



Inversion of Earthquake Rupture Process: Theory and Applications

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3. Applications

- **3.1** The M_W 7.8 Kunlun Mountain Pass earthquake of 14 November 2001
- 3.2 The *M*_W7.9 Wenchuan, Sichuan, earthquake of 12 May 2008
- 3.3 The *M*_W6.9 Yushu, Qinghai, earthquake of 14 April 2011
- **3.4 Applications to the earthquake emergency response**
- 3.5 Summary

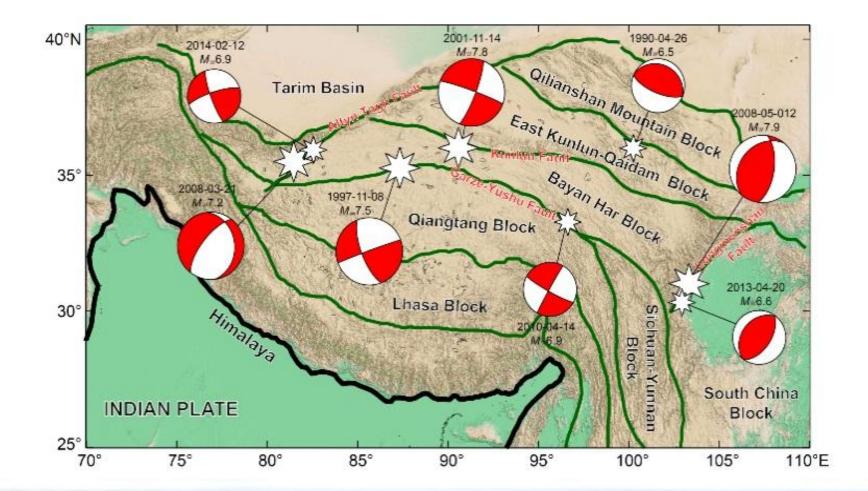
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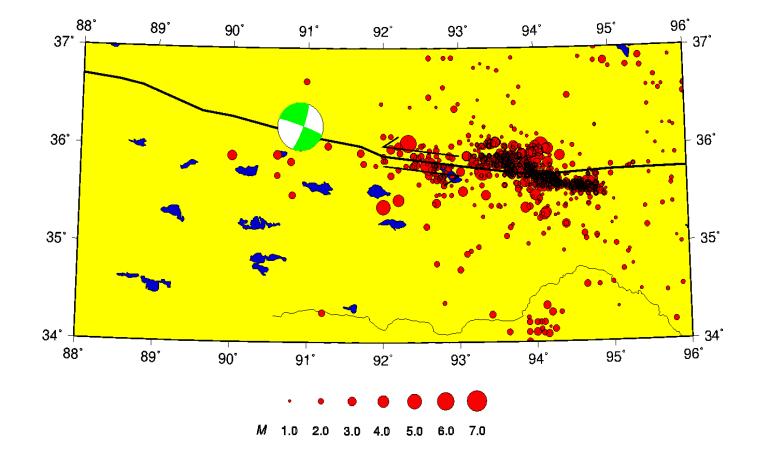
Recent significant earthquakes in the Tibetan plateau



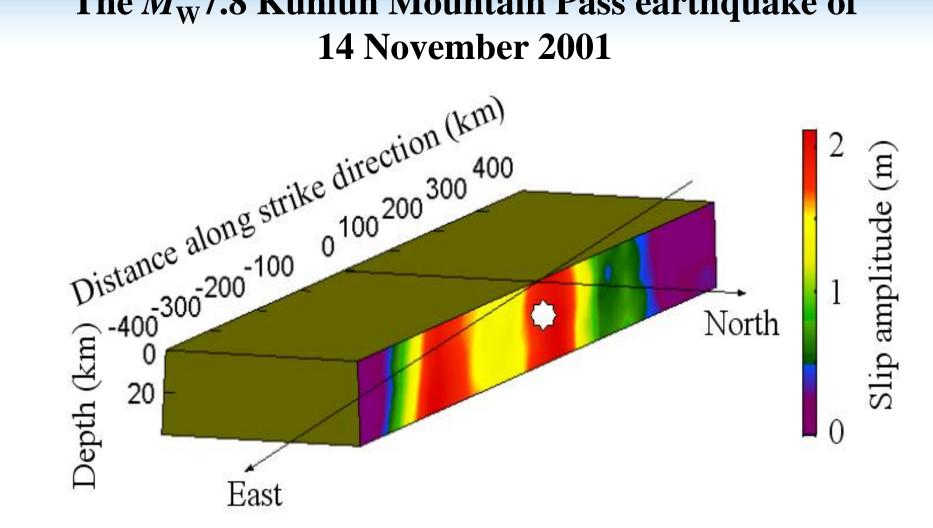
Focal mechanisms of the recent significant earthquakes in the Tibetan plateau

No	Date a-m-d	Time hmin:s	Lat (*)	Long (*)	h (km) M _W M _S	, M ₀	NPI			NPI			Place	Source
							"s (N·m)	Strike(*)	Dip(*)	Rake(*)	Strike (*)	Dip (*)	Rake (*)		
1	1990-04-26	17:37:15	35.986	100.245	5 8.1	6.5 6	.9 9.4×10 ¹⁸	113	68	89	294	22	91	Gongkhe,Qinghai	Xu and Chen,1997
2	1997-11-08	18:02:55	35.26	87.33	40	7.57	.4 3.4×10 ²⁰	250	88	19	159	71	178	Mani, Tibet	Xu and Chen,1999
3	2001-11-14	17:26:12	35.880	90.580	15	7.8 8	.1 3.2×10 ²⁰	113	68	89	294	22	-175	Kunhin Mt. Pass	Xu and Chen,2006
4	2008-03-21	06:32:58	35.490	81.467	10	7.27	.3 8.3×10 ¹⁹	353	29	-131	219	69	-68	Yutian, Xinjiang	USGS CMT Solution
5	2008-05-12	14:28:01	31.002	103.322	19	7.9 8	.0 2.0×10 ²¹	220	32	118	8	63	74	Wenchuan, Shichuan	Liu et al.,2008
6	2010-04-14	07:49:37	33.271	96.625	14	6.97	.1 3.2×10 ¹⁹	119	83	-2	209	88	-173	Yushu, Qinghai	Zhang et al.,2010
7	2013-04-20	08:02:48	30.314	102.934	13	6.77	.0 1.6×10 ¹⁹	34	55	87	220	35	95	Lushan, Sichuan	Liu et al.,2013
8	2014-02-12	17:19:48	35.922	82,558	12.5	5 6.9 7	3 1.5×10 ¹⁹	160	80	167	252	77	11	Yutian, Xinjiang	Zhang et al.,2014

The M_W7.8 Kunlun Mountain Pass earthquake of 14 November 2001

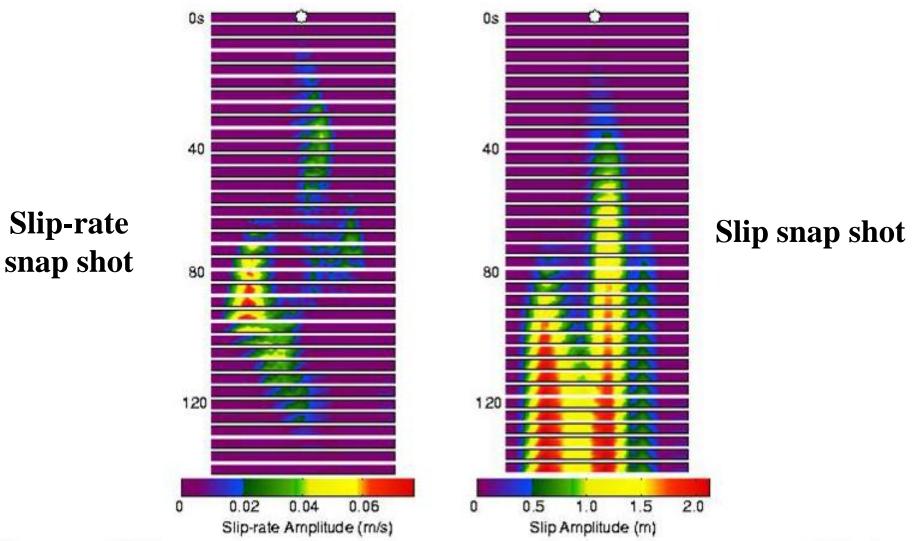


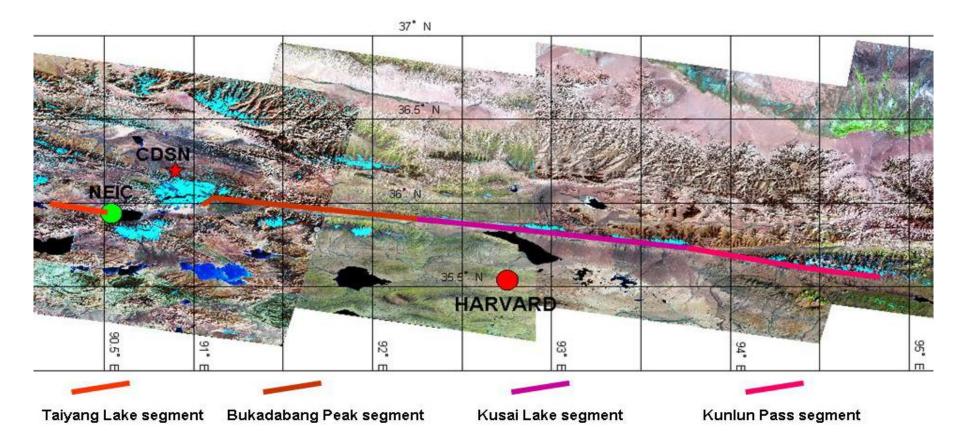
The M_w7.8 Kunlun Mountain Pass earthquake of **14 November 2001**



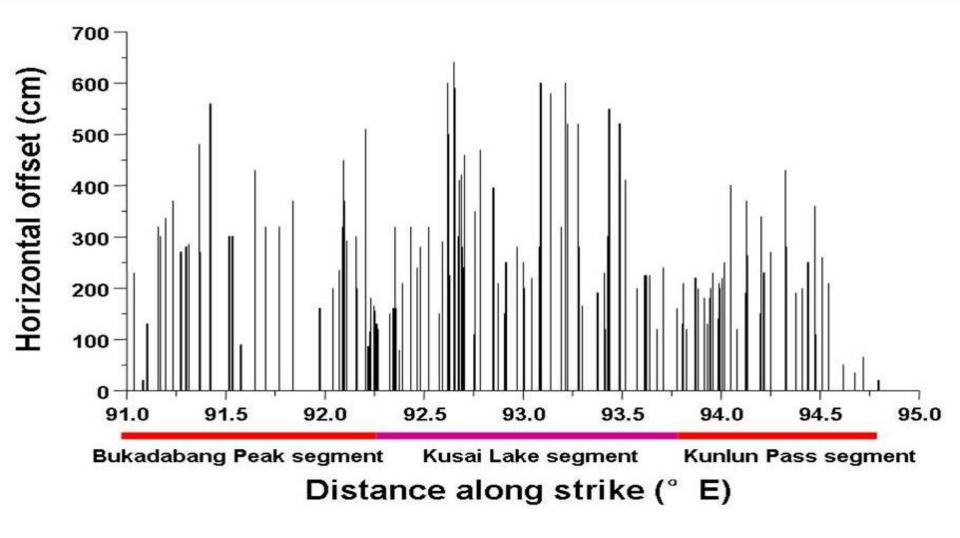
Distribution of static (final) slip on the fault plane obtained by the inversion. White star represents the hypocenter.

The *M*_W7.8 Kunlun Mountain Pass earthquake of 14 November 2001

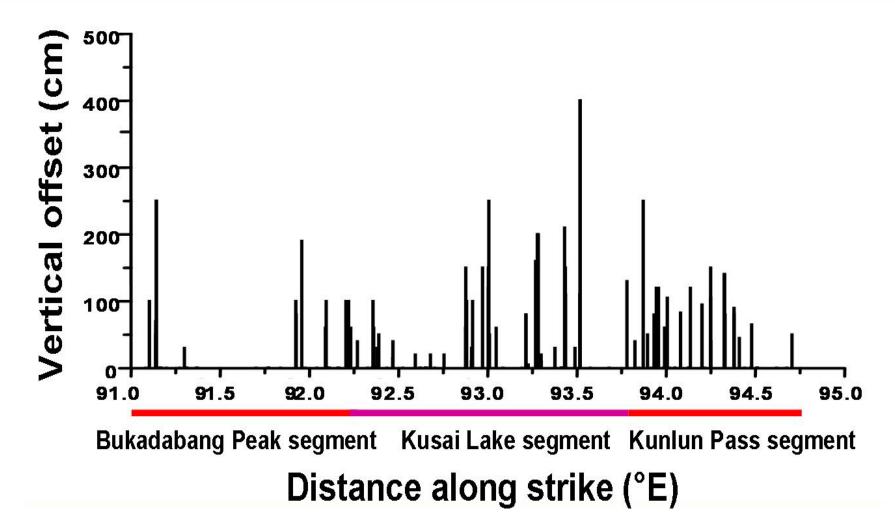




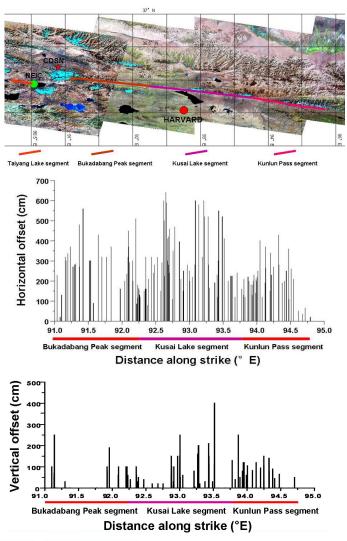
(a) Map view of surface ruptures



(b) Horizontal offset distribution along strike



(c) vertical offset distribution along strike



(a) Map view of surface ruptures

(b) Horizontal offset distribution

along strike

(c) vertical offset distribution

along strike

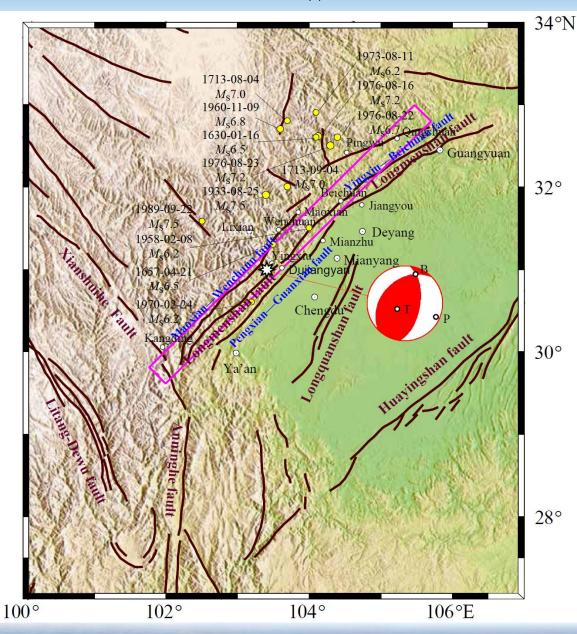
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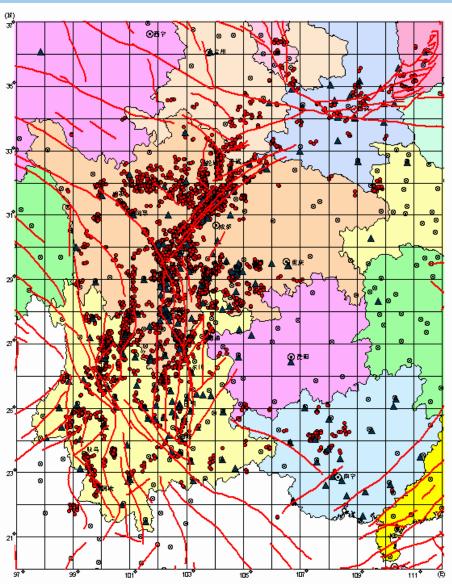
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The 2008 M_W 7.9 Wenchuan earthquake



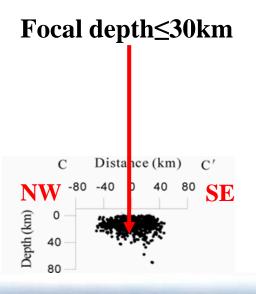
Epicenter location, main faults in epicentral area, historical earthquakes, main cities along Longmenshan Fault, and focal mechanism (strike 225° /dip 39° /rake 120°) of the 2008 *M*_W7.9 Wenchuan earthquake

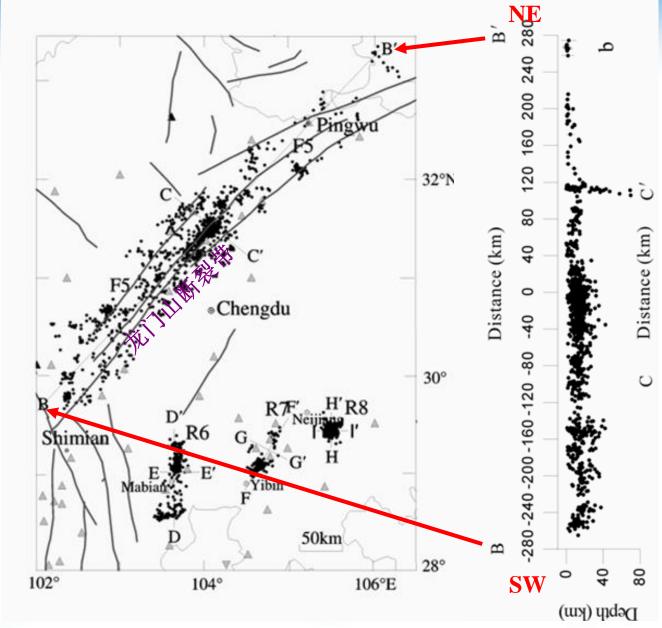
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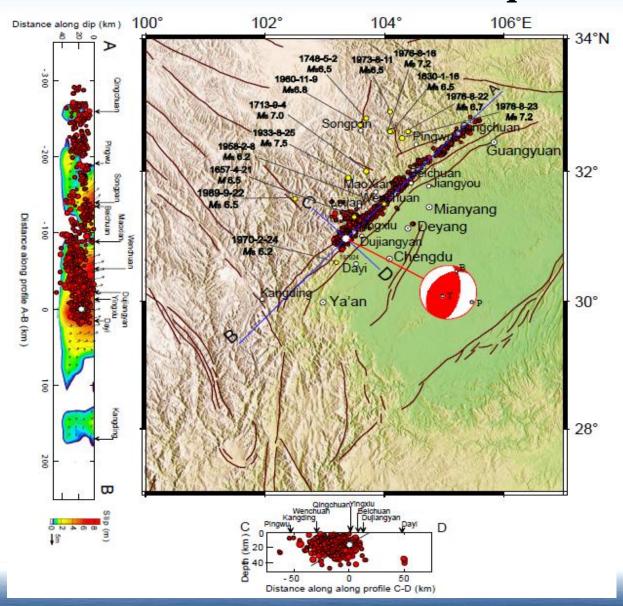
Epicentral distribution of the 6,496 relocated earthquakes in central-western China using the double-difference algorithm

Longmenshan Fault is a seismic zone of 470km×50km

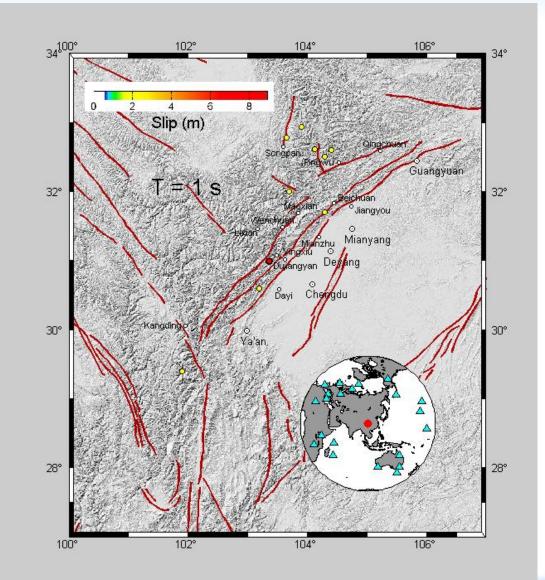




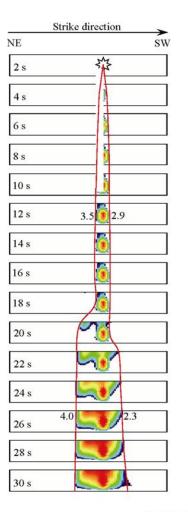
Distribution of the static (final) slip and aftershocks of the 2008 Wenchuan earthquake



Spatio-temporal rupture process of the 2008 Wenchuan earthquake

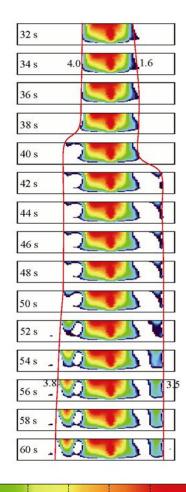


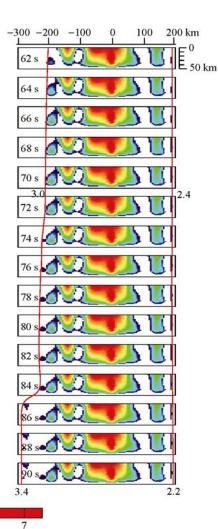
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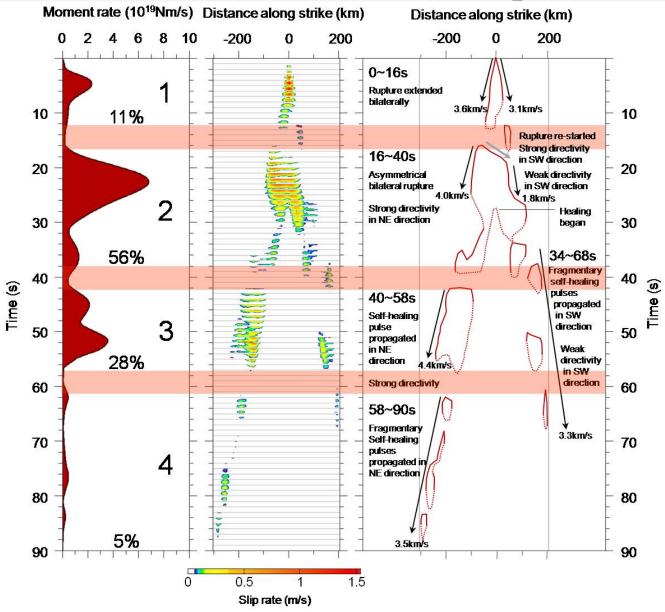




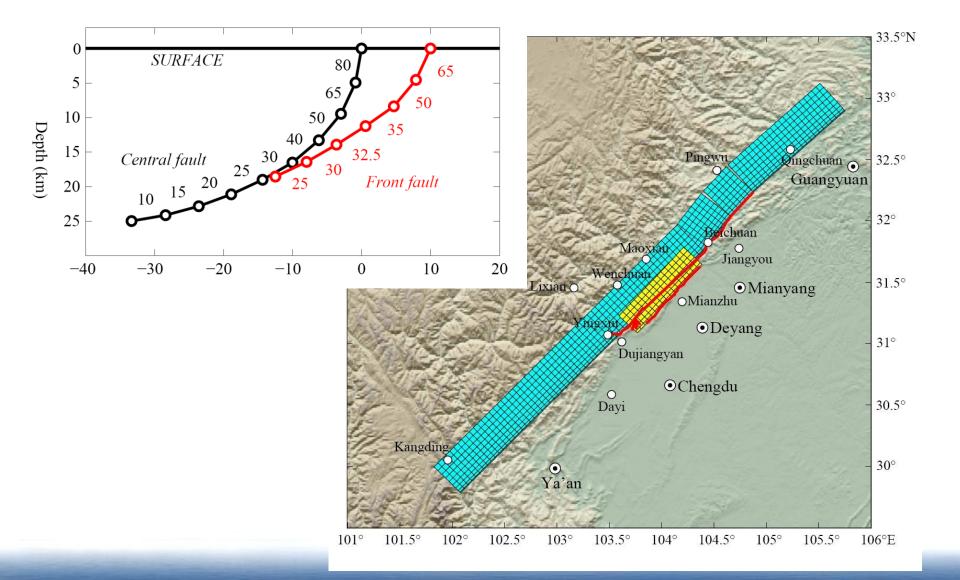


2 3 4 5 6 Slip (m)

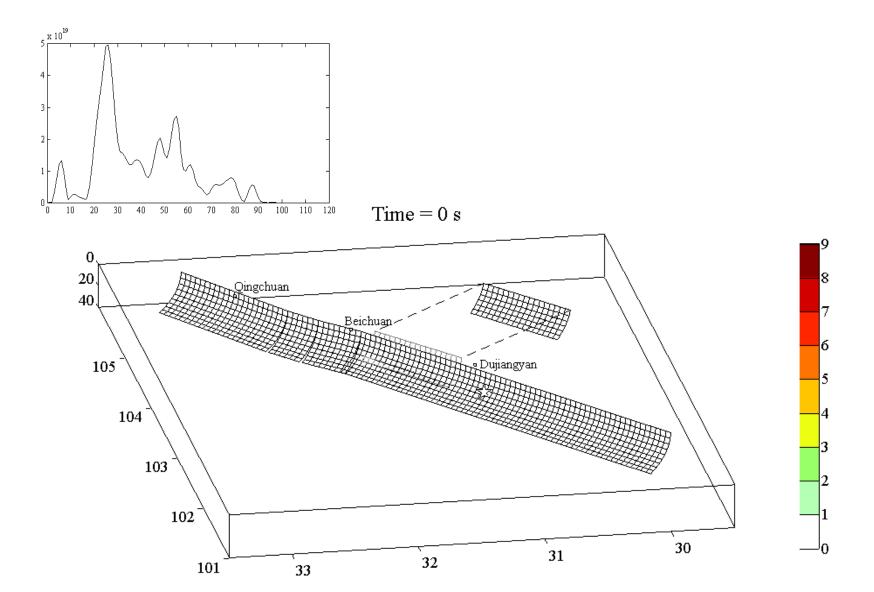
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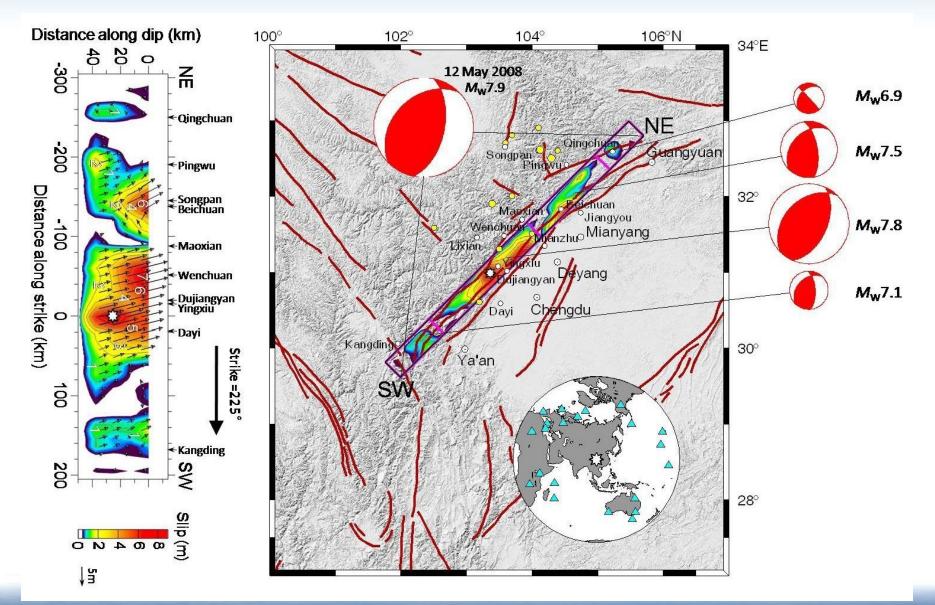
Fault model of the 2008 Wenchuan earthquake for the joint inversion of seismic and GPS data earthquake



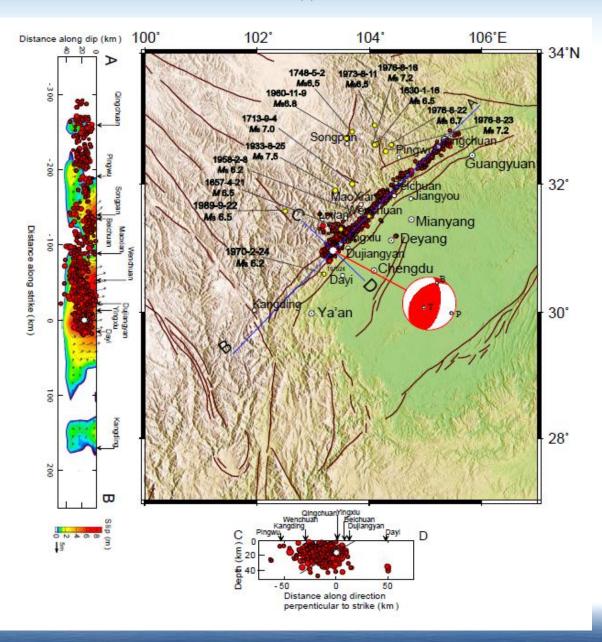
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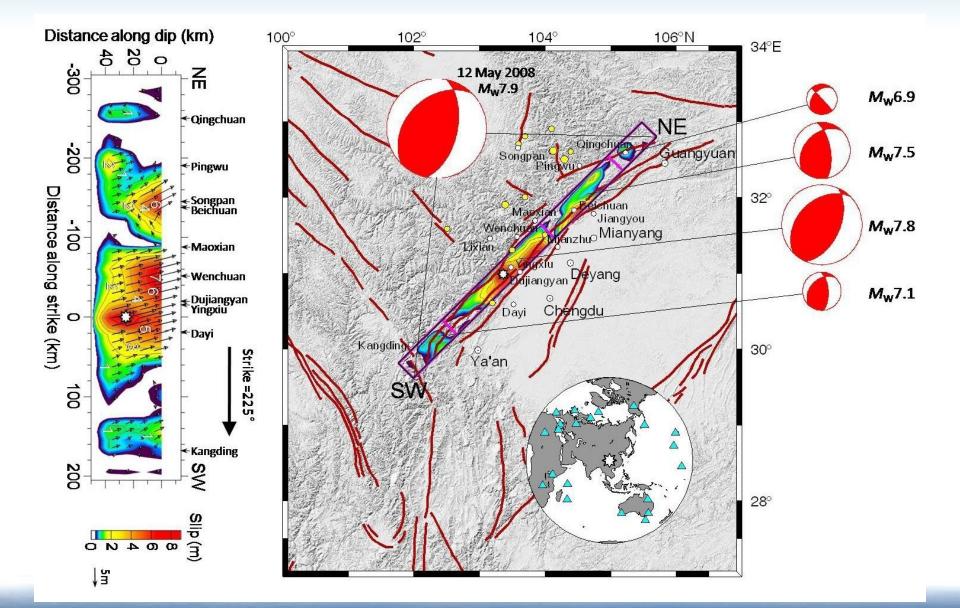
Static slip distribution on the fault plane



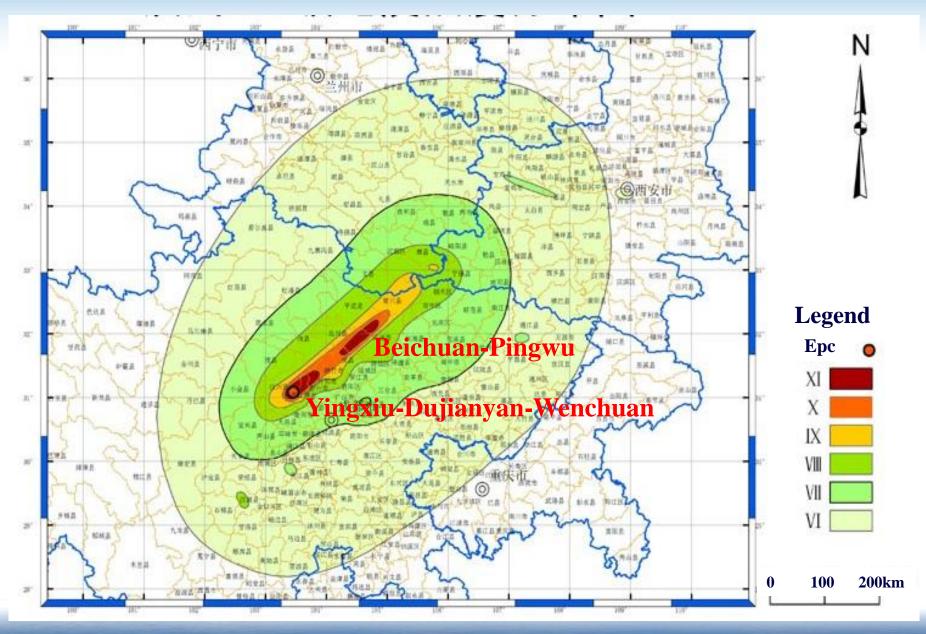
Aftershocks of the 2008 M_W 7.9 Wenchuan earthquake



Variation in focal mechanism



Isoseismals of the 2008 Wenchuan earthquake

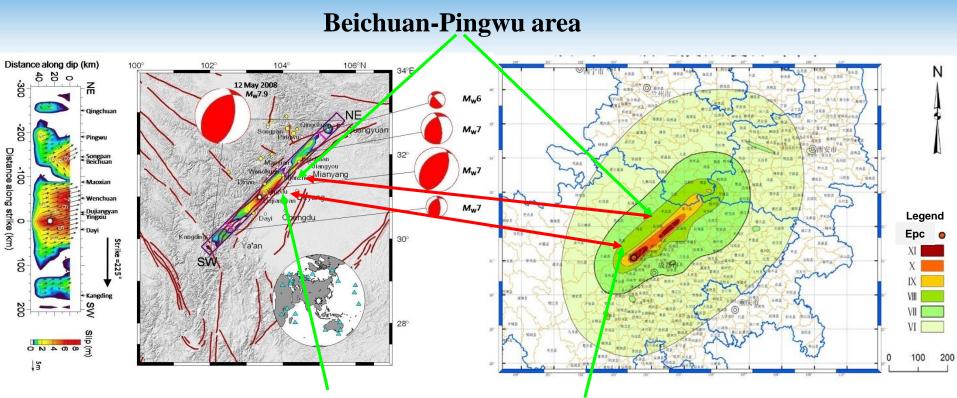




Yingxiu-Dujianyan-Wenchuan area



Yingxiu-Dujianyan-Wenchuan area



Yingxiu-Dujianyan-Wenchuan area

In Wenchuan earthquake two significant patches with peak slips of 8.9m and 6.7m just underneath the Yingxiu-Dujiangyan-Wenchuan and Beichuan-Pinwu areas respectively, breached the ground surface correspond to the two meizoseismal areas Yingxiu-Dujiangyan-Wenchuan area: peak-slip on the surface: calculated 7.5m, observed 6.6m;

Beichuan-Pinwu area:peak-slip on the surface: calculated 6.7m, observed 5.7m

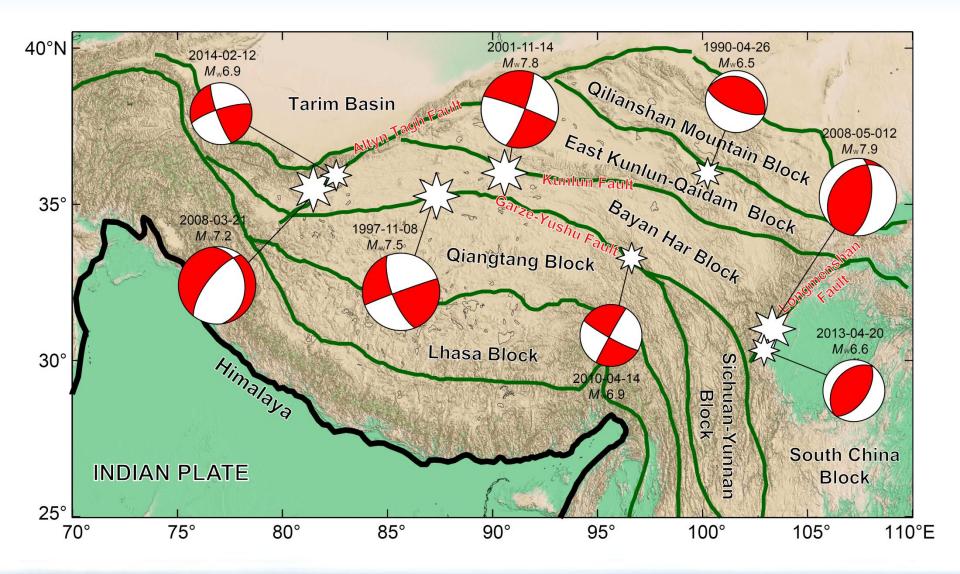
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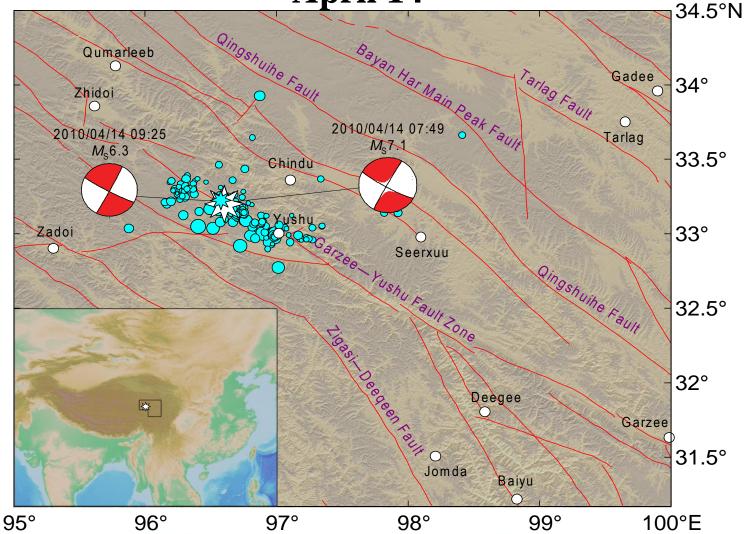
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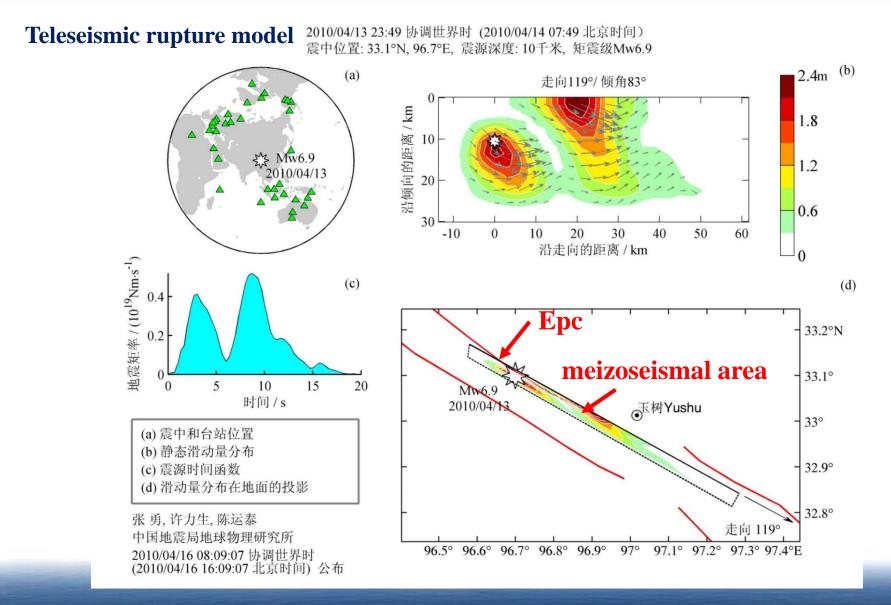
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3.3 The *M*_W6.9 Yushu, Qinghai, earthquake of 2010 April 14

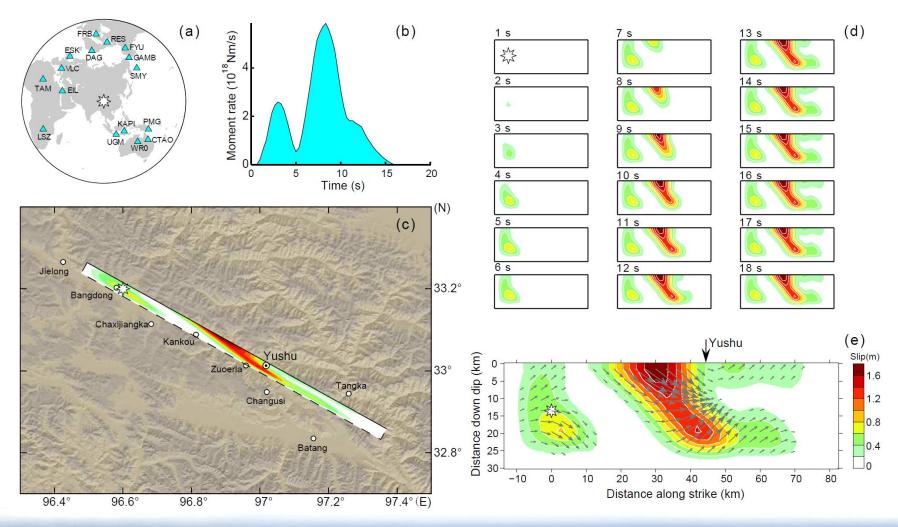


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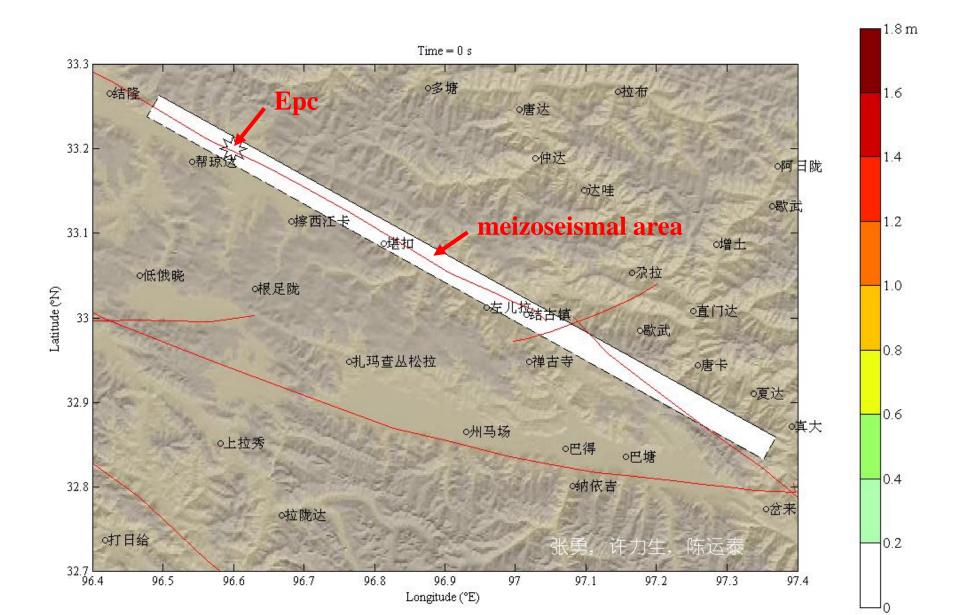


3.3 The *M***_W6.9 Yushu, Qinghai, earthquake of 2010 April 14**

Teleseismic rupture model



3 The $M_{\rm W}$ 6.9 Yushu, Qinghai, earthquake of 2010 April 14



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The spatio-temporal rupture process of the significant earthquakes worldwide since 2009 were determined using the fast and robust inversion method we developed in the last two decades, and the inverted results obtained within a few hours after the occurrence of the earthquake were reported immediately to the authorities and released to the public. The method proved to be very useful in the earthquake disaster emergency response.

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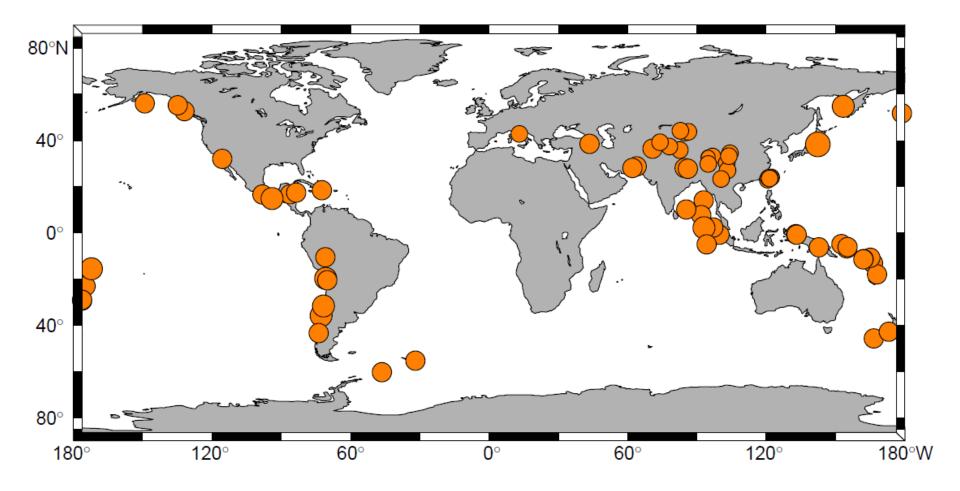
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Applications to the significant earthquakes since 2009 for domestic M>6.5, worldwide M>7.5



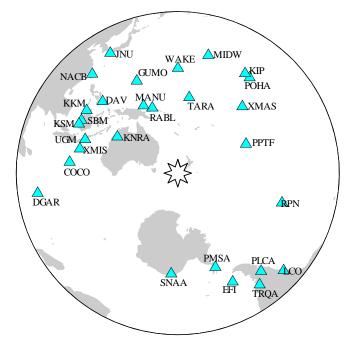
Applications to the significant earthquakes since 2009

表1 2	009-2018 重大地震破裂	过程快速反演的主	三要参数] [
地震发生	也 发震时刻(UTC)	震中	震源深	矩震级	反演耗时		伊朗巴基斯坦交界	伊朗巴基斯坦交界 2013-04-16 10:44	伊朗巴基斯坦交界 2013-04-16 10:44 (28.1°, 62.1°)	伊朗巴基斯坦交界 2013-04-16 10:44 (28.1°, 62.1°) 82	伊朗巴基斯坦交界 2013-04-16 10:44 (28.1°, 62.1°) 82 7.7
吧辰 反 生 !	也 反辰时刻(UIC)	(latitude, longitude)	度(km)	$(M_{\rm W})$	(Hour)		四川芦山	四川芦山 2013-04-20 00:02	四川芦山 2013-04-20 00:02 (30.3°, 103.0°)	四川芦山 2013-04-20 00:02 (30.3°, 103.0°) 12	四川芦山 2013-04-20 00:02 (30.3°, 103.0°) 12 6.8
巴布亚群岛	2009-01-04 04:43	3 (-0.5°, 132.8°)	33	7.7	6.4		鄂霍次克海	鄂霍次克海 2013-05-24 05:44	鄂霍次克海 2013-05-24 05:44 (54.9°, 153.3°)	鄂霍次克海 2013-05-24 05:44 (54.9°, 153.3°) 610	鄂霍次克海 2013-05-24 05:44 (54.9°, 153.3°) 610 8.3
巴布亚群岛	出 2009-01-04 06:33	3 (-0.7°, 133.2°)	33	7.5	5.7		台湾南投	台湾南投 2013-06-02 05:43	台湾南投 2013-06-02 05:43 (23.8°,121,1°)	台湾南投 2013-06-02 05:43 (23.8°,121,1°) 20	台湾南投 2013-06-02 05:43 (23.8°,121,1°) 20 6.2
汤加	2009-03-19 18:17	7 (-23.0°, -174.7°)	10	7.8	8.3		甘肃岷县漳县	甘肃岷县漳县 2013-07-21 23:45	甘肃岷县漳县 2013-07-21 23:45 (34.5°,104.2°)	甘肃岷县漳县 2013-07-21 23:45 (34.5°,104.2°) 10	甘肃岷县漳县 2013-07-21 23:45 (34.5°,104.2°) 10 6
加勒比海	2009-05-28 08:24	(16.8°, -86.2°)	15	7.2	8.6		台湾花莲	台湾花莲 2013-10-31 12:02	台湾花莲 2013-10-31 12:02 (23.6°,121.4°)	台湾花莲 2013-10-31 12:02 (23.6°,121.4°) 12	台湾花莲 2013-10-31 12:02 (23.6°,121.4°) 12 6.3
台湾花莲海	域 2009-07-13 18:05	5 (24.1°, 122.2°)	6	6.4	3.0		斯科舍海	斯科舍海 2013-11-17 09:04	斯科舍海 2013-11-17 09:04 (-60.3°,-46.4°)	斯科舍海 2013-11-17 09:04 (-60.3°,-46.4°) 10	斯科舍海 2013-11-17 09:04 (-60.3°,-46.4°) 10 7.8
新西兰南	岛 2009-07-15 09:22	2 (-45.7°, 166.6°)	33	7.8	3.7		新疆于田	新疆于田 2014-02-12 09:19	新疆于田 2014-02-12 09:19 (35.9°,82.6°)	新疆于田 2014-02-12 09:19 (35.9°,82.6°) 13	新疆于田 2014-02-12 09:19 (35.9°,82.6°) 13 6.9
安达曼群	岛 2009-08-10 19:55	5 (14.1°, 92.9°)	33	7.8	4.2		智利北部近海	智利北部近海 2014-04-01 23:46	智利北部近海 2014-04-01 23:46 (-19.6°,-70.8°)	智利北部近海 2014-04-01 23:46 (-19.6°,-70.8°) 20	智利北部近海 2014-04-01 23:46 (-19.6°,-70.8°) 20 8.2
萨摩亚群	岛 2009-09-29 17:48	3 (-15.5°, -172.2°)	33	8.0	3.3		智利北部近海	智利北部近海 2014-04-03 02:43	智利北部近海 2014-04-03 02:43 (-20.4°,-70.1°)	智利北部近海 2014-04-03 02:43 (-20.4°,-70.1°) 20	智利北部近海 2014-04-03 02:43 (-20.4°,-70.1°) 20 7.7
苏门答腊南	前部 2009-09-30 10:16	5 (-0.8°, 99.8°)	60	7.6	4.5		所罗门群岛海域	所罗门群岛海域 2014-04-12 20:14	所罗门群岛海域 2014-04-12 20:14 (-11.3°,162.2°)	所罗门群岛海域 2014-04-12 20:14 (-11.3°,162.2°) 29	所罗门群岛海域 2014-04-12 20:14 (-11.3°,162.2°) 29 7.6
瓦努阿图	2009-10-07 22:03	3 (-13.0°, 166.3°)	33	7.8	2.7		所罗门群岛海域	所罗门群岛海域 2014-04-13 12:36	所罗门群岛海域 2014-04-13 12:36 (-11.5°,162.1°)	所罗门群岛海域 2014-04-13 12:36 (-11.5°,162.1°) 35	所罗门群岛海域 2014-04-13 12:36 (-11.5°,162.1°) 35 7.5
台湾花莲	-		30	6.6	3.5		巴布亚新几内亚	巴布亚新几内亚 2014-04-19 13:27	巴布亚新几内亚 2014-04-19 13:27 (-6.7°,154.9°)	巴布亚新几内亚 2014-04-19 13:27 (-6.7°,154.9°) 31	巴布亚新几内亚 2014-04-19 13:27 (-6.7°,154.9°) 31 7.5
海地	2010-01-12 21:53		10	7.1	5.2		阿拉斯加	阿拉斯加 2014-06-23 20:53	阿拉斯加 2014-06-23 20:53 (51.8°,178.8°)	阿拉斯加 2014-06-23 20:53 (51.8°,178.8°) 114	阿拉斯加 2014-06-23 20:53 (51.8°,178.8°) 114 7.9
智利中音			33	8.6	3.2		云南鲁甸	云南鲁甸 2014-08-03 08:30	云南鲁甸 2014-08-03 08:30 (27.1°,103.3°)	云南鲁甸 2014-08-03 08:30 (27.1°,103.3°) 12	云南鲁甸 2014-08-03 08:30 (27.1°,103.3°) 12 6.1
台湾中部			5	6.5	3.5		云南景谷	云南景谷 2014-10-07 13:49	云南景谷 2014-10-07 13:49 (23.4°,100.5°)	云南景谷 2014-10-07 13:49 (23.4°,100.5°) 5	云南景谷 2014-10-07 13:49 (23.4°,100.5°) 5 6
墨西哥北部			10	7.2	4.8		新不列颠地区	新不列颠地区 2015-03-29 23:48	新不列颠地区 2015-03-29 23:48 (-4.8°,152.6°)	新不列颠地区 2015-03-29 23:48 (-4.8°,152.6°) 18	新不列颠地区 2015-03-29 23:48 (-4.8°,152.6°) 18 7.5
室四司北 苏门答腊南				7.2			尼泊尔	尼泊尔 2015-04-25 06:11	尼泊尔 2015-04-25 06:11 (28.1°,84.6°)	尼泊尔 2015-04-25 06:11 (28.1°,84.6°) 40	尼泊尔 2015-04-25 06:11 (28.1°,84.6°) 40 7.9
			31		3.1		尼泊尔	尼泊尔 2015-05-12 07:05	尼泊尔 2015-05-12 07:05 (27.8°,86.1°)	尼泊尔 2015-05-12 07:05 (27.8°,86.1°) 15	尼泊尔 2015-05-12 07:05 (27.8°,86.1°) 15 7.2
青海玉枫			10	6.9	2.5		新疆皮山	新疆皮山 2015-07-03 01:07	新疆皮山 2015-07-03 01:07 (37.5°,78.1°)	新疆皮山 2015-07-03 01:07 (37.5°,78.1°) 15	新疆皮山 2015-07-03 01:07 (37.5°,78.1°) 15 6.3
尼科巴群岛			30	7.6	4.6		智利中部近海	智利中部近海 2015-09-16 22:54	智利中部近海 2015-09-16 22:54 (-31.6°,-71.7°)	智利中部近海 2015-09-16 22:54 (-31.6°,-71.7°) 13	智利中部近海 2015-09-16 22:54 (-31.6°,-71.7°) 13 8.2
瓦努阿图		()	20	7.4	2.4		兴都库什	兴都库什 2015-10-26 09:09	兴都库什 2015-10-26 09:09 (36.4°,70.7°)	兴都库什 2015-10-26 09:09 (36.4°,70.7°) 213	兴都库什 2015-10-26 09:09 (36.4°,70.7°) 213 7.5
巴基斯坦西			10	7.1	4.1		巴西塔劳阿卡	巴西塔劳阿卡 2015-11-24 22:45	巴西塔劳阿卡 2015-11-24 22:45 (-10.5°,-70.9°)	巴西塔劳阿卡 2015-11-24 22:45 (-10.5°,-70.9°) 600	巴西塔劳阿卡 2015-11-24 22:45 (-10.5°,-70.9°) 600 7.4
日本东北			24	9.0	2.5		苏门答腊海域	苏门答腊海域 2016-03-02 12:49	苏门答腊海域 2016-03-02 12:49 (-4.9°,94.2°)	苏门答腊海域 2016-03-02 12:49 (-4.9°,94.2°) 10	苏门答腊海域 2016-03-02 12:49 (-4.9°,94.2°) 10 7.7
克马德克群			10	7.7	2.9		南乔治亚岛	南乔治亚岛 2016-08-19 07:32	南乔治亚岛 2016-08-19 07:32 (-55.3°,-31.9°)	南乔治亚岛 2016-08-19 07:32 (-55.3°,-31.9°) 10	南乔治亚岛 2016-08-19 07:32 (-55.3°,-31.9°) 10 7.4
克马德克			33	7.5	2.9		青海杂多	青海杂多 2016-10-17 07:14	青海杂多 2016-10-17 07:14 (32.8°,94.9°)	青海杂多 2016-10-17 07:14 (32.8°,94.9°) 9	青海杂多 2016-10-17 07:14 (32.8°,94.9°) 9 5.8
土耳其东	部 2011-10-23 10:41	(38.6°, 43.5°)	20	7.3	3		意大利诺尔恰	意大利诺尔恰 2016-10-30 06:40	意大利诺尔恰 2016-10-30 06:40 (42.9°,13.1°)	意大利诺尔恰 2016-10-30 06:40 (42.9°,13.1°) 10	意大利诺尔恰 2016-10-30 06:40 (42.9°,13.1°) 10 6.3
墨西哥	2012-03-20 18:02	$(16.7^\circ, -98.2^\circ)$	20	7.5	2.7		新西兰南岛	新西兰南岛 2016-11-13 11:02	新西兰南岛 2016-11-13 11:02 (-42.8°,173.1°)	新西兰南岛 2016-11-13 11:02 (-42.8°,173.1°) 10	新西兰南岛 2016-11-13 11:02 (-42.8°,173.1°) 10 7.9
苏门答腊北部	3海域 2012-04-11 08:38	3 (2.3°, 93.1°)	23	8.6	3.6		新疆阿克陶	新疆阿克陶 2016-11-25 14:24	新疆阿克陶 2016-11-25 14:24 (39.3°,74.0°)	新疆阿克陶 2016-11-25 14:24 (39.3°,74.0°) 12	新疆阿克陶 2016-11-25 14:24 (39.3°,74.0°) 12 6.5
新疆新渡	2012-06-29 21:07	7 (43.4°, 84.8°)	7	6.3	3.3		新疆呼图壁	新疆呼图壁 2016-12-08 05:15	新疆呼图壁 2016-12-08 05:15 (43.8°,86.4°)	新疆呼图壁 2016-12-08 05:15 (43.8°,86.4°) 6	新疆呼图壁 2016-12-08 05:15 (43.8°,86.4°) 6 6.2
哥斯达黎	加 2012-09-05 14:42	2 (10.1°, 85.3°)	41	7.6	2.6		智利	智利 2016-12-25 14:22	智利 2016-12-25 14:22 (-43.4°,-73.8°)	智利 2016-12-25 14:22 (-43.4°,-73.8°) 40	智利 2016-12-25 14:22 (-43.4°,-73.8°) 40 7.5
夏洛特皇后	群岛 2012-10-28 03:04	4 (52.8°, -131.9°)	18	7.8	3.2		所罗门群岛	所罗门群岛 2017-01-22 04:30	所罗门群岛 2017-01-22 04:30 (-6.1°,155.2°)	所罗门群岛 2017-01-22 04:30 (-6.1°,155.2°) 168	所罗门群岛 2017-01-22 04:30 (-6.1°,155.2°) 168 7.9
阿拉斯加东南	〕海域 2013-01-05 08:58	3 (55.2°, -134.8°)	10	7.5	2.2		四川九寨沟	四川九寨沟 2017-08-08 13:19	四川九寨沟 2017-08-08 13:19 (33.2°,103.8°)	四川九寨沟 2017-08-08 13:19 (33.2°,103.8°) 10	四川九寨沟 2017-08-08 13:19 (33.2°,103.8°) 10 6.5
圣克鲁斯郡	岛 2013-02-06 01:12	2 (-10.8°, 165.1°)	6	7.8	2.7		新疆精河	新疆精河 2018-08-0823:27	新疆精河 2018-08-0823:27 (44.3°,82.9°)	新疆精河 2018-08-0823:27 (44.3°,82.9°) 11	新疆精河 2018-08-0823:27 (44.3°,82.9°) 11 6.3
台湾南拐	2013-03-27 02:03	3 (23.8°, 121.1°)	21	6.0	2.8		墨西哥	墨西哥 2017-09-08 12:49	墨西哥 2017-09-08 12:49 (14.9°,-94.0°)	墨西哥 2017-09-08 12:49 (14.9°,-94.0°) 30	墨西哥 2017-09-08 12:49 (14.9°,-94.0°) 30 8.1

Applications to the significant earthquakes since 2009

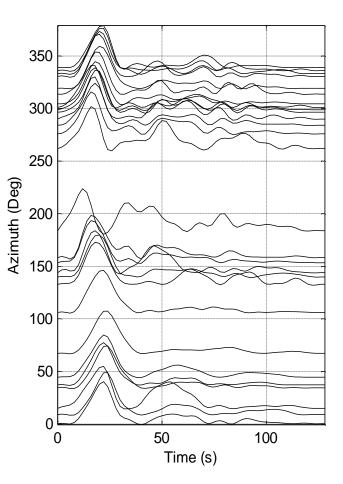
表 1 2009-2018 重大地震破裂过程快速反演的主要参数							
		震中	震源深	矩震级	反演耗时		
地震发生地	发震时刻(UTC) (la	atitude, longitude)	度(km)	$(M_{\rm W})$	(Hour)		
巴布亚群岛北	2009-01-04 04:43	(-0.5°, 132.8°)	33	7.7	6.4		
巴布亚群岛北	2009-01-04 06:33	(-0.7°, 133.2°)	33	7.5	5.7		
汤加	2009-03-19 18:17	(-23.0°, -174.7°)	10	7.8	8.3		
加勒比海	2009-05-28 08:24	(16.8°, -86.2°)	15	7.2	8.6		
台湾花莲海域	2009-07-13 18:05	(24.1°, 122.2°)	6	6.4	3.0		
新西兰南岛	2009-07-15 09:22	(-45.7°, 166.6°)	33	7.8	3.7		
安达曼群岛	2009-08-10 19:55	(14.1°, 92.9°)	33	7.8	4.2		
萨摩亚群岛	2009-09-29 17:48	(-15.5°, -172.2°)	33	8.0	3.3		
苏门答腊南部	2009-09-30 10:16	(-0.8°, 99.8°)	60	7.6	4.5		
瓦努阿图	2009-10-07 22:03	(-13.0°, 166.3°)	33	7.8	2.7		
台湾花莲	2009-12-19 13:02	(23.8°, 121.7°)	30	6.6	3.5		
海地	2010-01-12 21:53	(18.5°, -72.4°)	10	7.1	5.2		
智利中部	2010-02-27 06:34	(-35.8°, -72.7°)	33	8.6	3.2		
台湾中部	2010-03-04 00:18	(23.0°, 120.7°)	5	6.5	3.5		
墨西哥北部	2010-04-04 22:40	(32.1°, -115.5°)	10	7.2	4.8		
苏门答腊南部	2010-04-06 22:15	(2.4°, 97.1°)	31	7.8	3.1		
青海玉树	2010-04-13 23:49	(33.1°, 96.7°)	10	6.9	2.5		
尼科巴群岛西	2010-06-12 19:26	(7.7°, 91.9°)	30	7.6	4.6		
瓦努阿图	2010-12-25 13:16	(-19.7°,168.9°)	20	7.4	2.4		
巴基斯坦西南	2011-01-18 20:23	(28.8°, 63.9°)	10	7.1	4.1		
日本东北	2011-03-11 05:46	(38.3°, 142.4°)	24	9.0	2.5		
克马德克群岛	2011-07-06 19:03	(-29.3°, -176.2°)	10	7.7	2.9		
克马德克岛	2011-10-21 17:57	(-29.0°, -176.2°)	33	7.5	2.9		
土耳其东部	2011-10-23 10:41	(38.6°, 43.5°)	20	7.3	3		
墨西哥	2012-03-20 18:02	(16.7°,-98.2°)	20	7.5	2.7		
苏门答腊北部海域	2012-04-11 08:38	(2.3°, 93.1°)	23	8.6	3.6		
新疆新源	2012-06-29 21:07	(43.4°, 84.8°)) 7	6.3	3.3		
哥斯达黎加	2012-09-05 14:42	(10.1°, 85.3°)	41	7.6	2.6		
夏洛特皇后群岛	2012-10-28 03:04	(52.8°, -131.9°)	18	7.8	3.2		
阿拉斯加东南海域	2013-01-05 08:58	(55.2°, - 134.8°)	10	7.5	2.2		
圣克鲁斯群岛	2013-02-06 01:12	(-10.8°, 165.1°)	6	7.8	2.7		
台湾南投	2013-03-27 02:03	(23.8°, 121.1°)	21	6.0	2.8		

/n òn m 박 # la ở B		(20.10.00.17)			-
伊朗巴基斯坦交界	2013-04-16 10:44	(28.1°, 62.1°)	82	7.7	4.3
四川芦山	2013-04-20 00:02	(30.3°, 103.0°)	12	6.8	3
鄂霍次克海	2013-05-24 05:44	(54.9°, 153.3°)	610	8.3	2.8
台湾南投	2013-06-02 05:43	(23.8°,121,1°)	20	6.2	2.6
甘肃岷县漳县	2013-07-21 23:45	(34.5°,104.2°)	10	6	2.4
台湾花莲	2013-10-31 12:02	(23.6°,121.4°)	12	6.3	1.7
斯科舍海	2013-11-17 09:04	(-60.3°,-46.4°)	10	7.8	1.6
新疆于田	2014-02-12 09:19	(35.9°,82.6°)	13	6.9	3.2
智利北部近海	2014-04-01 23:46	(-19.6°,-70.8°)	20	8.2	2.8
智利北部近海	2014-04-03 02:43	(-20.4°,-70.1°)	20	7.7	1.3
所罗门群岛海域	2014-04-12 20:14	(-11.3°,162.2°)	29	7.6	5
所罗门群岛海域	2014-04-13 12:36	(-11.5°,162.1°)	35	7.5	2.4
巴布亚新几内亚	2014-04-19 13:27	(-6.7°,154.9°)	31	7.5	1.3
阿拉斯加	2014-06-23 20:53	(51.8°,178.8°)	114	7.9	2.7
云南鲁甸	2014-08-03 08:30	(27.1°,103.3°)	12	6.1	2.4
云南景谷	2014-10-07 13:49	(23.4°,100.5°)	5	6	1.6
新不列颠地区	2015-03-29 23:48	(-4.8°,152.6°)	18	7.5	2.6
尼泊尔	2015-04-25 06:11	(28.1°,84.6°)	40	7.9	2.2
尼泊尔	2015-05-12 07:05	(27.8°,86.1°)	15	7.2	2.9
新疆皮山	2015-07-03 01:07	(37.5°,78.1°)	15	6.3	1.7
智利中部近海	2015-09-16 22:54	(-31.6°,-71.7°)	13	8.2	2.3
兴都库什	2015-10-26 09:09	(36.4°,70.7°)	213	7.5	2
巴西塔劳阿卡	2015-11-24 22:45	(-10.5°,-70.9°)	600	7.4	2.6
苏门答腊海域	2016-03-02 12:49	(-4.9°,94.2°)	10	7.7	1
南乔治亚岛	2016-08-19 07:32	(-55.3°,-31.9°)	10	7.4	2
青海杂多	2016-10-17 07:14	(32.8°,94.9°)	9	5.8	1.9
意大利诺尔恰	2016-10-30 06:40	(42.9°,13.1°)	10	6.3	1.7
新西兰南岛	2016-11-13 11:02	(-42.8°,173.1°)	10	7.9	1.7
新疆阿克陶	2016-11-25 14:24	(39.3°,74.0°)	12	6.5	1.8
新疆呼图壁	2016-12-08 05:15	(43.8°,86.4°)	6	6.2	3.5
智利	2016-12-25 14:22	(-43.4°,-73.8°)	40	7.5	1.6
所罗门群岛	2017-01-22 04:30	(-6.1°,155.2°)	168	7.9	1.4
四川九寨沟	2017-08-08 13:19	(33.2°,103.8°)	10	6.5	1.7
新疆精河	2018-08-0823:27	(44.3°,82.9°)	11	6.3	1.1
墨西哥	2017-09-08 12:49	(14.9°,-94.0°)	30	8.1	1.3



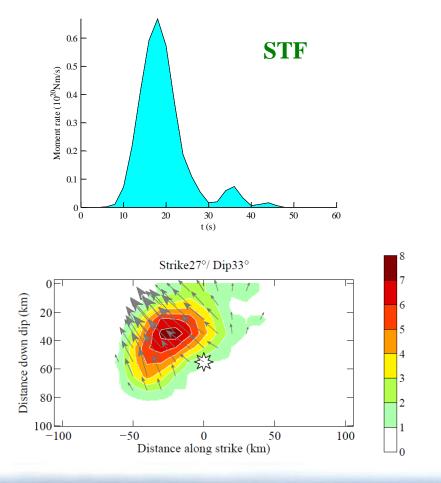
No.6

Distribution of earthquake epicenter (\clubsuit) and seismic stations (\triangle)

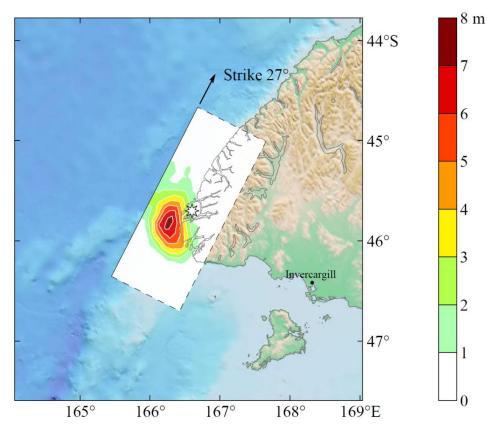


Azimuth-dependant apparent source time function (ASTF)

Obtained and released 3.75 hours after the earthquake occurrence

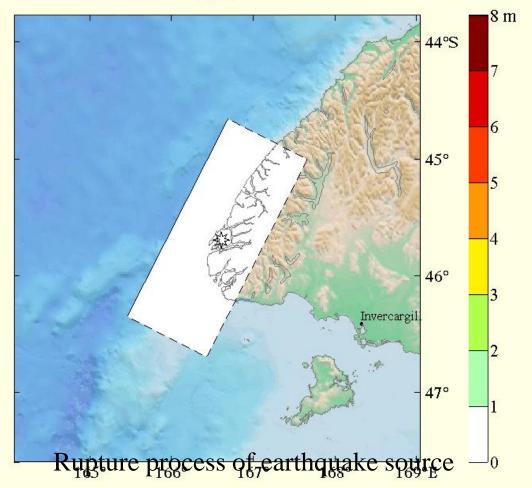


Slip distribution on the fault plane

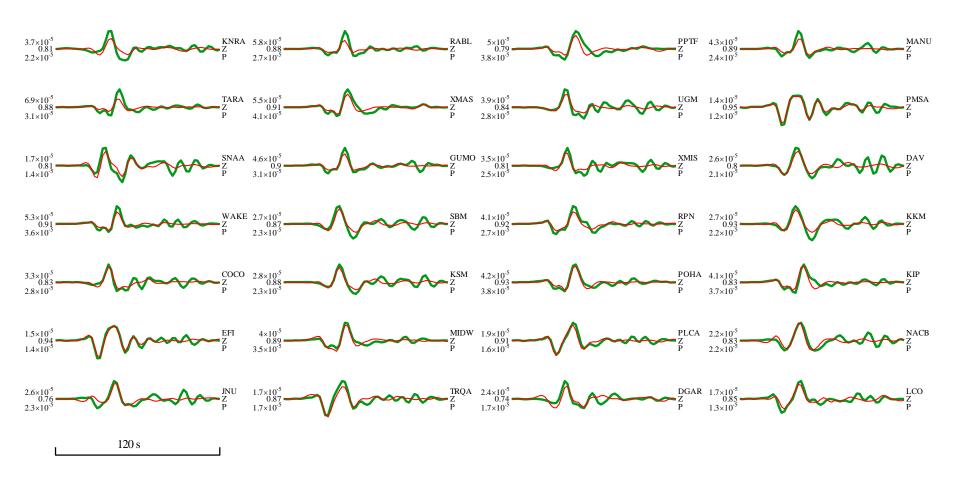


Ground surface projection of slip distribution on the fault plane

0 s



Earthquake rupture process



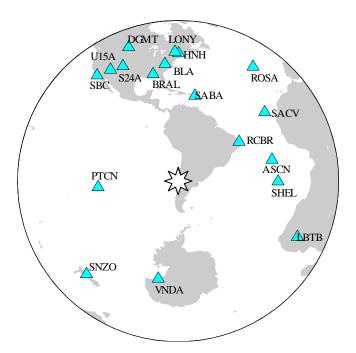
Fitness of observed (—) and synthetic (—) seismograms

Applications to the significant earthquakes since 2009 for domestic M>6.5, worldwide M>7.5

表 1 2009-2018 重大地震破裂过程快速反演的主要参数							
地震发生地	发震时刻(UTC)	震中	震源深	矩震级	反演耗时		
		latitude, longitude)	度(km)	(<i>M</i> _W)	(Hour)		
巴布亚群岛北	2009-01-04 04:43	(-0.5°, 132.8°)	33	7.7	6.4		
巴布亚群岛北	2009-01-04 06:33	(-0.7°, 133.2°)	33	7.5	5.7		
汤加	2009-03-19 18:17	(-23.0°, -174.7°)	10	7.8	8.3		
加勒比海	2009-05-28 08:24	(16.8°, -86.2°)	15	7.2	8.6		
台湾花莲海域	2009-07-13 18:05	(24.1°, 122.2°)	6	6.4	3.0		
新西兰南岛	2009-07-15 09:22	(-45.7°, 166.6°)	33	7.8	3.7		
安达曼群岛	2009-08-10 19:55	(14.1°, 92.9°)	33	7.8	4.2		
萨摩亚群岛	2009-09-29 17:48	(-15.5°, -172.2°)	33	8.0	3.3		
苏门答腊南部	2009-09-30 10:16	(- 0.8°, 99.8°)	60	7.6	4.5		
瓦努阿图	2009-10-07 22:03	(-13.0°, 166.3°)	33	7.8	2.7		
台湾花莲	2009-12-19 13:02	(23.8°, 121.7°)	30	6.6	3.5		
海地	2010-01-12 21:53	(18.5°, -72.4°)	10	7.1	5.2		
智利中部	2010-02-27 06:34	(-35.8°, -72.7°)	33	8.6	3.2		
台湾中部	2010-03-04 00:18	(23.0°, 120.7°)	5	6.5	3.5		
墨西哥北部	2010-04-04 22:40	(32.1°, -115.5°)	10	7.2	4.8		
苏门答腊南部	2010-04-06 22:15	(2.4°, 97.1°)	31	7.8	3.1		
青海玉树	2010-04-13 23:49	(33.1°, 96.7°)	10	6.9	2.5		
尼科巴群岛西	2010-06-12 19:26	(7.7°, 91.9°)	30	7.6	4.6		
瓦努阿图	2010-12-25 13:16	(-19.7°,168.9°)	20	7.4	2.4		
巴基斯坦西南	2011-01-18 20:23	(28.8°, 63.9°)	10	7.1	4.1		
日本东北	2011-03-11 05:46	(38.3°, 142.4°)	24	9.0	2.5		
克马德克群岛	2011-07-06 19:03	(-29.3°, -176.2°)	10	7.7	2.9		
克马德克岛	2011-10-21 17:57	(-29.0°, -176.2°)	33	7.5	2.9		
土耳其东部	2011-10-23 10:41	(38.6°, 43.5°)	20	7.3	3		
墨西哥	2012-03-20 18:02	(16.7°,-98.2°)	20	7.5	2.7		
苏门答腊北部海域	2012-04-11 08:38	(2.3°, 93.1°)	23	8.6	3.6		
新疆新源	2012-06-29 21:07	(43.4°, 84.8°)	7	6.3	3.3		
哥斯达黎加	2012-09-05 14:42	(10.1°, 85.3°)	41	7.6	2.6		
夏洛特皇后群岛	2012-10-28 03:04	(52.8°, -131.9°)	18	7.8	3.2		
阿拉斯加东南海域	2013-01-05 08:58	(55.2°, -134.8°)	10	7.5	2.2		
圣克鲁斯群岛	2013-02-06 01:12	(-10.8°, 165.1°)	6	7.8	2.7		
台湾南投	2013-03-27 02:03	(23.8°, 121.1°)	21	6.0	2.8		

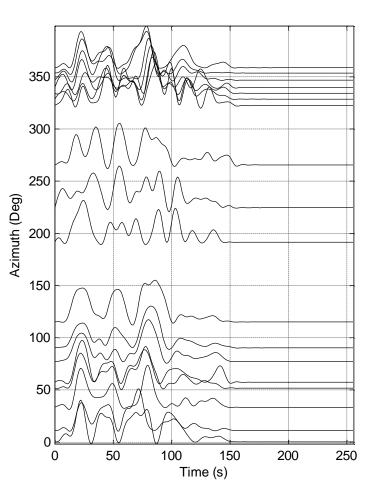
伊朗巴基斯坦交界	2013-04-16 10:44	(28.1°, 62.1°)	82	7.7	4.3
四川芦山	2013-04-20 00:02	(30.3°, 103.0°)	12	6.8	3
鄂霍次克海	2013-05-24 05:44	(54.9°, 153.3°)	610	8.3	2.8
台湾南投	2013-06-02 05:43	(23.8°,121,1°)	20	6.2	2.6
甘肃岷县漳县	2013-07-21 23:45	(34.5°,104.2°)	10	6	2.4
台湾花莲	2013-10-31 12:02	(23.6°,121.4°)	12	6.3	1.7
斯科舍海	2013-11-17 09:04	(-60.3°,-46.4°)	10	7.8	1.6
新疆于田	2014-02-12 09:19	(35.9°,82.6°)	13	6.9	3.2
智利北部近海	2014-04-01 23:46	(-19.6°,-70.8°)	20	8.2	2.8
智利北部近海	2014-04-03 02:43	(-20.4°,-70.1°)	20	7.7	1.3
所罗门群岛海域	2014-04-12 20:14	(-11.3°,162.2°)	29	7.6	5
所罗门群岛海域	2014-04-13 12:36	(-11.5°,162.1°)	35	7.5	2.4
巴布亚新几内亚	2014-04-19 13:27	(-6.7°,154.9°)	31	7.5	1.3
阿拉斯加	2014-06-23 20:53	(51.8°,178.8°)	114	7.9	2.7
云南鲁甸	2014-08-03 08:30	(27.1°,103.3°)	12	6.1	2.4
云南景谷	2014-10-07 13:49	(23.4°,100.5°)	5	6	1.6
新不列颠地区	2015-03-29 23:48	(-4.8°,152.6°)	18	7.5	2.6
尼泊尔	2015-04-25 06:11	(28.1°,84.6°)	40	7.9	2.2
尼泊尔	2015-05-12 07:05	(27.8°,86.1°)	15	7.2	2.9
新疆皮山	2015-07-03 01:07	(37.5°,78.1°)	15	6.3	1.7
智利中部近海	2015-09-16 22:54	(-31.6°,-71.7°)	13	8.2	2.3
兴都库什	2015-10-26 09:09	(36.4°,70.7°)	213	7.5	2
巴西塔劳阿卡	2015-11-24 22:45	(-10.5°,-70.9°)	600	7.4	2.6
苏门答腊海域	2016-03-02 12:49	(-4.9°,94.2°)	10	7.7	1
南乔治亚岛	2016-08-19 07:32	(-55.3°,-31.9°)	10	7.4	2
青海杂多	2016-10-17 07:14	(32.8°,94.9°)	9	5.8	1.9
意大利诺尔恰	2016-10-30 06:40	(42.9°,13.1°)	10	6.3	1.7
新西兰南岛	2016-11-13 11:02	(-42.8°,173.1°)	10	7.9	1.7
新疆阿克陶	2016-11-25 14:24	(39.3°,74.0°)	12	6.5	1.8
新疆呼图壁	2016-12-08 05:15	(43.8°,86.4°)	6	6.2	3.5
智利	2016-12-25 14:22	(-43.4°,-73.8°)	40	7.5	1.6
所罗门群岛	2017-01-22 04:30	(-6.1°,155.2°)	168	7.9	1.4
四川九寨沟	2017-08-08 13:19	(33.2°,103.8°)	10	6.5	1.7
新疆精河	2018-08-0823:27	(44.3°,82.9°)	11	6.3	1.1
墨西哥	2017-09-08 12:49	(14.9°,-94.0°)	30	8.1	1.3

27 February 2010 Chile M_W 8.8 earthquake



No.13

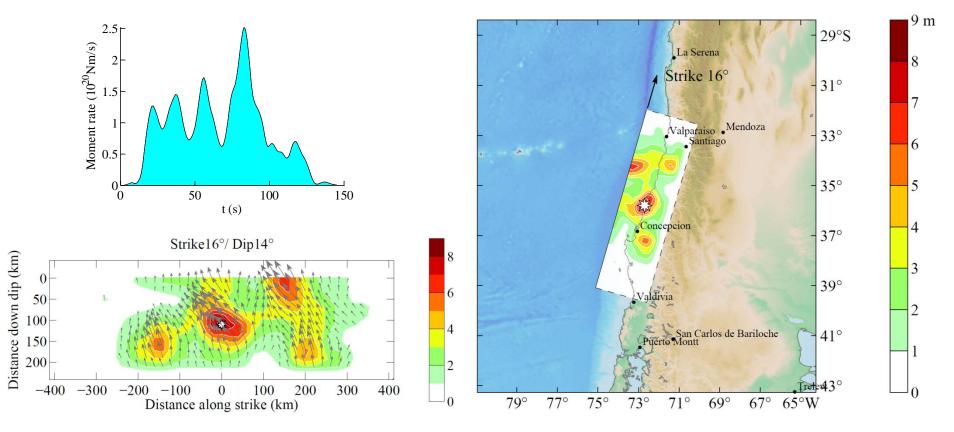
Distribution of earthquake epicenter ($\stackrel{\sim}{\searrow}$) and seismic stations (\bigtriangleup)



Azimuth-dependant apparent source time function (ASTF)

27 February 2010 Chile M_W8.8 earthquake

Obtained 3.2 hours after the occurrence

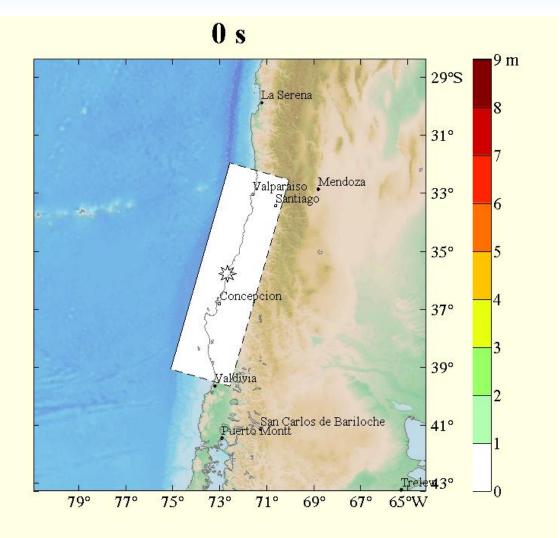


Slip distribution on the fault plane

No.13

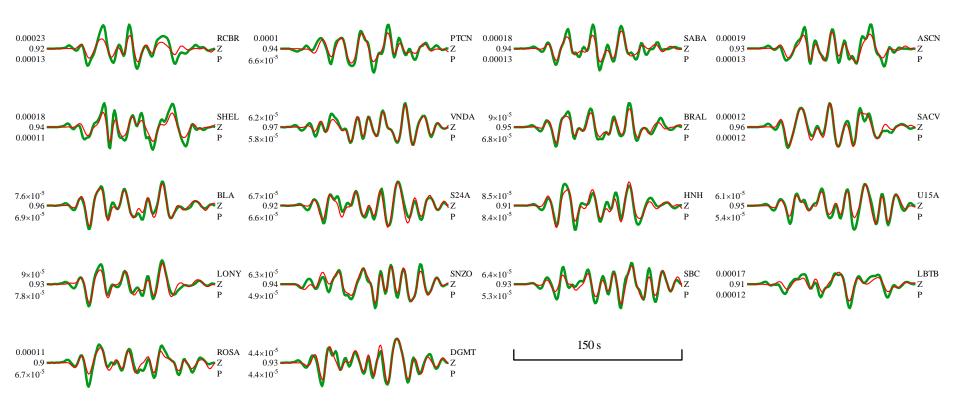
Ground surface projection of slip distribution on the fault plane

No.13 27 February 2010 Chile *M*_w8.8 earthquake



Earthquake rupture process

No.13 27 February 2010 Chile *M*_W8.8 earthquake



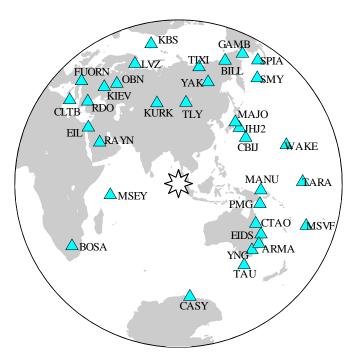
Fitness of observed (-----) and synthetic (----------) seismograms

Applications to the significant earthquakes since 2009 for domestic M>6.5, worldwide M>7.5

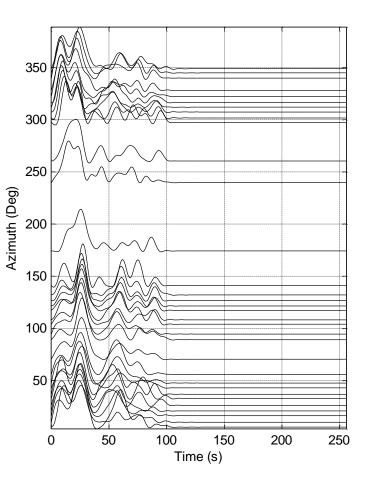
表 1 2009-2018 重大地震破裂过程快速反演的主要参数							
bland and an all	(D) 研究 Link (Transp)	震中	震源深	矩震级	反演耗时		
地震发生地	发震时刻(UTC)	(latitude, longitude)	度(km)	$(M_{\rm W})$	(Hour)		
巴布亚群岛北	2009-01-04 04:43	(-0.5°, 132.8°)	33	7.7	6.4		
巴布亚群岛北	2009-01-04 06:33	(-0.7°, 133.2°)	33	7.5	5.7		
汤加	2009-03-19 18:17	(-23.0°, -174.7°)	10	7.8	8.3		
加勒比海	2009-05-28 08:24	(16.8°, -86.2°)	15	7.2	8.6		
台湾花莲海域	2009-07-13 18:05	(24.1°, 122.2°)	6	6.4	3.0		
新西兰南岛	2009-07-15 09:22	(-45.7°, 166.6°)	33	7.8	3.7		
安达曼群岛	2009-08-10 19:55	(14.1°, 92.9°)	33	7.8	4.2		
萨摩亚群岛	2009-09-29 17:48	(-15.5°, -172.2°)	33	8.0	3.3		
苏门答腊南部	2009-09-30 10:16	(-0.8°, 99.8°)	60	7.6	4.5		
瓦努阿图	2009-10-07 22:03	(-13.0°, 166.3°)	33	7.8	2.7		
台湾花莲	2009-12-19 13:02	(23.8°, 121.7°)	30	6.6	3.5		
海地	2010-01-12 21:53	(18.5°, -72.4°)	10	7.1	5.2		
智利中部	2010-02-27 06:34	(-35.8°, -72.7°)	33	8.6	3.2		
台湾中部	2010-03-04 00:18	(23.0°, 120.7°)	5	6.5	3.5		
墨西哥北部	2010-04-04 22:40	(32.1°, -115.5°)	10	7.2	4.8		
苏门答腊南部	2010-04-06 22:15	(2.4°, 97.1°)	31	7.8	3.1		
青海玉树	2010-04-13 23:49	(33.1°, 96.7°)	10	6.9	2.5		
尼科巴群岛西	2010-06-12 19:26	(7.7°, 91.9°)	30	7.6	4.6		
瓦努阿图	2010-12-25 13:16	(-19.7°,168.9°)	20	7.4	2.4		
巴基斯坦西南	2011-01-18 20:23	(28.8°, 63.9°)	10	7.1	4.1		
日本东北	2011-03-11 05:46	(38.3°, 142.4°)	24	9.0	2.5		
克马德克群岛	2011-07-06 19:03	(-29.3°, -176.2°)	10	7.7	2.9		
克马德克岛	2011-10-21 17:57	(-29.0°, -176.2°)	33	7.5	2.9		
土耳其东部	2011-10-23 10:41	(38.6°, 43.5°)	20	7.3	3		
墨西哥	2012-03-20 18:02	(16.7°,-98.2°)	20	7.5	2.7		
苏门答腊北部海域	2012-04-11 08:38	(2.3°, 93.1°)	23	8.6	3.6		
新疆新源	2012-06-29 21:07	(43.4°, 84.8°)	7	6.3	3.3		
哥斯达黎加	2012-09-05 14:42	(10.1°, 85.3°)	41	7.6	2.6		
夏洛特皇后群岛	2012-10-28 03:04	(52.8°, -131.9°)	18	7.8	3.2		
阿拉斯加东南海域	2013-01-05 08:58	(55.2°, -134.8°)	10	7.5	2.2		
圣克鲁斯群岛	2013-02-06 01:12	(-10.8°, 165.1°)	6	7.8	2.7		
台湾南投	2013-03-27 02:03	(23.8°, 121.1°)	21	6.0	2.8		

伊朗巴基斯坦交界	2013-04-16 10:44	(28.1°, 62.1°)	82	7.7	4.3
四川芦山	2013-04-20 00:02	(30.3°, 103.0°)	12	6.8	3
鄂霍次克海	2013-05-24 05:44	(54.9°, 153.3°)	610	8.3	2.8
台湾南投	2013-06-02 05:43	(23.8°,121,1°)	20	6.2	2.6
甘肃岷县漳县	2013-07-21 23:45	(34.5°,104.2°)	10	6	2.4
台湾花莲	2013-10-31 12:02	(23.6°,121.4°)	12	6.3	1.7
斯科舍海	2013-11-17 09:04	(-60.3°,-46.4°)	10	7.8	1.6
新疆于田	2014-02-12 09:19	(35.9°,82.6°)	13	6.9	3.2
智利北部近海	2014-04-01 23:46	(-19.6°,-70.8°)	20	8.2	2.8
智利北部近海	2014-04-03 02:43	(-20.4°,-70.1°)	20	7.7	1.3
所罗门群岛海域	2014-04-12 20:14	(-11.3°,162.2°)	29	7.6	5
所罗门群岛海域	2014-04-13 12:36	(-11.5°,162.1°)	35	7.5	2.4
巴布亚新几内亚	2014-04-19 13:27	(-6.7°,154.9°)	31	7.5	1.3
阿拉斯加	2014-06-23 20:53	(51.8°,178.8°)	114	7.9	2.7
云南鲁甸	2014-08-03 08:30	(27.1°,103.3°)	12	6.1	2.4
云南景谷	2014-10-07 13:49	(23.4°,100.5°)	5	6	1.6
新不列颠地区	2015-03-29 23:48	(-4.8°,152.6°)	18	7.5	2.6
尼泊尔	2015-04-25 06:11	(28.1°,84.6°)	40	7.9	2.2
尼泊尔	2015-05-12 07:05	(27.8°,86.1°)	15	7.2	2.9
新疆皮山	2015-07-03 01:07	(37.5°,78.1°)	15	6.3	1.7
智利中部近海	2015-09-16 22:54	(-31.6°,-71.7°)	13	8.2	2.3
兴都库什	2015-10-26 09:09	(36.4°,70.7°)	213	7.5	2
巴西塔劳阿卡	2015-11-24 22:45	(-10.5°,-70.9°)	600	7.4	2.6
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南乔治亚岛	2016-08-19 07:32	(-55.3°,-31.9°)	10	7.4	2
青海杂多	2016-10-17 07:14	(32.8°,94.9°)	9	5.8	1.9
意大利诺尔恰	2016-10-30 06:40	(42.9°,13.1°)	10	6.3	1.7
新西兰南岛	2016-11-13 11:02	(-42.8°,173.1°)	10	7.9	1.7
新疆阿克陶	2016-11-25 14:24	(39.3°,74.0°)	12	6.5	1.8
新疆呼图壁	2016-12-08 05:15	(43.8°,86.4°)	6	6.2	3.5
智利	2016-12-25 14:22	(-43.4°,-73.8°)	40	7.5	1.6
所罗门群岛	2017-01-22 04:30	(-6.1°,155.2°)	168	7.9	1.4
四川九寨沟	2017-08-08 13:19	(33.2°,103.8°)	10	6.5	1.7
新疆精河	2018-08-0823:27	(44.3°,82.9°)	11	6.3	1.1
墨西哥	2017-09-08 12:49	(14.9°,-94.0°)	30	8.1	1.3

No.16 6 April 2010 Sumatra M_W7.8 earthquake

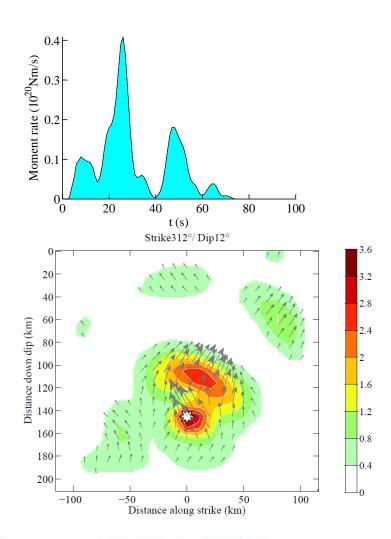


Distribution of earthquake epicenter $(\stackrel{\wedge}{\searrow})$ and seismic stations (\triangle)



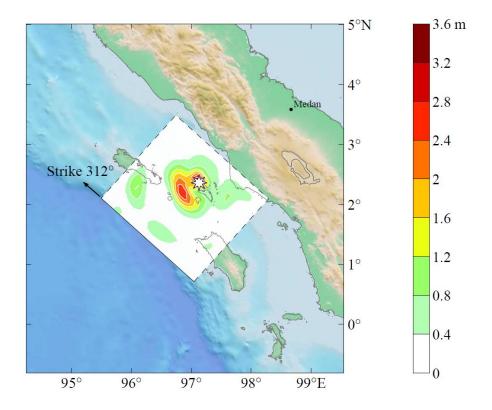
Ground surface projection of slip distribution on the fault plane

No.16 6 April 2010 Sumatra M_W7.8 earthquake



Slip distribution on the fault plane

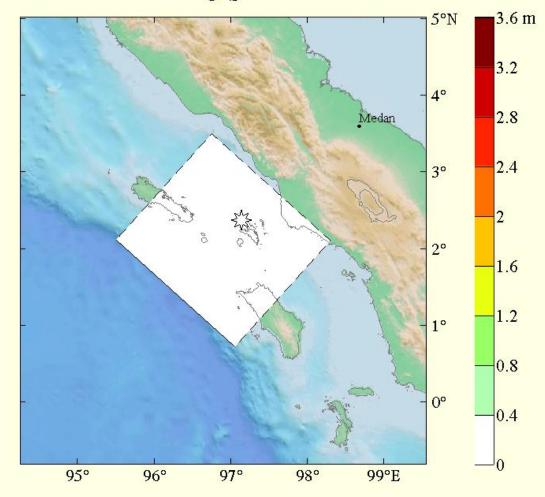
Obtained 3.1 hours after the occurrence



Ground surface projection of slip distribution on the fault plane

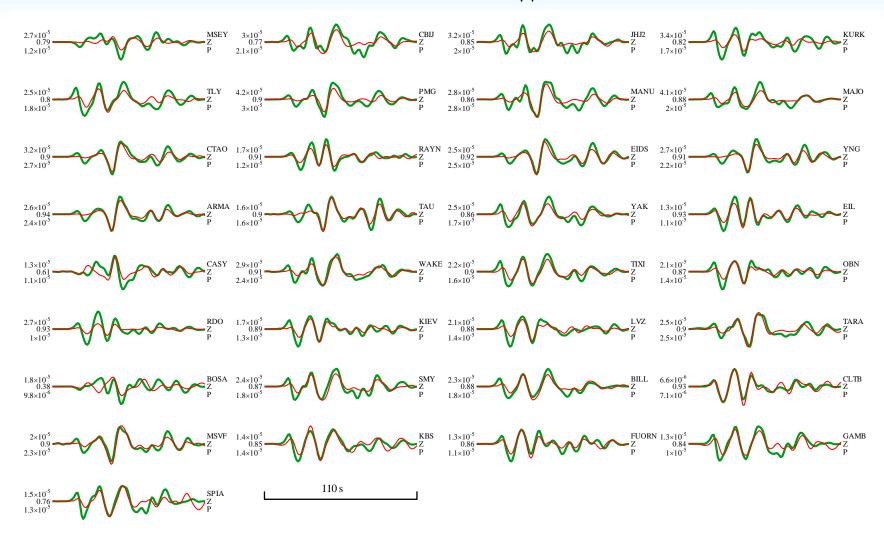
No.16 6 April 2010 Sumatra M_W7.8 earthquake

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Earthquake rupture process

No.16 6 April 2010 Sumatra M_W 7.8 earthquake



Fitness of observed (—) and synthetic (—) seismograms

3. Applications

3.1 The *M*_W7.8 Kunlun Mountain Pass earthquake of 14 November 2001

- 3.2 The *M*_W7.9 Wenchuan, Sichuan, earthquake of 12 May 2008
- 3.3 The *M*_W6.9 Yushu, Qinghai, earthquake of 14 April 2011
- **3.4 Applications to the earthquake emergency response**
- 3.5 Summary

Summary

During the past decades several significant earthquakes occurred worldwide were determined using the fast and robust inversion method we developed in the last two decades.

Summary

The knowledge obtained from these studies has much improved our understanding of the complexities of the earthquake source and causative mechanism of the seismic disaster, and is of important reference value in seismic disaster mitigation such as earthquake emergency response.

Summary

The inverted results obtained within a few hours after the occurrence of the earthquake were reported immediately to the authorities and released to the public. The method proved to be very useful in the earthquake disaster emergency response.

Summary

Although the debate about the earthquake prediction or forecast remains unsolved, we still can do something for prevention and mitigation of earthquake disasters. The fast inverted results of the spatio-temporal rupture process of the earthquake sources as we described in this studies can provide some useful information such as possible disastrous areas and the timely release of these results is very helpful to earthquake emergency response and seismic disaster relief efforts.



Scientists should do everything we can for earthquake disaster reduction.

Promote our knowledge on earthquake occurrence and improve our measures to earthquake disasters prevention and mitigation.

Summary

Studies on the regularities of earthquake occurrence should be greatly strengthened.

Summary

• A large part of the time, about half an hour, was spent to get the data. This can be further reduced to about 10 minutes if the real-time data flow is available, and to several minutes if local waveform data were used for the inversion.

谢谢! Thank you! Спасибо!