VALIDATION AND INTERPRETATION OF DATA OBTAINED BY THE NEWLY DEVELOPED LOW-COST GEODETIC INTEGRATED MONITORING SYSTEM (GIMS)

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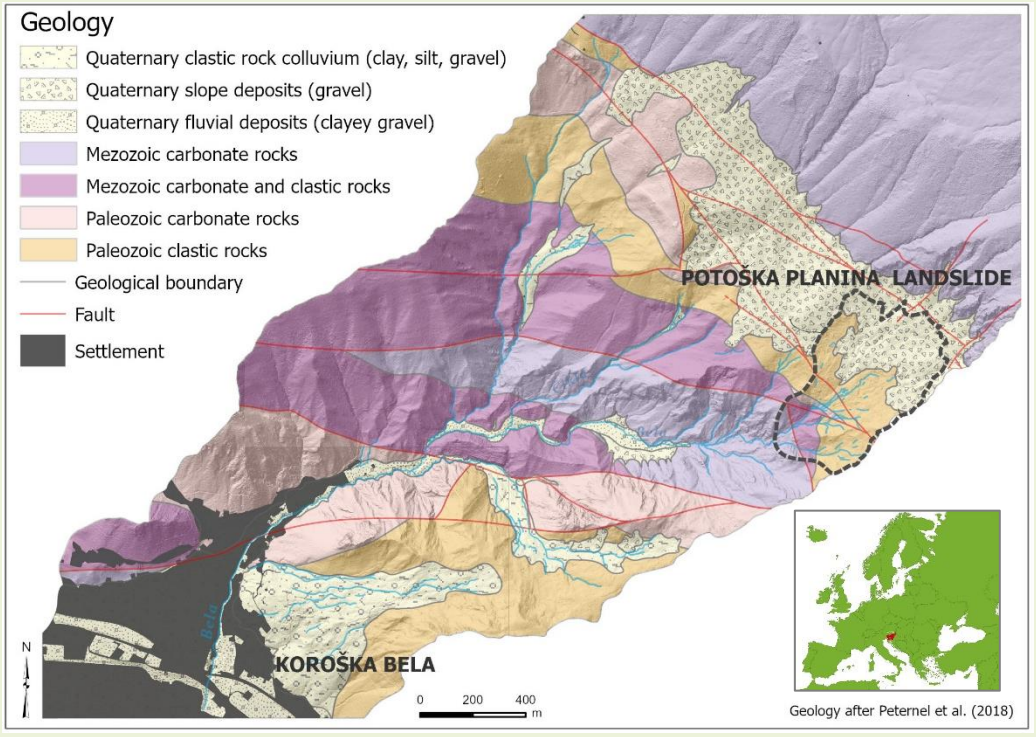
Geodetic Integrated Monitoring System (GIMS) has been developed as a low-cost solution for detecting and measuring ground movements (https://www.gims-project.eu/). The prototype has been tested on the landslide Potoška planina in the north of Slovenia that has been monitored by seven GIMS units. Units consisting of GNSS antenna and inclinometer provide live monitoring data with millimetric precision. We present the first scientific contribution of this prototype measuring system and estimate its applicability in the modern landslides monitoring. The GIMS measurements have been validated by the wire crackmeter located at the site. The data were also correlated to the amount of precipitation detected at the rain gauge. Results of GIMS units show good comparability to wire crackmeter measurements and increased precision in detecting variations in landslide movements.

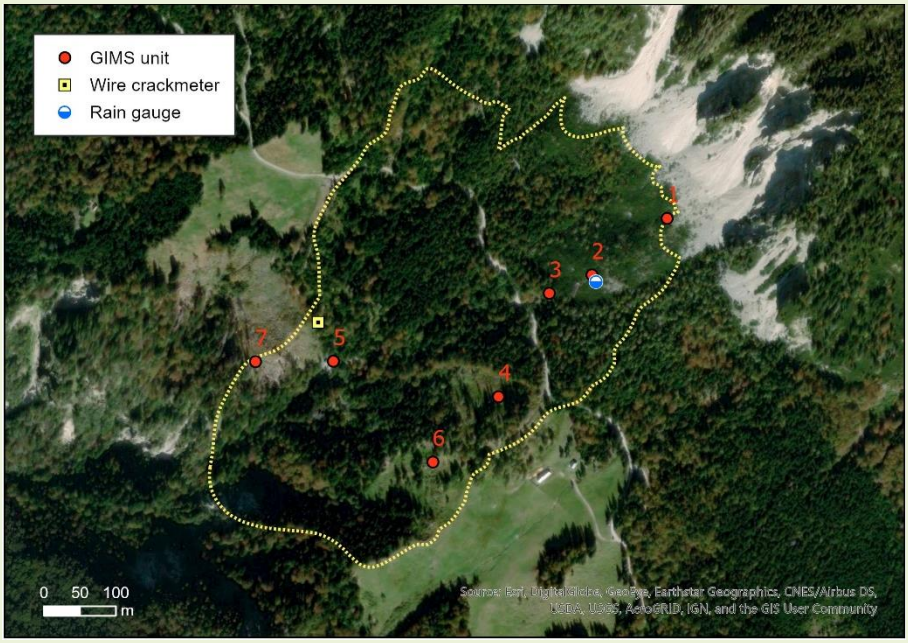
STUDY AREA

Potoška planina landslide area is located in Karavanke mountain range in northern Slovenia above the settlement of Koroška Bela with almost 2,200 inhabitants. Landslide area covers approximately 275 000 m². Its upper part consists of carbonate rocks and scree deposits, while the main body extents in heavily deformed Upper Carboniferous and Permian clastic rocks. Landslide is considered to be a rotational deep-seated slow-motion slide (Jež et al. 2008, Komac et al. 2012, Peternel et al. 2018).

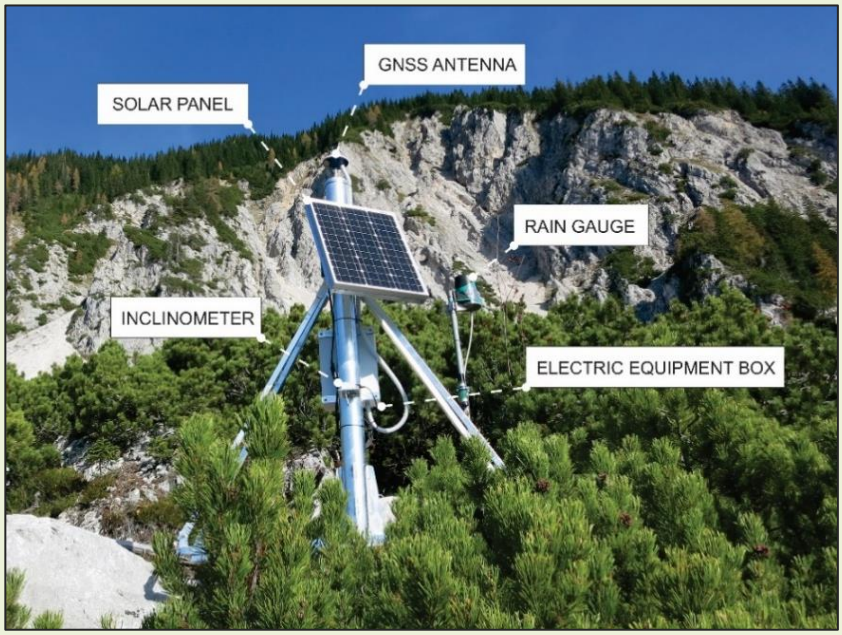


Geology after Peternel et al. (2018)

METHODS



The analysed dataset was collected between 24.10.2019 and 20.4.2020. 7 GIMS units have been installed on the landslide area. Three units had been installed in the head of the landslide (units 1,2 and 3) to monitor the activity of the scree accumulation zone of the landslide under the steep slopes of the rocky mountain ridge. Two GIMS units (units 4 and 6) were installed at the flank of the landslide to test activity of the external-most part of the landslide and its extent. One GIMS unit (unit 5) has been allocated to the funnel-shaped lowest part of the landslide. Due to diverse terrain morphology, the highest slope movements were expected here. One GIMS unit (unit 7) has been installed on the stabile rocky ridge near the landslide toe as a reference point.



For the validation of the prototype GIMS unit, the data acquired from GIMS unit 5 were compared to the measurements provided by the wire crackemeter installed app. 50 m away. All GIMS units have been considered for the interpretation of the landslide dynamics. The data was integrated with the precipitation data from a rain gauge.

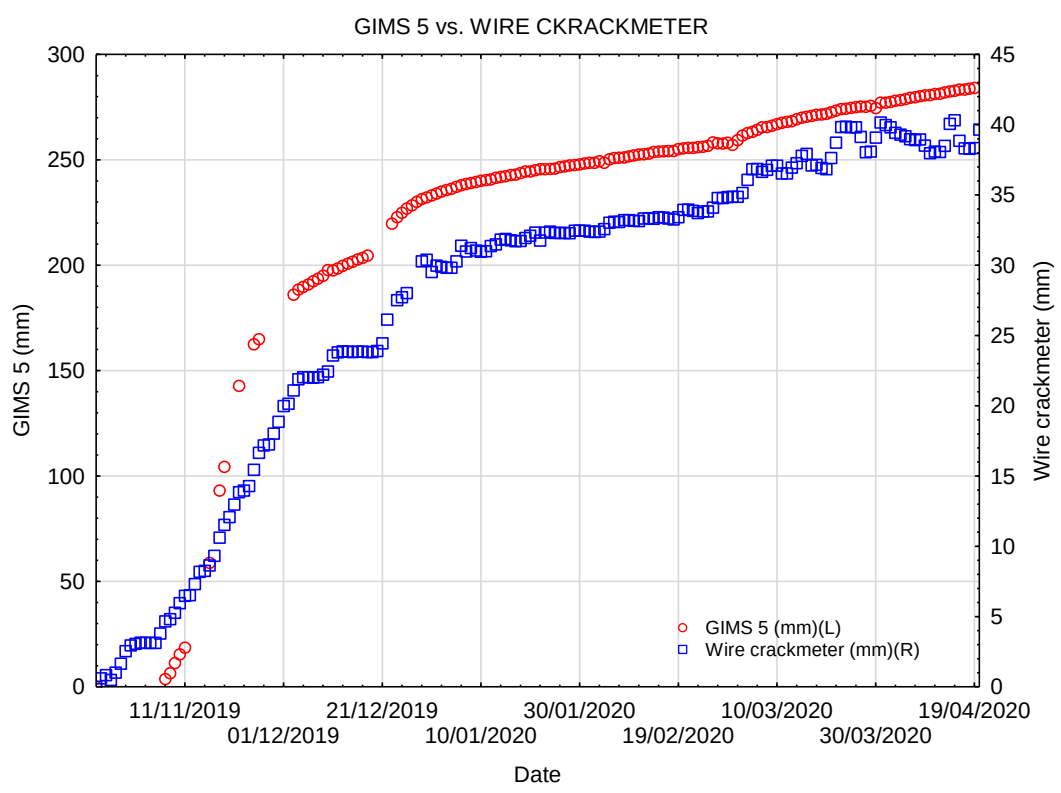
VALIDATION OF THE MEASURED DATA

For the analysed period, both wire crackmeter and GIMS unit 5 show comparable displacement trends.

Both methods detected the same pattern of landslide movement characterized by the two displacement rates: i) continuous, slow and small displacement, and ii) periodical, fast and large displacement.

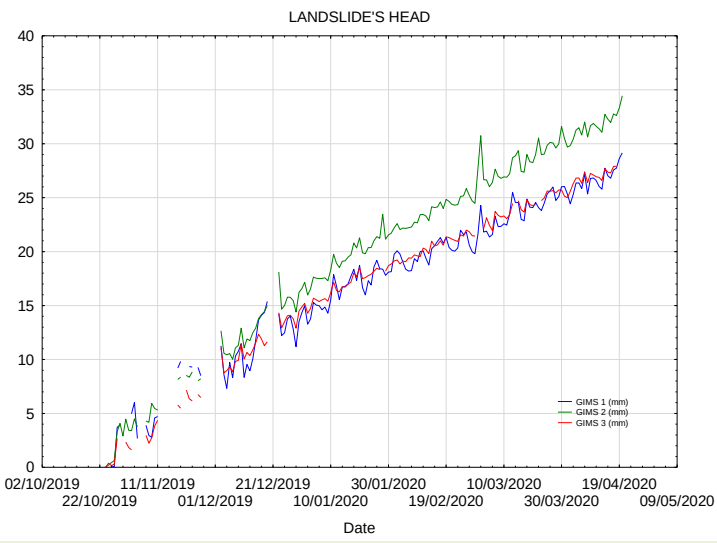
However, GIMS unit measured 284.09 mm, while wire crackmeter detected 39.6 mm of the total displacement during the analysed period. This deviation is due to different monitoring technique: i) GIMS unit is installed on the boulder which constitute the surface layer of the weathered material and as such it measures the displacement of the unconsolidated slope material. Larger displacements are most probably related with boulder rotation. ii) On the other hand, wire crackmeter measures the movement of anchor anchored into the landslide body. The instruments are located approximately 50 m apart which contributes to the different local

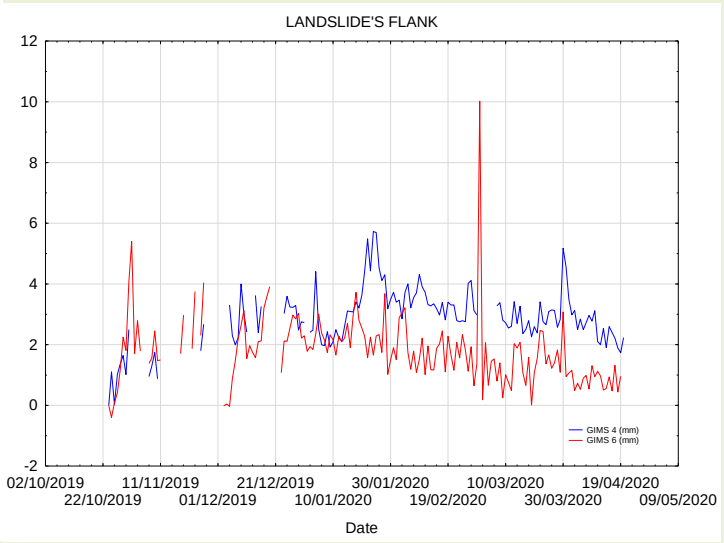
dynamics as well. This is also the reason for the different displacement rates obtained from both methods. GIMS unit shows the displacement rate of 8.8 mm/day during the periods of fast movement, while wire crackmeter exhibit the displacement of 0.6 mm/day. Low and constant (background) displacement is established to be 0.09 mm/day at wire crackmeter and 0.37 mm/day at the GIMS unit.



CONTRIBUTION TO THE INTERPRETATION OF THE LANDSLIDE DYNAMICS

GIMS units considerably contributed to the understanding of the landslide dynamics due to very good spatial coverage of the monitoring. The measurements show that the landslide's head moved at the constant, slow rate of the app. 0.17 mm/day and exhibits no periodical larger displacements during the rain events. Such displacement trend is valid for the entire upper part of the landslide that is covered by GIMS units 1, 2 and 3.

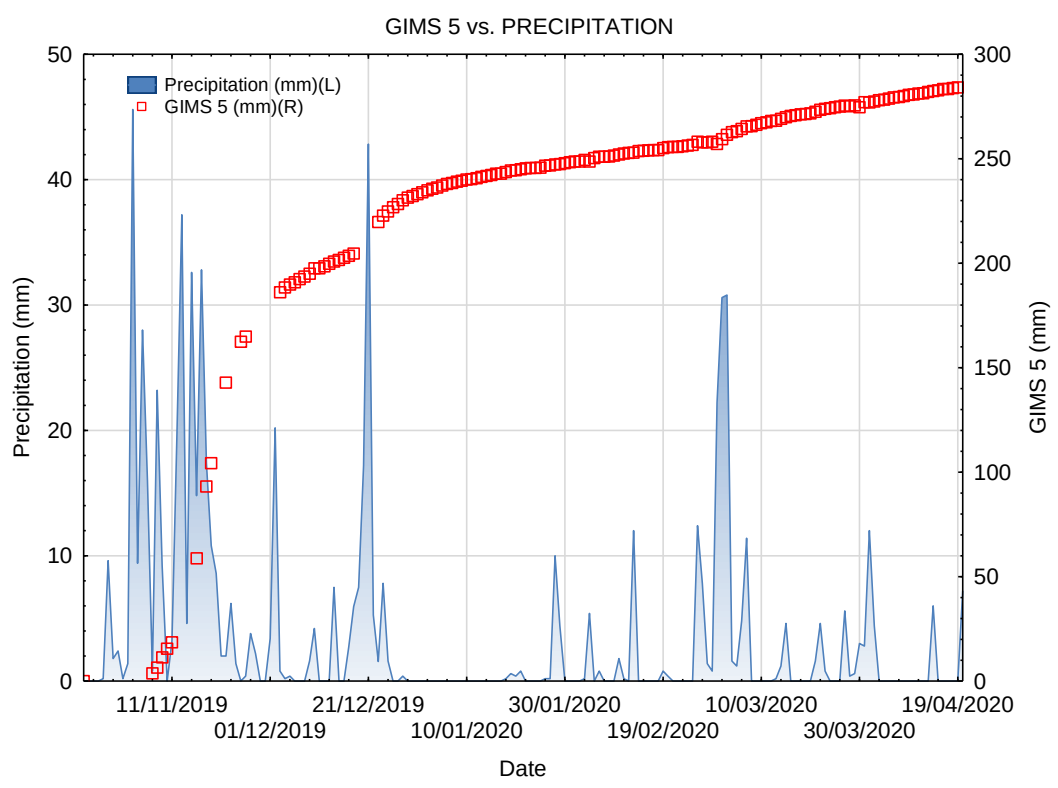




The flank of the landslide that is being monitored by GIMS units 4 and 6 exhibits negligible displacement. This area currently does not show active displacements.

GIMS unit	Total displacement recorded in the entire observation period with the reference to the GIMS unit 7 (mm)
1	29.16
2	34.44
3	28.31
4	2.23
5	284.09
6	0.96

As expected, the highest displacement rates are observed at unit 5 located at the funnel-shaped lowest part of the landslide. There, the constant slow-motion displacement is interrupted by the periodical large movements at over 20-times larger displacement rate. Such displacements strictly occur as a consequence of the intense rain events.



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