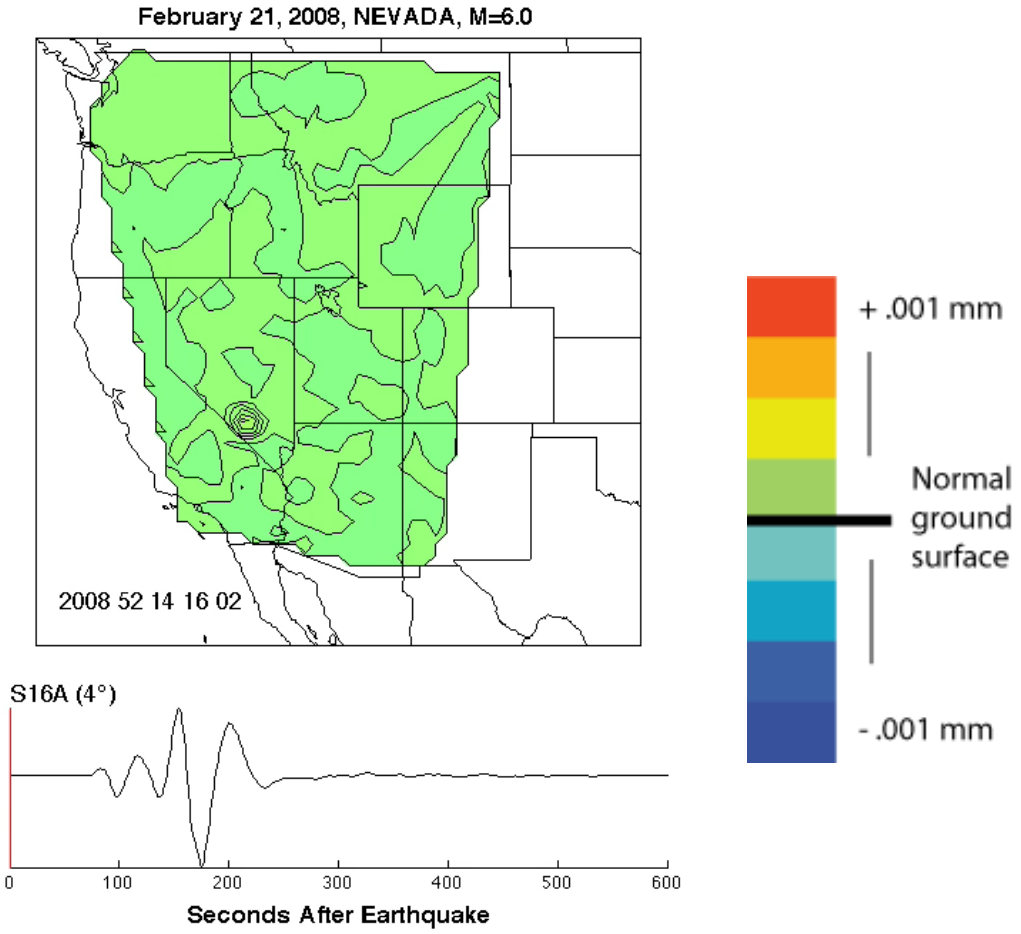
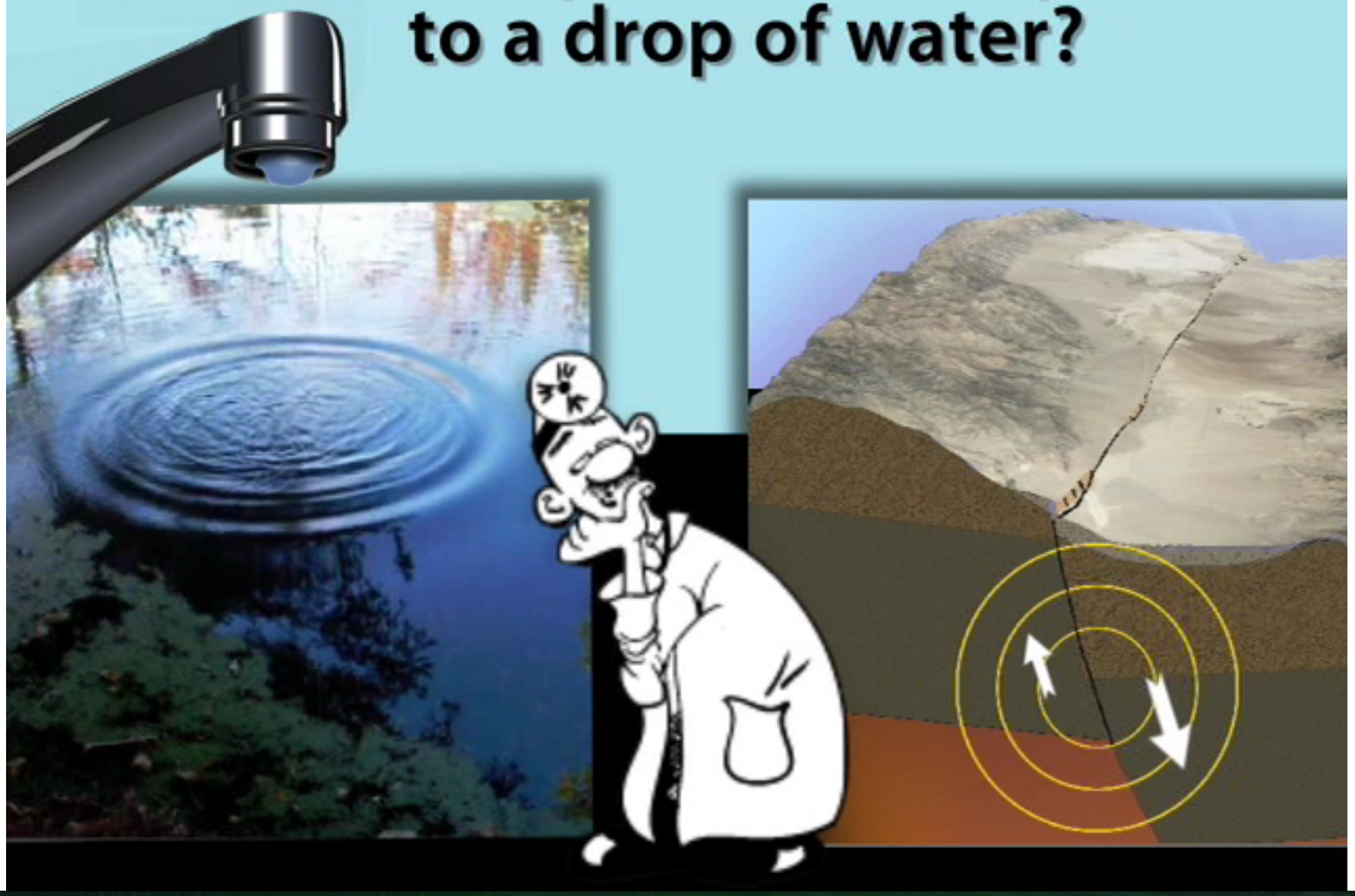
Beyond the slinky: Sequencing activities, earthquake visualizations, and demonstrations to enhance student learning of seismic waves

John Taber and
Michael Hubenthal
IRIS Consortium

Let's Compare



Can an earthquake be compared to a drop of water?



An earthquake is also unlike ripples

Ripples in Pond

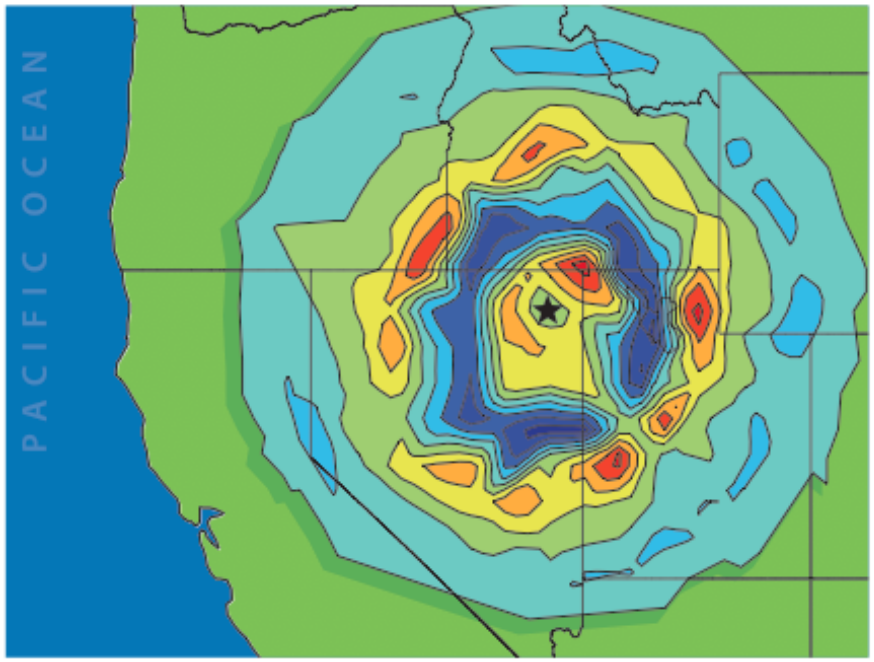
Waves from earthquake

Part 2

IRIS

EARTHQUAKES...LIKE RIPPLES ON WATER?

Instructors' Guide | REVISED: March 2013 | **VERSION: 1.0** | ***http://www.iris.edu/hq/inclass/lesson/EQ_like_ripples/***

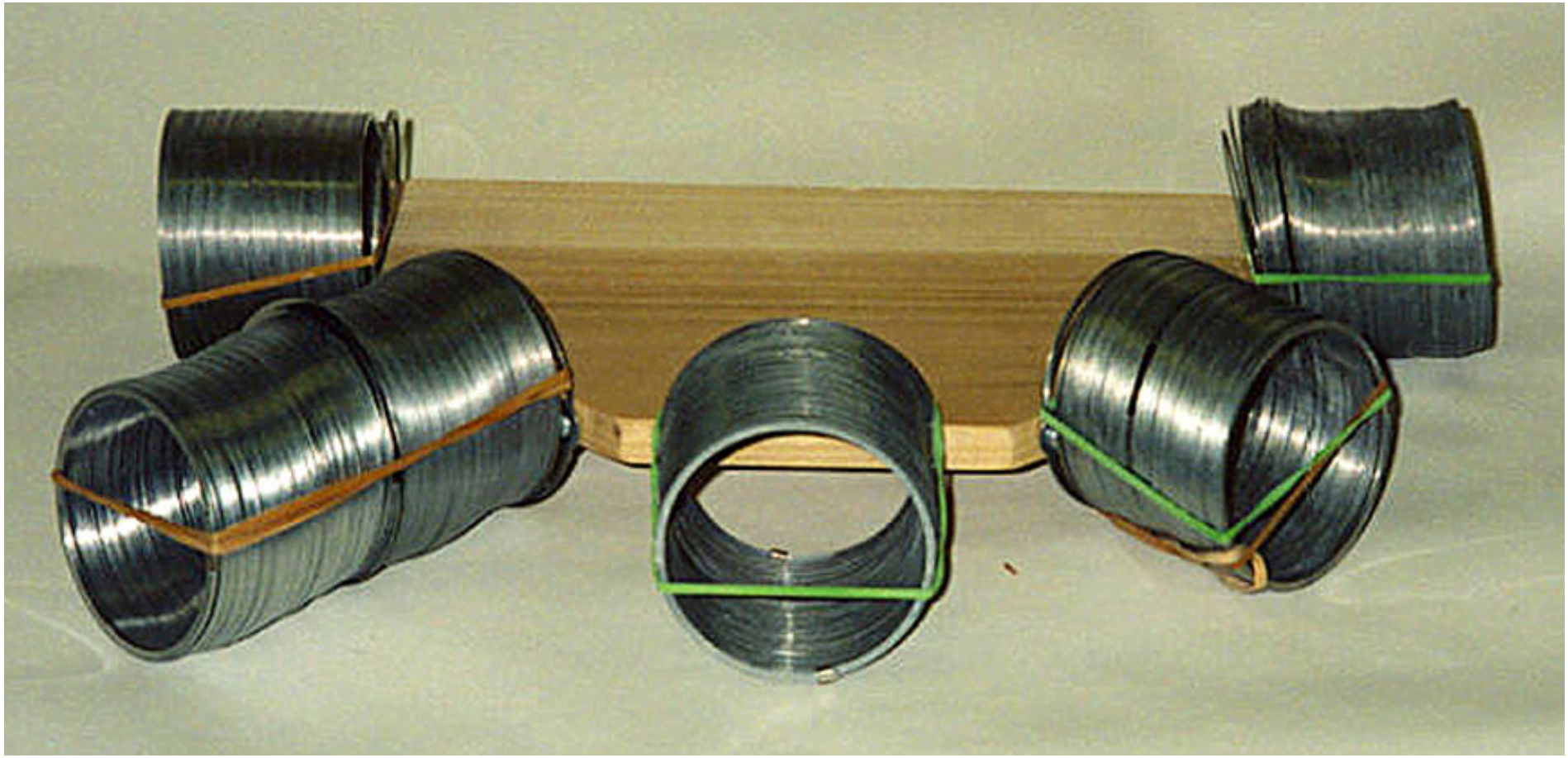


WHAT'S INCLUDED:

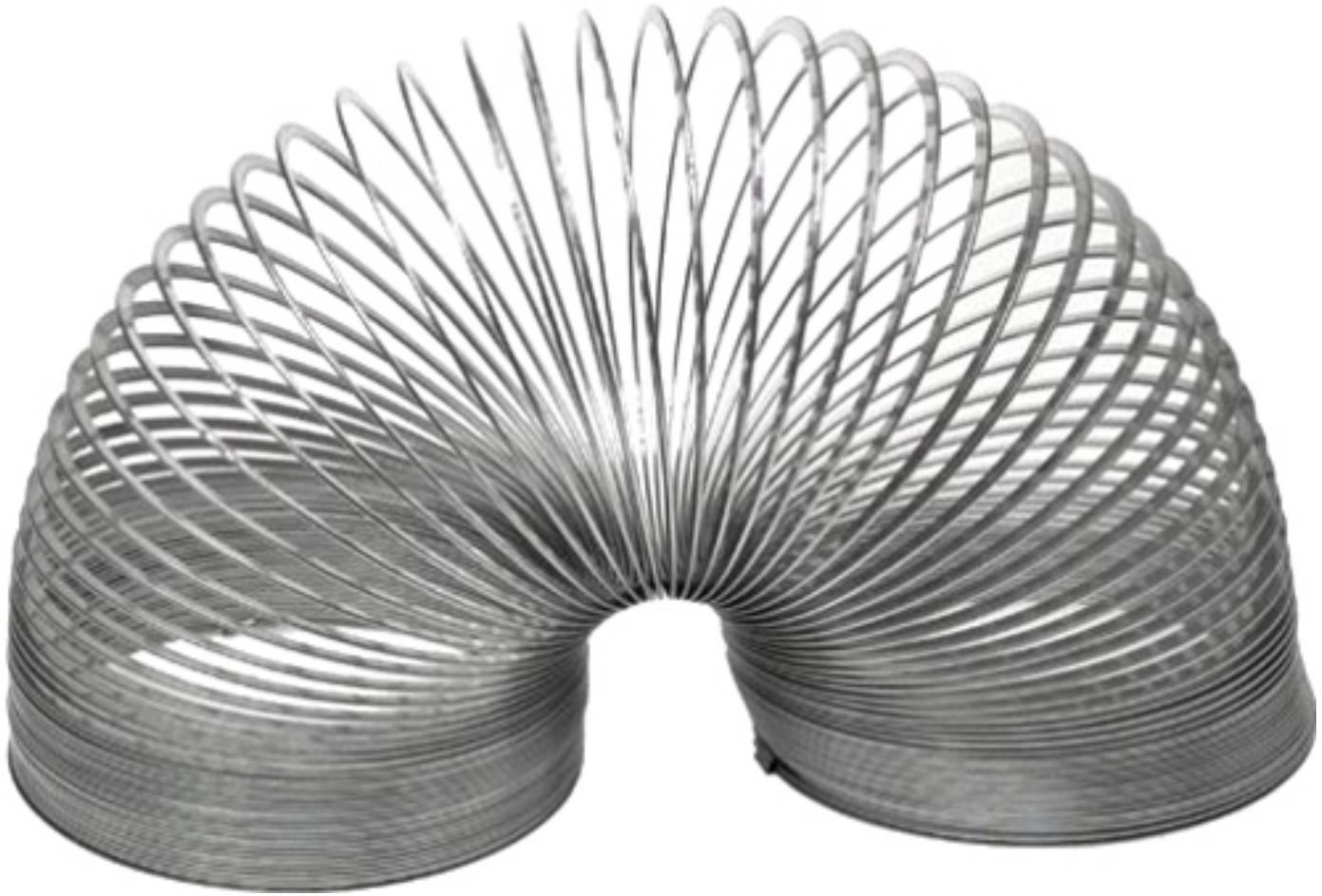
See this activity as part of one or more learning sequences at:

www.iris.edu/hq/inclass/sequences

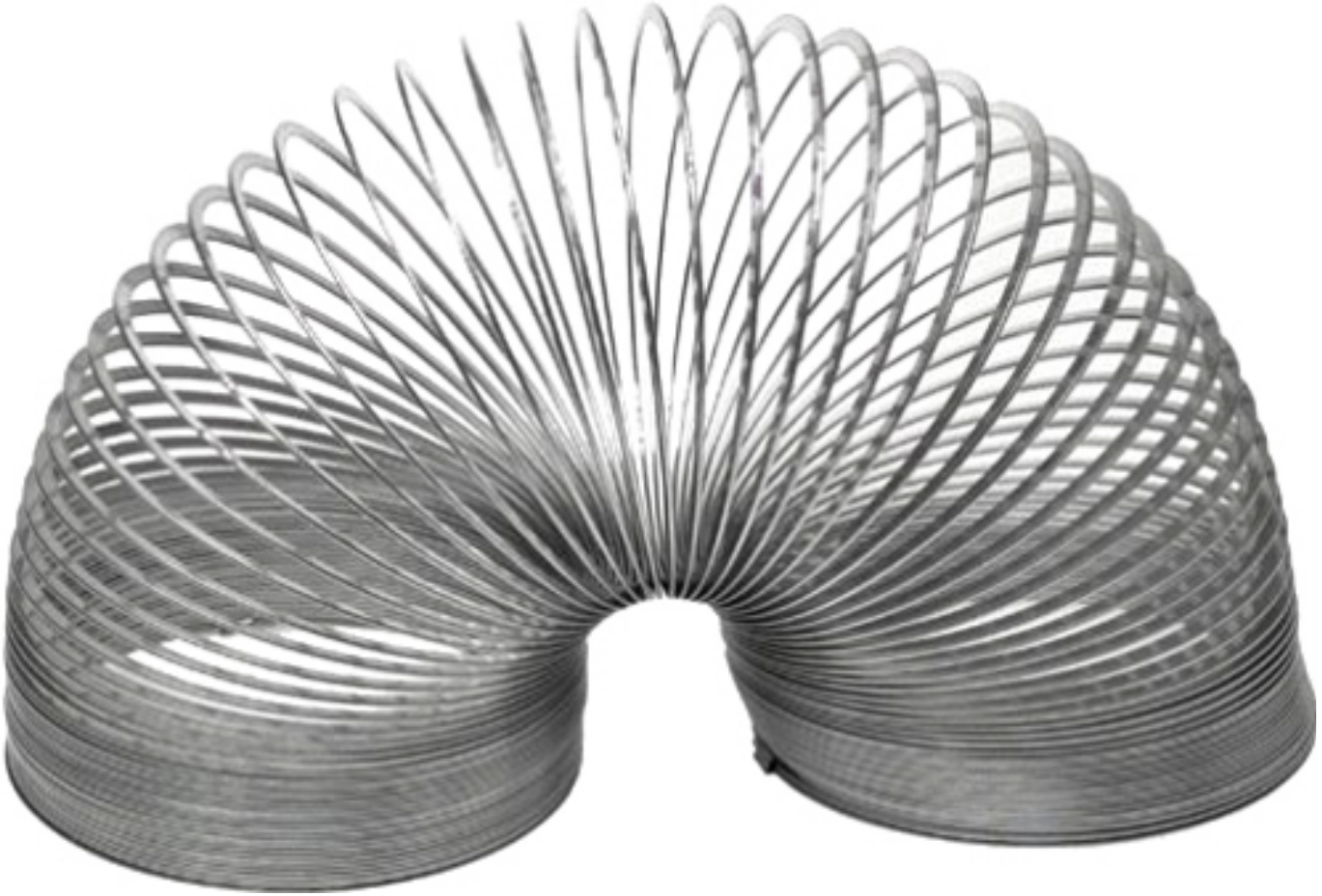
Wave fronts to ray paths – following packets of energy



Slinky



If you need an elastic spring for waves to travel in a material, where is the spring in the Earth?



ROCKS ARE ELASTIC!

Instructors' Guide | REVISED: Nov 2012 | **VERSION: 1.0** | ***http://www.iris.edu/hq/inclass/lesson/elastic_rocks***

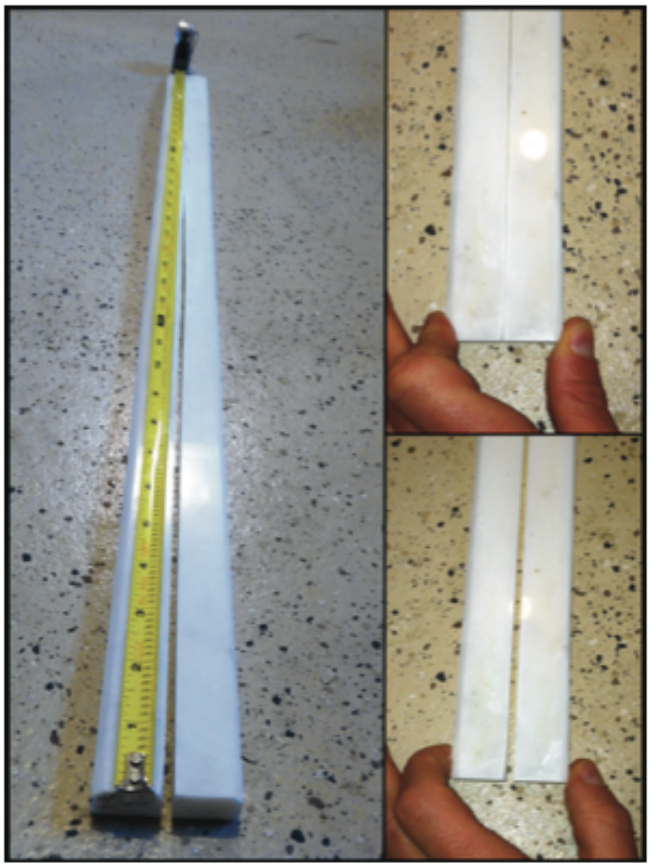


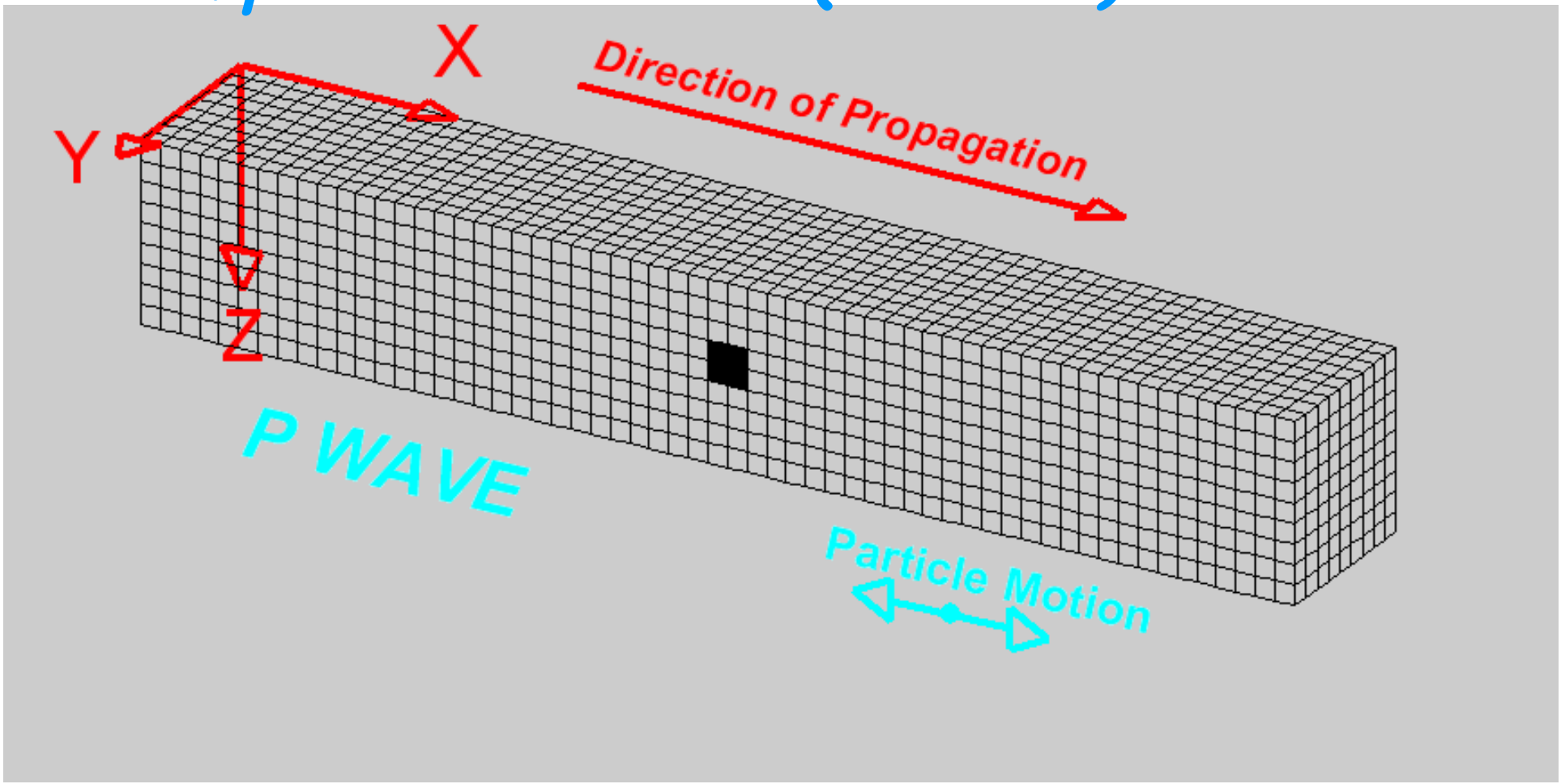
Figure 1. *Marble tongs. Made from a common marble threshold, these tongs physically demonstrate that rocks are elastic solids.*

WHAT'S INCLUDED:

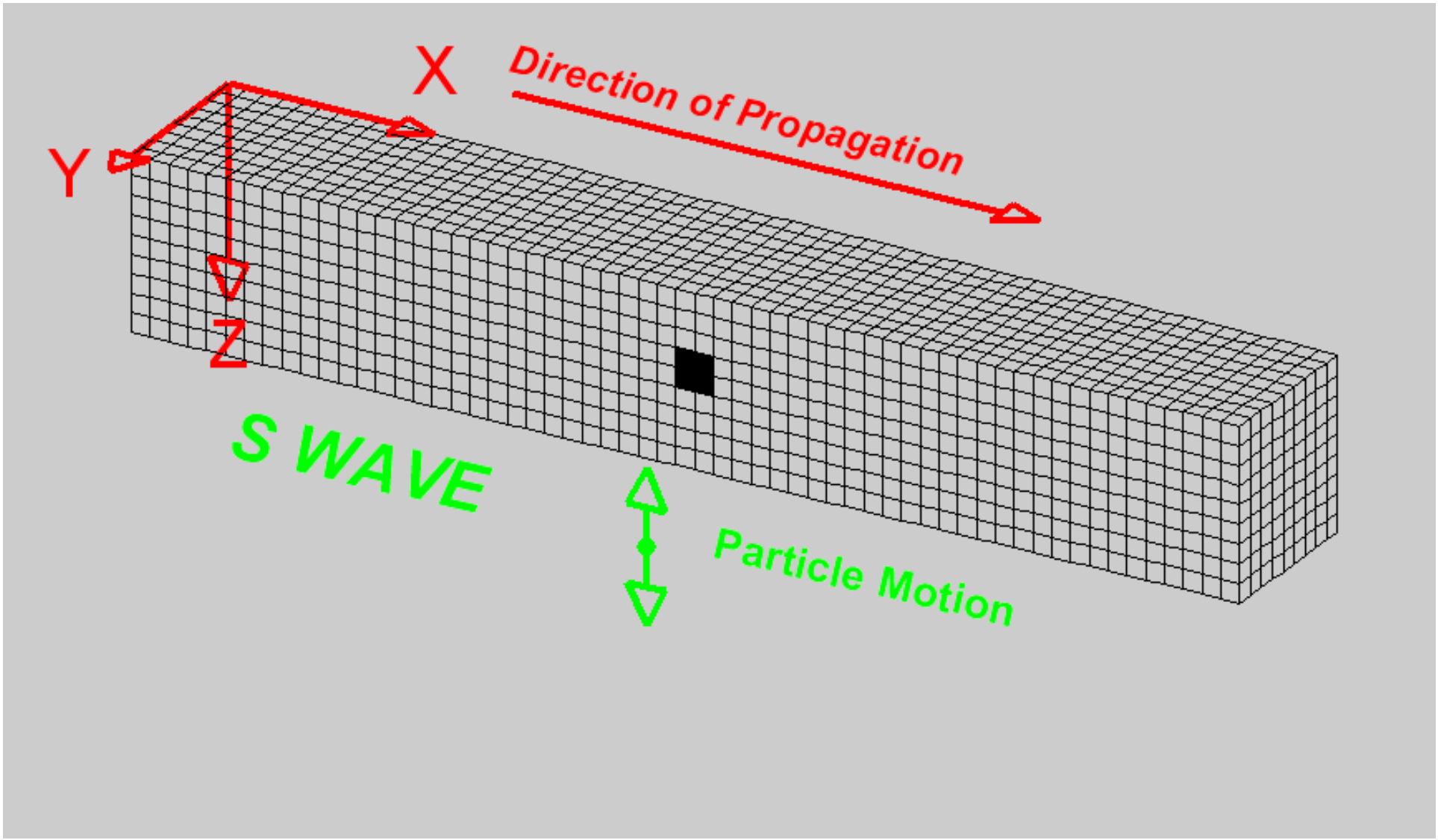
See this activity as part of one or more learning sequences at:

www.iris.edu/hq/inclass/sequences

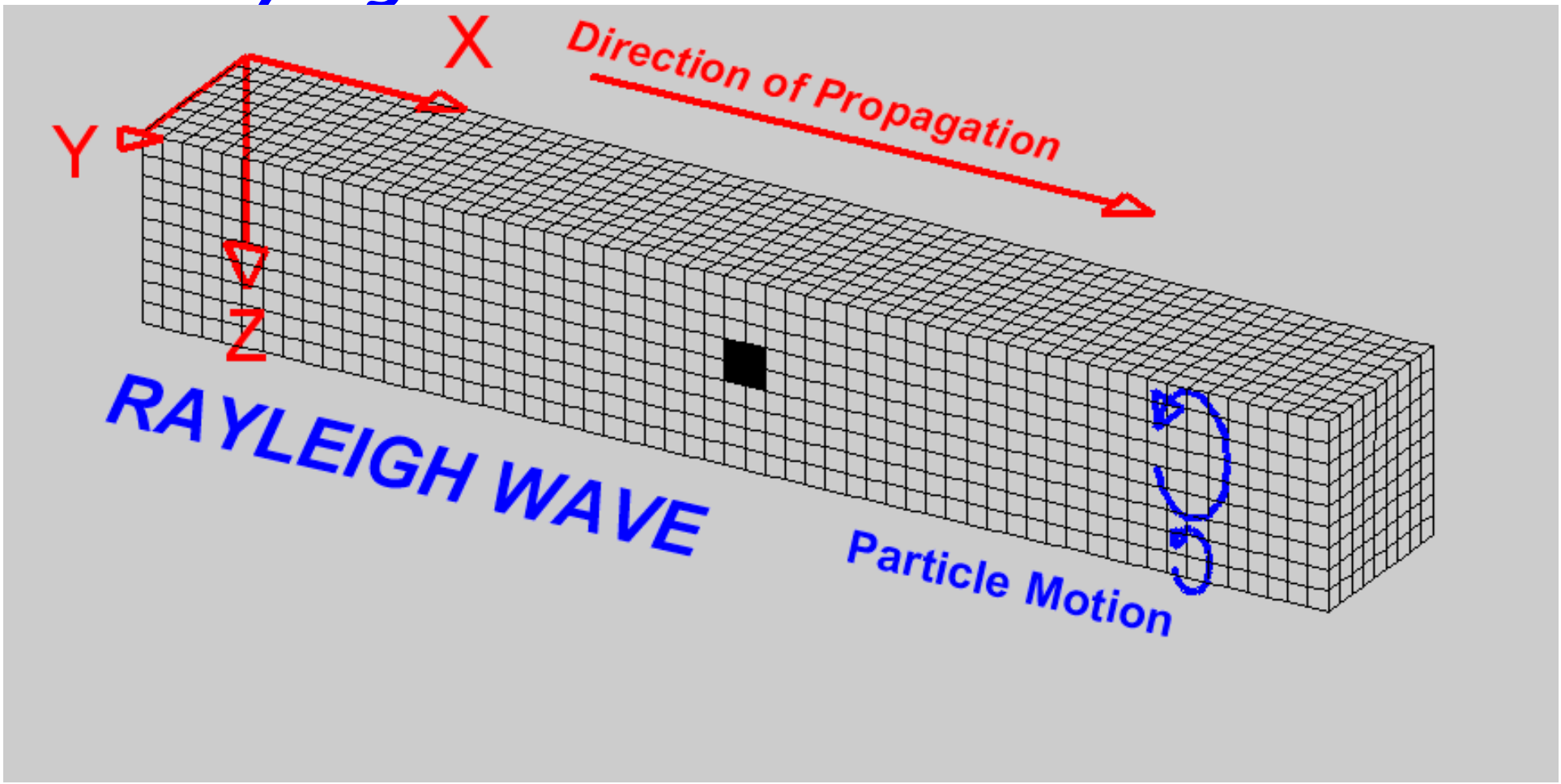
Compressional Wave (P-Wave)



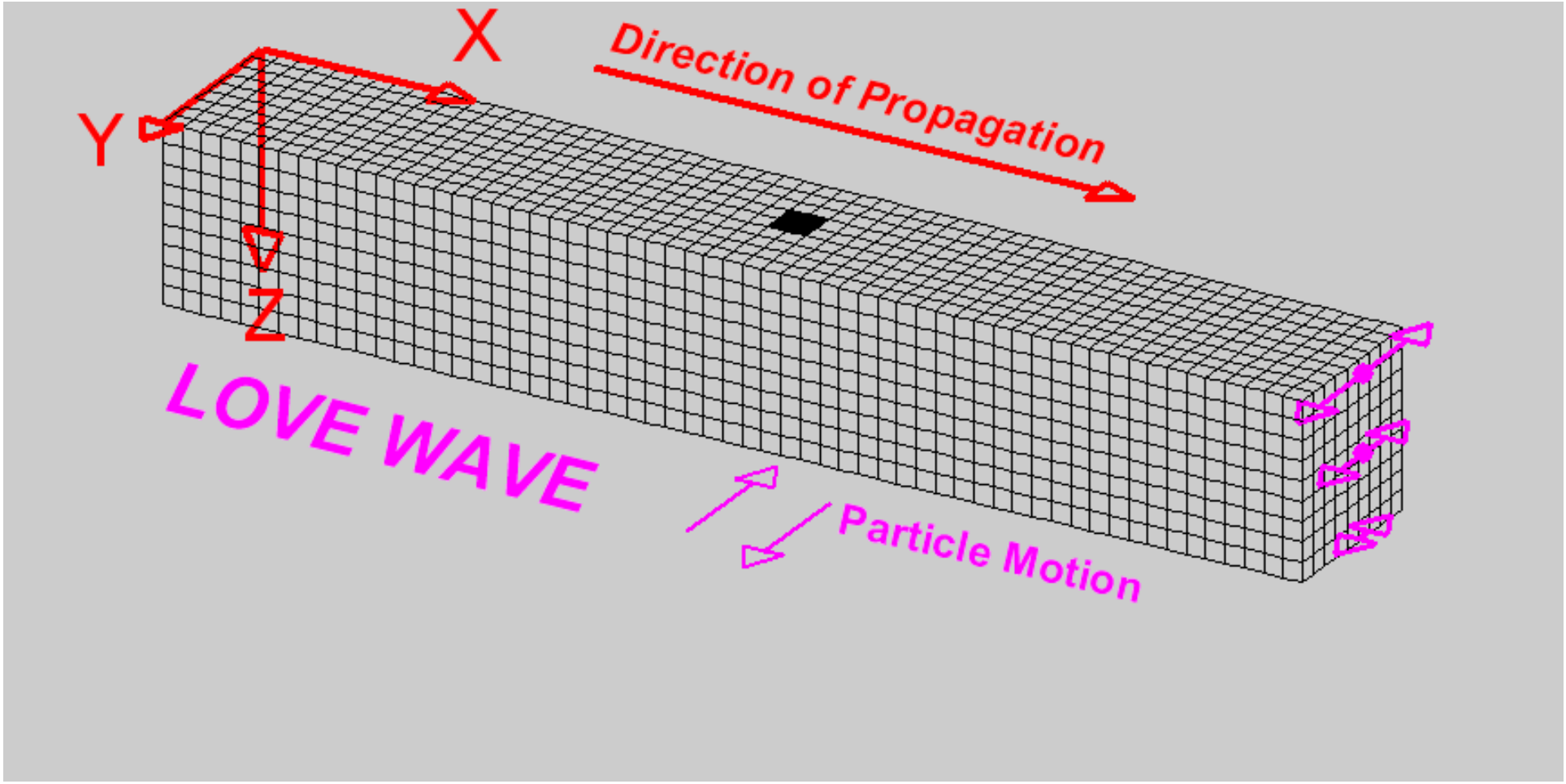
Shear Wave (S-Wave)



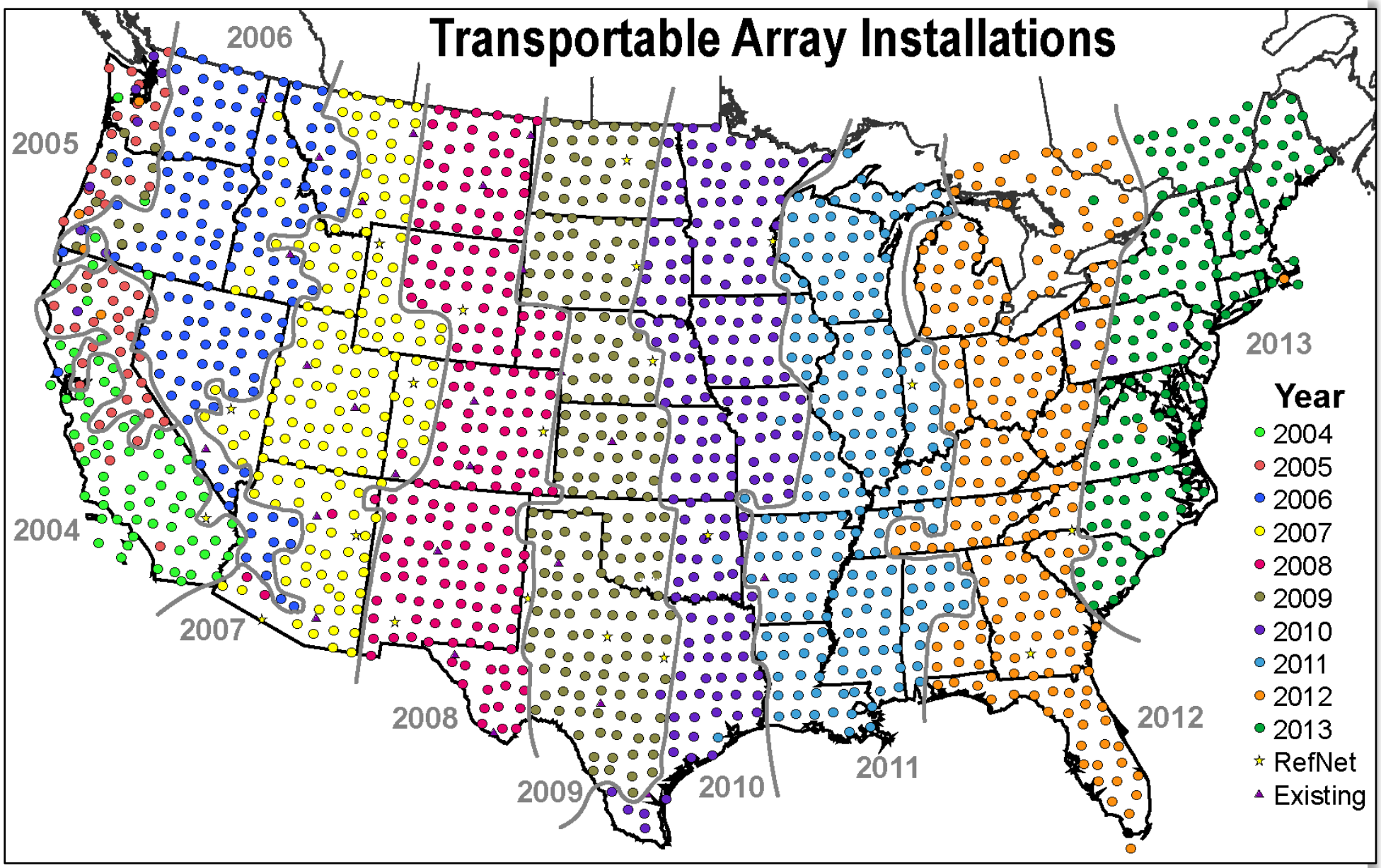
Rayleigh Wave



Love Wave



Human Wave


Transportable Array Installations
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
Year
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
RefNet
Existing

IRIS DMS Combined Ground Motion Visualization

GULF OF CALIFORNIA 2007 - 2013

IRIS

IRIS DMS Combined Ground Motion Visualization

Gulf of California, 2007-2013

Max Lat: 26.20

Min Lon: 110.60 | 109.10 | Max Lon:

Min Lat: 24.67

Start Date: 2007-09-01 00:00

End Date:

Magnitude: 5.5 - 7.7

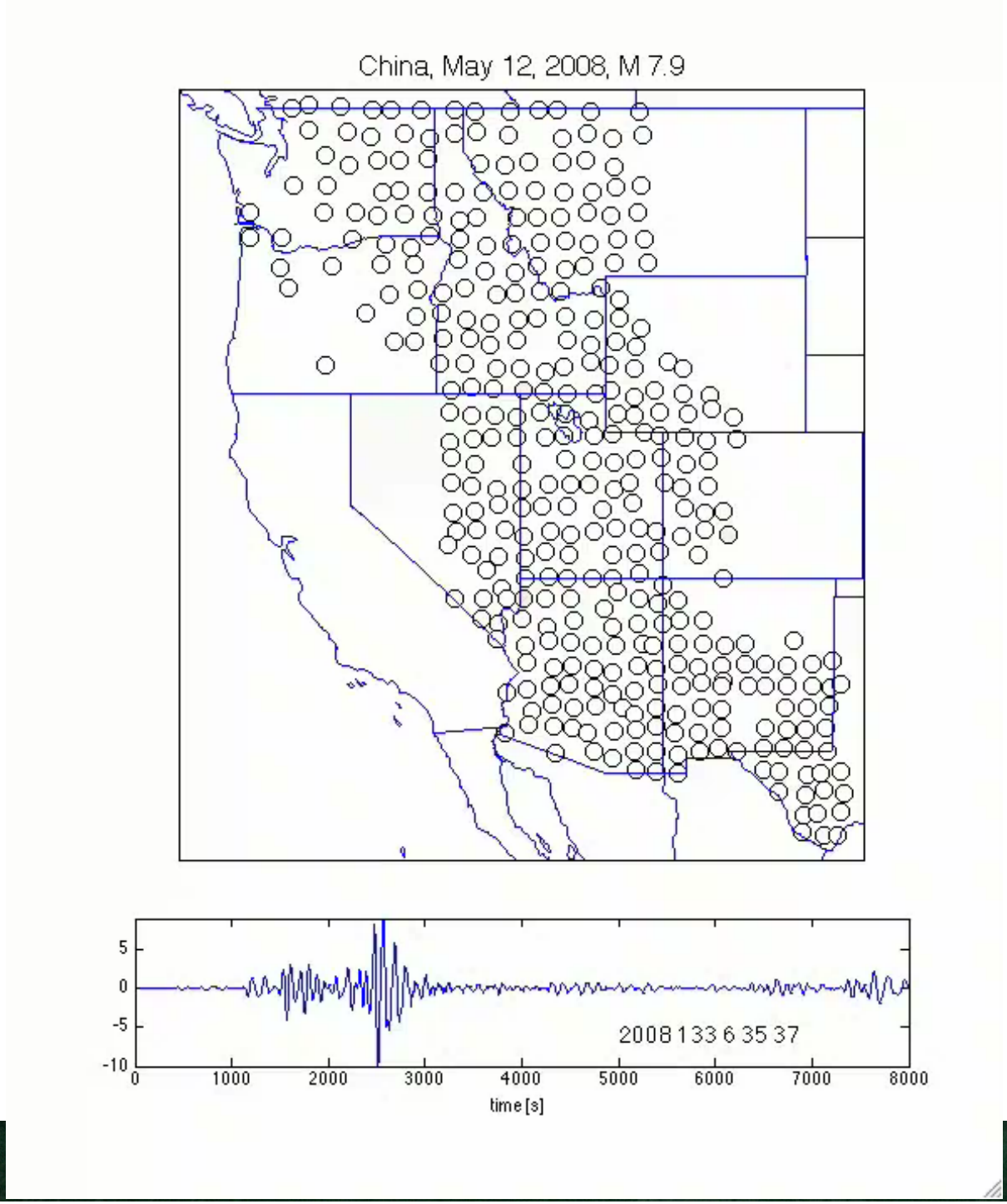
Depth (km): 0 - 700

Strike: 0 - 360

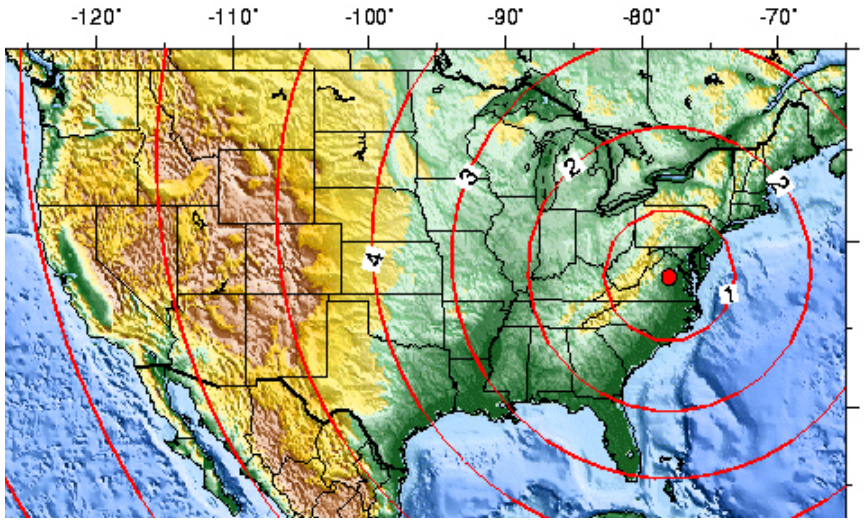
Dip: 0 - 90

Rake: -180 - 180

	Event Time (UTC)	Depth (km)	Mag	Latitude	Longitude	FM	Region
1	2013-10-19 17:55:08	15.1	6.6	26.17	-110.58		GULF OF CALIFORNIA
	2013-01-15 16:28:27	18.4	5.7	25.88	-110.28		GULF OF CALIFORNIA
2	2012-10-06 06:28:25	19.7	6.0	25.17	-109.73		GULF OF CALIFORNIA
	2012-09-25 23:45:27	12.0	6.3	24.92	-110.29		BAJA CALIFORNIA, MEXICO
3	2011-07-26 17:44:22	17.5	6.0	25.06	-109.68		GULF OF CALIFORNIA
	2011-08-12 13:26:02	20.6	5.6	25.27	-109.87		GULF OF CALIFORNIA
4	2010-10-21 17:53:19	14.2	6.7	24.83	-109.29		GULF OF CALIFORNIA
	2010-10-20 06:58:16	15.5	5.8	24.72	-109.16		GULF OF CALIFORNIA
	2010-10-20 04:15:38	17.4	5.7	24.89	-109.15		GULF OF CALIFORNIA
	2010-10-20 04:03:47	19.4	5.8	24.74	-109.19		GULF OF CALIFORNIA
5	2009-07-09 11:00:17	14.4	5.9	25.20	-109.87		GULF OF CALIFORNIA
6	2007-09-01 19:14:26	14.9	6.1	24.76	-109.89		GULF OF CALIFORNIA

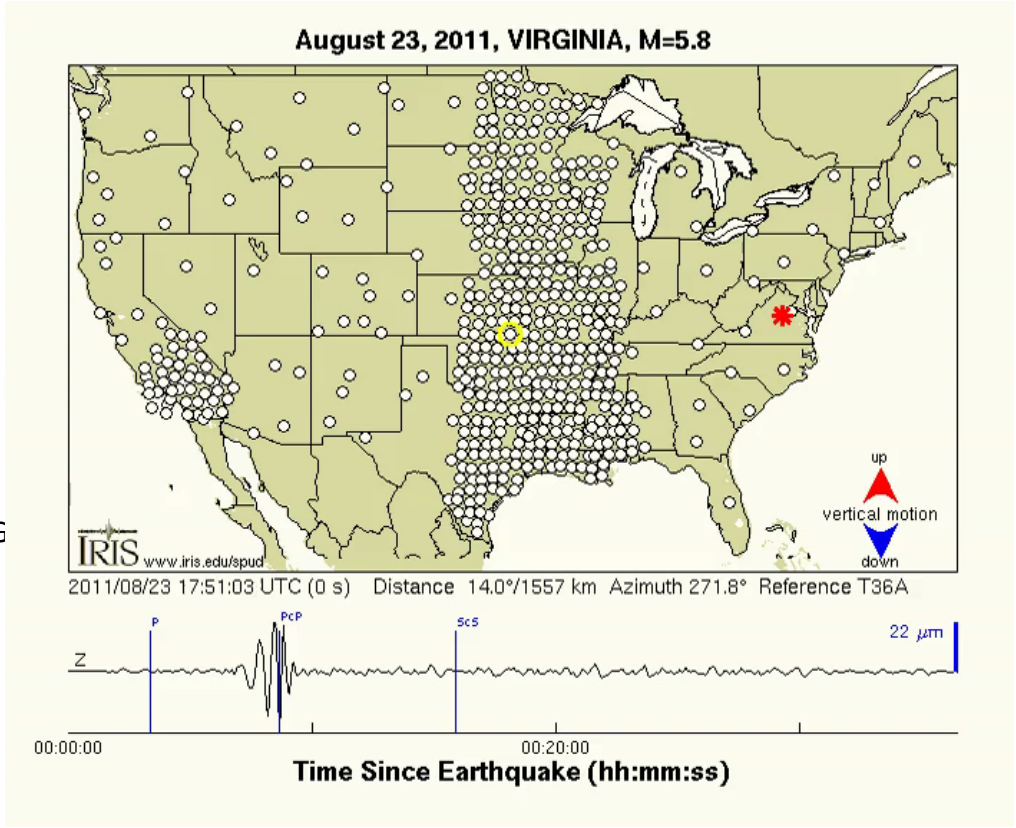

China, May 12, 2008, M 7.9
5
0
-5
-10
0
1000
2000
3000
4000
5000
6000
7000
8000
time [s]
2008 133 6 35 37

Magnitude 5.8 VIRGINIA
Tuesday, August 23, 2011 at 17:51:04 UTC

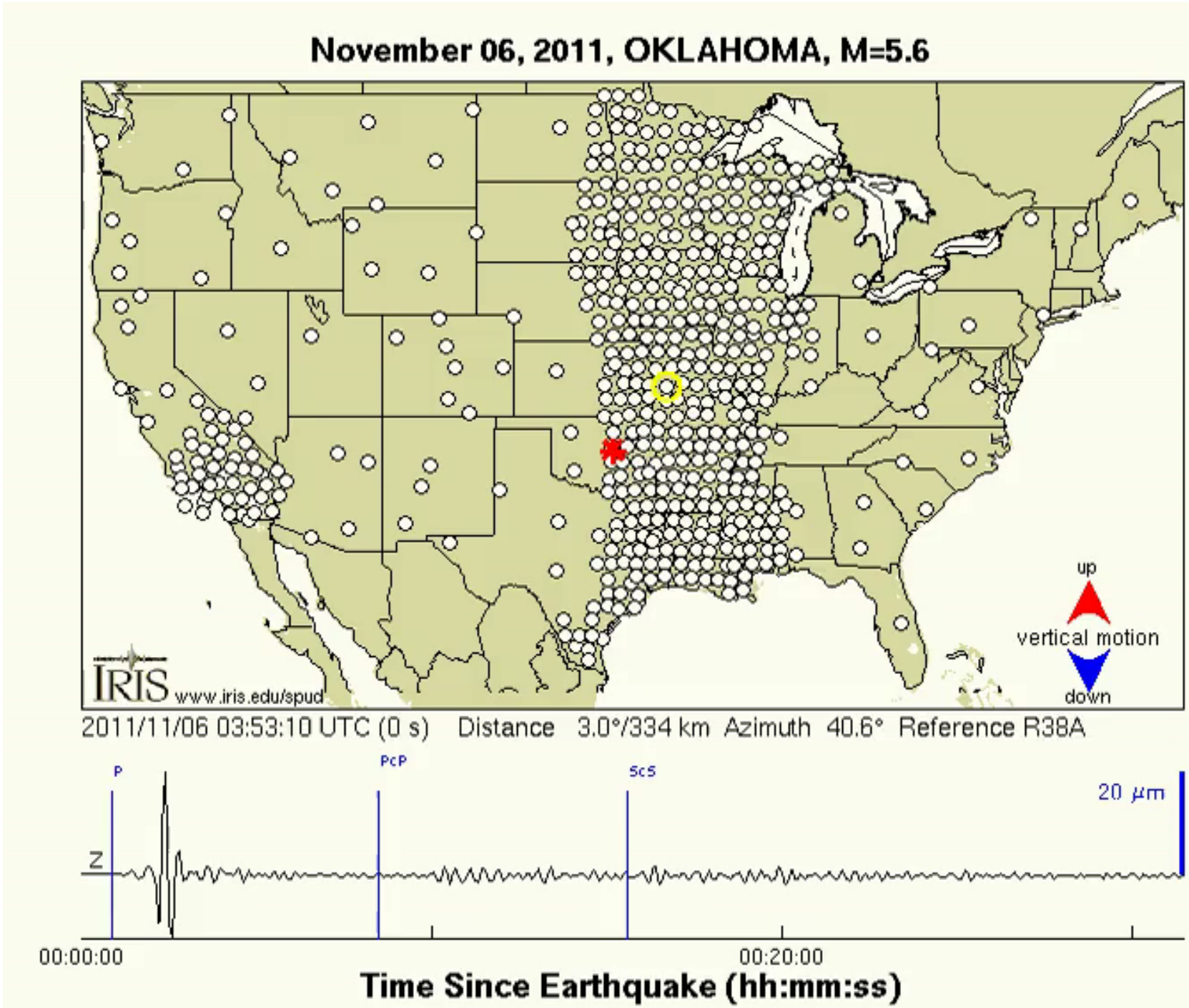


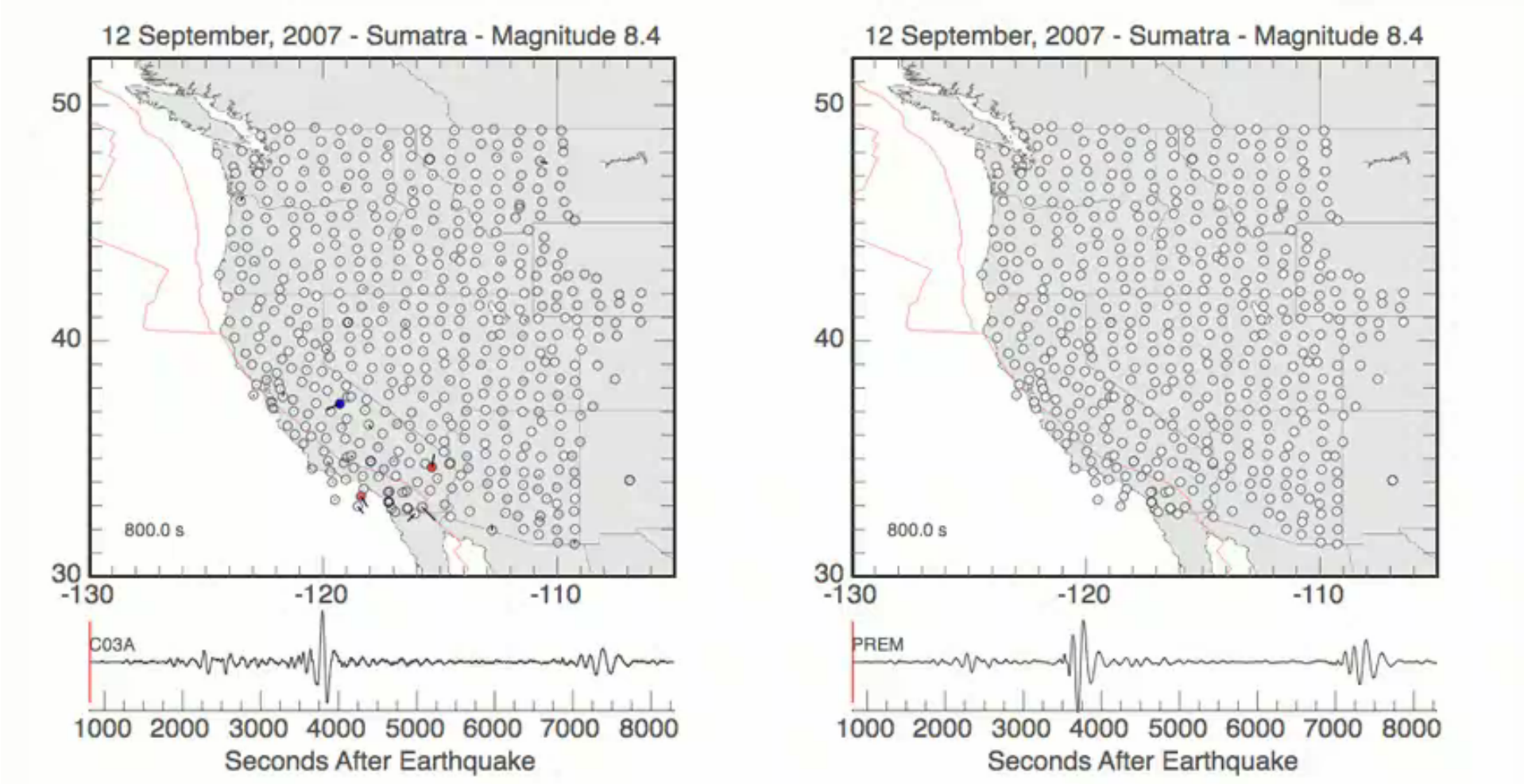
Courtesy USG

The above map shows the predicted (theoretical) travel times, in minutes, of the first compressional (P) wave from the earthquake across the United States.



Movie showing seismic waves crossing the US recorded by the USArray.


November 06, 2011, OKLAHOMA, M=5.6
IRIS www.iris.edu/spud
up
vertical motion
down
2011/11/06 03:53:10 UTC (0 s) Distance 3.0°/334 km Azimuth 40.6° Reference R38A
P
PcP
ScS
20 μm
Z
00:00:00
00:20:00
Time Since Earthquake (hh:mm:ss)


12 September, 2007 - Sumatra - Magnitude 8.4
50
40
30
-130
-120
-110
800.0 s
C03A
1000 2000 3000 4000 5000 6000 7000 8000
Seconds After Earthquake
12 September, 2007 - Sumatra - Magnitude 8.4
50
40
30
-130
-120
-110
800.0 s
PREM
1000 2000 3000 4000 5000 6000 7000 8000
Seconds After Earthquake

Sequence summary

- Earthquakes: Like ripples on water?
  - How same?
  - How different?
- Wave fronts to ray paths – 5 slinky model
- Slinky
  - P, S waves
  - Energy transfer
  - Elastic medium
- Bendable rock
- Other Earth materials
  - Silly putty <-> mantle
  - Layers – metal/plastic slinky
- Human wave
- USArray visualizations
  - Intro versions
  - Choose a recent earthquake
  - Using data to improve Earth models