

Wind Shear Parameters

1. Wind Shear Parameters

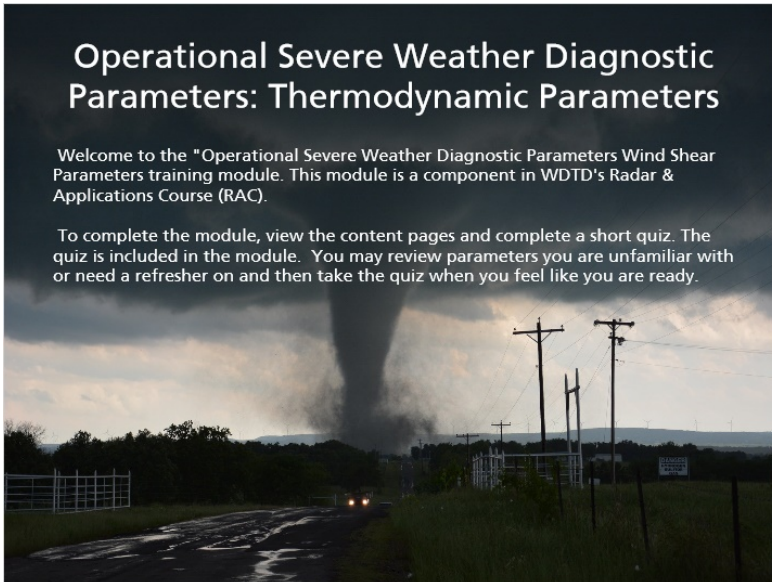
1.1 Operational Severe Weather Diagnostic Parameters:

Wind Shear Parameters



Notes:

1.2 Operational Severe Weather Diagnostic Parameters: Thermodynamic Parameters

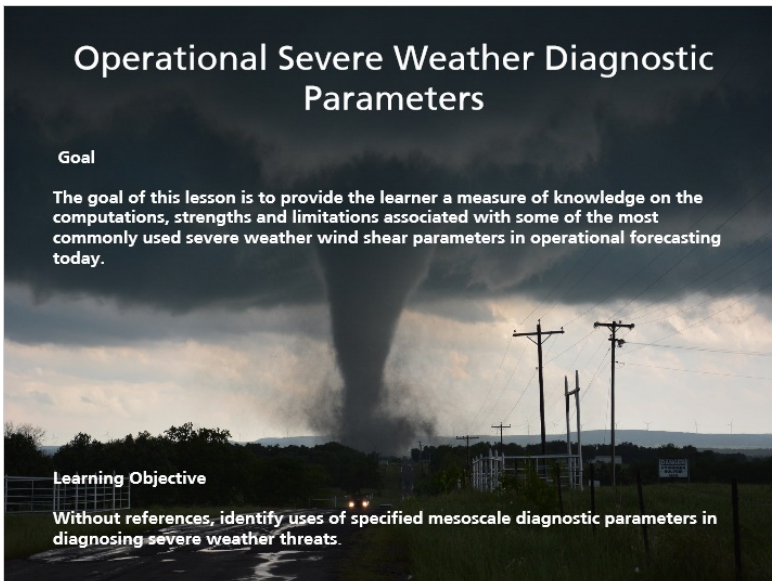


Operational Severe Weather Diagnostic Parameters: Thermodynamic Parameters

Welcome to the "Operational Severe Weather Diagnostic Parameters Wind Shear Parameters training module. This module is a component in WDTD's Radar & Applications Course (RAC).

To complete the module, view the content pages and complete a short quiz. The quiz is included in the module. You may review parameters you are unfamiliar with or need a refresher on and then take the quiz when you feel like you are ready.

1.3 Operational Severe Weather Diagnostic Parameters



Operational Severe Weather Diagnostic Parameters

Goal

The goal of this lesson is to provide the learner a measure of knowledge on the computations, strengths and limitations associated with some of the most commonly used severe weather wind shear parameters in operational forecasting today.

Learning Objective

Without references, identify uses of specified mesoscale diagnostic parameters in diagnosing severe weather threats.

1.4 Wind Shear Parameters

Wind Shear Parameters

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Notes:

1.5 Bulk Shear

Bulk Shear

Bulk Shear

This is actually the bulk wind vector difference and is calculated by subtracting the wind between two layers, such as the surface or boundary layer (ex. 0 - 500 m AGL mean wind) and a representative middle layer (such as 6 km AGL). Dividing by the depth of the layers gives the true bulk shear.

[Strengths
Part 1](#)

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In BUFKIT, the bulk shear is labeled "Shear layer difference" and can be plotted on the overview screen (See [BUFKIT overview example](#)).

Mean Shear

Mean shear is defined as the length of the hodograph divided by the depth over which the hodograph was measured. This quantity is computable in the BUFKIT overview screen by selecting the button labeled "Shear (length of hodo)" and clicking on units of (m/s) / km.

The value of shear shown in the lower left of the [hodograph graphic](#) in BUFKIT is actually hodograph length (in m/s and in (m/s)/km) as computed from summing around all the points of the hodograph. The ending point that determines the length of the hodograph computations are selectable in kilometer increments from 1 to 6 km. The default is 4 km. (Note: CAPE values are also displayable in layer integral amounts as well).

1.6 Bulk Shear Strengths Part 1

Bulk Shear Strengths Part 1

[Bulk Shear](#)

Strengths Part 1

- Shear is the most important parameter for convective storm organization and persistence. Increasing vertical shear (for a given amount of thermodynamic instability) often results in greater convective storm organization, and longevity.

[Strengths Part 2](#)

- From observations and numerical modeling simulations, bulk shear, mean shear, and/or hodograph length have all been used to help quantify the amount of vertical wind shear capable of producing the dynamic pressure perturbations and resulting midlevel rotation in supercells.

[Limitations](#)

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- The interaction of the updraft with an environment characterized by strong vertical shear of the horizontal wind permits some storms to develop nonhydrostatic vertical pressure gradients that can be as influential in developing updrafts as the buoyancy effects (Weisman and Klemp 1984).

1.7 Bulk Shear Limitations

Bulk Shear Limitations

[Bulk Shear](#)

[Strengths Part 1](#)

- Bulk shear (surface to 6 km) has limited utility in distinguishing between supercells that produce significant tornadoes and those that do not (see Rasmussen and Blanchard, 1998).

[Strengths Part 2](#)

- Hodograph length is more sensitive to vertical resolution and noise in the observations. Computations using numerous model sounding layers often yield unrealistically high values of shear and should be

Limitations

- The bulk wind difference can hide important aspects regarding hodograph shape.

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- It is also important to note that an appropriate layer depth should be used for the expected storm environment (Using a 0-6km layer in an environment for shallow supercells would yield unrealistic expectations).

1.8 Bulk Shear Strengths Part 2

Bulk Shear Strengths Part 2

[Bulk Shear Strengths Part 1](#)

Strengths Part 2

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- Operationally, lower-bound thresholds of bulk shear (0 to 6 km) of 15-20 m/s (~ 30 – 40 kts) and mean shear values around .001 s⁻¹ can be used as a first approximation to help determine potential supercell environments. Note: additional factors (e.g., buoyancy distributions, mesoscale variations, etc., should be considered as well because they can significantly modulate the character of severe storm environments.
- [Rasmussen and Blanchard \(1998\)](#) found that mean shear in the lowest 4 km AGL was able to distinguish (to a degree) between supercells that produced significant tornadoes and those that only produced large hail. Recent and ongoing research has focused on mean shear in the lowest kilometer above the ground and have found even more distinguishing signals (See section on 0-1 km SRH). SPC typically uses 20 kts of shear in the lowest 1 km AGL as a lower bound threshold for a significant tornadic supercell
- Other research such as Craven et al. (2002) and Markowski et al. (2002) using proximity soundings, found that the 0-1 km layer AGL shear was the primary distinguishing kinematic parameter separating supercells that produced significant tornadoes from those that did not.
- [This figure](#), from Craven et al. (2002), shows a remarkable lower threshold of 10 m/s (20 kts) in the statistical distribution.

1.9 Storm-Relative Helicity (SRH)

Storm-Relative Helicity (SRH)

$$SRH = \int_0^h (V - C) \cdot w dz$$

Storm-Relative Helicity (SRH)

[Strengths](#)

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- Storm-Relative Helicity (SRH) is a measure of the streamwise vorticity within the inflow environment of a convective storm and is proportional to streamwise vorticity and storm-relative winds and takes into account storm motion. The mathematical expression for SRH, as defined Davies-Jones et al. (1990) is shown above where V is the horizontal velocity (ground-relative vector wind), C is the storm motion, and w is the horizontal vorticity vector. The integration is over the inflow layer of the storm from 0 km to some depth h (typically 1 to 3 km).
- In BUFKIT the SRH is labeled "Helicity". The storm motion vector used in the helicity computations incorporates the Bunker's Storm Motion Technique.
- Note: The RUC and Eta model output of Helicity incorporates the Bunker's Storm Motion, displayable from the Volume Browser. However, the LAP5 model uses a slightly different storm motion for its SRH calculations. LAP5 storm motions are typically 25 degrees to the left of the Bunker's Storm Motion and thus, often result in lesser SRH values than the Eta or RUC.
- Research has shown that the signal found in 0-3 km SRH for tornadic supercells is not as strong as the signal in 0-1 km SRH.

1.10 Storm-Relative Helicity (SRH) Strengths

Storm-Relative Helicity (SRH) Strengths

[Storm-Relative Helicity \(SRH\)](#)

Strengths

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- Research and operations have found some correlations between increasing SRH values (from the surface to the lowest 3 kilometers) and tornado intensity (Johns et al. (1990), Davies-Jones et al. (1990), and Kerr and Darkow (1996).
- Observed 0-3 km mean SRH using Kerr and Darkow's proximity sounding study showed the following SRH values for various intervals of F scale: Mean 0-3 km SRH was 66 m²/s² for F0, 140 m²/s² for F1 tornadoes, 196 m²/s² for F2, 226 m²/s² for F3 tornadoes, and 249 m²/s² for F4 tornadoes. (note: No F5 tornadoes were in their study).
- However, operational experience has shown that current or projected 0-3 km SRH values exceeding 100 m²/s² often reflect a potential for supercells. The higher the SRH, the greater the potential for supercells.
- Rasmussen, 2001 found that there is a relationship between 0-1 km SRH and supercells that produce significant tornadoes (F2 or greater). See this [graphic](#) which shows a box and whiskers graph of 0-1 km SRH for soundings associated with supercells with significant (F2 or greater) tornadoes labeled "TOR", supercells without significant tornadoes (only large hail), labeled "SUP", and nonsupercell thunderstorms (only lightning was reported near the sounding), labeled "ORD". The gray boxes denote the 25th to 75th percentiles of the data set, with the heavy horizontal bar at the median value. Vertical lines (whiskers) extend to the 10th and 90th percentiles (as in Rasmussen and Blanchard, 1998).

1.11 Effective Storm-Relative Helicity (ESRH)

Effective Storm-Relative Helicity (ESRH)

Effective Storm-Relative Helicity (ESRH)

[Strengths](#)

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- Is a method of calculating SRH based on threshold values of CAPE (100J/kg) and CIN (-250 J/kg).
- Confines the SRH calculation to the part of a sounding where lifted parcels are buoyant, but not strongly capped.
- This is determined by starting with a surface parcel level and going upward until a lifted parcel's CAPE increases to 100J/kg or more with an associated CIN > than -250J/kg. From this level (the "effective inflow base") one continues to look upward in the sounding until a lifted parcel reaches a CAPE of < 100 J/kg or a CIN < -250 J/kg.

1.12 Effective Storm-Relative Helicity (ESRH) Strengths

Effective Storm-Relative Helicity (ESRH) Strengths

[Effective Storm-Relative Helicity \(ESRH\)](#)

Strengths

[Limitations](#)

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- Provides a more reasonable estimate of SRH in elevated supercell environments.
- More clearly discriminates between tornadic and non-tornadic storms than the standard, fixed layer versions of SRH. (see this [figure](#))

1.13 Effective Storm-Relative Helicity (ESRH) Limitations

Effective Storm-Relative Helicity (ESRH) Limitations

[Effective Storm-Relative Helicity \(ESRH\)](#)

[Strengths](#)

Limitations

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- The ESRH can be missing from a sounding due to:
 1. Insufficient buoyancy
 2. Excessive CIN
 3. The effective inflow layer is a single level within a sounding
- Not a good distinguisher between supercells and non-supercells.

1.14 Storm-Relative Wind (SR-Wind)

Storm-Relative Wind (SR-Wind)

Storm-Relative
Wind (SR-Wind)

[Strengths](#)

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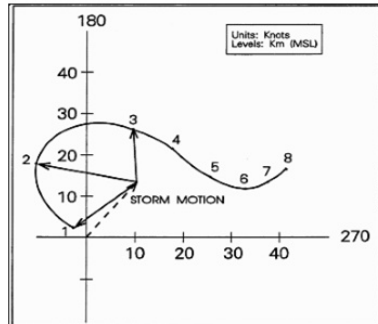


Figure 2. A hodograph showing storm relative wind "inflow" vectors and storm motion. (from NWSTC RTM-230).

- SR-wind is determined by subtracting the parent storm motion vector from the environmental wind vector. Vectors on a hodograph represent wind flow that the storm experiences at various levels as the storm moves through the environment (see figure at left).

- SR-wind affects the precipitation distribution of a storm with respect to the main updraft.

- Higher values of mid and upper-level SR-wind carry precipitation away from the updraft summits of well-organized storms (such as supercells) thereby diminishing the potential for significant water-loading (OTB, 1993).

1.15 Storm-Relative Wind (SR-Wind) Strengths

Storm-Relative Wind (SR-Wind) Strengths

[Storm-Relative
Wind \(SR-Wind\)](#)

[Strengths](#)

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- SR-wind is more physically significant in producing a particular storm structure than ground relative winds. Strong SR-wind at midlevels mitigates precipitation loading in updrafts, while strong low-level SR-wind is often associated with strong storm-relative helicity and low-level mesocyclones. One can qualitatively assess the amount of SRH by looking at the amount of area swept out on hodograph by the storm-relative wind vectors.

- Thompson (1998) found that supercells were more likely to produce tornadoes when midlevel (~ 500 mb) storm-relative winds were greater than 8-10 m s⁻¹.

- Evans and Doswell (2001) found 0-2 km system-relative winds stronger in derecho events than in non-derecho events. This was likely due to faster forward speed and low-level convergence in derecho events.

- Near-ground (0-1 km) storm-relative wind (speed) may also be crucial to tornadogenesis (Markowski et al. 2002).

- SR-wind significantly influences hail growth because it determines hail trajectories across the updraft.

1.16 Storm-Relative Wind (SR-Wind) Limitations

Storm-Relative Wind (SR-Wind) Limitations

[Storm-Relative Wind \(SR-Wind\)](#)

[Strengths](#)

Limitations

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- Storm-relative wind requires an estimate of storm motion, which is often difficult to determine from observations and especially, in forecasts. It can be difficult to determine the appropriate layer in which SR-wind effects are greatest in a storm.
- Multiple storm motions can occur simultaneously with storm systems making storm-relative flow estimates difficult with multicell systems.
- Most of the differences in storm-relative wind between tornadic storm and non-tornadic storms reside in the lowest kilometer or so above the ground, where observations of environmental winds on a sub-mesobeta time and space scale are sparse.
- Storm-relative wind was not a statistically significant tornado discriminator when RUC proximity soundings were analyzed (see Markowski et al. 2002).

1.17 Storm-Relative Helicity (SRH) Limitations

Storm-Relative Helicity (SRH) Limitations

[Storm-Relative Helicity \(SRH\)](#)

[Strengths](#)

Limitations

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- SRH is very sensitive to changes in the horizontal wind vector and storm motion and thus, to use it effectively in mesoscale analysis, the parameter inputs must be updated frequently by METARS, profilers, VAD winds, ACARS, or other data sources.
- Many studies such as Johns et al. (1993) and Edwards and Thompson (2000) indicate a wide spectrum of SRH values associated with any single tornadic event. (This [graphic](#) from Edwards and Thompson's study is an example of the data scatter associated with CAPE and 0-3 km SRH.)
- In AWIPS model calculations of 0-1 km shear (or SRH), there are typically insufficient model layers in the vertical to adequately sample the layer. In BUFKIT, the native resolution of the model is retained.
- Due to differences in storm motion calculations, model derived SRH can vary.

1.18 Effective Bulk Shear (EBS)

Effective Bulk Shear (EBS)

EBS

[Strengths and Limitations](#)

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- This is the bulk vector difference from the effective inflow base upward to 50% of the equilibrium level height for the most unstable parcel in the lowest 300 mb.
- This parameter is similar to the 0-6 km bulk shear, though it accounts for storm depth (effective inflow base to EL) and is designed to identify both surface based and elevated supercell environments.
- Supercells become more probable as the effective bulk shear vector increases in magnitude from 25-40 kt and greater.

1.19 Effective Bulk Shear (EBS) Strengths/Limitations

Effective Bulk Shear (EBS) Strengths/ Limitations

[EBS](#)

Strengths and Limitations

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Strengths:

- Normalizes the shear values for shallow and tall storms, allowing for more realistic assessments of these storm profiles.
- Allows for elevated and surface-based storm environments to be treated similarly.
- Does a good job of discriminating between supercell and non-supercell storms

Limitations:

- Effective Bulk Shear does not perform well in distinguishing between tornadic and non-tornadic storms.

2. Wind Shear Parameters Quiz

2.1 This has limited utility in distinguishing between supercells that produce significant tornadoes and those that do not.

(Multiple Choice, 10 points, 1 attempt permitted)

This has limited utility in distinguishing between supercells that produce significant tornadoes and those that do not.

- ☐ Storm-Relative Helicity
- ☐ Effective Storm-Relative Helicity
- ☐ Effective Bulk Shear
- ☒ Bulk Shear

Correct	Choice
	Storm-Relative Helicity
	Effective Storm-Relative Helicity
	Effective Bulk Shear
X	Bulk Shear

Feedback when correct:

That's right! You selected the correct response.

Feedback when incorrect:

You did not select the correct response.

Correct (Slide Layer)

This has limited utility in distinguishing between supercells that produce significant tornadoes and those that do not.

- ☐ Storm-Relative Helicity
- ☐ Effective
- ☐ Effective
- ☒ Bulk Shear

Correct

That's right! You selected the correct response.

Continue

Incorrect (Slide Layer)

This has limited utility in distinguishing between supercells that produce significant tornadoes and those that do not.

- ☐ Storm-Relative Helicity
- ☐ Effective
- ☐ Effective
- ☒ Bulk Shear

Incorrect

You did not select the correct response.

Continue

2.2 This parameter accounts for storm depth and is designed to identify both surface based and elevated supercell environments.

(Multiple Choice, 10 points, 1 attempt permitted)

This parameter accounts for storm depth and is designed to identify both surface based and elevated supercell environments.

- ☒ Effective Bulk Shear
- ☐ Bulk Shear
- ☐ Effective Storm-Relative Helicity
- ☐ Storm-Relative Helicity

Correct	Choice
X	Effective Bulk Shear
	Bulk Shear
	Effective Storm-Relative Helicity
	Storm-Relative Helicity

Feedback when correct:

That's right! You selected the correct response.

Feedback when incorrect:

You did not select the correct response.

Correct (Slide Layer)

This parameter accounts for storm depth and is designed to identify both surface based and elevated supercell environments.

☒ Effective Bulk Shear

☐ Bulk Shear

☐ Effective

☐ Storm-R

Correct

That's right! You selected the correct response.

Continue

Incorrect (Slide Layer)

This parameter accounts for storm depth and is designed to identify both surface based and elevated supercell environments.

☒ Effective Bulk Shear

☐ Bulk Shear

☐ Effective

☐ Storm-R

Incorrect

You did not select the correct response.

Continue

2.3 SR-wind affects the precipitation distribution of a storm with respect to _____

(Multiple Choice, 10 points, 1 attempt permitted)

SR-wind affects the precipitation distribution of a storm with respect to _____

- ☐ Storm-Relative Helicity
- ☐ The main downdraft
- ☐ The rear flank downdraft
- ☒ The main updraft

Correct	Choice
	Storm-Relative Helicity
	The main downdraft
	The rear flank downdraft
X	The main updraft

Feedback when correct:

That's right! You selected the correct response.

Feedback when incorrect:

You did not select the correct response.

Correct (Slide Layer)

SR-wind affects the precipitation distribution of a storm with respect to _____

- ☐ Storm-Relative Helicity
- ☐ The main downdraft
- ☐ The rear flank
- ☒ The main updraft

Correct

That's right! You selected the correct response.

Continue

Incorrect (Slide Layer)

SR-wind affects the precipitation distribution of a storm with respect to _____

- ☐ Storm-Relative Helicity
- ☐ The main downdraft
- ☐ The rear flank
- ☒ The main updraft

Incorrect

You did not select the correct response.

Continue

2.4 _____ is a measure of streamwise vorticity within the inflow environment of a convective storm and is proportional to streamwise vorticity and storm-relative winds and takes into account storm motion.

(Multiple Choice, 10 points, 1 attempt permitted)

_____ is a measure of streamwise vorticity within the inflow environment of a convective storm and is proportional to streamwise vorticity and storm-relative winds and takes into account storm motion.

- ☐ Effective Bulk Shear
- ☐ Storm-relative Wind
- ☒ Storm-Relative Helicity
- ☐ Effective Storm-Relative Helicity

Correct	Choice
	Effective Bulk Shear
	Storm-relative Wind
X	Storm-Relative Helicity
	Effective Storm-Relative Helicity

Feedback when correct:

That's right! You selected the correct response.

Feedback when incorrect:

You did not select the correct response.

Correct (Slide Layer)

_____ is a measure of streamwise vorticity within the inflow environment of a convective storm and is proportional to streamwise vorticity and storm-relative winds and takes into account storm motion.

- ☐ Effective
- ☐ Storm-re
- ☒ Storm-R
- ☐ Effective

Correct

That's right! You selected the correct response.

Continue

Incorrect (Slide Layer)

_____ is a measure of streamwise vorticity within the inflow environment of a convective storm and is proportional to streamwise vorticity and storm-relative winds and takes into account storm motion.

- ☐ Effective
- ☐ Storm-re
- ☒ Storm-R
- ☐ Effective

Incorrect

You did not select the correct response.

Continue

2.5 True or False: Effective Storm-Relative Helicity is a good distinguisher between supercells and non-supercells

(True/False, 10 points, 1 attempt permitted)

True or False: Effective Storm-Relative Helicity is a good distinguisher between supercells and non-supercells

☐ True

☒ False

Correct	Choice
	True
X	False

Feedback when correct:

That's right! You selected the correct response.

Feedback when incorrect:

You did not select the correct response.

Correct (Slide Layer)

True or False: Effective Storm-Relative Helicity is a good distinguisher between supercells and non-supercells

- ☐ True
☒ False

Correct

That's right! You selected the correct response.

Continue

Incorrect (Slide Layer)

True or False: Effective Storm-Relative Helicity is a good distinguisher between supercells and non-supercells

- ☐ True
☒ False

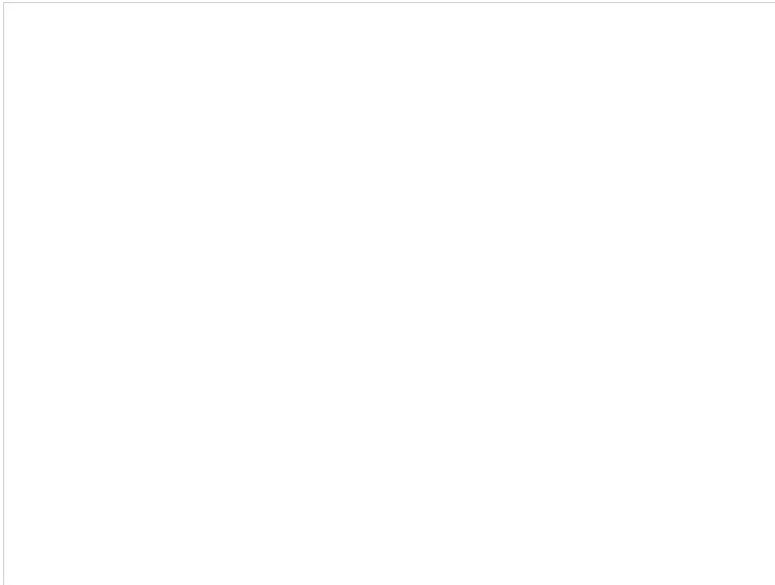
Incorrect

You did not select the correct response.

Continue

2.6 Results Slide

(Results Slide, 0 points, 1 attempt permitted)



Results for
2.1 This has limited utility in distinguishing between supercells that produce significant tornadoes and those that do not.
2.2 This parameter accounts for storm depth and is designed to identify both surface based and elevated supercell environments.
2.3 SR-wind affects the precipitation distribution of a storm with respect to _____
2.4 _____ is a measure of streamwise vorticity within the inflow environment of a convective storm and is proportional to streamwise vorticity and storm-relative winds and takes into account storm motion.
2.5 True or False: Effective Storm-Relative Helicity is a good distinguisher between supercells and non-supercells

Result slide properties

Passing 80%


Score

Success (Slide Layer)

Results

Your Score:	%Results.ScorePercent%% (%Results.ScorePoints% points)
Passing Score:	%Results.PassPercent%% (%Results.PassPoints% points)

Result:

 Congratulations, you passed.


[Review Quiz](#)[Retry Quiz](#)

Failure (Slide Layer)

Results

Your Score:	%Results.ScorePercent%% (%Results.ScorePoints% points)
Passing Score:	%Results.PassPercent%% (%Results.PassPoints% points)

Result:

 You did not pass.

[Review Quiz](#)