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

Landslide Disaster Monitoring using space-based technologies

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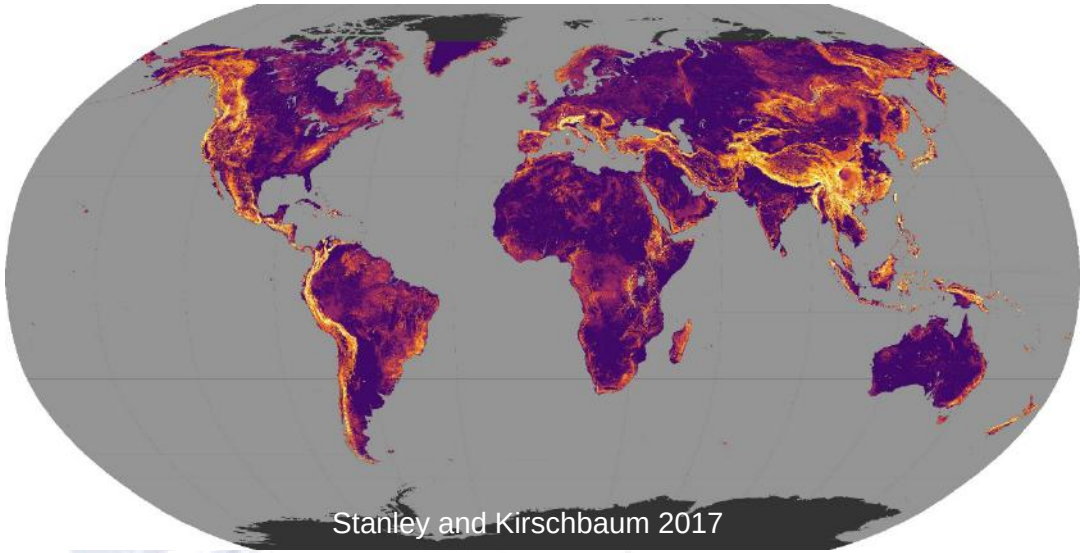
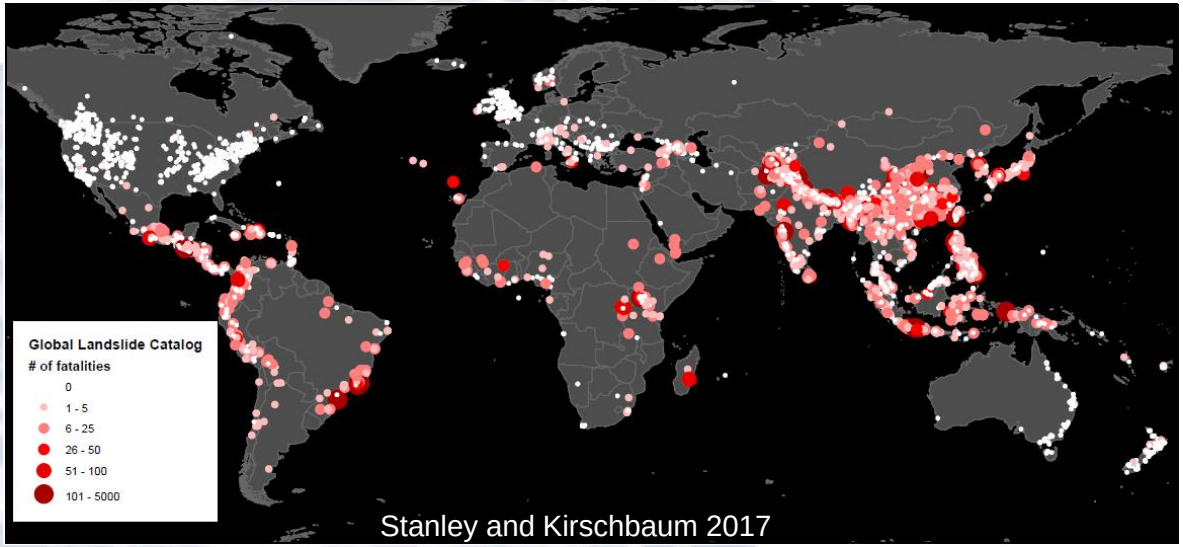
October 23rd, 2017

Global Landslide Hazards



Global landslide susceptibility map

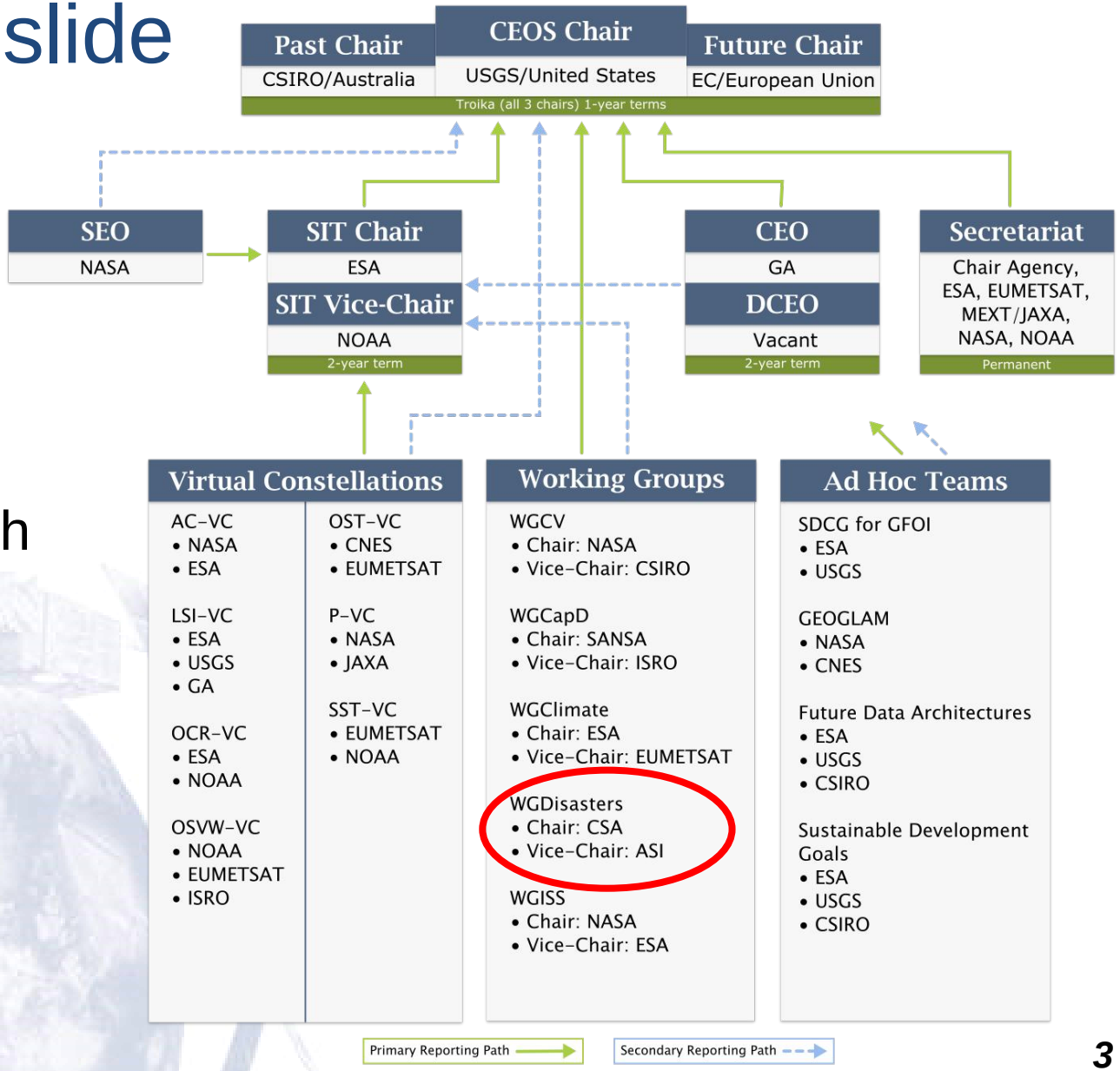


Global landslide Catalog - # of Landslides

Global Landslide Hazards

CEOS

Committee on Earth Observation Satellites



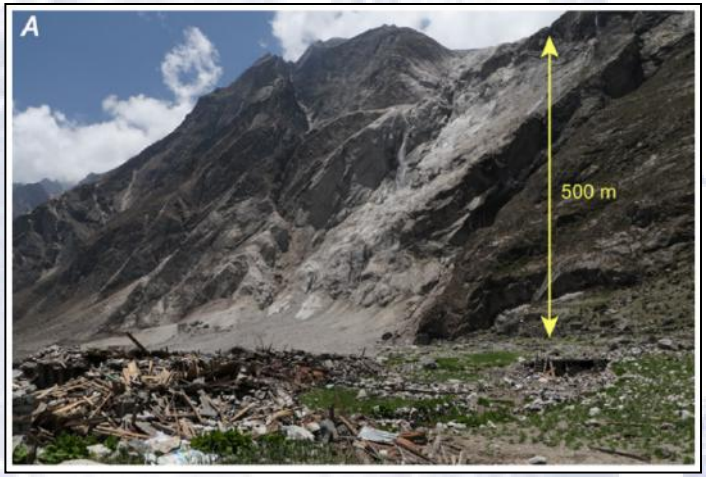
Global Landslide Hazards

Plenary endorsed creation of multi-hazard landslide pilot team at the 29th CEOS Plenary in 2016

Main Goals of the landslide pilot:

To demonstrate the effective exploitation of Earth observations (EO) data and technologies to detect, map and monitor landslides, in different physiographic and climatic regions.

To apply satellite EO across the cycle of landslide disaster risk management, including preparedness, situational awareness, response and recovery with a distinct multi-hazard focus on cascading impacts and risks.



View from the ground (Photo credit USGS)

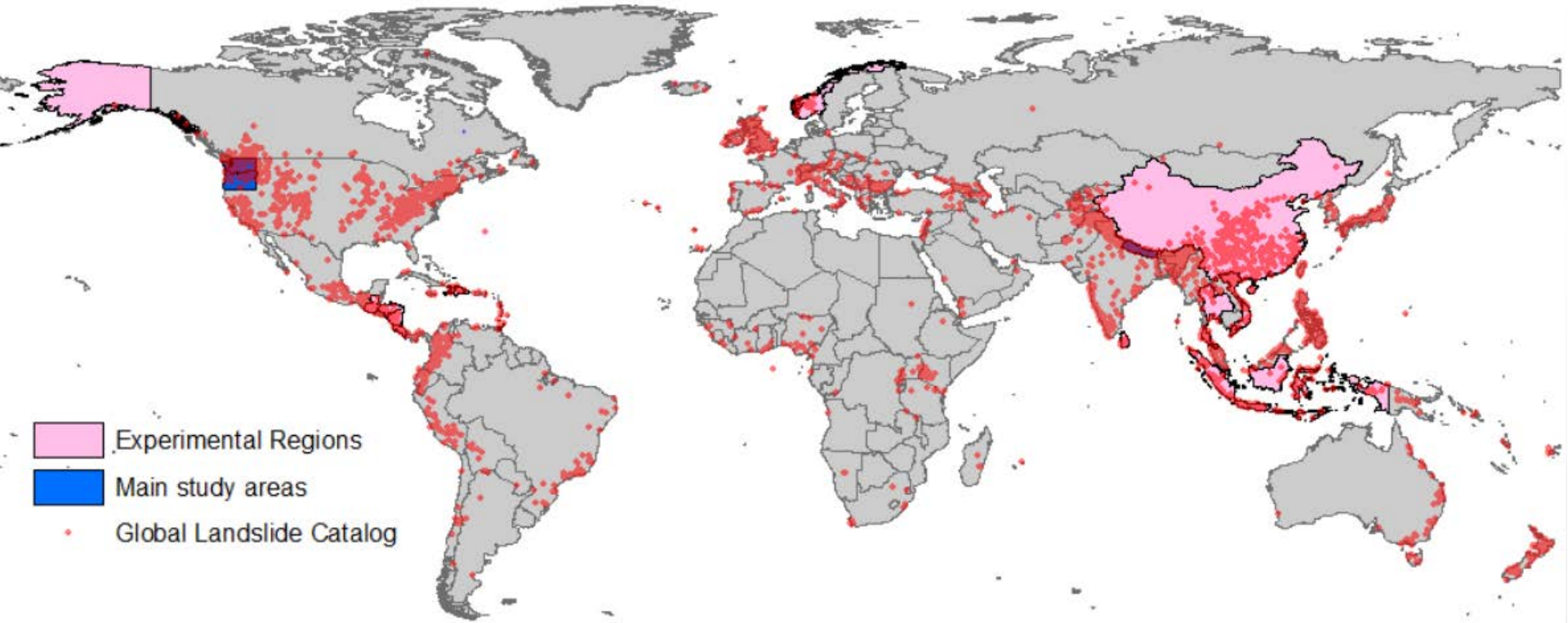
Damage Proxy Map (DPM) from ALOS-2 Data

Methodology

I. Mapping
- Creating inventories
- Documentation

II. Monitoring
- Routine processing over sample sites

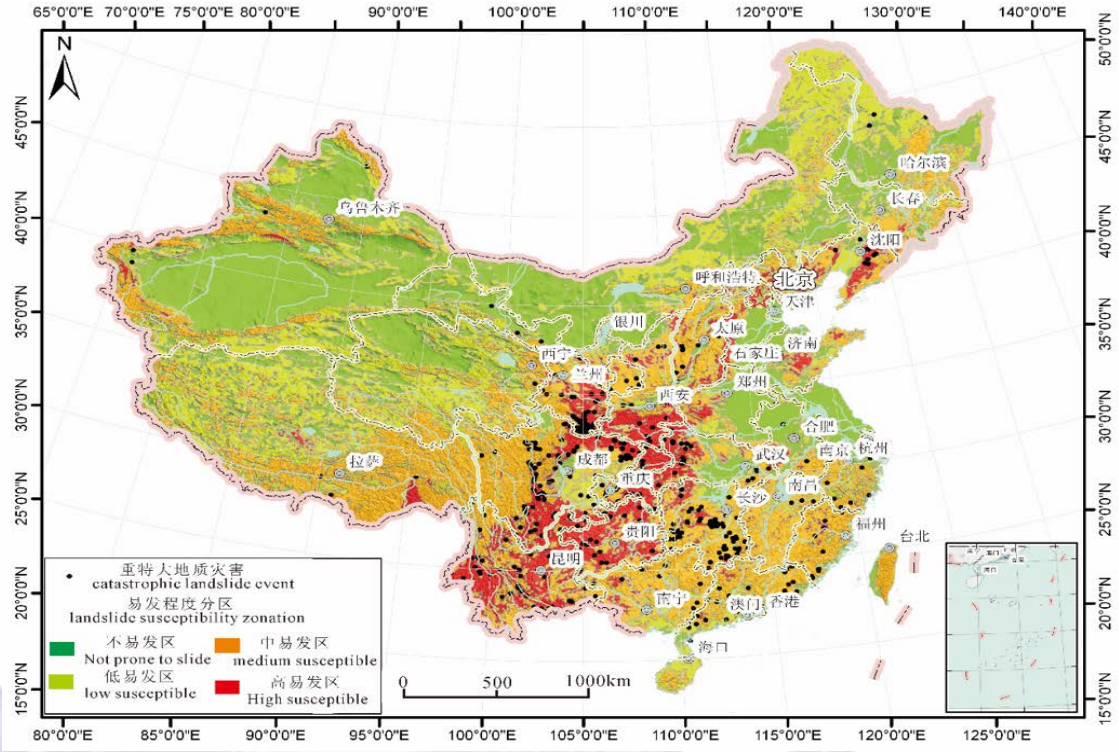
III. EO-based Analysis
- Establishing automatic and standardized methods for landslide hazard analysis.



Main Focus areas:
- **Nepal**
- **Pacific Northwest, US**

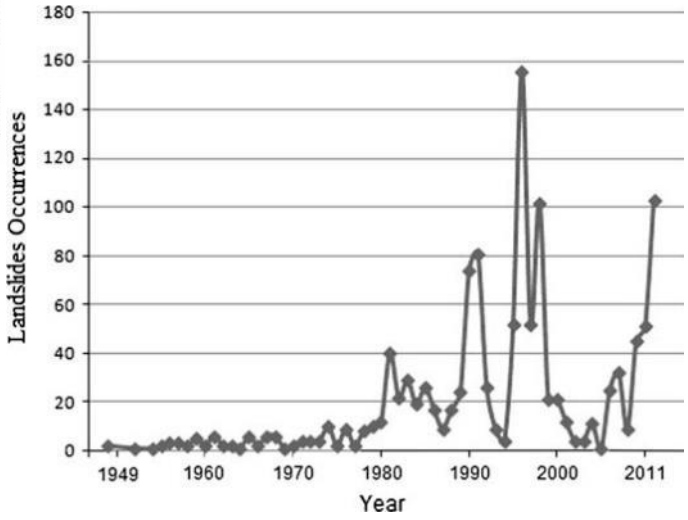
Experimental areas:
- SE Alaska
- China
- The Caribbean (Cuba, Haiti, Antillas)
- Sri Lanka/India

Landslide Hazards in China

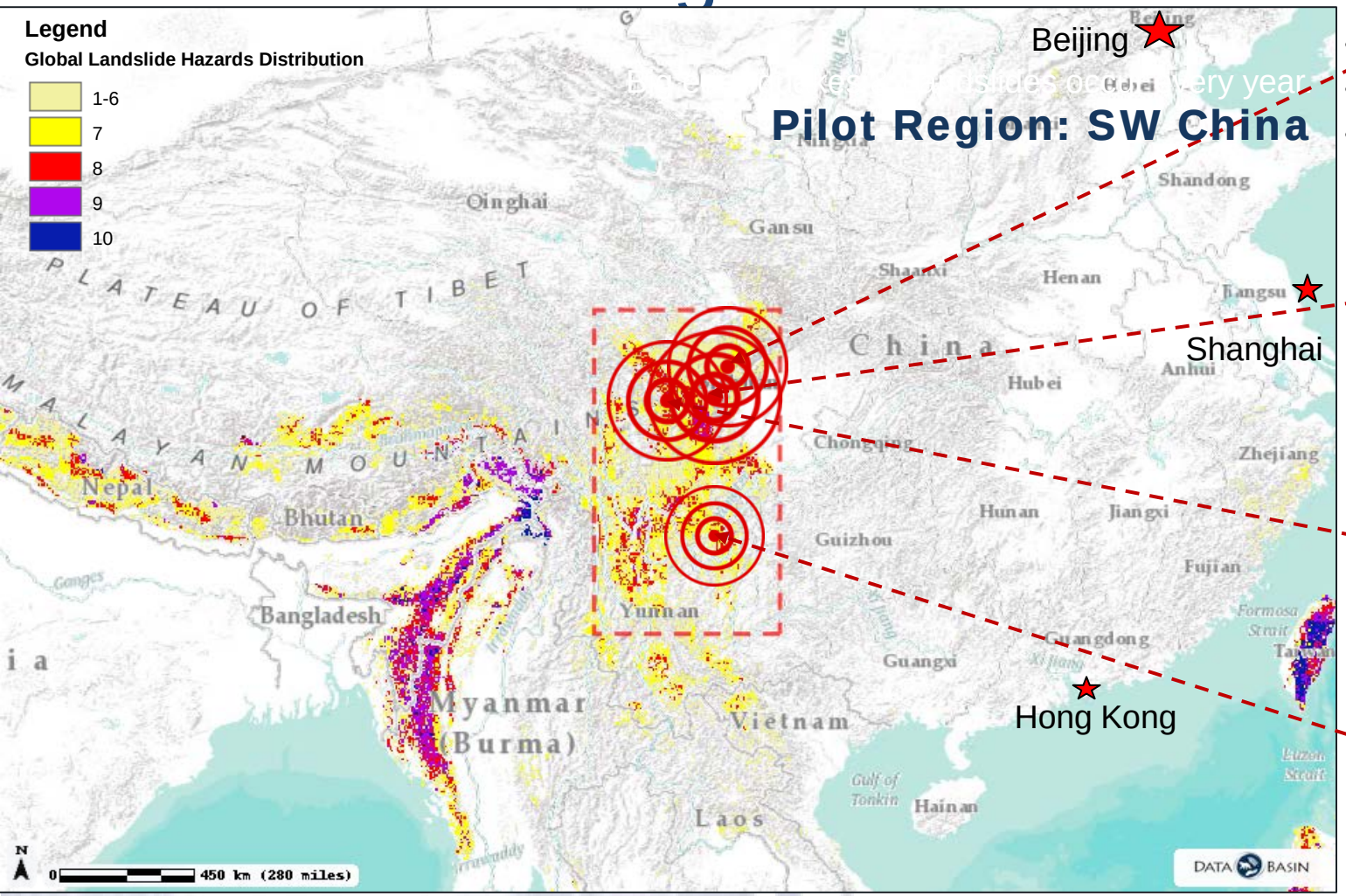


Landslide susceptibility map and catastrophic landslide events during 2001-2010 in China (Jusong Shi et al., 2012)

The number of landslide events over past 60 years



China Pilot – Region of Interest



Ms7.0 Earthquake

- **Jiuzhaigou, August 8, 2017**
- **No. of landslides: unknown**
- 617 deaths, 112 missing.

Ms8.0 Earthquake

- Wenchuan, May 12, 2008
- 48,000 landslides*
- 70,000 fatalities (20,000 by landslides)

Ms7.0 Earthquake

- **Ya An, April 20, 2013**
- **No. of landslides: unknown**
- 196 deaths

Ms6.5 Earthquake

- **Ludian, August 3, 2014**
- **1,000+ big landslides**
- Thousands killed in slides

Global Landslide Hazards Distribution

https://databasin.org/datasets/b5c842f4b248464593a7673f5ad7f10f

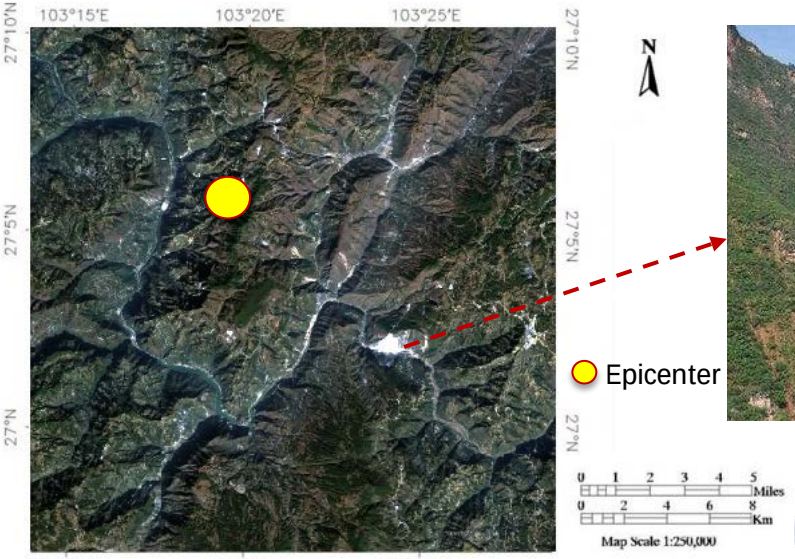
(*Runqiu Huang et al., 2011)

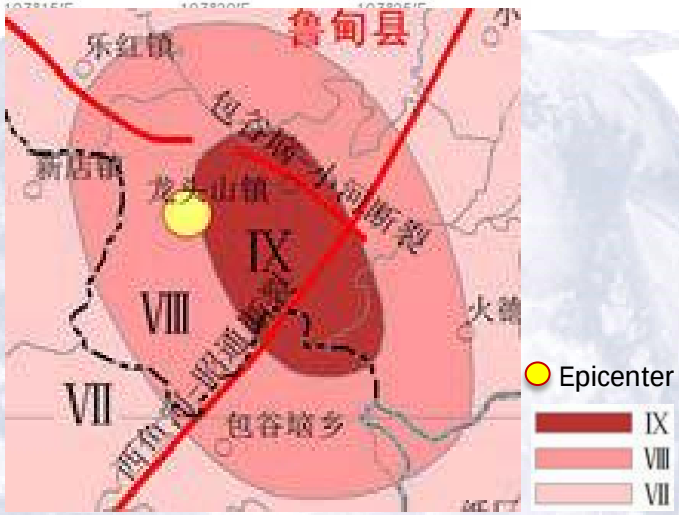
Credits: Center for Hazards and Risk Research (CHRR); Center for International Earth Science Information Network (CIESIN), Columbia University; Norwegian Geotechnical Institute (NGI)

China Pilot – Study Area and Data

Landslides & Barrier Lake
(water level 58m)

Floods
(10+ towns, 30 ㎢ croplands)



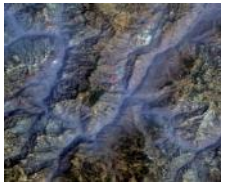


Optical Images Time Series

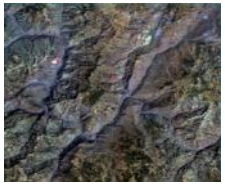
(332 images with 8-30m Res., 2000-2016)

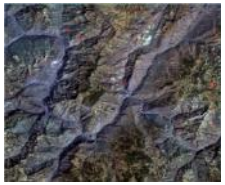
Satellite Sensor	Period	Images No.	Revisit period	Spatial Res.	Country
Landsat TM/ETM+/OLI	2000~	**172**	16 d	15/30 m	USA
GF-1 CCD	2013~	**68**	4 d	2/8/16m	China
HJ-A/B CCD	2008~	**92**	4 d	30 m	China

China Pilot – Landslides by visual interpretation (2000-2015)

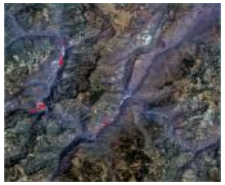

2000 (6)


2001 (6)


2002 (12)


2003 (15)

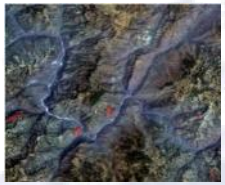
Year (Landslides)


2004 (16)


2005 (12)


2006 (12)


2007 (10)


2008 (17)

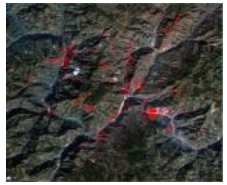

2009 (10)


2010 (14)


2011 (5)


2012 (10)


2013 (7)


2014 (526)

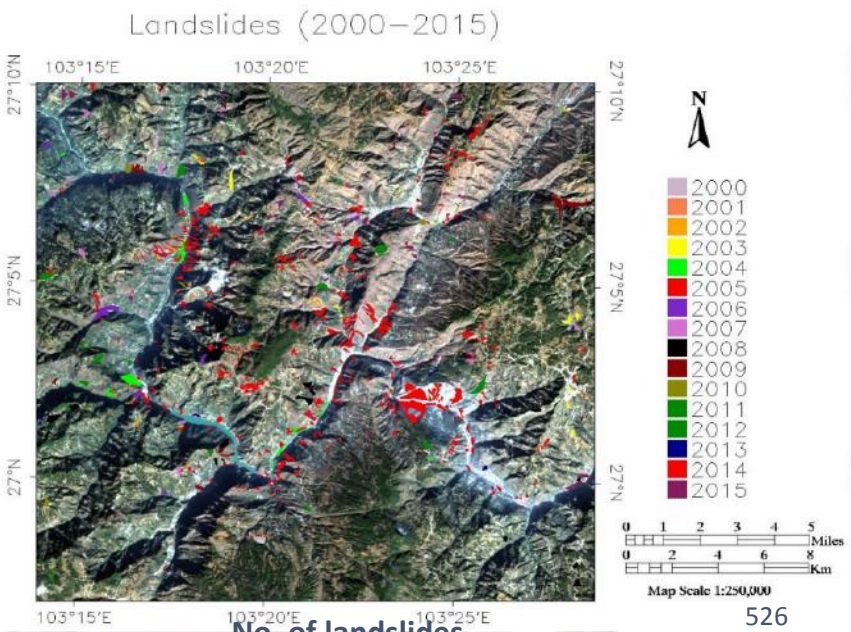

2015 (28)

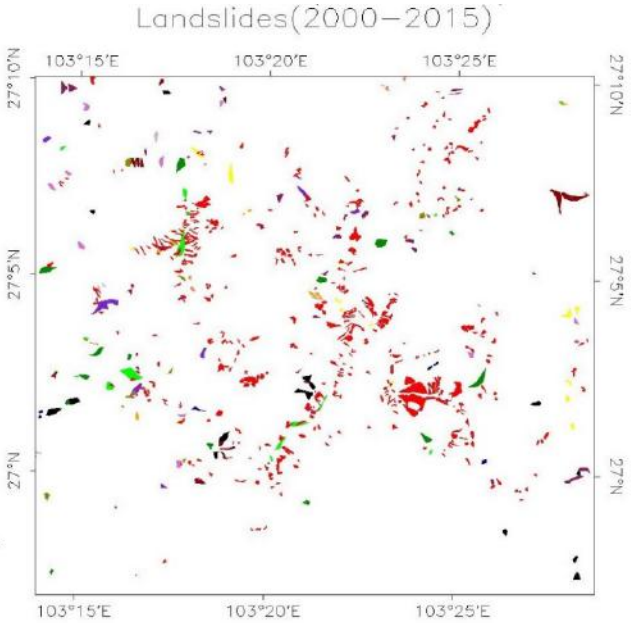
Landslides > 90*120 m²

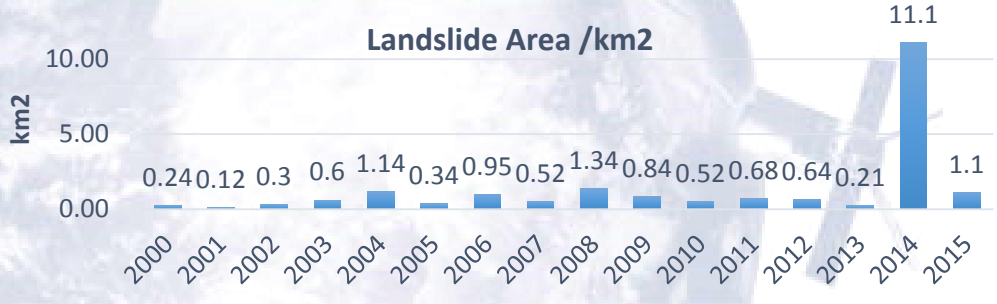
Images of Landsat, GF-1/2 and HJ-CCD captured in summers

Year	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Landslides	6	6	12	15	16	12	12	10	17	10	14	5	10	7	526	28
Total Area (km²)	0.24	0.12	0.30	0.60	1.14	0.34	0.95	0.52	1.34	0.84	0.52	0.68	0.64	0.21	6.5	1.10

China Pilot – Map of Landslides (> 0.01km^2 , 2000-2015)

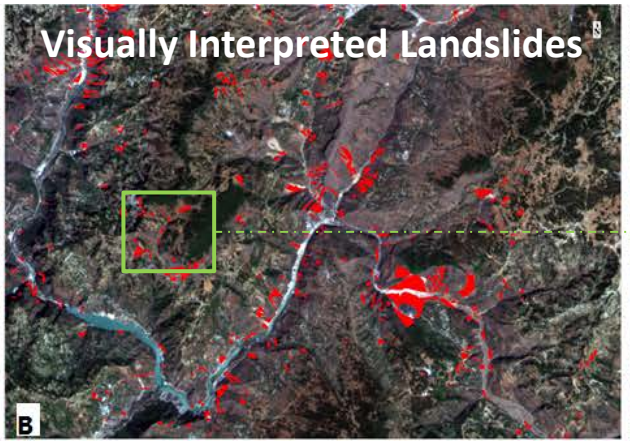


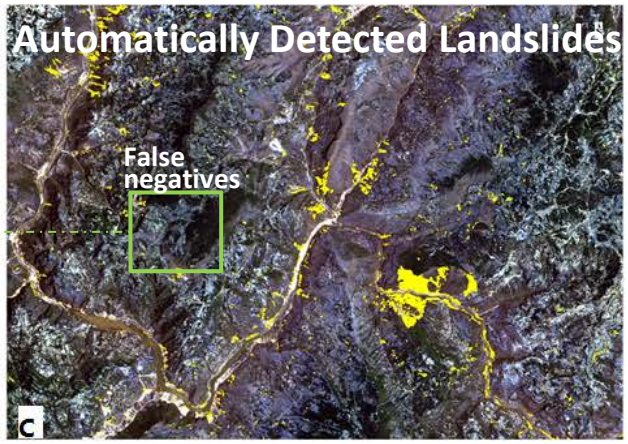




- Landslides occurred every year
- Large amount of huge landslides were induced by earthquake in 2014

China Pilot – Landslide Detection in Multi-temporal Images





Results:

Auto-matic	Visual	True Positive	False Negative	Producer Accuracy	User Accuracy
1372	1017	872	145	63.56 %	**85.74 %**

- Principle to detect landslides

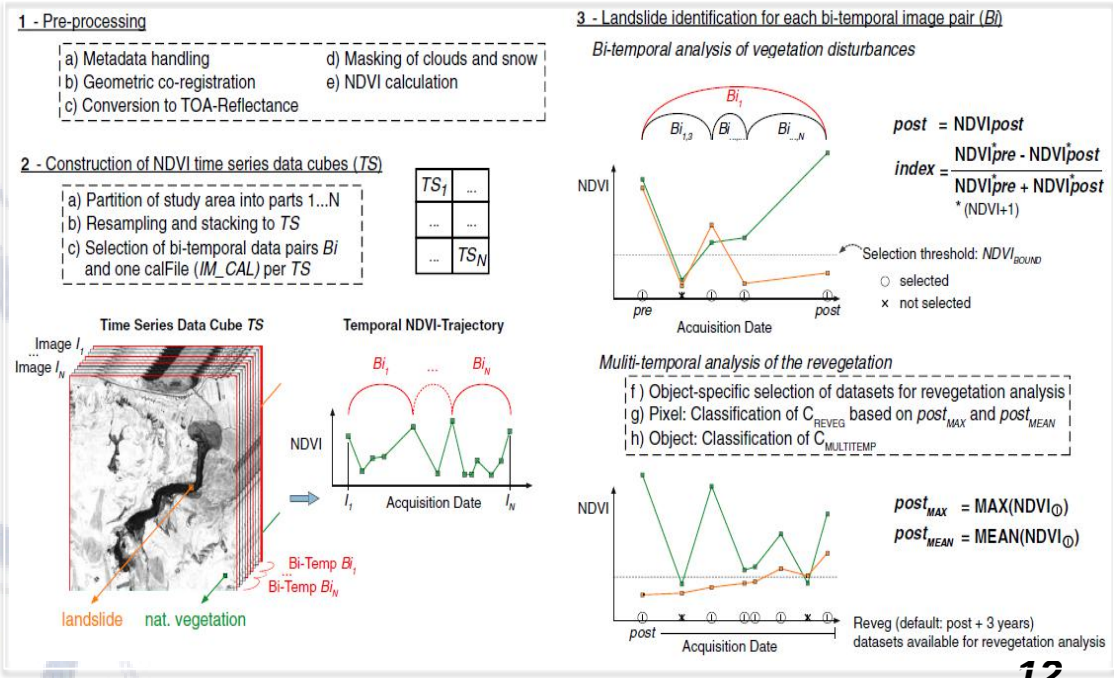
  Vegetation cover changes before and after landslide candidates.

- What are false landslides?

  New roads and quarries.

- What are missing landslides?

  Shallow slopes with little vegetation.



R. Behling, S. Roessner, D. Golovko, et al., "Derivation of long-term spatiotemporal landslide activity—A multi-sensor time series approach," Remote Sensing of Environment (**2016**).

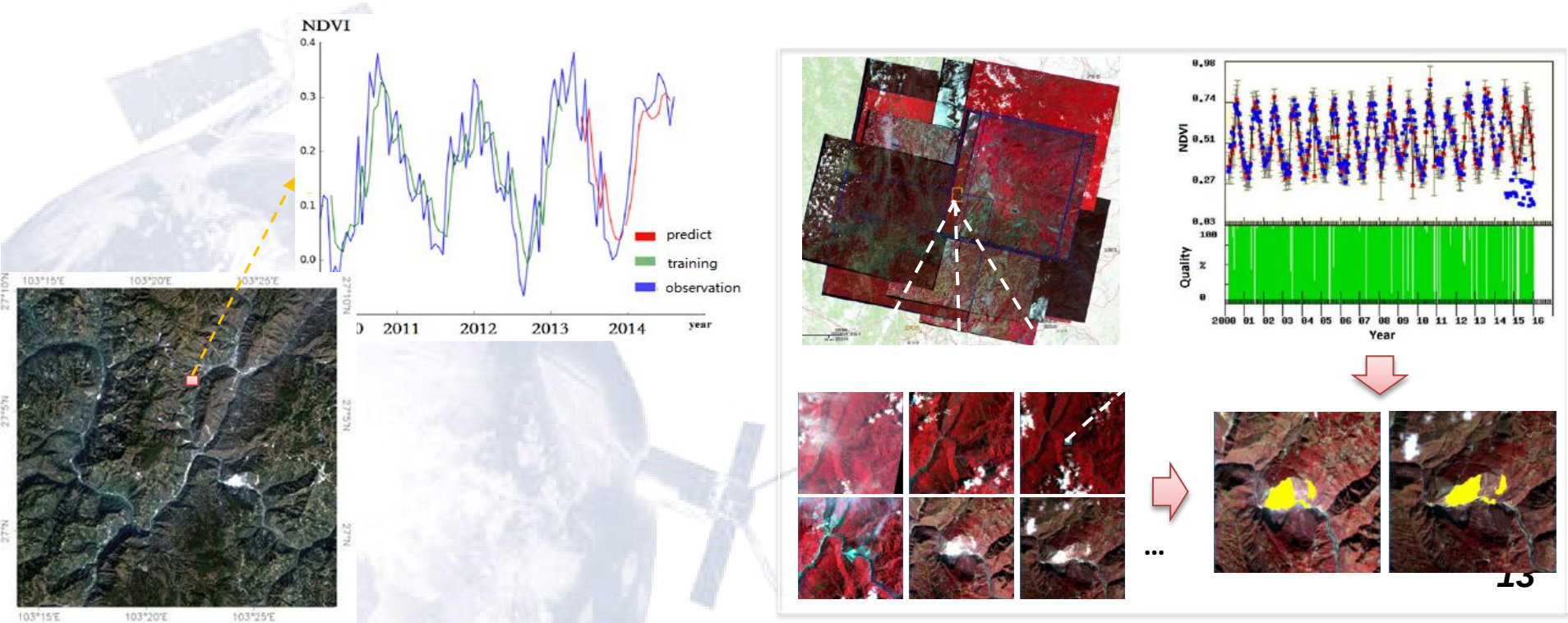
China Pilot – What's in next two years

- **Objective A:**

Develop more effective **multi-temporal** methods for merging multi-source satellite images to better detect historical landslides **on a quarterly to monthly basis**.

- **Objective B:**

Develop machine learning methods to understand **variation patterns** in time series images and to **rapidly detect new landslides** in new available satellite images.



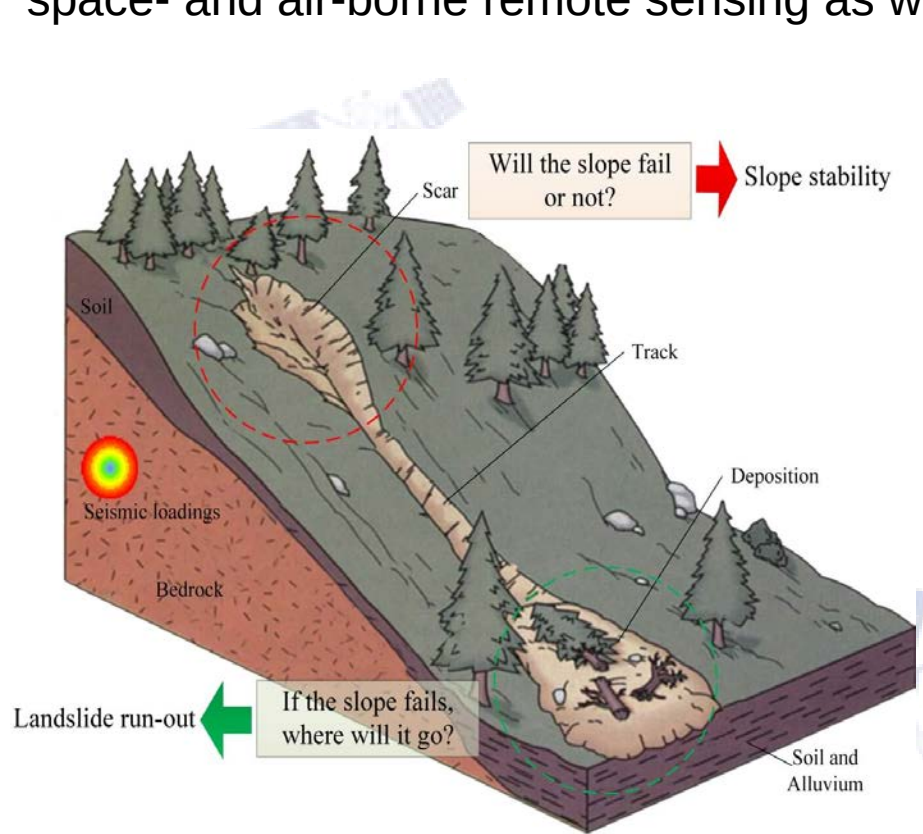
China Pilot – Long-range objectives

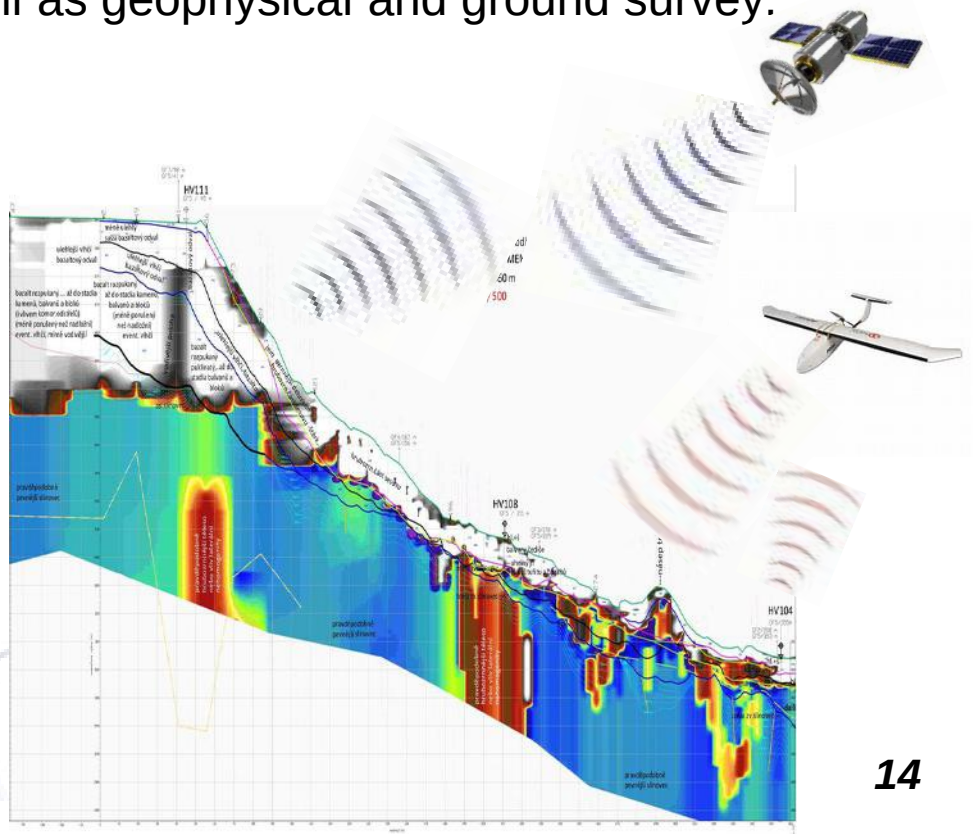
- **Objective 1:**

Improve abilities in monitoring the **process of landslide development** based on integration of space-based remote sensing and geophysical survey technologies.

- **Objective 2:**

Develop methodologies on **landslide short-term forecast** using big data of space- and air-borne remote sensing as well as geophysical and ground survey.





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Thank you!