Satellite radar observations in support of landslide disaster risk reduction

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Acknowledgements

- Newcastle Imaging Geodesy Team
- Centre for Observation and Modelling of Earthquakes, Volcanoes and tectonics (COMET)

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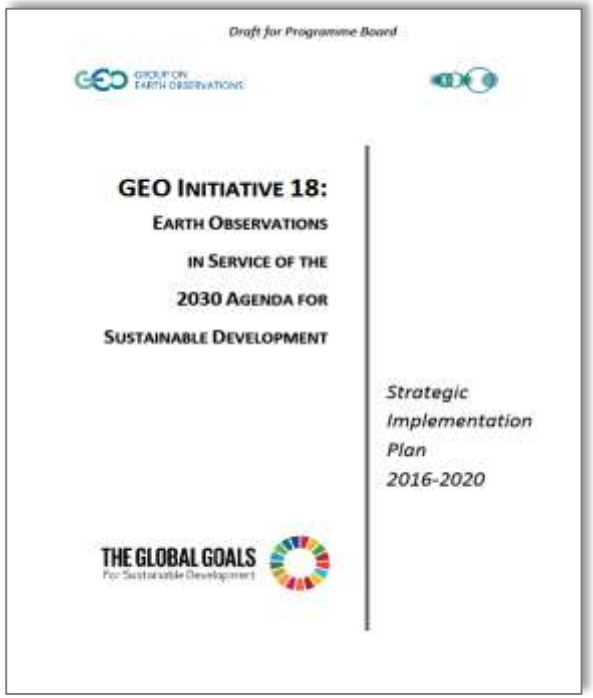
- Wuhan University: Deren Li, Jingnan Liu

The Agenda 2030 for Sustainable Development

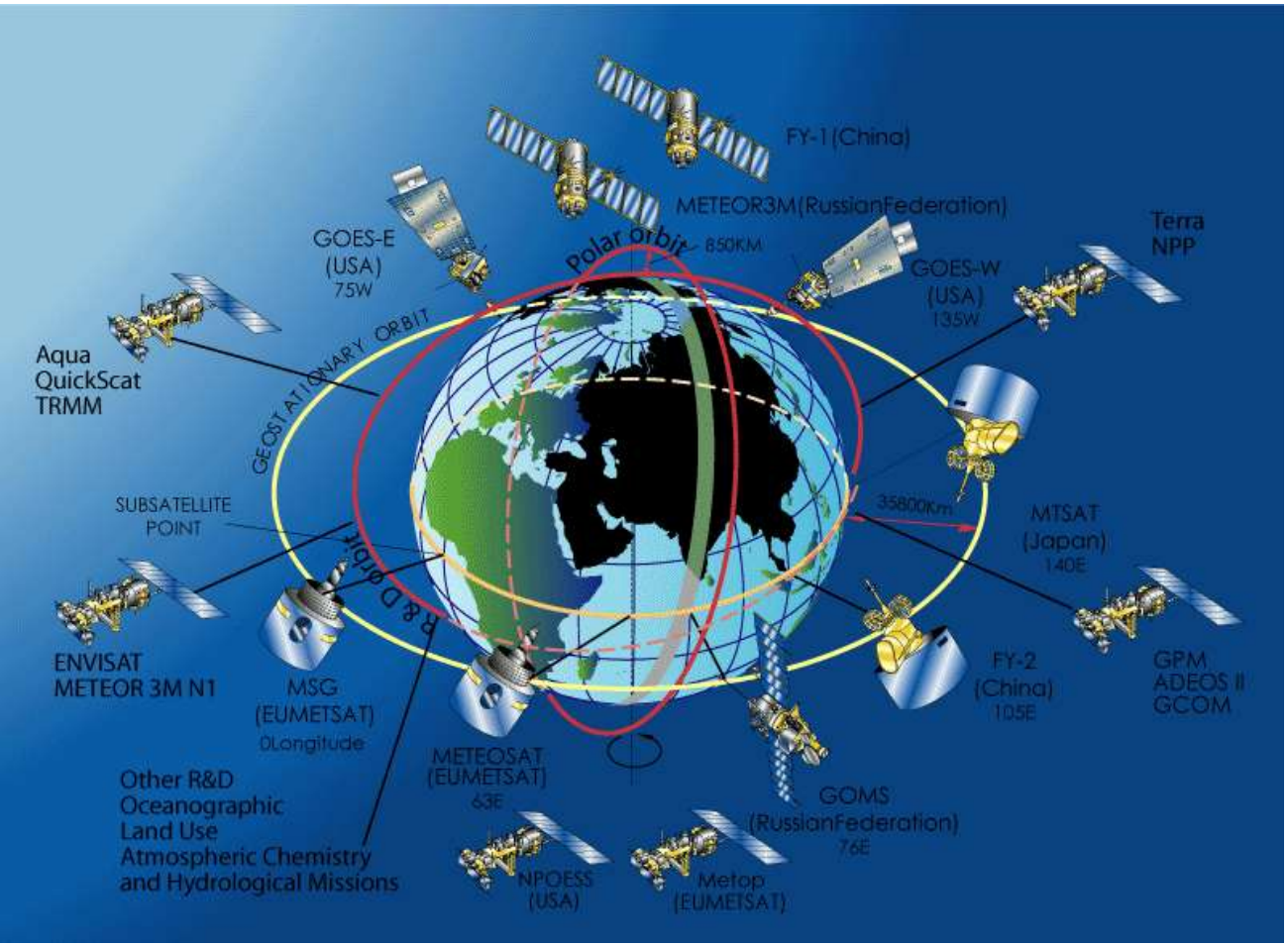
Transforming Our World: The 2030 Plan for Global Action - Article 76: "We will promote transparent and accountable scaling-up of appropriate public-private cooperation to exploit the contribution to be made by a wide range of data, including Earth observation and geo-spatial information, while ensuring national ownership in supporting and tracking progress."

GEO Initiative 18

GEO Initiative 18:
Earth Observations in Service of the 2030 Agenda for Sustainable Development



Earth Observation (EO)



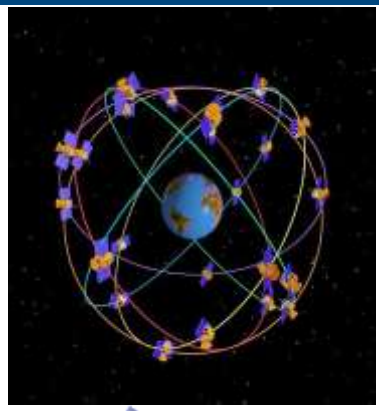
EO Components:

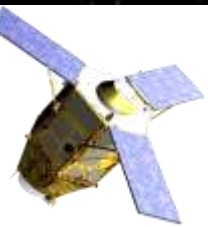
- Spaceborne, airborne and ground observations
- Numerical Models
- Decision-support tools

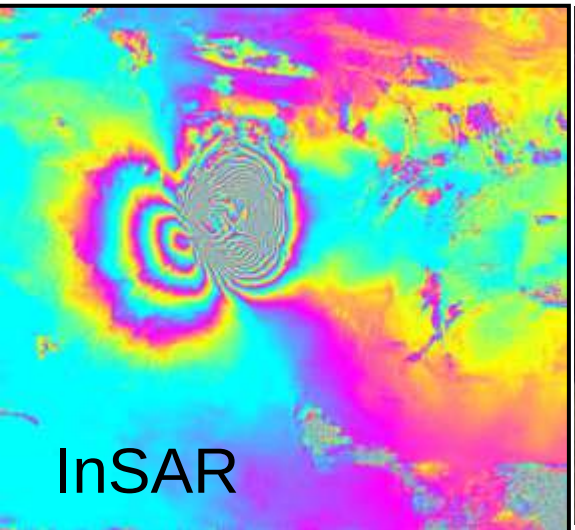
EO Missions (incomplete)

Earth Observation (EO) @ Newcastle Imaging Geodesy Team

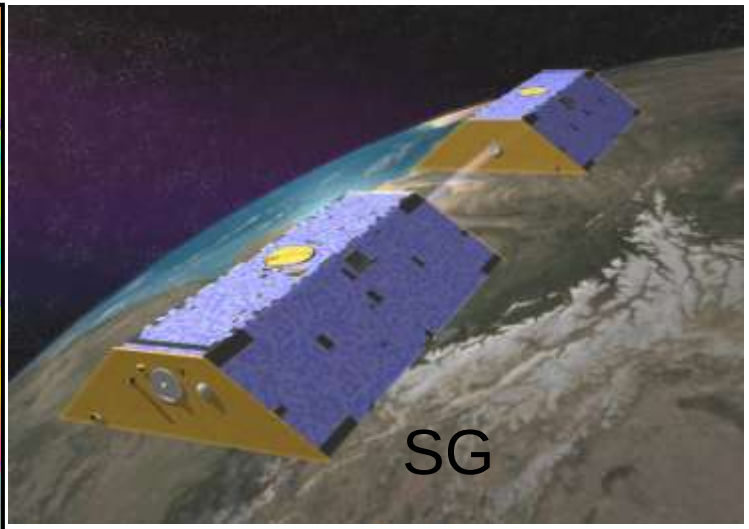
- ❖ Point Positioning
  - ➢ Global Navigation Satellite System (GNSS)
- ❖ Imaging Geodesy
  - ➢ Interferometric Synthetic Aperture Radar (InSAR)
  - ➢ Very-high-resolution optical → Topography
  - ➢ Satellite Gravimetry (SG) / Satellite Altimetry (SA)



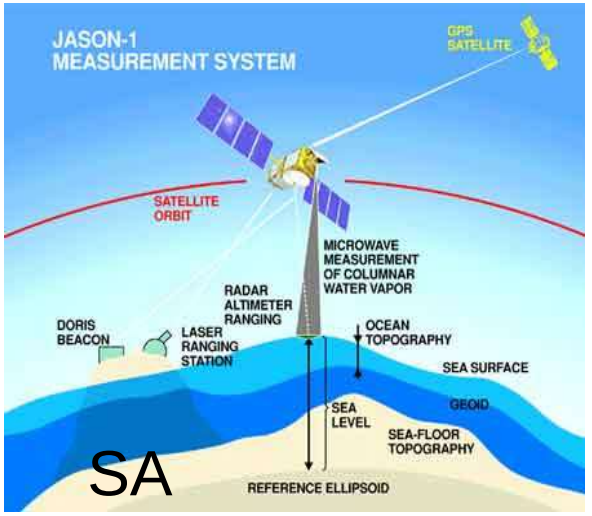




InSAR



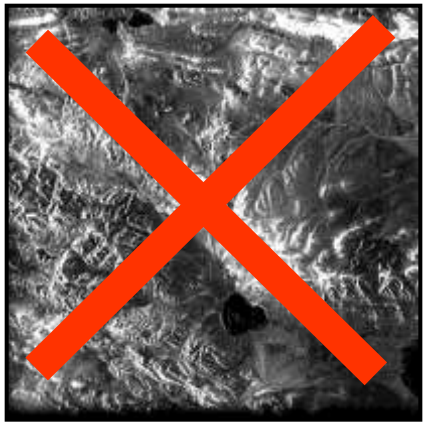
SG



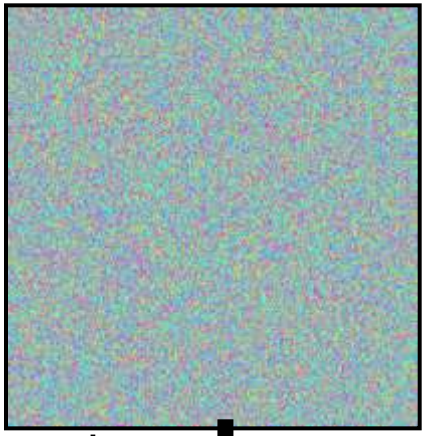
SA

Imaging Geodesy:
Interferometric Synthetic Aperture Radar (InSAR)

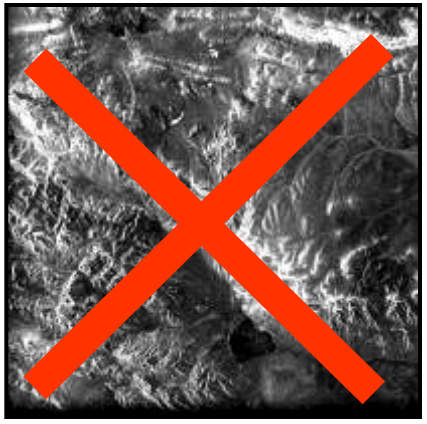
Radar Image A: 071123

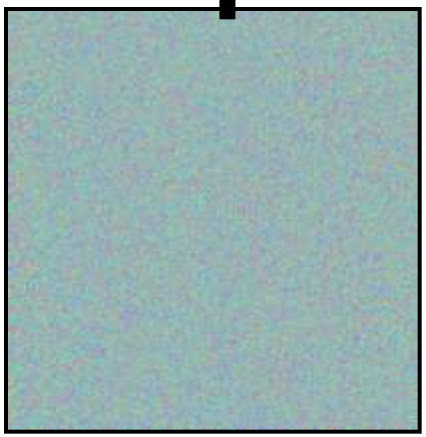


Amplitude



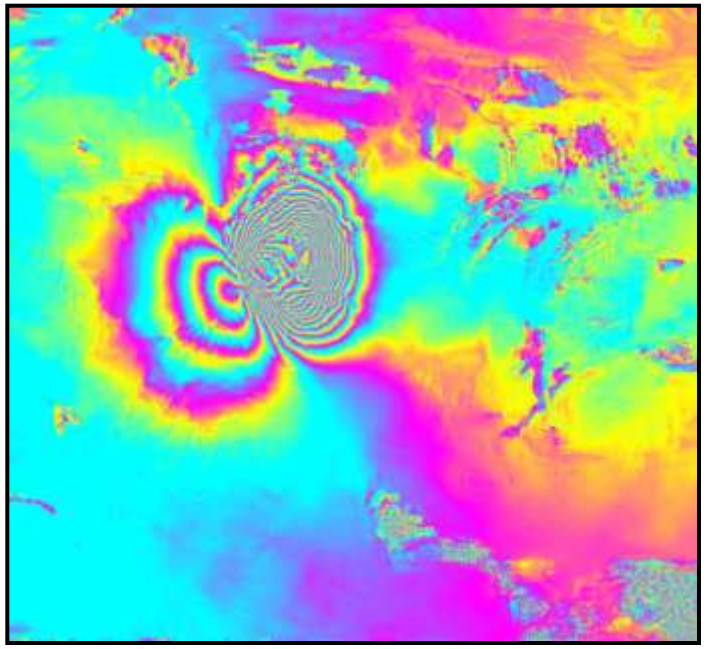
Phase





Radar Image B: 080201

Interferogram =
Phase A – Phase B



2008 Gaize Earthquake (Tibet)

Magic of Interferometry!

EO for Disaster Management

Emergency exercises/training

Long-term hazard assessment

Early Warning System (EWS)

Public Education

Monitoring unrest

Understanding the event

Damage assessment

Reconstruction strategy: e.g. temporary housing

Is the event over?

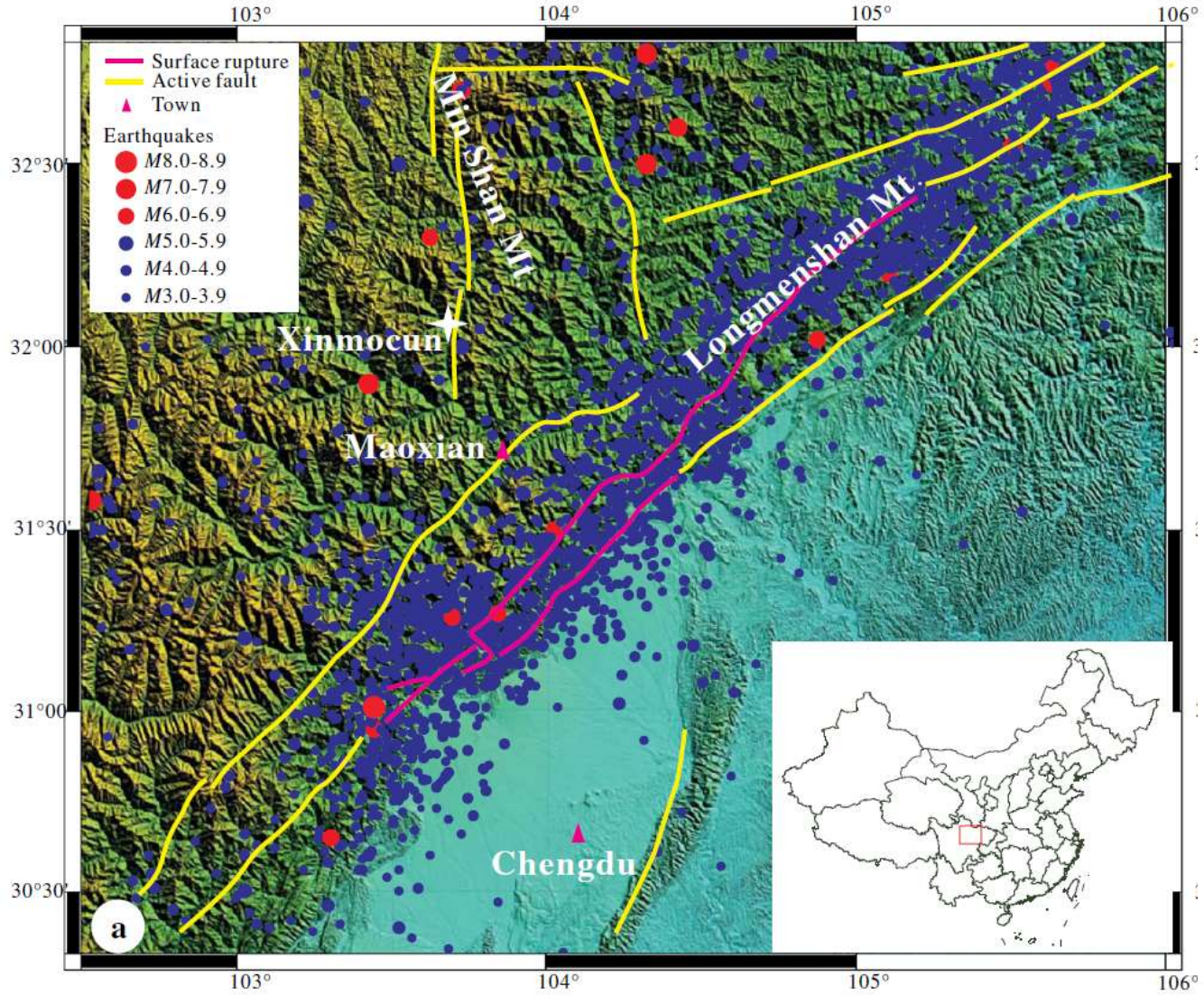
Assessment of ongoing hazard

Newcastle University

Disaster Response/Preparation:

The 2017 Maoxian (China) landslides

Maoxian Landslide



Xinmo village (新磨村)

- 50 km to the epicentre of the 2008 Mw 7.9 Wenchuan Earthquake
- 20 km to the epicentre of the 1933 Mw 7.3 Diexi earthquake

(Jiang *et al.* 2014)

Xinmo Village: Pre-event

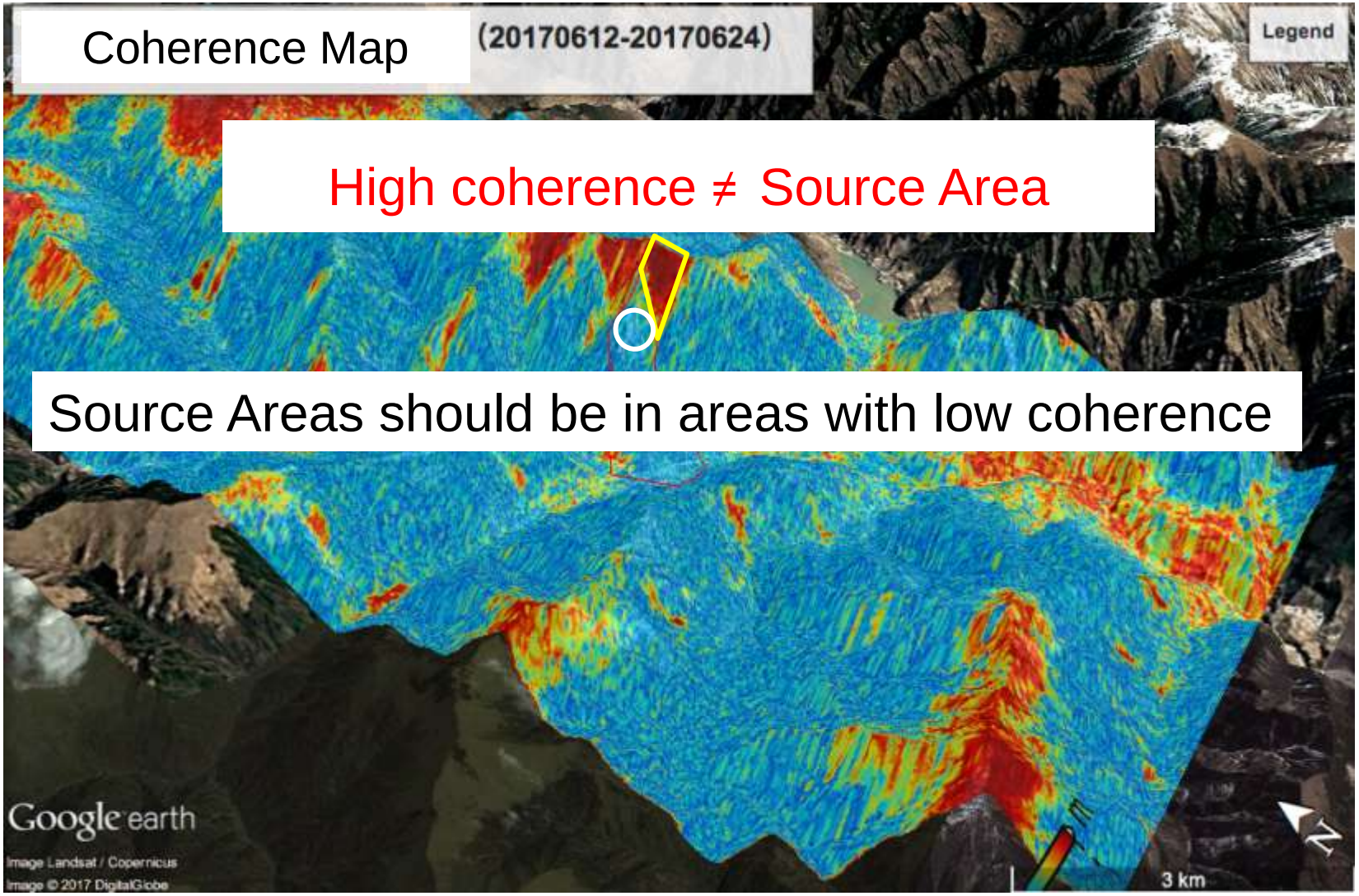
Xinmo Village (新磨村): Pre-event

Xinmo Village: Post-event

Xinmo Village (新磨村): Post-event

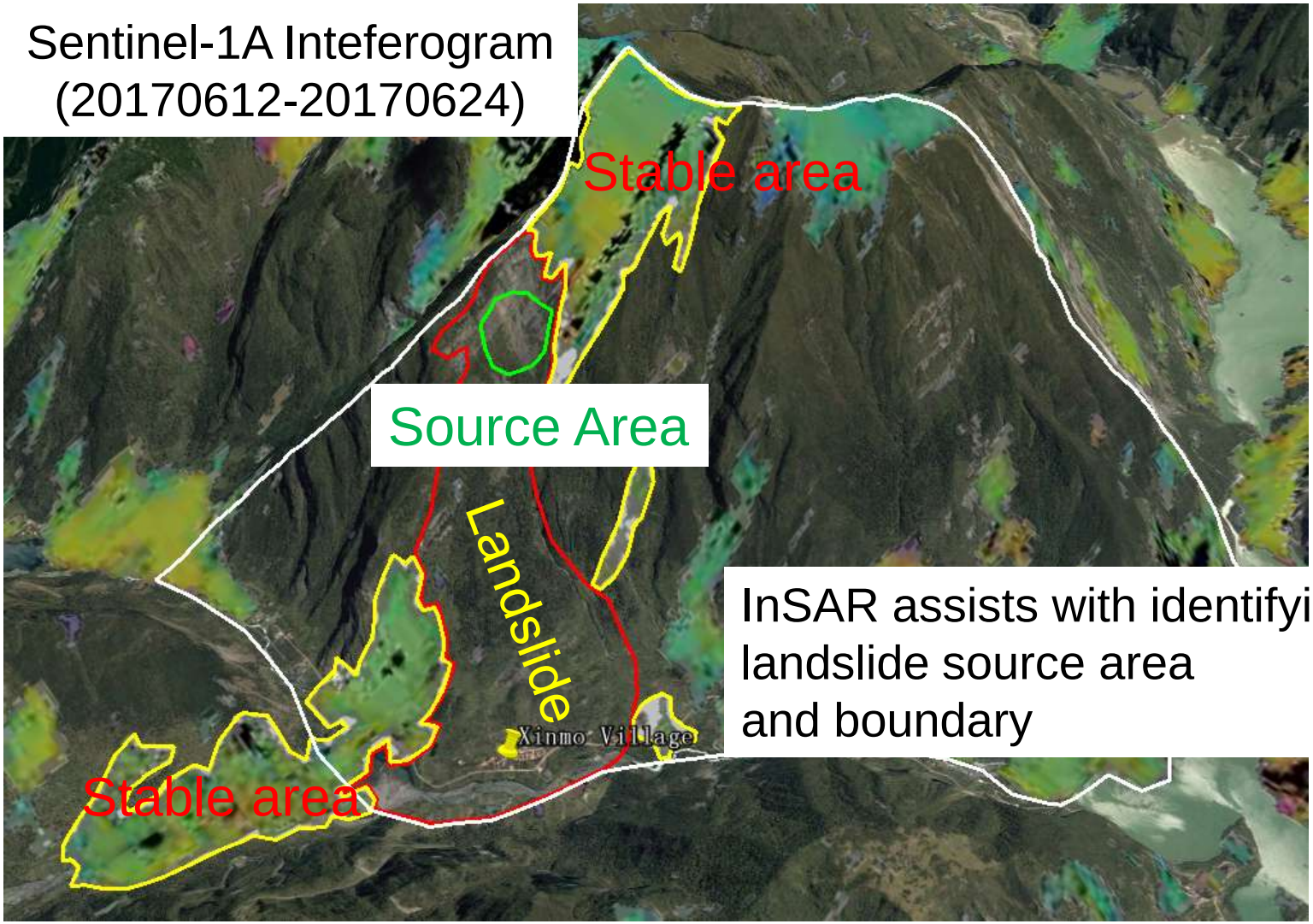
- 64 houses were buried
- 10 dead people were found, 73 people in the ‘missing list’
- The landslide volume was estimated to be 13 million m^3 (Fan et al., 2017, Landslides)

SAR coherence vs landslide source area



SAR coherence + amplitude: landslide source area and boundaries

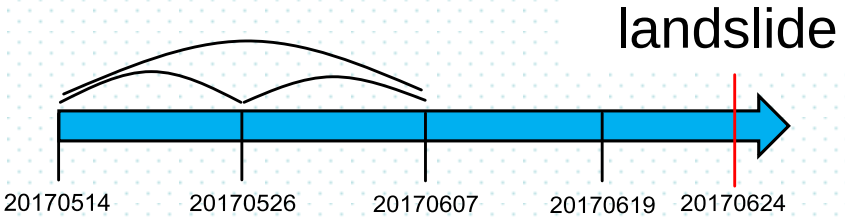
Sentinel-1A Inteferogram
(20170612-20170624)



InSAR assists with identifying landslide source area and boundary

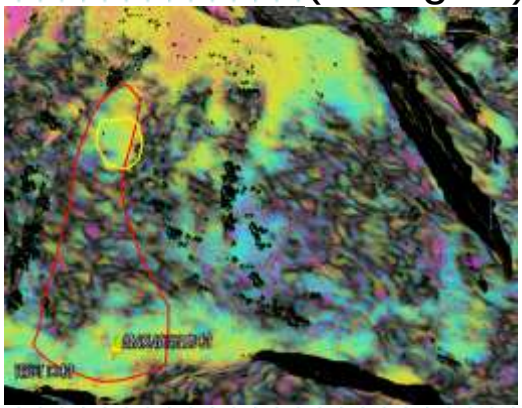
InSAR: Pre-event movement signals (Xinmo landslide)

UAV imagery

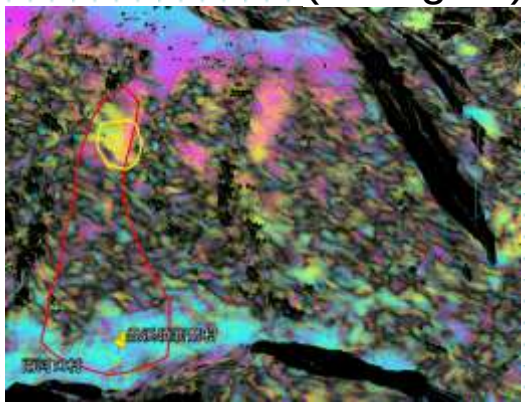


- 20170514-20170607: no clear signal

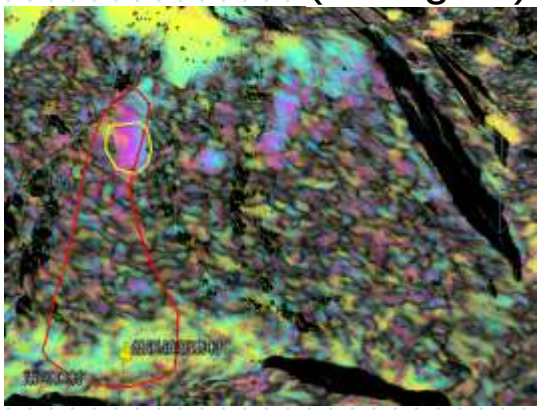
20170514-20170526 (no signal)



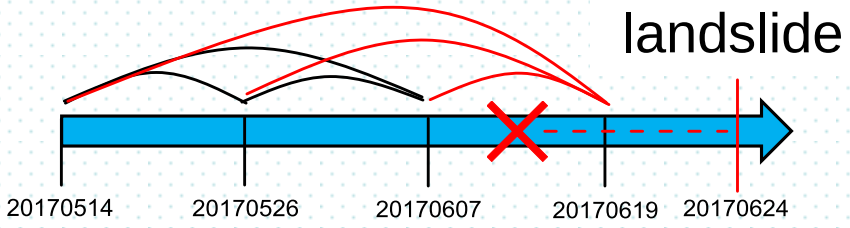
20170526-20170607 (no signal)

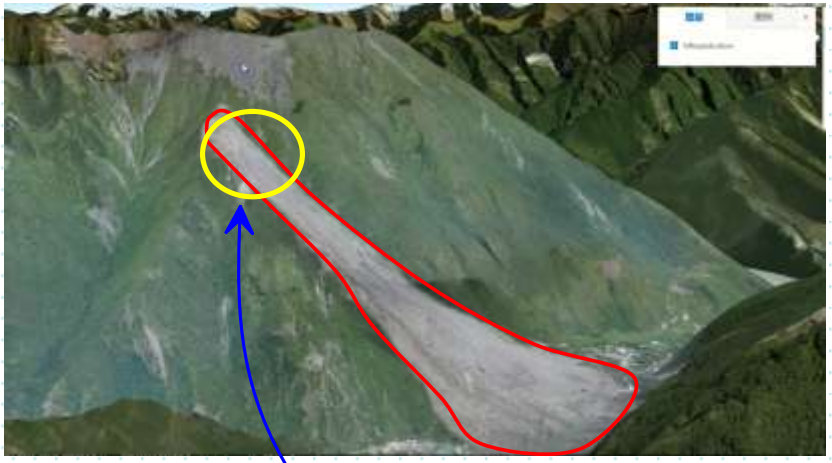


20170514-20170607 (no signal)



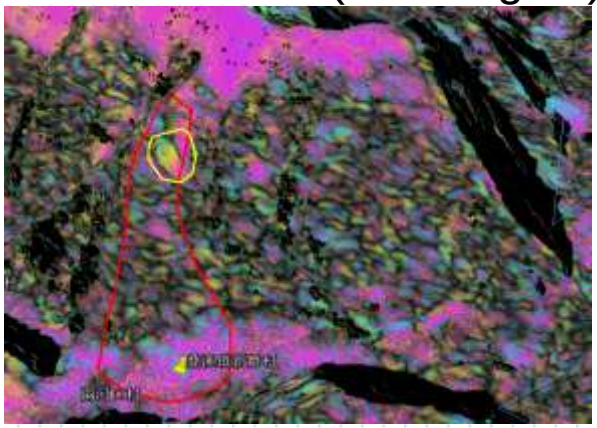
InSAR: Pre-event movement signals (Xinmo landslide)



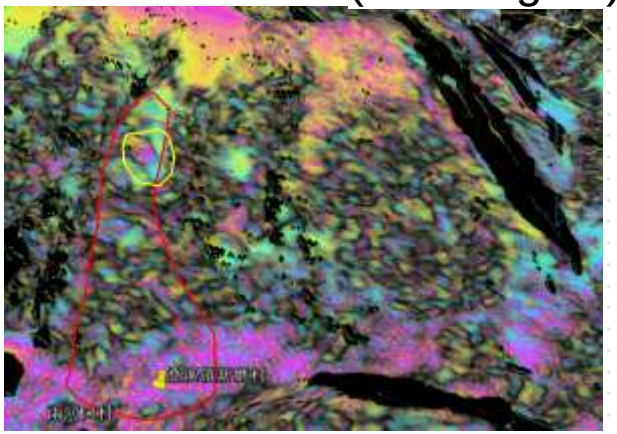


- 20170607-20170619: clear signals
- Movement signals exhibited in the source area

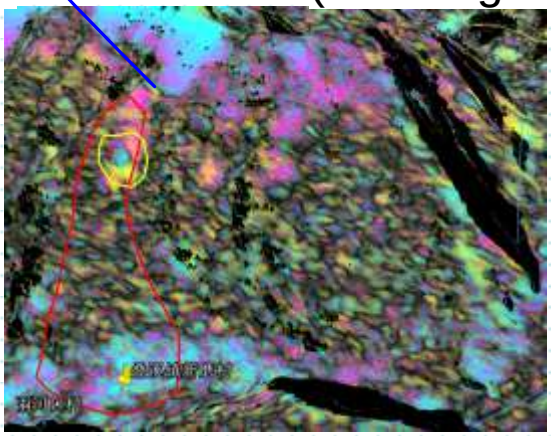
20170607-20170619(clear signal)



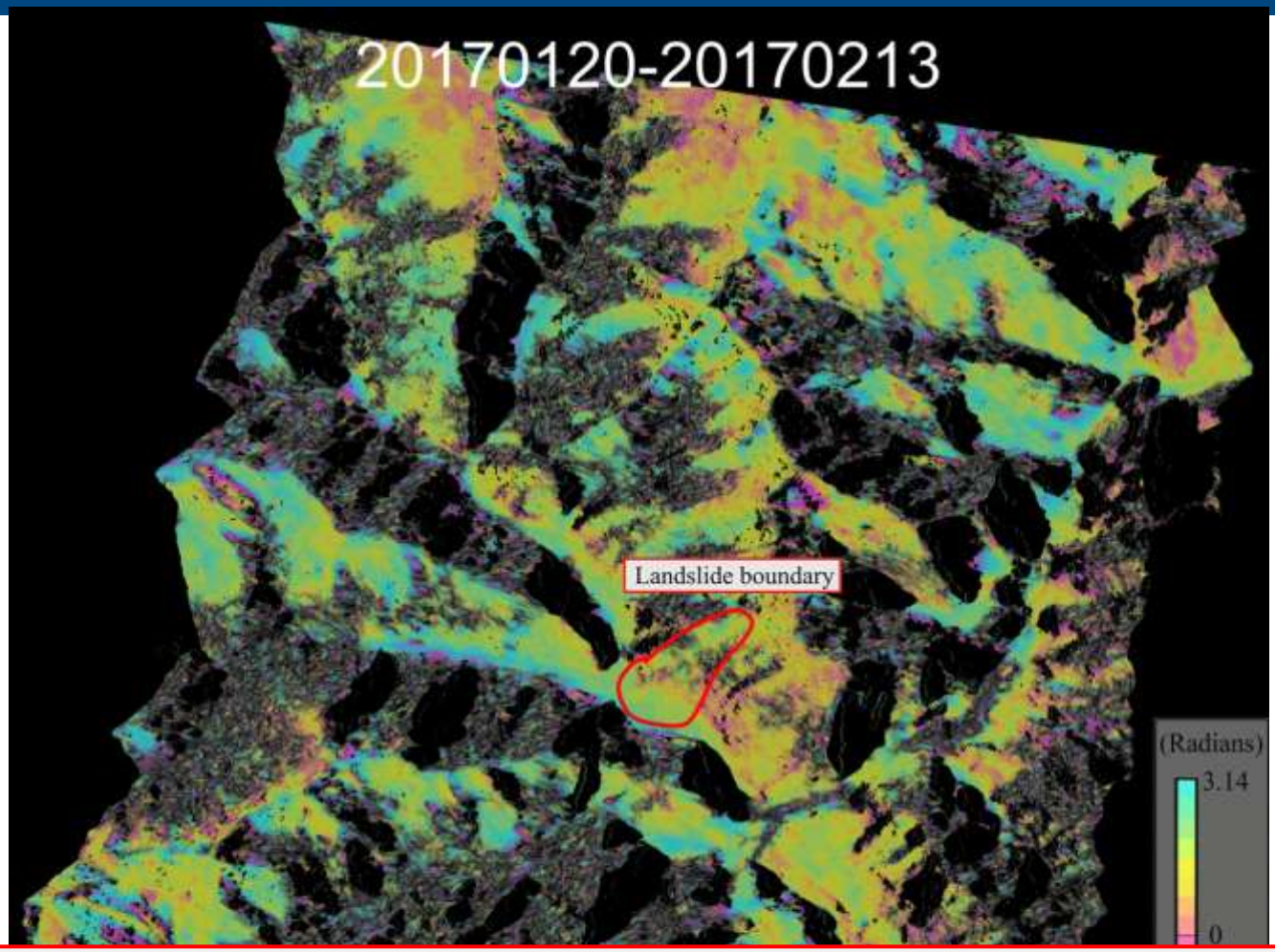
20170526-20170619(clear signal)



20170514-20170619(clear signal)

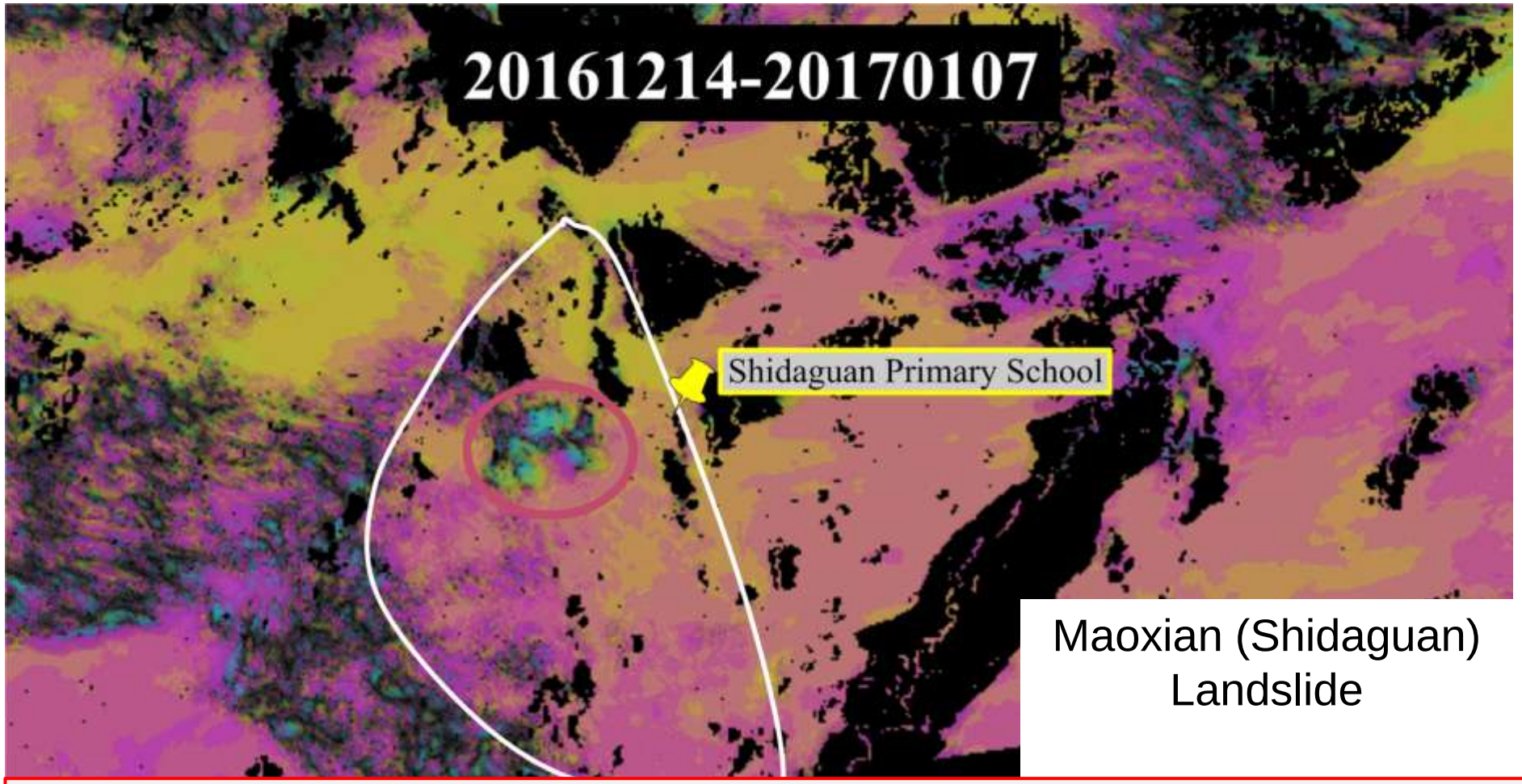


InSAR: Pre-event movement signals (Xinmo landslide)



- Pre-event signals exhibited in the source area during the period from 07 to 19 June 2017 for the Xinmo landslide

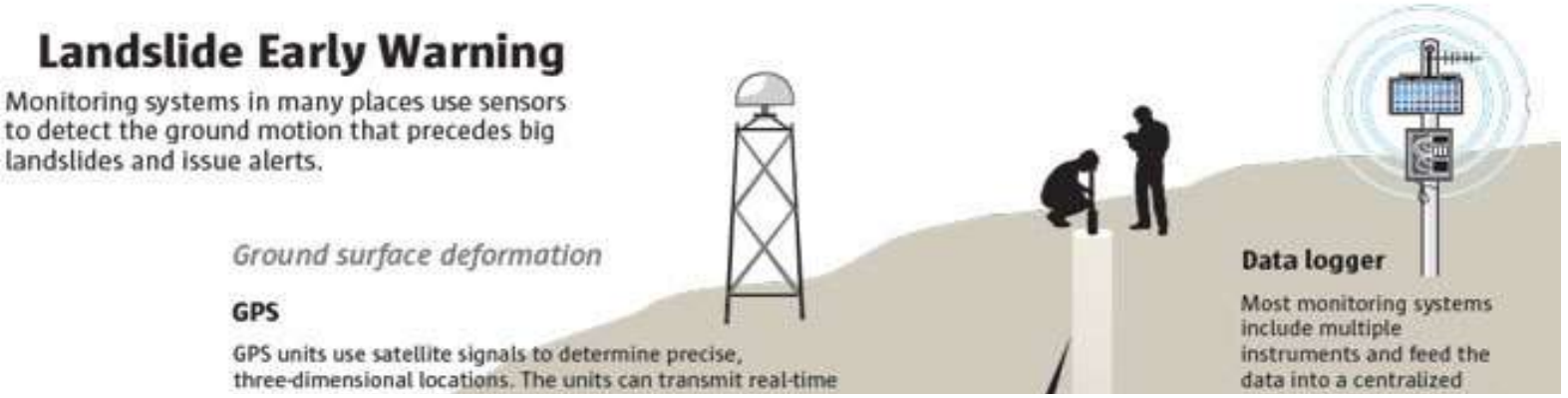
InSAR: Pre-event movement signals (Shidaguan landslide)



Maoxian (Shidaguan) Landslide

- Clear pre-event signals exhibited in the source area for at least six months before the event.

So What?



Key Features

- In Real Time
- Sensitive
- Precise
- Reliable

Solution to Landslide Hazards?

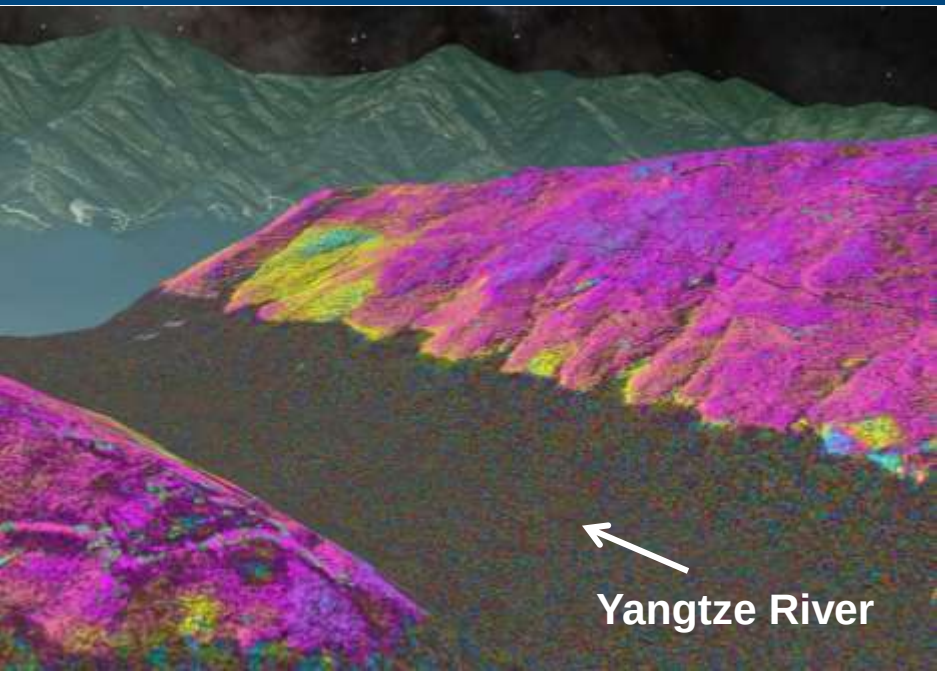
WP1 Automatic Landslide Detection at regional scales
Objective: To identify sites with potential landslide hazards
Key Techniques: Multi-platform, Conventional/Advanced InSAR

WP2 Expert Interpretation + Impact Assessment at local scales
Objective: To decide sites where RTLM is required
Key Tech: Field investigation + Detailed InSAR analysis + Simulation

WP3 Real-Time Landslide Monitoring (RTLM)
Objective: To identify sites with potential landslide hazards
Key Tech: Multi-GNSS/Sensors Integrated System

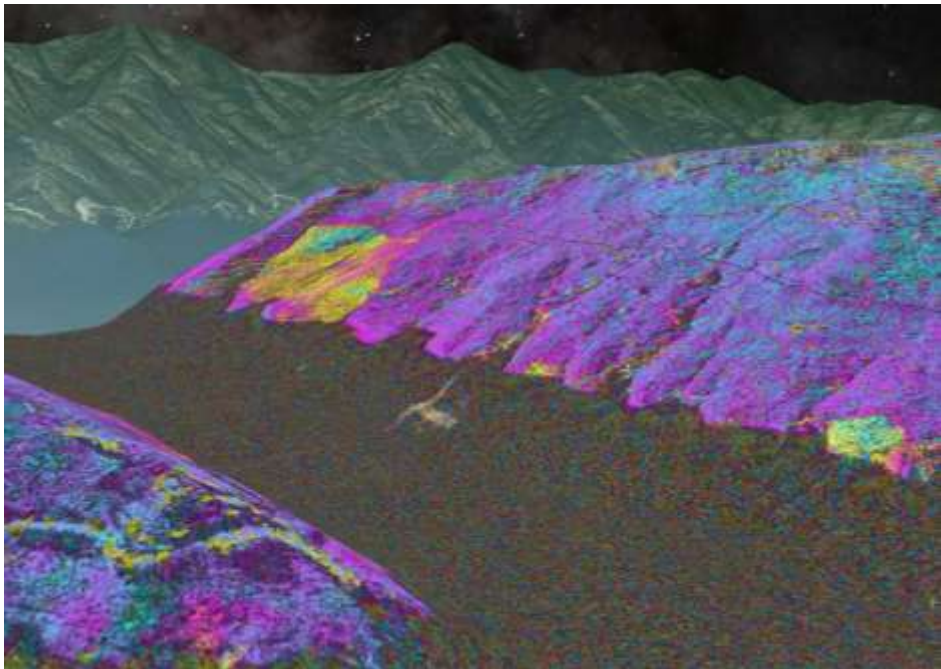
WP4 Engagement Activities
Objective: To transfer knowledge to local communities and governments
Key Tech: Community-based disaster reduction management (CBDRM)

Identifying active landslides from space



4th Feb – 15th Feb 2012

26th Feb – 8th March 2012



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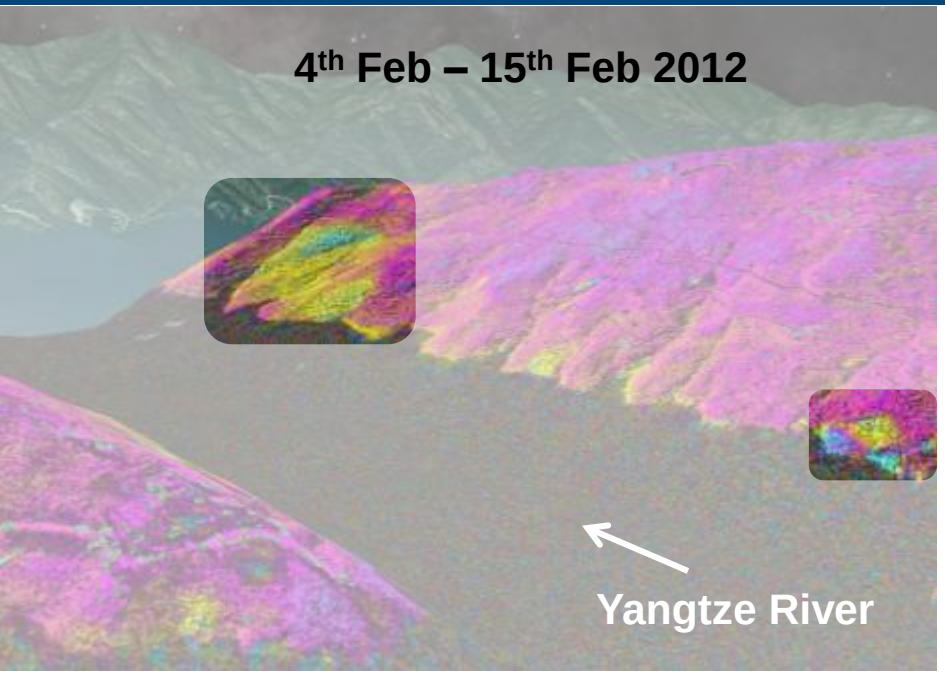
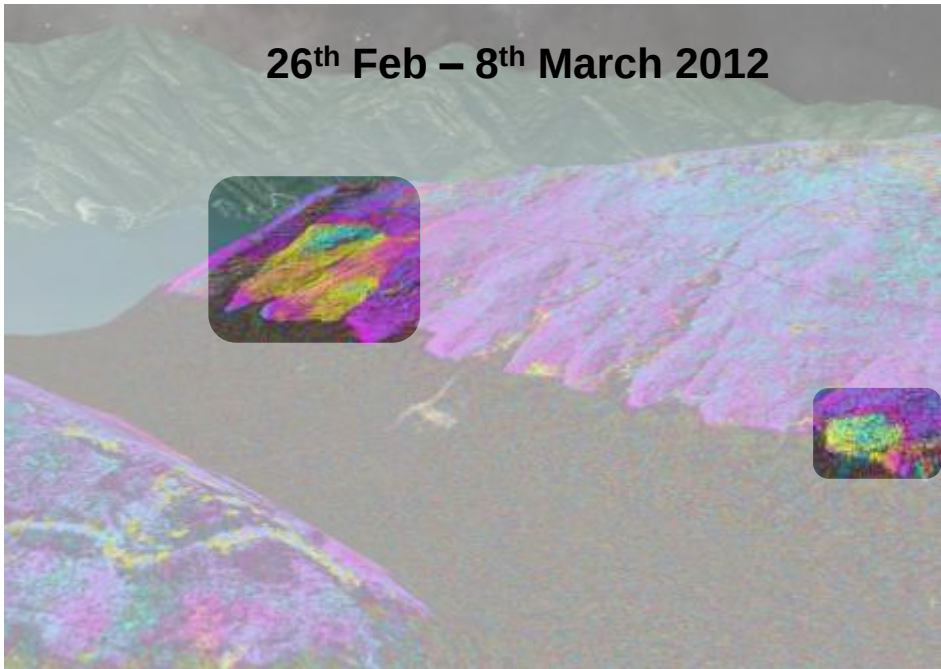
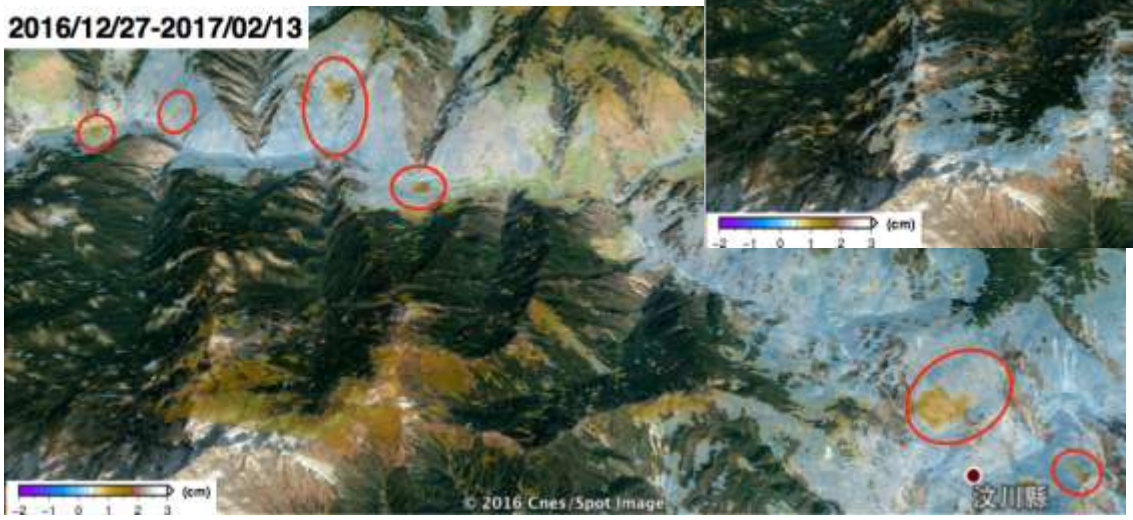




Identifying active landslides from space



Zagunao River Basin

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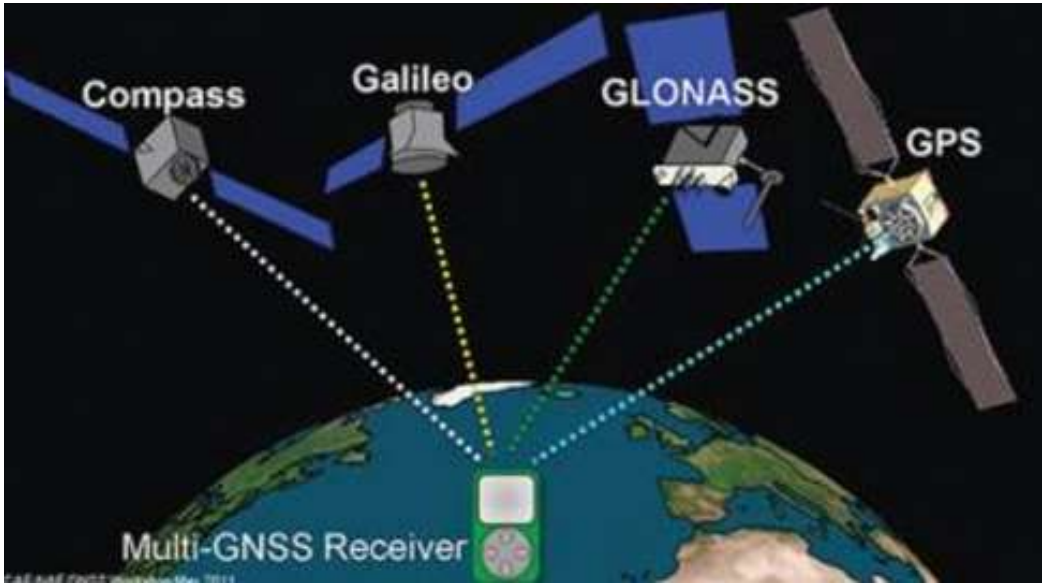
Newcastle University

Real Time High Precision Deformation Monitoring System with Multi-GNSS RTK

@

Newcastle Imaging Geodesy Team



Main Features

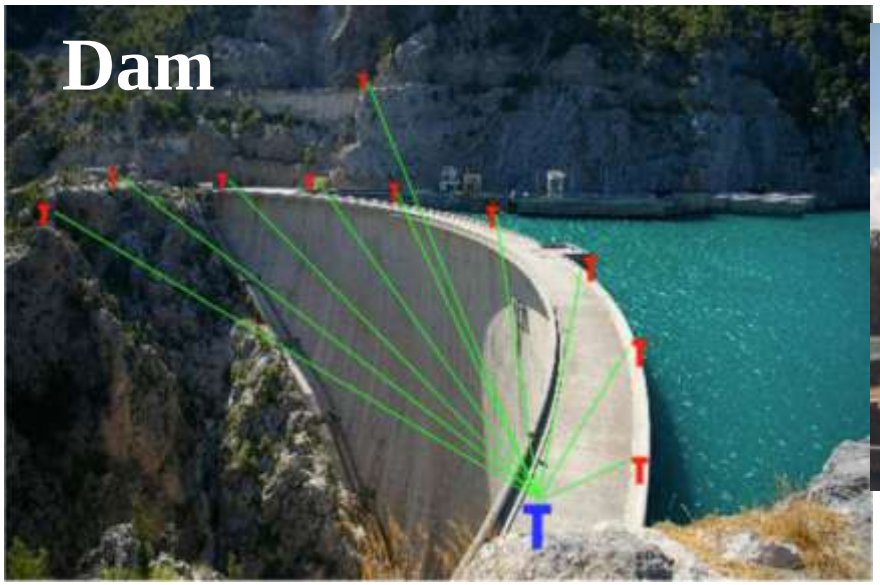
Multi-GNSS RTK for real time deformation monitoring

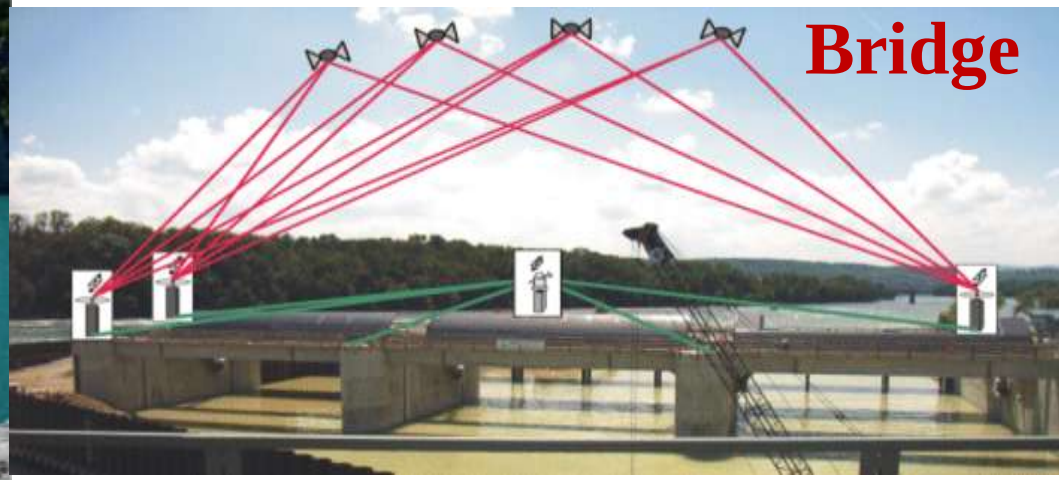
- Precision: horizontal 1~2.5 mm, vertical 2~5 mm
- Extended Kalman filter with filter information recorded -> High efficiency
- High ambiguity fixing rates
- High sensitivity to both small transient and long-term deformations
- Compatible with GPS, GLONASS and BEIDOU – with Galileo soon…
- Operational under all weather conditions

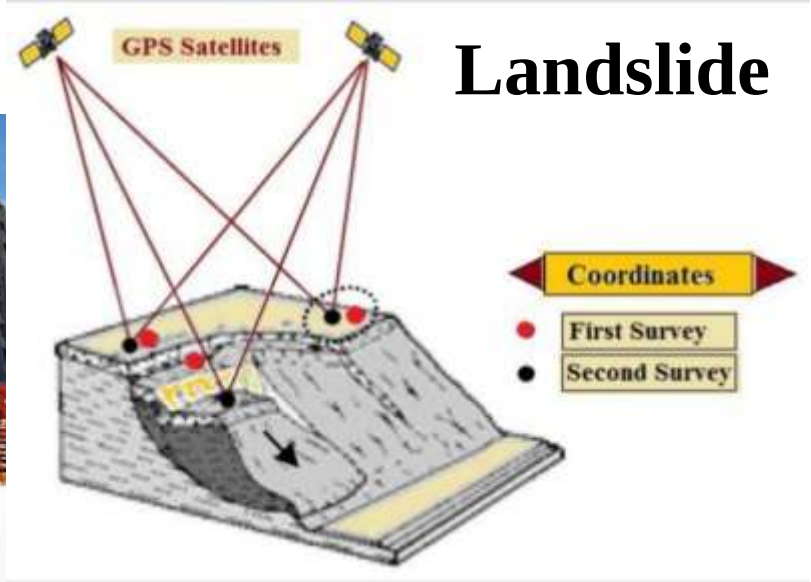
Potential applications

- Landslide/Volcano Early Warning System (EWS)
- Stability of man-made infrastructure (e.g. buildings, dams and bridges)

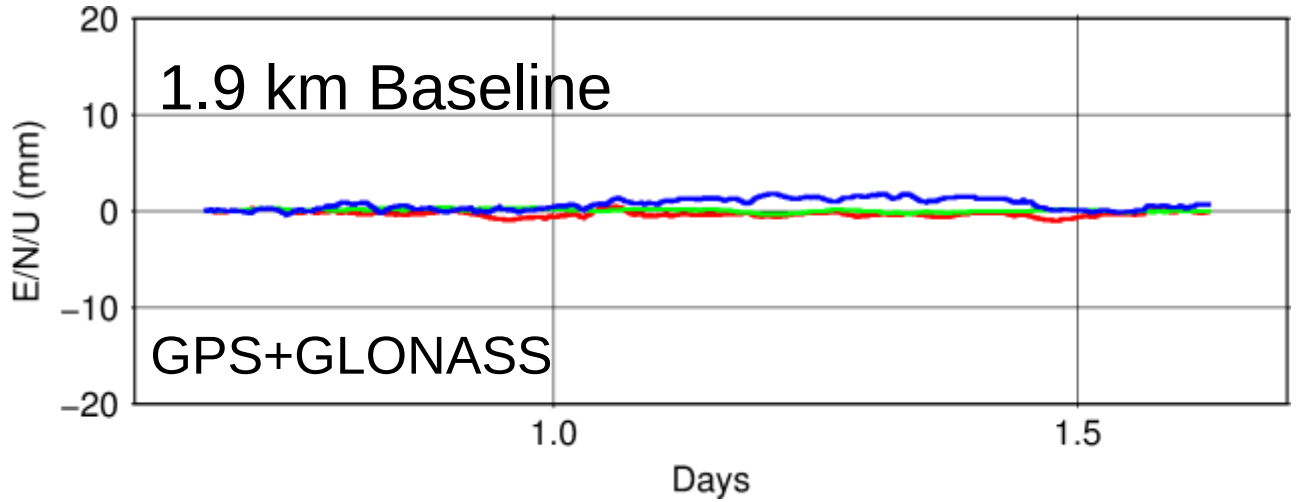
Potential applications







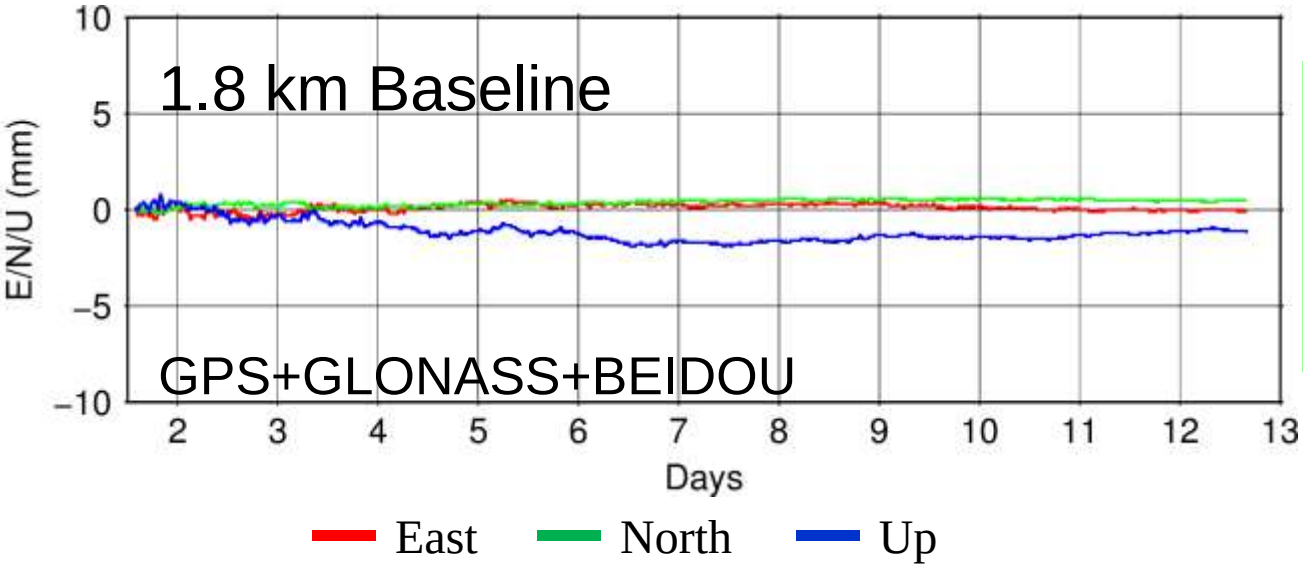
Performance of RT Multi-GNSS Monitoring System



$StdDev_{east}$ = 0.8 mm

$StdDev_{north}$ = 1.1 mm

$StdDev_{up}$ = 1.9 mm



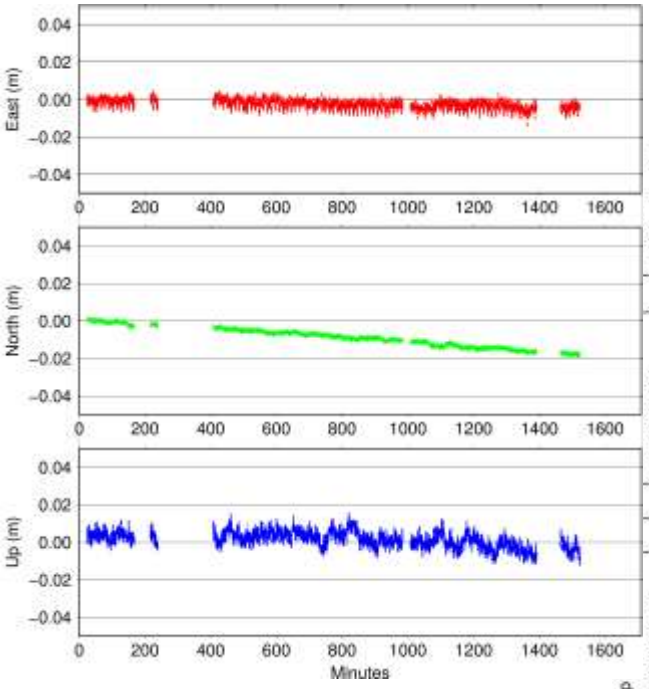
$StdDev_{east}$ = 0.6 mm

$StdDev_{north}$ = 0.7 mm

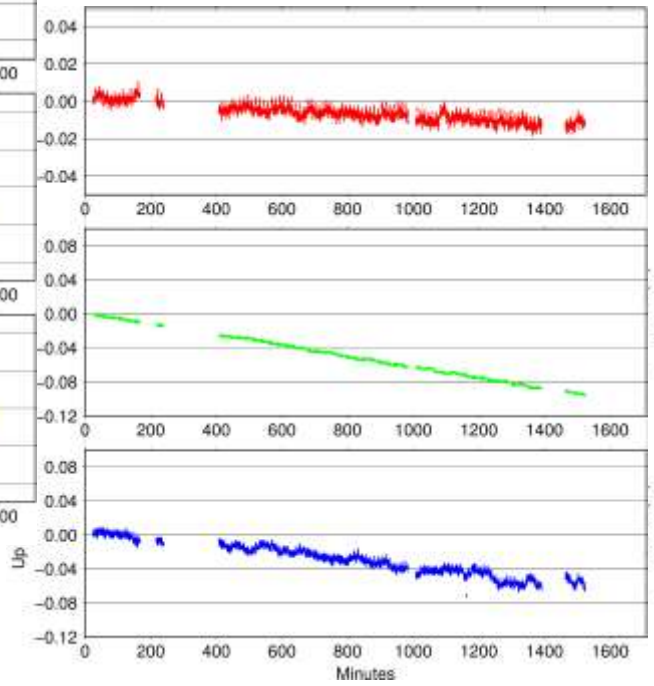
$StdDev_{up}$ = 1.7 mm

Two landslides

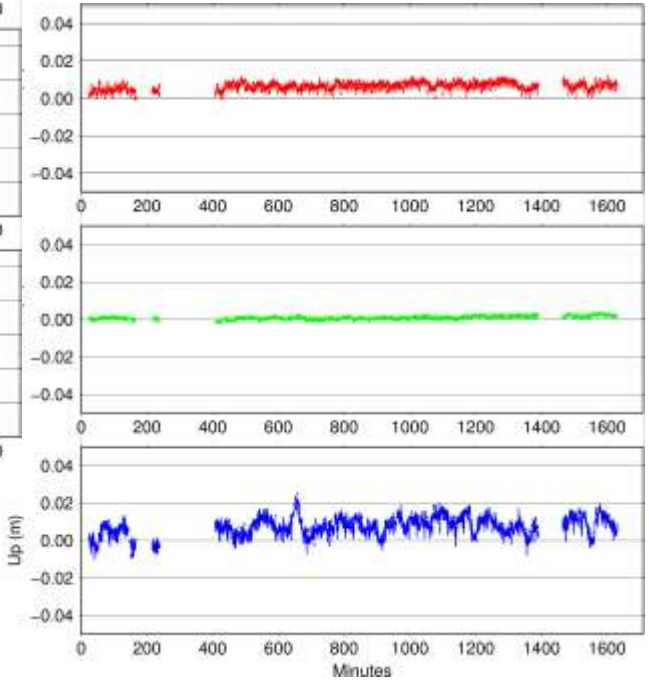
Multi-GNSS RTK solutions



GPS02-GPS01



GPS04-GPS01



DB01-BD02

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Satellites may warn of killer landslides

Tech July 14, 2017 10:38
By China Daily/ANN

LONDON - Researchers in China and the United Kingdom hope to use satellite imaging for the early detection of landslides in Southwest China, such as the one in late June that engulfed a village in Maoxian county, Sichuan province, leaving at least 10 dead and 73 missing.

A team of researchers from the UK's Newcastle University and several Chinese institutions analyzed before and after satellite images of the Maoxian region that show the danger area had been moving at a slow pace

Conclusions

- Satellite radar observation can play a key role in DRR

- EO for Landslide Disasters:

Disaster Response -> Recovery -> Mitigation -> Preparation

- Future Work:
  - How to extract the useful information from BIG DATA automatically?
  - How to best build Early Warning Systems (EWSs) to save lives?
  - How to better transfer EO+DRR knowledge to local communities?