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Climate of the Past Discussions

Interactive comment on "Sulphur-rich volcanic eruptions triggered extreme hydrological events in Europe since AD 1850" *by* Cristina Di Salvo and Gianluca Sottili

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Anonymous Referee #1 This paper presents an analysis of the relationship between years with elevated volcanic sulphate deposition in a Greenland ice core (GISP2), and riverflow or rain gauge data from four climate zones across Europe. The analysis is detailed, and suggests that there is evidence for a link between the volcanic forcing and the hydrological response in datasets since 1850 CE.

The major weakness of the paper is that the analysis deals almost entirely with derived datasets; and makes no attempt to show the reader the time-series of the data. There is also a lack of clarity about the precise nature of the primary datasets that are used - making it difficult for the reader to compare and contrast results across different studies

(e.g. what happened in 1913? or 1982?). It is essential that, in revision, the authors at least provide full citations and links to all of the datasets used in the analysis; and provide a fuller explanation of how they chose the datasets that are used in this analysis, and of the limitations (time, space, resolution) of each dataset.

Specific comments:

Comment by referee#1; Line 17 'since the second half..'- actually your records don't start until the 1877? The analysis stops at 1985.

Answer to comment: we agree and we will correct the title considering 1877 as starting year for our elaboration, instead of 1850.

Comment by referee#1; Line 32 how can there be 'large disagreement among models' but yet be 'widely accepted' that global precipitation decreases? More careful and critical analysis of the published literature is needed here: what do the empirical observational data suggest? What do different models suggest? See for example the recent paper by Liu et al 'Global monsoon precipitation responses..' Scientific Reports, | 6:24331 | DOI: 10.1038/srep24331

Answer to comment: Indeed, on the basis of the cited literature, we confirm that it is widely accepted that, on a global scale, annual precipitations decrease from one to two years after large explosive volcanic eruptions. However, on a regional scale, it is also accepted that there can be complex precipitations variations, as, for example, in monsoon regions (Wegmann et al., 2014; Liu et al., 2016); for this reason , we propose a rainfall intensity analysis on a local (i.e., individual basins) scale. However, in the revised version of the manuscript "large disagreement among models"could be deleted in order to better explain the above mentioned role of local trends on masking and/or filtering general, global scale patterns.

Comment by referee#1; Line 67 – explain why you chose to use the GISP2 record, and give the proper citation to the timeseries that you analyse in this paper (it isn't

Meese et al., 1997, which presents an age model). Why not present this record for completeness; this would help the reader understand the nature of the analysis? Is it actually annual (rather than biannual?). How does the age/identification of volcanic events compare to those in Siglet al (2015, Nature doi:10.1038/nature14565)? How are the sulphate concentrations you quote determined? (is it the sulphate deposition record, or an atmospheric aerosol record; how did the authors determine the volcanic contribution to the sulphate?) Why would you treat Icelandic (local) and non-local eruptions in the same way in your analysis? Does the time range of your analysis stop at 1985? why not extend this to include the last 30 years of analysis (and another VEI 6 eruption)?

Answer to comment: As also mentioned by the referee#1, the correct primary data source for GISP2 is: "Greenland Ice Sheet Project 2 Science Management Office (1993), GISP2 core data book, 114 pp., Univ. of N. H., Durham". For sake of clarity, we will add this reference when presenting the GISP dataset. We will also explain that GISP2 record provides a continuously dated record of annual SO2 accumulation (Meese et al., 1994), in which the depth-age scale was obtained with the use of specific, independent techniques to count annual layers in the core. In our analysis we consider the concentration of volcanic SO2 over the Norh Atlantic region, as derived from the GISP record, irrespectively of the SO2 source areas. In fact, in our analysis, the effects of SO2 on the European hydrological cycle are not related to the total amount of SO2 released by individual volcanic events nor to the intensity of volcanic eruptions; indeed, in our model, the effects of SO2 are strictly related to the concentration of SO2 in the North Atlantic region. Concerning the analysed time range, we confirm that our analysis stops at 1985, i.e. the temporal window reported in the GISP2 project.

Comment by referee#1; Line 85-86 what exactly does your method do? What is the fixed threshold, and how did you identify it?

Answer to comment: Since the intensity of SO2 peaks is neither related to the intensity

of volcanic eruptions nor their geographical locations, we based our analysis on SO2 concentration values. Specifically, the effects of annual SO2 concentrations on rainfall intensities (i.e., twenty-five (ERE25) and ten (ERE10) most intense precipitation episodes) was evaluated by considering two classes of SO2 concentrations, i.e., years with no detectable SO2 and years with SO2$\geq$20 ppb. We remark that the number of years with SO2$\geq$20 ppb represents at least the 10% of individual rain gauge records. We propose that, in the revised version of the table 2, we could add the number of years with SO2$\geq$20 ppb for each rain gauge record.

Comment by referee#1; Line 237 '12 events..' please specify. Are these all large explosive eruptions? Is there any dependence on hemisphere/latitude of the source eruption?

Answer to comment: Again, we remark that the intensity of SO2 peaks is not related to the intensity of volcanic eruptions nor their geographical locations; in the revised version of the manuscript, we could report more details on the eruptive styles associated to the most intense SO2 peaks.

Comment by referee#1; Figure 1 – caption has the wrong citation?

Answer to comment: We will correct the caption with the correct citations as follow: "Figure 1: Location of hydrometric and rainfall gauges considered in the present study; the six European climate zones based on information provided by EUCA15000 (Schneider et al., 2013) and the position of Greenland Ice Sheet Project 2 (GISP2) are also shown."

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