Got Thermal?

Kinematics of growing Cumuli derived from airborne Doppler measurements.

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Shallow and Congestus Cumulus cloud convection is of fundamental importance in the interpretation of transport of energy, mass and momentum in the atmosphere. Modeling the specific dynamics of these clouds is important to identify aspects of microphysics, precipitation development and radiative feedback characteristics that, in turn, have consequences on both climate and weather. Classic approaches to the problem of buoyancy driven flows include lab and *in-situ* experiments, ground-based remote sensing, analytical models, and numerical simulations.

Airborne remote sensing coupled with *in-situ* observations from the same aircraft provide a unique tool to analyze cloud dynamics and precipitation processes. Capitalizing on Doppler capabilities with a mobile platform is perhaps the most profitable remote sensing technique in this regard.

High resolution airborne single and dual-Doppler analyses of cumulus kinematics were performed for selected cases of developing cumuli over the high southeastern plains of Wyoming during the *'High Plains Cumulus Experiment'* (Hi-Cu) campaign in the summer of 2003. The $95\ \mathrm{GHz}$ Wyoming Cloud Radar was used in dual-antenna configurations, providing fine scale scans of the clouds in horizontal and vertical planes. In dual-Doppler mode, the data from the two radar beams were regridded into a Cartesian grid of resolution between 30 and $45\ \mathrm{m}$. Since only two velocity components are measured, an *ad-hoc* reverse decomposition algorithm has been implemented.

The analyses of the velocity vector fields showed evidence of cumuli as eroding bubble entities. From the former, one can derive the distribution of horizontal and vertical components of the vorticity and the characteristic length scales of the circulations. Sequences of two-dimensional cloud transects, combined with *in-situ* measurements, confirm the validity of the *'shedding thermal'* model.

Vertical sections reveal the frequent presence of recirculation associated with ascending thermal cores. This indicates the re-injection of larger hydrometeors at the bottom of the bubble, which may then accelerate the generation of precipitation.

Horizontal dual-Doppler fields and *in-situ* data show that the magnitudes and gradients of velocity are comparable to those observed in the vertical. The derived vertical component of vorticity exhibits well organized structures suggesting interaction between vertical and horizontal momentum.