Clear Lake Volcanic Disasters

Creating a Deformation Record Using InSAR to Assess Hazards and Detect Volcanic Unrest in Clear Lake Volcanic Field

Project Synopsis

Clear Lake Volcanic Field (CLVF) in northern California is at a high threat potential for volcanic hazards. Eruptions leading to increased seismic activity could result in silicic domes, cinder cones, and flows dangerous to the residential areas. Remotely sensed Earth observations can reveal volcanic processes in the subsurface, which are essential to the timely monitoring of potential volcanic activity. Sentinel-1's C-band Synthetic Aperture Radar (C-SAR) and Digital Elevation Model (DEM) data capture relative surface deformation at unprecedented high spatial and temporal resolutions. Leveraging C-SAR and DEMs, we conducted interferometric analysis from January 2016 to December 2023. The time series of deformation revealed that the volcanic field experienced 5-10cm of deformation and that active fault zones experienced 2-5 cm of displacement, suggesting a correlation between seismic activity and surface displacement. We also investigated SO_2, land surface temperature, and land cover but found no strong relationship between these parameters and experienced deformation. Using the time series analysis, the partners can establish a deformation baseline to inform their hazards assessment in the Clearlake Volcanic Field and plan future emergency response activities.

Objectives

- **Assist** the USGS California Volcano Observatory's management in assessing hazards within Clear Lake Volcanic Field
- **Utilize** Sentinel-1 C-SAR data and DEMs to create a historic time series of deformation with interferometric analyses
- **Identify** regions of interest that may imply risk to local communities
- **Develop** a baseline of volcanic ground deformation patterns for the USGS
- **Aid** future hazard assessments and potential risk communications

Methodology

DInSAR Time-Series

Correct interferograms for unwrapping errors → Invert data to create time-series → Correct for atmospheric and ground effects → Convert phase values to displacement → **Calculate average displacement velocities**

DEM Time-Series

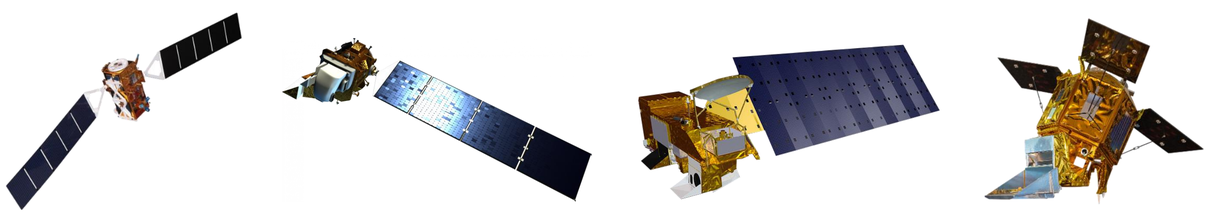
Extract elevation from MERIT data → Interpolate for no-data values → Calculate mean elevation of each month → **Compare mean monthly values in time-series**

Environmental Variables

Investigate the relationship between SO_2, land surface temperature, and land cover and experienced deformation

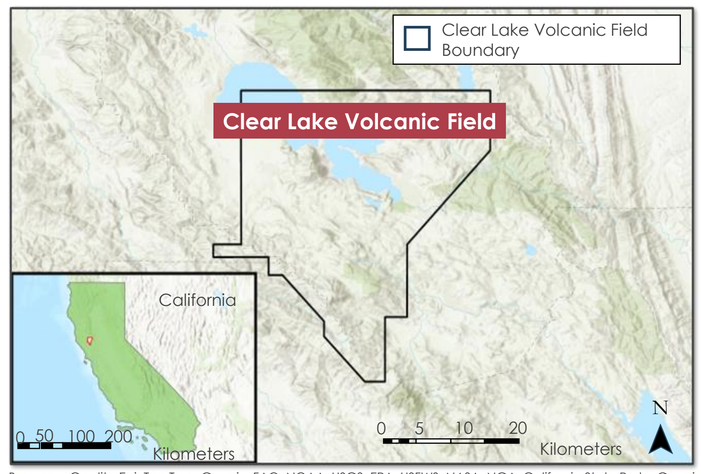
Land Surface Temperature (LST)	Sulfur Dioxide (SO_2)	Landcover
MODIS LST	Sentinel-5 TROPOMI	Landsat & National Land Cover Database (NLCD)

Earth Observations



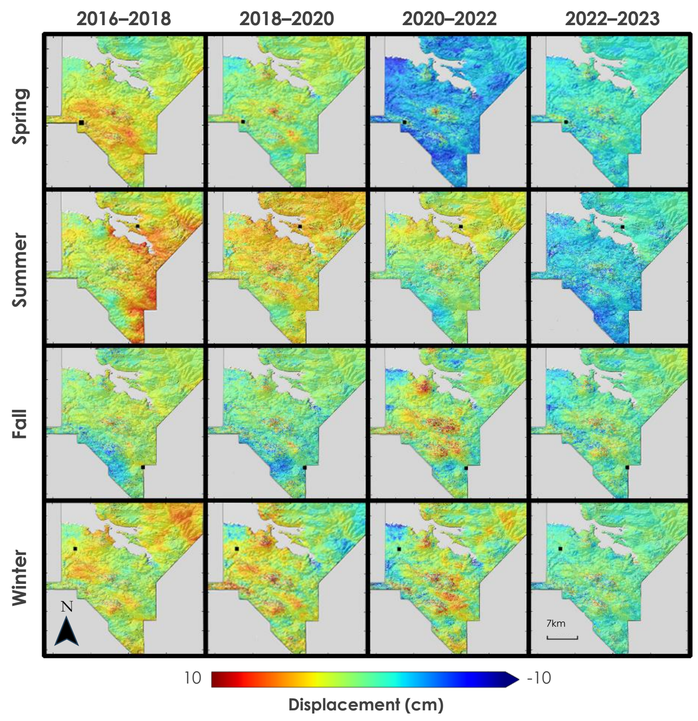
Sentinel-1 C-SAR | **Landsat 8** OLI | **Aqua** MODIS | **Sentinel-5** TROPOMI

Study Area



Basemap Credits: Esri, TomTom, Garmin, FAO, NOAA, USGS, EPA, USFWS, NASA, NGA, California State Parks, Garmin, SafeGraph, METI, Bureau of Land Management, NPS

Results



We created an InSAR time-series depicting ground deformation at Clear Lake Volcanic Field from 2016-2024, divided by season. There were three areas for which we detected significant uplift (shown in red below), and two areas displaying significant subsidence (shown in blue). By analyzing these displacement maps in respect to supplemental data collected we were determined trends and drew conclusions. This deformation appears to be correlated with active fault lines and geyser locations, indicating that subsidence likely due to seismic activity than volcanism.

Conclusions

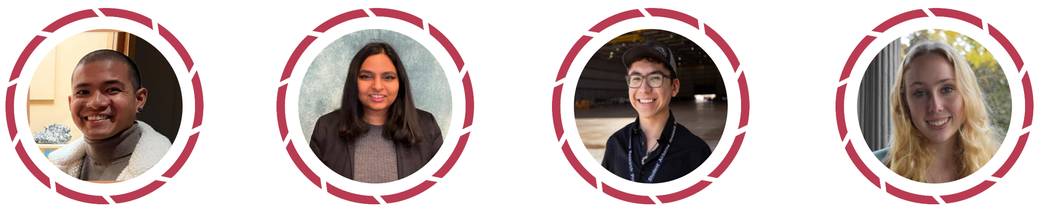
- We detected considerable deformation of Clear Lake Volcanic Field, ranging from approximately 5 to 10 centimeters, with notable differences in surface displacement across seasons.
- Deformation is predominantly associated with seismic activity and geothermal changes in the geyser field – limited evidence suggesting deformation would be corelated with volcanic activity.
- Baseline of deformation created will help inform USGS's California Volcano Observatory in detecting future volcanic hazards, though future assessment.

Project Partners

USGS science for a changing world

- USGS, California Volcano Observatory

Team Members



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