EASTERN REGION TECHNICAL ATTACHMENT
No. 83-11
June 27, 1983

ATTACHMENT #1

MESOANALYSES OF "AIR MASS" THUNDERSTORM CONDITIONS

The Eastern Region (ER) area during the week of June 13-17 was generally under the influence of high pressure both surface and aloft. Synoptic scale dynamics were minimal during this period and provided an opportunity for the study of "air mass" type thunderstorms using mesoscale techniques.

We attempted to determine factors favorable for the beginning of convection utilizing the 12Z raob reports and surface reports during the morning hours. Hourly analyses of surface temperature, mixing ratio, and moisture convergence between 13Z and 19Z were obtained during this period using the SAO decoder and the MESO1 program (Spry and Anderson, 1981). Upper level divergence fields between 200mb and 300mb were also examined using MESO1. A grid scale of 1 degree of latitude was used.

During periods of weak synoptic influence such as the week of June 13-17, static stability can be used to approximately determine the area of convective activity for the afternoon. K indices in the 30's, negative lifted indices, and positive BI indices (Stone, 1983) were characteristic of the convective areas during this week. It appears that the BI index determines the convective area somewhat more accurately than either the K or lifted index. A typical example of the three index fields from 12Z data and the 18Z radar chart for June 16th is shown in Fig. 1. By 18Z a severe thunderstorm watch had been issued for most of eastern N.Y. State, northeast Pennsylvania, and northern N.J., which coincides approximately with a maximum area of the lifted and BI indices.

Scattered thunderstorm activity was present over most of the ER on the previous day, Wednesday, June 15th, with the most intense activity in the New England area continuing into the early morning hours of Thursday, June 16th. By 13Z on Thursday, practically all of the ER was clear except for New England which was cloudy with a few thunderstorms continuing. The outflow from the thunderstorms produced a strong temperature gradient through western New England up to the N.Y. border. Fig. 2 shows maps of surface temperature, surface mixing ratios, moisture convergence, and the radar echoes at 13Z Thursday.

A temperature maximum is located from N.J. through eastern N.Y. approximately coinciding with a mixing ratio maximum and a weak moisture convergence maximum. Thunderstorm cells in the moisture divergent area of eastern New England diminished to showers in 2 hours; the cell on the Massachusetts-New York border in the moisture convergent area continued to grow for three hours drifting southeastward and diminishing as it crossed Long Island Sound.

By 15Z moisture convergence continued to increase through N.J. and eastern N.Y. followed by the appearance of new radar echoes (Fig. 3). The area of maximum temperature and mixing ratio continued in this location through the day. At 17Z (Fig. 4) moisture convergence was still increasing accompanied by increasing convective activity. A severe thunderstorm watch was issued for the eastern N.Y. area by 18Z (Fig. 1). Conditions at 19Z are shown in Fig. 5.

Maximum moisture convergence inside the severe thunderstorm box was tabulated each hour between 13Z and 20Z along with the percentage of area covered by level 5 or 6 radar echoes approximated from the 90R AFOS chart. The variation of these two

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quantities with time is shown in Fig. 6. Moisture convergence increases by about 50% one to two hours prior to the development of level 5 echoes in the box. New level 1 echoes appeared at 15Z with some rapidly growing to level 5 by 16Z. The one- to two-hour lead time between increase of moisture convergence and the beginning of convection is in agreement with the findings of Cunning, et al. (1982) and Ulanski and Garstang (1978).

Severe weather, large hail and wind damage, did occur in portions of N.Y., western New England and northern N.J. during the afternoon. Equilibrium levels in the severe thunderstorm box area ranged from 36 to 40 thousand feet, while maximum cloud tops observed by radar ranged from 50 to 55 thousand feet between 16Z and 21Z. Radar tops exceeding the equilibrium level are commonly associated with severe weather.

The TDL 2-6 hour severe thunderstorm probability guidance (AFOS chart Ø1Ø) for the period 20Z-00Z (Fig. 7) indicated a high probability in the northeast part of their grid where some severe weather did occur. All through the week of June 13-17 TDL thunderstorm guidance (AFOS charts Ø1Ø and Ø11) provided useful information.

The role of upper level divergence (200-300mb) in the initiation of convection could not be determined with certainty from the data collected this week. It seems likely that upper level divergence over an unstable area should be conducive to convection, but it is not necessary, since strong convection sometimes begins under upper level convergence. It is known that strong convection causes the upper level flow to become divergent (Maddox, 1980).

Fig. 1 shows an area of instability from Tennessee southwestward which exceeds the instability in N.J. and N.Y. Although the area was convectively active, there were only three reports of severe weather compared to fourteen in the north. Morning temperatures in the southern area were cooler and moisture convergence weaker than in the north. Although moisture convergence increased during the day, it never attained the strength of the northern convergence, and cloud tops in the south were generally 10 thousand feet lower.

SUMMARY

The mesoscale analyses for Thursday presented here were typical of the week in general. In summary, when synoptic scale influences are minimal, the BI stability index seems to delineate fairly well the area of convective activity for the afternoon. Convection has been observed with BI in the range of -50 to zero, but the strongest convection with possible severe weather occurs with positive values of BI. In addition where high values of surface mixing ratio and temperature coincide with high BI values, this area is likely to start convection earlier in the day, and convection will likely be more intense than other areas. The beginning of convection in such an area is usually signalled by an increase of moisture convergence an hour or two ahead of time. The moisture convergence field is usually quite variable with time and must be examined each hour to determine significant changes.

The number one predictor in the TDL 2-6 hour general and severe thunderstorm probability forecasts is observed surface moisture convergence. Following the moisture convergence, locally, should help the forecaster to determine trends in the most likely area for thunderstorm development and will also make possible an assessment of the TDL forecasts.

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Obviously, all of the various methods of diagnosing and forecasting thunderstorm activity have not been described in this Attachment. For example, the usual satellite techniques (differential heating at the edge of cloud shields, etc.) also worked quite well. Don't rely on any single technique. If it works, use it.

REFERENCES

Stone, H. M., 1983: Stability Analysis Program, NOAA, Eastern Region Computer Programs and Problems NWS ERCP - No. 9. National Weather Service, Garden City, NY.

Cunning, J. B., et al., 1982: Convective Evolution and Merger in the FACE Experimental Area: Mesoscale Convection and Boundary Layer Interactions, Journal of Applied Meteorology, 21, 953-977.

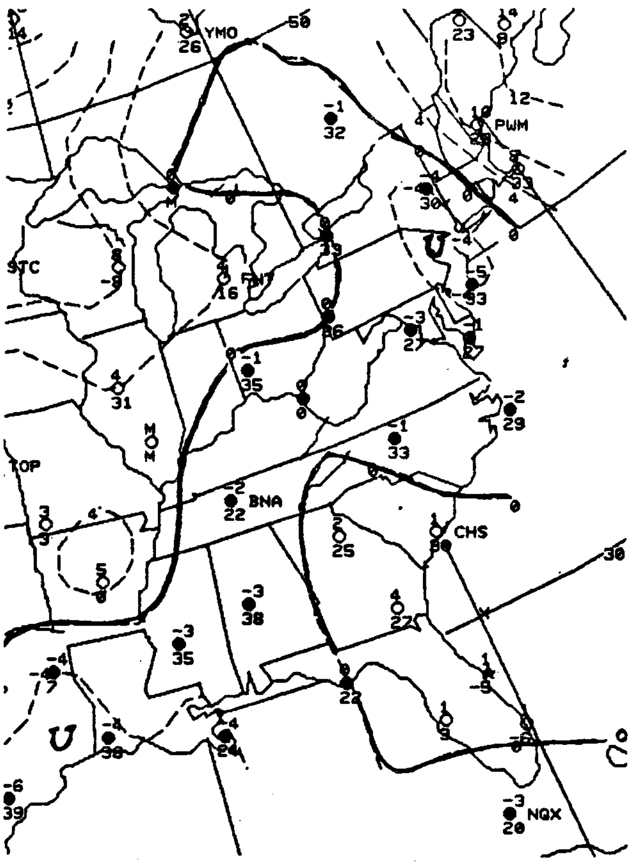
Ulanski, S. L. and M. Garstang, 1978: The Role of Surface Divergence and Vorticity in the Life Cycle of Convective Rainfall. Part I: Observation and Analysis, Journal of the Atmospheric Sciences, 35 1047-1062.

Maddox, R. A., 1980: An Objective Technique for Separating Macroscale and Mesoscale Features in Meteorological Data, Monthly Weather Review, 108, 1108-1121.

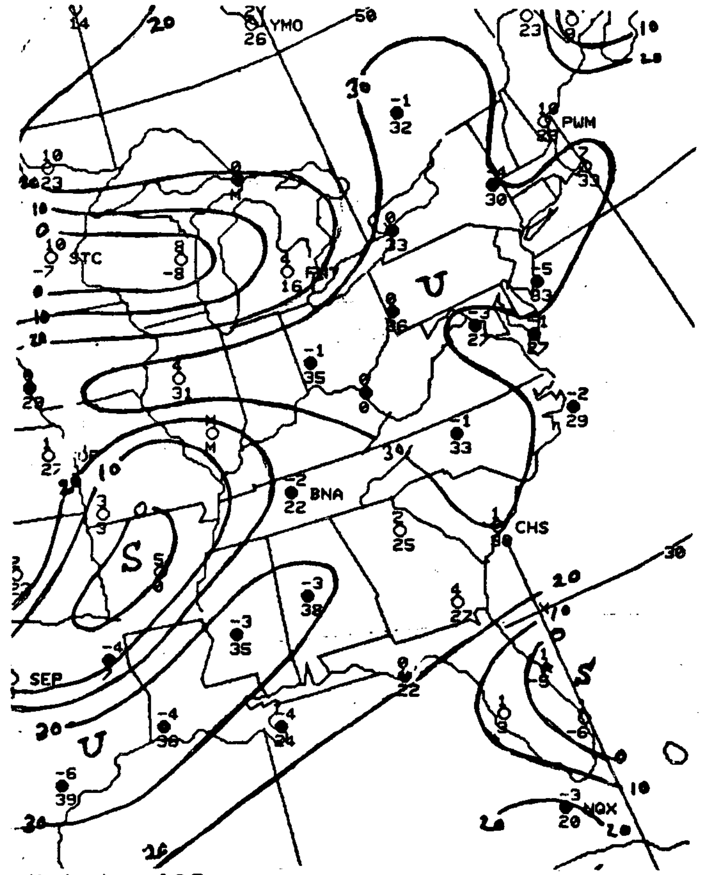
Spry, A. J. and J. L. Anderson, 1981: Mesoscale Objective Analysis, NOAA, Western Region Computer Programs and Problems, NWS WRCP - No. 33, National Weather Service, Salt Lake City, UT.

SCIENTIFIC SERVICES DIVISION, ERH
June 27, 1983

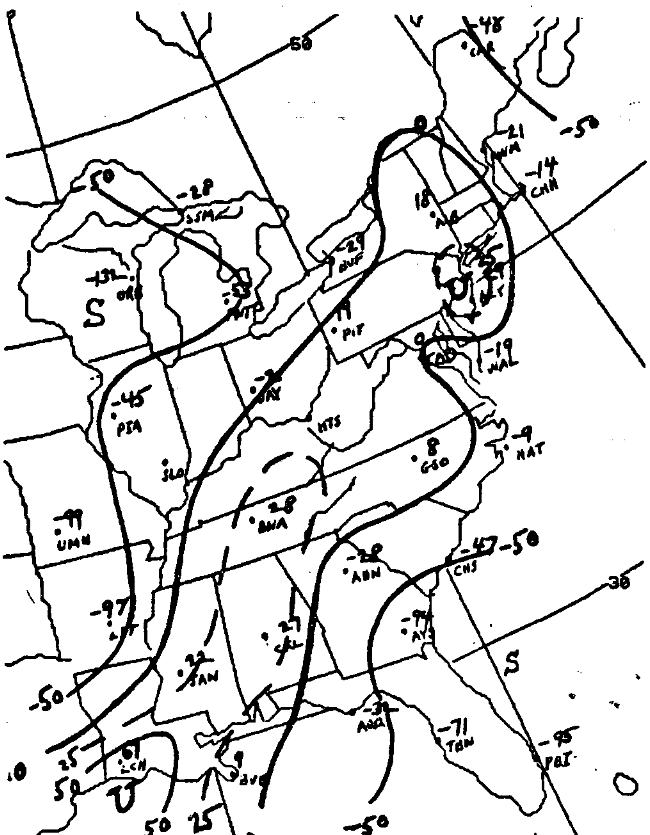
Attachments - Figures 1-7



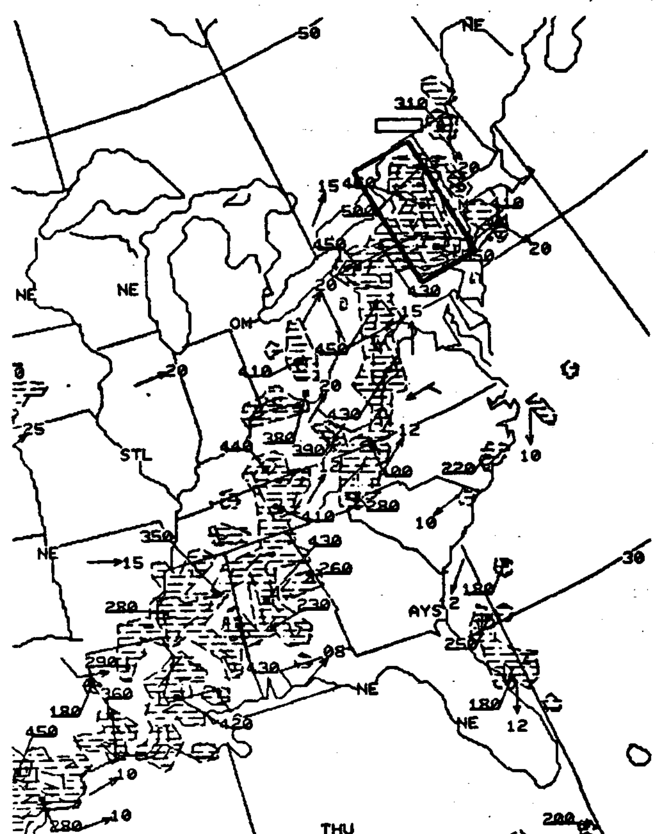
Lifted Index 12Z



K Index 12Z



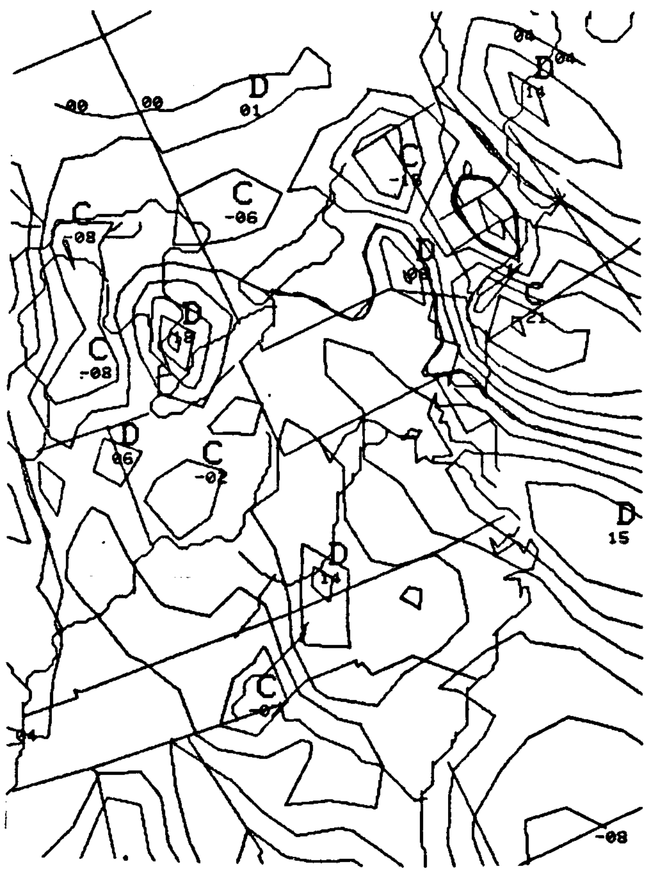
BI Index 12Z



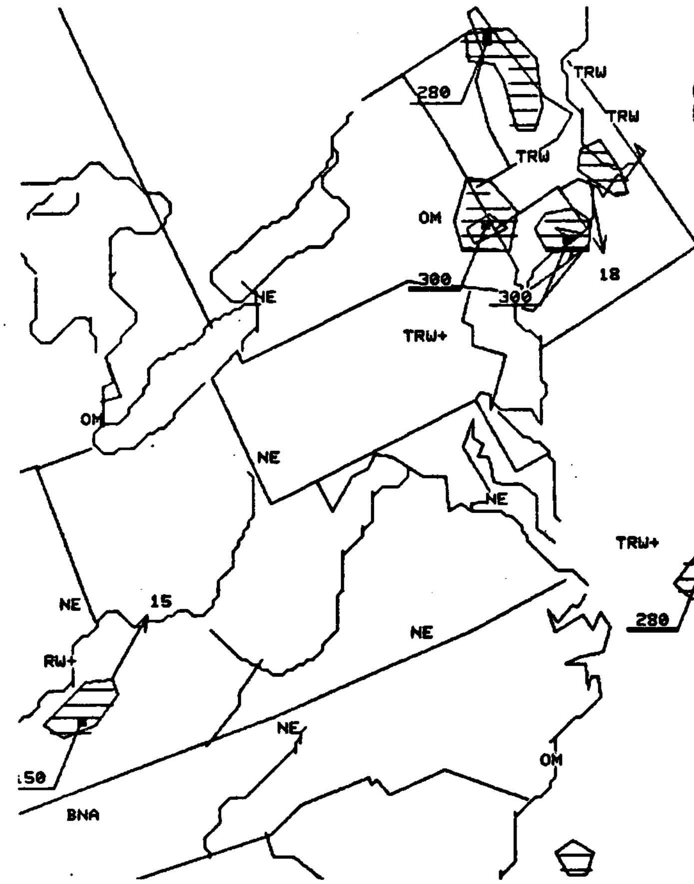
Radar 18Z

Figure 1. Stability indices at 12Z and radar 18Z, 6/16/83.

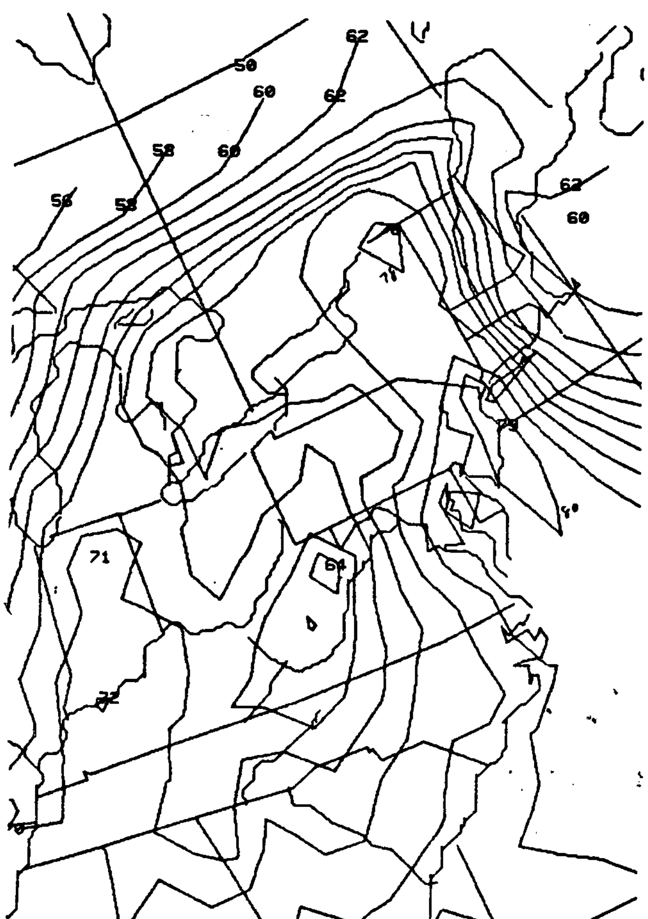
OSU-ERH



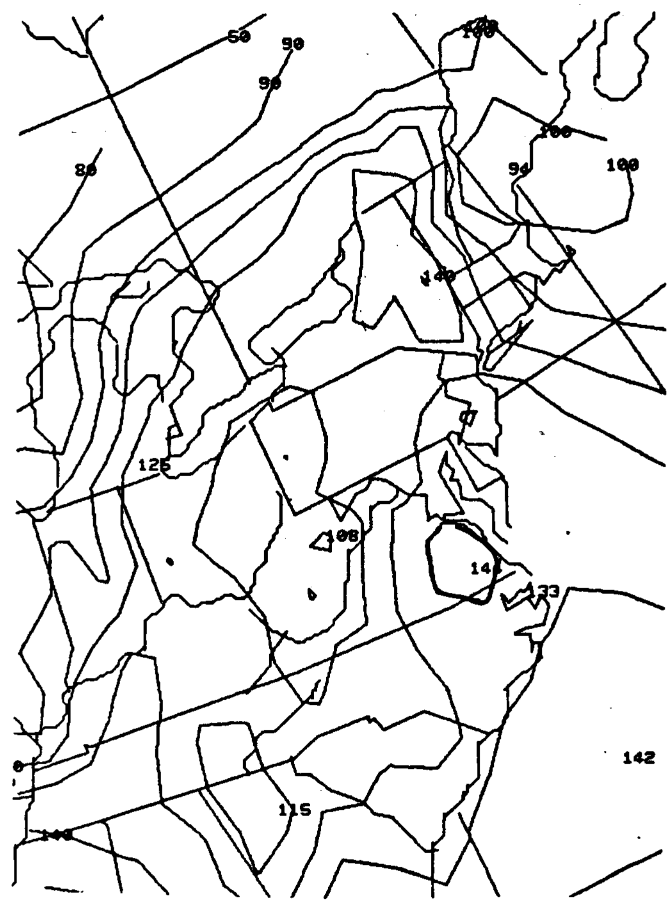
Surface Moisture Convergence



Radar

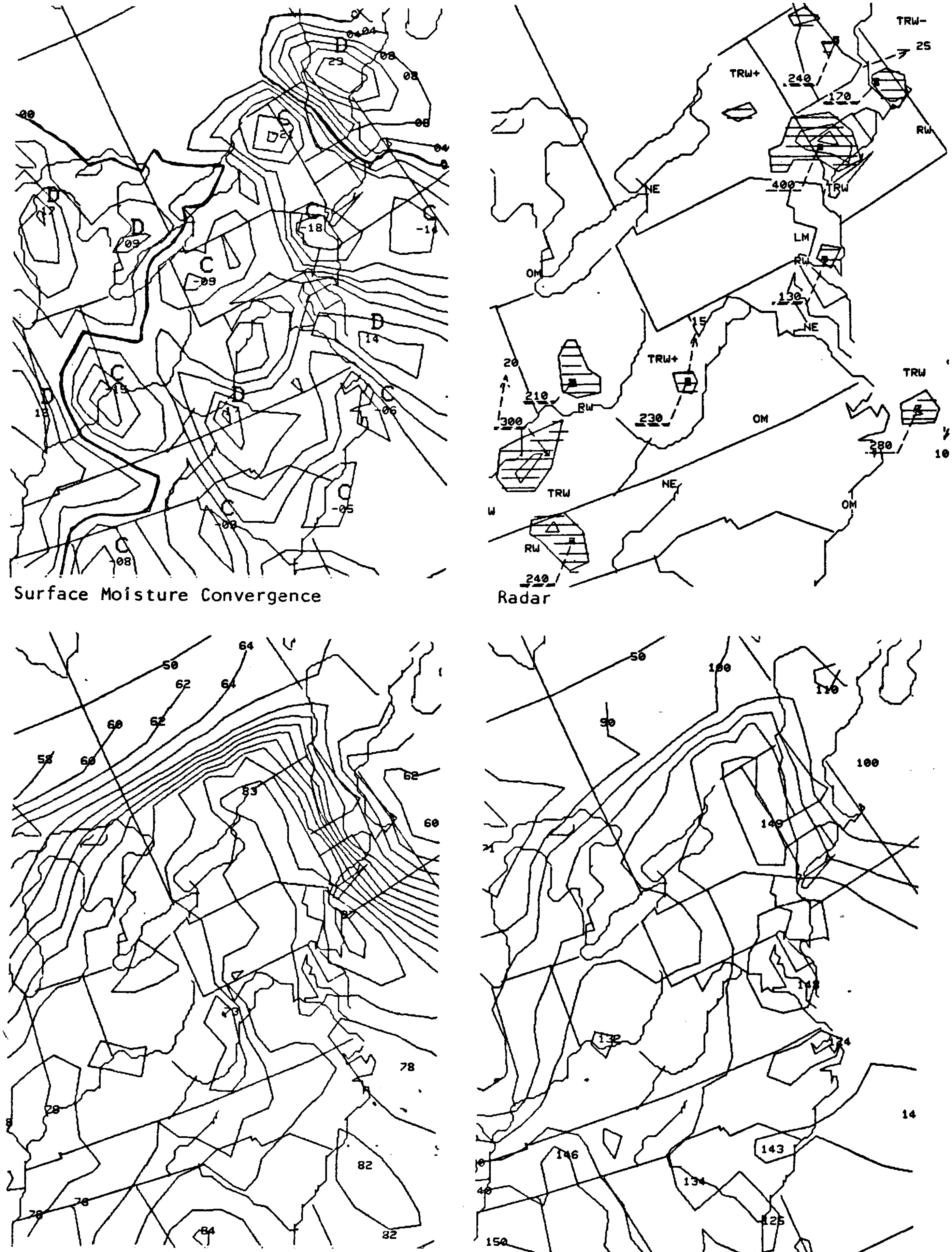


Surface Temperature



Surface Mixing Ratio

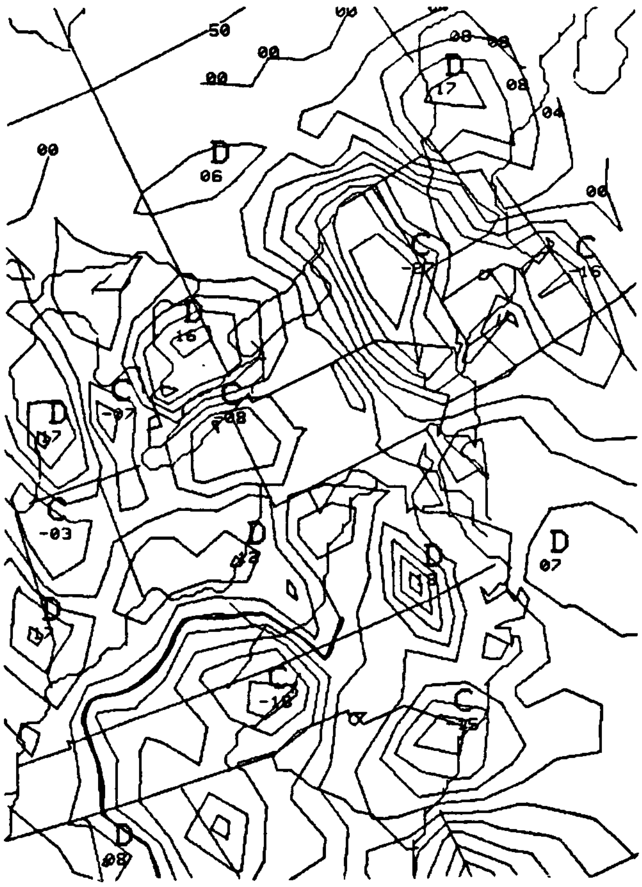
Figure 2. Time 13Z, 6/16/83.



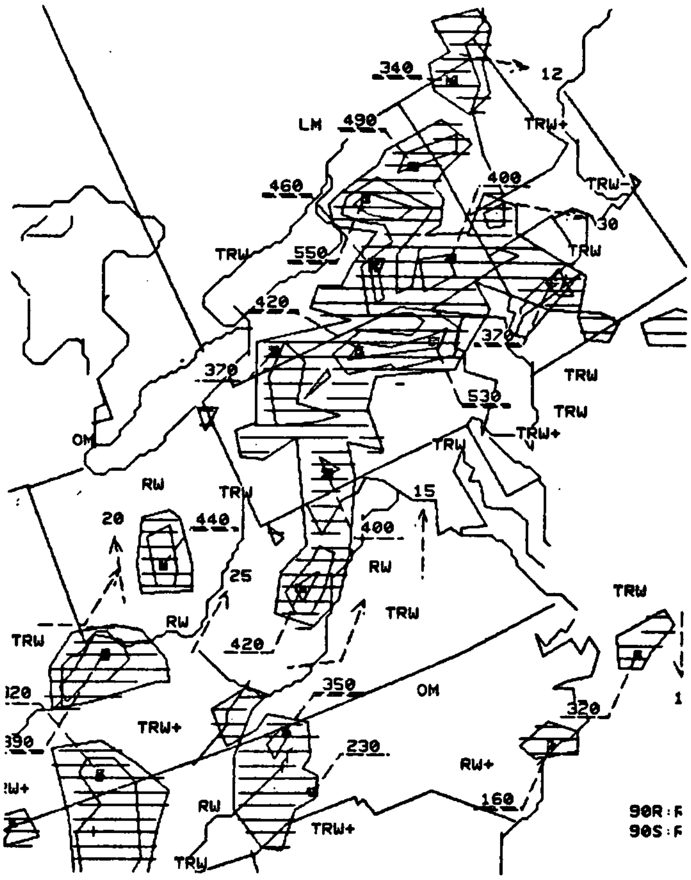
Surface Moisture Convergence — Radar

Surface Temperature — Surface Mixing Ratio

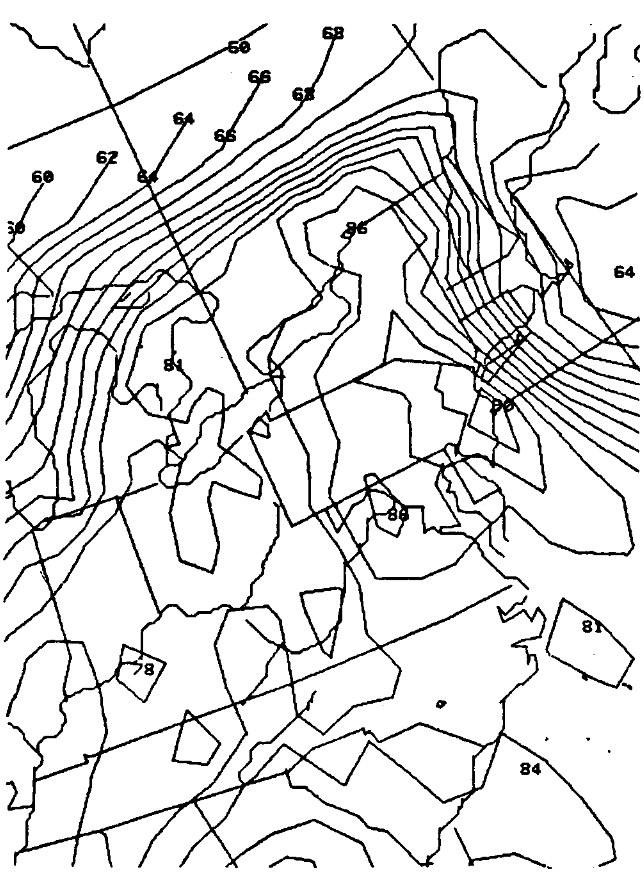
Figure 3. Time 15Z, 6/16/83



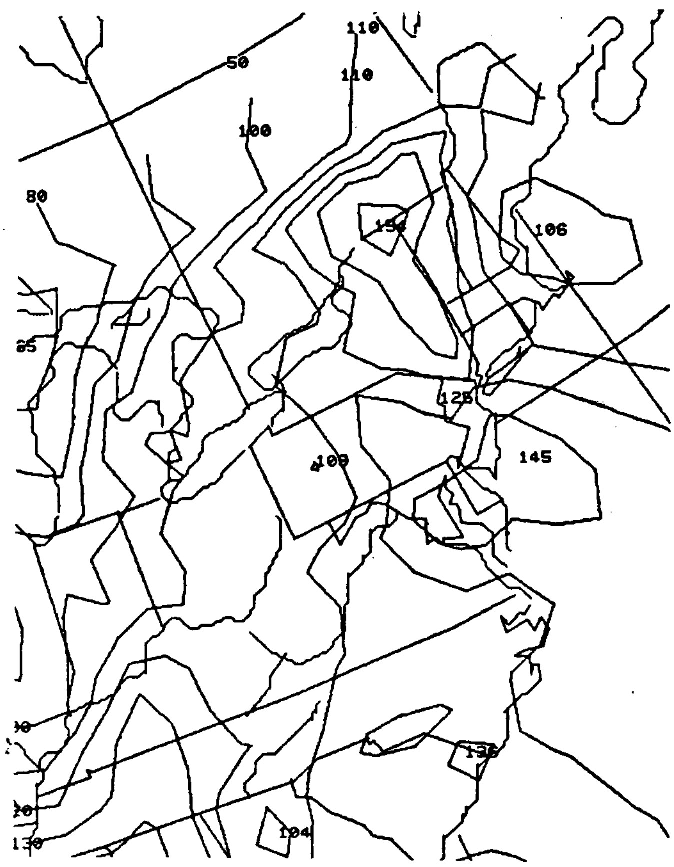
Surface Moisture Convergence



Radar

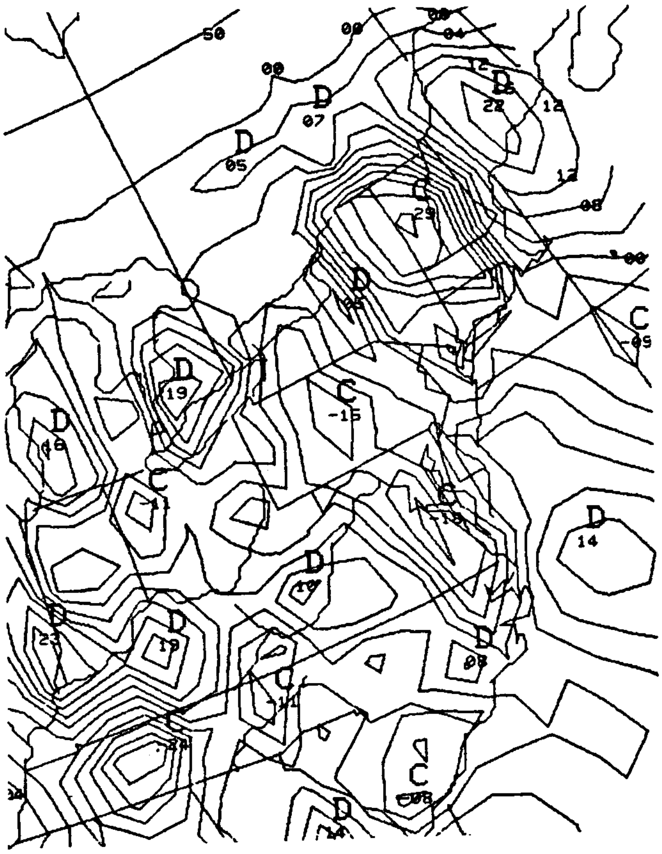


Surface Temperature

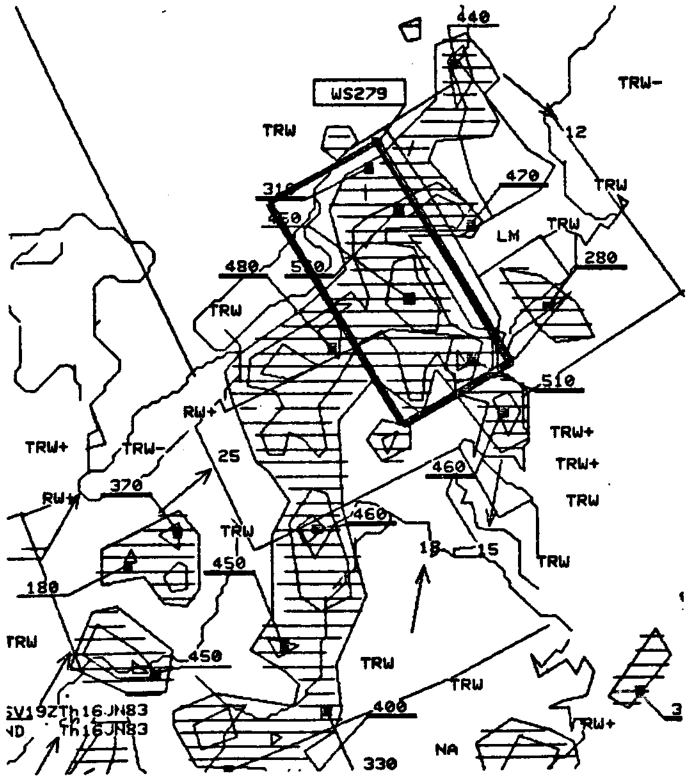


Surface Mixing Ratio

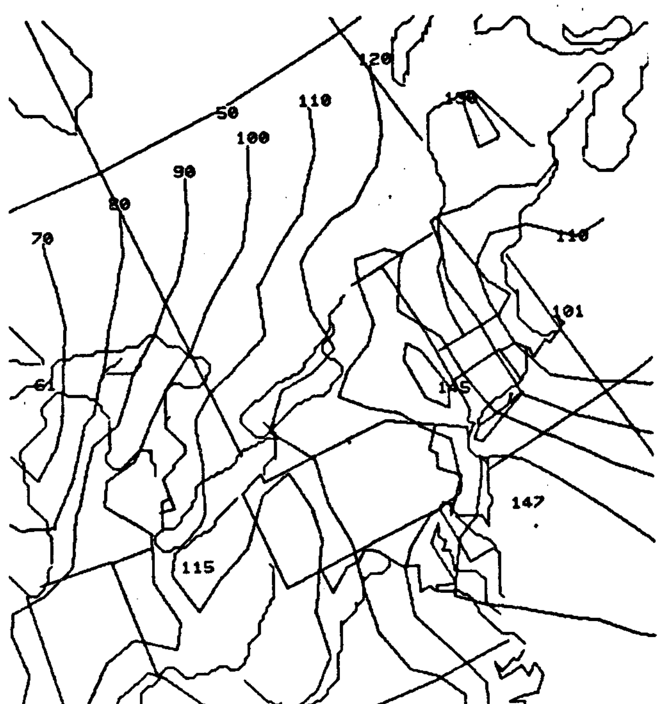
Figure 4. Time 17Z, 6/16/83.



Surface Moisture Convergence



Radar



Surface Mixing Ratio

Figure 5. Time 19Z, 6/16/83.

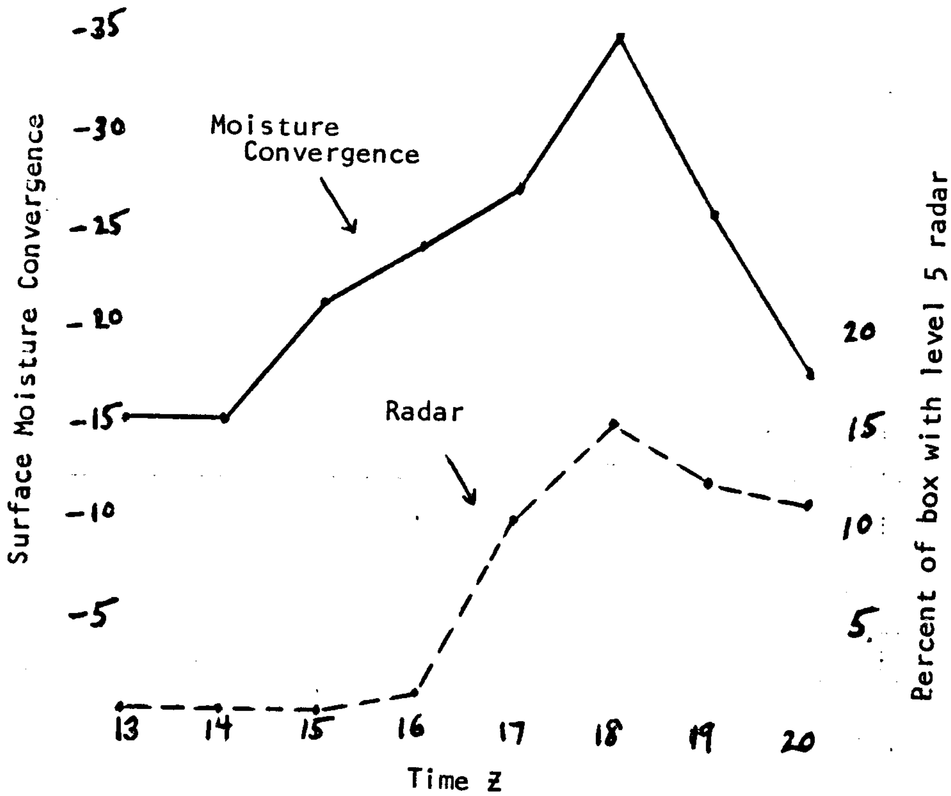


Figure 6. Variation of surface moisture convergence and level 5 radar with time. 6/16/83.

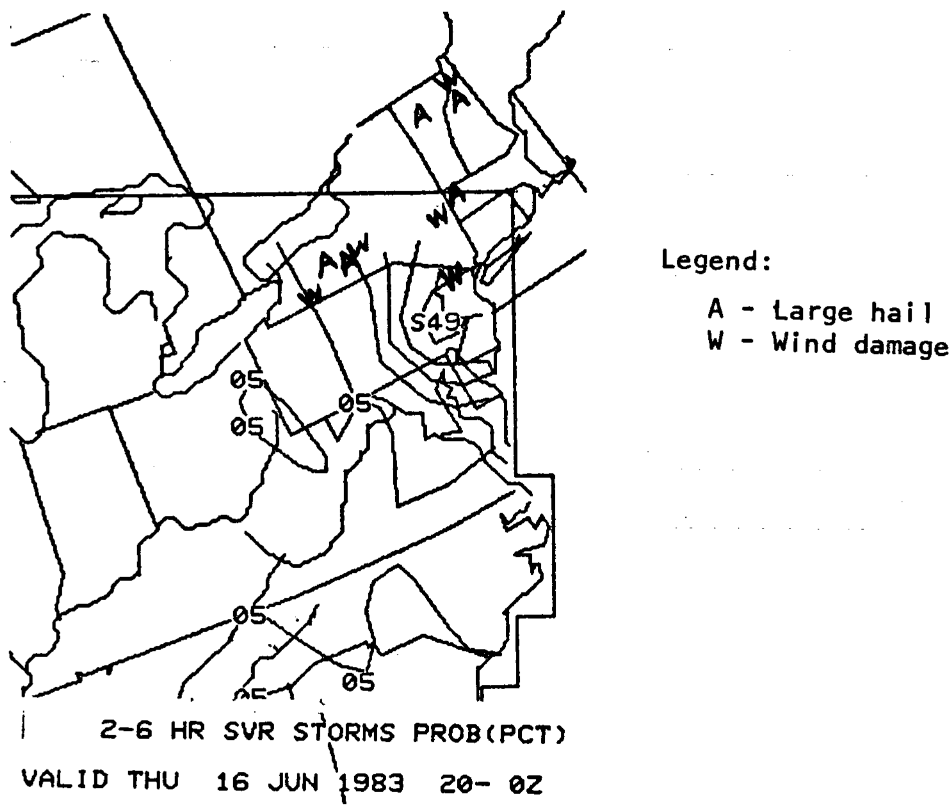


Figure 7. AFOS chart Ø1Ø, 6/16/83.