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Two-Stage Estimation of Tropical Cyclone Intensity Based on Fusion of Coarse and Fine-Grained Features from Satellite Microwave Data

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Abstract : Accurate estimation of tropical cyclone intensity is of great importance for disaster prevention and mitigation. Existing techniques are largely based on satellite imagery data, and research and utilization of the inner thermal core structure characteristics of tropical cyclones still pose challenges. This paper presents a two-stage tropical cyclone intensity estimation network based on the fusion of coarse and fine-grained features from microwave brightness temperature data. The data used in this network are obtained from the thermal core structure of tropical cyclones through the Advanced Technology Microwave Sounder (ATMS) inversion. Firstly, the thermal core information in the pressure direction is comprehensively expressed through the maximal intensity projection (MIP) method, constructing coarse-grained thermal core images that represent the tropical cyclone. These images provide a coarse-grained feature range wind speed estimation result in the first stage. Then, based on this result, fine-grained features are extracted by combining thermal core information from multiple view profiles with a distributed network and fused with coarse-grained features from the first stage to obtain the final two-stage network wind speed estimation. Furthermore, to better capture the long-tail distribution characteristics of tropical cyclones, focal loss is used in the coarse-grained loss function of the first stage, and ordinal regression loss is adopted in the second stage to replace traditional single-value regression. The selection of tropical cyclones spans from 2012 to 2021, distributed in the North Atlantic (NA) regions. The training set includes 2012 to 2017, the validation set includes 2018 to 2019, and the test set includes 2020 to 2021. Based on the Saffir-Simpson Hurricane Wind Scale (SSHS), this paper categorizes tropical cyclone levels into three major categories: pre-hurricane, minor hurricane, and major hurricane, with a classification accuracy rate of 86.18% and an intensity estimation error of 4.01m/s for NA based on this accuracy. The results indicate that thermal core data can effectively represent the level and intensity of tropical cyclones, warranting further exploration of tropical cyclone attributes under this data.

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