

Interactive comment on “Foliage surface ozone deposition: a role for surface moisture?” by N. Altimir et al.

N. Altimir et al.

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We appreciate the constructive and positive comments given by A. Carrara and his careful reading and understanding of our work and apologise for this late response. This reply answers to his general and specific comments about the paper. Mention of changes refers to the version of the paper that will be considered for the final stage of publication in Biogeosciences. Quotes indicate text from the reviewer’s letter:

A. Carrara wonders on the advantage of using stomatal CO₂ conductance to calculate ozone uptake instead of the classic water vapour flux approach. The basic advantage in the use of the photosynthesis model is that it allows the calculation of stomatal conductance for a wider range of conditions than the water vapour flux approach allows. The calibration of the photosynthesis model parameters is based on CO₂ exchange measurements. Since the water vapour flux approach is based on measurements of evapo-transpiration, the estimation of stomatal conductance only succeeds during dry

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conditions, as we know. Thus, the photosynthesis model provides information about the stomatal conductance at times when the water vapour flux approach can not.

“It could have been interesting to compare both approaches also for wet conditions (for example to estimate non-stomatal sink), since the stomatal conductance inferred from water vapour flux is likely to be overestimated due to evaporation occurring during wet conditions, as mentioned by the authors.”

We understand this idea is suggesting that the non-stomatal ozone sink could be inferred from the difference between ozone conductance values estimated by the two ways we used in the paper. This difference would reflect the surface evaporation strength. Evaporation and surface adsorption are by definition not expected to coincide in time but rather be anti-correlated or show some degree of hysteresis. When the evaporation is strong the surfaces are drying which means the surface wetness is decreasing. Our results show that clear surface wetness accumulation (e.g. such as sunrise) coincides with a pick in non-stomatal ozone sink. Evaporation strength is not a direct indicator of the momentaneous surface wetness, particularly at high time resolution. It would be nonetheless interesting to compare further and analyse the two ways of estimating stomatal conductance and whether the difference between them can provide information on the ozone sinks in some way or other (see also our discussion in section 4.3.2).

“Specific comments:”

A. Carrara detected inconsistencies in the definitions and representations of dry and wet conditions and we agree that there was place for confusion. Criteria for dry conditions were no rain + more than 12h since $RH > 70\%$, which is a way of saying that now it is not raining and last time it was wet and moist was 12 hours ago or more. In practice this data was selected based on measurements from the tipping bucket, the droplet detector, the RH, and time count. Data selection was exclusive, that is all the criteria needed to be fulfilled for a certain period to be declared dry. Wet conditions

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happened during rain or when $RH > 70\%$ or it had been $> 70\%$ less than 12 hours ago. These were inclusive, that is, if at least one of this criteria held, it was considered wet. It is understood that assignment to dry or wet was not possible if there was instrument failure. Also, these definitions were not applicable during minus temperatures (this is mentioned in Sec 2.1). We have added corrections and explanations to make this procedure more clear. The markers (X) in Fig 2 and 3 were perhaps confusing because the caption led to understand that the symbols refer to wet conditions including all criteria. If we produced such graph, the large size of the symbols and the high resolution of the data yielded an uninformative continuous mark. The intention in Fig 2 and 3 was to give information, at a glance, of the dry/wet regime of the site during the years. So, actually, the markers (X) signal the records of droplet detection from the DRD and complement the RH and temperature data with the records of precipitation and, during minus temperatures, snow/ice cover. Thus in Fig 2 and 3 the reader needs to visually combine the presented data. We have rephrased the caption to clarify.

“Fig. 1: Ozone flux measured at shoot scale is not defined in the text.”

We are not sure what this comment refers to. The shoot scale flux measurements are explained in section 2.3.1 of the main text.

“Fig 1. I suspect that units are not consistent. For CO₂, the ratio between canopy flux and shoot flux is about 3 during growing season, while for O₃, the ratio between canopy flux and shoot flux is about 0.1. If canopy fluxes refer to 1 m² of horizontal surface and shoot fluxes refer to 1 m² of needle surface, I do not understand such a discrepancy between these ratios. I would have expected a ratio of about 7 between canopy and shoot O₃ fluxes, as in Fig. 6.”

Yes, the units were not consistent, the shoot scale the O₃ fluxes should be in ng, not μg . When the units are corrected the ozone fluxes ratio canopy to shoot approximates 7.

“Fig. 8: In my opinion, 2 more graphs presenting dependence on surface wetness

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would be welcome.”

Such graphs demands too much from the available data. The data from the surface wetness sensors is very consistent in pattern but variable in magnitude. We discuss in Section 3.4 that the degree of accordance between the non-stomatal ozone deposition and the surface wetness measured by the surface wetness sensors varied between days. Day by day linear regression yielded stronger and weaker agreements ($0.1 < r < 0.8$) and almost one order of magnitude range in the slope, although the correlation was indeed predominantly positive. Thus the correspondence can be best visualised when means are taken as in Fig 9 or a small portion of data is shown as in Fig 10. But for a large range of data as the one shown in Fig 8 the result would be impossible to interpret.

“Fig. 10: In my opinion, the addition of similar graphs with Gnonsto,O3 at canopy scale, even if patterns are not so "nice", would strengthen the demonstration.”

Yes, patterns are bound to be not so nice because Gnonsto,O3 includes also the understorey whereas the SW sensors were on the upper canopy. We have added the proposed graph only for the nice weather days. There is a rise in Gnonsto,O3 that seems to coincide more or less with the rise in surface wetness. It was not possible to add it for the wet weather days since those were a mixed of rainfalls at different time and no daily patterns was expected to appear anyway. Accordingly, we have added explanations in the text.

“Technical corrections”

All other suggested technical corrections have been incorporated.

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