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REAL-TIME USE OF THE ADAP MESO-ANALYSIS PROGRAM TO FORECAST A SEVERE WEATHER OUTBREAK

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1. INTRODUCTION

On June 22nd, 1988, Massachusetts experienced a severe weather outbreak. Hail as large as golf balls, wind gusts as high as 80 miles per hour and numerous reports of wind damage were received from the Berkshires to Boston as severe thunderstorms raced across the state at 50 to 60 miles per hour between 600 pm and 1000 pm. This paper discusses how the ADAP (AFOS Data Analysis Programs) meso-analysis program (Bothwell, 1988) was used to help forecast what areas had the greatest potential for severe weather.

2. BACKGROUND

On June 21st, a hot, moist air mass covered the northeast. High temperatures in the upper 80's to the upper 90's covered the eastern quarter of the country with highs over 100 degrees in the Great Lakes and northern Plains. Dew points in the northeast ranged from the upper 50's to lower 60's. At the surface, a high was located over the southeast, a weak trough had moved off the New England coast during the morning, and a strong cold front was moving into the Dakotas.

At 0300Z on the 22nd, the ADAP program was run using the 0000Z sounding data. The program indicated that the atmosphere was relatively unstable, with stability indices (AFOS graphic SSL) ranging from zero over central New England to -8 over northern Virginia. The forecast lifted index values from the 0000Z LFM for that afternoon and evening were in the -4 to -7 range over the northeast (the NGM was not quite as unstable-about -1 to -4). The MOS probability of thunderstorms ranged approximately from 25% to 35%. In addition, the 0000Z Computer Worded Forecast (OWF) used the phrase "...showers and thunderstorms..some possibly severe..this afternoon" for all stations in New England, as well as Albany and New York City.

With atmospheric instability already in place as indicated by the ADAP program and the lack of any mechanism to significantly stabilize the atmosphere (continuing warm and low level moisture advection was expected), the atmosphere seemed primed for convective activity. Additionally, the models forecast an upper level jet streak to move just north of the region the following evening with upper level difluence/divergence forecast over southern New England. Given the above, the possibility of severe thunderstorms later that afternoon was forecast in the 400 AM zone package for all of southern New England except Cape Cod and the Islands. All of the ingredients for severe weather were in place except one - a triggering mechanism.

3. THE EVENT

At 1800Z on the afternoon of the 22nd, the cold front which was in the Dakotas the previous day, was located over the eastern Great Lakes and the St. Lawrence River Valley. A warm front extended from near Massena, New York to eastern Massachusetts. Some showers and small thunderstorms did form just to the north of this warm front, but by 1900Z these showers and thunderstorms had moved off the New England coast. Another band of showers and thunderstorms were over the Great Lakes along the cold front, and a few small isolated thunderstorms were over southeastern Pennsylvania and the northern Virginia foothills. Satellite pictures indicated the jet at 1800Z was just beginning to move into northern New York state and northern New England.

Figure 1 shows the ADAP stability index (SSL) and cap strength (SSC) for 1900Z. An axis of instability extended from the Delmarva peninsula through central New York. The stability index over Massachusetts at this time was only -3 to -4. At this time, there was no atmospheric cap over New Jersey and eastern Pennsylvania, while a 1-2 degree C cap was present over southern New England. The cap over southern New England earlier in the day (not shown) was about 4 degrees C at 1500Z and 2-3 degrees C at 1700Z. Previous studies (Graziano and Carlson, 1987 and Bothwell 1987) recommend using a 2 degree C isopleth of cap strength to define the boundaries of the convective lid. It has also been found that if convection does occur in unstable air where the cap strength previously exceeded 2 degrees C, it will likely become severe.

By 2100Z (Figure 2), the axis of instability had expanded eastward over southern New England with stability indices over Massachusetts now around -6. The cap strength at 2100Z was zero over southern New England, indicating that the atmosphere had enough buoyant energy to erode the cap. Figure 3, ADAP surface mixing ratio (SMR) for 2000Z, shows abundant low level moisture, especially along an axis from Delmarva through central New York.

It was apparent that things were ready to pop, and once they did, the thunderstorms would develop rapidly in the extremely unstable air without the hindrance of a convective cap. Figure 4, the 300mb plot for 0000Z on the 23rd, shows the jet from the northern Great Lakes southeast to western New York, and east through the northern half of New York and New England, with difluence over southern New England. The only remaining question was what would be the low level forcing mechanism and where would it be focused.

The answer was uncovered by the ADAP surface moisture flux convergence charts. Moisture flux convergence is made up of two terms - wind convergence multiplied by the mixing ratio, and moisture advection (Bothwell, 1986). Storms often form in areas where the gradient of moisture flux convergence is large, with the development taking place on the moist side of the axis. Additionally, it is often the change in moisture flux convergence, rather than the magnitude at a specific time which is more significant in indicating possible storm development.

Figure 5 shows the surface moisture flux convergence charts for 1800Z and 2000Z (AFOS graphic SMC). During this time the convergence center shifts eastward across central New York, and the west-east gradient north of the convergence center tightens. Figure 6 contains severe thunderstorm watch number 243 issued by SELS valid at 2100Z (solid), and the approximate areal extent of the severe weather reports received between 2050Z and 0130Z on June 23rd (dashed) based on the preliminary reports (AFOS product STADTS).

Figure 7 shows the surface moisture flux convergence at 2200Z and the total change from 1700Z to 2200Z. During this time the area of moisture convergence expands into Massachusetts, setting up a strong east-west gradient from central New York to northeastern Massachusetts and southeastern New Hampshire. Thunderstorms began developing over eastern New York between Utica and Albany between 2000Z and 2100Z. These storms grew rapidly as they raced eastward at 50 to 60 miles per hour, moving over and north of Albany, across southern Vermont, southern New Hampshire, and northern Massachusetts. These storms passed through the Merrimack River Valley and off the coast a little after 0000Z.

A second area of storms formed west-southwest of Albany, moved over and south of Albany and into the Berkshires of Massachusetts around 2300Z. These storms also rapidly developed, with reported tops approaching 60,000 feet. They moved quickly across the northern half of Massachusetts, reaching Boston between 0100Z and 0130Z. All of the storms formed along the moisture convergence gradient indicated by the ADAP program, developing on and moving along the moist side of the axis.

4. CONCLUSIONS

The severe weather outbreak of June 22nd was one of the largest and most widespread in Massachusetts this decade. The ADAP meso-analysis program was very useful in determining the severe weather threat well before the event. As the event approached, the ADAP output enabled us to better define which areas had the greatest potential for severe weather by not only depicting where the maximum instability was, but what the forcing mechanism would be and where it would be focused. This allowed us to anticipate where the development of severe weather would take place and issue the appropriate warnings.

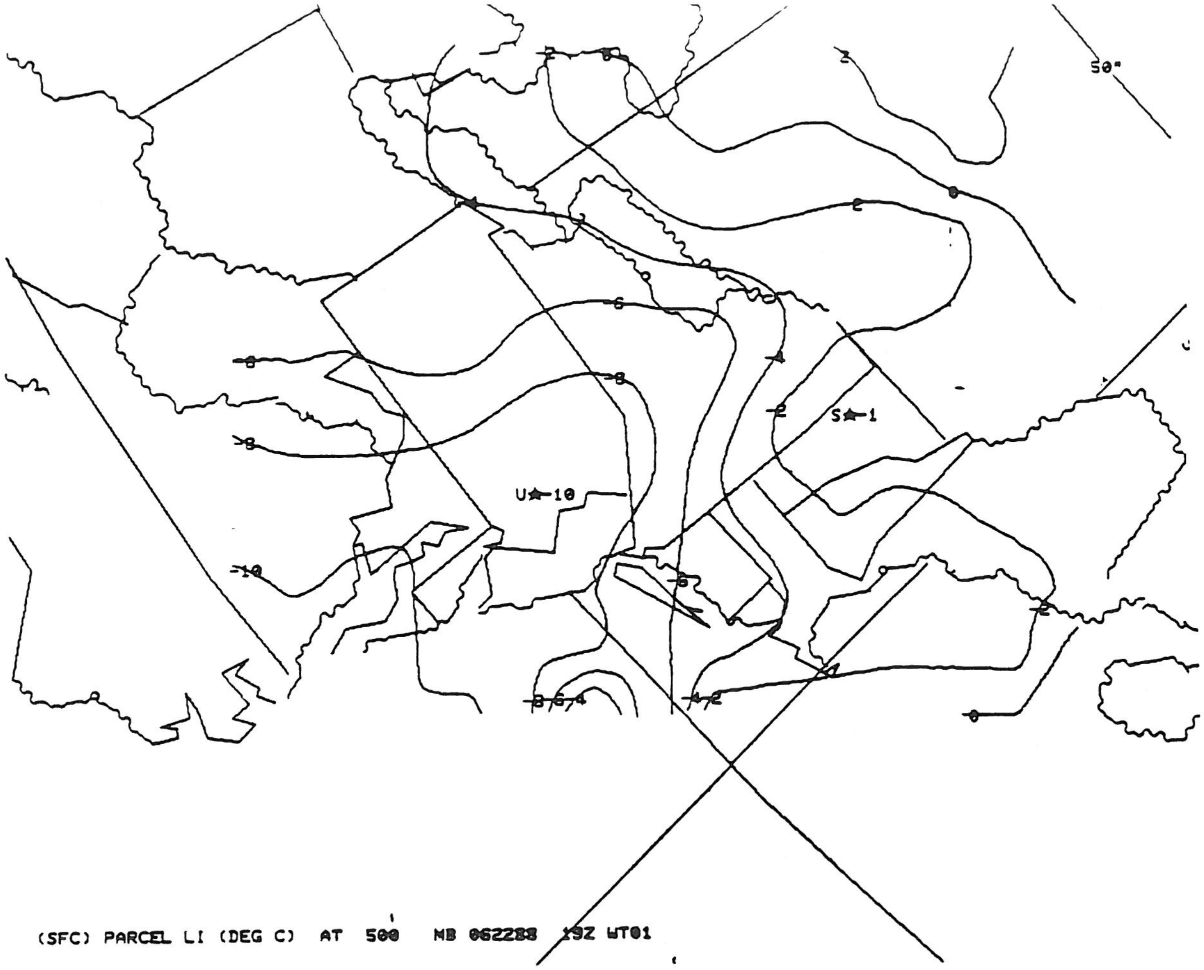
5. REFERENCES

Bothwell, P. D., 1988: Forecasting Convection with the AFOS Data Analysis Programs (ADAP-Version 2.0). NOAA Technical Memorandum NWS SR-122, Fort Worth, Texas, 92pp.

_____, 1987: Analysis of a Capping Inversion as an Aid in Defining the Severe Weather Threat Area. Preprints, 15th Conf. on Severe Local Storms (Baltimore, MD), AMS, Boston, 464-467.

_____, 1986: The Role of Moisture Convergence on Initiating and Sustaining Convection. MESOS Data Analysis Note Number 4 - Technical Attachment SR 4-15-86, Fort Worth, Texas, 4pp.

Graziano, T. M., and T. N. Carlson, 1987: A Statistical Evaluation of Lid Strength on Deep Convection. Weather and Forecasting, 2, 127-139.



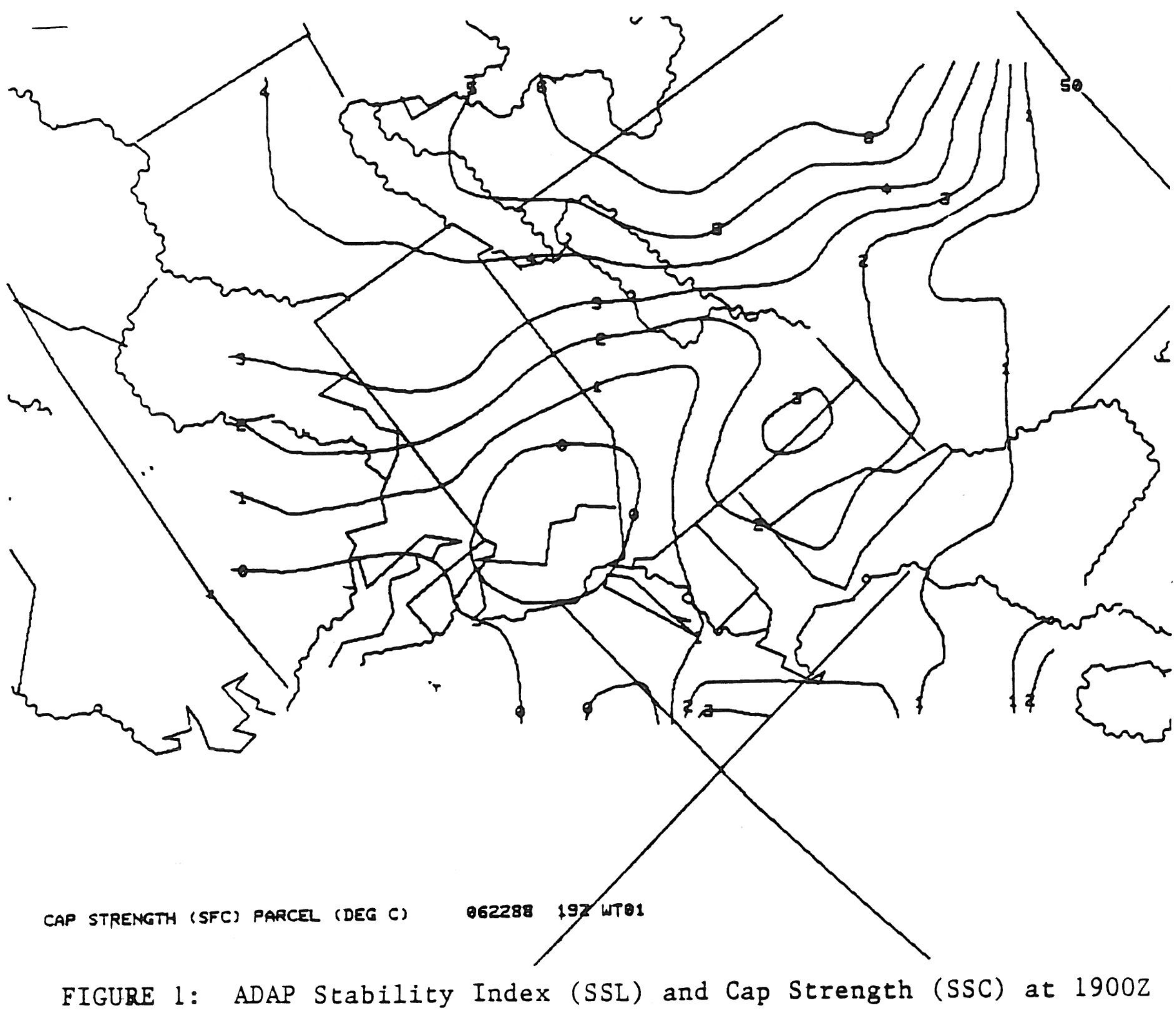
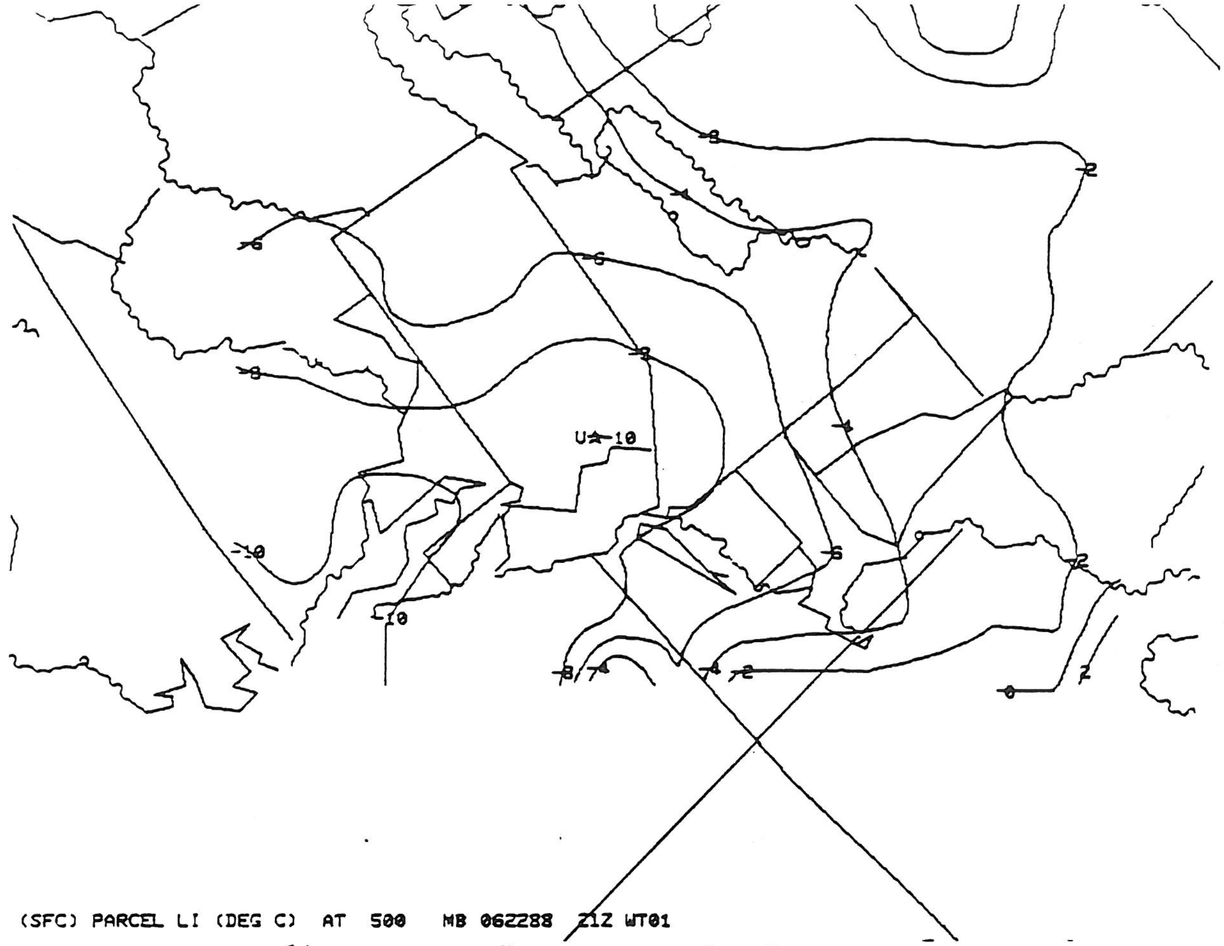


FIGURE 1: ADAP Stability Index (SSL) and Cap Strength (SSC) at 1900Z



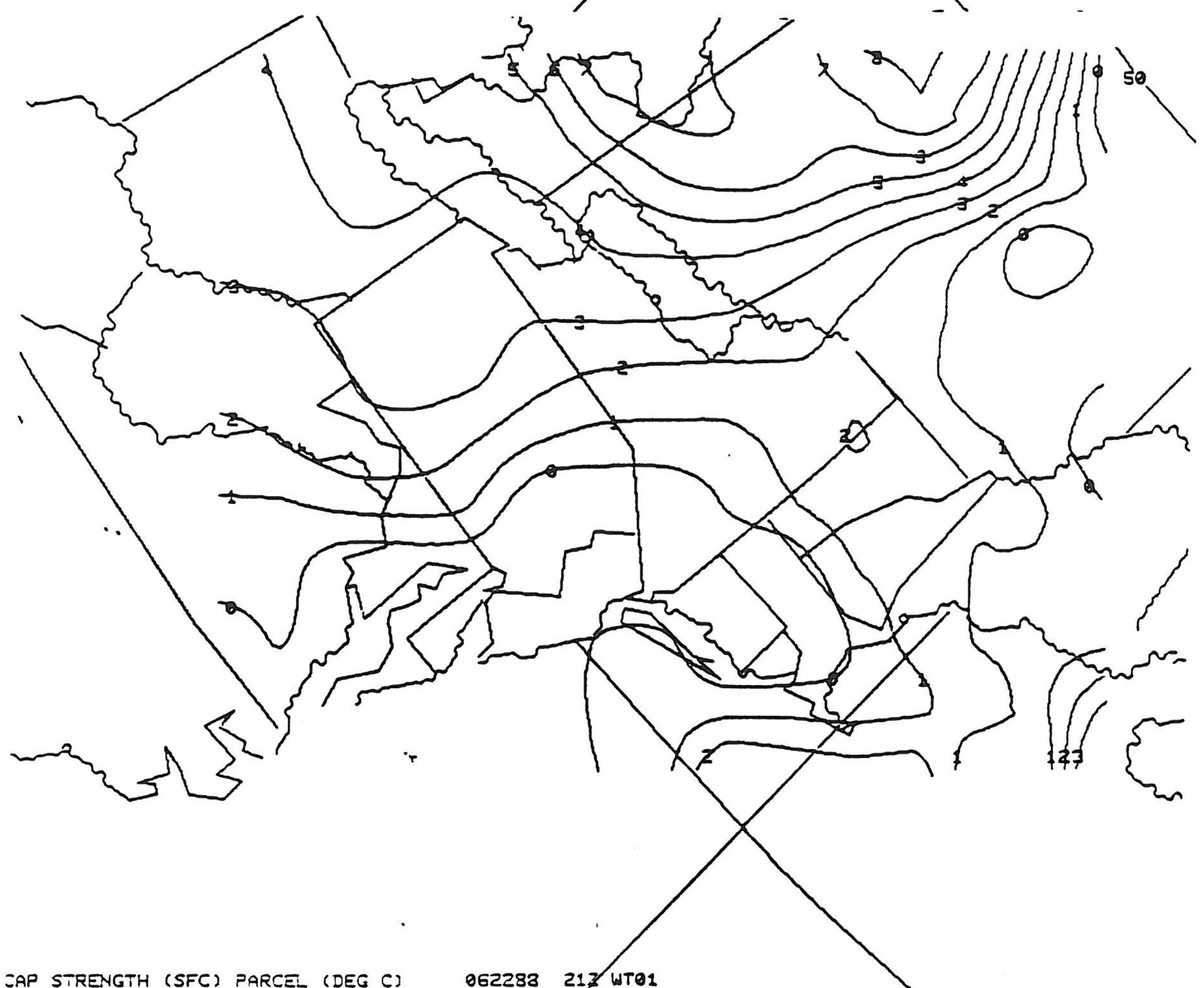


FIGURE 2: ADAP Stability Index (SSL) and Cap Strength (SSC) at 2100Z.

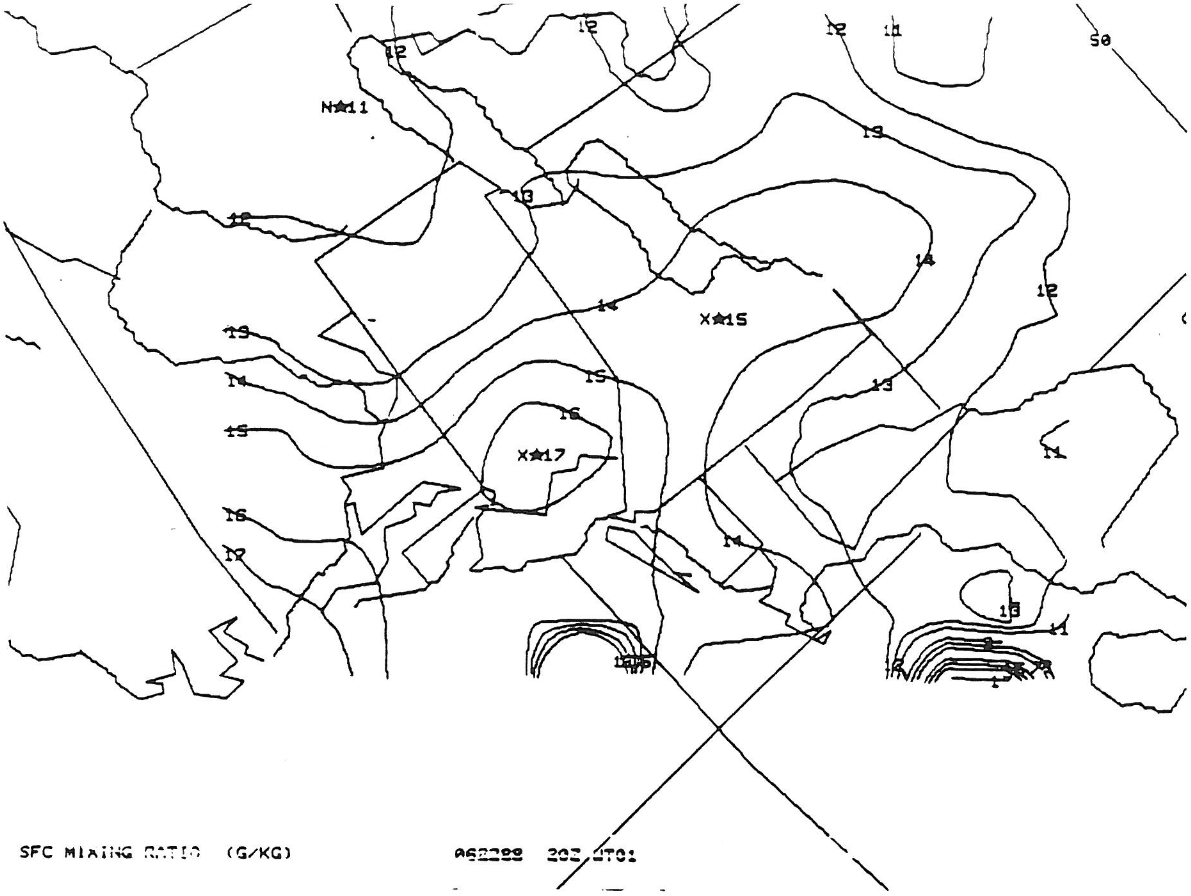


FIGURE 3: ADAP Surface Mixing Ratio (SMR) at 2000Z.

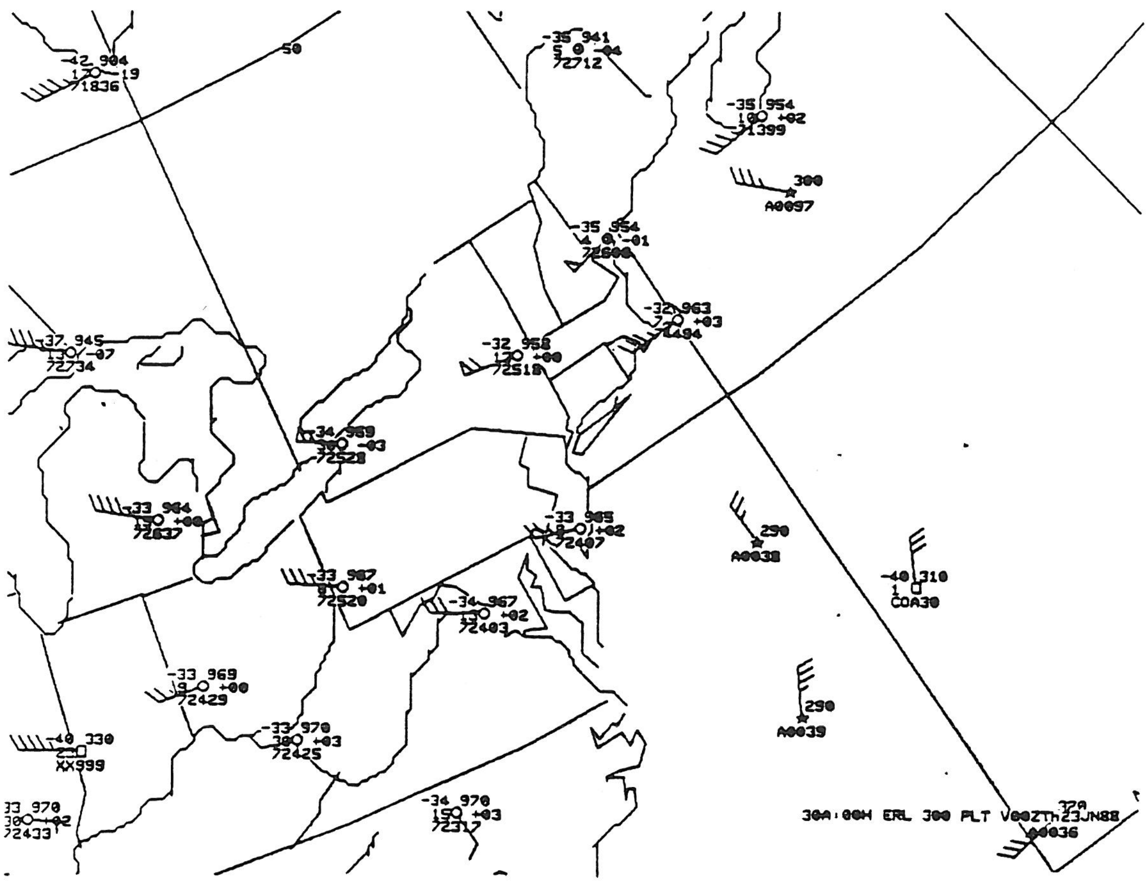


FIGURE 4: 300 mb Plot at 0000Z June 23rd.

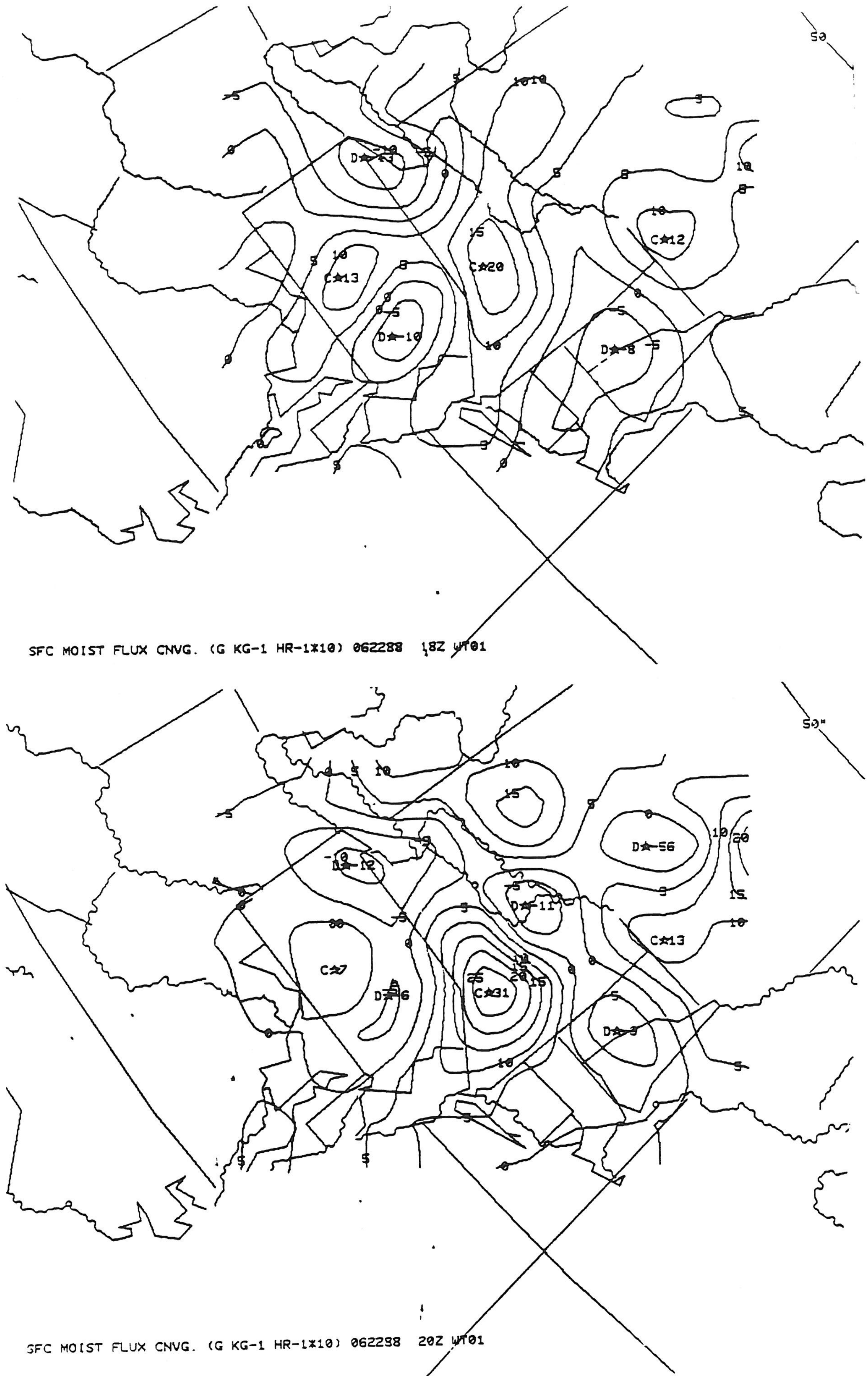


FIGURE 5: ADAP Surface Moisture Flux Convergence (SMC) at 1800Z and 2000Z.

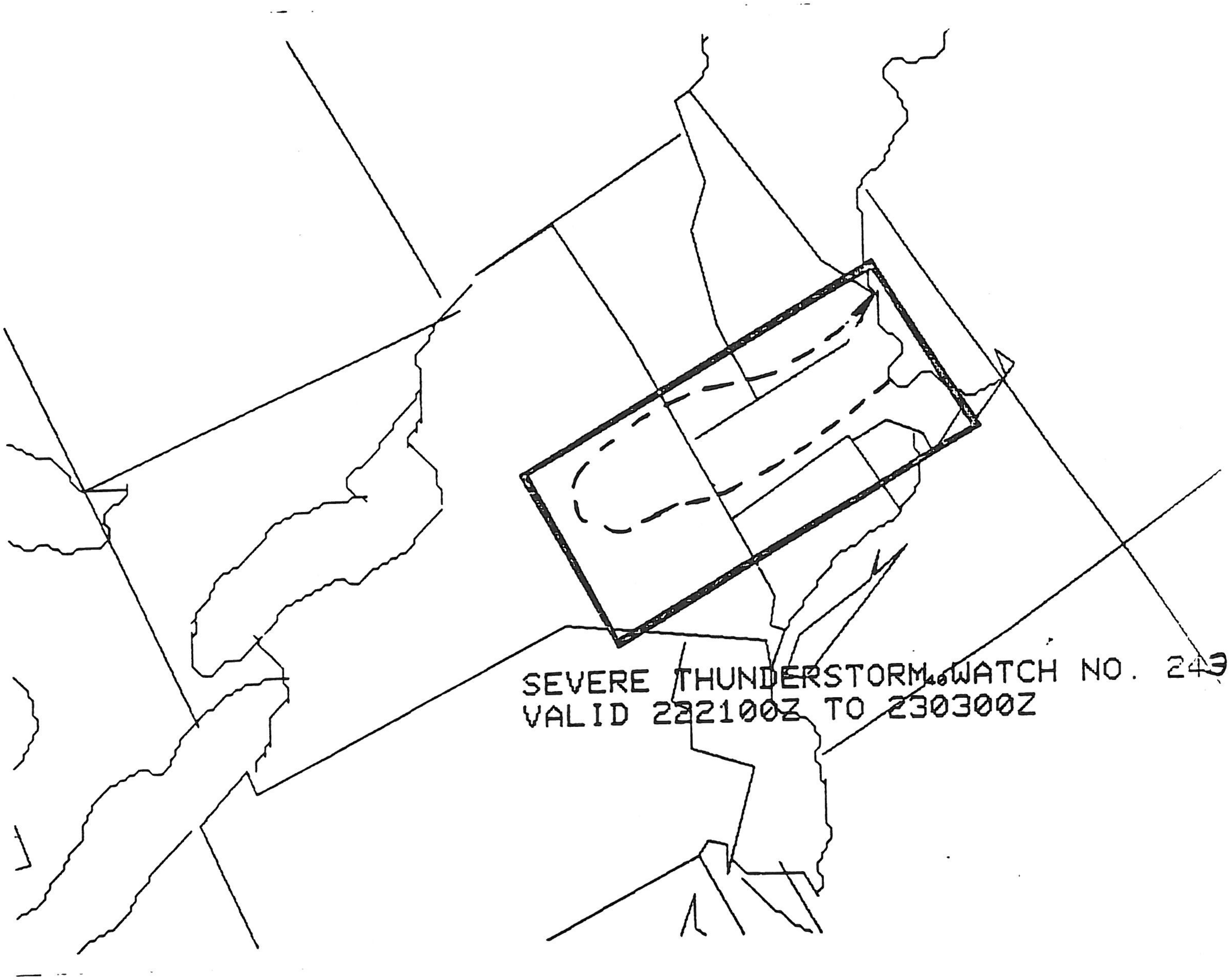


FIGURE 6: Severe Thunderstorm Watch Nubmer 243 (Solid) and Area Where Severe Weather was Reported (Dashed).

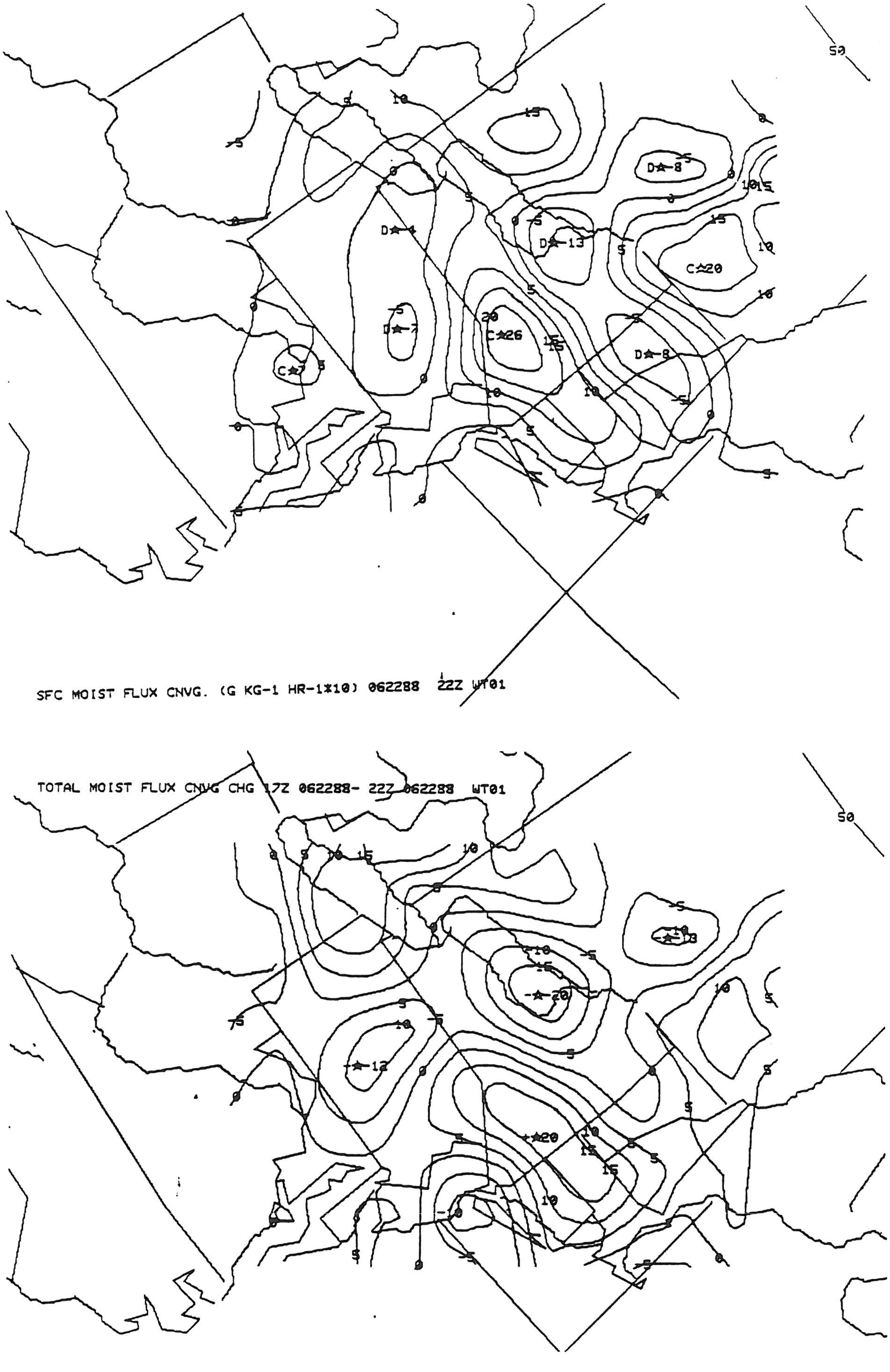


FIGURE 7: ADAP Surface Moisture Flux Convergence (SMC) at 2200Z and Total Moisture Flux Convergency Change (SCC) Between 1700Z and 2200Z.