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Advancing Earth Science Predictive Modeling through Machine Learning and Deep Learning: A Multidisciplinary Approach

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Abstract

Wildfires pose an increasing threat to ecosystems, infrastructure, and public health, with smoke emissions significantly impacting air quality and climate. Fire-induced smoke emissions are influenced by numerous factors, including fire size, intensity, atmospheric conditions, and fuel bed composition. However, traditional environmental models for predicting smoke emissions face challenges such as high computational costs and inadequate parameterization of complex processes, limiting their predictive accuracy.

This study leverages Artificial Intelligence to analyze vast datasets, uncover hidden patterns, and enhance the accuracy of wildfire smoke emission predictions. Using NASA's Big Data, including 24 years of historical environmental variables, we developed machine learning (ML) and deep learning models to improve wildfire smoke forecasting. Our results demonstrate that Long Short-Term Memory (LSTM)-based deep learning models outperform other ML-based approaches in predicting fire-induced smoke emissions during wildfire seasons.

To further refine predictive performance, we aim to address spatial variability through the implementation of Convolutional Neural Networks. This approach will enhance the model's ability to capture spatial dependencies in wildfire-related data, ultimately improving predictive capabilities for wildfire management and environmental resilience.