Investigating the Vertical Structure of Updraft Helicity in An Idealized Supercell Simulation

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Introduction

- Updraft helicity (UH) is commonly used as a forecasting parameter in convection-allowing models (CAMs) to identify rotation in simulated storms
- UH is calculated between two layers:

$$UH = \int_{z1}^{z2} w\,\zeta\,dz$$

where ζ is vertical vorticity and the layer is typically 2-5km for mid-level rotation and 0-3km for low-level rotation

- The vertical structure of wζ in simulations of real environments is complex, with areas of both positive and negative wζ within the 2-5km layer (Milne, et. al 2018).

Methodology

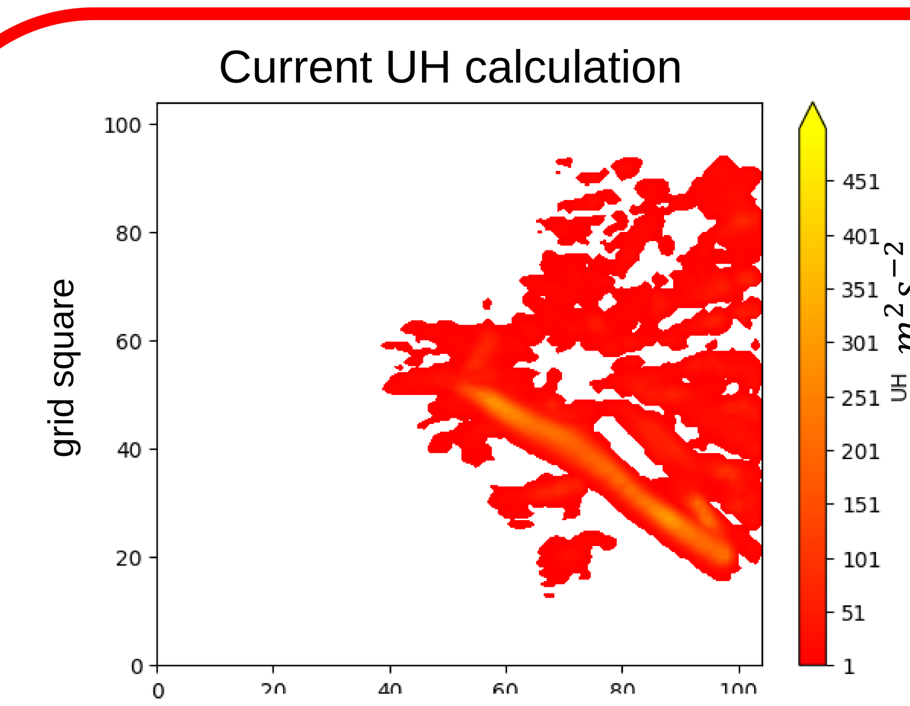
- Run 3km NSSL-WRF:
  - Output full wind field and hourly maximum UH every 5 minutes
  - WRFv3.4.1
  - WSM6 microphysics, no PBL
  - 3km horizontal grid spacing, 41 vertical levels, 12s time step
  - 5- or 10-hour simulation
  - 105x105 or 210x210 grid square domain, depending on length of simulation
- Compute instantaneous ζ and wζ from wind field every 5 minutes
- Run with several different initial soundings, including default supercell sounding

New UH Calculation

- Want new method to scale vertically with storm
- Don't want to include downdrafts in new UH calculation
- Integrate from surface until lowest level of downward w
- Consider positive and negative ζ separately:
  - If ζ > 0, then $HMAX(\int_0^{Z_{w<0}} w\zeta dz)$
  - If ζ < 0, then $HMIN(\int_0^{Z_{w<0}} w\zeta dz)$
  - Output height at which calculation stops
- Calculations currently done in post-processing

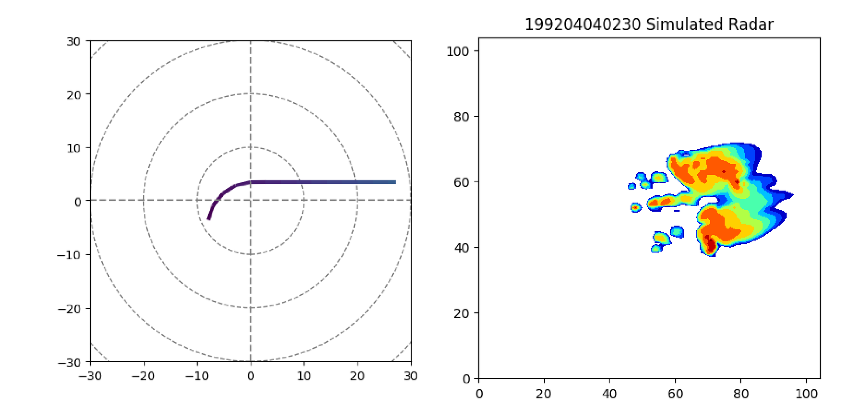
Conclusions and future work

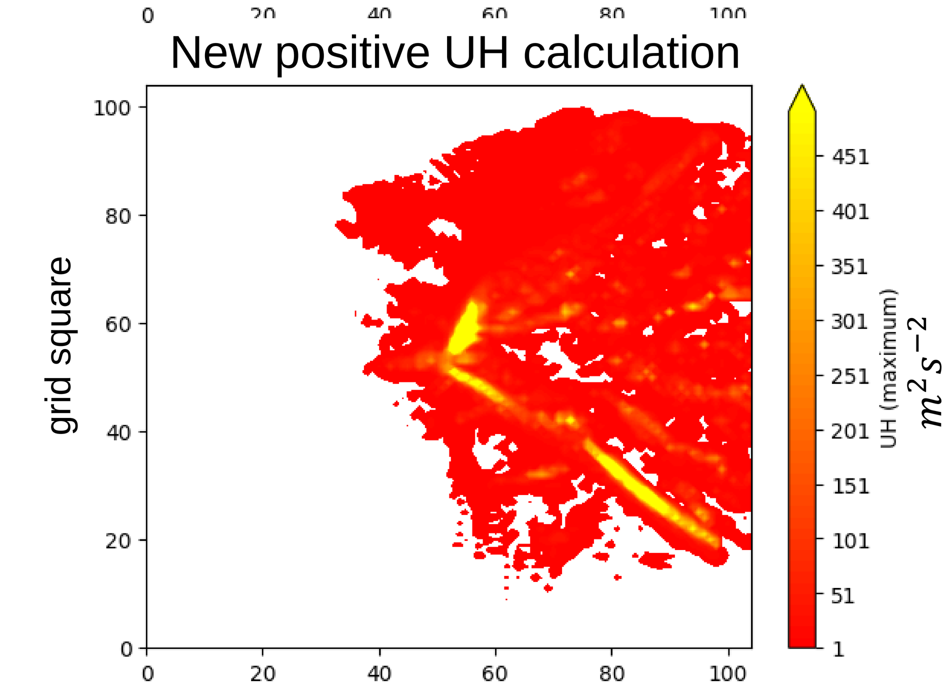
- New UH calculation captures more information than current calculation
- The information about the top of the calculation could provide useful information about the vertical structure of a storm, but more research is needed.
- Future work includes putting the new calculation in WRF and testing on real cases.

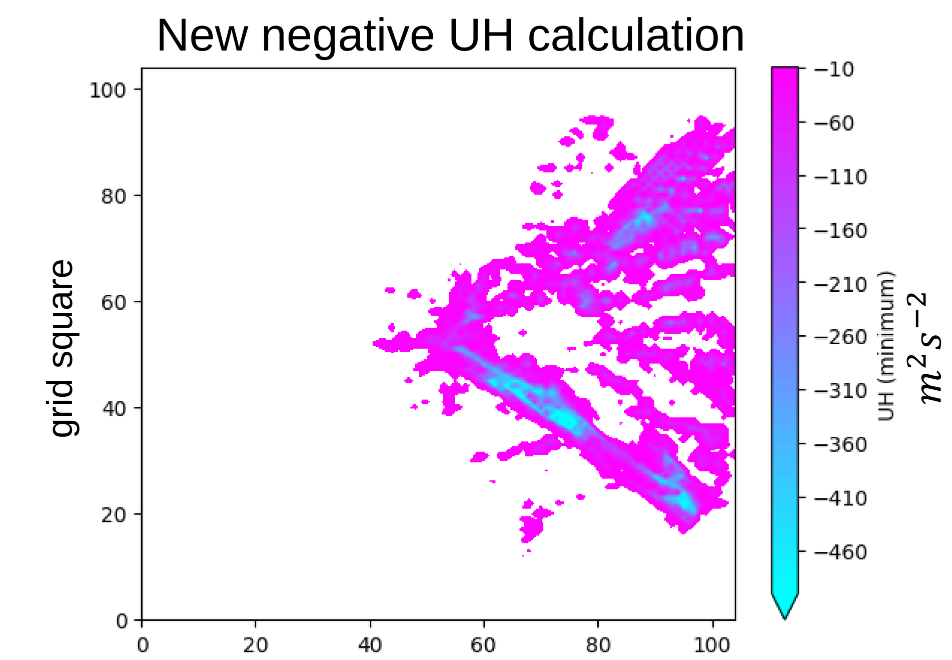


Supercell Case

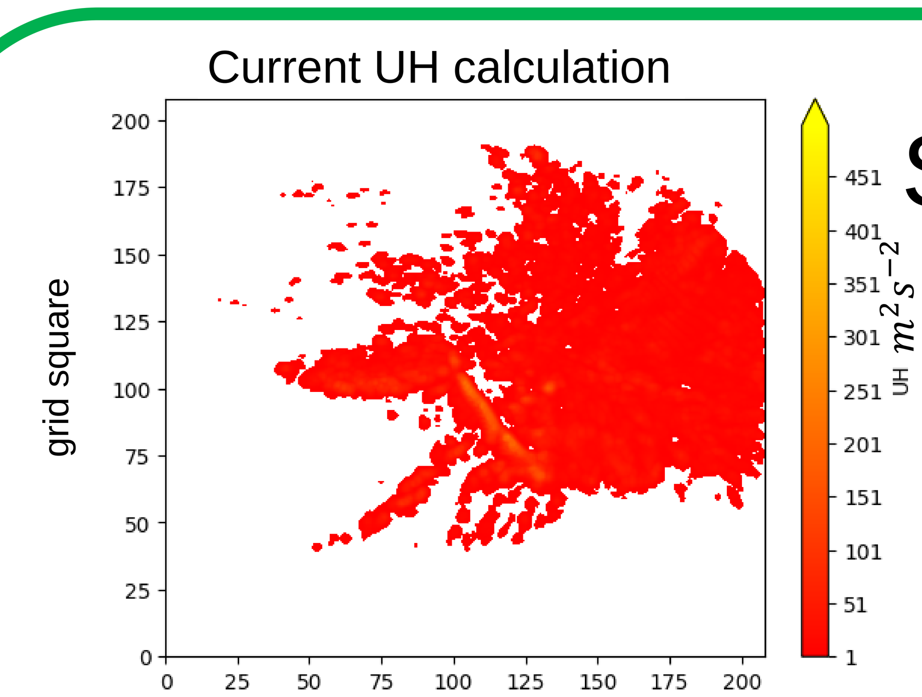
- 5-hour simulation
- All UH fields are total accumulation





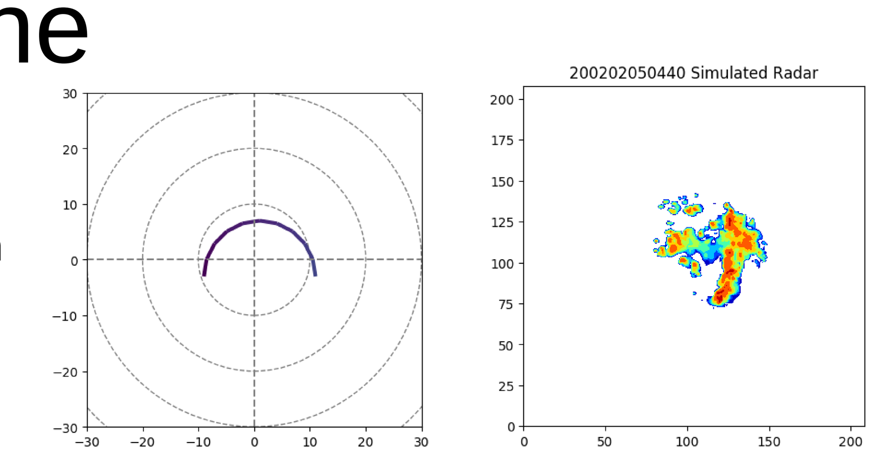


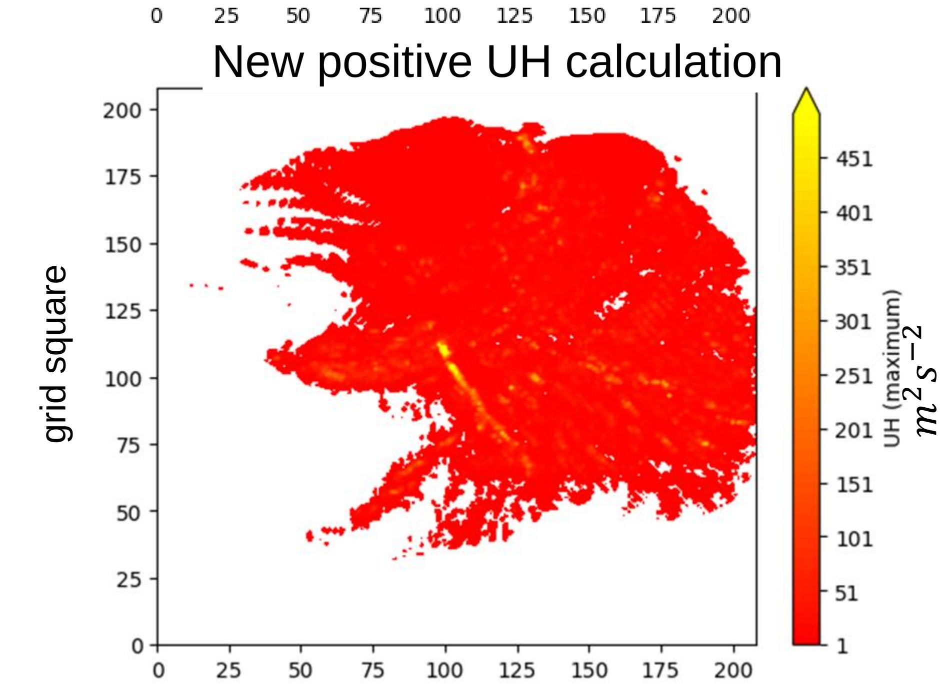
- The left mover is heavily emphasized in the new positive UH calculation
- Relative minimum in positive calculation coincides with relative maximum in new negative UH calculation

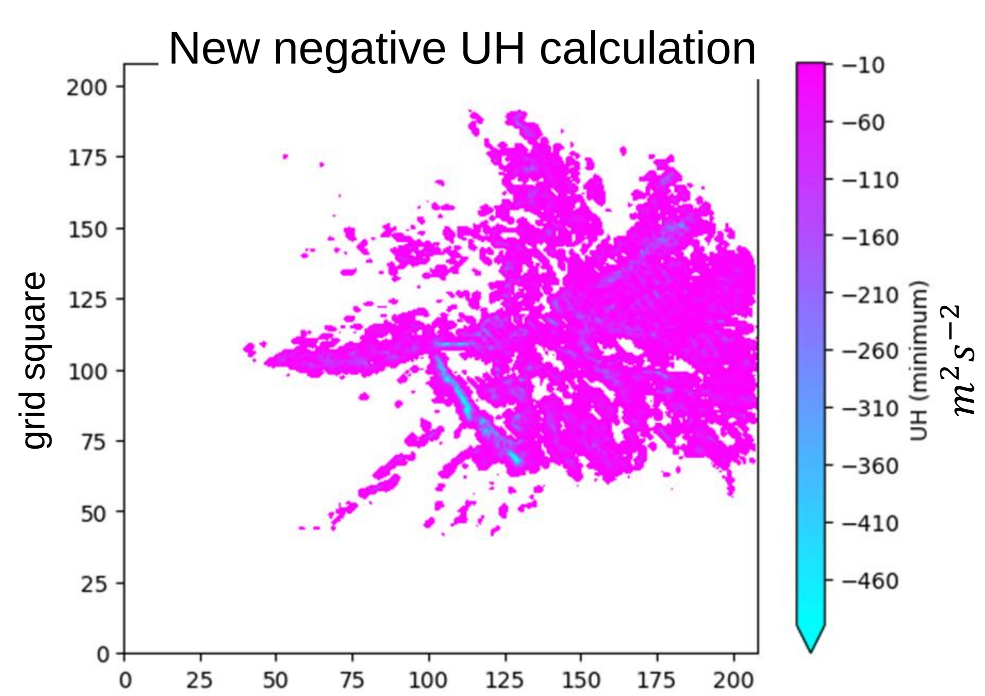


Squall Line Case

- 10-hour simulation
- All UH fields are total accumulation







- Right mover initially emphasized in new positive UH calculation
- Right mover more apparent in new negative UH calculation