

Review of ‘Extending the Modular Earth Submodel System (MESSy v2.55) model hierarchy: The ECHAM/MESSy idealized (EMIL) model set-up’

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GMD manuscript number: gmd-2019-330. *Recommendation*: Major Revision

Reviewer Name: Penelope Maher

1 Summary of the Review

This manuscript describes the implementation of the Held–Suarez configuration, with the Polvani–Kuchner amendment for the stratosphere, within the ECHAM/MESSy modelling framework. From the model description, it seems the model has been implemented in a modular nature which is a credit to the modelling effort (this can be a development nightmare otherwise). The manuscript has a well described parameterisation equation set, and has tested the relevant parameter spaces for the tunable variables and compares their results with the literature. The new model set-up is then used, as a proof of concept, for looking at how CFCs impact the polar vortex and monsoon circulation. In these regards the manuscript is both novel and interesting. There were, however, a number of things that I was confused about and that need further clarification or description. I also feel there are a number of figures that could benefit from further work. This manuscript is well suited for publication in GDM, is written in a way consistent with the journal style and with further revision I believe it will be suitable for publication in GMD. In this review I have used the notation “PxLy” and this should be interpreted as page x and line y .

2 Major Comments

1. The introduction is well motivated in terms of the using idealised models in general (the philosophy of idealised models), however, I think more introductory material is needed for describing the need for adding chemistry into the hierarchy and what these styles of models are used for. For example, it may not be clear to readers if/why chemistry models are needed to investigate the polar vortex or monsoons.
2. I felt the abstract, introduction and conclusions did not sufficiently describe what is currently possible within the ECHAM vs MESSy models. I initially assumed this paper was the first to implement the Held-Suarez test case within ECHAM but realised my mistake on page 10 when the authors described the study of Wan et al 2008. I think what options are (or not) previously available needs to be said much earlier or more clearly. I understand the RELAX submodel is new (ie implementing the parameterisations of newtonian cooling and drag), but were changes to the dynamical core needed or where they already available (if it was available, is it the same/similar as Wan et al 2008)? I am confused by what is new and what was existing in ECHAM.

3 Minor Comments

1. The introduction would benefit from a plain language description of ECHAM vs ECHAM/Messy (ie what is the standard GCM, atmosphere only or ECM).
2. The manuscript would be easier to read to non-ECHAM specialists if there was a table of acronyms with a short description of each model and where it fits in with the other options.
3. From my perspective, sections 1 through to 4 are describing the implementation and the validation of the code. While in section 5, the model infrastructure is now well justified to use with the chemistry models. I think at the beginning of section 5 this should be more clearly communicated to let the reader that we have reached to point of advertising why a model like this is useful.

Figures often reflect personal styles and different perspectives. I have listed quite a few changes to the figures. These are separated into changes I would like to see made (below) and suggestions which I feel would help (these can be actioned at your discretion, see clarifications section).

Requesting the following changes be made to the figures/captions:

1. Fig 1: Are there four options on the y-axis or more? I found it hard to interpret this figure and I am not sure which set-up has which chemistry option. What does ‘/...’ in the 3D dynamical core mean?

2. Consistent colour bars are needed. Fig 2, 3, 10 use a yellow-to-red colour bar to describe T , uv and vT . Suggest Fig 3 has different colour bar for the fluxes. The blue-to-red colour bar is used for diffs in Fig 3, 7 but for T in Fig 4 and Φ in Fig 15-16. Suggest diffs for blue-to-red, T use yellow-to-red and another colour option for Φ etc.
3. Many subplots all have the colour bar repeated. Suggest only having one colour bar or legend per plot.
4. Fig 5 caption should explain P_{TW} and γ are from the legend and point to relevant equations.
5. Fig 13: The jet colour map is generally considered bad practice and I suggest a different colour. I found it hard to interpret the zonal mean zonal wind in white and it look me a while to identify what the breaks were a SSW (also is this surface wind or aloft?). On first reading I thought the top panel was u divided by w so the title was confusing for me. Are both u and w essential (could it be described instead as the inverse in general)?. I suggest exploring some other formats for this plot to help draw out the features.

4 Clarifying Comments

4.1 Figures

Suggestion the following changes be made (optional):

1. Fig 1: The y-axis title 'Chemistry' is floating in a way that it feel out of place (either remove or move). I am not sure what the purpose of the two dotted vertical lines are.
2. Fig 2: The title on the fig is not helpful (suggest removing it).
3. Fig 3: I find the left plots very hard to see. Suggest moving the left panel to a new plot and then keep the flux plots together. Alternatively you could consider only plotting 0-90 in one hemisphere given they are symmetric in this case. What does the 'MA' in the caption (and text) mean? The fonts are too small (also in other plots).
4. Fig 4 Suggest subplot titles are larger and also included in bottom panel.
5. Fig 5: Suggest you use the same seaborn colours as in Fig 8 (matching the values of γ in fig 8) – this assumes these are in python though I notice a mix a languages used to generate the plots which is fine.
6. Fig 6 (but in general): might want to consider skipping either red or green in your line plots so everyone can easy see it. I would prefer you use the same colour choices as in Fig 7.
7. Fig 7 (and text): add the equilibrium temp to the legend. What do you mean by 'plane' in titles (and text)?
8. Fig 11-12 bottom panels: suggest using colours not already used in the top panels and they are different so as not to confuse latitude, wind speed and temp differences.
9. Fig 14, if this image is a a pdf/png/jpg or similar, then I would suggest replacing the error bars with filled upper and lower intervals with lower alpha values (ie shading). If your using ps/eps this won't work.
10. Fig 14: the line width is not consistent (thinner is nicer) and I suggest removing titles. The choice of black gives this authority (as is commonly done for obs), was this intentional?

4.2 Abstract

1. P1L1: I think it would help to explain why you mean by 'a need emerges'. I know what you mean but it might help to explicitly say it.
2. P1L2: I would suggest a more general description instead of 'process understanding', perhaps 'simulations of the climate'

4.3 Introduction

1. P2L8-13: In terms of the Held-Suarez description, a reader could easily get confused about a models dynamical core vs the parameterisation set-up of HS. Suggest rewriting L8-13 to make it clearer that HS was designed as a test for the dynamical core.
2. P3L2: The sentence starting ‘The motivation of the MESSy framework was’ is an excellent sentence that helped ground me in the context of the configurations. Could I request you add this (word for word is fine) to the abstract (something similar is already in the abstract but not as clear) and something just as cleanly described for the EMIL.
3. L9: Could you include what MECCA stands for? Is MECCA the chemistry model of EMAC or it more subtle?

4.4 Model Description

1. What surface conditions are you using? Is it generally an aquaplanet with ‘water’ mountains or does it have a land like surface heat capacity?
2. Equ 2: Worth mentioning the extra term ($\epsilon \sin \phi$) that is not in the original HS formulation is from PK.
3. P6L12: suggest replacing $(40\kappa_a)^{-1}$ with $0.025\kappa_s^{-1}$ and $(4\kappa_s)^{-1}$ with $0.25\kappa_s^{-1}$
4. Equ 8: Why use σ_0 here and σ_b in equ 3?

4.5 Model test cases, sensitivity simulations and application examples

1. Fig 4: titles and caption have inconsistent window for the averages, were they 10 or 11 years?
2. P15L1: might help to define UTLS and what it’s acronym is.
3. P24L5: a key task of what?
4. P24: I think you should state early in section 5.2 that the monsoon simulations are run with the chemistry scheme. I think you should also say if this is usual, and if not, why is the chemistry scheme is helpful.
5. Sect 5.2: Is there temporal variability in these simulations? If it was said then I missed it.

4.6 Summary and Outlook

1. P25L7: Suggest removing ‘In the paper presented here,’ (it works better without it).
2. L2511: suggest replace ‘based on the suggestions by HS94 and PK02’ with ‘as described in HS94 and PK02’. I would then start a new sentence that described what is new in your implementation.
3. P25L25-27: I found the description of ‘climate states’ confusing. I also suggest rewriting this sentence (or even multiple sentences) as the grammar has gotten complicated.
4. Please add in the acknowledgements where the SPARC and Era-I data can be downloaded from.

5 Editorial comments

There were a number of times where latex has compiled with ” instead of “ (please review).

5.1 Title and abstract

I think the title is too technical. By their very nature GMD papers are technical but I think you could make your title easier to read/understand (and remove some of the acronyms where possible).

1. I found the number of acronyms hard to digest. Given the subject matter, I think ECHAM, MESSY and EMIL are probably fine to use but I would suggest removing RELAX and EMAC as they are not essential. I also think referring to the model as only EMIL or ECHAM/Messy idealied model would help readability. There is a lot of switching between model names which makes it hard to read at times for non-ECHAM experts.
2. I don’t think you need to citations in the abstract. I think it is fine to say Held-Suarez model.

5.2 Introduction

1. P1L1 ‘more and more processes and compartments’ is awkward, suggest changing to ‘increasing complexity’ or similar
2. P2L13 (or thereabouts) suggest stating that the HS model will be described in detail in section 2.
3. P2L32: The description ‘currently underway’ reads as though these models are yet to be released. Suggest rewording as both Isca and CESM are broadly used for idealised studies.
4. P3L3: suggest adding ‘0d’ before box model.
5. P3L22-27: I very much liked this paragraph. I would suggest moving it earlier in the introduction. Maybe even as the first paragraph.
6. P3L28: What do you mean by ‘consistent’?
7. P3L28: I like the description of model hierarchy of chemistry-dynamical coupling and I suggest you use this more often (esp in abstract).
8. P3L28-P4L2: Suggest moving this paragraph to outlook section.
9. P4L5: replace ‘to’ with ‘two’ and suggest separating into two sentences, one that talks about section 3 and one for section 4.
10. P3L6: Suggest joining the two paragraphs that describe what is coming up in the paper.

5.3 Model description

1. P5L12: Suggest adding convection to the list of parameterisations.
2. P5L13: suggest you mention Held-Suarez in this sentence.
3. P5L17-20: Suggest you add these as dot points rather than a list in a sentence.
4. P5L25: should cite HS in here.
5. P5L27 (and else ware): suggest replace ‘local’ with ‘environmental’.
6. P5L28: suggest adding this paragraph to the one before and list dot points for the ways of implementing κ and T_{equ}
7. P6L12: The discussion on h_{frac} should start with a description of ϵ .
8. P6L14: suggest replacing ‘sign’ with \pm
9. P8L15: suggest replacing ‘employed’ with ‘added’.
10. P8L18: suggest replacing ‘reads’ with ‘is given by’

5.4 Sensitivity simulations

1. P16: Fig 11-12 are referred to before 9-10. You might want to consider moving figs or mentioning 9-10 earlier.
2. P17L6 and Fig 9: Could you explain why there are multiple Lindgren lines on these plots (which variables are changed)?

5.5 Supplementary

The tables would benefit from latex hlines and vlines so they look more like tables. Suggest removing the quotations from all variables. I don’t think Fig1-2 are needed but I do not feel strongly about this. Fig 3 is a nice aid to see the call sequence (well done).