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LIGHTNING AS A PRECURSOR OF OUTFLOW AND DOWNBURSTS FROM THUNDERSTORMS.

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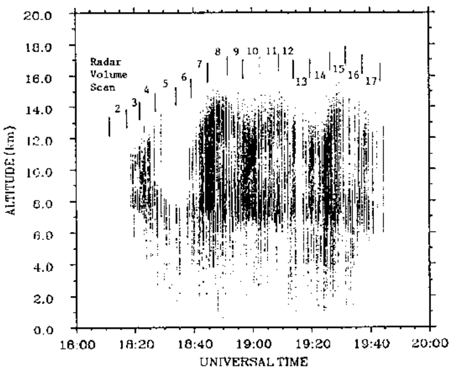
The onset of lightning in a storm cell occurs during vigorous vertical growth of the cell, and this has given rise to the idea that lightning could be used as a precursor of outflow or downburst events from electrically active storms (e.g., D. Latham, E. Williams). In this paper we present results from an initial test of this idea using observations from the Lightning Detection and Ranging (LDAR) system at Kennedy Space Center of a relatively small, multicell storm on September 2, 1994. Earlier studies have related the lightning to the radar reflectivity structure of the storm (Maier et al., 1995; Stanley et al., 1996).

The LDAR system locates RF radiation sources from individual lightning flashes in three spatial dimensions and time. Examination of the overall lightning activity of a storm readily shows the growth and decay of individual cells within the storm. This is illustrated by simple plots of the source heights vs. time, as shown below for the Sept. 2 storm. The plot shows several upward-growth phases characteristic of new cell development; each upward phase reflects the increasing height of intracloud lightning discharges between negative charge at mid-levels of the storm (7-8 km altitude) and positive charge in the upper part of the storm. Radiation from cloud-to-ground lightning events remains at constant or slightly decreasing height within the negative charge region of the cells.



Doppler observations from the Melbourne NEXRAD 45 km to the south of the initial cell were used to detect low-level outflow from the storm. The radar performed a volume scan about every 6 minutes, or about 17 volume scans during the active part of the storm. The 0.5° elevation scan intersected the storm 300-400 m above ground and clearly showed the outflow from each cell. To test the relation between the outflow and lightning, the complete sequence of low-level Doppler scans was compared with the immediately preceding lightning activity. It was found that outflow at the beginning of a given volume scan was well predicted by the lightning activity 4-10 minutes earlier. The best predictor of the outflow location was the lightning sources between 7 and 9 km altitude, i.e. within the negative charge region.

The figure on the next page shows results for the four major cells of the storm. The outflow regions are detected as velocity couplets toward and away from the radar; for this storm the velocity differences across the outflow region were relatively modest, about 15 m/s. In each case the lightning sources 4-10 minutes earlier were nearly centered above the couplet, being displaced slightly to the southeast of the center due to upper-level shear. The outflow regions are better depicted in color plots of the Doppler data, available in a copy of the paper at http://www.ee.nmt.edu/~stanley/ or ~rison/. These document that the outflow velocities were away from the radar on the north (upper) side of the cells, and toward the radar on the south side.

Low level outflow of varying intensity occurred throughout the full duration of the storm after its initial onset but was continually well predicted and located by the lightning activity. The monitoring of lightning activity in the vicinity of airports could therefore be a useful tool for predicting outflows potentially hazardous to aircraft where good quality Doppler data are not available. The technique would clearly not predict microbursts produced by smaller storms that do not become electrified. However, the storm studied here was of modest size and produced correspondingly moderate outflows. Larger storms having more hazardous outflow events would undoubtedly be well delineated by the lightning activity. The NM Tech group are currently developing a deployable version of the LDAR system using GPS and wireless communications technology, of the type that could be used for such an application.

REFERENCES

Maier, L., C.Lennon, P.Krehbiel, M.Stanley, and M.Robison, Comparison of lightning and radar observations from the KSC LDAR and NEXRAD radar systems, Proc. 27th Conf. Radar Meteorol., 648-650, 1995.

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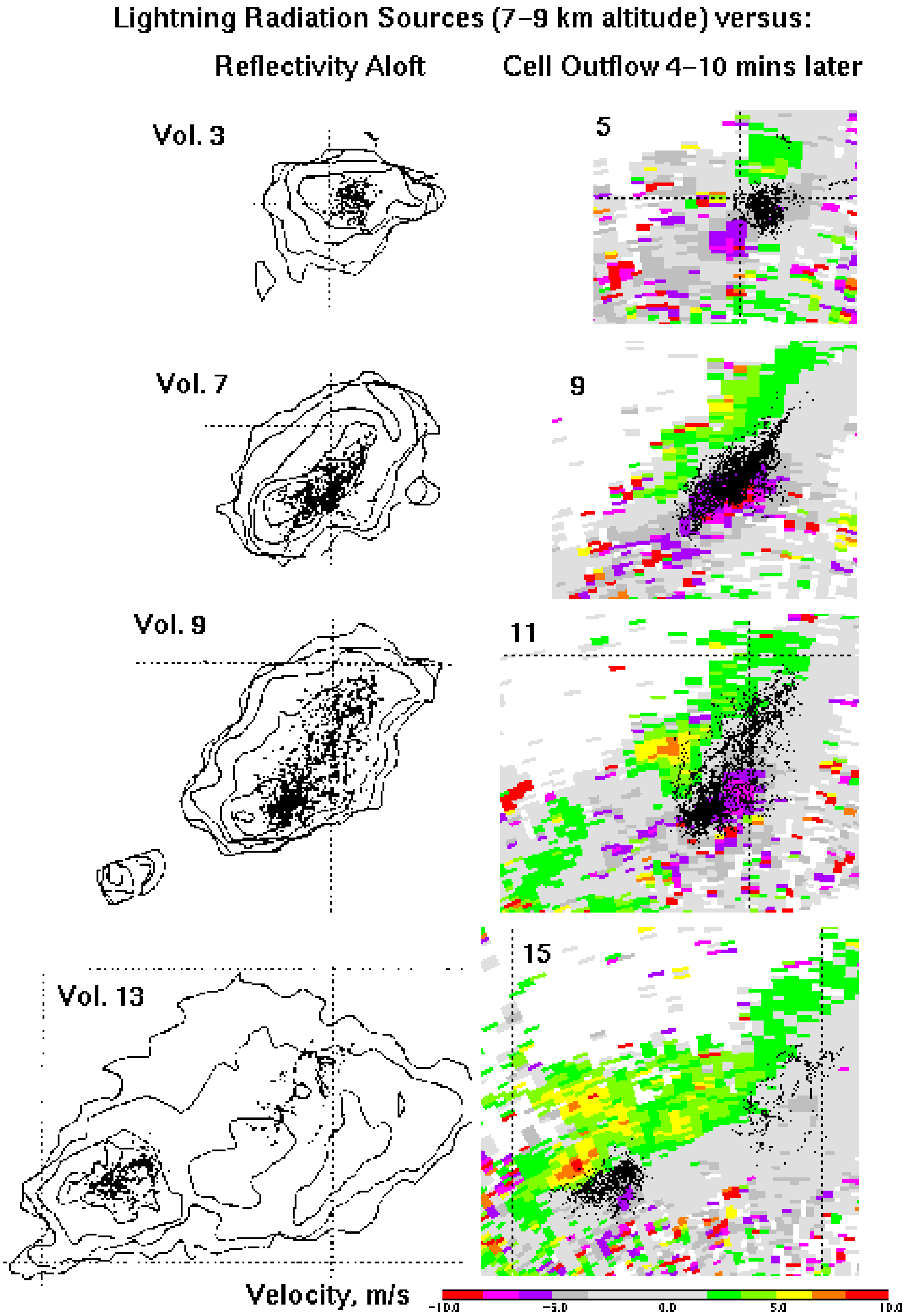

NEXRAD Doppler observations of low-level outflow from the four major cells of the storm of September 2, 1994, compared with lightning activity 4-10 minutes prior to the outflow (right column). Radar reflectivity structure at the time and height of the earlier lightning activity (left column, from Stanley et al., 1996). The numbers indicate the volume scans of the radar observations. The storm had a small velocity component toward the radar, located 45 km south of (below) the initial cell. The outflow regions toward the radar on the south side of the cells is somewhat obscured by the lightning sources due to slight southeast shear of the storm.