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NATURAL FORCE THREATS, MONITORING AND RESEARCH NEEDS

Southern California Thomas Fire and Montecito Debris Flows

Timeline/Description of Conditions

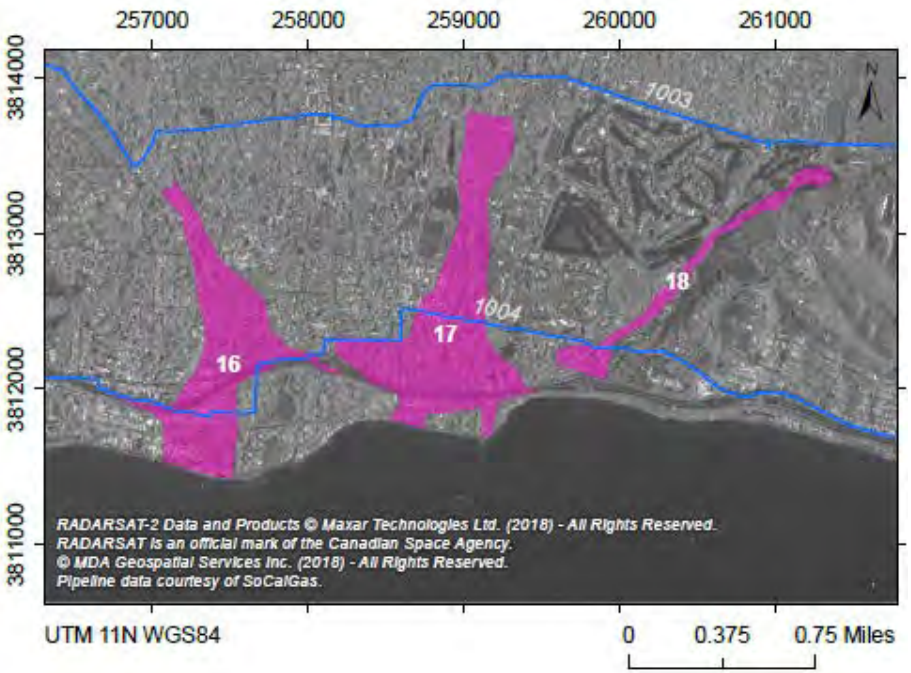
- Between December 4, 2017 and January 12, 2018, over 280,000 acres of land was burned in Ventura and Santa Barbara counties
- Largest area affected by fires in modern recorded history
- Substantially reduced ground cover
- Heavy rains on January 9, 2018

Timeline/Description of Conditions

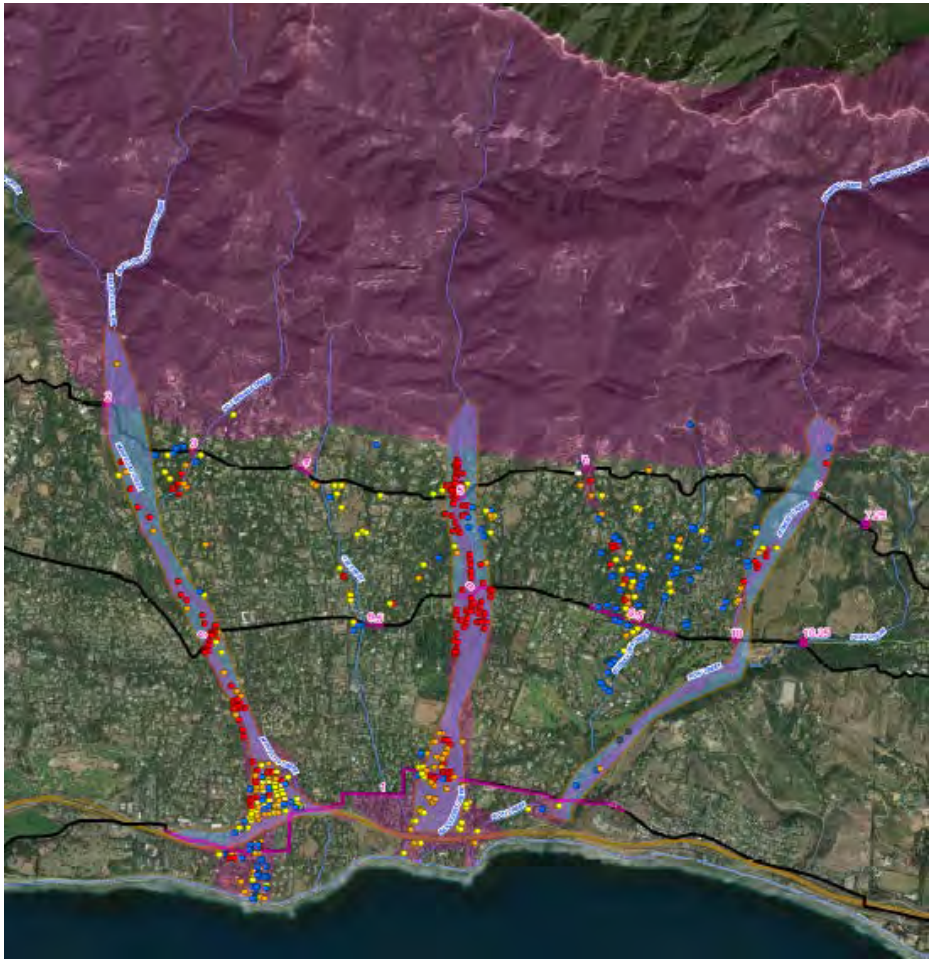
- Absence of land cover + heavy rains = debris mudflows
- Boulders as large as 20 ft in diameter carried down several creeks
- 22 deaths, destructions of homes and infrastructure
- Mechanical failure on a high pressure pipeline in one creek
- Concrete slab destroyed in another creek, exposing pipeline

Montecito, CA

Mudslides, Wildfires



Map showing mudslide areas



Map showing wildfire and mudslide areas

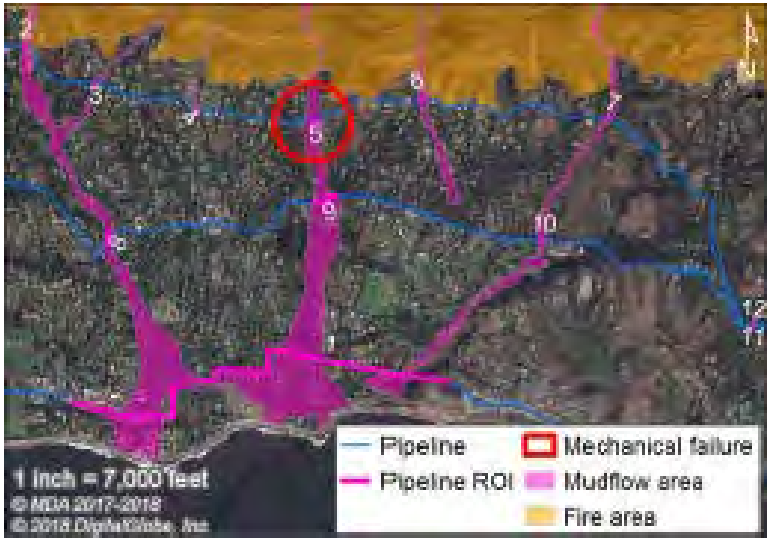
Response Effort

- SoCalGas had an established program of satellite monitoring of its Coastal Mountains Pipeline System.
- Data is collected every 24 days over each beam mode extent.
- Mudslide occurred January 9, 2018
- The Montecito area was captured by a SAR image acquired the next day on January 10, 2018.
- In addition, The Montecito area was captured by a Optical Satellite Imagery on January 10, 2018.
- SAR image and Optical image showed same boundaries of debris flow.

RADARSAT-2 SAR coverage of SoCalGas's Coastal Mountain Pipeline System

Response Effort

- Satellite Imagery – Identified Region of Interests (ROIs)
- Focused on existing debris flow locations & potential for additional debris flows
- Visual Field Reconnaissance by Transmission Operations & Geologists
- Mechanical failure of one of the transmission lines at one creek crossing > shut-down
- Exposed transmission line at a different creek crossing > lowered pressure
- Entire length of each pipeline within the affected area needed to be evaluated to determine if the integrity was compromised in any way at any location.



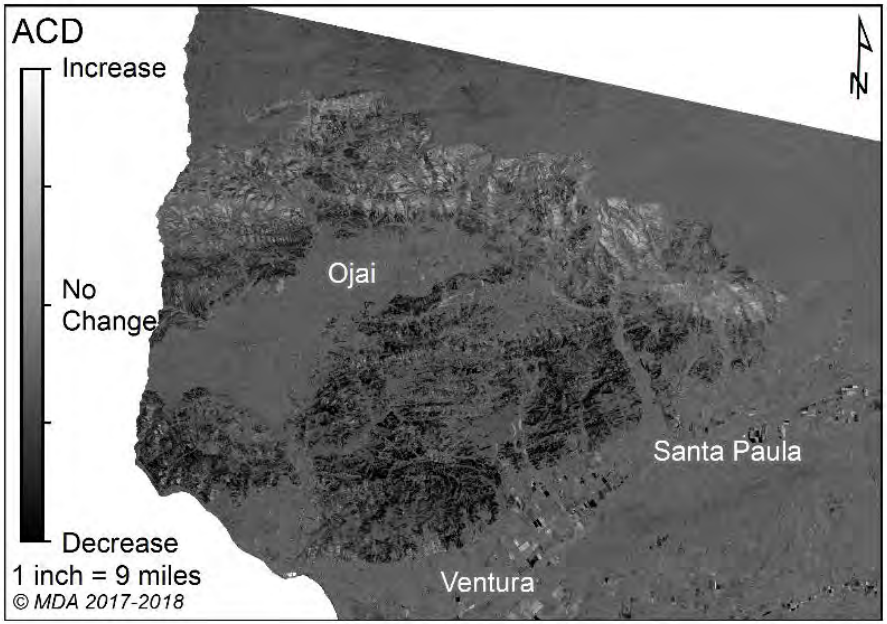
The linear pink features show the higher susceptibility areas. These areas were consistent with the locations where the Montecito mudflows occurred.

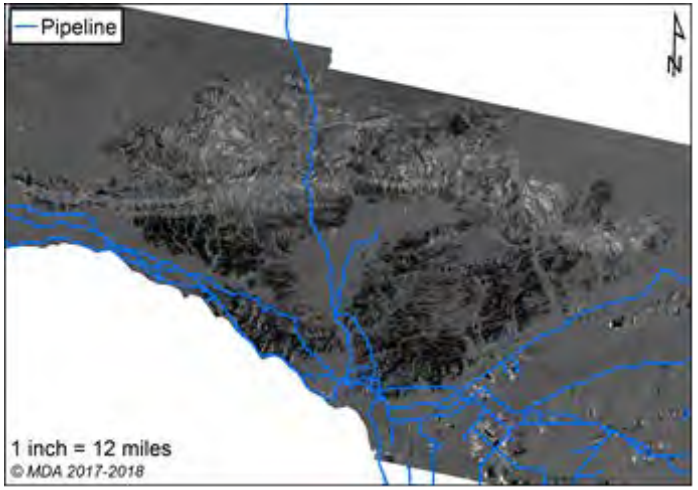
Application of Satellite Data Products for Fires and Debris Flows Monitoring

- Areas affected by natural disasters can be identified using SAR satellite data and applying ACD and CCD methods
- Amplitude change detection (ACD) – variations in amplitude from time series images of a specific location based on surficial changes
- Coherence change detection (CCD) – variations in coherence between interferometric pairs
- Satellite monitoring program for the Coastal Mountains, data collected on 24-day basis (FineQuad opposite look direction as background mission)

Amplitude Change Detection (ACD)

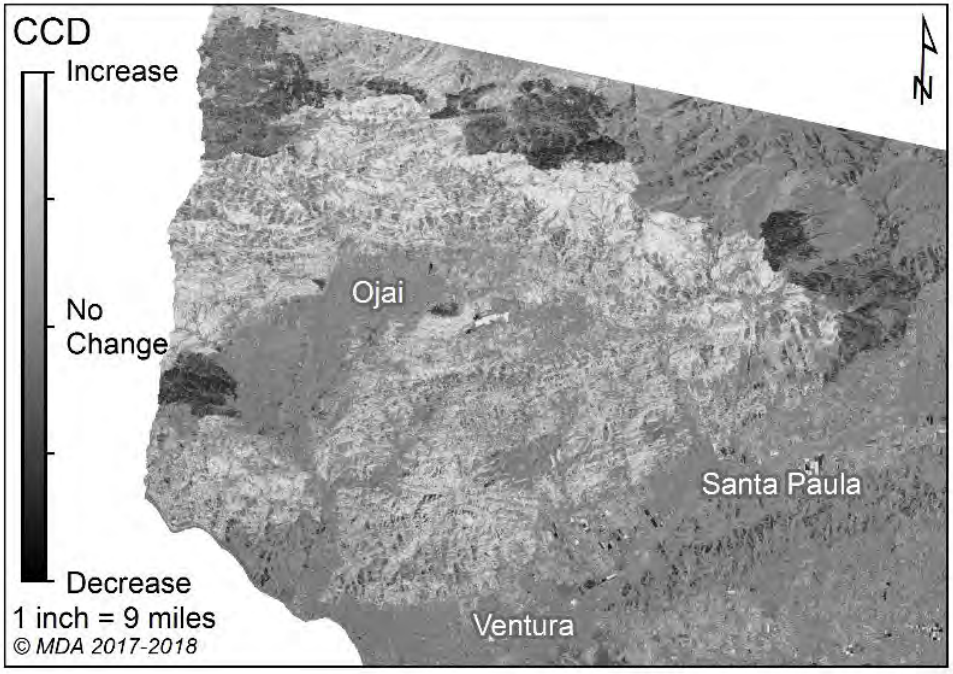
- The established monitoring program proved to be a significant asset to evaluating and responding to the emergency conditions that were the results of the fires and subsequent debris flows
- Overview of Thomas Fire burn scar derived from RADARSAT-2 ACD image.
- Dark and bright areas indicate a substantial change in radar signal return.
- SoCalGas pipeline infrastructure is shown by the blue lines.





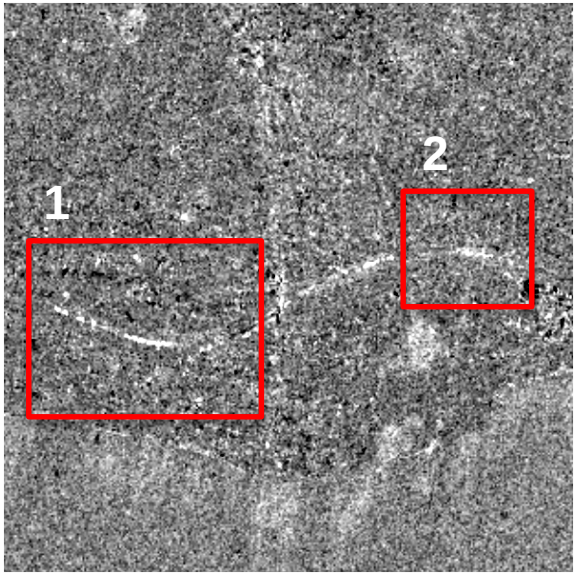
Coherence Change Detection (CCD)

- Identification of areas where there was an increased potential for ground movement following the fires and rainfall events
- CCD indicating the Thomas Fire extent as of January 3, 2018.
- The darker areas indicate an overall decrease in coherence within each resolution cell and suggest an area burned since last SAR image (new burn areas).
- Brighter areas indicate an overall increase in coherence over previously burned zones.



SAR Optical Synergy

- RADAR was able to identify areas of change
- Optical imagery confirmed the detected change



Conclusions

- Demonstration of significant value and benefits of using satellite data products and analytical techniques to support planning and response to natural disaster events that could impact pipeline infrastructure

- Limited resources need to be optimized

- Satellite included as part of a comprehensive response effort to help identify locations where more detailed inspections should be conducted

- Planning requirements

- Element of natural disaster planning

Additional Considerations

- Remote sensing systems – pre- and post-storm assessment, multiple platforms and sensors

- SAR satellite-based Flood Analysis for pipelines

- Old school still works – planes and helicopters are essential to an effective recovery strategy (for now)

- Unmanned Aerial Systems (UAS) - need to have resources aligned and pre-qualified before incident to ensure FAA regulations are met. However, use of the technology is dependent on FAA regulatory restrictions.

- Long-term, regular monitoring with satellite technology

Any Questions?