EGU21-15678
https://doi.org/10.5194/egusphere-egu21-15678
EGU General Assembly 2021

Jointly learning variational data assimilation models and solvers for geophysical dynamics

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This paper addresses representation learning for the resolution of inverse problems with geophysical dynamics. Among others, examples of inverse problems of interest include space-time interpolation, short-term forecasting, conditional simulation w.r.t. available observations, downscaling problems... From a methodological point of view, we rely on a variational data assimilation framework. Data assimilation (DA) aims to reconstruct the time evolution of some state given a series of observations, possibly noisy and irregularly-sampled. Here, we investigate DA from a machine learning point of view backed by an underlying variational representation. Using automatic differentiation tools embedded in deep learning frameworks, we introduce end-to-end neural network architectures for variational data assimilation. It comprises two key components: a variational model and a gradient-based solver both implemented as neural networks. A key feature of the proposed end-to-end learning architecture is that we may train the neural networks models using both supervised and unsupervised strategies. We first illustrate applications to the reconstruction of Lorenz-63 and Lorenz-96 systems from partial and noisy observations. Whereas the gain issued from the supervised learning setting emphasizes the relevance of groundtruthed observation dataset for real-world case-studies, these results also suggest new means to design data assimilation models from data. Especially, they suggest that learning task-oriented representations of the underlying dynamics may be beneficial. We further discuss applications to short-term forecasting and sampling design along with preliminary results for the reconstruction of sea surface currents from satellite altimetry data.

This abstract is supported by a preprint available online: https://arxiv.org/abs/2007.12941