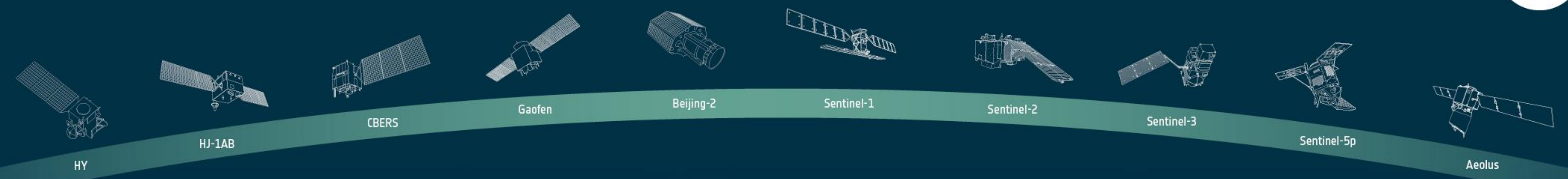


2022 DRAGON 5 SYMPOSIUM

MID-TERM RESULTS REPORTING

17-21 OCTOBER 2022

[PROJECT ID. 56796]

THURSDAY, 20 OCTOBER 2022

ID. 56796

INTEGRATION OF MULTI-SOURCE REMOTE SENSING DATA TO DETECT AND MONITORING LARGE AND RAPID LANDSLIDES AND USE OF ARTIFICIAL INTELLIGENCE FOR CULTURAL HERITAGE PRESERVATION

2ND YEAR REPORTING

EUROPEAN LI: **JOAQUIM J. SOUSA**

CHINESE LI: **JINGHUI FAN**

CO-AUTHORS: SHIBIAO BAI, YOUFENG LIU, HONGLEI YANG, JIAHUI LIN, GUANG LIU, QUN WANG, STEFAN STEGER

EO Data Delivery

Data access (list all missions and issues if any). NB. in the tables please insert cumulative figures (since July 2020) for no. of scenes of high bit rate data (e.g. S1 100 scenes). If data delivery is low bit rate by ftp, insert “ftp”

ESA Third Party Missions	No. Scenes
1. RADARSAT-2 ftp	4
2. PAZ	25
3.	
4.	
5.	
6.	
Total:	29
Issues:	

ESA Third Party Missions	No. Scenes
1. Sentinel-1	1755
2. ERS-1/2	164
3. Envisat	90
4.	
5.	
6.	
Total:	2009
Issues:	

Chinese EO data	No. Scenes
1. ZY-3	8
2.	
3.	
4.	
5.	
6.	
Total:	8
Issues:	

Team Composition:

J. Sousa (EU LI)

L. Reis

Fan Jinghui: (CH LI)

Z. Perski (PI)

S. Steger (PI)

Bai Shibiao (PI)

MTI Techniques for deformation

Extreme weather events

Vegetation monitoring

Artificial Inteligence

Gravitational mass movement

Ground measurements

Natural Hazards

Segmentation of SAR and optical data

Modeling

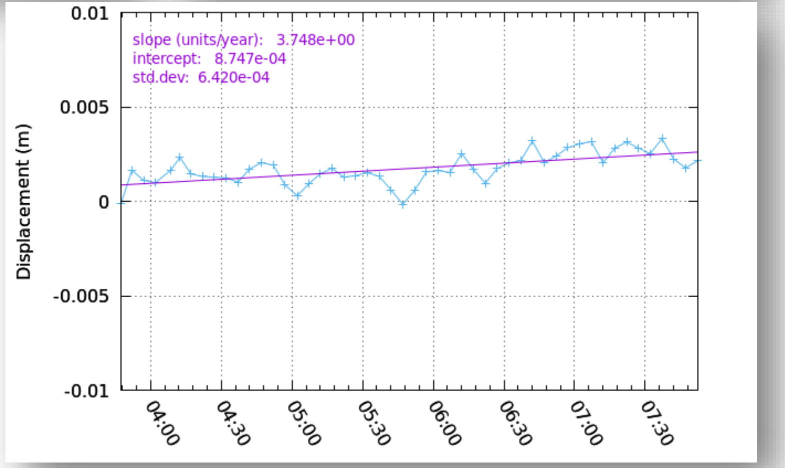
GIS and RS

Case Study 1

On August 16, 2021, a Ground-based SAR (the GPRI-II), was tested in monitoring the deformation of Huangyukou landslide, in the Yanqing district, Beijing, China. We expect that in the future, EO results of ground deformation could be validated by this GBSAR and GNSS measurements.

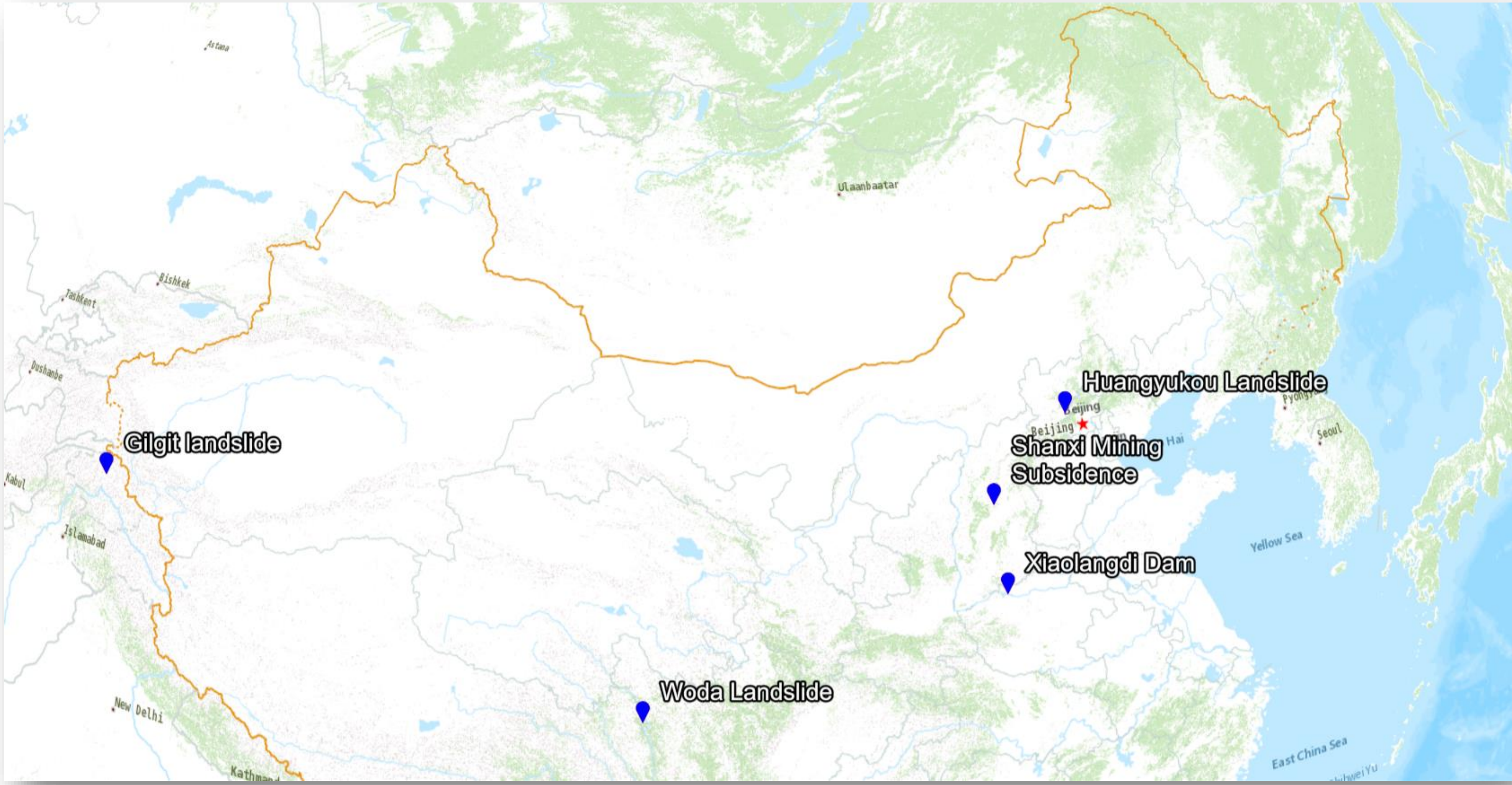
Test of GPRI-II monitoring near Huangyukou Landslide in Yanqing District, Beijing

One possible deforming site in Huangyukou Landslide identified based on GRRI-II



Other Case Studies

1. InSAR methods are been applied in Woda landslide region;
2. PSI-based and Small BAseline Subsets methods are been used respectively in Gilgit area, Pakistan and Xiaolangdi Dam, China;
3. DL models and DInSAR are being combined to extract the spatial distribution of mining subsidence in Shanxi Province, China.



Research sites of China partners in the last 2 years

Case Study 2: Woda landslide

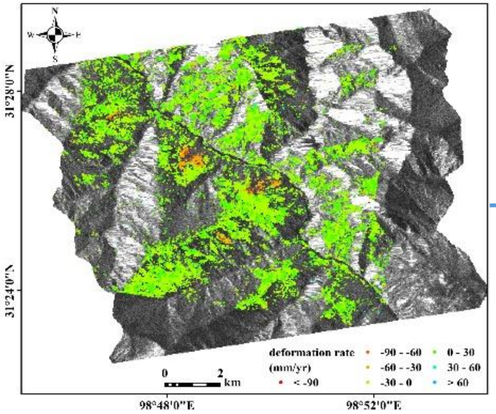
Objectives

1. Increase the density of monitoring points in low coherence areas
2. Map 2D surface deformation using ascending and descending geometries
3. Surface deformation analysis

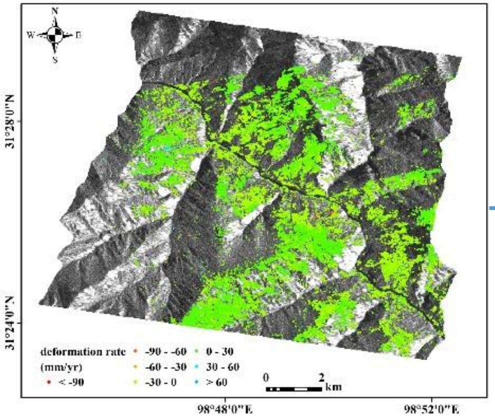
Research Approach

1. Combination of distributed scatterers (DS) and permanent scatterers (PS)
2. Calculation of two-dimensional deformation from 106 ascending SAR data and 102 descending SAR data
3. Stability analysis of the ground surface based on the rescaled range (R/S) method

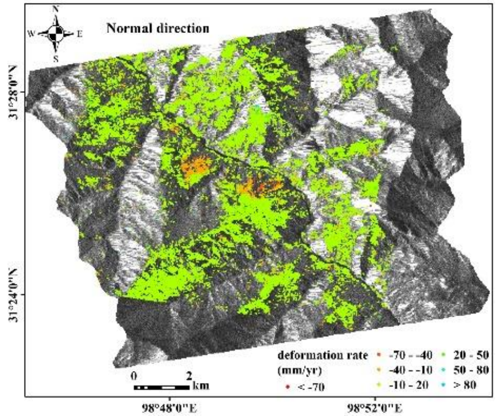
Case Study 2: Main Results

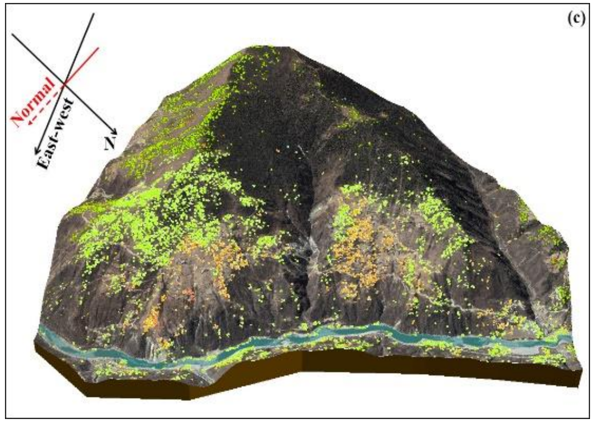


ascending

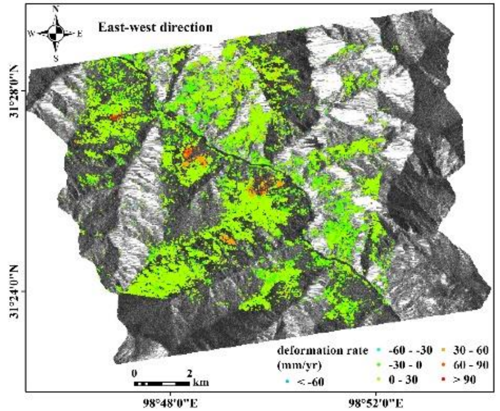


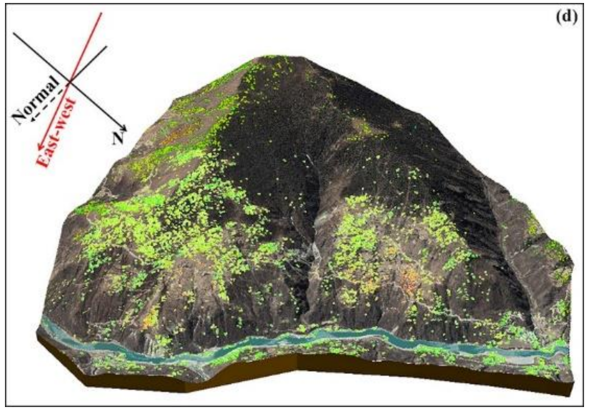
descending



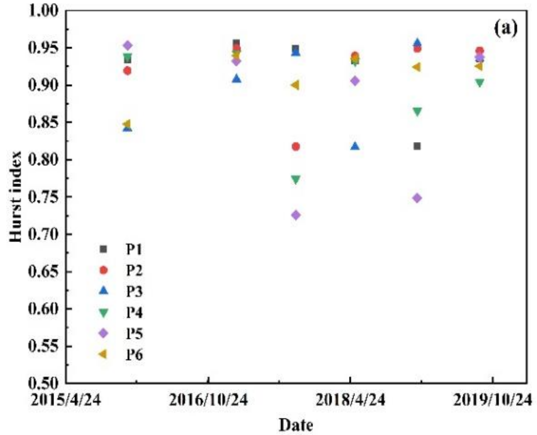


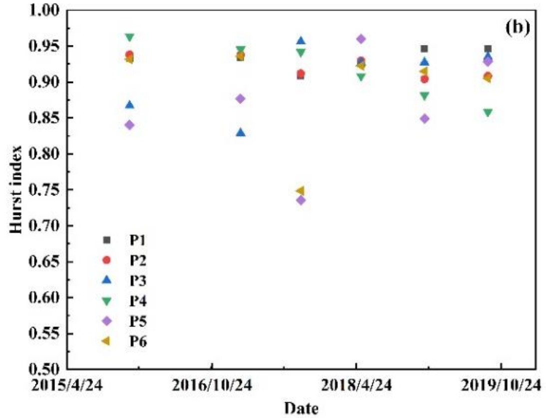
Maximum deformation:117.1mm/yr; percentage of deformation between ±10mm/yr:82.9%.





Maximum deformation:-80.3mm/yr; percentage of deformation between ±10mm/yr:85.4%.

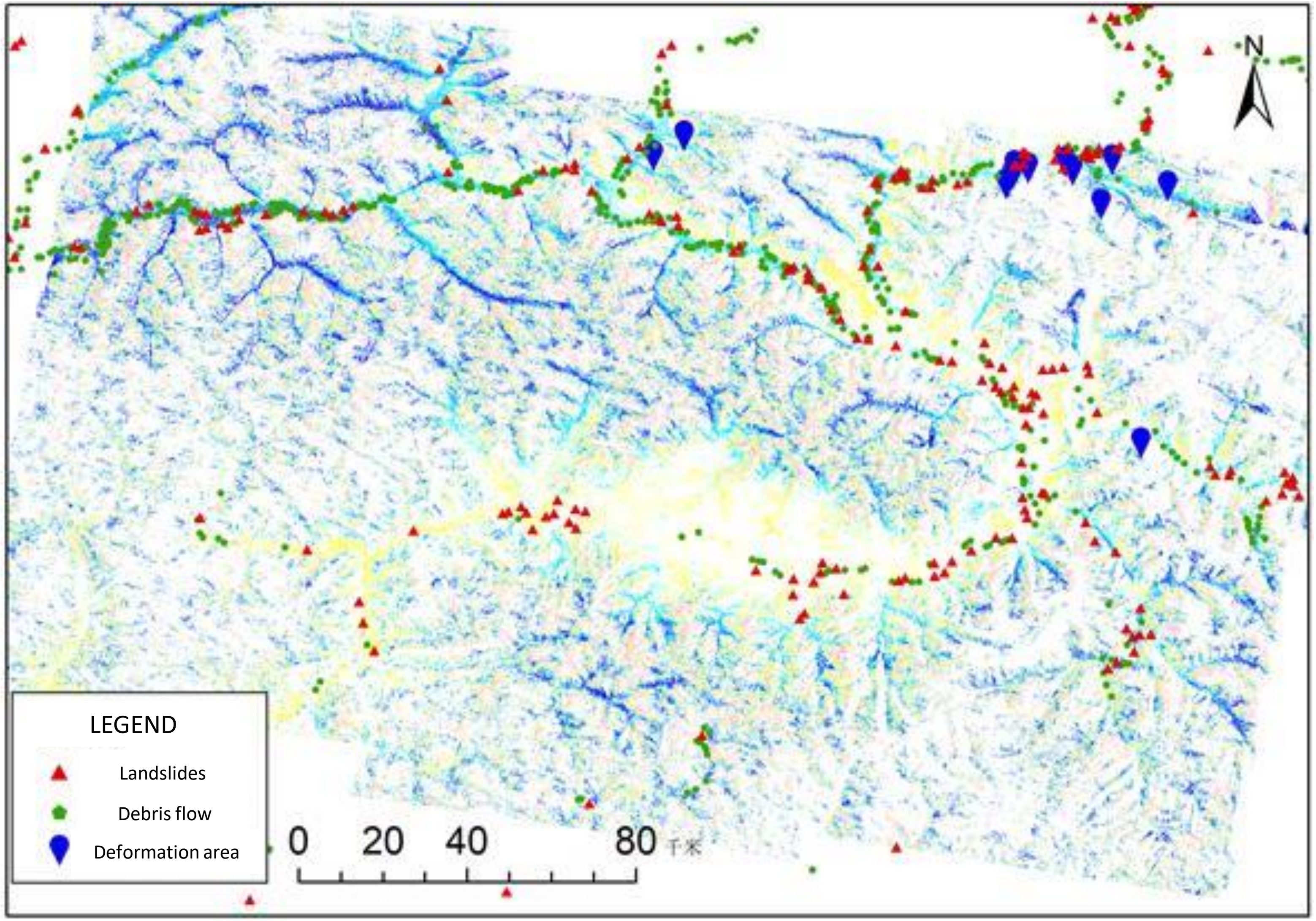




R/S analysis

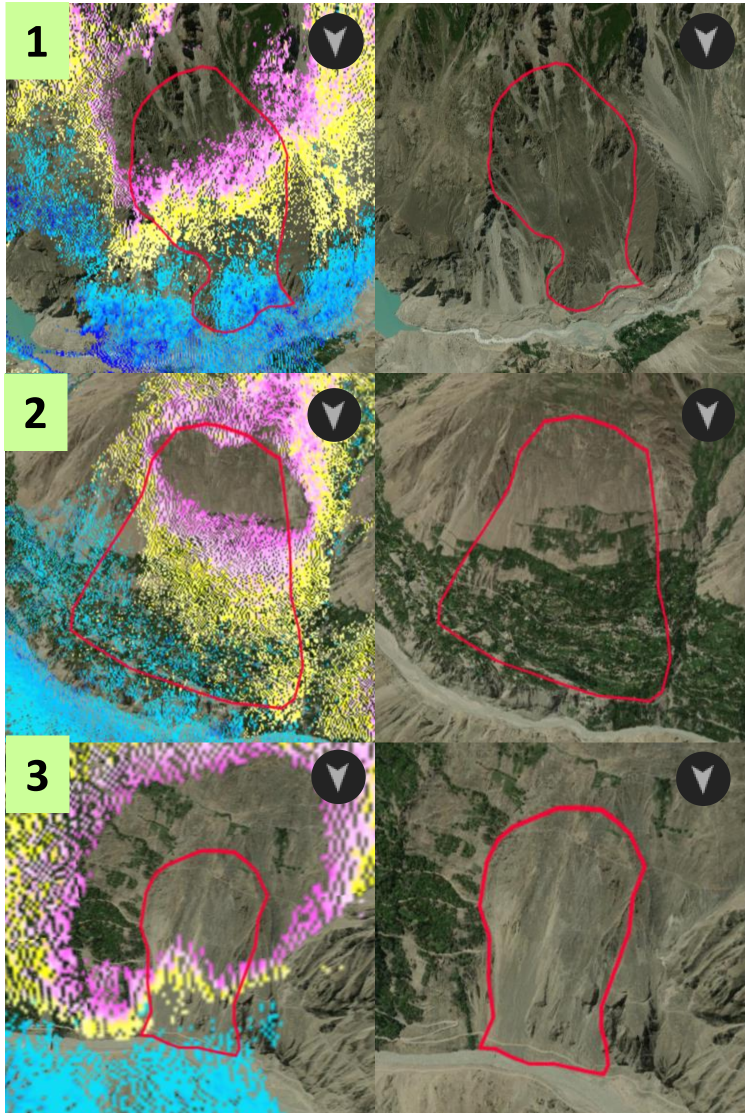
Case Study 3: Gilgit area

China Aero Geophysical Survey and Remote Sensing Center, Nanjing Normal University and The Aga Khan University (AKJU), Pakistan, have applied stacking-insar method in Gilgit region, Pakistan. Sentinel-1 images acquired between 2019 and 2020 are used.



Preliminary ground deformation monitoring result in in Gilgit, Pakistan

Case Study 3: Gilgit area

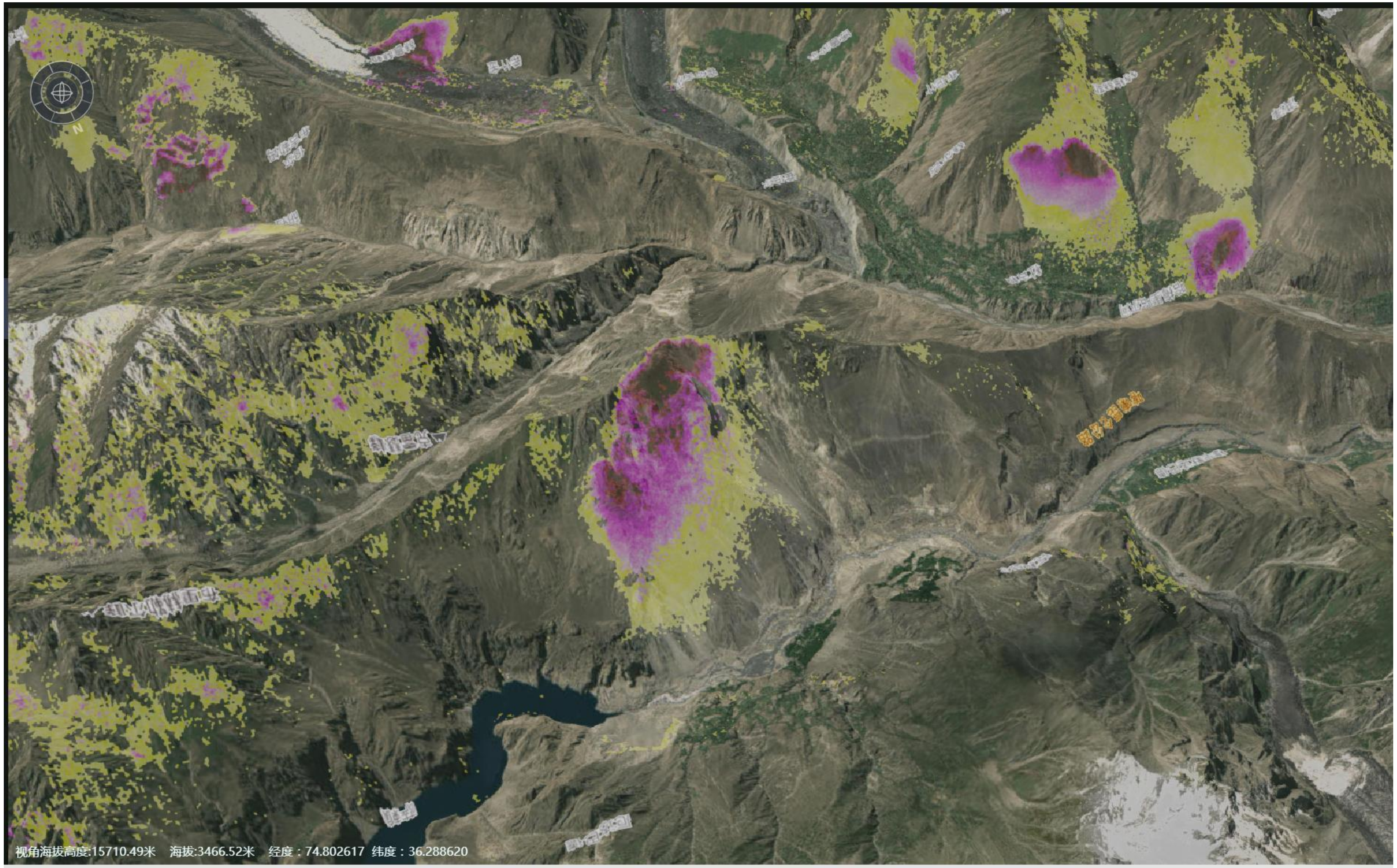


Information of the typical geohazard identified by EO monitoring

ID	Elevation	Administrative District	Main risks
1	3124m	Gilgit–Baltistan, Pakistan	Lake Weir
2	2750m	Punjab, Pakistan	Destruction of villages
3	2355m		Blocking the road

Case Study 3: Gilgit area

3D prototype developed by AGRS



Case Study 3: Gilgit area

3D prototype developed by AGRS

Case Study 4: Xiaolangdi Water Conservancy project

Application of InSAR Technique in Deformation Monitoring of Water Conservancy and Hydropower Engineering

We demonstrate the application of InSAR techniques in water conservancy hydropower projects.

Case Study 4: Xiaolangdi Water Conservancy project

Xiaolangdi Water Conservancy

Method and data

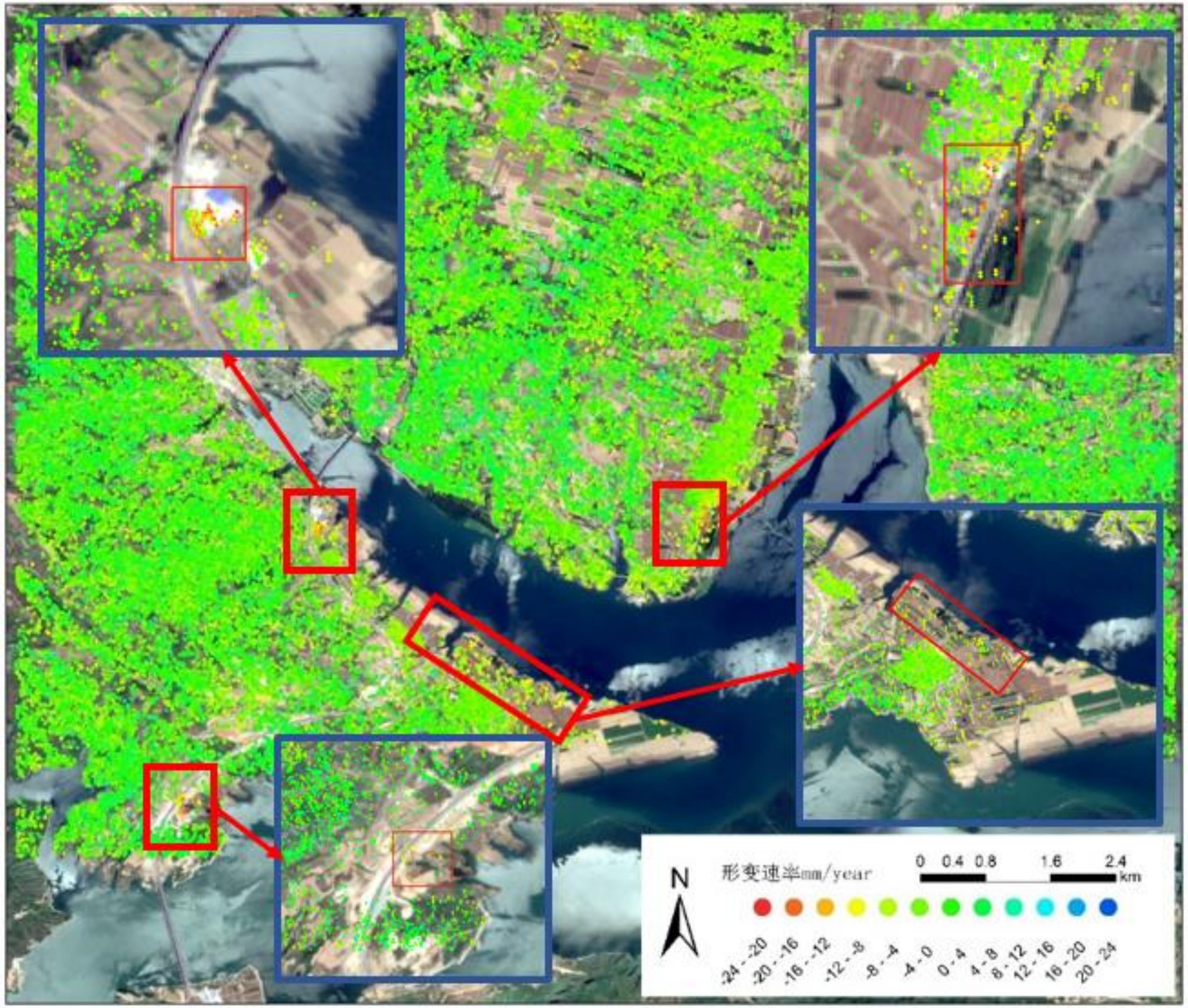
SBAS technique was applied to 22 Sentinel-1 images covering Xiaolangdi, from August 2020 to April 2021.

Case Study 4: Results and discussion

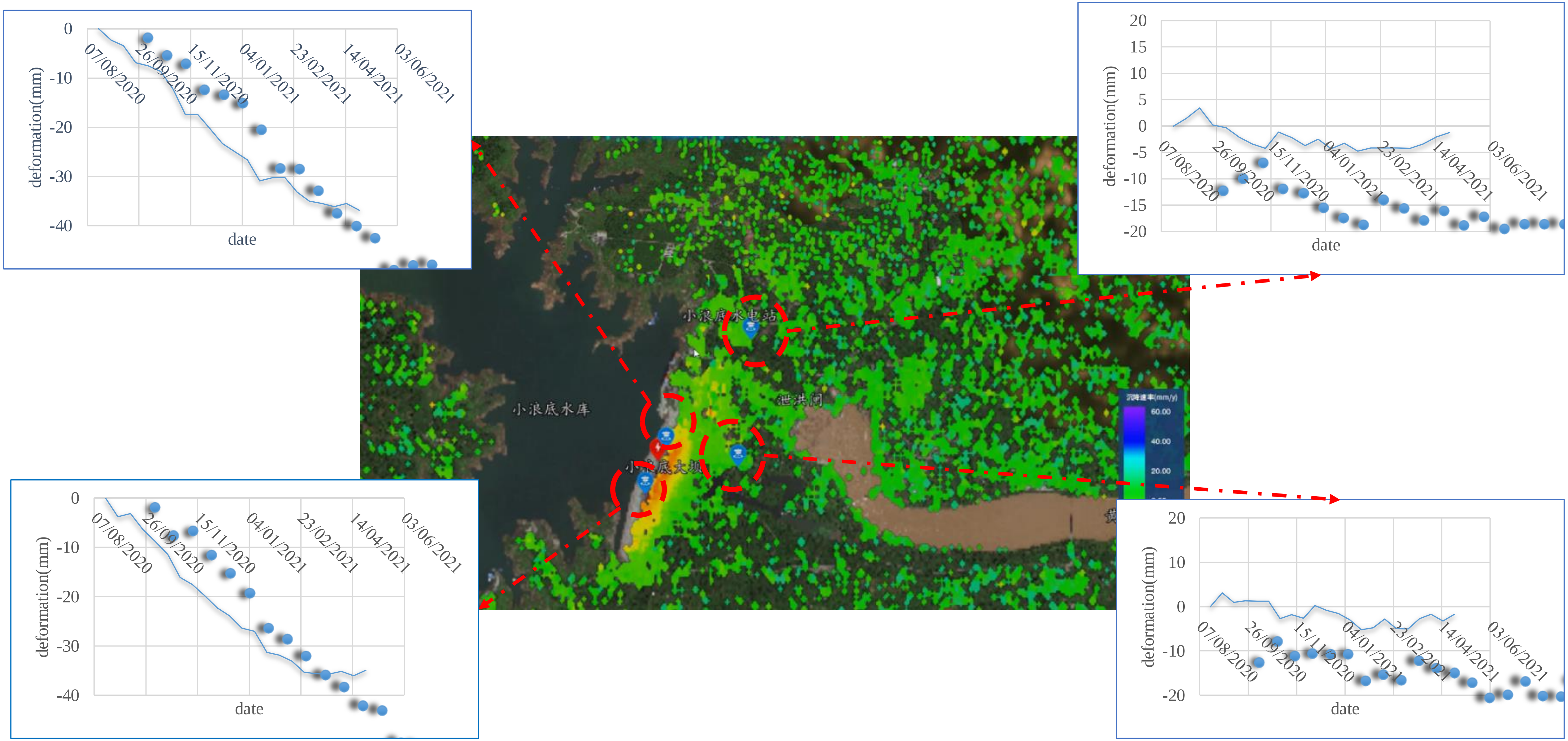
The slope of the reservoir is generally stable;

Strong deformation in a small part of the bank slope

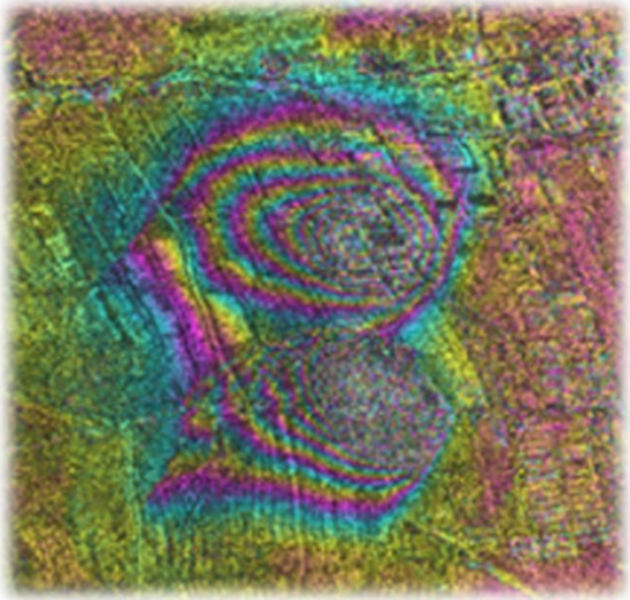
Four suspicious and unknown danger areas were found

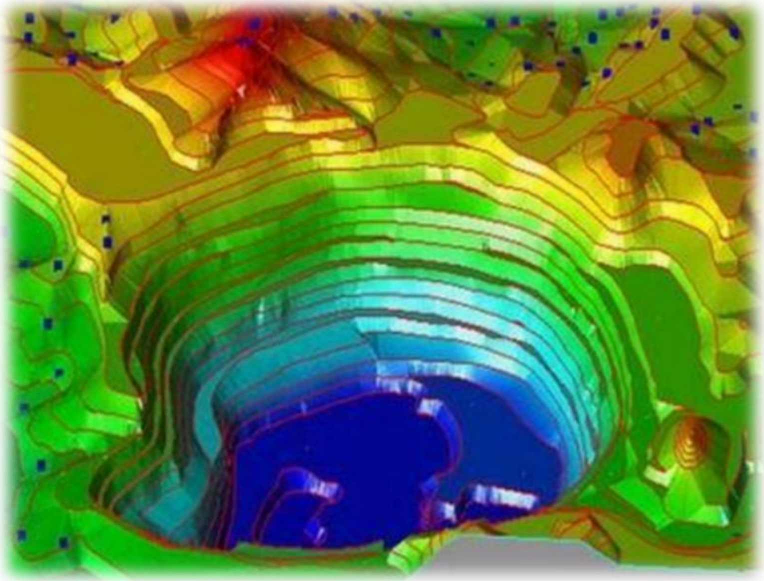


Case Study 4: Results and discussion



Mining sites monitoring





Case Study 5: Methodology

We use deep learning (DL) and InSAR technology to obtain the spatial distribution of mining subsidence;

Our DL approach includes FCN, PSPNet, Deeplabv3 and U-Net models.

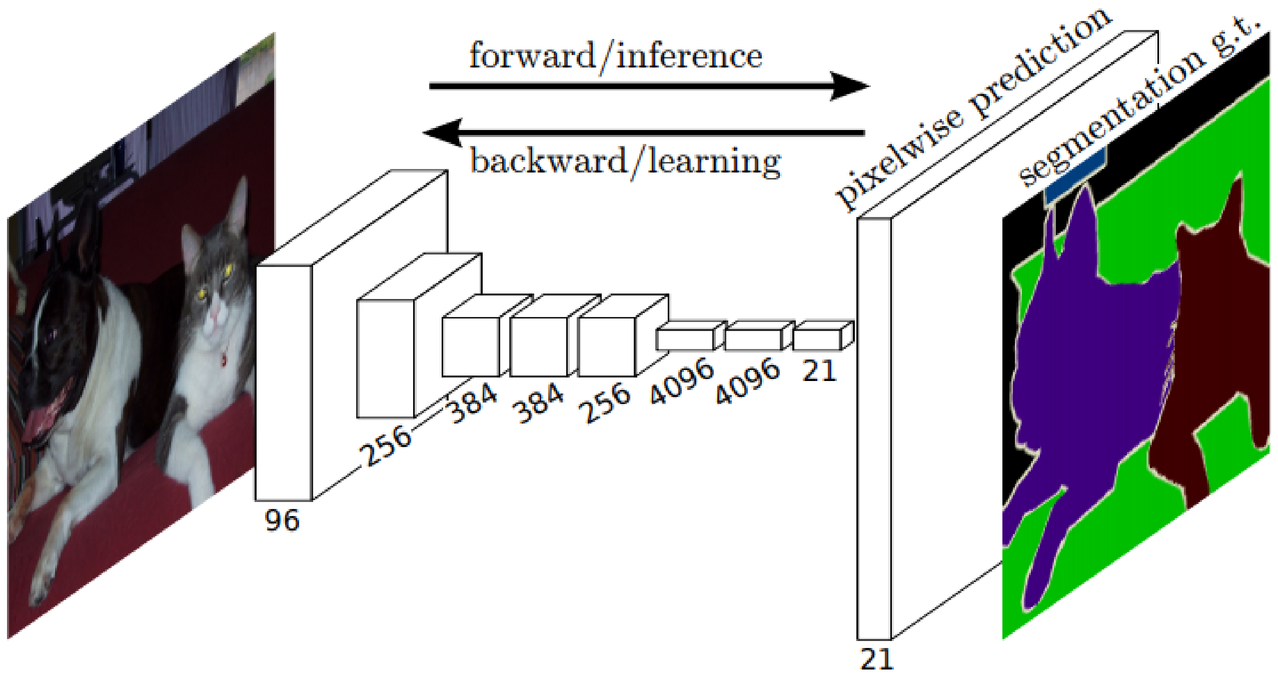
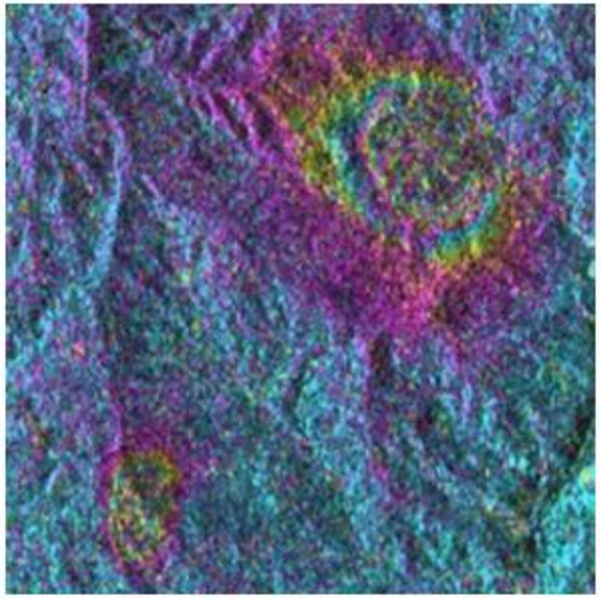


Figure 2 FCN model, according to [1]

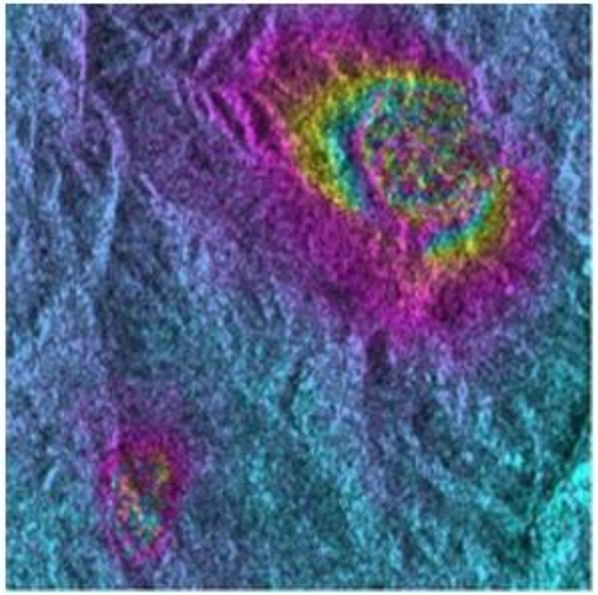
[1]Long, Jonathan, Shelhamer, et al. Fully Convolutional Networks for Semantic Segmentation[J]. IEEE Transactions on Pattern Analysis & Machine Intelligence, 2017.

Differential interferogram and conversion processing effect

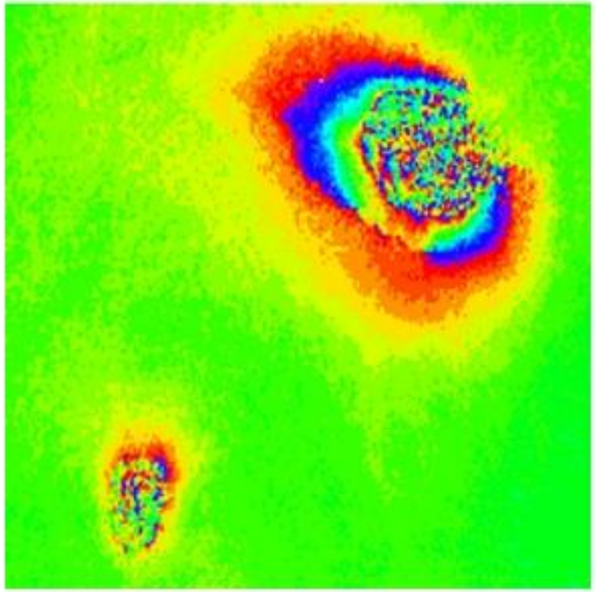
We should preprocess the data, including image coregistration, multi-looking, filtering and so on.



Differential interferogram



Filtered differential interferogram

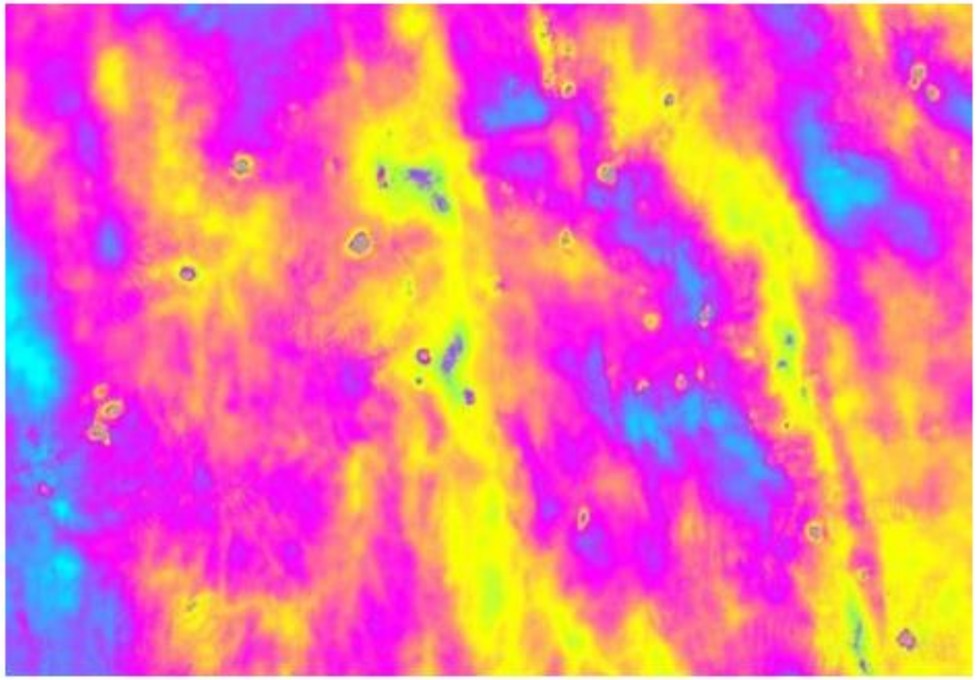


Phase diagram with value [- π, π]

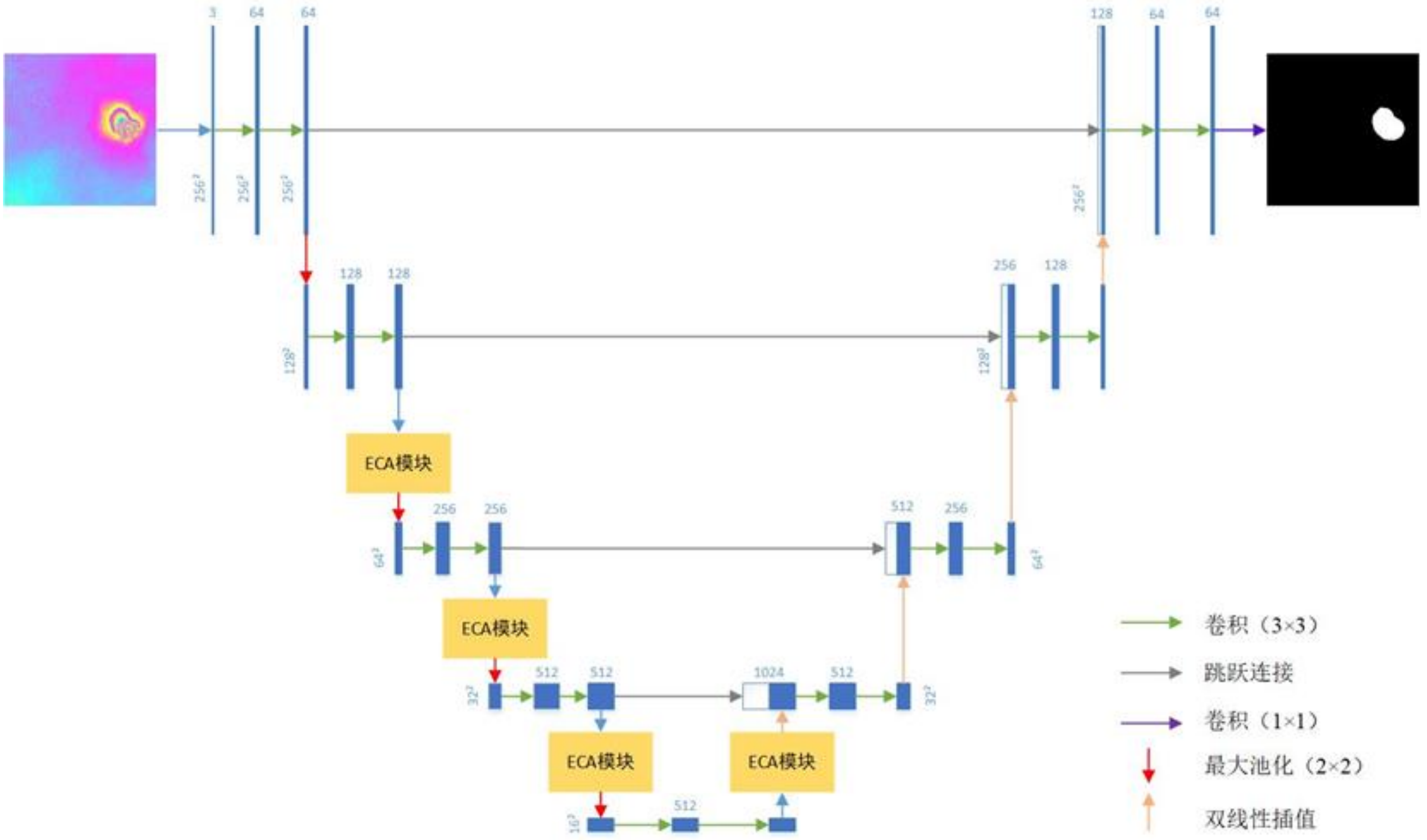
Case Study 5: Training

Semantic segmentation sample of mining subsidence

We use lableme software to mark the subsidence mining area and background area.



Case Study 5: Improved U-Net model



ECA-Unet model structure

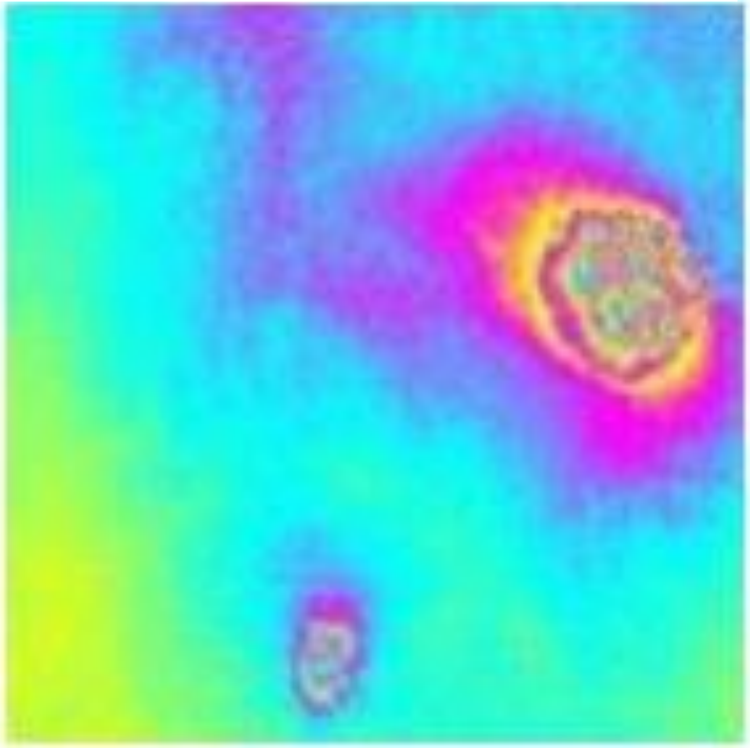
Case Study 5: Results

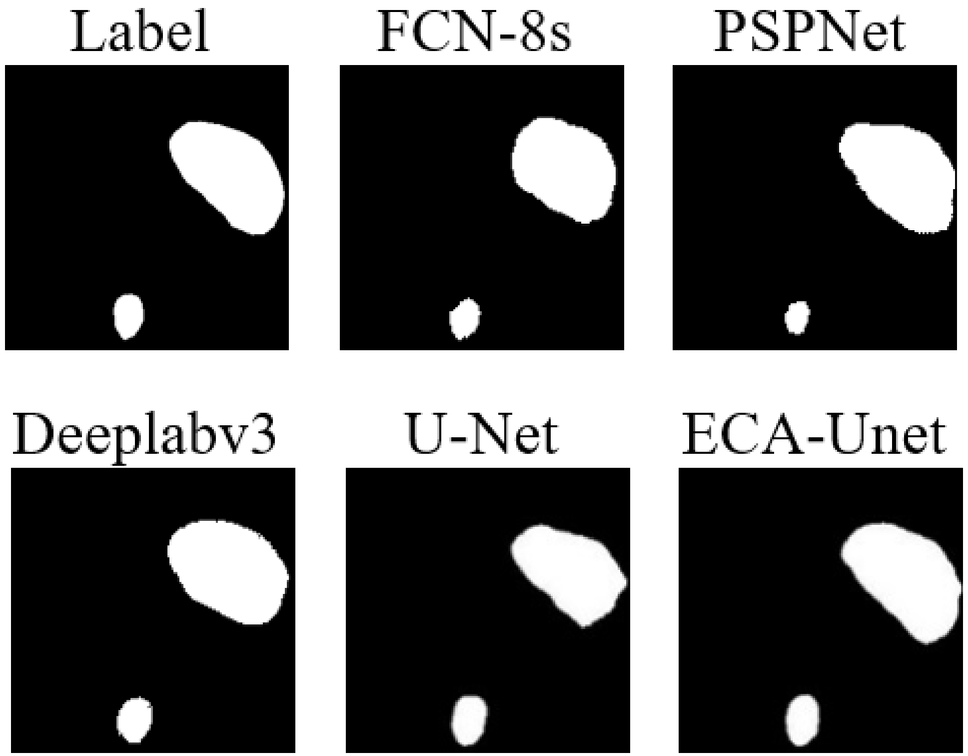
Accuracy evaluation of different models on test dataset

	PA	MIoU	IoU (background)	IoU (mining subsidence)	Training time/h
FCN32s	97.71%	73.68%	98.21%	49.15%	1.84
FCN16s	98.32%	78.35%	98.50%	58.20%	1.88
FCN8s	98.53%	79.32%	98.58%	60.05%	2.11
PSPNet	98.16%	79.21%	98.65%	59.77%	6.50
Deeplabv3	98.20%	79.71%	98.57%	60.85%	7.50
U-Net	98.31%	79.24%	98.27%	60.20%	5.08
ECA-UNet	98.55%	80.58%	98.41%	62.74%	6.36

Case Study 5: Results

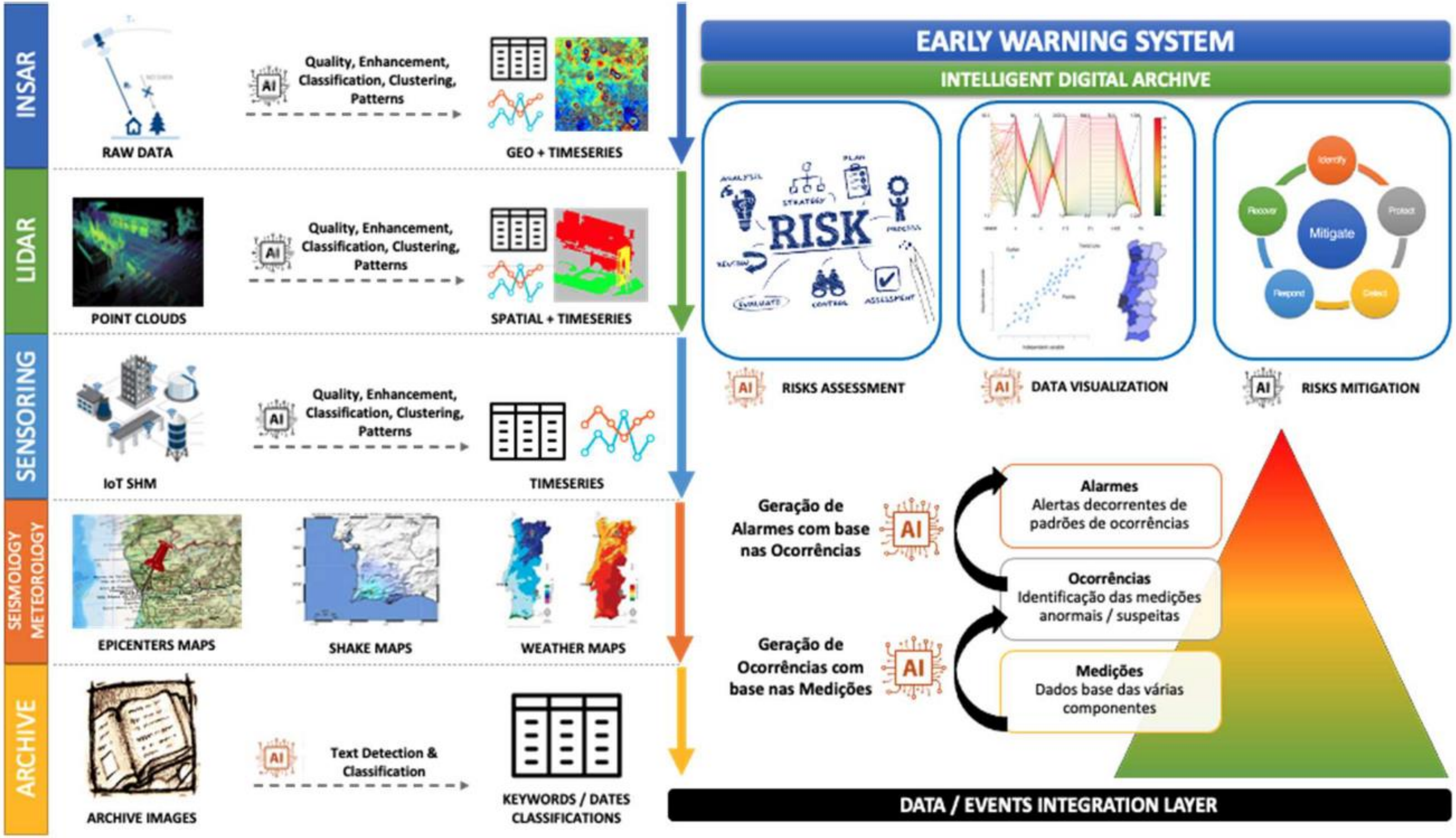
Interferogram



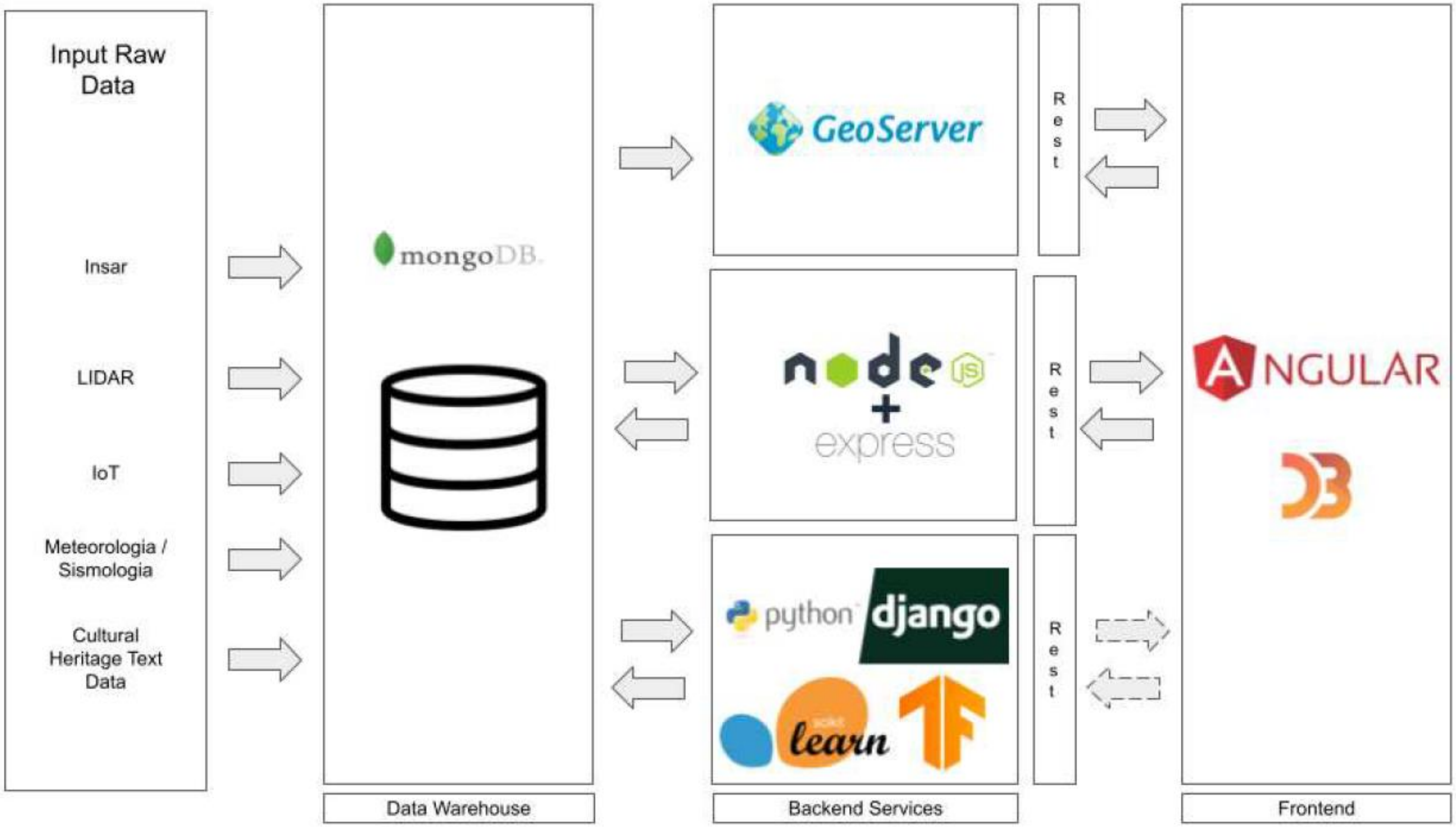


Results of different models

Case Study 6: Cultural Heritage preservation

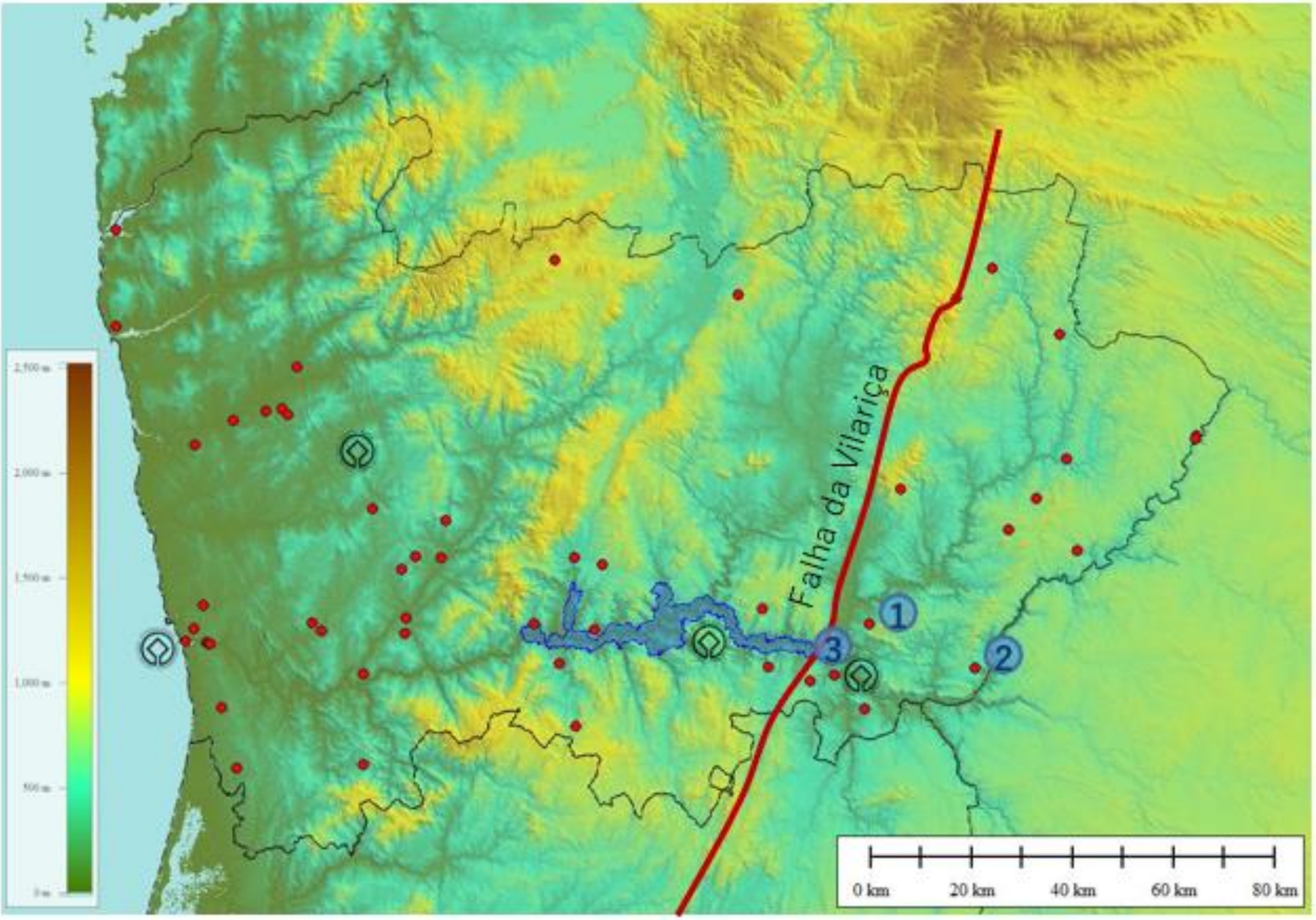


Case Study 6: Cultural Heritage preservation



Case Study 6: Cultural Heritage preservation

Study areas



1 Torre de Moncorvo

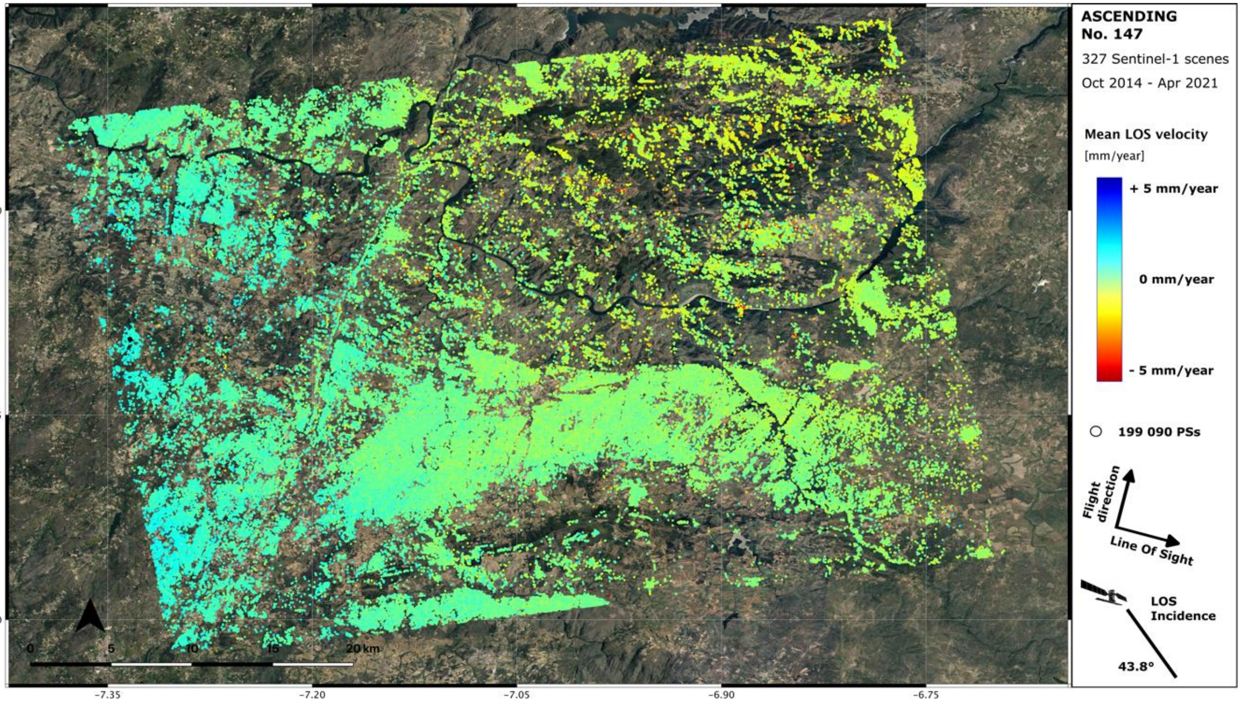
2 Freixo de Espada à Cinta

3 Foz Côa

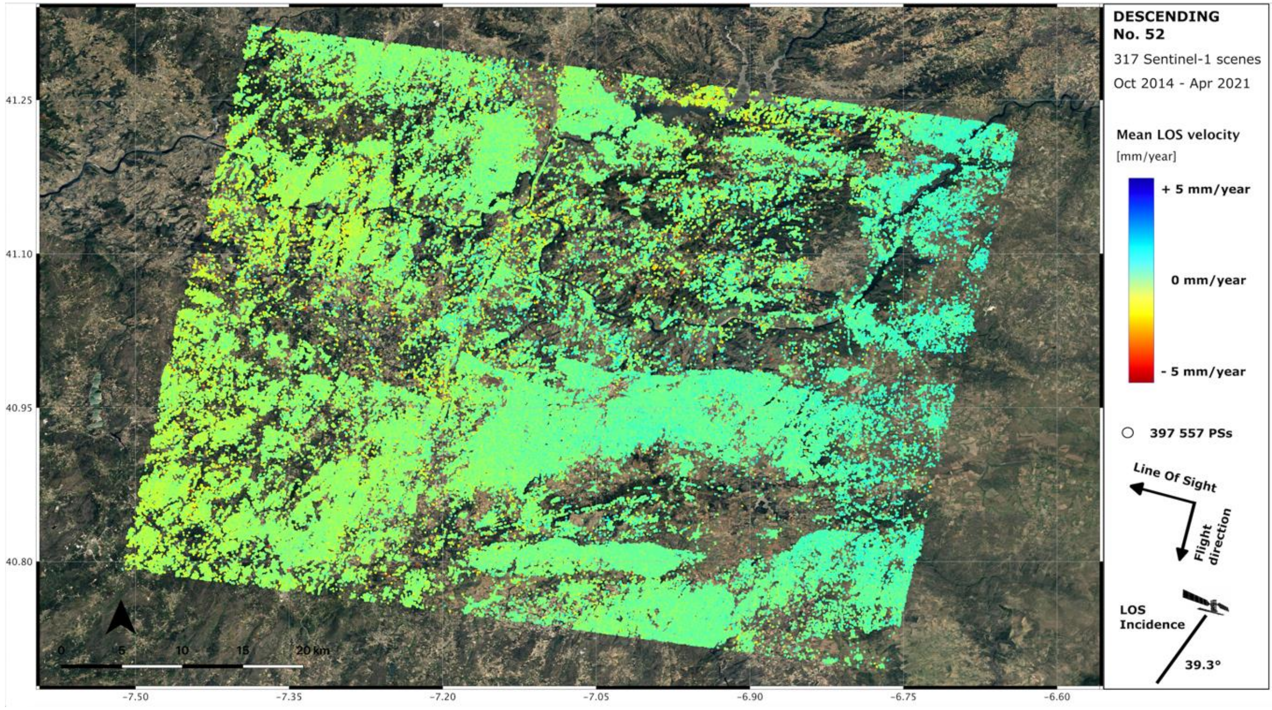
Location of properties classified under the scope of the DRCN. The three structures selected for the project are highlighted.

Case Study 6: Cultural Heritage preservation

Large Area Processing

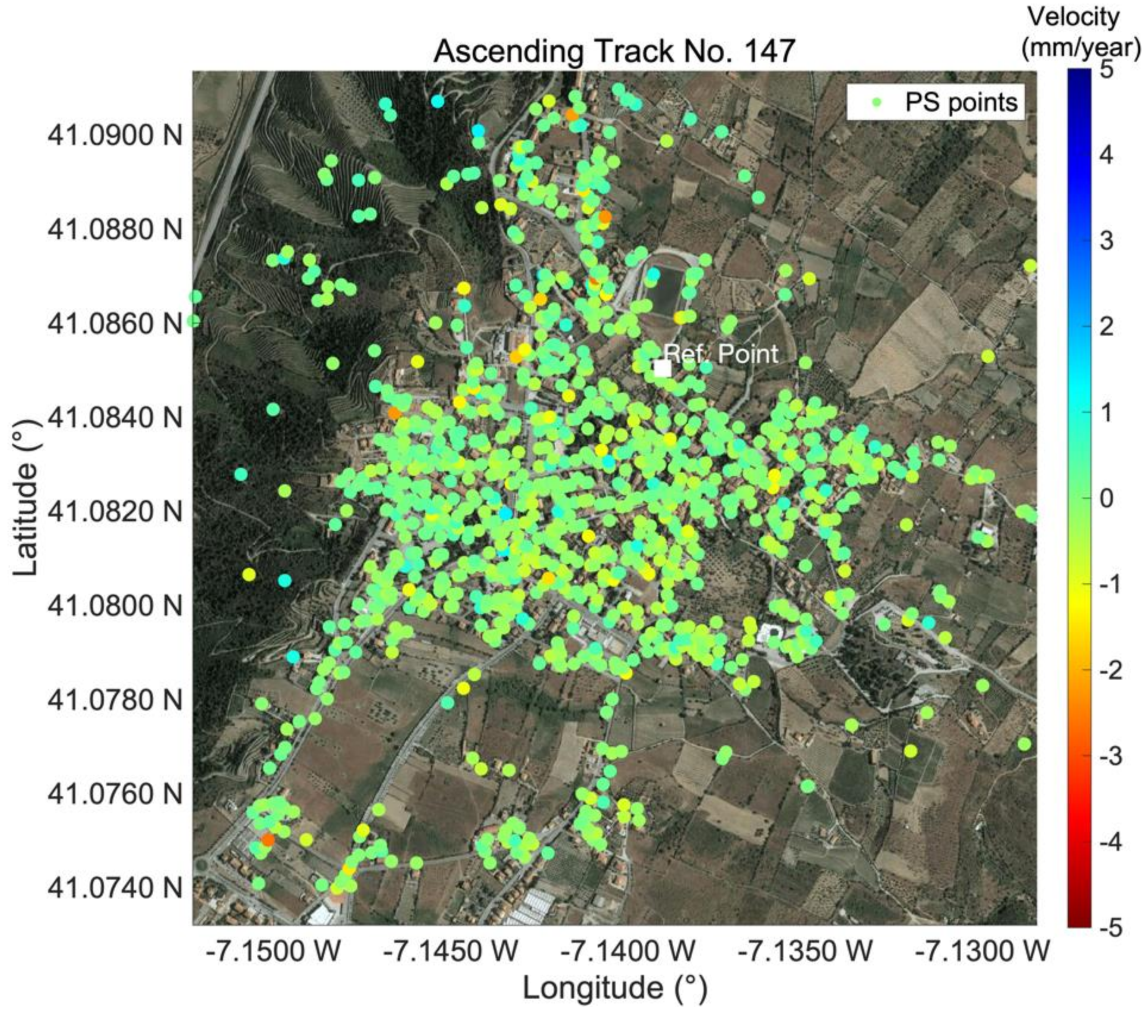


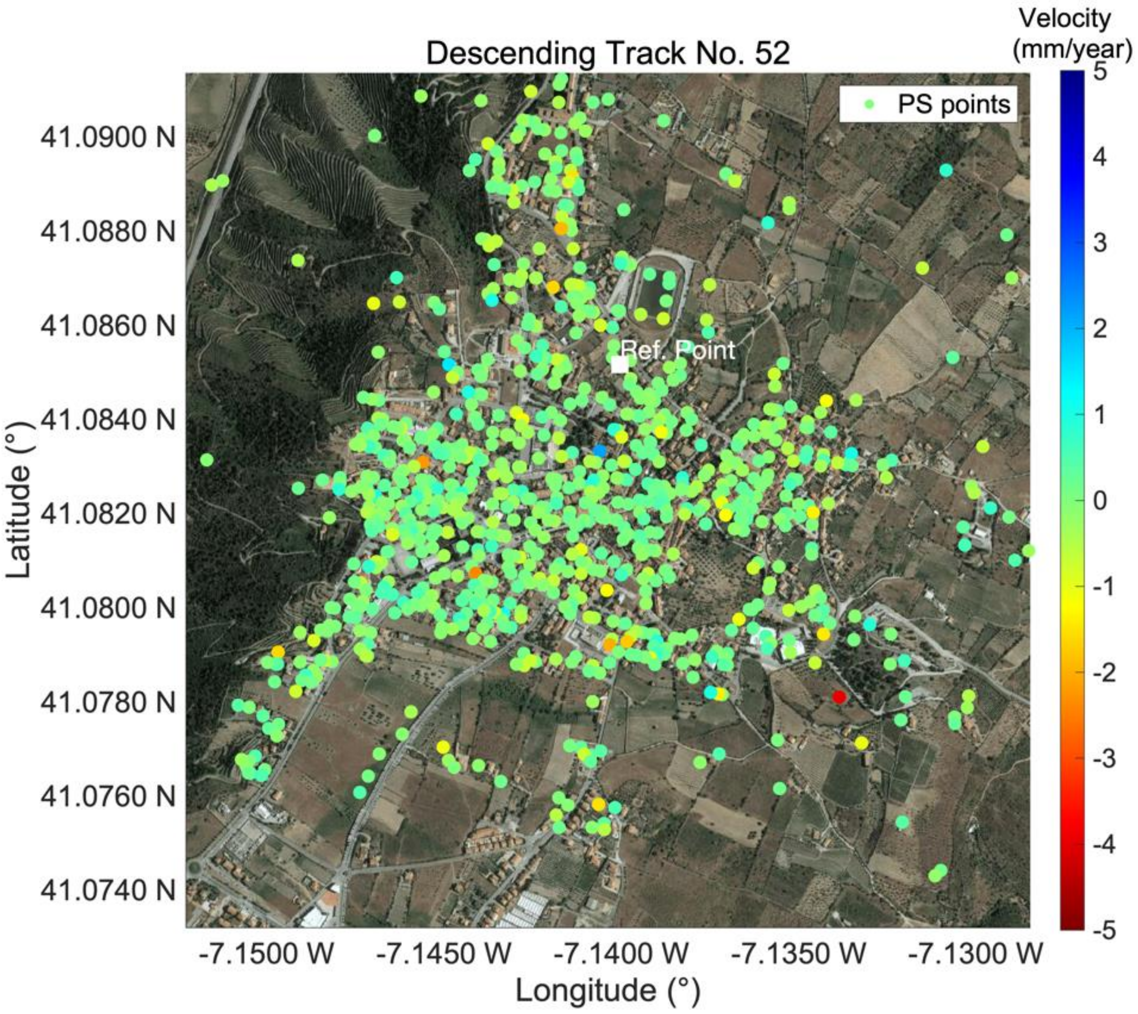
ASC. TRACK 147: Wide Area LOS displacement velocity map



DESC TRACK 52: Wide Area LOS displacement velocity map

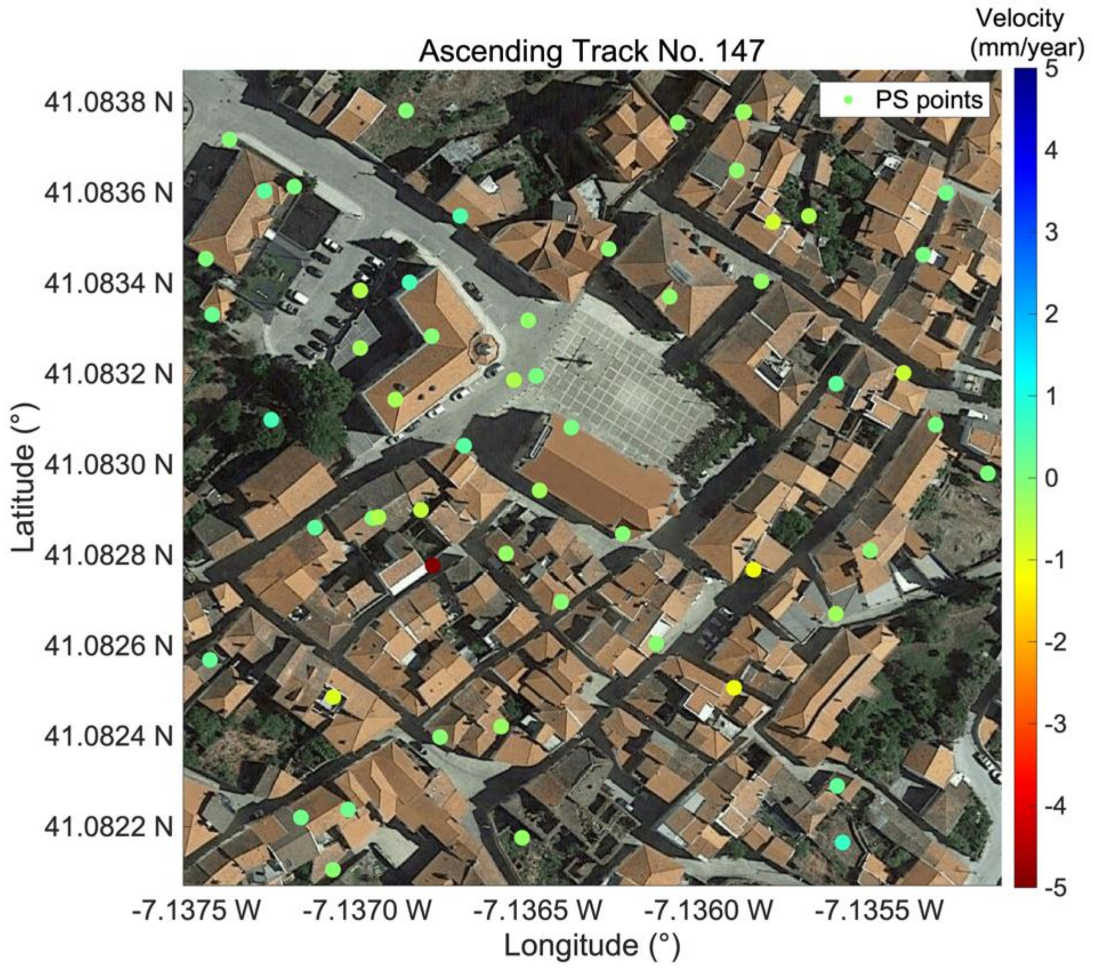
Specific Site Analysis (Vila Nova de Foz Coa)

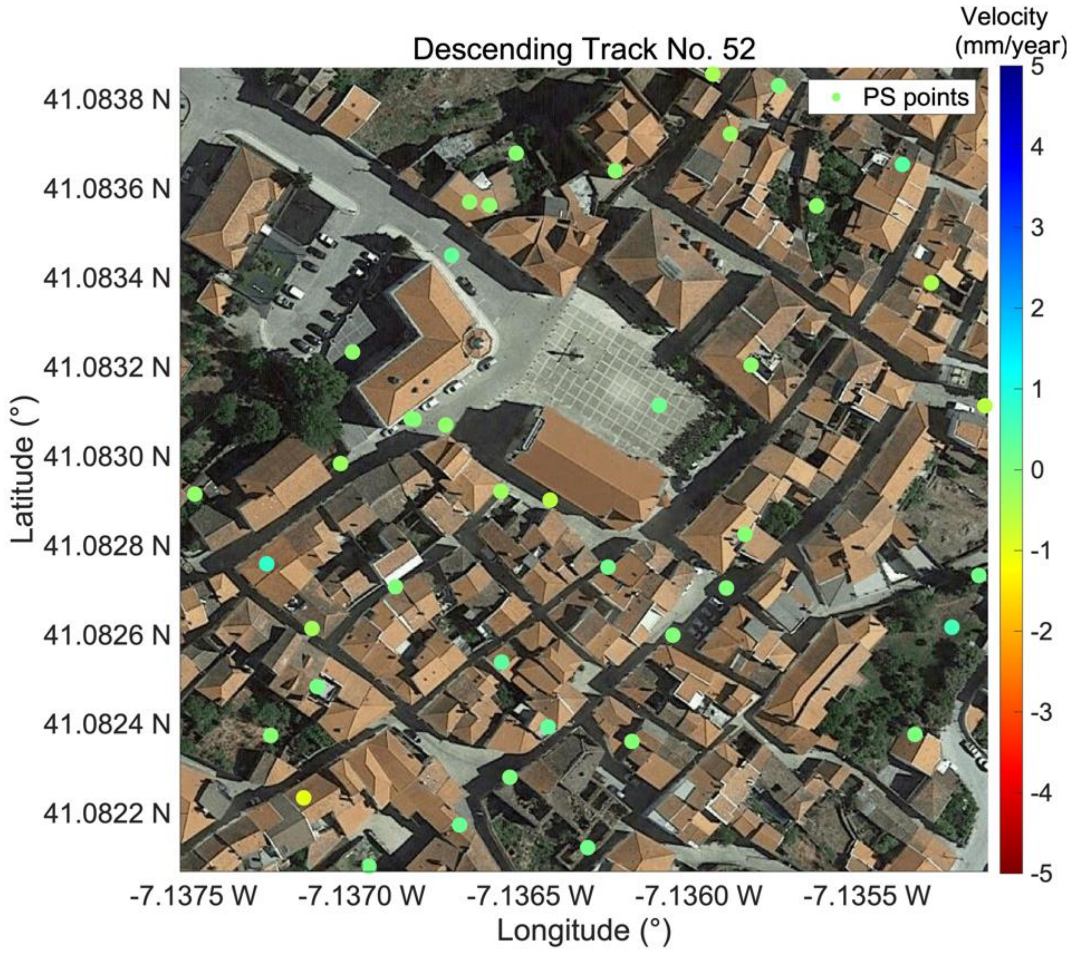




Case Study 6: Cultural Heritage preservation

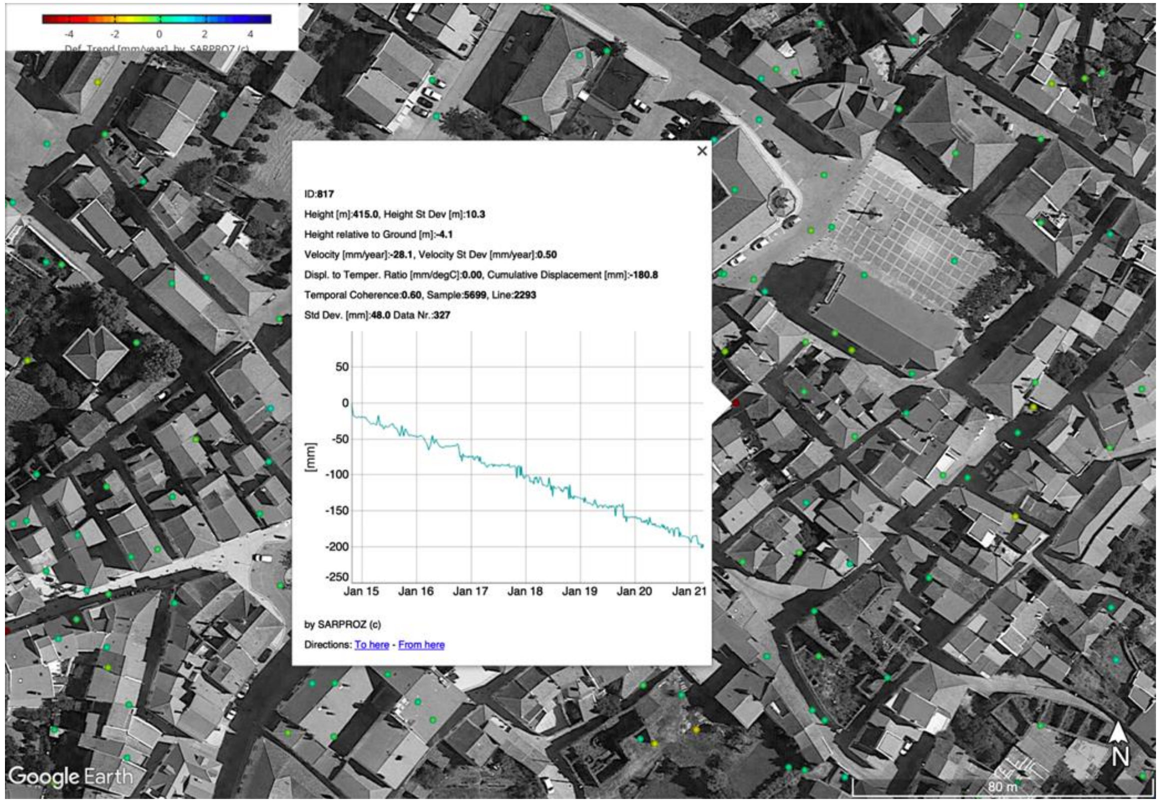
Specific Site Analysis (Vila Nova de Foz Coa)



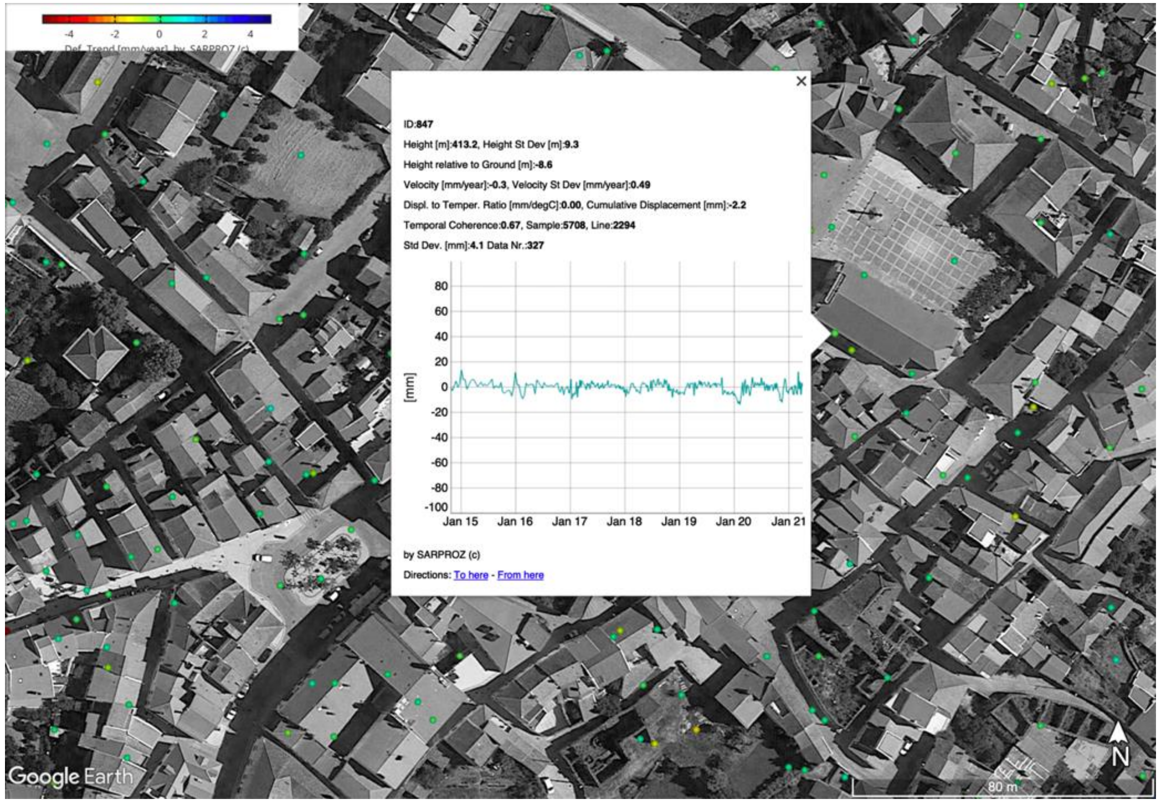


Case Study 6: Cultural Heritage preservation

Specific Site Analysis (Vila Nova de Foz Coa)



ASCENDING TRACK 147: Subsiding displacement trend of -28 mm/year found in a vicinity of the main church



ASCENDING TRACK 147: Seasonal movement detected over southernmost wall of the main church

Case Study 6: Cultural Heritage preservation

Specific Site Analysis (Vila Nova de Foz Coa)
PAZ data

PAZ ASCENDING TRACK. Temp Coh > 0.75
25 images, from Octobre 2021 to March 2022

Case Study 7: multi-temporal change detection

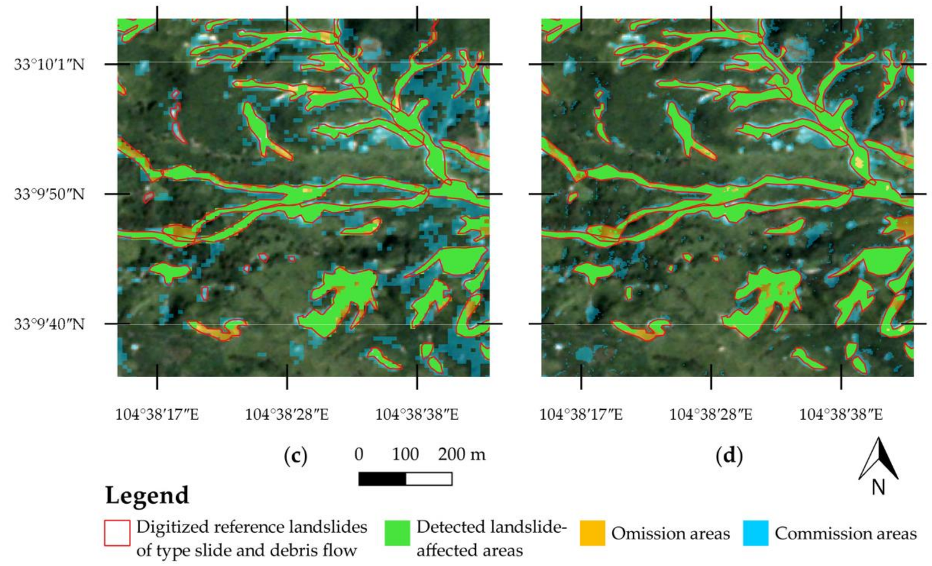
- **Project objectives:**
  - Follow-up and further evaluation of Eurac Dragon 4 activities
  - Automated multi-temporal landslide detection and mapping using optical time series
  - Validation/calibration using updated landslide databases and ground truth data
  - Testing additional features related to newly available static and dynamic landslide susceptibility models (i.e. probability-based masking)

- EO-Data: Copernicus Sentinel2, Third Party Mission: Planet Scope Imagery

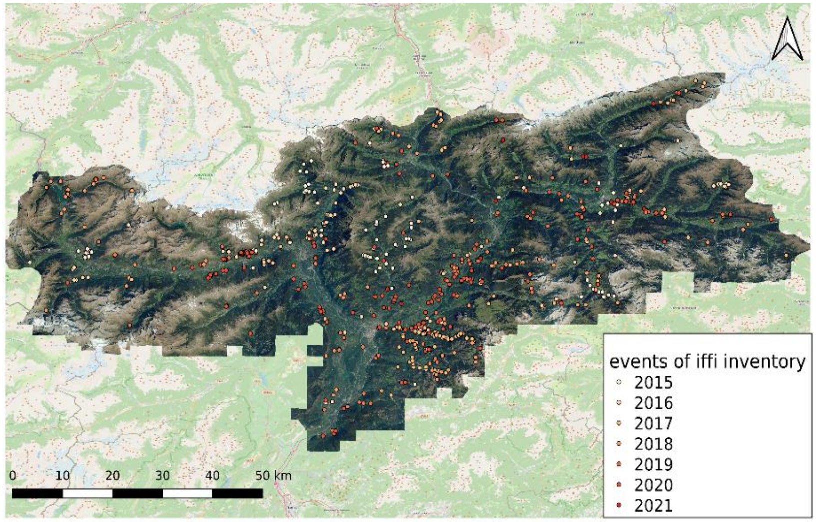
- Study area: South Tyrol, Italy & Longnan Administrative Area, P.R. China

- Period: 27.06.2015 – 2021.01.11

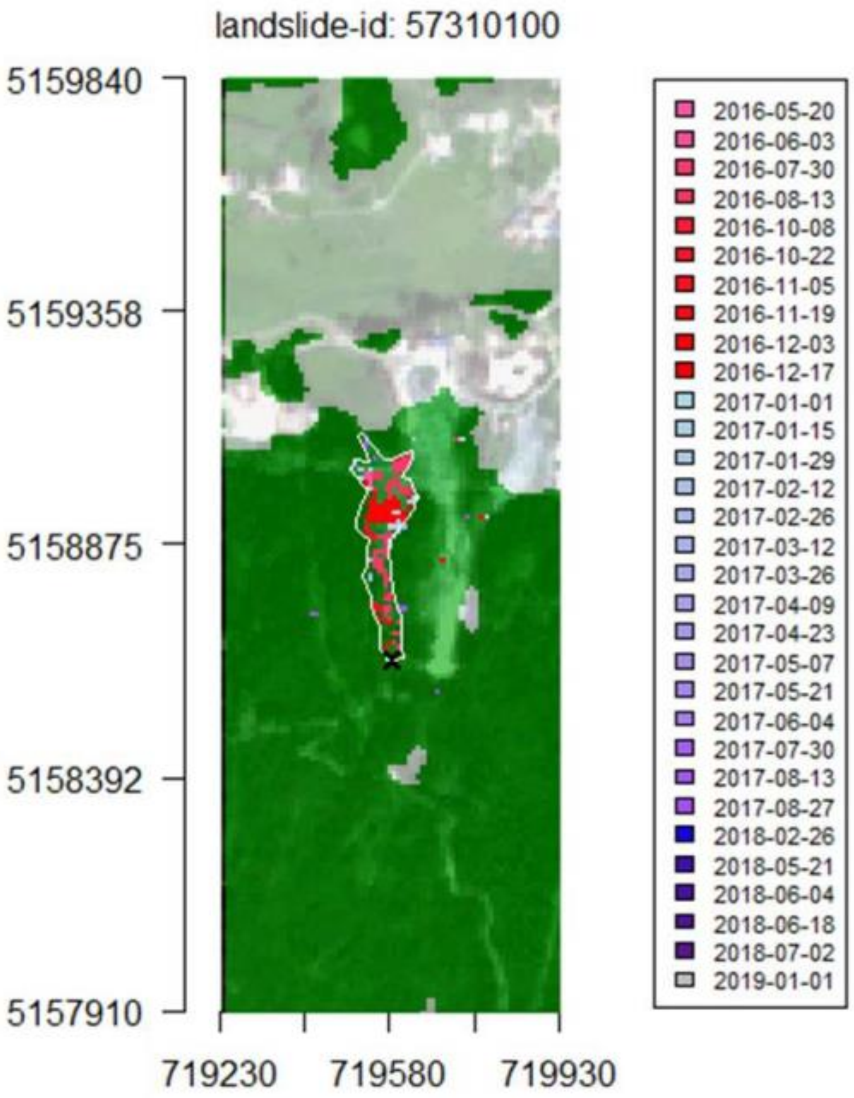
Case Study 7: multi-temporal change detection



Eurac Results within the Dragon 4 project (Sousa et al. 2021)



Results of the multi-temporal change detection approach in Dragon 4 in South Tyrol, Italy (by P. Mayrhofer)



Landslide inventory locations from 27.June 2015 to 1.11.2021

Plans for the next year

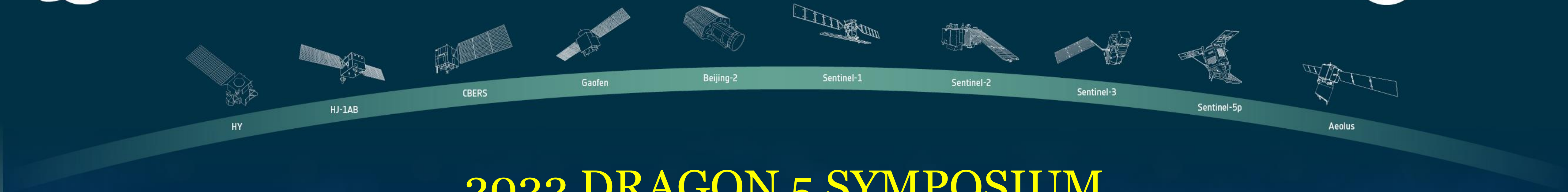
1. In the following year, different Time Series InSAR methods will be continually explored to be applied in different sites in order to get more reliable results with variable natural conditions;
2. GBSAR will be used to validate the EO results, as soon as the field campaign is possible;
3. Regarding Cultural Heritage, AI algorithms will continue to be developed to integrate different types of observations and improve ifgs quality;
4. Planet data will be used to compare S-2 capabilities in building an automate landslide detection approach.

Chinese Young scientists contributions in Dragon 5

Name	Institution	Poster title	Contribution
Youfeng Liu	China University of Geosciences, Beijing	Monitoring and stability analysis of Woda landslide in Tibet, China, with distributed scatterer InSAR method	Combination of distributed scatterers (DS) and permanent scatterers (PS). Calculation of two-dimensional deformation and stability analysis of Woda landslide.
Qun Wang	China Center for Resources Satellite Date and Application	Application of InSAR Technique in Deformation Monitoring of Water Conservancy and Hydropower Engineering	22 Sentinel-1 images covering Xiaolangdi Dam from August 2020 to April 2021 were processed by SBAS-InSAR to obtain the deformation distribution of the Dam
Jiahui Lin	Aerospace Information Research Institute, Chinese Academy of Sciences	Research on the Method of mining subsidence extraction by combining improved U-Net model and DInSAR Technology	Using deep learning model and DInSAR technology to obtain the spatial distribution of mining subsidence intelligently. ECA-Unet model has been researched and applied.

European Young scientists contributions in Dragon 5

Name	Institution	Poster title	Contribution
Diogo Couto	UTAD		AI developments to improve good quality ifgs selection and correct unwrapping jumps;
Luís Pires	UTAD		Integrated use of satellite InSAR and in-situ deformation monitoring sensors
Vanessa Rittlinger	Eurac Research		The multi-temporal change detection



2022 DRAGON 5 SYMPOSIUM

MID-TERM RESULTS REPORTING

17-21 OCTOBER 2022

[PROJECT ID. 56796]