Deep learning for extreme wind speed prediction with CyGNSSnet

Arnold, Caroline[1]; Zhao, Daixin[3]; Xiao, Tianqi[2]; Mou, Lichao[3]; Asgarimehr, Milad[2]

1 German Climate Computing Center DKRZ, Hamburg, Germany

2 German Research Centre for Geosciences GFZ, Potsdam, Germany

3 German Aerospace Center DLR, Oberpfaffenhofen, Germany

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Abstract

The CyGNSS (Cyclone Global Navigation Satellite System) satellite system measures GNSS signals reflected off the Earth's surface. A global ocean wind speed dataset is derived, which fills a gap in Earth observation data and can improve cyclone forecasting. We proposed CyGNSSnet(1), a deep learning model for predicting wind speed from CyGNSS observables, and found an improved performance of 29% compared to the current operational model. However, the prediction of extreme winds remained challenging: For wind speeds exceeding 12 m/s, the operational model outperformed CyGNSSnet.

Here, we explore methods in machine learning to improve the performance of CyGNSSnet at high wind speeds. We introduce a hierarchical model, where we first train separate instances for CyGNSSnet for samples below and above a given wind speed threshold. In addition, we train a classifier that selects whether a given CyGNSS Delay Doppler map (DDM) corresponds to a wind speed below or above that threshold. In inference, we apply the suitable model. In addition, we explore strategies to improve the wind speed predictions by using weights in training, and we discuss the potentials and shortcomings of the approaches.

[1] Asgarimehr, M., Arnold, C., Weigel, T., Ruf, C. & Wickert, J. GNSS reflectometry global ocean wind speed using deep learning: Development and assessment of CyGNSSnet. Remote Sensing of Environment 269, 112801 (2022).