Technical Memorandum: NASA Develop Group Study on the Black Rock Playa

Revision 2

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The National Aeronautics and Space Administration (NASA) Develop is a training program where NASA scientists work with college interns to use space-borne imagery systems to address land use problems and questions of concern to land management agencies. The Black Rock Field Office of the Winnemucca, Nevada, BLM requested NASA's assistance to look at surface deformation on the Black Rock Desert playa.

The questions the NASA team would attempt to answer are as follows:

- Is there dune/mound growth out on the Black Rock Desert playa?
- What is the amount of surface deformation from the Burning Man Event on the Black Rock Desert playa?

The team used satellite imagery from the Landsat program and C-band synthetic aperture radar (SAR) imagery from Sentinel-1. National Agriculture Imagery Program (NAIP) aerial imagery was also used in the study. The resolution of Landsat is 30 meters, Sentinel-1 is 15 to 30 meters in the horizontal direction, and NAIP is just under 1 meter. (Sentinel-1, when used in differential interferometry, has a resolution of centimeters in the vertical direction. While some may question the utility of these satellites given their resolution, earlier research has demonstrated that these can address the questions above (see Bodart et al. 2009; Paisley 1991).

For 2017, a time series of images from Sentinel-1 was created to examine the Black Rock Desert playa's surface. Sentinel-1 overflies the playa every 12 days. The NASA team found that the two major disturbances to the playa surface are when it floods (or the soil is saturated with water) and during the Burning Man Event. The footprint of Black Rock City is evident in the radar images several weeks after the Event.

Black Rock City is the largest human disturbance on the playa. While there are probably other activities that disturb the surface of the playa, they are not detected at the 15–30-meter resolution of the satellite imagery. This reaffirms some of the work by Tollerud and Fantel (2014), who examined surface roughness of the playa using C-band SAR from ENVISAT.

The Sentinel-1 time series also detected two dust storms—one in September and the other in November 2017—over the Event site and the rest of the playa after the Event. While ground-based radars have detected dust storms, this phenomenon has been little noted and little studied in space-based C-band SAR imagery (Williams et al. 2008; van den Broeke and Alsarraf 2016). One of SAR's utilities is that it can penetrate rainstorms and dust storms (Oazi 2016). One working hypothesis is that there was a high concentration of the dust in the air that was reflecting the radar signal.

Co-registering the SAR imagery from Sentinel-1, the coherence and correlation between images was calculated (see Slide 13 of the attachment below). The coherence between the Black Rock

City site before and after the Event was too low to perform differential interferometry. This is one technique that might have been able to determine how much soil is lost from wind erosion during the Burning Man Event; however, It is not a viable technique to determine this soil loss.

The NASA team created flood maps from 1997 through 2017 from the archive of Landsat imagery. While Quinn Lake forms each winter and spring, the Burning Man closure area does not always become submerged under floodwaters. Between 1997 and 2017, the Burning Man closure area was flooded only in 2002 and 2017.

From reviewing the literature on the geochemistry of the playa, "dunes" do not technically form on the playa nor on the playa's rim; this is because the playa is composed primarily of fine clays and silts. Dunes technically have a high sand content; the playa lacks the sand content. What forms on the playa's rim is technically a mound.

With the NAIP imagery, the NASA team looked at changes in the dune/mound field from 2000 to 2015 on the old western shoreline of the playa. There is some slight mound formation but nothing overly significant in terms of growth. The postulate is that the flooding of the playa may reduce mound formation; also, the mounds are suspected to be held in place by vegetation. Further research was done in 2018 to further look at mounds on the playa. Sub-meter drone imagery is being used to look not only at the mounds on the playa's rim, but also if mounds form on the playa's interior.

References

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Tollerud, Heather J., and Matthew S. Fantle. 2014. "The temporal variability of centimeter-scale surface roughness in a playa dust source: Synthetic aperture radar investigation of playa surface dynamics." *Remote Sensing of Environment* 154: 285–297.

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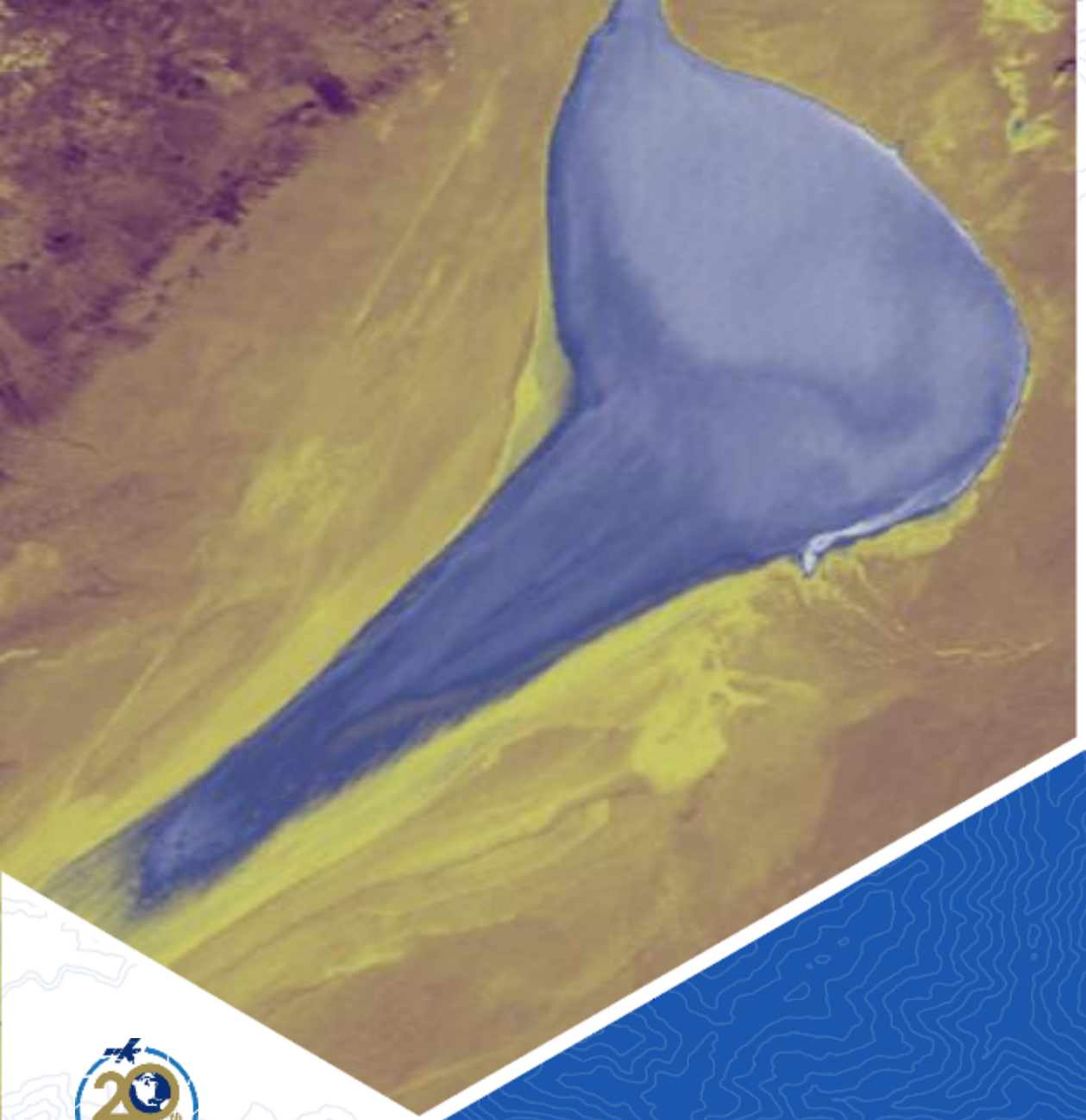

National Aeronautics and Space Administration

BLACK ROCK PLAYA URBAN DEVELOPMENT

A Multi-Sensor Approach to Determine the Impacts of Human Activity and Natural Surface Deformation on the Black Rock Playa, Nevada

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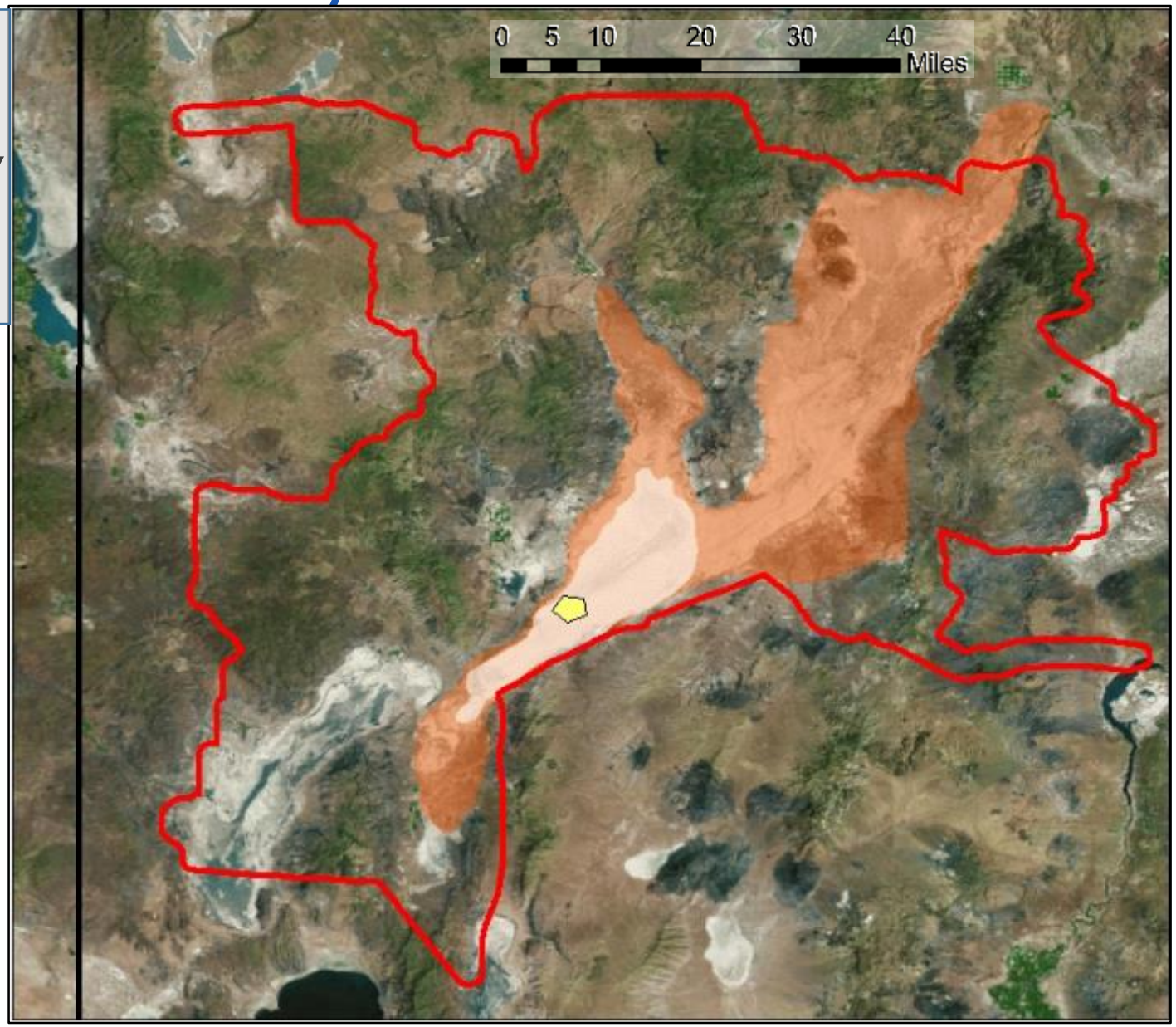
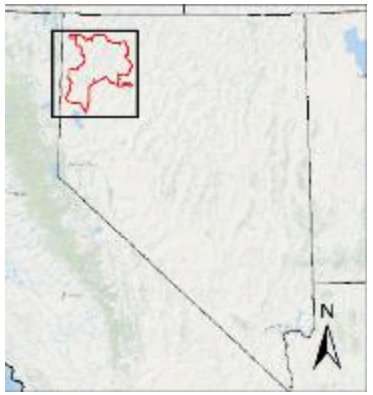
Marcella Rose
Nick Rousseau

Black Rock Playa

Study Area

- Black Rock Desert
- Burning Man Event 2017
- Black Rock Playa
- Black Rock Desert





Black Rock Playa


Image Credit: Creative Commons-Flikr

- Ephemeral, alkali **lakebed**
- **Lacks vegetation** due to evaporate-rich soils
- Renowned as one of the largest and **flattest** surfaces on Earth
- Popular spot for recreational activities…
  - Speed racing
  - Rocket launches
  - Land sailing
  - **Burning Man**

Conservation

"In order to **conserve**, **protect**, and **restore nationally significant landscapes** that have outstanding cultural, ecological, and scientific values for the benefit of current and future generations, there is **established in the Bureau of Land Management** the National Landscape Conservation System."

~ Omnibus Public Land Management Act (2009), Section 2002(a)

Image Credit: Creative Commons-Flikr

Community Concerns: Unnatural “Dunes”

In recent decades the community has noticed the **formation** & **expansion** of “dunes” along the playa shoreline

Formations are **round** in shape and **anchored by vegetation**

Image Credit: Marcella Rose

Community Concerns: Unnatural “Dunes”

Indication of **reduced air quality** and **increased dust emission**

Unnatural to the playa landscape and **inhibit recreational activities**

Image Credit: Marcella Rose

Potential Causes

- ✓ Recreational Activities
- ✓ Drought
- ✓ Natural Geologic Processes

There is concern that the **Burning Man** event is accelerating the rate of **dune encroachment**

Partner

Black Rock Field Office,
Winnemucca District, Bureau of Land Management
Field Manager: **Dr. Mark Hall**

Image Credit(s): Bureau of Land Management

Objectives

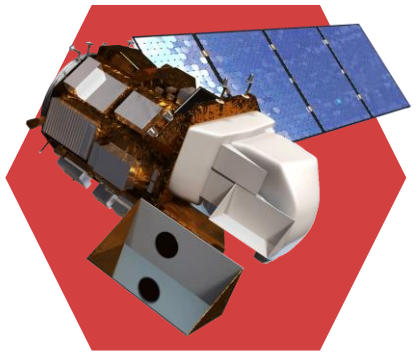
Generate surface deformation maps using Synthetic Aperture Radar (SAR) imagery

Examine the morphology, spatial distribution, and temporal changes in dune formations

Analyze the relationship between temporal changes in dune formation and recreational activities, drought conditions, flooding events, and weather patterns

Assess the mechanism behind dune formation

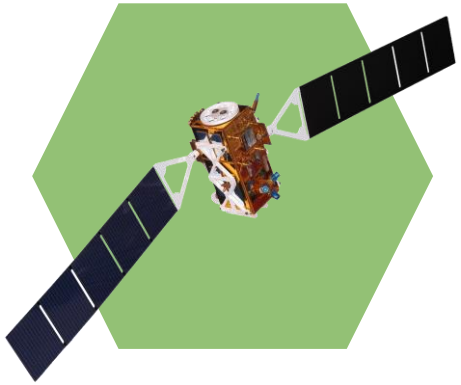
Earth Observations



Landsat 8 OLI

Landsat 5 TM

1997 2011 2013 2017



Sentinel-1 C-SAR

Image Credit: NASA

Methodology

(1) Download Sentinel-1 C-SAR data from 2017

Radar

Create correlation images → Normalize images → Identify areas with most change

(2) Download Landsat 5 & 8 and NAIP imagery from 1997-2017

Optical

Digitize Inundation Areas → Digitize dune features → Identify areas with most change

Compare pre- and post-Burning Man images

↓

Compare radar and optical results

↓

Make inferences

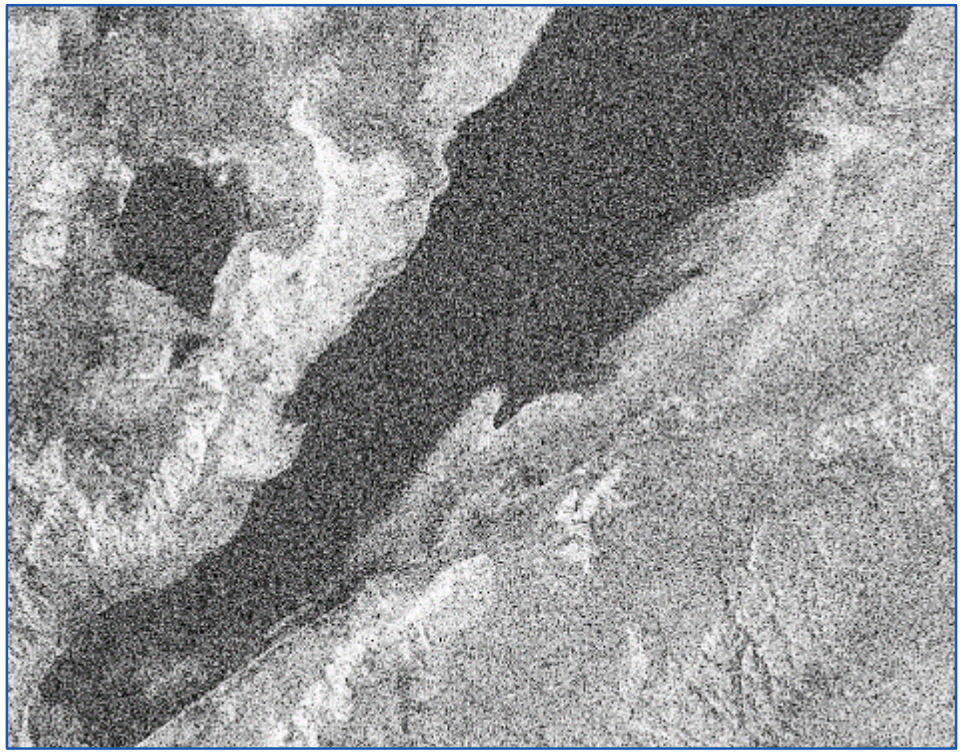
Results

- Synthetic Aperture Radar (SAR)
  - Correlation Maps
- Optical
  - Time Series
- SAR & Optical Comparison

Image Credit: Creative Commons-Flikr

SAR Correlation Maps

Increasing Correlation



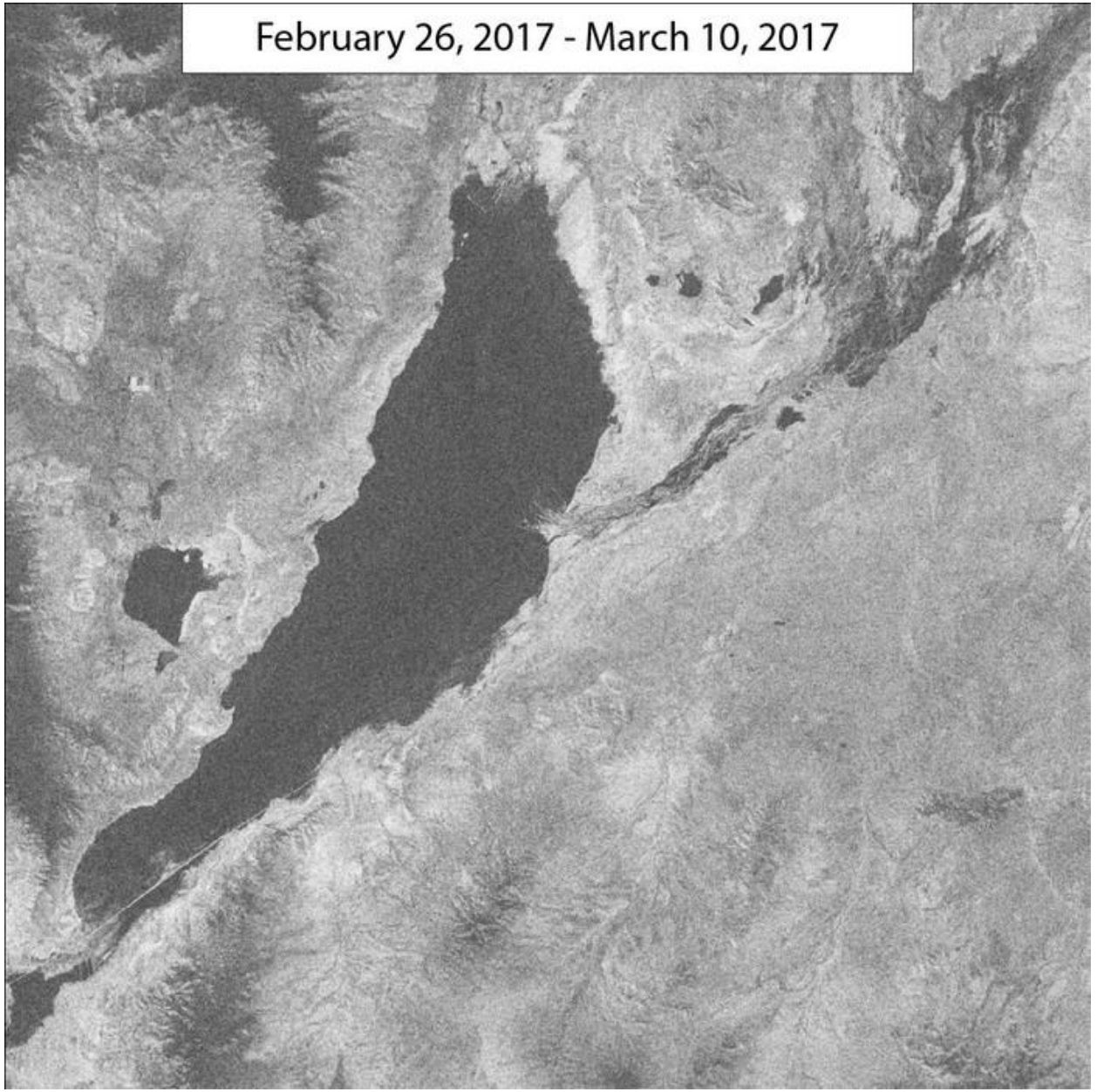
Darker Area = Decreasing Correlation = Most Landscape Change

SAR Methodology

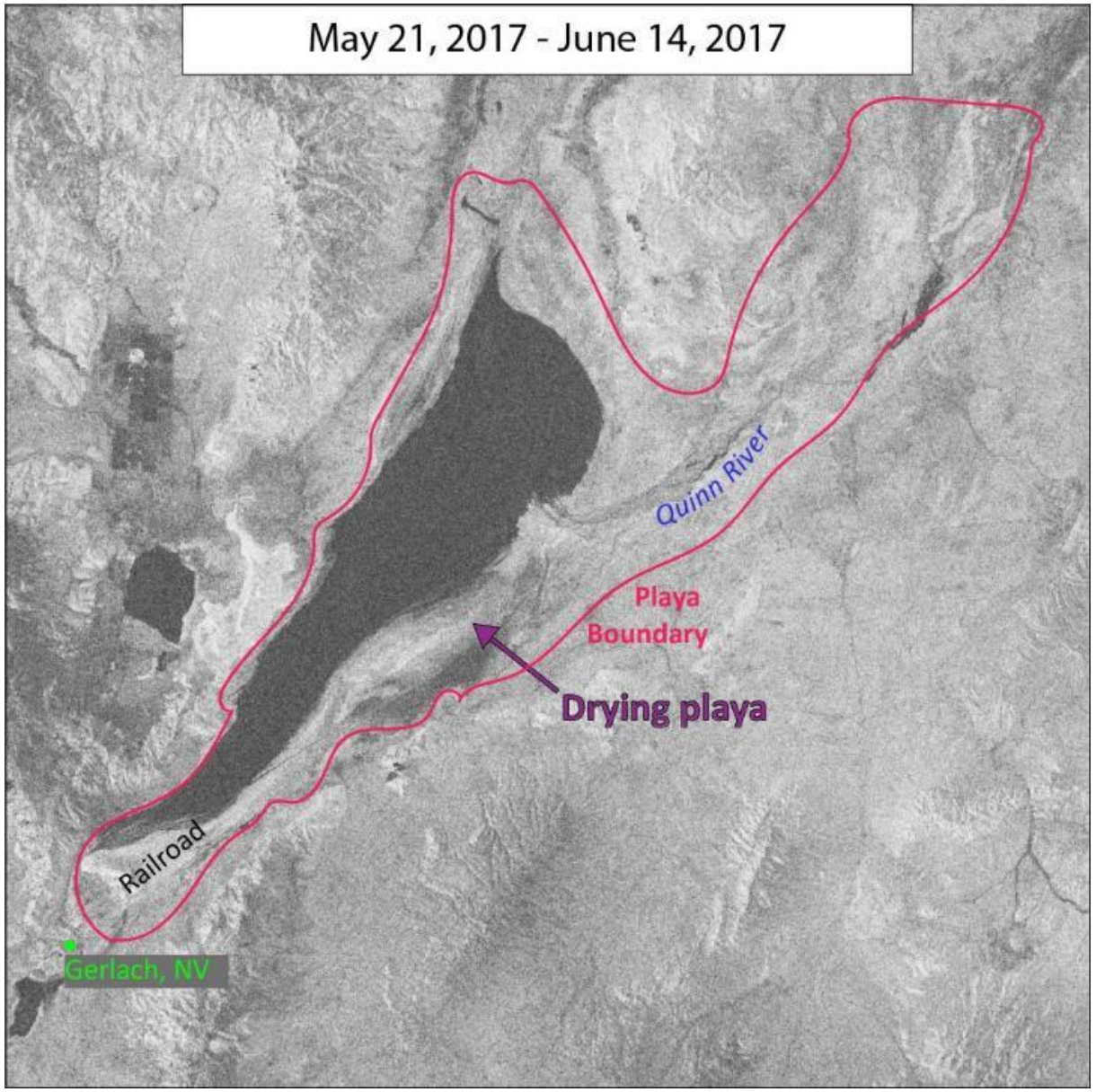
1. Coregister image pairs
2. Interferometric Correlations
3. Deburst
4. Orthorectification
5. Coregister the stack
6. Normalization

Pictured: SAR intensity and coherence images from August 25-September 6, 2017

SAR Time Series



SAR Analysis



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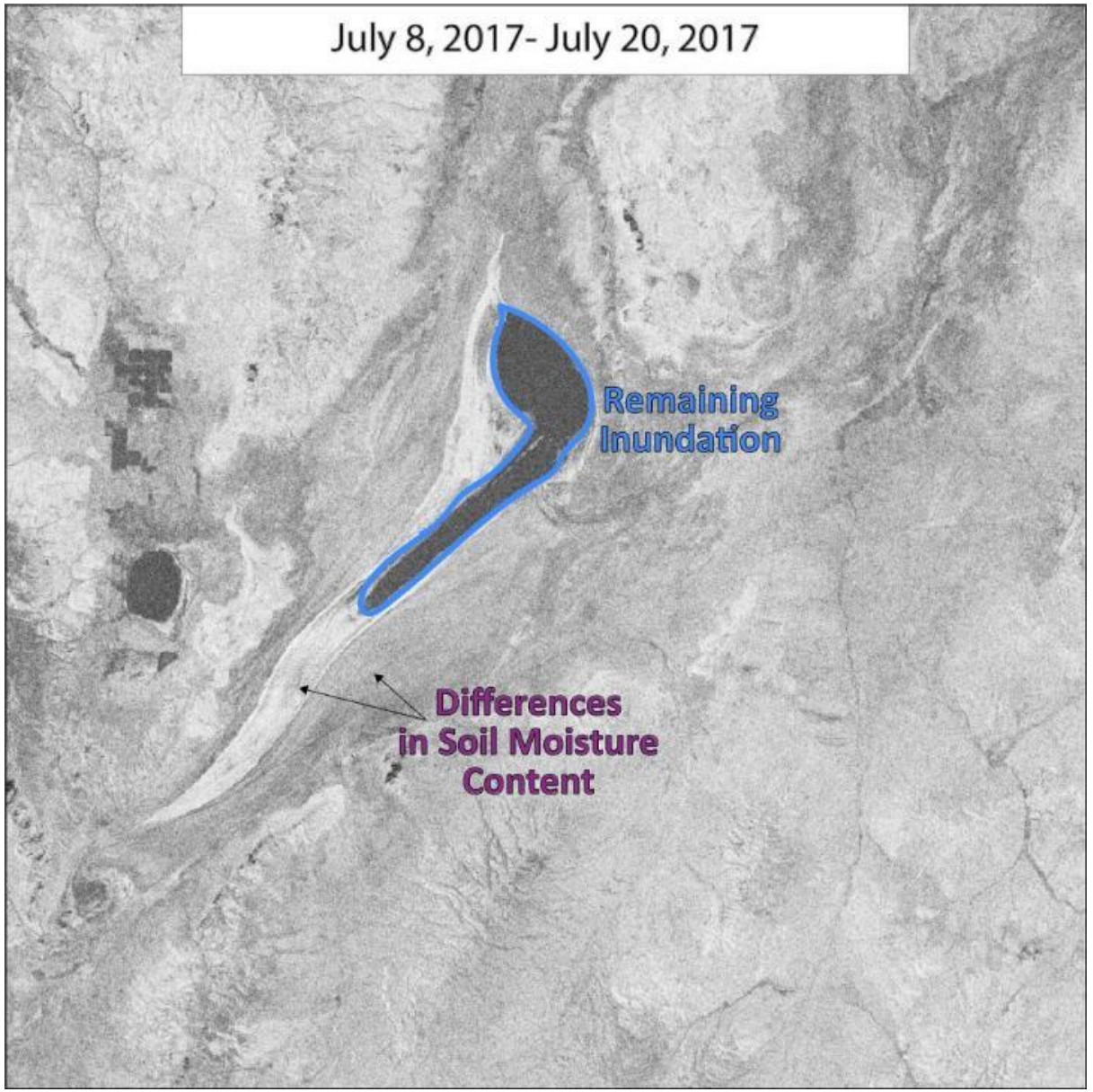

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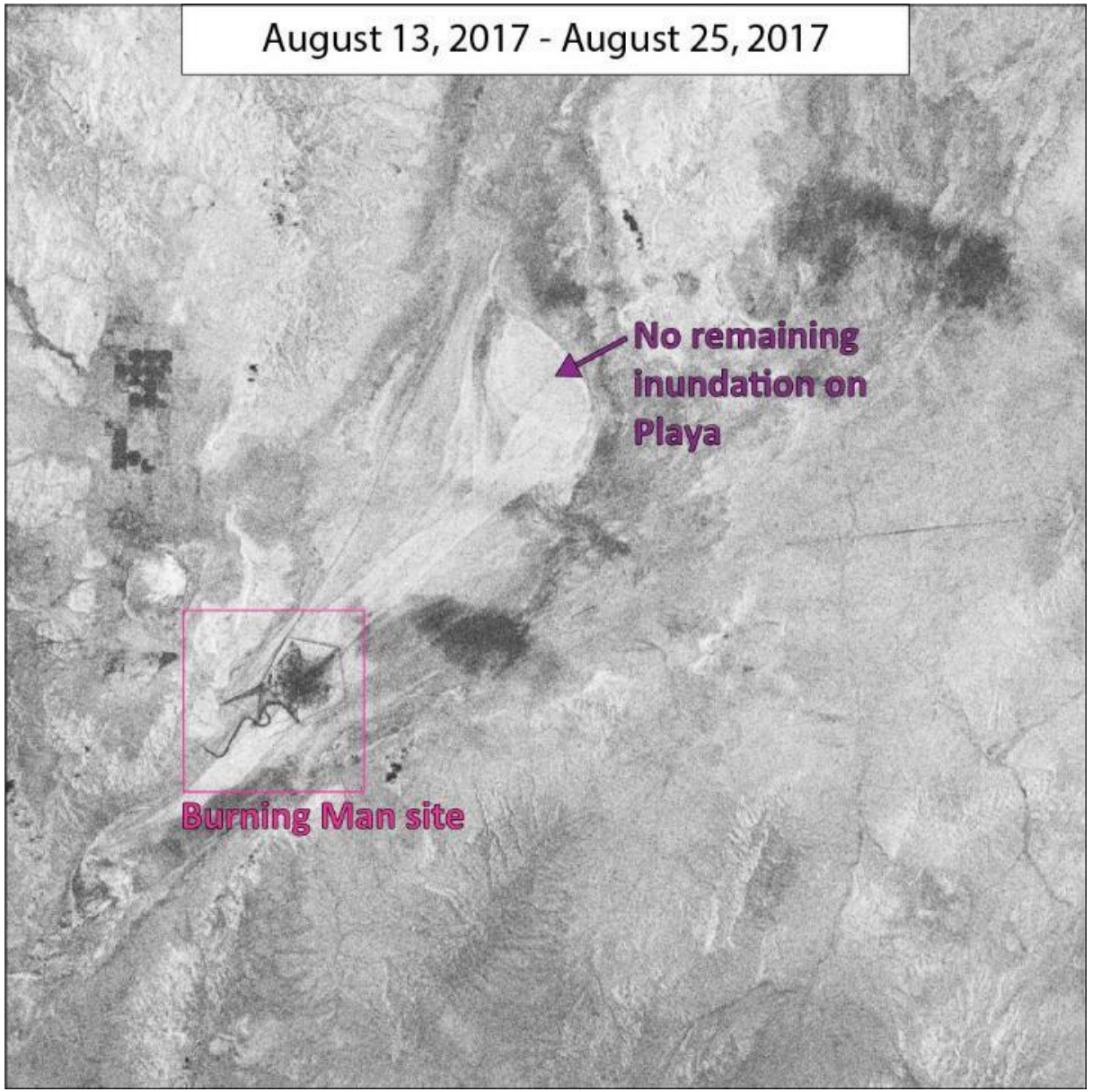

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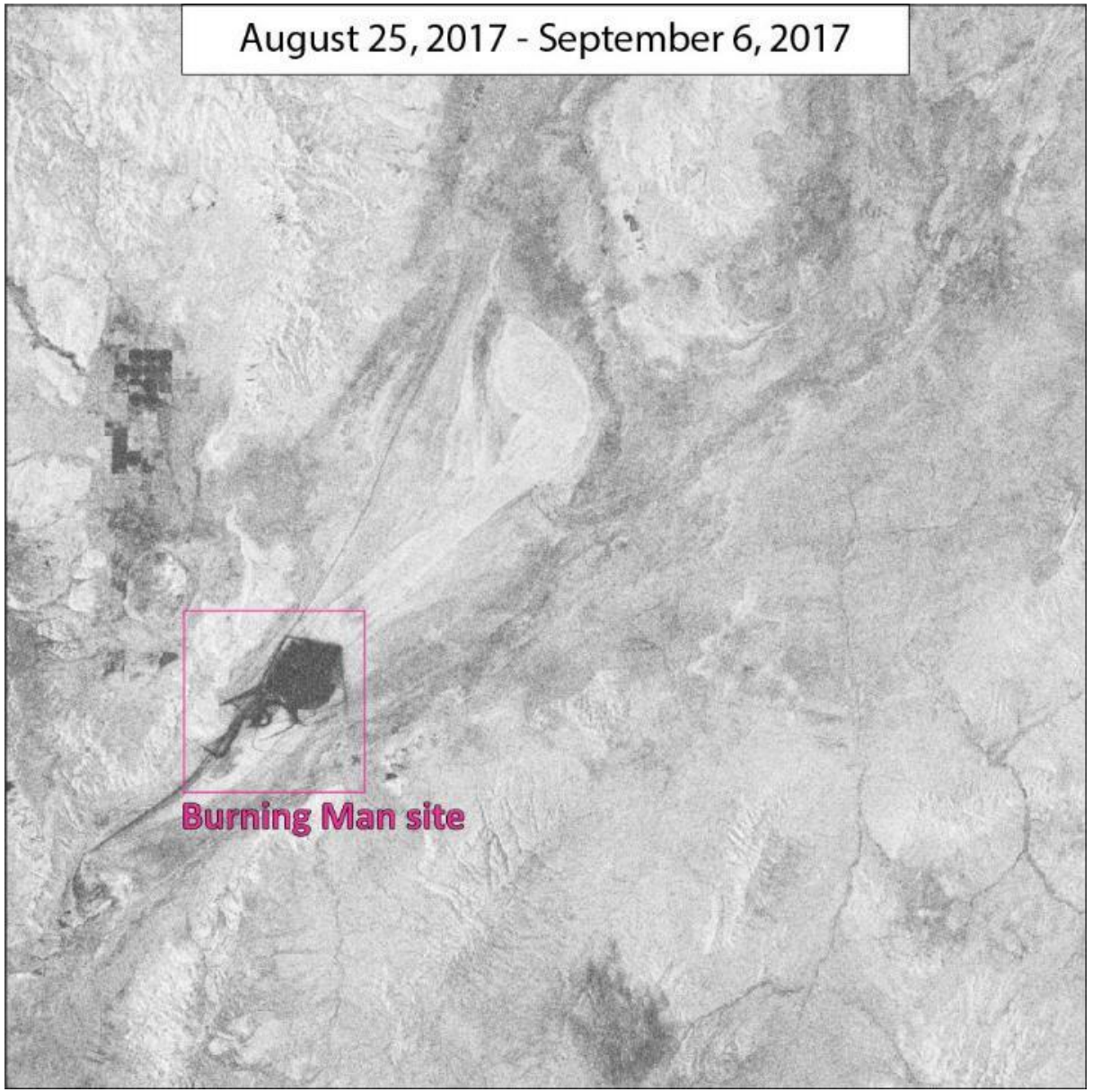

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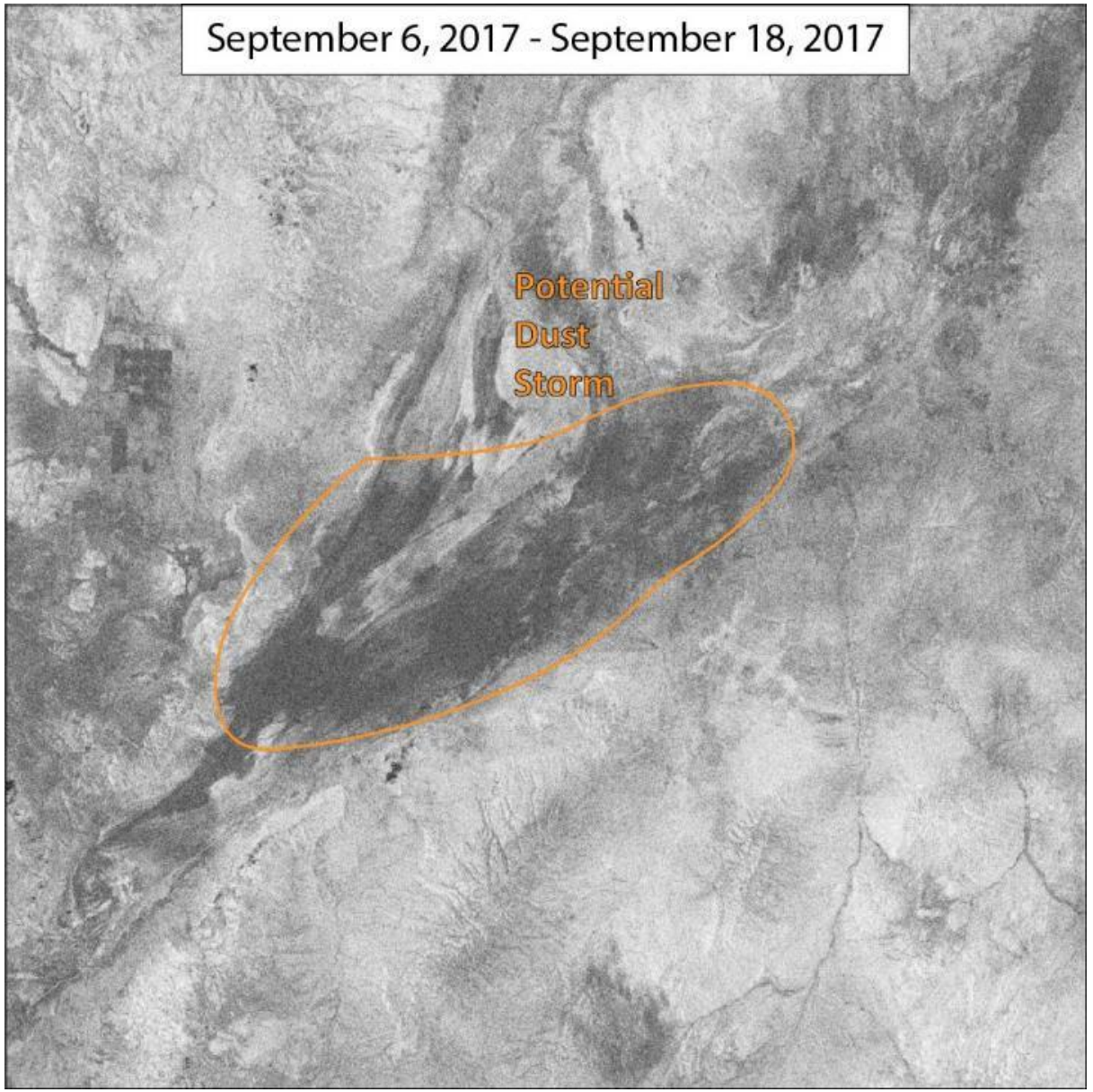

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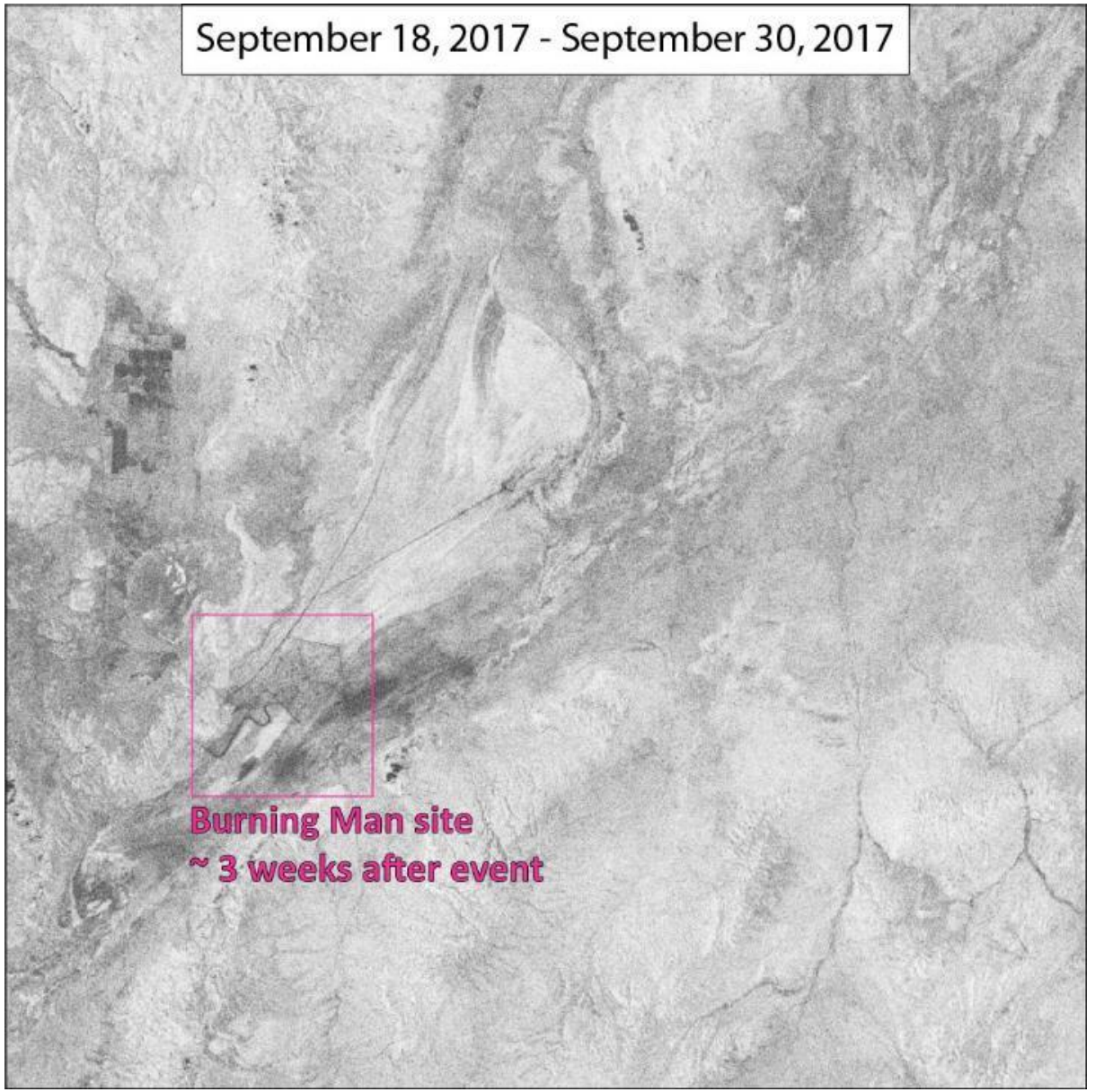
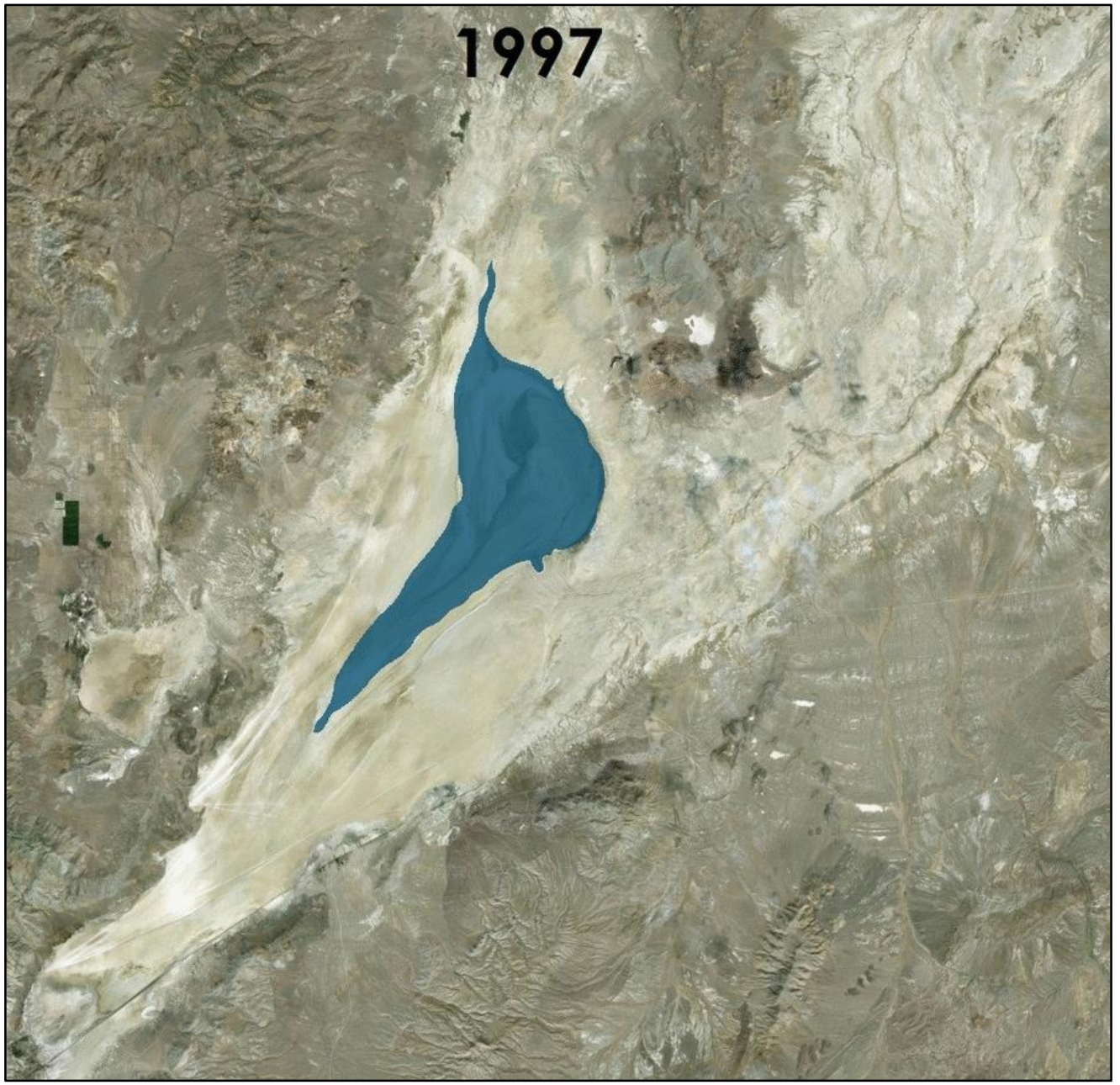


Optical Time Series



Radar & Optical Comparison

In Conclusion

- Found that the “dunes” are actually vegetation mounds
- No observed mound movement
- Inundation potential mitigator
- Provided BLM with sound methodology for radar processing

Decision Making Impact


Image Credit: Creative Commons-Flikr

- Assess Burning Man's request for a permit renewal & increased event attendance
- Provide methodology for the BLM to evaluate impact of recreational activities
- Observed that the "dunes" are actually vegetation mounds
- Assist in the preservation of Black Rock Playa

Acknowledgements

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Thank you!

Pictured(left to right): Dara Laczniak, Marcella Rose, Neda Kasraee, & Nick Rousseau