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Atmospheric Chemistry and Physics Discussions

Interactive comment on "The summertime Boreal forest field measurement intensive (HUMPPA-COPEC-2010): an overview of meteorological and chemical influences" *by* J. Williams et al.

J. Williams et al.

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We thank Dr. Mackenzie for his careful reading of the manuscript and points raised. These have been addressed as described in detail below. 1) The reviewer cites three examples where the text "reads more like a proposal than a paper written after the event". Each case has been addressed as described below. In addition, it should be noted that we have inserted information from, and references to,specific papers in preparation or since published (in response to reviewer 3, e.g. Ebben et al. 2011, Yassaa et al. 2011, Nölscher et al. 2011).

In the first case the proposal like sentence has been removed, and the information condensed into the paragraph. The revised paragraph now reads as follows:

FTIR spectroscopy was used to quantify nearly 100% of the organic mass as aliphatic groups, carboxylic acid groups, organic hydroxyl groups, primary amine groups, and non-acid carbonyl groups (Russell et al., 2009). Organic functional groups in combination with elemental concentrations (measured by XRF) and other chemical measurements have been used to associate the functional group composition of the aerosol with biogenic and biomass-burning sources in other Boreal forests (Schwartz et al., 2010; Bahadur et al., 2010; Takahama, et al., 2011; Russell et al., 2011). However, the HUMPPA-COPEC campaign additionally provided the opportunity to associate these functional groups on submicron aerosol with specific biogenic precursors. In the second case, p 15930, line 10, although no new parameterizations are available yet, we have inserted a reference (Boy et al. 2011) after nucleation rates, so as to provide a direct reference to this work.

In the third case (p. 15932, line 2) sentence starting "one aim of this campaign. . ." has been removed. Instead, "within the boreal forest environment" has been inserted for clarity at the beginning of the paragraph.

2) The importance of co-located BVOC and OH inlets due to the intensity of segregation is now noted by the addition of the following sentence and two references in section 3. "Furthermore, close proximity of OH and reactive organic inlets is essential when investigating intensity of segregation effects that can effectively reduce the overall rate of isoprene oxidation due to inhomogeneous mixing (e.g. Butler 2008, Pugh et al. 2011)."

3) The referee is concerned that the relevance of the dataset to future climate scenarios in the boreal regions may be overstated. We certainly do not wish to imply that the short term effects of a heatwave can be taken as a direct analogy of far future climate conditions, in which numerous ecological feedbacks can play a role and meteorolog-

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ical patterns may differ. The abstract has been modified slightly to “the campaign is relevant for the analysis of possible future climate impacts”, however, the main clarifications/caveats to this point are now inserted in the conclusion section as follows: The unusually high temperatures experienced on this campaign are also useful to gauge the response of the Boreal forest to warmer conditions, at least in the short term. For example strong increases in highly reactive mono- and sesqui- terpene emissions were observed during this campaign at higher temperatures, leading to higher OH reactivities. Temperatures in boreal regions are predicted to rise over this century, and datasets such as HUMPPA-COPEC 2010 can help verify proposed feedbacks to atmospheric properties. It should be noted, however, that over longer climate-scale periods ecological feedbacks as well as larger scale synoptic shifts may dominate.

4) We thank the reviewer for their helpful comments and have extended the conclusion to include all of the suggested points, and an additional summary of the landcover analysis. This expansion of the conclusion section was also requested by referee 2. - First point, transport regimes – the following text in now included to summarize this work “During the campaign air was advected mostly from the SW (53.7%) of the time with smaller influences from the SE (20.7%) and the NW (10.3%). In comparison with the previous five years the campaign period in 2010 was more impacted by air from the south (SW and SE) leading to higher ozone and temperature values at the site.” - Second point, boundary layer. The following text was added: “Analysis of meteorological sonde data has shown that the boundary layer height, although variable during the campaign, increased typically from less than 200 m in the early morning to around 1700 m at the end of the afternoon.” - Third point, sawmill extension of VOC:NOx space. The following text has been inserted “The latter has the effect of extending the VOC:NOx space measured in the campaign and was a valuable test of the OH reactivity measurements.” - Finally, we have additionally inserted a summary sentence on the regional landcover analysis for completeness thus: “. A regional 50km wide surface cover analysis showed that the southern sectors (SW and SE) contain more anthropogenic influence than the NW sector, although coniferous forest was found to

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dominate in all sectors."

5) The reviewer is correct and "of" has been removed.

6) PTR-MS was used for OH reactivity (See our referenced paper Sinha et al. 2008). We have developed a GC-PID system for the same purpose (as stated in the goals section 2.1).

7) "biochemically distinct" used as suggested. Sentence amended for clarity to "Recently laboratory studies have shown that ozone reacting with stereoisomers on the surface of aerosol particles coated with chiral semivolatile organic compounds may depend on stereochemistry and that the differences in chemical accessibility could lead to the enrichment of one oxidation product stereoisomer over the other in ambient air (Stokes et al. 2009)."

8) VOC added to this sentence and broken sentence repaired.

9) The study by Pugh et al is now referenced in the instrumentation section.

10) Sentence changed for clarity to "The main height at which new particles form remains controversial andrecent findings in atmospheric modeling suggest that reactive organic compounds emitted from the canopy or soil with a strong gradient in the entrainment zone at the top of the atmospheric mixed layer are needed to explain the observed vertical distribution (Boy et al., 2011). "

11) We now insert "disjunct eddy covariance and gradient method" to clarify the methods used.

12) Figure 1c has been enlarged as suggested.

13) We agree with the reviewer that the Figure was unclear as was and have made this much more specific by adjusting the explanatory caption texts. The caption text of Figure 3a and the caption text of Table 3 have been changed to clarify the use of trajectories, as follows: "Table 3. The percentage distribution within the sectors (NW,

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SW, SE, NE) for the 10th July-12 August (period of the HUMPPA-COPEC campaign) are shown for the years 2005-2010. The trajectories used percentage is the fraction of trajectories that did not hit ground or were otherwise not attributable to a wind sector. "Figure 3a. A map showing schematically the proportion of airmasses influencing the site during the HUMPPA-COPEC campaign, deduced from 3 day back trajectory analysis and segregated into wind sectors (NW, NE, SW, SE). The arrow sizes approximate to the proportion of trajectories and the statistics of the analysis are given in Table 3." The required citation to the READY website is given in the acknowledgements and the two references (Drexler and Rolph 2010 and Rolph 2010) are inserted in the text.

14) The correct height of the wind direction measurement has been added. Furthermore Figure 3b has been significantly improved as suggested to include the histogram of wind directions for the previous 5 years. This supports the meteorological analysis. The figure caption has been changed to: "Figure 3b.A histogram of wind direction for the HUMMPA-COPEC 2010 campaign period (5 minute average), compared to those taken from the years 2005-2009.Data from 16.8m on the main mast." "Figure 3b also includes wind direction data from the previous 5 years for comparison and it shows that 2010 had more southerly and less northwesterly influence than in previous years."

15) "Stable" changed to "steady"

16) Sentence changed for clarity to "The year 2010 has a significantly larger proportion of trajectories from the south than all other years analyzed"

17) Regarding the turbulent timescale – in order to provide a reference we have revised the sentence "For example, at 14:00 LT the characteristic turbulent time scale is estimated to be around 10 minutes." To "For example, at 14:00 LT the free convection time scale (Stull, 1988) is estimated to be around 10 min." and included the Stull reference. Note this was also requested by reviewer 2.

18) Yes, as stated only the maximum potential temperature is taken into account, but residual layers in the free troposphere are ignored. The strong temperature gradient

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at 2 km is not connected to the current boundary layer, but to advection and residual layers and is therefore notconsidered. At 1.1 km, the atmosphere is stably stratified and characterized by an inversion jump difference of 1.5 K. The following sentence has been inserted for clarity “Note the strong temperature gradient at 2 km is not connected to the current boundary layer, but to advection and residual layers and is therefore notconsidered.”

19) To clarify, “near the inversion layer” has been added after “the maximum potential temperature gradient” in line 3.

20) This discussion has been made more precise as requested by replacing ““After the ground inversion has broken up (after 08:30 LT), the boundary layer growth overshoots and the layer is rapidly merged with the residual layer aloft. In spite of the large sensible heat flux at the surface (maximum value of 350 W m-2 near noon), the boundary layer growth was less than expected possibly due to the advection of cold air from the nearby lake. Such” with: ““After the ground inversion has broken up (after 08:30 LT), the boundary layer connects with the residual layer aloft and is rapidly merged. After this, the boundary layer resumes its growth by entrainment. In spite of the large sensible heat flux at the surface (maximum value of 350 W m-2 near noon), the final boundary layer height was less than expected, possibly due to subsidence and differences in horizontal heat advection between the boundary layer and free troposphere, which can be induced by horizontal differences in land use conditions. Model results show that not taking this into account leads to an overestimation of 600 m of the boundary layer height at 18 LT. Governing”

21) The sentence “The influence of anthropogenic sources is discussed further in section 5.4.” has been inserted to refer the reader to more detailed discussion as suggested. The sentence suggesting BVOC dominance from the land cover analysis has been removed

22) Typo corrected, thanks.

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23) On reflection we agree with the reviewer 2 that the link to Arctic haze formation is tenuous and have removed both instances it was mentioned.

24) In order to make the reviewer′s point that the sawmill influences extend the range of the monoterpenes we have added the following text at the location suggested. “Case studies of these events,which increase for short periods to an order of magnitude higher than average values, can help elucidate the efficiency of OH radical recycling as a function of monoterpene concentrations.“

Interactive comment on Atmos. Chem. Phys. Discuss., 11, 15921, 2011.