LCSN
Lamont-Doherty Cooperative Seismographic Network

ANSS

LCSN NEWSLETTER

Issue 1 **July 2008**

Earthquake of the Month

On July 5, 2008 at 02:12 UTC, a big earthquake of moment magnitude (Mw) 7.7 occurred beneath the Sea of Okhotsk. The shock was the largest event that occurred during June-July 2008 and it occurred at a focal depth of about 630 km (deep-focus earthquake). The shock occurred on the descending slab (Pacific plate) that dips to the west-northwest beneath Kamchatka and the Kuril Islands with a predominantly normal faulting mechanism. You can find more details about tectonic settings and a summary poster for this event on the ANSS/USGS web site at: http://earthquake.usgs.gov/eqcenter/eqarchives/poster/2008/20080705.php

The event caused no known damages or casualties in the epicentral area. The strong seismic signals from the shock provide an opportunity to calibrate instruments at the seismographic stations of LCSN. Figure 1 shows one hour of vertical-component records from 21 LCSN stations. LCSN stations are at distance ranges of 73.7° to 77.7° and azimuth ranges of 32.5° to 38.4° from the shock. Strong first arrival *P* waves with high frequency content dominates these vertical records. Notice lack of surface waves – Rayleigh wave on these vertical records, due to very poor excitation of surface waves from such deep focus earthquake.

ANNOUNCEMENTS

- **Reminder**: Annual Station Operators Workshop is scheduled for Saturday, October 25, at the Lamont campus. If you plan to attend, but, have not yet responded, please let me know.
  Charles Scharnberger
  Chairperson, LCSN Advisory Committee

- **LDEO's Annual Open House**– October 4, 2008, 10:00 am-4:00pm. This years theme "Science to Sustain the Planet". **Open to the public**.

LCSN Partners

ACCN (Adirondack Com. College, NY)
Adirondack Community College, SUNY, Glens Falls, NY

ALLY (Allegheny, PA)
Allegheny College, PA

BRNJ (Basking Ridge, NJ)
William Annin Middle School, Basking Ridge, NJ

BRNY (Black Rock Forest, NY)
Black Rock Forest Consortium, Cornwall, NY

CPNY (Central Park, NYC)
Central Park Conservancy, New York City

CUNY (City University, NY)
Queens College, CUNY, Queens, NYC

FMPA (Franklin & Marshall College, PA)
Franklin and Marshall College, PA

FOR (Fordham University, NYC)
Fordham University, the Bronx

FRNY (Flat Rock, Altona, NY)
Miner Agricultural Research Institute

HBVT (Hainsburg, VT)
University of Vermont, Burlington, VT

HCNY (Howe Caverns, NY)
Howe Caverns, Cobleskill, New York
SUNY Cobleskill
LONY (Lake Ozonia, NY)
Advanced National Seismic System/ USGS

LUPA (Lehigh University, PA))
Lehigh University, Lehigh, PA

MDV (Middlebury, VT)
Middlebury College, VT

MIV (Mineville, NY)
Middlebury College, VT

MEDO (Medina, NY)
POLARIS Consortium, Canada

MMNY (Mount Morris Dam, NY)
US Army Corps of Engineers, Buffalo District
Geneseo College, SUNY

MSNJ (Montclair State, NJ)
Montclair State University, NJ
Nature Center, Rifle Camp Park, Passaic County, NJ

MVL (Millersville, PA)
Millersville University, PA

NCB (Newcomb, NY)
College of Environmental Science and Forestry, Syracuse, SUNY
U.S. National Seismic Network, USGS/ NEIC, Golden, CO

NED (Newark, DE)
Delaware Geological Survey, MD

NPNY (New Paltz, NY)
Mohonk Preserve, New Paltz, NY
SUNY – New Paltz, NY

ODNJ (Ogdensburg, NJ)
Sterling Hill Mining Museum, Ogdensburg, NJ

PAL (Palisades, NY)
Lamont-Doherty Earth Observatory

PANJ (Princeton, NJ)
Princeton Academy of the Sacred Heart
Princeton University, NJ

PNZ (Plattsburgh, NY)
Plattsburgh State, SUNY

PRNY (Paleontological Res. Inst., NY)
Paleontological Research Institution, Museum of the Earth, Ithaca, NY
Cornell Univ., Ithaca, New York

PTN (Potsdam, NY), POTS (Potsdam, NY)
Potsdam College of Art & Science, SUNY

SDMD (Soldiers Delight, MD)
Maryland Geological Survey, MD
Towson University, MD

UCCT (University of Connecticut, CT)
University of Connecticut, Storrs, CT

WCCN (Westchester Com. College, NY)
Westchester Community College, SUNY, Valhalla, NY

WCNY (West Carthage, NY)
Carthage Central High School, NY

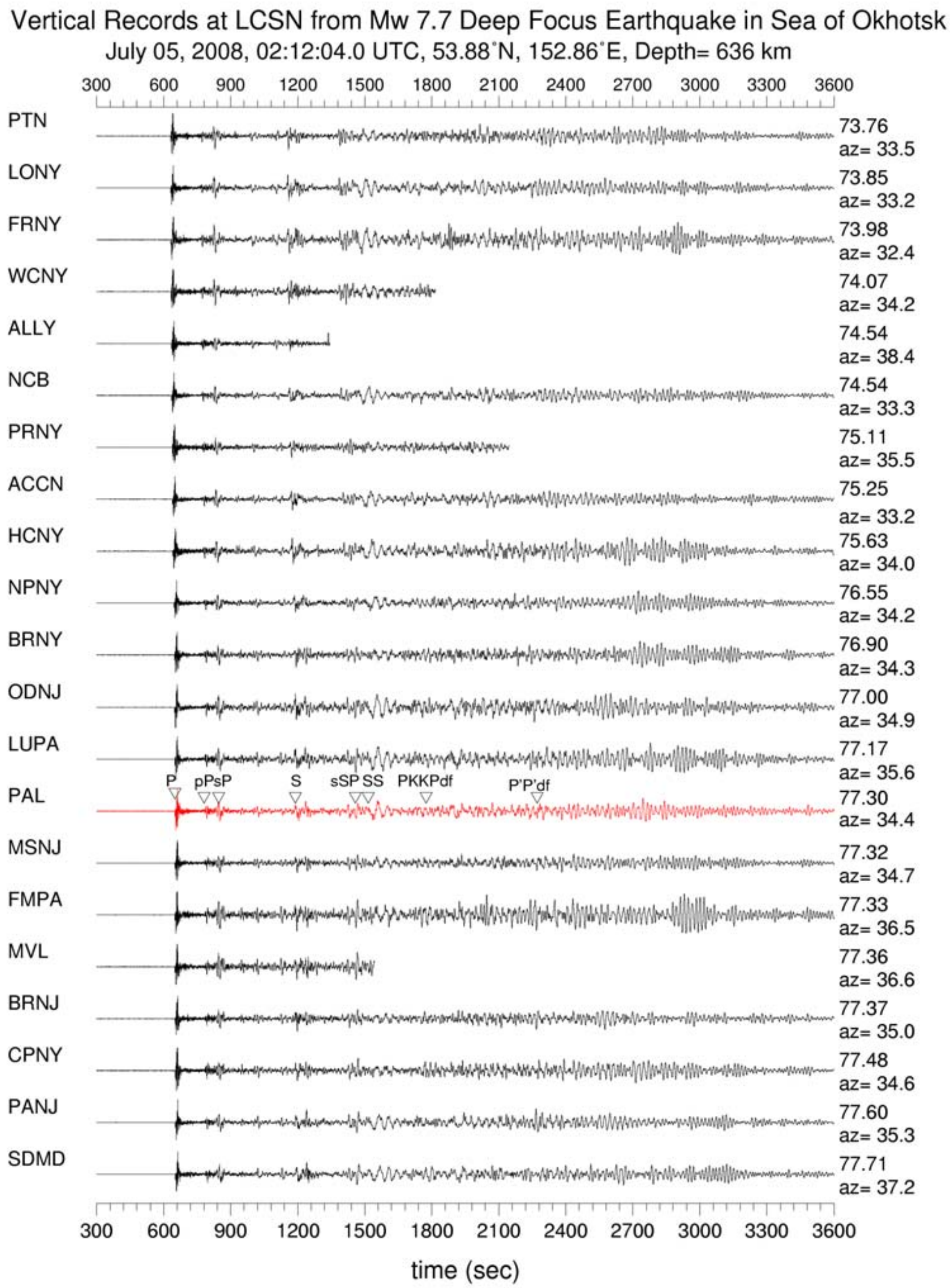

Figure 1. One hour of vertical records at LCSN stations from Mw 7.7, deep focus earthquake that occurred in Sea of Okhotsk on 5 July 2008. Notice strong first arrival *P* waves and lack of surface waves – Rayleigh wave on these vertical records.

Earthquake of the Month, Con't

From this plot, we can see that vertical records at stations, WCNY, ALLY, and MVL, are shorter than one hour, because seismic records at these stations have data drop offs and are discontinuous. These stations need improved data acquisition system with better connection for stable data transfer. Three stations of LCSN are missing from the figure: CUNY (Queens College, City University of New York; station down); FOR (Fordham; datalogger damaged due to lightning in early July, 2008, and UCCT (UConn, poor spread-spectrum radio telemetry). Analysis of these records is given in Education & Outreach section.

Station Profile: MVL, Millersville University, Pennsylvania

Station MVL was opened October 23, 1974, at Millersville State College (now Millersville University) in Lancaster County, Pennsylvania. The station coordinates are: 39.999° N. latitude, 76.351° W. longitude, 91 m. elevation.

Originally, the station operated with a Sprengnether smoked-paper MEQ recorder, set up in observatory mode. The seismometer was a 1-second vertical instrument provided by The Pennsylvania State University. The original location of the seismometer vault was a shallow bore hole with a steel casing and concrete base, located just outside the main entrance to Roddy Hall, the main science building on campus. This location facilitated placing the recorder on display in the main hallway, just inside the entrance. While this location produced reasonably good records of seismic events, it also recorded quite a lot of environmental noise, mostly from foot traffic in and out of the building.

In 1978, the vault was relocated to a site behind the building, away from sidewalks and roadways. The bore hole needed to be sunk only about four feet to reach bedrock, which is the Late Cambrian Conestoga Formation, a phyllitic marble. The drum recorder was moved to a location within the building closer to the new vault.

From 1974 to some point in the 1980s, station MVL was part of the Pennsylvania Seismic Network, maintained by Penn State University under the direction of Shelton Alexander. Data was transmitted by dedicated telephone line, which often was disrupted.

In 1984, following a magnitude 4.1 earthquake with an epicenter near the village of Marticville in southern Lancaster County, the MEQ 800 was replaced by a Sprengnether VR-60 ink recorder. The new recorder was placed in a closet that was modified to have a window and a light, which enabled the record to be viewed from the hallway. The 1984 earthquake also marked the beginning of the relationship between Millersville University and the Lamont-Doherty Earth Observatory, when John Armbruster and Nano Seeber came to Lancaster County to record aftershocks.

As a consequence of the 1994 magnitude 4.7 Cacoosing earthquake in Berks County, PA, Millersville University was awarded a contract by the Pennsylvania Emergency Management Agency to produce an assessment of seismic vulnerability in Pennsylvania. Funds from this contract were used to purchase a Guralp CMG-3 digital seismometer, which was installed in a new, larger vault immediately adjacent to the old vault. The new vault is cased by PVC pipe, and includes Styrofoam insulation. With the new instrument, station MVL became part of the Lamont Cooperative Seismographic Network.

Charles Scharnberger, Professor Emeritus of Earth Sciences, is the volunteer station operator. He may be contacted at: cscharnberger@millersville.edu.

LCSN Advisory Committee

An Advisory Committee for the LCSN was formed in 2005 at the suggestion of Won-Young Kim, Director of the Network. Kim asked Charles Scharnberger, operator of station MVL at Millersville University to chair the committee.

At present, the Committee consists of the following six members, in addition to Scharnberger: William Brennan (SUNY Geneseo), Zach Miller (Carthage, NY, Central High School), Don Minkel (Adirondack Community College), Frank Revetta (SUNY Potsdam), Rob Ross (Cornell University), and Rob Sternberg (Franklin and Marshall College).

The Committee has had only one formal meeting, in 2006. Future meetings may be held in conjunction with the annual station operators' meeting, usually held at the Lamont campus in the fall.

Currently, all members of the Advisory Committee are LCSN station operators. As the purpose of the Committee is to advise the Network Director regarding initiatives, projects, priorities, etc., it probably would be a good idea to expand the Committee to include "consumers" of the Network's products, e.g., public officials, emergency managers, and first responders. This will be discussed at the Committee's next meeting in October.

Gurlap Systems Limited Opened Its New U.S. Office

In June 2008, Guralp Systems Ltd. (GSL) announced that it was terminating contract with DTA (Digital Technology Associates) regarding DTA as its U.S. agent. Many stations of LCSN use Guralp broadband seismographs consisting of a broadband seismometer and DM24 datalogger and this change will affect many LCSN partners.

The director of GSL, Dr. Cansun Guralp, wrote in his letter to customers on June 3, 2008.

"We also implemented changes in our world wide network of representatives in order to make the communication between you and the company more direct and immediate. As part of this restructuring, GSL has set-up its own sales and technical service centre in the United States, staffed by immediate GSL employees. From this new office we will be able to support the full range of our products. For a detailed product description visit our website at www.guralp.com

A warehouse in California with an extensive array of products and spare parts will complement this office. This will allow us to implement fundamental changes in our repair procedures. From now on, we will be able to ship you "loaner" equipment, while your instruments are on repair. This will drastically reduce the "downtime" of your stations or networks.

Starting on June 17, 2008 please direct all inquiries about sales, product information or technical questions exclusively to our branch in the United States, which will be located in the San Francisco Area."

Here is contact address for GSL's US Office.
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Horst Rademacher
Senior Seismologist
Guralp Systems Limited
hrademacher@guralp.com

US Office:	Headquarters:
12 Southwood Dr.	3 Midas House, Calleva Park
Orinda, CA 94563	Aldermaston RG7 8EA. U.K.
Tel: (925) 254 - 1357	Tel: +44 118 9819056
Fax: (925) 254 - 1361	Fax: +44 118 9819943
email: usa@guralp.com	www.guralp.net

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On July 19th, 2008, Mr. Horst Rademacher of GSL visited LDEO to inspect few broken seismographs and to discuss future service of Guralp seismographs used in LCSN. During his visit, Mr. Rademacher inspected damaged DM24 datalogger from FOR (Fordham) and seismometer with bad Z-component from LUPA (Lehigh) and another seismometer with a bad NS-component from WCNY (West Carthage) and he recommended to ship those instrument to GSL Headquarters in U.K. for repair. In the mean time, Mr. Rademacher promised to loan us a pair of DM24 datalogger for Fordham. We hope this will be a good development for LCSN and its partners.

--- WYK.

Network services

The West Carthage (WCNY) sensor (CMG-3ESP) was replaced on June 10, with another unit due to a faulty component which will require repair at Guralp.

A Reftek digitizer failed at Flat Rock, NY (FRNY) and required a replacement (June 10).

Lehigh University (LUPA) was serviced on June 19th to center the sensor masses (CMG-3T), N-S component of which was far off-center, but otherwise the site appeared to be in good shape.

Howe Caverns (HCNY) was serviced on June 27th to center the sensor masses (CMG-3T), N-S component had drifted far enough to not have good signal.

In early July, two seismographs at Fordham (FOR)--CMG-3ESPD & CMG-5TD, appear to have suffered a lightning strike resulting in damaged digitizers that will require repair.

In mid-July, LUPA (Lehigh) appear to have suffered a lightning strike resulting in damaged digitizer (Reftek 72A-07), a spread-spectrum radio, and power supply system.

We serviced the PTN station near Potsdam a few times to fix digitizer and telemetry issues which are ongoing. (5/16, 6/10, 6/27)

From these station services, we realized that:

- broadband seismometers at remote sites need to be mass centered at least once a year,
- seismograph damages from lightning strike or power surge are one of the most serious problem, and we will discuss this issue during the upcoming operators workshop in October.

Education & Outreach

Analysis of the vertical records from the Mw 7.7 deep focus earthquake that occurred in Sea of Okhotsk on 5 July 2008 may be useful for this section. About six minutes of vertical-component records following the first arrival P waves are plotted in Figure 2. The vertical-records are low-pass filtered by using 3rd order Butterworth filter with cut-off at 0.1 Hz, that is, we pass seismic signals with frequency lower than 0.1 Hz (or period longer than 10s) in order to see P and S waves from earthquakes afar (teleseismic P & S waves). In Figure 2, we can see that the direct P wave is followed by PcP phase by about 8s. PcP phase is the P wave reflected on the core--mantle boundary before arriving at the stations. The ray path of PcP and other phases are plotted in Figure 3. For these records, PcP must be too weak to be identified due to strong direct P arrivals.

The phase designated as pP arrives about 130 s after the direct P phase. The pP phase is leaving the source as an up-going P wave, then reflected under the free surface near the epicenter and travels to the stations following a ray path similar to the direct P wave. Hence, the arrival time difference between the pP and direct P phases gives an obvious hint on the depth of the earthquake source. The time difference, (pP – P), represents two-way travel time of P waves between the source and free surface, and hence, it can be used to determine the focal depth as,

(pP – P) / 2 $\times$ Vp [average speed of up-going P wave ~8 – 10 km/s]

= 130 s / 2 $\times$ 10 km/s ~ 650 km.

So, pP phase is called the *depth phase*. There is another type of depth phase written as, sP, which is the S wave leaving the source as an up-going wave, then converted to P wave upon reflection on the free surface above the source, and it travels to the stations as P wave following a ray path similar to the direct P wave. Hence, arrival time difference, sP – P, can also be used to estimate focal depth. The (sP – P) time difference represents,

(sP – P) time = focal depth (km) / Vs [average S wave speed above the source] (km/s)
+ focal depth (km) / Vp [average P wave speed above the source] (km/s).

or

(sP – P) = focal depth / Vs + focal depth / Vp

Hence, focal depth, h, can be written as,

h (km) = (sP – P)[sec] $\times$ (Vp x Vs) [km/s] / (Vp + Vs) [km/s]

If we use our observation, sP – P = 195s, and assuming that Vp= 10 km/s and Vs = 5 km/s, then

h (km) = 195 sec $\times$ (10 x 5) km/s / (10 + 5) km/s
= 650 km.

A key feature of the depth phases such as, pP and sP, is that time difference between the depth phases and direct arrival P phases are nearly constant at all stations within a seismographic network such as LCSN (see Figure 2). Hence, pP – P times at stations PTN in Adirondacks, NY through SDMD (Soldier's Delight, MD) in the south are nearly constant.

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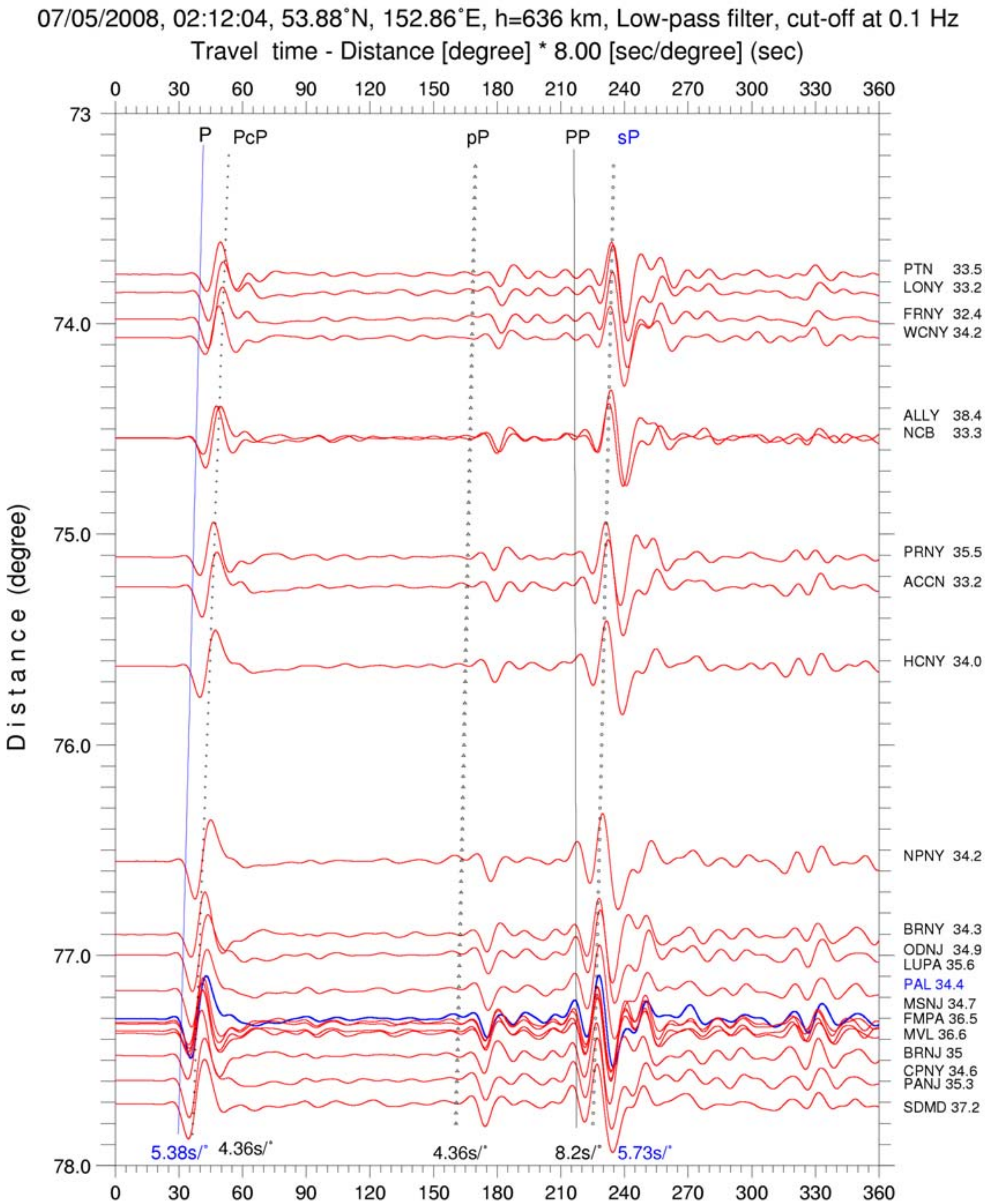

Figure 2. Seismic record section for the first 360 s of P waves at LCSN stations. Vertical records are plotted with reduced slowness=8.0 s/degree (travel time - distance*slowness). Records are low-pass filtered by 3rd order Butterworth filter with cutoff at 0.1 Hz. Vertical axis is distance in degrees, and calculated phase arrival times using IASP91 seismic velocity model are indicated. Slowness (=ray parameter) in seconds/degree of each phase is indicated at the bottom of the traces.

Education & Outreach, Con't

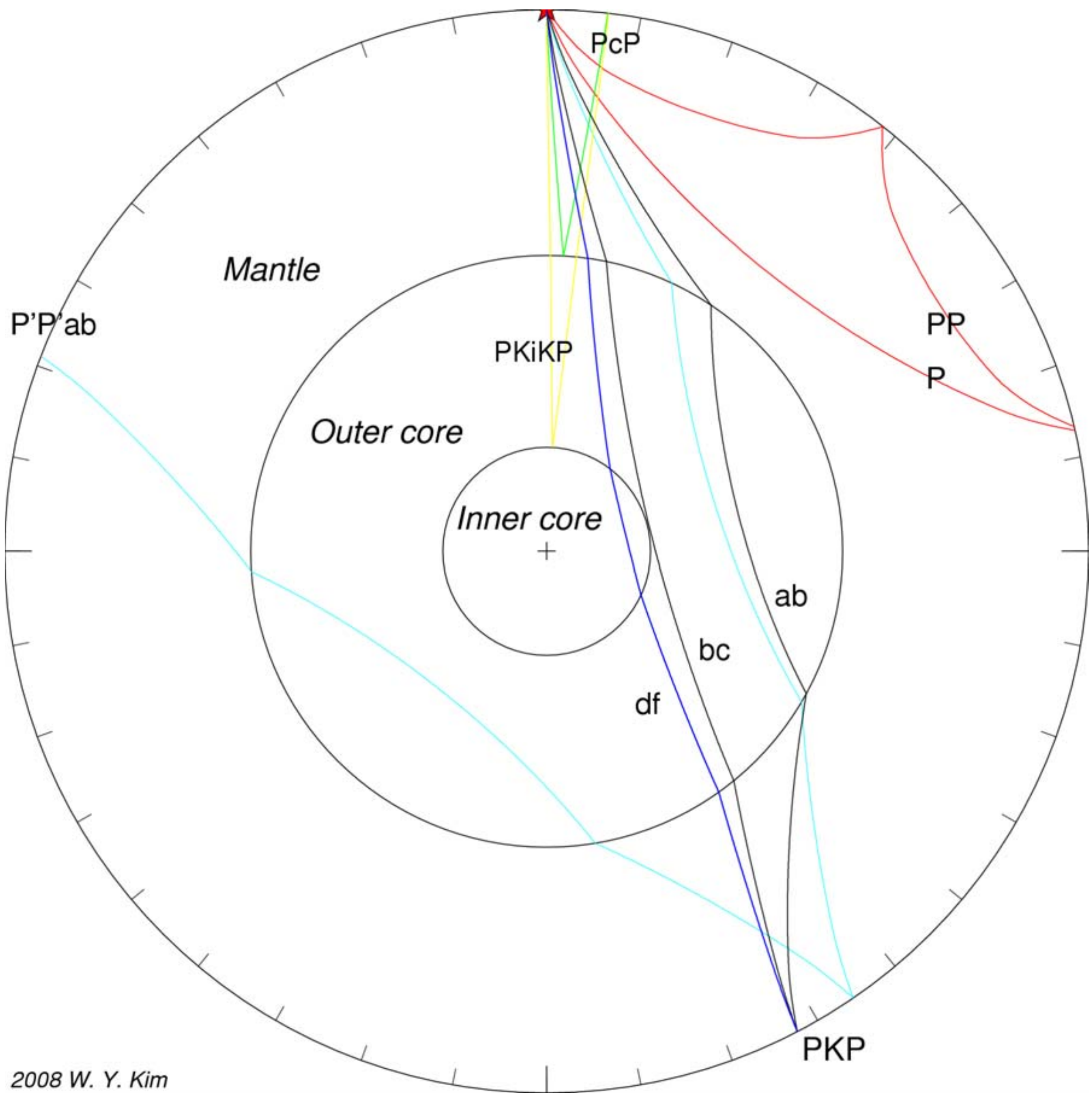

Figure 3. Seismic rays and their paths. P & PP = Mantle phases observed at teleseismic distance ranges; PcP = reflection from the Earth's outer core, PKiKP = reflection from the Earth's inner core boundary; PKPab = P waves bottoming in the upper outer core, PKPbc = P waves bottoming in the lower outer core, PKPdf = P waves bottoming in the inner core; P'P'ab = Free surface reflection of PKP, alternately called PKPPKPab; PKKP = P wave reflected once from the inner side of the core-mantle boundary (ray path not shown). For more details see, Storchak et al. (2003). The IASPEI standard seismic phase list, Seismological Research Letters, vol. 74, pages 761-772.

Education & Outreach, Con't

Notice that there is PP phase arrival between pP and sP depth phases. The ray path of PP is shown in Figure 3. Arrival times of PP phase calculated by using IASP91 Earth's model predict slowness of the phase about 8.2 s/degree, that is, it takes about 8.2s for the PP phase to travel 1 degree. For example, stations FRNY (Flat Rock, Altona, NY) and PRNY (Paleontological Research Inst., Ithaca, NY) are about 1.13 degree apart, so the PP phase arrivals at these stations will be about 9.3s apart (= 8.2 s/degree x 1.13 degree). Waveform data from the seismographic network will allow us to identify various phases and understand propagation of such seismic waves inside the Earth, which in turn will let us study internal structure along those ray paths.

Figure 4 shows three components of records at PAL (Palisades, NY) from the 5 July 2008 event. Again the records are low-pass filtered with cut-off at 0.1 Hz. North-South and East-West component records are rotated so that wave motions along the source-receiver path (radial or longitudinal component) and wave motion perpendicular to the source-receiver path (transverse-component) are aligned or separately recorded to emphasize characteristics of seismic waves.

At a first glance of Figure 4, you notice that there are no P waves on transverse-component until S wave arrival, and that S wave arrivals -- S, sS, SS and SSS phases, are clearly seen on the transverse-component. Hence, the transverse-component is used to look for *pure* S wave arrivals. In the case of LCSN stations, shallow and deep focus earthquakes that occur in the west coast of South America (Chile, Peru, Colombia) are usually aligned along N-S direction, hence ray paths of P and S waves from such events are naturally polarized. That is, N-S component is nearly radial and E-W component is nearly a transverse-component.

On the radial-component record, there are P and S waves, in particular, waves that underwent S to P conversion along the paths are usually well developed on radial-component. P, sP, S, SKS and SS are present in the records. SKS phases are similar to PKP phases, but since the outer core is fluid, an S wave can not travel through it, so the portion of ray path in the fluid outer core is P wave (letter K on the phase name), then converted back to S waves at the core–mantle boundary before arriving at the stations.

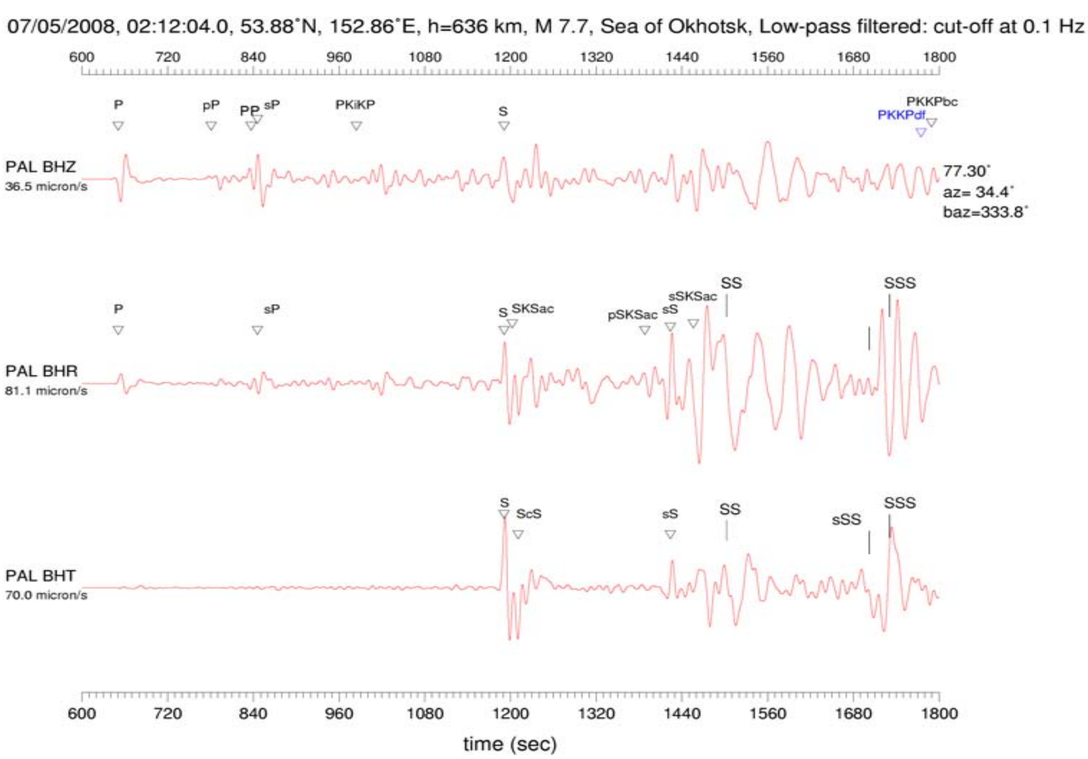

Figure 4. Vertical-, radial- and transverse-component of records at PAL (Palisades, NY) from the 5 July 2008 event. Records are low-pass filtered with cut-off at 0.1 Hz.