

## Volumetric Detection of Tornadic Vortices Associated with Typhoon Nanmadol (2017) Using PAWR and Deep Learning

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Tornadoes spawned by miniature supercells associated with typhoon are one of critical issues for disaster risk reduction in Japan. However, it is not easy to monitor and predict their occurrence because the parent storm is considerably small compared with classic-type tornadic supercell. We try to overcome this problem by combining cutting-edge technologies using rapid-scan phased array weather radar (PAWR) and deep learning analysis. We present a case study of tornado-like vortices which caused damages in Souka city, Saitama, during the approach of Typhoon Nanmadol (2017). We performed data analysis of two rapid-scan phased array weather radars operated by Meteorological Research Institute in Tsukuba and operated by Japan Radio Co., Ltd. in Chiba. To detect vortices from the PAWR-observed Doppler velocity data, we employed a vortex pattern finding scheme using convolutional neural network. Since PAWR carries out quasi-simultaneous observation of multi-elevational angles, we considered a group of vortices located in a radius of 4-km as a single vertically-extending volumetric vortex. By analyzing the spatiotemporal structure, we found a significant growth of a tornadic vortex about five minutes prior to its passage over the ground damage area. This finding suggests that a combination of rapid-scan PAWR observation and deep learning analysis is useful for monitoring and short-term forecasting of tornadoes associated with typhoon.

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