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Atmospheric Measurement Techniques Discussions

Interactive comment on "Studies of the horizontal inhomogeneities in NO_2 concentrations above a shipping lane using ground-based MAX-DOAS and airborne imaging DOAS measurements" *by* André Seyler et al.

Anonymous Referee #2

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This paper presents measurements of NO2 from ship emissions in the German Bight using MAX-DOAS instrument, and shows that horizontal information on the NO2 distribution can be derived using an onion peeling method with NO2 slant columns derived separately in the UV and visible, which are observing slightly different air masses. The authors show two case studies of different wind directions, and use coincident airborne remote sensing observations of plume extents to derive mixing ratios from the MAX-DOAS measurements.

The paper is concisely written, well-organized and logical. The figures are very clear

and easy to follow. Overall I found the paper interesting and recommend it be eventually published. I did find it somewhat lacking in a description of motivation for the work and its possible application. The method for deriving horizontal information from MAX-DOAS using onion peeling was previously demonstrated for an urban area, and this paper is now applying it to ship emissions. This seems useful in theory, but it's not clear how the information would be used. Without plume extent information, the VMRs are derived over a long path in Section 4. Section 5 uses the airborne information to derive more precise VMR inside the plume, but these airborne measurements are rare and not regular. What would be the purpose of the MAX-DOAS measurements over a long time period? Would they be useful for trends, emissions estimates, monitoring etc? How can this be accomplished without plume width information, and are there other sources of this information? Can better modeling of ship plumes and NOx chemistry improve the estimates?

Also, aerosols, plume height and a few other sources of errors are quickly mentioned in Section 3.1, and clouds are quickly mentioned in Section 4.1. However, there is no thorough quantitative error assessment. I think the error sources need to be discussed and quantified in more detail. If you don't want to get into clouds, at least mention that for now you will only consider and draw conclusions about clear days. Also, error sources for the the AirMAP measurements should be described. There is an uncertainty given, but it is not clear from where it is derived. There are many possible error sources (fitting uncertainty, surface albedo, profile shape, aerosols etc).

Specific points:

Page 2, Line 5: specify whether these are ship or land based in situ measurements

Page 3, Section 2.1: Mention temporaral resolution of measurements here

Page 4, Line 7: Not sure column amount is a concentration?

Page 8, Line 9: Not sure what you mean by "instrument measures in wind direction"

Page 8, Line 14: NO2 only increases up to a point...

Page 11, Figure 6/7: In situ value colour saturates. Please mention what is the value in the text if not planning to change the colour scale. Maybe you could include it in Figure 5 as a function of time?

Figures 6/7/8/9: I find the forward trajectory of the plumes a bit hard to interpret. What is the timescale on these? Do the black to grey values denote anything?

Figure 10 and discussion in Section 5.3: I find the discussion of plume height a bit confusing and how it is used in the airborne observations. The MAX-DOAS on the tower seems to measure above the ship according to Figure 10, and the plume is not at the surface in the figure. Is there an assumed start height of the plume above the ocean? The AirMAP instrument is measuring the column to the surface. Why is 500 m used for the AMF calculation and not 335 m? Do the 335 m and 500 m height box profiles include a constant VMR to the surface? I don't think different assumptions will change the results by much, but the description of profiles and relation to the figure could do with some clarity.

Figures 11 and 14: Why show VMR and not DSCD for the MAX-DOAS here? Even though the DSCD is very diluted over a large area, it would at least put the measurements in the same units for easier visual comparison.

Technical corrections:

Page 2, Line 14: change colon to semicolon

Page 3, Line 25 and 26: Change "in a" to "at a" in both cases

Page 13, Line 2: "lightboth" not a word

figure 10: change "not up to scale" to "not to scale"

Page 18, Line 3: change colon to semicolon

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