4-Frequency ER2 Airborne Radar Measurements During IPHEX

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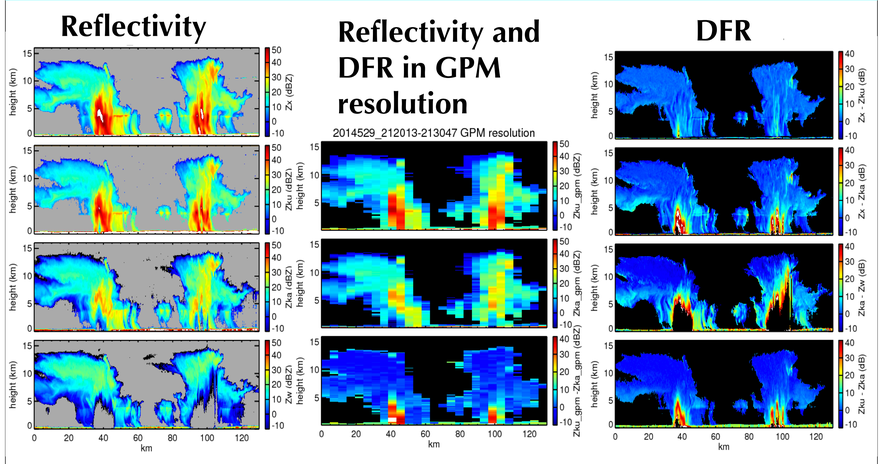
Summary

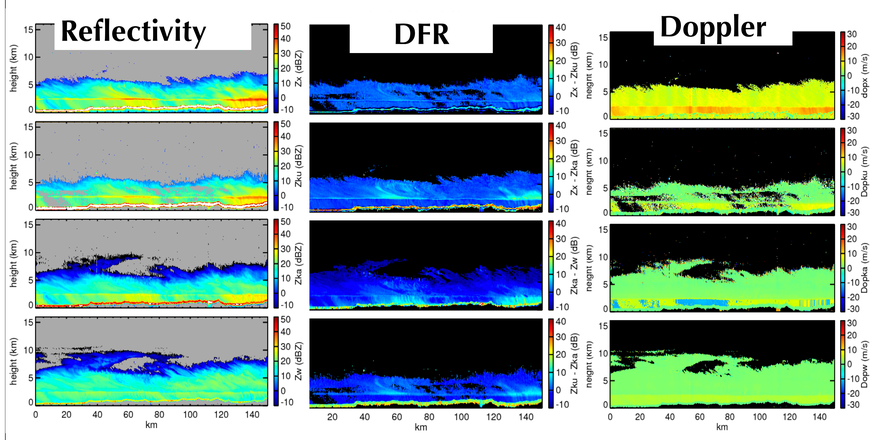
ER-2 made 20 flights during IPHEX. In all flights but three, four frequencies, X, Ku, Ka and W bands, radar data are available. The data was taken from three radars flew on ER-2 for the first time. Those flights covers several different warm season rain regime that dominated the regions of Southern Appalachians, spanning into the Piedmont and Coastal Plain regions of North Carolina. Those rain regime include (1) light to moderate rainfall (Rainrate < 5mm/hr) associated with orographic modulation of incoming moist air masses and seeder-feeder interactions (>50% of all observed rainfall falls in this category); (2) Heavy short duration rainfall and graupel associated with isolated thunderstorms initiated in the inner mountain region; (3) Heavy rainfall associated with westerly and southerly convective systems modulated by orography as they propagate across the inner ridge-valley region; and 4) Very heavy rainfall from Tropical and Extratropical Systems (typically southerly and southeasterly). Such diversity of rain type over land especially over mountain regions pose great challenges to GPM radar and radar-radiometer combined algorithms. In this presentation, we will present selected cases of 4-frequency radar observations from IPHEX and discuss how those observations could be used for evolution and improving the representation of microphysics in GPM algorithms.

Heavy Rain
2120-2130 UTC, 29 May 2014



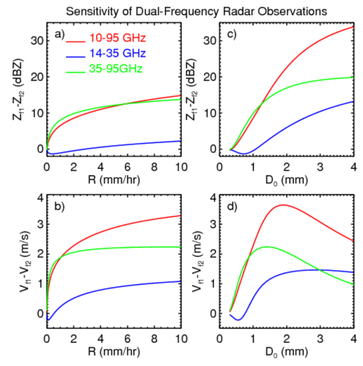
- Note the difference of reflectivity between X-W, X-Ka, Ka-W, and Ku-Ka

Light to Moderate Rain
1133-1145 UTC, 18 May 2014



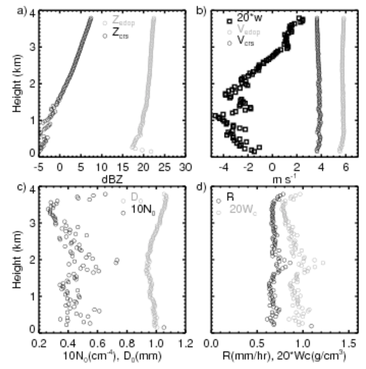
- For light rain, the differences of reflectivity (DFR) at Ku and Ka band is too small for meaningful dual-wavelength retrieval. We could use the difference of reflectivity at X and W, X and K, and X and W for rain retrieval.
- We can also use the difference of Doppler velocity at X and W band, which doesn't affected by attenuation for rain retrieval.

Light Rain Retrieval

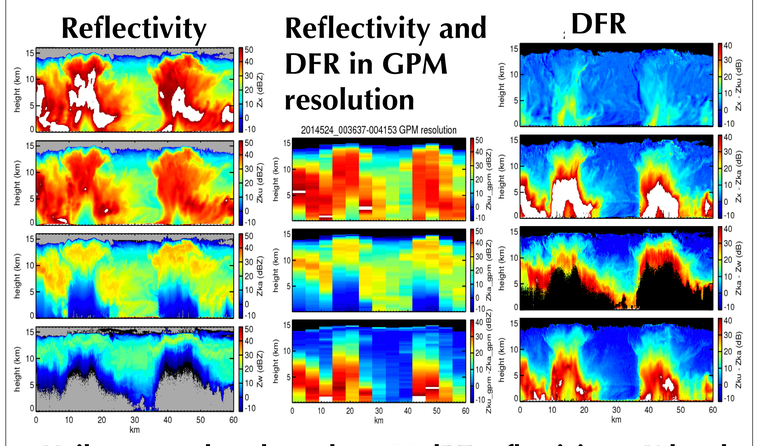


Left: Difference of reflectivity (DFR) and difference of the Doppler velocity (DDV) at two different radar frequencies as a function of rain rate, R, and medium drop diameter, D_0. Three pairs of radar frequencies are examined: 10 and 95 GHz, 14 and 35 GHz, 35 and 95 GHz. It shows that the combinations of 10 and 95 GHz radars are much more sensitive to the light rain than that of 14 and 35 GHz for light rain retrieval.

Right: the vertical profiles of a) Reflectivities at X- and W-band. The downward decrease of the reflectivity at the X-band could be due to evaporation and drop breakup; b) Doppler velocities at X- and W-band, and the retrieved vertical air velocity (w); c) Retrieved D0 and N0; d) rainfall rate R, and rain water content Wc. The increase in N0 and the decrease in D0 from the top of the column to about height are consistent with breakup of large drops formed by the melting of large aggregate snowflakes. This is also consistent with the near constancy of the rainfall rate.

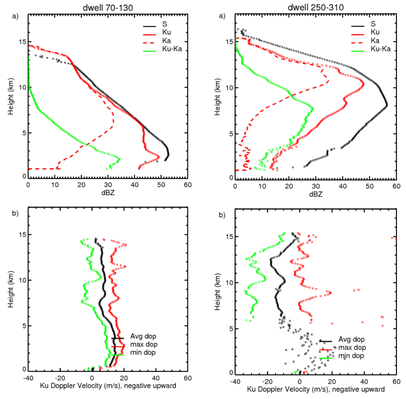


Hail Storm
0036-0041 UTC 24 May 2014



- Hail at ground as shows by > 55 dBZ reflectivity at X-band
- Multiple scattering at Ka and W band
- Non-uniform beam filling

For GPM applications, we need to understand how Ku/Ka band signals respond to hail and graupel.



- Left figs shows two examples of the vertical profiles of reflectivity and Doppler velocity.
- Note the difference of the reflectivity between Ku, Ka, and S-band. Such differences made it possible to identify the regions of hail/graupel in convective storm.

Right: a) reflectivity, b) DFR, and c) Attenuation coefficient for mono-dispersed dry hail.