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Towards a dynamical understanding of flood regime changes

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Flood regime changes can be analysed and statistically attributed by disentangling a whole network of driving processes and interactions, from ocean-atmospheric processes to land-related changes. However, such approaches do not provide dynamical dependence necessary to tackle changes in the process network itself, namely variations in the causal hierarchy.

The present study addresses this issue by introducing a cross-platform mathematical framework aimed at the retrieval, analysis and modelling of dynamical features from hydrological datasets representing continuous and discrete physical processes of different nature. In doing so, a unified approach is devised for a more systematic and consistent analysis of hydrological processes and their interactions irrespective of whether they are governed by continuous, semi-discrete or fully discrete dynamical systems.

The novel methodological developments are then used to investigate emerging behaviours in climate and hydrological regimes not resolved by any of the individual classes of dynamical systems.

In the present study we are particularly interested in addressing flood regime changes, including seasonality changes and shifts between flood rich and flood poor periods. The new framework reveals that these changes may be associated to physical features emerging from nonlinear interactions in low-order dynamical models involving climate and land-related drivers.

The spatiotemporal variability and nonlinear twists of the causal relationships are also investigated, noting that drivers of flood change have different impacts on different spatial and temporal scales. In this regard, multilateral interactions, feedbacks and structural causal changes are found among oceanic, atmospheric and land-related processes, and their combined influence is seen to explain flood change patterns that could not be explained by linear superposition of individual drivers or static causal hierarchies.

In conclusion, investigating dynamical links between flood regime changes and a basic selection of key physical drivers may shed new light on the dynamical mechanisms justifying the existence of flood regimes, their non-periodic alternating transitions and long-term changes.