A Python-Based Tracking Algorithm for Coarse Temporal Resolution WRF-Simulated Supercells

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Overview

The purpose of the this algorithm is track supercells within a 'coarse' temporal resolution dataset.

- The dataset is composed of two dynamically-downscaled 13 year 4 km WRF simulations of the CONUS, under two different climate conditions, a modern and future climate (Li et al. 2016).
- Only 2D surface data and reflectivity data is available hourly; 3D variables are only available every 3 hours.
- Data storage issues (192 TB) forced the authors to store the data in this manner; the main challenge was determining how to track supercells without having explicit information hourly.

General Flow of the Tracking Process

4 km grid spacing WRF data with coarse temporal resolution (Li et al. 2016)

Three hourly 3D atmospheric data (i.e. Full wind profiles and temperature profiles)

Hourly 2D Reflectivity Data

Hourly 2D Surface Data

Calculation of needed parameters (Updraft helicity, vertical velocity, Bunker's Storm Motion, Mean Wind, etc.)

Ingest into modified TINT tracking after converting into Py-ART format

Using 3 hourly data to infer hourly locations

Determination if cell is a supercell

A cell was flagged as a supercell if:

- the cell was isolated and
- an hourly dBZ of 45 was observed and
- UH > 25 m^2s^{-2} or
- cell location tracked closer to the estimated Bunker's storm motion location vs the estimated mean wind location at non-3D variables hours

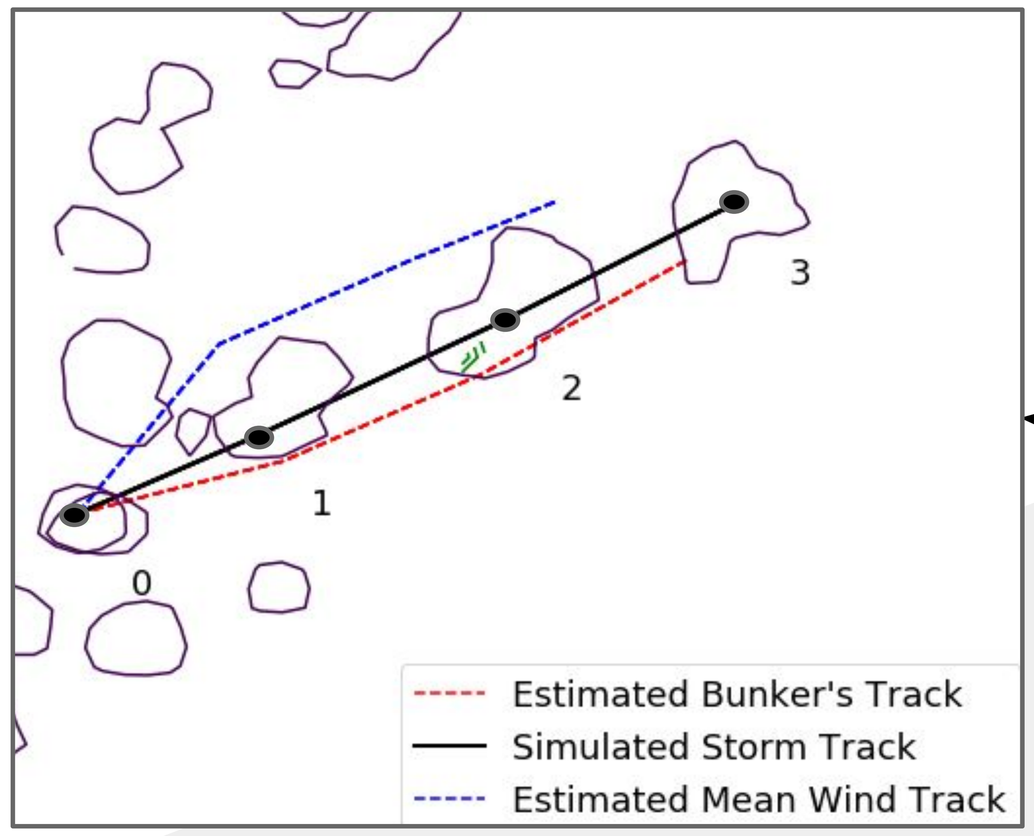
***Key Point*: Hourly reflectivity data is used to track convective cells, while the 3 hourly data is used to infer if the cell is supercellular by estimating where it 'should' be.**

Implementation

Given the quality of available Python packages for handling certain types of data ingestion and tracking, we started from pre-developed packages.

- The Py-ART radar package was used a starting point (Helmus and Collins 2016). Py-ART did not have an explicit feature for handling simulated radar data, so a 'WRF object to Py-ART object' script was formulated that allowed for Py-ART to handle the WRF radar data.
- The Py-ART implementation was necessary as the radar tracking library TINT (Picel et al. 2018) was then used for tracking of cells. While TINT is not formulated for hourly temporal resolution, the library was adjusted to allow for this.
- Lastly, the WRF-Python (Ladwig 2017), library was used for calculations involving the 3D WRF data.

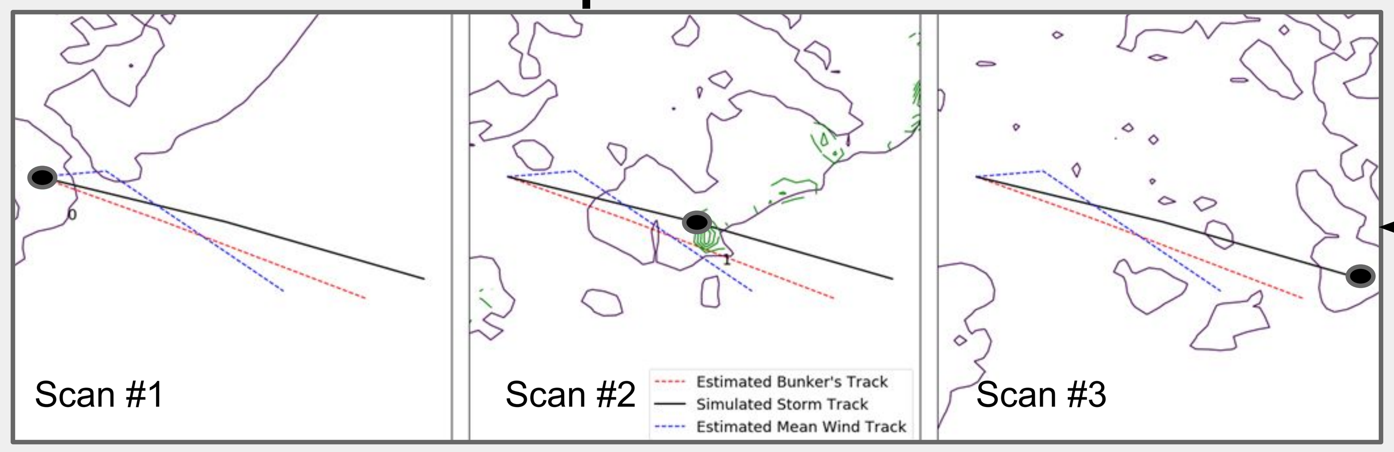
Sample Supercell Case



Example of supercell:

- Overlay of four consecutive simulated radar scans. Purple lines are outlines of 45+ dBZ reflectivity, for ease of visualization. Blue and red line indicate the inferred location of the cell based on mean wind and Bunker's motion, respectively. Black indicates the observed track of the max reflectivity centroid.
- Only time #2 contained full 3D information; the positions at time #0, #1, and #3 were inferred based on the Bunker's motion at time #2. Given the presence of high UH (small area of green at #2) and the close following of the cell to the Bunker's motion relative to the mean wind estimation, this cell was assumed to be supercellular

Sample Null Case



Example of a null case:

Three consecutive simulated radar scans from left to right. Purple lines are outlines of 45+ dBZ reflectivity. Despite the presence of high UH (green area at #2), the cells shown here were not sufficiently isolated and thus not considered supercells.

Future Work

The algorithm is being used within a larger project of assessing the impact of climate change on supercell thunderstorms

- Using the described process, each supercell will be tracked in each 13 year simulation.
- Mesoscale and storm scale characteristics of the modern and future supercells will be collected and compared.
  - Identifying changes in lifetime, initiation, changes in convective type, unique environments in the future, etc.
- These results will then be used to help drive idealized simulations of future supercells to further assess storm scale dynamics in modern and future supercells