Handout EGU22-5841

Upstream-downstream asymmetries of drought impacts in major river basins of the European Alps

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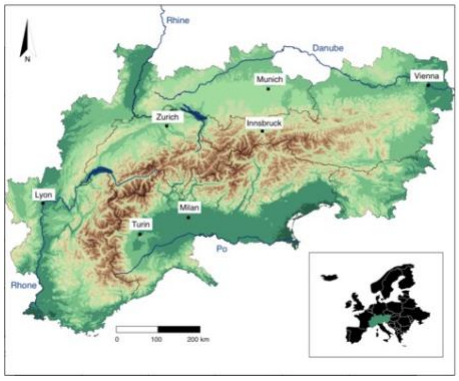


Research question

How does the occurrence of drought impacts differ in up- and downstream regions of the Rhine, Rhone, Po and Danube basin?

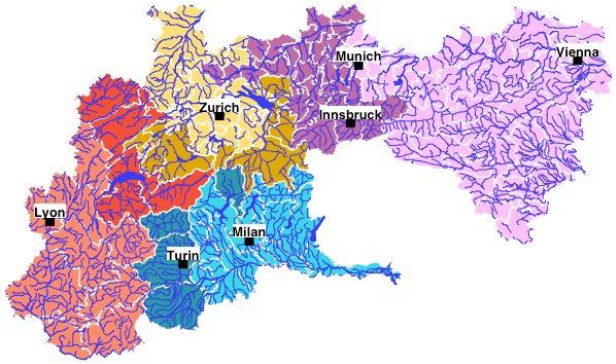
Hypothesis

Drought impacts occur more often downstream than upstream.

Data and methods

Upstream-downstream classification

1. Distance approach



Rhine
- downstream
- upstream

Rhone
- downstream
- upstream

Po
- downstream
- upstream

Danube
- downstream
- upstream

2. Human footprint approach

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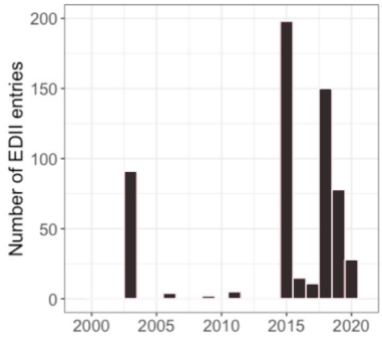
Data and methods

Drought impact analysis

European Drought Impact Report Inventory (EDII)



- Collection of text reports on negative drought impacts
- Covering 15 impact categories
- Time period: 2000-2020

Data and methods

Hypothesis testing

Comparison of impact categories

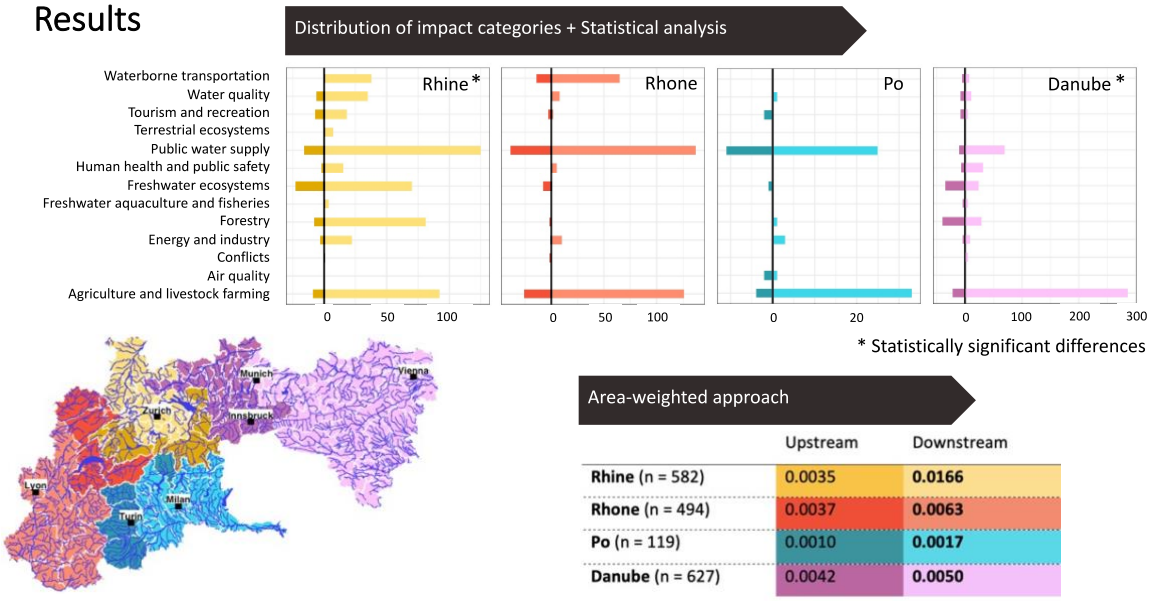
Statistical approach (Mann-Whitney-U Test)

Area-weighted approach

To classify the four basins into up- and downstream, we tested several approaches and decided to go with two different classifications, the distance and the human footprint classification.
Due to the limited time, I will focus on the first approach today which builds on geographical distances. Here, the distance between each sub basin within the larger basins and the outlet of the main river, is calculated. The map as you can see it here shows the darker upstream parts as source regions of the river that include the most upstream headwaters of the basins.
In a second step, we combined this upstream-downstream classification with drought impact data of the European Drought Impact Report Inventory database. The EDII presents a collection of text reports on negative drought impacts. The reports can be categorized into 15 impact categories. For this study we chose to focus on drought impacts that occurred between 2000-2020, as the graph shows exemplarily for the Rhine basin. By combining up- and downstream areas and the drought impacts data, we received a matrix showing which parts of the basins experienced drought impacts, during which time period, and in which impact categories.
To test our hypothesis, we:

- Analyzed the distribution of impacts within the individual sectors
- Applied a statistical analysis to test whether a significant difference regarding the number of reported drought impacts exists between up- and downstream areas
- Applied an area-weighted approach

Results



Area-weighted approach

	Upstream	Downstream
Rhine (n = 582)	0.0035	**0.0166**
Rhone (n = 494)	0.0037	**0.0063**
Po (n = 119)	0.0010	**0.0017**
Danube (n = 627)	0.0042	**0.0050**

The four graphs present how the drought impacts are distributed within the basins in the individual sectors. On the x-axis you can see the number of impacts that occurred.
We found that the four basins show very different sectoral patterns. In the Rhine and Danube basin many impacts occurred in several sectors. In the Rhone and Po basin the impacts concentrate in the sectors *Public water supply* and *Agriculture and livestock farming*. Hereby, especially in the Po basin just a small number of impacts occutred. But in general, the graphs visualize quite well that more impacts occurred in down- than in upstream regions.
Also, we found statistically significant differences in the number of impacts between up- and downstream areas for the Rhine and Danube basin. For the Rhone and the Po basin, no statistical differences occurred.
Focusing on the upstream-downstream map again, it becomes clear that the up- and downstream areas of the basins have very different spatial extents. The downstream areas are always way larger, especially in the Danube basin. Therefore, we also weighted the impacts per area to get a more objective picture. With these weighted impact results, presented in the table, we could prove our hypothesis that more impacts occurred in downstream areas. Especially the Rhine basin shows a large difference between the impacts per square kilometer in up- and downstream areas.

Conclusions

Hypothesis
Drought impacts occur more often downstream than upstream.

- For the upstream-downstream classification based on distances the number of drought impacts per area is higher in downstream regions.
- Differences are statistically significant for the Rhine and Danube basin applying the distance approach.

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