Making the most of airborne cloud radar observations

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Deploying aircraft in field campaigns is resource-intensive and expensive. It is therefore important to make the best use of the deployed instruments by optimizing both the data collection and processing. The HIAPER Cloud Radar (HCR), a 94 GHz W-band radar, is requestable by the scientific community for field campaigns on the NSF NCAR Gulfstream V HIAPER aircraft. It has been deployed in five major field campaigns, spanning from the Southern Ocean to the tropics of Central America. Recently, enhancements to the capabilities of the radar were made by (a) upgrading the hardware for signal processing and (b) adding new products in post-processing.

To optimize data collection, the HCR team developed a new pulsing scheme which allows for the interleaved transmission of long and short pulses. This pulsing scheme provides the benefits of both pulse lengths without having to compromise by choosing one only. Long pulses increase the sensitivity of the radar and extend the maximum range, while short pulses provide observations with higher range resolutions. Coupled with the dual pulse lengths is dual pulse repetition time (PRT) operation, which aids in velocity dealiasing. A merging technique was developed, which combines the long- and short-pulse observations into merged radar moments fields.

HCR Doppler spectra from past field campaigns were used to calculate higher-order moments, such as skewness and kurtosis, and other spectral parameters. Doppler spectra from vertically-pointing cloud radars provide information that can aid our understanding of cloud microphysics and dynamics. However, they are currently under-utilized because the creation of high-quality Doppler spectra is non-trivial and the derived higher-order moments are often regarded as too noisy for scientific analysis. In addition, most data users are not equipped to handle the tens to hundreds of terabytes of raw I/Q time series data that are required to create Doppler spectra. Airborne spectra pose additional challenges. Because the beamwidth is non-zero (0.73° for HCR), the horizontal air velocity component, which is dominated by the high speed of the aircraft, causes a broadening of the airborne spectra, even when the radar is pointing exactly vertically. We developed a robust method which corrects the Doppler spectra for this broadening effect, and identifies and removes unwanted signal. From the corrected and denoised spectra we calculate high-quality higher-order moments and spectral parameters, which provide information on the physical properties of clouds that is not necessarily apparent from the more common lower-order moments.