Office of Satellite and Product Operations
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Enterprise/Blended Flood Mapping External Users' Manual

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Environmental Satellite Processing Center

Enterprise/Blended Flood Mapping External Users' Manual

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Changes/Revisions Record

This external users' manual is changed as required to reflect system, operational, or organizational changes. Modifications made to this document are recorded in the Changes/Revisions Record below. This record will be maintained throughout the life of the document.

Version Number	Date	Description of Change/Revision	Section/Pages Affected	Changes Made by Name/Title/ Organization
1.0	11/2020	Original – Created version 1.0	All	Doss
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1.1	07/2023	Minor patch delivery update for metadata definition, typo correction	Multiple	Lindeman
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Preface

This document comprises the National Oceanic and Atmospheric Administration (NOAA) National Environmental Satellite, Data, and Information Service (NESDIS), Office of Satellite and Product Operations (OSPO), publication of this Enterprise/Blended Flood Mapping (FM) External Users' Manual (EUM). This document reflects current operations for the DOC/NOAA/NESDIS Environmental Satellite Processing Center (ESPC) (NOAA5045) information technology systems. This document describes the established ESPC procedures for external users of Enterprise/Blended FM in accordance with Federal, DOC, NOAA, NESDIS and OSPO requirements.

Future updates and revisions to this document will be produced and controlled by DOC/NOAA/NESDIS for ESPC information technology systems.

The published version of this document can be found at the OSPO SharePoint Products Library.

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1. Products

This is the External Users' Manual (EUM) document describing the operational VIIRS, ABI, and Blended Flood Mapping (FM) products such as VIIRS Flood Mapping (VFM), ABI Flood Mapping (AFM), and Blended Flood Mapping (BFM). The intended users of the EUM are end users of the VFM/AFM/BFM products and the product verification and validation (V&V) teams. External users are defined as users who do not have direct access to the processing system. The purpose of this manual is to provide end-users and validation teams with information on how to access the product, understand the product, and use the product.

1.1. Product Overview

Because floods are a short-term event on a large scale, satellite images show special advantages in flood mapping because these images can see the big pictures of floodwater with rapid updates on the flood status. Thus satellite-derived Flood Mapping products have been developed for GOES-R ABI and JPSS VIIRS satellite data, and this version also contains a daily VIIRS/ABI blended version of FM. The VIIRS and ABI flood products, referred as VFM and AFM, respectively, are newly developed products generated from JPSS/VIIRS imagery (Suomi-NPP and NOAA-20 and NOAA-21), and GOES-16&17&18&19/ABI imagery to depict flood extent in floodwater fractions. Relative to the Enterprise Flood Mapping algorithm, the Blended Flood Mapping package adds a unit that takes the VIIRS 1-day composites and ABI 1-day composites as input to produce output that combines the VIIRS and ABI data together. Here, floods are defined as an overflow of water that submerges or "drowns" land that is normally dry. With the definition, the floodwater detected in VFM, AFM, and Blended FM includes disastrous flood water caused by ice-jam/snow-melting or intensive rainfall that brings about damages or economic loss, and non-disastrous flood water such as tides, agriculture-related water and other hydrologic-activity-related water.

1.1.1. Product Requirements

The requirements of VFM products are listed in **Error! Reference source not found.**.

Table 1-1 - Requirements of VIIRS Flood Products

Product Name	Latency	Measurement Range	Product Accuracy
Suomi-NPP &NOAA-20 & NOAA-21/VIIRS near real-time flood product	126 minutes	Water fraction 25% to 100%	80% under clear-sky conditions
NWS regional Suomi-NPP &NOAA-20 & NOAA-21/VIIRS near real-time flood product	126 minutes	Water fraction 25% to 100%	80% under clear-sky conditions
Suomi-NPP &NOAA-20 & NOAA-21/VIIRS daily composited flood product	3 hours	Water fraction 25% to 100%	N/A
Suomi-NPP &NOAA-20 & NOAA-21/VIIRS 5-day composited flood product	3 hours	Water fraction 25% to 100%	N/A

The requirements of AFM products are listed in Table 1-2.

Table 1-2 - Requirements of ABI Flood Products*

Product Name	Latency	Measurement Range	Product Accuracy
ABI hourly composited flood product (GOES-16, 18)	1 hour	Water fraction 25% to 100%	70% under clear-sky conditions
ABI daily composited flood product	1 hour	Water fraction 25% to 100%	70% under clear-sky conditions

*Has been tested with G-17 and G-19 data (G-19 will replace G-16 when operational)

The Blended Flood Mapping product requirements are shown in Table 1-3. These products are produced daily, and are required to be generated within one hour after the VIIRS and ABI flood products are produced.

Table 1-3 - Requirements of Blended Flood Products

Product Name	Latency	Measurement Range	Product Accuracy
Blended Flood Product (GOES/VIIRS)	Less than 2 hours	Water fraction≥25%	70% under clear sky conditions

Note that PNG output files are for internal monitoring purposes only.

1.1.2. Product Team

The VIIRS/ABI Flood Mapping Product team consists of members from George Mason University (GMU), STAR, OSD, and OSPO. The roles and contact information for each product team member can be found in **Error! Reference source not found.**.

Table 1-4 - Product Team Information

Role	Name	Email Address
OCS Product Management Division Chief	Walter Wolf	walter.wolf@noaa.gov
Science Team Lead	Sean Helfrich	sean.helfrich@noaa.gov
Science Team	Sanmei Li	sanmei.li@noaa.gov
OSPO PAL	Liqun Ma	liqun.ma@noaa.gov
OSPO Team	N/A	
PPM	Jena Kent	jena.kent@noaa.gov
PIB	Jianbin Yang	jianbing.yang@noaa.gov
ASSISTT Management Team	Priyanka Roy	priyanka.roy@noaa.gov
ASSISTT Standalone Integration Team Lead(s)	Letitia Soulliard	letitia.soulliard@noaa.gov
	Shukming Wu	shukming.wu@noaa.gov
	Michael Butler	michael.butler@noaa.gov
	Zhengpeng Li	zhengpeng.li@noaa.gov
ASSISTT Standalone Integration Team	Joyce Byun	joyce.byun@noaa.gov
	Dongsheng Wu	dongsheng.wu@noaa.gov

Role	Name	Email Address
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ASSISTT R2O Team Lead	Ramaswamy Tiruchirapalli	ramaswamy.tiruchirapalli@noaa.gov
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ASSISTT Lifecycle QA Team Lead	Tracey Dorian	tracey.dorian@noaa.gov
ASSISTT Lifecycle QA Team	Mingming Yao	mingming.yao@noaa.gov
ASSISTT Science QA Team Lead	Hua Xie	hua.xie@noaa.gov

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Feedbacks, comments, criticisms, suggestions, are welcome and should be sent to:

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Joyce Byun	joyce.byun@noaa.gov
Dongsheng Wu	dongsheng.wu@noaa.gov
Priyanka Roy	priyanka.roy@noaa.gov

1.1.3. Product Description

The VIIRS/ABI Flood Mapping products will be used as a risk reduction assessment for a cost-effective implementation of common NESDIS algorithms. The OCS Algorithm Scientific Software Integration and System Transition Team (ASSISTT), integration, and python development teams prepared for its implementation into the NESDIS Cloud Common Framework (NCCF). VFM and AFM are currently running in NCCF.

The Blended Flood Mapping algorithm is an upgraded version of the existing Enterprise Flood Mapping algorithm. Relative to the Enterprise Flood Mapping algorithm, the Blended Flood Mapping package adds a unit that takes the VIIRS 1-day composites and ABI 1-day composites as input to produce output that combines the VIIRS and ABI data together.

The VFM products include: VIIRS global near real-time gridded flood product in granules from Suomi-NPP and NOAA-20 and NOAA-21 between 80°S and 80°N, VIIRS near real-time gridded flood product in the NWS domains from Suomi-NPP and NOAA-20 and NOAA-21, VIIRS global daily composited flood product and VIIRS global 5-day composited flood product in 136 areas of interest (AOI) covering the global land regions between 60°S and 75°N. Table 1-5 lists all the products produced in the operational system.

Table 1-5 - VIIRS Flood Products Produced in the Operational System

Product Name	Spatial Resolution	Geographic Coverage	Temporal Coverage	Description
Suomi-NPP &NOAA-20 & NOAA-21/VIIRS near real-time flood product	375 m	Global land between 80°S and 80°N	DOY: 1 ~ 59, or 291 ~ 366: $\theta \leq 85°$ (N), $\theta \leq 76°$ (S) DOY: 60 ~ 99, or 251 ~ 290: $\theta \leq 80°$ DOY: 100 ~ 250: $\theta \leq 76°$ (N), $\theta \leq 85°$ (S) DOY: Day of Year θ: Solar zenith angle N: North Hemisphere S: South Hemisphere	Reflect the current flood status at the time of the overpass
NWS regional Suomi-NPP &NOAA-20 & NOAA-21/VIIRS near real-time flood product	375 m	8 NWS domains in the CONUS and Alaska		Reflect the current flood status at the time of the overpass
Suomi-NPP &NOAA-20 & NOAA-21/VIIRS daily composited flood product	375 m	Global land between 60°S and 75°N in 136 AOIs		Reflect the daily maximal flood extent from Suomi-NPP and NOAA-20 and NOAA-21
Suomi-NPP NOAA-20 & NOAA-21/VIIRS 5-day composited flood product	375 m	Global land between 60°S and 75°N in 136 AOIs		Reflect the maximal flood extent in the latest 5 days from Suomi-NPP and NOAA-20 and NOAA-21

The VIIRS NRT floodwater detection dataset and its quality flag are with the same size of gridded VIIRS NRT granules, or in NWS 8 defined domains (Figure 1-1). The daily and 5-day composites and the corresponding quality flags are in 136 defined areas of interest (AOI) covering global land between 60°S and 75°N in latitudes (Figure 1-2).

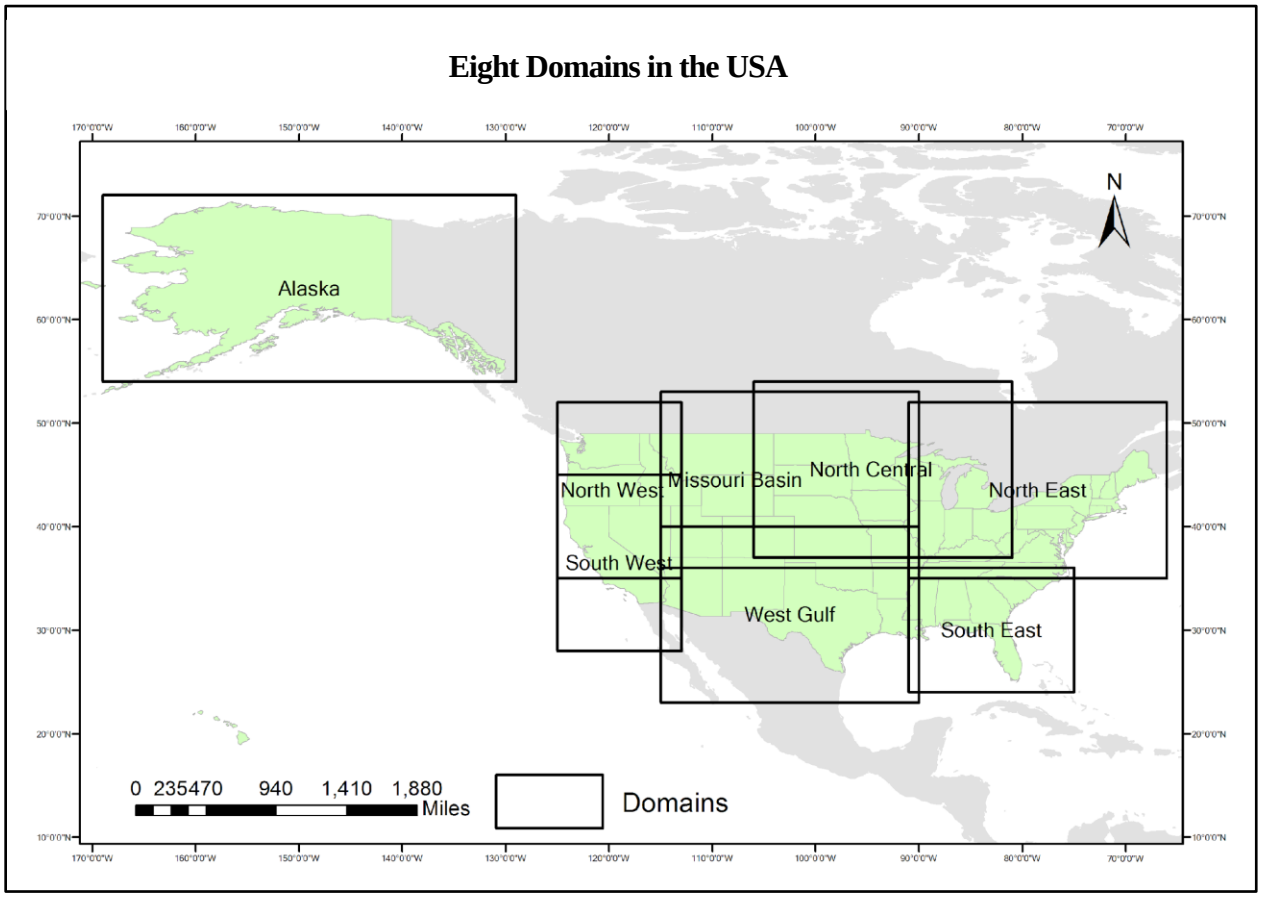

Figure 1-1 - Sketch of NWS 8 Domains

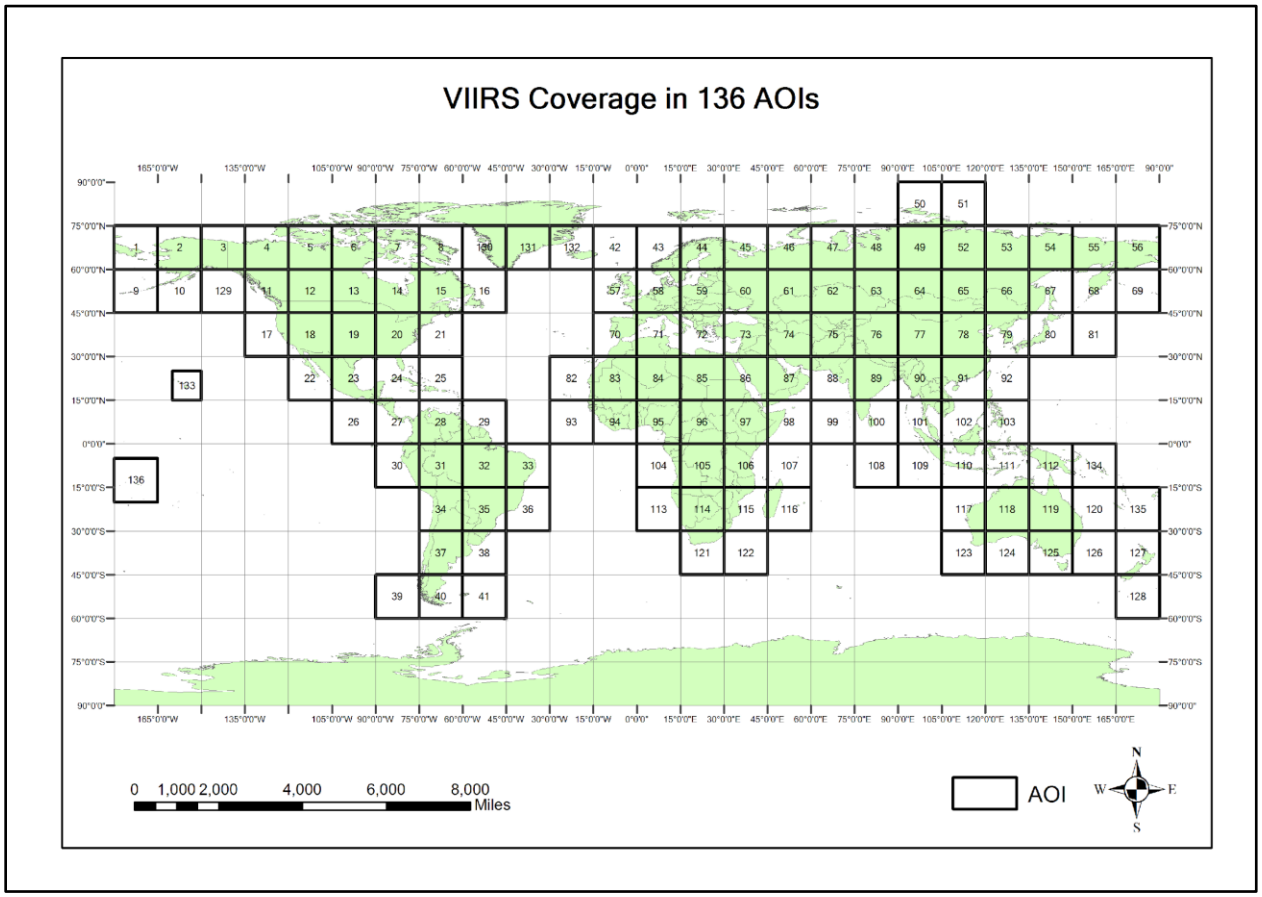

Figure 1-2 - Sketch of Global 136 AOIs for VFM Daily and 5-Day Composited Products

The AFM products include ABI hourly composited flood product and ABI daily composited flood product in American mainland and islands between 50.5°S and 50.5°N. Table 1-6 lists the two products produced in the operational system.

Table 1-6 - ABI Flood Products Produced in the Operational System

Product Name	Spatial Resolution	Geographic Coverage	Temporal Coverage	Description
ABI hourly composited flood product	1 km	American mainland and islands between 50.5°S and 50.5°N	DOY: 1 ~ 59, or 291 ~ 366: $\theta \leq 75°$ (N), $\theta \leq 70°$ (S) DOY: 60 ~ 99, or 251 ~ 290: $\theta \leq 70°$ DOY: 100 ~ 250: $\theta \leq 70°$ (N), $\theta \leq 75°$ (S) DOY: Day of Year θ: Solar zenith angle N: North Hemisphere S: South Hemisphere	Reflect the flood status from the first observation to the current hour on a day
ABI daily composited flood product	1 km	American mainland and islands between 50.5°S and 50.5°N		Reflect the flood status from the first observation to the last observation on a day

The ABI hourly and daily composited floodwater detection datasets and their quality flags are the same size in the four defined domains. Figure 1-3 presents an example of ABI daily composited flood map in the four domains.

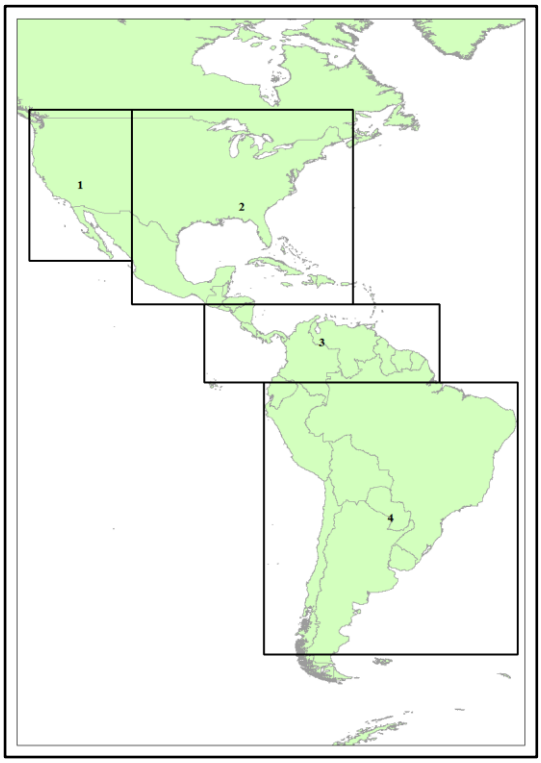

Figure 1-3 - Sketch of 4 Domains for ABI Flood Products

The Blended Flood Mapping products produced operationally is shown in Table 1-7.

Table 1-7 - Blended Flood Mapping Products Produced in the Operational System

Product Name	Spatial Resolution	Geographic Coverage	Temporal Coverage	Description
Blended FM	375 m	American mainland and island between 50.5° S and 50.5°N in latitudes	Daily	Floodwater extent and fractions (Blended)

Figure 1-4 presents an example of Blended daily composited flood map in the 30 domains.

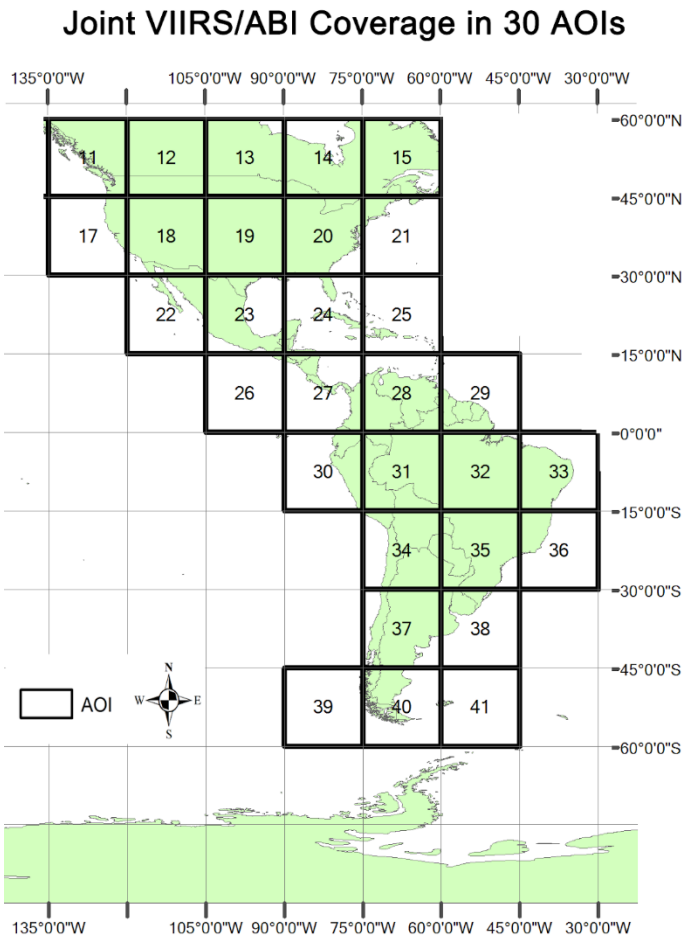

Figure 1-4 - Sketch of 30 Domains for Blended Flood Products

Detailed information on the science algorithms and products can be found in the VFM/AFM and BFM Algorithm Theoretical Basis Documents (ATBD).

1.2. Product History

The VIIRS/ABI/Blended flood mapping products are newly developed products without any existing operational algorithms or products to inherit from the previous satellite missions or programs.

1.3. Product Access

Table 1-8 shows the output file names and formats. The output file formats depend on the individual products, and can consist of NetCDF files, png and geotiff images, and zip files containing shapefiles (refer to the definitions beneath Table 1-8 to see the output file formats available for each product). The algorithm version is v1r0 for ABI and v2r0 for VIIRS.

VIIRS Flood Mapping products will be archived following the existing archive plan for the S-NPP, NOAA-20 and NOAA-21 products. ABI products will be archived. The L3 Blended Flood Mapping Detection Product NetCDF4 output files will be archived in NCEI/CLASS.

Table 1-8 - VIIRS/ABI/Blended Flood Mapping Output File Names

Description of File	Naming Convention
VFM Granule (netCDF)	VIIRS-Flood_v2r0_{sat ID}_s{start time}_e{end time}_c{creation time}.nc
VFM Granule (PNG)	VIIRS-Flood_v2r0_{sat ID}_s{start time}_e{end time}_c{creation time}.png
VFM NWS Mosaic (netCDF)	VIIRS-Flood-NWS{NWS domain ID}_v2r0_{sat ID}_s{start time}_e{end time}_c{creation time}.nc
VFM NWS Mosaic (PNG)	VIIRS-Flood-NWS{NWS domain ID}_v2r0_{sat ID}_s{start time}_e{end time}_c{creation time}.png
VFM Global Mosaic (netCDF)	VIIRS-Flood-GLB{AOI}_v2r0_{sat ID}_s{start time}_e{end time}_c{creation time}.nc
VFM 1-day Composite (netCDF)	VIIRS-Flood-1day-GLB{AOI}_v2r0_blend_s{start time}_e{end time}_c{creation time}.nc
VFM 1-day Composite (geoTIFF)	VIIRS-Flood-1day-GLB{AOI}_v2r0_blend_s{start time}_e{end time}_c{creation time}.tif
VFM 1-day Composite (PNG)	VIIRS-Flood-1day-GLB{AOI}_v2r0_blend_s{start time}_e{end time}_c{creation time}.png
VFM 1-day Composite (zipped shapefile)	VIIRS-Flood-1day-GLB{AOI}_v2r0_blend_s{start time}_e{end time}_c{creation time}.zip
VFM 5-day Composite (netCDF)	VIIRS-Flood-5day-GLB{AOI}_v2r0_blend_s{start time}_e{end time}_c{creation time}.nc
VFM 5-day Composite (geoTIFF)	VIIRS-Flood-5day-GLB{AOI}_v2r0_blend_s{start time}_e{end time}_c{creation time}.tif
VFM 5-day Composite (PNG)	VIIRS-Flood-5day-GLB{AOI}_v2r0_blend_s{start time}_e{end time}_c{creation time}.png
VFM 5-day Composite (zipped shapefile)	VIIRS-Flood-5day-GLB{AOI}_v2r0_blend_s{start time}_e{end time}_c{creation time}.zip
ABI Hourly Composite (netCDF)	ABI-Flood-HCOM-AOI{domain ID}_v1r0_{sat ID}_s{start time}_e{end time}_c{creation time}.nc
ABI Hourly Composite (geoTIFF)	ABI-Flood-HCOM-AOI{domain ID}_v1r0_{sat ID}_s{start time}_e{end time}_c{creation time}.tif
ABI Hourly Composite (PNG)	ABI-Flood-HCOM-AOI{domain ID}_v1r0_{sat ID}_s{start time}_e{end time}_c{creation time}.png

Description of File	Naming Convention
ABI Hourly Composite (zipped shapefile)	ABI-Flood-HCOM-AOI{domain ID}_v1r0_{sat ID}_s{start time}_e{end time}_c{creation time}.zip
ABI Daily Composite (netCDF)	ABI-Flood-DCOM-AOI{domain ID}_v1r0_{sat ID}_s{start time}_e{end time}_c{creation time}.nc
ABI Daily Composite (geoTIFF)	ABI-Flood-DCOM-AOI{domain ID}_v1r0_{sat ID}_s{start time}_e{end time}_c{creation time}.tif
ABI Daily Composite (PNG)	ABI-Flood-DCOM-AOI{domain ID}_v1r0_{sat ID}_s{start time}_e{end time}_c{creation time}.png
ABI Daily Composite (zipped shapefile)	ABI-Flood-DCOM-AOI{domain ID}_v1r0_{sat ID}_s{start time}_e{end time}_c{creation time}.zip
Blended VIIRS/ABI Flood Maps (netCDF)	VIIRS-ABI-Flood-GLB{AOI}_v1r0_blend_s{start time}_e{end time}_c{creation time}.nc
Blended VIIRS/ABI Flood Maps (geoTIFF)	VIIRS-ABI-Flood-GLB{AOI}_v1r0_blend_s{start time}_e{end time}_c{creation time}.tif
Blended VIIRS/ABI Flood Maps (PNG)	VIIRS-ABI-Flood-GLB{AOI}_v1r0_blend_s{start time}_e{end time}_c{creation time}.png
Blended VIIRS/ABI Flood Maps (zipped shapefile)	VIIRS-ABI-Flood-GLB{AOI}_v1r0_blend_s{start time}_e{end time}_c{creation time}.zip

Where:

Convention	Description/Meaning
{AOI}	Zero-padded 3 digit number corresponding to one of the 136 global areas (AOIs): "001", "002", …, "135", "136"
{NWS domain ID}	Zero-padded 3 digit number corresponding to one of the 8 areas specified by the National Weather Service (NWS): "001", "002", …, "007", "008"
{domain ID}	Zero-padded 3 digit number corresponding to one of the 4 domains for ABI flood products: "001", "002", "003", or "004".
{sat ID}	Satellite ID: "npp", "n20", "n21", "g16", "g17", "g18", or "g19".
{start time}	Start timestamp with format <YYYYMMDDhhmmsss>.

Convention	Description/Meaning
{end time}	End timestamp with format <YYYYMMDDhhmmsss>.
{creation time}	Creation timestamp with format <YYYYMMDDhhmmsss>.

Example names for the NetCDF output files:

ABI-Flood-DCOM-AOI003_v1r0_g16_s202205061930204_e202205061939510_c202303070759033.nc

ABI-Flood-HCOM-AOI003_v1r0_g16_s202205061930204_e202205061939510_c202303070757057.nc

ABI-Flood-AOI003_v1r0_g16_s202205061930204_e202205061939512_c202303070754036.nc

VIIRS-Flood-1day-GLB019_v2r0_blend_s202002251909150_e202002251910390_c202303071636516.nc

VIIRS-Flood-5day-GLB018_v2r0_blend_s202002251909150_e202002251910390_c202303071638054.nc

VIIRS-Flood_v2r0_n20_s202002251909150_e202002251910395_c202303071632051.nc

VIIRS-Flood-GLB020_v2r0_n20_s202002251909150_e202002251910390_c202303071635592.nc

VIIRS-Flood-NWS003_v2r0_n20_s202002251909150_e202002251910390_c202303071634512.nc

VIIRS-ABI-Flood-GLB026_v1r0_blend_s202311051819470_e202311052113180_c202407311449445.nc

The output files can vary considerably in size. Table 1-9 lists average file sizes for each product.

Table 1-9 - Average File Sizes for the VFM/AFM/BFM Products

Output File Type	Estimated Average File Size
ABI Daily Composite netCDF4	1.33 MB
ABI Hourly Composite netCDF4	1.35 MB
ABI Flood Detection netCDF4	1.44 MB
VIIRS 1-Day Composite netCDF4	1.80 MB
VIIRS 5-Day Composite netCDF4	2.14 MB
VIIRS Granule netCDF4	2.12 MB
VIIRS Global Mosaic netCDF4	1.63 MB
VIIRS NWS Mosaic netCDF4	3.47 MB
ABI Daily Composite GeoTIFF	8.48 MB
ABI Hourly Composite GeoTIFF	8.92 MB
VIIRS 1-Day Composite GeoTIFF	19.55 MB
VIIRS 5-Day Composite GeoTIFF	18.90 MB
ABI Hourly Composite Shapefiles	0.15 MB
ABI Daily Composite Shapefiles	0.18 MB
VIIRS 1-Day Composite Shapefiles	0.43 MB
VIIRS 5-Day Composite Shapefiles	1.25 MB
ABI Daily Composite PNG	0.20 MB

Output File Type	Estimated Average File Size
ABI Hourly Composite PNG	0.22 MB
VIIRS 1-Day Composite PNG	0.44 MB
VIIRS 5-Day Composite PNG	0.54 MB
VIIRS Granule PNG	0.29 MB
VIIRS NWS Mosaic PNG	0.97 MB
VIIRS-ABI Blended Composite Daily NetCDF4	1.5 MB
VIIRS-ABI Blended Composite Daily GeoTIFF	19 MB
VIIRS-ABI Blended Composite Daily PNG	0.02 MB
VIIRS-ABI Blended Composite Daily Shapefiles	0.02 MB

The AFM/VFM Flood Mapping NetCDF file contents are shown in Table 1-10.

Table 1-10 - AFM/VFM Output NetCDF File Product Description

Variable	Type	Description	Dim	Units	Range
QualityFlag	Short	0: high quality detection, 1: moderate quality detection, 2: low quality detection, 255: FillValue	2	None	N/A
WaterDetection	Short	1: no_valid_data, 15: Floodwater without fraction retrieval, 16: Bareland, 17: Vegetation, 20: Snow_ice, 27: River/lake ice; 30: Cloud, 38: Supar-snow/ice water or mixed ice&water or melting ice, 50: Shadow, 99: NormalWater; 100-200: Water Fractions	2	None	N/A
Lat	Float	latitude	1	degrees north	N/A
Lon	Float	longitude	1	degrees east	N/A
quality_information	String	total number of retrievals, percentage of optimal retrievals, percentage of sub-optimal retrievals, percentage of bad reviews	N/A	N/A	N/A

Variable	Type	Description	Dim	Units	Range
WaterDetection_NEARINTERPOLATION*	Short	1: no_valid_data; 15: Floodwater without fraction retrieval; 16: Bareland; 17: Vegetation; 20: Snow_ice; 27: River/lake ice; 30: Cloud; 38: Supar-snow/ice water or mixed ice&water or melting ice; 50: Shadow; 99: NormalWater; 100-200: Water Fractions	2	N/A	N/A

*Variable only present in the Blended VIIRS/ABI product.

For each product in shapefile format, only floodwater fractions are converted from raster pixels to vector polygons. Raster pixels create jagged edges in the product while vector polygons make the edges look much smoother. The water fractions are divided into 5 types of water polygons listed in **Error! Reference source not found.**.

Table 1-11 - Definition of Water Polygons in the Output VFM Shapefile Files

Polygon Value	Definition
2	1≤Water fraction (%)≤19
4	20≤Water fraction(%)≤39
6	40≤Water fraction(%)≤59
8	60≤Water fraction(%)≤79
10	80≤Water fraction(%)≤100

Product-monitoring metadata is included with the NetCDF output files for AFM/VFM. Metadata included with the output files are listed in Table 1-12.

Table 1-12 - AFM/VFM Output File Metadata

Attribute	Description	Type	Array Size
Conventions	Conventions used here	String	Scalar
creator_email	Email for the algorithm development team	String	Scalar
creator_name	Indicates the line office and algorithm team responsible for product development	String	Scalar
creator_url	Website for end users	String	Scalar
metadata_link	Contains a URL where detailed metadata or a product information page is located	String	Scalar
ascend_descend_data_flag**	Flag indicate whether satellite ascending or descending	Integer	Scalar
cdm_data_type	States the geographic category the product represents	String	Scalar
date_created	UTC time the product file was created in 4-digit year, 2-digit month, 2-digit day, 2-digit hour, 2-digit minute, 2-digit second format	String	Scalar

Attribute	Description	Type	Array Size
DaynightFlag	flag which indicates whether it is day or night	String	Scalar
day_night_data_flag**	flag which indicates whether it is day, night, or both	String	Scalar
end_orbit_number**			
fillvalue_pixel_percent	Percentage of fill-value pixels	Float	Scalar
flood_pixel_count	Number of pixels that count as flooded	Integer	Scalar
flood_pixel_percent	Percentage of pixels that count as flooded	Float	Scalar
geospatial_lat_max	Describes the maximum latitude of the geospatial coverage of the grid, includes -90 (south) to 90 (north)	Float	1
geospatial_lat_min	Describes the minimum latitude of the geospatial coverage of the grid, includes -90 (south) to 90 (north)	Float	1
geospatial_lat_resolution	Indicates uniform spacing of points in latitude measured in degrees_north	Float	1
geospatial_lat_units	Indicates unit associated with geospatial latitude	String	Scalar
geospatial_lon_max	Describes the maximum longitude of the geospatial coverage of the grid, includes -180 (west) to 180 (east)	Float	1
geospatial_lon_min	Describes the minimum longitude of the geospatial coverage of the grid, includes -180 (west) to 180 (east)	Float	1
geospatial_lon_resolution	Indicates uniform spacing of points in longitude measured in degrees_east	Float	1
geospatial_lon_units	Indicates unit associated with geospatial longitude	String	Scalar
keywords	Look-up words/phrases associated with this product	String	1
lowquality_pixel_percent	Percentage of low quality pixels	Float	Scalar
moderatequality_pixel_percent	Percentage of moderate quality pixels	Float	Scalar
platform	Indicates the satellite(s) used to create the product	String	Scalar
history	Indicates algorithm name and version responsible for creating the file	String	Scalar
id	Unique identifier for the product	String	Scalar
institution	Indicates institution responsible for product file	String	Scalar
instrument	Name of the relevant satellite instrument	String	Scalar
naming_authority	Organization responsible for providing the "id" attribute	String	Scalar
Observingdate	Date of the observations	Integer	Scalar
Observingtime	Time of the observations	String	Scalar
processing_level	Level of processing associated with product file	String	Scalar
production_environment	Processing string responsible for generating the product	String	Scalar
production_site	Processing site for the product	String	Scalar

Attribute	Description	Type	Array Size
project	Indicates the name(s) of the project(s) responsible for generating the original data used as input to the processing system	String	Scalar
publisher_email	Provides an email that can be used to contact the person or entity who is responsible for publishing the output files to the proper end users	String	Scalar
publisher_name	Provides the name of the organization responsible for the product's publication	String	Scalar
publisher_url	Provides URL of publisher's website	String	Scalar
references	Info for additional information	String	1
Resolution	horizontal resolution	String	Scalar
SensorIdentityCode	ID name of the sensor	String	Scalar
source	Provides a list of all significant input files into the product system as a comma separated list	String	Scalar
standard_name_vocabulary	Provides the name and corresponding version number of the controlled vocabulary used	String	Scalar
start_orbit_number**			
summary	Provides a brief summary of the product	String	Scalar
time_coverage_end	Indicates the end time of the observation associated with the file in 4-digit year, 2-digit month, 2-digit day, 2-digit hour, 2-digit minute, 2-digit second format	String	Scalar
time_coverage_start	Indicates the start time of the observation associated with the file in 4-digit year, 2-digit month, 2-digit day, 2-digit hour, 2-digit minute, 2-digit second format	String	Scalar
title	Provides the short name for the product	String	Scalar
num_flood_pix_VIIRS*	Number of pixels designated as flood in VIIRS data	Integer	Scalar
num_flood_pix_ABI*	Number of pixels designated as flood in ABI data	Integer	Scalar
cloud_pix_percent*	Percentage of cloudy pixels	Float	Scalar
clear_pix_percent*	Percentage of clear pixels	Float	Scalar

*Metadata attributes only included in the Blended Flood products.

**Metadata attributes only included in the VIIRS granule products.

2. Algorithm

2.1. Algorithm Overview

Enterprise Flood Mapping has two main components: ABI and VIIRS processing. Following are descriptions of the algorithmic process for both satellite data types.

VIIRS Processing

There are six major procedures included in the VIIRS flood mapping system: Swath projection, flood detection, mosaic process, daily composition, 5-day composition and image display. The Swath

projection processes VIIRS SDR and EDR data from Suomi-NPP, NOAA-20, and NOAA-21 in the Imager bands (I-bands 01, 02, 03, 05), terrain corrected geolocation data (GITCO) and projects the SDR data and EDR data into gridded granule data. The output from the swath projection process is used as the input of the flood detection process together with the ancillary datasets. The flood detection process outputs VIIRS near real-time flood detection results in granules for further mosaic process in the 8 NWS domains and the 136 AOIs covering global land between 60°S and 75°N. With the mosaicked data in the 136 AOIs, the daily composition composites the near real-time flood detection results and generates daily composited flood datasets from Suomi-NPP, NOAA-20, and NOAA-21. The daily composited flood datasets are further used as the input for 5-day composition process to derive VIIRS 5-day composited flood datasets. All the flood datasets are in NetCDF format, and an image display process is applied on these NetCDF datasets to generate VIIRS flood maps in geotiff and vector data in shapefile format.

Among the major procedures, the VIIRS flood detection process has the core algorithm for flood mapping. The algorithm consists of six major processes including water detection, cloud shadow removal, terrain shadow removal, minor water detection, water fraction retrieval and floodwater determination. With the input data, the algorithm performs water detection using a combination of methods and approaches including decision-tree technique, threshold method, histogram method and change detection to differentiate among cloud, snow cover, river/lake ice, vegetation, bare land, supra-snow/ice water, supra-veg/bare land water without sun-glint contamination and supra-veg/bare land water with minor to moderate sun-glint contamination. Because cloud shadows and terrain shadows share similar spectral features with water surface, most shadow pixels are mixed with water pixels during the classification process. A geometry-based method is applied to remove cloud shadow pixels from water pixels, and then an object-based method is applied to remove terrain shadows pixels from water pixels. The rest water pixels are retrieved in water fractions and are used as seeds for minor water detection with change detection approach. With minor water detection, most of the water pixels with small water fractions are picked up and are applied in cloud shadow and terrain shadow removal afterward to remove potential shadow pixels. These new minor water pixels are also applied in water fraction retrieval to derive water fractions. Except supra-snow/ice water, which is used as a separate type in VIIRS flood maps, all the supra-veg/bare land water pixels are compared with water reference maps to determine floodwater pixels in water fractions.

ABI Processing

The major procedures of ABI flood mapping system include ABI data projection and flood detection, rolling composition and image display. The ABI data projection and flood detection module ingests ABI 5-minute or 10-minute data in five channels and projects the data in equidistant cylindrical projection using an inverse weighted distance method, detects floods with the assistance from ancillary datasets and outputs ABI 5-minute or 10-minute intermediate flood products in NetCDF4 format. The intermediate flood datasets are then applied in the rolling composition module to derive the ABI hourly and daily composited flood products. The image display module converts the hourly and daily NetCDF4 outputs to raster images in geotiff and png formats and vector data in shapefile format.

Among these procedures, the ABI data projection and flood detection module has the core algorithm for data process and flood mapping. The detection algorithm is adjusted from VIIRS flood detection algorithm with improvements to fit ABI's calibration and spatial resolution. Additionally, the cirrus channel (centering at 1.37 μm) is used for better discrimination between snow/ice and cloud cover. A

data correction method is also developed to reduce the fluctuation of reflectance in the visible to short-wave infrared channels during daytime. The input data are firstly projected into equidistant cylindrical projection. After calibration conversion, a data correction is applied in the visible, near-infrared and shortwave infrared channels. After that, all the pixels are applied in classification to differentiate among cloud, snow cover, river/lake ice, vegetation, bare land, supra-snow/ice water, supra-veg/bare land water without sun-glint contamination and supra-veg/bare land water with minor to moderate sun-glint contamination. A geometry-based cloud-shadow removal algorithm and an object-based terrain-shadow removal algorithm are then used to differentiate water pixels from cloud shadows and terrain shadows. The determined water pixels are retrieved in water fractions and are used as seeds for minor water detection using a change detection approach. The detected minor water pixels are firstly differentiated from cloud shadows and terrain shadows, and are then retrieved in water fractions. All the water pixels including supra-snow/ice water pixels and supra-veg/bare land water pixels are compared with an ABI water reference map to determine floodwater pixels.

Blended Flood Mapping Processing

The Blended VIIRS/ABI Flood Product inherits the advantages of VIIRS and ABI flood products and provides the flood inundation with the best quality in comparison to the separate VIIRS or ABI flood products.

The joint VIIRS/ABI Flood Product blends the daily flood detection results from VIIRS and ABI in two ways: a nearest interpolation method and a simplified downscaling method. The nearest interpolation method is based on the VIIRS 375-m flood maps, and uses the 1-km ABI clear-sky flood detection results to fill the gaps of clouds and cloud shadows in the VIIRS maps. The simplified downscaling method downscales the ABI 1-km flood water into 30-m flood extent, and then re-calculates floodwater fractions in 375-m resolution to match the VIIRS resolution, and then fill the gaps of cloud and cloud shadows in VIIRS flood maps. The two methods show the flood extent under the maximal clear-sky coverage derived by the satellites during daytime, and keep the finer VIIRS 375-m spatial resolution. The product has the same spatial coverage with the ABI flood product in American mainland and islands between 50.5° S and 50.5°N in latitudes.

2.2. Input Satellite Data

2.2.1. Satellite Instrument Overview

The Visible Infrared Imaging Radiometer Suite (VIIRS) is a critical sensor on-board Suomi-NPP, NOAA-20, NOAA-21, and future JPSS series satellites. There are 22 spectral bands covering the spectral range of 412 nm to 12 μm with nominal spatial resolution of 375 m to 750 m. Among the 22 bands, there are five Imager bands with 375m spatial resolution in the visible (VIS) and infrared (IR) regions. The swath coverage of one scan reaches about 3040km with relatively constant spatial resolution across the scan.

Advanced Baseline Imager (ABI) is a multi-channel passive imaging radiometer designed to observe the Western Hemisphere and provide variable area imagery and radiometric information of Earth's surface, atmosphere and cloud cover. This instrument is onboard the GOES-16/17/18/19 satellites. The instrument has multiple scan modes. In mode 4, or continuous full disk mode, the ABI produces a full disk (Western Hemisphere) image every five minutes. In mode 3, or flex mode, the ABI concurrently

produces a full disk every 15 minutes, a CONUS image (resolution 3000 km by 5000 km) every five minutes, and two mesoscale domains (resolution 1000 km by 1000 km at the satellite sub-point) every 60 seconds or one sub-domain every 30 seconds. Mode 6, or 10-minute flex mode, which became the default operating mode for GOES-16 and GOES-17 in April 2019, provides a full disk image every 10 minutes, a CONUS (GOES-16) / PACUS (GOES-17) image every five minutes, and images from both mesoscale domains every 60 seconds (or one sub-domain every 30 seconds). All ABI bands have on-orbit calibration.

2.2.2. Satellite Data Preprocessing Overview

The satellite data is processed prior to being used by VFM/AFM/BFM.

2.2.3. Input Satellite Data Description

VFM requires VIIRS level-1b SDR data in I-bands 01, 02 03, 05 and four geometry angles (solar zenith, solar azimuth, sensor zenith and sensor azimuth) in the terrain-corrected geolocation data (GITCO).

Table 2-1 lists the specifications of VIIRS level-1 SDR data for flood detection.

Table 2-1 - Specifications of VFM Input VIIRS Level-1b SDR Data

Input File	Spatial Resolution	Name Pattern	Content	Format
VIIRS Imager band 01	375m	e.g. SVI01_j01_d20200225_t1909150_e1910395_ b11768_c20200226160556032790_nobc_ops	Visible channel reflectance centering at 640nm	HDF5
VIIRS Imager band 02	375m	e.g. SVI02_j01_d20200225_t1909150_e1910395_ b11768_c20200226160556032790_nobc_ops	Near-infrared channel reflectance centering at 865 nm	HDF5
VIIRS Imager band 03	375m	e.g. SVI03_j01_d20200225_t1909150_e1910395_ b11768_c20200226160556032790_nobc_ops	Short-wave infrared channel reflectance centering at 1.61μm	HDF5
VIIRS Imager band 05	375m	e.g. SVI05_j01_d20200225_t1909150_e1910395_ b11768_c20200226160556032790_nobc_ops	Thermal infrared channel brightness temperature centering at 11.45μm	HDF5
VIIRS terrain-corrected navigation data	375m	e.g. GITCO_j01_d20200225_t1909150_e1910395_ b11768_c20200226160606186943_nobc_ops.h5	solar zenith, solar azimuth, sensor zenith and sensor azimuth, longitude and latitude	HDF5

There are two kinds of input data for the ABI flood detection algorithm:

- ABI level-1b data in channel 02, 03, 04, 05 and 13
- ABI static sensor azimuth angle and sensor zenith angle (included in the delivery package with the ancillary data)

Table 2-2 lists the specifications of ABI level-1b data for flood detection.

Table 2-2 - Specifications of AFM Input ABI Level-1b Data

Input File	Spatial Resolution	Name Pattern	Content	Format
ABI channel 02	500m	e.g. OR_ABI-L1b-RadF-M6C02_G16_s20221261930204_e20221261939512_c20221261939549.nc	Visible channel reflectance centering at 640 nm	netCDF4
ABI channel 03	1km	e.g. OR_ABI-L1b-RadF-M6C03_G16_s20221261930204_e20221261939512_c20221261939561.nc	Near-infrared channel reflectance centering at 865 nm	netCDF4
ABI channel 04	2km	e.g. OR_ABI-L1b-RadF-M6C04_G16_s20221261930204_e20221261939512_c20221261939544.nc	Short-wave infrared channel reflectance centering at 1.61μm	netCDF4
ABI channel 05	1km	e.g. OR_ABI-L1b-RadF-M6C05_G16_s20221261930204_e20221261939512_c20221261939558.nc	Cirrus channel centering at 1.385μm	netCDF4
ABI channel 13	2km	e.g. OR_ABI-L1b-RadF-M6C13_G16_s20221261930204_e20221261939522_c20221261939577.nc	Thermal infrared channel brightness temperature centering at 11.45μm	netCDF4

Blended Flood Mapping takes the VIIRS 1-day composites and ABI 1-day composites as input to produce output that combines the VIIRS and ABI data together.

2.3. Input Ancillary Data

VFM static ancillary data includes land cover, land/sea mask, water reference mask, sun-glint lookup table, DEM, climatology of land surface temperature and sea surface temperature, albedo climatology and pre-trained decision trees. **Error! Reference source not found.** lists the static ancillary datasets used by VFM.

Table 2-3 - Static Ancillary Datasets Used by VFM

Input File	Name Pattern	Source	Format
Global land cover at 1km resolution	Global_land_cover_IGBP_2017_USGS_types.raw	VIIRS surface type in 2017 and AVHRR land cover dataset in 2000	raw
Global Digital Elevation Model at 375-m resolution	Global_DEM375m_W180_W090_N90_S90.raw, … Global_DEM375m_E090_E180_N90_S90.raw	SRTM/DEM ASTER DEM	raw
Sun-glint lookup table	Sun_Gliter_mask_005.dat	Self-support	raw
Global land/sea mask at 1km resolution	lw_geo_2001001_v03m_1km.raw		raw
Global water mask	VIIRS_Global_MOD44W_Water_Mask.raw	MOD44W, ESA's global water mask, NLCD 2006	raw
Land/sea surface temperature 16-day climatology at 5km resolution	AQUA_Daytime_LST_SST_Climatology_NNN.raw	MODIS LST/SST	raw

Input File	Name Pattern	Source	Format
Global Albedo monthly climatology at 5km resolution in visible channel	CMG-SMT-P0B1_ch1_{Channel number}.raw	MODIS Albedo dataset	raw
Pre-trained decision trees and tree attribute files	Tree_{tree number}_attr.txt Tree{tree number}_J48graft_{description}.txt	Self-support	txt
User AOI definition file: to list the geographic information of each subset	User_AOI_Definition.txt	User defined	txt

AFM static ancillary data includes land cover, land/sea mask, water reference mask, sun-glint lookup table, DEM, climatology of land surface temperature and sea surface temperature, albedo climatology and pre-trained decision trees. Table 2-4 lists the static ancillary datasets used by AFM.

Table 2-4 - Static Ancillary Datasets Used by AFM

Input File	Name Pattern	Source	Format
ABI static sensor zenith angle	goes16_75.2W_1kmgrid_satzen.dat goes17_fd_1kmgrid_satzen.dat	GOES-R Program	raw
ABI static sensor azimuth angle	goes16_75.2W_1kmgrid_satazm.dat goes17_fd_1kmgrid_satazm.dat	GOES-R Program	raw
Global land cover at 1km resolution	Global_land_cover_IGBP_2017_USGS_types.raw	VIIRS surface type in 2017 and AVHRR land cover dataset in 2000	raw
Global Digital Elevation Model at 1-km resolution	Global_DEM_1km_NOAA_36000_18000.raw	SRTM/DEM ASTER DEM	raw
Sun-glint lookup table	Sun_Gliter_mask_005.dat	Self-support	raw
Global land/sea mask at 1km resolution	lw_geo_2001001_v03m_1km.raw		raw
Water mask in west hemisphere	ABI_WEST_MOD44W_Water_Mask_30mlandcover.raw	MOD44W, ESA's global water mask, NLCD 2006	raw
Land/sea surface temperature 16-day climatology at 5km resolution	AQUA_Daytime_LST_SST_Climatology_NNN.raw TERRA_Daytime_LST_SST_ClimatologyNNN.raw	MODIS LST/SST	raw
Global Albedo monthly climatology at 5km resolution in visible channel	CMG-SMT-P0B1_ch1_{Channel number}.raw	MODIS Albedo dataset	raw
Pre-trained decision trees and tree attribute files	Tree_{tree number}_attr.txt Tree{tree number}_J48graft_{description}.txt	Self-support	txt

Input File	Name Pattern	Source	Format
User AOI definition file: to list the geographic information of each domain	User_AOI_Definition.txt	User defined	txt

Blended Flood Mapping takes the VIIRS 1-day composites and ABI 1-day composites as input to produce output that combines the VIIRS and ABI data together. Static files (included with the delivery) required for BFM are listed in Table 2-5.

Table 2-5 - Static Ancillary Datasets Used by BFM

Input File	Name Pattern	Source	Format
30-m CDSM data	30m	e.g. Copernicus_DSM_COG_10_N40_00_W096_00_DEM_30m.raw	Copernicus Digital Surface Model
30-m water mask and tree cover data	30m	e.g. swbd_treecover2010_40N_090W_25m.raw	Merged SWBD and MLCD data
1-km river line data	1 km	e.g. ABI_1km_Hydro_River_na_ca_sa_10314_11564.raw	River lines
1-km river/lake water level data	1 km	e.g. ABI_1km_Hydro_riverlake_waterlevel_na_ca_sa_10314_11564_CDSM.raw	River/lake water levels
1-km HUC level-08 data	1 km	e.g. ABI_1km_Hydro_HUC04_na_ca_sa_10314_11564.raw	Hydrologic Unit Code Level-08 data
1-km HUC level-10 data	1 km	e.g. ABI_1km_Hydro_HUC10_na_ca_sa_10314_11564.raw	Hydrologic Unit Code Level-10 data

Note that VFM/AFM does not require dynamic ancillary data.

3. Performance

3.1. Product Testing

3.1.1. Test Data Description

Test cases are provided with each CCAP to OSPO for product verification before transition to operations. The test cases provide input and static and dynamic ancillary data, and the resulting product datasets for verification. Requirements as specified in the RAD document must be met in testing, and only after OSPO is satisfied that requirements are met will the VFM/AFM/BFM products will be transitioned into operations.

3.1.2. Unit Test Plans

VFM/AFM/BFM products (and all products) are tested regularly with each update. The science teams, which develop these products, test them for accuracy and validation. The Office of Common Services (OCS) group tests the algorithms and scripts to ensure that RAD requirements are met, and then operations must test these products to make sure that they run successfully on their systems. If there are problems in any one of these testing procedures, then the relevant groups must work together to iron-out any issues.

3.2. Product Accuracy

The VFM/AFM/BFM products must meet accuracy standards set forth by the science team which can be found in the RAD document.

3.2.1. Test Results

Algorithm validation test results by the science team can be found in the Algorithm Basis Theoretical Documents (ATBD).

3.2.2. Product Accuracy

VIIRS/ABI Flood Mapping products have been validated against observations. The accuracy and precision of the Flood Mapping products fall well within the accuracy and precision specifications.

3.3. Product Quality Output

The quality of the output products can be found in the 'QualityFlag' variable and metadata contained within the NetCDF files (section **Error! Reference source not found.**). Operations also qualitatively examines the *.png output products.

3.4. External Product Tools

There are no external product tools associated with the Flood Mapping algorithm package. External users can choose their own preferred tools to display and analyze these output files.

3.5. Output Files

Enterprise Flood Mapping final products are available on PDA for user subscription. The data retention time on PDA is the standard 7 days.

3.5.1. Product Monitoring and Visualization

Product quality is monitored using the NCCF Product Monitoring Tool at https://nccf-prod-dashboard.nccf.nesdis.noaa.gov/mtool/index.html.

Users can use this page to monitor summaries of the Enterprise Flood Mapping quality based on parameter thresholds determined by the PAL.

The NCCF Products Visualization Page is located at https://www.ospo.noaa.gov/products/land/efm/.

EFM products are updated daily.

4. Product Status

4.1. Operations Documentation

NESDIS/STAR (2023), FY23 Enterprise Algorithm Project Plan - NLR Land & Surface Hydrology: Blended Flood Mapping

NESDIS/STAR (2023), FY23 Enterprise Algorithm Project Plan - NLR Land & Surface Hydrology: Flood Mapping Products

NESDIS/STAR (2021), VIIRS Flood Mapping Product Processing System Algorithm Readiness Review (ARR) Presentation

NESDIS/STAR (2020), VIIRS Flood Mapping Requirements Allocation Document (RAD)

NESDIS/STAR (2023), Algorithm and Theoretical Basis Document for VIIRS and ABI Flood Mapping Products

NESDIS/STAR (2024), Algorithm and Theoretical Basis Document for NOAA Blended VIIRS/ABI Flood Mapping (BFM) Product

NESDIS/STAR (2024), The Enterprise Flood Mapping System Maintenance Manual

NESDIS/STAR (2024), VIIRS/ABI Flood Mapping DAP Documents including the Readme file, Delivery Memo, and Production Rules

NESDIS/STAR (2022), FY23 Enterprise Algorithm Project Plan NLR Land & Surface Hydrology: Flood Mapping Products (Draft version)

NESDIS/STAR (2022), Critical Design Review (CDR) for ABI Flood Mapping

4.2. Maintenance History

END OF DOCUMENT

5. Acronyms

Acronym	Definition
ABI	Advanced Baseline Imager
AFM	ABI Flood Mapping
AOI	Area of Interest
ASSISTT	Algorithm Scientific Software Integration and System Transition Team
ATBD	Algorithm Theoretical Basis Document
AVHRR	Advanced Very-high-resolution Radiometer
BFM	Blended Flood Mapping
CCAP	Cloud Containerized Algorithm Package
CDR	Critical Design Review
CLASS	Comprehensive Large Array-data Stewardship System
CONUS	Continental United States
DEM	Digital Elevation Model
DM	Dry Mass
DOC	Department of Commerce
EDR	Environmental Data Record
EFM	Enterprise Flood Mapping
ERT	Earth Resources Technology, Inc.
ESPC	Environmental Satellite Processing Center
EUM	External Users' Manual
FM	Flood Mapping
GITCO	Terrain-Corrected Geolocation Data
GMU	George Mason University
GOES	Geostationary Operational Environmental Satellite
IR	Infrared
JPSS	Joint Polar Satellite System
NCCF	NESDIS Common Cloud Framework
NCEI	National Centers for Environmental Information
NESDIS	National Environmental Satellite, Data, and Information Service
NetCDF	Network Common Data Form
NOAA	National Oceanic and Atmospheric Administration
NPP	National Polar-orbiting Partnership
NRT	Near-real Time
NWS	National Weather Service
OCS	Office of Common Services
OMS	Operations, Maintenance, and Sustainment
OSD	Office of Systems Development
OSPO	Office of Satellite and Product Operations
PAL	Product Area Lead
PDA	Product Distribution and Access
PIB	Product Implementation Branch
PPM	Project Portfolio Management
QA	Quality Assurance
R2O	Research to Operations
RAD	Requirements Allocation Document
SDR	Satellite Data Record
SMM	System Maintenance Manual
STAR	Center for Satellite Applications and Research
V&V	Verification and Validation

Acronym	Definition
VFM	VIIRS Flood Mapping
VIIRS	Visible Infrared Imaging Radiometer Suite
VIS	Visible