Global River Width and Inundation Database from Sentinel-1 SAR Satellites

C. Gangodagamage, F. Meyer, F. Policelli, J. Kennedy, S. Lamont, and K. Hogenson

Hydrologic Science Laboratory, NASA Goddard Space Flight Center

Earth System Science Interdisciplinary Center (ESSIC), University of Maryland, MD

Alaska SAR Facility Center, University of Alaska, Fairbanks, AK
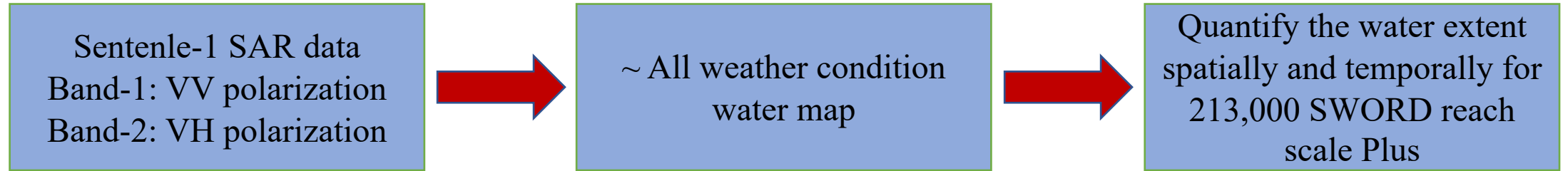
One Concern, Menlo Park, CA

Objectives:

- Effective river widths for the SWORD (SWOT River Database) river reaches from 2015 to near real-time for the Sentinel-1 images.

- Pixel-level river widths for river center lines derived from Sentinel-1 images over time for river reaches.

- An inundation map for river reaches covering the entire globe assimilates satellite data with other low temporal frequency elevation datasets.

Approach:

- Partner with U. Alaska Fairbanks/ Alaska Satellite Facility to use archived and near real time data from ESA Sentinel-1 satellite.

- Develop surface water maps as described in Twele et al., 2016 and modified by ASF

- Measure river width using modification of method by Pavelsky et al., 2008

- Evaluate surface water maps and river width measurements using commercial high resolution satellite data

- Evaluate utility of river width data for estimating river flow rate

Our Approach:

Sentenle-1 SAR data
Band-1: VV polarization
Band-2: VH polarization

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~ All weather condition water map

→

Quantify the water extent spatially and temporally for 213,000 SWORD reach scale Plus

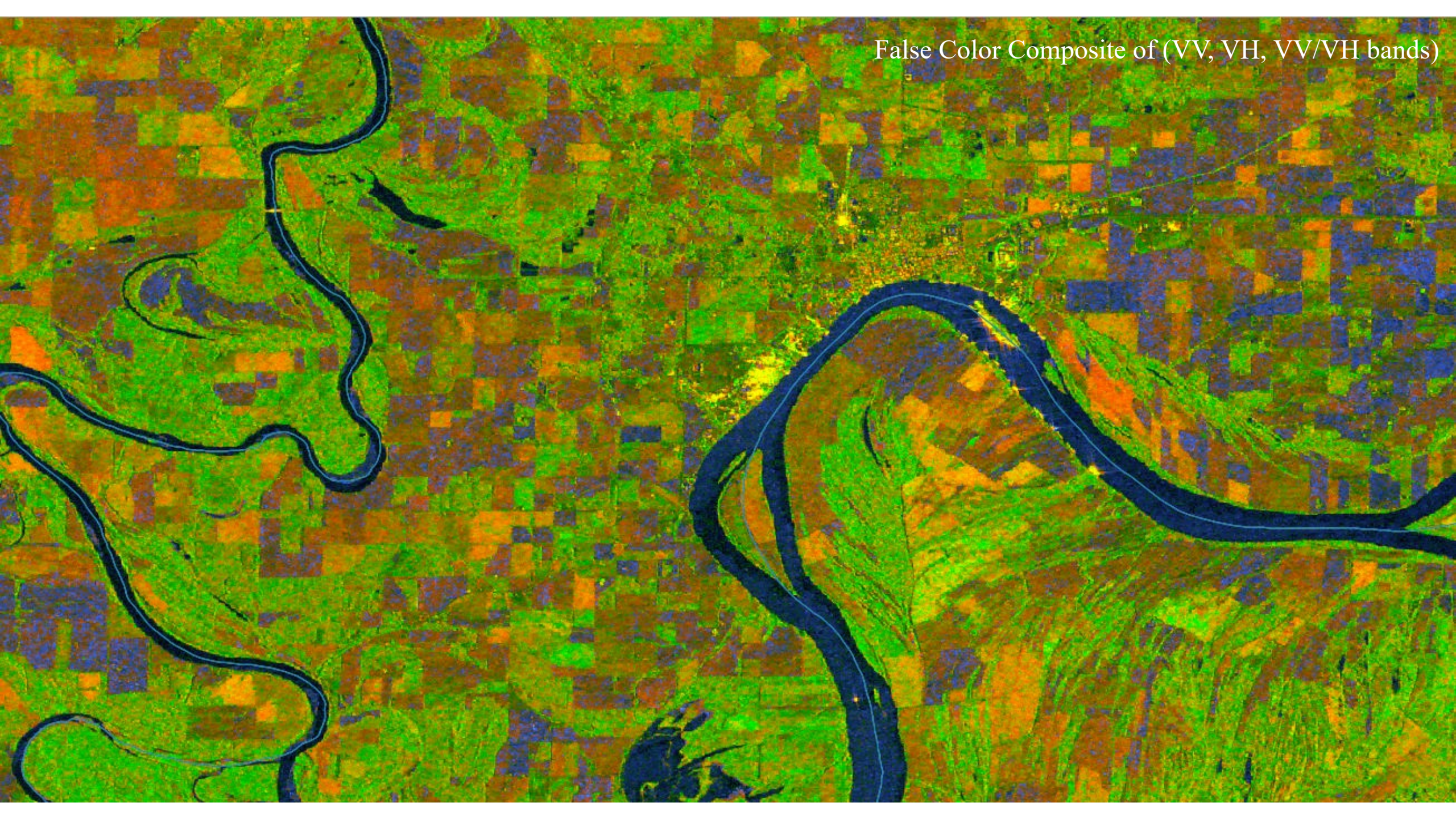False Color Composite of (VV, VH, VV/VH bands)
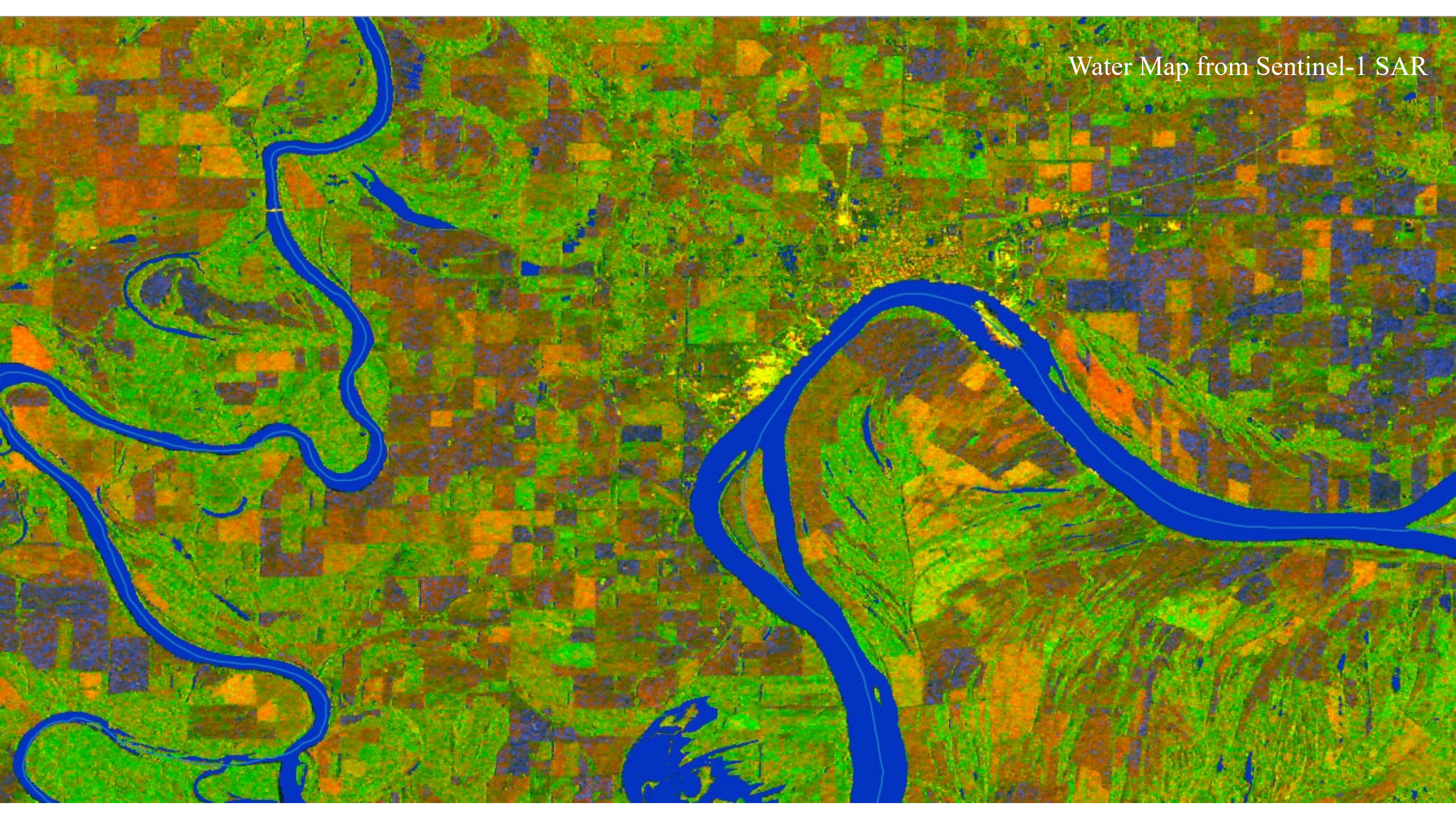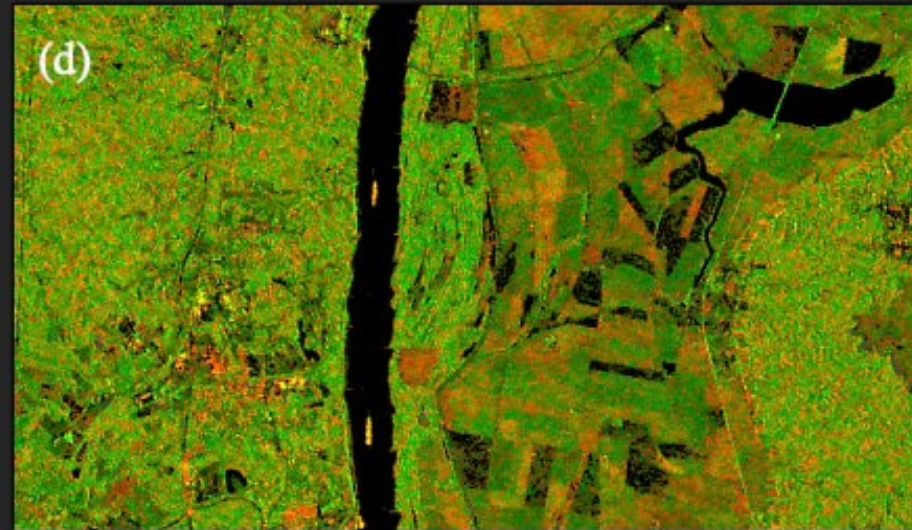
Water Map from Sentinel-1 SAR

Water extend quantified at each river reach

False Color Composite of (VV, VH, VV/VH bands)
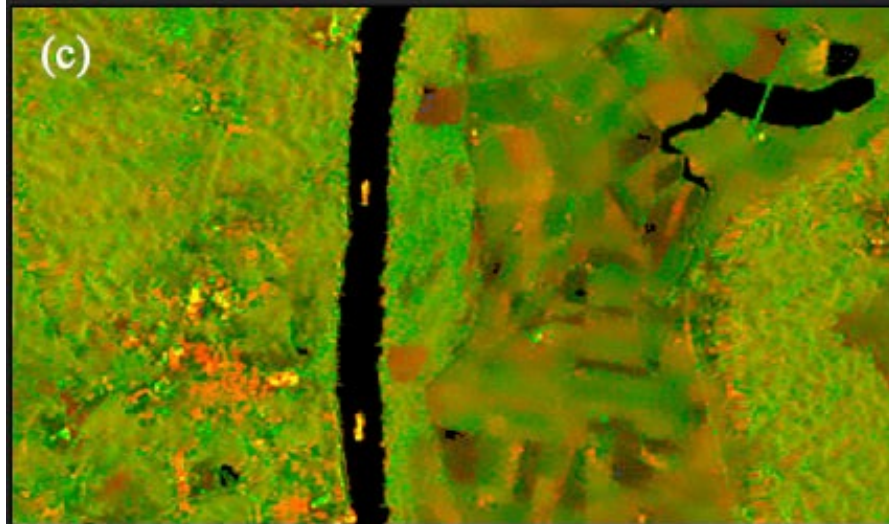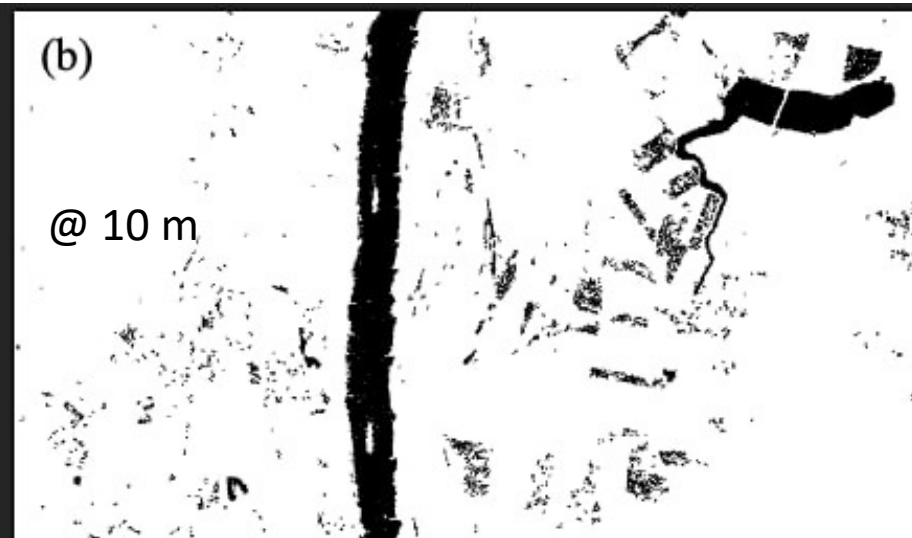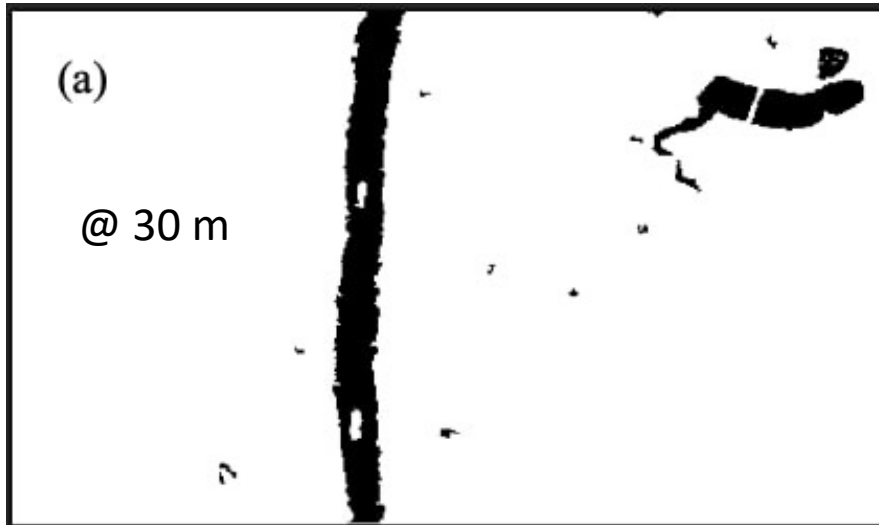
Water Map from Sentinel-1 SAR

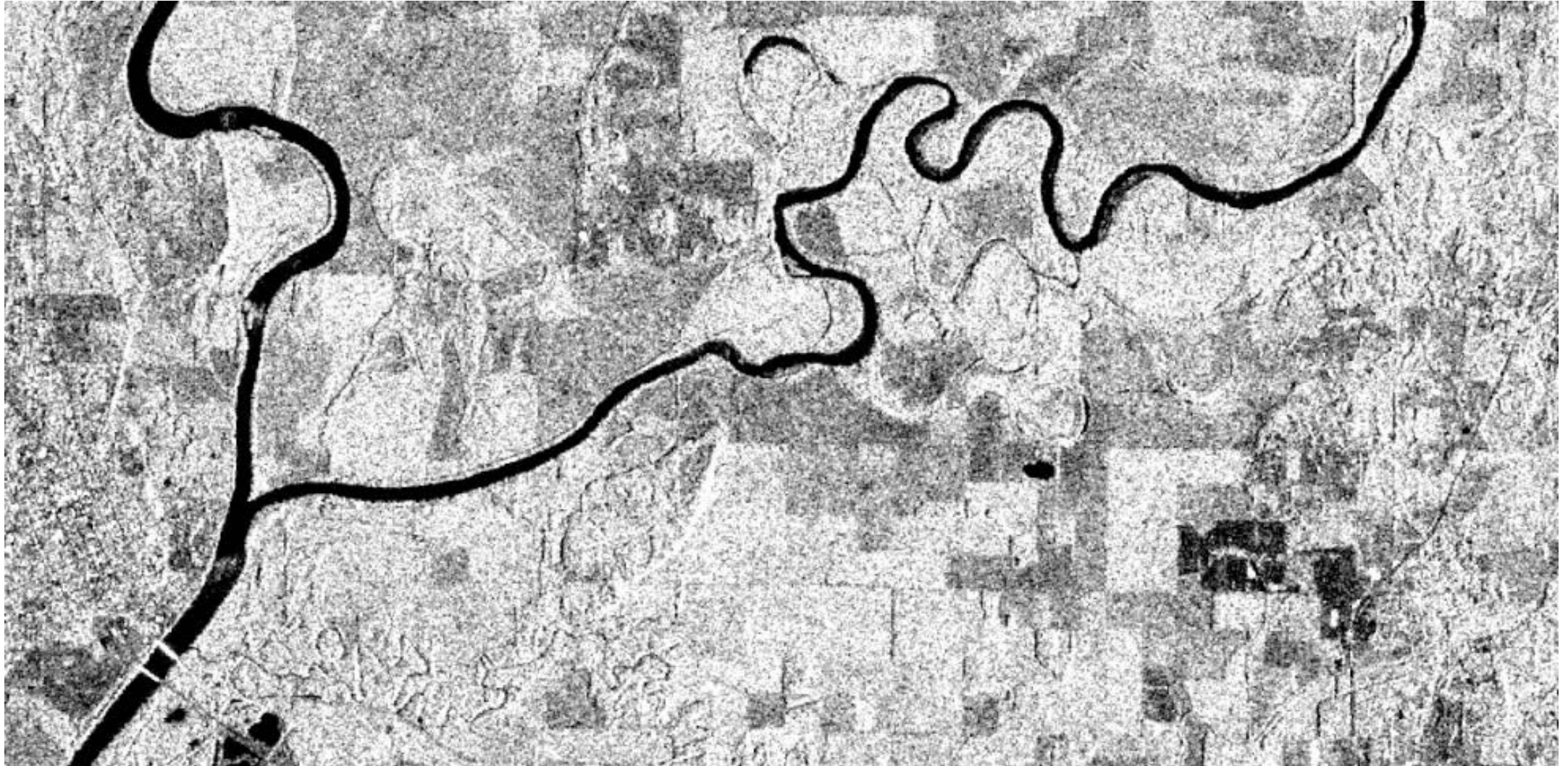Water extend quantified at each river reach

Water maps from Sentinel-SAR data at 10 m resolutions

- VH as well as VV polarization for the initial surface water map. This decrease false negatives (with some possibility of increase false negatives).

- The fuzzy-logic water pixel refinement following the initial surface water mapping to significantly mitigate the false positives, for both polarizations.

- Multi-mode Expectation Maximization (EM) thresholding for the determination of the backscatter threshold for initial surface water mapping

- Use Height Above Nearest Drainage (HAND) as a fuzzy logic element. HAND is a more likely indicator of areas not likely to hold surface water than elevation above the nearest streams.
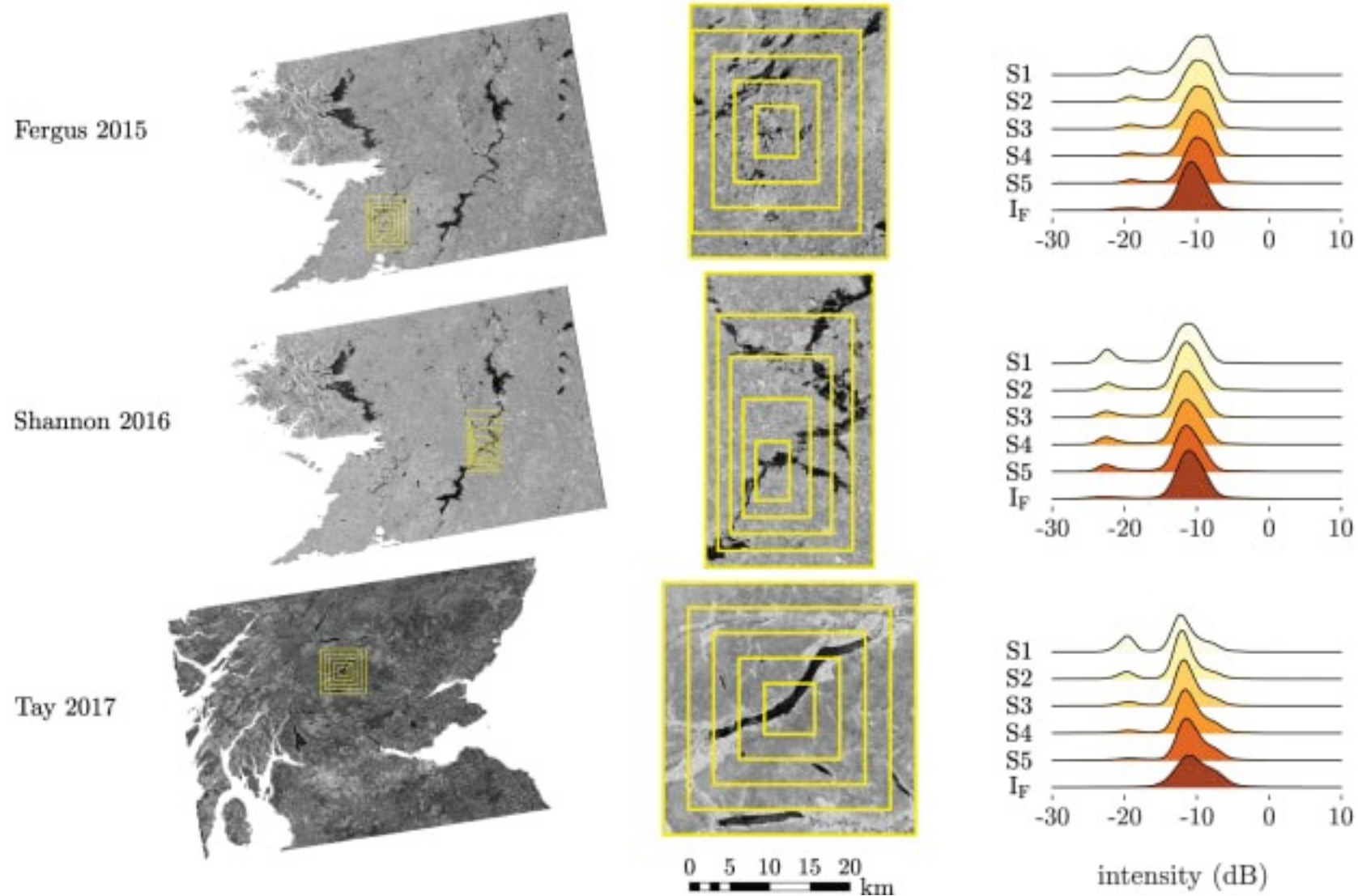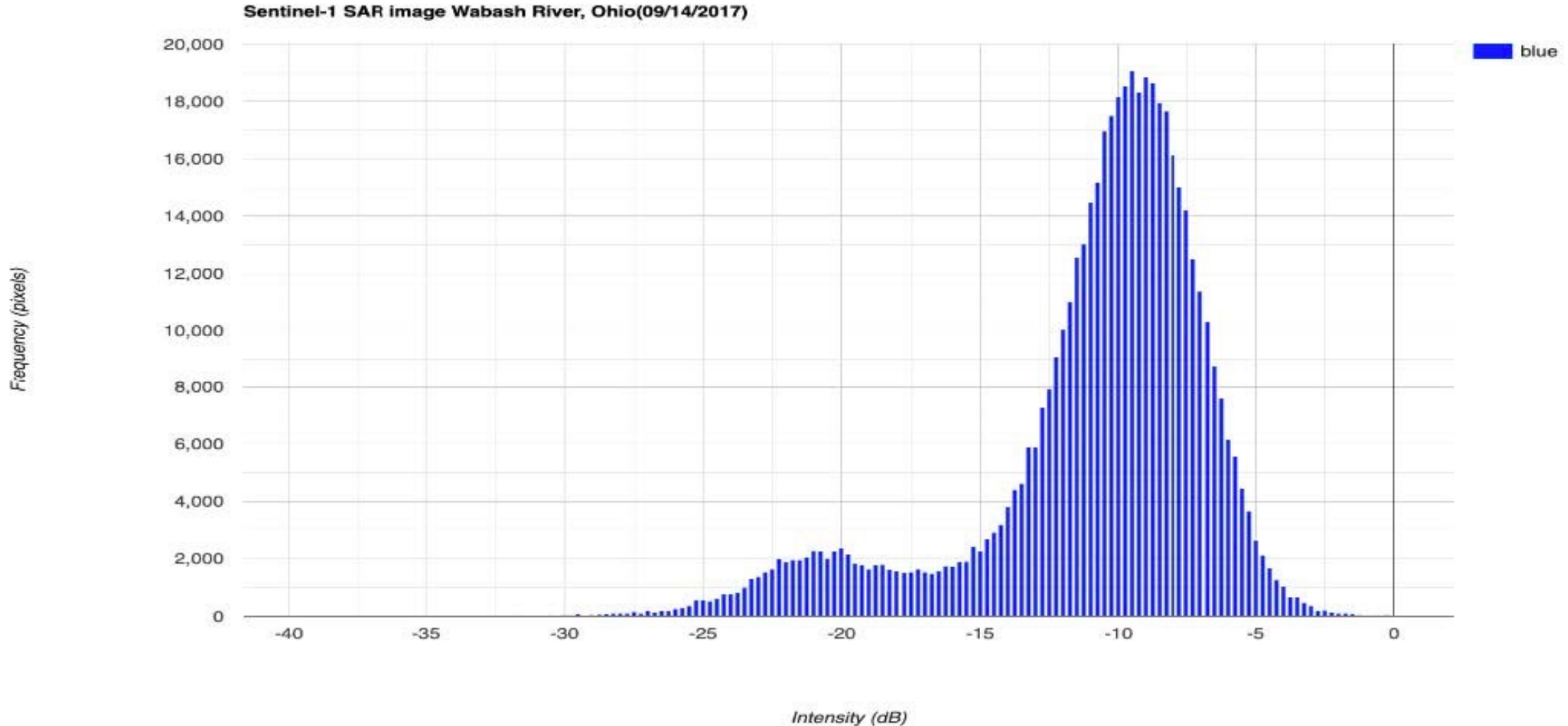
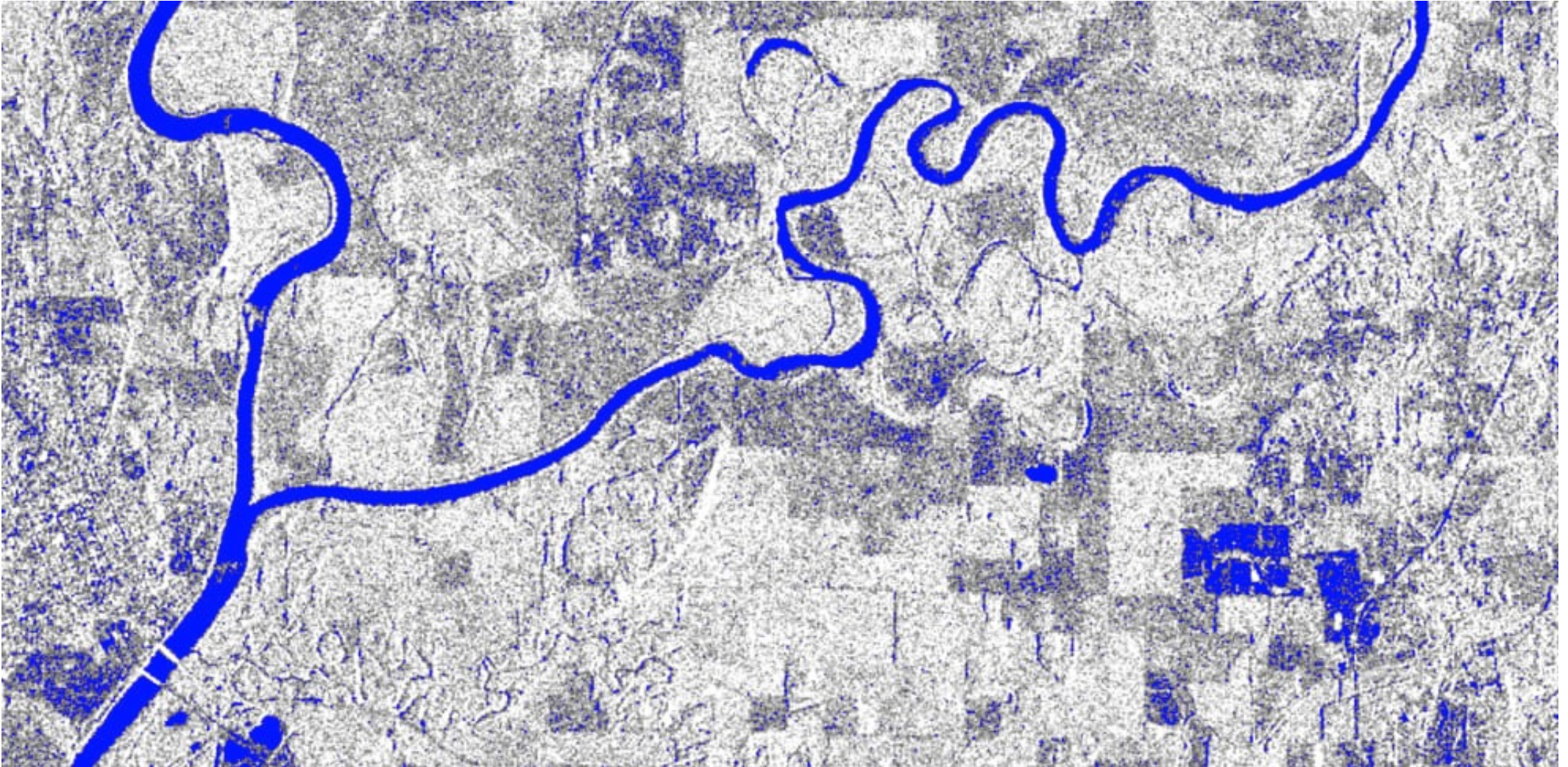# Sentinel-1 SAR image water maps at 10 m and 30 m

VH Band: Ohio River Basin
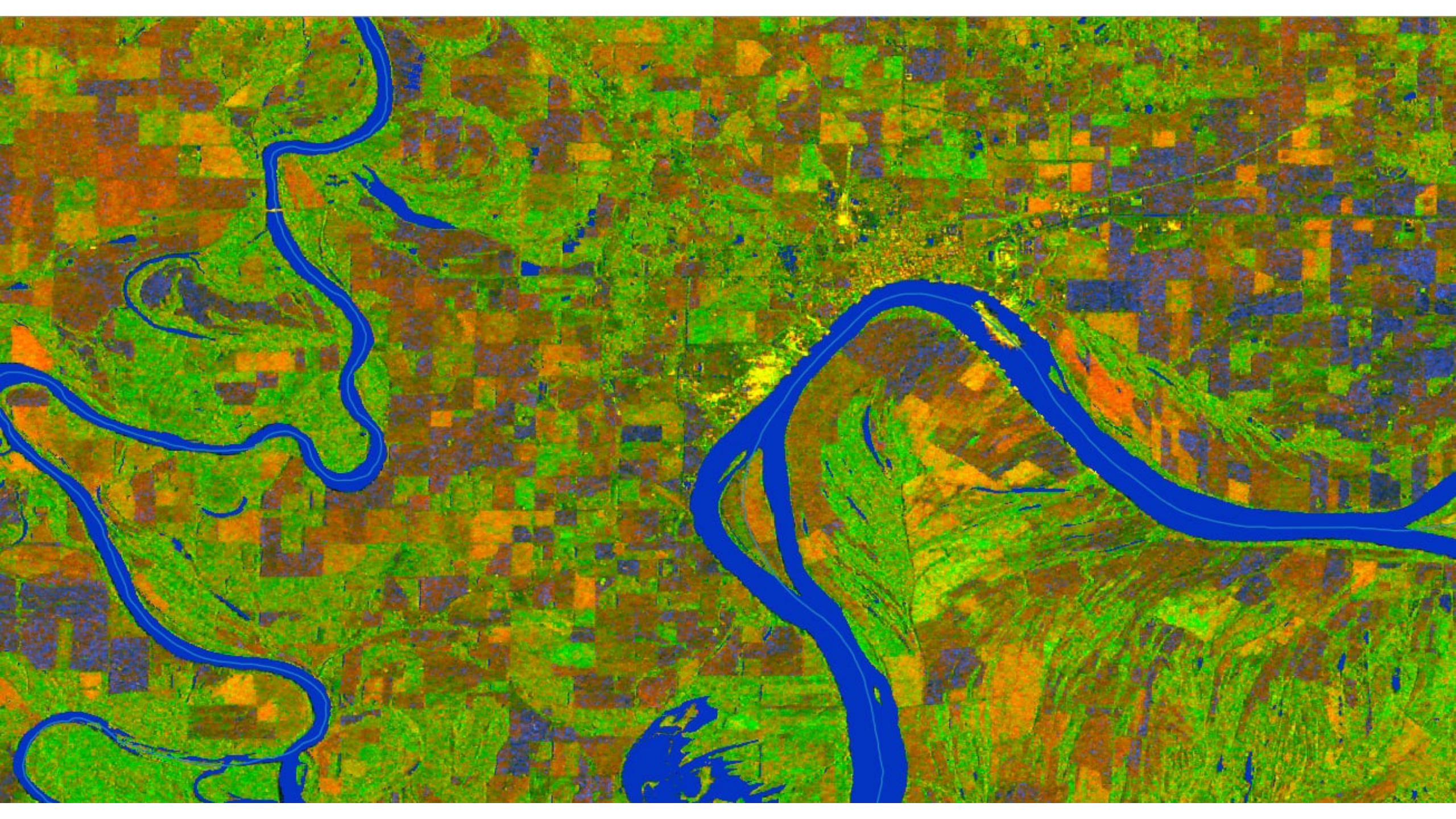
Scale dependency of the water and not water pdfs

Landuyt et al (2019)

Scale dependency of the water and not water pdfs: Scale s1

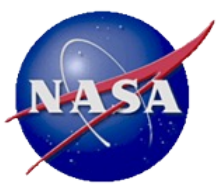Sentinel-1 SAR image Wabash River, Ohio(09/14/2017)

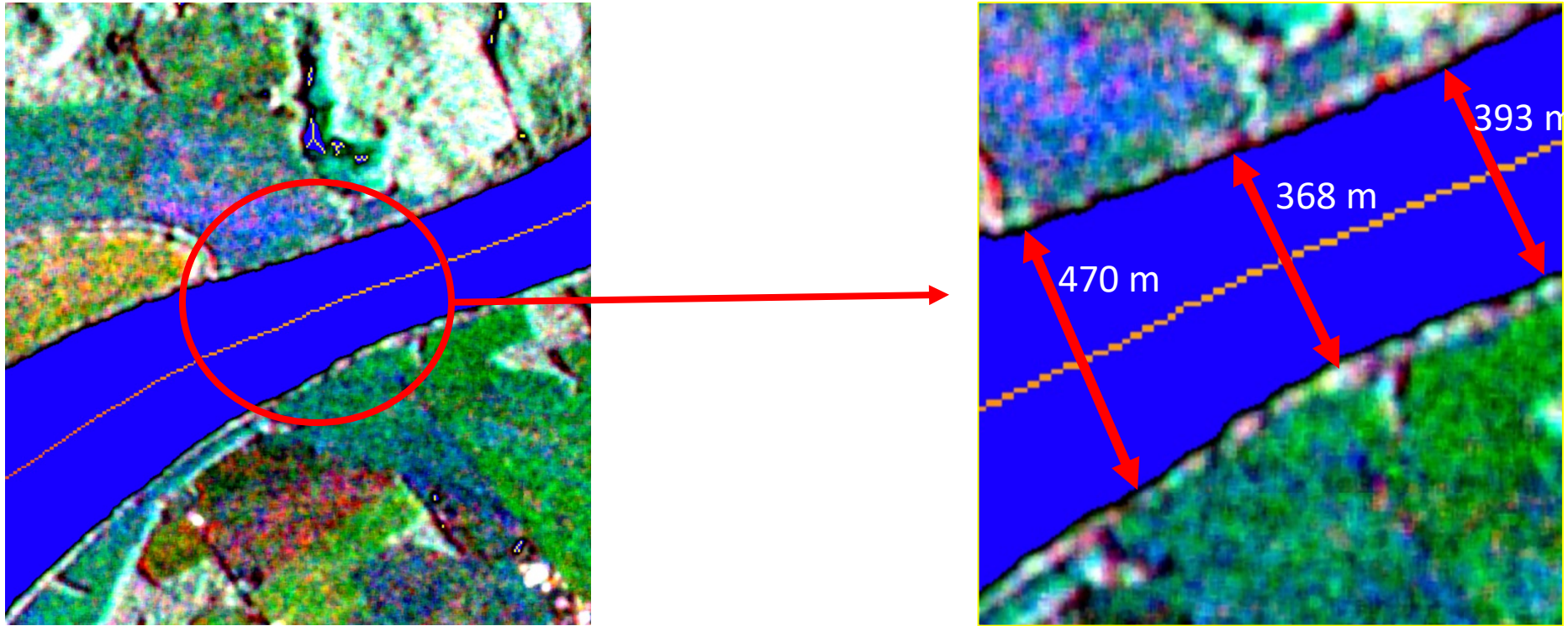# Water and not water classification at scale s1

River Width - Scientific significance, societal relevance, and relationships to future missions:

- We generate near real time and historical all-weather river width measurements corresponding to the river reaches to be measured by the SWOT mission.

- It is expected that these measurements will be useful to enable decreased temporal gaps in NASA SWOT mission estimates of river flow rate - a critical measurement for closing the water budget and for hydrological applications.

- A secondary/intermediate product of the project will be global, near real time and historical all-weather surface water maps for which we expect to find utility for flood depth measurement, flood mapping, and/or evaluation of other surface water mapping efforts.
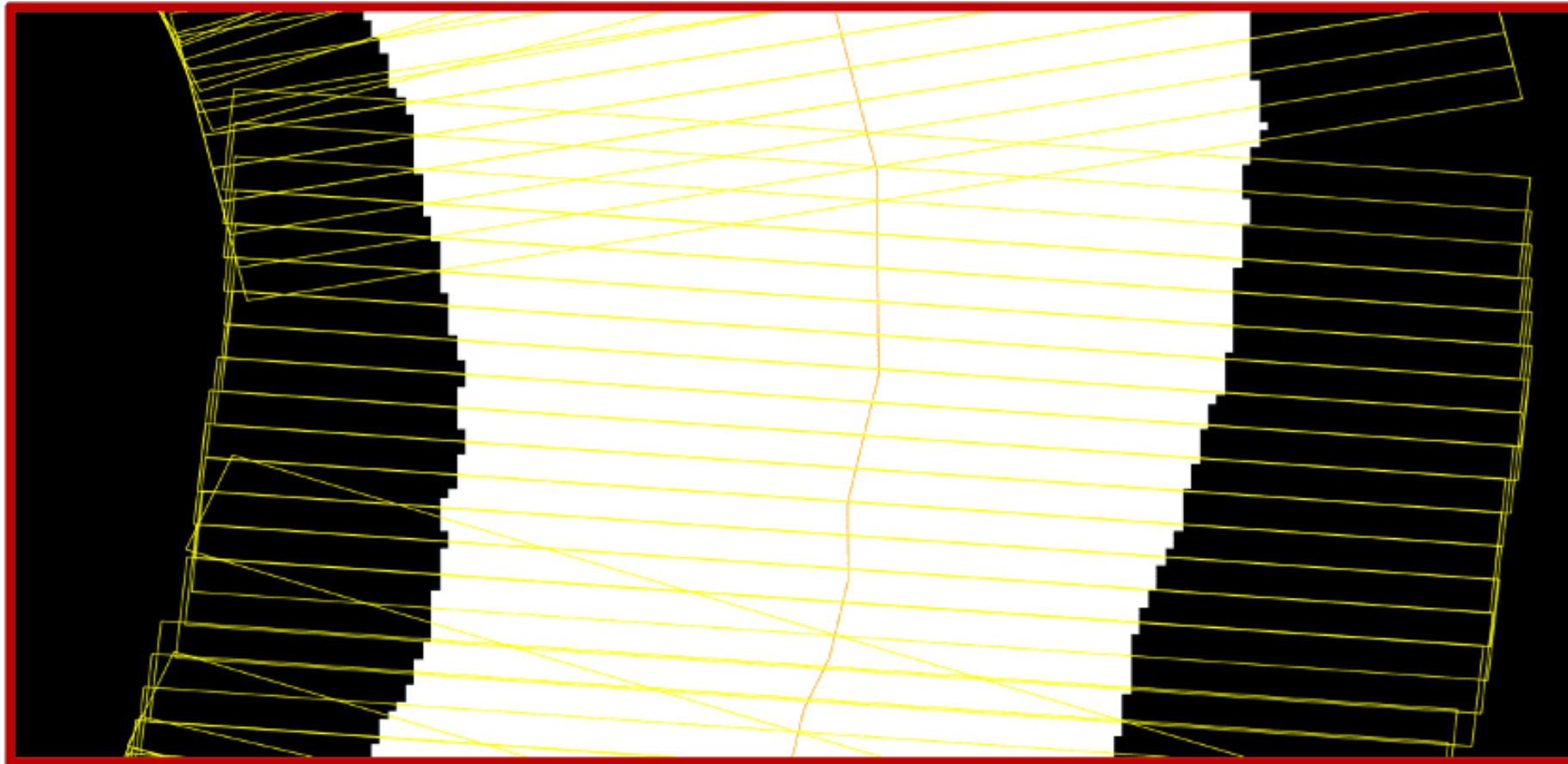
All-weather, Global Surface Water and River Width Data:
River center lines and river widths

393 m

368 m

470 m

Right: prototype river width measurement derived from the surface water product. Global production of these datasets will be automated for archiving and distribution of historical and near real time data.
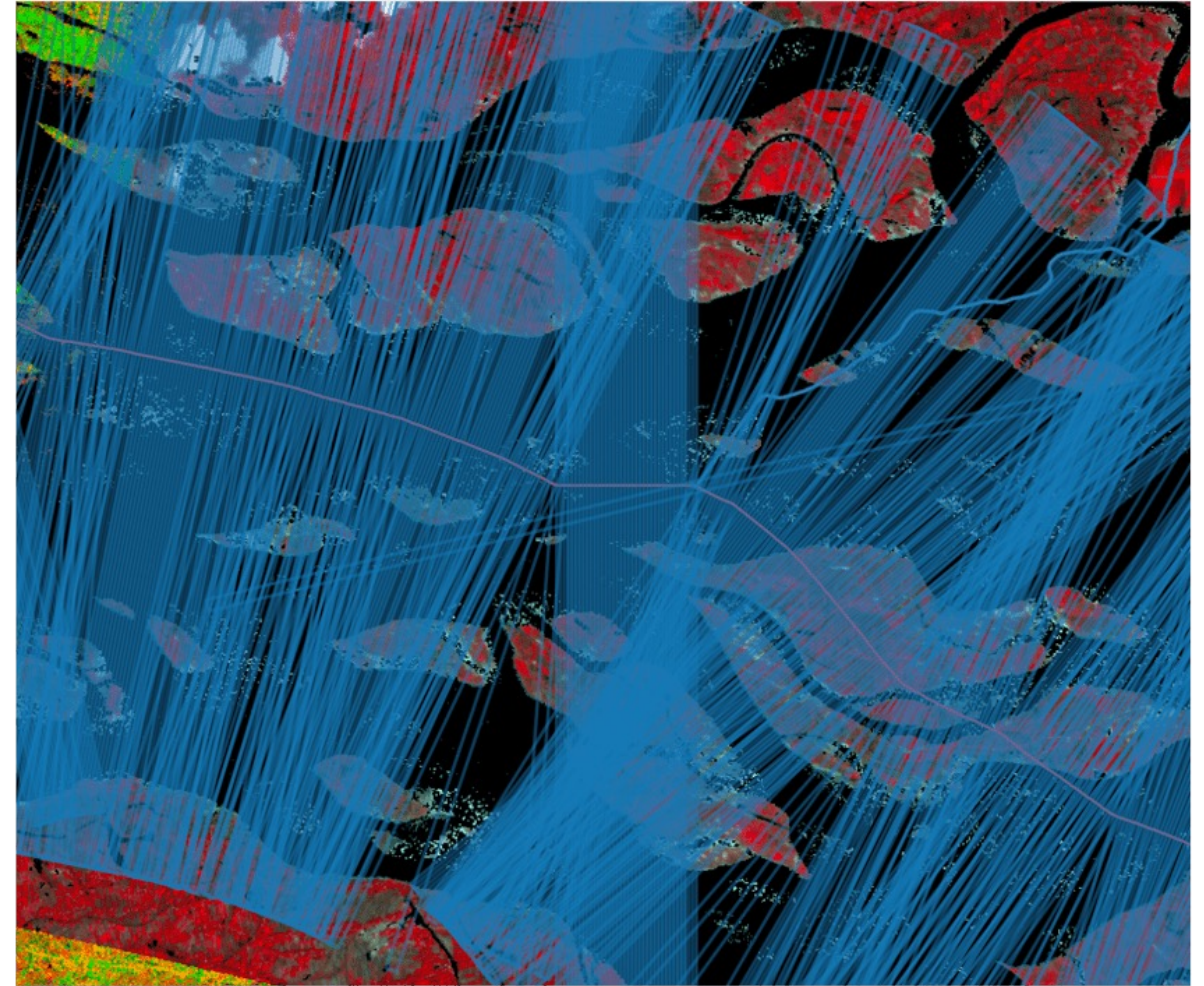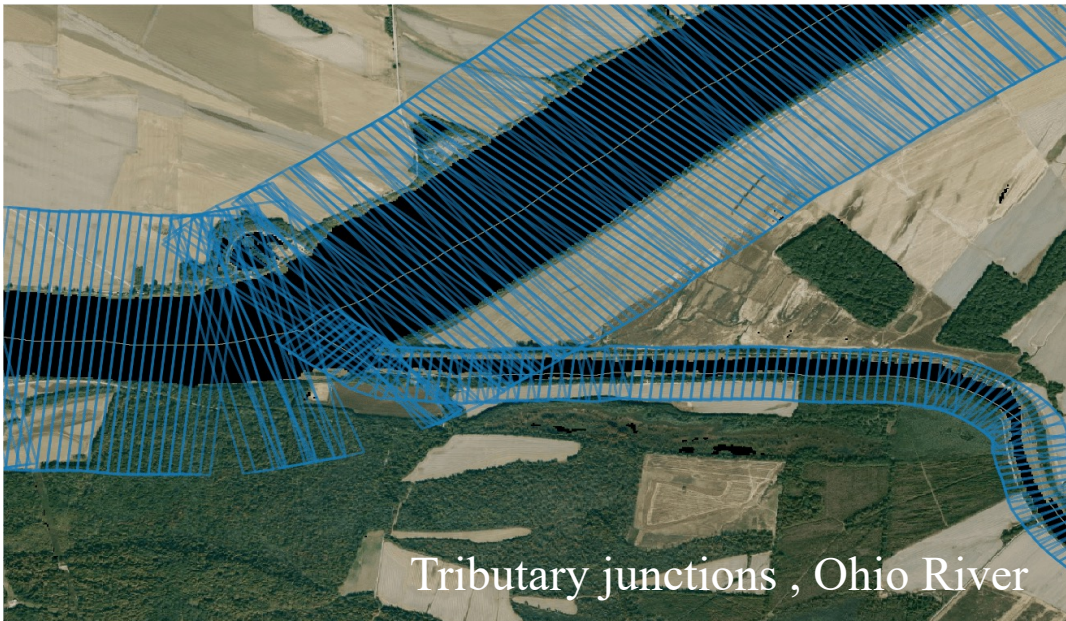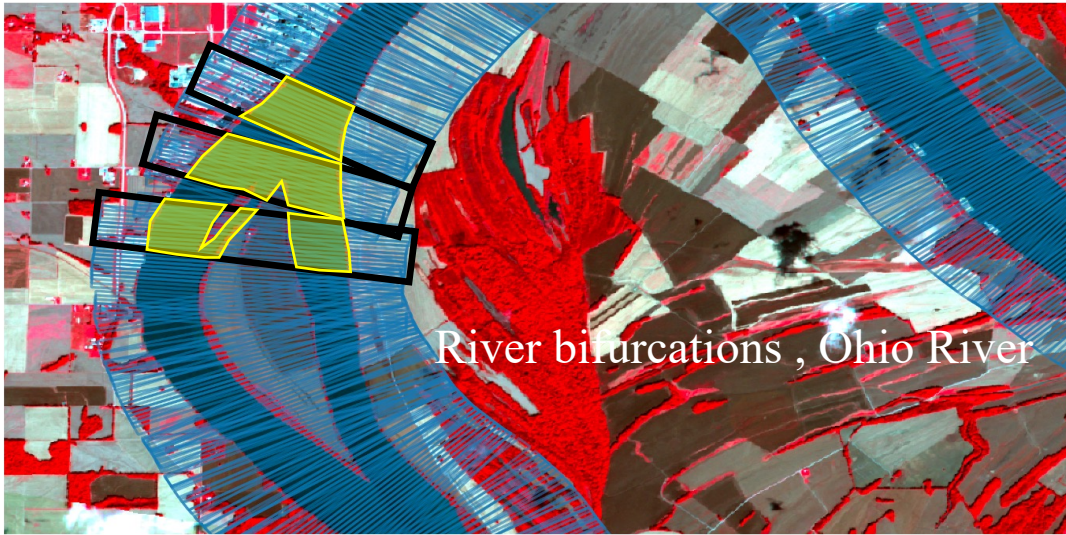
Effective River width database for SWORD river reaches

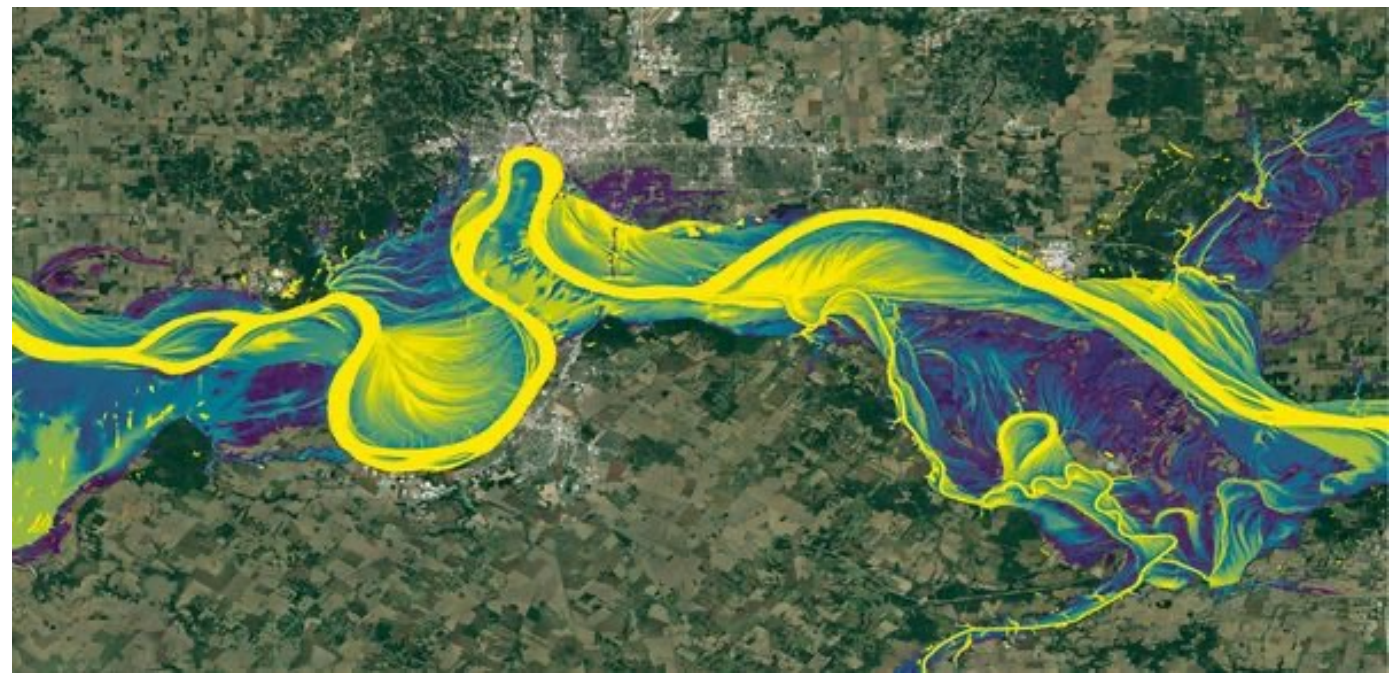|	reach_id	effective_
92	74267100081	657.06133862592...
93	74267100081	648.56943118003...
94	74267100081	644.32347745708...
95	74267100081	645.3849658878...
96	74267100081	655.4691059798...
97	74267100081	655.4691059798...
98	74267100081	661.30729234887...
99	74267100081	665.0225018564...
100	74267100081	666.61473450255...
101	74267100081	666.0839902871...
102	74267100081	650.16166382613...
103	74267100081	644.32347745708...
104	74267100081	647.50794274929...
105	74267100081	648.0386869646...
106	74267100081	646.97719853392...
107	74267100081	644.32347745708...
108	74267100071	609.82510345814...
109	74267100071	591.77980013562...
110	74267100071	576.9189621053...
111	74267100071	559.4044029981...
112	74267100071	542.95133232174...

- SWOT River Database (SWORD) will serve as the framework for the SWOT satellite mission (Launch is targeted for November 2022)

- SWORD contains a total of 213,485 reaches

More flexible approach to revolve bifurcation, tributaries and braided rivers

River bifurcations , Ohio River

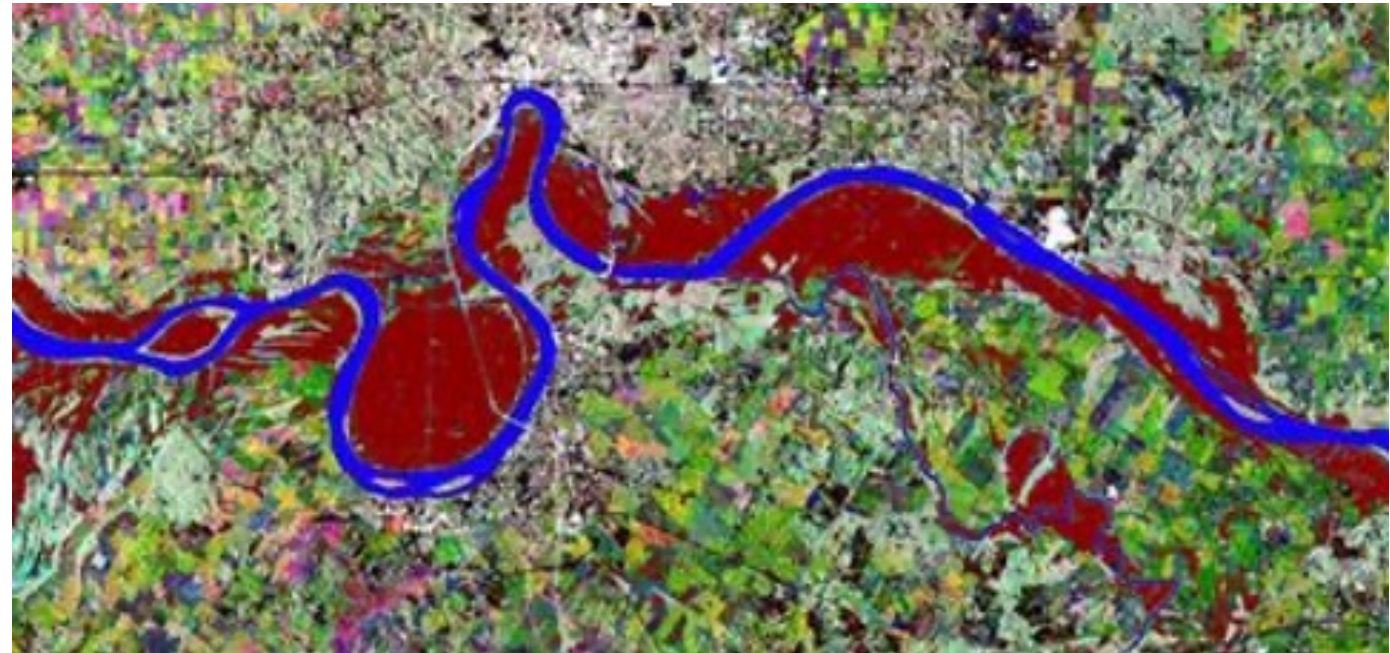Tributary junctions , Ohio River

Braided river, Brahmaputra River, India

Inundations Maps for SWORD river reaches: Assimilating satellite observed water surfaces
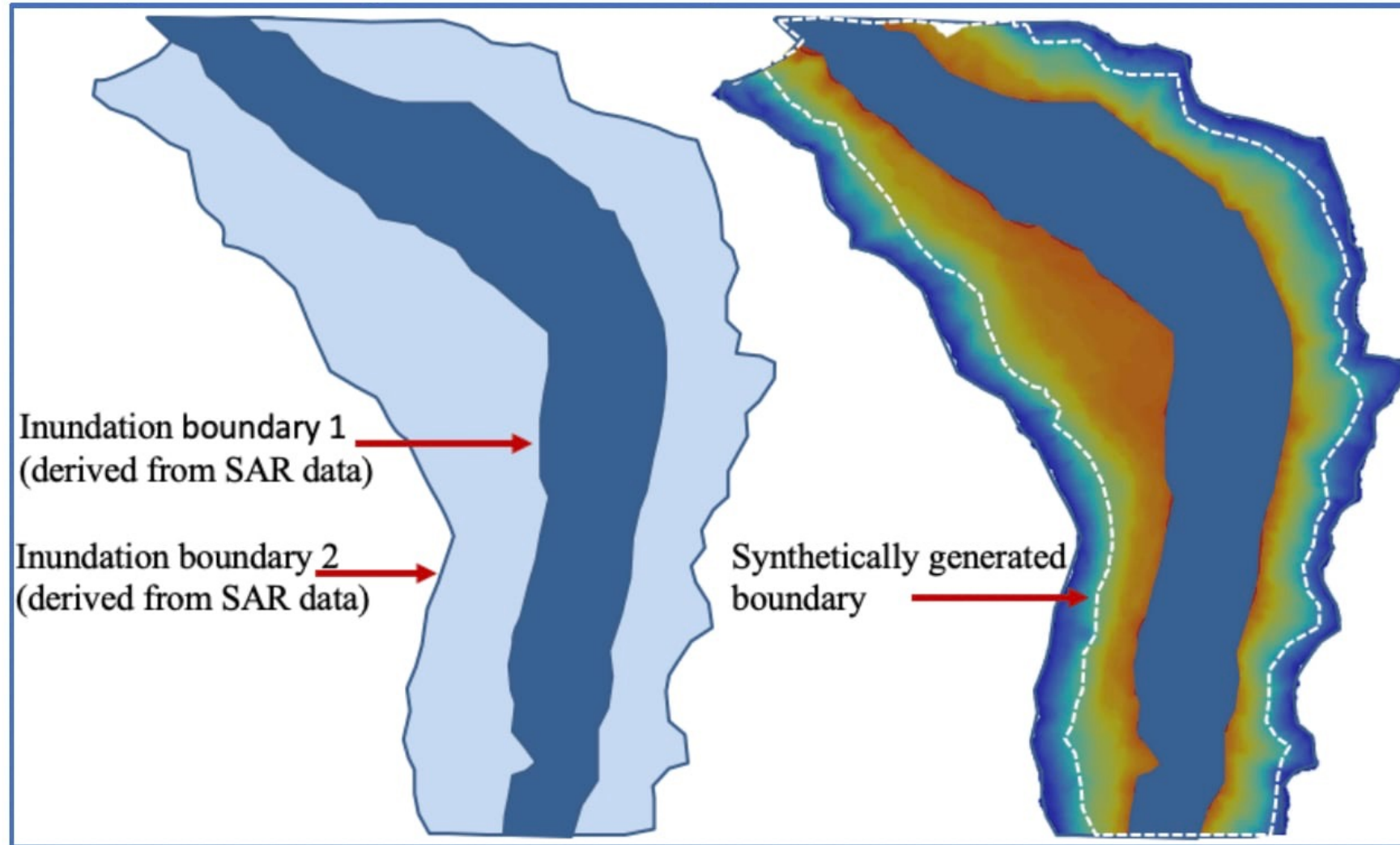

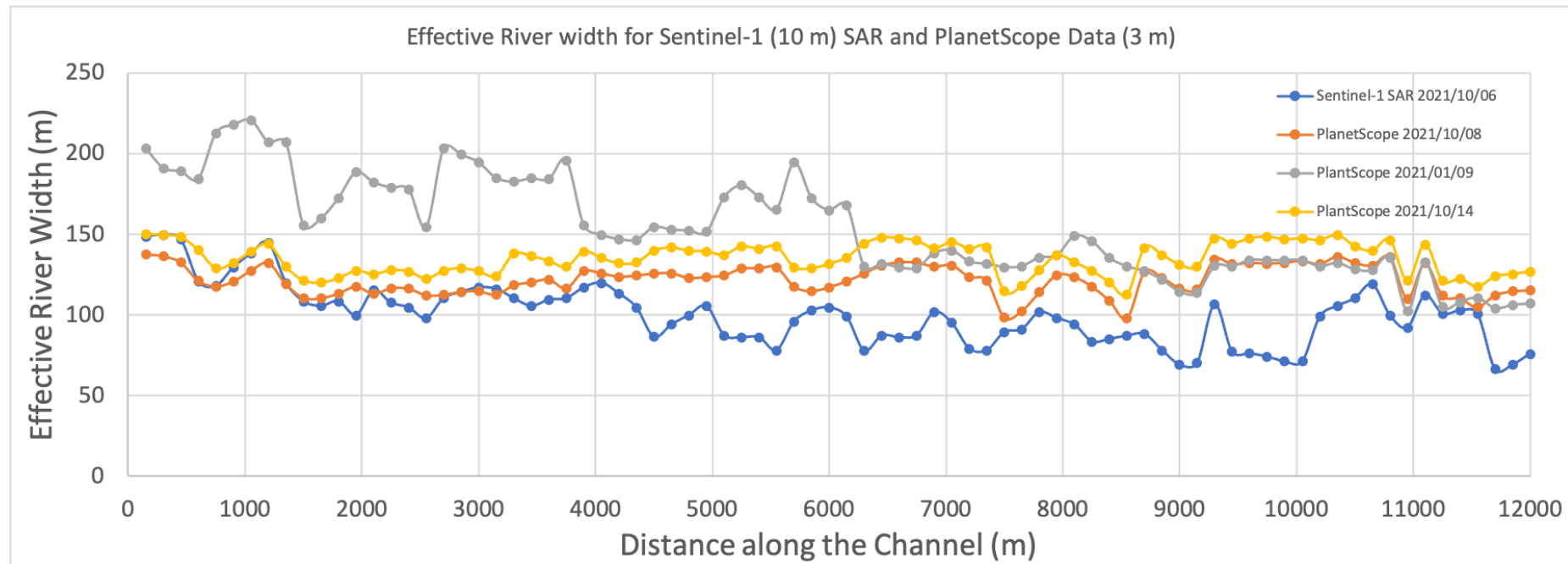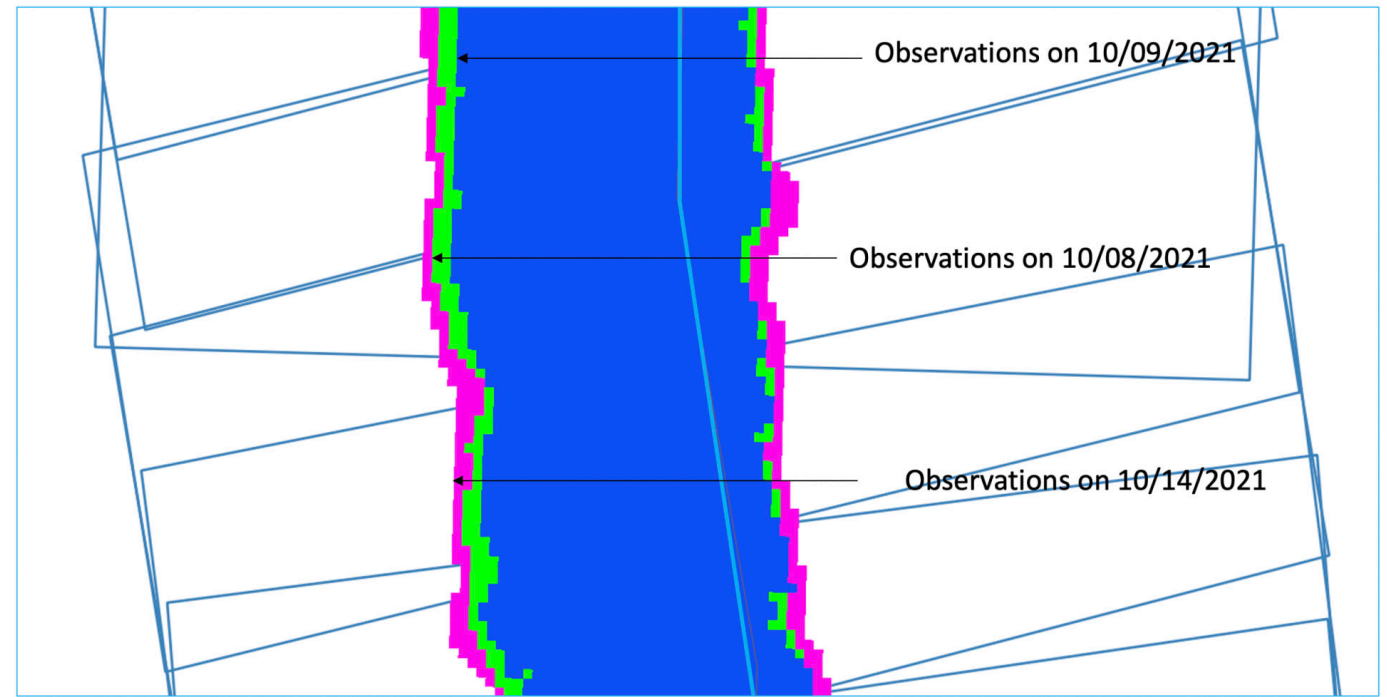An example of modeled inundations (credit LISFlood)

An example of Sentinel-1 SAR image for the same river reach (dates are not the same)

Assimilation inundation water surface to HAND dataset: Generating synthetic inundation areas

Spatial and temporal distribution of river widths

Observations on 10/09/2021

Observations on 10/08/2021

Observations on 10/14/2021

Effective River width for Sentinel-1 (10 m) SAR and PlanetScope Data (3 m)

- Sentinel-1 SAR 2021/10/06
- PlanetScope 2021/10/08
- PlantScope 2021/01/09
- PlantScope 2021/10/14

Effective River Width (m)

Distance along the Channel (m)

Future work:

- Validations of the surface water maps and river widths are continuing.

- Effective river width for SWORD river reaches from 2015 to near real time from Sentinel-1 SAR data are compositing.

- Linking our river width and inundation products using a cloud database in Amazon Web Services so that users can retrieve the river width/inundation time-series information over the web is on going.

- River width products will be available to use with other river geometry and historical streamflow discharge information to provide estimated river flow rates to enhance the NASA SWOT mission time series.