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Regional synchronisation of hydrological regimes – is the variability of extremes linked to mean conditions?

L. Gudmundsson (1), L. M. Tallaksen (1), K. Stahl (1), and H. Lange (2)

(1) Department of Geo Sciences, University of Oslo, Oslo, Norway (lukas.gudmundsson@geo.uio.no), (2) Norwegian Forest and Landscape Institute, Ås, Norway

General questions that arise while investigating hydrological extremes are whether these have distinct spatial and temporal variations and how these variations are linked to mean flow conditions. We analyze a large set of European stream flow series. Based on daily observations we derive annual series of stream flow deciles ranging from the minimum to the maximum, resulting in a set of eleven series for each station representing the year to year variability of the flow regimes.

In order to determine common temporal structures we develop a two level strategy: First, matrices of correlations between the annual deciles series of all stations are derived for the eleven decile series between all stations are derived. This leads to a set of correlation matrices representing temporal similarity of the corresponding part of the regime between the different stations. A second step develops the framework of Principal Coordinates of Distance Matrices (PCoDM) that enables to uncover related structures from the set of matrices derived in step one. The resulting generalized similarity matrices (GSM representing between-station similarities) are subject to further multivariate analysis.

PCoDM shows that the same structure is dominating the in the between-station correlations throughout the different deciles, except for the series of annual maxima. This shows that within the given geographical region, the flow regime has a synchronized year to year variability, except for the peak flows. The first residual pattern thus is related to the peak flows. The leading GSMs are used as input for cluster analysis. Plotting the clusters of the leading GSM into a geographical map reveals clearly disjunct regions with synchronous behavior throughout all deciles. In contrast, the first residual GSM has large correlations with the extreme deciles and are spatially heterogeneous. The results point to a synoptic-scale climate forcing for a wide range of flow conditions, whereas the upper extreme flows are more influenced by local properties of the individual catchments.