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Identifying changes in hydrological behaviour of Russian Plain rivers over the last 70 years by using clustering analysis

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In the past two decades we see many signs of changing behaviour in hydrological regimes of Russian Plain rivers. River regimes classification was done in the early 1990s and it's possible that some rivers (especially in Don and Oka river basins) have already changed their behaviour. We believe that's the first time this was done by objective analysis and without reliance on experts opinion.

In this work we make an attempt at automatic and objective classification of water regime types for 220 rivers of Russian Plain and propose a method for automatic assesment of changes in hydrological behaviour of local rivers. We use monthly data and k-means clustering algorithm to classify each river water regime for every year with available data. Unlike most of other approaches we do not divide data by year but create clusters from all datapoints simultaniously. This allows us to use more datapoints and establish a more robust result. Next, when we have annual clusters for every datapoint we can assess the stability of water regime for each catchment over several decades and identify catchments with unstable and changing behaviour.

By using this method we're able to automatically identify 5 distinct water regimes for the rivers of Russian Plain: three with dominant peaks caused by spring freshets in March, April and Februaty with most discharge happening over the course of a single month and two types of water regimes with maximal discharges in April and June, but lacking a pronounced peak in these months. Unlike previous calssifications we can identify the closest water regime for every year and therefore make an attempt at quantifying stability of these regimes and changes over time. By using a very naive approach and calculating a standard deviation over a moving window of 10 years it's possible to detect unstable regions and therefore select periods of stability and shifts for each subregion of Russian Plain.

We're able to identify Don and Oka basins as regions with the most changes in water regimes and it corresponds with research data. In addition rivers in Kola peninsula and Ural regions peninsula demonstrate a slight shift in stability. In terms of hydrological behaviour we see siginificant changes in Don and Oka river basins that shifted from spring freshet peak in April into water regime type with a peak in March or a more southern water regime with less pronounced April peak having precedenig winter thaws.

We believe that this simple approach at identifying water regimes and changes in them can be

successfuly used for other regions than Russian Plane.

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