ClimateNet: Machine Learning for Extreme Weather Detection

Abstract

Climate change has intensified the need for accurate and scalable detection of extreme weather events such as tropical cyclones (TCs) and atmospheric rivers (ARs). Traditional detection techniques rely heavily on threshold-based or heuristic rules that often miss smaller or borderline events. To address this, Prabhat et al. (2021) introduced ClimateNet, a machine learning framework combined with an expertly labeled dataset derived from Community Atmospheric Model (CAM5.1) outputs. The methodology involves applying deep convolutional neural networks (CNNs), particularly a U-Net and later a Context-Guided Network (CGNet) architecture, to perform semantic segmentation of 2D climate variable maps. These inputs include atmospheric features like wind, pressure, and humidity. The model is trained to perform pixel-level classification to identify TCs and ARs. Comparative analysis with standard threshold-based detection methods demonstrates that ClimateNet achieves higher recall and precision, especially in detecting small-scale or ambiguous weather events. This advancement underscores the potential of deep learning in improving the granularity and reliability of climate pattern recognition. This project is grounded in the framework and results presented by Prabhat et al. and reflects an ongoing research direction in applying machine learning to Earth system science and climate analytics.

Reference

[1] Prabhat, Balaprakash, P., et al. (2021). *ClimateNet: An expert-labelled open dataset and deep learning architecture for enabling high-precision analyses of extreme weather*. Geoscientific Model Development, 14(1), 107–124. https://doi.org/10.5194/gmd-14-107-2021

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