Project Summary

Monitoring Surface Displacement in The Three Gorges Area, Dangxiong-Lhasa and Jiangsu Province Area

ID: 5343 ，Three Gorges

June 22, Tuesday

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2. Research Progress & Outputs
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Objectives

1. To develop a robust and reliable method to measure the pre-landslide ground surface displacement in the Three Gorges Area as well as monitor ground deformation in the Jiangsu area;
2. To apply ScanSAR differential interferometry in Dangxiong-Lasha Region to measure the displacement introduced by earthquake and tectonic activity and assess its potential impact on major ground infrastructures in the Tibetan region.
3. To refine the interferometric WV correction method used for ScanSAR differential interferometry

Research Progress over the past year

1. Co-seismic deformation of Japanese Earthquake measured by using InSAR processing
2. Crustal displacement field of Dunxiiong Earthquake (2008) surveyed by using PS InSAR and SBAS time series analysis
3. Qinghai-Tibet railway deformation Mapped by using SBAS time-series technique
4. Assessment of spaceborne DEMs using ICESat
5. Pre-landslide slope movement of Shuping Landslides (3G) measured using SAR image correlation analysis
6. Landslide Monitoring in the Three Gorges Region by using InSAR Time-Series Techniques

Strong Earthquake in Japan on Mar. 11. 2011

On 11 March, 2011, Ms. 9.0 earthquake hit Japan. This was the 4th strongest one on record in the world, the biggest one in Japan's recorded history.

Many aspects about this strong earthquake out of expectation from seismologists:

1. Near the epicentre of this quake, 2 strong quakes over Ms7.0 occurred respectively in 1978, 2005, 2 days before and 27 days after the main quake, strong shocks happened. It is really peculiar.
2. Japanese seismologist put all their attention to the Tokyo region, because of around 70 years of strong quakes in the Tokyo region, and also huge risk potential

Data issued by ESA and JAXA up to March 31, 2011 for the quake

Envisat ASAR: track 347 and 297, in total 116 scenes before and after the quake

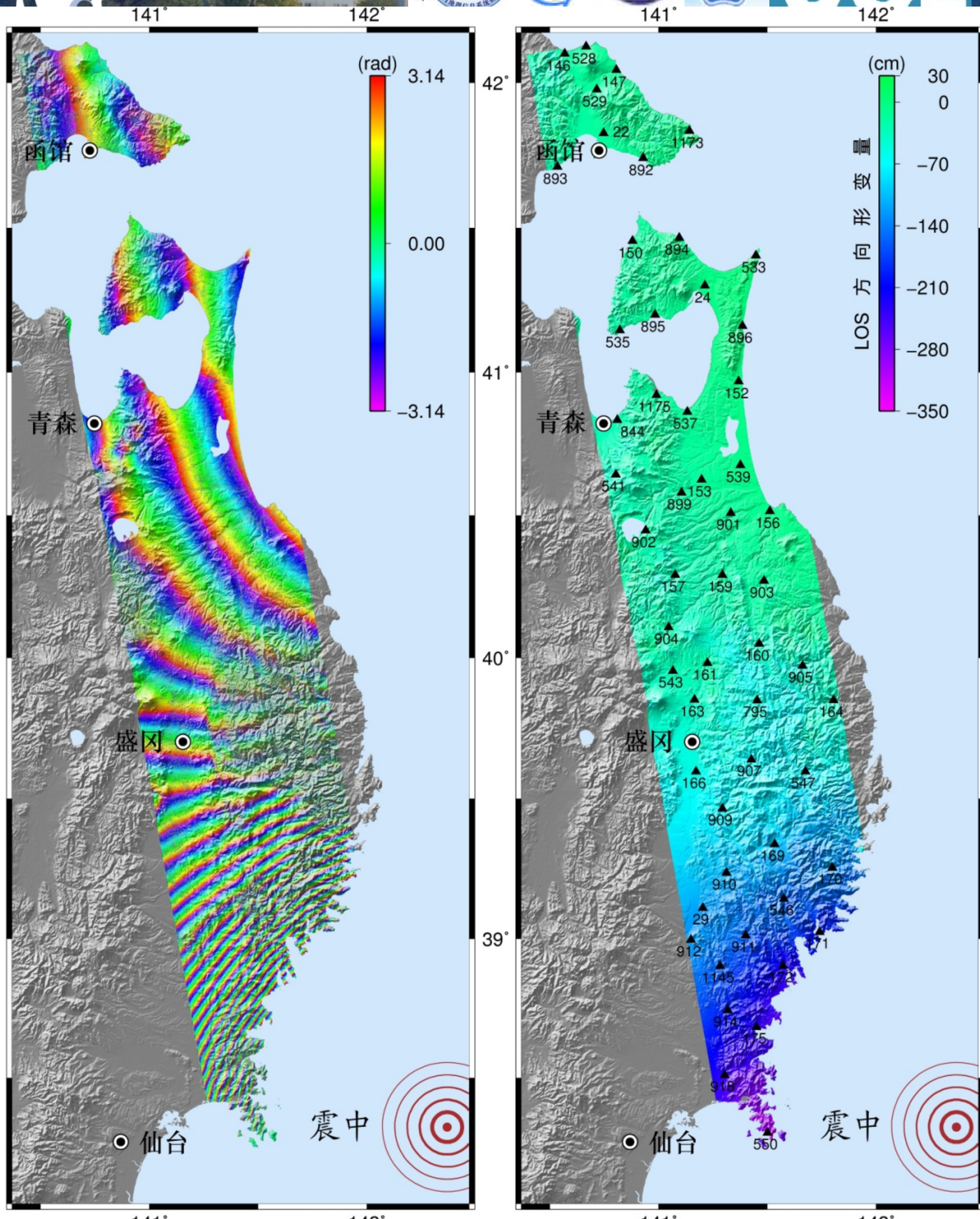
ALOS PALSAR

Mode: FBS, FBD, WS1

in total13 irregular long track scenes

After trial and error, the following data were found to derive a reasonable result

Data Sources	Date	Mode	Track	Band	Bp (m)	Oribit Dir.
ALOS PALSAR	2010-10-28 2011-03-15	FBD FBS	401	L	~1500	A
Envisat ASAR	2011-02-19 2011-03-21	IM	347	C	~-170	D



(a) (b)

ALOS PALSAR

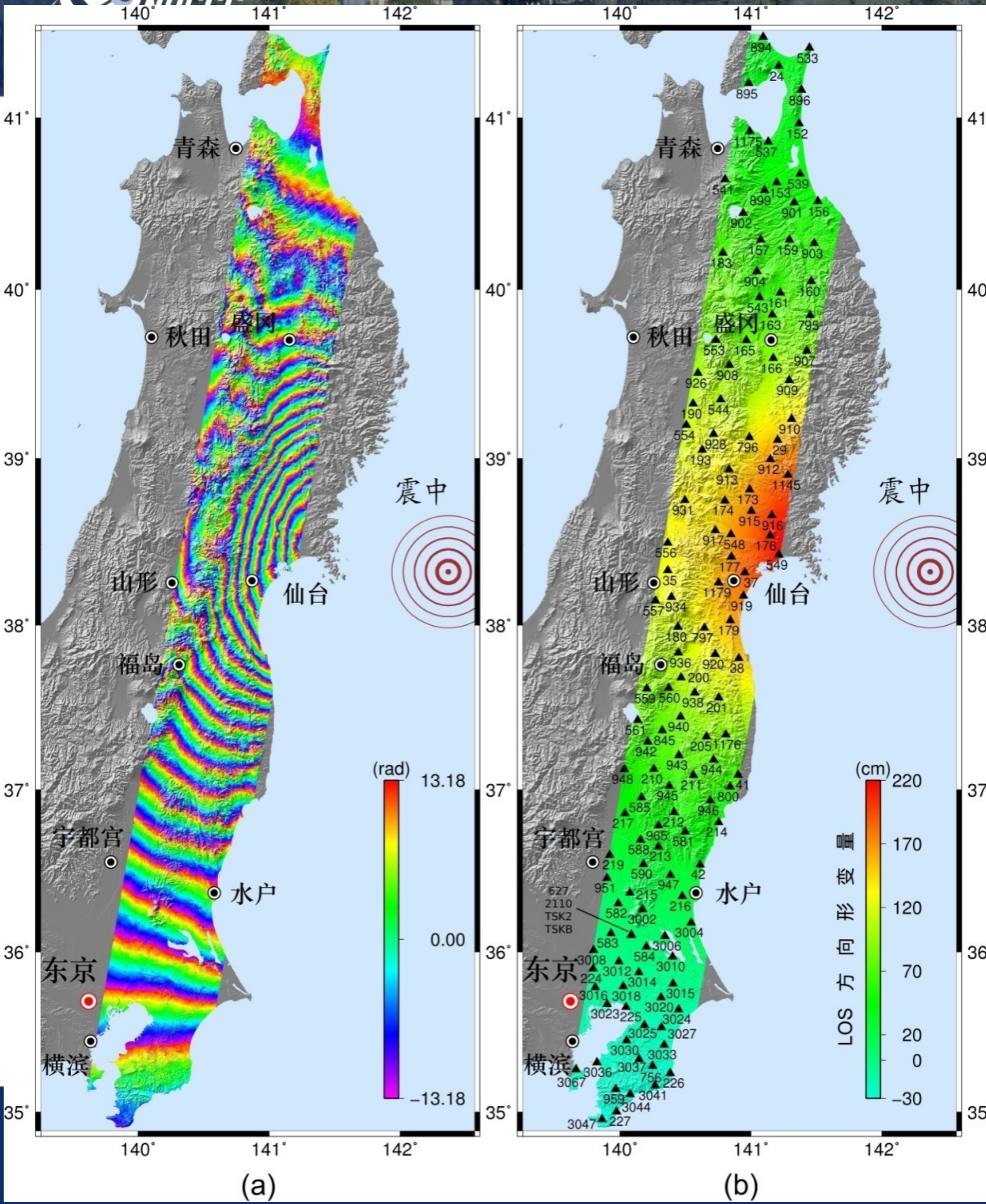
Left: wrapped interferogram

Right: displacement in LOS direction

Black triangle: GPS station

Track width: 94Km

Length: 440Km



Envisat ASAR

Left: rewrapped in period of L band for comparison

Right: displacement in LOS direction

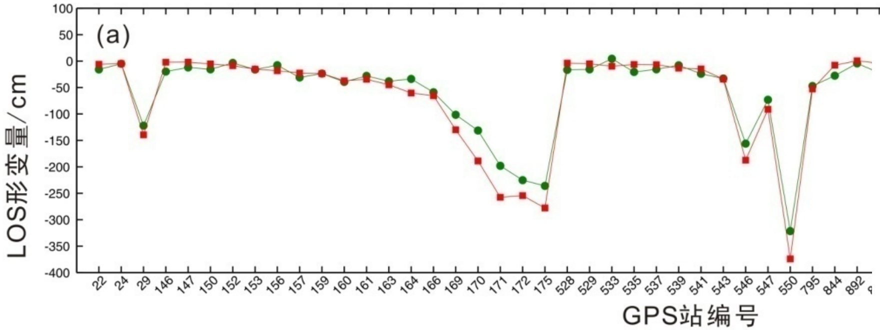
Black triangle: GPS station

Track width: 98Km

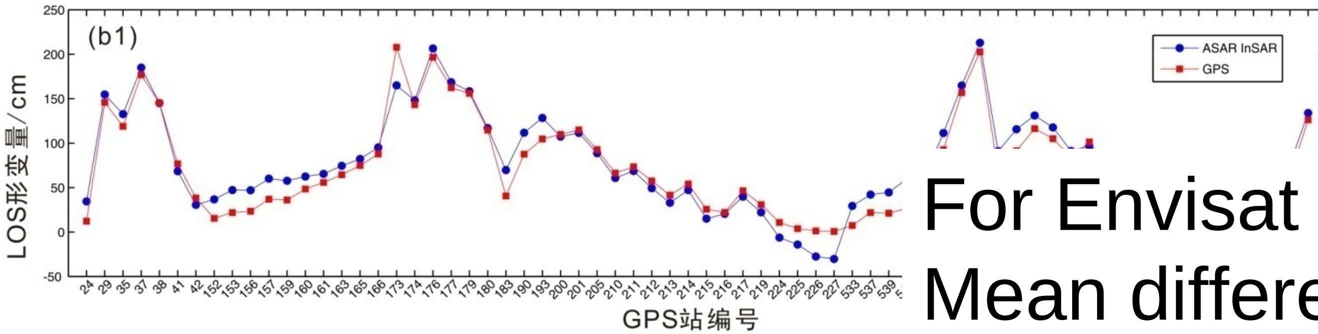
Length: 747Km

DInSAR measurements compared to GPS

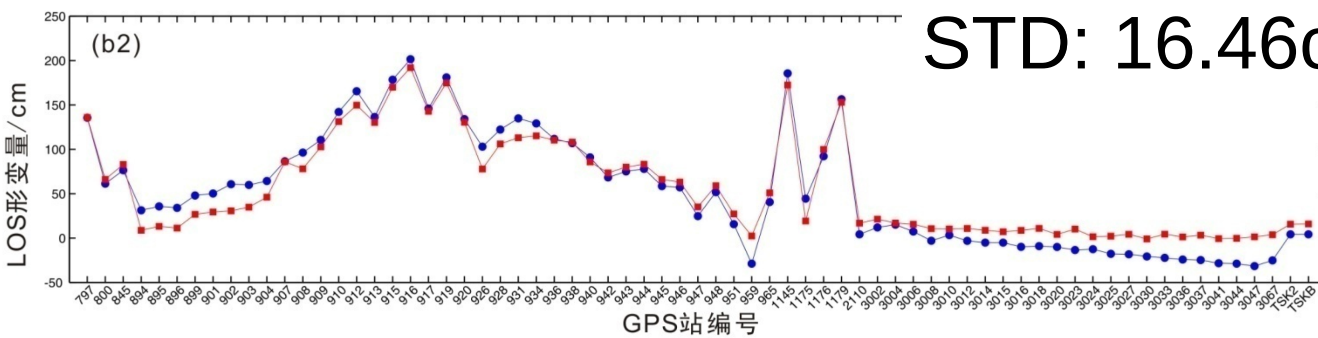
- There are in total about 1000 GPS stations (GSI) distributed over Japan, among them
  - 55 GPS in PALSAR result region
  - 137 GPS in ASAR result region
- ARIA group from JPL/Caltech issued these GPS ENU components during 5:40 to 5:55 UTC of Mar. 11, 2011 by using GPSGIPSY-OASIS
- We synthesized the ENU components and then projected them on LOS direction of DInSAR result



For ALOS PALSAR
Mean difference: 7.60 cm
STD: 18.53cm

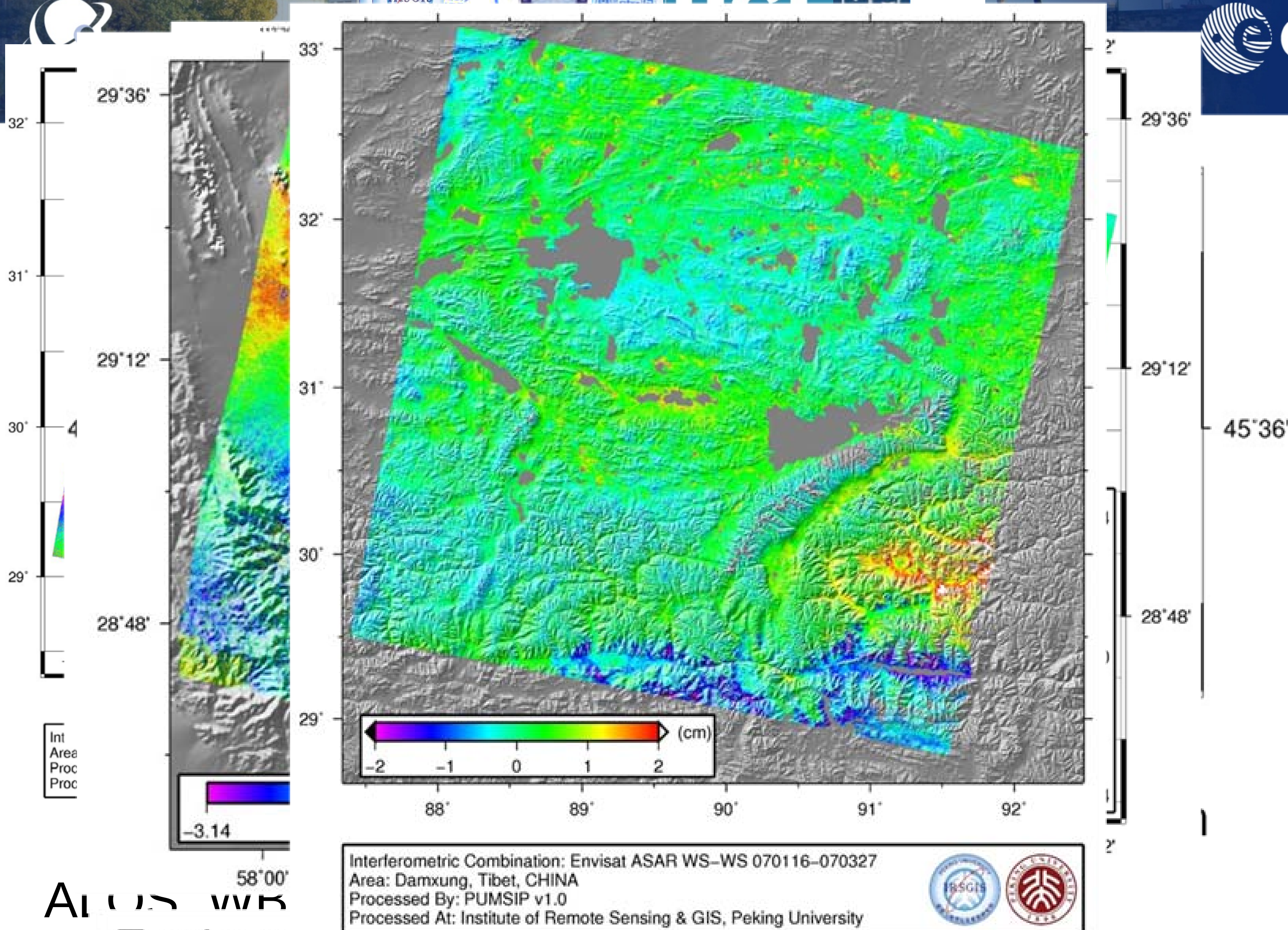


For Envisat ASAR
Mean difference: 0.31cm
STD: 16.46cm



Peking University Multi-mode SAR Interferometry Processing kit

- based on ROI-PAC
- interferometric processing for ScanSAR, AP
- open source and freely accessible via ROI-PAC wiki (Jan. 3, 2010)
- upgraded on Sep. 20, 2010, fixed some bugs, and improved some functions
- up to now, more than 9 institutions from Europe, Asia have consulted



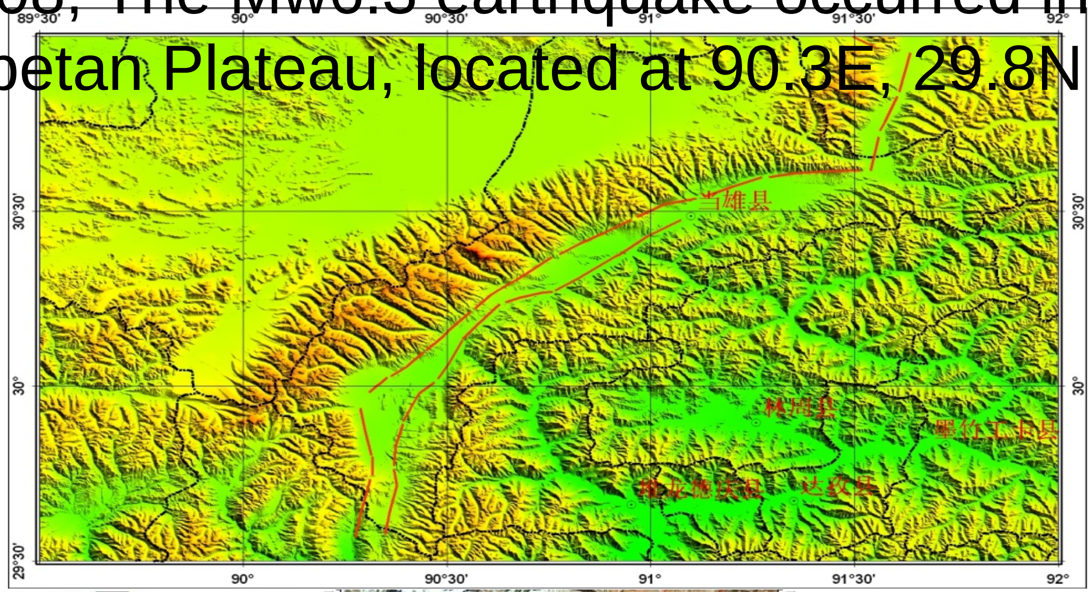
Envisat_

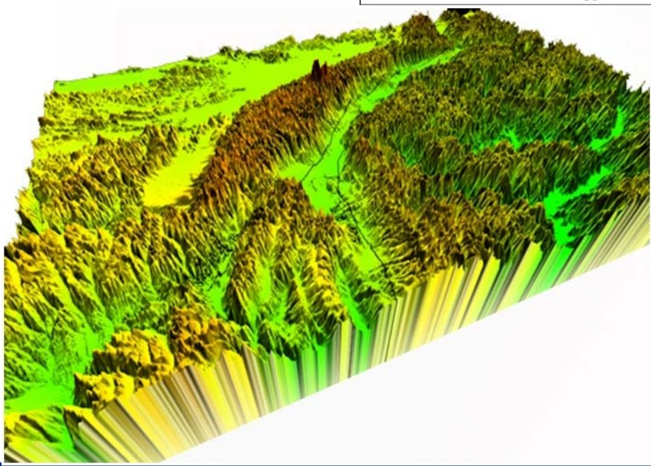
Envisat IM-WS Bam

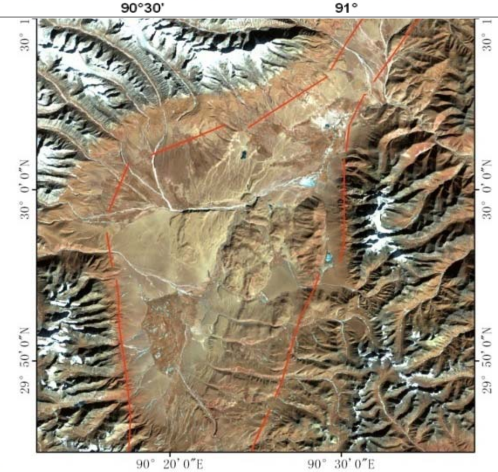
Envisat_WS-WS_Dangxiong

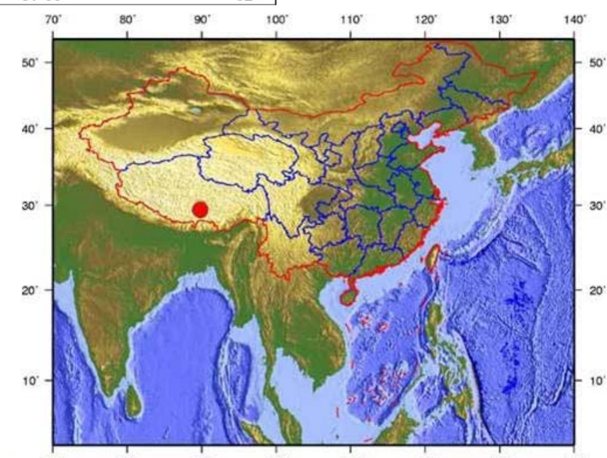
Geological & Seismological Features

October 6, 2008, The Mw6.3 earthquake occurred in Damxung area of the Tibetan Plateau, located at 90.3E, 29.8N (CENC). Depth 8.0 km.

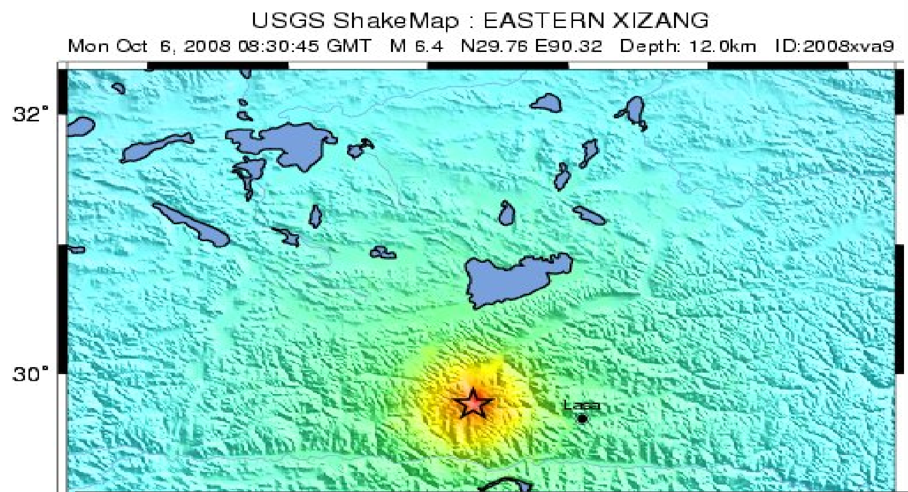


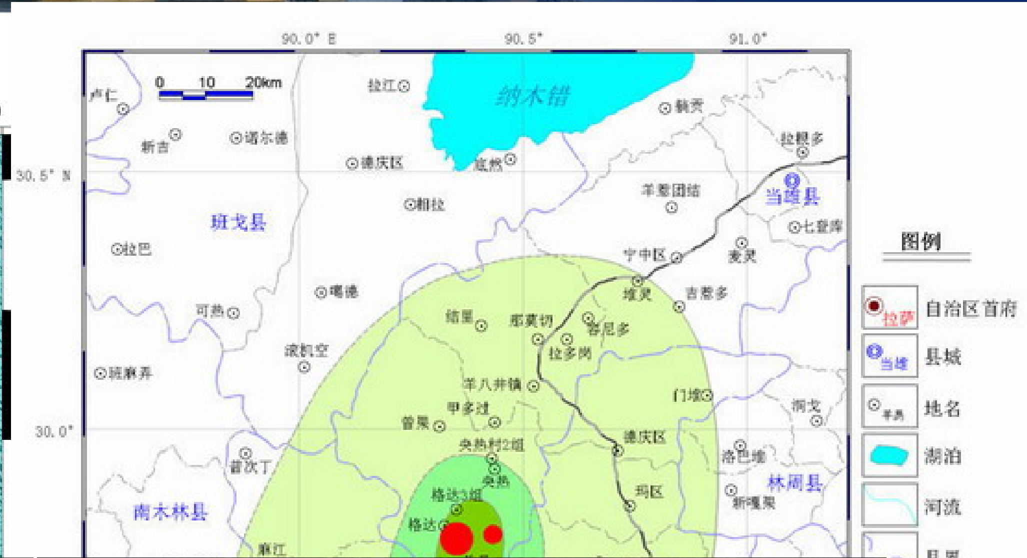






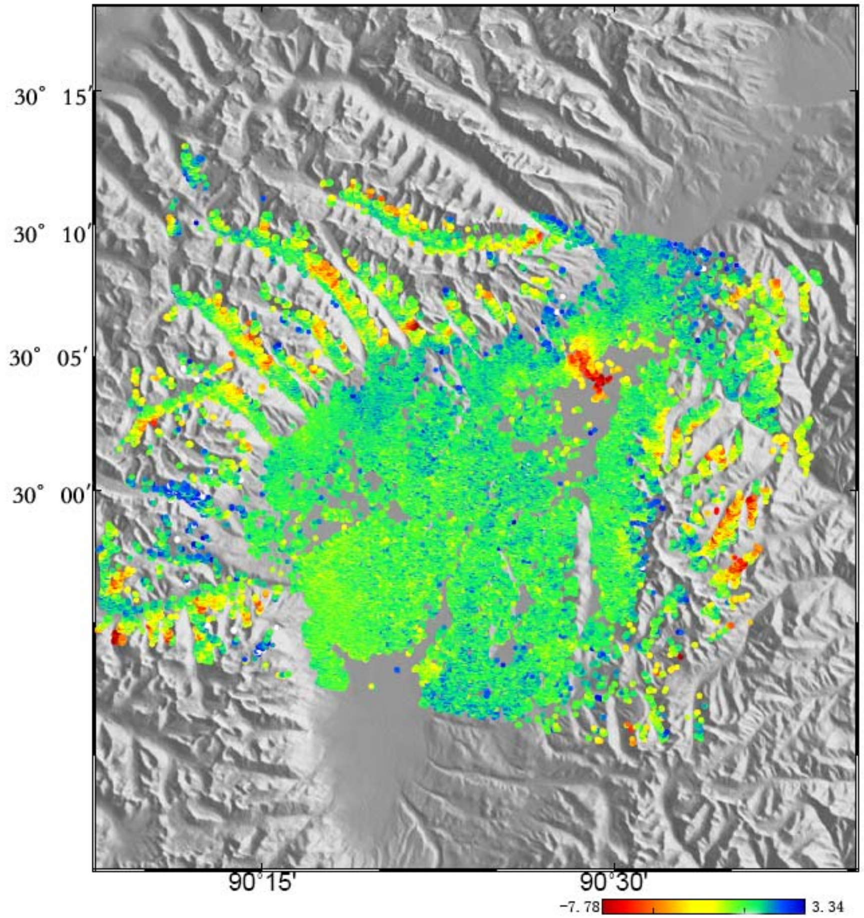
Geological & Seismological Features



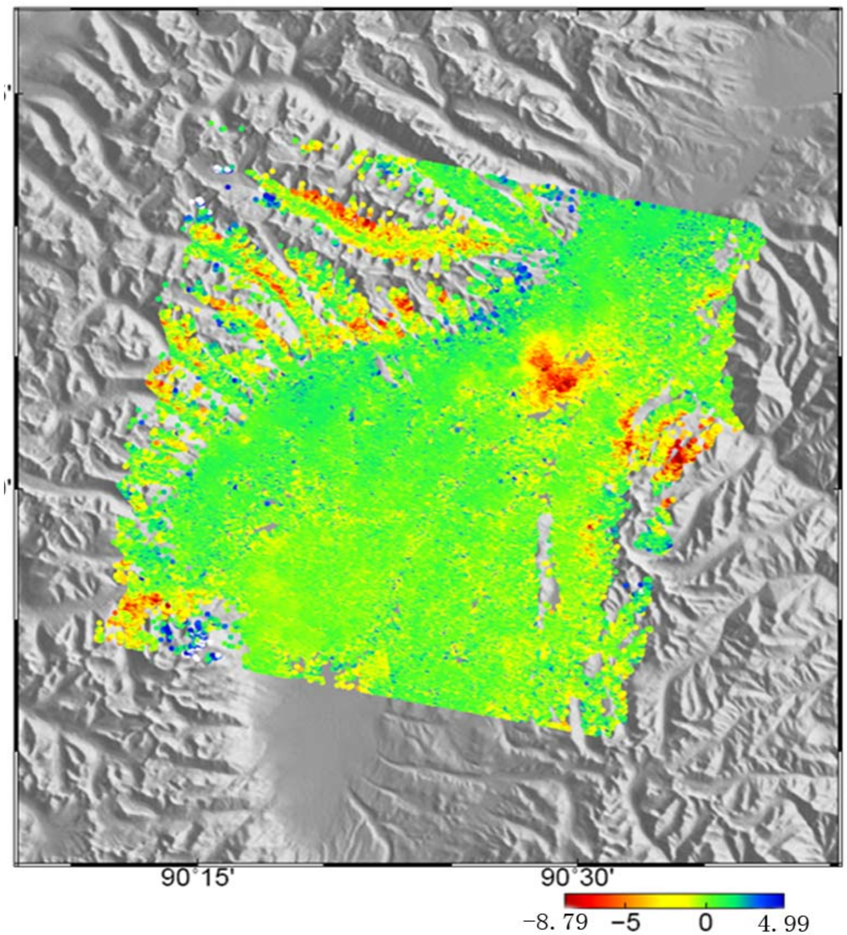


Time series analysis before the earthquake

PS InSAR

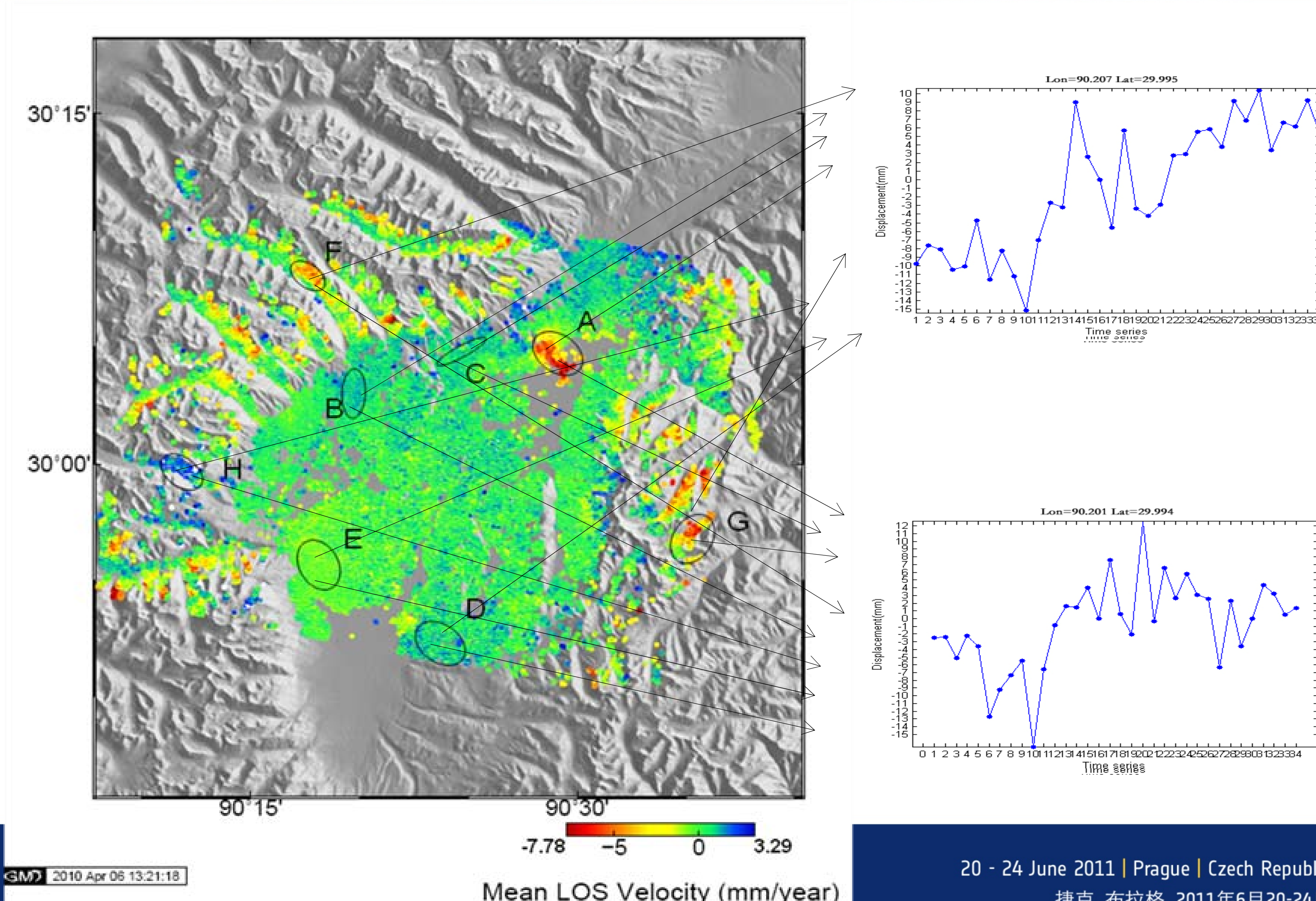


SBAS InSAR

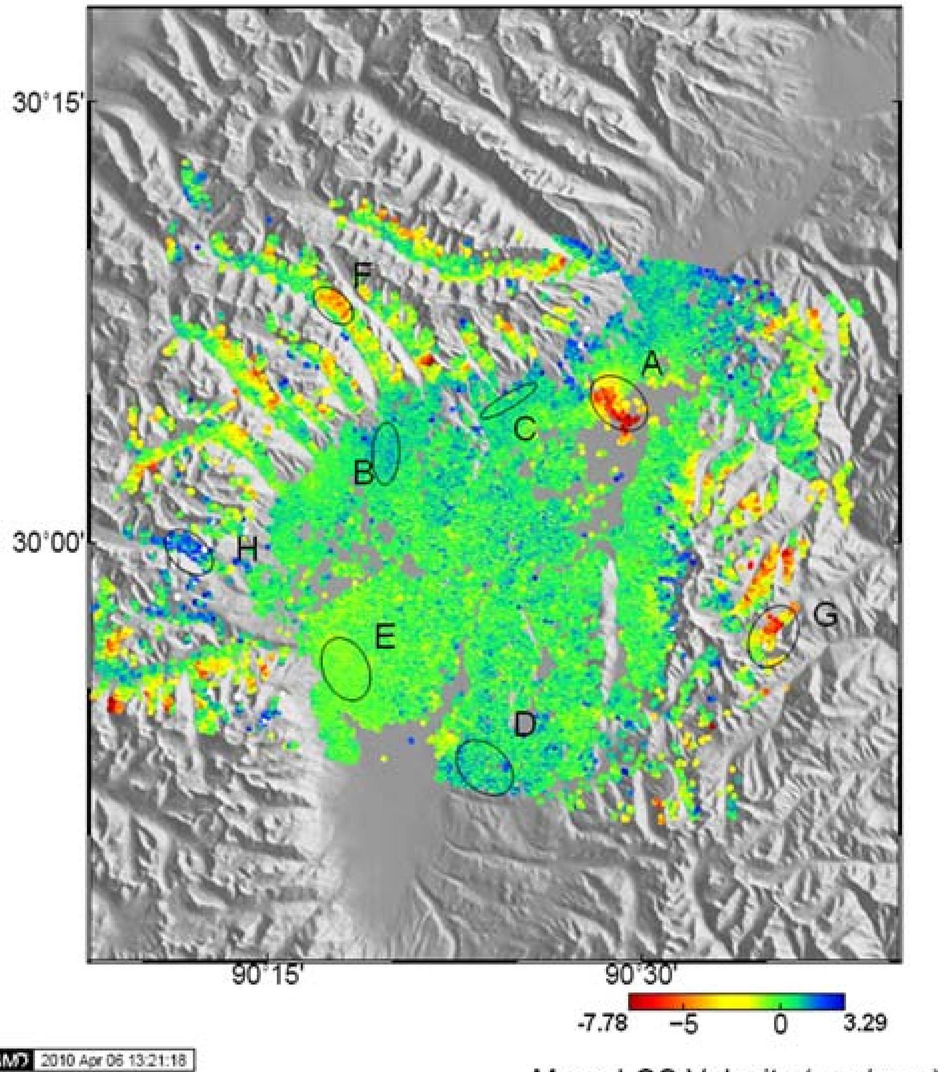


2003/04-2008/9, 34 ASAR,

PS Time series analysis before the earthquake



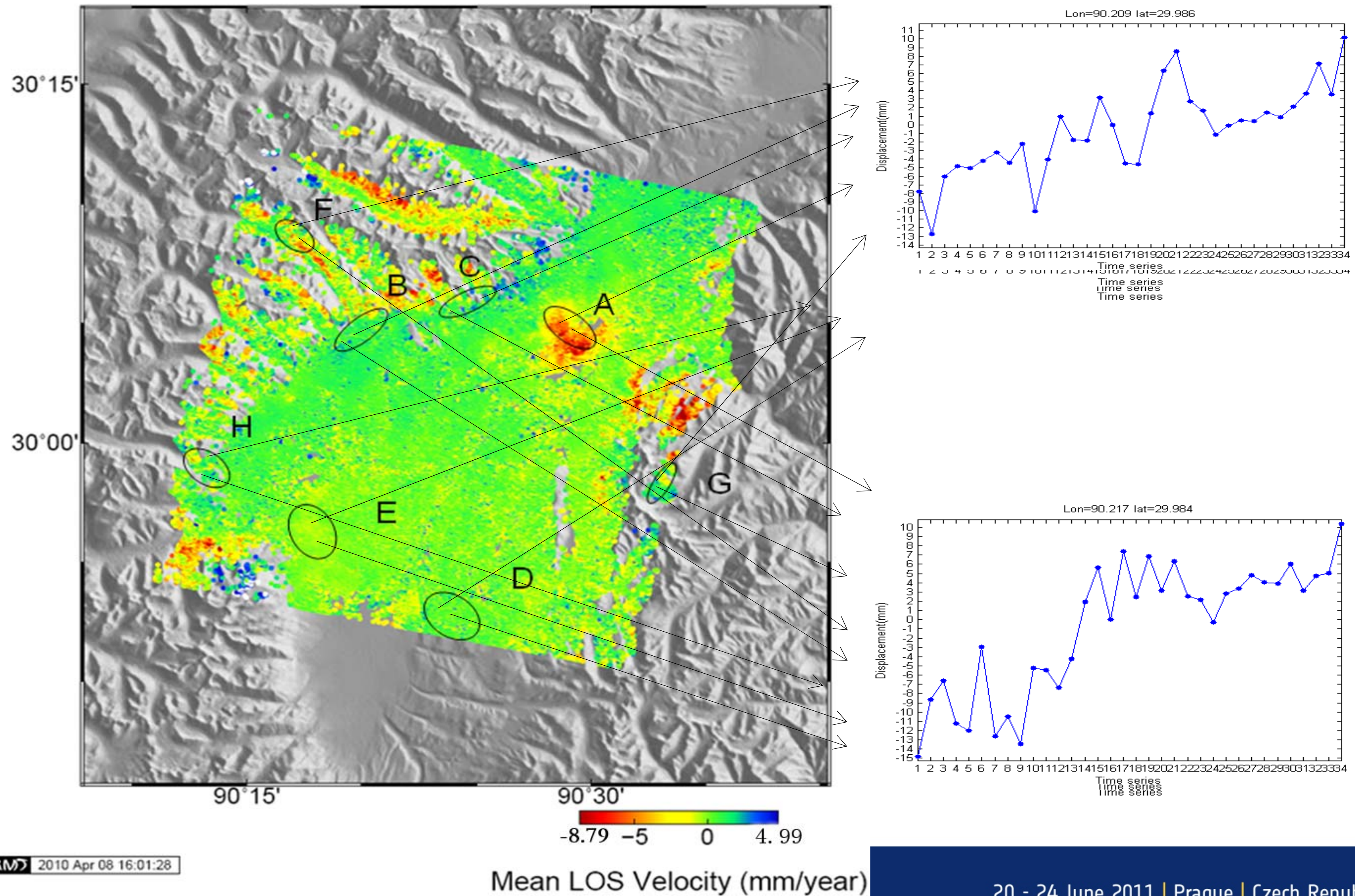
PS Time series analysis before the earthquake



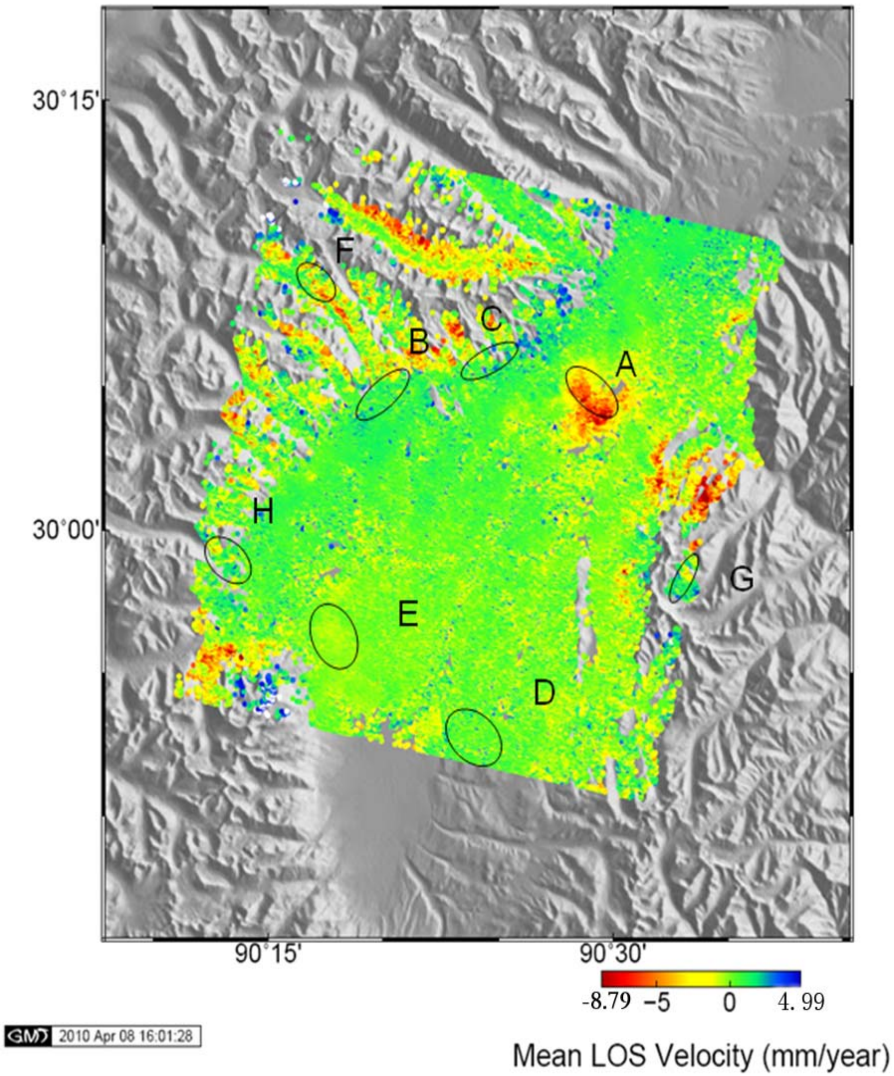
Standard deviations of the selected points in 8 areas

	Lon	Lat	mean_v (mm/year)	Std (mm/year)
区域 A	90.482	30.075	-6.74	0.61
	90.488	30.072	-7.78	0.76
区域 B	90.314	30.059	3.00	0.75
	90.310	30.059	2.33	0.69
区域 C	90.446	30.101	2.53	0.75
	90.464	30.121	3.30	0.72
区域 D	90.394	29.875	2.05	0.66
	90.384	29.887	1.63	0.53
区域 E	90.325	29.936	-1.04	0.49
	90.314	29.952	-1.73	0.45
区域 F	90.252	30.165	-3.82	1.62
	90.313	30.121	-1.92	1.15
区域 G	90.575	29.975	-4.21	1.5
	90.598	29.980	-3.93	1.44
区域 H	90.207	29.995	2.3	1.48
	90.201	29.994	3.16	1.48

SBAS Time series analysis before the earthquake



SBAS Time series analysis before the earthquake

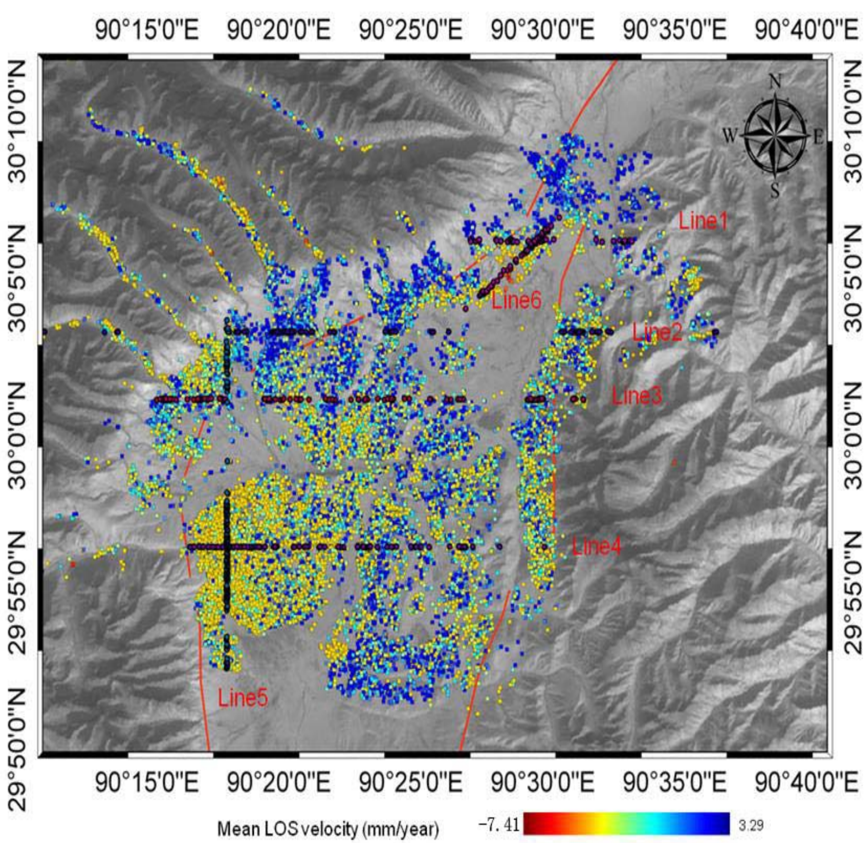


Standard deviations of the selected points in 8 areas

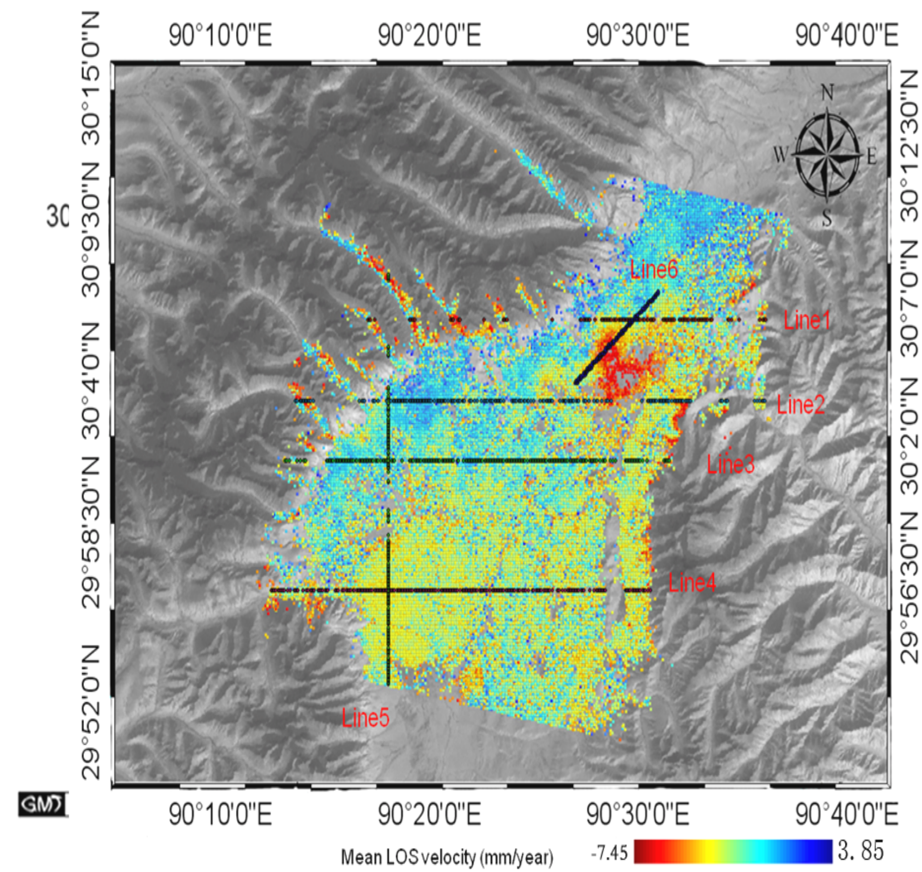
	Lon	Lat	mean_v (mm/year)	Std (mm/year)
区域 A	90.487	30.072	-7.20	0.62
	90.485	30.071	-7.23	0.65
区域 B	90.317	30.059	2.06	0.43
	90.317	30.06	2.28	0.29
区域 C	90.463	30.127	3.64	0.66
	90.464	30.125	3.15	0.54
区域 D	90.387	29.876	1.84	0.41
	90.381	29.881	2.21	0.45
区域 E	90.312	29.930	-1.11	0.33
	90.31	29.934	-0.98	0.32
区域 F	90.31	30.121	-6.08	0.6
	90.296	30.134	-5.93	0.82
区域 G	90.574	30.15	-4.21	0.86
	90.577	30.076	-2.07	0.78
区域 H	90.209	29.986	2.21	0.76
	90.217	29.984	3.68	0.85

Time series analysis before the earthquake

去噪后年形变速率（LOS）



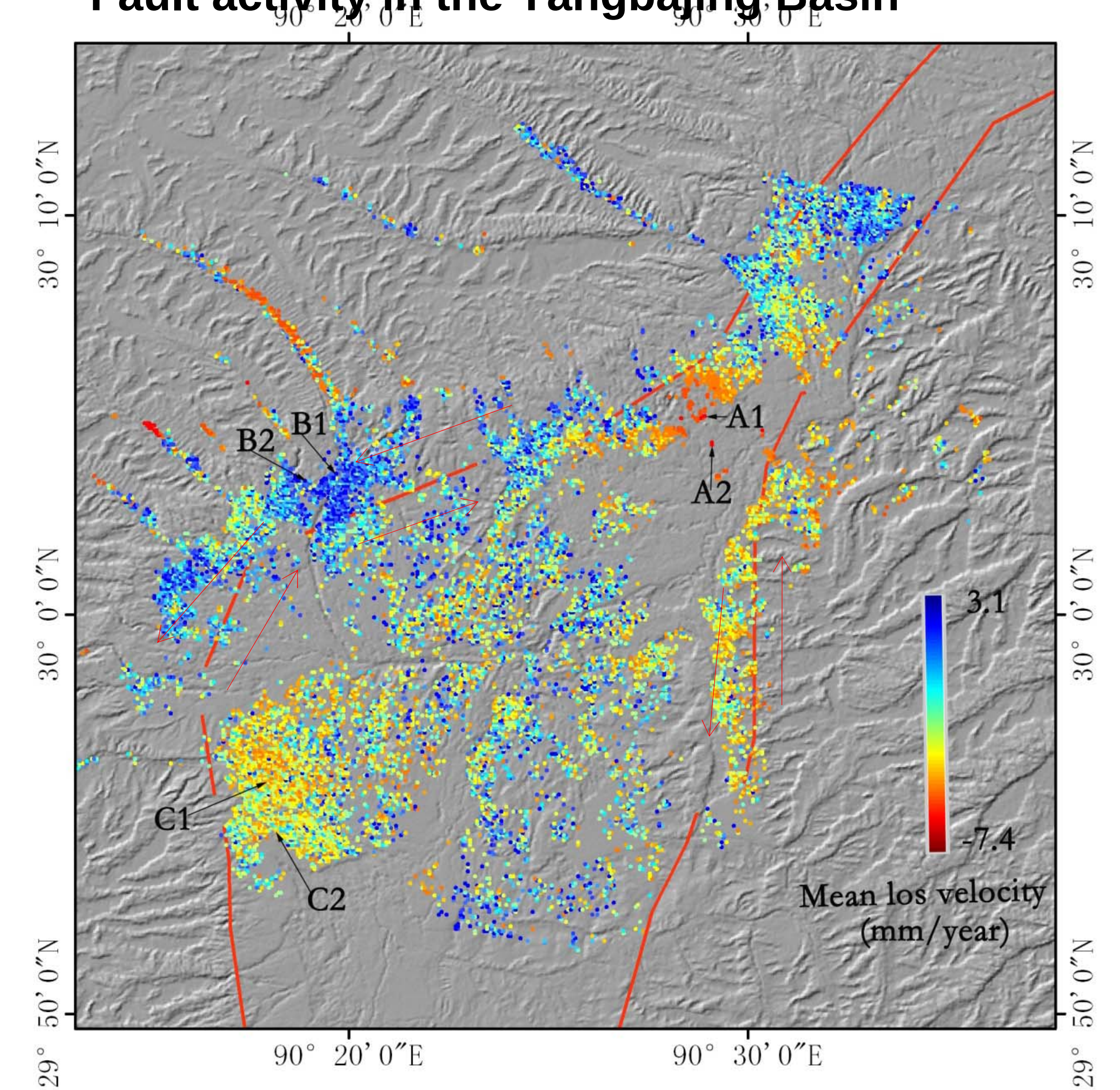
PS-meanv



SBAS-meanv

Time series analysis before the earthquake

Fault activity in the Yangbajing Basin

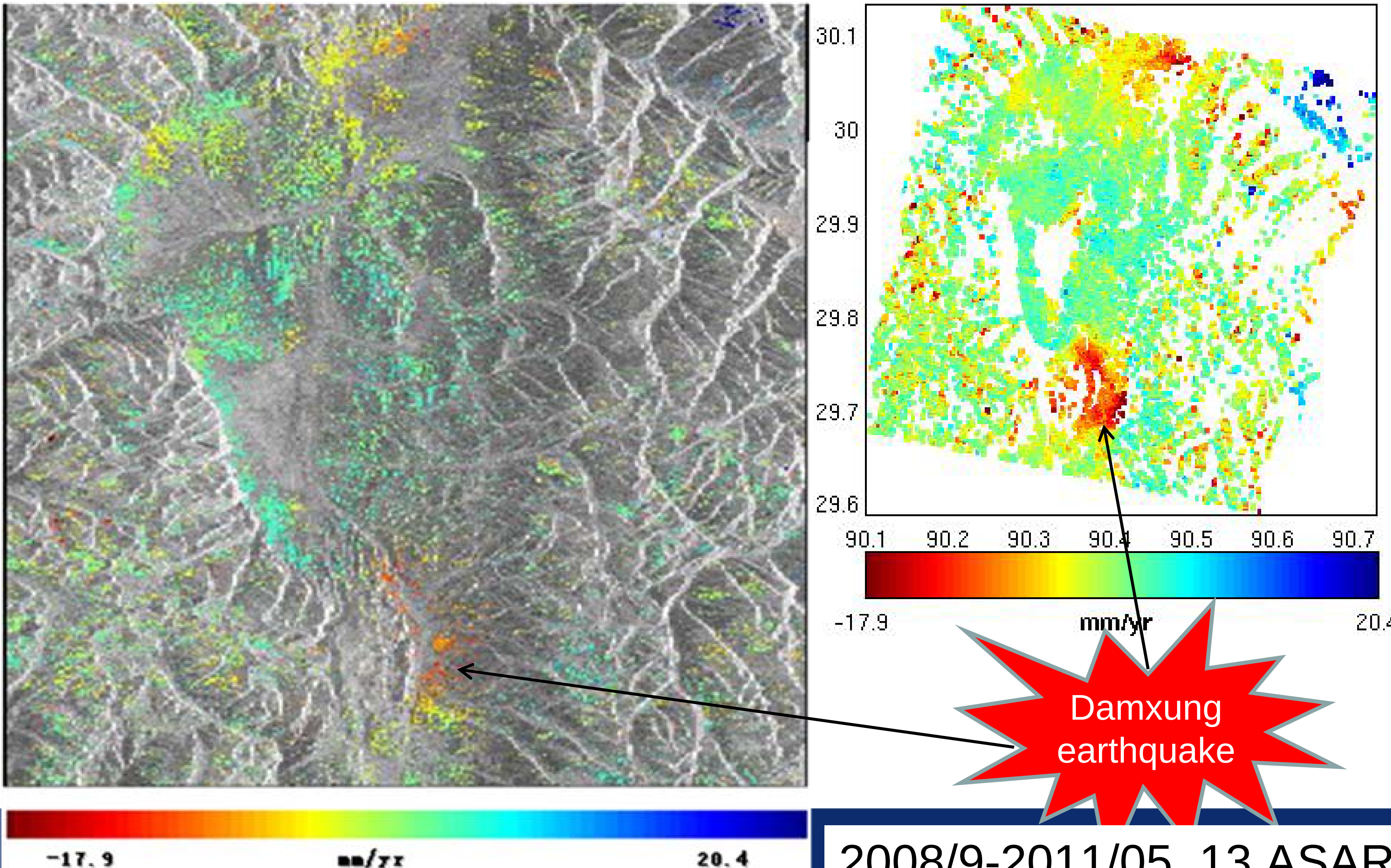


A: -5~-8mm/a

B：3~5mm/a

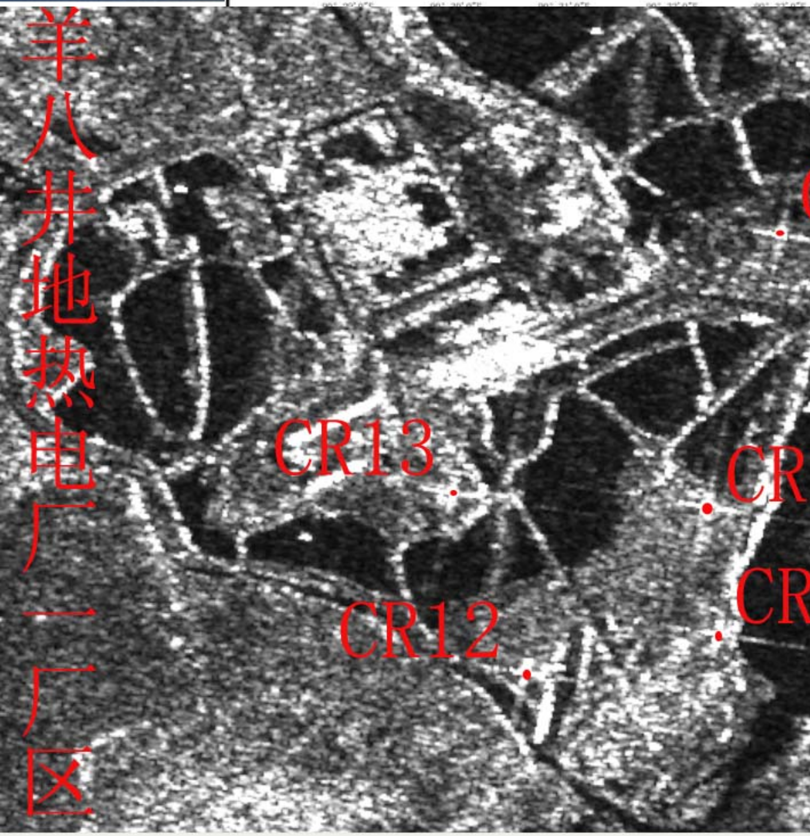
C:-1.5~2.0mm/a

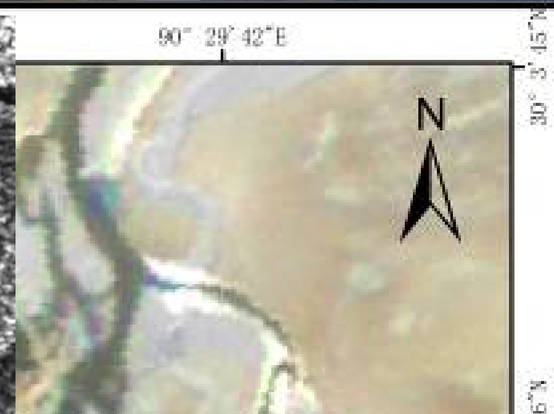
Time series analysis after the earthquake

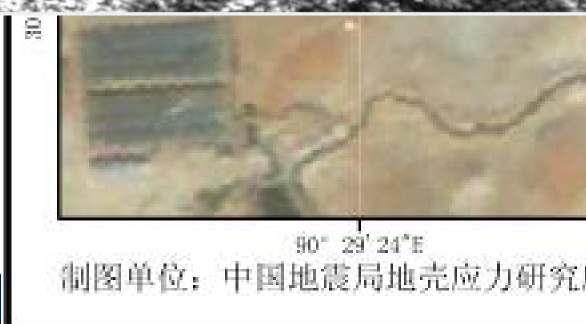


2008/9-2011/05, 13 ASAR

Corner reflector detection

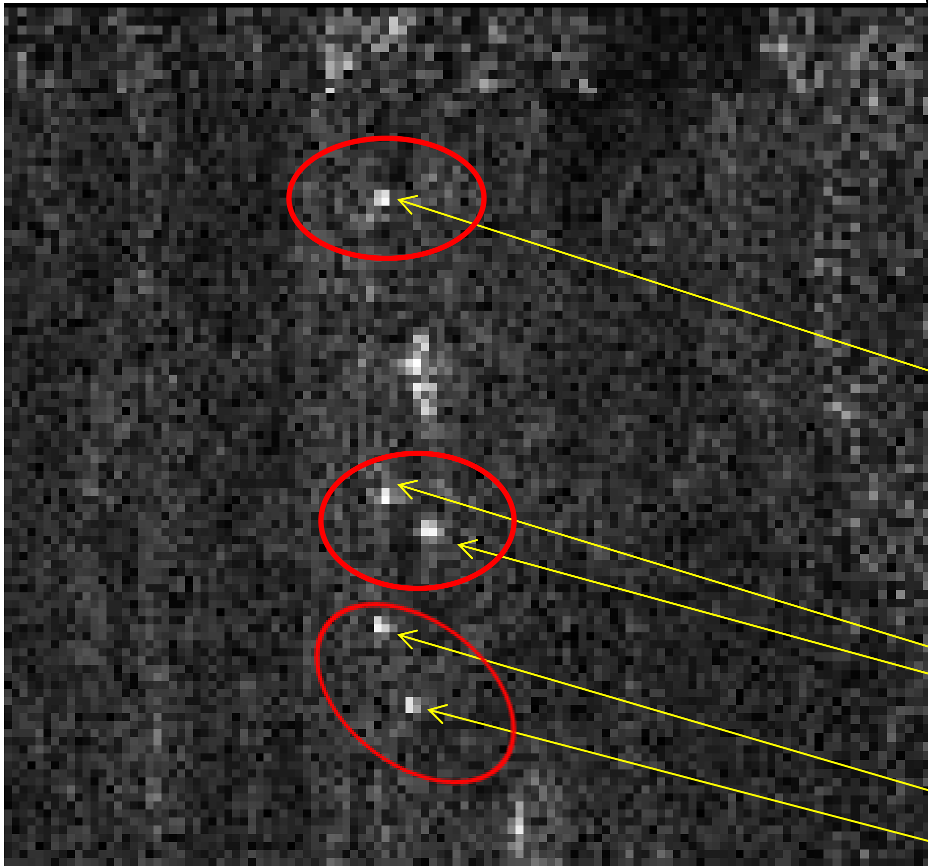


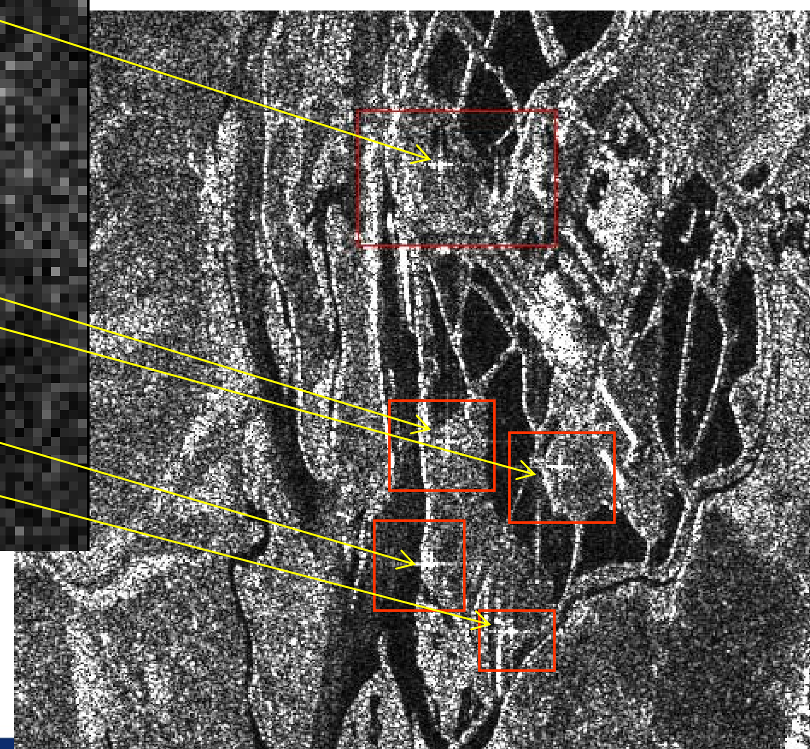




Corner reflectors detection

CR in the ASAR images, we filtered it and the
Corner reflectors are clear. It corresponds
to that in the TerraSAR images.





UCL-PKU# contributions

Xiao-Fan Li#, Jan-Peter Muller,
Yong-Hong Zhao#, Hayley Larkin

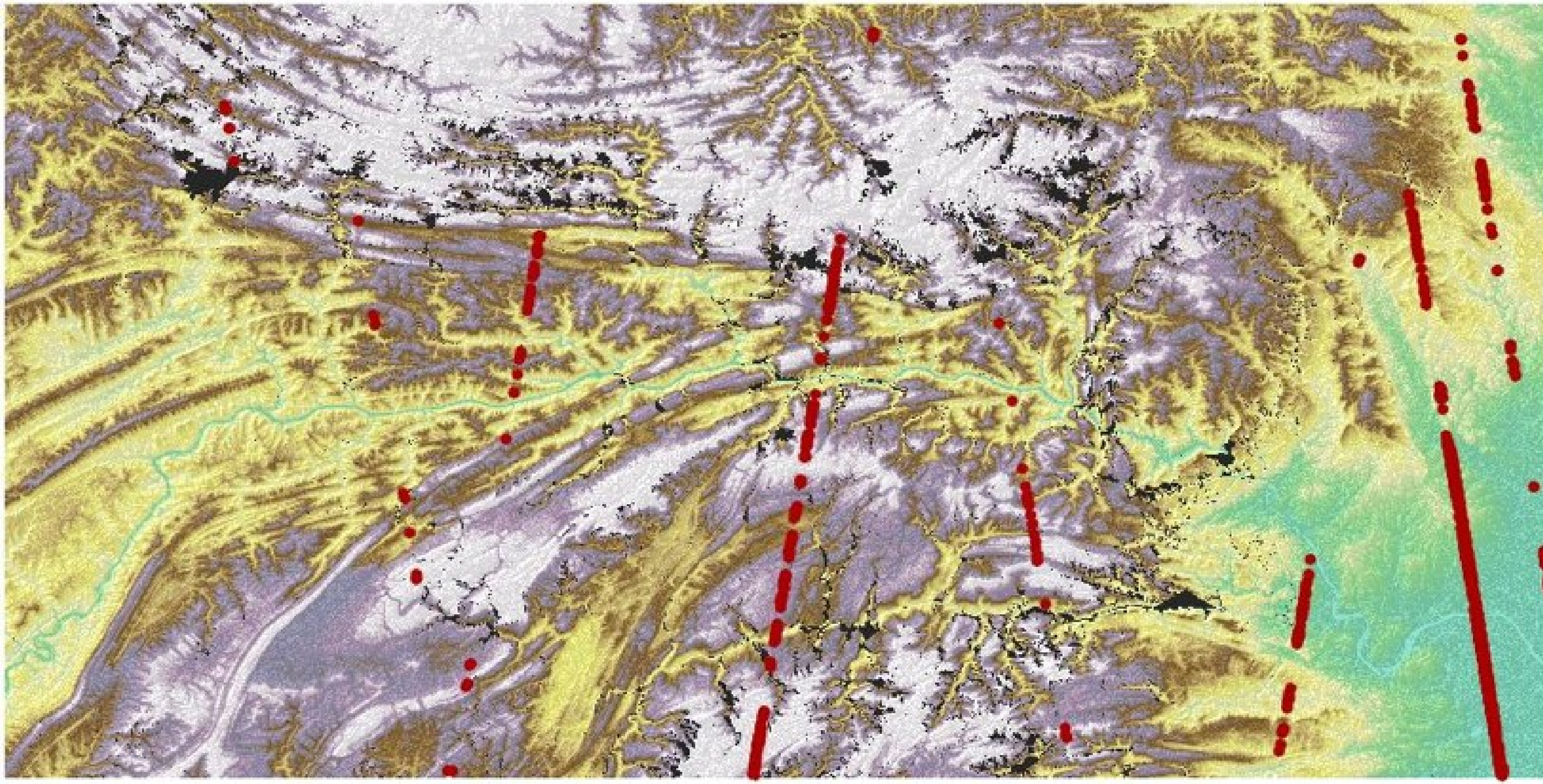
Overview

- Assessment of DEMs over Three Gorges area using processed ICESat heights
- Landslide creep measurements using TerraSAR-X phase correlation

DEM assessment

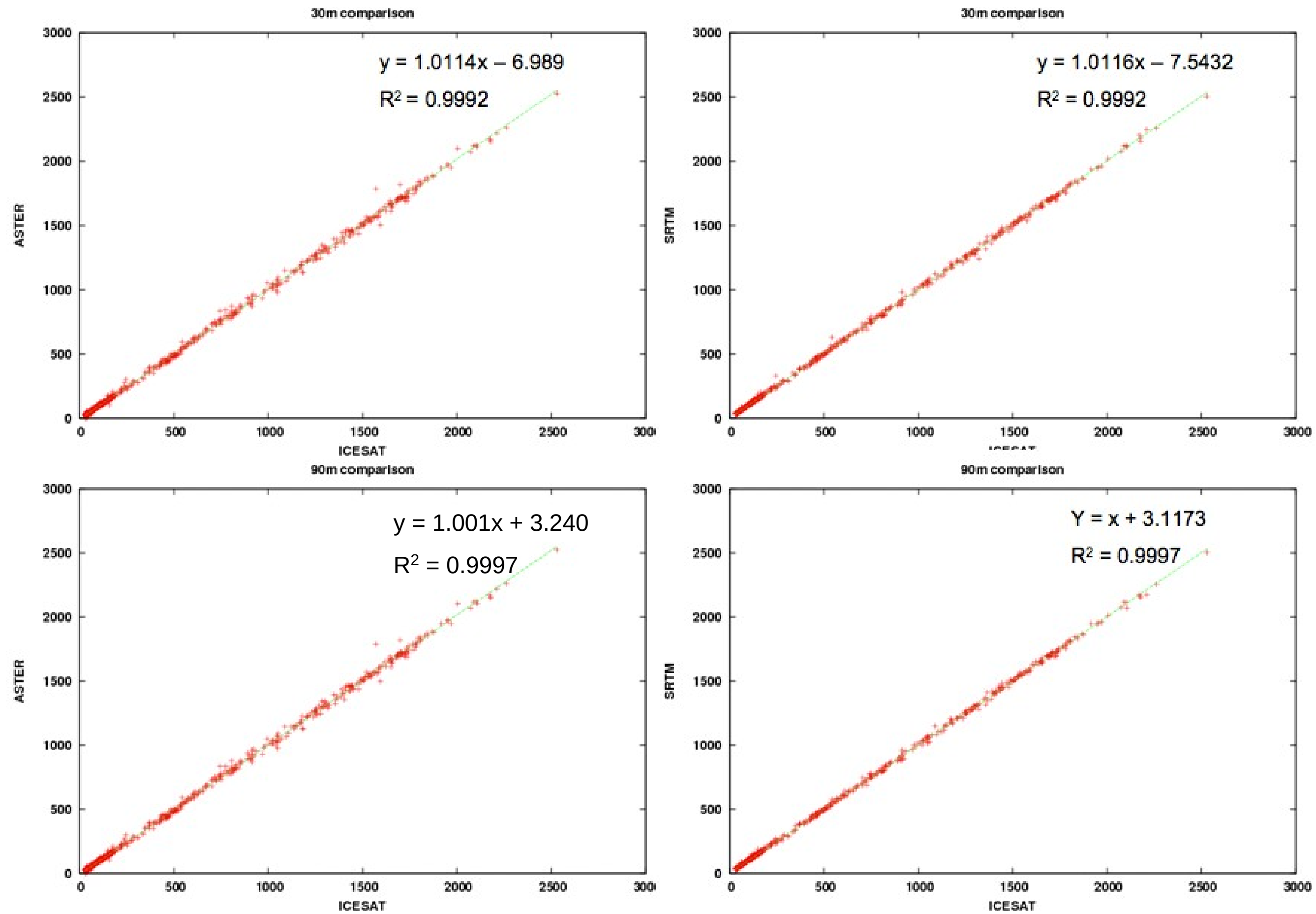
- Claudia Carabajal (NASA Goddard Space Flight Center) has re-processed ICESat waveforms to retrieve ToC (Top-of Canopy) and DTM (Digital Terrain Model)
- These have used a coarse model for slope effects as well as vegetation penetration
- These heights have been compared with the nearest neighbour heights from SRTM v2 and ASTER GDEM v1

ICESat “bare earth” points after filtering for clouds



colourised and hill-shaded image SRTM v2 DEM, see poster L24 from Hayley Larkin

ICESat “bare earth” points cf ASTER & SRTM

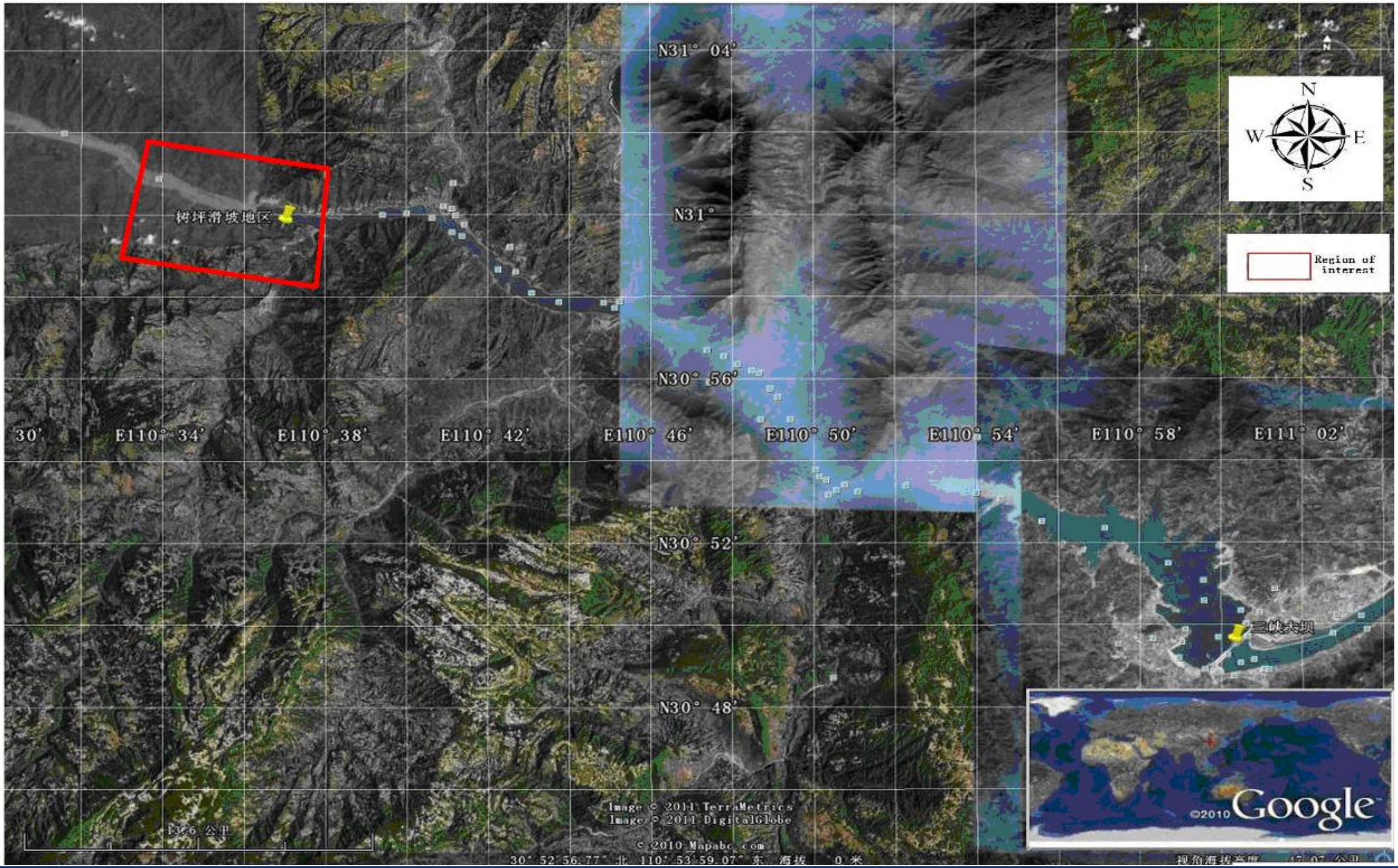


N.B. Little difference apparent between the two data sources for ICESat points

Landslide “creep” measurement

- Xiaofan Li, PhD (PKU) applied sub-pixel phase correlation to the mapping of deformation
- ASTER DEM v1 was employed to provide terrain correction of TerraSAR-X (TSX) amplitude imagery to eliminate first order deformation effects
- Phase correlation (ENVI©TM plug-in) from Caltech (cosi_corr) was then applied to look for successive changes in East-west and North-South SAR amplitude

Location image map showing location of TSX



Shuping Landslide in the Three Gorges Area

Wang et al. 2007

TerraSAR - X characteristics

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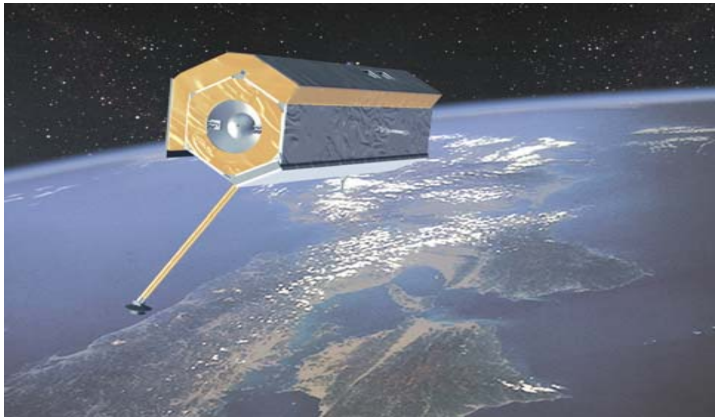
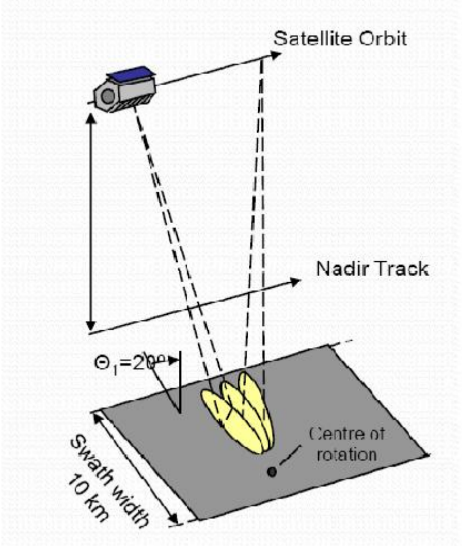
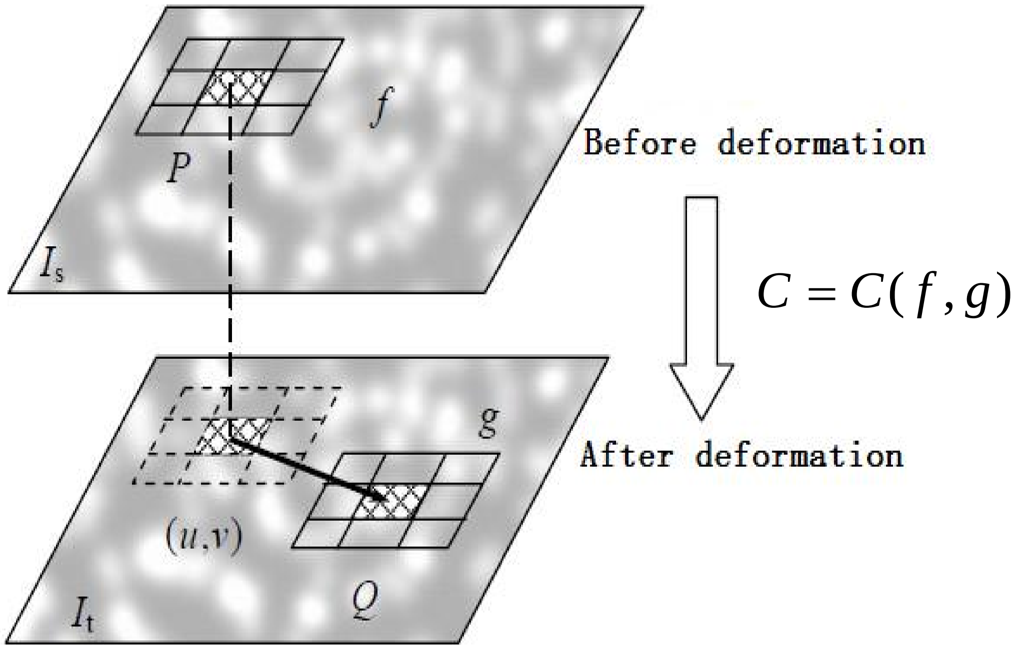




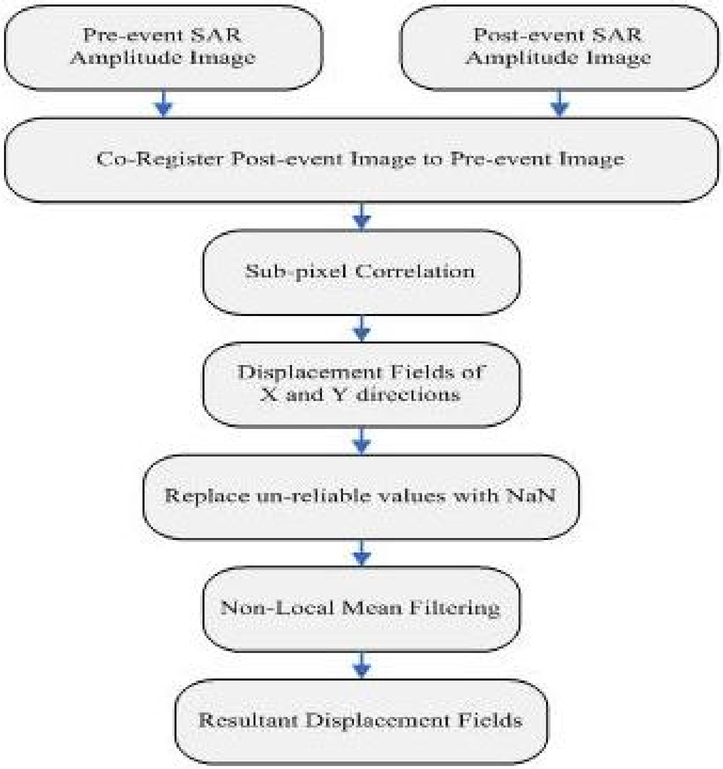
- High Resolution
- Multi-polarization
- Short re-visit cycle

Parameter of SL	**Value**
Scene extension	5 km (azimuth) x 10 km (ground range)
Full performance incidence angle range	20° - 55°
Azimuth resolution	1.1 m (single polarization) 2.2 m (dual polarization)
Ground range resolution	1.48 m - 3.49 m (@ 55°..20° incidence angle)
Polarizations	HH or VV (single) HH/VV (dual)

Principles of sub-pixel correlation

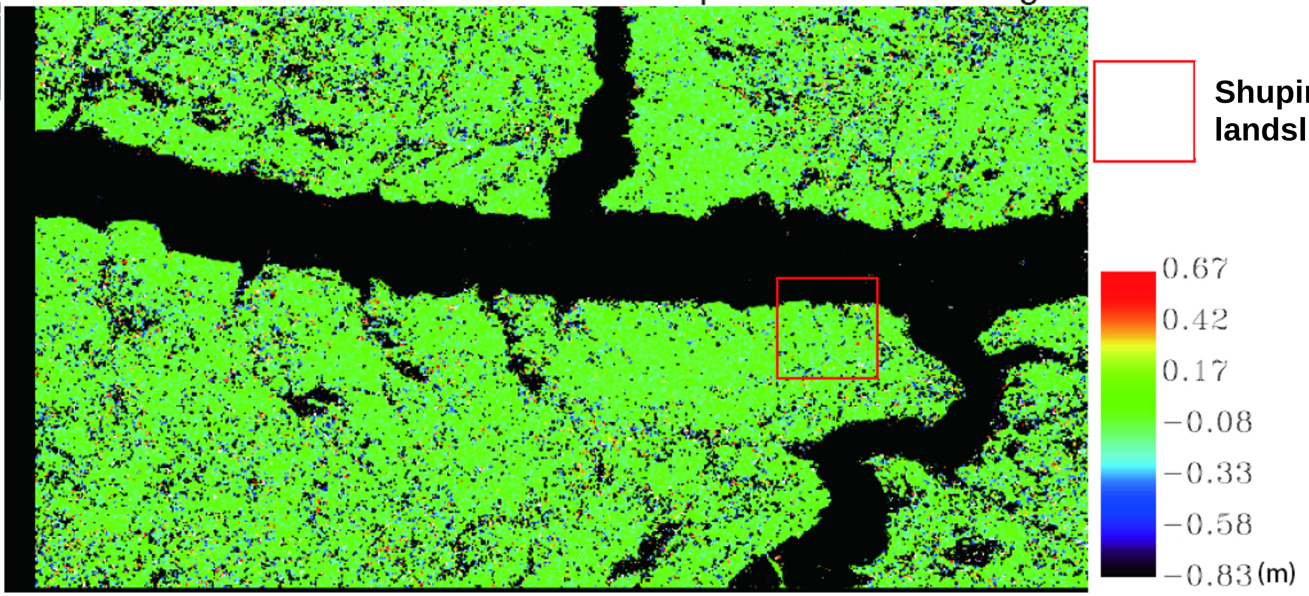


The position Q where the correlation function C reaches its maximum represents the best matched position of P. (u, v) is the displacement from P to Q.

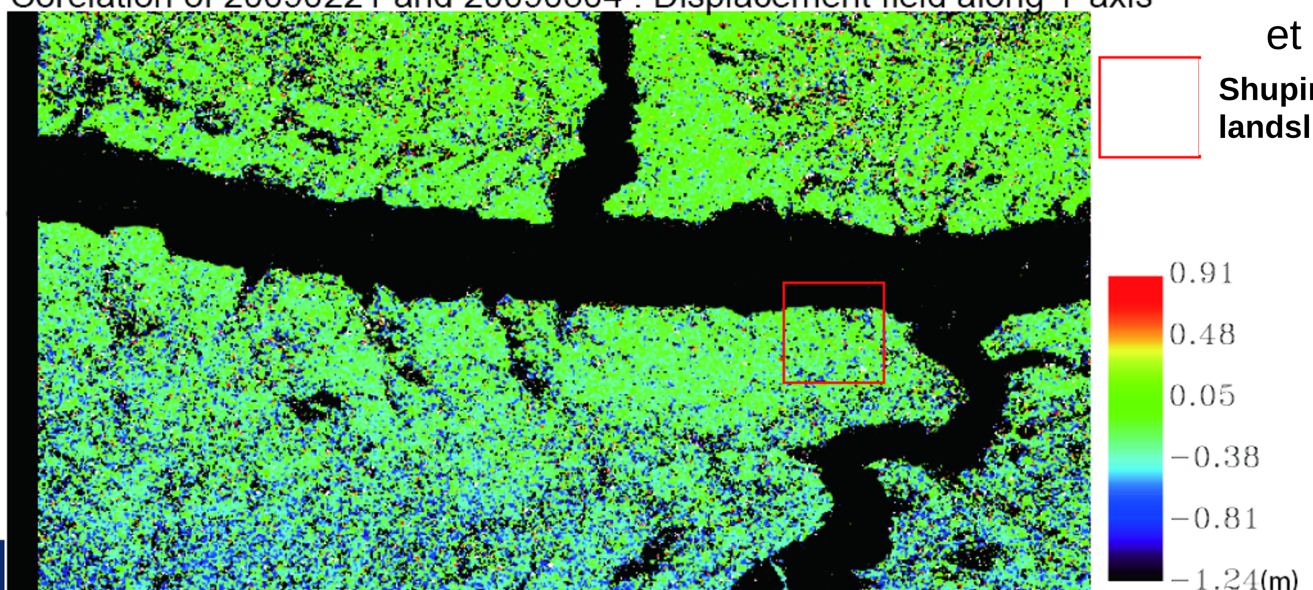


The flowchart of sub-pixel correlation

Corelation of 20090221 and 20090304 : Displacement field along X axis

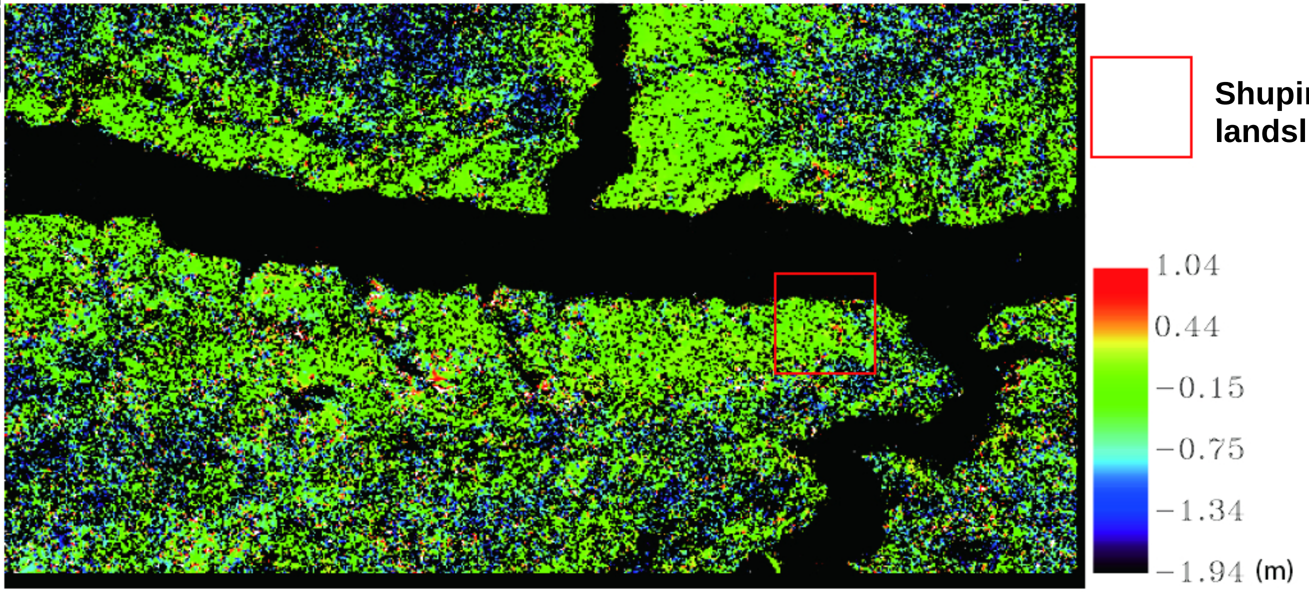


Corelation of 20090221 and 20090304 : Displacement field along Y axis



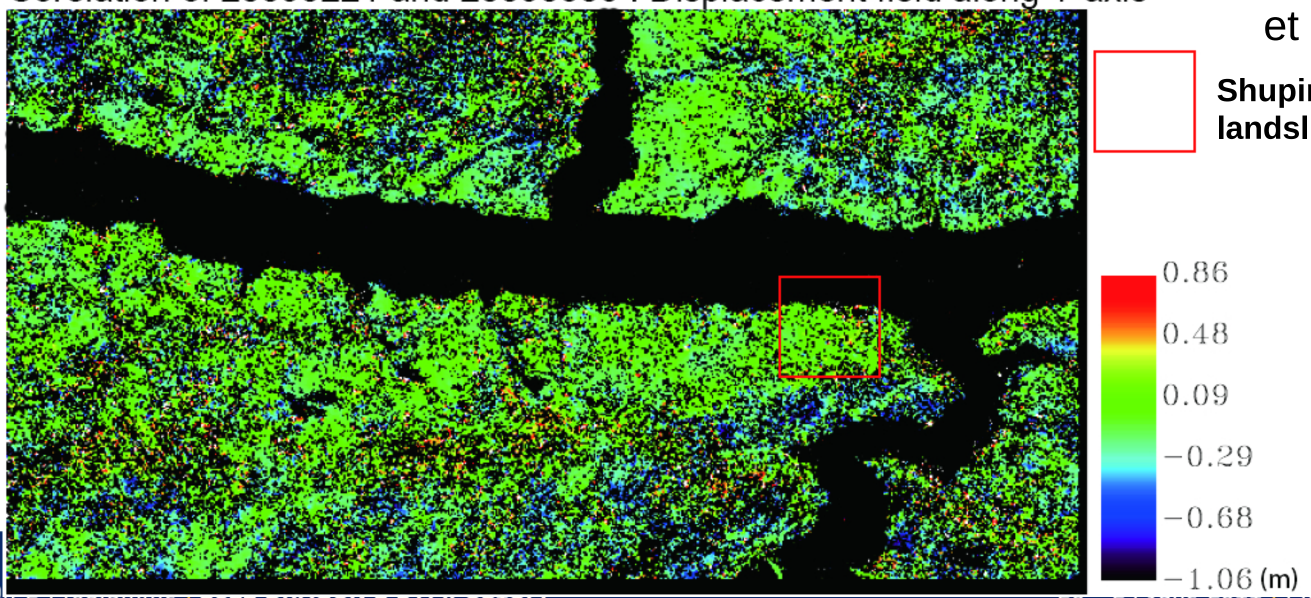
Taken from Li, X et al. (2011)

Corelation of 20090221 and 20090509 : Displacement field along X axis

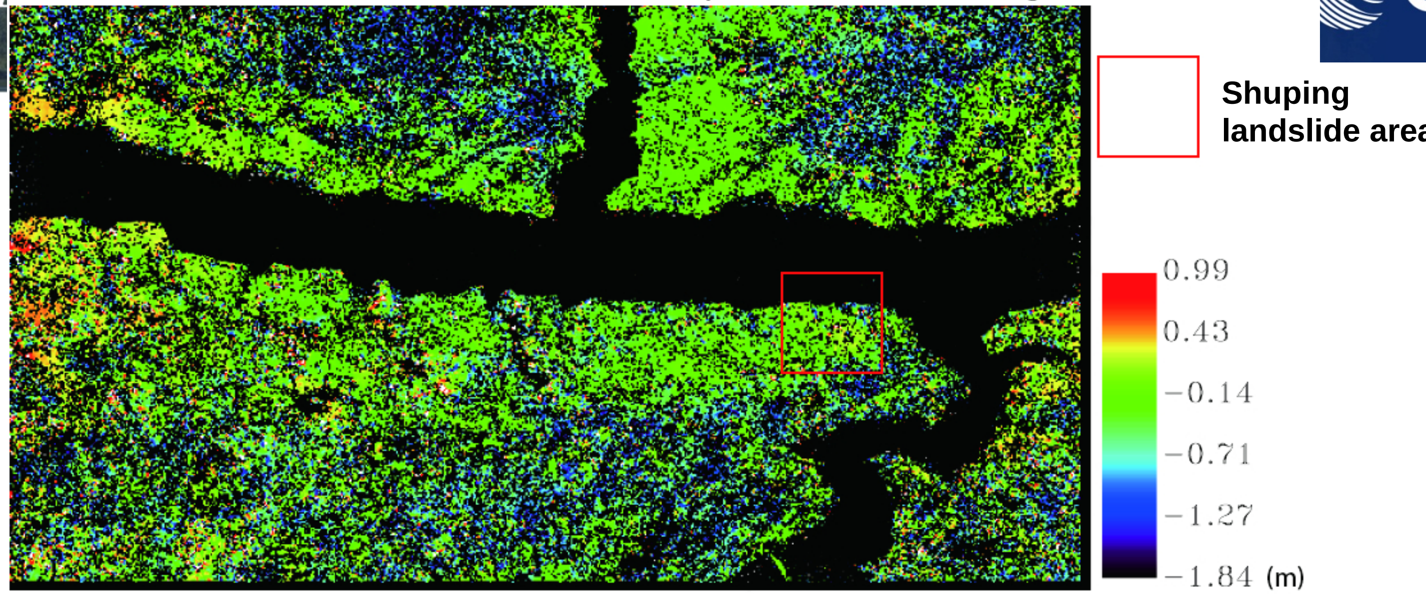


Taken from Li, X et al. (2011)

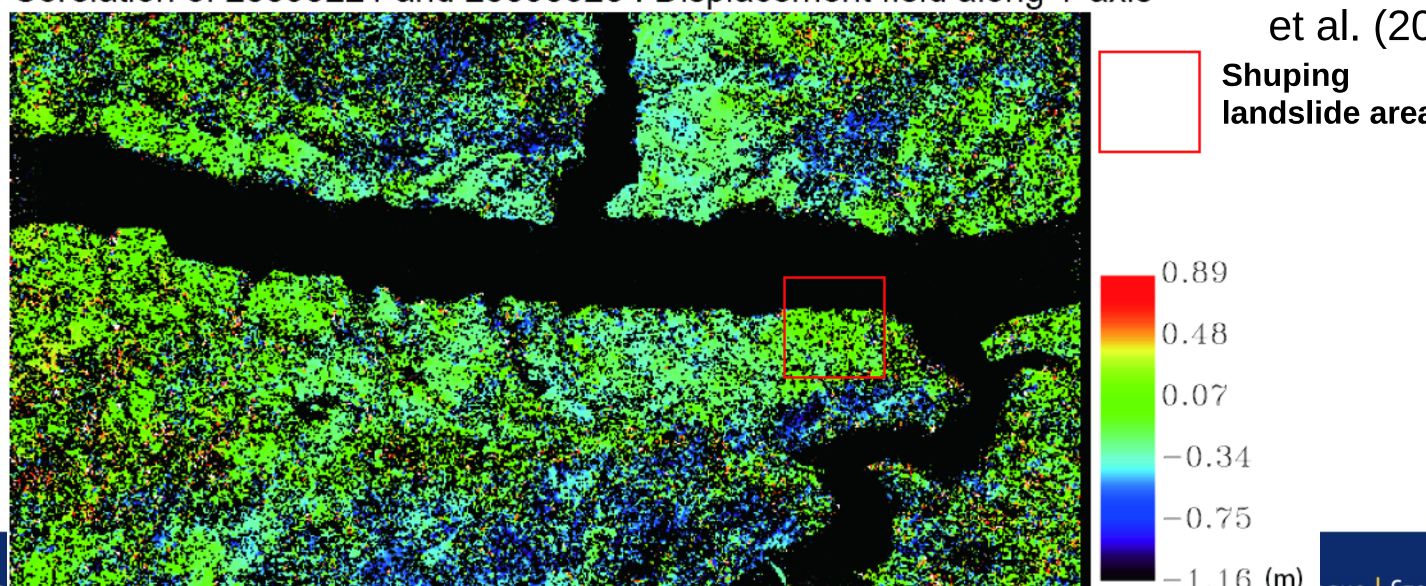
Corelation of 20090221 and 20090509 : Displacement field along Y axis



Corelation of 20090221 and 20090520 : Displacement field along X axis

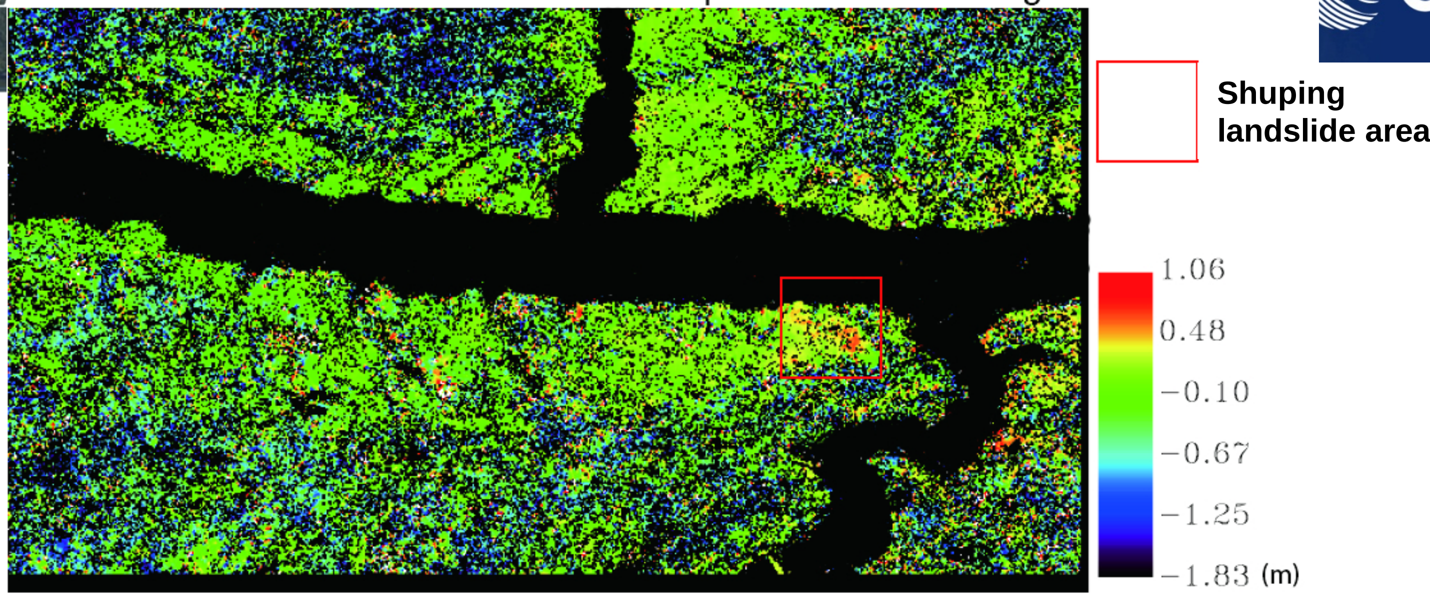


Corelation of 20090221 and 20090520 : Displacement field along Y axis

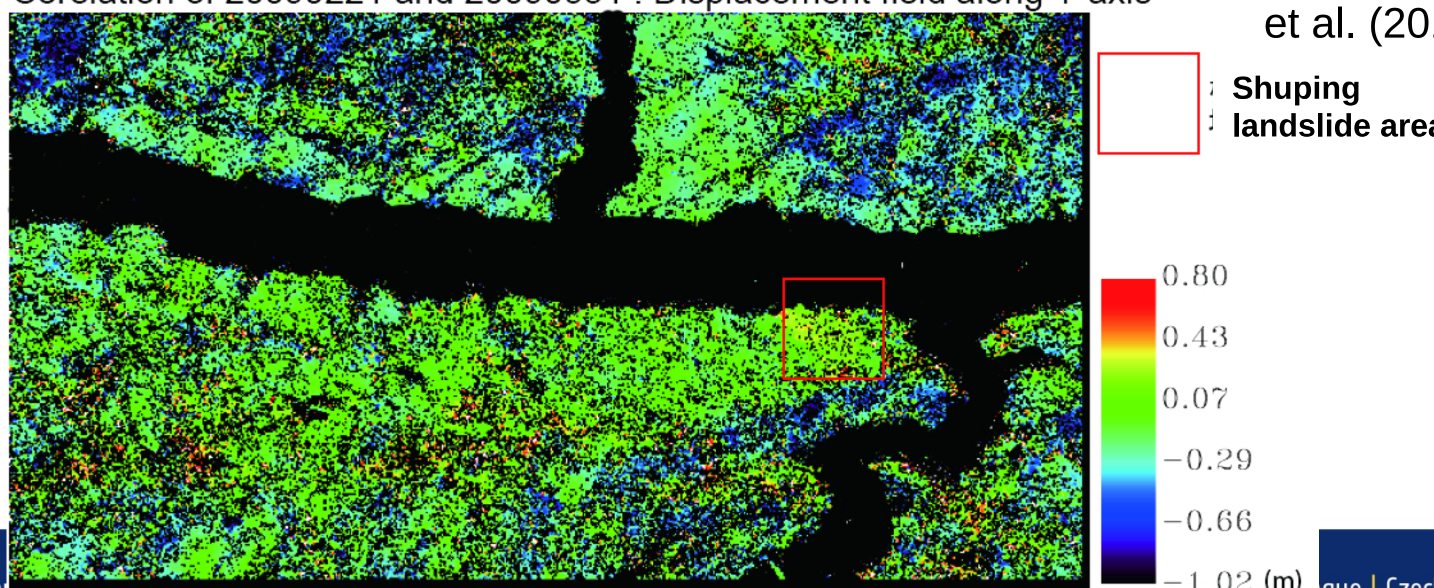


Taken from Li, X et al. (2011)

Corelation of 20090221 and 20090531 : Displacement field along X axis

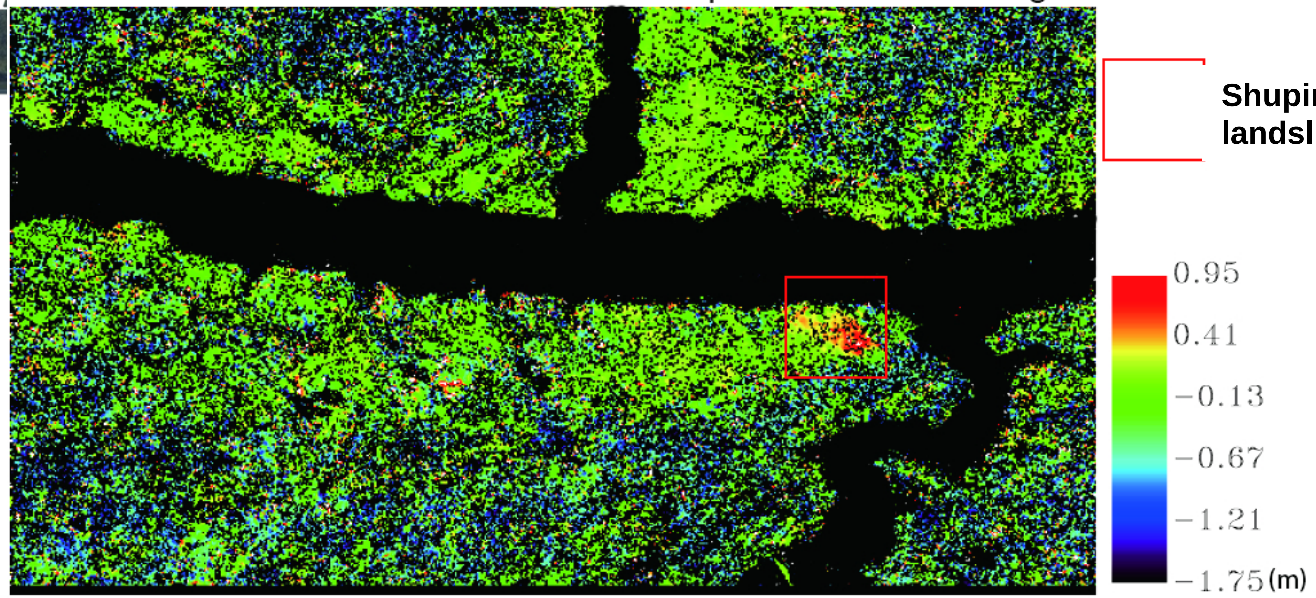


Corelation of 20090221 and 20090531 : Displacement field along Y axis



Taken from Li, X et al. (2011)

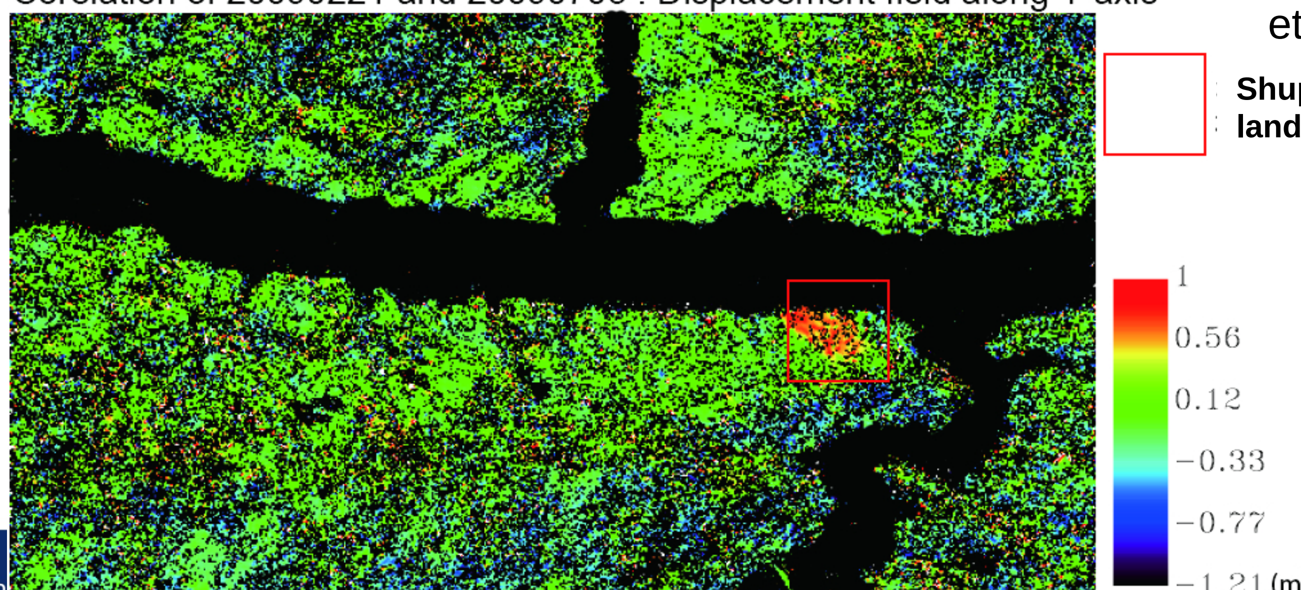
Corelation of 20090221 and 20090703 : Displacement field along X axis



Shuping landslide area

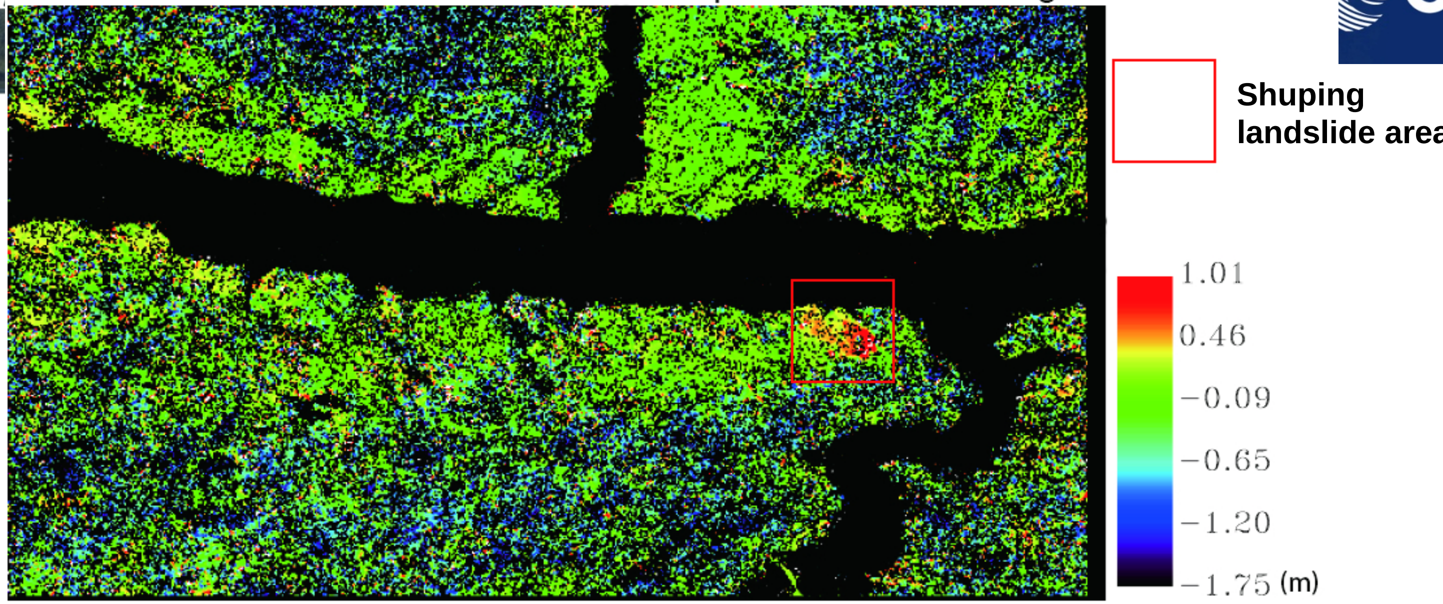
Taken from Li, X et al. (2011)

Corelation of 20090221 and 20090703 : Displacement field along Y axis



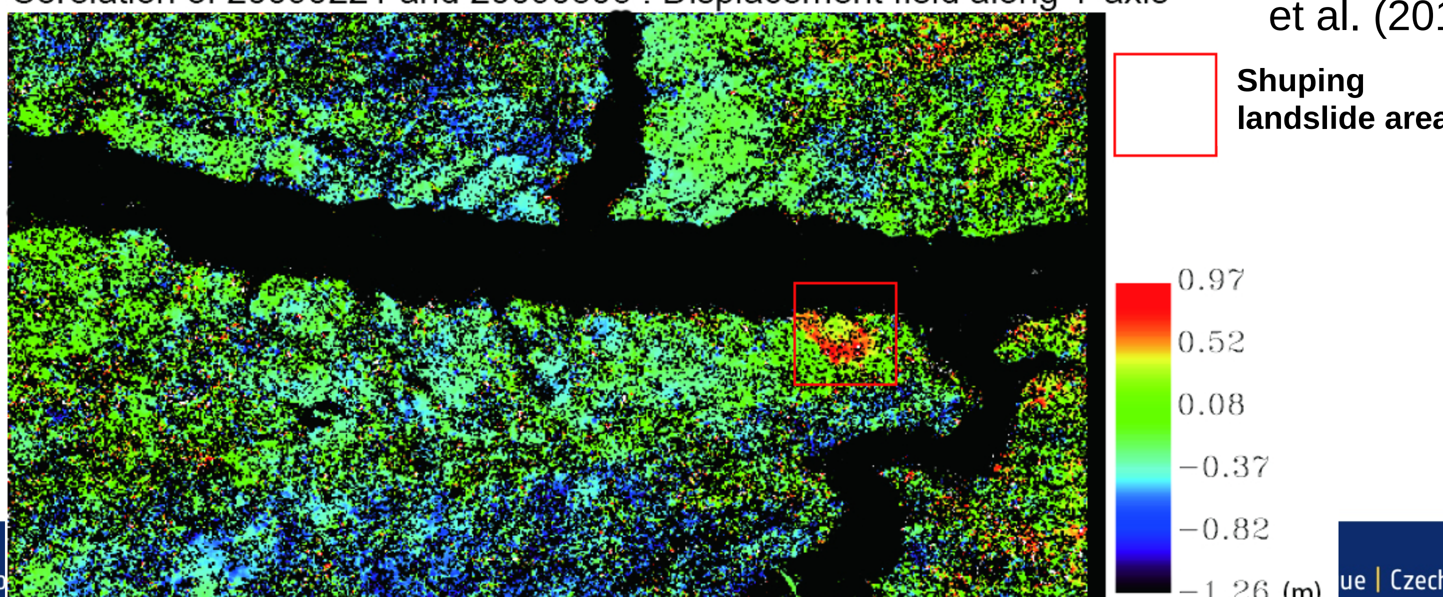
Shuping landslide area

Corelation of 20090221 and 20090805 : Displacement field along X axis

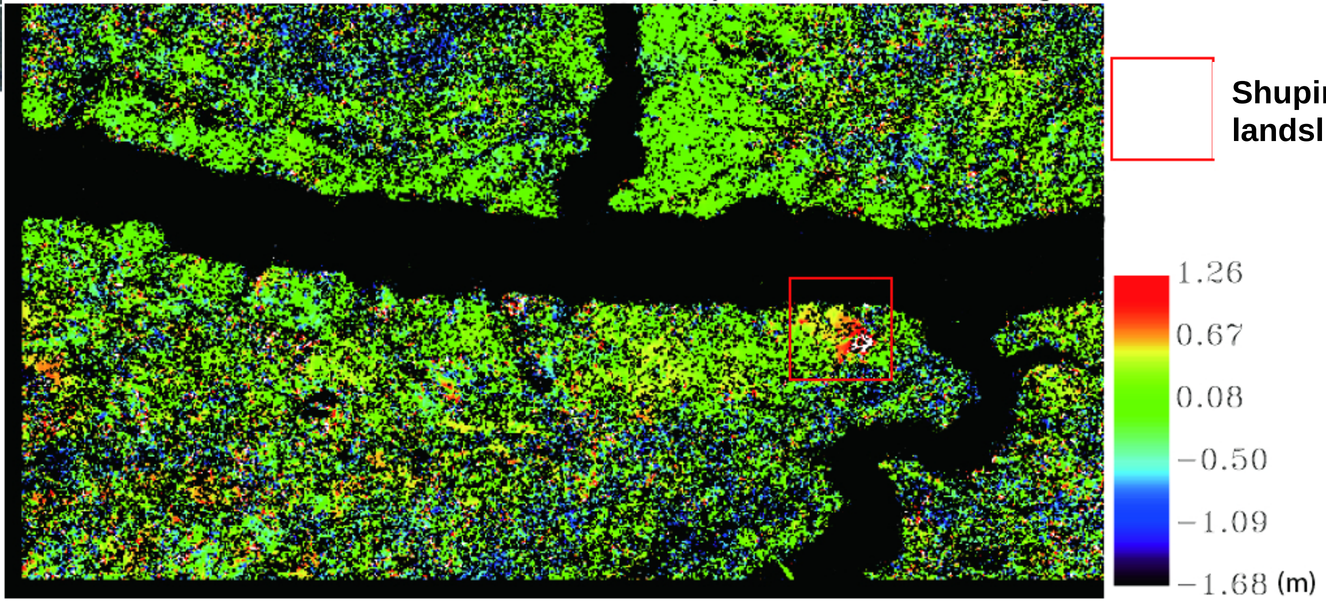


Taken from Li, X et al. (2011)

Corelation of 20090221 and 20090805 : Displacement field along Y axis

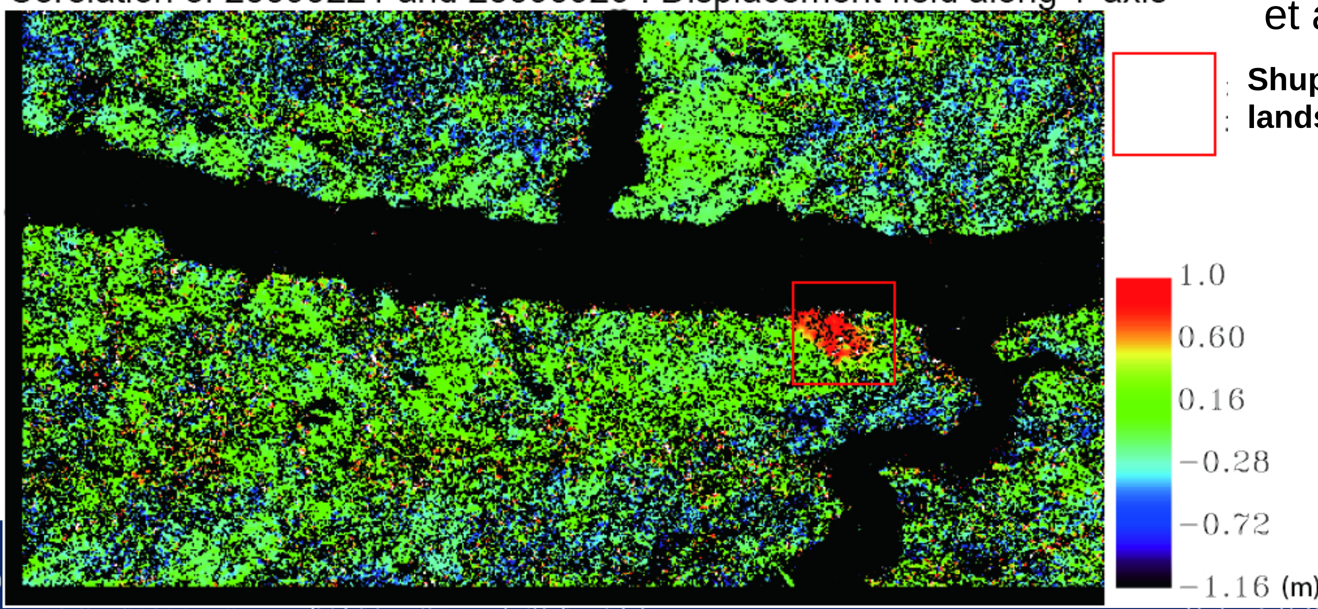


Corelation of 20090221 and 20090929 : Displacement field along X axis

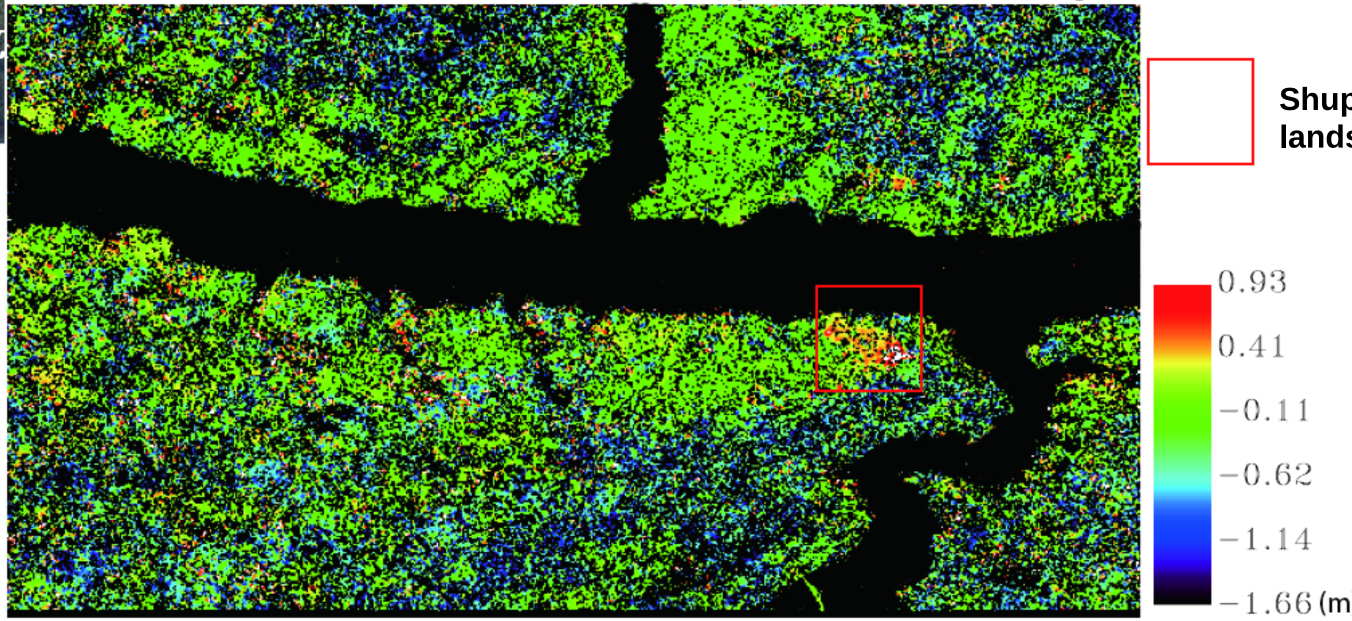


Taken from Li, X et al. (2011)

Corelation of 20090221 and 20090929 : Displacement field along Y axis

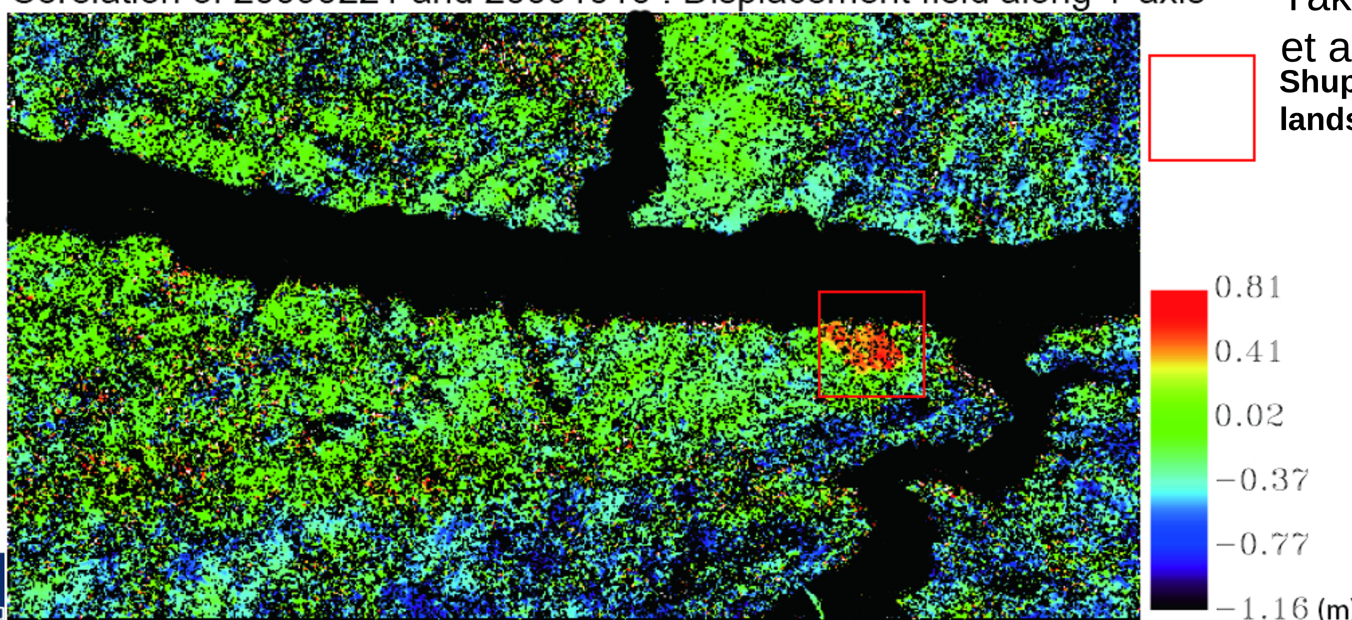


Corelation of 20090221 and 20091010 : Displacement field along X axis



Shuping landslide area

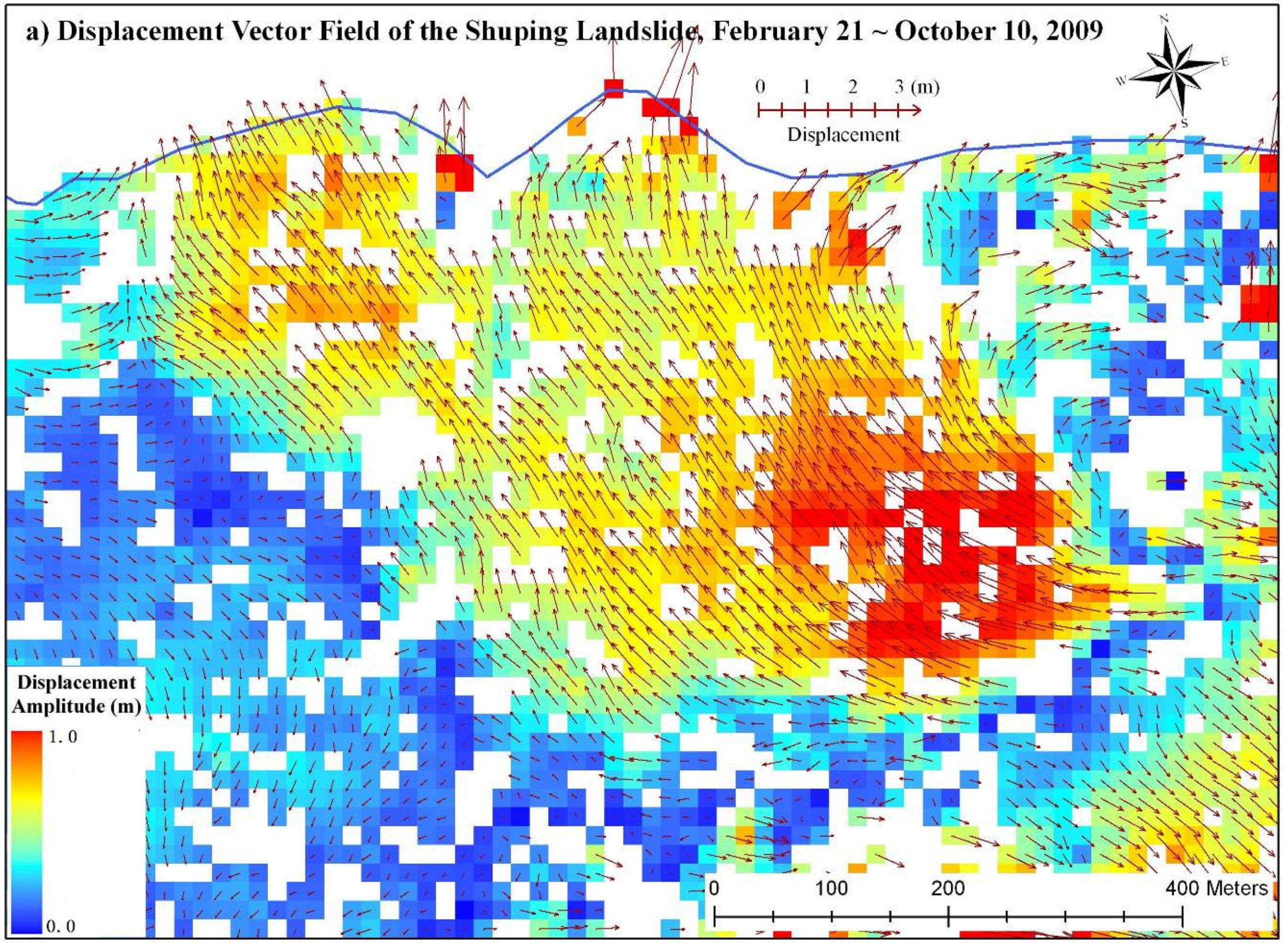
Corelation of 20090221 and 20091010 : Displacement field along Y axis

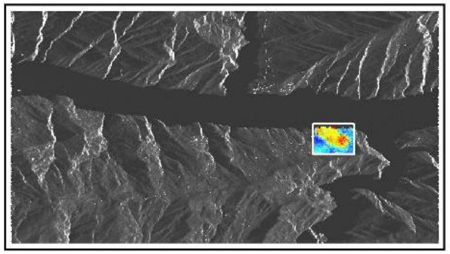


Taken from Li, X et al. (2011)

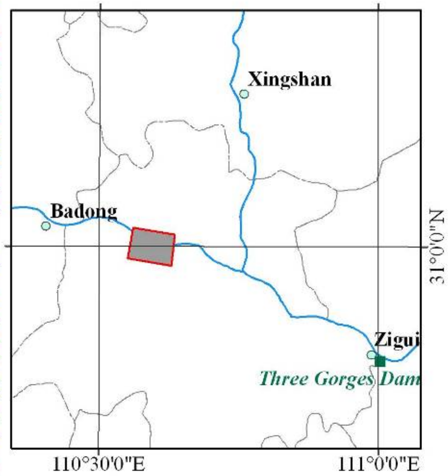
Shuping landslide area

The displacement vector field of 20090221-20091010 in ShuPing area

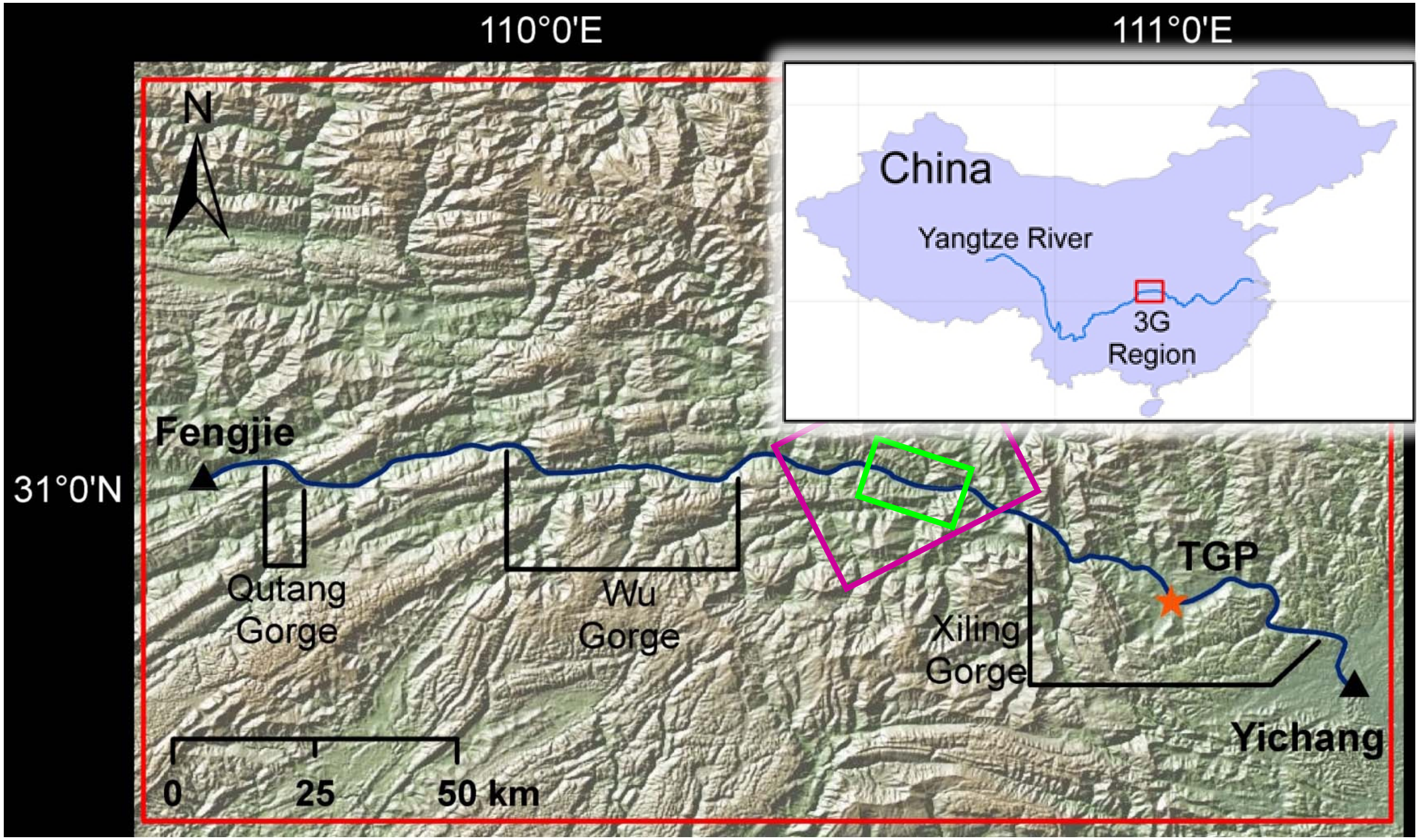




b) The Location of the Landslide in the Research Area (TerraSAR Image as Background)

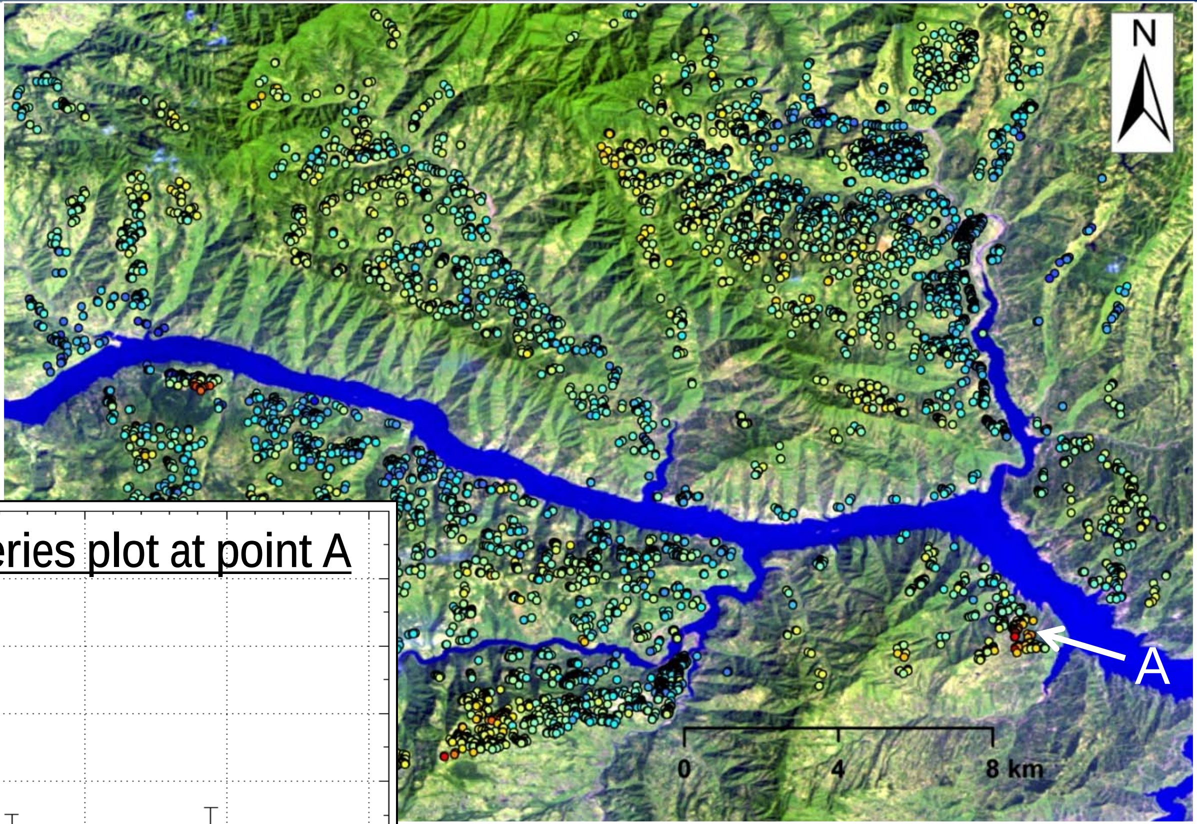


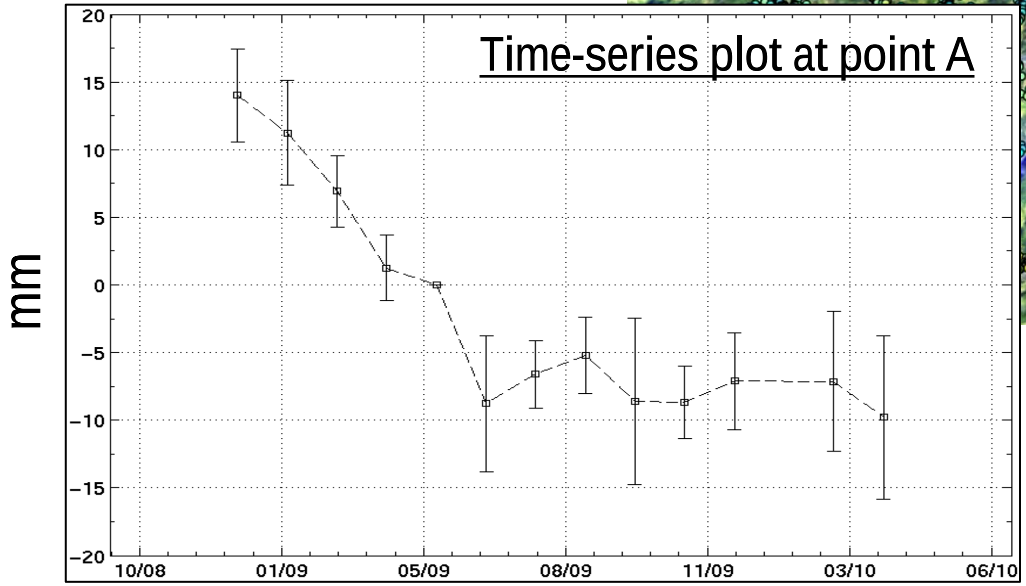
c) The Location of the Research Area



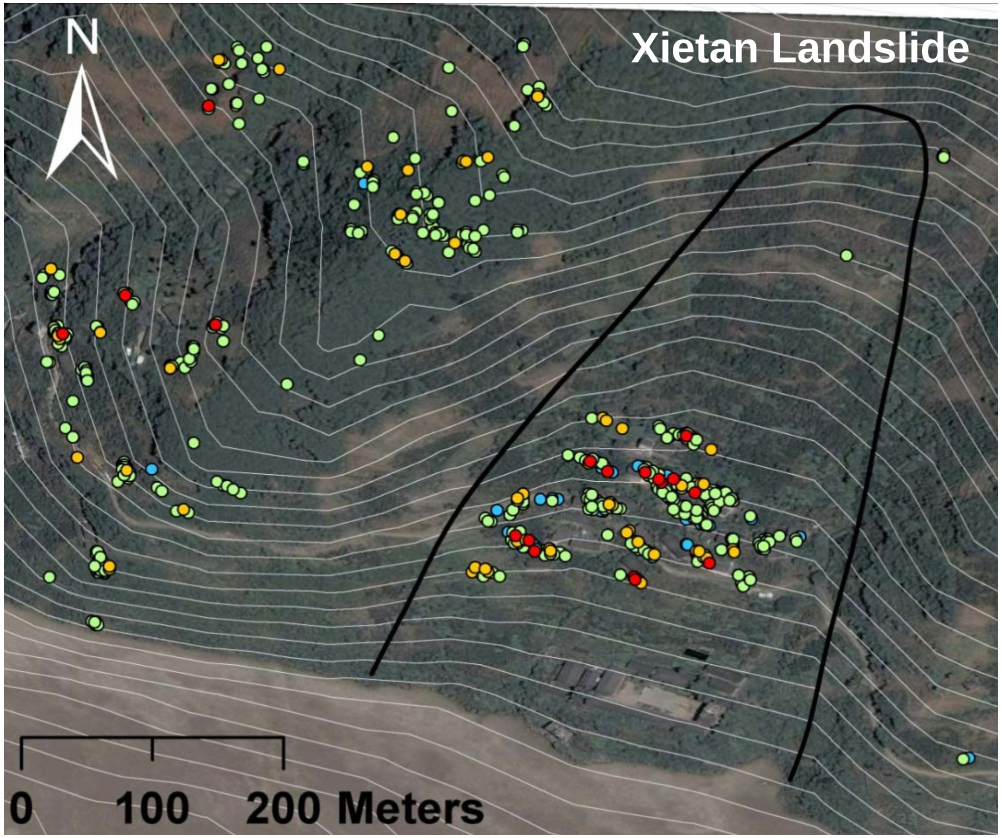
TSX Spotlight and Stripmap Data

Envisat ASAR Data


18
0
(mm / yr)
- 20
N
A
0
4
8 km


Time-series plot at point A
mm
20
15
10
5
0
−5
−10
−15
−20
10/08
01/09
05/09
08/09
11/09
03/10
06/10

Mean LOS Velocity Map from TSX Stripmap



mm/yr

>60	- 40 to -10	- 10 to 10	10 to 40	> 60

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2011 DRAGON 2 SYMPOSIUM
中国科技部-欧洲空间局合作 “龙计划”二期
“龙计划”二期2011年学术研讨会

Mapping the Qinghai-Tibet railway deformation using small baseline InSAR time-series technique

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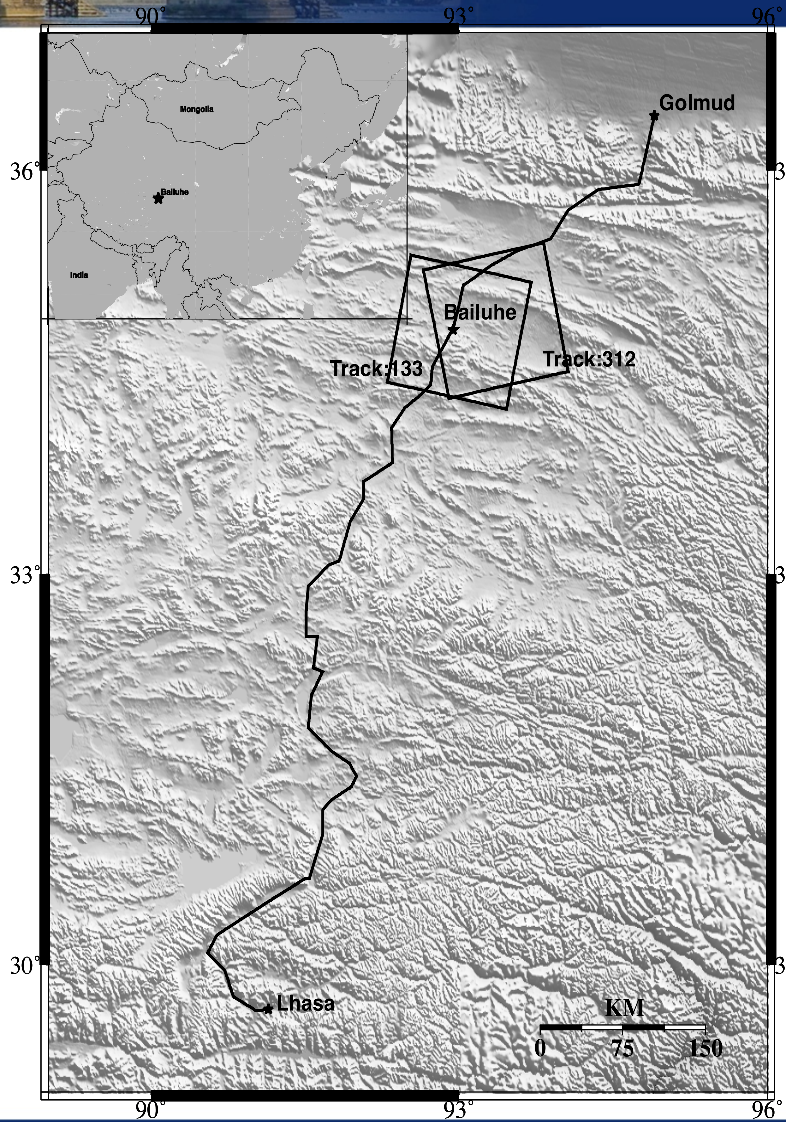
捷克 布拉格 2011年6月20-24日

Study area and data

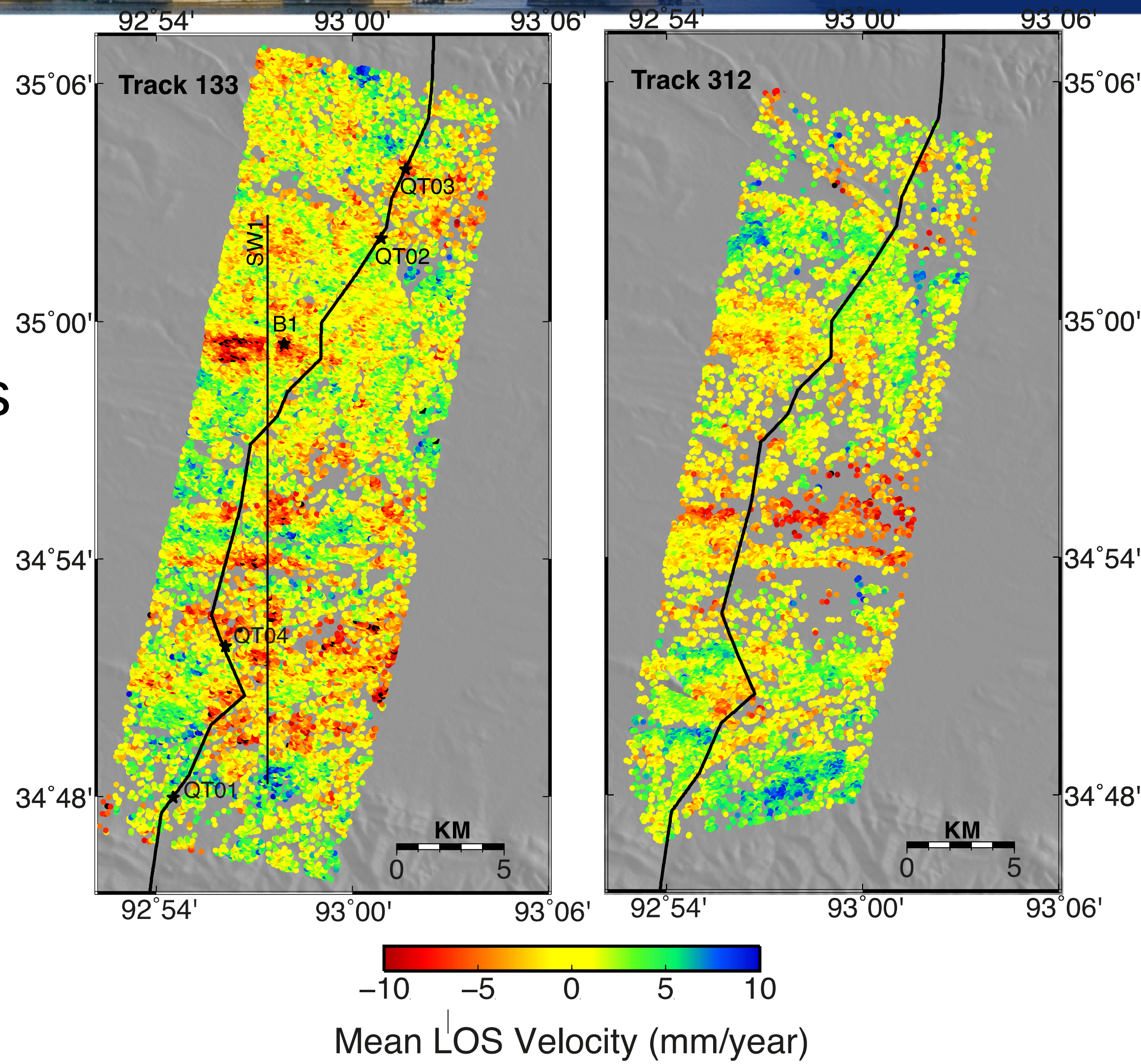
- **Bailuhe region**

- **Two independent adjacent Envisat tracks**
  - Ascending track 312, 22 images (10/2006~08/2010)
  - Descending track 133,35 images (11/2004~06/2010)



Mean velocity maps

- Four sites on the railway for time-series
- One site on the permafrost for time-series
- One 2km-width swath profiles



Conclusion and future work

Combining these suggests that InSAR has the potential to monitor the deformation of Qinghai-Tibet railway on areas with permafrost

- **Future work**
  - **Modelling the deformation and assessing the damage**

Publications: Journal and Conference

1. Cunren Liang, Qiming Zeng, Jian Jiao, Xi'ai Cui, ScanSAR-Stripmap interferometry using Envisat ASAR data, *Journal of Remote Sensing*, No. 4, 2011.(in press)
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10. Bin Liu, Yi Luo, Jingfa Zhang, Lixia Gong, Wenliang Jiang. PS InSAR time-series analysis for monitoring ground subsidence，The Fifth International Symposium on In-situ Rock Stress. Beijing, China, August 25-27, 2010.
11. Gong Lixia, Wu Fan, Zeng Qiming, and Zhang Jingfa. Multi-temporal filtering of SAR images. *Computer Engineering*, 2011, In Press.
12. Huifang Zhou, Jingfa Zhang, Lixia Gong, and Xiaoqing Shang. Comparison and Validation of Different DEM Data Derived from InSAR. 2011 International Conference on Earth Sciences and Engineering, Hong Kong, China, February 20-21, 2011.
13. Leyin Hu. InSAR measurement of fault activity in Red River fault zone. The Fifth International Symposium on In-situ Rock Stress. Beijing, China, August 25-27, 2010.

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1. Liang Chang, He Xiufeng. InSAR atmospheric distortions mitigation: GPS observations and NCEP FNL data[J].Journal of Atmospheric and Solar-Terrestrial Physics, 2011, 73(4):464-471.
2. . Liang Chang, Xiufeng He, Jonathan Li. A Wavelet Domain Detail-compensation Filtering Technique for InSAR Interferogram[J]. International Journal of Remote Sensing, doi:10.1080/01431161.2010.531787.
3. 何秀凤, 仲海蓓, 何敏. 基于PS-InSAR和GIS空间分析的南通市区地面沉降监测[J]. 同济大学学报（自然科学版），2011, 39(1):129~134
4. Xu J., Han W., He X. F. 2010. Small target detection in SAR image based on the alpha-stable distribution. International Conference on Image Analysis and Signal Processing (IASP 2010), XiaMen, China, 12-14 April, 2010.
5. He Min, He Xiufeng. Building Damage Detection Using Satellite SAR Images for Wenchuan. CPGPS 2010 Technical Forum On Satellite Navigation and Positioning, Shanghai, August 18-20, 2010.
6. He Min, He Xiufeng. 利用InSAR技术监测湿地水位变化. CPGPS 2010 Technical Forum On Satellite Navigation and Positioning, Shanghai, August 18-20, 2010.

Personnel Exchange

- Dr. Zhenhong Li (U. of Glasgow) visited Beijing in March 2010
- Mr. Jiang Wenliang et al. visited Imperial College and University of Glasgow UK, in Nov. 2010

Future Work Plan

- Survey and detect the fault activity in Tibet – Sichuan region by using PS InSAR and SBAS time series analysis techniques,
- To apply the latest WV corrections to WSM processed results over Tibet & Beijing
- Derive ALOS-PALSAR at 50m and TanDEM-X DEM at 10m of the Three Gorges area
- Apply TerraSAR-X to a time series analysis of landslide movement in 2010
- Data fusion of ENVSAT-ASAR with TerraSAR-X measurements to provide an inter-comparisons

Thanks for your attention!

Questions Welcome!