

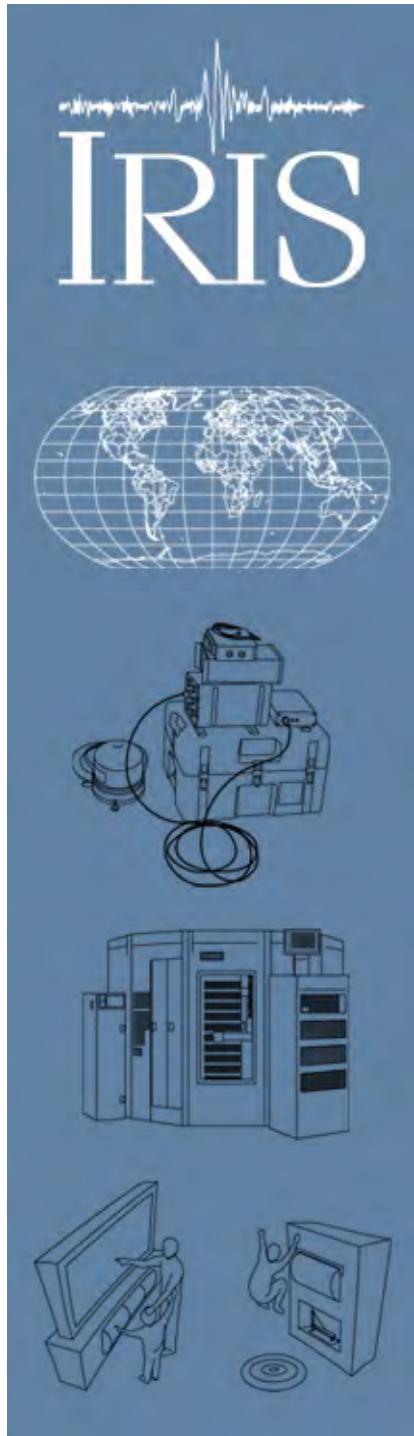
Earthquakes, Tsunamis and Nuclear Explosions: Open Data Exchange for Research and Monitoring in Seismology

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



Seismology - A Global and International Science

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

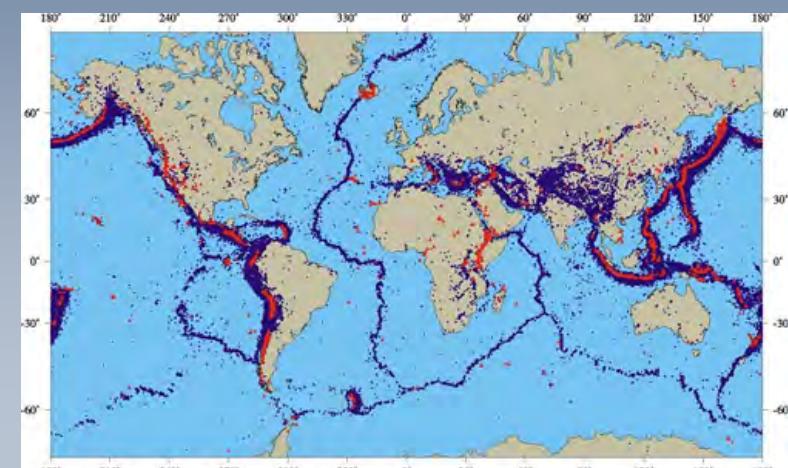
Seismology supports a rich portfolio of research and societal applications:

Research:

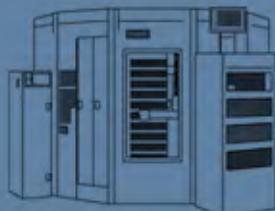
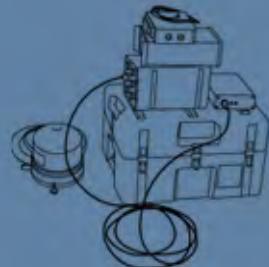
- Deep Earth structure
- Global Seismicity
- Earthquake source processes

Applications:

- Earthquake hazards
- Monitoring nuclear test ban treaties



IRIS

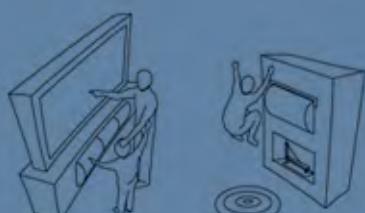
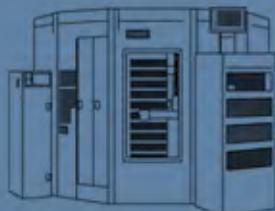
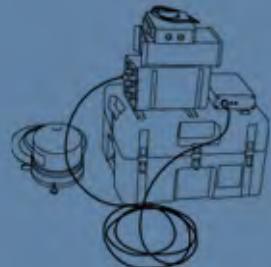


Evolution of Global Networks



British and Jesuit Networks
1900 - 1930's

IRIS

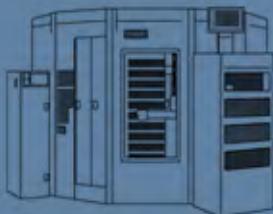
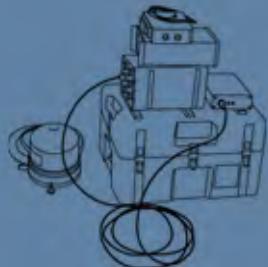


Evolution of Global Networks

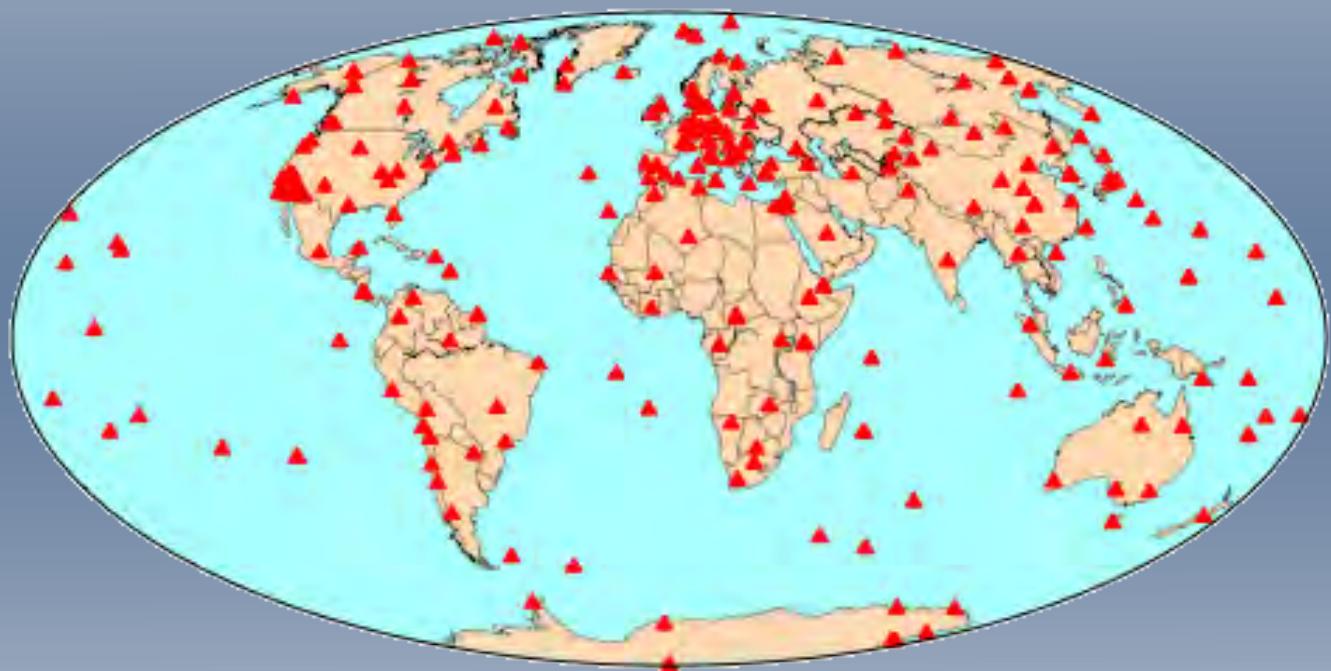


World Wide Standardized Seismographic Network
1960 - 1980's

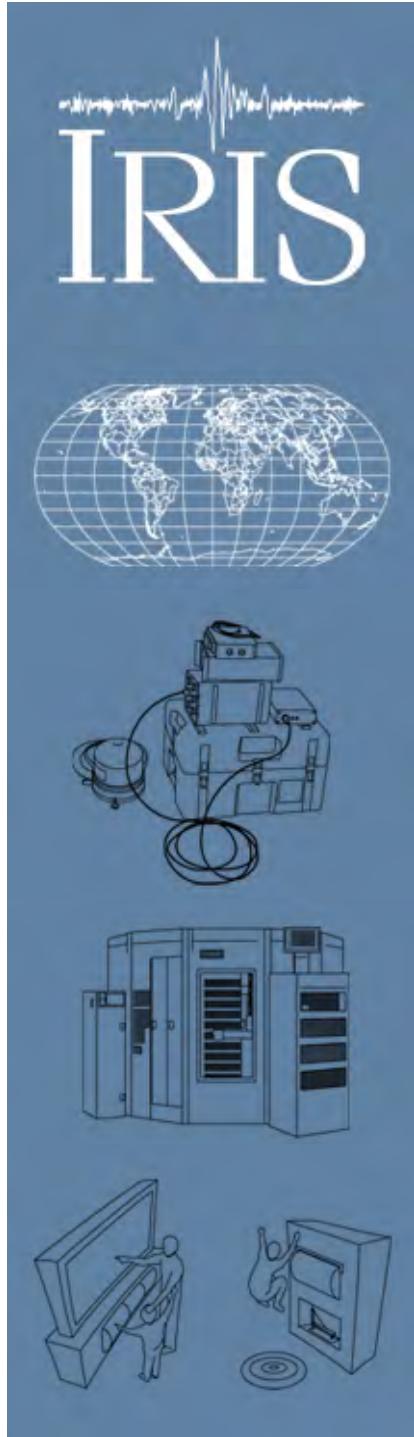
IRIS



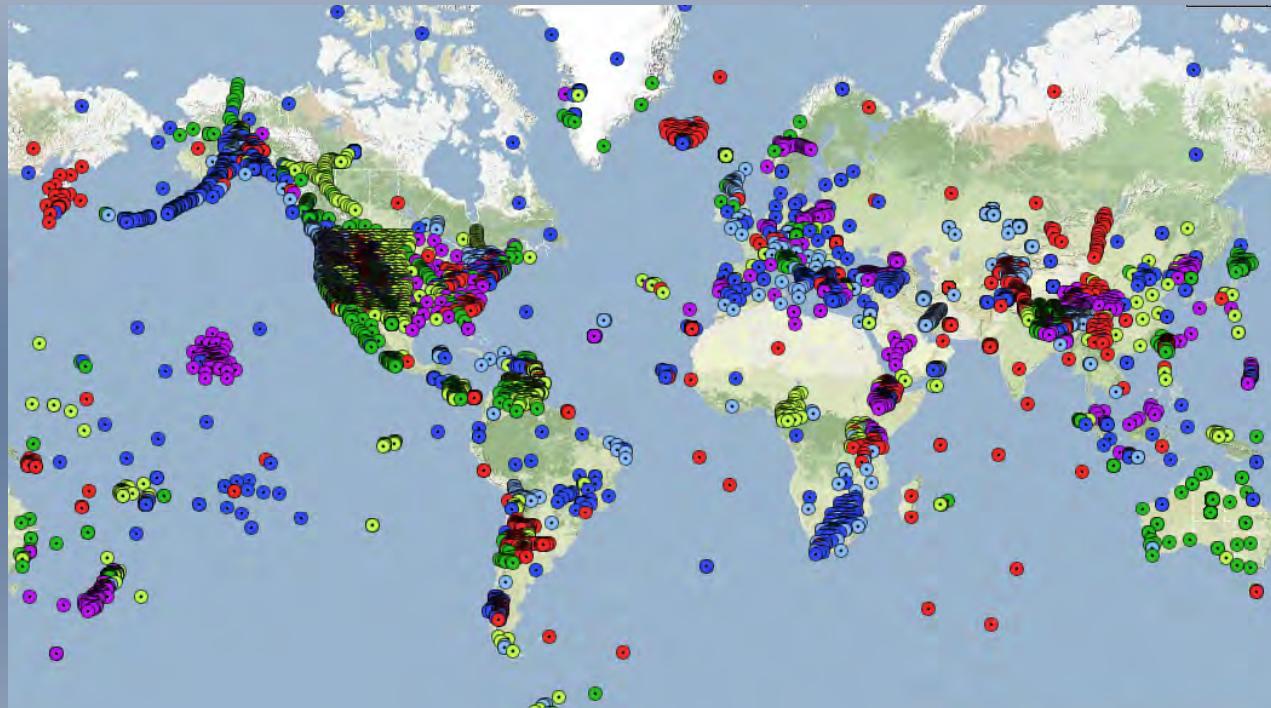
Evolution of Global Networks



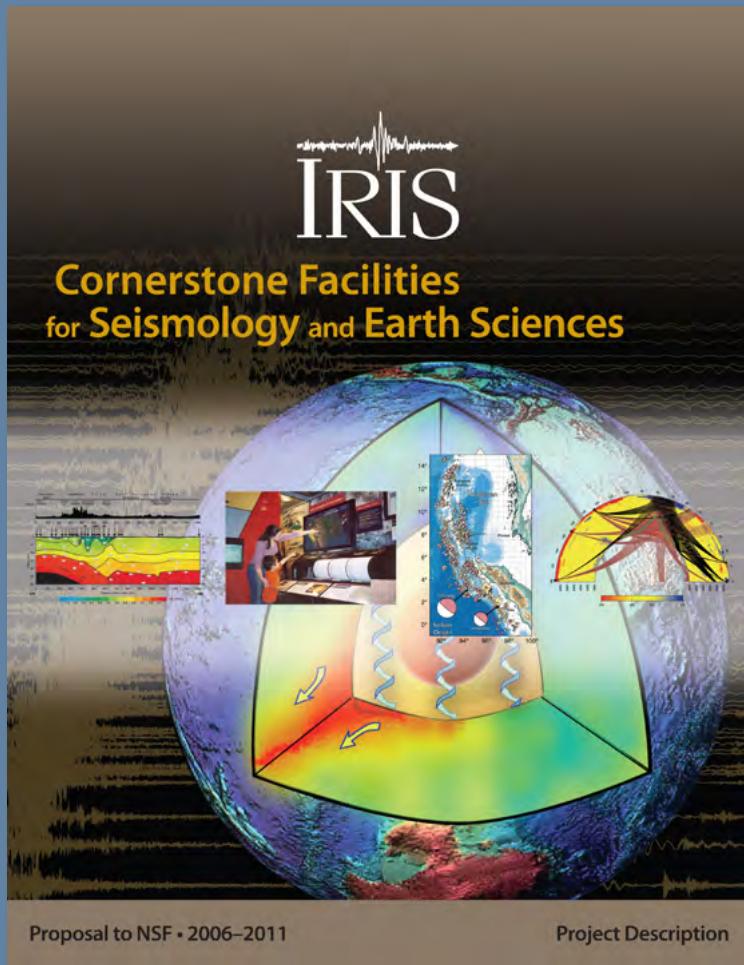
Federation of Digital Broadband Networks
2009



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

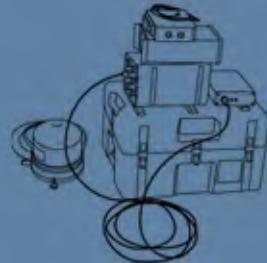


IRIS Consortium Mission Statement

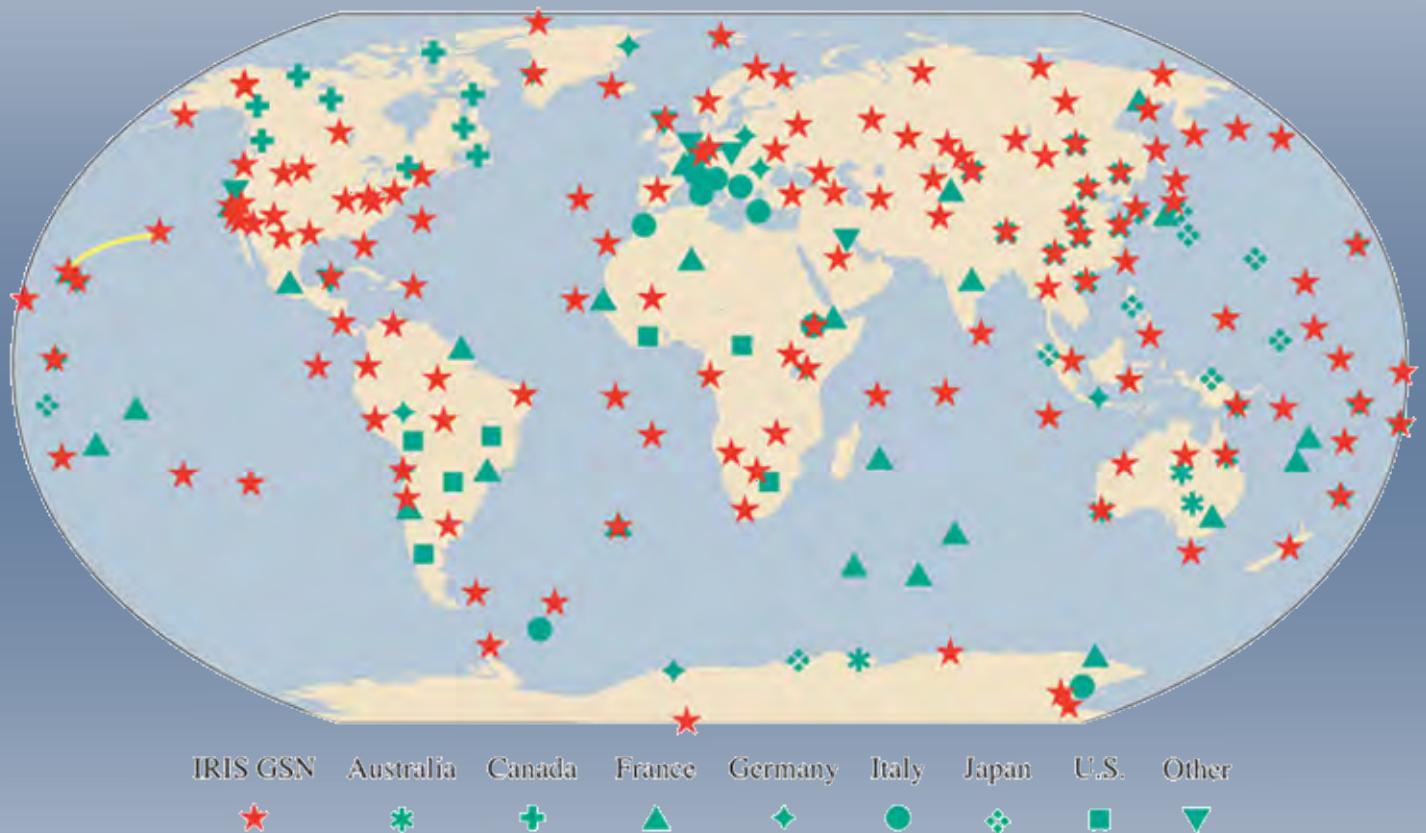
- Facilitate and conduct geophysical investigation of seismic sources and Earth properties using seismic and other geophysical methods.
- **Promote exchange of geophysical data and knowledge, both through use of standards for network operations, data formats and exchange protocols, and through pursuing 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

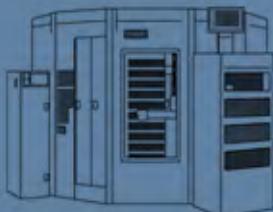
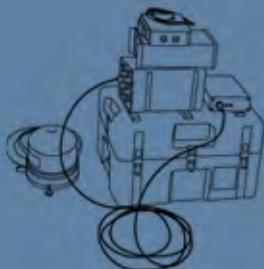


IRIS Core Programs *Global Seismographic Network (GSN)*



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

IRIS



Global Seismographic Network



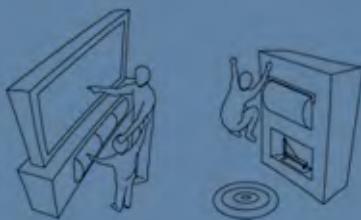
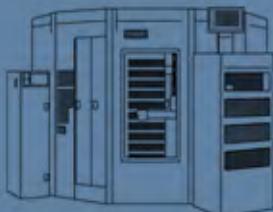
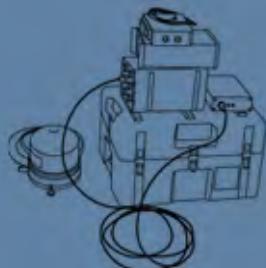
Falkland Islands Station (EFI)

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

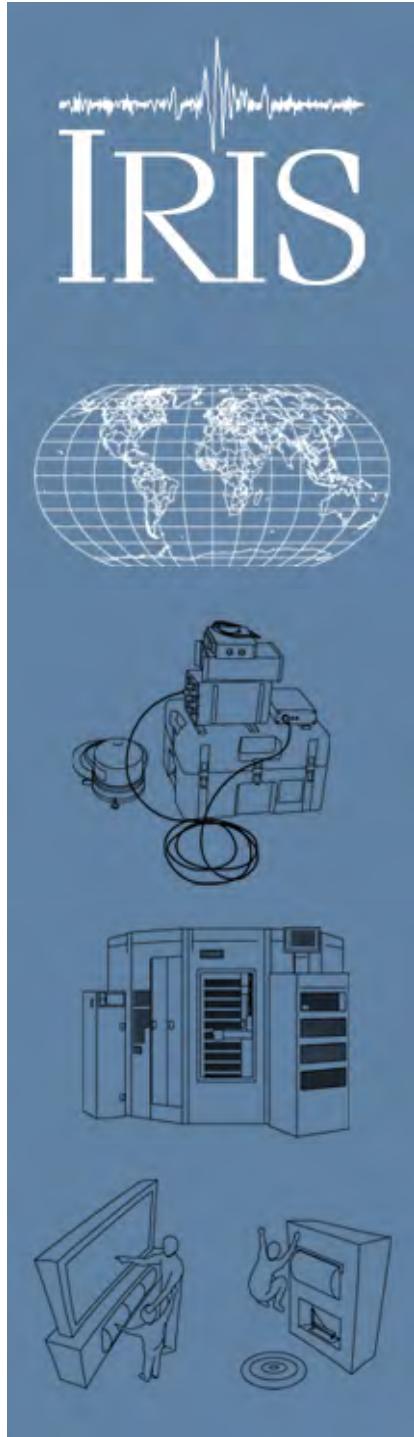


Global Seismographic Network

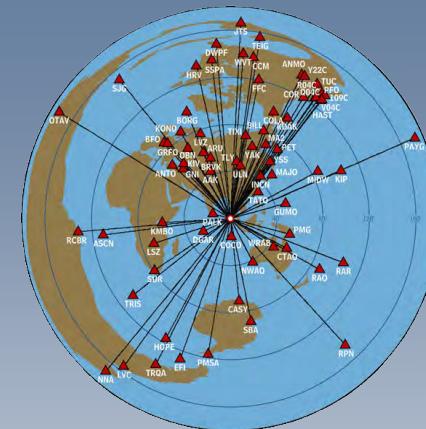
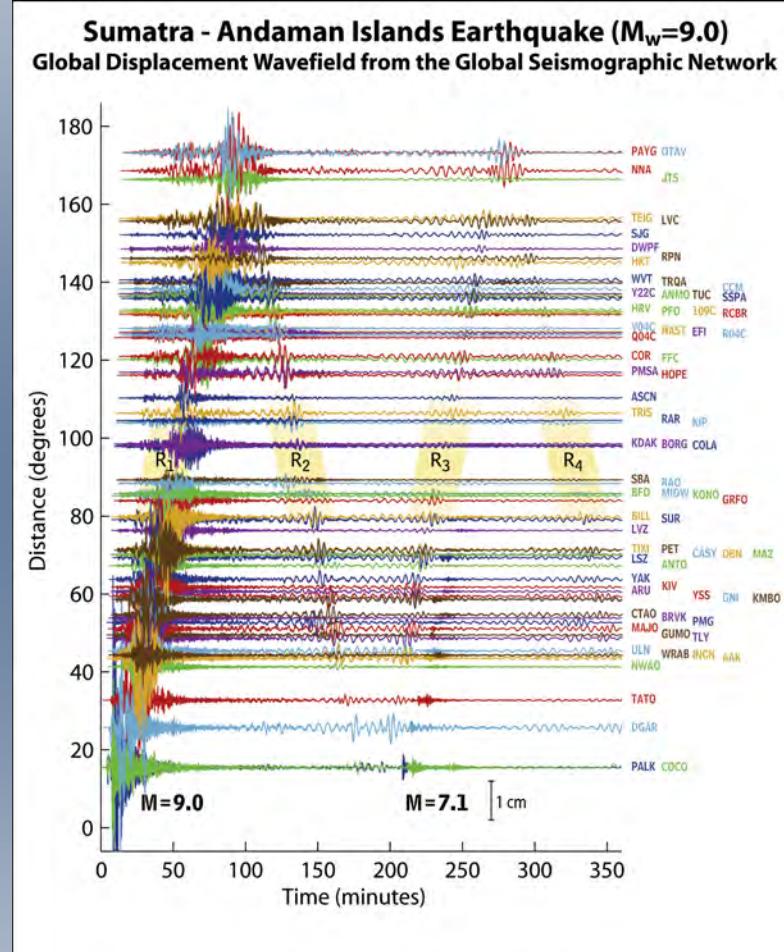


IRIS-established standards for observatory instrumentation

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



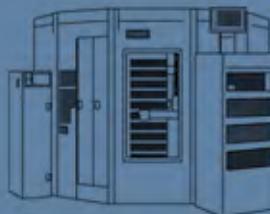
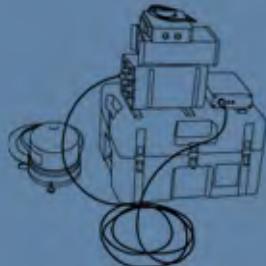
Great Earthquakes



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



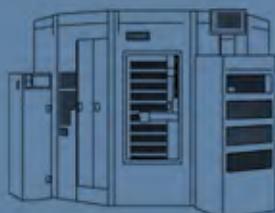
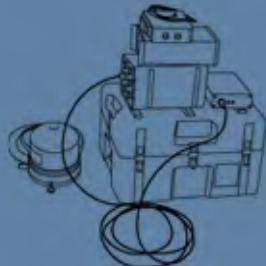
IRIS Core Programs

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



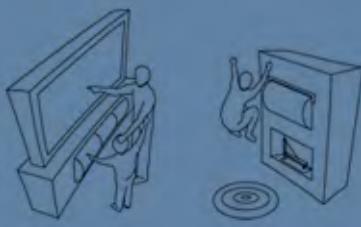
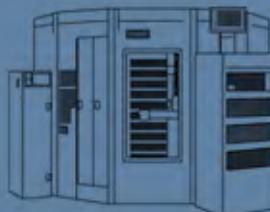
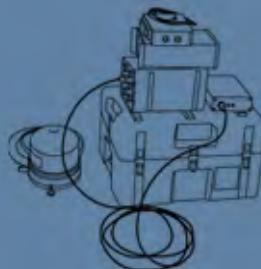
PASSCAL



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.



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.



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





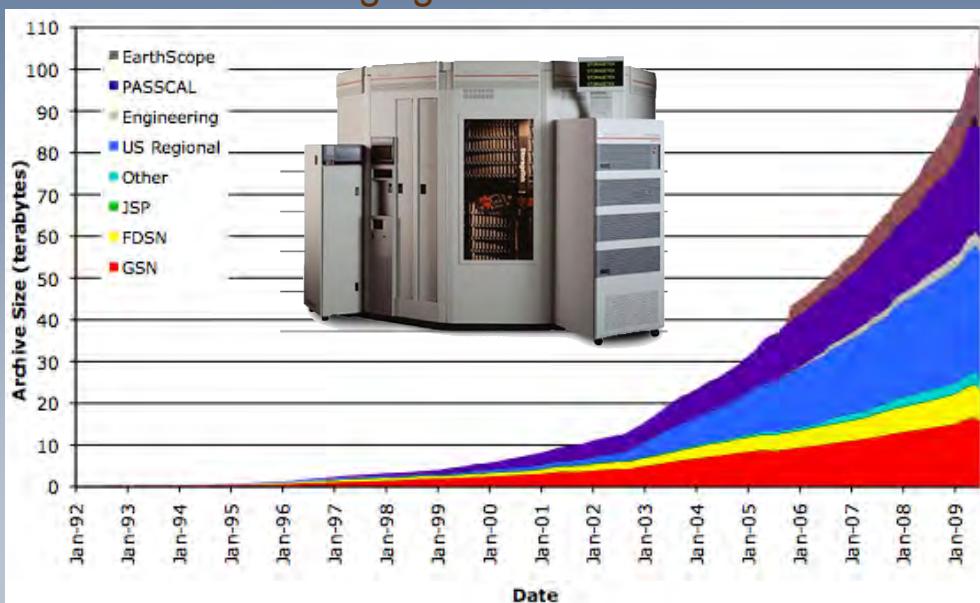
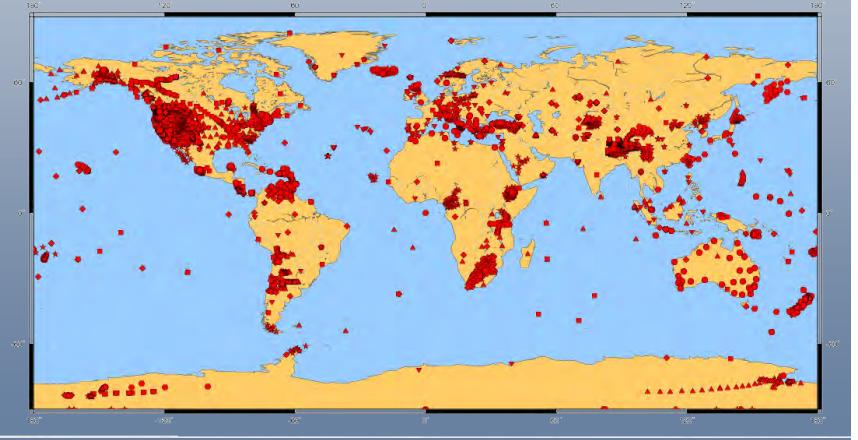
IRIS Core Programs

Data Management System - DMS

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

Includes:

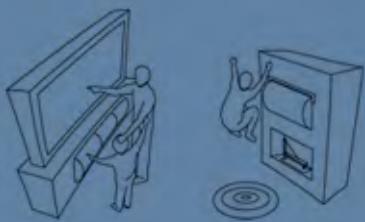
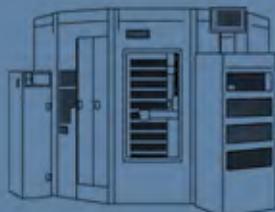
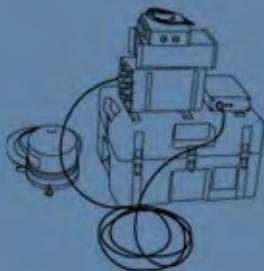
- Permanent Networks
 - FDSN Global Nets
 - National and Regional Nets
- Temporary Deployments
 - Research Arrays
 - Aftershock Studies
 - Crustal imaging



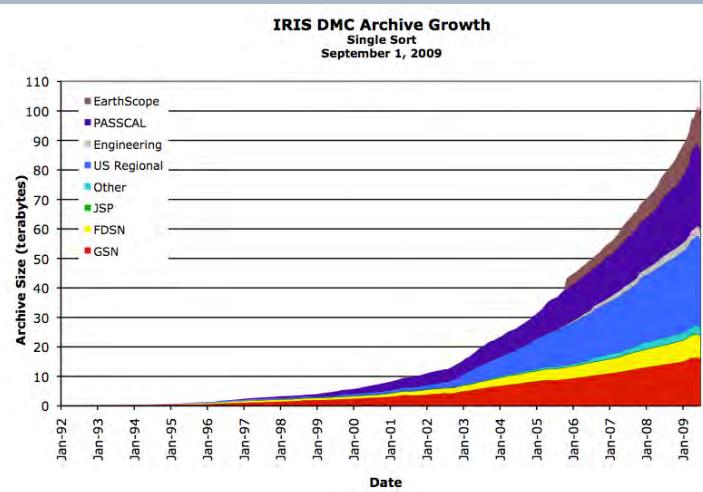
**Designated as
FDSN Global
Archive for
Continuous Data**

**Free & open access
100 terabytes of
observational data**

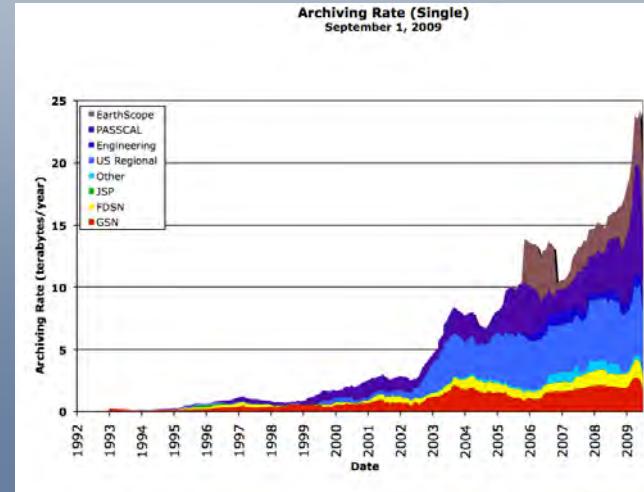
IRIS



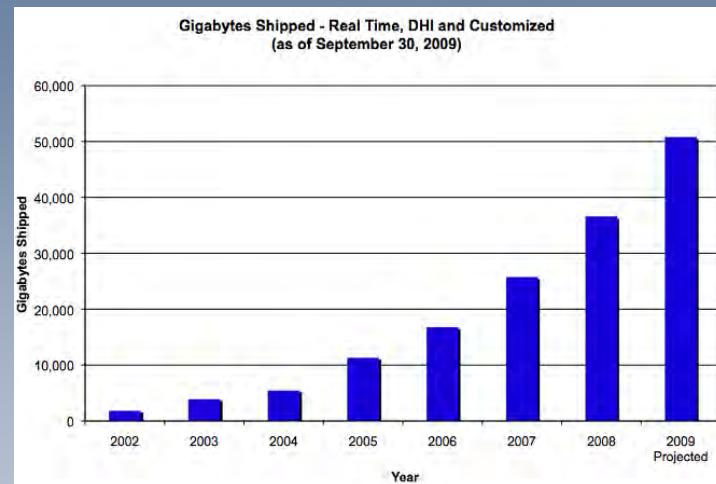
IRIS Data Archive - Data in and Data out



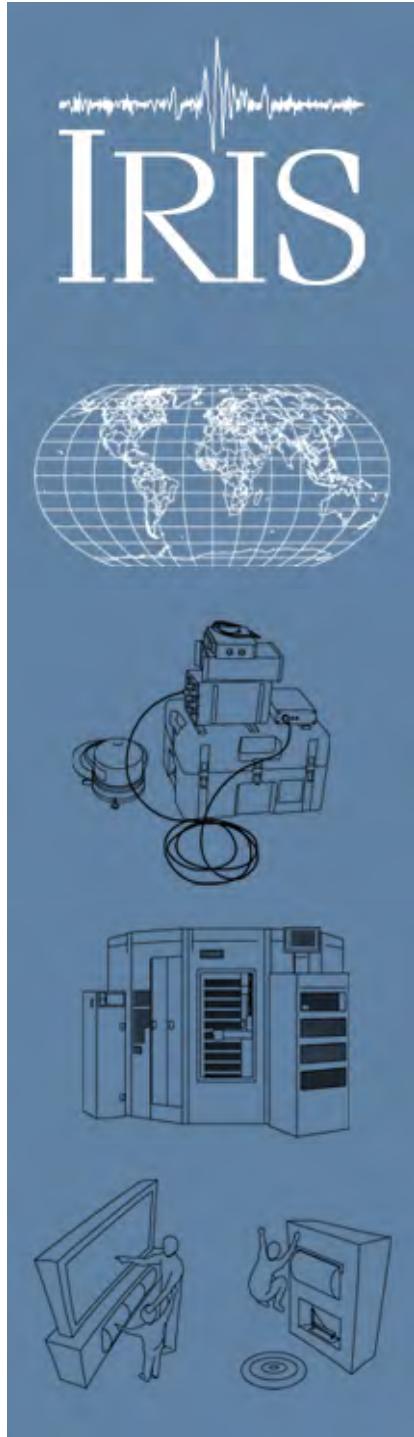
Total Archive - 100 Terabytes



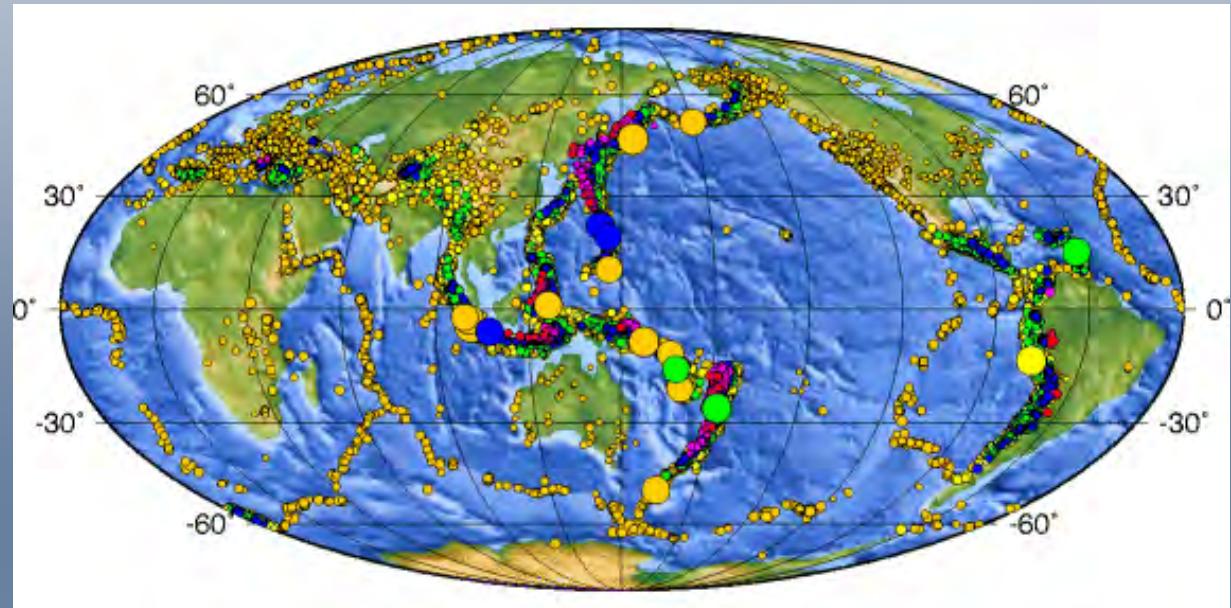
Archive Growth - 20 Tbytes/year



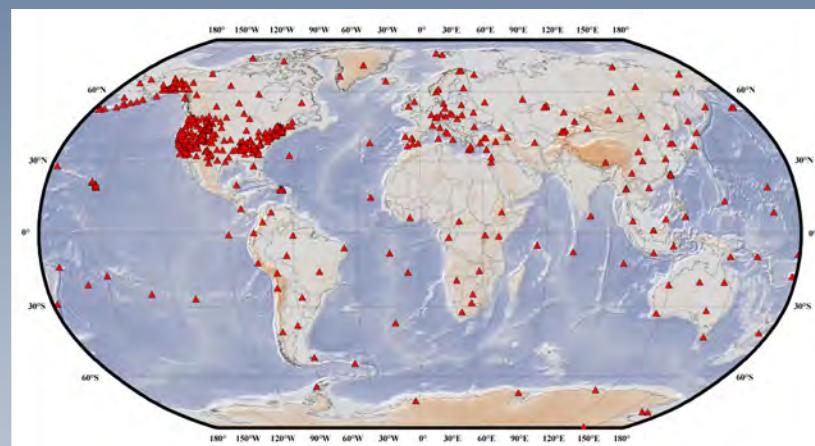
Data Distribution - 50 Tbytes/year



Mission Applications - Global Seismicity



USGS NEIC - Global Seismicity 2007



Real time data exchange
for monitoring of
earthquakes and tsunamis

~900 real time stations used by NEIC operations



IRIS-USGS Global Seismographic Network

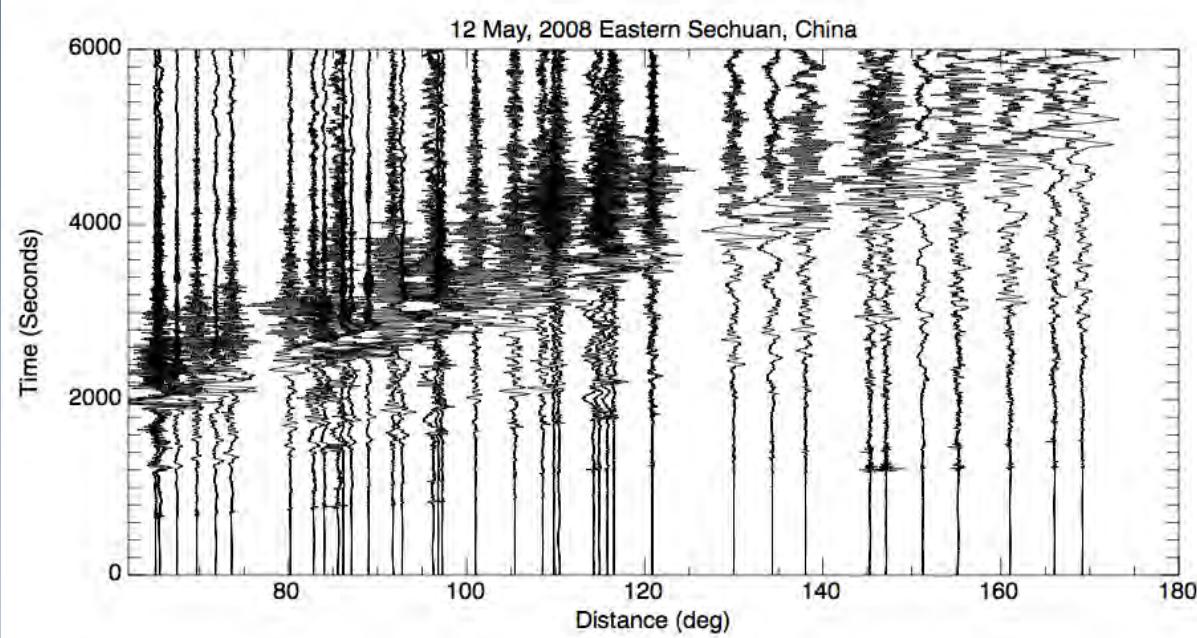
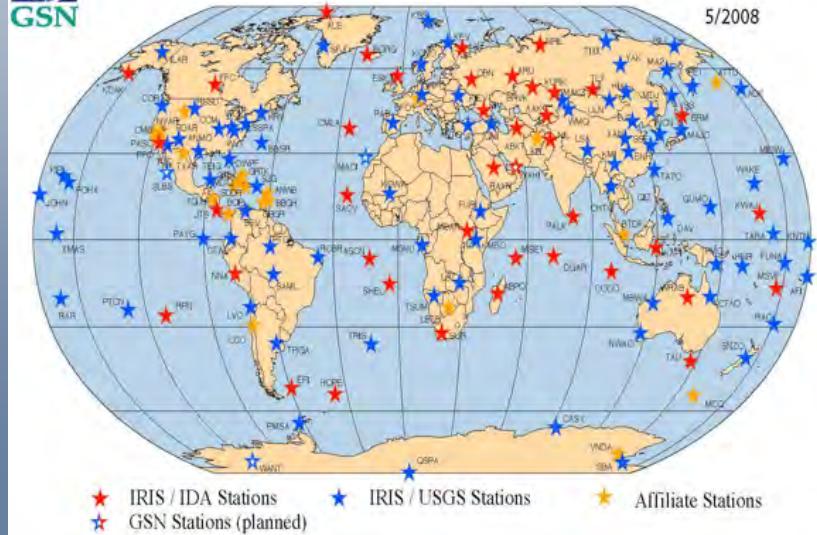
Stations of the GSN

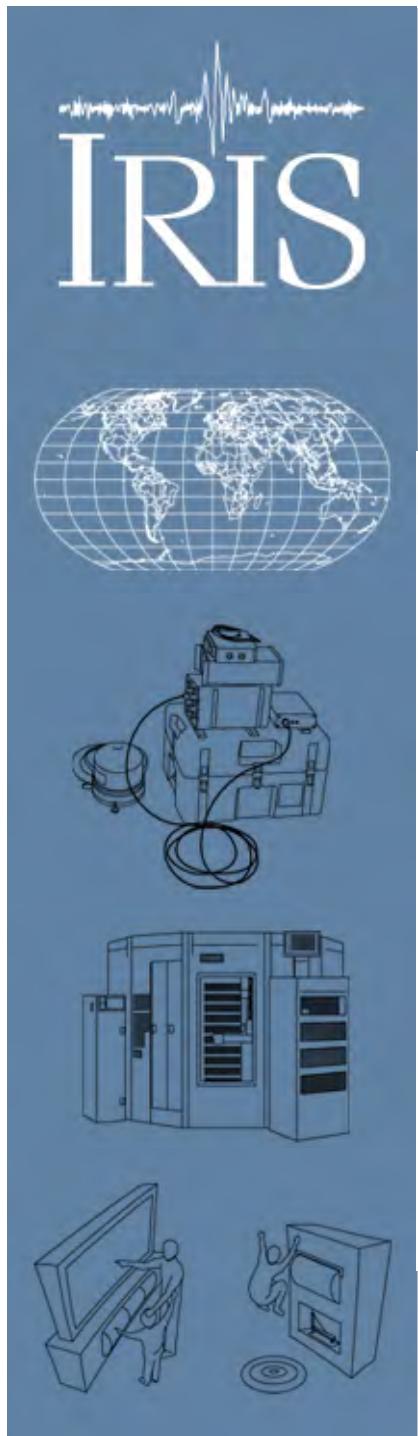
150 stations

All committed to free and open,
real time data access

GSN recording of
May 12, 2008
Sichuan earthquake

GLOBAL SEISMOGRAPHIC NETWORK

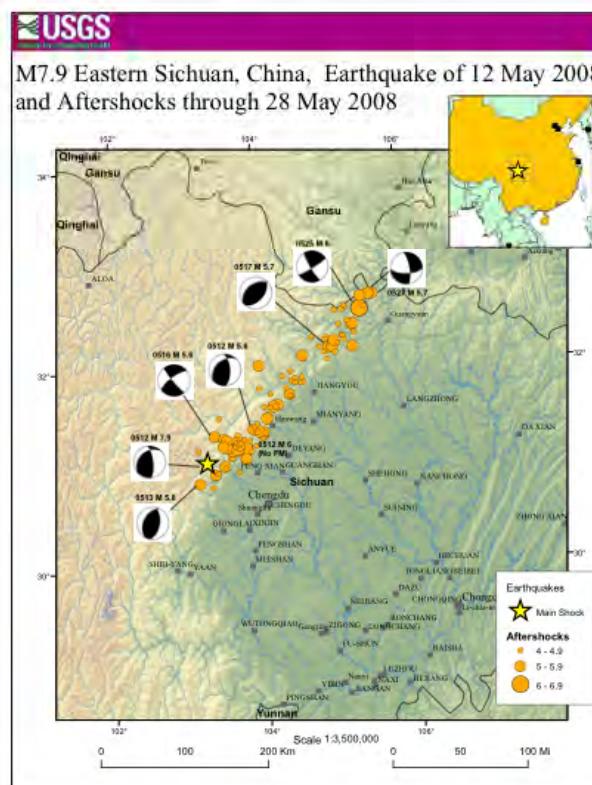
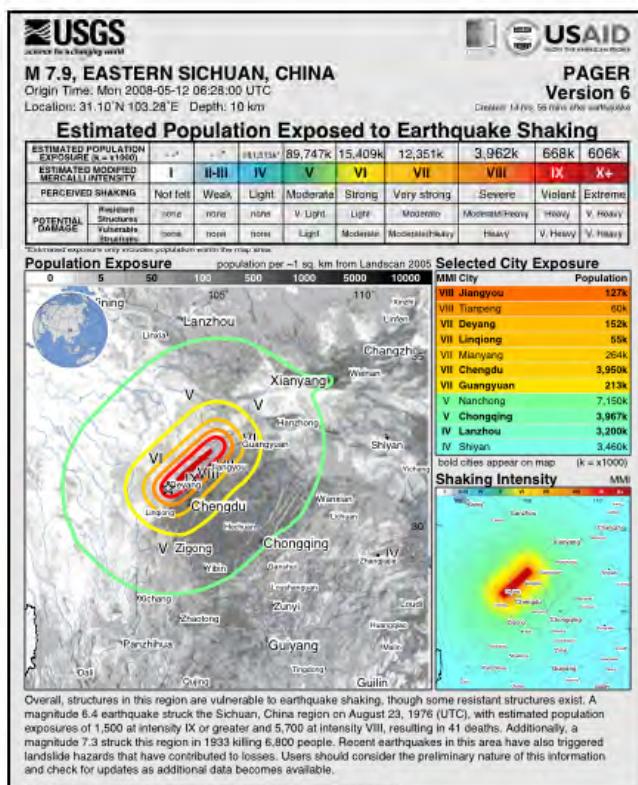




USGS - National Earthquake Information Center

Earthquake reporting from open global data

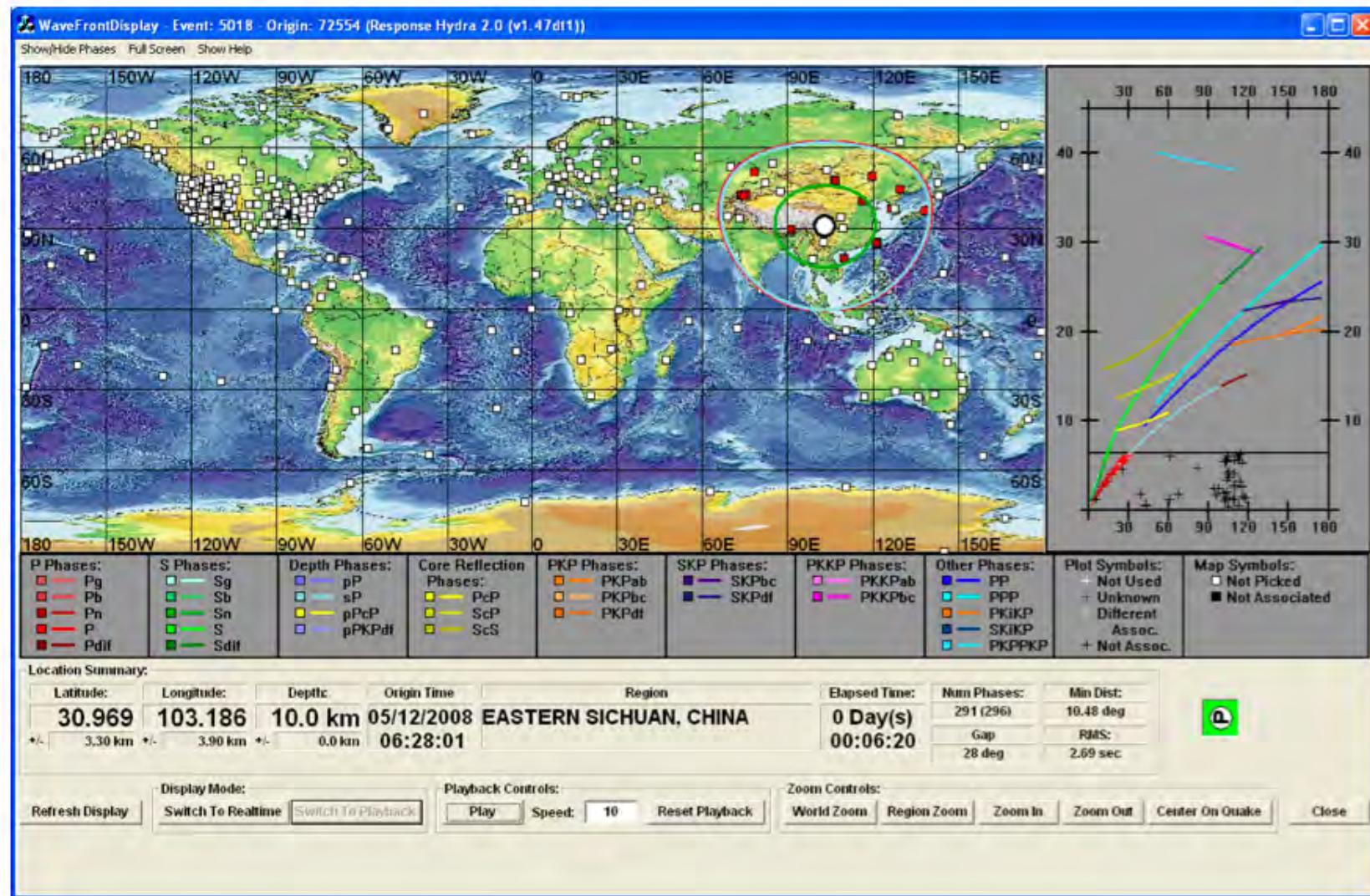
Example of the Sichuan China earthquake - May 2008



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

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

ESTIMATED POPULATION EXPOSURE (k = x1000)	I	II-III	IV	V	VI	VII	VIII	IX	X+
ESTIMATED MODIFIED MERCALLI INTENSITY	Not felt	Weak	Light	Moderate	Strong	Very strong	Severe	Violent	Extreme
PERCEIVED SHAKING	none	none	none	V, Light	Light	Moderate	Moderate/Heavy	Heavy	V. Heavy
POTENTIAL DAMAGE	Resistant Structures	none	none	Light	Moderate	Moderate/Heavy	Heavy	V. Heavy	V. Heavy
POTENTIAL DAMAGE	Vulnerable Structures	none	none	Light	Moderate	Moderate/Heavy	Heavy	V. Heavy	V. Heavy

*Estimated exposure only includes population within the map area.

Population Exposure

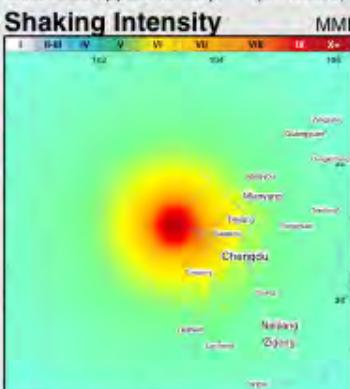
population per ~1 sq. km from Landscan 2005



Selected City Exposure

MMI City	Population
VII Tianpeng	60k
VII Linqiong	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)



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.

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

PAGER Version 3

Created: 2 hrs, 15 mins after earthquake

2.25 hours

Updated population exposure results

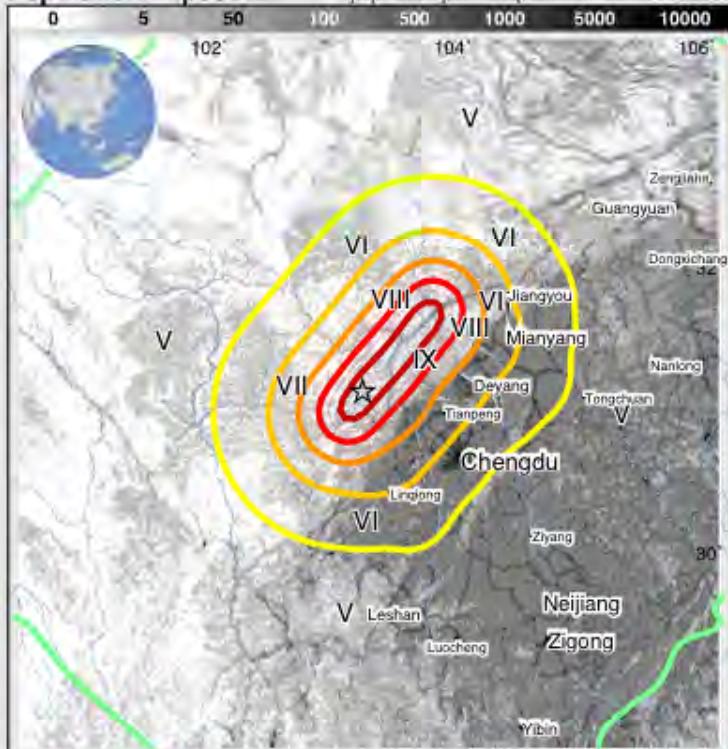
Estimated Population Exposed to Earthquake Shaking

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

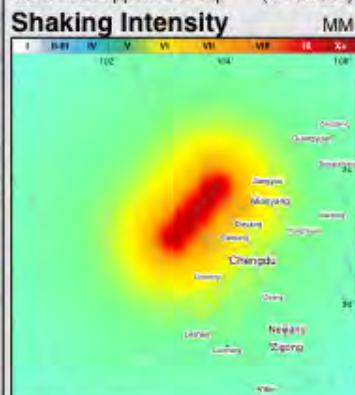
population per ~1 sq. km from Landscan 2005



Selected City Exposure

MMI City	Population
VII Tianpeng	60k
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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)

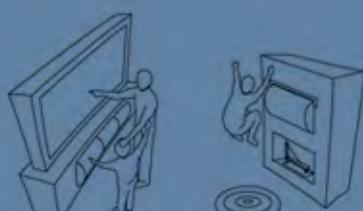
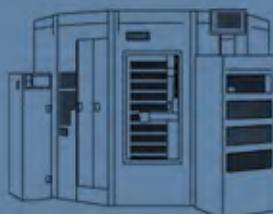
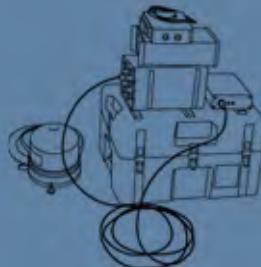


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1.1 million \geq MMI VIII
5.9 million \geq MMI VII

Prompt
Assessment of
Global
Earthquakes for
Response

IRIS



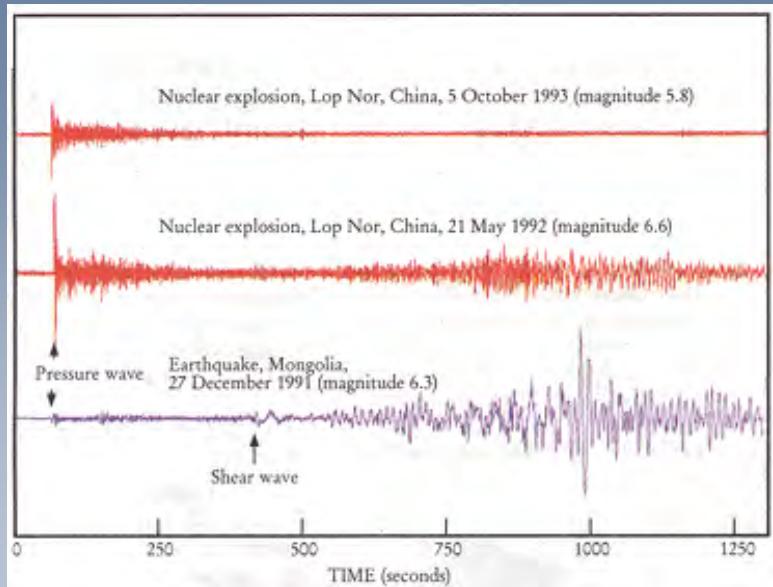
Mission Applications - Nuclear Test Monitoring and Research



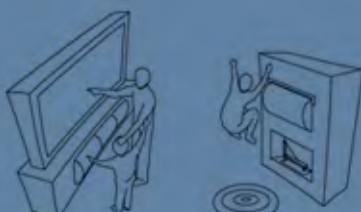
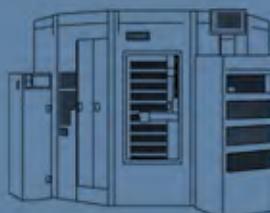
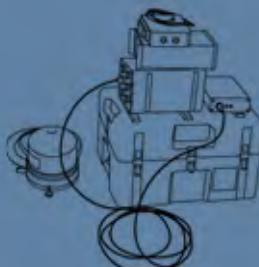
GLOBAL SEISMOGRAPHIC NETWORK
& INTERNATIONAL MONITORING SYSTEM (IMS)



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

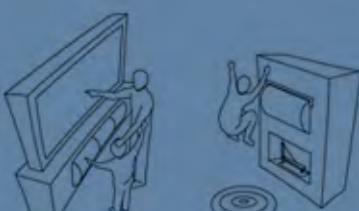
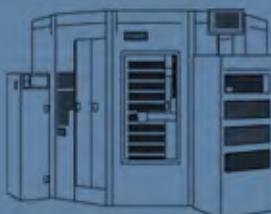
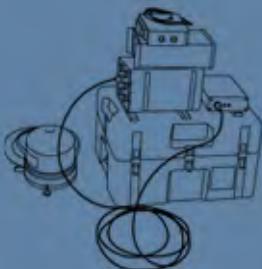
Multi use and re-use of data

Community-designed Networks and Experiments

EarthScope/USArray

NERIES - ORFEUS - Europe

ChinaArray



Drivers of Open Data Exchange

Advancing Technology

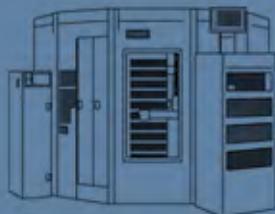
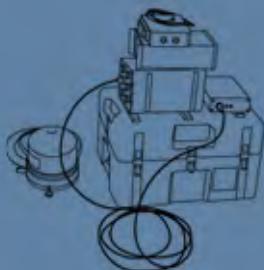
- Global communications
 - Satellite, cell, Internet
- Mass storage devices
 - K\$'s per Terabyte
 - Advanced DBMS systems

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

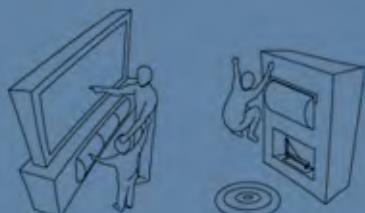
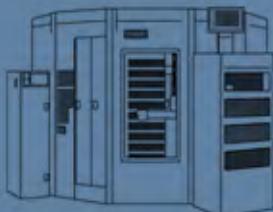
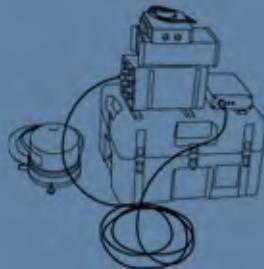
Local network operations and advanced research

Quality Control and Feedback

“Eyes on the data” improves quality and performance

Support for archival resources and maintenance

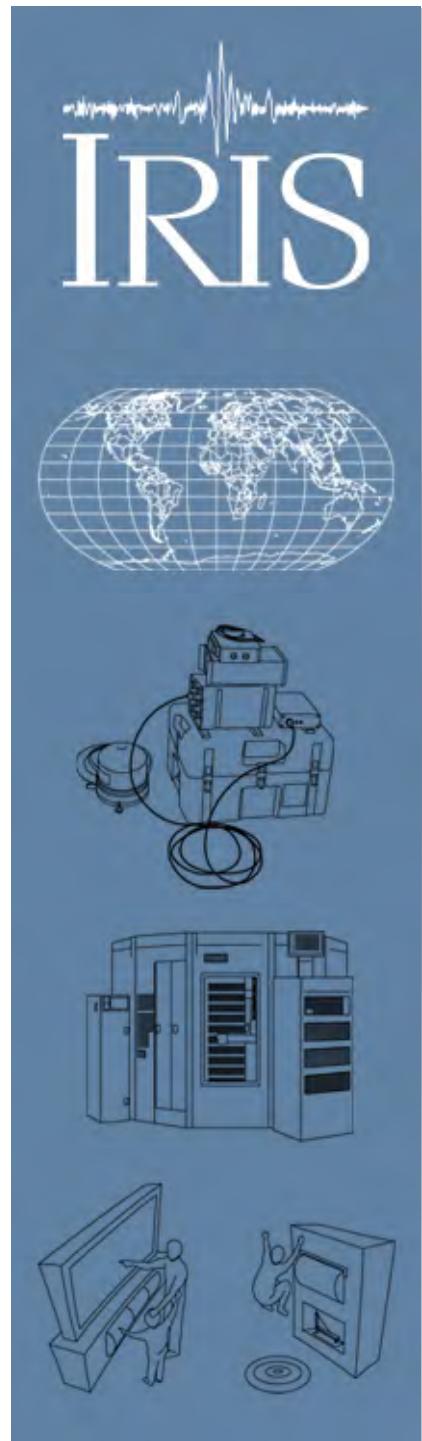
IRIS



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





The word "IRIS" is written in a large, blue, serif font. Above the letter "I", there is a blue seismogram waveform. The background is a solid blue gradient.