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Dam Rehabilitation & Improvement Project

Central Water Commission

Monitoring of Landslides between Tehri and Koteshwar Dams in Uttarakhand

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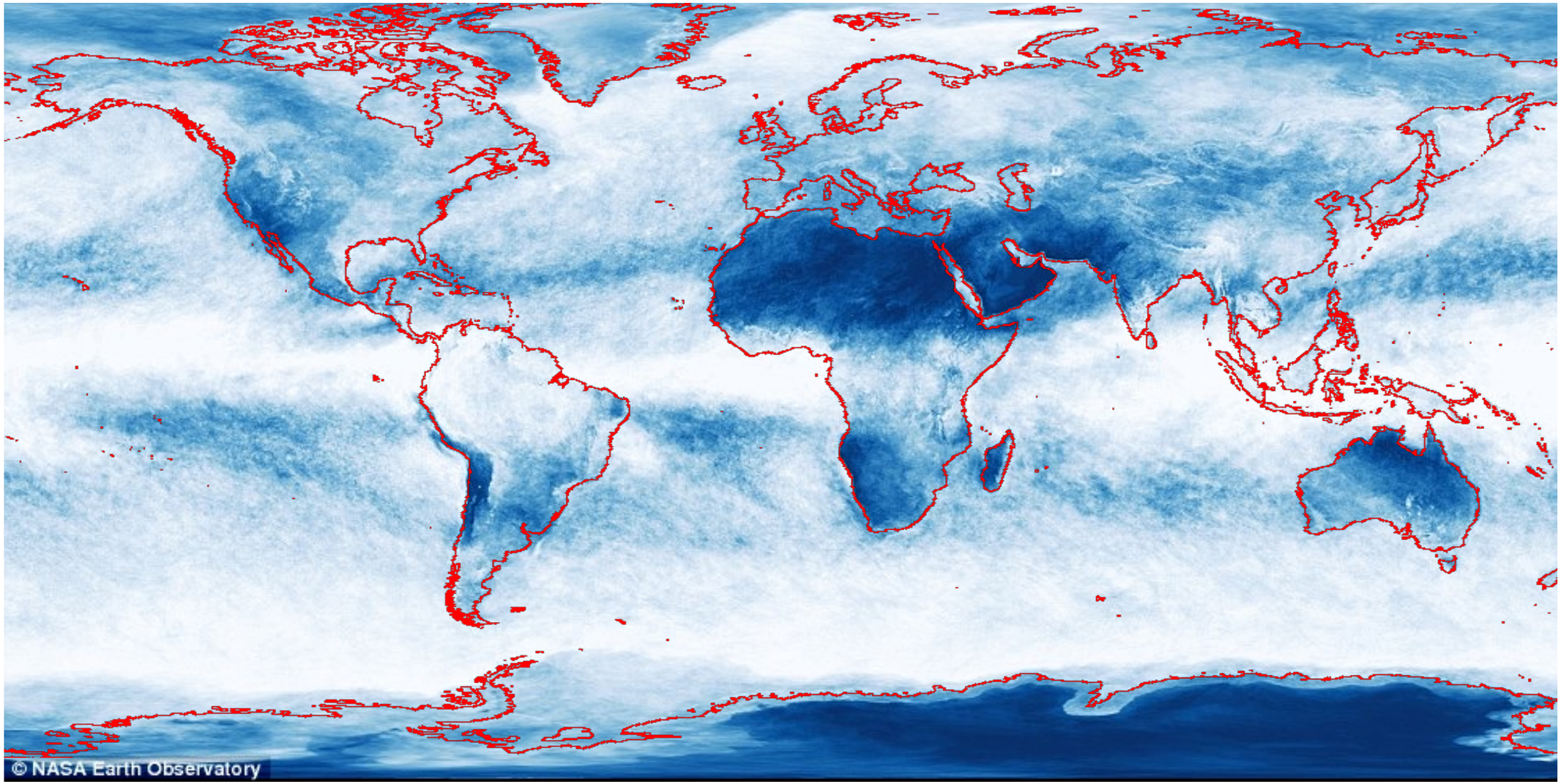
** Presenting Author*

Motivation

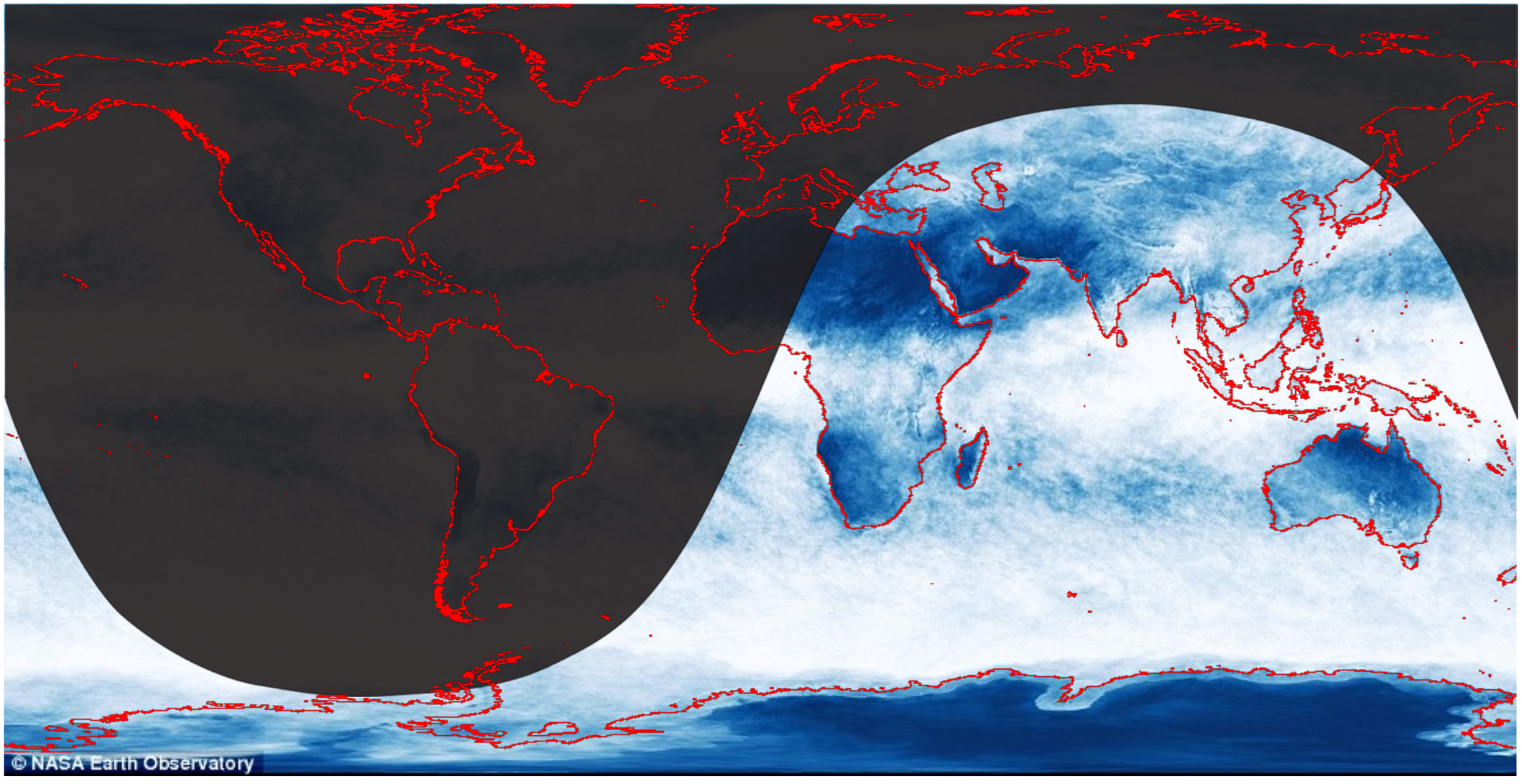
- Landslides can cause great impact on hydropower projects.
- Investigation and observation of landslides along the rim of dam reservoirs is essential.
- Non-invasive geospatial technologies holds the key for periodic monitoring of landslides, i.e., Satellite Radar Technology including Synthetic Aperture Radar (SAR).
- SAR data can be acquired during day and night, rainfall, and cloudy weather as it utilizes microwaves
- Interferometric SAR (InSAR) is able to produce a map of deformation due to landslides with centimeter-scale accuracy.



Courtesy: Dr. Sang-Ho Yun, JPL, NASA

Average cloudiness over Earth in April 2015 seen from Aqua Satellite.

Microwaves can penetrate through clouds

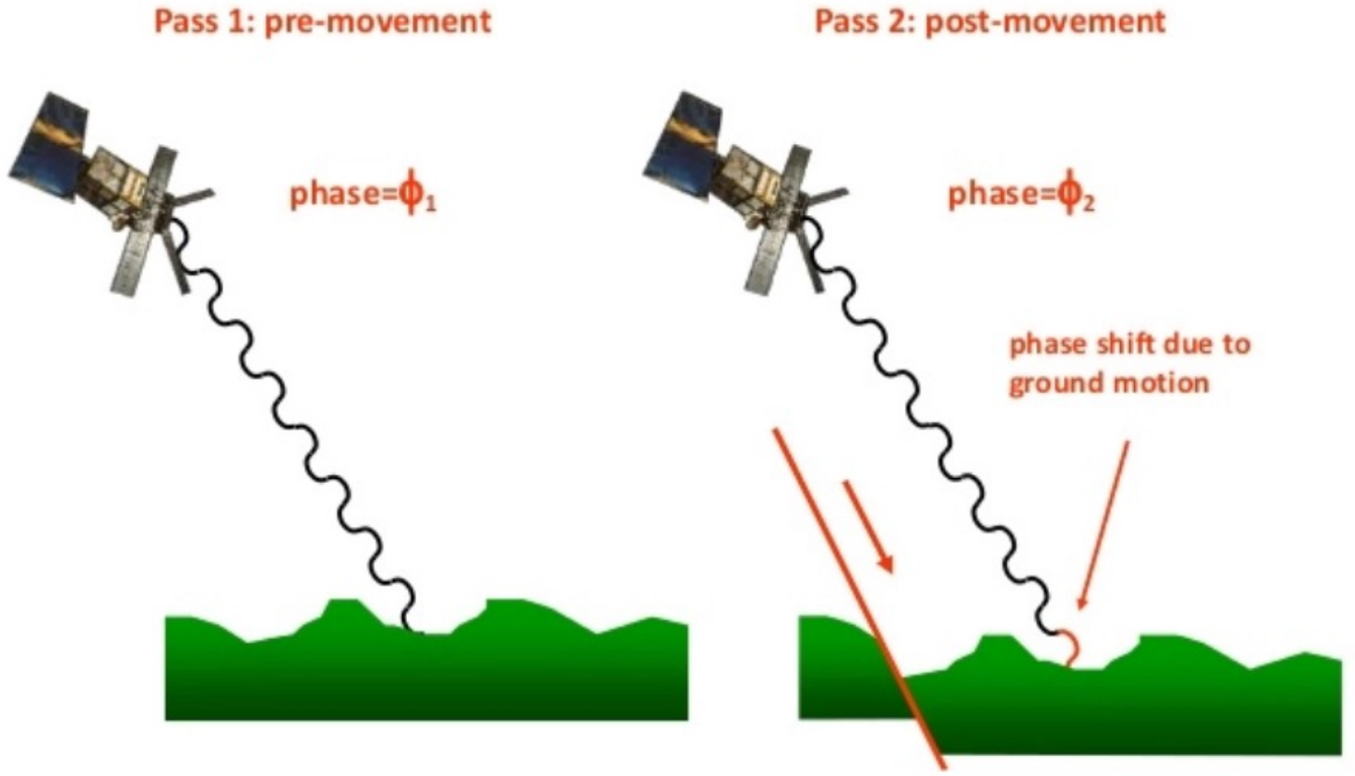


Courtesy: Dr. Sang-Ho Yun, JPL, NASA

At any given time, 50% of the Earth is dark.

Microwaves do not rely on Sun for the source of illumination

InSAR: How it works



Credit; G. Funning

https://comet.nerc.ac.uk/earth-observation/insar/how-insar-works/

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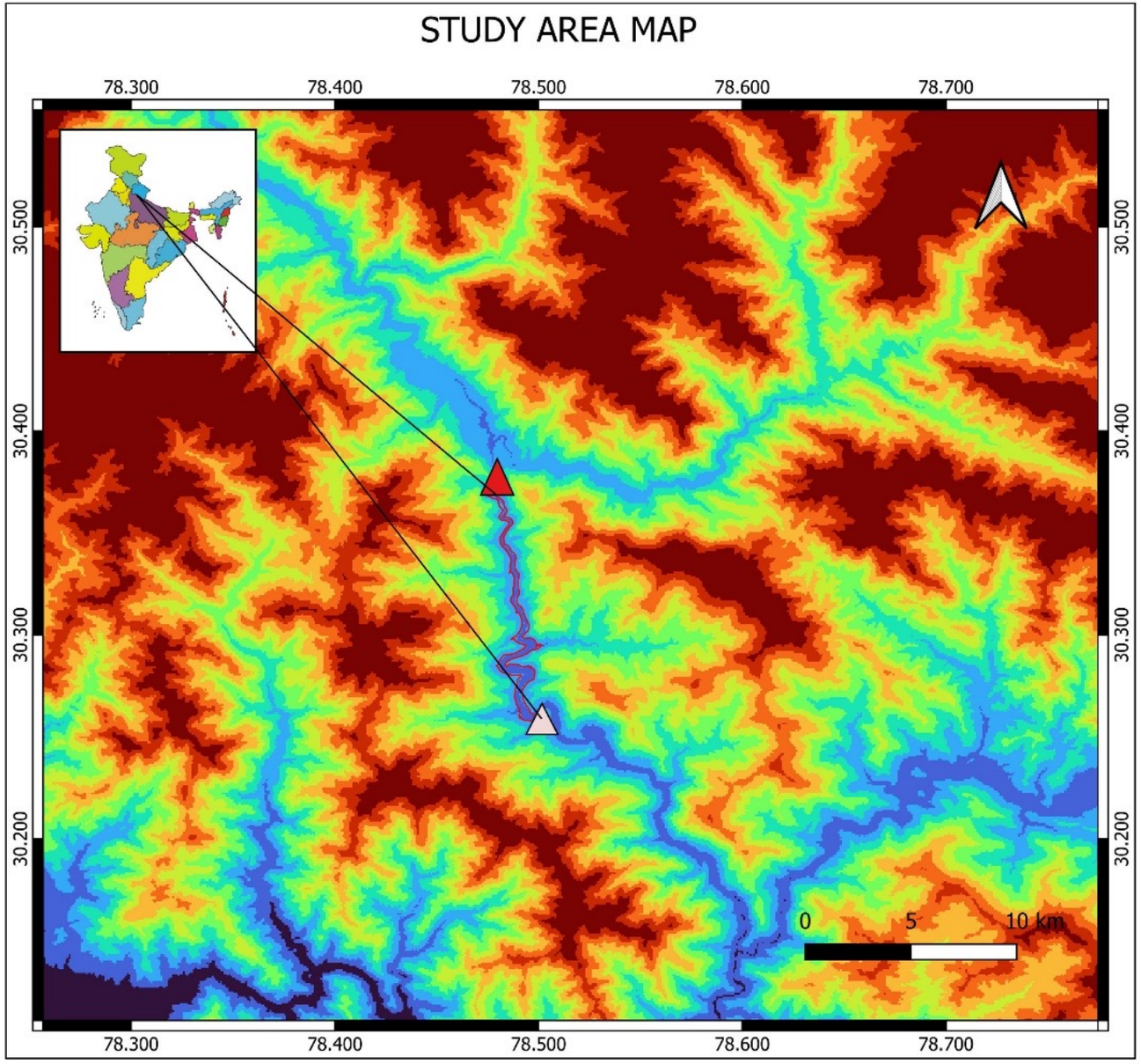


Koteshwar Dam

The Koteshwar Dam is a gravity dam on the Bhagirathi River, located 22 km (14 mi) downstream of the Tehri Dam in Tehri District, Uttarakhand, India. The dam is part of the Tehri Hydropower Complex and serves to regulate the Tehri Dam's tailrace for irrigation and create the lower reservoir of the Tehri Pumped Storage Power Station. In addition, the dam has a 400 MW (4x100 MW) run-of-the-river power station.

Legends

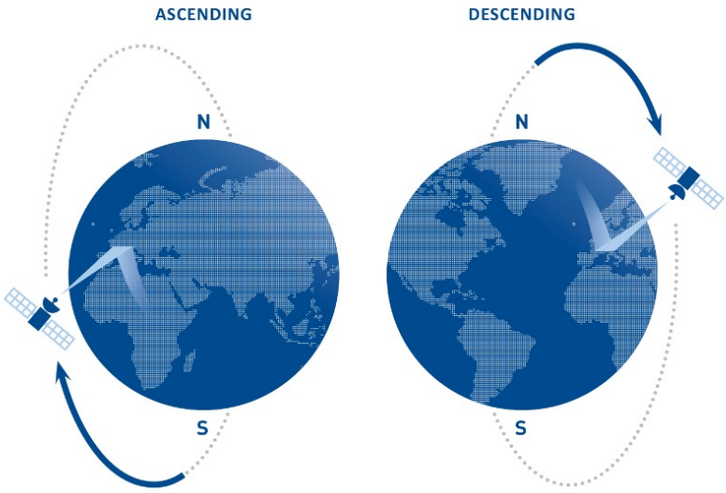
- <= 468
- 468 - 638
- 638 - 809
- 809 - 979
- 979 - 1149
- 1149 - 1319
- 1319 - 1489
- 1489 - 1660
- 1660 - 1830
- > 1830

- Koteshwar Dam
- Reservoir Rim
- Tehri Dam

Dataset and Methods

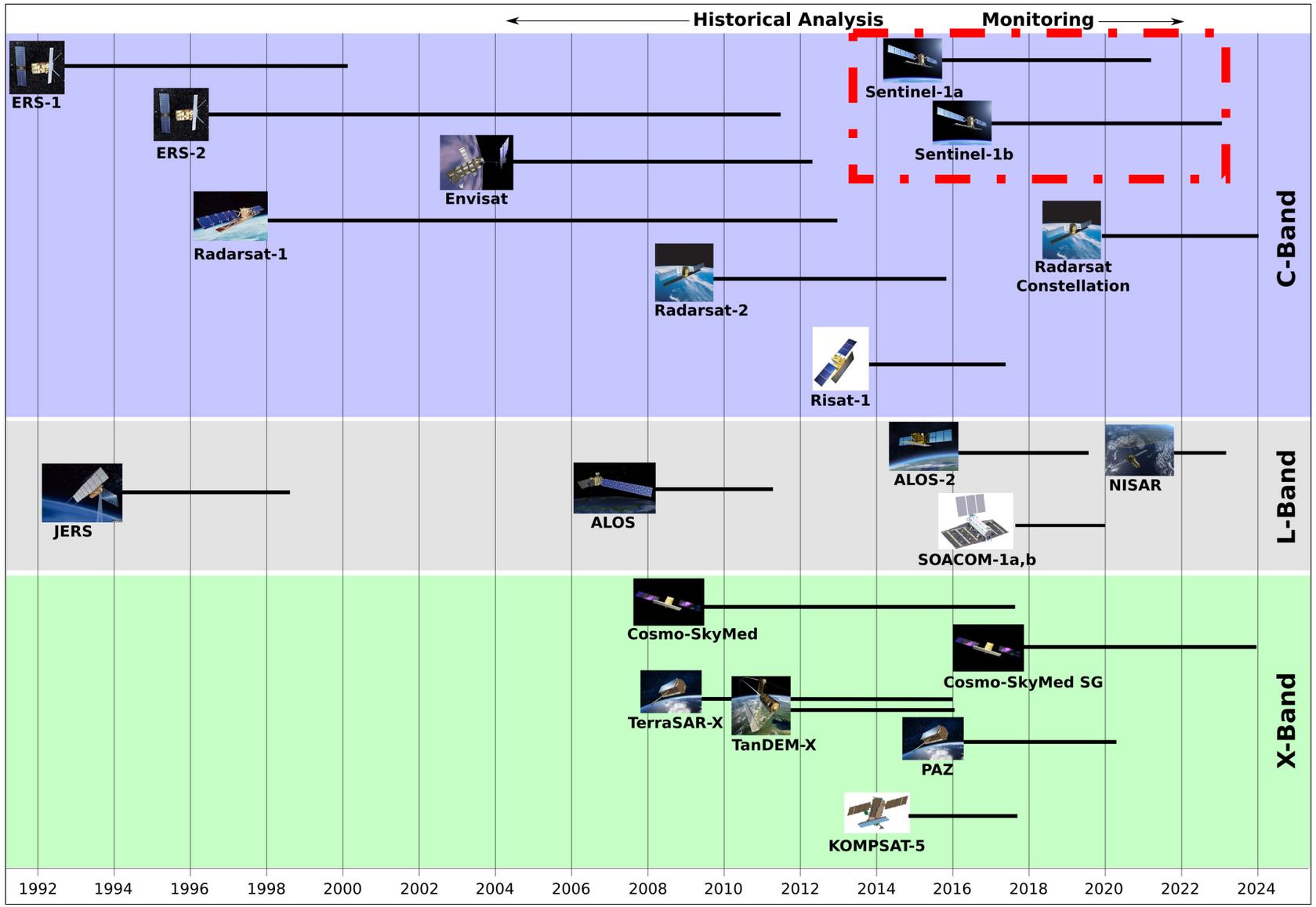
- A total of 42 images were acquired between the start and end dates (refer Table).
- Sentinal-1A Level-1 SLC products area available for free download from the ASF website (https://vertex.daac.asf.alaska.edu/).

Satellite	Start Date	End Date	Orbit	Path	Frame	Polarization
Sentinel-1	01/01/2021	30/06/2022	Descending	63	492	VV+VH



www.site.tre-Altamira.com/insar/

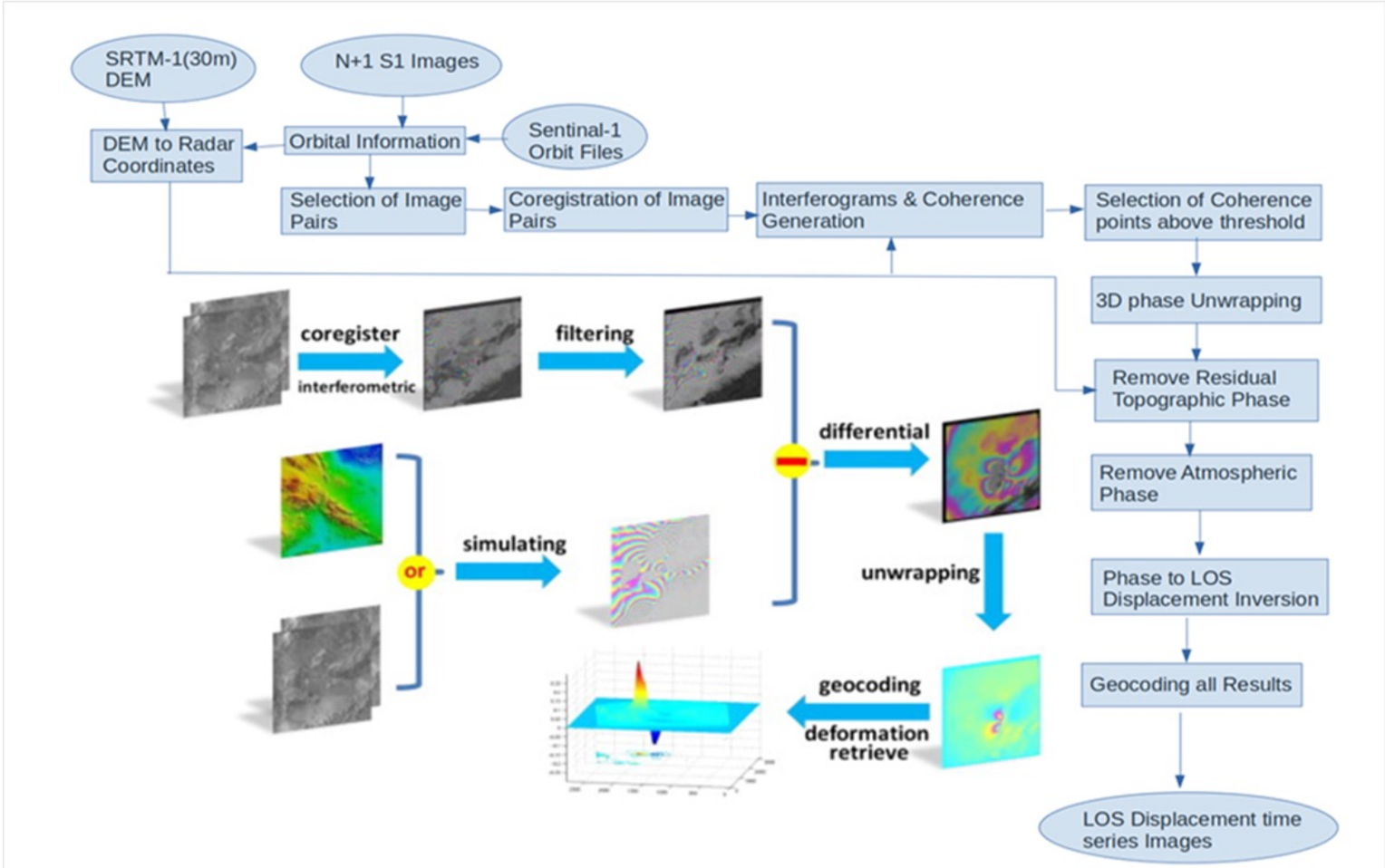
Dataset and Methods



Courtesy: UNAVCO

Method 1: Small BAseline Subset (SBAS) InSAR

We applied SBAS using open-source script-based software named *GMTSAR*

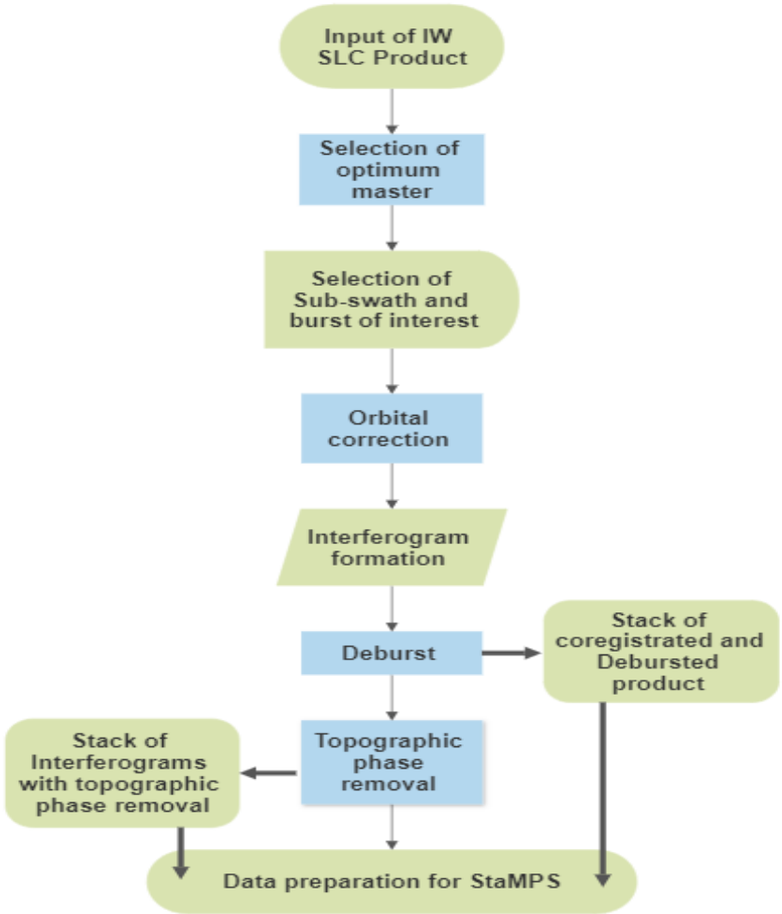


Hu, J., Li., Z.W., Ding, X.L., Zhu, J.J., Zhang, L., Sun, Q. (2014). Resolving three-dimensional surface displacements from InSAR measurements: A review, *Earth Science Reviews,* 133, 1-17
Berardino, P., Fornaro, G., Lanari, R., Sansosti, E. (2002). A new algorithm for surface deformation monitoring based on small baseline differential SAR interferograms, *IEEE Transactions on Geoscience and Remote Sensing*, 40(11), 2375-2383
Sandwell, D., Mellors, R., Tong, M. Wei, Wessel, P. (2011). Open radar interferometry software for mapping surface deformation, EOS Transactions, AGU, 92(8)

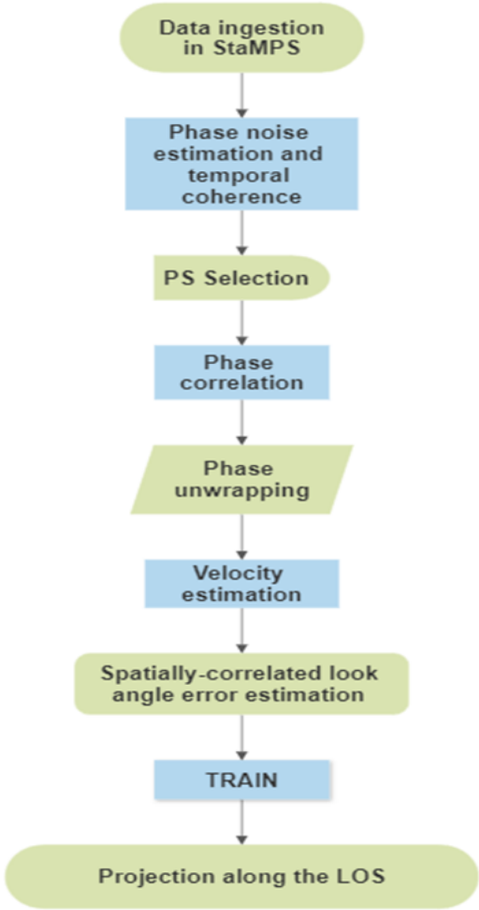
Method 2: Permanent Scatterer InSAR (PSInSAR)

We applied PSInSAR using SNAP and StaMPS. PSI processing is divided into two individual workflows

1.Single master InSAR processing using ESA SNAP



2.PSI processing using StaMPS



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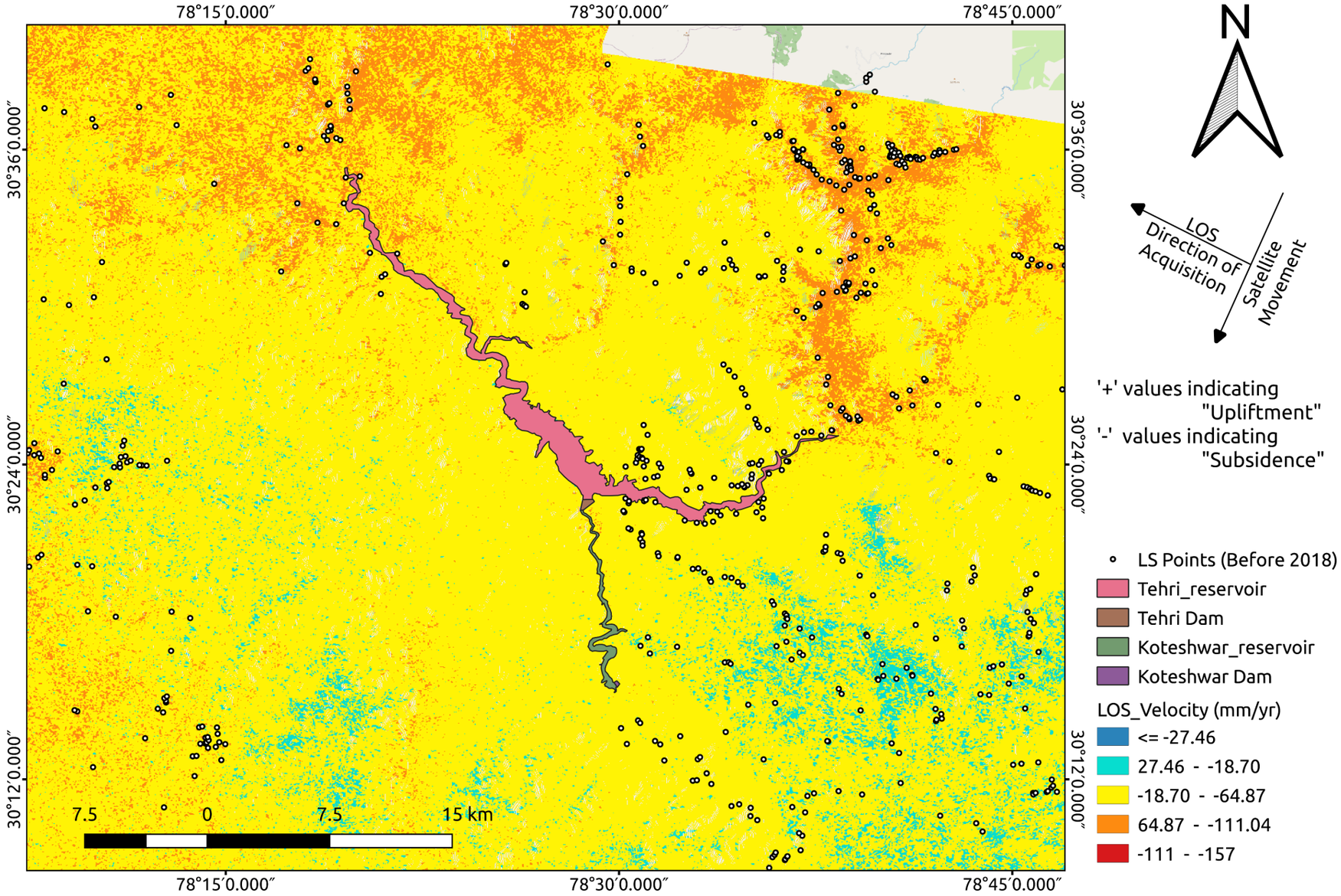
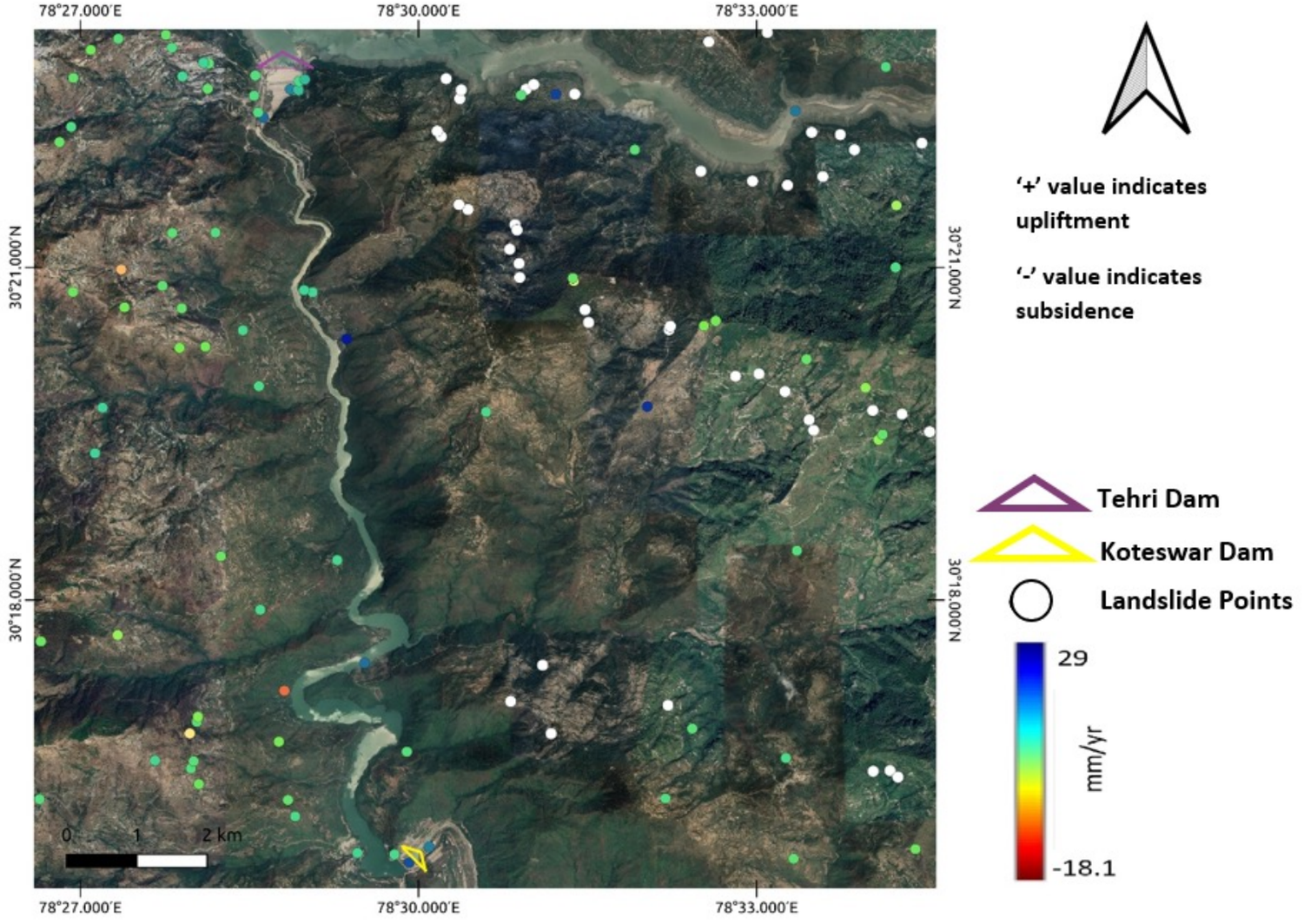
SBAS Results Map for Tehri and Koteshwar Dams & Reservoirs



10-12 October 2022 at Jaipur, Rajasthan (India)

PSInSAR results map for Koteswar Dam & Reservoir



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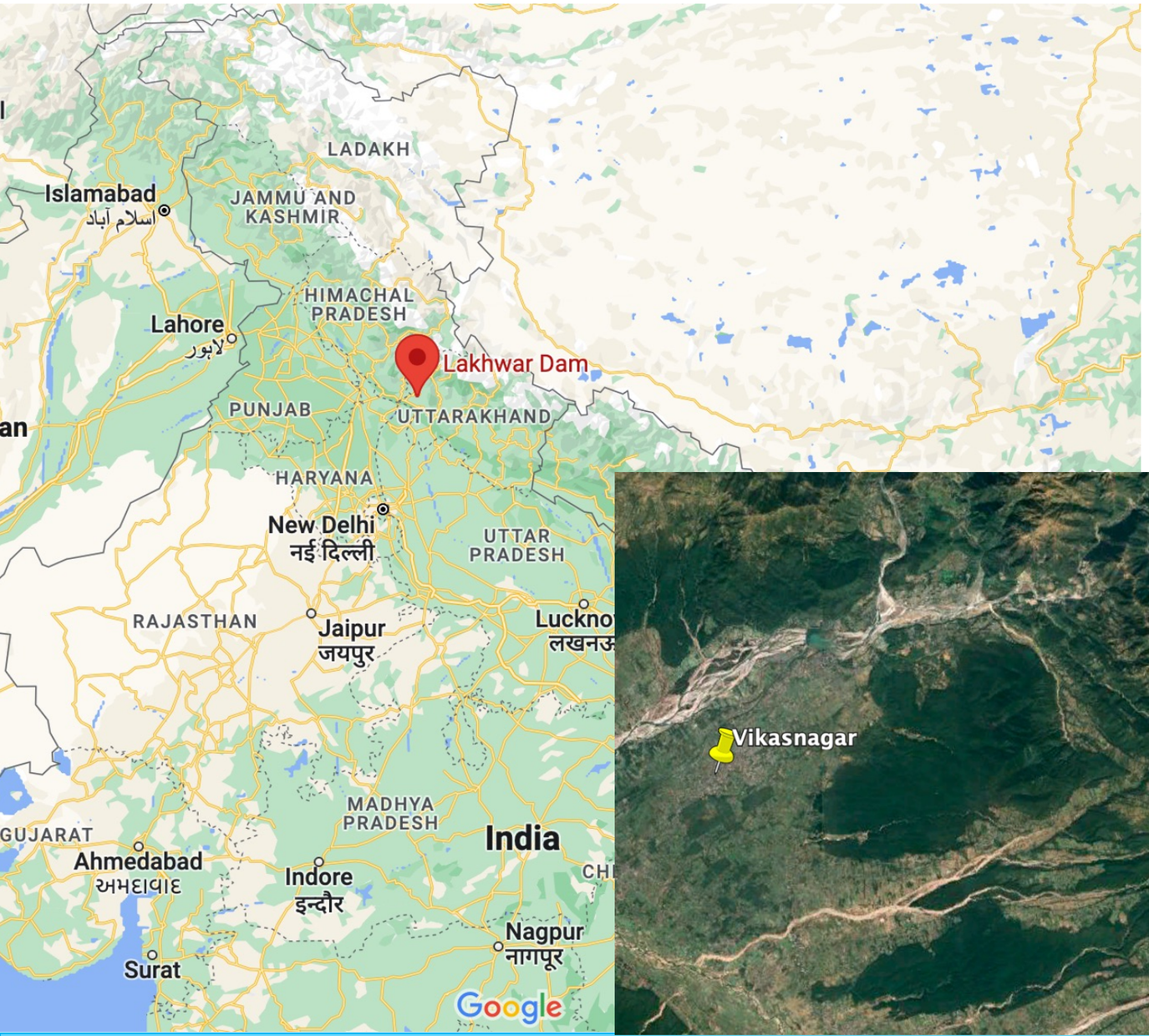

Lakhwar Vyasi Dam, Uttarakhand

10-12 October 2022 at Jaipur, Rajasthan (India)

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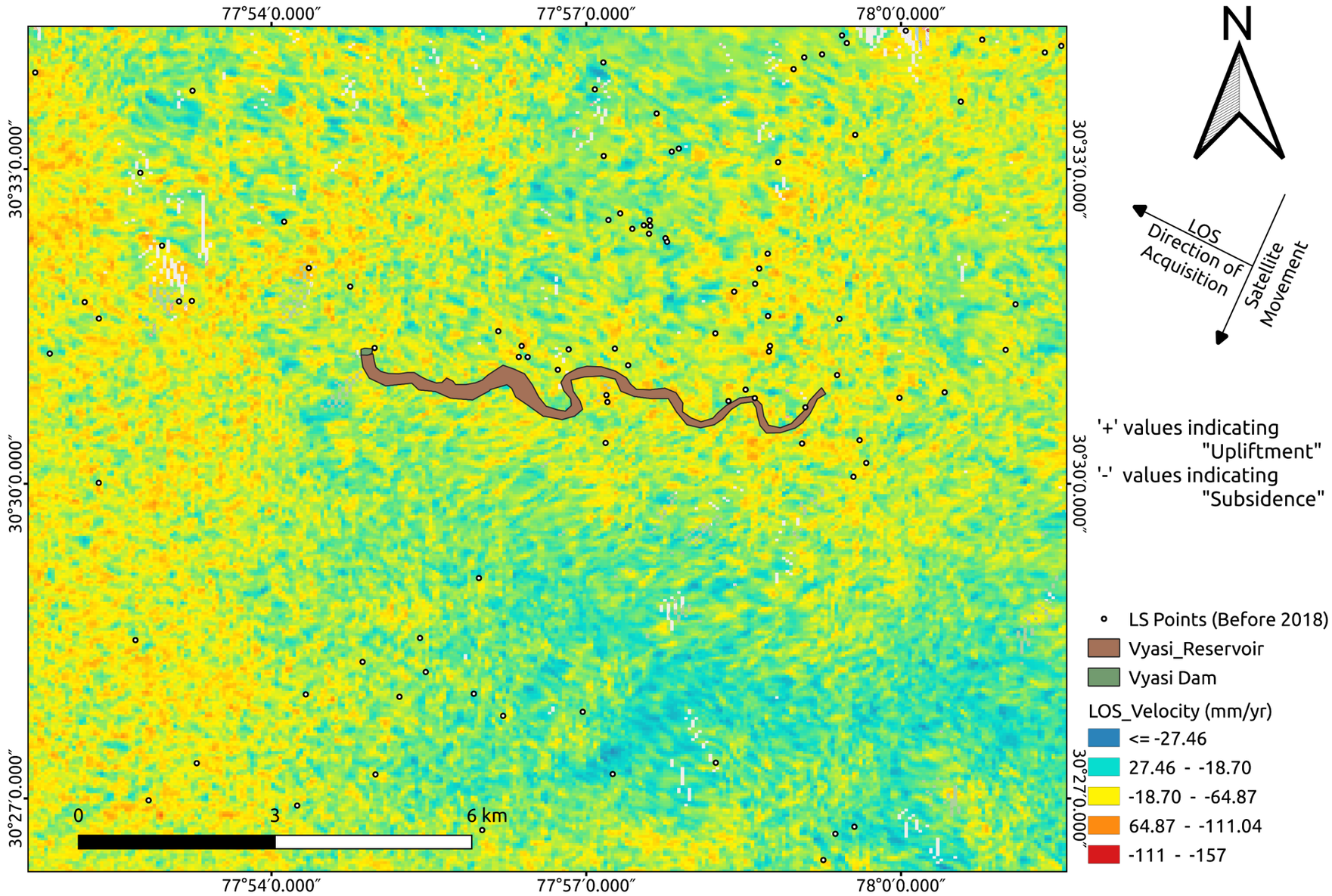
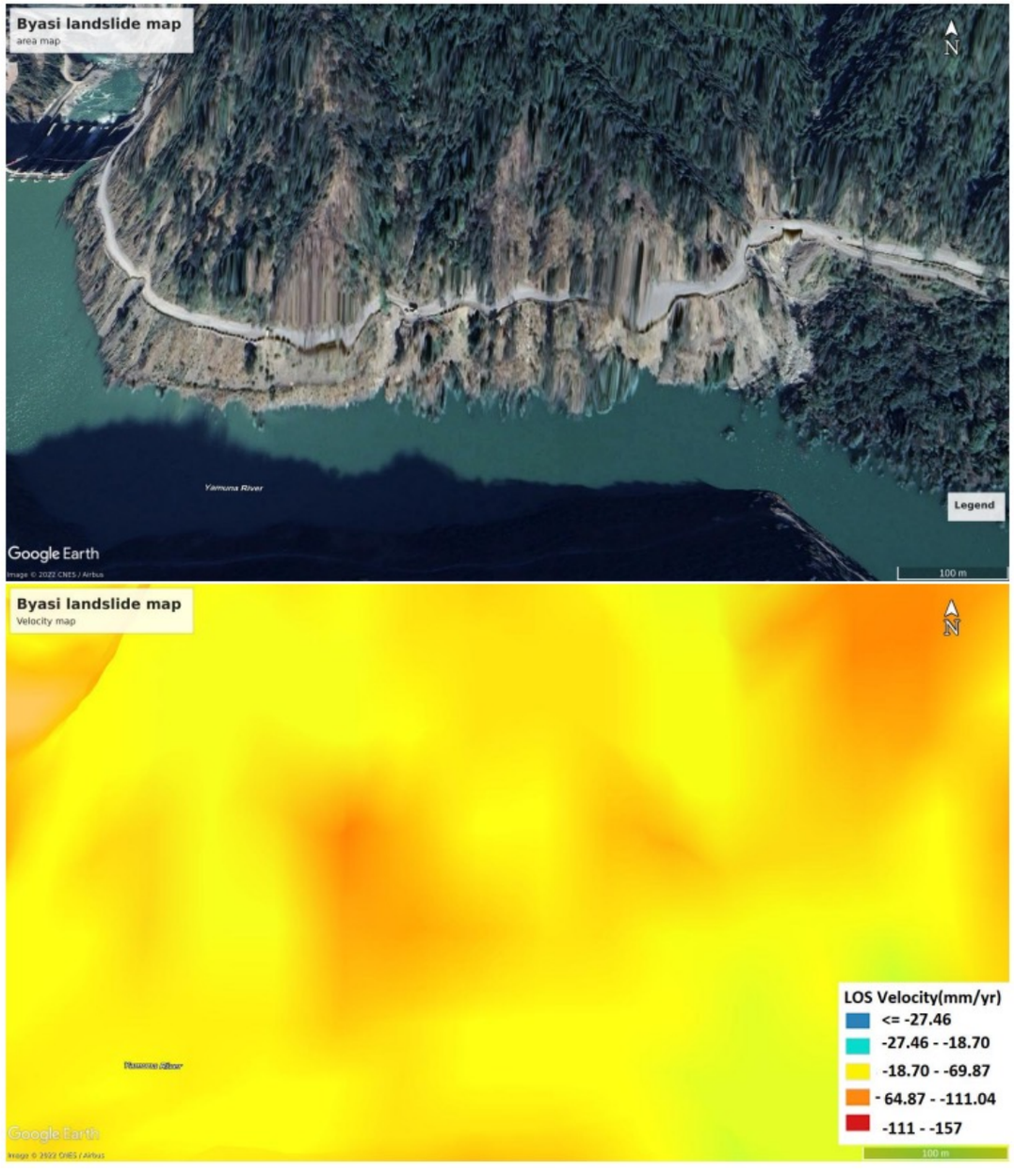
SBAS Results Map for Vyasi Dam and Reservoir



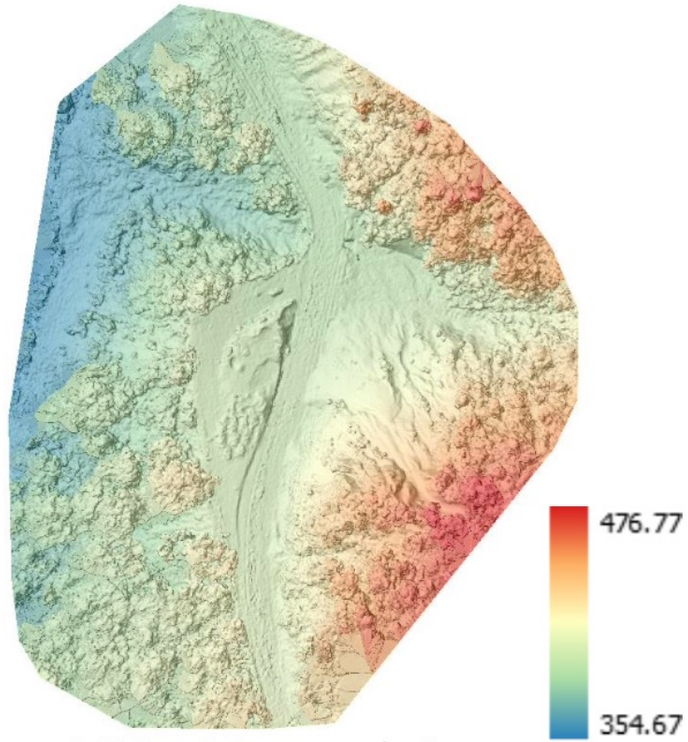
10-12 October 2022 at Jaipur, Rajasthan (India)


Byasi landslide map
area map
N
Yamuna River
Legend
Google Earth
100 m
Byasi landslide map
Velocity map
N
LOS Velocity(mm/yr)
<= -27.46
-27.46 - -18.70
-18.70 - -69.87
-64.87 - -111.04
-111 - -157
Google Earth
100 m

DRONE-BASED LANDSLIDE STUDIES: AN EXAMPLE

SNAP-M Drone

Orthorectified Image at 3.6 cm resolution



DEM at 3.6 cm resolution

Geospatial Data Availability & Data Generation

- Public Domain SAR datasets
- High-Resolution Optical Images with 50 cm or better spatial resolution
- Drone Surveys

Results

- Track velocity of landslide motion
- Volume of generated landslide debris
- Direction of landslide debris movement at high-resolution

Advantages to Dam Safety

- Track landslide motions periodically
- Quantify the volume of debris releasing from landslides
- Deriving direction of debris releasing from landslides
- Quantifying the sediment load from landslides along the reservoir rim

Thank You