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Earth System Dynamics
Discussions

Interactive comment on "Inter-hemispheric asymmetry in the sea-ice response to volcanic forcing simulated by MPI-ESM (COSMOS-Mill)" *by* D. Zanchettin et al.

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We thank Anonymous Reviewer #1 for his/her appreciation of our work and his/her constructive criticism. In this short response we would like to briefly reply to the two major concerns he/she expressed in the main comment published online in the discussion.

1. The Antarctic sea-ice response is no surprise.

We tend to disagree with the Reviewer's comment that the observed Arctic-Antarctic sea-ice dichotomy is robustly simulated by climate models, and that there is no mystery about Antarctic sea-ice response to volcanic forcing. For instance, Turner et al. (2013), who analyzed Antarctic sea-ice representation in an ensemble of CMIP5 sim-

ulations, conclude that processes responsible for the observed increase over the last 30 years are not simulated correctly. Moreover, in his recent comment published in Nature, John King concludes about Antarctic sea ice that "understanding its behavior and improving its representation in climate models must remain a high priority for climate scientists" (King, 2014). We agree that there is not only room but need for improving our understanding of simulated sea-ice behavior, and our study primarily stems from this need. In particular, there are few assessments of simulated responses of Antarctic sea ice to volcanic forcing. Our study is to our knowledge the first description of ensemble-simulated decadal climate responses to extremely large volcanic eruptions that focuses on inter-hemispheric asymmetry and sea ice. We found especially the Antarctic response interesting and its interpretation challenging, so much that fully disentangling the effects of dynamical and thermodynamical, as well as of local and global contributions would require dedicated additional sensitivity experiments. As we stressed out in the manuscript, we indeed regard idealized "supervolcano" experiments as reverse analogs of warming experiments. However, as we explained in the manuscript, they do not merely describe the opposite climatic effects of positive radiative imbalances, since volcanic forcing induces complex multi-scale dynamical and thermodynamical responses. If we are encouraged to submit a revised manuscript, we will extend the discussion about the present state of research concerning the Antarctic sea ice response to global warming.

2. The model should be evaluated.

MPI-ESM (COSMOS-Mill) (Jungclaus et al., 2010) is based on the well known and widely used ECHAM5/MPIOM coupled general circulation model (CGCM) developed at the Max Planck Institute for Meteorology in Hamburg (MPI-M), with implementation of an interactive carbon cycle. The ECHAM5/MPIOM CGCM participated to the CMIP3 exercise, and has been extensively evaluated in that context.

MPI-ESM (COSMOS-Mill) was developed as part of the internal project "Community Simulations of the last Millennium" at

MPI-M (http://www.mpimet.mpg.de/en/science/projects-new/projects-archive/millennium.html) and was further developed thereafter to allow performing idealized volcanic experiments (Timmreck et al., 2010). More details about the characteristics of MPI-ESM (COSMOS-Mill) can be found in the report by Budich et al. (2010).

Different aspects of the climate and its variability simulated by MPI-ESM (COSMOS-Mill) have been assessed in a number of studies in comparison to observations, proxy-based reconstructions as well as within a multi-model framework (e.g., Henriksson et al., 2012; Beitsch et al., 2013; Bothe et al., 2013; Fernández-Donado et al., 2013; Schubert et al., 2013; Zanchettin et al., 2013a,b). We will expand the description of the model and include a list of references regarding its evaluation if we are encouraged to submit a revised manuscript.

As a final note, the model's name adopted in this and other studies (e.g., Bothe et al., 2013) reflects the fact that the COSMOS community used it for the Millennium Experiment. The name also prevents confusion between the ECHAM5/MPIOM ESM and its successor: the ECHAM6/MPIOM-based MPI-ESM used in CMIP5. Giorgietta et al. (2013) and Jungclaus et al. (2013) describe the characteristics of the atmospheric and ocean components of the ECHAM6/MPIOM-based MPI-ESM.

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