DATA-DRIVEN ANTICIPATION AND PREDICTION OF ATLANTIC MERIDIONAL OVERTURNING CIRCULATION COLLAPSE USING NON-AUTONOMOUS SPATIO-TEMPORAL DYNAMICAL MODELLING

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A data-driven methodology for identifying, anticipating and predicting critical transitions in high-dimensional model or observational data sets is introduced, based on explicit non-stationary low-order modelling of the tipping dynamics, allowing for dynamical understanding of the underlying tipping mechanism and genuine prediction of the future system state by extrapolation. A set of spatial modes carrying the tipping dynamics are identified and a stochastic model of appropriate complexity is estimated in the subspace spanned by these modes. Analysis of the reconstructed dynamics allows to determine the proximity to a bifurcation point and the type of the impending bifurcation. Different competing tipping mechanisms can be compared and assessed using likelihood inference and information criteria. The method allows to quantify the likelihood or risk of a critical transition at some point in the future having observed a certain amount of data up to present. The methodology is here applied to a data set from a simulation of AMOC collapse with a complex climate model, actually a freshwater hosing experiment with the FAMOUS GCM. The AMOC on-state is found to lose stability via a subcritical Hopf bifurcation; however, the transition to the off-state occurs far ahead of the bifurcation point. The early collapse can be explained by a combination of rate-induced and noise-induced tipping.