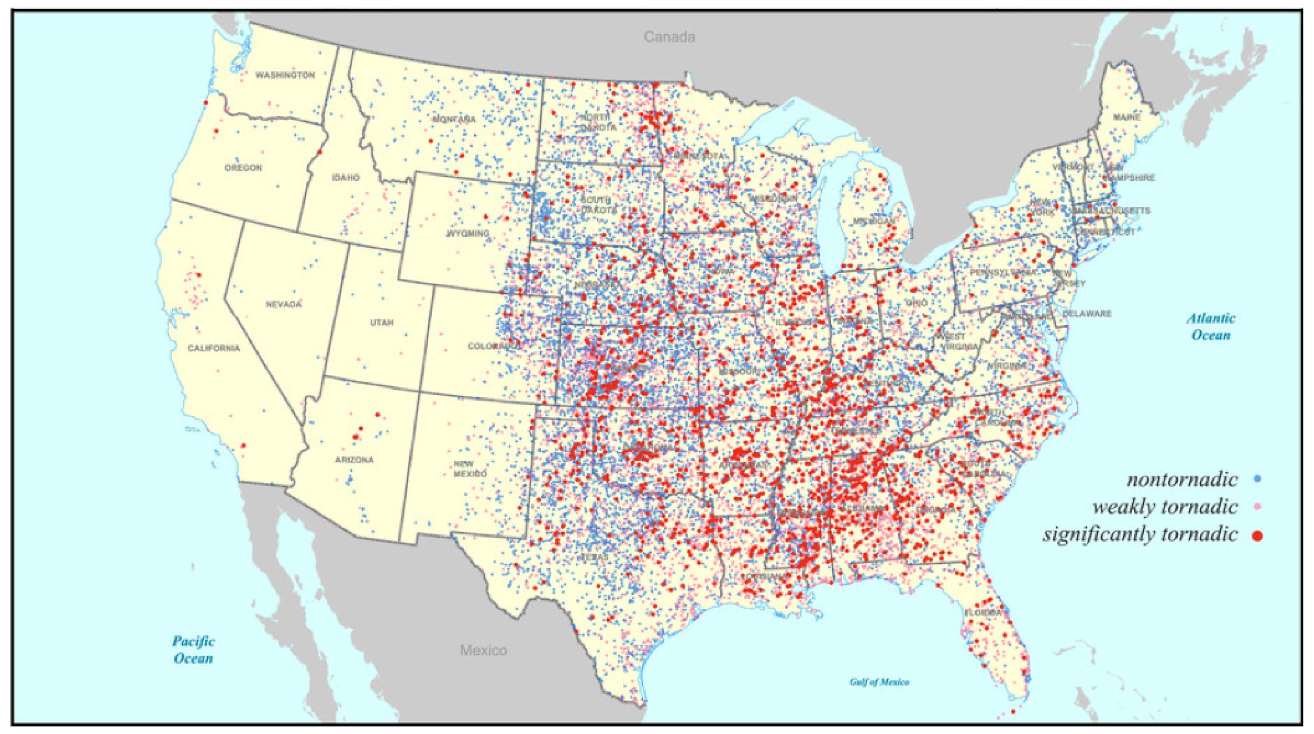
Exploring the operational utility of entraining CAPE in supercell tornado forecasting

Brice Coffer, Kelton Halbert, John Peters, Richard Thompson
North Carolina State Univ/, CIWRO/The Univ. of Oklahoma, Pennsylvania State Univ.,NOAA/Storm Prediction Center

CAPE has little skill at differentiating nontornadic from significantly tornadic supercells across a wide range of cases

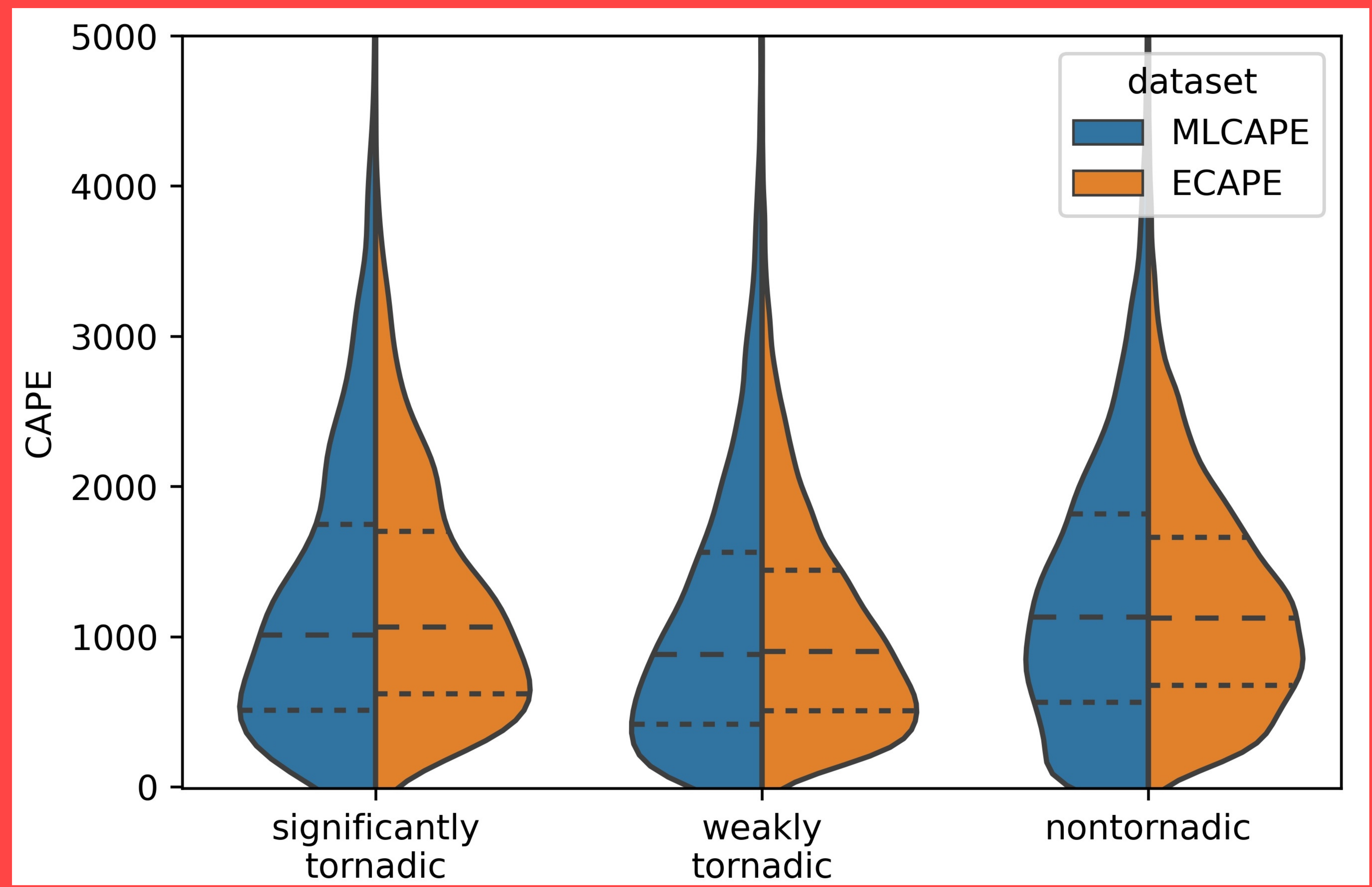
- Despite widespread use in convection forecasting, the main benefit of CAPE appears to be delineating where deep convection is possible and where it is unlikely.
- A significant fraction of severe weather events occur in low buoyancy environments, with less than 500 J/kg of CAPE.
- The formulation of CAPE makes many assumptions using parcel theory and does not accurately reflect maximum updraft speeds within simulations of supercells.

SPC Storm Mode Database



- Supercells were identified from radar characteristics for the years of 2005-2021 for tornadic supercells and 2005-2017 for nontornadic supercells (Smith et al. 2012), resulting in 23,703 supercells with 2,066 significant tornadoes (EF2+), 10,798 weak tornadoes (EF0-1), and 10,839 nontornadic storms.
- A proximity sounding for each storm was extracted via the SPC's Mesoscale Analysis archive (Bothwell et al. 2002), underpinned by the operational RUC/RAP models.

Entraining-CAPE provides a slight increase in forecast skill, particularly in high shear, low CAPE severe weather environments



Distributions in MLCAPE vs ECAPE are similar but differences arise when combining ECAPE with other parameters in the STP

True Skill Score for Significant Tornado Parameter variants STP500 vs STP-ECAPE

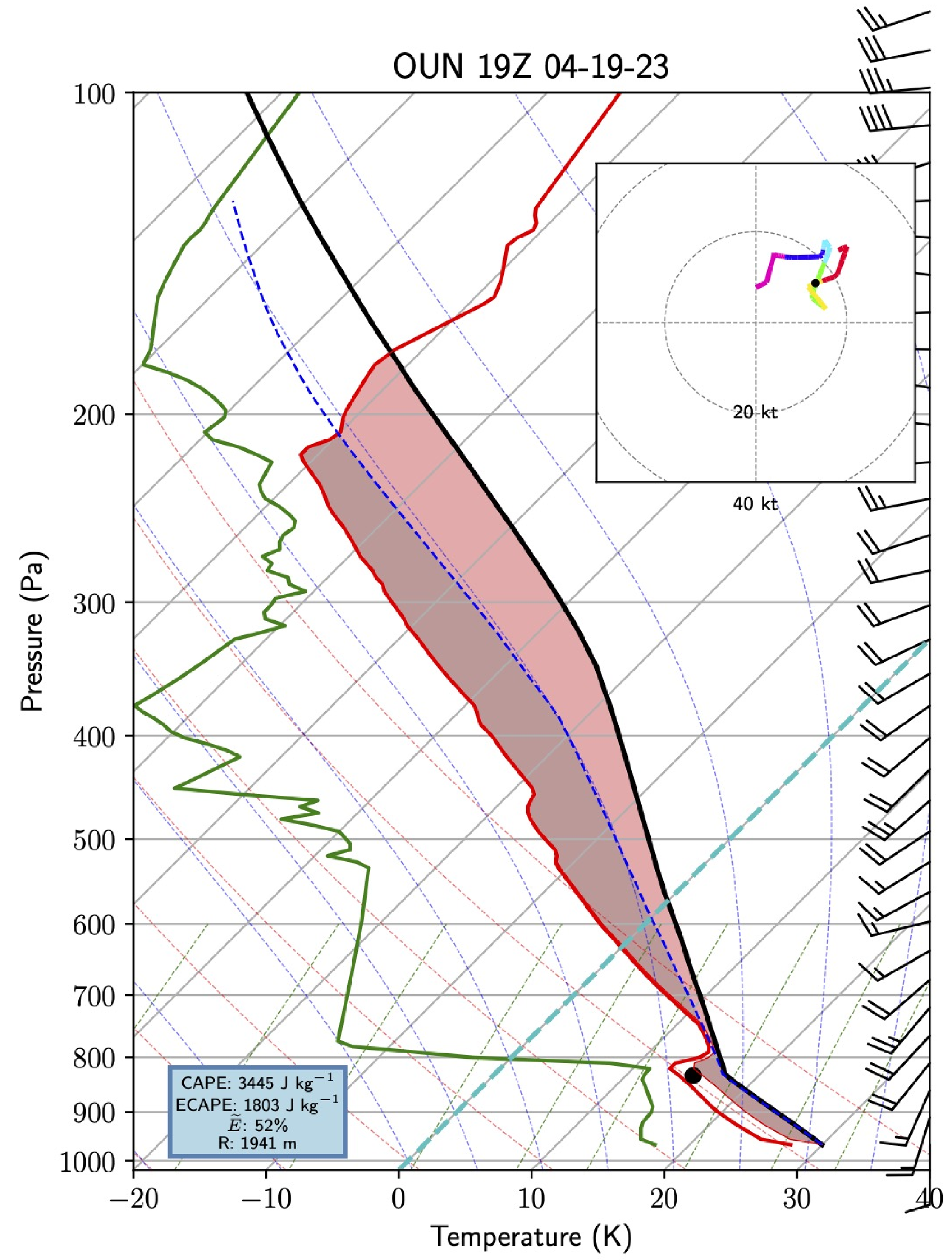
STP500: 0.470
STP500-ECAPE: 0.504

High Shear/Low CAPE	High Shear/High CAPE
STP500: 0.483 **STP-ECAPE: 0.518** 9939 cases (973 sig tor, 4816 weak tor, 4150 non tor)	STP500: 0.522 **STP-ECAPE: 0.527** 9270 cases (970 sig tor, 3595 weak tor, 4705 non tor)
Low Shear/Low CAPE	**Low Shear/High CAPE**
STP500: 0.349 **STP-ECAPE: 0.372** 1860 cases (47 sig tor, 1167 weak tor, 646 non tor)	STP500: 0.369 **STP-ECAPE: 0.375** 2634 cases (76 sig tor, 1220 weak tor, 1338 non tor)

True Skill Score = Hit Rate – False Alarm Rate
Perfect forecasts receive a score of +1, random forecasts receive a 0, forecasts inferior to random receive a negative score.

ECAPE Formulation

- To better predict the maximum updraft speeds within supercells, Peters et al. (2020,2023) introduced formulas to account for entrainment within storm updrafts, based on the *free troposphere relative humidity and updraft width*.
- Storms in environments with higher relative humidity and stronger shear realize more available buoyancy due to less entrainment. This may help explain why storms in low buoyancy environments, but with strong shear, are still capable of producing severe weather.



Future Work

- CAPE and the Significant Tornado Parameter are typically accessed using proximity soundings, however there may be additional benefits to ECAPE by evaluate the spatial characteristics as well (Tochimoto et al. 2019).
- The forecast skill of ECAPE in low buoyancy environments may be representative of distinct storm dynamics favorable for tornadoes, which could be explored in modeling experiments.