Translating water extent into water availability scores. A methodology to diagnose surface water availability problems

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Water availability as a source of unrest

- When water supply deviates from the “usual” problems can arise. Excess or shortages can happen anywhere on the globe!

At one point, the Guri Dam generated 70% of Venezuela’s electricity. What is the current status of the reservoir? Is it enough to meet Venezuela’s electricity demands?

In 2017-2018, severe water supply shortages almost led to interruption of services in Cape Town. Will another Day Zero happen this year?

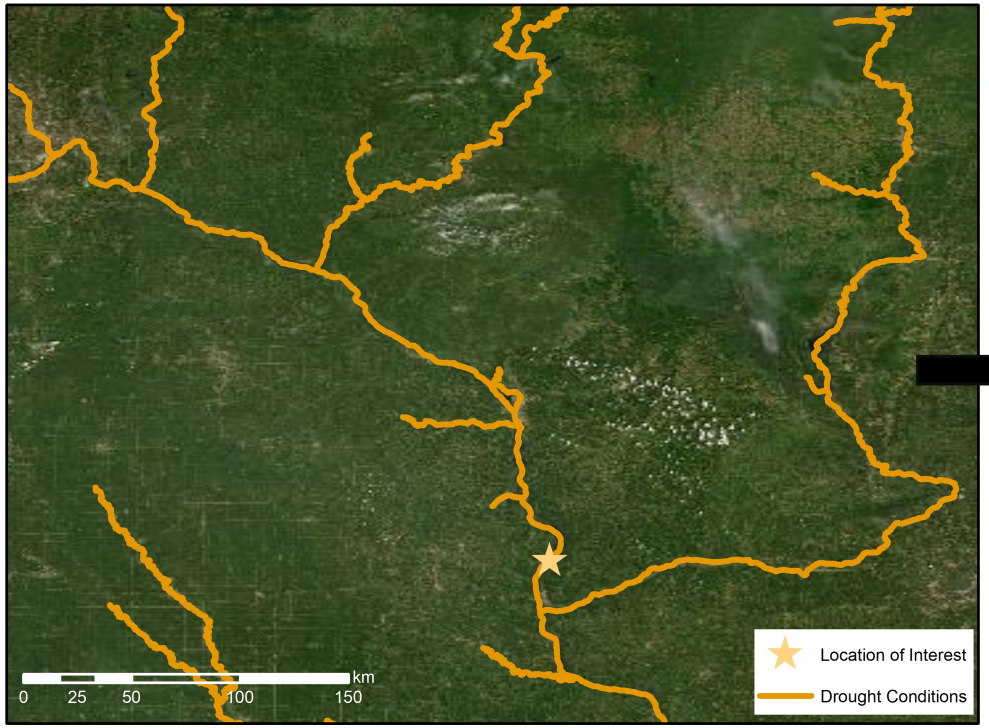
➡ Remote Sensing data can provide answers

What is the current status of the basin?

Question

Is the area of interest water-stressed?

Data

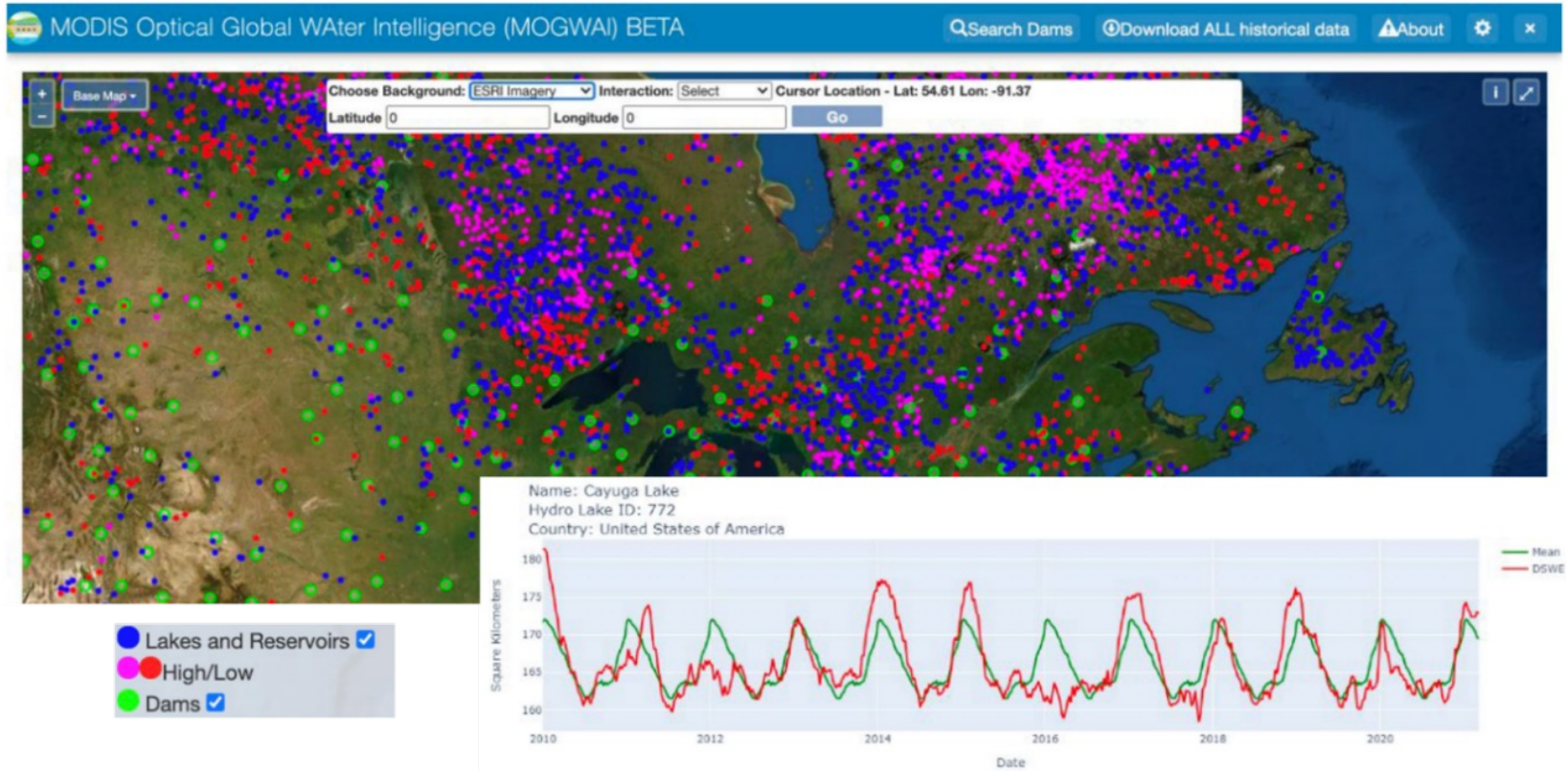


Decision

1. **Historical low flows detected: implement water saving plans**
2. Take no action

Using remote sensing to detect water supply issues

- Tools to assess water stores based on remote sensing exist.
- Extensive use of Remote Sensing assets for Lake information



What's missing:

Where are the rivers?

MODIS lacks the resolution to resolve river width changes in most rivers

Through higher resolution imagery, we will enable the tracking of river width dynamics.

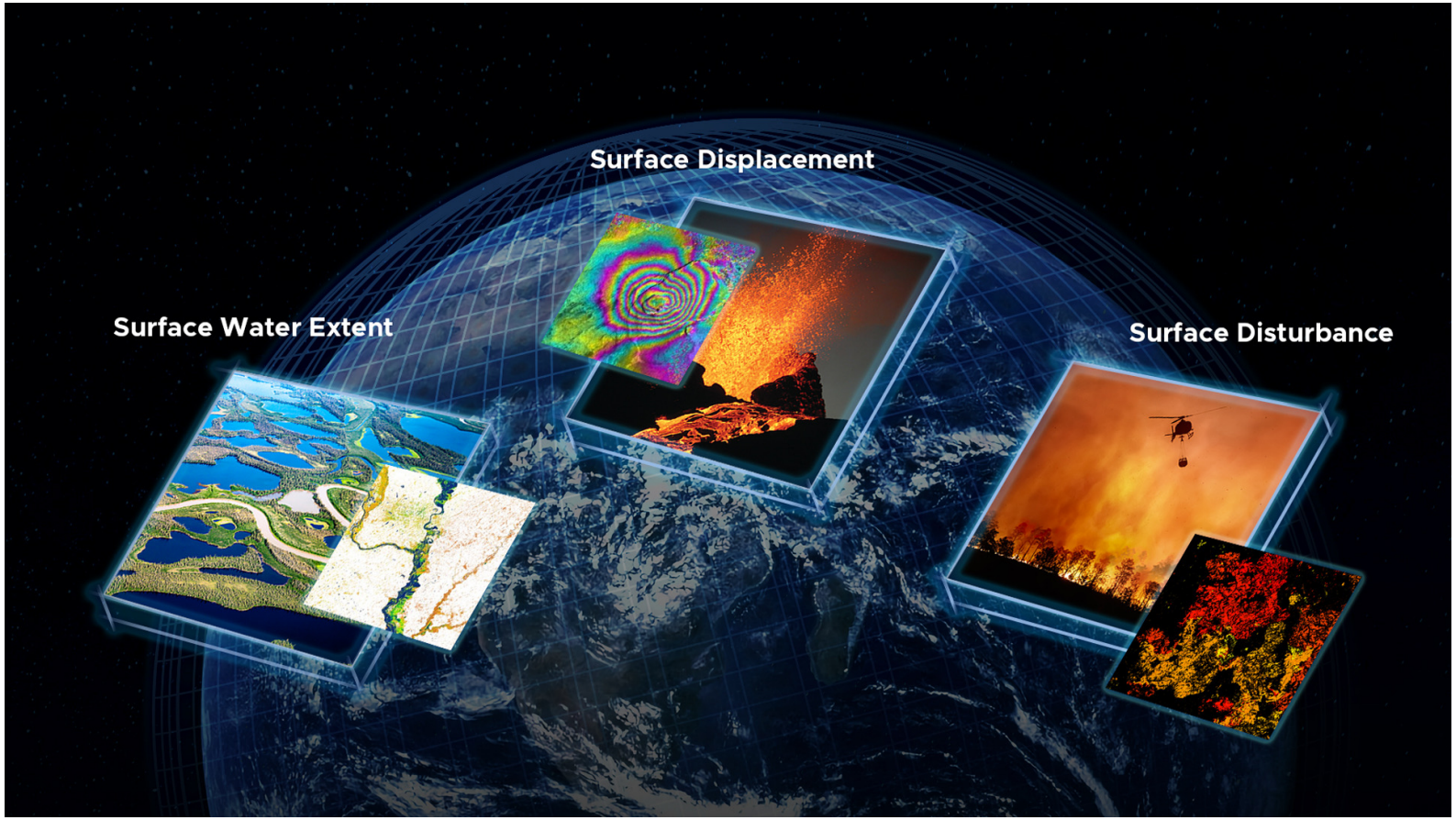
D. Brown, M. Pham, K.A. Cotterman, and M.D. Wahl, "MODIS Optical Global Water Intelligence (MOGWAI)", 2021.

Observational Products for End-Users from Remote Sensing Analysis - OPERA

Dynamic Surface Water Extent:

- Produce water occurrence maps from optical and SAR measurements
- Optical platforms: Landsat and Sentinel 2
- SAR includes Sentinel 1 and NISAR

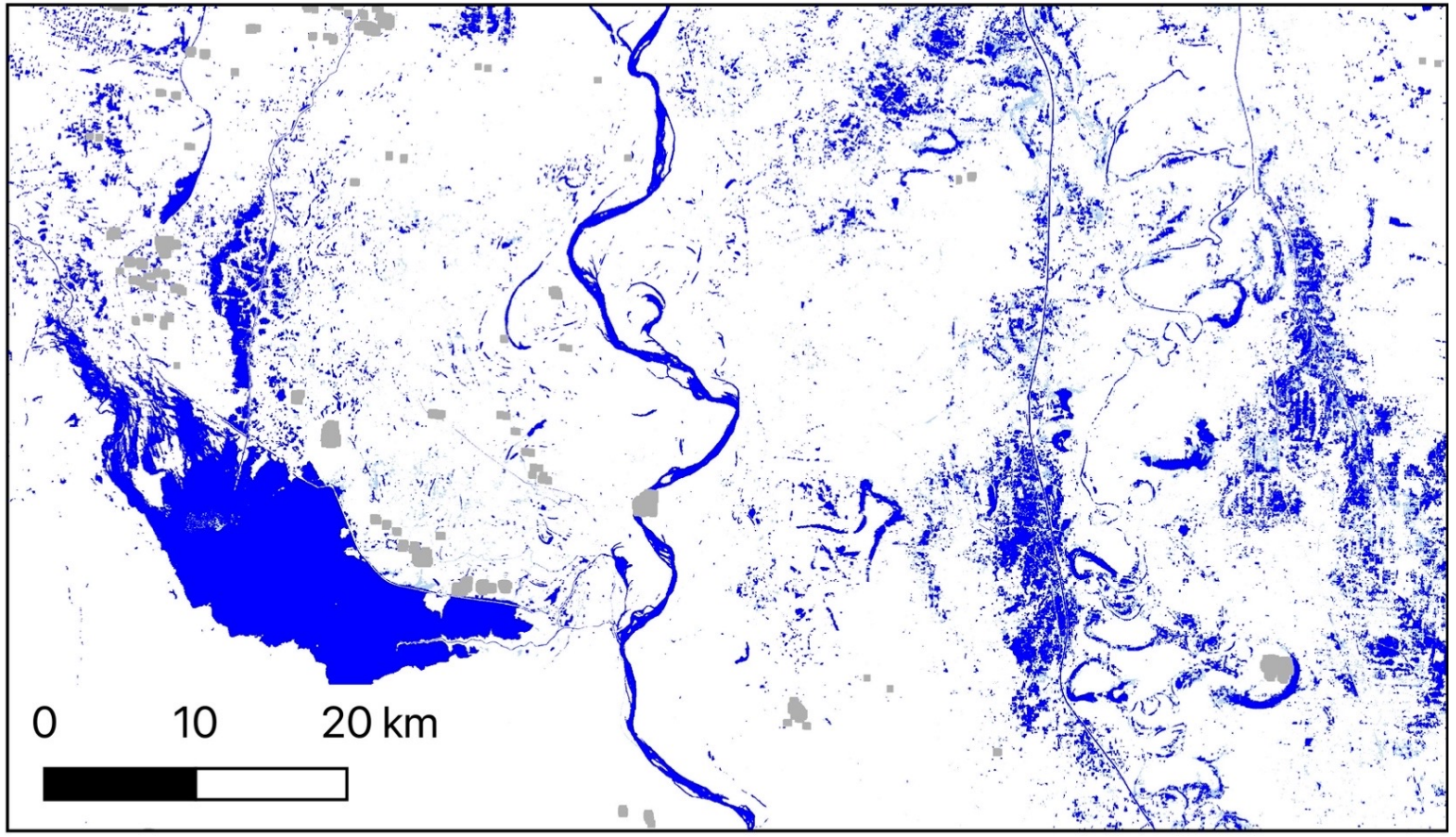
Opens the door for tracking water dynamics in rivers as wide as 100 m



https://www.jpl.nasa.gov/go/opera/products

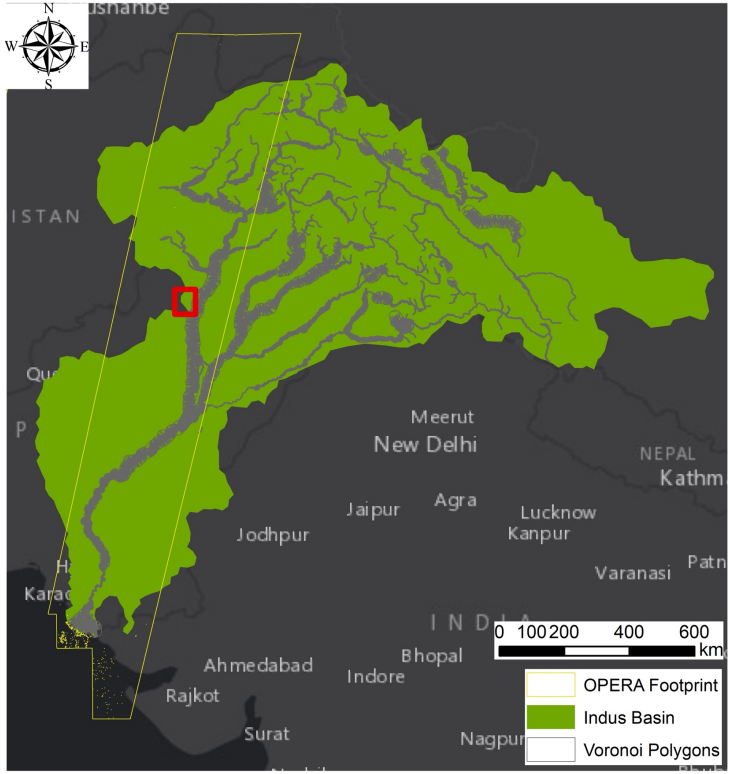
Dynamic Surface Water eXtent – HLS product

- Compositing window:
  - 07-July to 15-July 2022
- Fairly compact in geotiffs
  - Few megabytes for 100 km by 100 km
- Not immediately interpretable without context

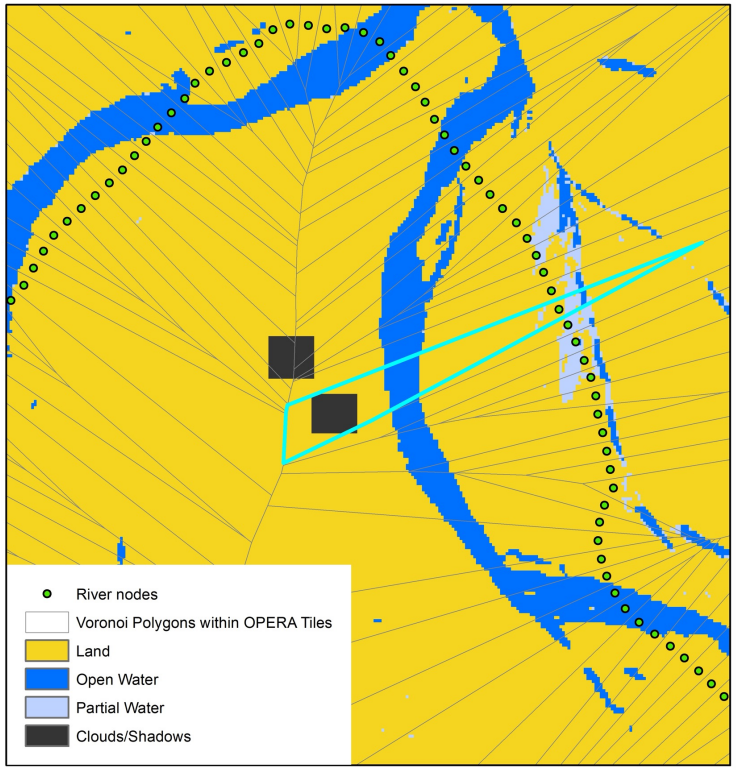


From DSWx to river widths

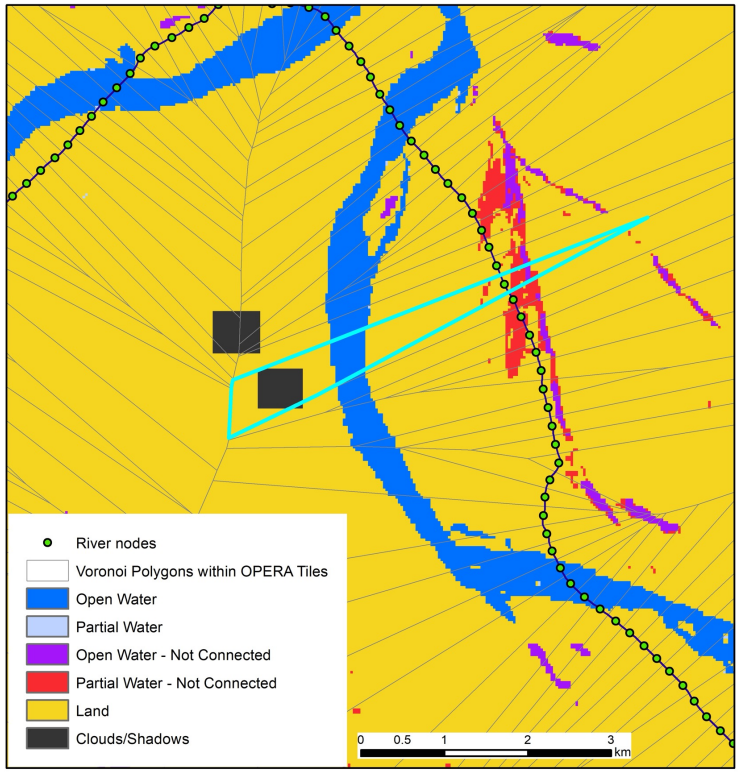
1: Creation of Voronoi polygons around the river network



2: Using DSWx as input, search for connected waterbodies

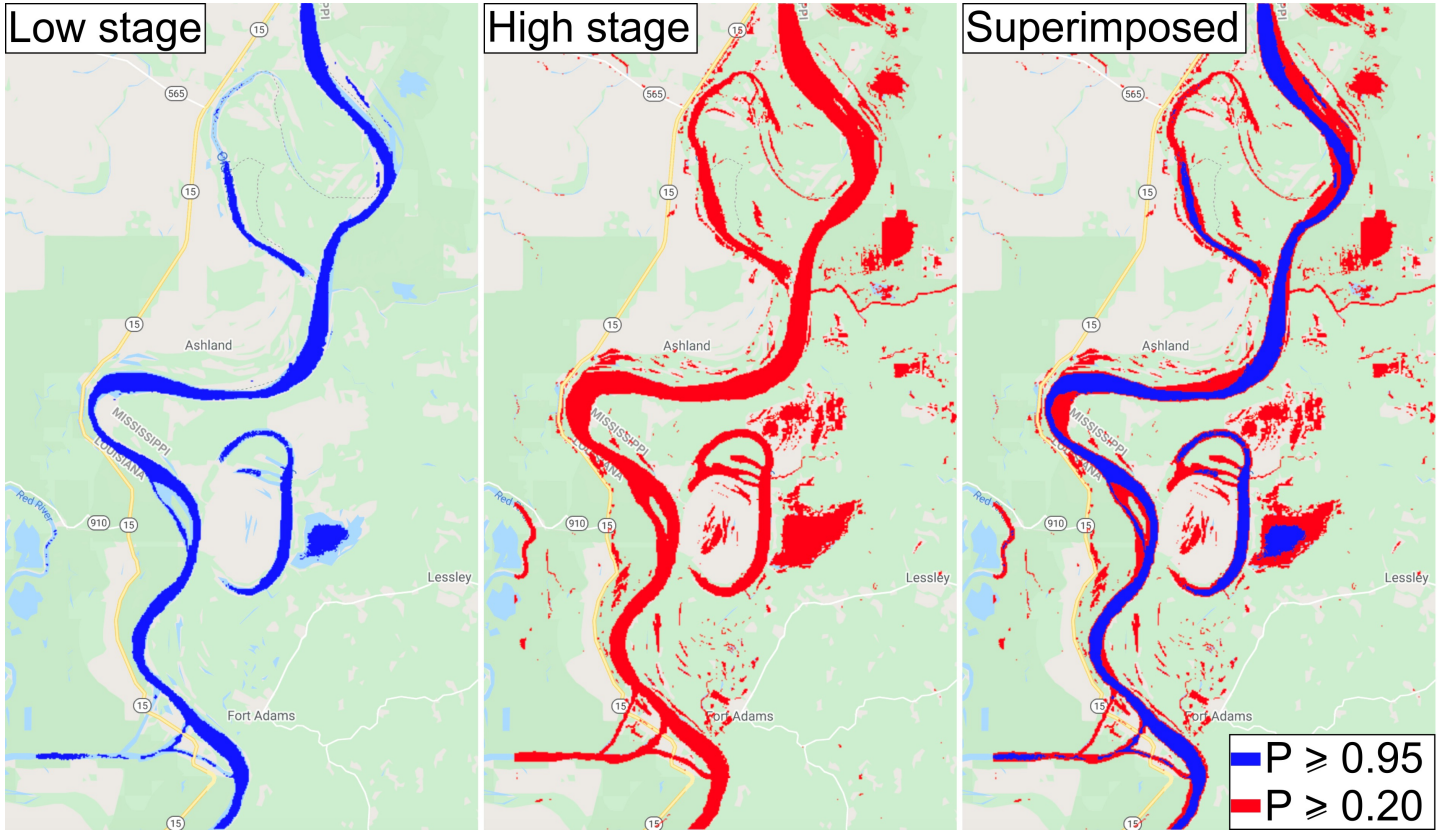


3: Assign connected water pixels to the river node

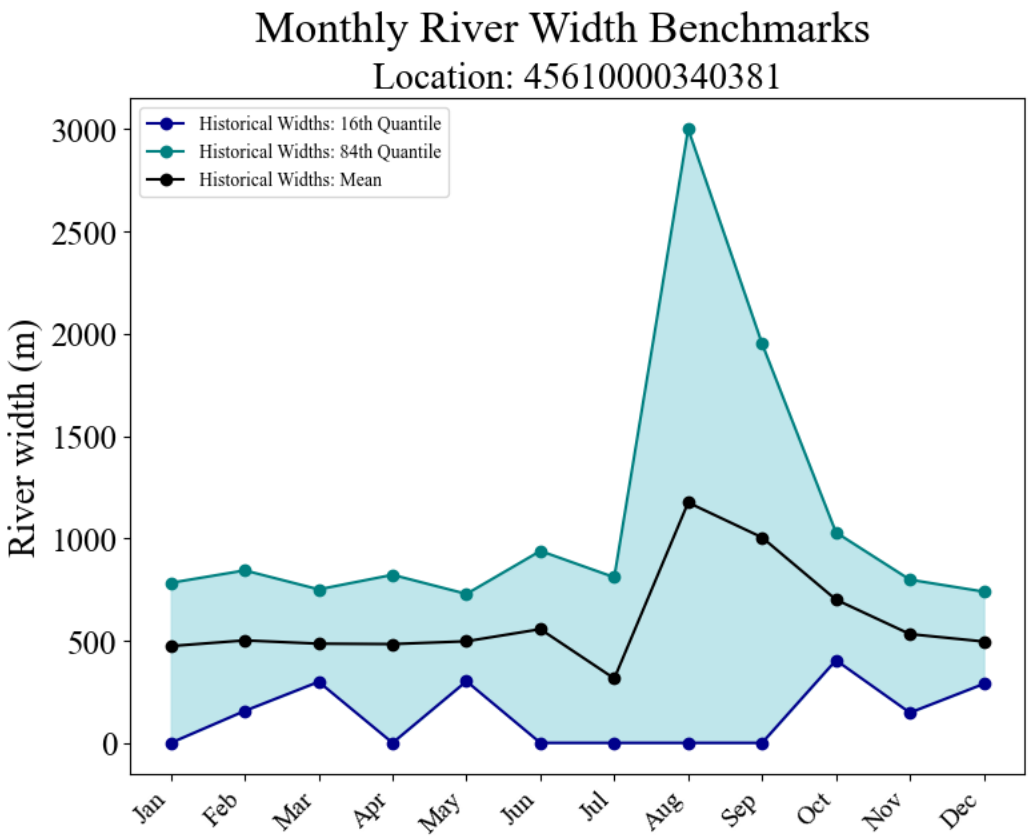


Historical context is key to producing intelligence

- When it comes to water and food security, what matters the most is how the **current state differs** from long standing **“normal” conditions**.
- Landsat-derived water probability maps by Pekel et al. (2016) can provide such context.
- Contrasting instantaneous measurements with high/normal/low conditions will allow visual assessments



Creating historical data



We processed the monthly water occurrence maps produced by the Joint Research Centre from 1985-2021 for the Indus River Basin. We computed the river widths at all Indus River nodes for each of the months to produce benchmark curves as shown on the left plot.

The lower curve shows the 16th percentile for each month. The central shows the average river width for the month, the top curve shows the 84th percentile. The interval defines a benchmark to interpret the instantaneous river widths, with those falling under the lowest curve representing likely water scarcity, those falling above representing risk of flooding.

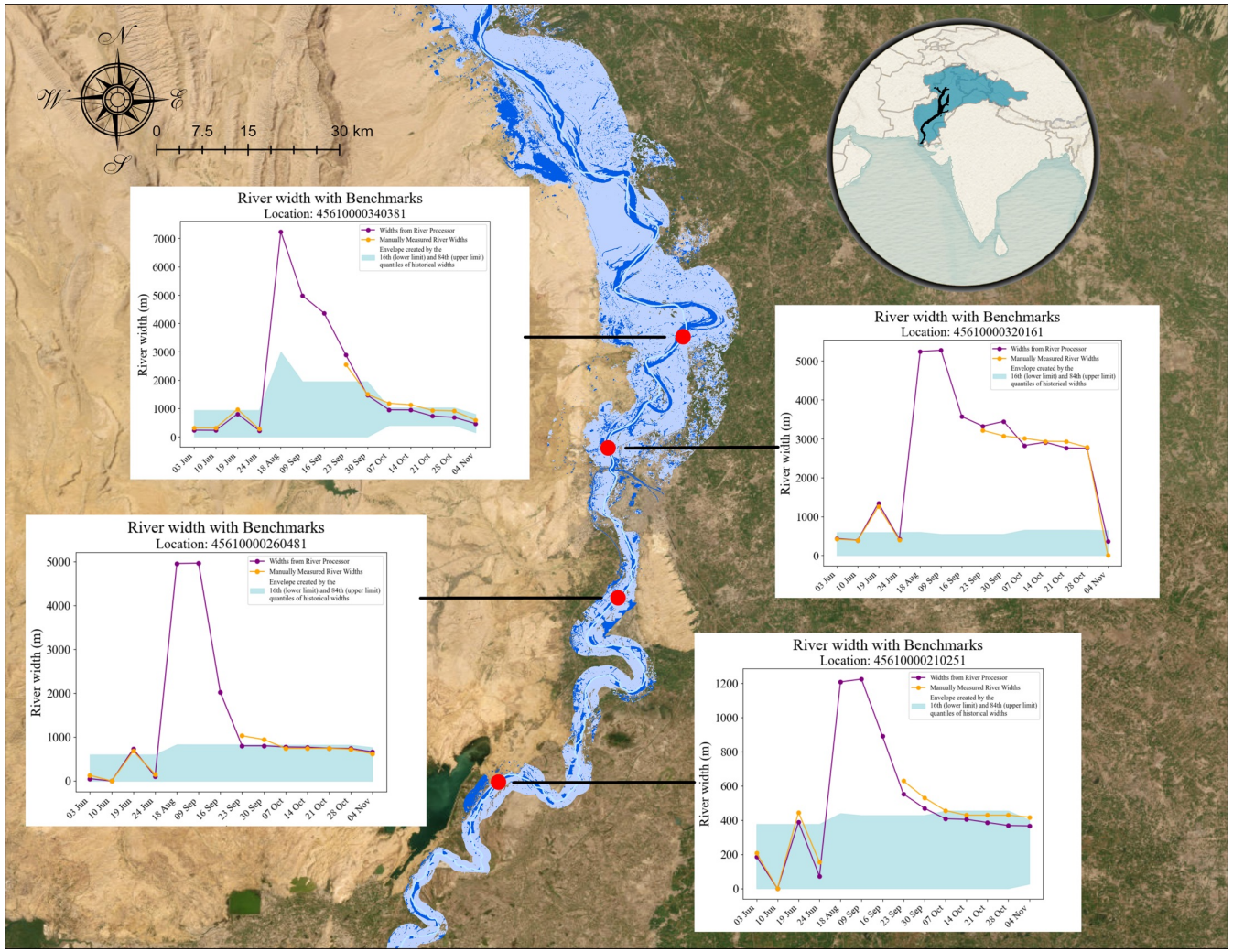
In the next slide, we will show a comparison of this historical envelope with the instantaneous measurements.

Study case: The 2022 flood of Indus River

Timeline of the event

- Following months of drought, rains began in June
- July and August show persistent cloud cover Flood peaks on August 29
- Water recession from September 5 through November.
- Covering this area requires mosaicking 36 tiles
- Cloud removal done through temporal compositing
  - 1 “cloud free” image per week in June and October-November
  - 1 “cloud free” image per month July and August
  - 1 “cloud free” image every two weeks in September

Study case: The 2022 flood of Indus River



River widths computed along the Indus River every 200 meters for 14 mosaics covering the flood of 2022
Image: OPERA Dynamic Surface eXtent product river at low flow (dark blue color) and high flow extents (light blue) superimposed on a basemap with 4 locations near the city of Hyderabad highlighted where the time series of width are shown.
Such time series are built at every node along the 400 by 1000 km basin.

The current set of ArcPro toolboxes has tools for:

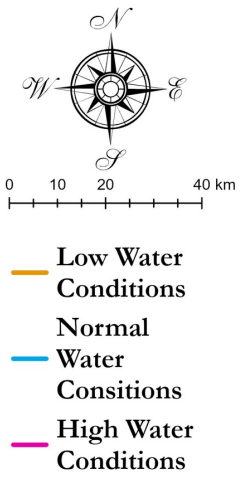
- Downloading data over the period of interest
- Mosaicking DSWx tiles to remove cloud cover
- Performing the water continuity segmentation
- Calculating river widths
- Output as CSVs or Shapefiles

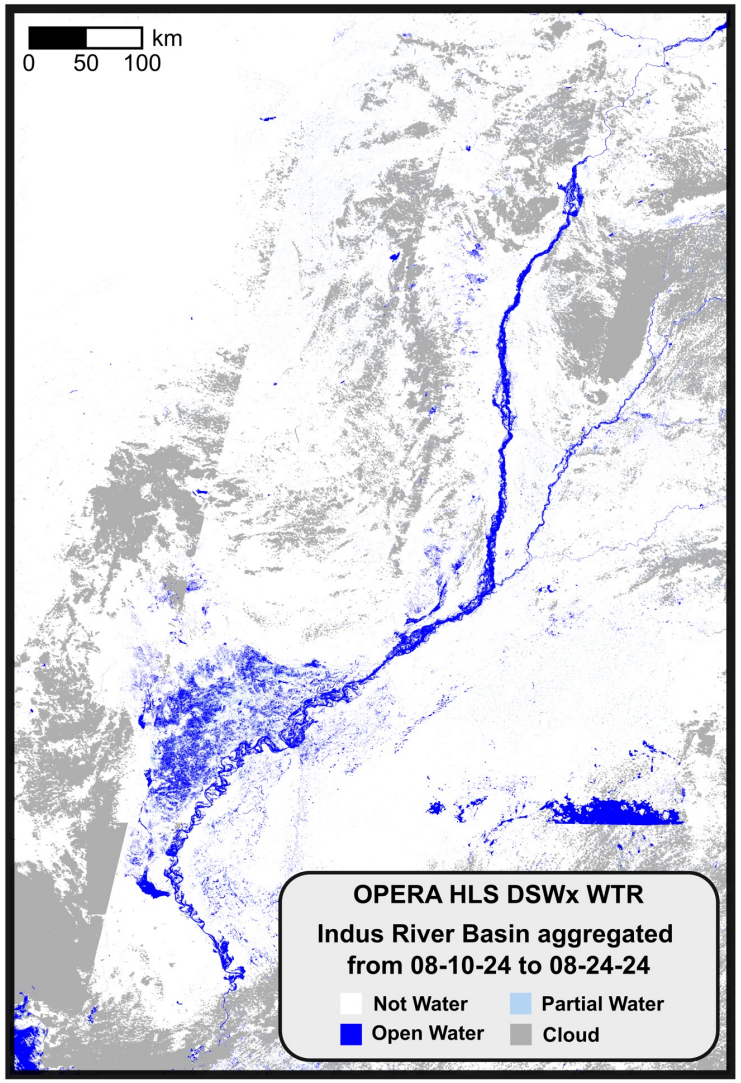
Conclusion

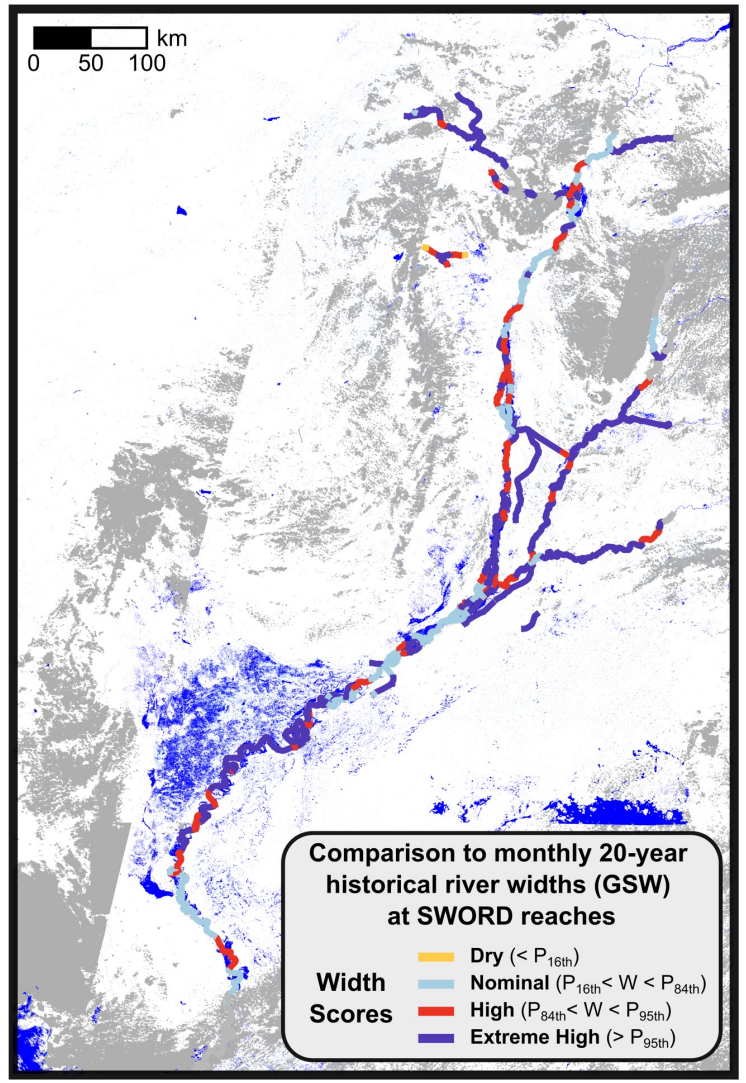
- Reported water availability status matches flood records in the international media near the city of Hyderabad.
- Solution scaled to the full basin
- Cheap enough to run in one laptop

Next steps:

- cross-comparison with SWOT widths
- Incorporate DSWx-S1

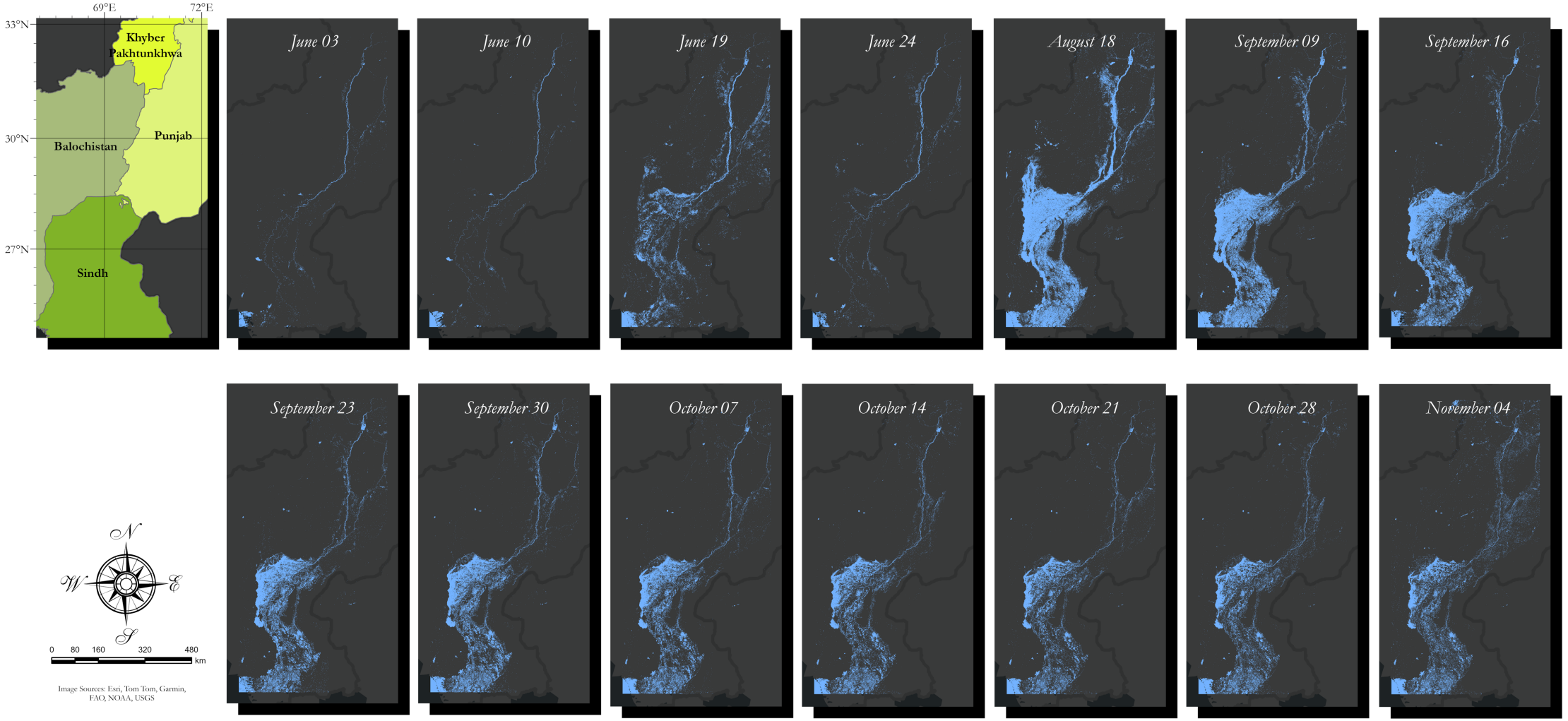






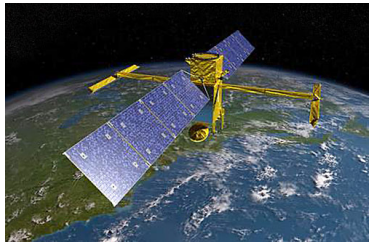
BACKUP slides

Study case: The 2022 flood of Indus River



Tracking river width from space

- Alone, Landsat, SWOT, NISAR, Sentinel 1 and 2 may not adequately resolve river dynamics.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- Multi-sensor fusion provides:
  - Higher temporal sampling
- The challenge:
  - Harmonizing observations taken with different techniques into a coherent product

Challenges to overcome

Multi-sensor fusion enables faster **temporal sampling**:

- Needed for tracking of river **dynamics**

SAR and **Optical** sensors can give inconsistent answers:

- Different response to vegetation
- Different response to buildings