1.2 CLOUD MODEL INTERPRETATION OF MECHANISMS RESPONSIBLE FOR THE SATELLITE-OBSERVED ENHANCED V AND OTHER FEATURES ATOP SOME MIDWEST SEVERE THUNDERSTORMS

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1. INTRODUCTION

Satellite observations have become an indispensable tool for the forecasting and study of severe thunderstorms, especially in places where conventional data are either sparse or unavailable. Over the years, important cloud top characteristics of severe thunderstorms have been studied and classified using satellite visible and infrared images, and utilized for the above-said purposes.

One of the peculiar characteristics has been defined as enhanced-V and several studies were performed to correlate this feature with severe storms (e.g., Negri, 1982; McCann 1983; Heymsfield et al. 1983ab; Heymsfield and Blackmer 1988; Adler and Mack 1986). For example, McCann (1983) accumulated V statistics from half-hourly enhanced IR data from April to July 1979. He found that storms with a V pattern had about 70% probability of producing severe weather, and that the median lead time from the onset of the V to the first severe weather was about 30 minutes. Adler et al. (1985) also presented similar evidence that the V feature is correlated with reported severe weather. They found that 75% of storms with the V feature had severe weather, but 45% of severe storm examined did not have this feature.

A notable classification was made by Adler and Mack (1986); they indicated that thunderstorms with thermal couplet may be classified according to thee types of thunderstorm tops:

- Class1: the IR cloud point is located with the cloud top and there is no close-in warm point;
- Class 2: similar to Class 1 except a warm point exists downwind of the cloud top.
- Class 3: cold and warm points exist and with the cold point displaced upstream of the cloud summit.

They found that thunderstorms could go through the three storm top classes during their lifetime.

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A more detailed analysis on satellite observation of V-Shape feature was performed by Heymsfield and Blackmer (1988). They studied nine different convective systems with different features from 1979 (five SESAME cases) to 1982 consisting of both isolated storms and squall lines comprised of supercell storms. The V-feature was present for all except one. On some of the days, the V was very well developed; on others it was poorly developed or very short-lived.

These investigators also performed studies to understand the mechanisms responsible for the formation of the enhanced-V. Heymsfield and Blackmer (1988) made a more comprehensive study on this subject and proposed a few conceptual models to describe the phenomenon. It would be desirable to use a numerical model to see if the proposed mechanisms can produce the V feature. However, previous numerical model studies were not conclusive mainly due to the lack of ice processes in the model microphysics (Schlesinger, 1984, 1988).

The present study attempts to use a numerical cloud model with more detailed microphysics (including the ice processes) to simulate a severe storm occurred in Montana in 1981 to see if the V feature and other important cloud top characteristics associated with severe thunderstorms as observed by previous investigators can be reproduced and, if so, to explain the mechanisms responsible for their formation.

2. DESCRIPTION OF THE CLOUD MODEL WISCDYMM

The cloud model utilized for the present study is the Wisconsin Dynamical/Microphysical Model (WISCDYMM), which is a 3D quasi-compressible, time-dependent, non-hydrostatic cloud model developed at the University of Wisconsin-Madison by the author's group. The governing equations and microphysical parameters are given in *Straka* (1989) and Johnson et al. (1994).

3. THE 2 AUG 1981 CCOPE SUPERCELL

The simulated storm for illustrating the plume-formation mechanism is a supercell that passed through the center of the Cooperative Convective Precipitation Experiment (CCOPE) (*Knight*, 1982) observational network in southeastern Montana on 2 August 1981. The storm and its environment were intensively observed for more than 5 h by a combination of seven Doppler radars, seven research aircraft, six rawinsonde stations and 123 surface recording stations as it moved east southeastward across the CCOPE network. This storm case was chosen because it provides much detailed observational data for comparison with model results in dynamics and cloud physics, and the author's group has obtained successful simulations of it previously.

4. RESULTS AND DISCUSSIONS

The results of the simulation show that those important features can also be reproduced. Examples of the results are shown in Fig. 1 and 2. The fact that the model used for the simulation does not contain the effects of radiation and yet is able to reproduce the essential features indicates that radiation effects are not central to these features. Rather, the main mechanism responsible for the observed features (enhanced V, warm-cold couplet, and distant warm areas, etc.) is the cloud-top gravity waves. Detailed descriptions of the model results and the mechanisms involved will be given at the time of the conference.

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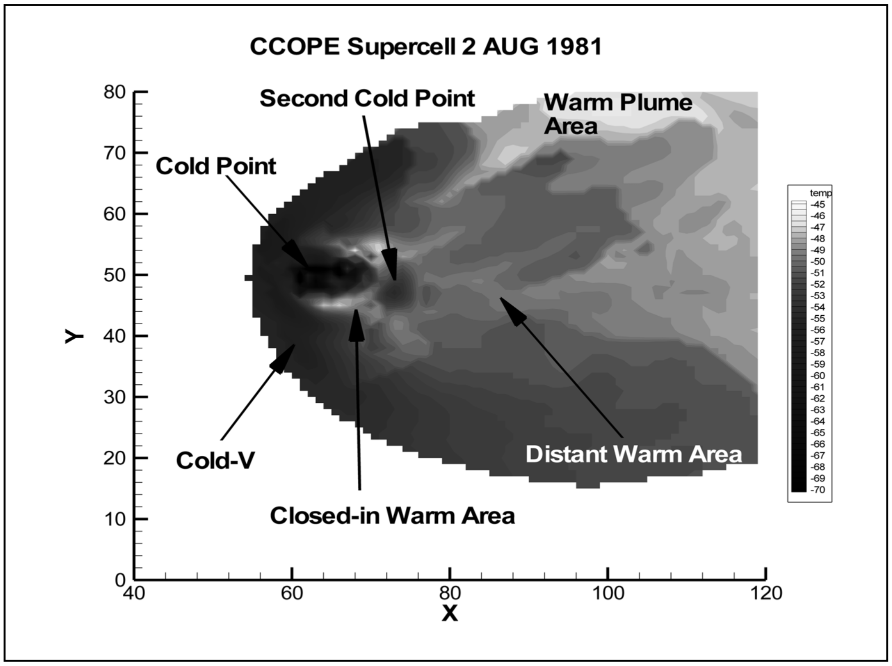

Fig. 1 Simulated cloud top temperature field of the CCOPE supercell of 2 Aug 1981, showing the V feature and other cloud top characteristics.

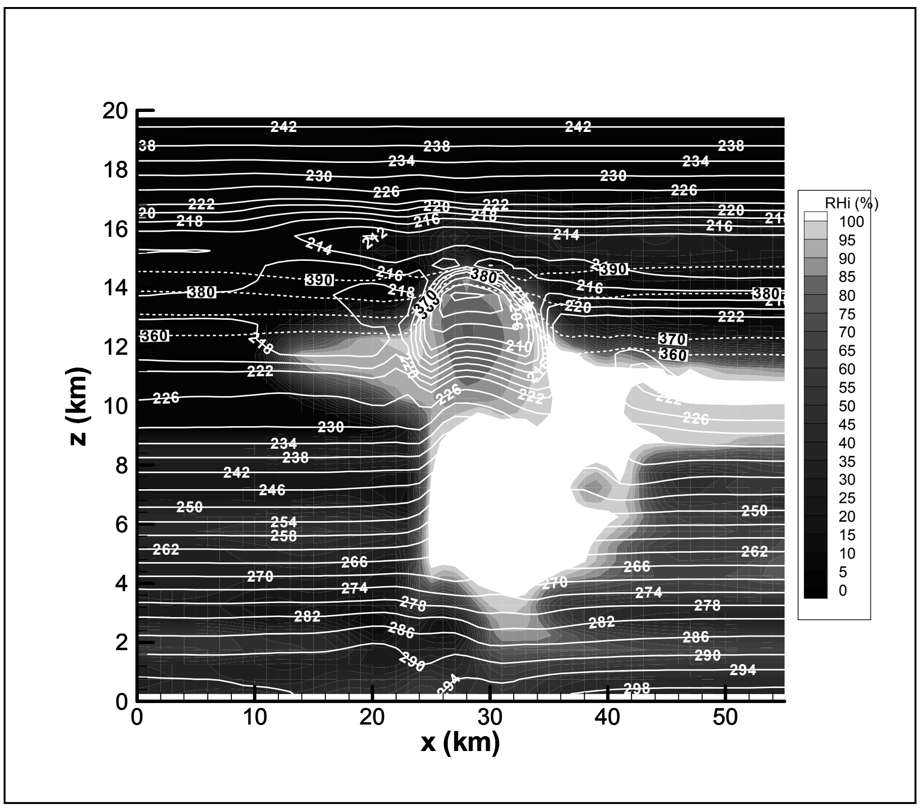

Fig. 2 Vertical cross-section at y = 27 km of the simulated storm showing the overlay of temperature (solid), potential temperature (dashed), and RHi fields at t = 124 min.