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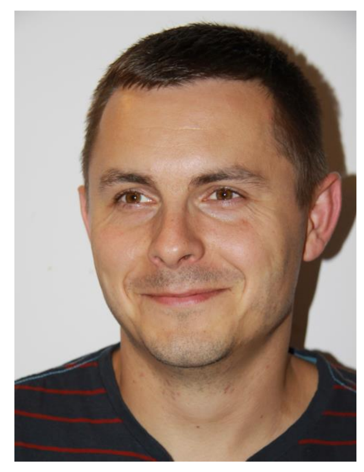
ANALYSIS OF COSEISMIC SURFACE DEFORMATIONS AFTER THE 2022 M6.2 AFGHANISTAN EARTHQUAKE

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INTRODUCTION

Studying the mechanism of a seismic phenomenon requires the observation of cracks after their occur. However, direct observation of the cracking process at a specific depth on a given surface is not possible. Therefore, it is necessary to obtain additional data that describes this process in order to model the source of the earthquake. Interferometric data are suitable for this purpose. After decomposition from displacements measured along the radar line of sight (LOS) into vertical and horizontal components, they are used to perform an earthquake source inversion to determine the parameters of the fault plane on which the tremor occurred. In addition, determination of the phase gradient from stacks of coseismic interferograms provides information about the concentration of stresses and cracks on the surface. Integrating satellite radar interferometry (InSAR) methods with the geophysical description allows for a more comprehensive understanding of the earthquake phenomenon.

DETERMINED INSAR DISPLACEMENTS

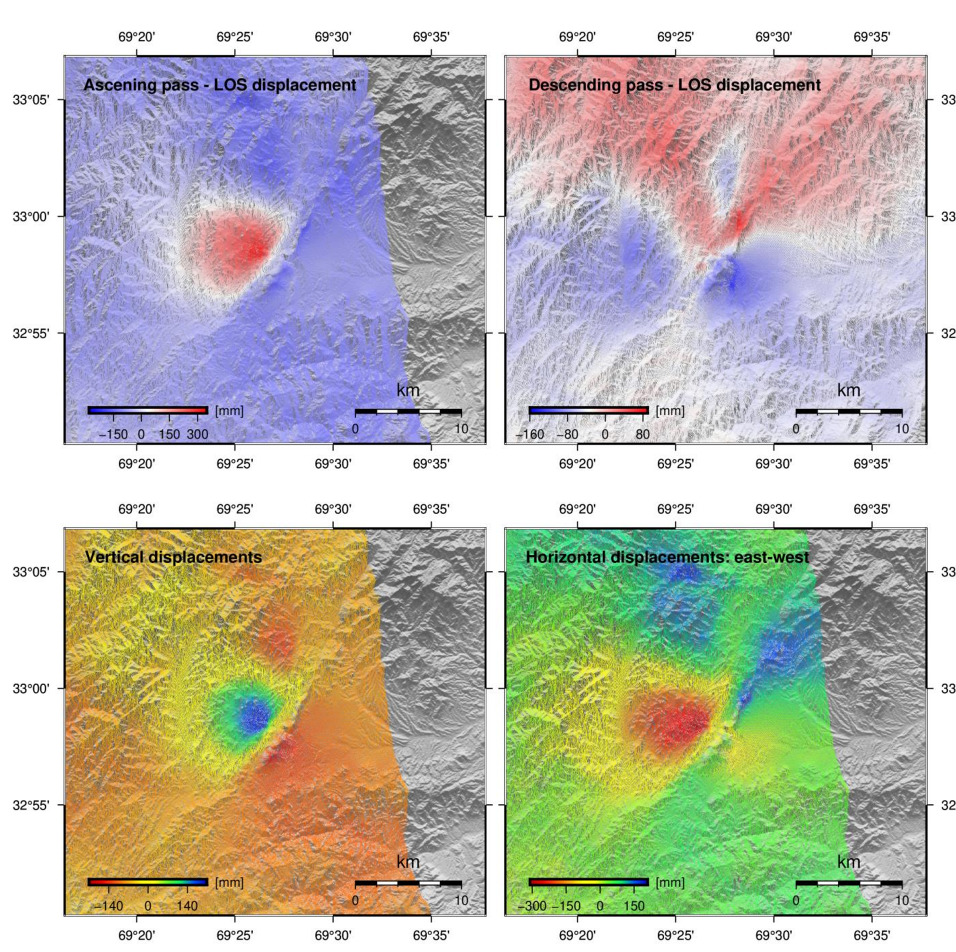

Figure 2. LOS displacements for ascending (upper left) and descending (upper right) tracks. Decomposition of dicplacements into a vertical (bottom left) and horizontal (bottom right) components..

In research was used 4 Sentinel-1 synthetic aperture radar (SAR) data from ascending (A071) and descending (D078) paths. Calculations of the differential interferograms were carried out using the Differential Interferometric Synthetic Aperture Radar (DInSAR) method in the GMTSAR. Computed LOS displacements have also been decomposed [1] into east-west horizontal and vertical components (Fig. 2).

FINE-FAULT SOUCE INVERSION

The earthquake source inversion for a finite rectangular fault plane was performed using Pyrocko scripts in GROND package [2]. InSAR data, information about the tremor obtained from Global CMT and Green's function, were used for the calculations.

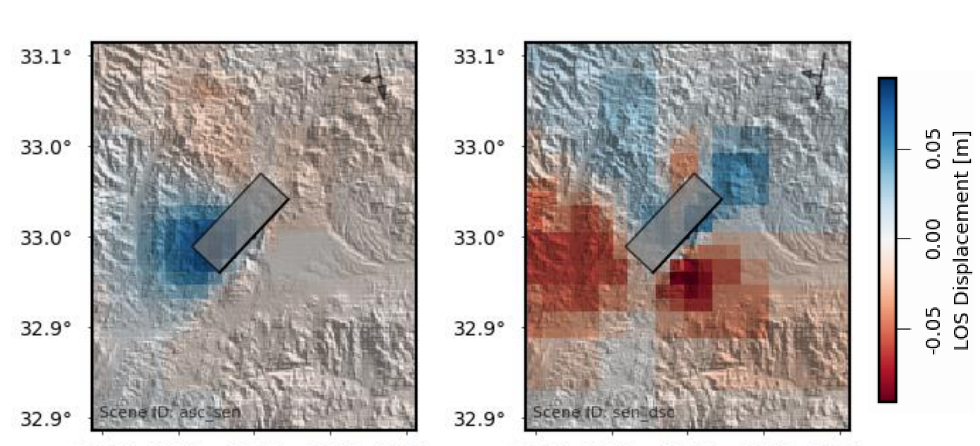

Figure 3. Projection of the fault plane (grey filled box) on the background of LOS surface displacements, thick-lined edge marking the upper fault edge.

Table 2. Determined parameters of the fault plane.

Parameter	East shift [m]	North shift [m]	Depth [m]	Leght [m]	Width [m]	Slip [m]	Strike [°]	Dip [°]	Rake [°]
Best solution	-4450	4880	1654	7420	10830	10	0.826	223.13	26.54

RESEARCH AREA

The Afghanistan M6.2 earthquake occurred on June 21, 2022 at 20:54:34 (UTC) with its range covering both the eastern area of Afghanistan and western and northern Pakistan (Fig. 1). According to information provided by the United States Geological Survey (USGS) [4], the seismic event was the result of a collision of the north-moving Indian plate with the Eurasian plate. Main shock was defined as strike-slip faulting, either left-lateral slip on a northeast-striking fault or right-lateral slip on a northwest-striking fault.

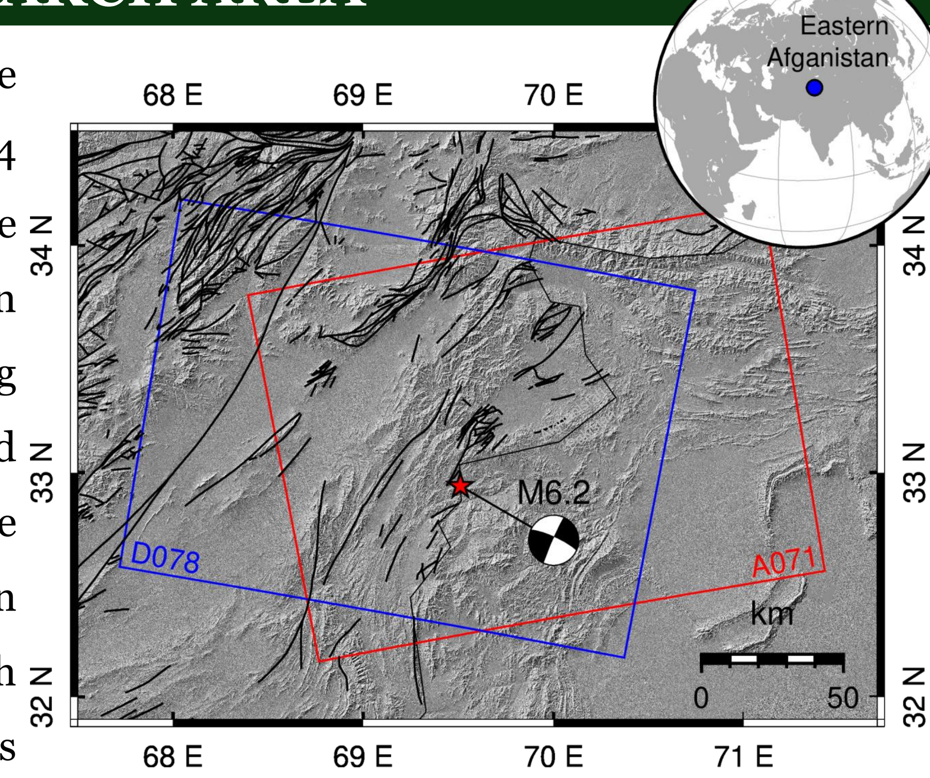

Figure 1. Area of interest. Selected Sentinel-1 scenes for ascending (A071) and descending (D078) tracks. A red star indicates the location of the tremor that occurred June 21, 2022. The focal mechanism is depicted with a with a "beachball".

Table 1. Focal mechanism solution. Source: Global Centroid Moment Tensor Catalogue (GCMT).

Lon [°]	Lat [°]	MW	Depth [km]	Dip [°]	Strike [°]	Rake [°]
69.51	32.94	6.2	15.1	57	202	10

PHASE-GRADIENT APPROACH

To detect small-scale discontinuous deformations, a computational approach based on the interferometric phase-gradient [3] was used. For each path, several coseismic interferograms were determined, stacked without the need to unwrap the phase. Subsequently, the results from subsequent interferograms were averaged, and on this basis the final strain maps were generated, presenting all cracks of the surface associated with the displacement of the rock mass on the fault.

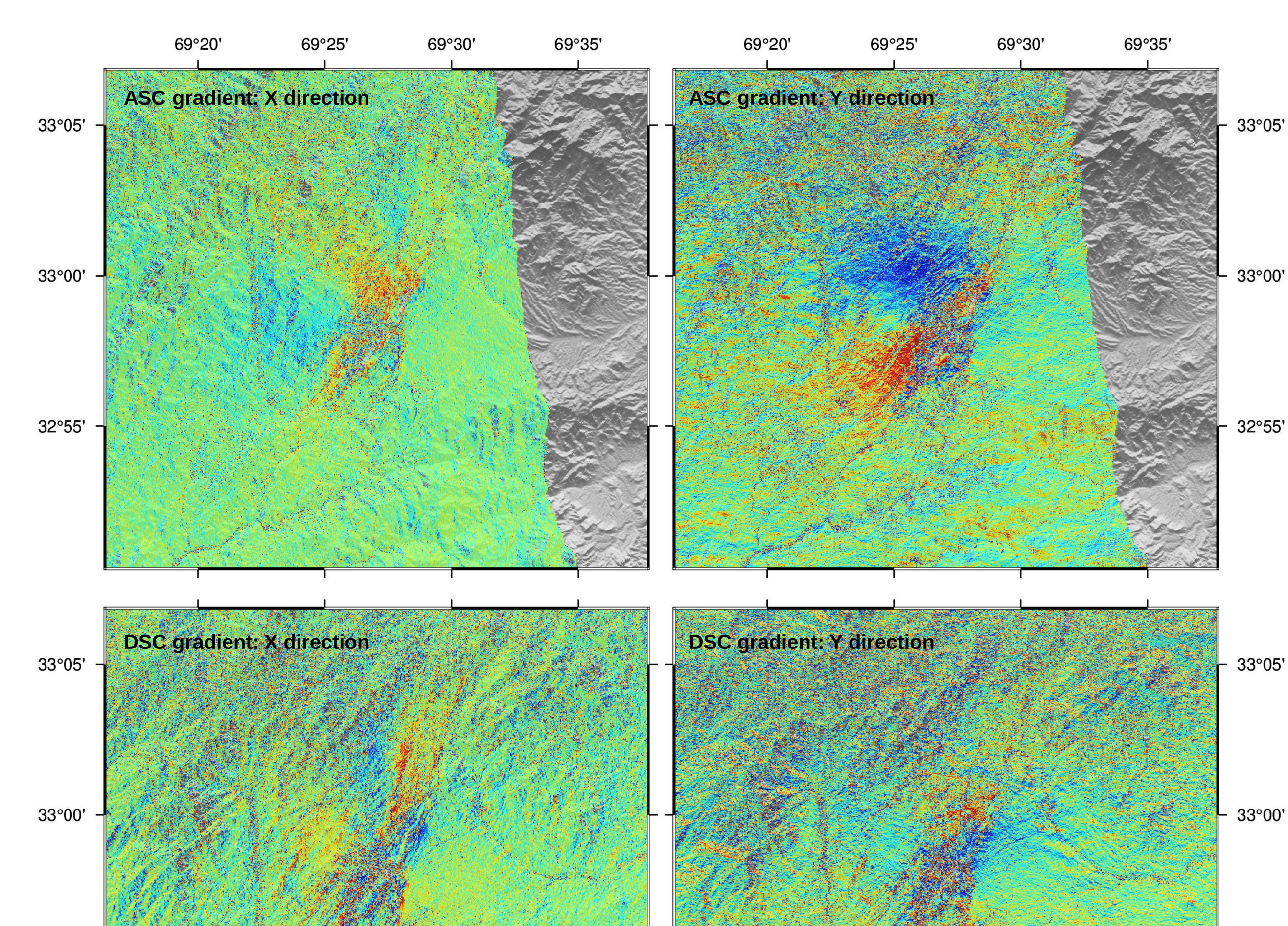

Figure 4. Phase gradient maps from stacked Sentinel-1 interferograms for ascending (upper left in X direction and upper right in Y direction) and descending (bottom left in X direction and bottom right in Y direction) tracks.

Acknowledgments

[1] Fuhrmann, T.; Garthwaite, M.C. *Resolving Three-Dimensional Surface Motion with InSAR: Constraints form Multi-Geometry Data Fusion.* Remote Sens. **2019**, 11,241.

[2] Heimann, S.; Isken, M.; Kühn, D.; Sudhaus, H.; Steinberg, A.; Vasyura-Bathke, H.; Daout, S.; Cesca, S.; Dahm, T. *Grond - A probabilistic earthquake source inversion framework.* V. 1.0. GFZ Data Services, **2018**.

[3] Xu, X.; Sandwell, D. T.; Smith-Konter, B. *Coseismic Displacements and Surface Fractures from Sentinel-1 InSAR: 2019 Ridgecrest Earthquakes.* Seismol. Res. Lett. **2020**, XX.

[4] https://earthquake.usgs.gov/earthquakes/eventpage/us7000hj3u/executive