An End-to-end Deep Learning Approach for Analyzing Tropical Cyclone 2-D Surface Winds Utilizing Satellite Data

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Abstract

Although tropical cyclone (TC) forecasts can fairly well capture the TC track and primary rainfall distribution, limited skills are found in forecasting TC structural changes and asymmetric gusty winds. The barrier to further understanding TC structural change is due mainly to the lack of observation, and it is difficult to have systematic 2-D wind analyses. Here, we developed a deep learning model — Deep Learning 2-D Structure Analysis Model for Tropical Cyclones (DSAT-2D) — to produce TC wind analysis in high-temporal-spatial resolutions based on generative adversarial networks (GAN). We use IR1 satellite observation and ERA5 reanalysis data as the model input for the DSAT-2D. The ASCAT surface wind data were collected and used as the label data. Note, however, that the ASACT analysis tends to underestimate winds greater than 15 m/s. Thus, we proposed several methods to fix this issue before training the model. Furthermore, other innovative designs in the DSAT-2D model include: (i) we regrid all data in a polar coordinate, and (ii) we also set the target of the DSAT-2D model as the TC radial wind and tangential wind.

Experiment results demonstrate that the DSAT-2D model can capture the TC asymmetric wind structure while possessing the capability of increasing the maximum estimation frequency from approximately 12 hours (e.g., ASCAT data) to less than one hour. The DSAT-2D model may help understand the TC asymmetric wind evolution and improve TC forecasts.