COMBINED USE OF MULTI-TEMPORAL OPTICAL AND SAR SENTINEL IMAGES FOR LANDSLIDE DETECTION

A test case in Chile: The Villa Santa Lucia landslide

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ABSTRACT

In this study we propose to combine the use of multi-temporal SAR C-band Sentinel-1 and Sentinel-2 images to detect the land cover changes induced by the Villa Santa Lucia landslide in Chile, triggered by intense rainfalls on 16th December 2017. The analysis consists in estimating changes of SAR backscattering amplitude derived radar brightness coefficient (β_0) from S-1 images and changes of NDVI from geometric and radiometric corrected S-2 images over specific fixed positions of the images including areas where the landslide occurred, comparing then the two resulting temporal series.
NDVI and β_0 measured inside the area affected by the landslide show drastic changes in correspondence of the event, while outside they remain stable.

INTRODUCTION

Landslides are frequent all around the world and cause huge losses to people. Over the years, landslide detection from remotely sensed images has been mostly carried out using optical data while Synthetic Aperture Radar (SAR) measures of the backscattering amplitude in the microwave range have not been systematically investigated and employed for many reasons including the chronic difficulties in gathering the images. The European Commission and European Space Agency with the Copernicus mission provide for free SAR and optical images offering an unprecedented opportunity to analyze changes on the Earth's surface in different spectral ranges and with high spatial resolution and temporal revisit time.

OBJECTIVE

The study area is located in Chilean Patagonia, in southern Palena province of Los Lagos Region (Fig.1). On 16th of December 2017, a massive detachment of morainic deposits of Yelcho glacier generated a huge debris flow that, impacting the northern sector of Villa Santa Lucia village, caused 18 fatalities and tens of injured people. The triggering factor was an intense rainfall event of about 122mm in 24h.

The aim of this study is to detect land cover changes caused by the occurrence of fast landslides using multi-temporal SAR Sentinel-1 and optical Sentinel-2 images.

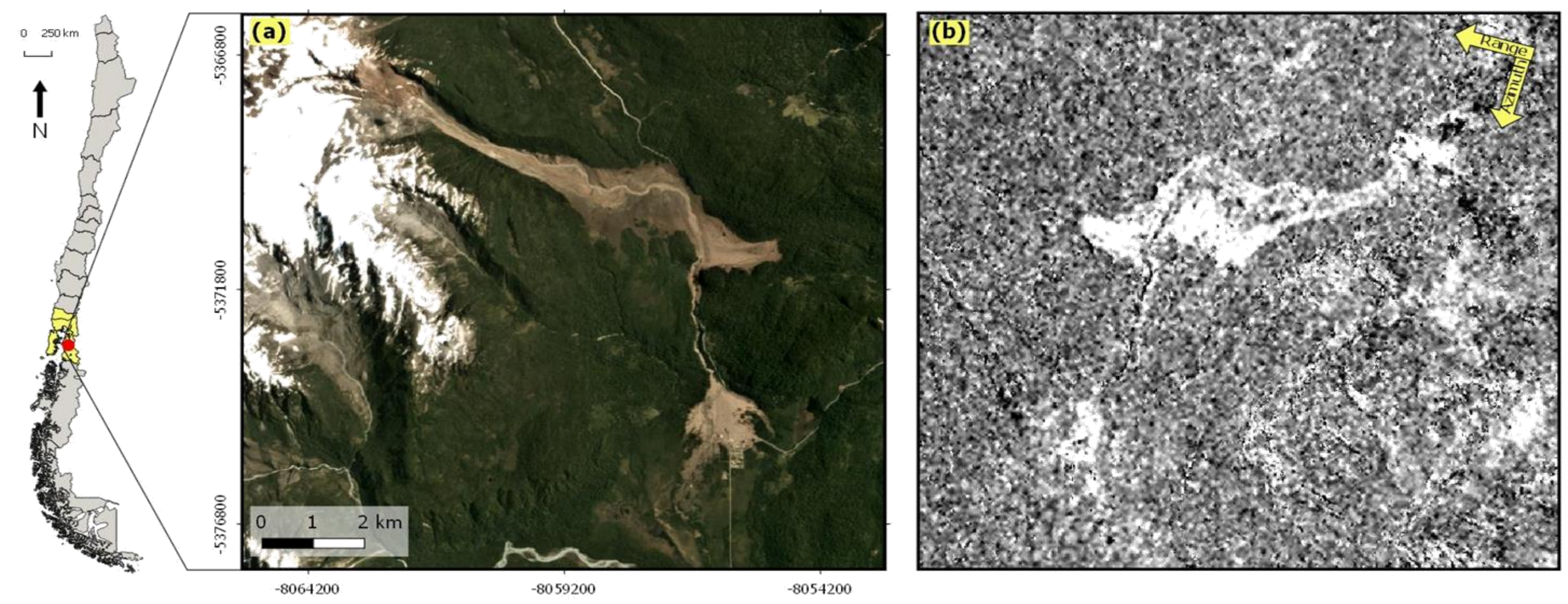


Fig.1 – Study area location. Sentinel-2 image acquired on January 2018 (a) and pre-post event Log Ratio of Sentinel-1 images acquired on December 2017 (b).

METHODS

	SENTINEL-1	SENTINEL-2
IMAGES	20 images - SLC mode and IW acquisition mode	16 images – S1C
PREPROCESSING	Thermal noise removal, radiometric backscatter β_0 calibration, precise orbit correction, de-burst, multi-looking, dem-assisted coregistration and speckle filtering. [software: ESA SNAP] ⇩ **Radar brightness coefficient (β_0)**	Atmospheric correction - S2A [software: ESA SEN2CORE] ⇩ **Normalized Difference Vegetation Index (NDVI)**
ANALYSIS	**MULTI-TEMPORAL ANALYSIS** Regions of interest (ROIs): analysis performed inside (orange) and outside (green) the landslide area. [software: QGIS and ESA SNAP]	

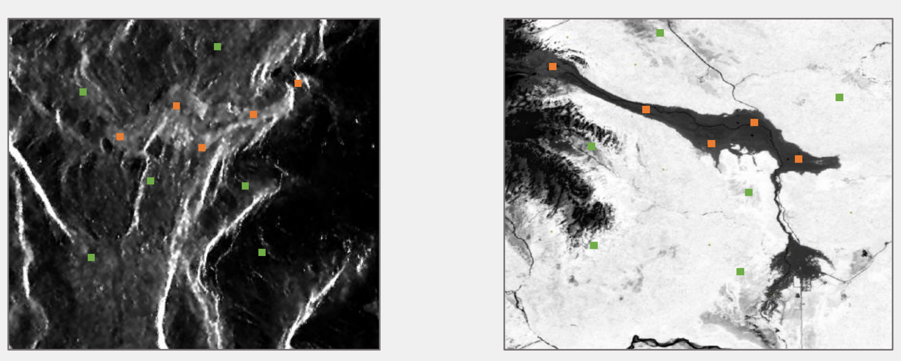
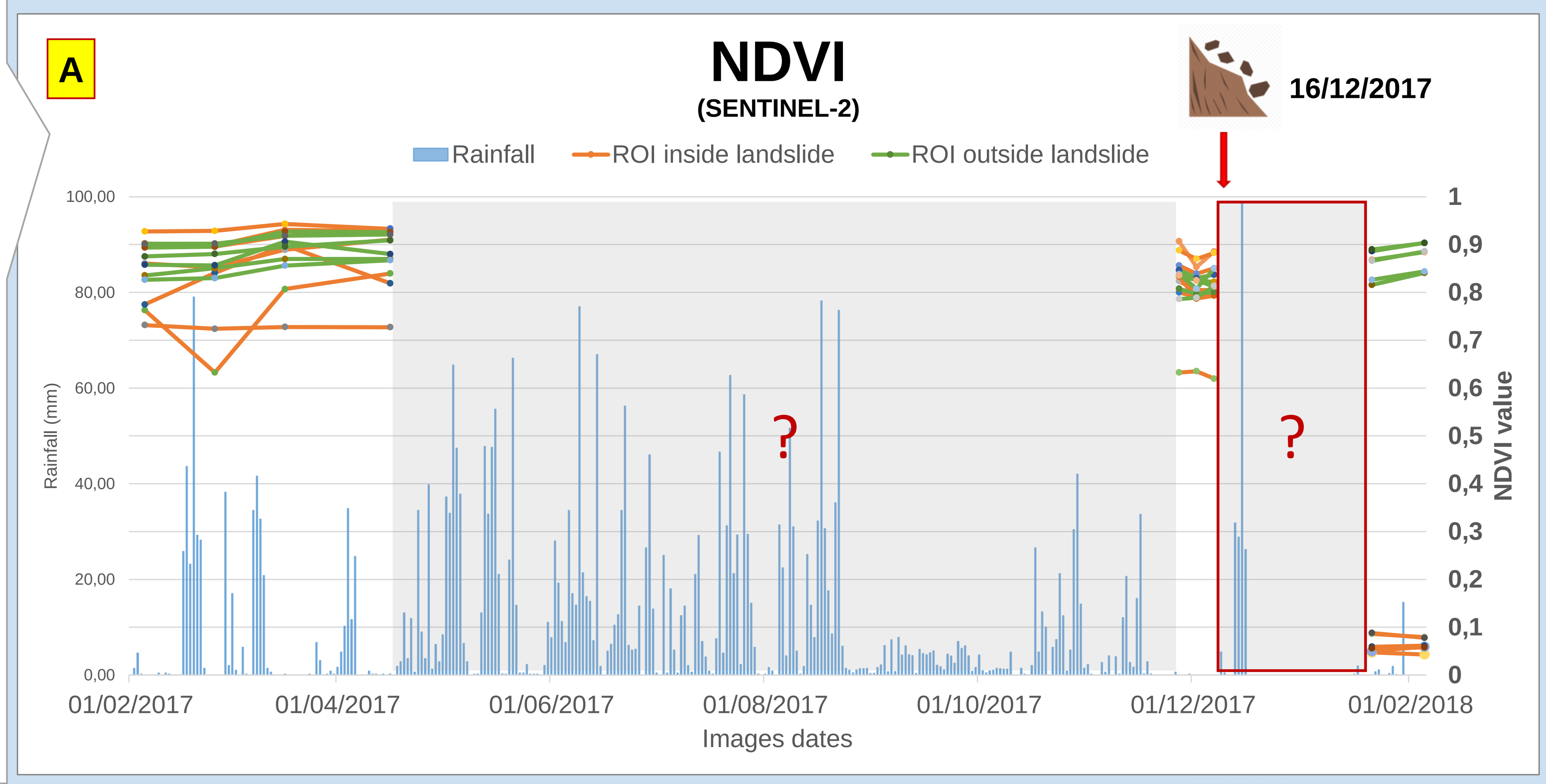


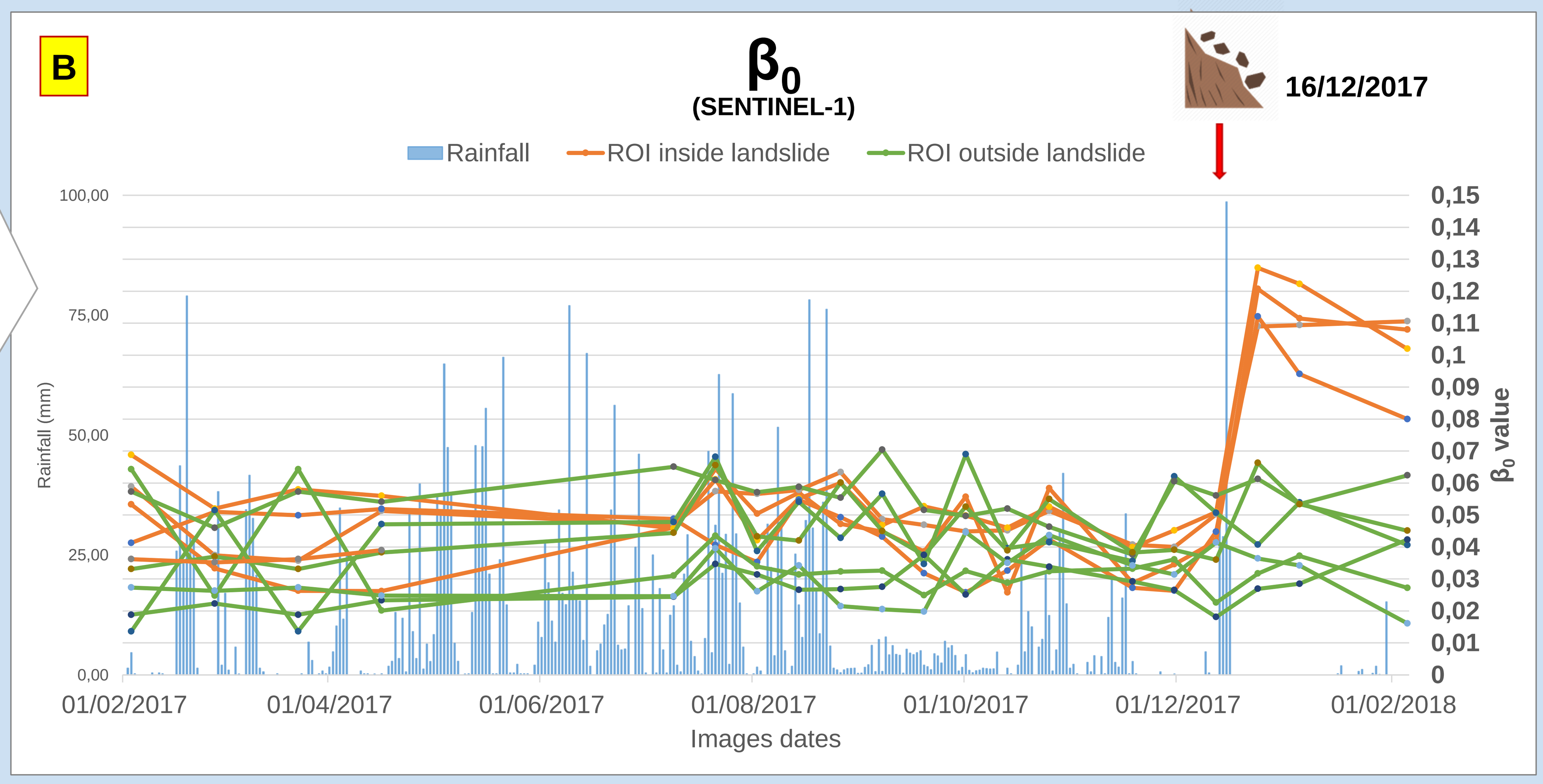
Fig.2 – Preprocessed S-1 (left) and S-2 (right) post-event images and regions of interest (ROIs).

RESULTS

Graph A illustrates the NDVI multitemporal series of 16 S-2 images. Orange and green lines groups refer respectively to inside landslide and outside landslide sampling points. The two grey blocks represent time gaps where S-2 images result not usable because dense in cloud cover. One gap is placed exactly during landslide occurrence, do not allowing to have any information about the event. In any case, the last available images of the series show a change in the trend of the signal for the orange group, which drops to very lower value of NDVI detecting a change of land cover due to landslide occurrence only after one month after the event.



Graph B shows the radar brightness coefficient trend of a multitemporal series of 20 S-1 images ranging from February 2017 to February 2018. As for Graph A, orange and green lines groups refer respectively to inside landslide and outside landslide sampling points. Before landslide occurrence the signal is quite stable for both the two groups while, after the event, the orange group evidences a sharp growth in β_0 values detecting the landslide occurrence.



DISCUSSION & CONCLUSIONS

For emergency management purposes, information about the occurrence of a new landslide must be available immediately after the event. When fast moving landslides (the most destructive one's) are caused by strong or prolonged rainfall, usable optical images for mapping or detecting are rarely available. In this work we tested the possibility of using all weather independent SAR Sentinel-1 images together with optical Sentinel-2 images to intercept signs caused by a landslide triggered by strong rainfall in an area and a period with an high persistence of clouds.

Sentinel-1 proved to be able to complement the optical images for landslide detection when Sentinel-2 were not available because of cloud coverage.

In a prognostic way, we plan to verify the proposed technique monitoring areas (ROIs) where the landslide susceptibility (or spatial probability of landslide occurrence) is high and where a priory layovering and shadowing effects are not expected.

MAJOR REFERENCES

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