Localization of deformation prone sites in the Himalayas using multi-temporal InSAR and Sentinel-1 images

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Abstract

Over the last two decades, the Himalayan region is affected by deformation events such as landslides and land subsidence, spread over different regions located within the Himalayas. The spatial distribution of these events may well depend on the tectonics occurring beneath, which requires understanding of long-term deformation over large areas. Studies related to the identification of deformation zones has earlier been carried out using conventional methods to identify deformation zones. However, we need efficient methods to update these earlier generated maps, which may require adding later events, which may also belong to different class of events left unencountered earlier. In this study, we make use of Sentinel-1 interferometric wide swath (IW) datasets from the European Space Agency to localize deformation prone sites in the Himalayan region. With over seven years of acquisition (2014-2021) and large coverage (˜270 km) of the dataset, we attempt to monitor and understand the deformation activities occurring in various parts of the Himalayas. This involves processing gigantic stacks of interferograms generated from a large time series of IW images, which may require devising better processing strategies. and further analysis to generate a map showing sites affected by different types of deformation events. This information can be used to identify sites which require critical monitoring (using field surveys) and rescue. The upcoming NISAR mission from NASA and ISRO is also focused towards understanding deformation activities in the Himalayas, and the proposed study may also benefit some of the studies planned for the NISAR mission.

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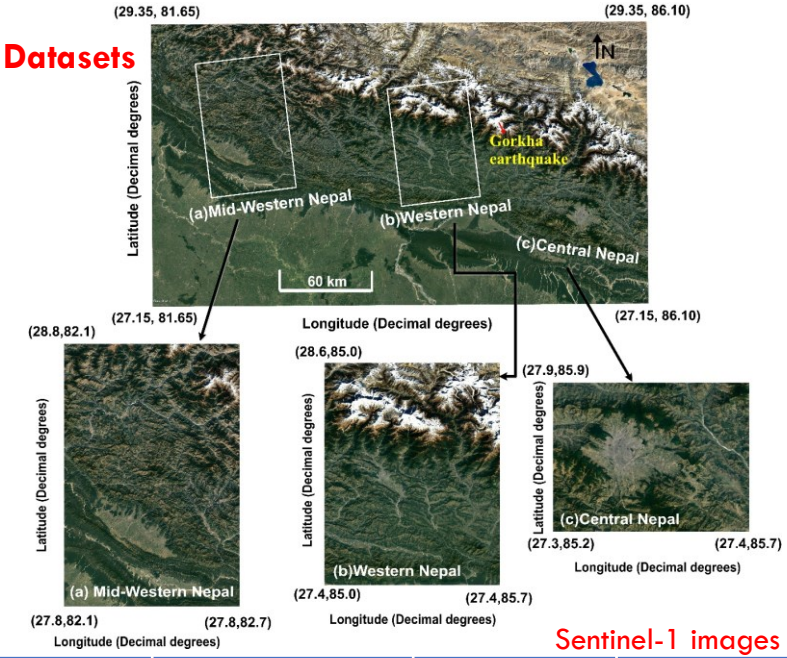
Introduction

Identification of deformation zones is essential for better planning and rescue operations.

The Himalayas is affected by deformation events such as landslides and land subsidence, spread over different regions located within the Himalayas.

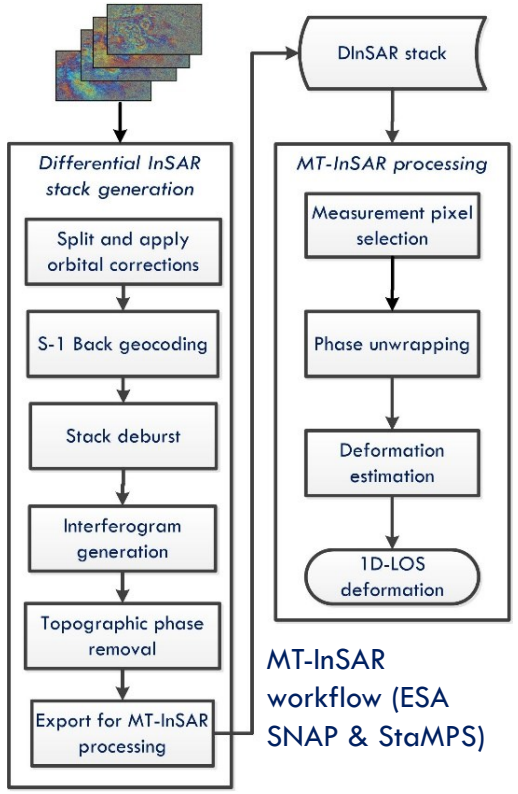
Multi-temporal interferometric synthetic aperture radar (MT-InSAR) technique an be effectively used to update deformation maps (including recent behavior), supporting identification of critically affected sites to be monitored with ground surveying.

Datasets



Sentinel-1 images

Parameter	Mid-Western Nepal	Western Nepal	Kathmandu
#images	10	11	11
B_T	0 to 240	0 to 264	0 to 264
$B_\perp$	0 to 180	0 to 160	0 to 160



MT-InSAR workflow (ESA SNAP & StaMPS)

Methodology

MT-InSAR processing involved similar steps as followed for small areas, but complete sub-swaths (or large portions) were processed.

Overall processing steps involve (i) orbital corrections, (ii) co-registration with respect to chosen master, (iii) complex multiplication for interferogram generation, (iv) topography removal, (v) measurement point selection, (vi) phase unwrapping & (iv) displacement estimation.

Areas detected with high magnitude displacement over a time series considered susceptible.

Results and Discussion

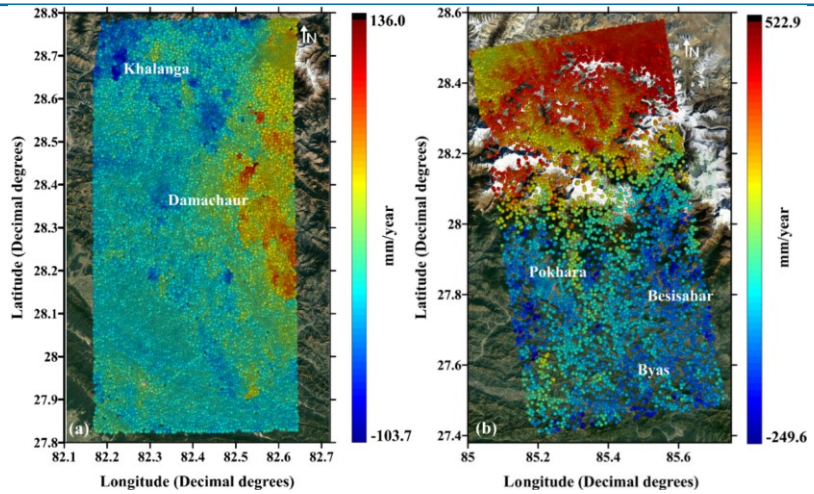
360532 and 832939 measurement points detected in Mid-Western and Western Nepal respectively.

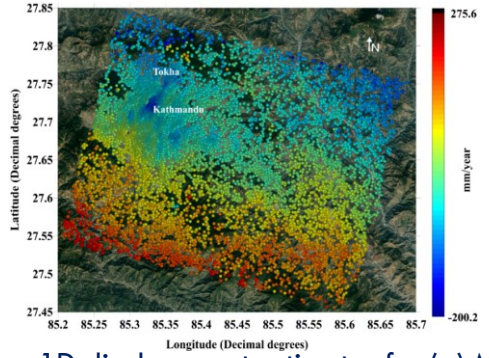
Khalanga and Damachaur regions in Mid-Western Nepal found to be under subsidence.

For western regions lying near Gorkha, higher magnitude subsidence observed in Pokhara, Besisar and Byas.

Kathmandu and Tokha in Central Nepal found to be under subsidence.

Detected deformation magnitudes affected by errors due to topography and atmosphere.





Probable contributors to high magnitudes of surface displacement:

(i) Inaccurate phase unwrapping in hilly terrains

(ii) Topographical errors

(iii) Atmospheric phase screen

1D displacement estimates for (a) Mid-Western Nepal, (b) Western Nepal and (c) Kathmandu city.

Summary

Proposed approach able to localize deformation zones in the study area but requires improvements in deformation estimation to better update the existing deformation maps.

Acknowledgement

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