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# RELATIONSHIP BETWEEN TROPOPAUSE HEIGHT AND SEVERE THUNDERSTORM TOPS*

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*EDITOR'S NOTE*

*The following is a reprint of a Central Region Technical Attachment. We would like to call your attention to Eastern Region Technical Attachment No. 74-7-29 on the same subject. The study by Darrah presents a breakdown of the data by severe weather type and geographic location.*

One of the radar criteria now in use in the NWS for identifying severe thunderstorms is a tropopause penetration of 1,500 meters ( 5,000 feet) or more. Considerable research has been recently undertaken by universities and research laboratories resulting in data showing large tropopause penetrations and sustained storm tops in hail storms but rapid top decreases associated with tornado production. This note examines the relationship between radar tops, tropopause heights, and severe weather events as derived from NWS data collected during 1968. Data consists of records, compiled by the NSSFC RADU unit in Kansas City, of all reported thunderstorm tops and known severe weather occurrences.

For the period of study, all radar reported thunderstorm tops within two hours of scheduled radiosonde release time were determined and compared with severe weather reports. Those tops lying east of 105°W which occurred within 30 miles and 30 minutes of reported severe weather (tornadoes, large hail, and wind gusts of 50 knots or more) were compared to the reported tropopause height. Those differences between radar top and raob tropopause height for each severe weather type is considered and presented in the following table:

## TABLE

Height of severe storm top with respect to tropopause (meters) and the relative frequencies of penetrating, near tropopause, and nonpentrating storms.

| | Number of Reports | Mean Alg. Diff. (Top-Trop) | 500 m or greater | ±500m | 500 m or more below |
|---|---|---|---|---|---|
| Tornadoes | 126 | 350 | 52% | 14% | 34% |
| Hail | 224 | 1140 | 62% | 16% | 22% |
| Windstorms | 220 | 110 | 45% | 21% | 34% |

It should be recognized that errors exist in these data due to infrequent sampling of radar storm tops and the possibility that those tops are with thunderstorms not related to the severe events.

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*This paper is part of a thesis in preparation for a Masters' Degree at the University of Wisconsin.

To show the space variation from the tabular values, Figures 1 through 3 were created by averaging all values within the 10° latitude-longitude square surrounding the plotted point. For continuity all squares overlap. The number of cases for each average is in parentheses alongside the difference in meters between the radar top and tropopause height. Negative values indicate radar tops that were below the reported tropopause.

Figure 1 is for windstorms. The differences across the area are not large, but are regular, with a small but significant tropopause penetration in the Plains area, and a small but consistent below-tropopause top in the east.

Figure 2 shows the same type of data for large hail cases. The E-W gradient is a bit stronger than that for winds but in the same sense. The slight positive tropopause penetration in the mid-Atlantic states is the main difference from Figure 1.

Figure 3 shows the data for tornadoes, here the gradient is again stronger and in the same sense as above. However, the minimum in the southeast is very pronounced, and the maximum penetration zone lies over "tornado alley."

Even though the sample is not large, the differences are statistically significant. The data imply that in the Great Plains area, severe storms are likely to have a tropopause penetration some time during their lifetime. This penetration has a magnitude close to the one used as a radar warning criterion. However, from the Appalachians eastward, the 1,500-meter criterion seems much too high. In fact, a requirement of any penetration seems inappropriate. It is quite clear that in the east the tropopause criterion should not be used for tornadoes.

The NWS does not consider tropopause penetration by itself for severe thunderstorm warning, and appropriately so, since our data suggests, on the basis of the May data only, that only approximately 25 percent of the radar echo tops penetrating the tropopause were accompanied by reported severe weather. Said in another way, three-fourths of the radar echoes penetrating the tropopause are <u>not</u> associated with reported severe weather.

A capsule conclusion of all this might be that while a sizable tropopause penetration of radar echoes may occur frequently in the Plains area, and most severe storms penetrate the tropopause there, tropopause penetration alone is definitely not a sufficient condition for severe weather there. Also, the penetration criterion is of questionable value elsewhere.

SCIENTIFIC SERVICES DIVISION, ERH
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Attachments: Figures 1-3

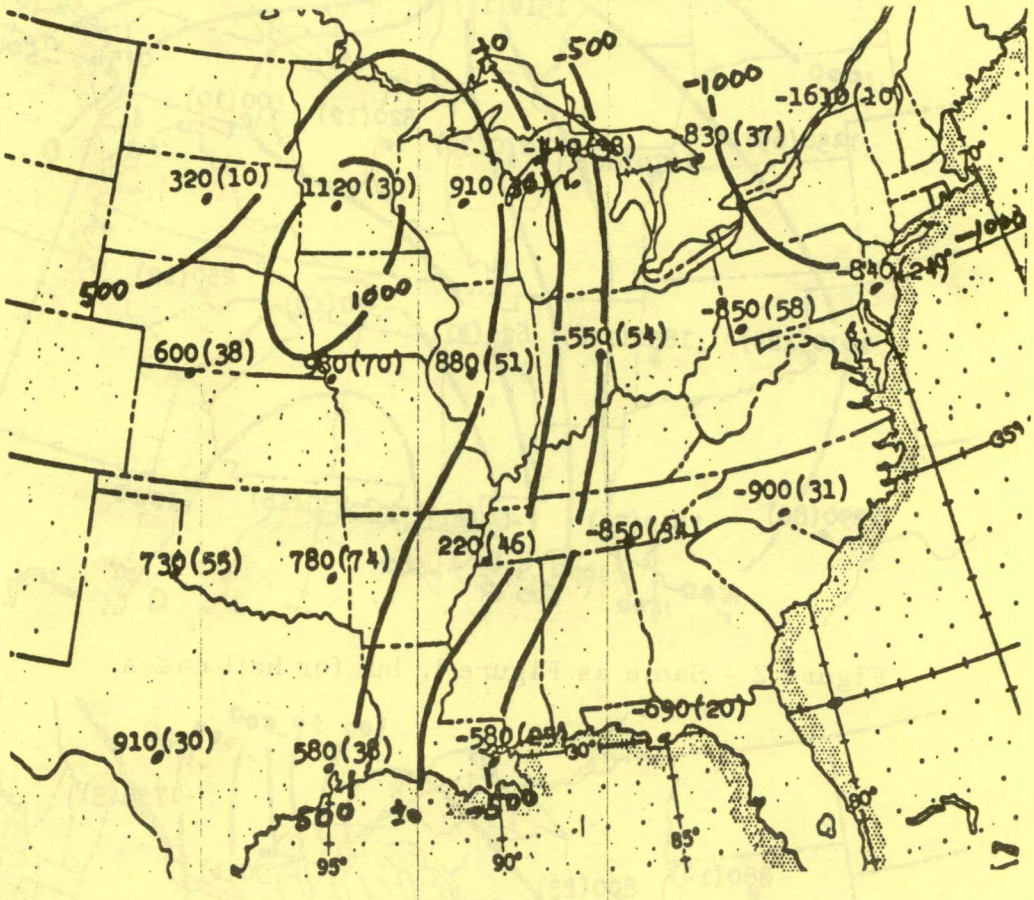


Figure 1 - Height of radar echo top (m) with respect to the height of the reported tropopause (number of cases in parenthesis) for high straight-line wind cases.

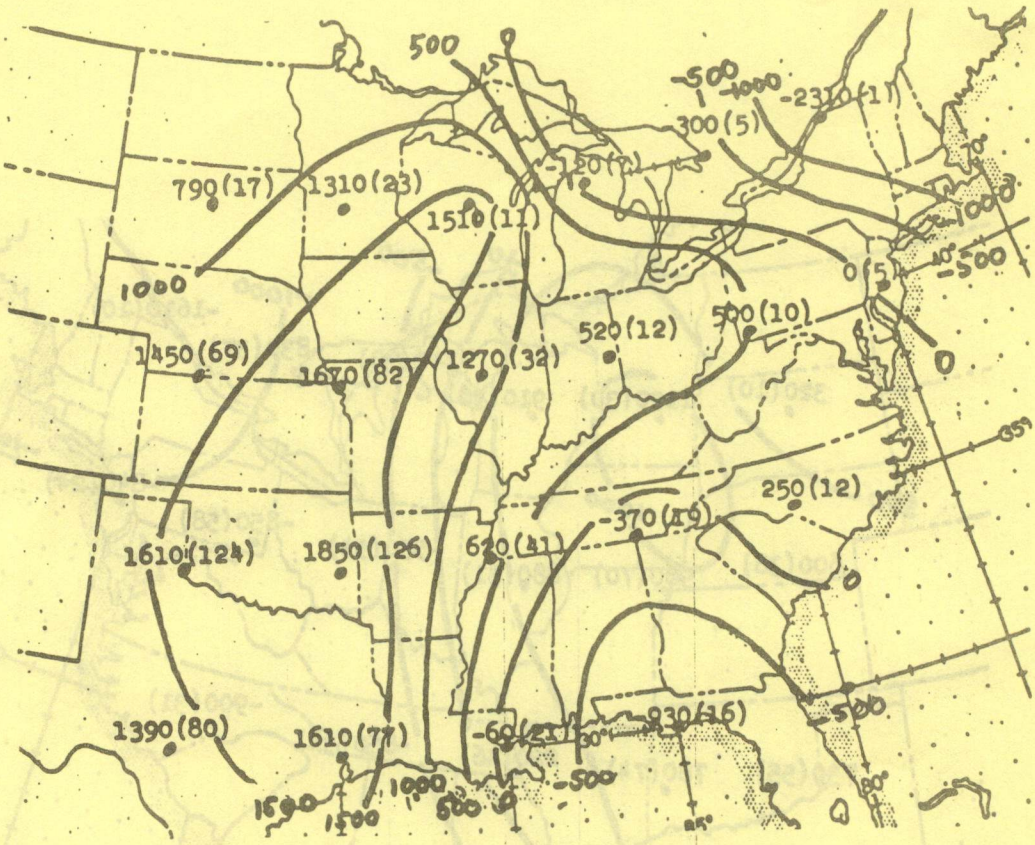


Figure 2 - Same as Figure 1, but for hail cases.

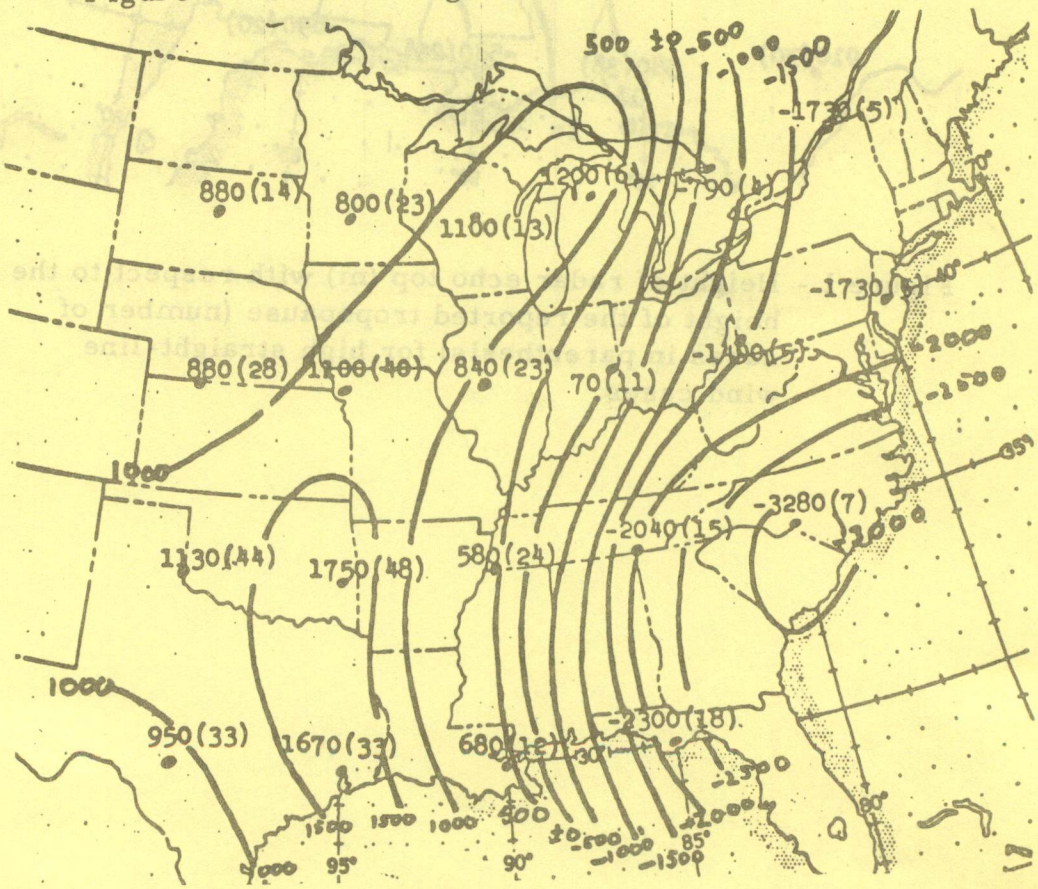


Figure 3 - Same as Figure 1, but for tornado cases.

ATTACHMENT

# A PREVIEW OF AUTOMATION - THE NWS "AUTOB"

You've all heard of AMOS. Now meet his cousin, "AUTOB," who has appeared at Summit, Alaska, and will appear shortly at Wendover, Utah. AUTOB (AUTomated OBservation) is an AMOS spinoff, the main difference being that the AUTOB sky cover report is completely automated, in contrast to AMOS, whose sky cover is often manually entered. AUTOB will provide:

CLOUDS. Amount and height from surface to 6,000 feet. Cloud height signals are sent from the RBC to a microprocessor for storage, while cloud amount is sensed by an innovative sampling and storage system. When there are no clouds below 6,000 feet, the microprocessor reports "60 CLK." When clouds are present, the "brain" checks the RBC every 5-minutes, determines layering by height category, and reports up to three layers. If visibility is less than 3/4 mile with no clouds detected, "WX" (an obscuration without a height) is reported; if visibility is less than 3/4, but clouds are detected, a "– X", for partial obscuration, is reported before cloud layers. Gadgetry fans will appreciate the RBC lamp system: if one lamp burns out, AUTOB switches to the spare and reports an "L" at the end of the report. If you see "SKY MMMM MMMM" at the end of an AUTOB report, it doesn't mean that the computer likes the sunset -- it only means that both lamps have burned out.

VISIBILITY. The sensor is a Videograph, which measures transmissivity much as a transmissometer does. The indicator "BV" is intended as an emphatic reminder that we're not talking about "prevailing" visibility here. AUTOB reports a one-digit visibility code, with "0" for less than 3/4 mile and "8" for better than 7-1/2 miles. A 10-minute max and min (along with current) visibility is reported.

TEMPERATURE, DEWPOINT, WIND, PRESSURE AND PRECIPITATION: All reported by conventional sensors. For example, a heated rain gage tips and weighs anything adding up to .01 inch of water or more. Tips are counted and the counter reset at each synoptic hour. An example AUTOB looks like this:

UMM AUTOB 3 SCT E7 BKN BV887 31/14/0305/974 000 SKY 2500 0600

Airways code fans will recognize everything but the "BV" and "SKY" groups. "BV887" tells us that the current visibility is better than 7-1/2 miles, the 10-minute max the same, and the 10-minute min between 6-1/2 and 7-1/2. The "SKY" groups indicate (by layered height increments) the percentage of time clouds were detected in the past 30 minutes, and in the 30-minute period before that.

Sounds great, right? In a way, it is. Sure beats sending you or me off to Fort Frosty-Cojones to take observations just to maintain a control zone for the monthly mail sled. But it has its drawbacks. Money, for one. AUTOB costs plenty! The real drawback right now is the fact that the sensors are partially blind. AUTOB can (and often does) report "60 CLR" on a perfectly beastly day. But NWS is working on it and has expressed confidence that they'll have most of that problem whipped by the time the iceworms nest again this coming spring.