Introduction of Himawari-8/AHI Flood Mapping Software

Version 1.0

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Contents

1. Introduction

Himawari-8/AHI flood mapping software is adjusted from GOES-16/ABI flood mapping software for automatic flood detection using the AHI data. There is one main module: H8_AHI_Flood_Detection_Version01 to do the flood detection using the AHI 10-minute HSD data. The hourly composition is done with the ABI composition module: ABI_Composition_Process and image display is done with Image Display module. With these modules, the software projects AHI bands (B03, B04, B05 and B13), static sensor zenith angle and static sensor azimuth angle in equidistant cylindrical projection, and then detects floods through a series of process to generate 10-minute flood detection result in HDF4 format. Based on the 10-minute flood datasets, the ABI_Composition_Process module aggregates the results through a rolling composition process to collect the maximal clear-sky coverage during an appointed period, and outputs composited results every hour in hdf4 format. The Image_Display module displays flood detection result in png with a kml description file and geotiff formats.

The software is developed in C/C++ and IDL programming languages, and runs in 32-bit or 64-bit Linux system (recommended).

2. Algorithm description

2.1 AHI flood detection

The algorithms of AHI flood detection are adjusted from the ABI and VIIRS flood detection algorithms. The details of these algorithms can be found in the following references:

[1]. Mitchell Goldberg, Sanmei Li, Steven Goodman, Dan Lindsey, Bill Sjoberg and Donglian Sun (2018). Contributions of Operational Satellites in Monitoring the Catastrophic Floodwaters Due to Hurricane Harvey, Remote Sens. 2018, 10(8), 1256

[2]. SanmeiLi, DonglianSun, Mitchell Goldberg, Bill Sjoberg, David Santek, Jay P. Hoffman, Mike DeWeese, Pedro Restrepo, Scott Lindsey, Eric Holloway (2017). Automatic near real-time flood detection using Suomi-NPP/VIIRS data, Remote Sensing of Environment, 204 (2018) 672–689

[3]. SanmeiLi, DonglianSun, Mitchell D.Goldberg & Bill Sjoberg (2015). Object-based automatic terrain shadow removal from SNPP/VIIRS flood maps, International Journal of Remote Sensing, Vol. 36, No. 21, 5504–5522

[4]. SanmeiLi, DonglianSun, YunyueYu, Ivan Csiszar, Antony Stefanidis & Mitchell D. Goldberg (2012). A New Shortwave Infrared (SWIR) Method for Quantitative Water Fraction Derivation and Evaluation with EOS/MODIS and Landsat/TM data. IEEE Transactions on Geoscience and Remote Sensing, Vol. 51, Issue 3

[5]. Sanmei Li, Donglian Sun & Yunyue Yu (2013). Automatic cloud-shadow removal from flood/standing water maps using MSG/SEVIRI imagery, International Journal of Remote Sensing, 34:15, 5487-5502

[6]. Sanmei Li & Donglian Sun, 2013. Development of an integrated high resolution flood product with multi-source data, UMI Dissertations Publishing 2013, ISBN: 9781303635939, http://search.proquest.com/docview/1492669000, 2013

[7]. DonglianSun, YunyueYu, RuiZhang, SanmeiLi, and Mitchel D. Goldberg (2012). Towards Operational Automatic Flood Detection Using EOS/MODIS data. Photogrammetric Engineering & Remote Sensing, 78 (6).

2.2 AHI multiple composition

The rolling composition is done using the ABI composition module. The detail of this module could be referred in the document: Introduction to ABI Flood Mapping Software.pdf

3. Module Description and Data flow

3.1 Module Description

3.1.1 Module 1: H8_AHI_Flood_Detection_Version01

H8_AHI_Flood_Detection_Version01 Module is developed to project AHI data including B03, B04, B05, B13, static sensor zenith angle and static sensor azimuth angle in equidistant cylindrical projection at 1-km spatial resolution. The projection requires using a user-defined geographic text table (e.g. User_AOI_Definition.txt). Flood detection is then done based on the projected datasets using a series of ancillary datasets: 1-km land cover, 1-km DEM, 1-km land-sea mask, 1-km water reference map, sun-glint lookup table, pre-trained decision trees, 5-km albedo climatic datasets and 5-km LST and SST climatic datasets. Finally, the module outputs the detection results in hdf4 format.

Project in subsets according to users' AOIs: To project AHI data in the

CONUS or full disk into subsets, the geographic range must be defined in a text file (e.g.User_AOI_Definition_AHI.txt) in the format shown in table 1.

Table 1 Format of user-define text file (User_AOI_Definition_AHI.txt)

Region ID (int)	Min Longitude (float)	Max Longitude (float)	Min Latitude (float)	Max Latitude (float)
001	108.0	125.0	23.0	40.0

The projection requires static sensor zenith angles and sensor azimuth angles under the ancillary folder:

- H8_SatAzimuth_2000m.dat: Himawari-8/AHI full-disk sensor azimuth angle file
- H8_SatZenith_2000m.dat: Himawari-8/AHI full-disk sensor zenith angle file

There are several situations that the module doesn't do any projection:

- Night-time data
- Data outside of the geographic range of the AHI tiles.

AHI flood detection: Based on the projected datasets, flood detection is done with the following ancillary datasets under the ancillary folder:

Global_land_cover_IGBP_2017_USGS_types.raw
AHI_East_MOD44W_Water_Mask.raw
Global_DEM_1km_NOAA_36000_18000.raw
lw_geo_2001001_v03m_1km.raw
Sun_Gliter_mask_005.dat
SST and LST climatology datasets
Albedo climatology datasets in the visible band.

All the process errors are recorded in the log file under the log file path: H8_AHI_Flood_Detection_Log.txt.

3.1.2 Module 2: ABI_Composition_Process

This module is to do hourly composition or daily composition on the AHI 10-m flood datasets. For the hourly composition, the module composites 10-minute AHI flood datasets from the first available 10-minute flood map to the appointed 10-minute flood map which is input as a module parameter on the same day into one flood dataset by collecting the maximal clear-sky coverage in the composited flood map. For the daily composition, the module composites all the 10-minute AHI flood datasets in a day into one flood dataset by collecting the maximal clear-sky coverage in the composited flood map.

The module uses two ancillary datasets:

AHI_East_MOD44W_Water_Mask.raw

lw_geo_2001001_v03m_1km.raw

All the process errors are recorded in the log file under the log file path: ABI_Composite_log.txt

3.1.3 Module 3: Image Display

This module is developed in IDL to display ABI flood detection result in png with a kml description file and geotiff format.

IDL_ABI_WaterMap.pro: to generate AHI flood detection images in png and geotiff formats.

3.2 Data flow

3.2.1 Input

AHI Flood Detection software requires both real-time AHI data input and static ancillary data inputs.

- **AHI real-time Bands (must-have) in different sections:**
  - ✓ B03 (spatial resolution: 500m), B04 (spatial resolution: 1-km), B05 (spatial resolution: 2-km), B13 (spatial resolution: 2-km)
- **AHI static sensor angles (must-have):**
  - ✓ Sensor zenith angle and sensor azimuth angle

The static ancillary data inputs are listed in table 2.

Table 2 Static ancillary data inputs of AHI flood mapping software

Filename	Description	Used in modules	Format
Global_land_cover_IGBP_2017_USGS_types.raw	Global 1-km land cover	H8_AHI_Flood_Detection_Version01	raw
Global_DEM_1km_NOAA_36000_18000.raw	Global 1-km Digital Elevation Model	H8_AHI_Flood_Detection_Version01	raw
lw_geo_2001001_v03m_1km.raw	Global 1-km land/sea mask	H8_AHI_Flood_Detection_Version01 ABI_Composition_Process	raw
AHI_East_MOD44W_Water_Mask.raw	1-km water mask in east hemisphere	H8_AHI_Flood_Detection_Version01 ABI_Composition_Process	raw
AQUA_Daytime_LST_SST_Climatology***.raw TERRA_Daytime_LST_SST_Climatology***.raw (*** means julian day)	5-km Land/sea surface temperature 16-day climatology	H8_AHI_Flood_Detection_Version01	raw
CMG-SMT-P0B1_ch1_**.raw (** means month from 01 to 12)	5-km Global Albedo monthly climatology	H8_AHI_Flood_Detection_Version01	raw
Sun_Gliter_mask_005.dat	Sun-glint look-up table	H8_AHI_Flood_Detection_Version01	raw

Pre-trained decision tress and tree attribute files: e.g. Tree1_J48graft_water_cloud_vegetation_bareland_wetland_MODIS.txt	Pre-trained decision tress and tree attribute files	H8_AHI_Flood_Detection_Version01	text
User AOI definition file: e.g. User_AOI_Definition.txt	User AOI geographic definition file	H8_AHI_Flood_Detection_Version01	text

3.2.2 Output

The final outputs include 10-minute flood detection datasets and composited flood datasets (both in hdf4 format) and flood detection images in png, geotiff and kmz formats.

- **AHI 10-minute flood detection data**: WaterDetection. 16-bit short data type in hdf4 format
- **AHI composited flood detection data**: WaterDetection. 16-bit short data type in hdf4 format
- **AHI flood detection images in png and geotiff formats**: the flood detection images are 8-bit one channel color-index png with a kml description file and geotiff images.
- **Logfile**: H8_AHI_Flood_Detection_Log.txt which is generated by H8_AHI_Flood_Detection_Version01 Module and ABI_Composite_log.txt which is generated by ABI_Composition_Process Module. Both the two log files are used to record the errors during flood detection and composition process.

1) Naming rule of the AHI 10-minute flood detection dataset

The naming rule of AHI 10-minute flood detection dataset is:

*WATER_H08_AHI_YYYYMMDD_YYYYJJJ_HHMMSSS_col_row_SBB(number of the starting section)EE(number of the eningd section)_ RRR (*region ID*).hdf*

For example, with two AHI files from section 2 to section 3:

HS_H08_20180216_0600_B03_FLDK_R05_S0210.DAT

HS_H08_20180216_0600_B03_FLDK_R05_S0310.DAT

The produced 10-minute AHI flood detection dataset in the region defined in table 1 is with the name:

WATER_H08_AHI_20180216_2018047_0600030_1700_1700_S0203_001.hdf

2) Naming rule of the AHI hourly composited flood detection dataset

The naming rule of AHI hourly composited flood detection dataset is:

*COM_H08_AHI_WATER_YYYYMMDD_YYYYJJJ_HHMM(Beginning)_HHMM(end)_col_row_N(numberof the total_10-minuteAHI files)_RRR(*region ID*).hdf*

The composited flood dataset from 05:30 to 06:00 (UTC) is with the name:

COM_H08_AHI_WATER_20180216_2018047_0530_0600_1700_1700_4_001.hdf

3) Naming rule of the AHI daily composited flood detection dataset

The naming rule of AHI hourly composited flood detection dataset is:

*COM_H08_AHI_WATER_YYYYMMDD_YYYYJJJ_col_row_RRR(*region ID*).hdf*

The daily composited flood dataset on Feb. 16, 2018 is with the name:

COM_H08_AHI_WATER_20180216_2018047_1700_1700_001.hdf

The images keep the same name rules of the corresponding files, and the suffixes are *.png*, or *.tif*, or *.kml*.

4. Environment requirements

4.1 Source Codes:

H8_AHI_Flood_Detection_Version01 and ABI_Composition_Process modules are written in C/C++.

Image_Display module is written in IDL.

4.2 System requirements:

The software is recommended to run in Linux 64-bit system with at least 4GB memory. It can also be run in Linux 32-bit system with at least 4GB memory.

To compile, build and run the software, the **GNU Compiler Collection** including GCC/GCC C++, and IDL (license is required) are required.

4.3 Running time

Running time depends on the region size and flooding situation. For example, it takes about 5-9 minutes to finish one 10-minute tile in the region defined in Table 1.

5. Run modules

5.1 Run module: H8_AHI_Flood_Detection_Version01

The parameters to run **H8_AHI_Flood_Detection_Version01** include:

- **-h:** [Necessary], file path AHI real-time hsd files
- **-b:** [Necessary], filename of any sectional AHI B03 hsd file to be processed
- **-a:** [Necessary], file path of the ancillary data.
- **-o:** [Necessary], file path of the output hdf4 results
- **-l:** [Necessary], file path of the log file
- **-u**: [Necessary], filename of user-defined geographic range txt file
- **-p**: [Necessary], file path of user-defined geographic range txt file

To run the executive module: **H8_AHI_Flood_Detection_Version01** with file in the region defined by table 1:

HS_H08_20180216_0600_B03_FLDK_R05_S0210.DAT

HS_H08_20180216_0600_B03_FLDK_R05_S0310.DAT

The test script is written as:

./H8_AHI_Flood_Detection_Version01 -h /AHI_data -b HS_H08_20180216_0600_B03_FLDK_R05_S0210.DAT -a /assdata/global -o /AHI_data/output -l /logfile -p / angles -u User_AOI_Definition_AHI.txt

Or,

./H8_AHI_Flood_Detection_Version01 -h /AHI_data -b HS_H08_20180216_0600_B03_FLDK_R05_S0310.DAT -o /AHI_data/output -a /assdata/global -l /logfile -p / angles -u User_AOI_Definition_AHI.txt

The two scripts produce a 10-minute flood dataset under the folder: */AHI_data/output*:

WATER_H08_AHI_20180216_2018047_0600030_1700_1700_S0203_001.hdf

5.2 Run module: ABI_Composition_Process

There are four parameters:

- **-h**: [Necessary], file path of AHI 10-minute flood datasets to be composited
- **-a**: [Necessary], file path of the ancillary datasets
- **-v**: [Necessary], filename of the latest AHI 10-minute flood dataset to be composited for hourly composition or filename of any AHI 10-minute flood dataset on the same day to be composited for daily composition
- **-o: [Necessary]**, file path of the output GEO composited hdf4 results
- **-l**: [Necessary], file path of the log file
- **-n**: [Necessary], composition type: 0, hourly composition; 1, daily composition

To run the executive module: ABI_Composition_Process with data and produce hourly composition results at 06:00 (UTC):

WATER_H08_AHI_20180216_2018047_0530030_1700_1700_S0203_001.hdf

WATER_H08_AHI_20180216_2018047_0540030_1700_1700_S0203_001.hdf

WATER_H08_AHI_20180216_2018047_0550030_1700_1700_S0203_001.hdf

WATER_H08_AHI_20180216_2018047_0600030_1700_1700_S0203_001.hdf

The test script is written as:

./ABI_Composition_Process -h /AHI_data -v WATER_H08_AHI_20180216_2018047_0600030_1700_1700_S0203_001.hdf -a /assdata/global -o /AHI_data/output -l /logfile –n 0

This produces a composited file under the folder */AHI_data/output* with the first one starting at 05:30 (UTC) under the same folder:

COM_H08_AHI_WATER_20180216_2018047_0530_0600_1700_1700_4_001.hdf

To run the executive module: ABI_Composition_Process with data and produce

daily composition results on Feb. 16, 2018:

WATER_H08_AHI_20180216_2018047_0530030_1700_1700_S0203_001.hdf

WATER_H08_AHI_20180216_2018047_0540030_1700_1700_S0203_001.hdf

WATER_H08_AHI_20180216_2018047_0550030_1700_1700_S0203_001.hdf

WATER_H08_AHI_20180216_2018047_0600030_1700_1700_S0203_001.hdf

The test script is written as:

./ABI_Composition_Process -h /AHI_data -v WATER_H08_AHI_20180216_2018047_0600030_1700_1700_S0203_001.hdf -a /assdata/global -o /AHI_data/output -l /logfile –n 1

This produces a composited file under the folder */AHI_data/output* with the first one starting at 05:30 (UTC) under the same folder:

COM_H08_AHI_WATER_20180216_2018047_1700_1700_001.hdf

5.3 Run module: Image Display

Before compile the IDL procedure: *IDL_ABI_WaterMap.pro*, make sure IDL is installed and IDL_Path is added to ${path}. Then copy the procedure in a directory, and add the directory path to ${path} too.

Under IDL run-time environment, compile the two procedures:

IDL>.compile IDL_ABI_WaterMap.pro

There are three parameters to run *IDL_ABI_WaterMap.pro*:

Inpath: file path to VIIRS calibrated projected SDR data

Outpath: file path to output generated images

Keywords: keywords of the appointed flood datasets, e.g. *.hdf or WATER*.hdf

To run IDL_ABI_WaterMap.pro in IDL run-time environment:

IDL>.compile IDL_ABI_WaterMap.pro

IDL> IDL_ABI_WaterMap, Inpath, Outpath, keywords

It will generate ABI 5-minute or composited flood maps in the Outpath folder including three files:

*.png, *.kml and *.tif.