Very Low Dewpoints in the Borderland Region-- Precursor of the Midwest's Severe Weather

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Cruces Atmospheric Sciences Forum

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In Spring--Very Dry air in New Mexico; why is it important?

Dry conditions here in the spring months are part of weather systems which cause thunderstorms bearing large hail, strong surface winds, and tornadoes, and lead to frequent severe weather episodes in which lives are lost, especially in the Plains States, the Mid-South, Ohio Valley and other regions of the USA.

Two days after extremely dry conditions in New Mexico, some severe-weather-related headlines:

At least 10 killed and dozens others are hospitalized as tornadoes and dangerous storms tear through the South and Midwest. https://www.cnn.com/2023/04/01/us/us-severe-storm-south-midwest-saturday/index.html

Storms Kill at Least 10 as Tornadoes Tear Through Midwest and South. https://www.nytimes.com/2023/03/31/us/midwest-storms-flood-weather.html

Three Dead After Large Tornadoes Hit Arkansas. https://www.wsj.com/articles/large-tornado-hits-little-rock-ark-as-central-u-s-braces-for-severe-weather-fb9d781

Severe weather, tornado threat already brewing for first week of April in central US. https://www.accuweather.com/en/severe-weather/severe-weather-tornado-threat-already-brewing-for-first-week-of-april-in-central-us/1506171

On 30 March 2023, an active weather system was in progress, crossing the Borderland. A cold front was approaching from the west and strong southwesterly winds at the surface and aloft were present.
Dewpoints in New Mexico and far West Texas fell to the single digits while at Grants, the dewpoint fell to -1F!

What is the dew point? It is the temperature that a "parcel" of air, if cooled, would reach saturation, and at which point dew would form.

How rare are such low dewpoints? Assuming the dew point temperature follows a "Standard," Gaussian, or "Bell Curve" distribution, a reasonable assumption, the dew point numbers are on the following slide. But first. let's review the Bell Curve distribution:

From Wikipedia: Characteristics of a Bell Curve
Around 68% of the data lies within 1 standard deviation.
Around 95% of the data lies within 2 standard deviations.
Around 99.7% of the data lies within 3 standard deviations

Biggs Army Air Field, (Biggs AAF,) is located just north of the El Paso International Airport, which is in northeast El Paso, TX

Holloman AFB is located about 6 miles southwest of Alamogordo, NM, about halfway between Alamogordo and White Sands National Park.

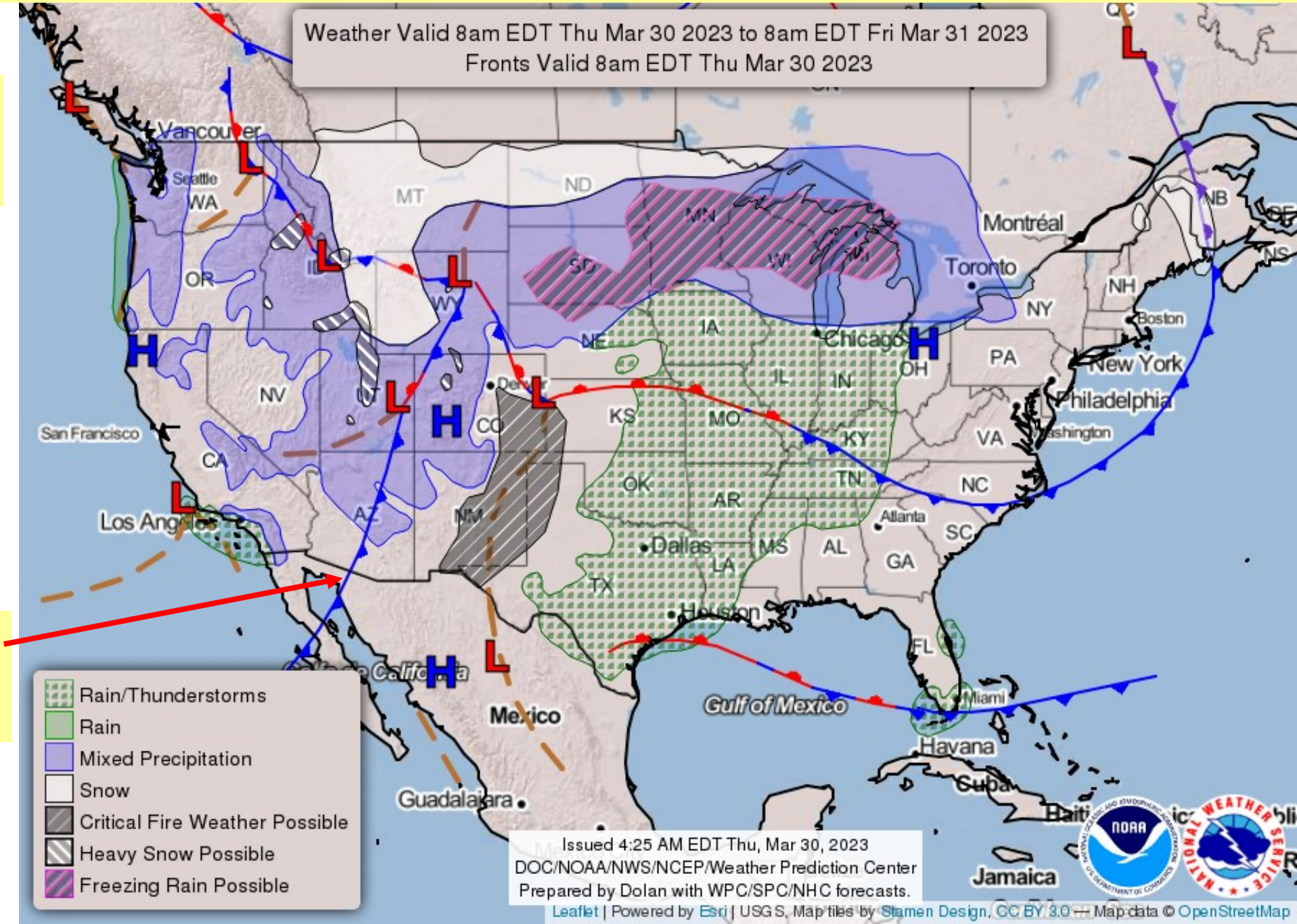
The Ampersand (&) is used below as the substitute for “Sigma” or one Standard Deviation. Mean is the mean dewpoint, “Mean-1&” is “Mean *minus* one &,” and so forth.

Location	March Mean	Mean-1&	Mean-2&	Mean-3&
BIGGS AAF	23.6F	15.7F	7.9F	0f
HOLLOMAN AFB	21.7F	13.2F	4.7F	-3.7F

To answer the question, “How rare an event are these dewpoints?” They seem to be at the 1% level. Data are from the Revised Uniform Summary of Surface Weather Observations for Biggs AAF, https://apps.dtic.mil/sti/pdfs/ADA175364.pdf, and Holloman AFB, https://apps.dtic.mil/sti/pdfs/ADA095335.pdf, extracts later in this infographic.

https://www.wpc.ncep.noaa.gov/noaa/noaa.gif

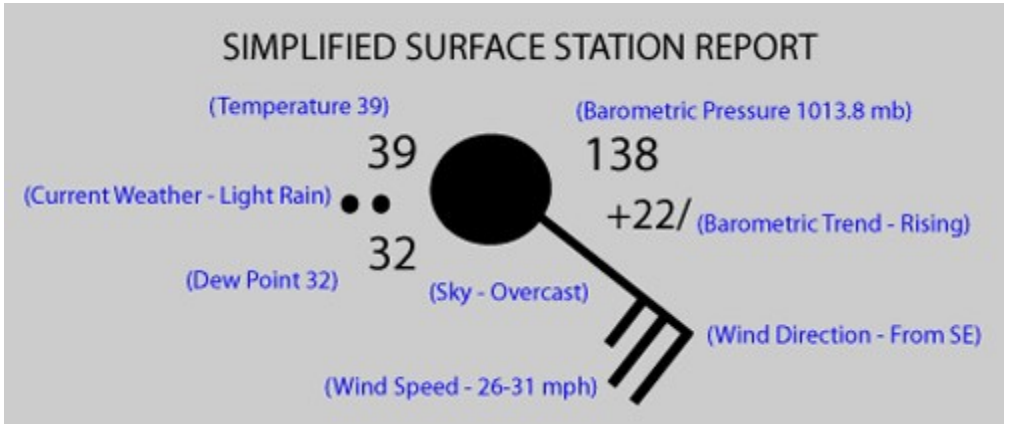
To set the table, here is the morning surface map valid 30 Mar 2023/12Z

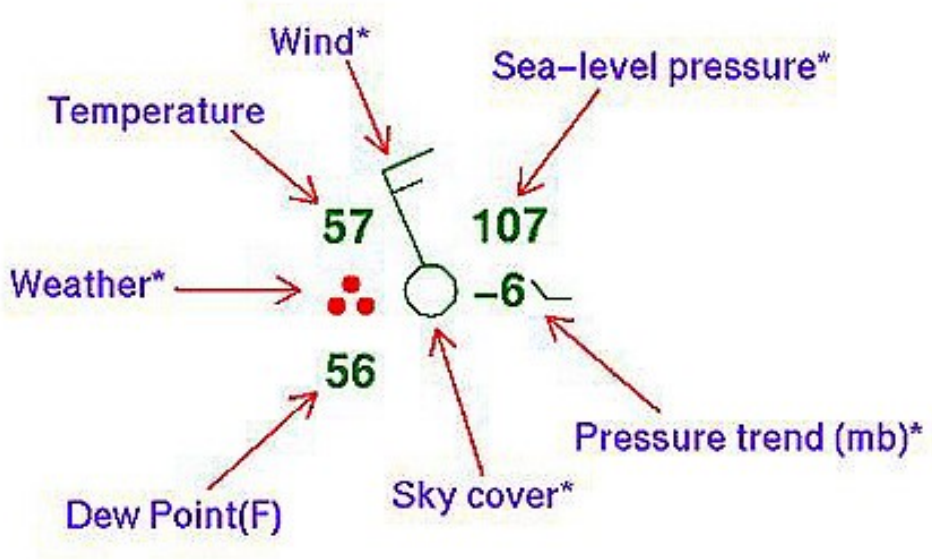


The system was bringing this active cold front to the Borderland Region.

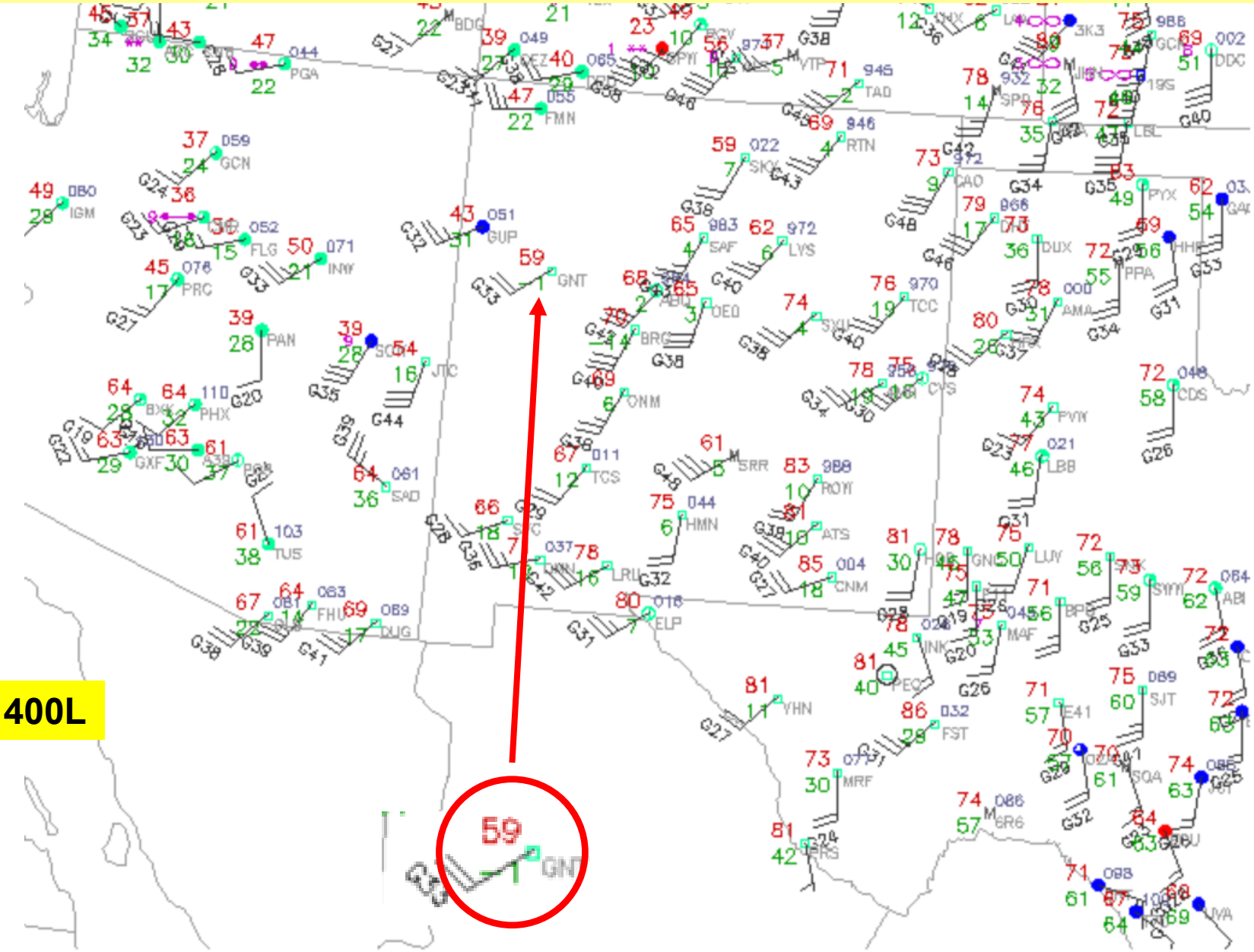
THURSDAY MORNING 0600L

Surface weather observations are plotted on a map in this stylized manner:





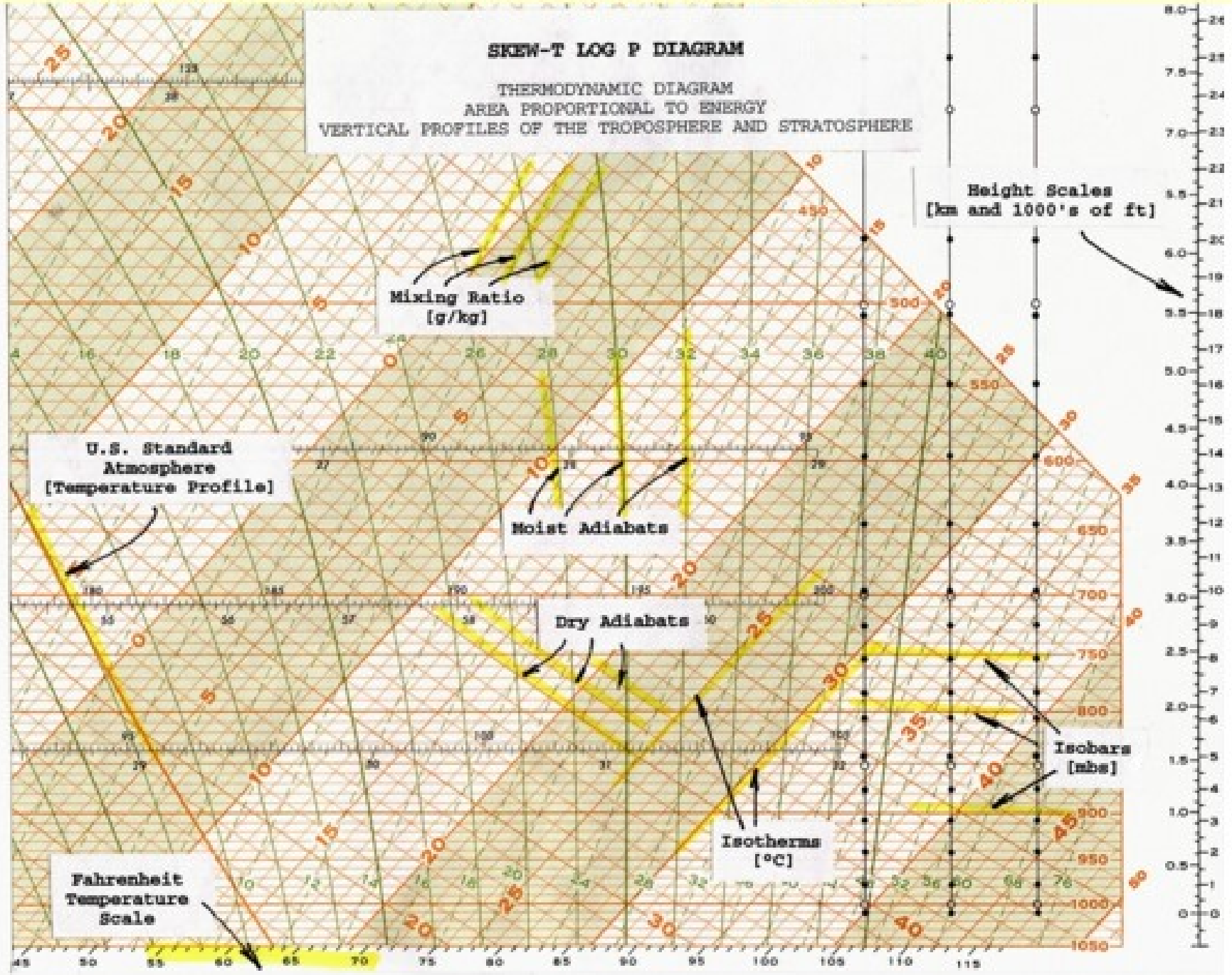
http://weather.rap.ucar.edu/surface/displaySfc.php?region=abq&endDate=20230330&endTime=-1&duration=0



THURSDAY 1400L

Page generated from http://weather.rap.ucar.edu/surface/ at Thu, 30 Mar 2023 20:58:38 UTC.

https://pielkeclimatesci.files.wordpress.com/2010/05/skew_t.jpg



http://weather.rap.ucar.edu/upper/epz.gif **Skew-T Log P diagram**

Pw = 1.83

Also Blue

in the Vertical

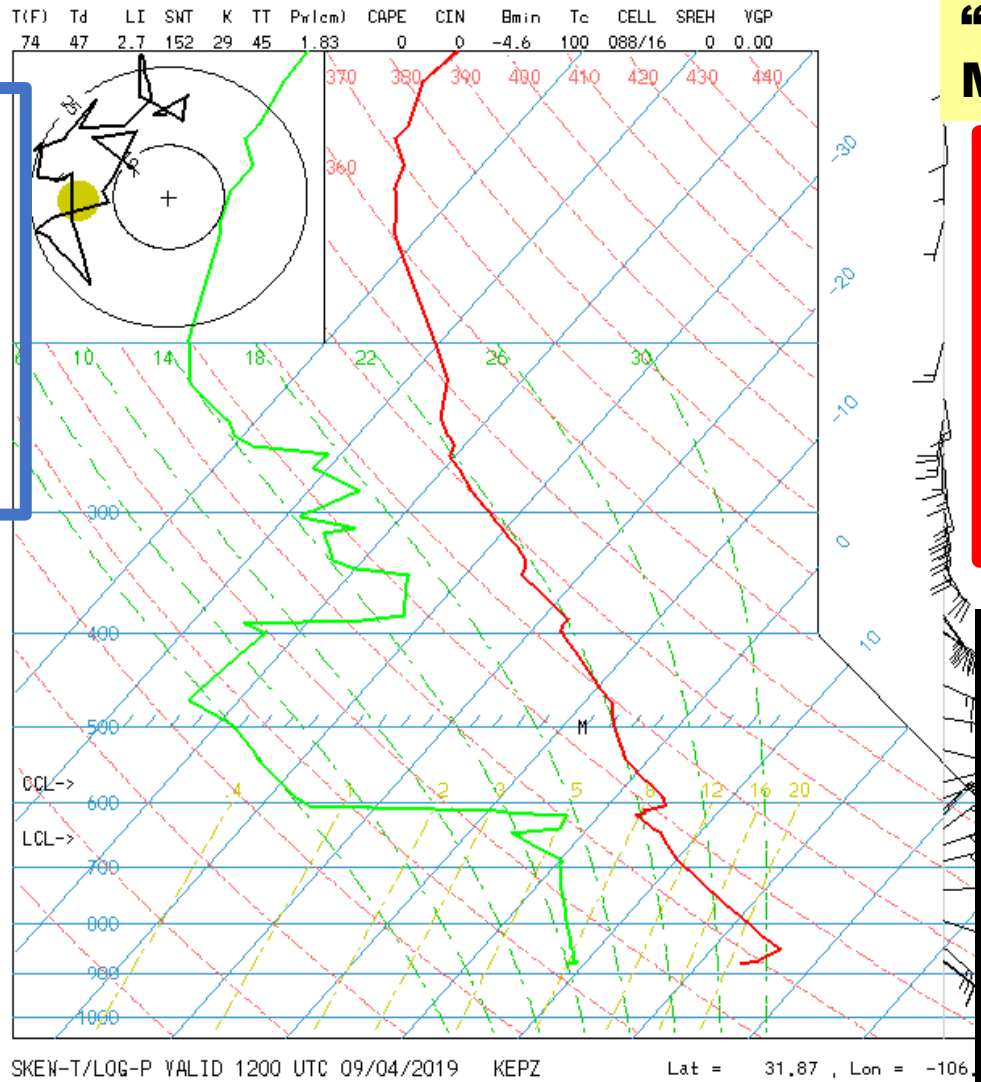
Pressures decrease

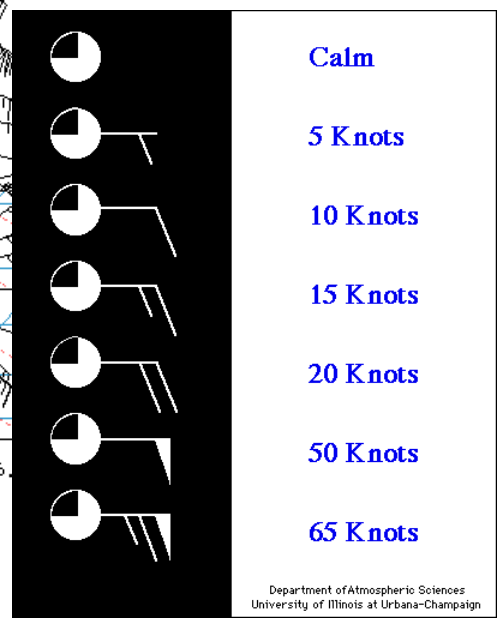
logarithmically

"Graph paper" for Meteorologists

The RED line is the temperature from the weather balloon sounding

The GREEN LINE is the Dew Point temperature from the same sounding.





4 Sep 2019/1200Z

Skewed Temperatures in Blue

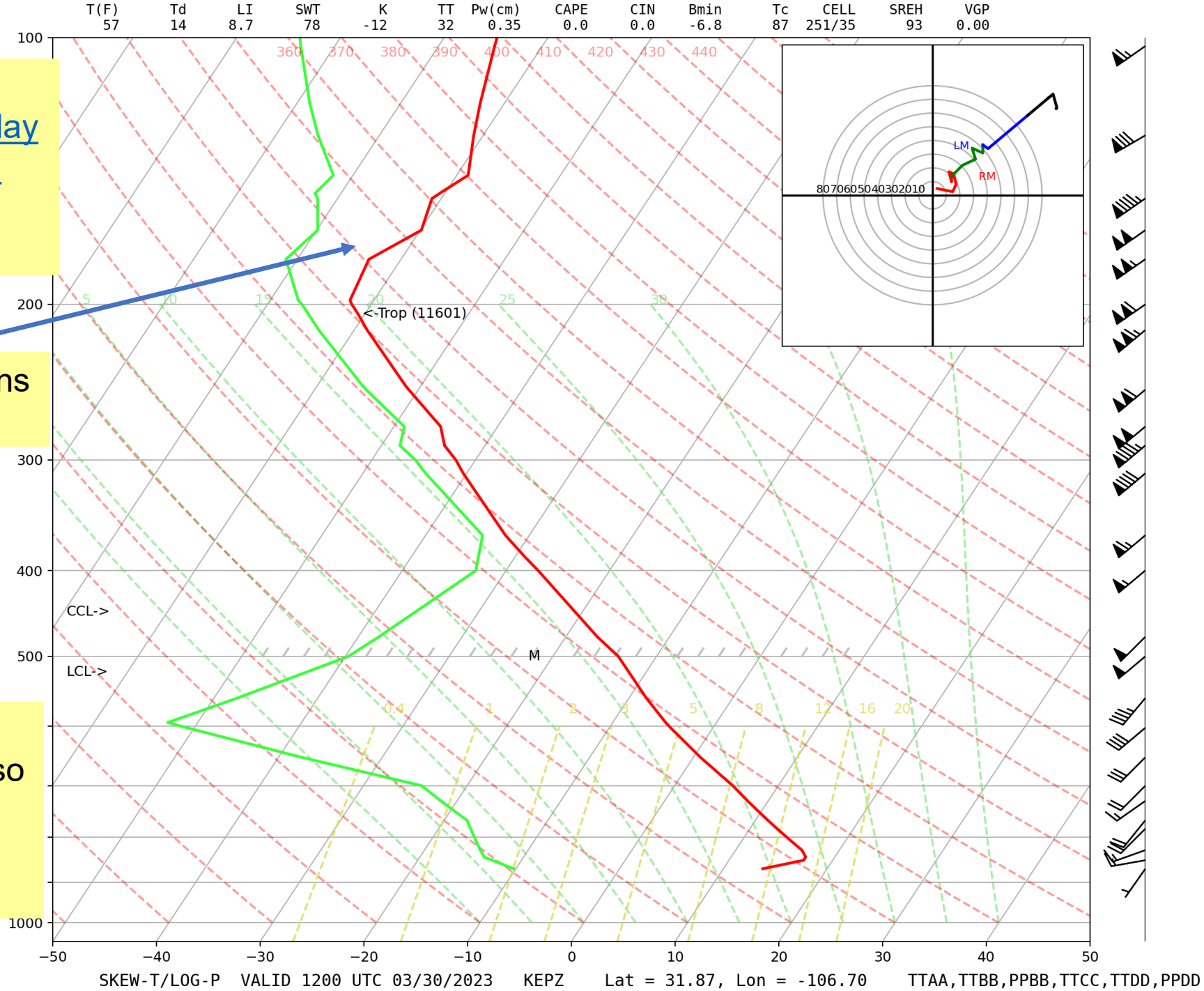
The Skew-T allows easy calculation of dozens of thermodynamic variables

http://weather.rap.ucar.edu/upper/displayUpper.php?img=KEPZ.png&endDate=-1&endTime=-1&duration=0

Hints of “leaved” tropopause; happens when the jet stream is very strong.

THURSDAY 0600L

This is the “Skew-T log-P “ thermodynamic chart with the El Paso sounding plotted.
More info on the Skew-T and the map plots of the data is here.

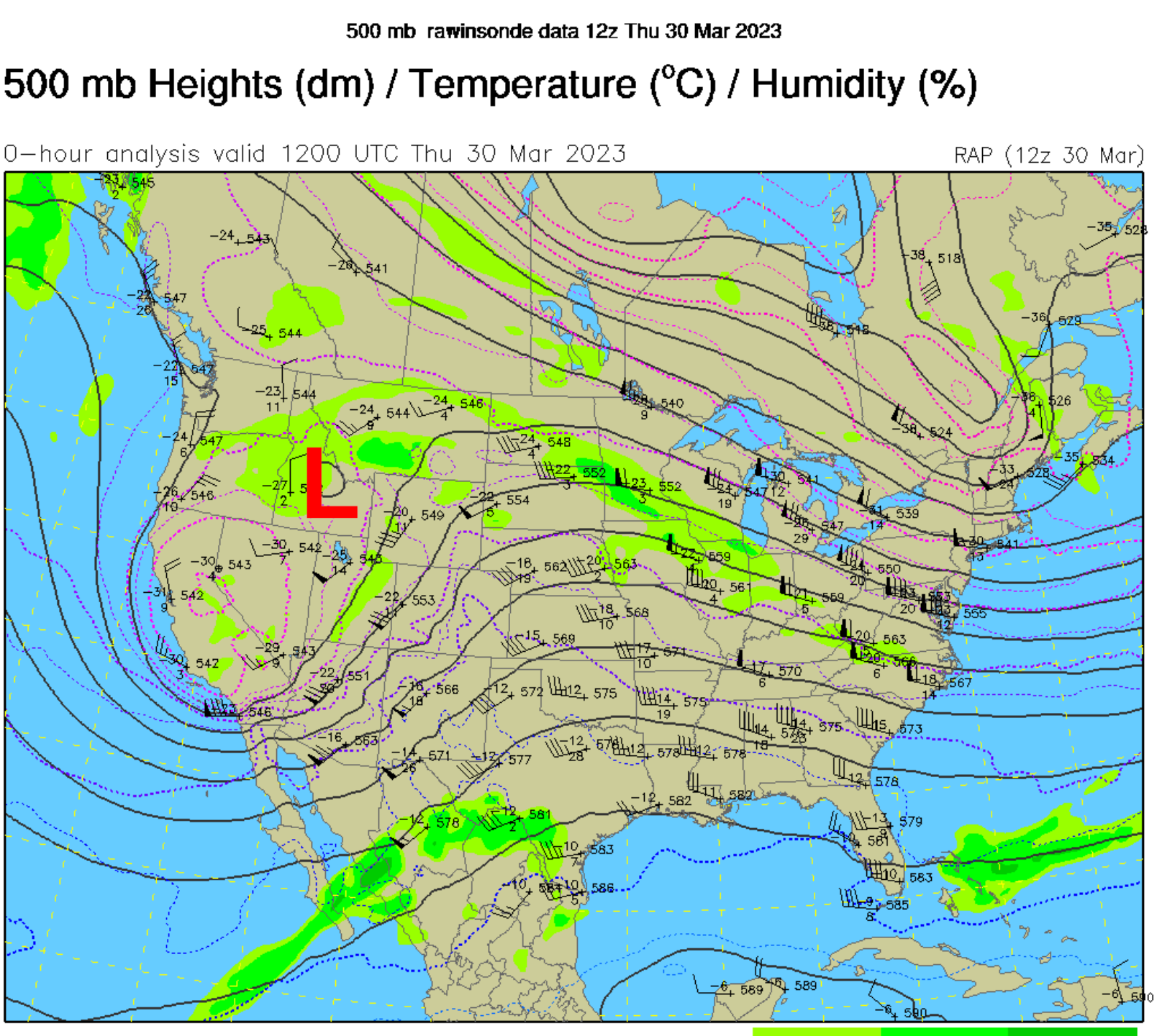


http://weather.rap.ucar.edu/upper/displayUpper.php?img=upaCNTR_500.gif&endDate=-1&endTime=-1&duration=0

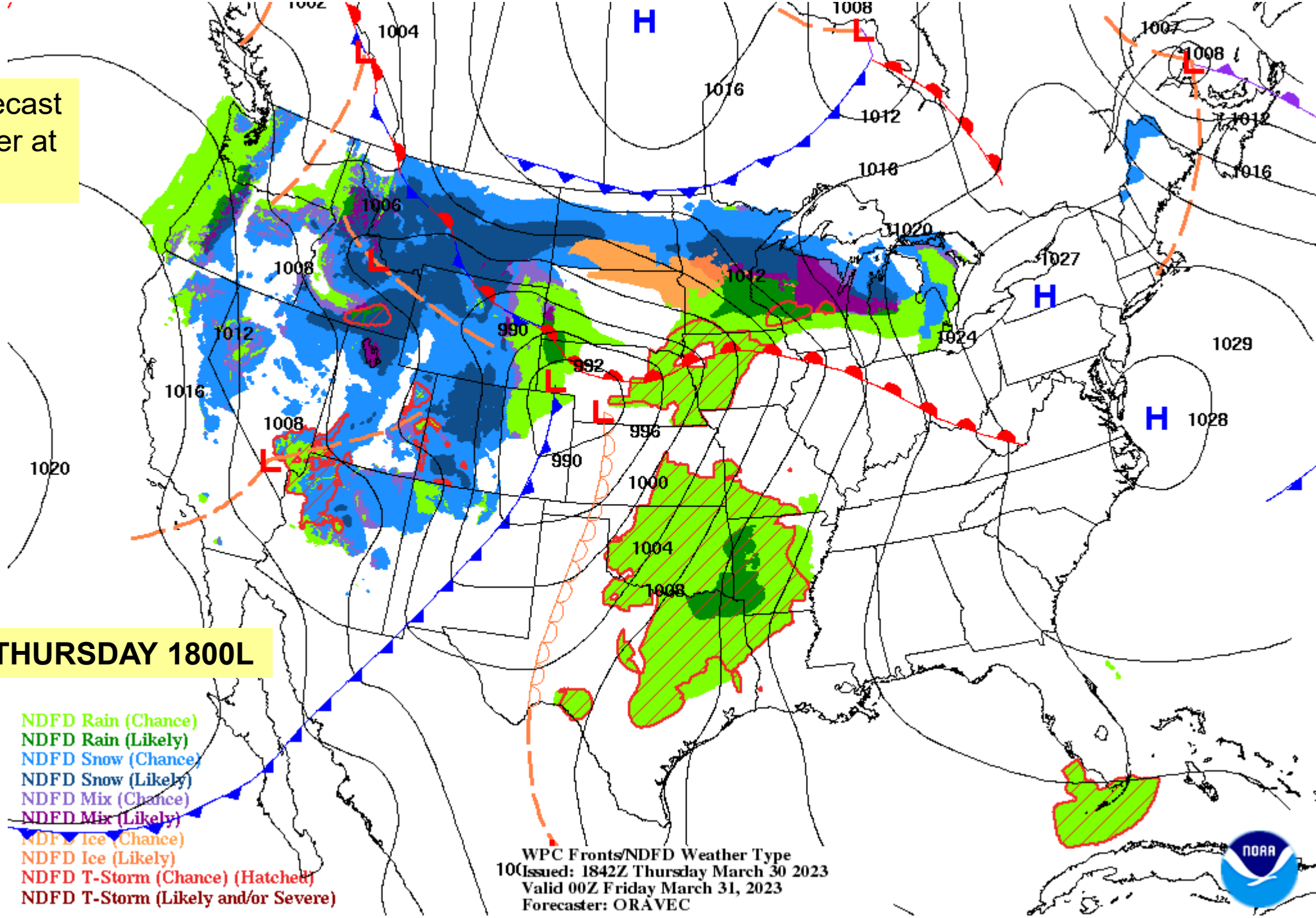
Map of temperatures, heights (of the 500 mb surface), and relative humidity of the 500 millibar surface, about halfway up through the mass of the atmosphere, about 18,000 Ft MSL.

The closed Low centered in Idaho, and the vigorous trough axis extending into southern California are parts of the strong spring storm bringing the very dry conditions to New Mexico.

THURSDAY 0600L



Here is the surface forecast map, valid 12 hours later at 31 Mar 2023/00Z

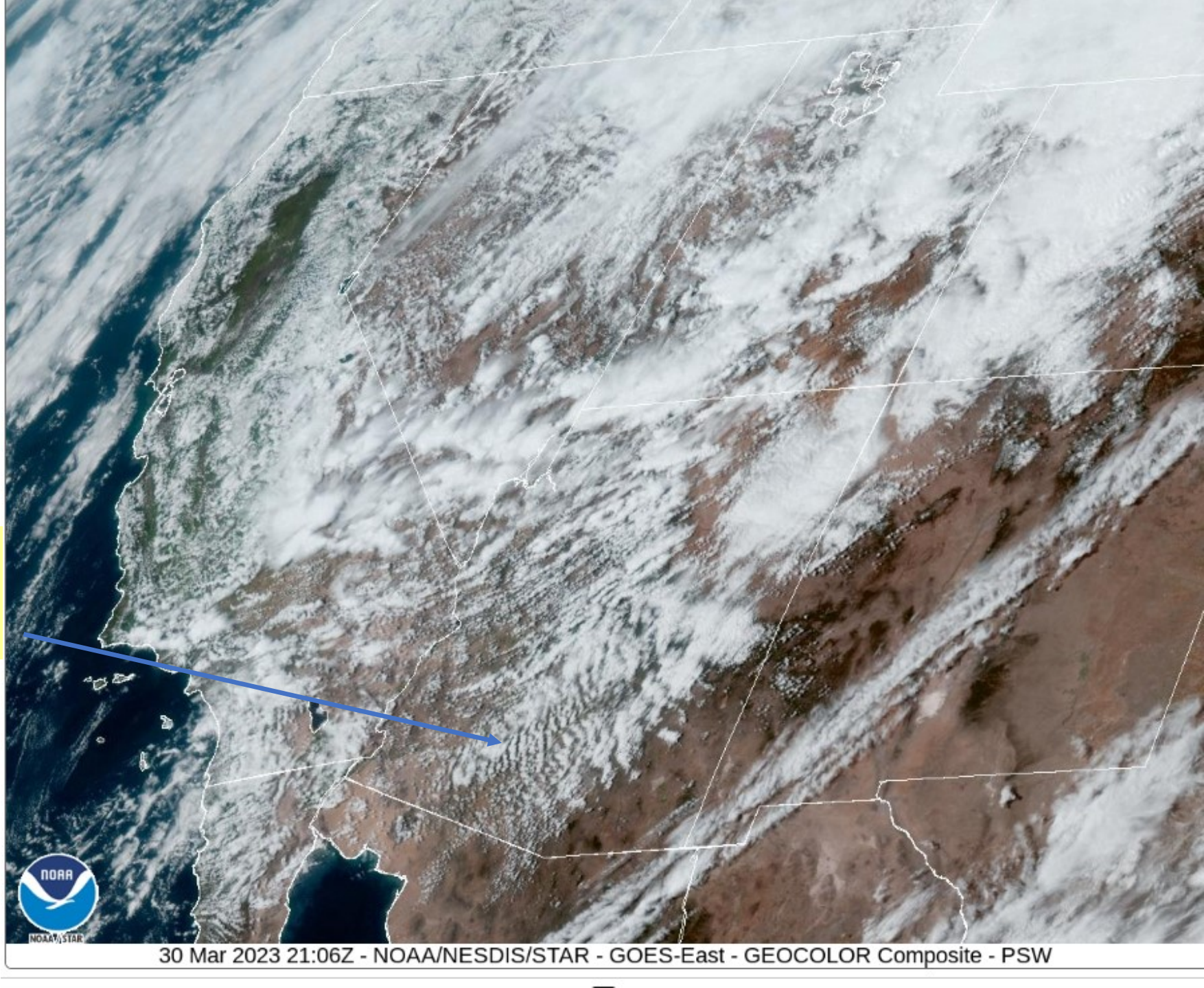


https://www.star.nesdis.noaa.gov/GOES/sector_band.php?sat=G16&sector=psw&band=GEOCOLOR&length=24

GOES Weather Satellite view of the system.

The strong winds aloft are producing mountain wave clouds, the rippled clouds, especially visible in Arizona.

THURSDAY 1500L



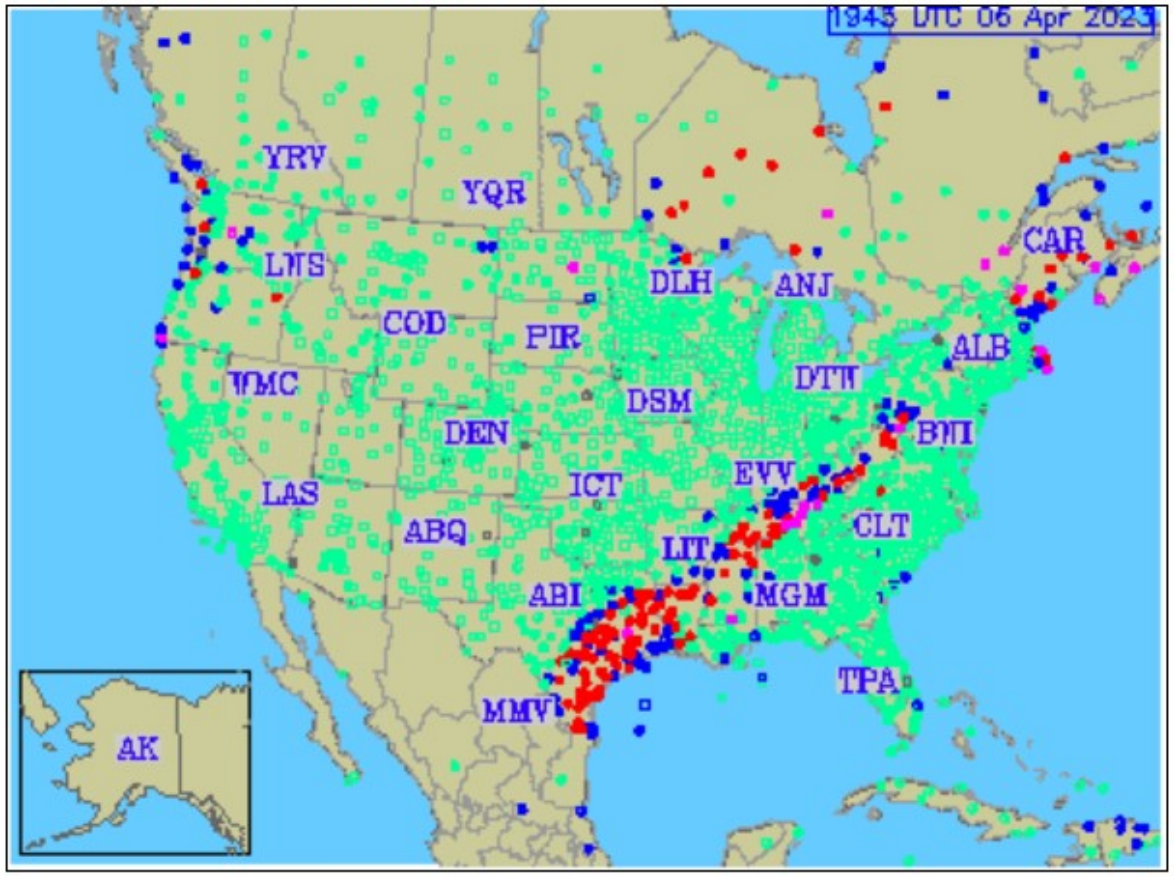
The National Center for Atmospheric Research
Operated by the University Corporation for Atmospheric Research

NCAR RAL Real-Time Weather Data

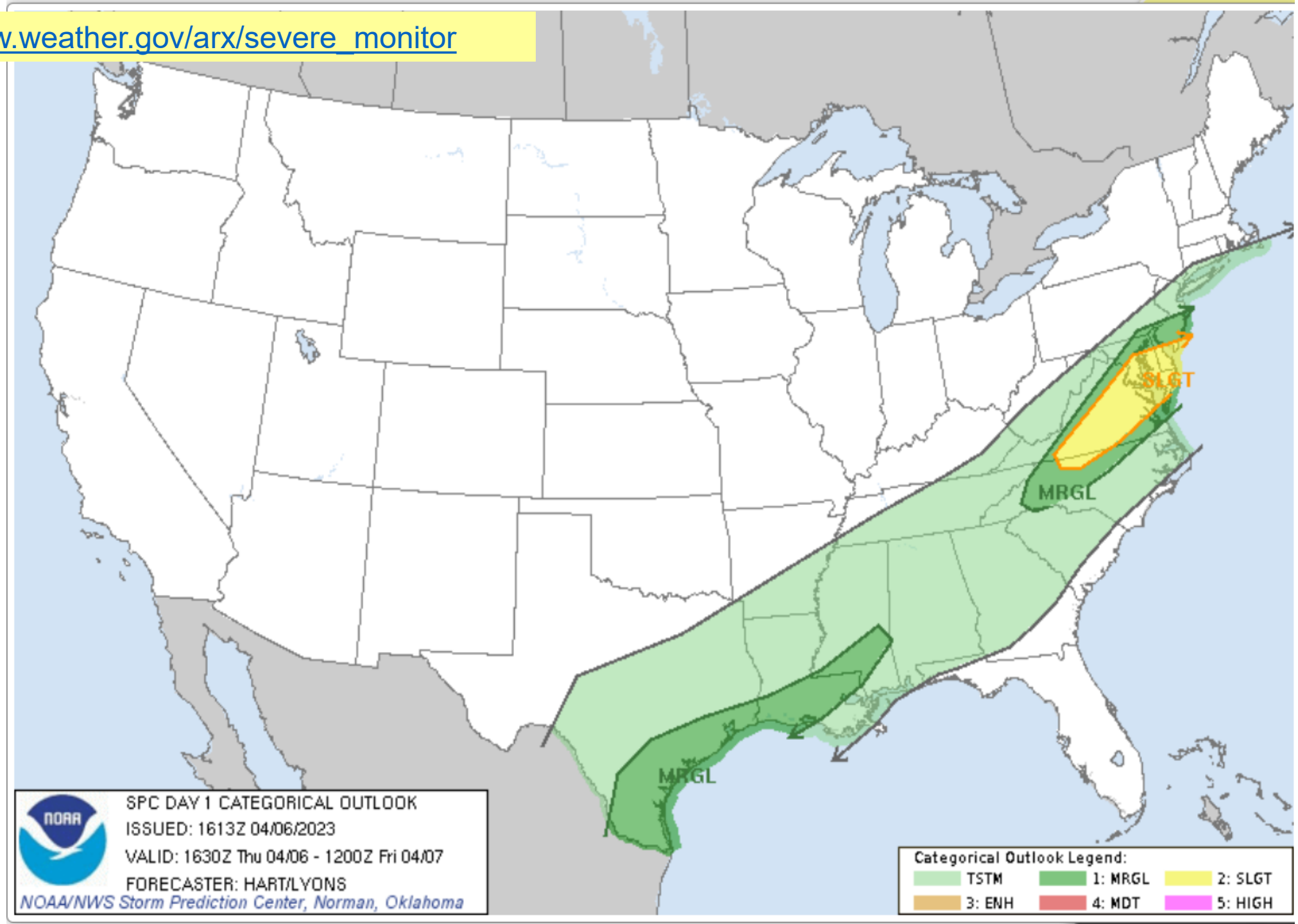
Home / RAL : Weather Home | Satellite | Radar | Surface | Upper-Air | Forecast

End date: Today
End time: Most recent
Loop duration: Single image

http://weather.rap.ucar.edu/surface/



https://www.weather.gov/arx/severe_monitor

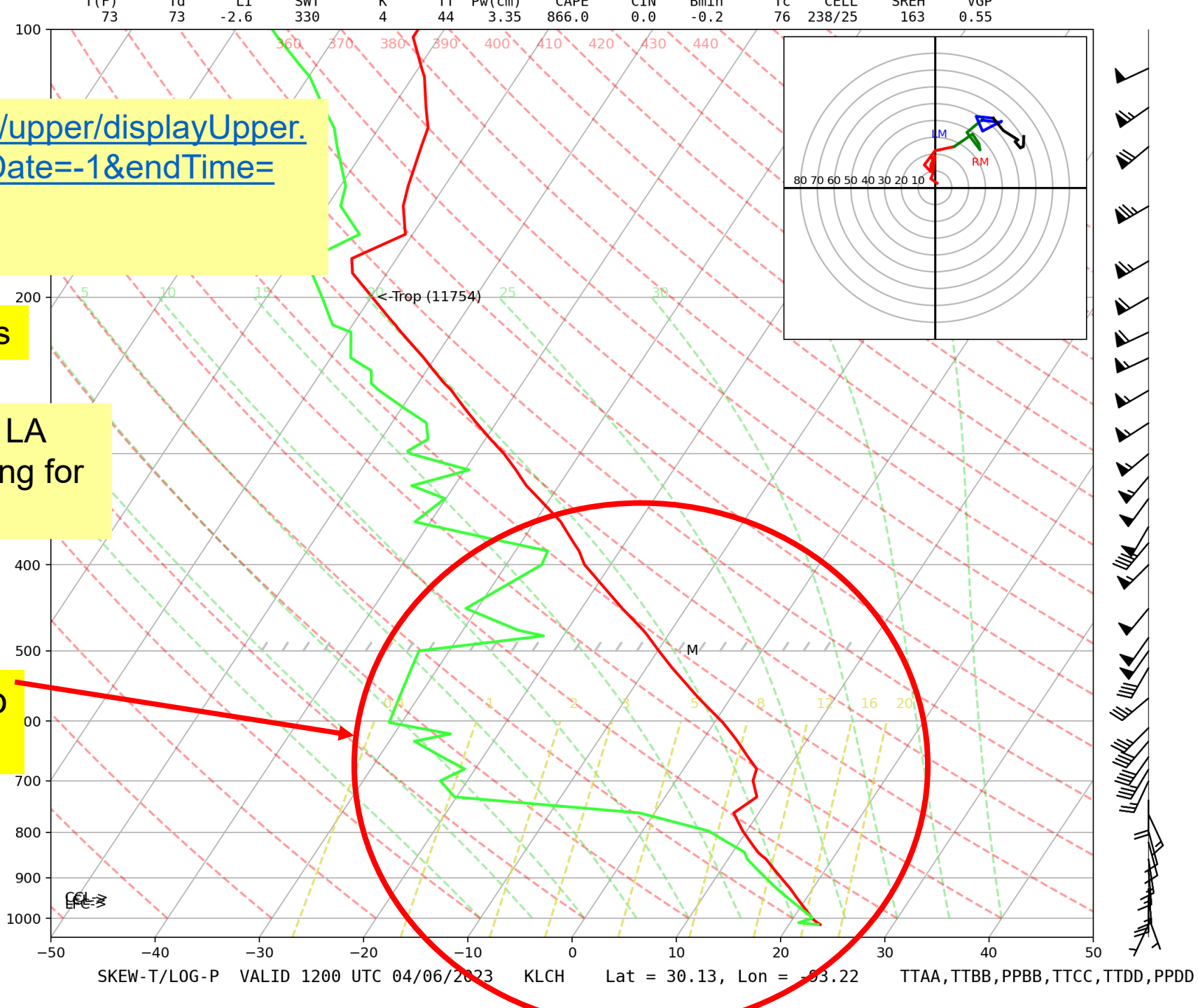


http://weather.rap.ucar.edu/upper/displayUpper.php?img=KLCH.png&endDate=-1&endTime=-1&duration=0

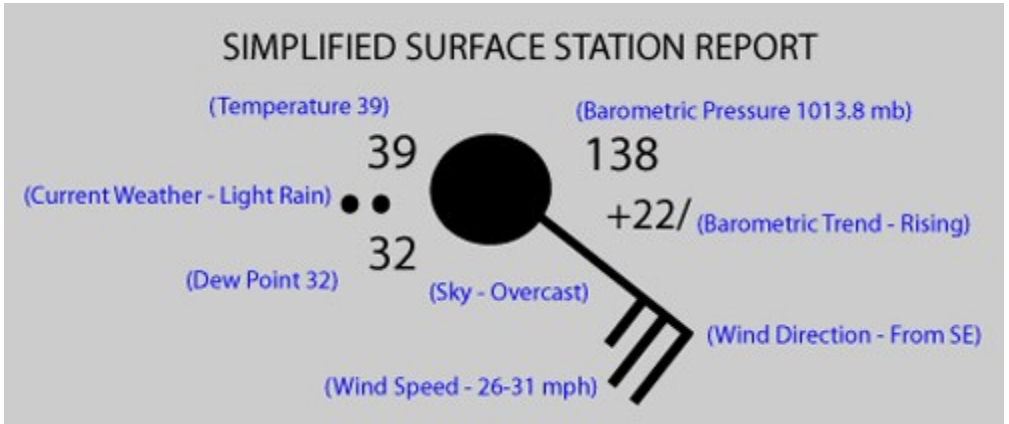
LCH means Lake Charles

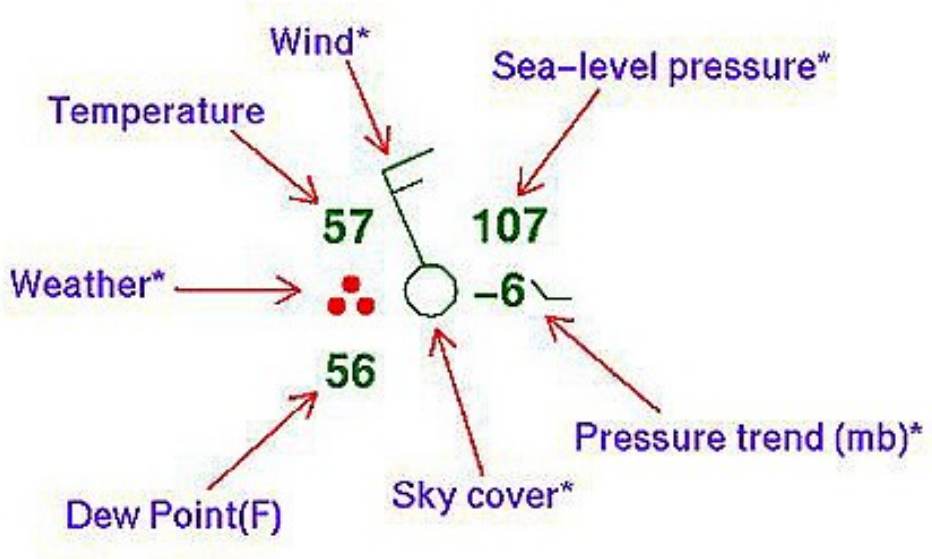
This is the Lake Charles, LA morning upper air sounding for 6 Apr 2023/1200Z

This is what a “Tornado Sounding” looks like



Surface weather observations are plotted on a map in this stylized manner:





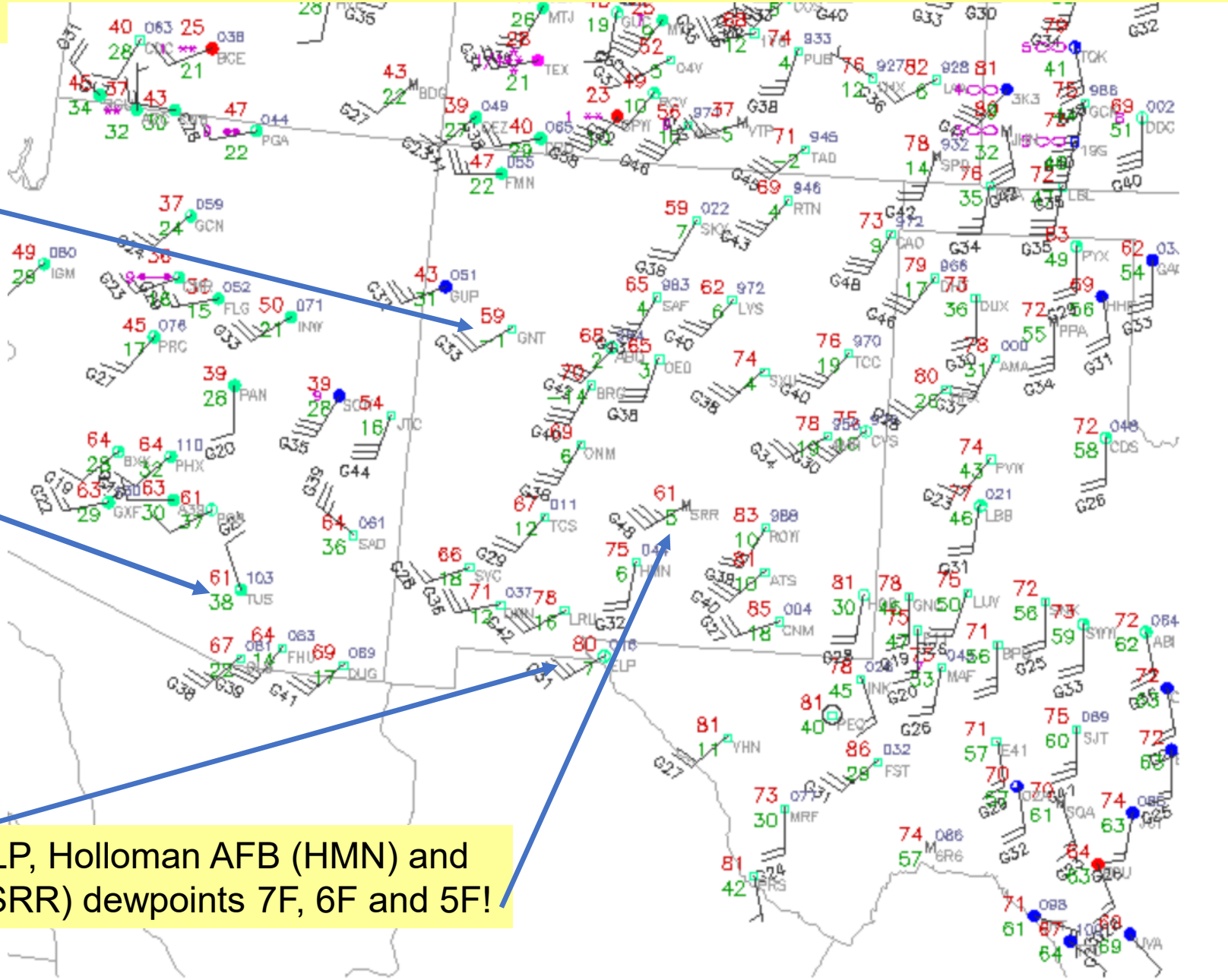
http://weather.rap.ucar.edu/surface/displaySfc.php?region=abq&endDate=20230330&endTime=-1&duration=0

Grants (GNT) dewpoint -1F!

Cold Front through Safford (SAD) and Tucson, (TUS), Northwest winds and more moist Pacific air, with dewpoints in the 30s

THURSDAY 1500L

El Paso ELP, Holloman AFB (HMN) and Ruidoso (SRR) dewpoints 7F, 6F and 5F!



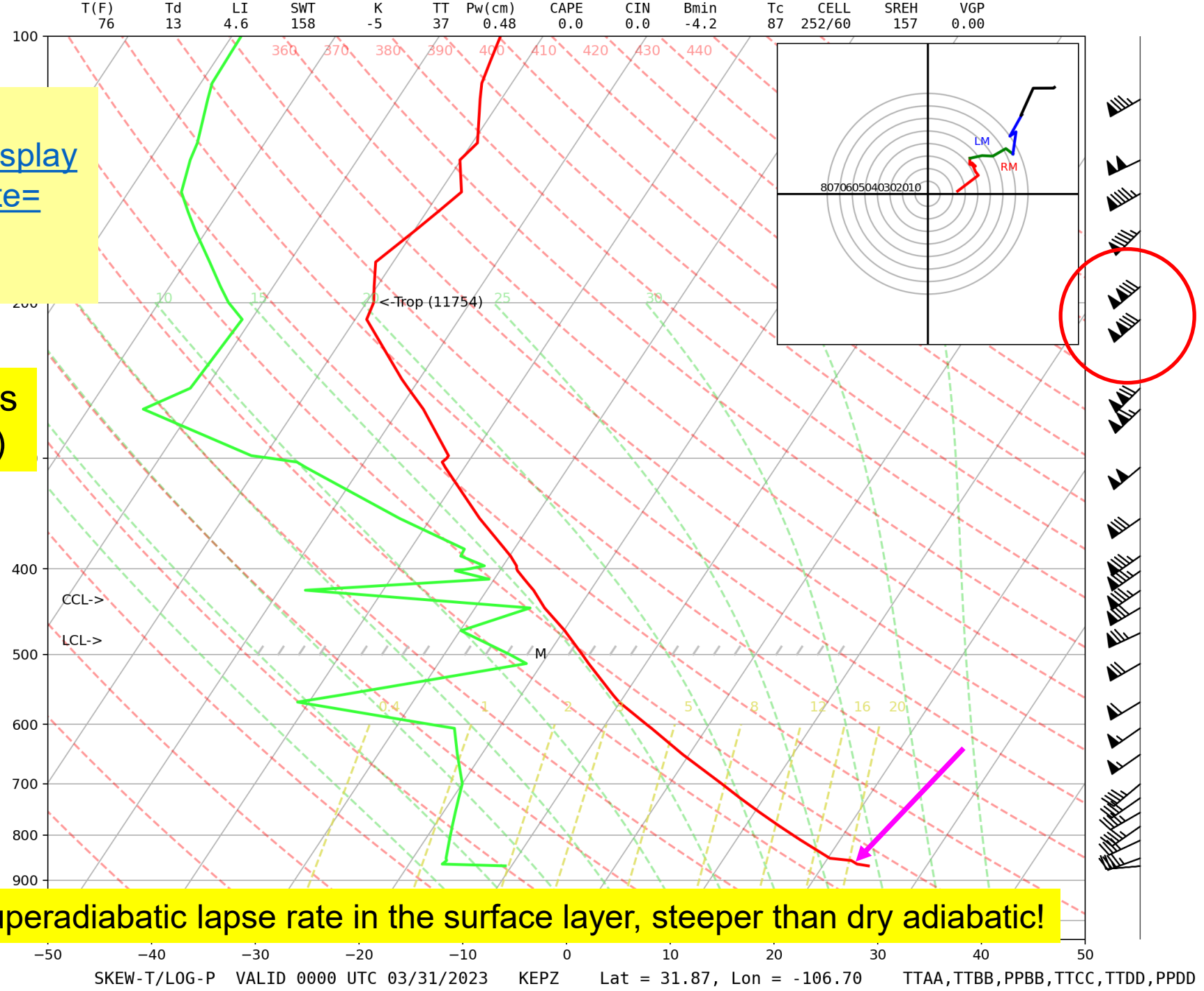
Page generated from http://weather.rap.ucar.edu/surface/ at Thu, 30 Mar 2023 20:58:38 UTC.

http://weather.rap.ucar.edu/upper/displayUpper.php?img=KEPZ.png&endDate=-1&endTime=-1&duration=0

Jet stream winds are 130 Knots at the tropopause. (Red Circle)

El Paso (EPZ) Sounding

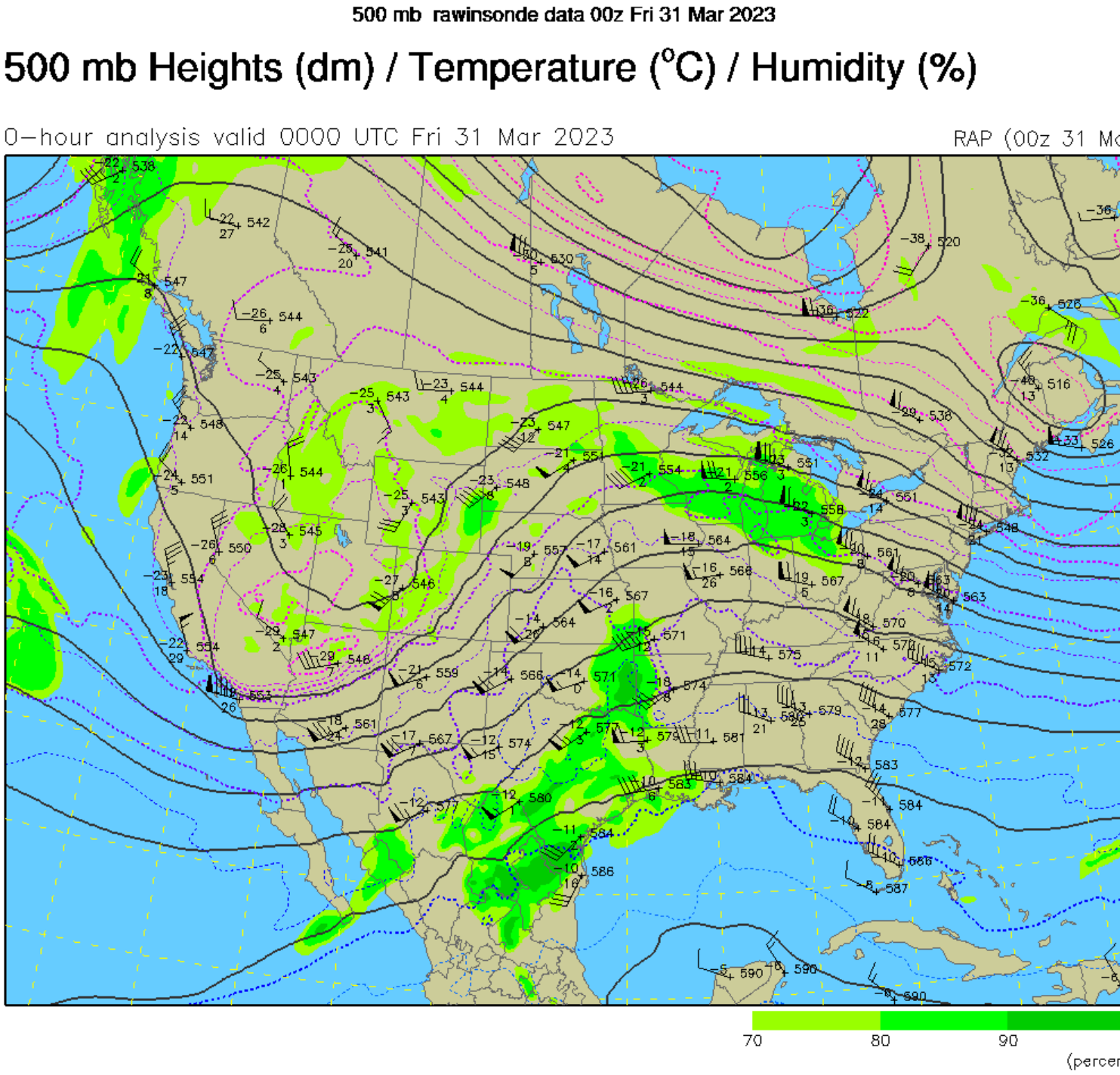
THURSDAY 1800L



Superadiabatic lapse rate in the surface layer, steeper than dry adiabatic!

http://weather.rap.ucar.edu/upper/displayUpper.php?img=upaCNTR_500.gif&endDate=-1&endTime=-1&duration=0

THURSDAY 1800L

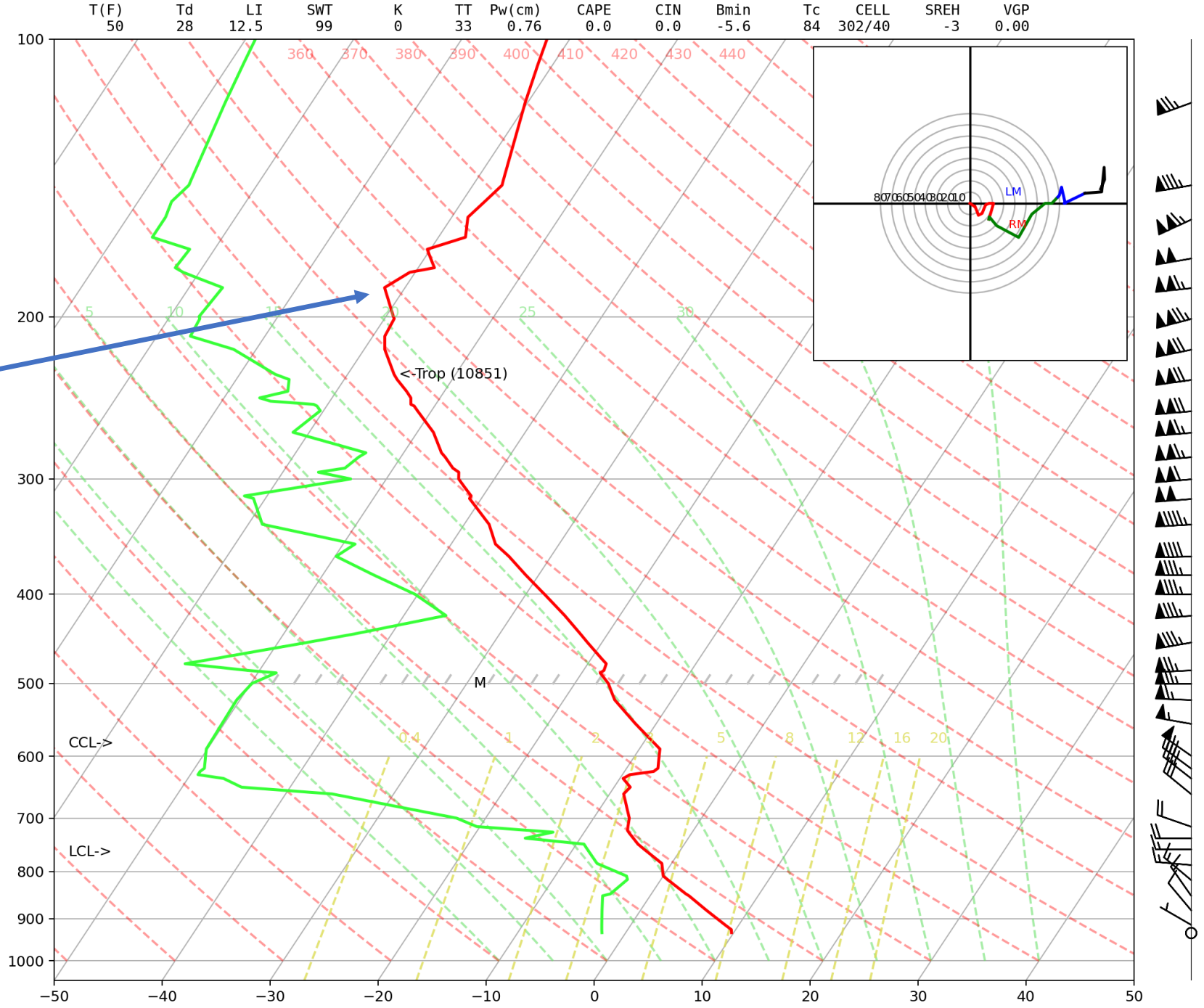


https://weather.ral.ucar.edu/upper/displayUpper.php?img=KTWC.png&endDate=-1&endTime=-1&duration=0

Friday AM sounding from **Tucson** shows the leaved structure of the Jet Stream-influenced Tropopause; almost “multiple tropopauses.”

The zone of winds in excess of 100 Knots extends from about 30,000 ft to 45,000 ft.

Tucson, Friday 0600



Technical Note 1

Many times, the explanation of severe weather set-up involves a moist “summer-like” air mass at and a few thousand feet above the surface, overlain with the dry air mass that forms in the Desert Southwest USA and adjacent Mexico.

The next three graphics show such a situation.

First of the three is a repeat of the Lake Charles sounding for the morning of 6 Apr 2023.

The second is a tornado sounding from Dodge City, Kansas on 24 May 2016.

The third is from a training graphic from the NWS, what they call a “Loaded Gun” sounding because of the explosive cloud growth when such a situation occurs.

http://weather.rap.ucar.edu/upper/displayUpper.php?img=KLCH.png&endDate=-1&endTime=-1&duration=0

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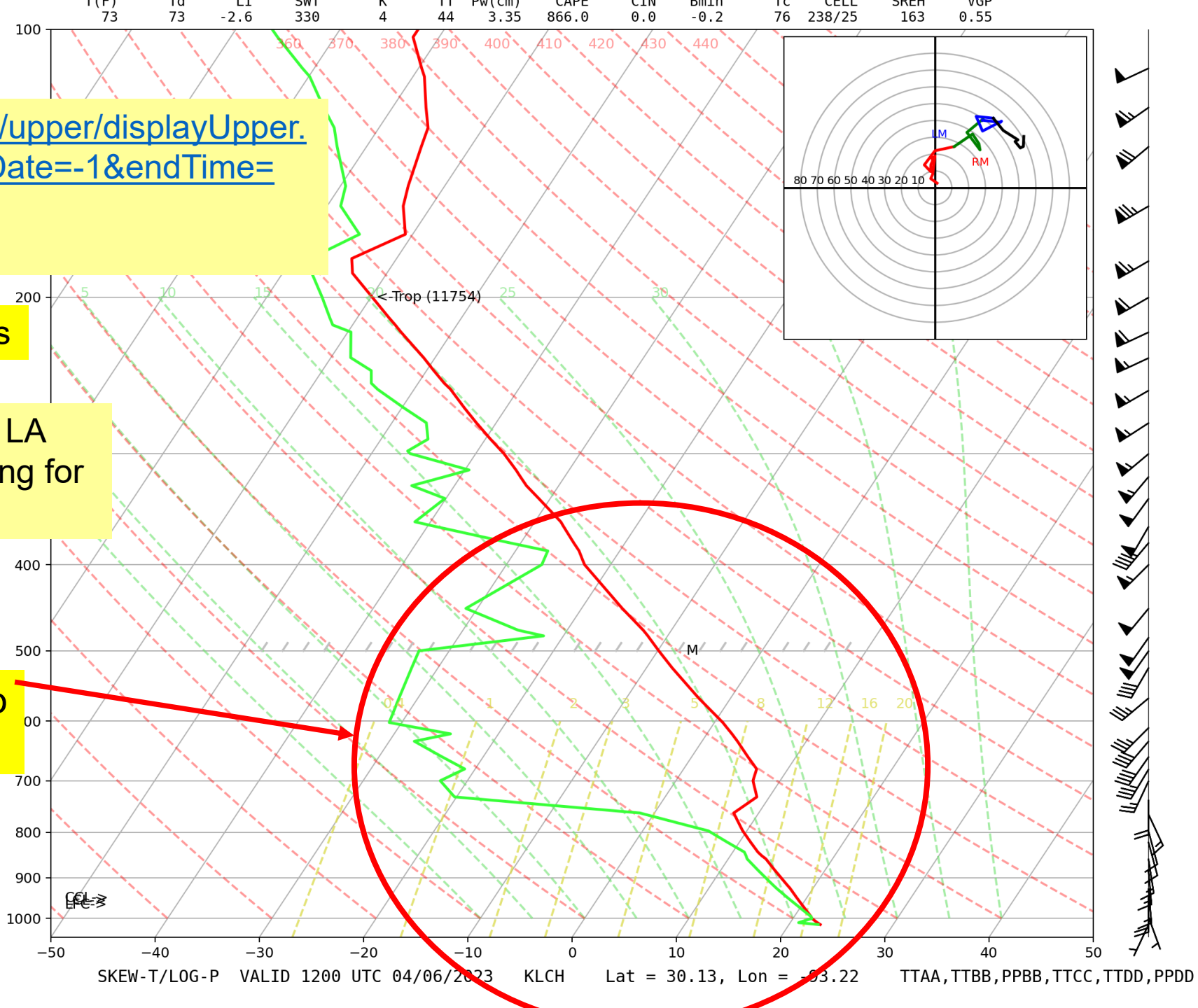
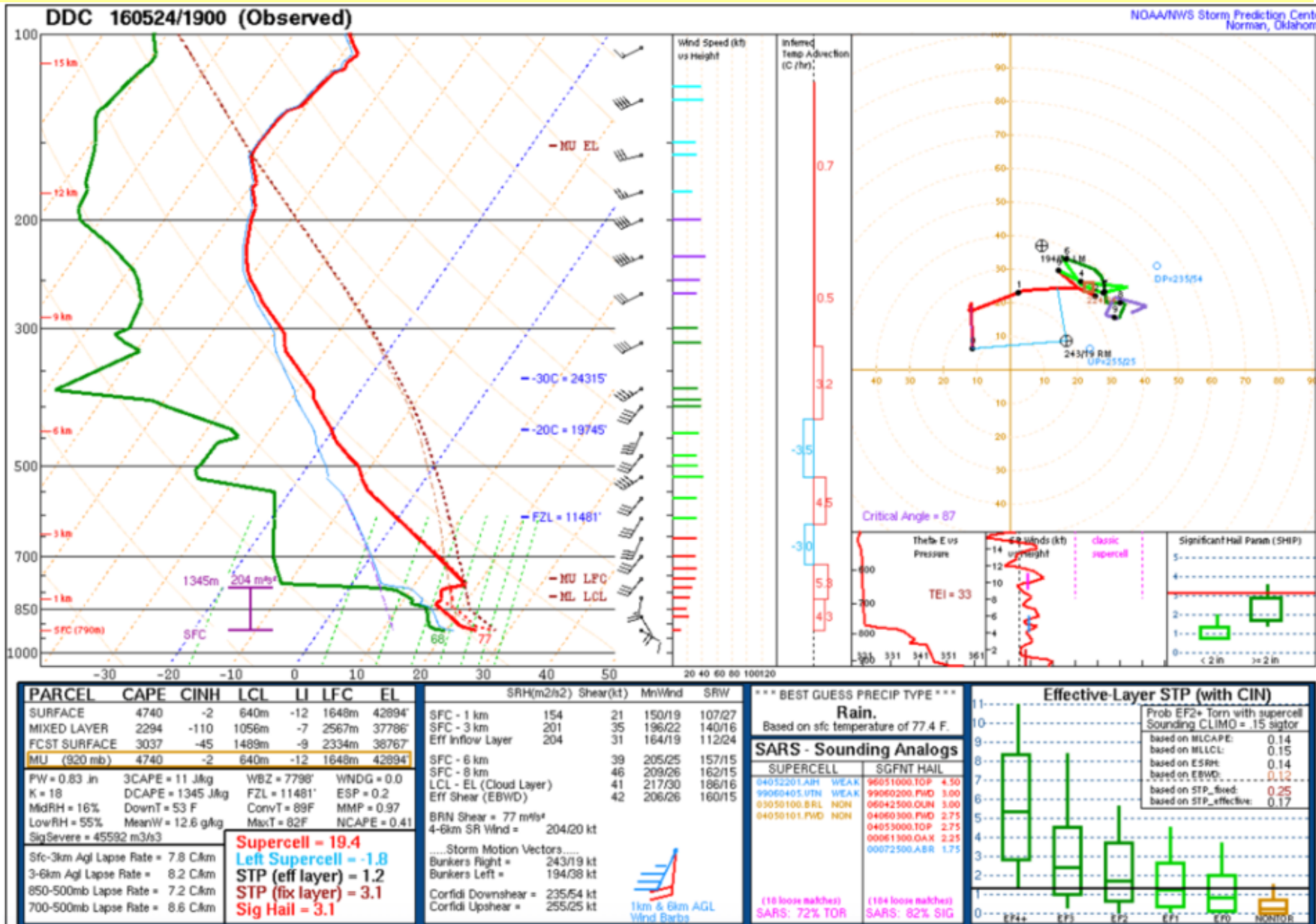


DDC-19z-sounding

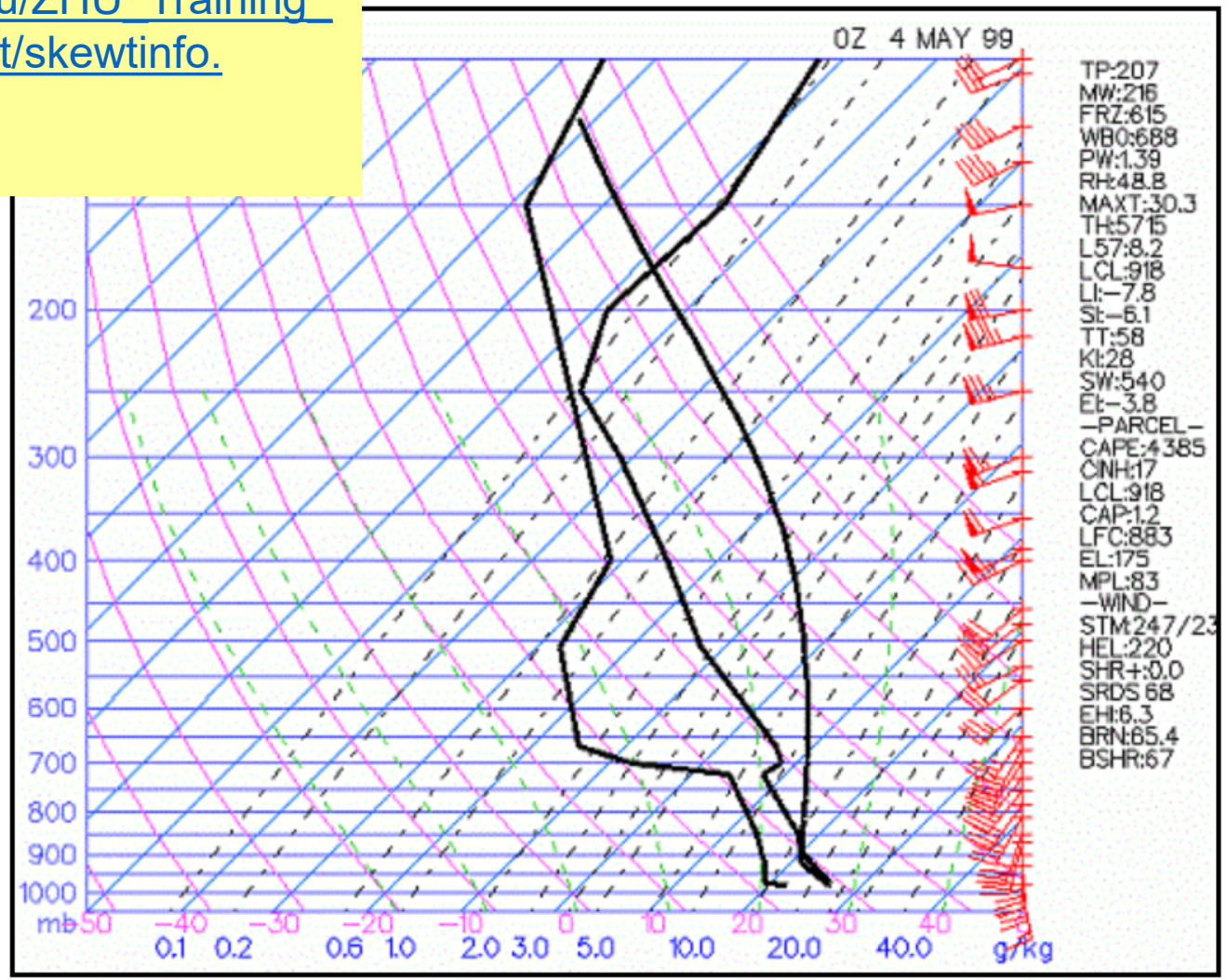
Textbook example of Tornado Sounding from Dodge City KS.

https://www.ustornadoes.com/2017/05/24/best-chase-ever-dodge-city-tornadofest-of-may-24-2016/ddc-19z-sounding/



Loaded Gun Sounding

https://www.weather.gov/source/zhu/ZHU_Training_Page/convective_parameters/skewt/skewtinfo.html#Sounding2



- Severe weather sounding (large CAPE, very unstable LI).
- Large hydrolapse in mid-levels (mT air in boundary layer capped by cT air).
- There must be an inversion above mT air.
- Most common and in Great Plains, Midwest and SE US.
- Most common severe weather: Large hail, tornadoes, convective wind gusts of 58 mph or greater.

Technical Note 2:

The extreme weather, specifically tornado-bearing thunderstorms, develops in squall-lines ahead of the cold air and cold front associated with these systems.

Another view of these conditions has this explanation:

When the air ahead of these systems is lifted, the saturated air cools MOIST adiabatically.

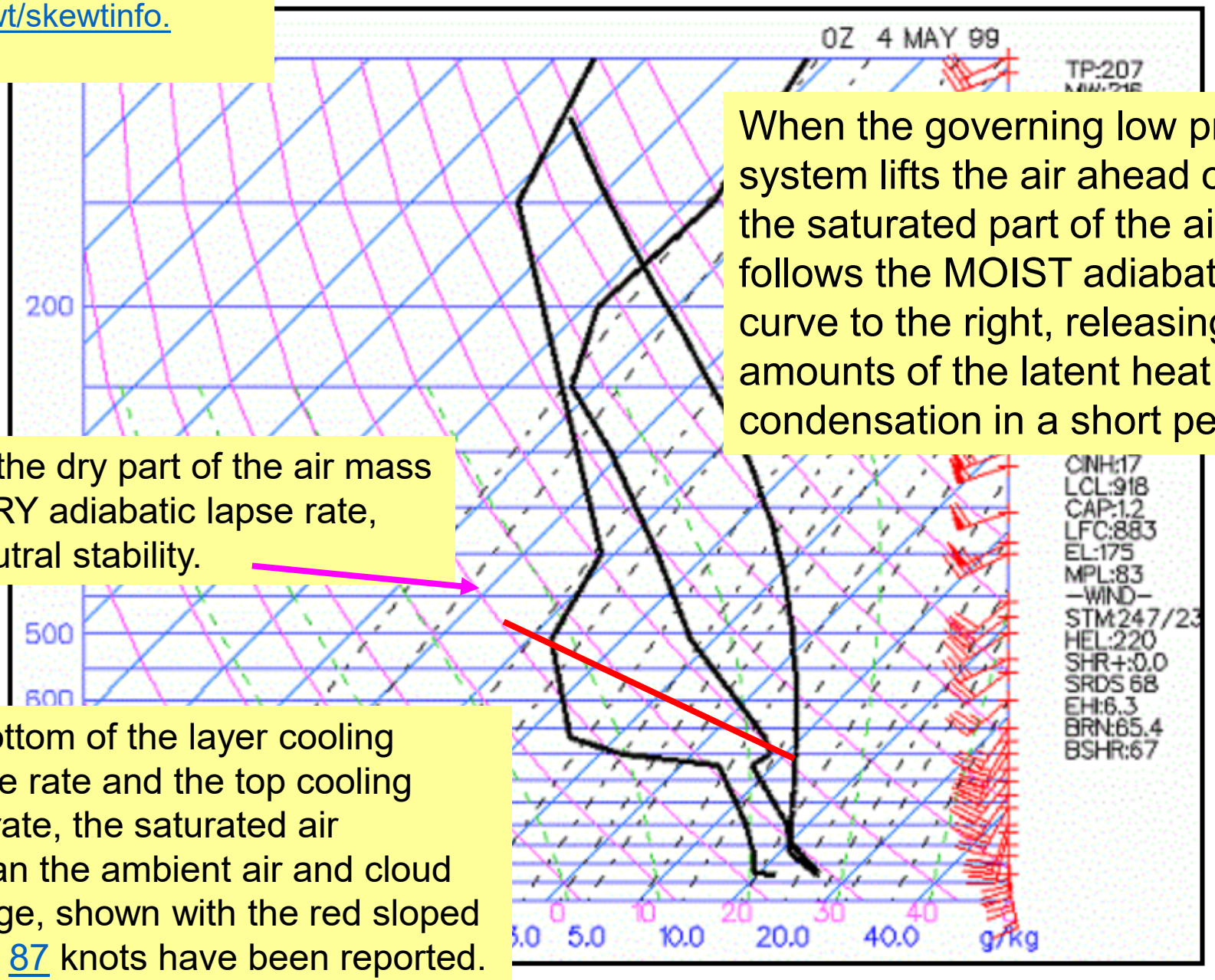
The dry air (from New Mexico and the Desert Southwest of the USA and adjacent Mexico) cools DRY adiabatically.

The resulting column of air becomes extremely unstable, and when afternoon heating of the surface is added, the huge thunderstorms, actually meso-cyclonic storms, have towers which accelerate to strong vertical wind speeds, and produces tornadoes.

I re-use the “Loaded Gun” sounding in the next graphic and annotate it to show what happens when the governing storm system lifts the air as it moves from west to east.

Loaded Gun Sounding

https://www.weather.gov/source/zhu/ZHU_Training_Page/convective_parameters/skewt/skewtinfo.html#Sounding2



When the governing low pressure system lifts the air ahead of the storm, the saturated part of the air mass follows the MOIST adiabat, the smooth curve to the right, releasing large amounts of the latent heat of condensation in a short period.

At the same time, when the dry part of the air mass is lifted, it cools at the DRY adiabatic lapse rate, the pink-purple lines, neutral stability.

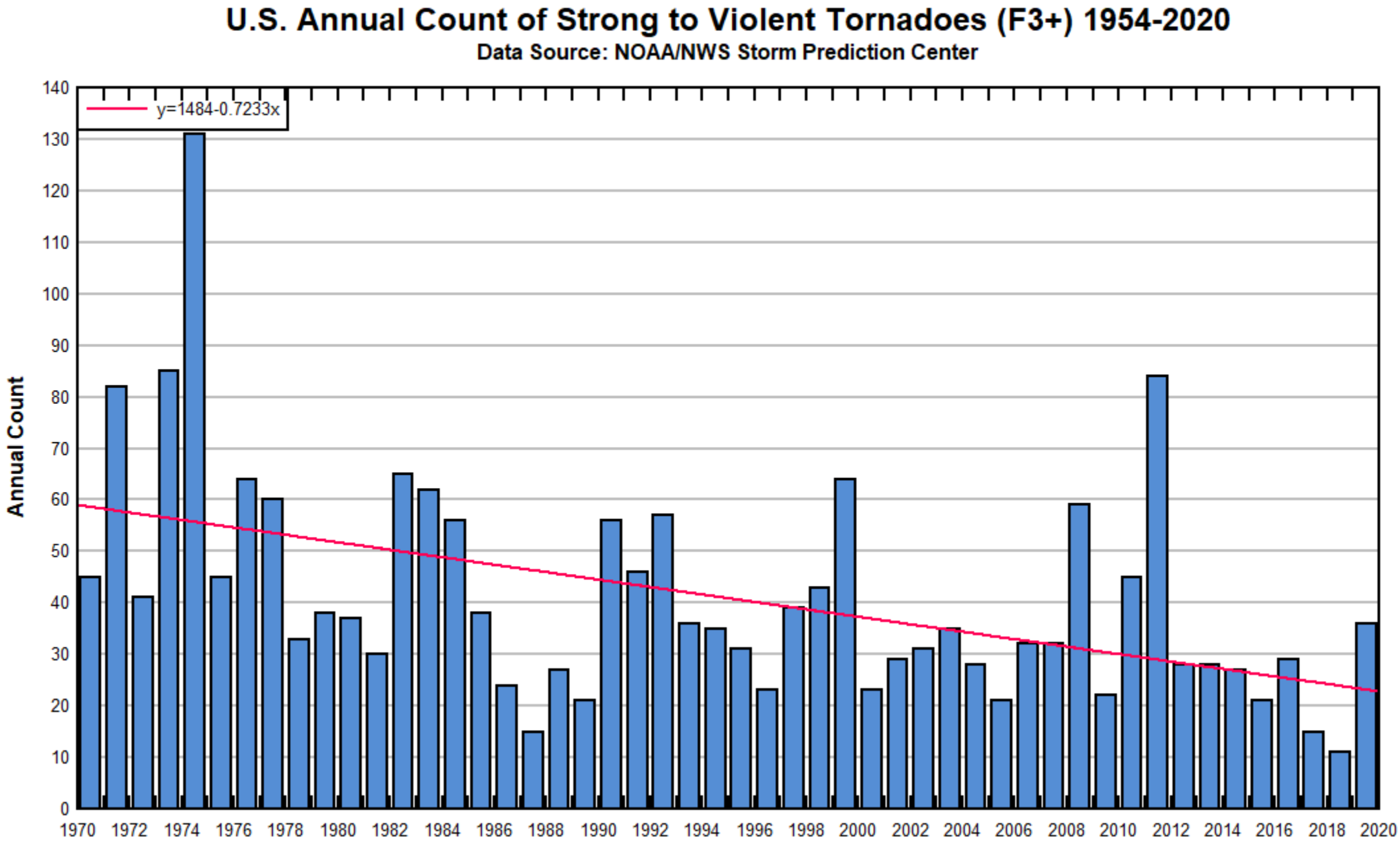
The result is that with the bottom of the layer cooling at the MOIST adiabatic lapse rate and the top cooling at the DRY adiabatic lapse rate, the saturated air becomes MUCH warmer than the ambient air and cloud climb rates become very large, shown with the red sloped line. Vertical wind speeds of 87 knots have been reported.

The strength of these severe storms is fed by the pole to equator temperature difference. The stronger that temperature difference, the stronger the storms.

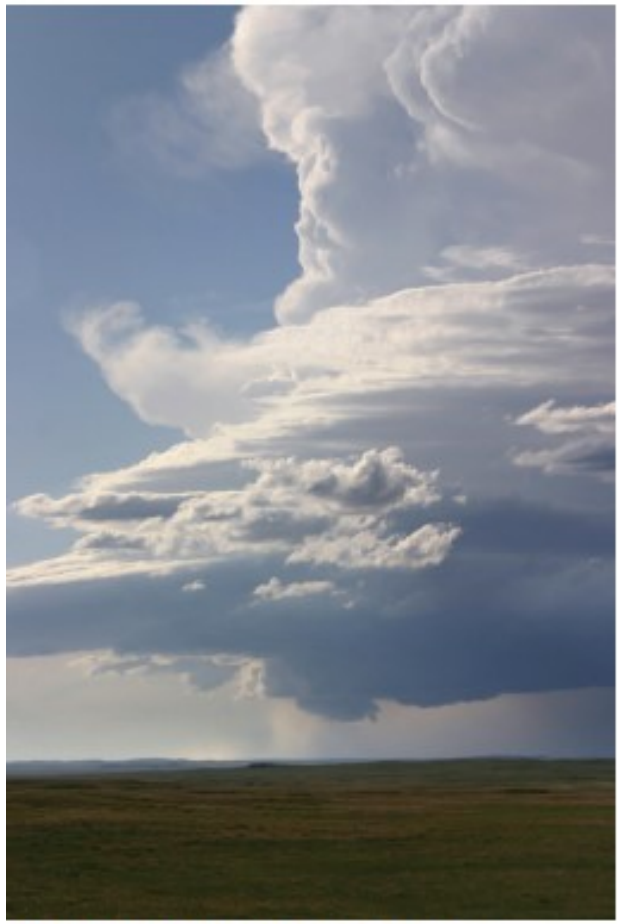
As the planet slowly warms, the warming is stronger in the polar regions, the equatorial region hardly changes at all. The temperature difference is slowly getting smaller.

The next chart shows the frequency of the strong tornado-producing storms is decreasing.

https://climateataglance.com/climate-at-a-glance-tornadoes/



Some images of tornado-producing thunderstorms from NOAA
https://www.weather.gov/media/unr/SpottersGuide2011_fielduse.pdf



Wall cloud and rain free base. Photo by Brian Morganti.

Shown is a severe thunderstorm in the distance with a visible thick anvil and large overshooting top. Photo by Gene Rhoden.

These are the types of storms which have vertical cloud speeds over 60 knots!

Reference Data follow:

USNM 747320 USAFETAC/DS-86/0066

https://apps.dtic.mil/sti/pdfs/ADA175364.pdf

AD-A175 364

DTIC FILE COPY

OPERATING LOCATION - A

USAFETAC

Air Weather Service (MAC)

REVISED UNIFORM SUMMARY OF
SURFACE WEATHER OBSERVATIONS

HOLLOMAN AFB NM MSC #7
N 32 51 W 106 06 ELEV 4093 FT

PARTS A - F HOURS SUMMARIZED: 0000 - 230

PERIOD OF RECORD:
HOURLY OBSERVATIONS: SEP 76 - AUG 86

SUMMARY OF DAY DATA: SEP 42 - FEB 46,
JUL 46 - AUG 86

TIME CONVERSION GMT TO LST -7

"Approved for public release; Distribution Unlimited."

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86 12

GLOBAL CLIMATOLOGY BRANCH
USAFETAC
AIR WEATHER SERVICE/MAC

https://apps.dtic.mil/sti/pdfs/ADA175364.pdf

MEANS AND STANDARD DEVIATIONS

DEW-POINT TEMPERATURES DEG F FROM HOURLY OBSERVATIONS

747320 HOLLOMAN AFB NM 76-86

STATION STATION NAME YEARS

HRS. (L.S.T.)		JAN.	FEB.	MAR.	APR.	MAY	JUN.	JUL.	AUG.	SEP.	OCT.	NOV.	DEC.	ANNUAL
00-02	MEAN	24.4	23.8	23.9	26.2	32.7	41.6	52.9	56.9	51.8	40.1	29.1	24.0	35.7
	S.D.	7.747	8.406	9.508	10.471	11.647	12.350	7.230	5.886	7.213	9.588	9.488	8.586	15.167
	TOTAL OBS	930	846	930	900	930	900	930	930	900	930	900	929	10955
03-05	MEAN	23.6	23.3	23.4	26.1	32.5	41.6	52.8	56.5	51.4	39.4	28.5	23.2	35.3
	S.D.	7.793	8.479	9.624	10.617	11.263	12.065	7.065	5.715	7.195	9.418	9.381	8.536	15.208
	TOTAL OBS	930	846	930	900	930	900	930	930	900	930	900	930	10956
06-08	MEAN	23.4	23.3	24.2	28.1	34.8	43.9	53.9	57.3	52.2	40.0	28.5	23.1	36.1
	S.D.	7.578	8.448	9.473	10.424	10.780	11.018	6.496	5.511	7.042	9.317	9.522	8.433	15.277
	TOTAL OBS	930	846	930	900	930	900	930	930	900	930	900	930	10956
09-11	MEAN	26.5	26.6	26.6	29.3	35.8	44.8	54.4	57.7	53.4	42.3	31.4	26.7	38.0
	S.D.	7.242	8.180	8.780	9.768	10.626	10.271	5.968	5.234	6.752	9.405	9.696	8.376	14.366
	TOTAL OBS	930	845	930	900	930	900	927	930	900	930	900	930	10952
12-14	MEAN	27.2	25.9	25.1	28.2	34.1	43.1	52.4	56.0	51.6	40.8	30.7	27.4	37.0
	S.D.	7.577	8.679	8.314	8.963	9.581	9.339	6.332	5.434	7.212	9.502	9.859	8.601	13.803
	TOTAL OBS	929	845	[illegible]	900	930	900	930	929	900	930	900	930	10953
15-17	MEAN	26.7	24.6	23.6	27.5	33.3	41.8	50.9	54.4	49.9	39.3	29.9	27.3	35.8
	S.D.	7.950	8.795	7.964	8.266	8.796	8.774	6.921	5.887	7.673	9.593	9.807	8.783	13.527
	TOTAL OBS	929	846	930	900	930	900	930	929	900	930	900	930	10954
18-20	MEAN	26.5	25.1	23.5	26.6	32.3	41.1	51.3	55.3	50.9	40.4	30.1	26.5	35.9
	S.D.	8.001	8.828	8.816	9.091	9.760	10.024	7.170	6.138	7.781	9.714	9.739	8.444	14.071
	TOTAL OBS	929	846	930	900	930	900	930	927	900	930	900	930	10952
21-23	MEAN	25.3	24.7	23.9	26.5	32.4	40.9	52.4	56.5	51.7	40.3	29.5	24.9	35.8
	S.D.	7.909	8.587	9.243	10.195	11.411	11.948	7.482	6.007	7.565	9.752	9.576	8.385	14.850
	TOTAL OBS	930	846	930	900	930	900	930	926	900	930	900	930	10952
ALL HOURS	MEAN	25.4	24.7	24.3	27.3	33.5	42.3	52.6	56.3	51.6	40.3	29.7	25.4	36.2
	S.D.	7.854	8.613	9.034	9.816	10.588	10.873	6.936	5.819	7.367	9.571	9.677	8.677	14.570
	TOTAL OBS	7437	6766	7440	7200	7440	7200	7437	7431	7200	7440	7200	7439	87630

ADE 850

DATA PROCESSING DIVISION
USAFETAC
Air Weather Service (MAC)

REVISED UNIFORM SUMMARY OF
SURFACE WEATHER OBSERVATIONS

BIGGS AAF TX (EL PASO) WBAN #23044
N 31 48 W 106 24 FLD ELEV 3913 FT ELP WMO #72270

PARTS A-F
POR FROM HOURLY OBS: SEP 72 - AUG 80

POR FROM DAILY OBS: JAN 50 - AUG 80

TIME CONVERSION GMT TO LST: -7

FEDERAL BUILDING
ASHEVILLE, N. C.

GLOBAL CLIMATOLOGY BRANCH
USAFETAC
AIR WEATHER SERVICE/MAC

https://apps.dtic.mil/sti/pdfs/ADA095335.pdf

MEANS AND STANDARD DEVIATIONS

DEW-POINT TEMPERATURES DEG F FROM HOURLY OBSERVATIONS

23044 (STATION) BIGGS AAF TX (EL PASO) (STATION NAME) 72-80 (YEARS)

HRS (L S T)		JAN.	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
00-02	MEAN	26.2	24.3	22.2	24.8	33.0	39.8	55.0	54.1	51.7	40.3	28.7	21.8	35.2
	S D	8.283	11.117	9.782	10.099	11.641	11.601	7.631	6.751	8.684	10.156	10.966	10.257	15.666
	TOTAL OBS	743	678	744	719	744	720	744	743	720	742	720	744	8761
03-05	MEAN	25.7	23.6	22.[illegible]	25.5	33.7	40.7	55.7	54.7	51.7	39.9	27.9	21.5	35.3
	S D	8.161	11.137	9.555	10.289	11.095	11.118	7.172	6.326	8.562	10.193	10.990	10.324	15.770
	TOTAL OBS	744	677	744	720	744	718	743	744	719	743	720	744	8760
06-08	MEAN	25.4	23.8	23.1	26.7	36.1	43.2	56.4	55.9	52.6	40.6	28.1	21.6	36.2
	S D	8.109	11.215	9.466	10.240	10.510	10.651	6.901	5.479	8.312	10.312	10.961	10.219	15.899
	TOTAL OBS	744	678	744	720	744	719	744	744	719	742	720	744	8762
09-11	MEAN	26.9	25.5	24.5	27.5	36.1	43.5	55.7	55.4	52.5	41.8	29.8	23.9	37.0
	S D	8.043	10.605	8.821	9.477	9.805	10.398	6.419	5.251	8.255	9.766	10.445	9.415	14.936
	TOTAL OBS	744	677	743	719	744	720	744	744	720	741	719	744	8759
12-14	MEAN	26.6	24.7	23.2	25.8	33.7	40.4	53.3	52.6	50.2	40.5	29.5	24.1	35.4
	S D	8.531	10.174	8.264	8.963	9.411	9.230	6.493	5.825	8.527	9.534	10.074	9.601	14.197
	TOTAL OBS	743	677	743	720	743	717	744	743	720	741	720	744	8755
15-17	MEAN	26.0	23.[illegible]	21.7	23.9	31.7	38.0	51.3	50.5	48.3	38.9	28.4	23.4	33.8
	S D	8.744	10.2[illegible]	8.581	8.809	9.587	8.975	7.205	6.567	9.114	9.852	10.225	9.802	14.076
	TOTAL OBS	743	6[illegible]8	744	720	744	719	744	743	720	744	720	744	8763
18-20	MEAN	26.4	23.2	21.2	23.2	31.5	37.8	51.5	51.4	49.3	39.4	28.7	23.1	34.[illegible]
	S D	8.618	10.861	8.887	8.981	10.970	10.082	8.188	7.454	9.237	10.374	11.056	9.866	14.71[illegible]
	TOTAL OBS	744	677	744	719	744	720	743	741	719	743	720	743	8757
21-23	MEAN	26.7	24.2	21.8	24.5	32.7	39.1	53.5	53.1	50.6	40.0	28.7	22.6	34.8
	S D	8.452	11.200	9.282	9.430	11.657	11.452	8.166	7.027	9.130	10.394	10.959	9.963	15.244
	TOTAL OBS	744	678	744	720	743	719	744	741	720	744	720	744	8761
ALL HOURS	MEAN	26.2	24.1	22.5	25.2	33.6	40.3	54.0	53.5	50.9	40.2	28.7	22.7	35.2
	S D	8.381	10.840	9.141	9.639	10.739	10.661	7.524	6.615	8.849	10.106	10.727	9.978	15.109
	TOTAL OBS	[illegible]949	5920	5950	5757	5950	5752	5950	5943	5757	5940	5759	5951	70078

More info on severe weather is at

https://www.weather.gov/media/zhu/ZHU_Training_Page/convective_parameters/Stability_Indices_severe_wx.pdf