The High-altitude Integrated Wind and Rain Profiler (HIWRAP) : New transceiver developments and recent observations

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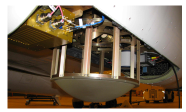
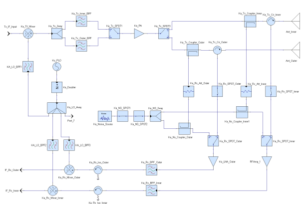
INTRODUCTION

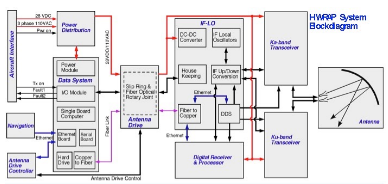
Airborne radars are critical to validate space-borne radar observations of convective weather, and fill gaps in observations from ground based radar systems. The NASA HIWRAP is a dual-frequency airborne radar that has been flying on the NASA ER-2 and Global Hawk aircrafts since 2010. The frequencies of HIWRAP (Ku- and Ka-bands) were chosen to be identical to the GPM mission, in order to enable calibration and validation efforts The original HIWRAP system was designed around-state of the art solid-state amplifiers which operated at 30 W (peak power) in the Ku-band and 8 W in the Ka-band. Herein, we describe recent upgrades to the HIWRAP transceiver and algorithmic modifications.

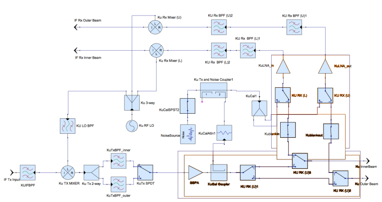


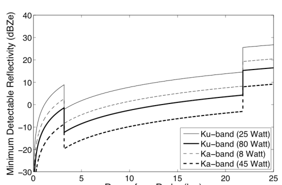
HARDWARE UPGRADES

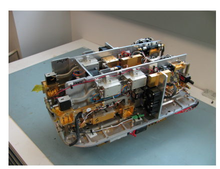
The HIWRAP system architecture is shown in Fig. 1b and consists of a computer control unit, power distribution unit, navigation unit, an IF convertor box that includes a base band signal generator, Ku and Ka-band transceivers, a multi-channel digital receiver and a dual offset beam antenna mounted on a circulating scanner. The Ka-band transceiver was upgraded first in the 2013 timeframe, when a 45W amplifier became commercially available. High power latching circulators were also developed which allowed one amplifier to be shared between the two beams. Latching circulators and updated LNAs were used to improve receive sensitivity. Significant mechanical modifications were required which also improved thermal performance and maintainability. The Ku-band transceiver upgrade was completed early this year with a 100W amplifier. Latching circulators and better LNAs were also used to enhance performance. Shown below are completely new chassis that were built for the Ku- and Ka transceivers that resulted in approximately 10 dB improvements in sensitivity each.



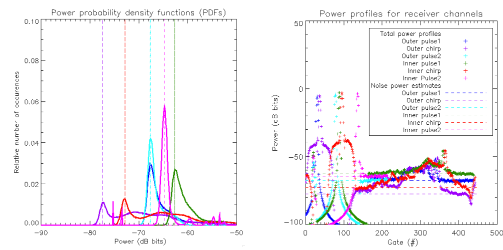








RECENT OBSERVATIONS



In addition to the hardware upgrades, significant changes were also made to the HIWRAP signal processing software. Precise estimation of radar reflectivity requires subtraction of receiver noise power. In turn, the noise power depends on the antenna brightness temperature – a quantity which can vary upto 1 dB due to the presence on lightning and hydrometeors. A common approach is to use one receiver channel at an offset frequency to sample receiver noise power and relate this back to the frequency of interest. However, since HIWRAP has multiple beams (Inner/Outer) and frequencies (Ku/Ka), spare receiver channels were not available. The need for continuous measurements of the radar noise power is met by estimating the probability density function (PDF) of total power. The idea is that the PDF of power in a range profile – to first order – is approximately Gaussian with a long tail appended to the right. Based on results obtained on the 3 radars, it has appeared reasonable to assume that the noise power measurements at various gates are identically Gaussian distributed. By the same measure, the signal power contributions are independently distributed and spread out to superimpose a long tail to the Gaussian distribution due to noise. By fitting a Gaussian around the peak of the power PDF across profiles, we have been able to get robust estimates of the noise power. An additional blended product was added, where the range-sidelobe of the chirp channel is replaced by samples form the corresponding pulse channel. Simulations of pulse-compression using the implemented transmit waveform were used to synthesize a mask.