中国科学院光电研究院
ACADEMY OF OPTO-ELECTRONICS,CHINESE ACADEMY OF SCIENCES

CEOS
Committee on Earth Observation Satellites

The Progress of landslides monitoring in China

Chuanrong Li

Key Laboratory of Quantitative Remote Sensing Information Technology, Academy of Opto-Electronics (AOE), Chinese Academy of Sciences (CAS)

1. Landslides pilot in China

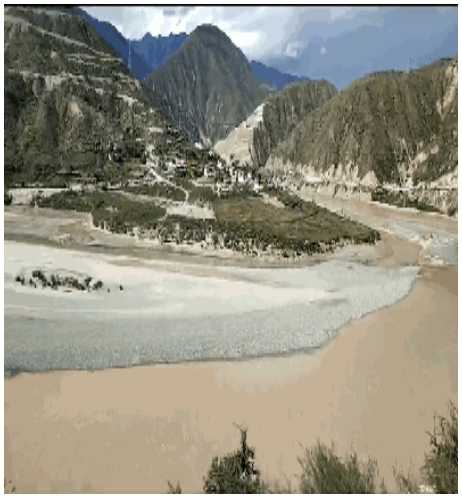
China is a country with frequent landslide disasters. The characteristics of geology, geomorphology and climate determine the distribution pattern of landslides in China.

- The most severe region: Southwest China;
- Other regions: Northwest and Southeast China.

Dujiang (2014)

Shenzhendian (2015)

Jiuzhaigou Valley (2017)

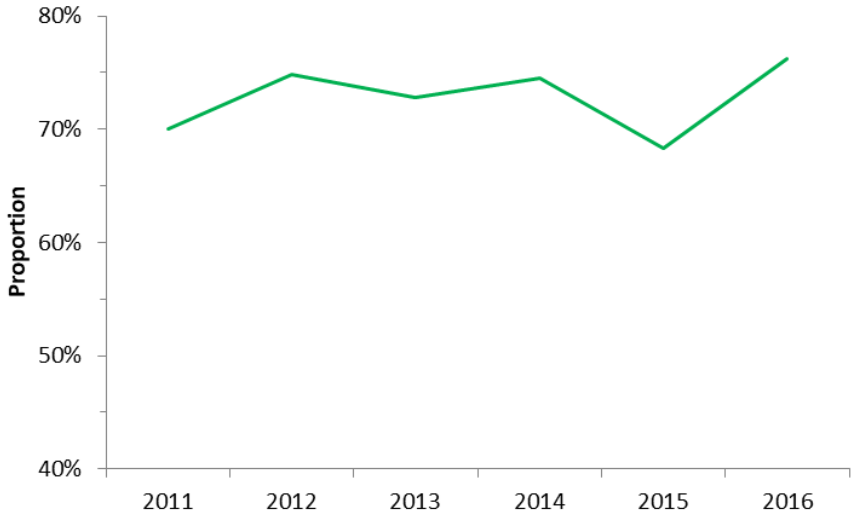


Jinshan river (2018)

1. Landslides pilot in China

The quantity of landslides accounts for more than 70% among all the natural disasters, which has caused great losses of life and property.

Year	Quantity	Proportion
2011	10122	70.0%
2012	10888	74.8%
2013	9326	72.8%
2014	8128	74.5%
2015	5616	68.3%
2016	7403	76.2%



It is very urgent and meaningful to develop the technology to monitor the dynamic changes of landslides.

2. The development of topographic deformation monitor

News

Yansan Highway was blocked because of landslide.

山体滑坡紧急抢修

2018-07-16 09:49

14日，下午15:00左右，延三公路五道水库段发生山体滑坡，导致道路被落石堵塞，车辆不能通行。事故发生后，交警部门设立警示告知牌，禁止过往车辆从此路段通行，以免发生危险。今天（15日）早上开始，道路养护部门动用挖掘机、铲车、翻斗车辆对山体滑坡路段的落石开始清理，由于山体还存在安全隐患，影响了清理作业进度，**预计今天（15日）内延三公路五道水库路段车辆不能通行，各部门明天将继续作业，确保此路段尽快通车。**

Landslides often occur in the part of road, where soft rocks were retrogressive slided, and hard rocks were also collapsed.

The topographic deformation monitor was installed to observe the deformation and displacement of the high slopes real-timely.

2. The development of topographic deformation monitor

Construction site

Installment of topographic deformation monitor

2. The development of topographic deformation monitor

We developed **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 product

The 2nd generation product

2. The development of topographic deformation monitor

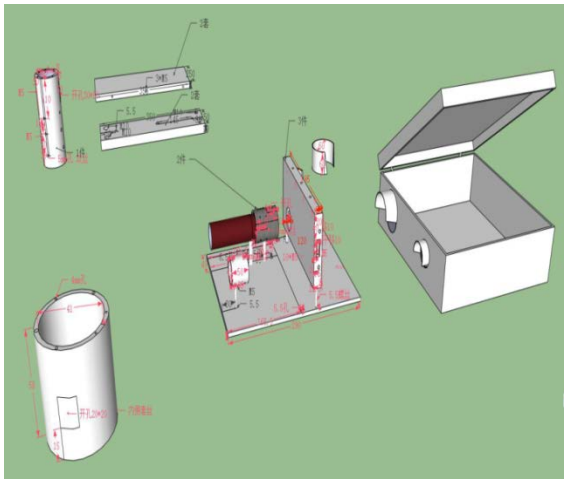
System architecture

- Digital images acquisition system
- Data pre-processing and remote transmission
- Data automatic analysis of the servers
- Remote control and alarm

2. The development of topographic deformation monitor

Hardware and control system

Camera structure design and machining



Thermo equipment

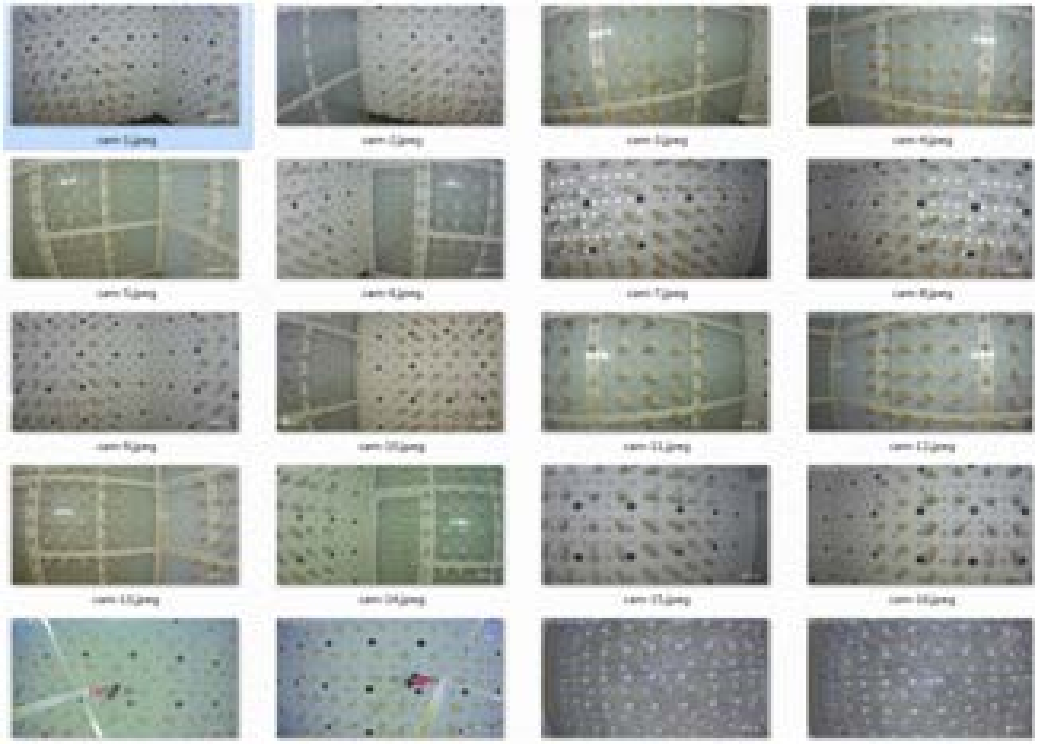
Night shot and alarm control system

Camera control system

2. The development of topographic deformation monitor

Camera calibration

- **Optical lens correction** was conducted at the panoramic calibration field, before collecting data.

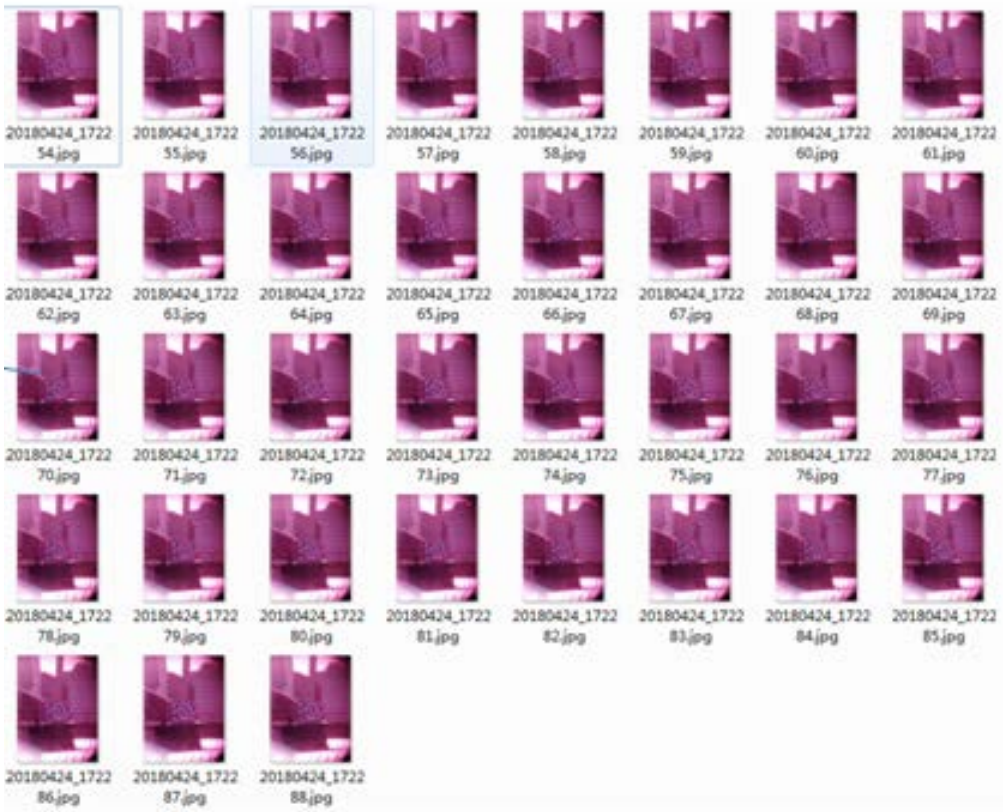


2. The development of topographic deformation monitor

Camera calibration

- Night shot calibration

Night shot experiment



2. The development of topographic deformation monitor

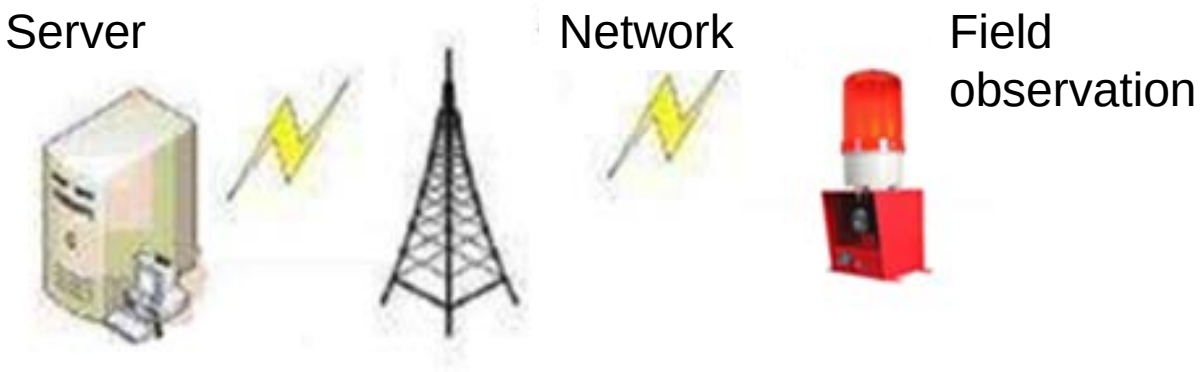
Technical parameters of the instrument

- ✓ **Continuous monitoring automatically** in 24 hours;
- ✓ Monitoring distance is 5m to 1000m, **with the displacement monitoring accuracy of 0.1mm when distance <10m**;
- ✓ **The operation temperature is -20℃ to 60℃**;
- ✓ The instrument **power is very small**, only from hundreds of watts to several watts;
- ✓ **The efficiency of data transmission is very high**, with 1M/10s;
- ✓ Monitoring frequency is 0.05HZ, 3 times per minute.

2. The development of topographic deformation monitor

Data pre-processing and remote transmission

- ✓ The digital images will be pre-processed after collecting, which includes numbering, classification and useful data selection.
- ✓ The data will be transferred to the servers by the network, and downloaded by users.



2. The development of topographic deformation monitor

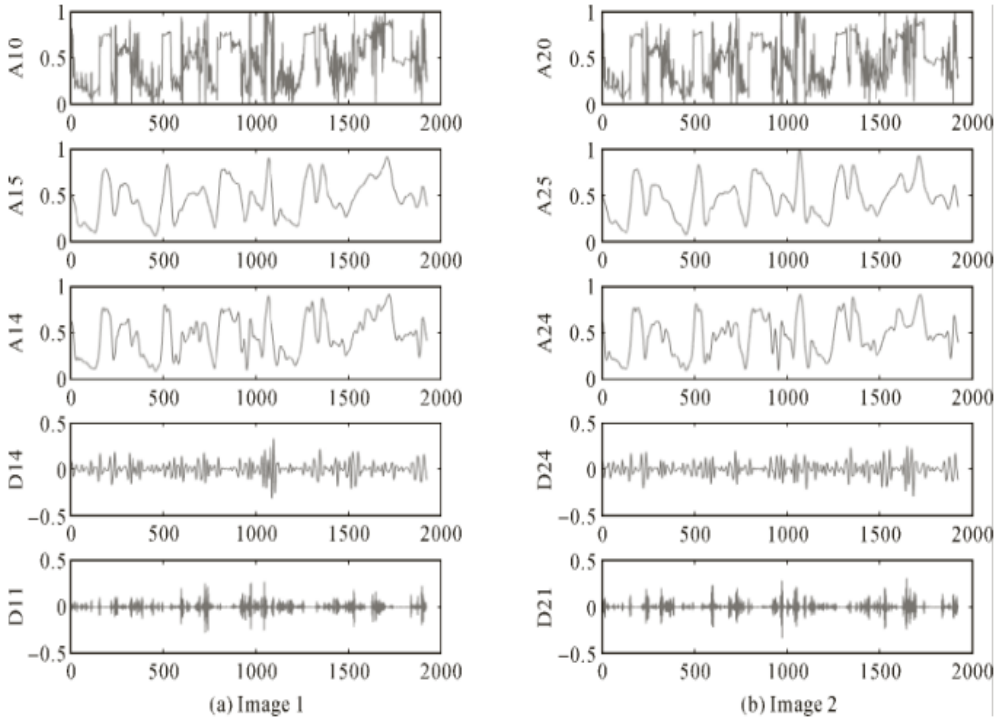
Data processing algorithm

- A new image matching method, i.e. all-pixels participated image matching algorithm, was proposed to process data. It takes all the pixels of the corresponding images to participate the matching procedure and calculate the geometric parameters by least square criterion.
- The principle of the algorithm includes:
  - ➢Gray corresponding equation;
  - ➢Information quantity equation;
  - ➢Procedure of least square solution.

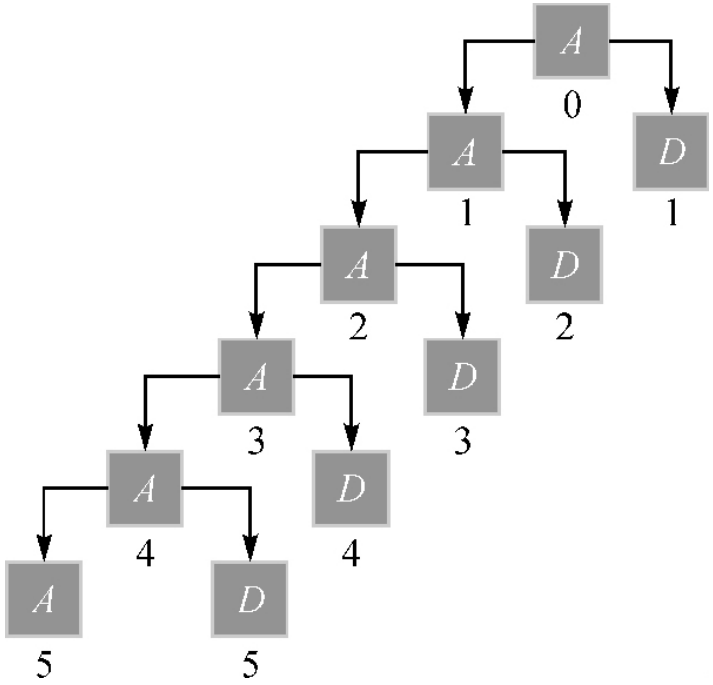
2. The development of topographic deformation monitor

Data processing algorithm

Wavelet analysis



Multi-scale wavelet analysis results of images.



Schematic diagram of image multi-scale wavelet analysis

From the two figures, Signal to Noise Ratio (SNR) values of different scales were calculated.

2. The development of topographic deformation monitor

Data processing algorithm

The SNR of image at different scales

尺度	σ_{G_1}	σ_{G_2}	σ_N	mean (σ_G^2/σ_N^2)	$\log_2$ (σ_G^2/σ_N^2)
A_5	0.200 6	0.193 7	0.031 8	38.441 4	5.264 6
A_4	0.208 2	0.202 0	0.037 6	29.820 9	4.898 3
D_4	0.065 7	0.067 2	0.043 5	2.335 7	1.223 9
D_3	0.072 2	0.073 0	0.054 5	1.773 1	0.826 3
D_2	0.068 3	0.065 2	0.047 3	1.989 8	0.992 6
D_1	0.041 9	0.047 1	0.038 0	1.375 1	0.459 5
A_0	0.243 7	0.239 2	0.099 8	5.853 0	2.549 2

- The higher the resolution, the lower the SNR values, especially for D1, D2 and D3, which might lead to some errors in the image matching.
- However, A4 and A5 had higher SNR and $\log_2$ values than the original signal A_0, indicating that the algorithm can greatly improve the accuracy of high resolution images matching.

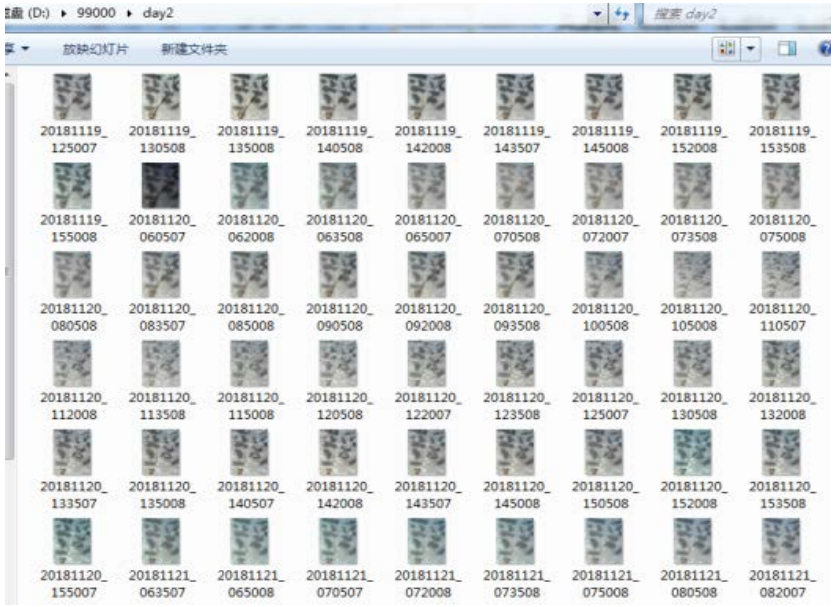
Journal of Geodesy and Geoinformation Science, 2017, 46(5):573-582.

3. Landslide monitoring with the new instrument – a case at Yansan Highway

Data collection

- Data collection at daytime

  (From 6am to 16:30pm)

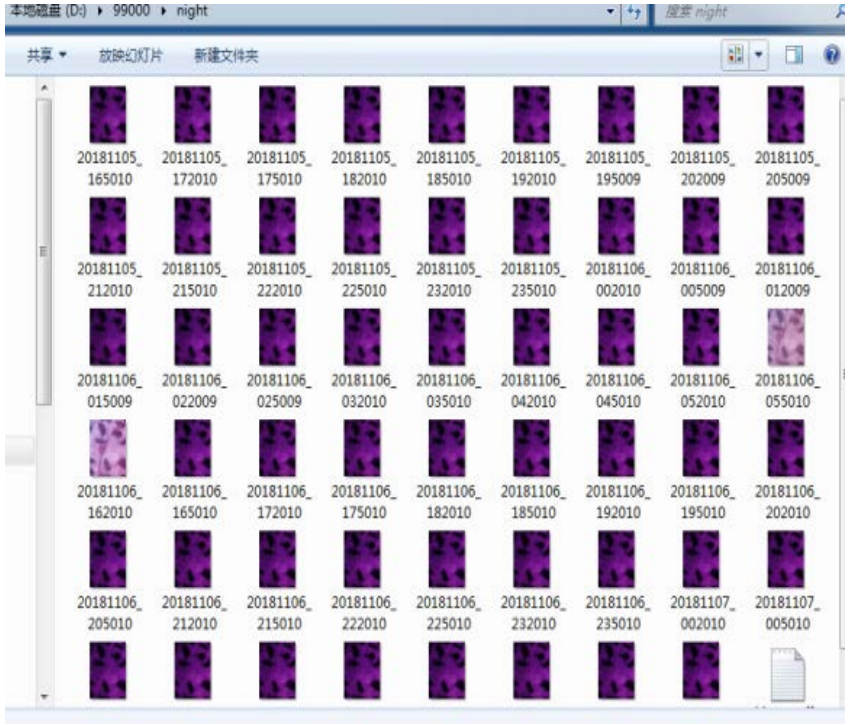


3. Landslide monitoring with the new instrument – a case at Yansan Highway

Data collection

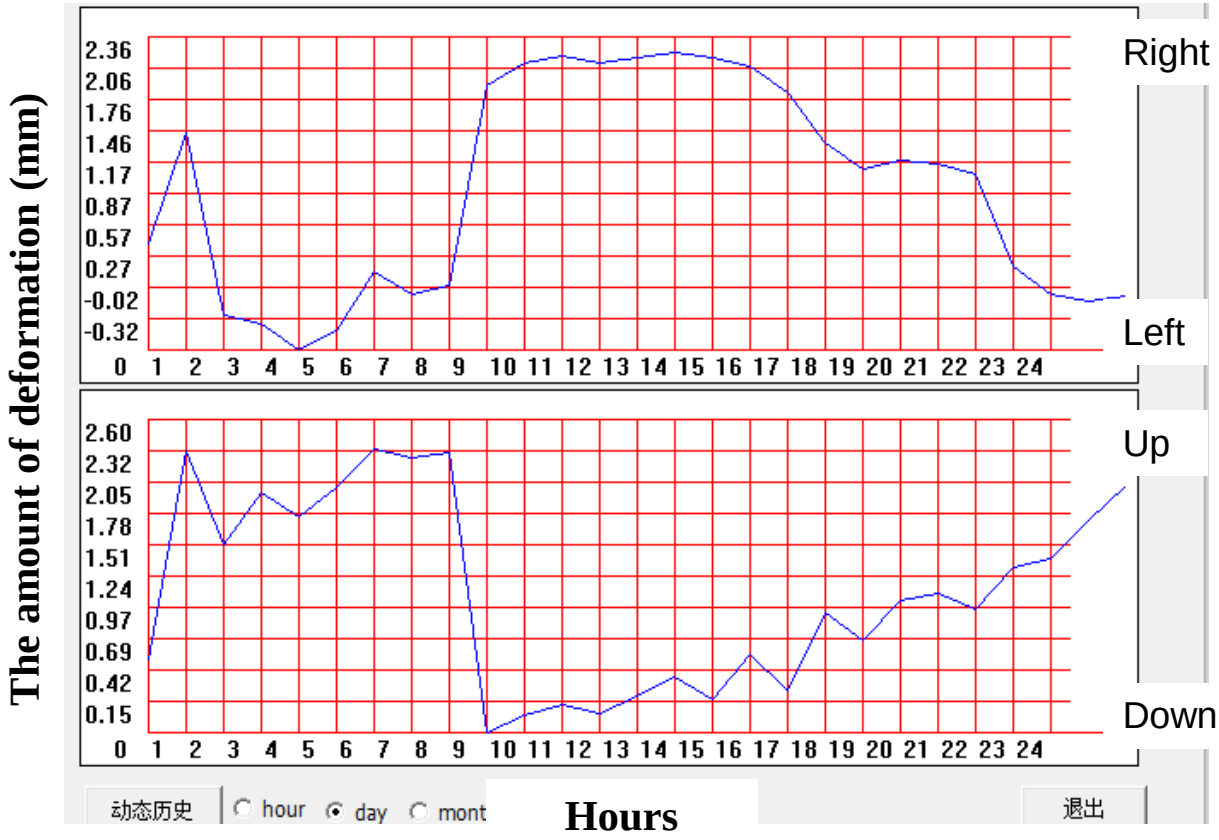
- Data collection at night

  (From 16:29pm to 6:16am)



3. Landslide monitoring with the new instrument – a case at Yansan Highway

Monitoring results



The changes of targets per hour can be observed from 4 directions.

The instrument has been working for about 7 moths, from July, 2018.

4. The next steps

- The experiment on site will be continued to collect more data.
- Efforts will be done on finding out relation between displacement and landslide, including refining interpretation model and pre-warning threshold.


ALTAY
MOUNTAINS
Mongolia
Kyrgyzstan
North Korea
Japan
HIMALAYAN MOUNTAINS
Pakistan
Nepal
India
Bangladesh
Myanmar (Burma)
Vietnam
Laos
Thailand
Cambodia
Philippines
Arabian Sea
Bay of Bengal
South China Sea
Thank you !
N
0
930 km (580 miles)
DATA BASIN