

# Flooding in the desert: Assessing the value of satellite observations of inundation from the North American Monsoon with the Pima County Regional Flood Control District

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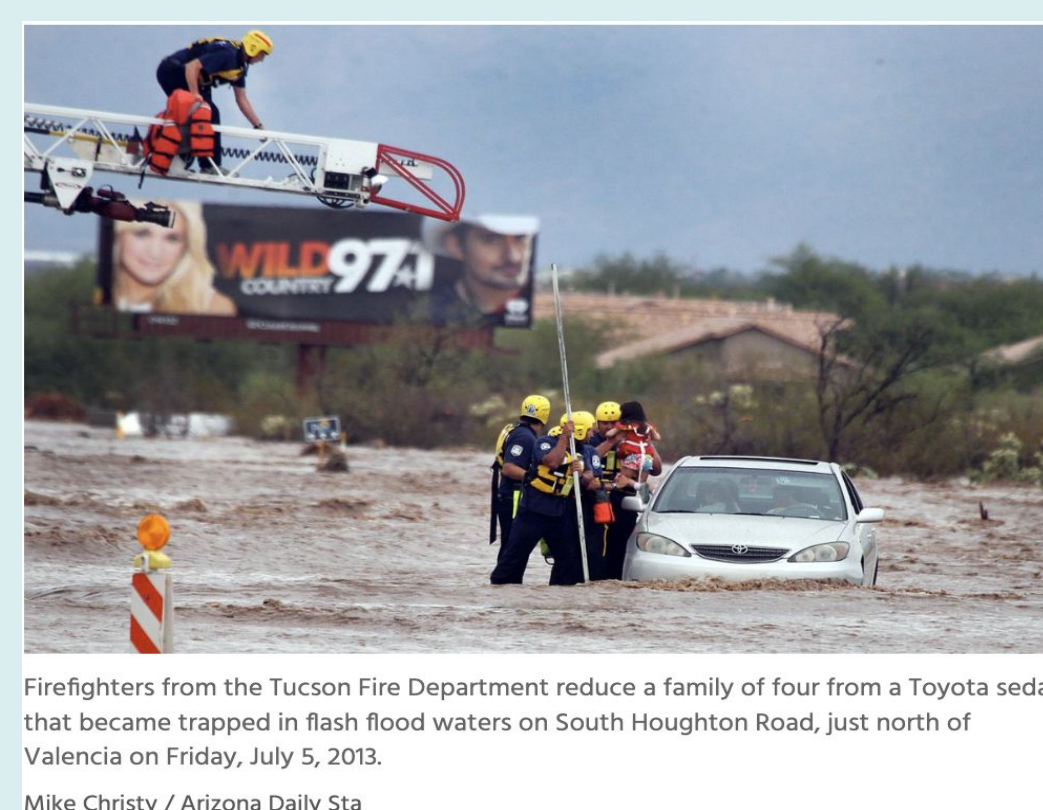
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## Can satellite observations show floods outside the 100-year floodplain?

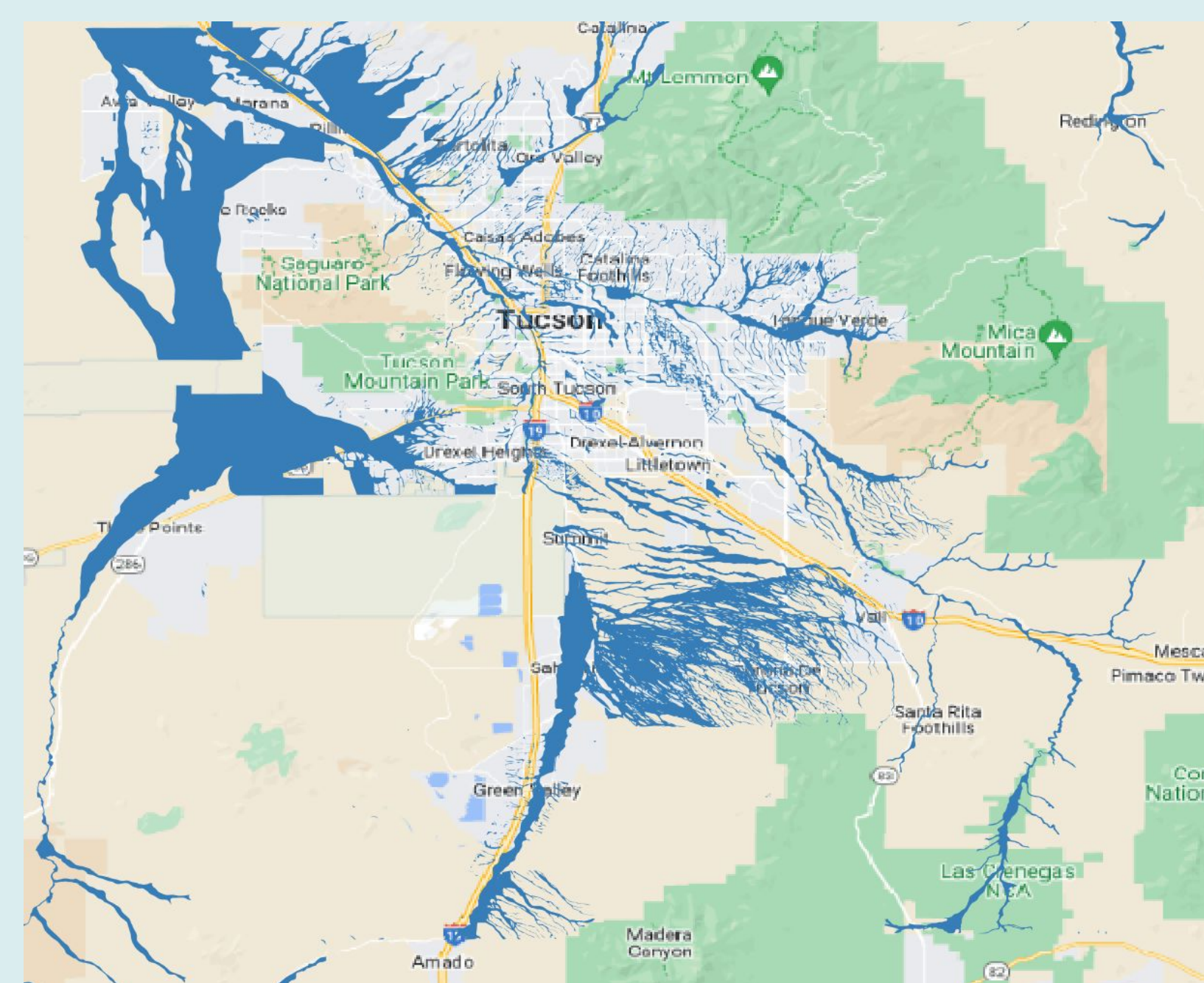


Microson clouds gather over the cactus forest in the Saguaro National Park West, Wednesday, August 10, 2016. Kelly Presnell / Arizona Daily Star



Firefighters from the Tucson Fire Department rescue a family of four from a Toyota sedan that became trapped in flash flood waters on South Houghton Road, just north of Valencia on Friday, July 5, 2013. Mike Christy / Arizona Daily Star

100-year floodplains in Tucson Arizona mapped by FEMA, the County, and developers



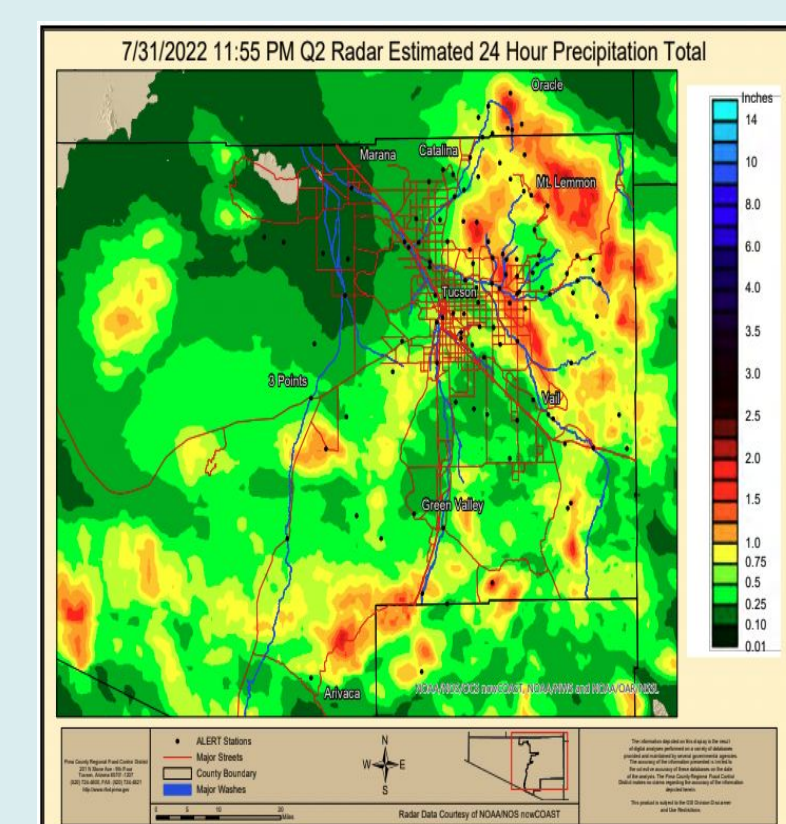
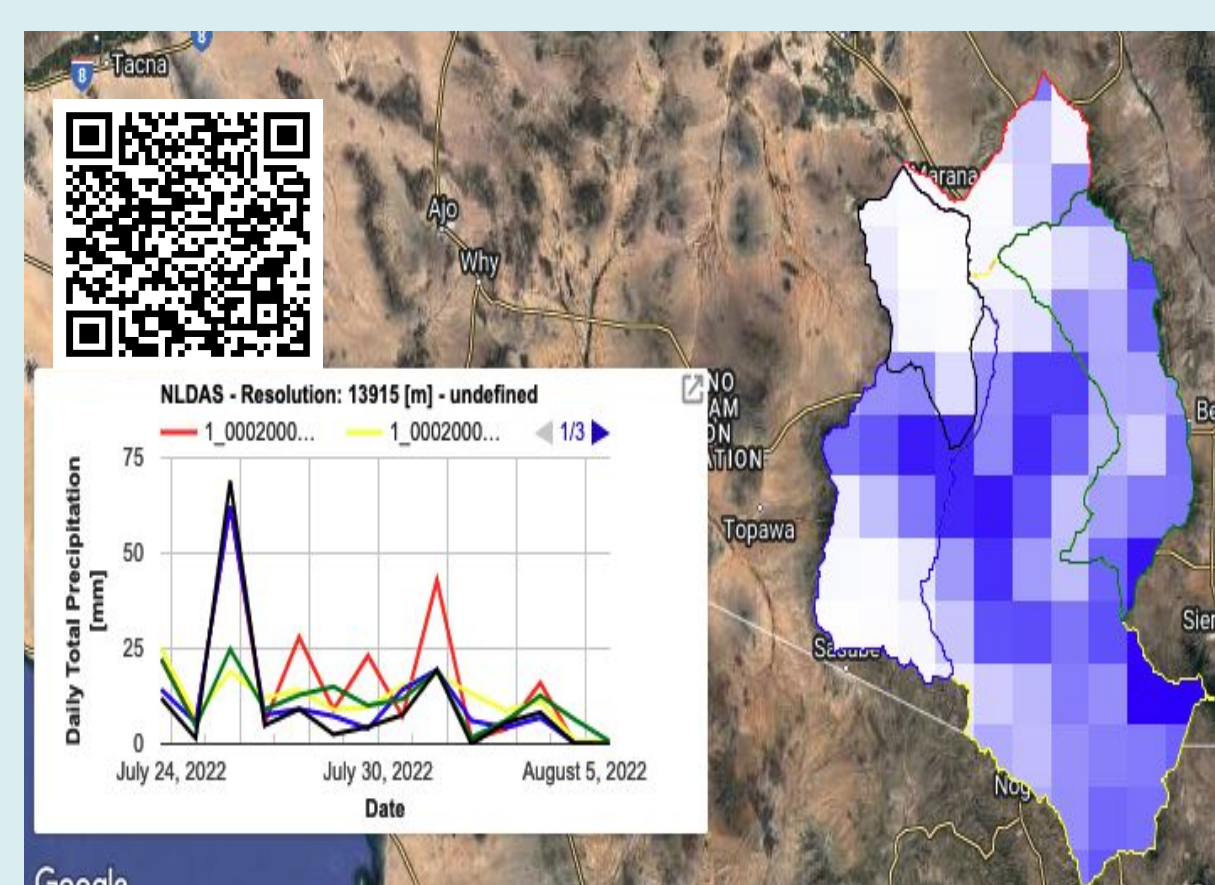
-It floods in the desert! The North American Monsoon brings intense storms and sometimes flash floods each summer. 2021 was the third wettest on record in Tucson (12.79 inches).

-broad, shallow floodplains here have poorly defined distributary flow networks, making flood water hard to model. More extreme precipitation with climate change also broadens floodplains.

-updating flood maps important for insurance access, targeting buyouts, and investing in flood resilience

## Finding peak flood with precipitation in 2021 and 2022

Google Earth Engine

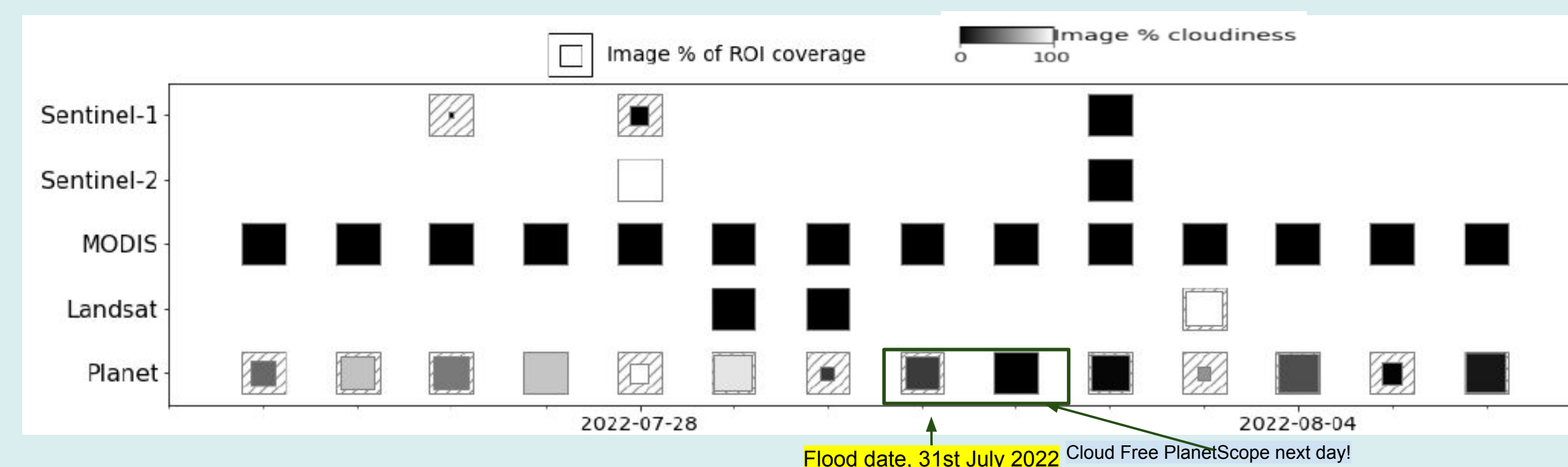


- 23rd July, 2020
- 23rd July, 2021
- 1st January, 2022
- 29th March, 2022
- 31st July, 2022
- 20th August, 2022
- 11th, September, 2022

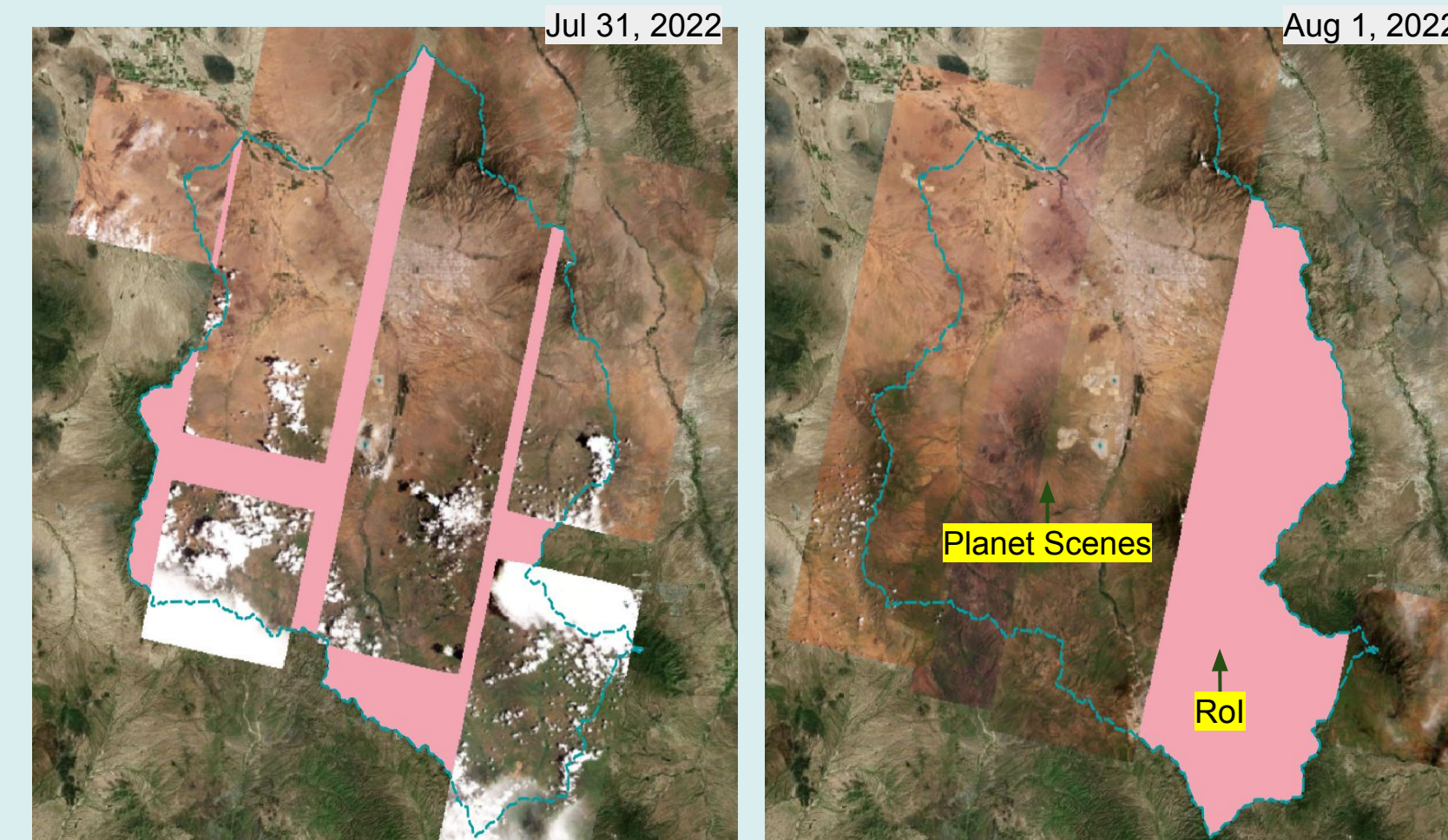
Pima County identified 10 flood events, of which 7 had with likely satellite coverage in the past 2 years. With the help of Earth Engine, spatial and temporal precipitation (NLDAS) time series to understand when and where the peak flood event likely occurred to search for imagery.

PUBLIC EARTH ENGINE APP TO GENERATE HYETOGRAPHS/ MAPS:  
<https://giezendanner.users.earthengine.app/view/pimacountyrainfallmonitoringnlds>

## Finding cloud free images at peak-temporal/spatial frequency makes Planetscope more valuable than other sensors



For each flood event, we use a python script to generate a graph showing the available remote sensing images, along with the percentage of overlap with the Region of Interest (ROI) and % of cloudiness. For successful flood mapping in the desert, consecutive cloud free images are needed to map rapid soil moisture change, and only Planetscope can provide that frequency.



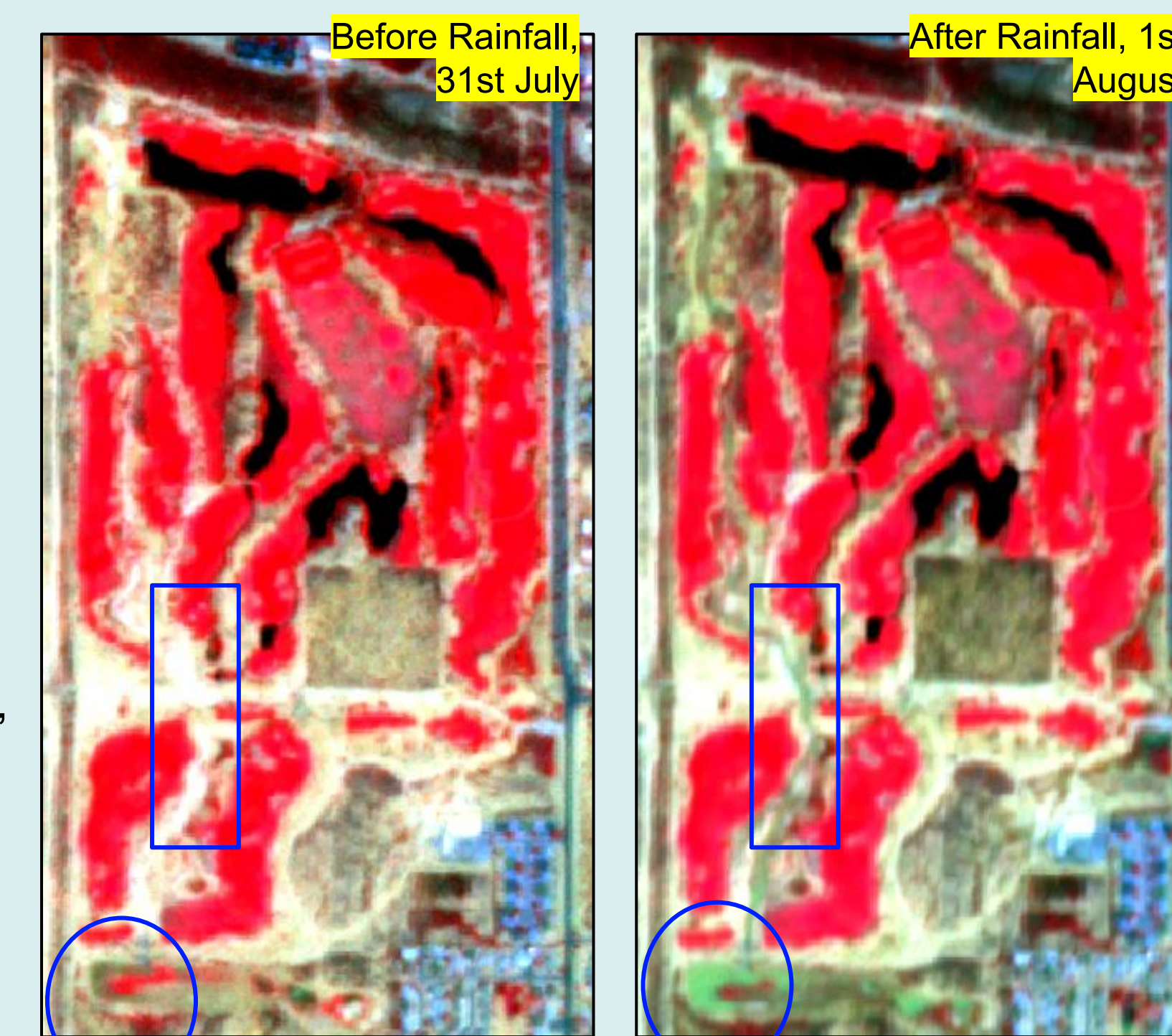
Example of two consecutive days covering a flood event, along with the available Planetscope images for the ROI.

## Water recedes fast in the desert!

Of 10 floods examined, only 7 had suitable cloud-free imagery with visible standing water

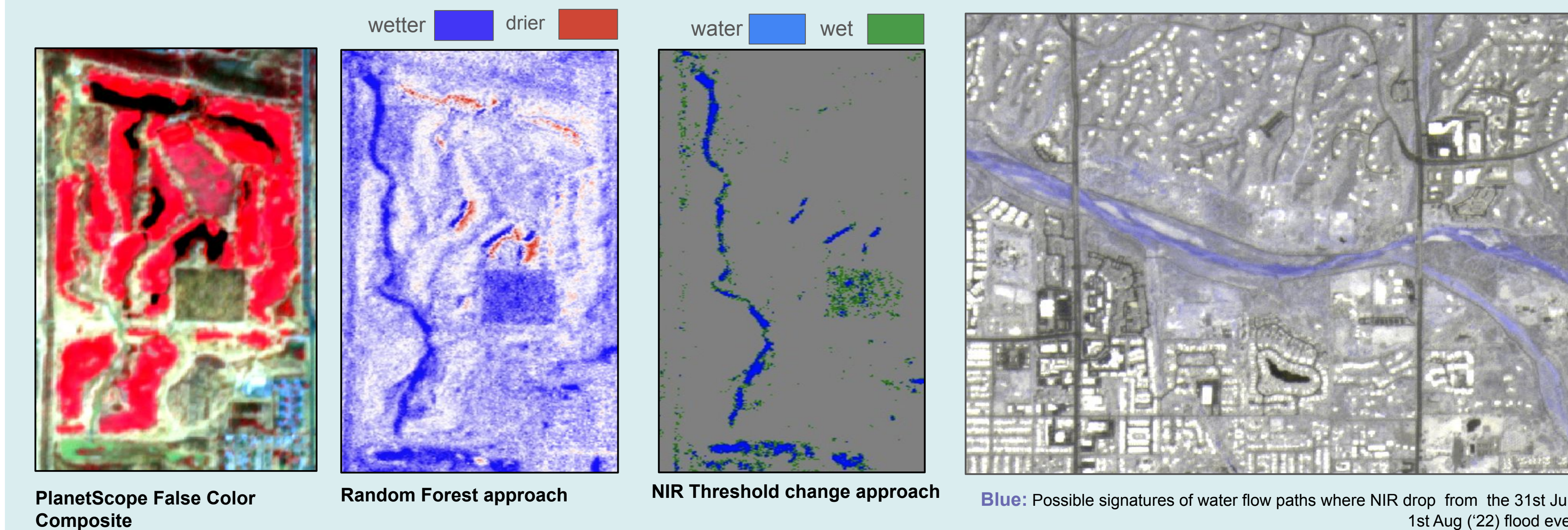
Monsoon floods occur in late afternoon and evening, but most satellite overpasses occur around 10 am, 12-20 hours after rainfall peaks

Most water has receded before satellite overpass (except in insets, green water), but some standing water remains matching modeled floodplains



Planetscope False Color Image Composite (NIR, R, G) Sewailo Golf Club, Pima County, Arizona

## Can wet soils show us where the water went?

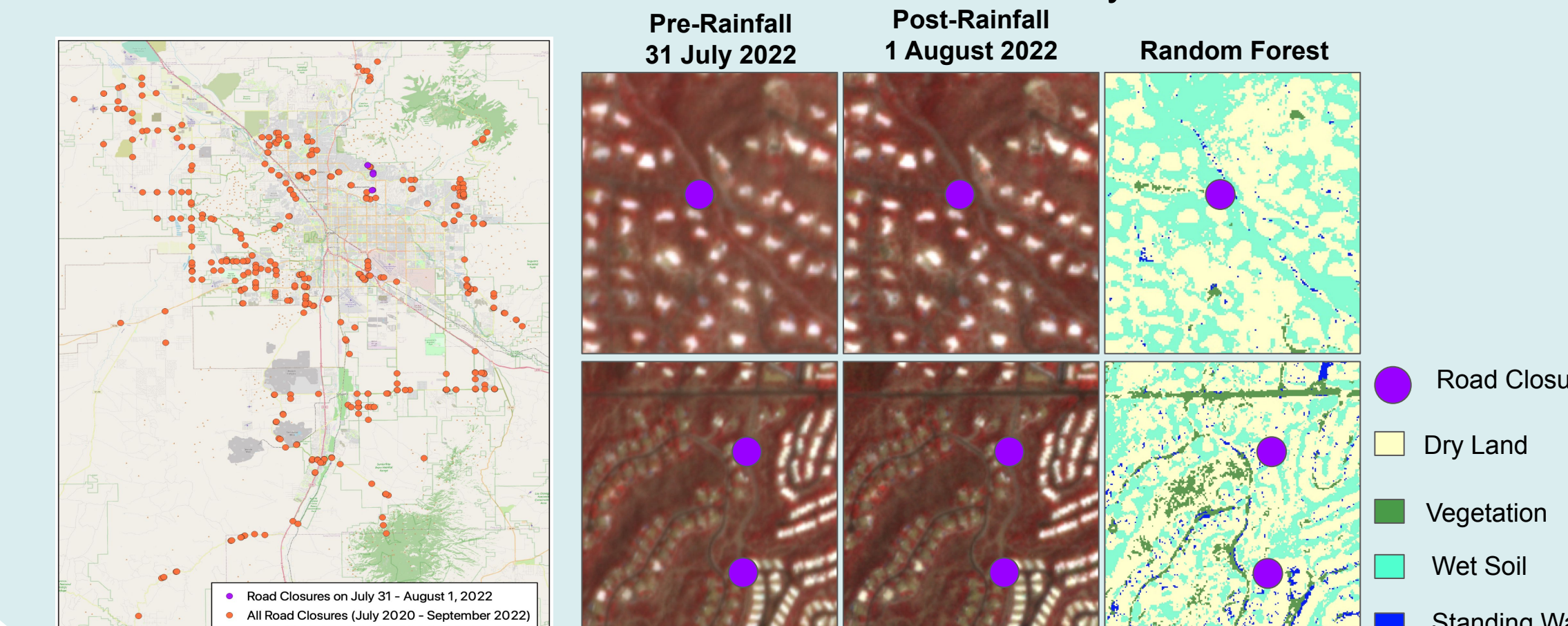


Changes in the Near-Infrared (NIR) band where reflectance decreases the day following floods reveal **wet soil** in addition to **standing water**. Threshold NIR change or random forest approaches are promising to differentiate classes of standing water versus wet soils where water flowed.

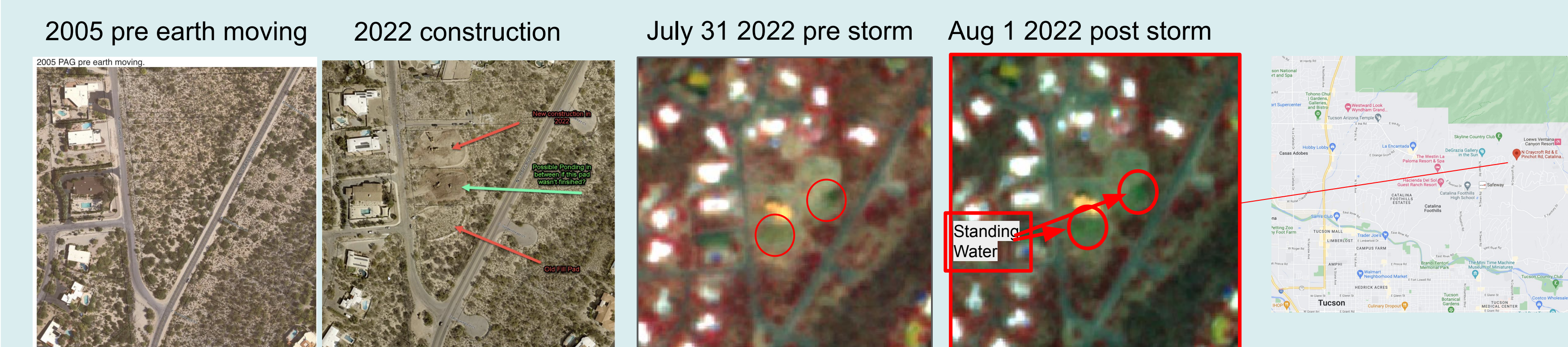
## Multi-approach model validation with road closures and hand labeled Planetscope data

The first approach is to assess observable floods using road closure points. Leading up to expected flooding, roads are closed to reduce losses and minimize harm. We use the point data locations and dates of closure on road segments to estimate the percent of flooded roads that satellites classifications identify as flooded.

The second approach is image classification accuracy assessment, where overall accuracy, commission and omission errors will be calculated. To conduct the accuracy assessment of observed flooding, we will visually interpret Planetscope imagery to create hand labeled annotations of flood and wet soil and compare with the model output. We will use the road closure points to determine locations where labels will be generated, and subsequently used to validate model accuracy.



## Changing flow paths and flood patterns in construction sites



Changing flow paths and flood water potentially due to new construction can be observed with daily Planetscope imagery. Left shows an example of water retention on an unfinished construction site property after August 1 2022 heavy rain in Northern Tucson in the Catalina foothills.