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Emerging Processes in Flood Regime Dynamics: Evidence from Spatiotemporal Statistics and a Nonlinear Dynamical Model of Coevolution.

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Emerging Processes in Flood Regime Dynamics are evaluated on the basis of symmetry breaks in the spatiotemporal sensitivity of flood regimes to changes in annual precipitation and a new dynamical model of flood regime change under nonlinearly interacting landscape-climate dynamics.

The spatiotemporal sensitivity analysis is performed at regional scale using data from 804 catchments in Austria from 1976 to 2008. Results show that flood peaks change in a more responsive manner with spatial (regional) than with temporal (decadal) variability. Space-wise a 10% increase in precipitation leads to a 23% increase in flood peaks in Austria, whereas timewise a 10% increase in precipitation leads to an increase of just 6% in flood peaks.

Looking at hydroclimatic regions in particular, catchments from stable dry lowlands and high wetlands exhibit similarity between the spatial and temporal flood responses to changes in precipitation (spatiotemporal symmetry) and low landscape-climate codependence. This suggests that these regions are not coevolving significantly.
However, intermediate regions show differences between those responses (symmetry breaks) and higher landscape-climate codependence, suggesting undergoing coevolution.

The break of symmetry is an emergent behaviour of the coupled system, stemming from the nonlinear interactions in the coevolving hydroclimate system.
A dynamic coevolution index is then proposed 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.

The diagnostic assessment of coevolution is complemented by a stylised nonlinear dynamical model of landscape-climate coevolution, in which landform evolution processes take place at the millennial scale (slow dynamics), and climate adjusts in years to decades (fast dynamics).

Coevolution is expressed by the interplay between slow and fast dynamics, represented, respectively, by spatial and temporal characteristics of the hydroclimate system. The model captures key features of the joint landscape-climate distribution and associated flood regime changes, supporting the diagnostic assessment.

This paper ultimately brings to light signatures of emergence in flood regime dynamics that arise from the nonlinear coupling of the landscape-climate system at slow and fast time 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.