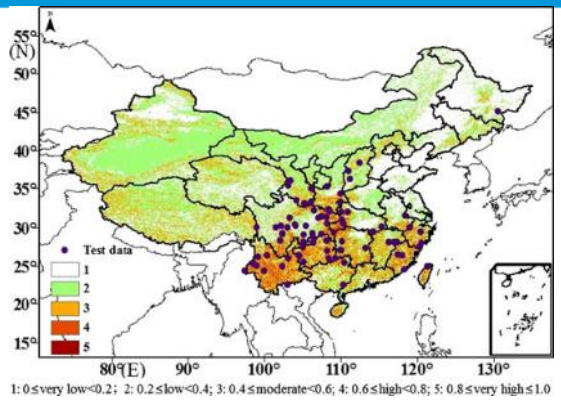


CEOS Landslide Pilot Chinese Region:

a recent progress

Ziyang Li

zyli@aoe.ac.cn

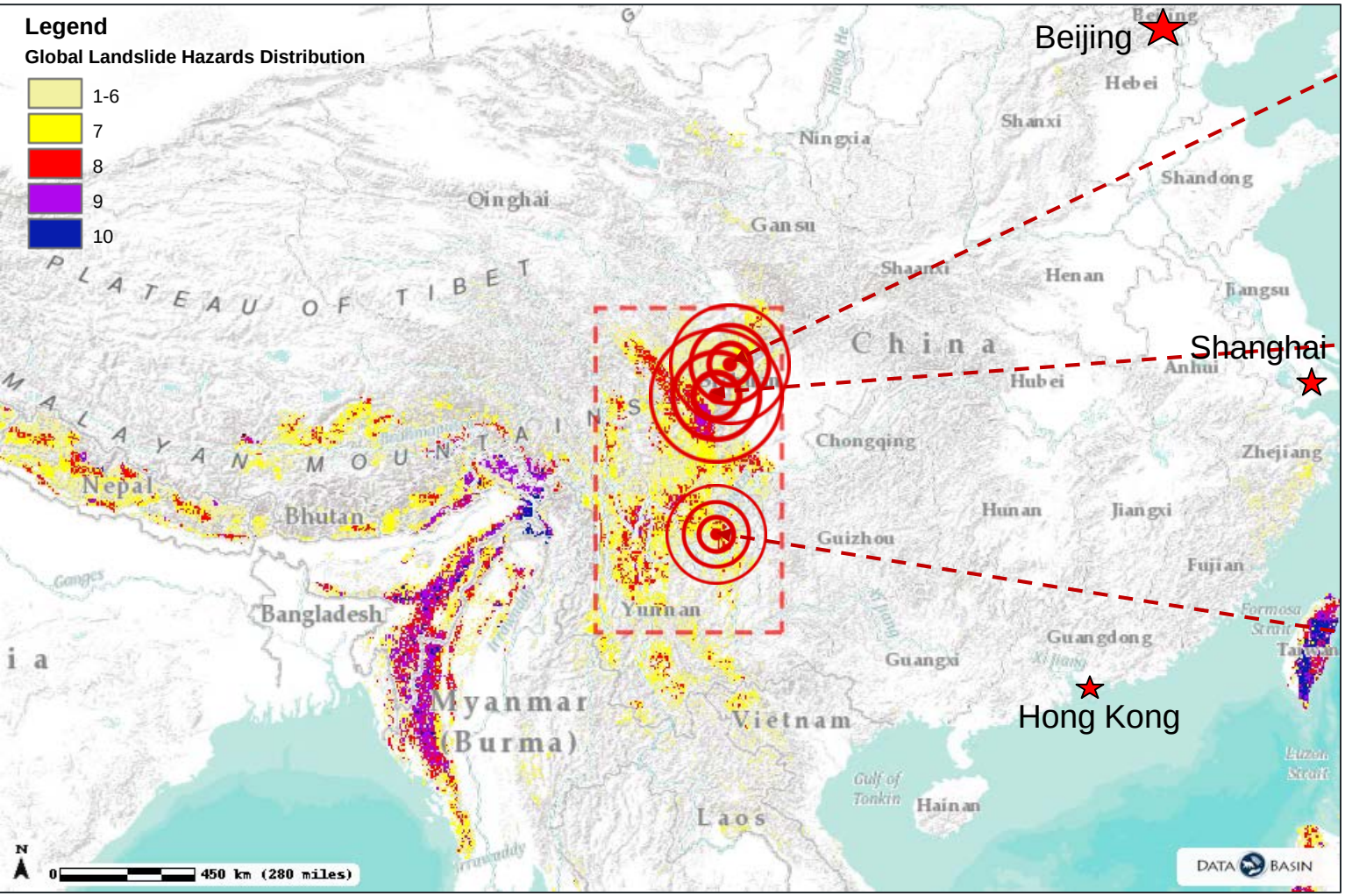
Key Laboratory of Quantitative Remote Sensing Information Technology, Academy of Opto-Electronics (AOE), Chinese Academy of Sciences (CAS)

Brussels, 13-15 March, 2018

China Pilot – Region of Interest

Pilot Region: SW China

Big earthquakes & Landslides occur every year.



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)

Ms6.5 Earthquake

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

Global Landslide Hazards Distribution

https://databasin.org/datasets/b5c842f4b248464593a7673f5ad7f10f

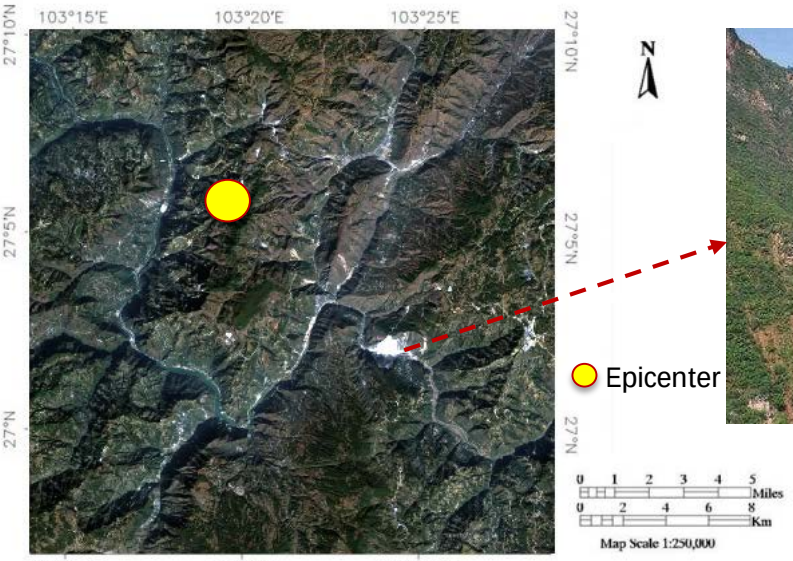
(*Runqiu Huang et al., 2011)

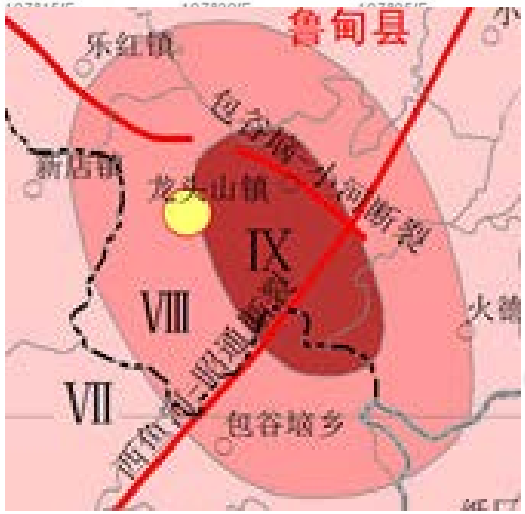
Credits: Center for Hazards and Risk Research (CHRR); Center for International Earth Science Information Network (CIESIN), Columbia University; Norwegian Geotechnical Institute (NGI)

China Pilot – Study Area and Data

Epicentral zone

of Ms6.5 Ludian Earthquake, 2014





Landslides & Barrier Lake

(water level 58m)

Floods

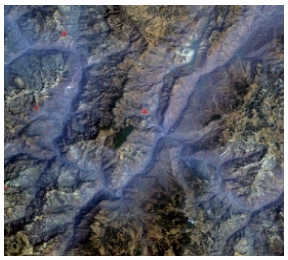
(10+ towns, 30 km² croplands)

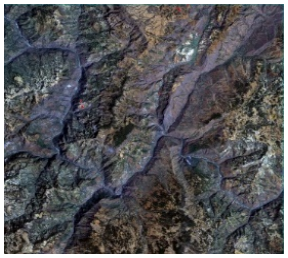
Optical Images Time Series

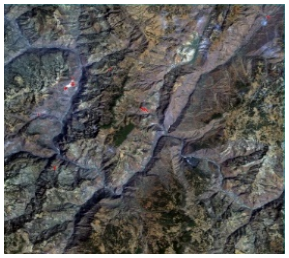
(332 images with 8-30m Res., 2000-2016)

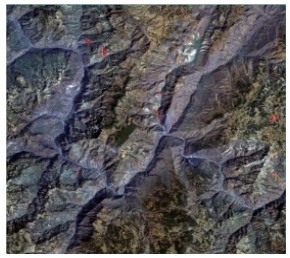
Satellite Sensor	Period	Images No.	Revisit period	Spatial Res.	Country
Landsat TM/ETM+/OLI	2000~	**172**	16 d	15/30 m	USA
GF-1 CCD	2013~	**68**	4 d	2/8/16m	China
HJ-A/B CCD	2008~	**92**	4 d	30 m	China

China Pilot – Visually Interpreted Landslides (2000-2015)


2000 (6)


2001 (6)


2002 (12)


2003 (15)

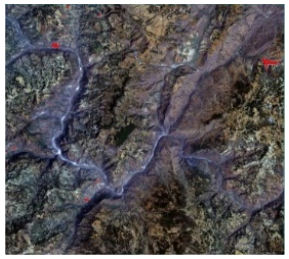

2004 (16)


2005 (12)


2006 (12)


2007 (10)


2008 (17)

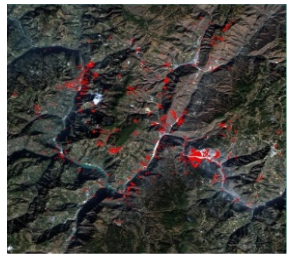

2009 (10)


2010 (14)


2011 (5)


2012 (10)


2013 (7)


2014 (526)

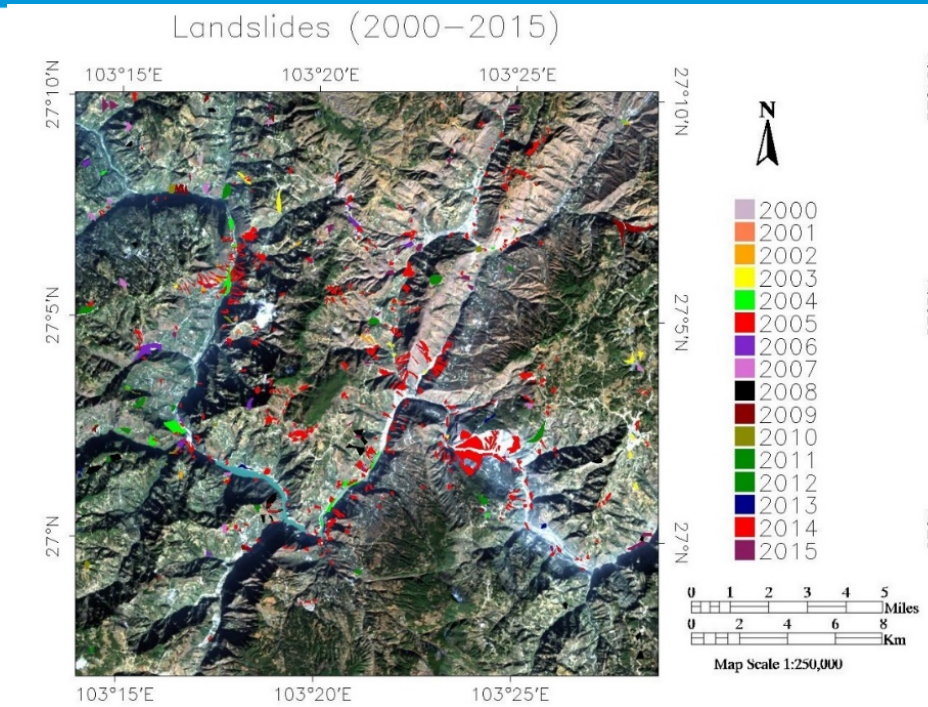

2015 (28)

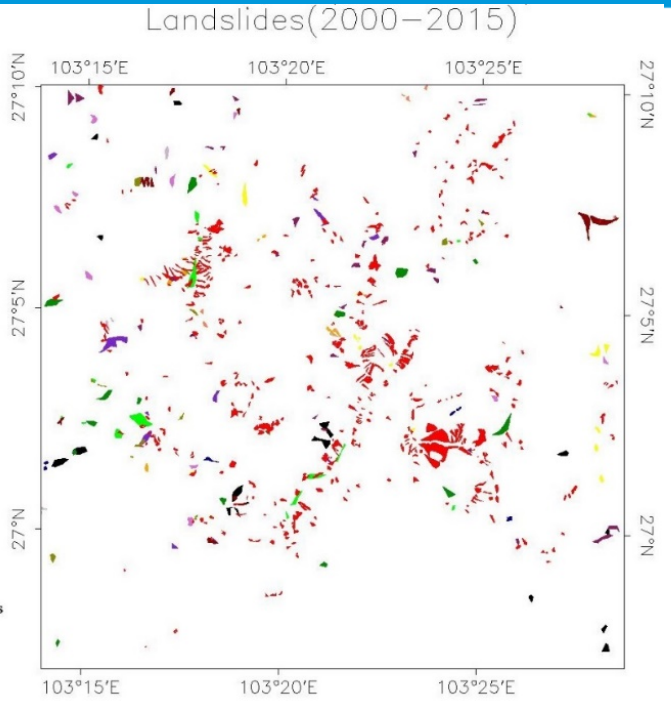
Year (Landslides)

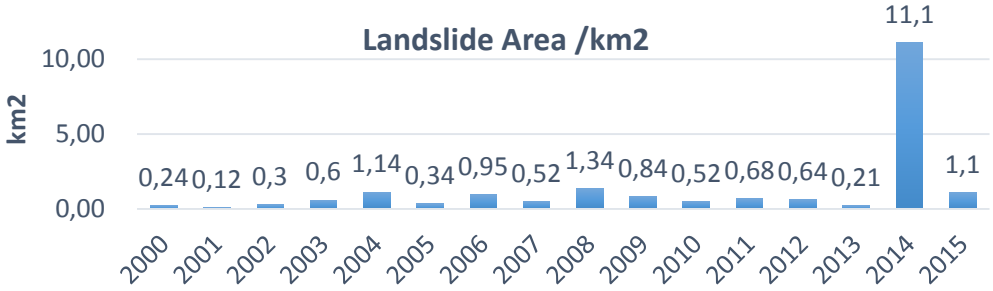
● **Landslides > 90*120 m²**

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)







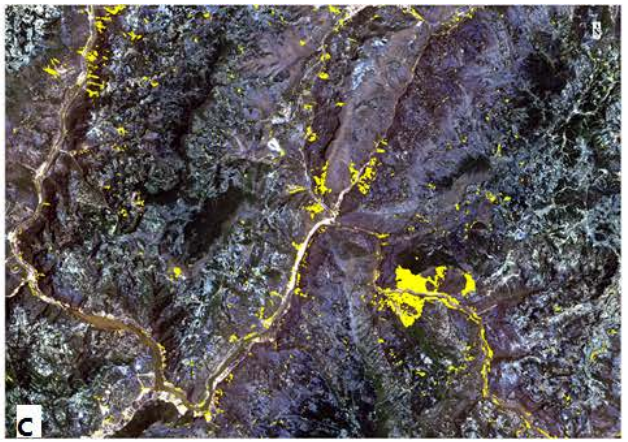
- Landslides occurred every year
- Large amount of huge landslides were induced by earthquake in 2014

Historical Landslides Detection in Multi-temporal Optical Images

Landsat-8 OLI, 22/04/2015

Visually Interpreted Landslides

Automatically Detected Landslides



Results:

Detect	Interpreted	TP	FN	Producer Accuracy	User Accuracy
1372	1017	872	145	63.56 %	**83.28 %**

- How to detect historical landslides?

  Dynamics of Vegetation cover pre-&post- landslides.

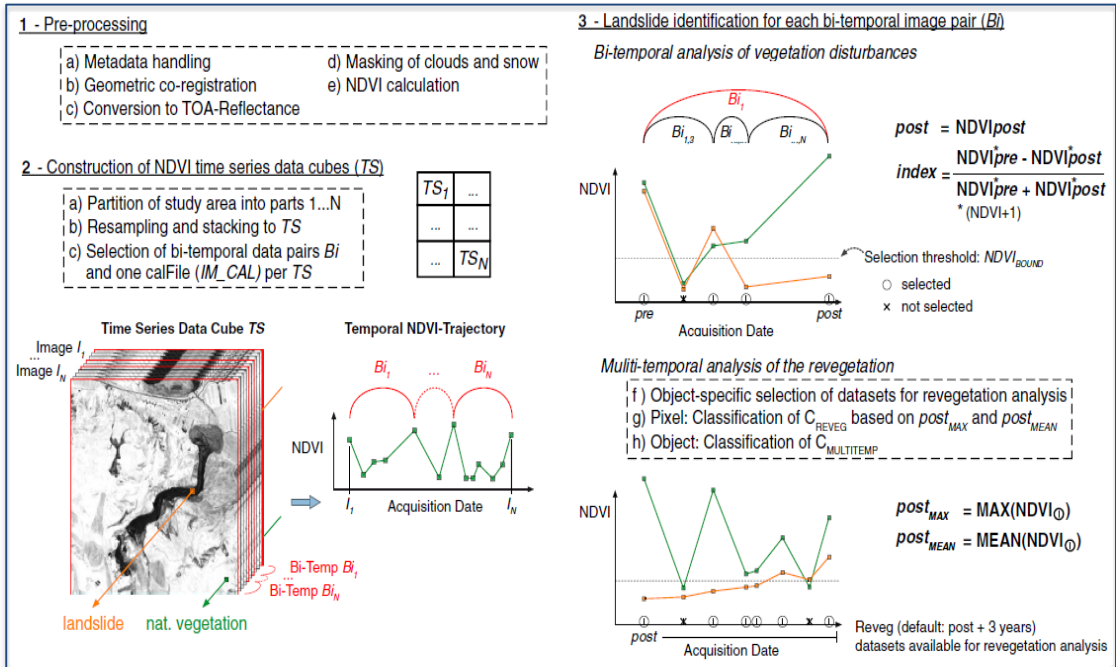
- What are false landslides?

  New roads and quarries.

- What are missing landslides?

  Shallow slopes with little vegetation.

Method used:

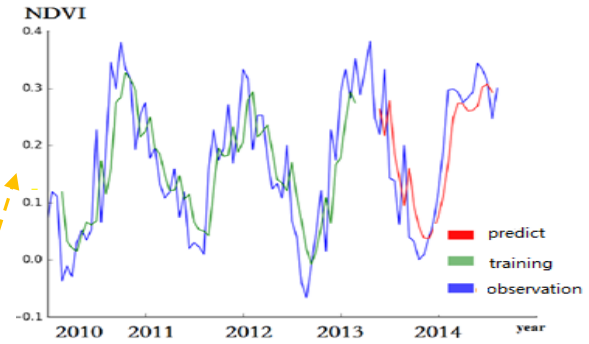


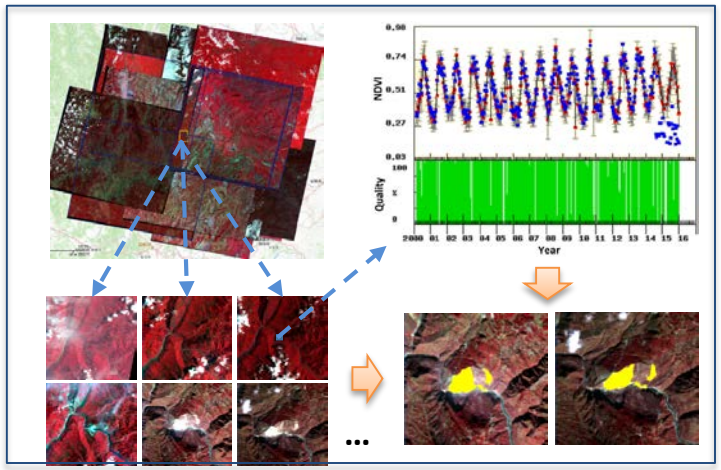
R. Behling, S. Roessner, D. Golovko, et al., "Derivation of long-term spatiotemporal landslide activity—A multi-sensor time series approach," Remote Sensing of Environment (**2016**).

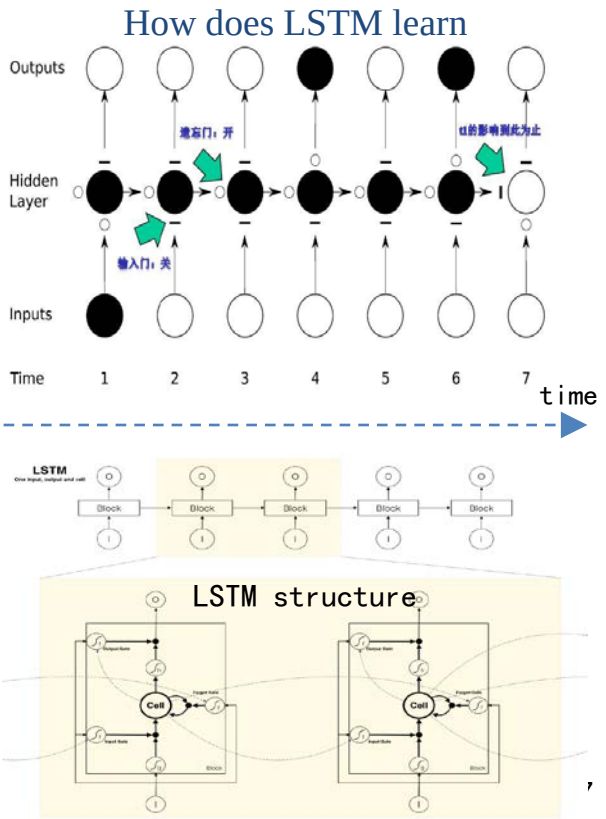
New Landslides Detection in Multi-temporal Optical Images

To rapidly detect new landslides in new available optical satellite images, a Machine Learning (Long-Short Term Memory, LSTM) based method is under developing.

LSTM can learn and predict land cover's patterns in images time series.







New Landslides Detection in Multi-temporal Optical Images

Feature extraction

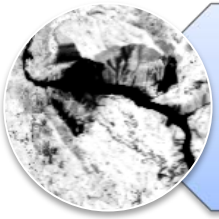
Landslides in complex terrain are difficult to be detected and non-landslides are easier to be mistakenly detected.

A series of landslides related and significant features must be selected.

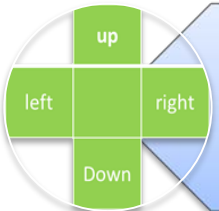
Blue, green, red and nir bands are most important spectral features.

Landslides often occur in areas with steep terrain. Slope is an important feature of landslides.

Aspect can help to detect landslides in sunshine areas and shadow areas.



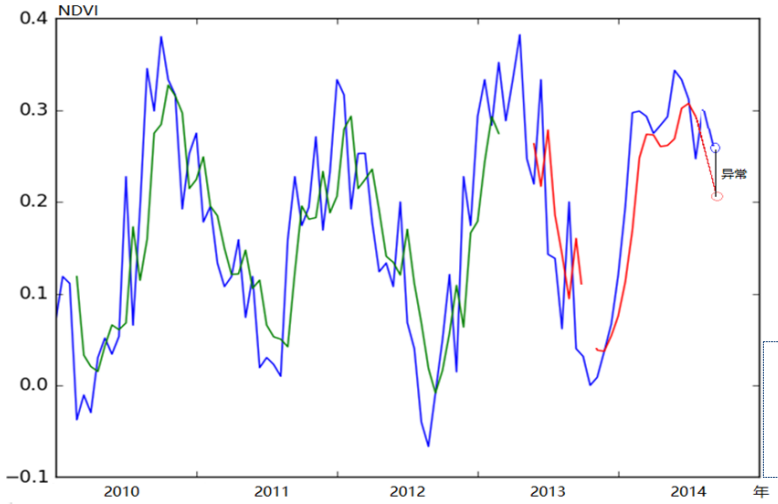
NDVI can be used to eliminate areas looks like landslides and have higher NDVI value.



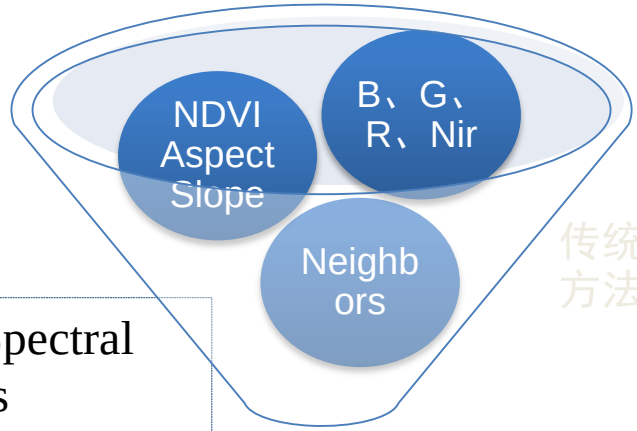
4-connect pixels are considered to eliminate single noise-polluted pixels.

New Landslides Detection in Multi-temporal Optical Images

Temporal features by LSTM



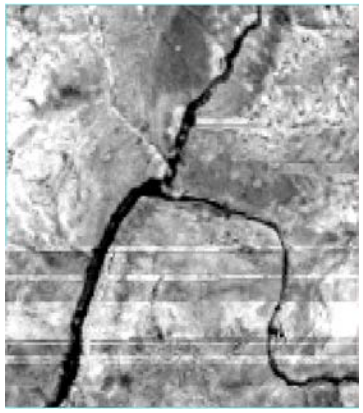
Spectral features by SVM

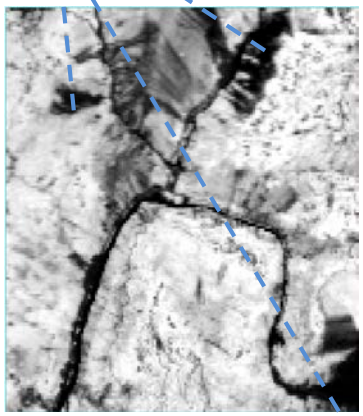


传统分类方法

Temporal & Spectral features

Possible new landslides





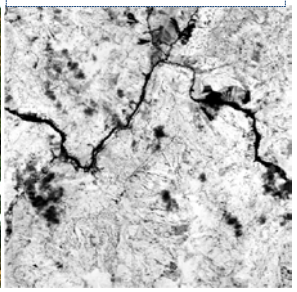
Predicted NDVI

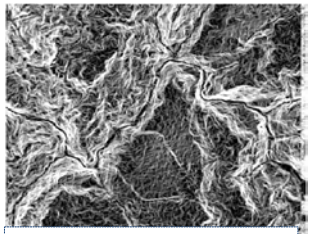
Observed NDVI

Refinement of Landslides detection

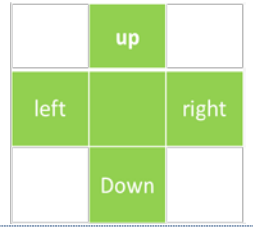
Spectral bands

NDVI





Slope & Aspects



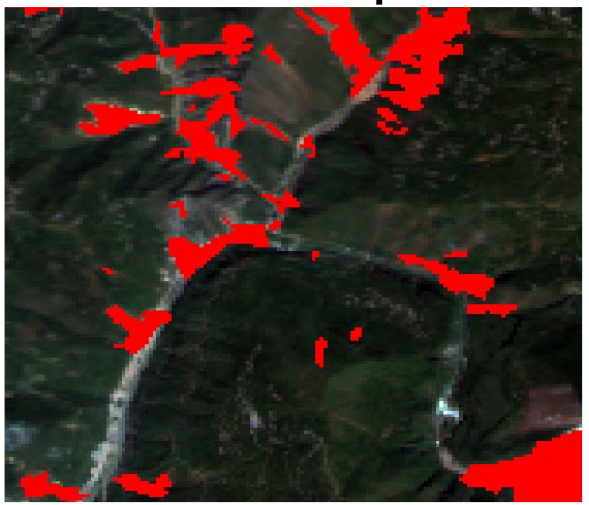
Neighbors

New Landslides Detection in Multi-temporal Optical Images

New available image
11/09/2014

New landslides detection
via LSTM and SVM

New landslides
via visual interpretation



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)

New Landslides Detection in Multi-temporal Optical Images

Detection errors to be considered:

False Alarm
- Mountain roads construction

False Alarm
- Man-made cutting slope

False Alarm
- Quarry

Missing Alarm
- Landslides in Shadow
- Shallow landslides

China Pilot – What's next

– **Detect and monitor Landslides with little vegetation:**

Take loess landslides as example, how to recognize landslides in sparse vegetation areas and how to monitor the displacement rate using satellite radar & optical images.

– **Explore new landslide features for future satellite remote sensing:**

Find new features of landslides activity, such as thermal radiation, water penetration, and electromagnetic radiation, through ground-based and air-borne experiments.