Long-term Vertical Air Velocity and Precipitation Parameter Retrievals in Rainfall from 95-GHz Doppler Radar Spectra

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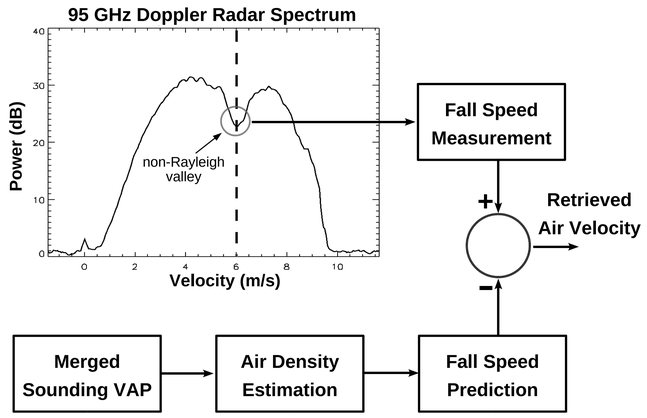
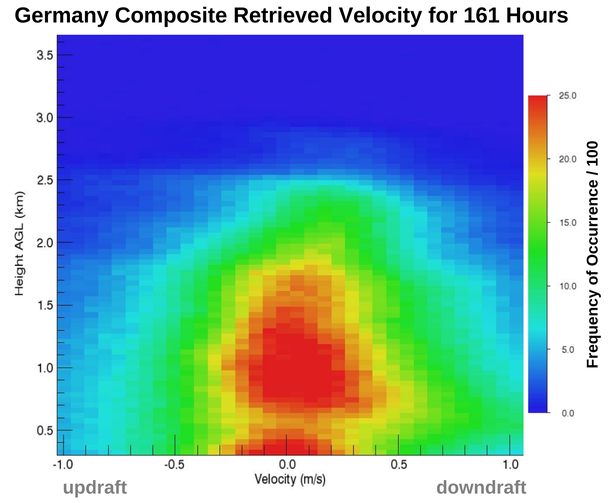
Introduction

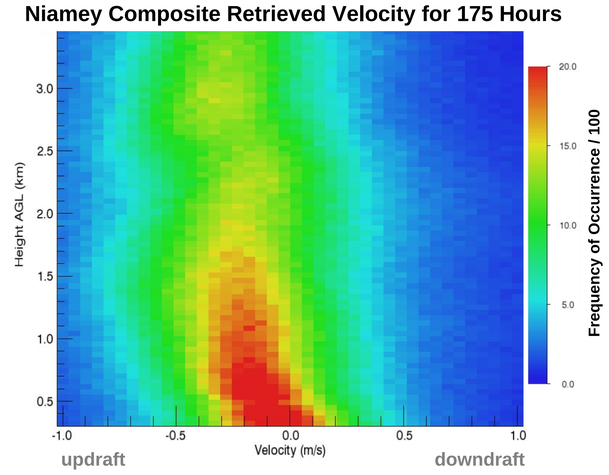
Recent ARM Mobile Facility (AMF) deployments include extended operations in the diverse environments of Niamey, Niger and Germany's Black Forest. Capitalizing on the AMF's continuous record of vertically pointing 95 GHz cloud radar spectra, long-term retrievals of mean vertical air motion and drop size parameters in precipitating clouds are performed. These retrievals are possible at excellent spatial/temporal resolution and at accuracy that benefits from the unique sensitivity of the 95 GHz cloud radar measurements to precipitation. The Niamey and Black Forest AMF deployments offer a large sampling of warm season precipitation events for which these retrievals are available. Bulk comparison between the long-term velocity retrievals in precipitation at these sites is performed.

Air Velocity Retrieval Methodology

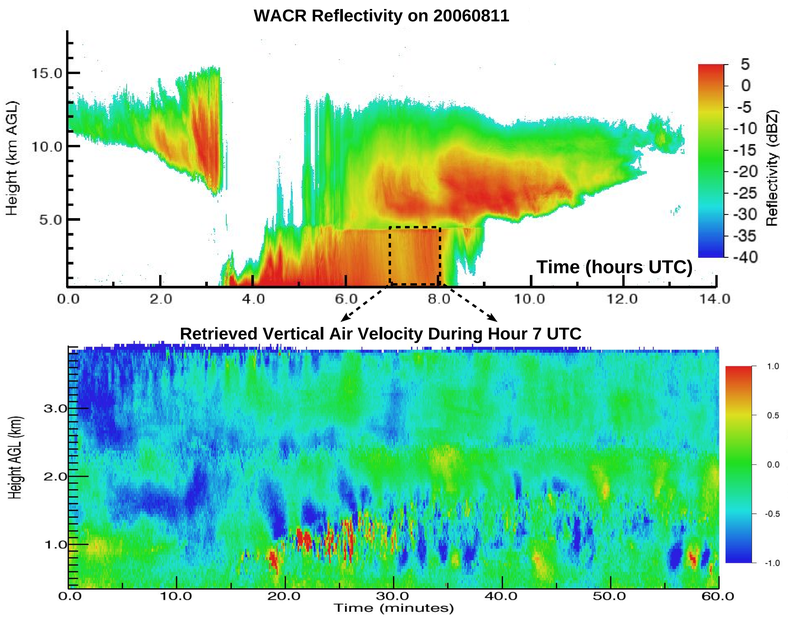


Bulk Vertical Velocity Retrieval Comparison for Niamey & Black Forest

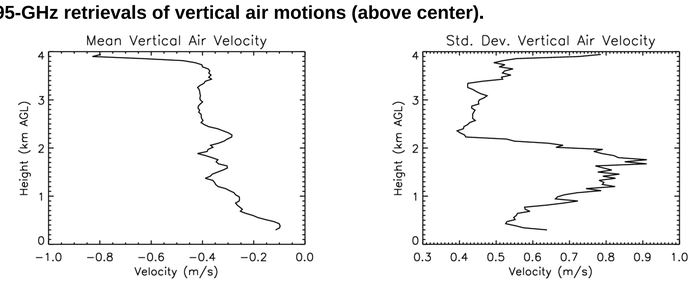




Niamey Wet Season Example

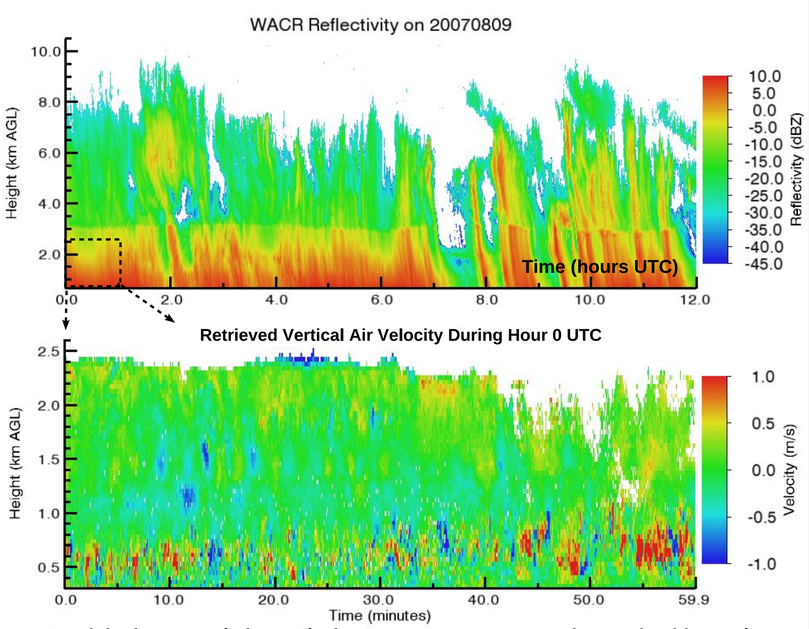


Wet season precipitation at Niamey commonly consists of intense convective cores followed by extended stratiform rain (above top), conditions extremely favorable for 95-GHz retrievals of vertical air motions (above center).

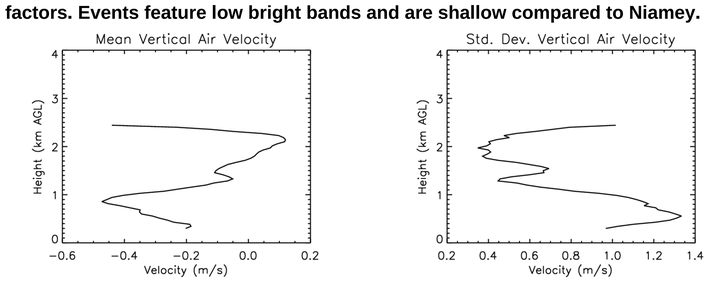


Mean and standard deviation of vertical air velocity over the full five-hour Niamey 20060811 precipitation event.

Black Forest Example



Precipitation sampled at Black Forest covers convective and wider-scale precipitation systems with potential enhancement/forcing by orographic factors. Events feature low bright bands and are shallow compared to Niamey.

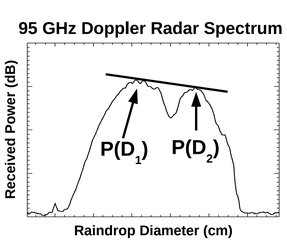


Mean and standard deviation of vertical air velocity over the full twelve precipitation hours on 20070809 at Black Forest.

Summary

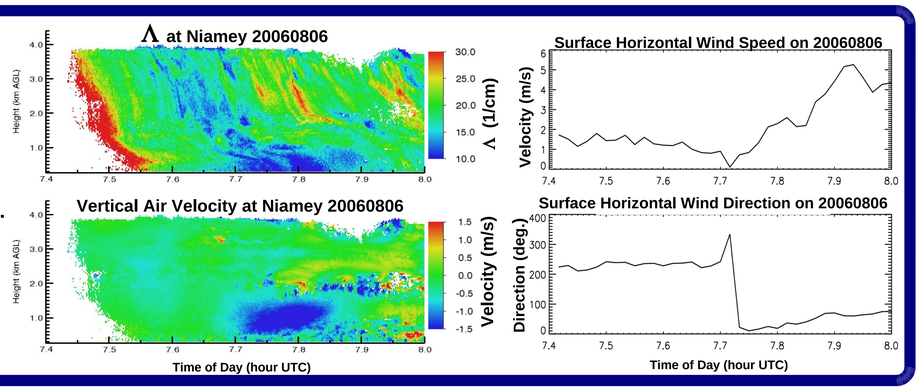
Using 95-GHz Doppler radar spectra, we have automated the retrieval of vertical air motion and drop size parameters in light to moderate rainfall at high spatial and temporal resolutions. The velocity retrievals are estimated to be accurate to within a range of 5 to 20 cm/s and have so far been applied to the majority of rainfall events occurring during the AMF Niamey and Black Forest deployments. High resolution velocity and precipitation characteristics retrieved from these systems are beneficial for establishing the links between storm dynamics and microphysics and understanding precipitation variability in time-height. Cumulative statistical properties of velocity measurements within precipitating and convective clouds is also of immediate interest for continued validation and improvement of GCMs.

DSD Parameter Retrieval



$$\Lambda = \frac{10\log_{10}\left|\frac{P(D_1)}{P(D_2)}\right| + 5.5}{4.343(D_2 - D_1)}$$

The plots to the right mark the arrival of a convective rain event.



In the radar spectrum above, Doppler velocity is substituted by raindrop diameter based on size vs. fall velocity relationship.

References

Lhermitte R., 1988: Observations of rain at vertical incidence with a 94 GHz Doppler radar: an insight of Mie scattering., Geophys. Res. Lett., 15 1125-1128.

Giangrande, S. E., E. P. Luke, P. Kollias, 2008: Retrievals of precipitation parameters using non-Rayleigh scattering at 95-GHz, J. Atmos. and Oceanic Tech., accepted pending revisions