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## Introduction

Mammatus are hanging cloud protuberances observed on the under surface of a cirrus anvil cloud. Measurements of mammatus characteristics have been extremely scarce to date. Recent investigations using Doppler radar observations reported by Martner(1995) and an aircraft penetration by Stith(1995) are the most quantitative mammatus observations in the literature over the last decade. Our understanding has not changed significantly since these studies were published. Three processes related to their formation have been identified: subsidence of a cloud interface layer, fallout of precipitation, and evaporation of precipitation (Score 1958). In this paper, we report results from high-resolution, ground based, radar observations of mammatus clouds observed during the Crystal-Face experiment. As was the case for previous mammatus studies, these observations were obtained opportunistically. An anvil advecting over the Eastern Crystal-Face Site on 22 July 2002 was studied

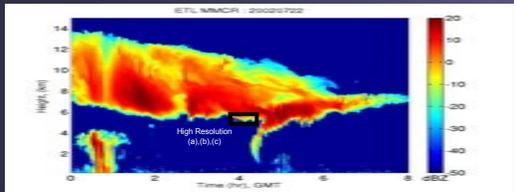


Fig. 1. Cloud reflectivity observed by ETL MMCR Radar. Clouds in the black box indicated were studied in detail.

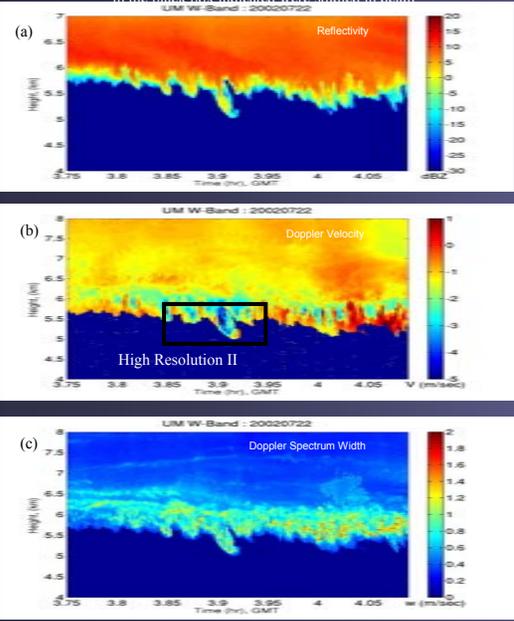
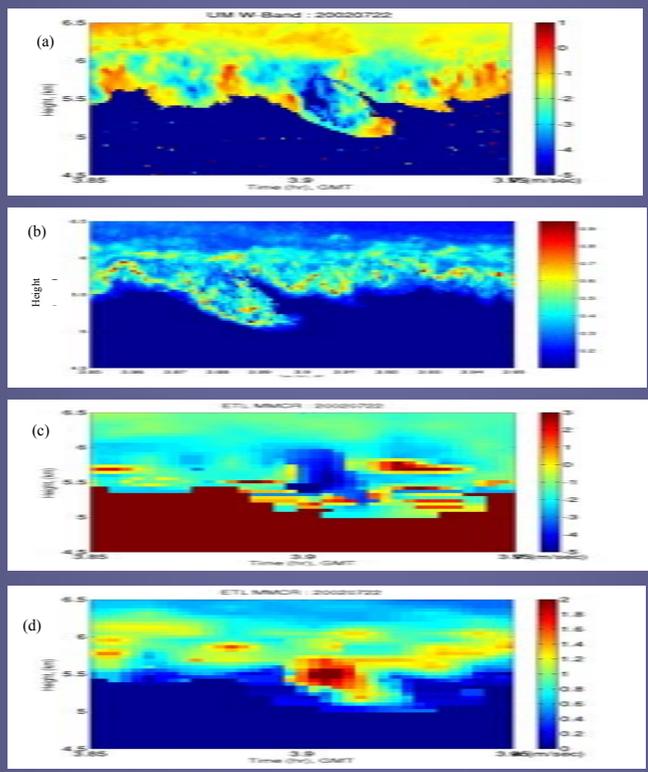


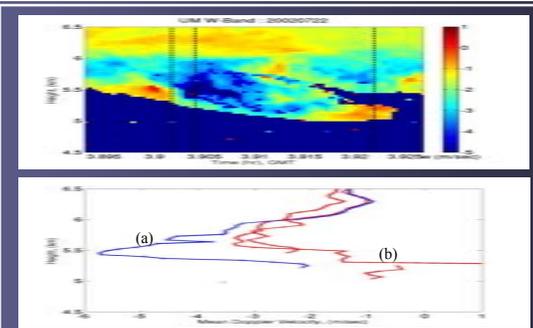
Fig. 2. High Resolution data collected from the UM W-Band Radar in the area defined by rectangular area shown in Figure 1: Panel (a) Reflectivity, (b) Mean Doppler Velocity, and (c) Doppler Spectrum Width.



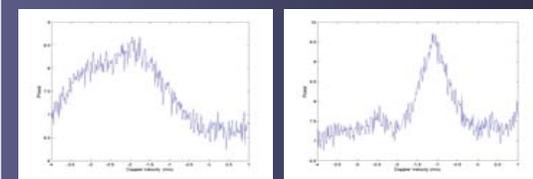
## High Resolution II



Single mammatus features: (a) and (b) Reflectivity and Mean Doppler Velocity observed with the UM W-band radar. (c) and (d) same characteristics observed with the ETL MMCR radar.



Mean Doppler Velocity at three different regions of the mammatus. (a) center of the lobe. (b) at the edges of the lobe.



Doppler Velocity at 5.6 Km      Doppler Velocity at 7.0 Km

## Summary

Radars operating in an upward-facing mode at the eastern ground site during CRYSTAL-FACE were used to examine the internal structure of mammatus clouds. These observations include high temporal resolution radar observations (1.2 s profiles) from the University of Miami's W-Band radar. Detailed features defined from the mean Doppler measurements include strong downdraft cores surrounded by updrafts near the bottom edge of the cloud. Such a circulation is consistent with a downward moving cloud core impinging upon a stable layer. The core have a vertical dimension of about 750-1000 m. The Doppler spectral width is large along the cell boundaries. Work is in progress to further develop a full dynamical and turbulence description of the mammatus.

## References

Martner, B.E., 1995: Doppler radar observations of mammatus. *Mon. Wea. Rev.*, 123, 3115-3121.  
 Scorer, R. S., 1958: Dynamics of mama. *Sci. Prog.*, 46, 75-82.  
 Stith, J. L. 1995: In situ measurements and observations of cumulonimbus mamma. *Mon. Wea. Rev.*, 123, 907-914.