Response to comments by Sibyll Schaphoff

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Sibyll Schaphoff's comments are in blue and our reponses in black.

Dear Authors,

thank you for your detailed response to the referees, and please accept my apologies—I initially overlooked your response letter when drafting my summary. After reviewing your replies, I would like to highlight a small set of additional points for resubmission, alongside implementing the revisions you already describe in your response:

- Soil moisture definitions and notation: Please ensure the revised manuscript unambiguously distinguishes volumetric soil moisture (m^3/m^3) from soil moisture expressed as a fraction of saturation. In particular, clarify the meaning of the stated bounds and the lower limit (0.25) used in the standard moisture modifier (as raised by Referee #2), and make sure variable names, units, and ranges are consistent and clearly mapped to the implemented formulation in the Methods.

Lines 121-123 we added this sentence to distinguish both soil moisture definition: "The Moyano's function uses the soil moisture calculated as a fraction of saturation (θ_{fs}) in contrast to the original function that used relative soil moisture to the wilting point (θ_{fv}). "

We use the same abbreviation θ_s for soil moisture at saturation and θ_v for volumetric soil moisture at the wilting point, throughout the manuscript.

The description of the standard moisture modifier lines 125-129 now reads:

"On one hand, in the reference version of ORCHIDEE employed in the present study, the moisture function θ is defined by eq. 2

$$f(\theta) = max(0.25, min(1, -1.1 \times \theta_{fv}^2 + 2.4 \times \theta_{fv} - 0.29)) \qquad (2)$$

with θ_{fv} being the volumetric soil moisture in m^3/m^3. $f(\theta_{fv})$ maximum value is 1 and to avoid no decomposition at all for dry soils a minimum value of 0.25 is considered."

We have also checked consistency between variables names, units and ranges in the text and the formulas in the Method section.

- PRSR/MPRSR construction: Even with the explanations in your response letter, the discretisation/recursion/normalisation procedure is difficult to reconstruct from the manuscript alone. Please add a concise, reader-facing stepwise description in the Methods so that the implementation is transparent and reproducible without consulting the rebuttal.

We improved some more the PRSR/MPRSR construction readibilité:

Lines 130 -139 read:
" On the other hand, in a modified model version named hereafter ORCHIDEE-M, the moisture function $f(\theta_{fv})$ from eq. 1 has been replaced by an empirical model from Moyano et al., (2012) to modify the litter and soil organic carbon dynamics. This is done in three steps. The PRSR empirical models are constructed for soil moisture that is defined as the proportion of soil moisture volume to the saturated porosity volume (θ_{fs}) and measured in cm^3

of water per cm^3 of pore-space. To be used in the model: (1) we calculate all the $PR_{SR}(\theta_{fs})$ values for θ_{fs} ranging from 0 to 1 by intervals of 0.01 using the relationships in Eq3 for mineral soil and in Eq4 for organic-rich soil; (2) we normalized the intermediate $PR_{SR}(\theta_{fs})$ values to only obtain the soil moisture control function, $MPR_{SR}(\theta_{fs})$ values between 0 to 1 with eq. 5; and (3) then we use $MPR_{SR}(\theta_{fs})$ value obtained using the grid cell's soil moisture content, clay fraction and soil OC in eq. 1 (Figure 1).
$PR_{SR}(\theta_{fs})$ values are defined by:"

Then lines 162 - 170 read:
" The $PR_{SR}(\theta_{fs})$ values are then normalized between 0 to 1 by:

$$MPR_{SR}(\theta_{fs})_n = SR_{ini} \frac{PR_{SR}(\theta_{fs})_n \times MPR_{SR}(\theta_{fs})_{n-1}}{MPR_{SR}(\theta_{fs})_{max}} \qquad (5)$$

where SR_{ini} is the initial respiration value and is assumed to be 1.0, n is the soil moisture content θ_{fs} interval number employed to estimate the PR_{SR} using equation 2. For the first interval number (n=1), the value of $MPR_{SR}(\theta_s)_{n-1}$ is 1. The soil moisture control function (MPR_{SR}) that corresponds to $f(\theta_{fs})$ in eq. 1 is scaled by subtracting all values with the smallest value ($MPR_{SR}(\theta_{fs})_0$) then normalizing with the highest one ($MPR_{SR}(\theta_{fs})_{max}$). At each timestep, the MPR_{SR} values employed to constrain soil OC decomposition by HR is determined by the soil moisture content θ_{fs} estimated by the model (Fig. 1). "
"

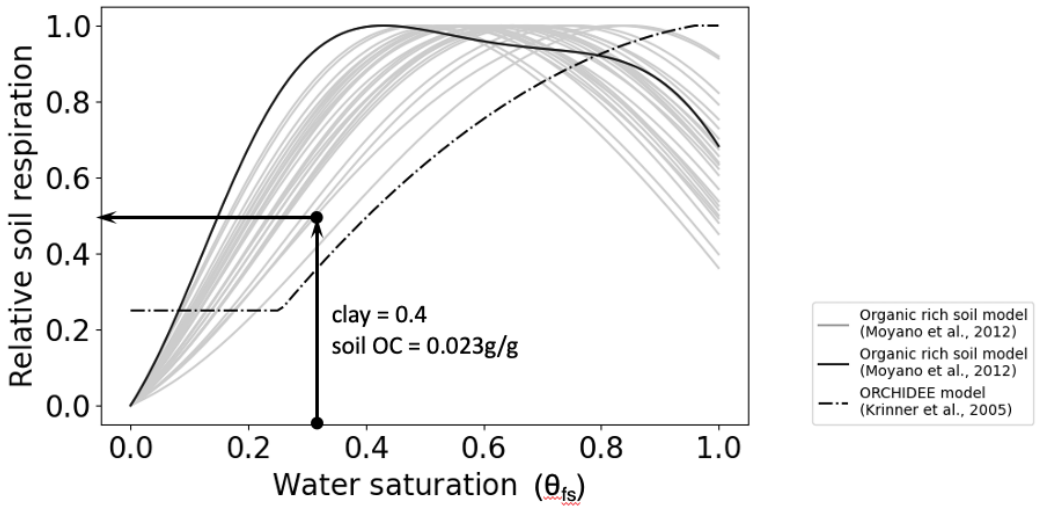

Figure 1: Representation of the control moisture function in ORCHIDEE (dash-dotted line, Krinner et al., 2005) and of the ensemble of control moisture function embedded in the modified ORCHIDEE-M version for the mineral soil (light grey solid lines) using clay fractions ranging between 0.27 and 0.34, soil OC ranging between 0.01 and 0.06 g C / g soil and for organic-richer soil (black solid line) with soil OC higher than 0.06 g C / g soil. An example, for a grid cell having a soil moisture θ_{fs} of 0.3, a clay fraction of 0.4 and a soil OC of 0.023 g C / g soil, the vertical arrow points to the MPRSR curve obtained using the grid cell's clay fraction and soil OC then the horizontal arrow points to the $f(\theta_{fs})$ value of 0.5, in this example, used to modify the litter and soil decomposition rate.

- Figure 7 panel order/labels: Please re-check Fig. 7 in the revised manuscript: the difference-map panels appear to be interchanged relative to the intended dataset/model pairing. Correct the panel ordering/labels (and caption where needed) to avoid reader confusion.

Figure 7 has been rechecked and read now:

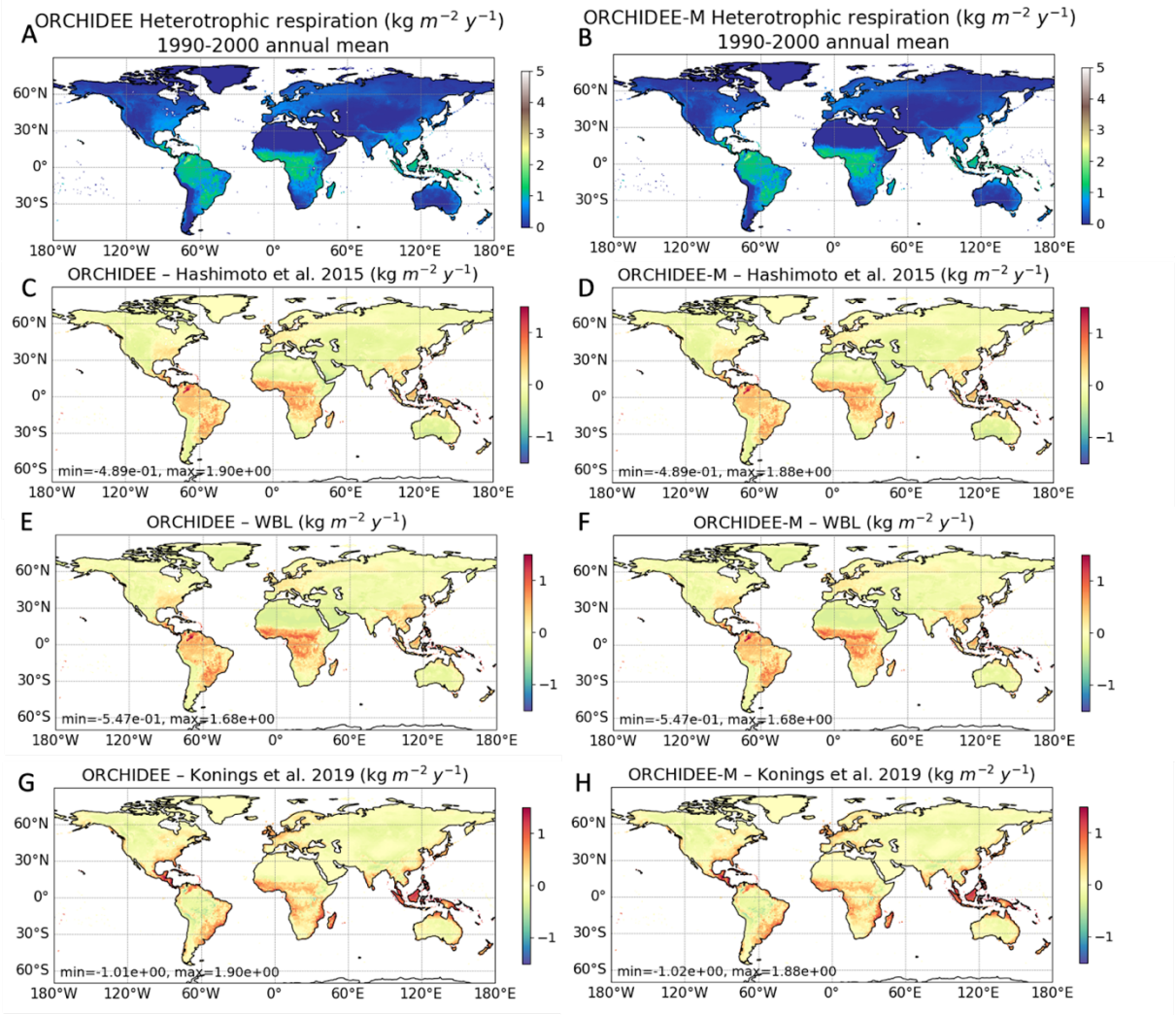

Figure 7: Annual mean HR CO_2 fluxes map for the period 1990-2000 of the model ORCHIDEE and ORCHIDEE-M (A-B) and differences (C to H) of simulated annual mean HR CO_2 fluxes and of the three databases of Hashimoto et al. (2015), Warner et al., (2019), and Konings et al., (2019) in kilograms per square meter per year (in the three-bottom row)

Thank you again for the careful engagement with the referee reports. I look forward to receiving a revised manuscript that incorporates the changes outlined in your response letter and addresses the additional points above.

Best regards,

Sibyll

Thank you for your additional points above that improve some more our manuscript and for you involvement in the editorial process.