Review of “An evolving Coupled Model Intercomparison Project phase 7 (CMIP7) and Fast Track in support of future climate assessment” by Dunne et al [egusphere-2024-3874]

Summary

The authors motivate and describe the seventh iteration of CMIP, including the new Fast Track set of experiments which serves the IPCC. The paper is mostly effective in achieving these goals, but there are a few areas needing improvement. This review largely deals with issues relevant to the Cloud Feedback Model Intercomparison Project (CFMIP).

Mark Zelinka
Maria Rugenstein
Alejandro Bodas-Salcedo
Jennifer Kay
Paulo Ceppi
Mark Webb
on behalf of the CFMIP Scientific Steering Committee

Major Comments

- Section 2.1 describes the first of four guiding questions in CMIP7, dealing with pattern effects. A large part of the reason the scientific community is interested in pattern effects is because of the science conducted by members of the CFMIP community (Andrews et al. 2015; Zhou et al. 2016; Andrews and Webb 2017; Ceppi and Gregory 2017; Andrews et al. 2018, 2022), facilitated by CFMIP experiments like amip-piForcing (Andrews 2014; Webb et al. 2017), and illuminated by CFMIP diagnostics (including satellite cloud simulator diagnostics that reveal the diverse cloud responses to warming patterns). The “Why expect progress now?” section completely excludes a role for CFMIP while instead mentioning the roles that can be played by DAMIP and AerChemMIP. The focus here seems to be more on what causes warming patterns (a worthy goal), but the understanding of the climate response (including but not limited to clouds) to diverse warming patterns is essential to this problem and should not be neglected. Moreover, the surface temperature response pattern is likely to be at least partly affected by how clouds and their radiative effects feed back on warming patterns (Myers et al. 2017; Erfani and Burls 2019; Rugenstein et al. 2023; Espinosa and Zelinka 2024; Breul et al. 2025) and are involved in teleconnections that propagate surface temperature anomalies from high to low latitudes (Kang et al. 2023; Hsiao et al. 2022). We suggest better acknowledging CFMIP contributions to the current understanding of the pattern effect and explicitly calling out the role that CFMIP can play in making progress. We also note

that the first sentence of this paragraph is rather hard to parse and is formulated rather weakly (“xyz may all help” – it remains unclear with what and how).

- CFMIP requests that the abrupt CO2 experiments (4x, 2x, and 0.5x) be run out to a minimum of 300 years, and we strongly encourage modeling groups to run beyond that (which could be noted at L331). Note that CFMIP requested this minimum duration as part of the FastTrack consultation process, which was then adapted into the request for the abrupt CO2 experiments. (See the abrupt-4xCO2 request: https://airtable.com/embed/appVPW6XAZfbOZjYM/shrqq9I4NJThwOT9W/tblkc1lkKEtiYKcho/viw9PLlrOnfUMcvHw/recl01t59HM8jz8ax.) Table 1 currently lists the abrupt-4xCO2 run as extending for “150+ (300)”, though it is not clear what this nomenclature means exactly. We request that “150+” be replaced with “**300+**” to make it clear that 300 years is the desired minimum, and “(300)” be replaced with “**(1000)**”. The reasons for requesting that the abrupt CO2 runs be integrated for a minimum of 300 years with strong encouragement to extend beyond that are manifold:
    - **Better ECS quantification:** Rugenstein and Armour (2021) quantified with 10 equilibrated CMIP5 and CMIP6 models that 400 years are necessary to estimate the true equilibrium climate sensitivity within 5% error. The model spread in equilibration is large and CMIP6/7 models probably need longer to equilibrate due to the "hot model problem" (Hausfather et al. 2022), which partly consists of temperature- and time-dependent feedbacks. Kay et al (2024) estimated an equilibrium timescale of 200+ years for 2xCO2 and 500+ years for 0.5xCO2, noting important implications for paleo cold climate constraints (e.g., LGM) that can only be understood if the simulations are long enough.
    - **Understanding centennial coupled behavior:** Simulations of at least 300 years are necessary for estimating the pattern effect, ocean heat uptake and convection (Gjermundsen et al. 2021), AMOC recovery (Bonan et al. 2022), and Equatorial Pacific response timescales (Heede et al. 2020).
    - **Understanding and quantifying feedback temperature dependence:** This is not well understood, could lead to tipping points and is, after the pattern effect and cloud feedbacks, the biggest unknown in estimating ECS, understanding hot models, and high-risk futures (Bloch-Johnson et al. 2021). It is very hard to quantify because it is obscured by the pattern effect, but is aided by longer simulations.
    - **Practical considerations:** Running existing simulations for longer is typically easier than running new simulations. Thus, if computing time is available at modeling centers, it is strongly encouraged that pre-industrial control and abrupt CO2 runs be extended as long as possible. Anecdotally, many of the model centers contributing to LongRunMIP (Rugenstein et al. 2019) had independently run their simulations for longer than 150 years and had the data sitting around, suggesting that in many cases such long simulations are already being performed or are trivial to extend. Currently, ~52 groups are using the LongRunMIP simulations for studies on internal variability, global warming levels, feedback quantification, paleo climate, oceanography, and training for data-driven machine learning approaches.

Minor Comments

- L34: Should it be "...include **experiments to diagnose** historical…"?
- Introduction section: This section may be too long. The main audience of this paper is the science community that want to understand the rationale and details of the experimental design, not the history of CMIP iterations.
- L90: should be Zelinka et al 2020
- L125-127: Suggest being more specific and use "modeling community", rather than "research community" as a whole. The research community benefits as a whole, but it doesn't share the burden.
- L130" "... the present experimental design includes some components …" This point is hard to parse. The entire paragraph reads well though, but the role DECK plays in climate services might need more highlighting. The remainder of the paper is phrased mostly in terms of science questions and the role climate service plays in there remains somewhat unclear.
- L140: Would it be worth listing a few big questions which were answered mainly or only through past CMIP cycles?
- L265-266: something wrong with the phrasing here
- Table 1: It's unclear why the request is for a small ensemble for historical and a large ensemble for amip
- Section 3.1.2: It would be helpful to see a plot of how the new forcing datasets differ from those used in CMIP6 during the 1850-2014 period.
- L310/Fig.2: This schematic might benefit from a vertical time axis. The current version leaves a lot of room for interpretation. What are the small orange arrows? What is the connection between DECK and AR7 Fast Track?
- L355: "year 100 or later of piControl" – is the rationale for this given anywhere in the manuscript?
- L383: The historical and AMIP simulations end in 2021 according to Table 1.
- L498: CFMIP deals with cloud **and non-cloud** feedbacks (all radiative feedbacks)
- L501: Figure 3 excludes RFMIP from the "Characterization" box, yet it is highlighted in this Characterization section, which is confusing.
- L510-511: Very hard to parse this statement
- L516: "Forcing" should be "Feedback"
- L517: I believe you mean "CFMIP" rather than (or in addition to) "CMIP" here
- L541: Missing section number
- Table 3, amip-p4K: missing word here? "feedbacks observed"
- Table 3, amip-p4K: the number of years should be 44 (1979 - 2022)
- Table 3, amip-piForcing: the number of years should be 153 (1870 - 2022)
- L638: 4 should be 3
- Appendix 1 table: Suggest specifying **top of atmosphere** albedo when referencing rsdt and rsut
- L712-713: Might be some missing words here

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