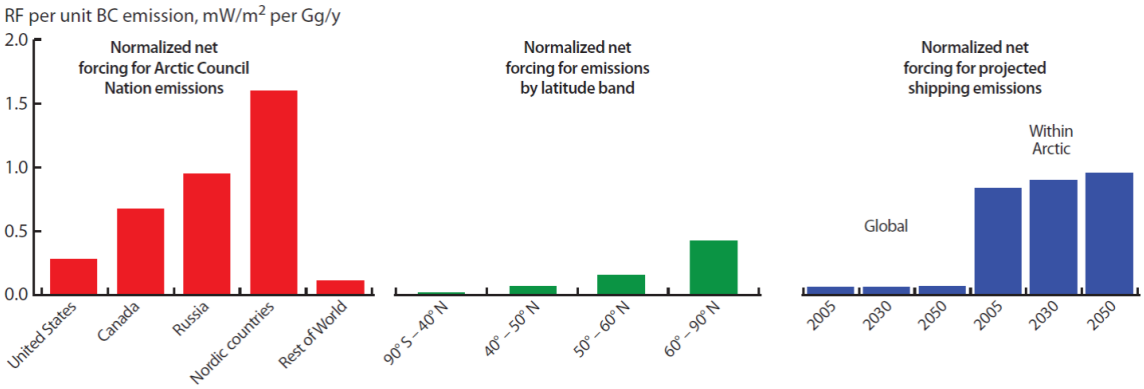


Figure 3: Source: AMAP, 2011

18 It has been more evident that it is of great importance to reduce short lived climate gases such as BC and methane if the global temperature increase should be sufficiently controlled, as shown in figure 4.

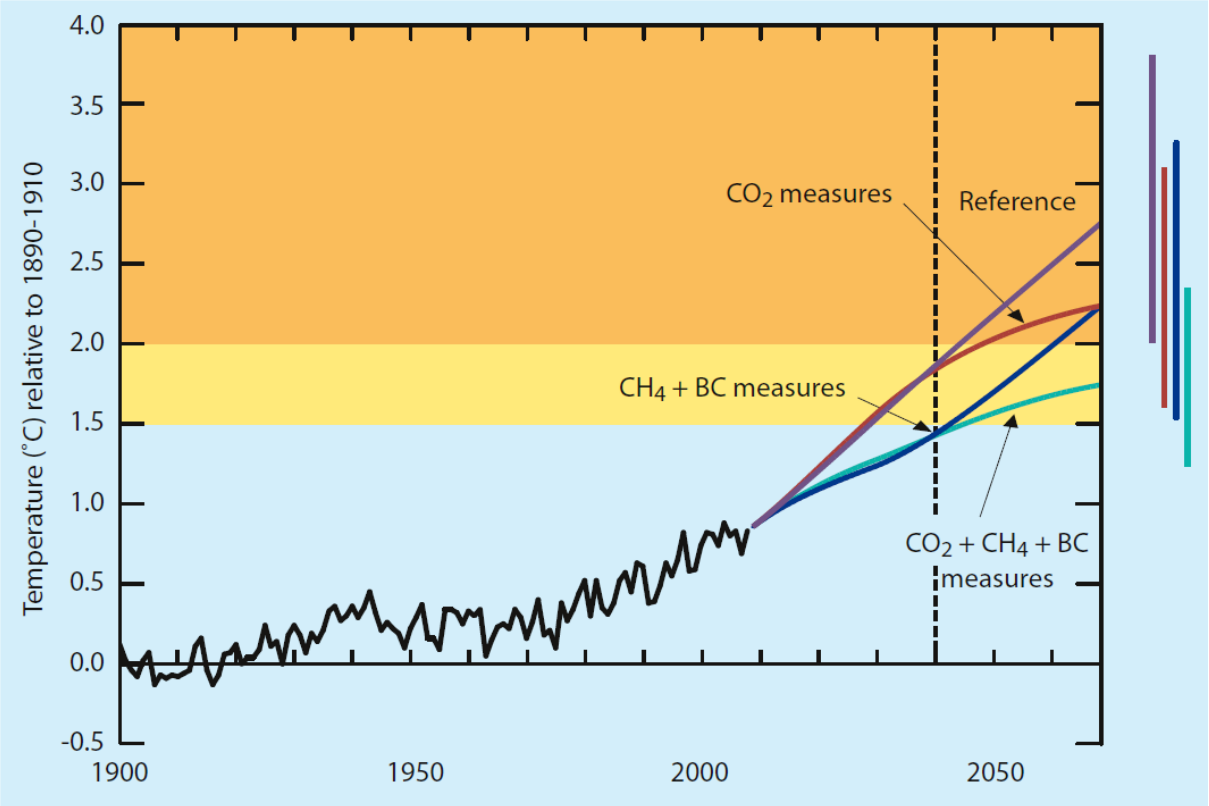


Figure 4: Source: UNEP/WMO using an average of two global composition models (GCMs) that estimates pollutant concentrations, radiative forcing and global climate.

Conclusion

19 The climate change effects of BC emissions are great importance. The results presented in this document clarify more precisley the emisson of BC within the Arctic region from international shipping and its impact on the Arctic climate.

20 Emissons of BC within the Arctic region are more significant than emisson in lower latitude regions. It is of great importance that the results and information presented in this document are taken into account when establishement potential mitigation action of BC will be considered.

Action requested of the Committee

21 The Committee is invited to consider the above information and take action as appropriate.