

Interactive comment on “The influence of cruise ship emissions on air pollution in Svalbard – a harbinger of a more polluted Arctic?” by S. Eckhardt et al.

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We would like to thank Referee one for the constructive comments and careful language/content checks on our manuscript. In the following list we will answer the questions (which we repeat in italic) and explain how we implemented them in the manuscript.

However, 500 passengers were used as a threshold for 24-h samples of SO₂ (see Sect. 1.4). (p.3076, lines 24 –25) I think you mean Sect 2.4, not Sect 1.4. But even in Section 2.4, I don't think a clear explanation is given. Could you please explain what

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you mean by using 500 passengers as a threshold for 24-h samples?

Yes, section 2.4 is meant, thanks for spotting this.

Indeed the formulation might be misleading. What we meant is as the sample goes over a 24 hours period, we counted the total number of passengers disembarking during the same period, as most ships are not in the harbor for all of the 24 hours. To be consistent with the hourly measurements, we used a threshold for this total number of 500 passengers. We improved the explanation in the manuscript

Section 2.2: You assume the measurements at Zeppelin to be affected by ship from the time of arrival in Ny Ålesund until 4 hours after the departure from Ny Ålesund. For measurements at Ny Ålesund, you assume the measurements to be affected by ship from its arrival in Ny Ålesund until 2 hours after its departure from Ny Ålesund . Did I understand this correctly? If so, then I find Fig 3 (b) strange. You state in Section 3 that Vistamar and Athena arrived at 7:30am and 10:30am respectively. But in Fig 3 (b), both ships seem to have arrived much earlier (e.g. increase in the passenger number due to the arrival of Athena occurs just after 8am). Could you please explain why this is the case?

These are the data from the harbor log in local summer time (i.e. UTC +2)

Wednesday	01.07.2009	07:30	01.07.2009	10:30	Vistamar	281
Wednesday	01.07.2009	10:30	01.07.2009	15:30	Athena	377
Wednesday	01.07.2009	12:30	01.07.2009	18:00	Albarquel	9
Wednesday	01.07.2009	15:00	01.07.2009	18:00	Quest	53
Wednesday	01.07.2009	20:00	01.07.2009	23:00	Expedition	73

This was indeed unclear due to mixed use of local time and UTC. All graphs are consistently plotted in UTC, while the explanation of the harbor log is in local time. So Vistamar arrived at 5:30 UTC and Athena at 8:30 (the peak you refer to in figure 3b: Athena is still here between 8 and 9 – but not in the next hour while Vistamar stays).

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Plotted is only the time in the harbor without the 4 hour extension. We added the UTC times in addition to the local times in the manuscript and clarify in the figure caption that only actual times in the harbor are plotted.

(3) I find p.3081, lines 15 –17 confusing . I think you mean that you wanted to exclude the possibility that the differences you observed between 'ships' and 'no ships' were really due to the presence of ships and not due to the daily cycle of pollutants.Could you please reword the sentence?

We replaced this sentence with the following text: Our data show a statistically significant difference between periods when ships are present compared to times when no ships are present. However, most ships arrive during the daytime and pollutant concentrations generally are also highest during daytime. To support our interpretation that the ship emissions cause the elevated pollutant levels and reject the alternative interpretation that ship presence and daily cycle of pollution are coincidentally correlated due to similar but unrelated daily cycles, we repeated our analysis shown in Fig. 4, but for every hour of the day separately.

The meaning of the phrase taking into account the different frequency of periods with or without ships (p.3081, lines 25–26 and also p.3083, line 1) is not very clear. Do you mean that the days when ships were present were rare? What percentage of days was affected by ships?

Yes, the main point was that we elaborated the difference between times when ships are present compared to times without ships. But this does not give any information about the overall influence of the ships. So if in extreme case ships are only present one day every year, there might be a big difference in pollution measured on this day, but the whole season mean would be influenced only slightly by this one event. To make this more clear, we calculated the hours where ships are present and the hours when no ships are present for every year. We added following sentence: While it is interesting to compare pollution levels for periods with and without ship influence, the

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overall influence of ship emissions on the seasonal mean concentrations depends also on the frequency and duration of the periods with ship presence.

You say that 'Figure 5 shows that the EBC and PN60 concentrations are higher in the afternoon than in the morning regardless of ship presence' (p.3081, lines 18 –19) but this is not very obvious to me. Also, I find the colour scheme in Fig 5 misleading. In my opinion, it would be better to use different colours for 'ships' and 'no ships.' As for Fig 3, the x-axis label is too cluttered. You could get rid of ':00' for time to make it more readable.

We revised Figure 5 so that it now only shows labels for every second hour, which removes the clutter. Adding the ":00" after the hour makes it immediately clear to the reader that this is a time axis. We tried to change the colors for ships and no ships, but the figure is more clear if every group in time is shown with the same color. For EBC and PN60 the mean daily cycle is indeed not very large, so it does not show up very clearly but it can be seen when looking carefully. However, the main point is that the concentrations are enhanced during ship presence throughout the day.

We corrected all minor comments as suggested, some are discussed in detail below:

22 Which DMA did you use?

The DMPS is a custom build, using the Vienna type DMAs in combination with an nephelometer TSI CPCs. The original DMPS was updated to EUSAAR standard and the new DMPS was built according to EUSAAR standard. This is the description from the Tunved et al., 2013 paper – which we added a reference to in the paper.

When the measurements started in the beginning of 2000, the system consisted of a CPC 3760 together with a short Hauke-type DMA (Jokinen and Makela, 1997; Knutson and Whitby, 1975). Initially, the observations covered the size distribution between 22 and 500 nm. In October 2000, the size range of the instrument setup was adjusted to observe the size distribution between 20 and 630 nm. This setup was used until the

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end of 2002, when the system was modernized and the short Hauke-type DMA was replaced by a medium size Hauke DMA. Both setups used the same TSI CPC 3760, and the size range observed remained the same.

we updated the citation from ACPD to ACP:

Tunved, P., Ström, J., and Krejci, R.: Arctic aerosol life cycle: linking aerosol size distributions observed between 2000 and 2010 with air mass transport and precipitation at Zeppelin station, Ny-Ålesund, Svalbard, *Atmos. Chem. Phys.*, 13, 3643-3660, doi:10.5194/acp-13-3643-2013, 2013.

30. What do you mean by hourly peak (p 3079, line 21)

We mean peak of hourly averaged concentrations – changed it in the text

42 showed enhancements of 45, 44 and 72% - p 3082, line 17 Where these results present.

The percentages were calculated based on Figure 4, where they were described only as absolute enhancements – We added a reference to Figure 4 to make this more clear.

Interactive comment on *Atmos. Chem. Phys. Discuss.*, 13, 3071, 2013.