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Physics-Informed Machine Learning to Predict Extreme Weather Events

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Abstract:

Extreme weather events refer to unexpected, severe, or unseasonal weather events, which are dynamically related to specific large-scale atmospheric patterns. These extreme weather events have a significant impact on human society and also natural ecosystems. For example, natural disasters due to extreme weather events caused more than $90 billion global direct losses in 2015. These extreme weather events are challenging to predict due to the chaotic nature of the atmosphere and are highly correlated with the occurrence of atmospheric blocking. A key aspect for preparedness and response to extreme climate events is accurate medium range forecasting of atmospheric blocking events.

Unlike the conventional approach based on numerical weather forecasting, we propose a new machine learning approach to make binary classification predictions based on recurring patterns from multi-dimensional data of time-evolving atmospheric flow patterns. This approach enables us to focus on the intrinsic connection between extreme weather events and the surrounding large-scale atmospheric patterns. We build an empirical model using Convolutional Neural Networks to classify the 2D atmospheric flow patterns images to predict whether that would cause an extreme weather event or not. We retrieve the spatio-temporal data from the dataset by converting them into coarse-graining images and categorizing and labeling them to predict extreme weather events. These categorized images are then fed to the Neural Network to give us the final prediction. We use a CNN with 4 Convolutional layers, which provides the best accuracy compared to when we have more or fewer layers.

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