

WinSAR and the Natural Laboratory/ Supersite approach to Geohazards

*Falk Amelung, CSTARS, University of Miami
and the WinSAR members.*

Outline:

1. Why do we need Natural Laboratories ?

Example 1: 2007 seismic crisis in Tanzania

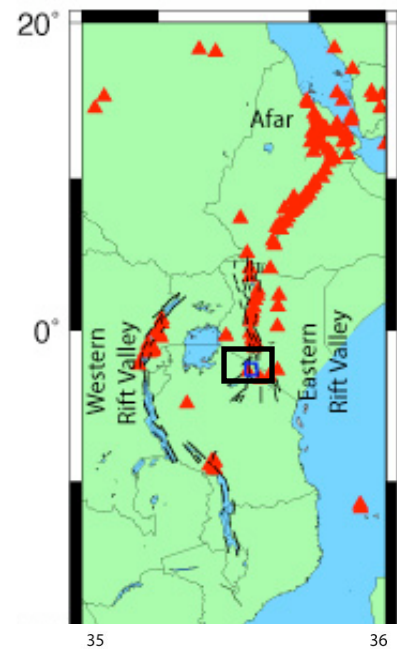
Example 2: The Sumatra earthquakes

2. Western North America Natural Laboratory,
Earthscope and WinSAR.

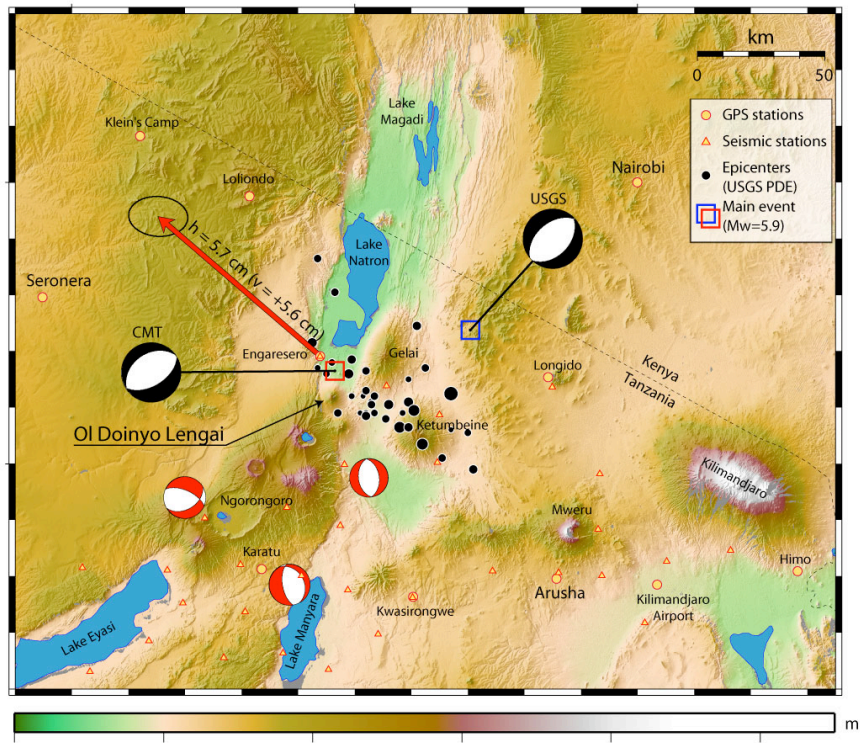
3. Current status of WinSAR at Unavco

4. International data sharing initiatives

Example 1: Tanzania seismic crisis, 7/2007



17 July 2007 M5.9 earthquake,
1-2 weeks of moderate events



Courtesy Elifuraha Saria, Erik Calais

Example 1: Tanzania seismic crisis, 7/2007



Courtesy Elifuraha Saria, Erik Calais

Example 1: Tanzania seismic crisis, 7/2007

without natural laboratory ...

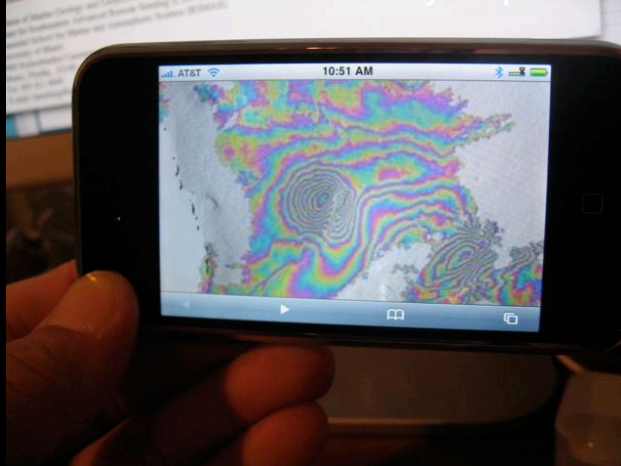
?



Courtesy Elifuraha Saria, Erik Calais

Example 1: Tanzania seismic crisis, 7/2007

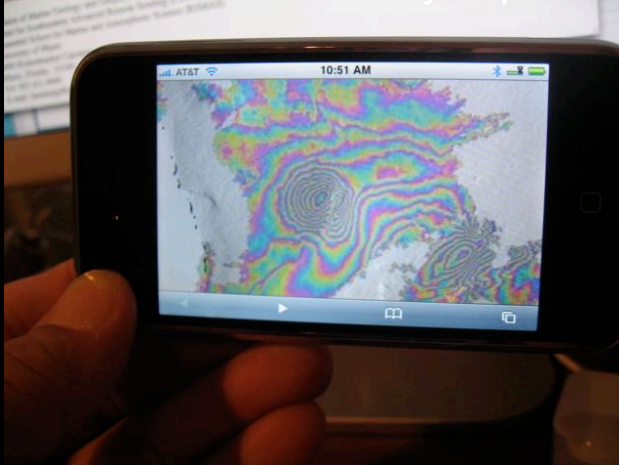
with natural laboratory in place...



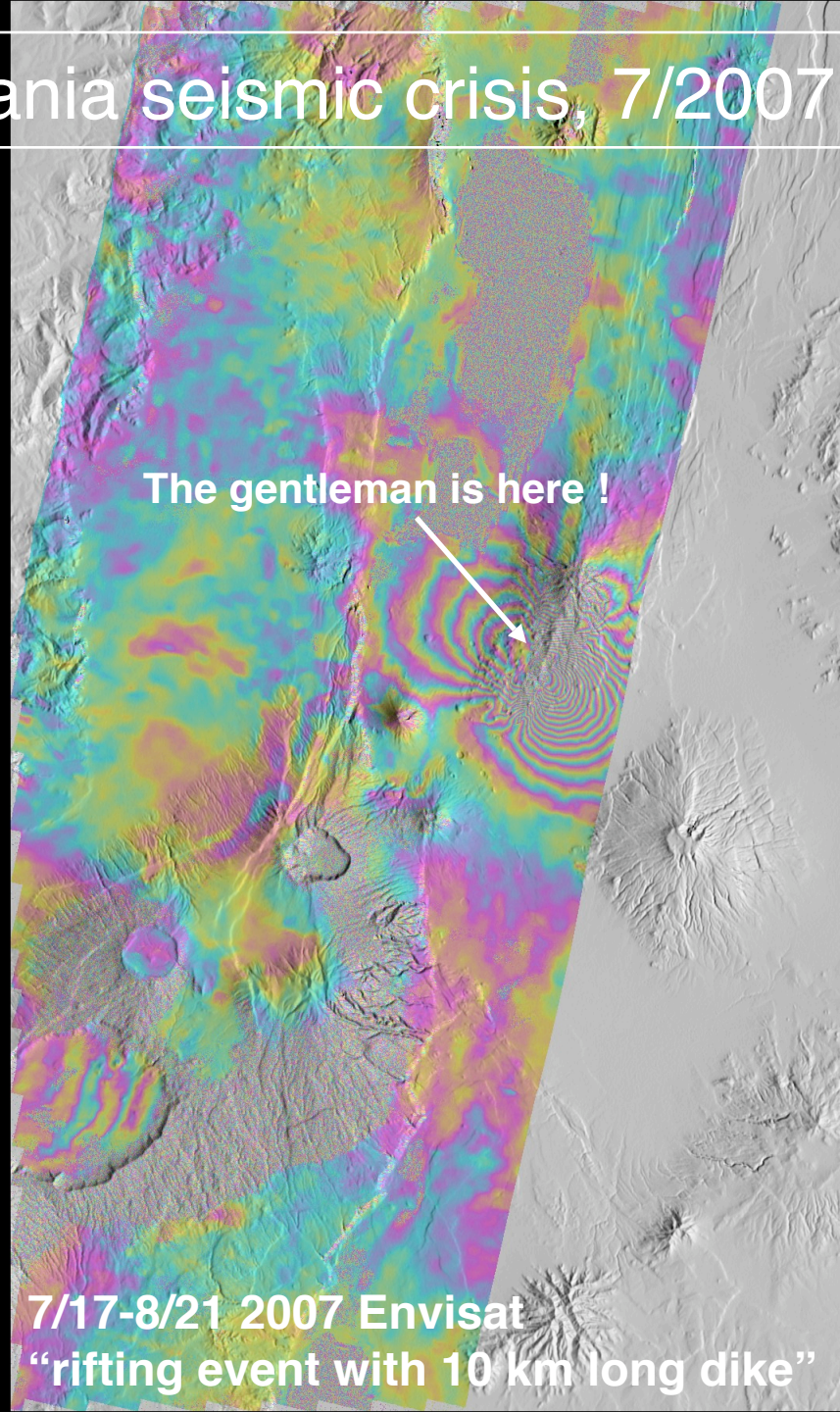
Courtesy Elifuraha Saria, Erik Calais

Example 1: Tanzania seismic crisis, 7/2007

with natural laboratory in place...



Natural laboratory provides data access
Research institution provides products



7/17-8/21 2007 Envisat
"rifting event with 10 km long dike"

Example 2: Sumatra 2004-2007



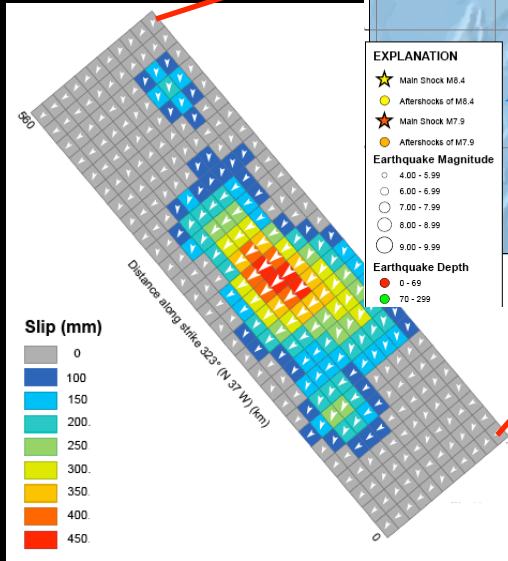
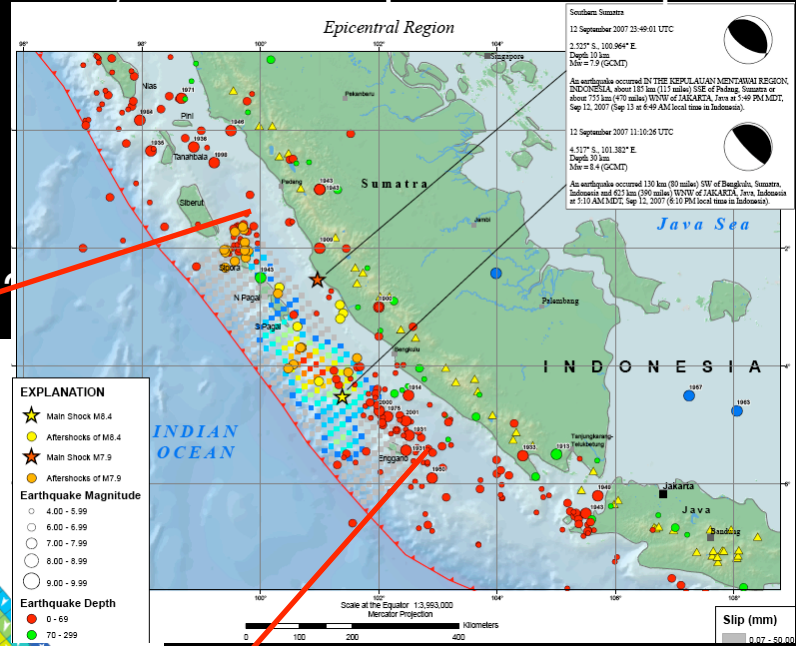
Science, News, 2007

The M9.2 2004 and M8.7 2005 earthquakes increased the stress along the Mentawai segment

Key Questions:

1. Which fault segment did the 2007 events rupture?
2. How much they increased the stress on the Mentawai segment?

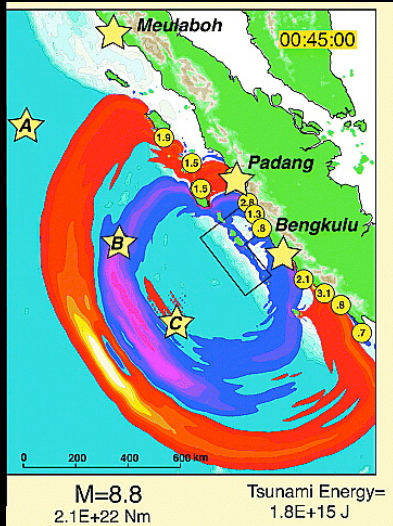
M8.4, M7.9 earthquakes 12 Sep 2007



NEIC earthquake poster, 2007

Fault slip distribution available from seismology hours after the earthquake, but was their significant aseismic slip?

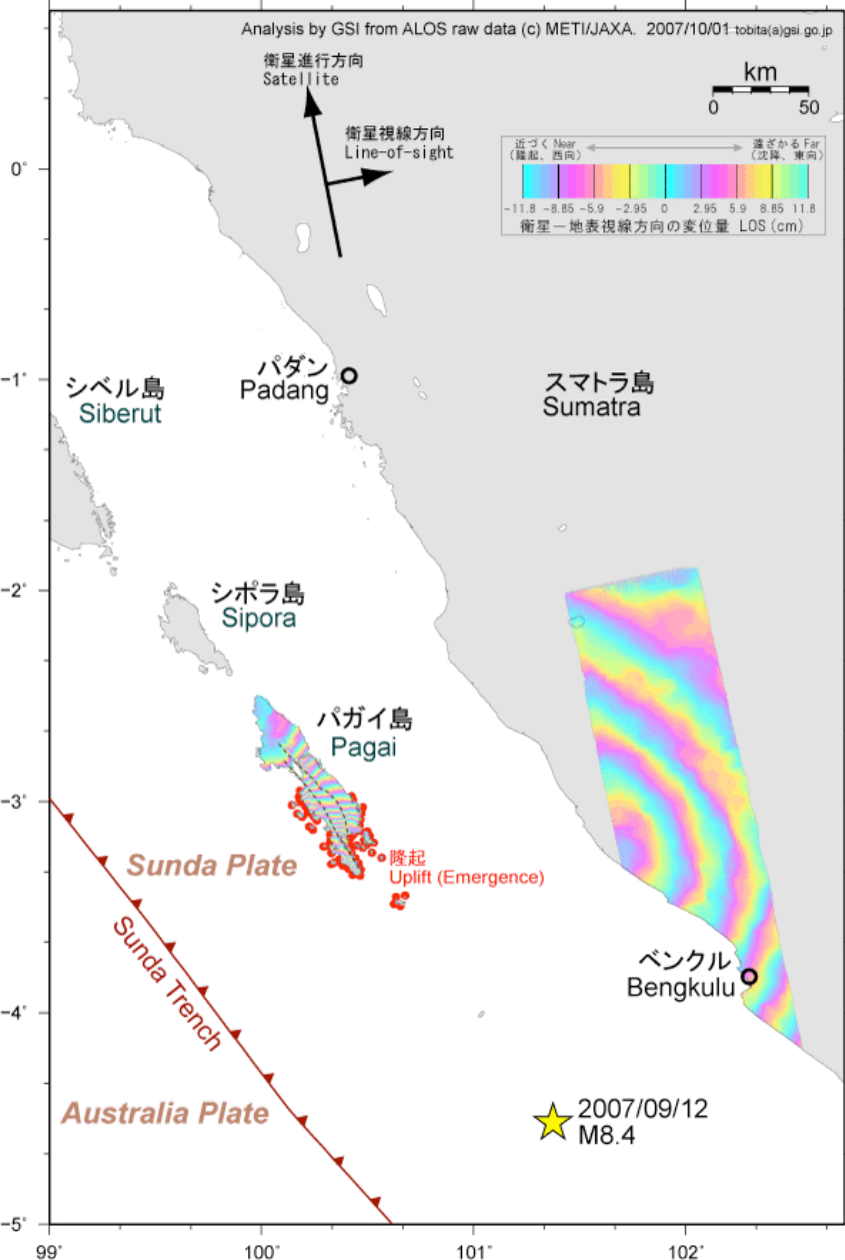
Tsunami threat for Padang (7 m a.s.l.)
previous event in 1833



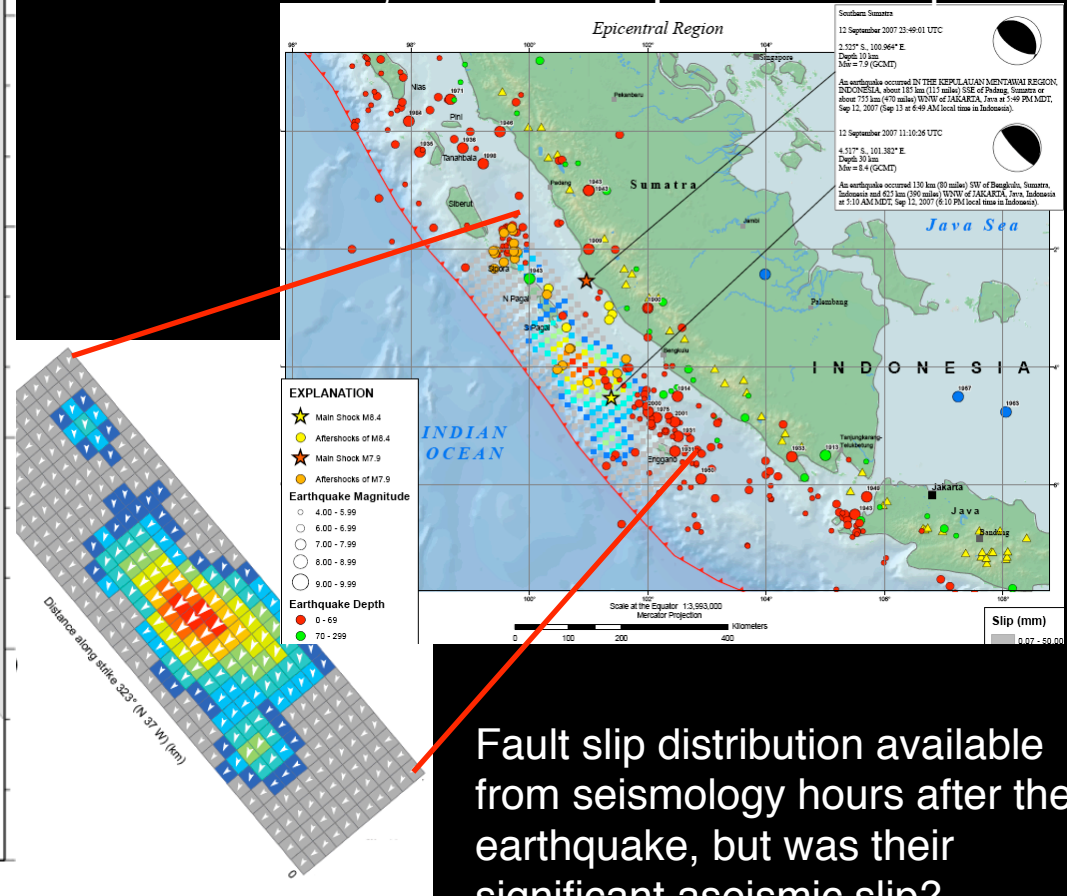
M=8.8
2.1E+22 Nm
Tsunami Energy= 1.8E+15 J

Natawidjaja et al., 2006

Example 2: Sumatra 2004-2007



M8.4, M7.9 earthquakes 12 Sep 2007



Fault slip distribution available from seismology hours after the earthquake, but was their significant aseismic slip?

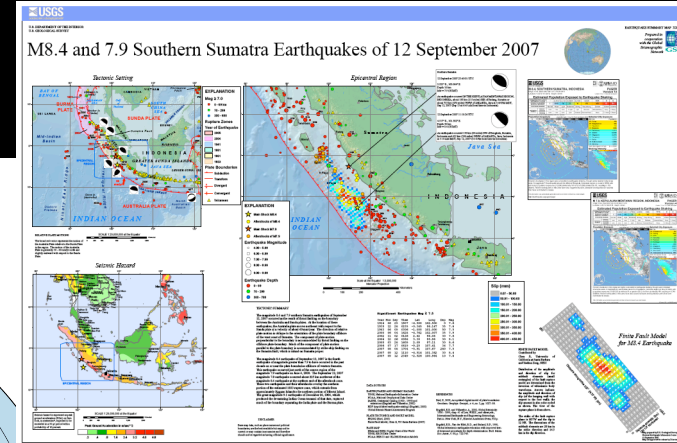
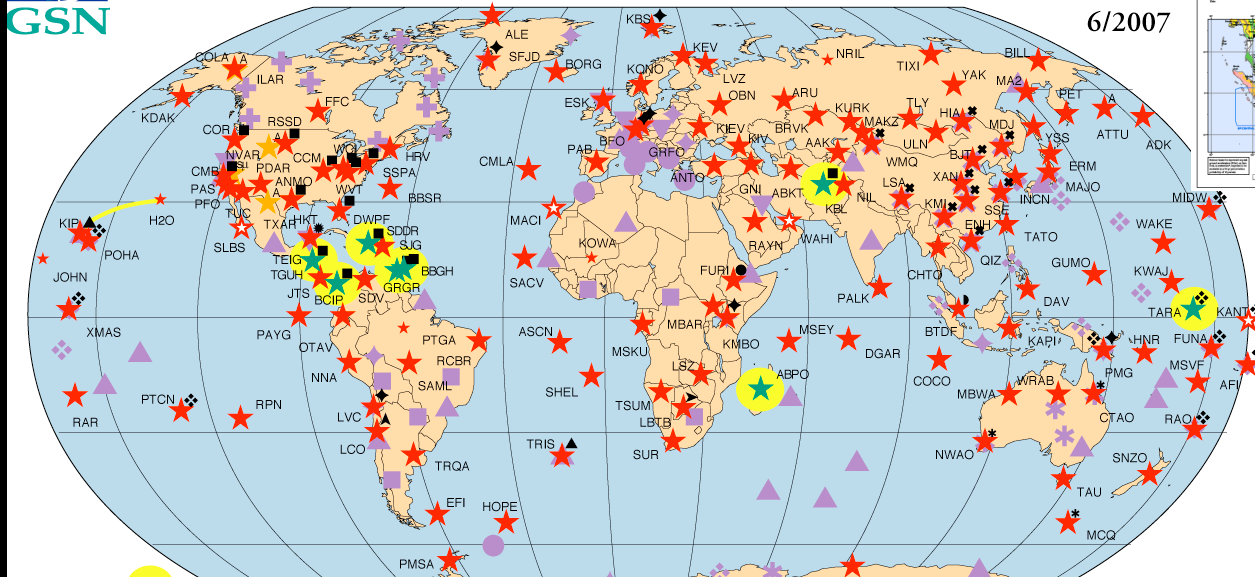
How do seismologists get near-real-time results ?

Distributed data sharing networks!



GLOBAL SEISMOGRAPHIC NETWORK
& INTERNATIONAL FEDERATION OF DIGITAL SEISMOGRAPHIC NETWORKS

6/2007



USGS NEIC interpretive posters
available 2-6 hours after earthquake



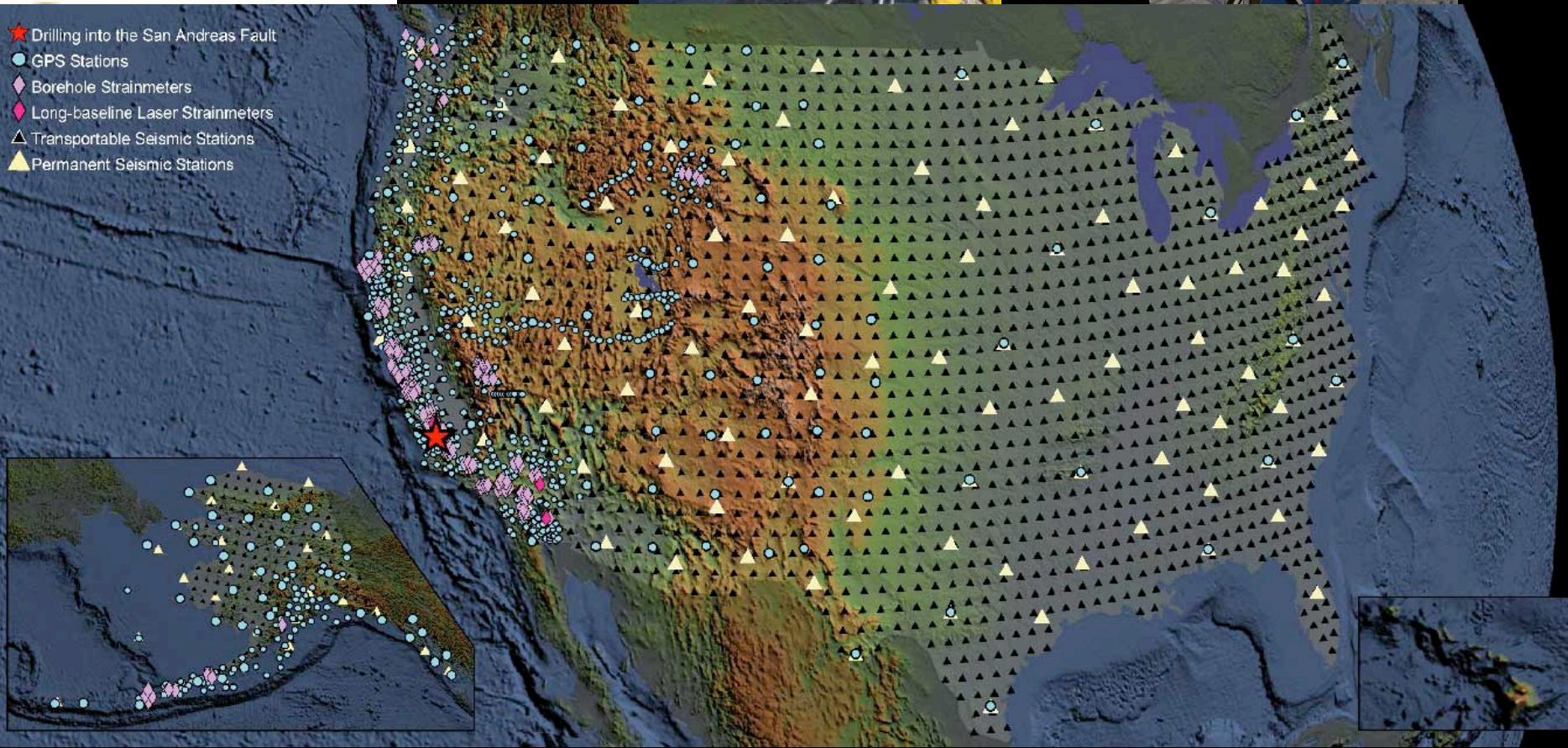
```
find_events -b 2007 -m 5 -R-130/-120/40/50 -r | \  
find_seismograms -c BHZ -B -2P -E 5S
```

IRIS's data sharing software

The Western North-America Natural Laboratory



- ★ Drilling into the San Andreas Fault
- GPS Stations
- ◇ Borehole Strainmeters
- ◇ Long-baseline Laser Strainmeters
- △ Transportable Seismic Stations
- ▲ Permanent Seismic Stations

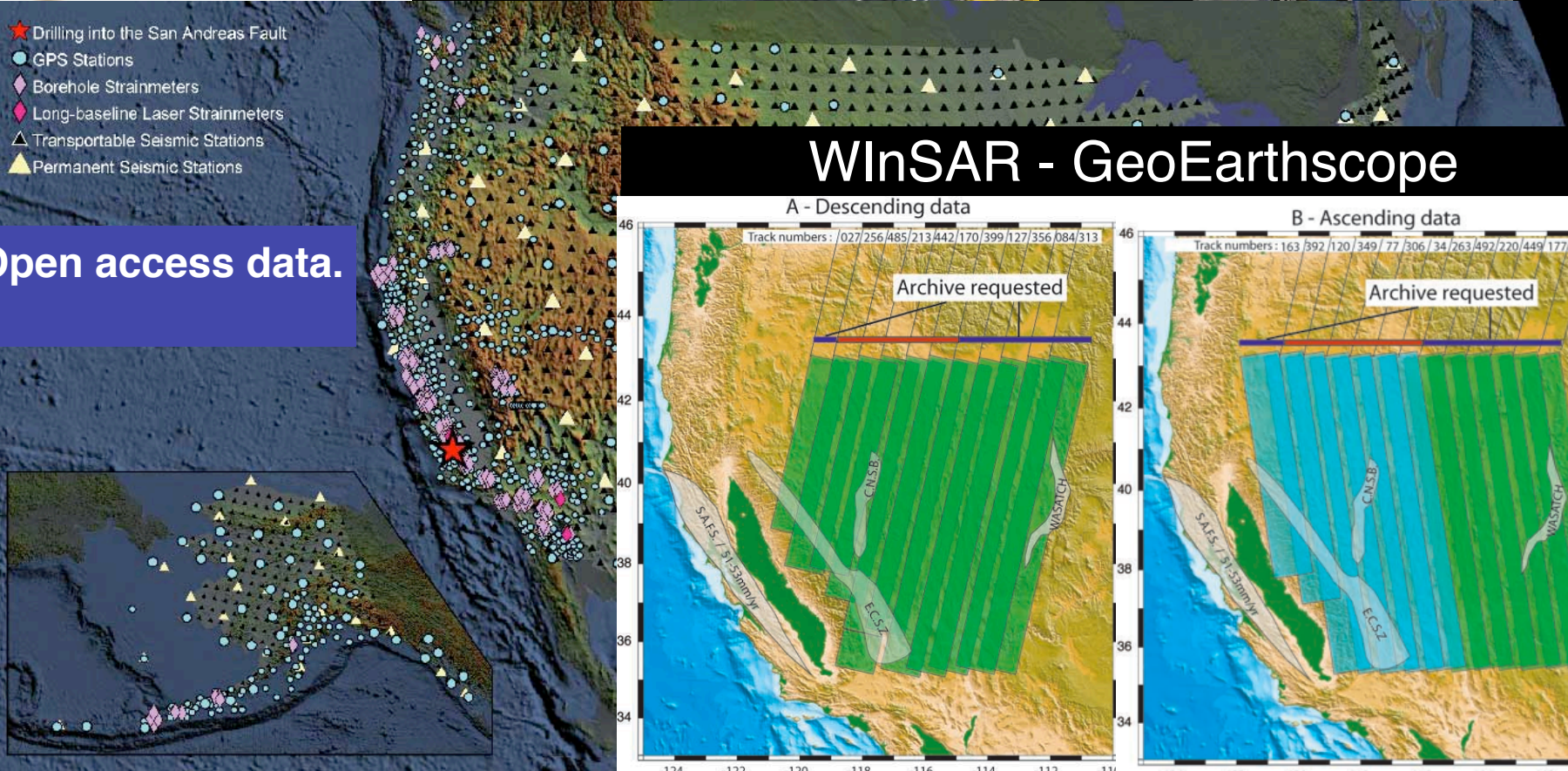


The Western North-America Natural Laboratory



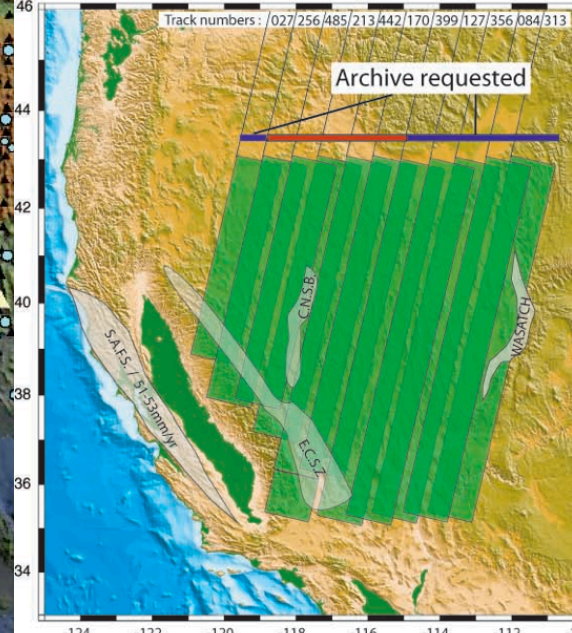
- ★ Drilling into the San Andreas Fault
- GPS Stations
- ◇ Borehole Strainmeters
- ◇ Long-baseline Laser Strainmeters
- △ Transportable Seismic Stations
- ▲ Permanent Seismic Stations

Open access data.

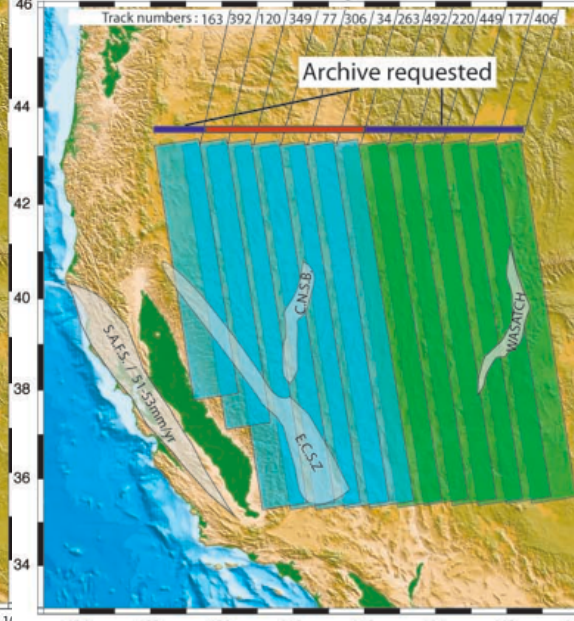


WinSAR - GeoEarthscope

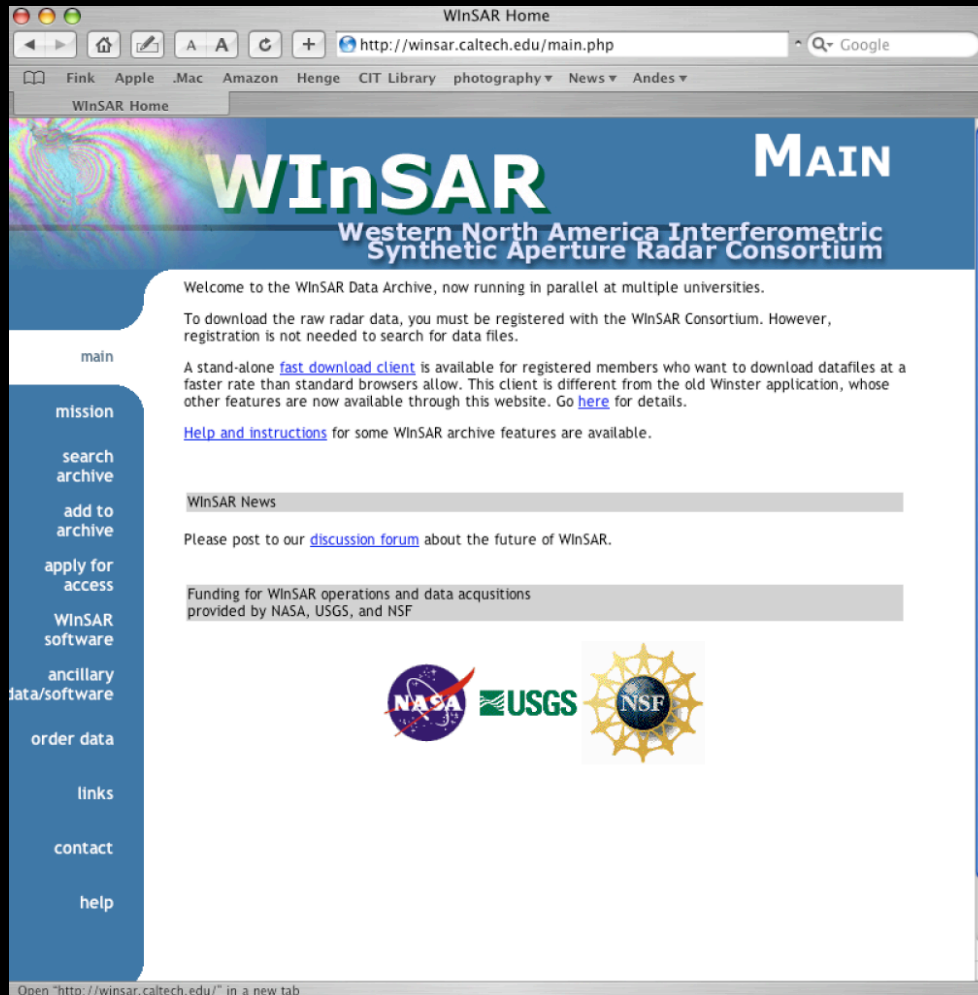
A - Descending data



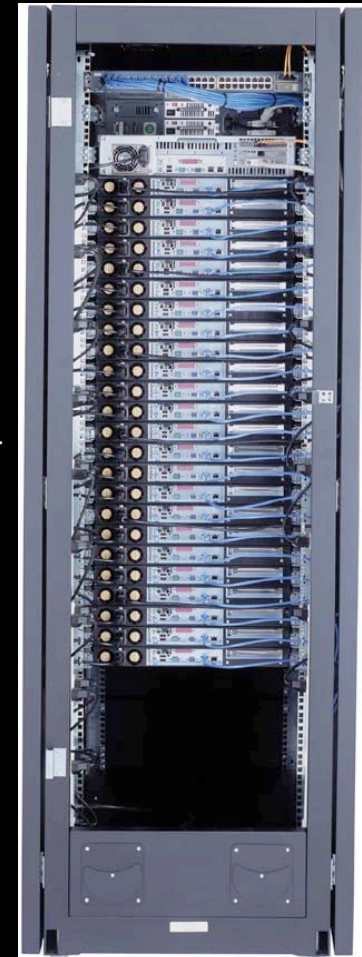
B - Ascending data



Western North American InSAR (WInSAR) data consortium



winsar.unavco.org



What is WinSAR ?

Internet SAR data portal for member institutions
(Password-protected SAR data sharing system)

Search and Order Data

WinSAR SEARCH
Western North America Interferometric Synthetic Aperture Radar Consortium

Numeric Criteria:
The numeric search form below will allow you to generate a list of data files matching your search criteria.

Map Criteria:
Alternatively, you can select a region on this map. Doing so should automatically fill in the proper sea (the track and frame ranges) on the numeric form. In some browsers (notably Safari) you may not see update until you click outside the map.

Search Form Fields:

- Radial Search:
 - Center Latitude:
 - Center Longitude:
 - Search Radius (km):
- Latitude:
 - Min: Max:
- Longitude:
 - Min: Max:
- Date:
 - From: Month: Day: Year:
 - To: Month: Day: Year:
- Track (Numeric Data Only):
 - From: To:
- Frame (Numeric Data Only):
 - From: To:
- Orbit #:

Map: A map of the Western North America region with several red dots indicating search locations. Buttons for 'Shift View', 'Select Region', and 'Zoom In' are visible below the map.

Note: If you don't see the applet running above automatically when you install the J2SE JRE or latest version; at least 1.3.1 is required for the Plug-in home page. If you are running JF 5 on a Mac, the Man Applet

WinSAR ORDERING
Western North America Interferometric Synthetic Aperture Radar Consortium

Search My Orders My Info

Save Results as Text

Order Checked Requests

Order#	sensor	phase	orbit	track	frame	bperp	bpar	datetime	lat1	lon1	lat2	lon2	lat3	lon3	lat4	lon4	description
<input type="checkbox"/>	E2	A	48120	170	2889	0	0	2004-07-03 18:31:10	36.1449	-117.838	35.9626	-116.763	35.0724	-116.996	35.2544	-118.059	requested by WinSAR user(s)
<input type="checkbox"/>	E2	A	29082	170	2889	-140	-173	2000-11-11 18:31:10	36.1449	-117.838	35.9626	-116.763	35.0724	-116.996	35.2544	-118.059	ordered by WinSAR
<input type="checkbox"/>	E2	A	32589	170	2889	-251	-99	2001-07-14 18:31:10	36.1449	-117.838	35.9626	-116.763	35.0724	-116.996	35.2544	-118.059	ordered by WinSAR
<input type="checkbox"/>	E2	A	47619	170	2889	-411	-199	2004-05-29 18:31:10	36.1449	-117.838	35.9626	-116.763	35.0724	-116.996	35.2544	-118.059	not archived at WinSAR
<input type="checkbox"/>	E2	A	47118	170	2889	-1132	-890	2004-04-24 18:31:10	36.1449	-117.838	35.9626	-116.763	35.0724	-116.996	35.2544	-118.059	not archived at WinSAR
<input type="checkbox"/>	E2	A	46617	170	2889	711	172	2004-03-20 18:31:10	36.1449	-117.838	35.9626	-116.763	35.0724	-116.996	35.2544	-118.059	not archived at WinSAR
<input type="checkbox"/>	E2	A	46116	170	2889	135	-42	2004-02-14 18:31:10	36.1449	-117.838	35.9626	-116.763	35.0724	-116.996	35.2544	-118.059	not archived at WinSAR
<input type="checkbox"/>	E2	A	45615	170	2889	-254	-185	2004-01-10 18:31:10	36.1449	-117.838	35.9626	-116.763	35.0724	-116.996	35.2544	-118.059	not archived at WinSAR
<input type="checkbox"/>	E2	A	45114	170	2889	-886	-582	2003-12-06 18:31:10	36.1449	-117.838	35.9626	-116.763	35.0724	-116.996	35.2544	-118.059	not archived at WinSAR
<input type="checkbox"/>	E2	A	44613	170	2889	-301	-202	2003-11-01 18:31:10	36.1449	-117.838	35.9626	-116.763	35.0724	-116.996	35.2544	-118.059	not archived at WinSAR
<input type="checkbox"/>	E2	A	44112	170	2889	744	226	2003-09-27 18:31:10	36.1449	-117.838	35.9626	-116.763	35.0724	-116.996	35.2544	-118.059	requested by WinSAR user(s)
<input type="checkbox"/>	E2	A	43611	170	2889	262	-90	2003-08-23 18:31:10	36.1449	-117.838	35.9626	-116.763	35.0724	-116.996	35.2544	-118.059	not archived at WinSAR
<input type="checkbox"/>	E2	A	43110	170	2889	-321	-177	2003-07-19 18:31:10	36.1449	-117.838	35.9626	-116.763	35.0724	-116.996	35.2544	-118.059	not archived at WinSAR
<input type="checkbox"/>	E2	A	42609	170	2889	-677	-175	2003-06-14 18:31:10	36.1449	-117.838	35.9626	-116.763	35.0724	-116.996	35.2544	-118.059	requested by WinSAR user(s)
<input type="checkbox"/>	E2	A	41607	170	2889	-1402	-789	2003-04-05 18:31:10	36.1449	-117.838	35.9626	-116.763	35.0724	-116.996	35.2544	-118.059	not archived at WinSAR
<input type="checkbox"/>	E2	A	41106	170	2889	496	97	2003-03-01 18:31:10	36.1449	-117.838	35.9626	-116.763	35.0724	-116.996	35.2544	-118.059	not archived at WinSAR
<input type="checkbox"/>	E2	A	40605	170	2889	-556	-409	2003-01-25 18:31:10	36.1449	-117.838	35.9626	-116.763	35.0724	-116.996	35.2544	-118.059	not archived at WinSAR

2-5 minutes download time for 1 scene
 Some institutions maintain mirrors (data processing from archive)

Western North American InSAR (WInSAR) data consortium

45 U.S. Member Institutions

Arizona State	Stanford	USGS
Caltech	U. Memphis	U. Utah
Central Washington	U. Miami	U. Texas
Cornell	UC San Diego	U. Hawaii
Harvard	UC Santa Cruz	U. Alaska
JPL	UC Los Angeles	Western Washington
LLNL	UC Davis	U. Nevada
MIT	UC Berkeley	U. Missouri
SDSU	USC	Purdue U.
U. Ohio		

8 International Member Institutions

PHILVOLCS (Phillipines)	Simon Fraser U. (Canada)
INGEOMINAS (Columbia)	U. of Western Ontario (Canada)
Canadian Geological Survey	CICESE (Mexico)
University College London (U.K.)	University of Beijing (China)

New members accepted by vote of Executive Committee

No commercial companies !

Mission

To provide access to as much raw InSAR data to as many geophysicists as possible (within constraints imposed by international space agencies and their commercial vendors).

Philosophy

- Data must be free to members, "Seismology effect"
- Simple and low cost (Internet distribution system)
- Minimal points of contact for funding/data agencies

Holdings

- 8000 ERS 1 and 2 (1992 - present) + Envisat, Radarsat, ALOS
- 3 TB of data

87 publications using WinSAR data !

3 types of membership:

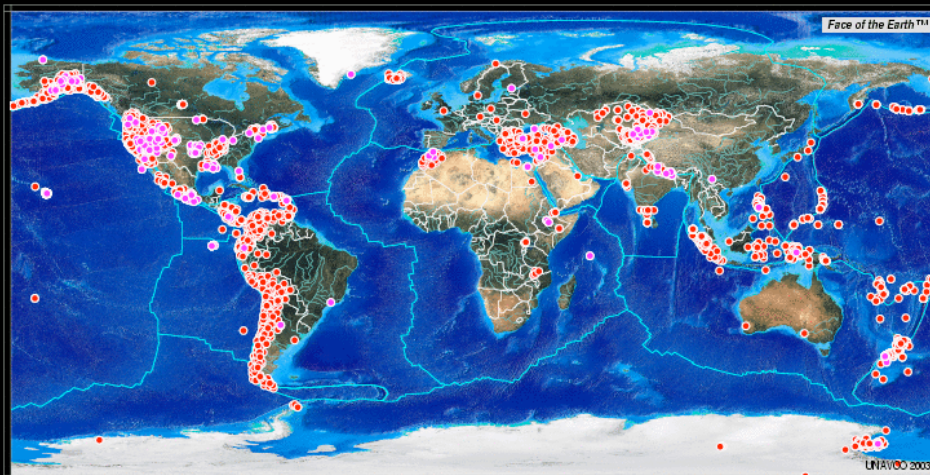
- Full: US institutions, full data access and order privilege.
- Adjunct-1: Canada and Mexico, full data access but no ordering.
- Adjunct-2: Rest of the world. Full access to all ALOS and Radarsat imagery. No ordering.

University NAVSTAR consortium



Mission: Promoting Earth science by advancing high-precision techniques for the measurement of crustal deformation

Activities: GPS support: permanent, campaign networks, data formats, data archiving
InSAR support: imagery acquisition and archiving (WinSAR, Natural labs)



GPS stations maintained by UNAVCO

Members: 67 U.S. + 43 foreign



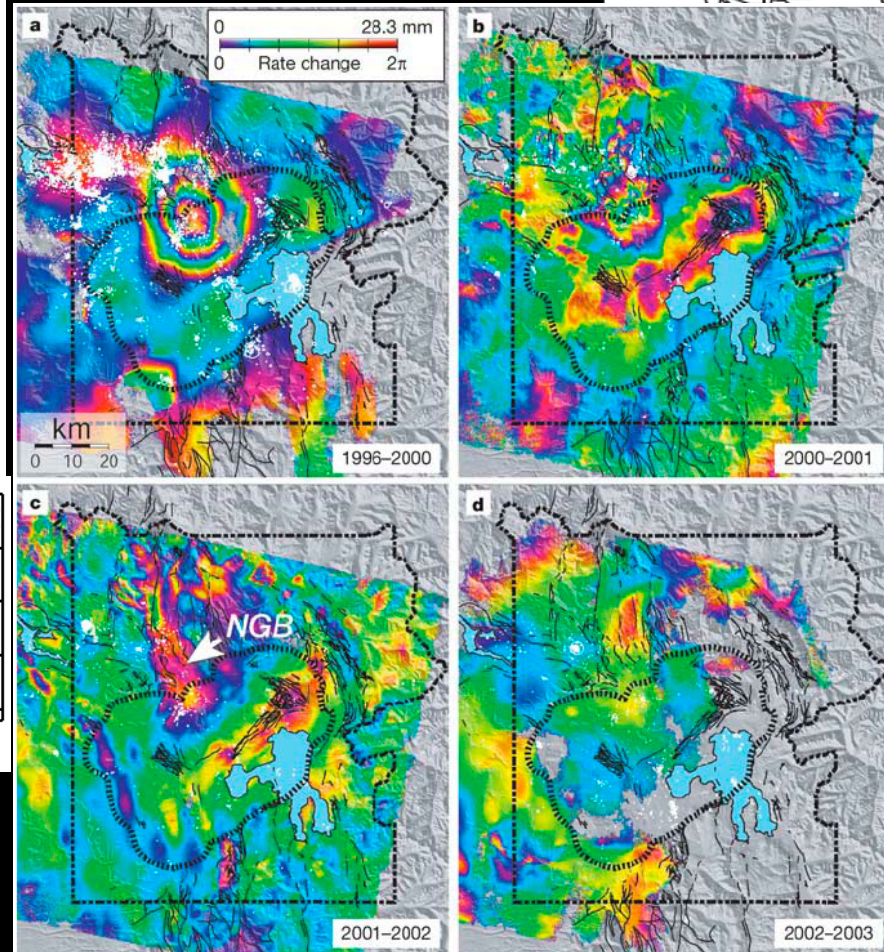
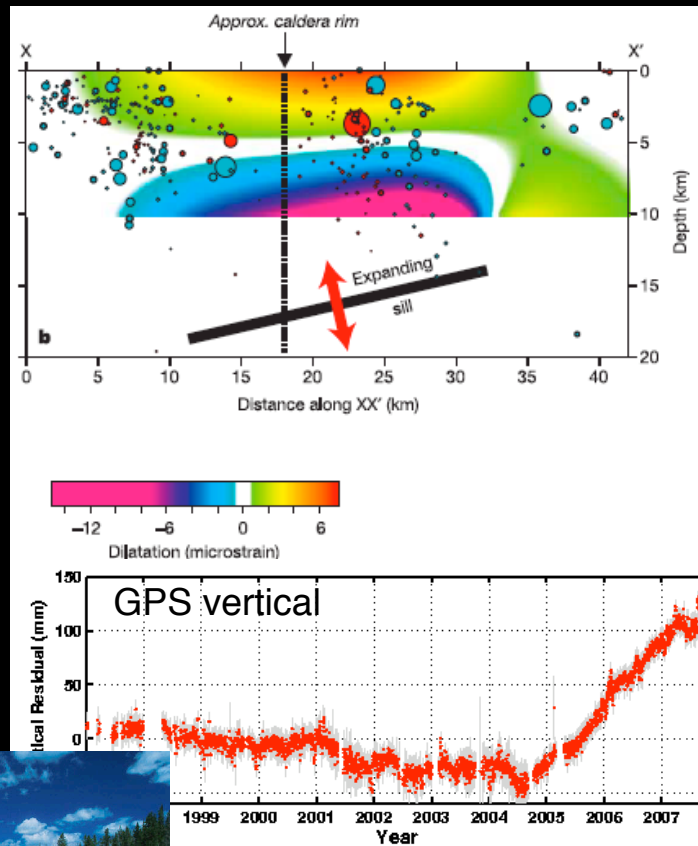
Sponsors:



WinSAR Science results (1): Yellowstone caldera

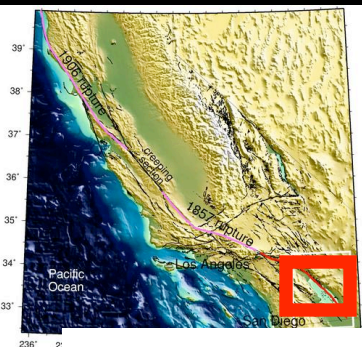


Model:

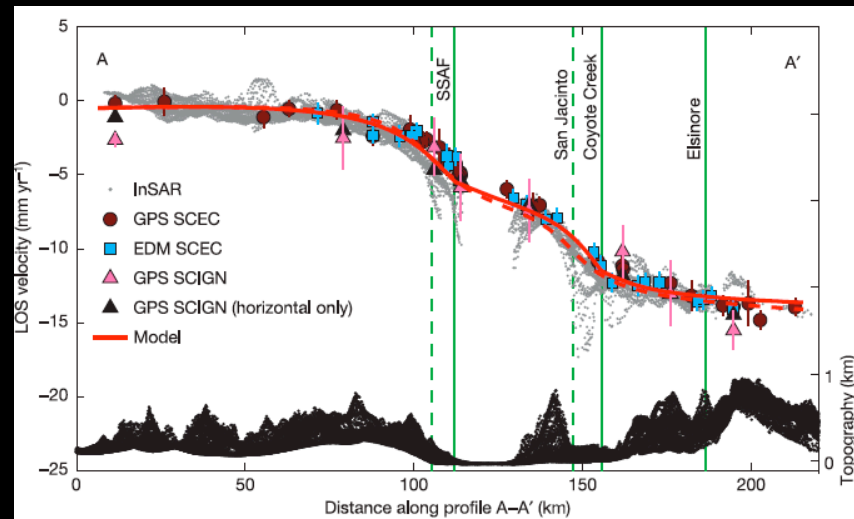
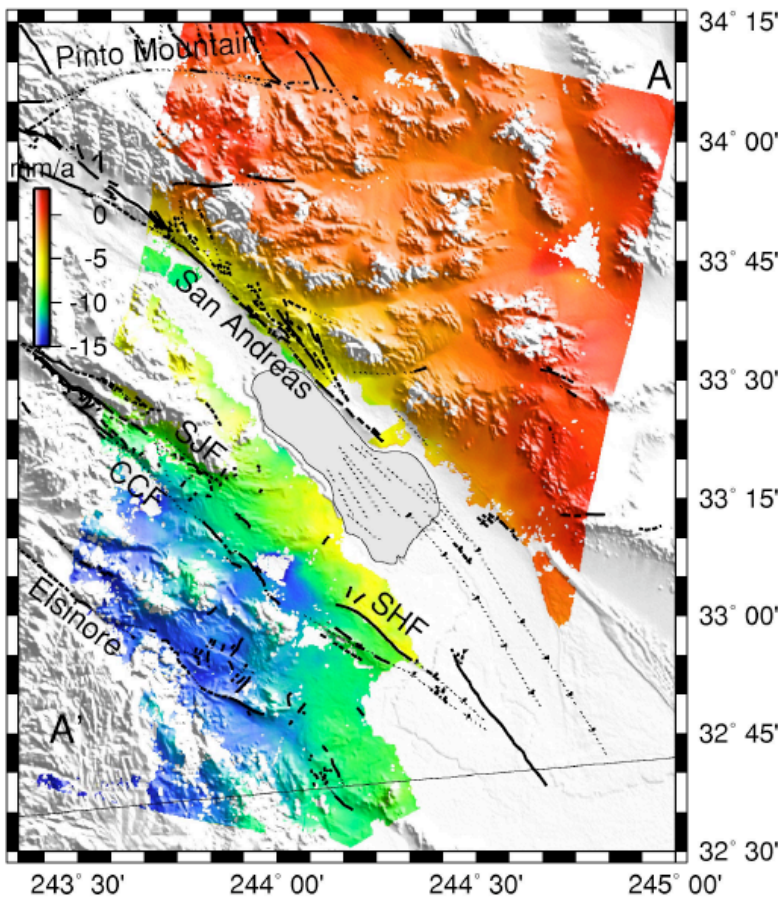


Science results (2): Southern San Andreas Fault

Equal strain partitioning between San Andreas and San Jacinto faults



Stack of 35 interferograms

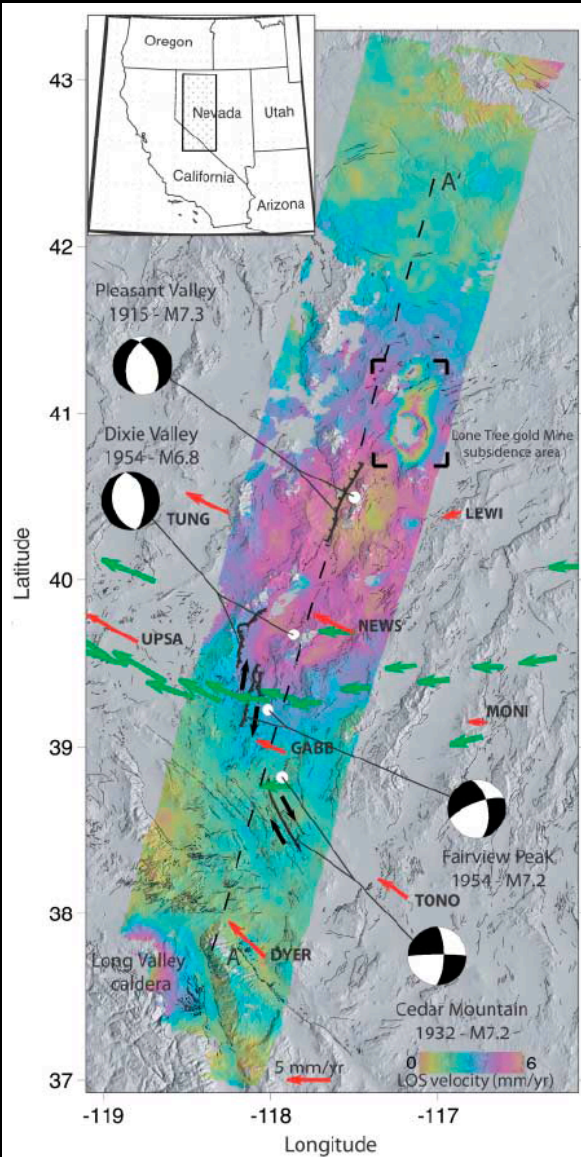


Fialko, Nature, 2006

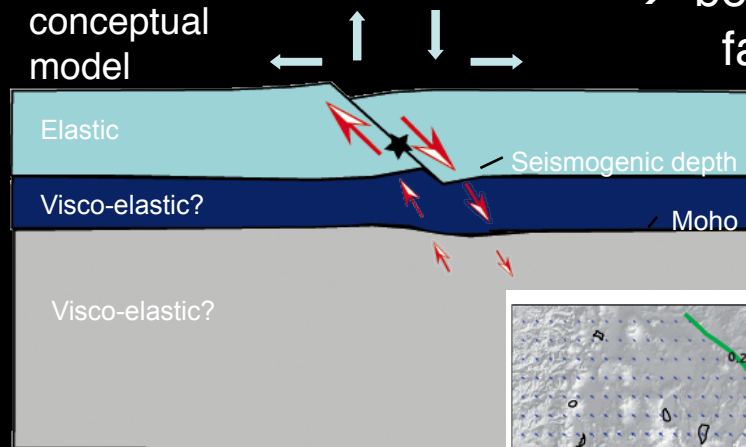
ERS1,2 SAR data

Science results (3): Nevada post-seismic deformation

Stack of 8 interferograms



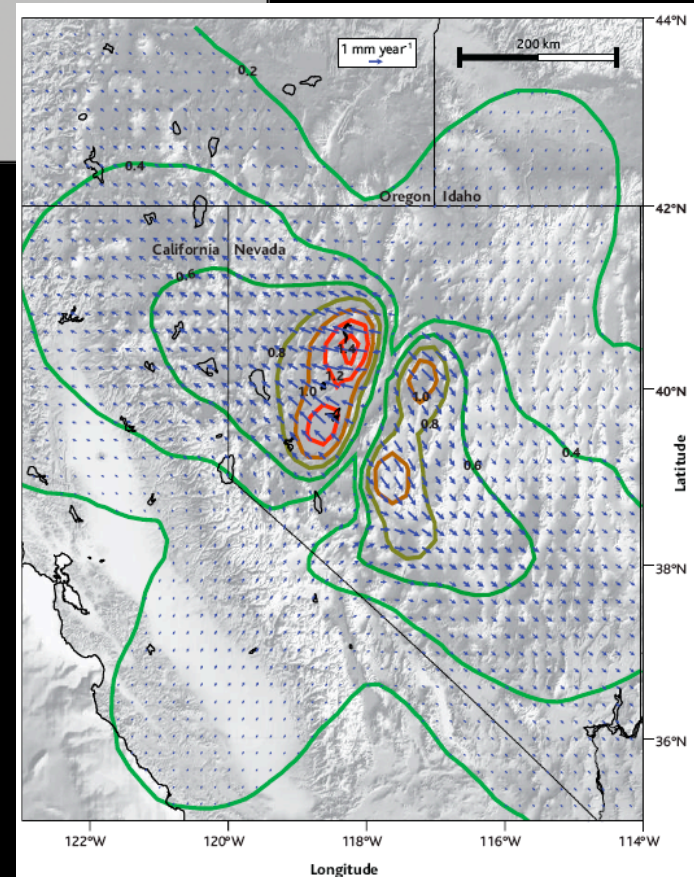
conceptual model



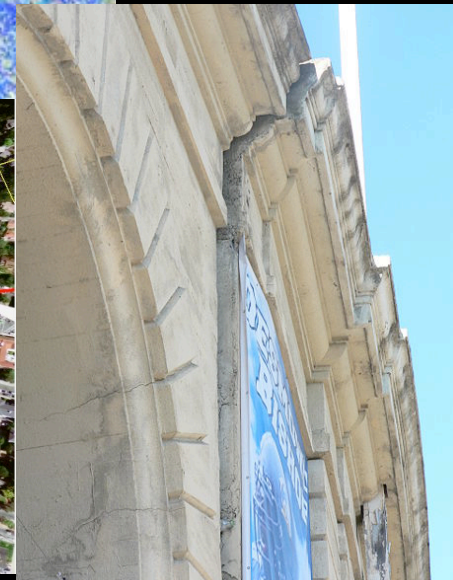
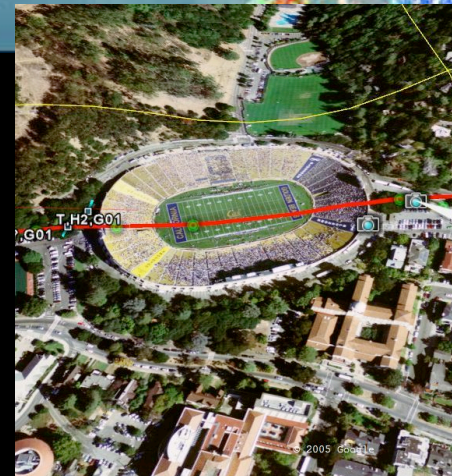
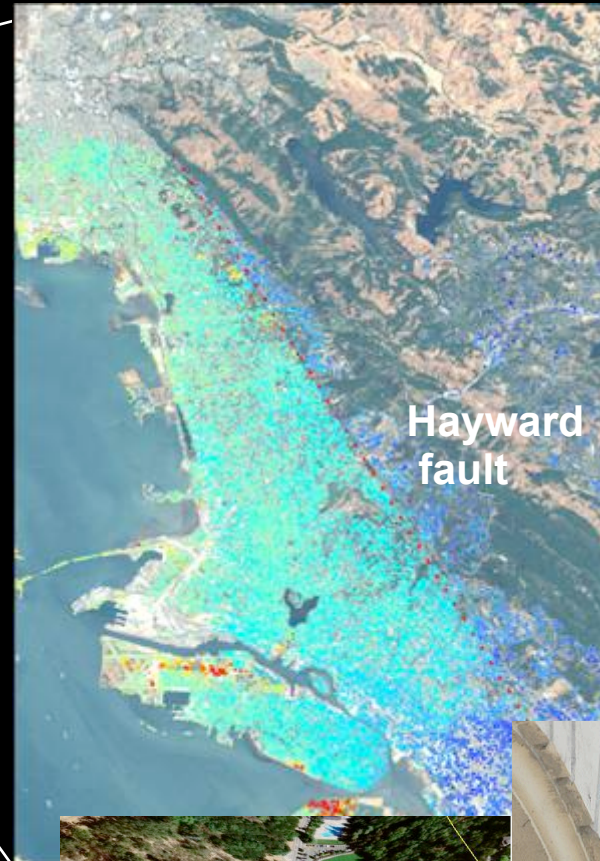
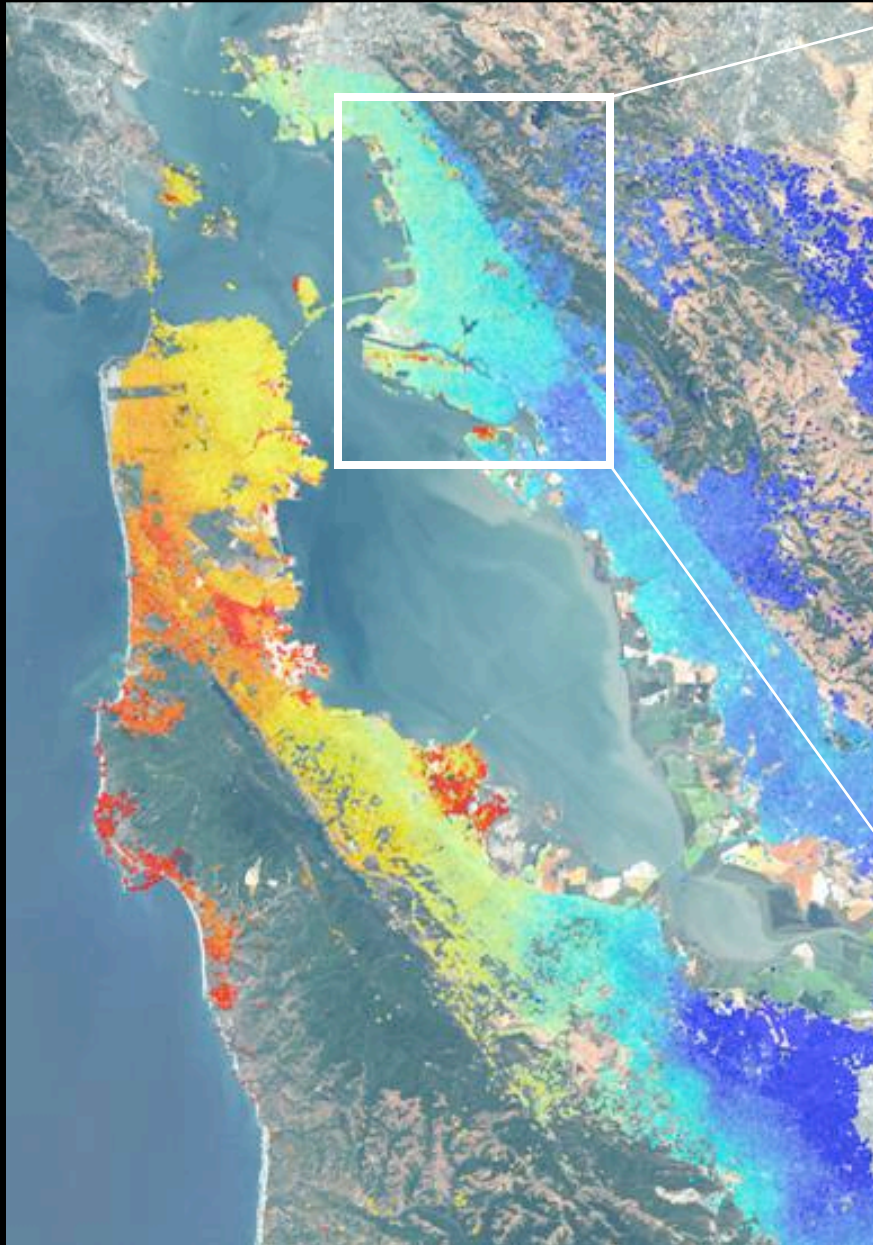
→ better understanding of fault loading rates

Several 1917-1954 M>7 earthquakes caused viscous flow in the Earth's mantle which is detectable at the Earth's surface.

Model prediction of post-seismic deformation field

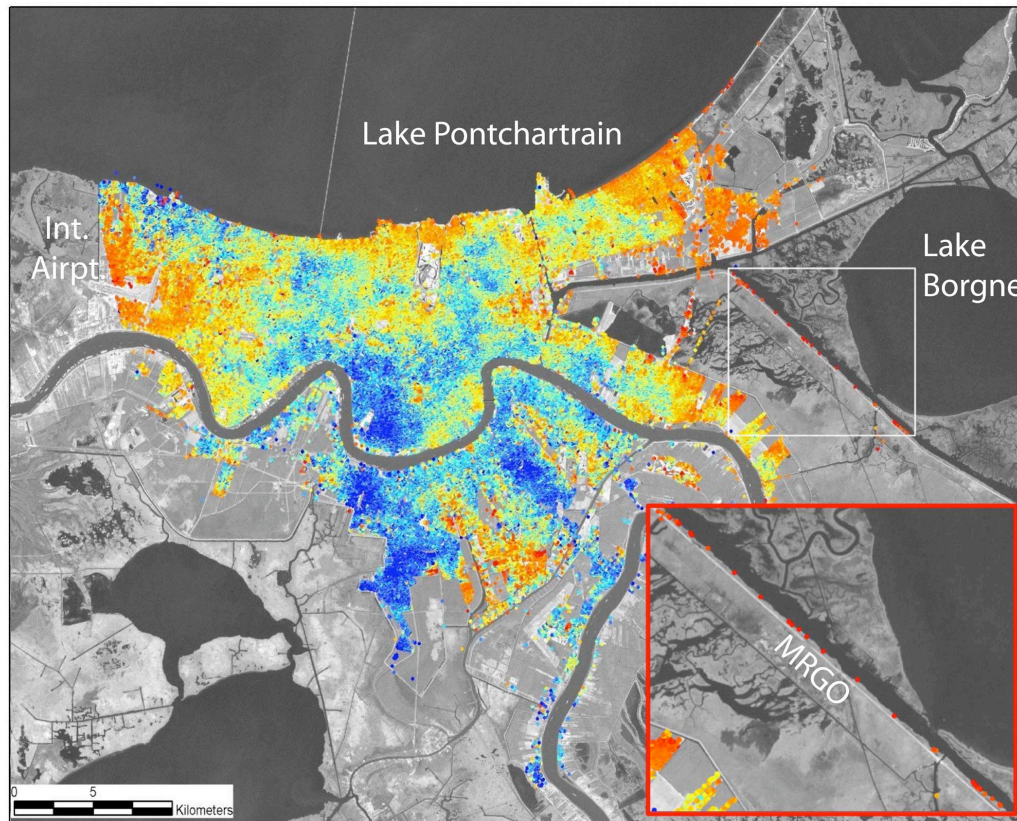
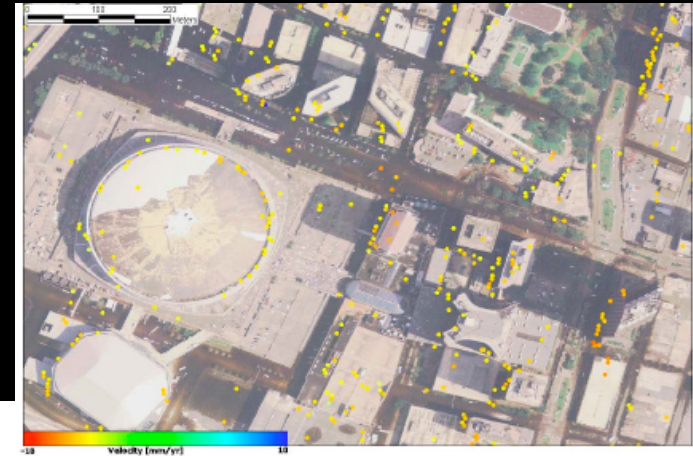


Science results (4): Creeping faults in San Francisco Bay area

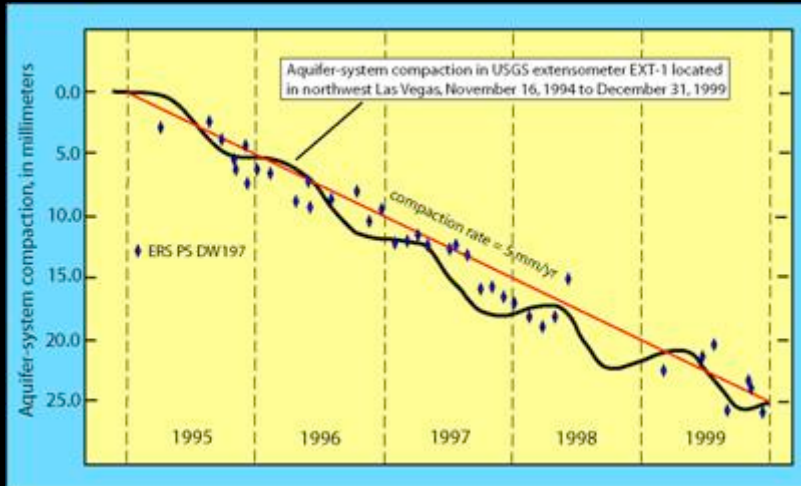
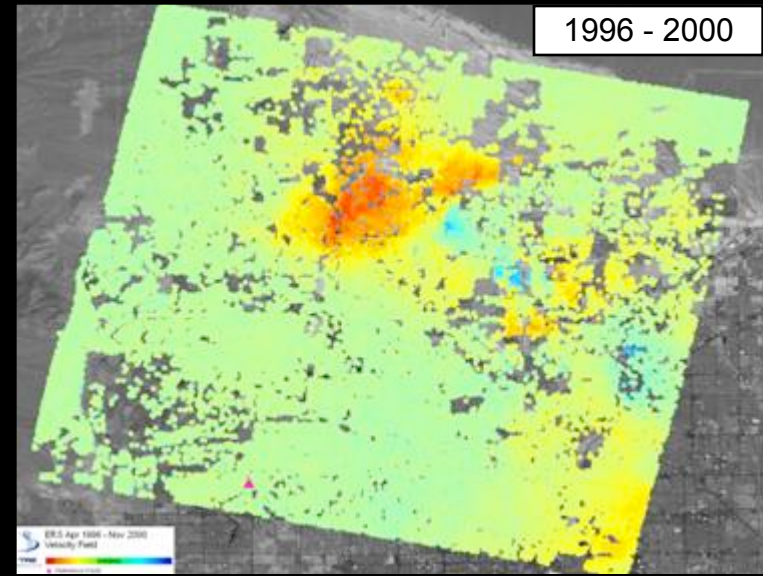
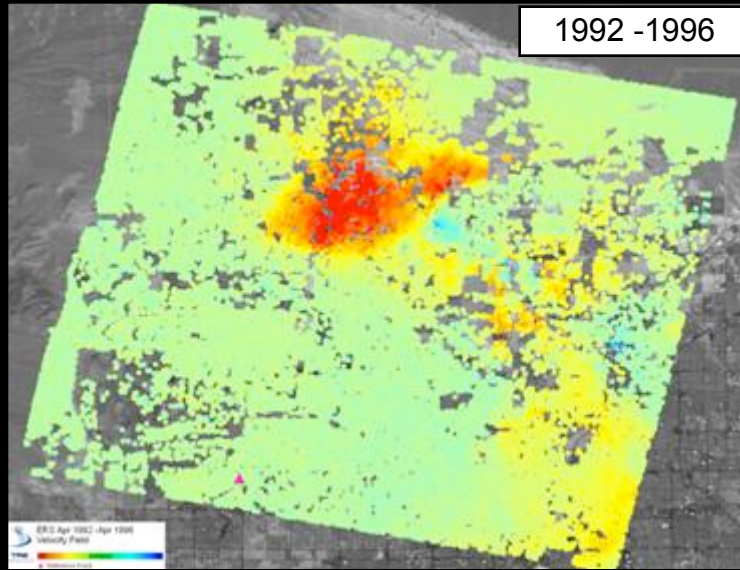


Buergmann et al., Science, 2000, Funning et al., 2007(?)

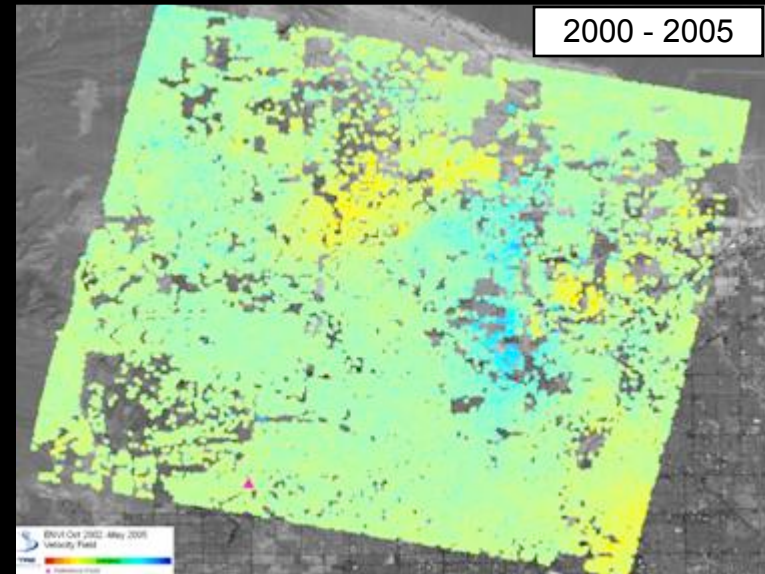
Science results (5): Land subsidence in New Orleans



Science results (6): Land subsidence in Las Vegas



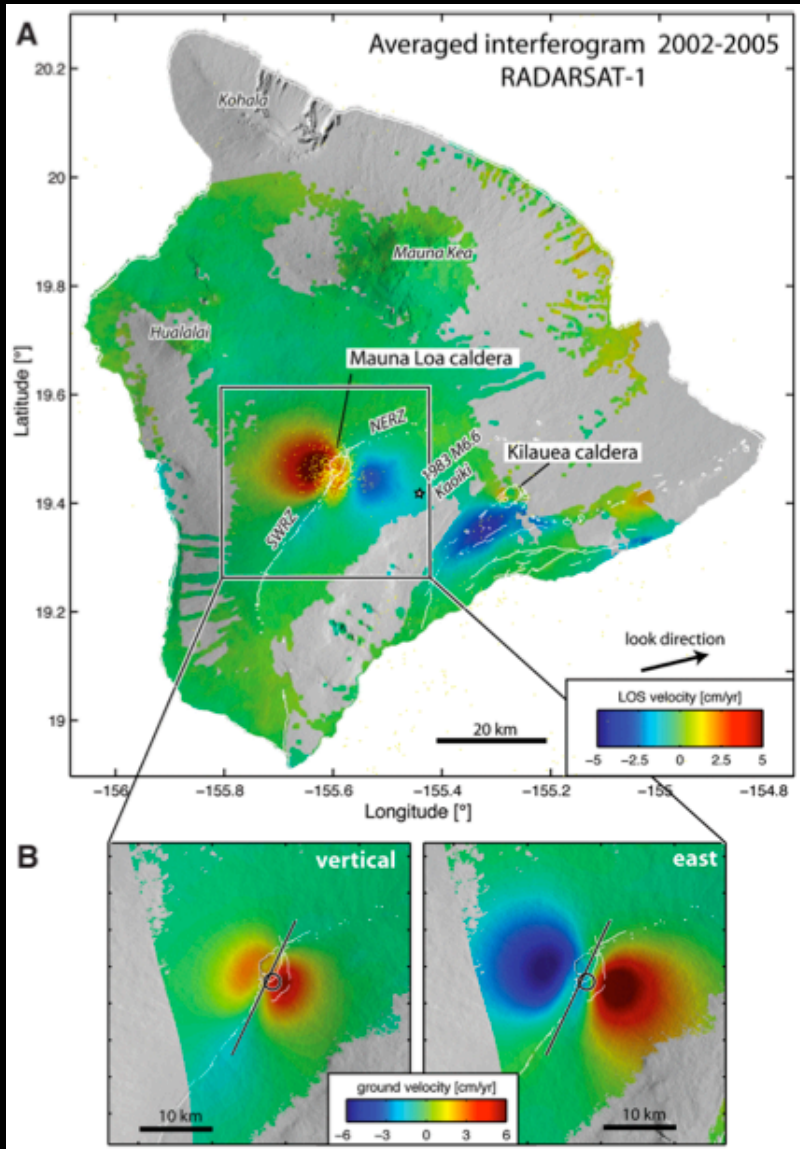
Courtesy of University of Nevada



Bell et al., WWR, in press

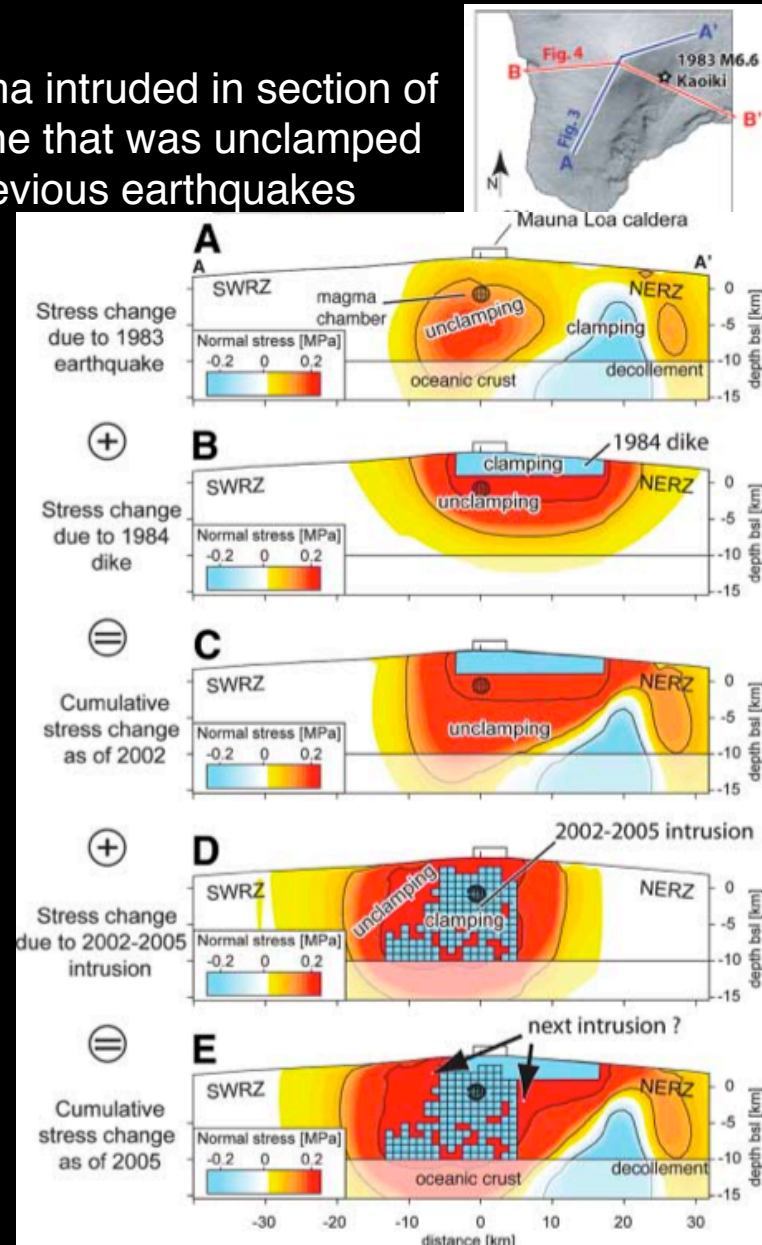
Science results (7): Inflation of Mauna Loa volcano, Hawaii

Magma intrusion into riftzone



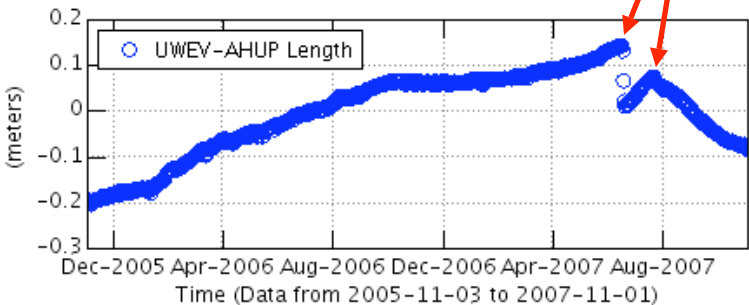
Magma intruded in section of riftzone that was unclamped by previous earthquakes

InSAR helps to predict eruption location !



Science results (8): June 2007 Kilauea crisis, Hawaii

June-July 2007 events

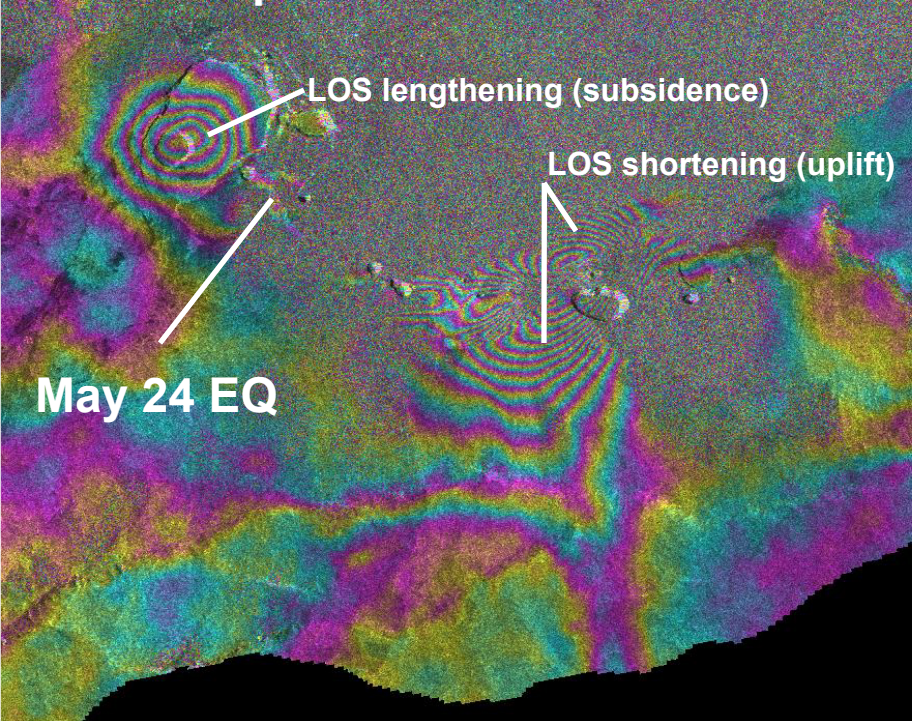


High note: near-real-time monitoring !
contributed in decision making

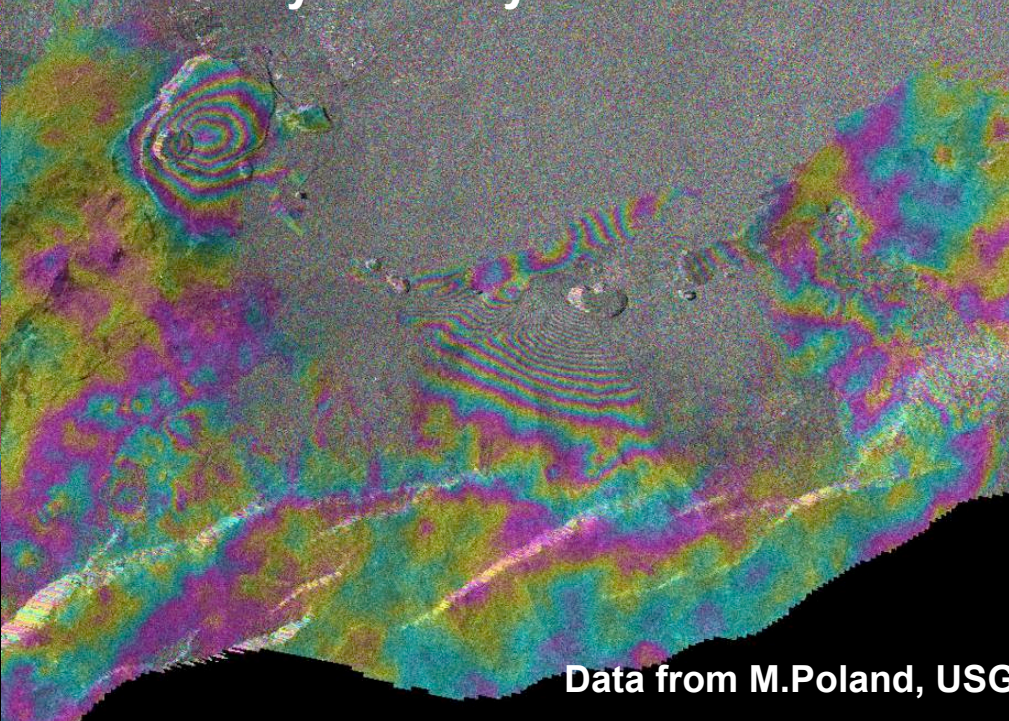
Low note: InSAR work occupied 1 staff member,
no time left for geophysical modeling

→ SAR imagery needs to be readily
available in near real time

Envisat: April 11– June 20 2007



Envisat: May 29 – July 3 2007



Recent high-impact publications


- 2004 Hilley, et al., Dynamics of slow-moving landslides from permanent scatterer analysis, *Science*, 304, 1952-1955.
- 2005 Gourmelen, N. and F. Amelung, Post-seismic mantle relaxation in the Central Nevada Seismic Belt, *Science* 310: 1473-1476.
- 2006 Fialko, Y., D. Sandwell, M. Simons, and P. Rosen, The origin of shallow earthquake slip deficit, *Nature*, 435.
- 2006 Fialko, Y., Interseismic strain accumulation and the earthquake potential on the southern San Andreas fault system, *Nature*, 441.
- 2006 Dixon, T. H., et al., Subsidence and flooding in New Orleans, *Nature*, 441, 587-588.
- 2006 Wicks, C., W. Thatcher, D. Dzurisin and J. Svarc, Uplift, thermal unrest and magma intrusion at Yellowstone caldera, *Nature*, 440, 72-75.
- 2007 Amelung, F., S.H. Yun, T. Walter and Paul Segall. Stress control of deep rift intrusion at Mauna Loa volcano, Hawaii. *Science*.
- 2007 Chang, W.-L., R. B. Smith, C. Wicks, J. M. Farrell, and C. M. Puskas, Accelerated uplift and magmatic intrusion of the Yellowstone Caldera, 2004 to 2006. *Science*.

**Publications rely on easy access to SAR
imagery through WinSAR !**

Recommendation:

Develop Natural Laboratory data facility to make SAR data available in near-real time for scientific research and disaster management!

- ⇒ Prototype facility exists at Unavco.
- ⇒ Uses WinSAR's software.
- ⇒ Can be moved to, or mirrored at, regional centers.
- ⇒ **NEEDS SAR DATA**



The screenshot shows a web browser window with the URL <http://naturallabs.unavco.org/main.php>. The page title is "Natural Laboratories". The header features the UNAVCO logo and the text "NATURAL LABORATORIES". A navigation menu on the left includes links for "main", "documents", "apply for access", "ancillary data/software", "links", and "contact". The main content area contains the following text:

Welcome to the Natural Laboratories SAR Archive at [UNAVCO](#).

This website provides Synthetic Aperture Radar data for the study of natural hazards in geologically active, natural laboratory regions. The data are provided in the spirit of NASA and the National Science Foundation (NSF) that easy access to Earth science data will promote their use, advance scientific research, and ultimately lead to a reduction of loss of life associated with natural hazards.

Data access is provided to [WinSAR](#) members and granted according to the rules of the data providers (the Space Agencies in most cases). WinSAR is the Western North America Interferometric Synthetic Aperture Radar consortium, a consortium of universities and research laboratories established to facilitate and advance Earth science research using SAR imagery. Any international research institution can apply for [WinSAR membership](#). Although WinSAR's original focus was Western North America, this website extends WinSAR's activities to natural laboratories in other parts of the world.

The Natural Laboratory website currently features JAXA (ALOS) and CSA (Radarsat-1) imagery. Click in a region in the map below for data access

The map shows a global view with several orange rectangular boxes highlighting specific regions: one in the Pacific Ocean near Japan, one in the Indian Ocean near Australia, one in the Atlantic Ocean near the Americas, and one in the Indian Ocean near the East African coast.

<http://naturallabs.unavco.org>

Recommendation:

Develop Natural Laboratory data facility to make SAR data available in near-real time for scientific research and disaster management!

- ⇒ Prototype facility exists at Unavco.
- ⇒ Uses WinSAR's software.
- ⇒ Can be moved to, or mirrored at, regional centers.
- ⇒ **NEEDS SAR DATA**



UNAVCO NATURAL LABORATORY

Welcome to the Southeast Asia Natural Laboratory !

On this website you can find SAR imagery to study natural hazards in South East Asia. We currently have archived ALOS PALSAR imagery. It is our plan that regional satellite downlink stations and international Space Agencies directly contribute imagery and develop this website into a clearinghouse for regional SAR imagery to better prepare for and respond to natural disasters.

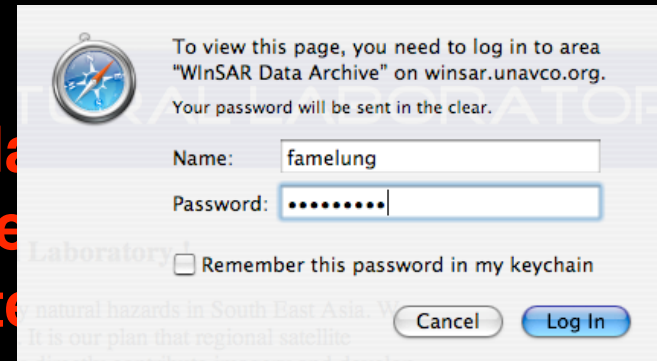
ALOS Data

[Links to data files for track T128, L41](#)
[Links to data files for track T213, L34](#)
[Links to data files for track T215, L41](#)

Recommendation:


Develop Natural Laboratory data archive to make SAR data available in new format for scientific research and disaster response.

- ⇒ Prototype facility exists at Unavco.
- ⇒ Uses WinSAR's software.
- ⇒ Can be moved to, or mirrored at, regional centers.
- ⇒ **NEEDS SAR DATA**



Recommendation:

**Develop Natural Laboratory data
make SAR data available in new
scientific research and disaster**



To view this page, you need to log in to area "WInSAR Data Archive" on winsar.unavco.org. Your password will be sent in the clear.

Name:

Password:

Remember this password in my keychain

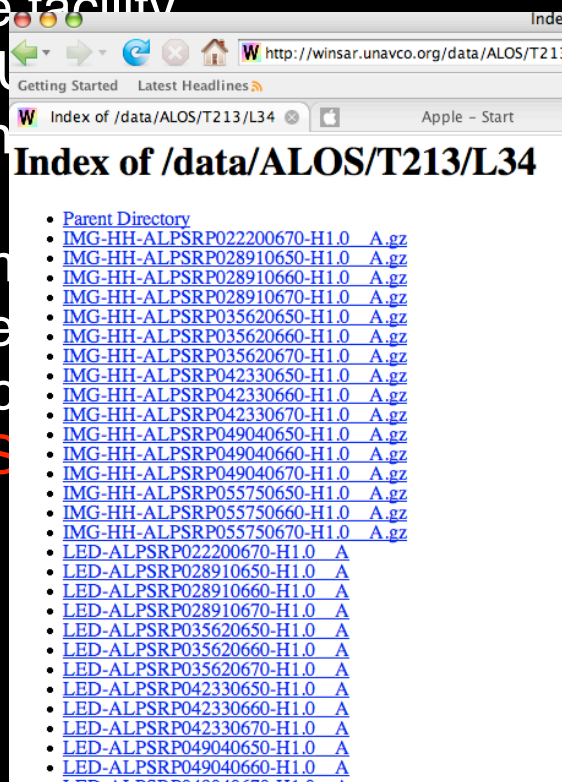
⇒ Prototype facility

exists at U

⇒ Uses Win software.

⇒ Can be mirrored or mirrored regional

⇒ **NEEDS S**



Getting Started Latest Headlines

Index of /data/ALOS/T213/L34

Apple - Start

Index of /data/ALOS/T213/L34

- [Parent Directory](#)
- [IMG-HH-ALPSRP022200670-H1.0](#) A.gz
- [IMG-HH-ALPSRP028910650-H1.0](#) A.gz
- [IMG-HH-ALPSRP028910660-H1.0](#) A.gz
- [IMG-HH-ALPSRP028910670-H1.0](#) A.gz
- [IMG-HH-ALPSRP035620650-H1.0](#) A.gz
- [IMG-HH-ALPSRP035620660-H1.0](#) A.gz
- [IMG-HH-ALPSRP035620670-H1.0](#) A.gz
- [IMG-HH-ALPSRP042330650-H1.0](#) A.gz
- [IMG-HH-ALPSRP042330660-H1.0](#) A.gz
- [IMG-HH-ALPSRP042330670-H1.0](#) A.gz
- [IMG-HH-ALPSRP049040650-H1.0](#) A.gz
- [IMG-HH-ALPSRP049040660-H1.0](#) A.gz
- [IMG-HH-ALPSRP049040670-H1.0](#) A.gz
- [IMG-HH-ALPSRP055750650-H1.0](#) A.gz
- [IMG-HH-ALPSRP055750660-H1.0](#) A.gz
- [IMG-HH-ALPSRP055750670-H1.0](#) A.gz
- [LED-ALPSRP022200670-H1.0](#) A
- [LED-ALPSRP028910650-H1.0](#) A
- [LED-ALPSRP028910660-H1.0](#) A
- [LED-ALPSRP028910670-H1.0](#) A
- [LED-ALPSRP035620650-H1.0](#) A
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- [LED-ALPSRP049040670-H1.0](#) A



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ALOS Data

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main
documents
apply for access
ancillary data/software
links
contact

<http://naturallabs.unavco.org>

Goal:

Obtain open, near-real-time access to **ALL** SAR data relevant for geophysical research (tectonics, volcanoes, land subsidence).

Why ?

Societal benefits through

- improved earthquake hazard assessment (earthquake forecasting)
- volcano monitoring and eruption forecasting
- assessing water resources
- subsidence monitoring of coastal cities --> forecast effect of sea-level rise

New InSAR studies should include the entire SAR archive. For example, a year-2050 scientist needs access to 1992 imagery.

Status of WinSAR/Geoeartscope:

1. ERS and Envisat:

Order and archive procedures in place.

Category-1 projects with ESA.

Entire archive through Super Cat-1 (Unavco is PI, Co-I's report to Unavco which reports to ESA, Mini Cat-1s).

2. Radarsat:

Entire North America archive will be transfered to WinSAR

Costs: free for data at ASF. \$150/datatake for data archived in Canada (Foreign Ground Station cost, FGS).

No restrictions from Canadian Space Agency!

Ingest software not complete.

3. ALOS:

Data obtained from the AADN (ASF) through credits with NASA, NSF.

Entire Western US archive expected.

Data in L-1 data pool at ASF, ingest software not complete.

4. JERS:

... not yet thought about ...

Supersite/Natural laboratory concept (1)

1. Concept put forward at International Geohazard conferences organized by IGOS Geohazard and GEO (Group of Earth Observation countries)
 - Recommendation of Kuala Lumpur 2006 Southeast Asia Geohazard workshop: **“To develop a satellite-based geophysical monitoring capability for SE Asia region”**.
 - “Frascati declaration” of 2007 International geohazard workshop: **”To develop an international effort to monitor and study selected reference sites by establishing open access to relevant datasets”**
2. Frascati Declaration endorsed by JAXA, NASA and CSA.
3. Proposed model:
 - WinSAR-type data archive at IGOS Geohazard in Orleans, France.
 - IGOS Geohazard will be Super Cat-1 user for ESA-data (Mini Cat-1s)
 - Data provided by ESA or contributed by WinSAR, INGV (and PIXEL ?).

(ESA has to charge for reproduction costs. No charges are required for already produced data. Data would be returned to ESA and then given to IGOS Geohazard).

 - JAXA should contribute ALOS/JERS imagery.
4. SAR and **ground-based data** (GPS, seismic data).

Supersite/Natural laboratory concept (2)

5. Site selection by community consensus: Well-studied sites plus sites to stimulate research.

U.S.: Yellowstone, Hawaii, San Francisco, Los Angeles, Las Vegas.

Canada: Vancouver.

Italy: Etna, Vesuvius.

Africa: Nyiragongo, Mt. Cameroon, Lengai.

Indonesia: Merapi, Mentawai seismic gap.

Japan: ?

6. Summary and next steps.

- ESA very supportive of Supersite/Natural Laboratory concept.
- IGOS Geohazard Joint Committee meeting on Jan 16.
- Space Agencies support data sharing networks as long as they don't have to do too much work.

InSAR community needs to put an international data sharing network in place !

Proposed Model for Data Sharing Network

1. Multiple international nodes with regional responsibilities:
 - WInSAR@Unavco: U.S. and rest of Americas
 - IGOS Geohazard: Supersites
 - PIXEL: Japan and rest of Asia
 - MACRES (Malaysia Center of Remote Sensing): SE Asia Radarsat
 - INGV Italy: Africa, Europe ?
2. Same or similar policies. Members of one node are automatically members of the other nodes.
 - Use WInSAR's archive/ingest system. Software coordination and maintenance by Unavco.
3. NASA is ally. Open data-sharing network is integral part of Desdynl mission. Opportunities if ALOS TDRS data link successful.

Next steps:

1. Coordinate between PIXEL and WinSAR. PIXEL members should become WinSAR members and WinSAR members become PIXEL members.
2. WinSAR strategic planning at UNAVCO Science workshop, Boulder, March 11-13, 2008. Representatives of PIXEL and JAXA are welcome !

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Domo arigato gozaimasu !