Meso-θ Scale Features Observed in Surface Network and Satellite Data

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ABSTRACT

Examination of National Hail Research Experiment (NHRE) mesoscale data taken on 31 July 1976 revealed significant fluctuations with time in the temperature, dewpoint temperature and wind speed. These variations displayed characteristics typical of summertime frontal passages. However, GOES-1 imagery revealed meso-θ (weather systems having wavelengths of 20–200 km) scale features that were likely responsible for the observed phenomena. It is shown that geosynchronous satellite data can be of significant value in the analysis and interpretation of mesonetwork data.

1. Introduction

During a study of the meteorological aspects of the Big Thompson flash flood (Maddox et al., 1977) surface data from the NHRE mesoscale network were analyzed. Significant fluctuations in temperature, dewpoint temperature and wind speed occurred at several sites on the afternoon of 31 July 1976. Although some of the variability seemed characteristic of a surface frontal passage, the timing and locations of events were not consistent with this premise.

The purpose of this brief study was not to develop detailed meteorological explanations of the events over the NHRE network; however, the data are presented to demonstrate the important role which high-resolution GOES imagery can play in the interpretation and analysis of mesonetwork data. Meteorological phenomena of varying scales affect the evolution of data measurements and the accuracy of a mesoscale analysis depends, to a large extent, upon the researcher’s ability to sort out the effects of different features. Examination of 30 min interval GOES-1 data suggested that the observed fluctuations on 31 July were related to the development and movement of specific cloud formations. Identification of these features would have been difficult if the GOES photographs had not been available.

2. Thermal variations

The 1976 NHRE Portable Automated Mesonetwork (PAM) observing sites and the surrounding area are shown in Fig. 1. The development, operation and data processing techniques of the PAM system are described in detail by Brock and Govind (1977). An upper air sounding taken at Sterling, Colo., at 1920 GMT 31 July 1976 is shown in Fig. 2. This sounding was considered representative of conditions over the NHRE region during the period of interest. The airmass displayed a cool, moist layer with easterly winds near the surface, which was capped by a temperature inversion with warmer, drier conditions and westerly winds above.

Temperature and dewpoint temperature time series for PAM sites 1 and 9 are displayed in Fig. 3. The features of interest are circled and consist of smooth temperature falls during the late afternoon. A more characteristic “noisy” temperature trace, produced by

![Fig. 1. Map of the 1976 NHRE mesoscale surface network. The 15 Portable Automated Mesonetwork (PAM) observation sites are indicated, as are nearby towns. An arrow of length 15 statute miles (24.1 km) is shown to scale the figure.](image-url)
turbulent heat fluxes and small cloud shadows, preceded the smooth temperature drop of 2°C. The time was late in the day and it might be argued that the temperature falls were a result of diurnal cooling. However, note that both temperature traces exhibit a slight temperature recovery after 30 min along with a return to a "noisy" profile.

Fig. 4 is the GOES-1 photograph for 2330 GMT, which corresponds in time with the end of the temperature fall at PAM 1 and with the beginning of the temperature fall at PAM 9. The locations of PAM 1 and 9 are shown on the photograph. The shadow of a small cumulonimbus had developed over PAM 1 about 30 min earlier and the cloud was rapidly dissipating at 2330. The dark shadow from another thunderstorm was just moving over PAM 9. These cloud shadows were the likely cause of the smooth temperature falls which were measured.

Similar smooth temperature falls were found in the temperature traces from four other northeastern Colorado locations for the afternoon of 31 July. In each case a very dark cumulonimbus shadow appeared to be correlated with the temperature fall.

3. Cloud band effects

Windspeed, temperature and dewpoint temperature time series for PAM Sites 5 and 10 are displayed in Fig. 5. There are distinct fluctuations in all wind and temperature traces, with a dewpoint jump occurring only at PAM 10. The changes might, at first glance,
Fig. 5a. PAM 5 wind speed time series from 1800 GMT 31 July to 0200 GMT, 1 August 1976. The wind speed increase centered at 2030 GMT is circled.

Fig. 5c. PAM 10 wind speed time series from 1800 GMT 31 July to 0200 GMT 1 August 1976. The wind speed increase at 2145 GMT is circled.

Fig. 5b. Corresponding temperature and dew-point time series for PAM 5. The temperature change at 2030 GMT is circled.

Fig. 5d. Corresponding temperature and dew-point time series for PAM 10. The changes at 2145 GMT are circled.

appear to be associated with a warm frontal passage. Closer examination of the data revealed no change in wind direction and an apparent west to east propagation. The eastward movement was not expected within the strong easterly flow field present—surface winds over the PAM network were from 90–120° at 5–10 m s⁻¹. However, the satellite data again helped to identify a likely causative feature. Satellite motion picture loops showed the development of a curved cloud band over the region east and south of Pine Bluffs, Wyo. This cloud formation moved eastward at 5–8 m s⁻¹ and passed over several stations in the northeastern portion of the NHRE network. The satellite loops suggest that the formation may have been produced by alternating enhancement and dissipation of the preexisting cloud field as a gravity wave propagated eastward; however, data were not available to verify this hypothesis.

The cloud band, preceded by a clear area and trailed by an area of scattered clouds, is shown in Fig. 6. The arc of thick cloud (identified by A, B, C) had moved just east of PAM 5 at 2030 GMT, the time of the temperature and wind speed increases. Fig. 7 shows the position of the cloud arc at 2030 and 2130. The cloud arc moved east of PAM 10 at about the time that abrupt temperature and wind speed increases were observed. The cloud band took ~1.5 h to pass over a single site. Heating and mixing were suppressed during this period, but after the cloud moved east of the site a rapid temperature recovery and wind speed increase occurred. Fig. 8 shows the wind speed trace from PAM 10. A smooth curve is shown superimposed
on the trace and the period the cloud arc was overhead is identified. Wind speed was suppressed and remained very constant while the cloud was overhead. This same general sequence of events occurred at five other PAM sites affected by the cloud arc.

4. Summary

The significant fluctuations in temperature, dewpoint temperature and wind speed which were observed within the PAM array on 31 July 1976 were not of particular importance in the evolution of the Big Thompson storm. However, identification of the cloud formations which were associated with these fluctuations would have been extremely difficult if high-resolution satellite data were not examined. This case study demonstrates the important role which GOES imagery can play in the interpretation and analysis of mesoscale data.

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REFERENCES

