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Atmospheric Chemistry and Physics Discussions

Interactive comment on "DO_3SE modelling of soil moisture to determine ozone flux to European forest trees" *by* P. Büker et al.

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General comments :

the reviewed paper presents the results from the development and evaluation of a method to estimate soil moisture status and its influence on stomatal conductance for a variety of forest tree species. This study has investigated four different modelling approaches. The analysis is very thorough and very good evaluations are done. With the exception of a few specific comments , I would recommend the manuscript for publication.

Specific comments :

- title : please remove "European" word because this study is also on North American

forest tree species.

We propose to remove the word "European" from the title of the paper.

- I think it would have been judicious to contact research teams also in France and in Italy.

We appreciate this comment and agree that it would have been ideal to include French and Italian datasets, especially those able to represent Mediterranean conditions. When starting this project, we made a comprehensive search for forest tree data that was both accessible and provided the model input data and soil water variable evaluation data necessary to conduct the study. This search led to contact with a large number of European colleagues. Further assessment of many of these datasets resulting from these contacts showed that not all data were appropriate for our modelling purposes and unfortunately we were unable to find any French or Italian datasets that either provided the required data or were ready for release. In an attempt to overcome the limited European Mediterranean dataset availability we looked to our American colleagues who were able to provide some data for conditions similar to the Mediterranean. The resource constraints of the project meant that we were unable to use data which might have become available over the duration of the project. We would hope that with the continuation of the development of this soil moisture module we would be able to use newly available datasets for future evaluation work.

- list of authors : give the author's contribution

We have checked with the guest editor Dr. Matthias Beekmann that this is not required. However, we would like to stress that all co-authors actively contributed to this paper, either by providing the experimental data and guidance on its use within the modelling work presented here, or through development and application of the modelling approaches used.

- introduction : concerning the effective dose please add the reference DIZENGREMEL

P, LE THIEC D, BAGARD M, JOLIVET Y. 2008. Ozone risk assessment for plants: central role of metabolism-dependent changes in reducing power. Environmental Pollution 156 : 11-15"

We intend to add this useful reference to the manuscript.

- introduction p33588 l 20 : please add some sentences about the interaction of drought and ozone. The authors will indicate the possible effect of ozone with different timing of drought during the vegetation season. Drought sometimes protects against ozone and sometimes the affects are additives.

We agree with this comment and propose to include the following text:

'Antagonistic, additive or synergistic interactions of drought and O_3 have been widely reported (for a comprehensive review, see Matyssek et al., 2006). In general, drought stress protects plants against O_3 through inducing stomatal closure which reduces pollutant uptake (Matyssek et al., 2006; Temple et al., 1992; Davidson et al., 1992; Broadmeadow and Jackson, 2000; Panek and Goldstein, 2001 and Karlsson et al., 2000). However, additive effects, mainly caused by an O_3-induced lose of stomatal regulation, can lead to a reduced ability of plants to cope with drought stress. Such effects were found by Maier-Maercker (1999), Grulke (1999), Alonso et al. (2003), McLaughlin et al. (2007) and Paoletti and Grulke (2010). In contrast, Le Thiec et al. (1994), Karlsson et al. (2002) and Wittig et al. (2009) reported no significant interaction between these two stressors. A further consideration of the role O_3 can play in affecting plant response to drought relates to the seasonal timing of these stresses; for example, in some European regions high O_3 levels may occur during spring, when plants are fully physiologically active and there are no water limitations. In these cases, O_3 might impair plant defence systems leading to a reduced ability to withstand other environmental stresses such as those triggered by drought, high temperature and solar radiation that may occur later in the season (Nali et al., 2005; Matyssek et al., 2006).'

- methods: the authors have to give a complete formula of each model!!!!

We believe that we have provided the formula of each model already, but accept that the methods chapter could be more concise and better laid-out for readers to be able to reproduce the suggested model approach. We propose to do this by rearranging the text to make the four methods used more visible and distinguishable with the respective model formulations more readily accessible.

- p33602 l4 : precise the sites where gsto data do exist

We have done this by suggesting tochange the respective sentence to:

'For those sites where E_t or g_{sto} data exist (i.e. Kranzberg, Miraflores, Norunda and Rhinelander), totals or daily maxima values were compared to equivalently presented modelled values.'

- p33602 l23 : please indicate which software was used to perform statistical analyses.

The formulations for statistical methods used, as referenced in the paper, have been applied using EXCEL.

- p33605 l28 : in fig5b and fig 3a : the correlation between modelled and observed data are very bad : the explanations are not persuasive, which data are good? modelled or measured?

Fig 3b: We wonder whether the reviewer was referring to Figure 3b rather than 3a. While the correlation between modelled and observed E_t is in general good, there is indeed a fairly long period at the beginning of the growing season characterised by a distinctive divergence between modelled and measured values of E_t. We suggest adding the following sentences explaining the possible reason for this discrepancy:

p33604, line 23: 'The discrepancy between modelled and measured E_t in Fig. 3b that occurs between days 130 to 170 might be related to the fact that the model assumes full physiological activity of the tree, whereas E_t measurements indicate that, in actuality, the full physiological potential has not yet been reached at this time; the fairly low E_t during this period could not be related to drought effects, as can be seen in Fig. 3a.'

Fig 5b: We are fully aware of the poor performance shown in Fig. 5b and have given an explanation for this effect in the text already. However, we accept that this explanation could be improved and have changed the respective sentence to:

'Up until August, modelled and observed g_{sto} values tend to match each other, although by September, towards the end of the drought period, observed g_{sto} showed a clear recovery, which was not mirrored by the modelled values (Fig. 5b). The observed recovery may have been related to precipitation events during this period. However, observations showed that such events only moistened the uppermost layer of the soil profile. Since this is a densely rooted litter layer, wetting may have resulted in increased water availability leading to the observations of increased g_{sto}. Such increases in g_{sto} would not have been captured by the soil water balance model which is less sensitive to upper layer changes in soil water due to the integration of soil moisture down to a depth of 80 cm (Figs. 5b and S6).'

- p33609 l9 : tables 6 and 7 do not provide statistics!!!! so change this sentence

We have done this by suggesting to change the respective sentence to:

'Table 5 provides summary statistics for the performance of all four models.'

- p33612 l9 : yes, gmax is very important and change with level of light inside to the canopy; maybe we need to modelize gmax with the tree's height and light or take into account leaf mass area which is a good indicator for sun and shade leaves.

We acknowledge the importance of the changing g_{sto} with light penetration through the canopy as well as canopy distribution of sun and shade leaf morpholgies (we prefer to use the term g_{sto} here as the models definition g_{max} is a single absolute value representing the maximum within growing season g_{sto} for a fully mature, sun-lit leaf of the upper canopy). We would like to stress that the DO_3SE model already accounts for the influence of light penetration through the canopy on g_{sto}, as reported in the paper on

page 33591, l 3:

'The LAI scaling employs a canopy light extinction model to estimate sunlit and shaded canopy fractions and hence scales stomatal resistance as a function of radiative penetration into the canopy.'

and

page 33613, l 15:

'The DO_3SE model accounts for variable sunlit and shaded leaf fractions through implementation of the canopy light extinction model (Norman, 1982).'

The existing discussion on page 33613 with regard to the necessity of future work to improve the model formulations to account for different leaf morphologies (which is the important point we believe the reviewer is referring to) is suggested to be changed to make it clearer that this is an important area for future research:

page 33613, l 16ff:

'However, there is currently no allowance made for the existence of different sun and shade leaf morphologies within the canopy. This will lead to an overestimation of water vapour loss and possibly stomatal O_3 deposition. Such diurnal and seasonal variations in sun vs. shade foliage proportions, and hence in whole-tree transpiration, may be available through model calibration against xylem sap flow assessments in tree trunks (Granier et al., 2000; Köstner et al., 2008; Matyssek et al., 2009) or by using leaf mass as a surrogate to define leaf morphology. This is an important area of research which will be prioritised in the future.'

- p33615 l 23 : this discussion is very important, actually the direct effect of ozone on gsto is not taken into account, it is a pity and there are a lot of papers where we observed this effect. We need absolutely studies on the effects of ozone on stomatal responses to environmental parameters (blue light, red light, CO2, VPD and temperature).

We acknowledge the importance of the direct effect of ozone on stomatal functioning and propose to add the following sentences to the discussion:

'The modelling performed in this study has assumed no direct effect of O_3 on g_{sto}. This assumption was deemed necessary at this stage, due to the uncertainties in the effect of O_3 on g_{sto} of different species and to different O_3 exposure profiles within the same species, both of which may affect the magnitude and even the direction of the response (Paoletti and Grulke, 2005).'

The manuscript also contains a sentence in the original submission stressing the importance of this aspect in future model development work.

Interactive comment on Atmos. Chem. Phys. Discuss., 11, 33583, 2011.