Estimation of High Ice Water Content Using Dual-Frequency Polarimetric Airborne Radar Data

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1. Extended Abstract

Large concentrations of small ice crystals in tropical convective systems are known to cause engine power loss and to damage commercial aircraft at high altitudes. Such clouds, often referred to as regions of high ice water content (HIWC) are considered a flight hazard. Researchers are developing algorithms for detecting and measuring ice water content (IWC) and for characterizing these environments. Recognition of this hazard has led to a series of international research flight campaigns dedicated to studying HIWC. In May 2015, the National Research Council of Canada's (NRC) Convair-580 aircraft participated in the international High Altitude Ice Crystal (HAIC) – High Ice Water Content (HIWC) field campaign conducted from an operational base at Cayenne, French Guyana. For this campaign, the Convair aircraft was instrumented by the NRC and Environment and Climate Change Canada with an array of in-situ cloud micro physics probes, atmospheric sensors and remote sensing systems that included the NRC Airborne W and X-band (NAWX) radar systems [1]. The NAWX antenna subsystem features three W-band, three X-band antennas and a two-axis motorized reflector plate for steering the W-band aft antenna's beam. The NAWX antenna configuration allows measurements of clouds and precipitation at nadir, zenith and side directions. The side looking antennas of the W and X-band radar have dual-polarization capability.

In this paper, measurements of IWC up to 3.5 gm^{-3} from in-situ probes and polarimetric radar products (specific differential phase (K_{dp}), differential reflectivity ratio (Z_{dr})) from the X-band side-looking antenna are used. The statistical relationship between the radar measurements and IWC is presented. In addition, this relationship as a function of air temperature is also included in the study. It is shown that when the aircraft roll angle is within ±10°, K_{dp} and Z_{dr} can be used to detect and estimate HIWC fairly accurately, even in the case of combinations of pristine ice crystals and aggregated crystals where the IWC-Z(X) estimates usually exhibit large errors. The IWC estimates from K_{dp} and Z_{dr} have an error of less than 30% with respect to the in-situ data depending on the values of IWC and the types of the particles.

2. References

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