Seismic events

Rüdiger Gens

Constraints of DInSAR for studying earthquakes

- lack of knowledge of when and where they occur
- initial uncertainty whether measured displacement is pre-seismic or post-seismic
- radar image acquisition
  - one image before the earthquake
  - one image after the earthquake
- two images together with a DEM or a third image need to be processable

Constraints of DInSAR for studying earthquakes

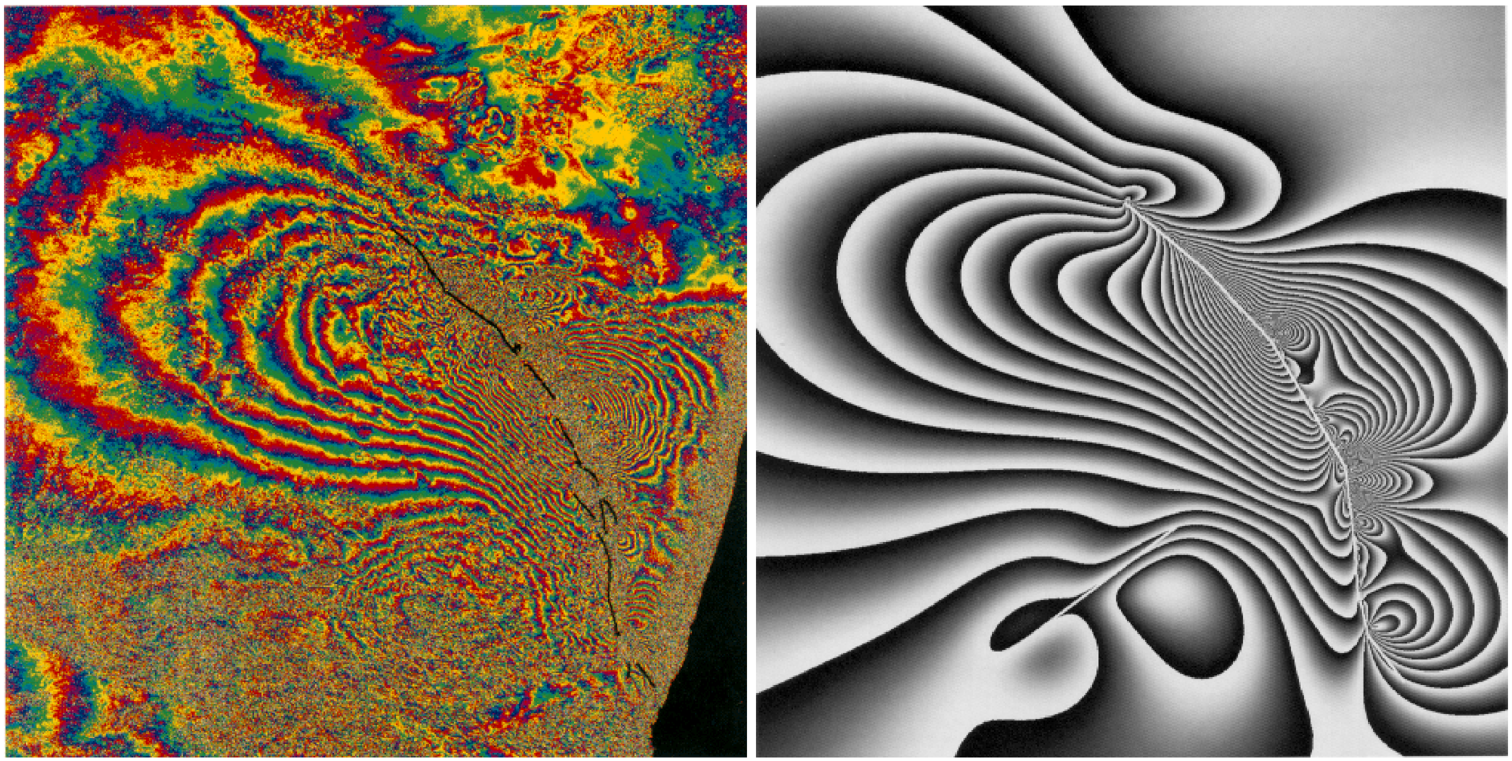
- vector displacements in a co-seismic deformation field must have sufficient magnitude and proper orientation
  - moderate magnitude (M > 5) at shallow depths (< 10 km) with dip-slip mechanism (predominantly vertical displacements)

Seismic events

Example: Landers, California

- Occurred on 28 June 1992 over 85 km along a complex fault system in the Mojave Desert of California.
- Magnitude 7.3
- Shallow strike-slip mechanism
- Ideal test case for radar interferometry, because its shallow depth produced spectacular surface rupture in an arid area less than three months after the ERS-1 satellite began acquiring radar images in its 35-day orbital cycle.

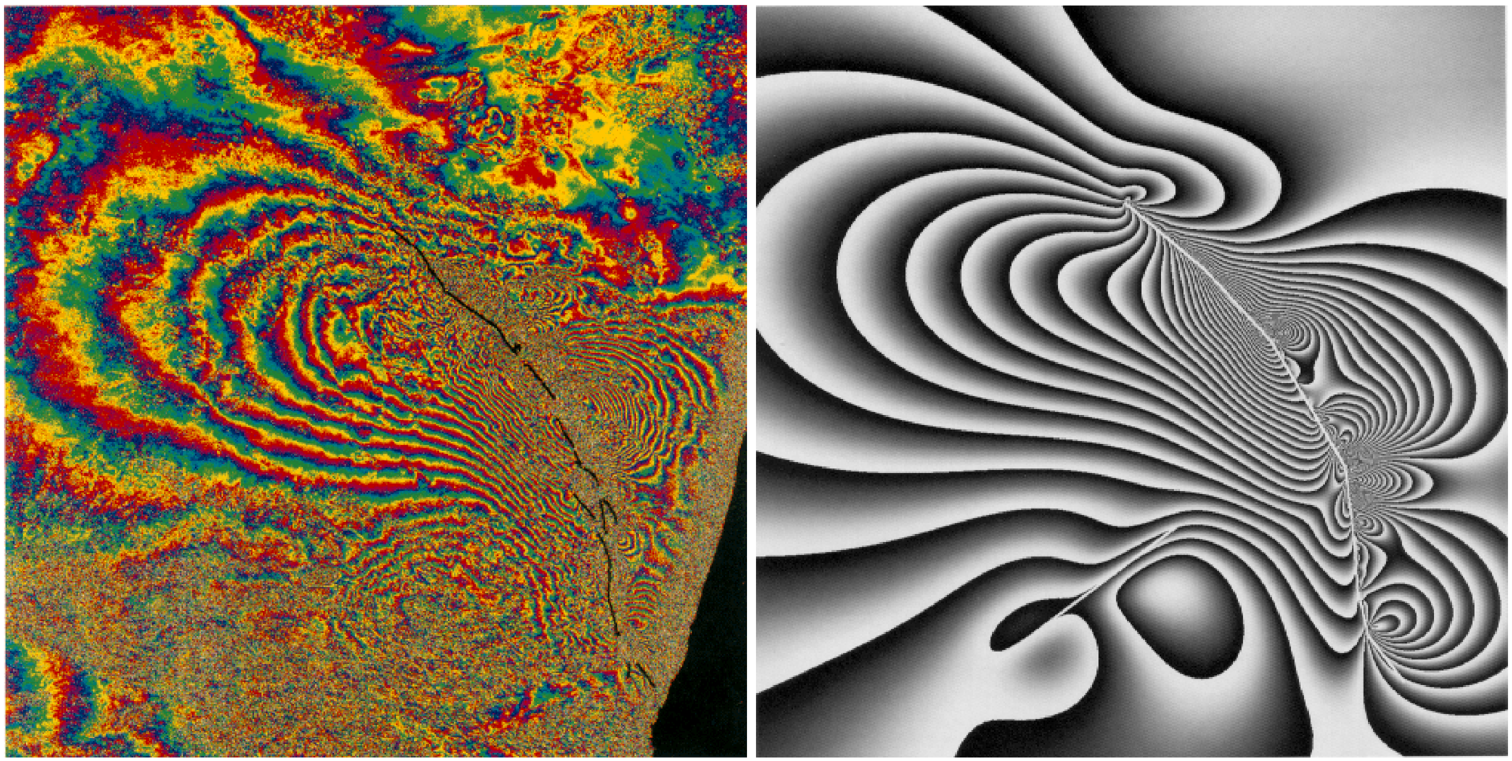
Example: Landers, California



(a) Observed interferogram calculated from ERS-1 SAR images taken before (April 24, 1992) and after (June 18, 1993) the earthquake. The asymmetry between the two sides of the fault is due to the curvature of the fault and the geometry of the radar. Black lines denote the surface rupture mapped in the field. (b) Modeled interferogram

Example: Landers, California

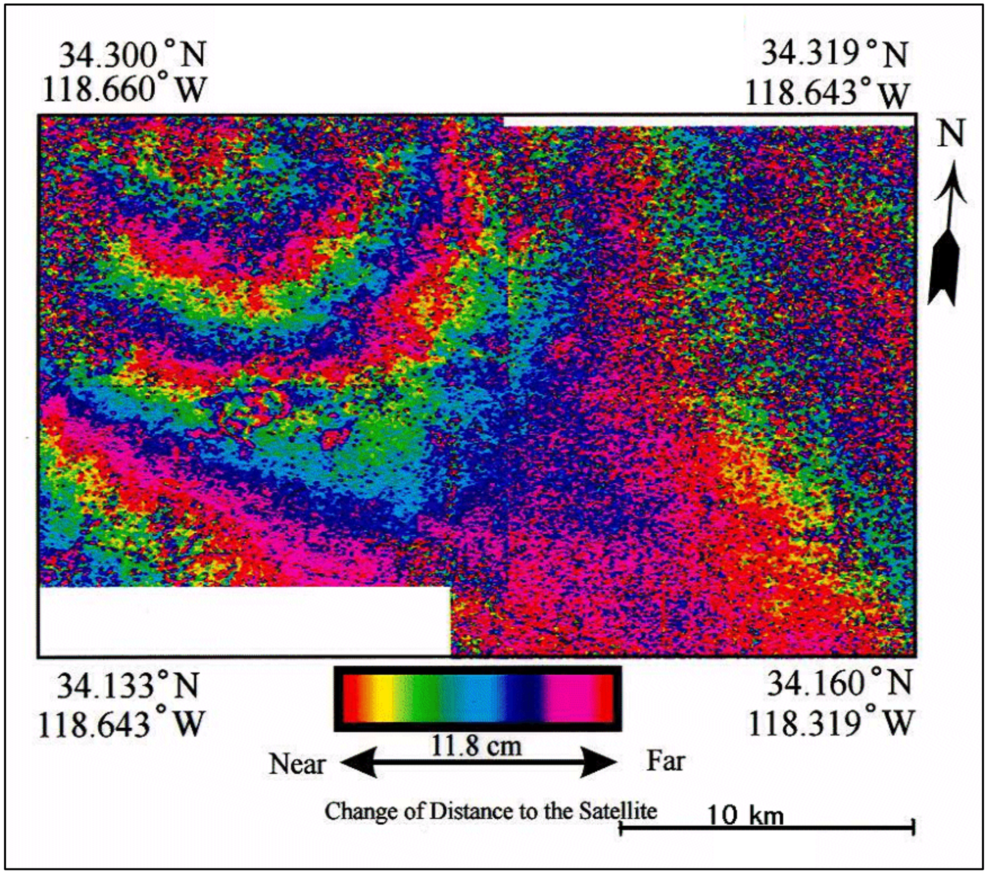
Seismic events



With 20 fringes in the shape of a crushed butterfly, the interferogram illustrates the coseismic deformation field with over a million pixels

Massonnet, D. et al 1993. The Displacement Field Of The Landers Earthquake Mapped By Radar Interferometry. *Nature*, **364**(6433): 138-142.

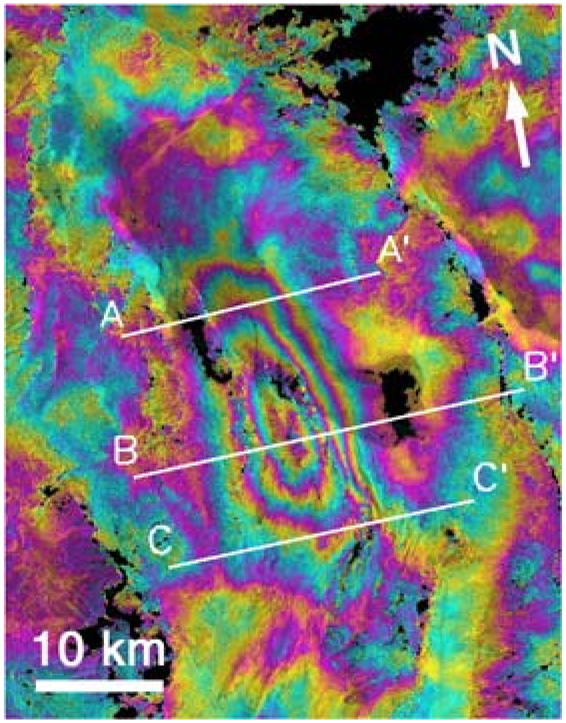
Example: Northridge, California Complex thrusting



Murakami, M., Tobita, M., Fujiwara, S., Saito, T. and Masaharu, H., 1996. Coseismic crustal deformations of 1994 Northridge, California, earthquake detected by interferometric JERS 1 synthetic aperture radar. *Journal Of Geophysical Research-Solid Earth*, **101**(B4): 8605-8614

Example: Eureka Valley, California Normal-faulting

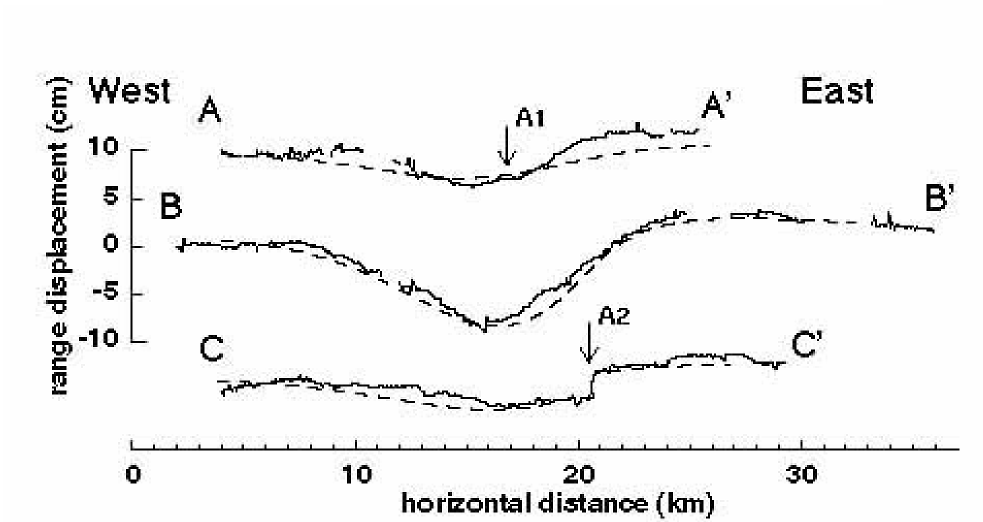
Seismic events

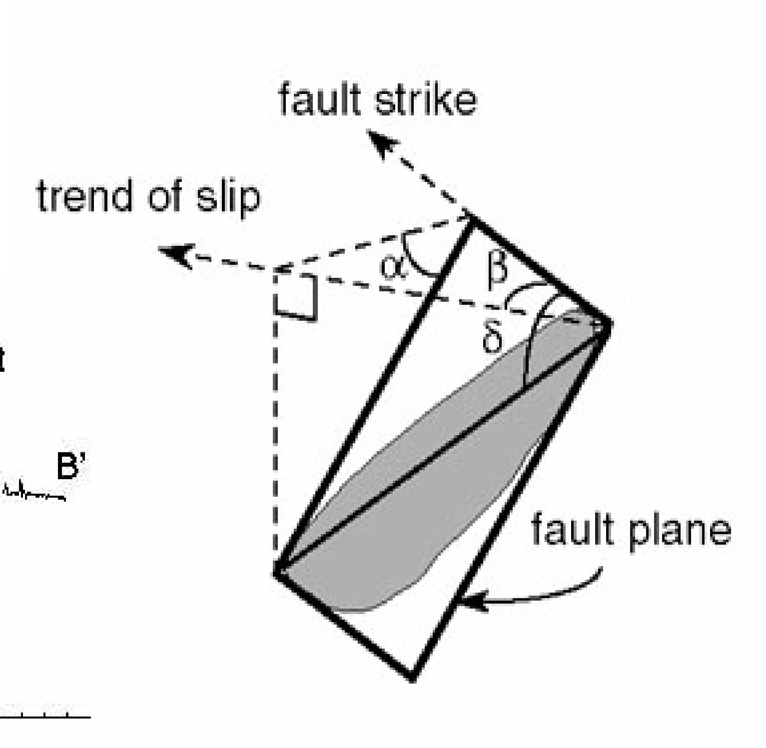


- source mechanism of the earthquake implies a north-northeast striking normal fault
- focal mechanism of the main shock indicates that the earthquake ruptured a north-northeast-striking fault, steeply dipping to the west

Peltzer, G. and Rosen, P., 1995. Surface Displacements Of The 17 May 1993 Eureka Valley, California, Earthquake Observed By Sar Interferometry. *Science*, **268**(5215): 1333-1336

Example: Eureka Valley, California Normal-faulting

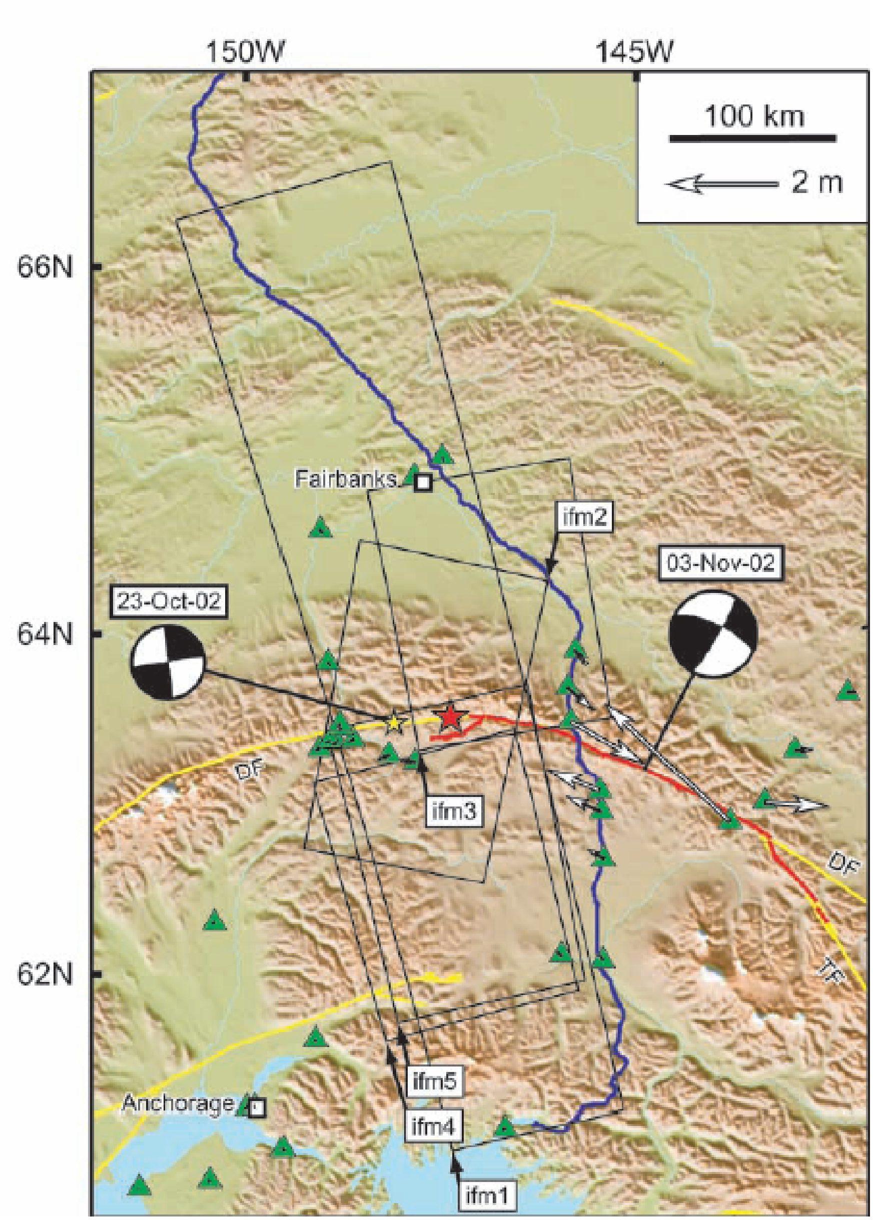




Peltzer, G. and Rosen, P., 1995. Surface Displacements Of The 17 May 1993 Eureka Valley, California, Earthquake Observed By Sar Interferometry. *Science*, **268**(5215): 1333-1336

Example: Denali

- Occurred on Nov 3, 2002
- largest continental strike-slip earthquake to occur since the development of InSAR
- earthquake ruptured about 300 km of the Denali fault system



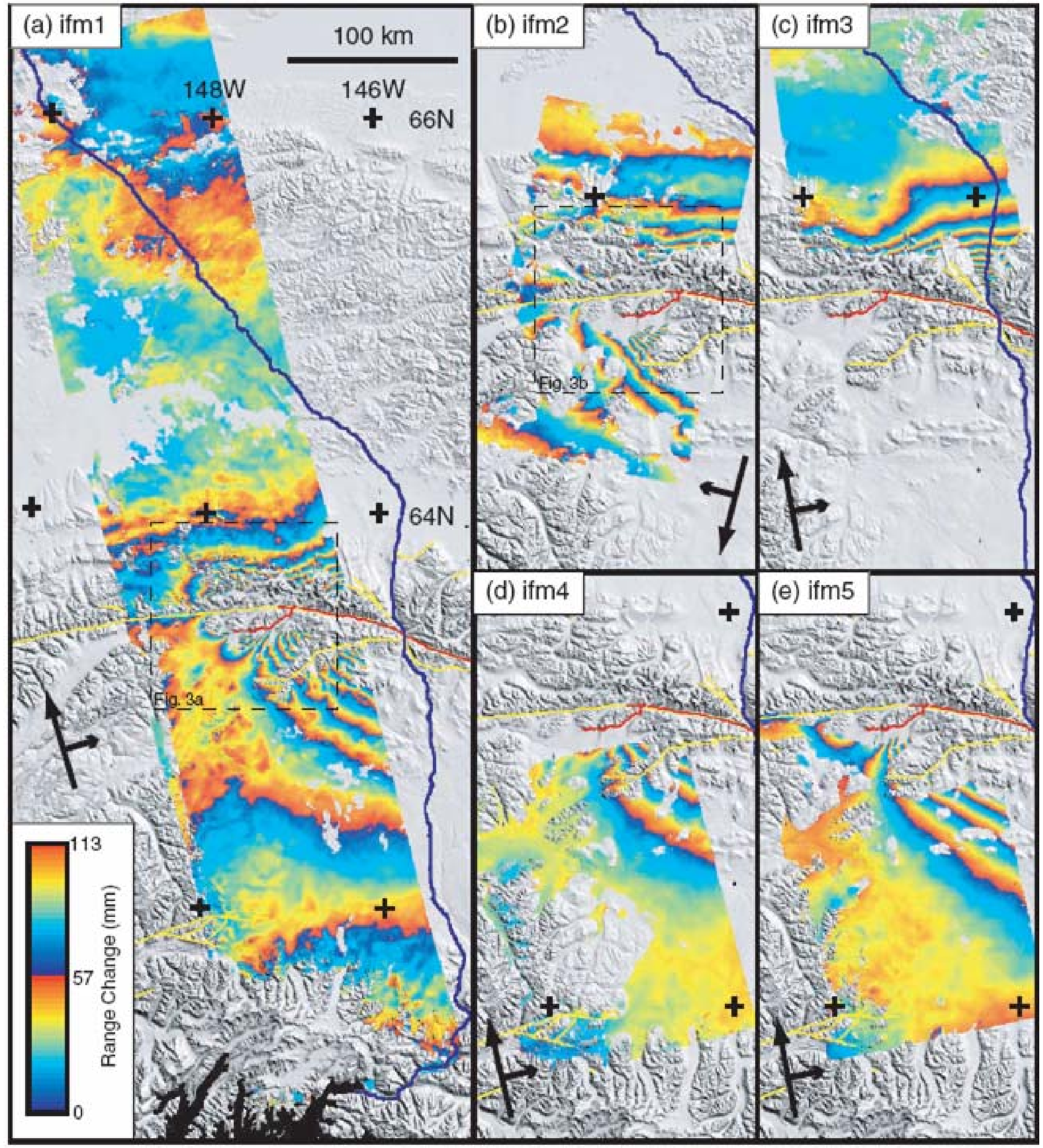
Wright et al., 2004, Constraining the Slip Distribution and Fault Geometry of the Mw 7.9, 3 November 2002, Denali Fault Earthquake with InSAR and GPS Data. Bulletin of the Seismological Society of America, Vol. 94, No. 6B, pp. S175–S189,

Example: Denali

Interferograms Constructed for This Study

	Date 1	Date 2	θ*	α†	$B_{\perp}$‡
ifm1	29-Oct-02	22-Nov-02	27.7	−14.5	110
ifm2	20-Oct-02	13-Nov-02	39.5	−169.1	−10
ifm3	11-Oct-02	4-Nov-02	47.0	−9.1	158
ifm4	18-Sept-02	5-Nov-02	23.4	−15.3	22
ifm5	15-Oct-02	8-Nov-02	34.2	−12.3	105

*Incidence angle at scene center.
†Satellite Azimuth (angle between the satellite ground track and local north).
‡Perpendicular baseline (in meters).

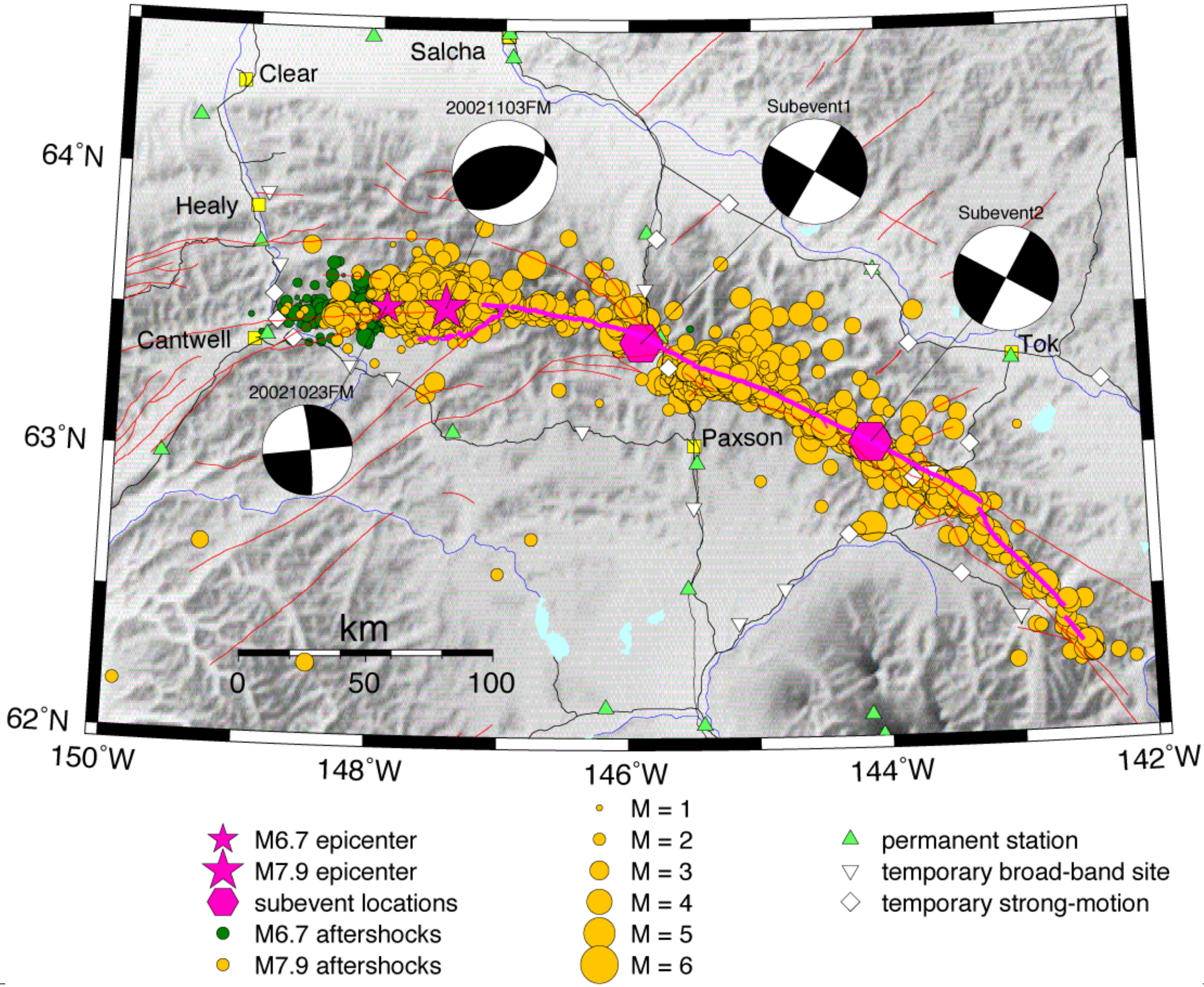


- Warm colors indicate motion toward the satellite, whose along-track and look directions are shown by the large and small black arrows, respectively.
- Yellow lines, mapped faults; red lines, 3 November 2002 rupture; blue line, pipeline.

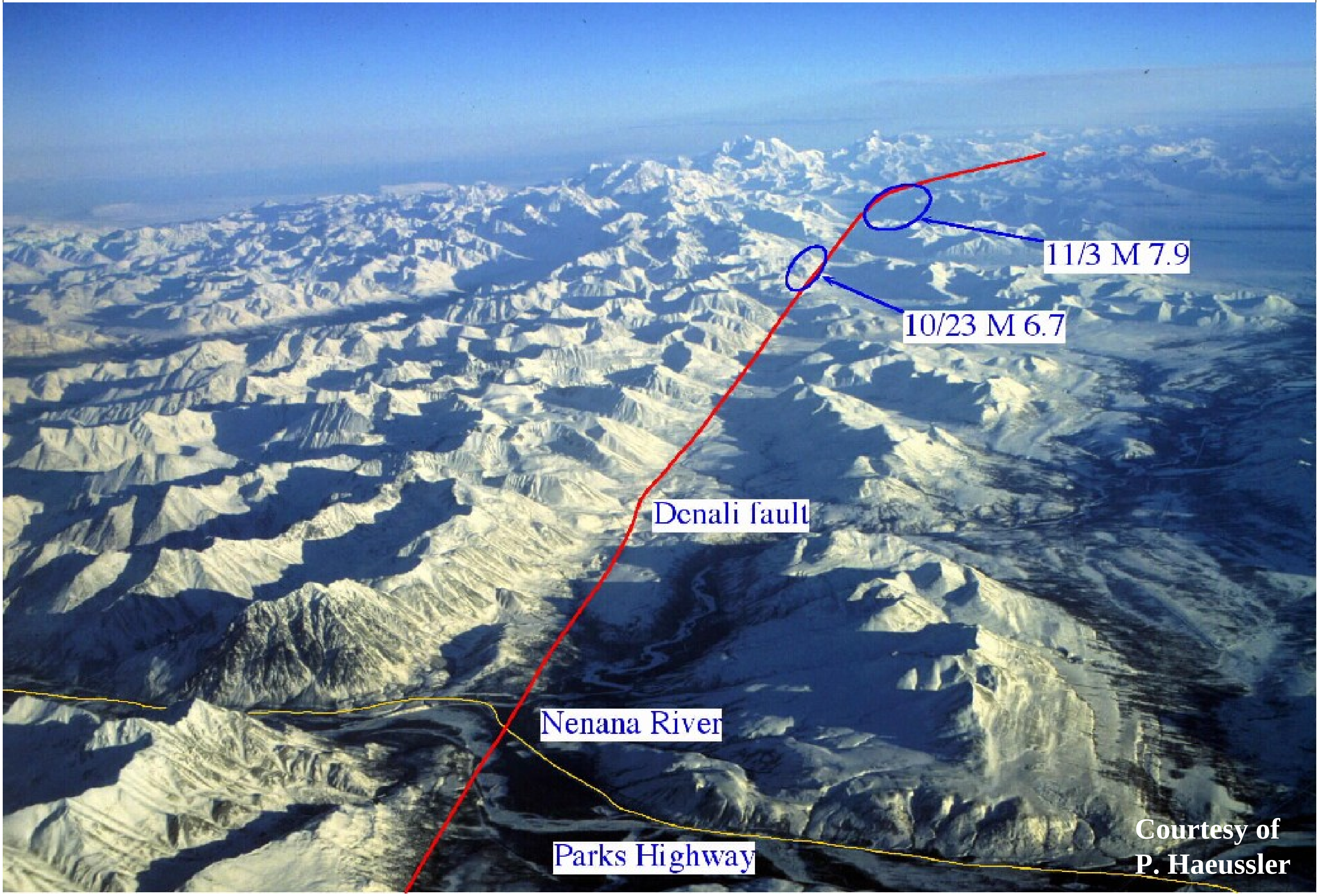
Example: Denali

Courtesy: Zhong Lu

Oct. 23 and Nov 3, 2002 Denali Earthquakes

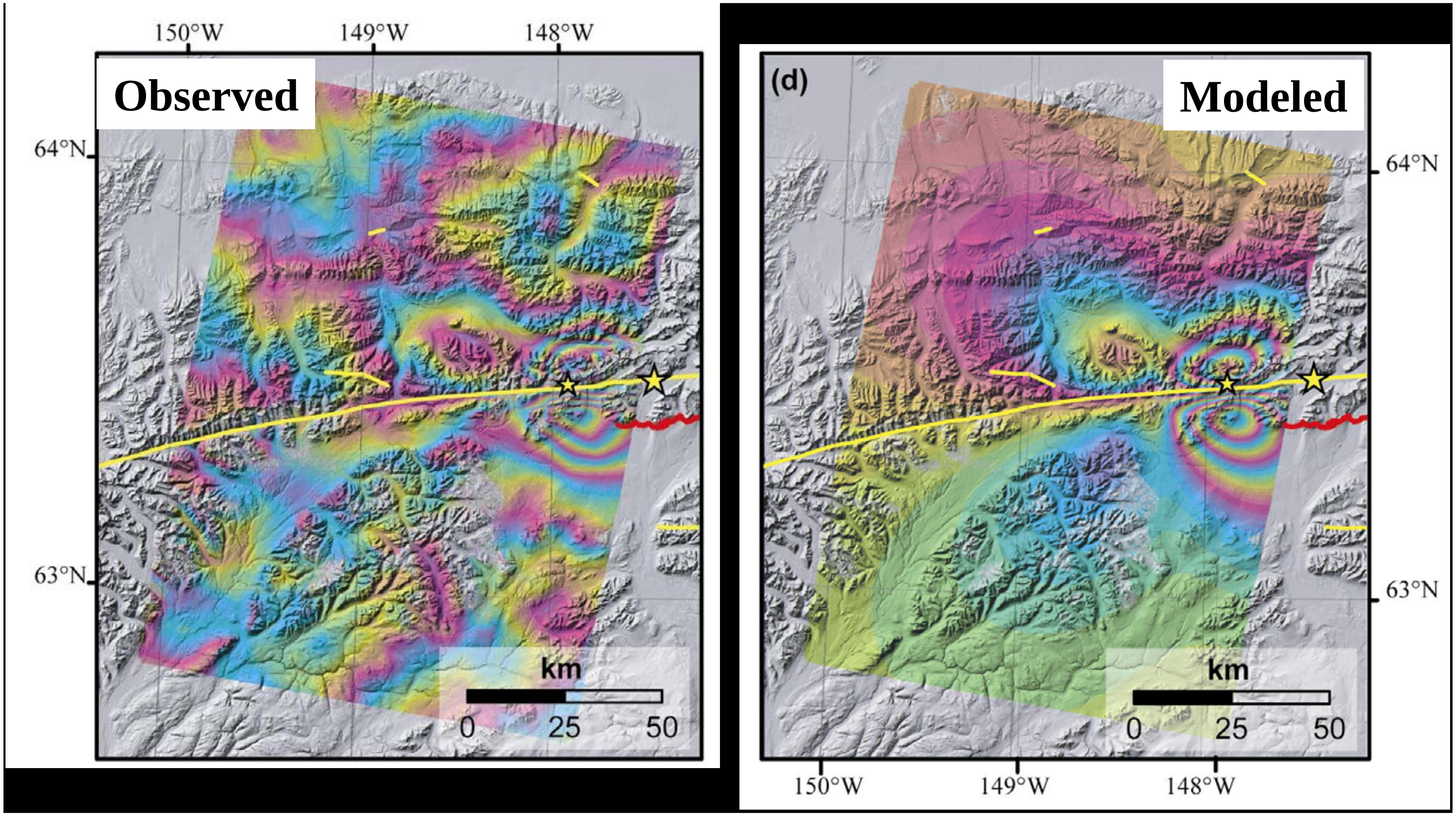


2002 Denali Fault Earthquakes



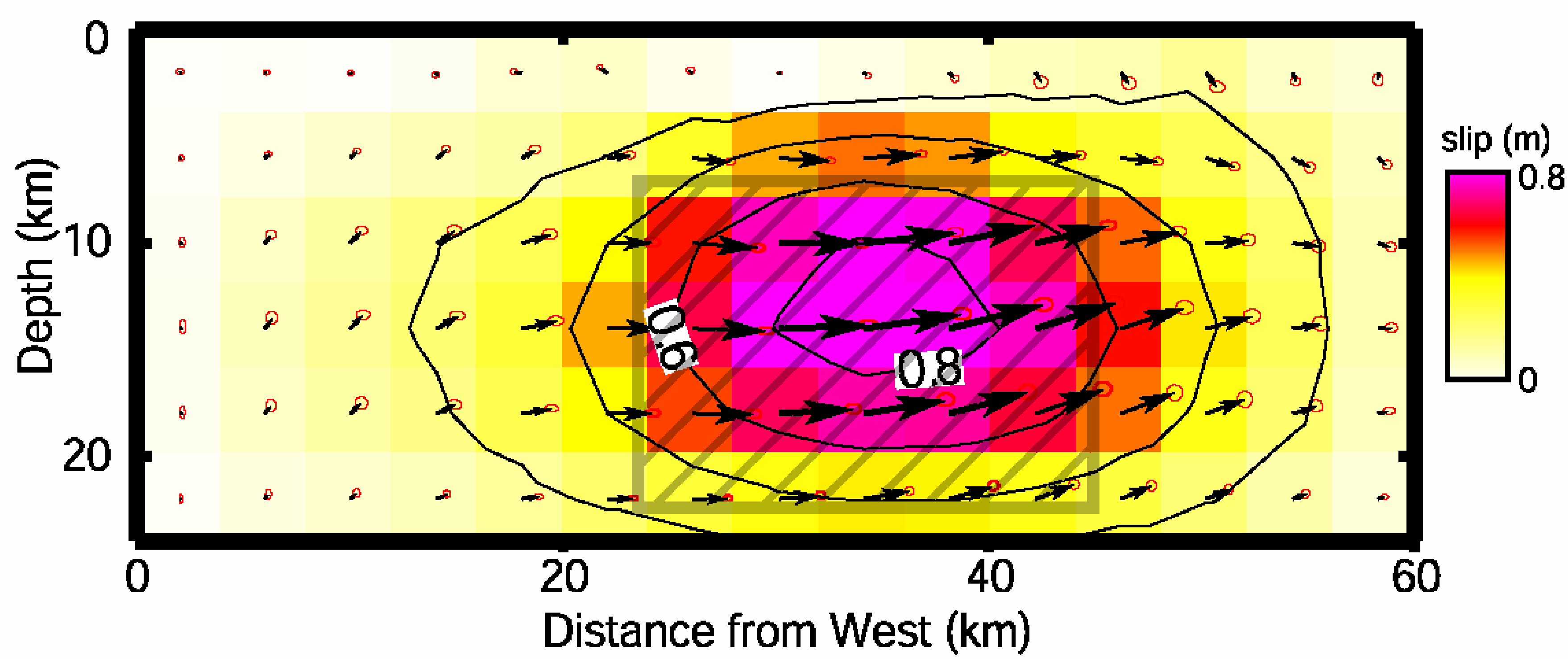
InSAR images: observed and modeled

Oct. 23, 2002 Earthquake



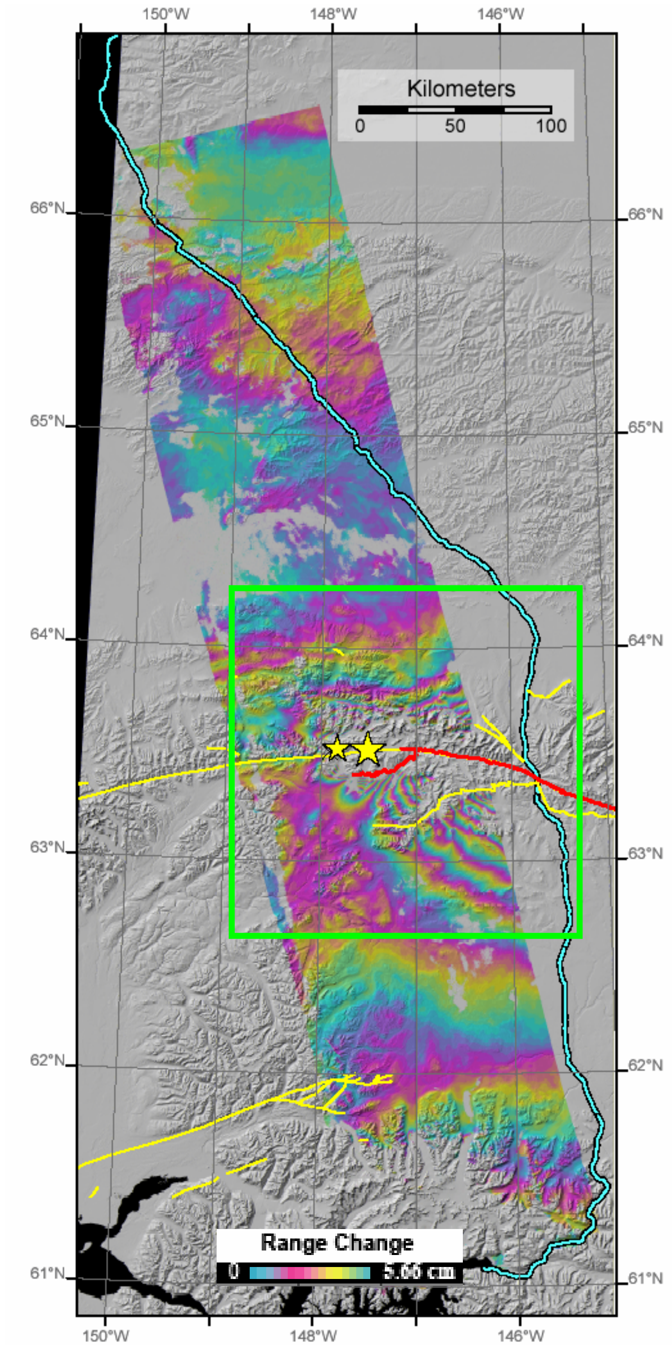
- Lu, Wright, Wicks, EOS, 2003

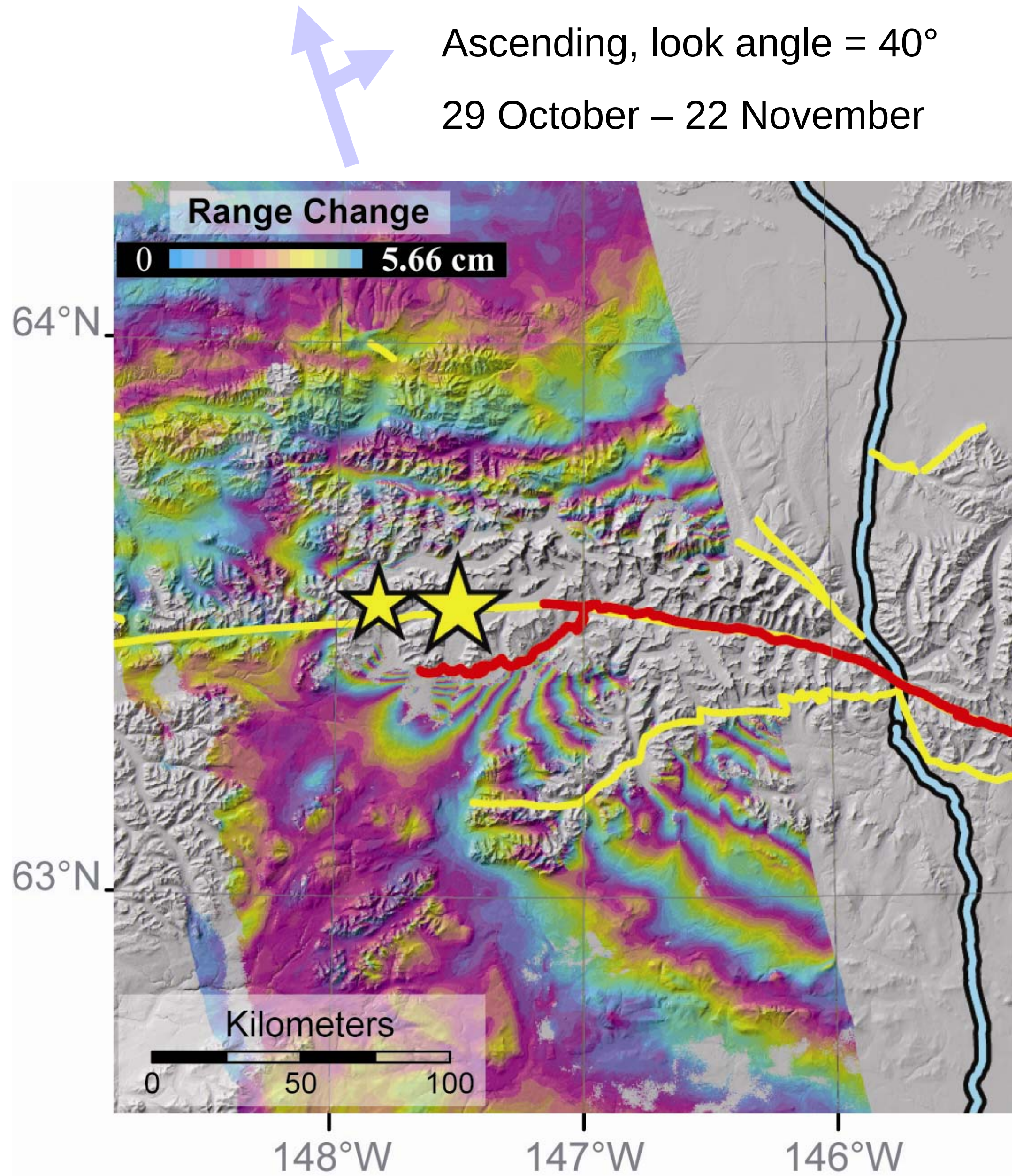
Slip Distribution of Oct 23, 2002 Earthquake



• **Wright, Lu, Wicks, GRL, 2003**

Nov. 3, 2002 Earthquake



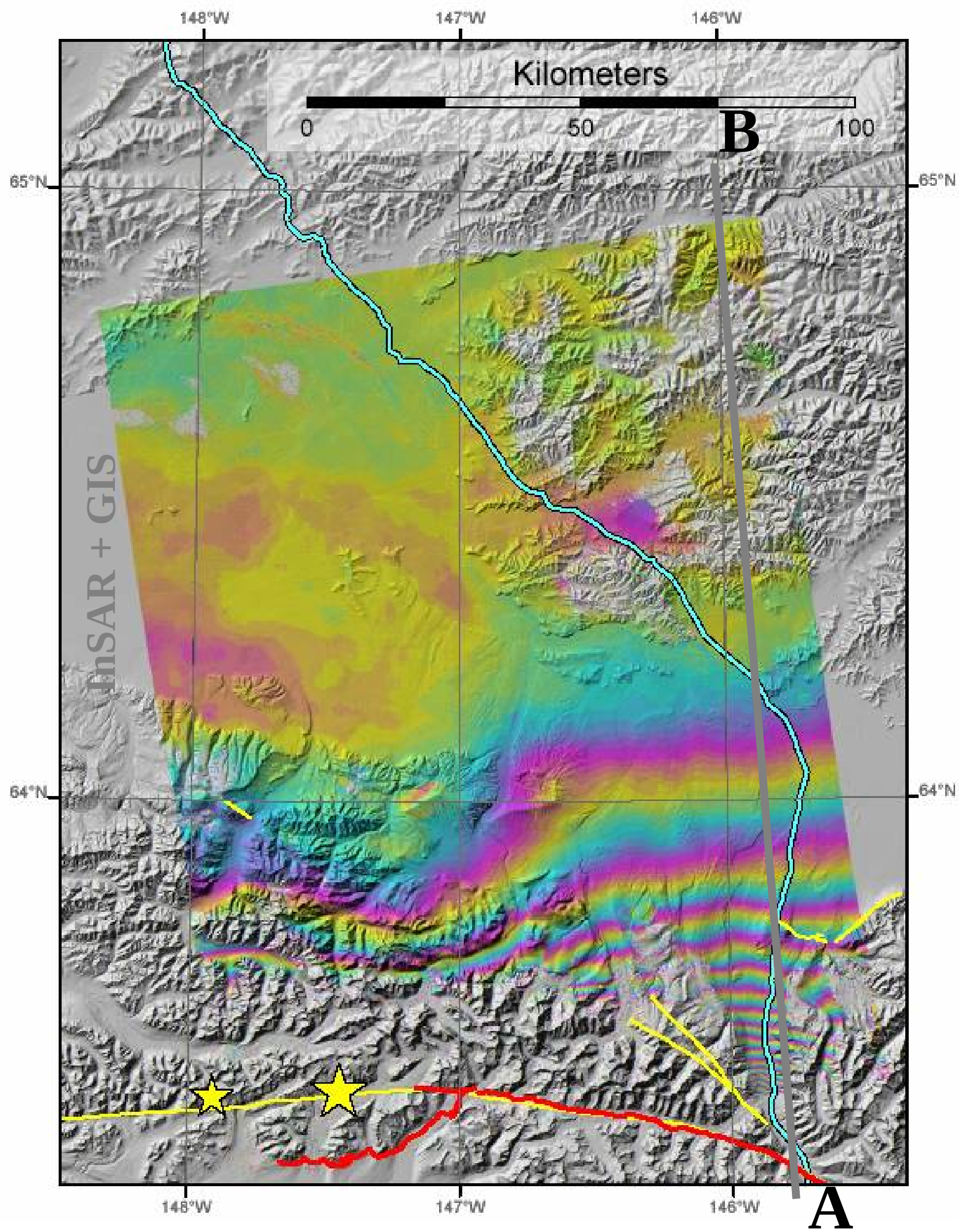


Ascending, look angle = 40°

29 October – 22 November

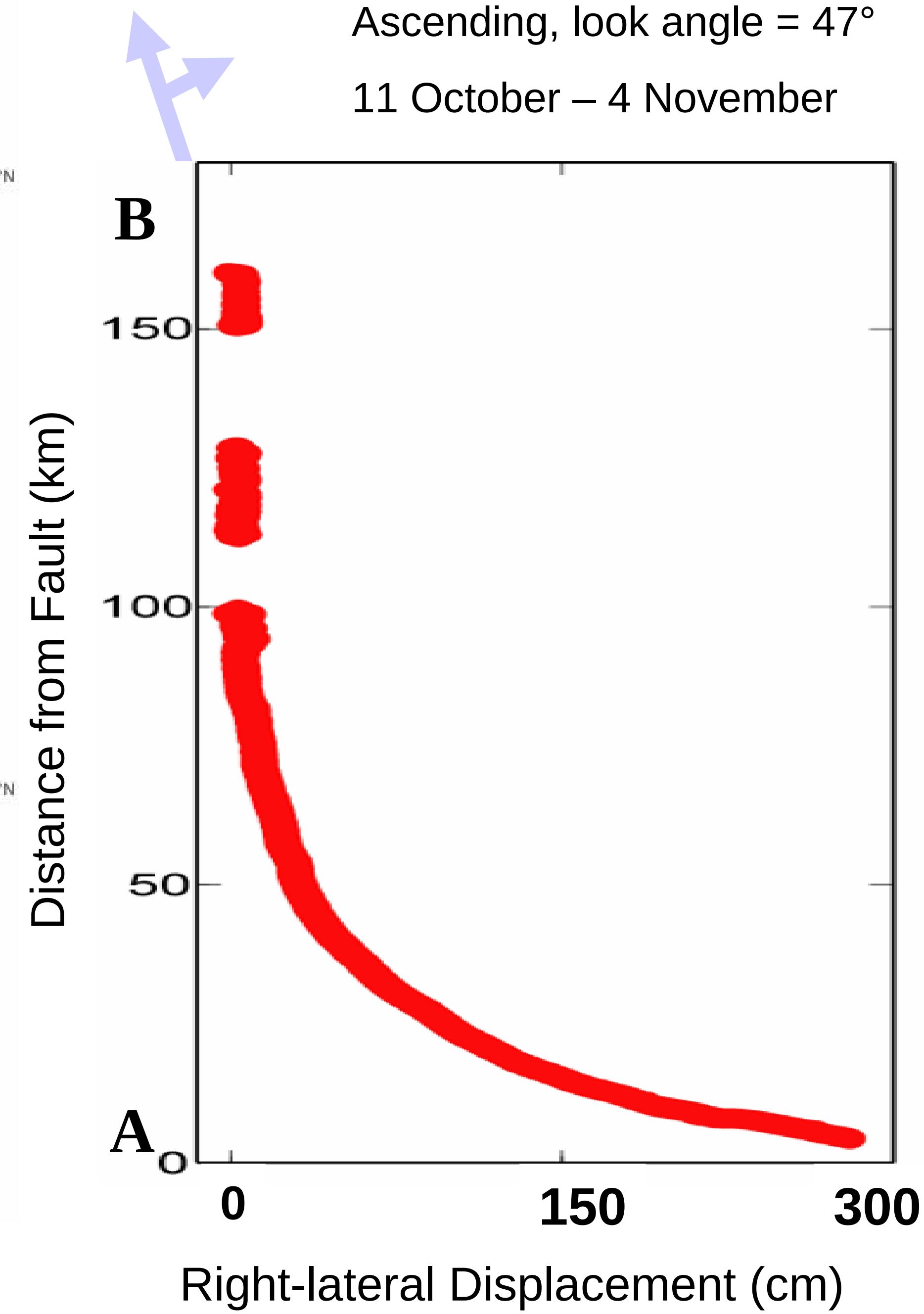
• **Lu, Wright, Wicks, EOS, 2003**

Nov. 3, 2002 Earthquake



Ascending, look angle = 47°

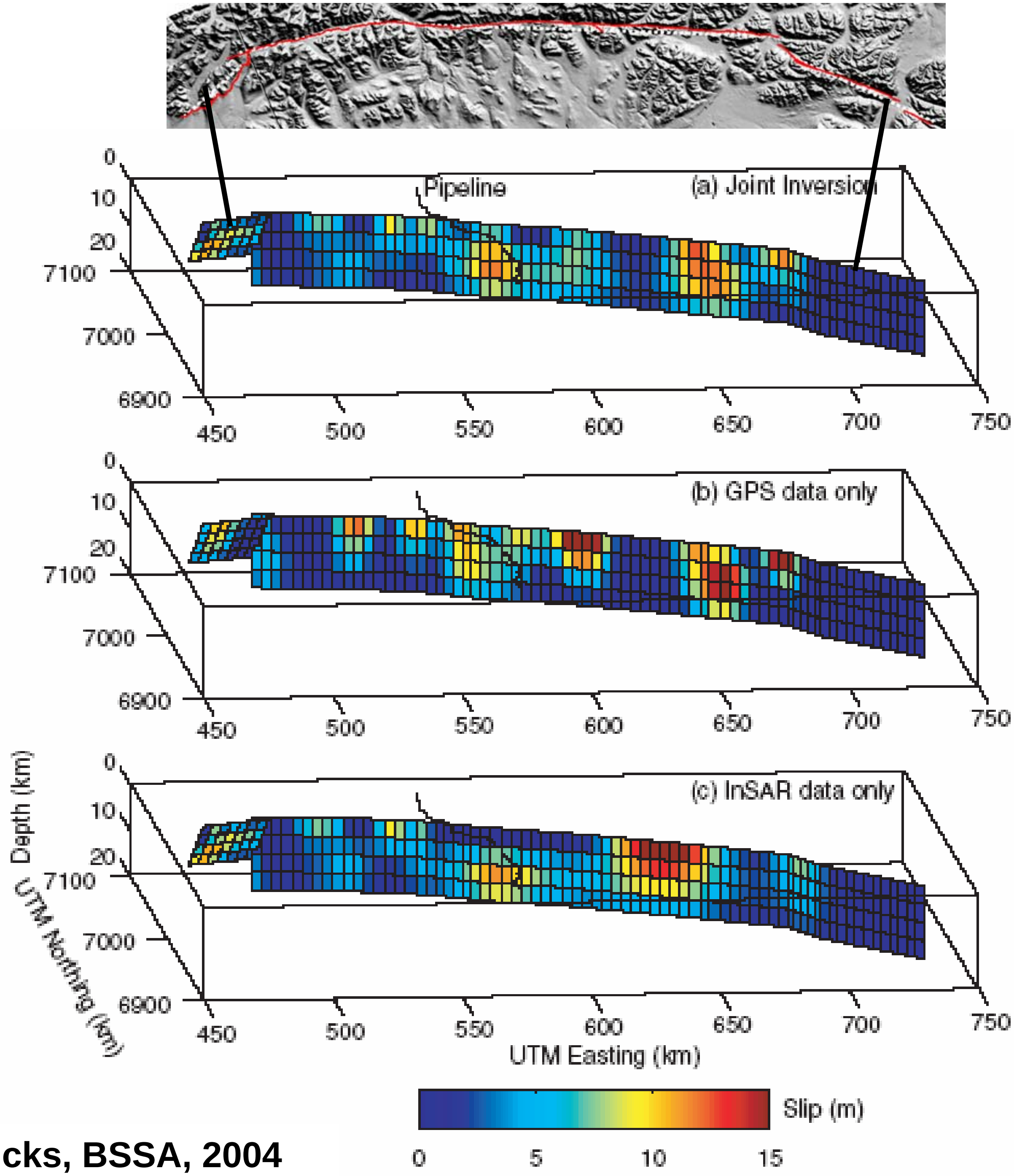
11 October – 4 November



Lu, Wright and Wicks, EOS 84 (41), p425,430-431, 2003

Nov 3, 2002 Earthquake

Slip Distribution



Joint

GPS

InSAR

• **Wright, Lu, Wicks, BSSA, 2004**