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A WATER VAPOR IMAGE FEATURE RELATED TO SEVERE THUNDERSTORMS

[Editors Note: The following is a summary of an article in the November, 1990 issue of the National Weather Digest, "A Water Vapor Image Feature Related to Severe Thunderstorms," by Gary P. Ellrod.]

Water vapor satellite images are typically used as a tool in synoptic scale analysis. Moist and dry regions can be related to upper level flow features such as troughs, deformation zones, and jet streams. However, water vapor pictures can also be used in mesoscale analysis during the convective season as an indicator of subtle flow features about large thunderstorm cells.

Figure 1 shows a series of water vapor images with a large thunderstorm complex over Missouri. There is a small, subtle dark band along the upstream edge of this thunderstorm complex (arrows A and D). Similar small dark bands can be observed on many large thunderstorm complexes when severe weather (large hail, strong winds or tornadoes) are observed. For example, in the three-month period from April-June 1990, this signature was observed 147 times over the central U.S. In 121 (82%) of these cases, severe weather was reported (the majority of cases contained large hail). While this signature occurs most often in the central part of the U.S., the identification of this feature and reasons for its formation can be used as a clue for severe thunderstorm activity in other areas of the country as well.

It is believed that these dark bands are related to upper-level downdrafts initiated when strong thunderstorm updrafts block the ambient upper-level flow. Figure 2 (from Lemon and Doswell, *Monthly Weather Review*, 1979, pgs. 1184-1197) shows a model of airflow in supercell thunderstorms. In strong thunderstorms where the updraft reaches the tropopause, the upper-level flow may detour around the thunderstorm, or may turn downward in a feature known as the "rear flank downdraft". This upper-level subsidence adiabatically warms and dries the upper-level air mass and is believed to be responsible for the dark band on water vapor satellite images. Dry and warm stratospheric air may also be pulled down in this downdraft.

The downdraft should be strongest when the upper-level winds are strong, and the thunderstorm updraft extends all the way to the tropopause. It is not surprising that the resulting dark band can be associated with severe weather, since strong upper-level winds and large, deep updrafts have also been associated with severe weather.

Moisture gradients associated with upper-level cyclones can also be seen on water vapor satellite pictures and convection can develop downstream of dark bands. The feature described here is different because the dark band develops as a result of the thunderstorm rather than the thunderstorm developing along a pre-existing dark band. Animation of satellite images using SWIS or MicroSWIS should be helpful in determining if the dark band was evident before the thunderstorm developed. The darkening is also very subtle, and is best viewed in subsector images using the color enhancement capability of SWIS and MicroSWIS to highlight the shading differences.

Since cirrus from widespread convection can obscure this dark band feature, it is most likely to be seen in cases of isolated or widely scattered convection. The feature is difficult to observe in cases of convection imbedded in middle-level clouds, since the middle-level moisture can mask the upper-level drying effect. Nonetheless, it should be kept in mind that water vapor satellite images can provide clues to mesoscale circulation features near summer convection, and this particular feature has been related to the occurrence of severe weather.

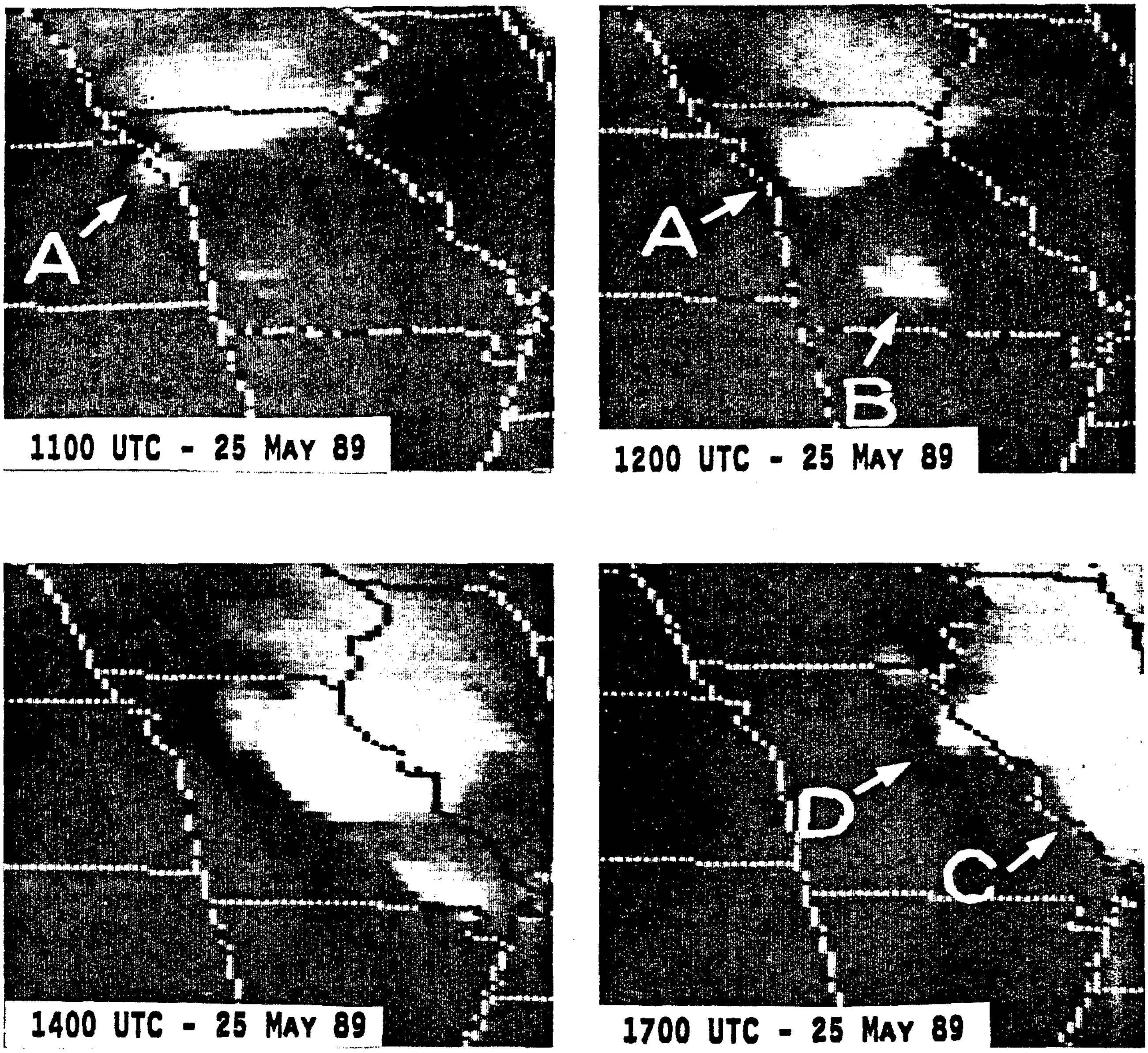

Fig. 1. Water vapor images from GOES-7 at (a) 1100 UTC, (b) 1200 UTC, (c) 1400 UTC and (d) 1700 UTC on 25 May 1989. Letters refer to thunderstorm areas described in text.

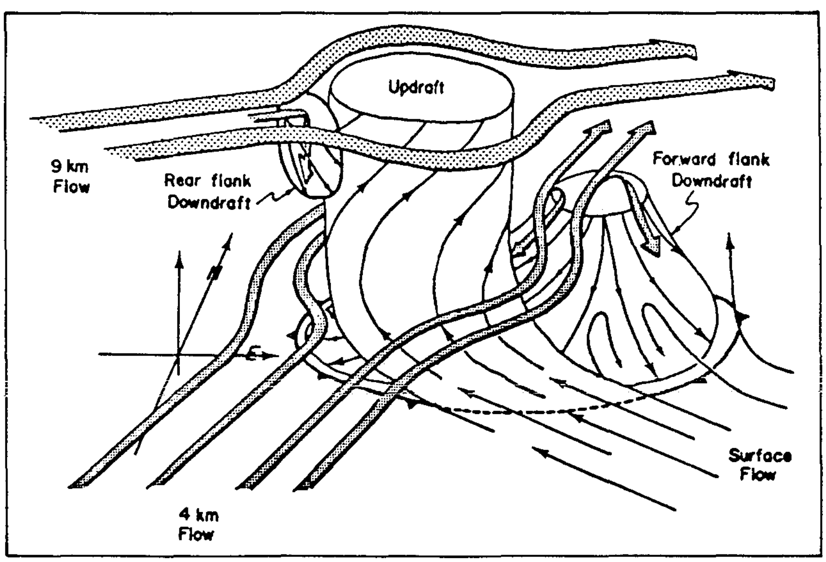

Fig. 2. Three-dimensional model of airflow during the early stages of a supercell thunderstorm (from Lemon and Doswell, 1979).