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Flood Regime Dynamics with Slow-Fast Landscape-Climate Feedbacks

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The dynamical evolution of flood regimes is evaluated in the general case whereby floods interact nonlinearly with coevolving climate and landscape factors at different scales.

For that purpose, a spatiotemporal analysis of the dynamic flood response to precipitation changes is conducted and a slow-fast nonlinear dynamical model is built linking flood regime dynamics with climate, landscape and their feedbacks. These involve nonlinear scale interactions, with landform evolution processes taking place at the millennial scale (slow dynamics), and climate adjusting in years to decades (fast dynamics).

A dynamic coevolution index is introduced relating spatiotemporal symmetry with relative characteristic celerities, which need to be taken into account in hydrological space-time trading. Coevolution is expressed here by the scale interaction between slow and fast dynamics, represented respectively by spatial and temporal characteristics of the hydroclimate dynamics.

The spatiotemporal analysis shows that in general floods are more responsive to spatial (regional) than to temporal (decadal) variability in its dominant controls, except in stable hydroclimatic regions.
In fact, on one hand catchments from stable dry lowlands and high wetlands exhibit similarity between spatial and temporal relative rates of change (spatiotemporal symmetry) and low landscape-climate codependence, suggesting they are not coevolving significantly. On the other hand, intermediate, dynamically evolving regions show differences between those sensitivities (symmetry breaks) and higher landscape-climate codependence, in line with undergoing coevolution. The break of symmetry is an emerging behaviour from nonlinear dynamic feedbacks within the hydroclimate system.

The dynamical model captures emerging features of the flood regime dynamics and nonlinear landscape-climate feedbacks, supporting the assessment of spatiotemporally asymmetric flood change.
Moreover, it informs on the precipitation and flood distribution at a given spatiotemporal position given the knowledge of the distribution or its drivers at another, along with their dynamic relation.
An example application is thus the estimation of hydroclimatic distributions in ungauged basins and their relation to areas where more information is available.

This study ultimately brings to light dynamical signatures of change in flood regimes arising from nonlinear slow-fast feedbacks in the landscape-climate dynamics, and provides dynamical links between flood regimes with nonlinearly interacting factors at different scales.

The present work builds on Perdigão and Blöschl (2014).
Perdigão, R. A. P., and G. Blöschl (2014), Spatiotemporal flood sensitivity to annual precipitation: Evidence for landscape-climate coevolution, Water Resour. Res., 50, doi:10.1002/2014WR015365.