APPLICATIONS OF THE
SKEW-T AND HODOGRAPH

IN SEVERE WEATHER FORECASTING

II. THE HODOGRAPH

KYLE J GILLETT

I. REVIEW

FORECASTING SEVERE CONVECTIVE STORMS
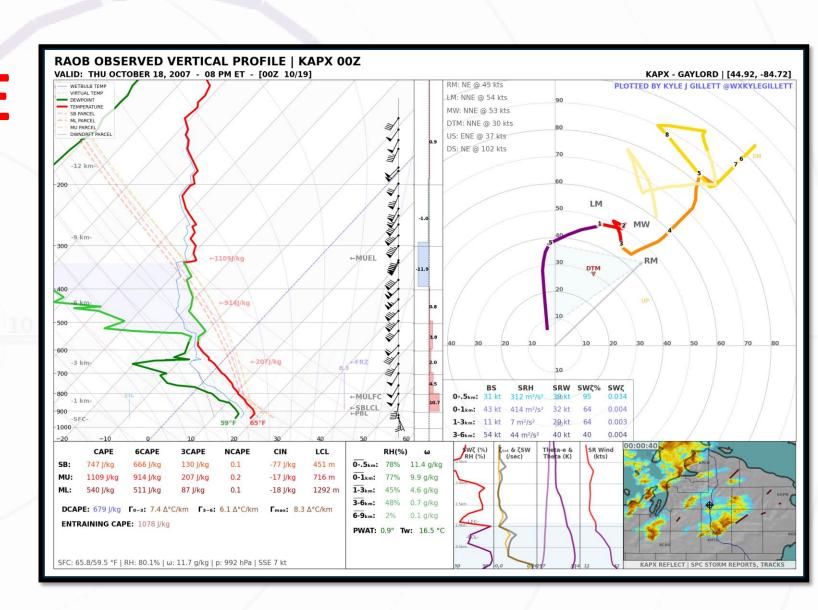
S.L.I.M

SHEAR. LIFT. INSTABILITY. MOSITURE.

WHAT'S A SOUNDING?

TEMPERATURE

DEWPOINT
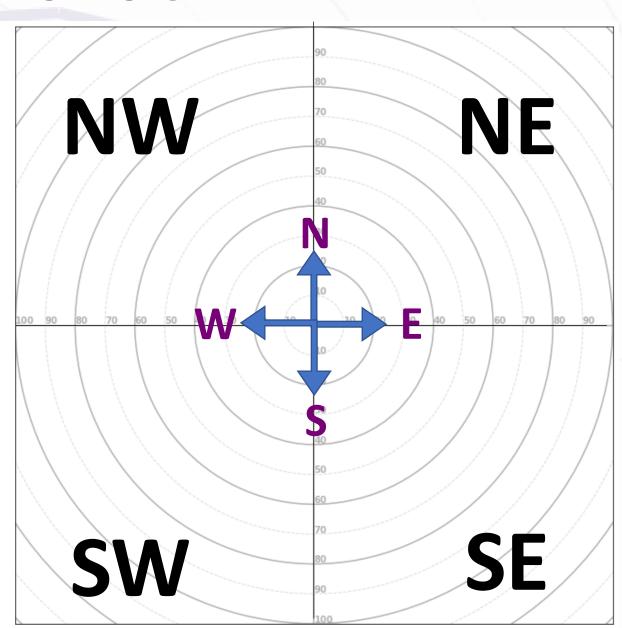
WIND

**That's *it*! **

Everything else plotted on a sounding is derived from those three values

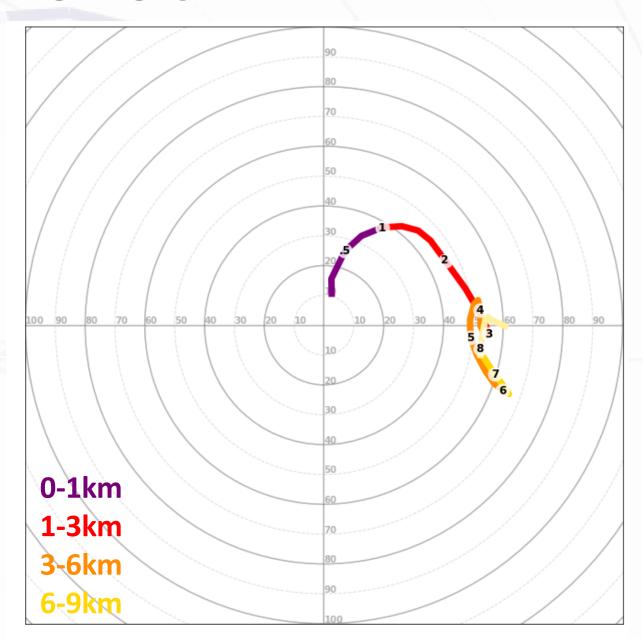# WHAT'S A HODOGRAPH?

X-axis = u-component of wind (from the west)

Y-axis = v-component of wind (from the south)

WHAT'S A HODOGRAPH?

Wind with height is plotted as a line.

The start of line is the sfc, the end of the line is the highest height.
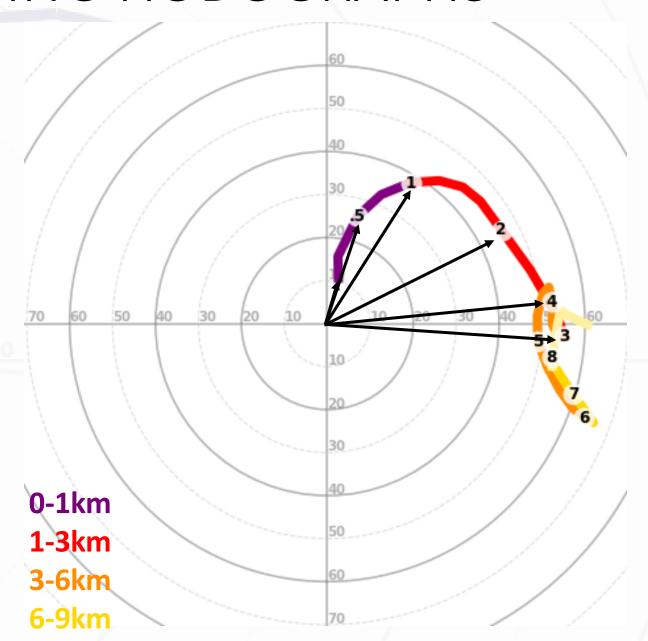

0-1km
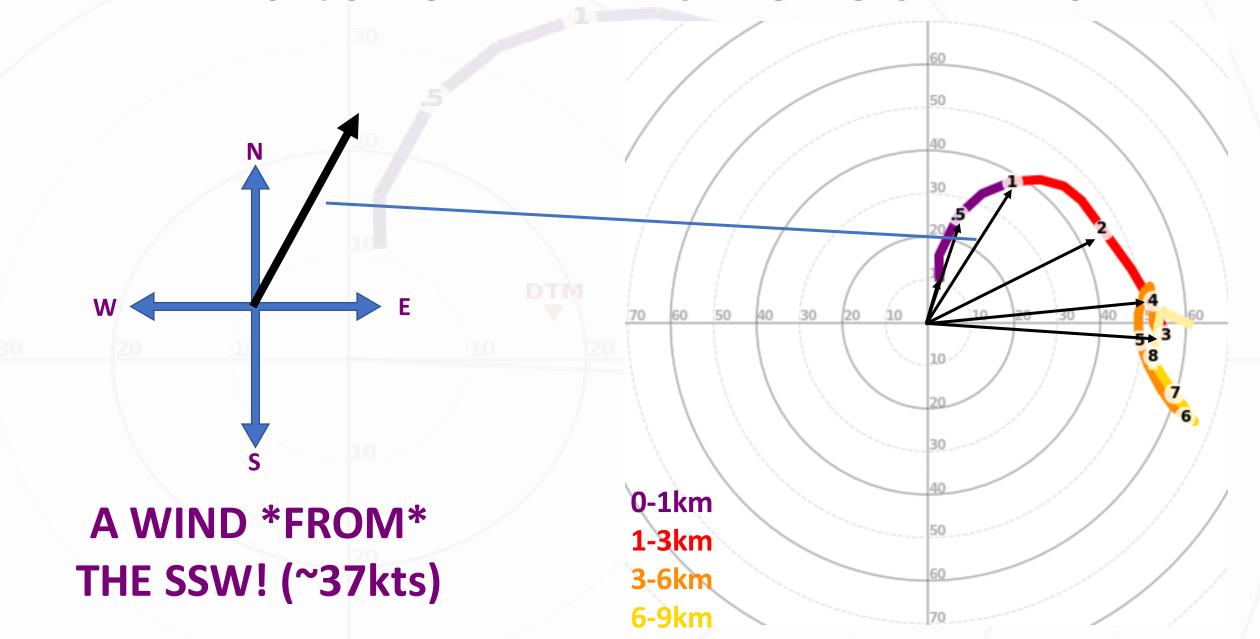**1-3km**
3-6km
6-9km

II. READIING A HODOGRAPH

BASICS TO READING HODOGRAPHS
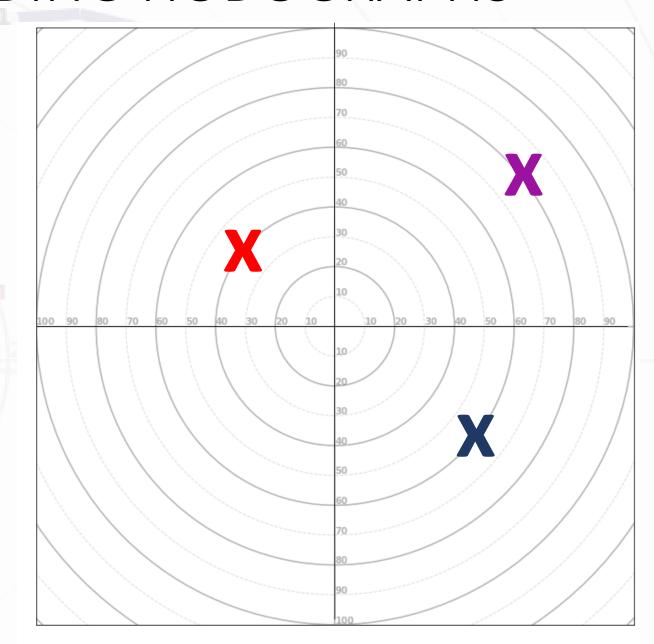
Each point on a hodograph represents the wind at some level.

You can draw a vector from the origin (0,0) to the wind line to find the wind at some level

0-1km
1-3km
3-6km
6-9km

BASICS TO READING HODOGRAPHS

**A WIND *FROM*
THE SSW! (~37kts)**

0-1km
1-3km
3-6km
6-9km

III. WIND SHEAR
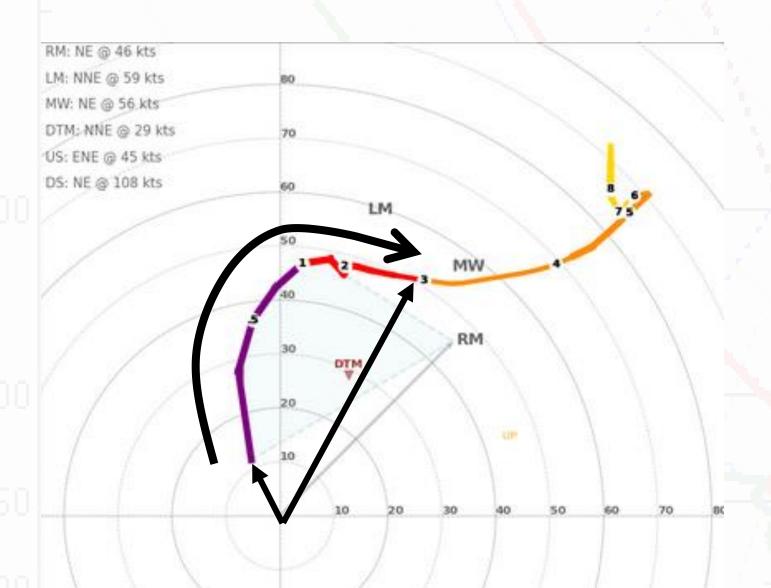
ANALYZING WIND SHEAR - SPEED

ELONGATION!

Wind shear is greater if there is a greater elongation of the 'wind shear vector' between levels

0-3km Wind Shear:
Spd: 11kts -> 50kts = 39kts

SHEAR VECTORS

RM: NE @ 46 kts
LM: NNE @ 59 kts
MW: NE @ 56 kts
DTM: NNE @ 29 kts
US: ENE @ 45 kts
DS: NE @ 108 kts
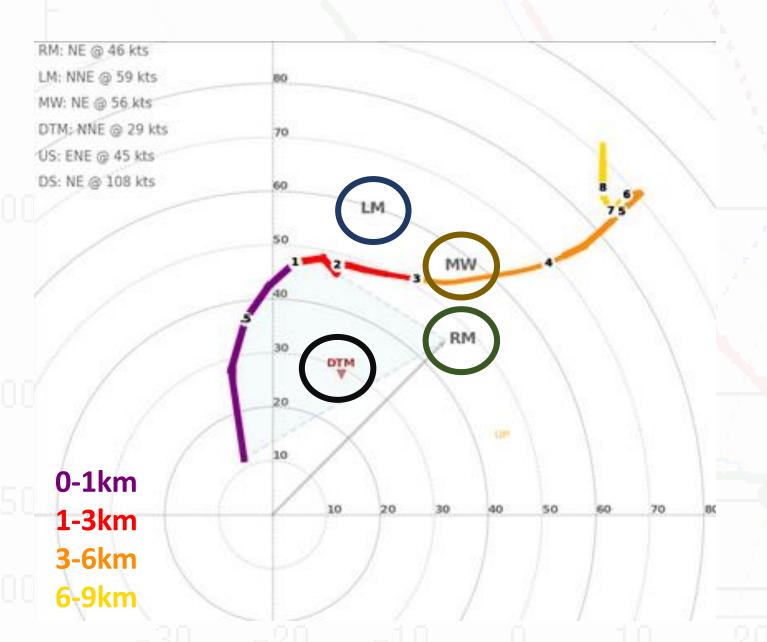
0-1km Shear

0.5-3km Shear

0-4km Shear

IV. STORM MOTION & RELATIVITY

STORM MOTION ON HODOGRAPHS
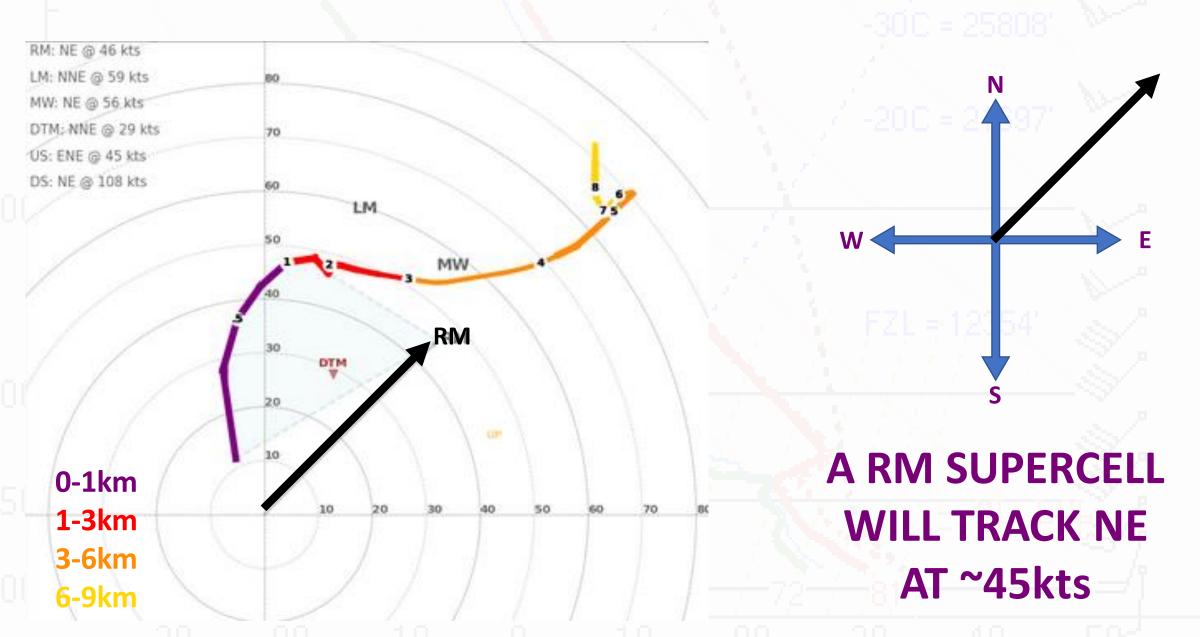
STORM MOTION ON HODOGRAPHS

RM: NE @ 46 kts
LM: NNE @ 59 kts
MW: NE @ 56 kts
DTM: NNE @ 29 kts
US: ENE @ 45 kts
DS: NE @ 108 kts

0-1km
1-3km
3-6km
6-9km

A RM SUPERCELL WILL TRACK NE AT ~45kts

BREAK – QUESTIONS?
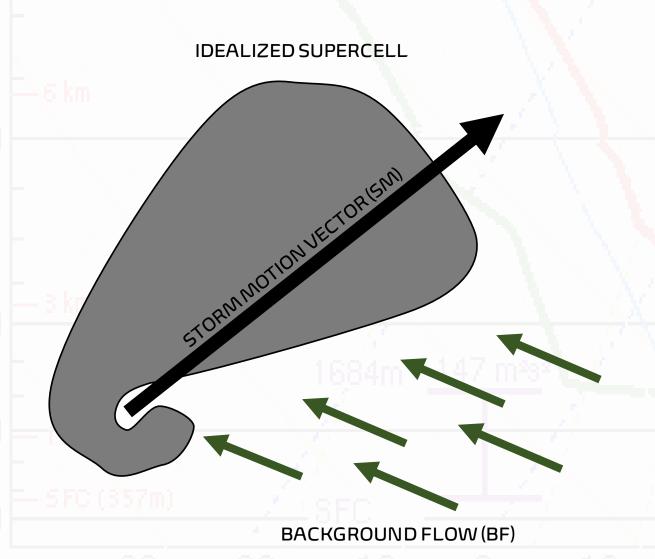
NEXT: IMPORTANT QUANTIES FOUND ON THE HODOGRAPH

V. STORM RELATIVE WIND

THE STORM RELATIVE WIND

IDEALIZED SUPERCELL

STORM MOTION VECTOR (SM)

where

$$\overrightarrow{SM} + \overrightarrow{BF} = \overrightarrow{SRW}$$

BACKGROUND FLOW (BF)

STORM RELATIVE WIND ON THE HODOGRAPH
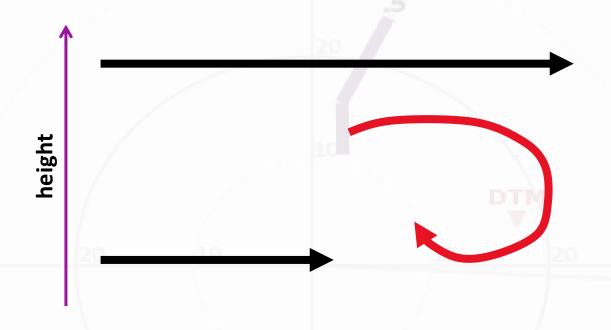
The 'wind' relative to a storm's motion (in this case, 'RM').

The Storm Relative Wind (SRW), in a very simplistic sense, "blows air into the storm's updraft".

0-1km
1-3km
3-6km
6-9km

IDEALIZED HODOGRAPH

VI. STORM RELATIVE VORTICITY

UNDERSTANDING VORTICITY

height
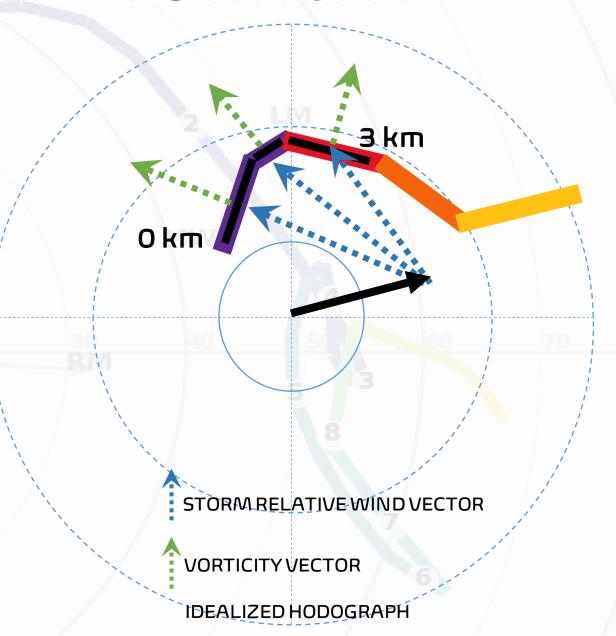
VORTICITY: a vector quantity that describes the rotation of air about some axis
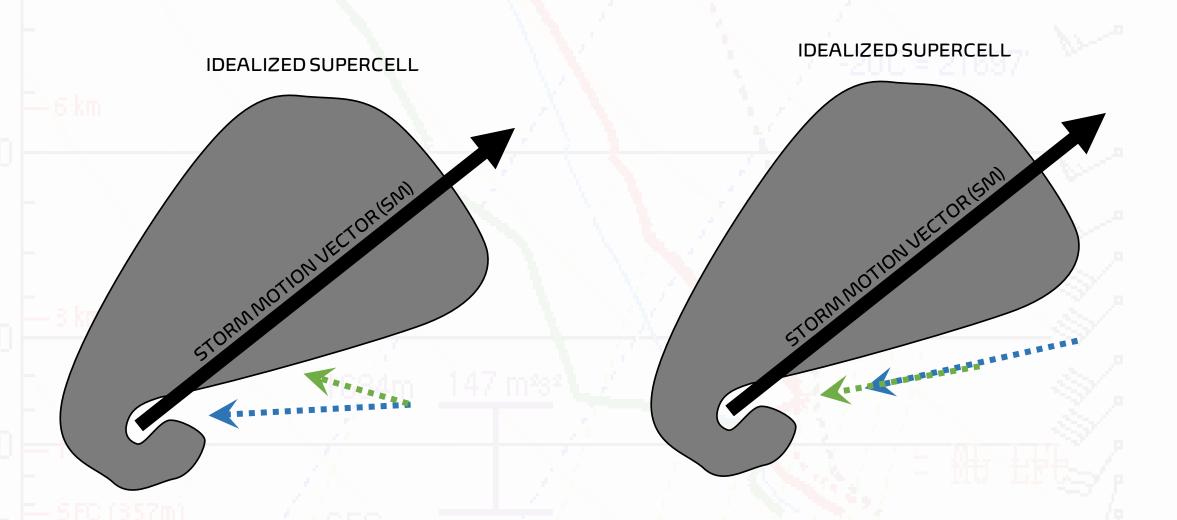
STORM RELATIVE VORTICITY

where vorticity = $(\nabla \times V)$

Thus, by the RHR, **environmental vorticity vectors** are normal to the **environmental wind vector.**
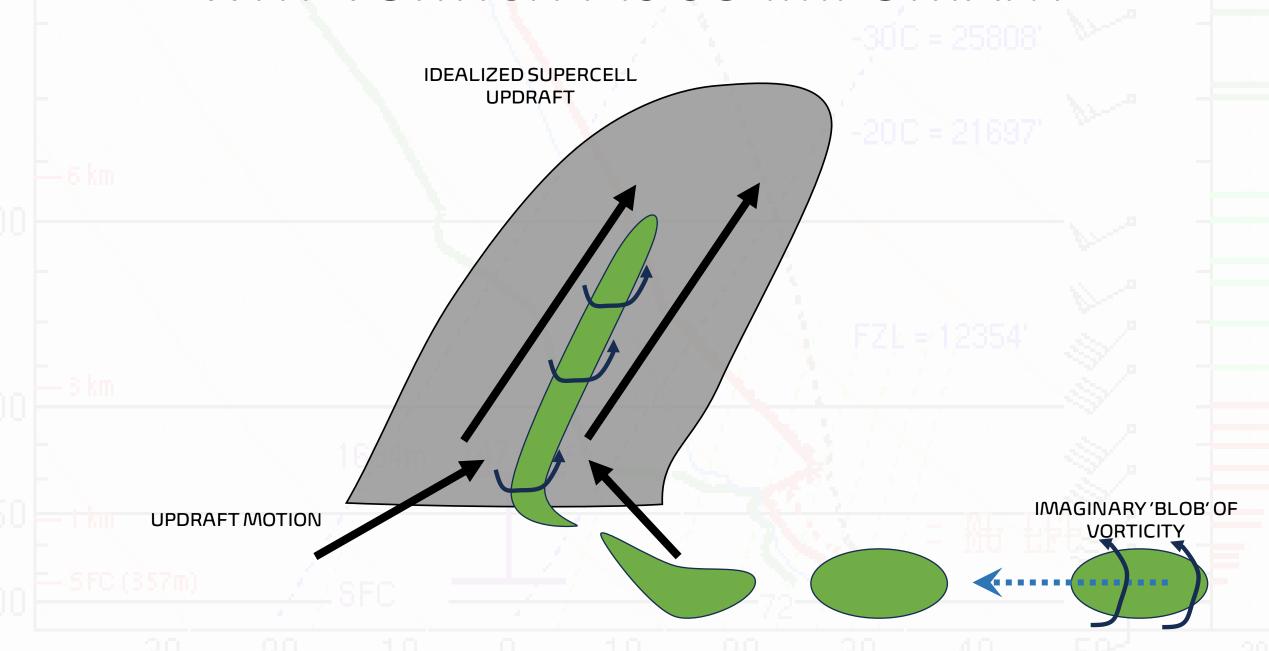
If the **environmental vorticity vector** is parallel to, or 'along' the **SRW vector**, then the **environmental vorticity** is "***streamwise***".

STORM RELATIVE WIND VECTOR

VORTICITY VECTOR

IDEALIZED HODOGRAPH
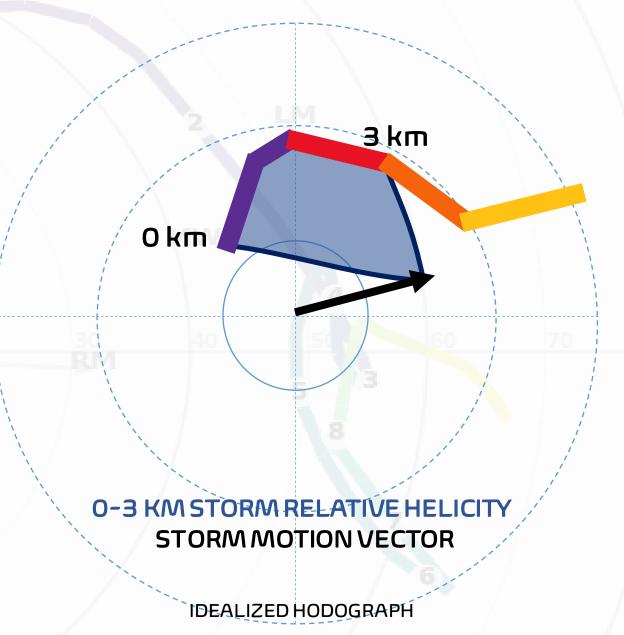
VII. STORM RELATIVE HELICITY

STORM RELATIVE HELICITY

HELICITY: property of a fluid that represents the potential for helical flow – a measure of the air's potential to rotate

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

0-3 KM STORM RELATIVE HELICITY
STORM MOTION VECTOR

IDEALIZED HODOGRAPH

A NOTE ABOUT STORM RELATIVE HELICITY...

$$SRH_d \equiv \int_{z=0}^{z=d} |V_{SR}| * \zeta_s \, dz$$
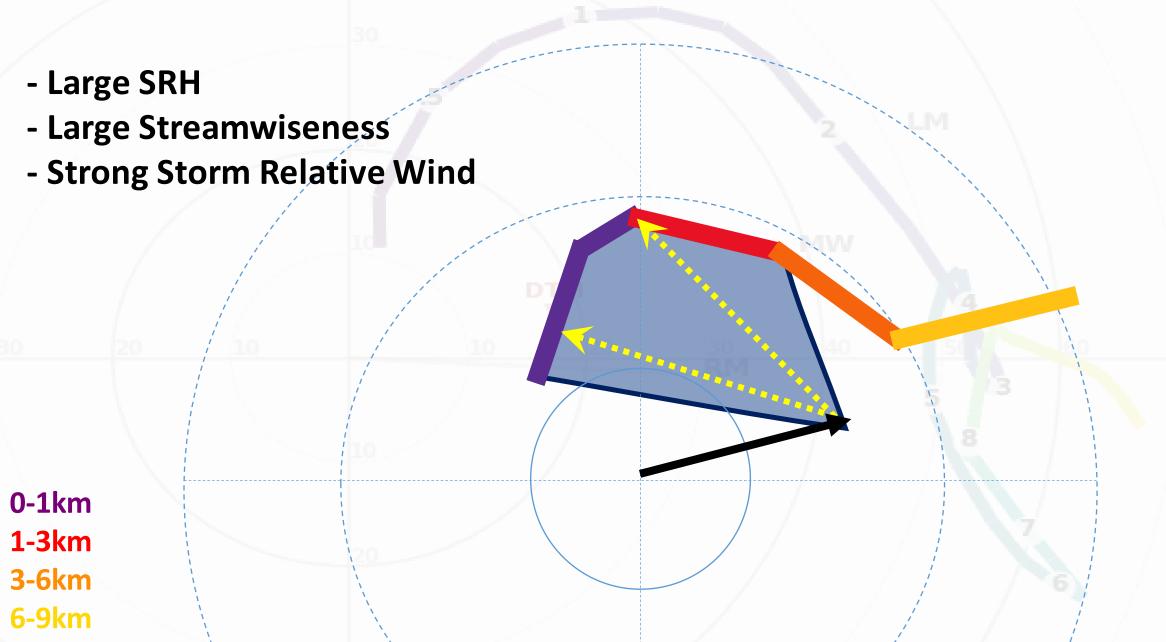
Low SRH is not always bad, and high SRH is not always good
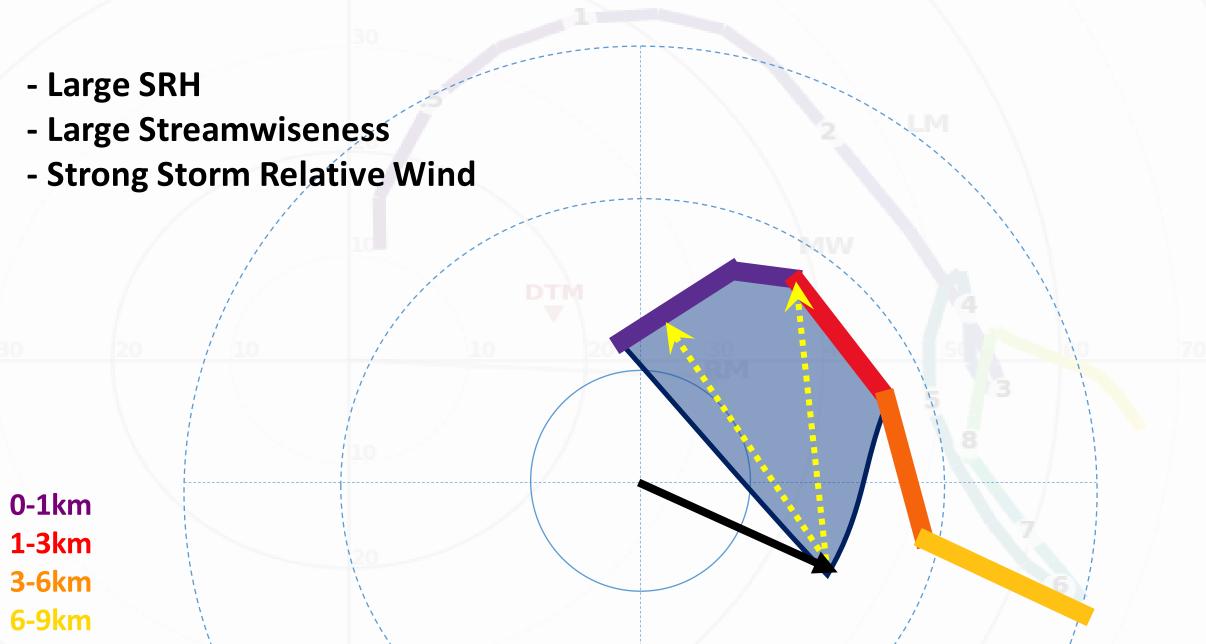
Forecasters should diagnose both terms, SRW & SRV, separately for a full picture

BREAK – QUESTIONS?
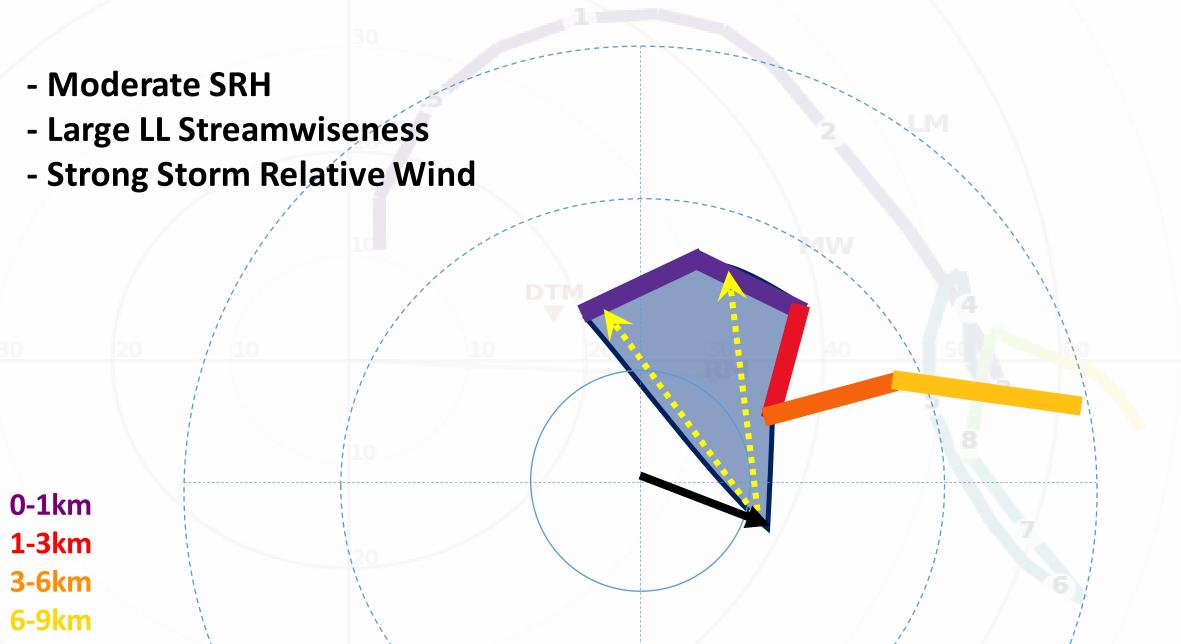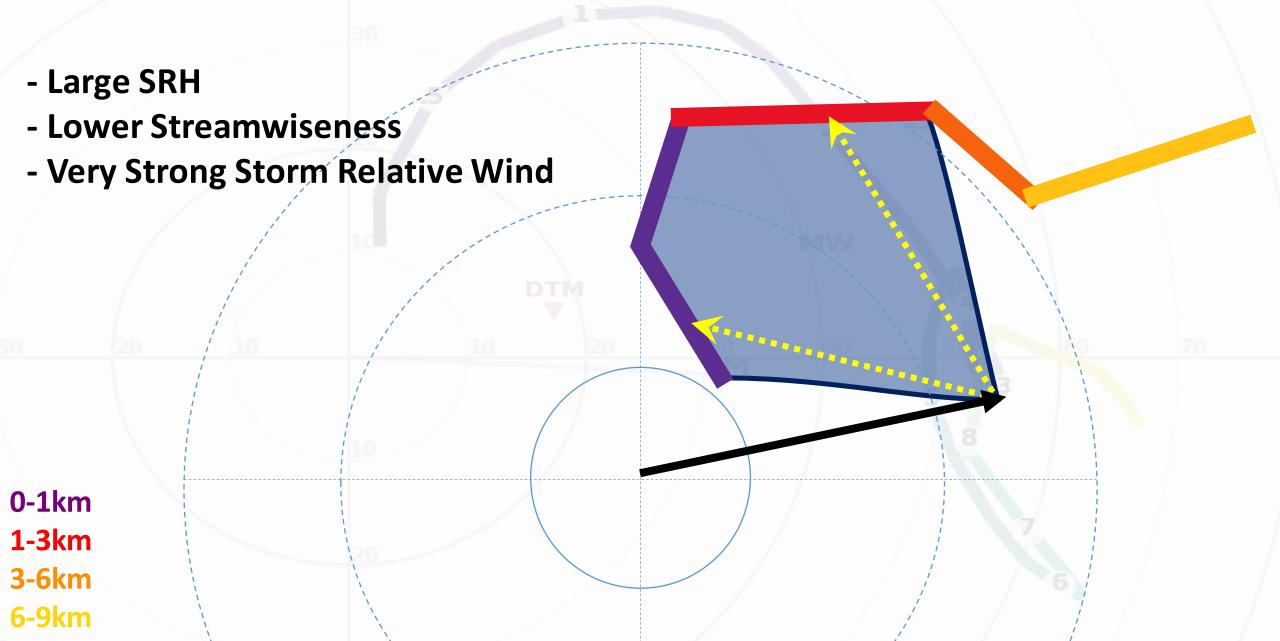
NEXT: IMPORTANT QUANTIES FOUND ON THE HODOGRAPH
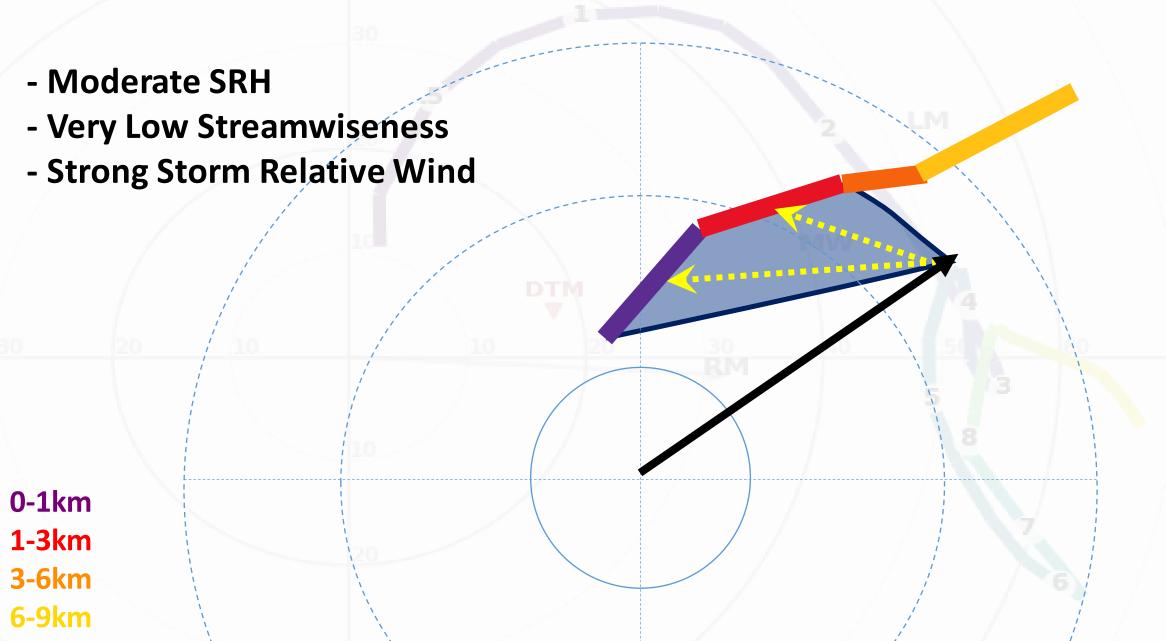
VIII. HODOGRAPH SHAPE

HODOGRAPH EXAMPLES

- **Large SRH**
- **Large Streamwiseness**
- **Strong Storm Relative Wind**

0-1km
1-3km
3-6km
6-9km

HODOGRAPH EXAMPLES

- **Small SRH**
- **Large Streamwiseness**
- **Weaker Storm Relative Wind**

0-1km
1-3km
3-6km
6-9km
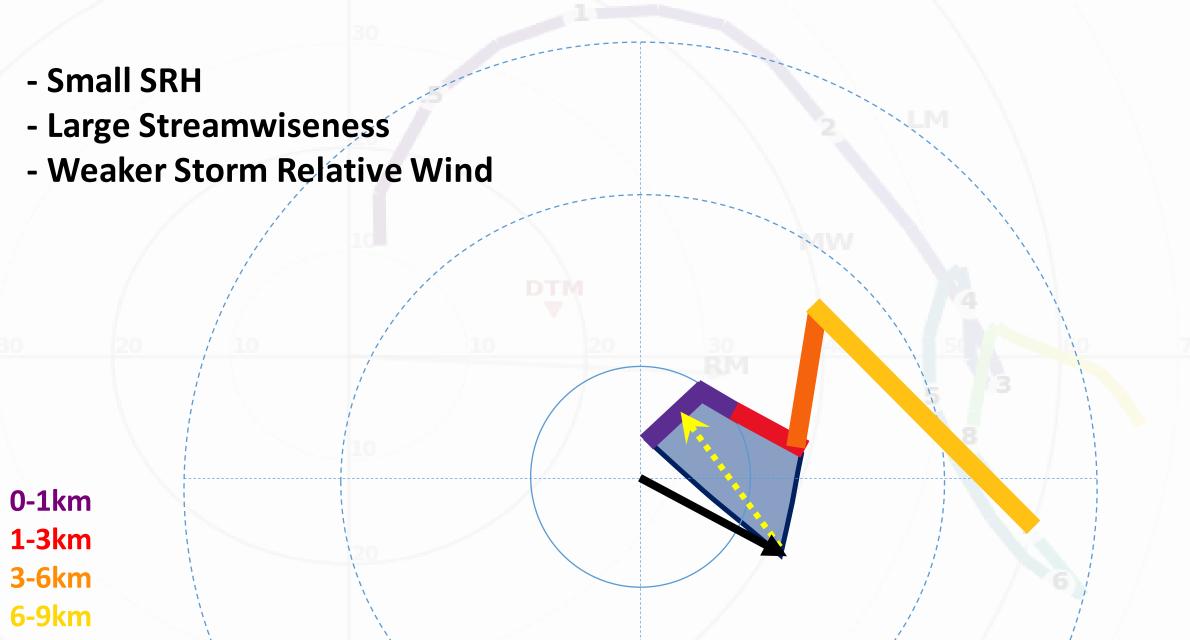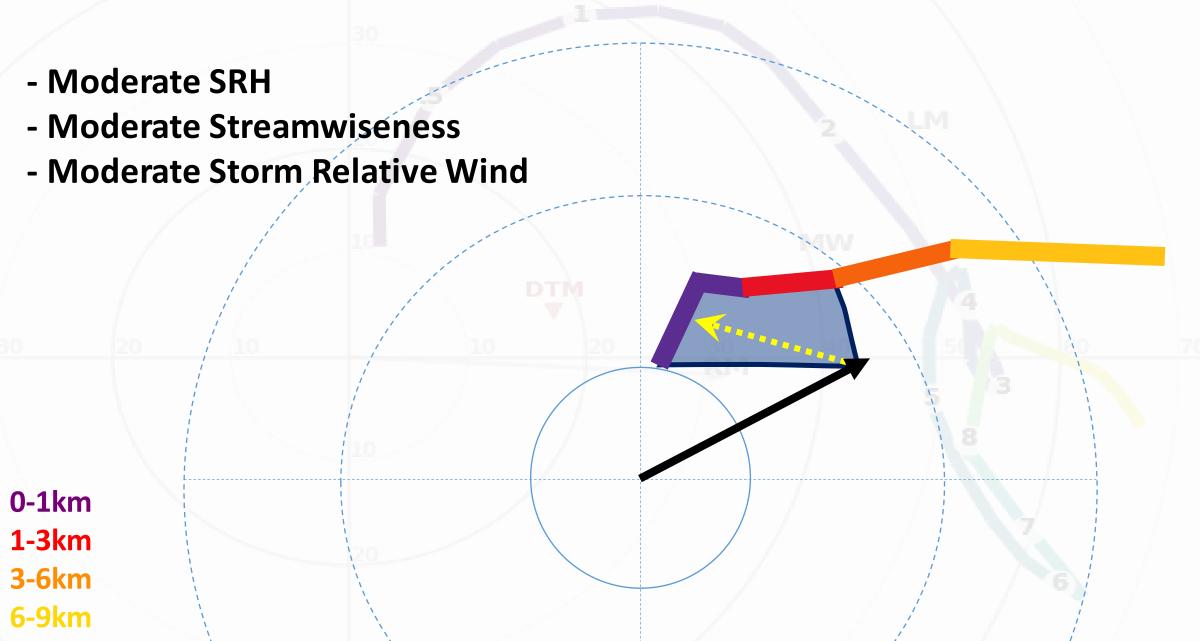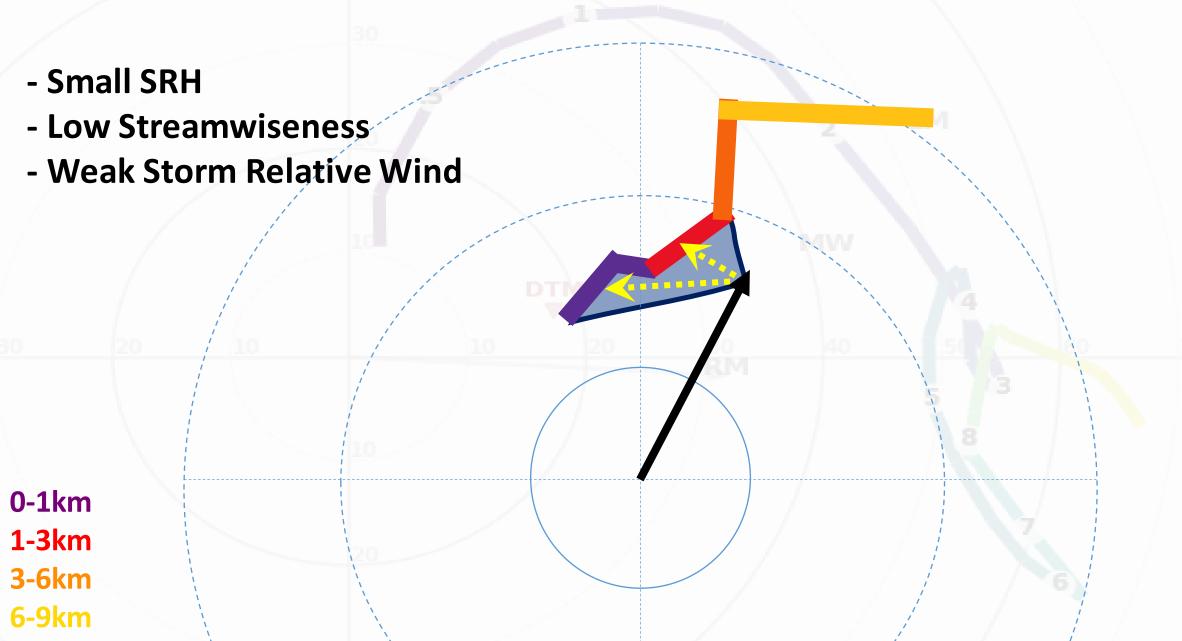
HODOGRAPH PARAMETERS

	SRW	SWV	SRH	BULK SHEAR
V. WEAK	≤ 10 kts	≤ 0.001 /sec	≤ 50 m²/s²	≤ 10 kts
WEAK	15 kts	0.005 /sec	100 m²/s²	20 kts
MODERATE	20 kts	0.025 /sec	200 m²/s²	30 kts
STRONG	30 kts	0.03 /sec	300 m²/s²	40 kts
V. STRONG	≥ 40 kts	≥ 0.04 /sec	≥ 400 m²/s²	≥ 50 kts

HODOGRAPH PARAMETERS

› **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**.

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

Peters et al. 2020

RAOB OBSERVED VERTICAL PROFILE | KAPX 00Z
VALID: THU OCTOBER 18, 2007 - 08 PM ET - [00Z 10/19]

KAPX - GAYLORD | [44.92, -84.72]

Legend:
- WETBULB TEMP
- VIRTUAL TEMP
- DEWPOINT
- TEMPERATURE
- SB PARCEL
- ML PARCEL
- MU PARCEL
- DWNDRFT PARCEL

RM: NE @ 45 kts
LM: NNE @ 54 kts
MW: NNE @ 53 kts
DTM: NNE @ 30 kts
US: ENE @ 37 kts
DS: NE @ 102 kts

←1109J/kg ←MUEL
←914J/kg
←207/kg
←FRZ
8.3
←MULFC
←SBLCL
←PBL
59°F 65°F

	BS	SRH	SRW	SWζ%	SWζ
0-.5km:	31 kt	312 m²/s²	39 kt	95	0.034
0-1km:	43 kt	414 m²/s²	32 kt	64	0.004
1-3km:	11 kt	7 m²/s²	29 kt	64	0.003
3-6km:	54 kt	44 m²/s²	40 kt	40	0.004

	CAPE	6CAPE	3CAPE	NCAPE	CIN	LCL
SB:	747 J/kg	666 J/kg	130 J/kg	0.1	-77 J/kg	451 m
MU:	1109 J/kg	914 J/kg	207 J/kg	0.2	-17 J/kg	716 m
ML:	540 J/kg	511 J/kg	87 J/kg	0.1	-18 J/kg	1292 m

DCAPE: 679 J/kg   Γ₀₋₃: 7.4 Δ°C/km   Γ₃₋₆: 6.1 Δ°C/km   Γmax: 8.3 Δ°C/km

ENTRAINING CAPE: 1078 J/kg

	RH(%)	ω
0-.5km:	78%	11.4 g/kg
0-1km:	77%	9.9 g/kg
1-3km:	45%	4.6 g/kg
3-6km:	48%	0.7 g/kg
6-9km:	2%	0.1 g/kg

PWAT: 0.9"   Tw: 16.5 °C

SWζ (%) / RH (%)
ζtot & ζSW (/sec)
Theta-e & Theta (K)
SR Wind (kts)

SFC: 65.8/59.5 °F | RH: 80.1% | ω: 11.7 g/kg | p: 992 hPa | SSE 7 kt

00:00:40

KAPX REFLECT | SPC STORM REPORTS, TRACKS