Global Hydrology Resource Center

Data User Guide

Hurricane and Severe Storm Sentinel (HS3) Hurricane Imaging Radiometer (HIRAD)

Introduction

The Hurricane Imaging Radiometer (HIRAD) utilized NASA Instrument Incubator Technology which provided unique observations of sea surface wind, temperature and rain. HIRAD data was collected during the HS3 field experiment. It measured brightness temperature at 4, 5, 6 and 6.6 GHz. Ocean surface wind speed and rain rate are derived from the brightness temperature measurements.

Citation

Cecil, Daniel J. and Sayak Biswas. 2015. Hurricane and Severe Storm Sentinel (HS3) Hurricane Imaging Radiometer (HIRAD) [indicate subset used]. Dataset available online [https://hs3.nsstc.nasa.gov/pub/hs3/HIRAD/] from the NASA EOSDIS Global Hydrology Resource Center Distributed Active Archive Center, Huntsville, Alabama, U.S.A. doi: http://dx.doi.org/10.5067/HS3/HIRAD/DATA201

Keywords:

NASA, GHRC; HS3, HIRAD; Atlantic Ocean; aircraft observations, Global Hawks; radiometer, multi-frequency interferometric radiometer, passive microwave sensor; sea surface wind, temperature, rain; hurricane, hurricane study campaign;

Campaign

The Hurricane and Severe Storm Sentinel (HS3) was a five-year NASA mission specifically targeted to investigate the processes that underlie hurricane formation and intensity change in the Atlantic Ocean basin. Goals for HS3 included: assessing the relative roles of large-scale environment and storm-scale internal processes; and addressing the controversial role of the Saharan Air Layer (SAL) in tropical storm formation and intensification as well as the role of deep convection in the inner-core region of storms. To achieve these goals, sustained measurements over several years was needed to get a large enough sample of storms. Therefore, field measurements took place from 2012 through 2014 for one month during each hurricane season. The HS3 campaign utilized two Global Hawks, one with instruments geared toward measurement of the environment and the other with instruments suited to inner-core structure and processes. The environmental payload included the scanning High-resolution Interferometer Sounder (S-HIS) and the AVAPS dropsonde system; the over-storm payload included the HIWRAP conically scanning Doppler radar, the HIRAD multi-frequency interferometric radiometer, and the HAMSR microwave sounder. More information about the HS3 campaign can be found at https://hs3.nsstc.nasa.gov/.

Instrument Description

HIRAD (Hurricane Imaging Radiometer) was a passive microwave sensor that operated in the C-band frequencies (4, 5, 6, and 6.6 GHz) to measure strong winds and rain over the ocean surface. Using a synthetic aperture technique with no moving parts, the instrument provided both along-track and cross track resolution of better than 2 km at nadir (~5 km near swath edges), with a swath width of approximately 60 km when flown on a high-altitude airborne platform. Similar to SFMR (Stepped Frequency Microwave Radiometer), it consisted of a single nadir-viewing antenna and receiver capable of making measurements of radio emission from the sea surface at six selectable frequencies between 4 and 7 GHz. The broad spectral coverage and signal processing algorithm enabled the simultaneous retrieval of both hurricane surface wind speeds and rain rates. HIRAD added the capability for cross-track wind retrievals by using a synthetic thinned array planar antenna. HIRAD was mounted forward of zone 61, beneath the tail of AV-1.

List of data products provided based on calibrated HIRAD observations during HS3.

Parameter	Description	Spatial Resolution†		Temporal Resolution††
Brightness temperature	Calibrated brightness temperature @ 4, 5, 6, 6.6 GHz for level flight legs over storm	***Along-Track x Cross-Track (km)***		1 second
Excess brightness temperature	Observed brightness temperatures @ 4, 5, 6, 6.6 GHz in excess of that based on a model using observed sea surface temperatures and assumptions of no rain and calm winds at ocean surface	*Angle* 0° 15° 30° 45° 60°	*Res.* 1.9x1.2 2.0x1.4 2.2x1.8 2.7x3.1 3.8x9.6	
Wind speed	Wind speed determined from application of inverse model to observed brightness temperatures			
Rain rate	Rain rate determined from application of inverse model to observed brightness temperatures			
Georeferencing information	Latitudes, longitudes, and times of observed brightness temperature in both absolute and storm-relative coordinates			
Aircraft navigation	Aircraft attitude (i.e. pitch, roll, heading), altitude, and ground speed			
Data Quality Flag	Flags indicating potential interference from RFI or land			

†The spatial resolution estimate is based on a nominal flight altitude of 18km and an aircraft ground speed of 200m/s. Spatial resolution are based on the 4 GHz footprint size.
††HIRAD observations are oversampled. The current product will be provided at evenly sampled times.

During operation, radio frequency interference (RFI) and land scenes are potential sources of contamination to HIRAD measurements in the C-band frequency range. Kurtosis-based and median filter detection routines are used to identify RFI and flags are provided to identify such circumstances. Any scenes with potential land contamination are also flagged.

More information about HIRAD can be found at http://hirad.nsstc.nasa.gov/ and https://www.nasa.gov/content/goddard/nasas-hs3-mission-spotlight-the-hirad-instrument/#.VcJFoflVhBc.

More details about HIRAD data format and metatdata can be found at https://hs3.nsstc.nasa.gov/pub/hs3/HIRAD/doc/HIRAD_data_hs3_2014.pdf.

Further details on specific data archived by the GHRC for HS3 HIRAD for Hurricane Gonzalo can be found at https://hs3.nsstc.nasa.gov/pub/hs3/HIRAD/doc/readme_gonzaloFLT2014.pdf.

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File Naming Convention

The HIRAD dataset files are named with the following convention:

HIRAD_data_yyyymmddTHHMMSS_ yyyymmddTHHMMSS_legNN.nc

Where,

NN = leg number. Data is divided into a number of flight legs.
yyyymmddTHHMMSS = UTC time for the start and end of each file with 'T' being a separator between date and time fields.

Data Format Description

The Hurricane and Severe Storm Sentinel (HS3) Hurricane Imaging Radiometer (HIRAD) data is available in NetCDF format.

References

Braun, S.A., Vasques, M. 2015. "Hurricane and Severe Storms Sentinel (HS3) Data Management Plan." Earth Science Division, NASA Science Mission Directorate.

Ruf, C.; Roberts, J.B.; Biswas, S.; James, M.; Miller, T., "Calibration and image reconstruction for The Hurricane Imaging Radiometer (HIRAD)," Geoscience and

Remote Sensing Symposium (IGARSS), 2012 IEEE International , vol., no., pp.4641,4643, 22-27 July 2012

Contact Information

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