We are grateful to the referees for their time and energy in providing helpful comments and guidance that have improved the manuscript. In this document, we describe how we have addressed the reviewers' comments. Referee comments are shown in black italics and author responses are shown in blue regular text. A manuscript with tracking changes is attached at the end.

Reviewer #2

Review for Development and evaluation of the ECHAM6-iMAPLE v1.0 coupled atmosphere-ecosystem model

In their manuscript "Development and evaluation of the ECHAM6-iMAPLE v1.0 coupled atmosphere-ecosystem model", the authors describe and present some benchmarking analysis of the ECHAM6 atmospheric model coupled to the iMAPLE v1.0 land model, in place of the JSBACH land model.

The manuscript is overall well written, and the benchmarking analysis is fairly clear. Following minor revisions, this study would be suitable for publication in the EGU family of journals.

My largest point of confusion was that it was unclear until fairly late in the manuscript if iMAPLE was being imposed alongside JSBACH to handle certain specific aspects of the land surface, or if JSBACH was being entirely removed and replaced by iMAPLE. Specific comments are listed line by line below.

- Thank you for your positive evaluations. In this revision, we have made these major changes following your comments:
  (1) We clarified the relationship between iMAPLE and JSBACH: iMAPLE replaces the carbon and water cycle components of JSBACH, rather than the entire JSBACH module, and these improved land-surface processes can further influence climate simulations in ECHAM6.
  (2) We expanded the descriptions of the differences in carbon and water cycle processes represented in iMAPLE and JSBACH.
  (3) We revised Figures 5 and 6 to more clearly demonstrate how ECHAM6-

iMAPLE reduces the simulation biases present in ECHAM6-JSBACH.

Line 108 – surely JSBACH was already doing this, was it not? (a process-based simulation of soil temperature and moisture, even if it was different than the approach used by NOAH-MP)

- Yes, JSBACH also employs process-based simulations of soil temperature and moisture. Therefore, this sentence highlights the key improvements introduced by iMAPLE relative to YIBs (the carbon module in iMAPLE), rather than serving as a comparison with JSBACH. In the revised paper, we clarified as follows:
  "This enables dynamical simulation of soil temperature and moisture and facilitates tight coupling between the carbon (simulated by YIBs) and water (simulated by Noah-MP) cycles (Niu et al., 2011)." (Lines 113-115)

Section 2.1 – clearly delineating what JSBACH did not do that required replacement with iMAPLE would be valuable. Or, if it is just a different approach to the land model (but covering the same processes as JSBACH), that is still valuable – the entire premiss of CMIP is "have more models/model combos" – but make it clear that that is the case.

- Thank you for this helpful suggestion. The main reasons for replacing JSBACH in ECHAM6 with iMAPLE are twofold. First, iMAPLE demonstrates improved performance in simulating carbon and water fluxes compared with JSBACH, which is expected to improve climate simulations when coupled with ECHAM6. Second, iMAPLE incorporates a broader range of biogeochemical processes, providing greater potential for extending land-atmosphere coupling to atmospheric chemistry in future applications. We have clarified in Section 2.3 as follows:

  "Although both JSBACH and iMAPLE participated in the multi-model intercomparison project for Global Carbon Budget, iMAPLE demonstrated superior performance relative to JSBACH in simulating key carbon (e.g., GPP) and water (e.g., ET) fluxes (Friedlingstein et al., 2025). In addition, iMAPLE incorporates a more comprehensive representation of biogeochemical processes, providing greater potential for extending land-atmosphere coupling to atmospheric chemistry in future applications." (Lines 285-291)

Section 2.1 – clearly delineating what the difference between NOAH-MP and iMAPLE is --- does iMAPLE add layers of complexity to NOAH-MP, or does it use parts of NOAH-MP's code (eg solving the soil energy budget) and not other parts?

- Thank you for this helpful suggestion. iMAPLE does not introduce additional layers of complexity to Noah-MP. Instead, the hydrological and soil-physics components of Noah-MP have been fully incorporated into iMAPLE, enabling the dynamic calculation of soil parameters required for carbon cycle simulations in iMAPLE (based on YIBs) and facilitating the coupling between carbon and water fluxes. In the revised manuscript, we have clarified this relationship in Section 2.1 as follows:

  "Furthermore, iMAPLE integrates the process-based hydrological scheme Noah-MP, including precipitation partitioning, infiltration, soil moisture redistribution, evapotranspiration, runoff generation, and groundwater-related processes. This enables dynamical simulation of soil temperature and moisture and facilitates tight coupling between the carbon (simulated by YIBs) and water (simulated by Noah-MP) cycles (Niu et al., 2011)." (Lines 110-115)

Line 183-185: was not clear here if ECHAM (JSBACH) or MAPLE is handling the land. Which component of the model is responsible for what? Does MAPLE just do the vegetation, or all land surface properties? How does that interact with the physical surface like feedbacks between leaf area and albedo?

- Thank you for pointing out this ambiguity. We have revised this part to enhance the clarity:

  "In the default ECHAM6 configuration, land surface processes are handled by JSBACH. After coupling with iMAPLE, JSBACH remains responsible for most land surface calculations in ECHAM6, whereas iMAPLE is used for vegetation processes. Details of the exchanged variables are given in Section 2.3." (Lines 207-210)

  iMAPLE feeds back only soil temperature, soil moisture and evapotranspiration to ECHAM6 in the present coupling. Physical surface processes of this type, including leaf-area–albedo interactions, therefore continue to be handled by JSBACH. We have acknowledged this incomplete coupling as a limitation in the Conclusion and Discussion, and it is also a priority for future model development:

"… not all vegetation properties simulated by iMAPLE are fully coupled to ECHAM6. For instance, dynamically simulated LAI is not consistently used by ECHAM6 to update land surface parameters or ecosystem emissions." (Lines 495-498)

Line 197-198: not clear if iMAPLE is replace JSBACH, or replacing only parts of it, OR only adding new functionality, and stuff that iMAPLE did that JSBACH was already doing doesn't get incorporated and the JSBACH processes are used.

- We are sorry for this misunderstanding. When iMAPLE is coupled with ECHAM6, JSBACH remains the default land component of ECHAM6 and continues to perform most land-surface calculations. The iMAPLE model is used to replace the carbon and water cycle in the JSBACH, which could further affect the climate simulations in ECHAM6. In the revised paper, we clarified as follows:

  "In the default ECHAM6 configuration, land-surface processes are handled by JSBACH. After coupling with iMAPLE, JSBACH remains responsible for most land-surface calculations in ECHAM6, whereas iMAPLE is used for vegetation processes." (Lines 207-210)

  "In return, iMAPLE feeds back simulated soil temperature, soil moisture, and *ET* to ECHAM6. These variables further change the surface energy and water balance, thereby altering heat and moisture fluxes that define the atmospheric lower boundary conditions and regulate near-surface climate." (Lines 300-303)

  "The replacement of near-surface soil moisture updates the land hydrological state, thereby modifying available soil water and regulating subsequent land-atmosphere moisture exchange. The resulting surface heat and moisture fluxes provide the lower boundary conditions for vertical turbulent transport of dry static energy and specific humidity in ECHAM6. Specifically, an implicit surface-atmosphere coupling scheme uses surface dry static energy and saturated surface humidity, constrained by the surface energy balance, as lower boundary conditions, after which the atmospheric column is updated upward from the lowest model level. Consequently, changes in land surface states, including soil temperature, soil moisture, and ET, propagate to near-surface air temperature and humidity, and further influence the atmospheric column through turbulent diffusion." (Lines 318-328)

Line 271-274: implies JSBACH is entirely removed/bypassed. Is that correct?

- Please see our responses in the above.

Figure 1 / related text: no discussion about representation of aerodynamic properties or turbulence - are they static, time evolving, using Monin Obukhov similarlity theory/something else?

- In the revised paper, we provided a more detailed description of the aerodynamic characteristics and turbulence:

  "Turbulent mixing in the atmosphere is represented by a turbulent kinetic energy (TKE) scheme, and surface fluxes are computed using bulk transfer coefficients with Louis-type stability functions based on the bulk Richardson number (Louis, 1979; Brinkop and Roeckner, 1995). Land roughness lengths are provided by JSBACH and evolve with the surface state." (Lines 198-202)

Figure 1: What component of the model is dealing with the entire centre column?

- The centre column of Figure 1 represents the coupling interface between ECHAM6 and iMAPLE, rather than a separate physical component. Atmospheric forcing is passed to iMAPLE through newly added interface code. Selected variables simulated by iMAPLE are then fed back to ECHAM6 along the existing JSBACH land-surface feedback pathway. In the revised paper, we have clarified in the caption of Figure 1 as follows:

  "The integrated modeling framework for ECHAM6-iMAPLE v1.0: Atmosphere-Ecosystem Coupled Model. Left: ECHAM6 atmospheric processes. Centre: land–atmosphere coupling interface. Right: iMAPLE vegetation and hydrology." (Lines 874-876)

Figure 5: Is this full column soil moisture, or near surface, or root zone, or something else? How does each model handle ground water (if at all – and is it included in this figure?)

- Thank you for this important clarification. Figure 5 shows near-surface soil moisture only. iMAPLE and JSBACH treat groundwater differently. In iMAPLE, Noah-MP uses the simple groundwater model (SIMGM). In JSBACH, deep groundwater components below bedrock are not considered as a separate store and the related subsurface outflows are represented in a simplified way through drainage (Hagemann and Stacke, 2015). In the revised paper, we have clarified this in Sections 2.1.2 and 2.2.2:

For iMAPLE: “Groundwater is treated explicitly in Noah-MP through the simple groundwater model (SIMGM) (Niu et al., 2007). An unconfined aquifer is placed beneath the soil column; aquifer water storage (W_a) evolves through recharge and discharge, and the water-table depth is diagnosed from W_a.” (Lines 184-187)

For JSBACH: “Deep groundwater components such as aquifers below the bedrock are not considered. These flows are conceptually simplified and included in the drainage.” (Lines 270-272)

Figure 6 (and also figure 5, but especially true in 6): this is quite hard to compare. Perhaps show MERRA-2, then the difference of iMAPLE-MERRA or JSBACH-MERRA in the middle and right columns?

- ➢ We have modified Figure 5 and Figure 6 as suggested.

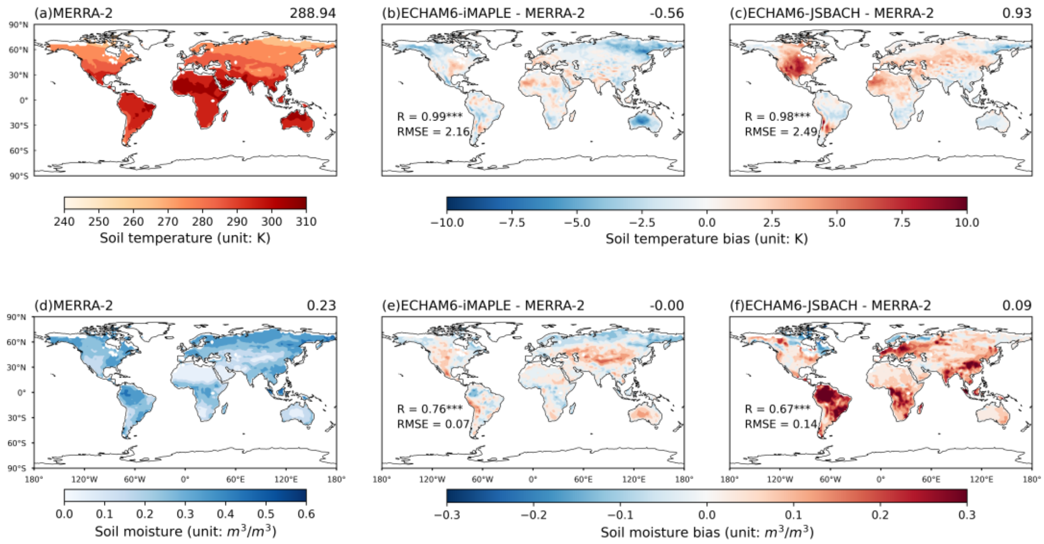

Figure 5. Spatial distributions of (a) soil temperature (ST, K) and (d) near-surface soil moisture (SM, m^3/m^3) from MERRA2 reanalyses, biases of (b, e) ECHAM6-iMAPLE and (c, f) ECHAM6-JSBACH relative to MERRA-2. Both model simulations and MERRA2 reanalyses are averaged for the period of 2005-2014. The spatial R and RMSE between simulations and reanalyses are shown in the lower left corner of simulation panels. The area-weighted mean (or mean biases) ST and SM are indicated at the top of each panel.

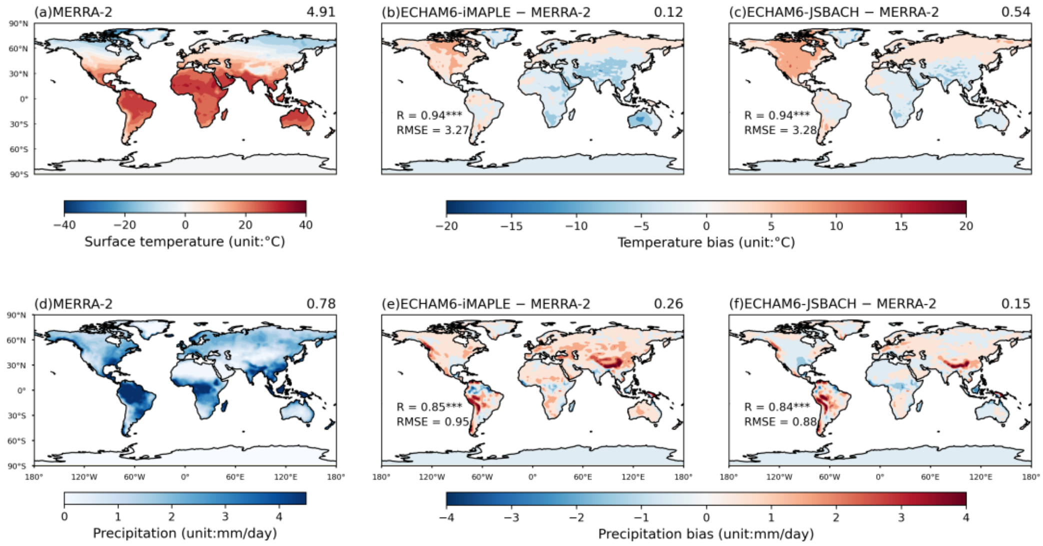

Figure 6. Spatial distributions of (a) surface temperature (T, °C) and (d) precipitation (PREC, mm/day) from MERRA2 reanalyses, biases of (b, e) ECHAM6-iMAPLE and (c, f) ECHAM6-JSBACH relative to MERRA-2. Both model simulations and MERRA2 reanalyses are averaged for the period of 2005-2014. The spatial R and RMSE between simulations and observations are shown in the lower left corner of simulation panels. The area-weighted mean (or mean biases) T and PREC are indicated at the top of each panel.

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