

29 March 2024

Thanks for your consideration of egusphere-2023-1477, "Hector V3.2.0: functionality and performance of a reduced-complexity climate model". We are grateful for the reviewers' making the time to review the manuscript revisions. Our responses below are in **bold**; line numbers refer to the final (clean) version of the revised manuscript.

We hope that the revised manuscript addresses all concerns, but of course welcome further feedback.

Thank you,
Kalyn Dorheim, for the authors

Referee 3

Thanks to the authors, who have worked hard in the revision. The detailed SI is very much appreciated, the calibration documentation is clearer and I'm particularly pleased to see that the default dynamical response of the model to low emission scenarios is now consistent with ESM scenarios. Nice work, and looking forward to seeing more from HECTOR in the future.

Thank you very much for taking the time to review the manuscript again. Your feedback greatly improved it!

Referee 4

The paper provides a comprehensive introduction of the Hector model and improvements/updates of the new version (V3.2.0).

The questions and comments:

(1) L550, Figure 1. The solid line of flux (4) representing one-way changes of "the aggregate CO₂ from respiration from the terrestrial biosphere and ocean carbon". It should be better to extend the horizontal line to connect the ocean too, i.e., denoting the respirations from both land and ocean.

Thank you for your suggestion, but we think it is better to leave arrows (4) and (6) separate from one another since they represent very different processes of respiration by the terrestrial biosphere (4) and outgassing from the oceans (6).

(2) L76, L185-186. There seems to be four temperature components, land (surface), air (troposphere) over land and over the ocean, and sea surface (mixed layer) in Hector. While in the complex CSM/ESM models, the temperatures are generally calculated in the component

models of atmosphere, land, and ocean, etc.. L261-262, Figure 4 (L563) lists three temperatures (air, land and sea surface). The latter two should represent the land surface (not land air) and sea surface temperature and can be compared directly between Hector and ESMs. How about the air temperature? In other words, how to calculate the (surface) air temperature in Hector, average of troposphere temperature over land and ocean?

We apologize for any confusion. Hector provides a global average air temperature (2 meters above the surface) that is directly comparable to the area-weighted global average of an ESM's 2 m temperature air results. Hector results also include global mean surface temperature which is the area-weighted average of sea surface temperature and land air temperature. The DOECLIM manuscript uses the term tropospheric temperature and air temperature 2 meters above the surface simultaneously.

We have clarified the language in our text, removing references to troposphere air temperature (which were only present because of terminology in the previous Kriegler et al. 2005 DOECLIM paper).

(3) L233, "et al., 2017) et al. (2017)", repeated text.

Corrected.

(4) L299, two "reproduces".

We have changed this wording to clarify the sentence's meaning.

(5) Supplement L3, SI Table1, too many "radiative forcing" in the description. It's better to omitting the two words or using abbreviation (like RF), and add more information of the GHGs (i.e., black carbon for BC).

Thank you for the suggestion. We have adopted the abbreviation of RF for radiative forcing, and added more descriptive names for non-halocarbon radiative forcers.

(6) L35, SI Table6, are the halocarbons in this table should be consistent with those in ST table 1? The CCl4 is not listed in table 1.

This has been corrected and now there are 26 halocarbons listed in both SI tables 1 and 6.

(7) L39, SI Table 7, the units "C/yr", missing unit in front of C? And the unit format should be unified through the manuscript, "/yr", or "yr⁻¹".

We have adopted the yr⁻¹ notation and use it consistently throughout both the SI and the main text.

(8) SI Table 10 and 11, the different ESM results have been used for Hector calculation and comparison. There might cause some inconsistent for result comparisons. Has the author compared the results using the same ESM results in Table 10 and 11?

We appreciate the point and thank the reviewer for raising it, but struggle to see how this is a problem. The fundamental test of the model's future performance is against the combined outputs of the ESMs listed in Table 11, regardless of the source of Hector's parameterization sources (which vary widely). Using the exact same set of models to parameterize the ocean temperature offsets might produce slightly different parameter values, and thus change Hector's tuning, but we're not making any claims about the ESMs' performance. The point of the manuscript—and of model evaluation more generally—is its output relative to observations (for the past) and CMIP (for the future). In summary, we do not believe that this is a problem and prefer to leave the tables as they are.