# An Initial Assessment of Environmental Influences on QLCS-tornadogenesis from PERiLS Field Campaign Datasets and High-Resolution Simulations

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## Problem Statement

Environmental heterogeneities in wind shear and buoyancy have been shown to influence low-level mesovortices and subsequent tornadogenesis in model simulations (e.g., Atkins and St. Laurent 2009, Flournoy and Coniglio 2021), but less is known about how those heterogeneities manifest in observations

With the PERiLS field campaign datasets, inferences can be made regarding how low-level buoyancy and shear evolve in advance of QLCSs and influence tornadogenesis at multiple time scales

Previous work has demonstrated that rapid destabilization in advance of QLCSs can lead to an increased risk of severe weather (King et al. 2017), but destabilization alone does not prescribe increased tornado risk

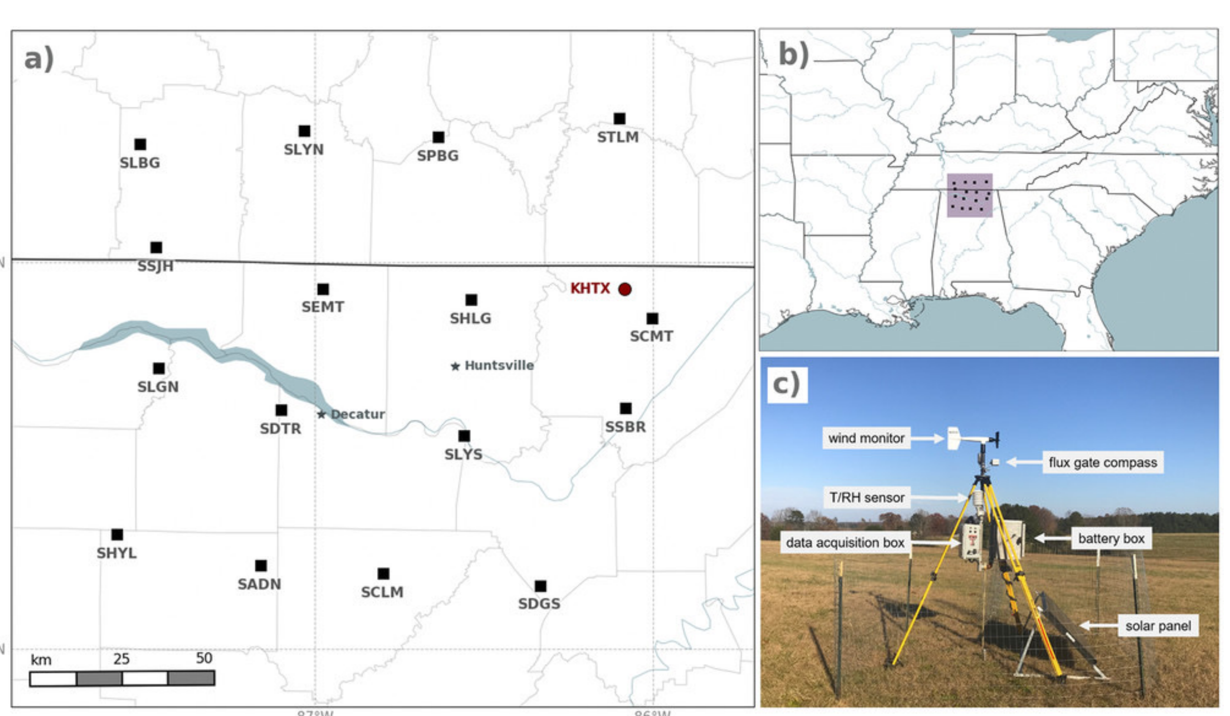
Growing evidence of baroclinically generated vorticity that influences tornado potential with mesovortices in QLCSs (McDonald and Weiss 2021, Ostaszewski and Weiss 2023 (in prep)), but environmental processes have not been "confirmed"

This project will integrate numerous datasets collected during PERiLS to characterize the relationships between environmental changes and tornadogenesis with QLCS events

In the future, particular emphasis will be placed on the ability of existing modeling systems and operational observational analyses to identify these small-scale heterogeneities

## StesoNet

Texas Tech University StickNets were arranged in a mesoscale array in advance of QLCS passage – known as the StesoNet




From McDonald and Weiss (2021). StesoNet locations (left) and zoomed out view of sampling domain during 2016-2017 VORTEX-SE field campaign (top right). Example StesoNet deployment (bottom right).

## Acknowledgments

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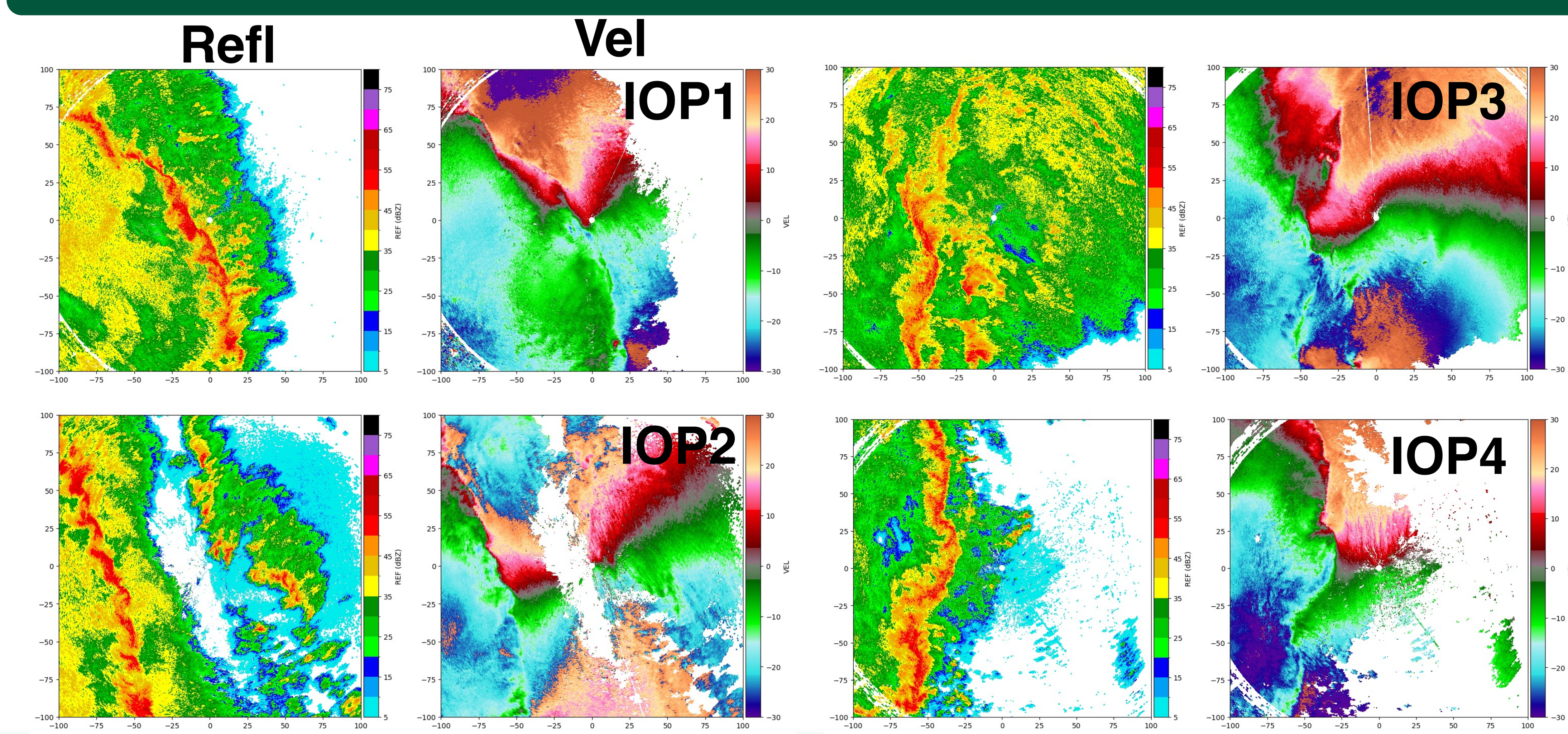
## IOPs

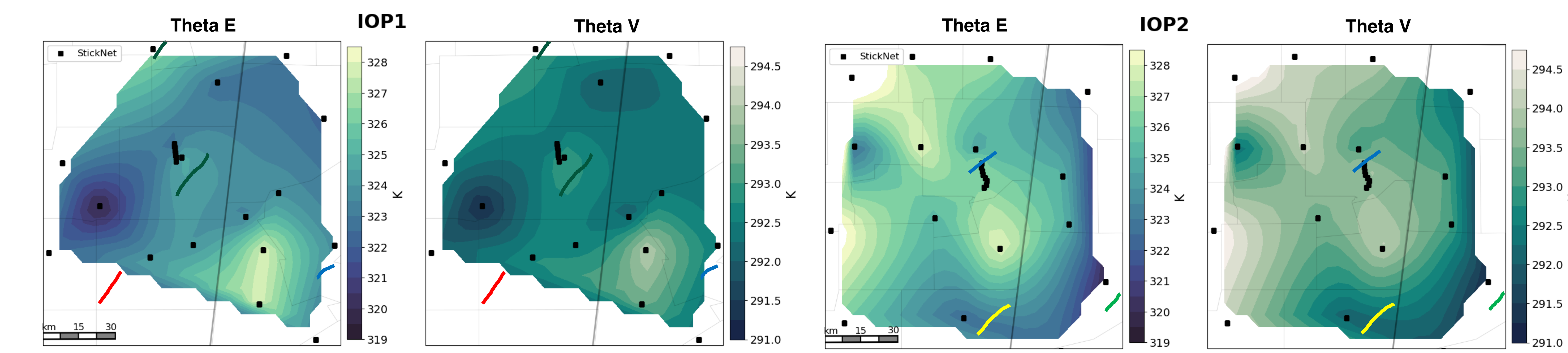



Four IOPs during 2022 field campaign, three in AL/MS domains and one north of Nashville, TN

Radar snapshots depict a range of QLCS evolutions and structures, including leading stratiform and single-cell supercell structures ahead of the main QLCS

Numerous mesovortices were sampled by the StesoNet providing an opportunity to characterize the pre-QLCS environment with unparalleled spatial and temporal frequency from a ground-based network

## Potential Buoyancy Heterogeneity




Base state theta e (left) and theta v (right) from IOPs 1 and 2 during PERiLS. Base states are calculated at the time of arrival of the QLCS as done by McDonald and Weiss (2021). Approximate locations of observed tornado tracks are marked with solid blue, green, yellow, and red lines for EF0, EF1, EF2, and EF3 rated tornados.

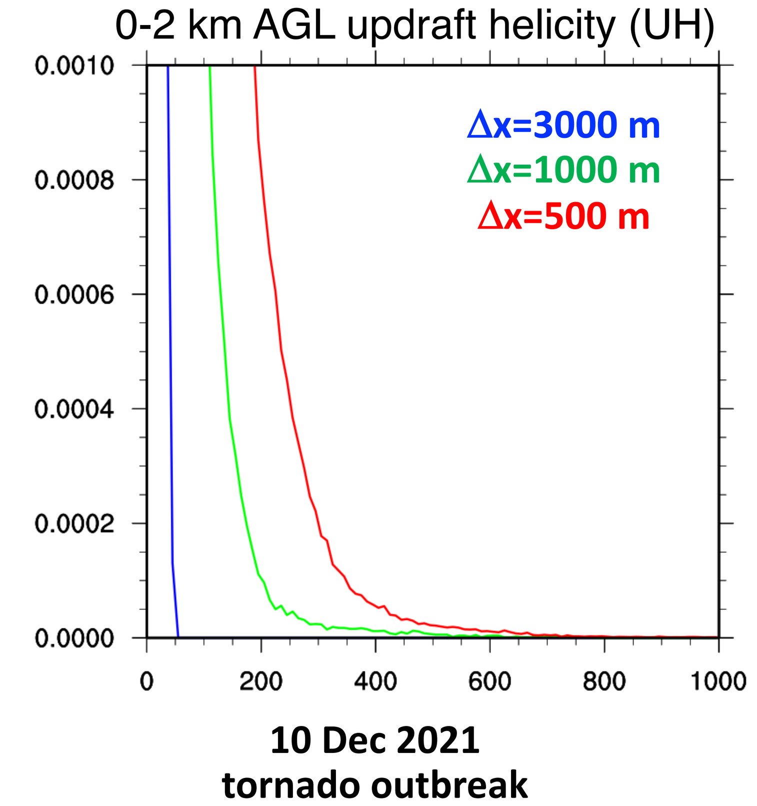
Subjectively, tornadic segments (and tornado warned segments (not shown)) appear loosely tied to areas of high potential buoyancy

A need for quantitative analysis between tornadic and non-tornadic mesovortex-associated environments

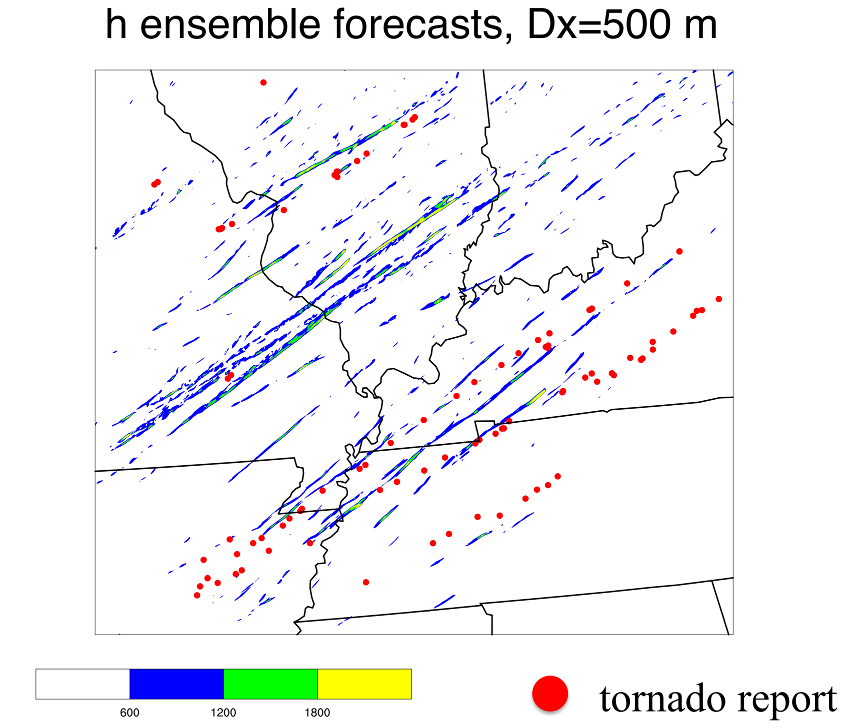
## Simulations

Ensemble forecasts with 3000, 1000, and 500 m horizontal grid spacing

frequency distributions (histograms) for 0-2 km AGL updraft helicity (UH)




maximum 0-2 km updraft helicity in 24-h ensemble forecasts, Dx=500 m




0-2 km UH ($m^2 s^{-2}$)

## Future Work

Systematic evaluation of high-resolution simulations and their ability to capture mesoscale/storm-scale heterogeneities

Comprehensive assessment of shear heterogeneities that contribute to enhanced/decreased chances of tornadogenesis (with other PERiLS datasets)

Additional IOPs from 2023 field campaign

Integrating mobile radar sweeps into mesovortex identification and connecting failed/successful tornadogenesis to environmental precursors

Integrate other near-surface and boundary layer observational platforms into analysis