Hydroclimatic change driven by land-water-use developments: the case of transboundary Sava River Catchment, South Eastern Europe

1. Introduction

Growing human demands for water, food and energy have led to extensive use and modification of world water bodies, for instance by construction of dams, reservoirs and channels for hydropower purposes. In this study we use the transboundary Sava River Catchment (SRC) as field case for investigating long-term hydroclimatic changes and their relation to regional hydropower and associated land-water-use developments.

The total SRC area: 100 095 km², population 8 176 000, elevation 0-2646 m a.s.l.

<table>
<thead>
<tr>
<th>20th century averages</th>
<th>T (°C)</th>
<th>P (mm)</th>
<th>R (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>-19</td>
<td>9</td>
<td>1108</td>
<td>531</td>
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-19 large dams
-22 hydropower plants (annual production of 8*10^7 MWh)
-0.6% of the total water use in the catchment is used for irrigation, 0.28% of the SRC area is systematically irrigated

2. Goal

The goal of our study is to test the possible relation between hydroclimatic change and hydropower development in this region, and assess the relation generality by comparison with other regional and global results.

3. Materials and Methods

Using T, P and R datasets we calculated average annual P, R and T within the SRC area (Fig 2). Based on results by Destouni et al (2013) and Jaramillo et al (2013) we estimated actual average annual evapotranspiration (AETwb) (1) from water balance in each subcatchment and also calculated two purely climate-driven AET measures, AETwb and AETwb, based on Turc (1954) and Budyko (1974). We computed the change of R (ΔRwb=) (Figure 5) subject to purely climate-driven AET wb change (according to Arora et al. (2002)).

Quantified is also the corresponding change in temporal R variability, in terms of the coefficient of variation of daily R, CV(R) (Figure 4).

\[
\begin{align*}
\Delta R = \frac{P - \Delta S}{P} - \frac{\Delta S}{P} & \quad (1) \\
\Delta S = 0 & \quad (2) \\
\Delta P = 0 & \quad (3)
\end{align*}
\]

4. Results

We found sustained increase in average annual evapotranspiration, and decrease in average annual runoff and temporal runoff variability as hydropower production increased in the SRC parts with the greatest such developments during the 20th century.

Purely climate-driven estimates of change in evapotranspiration and runoff cannot capture these changes (Fig 5).

5. Conclusions

- Change in evapotranspiration and runoff are apparently related to the land and water use changes associated with hydropower development.
- Direct comparisons with corresponding results from other world regions and global estimates show consistent cross-regional results, supporting generalization of obtained specific numerical results and the used analysis approach on different scales and across different parts of the world.
- Even in such areas, with less than ideal conditions regarding environmental monitoring, it is possible to find and compile relevant data series of sufficient length for capturing and distinguishing important dynamics and patterns of long-term hydroclimatic change and its possible land-water-use drivers

6. References

Arora V K 2002 The use of the aridity index to assess climate change effects on annual runoff Journal of Hydology 263 164-177


7. Acknowledgments

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