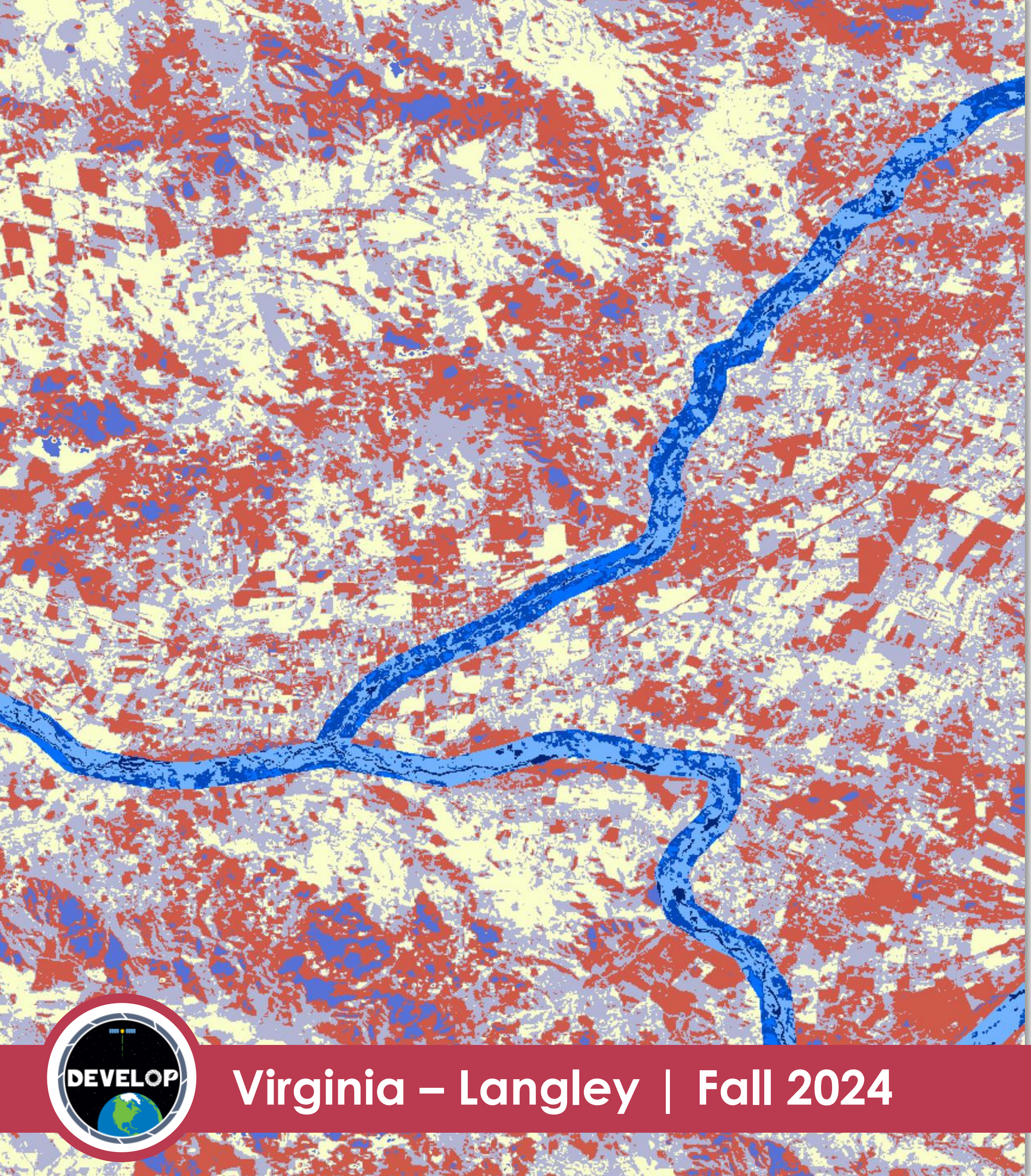

National Aeronautics and
Space Administration

CHILE METROPOLITAN REGION DISASTERS

Enhancing Authority Response to Storm Floods in Chile Leveraging Automatic Satellite Image Processing

Isabella Giordano
Viviana Bravo Ortiz
Jackie Encinas
Patrick O'Shea

Virginia – Langley | Fall 2024

The Team

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Outline

Background

Community concerns, partners, study area & period

Objectives

Addressing partner and project goals

Methodology

Earth observations and data analysis

Results

Findings, errors, and uncertainties

Conclusion

Feasibility and acknowledgements

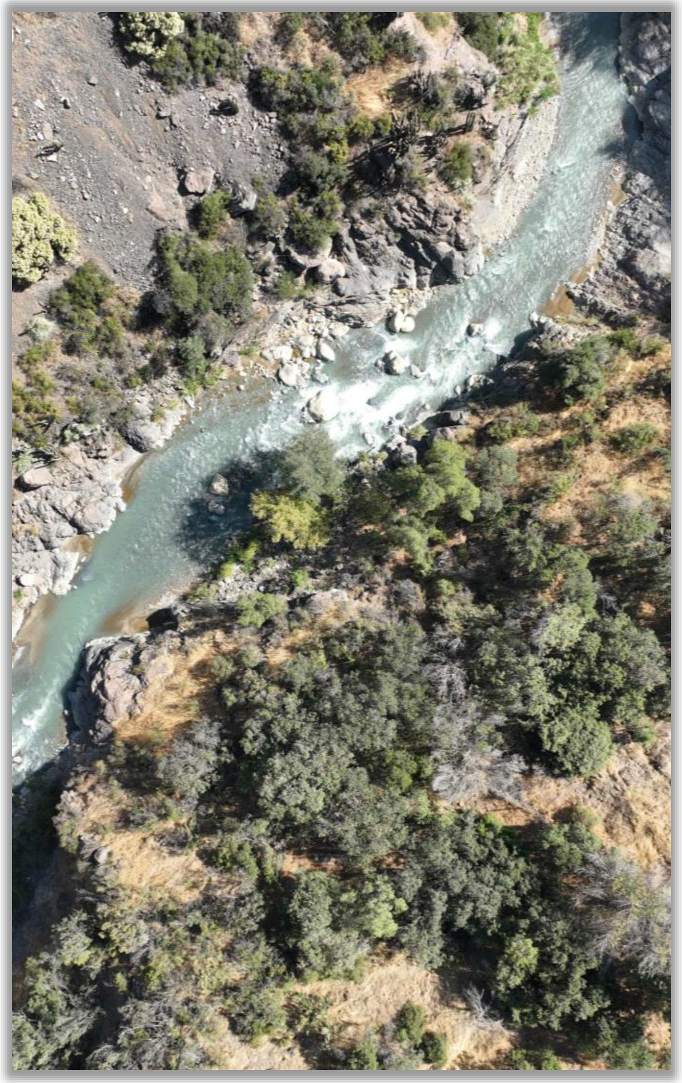
Background – Flooding In Chile

1.2%

Yearly loss of annual GDP due to disaster relief efforts

Image credits: CIREN

Partners



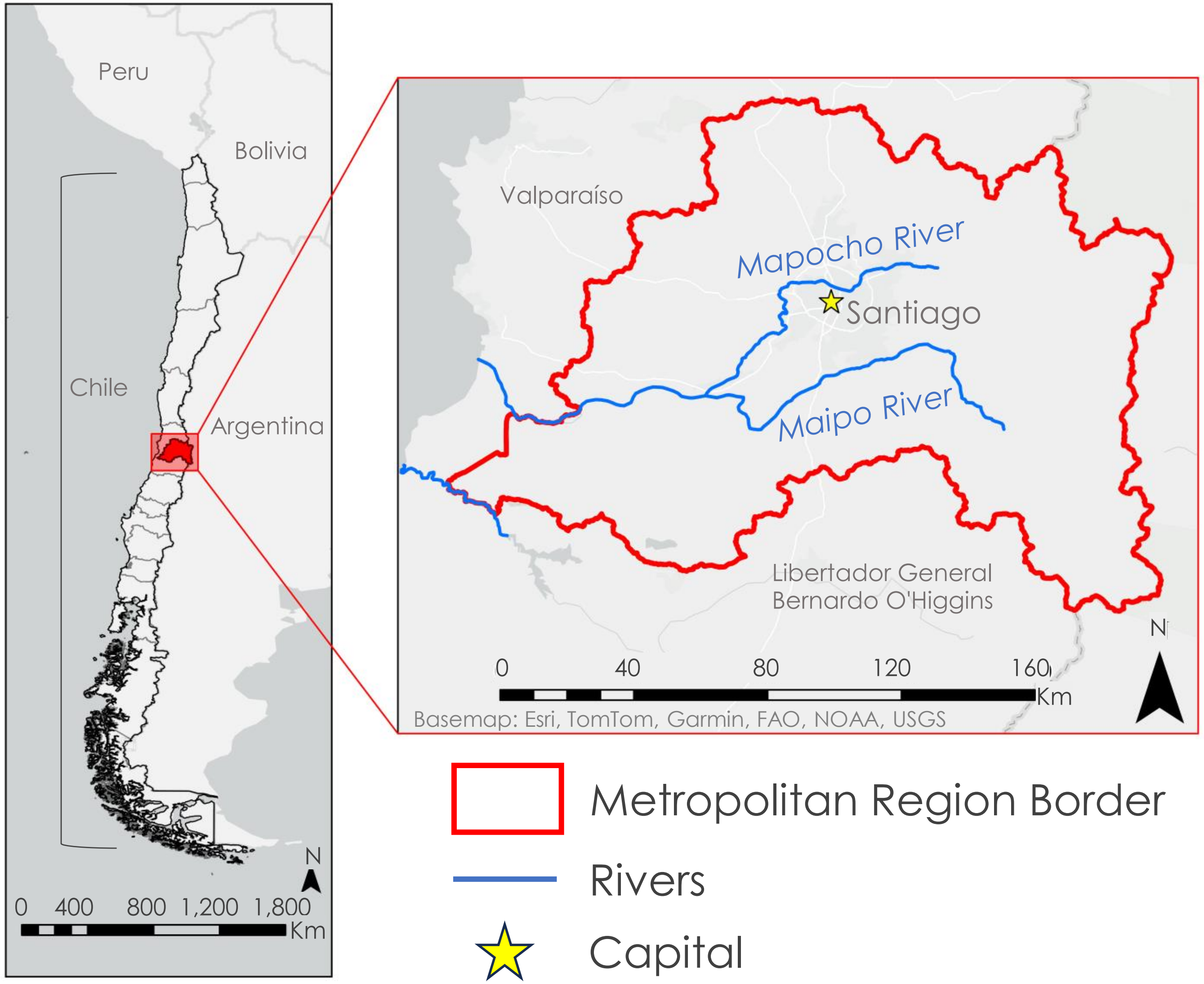
CIREN & Embassy of Chile, Agricultural Office

Research and **manage** Chile’s natural resources

Use GIS and remote sensing for **decision-making** and **sharing information** with stakeholders

Image credits: CIREN

Study Area and Period



Santiago Metropolitan Region, Chile

2021-2023

Objectives

Estimate flood extent within the Metro Region using a hydraulic model

Identify flooded areas in the Region using optical and radar datasets

Assess the feasibility of these methods to map flood extent in the Region

Earth Observations

Image credits: NASA, Rama

Hydraulic Modeling with HEC-RAS

HEC-RAS is a free hydraulic modeling platform created by the Army Corp of Engineers

The model supports **two-dimensional unsteady flow modeling** and GIS integration

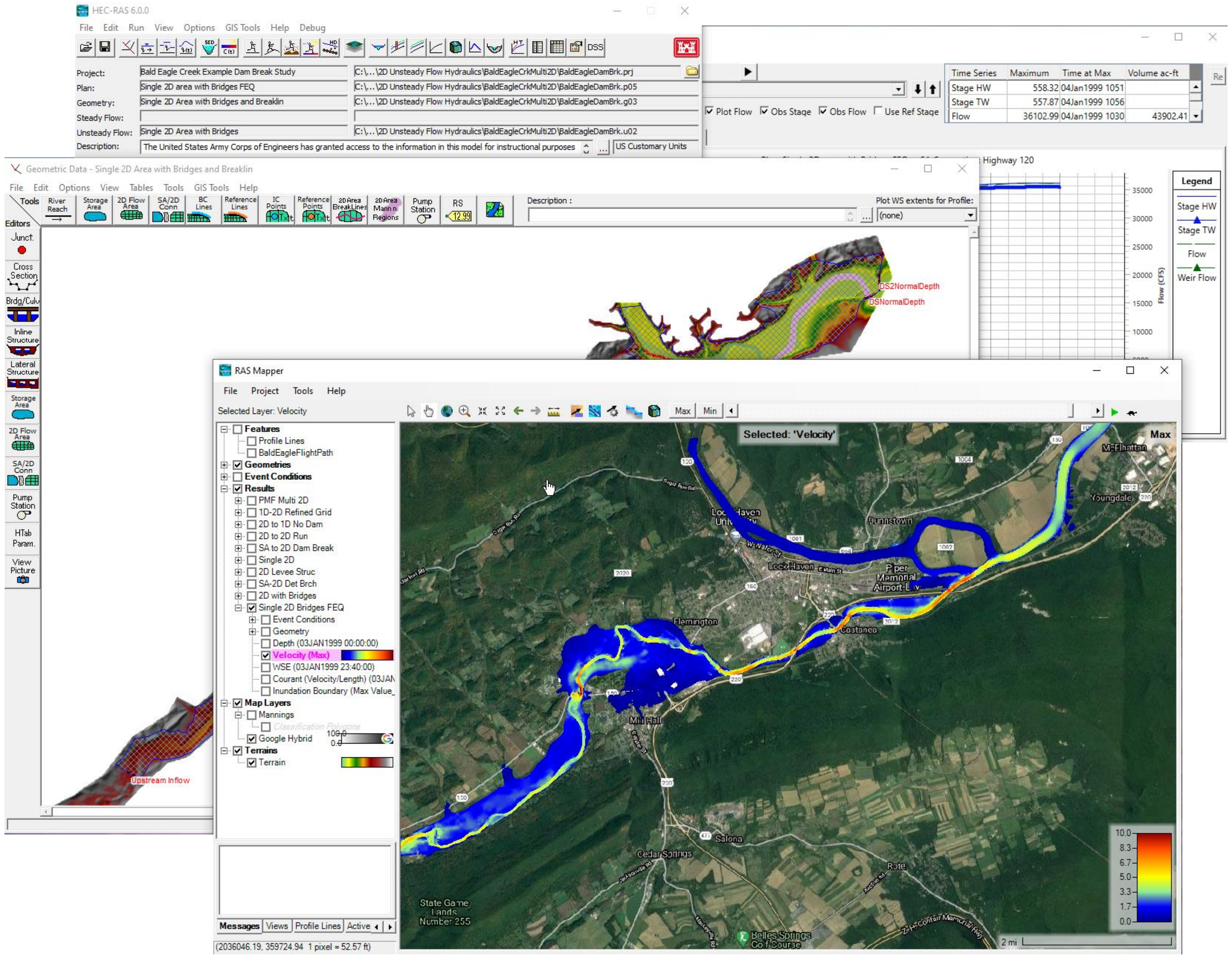


Image credits: USACE

Hydraulic Model Workflow

Data Acquisition

- Stream Gauge Information
- SRTM Digital Terrain Model (DTM)
- Land Cover Polygons

Data Processing

- Construct and Refine 2-D Model Grid
- Create Manning's *n* Layer From Polygons
- Create Flow File Using Gauge Data and Stream Slope
- Create Unsteady Flow Simulations for Jan 2021 and Aug 2023 Events

Data Analysis

- Summarize Hydraulic Model Statistics
- Evaluate Elevation Trend of Floodplain Width
- Compare Modeled and Official Floodplain

Hydraulic Modeling Results

Model Simulation Summary Table		
Statistic	**1/29/2021 Simulation**	**8/23/2023 Simulation**
Max Observed Velocity (m/s)	**23.0**	**15.7**
Max Observed Discharge (m^3/s)	**495.1**	**418.5**
Max Observed Depth (m)	**6.2**	**6.0**
Max Floodplain Width (m)	**185.7**	**119.3**
Average Floodplain Width (m)	**89.2**	**56.8**

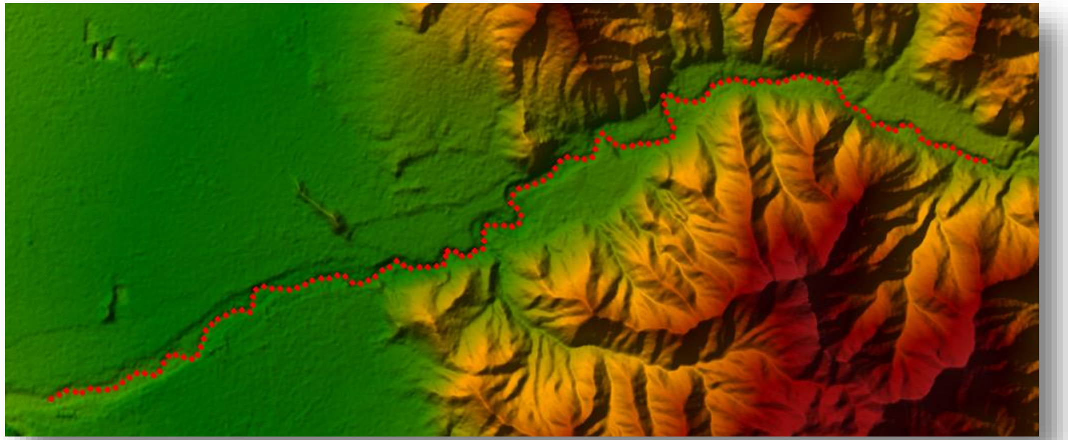
January 2021 Particle Tracing

August 2023 Particle Tracing

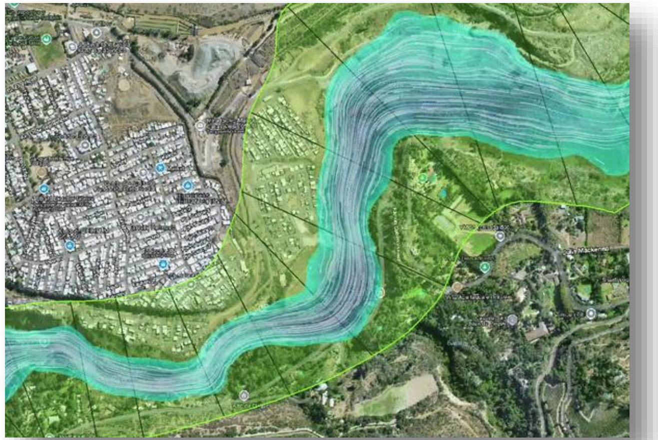
Basemap: Google Hybrid, Map data 2015 Google

Hydraulic Modeling Results

200-Meter Sampling Points



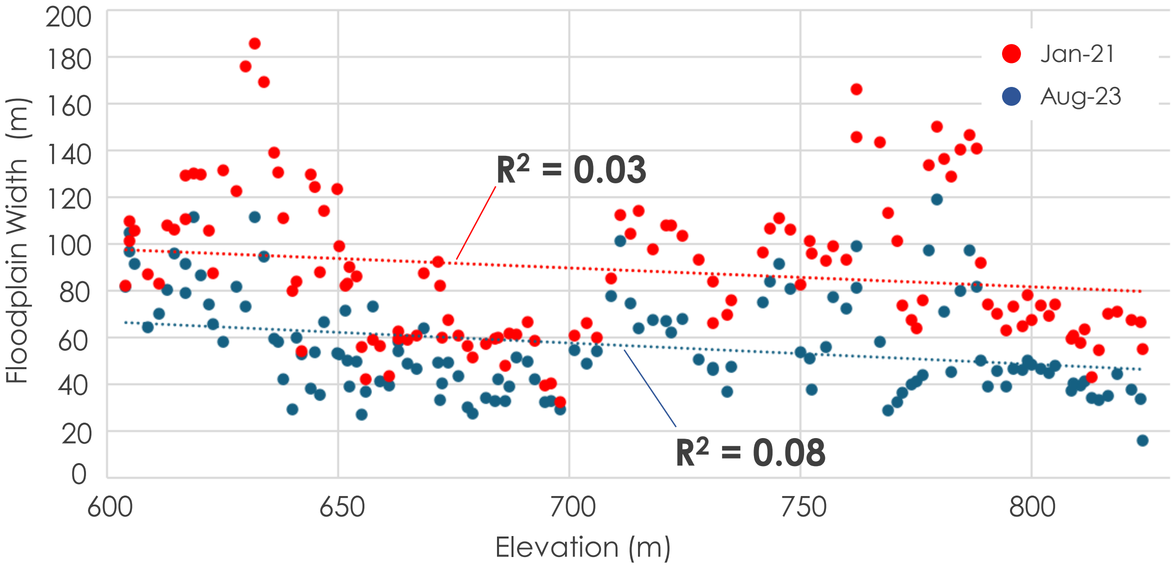
Model – CIREN Floodplain Comparison



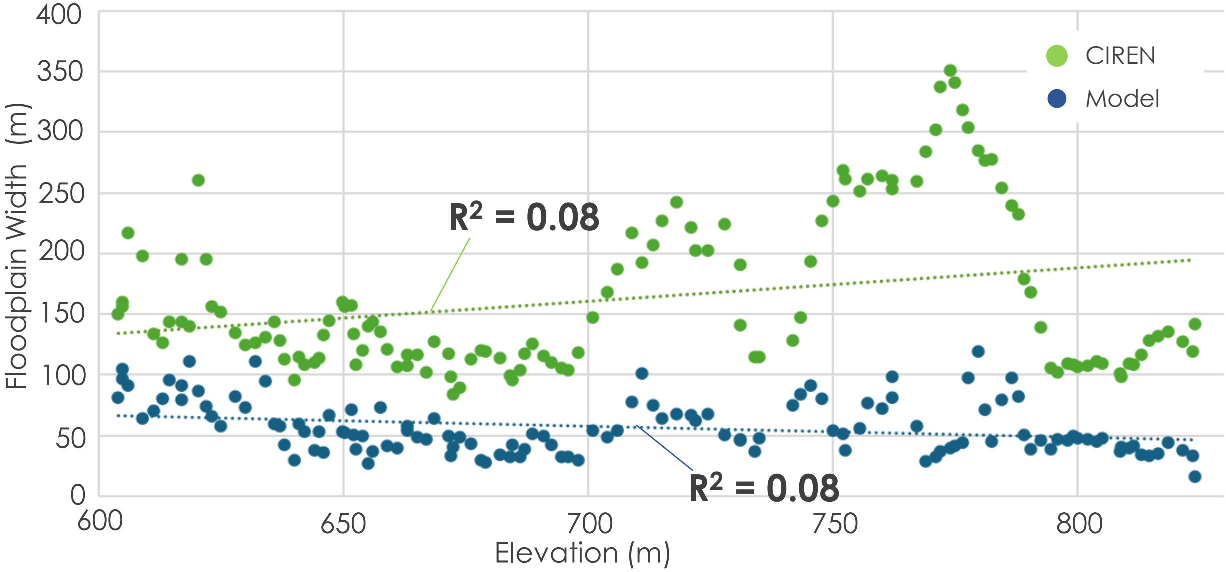
Basemap: Google Hybrid, Map data 2015 Google

Model vs CIREN Floodplain Differences (m)
Max Difference
310.5
Min Difference
15.4
Average Difference
106.4

2021 and 2023 Model Floodplain Width with Elevation



2023 Floodplain Width Model – CIREN Comparison



Optical Datasets Workflow

Data Acquisition

Landsat 8 OLI
Landsat 9 OLI-2

Dates Acquired

Aug. 6 & 30, 2023

Sentinel-2 MSI

Dates Acquired

Jan. 13 & Feb. 2, 2021

Aug. 6 & 26, 2023

Data Processing

Mosaic and clip raster to study area

Apply snow & cloud mask

Calculate NDWI

$$\mathrm{NDWI} = \frac{\mathrm{Green} - \mathrm{NIR}}{\mathrm{Green} + \mathrm{NIR}}$$

Data Analysis

Calculate NDWI Difference

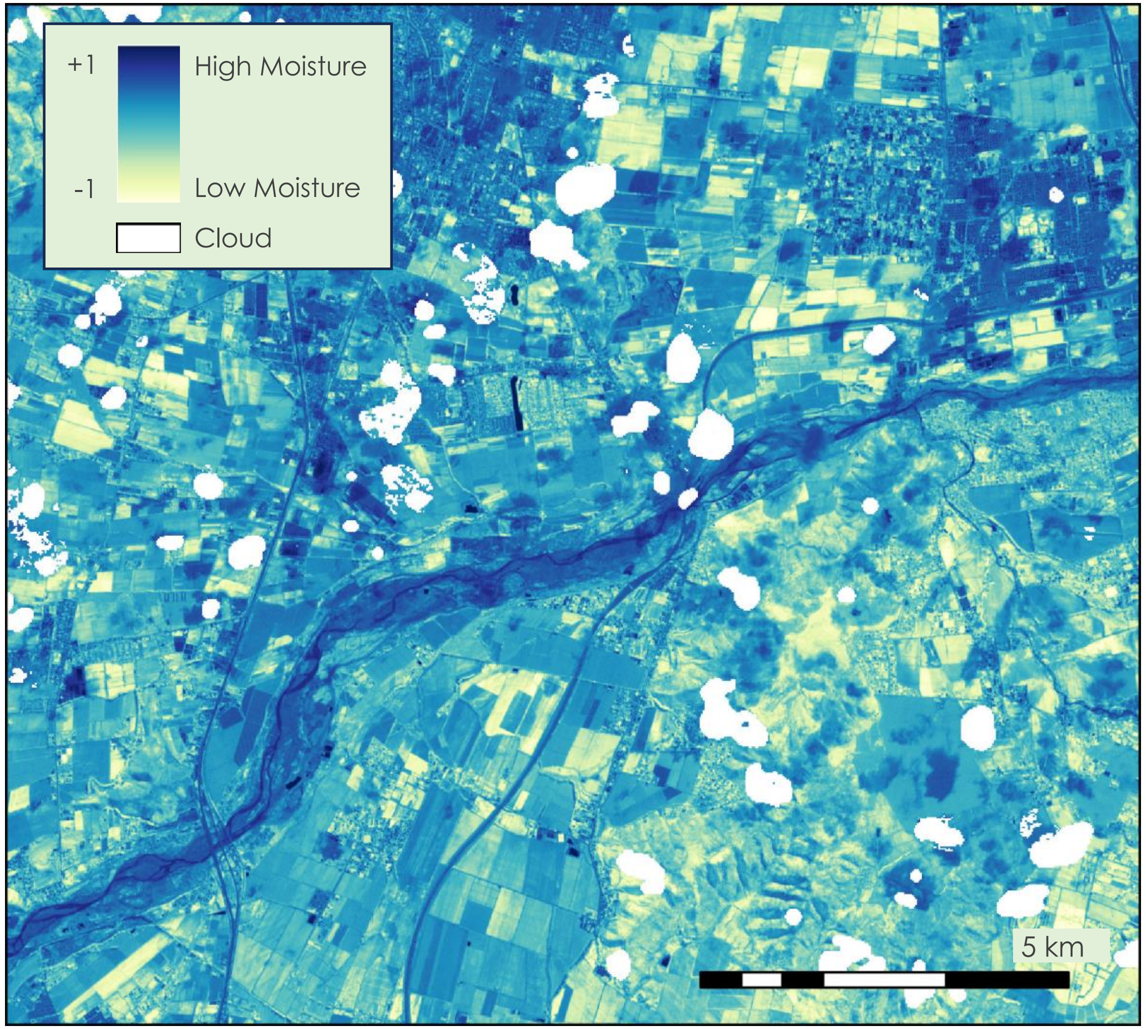
$$\Delta\mathrm{NDWI} = \mathrm{NDWI}_{\text{Post-Flood}} - \mathrm{NDWI}_{\text{Pre-Flood}}$$

Output

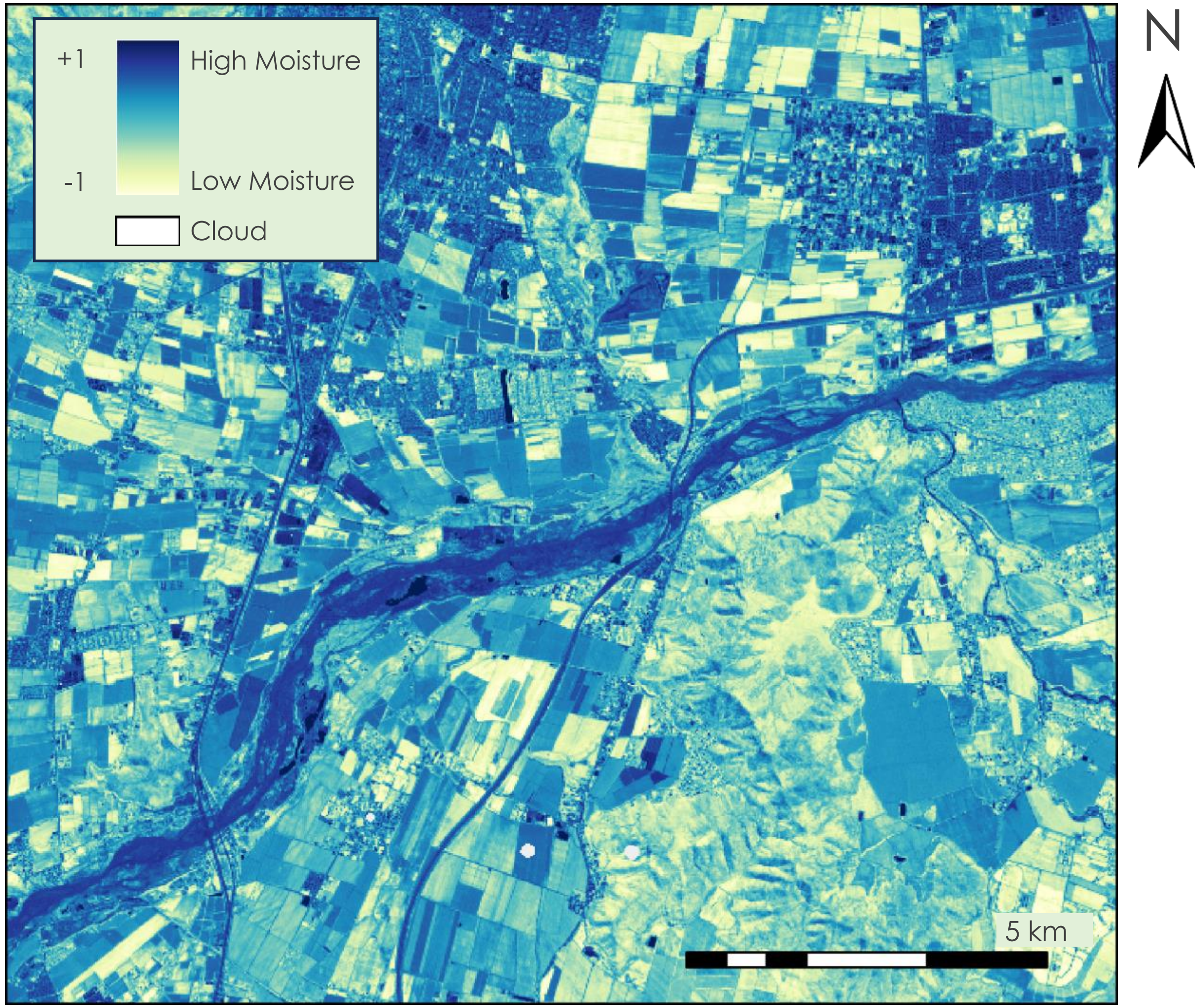
Flood Impact Assessment Maps

NDWI Assessment – Sentinel-2 MSI

Pre-Flood NDWI (August 6, 2023)



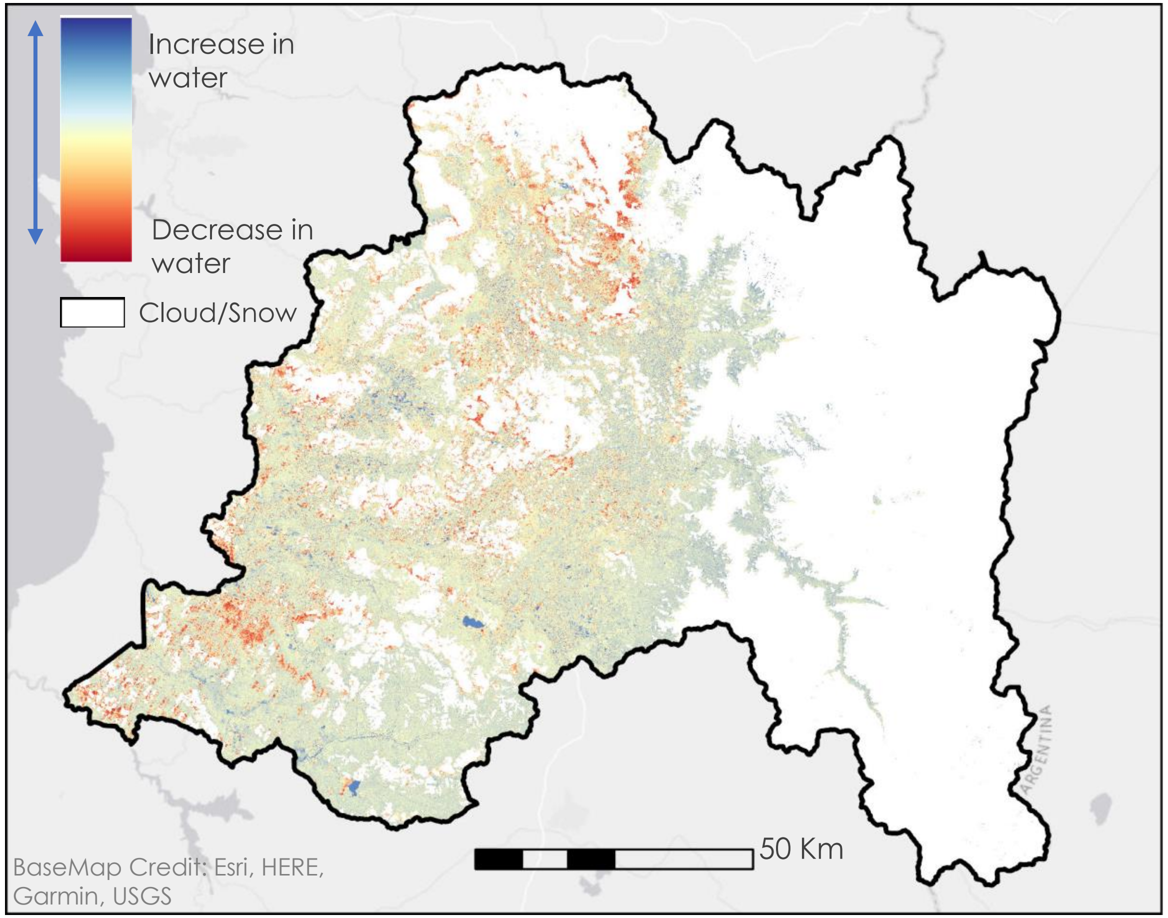
Post-Flood NDWI (August 26, 2023)



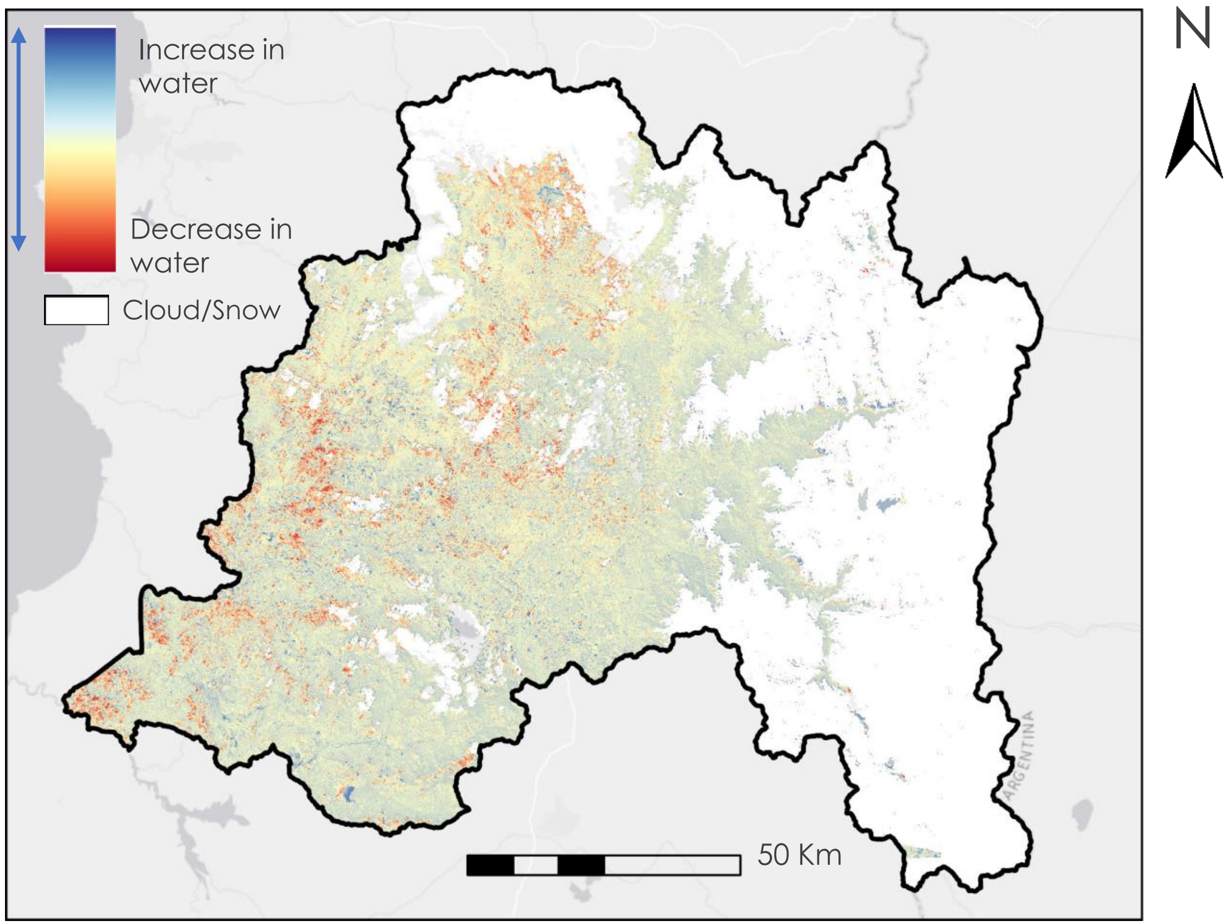
Basemap: Esri, HERE, Garmin, USGS

Flood Impact Assessment

NDWI Difference (**Sentinel-2 MSI**)



NDWI Difference (**Landsat 8 OLI/9 OLI-2**)



Flood event - August 2023

Radar Dataset Workflow

Data Acquisition

Sentinel-1 C-SAR GRD

<u>Dates Acquired</u>

Jan. 26 & Feb. 1, 2021

Jun. 12 & 26, 2023

Data Processing

- **Set backscatter to gamma nought**
- **Match DEM to imagery**
- **Set pixel spacing**
- **Set scale to power**
- **Clip to study area**

Data Analysis

- **Apply Log Difference Tool from ASF ArcGIS Toolbox**
- **Visualize positive and negative change**

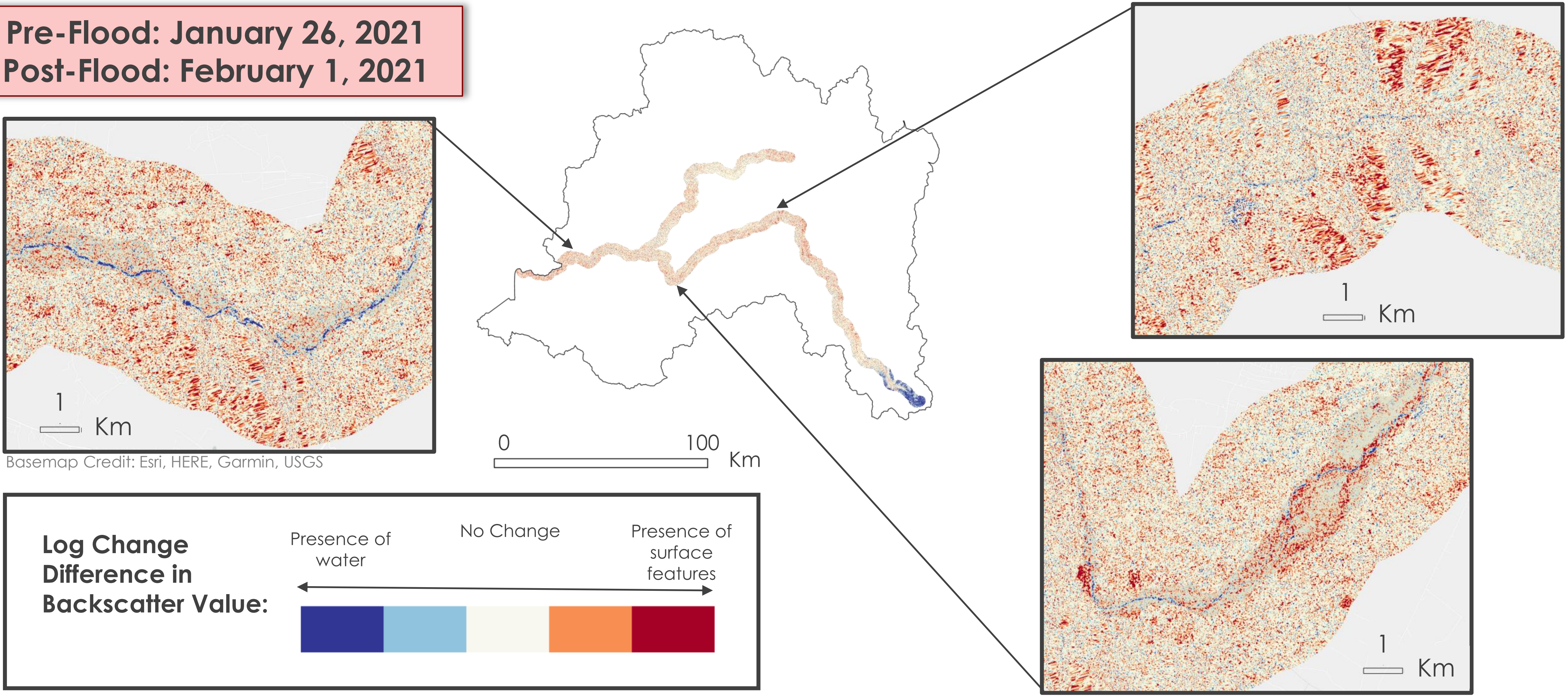
Output

Log Difference Raster

Using SAR to Detect Flooding

Flood Event: January 29, 2021

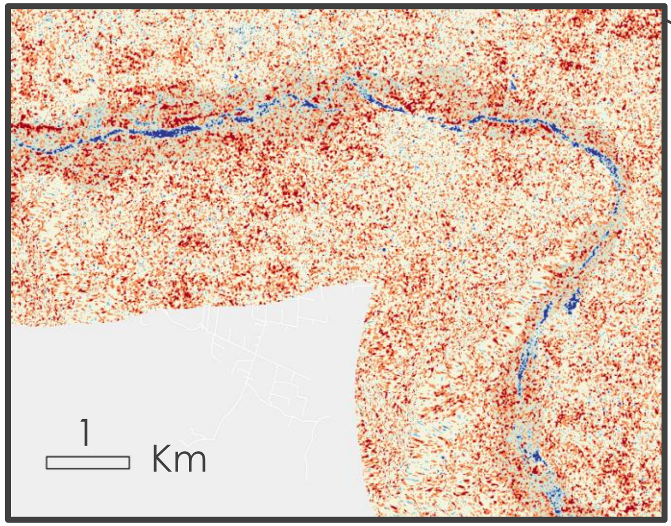
Pre-Flood: January 26, 2021
Post-Flood: February 1, 2021



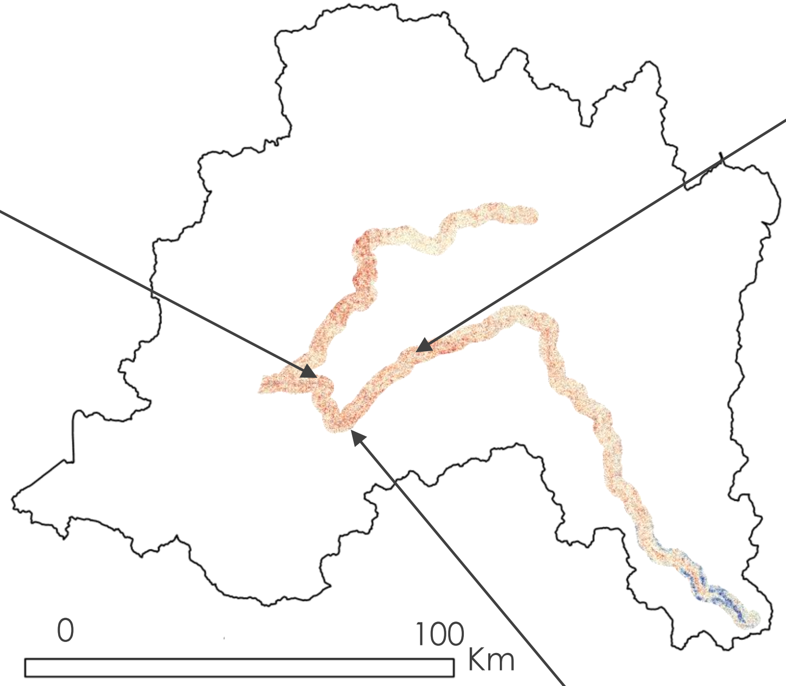
Using SAR to Detect Flooding

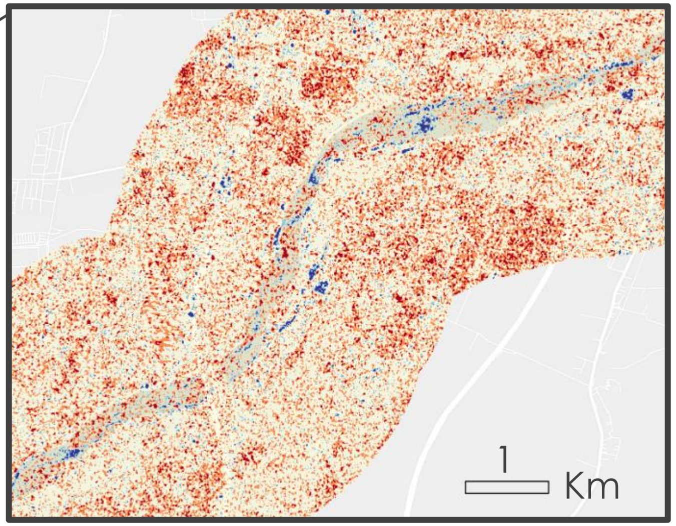
Flood Event: June 23, 2023

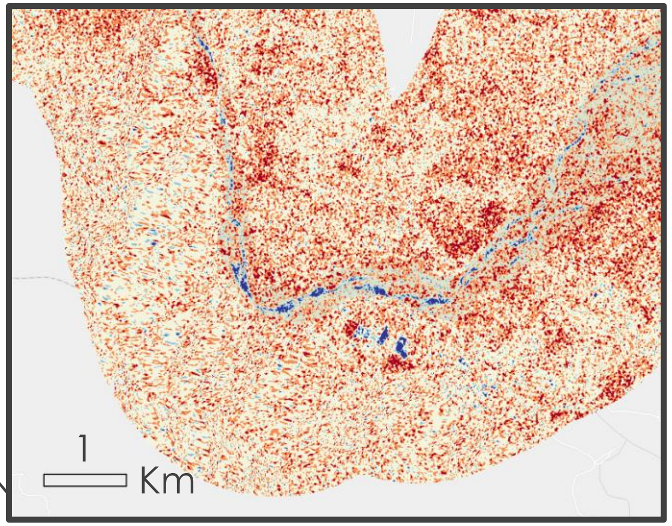
Pre-Flood: June 14, 2023
Post-Flood: June 26, 2023



Basemap Credit: Esri, HERE, Garmin, USGS





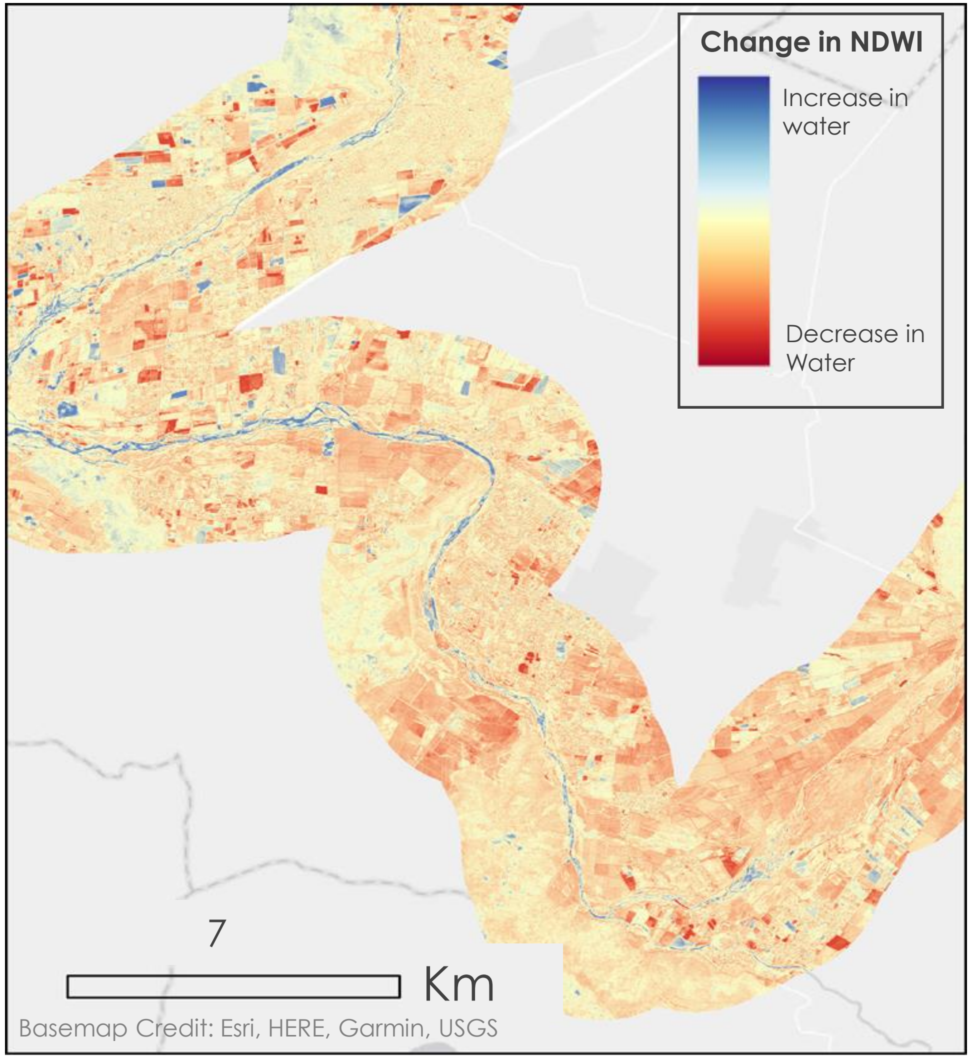


Log Change Difference in Backscatter Value:

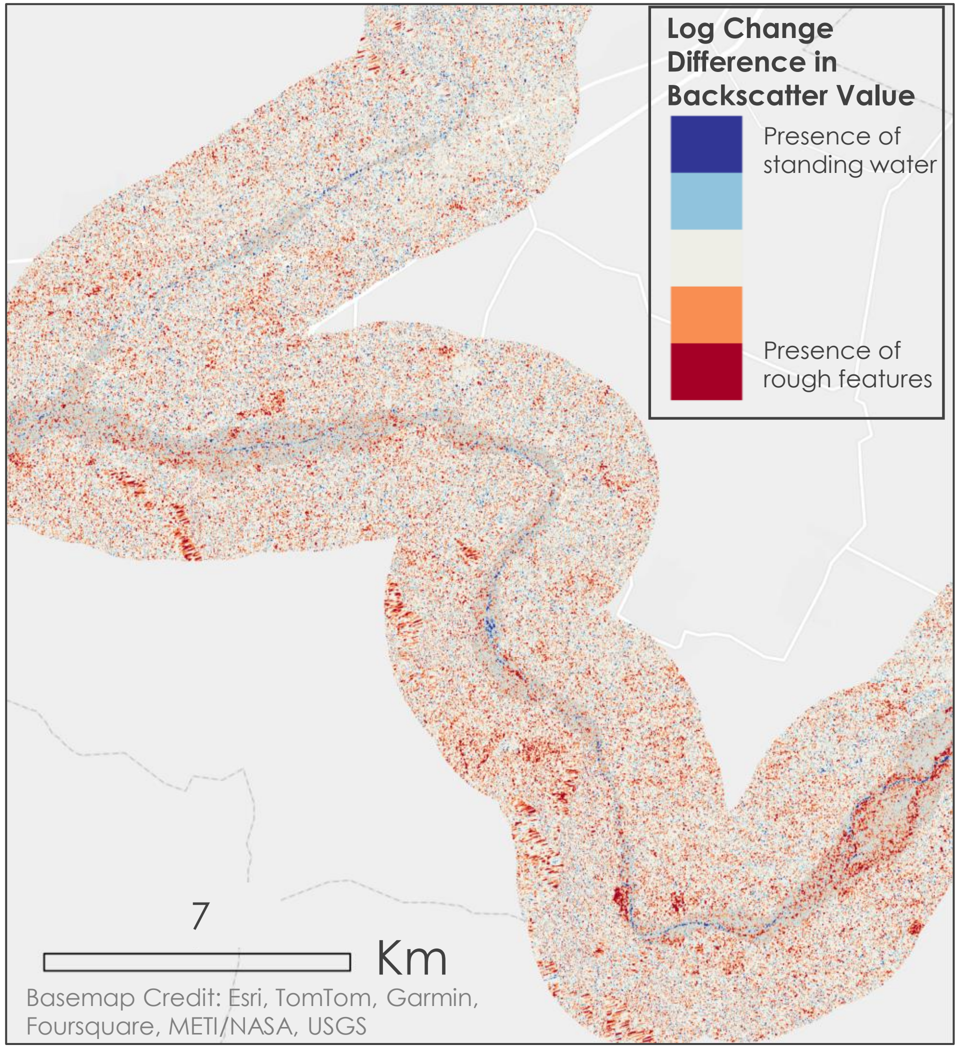
Presence of water — No Change — Presence of surface features

January 2021 Flood Event Comparison

Optical
January 13 & February 2, 2021



Radar
January 26 & February 1, 2021



Feasibility and Partner Implementation

Hydraulic Modeling is a **feasible** method for predicting flood characteristics.

Our methods for using **optical data** and **radar data** are **feasible** for flood monitoring and post-flood assessment, **with limitations.**

CIREN can **enhance** the hydraulic model with **local conditions** to improve estimations. Earth observations can be used, but **with consideration**.

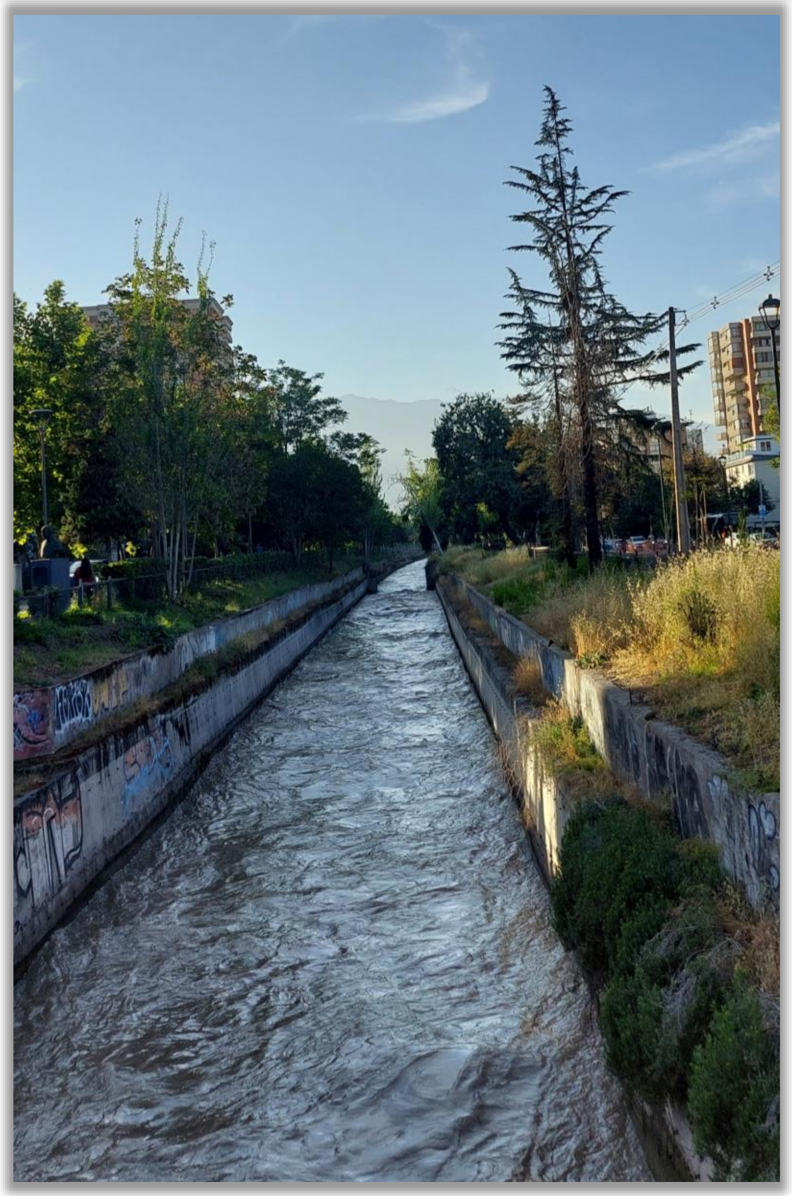


Image credit: CIREN

Limitations

Hydraulic Modeling

- Model run using diffusion wave, not full momentum equations
- Active channel scour and additional runoff not modeled
- Hydraulic controls from bridges and dams not accounted for

Radar

- Processing difficulties
- Temporal resolution and flood dates
- Spatial resolution and topography
- Effects of topography and city buildings

Optical

- Temporal resolution and flood dates
- Spatial resolution and small water bodies
- Vegetation and seasonality
- Effect of turbidity and sediment on reflectance readings

Conclusions

We were able to **resolve** flood extents, **evaluate** flooding trends with elevation, and **compare** Earth observation methods for Riverine flood mapping.

We found that **hydraulic modeling is a feasible method** for characterizing riverine floods, while **optical imagery and SAR are less feasible** given issues with data quality and temporal constraints .

Image credit: CIREN

Acknowledgments

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- **Dr. Kenton Ross** (Langley Research Center)
- **Alyson Bergamini** (Virginia – Langley)
- **Brooklyn Appling** (Virginia – Langley)

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