TorSight: Transitioning From Tornado Detection to Prediction Through Pre-Tornadic Signatures

Gao, Jack (School: Thomas Jefferson High School for Science and Technology)

Tornadoes are among the deadliest and costliest weather phenomena in our world and remain challenging to predict despite significant advancements in weather forecasting. Current tornado forecasting relies on mathematical algorithms to identify existing tornadoes; however, these algorithms have high false alarm rates, intensive computational requirements, and no predictive capability. By taking on the challenge of identifying pre-tornadic signatures, TorSight aims to replace these detection algorithms, crucially enabling tornado forecasting to move from detection to prediction, and identifying the minute features between standard convective systems and tornadoes that current models and studies struggle to recognize. This was achieved through a multi-layer convolutional neural network, a type of model often used for complex image analysis, trained on a dataset of over two hundred thousand storm events, which was adapted to enable pre-tornadic signature detection. To refine the model's skill, the number of layers, learning rate, start filters, label smoothing, and other hyperparameters were tuned across multiple trials. TorSight surpasses the current operational tornado detection algorithms even while detecting pre-tornadic signatures 5 minutes before tornado formation with an area under the receiver-operating-characteristic curve (AUC) of 0.8660, an area under the performance diagram (AUC-PD) of 0.5546, and a critical success index (CSI) of 0.3363. This study demonstrates the viability of pre-tornadic detection models for replacing current operational algorithms and their potential to drastically increase tornado lead times, while also providing invaluable insights into the specific structures involved in tornado formation and helping to prove the Rotunno hypothesis.

Awards Won:

Third Award of $1,200