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Climate of the Past Discussions

Interactive comment on "A volcanically triggered regime shift in the subpolar North Atlantic ocean as a possible origin of the Little Ice Age" *by* C. F. Schleussner and G. Feulner

Anonymous Referee #1

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General:

The manuscript addresses the question whether volcanic outbreaks could exert an influence on the northern North Atlantic Ocean circulation and hence climate using a model with intermediate complexity forced with different combinations in the evolution of external forcings. The length of the paper is quite short and therefore a lot of modelling studies analysing similar questions are not properly addressed. The experimental design is not explained in great detail and results seem to be very sensitive to the tuning of model parameters. I cannot suggest publication of the manuscript in the present form. The specific points are outlined below.

Specific comments:

Title: The title does not indicate that the manuscript deals with results based on a specific climate model simulation

Abstract:

First sentence of abstract is from a scientific point of view very unspecific.

Introduction:

Compared to the literature that is available and deals with the LIA the introduction is very short and does not set the stage for the paper. The reader should be informed about the general relevance of oceanic processes for the North Atlantic climate and the influence of the volcanic forcing.

Moreover, authors should motivate why the EMIC is an appropriate tool to address their specific question of interest, especially given the fact that there are readily simulations available with comprehensive AOGCMs including internal variability with data that are freely accessible [http://esgf-data.dkrz.de/esgf-web-fe]. In the current form I see no reason why this study should outperform AOGCM studies previously carried out. The present setup is just a replication of studies that have already been carried out. As such they should at least be addressed and the results of the EMIC, given the first-order-assessment of the generation of atmospheric forcing fields, should be critically assessed.

I would also expect a more detailed description and discussion of the basic influence of volcanic eruptions on climate, specifically in the North Atlantic realm. There is a broad band of literature from empirical and modelling studies describing the effect of volcanic outbreaks on climate including ocean circulation (cf. Zanchettin et al., 2012, Timmreck, 2012; Robock, 2000 and earlier studies of Stenchikov et al., 1998 and Kirchner et al. 1999 related to Pinatubo) Also articles addressing the sensitivity to wind and thermal forcing on the variability on the Atlantic meridional overturing, the Atlantic multidecadal oscillation and their potential impacts on ocean circulation should be mentioned (Hunt et al., 2012). This would then also allow to introduce potential internal climate variability as one factor inducing anomalous climatic periods.

This information is of vital importance for the reader to understand how volcanic eruptions directly and indirectly affect atmospheric and oceanic circulation. It is also of importance to put results of the study into perspective and into context of other studies and motivate the added value of the EMIC investigating volcanic effects on North Atlantic Ocean circulation.

Given the limitations in the use of EMICs in the context of the large sensitivity to freshwater changes, the goal of the study should be focussed on a more conceptual view of the climate system under idealized conditions. This would then also help to put the results critically in context of studies carried out with studies with more complex models.

Model description:

The author state the CLIMBER was used in several study but especially for the oceanic component but only little is done to justify the usage of the model to test their hypotheses. i.e. providing difference maps between modelled and observed SSTs, sea ice or salinity – surface ocean currents are also important fields for the characterization of oceanic processes in the model world – when the plots for observational periods are not provided at least a paragraph addressing these points or including the results of related studies should be mentioned.

Experiment setup:

p. 6203, ll. 14ff.: The authors should state due to construction the variability of the atmospheric circulation is restricted by the bandwidth of the NCEP/NCAR data for the 2nd half of the 20th century. I still do not understand why the authors do not use wind fields of available studies carried out with comprehensive GCM studies – most of these

studies are freely accessible in the context of the PMIP3 simulations and would circumvent most problems related to the bandwidth of potential NAO states and also implicitly include internal climate variability. Moreover the influence of the atmospheric circulation was also previously studied for present day climate with more complex models – some of these studies could for instance be mentioned in this chapter.

p. 6204, l.25: Why do the authors – while using volcanic forcing for the spin down – not use the Crowley 2012 data set from 850 AD onward ? Also the reader needs a lot of information of the Mengel et al. 2012 study to understand the exact experimental setup. In this context it would be important to summarize the most important settings with respect to the hypotheses the authors would like to address with their study. For instance I do not understand what 'repeated NCEP wind field variability' means. I guess the authors perform a perpetual forcing with the NCEP data with selected years or the whole 60 yr time series. Another point is that volcanoes also influence atmospheric circulation. As the wind forcing and the volcanic forcing are independent from one another this could, especially in the North Atlantic region also have effects (cf. midwinter warming after large tropical eruptions) and could partly offset the direct cooling effect of large tropical eruptions.

Results:

p. 6205, ll. 11.: In my opinion this statement is not a proof of concept but rather a disproof of concept as already slight changes could lead to pronounced changes and hence I assume that the following model results are very sensitive to the tuning of specific model parameters – authors should state in greater detail the implications of this sensitivity. The clustering of volcanic outbreaks is also evident prior to the onset of the LIA, including even more pronounced eruptions for instance around 1259 and the subsequent decades. Why does ocean circulation not already respond in these earlier times ?

p. 6206, ll. 7 ff: The authors only use one possible reconstruction of the TSI – how would other scalings of the TSI potentially affect the evolution of the SPG, i.e. how sensitive does the model react on different scalings ?

p. 6206, l. 10: How is the volcanic forcing included in the atmospheric response – as much as I could understand the atmospheric forcing is based on a stochastic reconstruction based on NCEP data

Discussion:

p. 6207, l 8 ff: In the context of changes in AMOC authors cite a study suggesting that the increase in sea ice reduces ocean convection – more important here would be how the mechanism in CLIMBER works and the authors should be careful in mixing results between different hierarchies in climate models because the controlling processes and time scales might be different.

p. 6208, l. 5 ff. The fact that the EMIC model results are agree and/or disagree with other modelling results should be viewed in terms of physical considerations. This way it can be interpreted as a coincidence that results are consistent or inconsistent.

Figures:

The figures are very small and can hardly be seen.

Figure 1: Please separate forcings from model results.

Suggested additional References:

Hunt, B.G. (2006): The Medieval Warm Period, the Little Ice Age and simulated climatic variability. Climate Dynamics, 27, 677-694, DOI: 10.1007/s00382-006-0153-5.

Goosse, H., Renssen, H., Timmermann, A., and R.S. Bradley (2005): Internal and forced climate variability during the last millennium: a model-data comparison using ensemble simulations Quaternary Science Reviews, 24, 1345-1360, DOI: 10.1016/j.quascirev.2004.12.009.

Gouirand, I., Moberg, A. and E. Zorita (2007): Climate variability in Scandinavia for the past millennium simulated by an atmosphere-ocean general circulation model. Tellus, 59, 30-49, DOI: 10.1111/j.1600-0870.2006.00207.x .

Kirchner, I., Stenchikov, G.L., Graf, H.-F., Robock A., and J. C. Antuña (1999): Climate model simulation of winter warming and summer cooling following the 1991 Mount Pinatubo volcanic eruption. Journal of Geophysical Research, 104, 19,039-19,055.

Robock, A. (2000): Volcanic eruptions and climate. Reviews in Geophysics, 38, 191-219.

Sedlacek, J. and L.A. Mysak (2009): Sensitivity of sea ice to wind-stress and radiative forcing since 1500: a model study of the Little Ice Age and beyond. Climate Dynamics, 32, 817-831 DOI: 10.1007/s00382-008-0406-6.

Stenchikov, G.L., Kirchner, I., Robock, A., Graf, H.-F., Antuña, J.C., Grainger, R.G., Lambert, A. and L. Thomason (1998): Radiative forcing from the 1991 Mount Pinatubo volcanic eruption. Journal of Geophyical Research, 103, 13,837-13,857.

Timmreck, C. (2012) Modeling the climatic effects of volcanic eruptions. Climate Change, 3, 545-564, doi: 10.1002/wcc.192.

Zanchettin, D., Timmreck, C., Graf, H.-F., Rubino A., Lorenz, S.J., Lohmann, K., Krüger K., and J. H. Jungclaus (2012): Bi-decadal variability excited in the coupled ocean-atmosphere system by strong tropical volcanic eruptions. Climate Dynamics, 39, 419-444, DOI: 10.1007/s00382-011-1167-1.

Interactive comment on Clim. Past Discuss., 8, 6199, 2012.