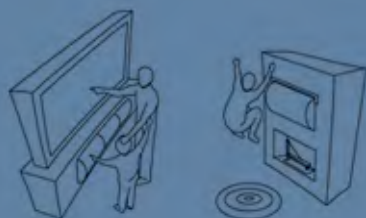
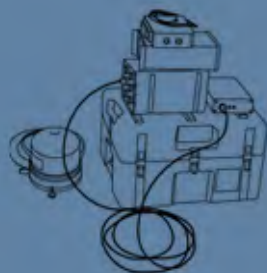




IRIS



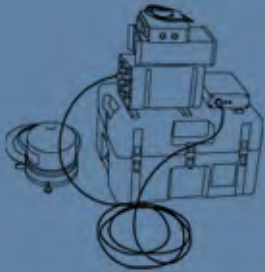
Earthquakes, Tsunamis and Nuclear Explosions: Open Data Exchange for Research and Monitoring in Seismology

David Simpson
IRIS Consortium
Washington, DC

**Symposium on
Data Sharing Plans for GEOSS
and
Benefits of Data Sharing for Science
Woodrow Wilson International Center for Scholars
November 16, 2009**



IRIS



Seismology - A Global and International Science

Earthquakes occur and are observed *globally*
International data exchange essential for monitoring and research

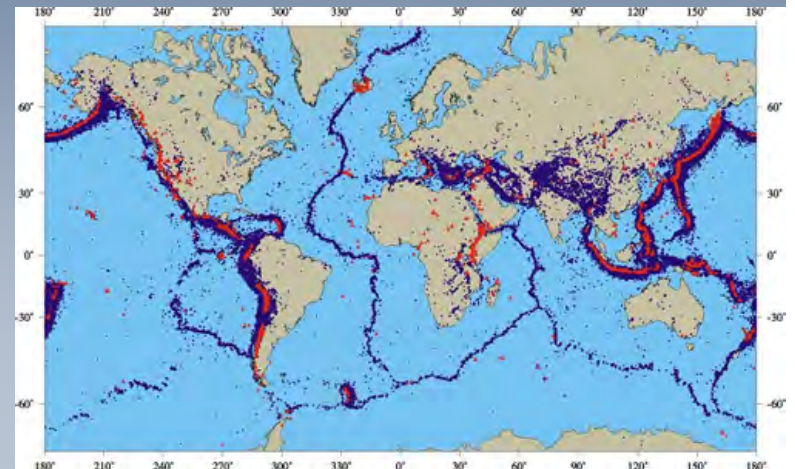
Seismology supports a rich portfolio of research and societal applications:

Research:

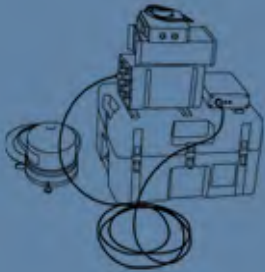
- Deep Earth structure
- Global Seismicity
- Earthquake source processes

Applications:

- Earthquake hazards
- Monitoring nuclear test ban treaties



IRIS

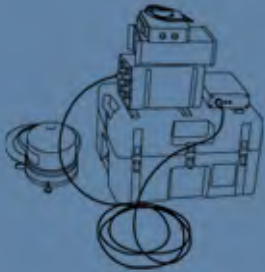


Evolution of Global Networks



British and Jesuit Networks
1900 - 1930's

IRIS

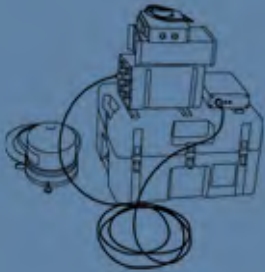


Evolution of Global Networks

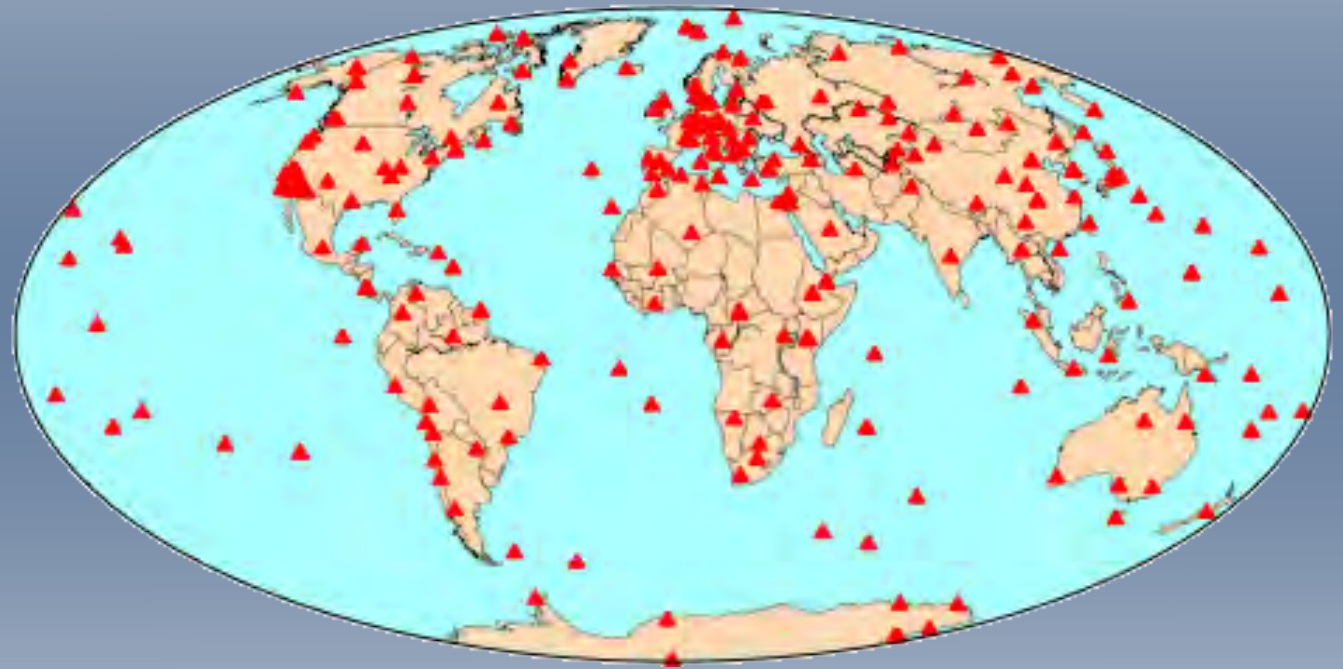


World Wide Standardized Seismographic Network
1960 - 1980's

IRIS

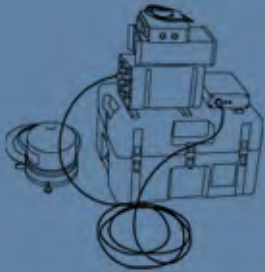


Evolution of Global Networks

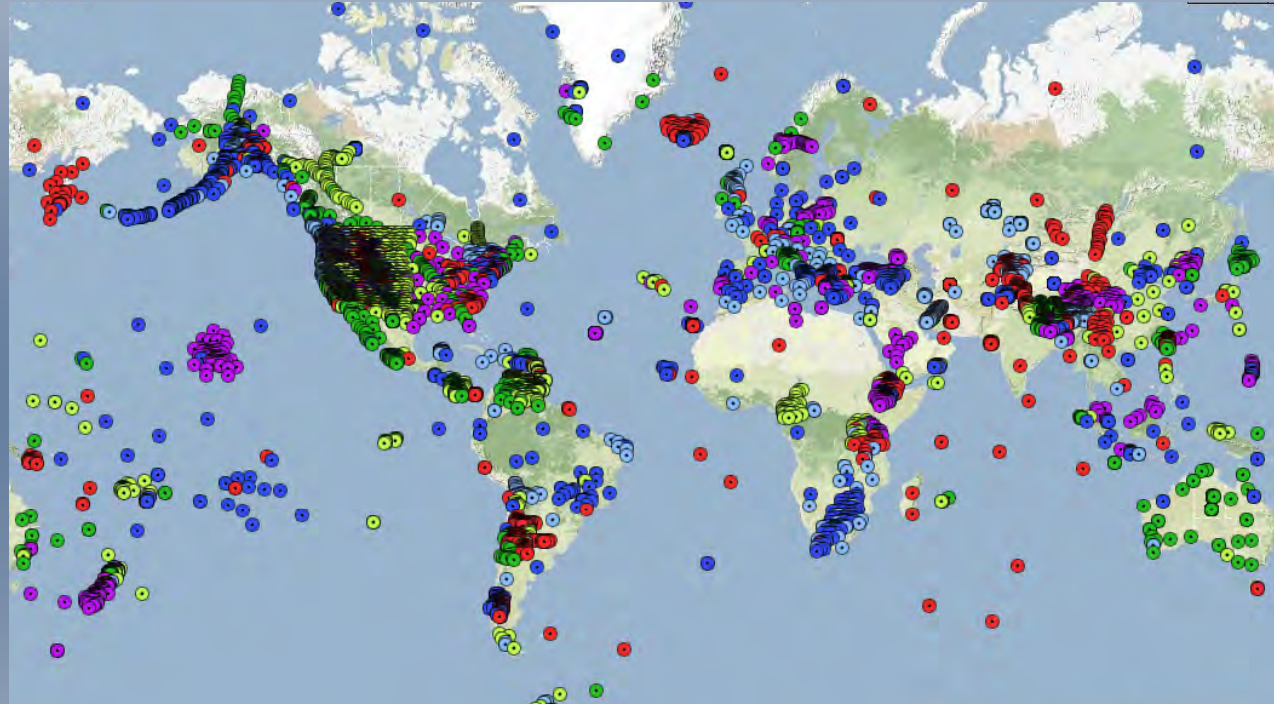


Federation of Digital Broadband Networks
2009

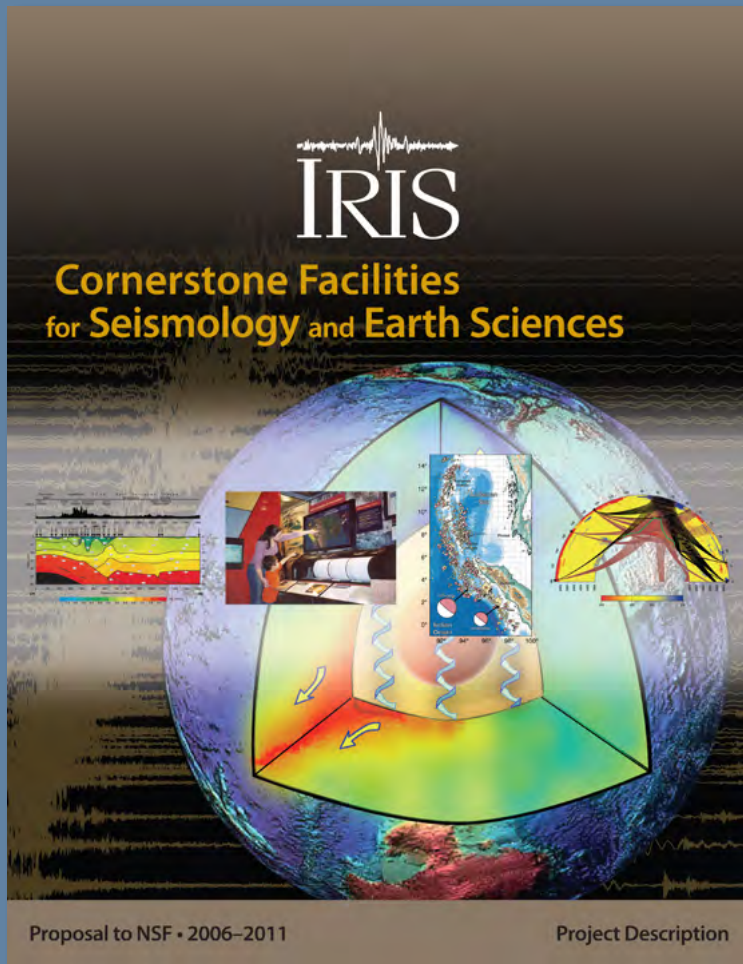
IRIS



Evolution of Global Networks



Holdings at IRIS Data Management Center, 2009
Continuous waveform data from 12,007 stations
from 248 permanent networks and temporary experiments



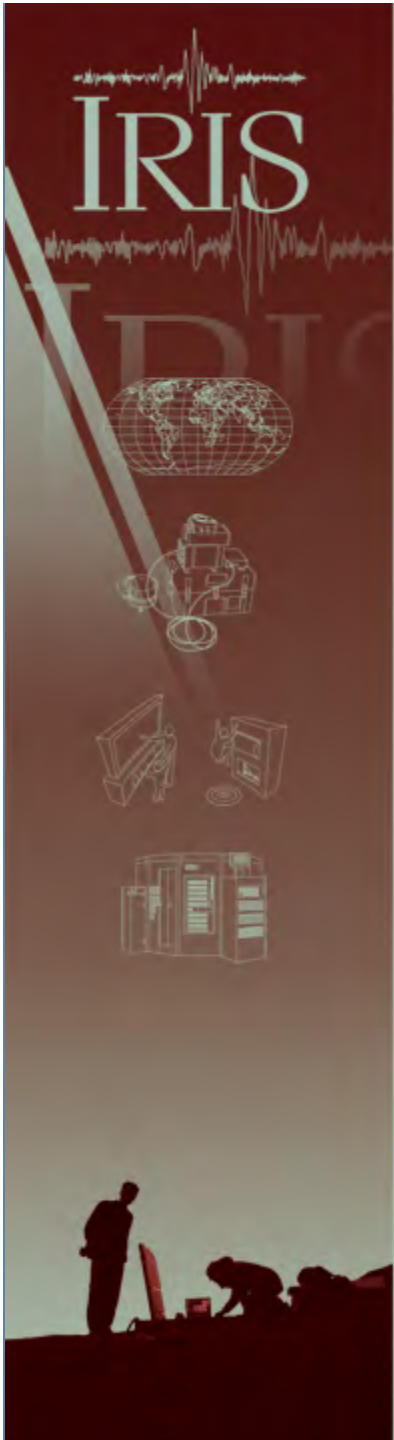
A facilities program established in 1984 to support research and education in the Earth sciences through the collection and distribution of seismological data for studies of:

- Earthquakes
- Earth Structure
- Earth Dynamics
- Verification of the CTBT

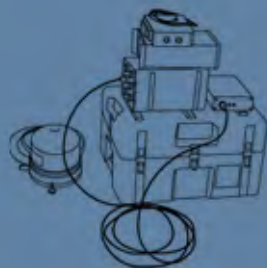
Developed and managed by the IRIS Consortium.
Funded through Cooperative Agreements with the
National Science Foundation, Earth Sciences Division
Instrument and Facilities Program
EarthScope Program
with additional funding from NSF/OPP,EHR, and DOE.
Implemented in cooperation with the USGS and
international partner organizations

IRIS Consortium Mission Statement

- Facilitate and conduct geophysical investigation of seismic sources and Earth properties using seismic and other geophysical methods.
- **Promote exchange of geophysical data and knowledge, both through use of standards for network operations, data formats and exchange protocols, and through pursuing policies of free and unrestricted data access.**
- Foster cooperation among IRIS Members, Affiliates, and other organizations in order to advance geophysical research and convey benefits from geophysical progress to all of humanity.



IRIS



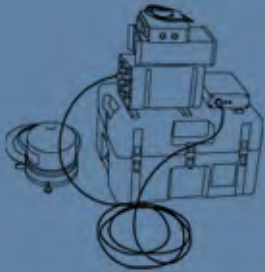
IRIS Core Programs *Global Seismographic Network (GSN)*



IRIS GSN	Australia	Canada	France	Germany	Italy	Japan	U.S.	Other
★	✱	+	▲	◆	●	❖	■	▼

Uniform global coverage
in cooperation with US Geological Survey
and partners in the international
Federation of Digital Seismograph Networks

IRIS



Global Seismographic Network



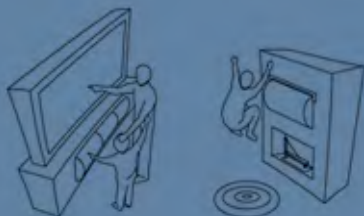
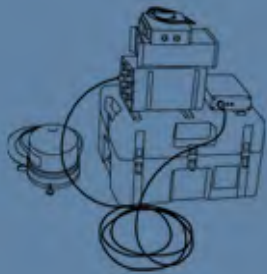
Falkland Islands Station (EFI)

150 GSN stations in unattended locations worldwide

- including remote oceanic islands and polar regions
- previously inaccessible regions of China and the former Soviet Union

Integration with national and regional networks in many developing nations

IRIS



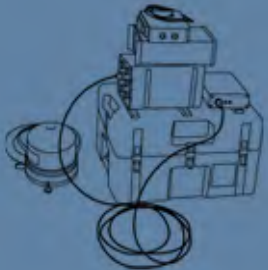
Global Seismographic Network



IRIS-established standards for observatory instrumentation

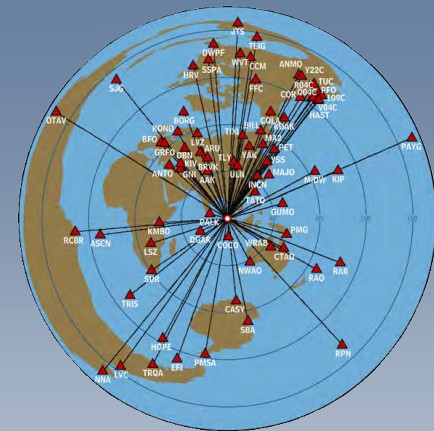
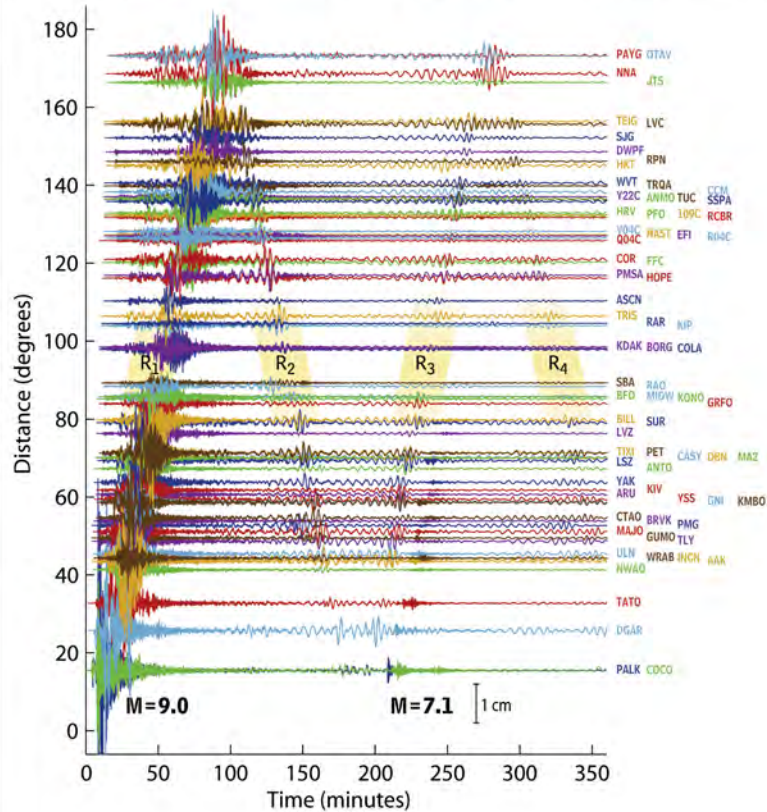
- Broadband (3000 sec to 10 hz), high resolution (24 bit)
- Continuous recording
- Real time telemetry at most sites
- Free and open data access

IRIS



Great Earthquakes

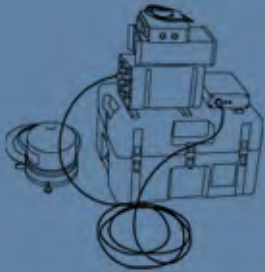
Sumatra - Andaman Islands Earthquake ($M_w=9.0$)
Global Displacement Wavefield from the Global Seismographic Network



On scale recording of the M 9.3 Sumatra-Andaman earthquake of Dec 26, 2004

- First detailed observations of a great tsunami generating earthquake
- Complex 500 second rupture of 1600km fault

IRIS



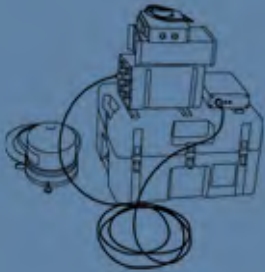
IRIS Core Programs

Program for the Array Seismic Studies of the Continental Lithosphere (PASSCAL)



Free access to portable instrumentation for use in NSF-funded research programs
Collaborative, international, multi-institution, multi-disciplinary
Requirement to deliver data to IRIS Data Management Center
for open release following 2-year proprietary period

IRIS



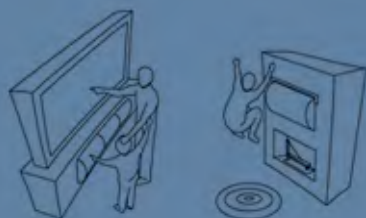
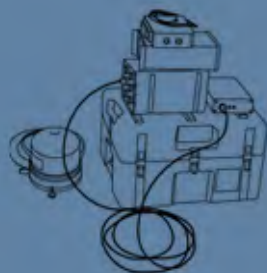
PASSCAL



Temporary field installations

- Deployments of 10's to 100's of instruments
- Experiments lasting from 1-2 weeks to 3 years

IRIS



Alaska. STEEP experiment.



La RISTRA, New Mexico.



Venezuela. Transporting gear the old fashioned way.



Tibet. Locals help with installation of a station.



Figure 1: Global extent of station coverage for the history of the PASSCAL program, now totaling more than 3800 stations.



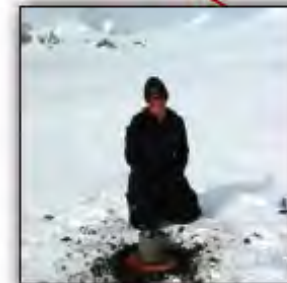
Chile. Installing an intermediate period sensor.



Kenya. A short period station being serviced while local Masai look on.

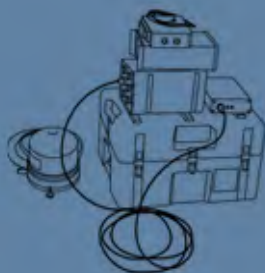


Tiwi. Specialized enclosure for a rainy environment.



Mt. Erebus. An intermediate period sensor is installed directly onto the bedrock flanking the volcano.

IRIS

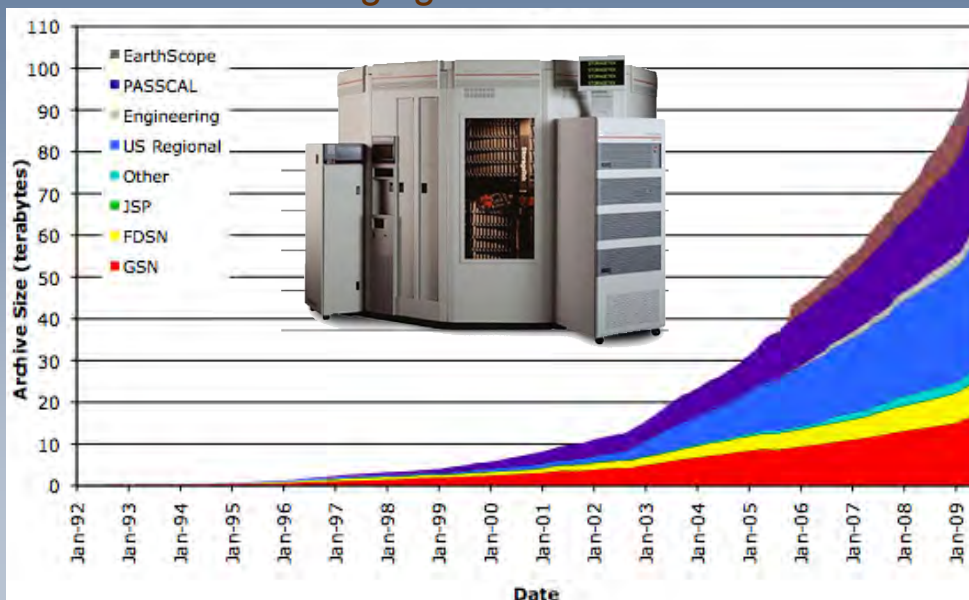
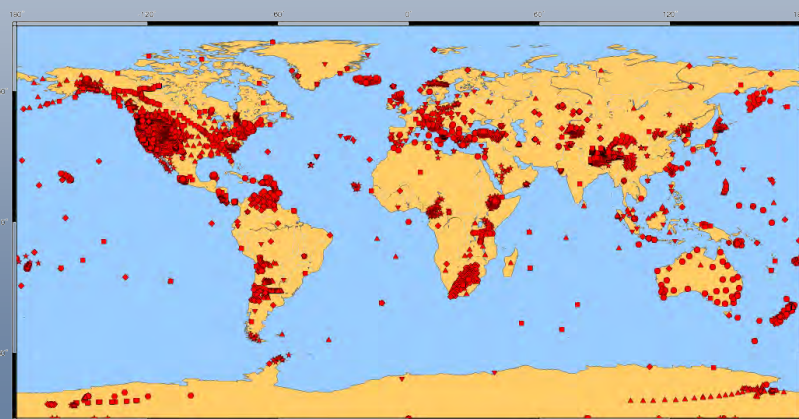


IRIS Core Programs *Data Management System - DMS*

Data from 12,007 stations
248 permanent networks
and temporary experiments
1920 stations in real-time

Includes:

- Permanent Networks
 - FDSN Global Nets
 - National and Regional Nets
- Temporary Deployments
- Research Arrays
- Aftershock Studies
- Crustal imaging

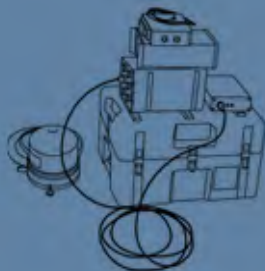


Designated as
FDSN Global
Archive for
Continuous Data

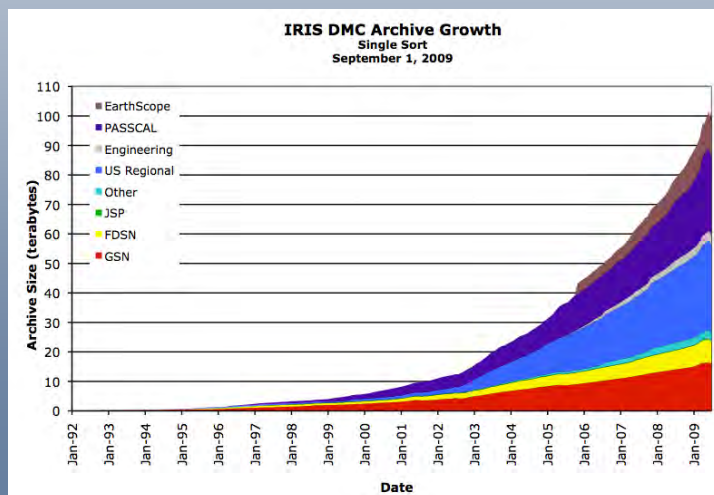
Free & open access

100 terabytes of
observational data

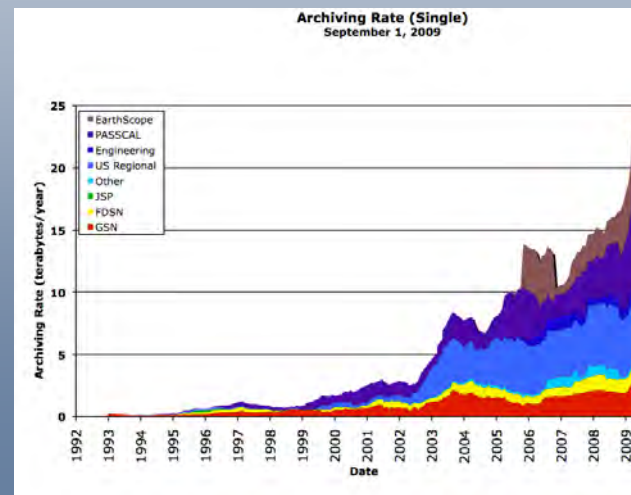
IRIS



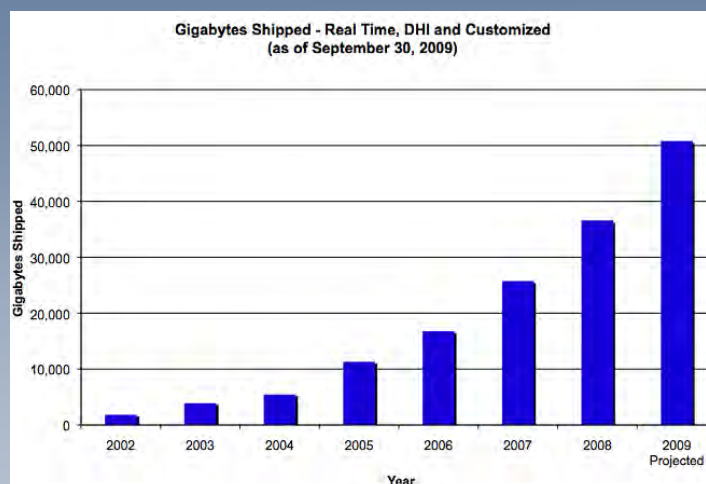
IRIS Data Archive - Data in and Data out



Total Archive - 100 Terabytes

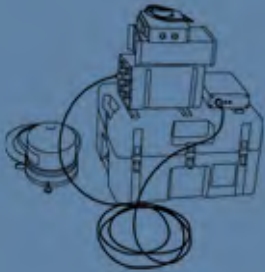


Archive Growth - 20 Tbytes/year

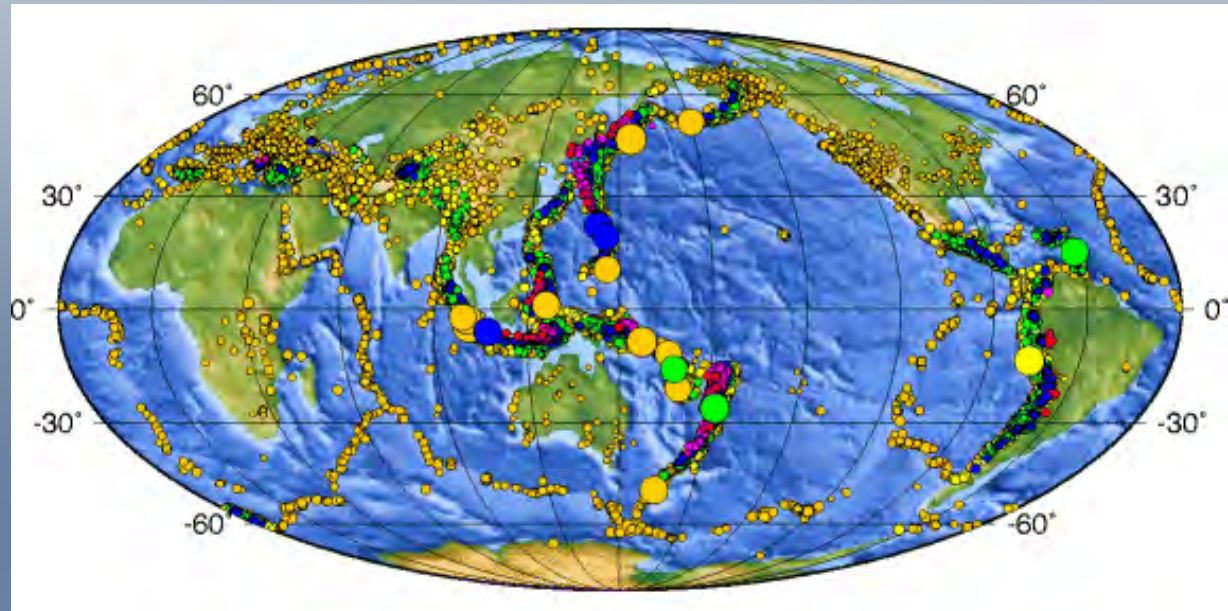


Data Distribution - 50 Tbytes/year

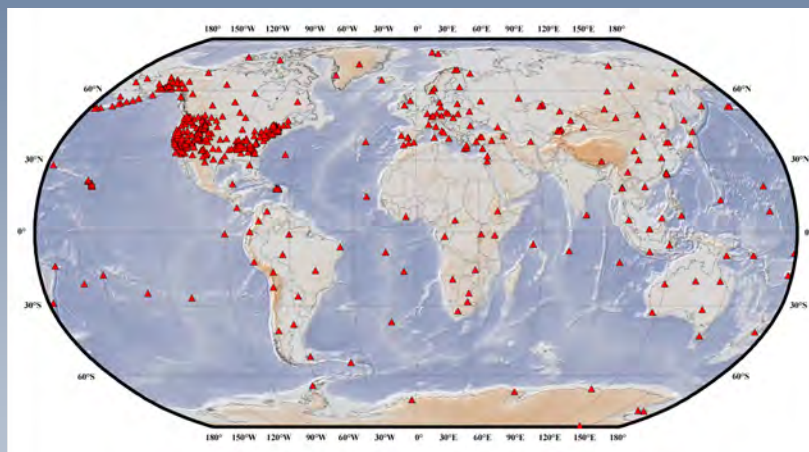
IRIS



Mission Applications - Global Seismicity



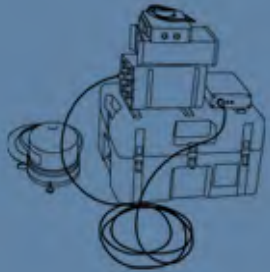
USGS NEIC - Global Seismicity 2007



~900 real time stations used by NEIC operations

Real time data exchange
for monitoring of
earthquakes and tsunamis

IRIS



IRIS-USGS Global Seismographic Network

Stations of the GSN

150 stations

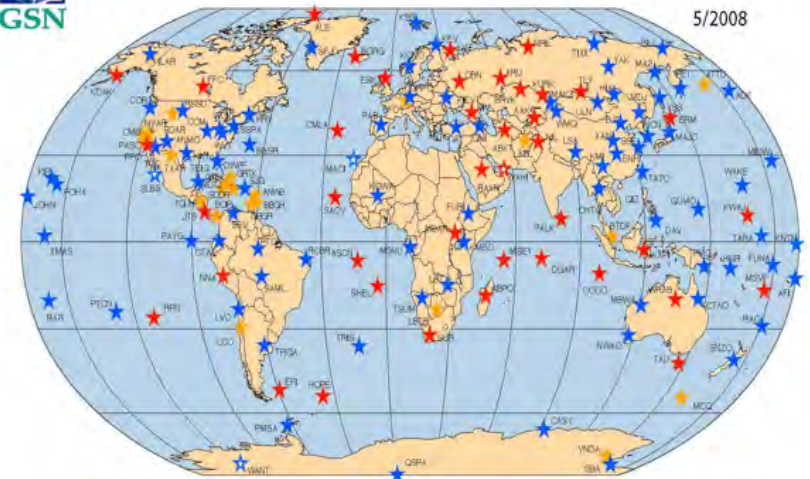
All committed to free and open,
real time data access

GSN recording of
May 12, 2008
Sichuan earthquake

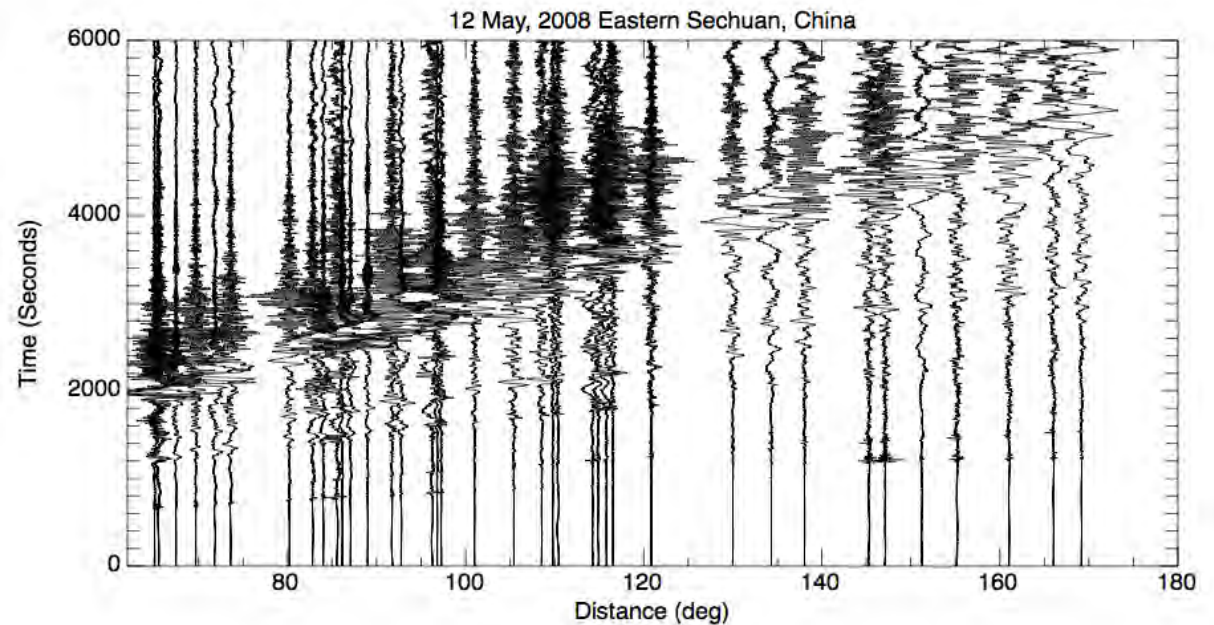


GLOBAL SEISMOGRAPHIC NETWORK

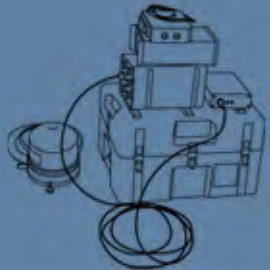
5/2008



★ IRIS / IDA Stations ★ IRIS / USGS Stations ★ Affiliate Stations
★ GSN Stations (planned)



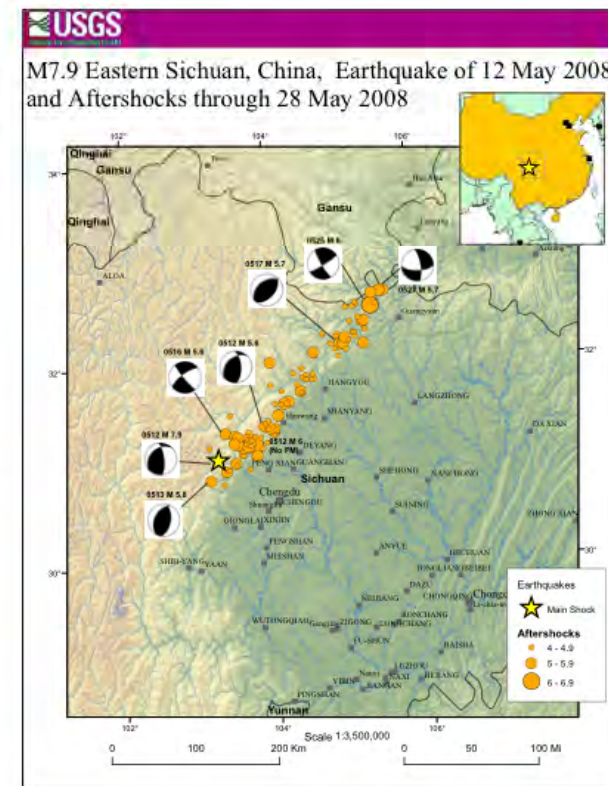
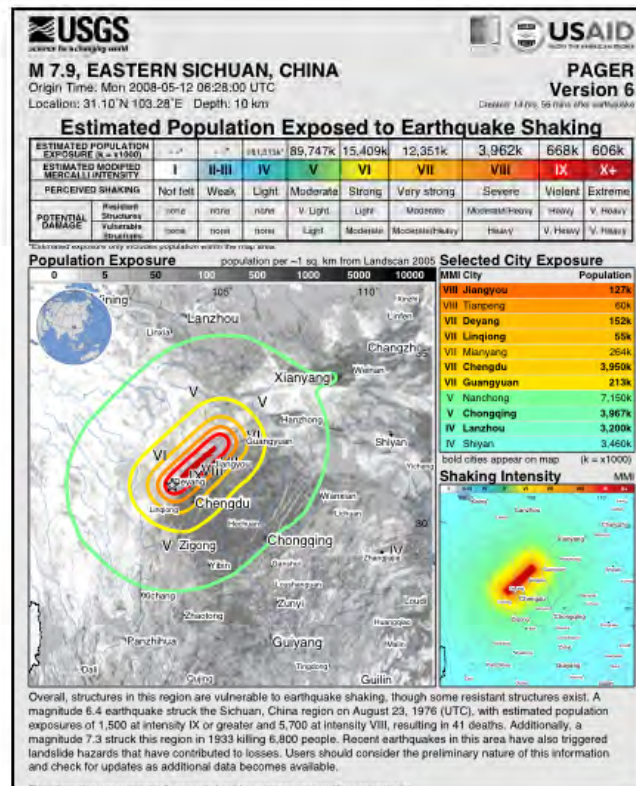
IRIS



USGS - National Earthquake Information Center

Earthquake reporting from open global data

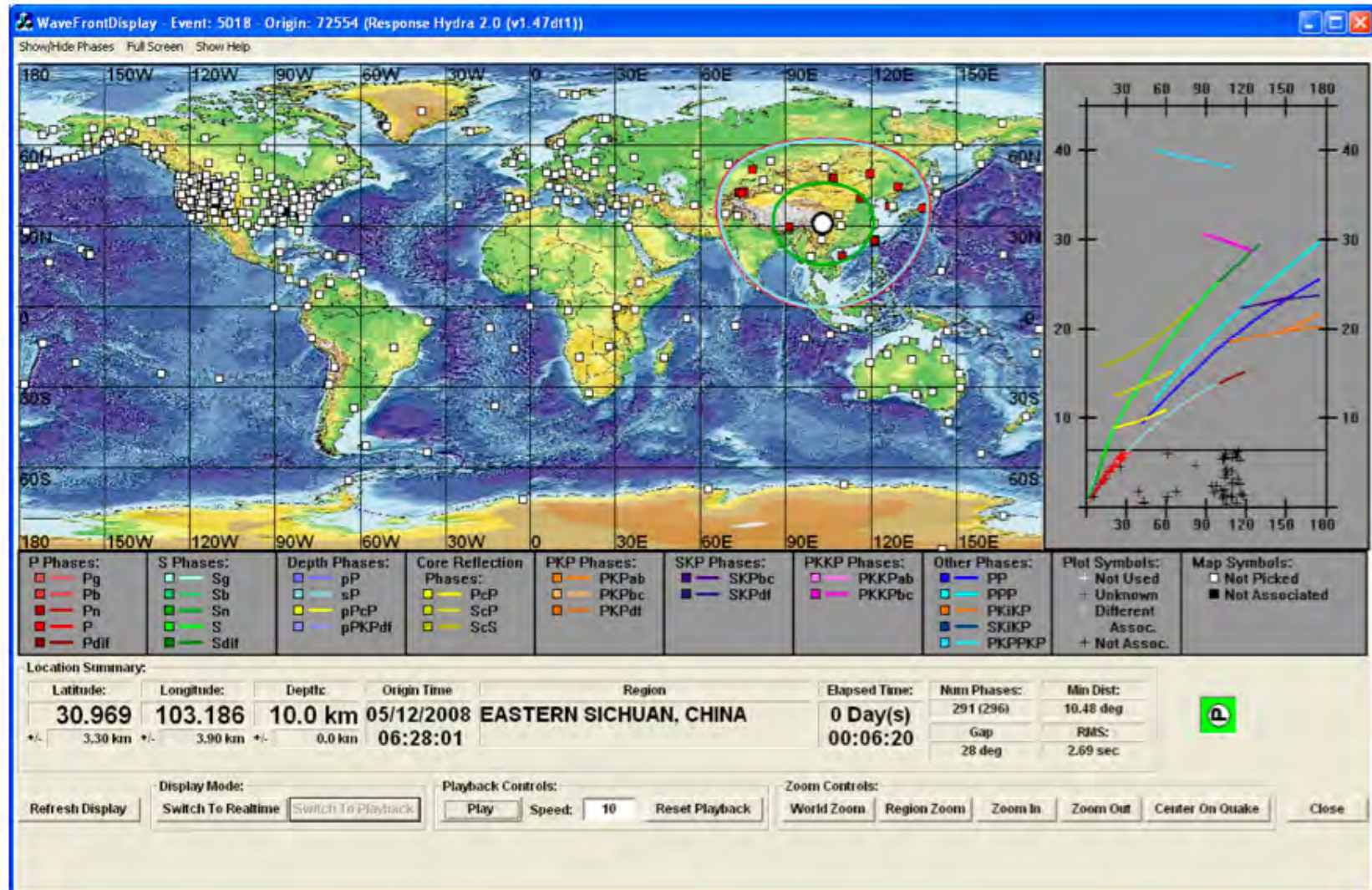
Example of the Sichuan China earthquake - May 2008



6 minutes

NEIC automatic detection

no magnitude, rough location and depth





M 7.5, EASTERN SICHUAN, CHINA

Origin Time: Mon 2008-05-12 06:28:00 UTC

Location: 31.08°N 103.27°E Depth: 10 km

PAGER

Version 1

Created: 30 mins, 54 secs after earthquake

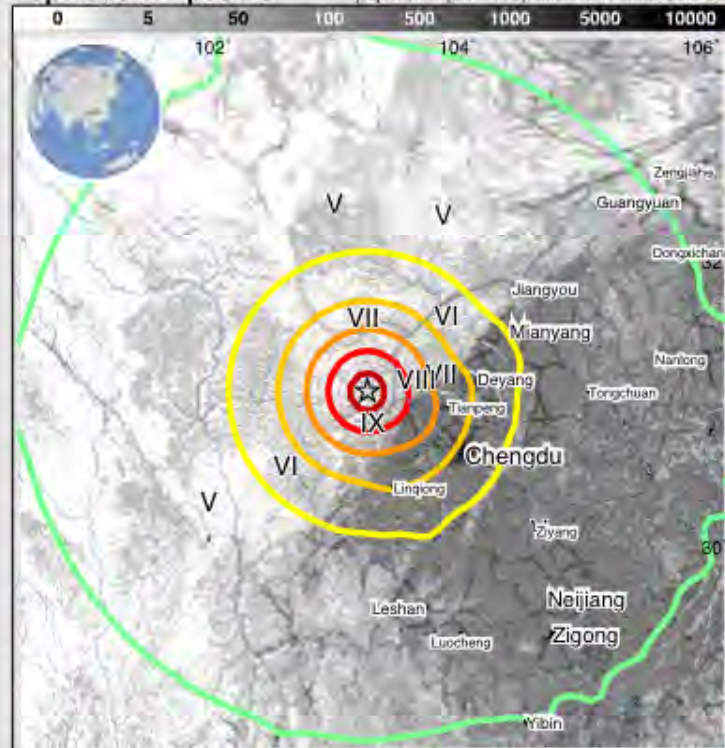
Estimated Population Exposed to Earthquake Shaking

ESTIMATED POPULATION EXPOSURE (k = x1000)	~	~	8,827k	42,892k	10,123k	3,567k	1,072k	86k	21k
ESTIMATED MODIFIED MERCALLI INTENSITY	I	II-III	IV	V	VI	VII	VIII	IX	X+
PERCEIVED SHAKING	Not felt	Weak	Light	Moderate	Strong	Very strong	Severe	Violent	Extreme
POTENTIAL DAMAGE	Resistant Structures	none	none	none	V. Light	Light	Moderate	Moderate/Heavy	Heavy
	Vulnerable Structures	none	none	none	Light	Moderate	Moderate/Heavy	Heavy	V. Heavy

*Estimated exposure only includes population within the map area.

Population Exposure

population per ~1 sq. km from Landsat 2005

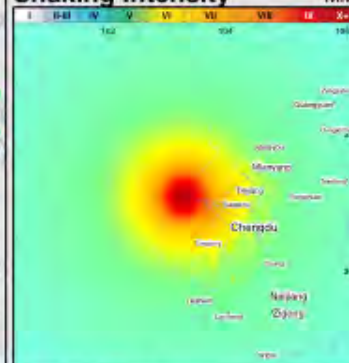


Selected City Exposure

MMI City	Population
VII Tianpeng	60k
VII Linglong	55k
VI Chengdu	3,950k
VI Deyang	152k
V Jiangyou	127k
V Mianyang	264k
V Ziyang	87k
V Neijiang	546k
V Zigong	689k
V Nanchong	7,150k
IV Yibin	242k

bold cities appear on map (k = x1000)

Shaking Intensity



Users should consider the preliminary nature of this information and check for updates as additional data becomes available. Population exposure estimates are NOT a direct estimate of earthquake damage; comparable shaking will result in significantly lower losses in regions with well built structures than in regions with vulnerable structures.

31 minutes

Automatic population exposure results

1.2 million \geq MMI VIII

4.7 million \geq MMI VII

Notified:

- USAID/OFDA
- United Nations
- Whitehouse
- State Department
- NorthCom
- SouthCom
- National Security Council
- Reuters
- Mercy Corps
- World Bank



M 7.8, EASTERN SICHUAN, CHINA

Origin Time: Mon 2008-05-12 06:28:00 UTC

Location: 31.12°N 103.26°E Depth: 10 km



USAID
FROM THE AMERICAN PEOPLE

PAGER

Version 3

Created: 2 hrs, 15 mins after earthquake

Estimated Population Exposed to Earthquake Shaking

ESTIMATED POPULATION EXPOSURE (k = x1000)	- -	- -	2,875k*	43,966k	13,538k	4,781k	866k	92k	117k
ESTIMATED MODIFIED MERCALLI INTENSITY	I	II-III	IV	V	VI	VII	VIII	IX	X+
PERCEIVED SHAKING	Not felt	Weak	Light	Moderate	Strong	Very strong	Severe	Violent	Extreme
POTENTIAL DAMAGE	Resistant Structures	none	none	none	V. Light	Light	Moderate	Moderate/Heavy	Heavy
	Vulnerable Structures	none	none	none	Light	Moderate	Moderate/Heavy	Heavy	V. Heavy

*Estimated exposure only includes population within the map area.

Population Exposure

population per ~1 sq. km from Landsat 2005

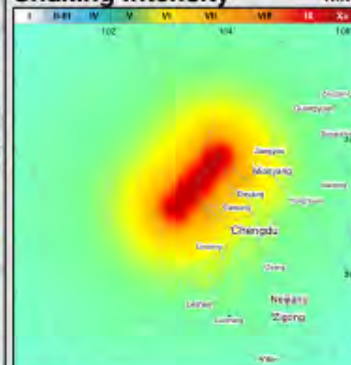


Selected City Exposure

MMI City	Population
VII Tianpeng	60k
VI Linglong	55k
VI Chengdu	3,950k
VI Jiangyou	127k
VI Mianyang	264k
VI Deyang	152k
V Tongchuan	58k
V Neijiang	546k
V Nanchong	7,150k
V Zigong	689k
V Yibin	242k

bold cities appear on map (k = x1000)

Shaking Intensity



Users should consider the preliminary nature of this information and check for updates as additional data becomes available. Population exposure estimates are NOT a direct estimate of earthquake damage; comparable shaking will result in significantly lower losses in regions with well built structures than in regions with vulnerable structures.

2.25 hours

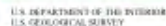
Updated population exposure results

1.1 million \geq MMI VIII

5.9 million \geq MMI VII

Prompt
Assessment of
Global
Earthquakes for
Response

following day



EARTHQUAKE SUMMARY MAP, NY

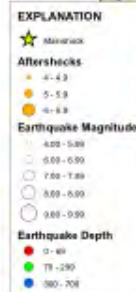


Prepared in
cooperation
with the Global
Seismographic
Network



RELATIVE PLATE MOTIONS

Each vector indicates relative velocity vectors. The Indian Plate is moving northeast, it lies to the Indian Plate at about 55 mm/yr.

[illegible]

The Sichuan earthquake of May 12, 2008, occurred as the result of motion on a northeast striking reverse fault or thrust fault on the northeastern margin of the Sichuan thrust. The earthquake's epicentre and aftershocks are contained within a few km westward of the line of contact on the Longmenshan fault or a subparallel related fault. The earthquake reflects intense stresses resulting from the convergence of crustal material slowly moving from the high Tibetan Plateau, to the south, against strong crust unloading by the Sichuan Basin and southern China.

The southwestern margin of the Salinas River has previously experienced destructive earthquakes. The magnitude 7.3 earthquake August 21, 1931, killed more than 6,800 people. Another 2,180 lives perished to the north of Salinas at a natural dam crossed by a landslide caused by the earthquake.

Costa del Mar:

DOORIGER, A. K. and HUBERT, H. A. 1976, National Earthquake Information Center
NEIC, National Geophysical Data Center
USFED, Federal Emergency Management Agency (1990–1999) and
seismology (Kingfield and Villaverde, 2002)
USFED, compilation of earthquake catalogs (August, 2002)

PLATE TECTONICS AND FAULTS (continued)
TRENTO 2006, 2007
Finite Fault Model, Chap. 8, U.S. Santa Barbara (2007)

NAME: Wafar
 NEDM and UEDM, Digital Chart of the World
 UEDM, UNEDM Data Center
 www.unedmdc.com/UNEDM/Datacenter/index.html

ANCIENT EPOCHES MAG 54-5

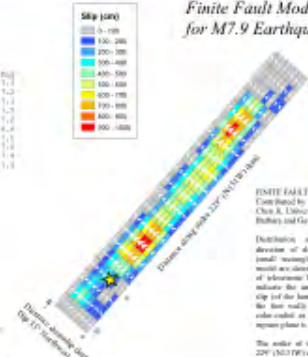
Year	Male	Female	Total	Male	Female	Total
1997	0.7	0.3	1.0	28,000	404,000	432,000
1998	0.8	0.4	1.2	30,000	420,000	450,000
1999	0.9	0.5	1.4	32,000	440,000	472,000
2000	1.0	0.6	1.6	34,000	460,000	494,000
2001	1.1	0.7	1.8	36,000	480,000	516,000
2002	1.2	0.8	2.0	38,000	500,000	538,000
2003	1.3	0.9	2.2	40,000	520,000	560,000
2004	1.4	1.0	2.4	42,000	540,000	582,000
2005	1.5	1.1	2.6	44,000	560,000	604,000
2006	1.6	1.2	2.8	46,000	580,000	626,000
2007	1.7	1.3	3.0	48,000	600,000	648,000
2008	1.8	1.4	3.2	50,000	620,000	670,000
2009	1.9	1.5	3.4	52,000	640,000	692,000
2010	2.0	1.6	3.6	54,000	660,000	714,000

Dod, P., 2003. A topological signed model of place foundations. *Geochron-Geophys. Geogr.*, v. 2, no. 3, pp. 1827–86.

1999-2000, 2001-2002

Enoch, D.E., Vander Wild, C.T., and Boland, R.B. 1999.
Global teleostean cartilage reduction with improved survival and procedures for depth discrimination. *Bull. Assoc. No. 34*, 2: 123-140.

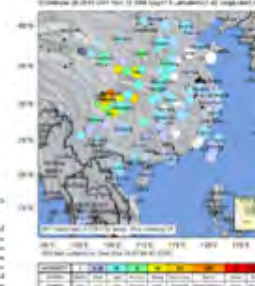
Finite Fault Model for M7.9 Earthquake



Distribution of the amplitude in direction of slip for individual elements (small rectangles) of the fault region could be determined from the inversion of teleseismic body waveforms. Arrows indicate the amplitude and direction of slip (of the hanging wall with respect to the foot wall); the slip amount is also indicated as shown. The view of the rupture plane is from above.

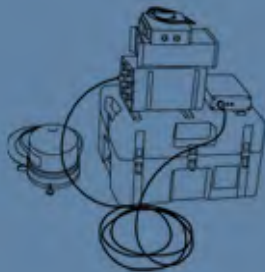
The strike of the fault segment plane is 229° (50.3°) and the dip is 15.5° . The directions of the null-tension elements are 18° km in the strike direction and 8 km in the dip direction. The normal stress plane based on this plane is 3113 – 32 dynes/cm².

Did You Feel It?



Revised by E. J. Connelley
 Department of Psychology
 University of Illinois
 Urbana, Illinois

IRIS



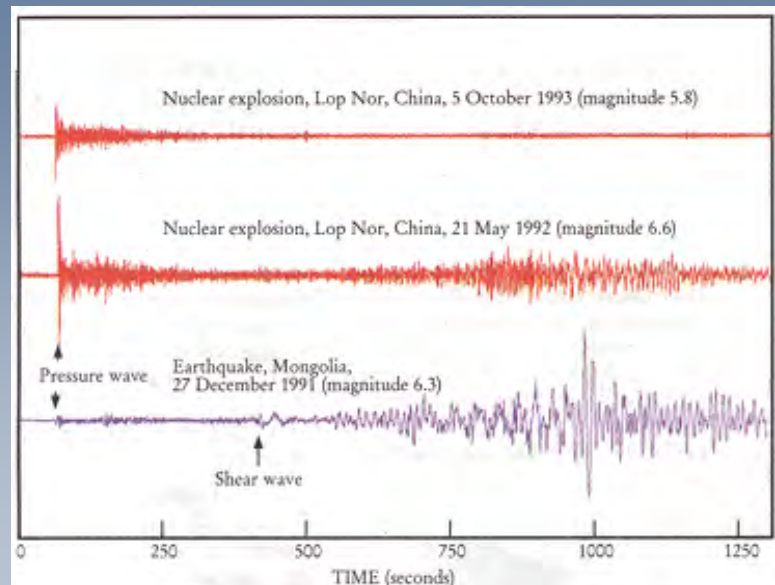
Mission Applications - Nuclear Test Monitoring and Research



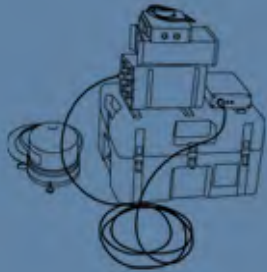
GLOBAL SEISMOGRAPHIC NETWORK
& INTERNATIONAL MONITORING SYSTEM (IMS)



Comprehensive Test Ban Treaty
International Monitoring System (IMS)
US National Security
DOD (AFTAC)



IRIS/NSF, USGS, DOD and DOE
Capitalization of GSN and PASSCAL
Open GSN and PASSCAL data
Applications in operation and research
Restricted IMS data



Open Data Sharing Changes and Trends

Permanent Global Networks

Growth of FDSN and GSN as open data resources

Core of GSN, GEOSCOPE (France) and other global programs

Designated exchange stations from other national members

Full waveforms

Real-time

Open archive of continuous data at IRIS DMC

National and Regional Networks

Extension beyond earthquake monitoring application

Relaxation of exchange restrictions

Temporary Research Networks (eg PASSCAL)

Commitment to coordinated archiving - away from “private bin” collections

Open access - following proprietary period

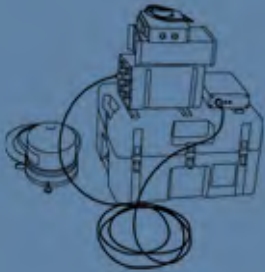
Multi use and re-use of data

Community-designed Networks and Experiments

EarthScope/USArray

NERIES - ORFEUS - Europe

ChinaArray



Drivers of Open Data Exchange

Advancing Technology

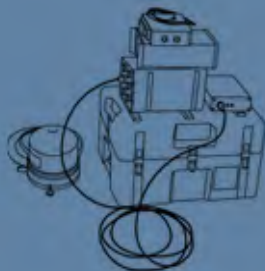
- Global communications
 - Satellite, cell, Internet
- Mass storage devices
 - K\$'s per Terabyte
 - Advanced DBMS systems

Acceptance of Standards

- Data and metadata standards
 - SEED - "Standard for Exchange of Earthquake Data"
- Instrumentation standards
- Quality standards and control

Organizational Structures

- International coordinating body
 - FDSN - "Federation of Digital Seismograph Networks"
 - under IASPEI / IUGG / ICSU
- Stable support for core facilities
 - IRIS Data Management Center (NSF)
 - ORFEUS (EU)
- Increasing collaboration with International Monitoring System of CTBTO



Drivers of Open Data Exchange

Overcoming cultural barriers

Advancing beyond “scientific colonialism”

Power of bi-lateral exchange

Value of global data as complement to regional observations

Recognition and exposure for data providers

International visibility

Collaborative research programs

Jointly designed and implemented

Education and training

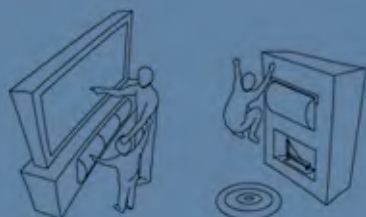
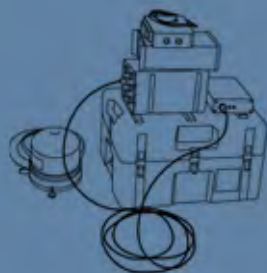
Local network operations and advanced research

Quality Control and Feedback

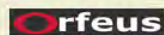
“Eyes on the data” improves quality and performance

Support for archival resources and maintenance

IRIS



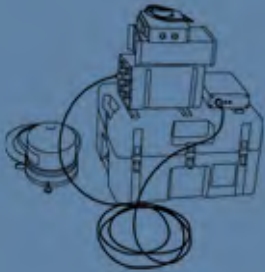
Managing Waveform Data and Metadata for Seismic Networks in Africa and the Mid East



Giza, Cairo, Egypt
8-16 November 2009

Hosted by
National Research Institute of Astronomy and Geophysics

IRIS



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