National Aeronautics and Space Administration

EARTHDATA

Discover and Access NASA's Near Real-Time Global Flood Products

9/17/2025

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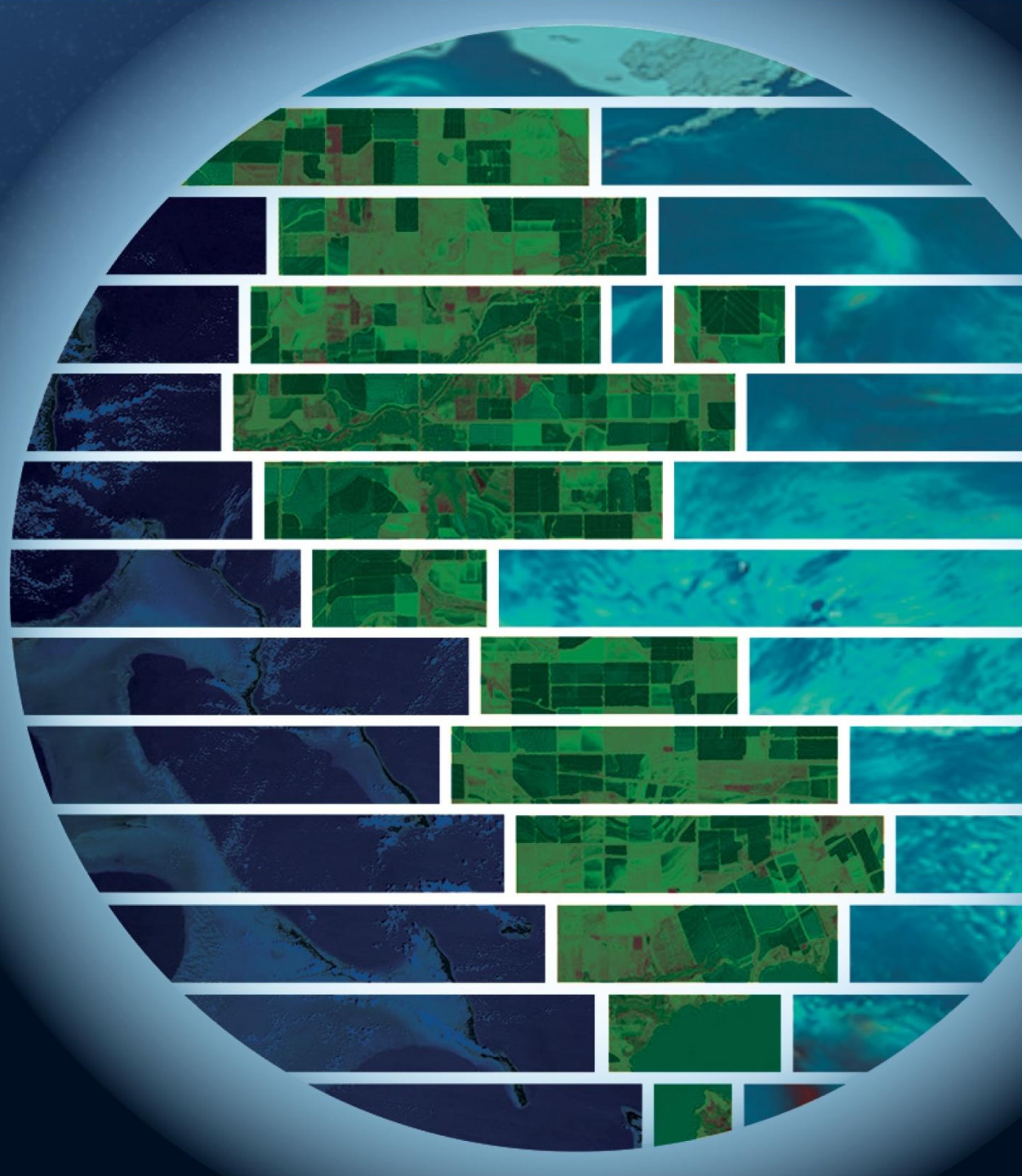
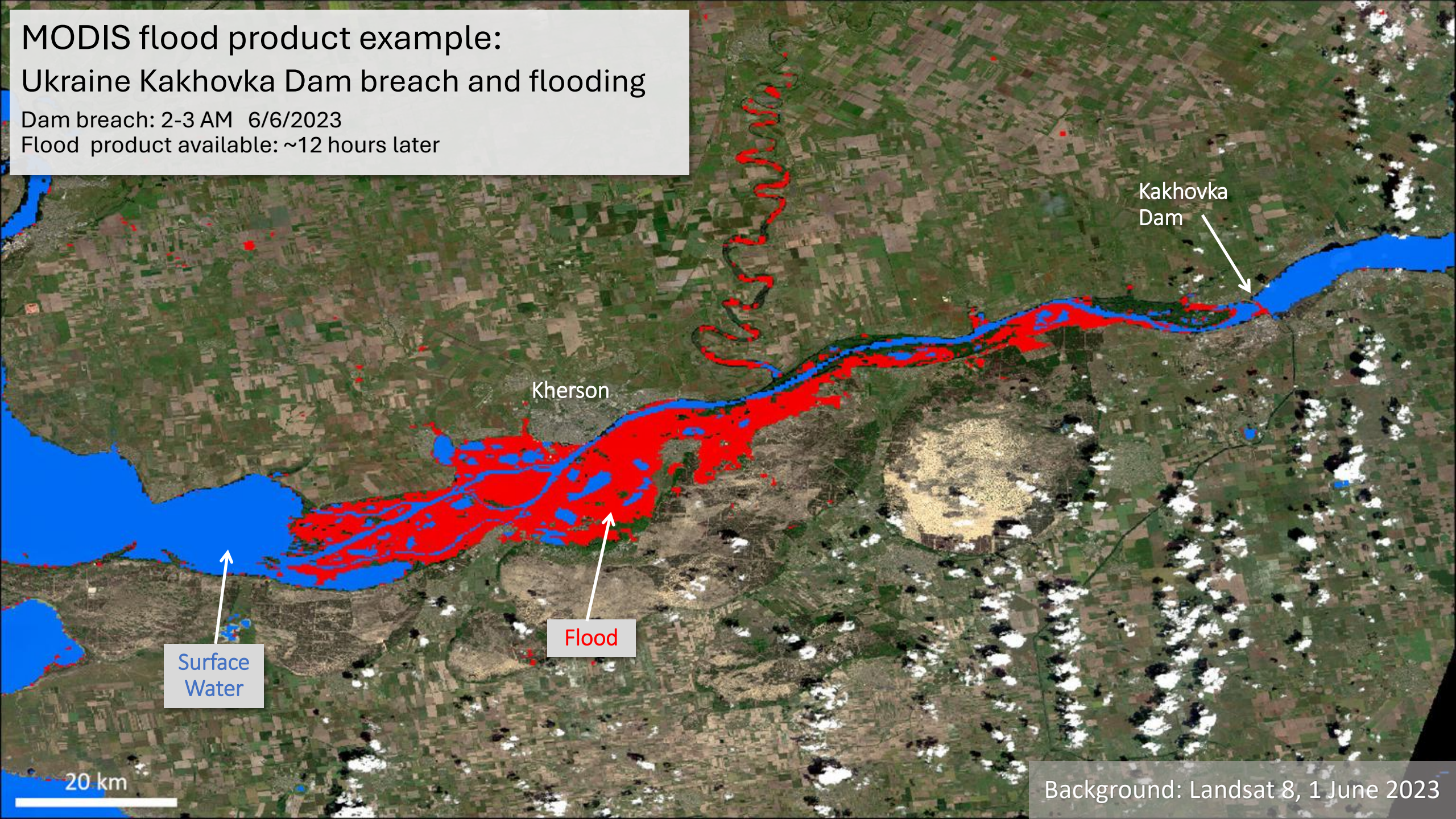
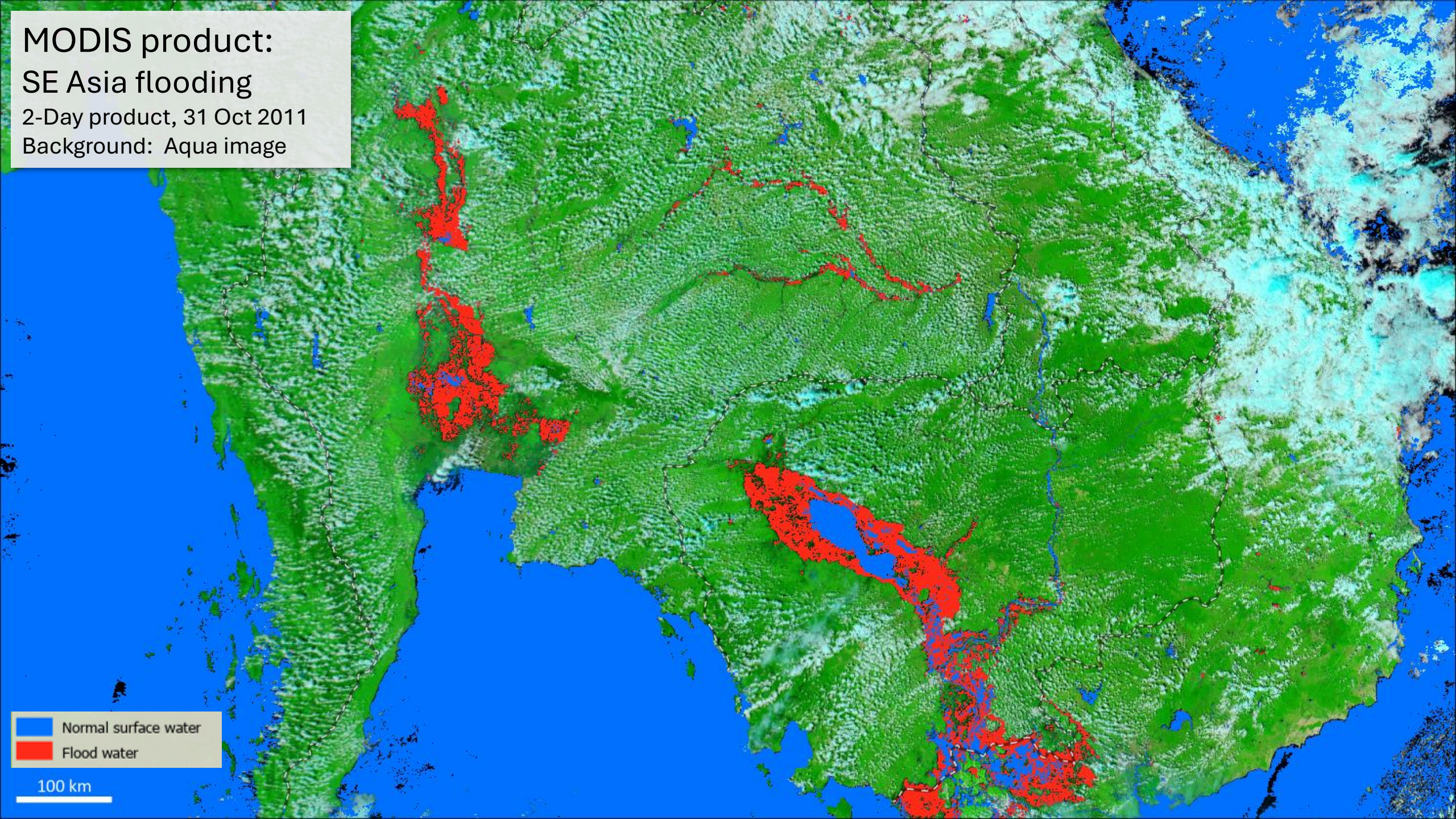


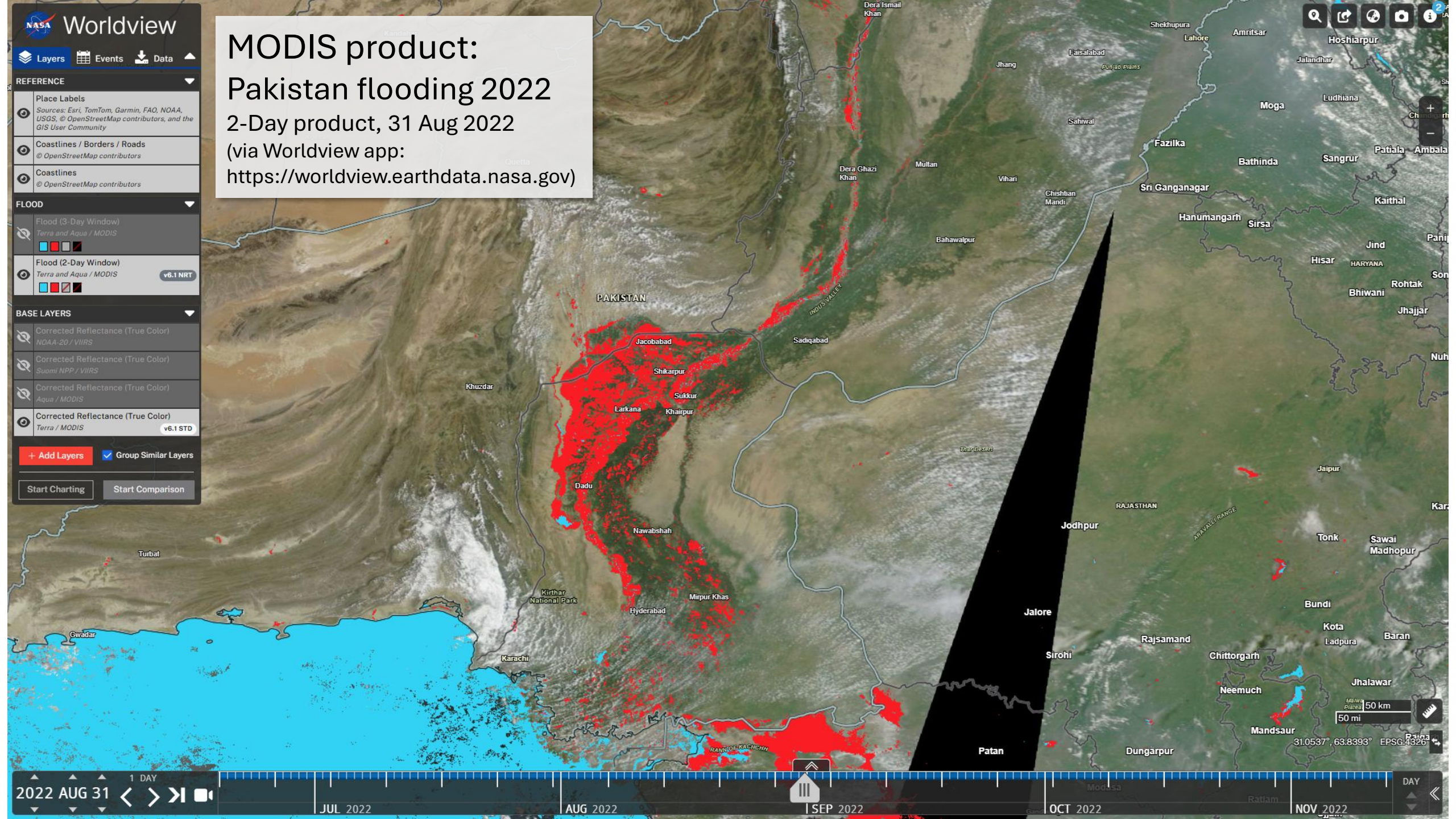
MODIS flood product example:

Ukraine Kakhovka Dam breach and flooding

Dam breach: 2-3 AM 6/6/2023
Flood product available: ~12 hours later

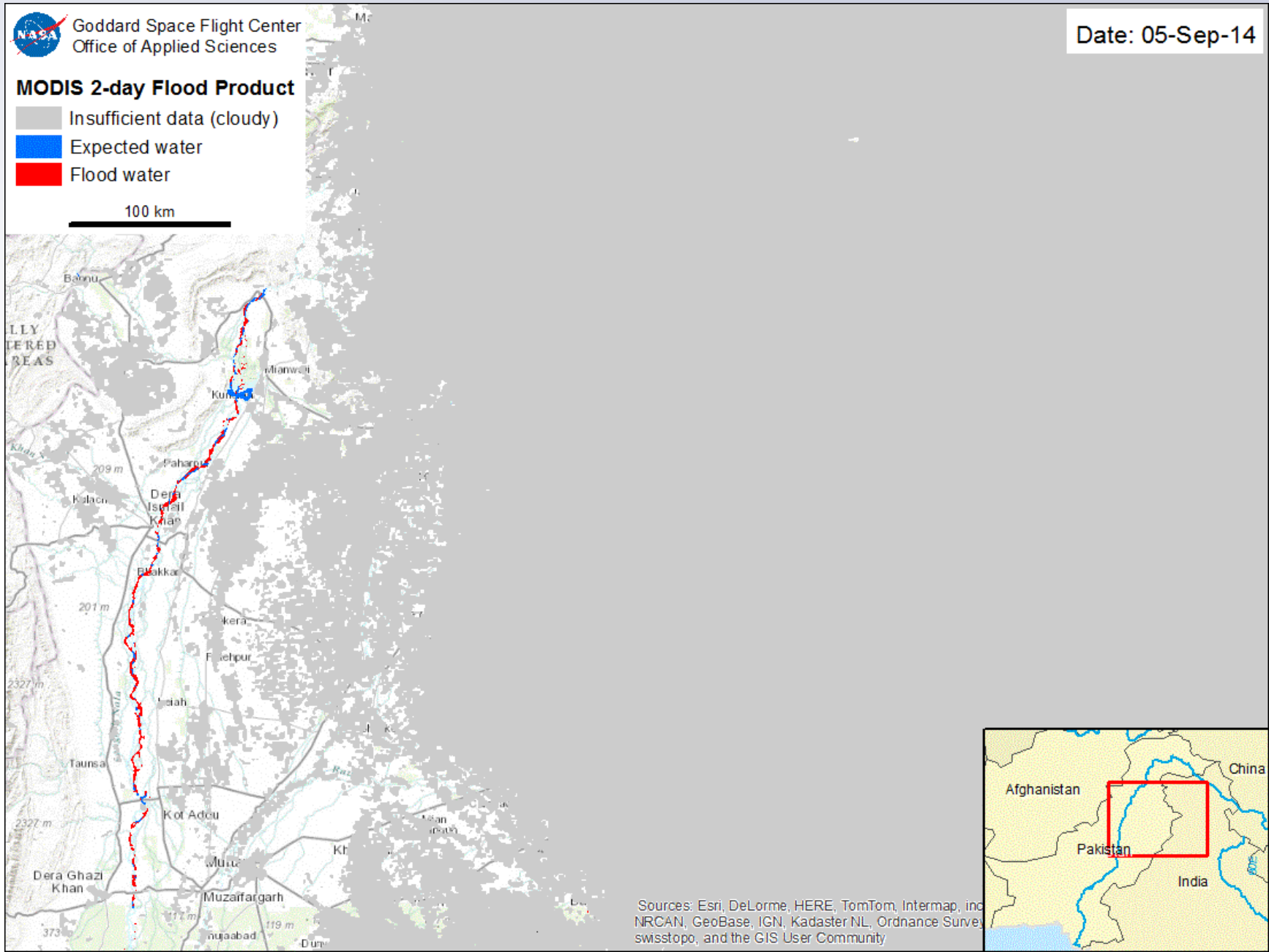



MODIS product:
SE Asia flooding
2-Day product, 31 Oct 2011
Background: Aqua image
Normal surface water
Flood water
100 km

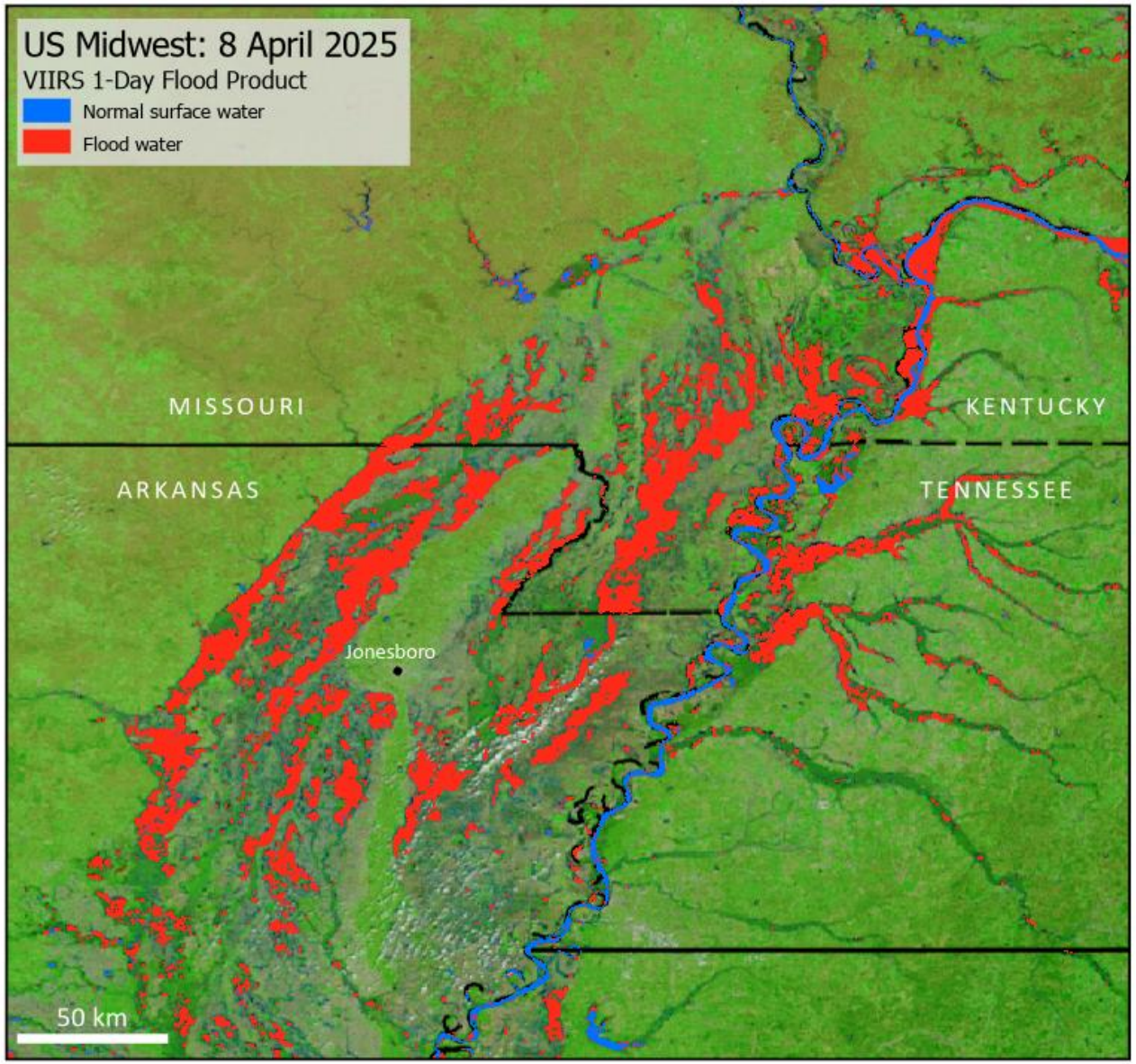

Worldview
Layers
Events
Data
REFERENCE
Place Labels
Sources: Esri, TomTom, Garmin, FAO, NOAA, USGS, © OpenStreetMap contributors, and the GIS User Community
Coastlines / Borders / Roads
© OpenStreetMap contributors
Coastlines
© OpenStreetMap contributors
FLOOD
Flood (3-Day Window)
Terra and Aqua / MODIS
Flood (2-Day Window)
Terra and Aqua / MODIS
v6.1 NRT
BASE LAYERS
Corrected Reflectance (True Color)
NOAA-20 / VIIRS
Corrected Reflectance (True Color)
Suomi NPP / VIIRS
Corrected Reflectance (True Color)
Aqua / MODIS
Corrected Reflectance (True Color)
Terra / MODIS
v6.1 STD
+ Add Layers
Group Similar Layers
Start Charting
Start Comparison
MODIS product:
Pakistan flooding 2022
2-Day product, 31 Aug 2022
(via Worldview app:
https://worldview.earthdata.nasa.gov)
PAKISTAN
Dera Ismail Khan
Shekhupura
Lahore
Amritsar
Hoshiarpur
Faisalabad
Jhang
Punjab Plains
Jalandhar
Moga
Ludhiana
Sahiwal
Fazilka
Bathinda
Sangrur
Patiala
Ambala
Dera Ghazi Khan
Multan
Vihari
Chishtian Mandi
Sri Ganganagar
Kaithal
Hanumangarh
Sirsa
Bahawalpur
Jind
Hisar
HARYANA
Rohtak
Bhiwani
Jhajjar
INDUS VALLEY
Jacobabad
Sadiqabad
Shikarpur
Khuzdar
Sukkur
Larkana
Khairpur
Thar Desert
Jaipur
Dadu
RAJASTHAN
Jodhpur
ARAVALLI RANGE
Tonk
Sawai Madhopur
Nawabshah
Turbat
Kirthar National Park
Mirpur Khas
Hyderabad
Jalore
Bundi
Kota
Baran
Ladpura
Rajsamand
Sirohi
Chittorgarh
Jhalawar
Neemuch
Gwadar
Karachi
RANN OF KACHCHH
Patan
Dungarpur
Mandsaur
50 km
50 mi
31.0537°, 63.8393°
EPSG:4326
1 DAY
2022 AUG 31
JUL 2022
AUG 2022
SEP 2022
OCT 2022
NOV 2022
DAY

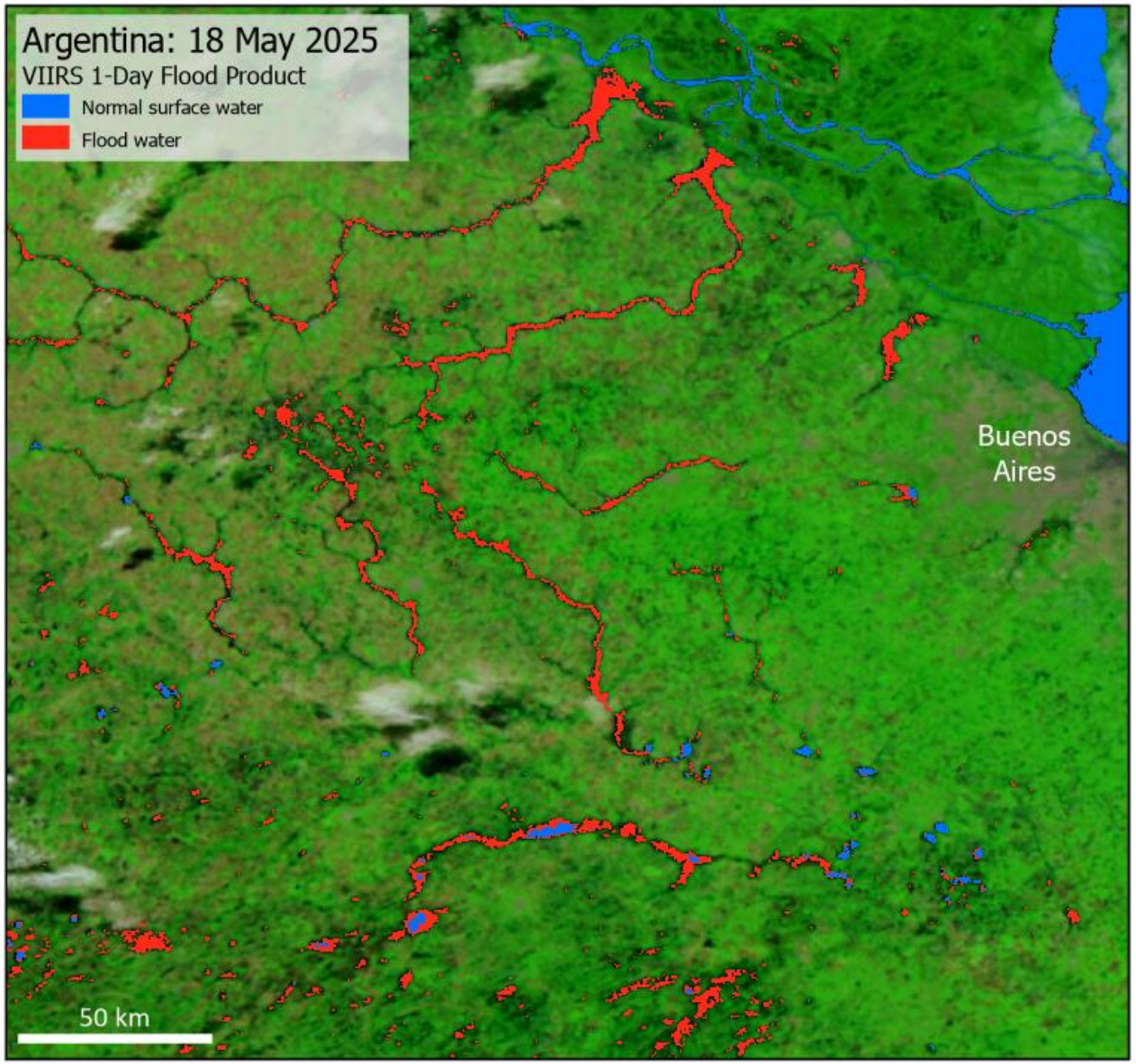
Pakistan flooding

5 - 18 Sept 2014



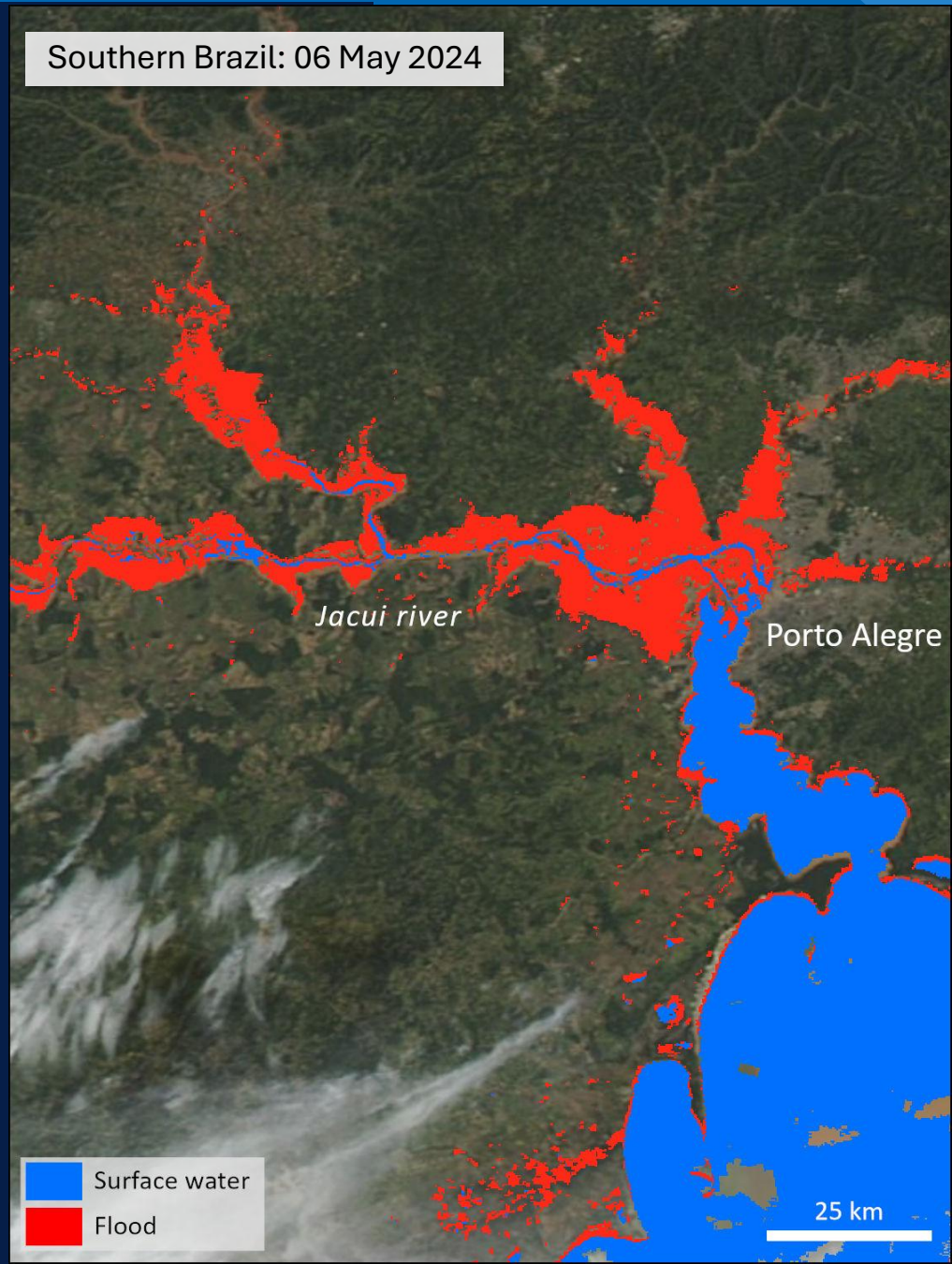
VIIRS flood product examples





Talk Outline

- Product overview
- Brief history
- Approach
- Recent Updates
- Evaluation
- Limitations
- Distribution
- Archive
- Future directions



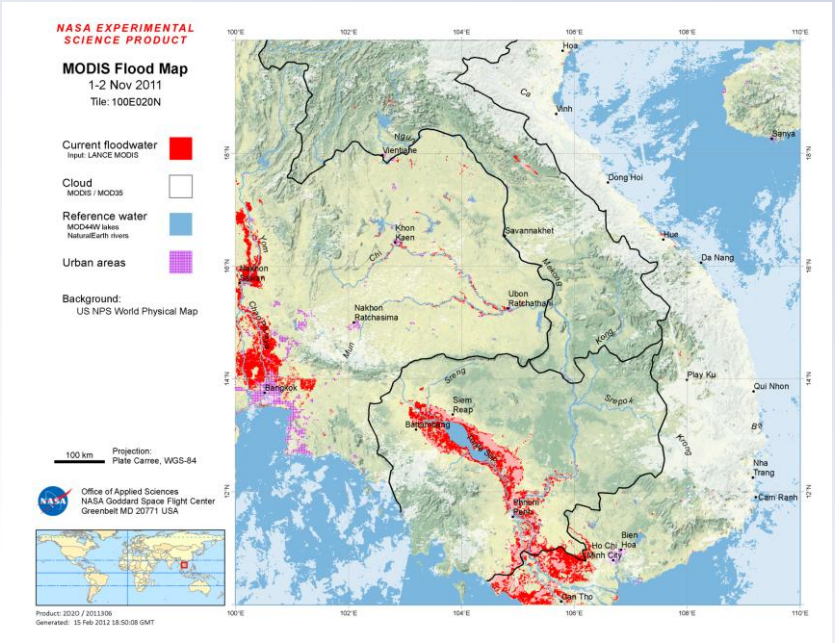
A Brief History

2005: Bob Brakenridge (Dartmouth Flood Observatory) developed method to manually generate flood maps from MODIS rapid response imagery. Generally effective, but:

- Not automated!
- Used rapid response jpegs not intended for data analysis.

2010: NASA GSFC's Office of Applied Science initiated a project to automate production.

- Using LANCE*-generated NRT surface reflectance.
- Automated global flood map production began 2012.
  - 223 10x10° tiles x 3 products (2-day, 3-day, 14-day).
  - Typically available within 6 hours of Aqua overpass (~ 8:00 PM local time).
- PI managed code and server resources.
- Operational 2011-2022. Now referred to as "legacy" product.



2021: Product fully transitioned to LANCE production.

- Completely recoded.
- Much more robust, minimal latency (< 3 hours).

2025: VIIRS product launched.

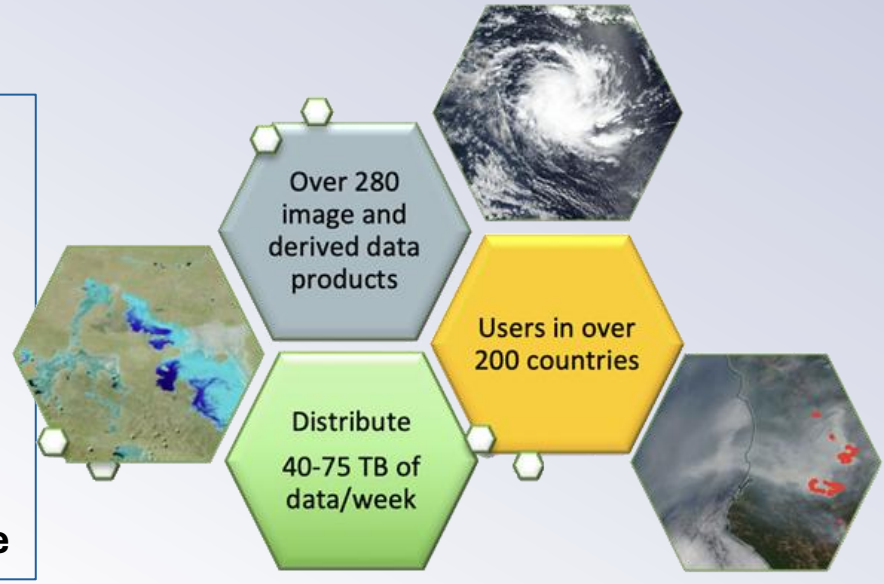
- Identical in approach to MODIS, but using VIIRS on NOAA-20 and NOAA-21

*LANCE = NASA's Land, Atmosphere Near-real-time Capability for Earth observation

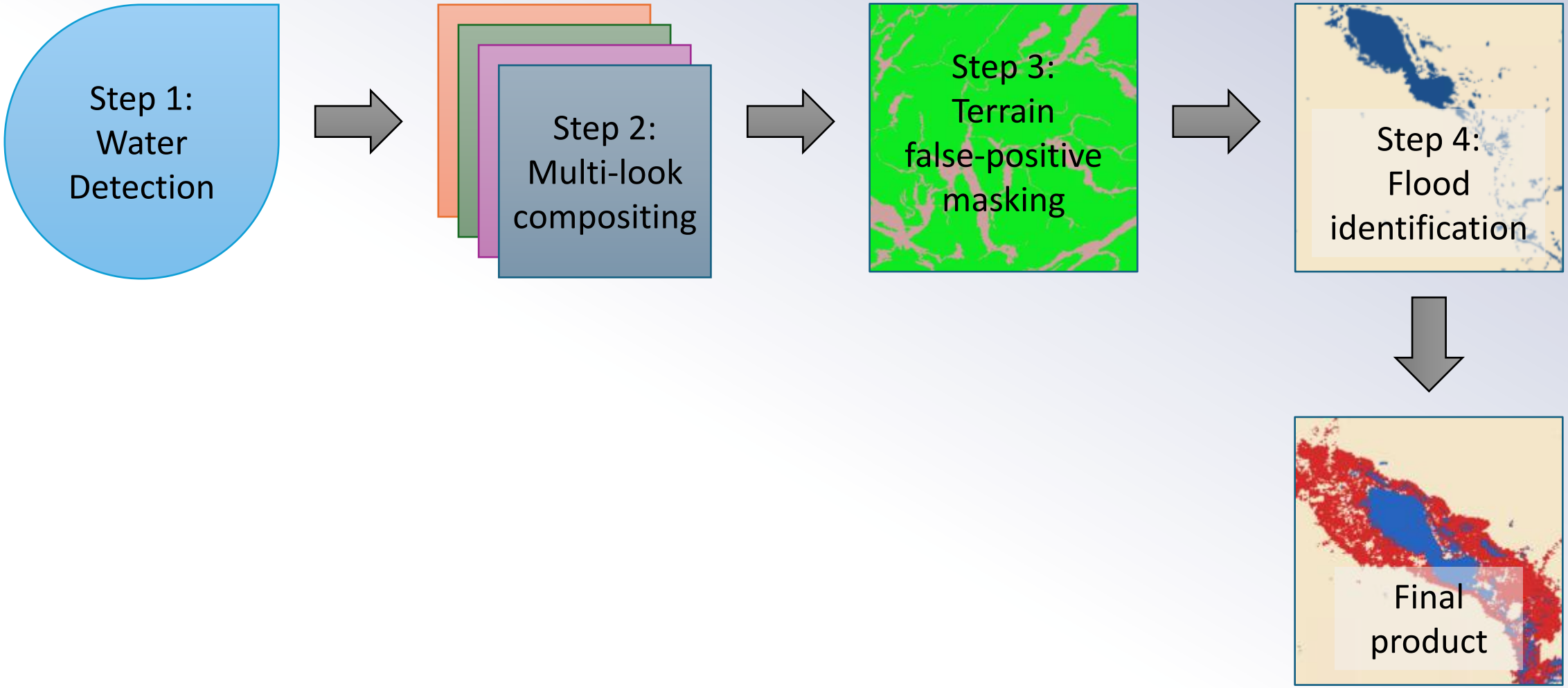
LANCE: Land Atmosphere Near real-time Capability for Earth observation

- Goal: to provide near real-time (NRT) data products within 3 hours of observations to meet the timely needs of applications users including disasters
- Provides timely data from 8 instruments within 3 hours of satellite overpass (except ICESat-2)
- NRT Imagery is available from GIBS and Worldview

- AIRS – Atmospheric Infrared Sounder
- ICESat-2 – Advanced Topographic Altimeter System (ATLAS) on the Ice, Cloud, and land Elevation satellite
- MLS – Microwave Limb Sounder
- **MODIS – Moderate Resolution Imaging Spectroradiometer**
- OMI – Ozone Monitoring Instrument
- OMPS – Ozone Mapping and Profiler Suite
- SMAP – Soil Moisture Active Passive
- VIIRS-Atmosphere and **VIIRS-Land – Visible Infrared Imaging Radiometer Suite**



Overview: four basic steps



Step 1: Water Detection

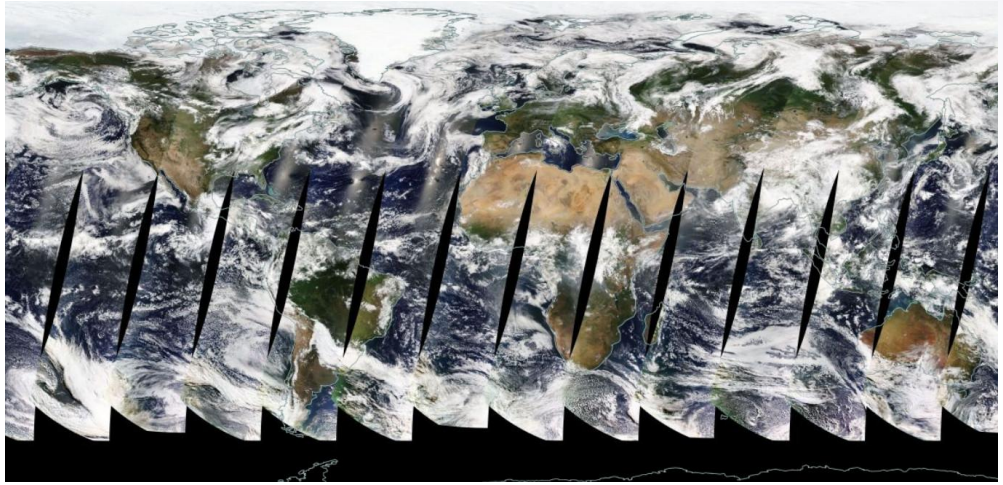
MODIS product source imagery:

MODerate resolution Imaging Spectroradiometer

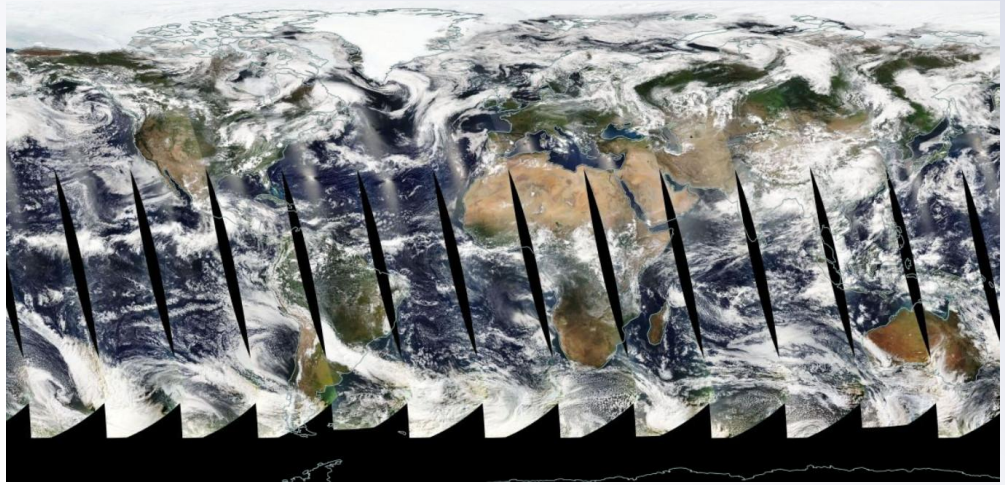
Key features:

- On board two NASA polar-orbiting satellites:
  - Terra: 1999 – present (ending ~ 2026)
  - Aqua: 2002 – present (ending ~2026)
- 250 m resolution
- Global
- 2 x Daily
  - Terra: ~10:30 AM local time
  - Aqua: ~1:30 PM local time
- Optical (cannot see through cloud)

Aqua single orbit (~ 90 minutes)



MODIS / Terra (10:30 am) Daily Collect: 6/18/2025



MODIS / Aqua (1:30 pm) Daily Collect: 6/18/2025

Step 1: Water Detection

VIIRS product source imagery:

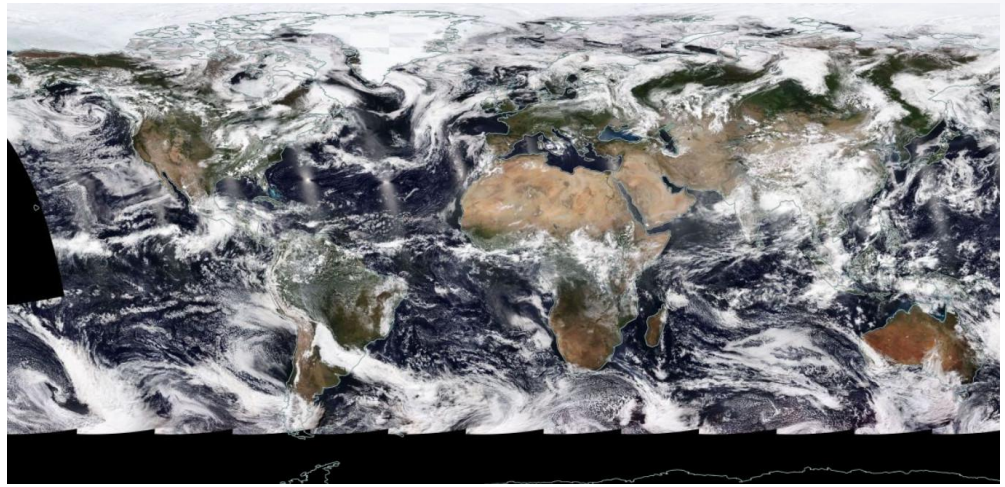
Visible Infrared Imaging Radiometer Suite

Key features:

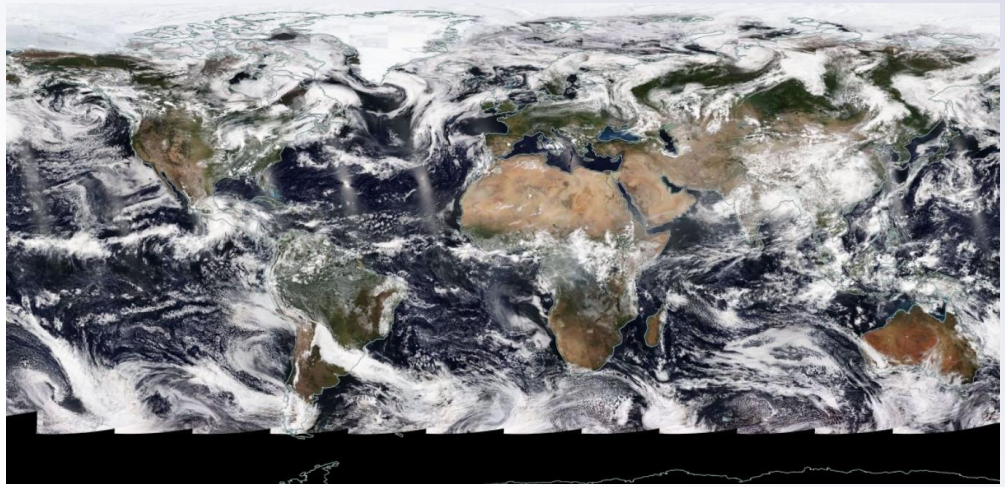
- On board two NOAA polar-orbiting satellites:
  - NOAA-20: 2017 – present
  - NOAA-21: 2022 – present
- 375 m resolution
- Global
- 2 x Daily
  - NOAA-20: ~1:30 PM local time
  - NOAA-21: ~2:20 PM local time
- Optical (cannot see through cloud)

Differences from MODIS:

- 375 m resolution, vs 250
- Only afternoon overpasses (within 40 minutes) vs 10:30 am / 1:30 pm
- No equatorial swath gaps!



VIIRS / NOAA-20 (1:30 pm) Daily Collect: 6/18/2025



VIIRS / NOAA-21 (2:20 pm) Daily Collect: 6/18/2025

Step 1: Water Detection

Water detection algorithm:

3 conditions must be met:

$$\frac{(NearIR + A)}{(Red + B)} < C$$

AND $Red < D$

AND $SWIR < E$

A	13.5
B	1081
C	0.7
D	2027
E	676

Band / Band #	Wavelengths (nm)	
(MODIS, VIIRS)	MODIS	VIIRS
Red (1, i1)	620-670	600-680
Near-IR (2, i2)	841-876	850-880
SWIR (7, m11)	2105-2155	2230-2280

Thresholds in units of scaled reflectance (0-10000)
Developed by Bob Brakenridge, Dartmouth Flood Observatory

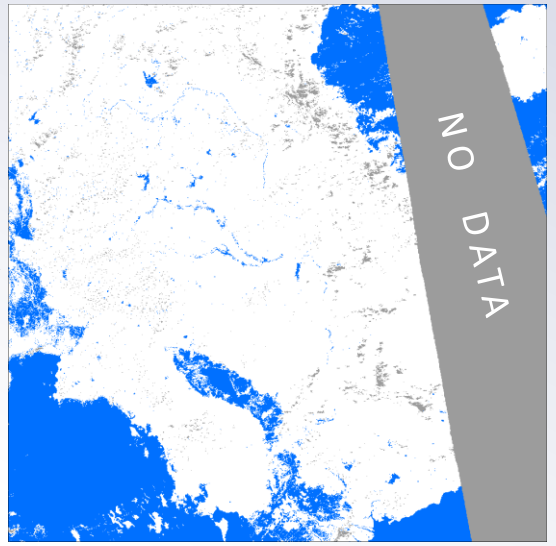
10° x 10° tile

Input Image: MODIS/Aqua

(11/1/2011, False-color)

Water detection algorithm

Output: Detected water



Step 1: Water Detection

Step 2: Multi-look compositing

1. Sum water detections from all available observations, over the composite period (1, 2, or 3 days).
2. If SUM >= THRESHOLD: mark pixel as water

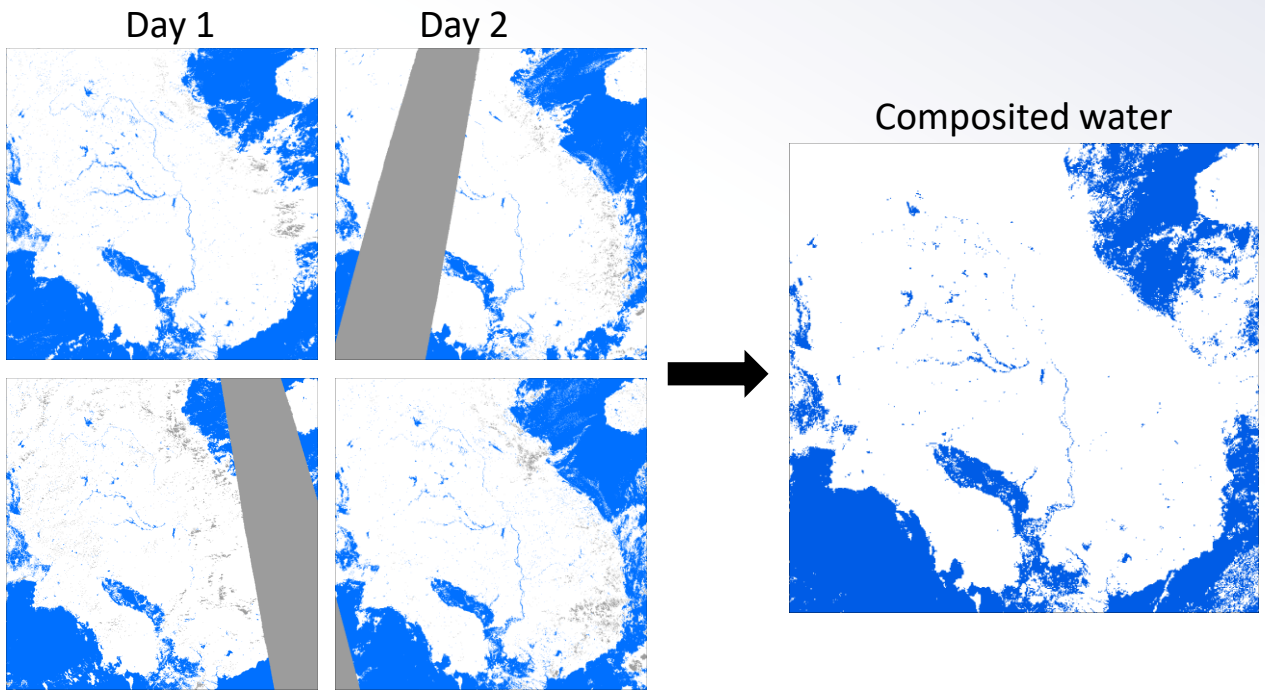
   The threshold is generally equal to the compositing period:
   - 1-day composite: 1
   - 2-day composite: 2
   - 3-day composite: 3

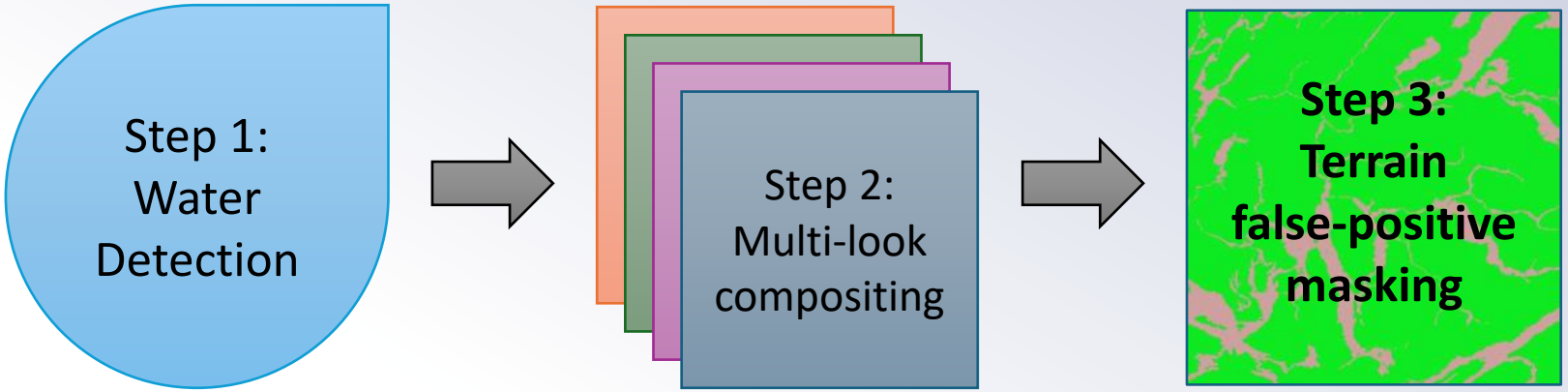
   (modified depending on the actual number of observations)

2-day composite example

MODIS/Terra 10:30 AM

MODIS/Aqua 1:30 PM





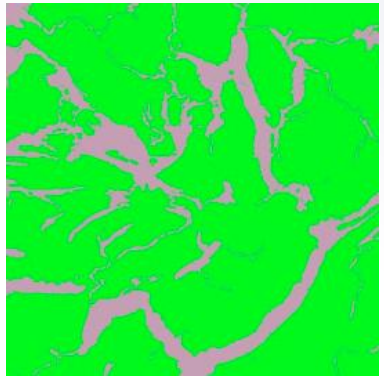
Apply terrain and topographic masks to remove likely false-positive water detections

1. Monthly computed terrain shadow masks.

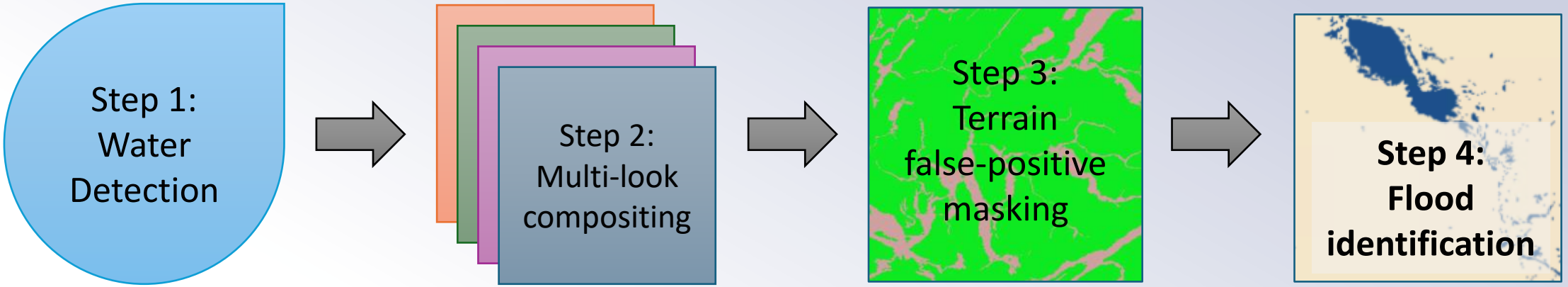
MODIS/Terra
February, 10:30 AM

MODIS/Aqua
February, 1:30 PM

2. General topographic mask
HAND: Height Above Nearest Drainage



HAND identifies areas unlikely to retain flood water, given 250 m resolution pixels



Flood identification

1. Compare detected water to reference water layer (=expected water).

   MOD44W land-water mask provides reference water.

2. Water not matching:
   ➔FLOOD

3. Water matching:
   ➔SURFACE WATER

Detail: False-positive masking

Shadows look like water → false positives!

- Shadow is very difficult to discriminate from real water in red and near-infrared wavelengths

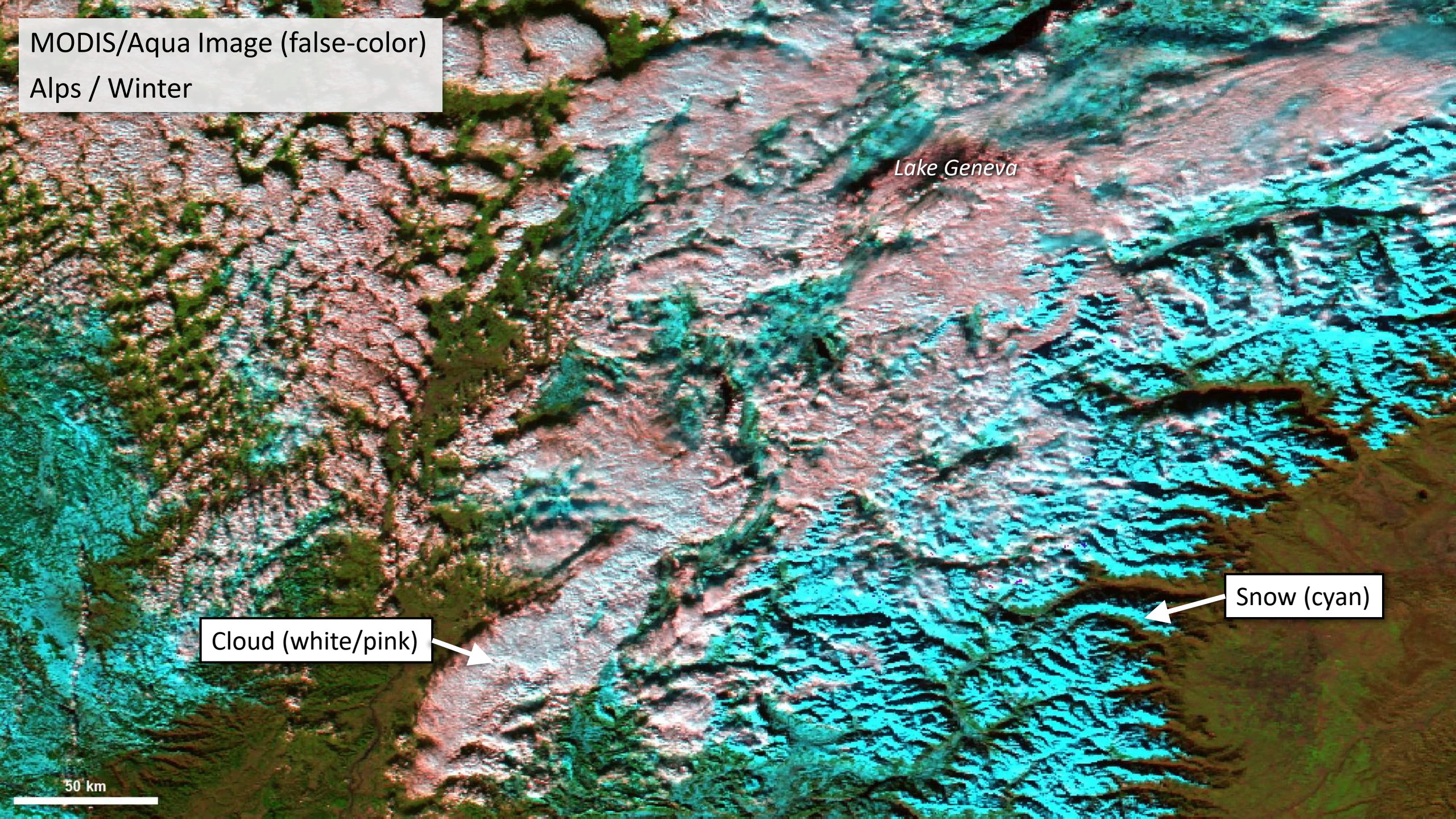
Terrain shadows

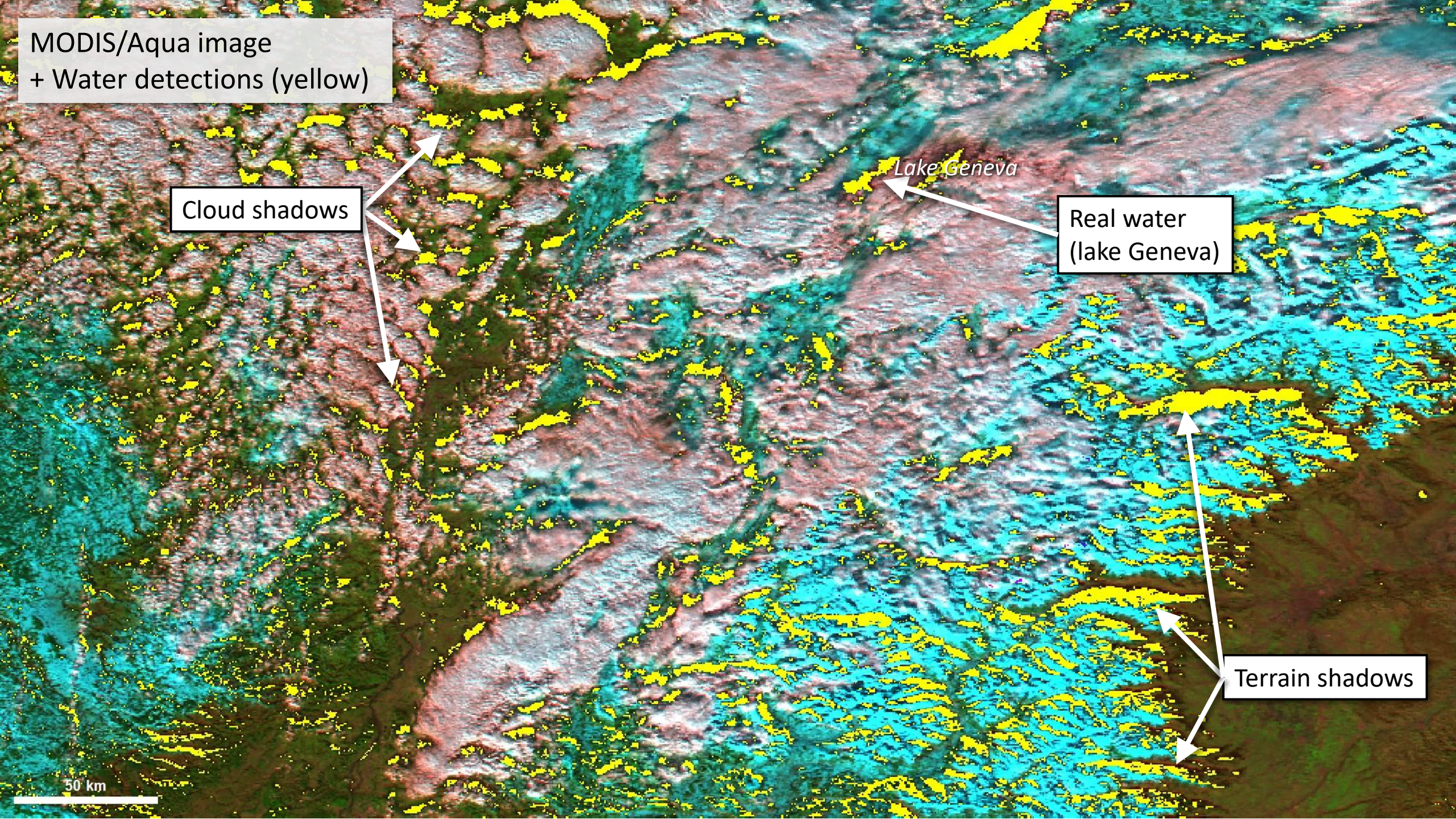
- In mountainous areas, mostly in winter
- First cut: apply computed terrain shadow masks (good but not perfect)
- Second cut: apply HAND topographic mask (masks areas where water should not be able to accumulate due to significant relief)

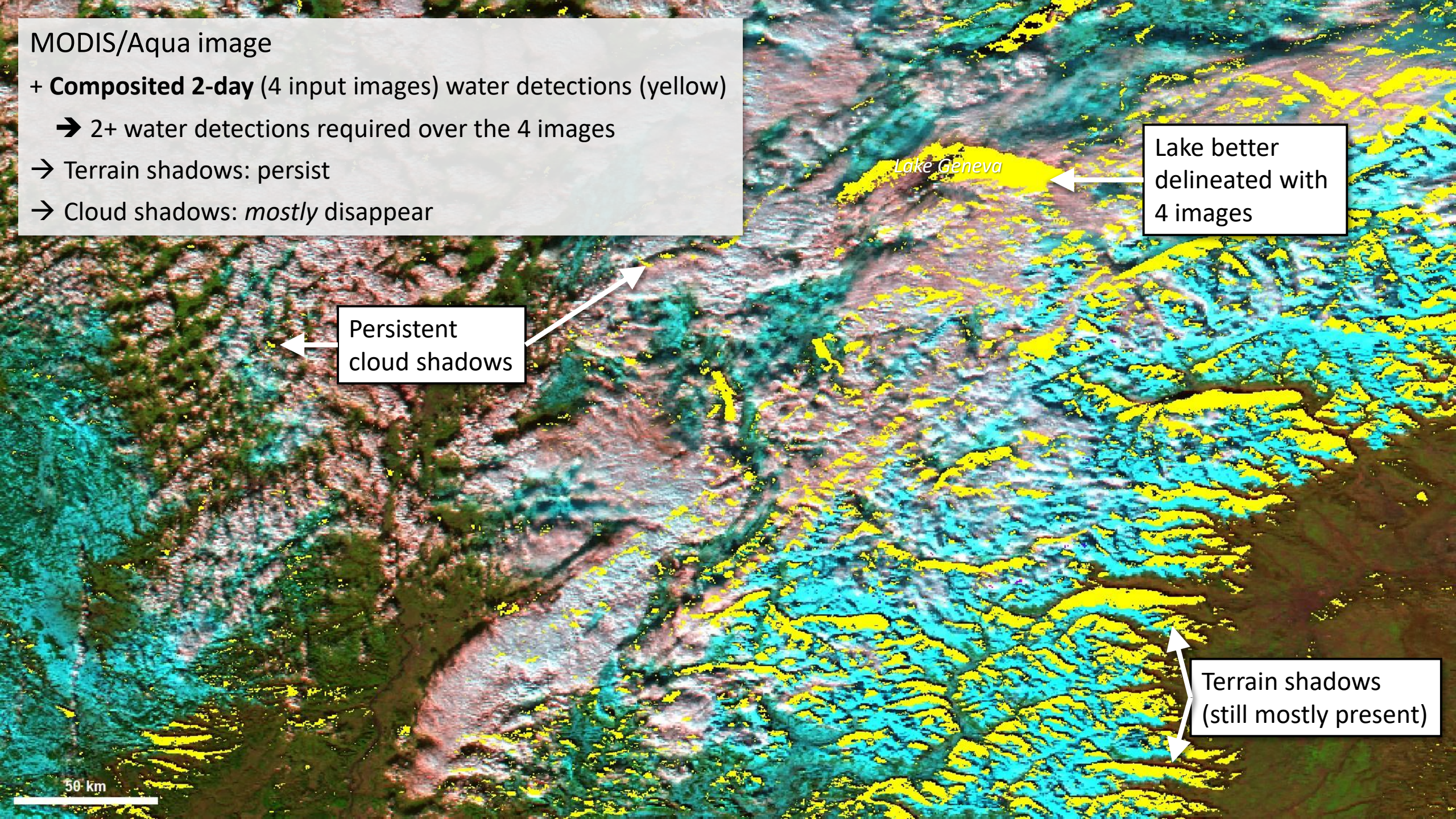
Cloud shadows

- Multi-look compositing eliminates most
- But: shadows can occasionally recur in the same location, leading to false-positives in 2 and (much less frequently) 3-day products

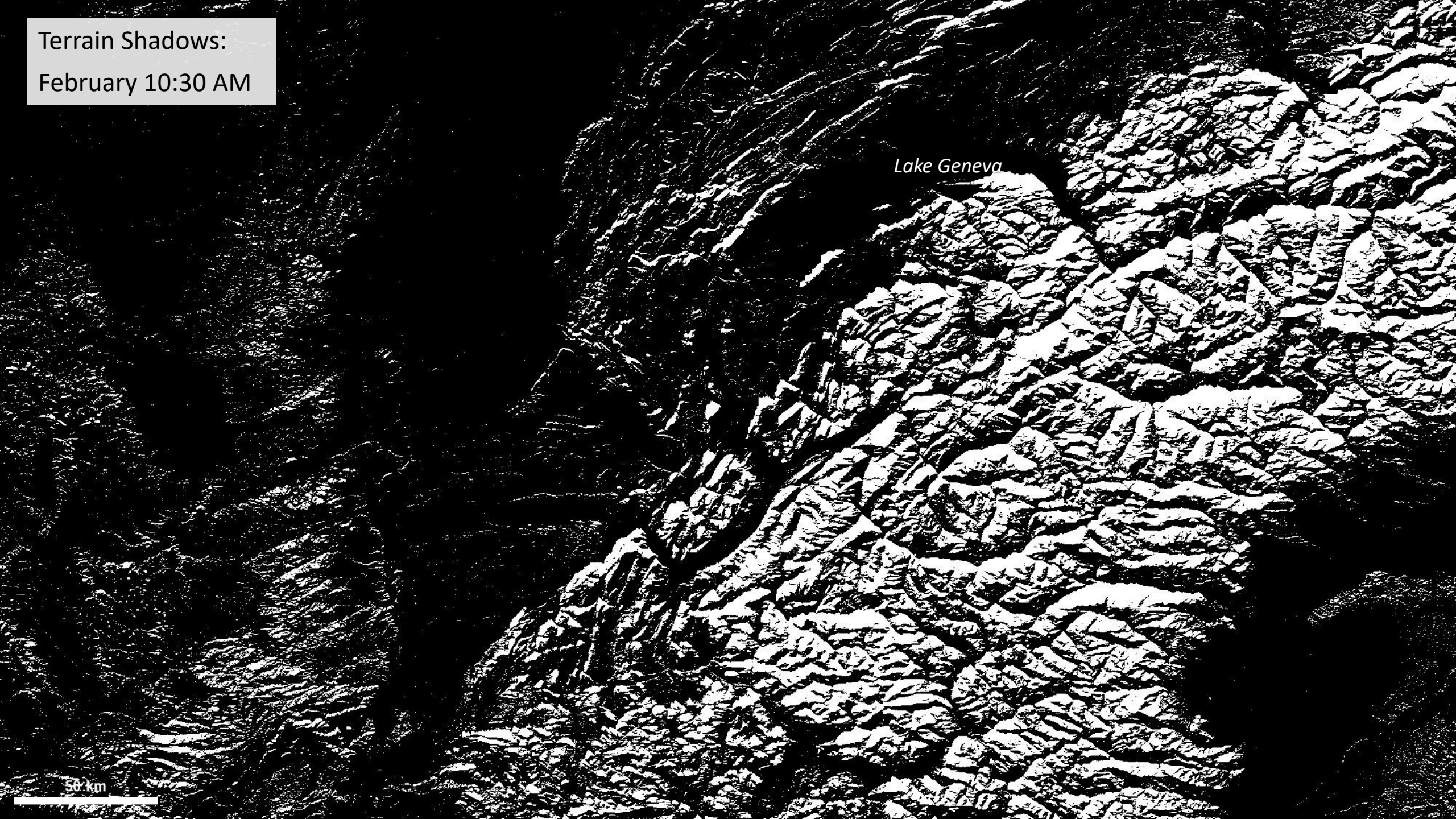
→Reviewing source imagery is critical to understanding potential cloud contamination!

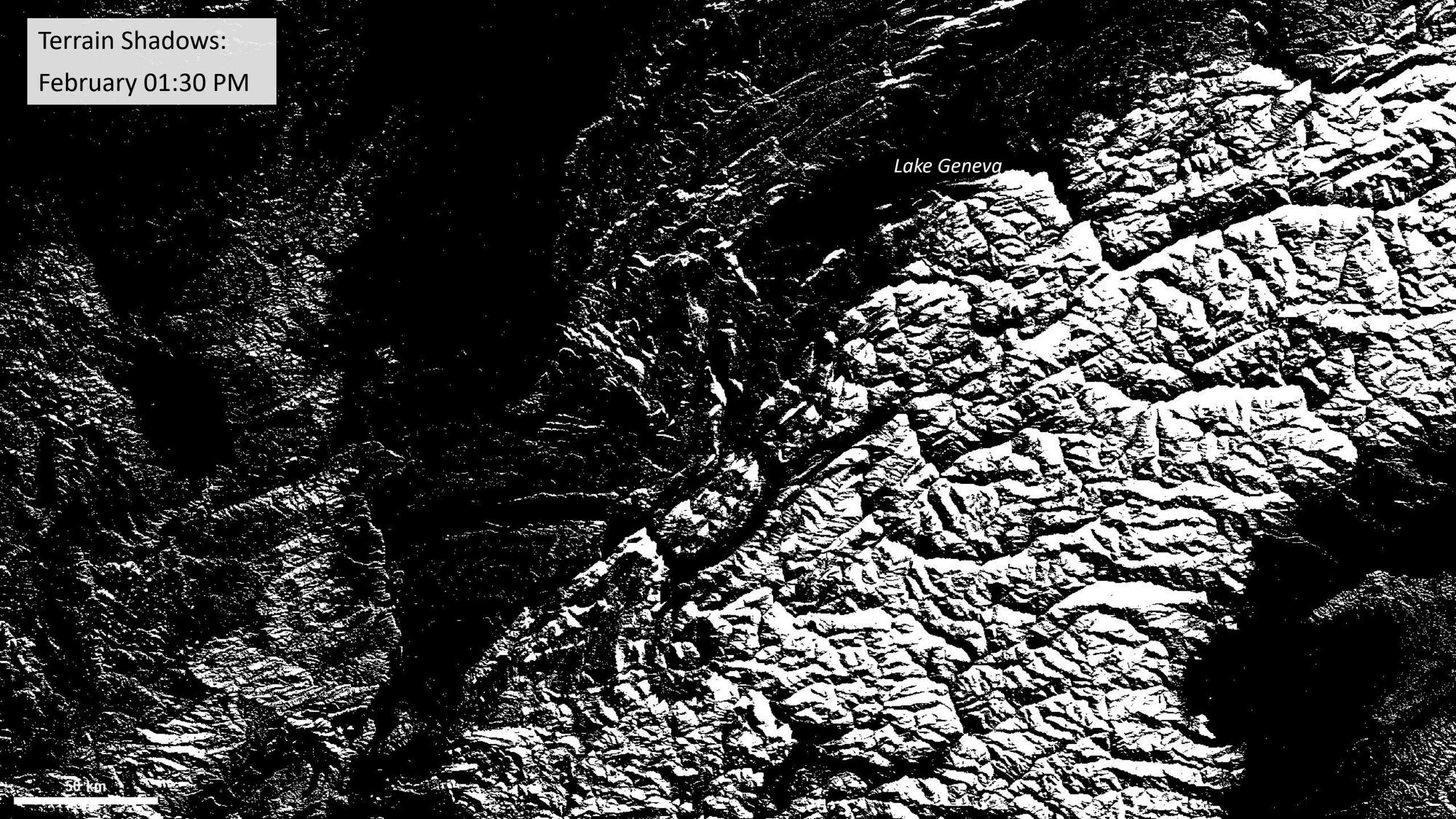

MODIS/Aqua Image (false-color)
Alps / Winter
Lake Geneva
Snow (cyan)
Cloud (white/pink)
50 km

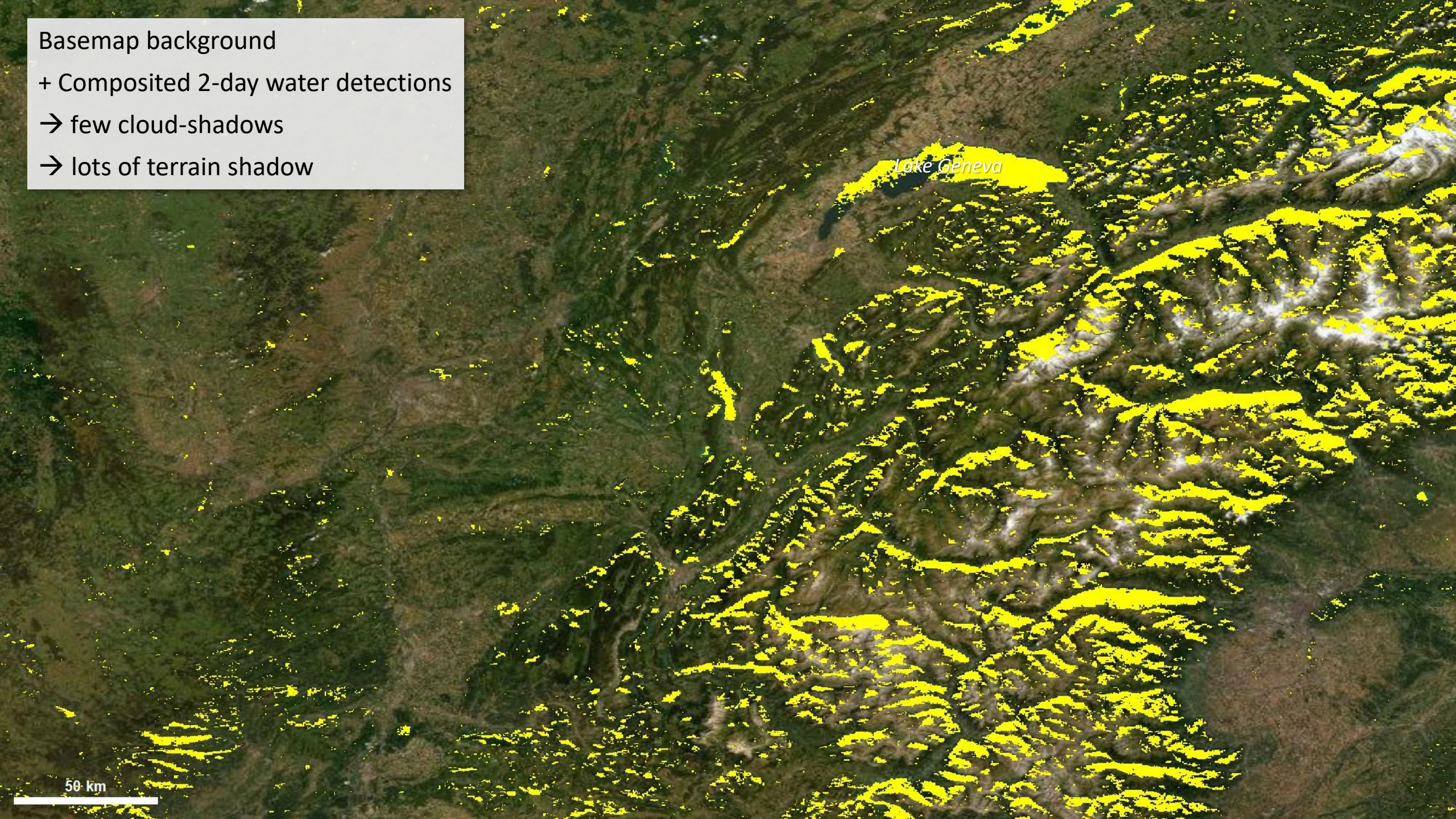

MODIS/Aqua image
+ Water detections (yellow)
Cloud shadows
Lake Geneva
Real water
(lake Geneva)
Terrain shadows
50 km

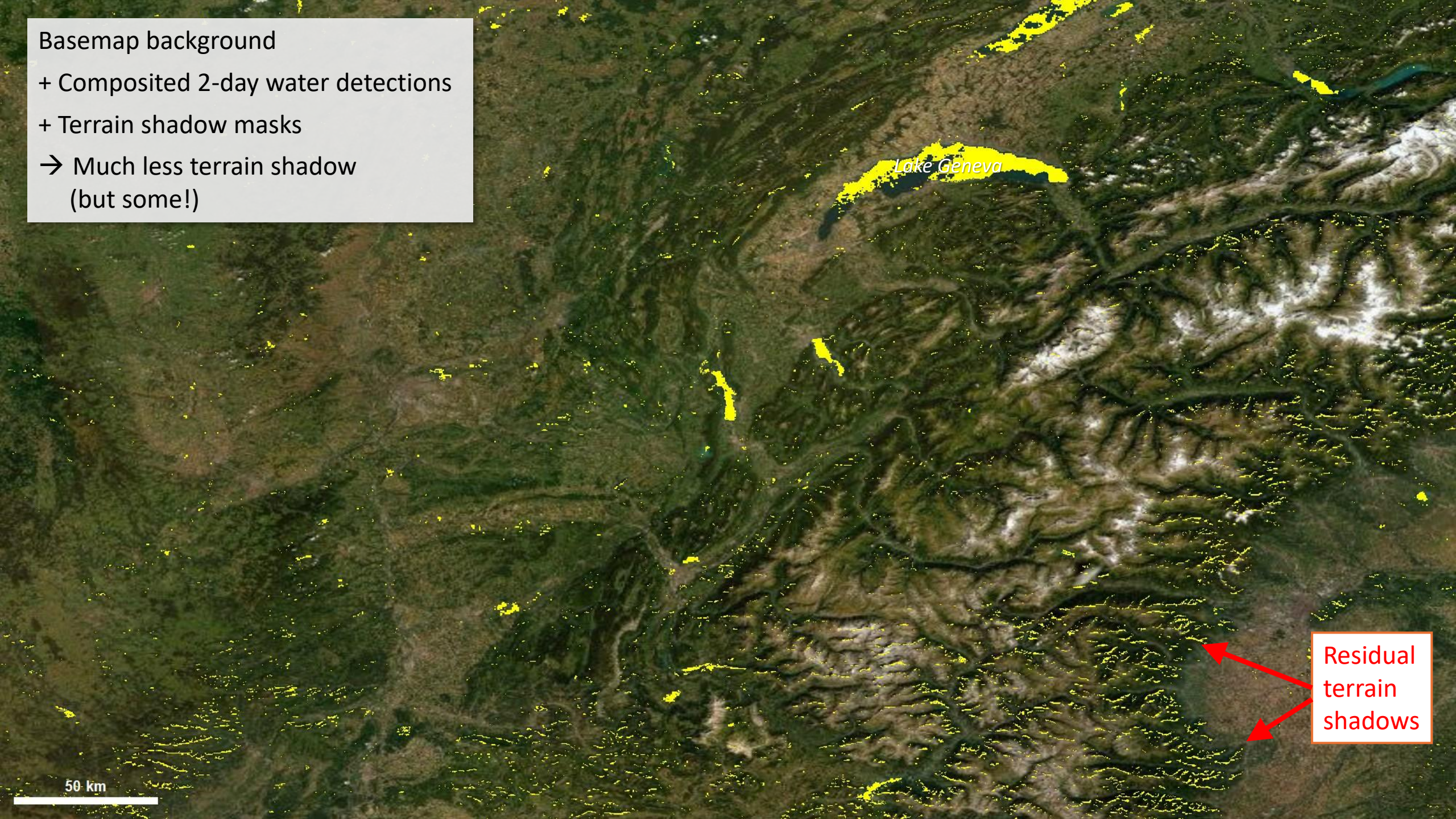

MODIS/Aqua image
+ **Composited 2-day** (4 input images) water detections (yellow)
➔ 2+ water detections required over the 4 images
→ Terrain shadows: persist
→ Cloud shadows: *mostly* disappear
Lake Geneva
Lake better delineated with 4 images
Persistent cloud shadows
Terrain shadows (still mostly present)
50 km

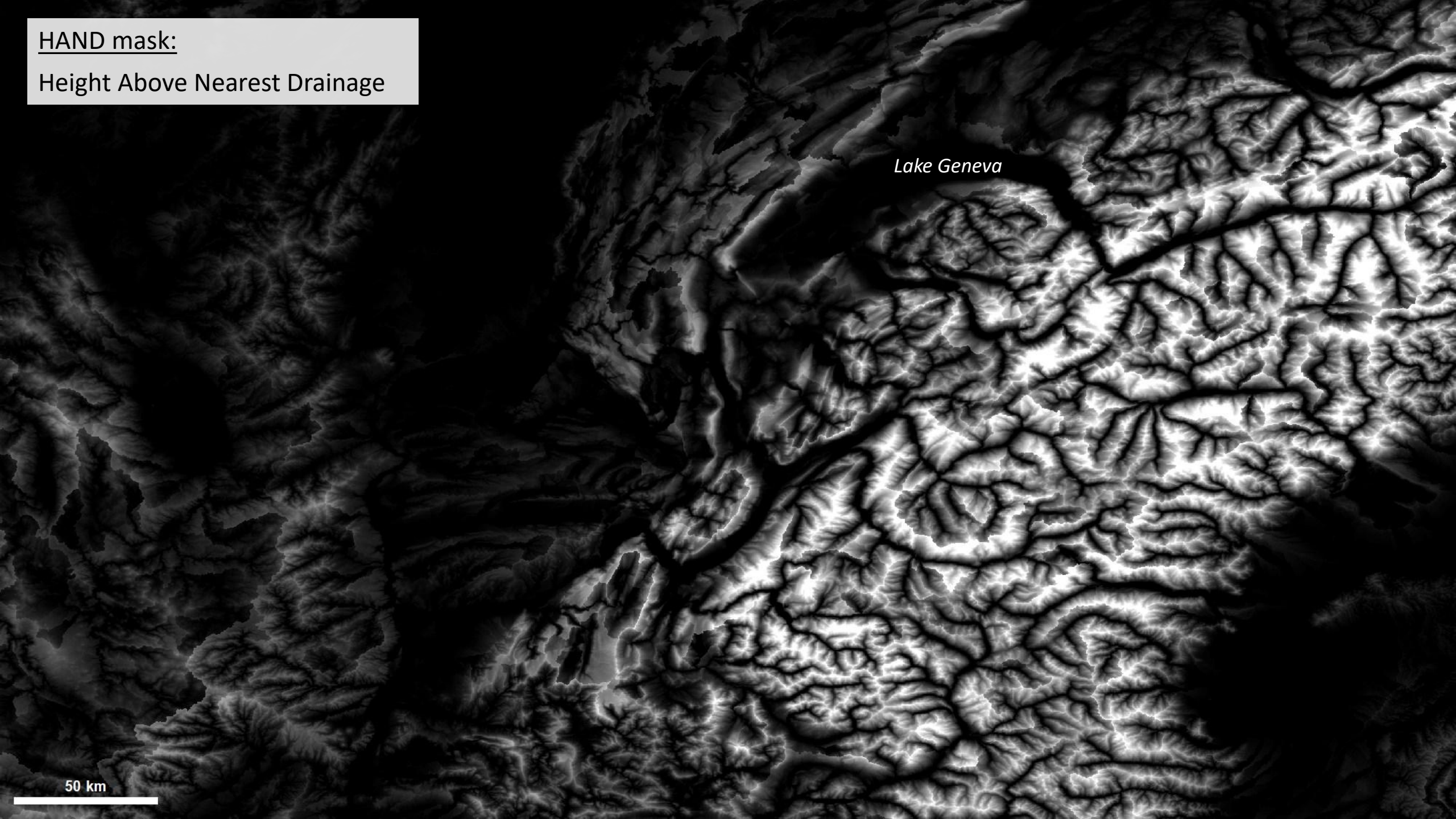
Example: Alps - terrain

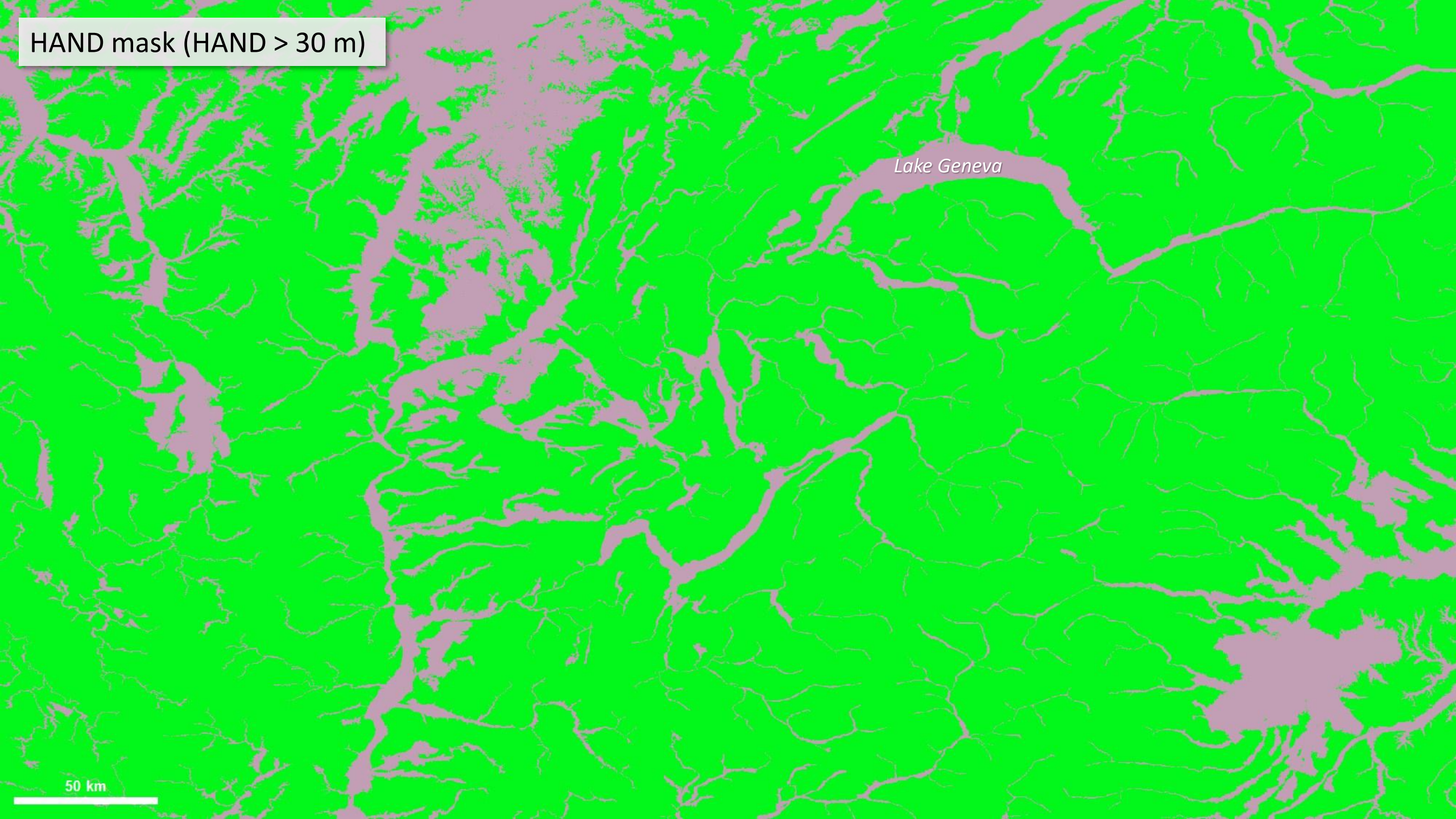

Terrain Shadows:
February 10:30 AM
Lake Geneva
50 km

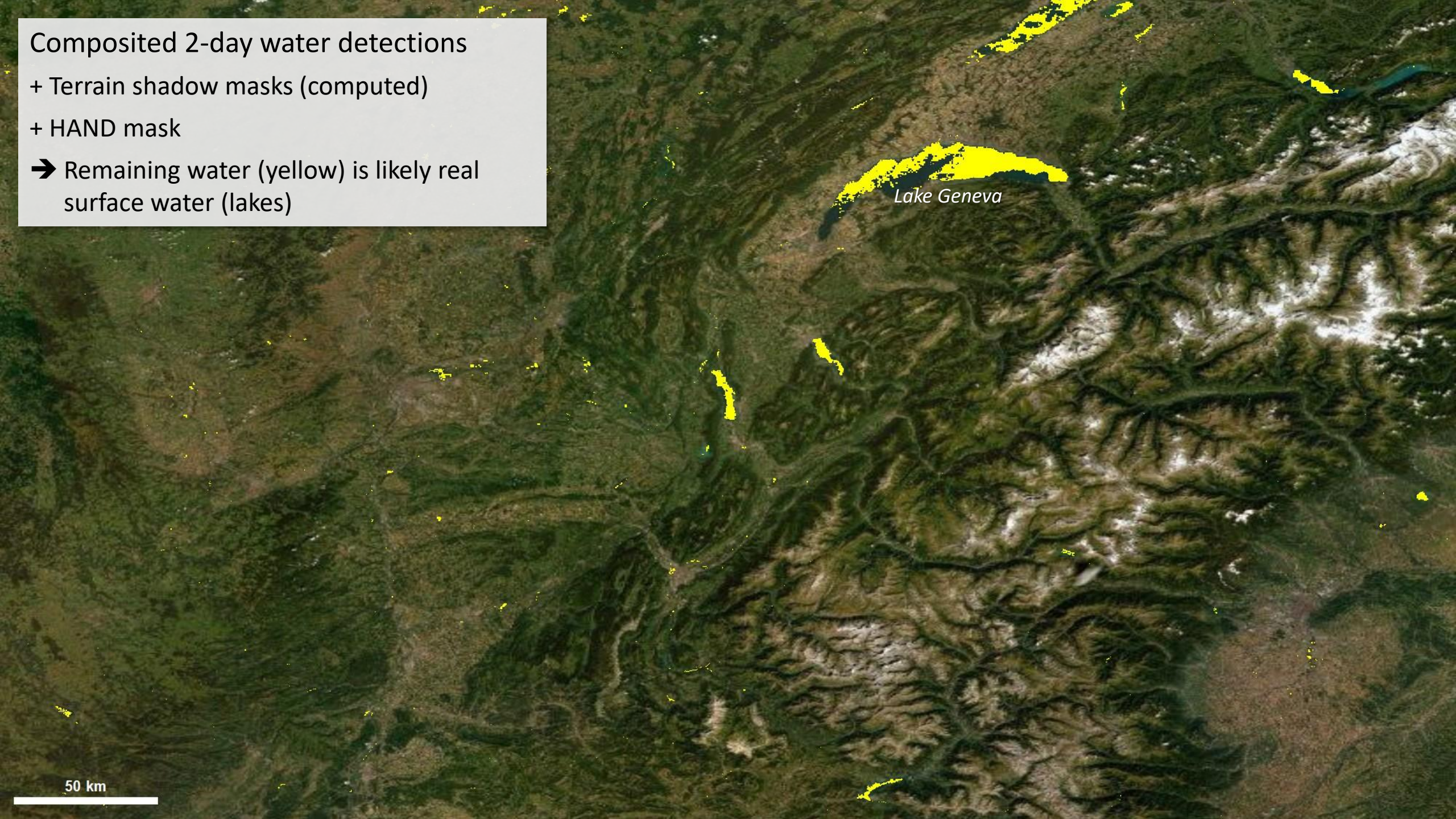

Terrain Shadows:
February 01:30 PM
Lake Geneva
50 km


Basemap background
+ Composited 2-day water detections
→ few cloud-shadows
→ lots of terrain shadow
Lake Geneva
50 km


Basemap background
+ Composited 2-day water detections
+ Terrain shadow masks
→ Much less terrain shadow
(but some!)
Lake Geneva
Residual terrain shadows
50 km


HAND mask:
Height Above Nearest Drainage
Lake Geneva
50 km


HAND mask (HAND > 30 m)
Lake Geneva
50 km


Composited 2-day water detections
+ Terrain shadow masks (computed)
+ HAND mask
➔ Remaining water (yellow) is likely real surface water (lakes)
Lake Geneva
50 km

Detail: Multi-look compositing

1. Sum water detections from all available observations, over 3 composite periods: 1 day, 2 days, and 3 days.
2. If SUM >= THRESHOLD: mark pixel as water
   - The threshold is generally equal to the compositing period: 1 for 1-day, 2 for 2-day, and 3 for 3-day.
     This is modified depending on the actual number of observations due to swath overlaps at higher latitudes.

2-day **standard product**: requires 2+ water observations over 2 days of imagery (generally 4 observations).

3-day product: requires 3+ observations over 3 days. Minimal false-positives. Potentially less up-to-date.

1-day product: requires JUST 1 observation over 1 day.

- Most current, but **WILL** probably contain cloud-shadow false-positives **IF** cloud is present.

Which product to use? Depends on cloud conditions, and:

- Tolerance for false positives (and false negatives).
- Need for only the most up-to-date information.

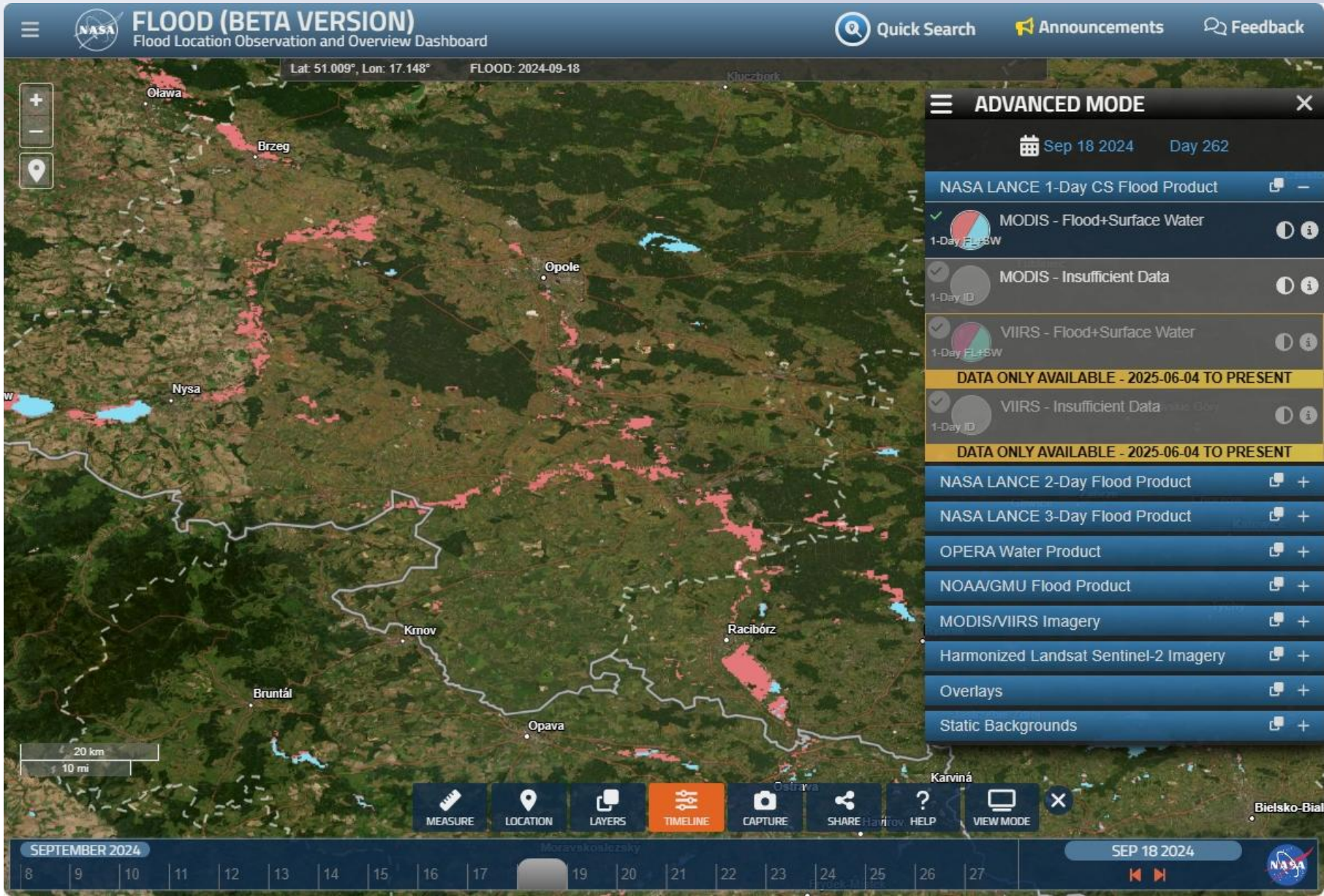
- Clear conditions? (Can verify visually in Worldview app: https://worldview.earthdata.nasa.gov/) → **Use 1-day**.
- Very sensitive to false-positives and/or currency is not critical? → **Use 3-day**.
- Need the latest info? → **Use 1-day, but CHECK CLOUDS!**
- Best approach? Review visible imagery for date/area of interest in conjunction with all products.

Composite example: 18 Sept 2024 southern Poland

1-Day Composite

Baselayer background

- Lots of flood
- Appears to follow linear-ish features (suggesting rivers): ✓



Composite example: 18 Sept 2024 southern Poland

1-Day Composite

MODIS/Terra image background

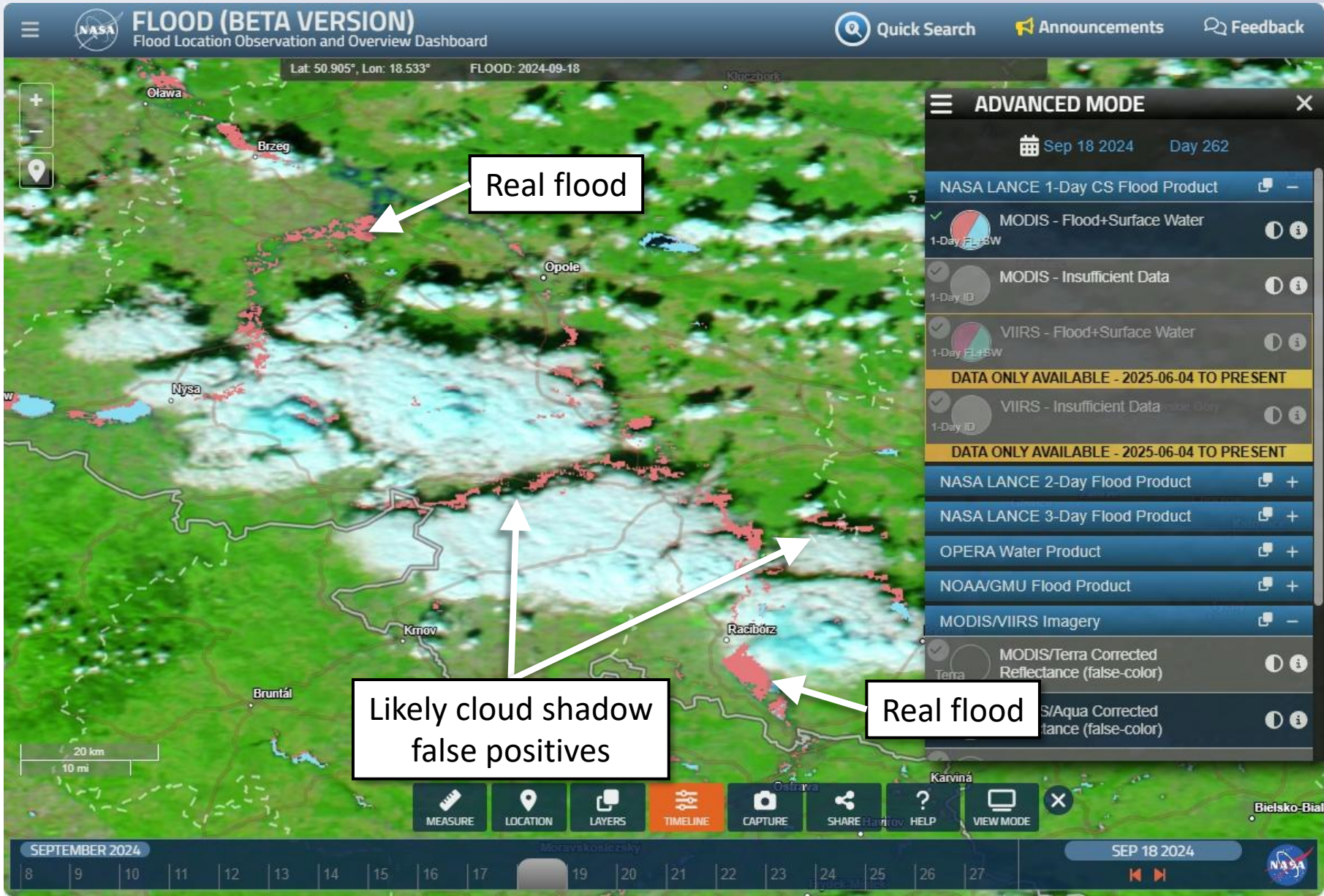
- Still looks reasonable.
- Minimal cloud; no obvious cloud issues: ✓

Composite example: 18 Sept 2024 southern Poland

1-Day Composite

MODIS/Aqua image background

- **!! Flood in cloud shadow !!**
- Some flood appears reasonable



Composite example: 18 Sept 2024 southern Poland

2-Day Composite

MODIS/Aqua image background

- Most (all?) cloud shadow false-positives have disappeared

For 2-day composite, 4 images should be reviewed:

- Terra: Current day
- Aqua: Current day
- Terra: Previous day
- Aqua: Previous day

Similarly for VIIRS: NOAA-20/NOAA-21 in place of Terra and Aqua

Composite example: 18 Sept 2024 southern Poland

3-Day Composite

MODIS/Terra image background

- All cloud shadow false-positives have disappeared!
- But much real flood has also disappeared!

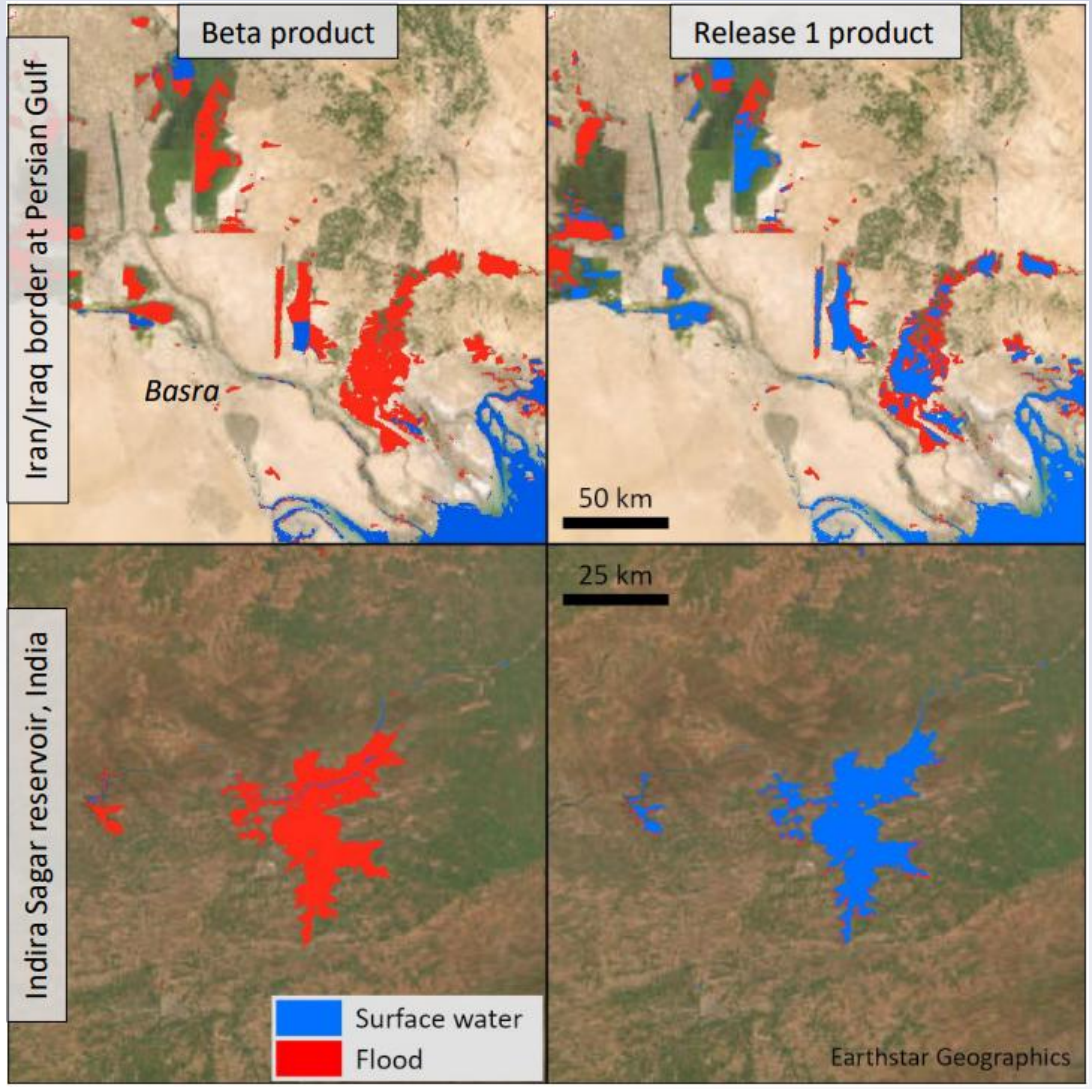
→ 2 days ago, area was entirely cloudy, so few pixels meet 3-day water-detection threshold

↓

16 Sept 2024 Terra: CLOUDY

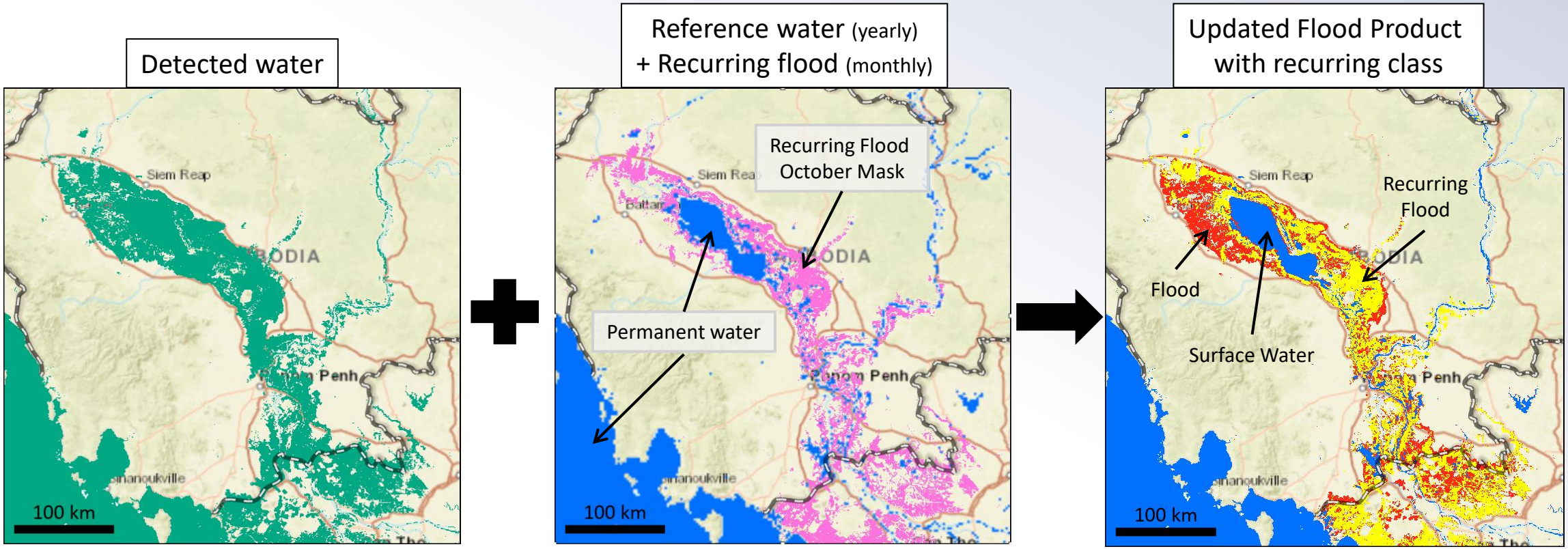
Recent Updates:
+ Updated Permanent Reference Water

- Originally used static MOD44W (“land water mask” product), circa 2009, to identify expected permanent water.
- Now use updated yearly MOD44W
  - Accounts for new reservoirs, changes in river courses, other permanent water changes
  - Release 1 (April 2024)

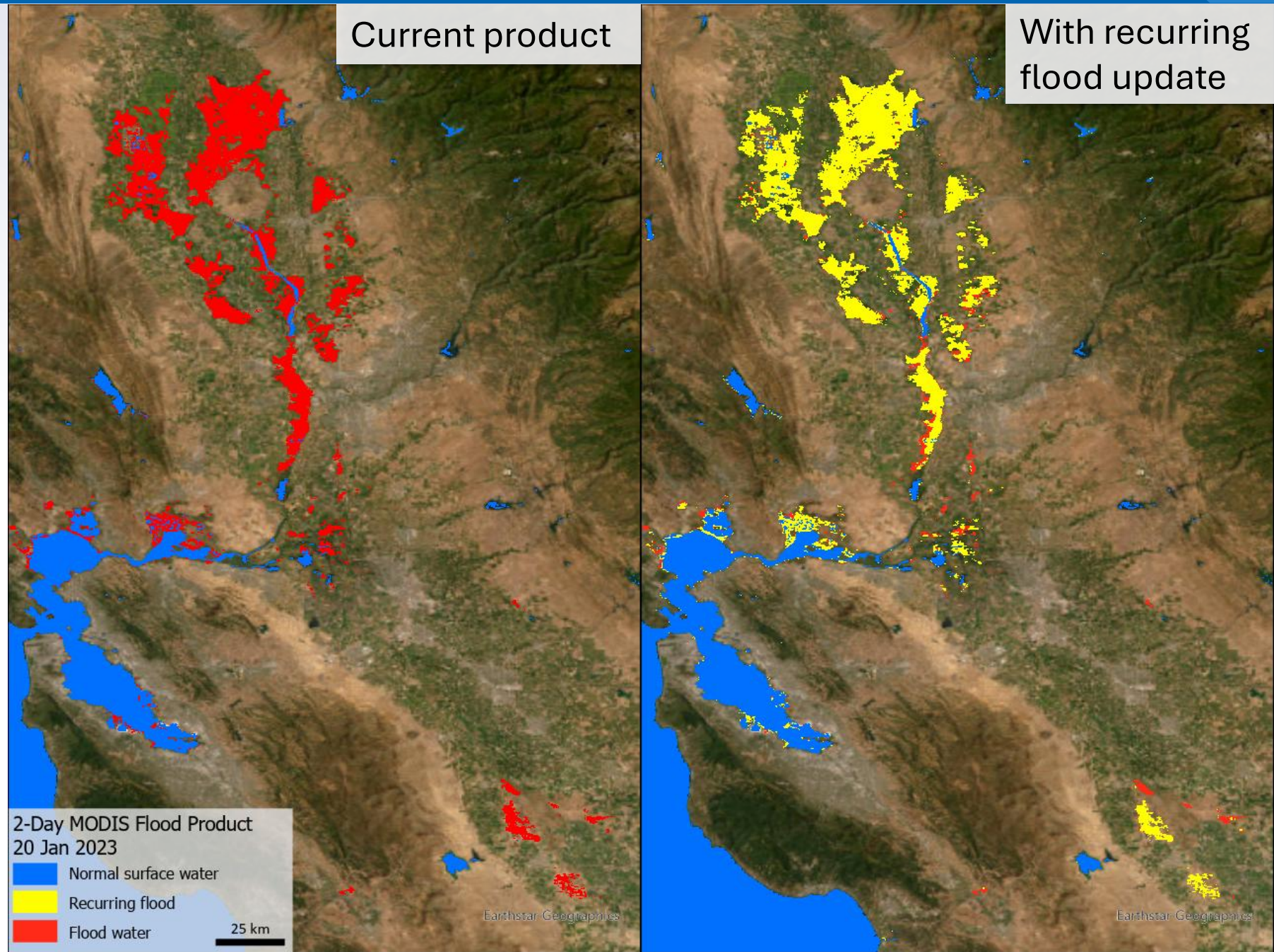


+ Identification of “recurring flood”

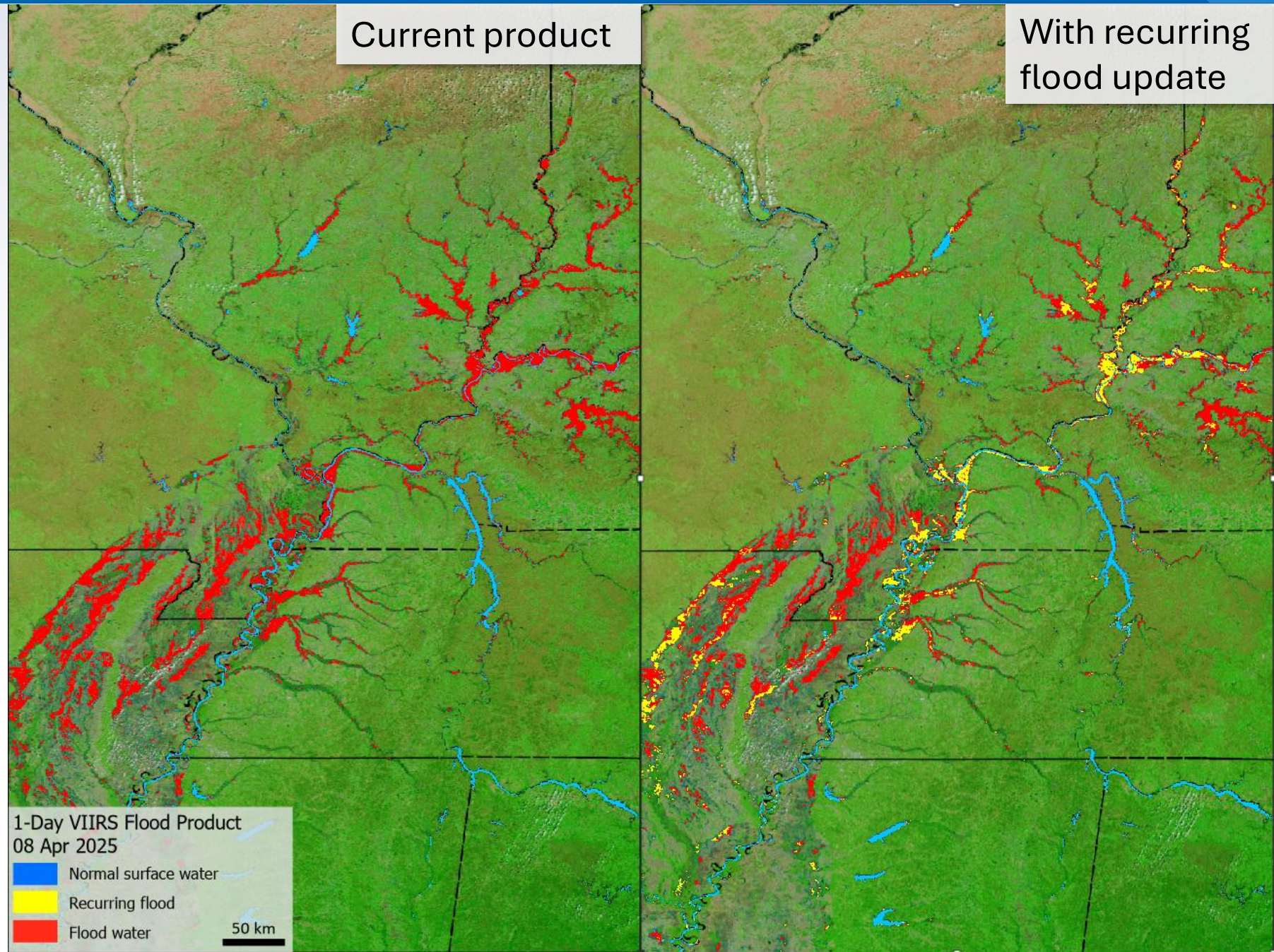
- NEW Feature! Releasing ~Sept 2025
- Monthly recurring flood masks based on 22 year product history (2003-2024)
- Helps discriminate regularly occurring seasonal flood from unusual flooding



Recurring flood:
N California example
January 2023



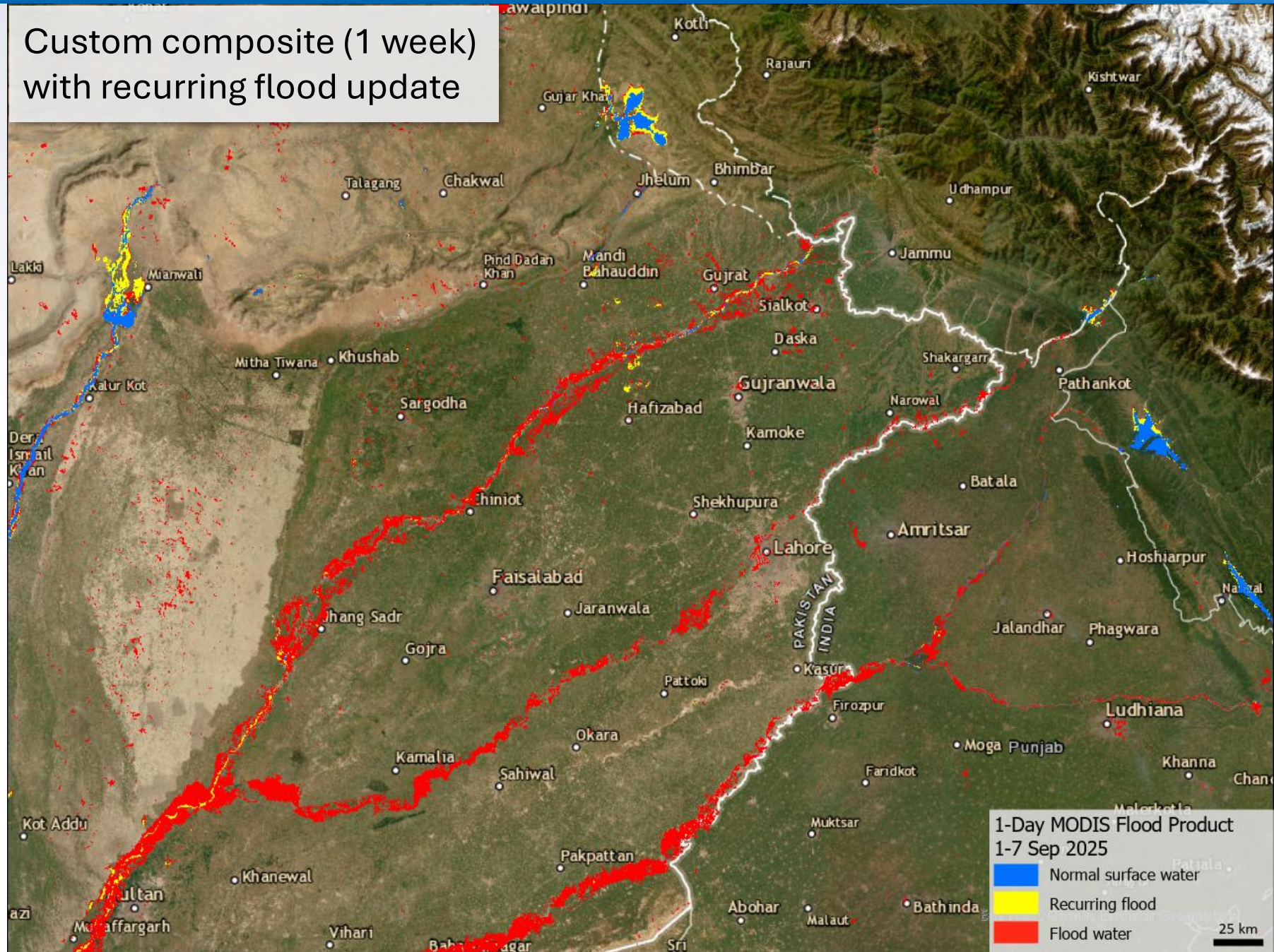
Recurring flood:
Mississippi – Ohio example
April January 2025



Custom composite (1 week) with recurring flood update

<u>Recurring flood:</u>
Indus/Punjab river system
Sept 2025

→ Mostly ***not*** recurring, but unusual flooding



Validation / Evaluation

Purpose:

- Is water detection algorithm correctly detecting water that is visibly obvious?
- Are certain events or situations problematic?
- Do we see differences between detection of flood vs normal water?

Caveat:

- No rigorous ground-truth dataset: ground truth is difficult to find, expensive to collect, and biased towards accessible locations

Method:

- Manual qualitative assessment, using MODIS or Landsat imagery to inform.
- 50 events selected from DFO master list of recent floods.
  - Global distribution.
  - Including areas with high and low cloud cover (humid tropics to arid regions).
  - Varying landcovers.
- + 50 permanent water sites for evaluation of surface water detection.
- Conducted for legacy product in 2014.

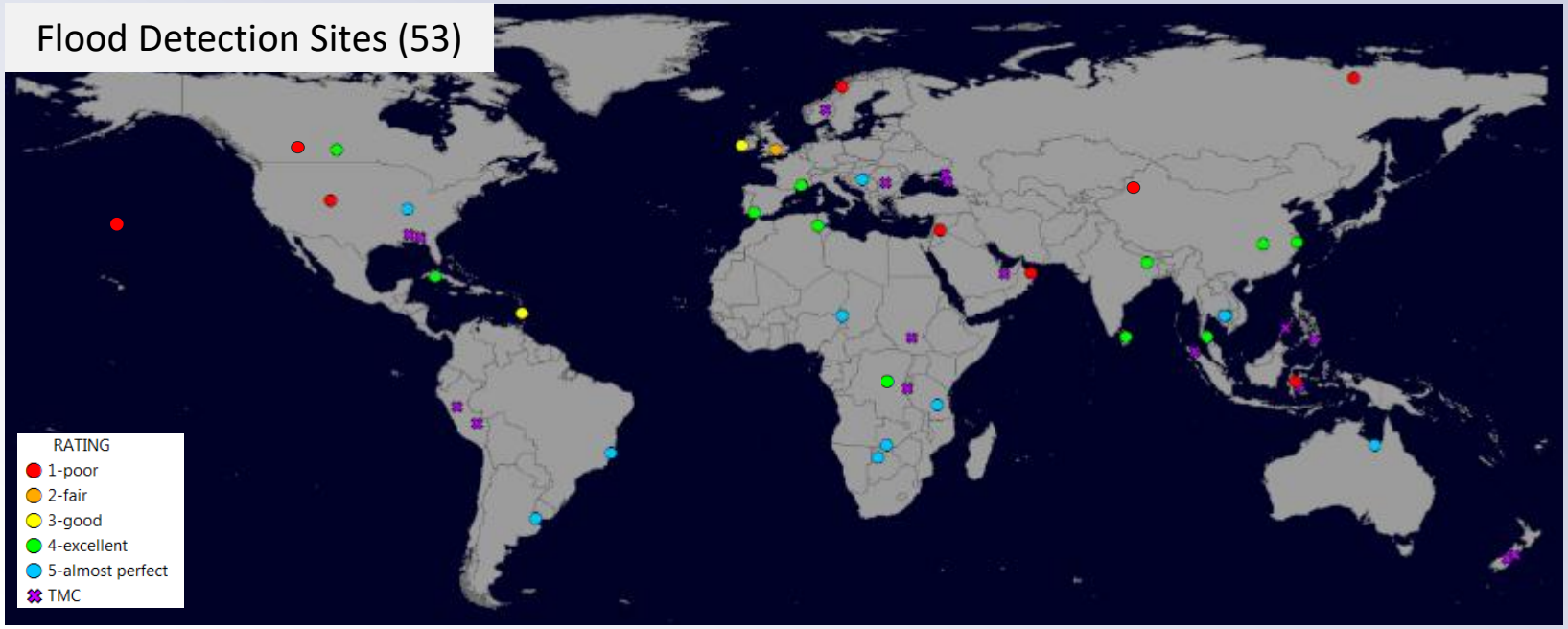
Flood Detection Ratings

RATING	Count	%
Good or better	**23**	**66**
Fair or poor	12	34
Total Assessable	35	100
Too cloudy	17	33
TOTAL EVENTS	53	

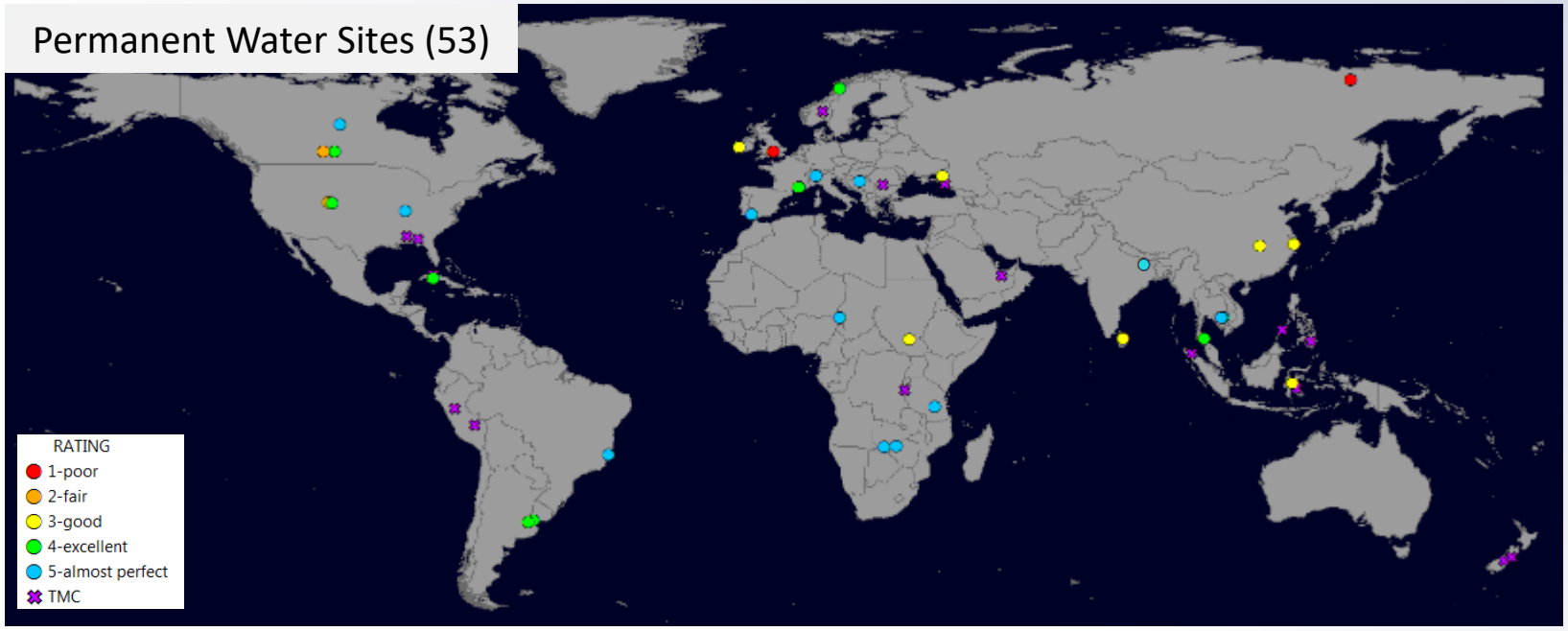
Permanent Water Ratings

RATING	Count	% Clear
Good or better	**31**	**85**
Fair or poor	6	16
Total Assessable	37	100
Too cloudy	16	30
TOTAL EVENTS	53	

Flood Detection Sites (53)



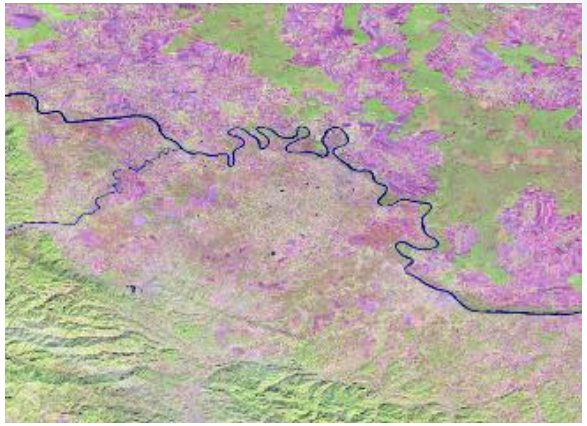
Permanent Water Sites (53)



Correct water & flood ID

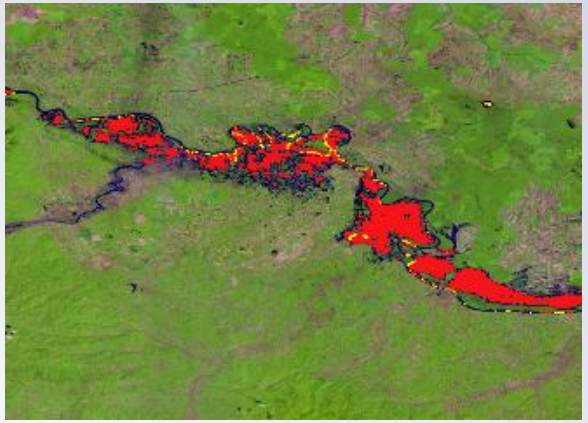
Bosnia and Herzegovina: 23 May 2014

Base map

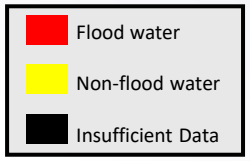


Landsat 8 Pre-flood
October 19, 2013

Landsat 8 Flood
May 22, 2014



MODIS NRT product
May 22, 2014

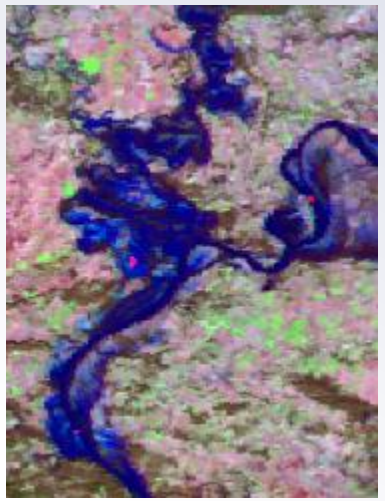


Correct water & flood ID

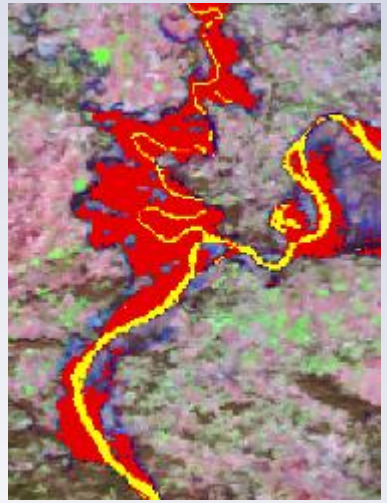
Kentucky: 04 Jan 2014

Base map

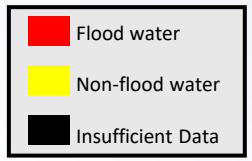
MODIS Pre-Flood
Oct 12, 2013



MODIS Flood
Jan 4, 2014



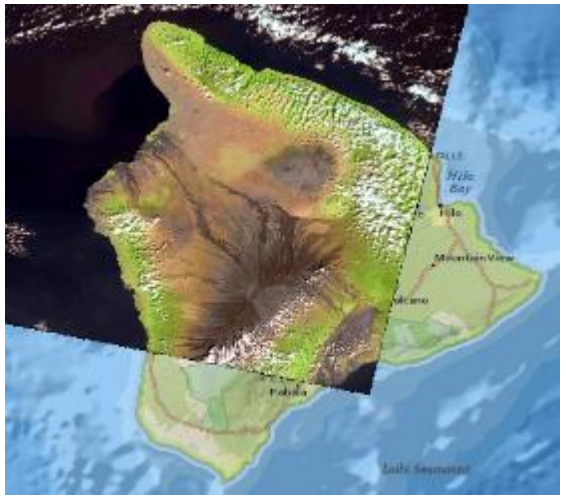
MODIS NRT Product
Jan 4, 2013



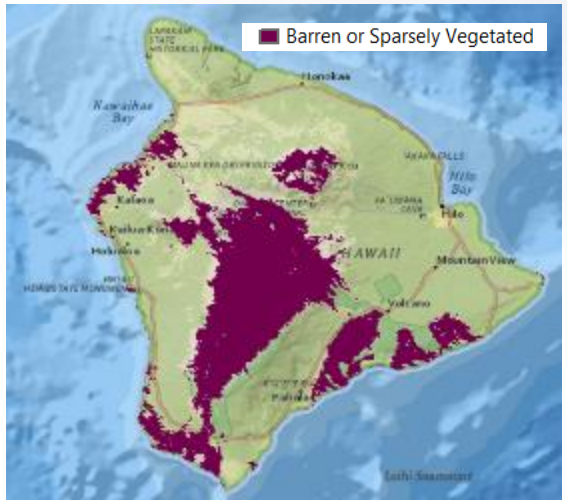
Dark volcanic rock false-positives

- Volcanic masks for a few locations.
- For Mauna Loa, HAND mask largely solved this problem.

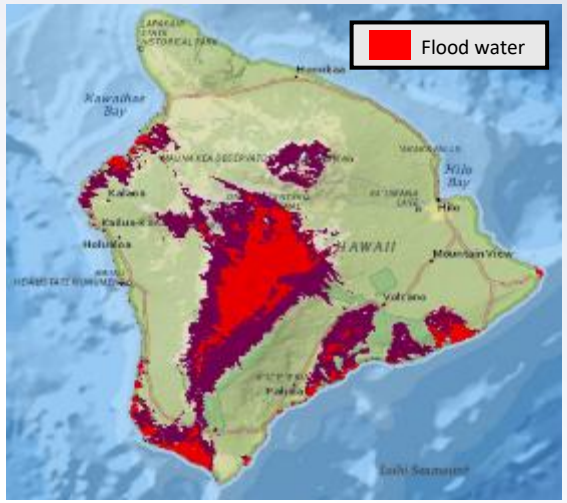
Mauna Loa, **Hawaii:** 17 Dec 2013



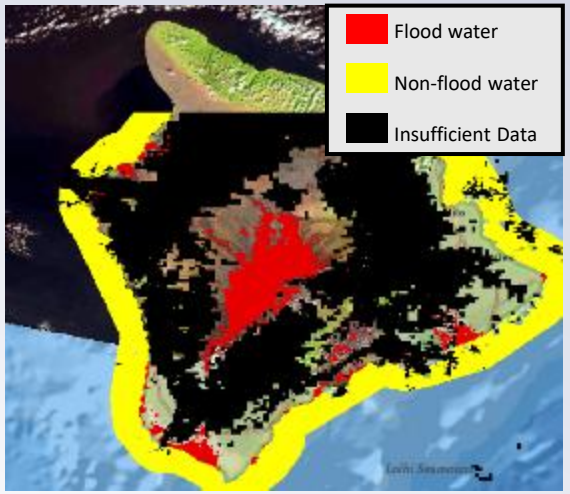
Landsat 8



MODIS (MCD12Q1) IGBP Land Cover

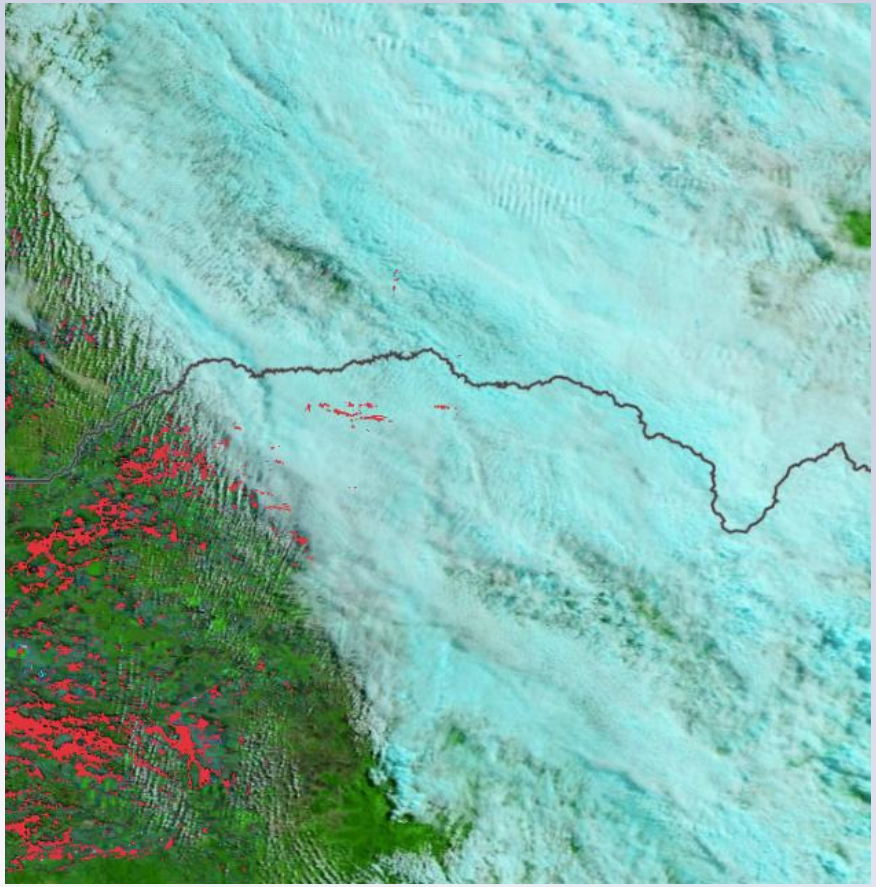


MODIS IGBP Land Cover with flood water



MODIS Flood Product

Product limitations recap

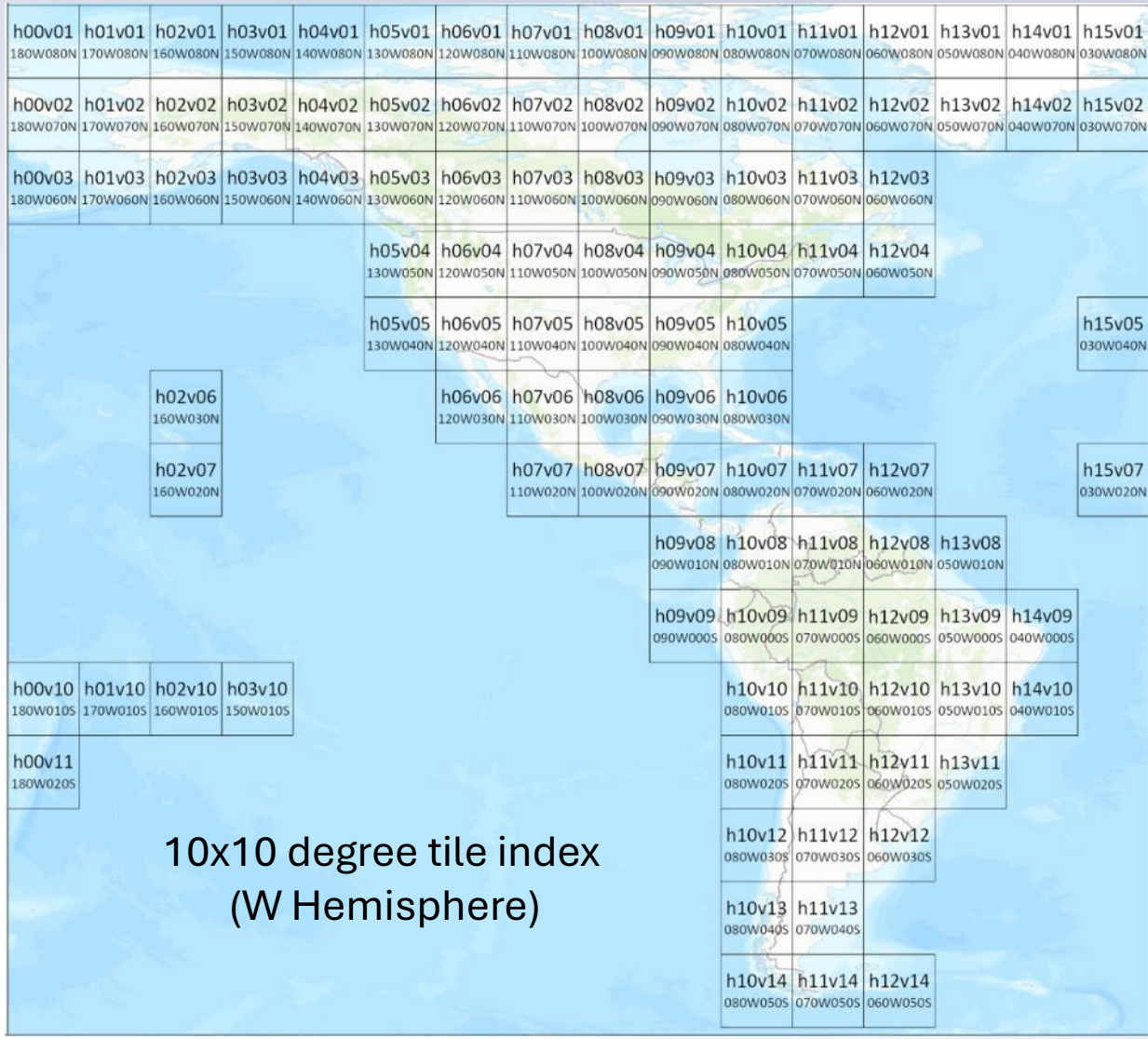


- Cloudiness
  - False-negatives: can't see the flood
  - False-positives: cloud shadows detected as water
- 250 m resolution
  - Floods with limited spatial extent are difficult to pick up
- Twice Daily Observations (within 1-3 hours of each other)
  - Flash floods usually not captured, unless lucky with overpass timing
- Landcover limitations
  - Water under tree cover will not be visible to satellite
  - Urban – too many buildings/objects not under water
- Recent changes in normal surface water extent
  - New reservoirs (will be picked up by reference water layer after filled for 3 years)
  - Changes in river courses
  - ** Users can easily reclassify the product using a custom surface water map, if available

Data Access: File download

- Main product: 1 HDF file / tile / day:
  - Flood layers (1, 2, 3-day composites)
  - Ancillary layers with: Water Counts, Valid Counts, and Total Counts. Allow users to create custom composites, or examine underlying data.
- GeoTIFF files for each flood layer
- Distributed in 10 x 10 degree tiles
  - 287 tiles globally in production
  - Full tile map on homepage, and in User Guide
- Flood layer data values:

Pixel value	
0	No water detected (potentially clear)
1	Surface water detected
2	*Recurring flood detected (coming soon)*
3	Flood detected
255	Insufficient data



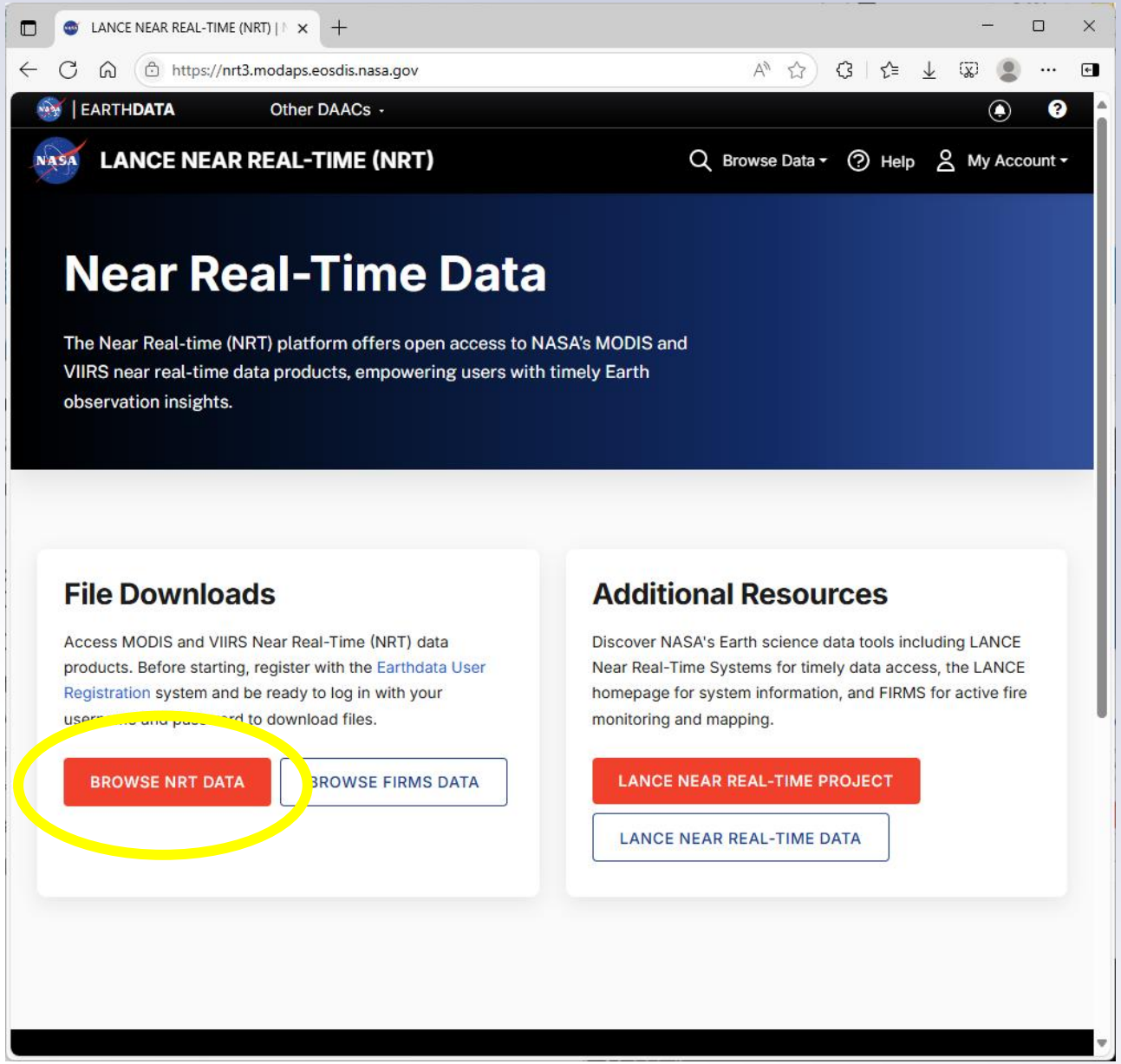
Data Access: File download

- https://nrt3.modaps.eosdis.nasa.gov (and nrt4)
- Free NASA EarthData account required
- MODIS product shortname: MCDWD
- VIIRS product shortname: VCDWD
- Navigate: “Browse NRT Data” → allData → <COLLECTION> → <PRODUCT> → Year → DOY (day-of-year)
- <COLLECTION> = 61 for MCDWD, 5200 for VCDWD
- For HDF files: <PRODUCT> = shortname + “_L3_NRT”

  Eg: MCDWD_L3_NRT or VCDWD_L3_NRT
- For Geotiff files: <PRODUCT> = shortname + “_L3_F1_NRT”

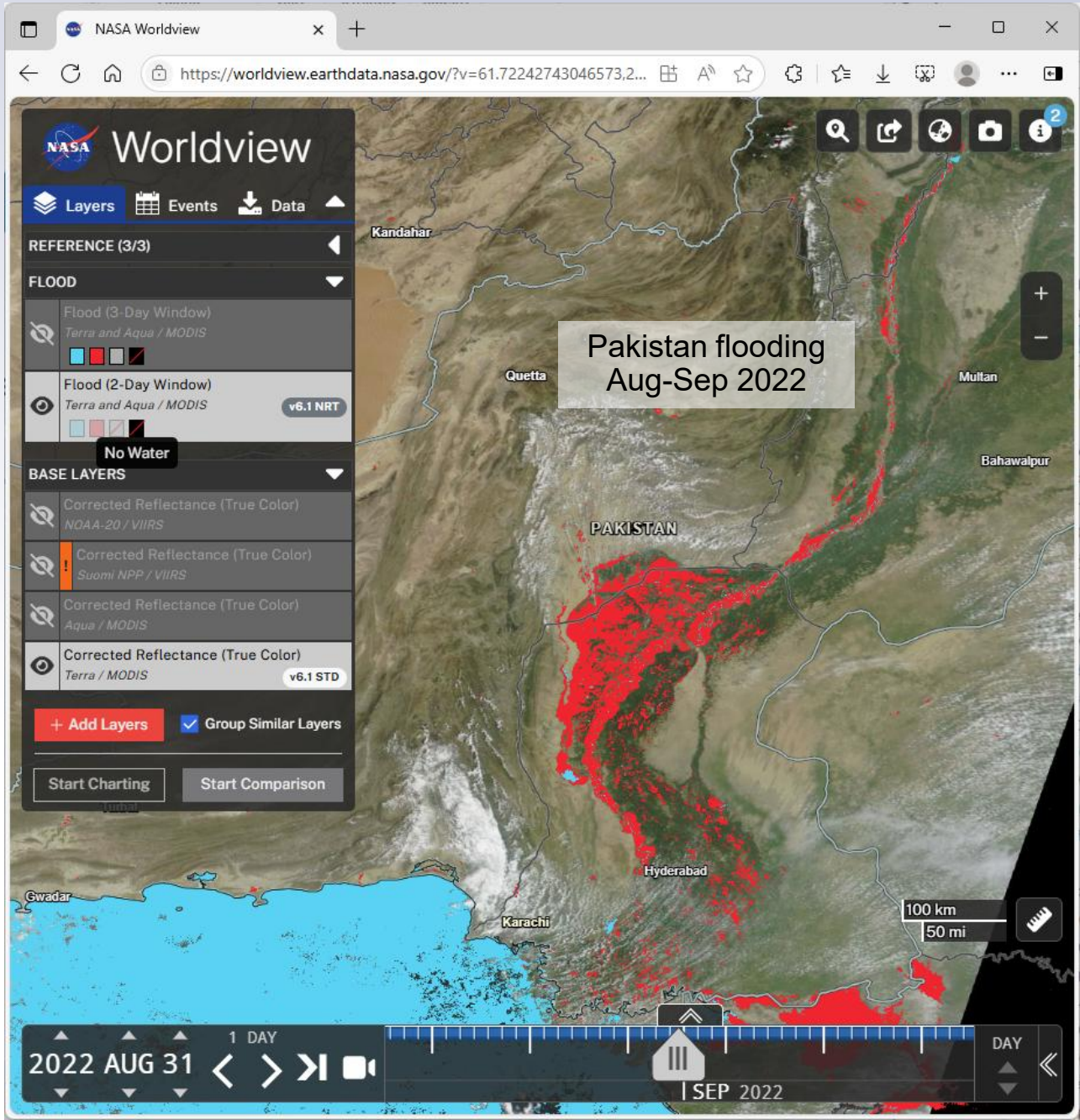
  F1/F2/F3 = 1, 2, and 3-day products. Eg: MCDWD_L3_F2_NRT, etc.

- **NRT sites only retain last ~1 week of data**
- **NRT products are *not* archived (officially)**

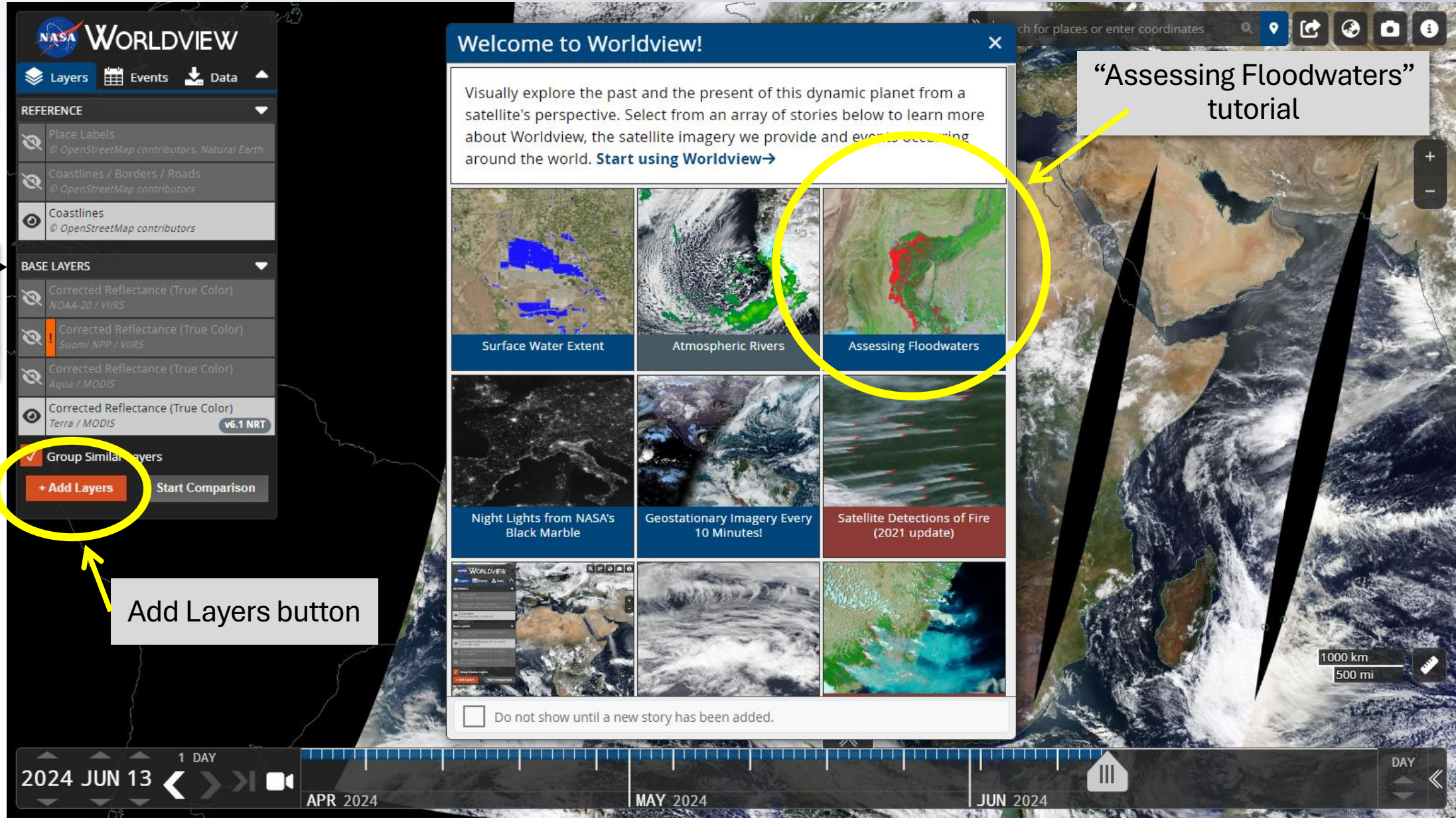


Data Access: APIs & Worldview

- NASA GIBS (Global Imagery Browse Service)
  - WMS, WMTS, TWMS services
  - Accessible via: ArcGIS, QGIS, Google Earth, NASA Worldview, and our new FLOOD viewer
  - Flood plus 1000+ other satellite imagery products
- Browsable web application: NASA Worldview (https://worldview.earthdata.nasa.gov)
  - MODIS Flood products from early 2021
  - VIIRS Flood products from June 2025
  - + Many other satellite imagery products
  - Allows comparison with source imagery
  - Allows comparison between dates or products
  - Only hosts 2 and 3-day flood products (not 1-day)
  - Navigate to: “Add Layers” → Floods → Flood → “Terra and Aqua MODIS” or → “NOAA-20 and NOAA-21/VIIRS”
  - Or: https://bit.ly/WorldviewFloods (pre-loaded with MODIS and VIIRS flood products)
  - Tutorial “Assessing Floodwaters” available on start page

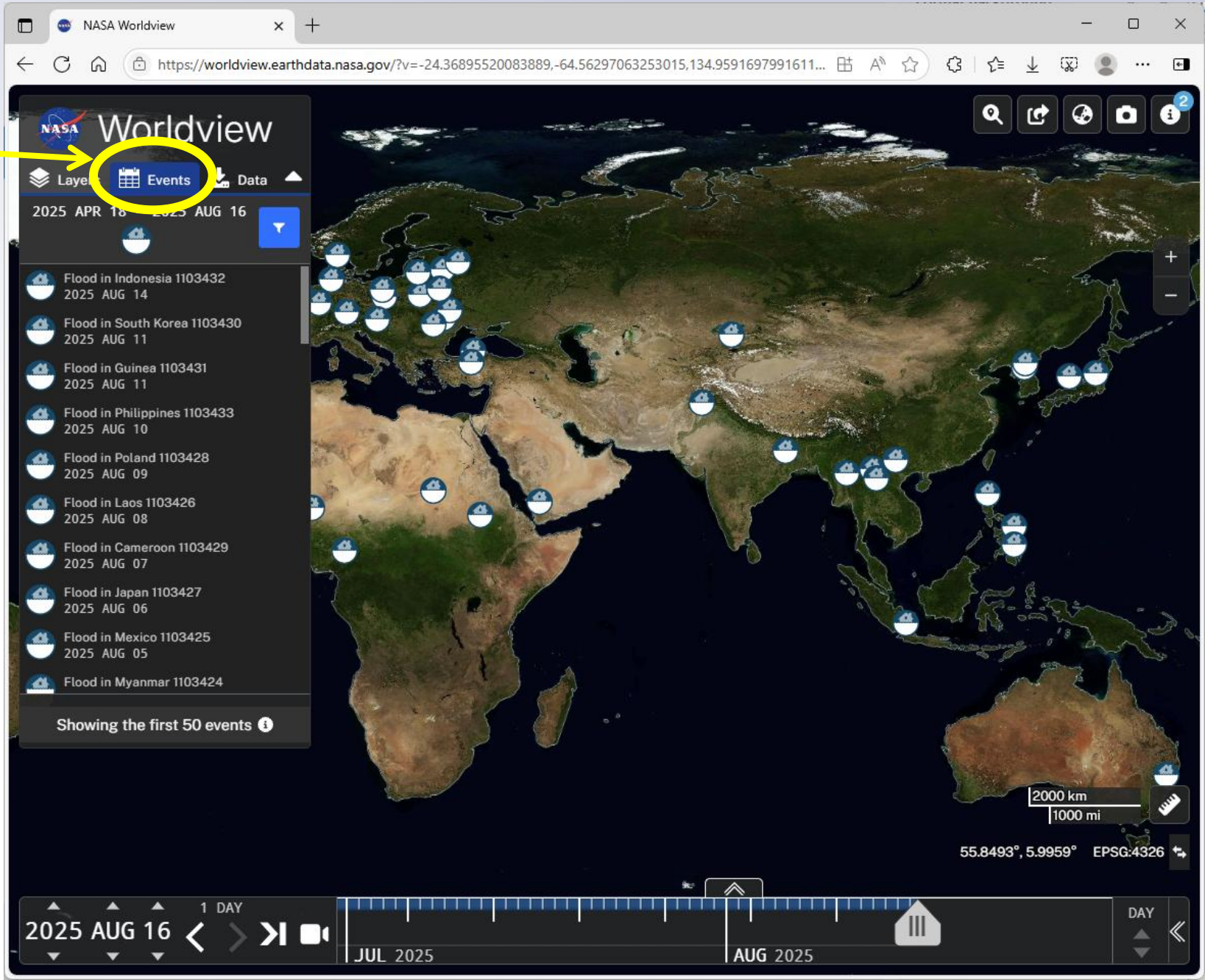


Data Access: Worldview



Data Access: Worldview

- New Feature: Flood Events
- Lists recent events, with locations, and dates
- Can then compare to flood products available in Worldview
- Source: GDACS (Global Disaster Alert and Coordination System, (UN/EC), gdacs.org)

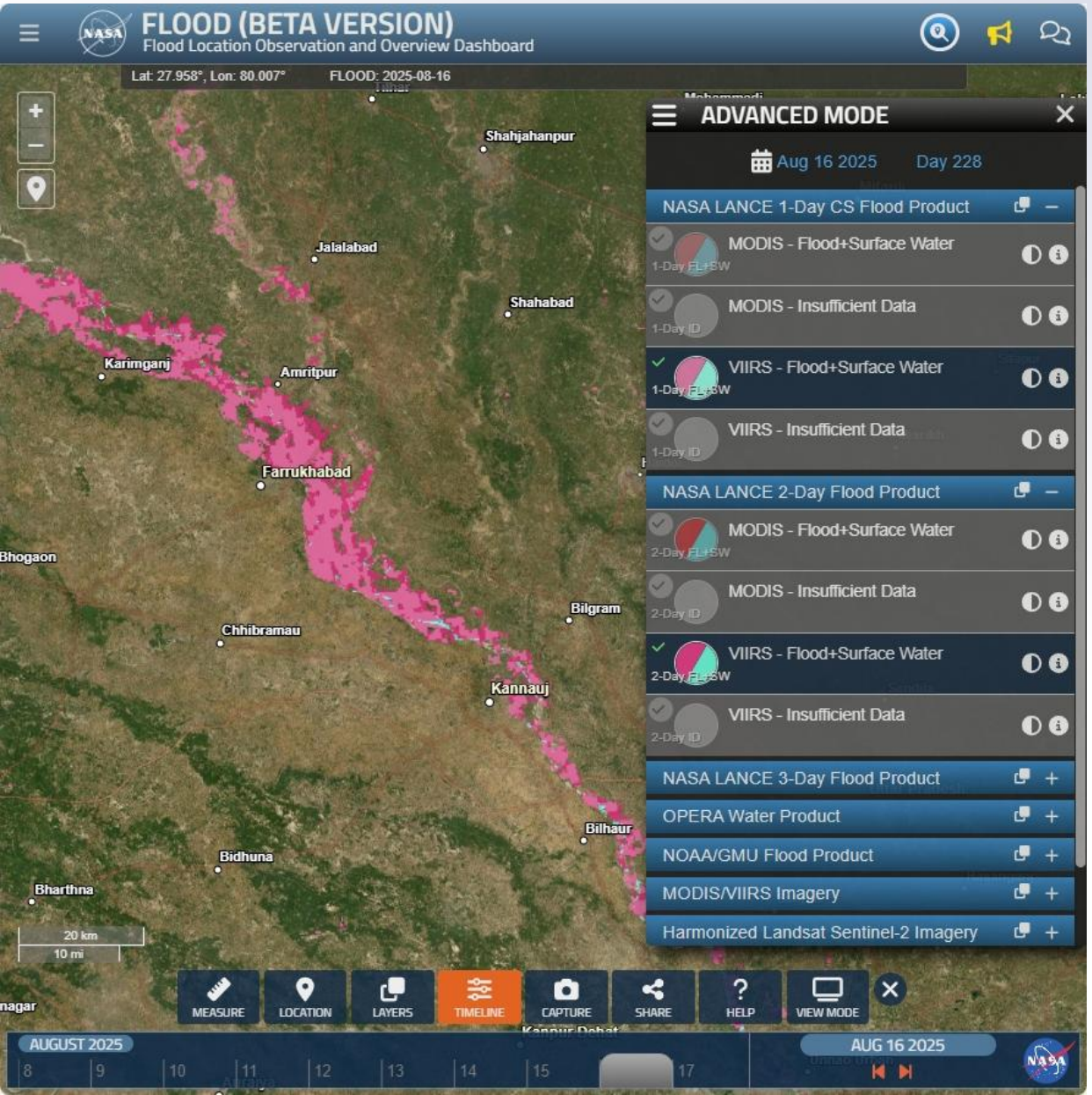


Worldview – live demo

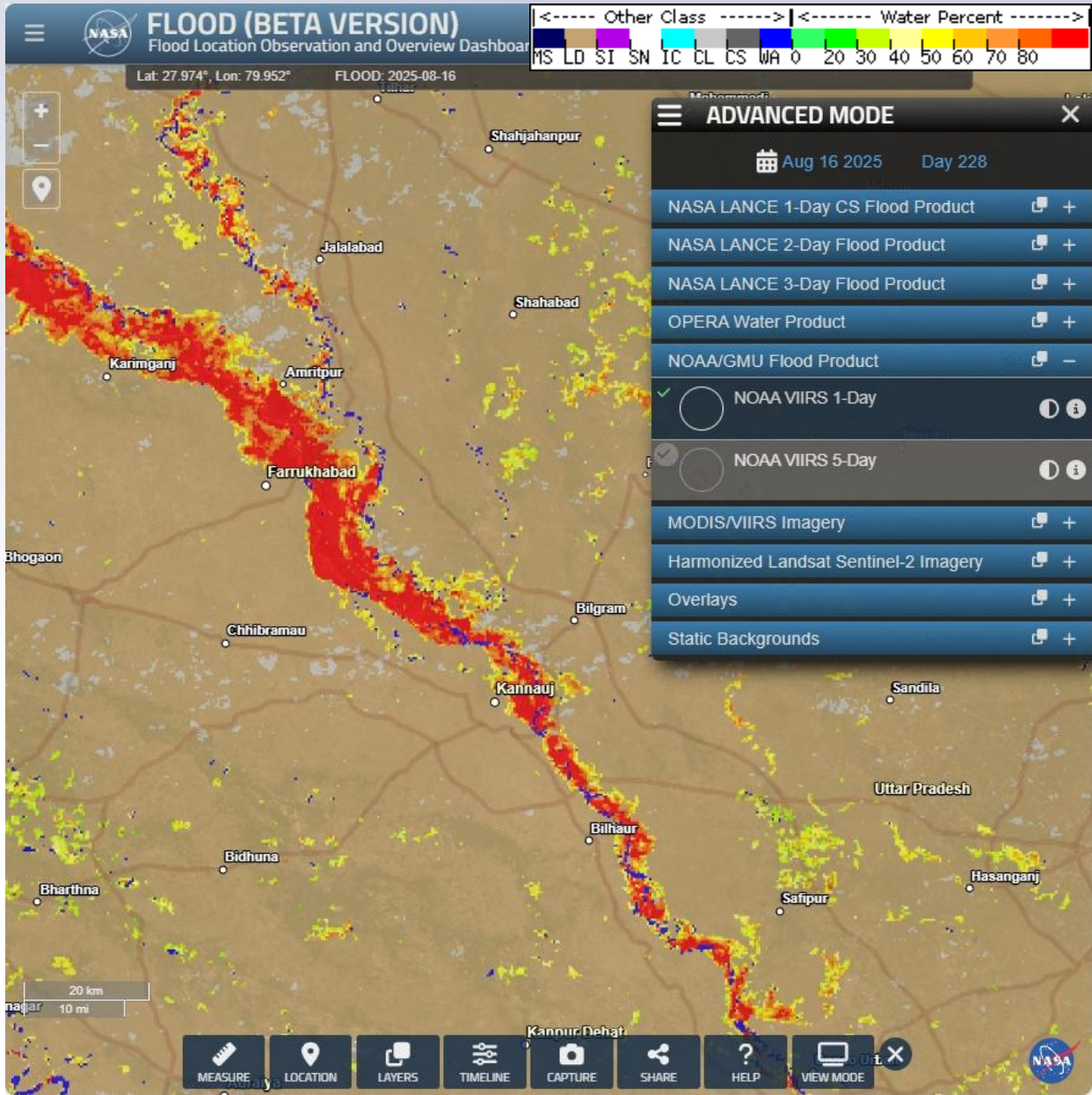
Data Access: FLOOD viewer

- Customized viewer for flood products.
- Coming soon!
- Focused on flood and flood-related products, including non-NASA products.
  - MODIS and VIIRS 1-day flood products (along with 2 and 3-day)
  - NOAA/GMU VIIRS 1-day and 5-day flood products
  - NASA OPERA Sentinel-1 and HLS Water products
- Basic Mode: only 2-day products
- Advanced Mode: all products.
- Future efforts:
  - Add other flood products, such as Copernicus Sentinel-1 GLOFAS product
  - Flood events (as in Worldview)
  - Comparison tool (as in Worldview)
  - Flood alerts, based on product detections

NASA VIIRS Flood Product



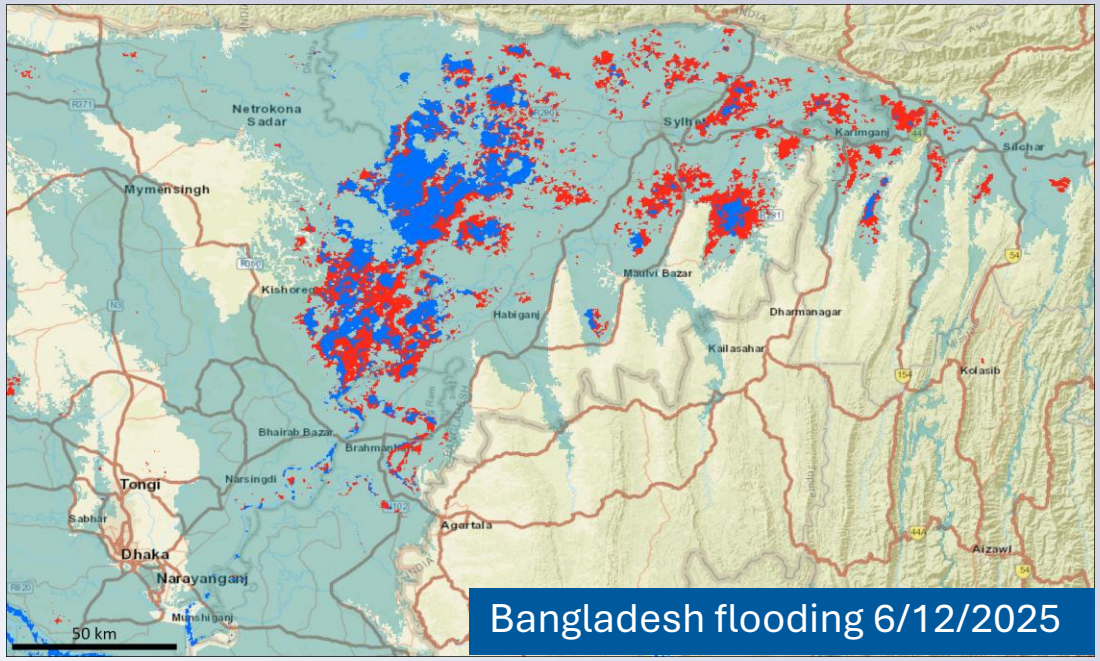
NOAA/GMU VIIRS Flood Product



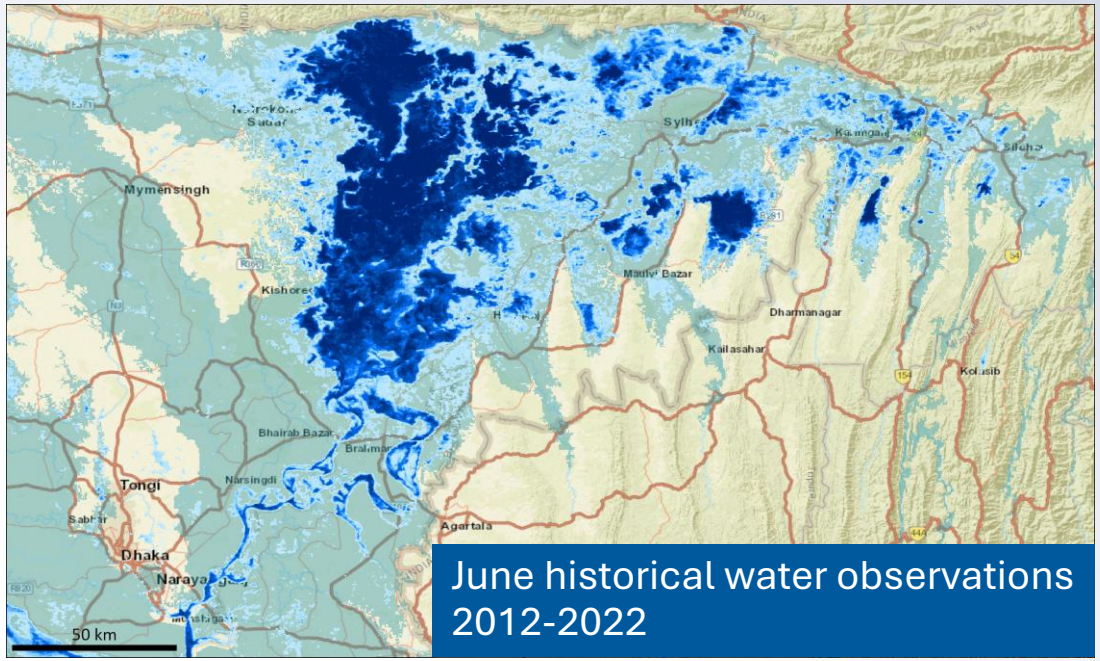
FLOOD – live demo

Product Archive

- Product fully reprocessed from Aqua launch (2002) through 2024, at Release 1
  - 22 full years: 2003-2024
- Finalizing:
  - Validation of the reprocessing.
  - Adding recurring flood class.
- Release expected soon (Fall 2025).
- Moving forward, MODIS and VIIRS products will be added to archive.
- Allows historical analyses and comparisons (such as development of the “recurring flood” mask).



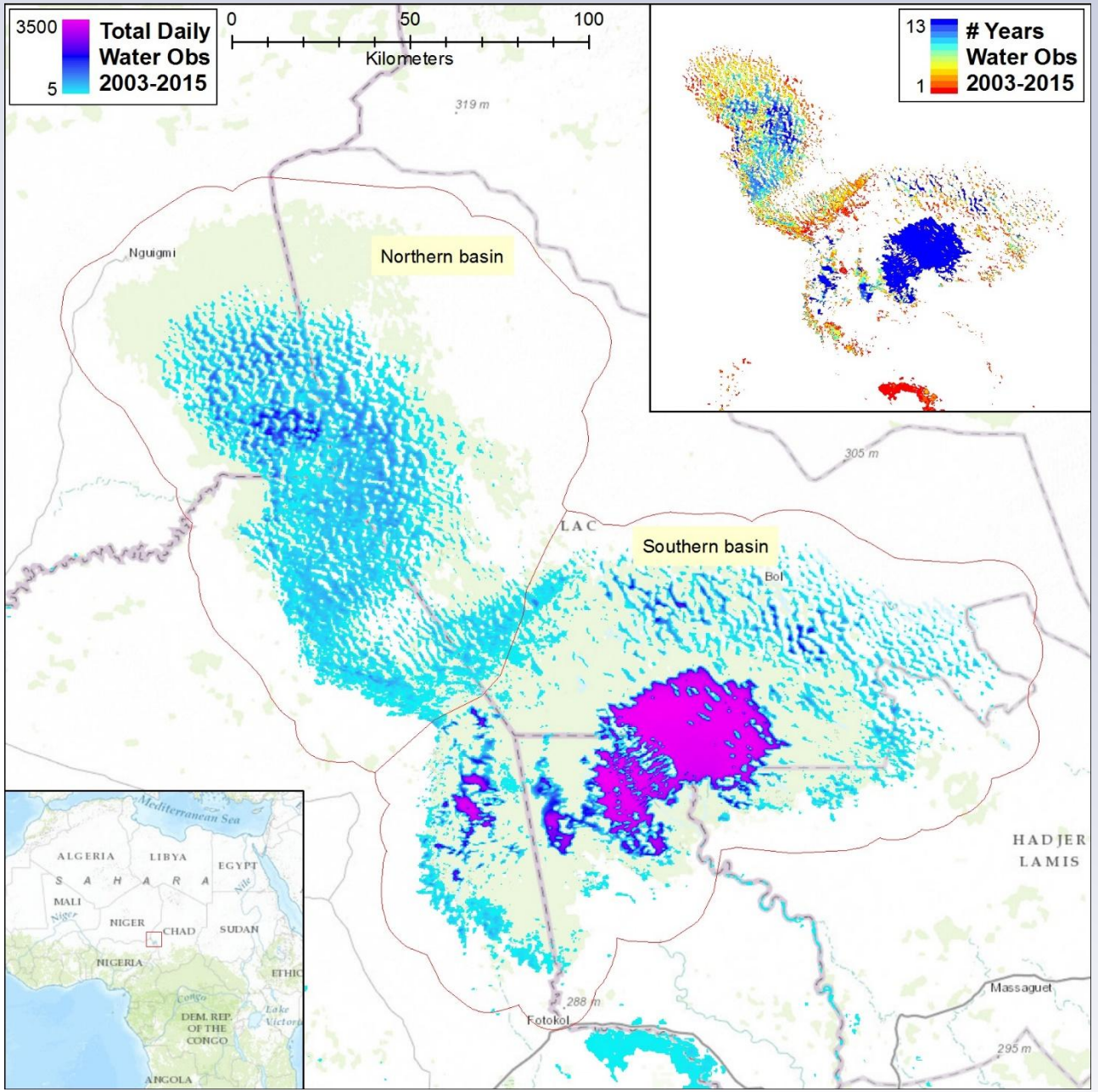
Bangladesh flooding 6/12/2025



June historical water observations 2012-2022

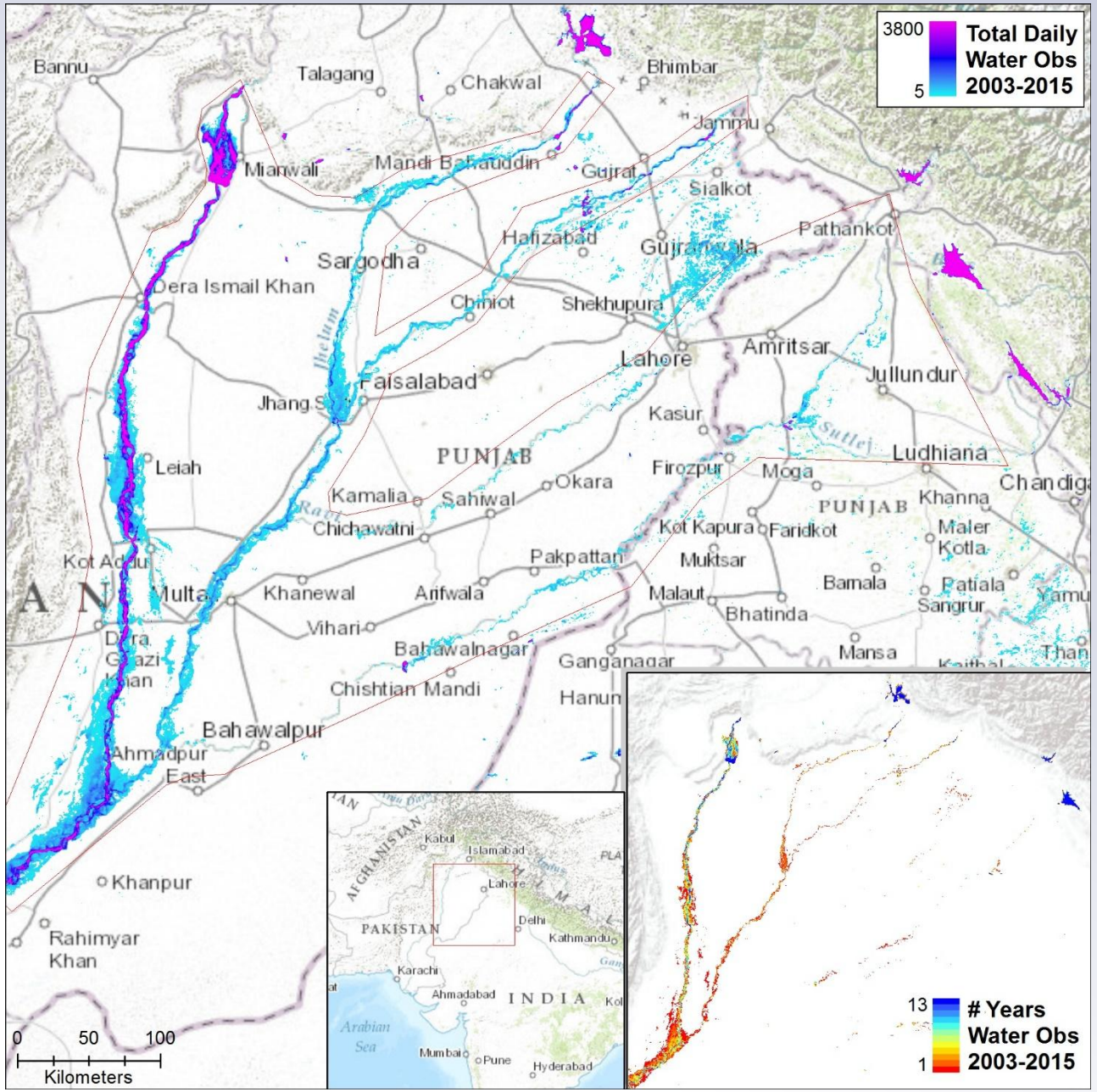
Historical analysis

Lake Chad: 2003 - 2015



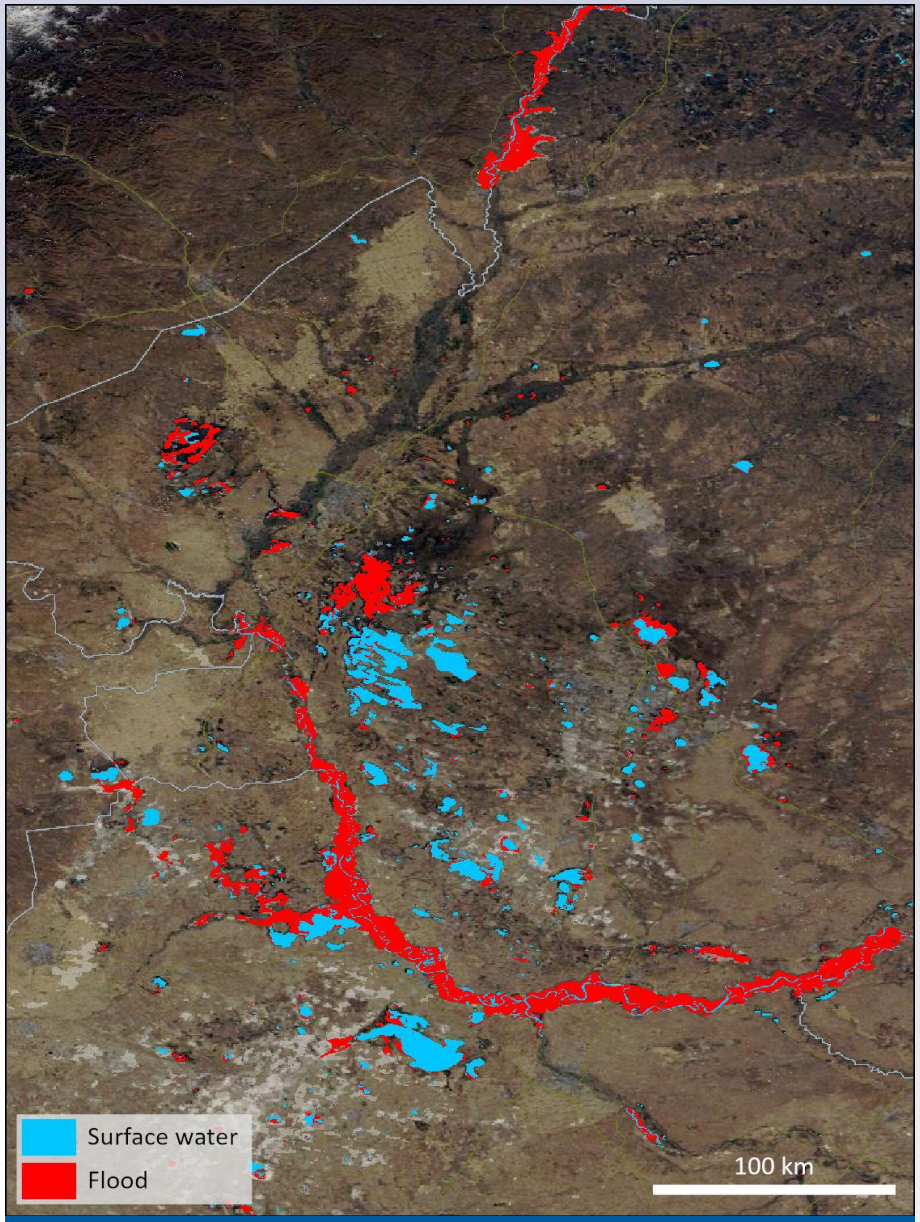
Historical analysis

Indus: 2003 - 2015



Future Directions:

- Beta release of FLOOD viewer
- Release of “Recurring flood” class update
- Release of reprocessed archive (2003-2024)
- Archiving moving forward
- Machine learning update to water detection algorithm (VIIRS)
  - Shows promise for ***not*** detecting shadows as water.
- Wish list:
  - Full MODIS flood product archive available in Worldview and FLOOD viewer
  - Sentinel-3/OLCI product



Songhua river flooding, NE China, 10/26/2020

National Aeronautics and Space Administration

EARTHDATA

Discover and Access NASA's Near Real-Time Global Flood Products

Homepage: https://earthdata.nasa.gov/global-flood-product

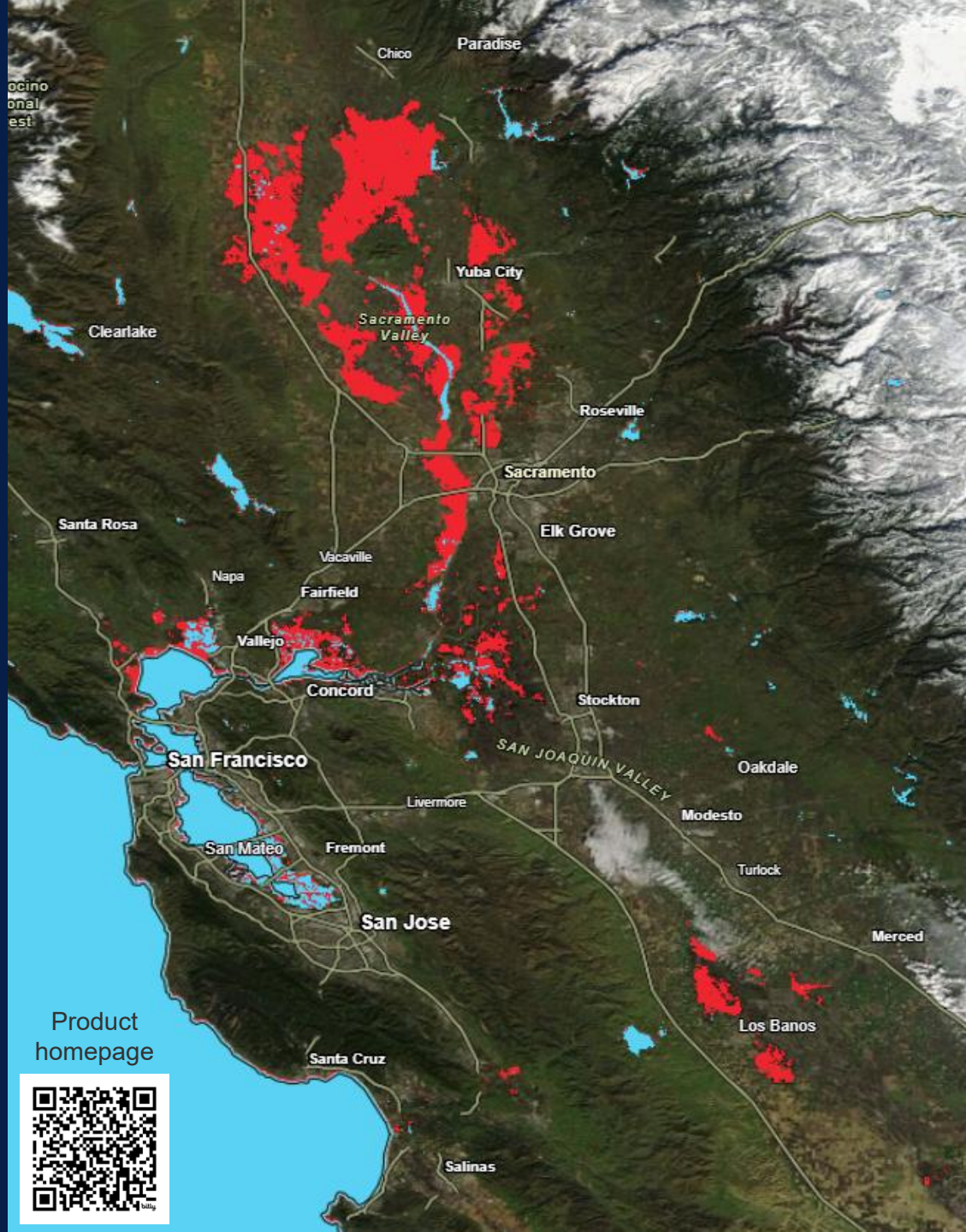
- User Guide & FAQs, mailing list
- Links to LANCE download sites

FLOOD viewer: https://lance.modaps.eosdis.nasa.gov/flood

Worldview: https://worldview.earthdata.nasa.gov

Worldview with flood loaded: https://bit.ly/WorldviewFlood

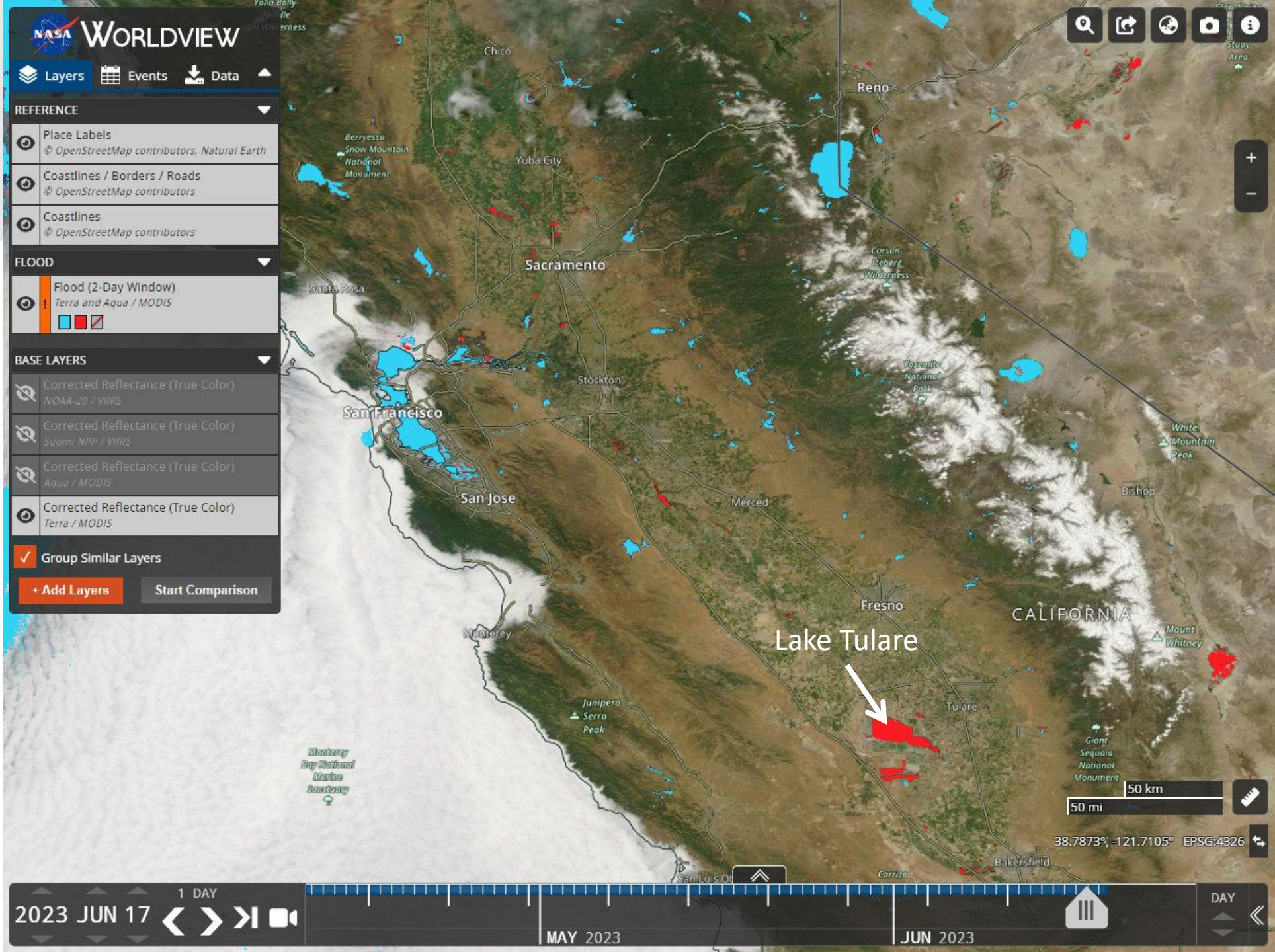
Questions/Suggestions: dan.slayback@nasa.gov
or earthdata-support@nasa.gov



Additional product examples

California

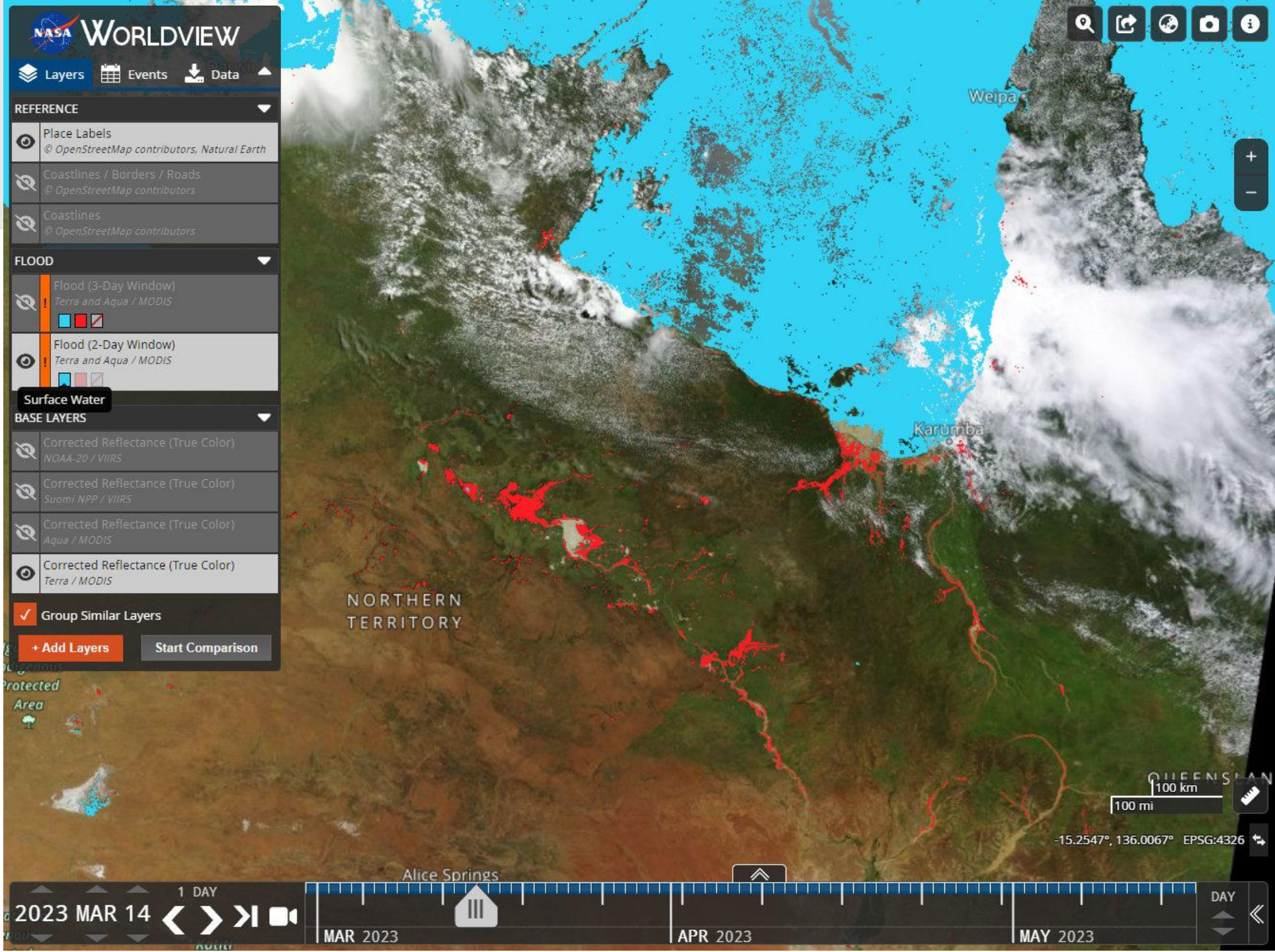
- June 2023
- Re-emergence of Lake Tulare



Australia

Northern Territory & Queensland

- March 2023



Upper Mississippi River

- April 2023