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Critical transition analysis via a flux-based network approach

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A new method for constructing complex networks from fluid flow fields is proposed. The approach focuses on spatial properties of the flow field, namely, on the topology of the streamline field. The network approach is applied to a model of the wind-driven ocean circulation which exhibits the prototype of a critical transition, that is, a back-to-back saddle-node bifurcation related to two separate dynamical regimes. The network analysis enables a structural characterization of, on the one hand, the viscous regime as weakly-connected and highly-assortative regime, and, on the other hand, of the inertial regime as a highly-connected and weakly-assortative regime. Moreover, the network analysis enables a robust early-warning signal of the critical transition emerging from the viscous regime: The upcoming global regime change induced by the critical transition may be anticipated by a drastic decrease in the overall closeness of the network, which reflects a preceding local regime change in the flow field. Hence, the results support the application of network-based topology measures complementary to time-series based statistical properties as leading indicators of critical transitions.