HAILSTONE SIZES

Size	Equivalent	Freefall Velocity	Freefall Energy
1/4	Pea	25 mph	0.02 ft-lbs
1/2	Marble	35 mph	0.09 ft-lbs
3/4	Dime	43 mph	0.44 ft-lbs
1	Quarter	50 mph	1.43 ft-lbs
1 1/4	Half Dollar	56 mph	3.53 ft-lbs
1 1/2	Walnut	61 mph	7.35 ft-lbs
1 3/4	Golfball	66 mph	13.56 ft-lbs
2	Hen Egg	72 mph	23.71 ft-lbs
2 1/2	Tennis Ball	80 mph	57.48 ft-lbs
2 3/4	Baseball	85 mph	85.95 ft-lbs
3	Tea Cup	89 mph	122.66 ft-lbs
4	Grapefruit	106 mph	413.31 ft-lbs
4 1/2	Softball	117 mph	724.85 ft-lbs

FUJITA SCALE

A scale of tornado damage.

F0: 40-72 mph. Twigs and branches snap off trees. Some windows break.
F1: 73-112 mph. Pushes moving cars off road. Flips mobile homes.
F2: 113-157 mph. Uproots large trees and rips roofs off frame houses.
F3: 158-206 mph. Severe damage. Cars lifted and thrown. Trains overturned.
F4: 207-260 mph. Levels well-built homes.
F5: 261-318 mph. Incredible damage. Foundations swept clean.

BEAUFORT WIND SCALE

No	Mph	Kts	Description
0	0-1	0-1	Smoke rises vertically
1	1-3	1-3	Wind moves smoke but not wind vanes
2	4-7	4-6	Wind felt on face; leaves rustle; wind vane moved
3	8-12	7-10	Leaves and small twigs in constant motion; wind extends light flag
4	13-18	11-16	Dust and loose paper raised; small branches moved
5	19-24	17-21	Small trees with leaves begin to sway
6	25-31	22-27	Large branches in motion; whistling in telephone wires
7	32-38	28-33	Whole trees in motion; resistance felt walking against wind
8	39-46	34-40	Twigs broken off trees; wind generally impedes progress
9	47-54	41-47	Slight structural damage occurs (chimney pots and slate removed)
10	55-63	48-55	Trees uprooted

METAR OBSERVATION FORMAT

```
KLEX 162354Z 20004KT 1 1/2SM -RA BR FEW004 BKN030
OVC050 22/21 A3006 RMK AO2 RAE05B34 SLP173 P0002
60007 70112 T02221011 51006=
```

KLEX, Lexington, Kentucky; 16th day of month; 2354 UTC; wind from 200 deg at 04 knots; visibility 1 1/2 statute mile in light rain and fog; few clouds at 400 ft; broken layer at 3000 ft; overcast layer at 5000 ft; temperature 22 deg C; dewpoint 21 deg C; altimeter setting (pressure) 30.06 inches; A02 (automated station, type 2 which reports precip); rain ended at 05 minutes past hour and began at 34 minutes past hour; sea level pressure 1017.3 mb; 0.02" of precip in past hour; 0.07" of precip in past 6 hours; 1.12" in past 12 hours; exact temp 22.2 deg C; exact dewpoint -1.1 deg C; pressure rising by 0.06 mb.

SYNOPTIC OBSERVATION FORMAT

```
68842 11682 72516 10176 20145 30126 40199 51010
69903 72052 875// 555 91020=
```

Port Elizabeth, South Africa (68842); precipitation data will be included (1); station type is manned and weather is included (1); lowest cloud height is 1000 to 1500m above ground (6); visibility is 40 km (82); sky cover 7/8ths (7); wind direction 250 deg (250); wind speed 16 kt (16); temperature 17.6 deg C (10176); dewpoint 14.5 deg C (20145); station pressure is 1012.6 mb (0126); sea level pressure 1019.9 mb (0199); pressure tendency rising then steady (1) changing by 1.0 mb (10); precipitation amount is trace (990) over a time period of 18 hours (3); weather is recent drizzle (20); previous weather had been drizzle (5) and clouds covering more than half of sky (2); low or middle cloud amount is 7/8ths (7); low cloud is stratocumulus (5); middle cloud is not visible (/); high cloud is not visible (/). Everything after the triple-digit group consists of regionally-defined data groups.

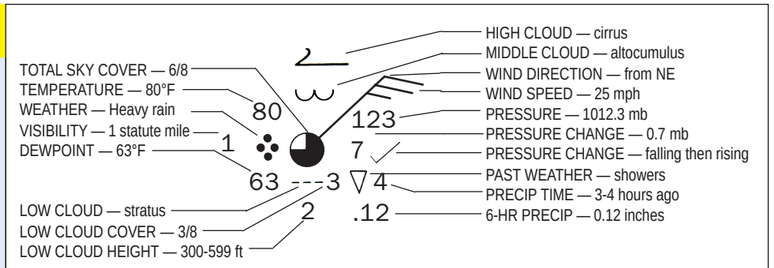
MISCELLANEOUS SYMBOLS

The numbers pertain to code representations used in transmitted reports, and the pictograms are used as part of a station plot.

N Total sky cover	a Pressure trend	W Past weather	C_L Low cloud	C_M Middle cloud	C_H High cloud
0 — No clouds.	0 — Rising then falling.	0 — Cloud covering half or less of sky throughout period.	0 — No low clouds.	0 — No middle clouds.	0 — No high clouds.
1 — 1/8, or 1 tenth cloud cover.	1 — Rising, then steady; or rising, then rising more slowly.	1 — Cloud covering both more than half and less than half of sky during period.	L1 — CUMULUS, with little vertical development and seemingly flattened.	M1 — ALTOSTRATUS, semitransparent, thin enough to see sun/moon.	H1 — CIRRUS, in the form of filaments or hooks, not invading the sky.
2 — 2/8, or 2 to 3 tenths cloud cover.	2 — Rising, steadily or unsteadily.	2 — Cloud covering more than half of sky throughout period.	L2 — CUMULUS, of considerable size. Towering cumulus.	M2 — ALTOSTRATUS or NIMBOSTRATUS. The sun/moon can't be seen.	H2 — CIRRUS, dense, and in patches/twisted sheaves, not invading sky.
3 — 3/8, or 4 tenths cloud cover.	3 — Falling or steady, then rising; or rising then rising more rapidly.	3 — Sandstorm, or duststorm, or drifting or blowing snow.	L3 — CUMULONIMBUS, tops are not fibrous, cirriform, or anvil-shaped.	M3 — ALTOCUMULUS, at single level, and semitransparent.	H3 — CIRRUS, often anvil-shaped and associated with cumulonimbus.
4 — 4/8, or 5 tenths cloud cover.	4 — Steady.	4 — Fog or thick haze.	L4 — STRATOCUMULUS, formed by the spreading out of cumulus.	M4 — ALTOCUMULUS, in patches, continuously changing.	H4 — CIRRUS, in the form of hooks or filaments, invading the sky.
5 — 5/8, or 6 tenths cloud cover.	5 — Falling, then rising.	5 — Drizzle.	L5 — STRATOCUMULUS, not formed by the spreading out of cumulus.	M5 — ALTOCUMULUS, invading sky and usually thickening.	H5 — CIRRUS or CIRRO-STRATUS, invading sky, bulk not 45° above horizon.
6 — 6/8, or 7 to 8 tenths cloud cover.	6 — Falling, then steady; or falling, then falling more slowly.	6 — Rain.	L6 — STRATUS, in continous layer or shreds. No stratus of bad weather.	M6 — ALTOCUMULUS, formed by spreading out of cumulus.	H6 — CIRRUS or CIRRO-STRATUS, invading sky, bulk 45° or more above horizon.
7 — 7/8, or 9 tenths cloud cover.	7 — Falling, steadily or unsteadily.	7 — Snow.	L7 — STRATUS, of bad weather (scud), and often with nimbostratus.	M7 — ALTOCUMULUS, not invading sky, usually double-layered/opaque.	H7 — CIRROSTRATUS, completely covering the sky.
8 — Sky completely covered with clouds.	8 — Steady or rising, then falling; or falling, then falling more rapidly.	8 — Showers.	L8 — STRATOCUMULUS and CUMULUS with bases at different levels and not formed by spreading Cu.	M8 — ALTOCUMULUS, in the form of cumuliform tufts (castellanus).	H8 — CIRROSTRATUS, not invading the sky and not completely covering sky.
9 — Sky obscured (clouds not visible due to rain, snow, fog, or other obscuration).	9 — NOT USED	9 — Thunderstorm, with or without precipitation.	L9 — CUMULONIMBUS, whose tops are clearly fibrous or anvil-shaped.	M9 — ALTOCUMULUS, at many layers (a chaotic sky).	H9 — CIRROCUMULUS predominating all other cirriform clouds.

CONVERSIONS

MPH = knots x 1.15
m/s x 2.2356
Knots = MPH x 0.8696
m/s x 1.944



WEATHER SYMBOLS

Numbers indicate the weather code as used in synoptic weather reports (ww, present weather reported from a manned weather station, as defined in WMO Pub. No. 306-A).

00 Cloud development not observed/observable during past hour.	01 Clouds generally dissolving during past hour.	02 State of sky unchanged during past hour.	03 Clouds generally forming or developing during past hour.	04 Visibility reduced by smoke.	05 Haze.	06 Dust suspended in the air, but not raised by wind.	07 Dust or sand raised by wind.	08 Dust devils now or within past hour.	09 Duststorm or sandstorm not at station but within sight.
10 Mist.	11 Patches of shallow fog at station, not deeper than 2 m (10 m at sea).	12 Continuous shallow fog at station, not deeper than 2 m (10 m at sea).	13 Lightning visible, but no thunder heard.	14 Precipitation visible but not reaching ground at station.	15 Precipitation reaching the ground not at or near the station but at a distance.	16 Precipitation reaching the ground not at the station but nearby.	17 Thunder heard but no precipitation at the station.	18 Wind squall now or during the past hour.	19 Tornado, waterspout, or funnel cloud observed now or during past hour.
20 Recent drizzle (not freezing, not showers) during past hour.	21 Recent rain (not freezing, not showers) during past hour.	22 Recent snow (not showers) during past hour.	23 Recent rain and snow (not showers) during past hour.	24 Freezing drizzle or rain (not showers), not now but during past hour.	25 Rain showers, not now but during past hour.	26 Snow showers, not now but during past hour.	27 Hail or hail and rain, not now but during past hour.	28 Fog, not now but during past hour.	29 Thunderstorm, with or without precipitation, not now but during past hour.
30 Slight/moderate duststorm or sandstorm, decreased during hour.	31 Slight/moderate duststorm or sandstorm, no change during hour.	32 Slight/moderate duststorm or sandstorm, increased during hour.	33 Severe duststorm or sandstorm, which has decreased during hour.	34 Severe duststorm or sandstorm, no change during past hour.	35 Duststorm or sandstorm, severe, has increased during past hour.	36 Drifting snow, slight or moderate.	37 Drifting snow, heavy.	38 Blowing snow, slight or moderate.	39 Blowing snow, heavy.
40 Fog at a distance but not at station during past hour.	41 Patchy fog.	42 Fog, sky discernable, and has become thinner during past hour.	43 Fog, sky not discernable, and has become thinner during past hour.	44 Fog, sky discernable, no change during past hour.	45 Fog, sky not visible, no change during past hour.	46 Fog, sky visible, has begun or become thicker during past hour.	47 Fog, sky not visible, has begun or become thicker during past hour.	48 Freezing fog, sky visible.	49 Freezing fog, sky not visible.
50 Drizzle, light, intermittent, not freezing.	51 Drizzle, light, continous, not freezing.	52 Drizzle, moderate, intermittent, not freezing.	53 Drizzle, moderate, continuous, not freezing.	54 Drizzle, heavy, intermittent, not freezing.	55 Drizzle, heavy, continous, not freezing.	56 Freezing drizzle, light.	57 Freezing drizzle, moderate or heavy.	58 Drizzle and rain mixed, light.	59 Drizzle and rain mixed, moderate or heavy.
60 Rain, light, intermittent, not freezing.	61 Rain, light, continous, not freezing.	62 Rain, moderate, intermittent, not freezing.	63 Rain, moderate, continuous, not freezing.	64 Rain, heavy, intermittent, not freezing.	65 Rain, heavy, continous, not freezing.	66 Freezing rain, light.	67 Freezing rain, moderate or heavy.	68 Rain and snow mixed, light.	69 Rain and snow mixed, moderate or heavy.
70 Snow, light, intermittent.	71 Snow, light, continous.	72 Snow, moderate, intermittent.	73 Snow, moderate, continous.	74 Snow, heavy, intermittent.	75 Snow, heavy, continous.	76 Ice needles, with or without fog.	77 Snow grains, with or without fog.	78 Snow crystals, with or without fog.	79 Ice pellets (sleet).
80 Rain showers, light.	81 Rain showers, moderate or heavy.	82 Rain showers, torrential.	83 Rain/snow showers mixed, light.	84 Rain/snow showers mixed, moderate or heavy.	85 Snow showers, light.	86 Snow showers, moderate or heavy.	87 Ice pellet showers, light.	88 Ice pellet showers, moderate or heavy.	89 Hail, light, not associated with thunder.
90 Hail, moderate or heavy, not associated with thunder.	91 Rain, light. Thunder heard during past hour but not now.	92 Rain, moderate or heavy. Thunder heard during past hour but not now.	93 Light snow or rain/snow mixed with hail. Thunder heard during past hour.	94 Moderate or heavy snow or rain/snow with hail. Thunder in past hour.	95 Thunderstorm, light or moderate. Rain or snow, but no hail.	96 Thunderstorm, light or moderate, with hail.	97 Thunderstorm, severe. Rain or snow, but no hail.	98 Thunderstorm, with duststorm or sandstorm.	99 Thunderstorm, severe, with hail.

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WEATHERGRAPH *Forecasting*

Planetary scale	10,000 + km	General atmospheric circulation
Synoptic scale	1,000 - 10,000 km	Frontal systems, synoptic highs and lows
Mesoscale	10 - 1,000 km	Thunderstorms, tropical cyclones
Microscale	1 - 10 km	Clouds, tornadoes, mountain waves

TROPICAL SYSTEMS

Classification	Sustained wind speed Knots	MPH
TROPICAL DISTURBANCE	33 or less	38 or less
TROPICAL DEPRESSION*	33 or less	38 or less
TROPICAL STORM	34-63	39-73
HURRICANE/TYPHOON	64 or more	74 or more
MAJOR HURRICANE**	96 or more	110 or more
SUPERTYPHOON* *	130 or more	149 or more

* Has a closed circulation ** Designation is nonstandard or may apply regionally

TROPICAL CYCLONE REQUIREMENTS

Sea surface temperatures in excess of 80 deg F over large open ocean areas.
Coriolis effect, equal to that at 5 degrees latitude or greater
Weak vertical wind shear; preferably below 20 kts shear from 850 to 200 mb

EASTERLY WAVES

A migratory disturbance in the tropical easterlies that moves westward. They are most common in the Atlantic basin and may evolve into tropical cyclones. Easterly waves are usually stable but may be one of the following:

Wave type	Precipitation	Slope w/ height	Wnd spd w/ height
Stable	West of wave	Eastward	Decreases
Neutral	At wave	Little if any	Little change
Unstable	East of wave	Westward	Increases

SAFFIR-SIMPSON HURRICANE SCALE

Cat 1 — Minimal damage
Pressure >980 mb (>28.92"); winds 74-95 mph; storm surge 4-5 ft.
Damage primarily to shrubbery, trees, foliage, and unanchored mobile homes. No real damage to other structures. Some damage to poorly-constructed signs. Low-lying coastal roads inundated, minor pier damage, some small craft torn from moorings in exposed anchorage.

Cat 2 — Moderate damage
Pressure 965-979 mb (28.49-28.92"); winds 96-110 mph; storm surge 6-8 ft.
Considerable damage to shrubbery and tree foliage; some trees blown down. Major damage to exposed mobile homes. Extensive damage to poorly-constructed signs. Some damage to roofing materials on buildings; some window and door damage. No major damage to buildings. Coastal roads and low-lying escape routes are cut by rising water two to four hours before the arrival of the storm. Considerable damage to piers. Small craft torn from mooring.

Cat 3 — Extensive damage
Pressure 945-964 mb (27.90-28.48"); winds 111-130 mph; storm surge 9-12 ft.
Foliage torn from trees. Large trees and signs blown down. Some structural damage to small buildings. Mobile homes destroyed. Serious flooding at coast. Large structures near coast damaged by battering waves and floating debris. Low-lying escape routes cut by rising water three to five hours before storm arrives.

Cat 4 — Extreme damage
Pressure 920-944 mb (27.17-27.89"); winds 131-155 mph; storm surge 13-18 ft.
Numerous trees blown down. Extensive damage to roofing materials. Complete failure of roofs on many small residences. Flat terrain is submerged ten feet or less above sea level as far as six miles inland. Major damage to lower floors of structures near shore due to battering by waves and floating debris. Major erosion of beaches.

Cat 5 — Catastrophic damage
Pressure <920 mb (<27.17"); winds >155 mph; storm surge >18 ft.
Considerable damage to buildings. Major damage to lower floors of all coastal structures less than 15 feet above sea level and within 500 yards of shore.

TURBULENCE

Using the 300, 250, and 200 mb charts, some favored areas for clear air turbulence are:
* Regions just poleward of the jet stream
* Horizontal wind shear of 40+ kts per 150 nm
* Vertical wind shear of 6+ kts per 1000 ft
* Temperature gradient of 5+ deg C per 120 nm
* Winds of 135+ kts in strong anticyclonic flow

WEATHER SYSTEM CATEGORIES

Type of system	Surface Indication	Upper Air Indication	Types of system
Cold barotropic low	Low	Deep low	Decaying frontal wave
			Cutoff low
Warm barotropic low	Low	Weak high	Heat low
			Tropical cyclone*
Cold barotropic high	High	Weak low	Arctic high
Warm barotropic high	High	Strong high	Subtropical high
Baroclinic low	Low	Wave	Frontal low
Baroclinic high	High	Wave	Migratory high

* High is usually only discernable at 300 mb or above.

HEAVY SNOW FORECASTING

With major frontal systems, the heaviest snow usually falls in a band between 50 nm and 200 nm to the left of the surface low s track. Heavy snowfall tends to diminish with passage of the 700 mb low.

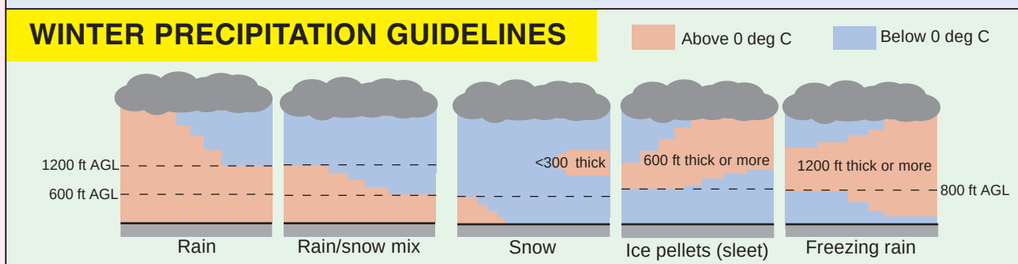
PROGGING RULES

- ❑ A major short wave trough moving **A** into **B** out of a long wave trough **A** deepens **B** fills the long wave trough.
- ❑ A major short wave ridge moving **A** into **B** out of a long wave ridge **A** builds **B** weakens the long wave ridge.
- ❑ A jet streak moving **A** toward **B** through **C** away from the axis of a long wave trough will cause it to **A** deepen and remain quasi-stationary **B** progress **C** fill and progress more rapidly.
- ❑ A jet streak moving **A** toward **B** through **C** away from the axis of a long wave ridge will cause it to **A** build and remain quasi-stationary **B** progress **C** weaken and progress more rapidly.
- ❑ An upper trough oriented NW-SE has negative tilt and tends to deepen; one oriented NE-SW has positive tilt and tends to fill.
- ❑ The stronger the westerly component of the upper-level wind, the faster the wave moves.
- ❑ Cold air advection deepens upper-level troughs and weakens upper-level ridges.
- ❑ Warm air advection builds upper-level ridges and fills upper-level troughs.
- ❑ Moisture in a parcel may increase due to these factors: upper divergence, warm air advection, frontal lift, orographic lift, boundary-layer convergence, colder air moving over a warmer surface, advection over a new moisture source, and on-shore flow.
- ❑ Moisture in a parcel may decrease due to these factors: upper convergence, cold air advection, adiabatic drying, warm air moving over a cold surface, and offshore flow.
- ❑ Cold fronts will move at roughly 85% of the 850 mb flow in the cold air behind the cold front.
- ❑ Warm fronts will move at roughly 70% of the 850 mb flow in the cold air ahead of the warm front.
- ❑ Dynamic lows tend to have a surface motion of 70% of the 700 mb flow or 50% of the 500 mb flow.

FORECAST MODEL OVERVIEW

Name	Forecast Model Full Name	Domain	Type	Grid Size	Horz Resolutn	Vert Lyrs	NWS Implem	Notes
LFM	Limited-area Fine Mesh	N. Amer.	Grid	53 x 57	190 km	7	1971	Discontinued
LFM II	Limited-area Fine Mesh	N. Amer.	Grid	53 x 45	127 km	16	1977	Discontinued
NGM	Nested Grid Model	N. Amer.	Grid	Nested	90 km	16	1985	
GSM	Global Spectral Model	Global	Spectral	126 waves	100 km	28	1980	Is also AVN (to 72h) and MRF (to 360h)
ETA	Eta (greek letter)	N. Amer.	Grid	N/A	80 km	38	1993	
ETA	Eta (greek letter)	N. Amer.	Grid	N/A	48 km	38	1995	
ETA	Eta (greek letter)	N. Amer.	Grid	N/A	32 km	45		Experimental
ETA	Mesoscale Eta	U.S./Can	Grid	N/A	29 km	50		Experimental
RUC1	Rapid Update Cycle	U.S.	Grid	81x62	60 km	25	1994	Discontinued
RUC2	Rapid Update Cycle	N. Amer.	Grid	151x113	40 km	40	1998	Model is assimilated every hour

WINTER PRECIPITATION GUIDELINES



These are only guidelines for typical situations. Layer humidity and other factors will affect these rules and must be taken into account.

STABILITY INDICES

VT — Vertical Totals Index; CT — Cross Totals Index); TT — Total Totals Index, deg C

$VT = T_{850} - T_{500}$ $CT = Td_{850} - T_{500}$ $TT = Td_{850} + T_{850} - (2 \times T_{500})$

VT	CT	TT	Indication
<25	<17	<43	Thunderstorms unlikely
	18-19	44	Isold-few tstms
26	20-21	46	Sct tstms
	22-23	48	Sct tstms, isold severe
30	24-25	50	Sct tstms, few severe, isold tornadoes
32	26-29	52	Sct-numerous tstms, few-sct severe, few tornadoes
>34	>30	56	Numerous tstms, sct severe, sct tornadoes

KI — K Index, deg C

$KI = T_{850} + Td_{850} - T_{700} + Td_{700} - T_{500}$

0-15	0% chance of tstms
18-19	20% chance of tstms
20-25	35% chance of tstms
26-30	50% chance of tstms
31-35	85% chance of tstms
40+	100% chance of tstms

LI — Lifted Index, deg C

$LI = Te_{500} - Tp_{500}$ Te = environment Tp = lifted parcel

>0	Thunderstorms unlikely
0 to -2	Thunderstorms possible
-3 to -5	Thunderstorms probable
< -5	Strong thunderstorm potential

TI — Thompson Index, deg C

$TI = KI - LI$

<25	Thunderstorms unlikely
25-34	Slight chance of tstms
35-39	Few, widely, or scattered tstms
>40	Severe thunderstorms

SWEAT Index, dimensionless

<272	Thunderstorms unlikely
273-299	Slight risk of severe. General thunderstorms.
300-399	Moderate risk of severe. Approaching severe limits.
400-599	Strong risk of severe. Few thunderstorms. Isolated tornadoes.
600-799	High risk of severe. Scattered tornadoes.
>800	Possibly unconducive to tstms but wind damage possible.

EHI — Energy-Helicity Index, dimensionless

EHI = (Positive SRH (0-2 km) x CAPE) / 160000

0-2.0	Significant mesocyclone-induced tornadoes unlikely
2.0-2.4	Mesocyclone-induced tornadoes possible (F0-F1 damage)
2.5-2.9	Mesocyclone-induced tornadoes more likely.
3.0-3.9	Strong tornadoes suggested.
4.0+	Violent tornadoes suggested.

CAPE — Convective Availability of Potential Energy; B+ — Positive Energy, j/kg

300-1000	Weak severe potential
1000-2500	Moderate severe potential
2500-3000	Strong severe potential

BRN — Bulk Richardson Number, dimensionless

BRN = CAPE / BRN Shear

<10	Thunderstorms unlikely
11-49	Moderate potential for storms. Supercells possible.
>50	Strong potential for storms. Multicells possible.

SRH — Storm Relative Helicity, $(m/s)^2$

150-299	Weak possibility of rotating storms
300-449	Moderate potential of rotating storms
>450	Strong possibility of rotating storms

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