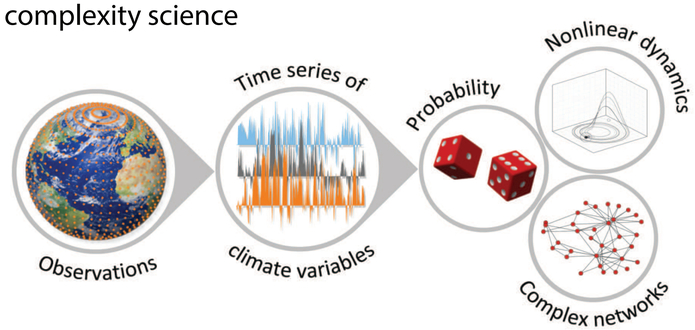
Atmospheric Rivers as Interacting Elements of the Earth System: A Complexity Science Perspective

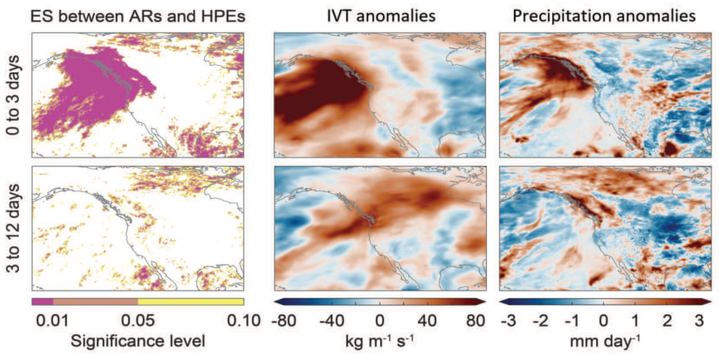
Sara M. Vallejo-Bernal[1,2]
Tobias Braun[1,2], Norbert Marwan[2,3], Ana Bastos[1], Miguel D. Mahecha[1], and Jürgen Kurths[2]

Atmospheric rivers through the lens of complexity science



What are the far-reaching effects of atmospheric rivers making landfall along the West Coast of North America?

Combining event synchronization (ES), a nonlinear temporal correlation measure, with synoptic-scale composite analysis, we reveal the role of atmospheric rivers (ARs) in the occurrence of inland heavy precipitation events (HPEs).



Intense, long-lasting ARs that make landfall along the coast of British Columbia in late summer can penetrate far inland, delivering the moisture needed to trigger heavy precipitation in central and eastern Canada.

Vallejo-Bernal et al. (2023). HESS, 27(14).

Atmospheric rivers lie at the intersection of weather and climate, interacting with all components of the Earth's climate system across a broad range of spatiotemporal scales.

By disentangling these interactions, complexity science can reveal hidden dynamics, advance impact attribution, and foster predictability while addressing uncertainty in atmospheric river science.

Credit: NASA's EPIC imager
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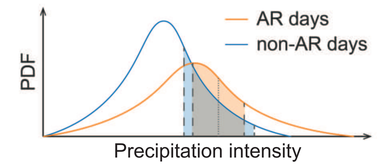
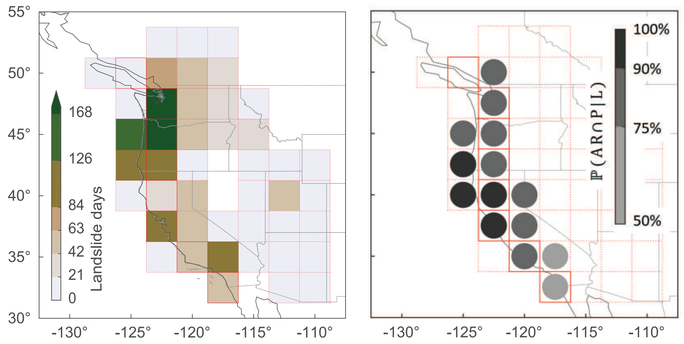
How many landslides can be attributed to atmospheric rivers making landfall along the West Coast of North America?

We propose a multi-step attribution framework.

Step 1: Employing probabilistic causality, we attribute precipitation to land-falling ARs.



Step 2: Employing event synchronization, we attribute the occurrence of landslides to AR-caused precipitation.



From 1996 to 2018, ARs caused 86% of landslide days in Western North America. The causal relation is statistically significant only along the West Coast.

Vallejo-Bernal et al. (2025). In preparation for GRL.

sara.vallejo@uni-leipzig.de

[1] Institute for Earth System Science and Remote Sensing, Leipzig University.
[2] Potsdam Institute for Climate Impact Research (PIK).
[3] Institute of Geosciences, University of Potsdam.

UNIVERSITÄT LEIPZIG

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Universität Potsdam