

Review HESS-egusphere-2025-3073

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

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Recommendation: acceptable after major revision.

The authors have taken into account many of the comments in the first round of the review. They have considerably improved the description of the data, although it is still a little confusing, and have increased the bootstrap sample size to 500. While they disagreed with the idea of removing non significant stations from their analysis, they modified Fig. 9 in such a way that the percentage of significant stations is available to the reader. Unfortunately, they do not seriously use this information in the discussion. Comments regarding this issue can be found under “Minor Comments”.

Major comment 1 of the first review round is neither addressed nor discussed in the new manuscript. I reiterate this comment under “Major Comment” below, and recommend this paper for publication if this comment is addressed.

Major Comment

Since the authors have estimated the GEV parameters for each month of the year (be it in the stationary or the non-stationary case), the seasonal and yearly return levels must be derived numerically, using the equation (here for the yearly return level)

$$G(z) = \prod_{j=1}^{12} G_j(z) = 1 - \frac{1}{T}$$

where G is the unknown yearly distribution, G_j is the GEV distribution for the j th month, z is the return level, and T is the return period.

If heavy precipitation has a seasonal cycle, as Fig. 5 suggests, the numerically derived return level will differ from the one estimated with a seasonal or yearly maximum. If the return level in itself is our ultimate interest, it may matter less, especially if the confidence intervals are large.

The purpose here, however, is to determine the trend in return levels over the period of observation. Since the trend differs from month to month (e.g. Fig.9), it is likely that the discrepancy between the numerically derived return levels and those estimated from seasonal or yearly maxima will differ from year to year. Thus, I expect the seasonal and

yearly trends to be sensitive to the way the seasonal and yearly return levels were determined, and therefore do not regard the seasonal and yearly trends estimated in the present manuscript as trustworthy.

I recommend that the seasonal and yearly return levels be derived from the monthly GEV distribution both in the stationary analysis and the trend analysis. In my view, it will be well worth the effort.

Minor Comments

General

- The description of the datasets is still a little confusing. See comments below. Wouldn't it be clearer to give each EDF dataset a name, EDFold and EDFrec for instance?
- Not enough effort is made to avoid misleading the reader with non-significant results. In fig. 9, the authors have paired the boxplots describing long-term trends in the north and south of the domain with a plot showing the corresponding percentage of significant stations. They do not mention these percentages when discussing the results in paragraph 486-491 (see comments below). In particular, the number of significant stations leading to the interpretation of the results should be mentioned when this number is small. Indeed, Fig. 9 should be modified to include this information (see comment below). Being straightforward about the number of significant stations, whether they are scattered, contradictory in trend, or deliver a concentrated signal, increases credibility and, in this case, does not even affect the interpretation.
- The discussion of the trends sometimes does not correspond to the evidence presented. See the comments below.
- Is Inner-Alpine the same as Intra-Alpine? If so, please use only one term. Otherwise, define both.
- Because of the switch to the seasonal stratification JFM-AMJ-JAS-OND, expressions such as "in early summer" become confusing. Is it July? Please clarify which series of 3 months correspond to the use of "spring", "summer", "autumn", "winter", and ensure that this convention is used in a consistent manner throughout the paper.

Line-by-line

36	"While this divide can be quite sharply defined from differences in topography, vegetation, and mean climatic influences, this does not necessarily imply that the same features apply to influences in extreme precipitation intensities. Eventually replace with: → "While differences in topography, vegetation, and mean climatic
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	influences can sharply define this divide, this may not be the case for extreme precipitation intensities”
111	This possibility has been exploited in a series of doctoral theses at the time Either → This possibility was exploited in a series of doctoral theses at the time Or → This possibility has been exploited in a series of doctoral theses
123	we build on and expand the work of Garavaglia et al. (2010); Blanchet et al. (2016, 2021a) to get an idea of the weather patterns behind high-intensity precipitation in the region → we build on and expand the work of Garavaglia et al. (2010) and Blanchet et al. (2016, 2021a) to get an idea of the weather patterns behind high intensity precipitation in the region
168	The datasets of EDF and Meteo-France combined we have time series for a total of 163 stations → The datasets of EDF and Meteo-France combined have time series for a total of 163 stations
171	but registration of precipitation at high temporal resolution (6 minute intervals) was first introduced within the Meteo-France network in the 1990s (data availability, see also Guillou, 2018). What is meant by “(data availability, see also Guillou, 2018)”?
189	“squared points in Fig. 1” → “squares in Fig. 1”
192	We complete this ‘recent’ dataset with digitalised observations covering the period from the late 1950s to the early 1980s (Garcon, 1993; Saidi-Bououdina, 1996; Kieffer-Weisse, 1998). → We complete this ‘recent’ dataset with an ‘old dataset’ of digitalised observations covering the period from the late 1950s to the early 1980s (Garcon, 1993; Saidi-Bououdina, 1996; Kieffer-Weisse, 1998), and comprising 65 stations.
195	Of this dataset → Of this ‘old dataset’
197	At the end of the paragraph, it would help to say something like: “In summary, we have 30 EDF stations with weekly maxima for 1h...24h approximately covering the period 1955 – 2022. (squares with colors purple to yellow in Fig.1)”
185 vs 200	daily observations at 6am as the sum over the preceding 24 hours precipitation that has accumulated in the 24 hours between 6am and 6am of the following day → which of the two is it? Please specify.
212	→ For the stationary analysis: all 96 Meteo-France stations and the ‘recent’ data from the 67 EDF stations (i.e. 162 time series of both

	hourly and daily data, and 1 time series of daily data), covering between 25 and 42 years of observation. While there are differences in instrumentation between EDF and Meteo-France, we assume each individual time series to be homogeneous in time.
215	→ For the trend analysis: all 67 EDF stations (i.e. 66 time series of both hourly and daily data, and 1 time series of daily data only), covering between 33 and 71 years of observations. At 30 of the stations, time series from different data sources are combined and thus contain known inhomogeneities from both changes in instrumentation and different quality control procedures before and after the 1980s.
219	During initial analysis → During the initial analysis
245	“if it has generated the maximum of season or month m in every respective year t, and 0 otherwise” → If it has generated the maximum of season or month m in year t, and 0 otherwise [“every respective” is confusing]
247	“We call the weather pattern showing the relatively highest contribution the dominant influence for seasonal maxima at a given station” [It seems to me that “relatively highest” doesn’t mean anything. Either it’s the highest, or it isn’t. And “highest”, in itself, already implies that it is higher than something else. Perhaps it would be clearer to simply say “We call dominant with respect to a given season (month) the weather pattern that is associated with the largest number of seasonal (monthly) maxima over the complete time series at a given station.”]
250	French Alps;. → French Alps.
253	“For the estimation of return periods” → “For the estimation of return levels”
285	“red solid line in Fig. 3” → Isn’t it Fig. 3A?
285	“return level is arbitrary, it aims” → return level is arbitrary; it aims
286	“Patterns” → spatial patterns?
309	“for a point j in the neighbourhood of i, N_i ” → What is N_i ?
329	between non-declusterised old and declusterised recent data → between non-declustered old and declustered recent data
365	“This did not result in significantly different spatial patterns” Does significantly mean “very”, here? Or has the degree of difference been quantified?
368	“applying it for hourly maxima is less robust” → What does “robust” really mean here? Please be more precise.
369	The main patterns resemble the daily patterns, but with a higher influence of Anticyclonic conditions between June and September (Fig. A2). • In what way does Fig. A2 help understand this statement? • “The main patterns” → Please be more precise: “the spatial distribution of the dominant weather patterns”
384	“small positive trends in May are followed by...”

	This is not very convincing (only 7 stations are significant). Why not skip May, and talk only about August to December where you seem to have a signal worth mentioning?
392	“and also overall less significant” → “Overall, the trend is significant at much fewer stations than for daily precipitation, and the number and location of such stations varies considerably from month to month and season to season. “
393	“with the highest range of values” → “with the widest range of values”
398	“with highest variability in spring and summer “ → “with the largest variability in spring and summer”
401	although most annual trends are statistically not significant. → “although the annual trends are statistically significant at only 2 of the stations, and are of opposite sign.”
488	“Between June and December, the southern part of the study region experiences much stronger trends, both positive and negative, for both hourly and daily extremes» → “Between June and December, the southern part of the study region experiences much stronger trends, both positive and negative, for both hourly and daily extremes. Note that for hourly extremes, the trends in the south only affect more than half the southern stations in November and December. In the other months, the signal of the significant stations is either scattered (June, 7 significant stations) or contradictory (August, 4 positive, 6 negative). The negative trend in March, while significant at only 7 stations, displays a spatially concentrated signal. For daily extremes, the signal is remarkably strong from August to December. In the other months, the number of significant stations is below 50%, and the apparent positive trend in May has only 7 significant stations. Interestingly, in March and July, the climatological divide cuts through a compact trend signal, weakening it on either side. ”
492	“Especially the autumn period (October to December) deserves attention” → The evidence points to this sentence being about the South. Please specify.
499	“and for which the mean trend over all stations in the south is always close to zero” → do you mean in the north? In Fig. 9, in the north, the mean is close to zero in all months but September. In the south, there seem to be a few more months with a mean that is not close to 0.
501	“Daily trends in the same period are overall negative” → “Daily trends in the same period are overall negative, except for June”

	Are the authors are still talking about the South here?
501	“To a lesser extent (in June and September) this is also true in the north, showing that during this time of the year hourly and daily extremes are not experiencing the same trends.” For September, this is not true: the hourly significant stations indicate a negative trend, just as do the daily significant stations.
507	“Trends of hourly extremes in the same season show both negative and positive trends” How do the authors come to this conclusion? The mean trends for July, August and September in Fig. 9 are all rather negative. Are the authors commenting on the contradictory trend information from all southern stations in these 3 months?
508	“with significant positive trends especially in the eastern part of the region, where the mountains are highest” The only significant positive trends in Fig. 10 (in the south, in July, August and September) are at 4 stations in August that are very close to stations with negative trends, and 2 others in September. Please rephrase.
512	“We further hypothesize that the drying effect might dominate in the pre-Alps (negative trends in some western parts of the region), while the increase of available energy might dominate in the interior of the Alps leading to positive trends in the eastern part (Fig. 10)” The hourly trend analysis hardly includes any EDF stations in the pre-Alps as described in Fig. 1, except in the north of the domain. Are the authors really discussing trends in the south in this sentence? Also, as mentioned in the comment for line 508, Fig. 10 does not seem to point to negative trends in the west and positive ones in the east, unless the authors have the plot for JAS in mind, and the northern part of the domain.
550	“At the hourly timescale, trends are more spatially variable, with a tendency towards positive trends prevalent in the high Alps and negative trends in the pre-Alps.” Is this assertion based on the discussion in line 508 and 512? See comments above.
558	“could be a potential change” → “could be a change” or “could potentially be a change”
561	“and in early summer as well as autumn for hourly extremes.” Does “early summer” refer to July? Fig.10 suggests that the authors rather have June in mind, which would be “late spring”, according to the authors’ definition of seasons.
562	“showing partially strong increases in the south (daily)” What does “partially strong” mean?

Fig.1	Description: “Stations maintained by Meteo-France are shown as circles, these are used for stationary analysis only due to the comparatively short period they have been operating for.” → “Stations maintained by Meteo-France are shown as circles, and are used for stationary analysis only, due to the comparatively short period they have been operating for.” “Stations maintained by EDF are shown as squares, these are used for both the stationary and the trend analysis” → “Stations maintained by EDF are shown as squares, and are used for both the stationary and the trend analysis” Legend: For the first 2 squares (26-30years, 30-40 years) the color cannot be distinguished. Could you please choose a lighter color?
Fig. 9	Please add the number of stations that are significant for each month, season, or for the year. In the legend, please remind the reader of the total number of stations.
Fig.A2	“Note that the colorbar is different from 7.” → What is 7?