Rapid flood and damage mapping using synthetic aperture radar

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InSAR Mini Project

- Typhoon Hagibis: Izu Peninsula of Shizuoka Prefecture, Japan, on October 12, 2019

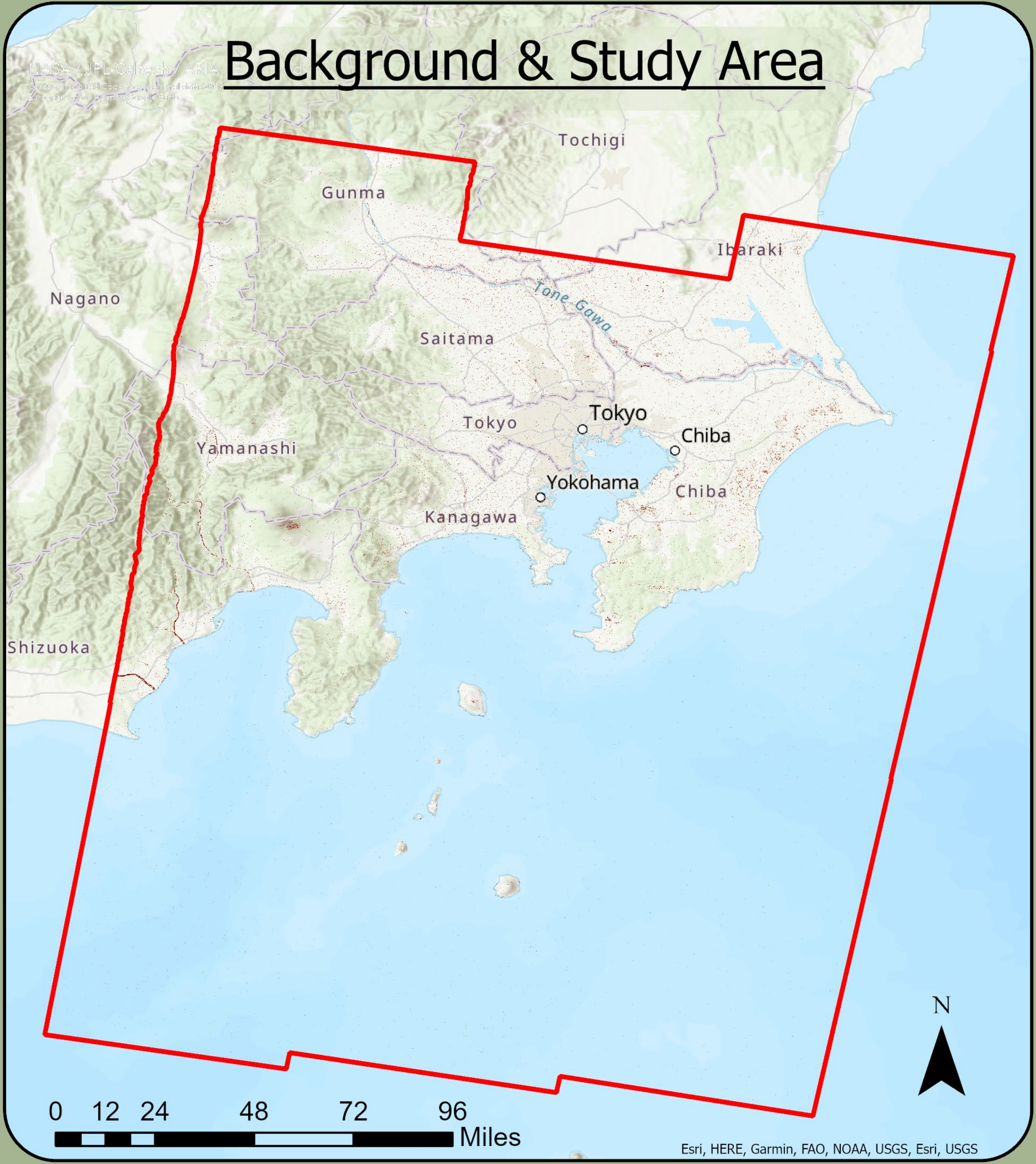
- Category 2 equivalent on the Saffir Simpson scale at landfall

- One of the strongest typhoons of the century to hit Japan

- Had one of the fastest intensifications from a category 1 to 5 status in less than a day

- Impacts:
  - At least 80 deaths
  - 135,000 people affected
  - 68,000 homes inundated
  - 10,000 buildings damaged

Background & Study Area



Motivation

- To support stakeholders in the region by:
  - Assessing the impacts of Typhoon Hagibis
  - Determining where to send resources

- Mapped flood and damage extents across Japan using pre- and co-event SAR imagery.

Methods: Flood Mapping

- Sentinel-1 and ALOS-2 SAR image pairs consisting of pre- and co-typhoon scenes

- Pre-processing steps:
  - Co-registered each co-event scene to its corresponding pre-event scene
    - Used NASAs SRTM Global 1 arc second (30m) resolution DEM
  - Geocoded SLCs and resampled to DEM resolution of 30m
  - Also passed scenes through a median filter to reduce speckle noise

- Computed logarithmic amplitude ratio (LAR) between each pair of scenes

$$\mathrm{LAR} = \log_{10}\left(\frac{A_{co-event}}{A_{pre-event}}\right)$$

Methods: Flood Mapping, Cont'd

- Set negative and positive thresholds for LAR values to determine which areas represent actual flooding

    - Thresholds were selected using the:

        - Landscape topography

        - Known extents of flooding from aerial imagery (and NDWI)

- Flood events typically result in negative LAR (i.e., amplitude decrease) because less signal is backscattered on the water's surface; however, they can occasionally result in a positive LAR (i.e., amplitude increase) if the water body is adjacent to semi-vertical features due to a double bounce effect.

- Applied these thresholds to the whole SAR image extent.

    - Pixel classified as flooded if LAR is above positive or below the negative threshold

Methods: Damage Mapping

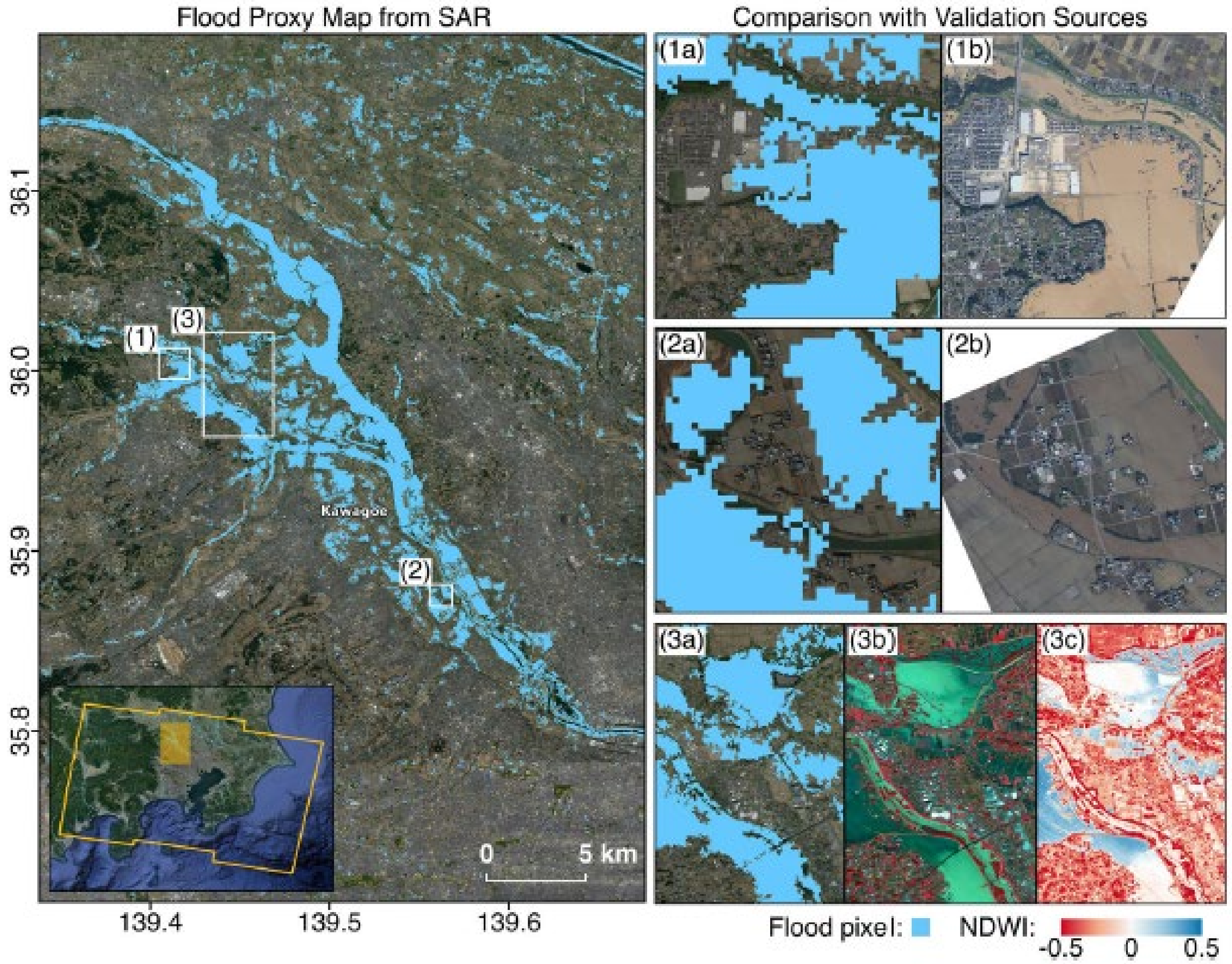
- Two pre- and one co-event Sentinel-1 SLCs
- Same pre-processing as the data for flood mapping
- Inferred damage from a loss of coherence between SAR images
- Calculated pre- and co-event interferometric coherences (γ) from a pair of images acquired before the event as well as a pair of images spanning the event

  - Pre-event coherence represents change unrelated to the event; background value
- Calculated coherence difference: $\mathrm{COD} = \gamma_{co-event} - \gamma_{pre-event}$

  - (-) COD (coherence gain) indicates surface changes between pre-event scenes

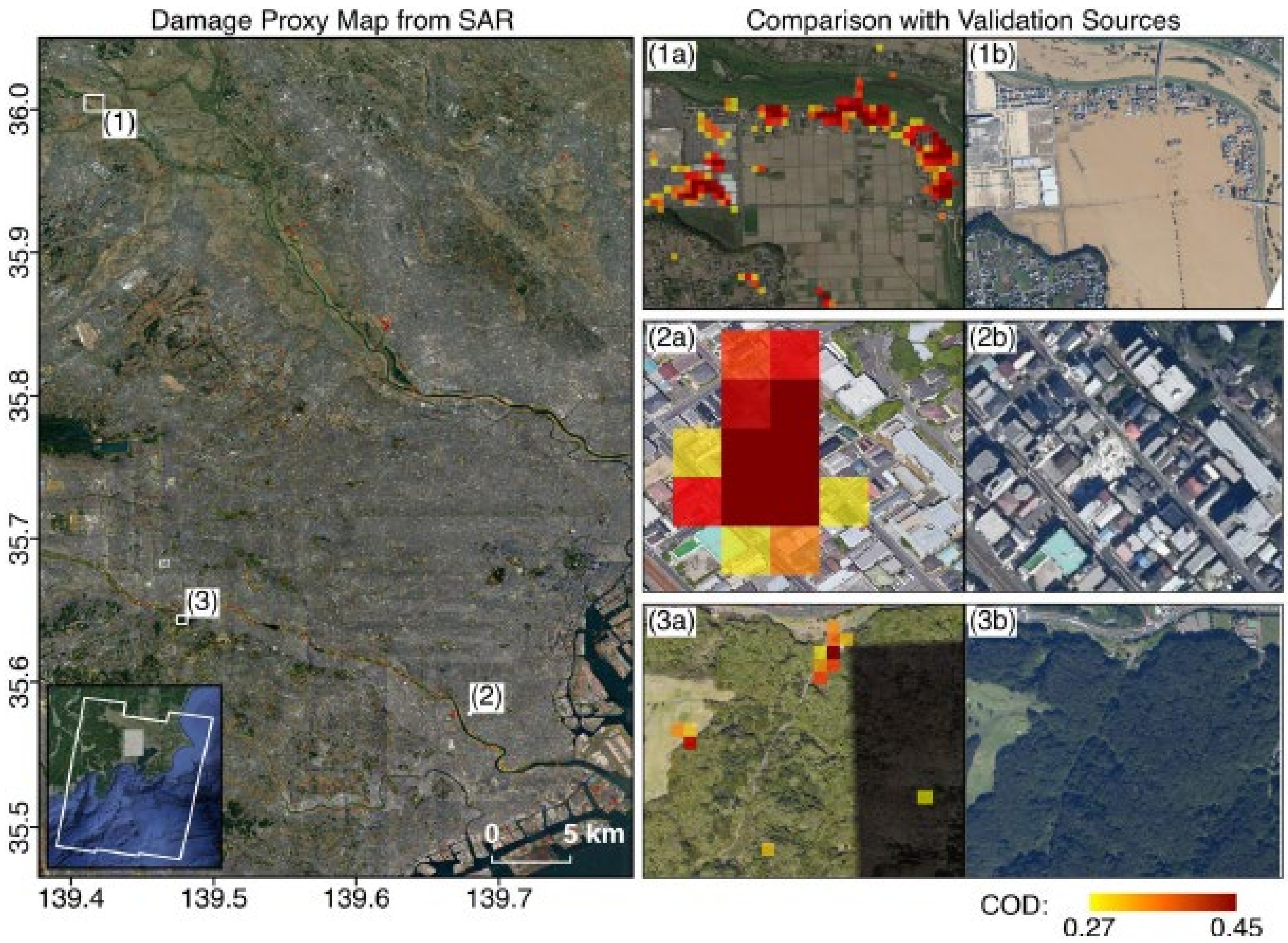
  - (+) COD (loss) indicates surface changes between pre- and co-event scenes
- Pixels above minimum positive COD threshold were classified as damaged

Results: Flood Mapping



Results show agreement with flooding extent on aerial imagery and NDWI probabilities

Results: Damage Mapping



Results show agreement with incoherent areas visible on aerial imagery. Coherence-based damage mapping was less reliable for open water

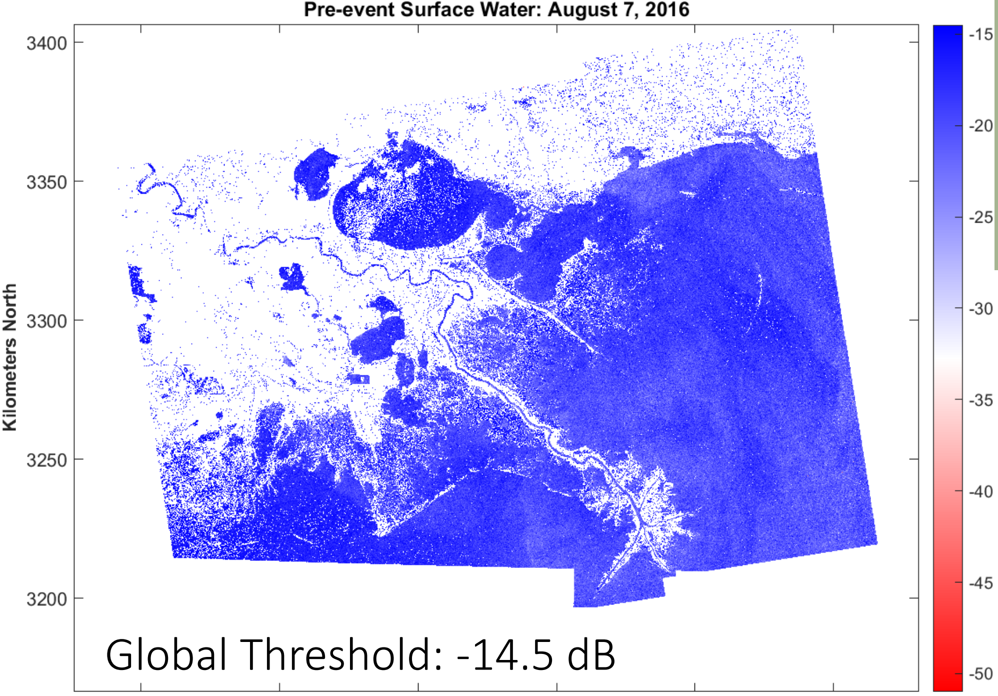
How’s it different from class?

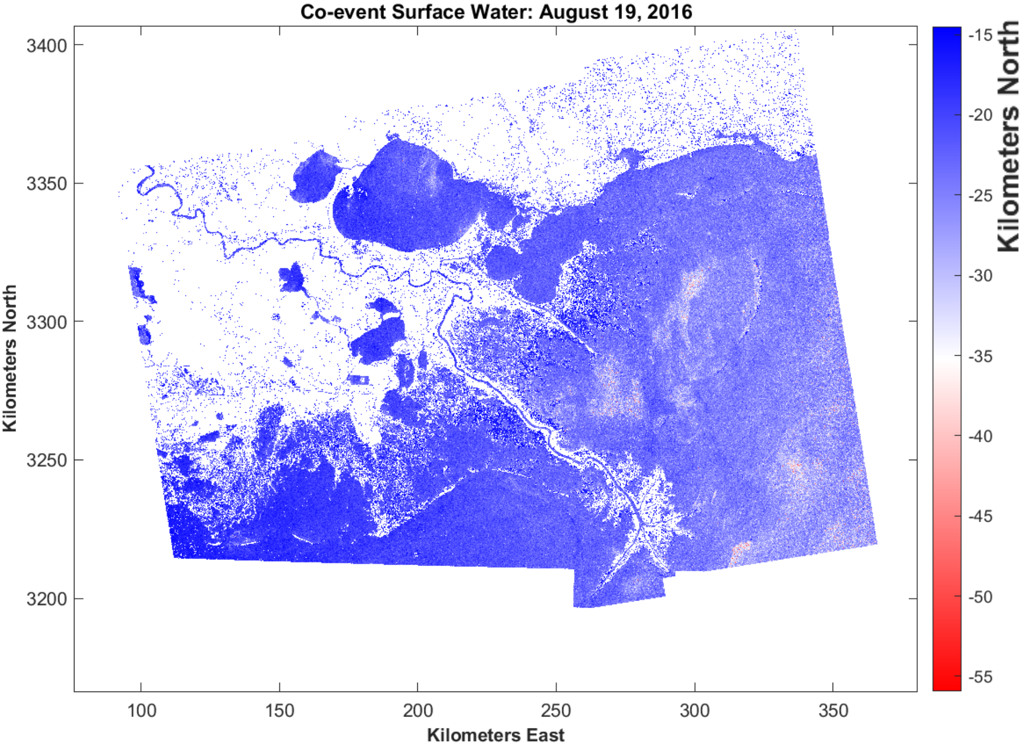
- They disregard phase and LOS displacement.
- Instead, they use amplitude and coherence.

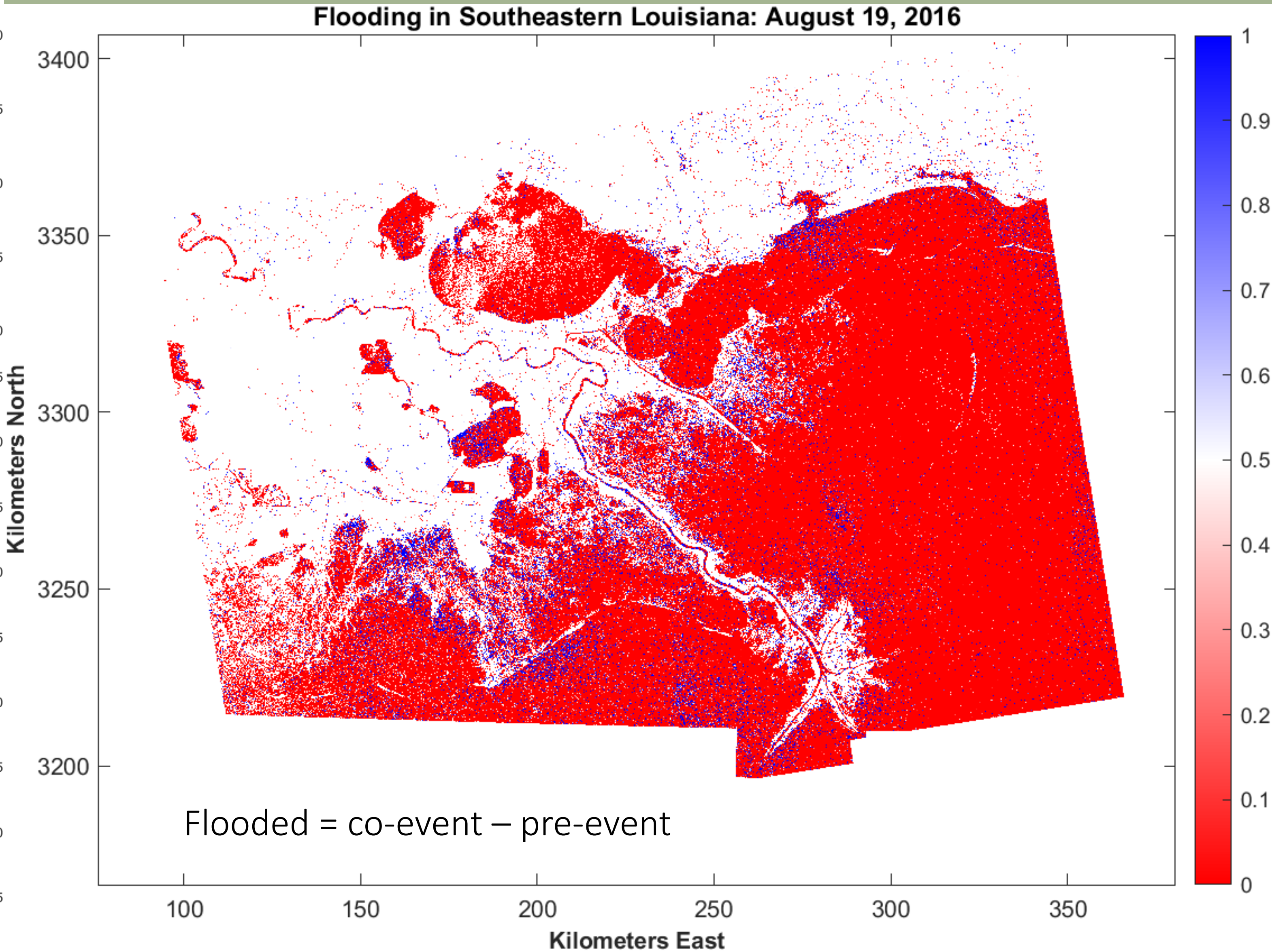
What did I do?

- Event: 2016 historic floods in southeastern LA
- Flood map: Instead, I used the decibel (dB) scale to map surface water and then used differencing on co-event and pre-event dB values to produce a map of flood extent.
  - Two Co-polarized (VV) Radiometric Terrain Corrected SLCs in dB scale
    - Pre-event: August 7, 2016
    - Co-event: August 19, 2016
- Damage map: Same methods as Tay et al., 2020.
  - Three pre-processed SLCs (SBAS)
    - Two pre-event: July 26, 2016; August 7, 2016
    - One co-event: August 19, 2016
  - Calculated two separate interferometric coherences using ASF Vertex
    - One pre-event coherence: July 26 and August 7 SLCs
    - One co-event coherence: August 7 and August 19 SLCs
  - Calculated coherence difference (COD) and masked using a minimum positive threshold

Flood Mapping Using dB



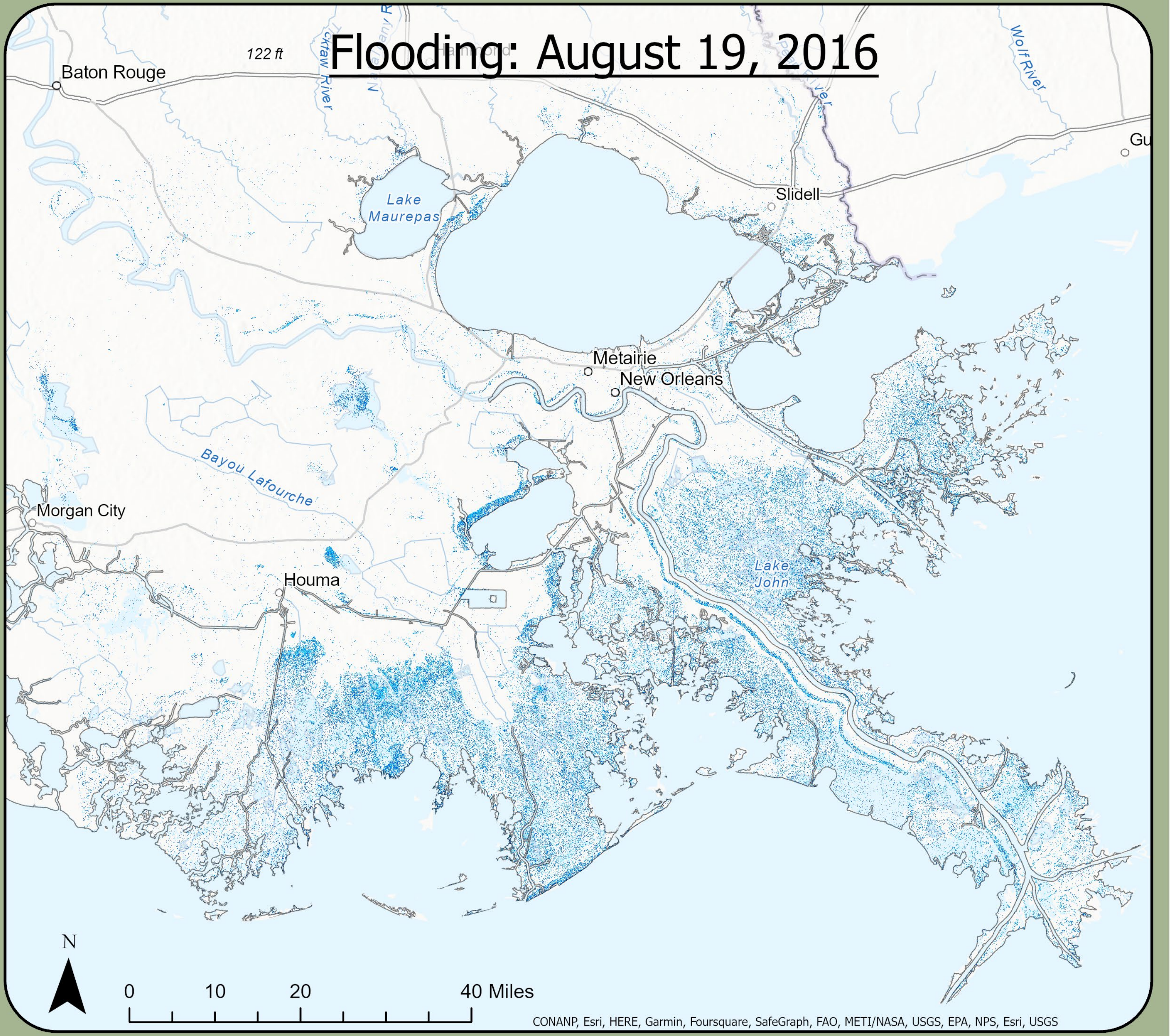




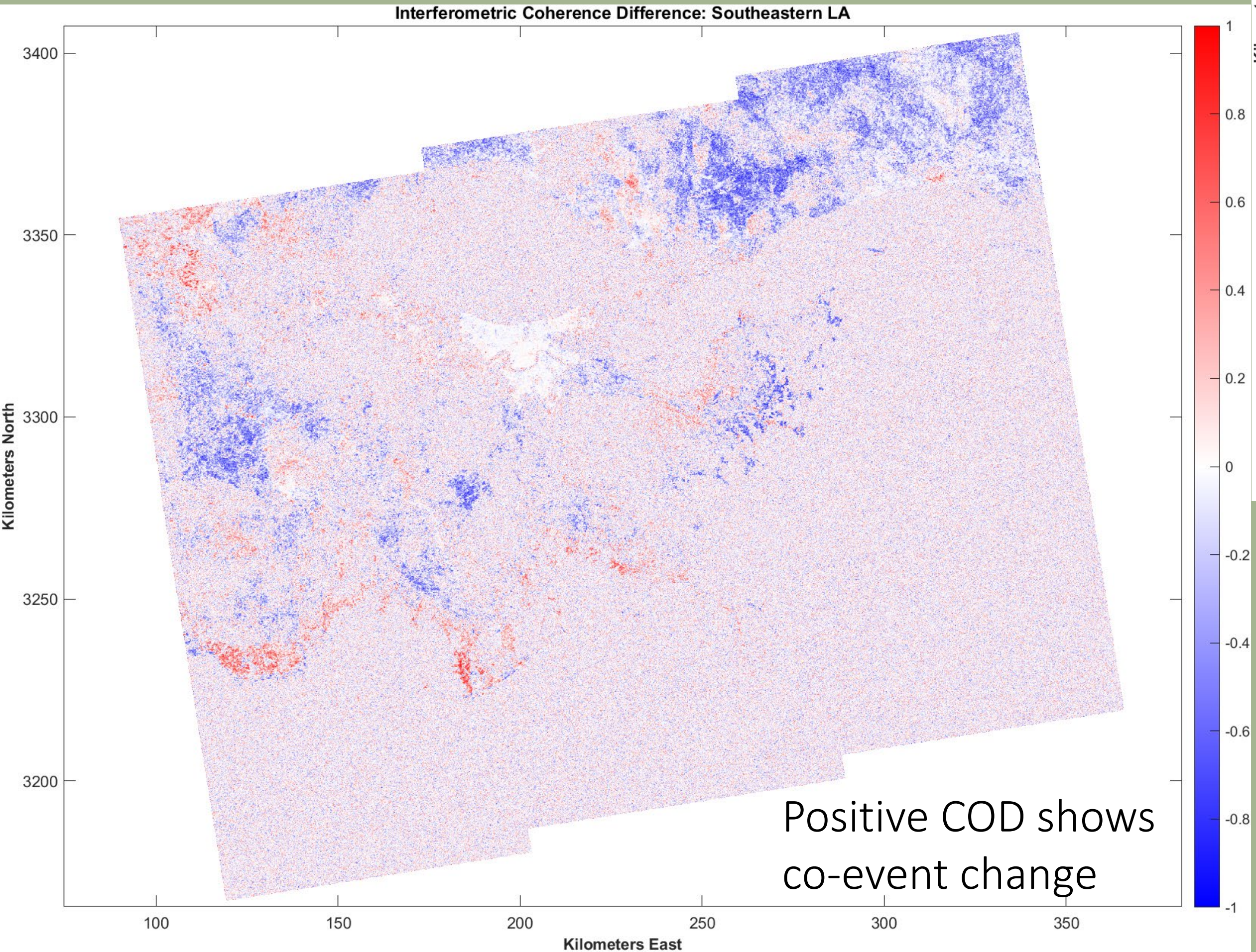
Results: Flood Mapping

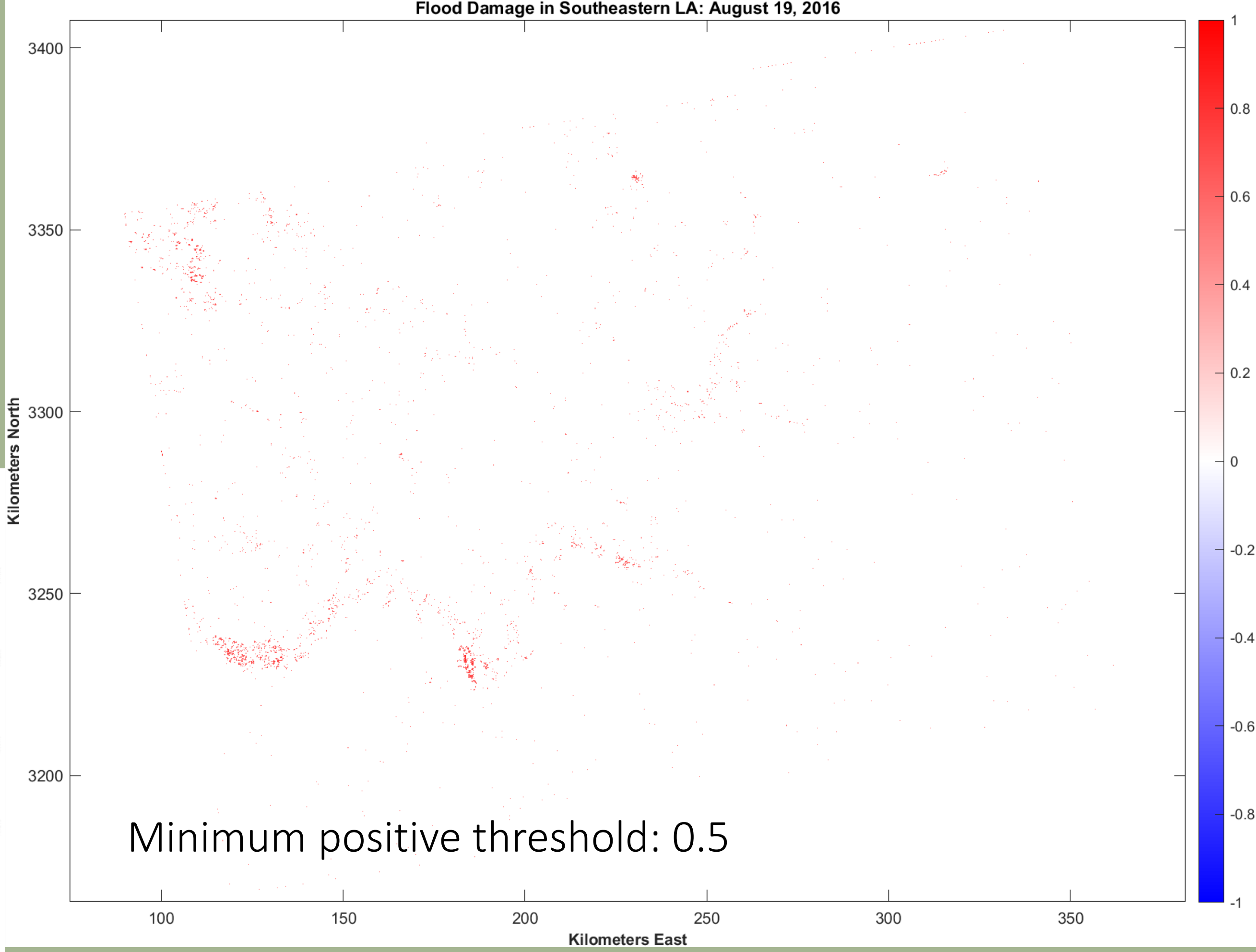
Blue pixels represent areas that contained water on August 19 but did not contain water on August 7.

In other words, the blue areas are flooded.

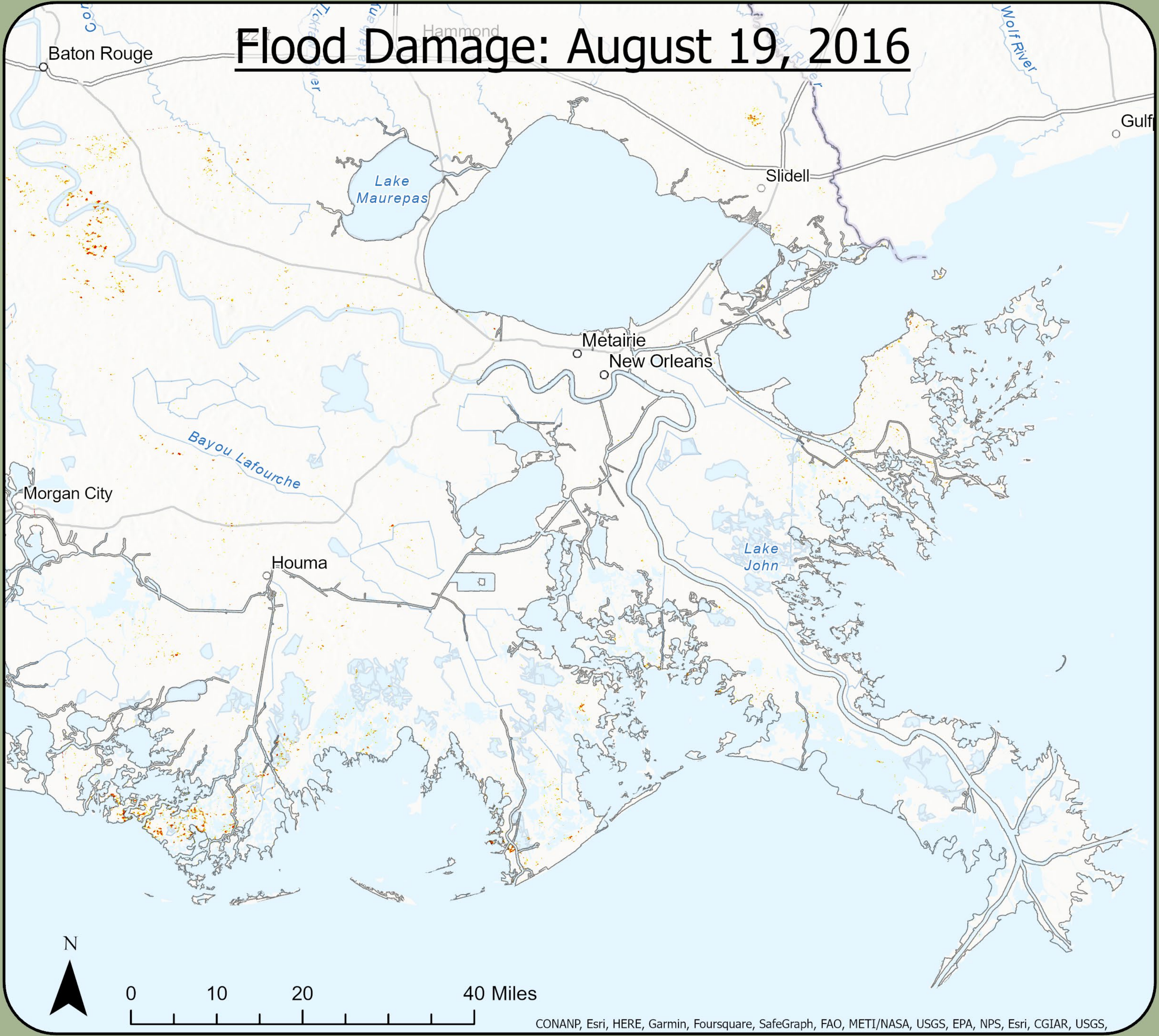


Damage Mapping Using Coherence





$$\mathrm{COD} = \gamma_{co-event} - \gamma_{pre-event}$$

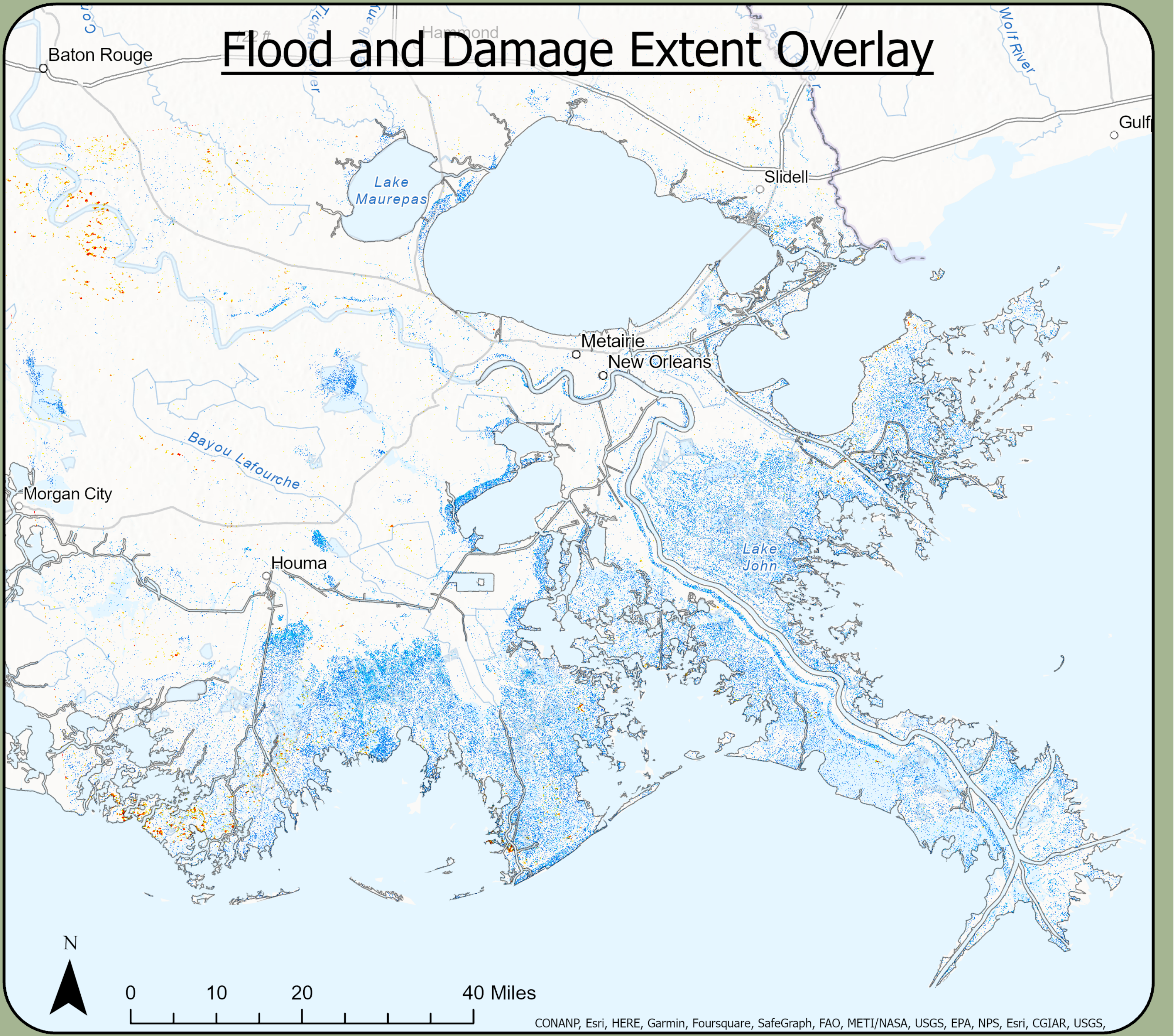


Results: Damage Mapping

Results: Combined

Looks like I might have set my minimum positive threshold for the damage map coherence differences a little too high.

The damage map is less reliable than the flood map.



Questions?

- Paper: Rapid flood and damage mapping using synthetic aperture radar in response to Typhoon Hagibis, Japan. Tay et al., 2020.