Data User Guide

GOES IMPACTS

Introduction

The GOES IMPACTS dataset consists of single reflective band radiance products from the Advanced Baseline Imager (ABI) onboard the GOES-16 geostationary satellite. These data were collected in support of the Investigation of Microphysics and Precipitation for Atlantic Coast-Threatening Snowstorms (IMPACTS) field campaign. IMPACTS was a three-year sequence of winter season deployments conducted to study snowstorms over the U.S Atlantic Coast (2020-2023). The campaign aimed to (1) Provide observations critical to understanding the mechanisms of snowband formation, organization, and evolution; (2) Examine how the microphysical characteristics and likely growth mechanisms of snow particles vary across snowbands; and (3) Improve snowfall remote sensing interpretation and modeling to significantly advance prediction capabilities. The GOES IMPACTS dataset files are available in netCDF-4 format from January 1 through February 29, 2020. This dataset contains data from the GOES-16 CONUS and Mesoscale sectors, although IMPACTS uses a subset of the GOES-16 CONUS domain. The complete collection of GOES data is available from the NOAA Comprehensive Large Array-Data Stewardship System (CLASS). It should be noted that this dataset will be updated in subsequent years of the IMPACTS campaign.

Citation

Brodzik, Stacy. 2020. GOES IMPACTS [indicate subset used]. Dataset available online from the NASA Global Hydrometeorology Resource Center DAAC, Huntsville, Alabama, U.S.A. doi: http://dx.doi.org/10.5067/IMPACTS/GOES/DATA101

Keywords:

NASA, GHRC, NCAR, NOAA, IMPACTS, GOES-16, ABI, EM, radiance, visible, near-infrared, infrared

Campaign

The Investigation of Microphysics and Precipitation for Atlantic Coast-Threatening Snowstorms (IMPACTS), funded by NASA's Earth Venture program, is the first comprehensive study of East Coast snowstorms in 30 years. IMPACTS will fly a complementary suite of remote sensing and in-situ instruments for three 6-week deployments (2020-2023) on NASA's ER-2 high-altitude aircraft and P-3 cloud-sampling aircraft. The first deployment began on January 17, 2020 and ended on March 1, 2020. IMPACTS samples U.S. East Coast winter storms using advanced radar, LiDAR, and microwave radiometer remote sensing instruments on the ER-2 and state-of-the-art microphysics probes and dropsonde capabilities on the P-3, augmented by ground-based radar and rawinsonde data, multiple NASA and NOAA satellites (including GPM, GOES-16, and other polar orbiting satellite systems), and computer simulations. IMPACTS addressed three specific objectives: (1) Provide observations critical to understanding the mechanisms of snowband formation, organization, and evolution; (2) Examine how the microphysical characteristics and likely growth mechanisms of snow particles vary across snowbands; and (3) Improve snowfall remote sensing interpretation and modeling to significantly advance prediction capabilities. More information is available from NASA's Earth Science Project Office's IMPACTS field campaign webpage.

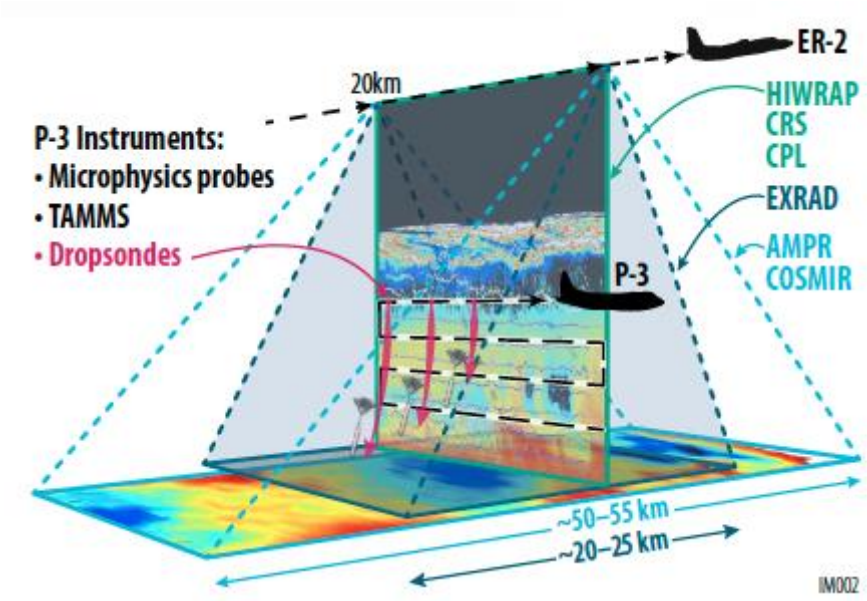

Figure 1: IMPACTS airborne instrument suite
(Image source: NASA IMPACTS ESPO)

Instrument Description

The Geostationary Operational Environmental Satellites - R series (GOES-R) is a geostationary satellite program comprised of a four-satellite fleet including GOES-R, GOES-S, GOES-T, and GOES-U. The GOES-R Series Program is a collaborative development and acquisition effort between the National Oceanic and Atmospheric Administration (NOAA) and the National Aeronautics and Space Administration (NASA) to develop, launch and

operate the satellites. The first satellite in the GOES-R series, GOES-R, launched on November 19, 2016 and became GOES-16 when it reached geostationary orbit (Figure 2). GOES-16 replaced GOES-13 as NOAA's operational GOES East satellite at 75.2 degrees west longitude on December 18, 2017. GOES-16 observes North and South America, as well as the Atlantic Ocean all the way to the west coast of Africa. More information about the GOES-R mission can be found at the GOES-R website.

GOES-16 provides high spatial and temporal resolution imagery of the Earth using its Advanced Baseline Imager (ABI). ABI is the main Earth observing instrument onboard GOES-16. It is a passive imaging radiometer that uses a total of 16 channels (spectral bands) to measure the outgoing radiance from the Earth's surface and atmosphere; including two visible bands, four near-infrared bands, and ten infrared bands (see Table 1). This provides key information about Earth's weather and environmental processes. ABI collects data for multiple image sectors including for the Continental U.S. (CONUS) and Mesoscale. "CONUS" provides coverage of the 5000 km x 3000 km rectangle over the continental U.S. and "Mesoscale" provides coverage of a 1000 x 1000 km box over a particular region of interest. The Mesoscale 1 and 2 sectors were specially dedicated to IMPACTS operations during the campaign. ABI has a number of scan modes. Mode 6 became the default operating mode in April 2019, and provides a full disk image every 10 minutes, a CONUS image every 5 minutes, and images from Mesoscale sectors 1 and 2 every 60 seconds. More information about ABI is available on the GOES-R ABI webpage.

Table 1: GOES ABI Spectral Bands

ABI Band Number	Description	Central Wavelength (μm)	Best Spatial Resolution
Band 1	visible; blue	0.47 μm	1 km
Band 2	visible; red	0.64 μm	0.5 km
Band 3	near-infrared; veggie	0.86 μm	1 km
Band 4	near-infrared; cirrus	1.47 μm	2 km
Band 5	near-infrared; snow/ice	1.6 μm	1 km
Band 6	near-infrared; cloud particle size	2.2 μm	2 km
Band 7	infrared; shortwave window	3.9 μm	2 km
Band 8	infrared; upper-level water vapor	6.2 μm	2 km
Band 9	infrared; mid-level water vapor	6.9 μm	2 km
Band 10	infrared; lower-level water vapor	7.3 μm	2 km
Band 11	infrared; cloud-top phase	8.4 μm	2 km
Band 12	infrared; ozone	9.6 μm	2 km
Band 13	infrared; "clean" longwave window	10.3 μm	2 km
Band 14	infrared; longwave window	11.2 μm	2 km

Band 15	infrared; “dirty” longwave window	12.3 μm	2 km
Band 16	infrared; CO_2 longwave	13.3 μm	2 km

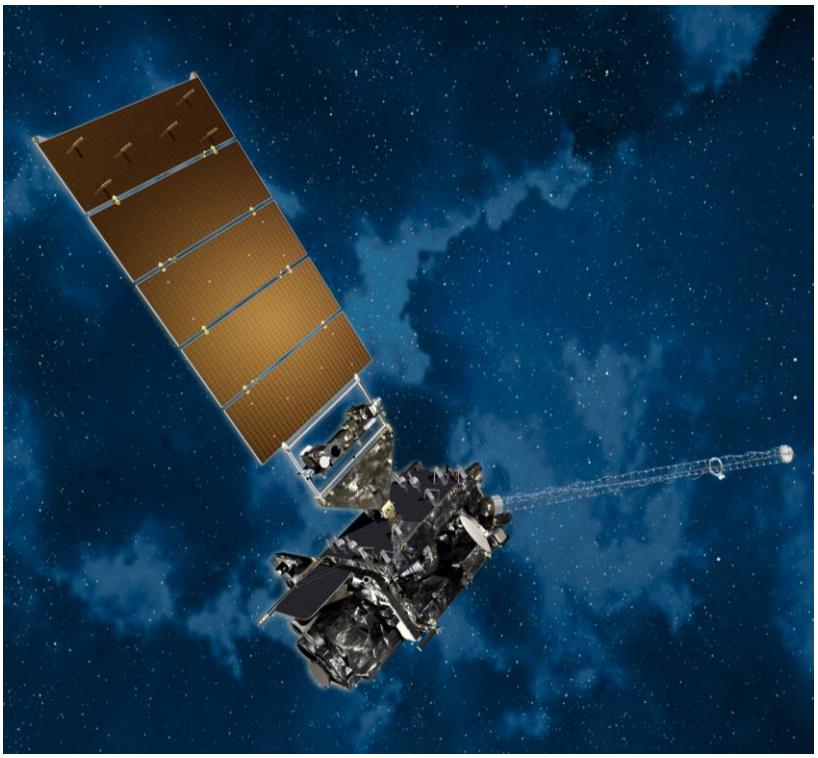

Figure 2: GOES-16 Satellite
(Image source: NASA)

Investigators

Stacy Brodzik
University of Washington
Seattle, WA

Data Characteristics

The GOES IMPACTS dataset contains single reflective band ABI radiance products. These data consist of digital maps of outgoing radiance values at the top of the atmosphere for visible, near-infrared, and infrared bands. The data are available for two sectors: Mesoscale and CONUS. The CONUS radiance data were navigated to a latitude/longitude grid using NCAR’s GoesRnetCDF2Mdv software. The Mesoscale data files are raw files that have not undergone any processing. The Mesoscale data include all 16 bands while CONUS data only include 5 of 16 bands (bands 1, 8, 9, 10, and 13). These data were collected in ABI scan mode 6, therefore CONUS files are available every 5 minutes and Mesoscale files every 1 minute. The Mesoscale data are available at a Level 1B processing level and the CONUS data

are available at a Level 3 processing level. More information about the NASA data processing levels are available on the EOSDIS Data Processing Levels webpage. The characteristics of this dataset are listed in Table 2 below.

Table 2: Data Characteristics

Characteristic	Description
Platform	NOAA GOES-16 Geostationary Satellite (GOES-16)
Instrument	Advanced Baseline Imager (ABI)
Spatial Coverage	N: 49.980 , S: 8.241, E: -50.126, W: -105.0 (Eastern half of United States - Subset of the ABI CONUS domain)
Spatial Resolution	CONUS: 0.02 deg (~20 km) Mesoscale: 0.5 - 2 km at nadir
Temporal Coverage	January 1, 2020 - February 29, 2020
Temporal Resolution	CONUS: 5 minutes Mesoscale: 1 minute
Parameter	Visible, Near-infrared, and Infrared radiance
Version	1
Processing Level	1B and 3

File Naming Convention

The GOES IMPACTS dataset files are named using the following convention:

Data files:
IMPACTS_goes16_[conus|mesoscale]_YYYYMMDD_hhmmss_<channel>.nc

Table 3: File naming convention variables

Variable	Description
YYYY	Four-digit year
MM	Two-digit month
DD	Two-digit day
hh	Two-digit hour in UTC
mm	Two-digit minute in UTC
ss	Two-digit second in UTC
[conus|mesoscale]	Data file type conus: GOES CONUS data files mesoscale: GOES Mesoscale data files
channel	ABI channel: ch01, ch02, ch03, ch04, ch05, ch06, ch07, ch08, ch09, ch10, ch11, ch12, ch13
.nc	netCDF-4 format

Data Format and Parameters

The GOES IMPACTS data files are organized by coverage area: CONUS or Mesoscale. The CONUS files contain radiance data from channels 1, 8, 9, 10, and 13 while the Mesoscale files contain radiance data from all 16 ABI channels. CONUS files are available every 5 minutes and Mesoscale files are available every 1 minute. The data fields contained in each CONUS file are listed in Table 4 while the data fields contained in each Mesoscale file are listed in Table 5.

Table 4: CONUS Data Fields

Field Name	Description	Data Type	Unit
time*	Data time	datetime64[ns]	-
x0*	Longitude	float32	degrees_east
y0*	Latitude	float32	degrees_north
z0*	Vertical level type unknown (positive: up)	float32	-
start_time	Start time	datetime64[ns]	-
stop_time	Stop time	datetime64[ns]	-
time_bounds	File time bounds	datetime64[ns]	-
grid_mapping_0	Grid mapping name (Latitude_Longitude)	int32	-
mdv_master_header	File header information	int32	-
GOESR_CH##*	Field depends on channel number 01: GOESR_CH01_vis_blue_0.47um 08: GOESR_CH08_upper_level_wv_06.2um 09: GOESR_CH09_mid_level_wv_06.9um 10: GOESR_CH10_low_level_wv_07.3um 13: GOESR_CH13_clean_IR_10.3um	float32	%

*This field will change depending on the spectral band. The field name will have the format *GOESR_CH##* where ## can be 01, 08, 09, 10, or 13; corresponding to the spectral bands available for IMPACTS CONUS files.

Table 5: Mesoscale Data Fields

Field Name	Description	Data Type	Units
t *	J2000 epoch mid-point between the start and end image scan in seconds	datetime64[ns]	-
y*	GOES fixed grid projection y-coordinate	float32	rad
x*	GOES fixed grid projection x-coordinate	float32	rad

y_image*	GOES-R fixed grid projection y-coordinate center of image	float32	rad
x_image*	GOES-R fixed grid projection x-coordinate center of image	float32	rad
band_id*	ABI band number	int8	1
band_wavelength*	ABI band central wavelength	float32	um
t_star_look*	J200 epoch time of star observed in seconds	datetime64[ns]	-
band_wavelength_star_look*	ABI band central wavelength associated with observed star	float32	um
Rad	ABI L1b radiances (TOA outgoing radiance per unit wavelength)	float32	W m^{-2} sr^{-1} um^{-1}
DQF	ABI L1b radiances data quality flags (0, 1, 2, 3, or 4) 0: good_pixel_qf 1: conditionally_usable_pixel_qf 2: out_of_range_pixel_qf 3: no_value_pixel_qf 4: focal_plane_temperature_threshold_exceeded_qf	float32	-
time_bounds	Scan start and end times in seconds since epoch (2000-01-01 12:00:00)	datetime64[ns]	-
goes_imager_projection	GOES-R ABI fixed grid projection	int32	
y_image_bounds	GOES-R fixed grid projection y-coordinate north/south extent of image	float32	rad
x_image_bounds	GOES-R fixed grid projection x-coordinate west/east extent of image	float32	rad
nominal_satellite_subpoint_lat	Nominal satellite subpoint latitude (platform latitude)	float64	Degrees north
nominal_satellite_subpoint_lon	Nominal satellite subpoint longitude (platform longitude)	float64	Degrees east
nominal_satellite_height	Nominal satellite height above GRS 80 ellipsoid	float64	km
geospatial_lat_lon_extent	Geospatial latitude and longitude references	float32	Degrees north (lat) Degrees east (lon)

yaw_flip_flag	Flag indicating the spacecraft is operating in yaw flip configuration (0 or 1) 0: false 1: true	float64	-
band_id	ABI band number	int8	
band_wavelength	ABI band central wavelength	float32	um
esun	Bandpass-weighted solar irradiance at the mean Earth-Sun...	float64	$W\ m^{-2}\ um^{-1}$
kappa0	Inverse of the incoming top of atmosphere radiance at curr...	float64	$(Wm^{-2}\ um^{-1})^{-1}$
planck_fk1	wavenumber-dependent coefficient (2 h c2/ nu3) used in the ABI emissive band monochromatic brightness temperature computation, where *nu* = central wavenumber and *h* and *c* are standard constants	float64	$W\ m^{-1}$
planck_fk2	wavenumber-dependent coefficient (h c nu/b) used in the ABI emissive band monochromatic brightness temperature computation, where *nu* = central wavenumber and *h* and *c* are standard constants	float64	K
planck_bc1	Spectral bandpass correction offset for brightness temperature (B(nu) - bc_1)/bc_2 where *B()* = planck_function() and *nu* = wavenumber	float64	K
planck_bc2	Spectral bandpass correction scale factor for brightness temperature (B(nu) - bc_1)/bc_2 where *B()* = planck_function() and *nu* = wavenumber	float64	-
valid_pixel_count	Number of good and conditionally usable pixels	float64	count
missing_pixel_count	Number of missing pixels	float64	count
saturated_pixel_count	Number of saturated pixels	float64	count
undersaturated_pixel_count	Number of undersaturated pixels	float64	count

focal_plane_temperature_threshold_exceeded_count	Number of pixels whose temperatures exceeded the threshold	float64	count
min_radiance_value_of_valid_pixels	Minimum radiance value of pixels	float64	W m^{-2} sr^{-1} um^{-1}
max_radiance_value_of_valid_pixels	Maximum radiance value of pixels	float64	W m^{-2} sr^{-1} um^{-1}
mean_radiance_value_of_valid_pixels	Mean radiance value of pixels	float64	W m^{-2} sr^{-1} um^{-1}
std_dev_radiance_value_of_valid_pixels	Standard deviation of radiance values of pixels	float64	W m^{-2} sr^{-1} um^{-1}
Maximum_focal_plane_temperature	Maximum focal plane temperature value	float64	K
focal_plane_temperature_threshold_increasing	Focal plane temperature threshold increasing bounds value	float64	K
focal_plane_temperature_threshold_decreasing	Focal plane temperature threshold decreasing bounds value	float64	K
percent_uncorrectable_L0_errors	Percent data lost due to uncorrectable L0 errors	float64	%
earth_sun_distance_anomaly_n_AU	Earth sun distance anomaly in astronomical units	float64	ua
algorithm_dynamic_input_data_container	Container for filenames of dynamic algorithm input data	int32	-
processing_parm_version_container	Container for processing parameter filenames	int32	-
algorithm_product_version_container	Container for algorithm package filename and product version	int32	-
star_id	ABI star catalog identifier associated with observed star	float32	-

*Note: The first nine fields are coordinate fields

Algorithm

ABI is a passive radiometer that images scenes by measuring the electromagnetic (EM) radiation emitted at the top of Earth's atmosphere. It measures the intensity of the outgoing radiation within the visible, near-infrared, and infrared portions of the EM spectrum. After collection, the CONUS ABI radiance data were navigated to a latitude/longitude grid using NCAR's GoesRnetCDF2Mdv software to create the digital radiance maps. More information about remote sensors and radiometers is available on the NASA Earthdata Remote Sensors webpage.

Quality Assessment

All of the ABI bands have on-orbit calibration capabilities. A solar diffuser is used to calibrate the visible and near-infrared bands while a temperature-controlled blackbody is used to calibrate the infrared bands. In addition, a number of field campaigns were undertaken in order to validate measurements from the GOES ABI including the GOES-R Post Launch Test (PLT) field campaign. GOES-R PLT provided post-launch validation of ABI, particularly in the first phase of the campaign, centered over the U.S. west coast. More information about ABI data validation can be found in the ABI Validation Planning document.

Software

This dataset is in netCDF-4 format and does not require any specific software to read. However, the data are easily readable and viewed in Panoply.

Known Issues or Missing Data

There are no known issues with these data or any known gaps in the dataset.

References

GOES-R Series Program Office. (2020). ABI Technical Summary Chart. https://www.goes-r.gov/spacesegment/ABI-tech-summary.html

GOES-R Series Program Office. (n.d.) Geostationary Operational Environmental Satellite (GOES) - R Series: ABI L2+ Surface Downward Shortwave Radiation and Top-of-Atmosphere Reflected Shortwave Radiation (DSR-RSR) Beta, Provisional and Full Validation Readiness, Implementation and Management Plan (RIMP). https://www.goes-r.gov/products/RIMPs/RIMP_ABI-L2_DSR-RSR_v1.0.pdf

GOES-R Series Program Office. (2020). Instruments: Advanced Baseline Imager. https://www.goes-r.gov/spacesegment/abi.html

NASA ESPO. (2020). IMPACTS. https://espo.nasa.gov/impacts/content/IMPACTS

Wu, X., Yu, F., Kondratovich, V., Efremova, B., Shao, X., Iacovazzi, R.... Cao, C. (2017). GOES-16 ABI On-Orbit Performance. *2017 EUMETSAT Satellite Conference*. www.eumetsat.int/website/wcm/idc/idcplg/PDF_EUM_USERS_SCIENCE_PRES_IACOVAZZI%20(1).pdf

Related Data

All other datasets collected as part of the IMPACTS campaign are considered related and can be located by searching the term “IMPACTS” in the GHRC Search Portal.

Contact Information

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

NASA Global Hydrometeorology Resource Center DAAC
User Services
320 Sparkman Drive
Huntsville, AL 35805
Phone: 256-961-7932
E-mail: support-ghrc@earthdata.nasa.gov
Web: https://ghrc.nsstc.nasa.gov/

Created: 08/03/20
Updated: 4/20/23