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Interactive Comment

Interactive comment on "Black carbon emissions from in-use ships: a California regional assessment" *by* G. M. Buffaloe et al.

Anonymous Referee #2

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General comment: The manuscript "Black carbon emissions from in-use ships: a California regional assessment" by Buffaloe et al. is based on the measurements of black carbon (BC) emitted from ocean going vessels during the California Nexus (CalNex) campaign. Although the presented data is very important and valuable interpretation needs to be more focused. In the present form, the data has been used just to compare among the ship vessels, but causes of variability is not very clear. The differences in EFs between different categories are small compared to variability in a given type of ship/engine exhaust. The paper does not highlight: how such small changes in EFs with respect to type of ship/engine can be useful to develop inventory or for air quality study? Sulfur content has been the issue of the discussion in the beginning but later its role in EFs (or variability) has been sidelined. Several BC instruments have been inter-

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compared, which is good, but on what way it is required or how it is used to estimate final BC emission factor is not very clear. Several key figures are presented as suppl. which can very much be part of the draft as there are only 5 Figures. Overall, Figure representation also needs some improvements. A discussion on general importance of EF in context of regional air quality and climate change is also necessary. Several of recently published works related to BC inter-comparison and microphysical properties of BC over California deserve citation. This paper may be accepted but require substantial revision. Following specific comments in different sections/subsections should also be considered for the revision.

Abstract:

In the phrase "...which measure the mass concentration of refractory BC directly", I do not think that all these instruments measure the mass concentration DIRECTLY. Moreover, importance of data measured using four independent instruments is not clear. I mean, why the data from one good instrument (for BC) is not sufficient? at least for such studies. The interception of vessels is random in that case general comparison between CalNex and TexAQS is not worthy, some specific aspects can be highlighted.

Introduction:

Page 24677 Line 10-20: In this region (California coast), little more details of for in-use ships (fractions of fuel consumed on annual basis, etc.) using HFO, MGO and MDO will provide wider acceptance of such case studies.

Page 24679 Line 10-20: However, without a reference species, how the measurement of SO_2 alone can confirm that the type of vessel uses LSFs or HSFs? This information is also important considering the distance of plume source from Atlantis varied hence the travel time and dilution of plumes.

Experimental methods:

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2.2 Definition of black carbon:

I do not find anything new in this section than already reported in other studies. And the contents do not deserve a separate (subsection). However, key information can be merged to subsection "2.3.2".

"2.3.2 Light absorption and equivalent black carbon measurements"

2.4 Emission factor determination:

There can be a realistic situation, when the distances between intercepted vessels are not very far. In this case, a measured plume may have got mixed, then how the plume is identified and separated? Is the wind direction/speed has been used to filter the data? How about the plume-to-plume variation in ABC and ACO2, do these vary significantly?

3 Results 3.1 BC measurement technique comparison

In the context of inter comparison between different BC instruments I recommend to cite following works.

Kondo, Y., Sahu, L., Moteki, N., Khan, F., Takegawa, N., Liu, X., Koike, M., Miyakawa, T. (2011). Consistency and traceability of black carbon measurements made by laser-induced incandescence, thermal-optical transmittance, and filter-based photo-absorption techniques. Aerosol Science and Technology, 45(2), 295-312, DOI:10.1080/02786826.2010.533215.

Kondo, Y., Sahu, L. K., Kuwata, M., Miyazaki, Y., Takegawa, N., Moteki, N., Imaru, J., Han, S., Nakayama, T., Oanh, N. T. Kim, Hu, M., Kim, Y. J. Kita, K. (2009). Stabilization of the mass absorption cross section of black carbon for filter-based absorption photometry by the use of a heated inlet. Aerosol Science and Technology, 43(8), 741-756, DOI:10.1080/02786820902889879.

Kanaya, Y., F. Taketani, Y. Komazaki, X. Liu, Y. Kondo, L. K. Sahu, H. Irie, H. Takashima,

(2012), Comparison of black carbon mass concentrations observed by multi-angle absorption photometer (MAAP) and continuous soot-monitoring system (COSMOS) on Fukue Island and in Tokyo, Japan, Aerosol Science and Technology, Aerosol Science and Technology, 47(1), 1-10, DOI:10.1080/02786826.2012.716551.

3.2 rBC size distributions

In Figure 2, Size distributions separately for the categories of slow speed diesel (SSD), medium speed diesel (MSD) and high speed diesel (HSD) will be interesting and informative than just average.

A brief comparison with respect to the fresh vehicular exhaust (size distribution) in California will be important.

In this context I would suggest to compare the size distributions of BC presented in following study for fossil fuel category over California. It suggested to cite following paper which also presents BC size distribution and emission ratio of BC for two different types of plumes over California.

"Sahu, L. K., Y. Kondo, N. Moteki, N. Takegawa, Y. Zhao, M. J. Cubison, J.-L. Jimenez, S. Vay, G. S. Diskin, A. Wisthaler, T. Mikoviny, L. G. Huey, A. J. J. Weinheimer, and D. Knapp (2012). Emission characteristics of black carbon in anthropogenic and biomass burning plumes over California during ARCTAS-CARB 2008. J. Geophys. Res., 117, D16302, doi:10.1029/2011JD017401."

3.3 Emissions by engine and ship classification

In reference to: "... and the SSD, MSD and HSD averages were 0.26 ± 0.26, 0.35 ± 0.35, and 0.29 ± 0.30 g-BC (kg-fuel)-1, respectively. The corresponding cut-average EFBC values are 0.21 ± 0.16, 0.27 ± 0.12 and 0.32 ± 0.26 g-BC (kg-fuel)-1 for SSD, MSD and HSD,respectively, ..."

In all categories, the variability in EF is almost comparable to the respective EF values. In addition, the differences in EFs between the categories of vessels are significantly lower than the EF value in a given type of plume. Well, the question is obvious. Given this data set, is it worth to take account of EF from different ship categories to improve or forecast the regional air quality?

3.3.1 Literature comparison and influence of fuel quality on EFBC

The literature survey is worthy, however, there are too many data presented along with the text to read. It can be concisely presented in a Table (Table 2 may include other data as well) or a Figure. In the text, some key points may be highlighted. More importantly, the cause of difference between present study and TexAQS is not very clear.

This sub-section should have followed "3.3.2 Influence of engine Load"

4 Conclusions: Towards the end of this section, a separate paragraph about the usage of EF data from ships should be discussed. How the models of regional air quality and climate change can benefit? Discussion of four different BC instruments has been relatively substantial. But both "Abstract" and "conclusions" fail to reflect the outcome of results presented in the different sections of the draft.

In Figure 1 caption: "Note the different scales for the figures in the top row compared with the bottom row." Here the meaning is not very clear.

Figure 2: The measured data points (in a size bean) should also be plotted along with the variability. Just line plot seems like the interpolation.

Figure 3: Too much overlapping, you can try log-scale for X-axis?

Figure 5: The representation using the combination of symbol and color code is not very clear? (For example, there is no "black "in color bar, but a symbol has been plotted in black)

Interactive comment on Atmos. Chem. Phys. Discuss., 13, 24675, 2013.