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Quantification of Europe-wide streamflow complexity and potential links to atmospheric circulation patterns

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Stream flow observations from a geographical region are known to often exhibit strong common behavior. In order to assess the temporal evolution of the complexity of stream flow time series from all over Europe, we employ the recently developed Linear Variance Decay dimension density (δ_{LVD}). It is estimated as the parameter of an exponential decay function fitted to the remaining variances of the eigenvalues of a covariance matrix. Scaling between zero and one, δ_{LVD} can be interpreted as a measure of the proportion of linear independent components in a multivariate record.

We analyze a large set (400) of daily European streamflow series taken from the European Water Archive (EWA), covering the period 1963 to 2005. We compute δ_{LVD} series for monthly aggregations as well as for a one-year long moving window (at monthly time steps). The resulting two series are highly structured. The series representing monthly δ_{LVD} values has a distinct annual cycle with the least complexity in the winter months. The series with the running annual δ_{LVD} values has a significant downward trend that accounts for 37% of the variance. In order to detect oscillatory behavior, we use Monte Carlo Singular System Analysis. We detect two significant oscillatory modes with large spectral power on narrow periodic bands (2.2 - 3.4 and 1.9 -2.9 years). These modes together account for 15% of the variance.

In order to seek the origin of these periodicities, we compare them to periodic components of northern hemisphere teleconnection indices. Among a variety of indices explored, the East Atlantic Pattern (EA), the West Pacific Pattern (WP) and the East Atlantic/West Russia Pattern (EA/WR) have modes with significant variability in the 1.9 to 2.9 years band. However only the signal extracted from EA/WR is strongly related to periodic behavior in the δ_{LVD} series of European stream flow.

Thus we conclude that an two to three year oscillation in the EA/WR may drive weather patterns that influence the strength of synchronous behavior of pan European stream flow.