“Slow earthquake” in Afghanistan

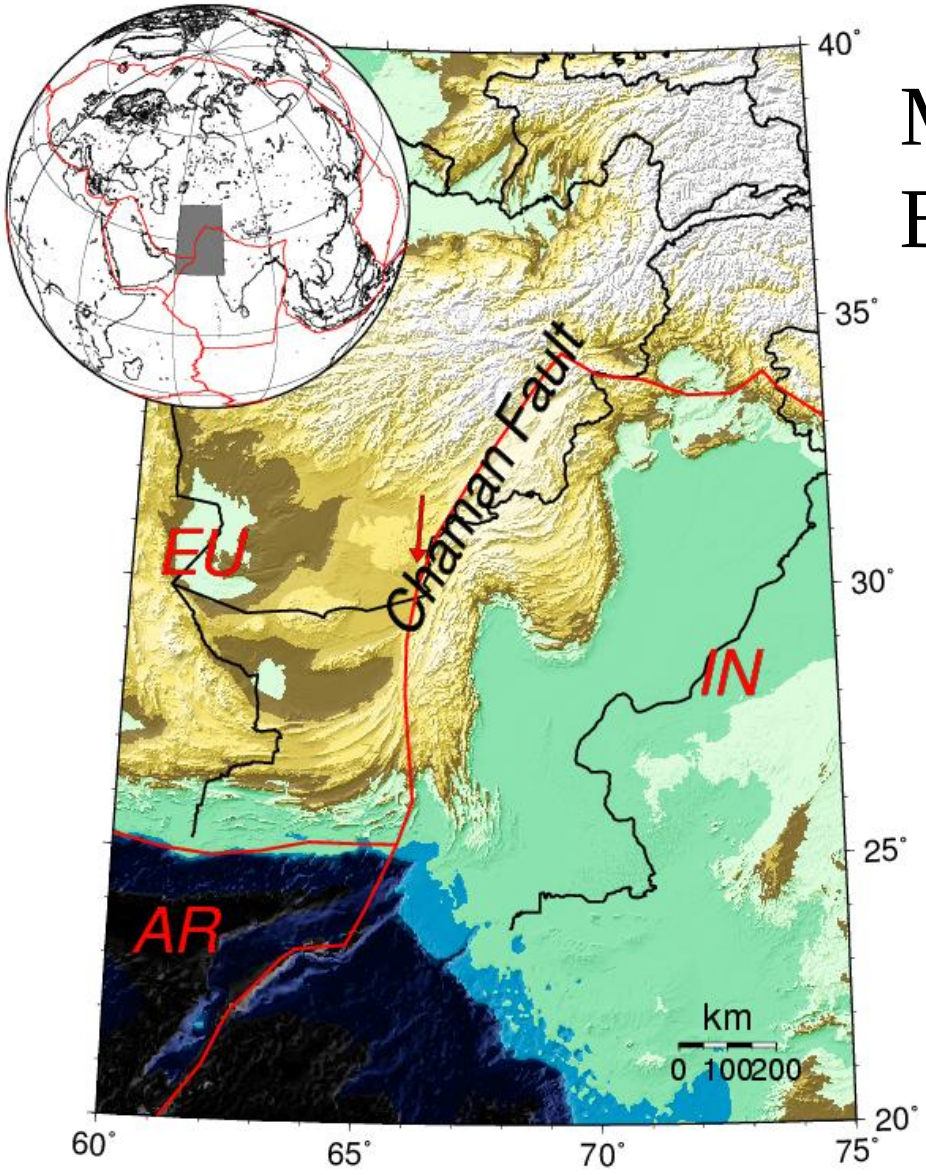
Long-lasting widespread afterslip due to a M5 earthquake at the Chaman Fault, Afghanistan

http://en.wikipedia.org/wiki/Image:US-UK-Sangin2007.jpg

Masato Furuya[1$] & S. P. Satyabala[2]

1. Hokkaido University, Sapporo, Japan
2. National Geophysical Research Institute, India.

Chaman fault



Major “ Transform Plate Boundary (EU/IN)” in Asia

Afghanistan-Pakistan

~900km

Left-lateral

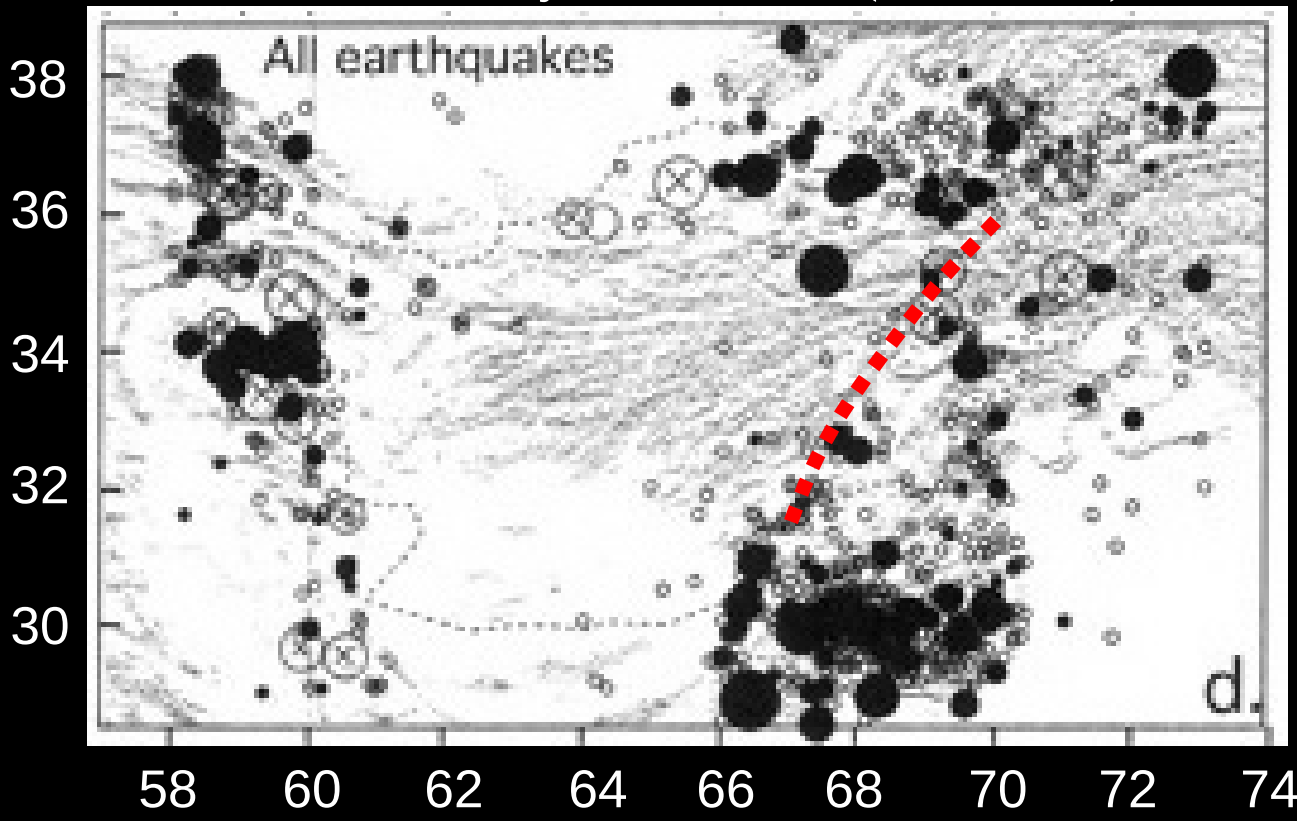
2~4 cm/yr w.r.t. IN

(Lawrence et al. 1992; DeMets et al. 1991)

Similar to San Andreas Fault (?)

Past Seismicity

Ambraseys and Bilham (2003, SRL)



Low seismicity : Locked?Freely slipping?

Left lateral slip 20~40mm/yr w.r.t. India Plate

(Lawrence et al. 1992 Geology; DeMets et al. 1991Paleomagnatism)

Geodetic data play a key role.

Earthquakes were indeed missing

1973	02 04	192548.30	31.67	67.26	40	3.90 mb GS
1978	02 23	160237.10	31.50	67.01	33	4.60 mb GS
1979	11 27	123933.40	32.67	67.15	33	4.80 mb GS
1980	10 29	195542.20	31.93	67.04	33	3.90 mb GS
1981	05 07	062859.80	31.35	66.69	33	3.80 mb GS
1984	04 11	055758.01	32.17	67.05	33	4.30 mb GS
1985	11 04	123723.71	31.80	67.54	33	4.50 mb GS
1986	02 19	043958.48	32.11	67.66	33	4.30 mb GS
1989	01 26	182229.51	31.75	67.18	33	4.20 mb GS
1989	03 31	033312.07	31.27	66.87	10	4.20 mb GS
1991	02 26	011927.39	31.35	67.20	33	4.30 mb GS
1992	02 05	193629.88	31.51	67.04	33	4.40 mb GS
1992	02 05	231048.63	31.43	66.82	17	5.50 MwHRV
1992	02 05	234136.85	31.36	66.86	33	5.00 mb GS
1993	03 11	000425.51	31.53	67.10	13	4.70 mb GS
1997	07 08	192658.52	31.29	66.63	33	
1997	08 25	141322.49	31.06	67.77	33	3.80 mb GS
1998	01 13	144019.29	32.56	67.05	33	
1998	03 03	001144.82	31.16	67.56	33	3.70 mb GS
1998	05 02	034929.92	31.06	67.77	33	3.80 mb GS
2000	01 22	091450.01	31.99	67.24	33	4.10 mb GS
2000	04 11	104659.99	31.02	67.74	33	3.80 mb GS
2001	02 22	075439.67	31.88	67.28	33	4.50 mb GS
2003	12 01	185328.62	31.79	67.89	33	3.70 mb GS
2005	10 17	131241.67	32.17	67.76	35	4.50 mb GS
2005	10 21	080359.15	31.96	67.55	10	5.00 MwHRV
2005	11 08	194929.15	31.71	66.83	10	3.60 mb GS

~3 cm/yr relative plate motion

▼

M>7 events < 200 yrs interval

Ambraseys & Bilham 2003

In other words…

M>5 events < 2 yrs interval

▼

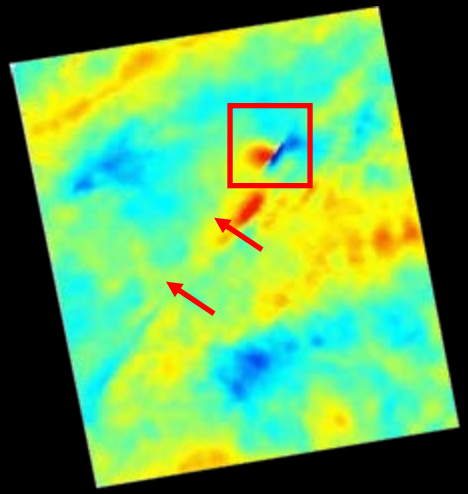
More than 10 eqks with M>5 are missing.

Lat 31-33N, Lon 66-68E, 30yrs

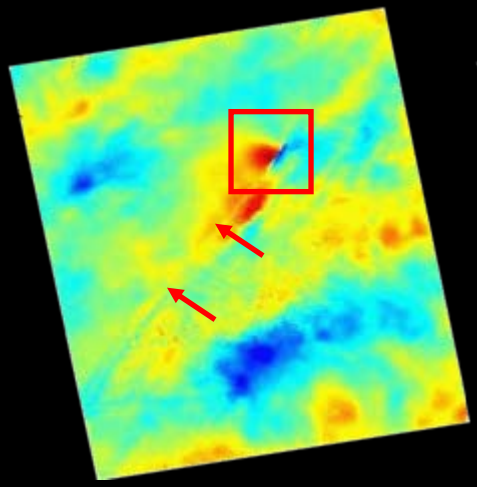
http://neic.usgs.gov/neis/epic/epic_rect.html

Co- and Postseismic Signal

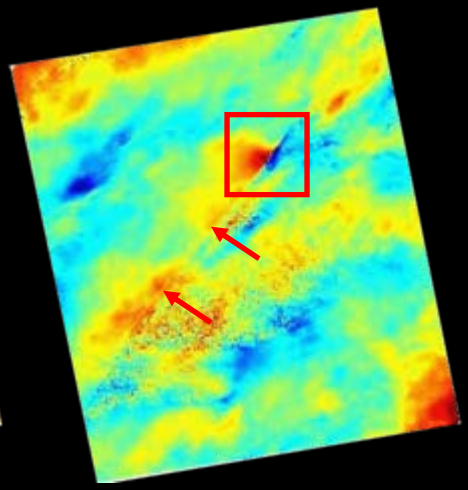
- Nov. 2005



- Dec. 2005



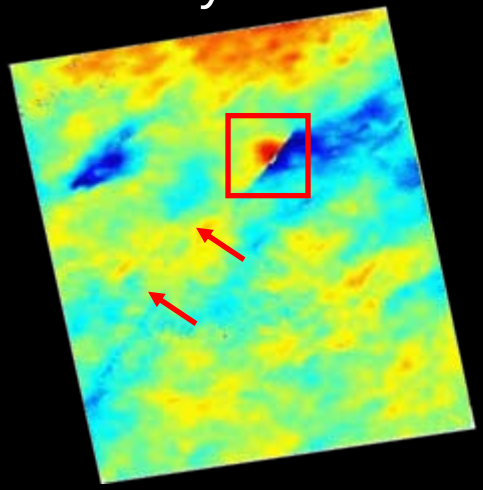
- Feb. 2006



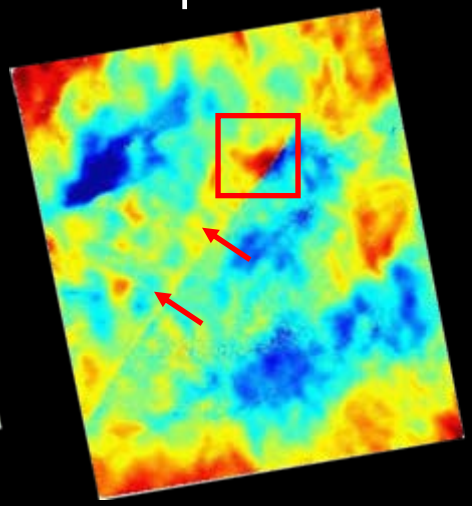
Oct. 21, 2005
Mw 5.0

Harvard CMT

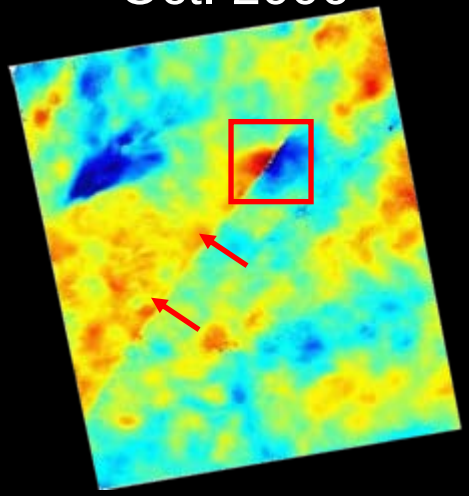
- May. 2006



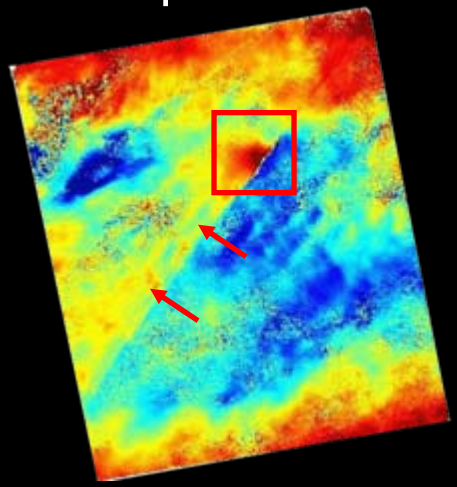
- Sep. 2006



- Oct. 2006



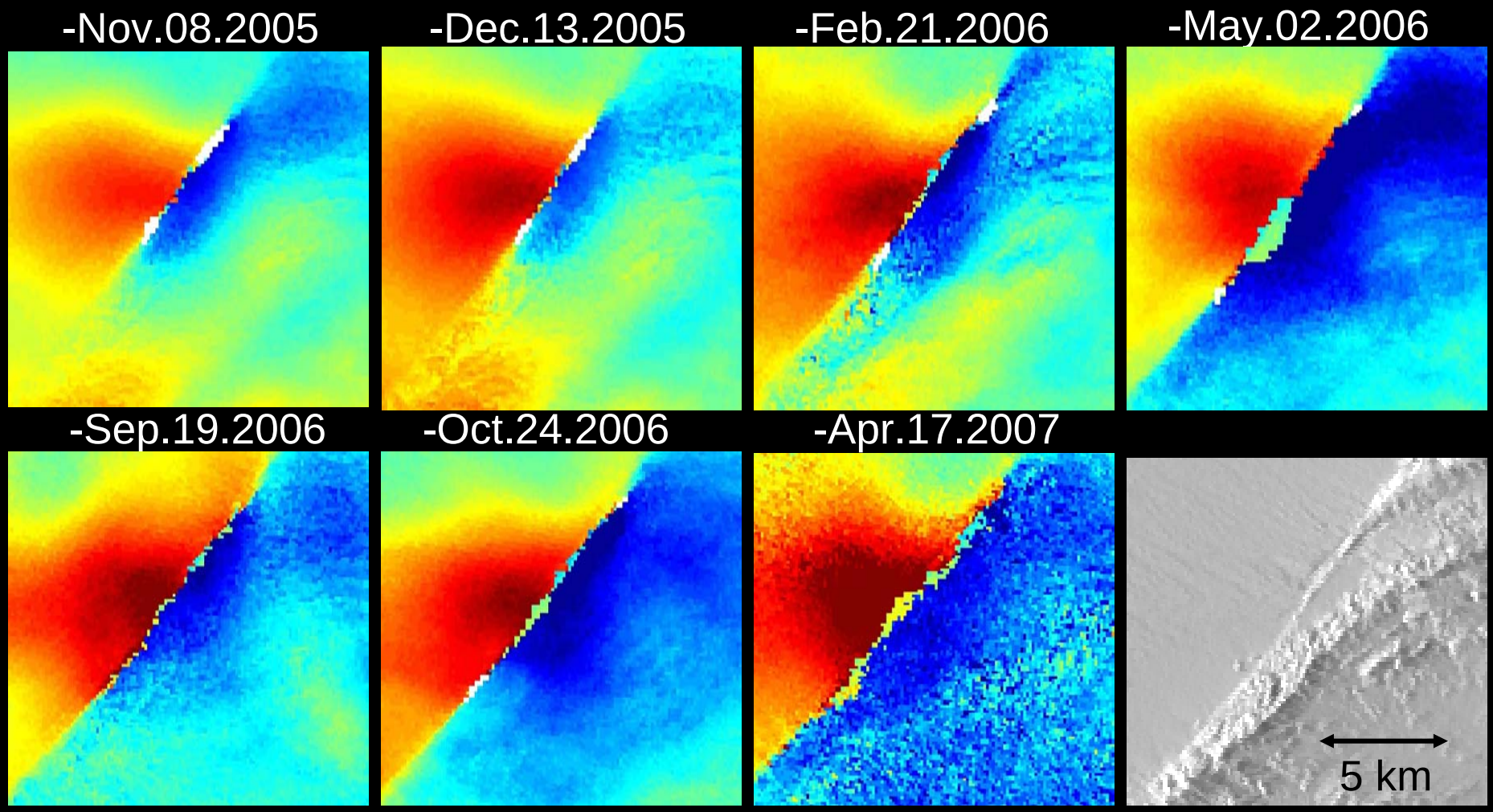
- Apr. 2007



Radar LOS changes

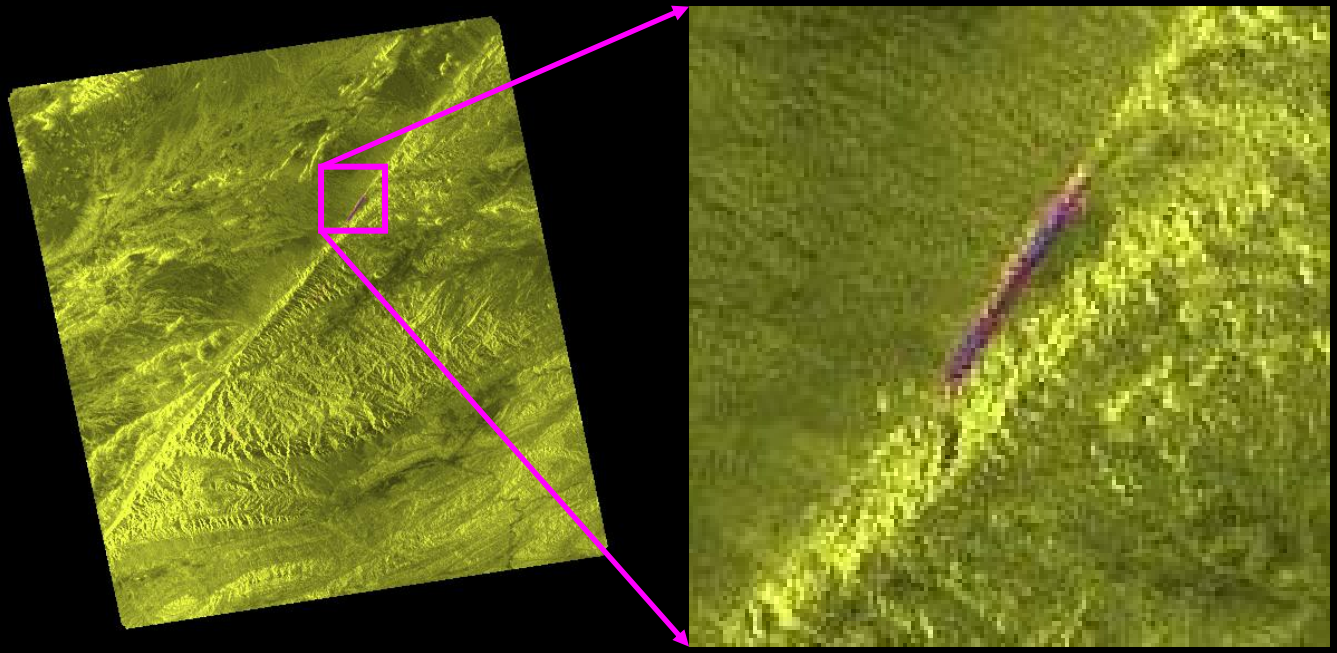
-1.4cm 0 +1.4cm

Co- and Postseismic Signal

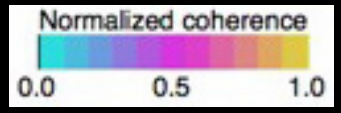


It lasted more than a year despite its small size (Mw5.0)!

Surface fault was formed!



Coherence:



Aug. 30. 2005 - Nov. 8. 2005 (Bperp. - 450 m)

Good coherence except the fault trace.

-> The earthquake slip breached the surface.

Post-seismic deformation mechanisms

- Visco-elastic relaxation in the lower crust and upper mantle

  e.g., Pollitz et al., Science, 2001

  … Stress perturbation by M5 earthquake would be too small.

- Poro-elastic deformation

  e.g., Peltzer et al., JGR 1998; Jónsson et al., Nature, 2003

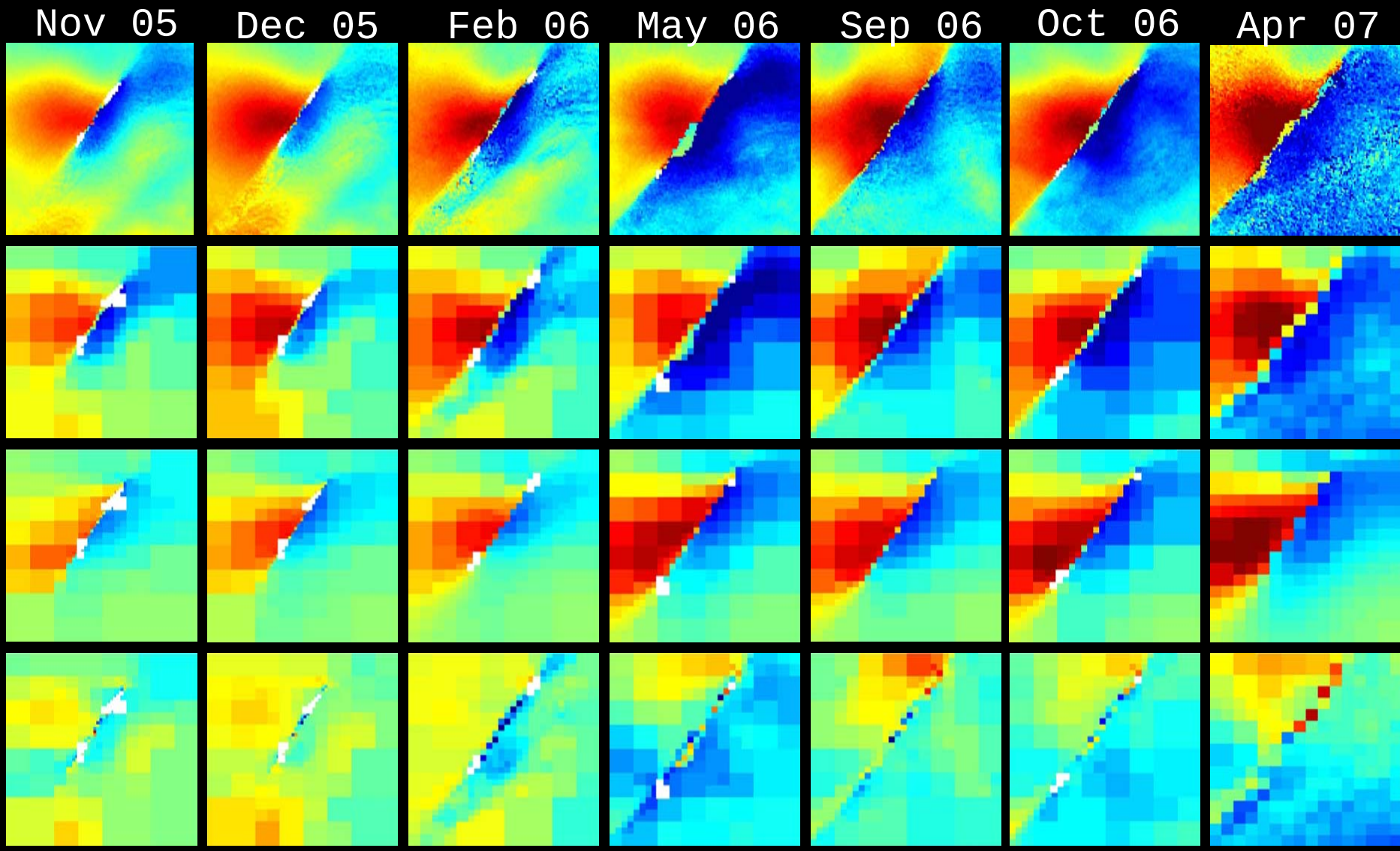
  … Deformation field should be in inverse sense to that of coseismic.

- Afterslip: *Marone et al. JGR. 1991*

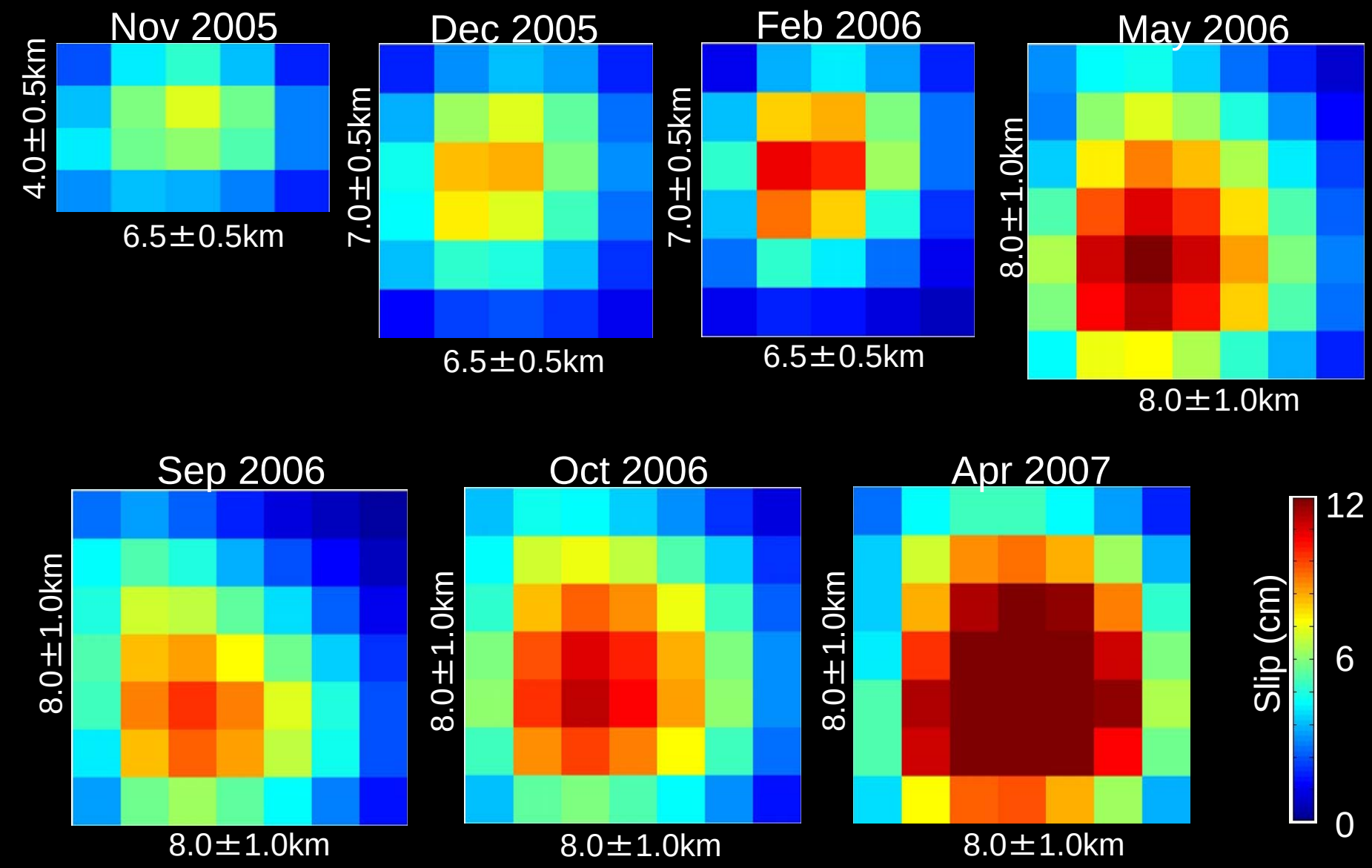
  e.g., Numerous reports around the world.
  The only mechanism for the Parkfield 2004 M6 event (Freed, GRL, 2007).

Slip distribution inversion based on Okada (1985)'s green function.

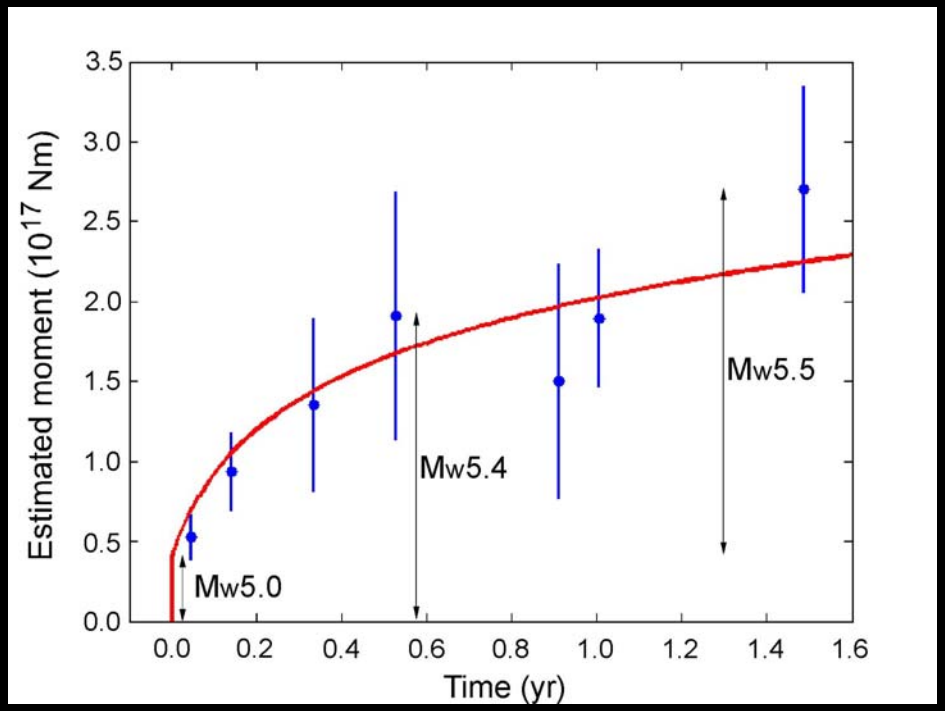
Re-sampling & Modeling



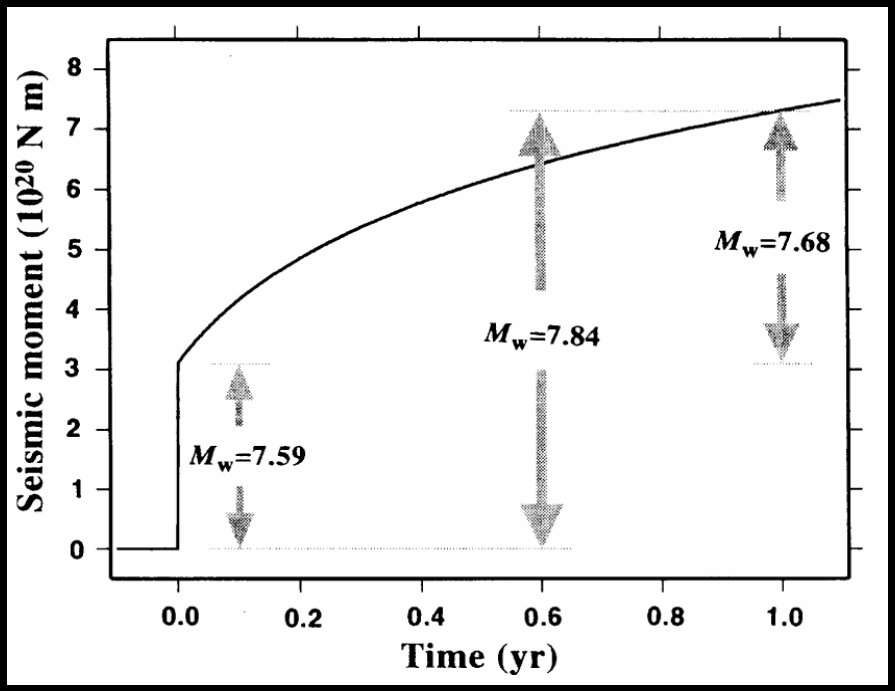
Fault slip evolution



Moment release



This study
(The 2005 M_w5.0 earthquake)



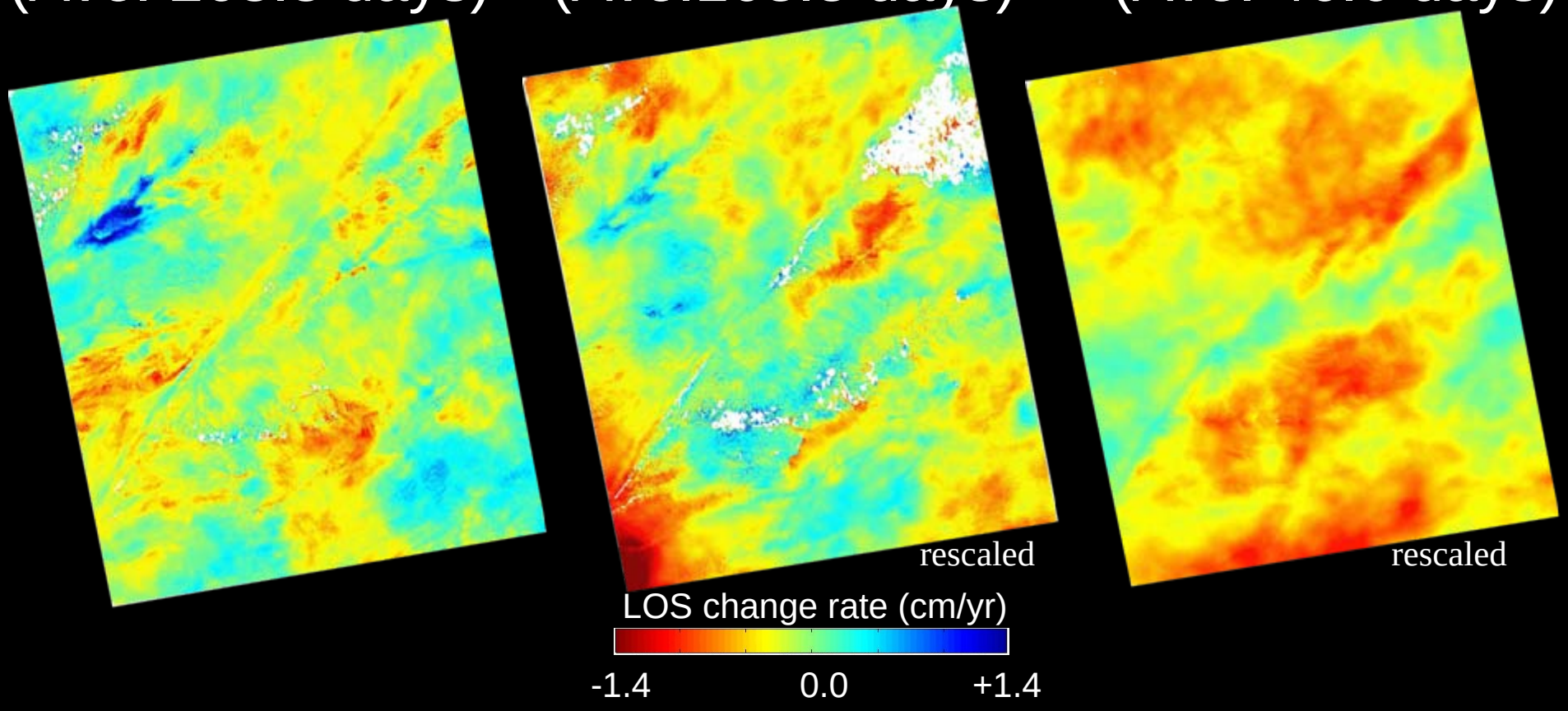
e.g., Heki *et al*., *Nature*, 1997
(The 1994 Sanriku, Mw 7.6)
Kawasaki *et al*., *JPE,* 1995
(The 1992 Sanriku Harukaoki, Mw6.9)

“Preseismic” stack

long-term (3)
(Ave. 268.3 days)

mid-term (3)
(Ave.163.3 days)

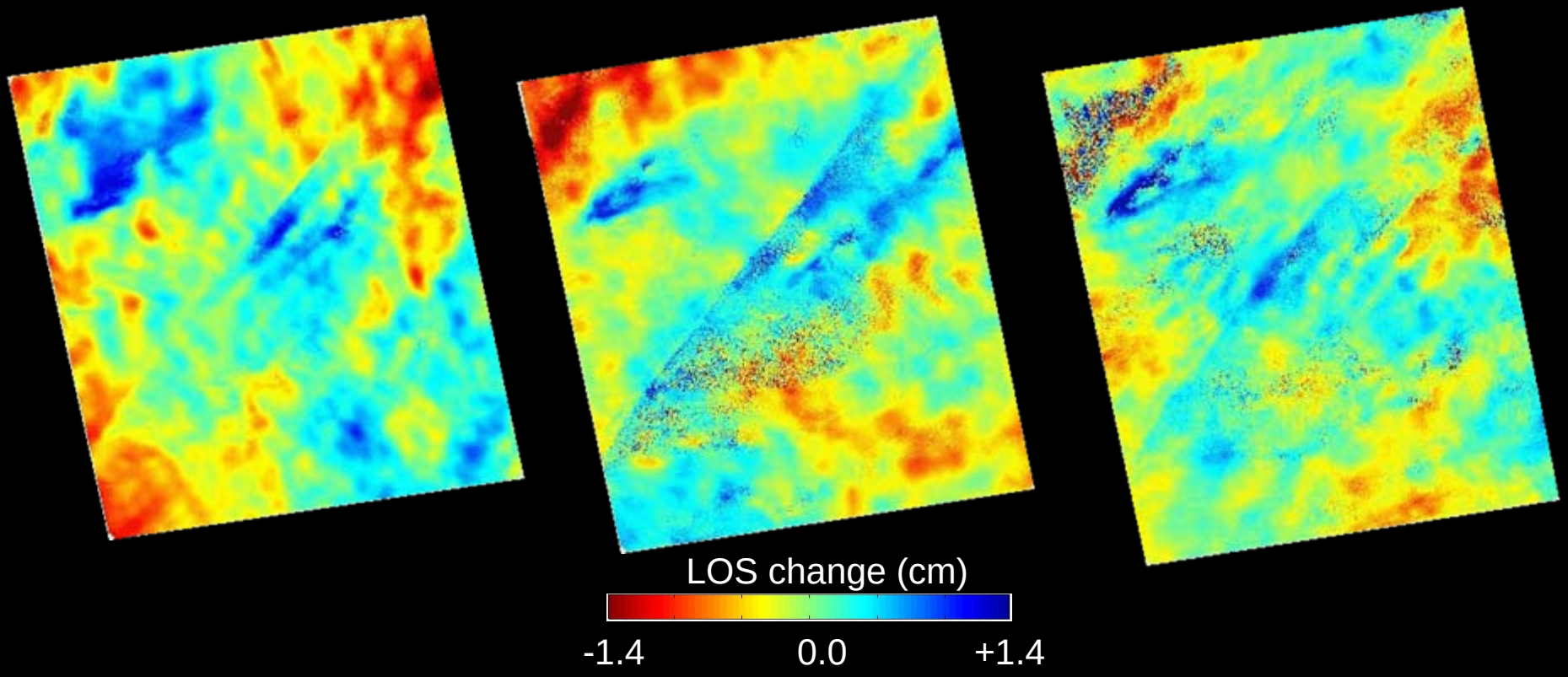
short-term (3)
(Ave. 46.6 days)



No steady creep motion prior to the M5 event.

“Post-seismic”

8 Nov 2005-19 Sep 2006 13 Dec 2005-24 Oct 2006 2 May 2006-17 Apr 2007



Wide-spread phase steps across the fault

-Presumably triggered by the M5 earthquake
(similar to Lyons & Sandwell (2003))

Earthquakes were missing, but...

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1978	02 23	160237.10	31.50	67.01	33	4.60	mb GS
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1980	10 29	195542.20	31.93	67.04	33	3.90	mb GS
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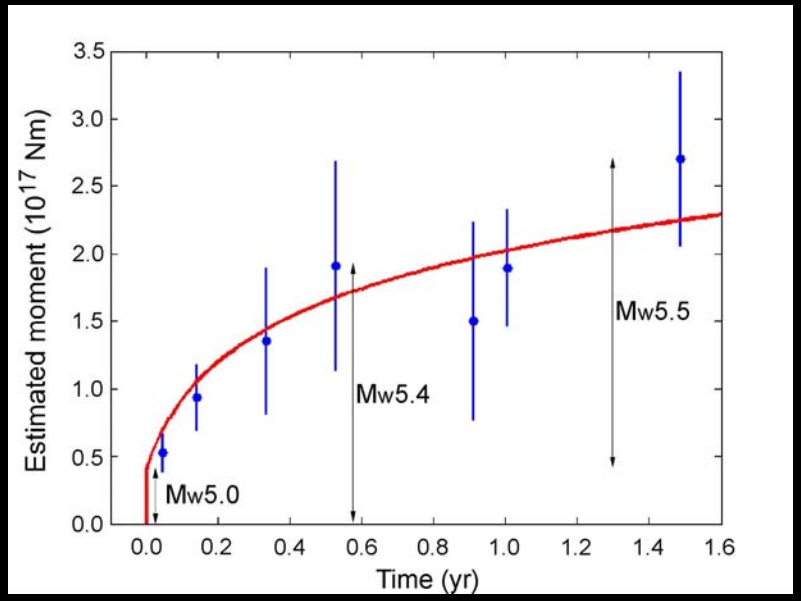
Lat 31-33N, Lon 66-68E, 30yrs

http://neic.usgs.gov/neis/epic/epic_rect.html

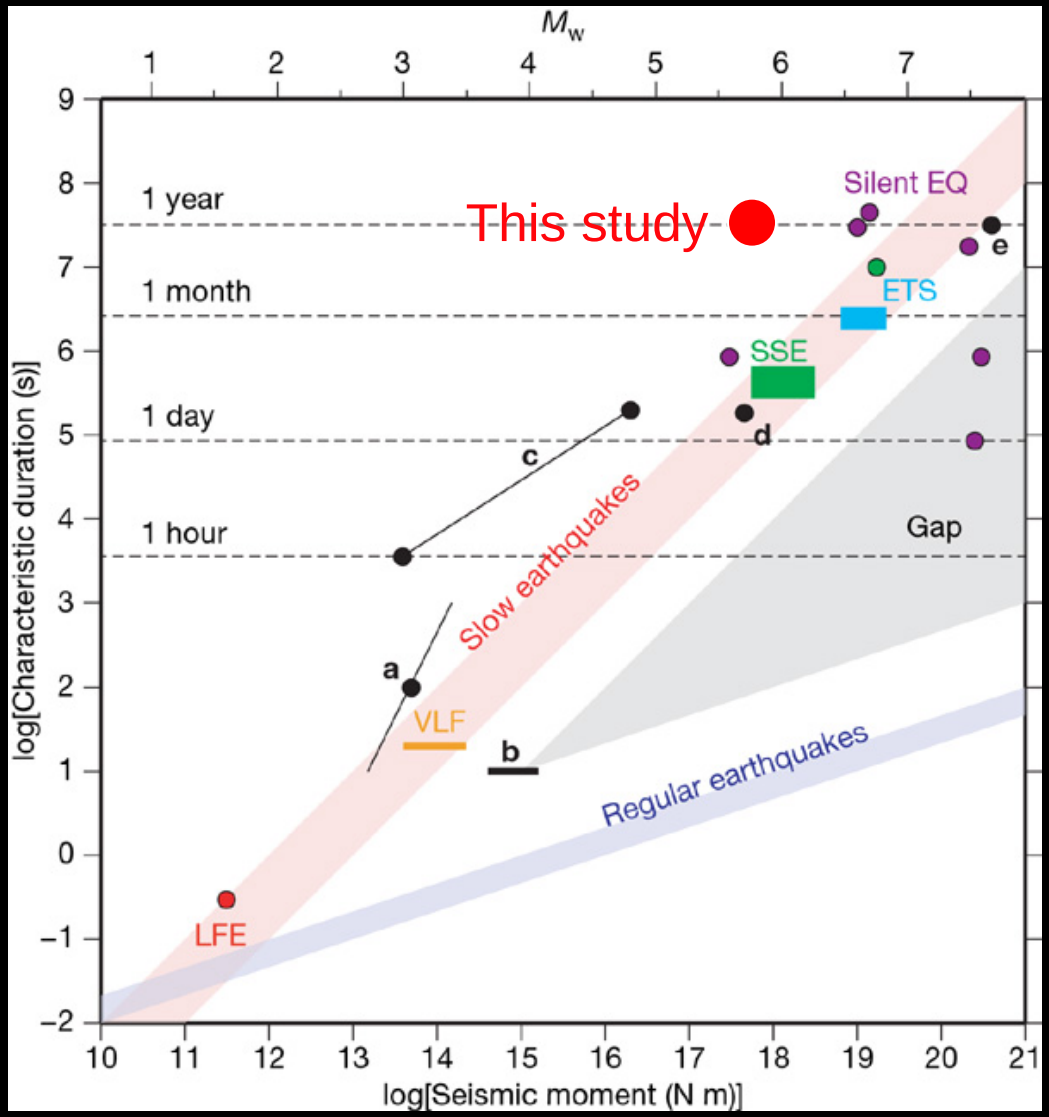
While more than 10 eqks with M>5 are missing,…



The postseismic moment 2×10^{17} Nm is equiv. to more than 8 M_w5.0 earthquakes!

The 1992 event probably caused a similar slow earthquake.

Does it follow the Ide's law?



Ide *et al*., A scaling law for slow earthquakes, *Nature*, 2007.

Summary

- A “slow earthquake” in Afghanistan was discovered by InSAR.

  …The M5 earthquake on Oct 21, 2005, was not a normal M5 event.

  …Unexpectedly large and widespread afterslip lasting more than one year despite the small magnitude.
- No “steady” creep motion (at least) along the analyzed portion.
- Widespread triggered afterslip was accompanying.

  … The total moment release of this “slow earthquake” does deviate from Ide’s law (Nature 2007).
- Plate motion is accommodated to infrequent moderate earthquakes plus significant afterslip in this plate boundary.

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The original Envisat level-0 data are copyrighted by, and courtesy of European Space Agency.