Graph-based Neural Weather Prediction for Limited Area Modeling

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Abstract

The rise of accurate machine learning methods for weather forecasting is creating radical new possibilities for modeling the atmosphere. In the time of climate change, having access to high-resolution forecasts from models like these is also becoming increasingly vital. While most existing Neural Weather Prediction (NeurWP) methods focus on global forecasting, an important question is how these techniques can be applied to limited area modeling. In this work we adapt the graph-based NeurWP approach to the limited area setting and propose a multi-scale hierarchical model extension. Our approach is validated by experiments with a local model for the Nordic region.

1 Introduction

Accurately forecasting weather is an immense challenge, but also a problem with broad impact on society. Today, Numerical Weather Prediction (NWP) systems combine vast amounts of physics knowledge with powerful computational resources in order to model the atmosphere. Performing these computations is however time-consuming, limiting the possibility to model finer resolutions and detect rare events [1]. Forecasting these events is vital in adapting society to the effects of climate change [2]. Recently, data-driven machine learning models have shown impressive weather forecasting performance, matching or even outperforming existing NWP systems [3–5]. These Neural Weather Prediction (NeurWP) models produce forecasts in a fraction of the time of traditional NWP, opening up many new possibilities. One successful family of NeurWP models, that we focus on in this work, utilize Graph Neural Networks (GNNs) to produce forecasts [6, 5]. As these models are trained on NWP data, with built-in physics assumptions, they represent a useful blend of existing knowledge and new possibilities introduced by machine learning.

While most existing work in NeurWP has been focused on global weather forecasting, it is of substantial interest how these methods can be utilized also for Limited Area Models (LAMs). Such local models are used by many institutes to create high resolution forecasts for specific regions of interest [7–14]. In this paper we adapt graph-based NeurWP to the limited area setting, and also introduce a hierarchical model extension.[1] The graph-based framework is an attractive choice for LAMs due to the freedom in designing the associated graphs. By choosing these graphs appropriately, a general model formulation can be applied to regions of different shape or alignment with global coordinate systems. We evaluate our graph-based models on a dataset from the MetCoOp Ensemble Prediction System (MEPS) LAM [7].

Climate Impact Due to climate change, access to efficient and accurate weather modeling is increasingly important. Fast NeurWP LAMs contribute to climate change mitigation and adaptation

[1] Our code is available at `https://github.com/joeloskarsson/neural-lam`.

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