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## A trajectories' guide to the state space - learning missing terms in bifurcating ecological systems

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Ecological systems typically can exhibit various states ranging from extinction to coexistence of different species in oscillatory states. The switch from one state to another is called bifurcation. All these behaviours of a specific system are hidden in a set of describing differential equations (DE) depending on different parametrisations. To model such a system as DE requires full knowledge of all possible interactions of the system components. In practise, modellers can end up with terms in the DE that do not fully describe the interactions or in the worst case with missing terms.

The framework of universal differential equations (UDE) for scientific machine learning (SciML) [1] allows to reconstruct the incomplete or missing term from an idea of the DE and a short term timeseries of the system and make long term predictions of the system's behaviour. However, the approach in [1] has difficulties to reconstruct the incomplete or missing term in systems with bifurcations. We developed a trajectory-based loss metric for UDE and SciML to tackle the problem and tested it successfully on a system mimicking algal blooms in the ocean.

[1] Rackauckas, Christopher, et al. "Universal differential equations for scientific machine learning." arXiv preprint arXiv:2001.04385 (2020).