Atmos. Chem. Phys. Discuss., 9, S1647–S1655, 2009
www.atmos-chem-phys-discuss.net/9/S1647/2009/

Atmospheric Chemistry and Physics Discussions

Interactive comment on "A new physically-based quantification of isoprene and primary organic aerosol emissions from the world's oceans" *by* B. Gantt et al.

B. Gantt et al.

Received and published: 23 April 2009

Note: All reviewer comments in italics. All responses by the authors in normal font.

We would like to thank the reviewer for his/her comments. We have done our best to address each of the points as detailed below.

1. The manuscript by Gantt et al. estimates emissions of isoprene, and primary and secondary organic aerosol from the oceans to the atmosphere. Several new and interesting aspects to the field are incorporated. These include additional laboratory measurements of isoprene production rates from several phytoplankton strains, the application of several variations of global maps of phytoplankton species/class/functional type reconstructed from satellite data, sensitivity studies of the speciation method and

mixed layer depth, estimates of both marine primary organic aerosol (linked to the water insoluble organic aerosol fraction) and secondary organic aerosol (linked to isoprene), and emission estimates for both the sub- and super-micron aerosol size fractions. The paper is a valuable contribution to ACPD as it adds to the body of knowledge on marine emissions which is thought to be very important contributor to atmospheric composition, chemistry, and climate issues but as yet is very poorly understood. It is also important because it addresses varying spatial and temporal scales, including diurnal and hourly periods, as well as compares recent efforts in the field to estimate marine emissions of isoprene and organic aerosols. The paper is generally well written and well structured, although in a few places the text could be more succinct. One example is the title; it could be shortened by use of "marine" rather than "from the world's oceans", which does not add necessary content. In addition, there are some inconsistencies or looseness in terminology that should be standardized. For example, choose emissions or fluxes, but not both. Similarly, choose tropical or equatorial waters, but not both. While these have slightly different definitions, they appear to be used a bit loosely here. Similarly, choose ocean-emitted or ocean-derived or marine. After addressing the specific comments listed below this paper should definitely be published in Atmospheric Chemistry and Physics.

We have adjusted the title of the revised manuscript, removing the phase "from the world's oceans" and replacing it with "marine" as suggested by the reviewer. We have also revised manuscript by changing all of the "fluxes" to "emissions" or "emission rates," and "ocean-emitted and "ocean-derived" to "marine." Regions of the oceans have been limited to "tropical," "mid-latitude," or "polar," and the boundaries of these regions have been defined.

Specific Comments

2. The use of "physically-based" in the title and throughout the text is unclear as this term is never defined. Virtually all parameterizations are based on physical observations, by their nature. Why is this highlighted?

ACPD

9, S1647–S1655, 2009

This is highlighted because we use new physical parameters such as light sensitivity and dynamic euphotic depth to represent marine isoprene emissions on a short time scale (1 hour). While previous global estimates of marine isoprene use physical parameters, they use monthly-average values which do not capture the diurnal nature of these parameters.

3. It is not clear until much further into the manuscript what is "new" as stated in the title. This is an important and necessary work that builds our body of knowledge in new ways. However others have also combined new laboratory data on emission rates with satellite maps of phytoplankton functional type. The authors should clearly identify and highlight the novel aspects of this paper (of which there are several, as listed above in General Comments).

We agree with the reviewer that several aspects of this study are similar to recent works. However, there are several key differences two of which are mentioned in response to comment 2 that lead to more realistic simulations. The abstract has been adjusted to clearly point out the new components of this study, including light sensitivity of marine isoprene emissions, variable euphotic depth, short time scales for marine isoprene and primary organic carbon (OC)emission, separate sub- and super-micron estimate for primary organic aerosol emissions, and the contribution by the primary and secondary OC aerosols to total OC emissions.

4. P2939, L5 - The list of species tested (from the methods section) does not match that in Figure 1. Mention of values taken from the literature is needed in the legend to Figure 1. Currently this is mentioned in the text, but not until several paragraphs after this sentence.

The legend has been adjusted to signify values that were taken from literature, and the text has been rearranged to elucidate the species and averaging that was used to determine the values.

5. P2939,L10 - A wide range of emission rates can be indicative of many things, only

ACPD

9, S1647–S1655, 2009

one of which is photoinhibition, that can vary by species. Please rewrite the sentence to address this more completely.

Statement has been changed in the revised manuscript.

6. P2939, L13 - What is the definition of "young" - earlier in the growth curve, or a batch closer to the initial transfer of a stock culture? If there is data to support this it should be mentioned (even just in this sentence is fine if it doesn't warrant a table). If not, and this is an anecdote, it should be removed. Sufficiently high variability exists in such biological systems that more substantial proof is required for inclusion.

Statement has been removed in the revised manuscript due to insufficient data.

7. P2939, L15 - Differences in emissions for various nutrient replete and deplete conditions is a very interesting observation. I recommend adding further comments/data to support this if available, as well as potential implications. For example, were nitrogen limited cultures slower growing and smaller isoprene producers?

As far as we are aware there is are no studies of phytoplankton and only one study of aquatic plants indicating that the abundance of nutrients may influence isoprene emission rates (Fares et al., 2008). Due to the insufficient data for this publication, we have removed the discussion about the nutrient impacts on the production rates.

8. P2939, L16-26 - This section is confusing, and requires reordering of the sentences to first explain that the emission factors were fitted to a curve, secondly how this fitting was done.

We agree that the description of the emission factors is somewhat unclear. The order of sentences has been changed and sentences describing the curve fitting procedure have been clarified in the revised manuscript.

9. P2945, L12 - Why is it important to capture diurnal variations in emission rates in this work if you are calculating monthly average emissions? Presumably the emission factors used already account for both day and night emissions. If not, then a rough

ACPD

9, S1647–S1655, 2009

estimate can be achieved by adjusting the emission factor, assuming 0 production at night and averaging over a typical light:dark hourly cycle. It seems the diurnal variability is of most interest for the purpose of testing the emissions relationship as a function of light level on an hourly basis. If so, please clarify.

We feel that reviewer is confused. We do not generate daily emission maps. All emissions of marine isoprene and primary OC are calculated on an hourly basis depending on surface incoming radiation. Therefore our simulations reproduce expected diurnal cycle of the emissions with one unique production factor for each phytoplankton group. A brief description has been added to clarify this point.

10. P2947,L8 - Table 1 is a very useful summary of recent work, including this manuscript. A brief several sentence comparison in the text is also warranted, including hypotheses as to why there is such a range in values for the various metrics.

Speculation as to why there is such as large range of estimates has been added.

11. P2948 - A brief statement should be added about why these particular parameters (speciation and MLD) are the most relevant to test.

Statement has been added to the revised manuscript.

12. P2949, L13 - This is a very interesting and neat way to determine the sensitivity to speciation. A small clarification is needed to the statement, in that differences in the magnitude of 1 phytoplankton class are estimated here. In reality, all phytoplankton classes will have similar issues, and thus this would be a minimal error estimate.

Clarification is added to the revised manuscript.

13. P2050, L16 - The diurnal variations could at most affect values by a factor of 2, whereas your table 1 shows differences on the order of factor of 10. So this is likely not a primary driver of the discrepancy.

According to Sinha et al., (2007) day/night marine isoprene emissions can change

ACPD

9, S1647–S1655, 2009

by factor of 5 to 10. However, in the paper we do not suggest that the wide range in marine isoprene global emission estimates can be explained solely by the diurnal cycle. Nonetheless, we have added the following statement in Section 3.2 to avoid confusion: "The large range of global marine isoprene and primary organic emission estimates is a result of the highly variable physical and biological characteristics of the ocean. Parameters like the mixed layer depth, diffuse attenuation, [Chl-a], and phytoplankton speciation which determine the rate of isoprene and primary OC emissions at a given location can vary greatly both horizontally and temporally."

Technical Corrections *14. P2934 "Main" is not a proper descriptor of phytoplankton types. Please specify as most abundant, representative of certain regions, etc. or remove.*

Removed from abstract, but replaced with "abundant" in section describing selected species.

15. P2934,L8 and L14 - "were scaled up" and "were used"

Changed in the revised manuscript.

16. P2934, L21-22 - Is this a peak or average value?

The reference was to the peak value. We have ended the sentence with the following phrase, "when isoprene emissions are highest" to clarify this point.

17. P2937, L1 " Please add comma after 8220;organic aerosols"

Added.

18. P2938, L27 - Please add "selected" before "diatom". It is important to recall that there can be dramatic variation in biological parameters by species, or even strain, within a given class.

Changed as suggested by the reviewer.

ACPD

9, S1647–S1655, 2009

19. P2940, L2 - Please change to "all types of phytoplankton tested in this work or retrieved from the literature to use in this work", or something similar.

Thank you for the suggestion to clarify this sentence. The sentence now includes the phase "tested in this work" and points to the agreement with literature.

20. P2940,L6 - The sentence stating "Amongst the diatoms" is a result, and should be moved elsewhere.

We agree that this statement is a result and considered moving it to a different section. However, the results of this paper are primarily the application of the isoprene production rates and other variables to the estimation of global marine isoprene emissions. We do not feel as though laboratory results for the production rate of different species would fit into this global emissions section.

21. P2940,L8 - This is an unusual choice for error bars, and needs to be mentioned in the Figure legend.

The error bars have been changed in the revised manuscript.

22. P2940, L19-20 - What are the emission factor units?

Emission factors have units of umol isoprene(g Chl-a)-1 hr-1 times natural logarithm of PAR. Since we cannot take a logarithm of a dimensional quantity, we really mean PAR/1. These units have been added to description of the emission factors in the revised manuscript.

23. P2940,Section 2.3, L12 - Capitalize and italicize Phaeocystis P2942, L12 - "have considerably" P2942, L2- Delete "strong"

These have been corrected.

24. P2945, L4 - Data is only presented for January and July, not throughout the year. How can there be elevated solar radiation throughout the year? Please reword sentence.

ACPD

9, S1647–S1655, 2009

Replaced elevated with "high solar radiation levels".

25. P2945, L29 - "...emissions can likely be attributed..."

Added.

26. P2946, L22 - "Sect. 3.4"

Fixed, but section is now 4.

27. P2947, L27 - "...in these polar regions."

Replaced with "in these mid-latitude waters," due to earlier definition of mid-latitudes.

28. P2947, L9 - It has been shown that marine-source SOA is very large, but the link to CCN effects is just a hypothesis. Please reword.

The revised manuscript has been changed to address the reviewer's point.

29. P2949 - Sections 3.5 and 3.6 would more appropriately be labeled 3.4.1 and 3.4.2

This has been corrected.

30. P2950, L7 - "performed"

This has been corrected.

31. Throughout - "tropical waters" and "polar waters" are referred to without mention of latitudinal bands or other identifier (e.g. abstract, P2947).

Specified tropical waters as 30S to 30N, mid-latitude waters as 30 to 60 N/S, and polar regions as 60 to 90N/S. This has been defined and used accordingly in the revised manuscript.

32. The authors cite Spracklen et al. 2008, but this is not in the reference list.

Spracklen reference added.

References:

ACPD

9, S1647–S1655, 2009

Interactive Comment

Fares, S. et al.: Isoprene emission and primary metabolism in Phragmites australis grown under different phosphorus levels, Plant Biology, Volume 10 Issue 1, Pages 38 - 43, 2008.

Sinha, V. et al.: Air-sea fluxes of methanol, acetone, acetaldehyde, isoprene and DMS from a Norwegian fjord following a phytoplankton bloom in a mesocosm experiment, Atmos. Chem. Phys., 7, 739-755, 2007.

Interactive comment on Atmos. Chem. Phys. Discuss., 9, 2933, 2009.