EGU2020-20845, updated on 22 Jan 2021
https://doi.org/10.5194/egusphere-egu2020-20845
EGU General Assembly 2020

Learning Lyapunov stable Dynamical Embeddings of Geophysical Dynamics

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Within the geosciences community, data-driven techniques have encountered a great success in the last few years. This is principally due to the success of machine learning techniques in several image and signal processing domains. However, when considering the data-driven simulation of ocean and atmospheric fields, the application of these methods is still an extremely challenging task due to the fact that the underlying dynamics usually depend on several complex hidden variables, which makes the learning and simulation process much more challenging.

In this work, we aim to extract Ordinary Differential Equations (ODE) from partial observations of a system. We propose a novel neural network architecture guided by physical and mathematical considerations of the underlying dynamics. Specifically, our architecture is able to simulate the dynamics of the system from a single initial condition even if the initial condition does not lie in the attractor spanned by the training data. We show on different case studies the effectiveness of the proposed framework both in capturing long term asymptotic patterns of the dynamics of the system and in addressing data assimilation issues which relates to the short term forecasting performance of our model.