Answer to Anonymous Referee #2:

First, we want to thank the referee for the positive comments and for concluding that the topic is important and the well written and interesting. We follow the suggestions for revisions that has lead to an improved manuscript. We reply to each comment below (the text in italic):

GENERAL COMMENTS

The manuscript reports a study that mainly aimed to predict shipping emissions and evaluate their impact on air quality over the Nordic, including the Arctic area, as well as to assess the health impact. The study is very interesting on a very important topic and is well written. Overall, the methodology was well performed. Nevertheless, there are some revisions that I recommend to be performed before publication.

SPECIFIC COMMENTS

1.Introduction

1.1 In the objective there is reference to "…assess the overall impact…". What does this mean? I mortality and morbidity going to be assessed?

Reply: In the description of the health assessment model, we give details on the health endpoints included. But we agree that more details should be given in the introduction. We have therefore added the text below.

Added to line 96: "The focus is here on mortality and the number of premature deaths associated with exposure to air pollution. "

2. Materials and methods

2.1 The figure with the study area domains should appear in the section that refers to the DEHM model, and no text should be between the section "2. Materials and methods" and the sub-section "2.1 Setup of shipping emissions inventory"

Reply: We have removed the text and moved the figure as suggested. We have also corrected a mistake in the numbering of the sections 2.2-2.4.

2.2 Please comment on the likelihood of the future scenarios presented.

Reply: SECA seems politically unlikely because the IMO adopted an HFO ban recently. The SECA, HFO ban and the global sulphur cap aim at reducing sulphur and PM emissions from ships. Introduction of a SECA without the Arctic HFO ban would have allowed the use of Ultra Low Sulphur Fuel Oil (ULSFO) in Arctic waters.

HFO ban was agreed at MEPC75 meeting in Nov 2020. This ban includes use and carriage of HFO in Arctic waters from July 1st 2024 onwards. However, there are exemptions to this for countries which have coastlines bordering Arctic waters, until July 2029. The HFO ban will enter in force for all vessels from that date onwards. It should be noted that hybrid fuels, like Very Low Sulphur Fuel Oil (VLSFO) and ULSFO are considered as heavy fuels and cannot be used in Arctic waters once the ban is in force. The use of these fuels

has increased considerably since the introduction of global 2020 sulphur cap. With the Arctic HFO ban, vessels operating at high latitudes need to switch to lighter distillate fuels.

We have assumed rather marginal growth of LNG vessels in the Arctic, because the lack of refueling infrastructure is a significant challenge. Gas tankers carrying LNG cargoes and using boil-off gas as a propulsion fuel would still be feasible, though. The scenarios developed in this work were aligned with those of the Third IMO GHG study.

We have now added some of these considerations to the discussion in Section 4:

*"*In terms of likelihood, the HFO ban scenario seems most likely at the moment as the IMO has recently (at the MEPC75 meeting in November 2020) adopted a HFO ban. This ban includes use and carriage of HFO in Arctic waters from July 1st 2024 onwards. However, there are exemptions to this for countries with coastlines bordering Arctic waters. The HFO ban will enter in force for all vessels from July 2029. This will, however, require that vessels operating at higher latitudes move away from the use of e.g. hybrid fuels, like Very Low Sulphur Fuel Oil and the use of these fuels has increased considerably since the introduction of global 2020 sulphur cap.*"*

3. Results

3.1 There is a very high amount of figures/tables in the main text. Please consider putting some in supplementary material (for example emission factors don´t need to be in the main text; table 2 has the same results as figure5, one should be chosen;.

Reply: We agree that some of the details given in the tables and figures can be moved to the Supplementary. We have therefore moved Figure 2 (Fuel related emission factors) and Figure 5 (summarizing Table 1 and 2) to a new section on the shipping emissions in the Supplementary. See also below.

3.2 In figures 7, 8, 10, 12 there are no legends in the axes. Maybe the figures related to health effects could be aggregated in a table where the several scenarios could be more easily compared.

Reply: Figure 8 has been improved (also following the comments from the other referee). Figure 10a has been deleted as the numbers are discussed in the text. Figure 10b has been moved and merged to the former Figure 12 in order to have the information on the contribution from shipping collected in one figure. We keep this as plots and not a table as we think it is easier to see the difference between the models and the difference between the scenarios in a plot like this.

3.3 Are the EEA estimates for exposure due to shipping emissions?

Reply: No, the EEA estimates are for total air pollution – so all emissions sources. We recognizes that that this is not completely clear from the text, so we have added the following text:

Line 414: From "where premature deaths attributable to $PM_{2.5}$, NO_2 and O_3 exposure" -> "where premature deaths attributable to *total* $PM_{2.5}$, NO_2 and O_3 exposure"

Line 419: From "In Figure 8 the EEA estimates for $PM_{2.5}$ mortality in four of the Nordic countries are compared to the current DEHM-EVA and MATCH-EVA estimates based on the Baseline 2015 simulations."-> "In Figure 8 the EEA estimates for $PM_{2.5}$ mortality in four of the Nordic countries are compared to the

current DEHM-EVA and MATCH-EVA estimates based on the Baseline 2015 simulations *including both land based and shipping emissions*."

4. Discussion

4.1 This section should include a subsection with the uncertainties related to all the estimations performed.

*Reply: We agree that a discussion of the uncertainties related to this kind of assessment study, is very important. In Section 4 we already state "*Future projections and health assessments are inherently associated with uncertainties. In the following some of the uncertainties and limitations of the presents study are discussed." *So we already discuss the uncertainties related to the different elements of our study. In Section 3.2 we also give the uncertainties given by EEA. In our conclusion we also state "*By using the health assessment model EVA, we estimate that for the Nordic area the number of premature deaths related to air pollution will decrease from approximately 9900 (9400-10.400) in 2015 to 7900 (7700-8200) in 2050.*" And "*The range of the numbers given in brackets, represents the results for the two models and illustrates the uncertainties related to this kind of assessments e.g. related to differences in the setup of the two CTMs.*"*