ESA-MOST Dragon Cooperation

中国科技部-欧洲空间局“龙计划”合作

2017 DRAGON 4 SYMPOSIUM

2017年“龙计划”四期学术研讨会

Earth observations for geohazard monitoring and risk assessment (ID: 32244)

European Lead PI

Prof Zhenhong Li

Chinese Lead PI

Prof Qiming Zeng

26–30 June 2017 | Copenhagen, Denmark

2017年6月26-30日，丹麦 哥本哈根

Overview of the Project

Earth observations for geohazard monitoring and risk assessment (ID: 32244)

Topic Nr.	PIs	Title
32244_1	*Prof. Zhenhong Li, Prof. Jingfa Zhang*	***Active Faults and Seismic Risk Assessment in China***
32244_2	*Prof. Jan-Peter Muller, Prof. Qiming Zeng*	***Understanding Landslide hazards in the Three Gorges, China and landslides induced by large earthquakes***
32244_3	*Dr. Yaxin Bi, Prof. Guoze Zhao*	***Earthquake Precursors from Space and Ground – Detecting Seismic Anomalies from Satellite and Ground Data with Multiple Parameters***

Sub-Project 1: Active Faults and Seismic Risk Assessment in China

Partners in China

Prof Jingfa Zhang, Prof Shuxin Yang, Dr Lixia Gong, Dr Yongsheng Li, Dr Yi Luo *Institute of Crustal Dynamics, China Earthquake Administration* (*InSAR + Seismic hazards*)
Prof Xinjian Shan *Institute of Geology, CEA* (*InSAR + Geophysical modelling*)
Prof Shunying Hong *Institute of Earthquake Science, CEA* (*Earthquake hazards*)
Prof Huaining Yang *National Earthquake Response Support Service , CEA* (*Earthquake hazards*)
Prof Shaomin Yang *Institute of Seismology, CEA* (*Active faults + Continental deformation*)
Leyin Hu *Earthquake Administration of Beijing Municipality, CEA* (*Active faults + GPS*)
Prof Caijun Xu, Dr Yangmao Wen, Dr Yang Liu, Dr Jianjun Wang *Wuhan University* (*InSAR + Geophysical modelling*)
Prof Qiming Zeng *Peking University* (*InSAR processing*)
Dr Jyr-Ching Hu *National Taiwan University* (*Active faults + Seismic hazards*)

Partners in Europe

Prof Zhenhong Li *COMET, Newcastle University* (*InSAR correction models and time series algorithms + Continental deformation + Earthquake hazards*)
Prof Tim Wright, Dr John Elliott *COMET, University of Leeds* (*Continental deformation + Earthquake hazards*)
Prof Barry Parsons *COMET, University of Oxford* (*Earthquake hazards*)
Prof Jan-Peter Muller *University College London* (*Earthquake hazards*)

PhD researchers

Qiang Li *ICD, CEA*
Keren Dai *Southwest Jiaotong University*
Jiajun Chen, Chen Yu *Newcastle University*
Juliet Stockamp *University of Glasgow*

Main Objectives

O1. Further develop the COMET InSAR processing chain to reduce atmospheric water vapour effects on radar measurements.

O2. Determine present-day deformation and strain map for selected regions using InSAR, GNSS and levelling.

O3. Enable our existing geodetic inversion packages to be automated for the determination of earthquake source parameters.

O4. Investigate post-seismic deformation for large events

O5. Assess time-dependent hazard following major earthquakes.

Sub-Project 2: Understanding Landslide Hazards in the Three Gorges, China and Landslides Induced by Large Earthquakes

Partners in China

Prof Qiming Zeng, Assoc. Prof Jiao Jian, Prof Yonghong Zhao *Peking University* (*InSAR processing + Solid mechanics*)

Prof Jingfa Zhang *Institute of Crustal Dynamics, CEA* (*Seismic hazards*)

Prof Xinjian Shan *Institute of Geology, CEA* (*Geology*)

Prof Jyr-Ching Hu *National Taiwan University* (*Structure Geology*)

Prof Ping Zhong *National University of Defense* (*InSAR Processing*)

Partners in Europe

Prof Jan-Peter Muller
University College London (*Remote sensing + Imaging processing*)

Prof Zhenhong Li
COMET, Newcastle University (*InSAR correction models and time series algorithms + Landslide monitoring*)

Dr Roberto Tomas Jover
Universidad de Alicante (*InSAR + Landslide modelling*)

Dr Cem Kincal
Dokuz Eylul University (*Landslide modelling*)

Main Objectives

O1. Integrate various SAR/InSAR/Optical techniques to detect and monitor extremely-slow through very-slow to slow-moving landslides

O2. Combine various SAR datasets to recover 2D/3D displacements of landslides

O3. Model earth observations to determine the geophysical mechanisms responsible for landslides and provide a quantitative risk assessment in the Three Gorges region

O4. Combine satellite optical and radar images to rapidly respond to landslides induced by large earthquakes.

Identifying of collapsed building induced by the Earthquake by using polarmetric SAR image

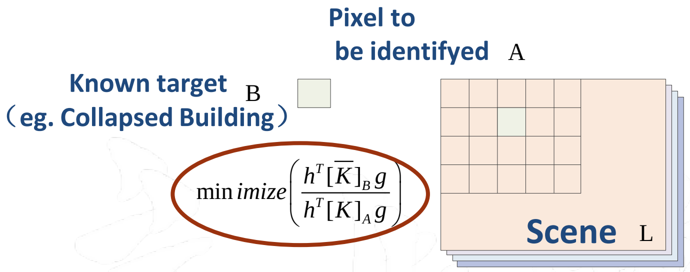
Haizhen Zhang, Qiming Zeng, Jian Jiao

- Relative optimal polarization matching
- Relative optimal polarization matching combine with coherence correction
- Rapid Building Collapse Extraction Using Generalized Optimum Polarimetric Contrast Enhancement with Only One Post-earthquake PolSAR Image (ref. to Poster by Haizhen Zhang *et al*) , including texture
- Generalized Optimum Polarimetric Contrast Enhancement with multi-variables
- Case studies: the Yushu Earthquake and Kumamoto Earthquake

Relative Optimal Polarmetric Matching (ROPM)

- If A is similar to B, their polarmetric scattering should be similar, then through rotating the T/R state the ratio should near 1
- However, the total power of A and B may have big difference when applying to any unknown A

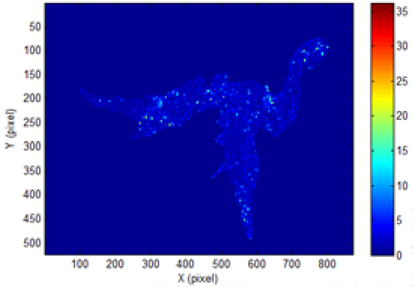
=>robust solution is transfer the question to seek maximal solution of the minimum of the ratio for possible combination of T/R state vectors



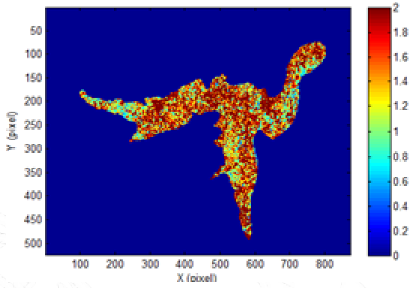
$$\min imize\left(\frac{h^T[\overline{K}]_B g}{h^T[K]_A g}\right)$$

$$\max\min\left(\frac{h^T[K]_A g}{h^T[\overline{K}]_B g}\right)$$

Result Analysis, Yushu case

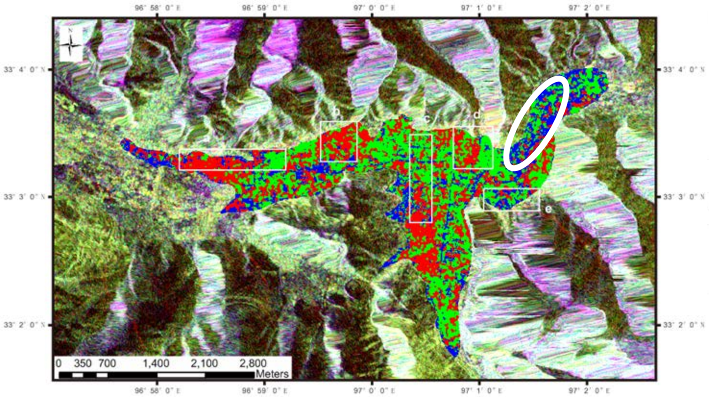


Original polarmetric ratio



enhanced polarmetric ratio

- ◆Radarsat 2, full polarization
- ◆Reference data: interpretation of airborne high resolution optical image (Huadong Guo *et al*)



Classified collapsed building, Red: Collapsed; Green: Intact; Blue: Open Area

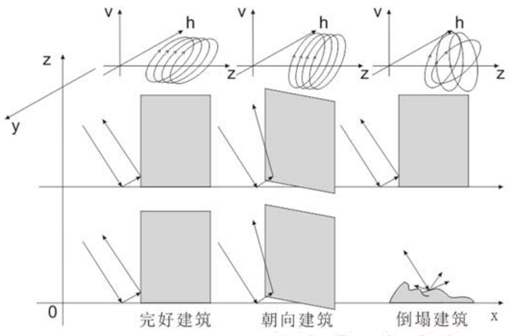
	Collapsed	Intact	Non Building	Total	UA (%)
Collapsed	3673	1475	1639	6787	54.12
Intact	1699	2983	1834	6516	45.78
Non B.	193	359	1656	2208	75.00
Sum	5565	4817	5129	15511	
PA (%)	66.00	61.93	32.29		
OA (%)	53.59	Kappa	0.529		

ROPM with coherence correction

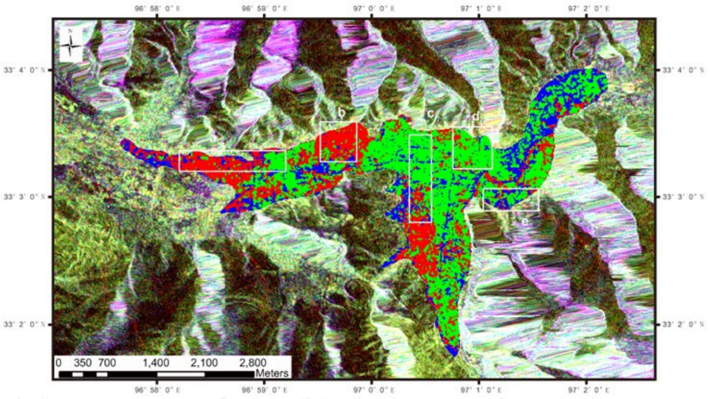
- co-seismic coherence（Foster et al，1964）

$$\gamma = \frac{E\left(x_1 x_2^*\right)}{\sqrt{E\left(|x_1|^2\right)E\left(|x_2|^2\right)}} \qquad 0 \le \gamma \le 1$$

$$|\hat{\gamma}| = \frac{\left|\sum_{i=1}^{N} w_N s_{1,i} s_{2,i}^* e^{-j\varphi_i}\right|}{\sqrt{\sum_{i=1}^{N}|s_{1,i}|^2 \sum_{i=1}^{N}|s_{2,i}|^2}}$$

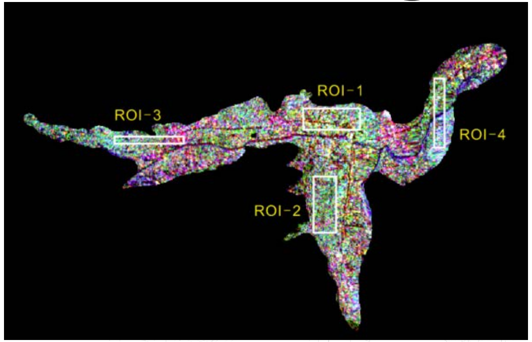


When building collapsed, the coherence reduced

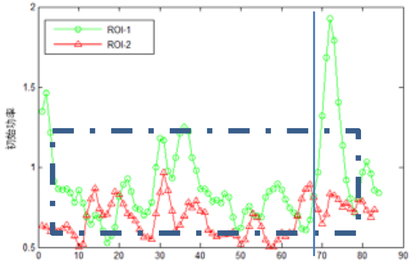


UA increased to 68.25%， PA up to 68.72%，
OA is 60.45%， Kappa was 0.601.
Some misclassified buildings along with direction in non-parallel, non-perpendicular has been corrected

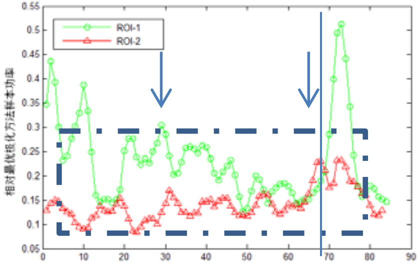
Highlights of some profiles



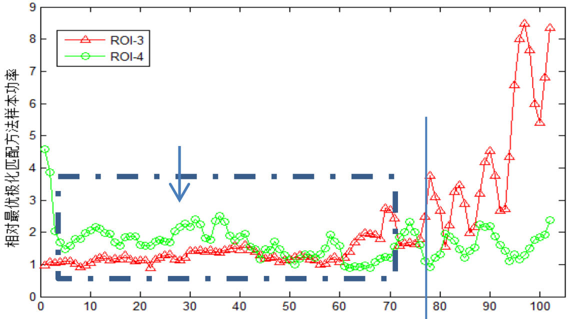
ROI distribution



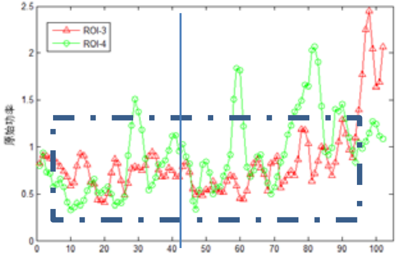
Original polarmetric ratio profiles for ROI 1/2

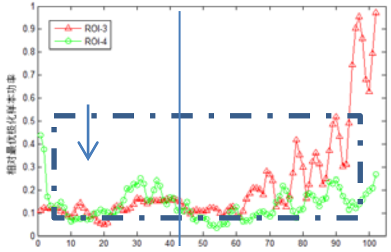


Enhanced Polarmetric Ratio profiles



By using ROPM, these phenomena partially solved





Original and enhanced ratio still have overlapping of collapsed building with Intact building in direction of 45° to radar illumination

Generalized Optimum Polarization （GOP）

GOP（Yang etal，2004）use more polarmetric information rather than power in ROPM

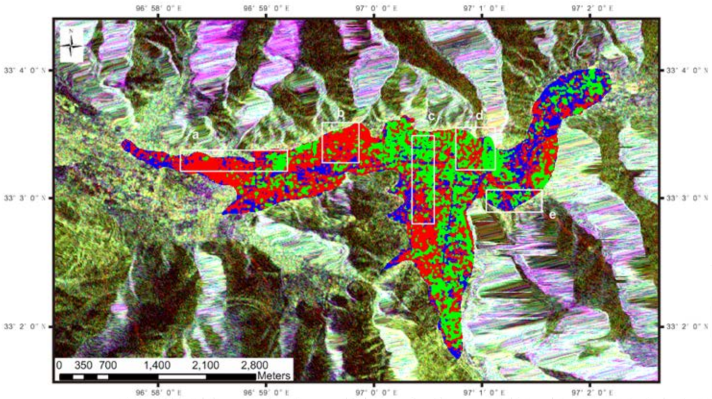
$$\max imize \left(\frac{\frac{1}{M}\sum_A \left[\sum_{i=1}^{3} \boxed{(x_i r_i)_A} \right]^2}{\frac{1}{N}\sum_B \left[\sum_{i=1}^{3} (x_i r_i)_B \right]^2} \times \frac{h^T [\overline{K}]_A g}{h^T [\overline{K}]_B g} \right)$$

$$r([S_1],[S_2]) = \frac{\left| (k_1^*)^T k_2 \right|^2}{\|k_1\|_2^2 \|k_2\|_2^2}$$

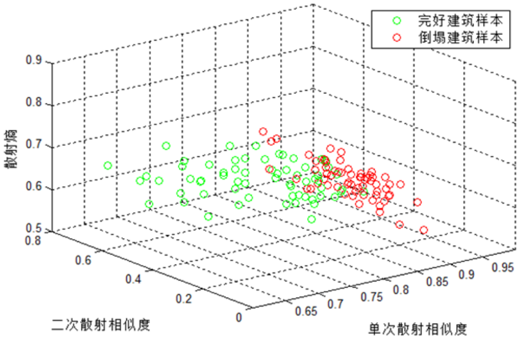
Including: polarmetric components, entropy, polarmetric similarity, ……

Polarmetric similarity independ on power and aspect of polarmetric angle

GOP



GOP classified result

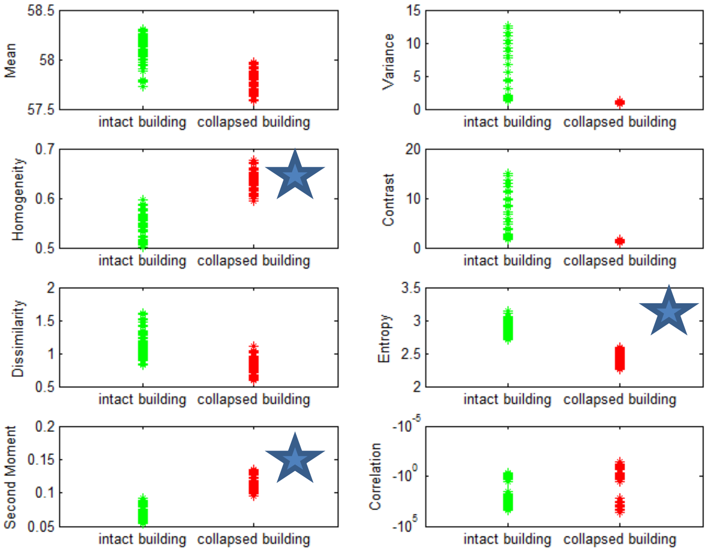


Green: intact building
Red: collapsed building

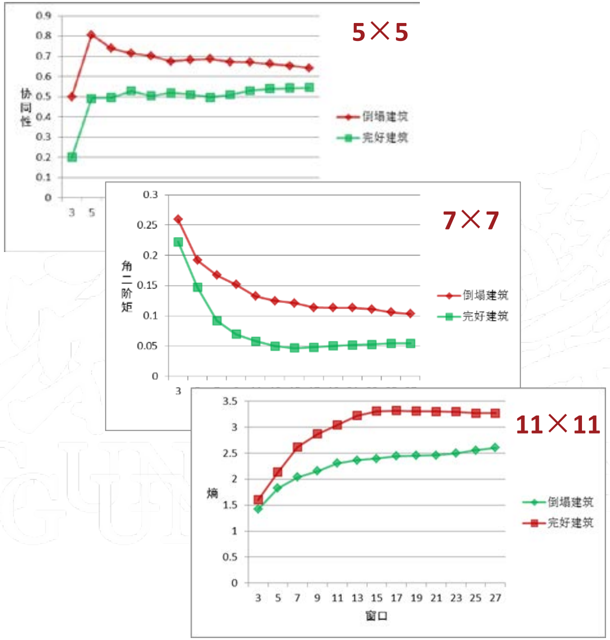
	collapsed	Intact	Non Building	total	UA (%)
Collapsed	4161	1652	1954	7767	53.57
Intact	1211	2806	1519	5536	50.69
Non B.	193	359	1656	2208	75.00
Sum	5565	4817	5129	15511	
PA (%)	74.77	58.25	32.29		
OA (%)	55.59	Kappa	0.537		

Texture

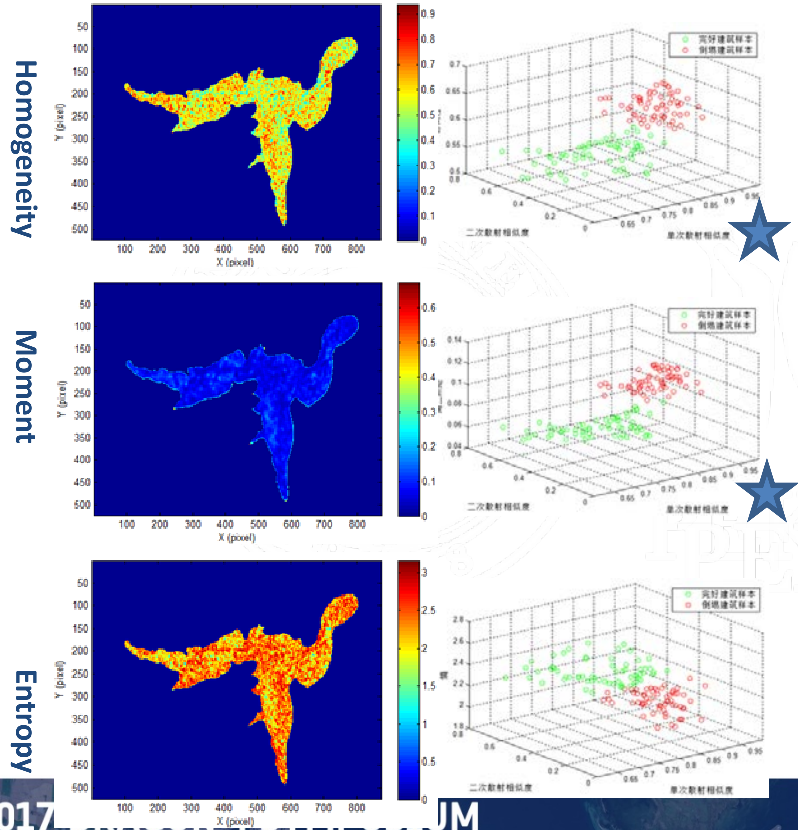
◻Texture based on GLCM

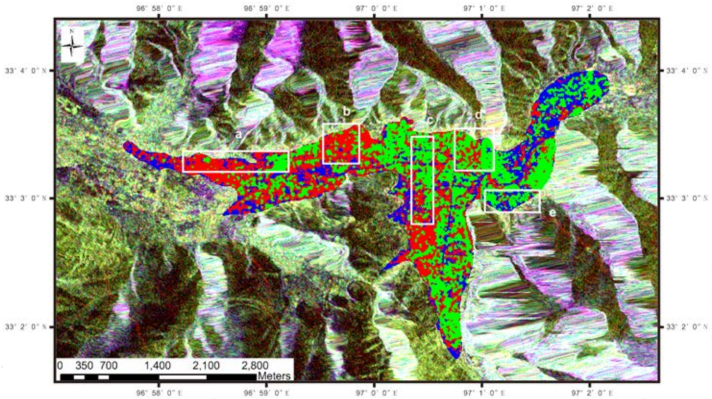


GLCM texture parameters statistics in 3×3 window



GOP with texture

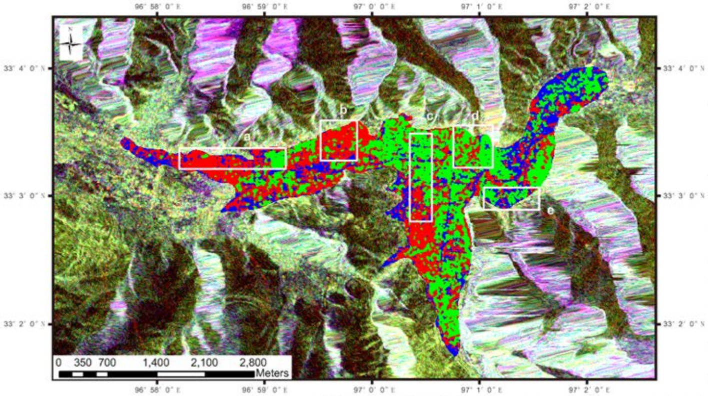




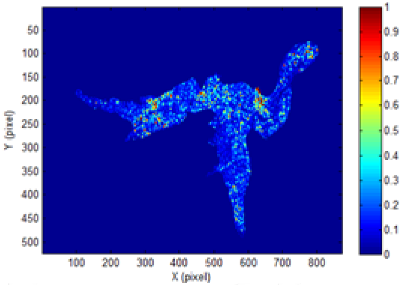
纹理-广义相对最优极化倒塌建筑提取结果

	Collapsed	Intact	Non B.	total	UA (%)
Collapsed	3677	1298	1640	6615	55.59
Intact	1695	3160	1833	6688	47.25
Non B.	193	359	1656	2208	75.00
Sum	5565	4817	5129	15511	
PA (%)	66.07	65.50	32.29		
OA (%)	54.75	Kappa	0.541		

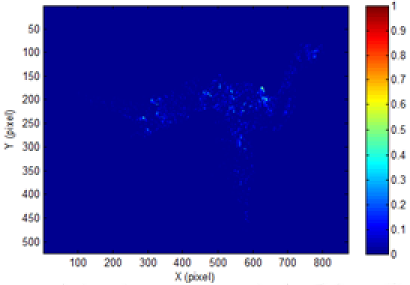
GOP combined with Coherence



同震相干性-广义相对最优极化倒塌建筑提取结果



GOP with coherence



difference

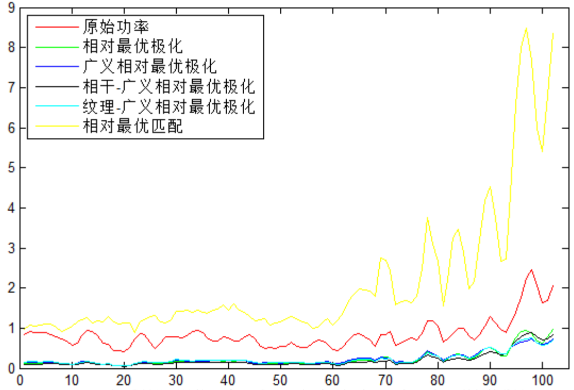
	Collapsed	Intact	Non B.	total	UA (%)
Collapsed	3935	1180	1743	6858	57.38
Intact	1437	3278	1730	6445	50.86
Non B.	193	359	1656	2208	75.00
Sum	5565	4817	5129	15511	
PA (%)	70.71	68.05	32.29		
OA (%)	57.18	Kappa	0.567		

GOP with multi-variables

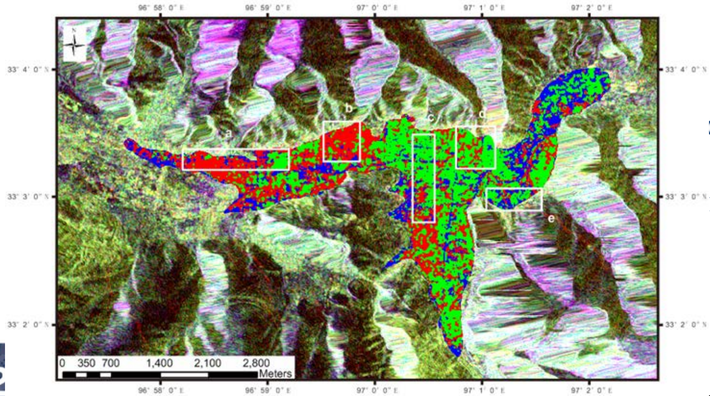
Variable	
Scattering Entropy	
Single scattering similarity	
Double bounce similarity	★
homogeneity	★
Entropy	
Angular	★
Co-seismic Coherence	★

$$\max imize\left(\frac{\frac{1}{M}\sum_A\left[\sum_{i=1}^{4}(x_i r_i)_A\right]^2}{\frac{1}{N}\sum_B\left[\sum_{i=1}^{4}(x_i r_i)_B\right]^2}\times\frac{h^T[\overline{K}]_A g}{h^T[\overline{K}]_B g}\right)$$

Result analysis & Comparison



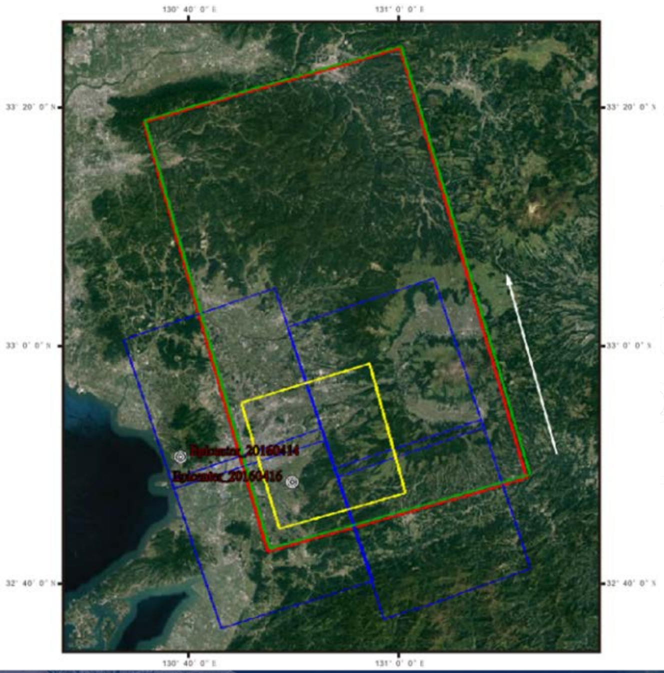
基于最优极化方法ROI-3剖面线分析



Method		Contrast Ratio	Collapsed UA	OA	Kappa	Capability for B. in 45°
Relative Optimal Polarization	Cross Pol		44.61%	48.36%	0.473	weakest
	ROP	2.22	53.36%	52.23%	0.515	Good
	ROPM	/	54.12%	53.59%	0.529	Better
	ROP with Coherence	/	68.25%	60.45%	0.601	Good
Generalized Optimal Polarization	GOP	2.48	53.57%	55.59%	0.537	Mediate
	GOP-Coherence	3.29	57.38%	57.18%	0.567	Better
	GOP-texture	3.08	55.59%	54.75%	0.541	Better
	GOP-multi varible	3.17	58.39%	66.49%	0.563	Better

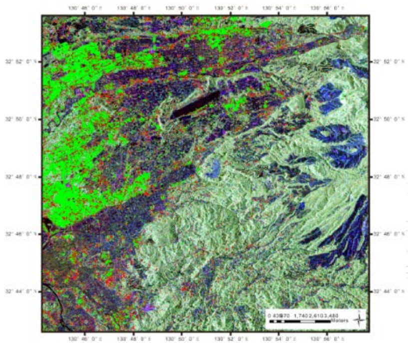
Case study: Kumamoto Earthquake

- Apr. 14, 2016

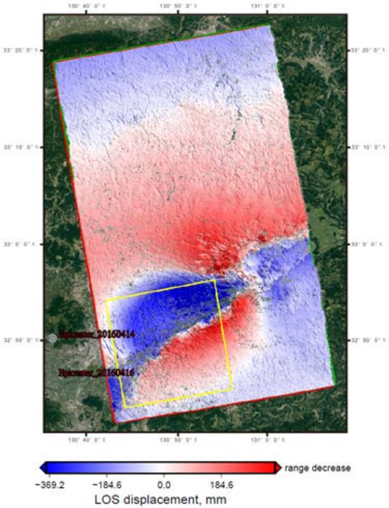


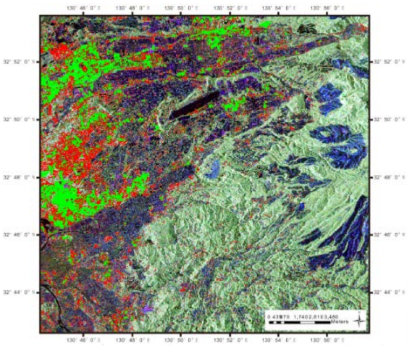
Sat./Sensor	Acquis. Date	Mode	Resolution	Direction
ALOS-2 PALSAR	2015.12.03	StripMap 2	6m	Ascending
ALOS-2 PALSAR	2016.04.21	StripMap 2	6m	Ascending
BJ-2	2016.05.04 2016.05.31	PAN MS	PAN: 0.7m MS: 3.7m	Ascending

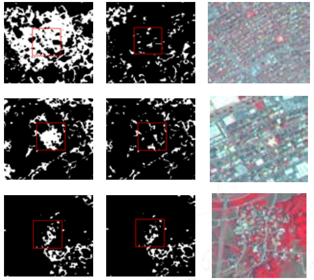
Result and validation



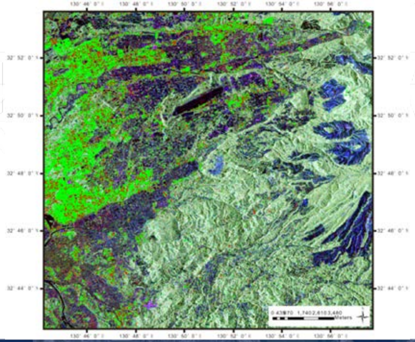
相干性-相对最优极化方法



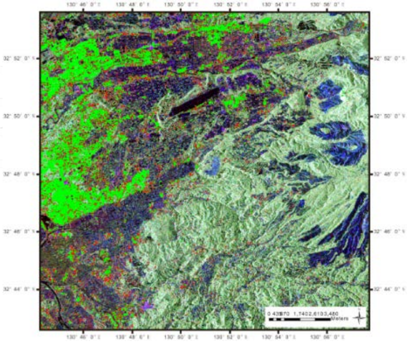




相对最优极化方法



相对最优极化匹配方法



纹理-广义相对最优极化方法

https://www.disasterscharter.org/web/guest/activations/-/article/earthquake-in-jap-1

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Sample	X (m)	Y (m)	Identify result: Collapsed	Intact	Non Building
1	669299.20	3628830.55	√		
2	669424.85	3629003.40	√		
3	669700.35	3629219.18	√		
4	670322.99	3629604.19	√		
5	669510.62	3628992.01	√		
6	669626.74	3629111.33			√
7	669638.19	3629019.36	√		
8	669803.98	3629170.71		√	
9	669835.62	3629237.47	√		
10	670180.44	3629328.79	√		
11	670186.67	3629268.45	√		
12	669824.03	3629169.85			√

method	Contrast	Relative accuracy	Relative errors	Relative ignorance
ROPM-Coh	5.86	100%	0%	0%
ROPM	/	61.22%	38.78%	35.39%
GOP-texture	6.99	76.34%	23.66%	26.21%

https://www.disasterscharter.org/web/guest/activations/-/article/earthquake-in-jap-1