MODIS/VIIRS NRT Global Flood Products

MODIS/Aqua+Terra Flood Map Daily L3 Global 250m LLL Grid NRT

VIIRS/JPSS1+JPSS2 Daily L3 Global Flood Composite 250m Linear Lat Lon Grid – NRT

VIIRS/JPSS1+JPSS2 Hourly Cumulative L3 Global Flood Composite 250m Linear Lat Lon Grid – NRT

Provided by NASA's Land Atmosphere Near real-time Capability for Earth observation (LANCE)

User Guide

Revision F

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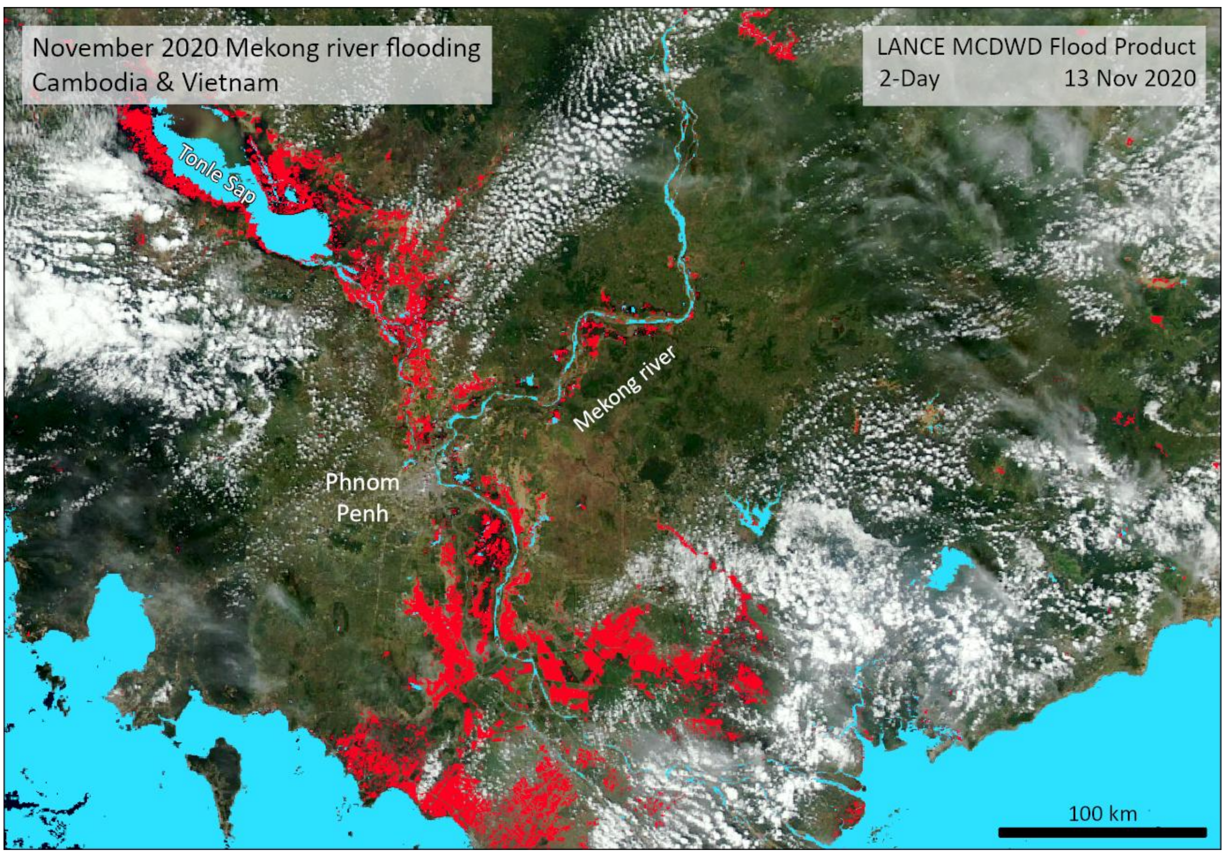

The 2-Day flood product showing extensive flooding (in red) in the lower Mekong region of Cambodia and Vietnam, and normal water (in cyan), overlaid on MODIS-Aqua imagery. Although a dramatic example demonstrating the product capabilities, much of the displayed flooding here is typical seasonal flooding.

Document Revision History

Revision	Date	Description
A	8 Mar 2021	Initial beta release
B	25 June 2021	Final beta release: qualitative eval complete, updated access info.
C	12 Jan 2023	Beta 2 release: addition of HAND mask.
D	16 Apr 2024	Release 1: updated compositing, updated Reference Water mask, additional tiles added to production.
D.1	26 Nov 2024	Updated contact email and website URLs, Figure 15, and other minor clarifications.
E	22 Apr 2025	Adding VIIRS product Beta 1 information
F	11 Dec 2025	MODIS and VIIRS Release 1.1: Recurring flood update

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1 Quick Start Summary

NASA's Land, Atmosphere Near real-time Capability for EO (LANCE) provides two global daily ~250 m resolution Near Real-Time (NRT) flood products:

- MCDWD from the MODIS instrument (on Terra and Aqua spacecraft), and
- VCDWD from the VIIRS instrument on NOAA-20 (JPSS-1) and NOAA-21 (JPSS-2) spacecraft.

The MODIS and VIIRS products are currently at Release 1.1 (under MODIS collection 6.1, and VIIRS collection 2).

The MODIS product has been in production since early 2021. Prior to this, a legacy product ("MWP") was generated from 2011 through 2022. The VIIRS product was released in April 2025. Apart from the difference in input data source (MODIS or VIIRS), the products are almost identical in algorithm and product formats. With the Terra and Aqua satellites reaching end of life, the VIIRS product was developed to replace the MODIS product. The flood product is an applications product, and there is no associated science product (unlike most LANCE products).

Product homepage: https://www.earthdata.nasa.gov/global-flood-product

Or: https://www.earthdata.nasa.gov/data/instruments/viirs/near-real-time-data/nrt-flood-products

Product Access

The NRT download sites are updated in near real-time as each incoming swath granule triggers product generation or update. For the VIIRS product, a cumulative hourly product is available for the current day (VCDWD**G:** the product with the latest hourly timestamp will have the most recent data). For previous days' products, or for the final product at the end of day, the VCDWD should be used. For the MODIS product, the product file is updated in place as new data is acquired (there is no hourly product).

HDF Files

MODIS:

longname identifier: MODIS/Aqua+Terra Flood Map Daily L3 Global 250m LLL Grid NRT

shortname identifier: MCDWD_L3_NRT

DOI: 10.5067/MODIS/MCDWD_L3_NRT.061

Example filename: MCDWD_L3_NRT.A2025071.h28v07.061.hdf

VIIRS daily:

longname: VIIRS/JPSS1+JPSS2 Daily L3 Global Flood Composite 250m Linear Lat Lon Grid – NRT

shortname: VCDWD_L3_NRT

DOI: 10.5067/VIIRS/VCDWD_L3_NRT.002

Example filename: VCDWD_L3_NRT.A2025071.h28v07.002.h5

VIIRS hourly:

longname: VIIRS/JPSS1+JPSS2 Hourly Cumulative L3 Global Flood Composite 250m Linear Lat Lon Grid – NRT

shortname: VCDWDG_L3_NRT

DOI: 10.5067/VIIRS/VCDWDG_L3_NRT.002

Example filename: VCDWDG_L3_NRT.A2025071.1100.h28v07.002.h5 (hourly timestamp = 11:00 GMT)

For more information on product filenames and naming conventions, see section 6.2.

The products can be downloaded from the LANCE NRT servers:
https://nrt3.modaps.eosdis.nasa.gov (preferred), or https://nrt4.modaps.eosdis.nasa.gov (backup)

On those sites, navigate as follows:

MODIS: NRT Data → allData → 61 → MCDWD_L3_NRT

VIIRS: NRT Data → allData → 5200 → VCDWD_L3_NRT (or VCDWDG_L3_NRT)

Or, directly:

https://nrt3.modaps.eosdis.nasa.gov/archive/allData/61/MCDWD_L3_NRT
https://nrt3.modaps.eosdis.nasa.gov/archive/allData/5200/VCDWD_L3_NRT
https://nrt3.modaps.eosdis.nasa.gov/archive/allData/5200/VCDWDG_L3_NRT

Although product names appear on the NRT sites as indicated above, the downloaded product files have production timestamps embedded, e.g.: VCDWD_L3_NRT.A2025071.h28v07.002.**2025071094247**.h5

Note you will need a (free) EARTHDATA account for access. Register at: https://urs.earthdata.nasa.gov

GeoTIFF files

GeoTIFF files of the four individual flood layers in each HDF file are also available. These have short name MCDWD_L3_<FloodComposite>_NRT (for MODIS product; VCDWD/VCDWDG for VIIRS), where <FloodComposite> is one of: F1, F1C, F2, or F3 (for the 1-day, 1-day with cloud shadow screening, 2-day, and 3-day products).

These are available in their own directories on the NRT servers:

MODIS: NRT Data → allData → 61 → MCDWD_L3_F1_NRT, etc.

VIIRS: NRT Data → allData → 5200 → VCDWD_L3_FI_NRT, etc*

* As of the date of this User Guide, VIIRS GeoTIFFs are not yet available, but are expected soon.

The MODIS GeoTIFF product DOIs are:

1-day: 10.5067/MODIS/MCDWD_L3_F1_NRT.061
1-day with cloud-shadow screening: 10.5067/MODIS/MCDWD_L3_F1C_NRT.061
2-day: 10.5067/MODIS/MCDWD_L3_F2_NRT.061
3-day: 10.5067/MODIS/MCDWD_L3_F3_NRT.061

Upon release, the VIIRS GeoTIFF product DOIs will be:

Daily:

1-day: 10.5067/VIIRS/VCDWD_L3_F1_NRT.002
1-day with cloud-shadow screening: 10.5067/VIIRS/VCDWD_L3_F1C_NRT.002
2-day: 10.5067/VIIRS/VCDWD_L3_F2_NRT.002
3-day: 10.5067/VIIRS/VCDWD_L3_F3_NRT.002

Hourly:

- 1-day: 10.5067/VIIRS/VCDWDG_L3_F1_NRT.002
- 1-day with cloud-shadow screening: 10.5067/VIIRS/VCDWDG_L3_F1C_NRT.002
- 2-day: 10.5067/VIIRS/VCDWDG_L3_F2_NRT.002
- 3-day: 10.5067/VIIRS/VCDWDG_L3_F3_NRT.002

Bulk Downloads / API interface

Instructions for automating bulk downloads can be found here:
https://nrt3.modaps.eosdis.nasa.gov/help/downloads

Products are generally only available for about 7 days on the NRT servers, and at present there is no publicly accessible archive of older products.

An API is available to query available files on the NRT systems. For example, the following URL will return a json-format listing of all MCDWD files available for 2022-362 (362 = day of year):

https://nrt3.modaps.eosdis.nasa.gov/api/v2/content/details?products=MCDWD_L3_NRT&archiveSets=61&temporalRanges=2022-362

The returned json can then be interrogated for specific tiles of interest or production times. For the MODIS product, this can be compared against previous queries to identify files that have been updated with new data. For the VIIRS VCDWDG hourly product, any newly generated files will appear with a new hourly timestamp in the filename.

Visualizing flood data in Worldview and the FLOOD Viewer

The product is also viewable in Worldview: https://worldview.earthdata.nasa.gov by clicking on "Add Layer", selecting the "Flood" item in the Floods category, and selecting the "Terra and Aqua/MODIS" subcategory (or VIIRS). The following link references Worldview with the flood layers already added: https://go.nasa.gov/globalflood.

The FLOOD Viewer (https://lance.modaps.eosdis.nasa.gov/flood) also provides an interface focused on flood products and related layers. Unlike Worldview, the 1-day composites are visible here, in the Advanced tab, as well as the NOAA-GMU VIIRS flood product, and NASA OPERA surface water layers.

Product Format

The product is distributed in 10x10° tiles (Figure 1), in a lat/lon (geographic) projection, in HDF files. The tiles are 4800 x 4800 pixels, with pixel size of 0.0020833 degrees (~232 m at the equator). Each file contains four flood composites (1-Day, 1-Day CS, 2-Day, and 3-Day; see below), and other ancillary layers (Table 6). An example product file name is MCDWD_L3_NRT.A2021046.h30v12.061.hdf, indicating date in YYYYDOY (YYYY=year; DOY=day-of-year) format, and tile h-v in MODIS linear latitude/longitude grid (https://modis-land.gsfc.nasa.gov/MODLAND_grid.html).

The VIIRS hourly cumulative files (VCDWDG) contain an additional hourly component in the filename: e.g., VCDWDG_L3_NRT.A2025071.**1100**.h28v07.002.h5, which has a timestamp of 11:00 GMT. If files with different hours are available, the highest timestamp has the most up-to-date observations, including all observations up to that point.

Separate GeoTIFF files are also available for each of the four flood composites. An example GeoTIFF filename for a 2-day product is: MCDWD_F2_L3_NRT.A2021046.h30v12.061.tif

The data values in the flood product are provided in Table 7. Note these differ from those in the legacy product (see Appendix 2 for additional details on differences).

Product Use and the 1, 2, and 3-Day Composites

Detecting flood water with MODIS 250 m imagery is relatively straightforward. Unfortunately, cloud and terrain shadows are often also be detected as water because they are spectrally similar in the primary red and near-infrared bands used by the products. By accumulating water detections from subsequent satellite observations, many false-positives can be removed because cloud shadows generally do not recur in the same locations on subsequent observations.

Because the location of flood water is not well known in advance, and because clouds are spatially variable, it is impossible to predict (and thus only generate) the best composite product for a given date or potential flood event. Instead, several composites are pre-generated: 1-Day, 2-Day, and 3-Day. These products sum observations over 1, 2, and 3 days of data, and except for the 1-day case, require multiple water detections, from all available observations in the composite time window, to mark a pixel as water. To minimize latency, the 1-Day composite only uses data from the current day, and has lower thresholds, which may result in cloud-shadow false-positives contaminating the product, if cloud shadows are present. But if clouds are not present, it will provide the most up-to-date view of current flood extent. It is incumbent on the user to decide which product provides useful information for a given event. We have also applied a useful-but-not-perfect cloud shadow mask on an additional version of the 1-Day product (1-Day CS) to remove many (but not all) cloud shadow issues, although at times it can also remove real water or flood.

The product Use Notes and FAQs in section 7 (page 37) provide more detailed guidance and users are advised to review this material.

Support

Contact Earthdata Support for product support: earthdata-support@nasa.gov

A low-volume distribution-only mailing list is also maintained for flood product announcements.

To subscribe: Send an e-mail to floodmap-join@lists.nasa.gov (no subject or body text is required).

To unsubscribe: Send an e-mail to floodmap-leave@lists.nasa.gov (no subject or body text is required).

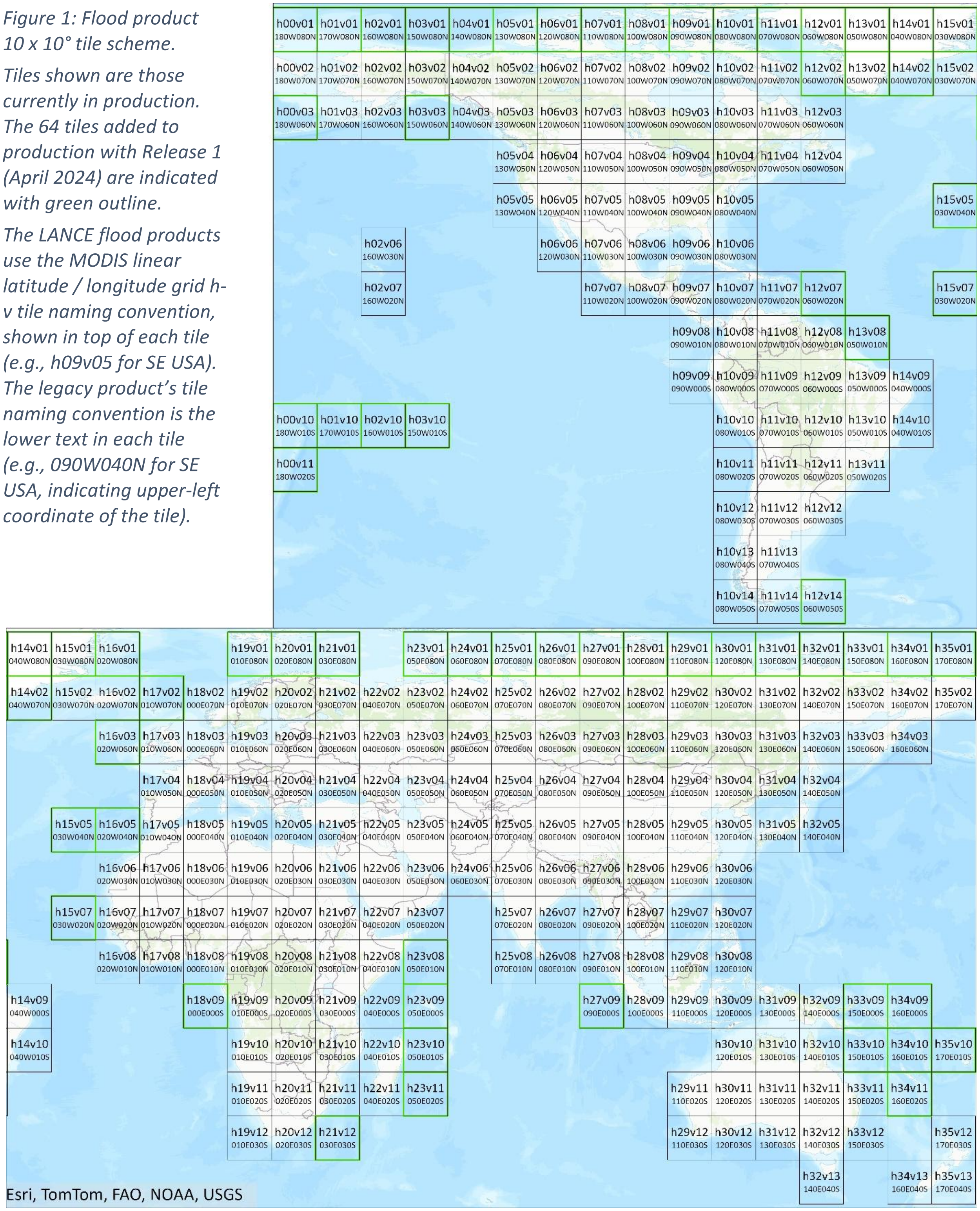

Figure 1: Flood product 10 x 10° tile scheme.

Tiles shown are those currently in production. The 64 tiles added to production with Release 1 (April 2024) are indicated with green outline.

The LANCE flood products use the MODIS linear latitude / longitude grid h-v tile naming convention, shown in top of each tile (e.g., h09v05 for SE USA). The legacy product's tile naming convention is the lower text in each tile (e.g., 090W040N for SE USA, indicating upper-left coordinate of the tile).

2 Introduction

This User Guide provides the most current information on the Collection 61 Terra and Aqua Moderate Resolution Imaging Spectroradiometer (MODIS) NRT Global Flood Product, and the Collection 2 NOAA-20 and NOAA-21 Visible Infrared Imaging Radiometer Suite (VIIRS) NRT flood product. It is intended to provide end users with practical information regarding the use of the product, including: a summary of the flood map algorithm; product evaluation; product format; product access; planned improvements; differences from the legacy product; usage notes and FAQs; and future release plans.

The VIIRS product was released in April 2025. This User Guide was initially developed for the MODIS product and has since been updated to incorporate information about the VIIRS product. The two products are very similar in most respects, and so in general where this User Guide states "MODIS", the VIIRS product can also be substituted. Where there are specific differences, the User Guide has been updated accordingly. We expect to add additional information comparing the MODIS and VIIRS products in a future update.

2.1 Background

NASA's Near Real-Time (NRT) Global Flood Mapping Project was developed through a partnership between the Dartmouth Flood Observatory (since relocated to the University of Colorado, Boulder; https://floodobservatory.colorado.edu) and a team at NASA's Goddard Space Flight Center with funds provided by NASA's Applied Sciences program (Policelli et al. 2017). The production of daily global flood maps with that system began in late 2011 and concluded at the end of 2022.

The core data product of the original flood mapping system (the "legacy" product, in this document) was the MWP (MODIS Water Product), with MODIS Surface Reflectance products (MOD09: (Vermote 2015)) as the primary input. Although it incorporated custom inputs from LANCE (Land, Atmosphere Near real-time Capability for Earth observation : http://earthdata.nasa.gov/lance), the overall production system was otherwise separate and PI-maintained. The current (from March 2021) LANCE MCDWD flood product is generated entirely within MODAPS (MODIS Adaptive Processing System: the production system within EOSDIS (Earth Observing System Data and Information System)), providing much more robust production capabilities. The product short name MCDWD is derived from "MCD", which is the convention for 'combined' products produced from data from both Terra and Aqua MODIS imagery, and "WD", for Water Detection. This new product is referred to in this document as the LANCE or the MCDWD product. With MODIS approaching end-of-life, a corresponding version of the product using imagery from the VIIRS instrument on board the operational NOAA polar orbiters (NOAA-20, NOAA-21) was developed and released in early 2025 (product short name VCDWD; see section 2.3 for details).

Since its inception, the flood product has proven valuable for detecting many types of large-scale flooding, despite its reliance on optical data, which cannot observe water on the ground obscured by cloud cover. Nevertheless, for many events cloud cover is partial, or shifts over the course of one or more days, revealing flood water below. One of the product's advantages is that its source imagery is available with near global coverage twice a day: the MODIS instrument is carried on two satellites (Terra, with a morning overpass, and Aqua, with afternoon), and VIIRS is also available from multiple satellites (NOAA-20 and NOAA-21, both with afternoon overpasses). Thus, there is no need to rapidly program a specific acquisition to capture an event (e.g., as necessary for many commercial sensors), or wait for a defined and fixed revisit period (Landsat and similar sensors). The input surface reflectance data from MODIS or VIIRS are well calibrated and consistently available twice daily, without the user requiring prior knowledge of precisely where the flood may be occurring and thus where to target imagery acquisition.

That said, clouds are problematic and create obstacles for the product—by obscuring the ground, and by casting shadows, which may be incorrectly detected as water (as they are spectrally very similar to water, in the wavelength bands available). Much of the complexity of the product suite arises from addressing these cloud-related issues.

Users of the flood product include the World Food Programme, FEMA (Federal Emergency Management Agency), UN OCHA (Office for the Coordination of Humanitarian Affairs), MapAction, GeoSur, UNOSAT (UN Operational Satellite Applications Program), several large reinsurance companies, and numerous academic researchers. Section 7.2 presents examples of product usage.

Unlike most LANCE products, the flood product was not derived from an existing NASA science product; it was instead originally developed as an applications-focused product developed by an early user of the MODIS Rapid Response imagery (Bob Brakenridge, founder of the Dartmouth Flood Observatory), who developed methods to map floods from rapid response images. As a result, there is no separately developed science product, supporting documentation set, or long-term archive (although the latter will be available in a future update).

2.2 LANCE MODIS product

In 2017, NASA Applied Sciences supported the transition of the legacy flood product to LANCE, with additional support provided by ESDIS (NASA Earth Science and Data Information System Project) and LANCE MODIS. LANCE is part of NASA's Earth Observing System Data and Information System (EOSDIS) and distributes NRT data and image products from many satellite instruments, typically within three hours of data acquisition.

The primary objective of transitioning the legacy flood product to LANCE was to ensure stable, long-term, and operational production. The transition required a complete rewrite of the original codebase to function within the EOSDIS MODAPS environment. During this process, we took advantage of this recoding opportunity to streamline and optimize the algorithmic workflow.

The flood product is distributed through the LANCE webpages (section 6.1) and imagery products are also accessible via NASA's Global Imagery Browse Services (GIBS) (https://www.earthdata.nasa.gov/engage/open-data-services-software/earthdata-developer-portal/gibs-api) and Worldview web application (https://worldview.earthdata.nasa.gov).

The updated product has been rolling out in different releases since early 2021. Details and future plans are summarized in section 8.

2.3 VIIRS product

With the Terra and Aqua satellites reaching end of life, a parallel product using surface reflectance from the VIIRS instrument was released in April 2025. The VIIRS sensor provides similar red and near infra-red bands as MODIS, along with similar daily global coverage (NASA VIIRS Land Science Team 2023).

However, the VIIRS instrument resolution is coarser, at 375 m resolution, compared to MODIS at 250 m. To streamline development and maximize reuse of the existing MODIS workflow, the VIIRS flood product is also generated at 250 m resolution. Incoming swath granules are resampled to the same output projection (geographic or lat/lon) and grid as the MODIS flood product.

VIIRS imagery from the NOAA-20 and NOAA-21 satellites is used (sometimes referred to by their pre-launch names of JPSS-1 and JPSS-2). Both satellites provide afternoon overpasses, with NOAA-20 at approximately 1:30 PM local solar time, and NOAA-21 about 50 minutes later at 2:20 PM. Thus, the VIIRS product lacks the typically less-cloudy morning observations provided by Terra for the MODIS product. We anticipate that may negatively impact VIIRS product quality, and plan to assess this over time. Preliminary analysis demonstrated that using both NOAA-20 and NOAA-21 VIIRS observations, even if only 50 minutes apart, performed better than relying on a single observation.

3 Algorithm

3.1 Overall approach

Flood product generation consists of three key steps:

- Water detection algorithm applied to each MODIS/VIIRS observation (incoming swath granules).
- Compositing of water detections, over time, to reduce errors and more rigorously identify water (including terrain and cloud shadow masking).
- Differentiating flood from expected surface water.

The compositing step is necessary because false-positives (from cloud or terrain shadows) can otherwise substantially contaminate the products. The flood products are generated with three compositing periods (1-day, 2-day, and 3-day), representing the number of days of data that are used for a given product. For example, a 3-day product will incorporate data from the product date, as well as the two previous days. The requirements of the user (such as latency requirements, and tolerance for false-positives and/or false-negatives), and the cloudiness during a given event will determine which product composite provides the best coverage. This does place a burden on the user to evaluate the observation conditions (cloudiness) and the available products for a particular event. The availability of these products in the Worldview web application and the FLOOD viewer makes it easier for users to compare and evaluate the different options. Figure 2 provides an overview of the process.

1. **Input: Surface Reflectance Imagery**
   - Process begins when a new swath granule is available (~2x/day).
2. **Water Detection:** Apply water detection algorithm (section 3.2).
3. **Shadow Masking (removes potential false-positive water detections)**
   - Apply terrain shadow mask.
   - For 1-Day CS ("cloud shadow") product only: apply cloud shadow mask.
4. **Temporal Aggregation**
   - Sum water detections from all granules over the composite period (1, 2, or 3 days).
5. **Thresholding:** Compare the summed water detection count to threshold (table 2)
   → If **Count ≥ Threshold**: mark output pixel as **Water**
6. **Flood identification:** Compare Water pixels to Reference Water layer
   - If the Water pixel is outside the Reference Water layer: label as **Flood**.
   - If the Water pixel is inside the Recurring Flood layer for the given month: label as **Recurring Flood**.
   - If the Water pixel is inside the Reference Water layer: label as **Surface Water**.

Figure 2: Overall process flow for generation of the flood product. Note this does not cover setting of the Insufficient Data flag values (255) – see section 3.4.4 for details.

3.2 Water detection algorithm

The water detection algorithm relies principally on a band ratio of red and near-infrared bands (bands 1 and 2 in MODIS and i1 and i2 in VIIRS), but also incorporates some single-band thresholding (including on a shortwave infra-red band (band 7 in MODIS; band m11 in VIIRS)) to help eliminate edge cases of false water detection. MODIS input data is from the MOD09 (Surface Reflectance) product (MOD09.NRT.061: https://doi.org/10.5067/MODIS/MOD09.NRT.061), in which bands 1 and 2 are provided at 250 m resolution, and band 7 at 500 m (pan-sharpened to 250 m to match bands 1 and 2).

For the VIIRS product, the similar VJ109/VJ209 Surface Reflectance product is used (VJ109_NRT.002: https://doi.org/10.5067/VIIRS/VJ109_NRT.002), with band 11 in place of MODIS band 7. As of Release 1.1, the product now uses the final cross-calibration for VJ209 (NOAA-21) surface reflectance (an upstream update).

The water detection algorithm is as follows:

$$\text{Mark pixel as water IF:}\quad \frac{(Band2 + A)}{(Band1 + B)} < C \quad \text{AND} \quad (Band1 < D) \quad \text{AND} \quad (Band7 < E)$$

The constants A, B, C, D, and E were determined empirically by DFO, and are provided in Table 1. If bands 1 or 2 contain saturated or other bad data or NODATA values, the pixel is marked as NODATA. If only band 7 (band M11 for VIIRS) contains bad values or NODATA, the rest of the computation is completed (with the Band 7 threshold component ignored).

Table 1: Water detection algorithm constants. *Note A, B, D, and E assume input reflectance is scaled by 10000 (standard surface reflectance product scaling).*

Constant	Value
A	13.5
B	1081.1
C	0.7
D	2027
E	675.7

3.3 Time compositing

Because cloud and terrain shadows are often detected as water by the water detection algorithm, multiple water observations are generally required before a pixel is marked as water. Cloud shadows move over time, so requiring multiple water detections is fairly effective at reducing such false-positives. Terrain shadows, however, recur from day to day, so compositing is not effective in removing them. The disadvantage to compositing is potentially increased latency, as the compositing window covers a larger number of days; a robust product typically cannot be generated from a single observation, unless conditions are cloud-free. The optimal composite for a given event and location thus depends on the cloudiness of the available MODIS imagery on the dates of interest.

Several different time composites are generated to provide options to the user: 1-Day, 1-Day CS (with **c**loud **s**hadow masking applied; see section 3.4.3), 2-Day, and 3-Day. Prior to Release 1, the 1, 2, and 3 day products required a total of 1, 2, or 3 water observations, respectively, to mark a pixel as water. This approach became problematic with the LANCE implementation product because the product now takes advantage of additional observations provided when subsequent orbital swaths (~100 minutes apart) overlap, which occurs above approximately 30° latitude in the MODIS product. For VIIRS, there is some level of swath overlap at all latitudes. These observations provide additional opportunities to observe surface water, but can also increase the potential for cloud shadow false-positives. As a result, the detection threshold is linked to the total number of observations, which is simply determined by the swath coverage, excluding bad data values (e.g., where we have an actual observation, whether of surface or potentially cloud). The count of the total number of observations is also provided in the HDF product files, in the "Total Counts" layers for each composite period (1-, 2-, and 3-Day products). Empirical work determined the optimal thresholds (Table 2) to balance reducing false-positives while still taking advantage of additional observations to detect water. Prior to the implementation of these thresholds in release 1, the product would often report excess cloud-shadow false-positives at high latitudes (> 50° N).

Table 2: Water detection thresholds*. Indicates the total number of water detections required to mark a pixel as water, over a compositing period. This depends on the total number of observations available (or "total counts"), which is essentially the sum of swath footprints over the composite period (Figure 3).*

Total number of observations	Total required water detections
1 – 2	1
3 – 4	2
5 – 7	3
8 – 11	4
12 – 16	5
17 – 23	6
24 +	7

Composites are generated by summing all valid water detections over the composite period and comparing this sum to the appropriate threshold. For the 1-day product, the composite period is the current day: all available Terra and Aqua (or NOAA-20 and NOAA-21) swaths over a pixel on that day are included. For the 2-day product, the composite period is the current day plus the previous day; for the 3-day product, the composite period is the current day plus the two preceding days. Note for the case where only 1 water detection is required (when the total number of observations is <= 2), this results in ***no*** removal of cloud-shadow false-positives via compositing, and thus these products can contain substantial false positives under some cloudy conditions (this *only* impacts the 1-day product). Figure 3 shows an example of the total number of potential observations over 1 and 2 day composites, demonstrating the increase at higher latitudes.

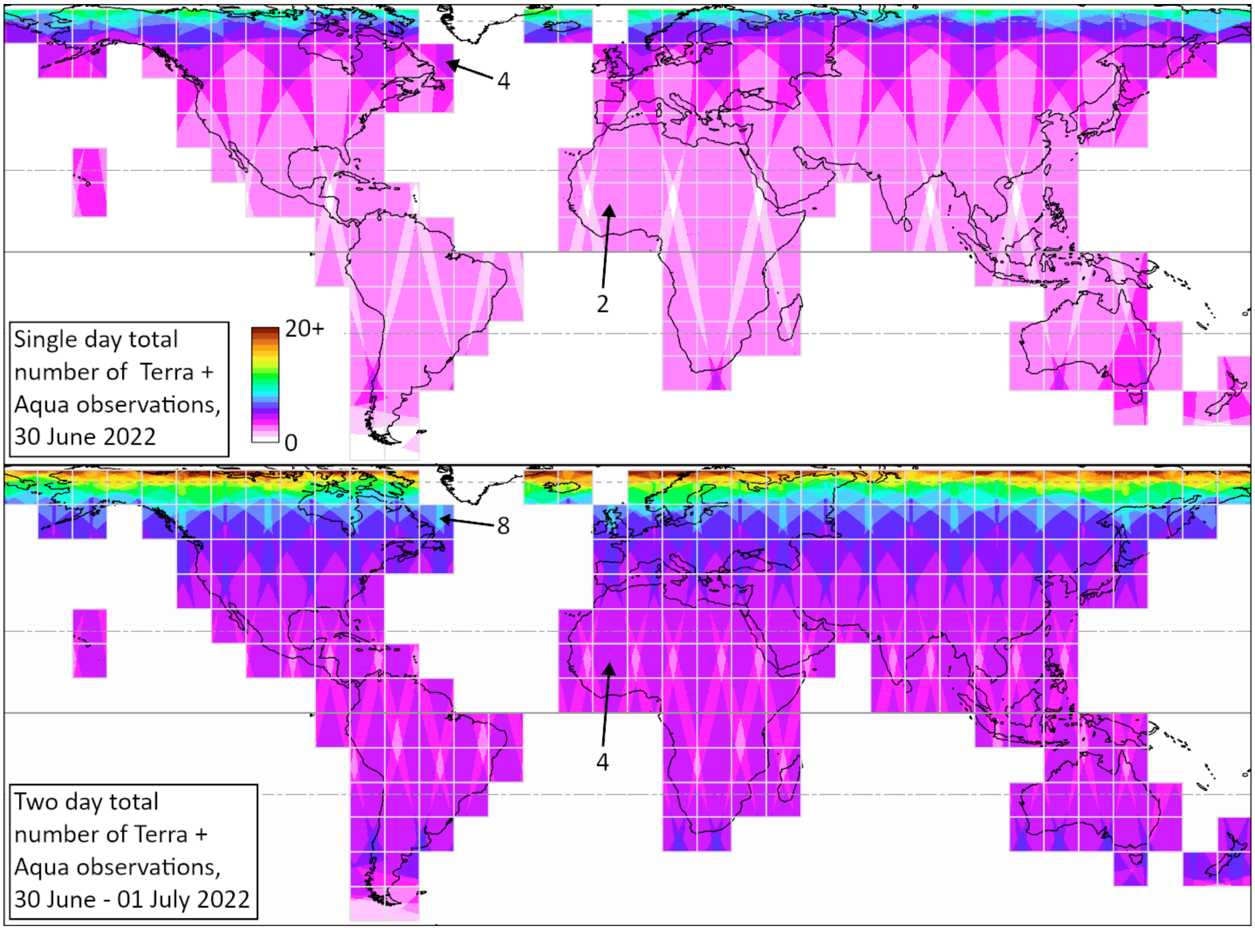

Figure 3:Total potential Terra + Aqua observations *("total counts"). Figure shows the number of overlapping swaths, from each satellite, for illustrative dates (30 June – 01 July 2022); swath positions shift from day to day so the overall pattern also shifts from day to day. The top image shows observations for a single day; note small diamonds around 15° N with zero observations, due to intersecting swath gaps. Above 30° N, but especially above 50°, 3 or even 4 observations may be available, due to increased overlap of swaths near the poles. The bottom image shows observations over two days. Product grid is for original 223 tiles. Note: VIIRS observations from NOAA-20 and NOAA-21 provide enhanced coverage due to the absence of equatorial swath gaps, but show a similar overall pattern with overlap increasing with latitude. Their orbital intersection pattern, however, is different because all VIIRS instruments orbit in the same direction.*

3.4 Terrain and Cloud Shadow Masking

To help reduce shadow-related false-positives, several masks are applied: terrain shadow, HAND (Height Above Nearest Drainage), and cloud-shadow. Terrain shadow and cloud shadow masks are applied to each individual water detection before compositing. In cases where the water detection algorithm flags a pixel as water and that pixel is also marked in either mask, that detection is removed before compositing proceeds. The cloud shadow masks are applied only to the 1-Day CS product. The HAND mask is applied after compositing and removes any pixels marked as water or flood.

3.4.1 Terrain shadow masks

For terrain shadows, a set of precomputed terrain shadow masks are applied. These masks were originally generated for the legacy product at a monthly time-step, on the 22nd of each month, using the

ASTER global digital elevation model (DEM) (https://asterweb.jpl.nasa.gov/gdem.asp), version 2 (NASA/METI/AIST/Japan Spacesystems and U.S./Japan ASTER Science Team 2009). They were computed for the nominal overpass times of 10:30 AM (Terra) and 1:30 PM (Aqua). For any given date, the most liberal monthly mask is applied, specifically the mask closest to the winter solstice, when terrain shadows are longest.

In the legacy product, terrain shadow masks were estimated to remove between 75-90% of terrain shadow false-positives in the 2-Day product; they are helpful, but substantial false-positives may remain. To address this, an additional terrain mask, the HAND mask (section 3.4.2), was developed and is now applied.

At present, terrain-shadow masks are applied only to the original 223 product tiles, and not to the expanded set of 287 tiles (Figure 1); the HAND mask is significantly more effective, so terrain-shadow masks have not been generated for the expanded set of tiles.

3.4.2 HAND mask

The HAND (Height Above Nearest Drainage (Nobre et al. 2011)) model provides a terrain-based metric of local drainage potential that is used to remove most remaining terrain shadow false positives, as well as many cloud shadow false-positives, occurring in mountainous terrain. It masks water detections from areas that are physically unlikely to flood (at the scales visible with 250 m optical imagery) because there is sufficient nearby drainage potential to carry away flood waters.

The HAND model assigns a height to each pixel indicating the vertical distance to that pixel's nearest drainage channel. These channels, and the corresponding heights, are derived from a DEM; the algorithm defines drainage channels using an *upstream area* parameter. Based on empirical experimentation, we chose an upstream area of approximately 48 km^2 (6000 pixels of the source 90-m DEM). The resulting HAND layer is resampled to the flood product grid (0.002083 degrees), and then an empirically determined 30 m threshold is applied to create a binary mask. This mask is cleaned up with a series of morphological operators (dilation and erosion) to remove small islands, voids, and pixelated noisiness that occur around the edges of the threshold value. Finally, known water bodies (from our reference water dataset, MOD44W; see section 3.5 below) are subsequently removed from the mask, after dilating by 1 pixel, to ensure water is reportable in known water bodies, as well as any immediately adjacent small-scale flooding. This can be important when the HAND mask contains inaccuracies due to errors or changes in the DEM, and for endorheic lakes and terminal basins elevated significantly above nearby drainages. When applied to the product flood layers, all pixels under the HAND mask are reassigned a value of 255 (NODATA), signaling that a mask has been applied in such areas and water (flood or surface water) will not be reported.

We used the global Copernicus 90 m DEM ("GLO-90"; European Space Agency, Sinergise 2021) to generate HAND. GLO-90 is based on WorldDEM (itself from TanDEM-X data), filled with other datasets in problematic areas. We utilized the 3 arc second version distributed by OpenTopography in AWS. We chose GLO-90 over SRTM-based DEMs because it is based on more recent observations (2011-2015), and thus is more accurate where new reservoirs and other changes have modified topography, impacting HAND. PCRaster tools (version 4.3.3; Karssenberg et al. 2010) were used to generate HAND.

Figure 4 shows a global overview view of the HAND mask. Figure 5 shows the mask in detail in an area in Mississippi, and in comparison to FEMA flood hazard zones. Figure 6 shows an example of the impact of the mask on the products in a mountainous area. This demonstrates that although multi-day compositing is quite effective at reducing false-positives (vs the 1-day product), a substantial number of false-positives can remain, but these are almost entirely eliminated by the HAND mask. If a user prefers a product without the HAND mask, this can be reconstructed by recomputing the composites using the ancillary layers in the product HDF file.

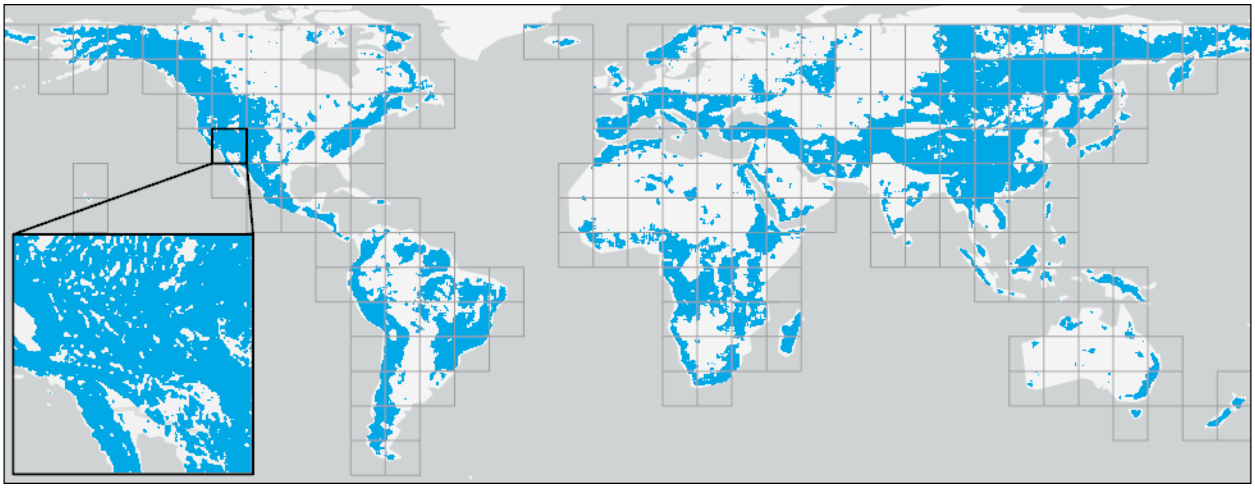

Figure 4: Global overview of HAND mask (with product tile grid). For display at this scale, mask pixels are aggregated and appear to cover areas more completely than they do; inset provides higher detail example.

Caveats with HAND:

- The HAND mask significantly reduces terrain and cloud-shadow false positives, but it will not entirely remove them; any false positives occurring outside the HAND mask areas remain in the product. In mountainous areas, this can have the practical impact of making unmasked cloud-shadow false-positives appear *more* realistic, even if greatly reduced in extent, by confining them to drainage channels where flooding potentially could occur.
- The HAND mask will be inaccurate when the source GLO-90 DEM is inaccurate, or does not reflect recent changes; new reservoirs constructed in HAND-masked areas will not show any water for the initial few years until the reference water mask is updated (see section 3.5).
- Using a ~48 km^2 upstream area to define drainages can result in masking of small endorheic and ephemeral lakes, if their upstream drainage does not meet this threshold. Using smaller upstream areas results in too many drainages being defined in mountainous areas where the product will not be able to detect significant flooding due to its spatial resolution. The ~48 km^2 threshold (6000 DEM pixels) provides a reasonable balance. The additional step to remove reference water pixels from HAND ensures any lakes identified in MOD44W will not be masked.

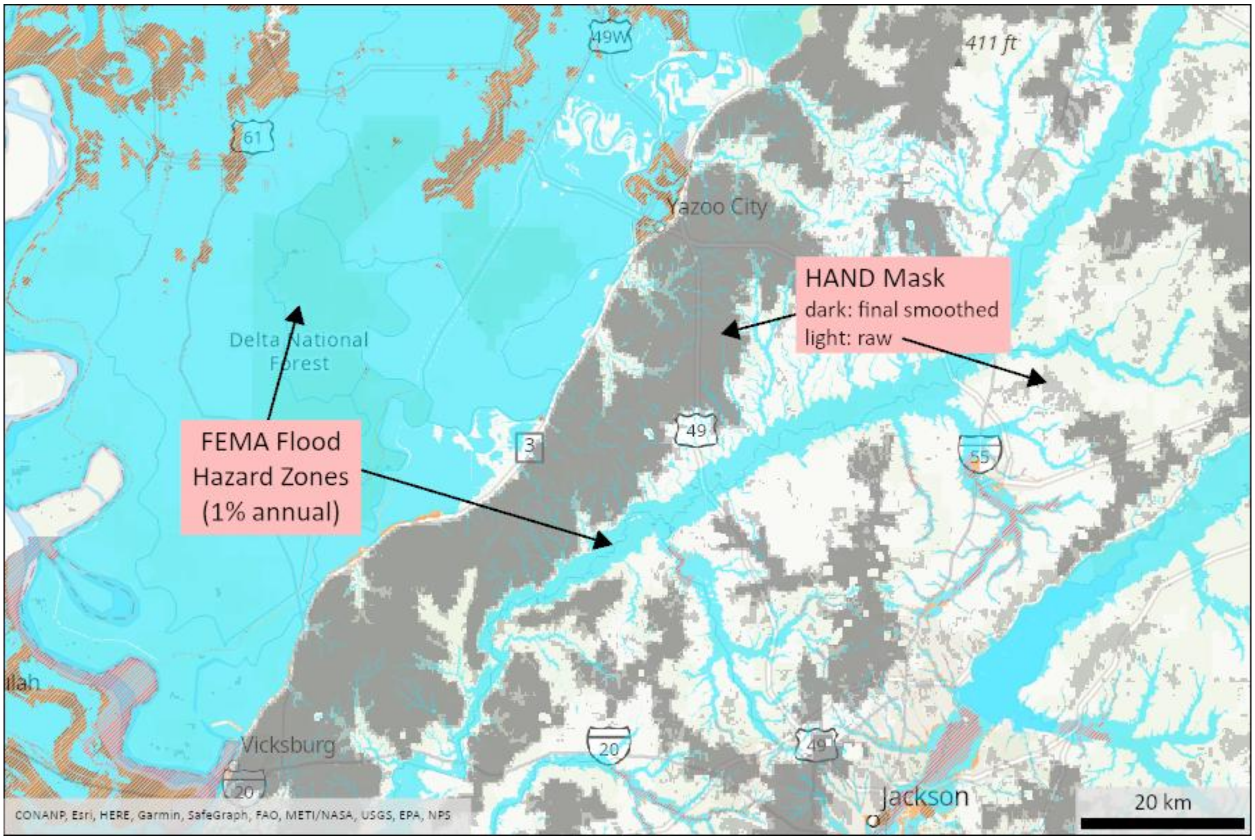

Figure 5: HAND mask in detail, Yazoo City / Jackson Mississippi area, with FEMA flood zones in cyan for comparison. Original unsmoothed HAND mask shown in lighter gray. Note small flood zone streams are masked by HAND (center of figure), but flooding in such small scale streams would not be detectible with 250 m imagery.

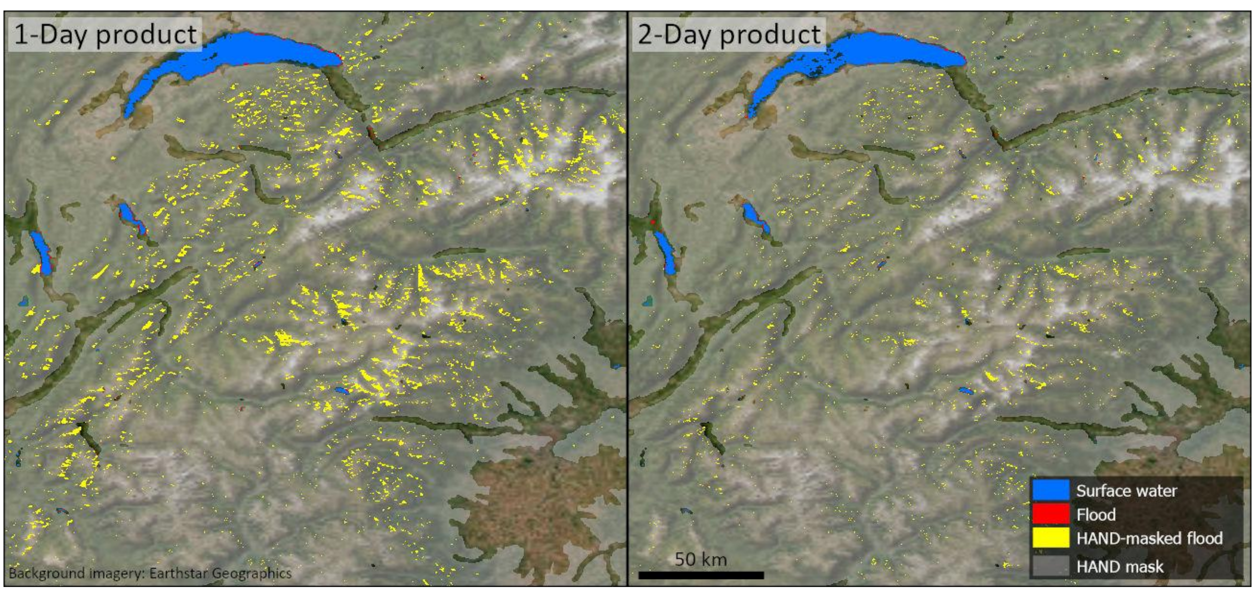

Figure 6: Example of impact of HAND on 1 and 2-day products, in the Alps south of Lake Geneva (tile h18v04; date 11 Nov 2022). Yellow indicates false-positives removed by the HAND mask. Note small areas of likely false-positives are retained (red pixels), but far less than without the HAND mask.

3.4.3 Cloud shadow masks

To help identify and eliminate cloud-shadow false positives, water detections are masked using the "cloud shadow" flag from the MOD09 (Surface Reflectance) State QA layer (see table 13 in the MOD09 User Guide, https://lpdaac.usgs.gov/documents/925/MOD09_User_Guide_V61.pdf) in the 1-Day CS product. For the VIIRS product, the same cloud shadow flag is used – see table 19 in the VIIRS Surface Reflectance User Guide: https://lpdaac.usgs.gov/documents/1657/VNP09_User_Guide_V2.pdf This cloud shadow mask is interpolated from 1 km to 250 m to match the resolution of the flood product. Unfortunately, detecting clouds, and especially their shadows, is difficult, and although this mask does a reasonable job much of the time, it can also fail and miss areas of cloud shadow, or mask out real water, not under cloud shadow. Thus, this mask is only applied to the 1-day product, which suffers most from cloud shadow false-positives, and a 1-day product without this mask is also provided, resulting in two 1-day products: "Flood_1-Day" (no cloud shadow mask); and "FloodCS_1-Day" (with **C**loud **S**hadow mask). A user who is concerned about potential cloud-shadow false-positives in a 1-day product should review both variants, and ideally do so in conjunction with viewing the reflectance imagery at the site of interest (as can easily be done in the Worldview web application), to determine the best product for their needs.

3.4.4 Insufficient data

A flag value of 255 in the flood layers indicates pixels with insufficient surface observations to be able to mark the pixel as water; in other words, the observation thresholds in Table 2 cannot be met due to an excess of bad data, missing data (e.g., swath gaps), or cloudy data. All pixels flagged by the HAND mask will also be assigned 255. These pixels will then not be marked as water (or flood). "Insufficient data" is used to describe these pixels instead of "No Data" because there may well be some valid data (including water observations), but there are *insufficient* such observations to meet the compositing threshold and thus marked as water. These "insufficient data" areas *might* be false-negatives, or they may be true negatives: we cannot say with the data available.

To identify pixels with insufficient data due to cloud cover, we use the "cloud state" flag from the MOD09/MYD09 (or VJ109/VJ209 for VIIRS) State QA layer, which reports pixels as either: clear, cloudy, mixed, or "not set". Pixels are considered cloud unless this flag is set to "clear". However, because this cloud information is not perfect, and the water detection algorithm will sometimes detect water in pixels that are reported as cloud (for example, if the cloud is thin, or along a cloud edge), any "insufficient data" values originating from cloud obscuration are **overwritten** by valid composited water detections. Thus, if a pixel meets the required number of water observations for compositing, it **will** be reported as water, even if the cloud layer suggests insufficient clear views, unless the pixel is later masked by HAND. Operationally, the output layer is first populated by insufficient data pixels, then it is overwritten by composited water detections, and finally overwritten by HAND. On occasion, this can result in the product displaying, for example, detected water in rivers that are entirely surrounded by Insufficient Data pixels, because the clouds were marked in the cloud state flag, but were thin enough for the algorithm to detect water through those clouds.

3.5 Flood identification

"Flood" is identified in this product by comparing detected water to a reference water map that represents normally expected water bodies such as lakes, rivers, and seas. Detected water pixels that match the reference water layer are labelled as "surface water", while detected water pixels not matching the reference are labelled as "flood". Beginning with Release 1.1, a "recurring flood" class was introduced to differentiate unusual flooding from flooding that has been repeatedly observed over the past 22 years of the product record – see details below.

3.5.1 Reference water map

For the MODIS beta releases (and legacy product), the original MODIS/Terra Land Water Mask product (MOD44W, Collection 5: Carroll et al. 2009) was used to identify flood. This had been generated from MODIS Terra imagery from 2000-2002 and SRTM (Shuttle Radar Topography Mission) data.

For Release 1, the reference water mask was updated to a yearly mask, taking advantage of newly available *yearly* MOD44W datasets (collection 61; Carroll et al. 2024). This helped solve problems where the original MOD44W had grown increasingly out of date: where new reservoirs have been built, the product would report flood, and where tropical rivers have changed course, the product would report the new course as flood.

To minimize year-to-year variations in the updated yearly MOD44W datasets that may simply reflect temporary surface water changes (e.g., a particularly wet or dry year in a location), the yearly reference mask was built from the previous 5 years of MOD44W: pixels are marked as surface water if MOD44W reports them as water in at least 3 of those 5 years. This approach prevents short-term anomalies from being misinterpreted as permanent water, while ensuring that genuinely persistent water bodies are recognized over time. As a result, new reservoirs will continue to show up as flood for a few years before graduating into the "surface water" class, but also anomalously wet years will not cause a region

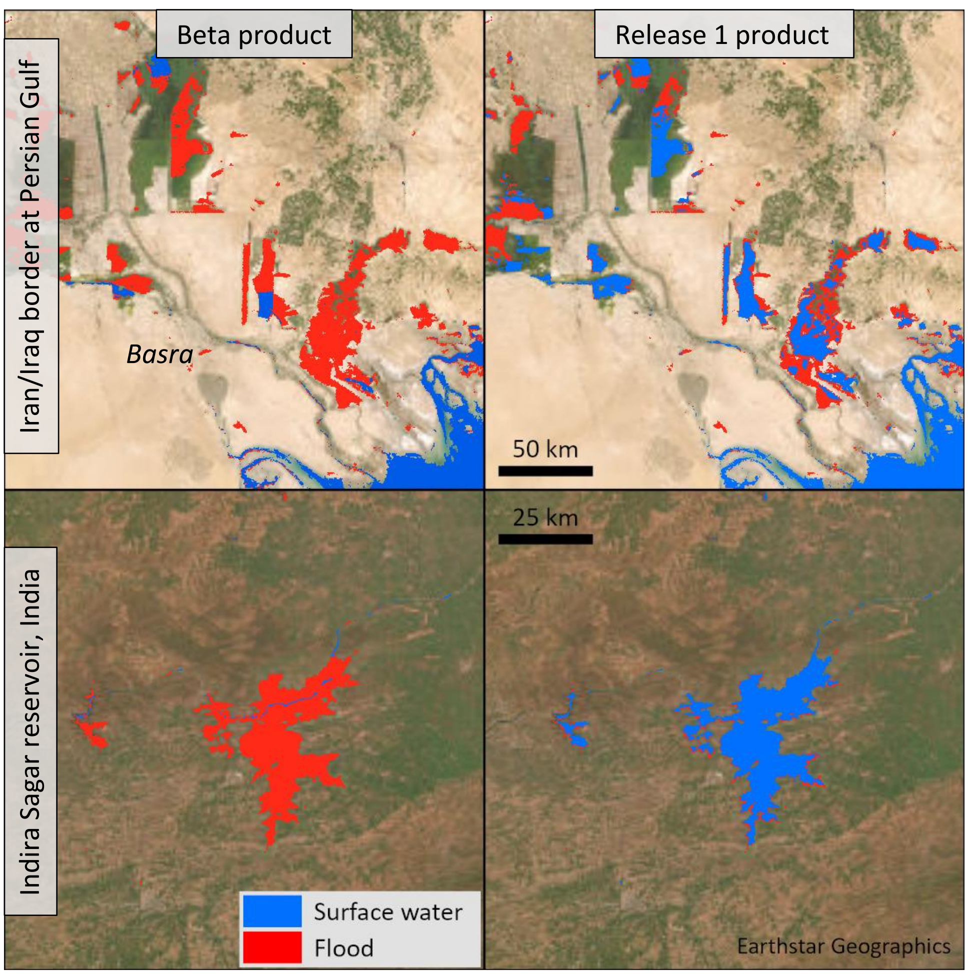

Figure 7: Example of impact of updated Reference Water on flood product.

Left shows existing beta 2 product date of 13 March 2024, 2-day flood product. Right shows same data, if updated reference water were applied.

Top shows Basra area of Iraq/Iran border, adjacent to Persian Gulf, which contains both significant wetland areas, as well as having a history of significant water engineering efforts.

Bottom shows Indira Sagar reservoir in Madhya Pradesh, India (filled in 2005).

to be marked as permanent water (and thus not flagged as flood in the product) when such water may likely disappear again. Figure 7 shows two examples of the impact of the improved reference water on the product.

To be clear, the updated reference water layer is simply a “best guess” as to the flood or non-flood status of detected water, using globally applied criteria. Users with more accurate or up to date surface water datasets can certainly use those to re-classify detected water as flood or non-flood.

Annual MOD44W layers are typically released in February of the following year, and will be used to update the reference water layer starting March 1. Thus, a 15 March 2025 product will use a reference mask generated from MOD44W from 2020-2024, while a 15 Feb 2025 product will use a mask generated from 2019-2023, etc.

3.5.2 Recurring flood

With Release 1.1, the “recurring flood” class was introduced. This separates out recurring flooding – flooding that occurs in the same location regularly – from more unusual flooding. To do so, monthly maps of recurring flood were generated, and if a detected water pixel matches the recurring flood mask, it is labelled as “recurring flood” (and given data value 2: see Table 7). Before this update, these pixels would most likely have *not* matched the reference water mask, and so would have been labelled as “flood” (data value 3).

The recurring flood masks are derived from the daily 2-day composite flood maps from the full 22-year MODIS flood product archive (2003-2024), which had been reprocessed (at Release 1) in early 2025. Rolling three-month windows, centered on each calendar month, are used to capture seasonal hydrology at a monthly timestep (e.g., the Jan window spans Dec–Jan–Feb). The goal is to identify pixels that have experienced statistically supported recurring flooding over the 22-year product archive. For each year and 3-month window, the algorithm sums:

- FloodCounts (K): number of daily 2-day flood composites indicating flood (maximum for a 3 month window is ~90);
- ValidCounts (N): number of daily 2-day flood composites with valid, non-cloudy observations (as defined by the MODIS Surface Reflectance cloud mask, which underlies the flood product’s “insufficient data” flag).

If the 3-month window for a given year has ValidCounts < 10, that pixel is excluded: such windows are considered to have insufficient clear-sky observations to reliably estimate flood frequency. With a maximum ValidCounts value of ~90 (for the 3 month window), this corresponds to requiring at least ~11% (10/90) of the days in the window to have valid observations. There is no constraint on how those valid observations are distributed within the window.

To account for sampling uncertainty—especially in windows with low ValidCounts—the algorithm computes a one-sided lower confidence bound on the true flood frequency for each pixel, window, and year using the Clopper–Pearson method with 90 % confidence (α = 0.10) (Brown et al. 2001). This lower bound q_L is calculated as:

$$q_L = p_L(K, N, \alpha)$$

q_L is the lower 90 % confidence limit on the fraction of valid observations that were flooded, derived from the observed counts of flooded and valid composites (K, N). It represents the minimum plausible fraction of time flooded, given the observed ratio K/N, and is then converted to an equivalent number of flooded days within the 3-month window:

$$D_{\mathrm{cp}} = T \times q_L,$$

where $T = 90$ days is the nominal duration of the window.

Conceptually, each valid 2-day composite is treated as a Bernoulli trial (flood / no-flood). The Clopper–Pearson bound serves as a conservative filter: when the number of valid observations N is small, the raw ratio K/N can overstate flood frequency due to random sampling or occasional false positives. Using the lower confidence limit $q_L$ensures that a pixel is only credited with flooding in a given year if there is statistical evidence that at least D flooded days occurred within that window. This approach reduces spurious detections in years with sparse data or marginal flood signals.

Then, a given year counts as a "flood year" for that pixel if

$$D_{\mathrm{cp}} \geq D,$$

where D is the minimum number of confidently flooded days required within the 3-month window. For a given pixel and window, the algorithm tracks *years_met*, the number of years where $D_{\mathrm{cp}} \geq D$. A pixel is classified as recurring flood for a given month if it meets or exceeds a minimum number of flood years Y within the most recent W years of data:

$$\text{recurring flood} = \begin{cases} 1, & \text{if years\_met} \geq Y \text{ (within the past } W \text{ years)}, \\ 0, & \text{otherwise.} \end{cases}$$

After generation of all masks, a 3×3 majority filter was also applied, in a *fill-only* mode, to minimize noise and fill small gaps or holes within the recurring flood extent. For the initial recurring flood release (product release 1.1), the following choices were used for the above D, Y, and W parameters:

- D = 3: selected after testing D = 3, 5, 7, and 9; D = 3 provided the best balance between capturing genuine floods in cloudy regions and suppressing the impact of spurious detections, which already largely appeared to be limited by the Y = 7 parameter.
- Y = 7: requires flooding in at least 7 of 22 years (~32 %). This threshold was selected as a practical, operational definition of *recurring flooding*—representing locations that have experienced inundation, on average, in at least one out of every three years. There is no widely accepted definition of what constitutes recurring flooding in the remote-sensing or hydrological literature. Intermittent or ephemeral flooding is sometimes described by occurrence frequencies of roughly 10–50 %, while permanent or persistent water is often associated with frequencies of 50–90 % or higher. The one-third-of-years criterion therefore provides , mid-range compromise—sufficiently restrictive to exclude rare or anomalous floods, yet inclusive enough to capture areas of regularly recurring inundation.
- W = 22: uses the full 22 year record, 2003–2024, to ensure longer return-period floods are fully considered, if they occur in the record. Initial explorations considered lower values of W (and Y), to ensure any recurring flooding was a recent phenomenon, but that would have also required generating (and applying) annual recurring flooding masks. As a first cut, we opted to create a single static mask.

This D / Y / W framework provides a transparent, reproducible, and statistically conservative approach for mapping recurring floodplain and seasonally inundated areas from the MODIS flood archive. In the future, we may explore updating the recurring flood mask on a regular basis.

Figure 8 shows example masks in two areas, demonstrating the impact on the flood product.

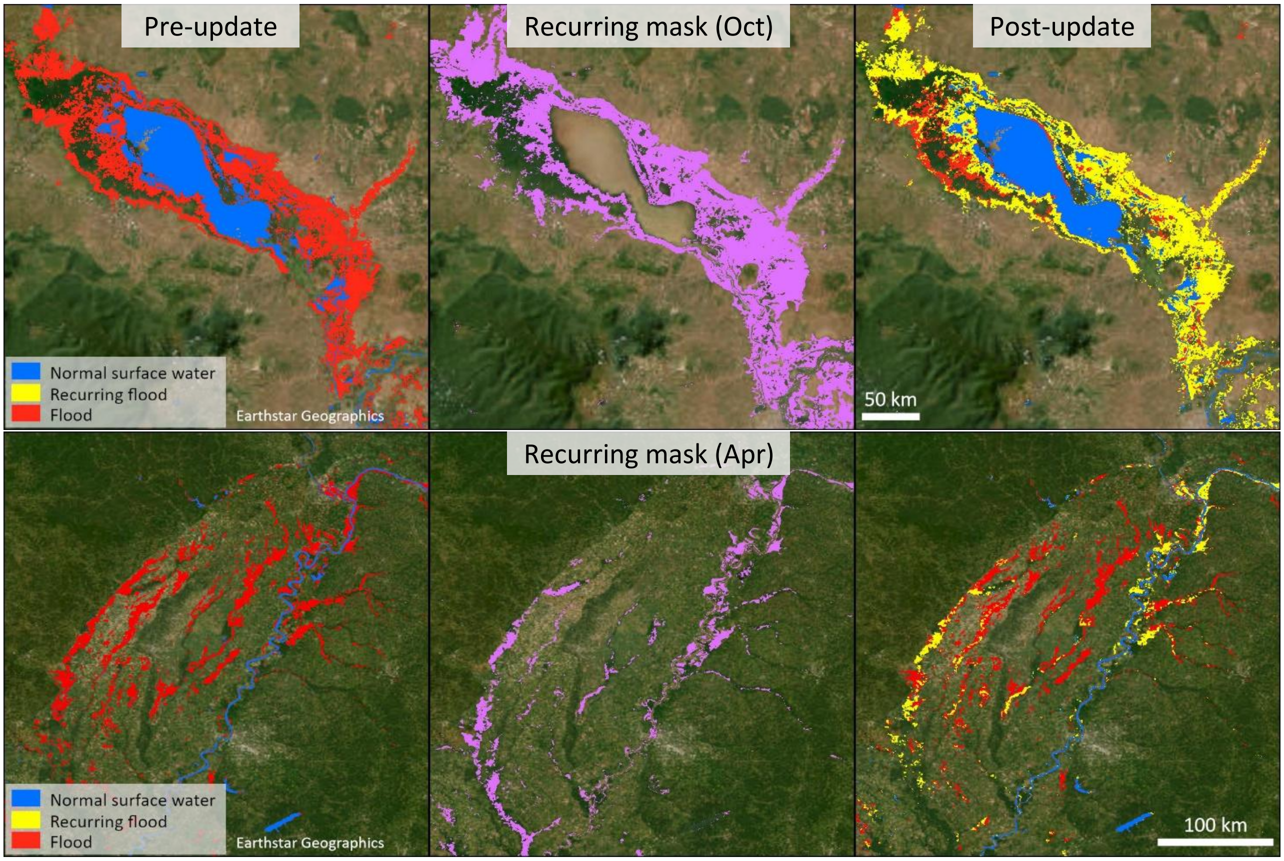

Figure 8: Recurring flood examples. Top: 2-day MODIS flood product over Tonle Sap (Cambodia), on Oct 17, 2025. Bottom: 1-day VIIRS product over US Midwest/Mississippi river, April 8, 2025. Left panel shows product without recurring flood. Center shows recurring flood mask for the relevant month. Right shows product after application of mask. For Cambodia, the updated product demonstrates that most flooding is occurring in regularly flooded areas. For flooding in the Mississippi flood plain in April, much of the observed flooding was unusual.

4 Product Evaluation

The beta release of the LANCE flood product was evaluated in two phases: (1) a quantitative comparison to the legacy product (to understand differences between the two) (section 4.1); and (2) a qualitative evaluation, following the methods used for the legacy product evaluation (section 4.2). The legacy product had originally been evaluated qualitatively (via visual interpretation), by examining its performance for a set of flood and non-flood events, and manually assigning performance scores.

4.1 Quantitative evaluation

<u>NOTE for User Guide revision E and later</u>: the evaluation in section 4.1 has not been updated after the HAND mask was introduced to the product (January 2023), which will impact these results. Nor has the VIIRS product yet been evaluated in this manner.

The performance of the MCDWD flood products has been statistically compared with the legacy MWP product. As an overall summary, Figure 9 shows the distribution of differences in reported flood area per tile, for the 3 products that exist in both systems (1-Day CS, 2-Day, 3-Day), over all tiles, for 98 days in late 2020 and early 2021. Figure 10 presents the same data as boxplots.

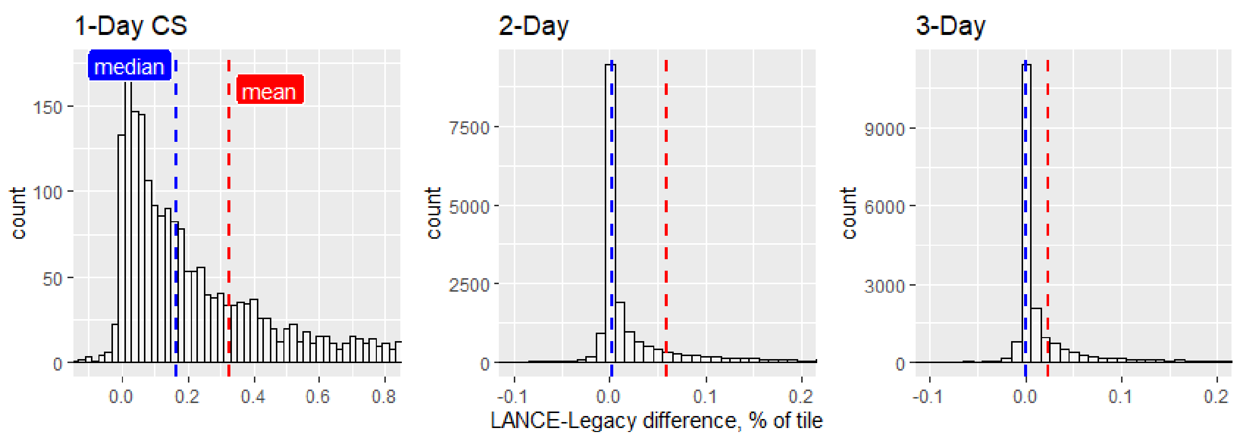

Figure 9: Histograms of differences between LANCE MCDWD and legacy MWP products in area of reported flood, per tile (as percent of tile reported as flood), with mean (red) and median (blue) marked. Computed over dates: 23-Sep-2020 – 07-Dec-2020 and 11-Jan-2021 – 01-Feb-2021 (non-contiguous because the NRT product was not archived between 8 Dec and 10 Jan). Note that because the 1-Day CS product was only run over the USA in the legacy system, there are substantially fewer observations.

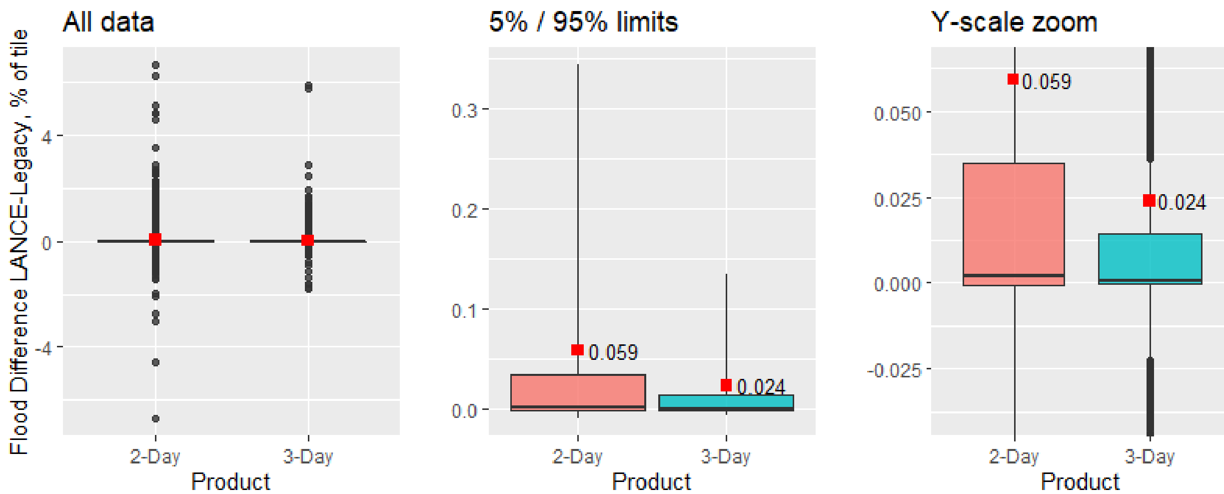

Figure 10: Boxplots of differences between LANCE MCDWD and legacy MWP products, in area of reported flood per tile (as percent of tile reported as flood), for all tiles. Mean is marked with red dots and labelled. Same data as in Figure 9. Note mean values fall outside the boxplot boxes (which indicate the interquartile range) because the distributions are significantly biased, and deviate from a normal gaussian. Center panel has data trimmed to 5/95% limits to see more detail. Right panel zooms in further on the y-scale so the medians (horizontal bars in boxes) are visible, very close to zero.

The positive bias shown in both figures, for all products, indicates that the MCDWD product is reporting more flood than the legacy product, but this effect decreases with increasing compositing window. A detailed look at individual products reveals that most of these differences are due to increased contamination of the product by cloud-shadow false-positives at higher latitudes. In the LANCE implementation of the product, all swaths are processed, and where swath overlap becomes significant (at higher latitudes), this results in several additional observations being available. Whereas in the legacy product, overlapping swaths are composited into one Terra and one Aqua image per day before the water detection algorithm is applied. Although the additional observations in the LANCE implementation can result in additional opportunities to see the surface as clouds move, it also presents additional opportunities for cloud shadow false-positives to recur in the same location and contaminate the product. With Release 1, compositing rules have been modified to minimize these effects. See additional discussion in sections 3.3 and 7.1.

Figure 11 shows the differences grouped by latitude band, confirming that differences are restricted to higher northern latitudes, and thus are explained by the higher number of available observations propagating cloud-shadow false-positives into the product. At worst, in the 60N band (over these dates in the winter when lower sun angles lead to more cloud shadow), the median difference is about 0.15% of a tile. With the tile dimensions of 4800 x 4800 pixels, 0.15% of a tile is 34560 extra flood pixels (with a tile containing ~23 million pixels). Of course, these 'extra' flood pixels (which, where examined in detail, were confirmed to be cloud-shadow false-positives) are randomly distributed, but will be lumped around dates and tiles with more frequent broken clouds. These differences diminish as the date moves away from the winter solstice, sun position rises, and shadows recede.

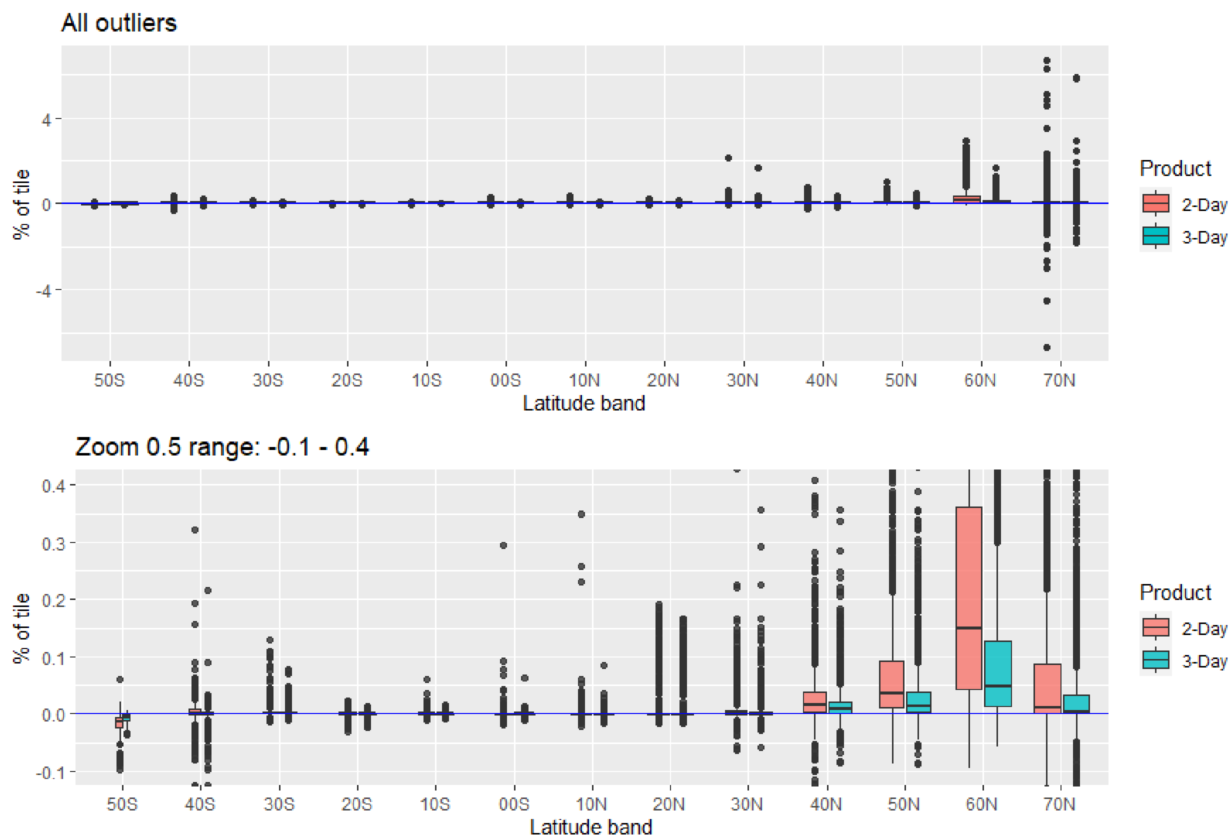

Figure 11: Boxplots of differences, grouped by latitude bands, in area of reported flood per tile (as percent of tile reported as flood), between LANCE MCDWD and legacy MWP products (refer to Figure 1 for map of tiles). Top plot includes all outliers; bottom zooms to -0.1 – 0.4 range on y-axis (% tile). Box width is proportional to number of observations (thus, number of tiles): 50S has only two tiles (tip of S America) while 50N has 24.

4.2 Qualitative evaluation

The legacy product was evaluated by qualitatively examining its performance for 109 events: 53 flood events from the DFO flood archive, and another 56 locations without flood, but containing surface water (generally in the same product tile as the flood event) (Nigro et al. 2014). The evaluations were qualitative subjective assessments of performance in the context of available imagery sources, including Landsat (when available), and the source MODIS reflectance imagery. Event selection did not require clear imagery to be available, so some events (approximately 1/3) were unable to be evaluated.

For the LANCE product evaluation, the MCDWD product was generated using historical MODIS data (from 2012-2014) for the same 109 events, and evaluated in comparison to the legacy MWP product. There were expected pixel-level differences due to geolocation improvements and differences in output grid, but overall, the MCDWD performed very well, and in some respects notably better than the MWP. Note that unlike the archived MWP products, the MCDWD product used in the evaluation was generated from archived science-quality surface reflectance inputs, and not the near real-time data stream, which may account for some geolocation improvements.

Two types of differences between the products were observed: (1) increased cloud-shadow false-positive issues in MCDWD in winter and higher latitudes; and (2) improved surface water detection with

MCDWD. These differences stem from the same source: the additional available swath observations in the LANCE product, as discussed above. Although these additional observations provide additional chances for cloud-free observations, and thus improve water detection, they also provide additional opportunities for cloud-shadow false-positives. At Release 1, the compositing rules have been adjusted to mitigate this effect (section 3.3). Table 3 summarizes the differences between the products, including how often increased cloud-shadow false-positives were observed. Overall, the MCDWD was an improvement in 26% of cases (14% of flood cases, 37% of non-flood surface water detection).

Table 3: Summary of qualitative differences between MCDWD and legacy product*. Numbers given as raw numbers and as percent of all events in the class (flood, surface water, or both). Cloudy indicates the number of events where clouds completely obscured water observations; the number of "Clear" events is the total number of events minus cloudy events. "Better" indicates qualitative improvement in performance of MCDWD product in delineating water extent; percentages are of "Clear" events. CSFP indicates events where an increase in cloud-shadow false-positives in the MCDWD product was noticeable (which generally does not impact the detection of actual flood or surface water, but it can be distracting by littering the product with false positives).*

	Flood	Surface Water	Total
# Events	53	56	109
# Cloudy / %	16 / 30%	15 / 27%	31 / 28%
# Clear events	37	41	78
# Better / %	5 / 14%	15 / 37%	20 / 26%
# CSFP / %	5 / 14%	5 / 12%	10 / 13%

Events were also rated using the legacy evaluations five-point scale (1=poor; 2=fair; 3=good; 4=excellent; 5=almost perfect). Table 4 shows the comparison of these ratings, aggregated into just two classes, between the legacy and LANCE products. Again, the LANCE product shows a mild improvement in flood detection (from 69% to 72% rated Good or better), but a more significant improvement in surface water detection (84% to 95% rated good+).

Type	Dataset	Poor-Fair (1-2)	Good+ (3-5)
Flood	Legacy	11 / 31%	24 / 69%
	LANCE	10 / 28%	26 / 72%
Surface Water	Legacy	6 / 16%	32 / 84%
	LANCE	2 / 5%	38 / 95%

Table 4: Summary of Qualitative Evaluation of LANCE flood product*, compared to legacy product. Ratings have been consolidated into two groups. Legacy ratings are from tables 6 and 10 in Nigro et. al. (2014), with a few legacy ratings being modified during the current evaluation exercise.*

5 Product Format and Content

5.1 File format

The MCDWD/VCDWD flood product and associated layers are delivered in a single HDF file per 10x10° tile, per day. The MCDWD HDF file conforms to HDF-EOS2 standard (version 2.20, based on HDF version 4; see https://wiki.earthdata.nasa.gov/display/DAS/Toolkit+Downloads and https://hdfeos.org), and the VCDWD HDF file conforms to HDF-EOS5 standard (https://www.earthdata.nasa.gov/about/esdis/esco/standards-practices/hdf-eos5). For user convenience, a GeoTIFF file is also provided for each flood layer in the HDF files. Table 5 provides details on the product tiling grid and projection. The data were processed using a sphere with radius 6371007.181 meters, although the HDF product files contain a metadata field "SphereCode=12". Depending on the software used, this spherecode may be reported as either the Clarke1866 or WGS-84 ellipsoid, but neither has practical implications given the pixel size of the product; thus for convenience, users may treat the coordinates as on a WGS-84 ellipsoid.   Note also that this is a fixed grid, with fixed pixel boundaries for all dates. The FAQ (section 7.3) provides sample code to export layers from the HDF files to GeoTIFF.

Projection	Geographic
Pixel size	0.002083333333333
Tile dimension	4800 x 4800
Tiling scheme	MODIS HV geographic with 10° x 10° tiles

Table 5: Tile and projection details for MCDWD product. *Data are generated on a sphere of radius 6371007.181 m but can generally be treated as on WGS-84 ellipsoid as the differences are much smaller than the pixel size. Note because of the geographic "projection", the ground pixel size varies with latitude, from ~232 m at the equator, to ~116 m at 60° latitude. This is an artifact of the geographic grid and does* ***not*** *reflect any real change in the resolution of the observations.*

The product uses the standard MODIS/Land Linear Latitude/Longitude h-v tiling scheme (https://modis-land.gsfc.nasa.gov/MODLAND_grid.html). Figure 1 shows the 287 tiles available for the flood product. Tiles are the same size and position as those used in the legacy product, but are differently labelled.

5.2 The MCDWD/VCDWD product layers

Each product HDF file contains 15 raster layers. These include four flood layers (1-Day CS, 1-Day, 2-Day, and 3-Day), along with ancillary layers that allow a user to construct alternative composites; most users will likely only be interested in the actual flood product layers (layers 1-4). Table 6 provides details of all layers in the MCDWD/VCDWD HDF files, and Table 7 provides pixel coding for the flood layers.

Two versions of the 1-day product are available: "FloodCS-1Day", and "Flood_1Day". "CS" refers to **C**loud-**S**hadow masked: the MOD09 (or VJ109/VJ209) cloud shadow masks are applied to this composite (see section 3.4.3). Due to potential inaccuracies which can lead to masking of real water, and the general effectiveness of the time-compositing approach to deal with false-positives over longer composites, the cloud shadow mask is not applied to the 2 and 3-Day products. The 1-day product without cloud shadow masking is also provided because in some cases the cloud shadow masking can obscure real flood water; users can verify by comparison to the optical source imagery.

The additional layers in the product file (total counts, water counts, and valid counts) allow the interested user to create custom composites. For example, a different number of water observations could be required, or the HAND mask could be omitted.

Table 6: MCDWD and VCDWD/VCDWDG product layers. *Key outputs are the flood layers 1-4. For all layers: units = none; data type = 8-bit unsigned integer; fill value = 255; valid range = 0-3 for flood layers, 0-254 for counts layers; scale factor = 1. 1-Day layers include data only from the product date, from Terra and Aqua (for MCDWD), or from NOAA-20 and NOAA-21 for VCDWD/G; 2-Day layers include data from the product date and previous day; 3-Day layers include data from the product date and two previous days. No cloud shadow mask applied to 2- and 3-Day products, but it is applied to the 1-day layers indicated with "CS" (mask is from the surface reflectance product). Total counts: number of potential observations, given orbital coverage. Valid counts: number of possible surface observations (not cloudy, not cloud-shadow, not terrain-shadow). Water counts: number of water detections from all observations during the compositing window that were not masked by terrain-shadow masks.*

Layer type	Layer	Layer name	Description (per pixel)
Flood (Flag values: 0-3: 0=no water; 1=surface water; 2=recurring flood; 3=flood)	1	FloodCS_1Day_250m	Flood product, 1-Day, cloud-shadow mask applied
	2	Flood_1Day_250m	Flood product, 1-Day, (no cloud shadow mask)
	3	Flood_2Day_250m	Flood product, 2-Day
	4	Flood_3Day_250m	Flood product, 3-Day
Total counts (Int. 0-254: no bad data; not in swath gap)	5	TotalCounts_1Day_250m	Total count of potential observations, 1-Day
	6	TotalCounts_2Day_250m	Total count of potential observations, 2-Day
	7	TotalCounts_3Day_250m	Total count of potential observations, 3-Day
Valid counts (Int. 0-254: no bad data values; not in swath gap; not cloud; not terrain shadow)	8	ValidCountsCS_1Day_250m	Total valid observations, 1-Day, cloud shadow mask applied
	9	ValidCounts_1Day_250m	Total valid observations, 1-Day, (no cloud shadow mask)
	10	ValidCounts_2Day_250m	Total valid observations, 2-Day
	11	ValidCounts_3Day_250m	Total valid observations, 3-Day
Water counts (Int. 0-254: not terrain shadow)	12	WaterCountsCS_1Day_250m	Total water detections, 1-Day, cloud shadow mask applied
	13	WaterCounts_1Day_250m	Total water detections, 1-Day, (no cloud shadow mask)
	14	WaterCounts_2Day_250m	Total water detections, 2-Day
	15	WaterCounts_3Day_250m	Total water detections, 3-Day

Table 7: Flood product layer pixel values. Value 2 (recurring flood) populated only from Release 1.1.

Value	Description
0	No water
1	Surface water (matching reference water)
2	Recurring flood
3	Flood (unusual)
255	Insufficient data

5.3 Internal product metadata and version information

The HDF products contain an "INPUTPOINTER" (MCDWD) or "InputPointer" (VCDWD) metadata item that provides information on which specific reflectance granules were used to generate the current product. These are indicated by MODWDLGA (Terra) and MYDWDLGA (Aqua) entries for the MCDWD product, and VJ1WDLGA (NOAA-20) and VJ2WDLGA (NOAA-21) for VCDWD. The filenames contain a granule time indicator; for VJ1WDLGA_NRT.A2025103.0606.h28v07.002.2025103094753.hdf, the granule time is 0606 = 6:06 UTM. For a given product, there may be one or more entries for each satellite, because more than one granule from a satellite may overlap the 10x10 product tile. These let the user know which specific observation granules were used as input for the current day only of the product. To see what granules were used for the previous days (e.g., for the 2-day or 3-day layers), the previous day's HDF products would need to be examined. The previous day's HDF product is also listed as an additional item in the pointer.

The product version release can be tracked by the "ALGORITHMPACKAGEVERSION" metadata field for the MCDWD product, and "AlgorithmVersion" for the VCDWD (**Table 8**). For MCDWD, this was not consistently used with the MODIS beta releases, but at Release 1 is set to 6.1.0: 6 refers to the MODIS Collection (which is actually collection 6.1); 1 refers to Release 1 of this product; and 0 refers to a patch number. The gdal command-line tool "gdalinfo" can be used to print these metadata fields. Section 8 includes additional information on product releases.

Table 8: Product version metadata fields for MCDWD and VCDWD*. ALGORITHMPACKAGEVERSION was inconsistently used prior to Release 1 ("6.1.1 patch 12" is an anomaly).*

MODIS: MCDWD

Date released	Product version (per User Guide)	User Guide revision	ALGORITHMPACKAGEVERSION
05 Jan 2021	Beta	A	1.0
12 Jan 2023	Beta 2	C	6.1.1 patch 12
16 Apr 2024	Release 1	D, E	6.1.0
11 Dec 2025	Release 1.1	F	6.1.1

VIIRS: VCDWD and VCDWDG

Date released	Product version (per User Guide)	User Guide revision	AlgorithmVersion
16 Apr 2025	Beta 1	E	Beta 1
11 Dec 2025	Release 1.1	F	2.1.1

6 Product Access

Product homepage: https://www.earthdata.nasa.gov/global-flood-product

Some terminology used in referencing the flood product:

MODIS product:

- Longname: "MODIS/Aqua+Terra Flood Map Daily L3 Global 250m LLL Grid NRT"
  (LLL refers to the Linear Latitude Longitude spatial reference system)
- Shortname: MCDWD_L3_NRT
  (MCD is the standard shorthand for products generated from a combination of Terra and Aqua imagery; WD is derived from "Water Detection".)
- Example filename: MCDWD_L3_NRT.A2025071.h28v07.061.hdf
- DOI: 10.5067/MODIS/MCDWD_L3_NRT.061

VIIRS daily product:

- Longname: "VIIRS/JPSS1+JPSS2 Daily L3 Global Flood Composite 250m Linear Lat Lon Grid – NRT"
- Shortname: VCDWD_L3_NRT
  (VCD is the shorthand for products generated from a combination of JPSS-1 (NOAA-20) and JPSS-2 (NOAA-21) imagery.)
- Example filename: VCDWD_L3_NRT.A2025071.h28v07.002.h5
- DOI: 10.5067/VIIRS/VCDWD_L3_NRT.002

VIIRS hourly product:

- Longname:
  "VIIRS/JPSS1+JPSS2 Hourly Cumulative L3 Global Flood Composite 250m Linear Lat Lon Grid – NRT"
- Shortname: VCDWDG_L3_NRT
- Example filename: VCDWDG_L3_NRT.A2025071.1100.h28v07.002.h5
  (1100 = hourly timestamp = 11:00 GMT)
- DOI: 10.5067/VIIRS/VCDWDG_L3_NRT.002

The standard product is provided as a single HDF file per tile, per day. Additionally, separate GeoTIFF products are available for each of the four flood layers in the HDF file.

The MODIS GeoTIFF product DOIs:

1-day: 10.5067/MODIS/MCDWD_L3_F1_NRT.061
1-day with cloud-shadow screening: 10.5067/MODIS/MCDWD_L3_F1C_NRT.061
2-day: 10.5067/MODIS/MCDWD_L3_F2_NRT.061
3-day: 10.5067/MODIS/MCDWD_L3_F3_NRT.061

VIIRS GeoTIFFs product DOIs:

Daily:

1-day: 10.5067/VIIRS/VCDWD_L3_F1_NRT.002
1-day with cloud-shadow screening: 10.5067/VIIRS/VCDWD_L3_F1C_NRT.002
2-day: 10.5067/VIIRS/VCDWD_L3_F2_NRT.002
3-day: 10.5067/VIIRS/VCDWD_L3_F3_NRT.002

Hourly:

1-day: 10.5067/VIIRS/VCDWDG_L3_F1_NRT.002
1-day with cloud-shadow screening: 10.5067/VIIRS/VCDWDG_L3_F1C_NRT.002
2-day: 10.5067/VIIRS/VCDWDG_L3_F2_NRT.002
3-day: 10.5067/VIIRS/VCDWDG_L3_F3_NRT.002

6.1 LANCE download servers

The LANCE near real-time distribution sites for HDF and GeoTIFF files:
https://nrt3.modaps.eosdis.nasa.gov : preferred/primary server
https://nrt4.modaps.eosdis.nasa.gov : backup server

The products are generated independently on each system. If nrt3 is down, please try nrt4.

Downloading products requires free registration with the Earthdata Login registration system:
https://urs.earthdata.nasa.gov

On the NRT download sites, the HDF product can be found by navigating:

MODIS: NRT Data → allData → 61 → MCDWD_L3_NRT

VIIRS: NRT Data → allData → 5200 → VCDWD_L3_NRT or VCDWDG_L3_NRT

For GeoTIFF products (2-day example):

MODIS: NRT Data → allData → 61 → MCDWD_L3_F2_NRT

VIIRS: NRT Data → allData → 5200 → VCDWD_L3_F2_NRT

Or, directly in the URL address bar with:
https://nrt3.modaps.eosdis.nasa.gov/archive/allData/61/MCDWD_L3_NRT

https://nrt3.modaps.eosdis.nasa.gov/archive/allData/5200/VCDWD_L3_NRT (or VCDWDG_L3_NRT)

And, for example, for 2-day (F2) MODIS GeoTIFFS:
https://nrt3.modaps.eosdis.nasa.gov/archive/allData/61/MCDWD_L3_F2_NRT

Info on automating downloads: https://nrt3.modaps.eosdis.nasa.gov/help/downloads

6.1.1 API access

An API allows users to query available files on the NRT systems. For example, the following URL will return a json-format listing of all MCDWD files available for 2022-362 (362=day of year=Dec 28):

https://nrt3.modaps.eosdis.nasa.gov/api/v2/content/details?products=MCDWD_L3_NRT&archiveSets=61&temporalRanges=2022-362

The user can then interrogate this json listing to determine if specific tiles of interest are available. For MODIS products, they may also wish to review production time stamps to compare against those from previous polls, to determine (for example) if a file has been updated with new data. For the VIIRS hourly product, any new file will have a new hourly timestamp in the filename, so is immediately recognizable without checking timestamps.

6.2 Product filenames

The HDF product filename is constructed as follows:

<SHORTNAME>.A<DATE>.[<HOUR>.]<TILE>.<COLLECTION>.<PRODTIMESTAMP>.<FILEFORMAT>

Example:

MODIS daily: MCDWD_L3_NRT.A2022361.h19v06.061.2022362024142.hdf
VIIRS hourly: VCDWDG_L3_NRT.A2025071.1100.h28v07.002.h5

<SHORTNAME> = MCDWD_L3_NRT: MCDWD = MODIS flood product; L3=level-3; NRT=near real-time.
<DATE> = 2022361: In YYYYDOY format (DOY = day of year = Julian day).
[<HOUR>] = 1100. 11:00 GMT. Only present in the VIIRS hourly dataset (VCDWDG).
<TILE> = h19v06: product tile in MODIS geographic HV tile grid (see Figure 1).
<COLLECTION> = 061: MODIS processing collection number 6.1 (current MODIS processing collection), or 002 for VIIRS collection 2 (current VIIRS processing collection).
<PRODTIMESTAMP> = 2022362024142: production timestamp, YYYYDOYHHMMSS: year, day-of-year, hour (24-hour), minute, second: 2022, day 362, 02:41:42. Note although this timestamp is in the actual filenames when downloaded, it is missing from the listings on NRT download sites.
<FILEFORMAT> = hdf (MCDWD) or h5 (VCDWD)

The core product file is an HDF file containing all flood products (1-Day, 1-Day CS, 2-Day, and 3-Day) along with ancillary layers (Table 6), for each product date and tile.

The GeoTIFF product shortnames have an additional component identifying the flood product:

MCDWD_**F1**_L3_NRT	(1-Day product)
MCDWD_**F1CS**_L3_NRT	(1-Day CS)
MCDWD_**F2**_L3_NRT	(2-Day)
MCDWD_**F3**_L3_NRT	(3-Day)

6.3 GIBS, Worldview, and the FLOOD viewer

NASA GIBS (Global Imagery Browse Services) provides access to the product as imagery (colorized map graphics, not data values):

https://www.earthdata.nasa.gov/engage/open-data-services-software/earthdata-developer-portal/gibs-api

GIBS layers can be pulled directly into end-user applications such as ArcGIS Pro and QGIS; please see the above site for more information and examples.

The flood layers are available for viewing and browsing in the Worldview web application (https://worldview.earthdata.nasa.gov), by clicking on “Add Layer”, and selecting the “Flood” item in the Floods category. The following link directly references Worldview with the MODIS flood layers added: https://go.nasa.gov/globalflood.

Worldview also allows the user to view the MODIS and VIIRS reflectance imagery used to generate the product. By default, Worldview displays Corrected Reflectance (True Color) for Terra/MODIS, but the same for Aqua/MODIS, NOAA-20/VIIRS and NOAA-21/VIIRS is also available in the Base Layers section of Worldview's table of contents. The 7-2-1 band combination can often be more helpful for visually evaluating water extent; this can be added by clicking on the "Add Layers" button, and then the "Corrected Reflectance" item in the "Floods" tile.

The Comparison feature can be helpful to compare the flood products for different dates, or to compare different composites, or to compare a flood product to the source imagery used to generate it (e.g., the current plus two previous days imagery for a given 3-day product). Clicking on the "Start Comparison" button adds two tabs (A and B), and allows the user to set any products on each, and page through the dates on each independently. Users can then swipe between the displayed products.

Note at present, Worldview and GIBS only contain flood product imagery beginning on 23 March 2021 for the MODIS product, and 03 June 2025 for the VIIRS product.

The FLOOD Viewer (https://lance.modaps.eosdis.nasa.gov/flood) is a customized web tool for examining these flood products, including the 1-day composite that is not available in Worldview, along with other related products. Initially this includes the NASA OPERA Surface Water layers, as well as the NOAA-GMU VIIRS flood product.

6.4 Timing, latency, and partial products

The NRT download sites are updated in near real-time, as data are received and products generated. This should be within the standard LANCE latency window of 3 hours or less from observation.

The MODIS and VIIRS instruments collect data in orbital swaths, as their host satellites travel from pole to pole in sun-synchronous orbits. The Terra and Aqua satellites carrying MODIS had nominal overpass times of 10:30 AM and 1:30 PM local time, respectively, until their orbits began slipping in the early 2020s, as they reached end-of-life. As of December 2025, their overpass times are closer to 9:00 AM (and drifting earlier) for Terra, and 3:00 PM (and drifting later) for Aqua.

The VIIRS instrument is carried onboard 3 satellites: SNPP, NOAA-20 (also referred to as JPSS-1), and NOAA-21 (JPSS-2). All have nominal overpass times of 1:30 PM, but their orbits have been adjusted to provide slightly different overpass times: NOAA-20 is at ~1:30 PM, and NOAA-21 follows 50 minutes later at about 2:20 PM. (SNPP is intermediate, but also the oldest, and not used in this flood product).

The swath data is processed (upstream from this product) in 5-minute chunks (6-minutes for VIIRS), termed granules: one granule contains the data collected as the satellite travels that length of time (approximately 2000 km for 5-minute/MODIS). Due to orbital characteristics, the granules are not fixed in space, but vary from day to day, as does the position of the swaths. Thus, there is no fixed alignment between granule extents and the product's 10x10° tiling scheme; their intersections, which impact the resulting production times, vary from day to day.

As soon as new swath granules are available, all 10x10° flood product tiles that intersect the newly acquired granules are generated. For VIIRS, a new VCDWDG file with an updated hourly timestamp is created. For MODIS, a new file is created for the tile if it did not already exist (e.g., from an earlier granule intersection), or the existing file is updated and replaced if it had already been created. Thus, if the product is downloaded shortly after the initial granule is received, the product may only have a portion of the full 10x10° tile populated with data from the current date. Figure 12 shows an illustrative example. For a 1-day composite product, the impact will be easier to see: missing swath granules will appear as chunks of Insufficient Data values, as in the figure. But for the 2-day and 3-day composites, it may be less obvious that more data may be coming, because those composites incorporate data from previous days, which may result in a more complete looking product (e.g. without large sections of Insufficient Data) even with only initial fragmentary coverage from the current date.

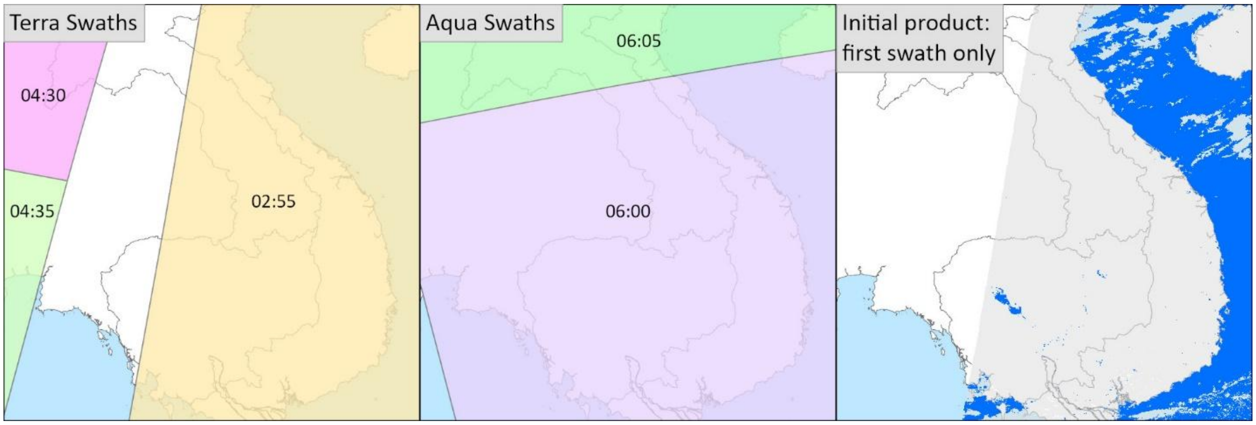

Figure 12: Swath granule intersections within a product tile. The colored sections of the left two panels show the intersection of individual swath granules from Terra and Aqua, respectively, with granule times (UTC) noted, for the 10° tile (h28v07) covering SE Asia (Thailand/Laos/Cambodia/Vietnam), for 2021173. On the right, the very first 1-day product is shown, which incorporates only the 02:55 Terra granule, with all water detections shown in dark blue. The clear area to the left contains Insufficient Data values. The shaded gray area on the right is where data exists, but no water is detected (value 0 in the data product). Thus, although this initial product does capture water (and flooding if present) in central Cambodia, it would not show flooding in central Thailand. Even waiting for the two additional Terra swath granules (04:30 and 04:35) would not provide complete coverage, due to the swath gap. Only when Aqua imagery becomes available (granules 06:00 and 06:05) a few hours later would the product potentially be able to show flooding in all areas of the tile. The situation is analogous for VIIRS.

For MODIS, the product naming convention provides no explicit indication that a product is "complete" and thus contains all data for the day. As subsequent incoming swath data is processed, previously published products are updated (and the original product file replaced). The product filenames are updated with a new production timestamp, although this is only visible on downloaded files, or by using the API interface, because the web interface drops the timestamps from its listings.

For VIIRS, the VCDWD is the daily file, generated at the end of the day; when that is generated, all data for that day have been received and processed. During the day, the VCDWDG file with the highest hourly timestamp will be the most complete. When midnight arrives, instead of generating a 2300 timestamp VCDWDG file (if new data are available), the final VCDWD file is generated.

Users manually viewing and downloading data products can do a few checks to help determine if they have the final product for the day (e.g., with all expected data), or if they should check back later for updates (in case later swaths intersect the tile). First, if the relevant Corrected Reflectance imagery (Terra and Aqua for MODIS product; NOAA-20 and NOAA-21 for VIIRS) is available in Worldview for the area of interest, the available flood product has very likely incorporated the same data. Second, if there are large areas of Insufficient Data values in the 1-day composite product, this suggests more data may be coming. Third, for VIIRS, if the current GMT time is more than 2 hours past the hourly timestamp in the VCDWDG file, then it is not likely to be updated further (additional swaths arrive ~100 minutes later, and should have been received and incorporated into a new VCDWDG file). If the highest timestamp is 2200, then although a 2300 file might be expected, this will instead be published in the day's VCDWD file, as that is the last hourly processing of the day. For MODIS, users can poll the NRT servers for file timestamps, and compare these with previous polls, to determine if the MCDWD files have been updated (see 6.1.1 above).

For ingest to GIBS and display in Worldview, there is an additional latency of about 2 hours, resulting in potentially a 5 hour total latency (maximum) from observation to the product appearing in Worldview. Thus, although Worldview is very convenient for quickly viewing the product, users requiring the most recent and up-to-date information would be advised to download the product files from the NRT site directly, as these may potentially be available up to 2 hours before the product appears in Worldview.

6.5 Archive availability

LANCE products are available in a rolling archive for approximately one week after generation. As the LANCE Global Flood products are NRT only and not standard products, they are handled differently to other standard products and are not formally archived at a NASA Distributed Active Archive Center (DAAC) (For more information on Near Real-Time versus Standard Products see: https://www.earthdata.nasa.gov/learn/earth-observation-data-basics/near-real-time-versus-standard-products).

Please note the LANCE Flood product GIBS imagery, accessible in Worldview, will remain available; the rolling archive does not apply to GIBS imagery.

It is expected that a long-term archive will be established to address the needs of application users. When this is available, updated information will be provided (and a notice sent to the mailing list). In the meantime, the flood team has a limited ability to respond to requests for archive data; please contact Earthdata support (see below).

6.6 Legacy product

The legacy MWP product was discontinued at the end of 2022, after being generated for 10 years. Its website and archive are no longer online. For more information, please contact support (earthdata-support@nasa.gov).

6.7 Support & Mailing list

Product questions should be submitted to: earthdata-support@nasa.gov (including “lance flood” in the subject line will help direct your email).

A low-volume distribution-only mailing list is maintained for flood product announcements.

> To subscribe: E-mail floodmap-join@lists.nasa.gov (no subject or body text is required).
>
> To unsubscribe: E-mail floodmap-leave@lists.nasa.gov (no text required).
>
> For mailing list issues: floodmap-owner@lists.nasa.gov.

For alerts about LANCE MODIS and VIIRS production issues, please sign up for the LANCE-MODIS mailing list:

> To subscribe: E-mail lance-modis-join@lists.nasa.gov (no subject or body text is required).
>
> To unsubscribe: E-mail lance-modis-leave@lists.nasa.gov (no text required).
>
> For mailing list issues: lance-modis-owner@lists.nasa.gov.

7 Use Notes and FAQs

7.1 Usage notes

This product detects water in 250 m pixels, when that water is observable by the satellites carrying MODIS (Terra and Aqua), or those carrying VIIRS (NOAA-20 and NOAA-21). Obstructions, whether they be clouds, treetops, or building roofs, will limit the capability of the system to detect water, and shadows (cloud or terrain) may introduce false-positive errors. The time of overpass (e.g. observation time) will also limit detection of fast-moving floods. These considerations are outlined below.

Timing

For MODIS, the Terra and Aqua satellite overpass time were initially separated by 3 hours (10:30 AM and 1:30 PM), until they started to drift in the early 2020s. This provides two discrete time-windows to potentially observe flooding. For VIIRS, two observations are also available per day, but only separated by about 50 minutes (1:30 PM and ~2:20 PM). Even so, we have found that the additional observation improves the product.   But in both cases, if the flood is rapidly moving, had yet to develop, or has already peaked and receded, by the time of observation, the product may fail to capture it.

Cloud obscuration

This product primarily relies on the red and near infra-red bands of MODIS (or VIIRS) which cannot penetrate clouds. Thus, if an area is cloudy, there may not be sufficient clear imagery to observe the surface or any water. However, the different overpass times of the satellites afford an additional observation opportunity, which can be valuable if clouds have moved, for example. Thus if cloud cover is patchy, or is moving through an area, there may still be clear imagery from one satellite, if not both. The various composites (see below section on composites) are an attempt to deal with these cloud cover complications by accumulating water detections over 1, 2, and 3 days.

Spatial resolution

The flood product pixels have a spatial resolution approximately 250 m. Flood water that does not cover a significant portion of a 250 m pixel may not be classified as water. This can result in events that are locally significant, such as local flooding swamping roadways, not being reliably detected. It will depend on the extent of flood water: a submerged four-lane highway should be picked up, but a two-lane road may not be, especially if the road margins are not extensively flooded, or if the water is obscured by vegetation or tree cover (next section). Similarly, detecting flooding in mountainous regions without significant flat land is difficult, as such flooding is usually more spatially constrained, and also usually flowing more rapidly, due to the topographic constraints on water flow. Thus 'flash floods' are usually not detected, both because they are often too small in spatial extent, and because the water may be present only for short (if dangerous) periods, and quite possibly not at the particular times of satellite observation (let alone to be captured by multiple observations).

Note that for VIIRS, the nominal spatial resolution is 375 m, not 250. The product is generated at the same 250 m resolution as MODIS to take advantage of the existing codebase for the MODIS product, but because the fundamental pixel observations do cover a larger area, it is possible that the VIIRS product will be somewhat less sensitive to areas of smaller water coverage.

Canopy cover & buildings

As with clouds, tree cover and buildings can obscure water detection; extensive flooding may be occurring on the ground, but if the area is heavily wooded, there may not be sufficient water signal reaching the satellite to be detected. Buildings can present the same problem in urban areas: the streets may be flooded, but generally the rooftops are providing a ‘dry’ signal to the satellite at the scale of these observations (250 m).

Composite products – 1-day, 2-day, 3-day

The composites work by setting a threshold for the number of water observations required to mark an output pixel as water, over a given number of days. Table 2 shows the specific thresholds. Each composite generally has twice as many observations available, due to the twice-daily MODIS / VIIRS observations. The goal is that with additional looks (over additional days) clouds may move, allowing the satellite to observe and detect water. But it may take days, or longer, for clouds to move entirely out of the way. If there were no clouds (or we could see through them perfectly), the 1-day product would be simpler and all that is needed. And thus if the user can verify that no clouds are present over their site and dates of interest, the 1-day product will provide the most up-to-date information on water extent. If clouds are present, then the 2-day or 3-day may better capture flood extent, but this is at the expense of potentially being less timely: the 2-day product could be showing water that was only present (and/or observable) on the previous day, or that was only present (and observable) on the current day, or that was present (and observable) on both days.

A complicating factor is cloud shadows, which will generally be detected as water by the algorithm (this is a common problem across optical satellite imagery: the reflectance of shadows is very similar to that of water). The requirement that water is observed multiple times in the 2 and 3-day products also helps filter out these spurious false-positive “water” detections, because cloud shadows generally move over time. Even so, they can recur in the same location from one observation to the next (albeit somewhat uncommon). The 3-day product, requiring 3 “water” observations, almost entirely eliminates such persistent cloud-shadow false-positives, but comes at the expense of timeliness. The source surface reflectance data does contain a useful cloud shadow flag. But as it is not perfect, and thus can remove real water detections, we only apply this to the 1-Day **CS** composite (see section 3.4.3).

Thus, although four different composites are provided to help address varying conditions, it is recommended that the user review the visible MODIS or VIIRS imagery to determine the level of cloud cover at the event and time of interest, and thus better understand the different composites for a given flood event. This is greatly facilitated by viewing both the product and source reflectance imagery in Worldview (see below). A user with some experience with the product will also more readily be able to detect reasonable flooding patterns, vs the typically more random patterns from false-positives.

Terrain shadow

Like cloud shadow, terrain shadows may be detected as water. Unlike cloud shadows, they do not move significantly between days, although they will shift from morning observations (Terra satellite) to afternoon (Aqua) due to sun angle. Nevertheless, during local winter, especially at higher latitudes, terrain shadow can significantly contaminate the flood products.

We apply two masks to deal with this: First, terrain shadow masks (computed on a monthly basis from average solar positions) attempt to directly mask out areas where shadows will fall; these remove 75-90% of terrain shadow artifacts. And second, the HAND mask provides a general topographic mask to remove flood pixels from areas where we are unlikely to be able to detect it (section 3.4.2).

Volcanic areas

Exposed areas of substantial dark volcanic rock will often trip the water detection algorithm, and be flagged as water. Because they do not change over time, they will then usually get marked as flood. In the United States, the Craters of the Moon area in south-central Idaho is an example of one such site. There are many other sites worldwide. In a future upgrade, masks could be used to remove these false-positives, and mark such areas in our products accordingly.

Viewing the product in the Worldview web application: https://worldview.earthdata.nasa.gov

The flood product is also available in the NASA EOSDIS Worldview application, which provides a useful tool for both quickly browsing the flood products, and for determining if clear imagery exists over an event of interest – and thus the reliability of reported flood in the different composites. It also allows users to compare flood products for different dates. See section 6.3 for more details. Note only 2- and 3-day composites are currently available in Worldview. A Worldview story has also been published which demonstrates use of the product: https://worldview.earthdata.nasa.gov/?tr=flood-product

7.2 Product examples

This section provides examples of the product to demonstrate product utility, limitations, and best practices for use. Most of the figures are screenshots from the NASA Worldview interface, and show surface water in cyan and flood water in red. Insufficient data is typically shown in gray, but has been turned off in most examples for clarity.

> *NOTE for User Guide revision C and later: the examples in this section have not been updated after the HAND mask was introduced to the product (January 2023), which would likely visibly impact the product.*

Effective flood mapping of annual Mekong river flooding, SE Asia. Figure 13 (same as title page figure) shows extensive, but likely largely routine, flooding along the Mekong river and Tonle Sap lake in Cambodia and Vietnam, on 13 Nov 2020. Although the image is clearly cloudy (and this is a cloudy region of the world), substantial flooding is still detectable with the product.

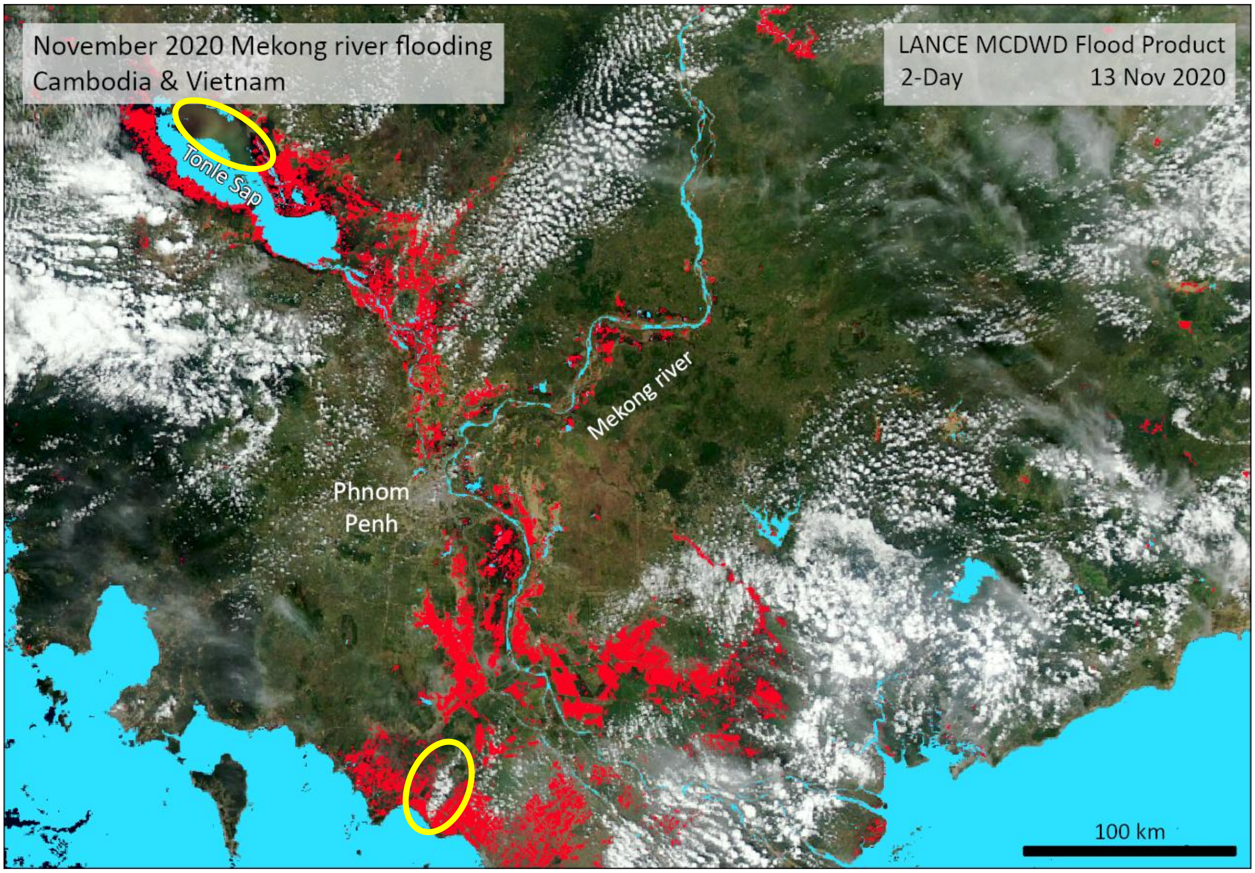

Figure 13: Example: Flood in lower Mekong region of Cambodia and Vietnam. The 2-Day flood product shows extensive flooding, overlaid on MODIS-Aqua imagery from 13 Nov 2020. Upper yellow polygon shows portion of Tonle Sap lake not being detected in the 2-day composite, even though the Aqua image appears relatively clear (it is reported in the 1-Day composite). Lower polygon shows an example of cloud obscuring flood detection.

Effective flood mapping of Cyclone Eloise in Mozambique, January 2021. Figure 14 demonstrates the utility of the product for the flooding near Beira, Mozambique, following the passage of Cyclone Eloise on 23 Jan 2021. The area remained cloudy until 27 Jan, and substantial flooding was then detected in the riverine flood plains on the 27th and 28th.

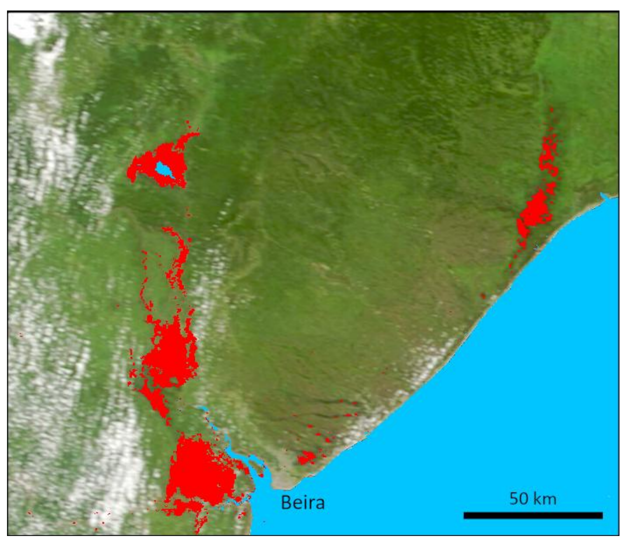

Figure 14: Example: Flood in Beira area, Mozambique. 2-Day product shows extensive flooding, along the Pungwe and Buzi rivers on 28 Jan 2021. Background image is MODIS-Aqua from 28 Jan.

Incorrect reference water resulting in flooding false positives. Figure 15 shows a reservoir in Cambodia formed after the completion of the Lower Sesan II dam in 2017 (https://earthobservatory.nasa.gov/images/91761/a-new-reservoir-in-cambodia). Prior to release 1, this reservoir was routinely reported as flood in the product, but that is no longer the case. However, any recently constructed reservoirs will show the same issue, until they have been filled for 3 years, at which point our reference water layer should show the reservoir as expected water (see section 3.5).

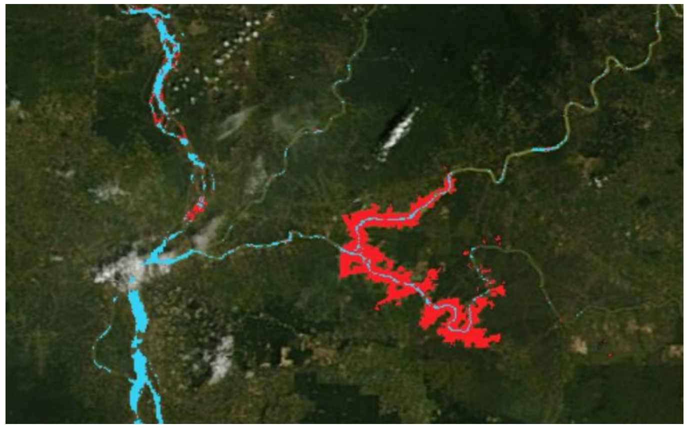

Figure 15: Example: New reservoir misidentified as flood. Lower Sesan II dam in Cambodia, 2-Day product, 11 Nov 2022, Worldview display.

Volcanic false-positives. Volcanic lava fields will often trigger the water detection algorithm because like water, they are optically very dark, and thus can often be reported as "flood" in the product. Figure 16 shows an example from the Craters of the Moon area of south-central Idaho. Note not all the visible lava flows are identified as water, but the darkest portions are. Some problematic lava flows on the islands of Hawaii and Maui have been masked out and others, such as this area in Idaho along with many others globally, may be masked in the future.

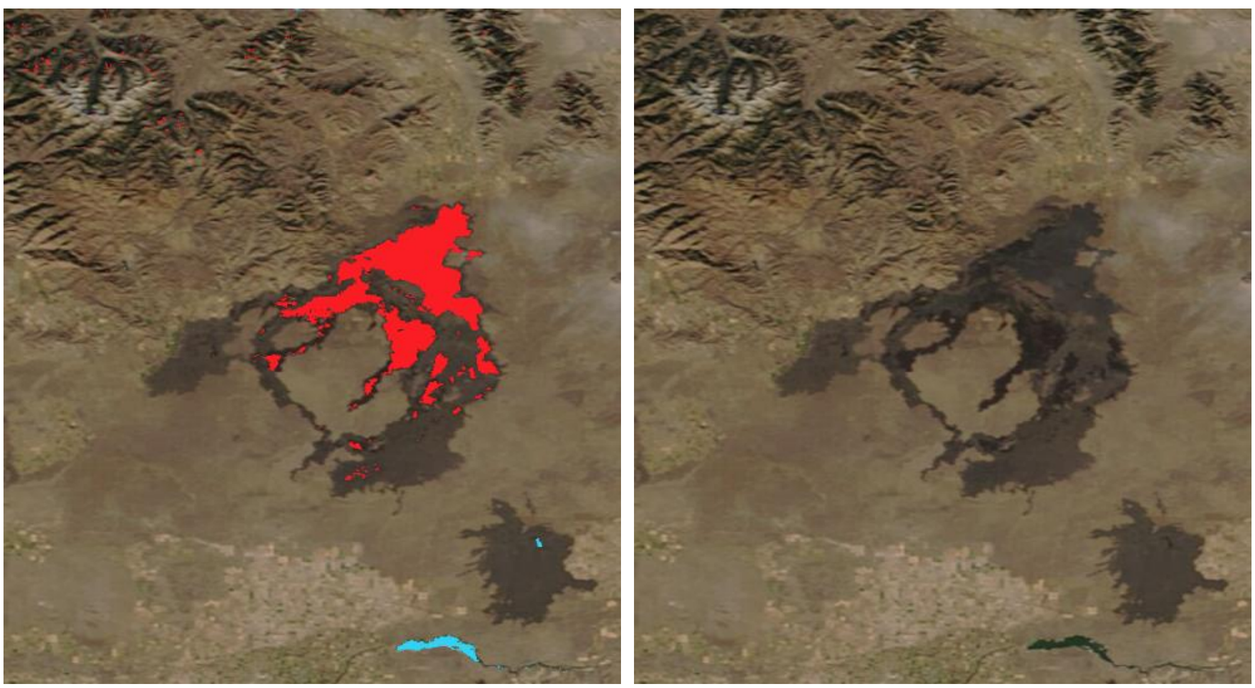

Figure 16: Example: Flood false-positives due to dark lava fields at Craters of the Moon National Monument, Idaho USA. Left shows flood product with false-positives; right the underlying MODIS-Terra reflectance imagery, demonstrating that only the darkest lava flows are misidentified. Note also scattered terrain-shadow false positives in the mountains in the northwest. 4-Nov-2020, south-central Idaho, 3-Day flood product.

Snow-melt "flood". In springtime, it is not uncommon for the product to report flooding over agricultural fields that were recently snow covered. For example, we have observed this in the northern great plains of the US (North Dakota), and in Kazakhstan. Although the product appears to be accurately reporting unusual water on the ground, it is typically not flooding of much concern, probably because it is very shallow water ponding on fields (unless accompanied by news reports suggesting otherwise). Examining the reflectance imagery for the preceding days will usually show snow cover recently present, that has turned dark (e.g., has melted into water). Figure 17 shows an example of this over Kazakhstan in April 2021.

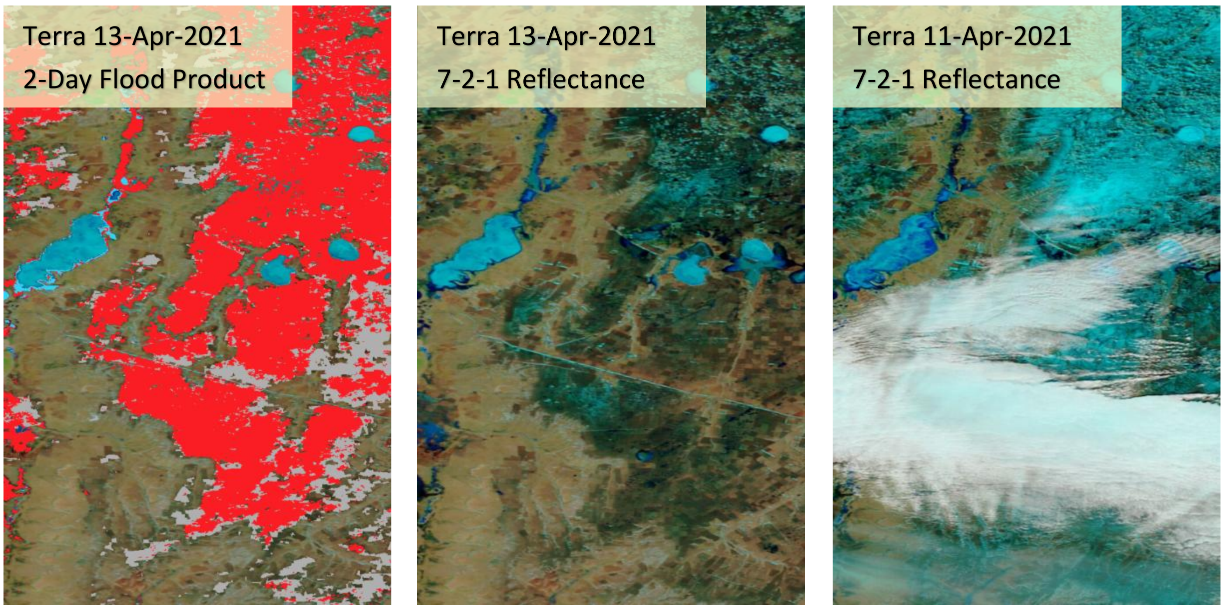

Figure 17: Example: Snow melt detected as "flood". Left shows 2-day flood product in an agricultural region of northern Kazakhstan (52.6° N, 65.6° E) from 15 Apr 2021. Middle shows MODIS/Terra (7-2-1) imagery for the same day. Right shows MODIS/Terra for 13 Apr 2021. These images clearly show significant snow cover (in bluish tones in the 7-2-1 imagery, vs cloud in white) on April 13th, but which had largely melted by the 15th. Although not shown here, the flood product for 13 April also shows flood in the darker portions of that image; much melting was already underway by this date. Imagery from 11 April is more solidly snow covered, and shows few flood pixels.

Difference between 1-Day, 1-Day CS, 2-Day, and 3-Day products. Figure 18 shows all four products for a site in northeastern China (west of Harbin) with substantial river flooding in late October 2020. In this case, substantial (but not wall to wall) cloud was present on the current product date (26 Oct), which limited the ability to detect water on that date, and also introduced cloud-shadow false-positives – an arc of this is apparent in the west, going against the topography (another hint it is not real). The 1-Day CS product (with cloud shadow screening) substantially but not entirely removes those false-positives, another clue they are not reliable. The 2-Day product then shows an area of flood largely omitted by the 1-Day and 3-Day (southeast of Qiqihar). If that area were of concern to a user, the 2-Day product looks best, but they would be advised to check the reflectance imagery to confirm.

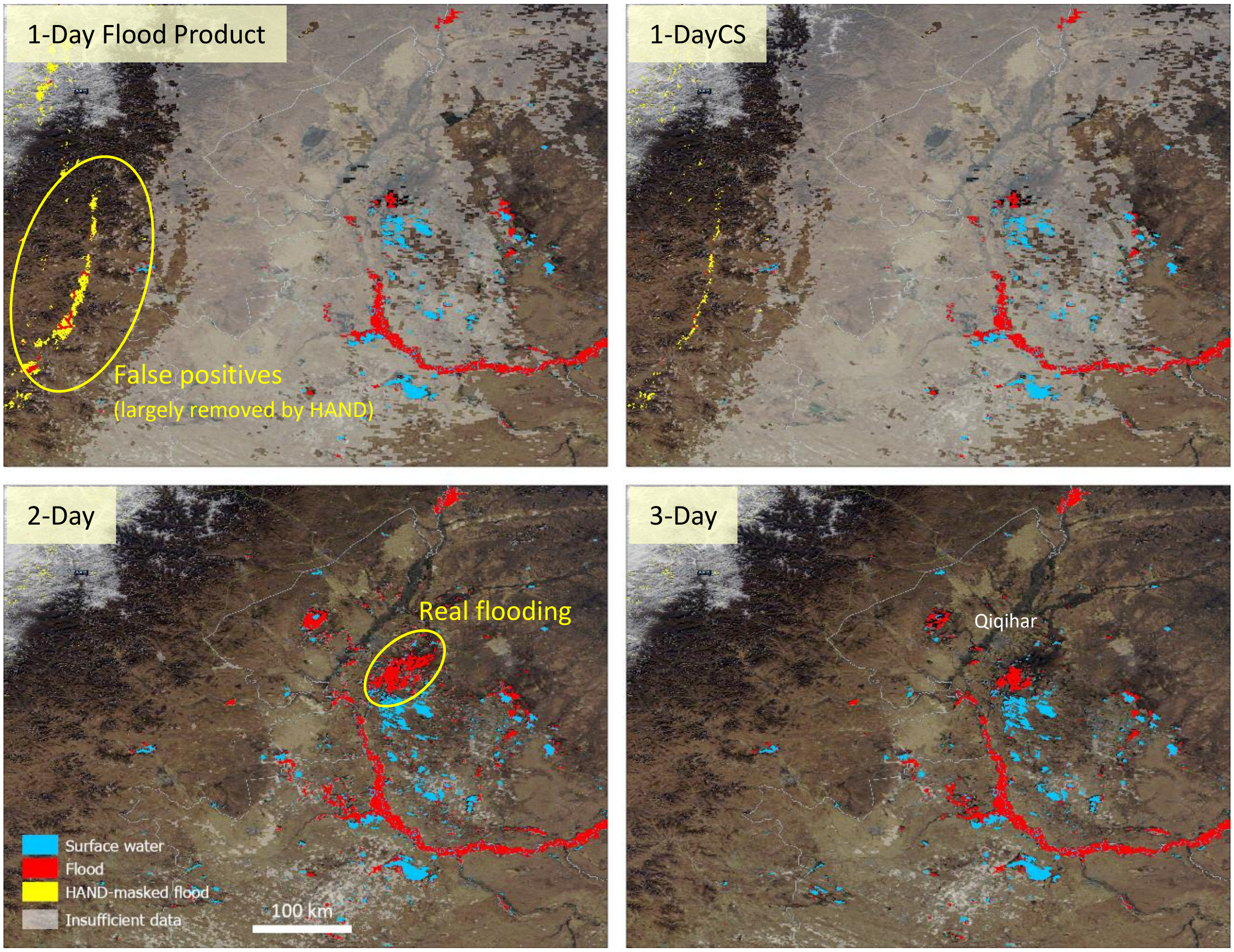

Figure 18: Comparison of the four composites: 1-Day, 1-Day CS (with Cloud Shadow screening), 2-Day, and 3-Day, during flooding of Songhua river, NE China, 26 Oct 2020. Oval in 1-Day panel highlights an area of cloud-shadow false-positives (in yellow and red). Most of these are eliminated by the HAND mask, leaving some (those in red). 1-DayCS panel shows the cloud-shadow mask is also quite helpful. These false-positives are completely removed by compositing in 2 and 3-Day products, even without HAND mask applied. However, the HAND mask does remove some persistent terrain shadow false-positives in the upper-left corner. Note that the remaining cloud-shadow false-positives in the 1-Day product, after HAND masking (in red), fill areas more realistically capable of flooding – along drainages – vs the original arc of false-positives cutting across drainages.

Yellow outline in 2-Day panel shows an area of flooding that is best captured in the 2-Day product; the 1-Day products had some cloud over this in both Terra and Aqua, and the 3-Day suggests there were not sufficient water observations (3) in the two previous days, for this to be captured. It is possible the water was not fully present on the two previous days if this is a rapidly evolving event, or that there was cloud obscuration; a review of the contributing MODIS imagery would clarify.

For reference Harbin is just east of the image. In this figure, semi-transparent white is displayed for the "Insufficient data" data value in the product (value 255). Similarly appearing whitish area in NW corner of the image is snow. Displayed background image is Terra from 23 Oct 2020, which had fewer clouds so was chosen for clearer background display. In the reflectance images relevant to this product (but not shown here) there is substantial cloud on 26 Oct (thus large areas of insufficient data on the 1-day panels), but much less on 24 or 25 Oct.

7.3 FAQs

Which product will show me the water extent for a particular flood event?

Please read through section 7.1, and then examine the product in light of the MODIS or VIIRS reflectance imagery in the Worldview application (https://worldview.earthdata.nasa.gov), to determine if the product has likely captured your event of interest.

Why are there two 1-day products in the HDF file? Which should I use?

The 1-Day CS product has cloud shadow masks applied to water detections, to help remove cloud-shadow false positives. However, these masks can be inaccurate and thus can remove real water. If you are able to review the MODIS or VIIRS reflectance imagery and confirm there are no clouds over your specific area of interest, then either product is fine, as they should be identical. If you see clouds, then it is recommended you use the "1-Day CS" product, keeping aware some cloud shadow false-positives may still exist; examine reported flood pixels carefully. In general, it is recommended that you only use the 1-day product if either: (1) you need the most timely information, or (2) you know there are no potential cloud shadow concerns, or you have been able to review the MODIS or VIIRS corrected reflectance (for both platforms for each sensor: Terra/Aqua for MODIS and NOAA-20/NOAA-21 for VIIRS) imagery in Worldview to confirm. If there **are** clouds **and** you need the most timely information, it is recommended to examine both 1-day products to see if either is showing flood water in areas of concern. If either does, then be sure to confirm from the reflectance imagery (most easily done via Worldview) that the reported flood pixels are not falling on cloud shadows for either Terra or Aqua observations.

If reviewing products in Worldview, please note that Worldview shows a composited view of overlapping swath granules: for a given day, the Corrected (or Land Surface) Reflectance layers will show just one – of potentially a few – overlapping images for a given sensor, when swaths overlap, towards the poles. It is possible that water detections are coming from imagery that is **not** visible in the Worldview composite. E.g., those water detections could be from a swath that was superseded in the mosaicking process to generate the displayed Corrected (or Land Surface) Reflectance imagery; when swath data overlaps, the data with view angle closest to nadir is generally selected for the imagery mosaic. Swath imagery may be available in a future release of Worldview, which will allow users to verify such concerns directly.

How can I pull out a specific layer (such as the 2-Day flood product) from the HDF file?

Standard gdal command-line utilities provide one method to extract layers from the HDF files to GeoTIFF or other formats. To do so, ensure you have gdal utilities installed – check https://gdal.org/ for more information. Both linux and windows installations are possible. Python package managers such as conda can also be used to install gdal.

Use gdalinfo to retrieve a listing of the layers in the HDF file (as interpreted by gdal):

```
gdalinfo MCDWD_L3_NRT.A2023333.h31v05.061.2023334024116.hdf
```

Below, the Subdatasets section returned by gdalinfo for this example is reproduced for a MCDWD product (many other product metadata fields are also output by gdalinfo but not displayed here). The VIIRS VCDWD product output is similar, with identical layer names (eg Flood_1Day_250m). If you have older MCDWD files, see Appendix 1 for an example listing for the beta product version.

```
SUBDATASET_1_NAME=HDF4_EOS:EOS_GRID:"MCDWD_L3_NRT.A2023333.h31v05.061.2023334024116.hdf":Grid_Water_Compos
ite:FloodCS_1Day_250m
SUBDATASET_1_DESC=[4800x4800] FloodCS_1Day_250m Grid_Water_Composite (8-bit unsigned integer)

SUBDATASET_2_NAME=HDF4_EOS:EOS_GRID:"MCDWD_L3_NRT.A2023333.h31v05.061.2023334024116.hdf":Grid_Water_Compos
ite:Flood_1Day_250m
SUBDATASET_2_DESC=[4800x4800] Flood_1Day_250m Grid_Water_Composite (8-bit unsigned integer)

SUBDATASET_3_NAME=HDF4_EOS:EOS_GRID:"MCDWD_L3_NRT.A2023333.h31v05.061.2023334024116.hdf":Grid_Water_Compos
ite:Flood_2Day_250m
SUBDATASET_3_DESC=[4800x4800] Flood_2Day_250m Grid_Water_Composite (8-bit unsigned integer)

SUBDATASET_4_NAME=HDF4_EOS:EOS_GRID:"MCDWD_L3_NRT.A2023333.h31v05.061.2023334024116.hdf":Grid_Water_Compos
ite:Flood_3Day_250m
SUBDATASET_4_DESC=[4800x4800] Flood_3Day_250m Grid_Water_Composite (8-bit unsigned integer)

SUBDATASET_5_NAME=HDF4_EOS:EOS_GRID:"MCDWD_L3_NRT.A2023333.h31v05.061.2023334024116.hdf":Grid_Water_Compos
ite:TotalCounts_1Day_250m
SUBDATASET_5_DESC=[4800x4800] TotalCounts_1Day_250m Grid_Water_Composite (8-bit unsigned integer)

SUBDATASET_6_NAME=HDF4_EOS:EOS_GRID:"MCDWD_L3_NRT.A2023333.h31v05.061.2023334024116.hdf":Grid_Water_Compos
ite:TotalCounts_2Day_250m
SUBDATASET_6_DESC=[4800x4800] TotalCounts_2Day_250m Grid_Water_Composite (8-bit unsigned integer)

SUBDATASET_7_NAME=HDF4_EOS:EOS_GRID:"MCDWD_L3_NRT.A2023333.h31v05.061.2023334024116.hdf":Grid_Water_Compos
ite:TotalCounts_3Day_250m
SUBDATASET_7_DESC=[4800x4800] TotalCounts_3Day_250m Grid_Water_Composite (8-bit unsigned integer)

SUBDATASET_8_NAME=HDF4_EOS:EOS_GRID:"MCDWD_L3_NRT.A2023333.h31v05.061.2023334024116.hdf":Grid_Water_Compos
ite:ValidCountsCS_1Day_250m
SUBDATASET_8_DESC=[4800x4800] ValidCountsCS_1Day_250m Grid_Water_Composite (8-bit unsigned integer)

SUBDATASET_9_NAME=HDF4_EOS:EOS_GRID:"MCDWD_L3_NRT.A2023333.h31v05.061.2023334024116.hdf":Grid_Water_Compos
ite:ValidCounts_1Day_250m
SUBDATASET_9_DESC=[4800x4800] ValidCounts_1Day_250m Grid_Water_Composite (8-bit unsigned integer)

SUBDATASET_10_NAME=HDF4_EOS:EOS_GRID:"MCDWD_L3_NRT.A2023333.h31v05.061.2023334024116.hdf":Grid_Water_Compo
site:ValidCounts_2Day_250m
SUBDATASET_10_DESC=[4800x4800] ValidCounts_2Day_250m Grid_Water_Composite (8-bit unsigned integer)

SUBDATASET_11_NAME=HDF4_EOS:EOS_GRID:"MCDWD_L3_NRT.A2023333.h31v05.061.2023334024116.hdf":Grid_Water_Compo
site:ValidCounts_3Day_250m
SUBDATASET_11_DESC=[4800x4800] ValidCounts_3Day_250m Grid_Water_Composite (8-bit unsigned integer)

SUBDATASET_12_NAME=HDF4_EOS:EOS_GRID:"MCDWD_L3_NRT.A2023333.h31v05.061.2023334024116.hdf":Grid_Water_Compo
site:WaterCountsCS_1Day_250m
SUBDATASET_12_DESC=[4800x4800] WaterCountsCS_1Day_250m Grid_Water_Composite (8-bit unsigned integer)

SUBDATASET_13_NAME=HDF4_EOS:EOS_GRID:"MCDWD_L3_NRT.A2023333.h31v05.061.2023334024116.hdf":Grid_Water_Compo
site:WaterCounts_1Day_250m
SUBDATASET_13_DESC=[4800x4800] WaterCounts_1Day_250m Grid_Water_Composite (8-bit unsigned integer)

SUBDATASET_14_NAME=HDF4_EOS:EOS_GRID:"MCDWD_L3_NRT.A2023333.h31v05.061.2023334024116.hdf":Grid_Water_Compo
site:WaterCounts_2Day_250m
SUBDATASET_14_DESC=[4800x4800] WaterCounts_2Day_250m Grid_Water_Composite (8-bit unsigned integer)

SUBDATASET_15_NAME=HDF4_EOS:EOS_GRID:"MCDWD_L3_NRT.A2023333.h31v05.061.2023334024116.hdf":Grid_Water_Compo
site:WaterCounts_3Day_250m
SUBDATASET_15_DESC=[4800x4800] WaterCounts_3Day_250m Grid_Water_Composite (8-bit unsigned integer)
```

Note there are 15 subdatasets (also see Table 6), each with a NAME and DESC field. The gdal_translate command-line command can be used to extract any desired subdataset using the NAME field. For example, for the 2-day flood product, the relevant NAME for this example would be:

```
HDF4_EOS:EOS_GRID:"MCDWD_L3_NRT.A2023333.h31v05.061.2023334024116.hdf":Grid_Water_Composite:Flood_2Day_250m
```

The general syntax for gdal_translate is:

```
gdal_translate <LAYERNAME> <OUTPUTFILE> <OPTIONS>
```

To extract the above 2-Day flood layer to a GeoTIFF file named “FloodProduct2Day.tif” with DEFLATE compression and with internal tiling (see https://gdal.org for more info):

```
gdal_translate HDF4_EOS:EOS_GRID:"MCDWD_L3_NRT.A2023333.h31v05.061.2023334024116.hdf":Grid_Water_Composite:Flood_2Day_250m
FloodProduct2Day.tif -co “COMPRESS=DEFLATE” -co TILED=YES
```

Note that the quotes as returned by gdalinfo are optional if there are no spaces in the field.

For VIIRS, with VCDWD product files in EOS-HDF5 format, the above approach will work with gdal version 3.7 or higher (released in May 2023: https://github.com/OSGeo/gdal/blob/v3.7.0/NEWS.md). For older versions of gdal, the projection and bounds must be specified in gdal_translate with `-a_srs` and `-a_ullr`, respectively. The bounds can be extracted from “BoundingCoord” items in the h5 metadata, such as “WestBoundingCoord”, etc.

How will Terra and Aqua orbit changes impact the product?

From launch in 1999 until 2022, Terra’s orbit was maintained at ~10:30 AM and Aqua’s at 1:30 PM (mean local time), via inclination adjustment maneuvers. At present, both spacecraft’s fuel supplies are exhausted and no further maneuvers are possible, causing Terra’s orbit to continuously drift to earlier crossing times (as of December 2025, about 9:00 AM), and Aqua to drift later (about 3:00 PM in December 2025, see section 8.2). Although science operations continue and data quality are not directly impacted to date, the earlier overpass times lead to larger terrain and cloud shadows, and thus potentially more extensive shadow false-positives. We will be monitoring this impact over time.

What is the difference between the MODIS and the new VIIRS products?

The MODIS and VIIRS products use the same overall algorithm and processing, with some differences:

- Resolution: MODIS source imagery is nominally at ~250 m resolution for the primary red and near-infrared bands used). VIIRS source imagery is 375 m resolution for those bands. To simplify adapting the code to work for VIIRS, the incoming VIIRS data is resampled to the same ~250 m lat/lon grid as the MODIS product. But because the VIIRS observations are fundamentally at lower resolution, it is expected to do less well at detecting small bodies of water.
- Observation times: Until 2022, the nominal equatorial overpass times for MODIS were 10:30 AM for Terra, and 1:30 PM for Aqua. As satellites reach end-of-life and fuel supplies are exhausted, these have drifted to ~9:00 AM and ~3:00 PM, as of December 2025, and will continue to drift. All VIIRS instruments only provide afternoon observations, nominally ~1:30 PM, although currently NOAA-20 and NOAA-21 are separated by about 50 minutes. The 50 minute separation was found to be sufficient to improve the product, compared to using data from only a single VIIRS instrument. But the VIIRS product is expected to be of somewhat lower quality than the MODIS product due to loss of the generally less cloudy morning observations provided by Terra. Future updates to the User Guide will contain a more detailed analysis of this impact, as both products are generated in tandem and the results analyzed.
- Swath overlap: For MODIS, there is a equatorial gap between swaths, of about 350 km, resulting in small areas with no data from either satellite each day, and larger areas with data from only

one satellite (see Figure 3). For VIIRS, this gap no longer exists, so even equatorial regions are imaged daily by both VIIRS sensors.

- Current day files: The MODIS MCDWD product files are updated in-place as new observations are received and processed throughout the day. The user must check timestamps on the files to determine if they have been updated. For the VIIRS product, there is a separate hourly cumulative product generated for the current day: VCDWDG. The filenames have an additional element indicating the hour of production. For example: VCDWDG_L3_NRT.A2025063.**2000**.h08v06.002.h5 was generated at 20:00 (GMT) . For a given tile, there will likely be 2 to 4 such files generated over the course of a day, as additional observations intersecting that tile are received. Thus, a user interested in the product for the current day, should select the file with the highest hourly timestamp. It will incorporate all data received to that point in the day. The file generated with what would be a 2300 timestamp contains all the data received for the day, so is generated as the final VCDWD product, not as VCDWDG (and so will be located in the VCDWD download directories).
- HDF format: The MODIS product is generated in EOS-HDF4 (with .hdf file extensions), while the VIIRS product is in EOS-HDF5 (with .h5 extension).

How should I cite this product?

Please use the following:

MODIS Aqua+Terra Global Flood Product MCDWD_L3_NRT distributed from NASA LANCE. Available on-line [https://www.earthdata.nasa.gov/global-flood-product].
DOI: 10.5067/MODIS/MCDWD_L3_NRT.061

VIIRS JPSS1+JPSS2 Daily Global Flood Product VCDWD_L3_NRT distributed from NASA LANCE. Available on-line [https://www.earthdata.nasa.gov/global-flood-product]. DOI: 10.5067/VIIRS /VCDWD_L3_NRT.002

VIIRS JPSS1+JPSS2 Hourly Cumulative Global Flood Product VCDWDG_L3_NRT distributed from NASA LANCE. Available on-line [https://www.earthdata.nasa.gov/global-flood-product].
DOI: 10.5067/VIIRS /VCDWDG_L3_NRT.002

8 Product Release History and Future Plans

Table 9 provides a summary of past and estimated future product releases. Further details on each release follow. All releases will be announced via the product mailing list (see section 6.7 above). The beta releases are classified as "beta" product maturity level, per the MODIS maturity status levels (https://landweb.modaps.eosdis.nasa.gov/help/maturity). See section 5.3 and for mapping between product releases and internal metadata. Note MODIS flood products have been released under MODIS Collection 6.1, and VIIRS under VIIRS Collection 2.

Table 9: MODIS and VIIRS product release history and future plans.

Release	Description	User Guide revision	Release date (actual/[est])
MODIS product			
Beta	Initial beta release.	A	5 Mar 2021
Beta	No change to product itself, but published to Worldview/GIBS, and separate GeoTIFF files released. Product evaluation supplemented with new information. User Guide updated accordingly.	B	25 June 2021
Beta 2	Add HAND mask.	C	12 Jan 2023
1	Update pixel selection and compositing rules; updated reference water; additional tiles added to production.	D / D.1 / E	16 Apr 2024
1.1	Update to add "recurring flood" output class.	F	11 Dec 2025
VIIRS product			
Beta 1	Initial beta release	E	16 Apr 2025
1.1	Updates to use final NOAA-21/JPSS-1 surface reflectance calibration, and to add "recurring flood" output class.	F	11 Dec 2025

8.1 MODIS releases

MODIS Beta release (5 Mar 2021)

The initial beta release was designed to most closely mimic the legacy product, by focusing on getting the core production operational within the new data workflow in LANCE, allowing a comparison between the legacy and the LANCE product (Appendix 12) before additional improvements were implemented. Nevertheless, there were still differences, mostly due to the additional looks available due to the change in the processing workflow (see section 3.3).

MODIS Beta 2 release (12 Jan 2023)

HAND mask to added to improve removal of false-positives in mountainous areas that are unlikely to retain floodwaters observable by this product. See section 3.4.2 above for details.

MODIS Release 1 (16 April 2024)

Release 1 addressed several issues noted since the inception of the LANCE product, and thus we moved from 'beta' product status to a full release. This includes 3 major updates:

- Updated compositing rules. The beta implementation replicated the compositing rules of the legacy product, which used composited daily Terra and Aqua images, and thus had at most two observations per day (one from Terra, one from Aqua). The compositing rules required 2 water observations for the 2-day product (potentially 4 observations available), and 3 for the 3-day product. In the LANCE implementation, all swath data is utilized, resulting in additional observations where swaths begin to overlap, above 30° latitude (although overlaps only become significant from 50°.) Under the fixed thresholding rules, these additional observations permit excess cloud-shadow false positives to accumulate at higher latitudes, if clouds are present. To address this, we implemented thresholds that vary according to the number of swath overlaps (see section 4.1).

- Set of tiles generated. We expanded the set of tiles produced from 223 to 287, to cover small pieces of land that were excluded in the initial production grid, and to cover Arctic areas from 70-80° north, where tracking changes in surface water may be valuable. Figure 1 shows the new and original set of tiles.
- Reference water update, to annual layers derived from the annual MOD44W product (section 3.5). The reference water layer used for the beta releases was that used in the legacy product, the original version of the MOD44W product (Collection 5, c2009 : Carroll et al. 2009), which was becoming increasingly out of date. The new reference water is updated annually.

Release 1 also changed the layer names and order in the HDF product files; see Table 6 for details.

MODIS Release 1.1 [11 Dec 2025]

A "recurring flood" class was added to the flood layer outputs, to discriminate regular flooding from unusual flooding. See section 3.5.2 for details.

8.2 VIIRS Releases

The Terra and Aqua satellites that carry the MODIS instrument were launched in 1999 and 2002, respectively. Both have long outlived their planned 6-year lifetimes, but remain operational and continue to return quality data. Unfortunately, their fuel supplies are now exhausted, preventing further orbital adjustments to maintain their nominal 10:30 AM and 1:30 PM equatorial crossing times. As a result, Terra's orbit is drifting to earlier crossing times (as of December 2025, approximately 9:00 AM), and Aqua to later (~3:00 PM) (further details: https://terra.nasa.gov, https://aqua.nasa.gov). The VIIRS instrument onboard the JPSS series of satellites provides the most analogous replacement for MODIS observations for the flood product. The VIIRS instrument is currently operational on 3 different satellites (SNPP, JPSS-1/NOAA-20, and JPSS-2/NOAA-21 (the JPSS name is changed to NOAA once on-orbit and operational)), but these (and future satellites) are all afternoon overpass platforms; no VIIRS platforms will provide morning-overpass observations, so there is no direct replacement for Terra's morning looks.

VIIRS Beta 1 (16 April 2025)

New product released, using VIIRS surface reflectance from NOAA-20 (JPSS-1) and NOAA-21 (JPSS-2), both with afternoon overpasses. At time of release, final calibration for NOAA-21 surface reflectance has not yet been implemented, so keeping this release at Beta 1.

VIIRS Release 1.1 [11 Dec 2025]

Release 1.1 wraps in two major updates (we jump directly from the beta release to 1.1 so the numbering remains in sync with the MODIS product). First, the final cross-calibration of the NOAA-21/JPSS-2 surface reflectance product has been incorporated; previously a preliminary calibration had been in place. Second, we add the recurring flood class to the flood layer outputs, to discriminate regular flooding from unusual flooding. See section 3.5.2 for details.

8.3 Copernicus/Sentinel-3

To replace the usually less-cloudy morning observations that MODIS/Terra currently provides, we are looking into the feasibility of using Copernicus Sentinel-3 OLCI imagery, which does provide a similar near daily global morning data record. Proceeding with this depends on NASA releasing a near real-time Sentinel-3/OLCI surface reflectance product, which is currently under consideration.

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11 Appendix 1: MCDWD Beta product details

Table 10 below shows the layers for the beta version HDF product (available before 16 April 2024). Please see Table 6 for the layers for the current Release 1 product.

Table 10: MCDWD product layers, for beta product releases.

Layer	Composite	Name	Description (per pixel)
1	1-day	Water Counts 1-Day 250m	Total water detections from current day, from all available Terra and Aqua images, after applying terrain shadow mask.
2		Water Counts CS 1-Day 250m	Total water detections from current day, from all available Terra and Aqua images, after applying terrain and cloud shadow masks.
3		Valid Counts 1-Day 250m	Total valid observations from current day, from all Terra and Aqua: no bad data values; not in swath gap; not cloud; not terrain shadow.
4		Valid Counts CS 1-Day 250m	Total valid observations from current day, from all Terra and Aqua: no bad data values; not in swath gap; not cloud; not terrain shadow; not cloud shadow.
5		Flood 1-Day 250m	Flood product, 1-Day: from current day's data. (no cloud-shadow masks applied to water detections).
6		Flood 1-Day CS 250m	Flood product, 1-Day: from current day's data. (cloud-shadow masks applied to water detections).
7	2-day	Water Counts 2-Day 250m	Total water detections from current AND previous day, from all available Terra and Aqua images, after applying terrain shadow mask.
8		Valid Counts 2-Day 250m	Total valid observations from current AND previous day, from all Terra and Aqua: no bad data values; not in swath gap; not cloud; not terrain shadow.
9		Flood 2-Day 250m	Flood product, 2-Day: from current and previous day's data.

10	3-day	Water Counts 3-Day 250m	Total water detections from current AND previous two days, from all available Terra and Aqua images, after applying terrain shadow mask.
11		Valid Counts 3-Day 250m	Total valid observations from current AND previous two days, from all Terra and Aqua: no bad data values; not in swath gap; not cloud; not terrain shadow.
12		Flood 3-Day 250m	Flood product, 3-Day: from current and previous two day's data.

Example layer name listing as output by gdalinfo for beta product (for comparison to Release 1 output given in the FAQ section example):

```
SUBDATASET_1_NAME=HDF4_EOS:EOS_GRID:"MCDWD_L3_NRT.A2020328.h04v02.061.hdf":Grid_Water_Composite:"Water
Counts 1-Day 250m"
SUBDATASET_1_DESC=[4800x4800] Water Counts 1-Day 250m Grid_Water_Composite (8-bit unsigned integer)

SUBDATASET_2_NAME=HDF4_EOS:EOS_GRID:"MCDWD_L3_NRT.A2020328.h04v02.061.hdf":Grid_Water_Composite:"Water
Counts CS 1-Day 250m"
SUBDATASET_2_DESC=[4800x4800] Water Counts CS 1-Day 250m Grid_Water_Composite (8-bit unsigned integer)

SUBDATASET_3_NAME=HDF4_EOS:EOS_GRID:"MCDWD_L3_NRT.A2020328.h04v02.061.hdf":Grid_Water_Composite:"Valid
Counts 1-Day 250m"
SUBDATASET_3_DESC=[4800x4800] Valid Counts 1-Day 250m Grid_Water_Composite (8-bit unsigned integer)

SUBDATASET_4_NAME=HDF4_EOS:EOS_GRID:"MCDWD_L3_NRT.A2020328.h04v02.061.hdf":Grid_Water_Composite:"Valid
Counts CS 1-Day 250m"
SUBDATASET_4_DESC=[4800x4800] Valid Counts CS 1-Day 250m Grid_Water_Composite (8-bit unsigned integer)

SUBDATASET_5_NAME=HDF4_EOS:EOS_GRID:"MCDWD_L3_NRT.A2020328.h04v02.061.hdf":Grid_Water_Composite:"Flood 1-
Day 250m"
SUBDATASET_5_DESC=[4800x4800] Flood 1-Day 250m Grid_Water_Composite (8-bit unsigned integer)

SUBDATASET_6_NAME=HDF4_EOS:EOS_GRID:"MCDWD_L3_NRT.A2020328.h04v02.061.hdf":Grid_Water_Composite:"Flood 1-
Day CS 250m"
SUBDATASET_6_DESC=[4800x4800] Flood 1-Day CS 250m Grid_Water_Composite (8-bit unsigned integer)

SUBDATASET_7_NAME=HDF4_EOS:EOS_GRID:"MCDWD_L3_NRT.A2020328.h04v02.061.hdf":Grid_Water_Composite:"Water
Counts 2-Day 250m"
SUBDATASET_7_DESC=[4800x4800] Water Counts 2-Day 250m Grid_Water_Composite (8-bit unsigned integer)

SUBDATASET_8_NAME=HDF4_EOS:EOS_GRID:"MCDWD_L3_NRT.A2020328.h04v02.061.hdf":Grid_Water_Composite:"Valid
Counts 2-Day 250m"
SUBDATASET_8_DESC=[4800x4800] Valid Counts 2-Day 250m Grid_Water_Composite (8-bit unsigned integer)

SUBDATASET_9_NAME=HDF4_EOS:EOS_GRID:"MCDWD_L3_NRT.A2020328.h04v02.061.hdf":Grid_Water_Composite:"Flood 2-
Day 250m"
SUBDATASET_9_DESC=[4800x4800] Flood 2-Day 250m Grid_Water_Composite (8-bit unsigned integer)

SUBDATASET_10_NAME=HDF4_EOS:EOS_GRID:"MCDWD_L3_NRT.A2020328.h04v02.061.hdf":Grid_Water_Composite:"Water
Counts 3-Day 250m"
SUBDATASET_10_DESC=[4800x4800] Water Counts 3-Day 250m Grid_Water_Composite (8-bit unsigned integer)

SUBDATASET_11_NAME=HDF4_EOS:EOS_GRID:"MCDWD_L3_NRT.A2020328.h04v02.061.hdf":Grid_Water_Composite:"Valid
Counts 3-Day 250m"
SUBDATASET_11_DESC=[4800x4800] Valid Counts 3-Day 250m Grid_Water_Composite (8-bit unsigned integer)

SUBDATASET_12_NAME=HDF4_EOS:EOS_GRID:"MCDWD_L3_NRT.A2020328.h04v02.061.hdf":Grid_Water_Composite:"Flood 3-
Day 250m"
SUBDATASET_12_DESC=[4800x4800] Flood 3-Day 250m Grid_Water_Composite (8-bit unsigned integer)
```

12 Appendix 2: Differences between LANCE MCDWD and legacy MWP MODIS products

Differences between the products are discussed below in terms of: (1) data production; (2) product features; and (3) data product format.

12.1 Data production

The primary *production* difference between the legacy MWP product and the LANCE MCDWD product is that the legacy product used as its main input data a set of pre-composited 10x10° daily Terra and Aqua images, whereas the MCDWD product processes each swath granule separately. For the legacy product, for each day, all Terra (and separately, Aqua) imagery intersecting each 10x10 degree tile was composited (by closest to nadir rule) into a single daily Terra and single daily Aqua dataset. This was done for surface reflectance (MOD09) as well as for Cloud Mask (MOD35) and Cloud (MOD06). One disadvantage was that this resulted in possibly clear observations being overwritten by cloudy pixels, in the mosaicking process when multiple observations were available. Another was the possibility of discontinuities in the product at the mosaicking line, especially if cloud or cloud shadows were present.

In the LANCE implementation, the water detection algorithm is applied on the swath granules first, which are then mapped to the 10x10° tiles, and those tiles are time-composited to create the products. In higher latitude areas where swaths begin to overlap substantially, this results in more actual looks at the surface, and more chances to see the ground as clouds move. Thus, one expected change is due to these additional looks at higher latitudes. See section 3.3 and discussion in section 4.1.

Furthermore, in the legacy implementation, the MOD35 cloud mask product was used to determine cloudy pixels, and thus where there is insufficient data to see the ground to make a water determination. In the LANCE implementation, the Cloud flag included in the MOD09 QA State layer is used. This is slightly different than the MOD35 cloud mask, but appeared of roughly equal utility. This will likely result in slight differences between the products, but note this only impacts the product's Insufficient Data values, and does not impact water detection; in both products, water detected under the cloud mask will still be labeled as water. In such cases, usually the cloud is high, thin, and fairly transparent, or this occurs around cloud edges. Note both cloud masks (MOD35 and Cloud flag in MOD09 QA State layer) are provided at 1 km resolution, and thus are interpolated to the product's 250 m resolution (and likely suffer edge errors from this).

Finally, in the legacy implementation, the clouds (from MOD35) are projected to ground using cloud height information derived from the MOD06 cloud product (cloud top temperature interpolated to a standard atmosphere), and solar position information. Largely due to limitations of the heights derived in this method, the accuracy of the cloud mask, and the spatial resolution of both (5 km and 1 km, respectively) the cloud shadow projections were helpful but often not sufficiently accurate. In the LANCE implementation, the cloud shadow flag included in the MOD09 QA State layer is used instead; this appears to be a reasonable mask in many cases. Nevertheless, due to limitations in its accuracy, it is only applied to one version of the 1-day product – the "1-Day CS" (CS for Cloud Shadow). A 1-Day product without this applied is also available ("1-Day"). And thus, some differences between the legacy and LANCE 1-day products are expected due to differences in the cloud shadow masking applied.

12.2 Product features

The LANCE MCDWD product has several improved features. The most significant may be the HAND topographic mask (section 3.4.2), which was implemented in the beta 2 release.

The legacy product also included a 14-day product, which is not provided in the LANCE product. This was essentially a second-order composite: it summed up the previous 14 3-day composites to provide a picture of short-term flooding history. It could be useful to consult when, for example, flooding is present but is blocked by clouds in the current day's product; the 14-day product would then show the user if flood had recently been detected, without having to check all recent available products. With the LANCE product being made available in the Worldview interface, it is now much easier for a user to rapidly browse through recent products directly.

12.3 Data format

The two products have substantial differences in data format. The core legacy product is provided in a set of MWP raster GeoTIFF files, generated for each product composite (1-Day, 2-Day, 3-Day). Earlier in its history, derivative files (MFW=MODIS Flood Water, and MSW=MODIS Surface Water) were generated from the MWP, in both raster and vector (shapefile and KML) formats, but these have been discontinued for some time, and are not included in the LANCE product. The core LANCE MCDWD product is a single HDF file containing all products (1-Day, 1-Day CS, 2-Day, 3-Day) along with ancillary layers (see section 0 above for details).

The LANCE flood product's data values also differ from those of the legacy product (Table 11).

Table 11: Comparison of flood product data values, between legacy MWP and LANCE MCDWD. ** Note the legacy product did not have the "recurring flood" label, and although this is planned for the LANCE product, it will not be implemented immediately.*

Description	Legacy flood product (MWP) data values	LANCE flood product (MCDWD) data values
No Water	1	0
Surface Water	2	1
Recurring Flood*	NA	2
Flood	3	3
Insufficient Data	0	255

The product's pixel grid is fixed in the LANCE MCDWD product (Table 5 provides details), resulting in each product raster being exactly 4800 x 4800 pixels, with fixed cell boundaries (they do not vary by date). In the MWP product, the tiles were slightly smaller (4552x4552), could vary slightly in pixel dimension (by one or two pixels), and cell boundaries would shift from one product date to another. For the MCDWD 4800x4800 grid, the pixel size is smaller: 0.0020833 degrees square, vs 0.0021968 in the legacy MWP. At the equator, this results in a pixel size of ~232 m for MCDWD, vs ~245 m for MWP.

The tile naming scheme has also changed. In the legacy MWP product, tiles were identified by their upper-left latitude-longitude coordinate, such as 100E020N. In the LANCE MCDWD product, a standard linear latitude/longitude product tiling scheme has been adopted, the HV tiling scheme (https://modis-land.gsfc.nasa.gov/MODLAND_grid.html). In this scheme, for example, 100E020N becomes h28v07. The tilemap in Figure 1 shows both schemes labelled.