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Hydrology and Earth System Sciences
Discussions

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

Anonymous Referee #2

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The study analyses trends in annual streamflow over the period 1950-2015 in Europe. This is a relevant topic certainly within the scope of HESS. The study generally applies standard methods for trend analysis (Theil-Sen slope, Mann-Kendall test). The spatial patterns of the trends are compared to spatial patterns of air temperature and precipitation. The study extends previous work on observed streamflow trends in Europe by including a higher number of catchments, particularly in Portugal, Spain, France and Italy. This was possible through assembling the database of streamflow records from various sources. The results largely confirm previous studies with dominant positive trends in northern Europe and dominant negative trends in the Mediterranean region.

Main comments:

1) Since the study states that records with missing data for more than two years were excluded from the database (L 107), I initially assumed that the calculated trends all relate to the period 1950-2015, which, looking at Fig. 2a, is apparently not the case. This has of course a strong influence on the results and needs to be clarified. If the series lengths vary between catchments it will probably be more useful to analyze trends for different periods with nearly complete records, as the trends of course depend on the period analyzed (as discussed in the introduction).

2) The criteria for inclusion/exclusion from the database should be described very clearly. It is not so clear whether the study aimed at only including near natural catchments. How were gaps smaller than 2 years treated? The steps that were undertaken to exclude inhomogeneous series, or series strongly affected by human interventions need to be mentioned clearly. For example, did the authors try to get information from the data providers on human interventions such as changes in flow abstractions etc. It should be described clearly how the database was 'consolidated and validated'. Did you apply any automatic screening tests to systematically check the series for possible inhomogeneities?

3) Some results are not very clear. The results section reports significant trends in 95% of the stations, which disagrees with results reported in Table 1. In the results section, it is not always clear whether results on trends also include non-significant trends.

4) I disagree with the finding of an inversion point in 1985 for the average series in the Mediterranean region. I do not see a change in the trend direction or trend slope in 1985. The fact that streamflow is above average before and below average after 1985 is a rather arbitrary result that depends on the selected study period. Streamflow has been decreasing since about 1965, and if anything, the rate of decrease has rather slowed down since the late 1980s.

5) The calculation of the Sen's slope from annual streamflow anomalies is described

as innovative, but if I do not overlook something this should not affect trends (and has probably been done in many studies).

6) The introduction should be improved. The introduction should clearly convey what has been found previously on annual streamflow trends in Europe? What is the gap in the current literature? How is this approached by this study? Please also check the logic of individual sentences and the subdivision of the introduction into paragraphs.

7) The explanation of streamflow trends by trends in air temperature and precipitation remains a bit vague and overlooks areas where it is probably not possible to explain streamflow trends with trends in air temperature or precipitation (such as positive streamflow trends in northern Spain). Some arguments need to be clarified e.g. it is not clear to me how groundwater or snowmelt effects would affect annual (and not only seasonal or monthly) streamflow.

Detailed comments

P1, L28-30: The logic of the sentence is not clear. There is no contrast between a lot of research and not finding uniform streamflow trends in Europe. When mentioning a lot of research that aimed at investigating streamflow trends in Europe, this should be backed up by some references and their main findings (e.g. Stahl et al., 2010, Stahl et al., 2012).

P2, L33-34: Did these studies also analyze changes in annual streamflow volume? What were the main findings? How did seasonal streamflow change?

P2 L40-47: The section on potential drivers of the streamflow trends remains a bit vague. Are changes in river cross-sections or boat tourism relevant for annual streamflow volumes?

P4, L97: I would suggest to first clearly list the criteria for selecting catchments and then mention the final number of selected catchments at the end.

P4, L101-102: You may use this in the introduction in order to emphasize your contri-

bution in comparison to previous studies.

P4, L103-109: The description of the criteria for inclusion/exclusion from the database should be very clear. It is not very clear whether you aimed at including only near natural catchments. Did you check information from the data providers on human interventions such as changes in flow abstractions etc. (that would directly influence the trends)? Your database contains $\sim$3900 series of 65-years data. It is a lot of work to visually scan daily data of all these series. Could you provide some detail on how this was achieved? Did you apply any automatic screening tests? How were inhomogeneities identified?

P5, L123ff: Why would it make any difference in terms of trend slope whether you calculate it on the original data or on the anomalies?

P5, L128: Delete “To homogenize the annual streamflow series”, since dividing by catchment area cannot homogenize a time series.

P5, L132ff: Have you checked the streamflow series for autocorrelation? How did you deal with series that contain significant autocorrelation?

P6, L138: Since the streamflow volumes were divided by area, runoff depths would be more appropriate (instead of streamflow volume), no? (adjust throughout the paper)

P6, L145 and 146: This seems not correct, Table 1 shows positive trends in 7% and negative trends in 5% of the catchments?

P6 Fig. 3: These figures are not necessary in my opinion.

P6, L151: The unit of annual streamflow per area is length/time (e.g. m^3/(km^2 year), or mm y-1). Therefore the change in runoff over a certain period is length/time^2 (e.g. m^3/(km^2 $year^2$)).

P7, L170; legend and caption of Fig. 5: replace rainfall by precipitation (assuming that snow is included).

P7, Fig. 4: Please add trend significance to the figure, e.g. different symbols for significant/insignificant trends.

P7, Fig. 4: I assume that the former Yugoslavian countries should also be part of the Mediterranean region?

P9, L175-177: Please add time periods, are you discussing observed or future projected air temperature changes (“expected to increase” points to future changes)?

P9, L177ff.: Please explain why earlier snowmelt would result in increased annual streamflow. This is not so straightforward and there are studies pointing to the opposite (e.g. Berghuijs et al., 2014).

P9, L182: Replace rainfall by precipitation.

P9, L184/185: There are large agreements between the changes in runoff and precipitation/air temperature. However, I do not agree that streamflow changes are “perfectly congruent” with the patterns of changes in air temperature and precipitation. For example, despite increases in air temperature and decreases in precipitation, streamflow has increased in northern Spain.

P9, L186-195: The discussion is not very clear. Please explain how groundwater or snowmelt effects would affect annual (and not only seasonal or monthly) streamflow. Furthermore, I would suggest keeping the different factors that may explain mixed positive and negative trends apart. For example, glacier melt processes are unlikely to be relevant in Northern Germany.

P10, Fig. 6, lower panel: Better only show significant trends. Also, better show percentage of positive/negative trends and add the number of stations, e.g. to the labels for each bar.

P10, L213: Looking at the 1950-2015 series, streamflow is above average 1955-1985 and below average 1985-2015. However, I do not see any particular change point in 1985. Streamflow has been decreasing since about 1965, and if anything, the rate of

decrease has rather slowed down since the late 1980s.

References

Berghuijs, W. R., R. A. Woods, and M. Hrachowitz. "A precipitation shift from snow towards rain leads to a decrease in streamflow." Nature Climate Change 4.7 (2014): 583-586.

Stahl, Kerstin, et al. "Filling the white space on maps of European runoff trends: estimates from a multi-model ensemble." Hydrology and Earth System Sciences 16.7 (2012): 2035-2047.

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