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ACCESS

Arctic Climate Change, Economy and Society

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D2.43 – Investigation of the decrease of ice by Arctic shipping and an assessment of potential governance solutions

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Dissemination Level		
PU	Public	
PP	Restricted to other programme participants (including the Commission Services)	
RE	Restricted to a group specified by the consortium (including the Commission Services)	
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1. Introduction

Arctic shipping routes may reduce global ship emissions due to shorter cruising distances. However, short-lived ship emissions and their products may contribute significantly to the regional pollution in the Arctic and thus may have an impact on the regional climate (Sand et al., 2013; Schwarz et al., 2013; Stohl et al., 2013). Of special concern is the locally emitted black carbon (BC) which, after deposition, may cause a particular efficient reduction in the albedo of sea ice and snow pack (Flanner et al., 2007). Within the ACCESS project, emissions for some exemplary ship types were calculated for different routes along the Northern Sea Route (NSR). Provided are emissions released per transit, based on fuel consumption and emission factors for the different ship types (Section 2). However, for a better ranking of the contribution of emissions due to local Arctic shipping, also emissions from other sectors (mainly from anthropogenic activities and boreal fires) have to be considered. Therefore, a review of recent corresponding model studies has been performed and section 3 summarizes results on the contribution of black carbon deposition at high northern latitudes from local Arctic shipping and from imported emissions (i.e. emissions released outside and then transported into the Arctic).

2. Calculated emissions for dedicated ships travelling along the Northern Sea Route

To better understand the impact of ship emissions due to Arctic shipping, the fuel consumption of different ship types as well as emissions emitted along the Northern Sea Route (NSR) were calculated within the ACCESS task D2.42: “Calculation of fuel consumption per mile for various ship types and ice conditions in past, present and future”. The Northern Sea Route is a shipping lane officially defined by the Russian government from the Atlantic Ocean to the Pacific Ocean, specifically leading along the Russian Arctic coast from Murmansk on the Barents Sea, along Siberia, to the Bering Strait and Far East. The entire route leads through Arctic waters.

The main factor influencing navigation through the NSR is the presence of ice. The navigation season for transit passages on the NSR starts approximately at the beginning of July and lasts through to the second half of November. There are no specific dates for commencement and completion of navigation as it depends on the particular ice conditions. In 2011 the navigation season on the NSR seaways for large vessels constituted 141 days in total, i.e. more than 4.5 months.

Using the routing software ICEROUTE (see D2.42), the fuel consumption was calculated as a function of power, ice conditions and speed for various ship types traveling on different ice routes in the Arctic. The result of this simulation is the basis for emission values calculated from the actual power consumption per mile for each leg and for the total voyage.

Four different transit routes along the Northern Sea Route were considered, presented in Figure 1. All 4 routes considered start from Murmansk and lead to Bering Strait via different alternatives.

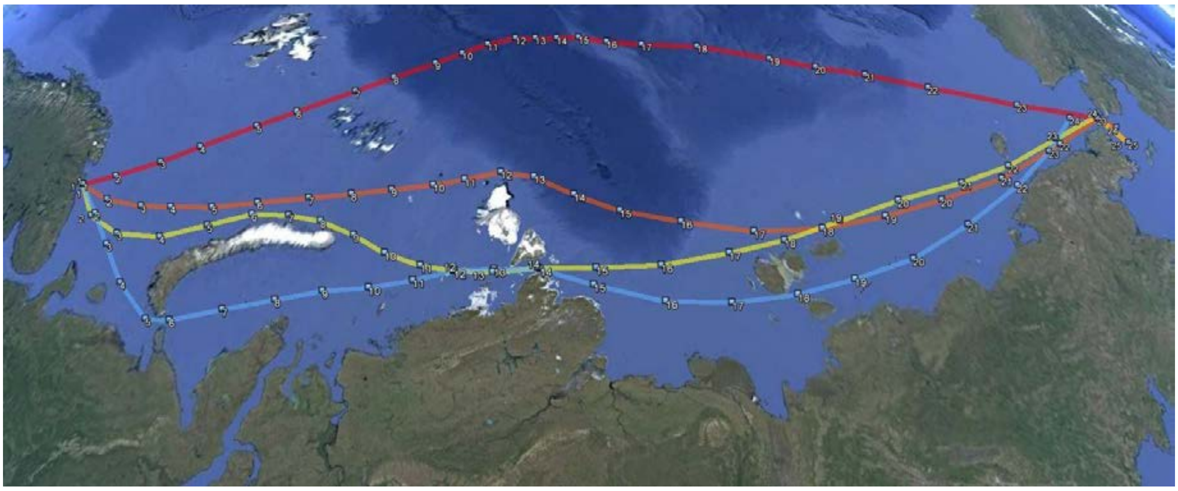

Figure 1: Different transit routes along the NSR: Route 1 (blue, 3048 nm), Route 2 (yellow, 2998 nm), Route 3 (orange, 2892 nm), and Route 4 (red, 2729 nm). Taken from ACCESS D2.42 (Figure 10).

Emission data for three different ship types were calculated including bulk carriers, oil tankers and LNG (liquefied natural gas) carriers (for a detailed technical description, see ACCESS report D2.42, section 3.1). Figure 2 shows a comparison of exhaust emissions exemplary for the 1980-November-Route 1 since this was one of the only transits completed by every ship. It is important to note that this route seems to be relatively ice free, as the ships have short travel times. This results in lower fuel rates, as the ships delivering less engine power are able to travel at a low power level due to the save speed in partly ice covered regions. While the Bulker needs more fuel and consequently exhausts more pollutants, Tanker01 has the highest emissions.

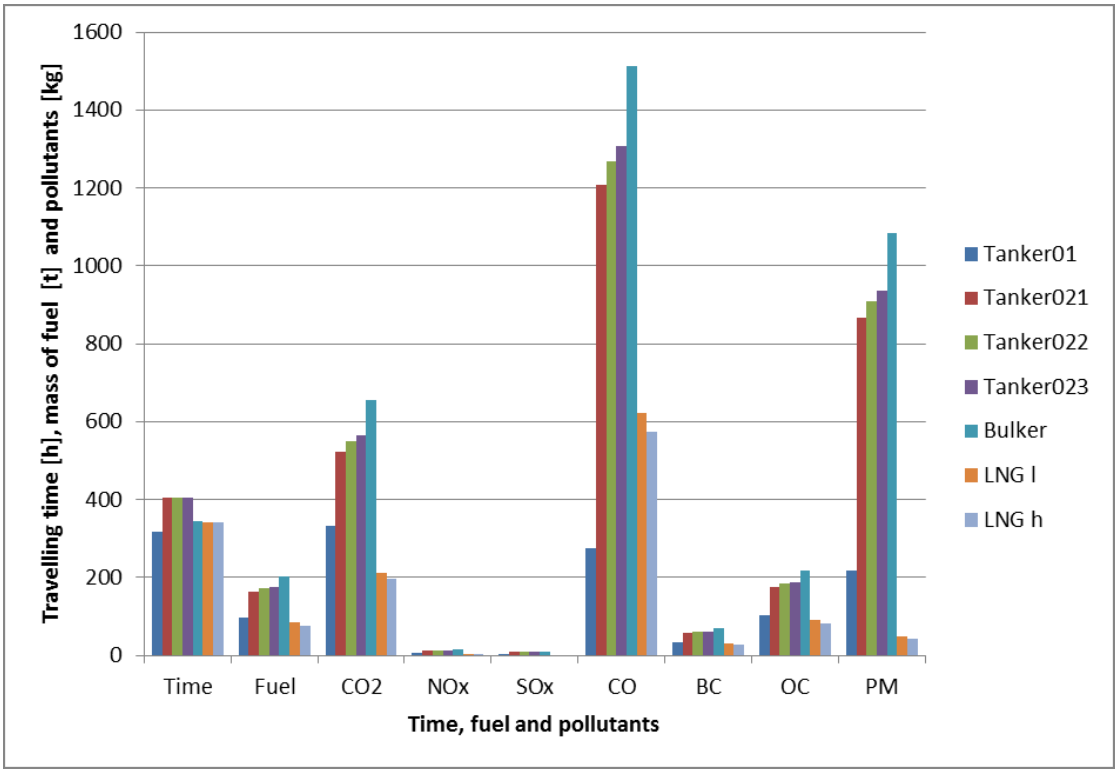

Figure 2: Exhaust gas emissions from all investigated ships in [kg] (1980-09-r1, see ACCESS D2.42, Figure 34).

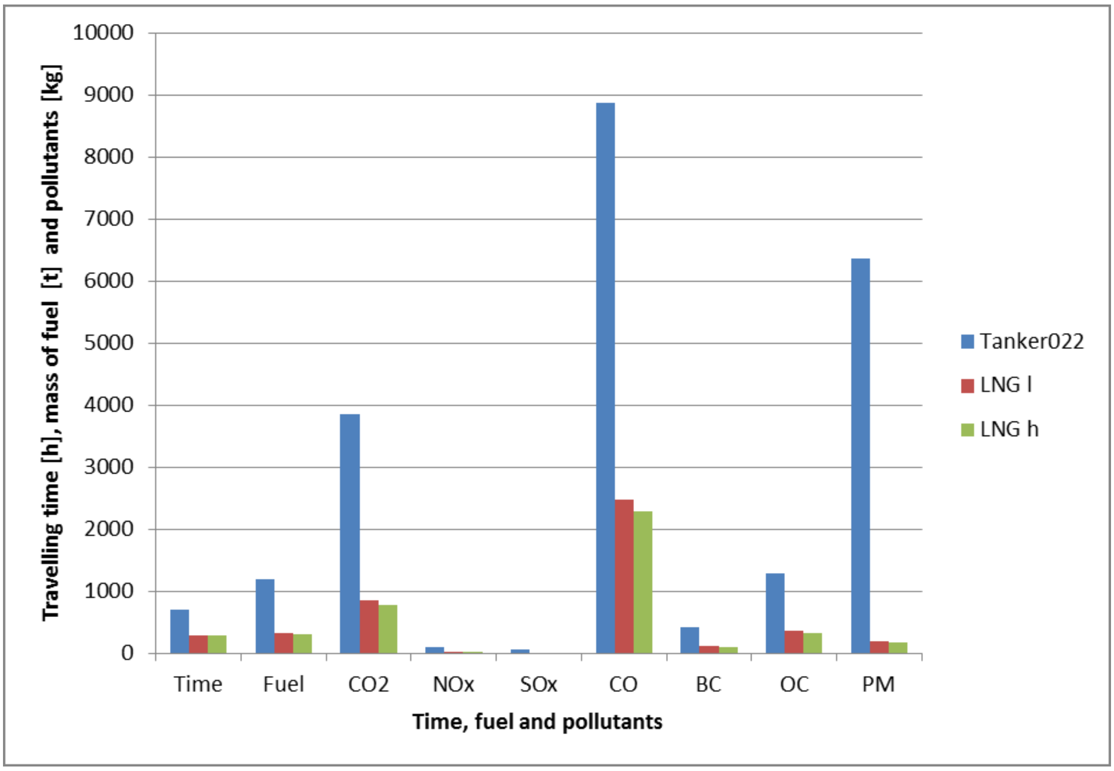

Figure 3: Exhaust gas emissions from LNG Carriers and the Bulker in [kg] (2040-09-r4, see ACCESS D2.42, Figure 35).

Figure 3 presents the emission data calculated for route 4 (forecast for November 2040), which is closest to the North Pole and therefore covered with more ice throughout the whole year. The results show that the Tanker01 has much higher consumption as the travel times is about 30 days compared to 11 days for the LNG Carriers, which have a high ice-breaking capability. In this case obviously the emissions depend on the travelling time as stated before. The magnitude of the LNG Carrier's emissions is about one third of the Tanker's.

In order to estimate the amount of Black Carbon from shipping in the Arctic, which may affect the melting of snow and ice, we use data on ship exhaust as described in the ACCESS-Report D 2.42 addressed above. According to data included in Chapter 3 the emission of black carbon from ships in Arctic waters amounts to 1 gram per 1000 kw power and per minute. Considering 50 to 70 ships using the NSR between Europe and East-Asia, an average installed power on ships of 18 MW, and an Arctic cruising time of 8 days, we calculate 12,4 Tons of BC emitted by transarctic shipping per present winter season.

Since most of these transarctic ships use the shipping in convoy guided by Russian Atom-icebreakers, the fuel consumption and associated emissions of the cargo vessels are reduced by approximately 50% due to less power required in open water than by breaking the level ice cover or even ice pressure ridges.

3. BC deposition in the Arctic from local shipping vs. imported pollution from southerly latitudes

It is well known that the Arctic chemical composition is not only affected by local emissions as for example from shipping, but also by imported emissions from extra-Arctic sources (e.g. Law et al., 2014, Roiger et al., 2014). Therefore, for a proper evaluation of the impact of Arctic shipping emissions, emissions from other sectors (industrial and forest fires) have to be taken into account as well.

A recent modelling study focused on the relative contribution of BC deposition due to Arctic shipping in comparison to BC deposition from imported emissions from sources at lower latitudes (Browse et al., 2013). Simulations with a chemical transport model (TOMCAT) coupled with a recently improved global aerosol model (GLOMAP, Browse et al., 2012), reveal BC transported from mid-latitudes into the Arctic to be the dominant contribution for BC deposition on Arctic ice. The study makes use of a detailed Arctic shipping emission inventory (Corbett et al., 2010) which includes two scenarios, a BAU (business as usual) and a HiG (Hi Growth) scenario. Both scenarios include legislations concerning shipping fuel standards, e.g. lower SO_2 emissions, which may indirectly impact on the lifetime of BC. Emissions from other sources than shipping, e.g. from anthropogenic sources and wildfires, were also included using state-of-the art emission inventories.

The model simulations show that currently (in 2004) the deposition of BC mass north of 60°N due to Arctic shipping is highest in July, but due to lower ice coverage in summer, the seasonal cycle of deposition on sea ice peaks in winter. Annually, Arctic shipping contributes 0.3% to the BC mass deposited north of 60°N. Due to emission import from lower latitudes, extra-Arctic shipping contributes more BC mass to deposition at latitudes of >60°N than Arctic shipping (68%). However, it is also important to note that BC deposition due to Arctic shipping originates from less than 1% of global shipping emissions.

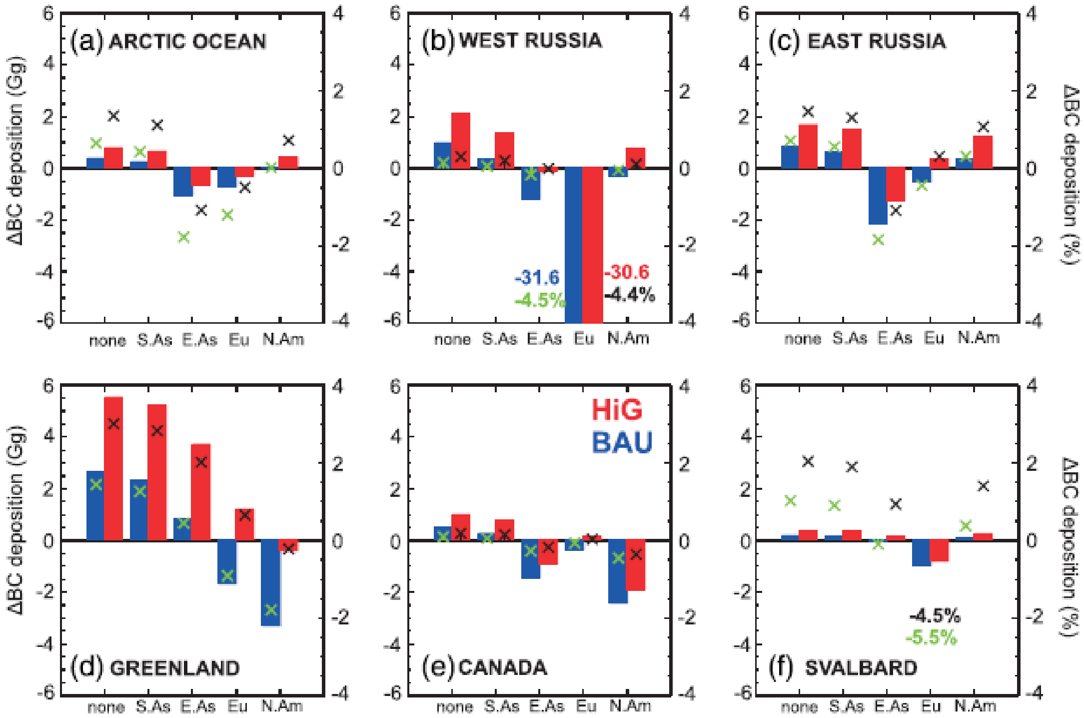

Figure 4 (a–f) Change in annual BC deposition between 2004 and 2050 over six different regions for the BAU (blue) and HiG (red) shipping scenarios and five different mitigation strategies: no mitigation (none), 10% reduction in South Asian BC emissions (S.As), 10% reduction in East Asian emissions (E. As), 10% reduction in European emissions (Eu), and 10% reduction in North American emissions (N.Am). The absolute change (left axis) is shown as the bars while the percentage change (right axis) is shown by the green (BAU) and black (HiG) crosses. Taken from Browse et al., 2014.

The projection for emissions from Arctic shipping for 2050 includes an increase of BC deposition north of 60°N. Nevertheless, in both the BAU and HiG scenario, the deposition over the entire Arctic remains relatively small, the maximum contribution of Arctic shipping to high latitude deposition is projected to be 5%. However, regional BC deposition in the sub-Arctic and close to heavy ship traffic may increase by up to 15%.

In order to confirm that extra-Arctic sources contribute more to BC deposition than Arctic shipping, Browse et al. (2013) performed model simulations of mitigation strategies for different Arctic regions. Figure 4 compares the modelled change in 2050 BC deposition for both the BAU and HiG shipping scenarios over six different Arctic regions. For example, over Greenland (Figure 4d), a 10% reduction in North American emissions results in a regional reduction in BC deposition (despite increased ship traffic), suggesting a high potential for mitigation strategies of extra-Arctic emission sources.

4. Conclusion

As expected, the fuel and exhaust gas calculations (see ACCESS D2.42) show a clear decrease of travelling time for all ship types due to the decline of the Arctic sea ice coverage and thickness. While this results in lower fuel consumption and consequently lower exhaust gas emissions, more vessels even with a low ice breaking capability have the opportunity to use the NSR, therefore increasing the total emission amounts.

It is important to note that there are still high uncertainties which hamper the prediction of future scenarios, with the ice forecast being one of the main uncertainties of the calculations. Another uncertainty is the number of ships, which may operate under reasonable safe and economic conditions. This number will depend on the development of the region and its infrastructure (socio economic factors). Additionally the travel time and operation condition of the different ship types include uncertainties, as the speed profile as well as the emission factors do not only depend on technical abilities and the ship types, but also on freight rates and type of goods to be transported along the Northern Sea Route.

Nevertheless, recent model studies show that regulations of Arctic shipping emissions alone are insufficient to reduce Arctic BC deposition, due to the import of BC from extra-Arctic sources. Therefore, emission controls of landbased sources need to be considered as well together with regulations of Arctic shipping.

EU –Legislation and IMO are presently working on a law to accept ships over 5,000 gross tons in European harbors only if driven by LNG -- beginning in 2018. This regulation will reduce the BC emissions of transarctic shipping departing from and arriving in Europe.

It is recommended that the European Commission convinces the Russian Government that also Russian ships operating in the Arctic should also use LNG. As a benefit these Russian ships would be allowed to transport goods to and from EU-harbors.

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