# Recent Studies in Mesometeorology

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**Abstract**

The introduction in this paper is a discussion of mesoscale, 10 to 100 miles in horizontal dimension, followed by a report of the recent work done by the Severe Local Storm Research Project at The University of Chicago. A study of radar echoes revealed the fact that the movement of individual echoes and that of the squall-line are quite different. Analysis shows that a mesosystem seen in Japan had features similar to those usually seen in the United States. It is concluded that international attention and cooperation to the study of this scale is important.

## 1. Introduction

Very small scale studies in meteorology were conducted by the Thunderstorm Project, Byers and Braham (1949), in Florida and Ohio. Many new facts were revealed through the use of surface network, airplanes, radar, etc. The three-dimensional structure of thunderstorm circulations, whose dimensions are on the order of 1 to 10 miles, was also studied.

A study of weather phenomena, whose dimensions are much larger than the individual thundercloud, was proposed by Tepper (1954) in his "pressure-jump" analysis of the Severe Local Storm Network area in the midwestern United States. Following this study the importance of weather analysis in the scale of 10 to 100 miles was indicated, and the term "mesometeorology" was proposed as a name for this field of research. The term had previously been used by Swingle and Rosenberg (1954) in a study utilizing radar weather data. It may be possible to define the mesoscale in terms of the dimensions of a group of echoes as seen on a radarscope.

Synoptic analyses of medium (meso) scale disturbances have been made by such authors as Brooks (1922), Suckstorff (1935), Byers (1942), Douglas (1949), Newton (1950), Lamb (1950), Fujita (1951), Bergeron (1954), Koschmieder (1955), and others, The term "meso" was not used by any of these workers; however, the nature of their investigations warrants this designation.

In 1955 Fujita developed techniques for the mesoanalysis of pressure, temperature, etc. The results then presented were obtained from the mesoanalysis of some of the Severe Local Storm Network data. Later, in 1956 Fujita, Newstein and Tepper presented a detailed analysis of data from the same network. The mesosystems in the area were analyzed with the use of isotherms, winds, radar echoes, clouds, severe storm reports, etc. A unique feature of the published paper was the inclusion of time sections for the network stations so that workers, wishing to repeat the analysis, might do so easily. The conclusions of this research clearly showed that severe storms, including tornadoes, are located within the boundaries of mesosystems.

As might be expected with research in a new field, the techiniques of mesoanalysis

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are in a continual process of revision, refinement and expansion. The present paper is intended to be a brief introduction to the more recent work accomplished.

## 2. Analysis of pressure

In the early stages of mesoanalysis sea level pressure was used. However, it was apparent that this pressure was not satisfactory. Whenever the temperature of a station dropped appreciably an induced jump of sea level pressure appeared through reduction of the station pressure. This was in complete disagreement with that quantity which was of most value in indicating meteorological phenomena, the barograph trace.

Barograph traces were reduced to sea level without changing the shape of the trace by Fujita in 1955. The following technique was used. The time mean of the station pressure was adjusted so that it coincided with an areal mean sea-level pressure analysis. This technique, however, proved to be inadequate when applied to areas of high elevation and large topography gradients. In the mountain areas apparent high and low mean pressure systems are produced which do not fit the mean wind patterns of the individual stations.

A revised technique for reducing station pressure has been proposed by Fujita and Brown (1957). A mean pressure pattern was successfully obtained whose gradient is approximately equall to the mean horizontal pressure gradient at the station level.

In recent mesoanalyses the mean station-pressure values were reduced to the mean adjusted pressure after smoothing them on the mean chart with the aid of the mean wind pattern. Results of these studies show a very good fit between station winds and isobars. Up to the present time this new reduction method has proved to be the most useful in analyzing mesosystems over mountain and slope areas.

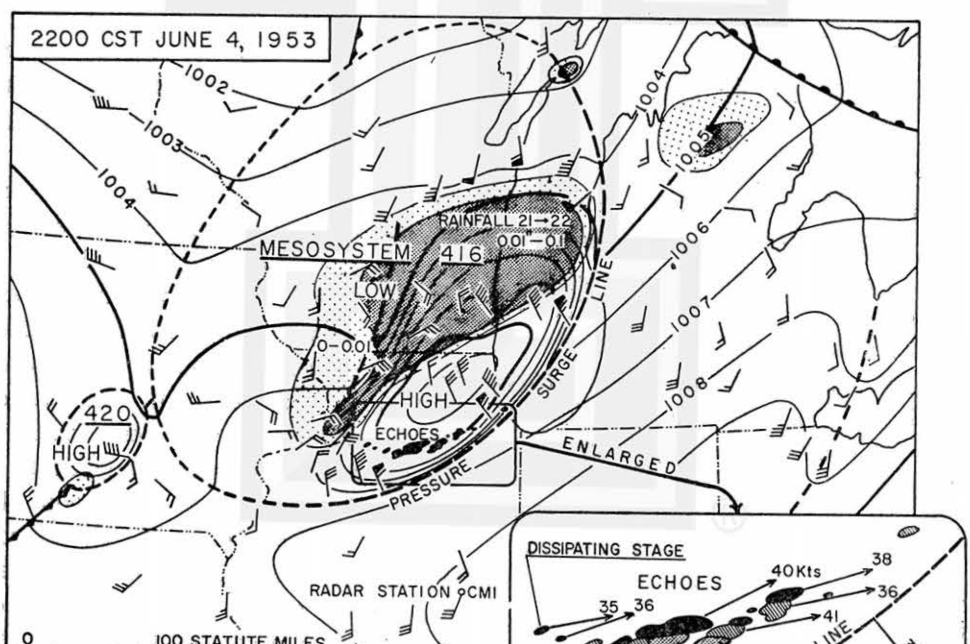


Fig. 1 A mesosystem in its mature stage. Movement of echoes northwest of the pressure surge line is almost perpendicular to that of the surge line.

## 3. Analysis of radar echoes

The study of radar echoes in relation to surface microsystems was first made by the Thunderstorm Project, 1949. Fujita, Newstein and Tepper (1956) and Brown (1956) studied radar reports from the Severe Local Storm Network by comparing them with the hourly mesosynoptic charts showing isobars, winds, isotherms, etc. Although the echoes proved to be associated with mesosystems, no definite causal relationships were determined.

Fujita and Brown (1957) analyzed radar pictures taken by the Illinois State Water Survey. After a careful study of echoes and associated mesosystems, it became apparent that the movement of an individual echo was quite different from that of a squall line. An example of the preceding analysis is given in Fig. 1. It should be noted that the new echoes emerge to the southeast of the dissipating echoes, resulting in a group movement toward the southeast.

A technique for constructing a time section of radar echoes was developed by Fujita. Such a time section can then be easily combined with time sections of the other elements such as pressure, winds, etc. Fig. 2 shows an example of a time section for Rantoul, Illinois. The pictures used in this construction were taken at Champaign, Ill.

## 4. Analysis of airplane observation data

During the last year, a tornado research airplane operated under contract with the U. S. Weather Bureau has taken measurements over areas where severe storms were predicted. The data thus obtained present an opportunity for the study of the vertical structure of the atmosphere in which these storms develop.

From the flight data supplied by the U. S. Weather Bureau, two cases, May 13 and June 11, 1956, were studied. The vertical cross section shown in Fig. 3 represents a part of the analysis of the second flight. The flight began several hours after the development of the squall line. The boun-

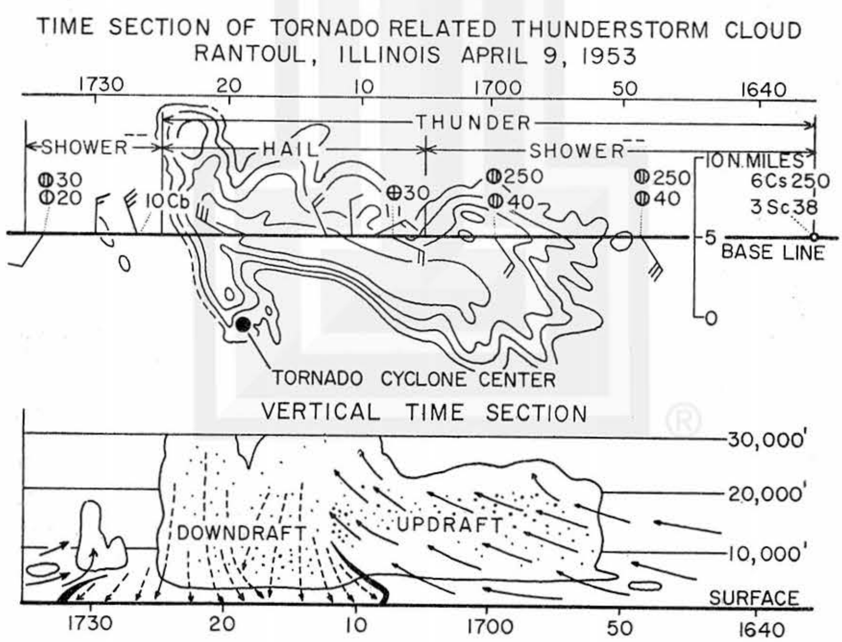


Fig. 2 Time section of tornado related radar echo at Rantoul, Illinois. Echo intensity is shown by contour lines obtained from reduced gain pictures.

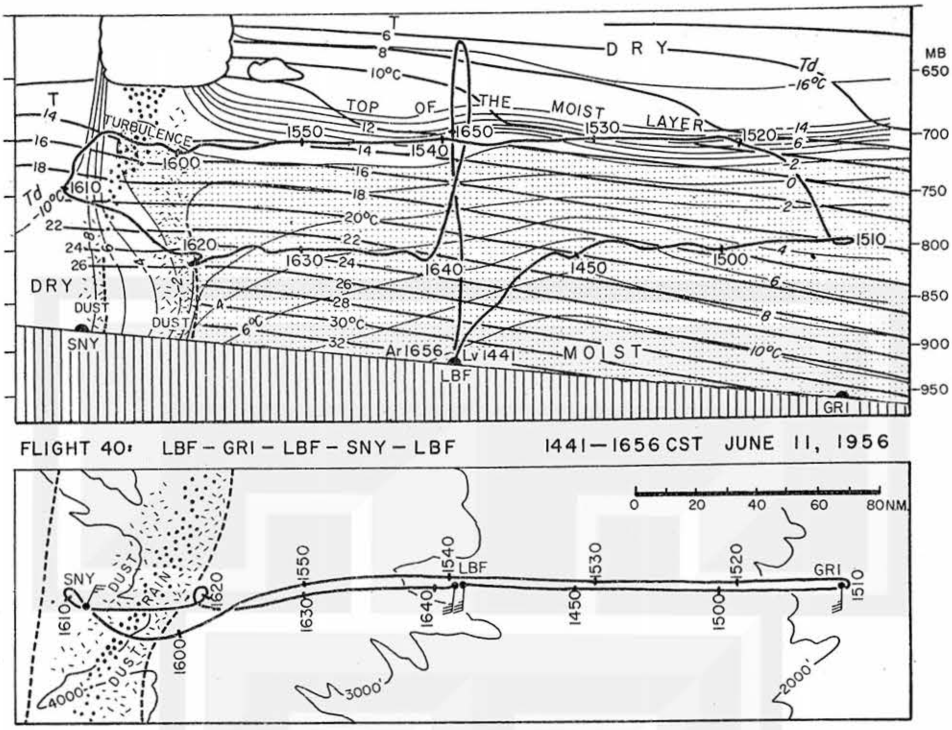


Fig. 3 An example of mesoscale analysis of flight data taken by the U. S. Weather Bureau Tornado Research Airplane.

daries of the moist layer are very sharply defined by the large dew point gradients at the top and to the west. These gradients were also seen in an earlier flight made prior to the initiation of the squall line. The temperatures along an isobaric surface, on the other hand, show a gradual increase toward the west. No appreciable change in temperature is seen at the almost vertical boundary of the moist and dry air to the west.

Due to the lapse of time from the beginning to the end of an airplane flight, the author introduced the idea of a time-adjusted chart. The chart is made by plotting the station weather observed at the moment when the plane crosses a line drawn through the station and perpendicular to its own flight path. When continuous observations from the surface station are not available, interpolations can be made with the help of hourly data. Thus plotted, the time-adjusted chart is analyzed, as if it were a regular synoptic chart. This method allows the relation of the temperature, dew point, etc., measured by the airplane, to the surface observations taken at the same time.

## 5. Conclusions

Mesometeorology, the study of an important scale in meteorology which was neglected until recently, is now under the sharp focus of meteorologists working with severe storms. It should be pointed out that mesosystems from 10 to 100 miles in size are to be seen in close relation to the occurrence of severe storms. The writer also feels that a similar feature, which might be slightly different in size and intensity, will be seen in other parts of the world. As an example Fig. 4 shows a mesosystem over the Noto Peninsula, Japan, whose features are very similar to the mesosystem over nothern Illinois in Fig. 1.

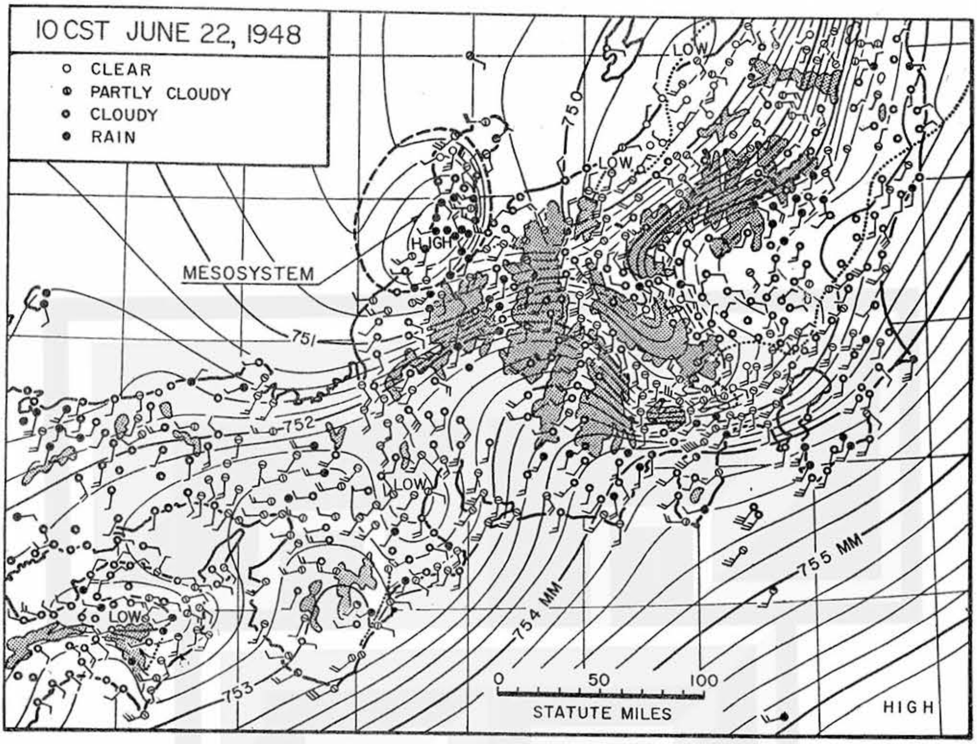


Fig. 4 Detailed analysis of mesoscale chart of Honshu, Japan. The mesosystem over Noto peninsula is now in an early stage of development. Mesolows seen on Shikoku and east Kinki are the result of topography and local heating.

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