

This is a preliminary point-by-point response prepared for the discussion stage to summarize our current position and planned revisions. A complete response, including the corresponding manuscript changes and finalized additional analyses, will be provided together with the revised manuscript.

General comments:

This is a well written paper describing a new LSM hybrid approach. I only have few comments / questions.

Recommendation: minor revisions.

Response: Thank you very much for your positive assessment. We appreciate your thoughtful questions and suggestions, which will help us clarify the current scope of ADELM v1.0 and discuss possible future extensions.

Particular comment:

- L. 90: The time step of the model must be clearly indicated in Section 2. Can the model represent the diurnal cycle? If not, what needs to be done to enable it to do so?

Response: Thank you for pointing this out. ADELM v1.0 currently operates at a daily time step and therefore does not explicitly resolve the diurnal cycle. We will state this clearly in Section 2. In the revision, we will also briefly discuss what would be required for a sub-daily implementation, including sub-daily meteorological forcing and corresponding modifications to processes that are currently represented at the daily scale. The differentiable framework itself is not tied to the daily time step, but these process representations would need to be extended accordingly.

- L. 341 (“compared using NSE”): You don’t only use NSE, since Figure 8 also shows R^2 values, and the text includes other metrics. Also missing is a table gathering several metrics (NSE, R, SD and RMSD) for comparing the three experiments.

Response: Thank you for this suggestion. In the revision, we will revise this description and add a summary table in the Appendix to compare the parameterization experiments using multiple performance metrics for GPP and ET.

- L. 443-444 (“hydraulic scheme”): Could in situ observations of plant water content be used for training purposes instead of an 'explicit soil–plant hydraulics scheme'? Are such observations available from ICOS stations? More generally, could the ADELM approach be used to simulate new variables that cannot be simulated by classical LSMs, based on sparse in situ observations?

Response: Thank you for raising this point. We agree that observations of plant water status could provide valuable additional constraints on parameter learning. We will clarify in the revision that such observations do not necessarily require a highly detailed soil-plant hydraulic scheme, but the model

does need a corresponding state variable or observation operator that connects the measured quantity to the simulated system. In ADELM v1.0, plant water content or leaf/stem water potential is not represented as an explicit state, so these observations cannot yet be assimilated directly. We will expand the discussion to explain how adding such state variables or differentiable observation operators would allow these data to constrain plant hydraulic behavior.

For future applications, we have considered using PSINet observations as an additional constraint once a more explicit representation of plant hydraulics is implemented. Such observations would not necessarily need to be colocated with the ICOS flux sites, because ADELM can make use of different sparse observational datasets to constrain different components of the model. The spatial support and scale mismatch between these observations and the model grid, however, will need to be considered explicitly.

- L. 672: Why use Jarvis instead of taking a slightly more biophysical approach? Is it because you don't simulate leaf temperature throughout the diurnal cycle?

Response: Thank you for this question. We chose the Jarvis formulation in ADELM v1.0 for two related reasons. First, it provides a relatively simple and empirical representation of stomatal regulation, which is well suited for demonstrating the central concept of the framework: how conventional process parameters can be selectively exposed to observation-constrained learning and subsequently diagnosed. Second, its level of process detail is consistent with the current ADELM v1.0 implementation, which operates at a daily time step and does not explicitly resolve a sub-daily surface energy balance. In the revision, we will make this modeling choice clearer and discuss how a more biophysical formulation coupling stomatal conductance, photosynthesis, and plant hydraulics could be incorporated within the same differentiable framework in future model versions.