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Spectral Causality Measures for Land-Atmosphere Interactions

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This talk addresses the problem of detecting and inferring the strength and directionality (i.e. causality) of Land–Atmosphere (L-A) interactions from available observations of climatic and hydrological variables. Our still incomplete understanding of L-A interactions – their inherent complexity, non-stationary features and multi-scale character – is in fact one of the main sources of uncertainty in current climate modeling, with strong implications for our ability to predict in an accurate way future climate.
We apply different causality-detection techniques, based on spectral methods and continuous wavelet transform, to unravel the coupling between soil moisture and air temperature, and to give evidence of the importance of soil moisture memory for climate. The proposed mathematical techniques have previously shown the ability of disentangling directional couplings within synthetic multi-scale processes. Also, the frequency-domain causal techniques presented here show several advantages in analyzing L-A couplings and feedbacks when compared to classic methods based on linear correlations, since they are explicitly designed to detect causal couplings and to infer multi-scale and non-stationary relationships.
By applying these spectral causal metrics to newly developed satellite-based products and climate reanalysis data, we uncover the contribution of processes acting at different time scales to the build-up of global soil moisture-temperature coupling hot spots, addressing at the same time possible causal effects in land-atmosphere interactions.