

Interactive comment on “An EC-Earth coupled atmosphere-ocean single-column model (AOSCM) for studying coupled marine and polar processes” by Kerstin Hartung et al.

Anonymous Referee #1

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*** General comments:**

This manuscript describes a new coupled single-column model (SCM) based on one-dimensional (1D) configurations of NEMO ocean and sea-ice model, OpenIFS atmospheric model and OASIS3-MCT coupler. The technical implementation of the coupling between the models is well described and can be used as guidelines for further coupled models developments. It must be noted that SCM are extensively employed to develop and compare ocean and atmospheric models and vertical parameterizations, but independently most of the time. The originality of this work relies on the possibility to couple each component (ocean, sea-ice and atmosphere) in the same 1D framework,

C1

and consequently to revisit and to extend the classical SCM approach. The limitations of this approach (horizontal terms are not represented in the SCM equations) are also carefully discussed and different existing solutions (prescribing lateral/vertical advection, geostrophic wind and nudging) are proposed and tested. The authors also give some useful recommendations to carefully design numerical experiments and to check the validity of the SCM results. The originality of the manuscript also relies on the multiple applications created with the coupled SCM at three different latitudes: the tropics (Pirata mooring), midlatitudes (Papa station) and polar regions (ACSE campaign). The sensitivity of the simulations to the different relaxation methods, strength and frequency is also discussed. Hence, the manuscript gives a complete description of what can be expected from a coupled SCM in realistic conditions. However, despite all these positive aspects, I found the manuscript quality uneven. This is especially true regarding the “Results” part which is poorly constructed and quite difficult to follow. I think this is mainly due to the authors intent to show a too much comprehensive study. The experimental setups and diagnostics are very different at the three locations, so no clear conclusion regarding the SCM behaviour and the relaxation methods can be easily drawn. Consequently, some work is needed to improve this disappointing part in order to get a more globally coherent and qualitative manuscript. Regarding the general form of the manuscripts, I suggest to merge the setup subsections 2.3.1 to 2.3.3 with the corresponding results subsections (3.1 to 3.3) to avoid any confusion between the three test cases. Most of the figures legends must be completed to get a better description. I also recommend a better usage of punctuation (especially commas) and a proofreading by a native English speaker to improve the manuscript readability.

*** Specific comments:**

The section 2.3 structure should be improved by merging specific experimental setup sections (2.3.x) with the corresponding results section (3.x). Some experiments are named (AOSCM-3h, . . .), others are not. An additional table summarising all the experiments can improve the readability of the results section. Please also address the

C2

comments and questions in the following section (especially from p.9 to p.16).

• * Specific and technical corrections:

p.1 l. 11: replace “Although the model can be extended” by “Finally” p.1 l. 12: suppress “already”

p.2 l. 2: remove “already” p.2 l. 3: remove the parenthesis p.2 l. 16: “and” -> “or” p.2 l. 32: replace “and” by a comma

p.3 l.5: “GCSS” acronym is not defined p.3 l.7: “model” -> “models” p.3 l.13: “SCM studies” -> please give some references p.3 l.14: please explain why a stably stratified ABL should not be forced by surface fluxes p.3 l.15: specify that this study concerns land surface p.3 l.22: near-surface observations and reanalysis cannot be considered as idealized forcing, please clarify p.3 l.26: “to” -> “into” ? p.3 l.28-31: can you give more details about the main results achieved by these studies please ?

p.4 l.3: I recommend to change the title to “Model description, setups and data” p.4 l.5: “realized” -> “builted” p.4 l.10: give reference and link for OASIS3-MCT please p.4 l.27: “optional” -> “also available”

p.5 l.19: “forcing is read” -> “forcing fields are read” p.5 l.23: surface emissivity only concerns the longwave radiation emitted by the surface and not the net surface LW flux. Please correct the equation. p.5 l.26: is there a skin layer conductivity parameterization for the ocean ? If not it could be better to talk about diffusivity for the ocean instead of conductivity. p.5 l.27-28: I don’t understand this sentence. Does it mean that the albedo is prognostic ?

p.6 l.1: one-dimensional version of Navier-Stokes equations p.6 l.8-9: please add a reference about equation of state formulation p.6 l.10: what is the interest to change the equation of state for the 1D ? numerical cost ? p.6 l.14: please give different time scale variable names for the different components (ocean, atmosphere, ice) p.6 l.20: please add Reffray et al. 2015 citation here. p.6 l.21: “for” -> “on” ? p.6 l.22: “way

C3

similar” -> “similar way” ?

p.7 l.10: “communication” -> “communications” p.7 l.18: “variable” -> “variables” p.7 l.22: “transferred” -> please add “from LIM3 to OIFS with OASIS” or something similar. p.7 l.27: “means of” -> “” (useless)

p.8 l.32: “.” should be “and” p.8 l.34: can you give a practical example or reference about this statement please ?

p.9 l.14: can you give more details or practical recommendations/exemples about the relationship between the horizontal resolution of the host model and the SCM please ? p.9 l.24: the computation of the forcing data is not the same depending on the considered experiment and should consequently be moved in the corresponding experiment section. p.9 l.25: can you give explanations/practical reasons about the T511 resolution choice please ? And the convective time step p.9 l.25: “ASCM” acronym is not defined p.9 l.31: specify that ORAS4 is a reanalysis

p.10 l.4: satellite chlorophyll climatology is used for Papa only or also in the 2 other locations ? If Papa only, this sentence can be moved in the 2.3.1 section. p.10 l.21: please give the start date of the long simulation p.10 l.24-26: what about relative humidity ?

p.11 l.1: “topical” -> “tropical” p.11 l.4: “at” -> “on” p.11 l.5: if all simulations are done with 60 vertical levels, this information can be moved in the general setup section. p.11 l.20: “loosely” ? p.11 l.25: “the forcing” -> “the atmospheric forcing” p.11 l.27: what is the LES boundary layer height ? is it constant ? p.11 l.27: “All. . .setup.” -> repetition with previous sentence p.11 l.28: why vertical advection from ERAI generates unrealistic results ? which kind of results ? please give more details about this point.

p.12 l.3: “east Pacific” -> “north-east Pacific” p.12 l.6: what about the wind conditions associated with the cold advection event ? p.12 l.14: “marine” -> “oceanic” p.12 l.15: what can you conclude from the fact that results are similar between AOSCM3h and

C4

6h ? Please add a few comments. p.12 l.18-19: can you add in the text the local inertial period at Papa station to compare it with the simulation oscillations please ? p.12 l.27: can you add the reanalysis in Figure 7 please to facilitate the comparison ? p.12 l.30-31: you should add a figure showing this result. p.12 l.31-32: the fact that nudging improves cloud and LW but deteriorate temperature and LH suggest there is errors compensation in your simulation. This should be stated in the text.

p.13 l.1: what about the skin SST parameterization in ERAI ? p.13 l.6: "is sensitive" -> "is also sensitive" p.13 l.10: "sixteen" -> "five" ?! p.13 l.14: I think you have inverted "warm" and "cold" in this sentence. p.13 l.15: "daily-mean" -> "observed daily-mean"

p.14 l.8: "deepening" -> "deeper" p.14 l.18-19: You cannot conclude that just by looking at the surface total heat flux in Fig. 8. A surface heat budget is needed for that. p.14 l.22-23: a timeseries with observed and simulated precipitations would be more convincing than Fig. 8b.

p.15 l.5: "traced in" -> "traced back by" ? p.15 l.10: "10-15 June" -> "12-15 June" p.15 l.19: "SCM" -> "OSCM" p.15 l.24: "ocean" -> "deep ocean" p.15 l.30: "moist intrusion" -> "moist warm intrusion" p.15 l.32: "atmosphere only" -> "atmosphere-only" ? p.15 l.34 – p.16 l.1: can you explain why the cloud formation is different from the LES ? Is it because the subsidence is not represented in the model ? If yes, why not force the model with a negative vertical velocity ?

p.16 l.10: the liquid water path is integrated over the entire atmosphere height ? p.16 l.22-23: is there any observations for the surface albedo ? if yes, can you validate your model albedo ? or directly use the observed albedo in your simulations ? p.16 l.26: "all" -> "how" ?

p.17 l.2: "demonstrate" -> "describe" ? p.17 l.5-6: "highlight avenues" -> "suggest advices" ? p.17 l.8: "demonstrate" -> "present" ? p.17 l.12: "infrequent": not sure if this the correct word to describe low-frequency forcing or the problems related to inertial frequency forcing

C5

p.18 l.27: "like thank" -> "like to thank" p.18 l.26: you recommend pressure gradient forcing without testing it directly. It would be better to present it as a promising possibility that need to be tested.

* Figures comments:

Figure 1: please detail the acronyms such as "GWD", ...

Figure 2: "concentration" -> "concentration" "interal" -> "internal" please detail the acronyms such as "BC", "BF", ...

Figure 4: This schematic is confusing because LIM3 is a part of NEMO. Perhaps A big "NEMO" box with inside 2 small boxes such as "OPA" and "LIM3" would be easier to understand.

Table 2: a "Table 3" with oceanic RMSE would be interesting

Figure 6: - Should be moved before Tables 1-2 - A third panel showing data from ERAI and Papa mooring would greatly improve this figure. - Color bars are missing - The initial mooring data appears to be missing in the figure, how do you initialize the ocean model if so ? - Why did you chose this period if there are a lot of missing oceanic data ? - Why are mooring oceanic observations missing between the surface and -10m ? - BLH is computed from the AOSCM or ERAI ? Please clarify it. - MDL is computed from observations or the AOSCM ? Please clarify it. - (c) and (d) panels description are missing

Figure 6 l.3: "included in" -> "represented by" ?

Figure 7: - please add Q2m and precipitation timeseries - please add ERAI to check how ERAI compare with observations and the model (it will also clarify your discussion).

Figure 8: - please separate panels descriptions for (a) and (b) - legend is missing for grey squares - panel (b): wrong x axis: "fluxes" -> rain I would remove panel (b) and replace it by precipitation timeseries in Figure 6.

C6

Figure 9 l.1: add “temperature” to “Atmospheric RMSE error”

Figure 10 l.5: the red dots (cloud base) are not visible.

Figure 12: the empty blue circle is not described in the legend.

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