Comments on "Use of Enhanced IR/Visible Satellite Imagery to Determine Heavy Snow Areas"

HAROLD A. ELKINS
O'Fallon, Illinois

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1. Introduction

I would like to challenge some of the ideas presented by Beckman (1987). These include the overdependence on the warm sector to explain cyclone structure and growth, and the generalizations concerning thunderstorms with snow (TS). This note will be brief, giving only results of my recent research, but hopefully it will be enough to generate renewed discussion on what I believe to be poorly understood concepts.

2. Cyclone structure

Mature cyclones are not occluded systems. Though definitive proof is not available at this time, conceptual arguments can be used to support this conclusion. My intent is to present an alternate idea and not to give rigorous proof.

Carlson's (1980) conceptual model (Fig. 1) has been generally accepted, but its impact has not been discussed. Two points are very important. First, there is a limiting streamline to the warm sector air as it ascends and turns anticyclonically away from the surface cyclone. This follows the geostrophic principle that warm sector air, representing warm air advection (WAA), veers with respect to height and time. Second, the cold conveyor belt is given an integral part in the structure and development of the midlatitude cyclone. Traditional polar frontal theory does not allow for these contributions. This contrast can be easily seen between Figs. 1 and 2.

Carlson does not extend his model to encompass the mature cyclone. Similarly, Browning and Hill (1985) discuss cyclonic airflows, but they do not connect them to the mature cyclone. My research led to a conceptual model of the mature cyclone (Fig. 3) created using relative wind isentropic analyses (equivalent potential temperature replacing potential temperature) and station by station sounding analyses. The cyclone matures with increasing influence from the cold sector (north of the cyclone) and not the warm sector.

For this discussion the main point is the absence of warm sector air in the heavy snow belts depicted by Beckman. The lack of warm sector air should not be confused with the lack of WAA! Ascending cold sector air produces significant WAA. Beckman states that the warm sector air from the Gulf of Mexico produces the heavy snow; however, conceptually we know that warm sector air ascends and veers away from the surface cyclone. In order for the warm sector air to arrive behind the cyclone, it will have to *back* in direction with respect to height and time. From an airflow perspective this is not the case.

3. Thunderstorms with snow

Unfortunately we refer to this phenomenon as a thunderstorm. The essential element is lightning production. We associate thunder with cumulonimbi; yet, lightning is independent of visible cloud structure. The important considerations are on the cloud physical microscale.

Proximity soundings of TS reveal a stable environment with respect to vertical convection (Curran and Pearson 1971); however, slantwise convection (represented by airflows in the previous section) is capable of producing an environment conducive to reaching breakdown potential. Snowstorms are known for their high electrical activity (Mason 1971). This is produced by the significant riming featured in most natural snowfall. An algorithm developed by Takahashi (1978) produces breakdown potential using typical data (sizes, concentrations, etc.) from snowfall. The calculated time of 24 minutes compares favorably with the personally observed range of 10–15 minutes.

Snow data [type (crystal, aggregate, graupel), size and riming characteristics] from TS indicate an increased riming process. Though difficult to prove, I believe TS are different from the thunderstorms observed in the warm sector. The electrification is identical, but the cloud structure is not. This subtle electrification and discharge are limited in their observa-

Corresponding author address: Mr. Harold A. Elkins, 123 Famous Ave., O'Fallon, IL 62269-1722.

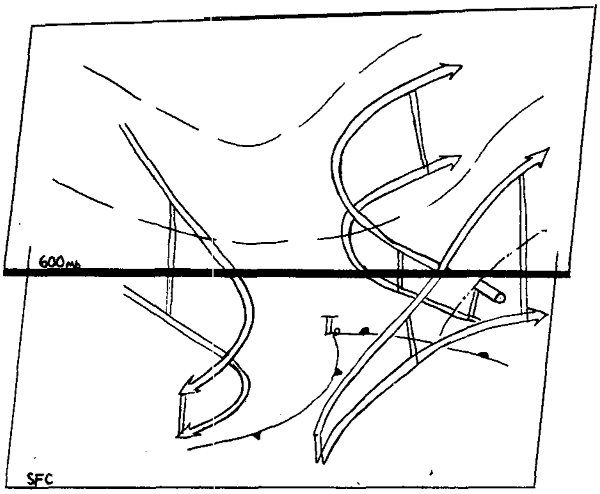

FIG. 1. A three-dimensional view of the conceptual model for a wave cyclone. Broad arrows give approximate airflow through the cyclone between the surface and 600 mb. Dashed lines at 600 mb represent geopotential height field (After Carlson 1980).

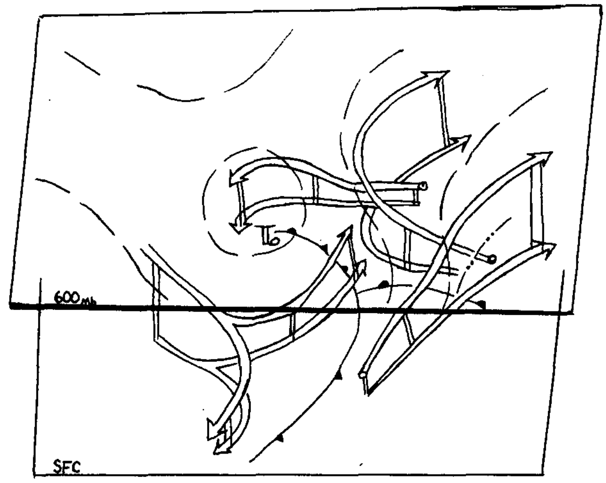

FIG. 3. A three-dimensional view of the proposed conceptual model of the mature cyclone. Symbols as in Fig. 1. The maturation of the cyclone is believed to involve an increased contribution by the cold sector. From this perspective a cyclone does not occlude but allows influence from all sectors of the cyclone.

bility and accounts for its apparent rarity. The lightning probably occurs with most major snowstorms, but the necessary conditions may not occur again over the same area for several years. Hopefully with more TS snow data gathered, these statements can be quantified.

Beckman mentions a seasonal variation of TS but offers no supportive data. Though limited in scope, I have surveyed 16 years of the Daily Weather Map series, and this shows February as the predominant month for TS. Similarly, the winter of 1986/87 produced the most TS reports during January. This is significantly different from the early and late winter maxima indicated by Beckman. An in depth study of TS synoptic climatology is needed.

Any diurnal tendency is associated with the ease of observing TS at night since the light contrast is increased and noise interference diminished. The greatest frequency of TS occur on the northwest side of the mature cyclone approximately 250 km from the surface low pressure center. This data indicate an integrated

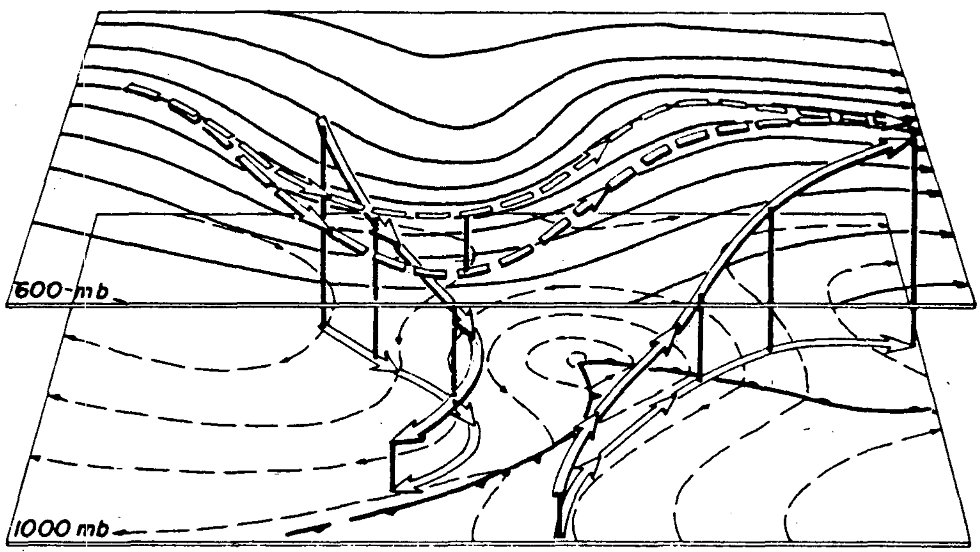

FIG. 2. As in Fig. 1 but not showing the contribution of the CCB. The air motions in the cold sector (north of the cyclone) can account for many of the attributes of the midlatitude cyclone that have always been given to the warm sector (From Palmén and Newton 1969).

synoptic situation where the airflow (slantwise convection) produces a specific cloud physical environment (large populations of supercooled water droplets). This environment produces electrical charge separation occasionally resulting in a intracloud discharge.

4. The challenge

I am offering an alternative and not definitive proof of a new perspective on cyclones and thunderstorms with snow. More data is available, but I feel a detailed discussion would not be appropriate in this note. My results and conclusions are preliminary, but there is enough support to renew discussion on cyclones and electrification within snowfall. Our understanding of synoptic processes and their influence on smaller scale phenomenon is poor. We need to bring our concepts up to date.

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