DigitalWorld 2023 Congress

Application of InSAR Method to Estimate the Surface Deformation of the May Embankment Dam, Turkey

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Rouhollah Nasirzadehdizaji

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Education

- Ph.D., in Civil Engineering, Hydraulic Program, Istanbul University, Turkey (2022).
- Ph.D., in Geomatic Engineering, Remote Sensing and GIS Program, Yildiz Technical University, Turkey (2020).
- M.Sc., degree in Geographical Information Technology, Istanbul Technical University, Turkey (2015).
- B.Sc., degree in Civil Engineering, I.A University Shabestar, Tabriz, Iran (2006).

Research Interest

- He has conducted research in several areas, including Interferometric SAR (InSAR) coherence and backscattering analysis, polarimetric SAR (PolSAR) analysis for crop variables investigation, and the integration of Optical and SAR data for crop mapping improvement. He has experience in flood mapping and permanent water bodies change detection using Radar data, as well as the application of remote sensing techniques in land monitoring.
- He has also conducted research on the application of hydrological models to assess the impacts of land use changes such as forest fires on runoff and sediment loads.

Current Profession

- He works as a specialist engineer in Water & Environment Department at Yüksel Proje Inc., Turkey, where he is working as a senior engineer on water-related projects, including conducting hydrological analysis and hydraulic modeling, as well as managing and developing GIS and remote sensing R&D projects related to water and environmental studies.

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- https://scholar.google.com/citations?user=AcOz2T4AAAAJ&hl=en
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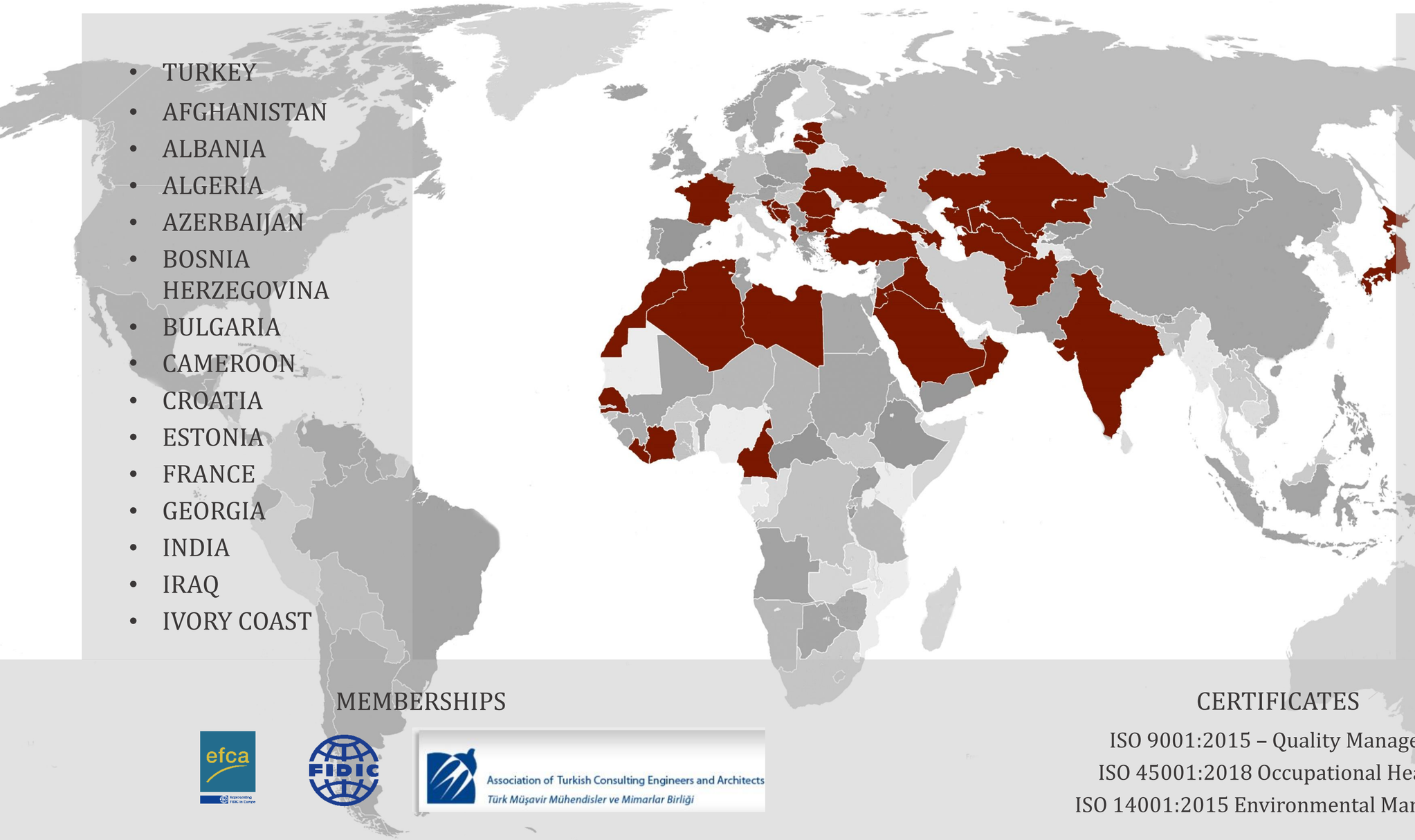

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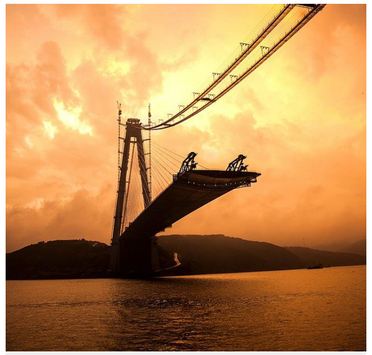

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- Railways
- Tunnels
- Metro & LRTS & Tram
- Marine Structures
- Airports

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- Natural Gas and Crude Oil Pipelines
- Natural Gas Storage Facilities
- Power Plants

HYDRO PROJECTS

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- Drainage and Wastewater Networks
- Water & Wastewater Treatment Plants
- Flood Protection & Sediment Control Structures

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- Smart Buildings
- Industrial Facilities
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- Education, Sports and Health Facilities

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- Soil Investigation Laboratory

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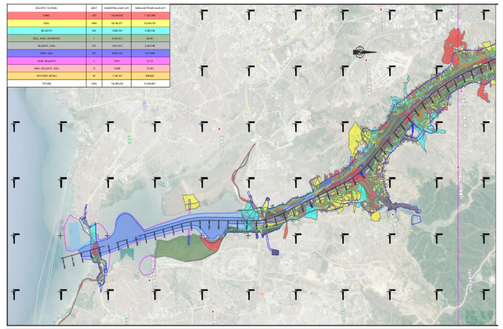
- Cost Estimation
- Existing Conditions Modelling
- Engineering Analyses
- Construction System Design
- Design Documents
- Design Review
- Site Utilization Planning
- Record Modelling

DESIGN

- Concept Design
- Interior Design
- Artwork Design
- Rendering
- Animation
- VR&AR



SOFTWARE DEVELOPMENT

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- Cloud Based Custom ERP Solutions
- CAD Automation Software Development
- BIM Support Tools
- Over 2500 Active Users (Including Supervisors and Subcontractors)
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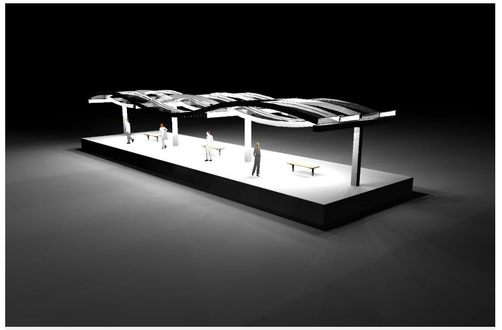
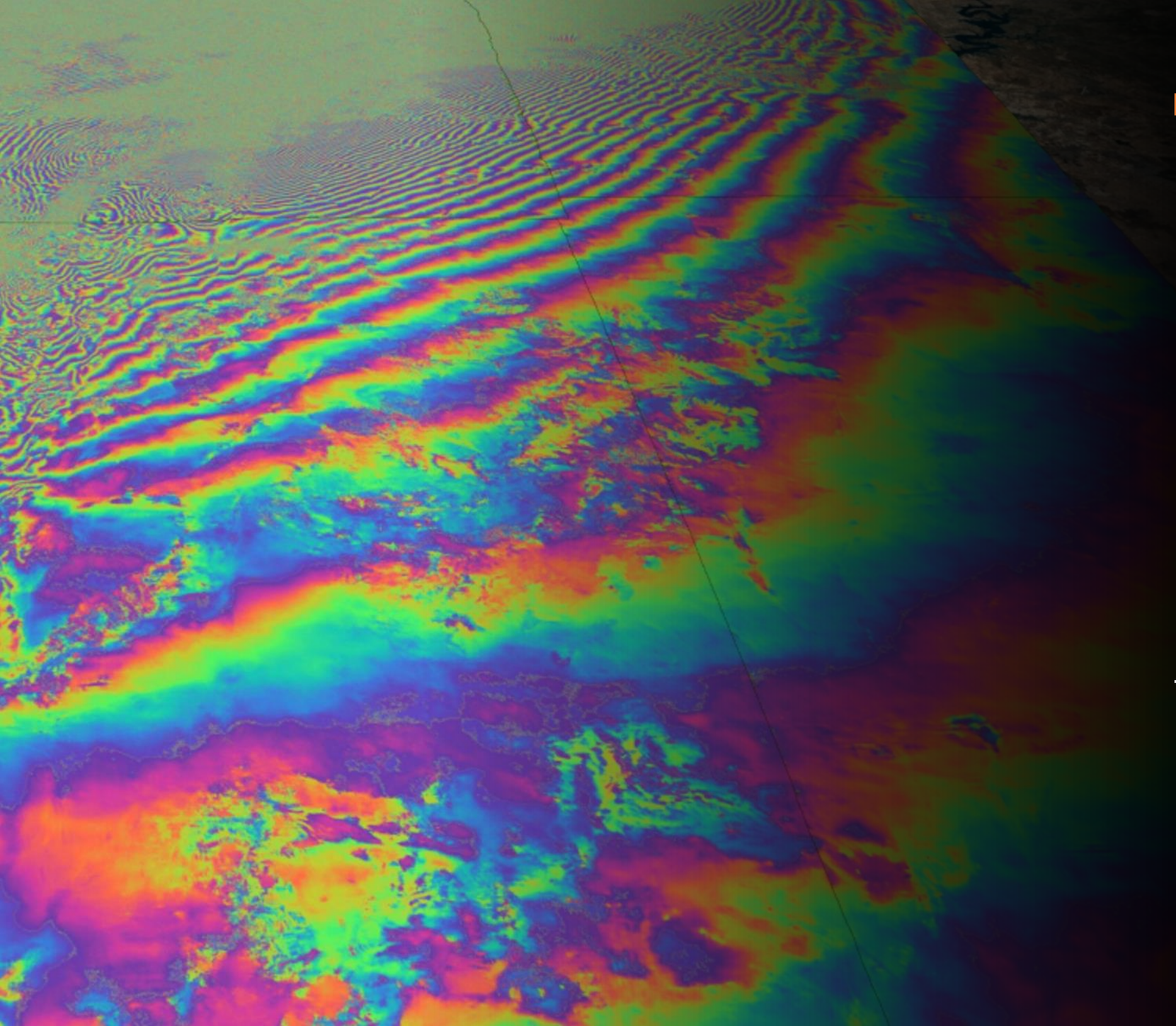


ENGINEERING ANALYSES

- Advanced Radio Capacity Analysis
- High-Low Voltage Simulation
- Electrical Selectivity Analysis
- Traction Power Simulation
- Acoustical Analysis
- CCTV Visualization Simulation
- Advanced Lighting Simulation
- Vibration Analysis
- Pedestrian Dynamic Simulation
- Fire Evacuation Simulation
- CFD Analysis
- Signaling System Design
- Tunnel Ventilation Simulation



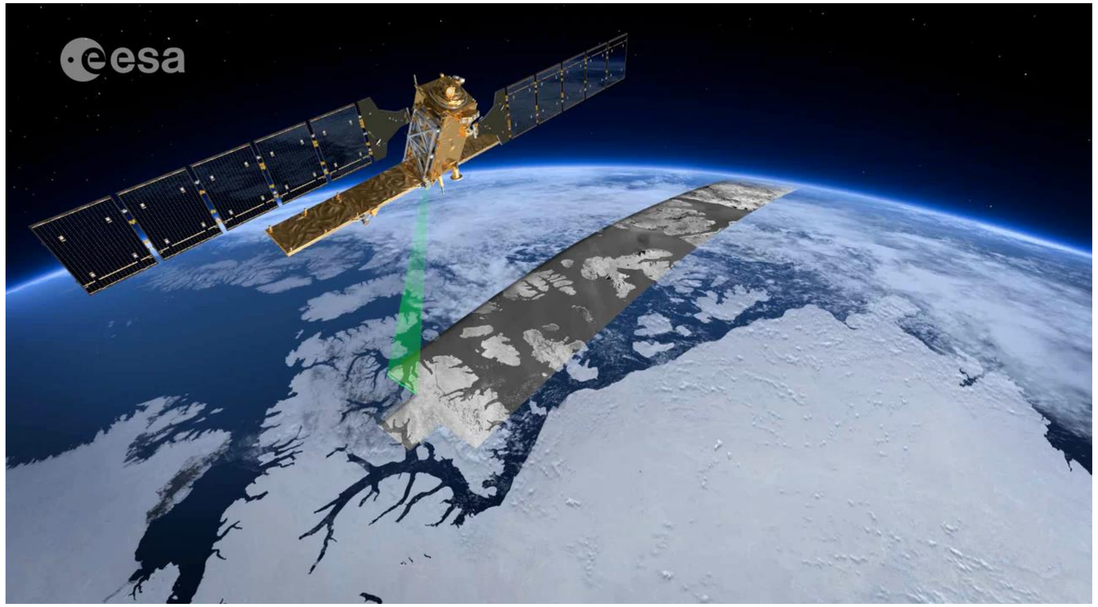
Precise Surface Deformation Monitoring and Mapping

Introduction

Natural events, and anthropogenic activities:

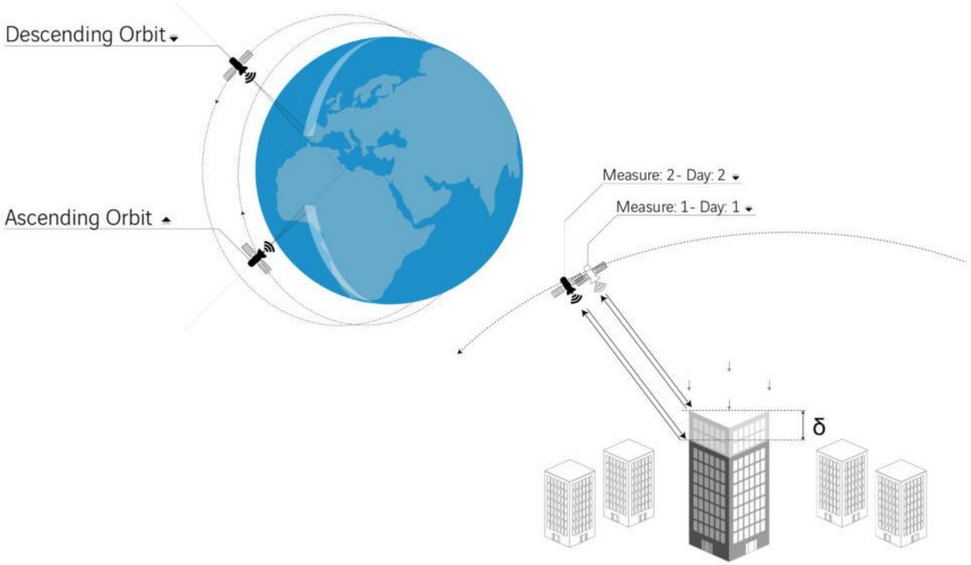
- Earthquakes
- Volcanoes
- Floods & Droughts
- Wildfires
- .
- .

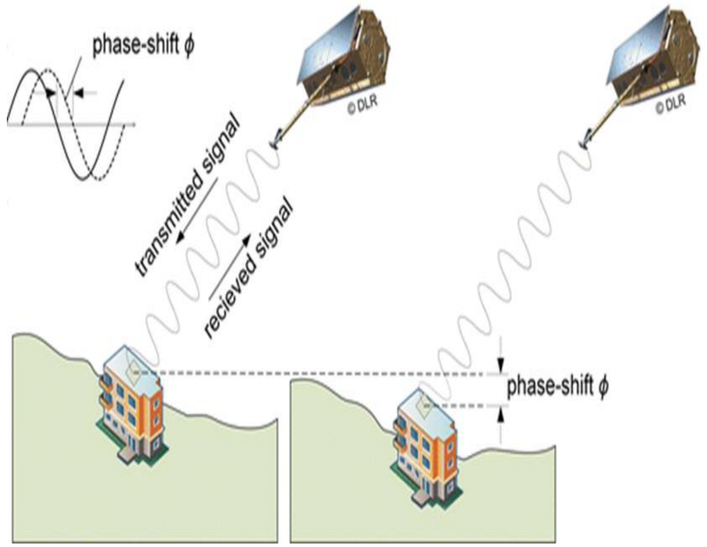
  - ➢ Land Use/Cover Change
  - ➢ Landslide
  - ➢ Ground subsidence

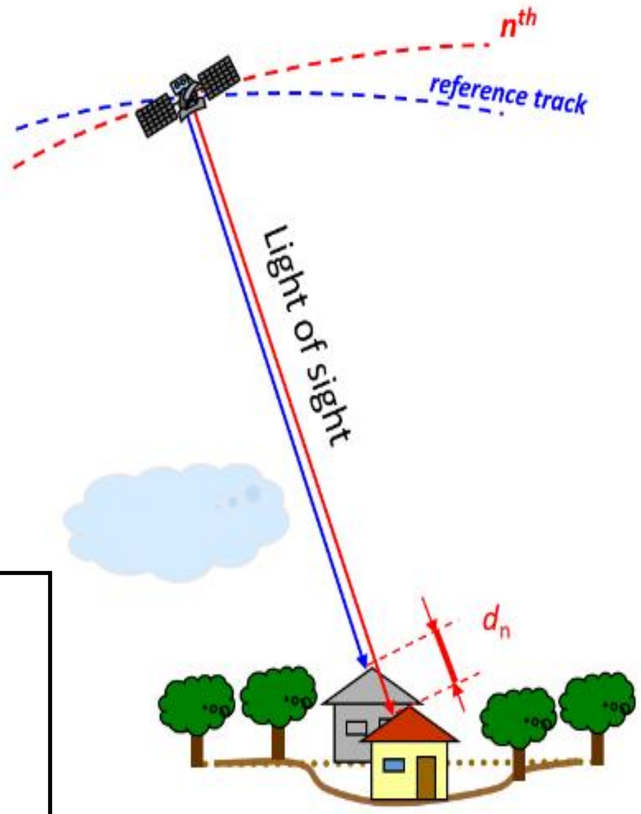


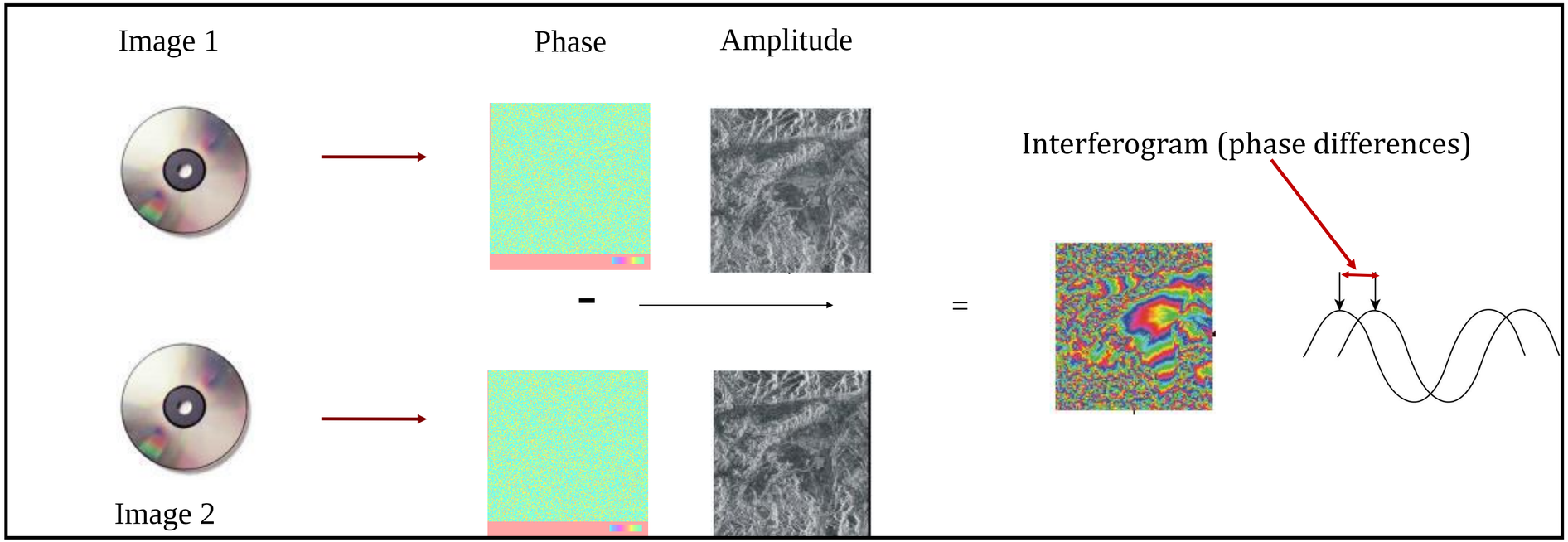
Interferometric Synthetic Aperture Radar (InSAR)

InSAR Method









Interferometric Phase

$$\Delta\varphi_{int} = \Delta\varphi_{DEM} + \Delta\varphi_{flat} + \Delta\varphi_{disp} + \Delta\varphi_{atm} + \Delta\varphi_{noise}$$

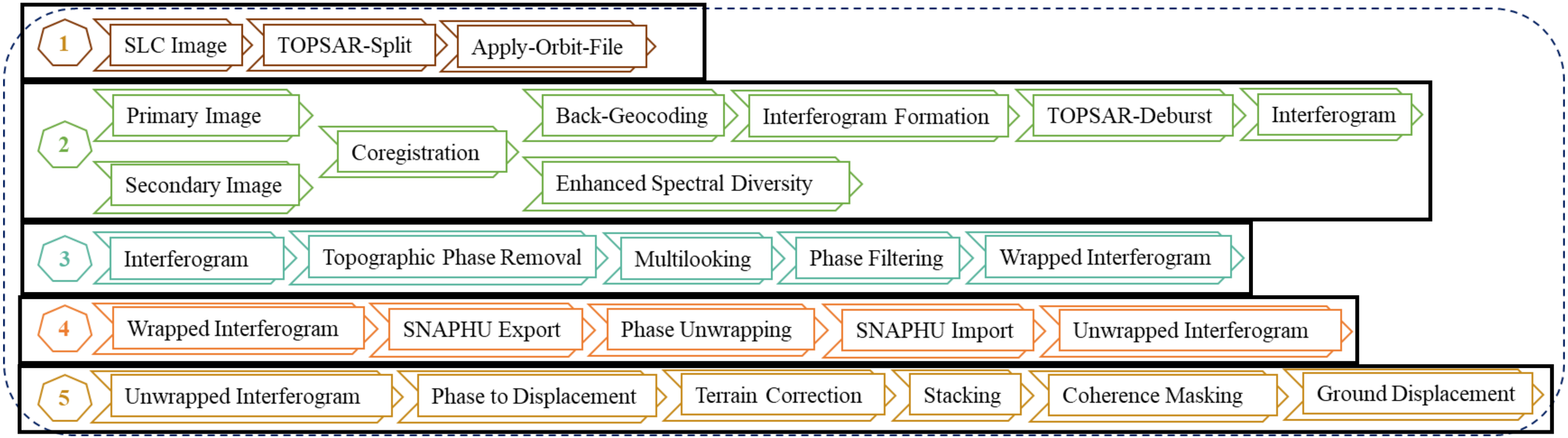
$$-\frac{\Delta q}{\sin\theta}\cdot\frac{B_n}{R_0}\cdot\frac{4\pi}{\lambda}$$

$$-\frac{4\pi}{\lambda}\frac{B_n s}{R\tan\theta}$$

$$+\frac{4\pi}{\lambda}d$$

Source: (Rocca et al., 2007)

Pre-processing Workflow Schema For Interferometric SAR



Motivation

- Optical satellite imagery revealed significant water volume variation at the May Dam over the past decade, prompting investigation due to the high seismic risk of the region and the potential consequences of dam failure for downstream lives and properties.

- To investigate the potentials of the InSAR method to estimate deformation of the upstream face and reveal the displacement rates of the structure of the Dam.

- The results of this study can be used to warn the relevant authorities to make appropriate decisions and necessary measures to strengthen the dam to prevent potential risks.

Study Area

(**Imagery sources**: Google Satellite, OSM and ESRI)

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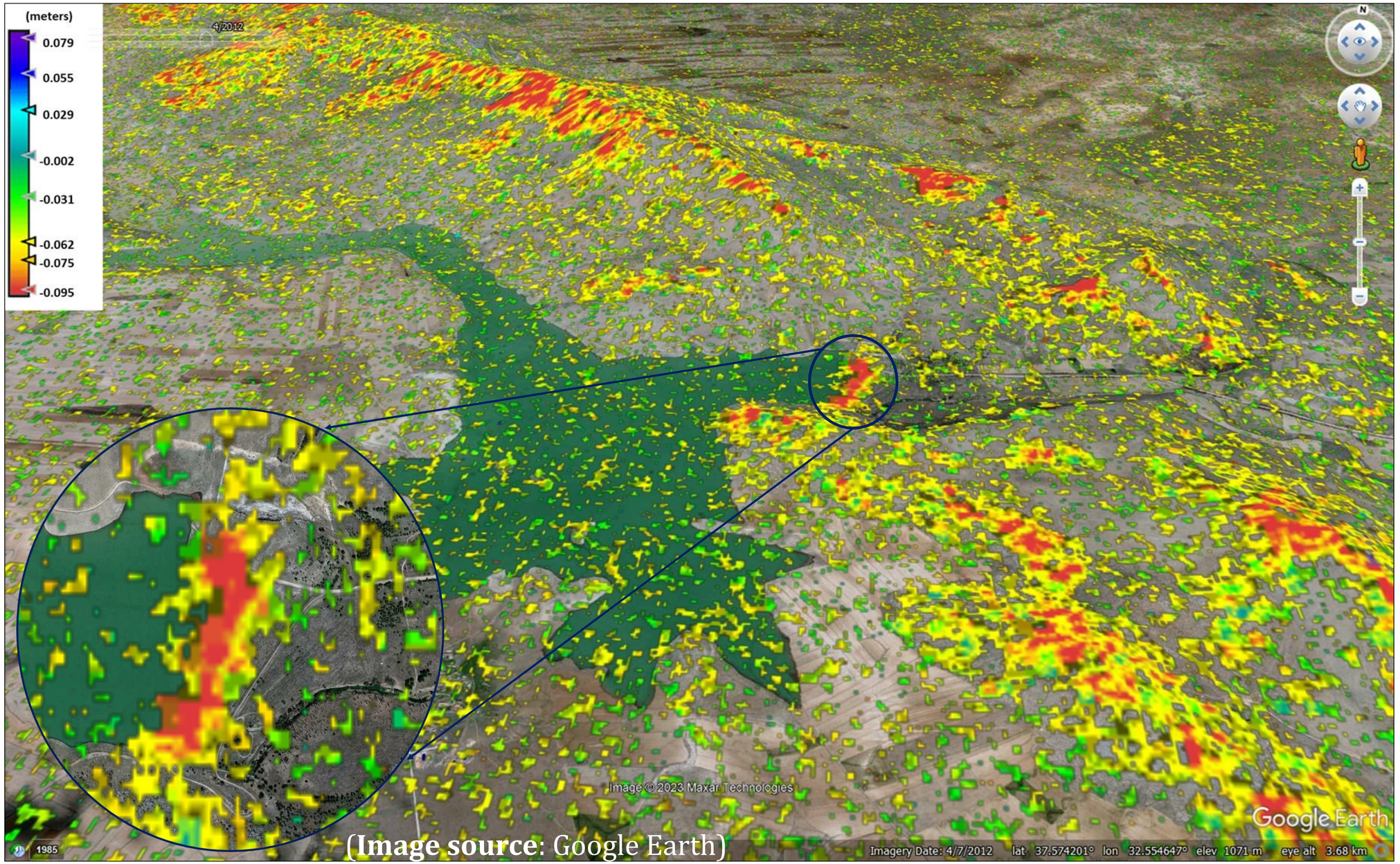
Acquisition Dates & Characteristics of Sentinel-1 Dataset & Interferograms Formation

Image No.	Abs.[a] Orbit-Frame	Acquition Date	Temporal Bas. (d)[b]	Perp.[c] Baseline (m)	Interferogram Formation
1	8282-119	23-Oct-2015			
2	13707-118	29-Oct-2016	372	25	2+1
3	18957-117	24-Oct-2017	360	-84	2+3
4	24382-117	31-Oct-2018	372	-18	3+4
5	29632-117	26-Oct-2019	360	177	4+5
6	35057-117	1-Nov-2020	372	-63	5+6
7	40307-117	27-Oct-2021	360	-110	6+7
8	45732-117	3-Nov-2022	372	107	7+8

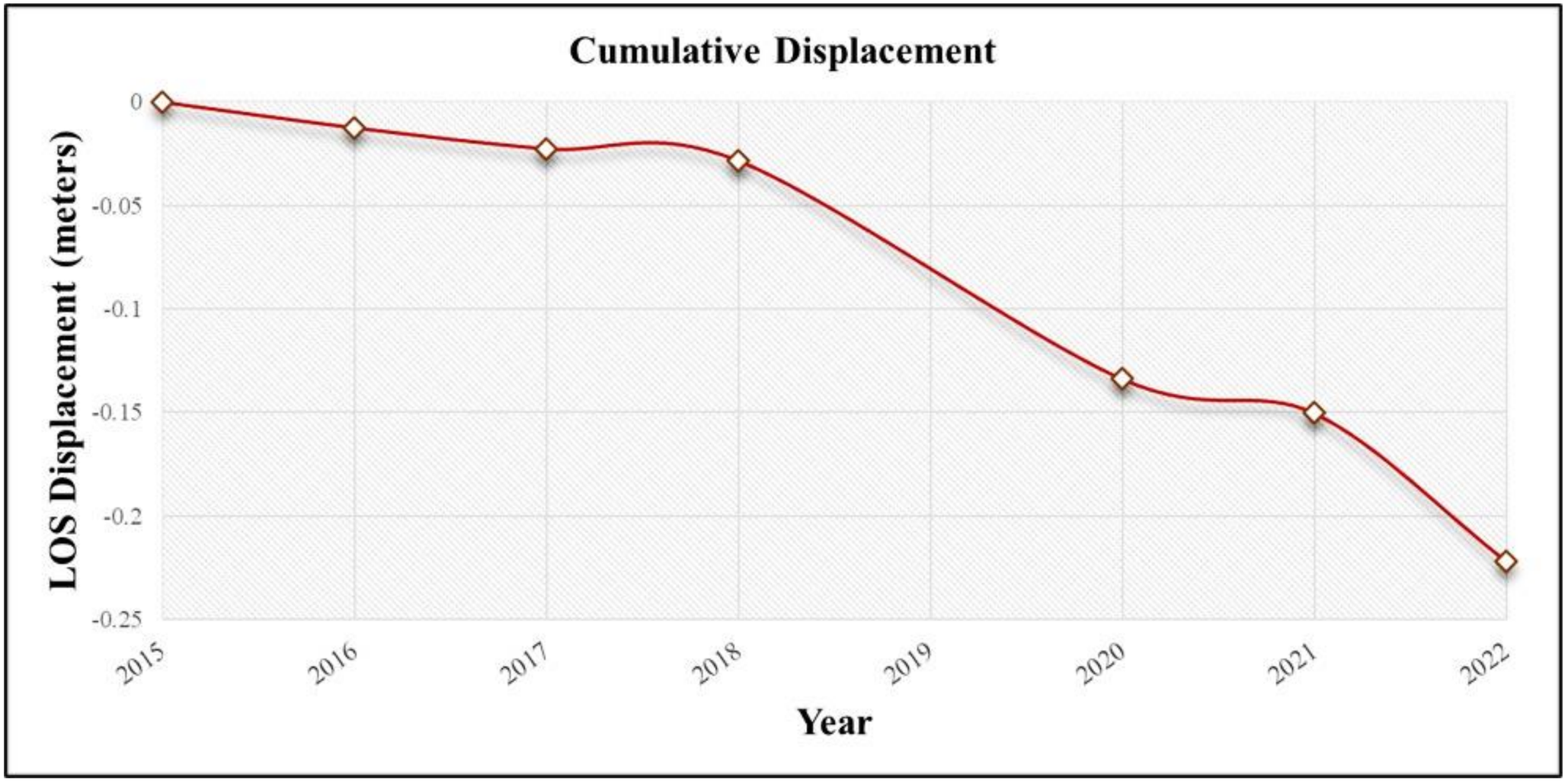
[a]Absolute Orbit, [b]Temporal Baseline (days), [c]Perpendicular Baseline (meters)

Displacement Map

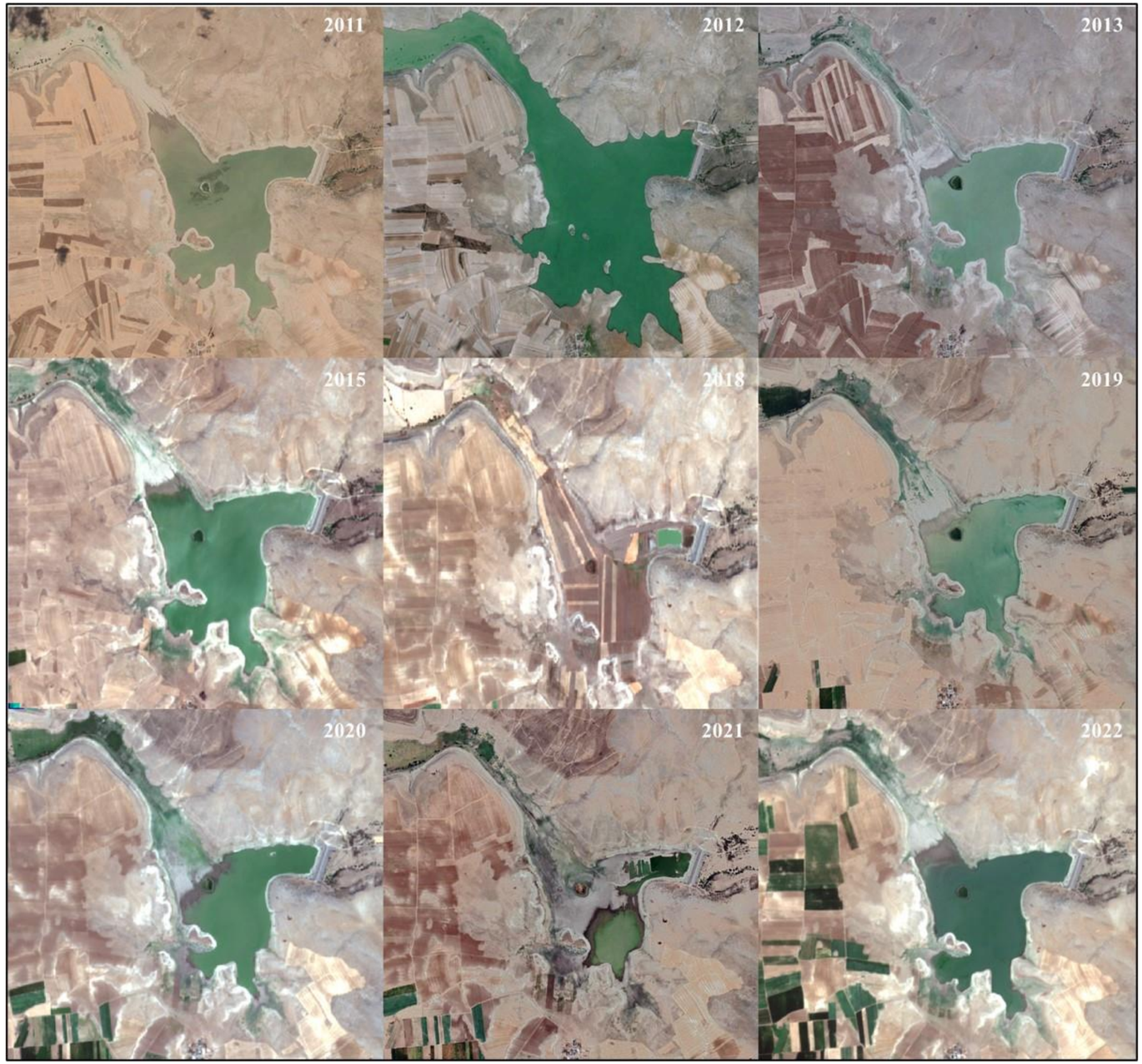


(Image source: Google Earth)

Time-series Analysis, and The Cumulative Displacement

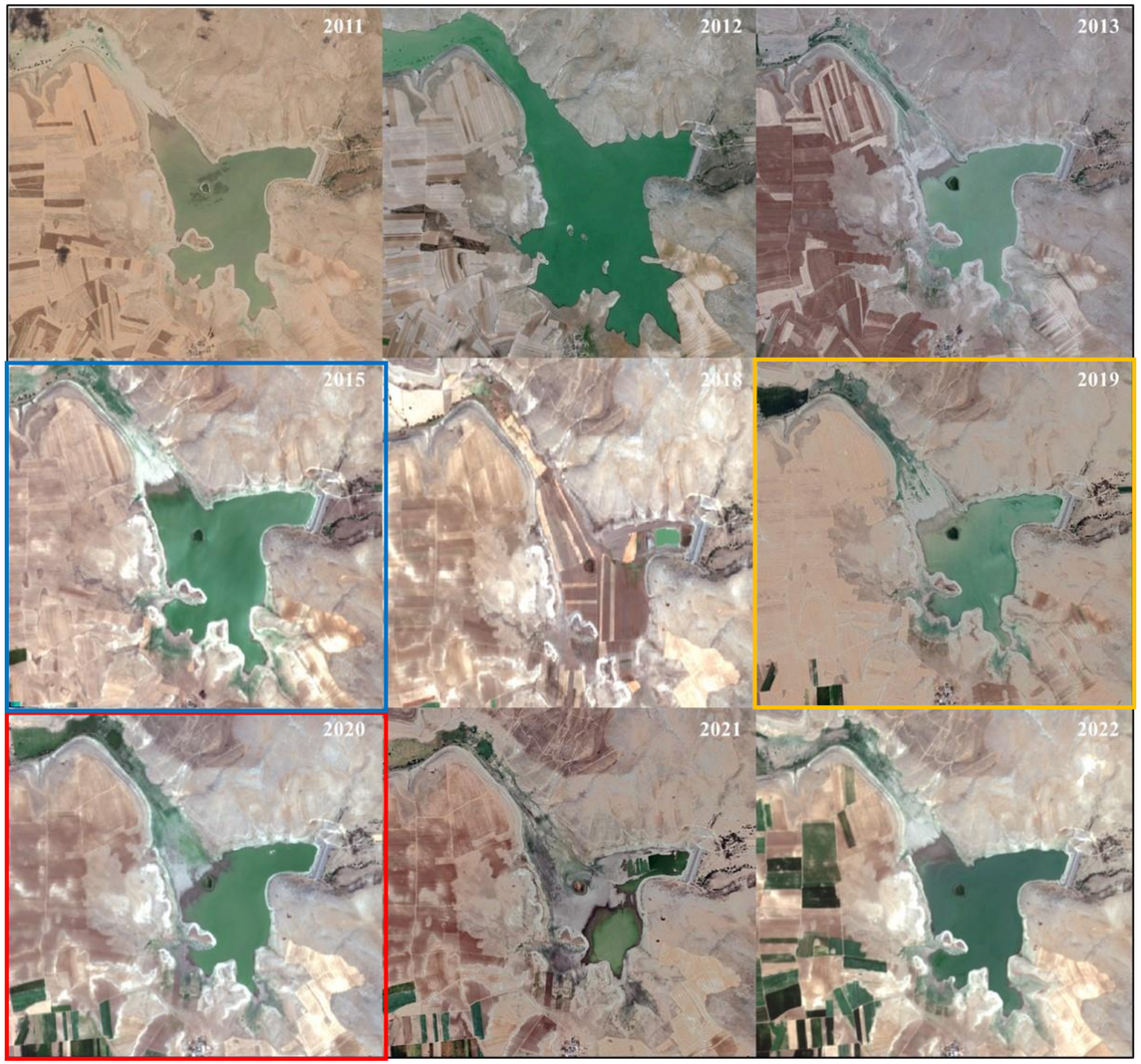


Dam’s Reservoir Variation During The Time Period of 2011-202

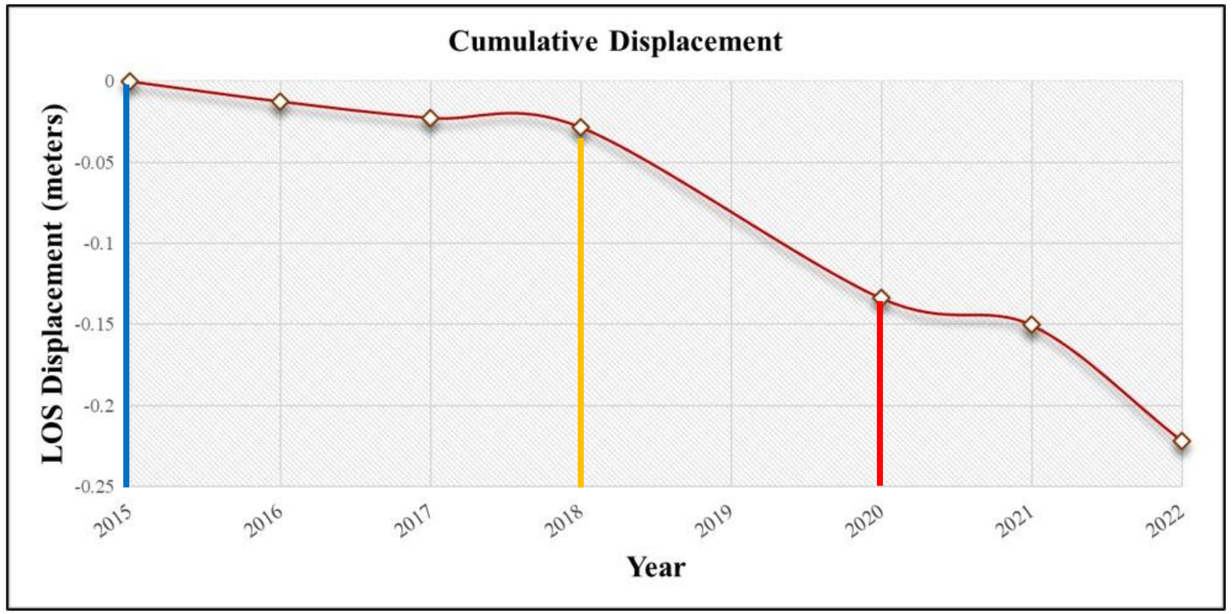


(**Imagery sources**:
Google Earth and
Copernicus Sentinel data
processed by ESA)

Correlation Between Dam's Reservoir Water Volume Variation and Deformation Rates



May Embankment Dam's reservoir variation during the time period of 2011-2022 (**Imagery sources**: Google Earth and Copernicus Sentinel data processed by ESA).



Time-series analysis, and the cumulative displacement on the dam's surface at the selected point.

The investigations revealed that 33 sinkholes had been formed at the dam reservoir

(**Imagery sources**:
Google Earth and
Copernicus Sentinel data
processed by ESA)

Conclusion

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- An evaluation of the effectiveness of InSAR methods for monitoring the structural health of dams in the context of earthquake preparedness and improve emergency response capabilities.

- The displacement rate of the dam was estimated at a linear rate of -9.5 millimeters per year as a result of the InSAR post-processing analysis.

- However, the cumulative deformation rate of the 7-year processed SAR data (2015-2022) for the dam's structure is estimated at -22.16 cm.

- A seismic and disaster safety assessment of dam structures, with a focus on the potential for InSAR methods to improve early warning systems and prevent catastrophic failures.

Future Works

- Processing and analyzing the Sentinel-1 SAR data on both ascending and descending orbit pass, to obtain the vertical displacement and east-west velocity rate.

- Investigation of the correlation between deformation rates obtained by the InSAR method and land-based measurement methods.

- Studying the relationship between the occurrence of sinkholes, groundwater level variations, and surface deformations in the study area.

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