CH-RUN: A data-driven spatially contiguous runoff monitoring product for Switzerland

https://doi.org/10.5194/egusphere-2024-993

Preprint. Discussion started: 22 April 2024

Contribution

The manuscript presents a method for creating spatially and temporally complete reconstructions of historical runoff for Switzerland, using machine learning techniques. The model can be run at low computational cost. The results compare favourably with reconstructions created using a complex distributed hydrological model over the same domain. Simulated catchment runoff data demonstrate temporal trends at decadal scales which are consistent with those previously reported.

Assessment

I do not have any major concerns about the paper. In general it is clearly written, and logically consistent, with appropriate caveats. I do not have expertise in current machine learning methods, and can't comment usefully on the methods employed. I do have are a number of concerns listed below, but none of them are likely to undermine the general conclusion of the paper (though see my major comment about robust quantification of trends).

Major Comments

1. L287 "Figure 5c illustrates how the models capture spatial patterns of annual trends" I'm not confident that the results in Fig 5c are robust. First, since there is no evidence shown that temporal trends for individual catchments are linear, it would be prudent to use a non-parametric trend slope (e.g., Sen slope), rather than a linear fit for each catchment. Second, the PREVAH points in Fig 5c look to be mostly a cloud, and it seems possible that the two points in the upper right have a lot of influence in determining the regression line. I suggest the authors either demonstrate that those two points are not influential by recomputing the regression without them and showing that it does not change much, or else use a robust regression method. Similar comments apply to the influence of the single LSTM point in the upper right. The use of a Pearson correlation coefficient to describe the association between variables in Fig 5c seems similarly unjustified, and Spearman rank correlations would be more appropriate in the presence of potential outliers.
   I list this as a major comment because the paper includes in its conclusion (L464) the claim that "Our model effectively captured … long-term trends"

Minor Points

2. L2. I would like to read slightly more detail about the method in the abstract. A few additional key words to let the reader know which specific machine learning technique(s) was preferred.

3. L10. “capturing annual variability” it would be clearer to say inter-annual, rather than annual.
4. L12. “These are characterized by an increased occurrence of dry years, contributing to a negative decadal trend, particularly during the summer months.” A negative trend in what?
5. L16. “the reduced data dependency … of our model” This statement makes sense in the context of comparison against PREVAH, but there are other traditional hydrological models which only require temperature and precipitation (e.g., HBV) which also have reduced data dependency; this is not a feature that is unique to these machine learning models.
6. L54 “2.2 Meteorological drivers” What is the spatial resolution of the gridded products? What is known about their accuracy, in particular, at high altitudes? How does the time-varying availability of the underlying climate observations affect the reliability of the product, especially in the early part of the period when presumably fewer stations are available?
7. Section 3: I do not have expertise in current machine learning methods, and can’t comment usefully on most of this section. The model evaluation appears to be well designed.
8. L258 “Understanding the capabilities of our model necessitates a thorough evaluation of daily runoff simulations” This sentence indicates that a thorough evaluation is about to be presented. However, I think that overstates the analysis which follows. Analysing model outputs in terms of squared differences between the measured and modelled time series, and then annual means, is a useful, but limited evaluation. There are many other ways to assess the performance of a model (e.g., its ability to reproduce multiple hydrologic signatures of interest). Does the model reproduce flood peaks well? Low flows? Seasonal variation? Recession characteristics? I think that the analysis provided is appropriate for this paper, but it’s a stretch to call it a “thorough evaluation”, so the phrase should be modified slightly.
9. Sections 4.2 and 4.3: I found the material here very helpful and well presented.
10. L352 “under these data-limited conditions” The point about being data limited is made several times. Can you explain why you say that having 98 catchments is data-limited? The spatial coverage of Switzerland is clearly patchy and partial (Figure 1), but that wouldn’t matter if spatial correlation lengths were large. Is there an objective method for assessing the extent to which any streamflow dataset contains a large or small amount of information, relative to a space (and time) domain of interest?
11. L418 “We hypothesize that the negative trend in summer is less related to snowmelt but rather connected to an increase in evapotranspiration via warmer air temperatures,” It

still seems possible to me that changes in snowmelt might affect summer streamflow. For what reason do you prefer your alternative explanation? How might such a hypothesis be tested to discriminate between these potential causes? I think that proposing hypotheses in a discussion is a great idea, but it would be good to know that they were testable, at least in principle.

12. L468 "… is contributing towards the negative decadal trend." Negative decadal trend in what?
13. L469 "… and linked to the summer months" This phrase is vague, and could be made much more specific. What happened in summer? Is it a cause or effect of the drier conditions?
14. Table A1 caption "onse" should be "ones"
15. L486 deontes should be denotes
16. L488 temporal_dropoput should be temporal_dropout
17. Table A2 caption. The meanings of the columns "allbasins sqrttrans static" are not defined; please refer the reader to the relevant material in section 3