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Earth System Dynamics
Discussions

Interactive comment on "Assessing the Impact of a Future Volcanic Eruption on Decadal Predictions" *by* Sebastian Illing et al.

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We thank the reviewer for the constructive comments and useful suggestions. Below we answer the different comments of the reviewer. We present all reviewer comments and our answers are given in blue.

General Comments:

This manuscript describes a set of decadal prediction experiments initialized with different phases of the NAO PDO where the effects of a volcanic eruption of the magnitude of Mt. Pinatubo are examined. The authors find expected responses in the temperature and precipitation fields in the global average, but find that the different initial states

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produce regional responses that are different. This is a nice result that has implications for how decadal predictions should be performed when a volcanic eruption happens.

The manuscript can be improved in terms of clarity and improvements in figures.

The paper is more or less complete in terms of analysis except for one issue that they could have explored a little more. This pertains to the 2014-Pinatubo experiment where the years 1-4 precipitation response (Figure 9) indicates a pattern that is very similar to an El Niño response. While this hints at a possible volcano triggered El Niño, they make no mention of it but discuss this possibility in the conclusions purely in other published references. It would be interesting to see if indeed the 2014-Pinatubo runs show that an ENSO event was triggered – while the 2012-Pinatubo doesn't.

We will address these points in the specific comments below.

Detailed comments:

1. Abstract. Line 12: A little more descriptive wording than just "the MiKlip prediction system" would be useful here.

We added a short explanation. A more detailed explanation of the MiKlip prediction system can be found in section 2.1.

2. Page 2, Line 1: Suggest changing "more attention is paid to the research field of decadal climate. . ." to "more attention is paid to decadal climate. . ."

We have accepted the proposed change.

3. Page 2, Line 18: The wording in "impact on atmospheric composition, atmosphere, ocean dynamics" does not make clear what other than composition is altered in the atmosphere.

You are right. There should be an AND instead of the comma. We changed it to: "SVEs also have an impact on atmospheric composition, atmosphere **and** ocean dynamics and on the hydrological cycle"

4. Page 2, Line 24: Not clear what a “positive impact on the North Atlantic Oscillation” means. The following sentence does not state it any better when one reads “. . .the positive NAO response could be better interpreted in terms of a deficit of negative NAO circulations”.

We changed the first sentence to make it more clear and removed the second one:
“There is some evidence **from observations and reconstructions that SVEs lead to a positive phase of the Northern Atlantic Oscillation (NAO)** in the first few winters following the eruption (e.g. Ortega et al., 2015; Swingedouw et al., 2017), but recent model studies suggest that this signal might not be that robust (Bittner et al., 2016; Ménégoz et al., in press).”

5. Page 3, Line 9: The use of “nowadays” sounds strange. Suggest rewording.

We reworded “nowadays” to “these days”
“. . ., the question arises what would happen if a large volcanic eruption occurs these days. . .”

6. Page 3, Lines 9-10: The sentence “. . .how dependent are the results from the start year and respectively the initial climate state?” implies that initial climate state and start year are delinked.

You are right. We rephrased the sentence.
“What would happen if a large volcanic eruption occurs these days and how dependent are the results on the start year and the associated initial climate state?”

7. Page 4, Line 3: The phrase “Pinatubo forecasts” should be changed or an uninformed reader may take it as a forecast of the eruption itself.

To avoid misunderstandings we rephrased the sentence.
“We perform our forecasts containing a Pinatubo-like eruption with the . . .”

8. Page 4, Line 11: “For decadal forecasting, a stand-by model system for rapid modelbased assessment. . .” Why the use of “stand-by”? Do you mean “operational”?

We agree, “operational” is the better wording.

9. Page 4, Lines 24-25: Suggest changing “. . .of the historical time period (1850 till today)” to “. . .since 1850”.

We changed it as you suggested.

10. Page 4, Line 32: “. . .using a lagged-day method” can be explained better in words or needs a reference.

The so called lagged-day method is a method to generate an ensemble. To create a spread in the ensemble the initialization date of each individual ensemble member is shifted by one day.
In order to make that clearer we rephrased the sentence:
“For our experiment, we perform two decadal forecasts for ten years with ten ensemble members each. For ensemble generation we use the lagged-day initialization method, which means that the individual ensemble member is started on different start days around the 31st December to spread the ensemble.”

11. Page 5, Line 1: Why "around"? Shouldn’t it be "on"? How many days before and after Dec 31 are the other forecasts?

See above comment.

12. Page 5, Line 11: What does “both variables” refer to?

“Both variables” refers to the previous mentioned indices NAO and PDO. To make that clearer we rephrased it a bit.
“The different phases of the NAO and PDO at initialization time enables us to investigate. . .”

13. Page 5, Line 12: What is a “a ‘nowadays’ setup”?

With nowadays setup we meant that we start the model with present day greenhouse gas conditions. We changed “nowadays set up” to “present day set up”

14. Page 6, Lines 5, 6: The word “significant” here (at least in the first instance) needs to be changed to “statistically significant at x

We changed it as you suggested.

15. Page 6, Line 29: Does the phrase “in less warm air being advected. . .” mean less advection or the air is less warm?

It means “less advection”. To make that more clear we changed the sentence as follows:
“The negative PDO phase results **in a reduced advection, which means less** warm air being advected from the North Pacific into this region, . . .”

16. Page 7, Line 27: Suggest using “On the other hand” instead of “On the contrary”.

Changed.

17. Page 8, Line 5: Not sure the difference between what and what stays nearly constant?

We talk about the difference between the Pinatubo and Baseline experiment. For instance, in Fig. 6b and c we find increased values of sea ice in the Pinatubo experiments and the difference between the two stays nearly constant for the whole simulation time. We changed the sentence as follows:
“That is, if there are increased values of SIC in one experiment (Fig. 6b, c, f), the difference of SIC values between the Pinatubo and the Baseline1 simulations stays nearly constant for all prediction years.“

18. Page 8, Line 24: Not clear what variable/difference “. . .stays significant for all lead-times.”

We added the missing information to the sentence.
“The **effect of reduced global mean precipitation due to the Pinatubo-like eruption** decreases with prediction time, but stays significant for all lead-times.”

19. Page 8, Line 31: Suggest rewording “Similar behavior has been found in CMIP5 model simulations, but it turned out that the precipitation. . .“ to “Similar behavior has been found in CMIP5 model simulations, although they underestimate the precipitation. . .”.

We accepted your suggestion and changed the sentence as follows.
“Similar behavior has been found in CMIP5 model simulations, **although they underestimated the precipitation changes** compared to observational data (Iles et al., 2013; Iles and Hegerl, 2014; Paik and Min, 2017).”

20. Page 9, Lines 9-10: “The drying effect is strongest over the tropics, particularly in Southeast Asia, and is even more pronounced in exp-2014. In general, exp-2014 shows a stronger drying response in the tropical region.” I am not sure it is a drying all across the tropics. I see the pattern in exp-2014 as an eastward shift of precipitation - a possible signature of El Niño. The interpretation of Fig. 9 presented needs to a relook and the authors can examine whether indeed this is an ENSO event in the model simulations.

Thanks for your comment. We included additional ENSO indices (Nino4 and ESPI, Fig. 10, attached) to the manuscript. Indeed, we find that the Pinatubo-2014 shows a tendency to El Nino conditions in the second prediction year. We therefore added discussion about ENSO to section “3.4 Precipitation”. It now reads as follows:

“In the global precipitation maps, we see a decrease of precipitation for both experiments through the volcanic aerosol in large parts, especially over land, in the first four prediction years (Fig. 9). The drying effect is strongest over the tropics, particularly in Southeast Asia, and is even more pronounced in exp-2014. In fact, the tropical precipitation pattern in Southeast Asia and the East Pacific in exp-2014 is very similar to an El Nino response. Recent model studies (Maher et al., 2015; Pausata et al., 2015; Khodri et al., 2017) revealed that volcanic eruptions have a significant impact on ENSO and there is some ongoing debate whether tropical volcanic eruption can trigger an El

Nino event (Meehl et al., 2015; Predybaylo et al., 2017; Swingedouw et al., 2017). To further investigate this, we calculated the temperature based Nino4 index (Trenberth and Stepaniak, 2001) and the ENSO precipitation index (ESPI, Curtis and Adler, 2000) for both experiments for the first four prediction years (Fig. 10) as twelve month running means to reduce variance. The ensemble initialized in 2014 with a Pinatubo-like eruption shows a tendency towards El Nino conditions, whereas the baseline1 ensemble favors a weak La Nina condition (Fig. 10 b, d). The difference between the two experiments in the ESPI is significant until simulation months 18-30 when both indices come back to neutral conditions. In exp-2012 there is no difference evident in the first three prediction years, but in year four the baseline1 ensemble starts simulating a La Nina phase (Fig. 10 a, c) with a significant difference to the Pinatubo-like experiment. In general, exp-2014 shows a stronger drying response in the tropical region. In contrast, in this experiment, wetter conditions over Western Europe can be found which does not occur in exp-2012 (Fig. 9)."

21. Page 10, Line 8: The phrase "...are in both experiments in a similar state..." may be reworded as "are in a similar state in both experiments".

Changed.

22. Page 10, Lines 31-32: "Therefore our simulations in this study should be extended with experiments starting with other initial conditions like the recent El Nino year 2015/2016." In your simulations, the ENSO response like pattern is seen for 2014-Pinatubo runs. The initial conditions for both runs were similar in terms of ENSO state - yet one of them produces what looks like an ENSO-like pattern. It should be relatively easy to check (and at least comment on) whether it triggered an El Nino. Initializing with ENSO conditions is not answering the question whether volcanoes might trigger ENSO events.

You are right. As mentioned above we included ENSO indices I section 3.4 and included discussion about volcanic triggered ENSO events.

Therefore, we rephrased the sentence in the conclusions:
"We only investigated the volcanic response to different initial conditions of the NAO and PDO. Therefore, our simulations in this study should be extended with experiments starting with other initial conditions like the recent El Nino year 2015/2016."

23. Page 24, Figure 7 caption: What does "two other" refer to?

There was a "the" missing. "The two" refers to the figures on the left and in the middle. "Differences of ensemble mean forecasts of frost days (FD) for prediction years 1-4. Left shows exp-2012 (Pinatubo-2012 - b1-2012), middle shows exp-2014 (Pinatubo-2014 - b1-2014), and right the difference **between the two** (exp-2012 - exp-2014)."

Technical Comments:

24. Page 19, Fig 2 caption: The coordinates "North Atlantic (60W, 0E, 50N, 65N)" is better written as "North Atlantic (60W-0E, 50N-65N)". Similarly for other regions.

Changed.

25. Figures 3,5, 7, 9 all have maps shown with no latitude/longitude markings or labels.

Yes, we left them out on purpose. As we show coast lines and in most cases maps of the whole globe, we think adding latitude/longitude labels would redundant information.

26. Figure 4: Vertical axes in hPa units would be better. Latitude axis can be shown with ticks/labels so effects in polar/tropical regions are better seen.

We changed the unit and added more x-ticks.

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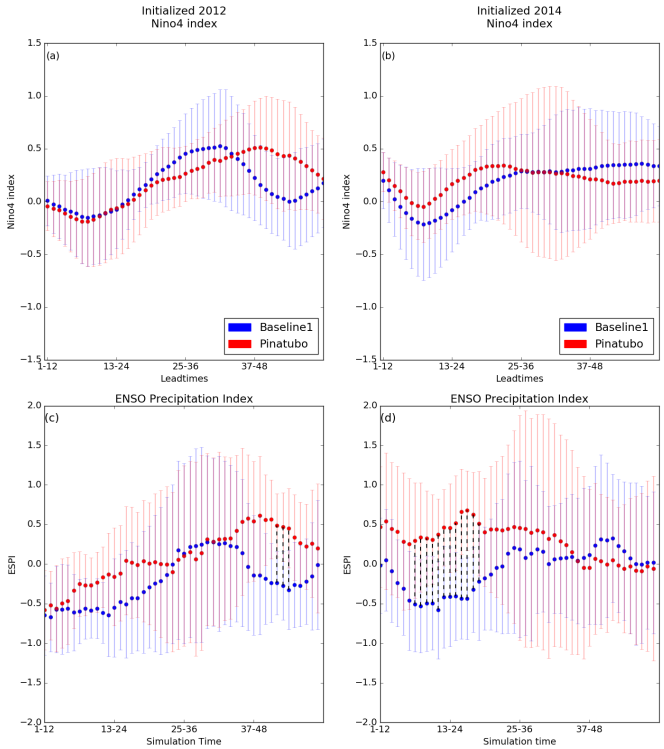

Figure 10: Top row shows the Nino4 index and bottom row shows the ENSO Precipitation Index (ESPI) for the first four prediction years calculated as a 12 month running mean to reduce variance. Left (right) column shows the 2012 (2014) initialized experiments. Error bars show the standard deviation of the ensemble and vertical black lines indicate a significant difference.

Fig. 1.

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