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Interactive comment on "The seamless and multi-model coupling between atmosphere, land, hydrology, ocean, waves and sea-ice models based on SURFEX surface model using OASIS3-MCT" *by* Aurore Voldoire et al.

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We thank the anonymous reviewers for their very constructive comments on our manuscript. The reviewers comments have greatly help in improving the quality of the manuscript. Below, we answer point by point (in italic) to the reviewer comments. Note that given the three reviewers comments that mainly stressed the lack of uniformity of the manuscript, we have largely reorganised and reworded the original text. As a consequence, it was not possible to highlight the manuscript changes. In the response to the comments, we have indicated the lines where the comment is addressed

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in the new manuscript (added as a supplementary material). We also summarize all the changes made at the end of this document (section by section).

Reviewer's Comment: The paper describes the capability of the surface model SURFEX to couple a whole range of different model components. The possibility to switch between different components i.e. for the ocean model with their individual pros and cons is a great advantage in climate research. Several examples on the usage of SURFACE on different scales are described in the paper. The title is not so well chosen, the word "seamless" does not appear in the paper. And its meaning is still unclear after reading the paper. Is it possible to use SURFEX in a coupled global model with two-way nesting refinements to have a seamless model in the spatial sense? Or is it meant in a temporal sense? If seamless is meant as the usage of SURFACE from global to high resolution models, the wording is not appropriate.

Authors' Answer: We agree that the term seamless was misleading here. We have therefore changed the title to: "SURFEX v8.0 interface with OASIS3-MCT to couple atmosphere with hydrology, ocean, waves and sea-ice models, from coastal to global scales" to better reflect the asymmetry (see below) in the system between atmosphere and the other components and to focus on the generic aspect of the interface which makes it usable at very different scales. RC: The general focus of the paper is the description of the coupling interface and not to discuss the advantages of coupled modelling. But reading the paper gives a different impression. The examples of the different applications with SURFEX (Chap 3.) take a lot of space and they are only a loose listing of studies, where in all examples different variables are discussed.

AA: We agree that section 3 is a long and heterogeneous list both in form and content. We have decided to keep this section since we would like to illustrate the diversity of applications that can take advantage of the new interface. However, we have tried to shorten and make it more uniform for all systems in terms of presentation. This was easier than in the original manuscript since some of the systems have now lead to published scientific studies, that can be cited. We have also added a new table (2) on

page 29 summarizing the different systems and indicated the number of cores used by each component of the coupled systems. We have also added at the beginning of section 3, a discussion on the motivation for listing these applications, but also on the coupling cost. This new part is found on lines 322-350.

RC: The frame is not so well defined as they all seems to use different SURFEX versions (Version 8, Version 7.2 and Version 7.3) and the differences are unclear. According to the introduction, the standard interface was introduced in Version 7.3. Please discuss the differences and the reason why there not using the same version.

AA: The interface was introduced in version 8, and back-phased in former versions because some applications use atmospheric models that are linked to specific version of SURFEX. It was easier to back-phase the coupling interface than to change the SURFEX version, since SURFEX coupling with atmospheric models is hard-coded. The SURFEX version in which the coupling has been developed is clarified at the beginning of section 2.3 (old 2.2). See lines 183-189. The explanation on the reason why the systems use different SURFEX versions is clarified in the new part added at the beginning of section 3, lines 349-350. The versions are also clearly listed in the new table 2 (page 29).

RC: The conclusion fits well to the intention of the paper and it would have been better to focus more on the points in the conclusion as most of them are not discussed in the paper itself (i.e. computational costs of the coupling, grid interpolation, etc.). As it is a more technical paper, it would have been better to discuss the technical aspects a bit clearer. Why is the atmospheric coupling omitted and which model component is calculating which fluxes and what problems could arise. This issue is superficially discussed in the conclusion, but it is very important for the coupling philosophy.

AA: We agree that some technical aspects were missing in the original manuscript. The computational costs are now discussed in section 3 (see above). We have also added more details on the coupling methods and interpolation. We have also reorganized

the end of introduction and section 2 to clarify the interface description. By doing so, we have created a new section 2.2 to discuss shortly the capacities of OASIS3-MCT. Most of the technical aspects that were not discussed are in fact tunable thanks to OASIS3-MCT namelist. We do not intend to describe exhaustively the OASIS3-MCT capacities, which are well described in the User Guide (Valcke et al, 2015), but this section gives the information on what is tunable via OASIS3-MCT. For the atmospheric coupling we have clarified this point in the introduction. The main point is that the coupling between SURFEX and ATM is done in a hard-coded way using a call to the SURFEX interface. Originally, SURFEX has been externalized from the atmospheric model so as to ease the development and sharing of the surface parameterisations in Meteo-France models, but the implicit coupling limited the possibility to use a coupler. The implementation of SURFEX within ATM is described in Masson et al. (2013) based on Best et al. (2004) structure and is clearly out of the scope of the study.

RC: And what about a two way nesting in the atmosphere with 3D coupling? This is not part of the SURFEX interface nor of the discussion (see seamless comment above). The approach of a general interface seems to be very tempting.

AA: The question of the two way nesting is interesting and was not addressed nor in the implementation nor in the manuscript. Several developments are notably needing to use the coupling interface with grid-nesting. We have added a discussion on this point in the conclusion as a perspective. See lines 359-352 on the question of the two-way nesting.

RC: What would be the problems to adapt the models for simulations i.e. over Africa? This is not clear to the user after reading the article. Every component seems to be available with certain license agreement, so how much more work is necessary?

AA: We have added a discussion on this point in the conclusion. The question of changing the region for limited area exemples is mainly a question of adapting each component to the region, there is no specific work to be done for the coupling in itself,

other than what is described at the end of section 2.3 (old 2.2) that has been also detailed. See lines 541-546 in the conclusion.

RC: The last sentence of the conclusions discusses the question about the initialization of the coupled system. It would be better to discuss the advantages of the SURFEX community a bit earlier and maybe in more details.The discussion could also be centered around the interpolation of different grids and the lateral boundary conditions in regional models. So the last sentence seems to be not really part of the rest of the paper. Please embed and write a nicer paragraph on this subject as it is very important when using SURFEX to have a community behind with a lot of support and possibilities for discussions and strategies for the future model development of SURFEX.

AA: The conclusion has been modified. A discussion on the advantages of the SURFEX community is now added in the conclusion, lines 524-532. The paragraph dealing with initial (and lateral boundary) conditions has been modified in the conclusion, lines 563-566.

RC: There are a lot of citations in the article where the authors give credit to related work. The number and quality of the references are appropriate. The abstract give a good overview over the article, the discussion of the interface with its pros and cons could be added. The language is fluent and precise.

Specific comments

RC: In the introduction, page 3, line 84: this sentence is unclear. Why and when is the surface parametrization implemented in SURFEX not valid? Which 0D cases are available? For radiation studies?

AA: We agree that the sentence was not clear. The introduction has been largely revised and this point has been clarified. One example of 0D case is the ocean flux bulk formulae (no level and made at each grid point). However, 0D case is not mentioned anymore in the introduction as it was not necessary for the objectives of the section.

RC: Please explain this in more detail and maybe not in the introduction. Page 5, line 122: “The fluxes are aggregated of the model grid-mesh”. Are the aggregated fluxes passed directly to the corresponding model? What about a tile approach? First pass on the state variables for each tile to the corresponding model and then calculated the fluxes for each tile separately and average in the end. (See Barthélemy et al 2016).

AA: SURFEX use a tiling approach as explained in section 2.1, so that the fluxes are aggregated to the atmospheric grid mesh (better explained lines 130-134 and new Eq. 1) The fluxes sent to the ocean model are those calculated only over the ocean fraction of the grid cell. This is now explained at the end of section 2.4.1 (old 2.3.1), lines 238-244.

RC: Page 5, line 140: What do the numbers refer to? Kind of obvious, but please use them first before you refer to them.

AA: Done

RC: Page 6, line 150: Where is this discussed again? This was not obvious in sections 3.2 or 3.3. It could be found in between the lines but please write a proper discussion about it. This is actually a very important subject for a coupling interface. How are the grids defined and what additional work is needed to adapt them to specific needs.

AA: We agree that this was not discussed clearly. We have added a discussion in section 2.3 (old section 2.2), lines 176-182.

RC: Page 6, line 156: What is SYMPHONIE (mentioned later but not here).

AA: The model reference has been added here and removed in section 3.

RC: Page 15, line 441-442: This is an important issue and could be discussed also in more details and show up in the conclusions.

AA: This issue concerning the parameterization of the wave effect on the surface roughness, the momentum flux and thus on the atmospheric boundary layer is now discussed

in section 2.4.2 (lines 271-274). In the conclusion (lines 356-358), we reassert this point indicating that surface flux parameterizations are critical physical schemes in the coupled mode and that the interface between SURFEX and OASIS3-MCT offers the opportunity to more easily test new parameterization in multi-model and coupled mode.

RC: It seems to be that the wave model so far is only coupled dynamically to ocean models and not to the atmosphere. Maybe it could be already mentioned in 2.3.2?

AA: The wave model is coupled both with ocean and atmosphere models as described in section 2.3.2. The atmospheric roughness length is estimated at the air-sea interface by Equation 8. The Charnock parameter is directly calculated by the wave model for the M2W system and estimated from the wind in the other model configurations.

Technical corrections

RC: The size of the pdf is much too large. The figures, especially Fig 1 and some of Fig 2 seem to be enormous. Please reduce the size substantially, there is no scientific gain to have a super high resolution topography figure with several layers in this pdf.

AA: The size of Figure 1 has been decreased. Several plots of Figure 2 have been modified.

Barthélemy, A., Fichefet, T., Goosse, H., & Madec, G. (2016). A multi-column vertical mixing scheme to parameterize the heterogeneity of oceanic conditions under sea ice. Ocean Modelling, 104, 28-44.

References:

Best, M. J., Beljaars, A., Polcher, J., and Viterbo, P., 2004: A Proposed Structure for Coupling Tiled Surfaces with the Planetary Boundary Layer. J. Hydrometeorol., 5, 1271–1278.

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Summary of all changes made in the manuscript (and rationale for the changes):

Title: changed

Abstract: few rewording, mainly unchanged.

Introduction: beginning unchanged until line 45, then mainly a reorganisation of existing text to provide examples along the different types of interpolation, plus clarification of pros and cons. From line 80-108 : rewording and adds on the implementation to better state the motivation, clarify the atmosphere/SURFEX coupling.

Section 2: section 2.1, only slightly modified (rewording)

Creation of new section 2.2 on OASIS3-MCT to better describe the technical implementation and highlight the capabilities of the implementation. This new section is partly based on existing paragraph from section 2.1 and 2.3.

Section 2.3: Changed to detail the necessary work to be done to set up a new coupled model and clarify the SURFEX version in which the developments have been made. Section 2.4: The header is only reworded

section 2.4.1: The beginning is unchanged. Mainly adds for the ICE coupling. Also detail the interaction between the tiling and the coupling.

section 2.4.2: the first part on the ATM-WAV coupling has been reworded to better introduce the motivation and to clarify the methods. Second part on OCE-WAV coupling only reworded.

section 2.4.3 : only slight rewording.

Section 3: creation of new paragraphs before section 3.1 to clarify the motivation for the examples described in this section and discuss the cost of coupling. This comes with new table 2.

Section 3.4 and 3.6 have been switched to provide examples from the largest scale to the smaller one (figures 6 and 8 have been switched accordingly).

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Sub-sections of section 3 have all been shortened and reworded for uniformization.

Conclusion: The conclusion has been largely revised to better discuss the pros and cons of the implementation. Some new perspectives have been added (new coupling fields, two-way nesting).

Authors contribution: unchanged

References: checked

Figures

Figure 1: unchanged

Figure 2: layout changed for uniformisation (and figures d and f switched)

Figure 3 unchanged

Figure 4: unchanged

Figure 5: simplified

Figure 6: add differences CPL-UNCPL (e and f)

Figure 7: remove one lag

Figure 8: improved following reviewer suggestions, captions reworded.

Tables

Table 1: rewording (“remove x and y components of”)

New table 2

Please also note the supplement to this comment:
https://www.geosci-model-dev-discuss.net/gmd-2017-91/gmd-2017-91-AC1-supplement.pdf

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