



The influence of cruise ship emissions on air pollution in Svalbard

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We have analyzed whether tourist cruise ships have an influence on measured sulfur dioxide (SO_2), ozone (O_3), Aitken mode particle and equivalent black carbon (EBC) concentrations at Ny Ålesund and Zeppelin Mountain on Svalbard in the Norwegian Arctic, during summer. We separated the measurement data set into periods when ships were present and periods when no ships were present in the Kongsfjord area, according to a long-term record of the number of passengers visiting Ny Ålesund. We show that when ships with more than 50 passengers cruise in the Kongsfjord, measured daytime-mean concentrations of 60-nm particles and EBC in summer show enhancements of 72 and 45% relative to values when no ships are present. Even larger enhancements of 81 and 72% were found for stagnant conditions. In contrast, O_3 concentrations were 5% lower on average and 7% lower under stagnant conditions, due to titration of O_3 with the emitted nitric oxide (NO). The differences between the two data subsets are largest for the highest measured percentiles while relatively small differences were found for the median concentrations, indicating that ship plumes are sampled relatively infrequently even when ships are generally present but carry high concentrations. We estimate that the ships increased the total summer mean concentrations of SO_2 , 60-nm particles and EBC by 15, 18 and 11%, respectively. Our findings have two important implications: Firstly, even at such a remote Arctic observatory as Zeppelin, the measurements can be influenced by tourist ship emissions. Careful data screening is recommended before summer-time Zeppelin data is used for data analysis or for comparison with global chemistry transport models. However, Zeppelin remains one of the most valuable Arctic observatories, as most other Arctic observatories face even larger local pollution problems. Secondly, given landing statistics of tourist ships on Svalbard, it is suspected that large parts of the Svalbard archipelago are affected by cruise ship emissions. Thus, our results may be taken as a warning signal of future pan-Arctic conditions, if Arctic shipping becomes more frequent and emission regulations are not strict enough.