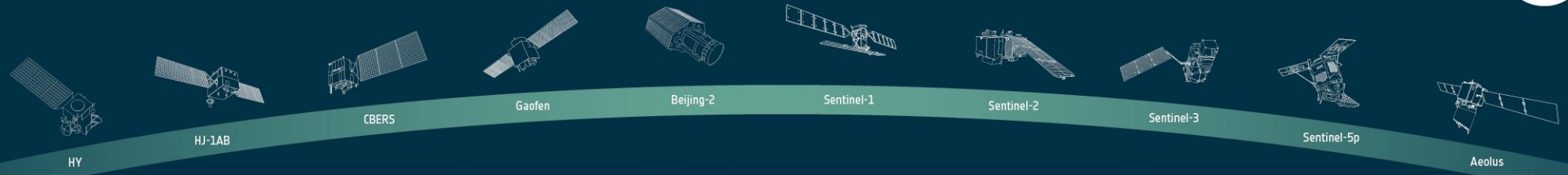

2022 DRAGON 5 SYMPOSIUM

MID-TERM RESULTS REPORTING

17-21 OCTOBER 2022

PROJECT ID. 59339

EARTH OBSERVATION FOR SEISMIC HAZARD ASSESSMENT AND LANDSLIDE EARLY WARNING SYSTEM

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Universitat d'Alacant
Universidad de Alicante

Dragon 5 Mid-term Results Project

FRIDAY, 21/OCT/2022

ID. 59339

PROJECT TITLE: EARTH OBSERVATION FOR SEISMIC HAZARD ASSESSMENT AND LANDSLIDE EARLY WARNING SYSTEM

PRINCIPAL INVESTIGATORS: ROBERTO TOMÁS (roberto.tomas@ua.es) & QIMING ZENG (qmzeng@pku.edu.cn)

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PRESENTED BY: ROBERTO TOMÁS

Main objective of the project

The primary goals of the project are to further develop advanced SAR and optical techniques to investigate seismic hazard and risk, detect potential landslides on wide regions, and demonstrate EO-based landslide early warning system over selected landslides.

EO Data Delivery

ESA Third Party Missions	No. Scenes
1. Sentinel 1-A/B	1024
2. ALOS PALSAR 1/2	570
3. ENVISAT	190
4. Cosmo-SkyMed	114
5. PAZ	21
Total:	1919

Issues: nothing to report

ESA Third Party Missions	No. Scenes
1.	
2.	
3.	
4.	
5.	
6.	
Total:	

Issues: nothing to report

Chinese EO data	No. Scenes
1.	
2.	
3.	
4.	
5.	
6.	
Total:	

Issues: nothing to report

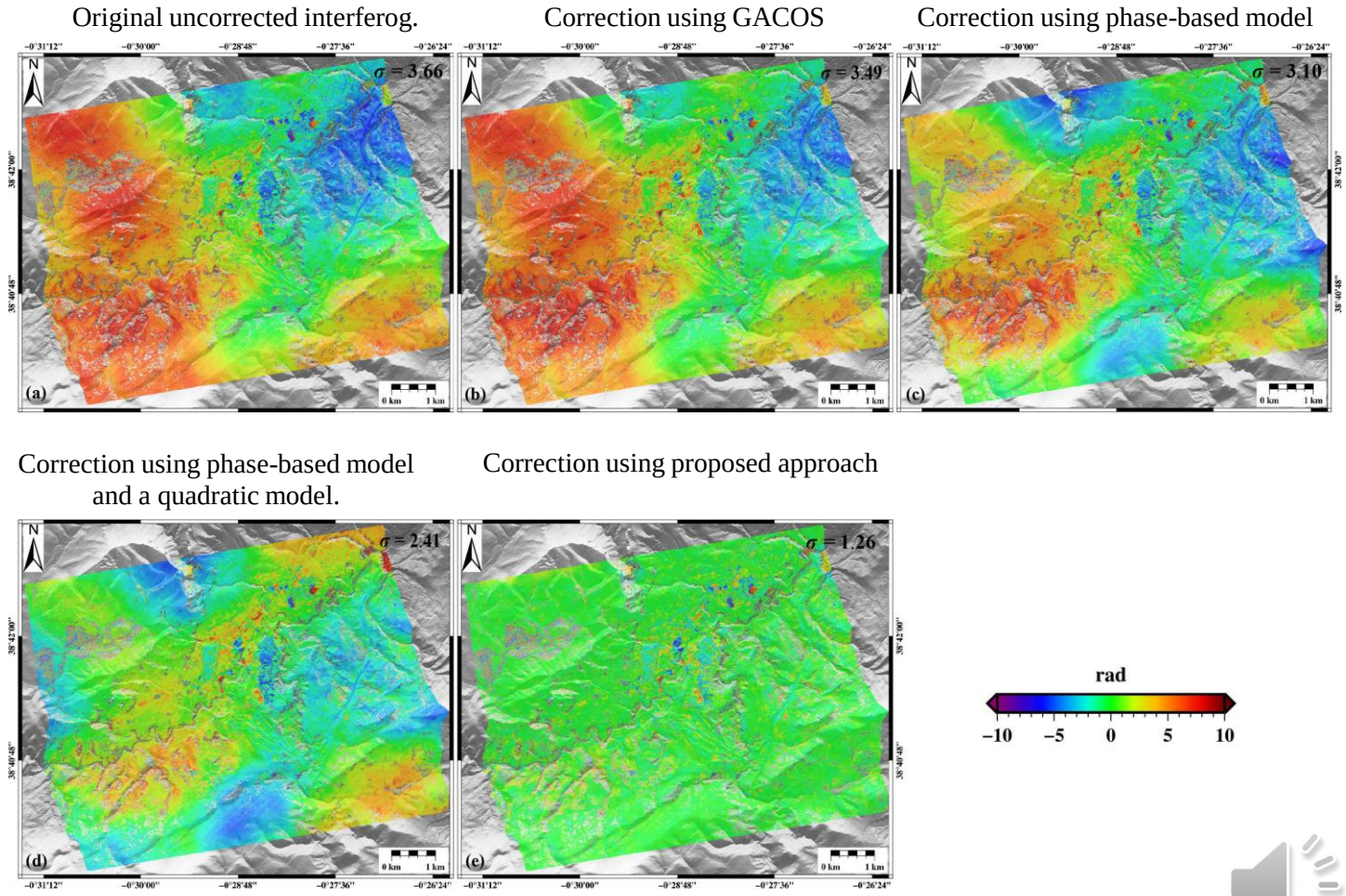
Main study areas

Field data collection campaigns

AREA	DATA COLLECTION/CAMPAIGN	SOURCE	USE
Alcoy, Spain	• Permanent GNSS station • Inclinometer • Surveying • Damage assessment • Geomorphological map • Landslide inventory map • Rainfall time series • Geological map • Geotechnical data • Seismic catalog	Instituto Cartográfico Valenciano (ICV) Ministerio de Fomento Ministerio de Fomento Own field campaign Own field campaign Geological survey of Spain (IGME) Spanish Meteorological Agency (AEMET) Geological survey of Spain (IGME) Geological survey of Spain (IGME) National Geographic Institute (IGN)	Validation Validation Validation Validation Characterization Validation Triggering factors analysis Conditioning factor análisis Modelling Triggering factors analysis
Deqin, China	• Landslide inventory map • Optical satellite images • UAV optical images	China Institute of Geo-environment Monitoring National Platform for Common Geospatial Information Services Own field campaign	Validation Photointerpretation Photointerpretation
La Unión, Spain	• Landslide inventory map • Rainfall timeseries • LiDAR point clouds • Geological map • Geotechnical data	Geological survey of Spain (IGME) Spanish Meteorological Agency (AEMET) National Centre for Geographic Information (CNIG) Geological survey of Spain (IGME) Geological survey of Spain (IGME)	Validation Triggering factors analysis Change detection Conditioning factor analysis Modelling
Jinsha river, China	• Seismic catalog • Digital surface model • Rainfall time series • River wáter level time series	China Earthquake Network Center (CENC) LOS AW3D30 DSM NASA's Global Precipitation Measurement Mission (GPM) Published data	Triggering factors analysis Calculation of direction derivatives Triggering factors análisis Triggering factors analysis

Results: Procedure for phase unwrapping errors and tropospheric delay correction

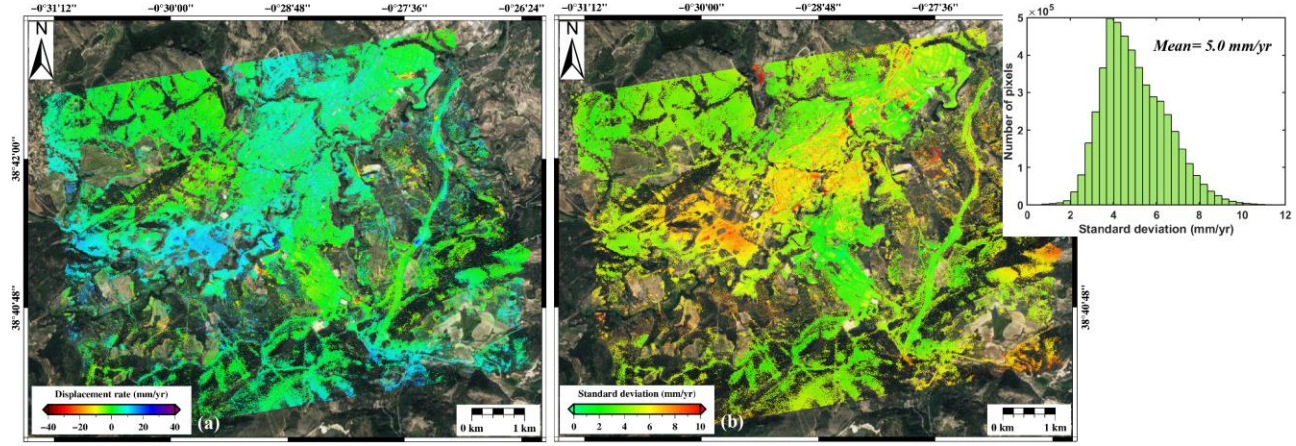
- A block-based correction algorithm based on principal component analysis (PCA) was proposed to correct the atmospheric artifacts in the interferograms.
- A comparison among the GACOS weather model, the traditional phase-based model correction method, the combination of the phase-based model and a quadratic model and in-situ measurements demonstrate the validity of the proposed method.



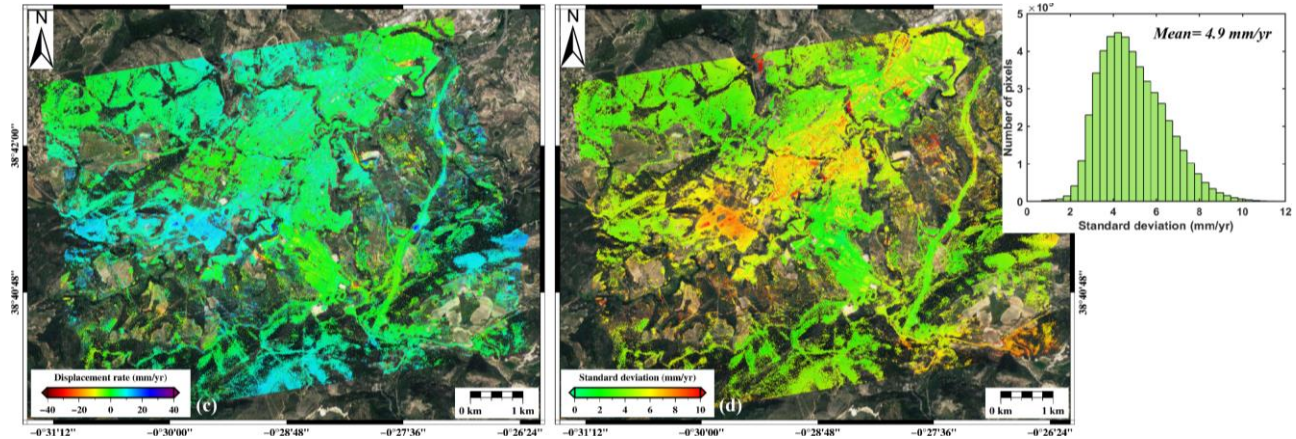
PAZ unwrapped interferogram of Alcoy (15 August 2020 to 28 September 2020)

Results: Procedure for phase unwrapping errors and tropospheric delay correction

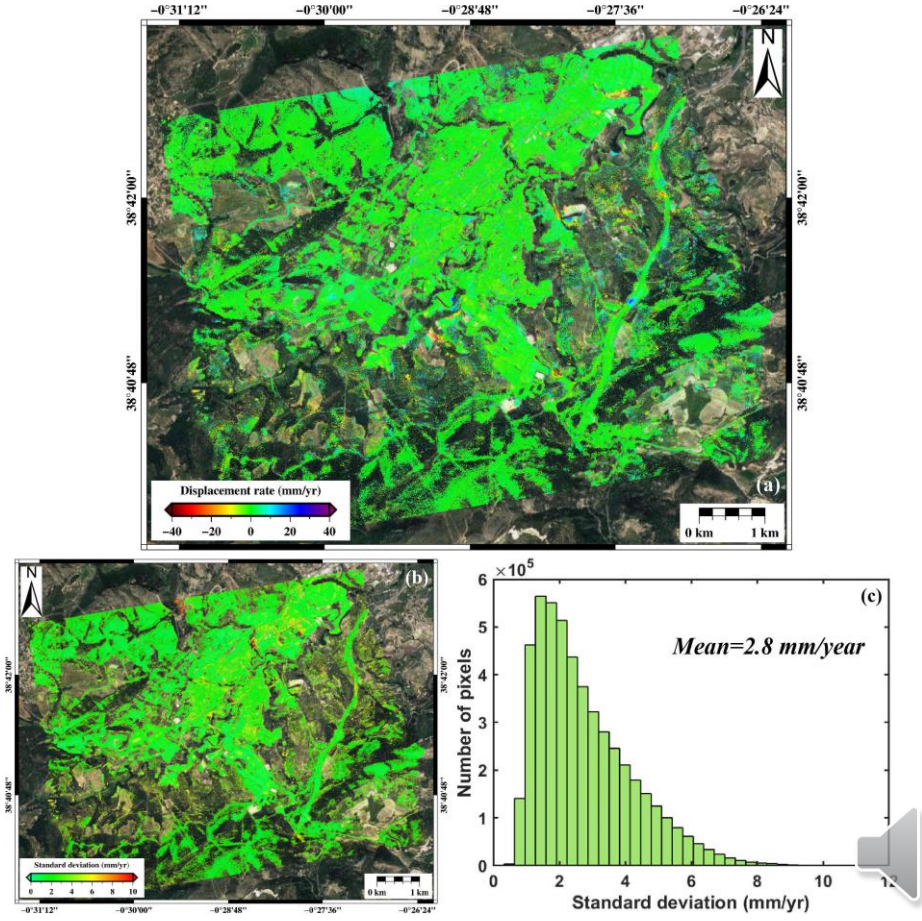
Atmosphere correction with GACOS



Atmosphere correction with phase-based method

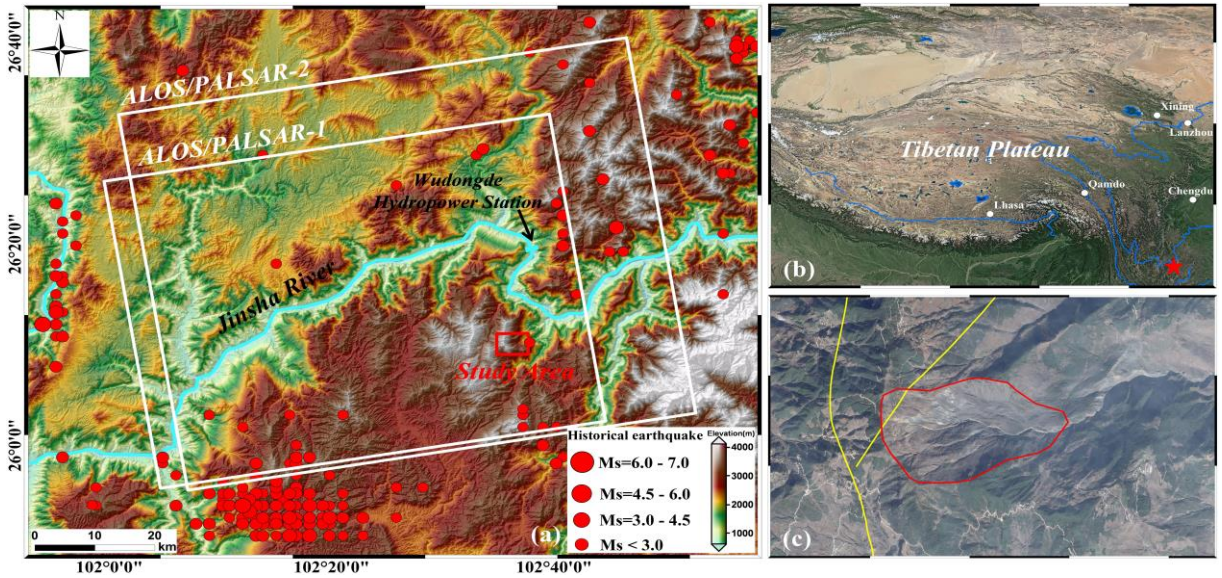


Proposed method



Results: Estimation of 3-D long-term landslide deformation

- High-precision 2D long-term time series displacements of a landslide have been calculated using cross-platform ALOS-1 and ALOS-2 images based on robust M-estimator, to avoid the gross errors in observations and to obtain high-accuracy deformation results.
- A robust method was proposed for estimating 3D long-term time series displacements of a landslide using cross-platform ALOS-1 and ALOS-2 images, based on the Total Least Square (TLS).
- The depth of the landslide was inverted using SAR-derived 3D deformation.



Laojingbian landslide in the Qinghai-Tibet Plateau, China

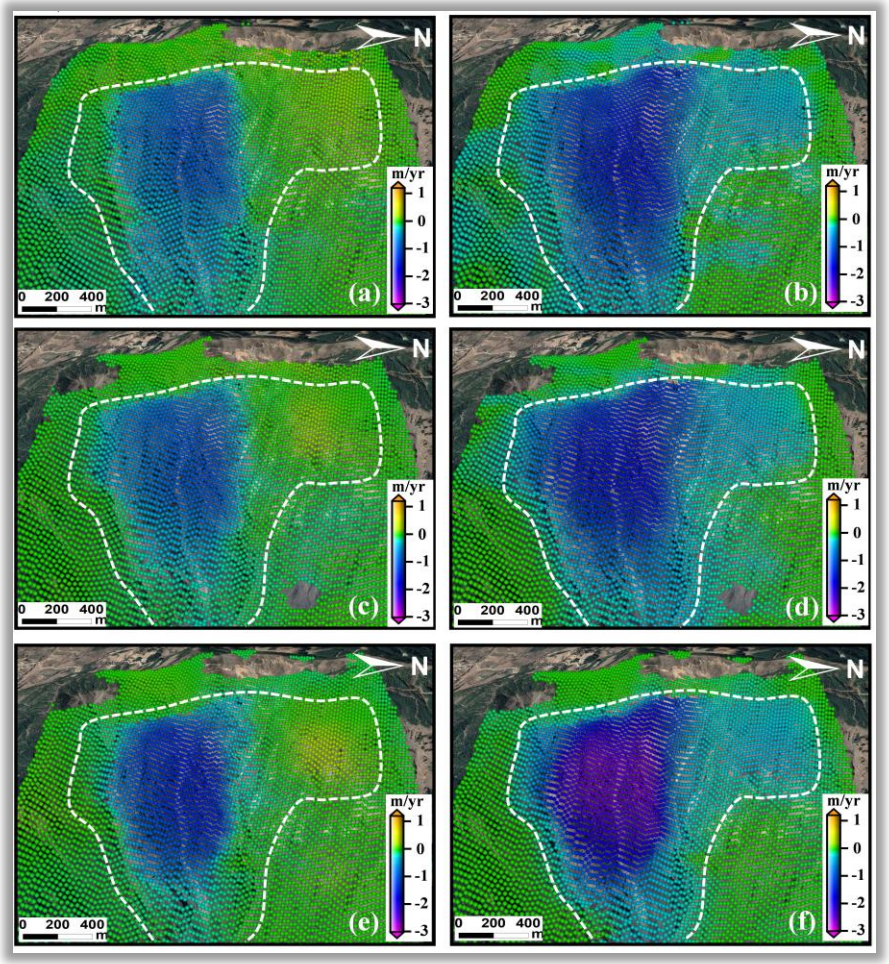
Results: Estimation of 3-D long-term landslide deformation

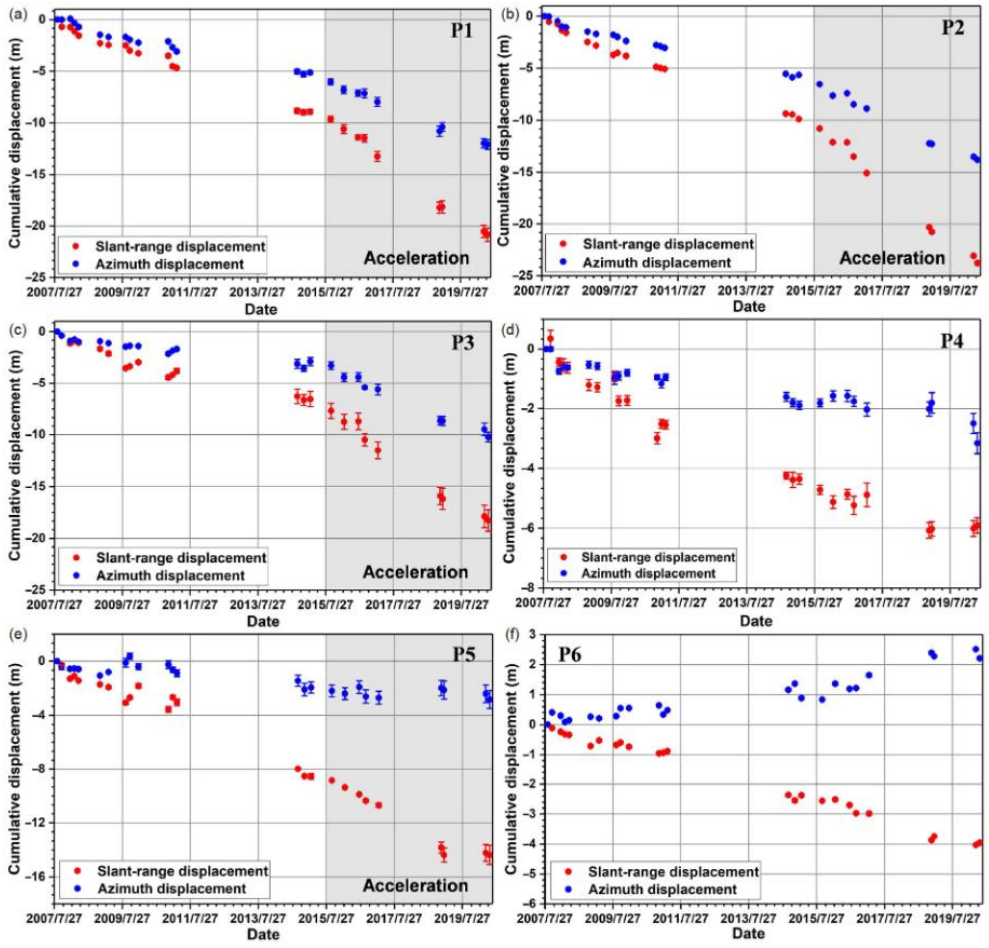
Azimuth direction Slant-range dir.

Aug 2007 - Mar 2011

Sep 2014 - May 2020

Aug 2007 - May 2020





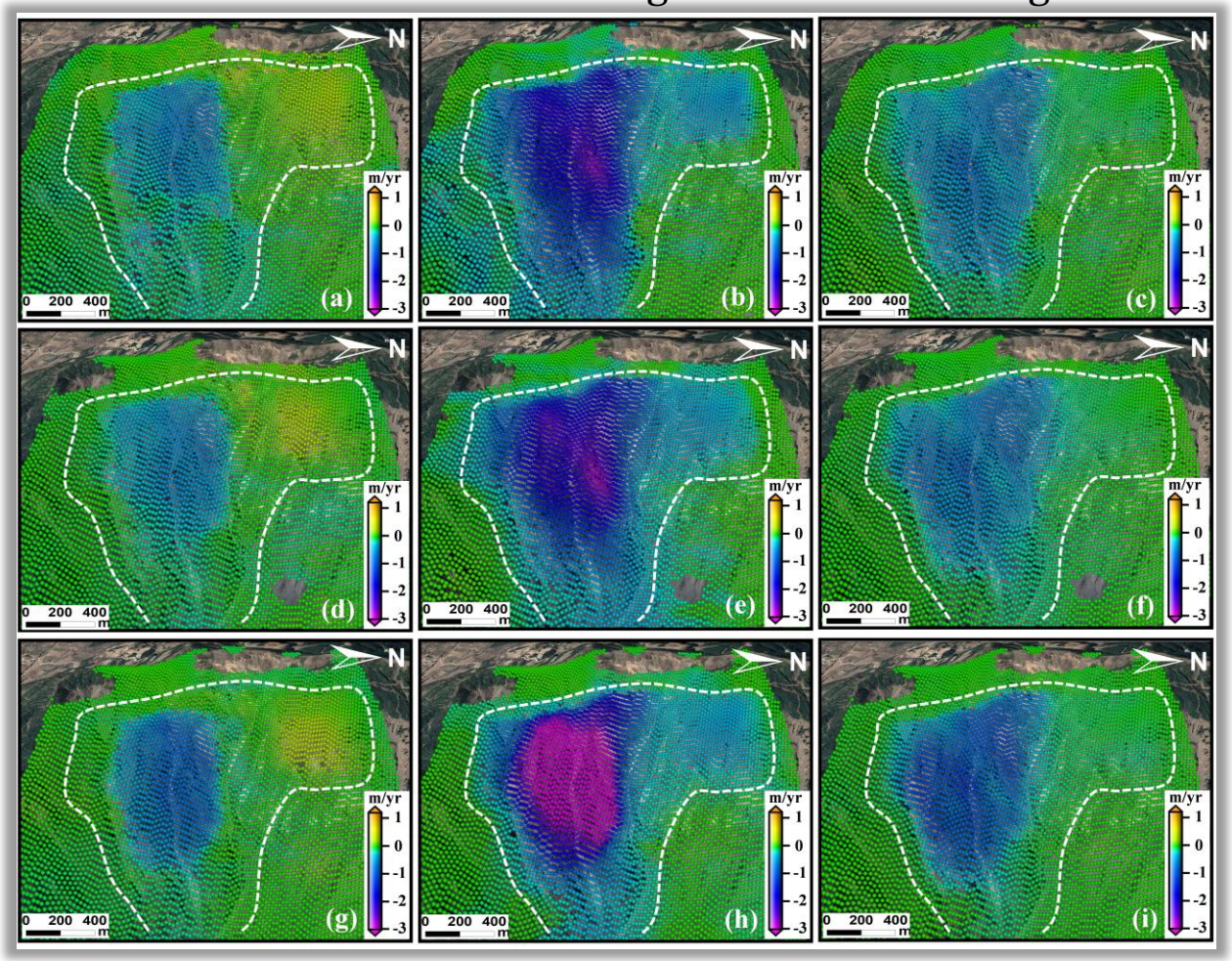
Results: Estimation of 3-D long-term landslide deformation

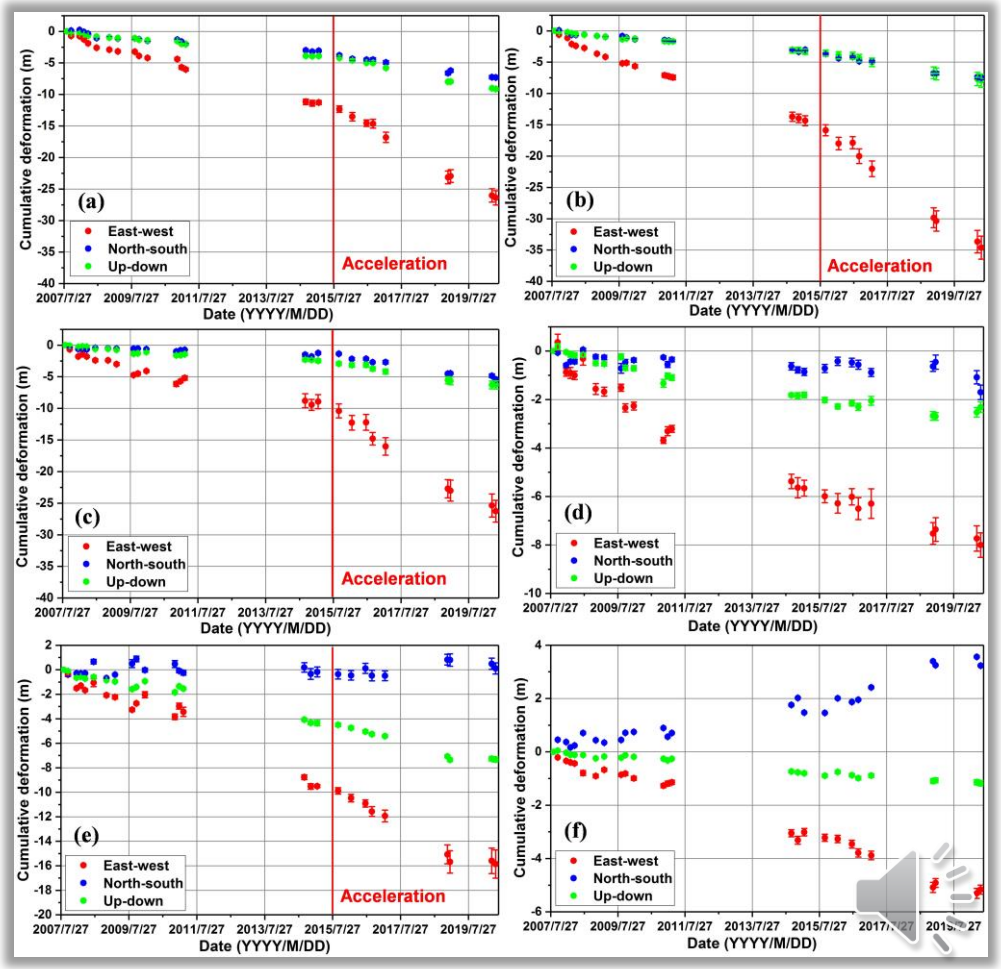
Azimuth direction | Slant-range dir. | Slant-range dir.

Aug 2007 - Mar 2011

Sep 2014 - May 2020

Aug 2007 - May 2020

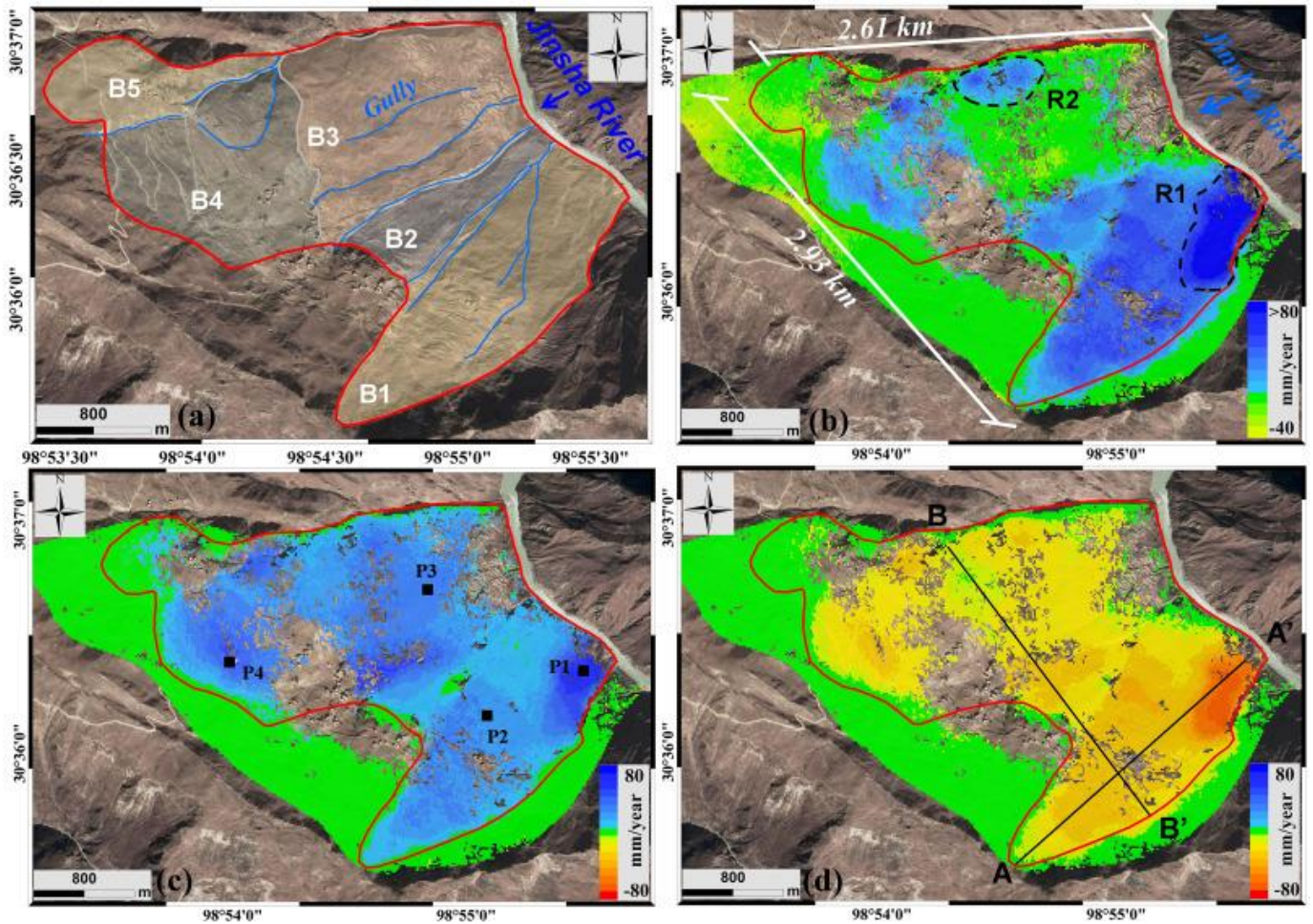




Results: Estimation of 3-D long-term landslide deformation

Shadong landslide

Orthophoto



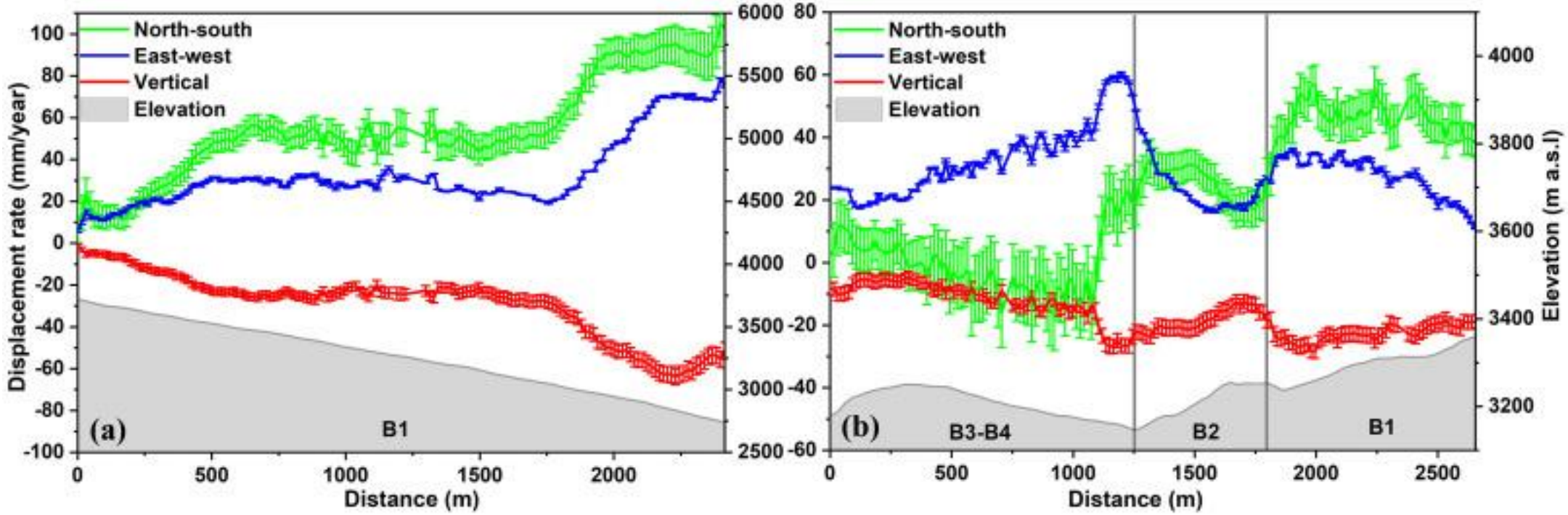
N-S displacement

E-W displacement

Vert. displacement

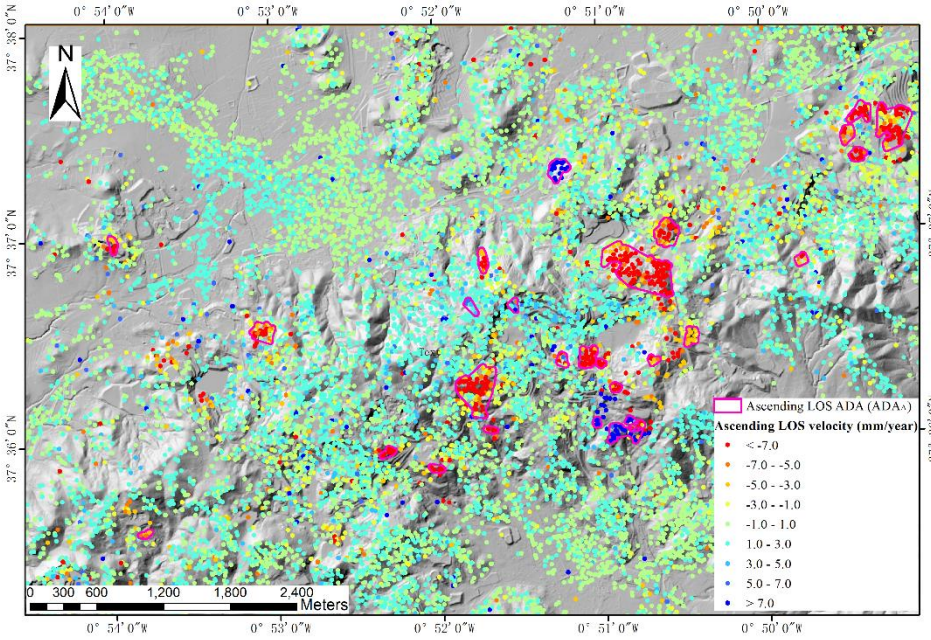
Results: Estimation of 3-D long-term landslide deformation

Shadong landslide

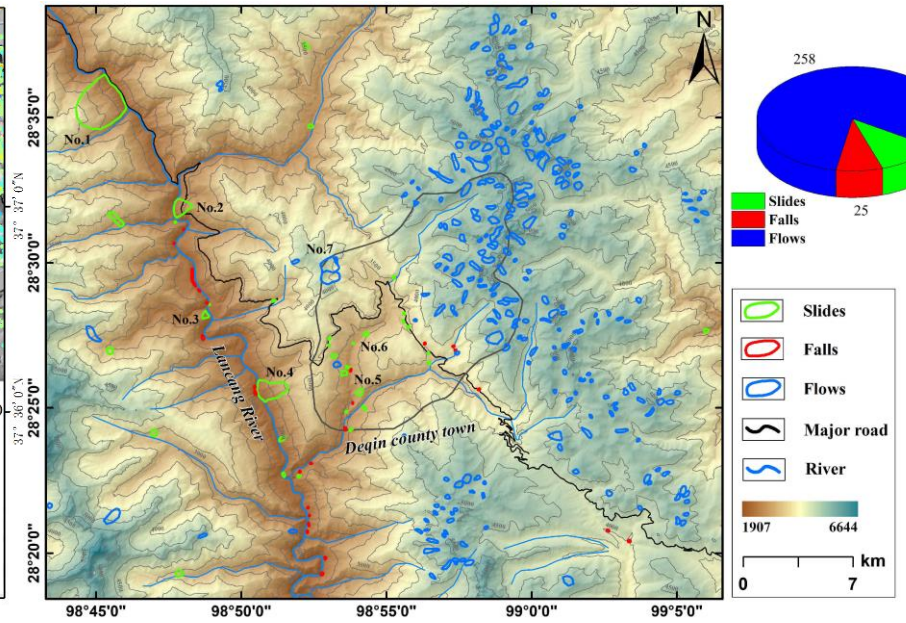


Results: Mapping and deformation monitoring of landslides

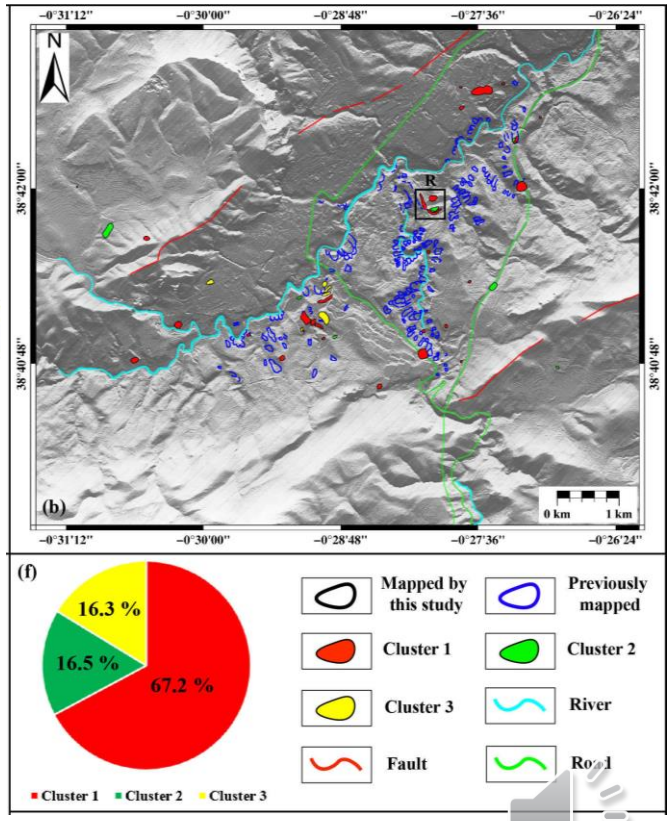
- ADA finder semi-automatic procedure has been improved to identify/classify clusters of active persistent scatterers over wide areas.
- It has been applied on different test sites in Spain and China.



La Unión, Spain



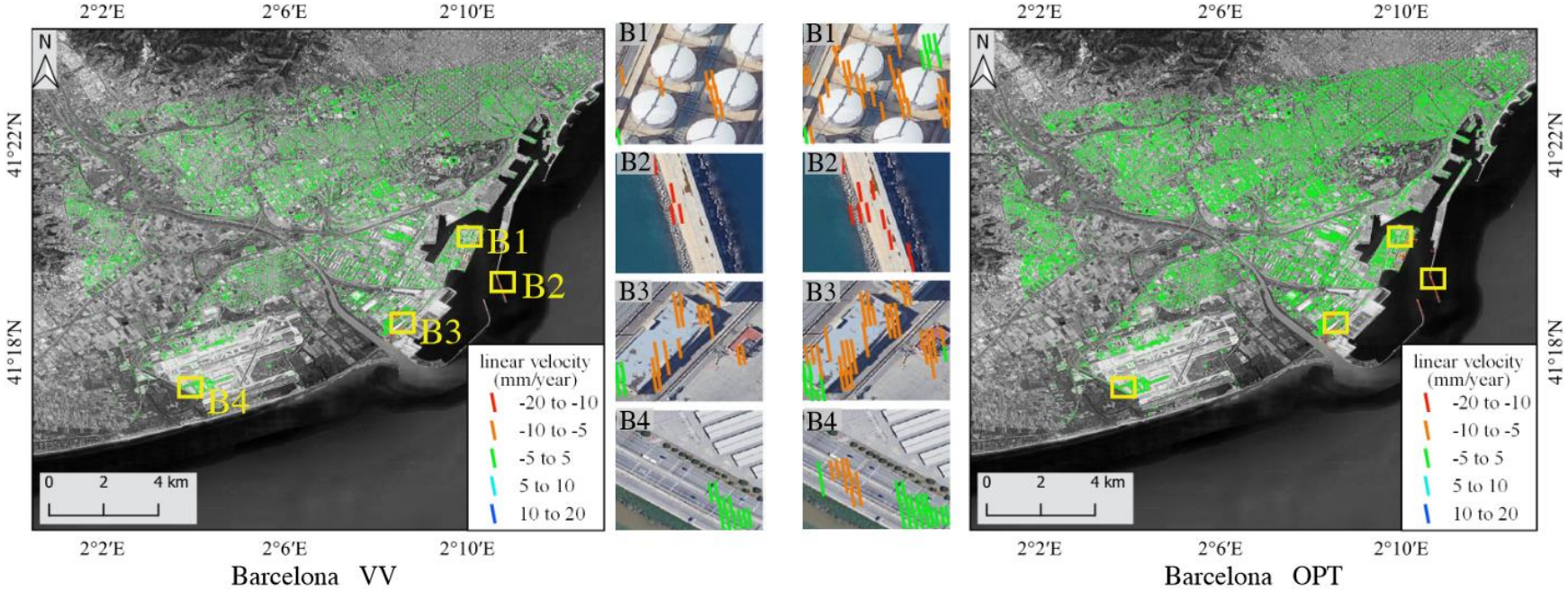
Deqin, China



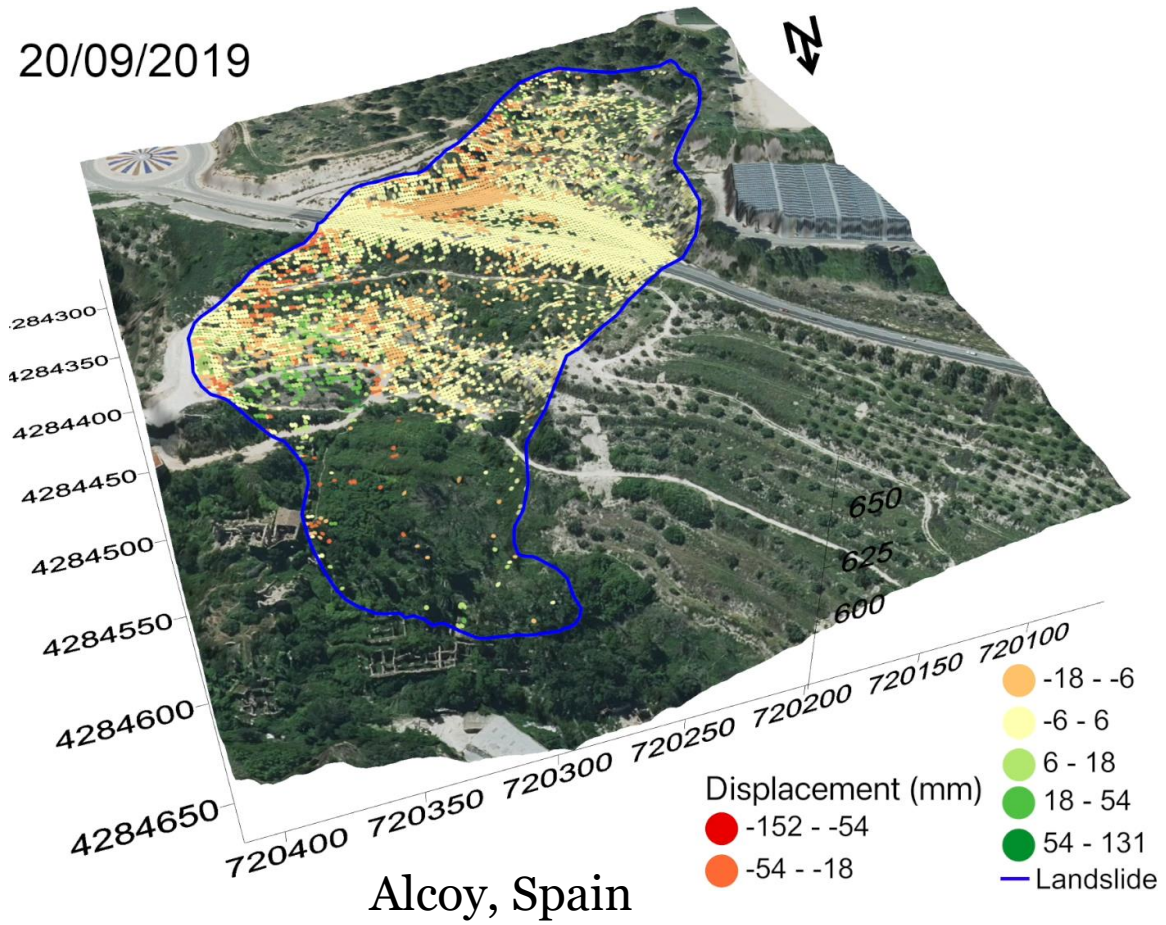
Alcoy, Spain

Results: Mapping and deformation monitoring of landslides

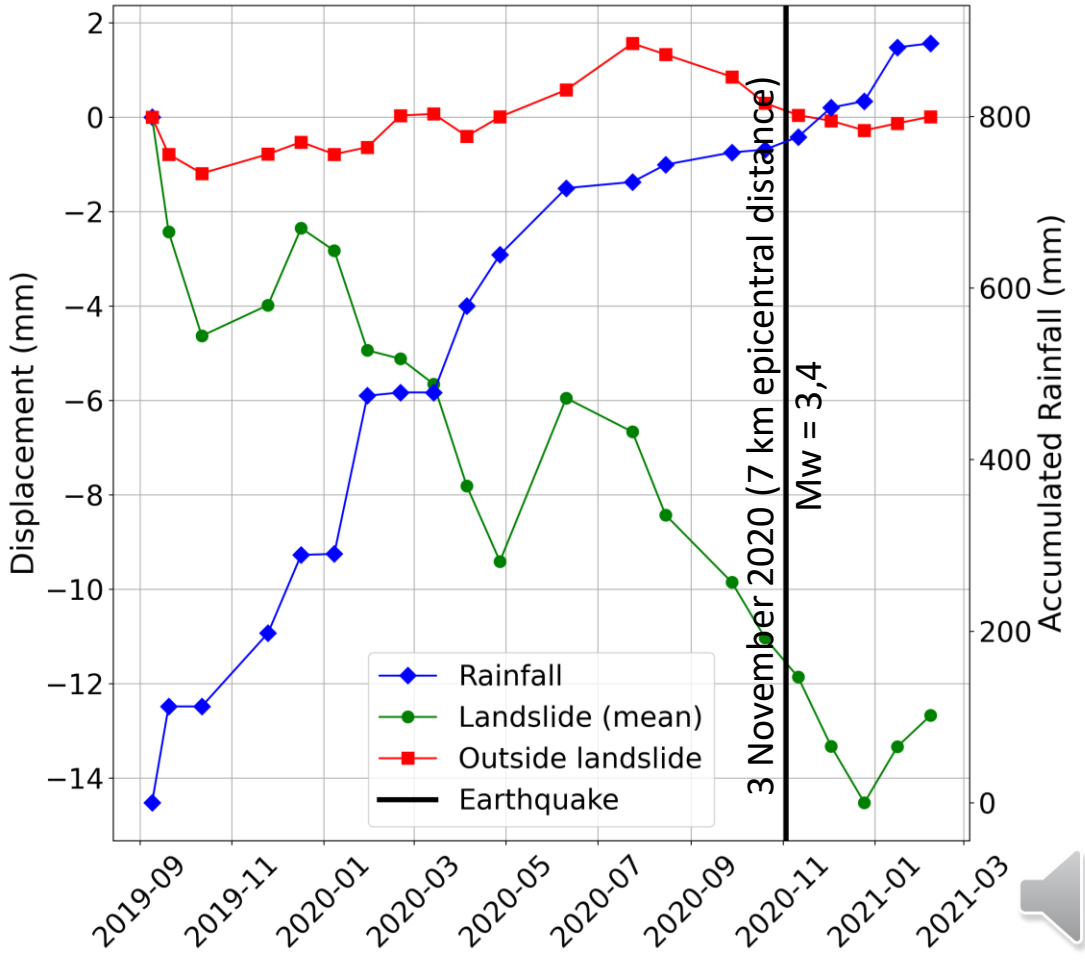
- PSI mostly exploits only the VV channel, whereas the VH channel is discarded for its lower amplitude: polarimetric persistent scatterer interferometry
- Mean amplitude increases for targets which have higher amplitude in VH channel, usually associated with rotated elements in the scene.
- VV channel is very sensitive to fluctuations and peaks but VH is insensitive to this changes thus increasing the number of PS.



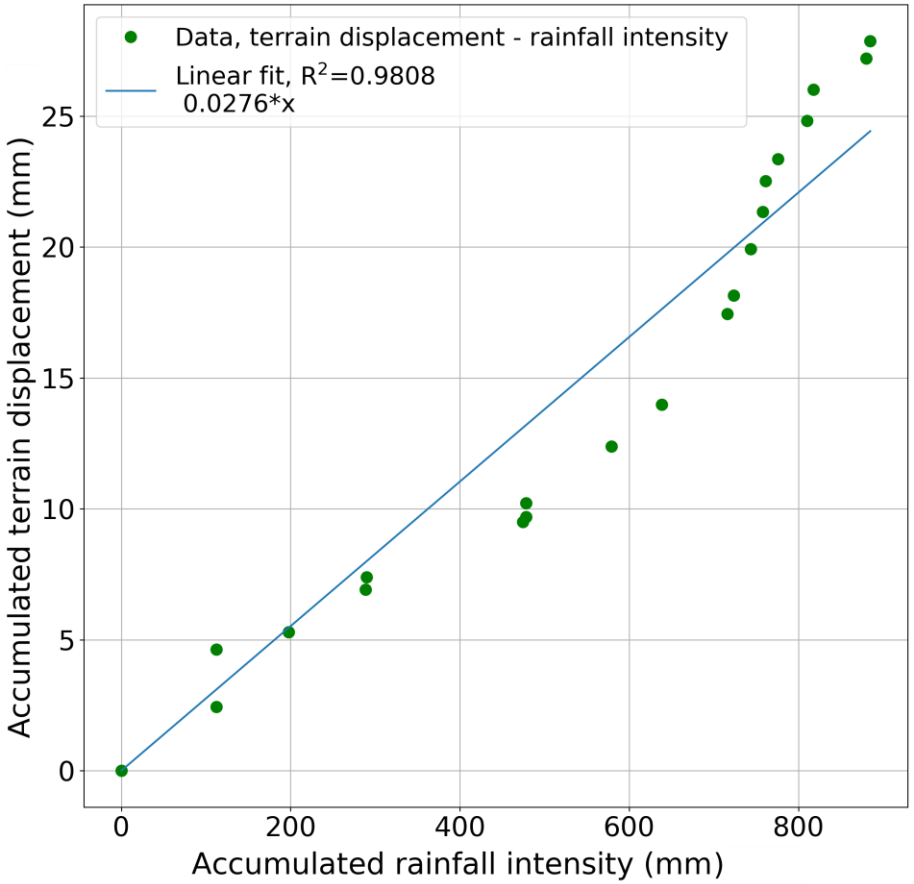
Results: Identification of triggering factors and modelling



Alcoy, Spain

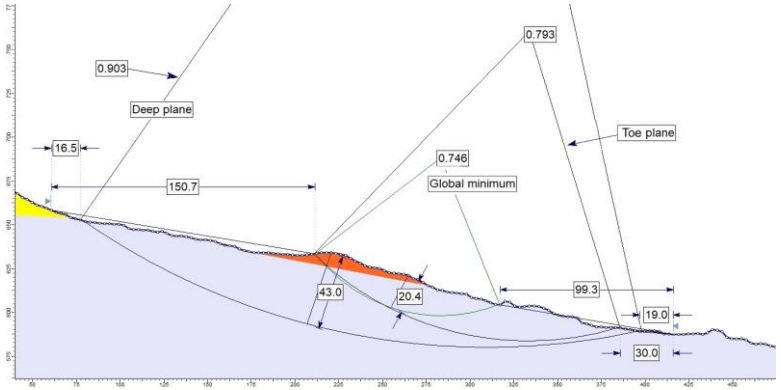


Results: Identification of triggering factors and modelling

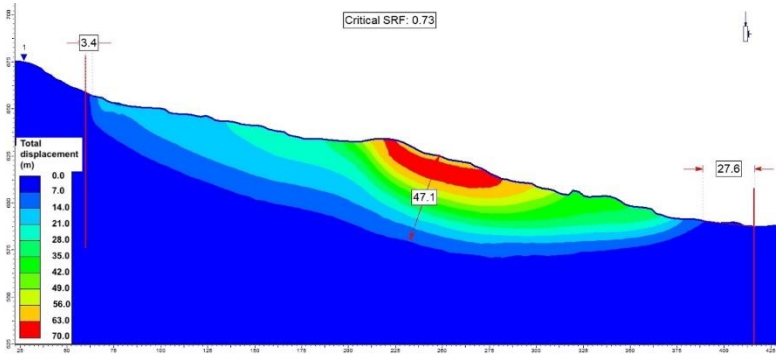


Alcoy, Spain

Results: Identification of triggering factors and modelling

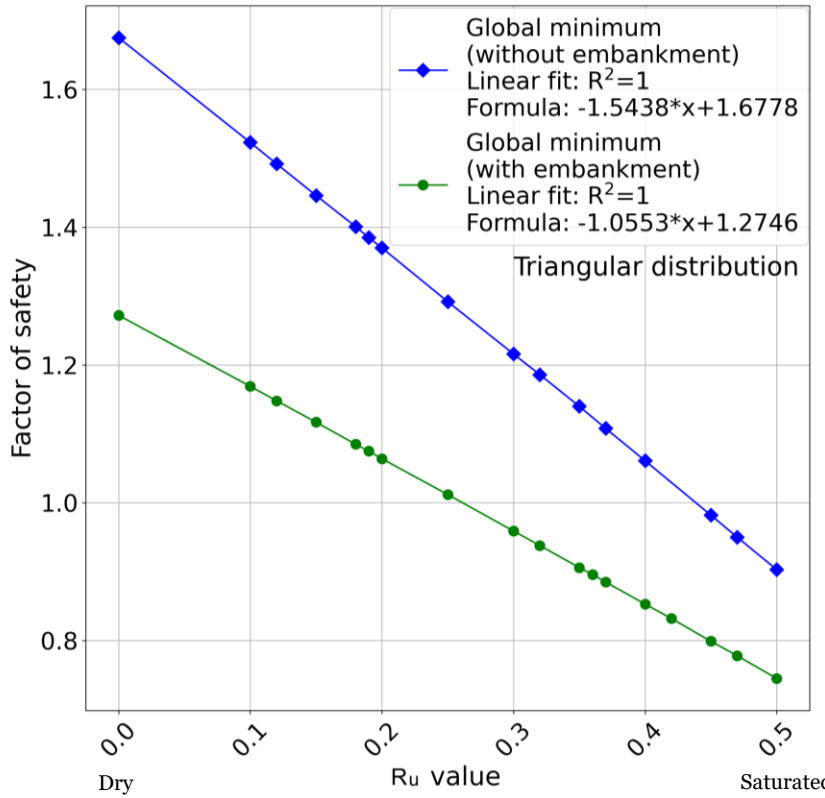


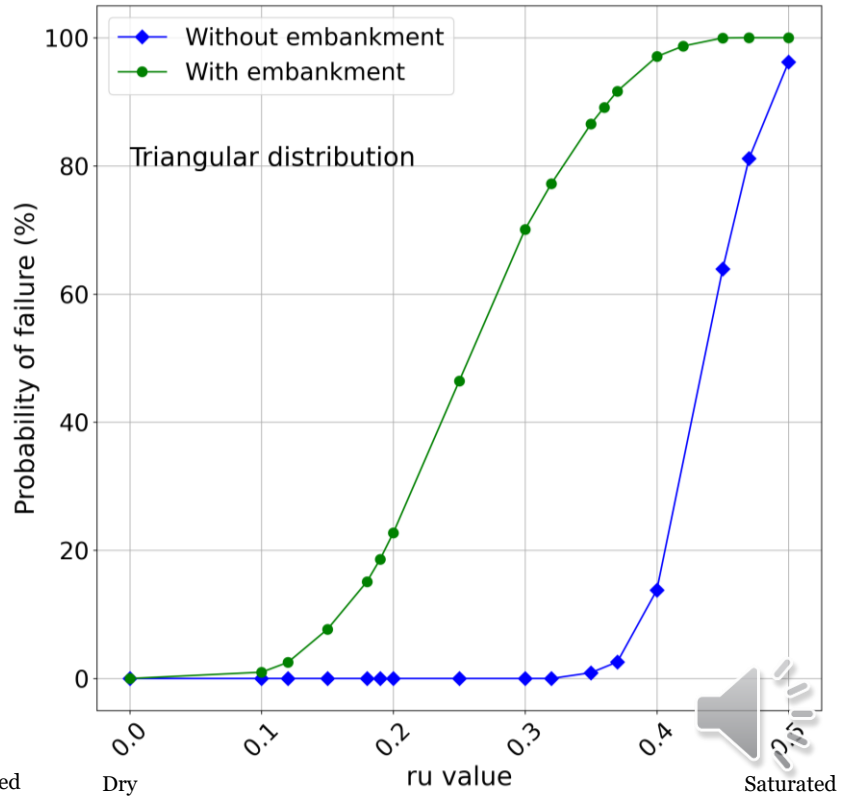
2D limit equilibrium model - Alcoy



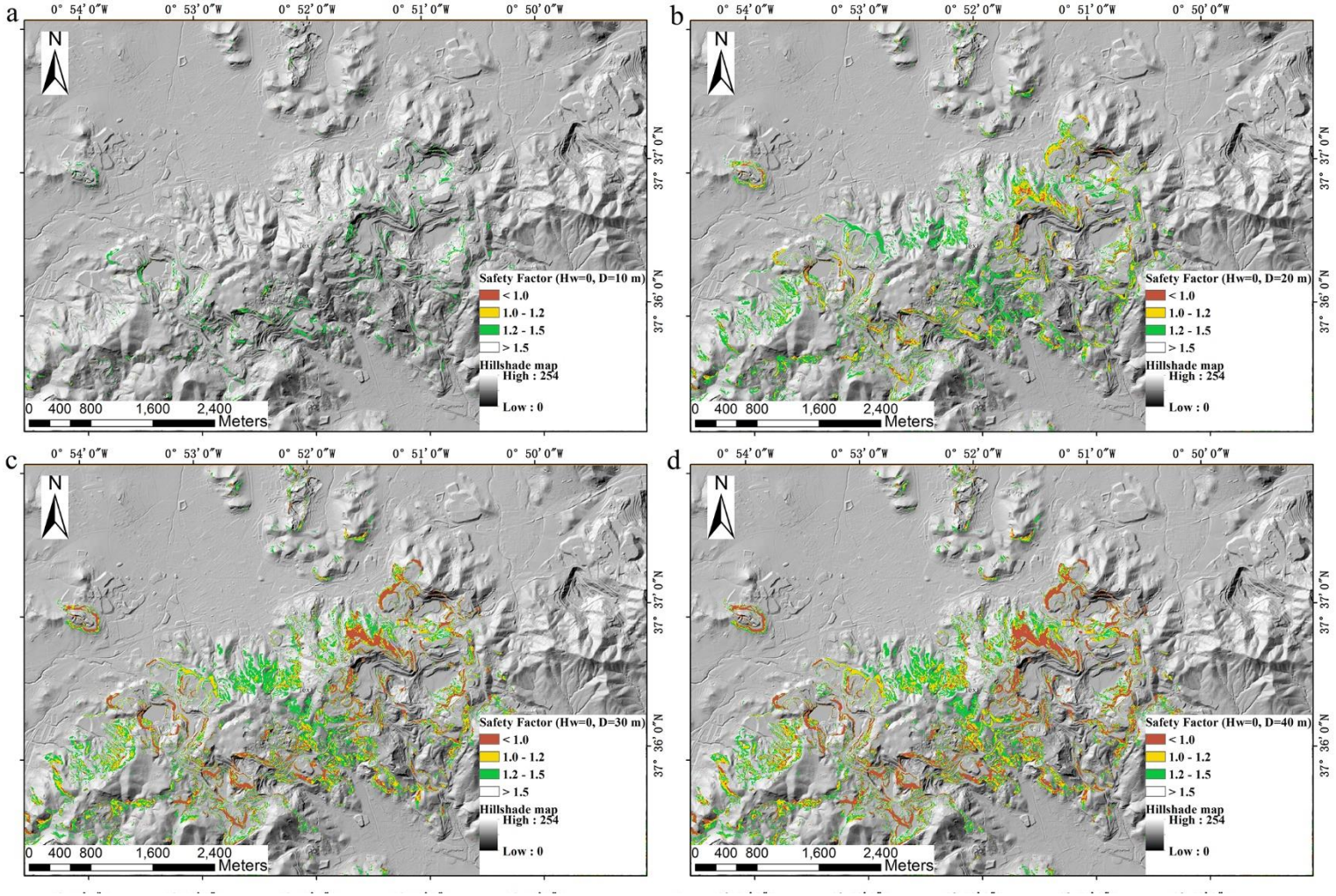
2D FEM model - Alcoy

Alcoy, Spain





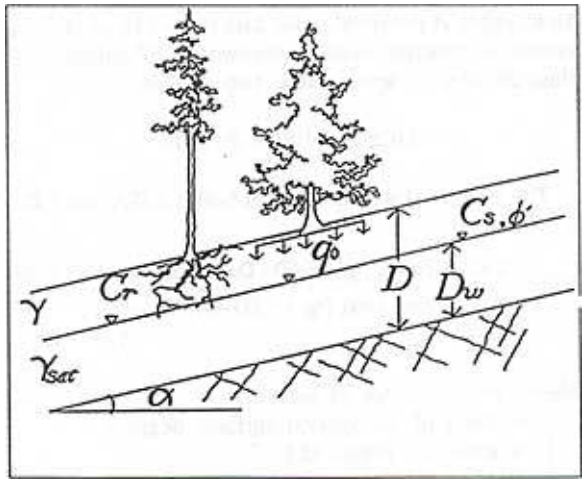
Results: Identification of triggering factors and modelling



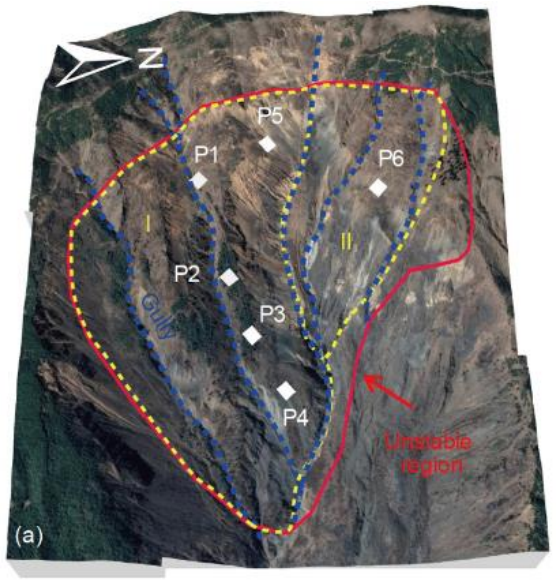
La Unión, Spain

Infinite slope model

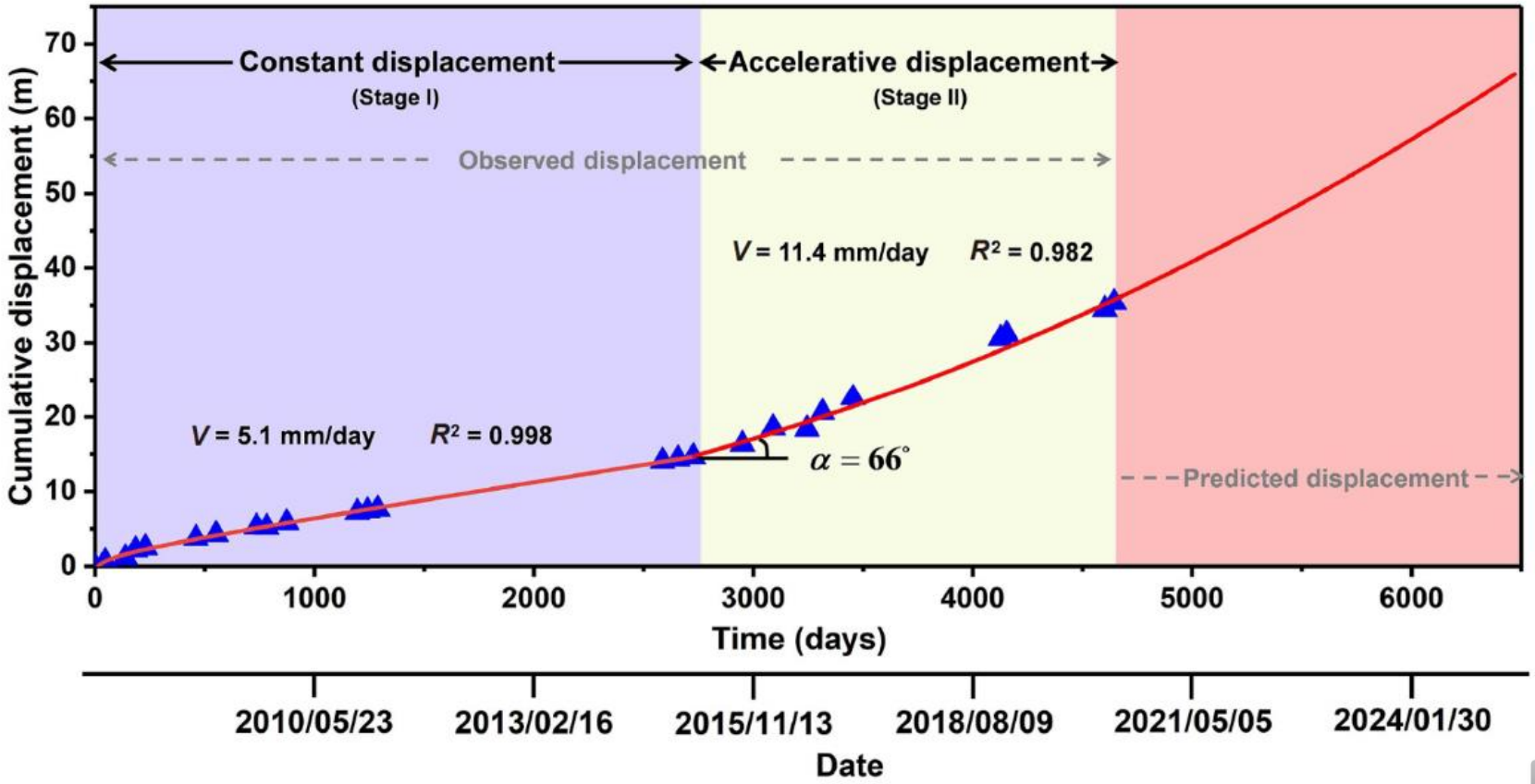
$$SF = \frac{C_s + [\gamma_m D + (\gamma_{sat} - \gamma_w - \gamma_m) H_w D] \cos^2 \beta \tan \varphi}{[\gamma_m D + (\gamma_{sat} - \gamma_w - \gamma_m) H_w D] \sin \beta \cos \beta}$$



Results: Application of InSAR-based landslide early warning system on selected sites



Jinsha River, China

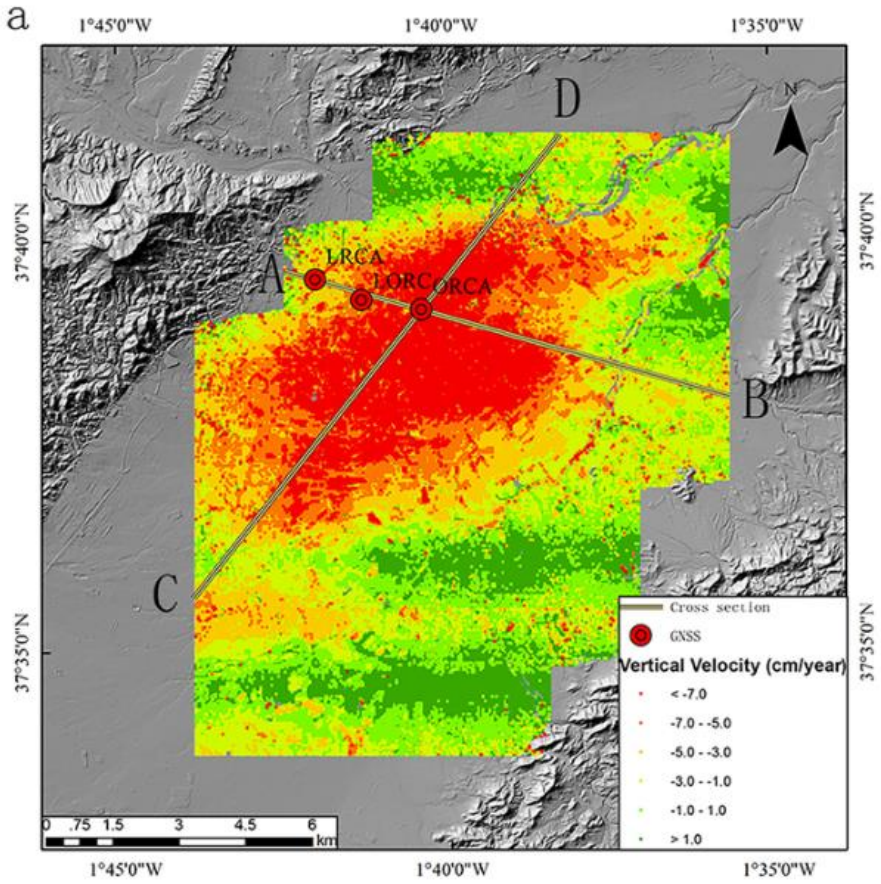


$$\alpha = \arctan\left(\frac{v}{v_0}\right)$$

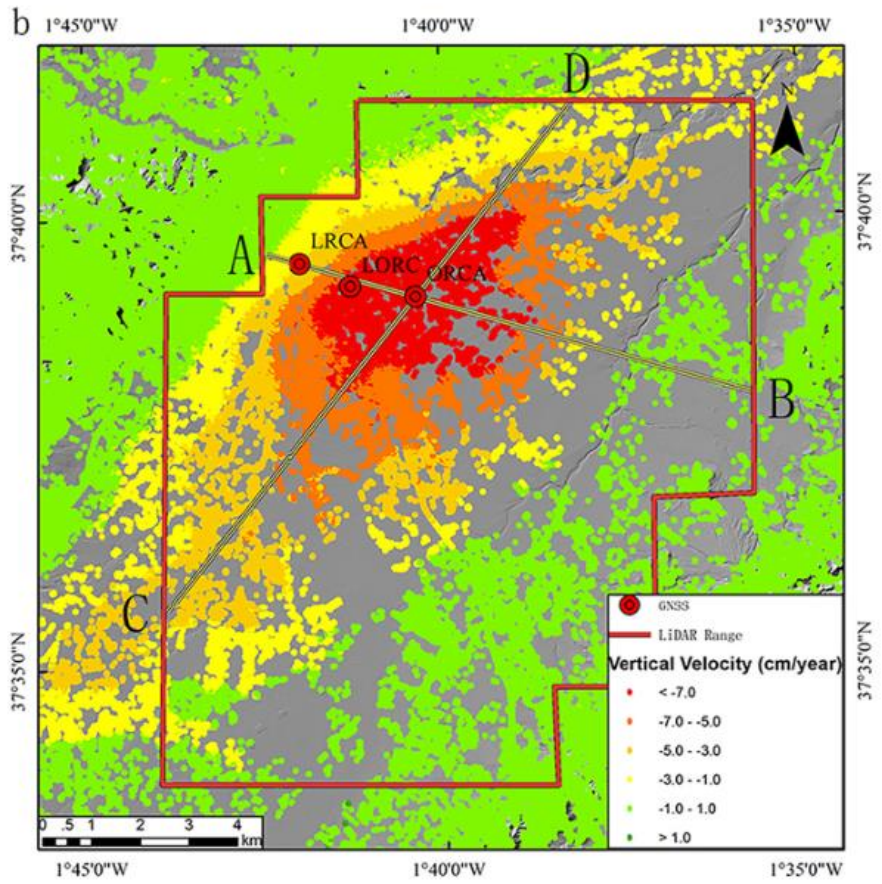
$$S = A + B\log(t) + Ct$$

Results: Other results

LiDAR

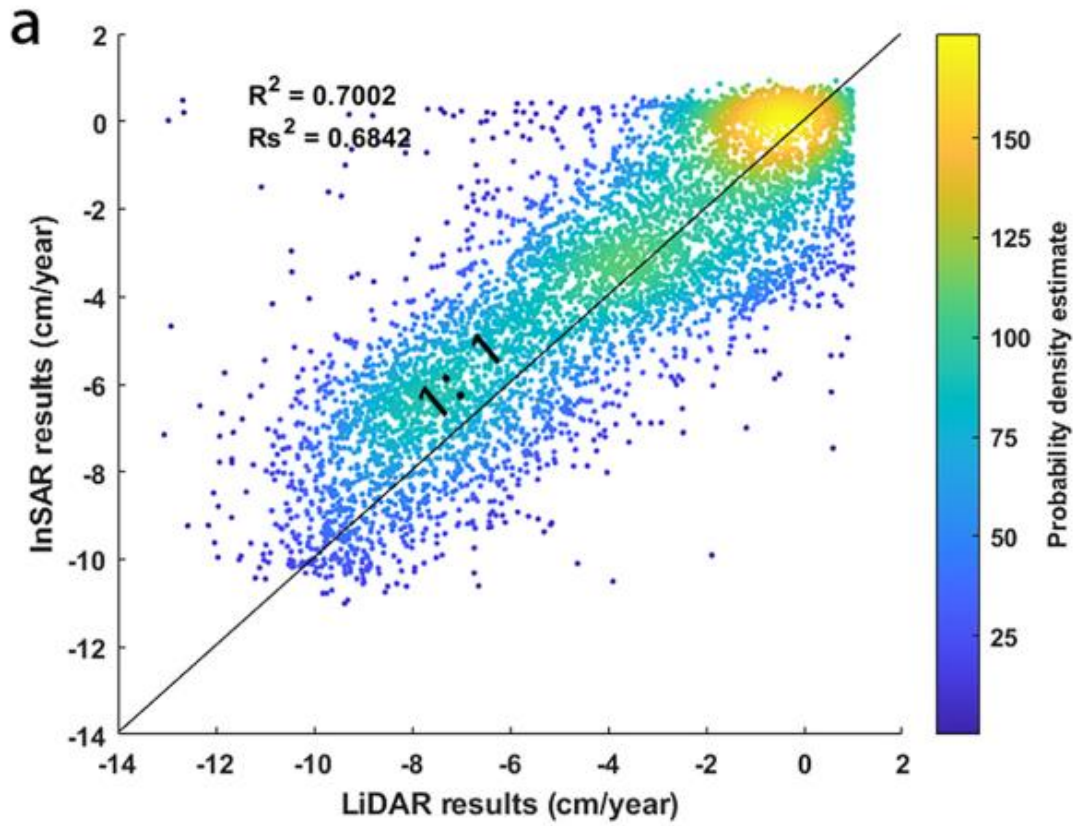


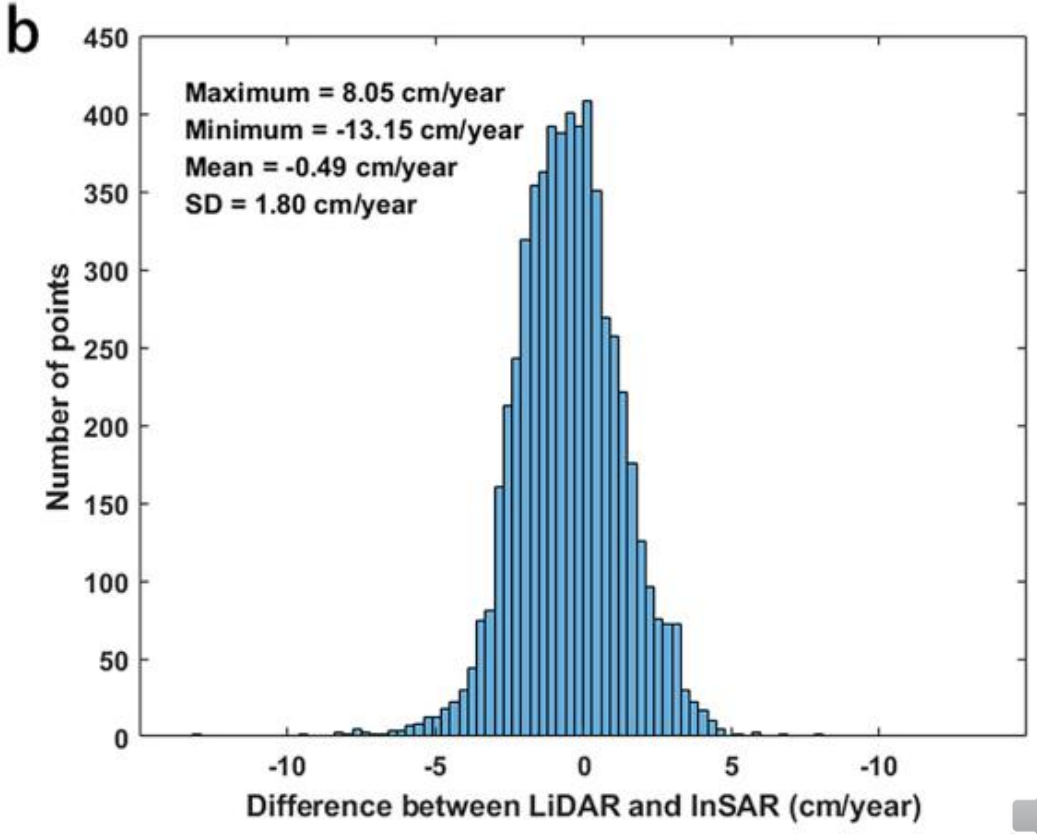
InSAR



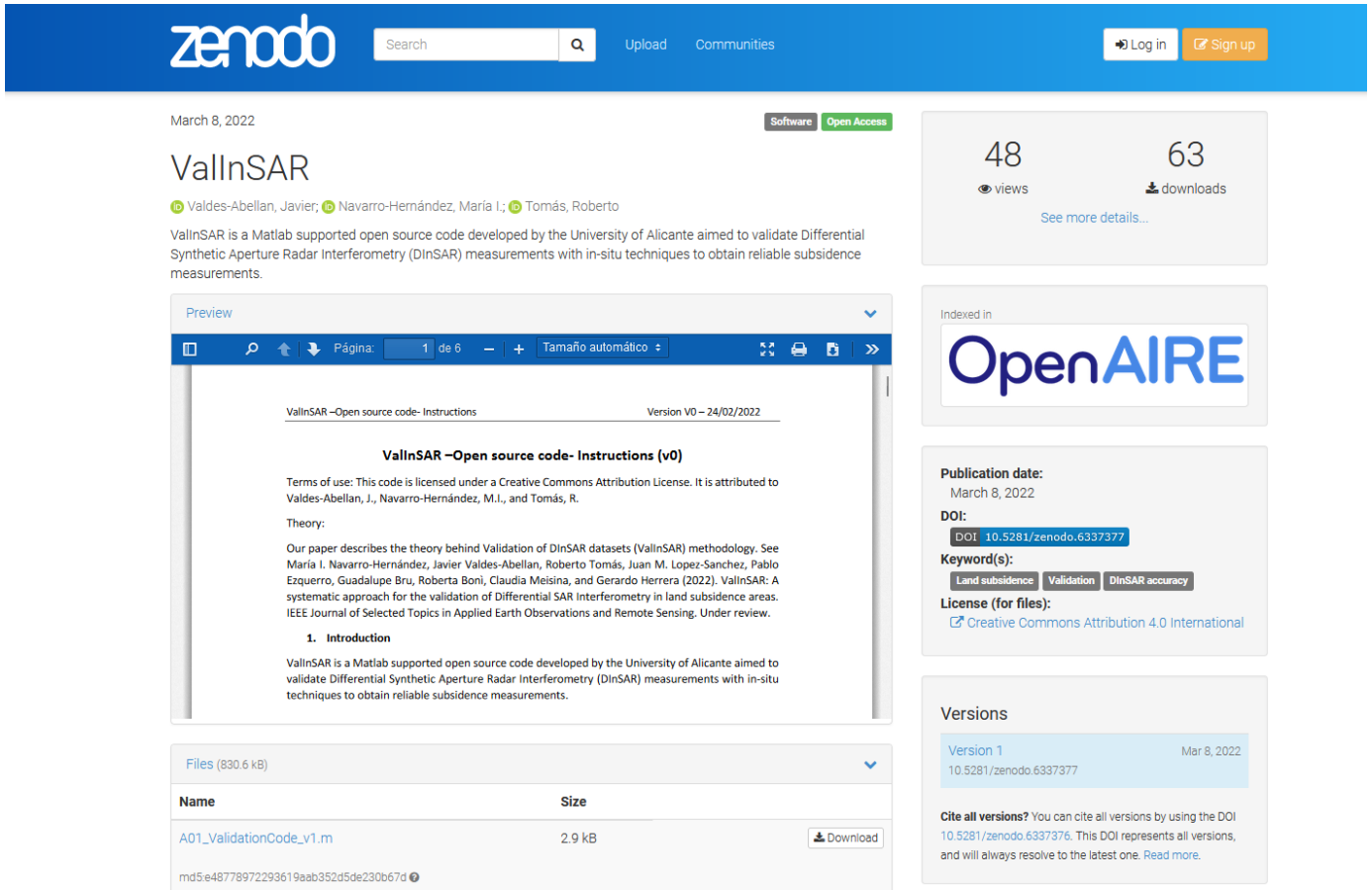
Results: Other results

Intercomparison





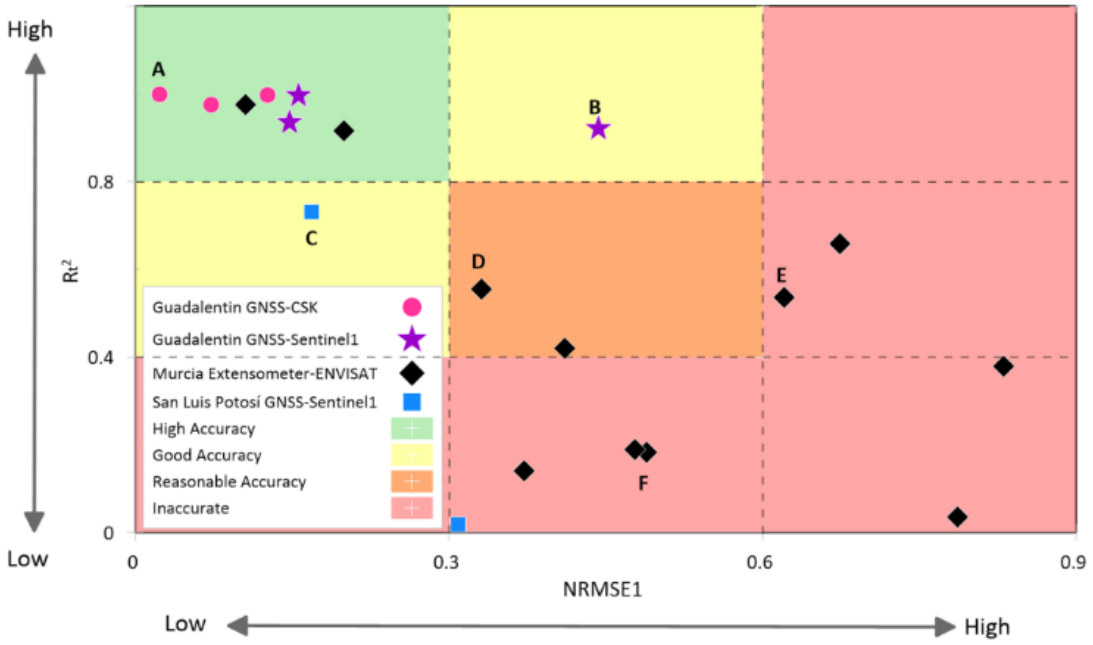
Results: Other results



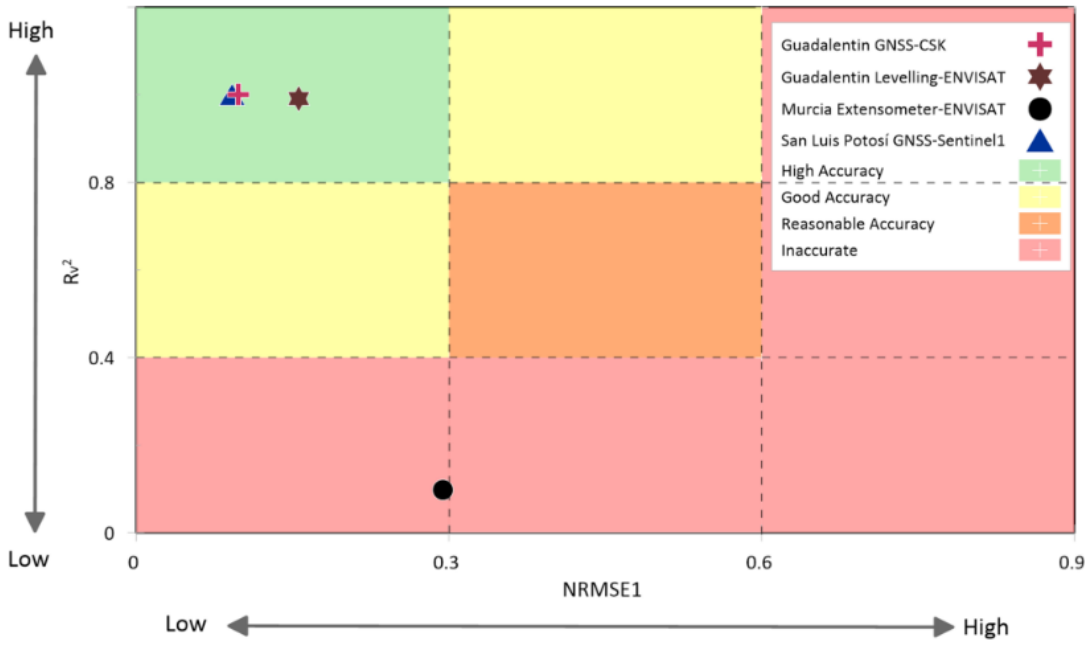
Available on line: https://zenodo.org/record/6337377#.YzcCvkxBxD9

Results: Other results

Accuracy thresholds proposed for DInSAR validation using displacement **time series**



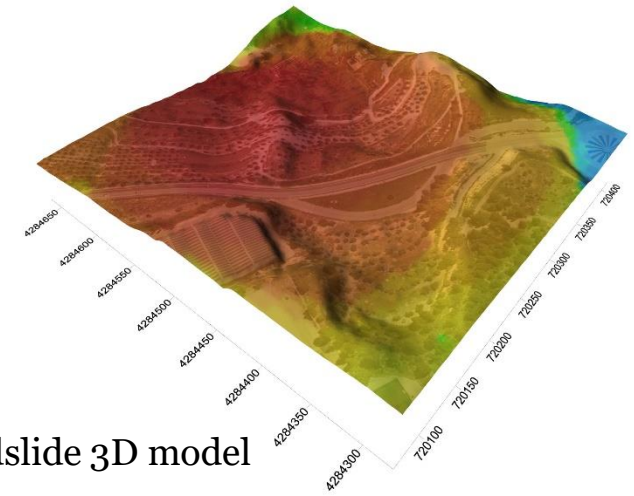
Accuracy thresholds proposed for DInSAR validation using **velocity values**.



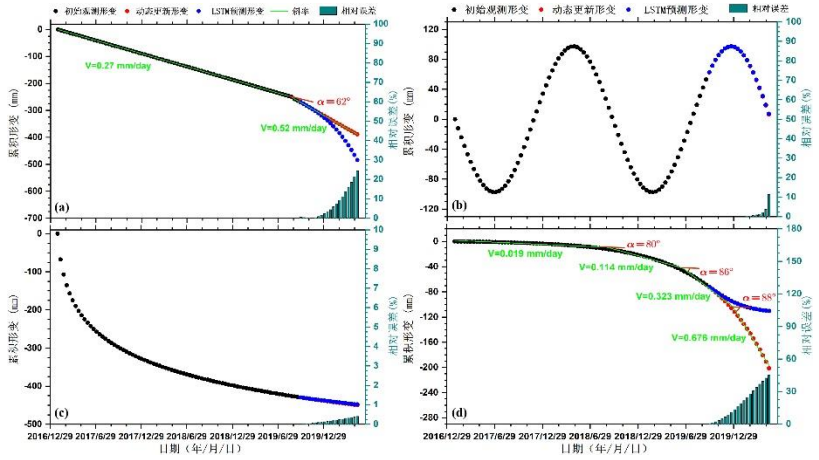
Project's schedule, planning & contribution of the partners for the following year

We are working on…

- Advance landslide models development and validation.
- Development of an automatic landslide detection method based on deep learning.
- Landslide time series prediction method based on deep learning.
- Validation of the developed methods.



Landslide 3D model



InSAR time series prediction using deep learning

Report on the level and training of young scientists on the project achievements, including plans for academic exchanges

YOUNG SCIENTIST	TRAINING ACTIVITY	HOST/ORGANIZING INSTITUTION	TIME PERIOD
M.I. Navarro-Hernández (PhD student UA)	• Researcher contract • Exchange - Erasmus+ trainership • 11 Courses/seminars • 3 journal paper • 9 conference contributions	University of Alicante University of Pavia, Italy UA, FECYT, UNESCO, RUS, Willey IEEE JSTARS, Land, RS IUACA, Living planet, EGU, E3S Web of Conferences, CIGEO, IAH	25/01/2021- 16/04/2022 - 20/07/2022
L. Hu (PhD student UA)	• Exchange – CSC scholarship • 10 Courses/seminars • 1 journal paper • 3 conference contributions	University of Alicante ICTP, ESA, ICEYE, COMET, UA, IEEE, RUS, WILEY RSE Living planet, ICTP and Dragon 5 workshop.	16/09/2021-17/09/2022
X. Liu (PhD student Chang'an university and UA - cotutelle)	• Exchange – CSC scholarship • 3 Courses/seminars • 4 journal paper • 1 conference contribution	University of Alicante Chang'an University and UA ENGEO, GRL, RE and RSE Dragon 5 workshop	13/03/2021 – 03/09/2022
J. Luo (PhD student UA)	• Researcher contract • 8 Courses/seminars • 1 journal paper • 1 conference contribution	University of Alicante ESA, UA and CUMT IEEE JSTARS Dragon 5 workshop	-

Report on the level and training of young scientists on the project achievements, including plans for academic exchanges

YOUNG SCIENTIST	TRAINING ACTIVITY	HOST/ORGANIZING INSTITUTION	TIME PERIOD
W.T. Szeibert (MSc student- currently employed in an InSAR company)	• 1 conference contribution • 1 MSc thesis	Simposio Nacional Taludes Universidad de Alicante	-
S. García-Pozo (MSc student- currently employed in a geotechnics company)	• 1 MSc thesis	-	-
H. Chen (PhD student Chang'an university and UA - cotutelle)	Exchange – CSC scholarship	University of Alicante	Planned in 2022-23
D. Orlandi (PhD student University of Pisa)	Exchange	University of Alicante	Planned in 2022-23

Academic publications (journals)

- Luo, J., Lopez-Sanchez, J.M., De Zan, F., Mallorqui, J.J., Tomás, R. (2022). Assessment of the Contribution of Polarimetric Persistent Scatterer Interferometry on Sentinel-1 Data. IEEE Journal of Selected Topics in Applied Earth Observations and Remote Sensing, On line.
- Hu, L., Navarro-Hernández, M.I., Liu, X., Tomás, R., Tang, X., Bru, G., Ezquerro, P., Zhang, Q. (2022). Analysis of regional large-gradient land subsidence in the Alto Guadalentín Basin (Spain) using open-access aerial LiDAR datasets. Remote Sensing of Environment, 280.
- Navarro-Hernandez, M.I., Valdes-Abellan, J., Tomás, R., Lopez-Sanchez, J.M., Ezquerro, P., Bru, G., Boni, R., Meisina, C., Herrera, G. (2022). ValInSAR: A systematic approach for the validation of Differential SAR Interferometry in land subsidence areas. IEEE Journal of Selected Topics in Applied Earth Observations and Remote Sensing, 15, 3650 – 3671.
- Yin, Y., Liu, X., Zhao, C., Tomás R., Zhang, Q., Lu, Z., Li, B. (2022). Multi-dimensional and Long-term Time Series Monitoring and Early Warning of Landslide Hazard with Improved Cross-platform SAR Offset Tracking Method. SCIENCE CHINA Technological Sciences, 65, 1891–1912.

Academic publications (journals)

- Luo, S.-l., Huang, D., Peng, J.-b., Tomás, R. (2022). Influence of permeability on the stability of dual-structure landslide with different deposit-bedding interface morphology: The case of the three Gorges Reservoir area, China. Engineering Geology, 296, 106480.
- Liu, X., Zhao, C., Zhang, Q., Yin, Y., Lu, Z., Samsonov, S., Yang, C., Wang, M., Tomás, R. (2021). Three-dimensional and long-term landslide displacement estimation by fusing C- and L-band SAR observations: A case study in Gongjue County, Tibet, China. Remote Sensing of Environment, 267, 112745.
- Liang, R.; Dai, K.; Shi, X.; Guo, B.; Dong, X.; Liang, F.; Tomás, R.; Wen, N.; Fan, X. (2021). Automated Mapping of Ms 7.0 Jiuzhaigou Earthquake (China) Post-Disaster Landslides Based on High-Resolution UAV Imagery. Remote Sens., 13, 1330.

Academic publications (conferences)

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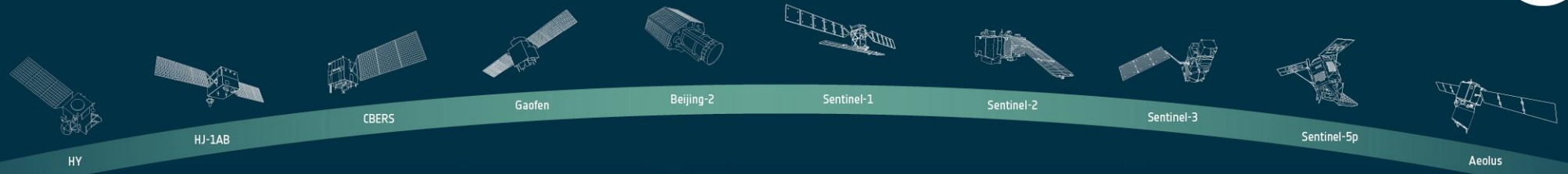
Chinese Young scientists contributions in Dragon 5

Name	Institution	Poster title	Contribution
Xiaojie Liu	University of Alicante & Chang'an University	Toward Early Warning of Landslides: the Methods for Robustly Estimating Two- and Three-dimensional Long-term Landslide Deformation Using Cross-platform SAR Offset Observations	InSAR data processing, programming of 3D calculation routines and analysis of results. This contribution is part of his PhD thesis.
Jianyin Luo	University of Alicante	Analysis of the Contribution of Polarimetric Persistent Scatterer Interferometry on Sentinel-1 Data for Deformation measurement	PolInSAR data processing and analysis of results. This contribution is part of her PhD thesis.
Liuru Hu	University of Alicante, Land Satellite Remote Sensing Application Center, & The First Topographic Surveying Brigade of Ministry of Natural Resources of the People's Republic of China	Updating Active Landslide Inventory Maps in Mining Areas by Integrating InSAR with LiDAR Datasets	InSAR and LiDAR data processing, implementation of slope stability model and analysis of results. This contribution is part of her PhD thesis.



2022 DRAGON 5 SYMPOSIUM

MID-TERM RESULTS REPORTING

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THANK YOU FOR YOUR ATTENTION!

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