Global Hydrology Resource Center

## Data User Guide

# *Hurricane and Severe Storm Sentinel (HS3) Statistical Hurricane Intensity Prediction Scheme (SHIPS) Intensity*

## Introduction

The Hurricane and Severe Storm Sentinel (HS3) Statistical Hurricane Intensity Prediction Scheme (SHIPS) Intensity dataset was obtained from March 18, 2014 through September 30, 2014 during the Hurricane and Severe Storm Sentinel (HS3) field campaign. Goals for the HS3 field campaign included assessing the relative roles of large-scale environment and storm-scale internal processes, addressing the controversial role of the Saharan Air Layer (SAL) in tropical storm formation and intensification, and the role of deep convection in the inner-core region of storms. The SHIPS model provides tropical storm intensity forecasts for the Atlantic Ocean and the eastern and central North Pacific Ocean storms and invest areas. SHIPS uses GOES infrared imagery as input to the systems. These SHIPS data are available in ASCII format.

## Citation

Cione, Joe, Mark DeMaria, Jim Gross, John Kaplan, John Knaff, Michelle Mainelli, Buck Sampson, Andrea Schumacher, Nick Shay, and Chris Sisko. 2018. Hurricane and Severe Storm Sentinel (HS3) Statistical Hurricane Intensity Prediction Scheme (SHIPS) Intensity [indicate subset used]. Dataset available online 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/SHIPS/DATA101

## Keywords:

*NOAA, GHRC, HS3, SHIPS, wind shear, wind direction, atmospheric temperature, atmospheric pressure, vertical wind shear, persistence, ocean heat content, RII*

## Campaign

The Hurricane and Severe Storm Sentinel (HS3) was a five-year NASA field campaign mission targeted to investigate the processes that underlie hurricane formation and intensity change, including assessing the relative roles of the large-scale environment and the storm-scale internal processes. To achieve these goals, three 5-week campaigns were carried out during 2012 - 2014 which consisted of 21 flight missions over nine storms, two undeveloped systems, and several Saharan air layer outbreaks. 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 (SHIS) 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. Information about instrument flights made during each campaign year are summarized in Table 2 of the HS3 2016 BAMS paper. More information about the HS3 campaign can be found at https://ghrc.nsstc.nasa.gov/home/projects/hs3.

## Product Description

The Statistical Hurricane Intensity Prediction Scheme (SHIPS) is one of the statistical forecast models used to forecast tropical storm intensity changes. SHIPS was developed in 1988 by John Kaplan from the Hurricane Research Division (HRD) and was built on a previous effort of statistical intensity forecasting by John Merrill. SHIPS combines predictors from climatology, persistence, atmospheric environmental parameters, such as vertical wind shear, and sea surface temperature (SST) to estimate changes in the maximum sustained surface winds of tropical cyclones using a linear regression technique. Infrared imagery (10.7 micrometers) from the Geostationary Operational Environmental Satellite (GOES) are also used as inputs in the SHIPS model.

The original SHIPS model was 'statistical-synoptic' where no information from large-scale forecast models were used; however, in 1997, the model was converted to a 'statistical-dynamical' model where predictors were obtained from atmospheric forecast models. Though the SHIPS forecasts have shown some skill compared to climatology and persistence forecasts, the model does not perform well for rapidly intensifying cases. Due to this, the Rapid Intensity Index (RII) was developed to provide an estimate of the probability of rapid intensification in the next 24 hours.

The SHIPS model provides intensity forecasts for the Atlantic Ocean and the eastern and central North Pacific Ocean. The final output of this model includes wind shear, wind direction, atmospheric temperature, atmospheric pressure, vertical wind shear, persistence, and ocean heat content estimates, as well as RII estimates. More information about the SHIPS model is available at the SHIPS Technique Develop web page, the TC Phase Space Study web page, DeMaria et al., 2005, DeMaria and Kaplan, 1999, and DeMaria and Kaplan, 1994.

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## Data Characteristics

The Hurricane and Severe Storm Sentinel (HS3) Statistical Hurricane Intensity Prediction Scheme (SHIPS) Intensity data files are available in ASCII format. These data are at a Level 4 processing level. More information about the NASA data processing levels are available on the NASA Data Processing Levels website. Table 1 shows the characteristics of the data files.

Table 1: Data Characteristics

| Characteristic | Description |
|---|---|
| Platform | Ground station and GOES satellite |
| Instrument | Rawinsondes, GOES IR |
| Spatial Coverage | N: 44.51, S: 7.19, E: -14.99, W: -179.11 (Tropics) |
| Spatial Resolution | 4 degrees |
| Temporal Coverage | March 18, 2014 - September 30, 2014 |
| Temporal Resolution | 6 hours |
| Parameters | Wind shear, wind direction, atmospheric temperature, atmospheric pressure, vertical wind shear, persistence, ocean heat content, RII |
| Version | 1 (applies to this GHRC HS3 SHIPS product subset) |
| Processing Level | 4 |

## File Naming Convention

The Hurricane and Severe Storm Sentinel (HS3) Statistical Hurricane Intensity Prediction Scheme (SHIPS) Intensity dataset has the file naming convention shown below. These data are available in ASCII format.

**Data files:** hs3_ships_YYYYMMDDhhBBxx####.txt

Table 2: File naming convention variables

| Variable | Description |
|---|---|
| YYYY | Four-digit year |
| MM | Two-digit month |
| DD | Two-digit day |
| hh | Two-digit hour in UTC |
| BBxx#### | Basin and storm or invest number:<br>EP = Eastern Pacific<br>CP = Central Pacific<br>AL = Atlantic |
| .txt | ASCII file format |

## Data Format and Parameters

The Hurricane and Severe Storm Sentinel (HS3) Statistical Hurricane Intensity Prediction Scheme (SHIPS) Intensity data files are available in ASCII format. The ASCII files includes estimations of environmental parameters, shown in Table 3, individual contributions to intensity change, and probability for intensification. More information about these data parameters are available the SHIPS Predictor Files document.

Table 3: SHIPS environmental parameter estimates

| Field Name | Description | Unit |
|---|---|---|
| TIME | Amount of time from model output | hr |
| V NO LAND | Velocity over ocean | kt |
| V LAND | Velocity over land | kt |
| Storm Type | Storm type:<br>Tropical storm, extra-tropical storm, hurricane | - |
| SHEAR | Wind shear | kt |
| SHEAR ADJ | Adjacent wind shear | kt |
| SHEAR DIR | Wind shear direction | deg |
| SST | Sea Surface Temperature | Degrees Celsius |
| POT. INT. | Potential intensity | kt |
| 200 MB T | Temperature at 200 mb | Degrees Celsius |
| TH_E DEV | Equivalent potential temperature | Degrees Celsius |
| 700-500 MB RH | Relative humidity at 700-500 mb | % |
| GFS VTEX | Global Forecast System estimated wind speed | kt |
| 850 MB ENV VOR | 850 millibar altitude environmental vorticy | $s^{-1}*10^{7}$ |
| 200 MB DIV | 200 millibar altitude divergence | - |
| 700-850 TADV | 700 - 850 mb temperature advection | degrees/ $sec*10^{6}$ |
| LAND | distance to land | km |
| LAT | Latitude | Degrees North |
| LONG | Longitude | Degrees West |
| STM SPEED | Storm speed | kt |
| HEAT CONTENT | Heat content | - |

## Algorithm

The SHIPS model combines predictors from climatology, persistence, atmospheric environmental parameters, such as vertical wind shear, and sea surface temperature (SST) to estimate changes in the maximum sustained surface winds of tropical cyclones using a linear regression technique. Environmental parameters are obtained from atmospheric forecast model models. The RII probabilities are provided as part of the SHIPS model text file and use a subset of the SHIPS predictors most related to rapid intensification in a discriminant analysis algorithm. The SHIPS model uses a linear regression technique with the impacts of land applied as a correction in a post-processing step. More information about the algorithms used in the SHIPS model is available at the SHIPS Technique Develop web page, the TC Phase Space Study web page, DeMaria et al., 2005, DeMaria and Kaplan, 1999, and DeMaria and Kaplan, 1994.

## Quality Assessment

The accuracy of the wind estimates of SHIPS are ±10-15 knots, while the average error in the minimum central pressure is about 10 mb. Also, weekly sea surface temperature analyses were replaced with climatological sea surface temperature to improve accuracy for the SHIPS model. More information about the quality of the SHIPS model is available in DeMaria et al., 2005 and DeMaria and Kaplan, 1999.

## Software

These data are available as ASCII data, so no software is required to view this dataset.

## Known Issues or Missing Data

Though the SHIPS forecasts have shown some skill compared to climatology and persistence forecasts, the model does not perform well for rapidly intensifying cases. Also, the model is skillful in the short range of 12 to 24 hours, but does not have nearly as much skill after 24 hours.

## References

Braun, Scott A., Paul A. Newman, and Gerald M. Heymsfield (2016). NASA's Hurricane and Severe Storm Sentinel (HS3) Investigation, *American Meteorological Society BAMS*, November 2016, 2085-2102. doi: https://doi.org/10.1175/BAMS-D-15-00186.1

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## Related Data

All data collected during the HS3 field campaign should be considered related datasets. To locate other HS3 data, use the GHRC search tool HyDRO 2.0 with the search term 'HS3'.

## Contact Information

To order these data or for further information, please contact:

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Created: August 17, 2018