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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 (RC) 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 in the new

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Discussion paper

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 manuscript describes the new coupling interface integrated in the SURFEX surface model. This interface allows SURFEX to communicate through OASIS3-MCT coupler with other models with similar coupling interfaces. After the technical description of the interface, different applications and illustrations are presented. The main criticism concerning the manuscript in my opinion is the irregularity of the global layout and content quality: some sentences are too long or not clear, some acronyms are not detailed and some figures are incomplete or incorrectly referenced. The manuscript gives the feeling that sections have been written by different authors and consequently lacks of consistency and homogeneity. A global and careful correction of the manuscript and the figures must be done by the authors to improve the manuscript reading, comprehension and consistency before publication. The main technical caveat is the lack of discussion about the computational performance of the new coupling interface (OASIS3-MCT in SURFEX) compared to the old one (OASIS3 in the atmospheric model) or to alternative coupling strategies such as the integration of all components in one executable.

Authors' answer: We agree that the question of the computational performance of the coupling was not really discussed. We have tried to rationalized section 3, to shorten the examples and we have added a discussion at the beginning of the section to highlight the objectives of this section. We have also added a discussion on the computational cost of the coupling in these examples and a table (table 2, page 29) giving the relative cost of each model component in the coupled system. We agree with the reviewer that it would have been interesting to provide the cost of using OASIS3 instead of OASIS3-MCT, however, this has not been possible in the context of SURFEX. This would have only been applicable to the climate applications which already existed before creating the new interface but this change came along with a change of all components versions and the interface with the old coupler was removed from the last

versions of the model. Additionally, the intermediate versions in which it would have been possible to make an evaluation, have not been ported to the new super-computer and are now unusable.

Separate performance tests have shown that OASIS3-MCT is much more efficient than the previous sequential OASIS3 version. Figure 4 in Craig et al. (2017) shows that the time for a back-and-forth coupling exchange between a T799 grid (i.e. a global atmospheric gaussian reduced grid with 843,490 grid points) and an ORCA025 grid (i.e a tripolar grid with 1442$\times$1021 grid points) is about an order of magnitude smaller in OASIS3-MCT for a large range of core counts. The coupling cost has not been very well documented in all applications because it is not straightforward and mainly because none of the group did faced with performance problems. As theses coupling models were implemented for research purposes, the first versions of the models were not carefully checked in terms of cost. Such a work is underway (but with a different quickness in the different teams) and OASIS3-MCT comes with a tool (lucia) to estimate the coupling costs. This work has been done for the CMIP6 climate model and the cost of the coupling with OASIS3-MCT is very limited if the components are adapted to run with a similar speed so that none of the component wait before coupling exchanges.

The reason why we have chosen the coupler strategy is clearly for flexibility and we know that it is of major importance for SURFEX that is used in many different models with various components developed in different teams. Given that the coupling cost is not important compared to the individual model cost, the comparison with an hard-coded coupling is out of the scope of our model development.

A discussion on the motivation for the applications and on the coupling cost have been added at the beginning of section 3 (lines 322-379).

RC: This could make the manuscript more useful for other modelling groups using different coupling strategies. Some models described in the manuscript allow to do

grid-nesting (NEMO with AGRIF, MESO-NH for example). Is the SURFEX coupling interface compatible with such type of coupled model configurations? This possibility or limitation should be discussed in the text.

AA: Several developments are needed before using the coupling interface with grid-nesting, notably to manage with OASIS and in the four steps indicated in section 2.3 (initialization, definition, exchanges, finalization) the use of several domains by one executable. A discussion about this issue has been added in the conclusion. See lines 559-562 on the question of the two-way nesting.

RC: A lot of different models are cited in the text, especially for the atmosphere and the hydrology. A supplementary table summarizing this list by category could facilitate the manuscript reading.

AA: The list of models has been added in the new table 2 (page 29).

Specific comments:

RC: Introduction: The introduction is not well organized: examples should be given just after describing the corresponding coupling strategy (i.e. add the COAWST model example just after the description of the “one executable” approach). A sketch or a table summarizing and comparing the 3 possible coupling strategies (one executable / multiple executable / integrated application) could help to better understand the strategy detailed in the manuscript.

AA: We have reorganised the introduction as suggested by the reviewer.

RC: Section 2: A separate paragraph for the description of OASIS3-MCT coupler is missing in the manuscript. The paragraph in introduction section from l.95 to l.102 could be moved in Section 2 and merged with l.128 to l.134 to create a new subsection describing OASIS3-MCT.

AA: We have created a new section 2.2 dedicated to OASIS3-MCT as suggested by the reviewer. This new section aims at providing the information of what OASIS3-MCT

handles but a complete description can be founded in OASIS3-MCT documentation (Valcke et al., 2015). Accordingly, we have fully reorganised section 2.

RC: A comparison of performances between the old implementation of OASIS3-MCT in ARPEGE-climate and the new version in SURFEX interface could give valuable information and improve the manuscript. A comparison of performances between OASIS3 and OASIS3-MCT version, which doesn't need to use dedicated processes contrary to OASIS3, could also give useful information for the modellers reading the manuscript.

AA: We have discussed this point above.

RC: It is not clear if SURFEX can be run in coupled mode with an atmospheric model through OASIS3-MCT at different resolutions or not (l.159). If SURFEX need always to be compiled and integrated with the atmospheric model executable at the same resolution, this limitation must be clearly stated somewhere in the manuscript.

AA: When coupled to an atmospheric models, SURFEX operates at the atmospheric model resolution and the coupling is hard-coded. This point is now clearly stated at the end of introduction (lines 84-85).

RC: Regarding the ICE model, (l. 184-l.195) it is not clear if it is coupled as an independent model to SURFEX or if the ICE model is already included in the OCEAN model and then is not coupled directly to SURFEX (such as LIM3 ice model in NEMO for example). This must be clearly stated in the text.

AA: The coupling interface does not make any hypothesis on this point. SURFEX can receive the ICE fields from an independent ICE model, this is managed through the OASIS namelist. This is now stated at the end of section 2.4.1 (old 2.3.1), lines 235-237.

RC: Section 3: A table summarizing the different coupled configurations based on SURFEX, their components and the corresponding versions could facilitate the Section 3 comprehension.

AA: A new table 2 (page 29) has been created as suggested by the reviewer.

RC: The section 3.1 describing how the different components of the ESM are tested and assembled is very interesting but incomplete. A more detailed description of the validation process of the different components before coupling them would greatly improve the manuscript technical interest. For example, a paragraph describing NEMO-SURFEX evaluation before their coupling with the other components.

AA: We agree that this would have been valuable but given the remarks of all the reviewers, we have chosen to shorten and uniformize the examples given in section 3, rather than to add more details.

RC: The analysis of the diurnal cycle in CNRM-RCSM6 is interesting. Did you perform any analysis concerning the surface heat budget to understand why the diurnal cycle is overestimated in summer and underestimated in winter? Is it related to turbulent fluxes / radiative fluxes / etc...?

AA: First, we apologize for the mistake on the season: the amplitude of the diurnal cycle is underestimated in OND which is autumn and not winter. Further analyzes on the reasons for the overestimation [underestimation] in summer [autumn] are planned. Our preliminary investigations indicate that the shortwave flux is overestimated by the model in summer. For what concerns the autumn, the wind representation for example should be studied in more detail.

RC: The MESONH-SYMPHONIE section is a bit redundant with the AROME-NEMO section because it uses the same dataset from Hymex IOP. Consequently, dataset description and the low-resolution simulations which is not presented in the manuscript can be removed to make this section easier to read.

AA: This section has been reorganized and reduced and motivations have been added et the beginning of section 3 (namely this validates the use of a different ocean model).

RC: Concerning the Figure 7, a third column presenting the differences between CPL

and UNCPL would facilitate the comparison discussed in the text.

AA: Done on Figure 6 (old Fig. 7)

RC: Concerning the MESONH-NEMO section, the illustration of the coupling effect on the tropical cyclone structure is not clear (and the units are missing). A better illustration would be to present the time evolution of the cyclone intensity or the water content averaged over the domain region.

AA: The evolution of the domain-averaged integrated water content is shown in Figure 1 (below, in this document) for the MESONH-NEMO model over the Indian Ocean. It shows that in the CPL run, there is systematically slightly more water than in the NOCPL run, but it does not show the impact on the structure of the system, and especially on the position and intensity of the eyewall represented by the region of maximum values of total water, which is what we want to illustrate. So, to render Figure 7 (old Fig. 8) more readable and in order also to enlarge the size of each plot, we have decreased the number of panels shown from 6 to 4. Only the 18 h and 30 h forecast ranges have been retained. The units are also shown on Figure 7.

Figure A: Domain-averaged total water content (mm) for the NOCPL run (in red) and for the CPL run (in blue).

Technical corrections:

RC: Figure 2: remove “limited-area” from the legend as CNRM-CM6 is global and use the same color bar for all the panels.

AA: Done

RC: Figure 3 is not well numbered.

AA: Corrected

RC: Figure 6: Panel are not numbered and the white iso-contours are not visible in the lower panels.

AA: Figure 8 (old Fig. 6) has been modified following your comment and guidelines.

RC: Figure 8: Units are missing

AA: Done in Figure 7 (old Fig. 8)

RC: l.1: Remove ń ăseamless ă Åij from the title which is not adapted in this context

AA: The title has been reworded to: “SURFEX v8.0 interface with OASIS3-MCT to couple atmosphere with hydrology, ocean, waves and sea-ice models, from coastal to global scales”.

RC: l.46: work done by Hewitt et al. 2016 at Met Office is relevant here

AA: We have added the reference.

RC: l.47: from the -> from a

AA: Done

RC: l.48-50: Please explain the pro and cons about the fully embedded coupling strategy compared to the multi-executable one to better understand the choices of the different modelling groups.

AA: The pros and cons of the strategy are now more detailed in the introduction (lines 57-60, 63-65, 75-77) and reasserted in the conclusion (531-533).

RC: l.52: communicate -> exchange regrid -> interpolate data into different grids

AA: Done

RC: l.55-59: the sentence should be divided in 2 to improve manuscript readability.

AA: We split the sentence. It now reads: “In the first category, coupling is achieved via component-level interfaces within one integrated application, e.g. the Earth System Modeling Framework (ESMF, http://www.earthsystemmodeling.org, Collins et al., 2005, Theurich et al, 2016) and requires users to split components into initialise, run, and

finalise parts. This approach limits the places where data exchanges can happen but offers opportunities for performance optimization as components can be easily run in different layouts on available resources."

RC: l.76: Ric chi -> Ricchi

AA: Done

RC: l.81: Is there any attempt to use Surfex coupled only to an ocean model (without atmospheric model)? If yes, it can be added here. If no (because of technical restrictions), it must be stated in the text.

AA: SURFEX stand-alone can be coupled to an ocean model. This is now clearly stated at the end of the introduction (lines 83-84) and referenced in the conclusion (lines 551-553)

RC: l.84: could you give a practical example about Surfex parameterization limitation in stand-alone model to improve the manuscript?

AA: This has been added to the introduction (lines 91-95).

RC: l. 104: use -> use cases

AA: Done

RC: l. 140-143: are SURFEX "OFFLINE" and SURFEX stand-alone modes the same? If yes, please use the same terms everywhere in the manuscript. It is also not clear why SURFEX need to communicate with OASIS in this mode. This should be detailed in the manuscript.

AA: We agree that this point was not clear in the manuscript. We have removed the OFFLINE word and used stand-alone everywhere instead. Additionally, the introduction has been detailed to better explain the way SURFEX is interfaced with the atmospheric model (hard-coded interface, lines 84-85).

RC: l. 146: called “namcouple”

AA: Done

RC: l.169: typo in the stress equation: Us-Ua-> Ua-Us

AA: It is not a typo as SURFEX uses a different convention than ocean models in general. This field is multiplied by -1 in the coupling step (and this is specified in the “namcouple” file).

RC: l. 210: za -> za

AA: Done

RC: l. 247: regarding the Dis term in the hydrological model, how is it considered by the ocean model? Precipitation?

AA: The ocean model takes into account a river discharge term in the coupling interface.

RC: l. 310: please add the typical value of CMIP5 models SSH drift. Is it possible to determine if this drift is also present in observations or just related to unrealistic water cycle in the model?

AA: This point has been removed from the manuscript because it was not properly done in the simulations presented here. The main reason is that the coupled model has not been run long enough in the examples provided to reach an equilibrium in term of water budget. Such an effort has been done since the submission of the manuscript and after ∼300 years of simulation the ssh drift is less than 10-5 mm per century. Even if this is an interesting point to discuss, it is quite complex (given the anthropogenic impact) and would necessitate a rather long discussion which was not the focus of the paper.

References:

Craig, A., S. Valcke, L. Coquart: Development and performance of a new version of the OASIS coupler, OASIS3-MCT_3.0. Geosci. Model Dev. Discuss., doi:10.5194/gmd-2017-64.

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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).

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-AC3-supplement.pdf

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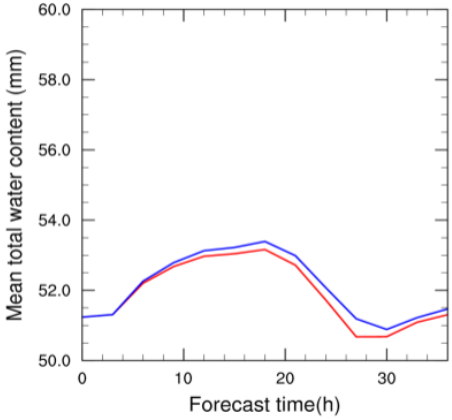

Fig. 1.

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