Isolated Tropical Convection Viewed by Dual-Polarimetric Radar

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1. Why is isolated convection important?

Larger features, such as MCSs, tropical cyclones, squall lines, and phenomena of even larger scale, like the MJO or convection in the ITCZ are fundamentally dependent upon the upscale growth of isolated convection for their existence.

Isolated convective elements, given their small spatial coverage, are typically large in number. The aggregate effects of such elements is sometimes important. For example, moistening prior to MJO onset is dependent upon the aggregate moistening effect of many isolated convective elements prior to larger-scale convective onset.

2. Data

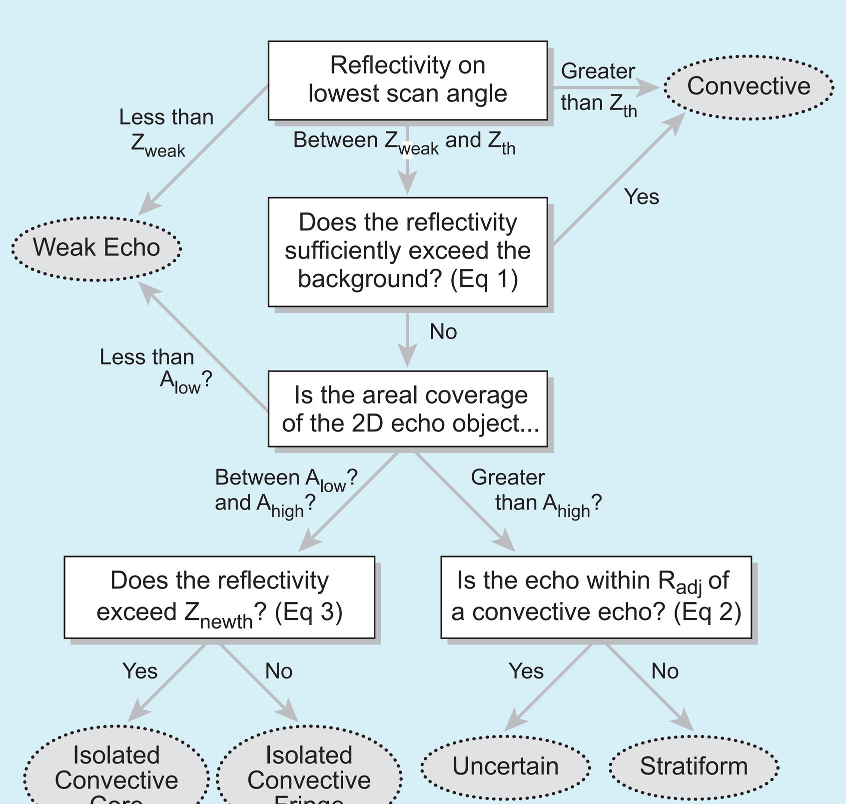
Data from S-PolKa during DYNAMO is used. Only RHI data is used from 8-14 October and 7-14 November, 2011, during pre-onset periods of two MJO events. Moderately deep cumulonimbi that moistened the troposphere were prevalent during these periods.

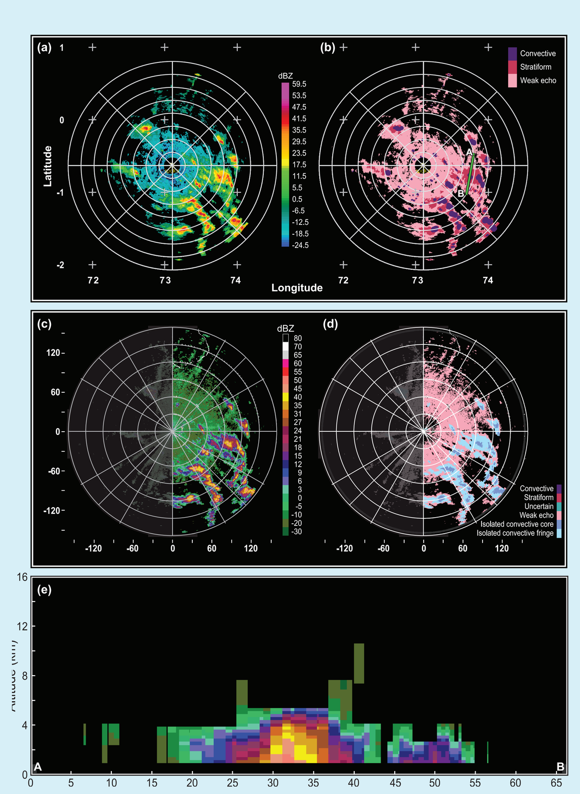
RHI data spanned the northeastern quadrant of the radar domain and elevation angles from 0 deg to 41 deg. The data used was separated in azimuth by 2 deg and by 0.5 deg in elevation.

3. Classifying isolated convection with precipitation radar

S-band radar does not generally observe non-precipitating convection, however, most free-tropospheric moistening is caused by deeper precipitating cloud elements (Powell 2016)[1].

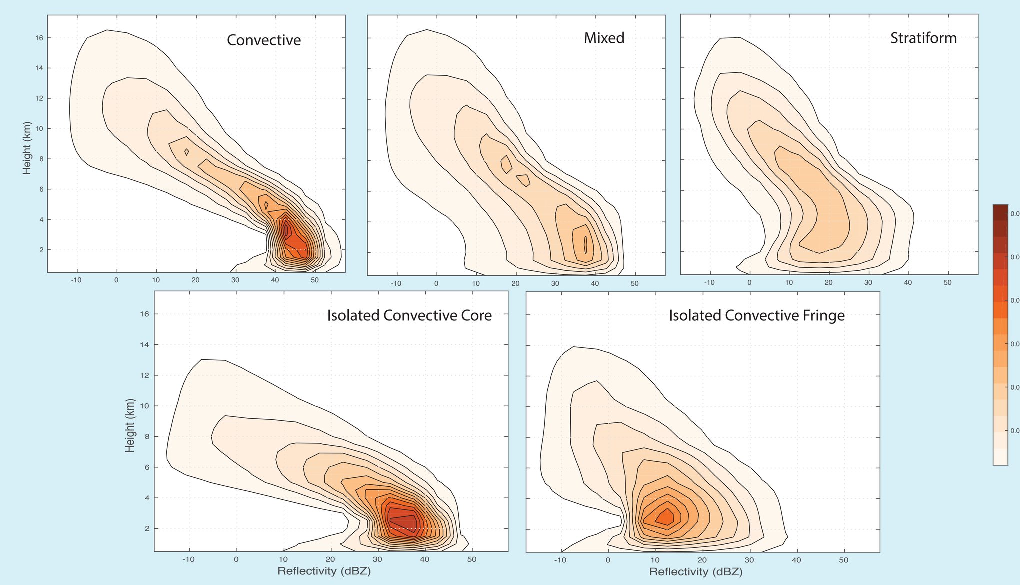
Powell et al. (2016) refined the "convective-stratiform" classification algorithm of Steiner et al. (1995). The update included separate classifications of isolated convective elements and also executed the classification algorithm on native polar coordinates of the radar in order to achieve higher-resolution (range gates are often spaced by 150m) classifications.



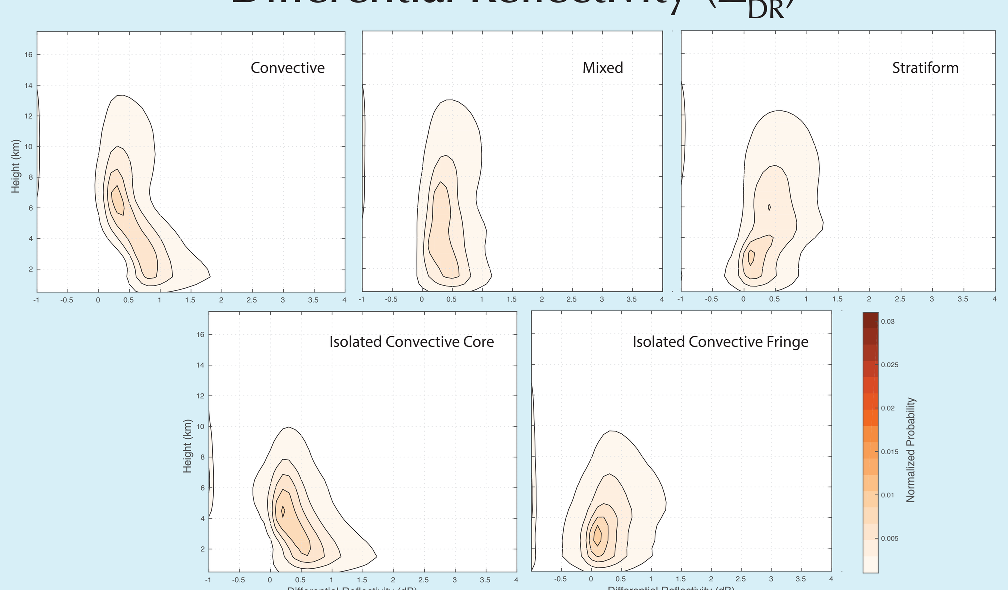


4. What is the observed dual-polarimetric structure of various convective categories?

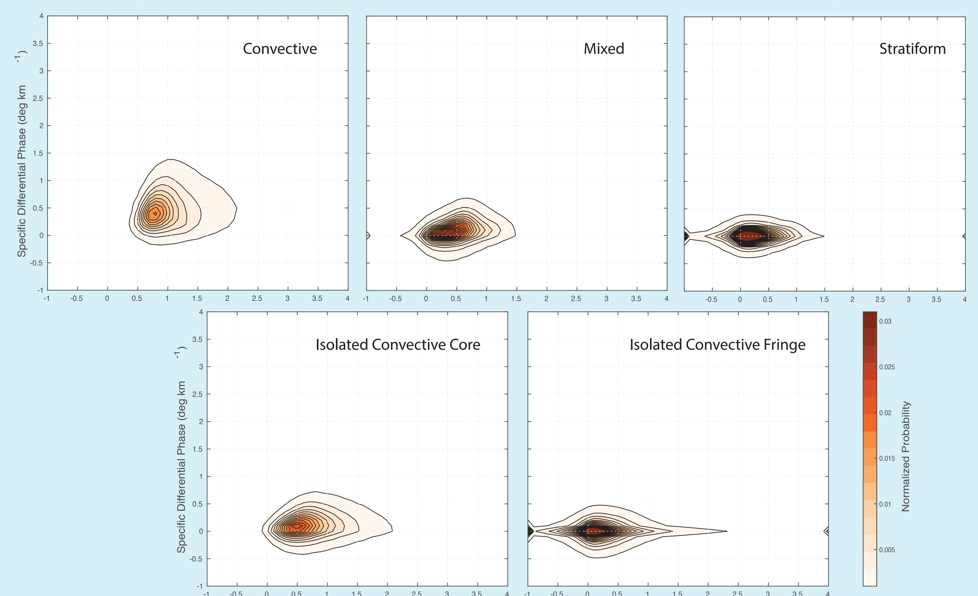
Reflectivity



Differential Reflectivity (Z_{DR})



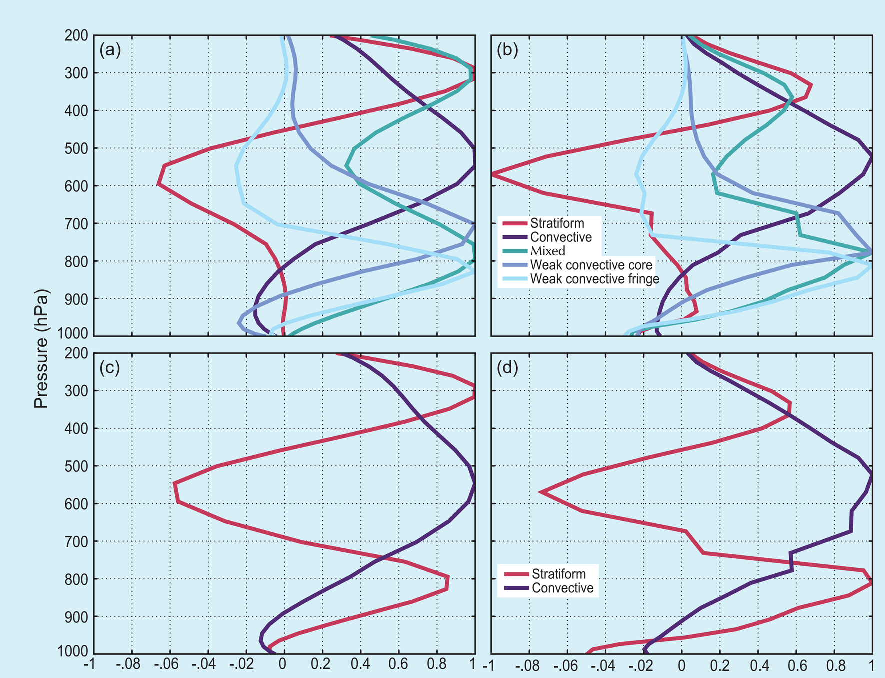
Z_{DR} vs. Specific Differential Phase (K_{DP})



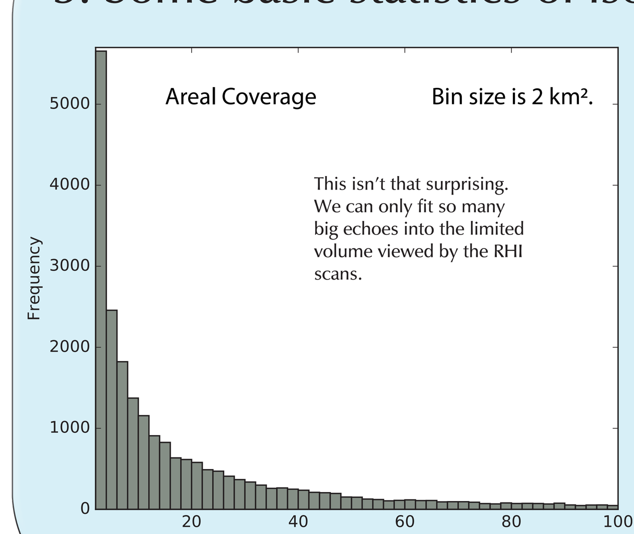
- Convective: Typically deep convection, with reflectivity near 2.5 km and below of greater than 40 dBZ.
- Stratiform: Brightband generally present
- Mixed: Echo surrounding convective cores within 5-10 km.
- Isolated Convective Core: Echo with areal coverage < 2000 km^2, but with reflectivity greater than at least 28 dBZ.
- Isolated Convective Fringe: Echo with reflectivity > 7 dBZ that is part of same echo object as isolated convective core.

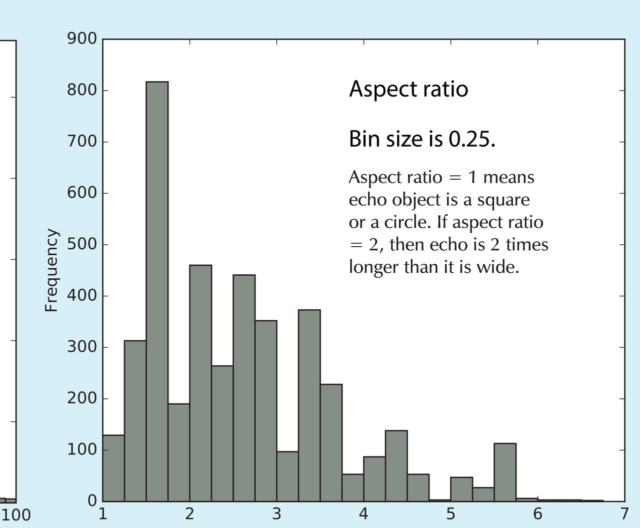
Z_{DR} and Z_{DR} vs K_{DP} distributions in isolated convective core look like convective echoes, but isolated convective fringe distribution resembles stratiform. Reflectivity distribution of isolated fringe is somewhat of a hybrid between convective and stratiform.

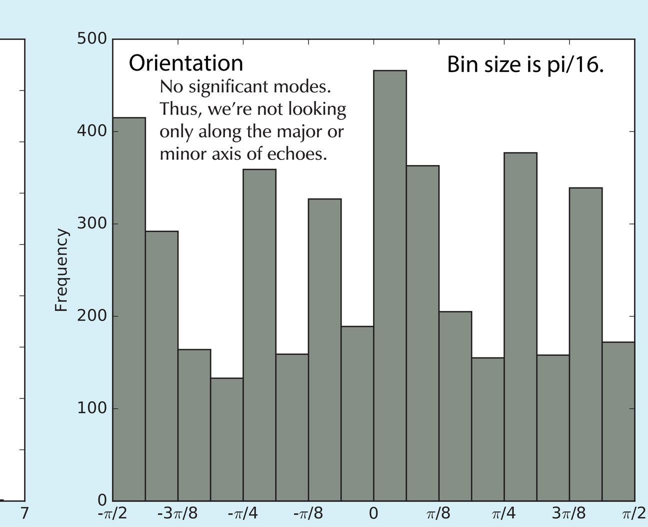
Right: Modeled vertical velocity and moist heating profiles in each category as modeled in WRF[1]. Fringe echo, in terms of a heating profile, looks like shallow convection, but based on radar observations, the hydrometeors present are more like what is seen in stratiform.



5. Some basic statistics of isolated convection

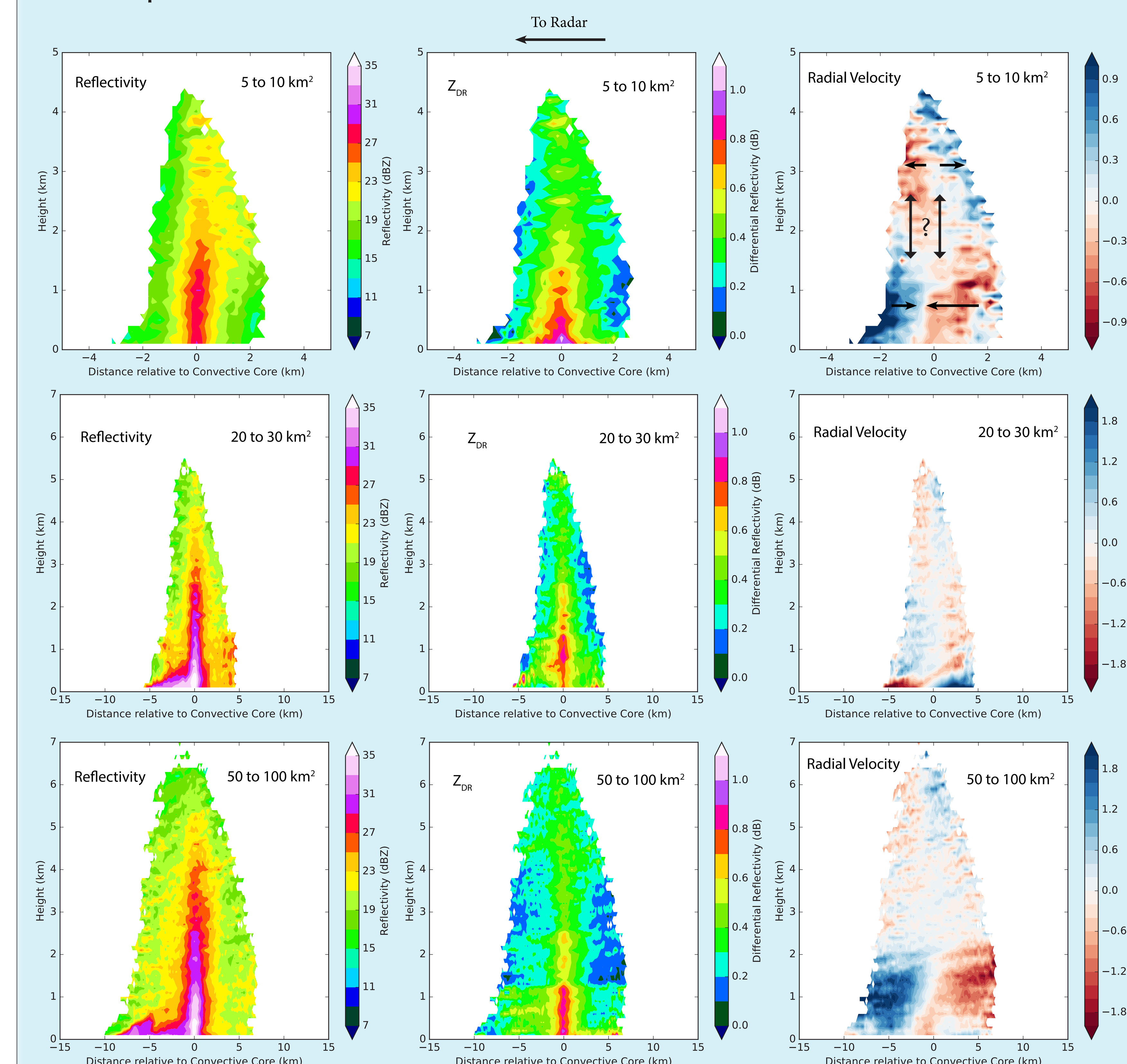






Orientation of major axis. 0 means orientation meridionally. pi/4 means that major axis is oriented NE to SW. -pi/4 means it is oriented NW to SE.

6. Composite cross-sections of isolated convection



- Distances are relative to strongest core echo around 300m above surface.
- Convective cores (reds and purples in left column) are generally less than 1 km across.
- Low Z_{DR} region in fringe seen clearly for larger echo objects.
- Radial velocity is cloud relative (thus mean velocity determined by sounding is subtracted first). A pattern of convergence in low levels of cloud and divergence in tops of cloud is apparent. Can approximate divergence, or even vertical velocity profiles, be computed?

7. Conclusions and More Questions

- When radar data isn't interpolated, it contains high resolution data. This can be exploited to look at the structural details of small convective elements.

- Isolated convective echo objects consist of two primary parts. The core, which resembles stronger convection, and fringe, which apparently contains slight upward motion but hydrometeors that are more commonly found in stratiform echoes.

- Will soon try to simulate isolated convection in an LES domain. Can the reflectivity observations be reproduced? Can a model tell us more about divergence profiles in shallow convection? Can single-Doppler measurements do that by themselves?

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