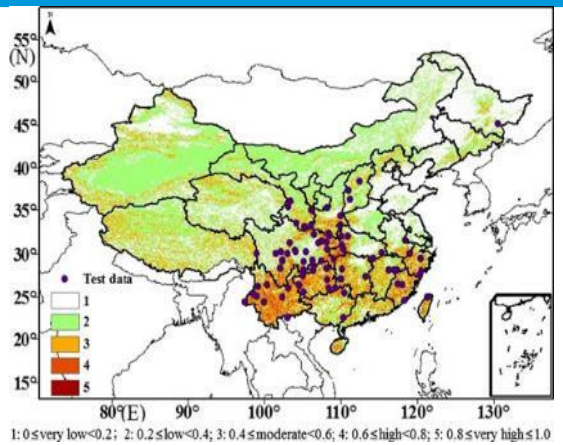

CEOS Landslide Pilot in Chinese Region:

A Recent Progress

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Iceland, 24-26 September, 2019

Overview

- **Landslide map of China (01-2019 to 08-2019)**
- Available data of the landslide-prone region in China
- Methods for the landslide disaster detection
- Equipment for validation
- Pilot Objectives

Pilot Region: SW China

Pilot Region: SW China

Active earthquake & Landslide-prone region

Landslide map of China (01-2019 to 08-2019)

Pilot Region: SW China

Active earthquake & Landslide-prone region

Landslide Triggers:

- Earthquakes
- Rainstorms

Landslide information are collected from the internet

Landslide in Shuicheng, Liupanshui, Guizhou

- Date: 23-7-2019
- Trigger: Heavy rain
- The landslide has a volume of about 20 cubic kilometers, a depth of 500 to 800 m, a travel distance of 1.1 km
- Death toll is 42, 9 missing.

23 houses buried

Rescuers are searching for the survivors

Shui Cheng, Liupanshui, Guizhou

Landslides in Yibin, Sichuan

- Date: 17-6-2019
- Trigger: 6.0 magnitude earthquake in Yibin, Sichuan

Landslide in Yongjia, Wenzhou, Zhejiang

- Date: 10-8-2019
- Triggers: Typhoon “Lekima” and Heavy Rain
- Death toll is 23, 9 missing

Landslide→Barrier Lake → Flood

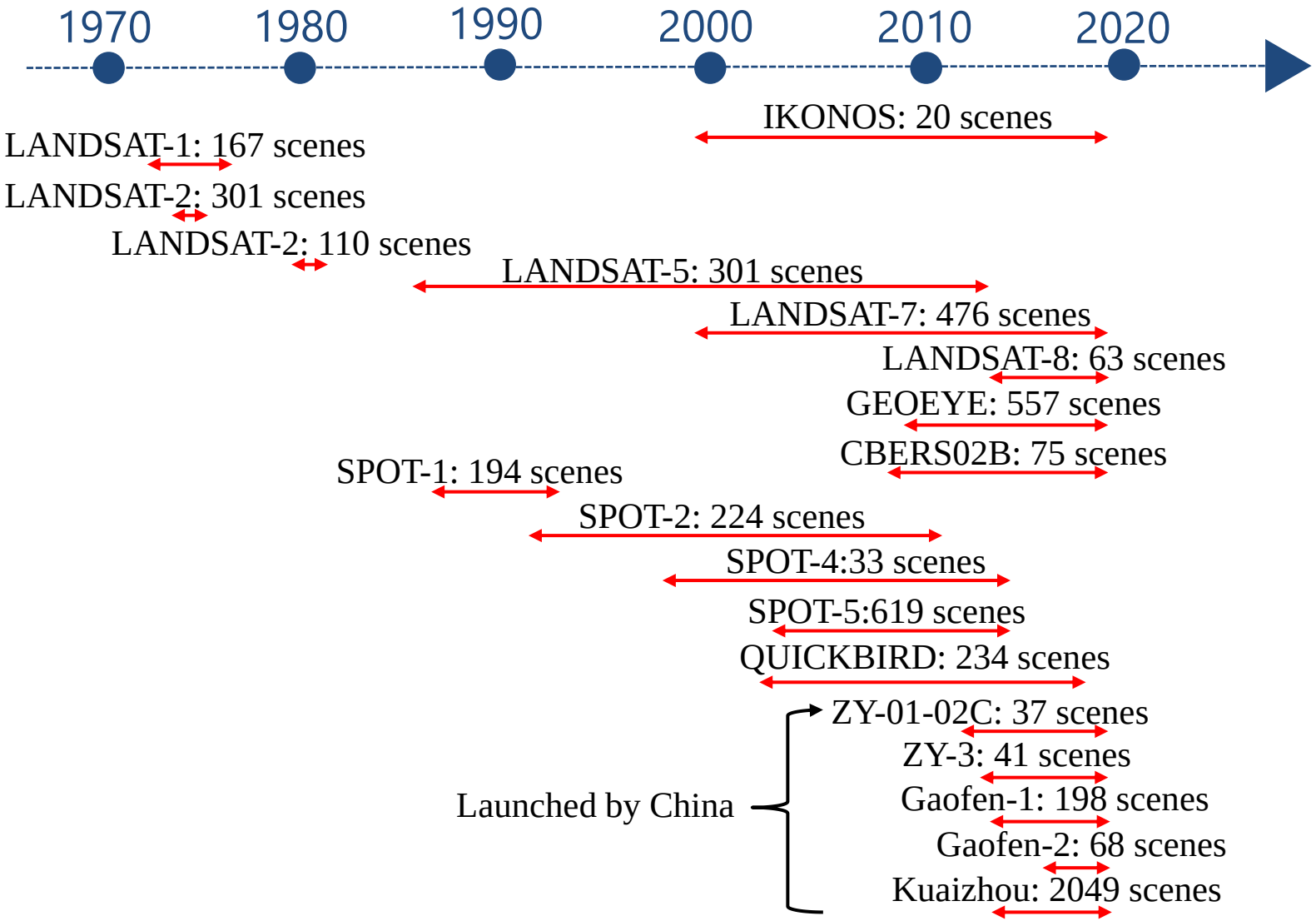
Yongjia, Wenzhou, Zhejiang

Overview

- Landslide map in China (01-2019 to 08-2019)
- **Available data of the landslide-prone region in China**
- Methods for the landslide disaster detection
- Equipment for validation
- Pilot Objectives

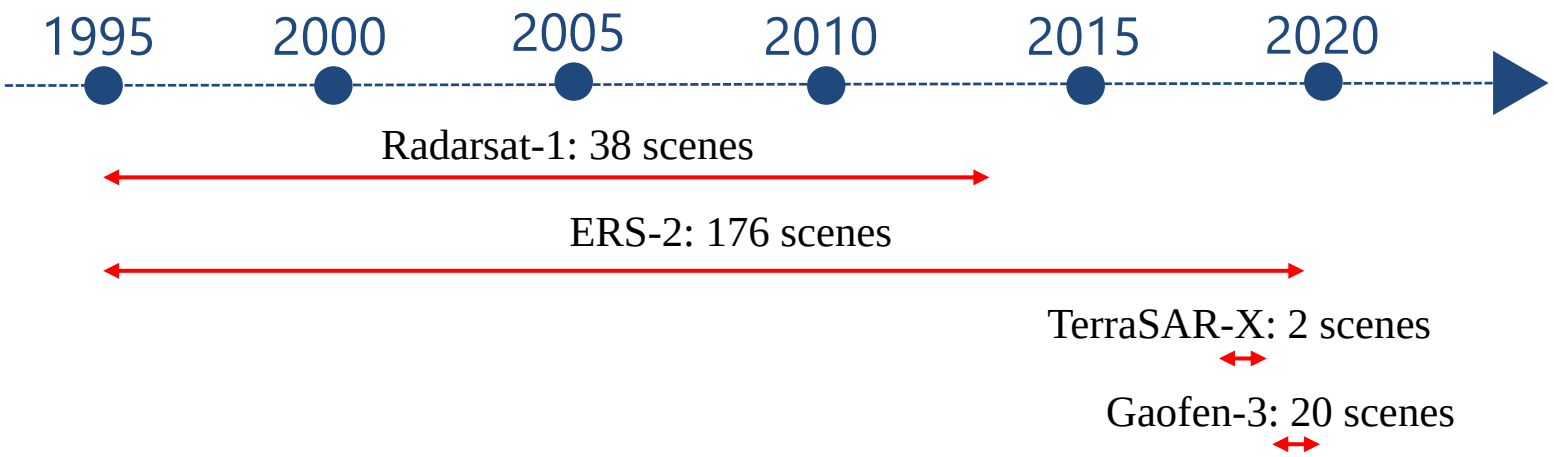
Optical Images

- 5808 Optical Images in Group's Dataset in Total



SAR Images

- 236 SAR Images in Group's Dataset in Total



- SAR Images from open database

Gaofen-3

- **Gaofen Project**
  - Supported by the government of China;
  - Aiming to develop a high-spectral resolution earth observation system by Year 2020.
- **Gaofen-3 satellite**
  - Launched on 10 August 2016 by the China Academy of Space Technology (CAST), in operation since January, 2017;
  - With a C-band SAR sensor;
  - Sun-synchronous dusk-dawn orbit at 755 km in altitude;
  - 12 different working modes: from high-resolution (1 m) to extremely-wide-swath (650 km), from single to full polarization;
  - Site access time: 3.5 days at most (1.5 day at 90% probability)

Gaofen-3

The Gaofen-3 data coverage map in China

11

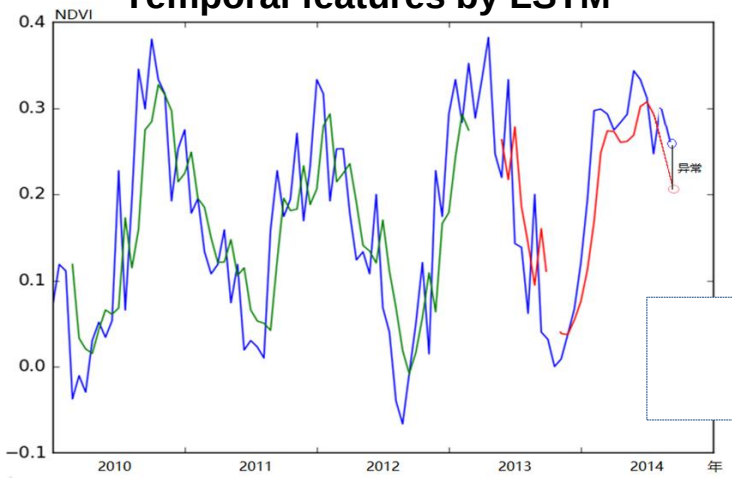
Overview

- Landslide map in China (01-2019 to 08-2019)
- Available data of the landslide-prone region in China
- **Methods for the landslide disaster detection**
- Equipment for validation
- Pilot Objectives

Landslide disaster detection by optical image

Features and models:

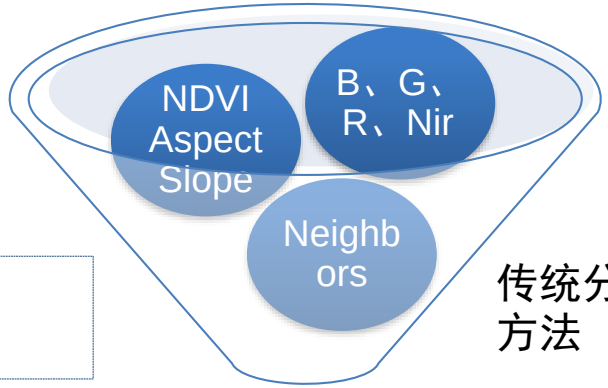
Temporal features by LSTM



+

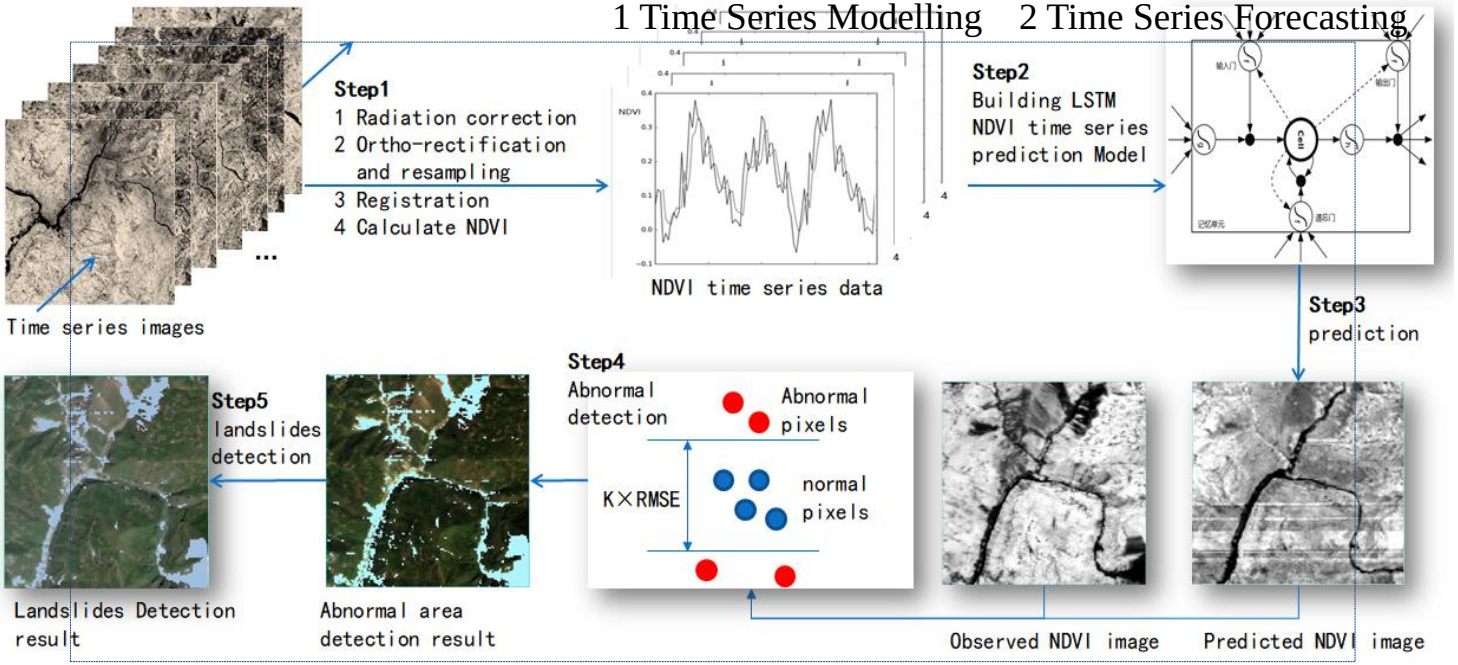
Temporal & Spectral features

Spectral features by SVM



传统分类方法

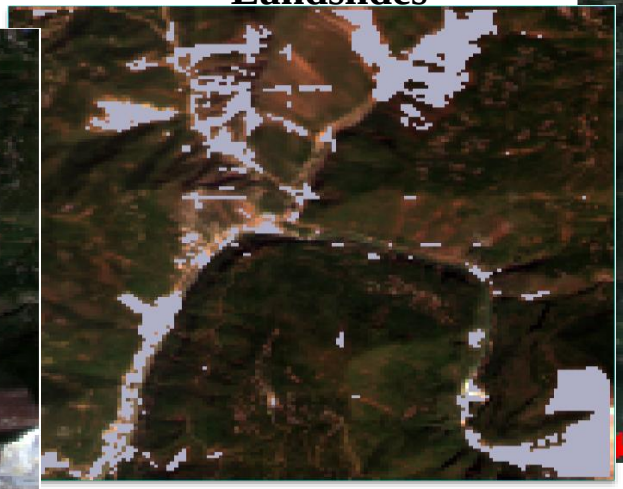
Method:



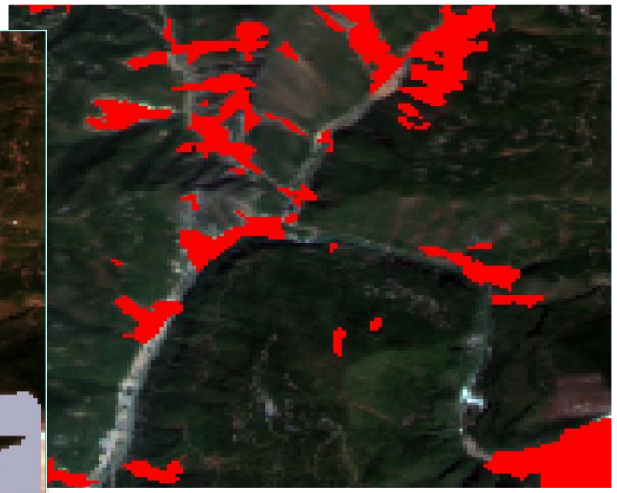
Landslide disaster detection by optical image

New available optical image
Gaofen-1 CCD, 11/09/2014

Automatically Detected Landslides



Visually Interpreted Landslides



C_{rate}	TP	TN	FP	FN	Precision	Detection rate	Accuracy
>=0.15	**1880**	**18399**	**1800**	**421**	51.09%	**81.70%**	**90.12%**
>=0.25	**1699**	**19564**	**635**	**602**	72.79%	**73.84%**	**94.50%**
>=0.35	**1576**	**19620**	**579**	**725**	73.13%	**68.49%**	**94.20%**
>=0.45	**1433**	**19677**	**522**	**868**	73.30%	**62.28%**	**93.82%**

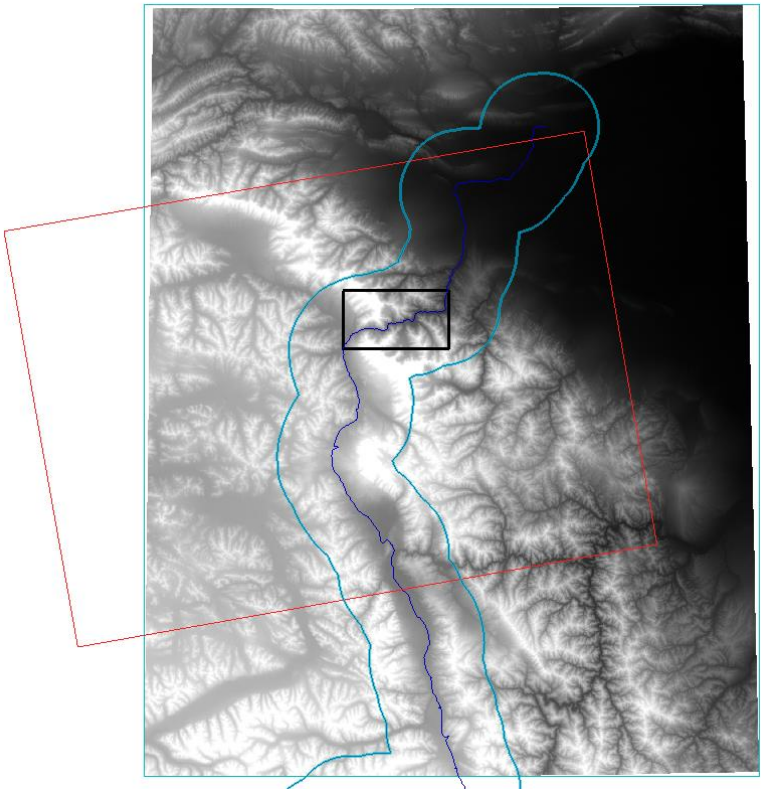
Change Rate: $C_{rate} = \frac{NDVI_{predict} - NDVI_{observed}}{NDVI_{predict}}$

Precision = TP/(TP+FP)
Detection Rate = TP/(TP+FN)
Accuracy = (TP+TN)/(TP+TN+FP+FN)

Landslide disaster detection by SAR image

- Data used

SAR images：Sentinel-1A IW mode, SLC(single-look complex) format.



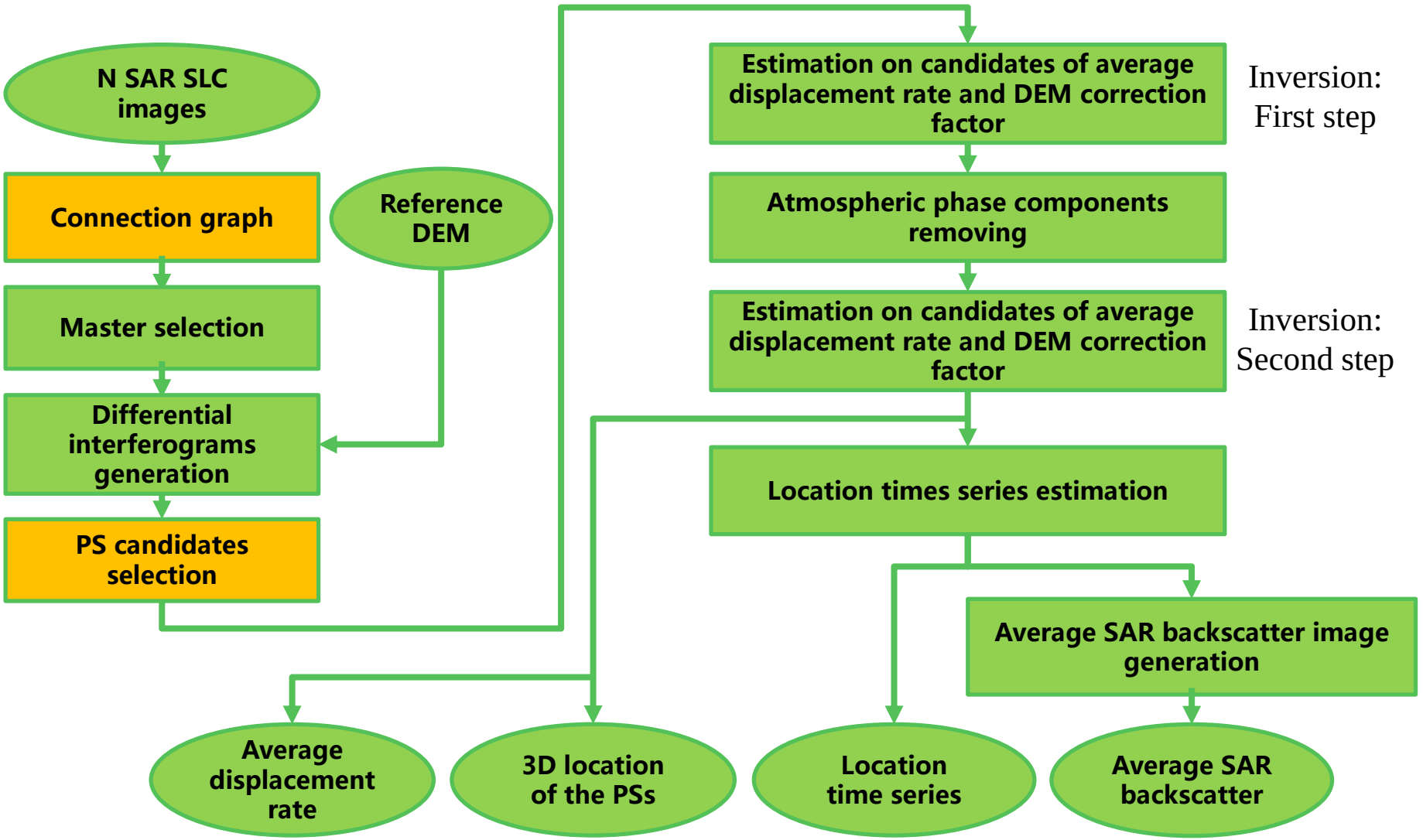
Background image: DEM data
Red box: coverage of S1A image
Blue curves: buffer area of the study region
Black box: Region of Interest(ROI), used for InSAR processing
Lat: 74°58’ E-75°30’E
Lon: 38°40’N-38°53’N

Acquisition dates of S1A SAR images used for InSAR processing
(30 scenes in total)

20150405	20150523	20150710	20150827	20151002
20151119	20160106	20160223	20160411	20160529
20160716	20160902	20161020	20161207	20170124
20170313	20170430	20170605	20170723	20170909
20171027	20171214	20180131	20180320	20180507
20180624	20180811	20180928	20181103	20181209

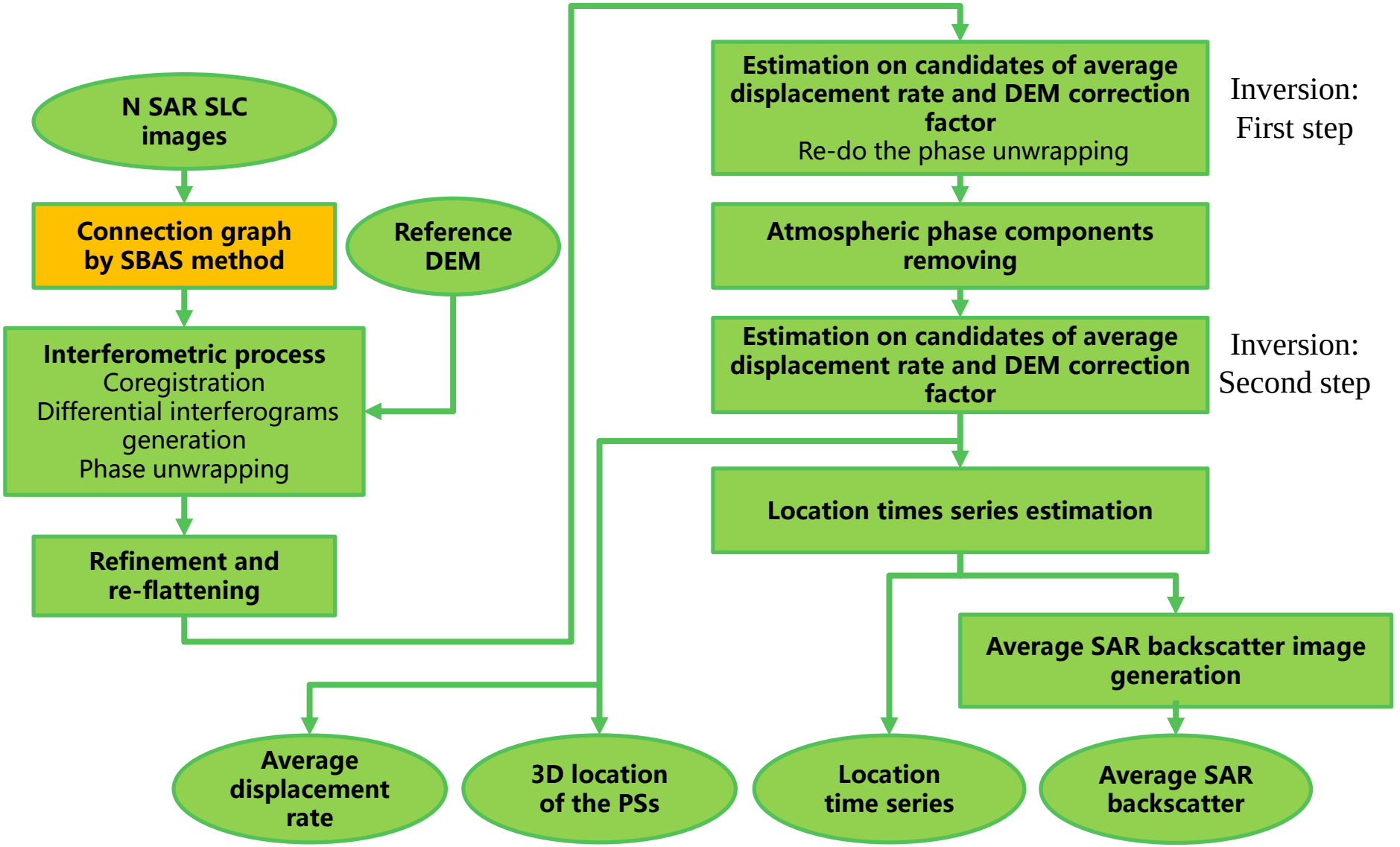
Landslide disaster detection by SAR image

- PS-InSAR processing flow chart (PS: Permanent Scatterers)



Landslide disaster detection by SAR image

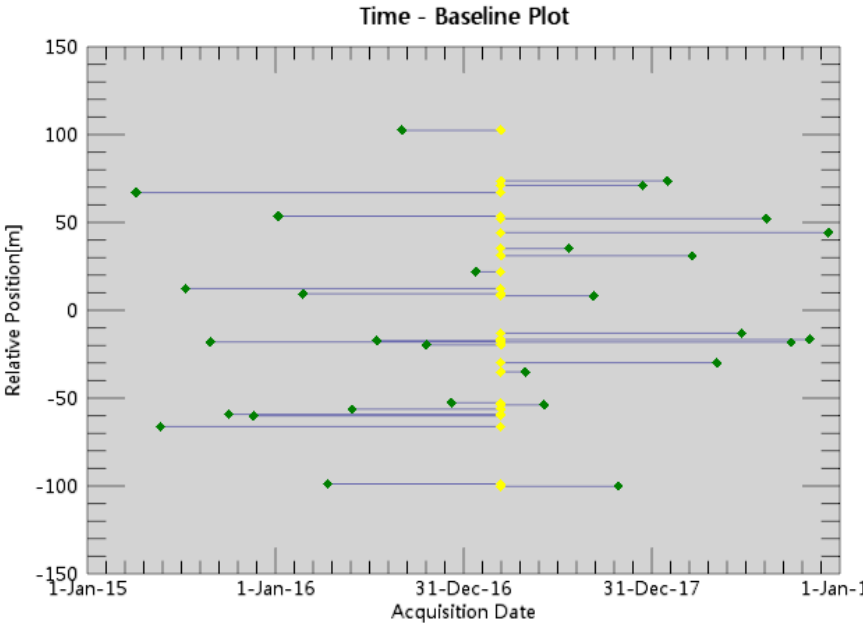
- SBAS-InSAR processing flow chart (SBAS: Small Baseline)



Landslide disaster detection by SAR image

- Connection graphs: PS-InSAR *vs*. SBAS-InSAR

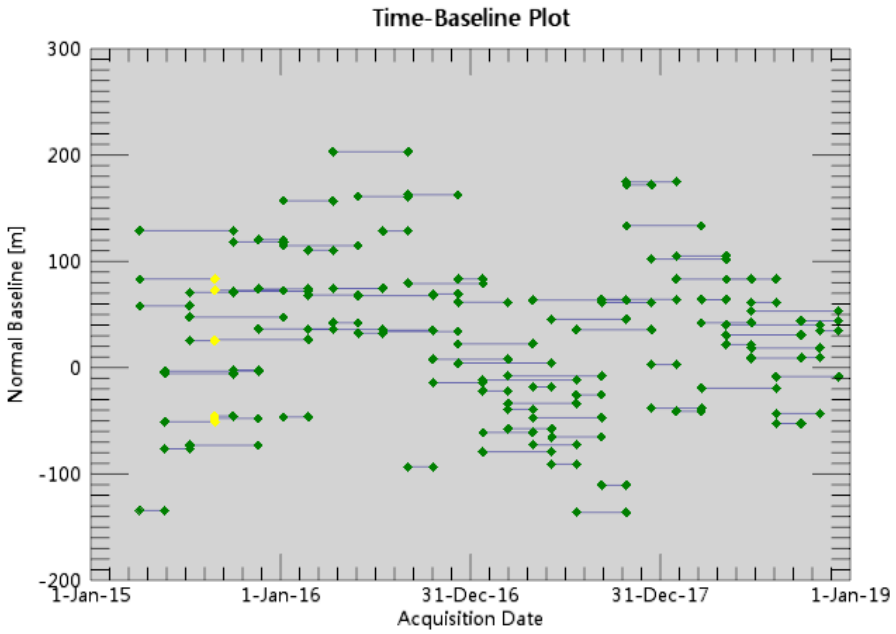
① PS-InSAR (30 scenes used)



Master image: 2017.03.13

InSAR image pairs: 29

② SBAS-InSAR (30 scenes used)

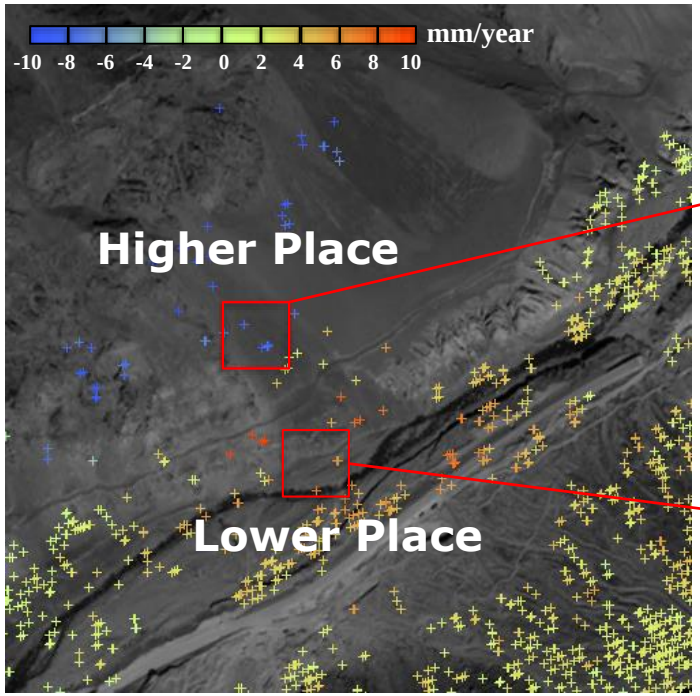


Super master image: 2015.08.27

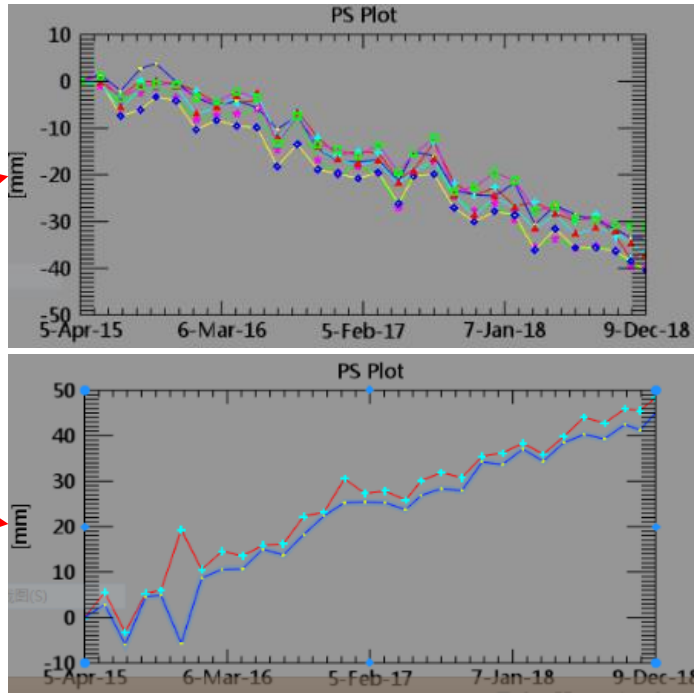
InSAR image pairs: 94

Landslide disaster detection by SAR image

- PS-InSAR processing result



The mapping of PS points

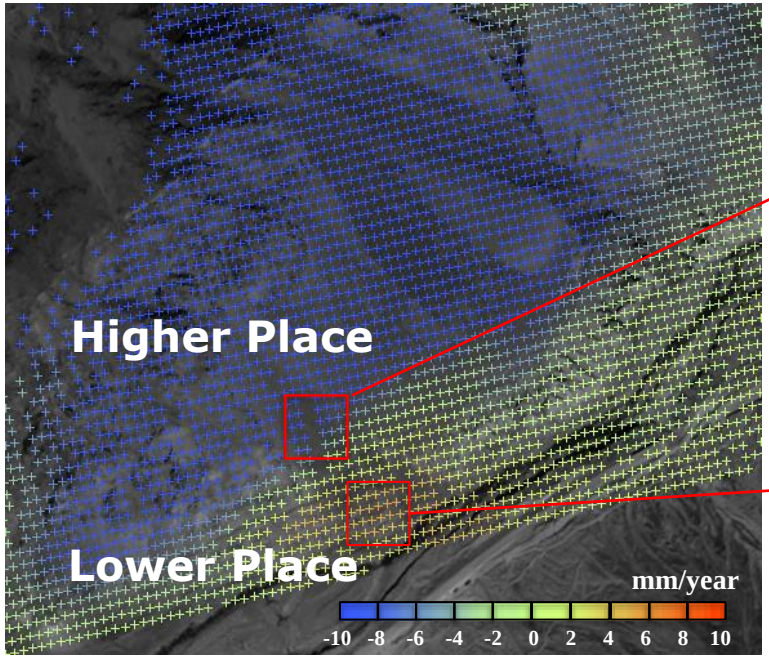


Surface deformation history extracted by PS method

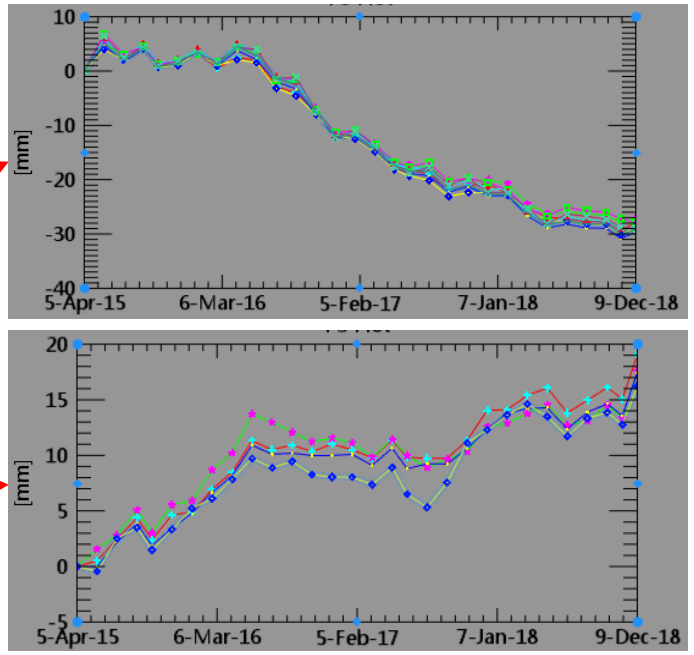
Area of interest: surface elevation descending and ascending both happened in the same period, which is close to the feature of landslide.

Landslide disaster detection by SAR image

- SBAS-InSAR processing result



Dot matrix of SBAS-InSAR processing result



Surface deformation history extracted by SBAS method

Result obtained by SBAS-InSAR is similar to the result obtained by PS-InSAR, in view of their trends.

Overview

- Landslide map in China (01-2019 to 08-2019)
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- **Equipment for validation**
- Pilot Objectives

Topographic Deformation Monitor

- **A new Topographic Deformation Monitor:**

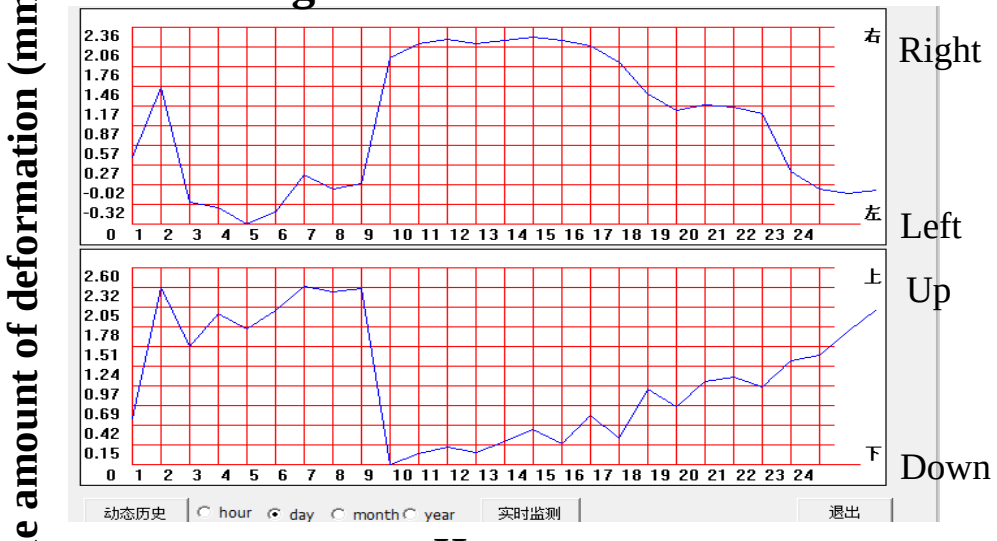
Based on the basic theory of photogrammetry, which has proven to be an effective tool to monitor the displacement and deformation caused by geological disasters.

The 1st generation

The 2nd generation

Installment

Monitoring results

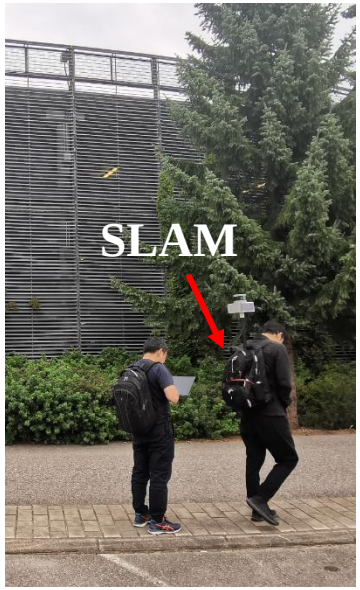


- The changes of targets per hour can be observed from 4 directions.
- The instrument has been working for about 14 months, from July, 2018.

SLAM

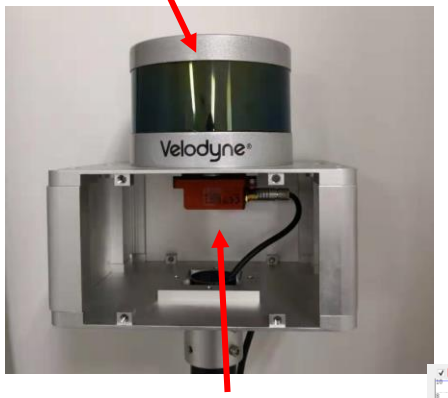
- **Simultaneous localization and mapping (SLAM) technology：**

Constructing or updating a map of an unknown environment while simultaneously keeping track of an agent's location within it.



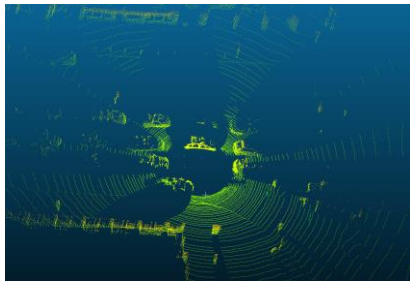
Outdoor mobile mapping experiment

LiDAR



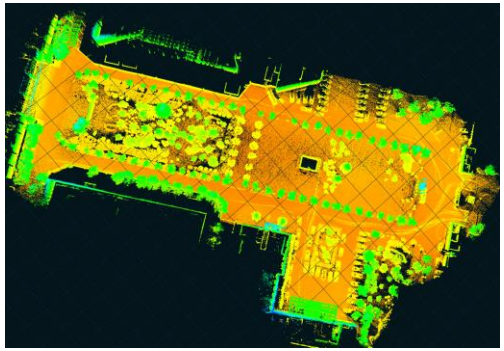
IMU (Inertial Measurement Unit)

Point cloud



SLAM

map



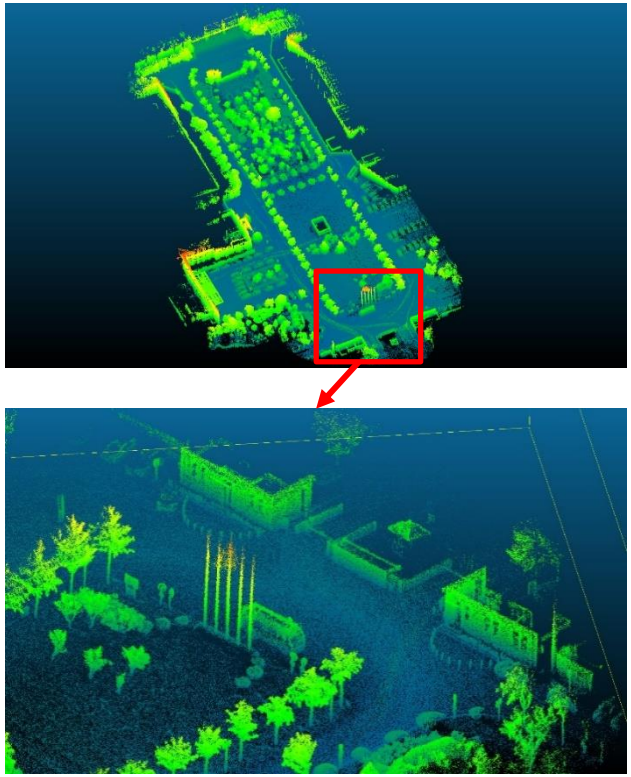
Inertial data

location

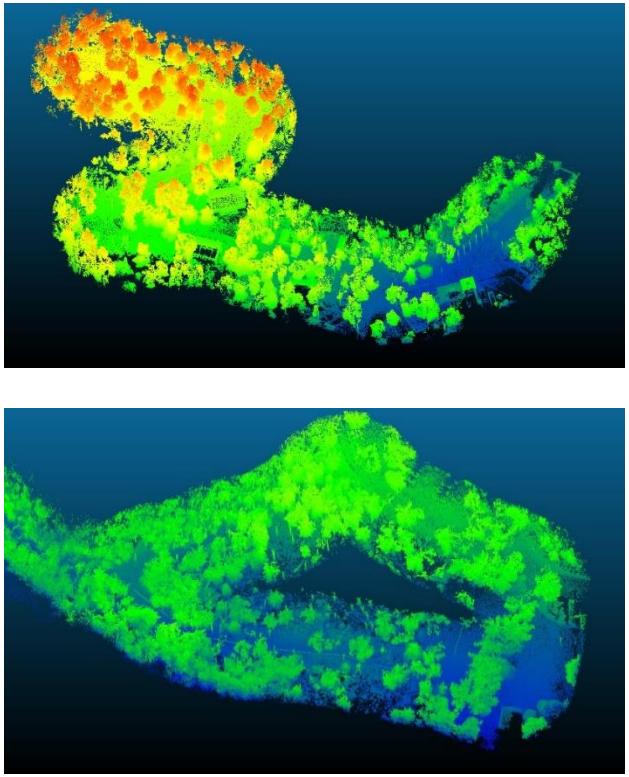
SLAM

Outdoor mobile mapping without GNSS, applying for Digital City, Terrain Mapping, Precision Forestry, autonomous UAV/UGV, et al. The drift error is around 0.3%.

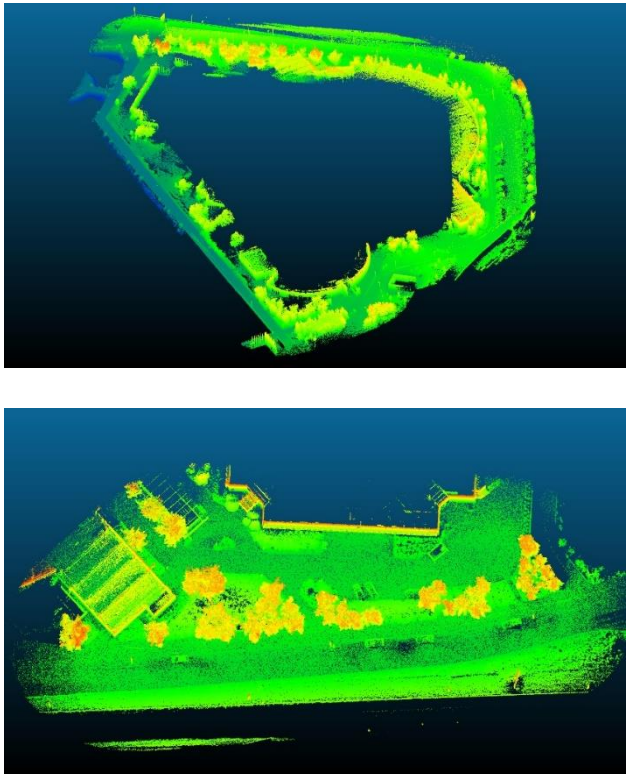
Park of Academy of Opto-Electronics



Nordic Forest in Finland



Outside Environment of Microsoft building (Finland)



Overview

- Landslide map in China (01-2019 to 08-2019)
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- **Pilot Objectives**

Pilot Objectives

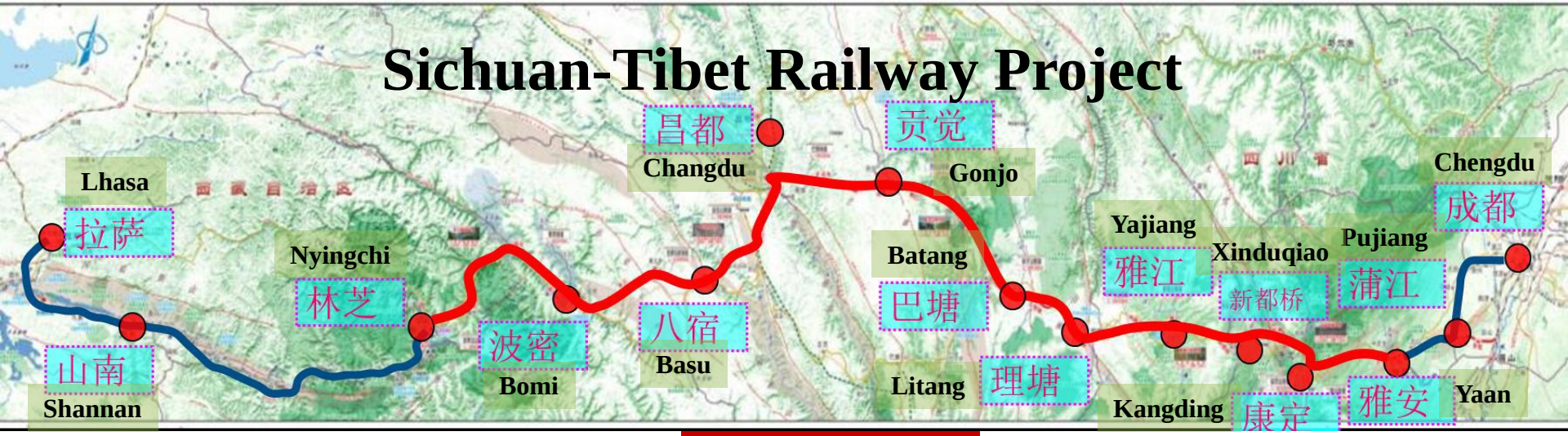
– **Objective A:**

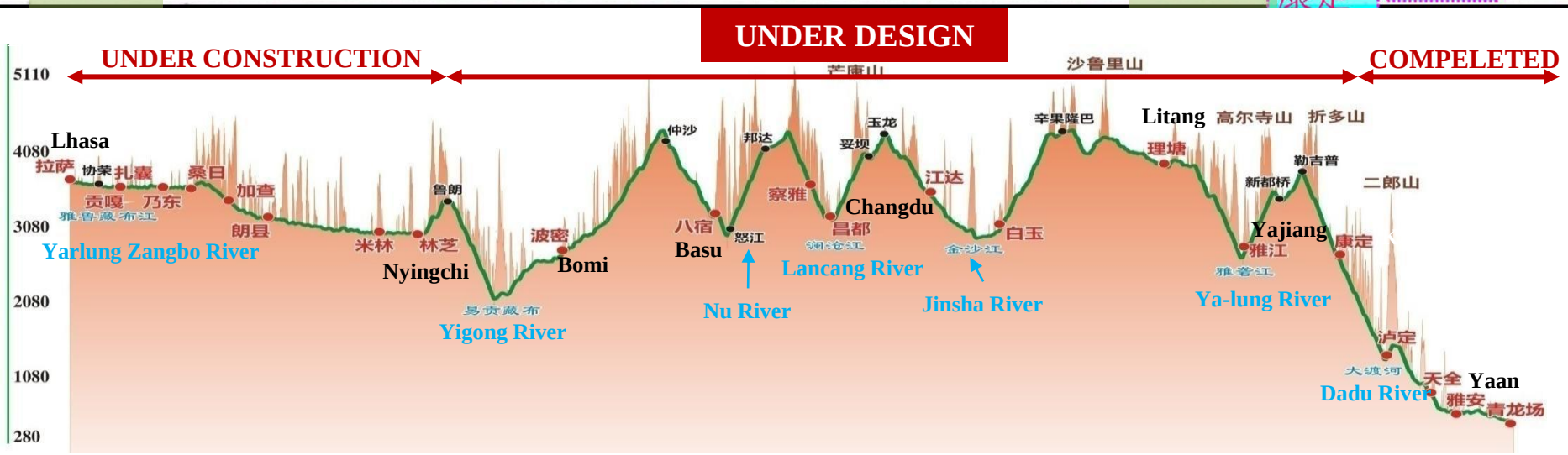
– Develop effective methodologies for the landslide risk management of Sichuan-Tibet Railway.

Sichuan-Tibet Railway Project

- Key project for China's 13th Five-Year Plan from 2016 to 2020, planned to be finished by Year 2030;
- The railway will connect Chengdu, Sichuan and Lhasa, Tibet;
- The second railway into southwest China's Tibet Autonomous Region after the Qinghai-Tibet Railway;

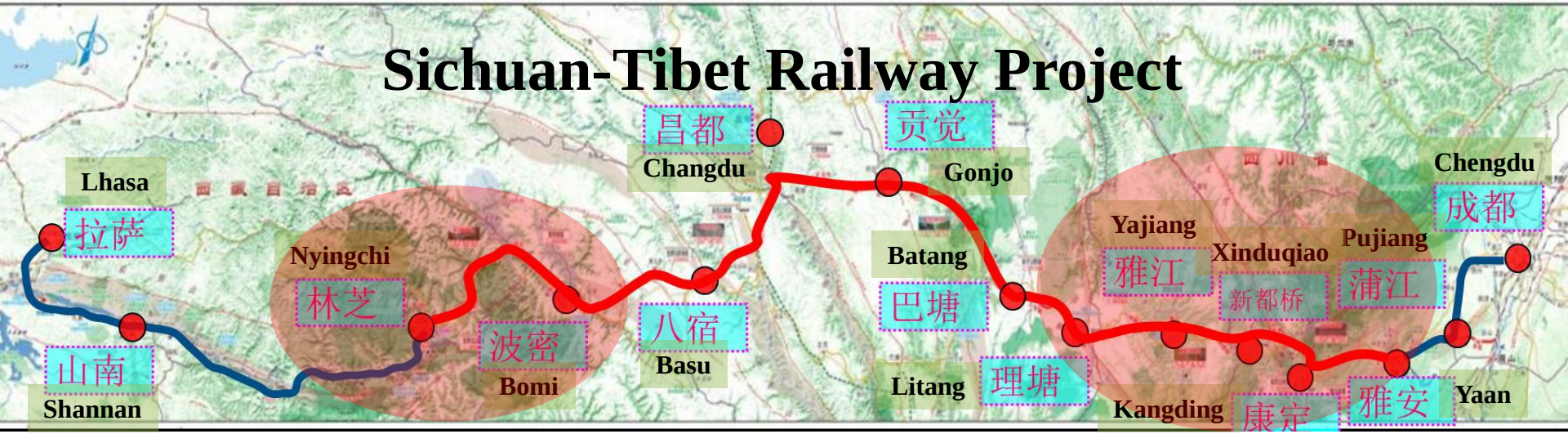
Sichuan-Tibet Railway Project





- Covering a distance of **1,543 kilometers**, the Sichuan-Tibet railway consists of three sections from east to west, **including Chegndu-Kangding, Kangting-Nyingchi and Nyingchi-Lhasa;**
- The Section from Kangding to Nyingchi, which is the most difficult and the longest section, is still under design.

Sichuan-Tibet Railway Project



The Sichuan-Tibet Railway has four major environmental characteristics:

- Significant terrain elevation differences
- Strong plate activities
- Frequent mountain disasters
- Sensitive ecological environment

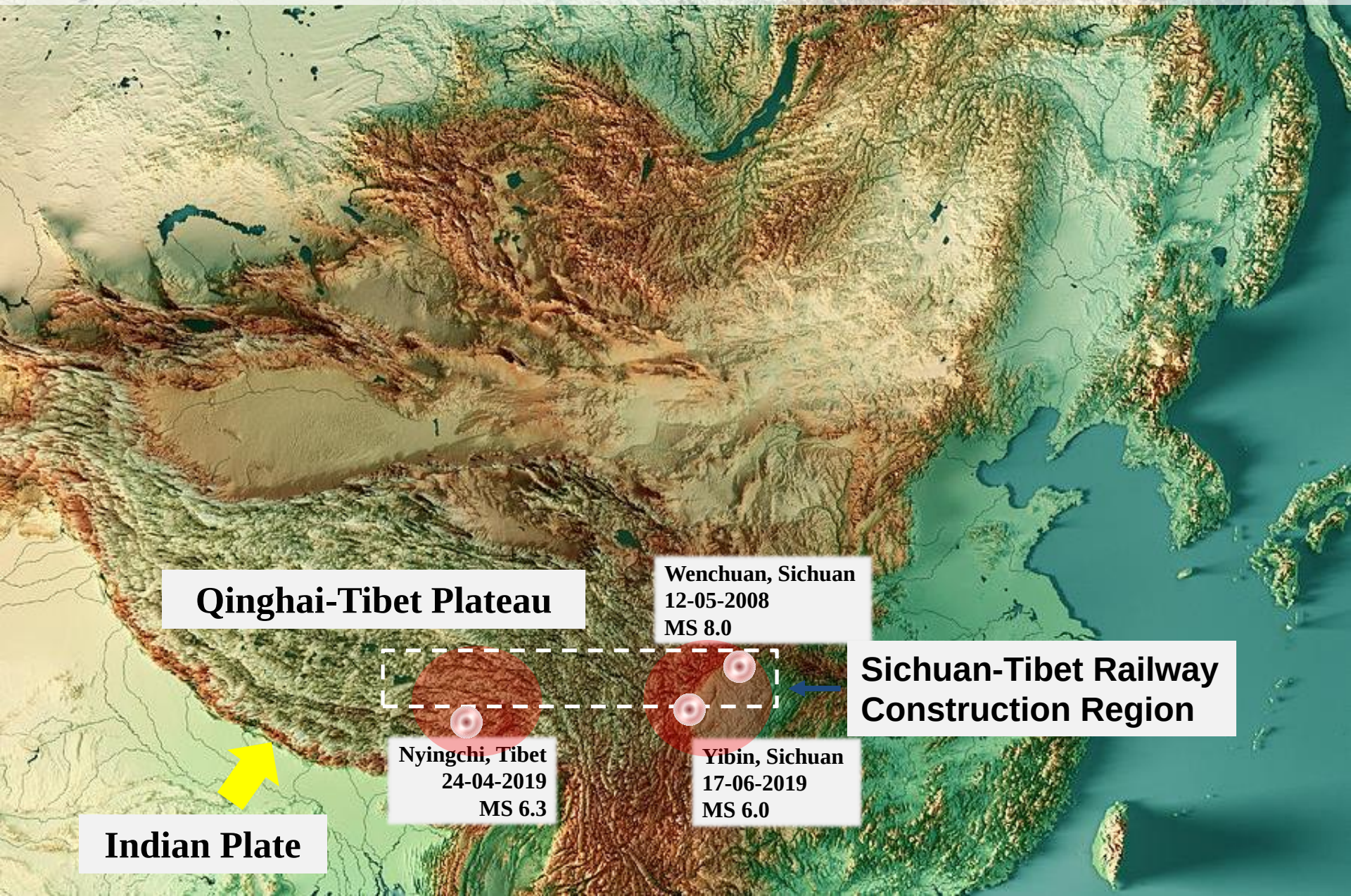
Including Landslides

The landslides mainly happen in the alpine gorges of the Hengduan Mountains and southeastern Tibet.

THE MAJOR CHALLENGE

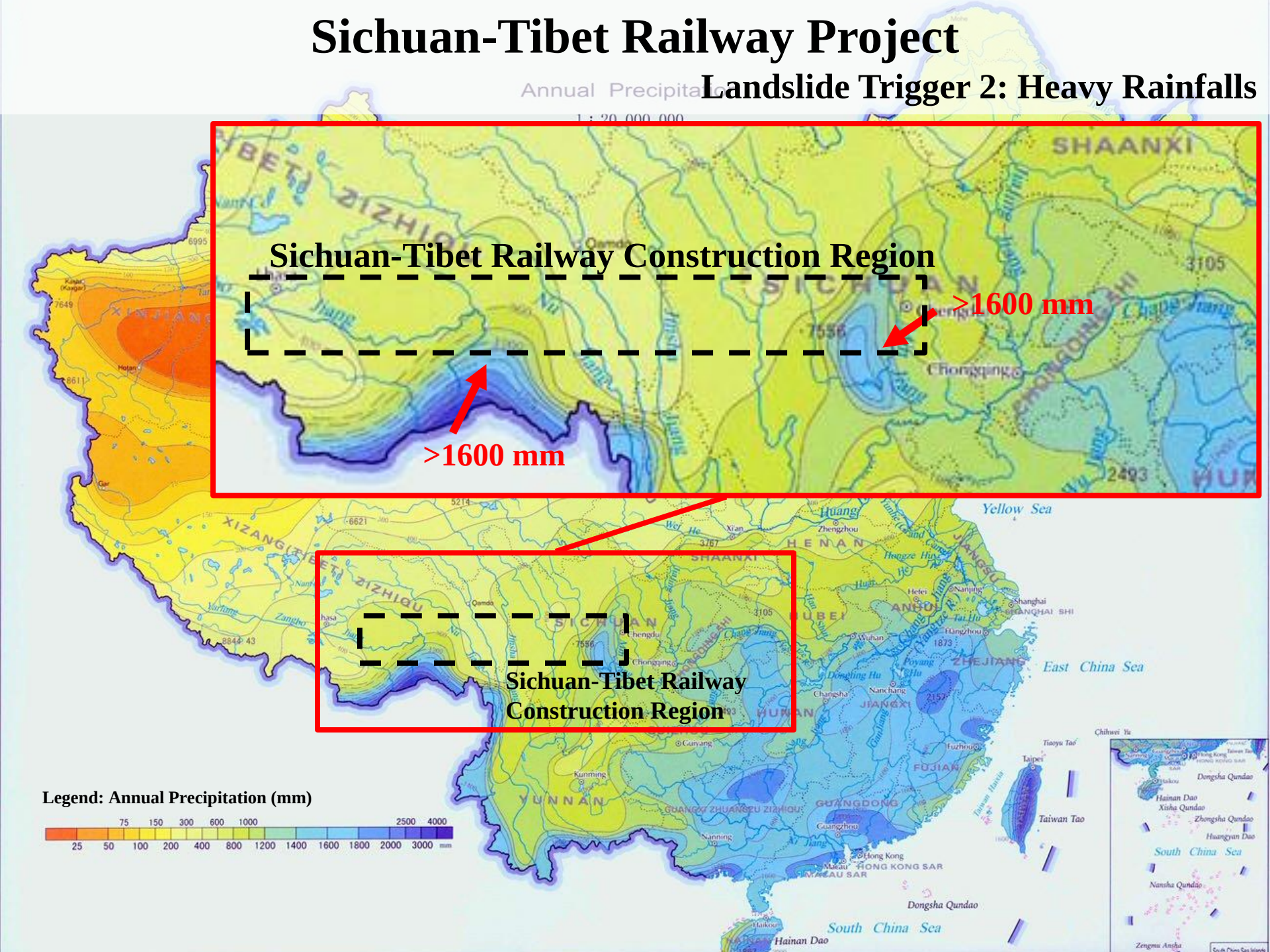
Sichuan-Tibet Railway Project

Landslide Trigger 1: Earthquakes



Sichuan-Tibet Railway Project

Landslide Trigger 2: Heavy Rainfalls



Sichuan-Tibet Railway Project

Inner Mongolia
Beijing
Tianjin
Hebei
Ningxia
Shanxi
Shandong
Qinghai
Gansu
Shaanxi
Henan
Jiangsu
Sichuan
Hubei
Anhui
Shanghai
Chongqing
Zhejiang
Jiangxi
Hunan
Diaoyu
Guiz
Yunnan
Zhongsha Islands

Pilot Region: SW China

Active earthquake & Landslide-prone region

Sichuan-Tibet Railway Construction Region

Pilot Objectives

- **Objective B:**
- Combining the aerospace and *in-situ* methods, develop landslide monitoring algorithms for optical, SAR and LiDAR images.

- **Objective C:**
- Develop landslide monitoring methods to support global disaster detection in the future.

Thank you！

Academy of Opto-Electronics (AOE)
Chinese Academy of Sciences (CAS)
www.aircas.ac.cn