MERGING HEIGHT FALL CENTERS

-TWO EXAMPLES-

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Abstract: Two case studies of merging height fall centers (HFC) condensed from a forthcoming report entitled, "Synoptic Patterns Favorable for Eastern U. S. Snowstorms".

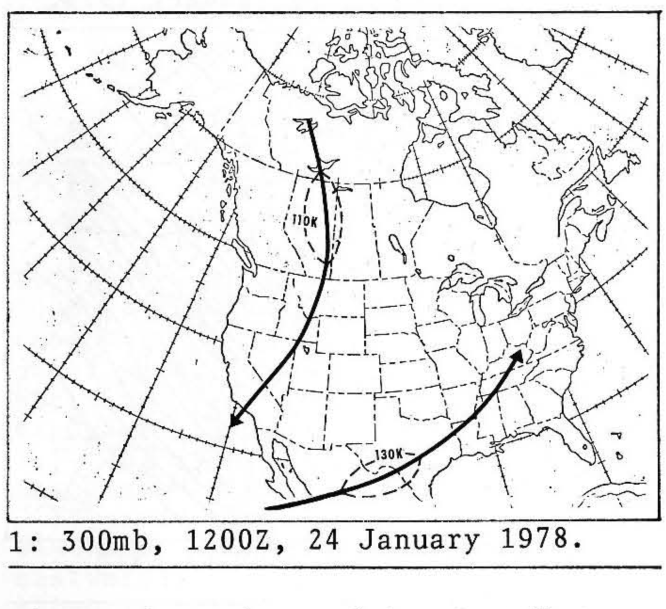
EXAMPLE 1. Eastern U. S. Superstorm, 26-27 January 1978.

Residents in the upper Midwest, Great Lakes and Ohio Valley experienced a giant, vicious storm during 26-27 January 1978 which left scores dead, thousands stranded and widespread power failures. In Ohio the storm was labeled the worst blizzard in the state's history. Record low-pressure readings were observed along the storm center's path through Ohio.

What atmospheric changes led to such an immense storm system? Indeed, there were many factors. In this case, we will take a brief look at synoptic features before and during storm development. Some synoptic features observed were:

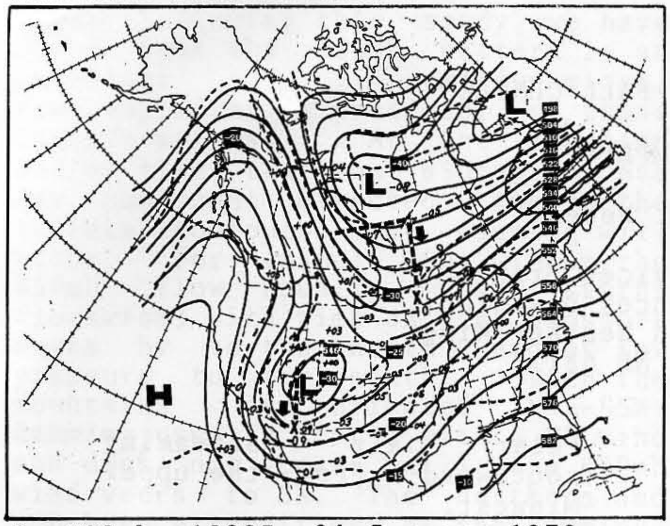
- A building upper ridge over western Canada and U.S.
- A long wave trough over the central U.S. moving eastward.
- Two jet stream systems which merged over the Southeastern U.S.
- Two positive vorticity centers approaching each other from different directions.
- Moisture-laden air from the Gulf of Mexico and Atlantic Ocean extended north and west of the Great Lakes.
- Polar air streaming southward from the upper Midwest.

Fig. 1 shows two jet-stream systems with their associated maximum isotach areas. A pronounced north-south ridge is off the western Canadian-U.S. coast as shown in Fig. 2. Two HFCs are noted in Fig. 2; -10 (-100m) over Minnesota and -09 (-90m) over southern Arizona. Both HFCs are moving southward instead of in their usual eastward direction. HFC movements towards the south are warnings of further deepening. The 500mb short wave low shown over Arizona usually poses a threat for heavy snowfalls over the Great Plains; however, this system behaved differently due to the short-wave impulse in Canada.

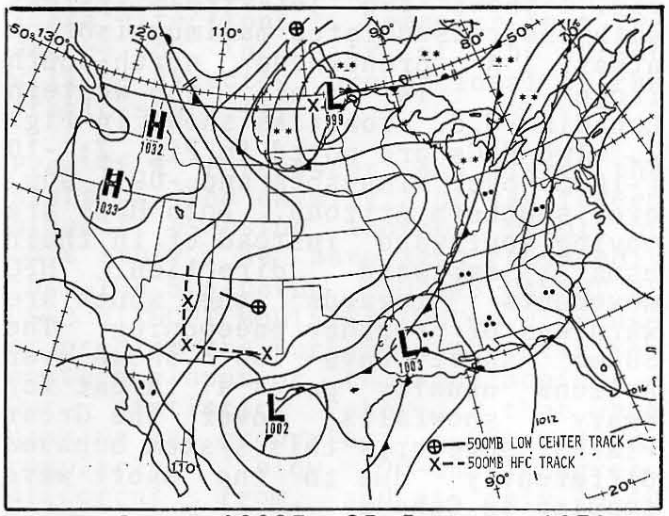


1: 300mb, 1200Z, 24 January 1978.

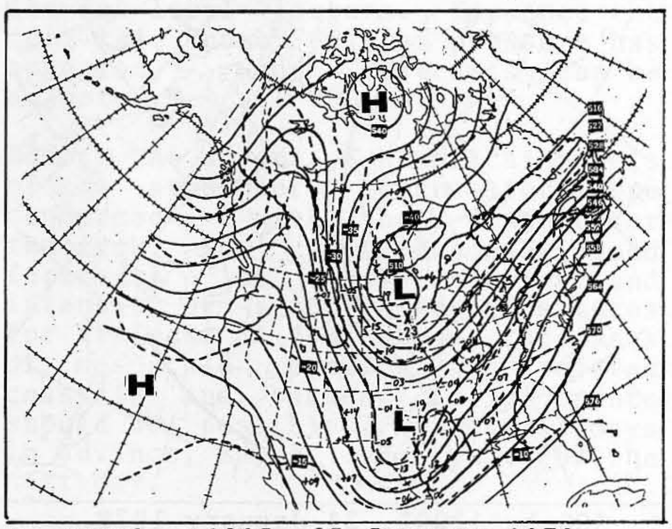
The surface chart (Fig. 3; 12h later than Fig. 1 and 2) reveals a typical frontal wave system. An extensive area of precipitation (mostly rain) runs from the Gulf Coast to Ohio. Note cP front over upper Midwest.



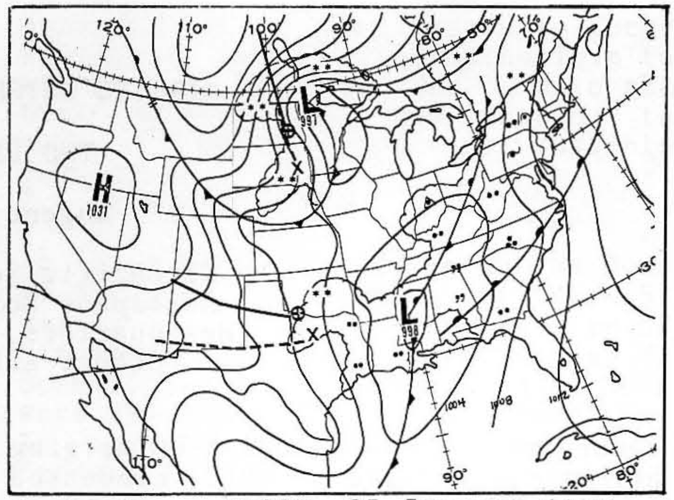
2: 500mb, 1200Z, 24 January 1978.



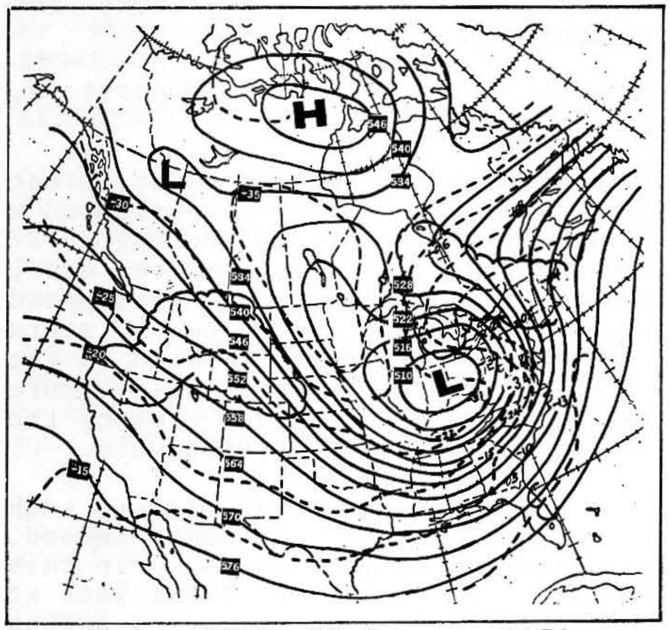
3: Surface, 0000Z, 25 January 1978.



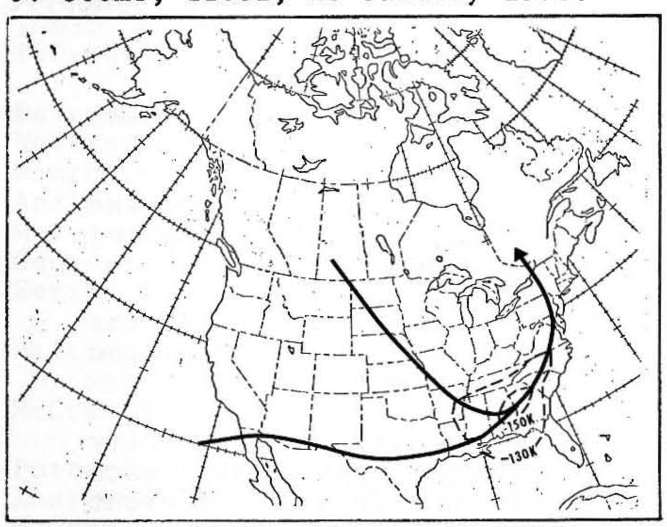
4: 500mb, 1200Z, 25 January 1978.



5: Surface, 1200Z, 25 January 1978.



6: 500mb, 1200Z, 26 January 1978.

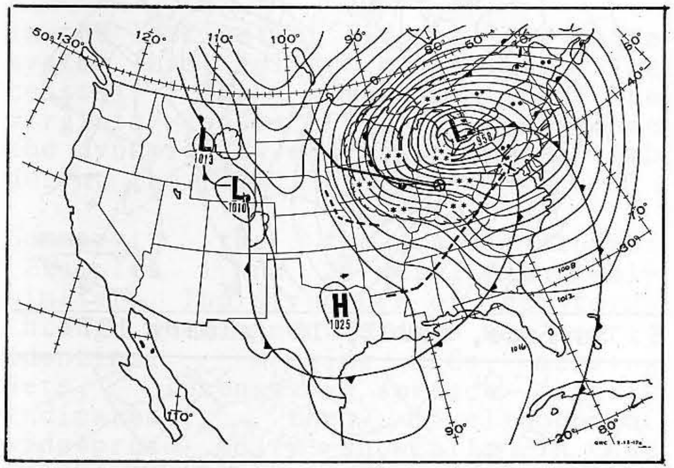


7; 300mb, 1200Z, 26 January 1978.

24h later (Fig. 4) the HFC over South Dakota increased to -23 and had shown a slow, erratic path as deepening continued. The southern system's HFC also increased (-17) as it moved eastward. The 500mb low centered west of Hudson Bay in Fig. 2 moved rapidly southward to North Dakota in the previous 24h.

The related surface features shown in Fig. 5 are not too different from 12h earlier (Fig. 3). Note the HFC movements (dashed tracks indicated by arrows). The northern center's movement southward and the Texas center eastward track would, in time, either appear to merge or transfer energy from one system to the other.

Fig. 6, 24h later, reveals only one strong HFC (-34) over West Virginia. Apparently the two HFCs shown in Fig. 4 merged as did the two jet streams shown initially in Fig. 1 and finally in Fig. 7. This has been found to be a common HFC pattern during East Coast "superstorm" formation. Fig. 8 shows the end result - a gigantic storm system over the Great Lakes. The low's central pressure fell 40 millibars in 24 hours! A true superstorm!



8: Surface, 1200Z, 26 January 1978.

EXAMPLE 2: A Major East Coast Snowstorm, 9-11 January 1977

This storm system spread a hefty blanket of snow across a large area from the lower Mississippi Valley to the Great Lakes. It was not an intense as the 26-27 January 1978 superstorm. The development, intensification and movement of this second example were, however, similar in many respects to the superstorm - both in the upper levels and at the surface.

All of the upper-level features highlighted in Example 1 can also be used in this example. They were:

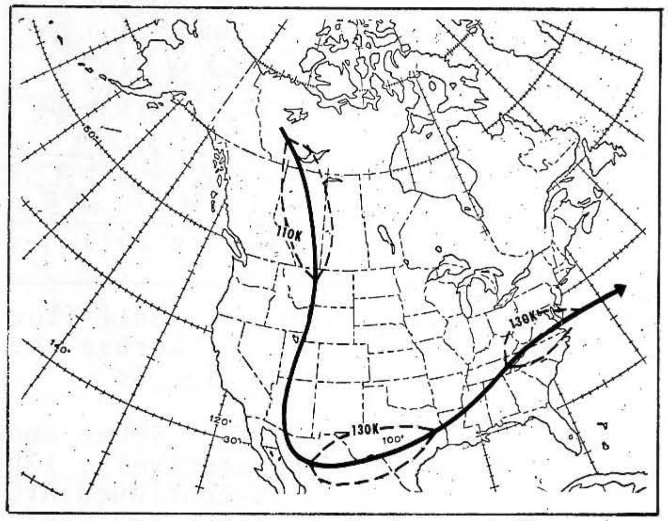
A building upper ridge over western Canada and U.S.

A long-wave trough over the central U.S. moving eastward.

Two jet streams which merged over the Southeastern U.S.

Two positive vorticity centers approaching each other from different directions.

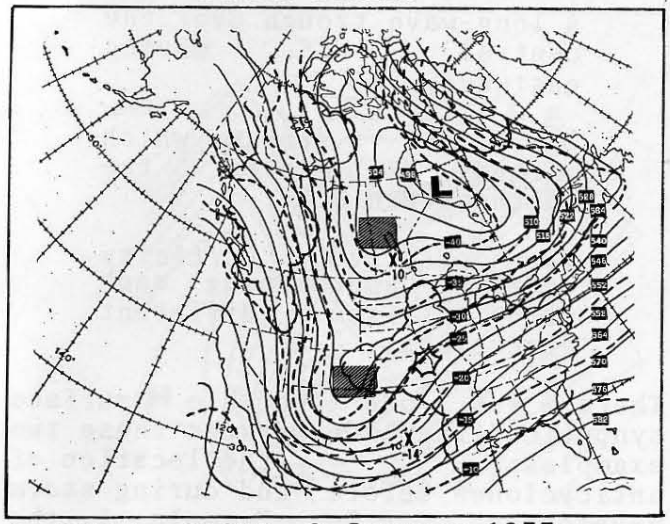
There was one notable surface synoptic difference between these two examples: the location of anticyclones before and during storm development. In Example 1, the primary anticyclone was mP and located well offshore, and southerly flow from the Gulf of Mexico produced mostly rain. In Example 2, however, a large stationary cP high prevailed over the central U.S., and snow resulted.



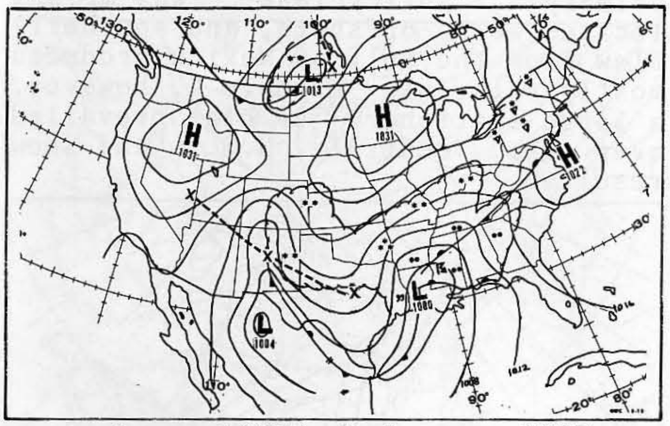
1: 300mb, 1200Z, 9 January 1977.

Figs. 1, 2 and 3 illustrate the 300mb, 500mb and surface pattern respectively during the initial development period. Compare the striking similarities between both examples' upper air patterns. In Fig. 2, two short waves with their associated HFCs appeared over Canada (-10 moving southward) and over the southern Rockies/Plains (-14 moving eastward). The two hatched boxes shown in Fig. 2 represent favorable 500-mb cyclogenesis areas.

At the surface (Fig. 3), widespread overrunning within the cold air is laying a blanket of light snow across the southern Plains towards the Ohio



2: 500mb, 1200Z, 9 January 1977.



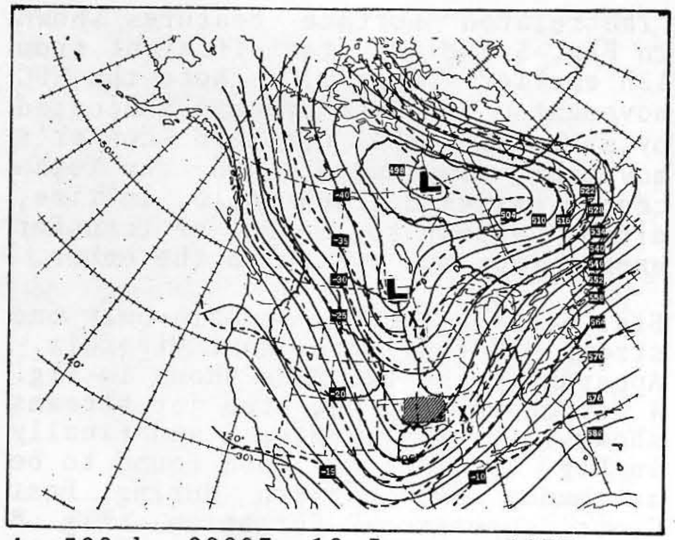
3: Surface, 1200Z, 9 January 1977.

Valley. A strong Gulf flow overrunning the polar air across the Ohio Valley is noted in Fig. 3.

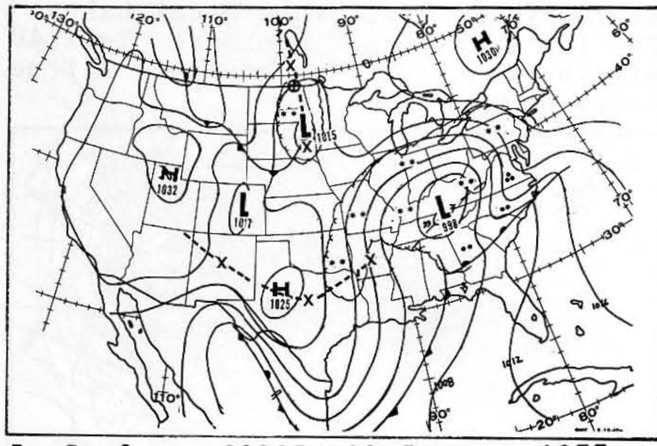
Figs. 4 and 5 represent 500mb and surface analyses, respectively, 12h later. In Fig. 4, note continued HFC movements from the north and west; both centers have increased in magnitude. In Fig. 5, snowfall continues within a disorganized pressure field, marked by the surface trough in eastern Tennessee and Kentucky.

Figs. 6, 7 and 8 show the changing upper and surface patterns 12h later. Two jet streams appeared to have merged over northern Georgia with a 150-kt jet max (Fig. 6). Only one HFC (-25) is shown on the 500mb analysis (Fig. 7); apparently the two HFC shown previously have merged. The 500-mb low that developed earlier within the hatched area (Fig. 2) has moved southeastward into Minnesota.

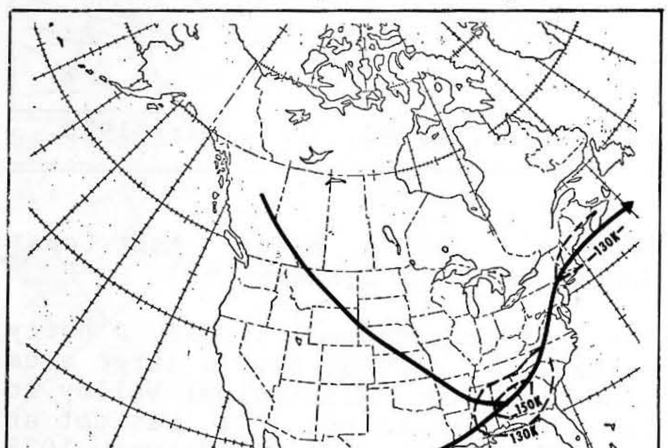
At the surface two lows are shown in



4: 500mb, 0000Z, 10 January 1977.

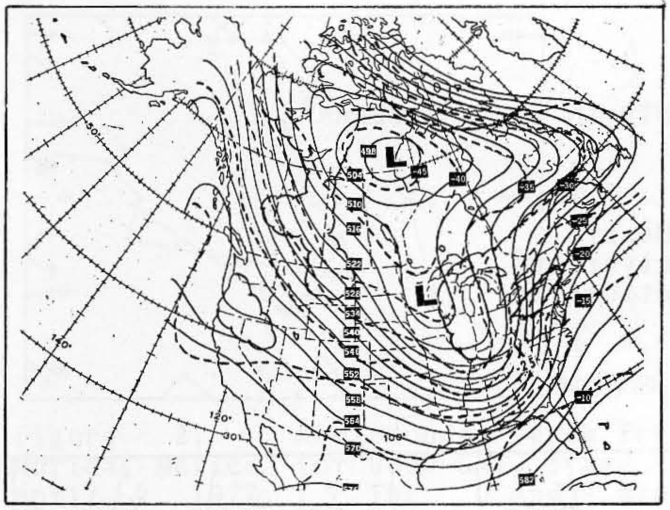


5: Surface, 0000Z, 10 January 1977.

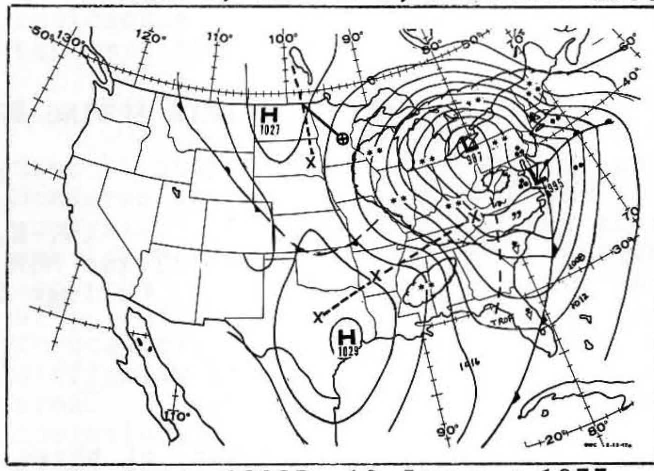


6: 300mb, 1200Z, 10 January 1977.

Fig. 8. The Lake Erie low is dissipating and probably reflects the approaching upper low. The new frontal low, forming off Virginia's coastline, appears to be developing ahead of the approaching HFC (-25) shown in Fig. 7. Precipitation has become widespread as shown in Fig. 8;



7: 500mb, 1200Z, 10 January 1977.

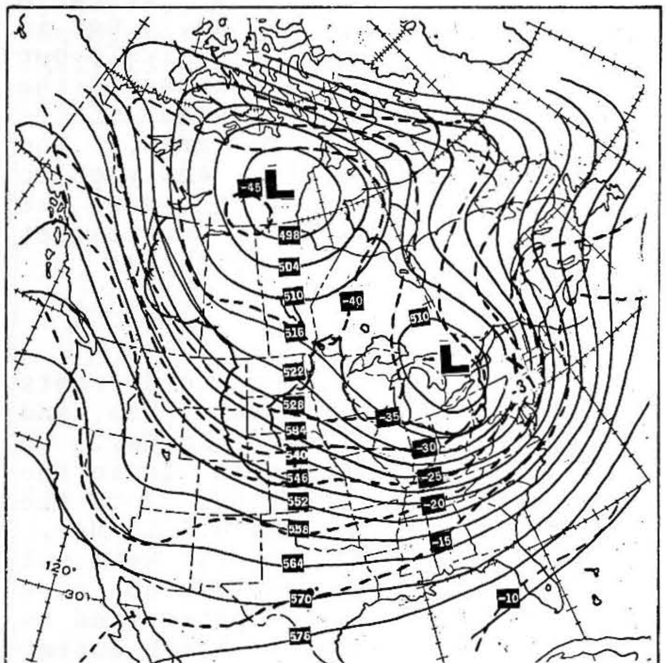


8: Surface, 1200Z, 10 January 1977.

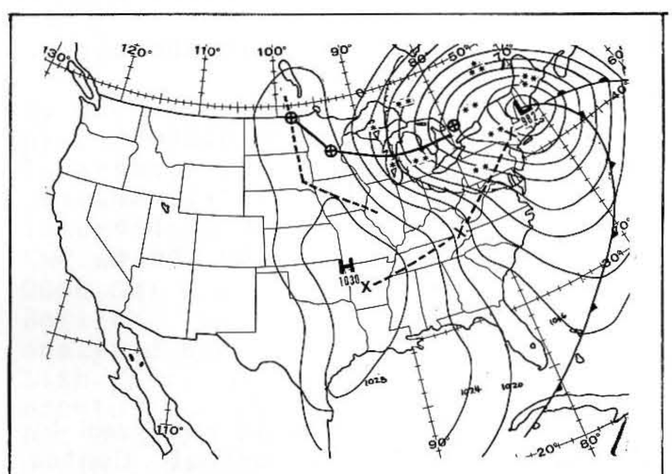
the heavy snowfall area appears to be to the left of the approaching 500-mb HFC track (note HFC track indicated by X in Fig. 8).

In the last set of figures, the storm system has fully organized. The coastal low which was off the Virginia coast (Fig. 8) has become the dynamic low and has deepened 13mb during the past 12h.

Summary: the two case studies (Examples 1 and 2) were remarkably similar. The structure of the storms through development stages was nearly identical. Merging HFCs, merging jets, intense surface storms indicated the likelihood of widespread heavy snowfall. In case 1, the result was a super storm that produced unparalleled blizzard conditions over the Great Lakes and Ohio Valley. Note central pressure of 958mb in case 1. In case 2, central pressures were in the 980-mb neighborhood - typical of great storms over the northeastern U.S. in winter. Heavy snow occurred with this storm also, but not nearly the extent of that with the super storm. The only difference between the two cases was the existence of continental polar (cold, dry) air in the development area of case 2 and the existence of maritime polar (cool, wet) air and later, maritime tropical (warm, wet) air in the development stages of the super storm. Use the concept of merging HFC to predict a significant storm; use the track of the 500-mb HFC to isolate the area of heavy snow; and look for other clues to determine when a real super storm is imminent.



9: 500mb, 0000Z, 11 January 1977.



10: Surface, 0000Z, 11 January 1977.