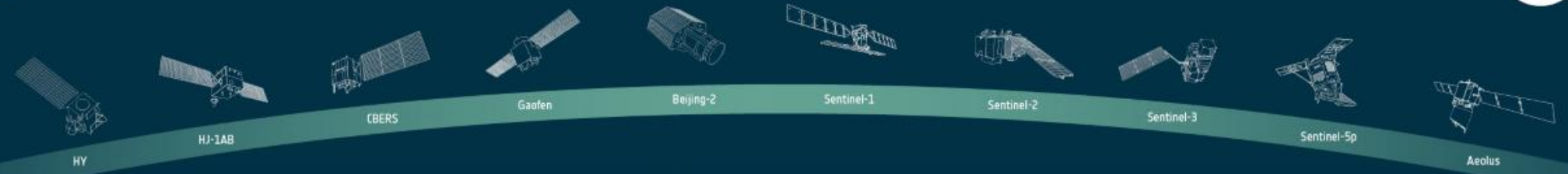

2022 DRAGON 5 SYMPOSIUM

MID-TERM RESULTS REPORTING

17-21 OCTOBER 2022

PROJECT ID. 58029

COLLABORATIVE MONITORING OF DIFFERENT HAZARDS AND ENVIRONMENTAL IMPACT DUE TO HEAVY INDUSTRIAL ACTIVITY AND NATURAL PHENOMENA WITH MULTI-SOURCE REMOTE SENSING DATA

Project Details

FRIDAY 21 OCTOBER 2022

ID. 58029

PROJECT TITLE:

COLLABORATIVE MONITORING OF DIFFERENT HAZARDS AND ENVIRONMENTAL IMPACT DUE TO HEAVY INDUSTRIAL ACTIVITY AND NATURAL PHENOMENA WITH MULTI-SOURCE REMOTE SENSING DATA

PRINCIPAL INVESTIGATORS: CRISTIANO TOLOMEI & LIANHUAN WEI

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PRESENTED BY:

CRISTIANO TOLOMEI

Project Objectives

The industrial district of Shenyang and Anshan plays an important role in the economic and social development of Northeast China. The mining activities strongly impact local environment due to ground excavations of coal and iron extraction. Anshan and Shenyang are subjected to multi-hazard including subsidence, landslides, and building damages.

Main goals of the project are to take advantage of the availability of remote sensing data to:

1) monitor and analyze the different hazards and environmental impact due to heavy industrial activity at Shenyang and Anshan areas (Fushun and Dagushan) and the Changbaishan volcano complex;
2) identification and modeling of single and multiple hazards, identifying the cross-related influence and causing factors;
3) forecast when and how hazards might happen, generate hazard scenarios, and provide support for disaster prevention and damage reduction.

The applied methodologies to achieve the above objectives consists on the joint analysis of multi-source EO data, by means of InSAR time-series, VNIR optical data series, seismic, geochemical, laser scanning data and modeling.

Data used (first 2 yrs)

To reach the proposed objectives the following data are used:

- Sentinel1 (C-Band) and COSMO-SkyMed (X-Band) data along both the ascending and descending orbit (Shenyang, and Fushun area);
- ALOS-2 (L-Band) data for the ascending orbit (Changbaishan volcano);
- Envisat and S1 (C-Band) data along the descending orbit (Changbaishan volcano);
- GF-1/GF-2/GF-6 (multi-spectral data) for Liaoning Province;
- Landsat8 images for the Fushun and Changbaishan area.

In-situ Monitoring network of Changbaishan volcano

12 real-time transmission seismic stations;

12 real-time transmission GPS stations;

Strain meter:100 samples/s;

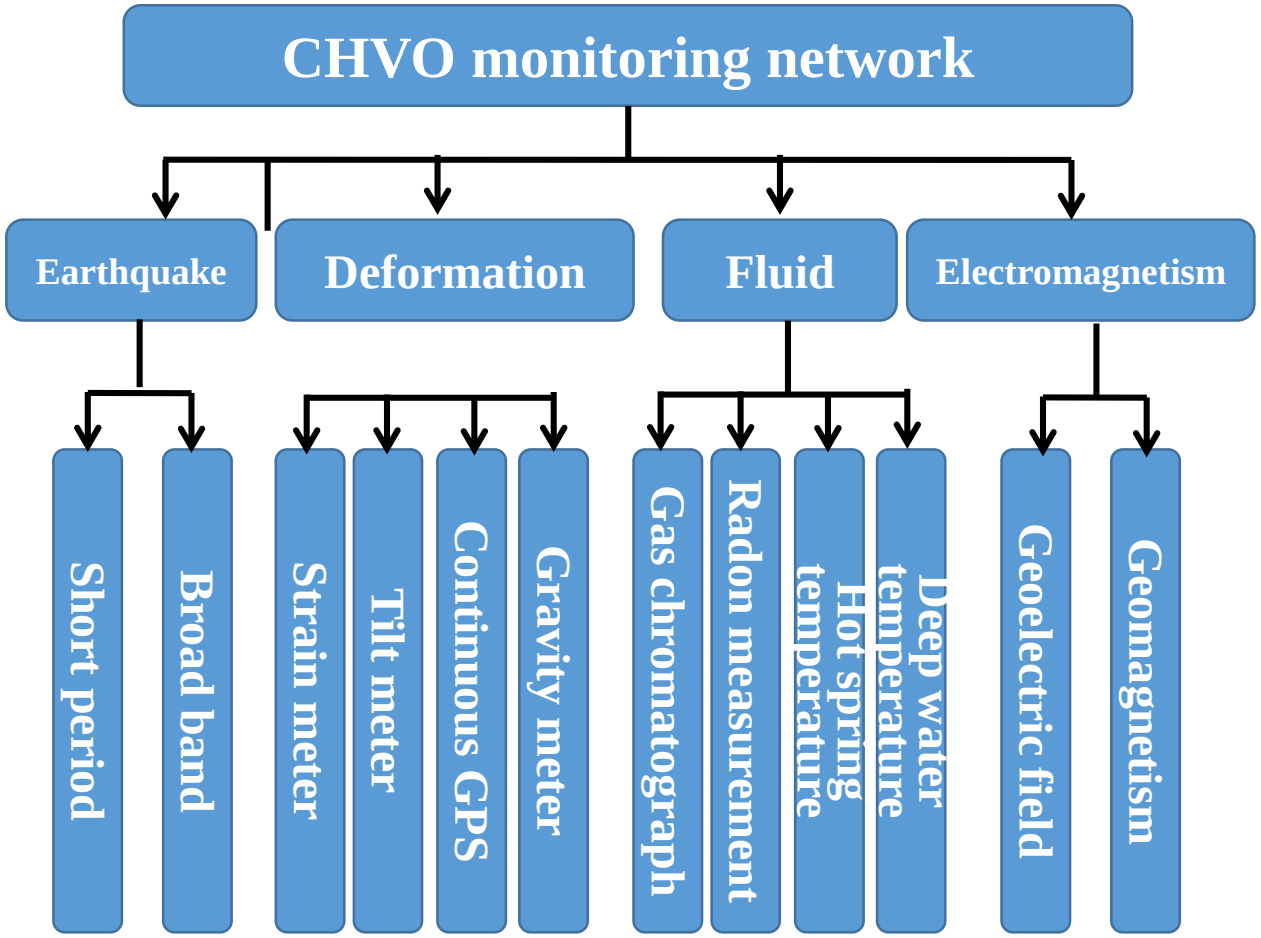
Tilt meter:100 samples/s;

Gravity meter:100 samples/s;

Gases,Radon and Temperatures:2-3 samples/month;

Geoelectric: 100 samples/s;

Geomagnetism: 4 samples/day



Retrieved results

In the first 2 years of the project we made:

- A deep investigation of the Changbaishan volcano by means of InSAR techniques (both SBAS and PS) using S1 (Jan. 2015- Sept. 2020), Envisat and ALOS-2 data (May. 2004- Jun. 2010);
- The source modelling of the Changbaishan volcano;
- Paper publication for the Changbaishan study → Trasatti E, at al., *Upward Magma Migration Within the Multi-Level Plumbing System of the Changbaishan Volcano (China/North Korea) Revealed by the Modeling of 2018–2020 SAR Data*. Frontiers in Earth Science 2021, 9, 1302, https://doi.org/10.3389/feart.2021.741287;
- Update of the Fushun and Shenyang analysis using InSAR techniques up to 2022 through S1 data;
- Completion of the Fushun pit mine study covering a new temporal interval (2018-2020, descending track) using CSK data provided by the Italian Space Agency.

Work for the Next Future

In the next 2 years of the project we plan to:

- Complete the study on the Changbaishan volcanic complex through new InSAR results and following source modelling;
- A new paper writing and submission on the Changbaishan volcanic complex;
- Update of the SAR analysis' outcomes on the Shenyang and Fushun pit mine areas;
- InSAR investigation on Dagushan mine site;
- Paper writing and submission on a peer-review journal for the two previous areas;
- Generate hazard scenarios, and provide support for disaster prevention and damage mitigation to Local Authorities (i.e. Civil Protection Dept.).

Young Scientist Training

- From 2023.01 a 1 year fellowship for an Italian Young Researcher will start (just selected and approved);
- Starting from 2021.07, one post-doc Chinese young researcher has been working on hazard monitoring in Northeastern University .
- 5 postgraduate students would finish their master's degree.

Data access

ESA Third Party Missions	No. Scenes
1.ALOS-2	20
2.COSMO-SkyMed	100
3.S1	205
4.SRTM-1 DEM	
5.ALOS DEM	
6. TERRASAR-X	30
Total:	355

Issues:
Both ALOS-2 and CSK data were downloaded via ftp from the related National Space Agencies' dedicated links.
S1 data were downloaded through the ASF Vertex site
DEMs were downloaded via ftp by the related online sites.

Chinese EO data	No. Scenes
1.GF-1/2/6	15
2.	
3.	
4.	
5.	
6.	
Total:	15

Issues:

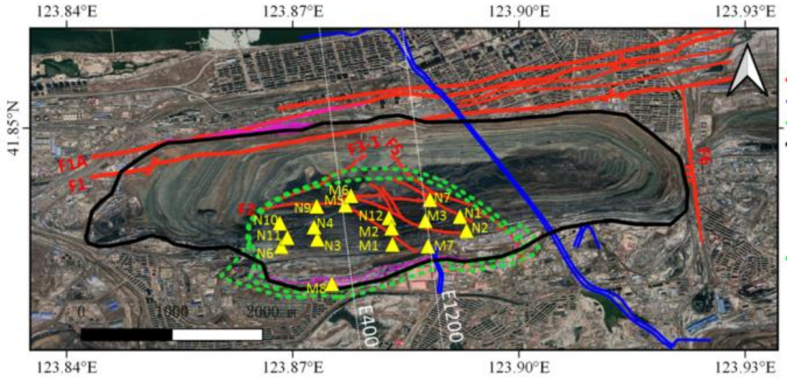
Young scientists contributions in Dragon 5

Name	Institution	Poster title	Contribution
	INGV		Fellowship will start on January 2023 lasting 12 months
Dr. Meng Ao	NEU		Post-doc research lasting from 2021.07 to 2023.07
Mr. Xiaotian Wang	NEU	Bridge High-precision Displacement Monitoring and Health Evaluation Using Multi-dimensional X-Band SAR Images	
Ms. Fang Wang	NEU	Study on the Method of Time Series SAR Offset Tracking of Mine Landslide	
Ms. Ying Sun	NEU	Study of Tianchi Volcanic in Changbai Mountain Based on Time-series InSAR	

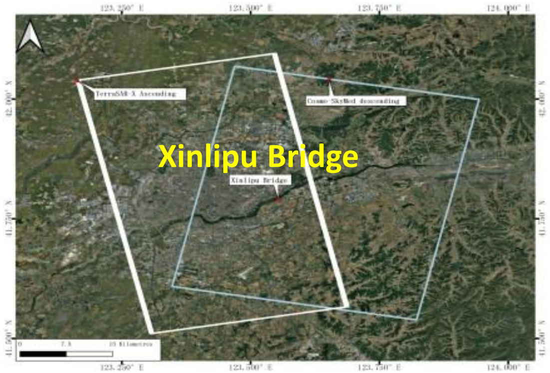
Preliminary results and joint publications

- Preliminary results and joint publications
  - Shenyang urban district analysis by InSAR data
  - Landslides analysis over open pit mine: Fushun Mine
  - Thermal dilation of Xinlipu bridge, Shenyang
  - Recent activity of Changbaishan Volcano

1. Shenyang



2. Fushun West Open Pit Mine

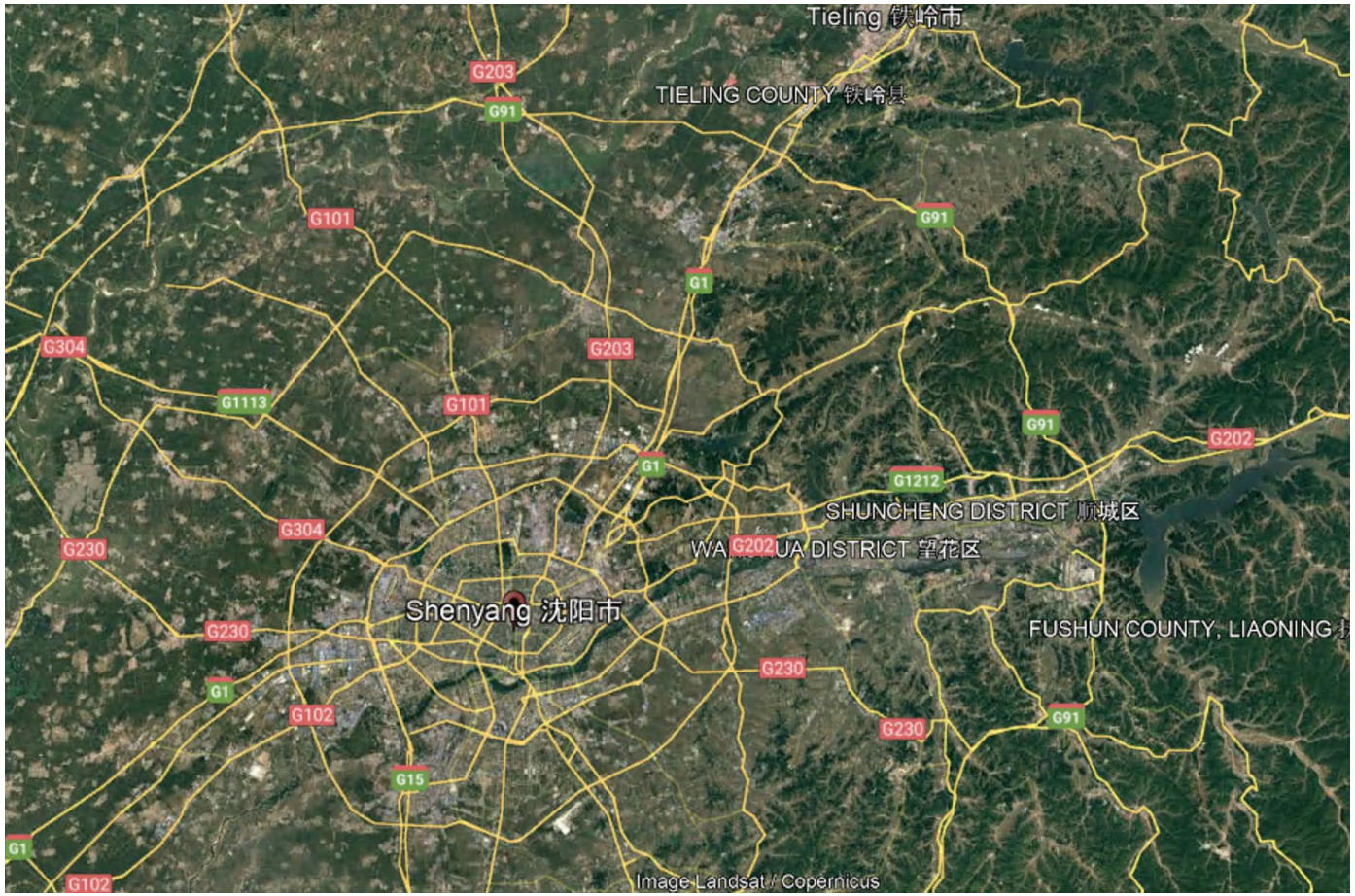


3. Xinlipu Bridge, Shenyang

4. Changbaishan Volcano

Preliminary results and joint publications

Shenyang and Fushun open pit mine sites (NE China)



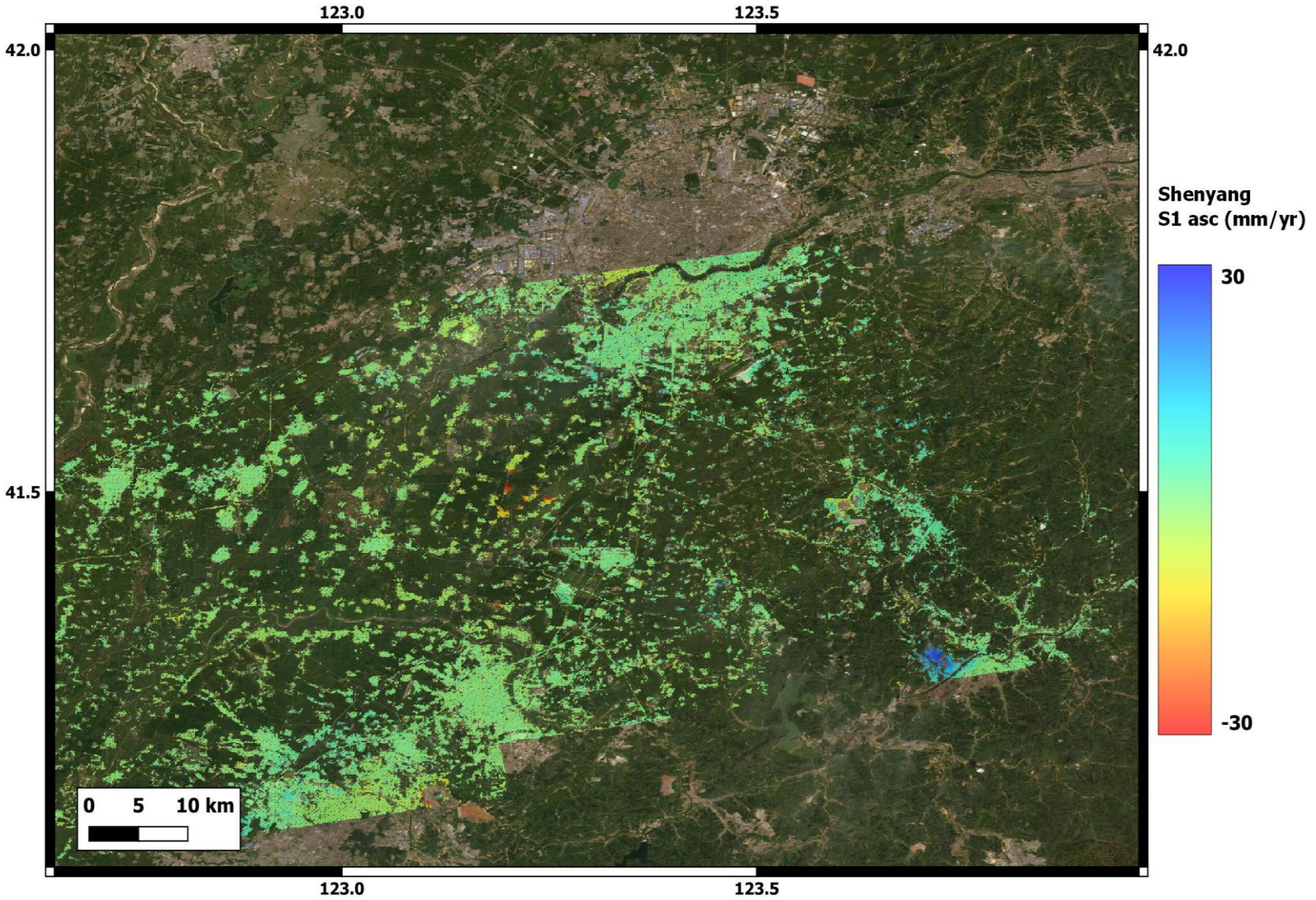
Preliminary results and joint publications

Shenyang and Fushun open pit mine sites (NE China)

Preliminary results and joint publications

Shenyang urban district

- S1 ascending 100 SLC (20180916_20211229) (only the lower south area is covered the SAR images, T25)
- S1 descending 100 SLC (T105) (20180810_20211216)
- SBAS approach



Preliminary results and joint publications

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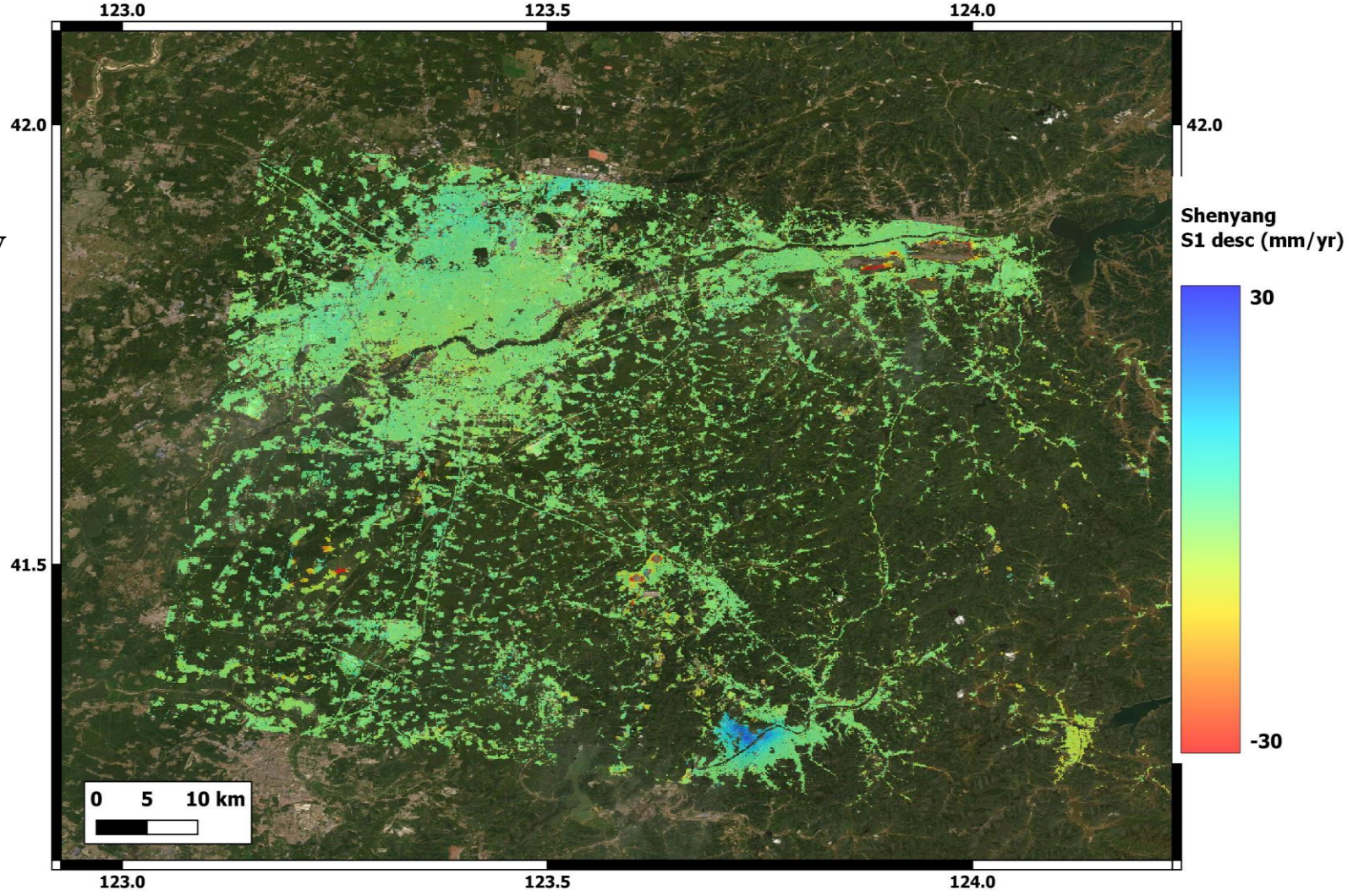

Preliminary results and joint publications

Shenyang urban district

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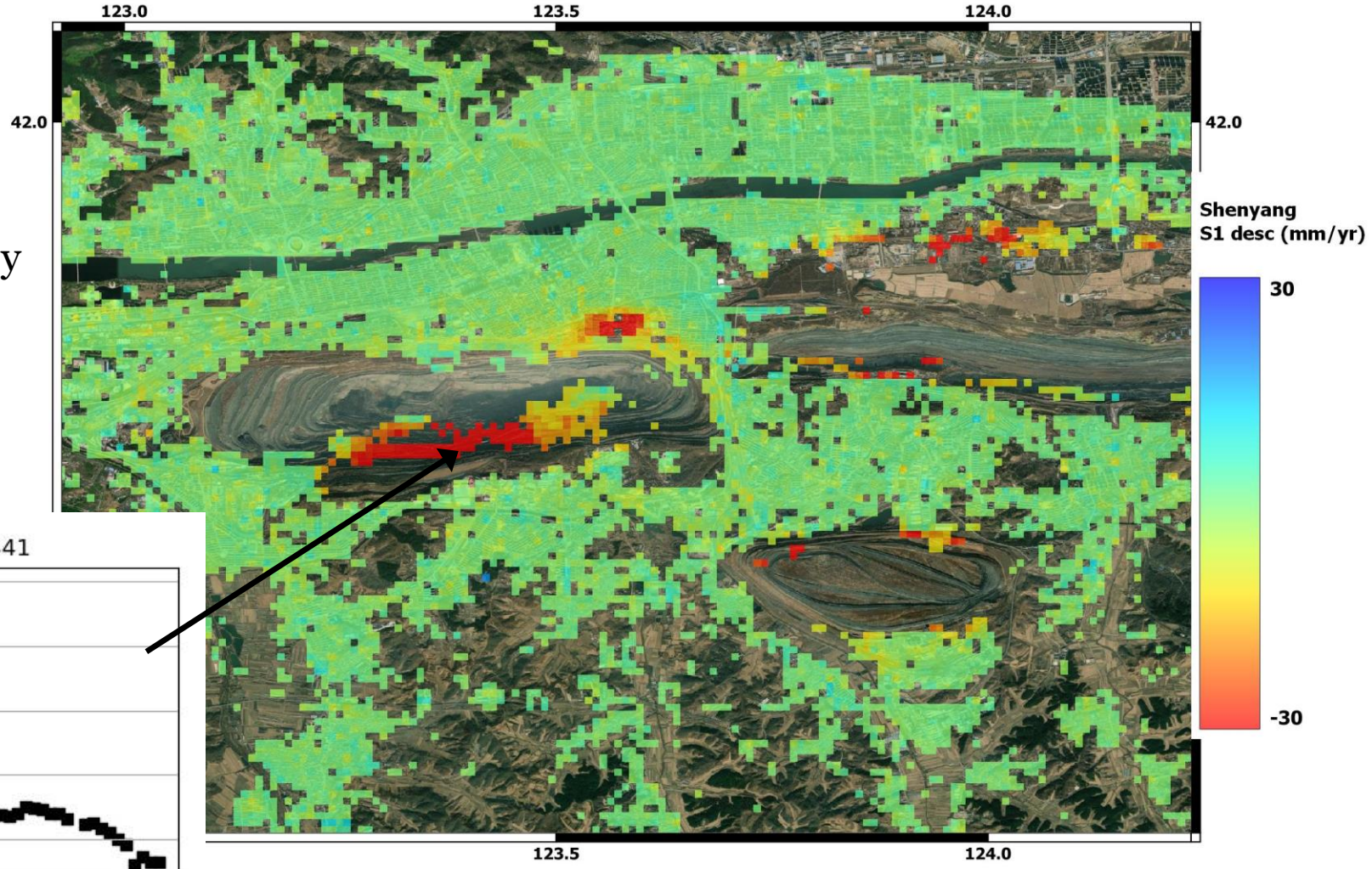
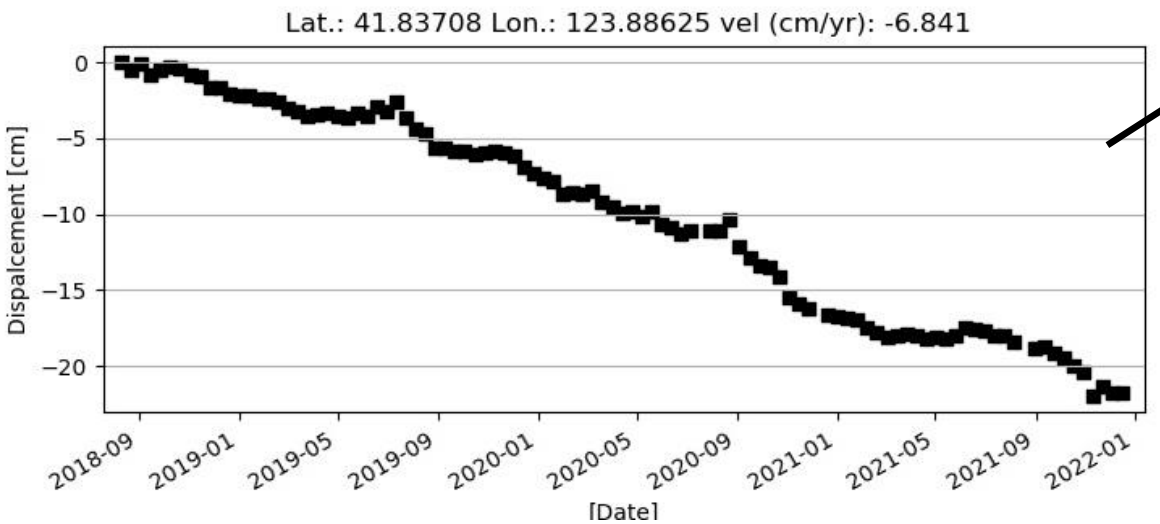




Preliminary results and joint publications

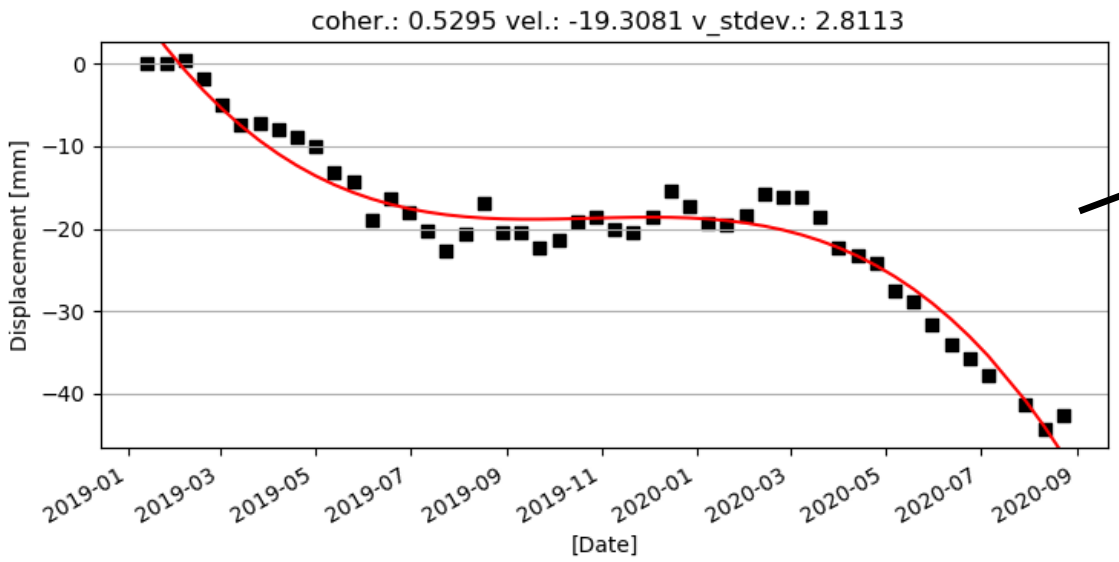
Funshun pit mine

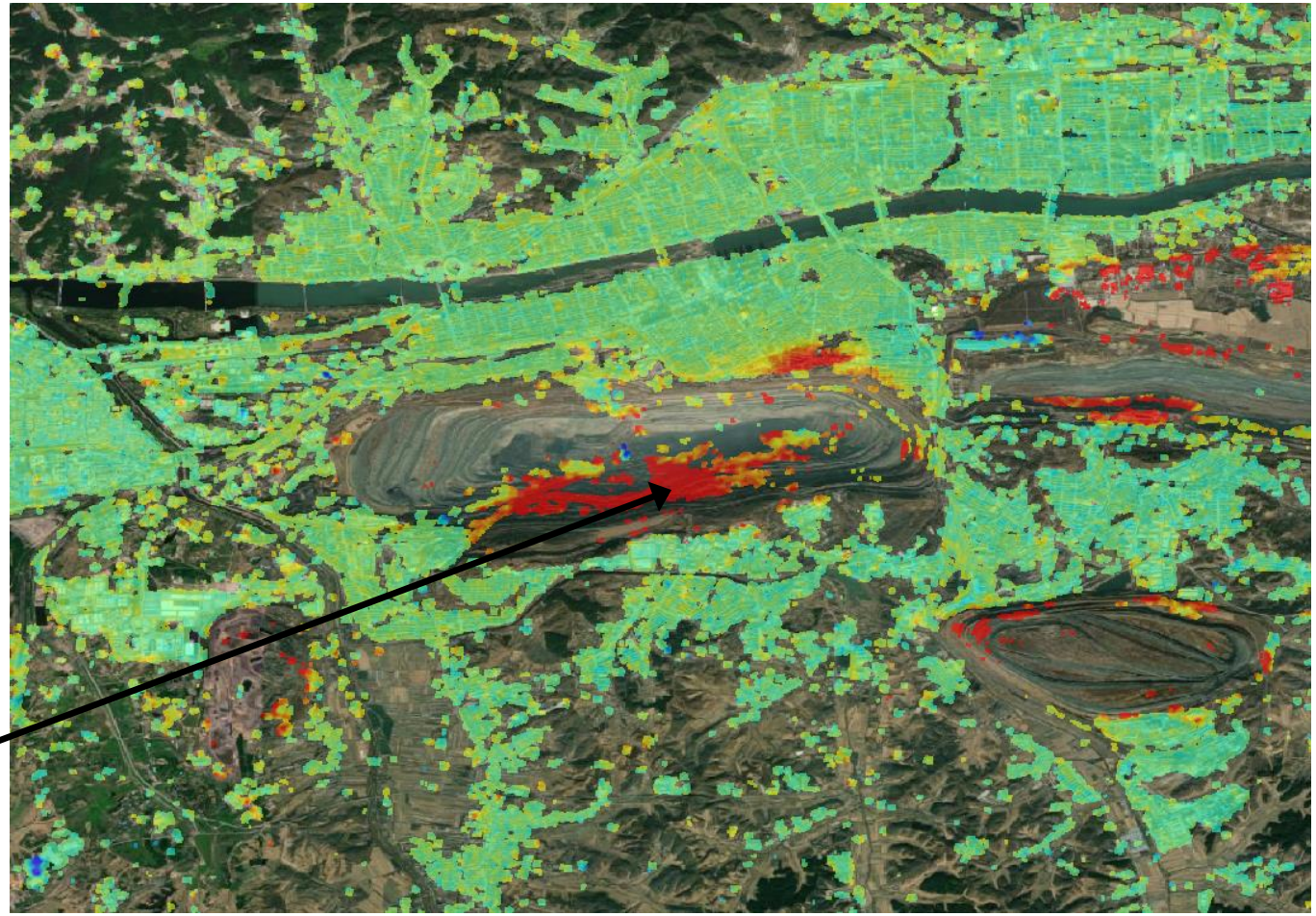
- COSMO-SkyMed data:

  Time spans 2011-14 and 2019-2020

  Descending orbit

  100 SLC



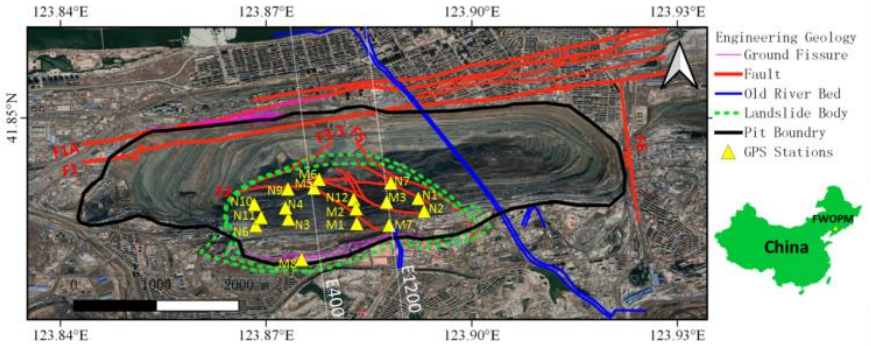


Preliminary results and joint publications

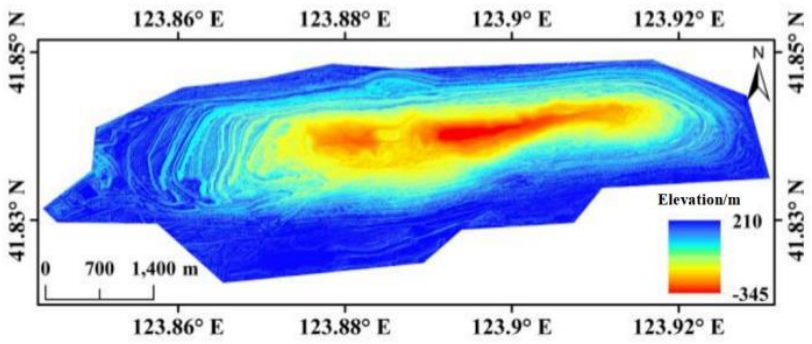
Landslide Monitoring in Fushun West Open Pit Mine

Study area and datasets

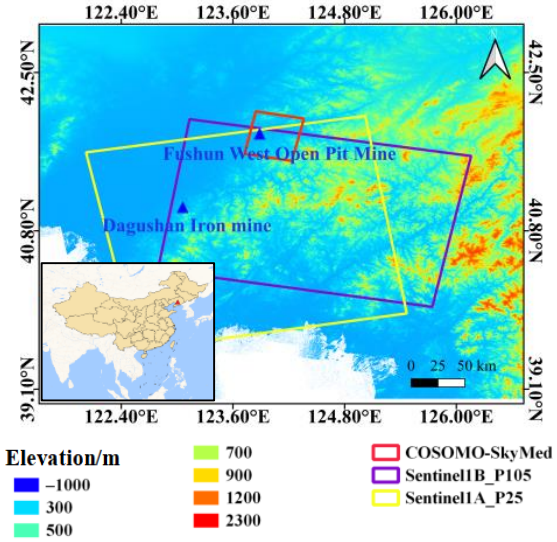
sensor	Number of images	Temporal Coverage	Orbit Direction	Heading (°)	Incidence Angle (°)
COSMO-SkyMed	7	2014/03/16-2016/12/18	Desc	−165	25.09
Sentinel-1B	116	2017/01/11-2020/12/21	Desc	−166.42	42.61



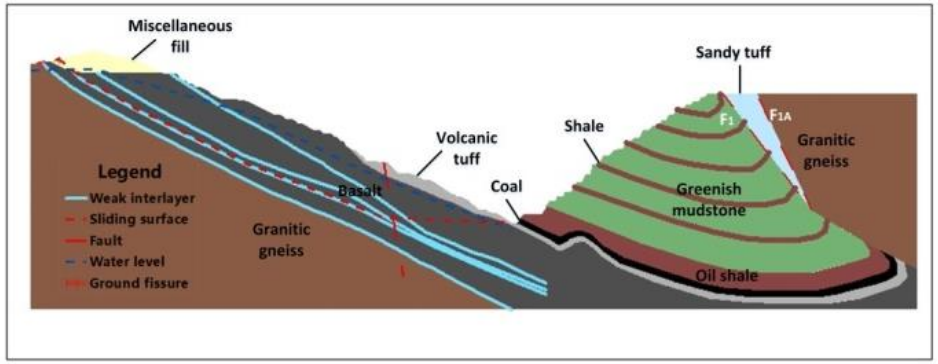
Fushun West Open Pit Mine



LiDAR DEM



Location of the Fushun mine



Geological setting of profile E400

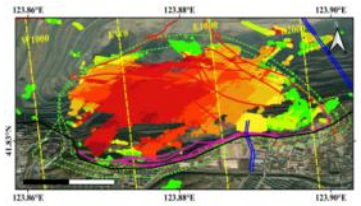
Preliminary results and joint publications

Landslide Monitoring in Fushun West Open Pit Mine

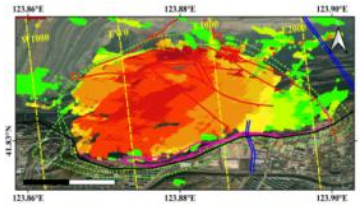
Down-slope displacements retrieved by POT

Amplitude-based POT is conducted with image pairs acquired approximately every half year. Then, the line-of-sight displacements is converted to downslope displacements with assistance of the LiDAR DEM

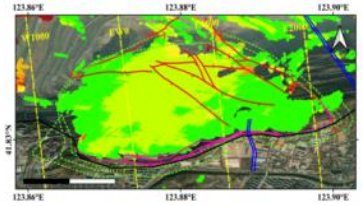
Down-slope displacements



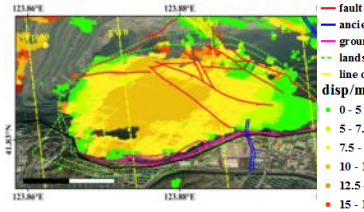
2014-03-16~2014-07-22



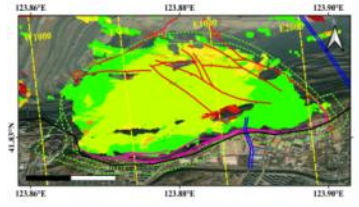
2014-07-22~2014-12-29



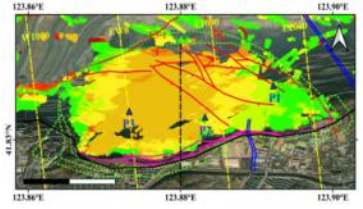
2014-12-29~2015-07-09



2015-07-09~2015-12-16



2015-12-16~2016-06-09



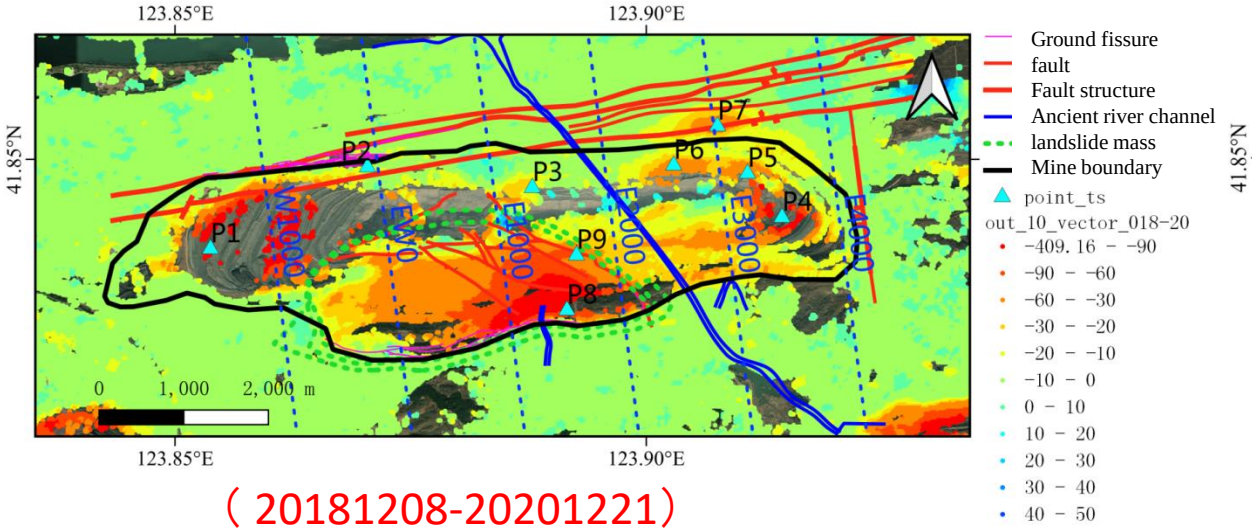
2016-06-09~2016-12-18

Accuracy assessment of three GPS points

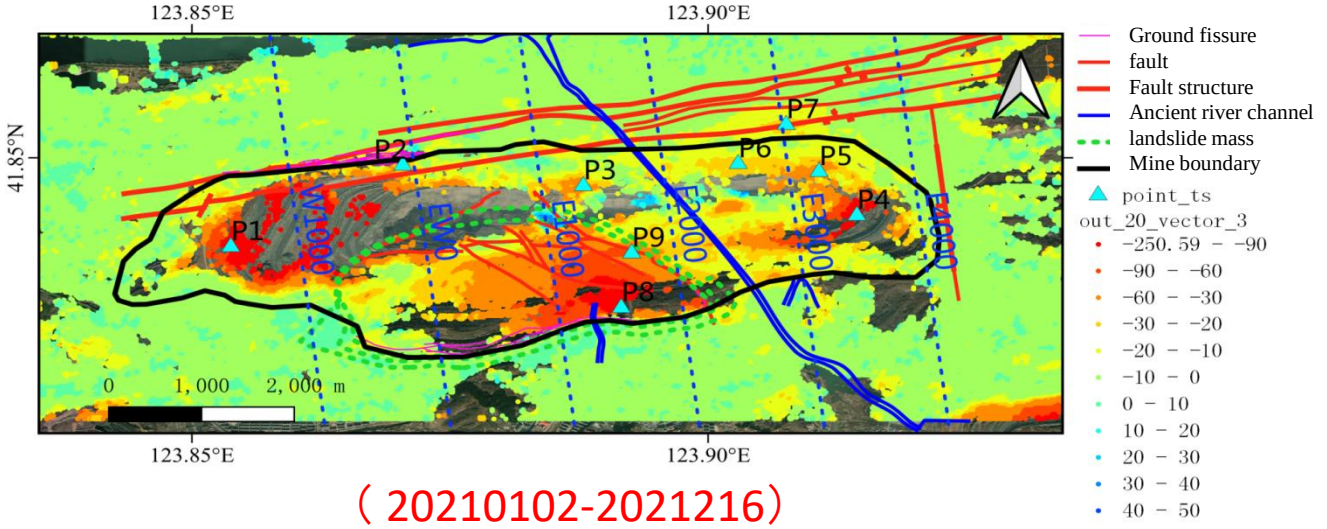
Point ID	P1			P2			P3		
period	GPS	POT	error	GPS	POT	error	GPS	POT	error
14-03-16~14-07-22	10.402	11.372	0.97	14.039	14.779	0.74	19.780	19.119	-0.661
14-07-22~14-12-29	8.888	8.596	-0.292	17.798	15.018	-2.78	17.990	17.632	-0.358
12-29~15-07-09	3.181	3.251	0.07	5.410	5.184	-0.226	5.820	6.304	0.484
07-09~15-12-16	5.994	5.890	-0.104	10.342	9.274	-1.068	11.066	11.013	-0.053
12-16~16-06-09	3.982	3.990	0.008	6.452	6.477	0.025	6.488	6.742	0.254
Mean Error	-	-	0.130	-	-	-0.662	-	-	-0.067
RMSE	-	-	0.489	-	-	1.349	-	-	0.459
Cumulative displacement	32.447	33.099	0.652	54.041	50.732	-3.309	61.144	60.810	-0.334
Relative precision		98%			93.9%			99.5%	

Preliminary results and joint publications

Landslide Monitoring in Fushun West Open Pit Mine



（20181208-20201221）

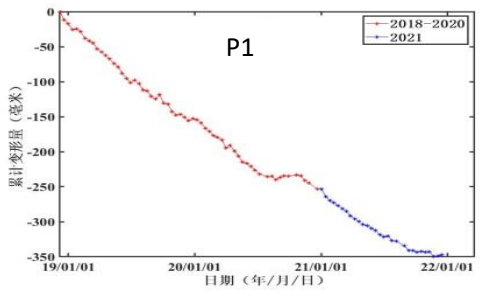


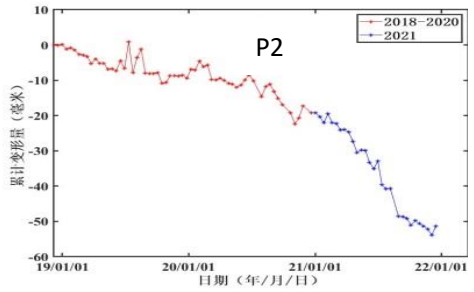
（20210102-2021216）

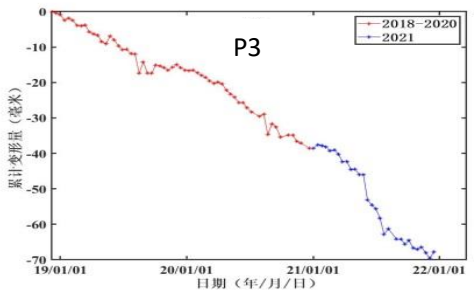
Deformation areas：

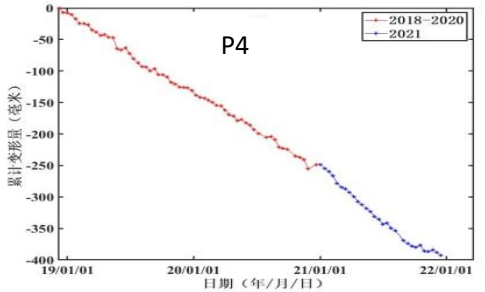
1. Qiantai Mountain Landslide on the south slope：the western part has decelerated in 2021 compared to 2018~2020, whereas the eastern part remains unstable, with maximum deformation near the ancient Liushan river channel (near P8).
2. City near the northeastern slope：elliptical subsidence area (centered on the intersection of E3000 and F1 Fault (near P7), has decelerated in 2021 compared to 2018~2020.
3. Western part of the north slope: historical landslide area, was stable during 2018~2020, whereas some local deformation occurred in 2021 (near P2).
4. Central part of the north slope (E1000~E1400,near P3): accelerates in 2021 compared to 2018~2020.
5. Western slope: reclaimed, with gentle slope angles, consolidation settlement of the backfill continuously occurs (near P1).
6. Eastern slope: steep slope, large deformation, vehicles passing by frequently, should be continuously monitored (near P4).

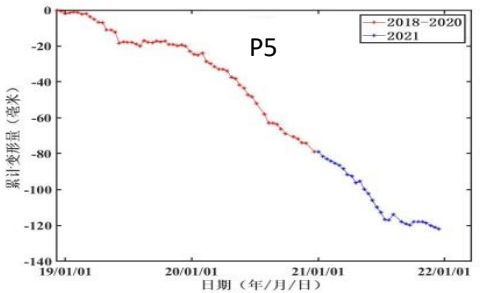
Preliminary results and joint publications

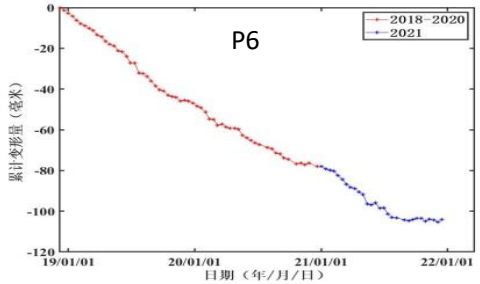


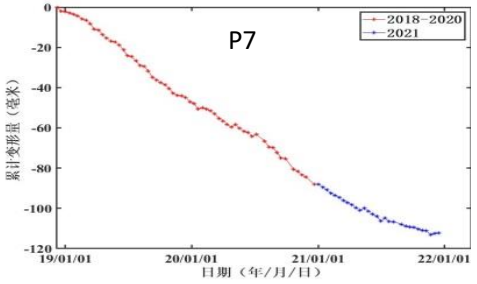


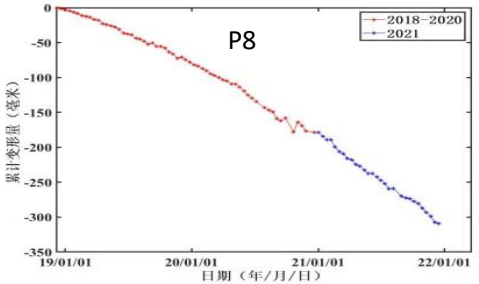


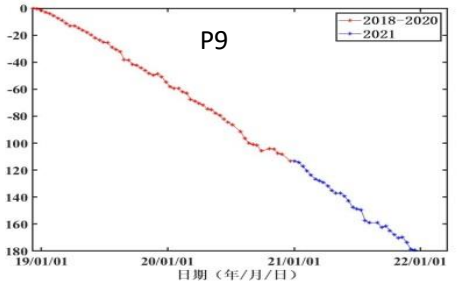










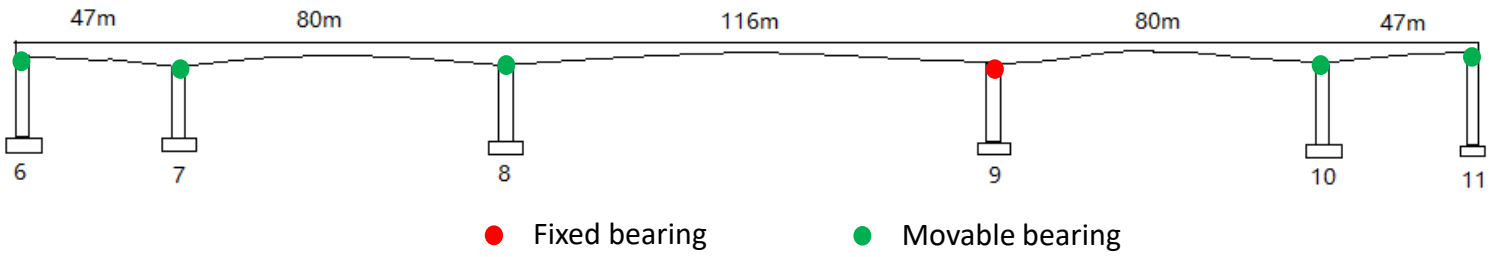


Point ID.	2018.12.08～2020.12.21 Vel. In LOS（mm/yr）	2021.01.02～2021.12.16 Vel. In LOS（mm/yr）
P1	124.09	97.24
P2	10.49	41.13
P3	21.73	39.49
P4	121.24	155.55
P5	37.82	48.62
P6	41.35	30.44
P7	42.82	25.32
P8	133.2041（Max.）	131.38（Max.）
P9	68.45	68.82

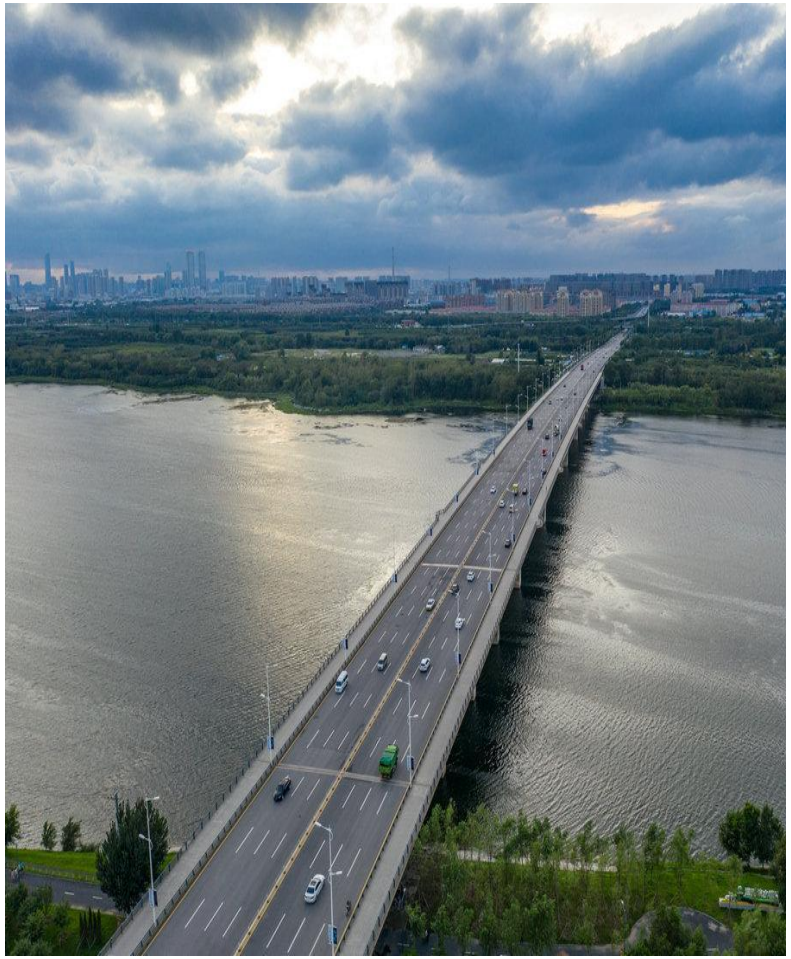
Thermal Dilation of Xinlipu Bridge in Shenyang

Since the 21st century, the rising deterioration of bridges in populated cities highlighted the importance of implementing effective structure health monitoring, reliable data analysis and interpretation specializing on individual bridges.

Xinlipu Bridge is a 5-span continuous beam bridge across the Hunhe river in Shenyang, with total length of 1337.75m, beam width of 40m.



Structural design of the main bridge



Xinlipu Bridge

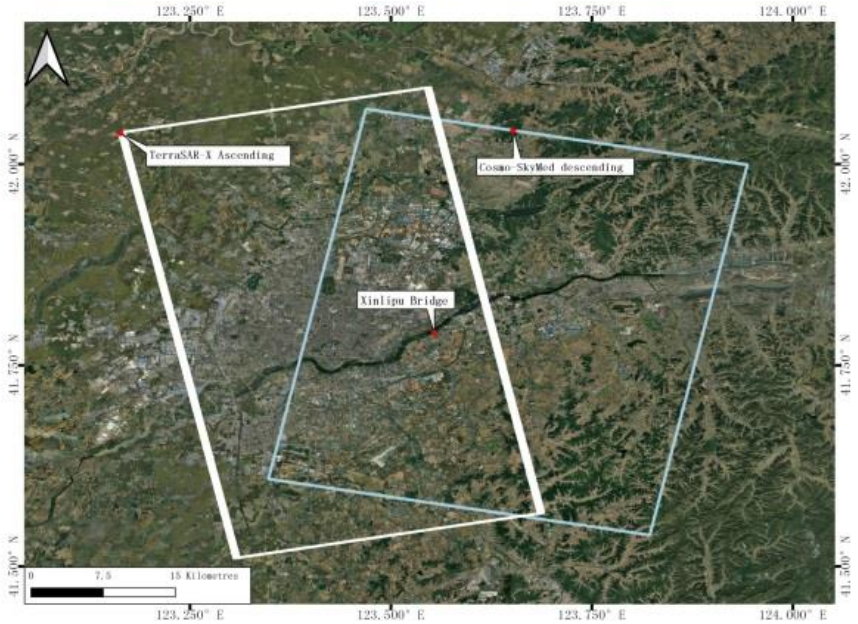
Thermal Dilation of Xinlipu Bridge in Shenyar

SAR datasets:

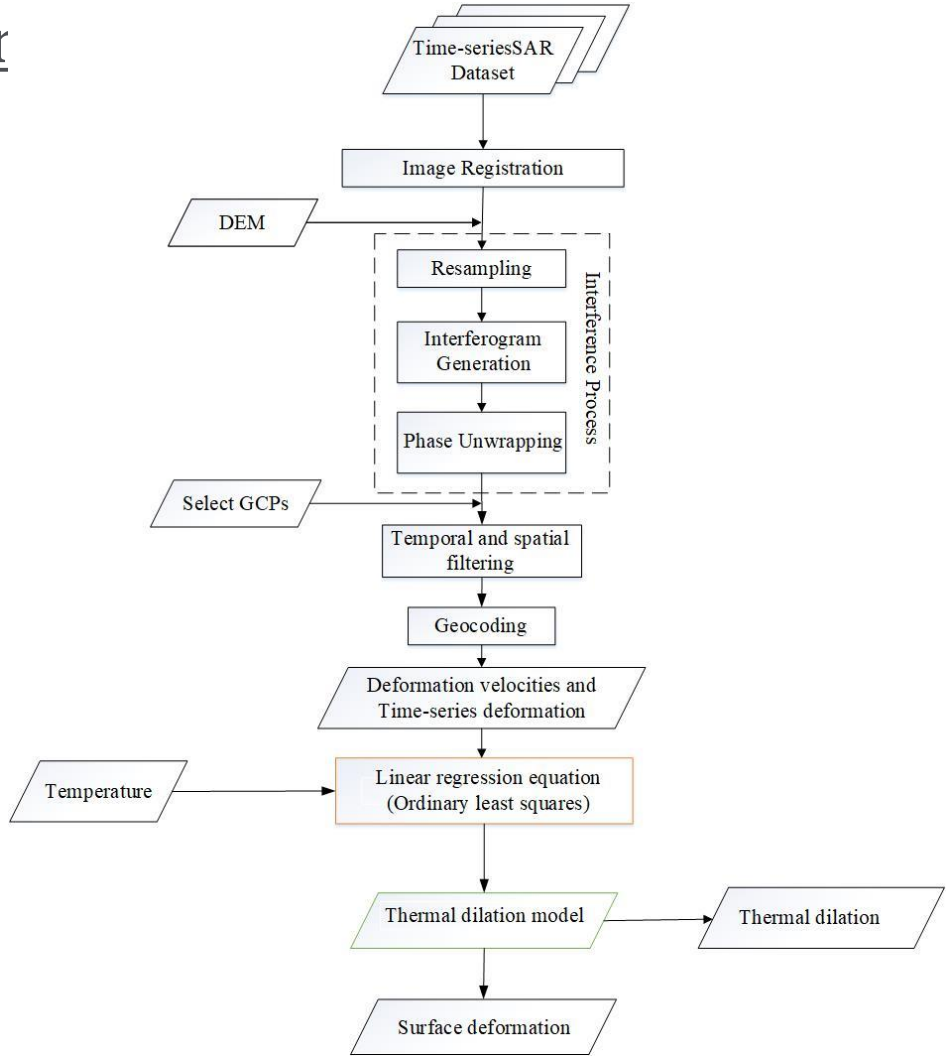
- 30 ascending TSX images (2015-08-25~2017-07-23)
- 42 descending CSK images (2015-02-07~2017-07-23)

Methodology:

A least squares thermal dilation model is adopted to SBAS processing. As a result, the thermal dilation of the main bridge is estimated.



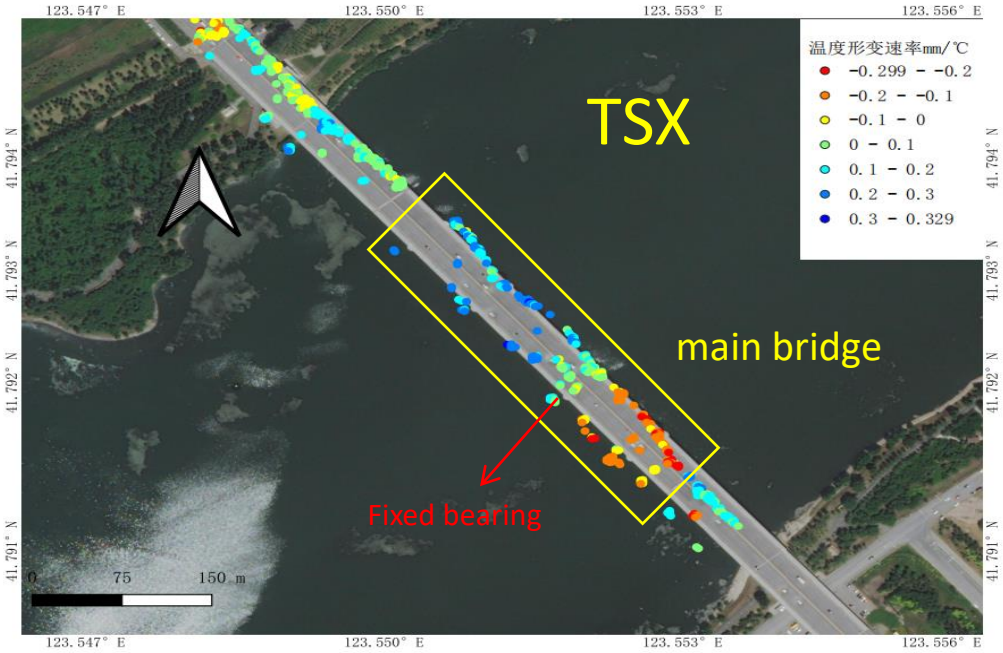
Spatial coverage of the SAR images

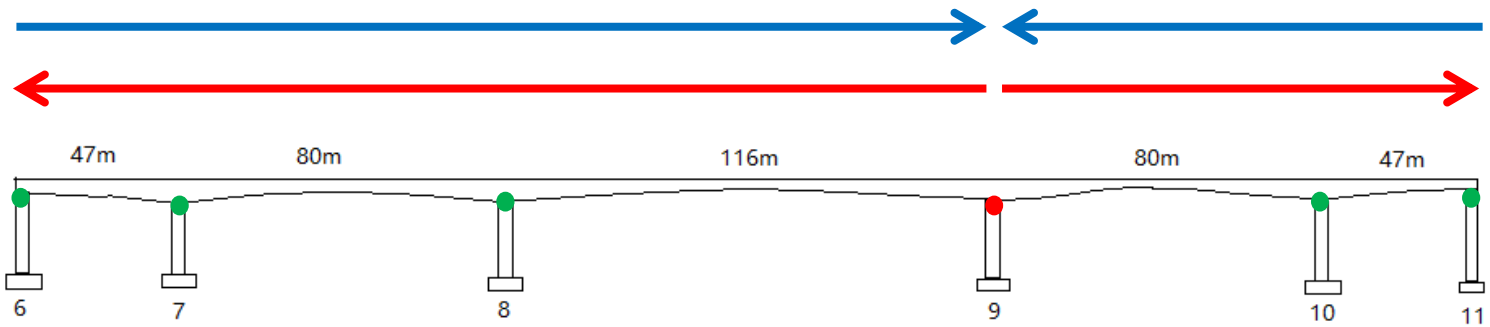


Flow chart of the methodology

Preliminary results and joint publications

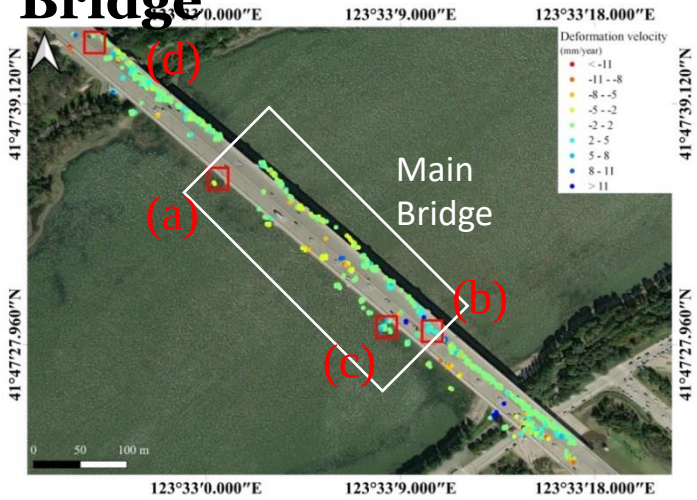
Thermal dilation velocities

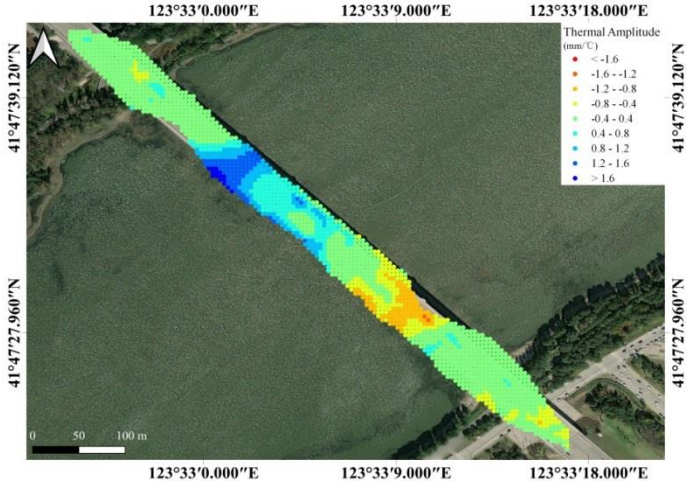




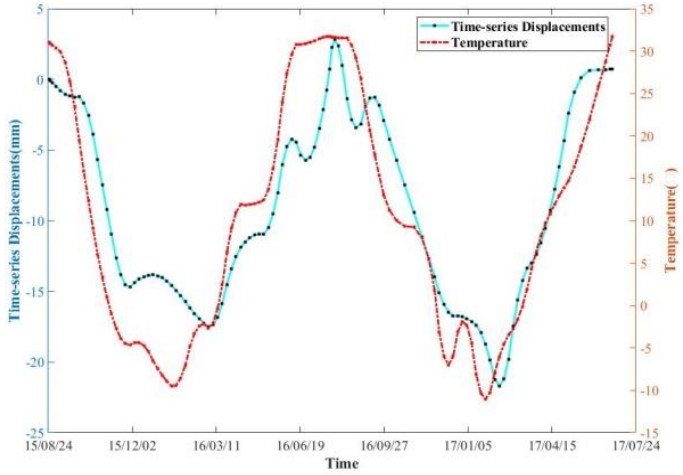
Preliminary results and joint publications

Thermal dilation of Xinlipu Bridge

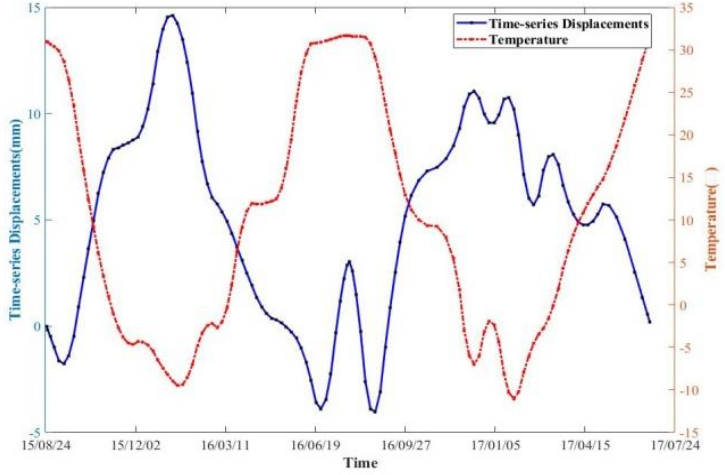


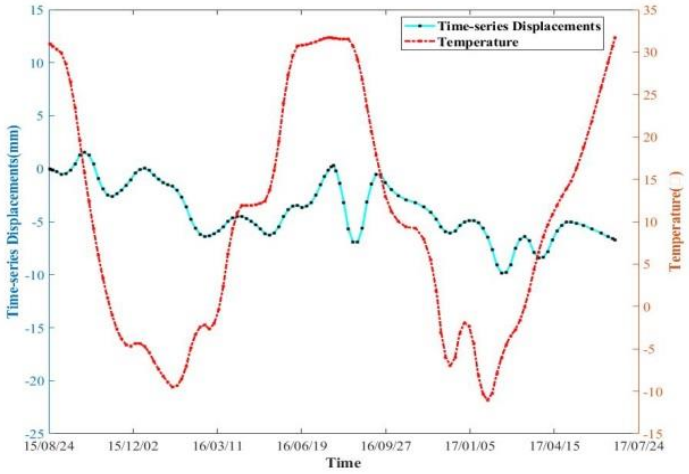


(a) Positive Correlation

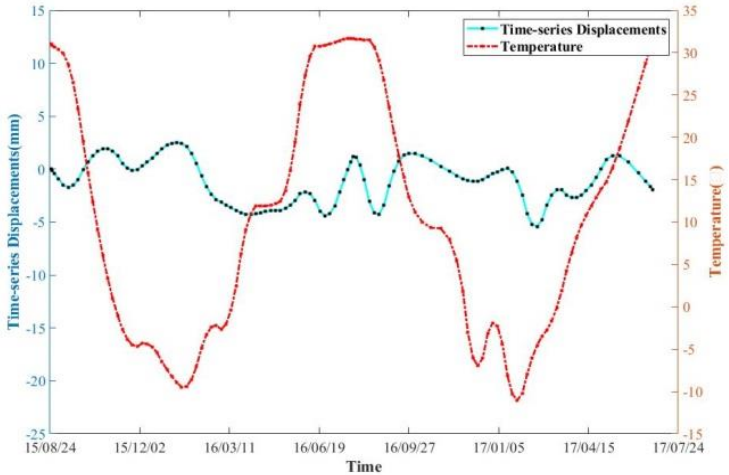


(b) Negative Correlation





(c) Linear



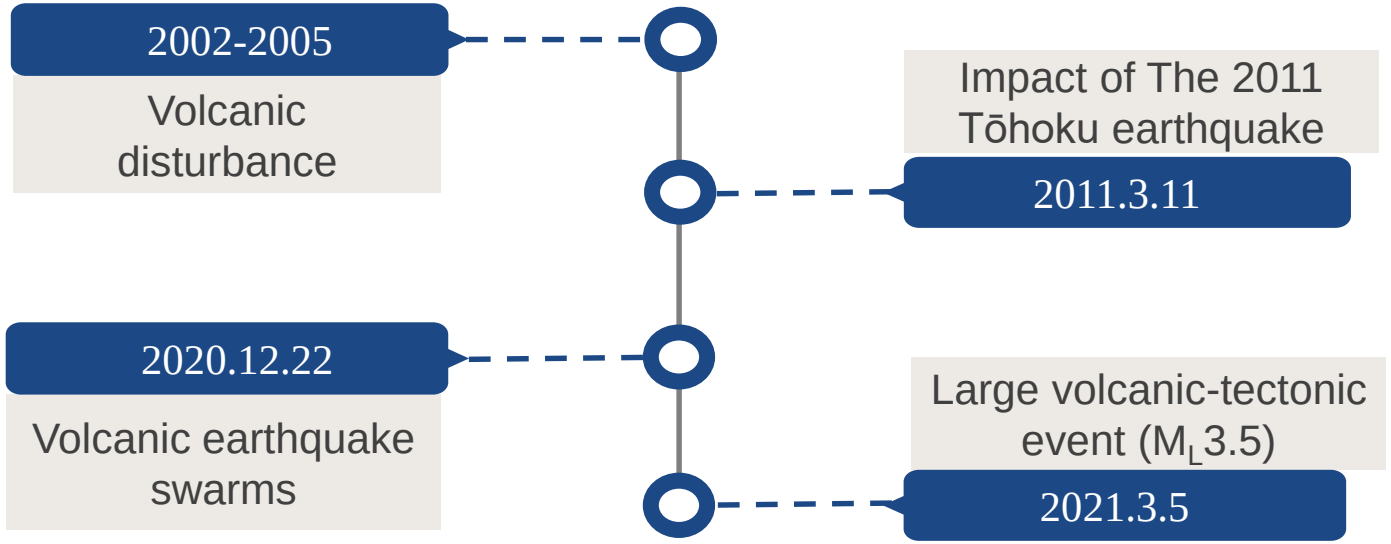
(d) Random Vibration

Preliminary results and joint publications

Recent activity of Changbaishan Tianchi Volcano

Study area

Changbaishan Tianchi volcano is the most complete Cenozoic composite volcano preserved in China. There is an annual uplift of about 4 mm close to the crater.

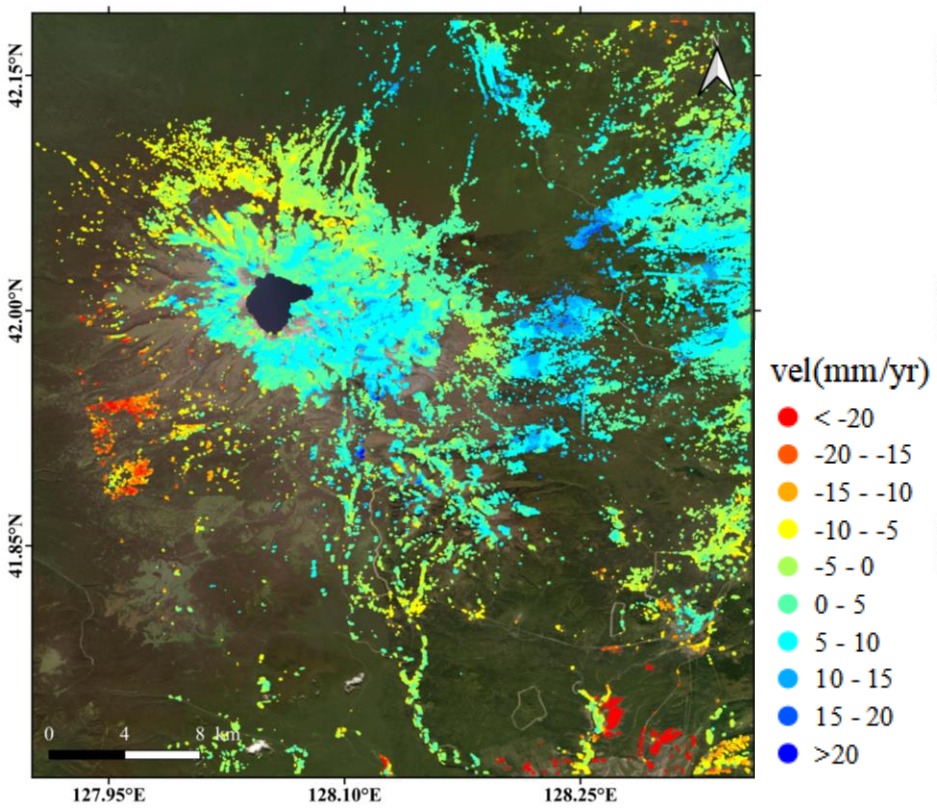


From 2002 to 2005, the Tianchi volcano has obvious magma disturbance events. On December 22, 2020, a volcanic earthquake swarms suddenly appeared on Tianchi Volcano. An earthquake of magnitude ML3.1 occurred on March 5, 2021, which was the largest structural volcanic earthquake event after the end of the volcanic disturbance period. There are 135000 Chinese and 31000 North Korean residents living within 50km of the volcano, and about 2 million tourists visit Changbaishan Volcano National Nature Reserve every year. Therefore, the dynamic monitoring of Tianchi volcano is very important to ensure the safety of these people's lives and properties.

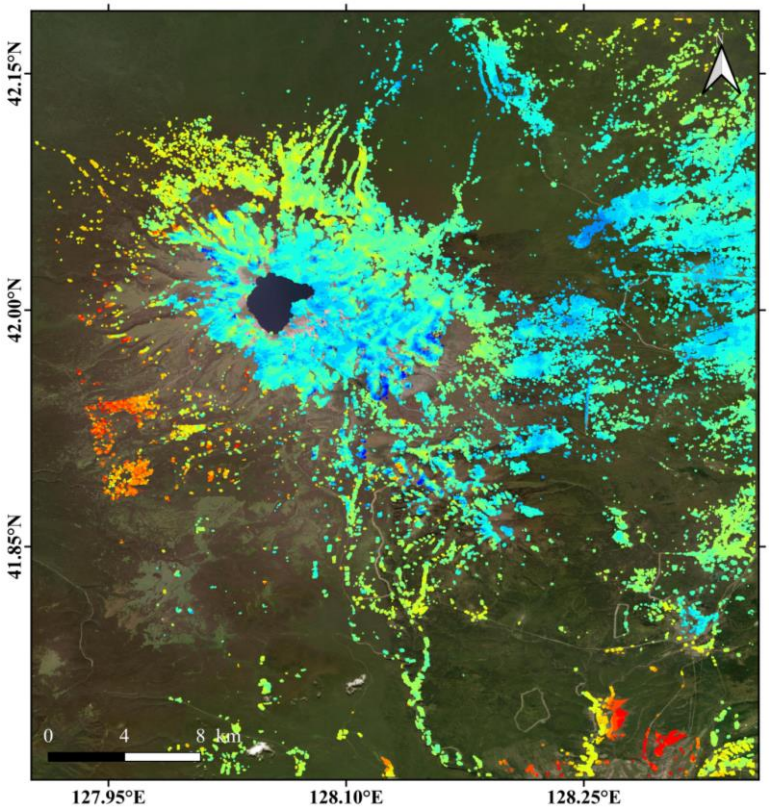
Preliminary results and joint publications

Recent activity of Changbaishan Tianchi Volcano

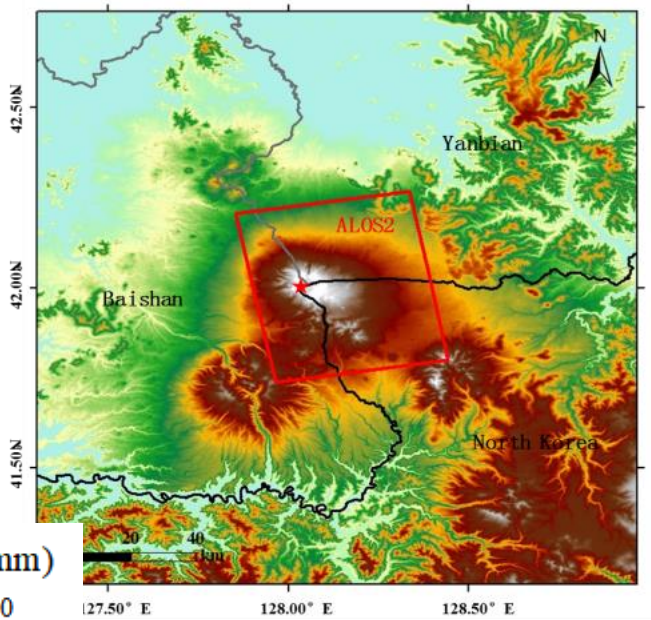
19 L-band ALOS-2 images (ascending orbit) covering the study area (right) from November 2018 to October 2020 were processed using PSI technique.



Displacement rate in LOS



Cumulative displacement in LOS

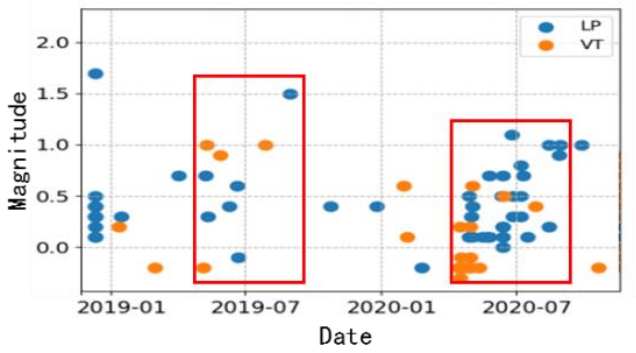


Study area

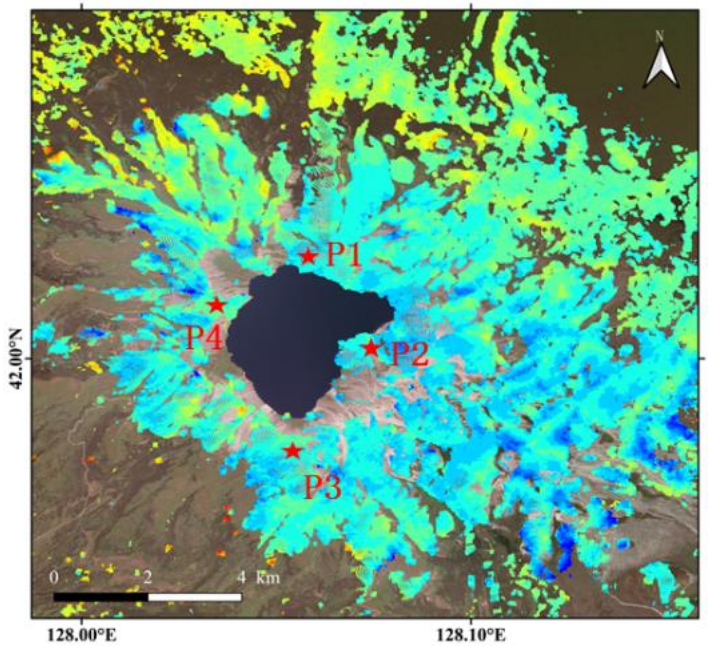
(manuscript published by Remote Sensing)

Preliminary results and joint publications

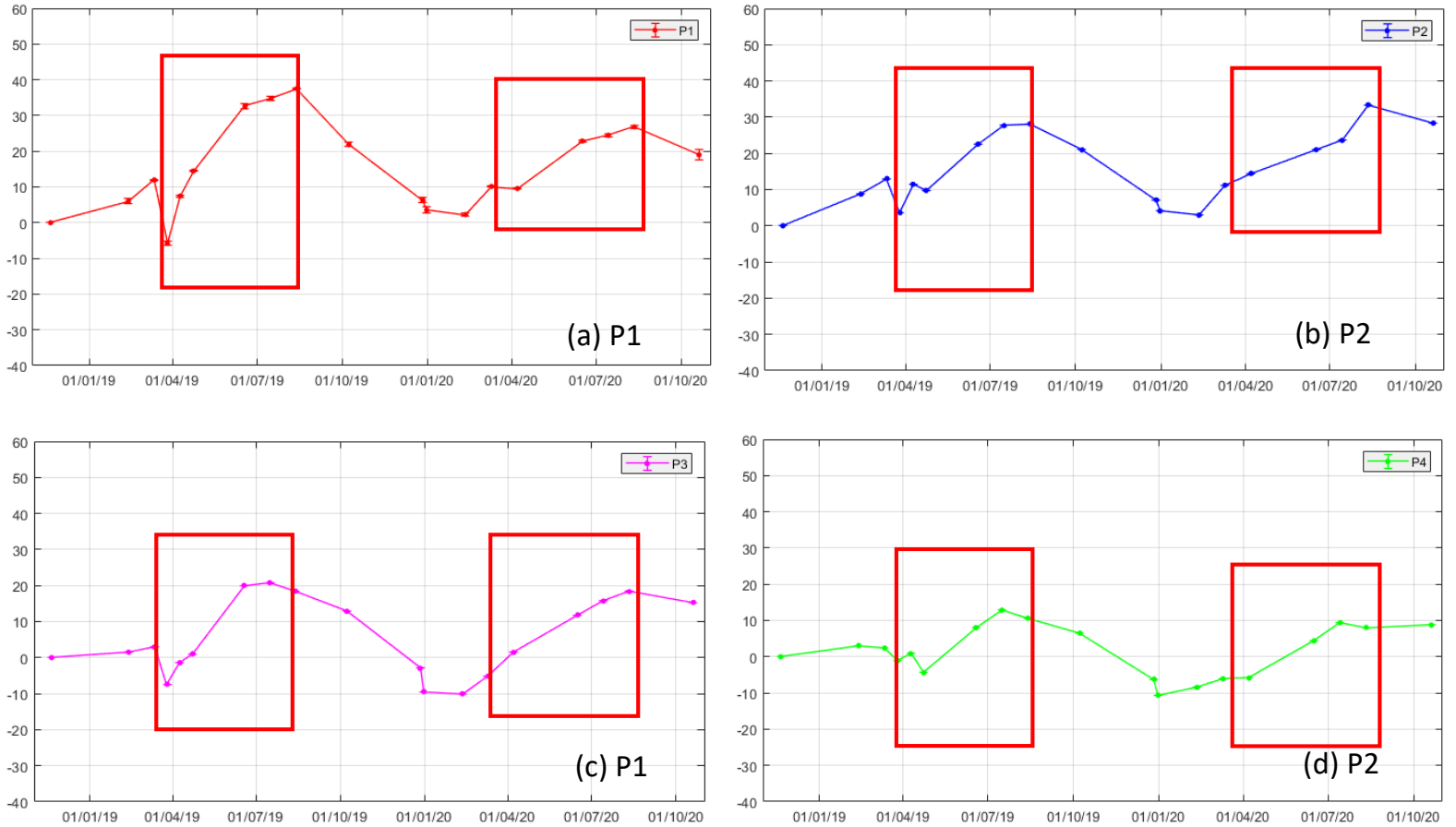
Recent activity of Changbaishan Tianchi Volcano



Seismic records



Cumulative displacement in LOS

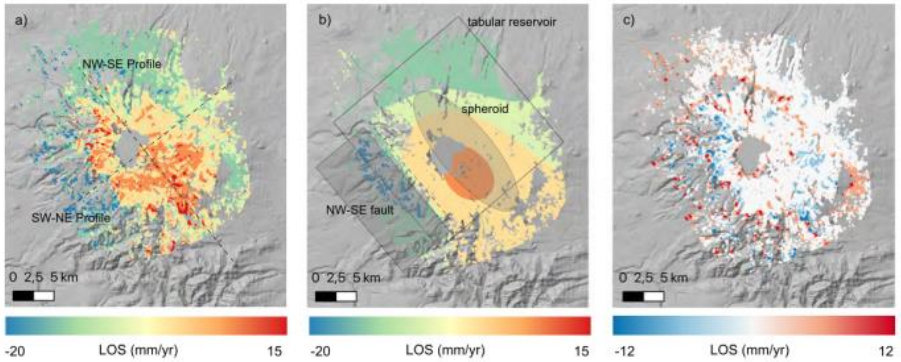


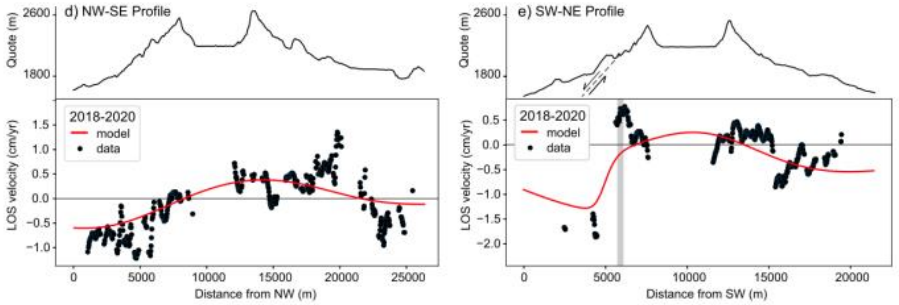
Displacement time series of P1-P4 sites in LOS

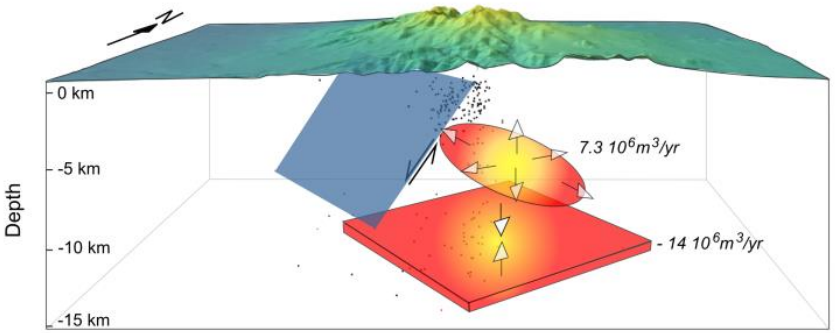
Preliminary results and joint publications

Recent activity of Changbaishan Tianchi Volcano

Geophysical Modeling



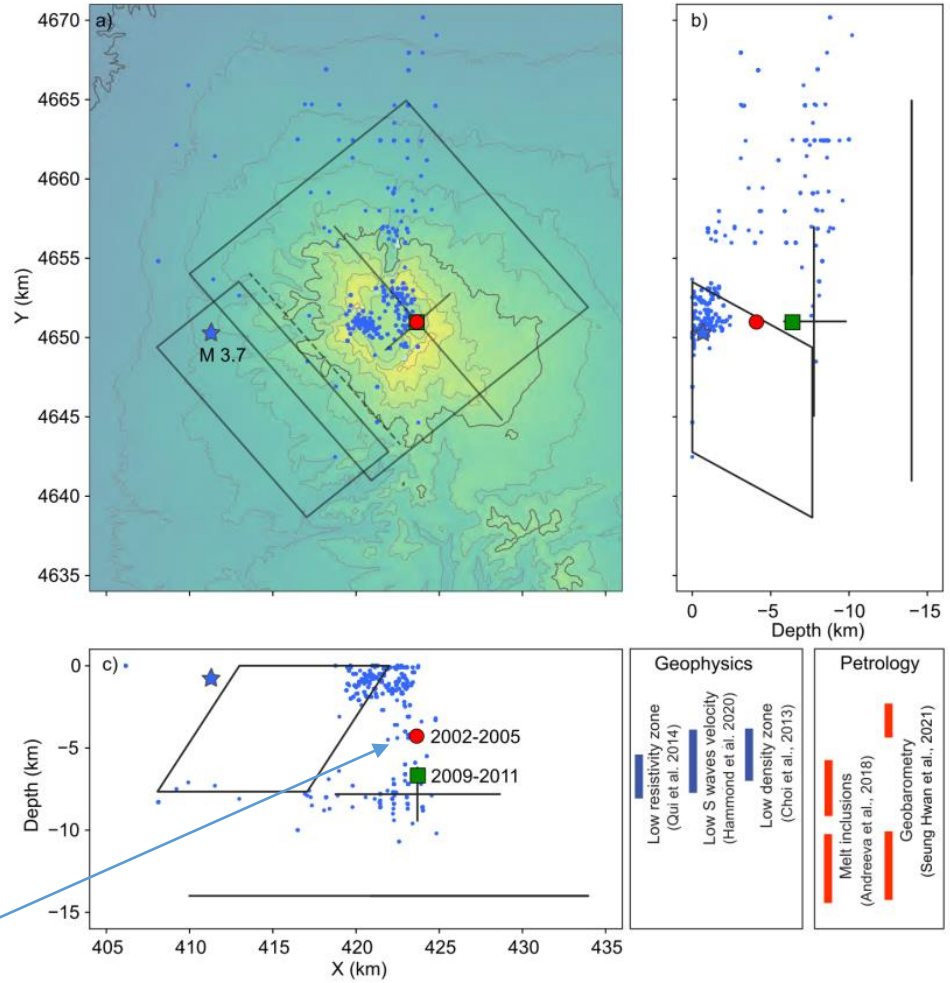




Three main sources:

- a deflating deep tabular source
- an inflating spheroid
- a dip-slip fault

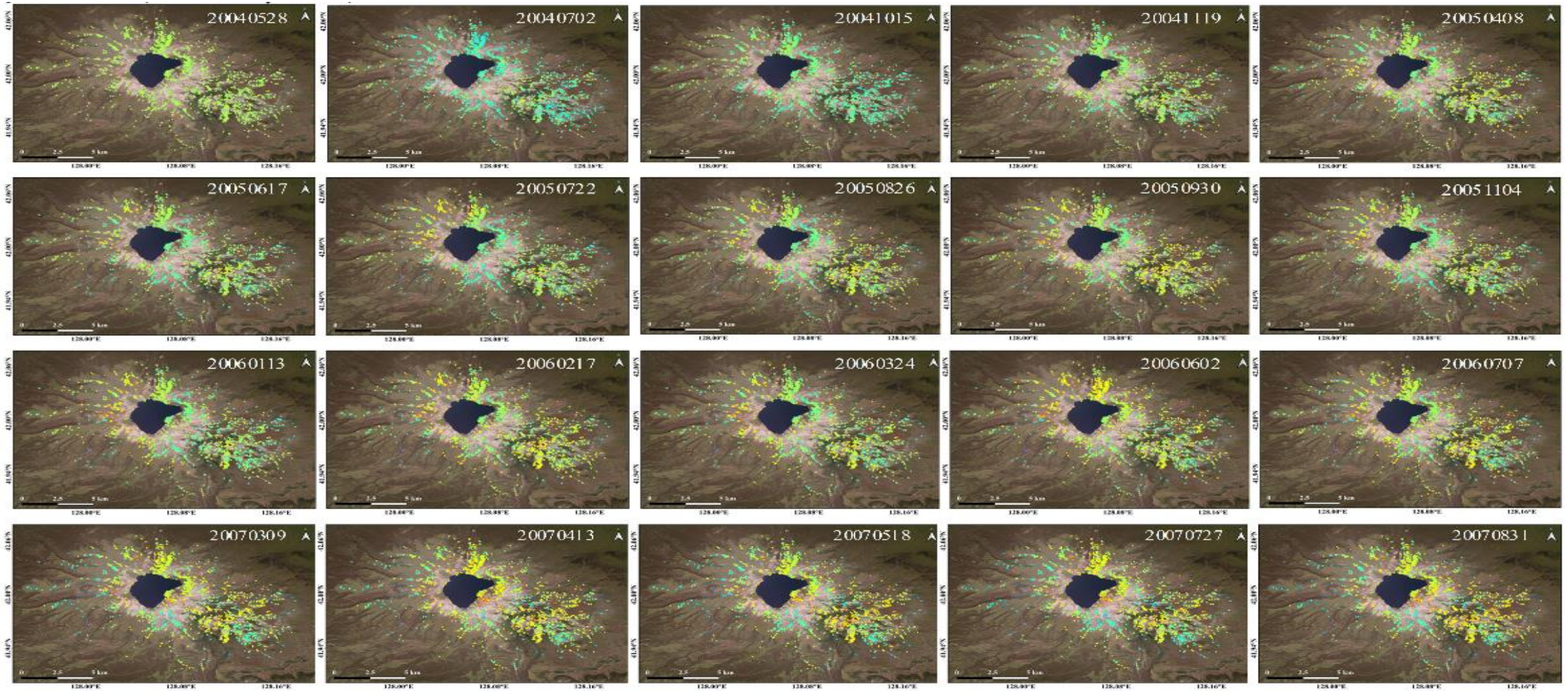
✓ **Changbaishan plumbing system is in a recharging phase with magma transfer from 14 to 7 km depth.**



Sources of the 2002-2005 uplift and 2009-2011 subsidence from levelling data

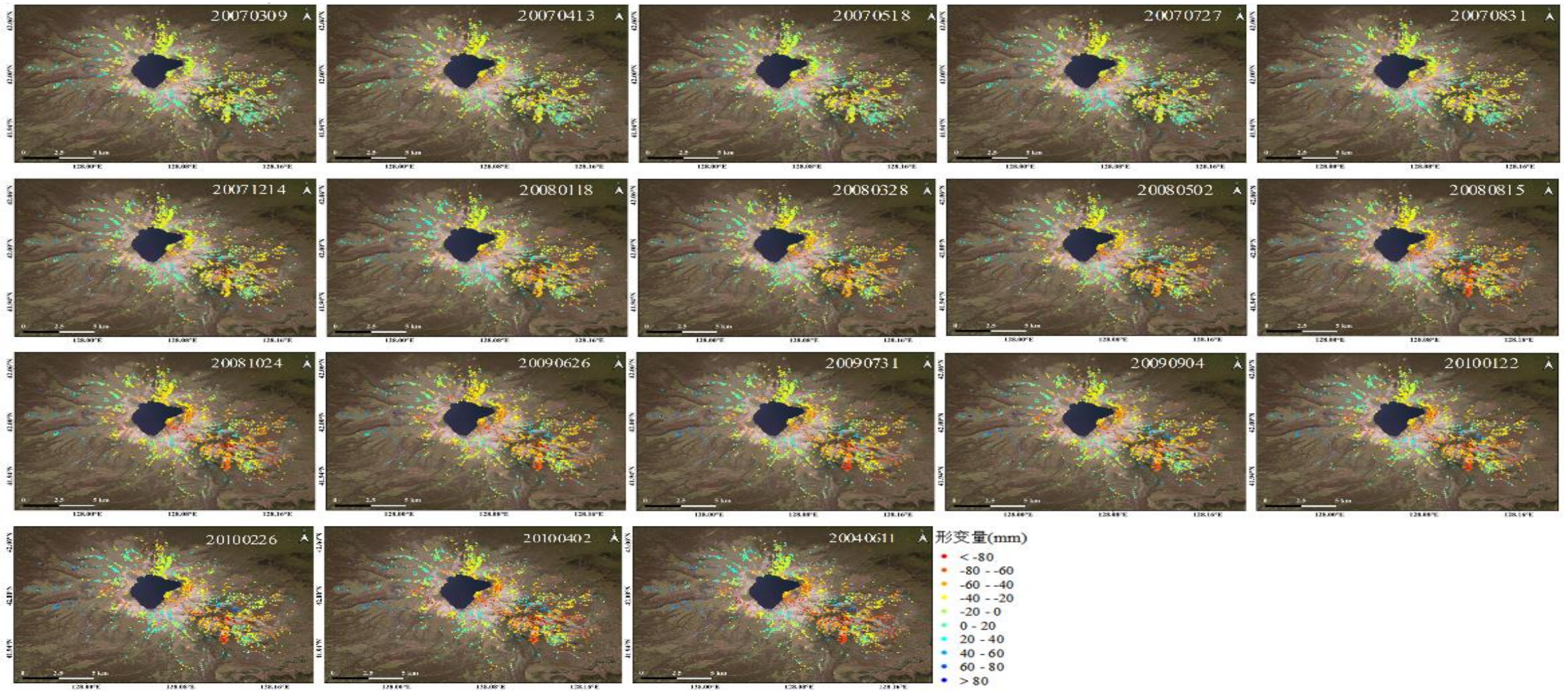
Preliminary results and joint publications

Time Series Displacements of Changbaishan during 2004 to 2010



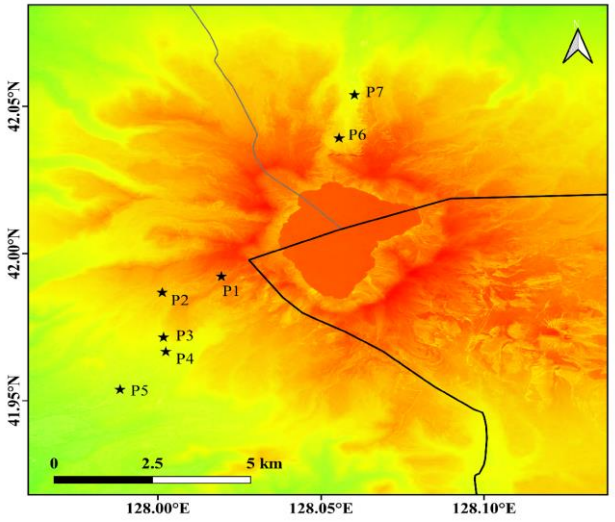
Preliminary results and joint publications

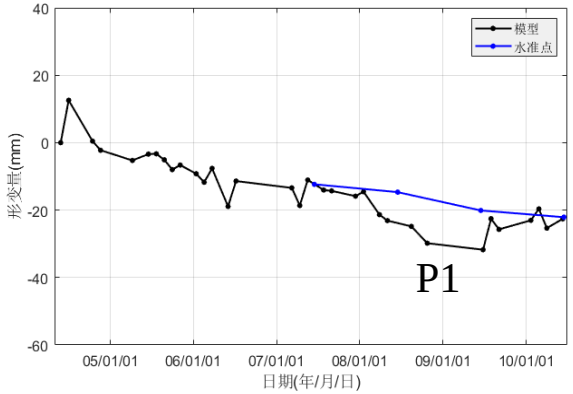
Time Series Displacements of Changbaishan during 2004 to 2010

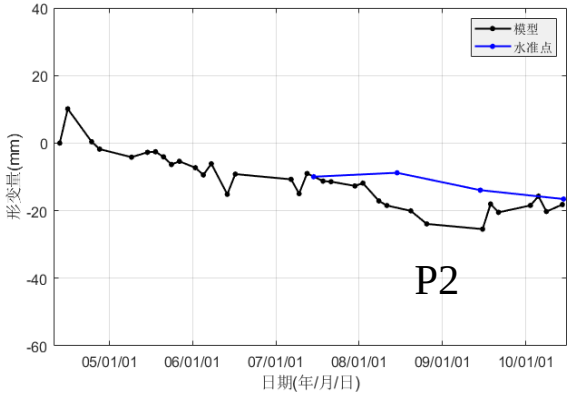


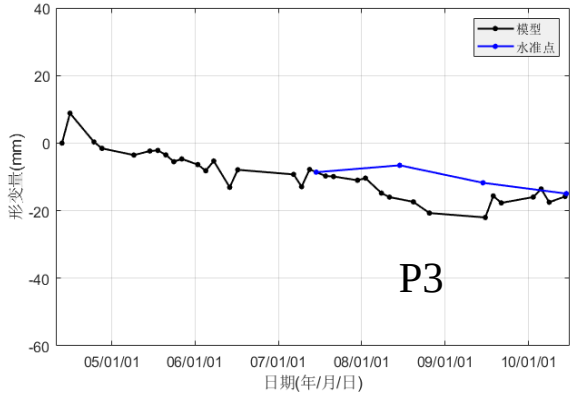
Preliminary results and joint publications

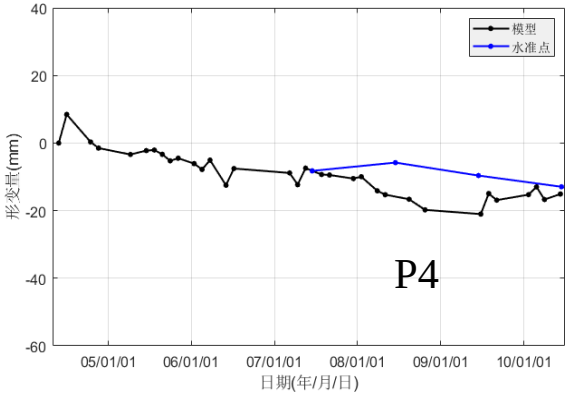
Comparison with Leveling Data

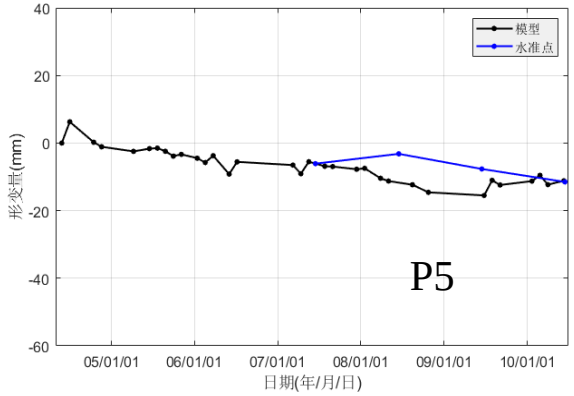


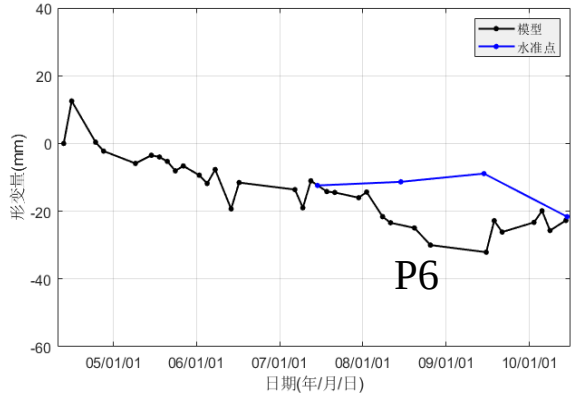












Academic activities

Online team meeting, public lectures

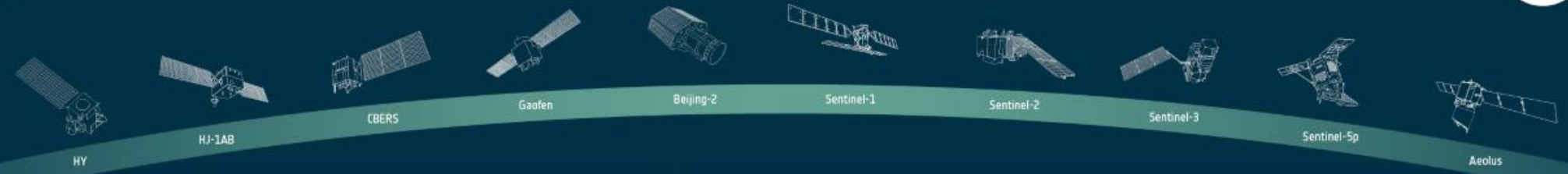
1. Online team meeting

2021-05-13
Discussion about Changbaishan on Zoom

2. Public Lectures / courses

2018-11-25
Course given by Dr. Christian Bignami

2020-09-28
Lecture given by Dr. Guido Ventura



2022 DRAGON 5 SYMPOSIUM

PROJECT ID. 58029

Thanks for your attention!

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weilianhuan@mail.neu.edu.cn