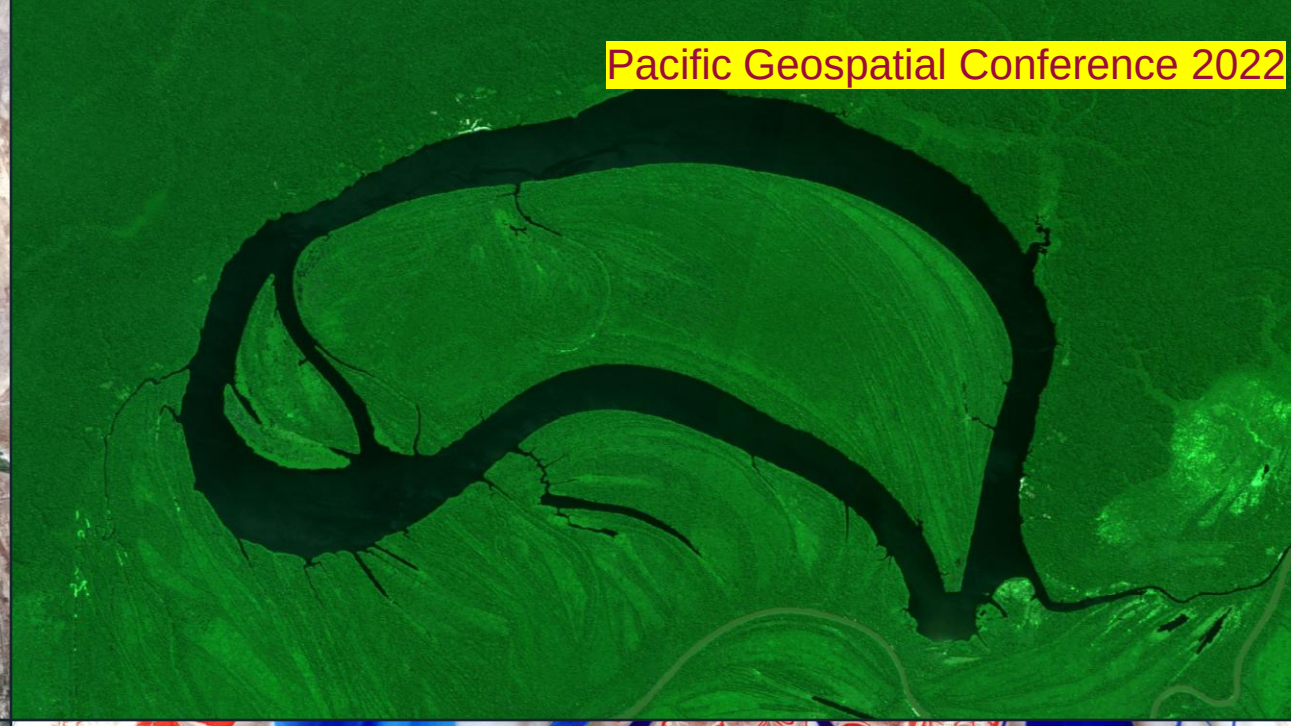

Pacific Geospatial Conference 2022

USE OF SYNTHETIC APERTURE RADAR (SAR) IMAGERY IN EMERGENCY RESPONSE AND DISASTER MANAGEMENT

Achieving rapid, actionable decisions in disaster assessment & response

November 29, 2022

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APAC Geospatial
Fellow SSSI
Adjunct Associate Prof University of the Sunshine Coast

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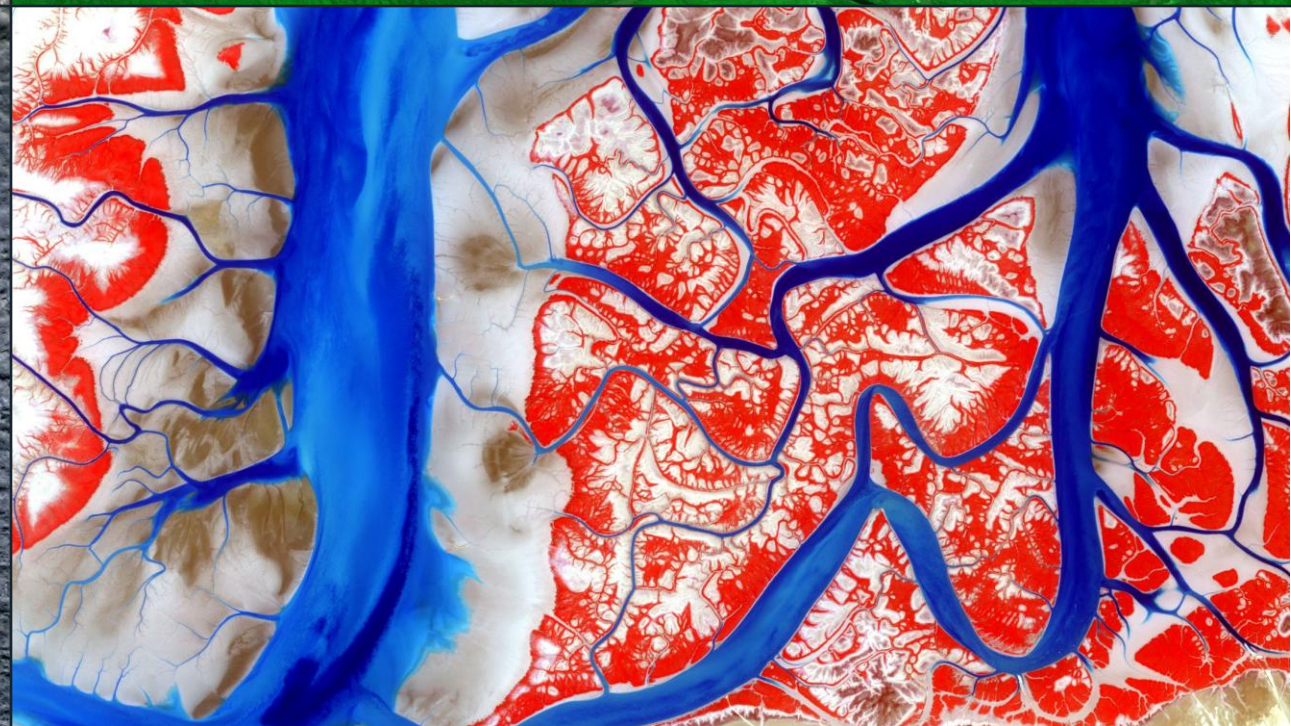

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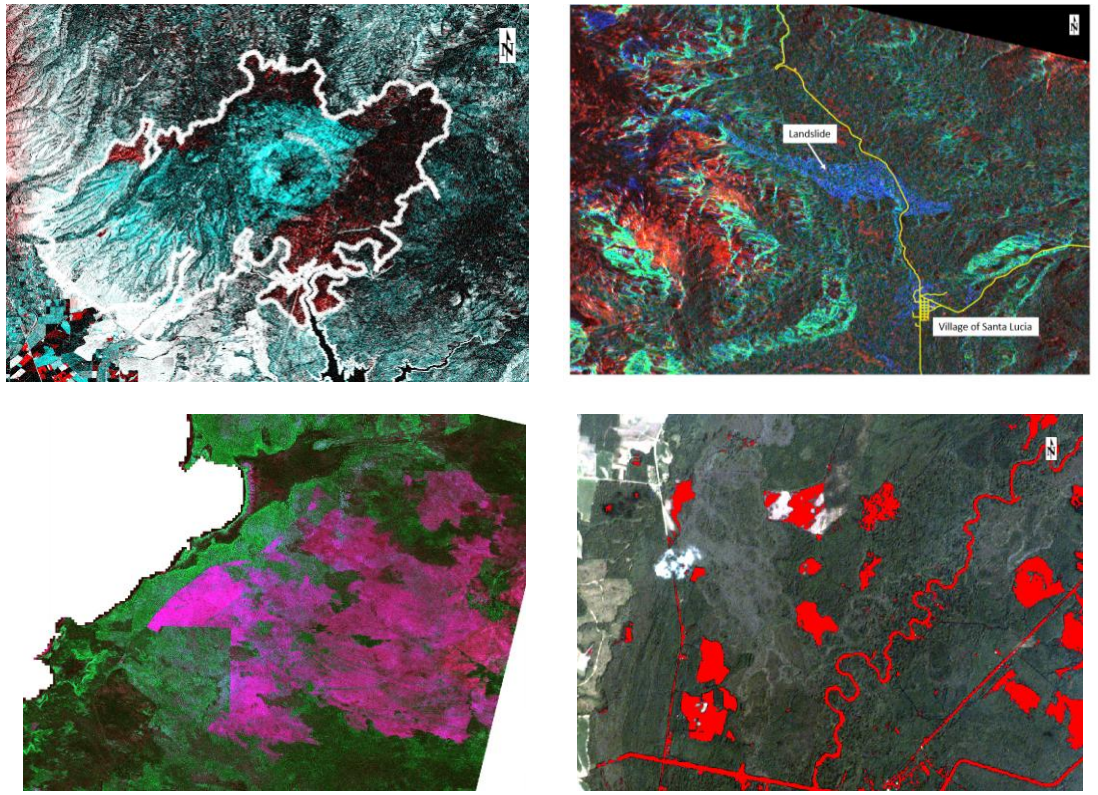
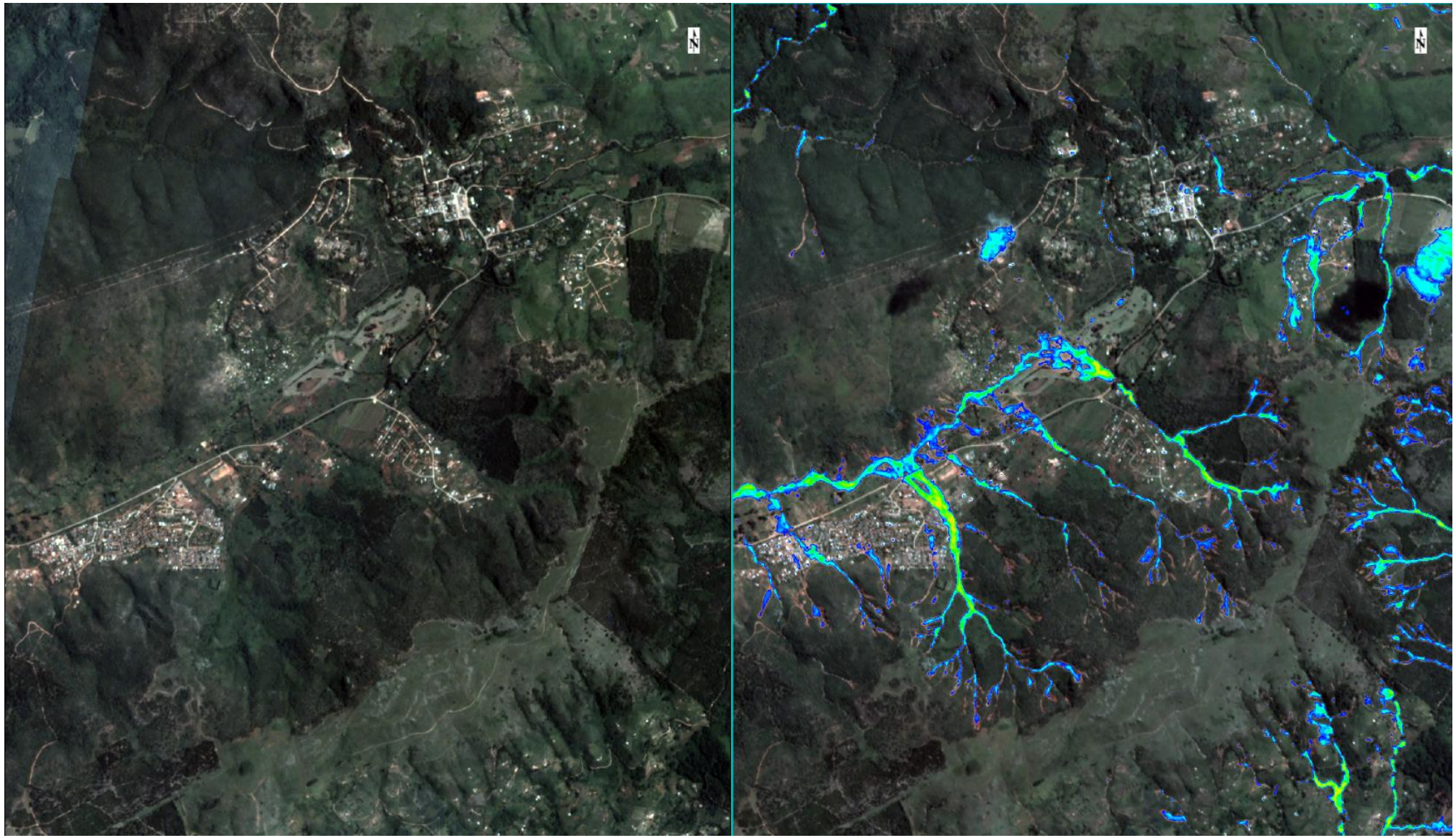
Disaster Management & Emergency Response

- Top priorities after a disaster are to:
  - Rapidly assess and quantify damage extent
  - Locate and identify hazards
  - Evaluate access to infrastructure
  - Task resources to help in the recovery effort based on where, and how severe, the damage is
- Imagery is a unique and valuable source of data for
  - Response efforts
  - Recovery
  - Impact analysis
- Respond quickly and effectively with remote sensing technology following natural and human-generated disasters:
  - Damage assessment: Oil spills, forest-/ wildfires, landslides, storms, floods, tsunamis, volcanoes, earthquakes, …
  - Hazard monitoring, road network identification, …
  - Minimizing time lag to first responders and planning for response

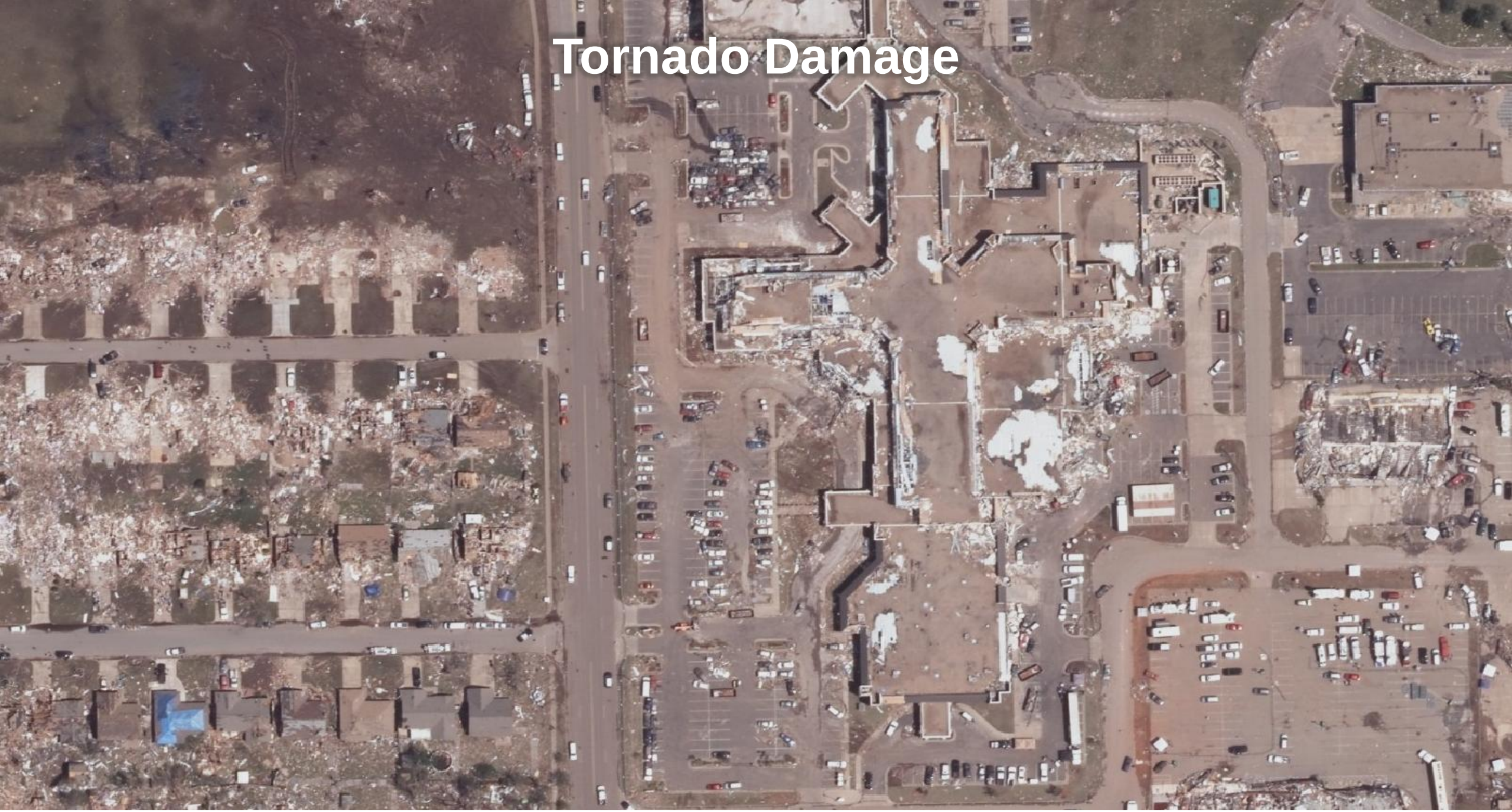


Examples of different natural disasters and how you can see them with remotely sensed data. Examples: Fire extent (top-left and lower-left), landslides (top-right), flooding (lower-right)

Deep Learning Landslide Mapping



Tornado Damage

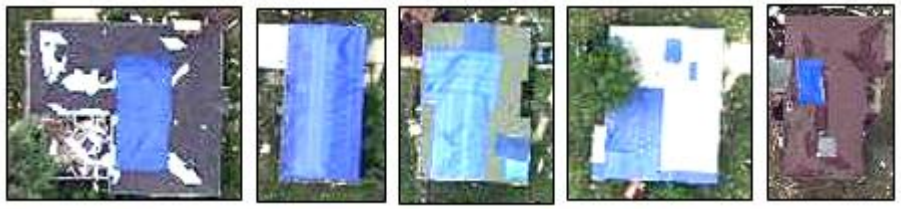


Deep Learning Building Damage Labeling

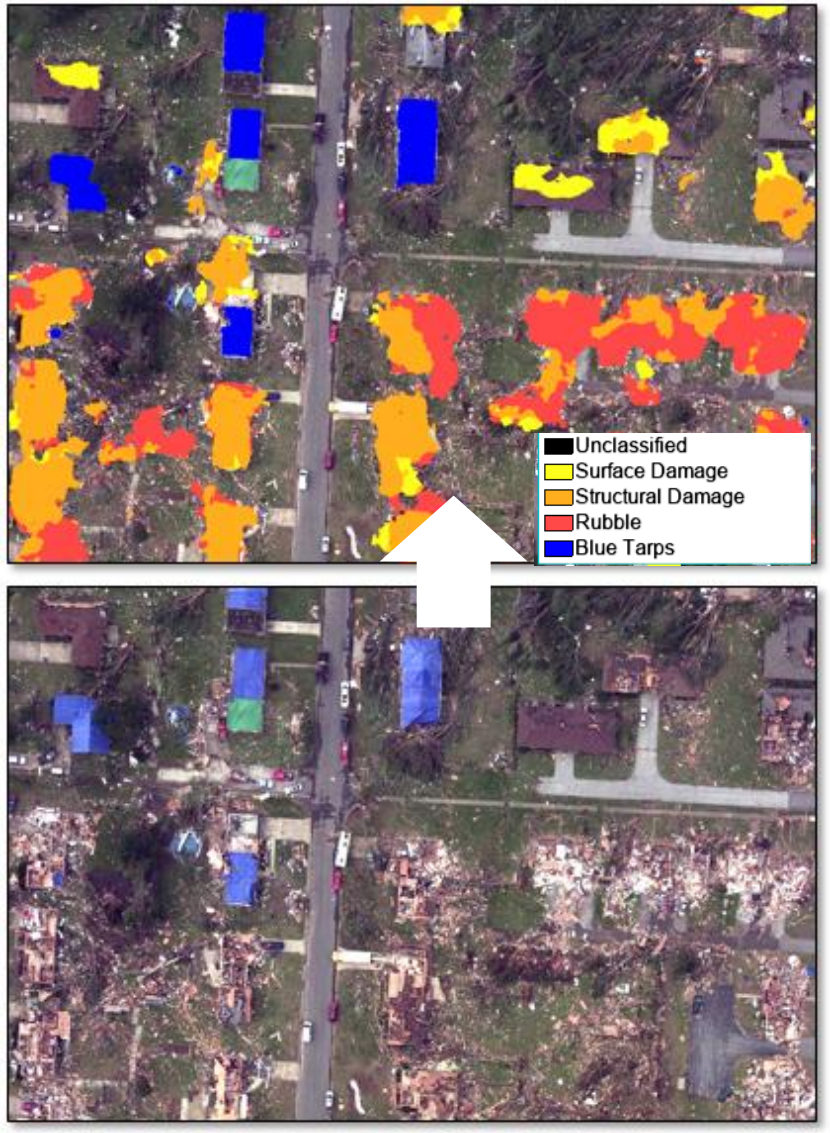
Roof / Surface Damage

Structural Damage

Rubble



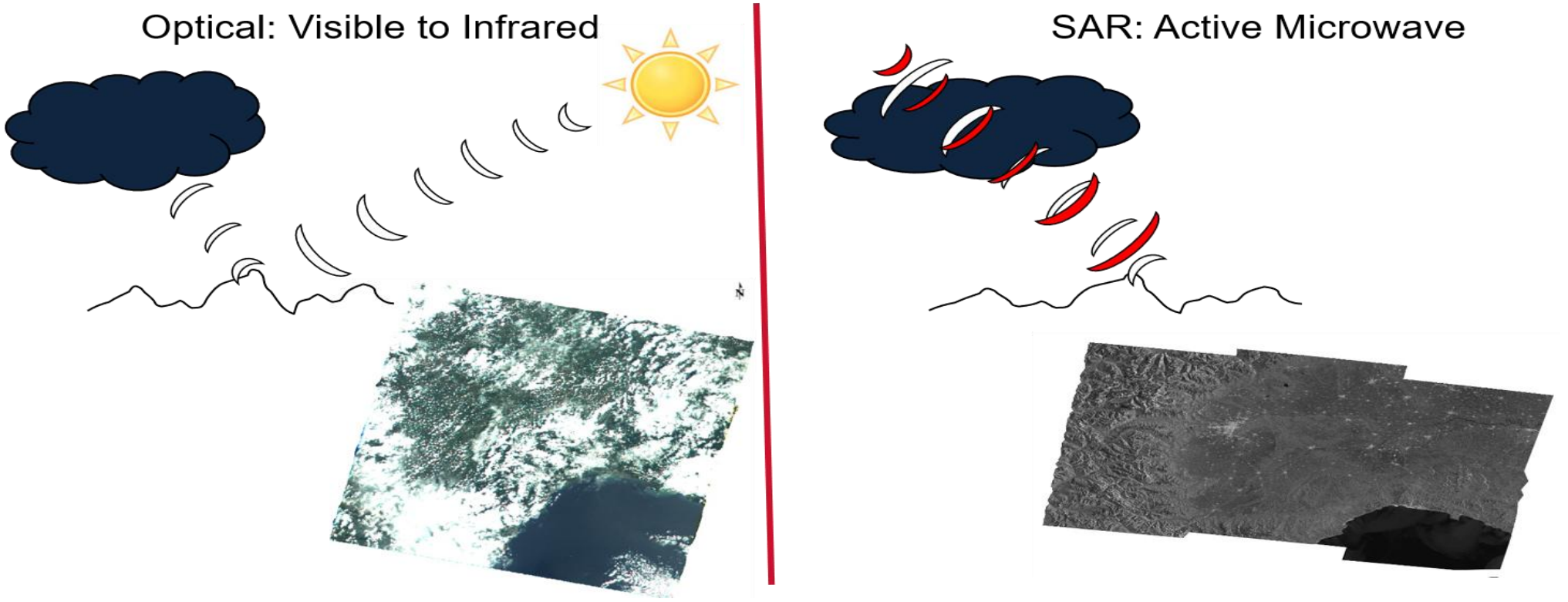
Blue Tarp



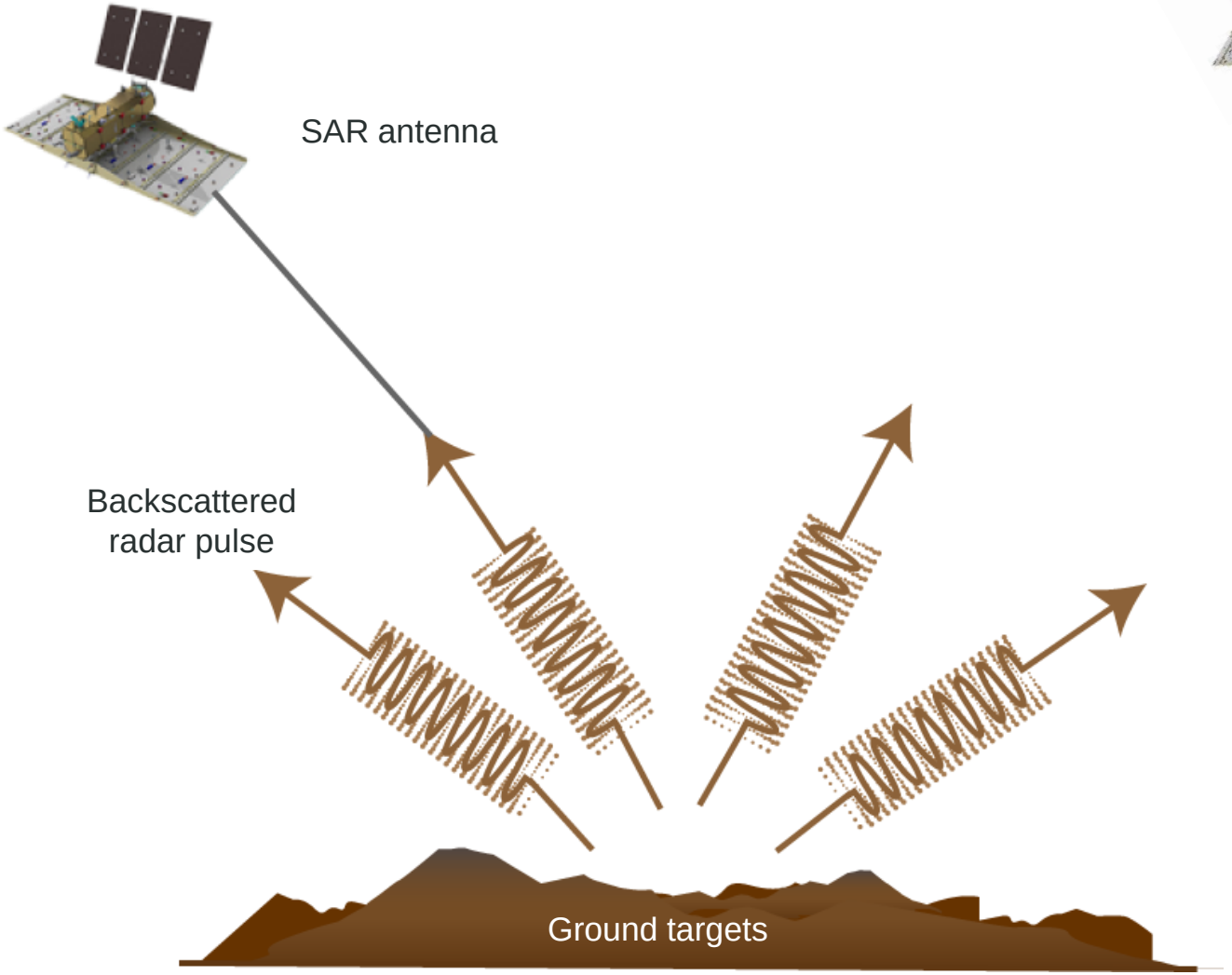
Deep Learning Building Damage Classification

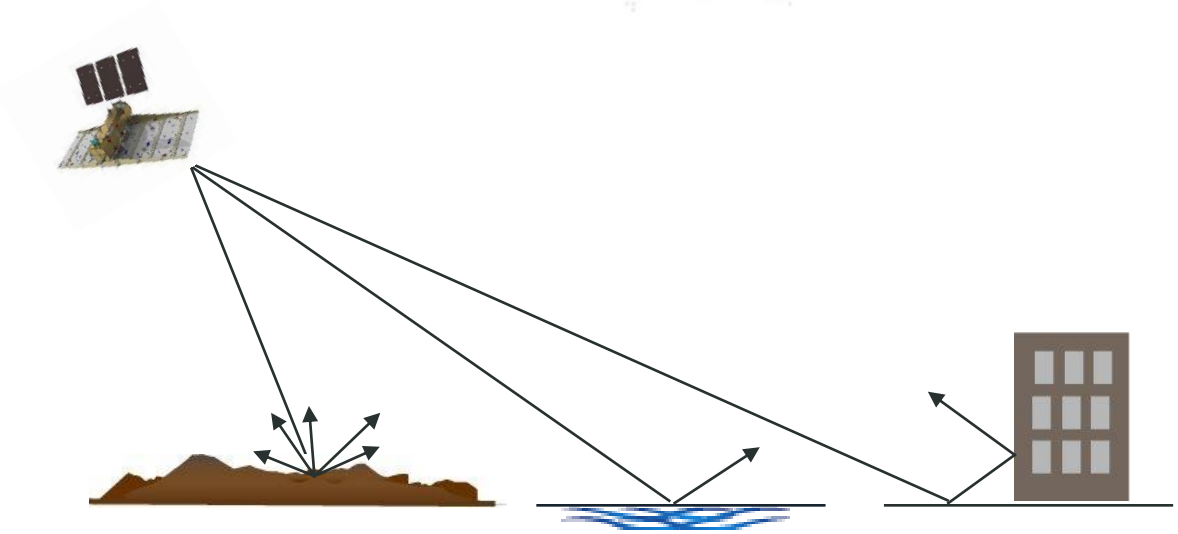
Synthetic Aperture Radar for Fire and Flood

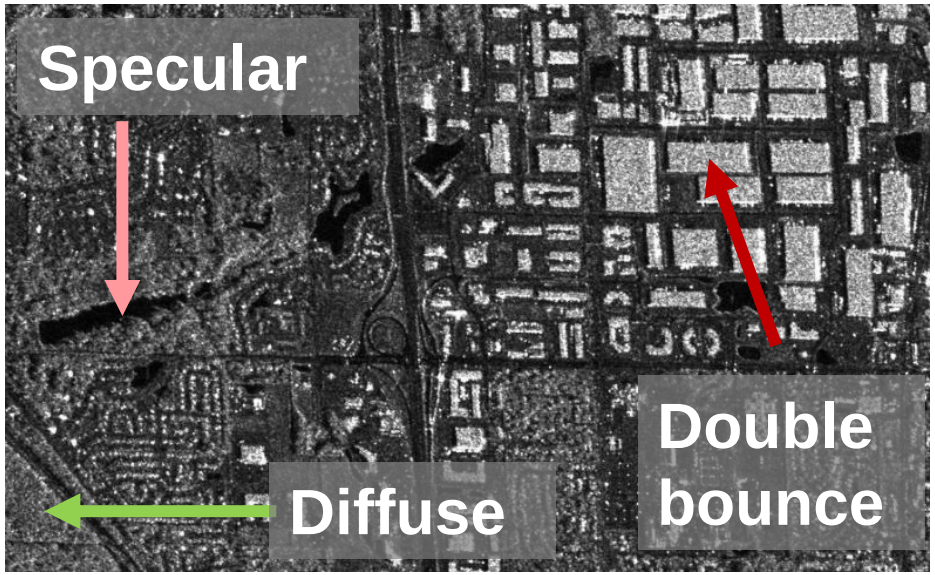
- Synthetic Aperture Radar (SAR) is an active imaging system, it is able to see through smoke and clouds to view changes on the earth's surface. With this we can track the fire burn/flooded areas while the fire/flood is occurring, even with covering smoke/cloud.



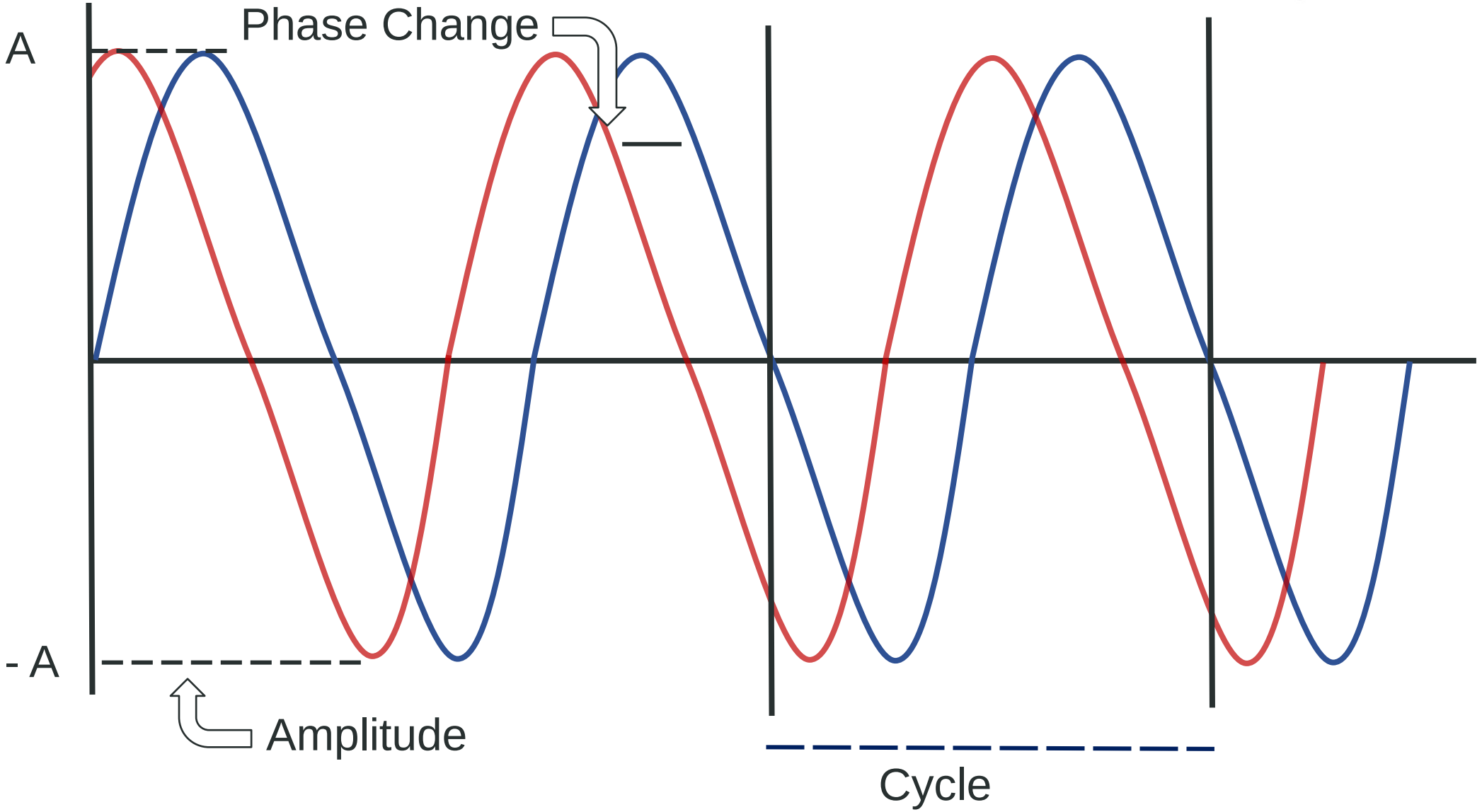
What is Synthetic Aperture Radar?





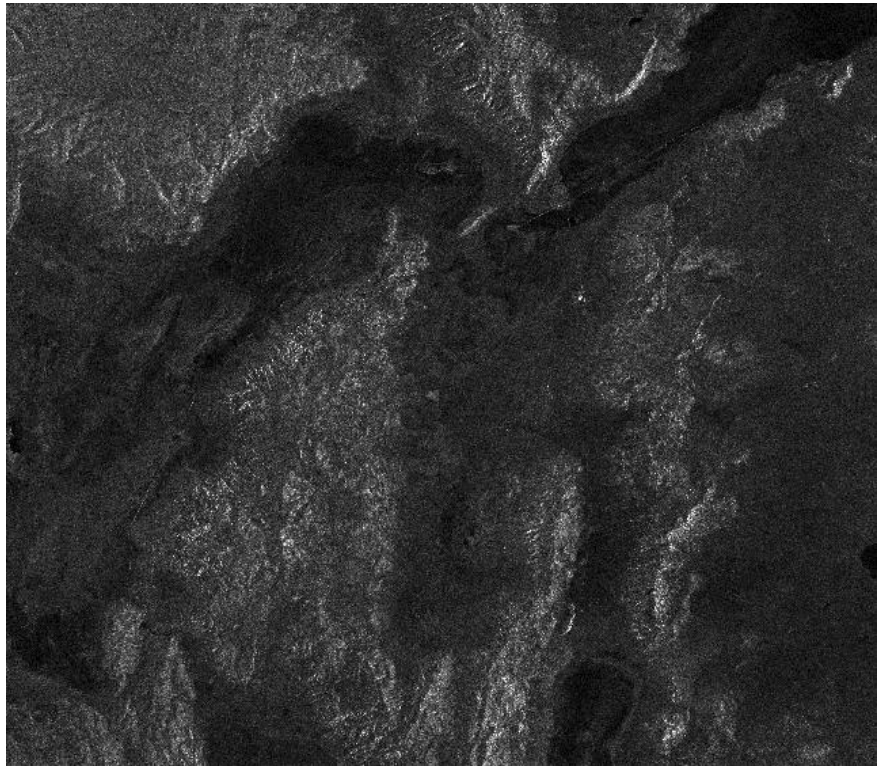


Backscatter Results: Amplitude and Phase



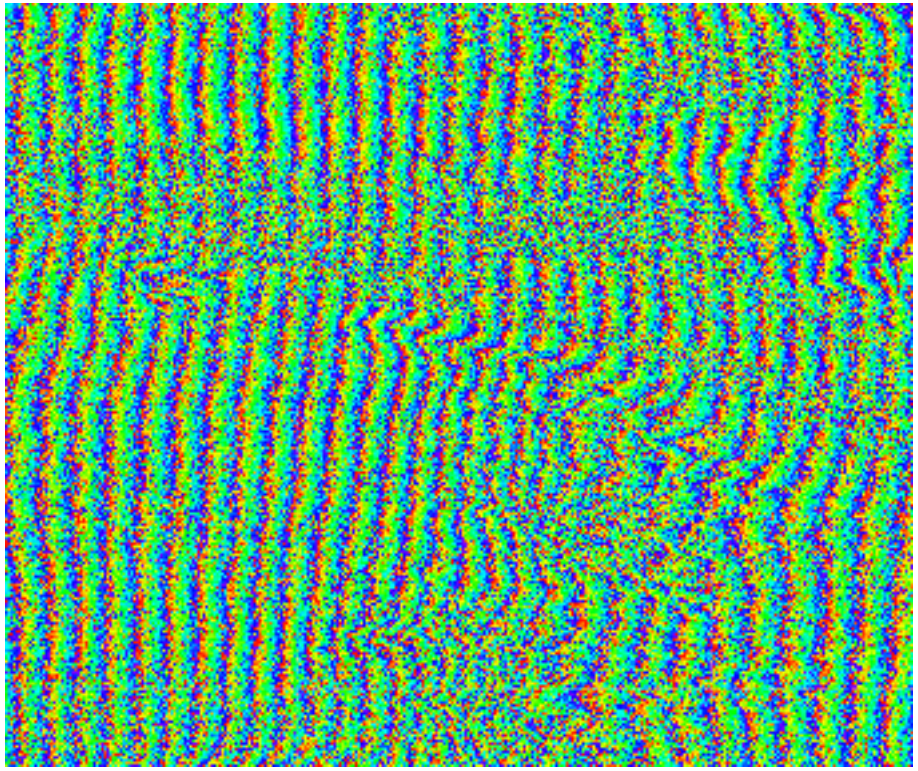
Amplitude and Phase

Amplitude/Intensity (A^2)



Amplitude shows visual characteristics based upon scattering returns, which can give us information on surface roughness and dielectric properties.

Phase



The phase of one scene may not be visually useful, but phase allows for powerful techniques such as polarimetry and interferometry over multiple scenes.

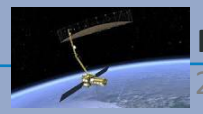
Synthetic Aperture Radar satellite missions

JERS
1992 - 1998

ALOS
2006 - 2011

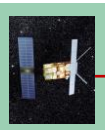
ALOS-2
2014

SAOCOM
2018



NISAR
2021

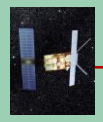
L-Band



ERS-1
1991 - 2000

EnviSat-1
2002 - 2012

RISAT-1
2012

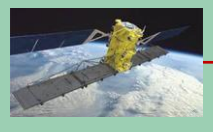


ERS-2
1995 - 2011

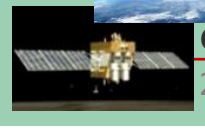
Sentinel-1A
2014

RADARSAT-2
2007

Sentinel-1B
2015



RADARSAT-1
1995 - 2013

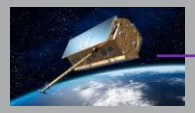


Gaofen-1
2013

C-Band

COSMO-SkyMed
2007

COSMO-SkyMed 2nd generation



TerraSAR-X
2007

CAPELLA SPACE constellation

TanDEM-X
2010

XpressSAR constellation

KOMPSAT-5
2013

ICEYE constellation

PAZ **UMBRA LAB**

X-Band

1991 | 2000 | 2005 | 2010 | 2015 | 2018 | 2020

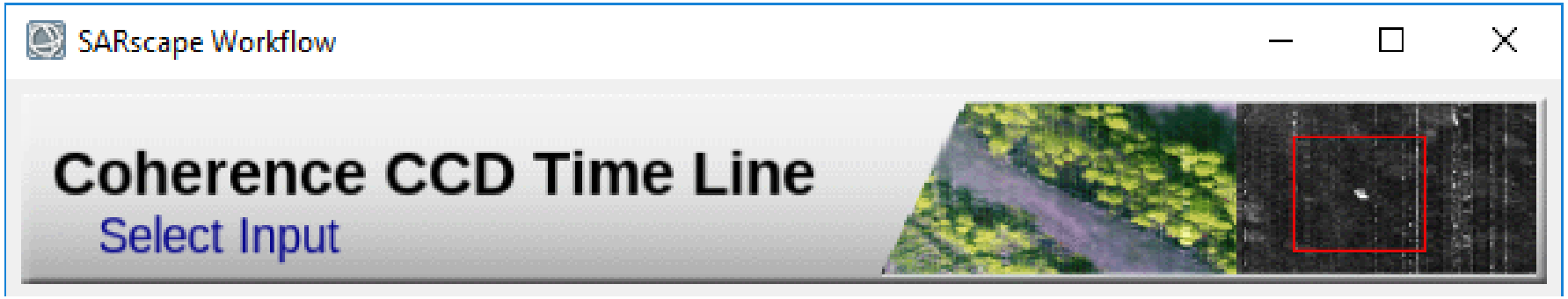
Lytton Fire Overview

- The Lytton Creek Wildfire began June 30, 2021
- The city of Lytton was destroyed by this fire, which was energized by the 2021 Western North America Heatwave.
- Over 51,336 hectares have burned as of August 5th, 2021.

View of the Lytton Wildfire, THE CANADIAN PRESS/Darryl Dyck

Coherence Change Detection over Wildfires

- SAR collects both intensity and phase, allowing us to track minor surface changes that you can not see with remote sensing data otherwise. In particular, phase can easily pick out areas that were once urban or vegetated that a major change has occurred in.
- Coherence Change Detection is a technique that uses both the intensity and phase to track changes between images.



CCD Output

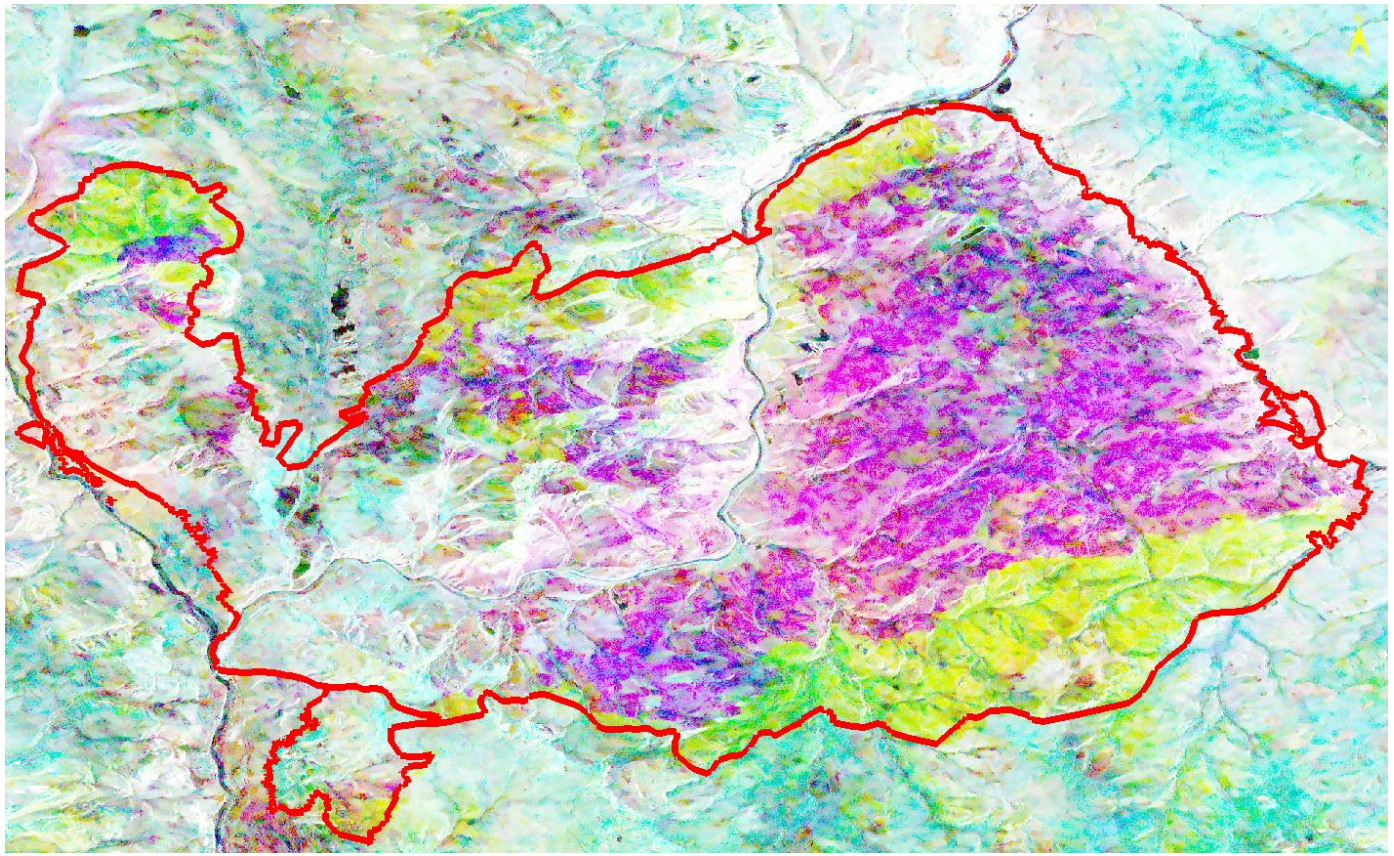
RGB image created from three CCD scenes

Red: July 26th to August 8th

Green: July 14th to July 26th

Blue: June 8th to June 20th

The colors shown highlight the time period in which the fire burned through those specific regions.



Boundary from BC Wildfire Service Data Catalogue

Vegetation Like Indices using SAR

The implemented approach consists in the multitemporal analysis based on vegetation indexes derived from Synthetic Aperture Radar (SAR) data.

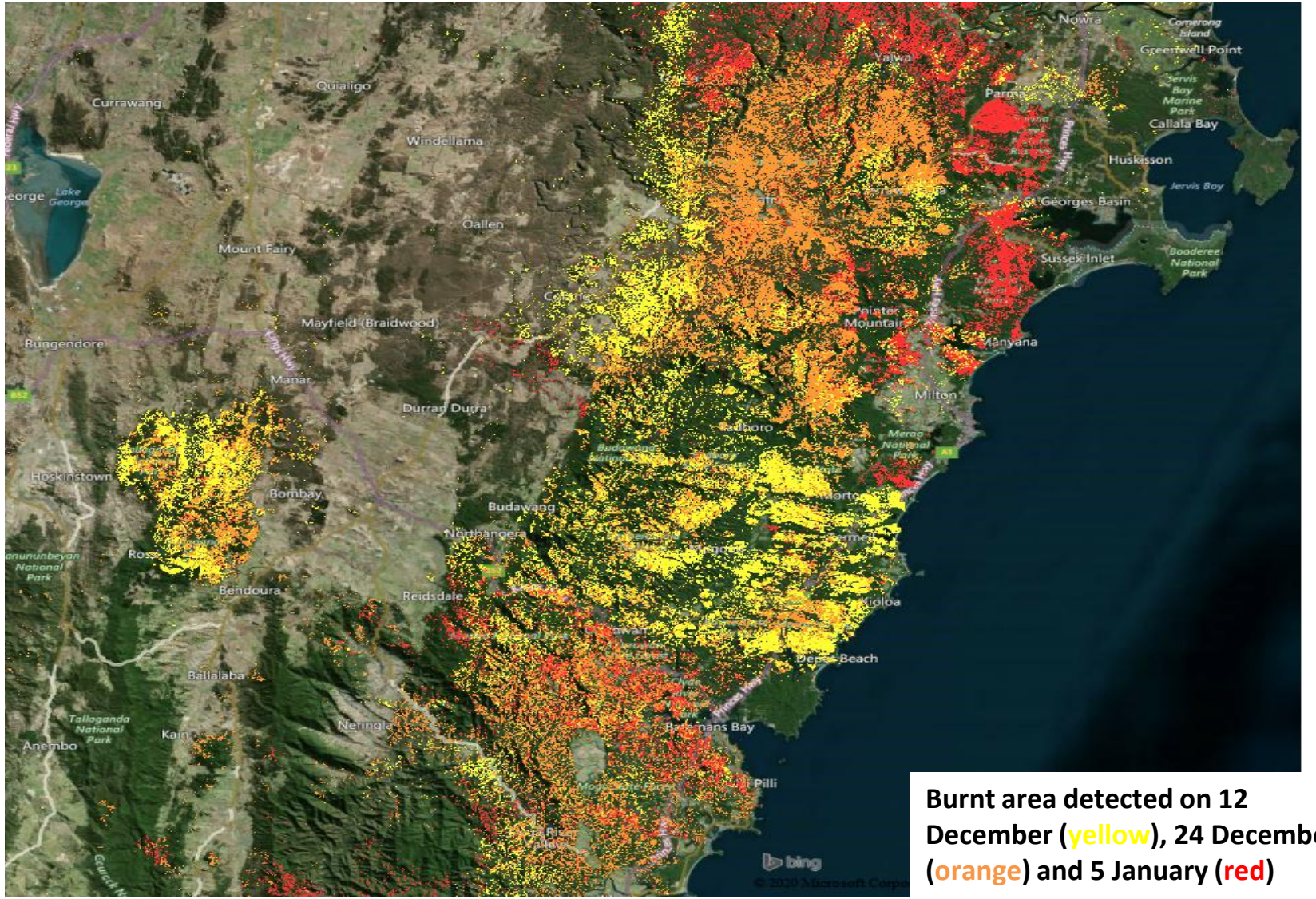
The indexes are calculated using Dual Polarization acquisitions from Sentinel-1A. The satellite revisiting frequency is 12 days with 20m spatial resolution.

The two indexes are namely:

- DPSVI (Dual Polarization SAR Vegetation Index)
- ESVI (Enhanced SAR Vegetation Index)

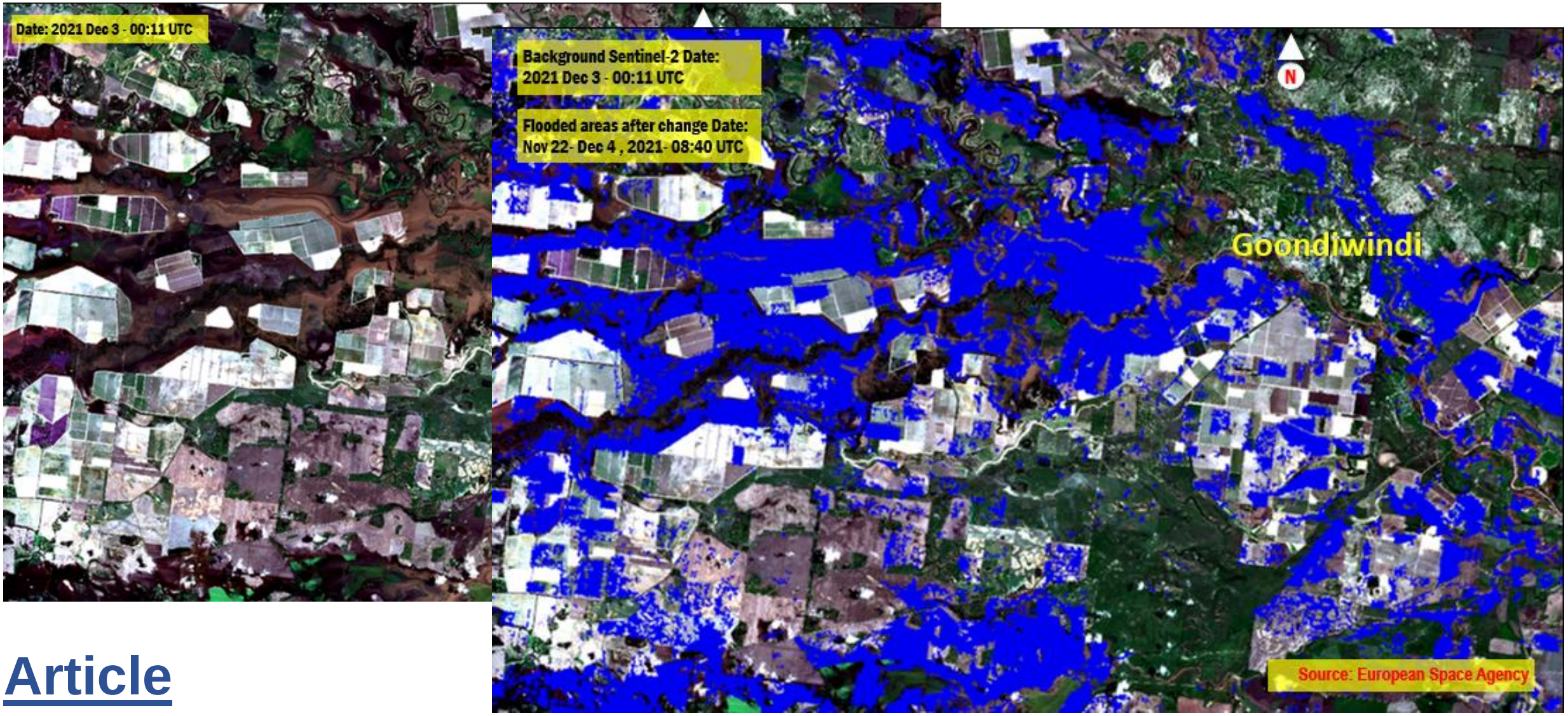
The overall analysis presented hereafter is based on the DPSVI analyses an area located SW of Jervis Bay, East of ACT.

DPSVI based analysis



Burnt area detected on 12 December (yellow), 24 December (orange) and 5 January (red)

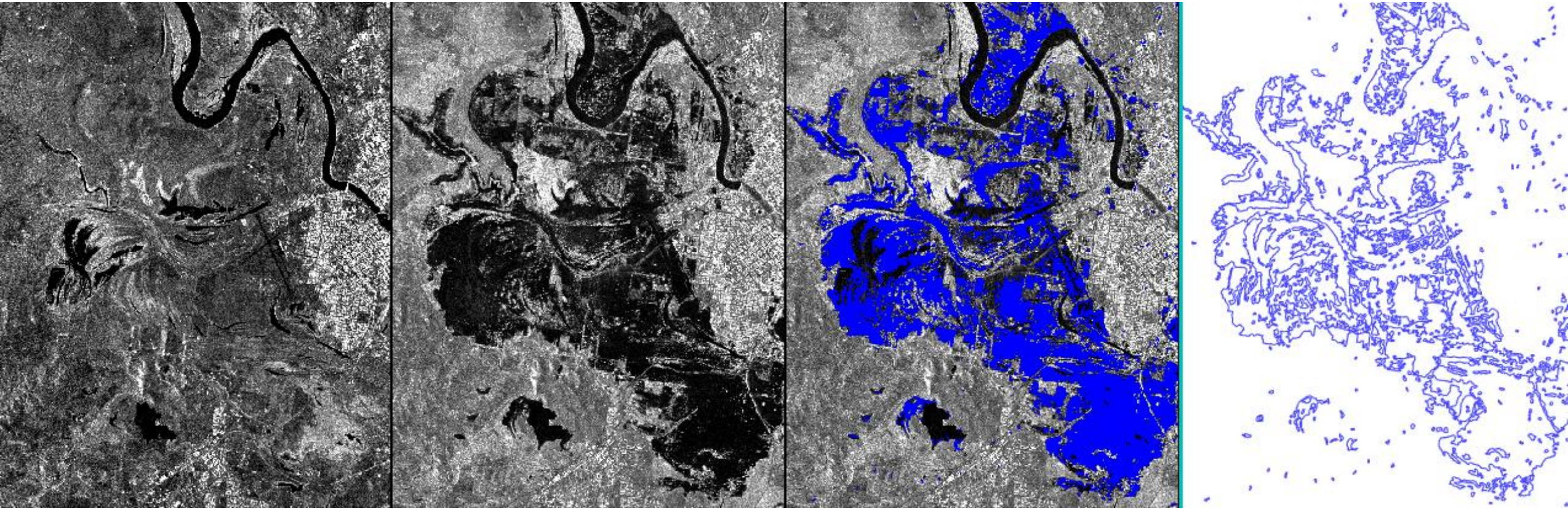
Disaster Management: Flood Mapping



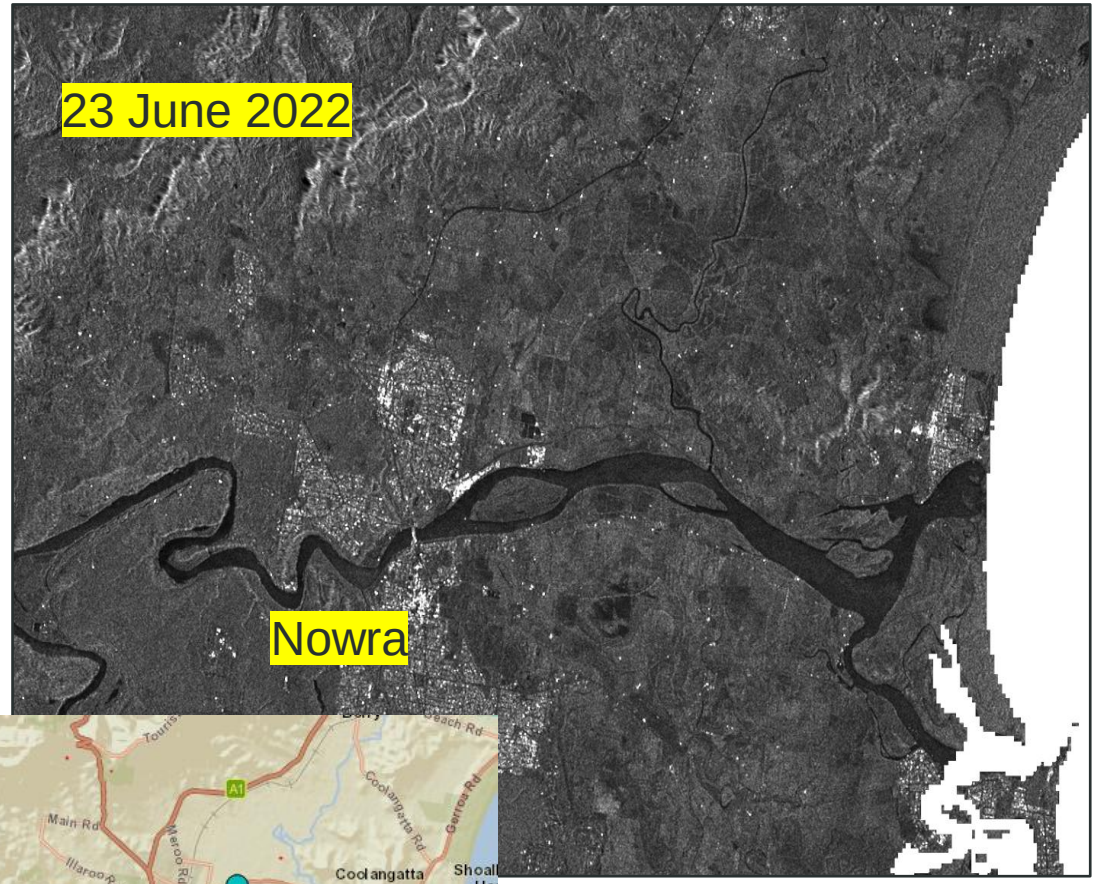
Article

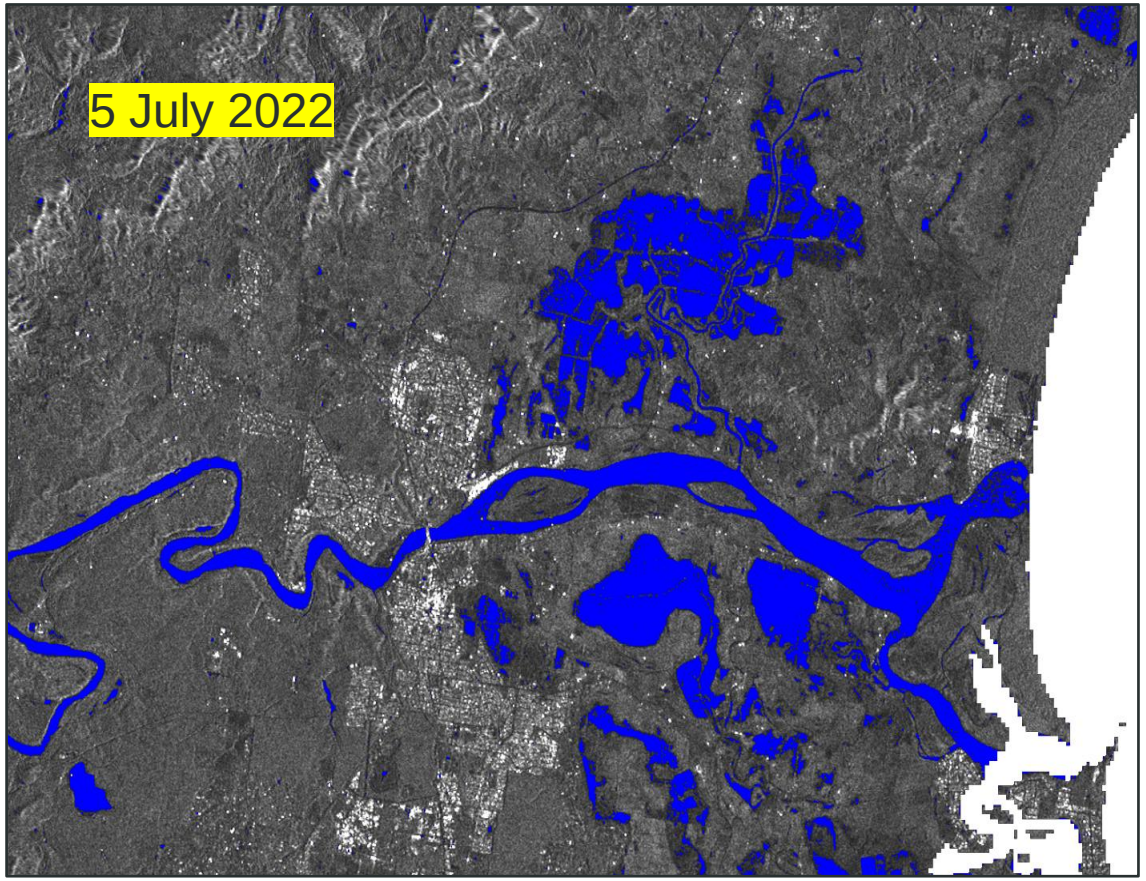
Disaster Management: Flood Mapping

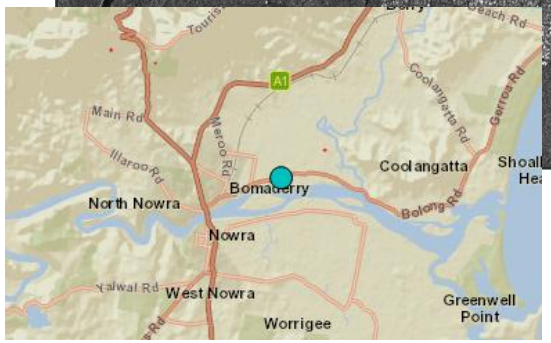
Rockhampton Flood 2011: Courtsey TerraSAR-X



SAR – Flood detection (East of the town of Nowra, NSW)

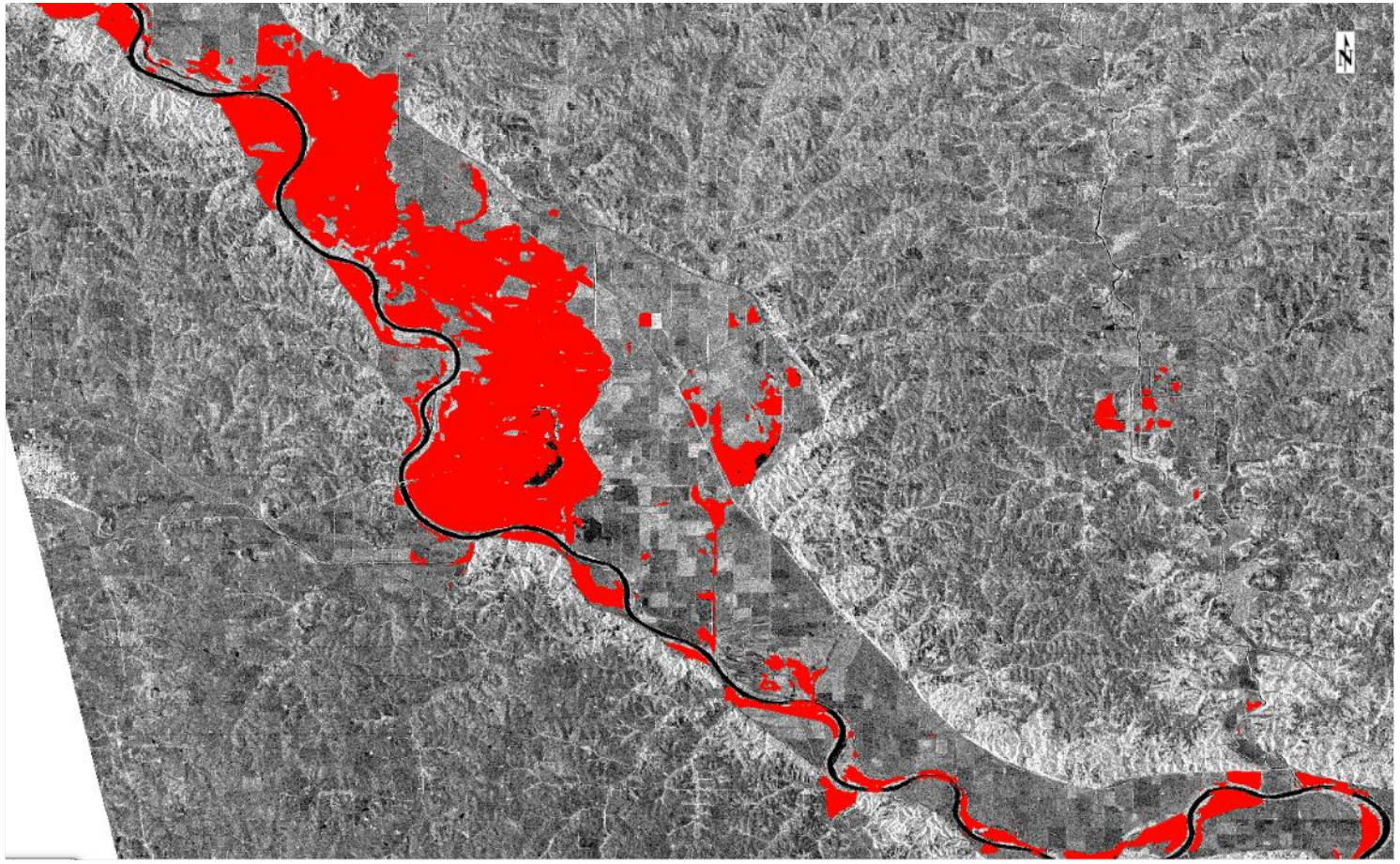


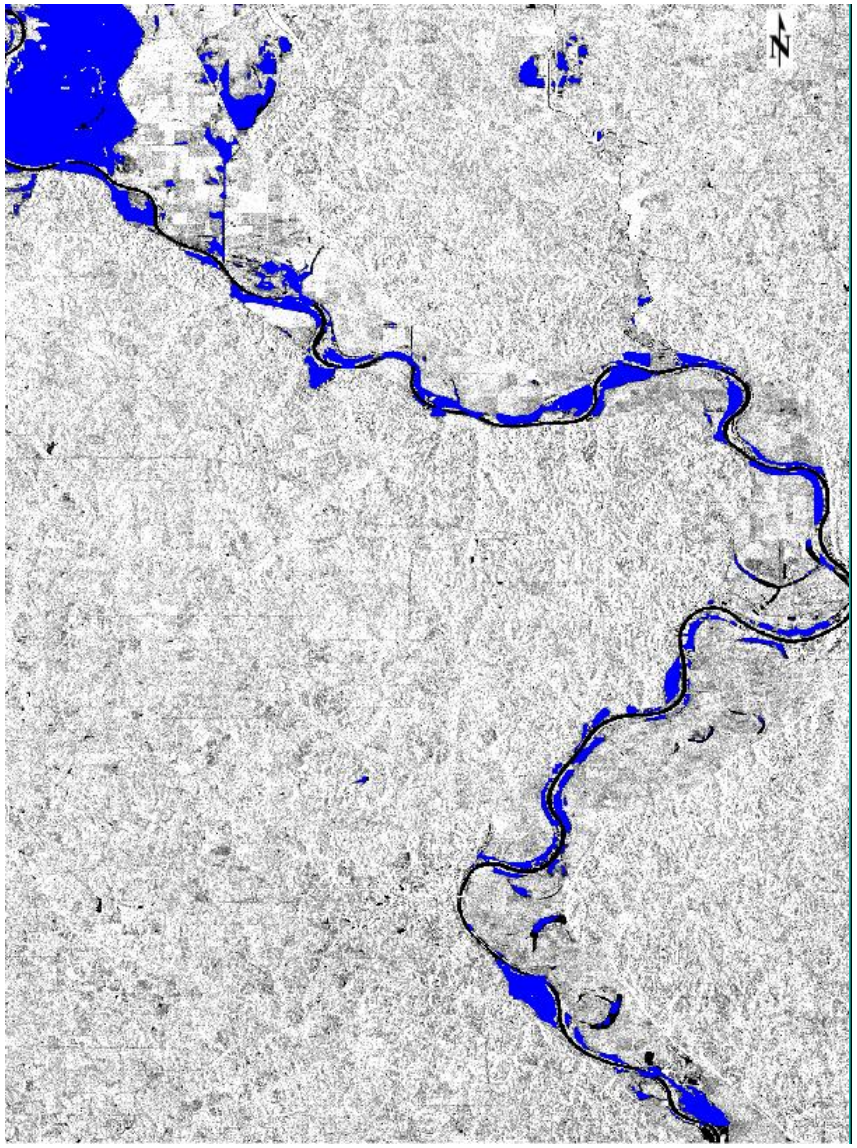




Flood Mapping using SAR

Flood Mapping Nebraska, U.S.A., 2019, using SAR

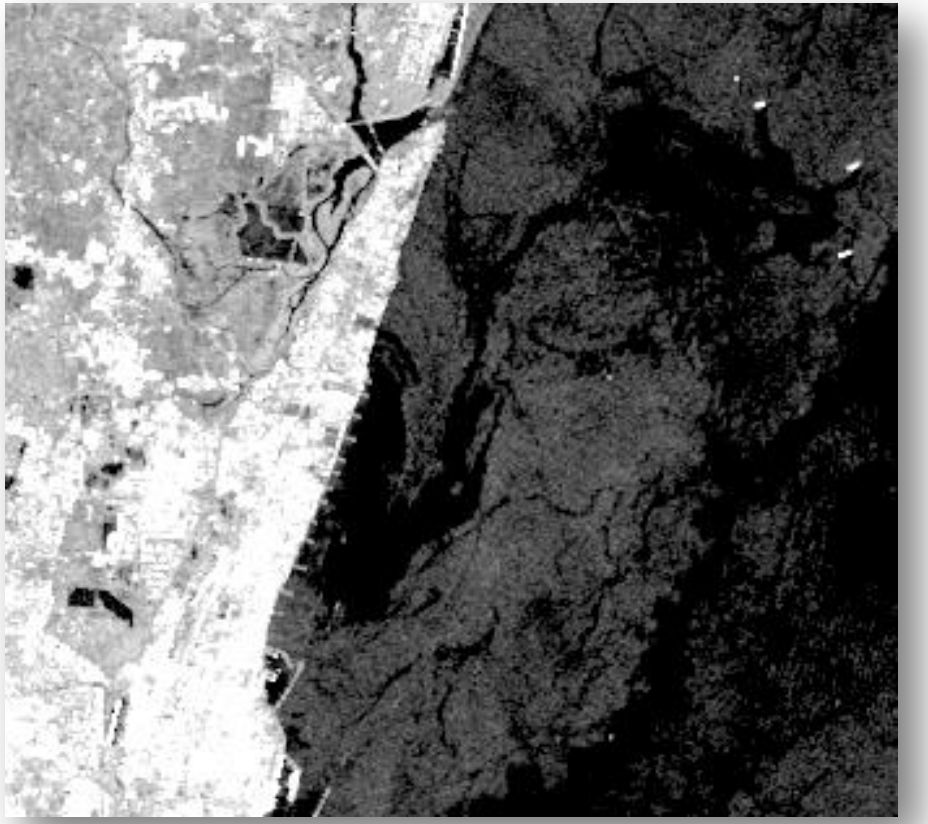




- 2x Sentinel-1 scenes (2019-02-22 and 2019-03-18) with VV polarization
- These images were stacked and run through ENVI Deep Learning

SAR Oil Spills Detection

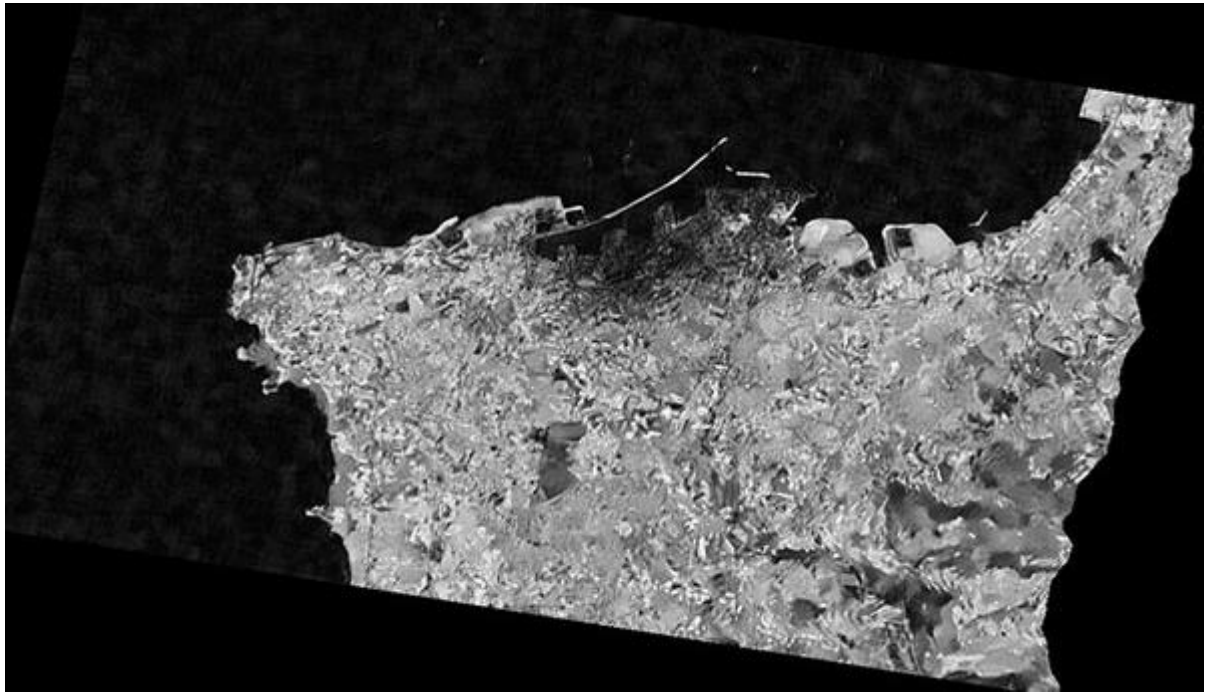
- Ennore
  - 28 January 2017, Kamarajar Port, Ennore, India
  - Cause: BW Maple collided with Dawn Kanchipuram
  - Sentinel-1 SLC (VV)

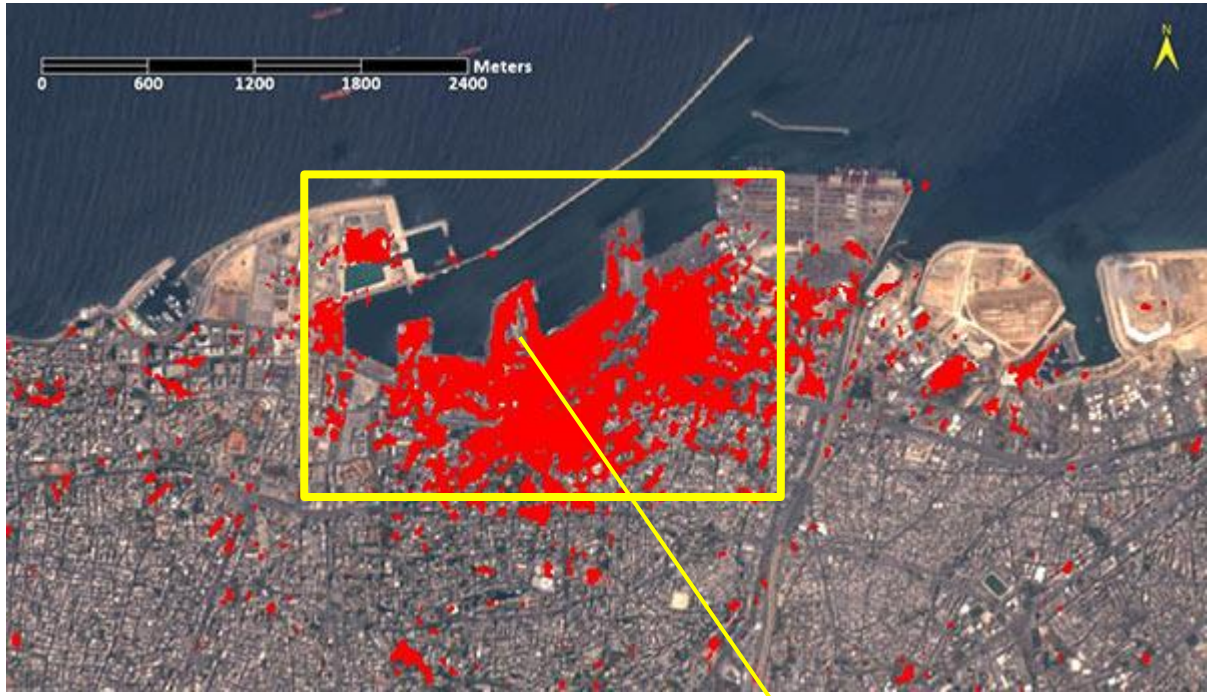


- Gotland Island
  - May 2005, Gotland Island, Sweden
  - Cause: Unknown
  - ENVISAT

Data courtesy sarmap

Extract Damage from 2020 Beirut Explosion using SAR



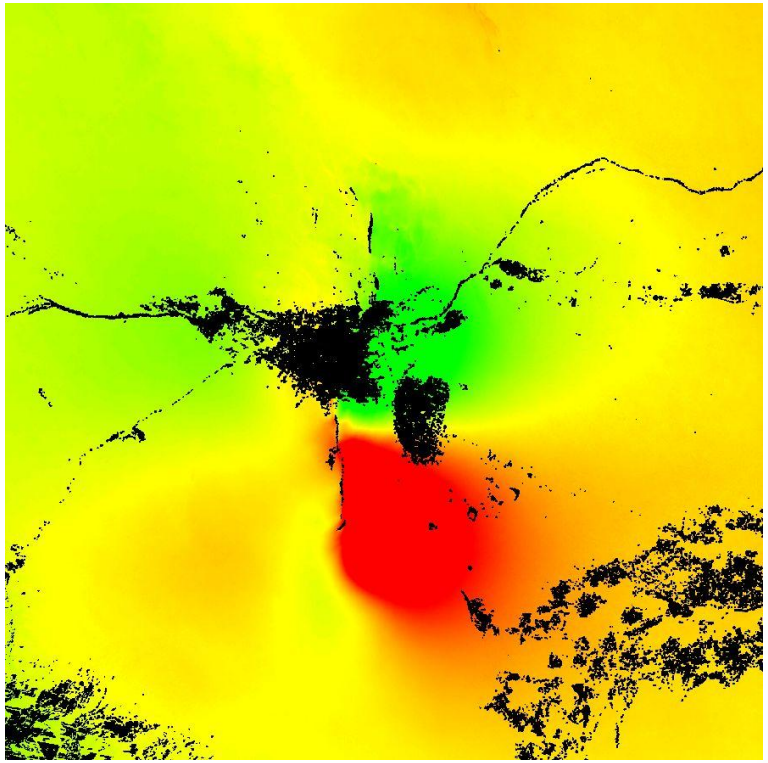


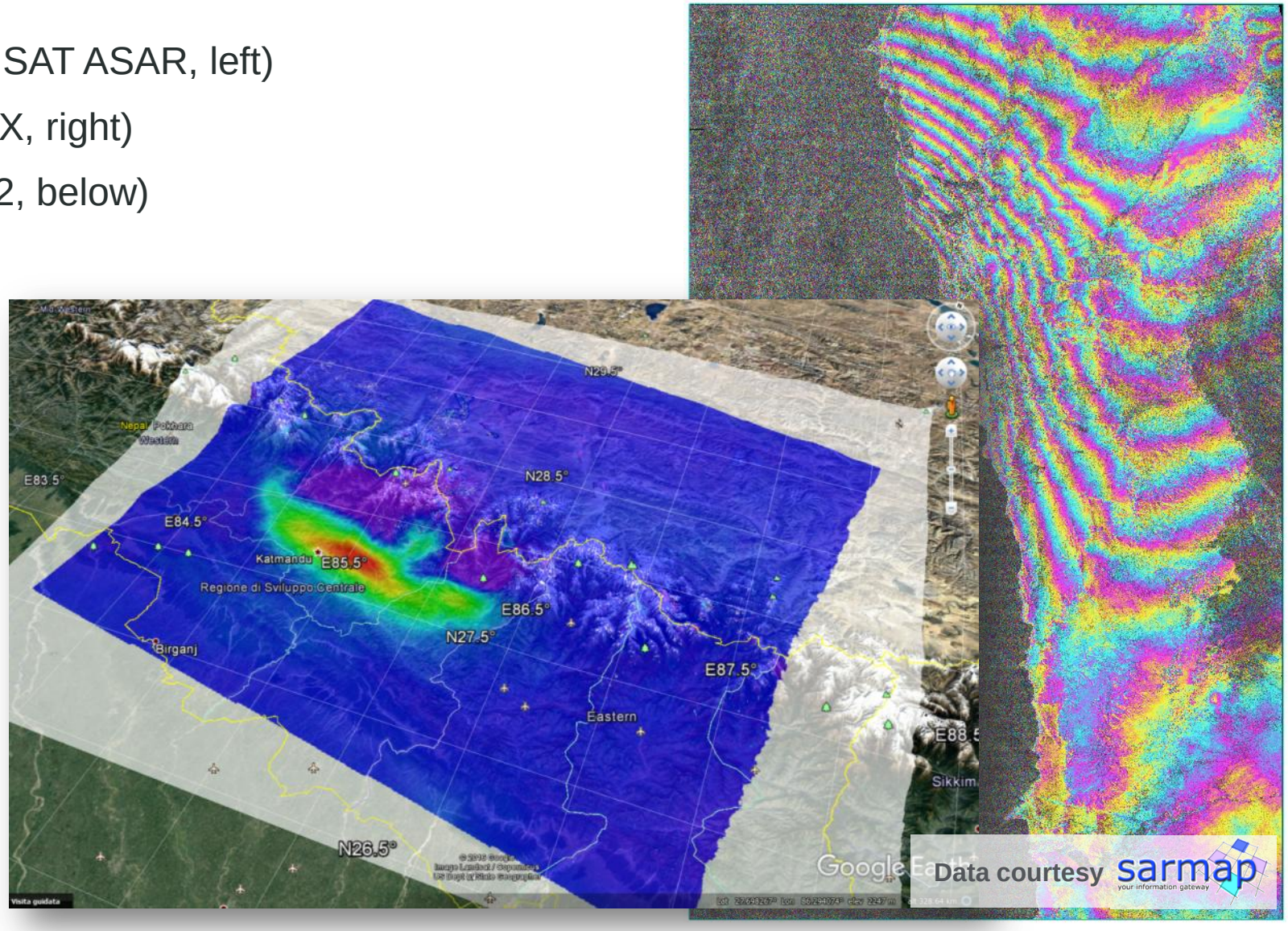
- On August 4, 2020, a huge explosion devastated the port area of Beirut, Lebanon
- SAR sensors and analytics can provide actionable information before smoke has cleared to assess destruction, guide aid and route emergency services, even with clouds and at night

Source: SAR Data Used to Extract Damage From Beirut Explosion: https://www.l3harrisgeospatial.com/Learn/Blogs/Blog-Details/ArtMID/10198/ArticleID/23935/ENVI-SARscape-Extracts-Damage-from-Beirut-Explosion

Earthquake Mapping using SAR Interferometry

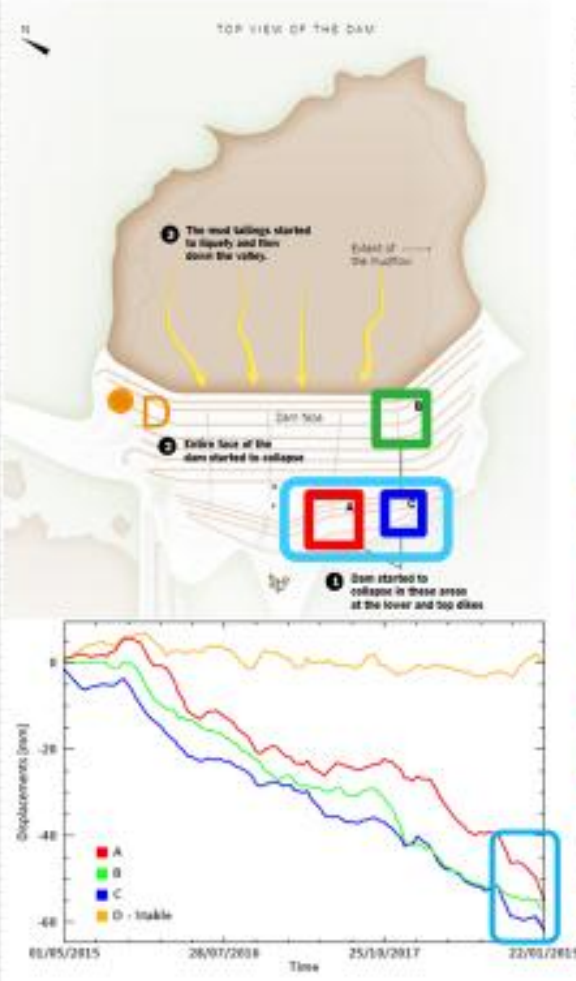
- Iran (Bam) 2003 earthquake (ENVISAT ASAR, left)
- Chile 2016 earthquake (TerraSAR-X, right)
- Nepal 2015 earthquake (PALSAR-2, below)



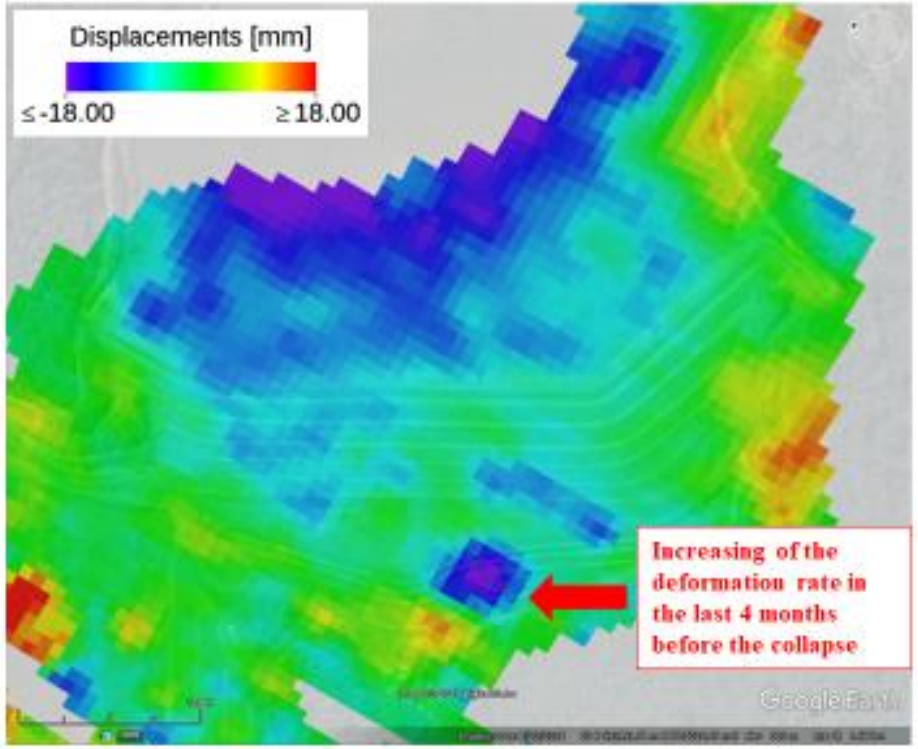


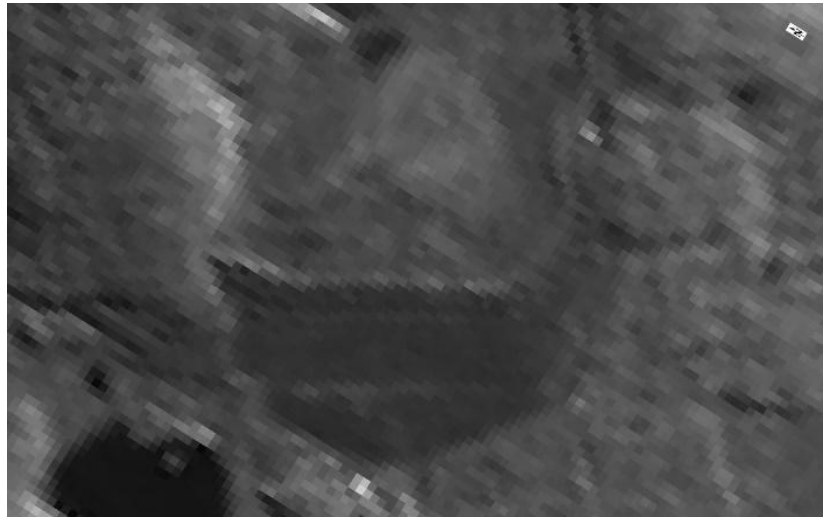
Dam Stability Monitoring: Brumadinho Dam, Brazil

Cumulative deformations between 24/9/2018 and 22/1/2019



The ongoing deformations showed an acceleration in between September 2018 and January 2019, particularly in points A and C.





Thank you!

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M: 045 000 4946