Review HESS-egusphere-2025-3073

Climatology and trends of observed daily and hourly extreme precipitation in the French Alps

Authors: Sebastian Berghald, Juliette Blanchet, Antoine Blanc, and David Penot

Recommendation: major revision

The study of Berghald et al. describes the development of extreme precipitation in the French Alps since 1970 based on an analysis of daily and hourly station data using extreme value statistics. A better understanding of changes in extreme precipitation worldwide is of general interest, yet current knowledge is insufficient. Therefore, this study is well suited for HESS. The study follows a well-described methodological approach and describes changes for the study area. However, I see some necessary improvements to be done before the paper can be accepted.

Major comments:

One main problem is that the analyses are not very in-depth, which gives the impression of a technical report. This is evident from the figures presented, the analyses performed and the conclusions drawn. The paper frequently points out that the results of this study are confirmed by other studies. While it is important to demonstrate agreement/disagreement, this cannot be the ultimate goal; rather, the current work must achieve new results. This should be made much clearer in the text which results go beyond those of other studies. While the authors correctly state that their study is the first on trends in extreme hourly precipitation for Alpine region, at the same time they miss to include some relevant recent papers on extreme hourly precipitation (in particular Zeder and Fischer, 2020 and Zeder and Fischer, 2024, see the list at the end of the paper) which are relevant for the study region as well.

A useful extension to the work presented could be to visualize the station time series used in the analyses (e.g. the 67 series used in the trend analysis). I fully understand the authors' motivation not to interpret individual time series, due to the risk of misinterpretation. However, visualizing the time series would give readers a better understanding of changes over time, as well as providing an impression of the length of the time series and the data gaps.

Another question concerns the homogeneity of the time series used. Extreme values are particularly prone to inhomogeneity. While there are currently no usable methods for homogenising hourly values, but homogenisation methods are already available for daily values (see e.g. Mestre et al., 2013). These methods are not without their weakness, but at least they indicate breaks that are/are not present in the series, an important information that should be possible to obtain using existing break detection methods. Even if no homogenisation has been carried out, this should be mentioned and with an explanation as to why this was not done.

I also see potential risk of a bias being introduced by the neighbourhood approach used, as stations at the margins of the study area have fewer or no neighbours within the specified search radius. Consequently, stations in the center of the study area are therefore used much more frequently for adjusting the frequency distribution parameters.

For regionalization of subregions (North and South of Alpine main divide) the border defined in the HISTALP data set is used (which is on a much larger region). It should be discussed in the paper if such divide is really the best choice in order to show +- robust subregions with similar extreme precipitation climatology. The main divide of the Alps must not be the relevant border for precipitation extremes.

As indicated above, another shortcoming of the work is that some of the figures presented (figures 5 to 12, which are the key figures of the study) are of low quality, both in terms of content and layout (differentiation of the values shown). Probably, some of the trend/climatology figures (maps) for individual month could be moved to the appendix and only the relevant one for interpretation could be kept in the main paper and increased in size and cartographic quality (figures 5, 8,, 9, 10, 12). Figure 11 serve as the basis for relevant interpretation and discussion in the paper but miss the information on significance of shown trends. This information could be added by bars showing the number of significant/non-significant series per box-plot. Generally, all figures have rather sparse description which should be extended to full information available in order to make understanding easy for the reader.

Minor comments:

Language: could be improved (e.g. repeating “However” etc. should be avoided), though the paper is generally very well to understand.

Title: I suggest to use a more informative title (which also would avoid the impression of technical report)

Abstract: Add some information to make the presented results of statistics data comprehensible. Otherwise the pure statistical results give impression of randomness. There is the result/indication of thermodynamic vs. weather pattern driven changes in the precipitation extremes, which could clearly go into the abstract as well. Distill your results carefully.

Introduction: (tried not to repeat comments from other reviewers)

75: ~~*Unfortunately,*~~ *there is no consensual definition of what characterises an ’extreme’.*

79: *More precisely, we here define extremes as 20-year return levels.* Can the authors give a motivation for exactly using this definition of extreme precipitation?

85/90: l*arge-scale circulation* better to write: “weather patterns” or “synoptic patterns”

90-92: …. l*arge-scale circulation patterns while short-duration high-intensity rainfall seems to be much closer correlated to air temperature through increased moisture holding capacity and increased energy available for convection (see also Giorgi et al., 2016).* clarify by writing … much closer correlated to air temperature through dependency of moisture holding capacity and energy available for convection on air temperature.

93-95: … *Barbero et al. (2017) found overall lower significance and temperature sensitivity of annual/seasonal maximum precipitation of hourly compared to daily precipitation over the contiguous United States,*…. Improve (significance of what?, what is mean with “contiguous US”)

99-100: *Only now are observational time series becoming long enough to attempt an analysis of extreme precipitation trends on an hourly timescale* … this is bit misleading (if thought as general statement and not only for France) as the main challenge hasn't been series length but the data to be digitized. There are many data on precipitation at time scale of e.g. 10 minutes in data archives of weather services which are still not digitized going back to 1950 and earlier.

104 and throughout the ms: do not mix up rainfall and precipitation

113-115: not really correct the study "*get an overview over the weather patterns behind high-intensity precipitation in the region. "* This would need much more meteorological information.

139-140: T*he Northern Alps, under Atlantic influence, are among the rainiest regions in France with a mean precipitation of 1172 mm/year* …. Would be good to describe the rainiest region with highest values within the region (1172mm is not that much compared to other regions in the Alps where values above 3500mm/year have been measured).

147: can you specify the "East Return" e.g. by reference.

161: What means "large-scale automatisation"?
161-162: "continuous precipitation observation": they are not continuous but has some sampling interval (e.g. 10 minutes), which would be interesting to know, e.g. how are hourly precipitation values derived from precipitation values of highest temporal resolution? (for both Meteo-France and EDF).

171: observations are not continuous for snow, runoff and precip (have some time resolution)

Numbers of stations in section 2 of the paper are bit confusing. Would be very useful to get information on how precipitation were measured from the begin of the temporally high resolution measurements until today. Are always values of hourly and daily precipitation from the same sensors? (in some countries this could be different)

Data: Section: Please pProvide a table showing the data used in the study providing/summarizing some meta-information (e.g. length, missing data, relocations if known, ...) and help the reader to distinguish the different data sets used in the analyses part.

215: Do not mix up "weather pattern" and "circulation pattern"

216: Do not use "circulation mode over the Alps", e.g. use "flow condition/pattern over the Alps" or "weather patterns over the Alps" (dependent on what should be explained)

223: make your grouping of WPs visible in Fig. 2 from the colors used for the time series (similar colors for same group)

242: I guess it is meant that "The quantiles of the distribution can now be obtained by **transforming** Eq. 1 or 2"

3.1.2 Non stationary GEV using a breakpoint in 1985: this is bit weak, as series could have other breakpoints as well and this was not tested in any way. So would be good to give more motivation for the selection of 1985.

302: *We then turn to the trends in extreme intensities.* Be more precise by saying “trends in 20-years return levels”.

Throughout the paper (and particular chapter 4) authors should be precise and clear describing the synoptic drivers from weather patterns. They shouldn’t use the terms Atlantic and Mediterranean circulation, which are misleading (see also my previous comment). Use the terms from the Garavaglia (which are not very well suited as well, in my opinion, but at least published). For the paper air flow against the Alps is the key interest from the weather patterns, so focus should be given to this.

320: “Mediterranean dominance” replace by something like “Mediterranean impact”

322: Why is anticyclonic influence associated with convective events (which should be more related to gradient weak weather patterns)? In fact this goes already into the discussion part.

334: incomplete sentence

335-336: not clear what is meant

343: … *not exact the same regions* … be more specific (it probably means that there are less stations per region included?)

387: again here, authors should be more precise in the discussion. If there results are confirmed by previous studies the question arises, what is new in the presented paper. In fact they could show confirmation of their results for the daily precipitation extremes with previous studies, but not for the hourly values (as this is new, as stated in the introduction).

For the discussion in 5.2 and 5.3 it would be useful to take into account which month of the year (in which region) are particularly relevant from stakeholder’s perspective, as known to have precipitation events resulting in flood events. This could maybe show that those months with significant trends are also those known as risky from the stakeholder’s perspective.

395-399: speculating on using temperature as estimator for parameter distribution leads to question why not giving it a try or at least showing the temperature evolution for the study region to get some feeling if it could work.

440: give more details on findings from Fulutome et al. (2015) here, if this could be useful for your results.

447-448: *Overall, the southern part in the study region experience much stronger trends* …. how does this fit to Figure 11 for hourly data?

450: what is meant with “l*arge scale circulations patterns*”?

454: *We thus partly attribute this* …. make clear that this is speculation, as you have no prove for really attributing it.

459: ...*is never much lower than zero* .. I guess it should read is close to zero

468: .. *with an increase with increasing temperature* …. rephrase

474: Make clear that Georgi et al (2016) is result from model simulation and explain in more details, otherwise is hard to understand for the reader.

477-479: again here (and mentioned earlier), would important to know the time resolution of precipitation sensors used by EDF and Meteo France

498: *Regarding the spatial and temporal of extremes*, … word is missing here

499-500: more precision is needed here "hourly extremes" and add the word "precipitation" to make it easier for the reader.

501-502: I do not understand this sentence "*While the general spatial and seasonal patterns confirm previous studies, our main contribution here lies in updating previous estimates of hourly extremes based on surface observations*". This is not what is described at the beginning of the paper.

501-505: this is not something for the conclusions → should be delete here

509: trend in June needs to be introduced earlier as well

511: you need to explain the "decoupling". How could/should this work in a physical sense?

Generally, the conclusions part is still a bit weak and should be improved. There is clear potential for doing so.

References:

Jiang, R., X. Cui, J. Lin, and J. Tian, 2023: 40-Year Statistics of Warm-Season Extreme Hourly Precipitation over Southwest China. *J. Appl. Meteor. Climatol.*, **62**, 1891–1908, https://doi.org/10.1175/JAMC-D-23-0018.1.

Zeder E. and M. Fischer. 2020. Observed extreme precipitation trends and scaling in Central Europe.Weather and Climate Extremes, Volume 29, September 2020, 100266, https://doi.org/10.1016/j.wace.2020.100266

Zeder E. and M. Fischer. 2024. Decadal to centennial extreme precipitation disaster gaps — Long-term variability and implications for extreme value modelling, Weather and Climate Extremes, Volume 29, September 2024, 100636, https://doi.org/10.1016/j.wace.2023.100636