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Geoscientific
Model Development
Discussions

Interactive comment on "MAESPA: a model to study interactions between water limitation, environmental drivers and vegetation function at tree and stand levels, with an example application to [CO_2] $\times$ drought interactions" *by* R. A. Duursma and B.E. Medlyn

Anonymous Referee #2

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This paper presents a new model where the MAESTRA model (which simulates radiative transfers in the canopy, photosynthesis and transpiration at the tree and stand scales) is coupled with a soil water balance model, allowing important improvements such as accounting for the effect of soil water availability on stomatal conductance, transpiration and photosynthesis, and the feedbacks between canopy functioning and soil water budgets. This paper might therefore be of much interest to the ecophysiologist community. However, the manuscript should be carefully revised, since it contains

some errors (including in the equations). Here are my main comments:

As already pointed out by reviewer 1, the model was not yet carefully validated against measured data, but this is planned by the authors and may be presented in another paper: this will be important to access model strengths and limitations, and to detect potential errors (see below).

One of the great advantages of the MAESTRA model is that it accounts for the stand structure, computes APAR, photosynthesis and transpiration at the tree scale, and can therefore be used to access competitions for light between large and small trees (and between species since there is a multi-species version of the model), and can be validated using data obtained at both the tree scale (e.g. sap flow measurements) and canopy scale (e.g. eddy-covariance measurements of CO2 and water vapor exchanges between the canopy and the atmosphere). The main limitation of MAESTRA is that it was uncoupled with the soil. The modeling framework proposed in this paper, to couple MAESTRA with a soil water balance model, represents an important improvement, but due to its simplicity, some strengths of the MAESTRA model are lost: for example, a unique leaf water potential is computed for all trees (and for all leaves within a tree) although it is well known that big trees, due to higher exposition to winds, light, and to air with higher VPD, and also due to increased path length resistances to water transport, etc, have generally much lower leaf water potential than small trees. Then, some of the advantages provided by the 3D representation of the canopy are lost in MAESPA due to the 1D framework for the iterative computation of leaf water potential and water uptake by roots. If I had to couple MAESTRA with a water-budget submodel, I would try to compute leaf water potential iteratively for each tree, although I agree that this would be very computer intensive. . ., and also would be quite challenging (due to the lack of information on root length density, etc , at the tree level).

Other comments: Page 465: f(D) (or f(ΨL)) was omitted in Equation 2;

Page 466 Line 4: Ψf is defined as: “the ΨL at which fΨL is 0.5”. This is wrong: when

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$\Psi L = \Psi f$, $f\Psi L = 0.5 + 0.5 \exp(sf * \Psi f)$.

In Equations 12, 13, 24, (ΨR-ΨS) should be replaced by (ΨS- ΨR), because during the day ΨR is normally more negative than Ψs. In some cases (e.g. in cases of hydraulic lift at night), ΨR may happen to be less negative than Ψs resulting in a water flux from the roots to the soil in dry soil layers, but this (hydraulic redistribution) does not seem to be considered by the model: I think the authors should mention this point in the discussion.

Page 470, Line 23, it is said that Rlg is small compared to Rrad. Then it could vanish from the denominator of Eq. 12, and indeed it no more considered in other Equations (e.g. Eq. 24). But on page 470, Line 24, it is also said that Rsr is small compared to Rrad. Then, Rsr should also vanish from the denominator of Eq. 12. But in spite of neglecting Rsr in Equations 23 and 24, the authors eliminated Rrad. This is not consistent. Probably Line 24, Page 470 you should replace "Rsr is small compared to Rrad" by "Rrad is small compared to Rsr".

Equation 14 is wrong: (ea-es) should be replaced by (es-ea): soil evaporation occurs when the water vapour pressure in the soil pore spaces is higher than in the air, not the opposite. . .

There are sometimes mismatches between units in the equations, and some units are completely wrong: e.g. Page 474, Line 14, the soil-to-root resistance is expressed in mol/m2/s. This may be the unit for a conductance but not for a resistance. In Eq. 22, Lv is in m/m3, Hs in m, and Ks in mol/m/s/MPa. Then the unit for Rsr should be MPa s m2/mol, as correctly given in Appendix A.

Equation 23 is wrong: in the denominator, "Rsr/LT" should be replaced by "Rsr*LT": Rsr is expressed in MPa s m2soil /mol and LT in m2leaf/m2soil, then the unit for Rsr*LT is MPa s m2leaf/mol, which is OK (I.e the inverse of Kp is also MPa s m2leaf/mol). By contrast, the units of Rsr/LT is wrong (i.e MPa s m4soil m-2leaf/mol).

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Equation 27 is wrong and this can be seen from the Units. If Kth is in W/m/K and (Ts2-Ts1) in K, then Qc would be in W/m. The right unit for Qc is W/m2. Then (Ts2-Ts1) should be divided by the depth difference (m) between soil layer 1 and 2.

There may have some other problems in the units and equations: I have not checked every-thing carefully.

Page 479, Ligne 11: "We used a hypothetical stand with total leaf area index of 3m2 m−2". However, in Table 2, Tree leaf area = 35 m2 and stand density is 1100 tree/ha, then LAI=35*1100/10000=3.85 m2/m2, not 3 m2/m2.

Page 485: "Although many studies on agricultural crops have demonstrated that biomass growth is more enhanced by eCa during drought (Rogers et al., 1994), a great number of studies, particularly on trees, fail to demonstrate this effect": drought may decrease C sink activity more than C assimilation, leading to a growth that can be (in these situations of water and/or nutrient limitations) uncoupled (not dependent) from assimilation as discussed by several papers that you could cite (Korner et al., 2003; Korner, 2006; Millard et al. 2007; Sala and Hoch., 2009).

Page 486, Lines 18-19, replace "Fig 5b" by "Fig 6b" and 'Fig 5c" by "Fig 6c".

For Fig 5 (and other Figs) replace "AT(Ratio eCa/aCa)" by "Ratio AT(eCa)/AT(aCa)"

Tables 2 and 3: - sf is not unitless: since Ψf is expressed in MPa, the unit for sf should be MPa-1 - At which reference temperature are given Jmax and Vcmax? 25°C? This should be specified since Jmax and Vcmax are dependent on temperature. - Some parameter values such as ΨRmin are not given.

Cited references: Korner, C. 2003. Carbon limitation in trees. Journal of Ecology. 91:4-17. Korner, C. 2006. Plant CO2 responses: an issue of definition, time and resource supply. New Phytologist. 172:393-411. Millard, P., M. Sommerkorn and G.-A. Grelet 2007. Environmental change and carbon limitation in trees: a biochemical, ecophysiological and ecosystem appraisal. New Phytologist. 175:11-28. Sala, A. and

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G. Hoch 2009. Height-related growth declines in ponderosa pine are not due to carbon limitation. Plant Cell and Environment. 32:22-30.

Interactive comment on Geosci. Model Dev. Discuss., 5, 459, 2012.