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Idealized "super-eruption" perturbation experiments as a tool to assess climate models' behavior under strong external forcing

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Comprehensive assessments of climate responses under idealized external forcings have been proven in the past to be valuable to understand features and mechanisms simulated by numerical climate models and, consequently, to delimit the validity of model-based inferences about climate dynamics and variability, as well as to compare the performance of different climate models. In this contribution, we advocate for a more extensive use of idealized "super-eruption" experiments, i.e. climate simulations describing the effects of explosive volcanic eruptions of magnitude several times larger than the strongest historical eruptions, as a tool to better understand climate models' behavior under strong external forcing.

We present the results of a 100-times-Pinatubo "super-eruption" simulation ensemble performed with the COSMOS version of the Max Planck Institute-Earth System Model (MPI-ESM-COSMOS), focusing on the simulated inter-hemispheric sea-ice response to the induced volcanic perturbation. We show how such "super-eruption" ensemble allows gaining insights on the relative importance of the thermodynamical and dynamical components of the sea-ice response to imposed negative net radiative imbalances in MPI-ESM-COSMOS. We also show that this "super-eruption" ensemble highlights known limits and less understood features that concern both general and specific aspects of the ocean/atmosphere/sea-ice coupled dynamics simulated by MPI-ESM-COSMOS.

We therefore discuss how idealized "super-eruption" perturbation experiments might help to delimit the reliability of forced climate responses in more general contexts, hence favor advancements in our understanding of simulated climate dynamics as well as models' sensitivity to external forcing. We present the several advantages we foresee in a more extensive, multi-model employment of "super-eruption" simulations as analog of, e.g., sudden warming experiments, in particular concerning their potential to clarify the role of decadal internal dynamics related to external radiative perturbations.