EGU22-591
https://doi.org/10.5194/egusphere-egu22-591
EGU General Assembly 2022

Identifying precursors for extreme stratospheric polar vortex events using an explainable neural network

Zheng Wu[1], Tom Beucler[2], Raphaël de Fondeville[3], Eniko Székely[3], Guillaume Obozinski[3], William Ball[4], and Daniela Domeisen[1,2]

[1]ETH Zürich, Zurich, Switzerland
[2]Institute of Earth Surface Dynamics, of Lausanne, Lausanne, Switzerland
[3]Swiss Data Science Center, ETH Zürich and EPFL, Switzerland
[4]Department of Geoscience and Remote Sensing, Faculty of Civil Engineering and Geosciences, TU Delft, the Netherlands

The winter stratospheric polar vortex exhibits considerable variability in both magnitude and zonal wave structure, which arises in part from stratosphere-troposphere coupling associated with tropospheric precursors and can result in extreme polar vortex events. These extremes can subsequently influence weather in the troposphere and thus are important sources of surface prediction. However, the predictability limit of these extreme events is around 1-2 weeks in the state-of-the-art prediction system. In order to explore and improve the predictability limit of the extreme vortex events, in this study, we train an artificial neural network (ANN) to model stratospheric polar vortex anomalies and to identify strong and weak stratospheric vortex events. To pinpoint the origins of the stratospheric anomalies, we then employ two neural network visualization methods, SHapley Additive exPlanations (SHAP) and Layerwise Relevance Propagation (LRP), to uncover feature importance in the input variables (e.g., geopotential height and background zonal wind). The extreme vortex events can be identified by the ANN with an averaged accuracy of 60-80%. For the correctly identified extreme events, the composite of the feature importance of the input variables shows spatial patterns consistent with the precursors found for extreme stratospheric events in previous studies. This consistency provides confidence that the ANN is able to identify reliable indicators for extreme stratospheric vortex events and that it could help to identify the role of the previously found precursors, such as the sea level pressure anomalies associated with the Siberian high. In addition to the composite of all the events, the feature importance for each of the individual events further reveals the physical structures in the input variables (such as the locations of the geopotential height anomalies) that are specific to that event. Our results show the potential of explainable neural networks techniques in understanding and predicting the stratospheric variability and extreme events, and in searching for potential precursors for these events on subseasonal time scales.