Exploiting high-resolution InSAR Rate Maps to the Fullest: Fault Slip, Landslides and Groundwater Changes in Northeastern Afghanistan

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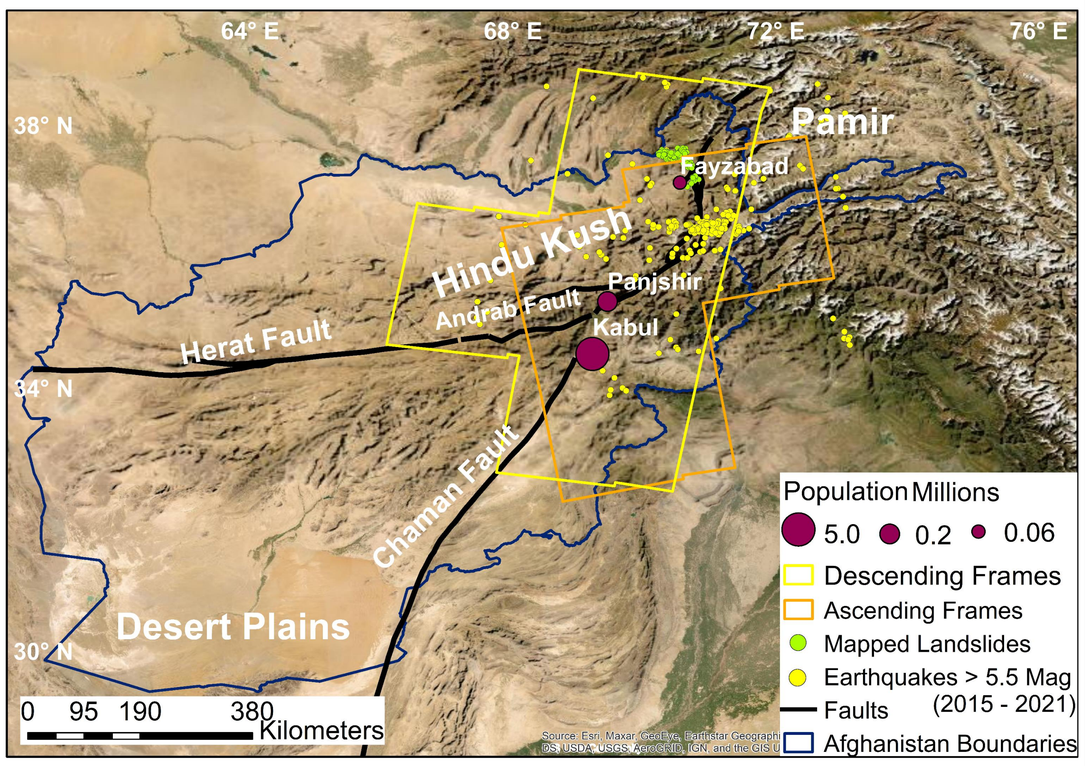
1. Motivation

Northeastern Afghanistan, with over 80% of mountainous territory and peaks rising well above 5000 meters and located at the India-Eurasian collision zone, faces many natural hazards such as floods, droughts, landslides, earthquakes, etc. The country has very limited infrastructures and capacities to map or monitor these hazards and take preventive measures. One outstanding structure is the NE-trending, dextral Panjshir fault in NE-Afghanistan. This region is also threatened by an increase of slope instabilities due to human activities, deforestation, and climate change. Together these facts result in an increased probability and number of landslides around the Fayzabad city. The capital Kabul, where the growing population and increase climate effect has limited the supply of freshwater access is facing to groundwater-level drops, local subsidence, and further infrastructural damages. Both processes - hillslope instabilities and ground-water pumping - are ideal targets for radar satellite interferometric analysis, because of their inherent surface-deformation signals.

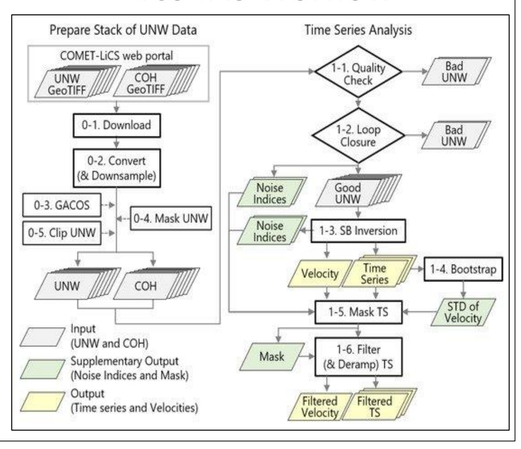


Aerial photograph (ESRI) and political borders of Afghanistan. Purple dots indicate the three study areas, the orange and yellow polygons are the ascending and descending Sentinel-1 radar frames used in this study.

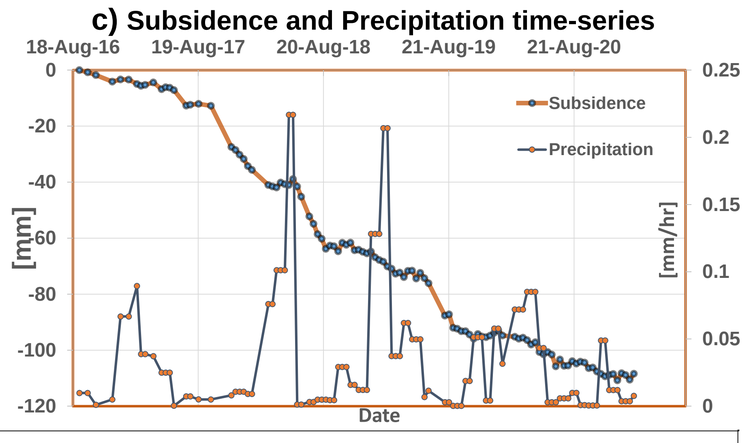
2. Methodology

We have combined four years of high-resolution interferometric radar (InSAR) data of NE-Afghanistan, acquired by the European Sentinel-1 radar satellite mission.

A total number of 2,468 unwrapped pre-processed interferograms of seven frames (~ 77.1GB) were processed using LiCSBAS software (Morishita, et al. 2020). We compared the resulting rates to the available landslide catalog, high resolution optical imagery, and field trip observations

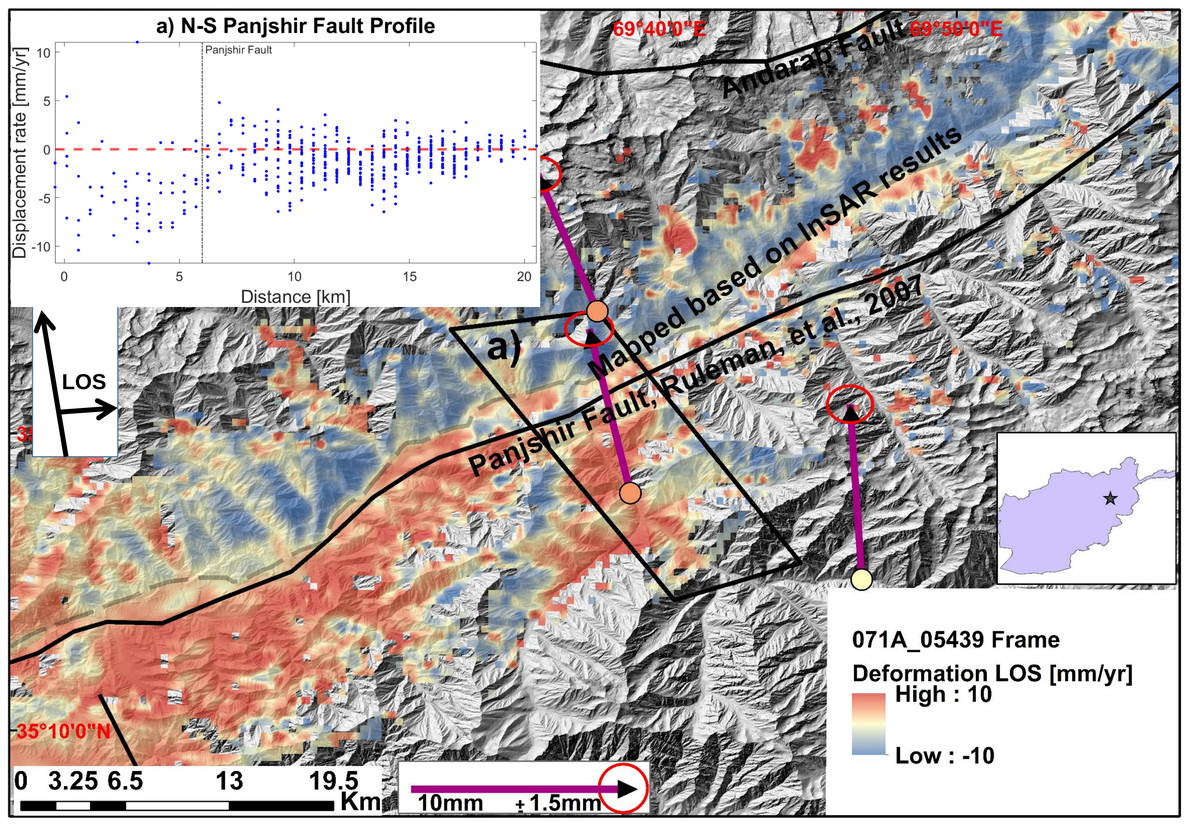


c) The subsidence rate decreases during the dry season, which becomes obvious when comparing the time-series at one pixel (green dot in subfigure a).

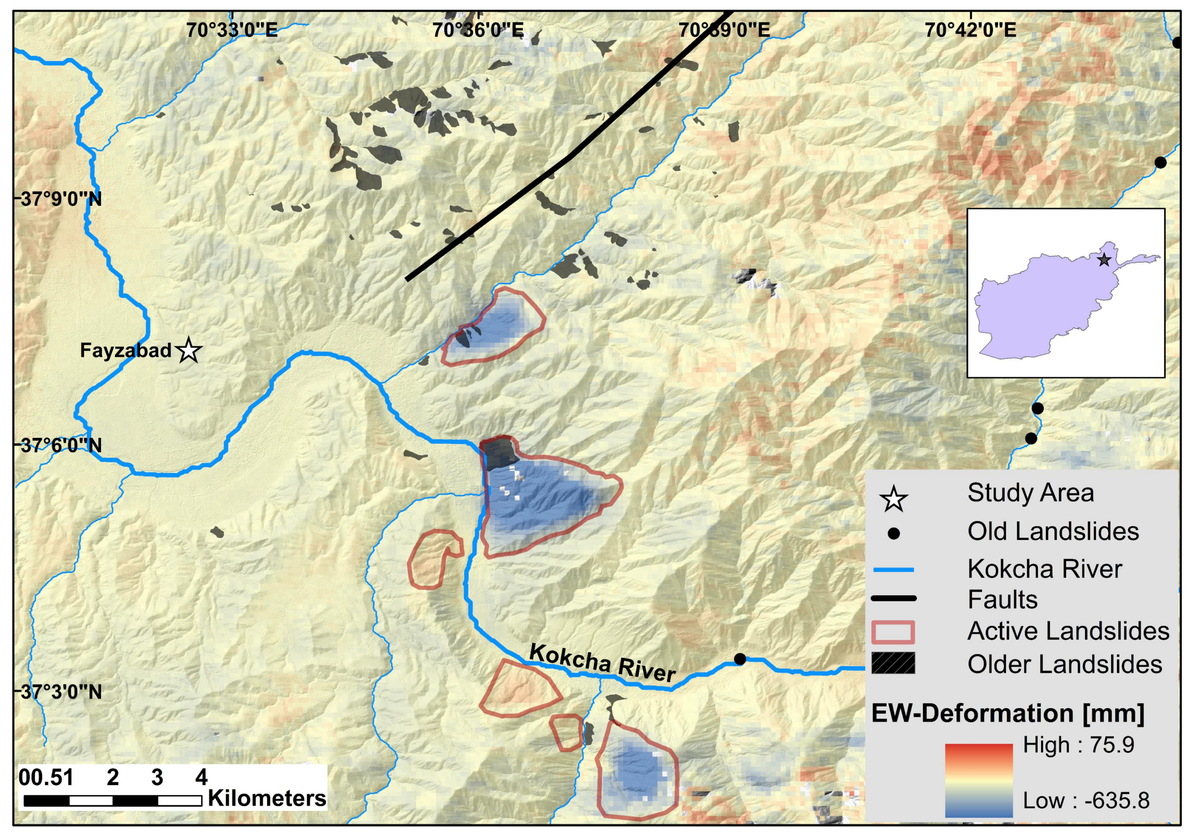


3. Results

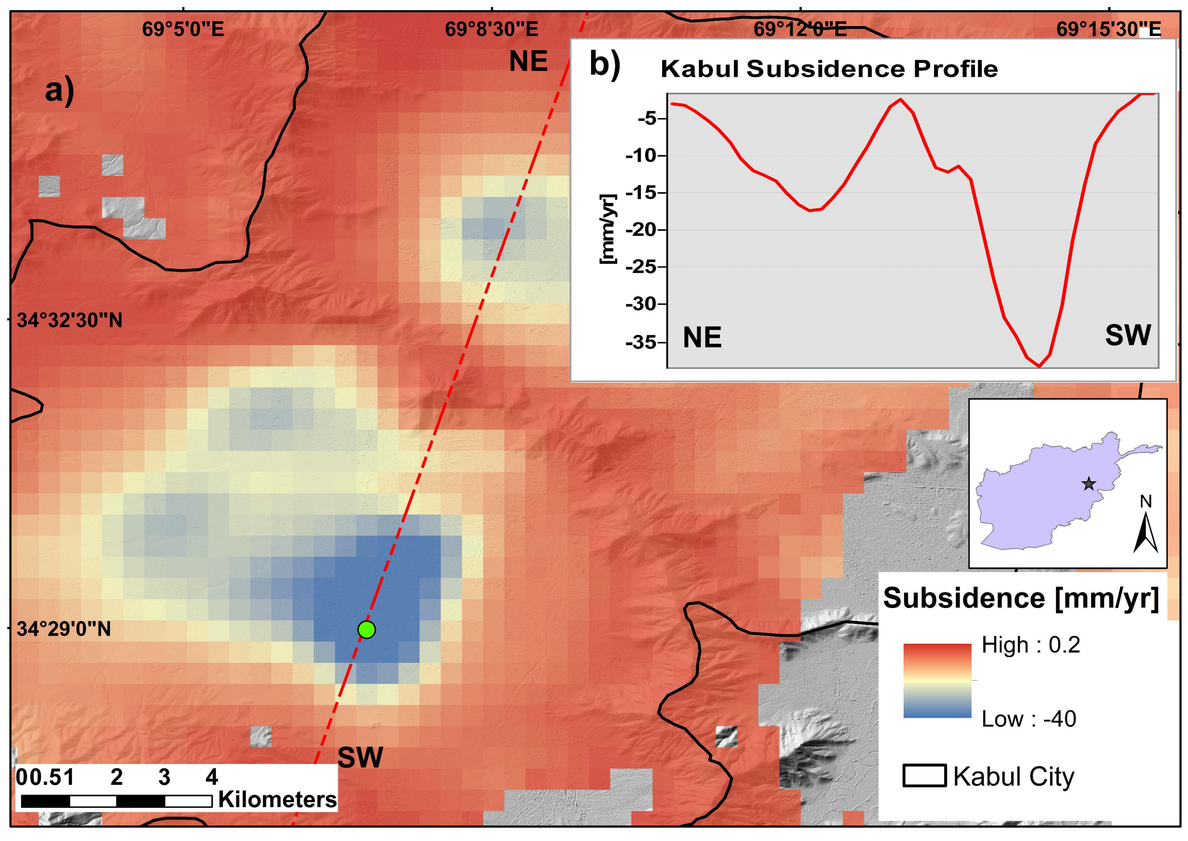
The resulting East rates exhibit a rate change of 3-10 mm/yr across the Panjshir fault caused by dextral slip. We identified tens of active landslides around the Fayzabad city e.g. Turgani landslide with a velocity of 12 cm/yr. The results also indicated subsidence of around 45 km2 area with up to 13 cm of total range increase due to groundwater extraction in Kabul city.



InSAR rates at the Panjshir fault in ascending view mode, showing that the rate change (dashed line) localizes further north than previously mapped. Arrows indicate GNSS rates and 1-sigma confidence a) InSAR rates along a swath crossing the Panjshir valley at the location of the GNSS sites.



Near Fayzabad, InSAR East rates highlighting several active landslides around the Kokcha River. The gray polygons and black dots show previously mapped landslides. The red polygons show active landslides detected with InSAR.



In Kabul, we observe two high-subsidence regions, located at the two Kabul basins. Subsidence increases towards the center of the basin (b), reaching 4 cm/yr.

4. Conclusions

Using InSAR time-series we can detect 1) slip at the Panjshir fault, 2) identify unmapped landslides near Fayzabad, and 3) quantify the extent and amount of groundwater level changes in Kabul city. These findings are very important information for the local communities and government. It allows them to correctly assess the risk of natural hazards using the open-access satellite data.

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