Comments on "Formation of Mesolows or Pressure Troughs in Advance of Cumulonimbus Clouds"

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Study of a recent paper by Hoxit *et al.* (1976) prompts some questions and comments concerning their analysis of the all-important mesoscale circulation accompanying deep organized convection. We are particularly interested since our intensive analysis of the Oklahoma convective storm of 14 May 1970 (Sanders and Paine, 1975; Sanders and Emanuel, 1977) discloses similar features. The similarity is somewhat surprising, since in the latter case (in contrast to Hoxit *et al.*'s cases) the convection was occurring aloft in warm air overrunning a slow-moving cold front, and its effects failed to penetrate significantly to the ground. The significance of the similarities, by the same token, is enhanced.

Our interpretation of events just in advance of the radar echo line, however, is somewhat different, mainly due to the great detail provided by our data coverage. We find a low-pressure trough along the leading edge of the radar echoes, as did Fankhauser (1974). [See Sanders and Emanuel's (1977) Figs. 5 and 9.] To judge from the behavior of the radiosonde balloons, however, the trough was filled with active convective clouds, in which the condensate had not yet had time to grow to radar-visible size. In the NHRE case

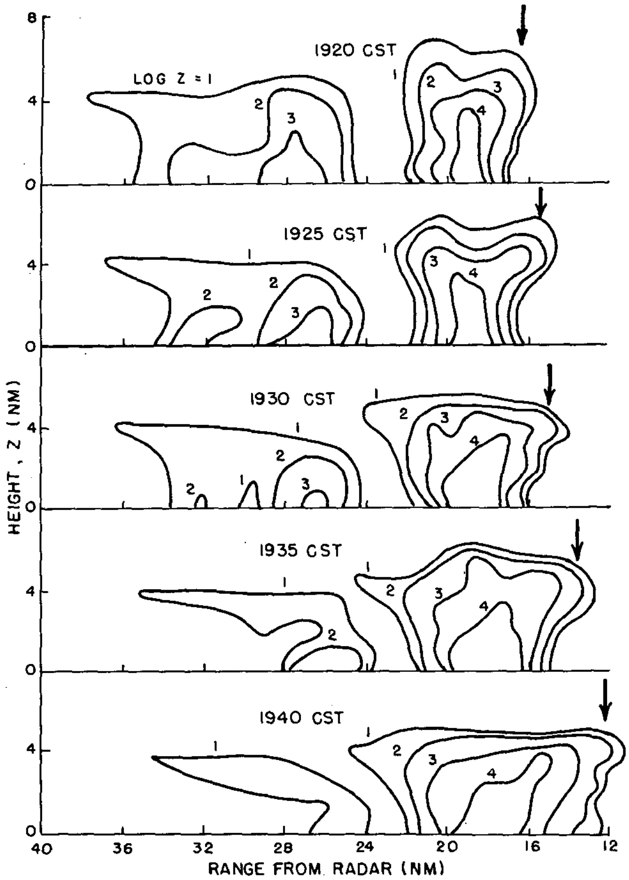

FIG. 1. Vertical cross sections of radar echoes along line from NSSL approximately normal to storm line, 14 May 1970. Heavy arrow indicates estimated position of pressure trough. After Meneely (1972).

shown in Hoxit *et al.*'s Fig. 2, the surface mesolow may also be in a region of active cumulus clouds not yet visible on radar. (My failing eyesight does not detect in their Fig. 3 the surface streamlines promised in the caption.)

We also found a mesoscale downdraft, considerably more intense than the one found by Hoxit *et al.*, located just in advance of the trough. The subsidence, however, was not associated with relative warmth, as Hoxit *et al.* suggest it should be. Rather, we interpret the downdraft as being driven by intense evaporative cooling from the tops of the deep cumulus set off when the unstable warm air is first lifted above strong low-level convergence. It did not appear, either visually or in radar pictures, that cloud matter from the main mesoscale updraft region extended over the leading downdraft area. A similar structure was observed by Stokes (1976) in a detailed analysis of the Oklahoma squall line of 26 April 1969.

The trough in the 14 May case extended to at least 425 mb. Since the mesoscale circulation is nearly in hydrostatic balance, as pointed out by Hoxit *et al.*, there must be a region of relative warmth above, although we could not observe it because of the 400 mb termination of our soundings. In a study of the radar echoes in this case, Meneely (1972) found some evidence of spreading of the upper part of the main cloud back toward the southeast, as illustrated in Fig. 1, although the main vertical shear was toward the northwest. This extension of the cloud may have brought warm air over the trough above the 425 mb level. This air, if cloudy, might be relatively warm because of its high equivalent-potential temperature. Any descent, until the cloud water evaporated, would be along the moist adiabat and would not generate further relative warmth. Another possible explanation of the warmth might lie in vertical convergence, above 400 mb, of heat transport on the convective scale, rather than on the mesoscale. It is difficult to make out from Hoxit *et al.*'s Fig. 4 what the origin and position of the upper tropospheric warmth is. This air does not appear to be especially dry. May it in fact be saturated? Were the entire paths of the balloons determined relative to the surface gust front, or were they merely placed correctly at the surface release point?

Our experience has been that the variability of soundings that enter the main convective region is enormous. We suggest, therefore, that the details of the structure shown in Hoxit *et al.*'s Fig. 4 to the left of (that is, later than) the time of the gust front should not be taken seriously. The soundings released at 2045 and 2135 CST surely represent the cumulus scale rather than the mesoscale.

Finally, the relationship between mesoscale circulations and severe convective events seems to us to remain generally obscure. The former seems to assure a long-lived convective system, but not necessarily a severe one. There were no severe events in the 14 May case. In the 3 April 1974 case, a number of major tornadoes were associated with prominent mesoscale surface pressure perturbations, as pointed out by Hoxit *et al.* Others, however, were not. The F5-scale tornado which destroyed Guin, Ala., and the severe tornadoes near Huntsville, were associated with little if any surface pressure perturbation, so far as we can determine. On the other hand, we have the impression that the mesoscale surface pressure perturbations are often strongly developed when the convection is dying or dead (see, e.g., Fritsch *et al.*, 1976, Figs. 1c–1e and 3).

Nonetheless, it is heartening that features of midlatitude convective systems seem to display a remarkable consistency despite considerable variety of synoptic circumstances. Soon, we hope, we will have got it right.

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