23/10/2025

Revision Comments on Version 2 of Quantifying Coupling Errors in Atmosphere-Ocean-Sea Ice Models: A Study of Iterative and Non-Iterative Approaches in the EC-Earth AOSCM

Valentina Schüller[a] , Florian Lemarié[b] , Philipp Birken[a] , and Eric Blayo[b]

[a] Lund University, Lund, Sweden.
[b] Univ. Grenoble Alpes, Inria, CNRS, Grenoble INP, LJK, Grenoble, France.
Correspondence: Valentina Schüller (valentina.schuller@math.lu.se)

Preface

We thank the reviewers for their reports and in particular reviewer #1 for the additional comments on the manuscript. We have addressed them as presented in the following pages. In the revised draft, they are marked in blue.

Response to Minor Comments from Referee Report #1

On introducing the SWR, well-posedness etc.

L. 21 – 22: I would slightly rephrase to "if the coupled problem is well-posed, then it has a unique solution which the iteration converges to", which explicitly refers to "well-posedness", as this is a key. The initial phrasing could also have been misunderstood: the "correctly constructed" thing could have either been the coupled problem itself (which is what the authors meant), or the SWR algorithm it tries to solve.

Revised as suggested.

Line 36, I suggest adding one further sentence for insisting on the utility (and limitations) of the SWR: while SWR cannot formally prove whether a coupled problem is well-posed, it does provide a valuable stress-test on the robustness of the model formulation's robustness. This might sound like a repetition of the phrase L. 34 – 35, especially to domain experts like the authors, but I think this point is important enough and might be subtle to grasp for some of the GMD readership, so insisting might be worthwhile. And it is in line with one of the main messages of the manuscript, on the sea-ice albedo and atmospheric convection irregularity.

Revised as follows:

> if the iteration does not converge, model development is advised. That is, one uses SWR not to formally obtain well-posedness results, but as a numerical stress test that specifically addresses the coupling layer.

On the mixed ocean/ice heat boundary conditions

I still do not agree with the authors' choice not to explicitly write a_i in Eq. 14, but I could live with it, provided the authors add one sentence explicitly saying that Q_i already accounts for a_i. I think that point is relevant, even if the scaling is done implicitly by SI3 (and rightfully so). In their answer to my initial concern, the authors say that §2.3.2 "explicitly mentioned" this, but:

- *Where is that explicit mention in §2.3.2?*
- *§2.3.2 is not a relevant location for this anyway, because it treats the 100% ice cover case, for which a_i does not bear much meaning. Right after Eq. 14 is a better spot, IMO.*

We think there was a typo in our last response, we regret the error. In the revised manuscript in §2.3.3, right after Eq. 14, we explicitly wrote "SI^3 takes into account the ice area fraction in computing \(Q^i\) and \(\mathcal{S}_t\)." To make this clearer, we have **revised** this by explicitly repeating the variable as well:

> SI^3 takes into account the ice area fraction a_i in computing Q^i and $\mathcal{S}_t$.

L. 244: "the" boundary condition (not "The")

Revised as suggested.

Further Changes to the Manuscript

1. Reviewer #1 had an additional comment on the manuscript that was not part of this review report but communicated personally:

Eq. (8b), I think c_p^a should be substituted with Λ^a; it's the specific enthalpy of fusion that should be there, I believe. Unless I'm mistaken, you need this for (8b) to have the correct dimension / units.

There were two mistakes in Eq. (8b) and, likewise, Eq. (11b), which we have fixed in accordance with the ECMWF's IFS documentation by

1. replacing specific heat c_p^a with latent heat of fusion L_q,
2. replacing the transfer coefficient C_H with a transfer coefficient C_Q.

We have furthermore adapted the sentence following Eq. 8b as follows:

> Therein, C_{H,o} and C_{Q,o} are the transfer coefficients for sensible and latent heat, respectively, and L_q denotes the latent heat of fusion.

2. Finally, we have updated the acknowledgements as follows:

> Thank you furthermore to Sophie Valcke for valuable input regarding the SWR implementation and coupling algorithm switching in OASIS3-MCT, as well as Charles Pelletier and an anonymous reviewer for valuable comments on the manuscript.