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Hydrology and Earth System Sciences Discussions

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Interactive comment

Interactive comment on "65-year changes of annual streamflow volumes across Europe with a focus on the Mediterranean basin" *by* Daniele Masseroni et al.

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COMMENT: The manuscript describes a large trend analysis of annual streamflow volumes recorded in European countries. The topic is surely interesting and the manuscript is pleasant and easy to read. While this kind of papers is generally useful for the scientific community, they usually include a common drawback present also in the submitted manuscript. Indeed, a lot of pages focus on results and conclusion while few details are given for the most important part of the paper that is the data selection and description.

REPLY: We thank Revr#1 for his/her queries that allowed us to improve substantially our manuscript. We will integrated the requested modifications into the revised version of the manuscript. Specifically, the data selection and description will be strongly improved including the criteria used for selecting rainfall, air temperature and river discharge time series and the procedures employed to mitigate errors and discontinuities in the whole dataset.

COMMENT: Line 100. “characterized by about 1.200 points of measure per year”. This sentence is not clear. As a consequence it is not clear how the annual streamflow volumes are estimated.

REPLY: The size of original dataset was about 3’900 stations. Of these, 3’485 were used for the analysis after filtering based on criteria for reliability, consistency and homogeneity, which will be clarified in the revised manuscript.Not all stations provided data for the whole analysis period, so that on average, the data were provided by 1200 stations/year Concerning the annual streamflow volume calculation, we will specify that this was carried out by summing the daily streamflow volume over the total number of days in the year.

COMMENT: Lines 107-110. The human activities in the river basin can significantly affect the trend, so it is not clear if a specific check on the time series was done. Specifically, a matching between analysed watersheds and dams could be helpful to understand if “ the degree of disturbance can be tolerated”. How many watersheds include a dam in it? When it was built? Etc. etc.

REPLY: We thank the reviewer for this suggestion. In the revised manuscript we will add details about the pre-processing activity carried out to filter the discharge time series used for the analysis. In particular, we will specify that: 1) each discharge time series has been accurately scrutinized through a visual hydrograph inspection to identify disturbed hydrographs due to e.g. the presence of dams/reservoirs. Discharge time series characterized by disturbed hydrographs were discarded from the analysis; 2) most of the basins considered in the analysis are taken from the EWA database, i.e. a discharge data collection of near-natural streamflow records from small catchments (Stahl et al, 2010). Moreover, to further answer to the questions raised by the reviewer, the Global Reservoir and Dam (GRanD, https://sedac.ciesin.columbia.edu/data/set/grand-v1-dams-rev01) will be downloaded and a further analysis will be carried out in the revised manuscript to identify if (how many) dams/reservoirs are actually present in the selected basins. At the end of this analysis we expect that no substantial differences will be found between the basins retained for the analysis and the basins for which a certain degree of disturbance can be tolerated.

Additional reference: Stahl, K., Hisdal, H., Hannaford, J., Tallaksen, L., Van Lanen, H., Sauquet, E., ... & Jordar, J. (2010). Streamflow trends in Europe: evidence from a dataset of near-natural catchments. Hydrol. Earth Syst. Sci., 14, 2367–2382

COMMENT: Fig. 2 is not fully clear or better an additional figure could be added showing the distribution of the time series length. Indeed, it is not clear if all the analysed series have the same length (from figure 2a it does not seem). Fig. 2b could be enriched by some statistics like the min and max contributing areas.

REPLY: We improved Figure 2. In particular, Fig. 2a is now replaced by a clearer picture (see reply to RC2) where available years for each station are shown. Fig. 2b is replaced by a table of the main statistics concerning the basins' characteristics (Table RC1.2).

COMMENT: Are the times series autocorrelated? And how much? This could affect the trend results and tests.

REPLY: Temporal autocorrelation was verified calculating lag-1 autocorrelation coefficient for each time series as proposed by Khaliq et al. (2009). Autocorrelation coefficients for each series are shown in the new figure RC1.1, together with their upper and lower 95% confidence bounds (y-axis: lag-1 autocorrelation coefficient; x-axis: series ID). All series of data are not significantly autocorrelated, therefore they were considered suitable for trend identification.

Additional reference: Khaliq, M. N., Ouarda, T. B. M. J., Gachon, P., Sushama, L., & St-Hilaire, A. (2009). Identification of hydrological trends in the presence of serial and cross correlations: A review of selected methods and their application to annual flow regimes of Canadian rivers. Journal of Hydrology, 368(1-4), 117-130.

COMMENT: The definition of Mediterranean is confusing, for sure it is an "official" characterization, however looking the figure 1 I see around 300-400 points that can be considered as affected by Mediterranean climate. For instance, all the basins located in the Alps at high altitude can be considered as Mediterranean? As well as all the basin around Portugal?

REPLY: Concerning the subdivision of the European continent in Mediterranean, Boreal, Continental and Atlantic macro-areas, we used the classification provided by Gudmundsson et al. (2017) which is the same reported by official data of the EU Environmental Agency, such as Natura 2000 biogeographical regions (https://ec.europa.eu/environment/nature/natura2000/platform/knowledge_base/103_browse_categories_en.htm). This classification consistent with the map of biogeographical regions of Europe reported also in Fernandez-Carrillo, A. et al. (2019). In this classification, the Alps and large parts of Portugal and Spain are included in the Mediterranean region.

Additional references: Fernandez-Carrillo, A., de la Fuente, D., Rivas-Gonzalez, F. W., & Franco-Nieto, A. (2019, October). A Sentinel-2 unsupervised forest mask for European sites. In Earth Resources and Environmental Remote Sensing/GIS Applications X (Vol. 11156, p. 111560Y). International Society for Optics and Photonics.

Gudmundsson, L., Seneviratne, S. I., & Zhang, X. (2017). Anthropogenic climate change detected in European renewable freshwater resources. Nature Climate Change, 7(11), 813.

COMMENT: The comparison with Rainfall and Temperature should be better described. Which is the time series length used in the rainfall and temperature analysis? Is it correct to compare trends of data set with different length?

REPLY: In the revised manuscript, we will provide more details on the selection of rainfall and air temperature time series. For every discharge series, we will calculate climatic trends on trimmed meteorological series, so as to guarantee perfect temporal overlap between the two series.

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Discussion paper

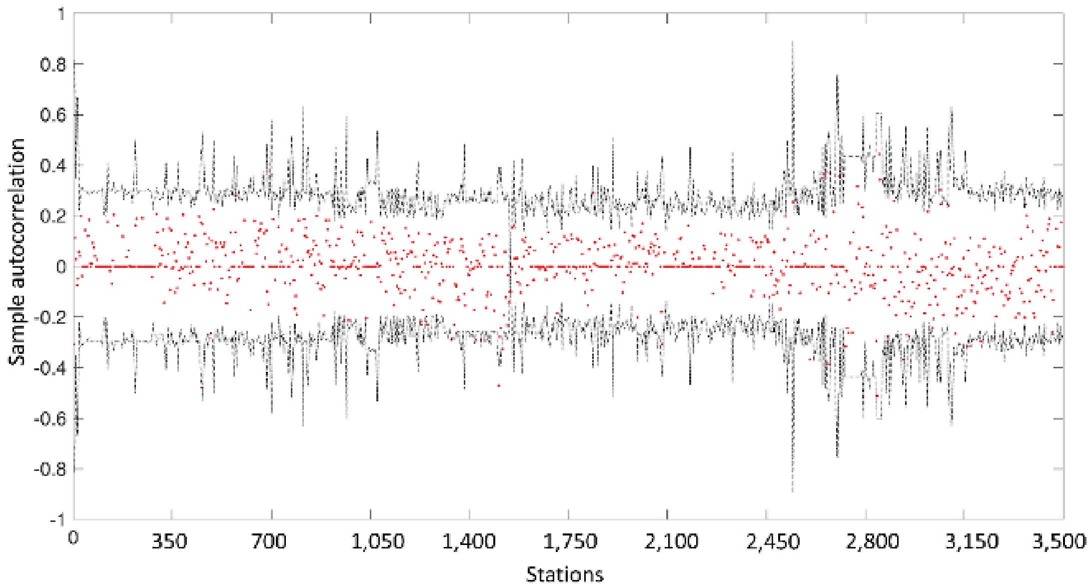

Fig. 1. Lag-1 autocorrelation in water discharge series

Area range (km^2)	Percentage of basins (%)	Elevation of basin centroid (m asl) Maximum – Minimum (Mean)	Annual streamflow volume (M m^3) Maximum – Minimum (Mean)
0-100	30	2900 - 2 (677)	247.40 – 40.81 (112.78)
100-200	21	2700 - 19 (510)	241.85 – 44.15 (139.03)
200-300	13	2170 – 30 (320)	306.06 - 52.82 (154.01)
300-400	10	2200 – 11 (621)	338.43 – 68.38 (188.40)
400-500	7	1980 – 10 (321)	431.28 – 80.36 (246.83)
500-600	6	1970 – 21 (452)	526.43 – 106.32 (307.59)
700-800	5	1856 – 31 (322)	90.12 – 554.09 (312.32)
800-900	3	1879 – 12 (398)	98.89 – 671.32 (363.59)
900-1000	3	1900 – 10 (532)	143.21 – 889.22 (488.03)
>1000	2	1970 – 8 (601)	150.01 – 931.21 (498.98)

Fig. 2. Descriptive statistics of cacthments analyzed in the present study

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