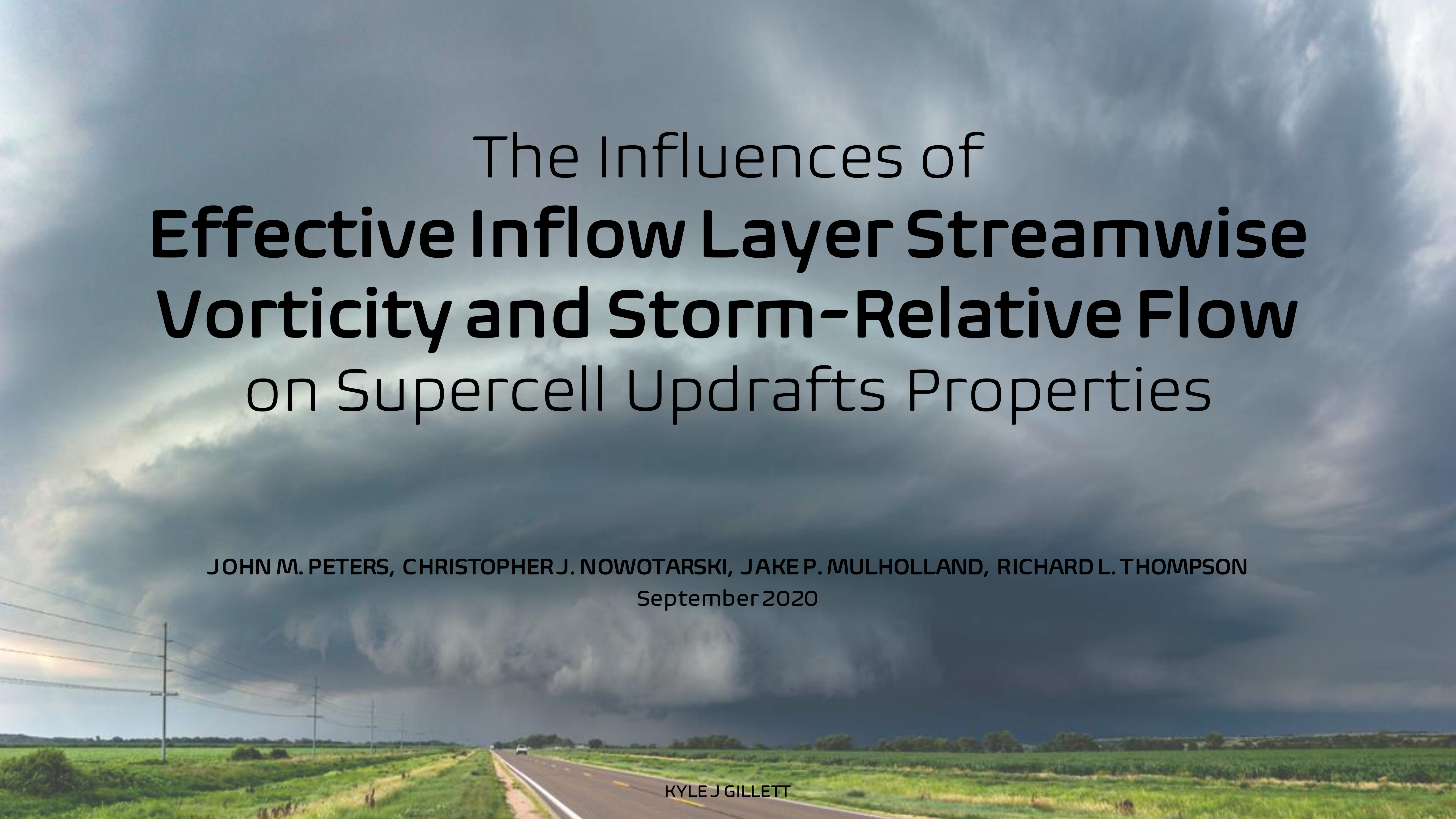

The Influences of **Effective Inflow Layer Streamwise Vorticity and Storm-Relative Flow** on Supercell Updrafts Properties

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ABSTRACT

1. Disentangle the influences of **SR flow (SRW)** and **streamwise vorticity (ζ_s)*** on a supercell's updraft.

2. Emphasize careful considerations of **Storm Relative Helicity (SRH)** during the supercell & tornado forecasting process.

* Streamwise vorticity is typically denoted as ω_S but will be denoted as ζ_s here for simplicities sake.

MOTIVATION

- To understand what processes govern various updraft properties of supercell thunderstorms

To thus improve…

- Forecaster’s ability to properly assess what environments best support supercells, and perhaps make predictions about storm behaviors.

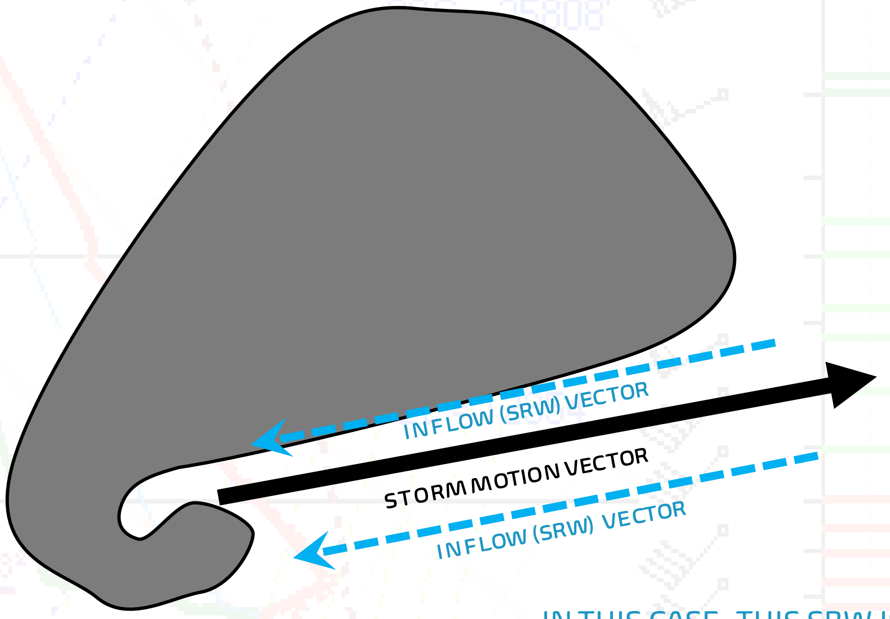
SOME BACKGROUND

- **SRW** – The flow of air into a storm's updraft, relative to the storm's motion.
- ζ_s – Vorticity that is streamwise (along SRI, in this case) capable of being ingested into a storm's updraft.
- **SRH** - Helicity (measure of spin) relative to a storm's motion.

SOME BACKGROUND

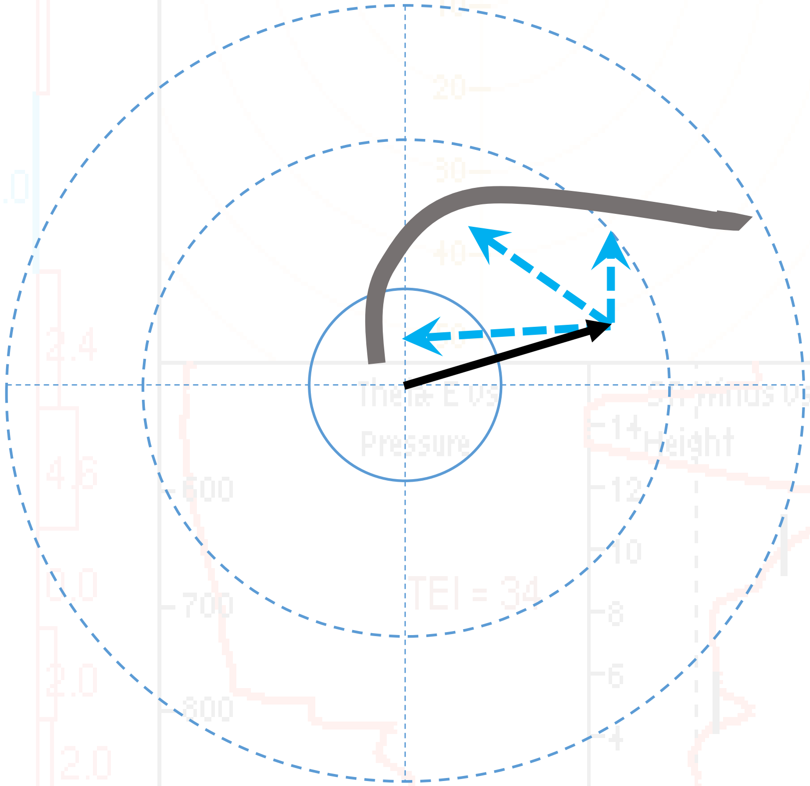
› "Relative to a storm's motion"

IDEALIZED SUPERCELL



IN THIS CASE, THIS SRW IS
'VERY STREAMWISE'

IDEALIZED HODOGRAPH



SOME BACKGROUND

› "STREAMWISE" VORTICITY

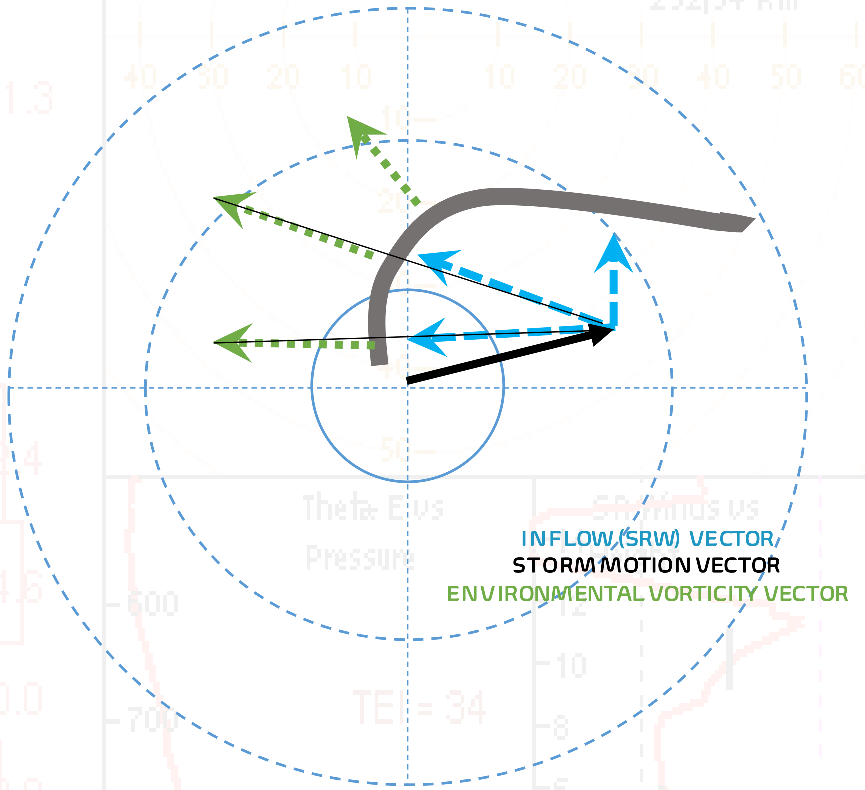
where vorticity = $(\nabla \times V)$
& by the RHR, environmental vorticity vectors are normal to the environmental wind vector.

So, when the SRW for a given layer is normal to the environmental wind vector, we know it will be parallel to the environmental vorticity vector.

If the environmental vorticity vector is parallel to, or 'along' the SRW vector, then the environmental vorticity is "very streamwise".

ζ_s is easily ingested into supercell's updrafts and is vital during tornadogenesis.

IDEALIZED HODOGRAPH



(Dahl 2017)
(Davies 1984)

SOME BACKGROUND

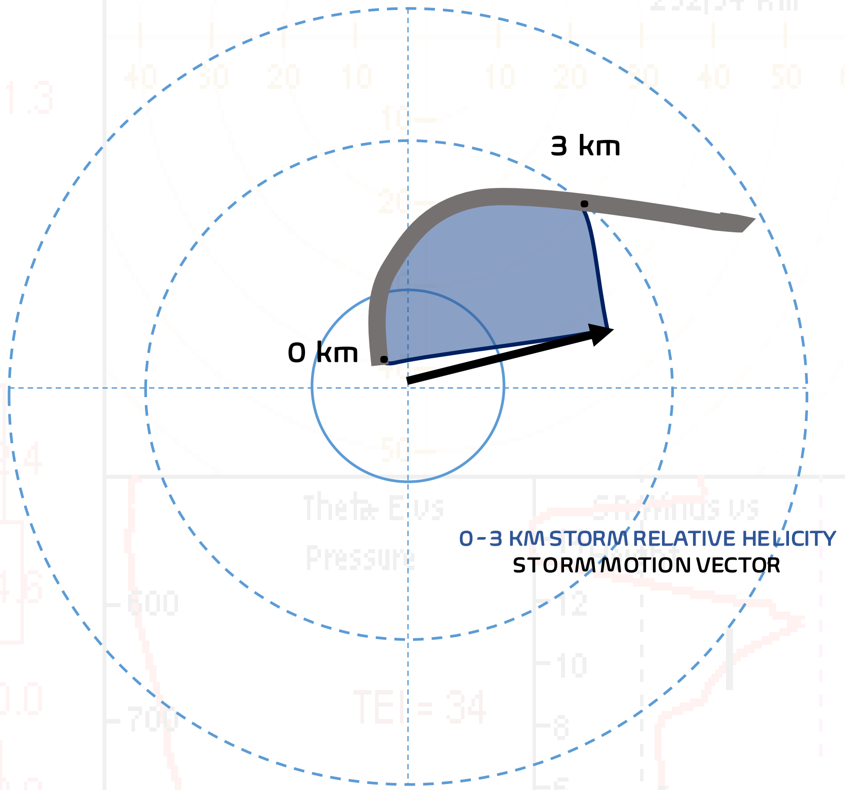
› STORM RELATIVE HELICITY

Conceptually, it is defined as the **area swept out** by the curve of the **hodograph** and the **storm motion**, over some depth.

This shows that **SRH** could be influenced by both ζ_s and **SRW**.

SRH is often used to diagnose ζ_s

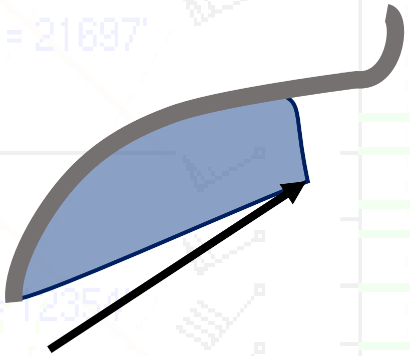
IDEALIZED HODOGRAPH



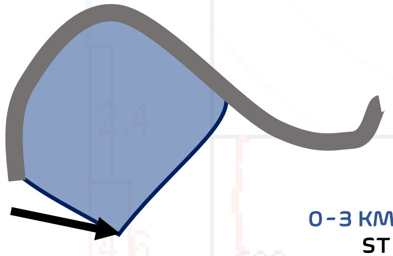
HODOGRAPHS AND HELICITY

› STORM RELATIVE HELICITY

Consider these too idealized hodographs, both have the same amount of SRH, but their shapes are very different.



This hodograph shows strong SRW, but lower ζ_s



0-3 KM STORM RELATIVE HELICITY
STORM MOTION VECTOR

This hodograph has weaker SRW, but ζ_s is much larger

Yet both hodographs have equal SRH

THE SRH PROBLEM

$$SRH_d \equiv \int_{z=0}^{z=d} |V_{SR}| * \zeta_s \, dz$$

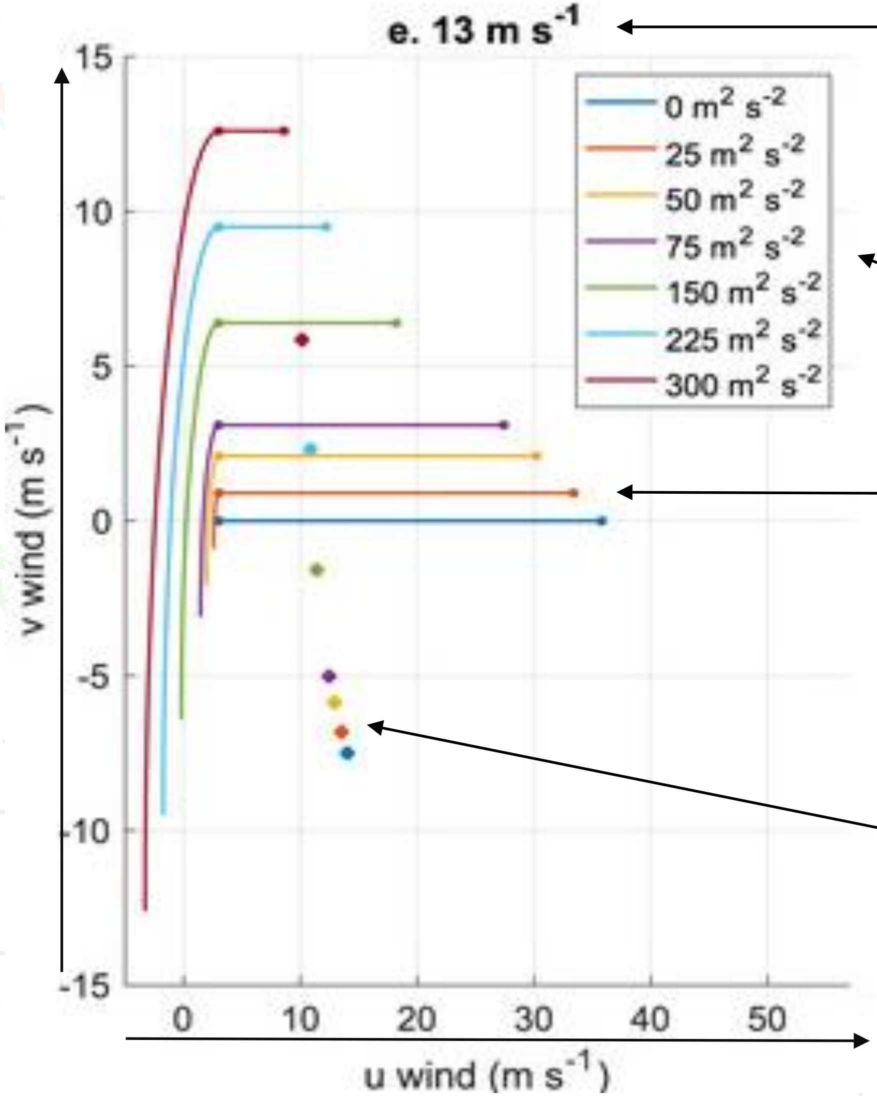
- Thus, **SRH** can mean *different things* depending on what term dominates the calculation.

where V_{SR} = Storm Relative Wind (SRW) and d = some depth

NUMERICAL EXPERIMENTS

- Cloud Model 1 (CM1) v.18
- 250m horizontal grid spacing
- 100m vertical level spacing
- 180km x 180km x 20km domain
- Model output saved every 5 mins.

NUMERICAL EXPERIMENTS

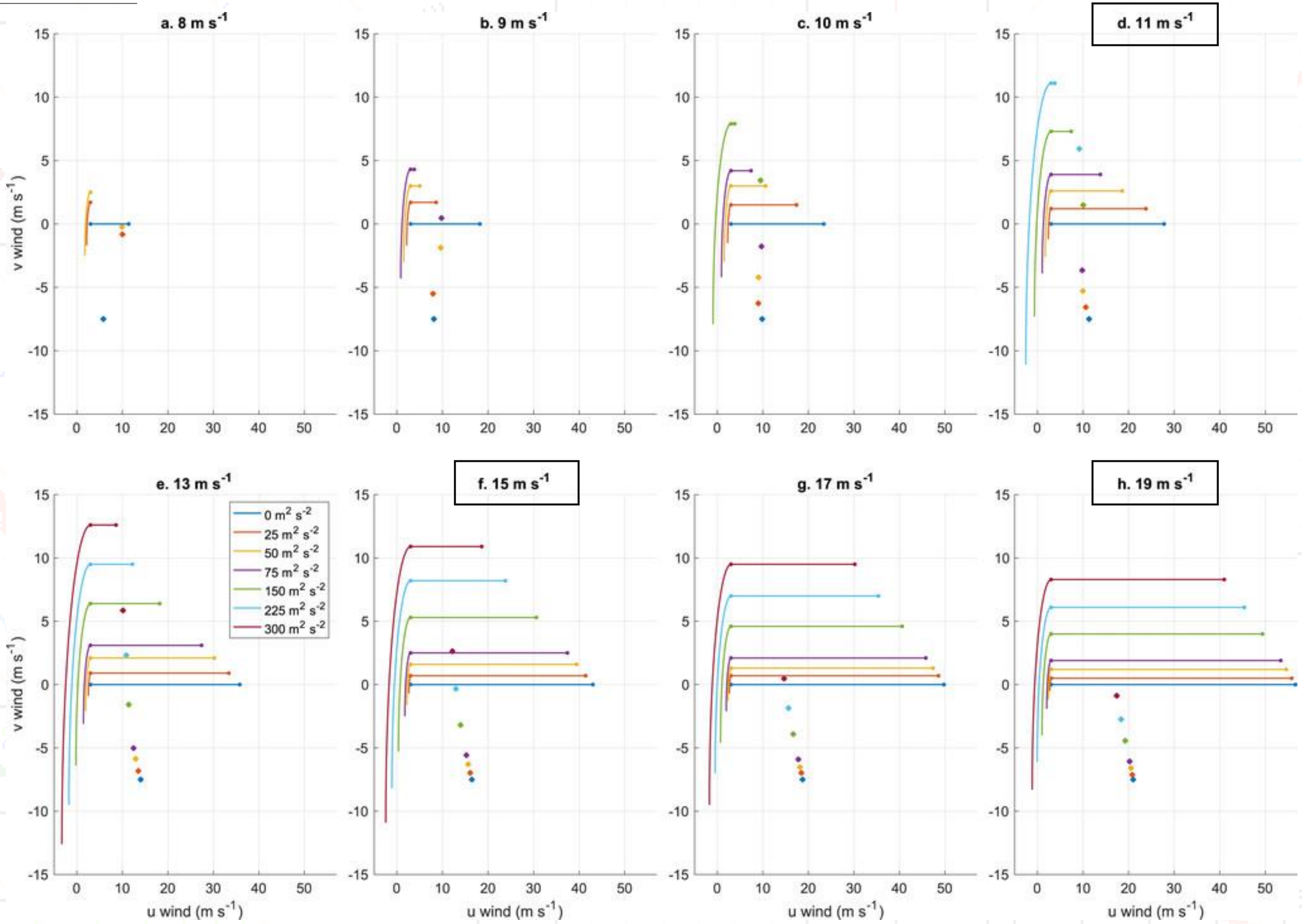


SRW Magnitude

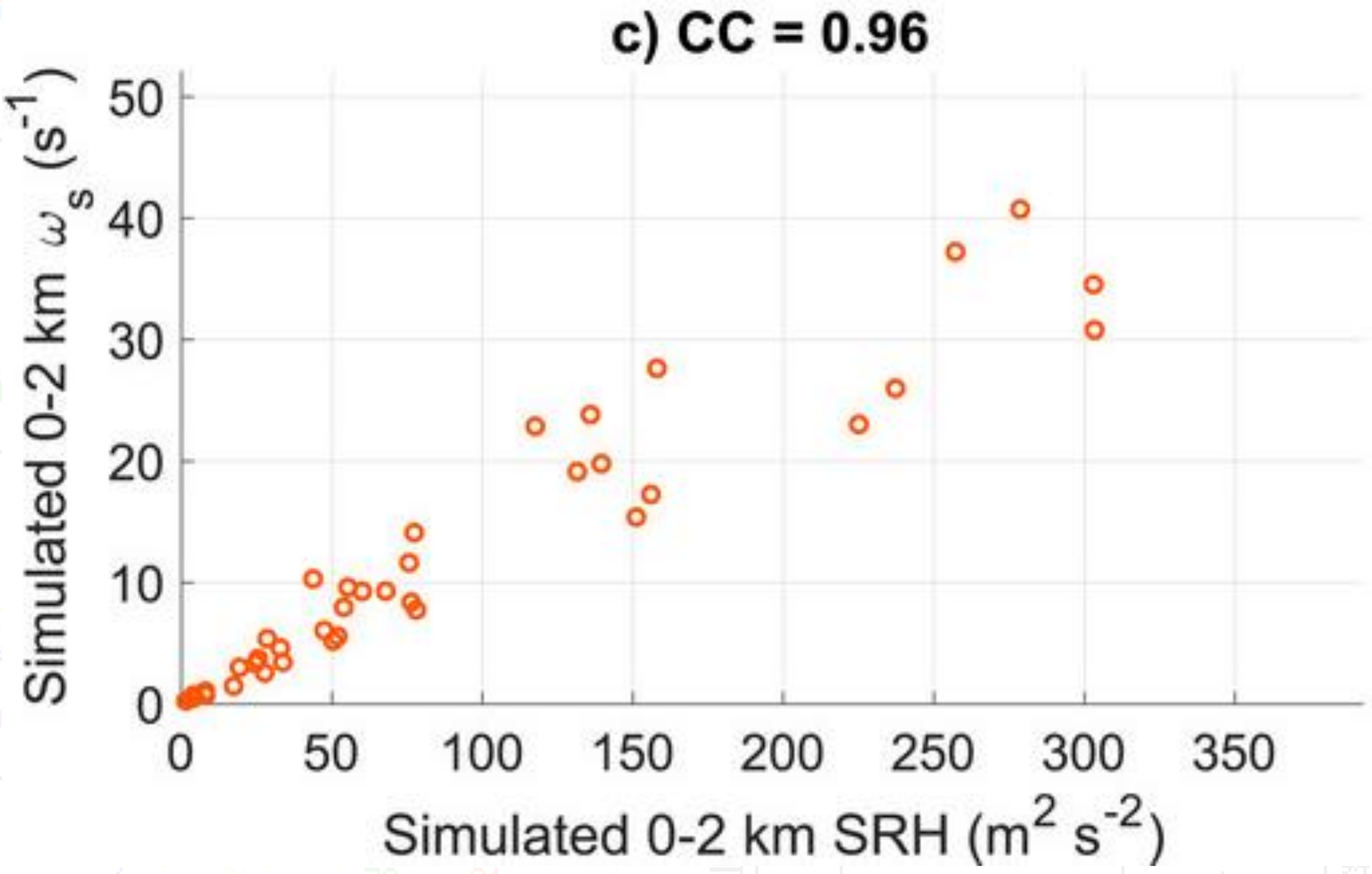
Various Hodograph shapes with SRW = 13ms^{-1}. Shape/size variation due to SRH magnitude. Colored by SRH magnitude.

Bunkers storm motions needed for each hodograph to create a SRW = 13ms^{-1}.
Colored by corresponding hodograph

NUMERICAL EXPERIMENTS



NUMERICAL EXPERIMENTS



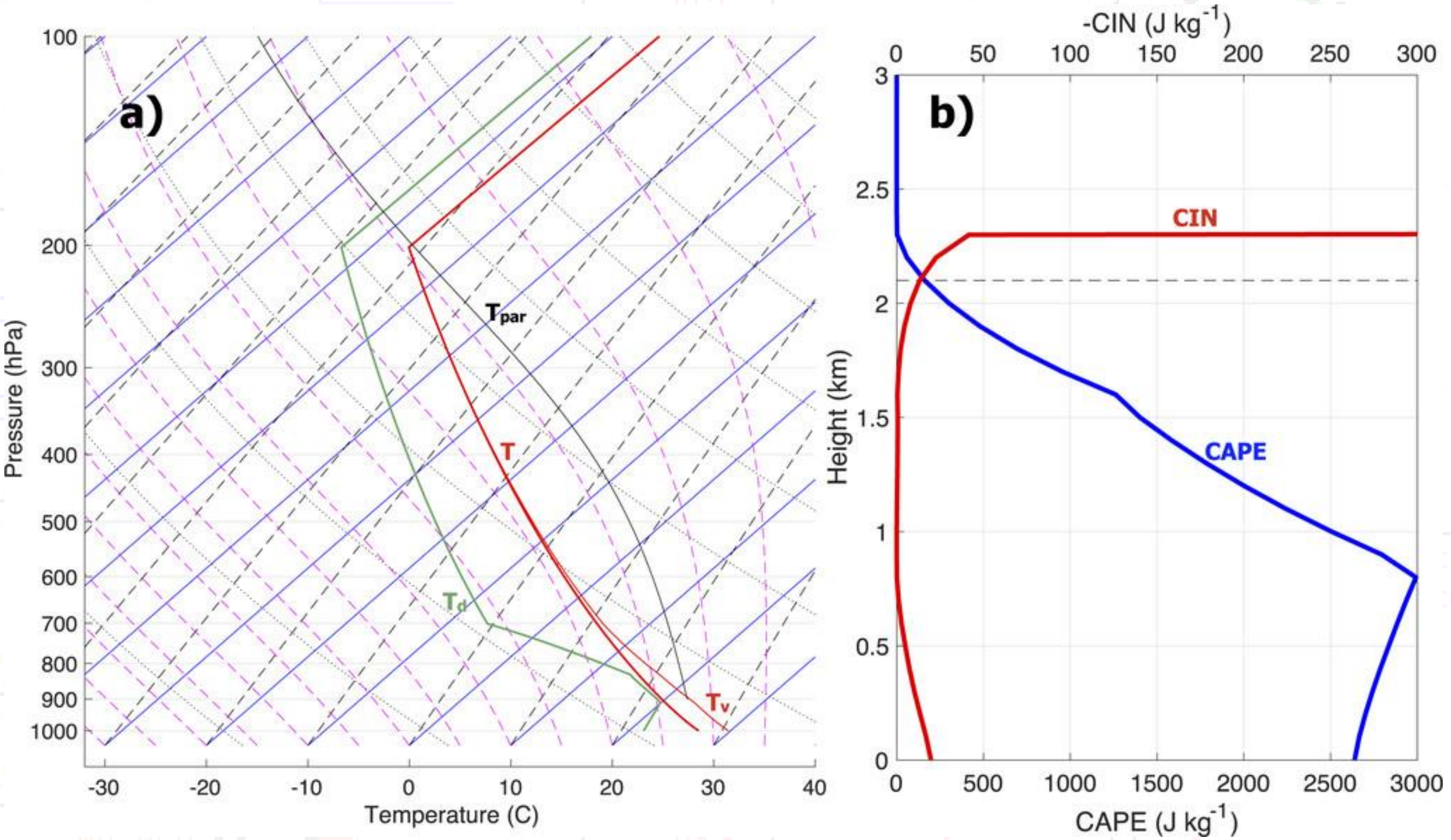
ζ_s is strongly correlated With SRH

Where SRW, was not, CC = 0.15

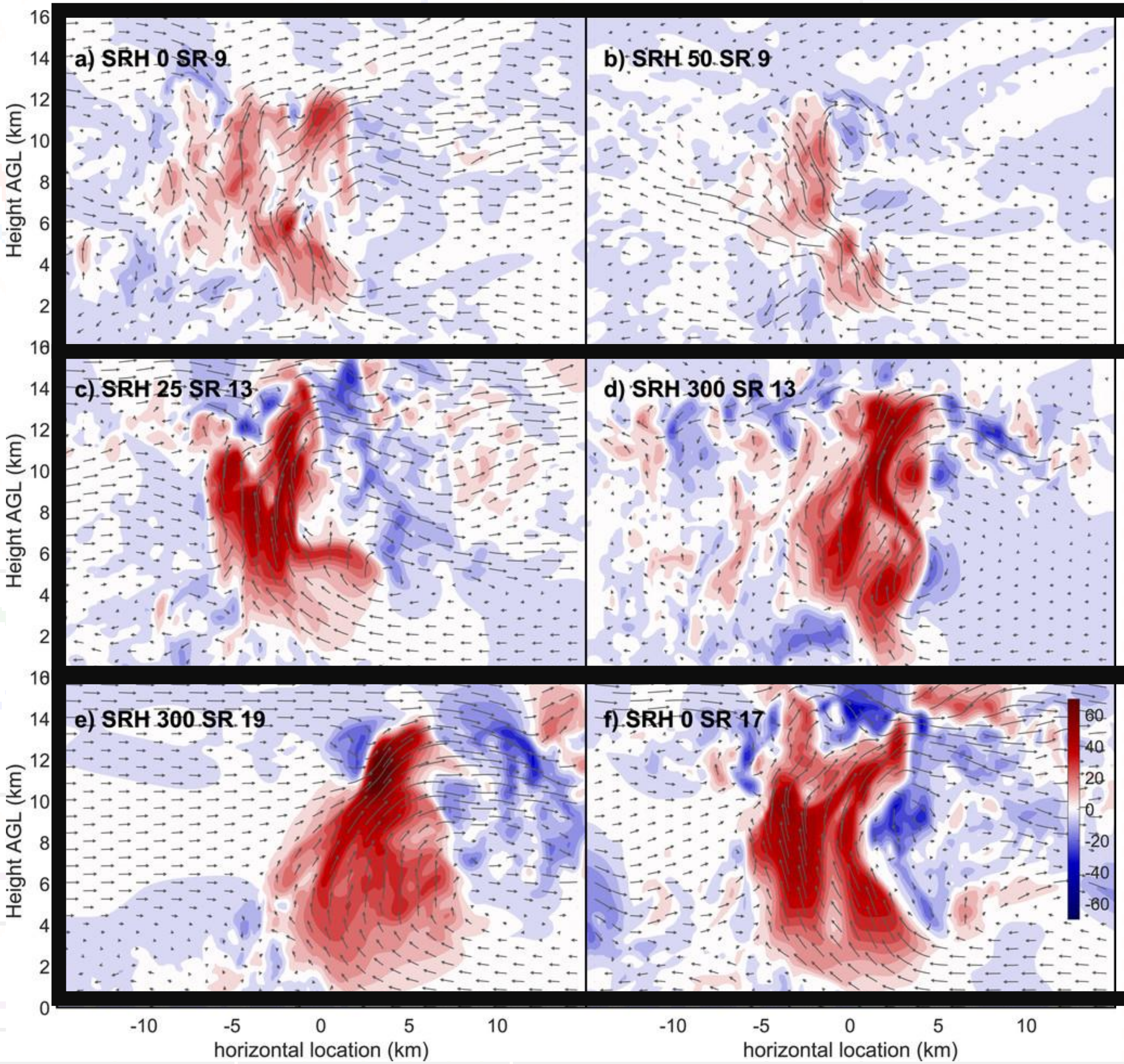
NUMERICAL EXPERIMENTS

Single thermodynamic profile used for all simulations

With thermodynamics held constant, all variations in storm mode should therefore be functions of the wind profile.



EXPERIMENT FINDINGS



WEAK SRW

weak pulse-like updrafts

MODERATE SRW

stronger, more plume-like updrafts

STRONG SRW

Dominate, deep plume updrafts

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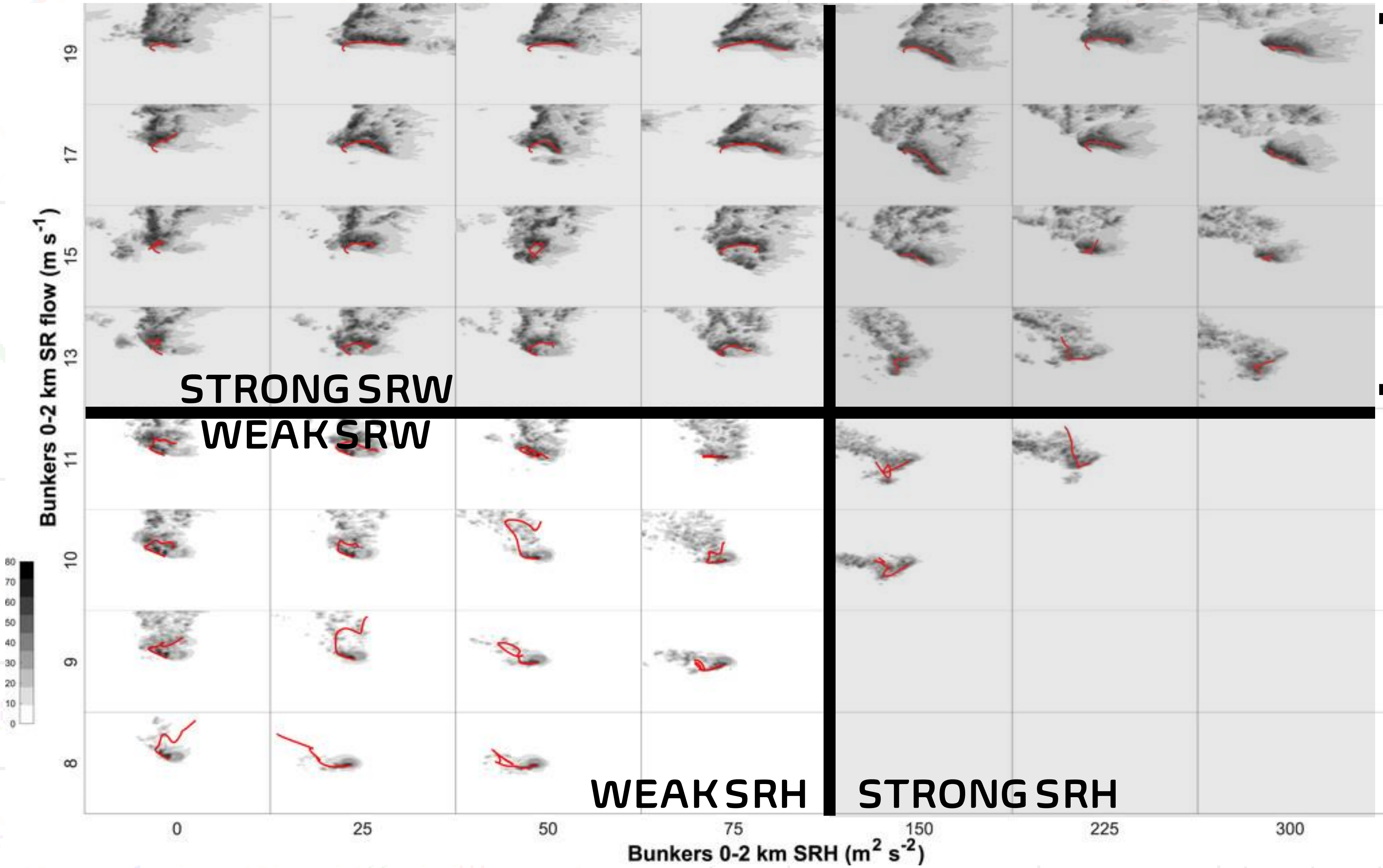
EXPERIMENT FINDINGS



Large SRW seems to best favor large sustained updrafts

when compared to SRH

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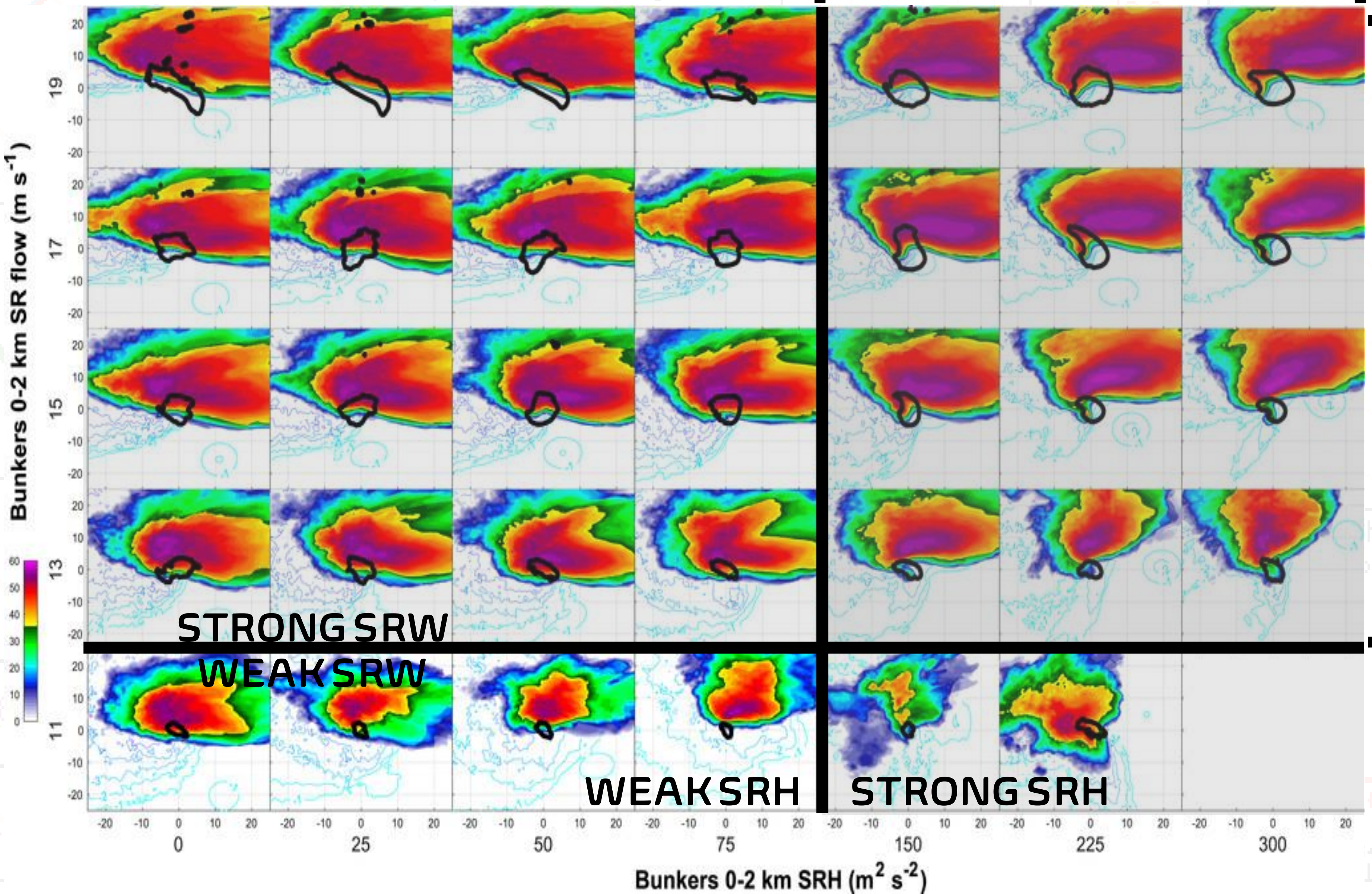
EXPERIMENT FINDINGS



Stamps with large SRH best support 'classic' supercell Reflectivity features

- Hook Echo
- Shape
- FF Precip
- RF Precip
- Circular Updrafts

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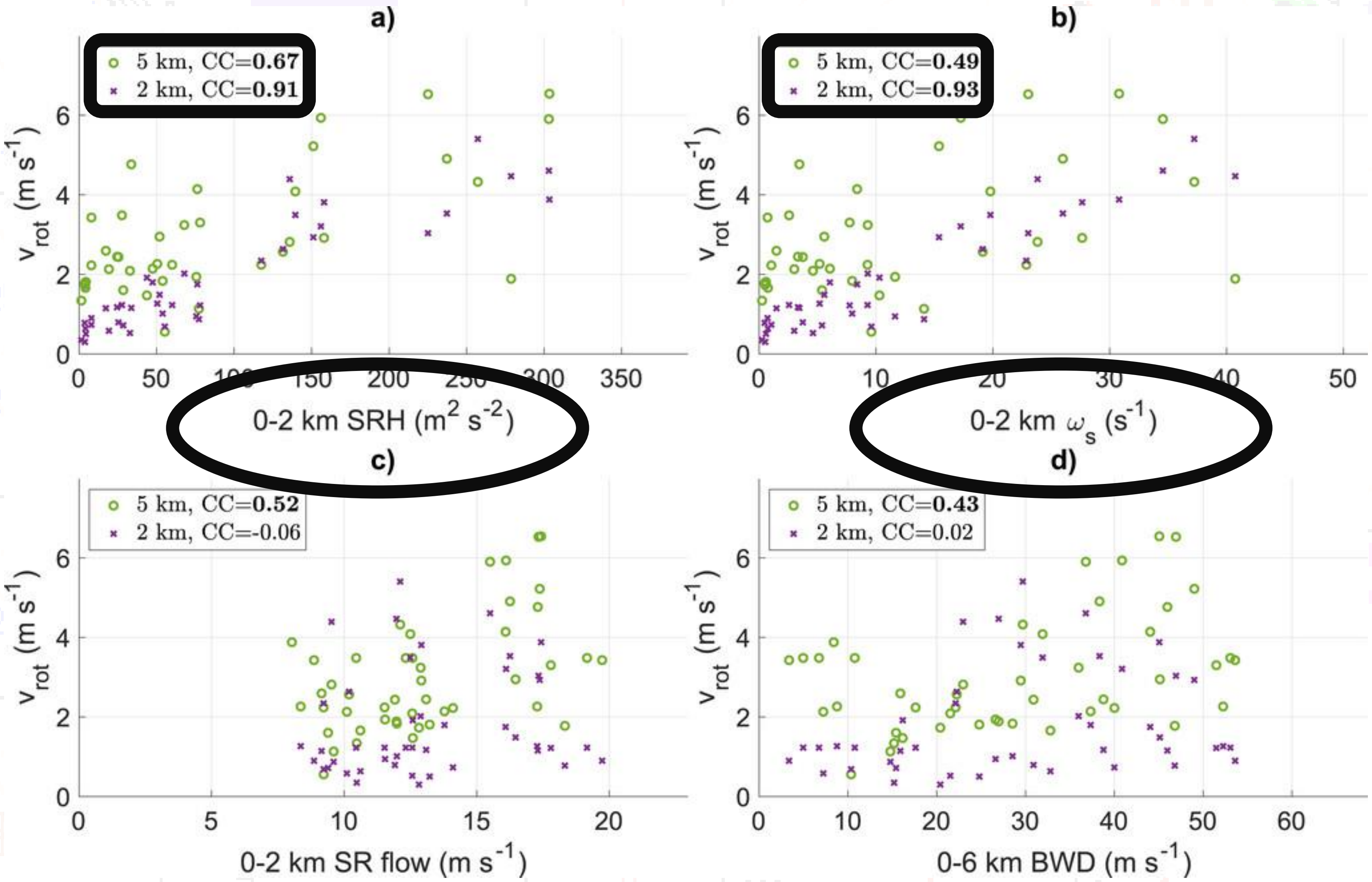
EXPERIMENT FINDINGS

UPDRAFT ROTATIONAL VELOCITY (V_{rot})

Strongly correlated with SRH and ζ_s



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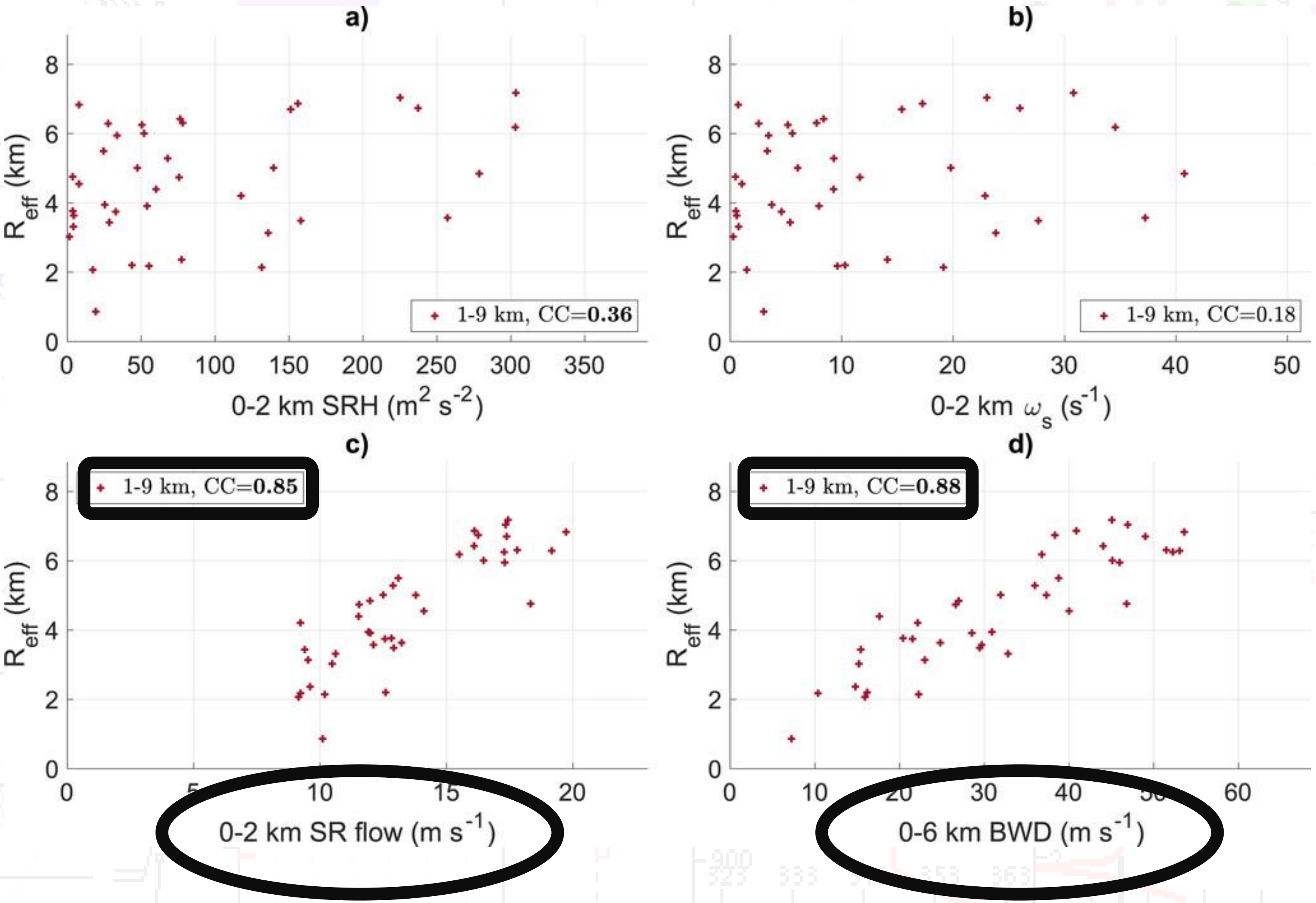
EXPERIMENT FINDINGS

UPDRAFT WIDTH

Strongly correlated with SRW and BWD



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CONCLUSIONS

- Deep-layer shear and **SRW** were the most skillful predictors for *supercellular vs nonsupercellular storm mode*.

- Important updraft properties such as *M*, updraft *width*, *maximum ζ*, and *maximum w* were primarily determined by **SRW** and deep-layer shear, rather than ζ_s.

- The primary influence of ζ_s on the updrafts was to increase *low-level w* and *low-level rotation* in environments with large ζ_s.

IMPORTANT TAKEAWAYS

- **SRH** can be dominated by **SRW** or ζ_s, so forecasters should understand which term is dominate.

- **SRW** is the best predictor of whether a *storm will be a supercell or not.* Thus, societal impacts from supercells may be sensitive to **SRW**.

- ζ_s is the best predictor of whether a storm will have *sustained low-level rotation* (LLMC, tornadoes)

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