**High-altitude Imaging Wind and Rain Airborne Profiler (HIWRAP)**

***Summary***

The High-altitude Imaging Wind and Rain Airborne Profiler (HIWRAP) is a dual-frequency (Ku- and Ka-band, similar to the Global Precipitation Mission (GPM) Dual-frequency Precipitation Radar (DPR) frequencies), and dual-look angle (30 & 40 degree incidence angle) Doppler radar system. It was developed under the support of the NASA Instrument Incubator Program (IIP) and flew for the first time on the NASA Global Hawk during Genesis and Rapid Intensification Processes (GRIP) in 2010 with a downward-looking conical scan antenna.

On Global Hawk, HIWRAP utilizes a dual-look angle antenna (30 & 40 degree incidence angle) with a dual-frequency (Ku- and Ka-band) feed at each angle. Each of the solid based transceivers (Ku and Ka-band) uses a single up-converter to generate an upper and a lower sideband signals, which are sent to the inner feed (30 degree) and the outer feed (40 degree), respectively. Therefore HIWRAP is able to transmit and receive four RF beams simultaneously. In addition, the use of a direct digital synthesizer (DDS) for transmit waveform generation and FPGA based digital receiver for data acquisition enable HIWRAP to transmit and receive a versatile waveform within each RF beam, including fully programmable FM chirps and conventional pulses. Each of the chirps or pulses has a slightly different center frequency so that they can be separated by the digital receiver. During GRIP, a waveform consists of a 20 μs linear FM chirp and a 2 μs conventional pulse was used for each RF beam. The 20 chirp pulse is the main return of interest. The conventional pulse is used to obtain returns near the radar in the “blind” zone of the chirp pulse. The reflectivity from the chirp channel has about 7 to 9 dB higher sensitivity than that of short pulses.

***Instrument Description***

Table 1. HIWRAP Ku-band System Specifications During GRIP

|  |  |
| --- | --- |
| Parameters | Specifications |
|  | Inner Beam  | Outer Beam  |
| RF Frequency (GHz) | Chirp mode: 13.915Pulse mode: 13.896 | Chirp mode: 13.464Pulse mode: 13.483 |
| Transmitter Peak Power (dBm)(at Transceiver Tx/Rx port)  | 40.27 | 40.00 |
| Antenna Gain (dB) | 35.40 | 35.20 |
| Antenna 3 dB Beamwidth AZ (o) | 3.07 | 2.90 |
| Antenna 3 dB Beamwidth EL (o) | 2.90 | 3.00 |
| PRF (Hz) | 4516/3859 |
| RF Pulse Width (μs)  | Chirp mode: 20.0 Pulse mode: 2.0 | Chirp mode: 20.0 Pulse mode: 2.0 |
|  Receiver Bandwidth (MHz)  | 2 | 2 |
|  Doppler Range (m/s) | +/- 97.4 | +/-100.6 |
|  Minimum Detectable Reflectivity (dBZ) (@10 km, ave 128 samples) | Chirp mode: 3.6Pulse mode: 11.2 | Chirp mode: 2.5Pulse mode: 9.5 |

Table 2. HIWRAP Ka-band System Specifications During GRIP

|  |  |
| --- | --- |
| Parameters | Specifications |
|  | Inner Beam  | Outer Beam  |
| RF Frequency (GHz) | Chirp mode: 35.546Pulse mode: 35.558 | Chirp mode: 33.733Pulse mode: 33.722 |
| Transmitter Peak Power (dBm)(at Transceiver Tx/Rx port)  | 31.0 | 33.0 |
| Antenna Gain (dB) | 42.80 | 42.20 |
| Antenna 3 dB Beamwidth AZ (o) | 1.20 | 1.33 |
| Antenna 3 dB Beamwidth EL (o) | 1.21 | 1.26 |
| PRF (Hz) | 4516/3859 |
| RF Pulse Width (μs)  | Chirp mode: 20.0 Pulse mode: 2.0 | Chirp mode: 20.0 Pulse mode: 2.0 |
|  Receiver Bandwidth (MHz)  | 2 | 2 |
|  Doppler Range (m/s) | +/- 38.1 | +/-40.2 |
|  Minimum Detectable Reflectivity (dBZ) (@10 km, ave 128 samples) | Chirp mode: -2.6Pulse mode: 5.1 | Chirp mode: -4.6Pulse mode: 3.1 |

***Data Release History***

*3-30-2012: - 9/16/2010, 9/24/2010 reflectivity and Doppler velocity, multiple files per day*

***File Naming Convention and Data Format***

* The data files are in NetCDF (Network Common Data Form), and are named as the example below:

grip\_hiwrap\_subc\_yymmdd\_hhmmss\_hhmmss.nc

subc – indicate radar frequency (Ku or Ka), inner or outer beam, and pulse sequence (chirp or pulse).

yymmdd\_hhmmss\_hhmmss – indicate the GPS (note that GPS time is ahead of UTC by 15 sec) start and end time of the data (year, month, day and hours, minutes, seconds)

* The vertical resolution is 150 meters and horizontal resolution is about 0.6 km.
* Measurements included within the data files are chirp radar reflectivity and Doppler velocity profiles for given radar frequency and antenna pointing angle (inner or outer beam).
* The Doppler velocity has been corrected for folding and aircraft motion.
* Other information associated with data positions is also included. These data can be read with most any NetCDF reader, thus no sample read software is provided by the data producer. More information about NetCDF may be found at

<http://www.unidata.ucar.edu/software/netcdf/>

* An example of metadata is given at the end of this document.

***Data Policy***

The HIWRAP data collection was funded by the NASA GRIP mission. Access to HIWRAP data is not restricted. However, we do ask that data users respect the experiment PIs and others with rights to the data. Acknowledgement or an offer of co-authorship on any publications, presentation, etc., should be made to the PI and his/her team if images and/or data are used (even if they are freely accessed).

***Contact Information***

Users are welcome to address questions and provide feedback to

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**Appendix I Example of metadata**

netcdf grip\_hiwrap\_kainnerchirp\_20100924\_071349-074250 {

dimensions:

 time = 75499 ;

 range = 162 ;

variables:

 short year ;

 year:long\_name = "Year the data was collected" ;

 float freq ;

 freq:long\_name = "Frequency of radar" ;

 freq:units = "GHz" ;

 float incid ;

 incid:long\_name = "Incidence Angle" ;

 incid:units = "Deg" ;

 float tilt ;

 tilt:long\_name = "Tilt Angle" ;

 tilt:units = "Deg" ;

 float gatesp ;

 gatesp:long\_name = "range gate spacing" ;

 gatesp:units = "m" ;

 float missing ;

 missing:long\_name = "missing value" ;

 missing:units = " " ;

 float noise\_thresh ;

 noise\_thresh:long\_name = "noise thresheld" ;

 noise\_thresh:units = " " ;

 float time(time) ;

 time:long\_name = "computer time (sec from last Sunday at 12 am)" ;

 time:units = "sec" ;

 float rot(time) ;

 rot:long\_name = "Rotation angle" ;

 rot:units = "degree" ;

 float range(range) ;

 range:long\_name = "range from radar" ;

 range:units = "km" ;

 float lat(time) ;

 lat:long\_name = "GPS Global Hawk latitude, minus sign= South" ;

 lat:units = "degree" ;

 float lon(time) ;

 lon:long\_name = "GPS aircraft longitude, minus sign=West" ;

 lon:units = "degree" ;

 float roll(time) ;

 roll:long\_name = "aircraft roll angle" ;

 roll:units = "degree" ;

 float pitch(time) ;

 pitch:long\_name = "aircraft pitch angle" ;

 pitch:units = "degree" ;

 float track(time) ;

 track:long\_name = "aircraft track angle" ;

 track:units = "degree" ;

 float alt(time) ;

 alt:long\_name = "aircraft altitude" ;

 alt:units = "meter" ;

 float head(time) ;

 head:long\_name = "aircraft heading" ;

 head:units = "deg" ;

 float evel(time) ;

 evel:long\_name = "East aircraft ground speed" ;

 evel:units = "m/s" ;

 float nvel(time) ;

 nvel:long\_name = "North aircraft ground speed" ;

 nvel:units = "m/s" ;

 float wvel(time) ;

 wvel:long\_name = "aircraft vertical speed" ;

 wvel:units = "m/s" ;

 float vacft(time) ;

 vacft:long\_name = "Estimate of aircraft Doppler component" ;

 vacft:units = "m/s" ;

 float sgate(time) ;

 sgate:long\_name = "Surfaec gate number" ;

 sgate:units = " " ;

 float pwr(time, range) ;

 pwr:long\_name = "Return power" ;

 pwr:units = "dB" ;

 float ref(time, range) ;

 ref:long\_name = "HIWRAP Radar Reflectivity" ;

 ref:units = "dBZ" ;

 float dopcorr(time, range) ;

 dopcorr:long\_name = "HIWRAP Doppler Velocity after correct for aircraft motion and folding" ;

 dopcorr:units = "m s-1" ;

// global attributes:

 :title = "HIWRAP Data, NASA Goddard Space Flight Center" ;

 :filename = "/karldata4/tian/GRIP/netcdf/grip\_hiwrap\_kainnerchirp\_20100924\_071349-074

250.nc" ;

 :experiment = "NASA GRIP" ;

 :source = "created from HIWRAP binary file, Version 0.0" ;

 :comments = "Contact: lin.tian-1@nasa.gov" ;

**}**