

Combining Sentinel-1 Ascending and Descending Data to Aspect Information in Term of the 3D Slope Creep Behavior

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Abstract

Slow downward movements of slope due to long term influence of gravity and physical environment are becoming a slope creep and intentionally towards the high risk ground movement area. We identify the creeping slopes in Ciloto, the prone landslide area in Indonesia using the advanced InSAR technique. Slowly Decorrelated Phase Filter is chosen as the processing multi-temporal method because the number of scatter candidates are greater than single master persistent scatter (PS) technique considering to rural and agriculture tested areas. A partial tropospheric propagation delay has been reduced as well in term of the phase-based power law correction on each interferogram. The InSAR displacement results are describing a very slow motion which might be no surface geomorphic evidence at the site but result in tilt of poles, slump and crack of structures and roads, or abnormal curvature of trees. We use two independent InSAR observations and aspect information determined by digital elevation model (DEM) assuming that the motion's direction is going to the downward slope. The least square inversion model takes into account for each selected merging ascending and descending scatters to derive 3D vectors; vertical, east-west and north-south components. The firstly two of them are defined based on SAR geometry line of sight looking both from ascending and descending. Since the north-south vector is the most insensitive of slant-range deformation, we assume the horizontal motion owning a projected relationship to slope direction. The result is then simulated to the vertical surface model and horizontal vector displacement on two active zones, Puncak Pass and Puncak Highway Landslides. Considering to two successive Puncak Pass Landslides occurred in February and March 2018, we construct the pre-event history from 2014 to 2017 and locate the zone of depletion and accumulation with the slope creep displacement of 1-2 cm/year. The vertical moves faster than the horizontal at the head scarp while it shows otherwise on the foot body.

Combining Sentinel-A Ascending and Descending Data to Aspect Information in Term of the 3D Slope Creep Behaviour

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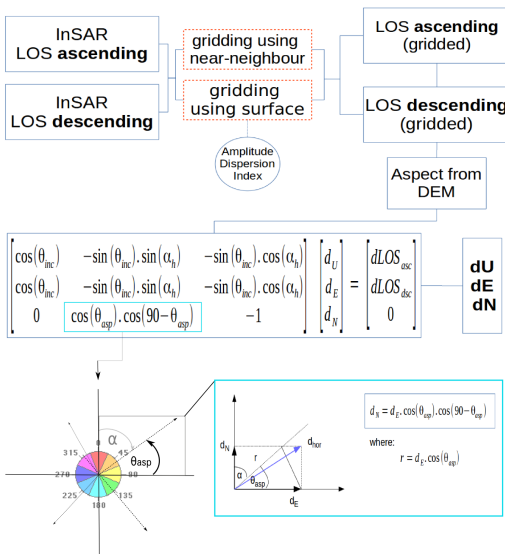
Introduction

InSAR technique has a limit geometry to observe ground surface movement which is seen along line of sight (LOS). In practical, it needs to project the LOS displacement into 3D (vertical, east-west and north-south direction) vectors.

Several methods to solve the problem:

- 2D** → LOS ascending, LOS descending, with N-S assuming ~ 0
- pseudo 3D** → LOS ascending, LOS descending + movement assumption
- 3D** → LOS ascending, LOS descending, AZI ascending, AZI descending } amplitude tracking or azimuth offset Multiple Aperture InSAR (MAI)

Method **pseudo 3D**



PS DISP

PS DISP is a bundle script written in bash shell and Matlab code. The purpose of PS DISP is to generate 2D or 3D vectors displacement from InSAR both ascending and descending orbit either from the mean velocity or time series data. Please contact the main author (N. Isya - email: n.isya@tu-bs.de) to further information accessing PS DISP.

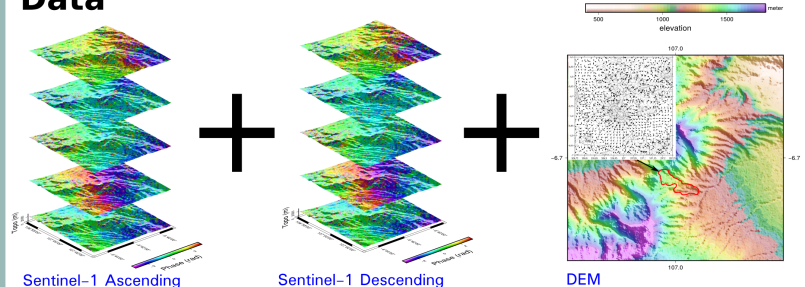
Conclusion

The method, for generating 3D vectors from two independent InSAR look directions, is using the original least square estimator which the additional information from the aspect angle taking into account for the north-west component's projection. The method could be also applied to other geophysical phenomena which have the characteristics of movement parallel to the down-slope, for instance, debris flow, glacier, volcano activity, etc.

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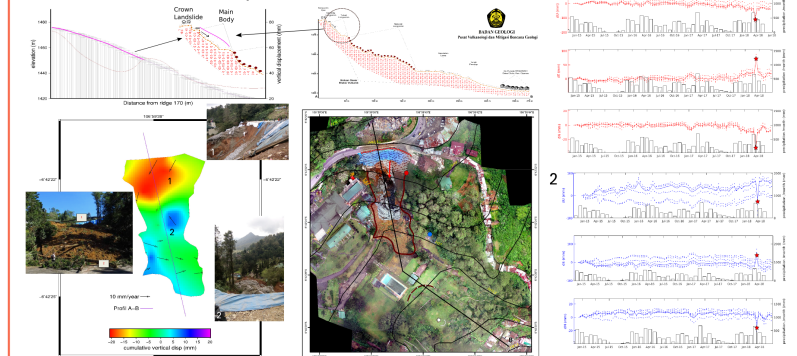
Data



Deriving the motion in 3D geometrically, it is assumed that N-S component is related to gravity behaviour which moving to downward surface elevation. Aspect takes into account as an identification for the downslope direction of the maximum rate of change in value from each cell to its neighbours.

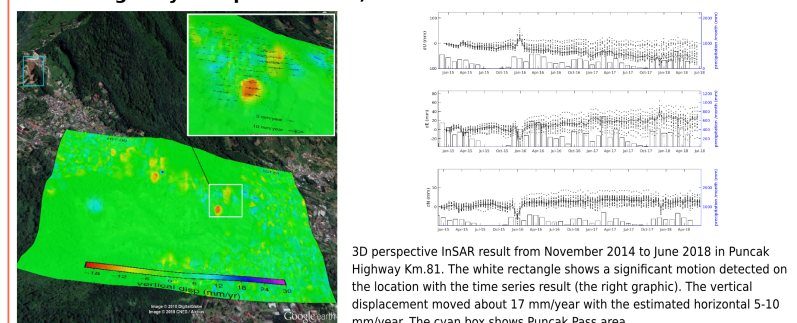
Result & Discussion

Puncak Pass Landslide, Ciloto - Indonesia



3D perspective InSAR result from November 2014 to September 2017. The left image shows a profile of vertical displacement at Puncak Pass area where the horizontal mean velocity was moving to west southern (1) and accumulated to east-southern (2). The middle image is an aerial photography after Puncak Pass Landslide occurred on 28th March 2018 (marked as *). The right graphics describe the time series displacements both at (1) and (2) zones.

Puncak Highway Creep Movement, Ciloto - Indonesia



3D perspective InSAR result from November 2014 to June 2018 in Puncak Highway Km.81. The white rectangle shows a significant motion detected on the location with the time series result (the right graphic). The vertical displacement moved about 17 mm/year with the estimated horizontal 5-10 mm/year. The cyan box shows Puncak Pass area.

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