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Editorial: Leveraging AI and machine learning for enhanced extreme weather forecasting

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Editorial on the Research Topic
Leveraging AI and machine learning for enhanced extreme weather forecasting

Approaches that rely on data and computation to link present and future weather conditions, often referred to as artificial intelligence or machine learning (AI/ML), have shown strong performance relative to the state of the art in weather forecasting. However, their utility for forecasts of extreme events is not as clear. On the one hand, the low likelihood of extreme events makes developing data-driven models for them more challenging. On the other hand, the severe impacts of many extreme events makes it particularly important for their forecasts to be skillful and well calibrated. The purpose of the present Research Topic was to assemble in one forum a broad range of current perspectives and results on this difficult problem.

Two contributions to the Research Topic were reviews of work in the area over the past decade or so. Kim and Kim surveyed keywords in thousands of articles on AI/ML extreme-weather prediction and response to identify 5 topical clusters that correspond to successful main research thrusts in this field, while also finding less mature research areas, such as those related to heatwave prediction. Ayaz et al. reviewed studies using ML models to predict health outcomes associated with extreme weather events, finding that here heatwaves were the main extreme event studied, although work was concentrated in high-income countries.

The other four contributions are more focused studies of ML methods for analyzing weather phenomena. Shandilya et al. evaluated a neural network architecture for classifying weather state based on outdoor images. Rezvov et al. deployed a neural network to downscale reanalysis winds to the same higher resolution as achieved by a regional weather model over the Barents and Kara Seas, finding that this downscaling was computationally efficient compared to the regional model and improved wave-height accuracy where buoy data were available. An et al. used a hierarchy of tree-based ML models to identify large-scale meteorological conditions from reanalysis associated with short-term heavy precipitation over the Yangtze River Delta. Finally, Megahed et al. compared several ML methods for identifying flood zones in Egypt's Red Sea Mountains as a function of hydro-topographic and geological predictors, where the developed models could then be used to estimate changes in susceptibility under continued global warming.

Overall, the publications under this Research Topic highlight the progress made in using AI/ML to respond more effectively to several kinds of extreme weather, while also pointing

out gaps in research and capabilities. Further progress will require not only methodological and computational advances but also long-term consistent collection of high-quality data and sustained integration with planning as well as emergency services.

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