

Location of the M 2.0 Earthquake on 08/22/2010 that Occurred 25 km North of West Valley, New York.

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Introduction

A small earthquake of magnitude Md 2.0 occurred on August 22, 2010 at 16:41:47 (UTC) about 25 km north of West Valley, New York. There were no felt reports by residents in the epicentral area following the shock. The Southern Ontario Seismic Network (SOSN) which is operated by the University of Western Ontario, Canada reported the earthquake using the information provided by the Geological Survey of Canada (GSC) in Ottawa. The shock is also located by the Lamont-Doherty Cooperative Seismographic Network (LCSN) which is the authoritative organization reporting earthquakes for the region under the Advanced National Seismic System (ANSS). The earthquake parameters reported by the two organizations are listed in Table 1.

Table 1. Earthquake locations reported by LCSN and GSC/SOSN^(*).

	Date	Time (UTC)	Latitude (°N)	Longitude (°W)	Depth (km)	Magnitude	Location
LCSN	2010/08/22	16:41:47.7	42.628	78.606	5.0	2.0 Md	35 km SSE of Buffalo, NY
GSC/SOSN	2010/08/22	16:41:47.9	42.691	78.646	5.0	2.3 Mn	33 km SE from Fort Erie, ON

^(*) Md= duration magnitude; Mn= short-period Nuttli magnitude used by GSC. NB: Mn scale tends to give slightly higher magnitude than other scales as reported in Kim (1998)¹.

The earthquake information reported by SOSN/GSC is on their web site with URL <http://www.gp.uwo.ca/docs/eqlist.html> and is listed in Appendix 1, whereas the information reported by LCSN is on their web site with URL <http://www.ldeo.columbia.edu/LCSN/recenteqs/> and details are given in Appendix 2.

The locations of the event on 08/22 reported by GSC/SOSN and LCSN (Lamont-Doherty) are plotted in Figure 1. The two locations are about 7.8 km (4.9 miles) apart and the discrepancy raises some questions about whether the Lamont-Doherty's seismic results will have enough geographic precision and location accuracy to improve our understanding of seismicity and structure in western New York.

¹ Kim, W. Y., The M_L scale in Eastern North America, *Bulletin of the Seismological Society of America*, **88**, 935-951, 1998.

Comparison and location accuracy of the earthquake on 08/22/2010

The location reported by SOSN is from the GSC in Ottawa and is located by using data from eight stations in Ontario, Canada and a station in New York State, MEDO (Medina, NY) as listed in the seismic bulletin from the GSC for the 08/22 shock given in Appendix 1. The GSC bulletin indicates that seismic data from nine stations in the distance range from 55 km to 235 km are used for the location. The data used for location has poor coverage with the maximum azimuthal gap of 251°. The bulletin lists no error ellipse, but gives standard deviation for epicenter coordinates as $\pm 0.01^\circ$ on both longitude and latitude (Figure 1). The stations used and their distribution is plotted in Figure 2.

22 August 2010, Md 2.0 Earthquake 15 miles north of West Valley, NY

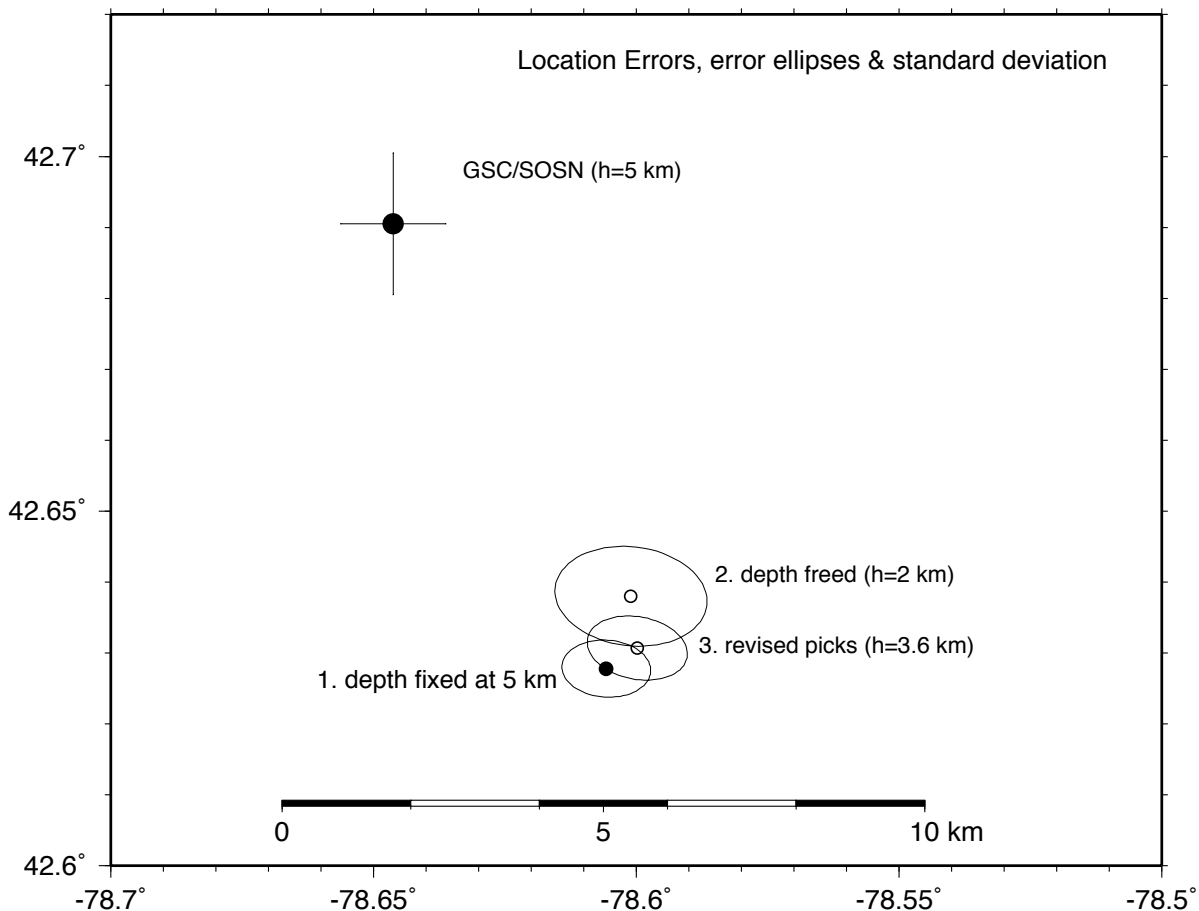


Figure 1. Epicenter reported by GSC/SOSN and locations of M 2 shock on 08/22 by LCSN are plotted. GSC location show standard deviation of 0.01 degrees in both latitude and longitude, where as three locations by LCSN are shown with the error ellipses which indicates 95% chance of containing the *true* hypocenter. The error ellipses are only an estimate, a true calculation of error ellipse would require knowing the uncertainties in every variable, including the crustal velocity model, which is nearly impossible.

The location reported by LCSN is given in its bulletin listed in Appendix 2. The bulletin indicates that data from 12 stations were used for locating the event. 23 *P*- and *S*-wave arrival times were used, and the nearest station is 24.5 km from the shock. The root mean squared (RMS) error of the solution is 0.15 seconds with a horizontal location error of 0.2 km. The maximum azimuthal gap of the station coverage is 115.2° (Figure 2). Although the event is small (Md 2.0), the maximum gap of 115° suggests that the event is fairly well recorded by the seismographic stations at all four quadrants with the closest station located 24.5 km from the shock – the station WVNY (West Valley, NY) that was deployed on August 6, 2010. LCSN location also used data from the station MMNY (Mt. Morris Dam, NY) located about 58.3 km due east of the epicenter. Hence, the data used for LCSN event location had a good control on eastern and southern quadrant, when compared with GSC location. Obviously, fairly good azimuthal coverage with stations located at close distances provides the location with reduced uncertainties.

The 95% confidence error ellipse of the event location suggests that the formal location error is on the order of 1.2 km in horizontal direction and about 2.0 km in vertical direction (depth) (see Figure 1). However, the *true* location error might be somewhat greater than these ranges due to uncertainty in seismic velocity structure between the source and stations in the region. We believe that the true location might be within about 2 to 3 km from the solution.

Real Time Data Exchange and Collaboration between Seismographic Networks

LCSN receives seismic data from 10 stations in eastern Canada from Geological Survey of Canada (GSC) in Ottawa in real time via the Internet and data from all other stations in Canada are accessible to LCSN within about 10 minutes. GSC also receives data from a nearly equal number of LCSN stations located along the USA-Canada border region in real time since around 2002.

Seismicity in the Western New York – Concluding Remarks

The earthquakes that occurred in the Erie–Ontario Lowlands and surrounding region during 1980–2004 are plotted in Figure 3. Source mechanisms of significant earthquakes in the region are also plotted with beach-balls and their *P* axes orientations are indicated. Notice the clusters of seismicity around western Lake Ontario, Niagara Falls area, and Attica, NY, which represent Western Lake Ontario – Niagara – Attica NY seismic zone (LONASZ). There are also clusters of seismicity around Ashtabula, Ohio; Painsville, Ohio and Pymatuning, Penn. One of the most notable feature of the seismicity in the Erie–Ontario Lowlands is that several significant shocks were likely induced by anthropogenic causes such as, Attica events of 06/13/1967 & 01/01/1966, and Ashtabula, Ohio shock on 01/26/2001 (see Figure 3). The hazards from these shocks are significant mainly due to the fact that these shocks occur at shallow depth (< 2 km) -- at the top of the basement rock formation. It is observed that the orientation of the broad scale regional stress field in the region is predominantly ENE-WSW (see Figure 3).

The data from seismic stations in Canada was important to locate the M 2.0 08/22/2010 event. Furthermore the data from the new seismographic station WVNY provided the most crucial data for accurate location. A couple of additional seismographic stations in the region will improve significantly our capacity to monitor earthquakes in the region and improve our understanding of geodynamics in western New York region.

Seismographic Stations in Western NY & Erie-Ontario Lowlands

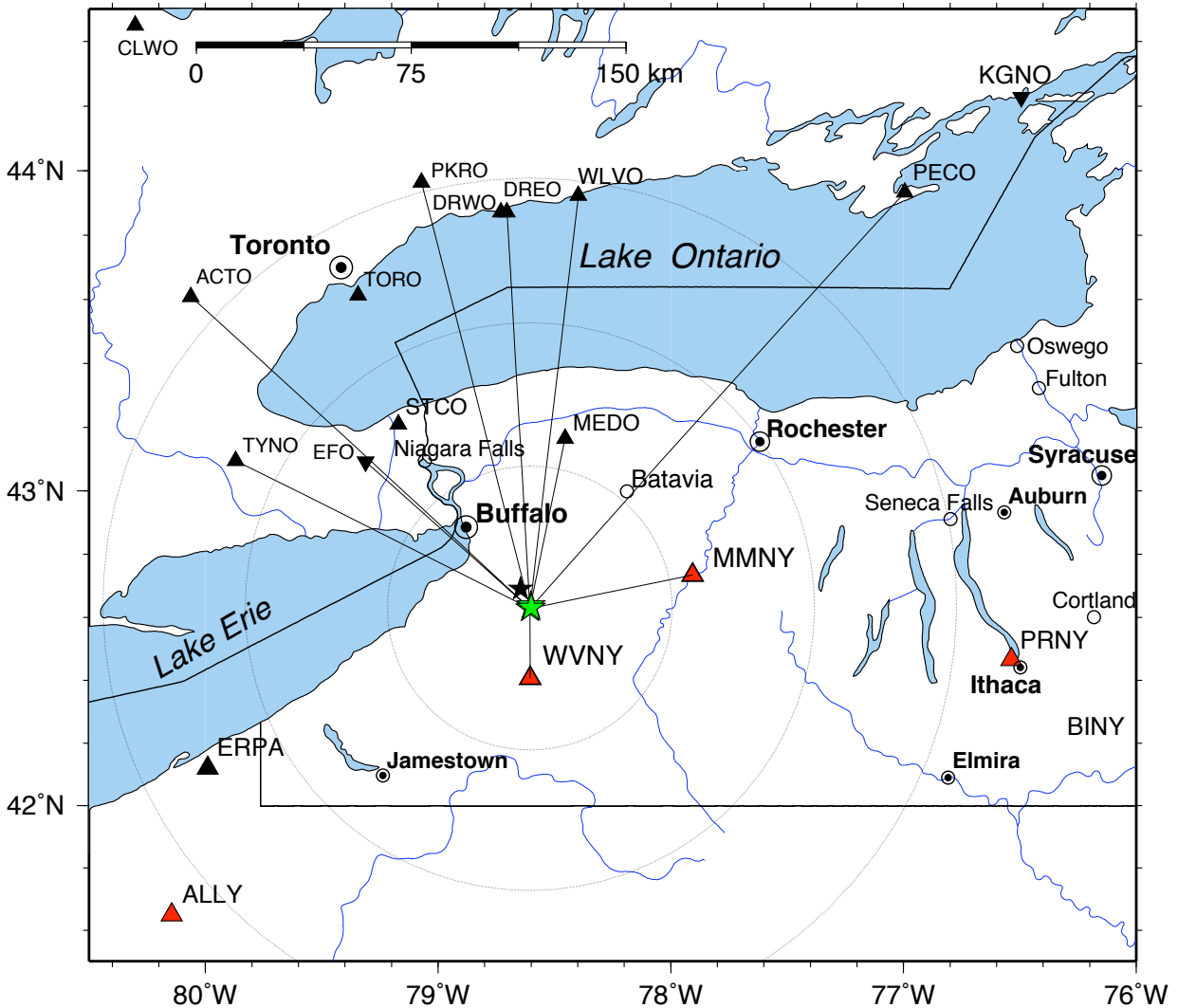


Figure 2. Seismographic stations around western New York and Erie-Ontario Lowlands region and the epicenter of the 08/22/2010 event is plotted. Stations used for the event location are indicated by source-station paths. LCSN stations (red triangles), and stations in Canada -- SOSN (solid triangles), CNSN (inverted triangles), and USNSN station ERPA are plotted. Circles around the epicenters are 50 km interval. The shock is fairly well covered by recent seismographic stations deployed in the region – WVNY (08/06/2010) and MMNY (Mount Morris Dam, 05/01/2008). MEDO (Medina, NY) is a SOSN station installed jointly by LCSN and GSC, Canada in 2005.

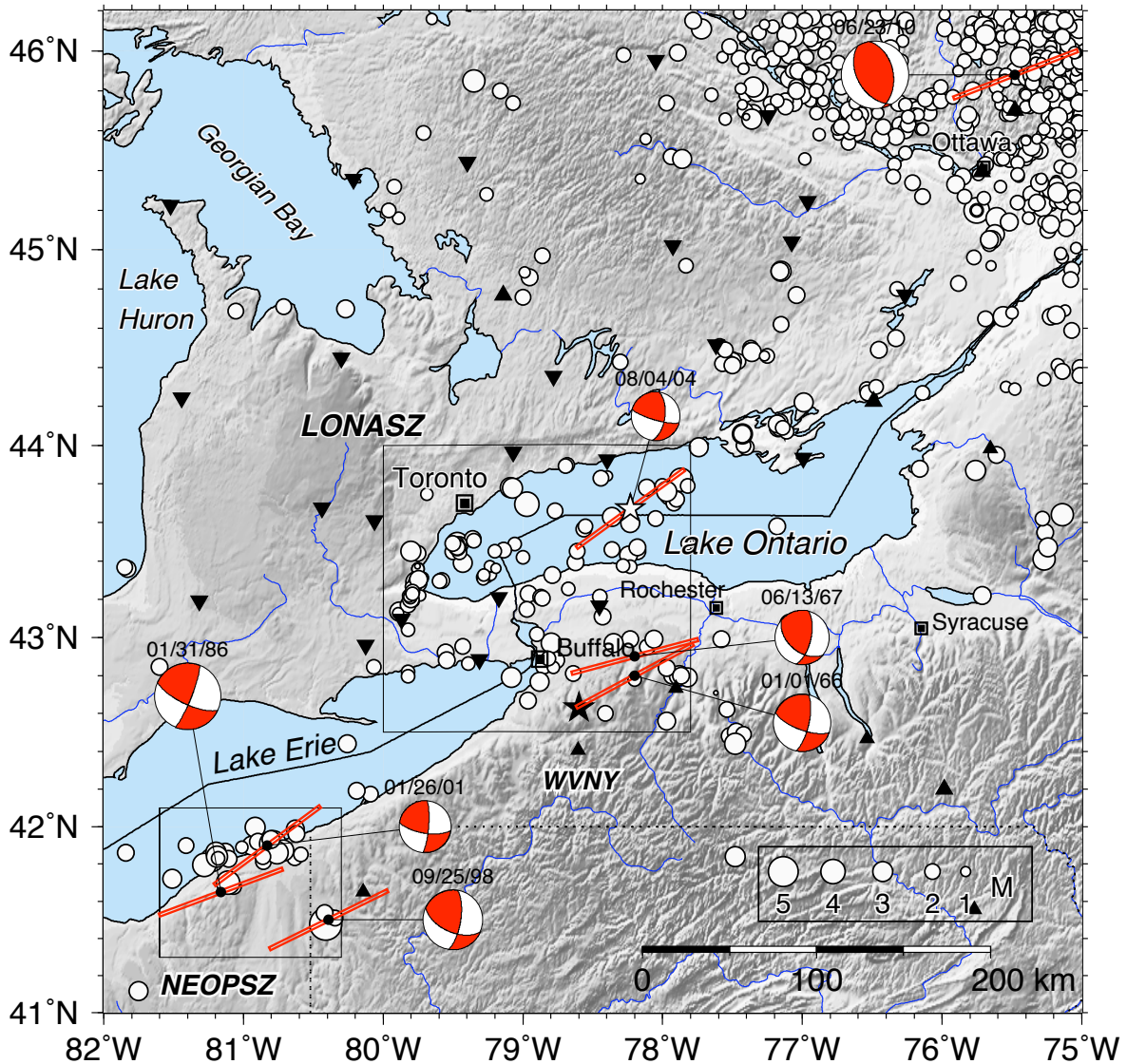


Figure 3. Epicenters of the earthquakes that occurred in the Erie–Ontario Lowlands and surrounding region during 1980–2004 are plotted with *circles*. LONASZ represents the western Lake Ontario – Niagara – Attica NY seismic zone with clusters of seismicity around: western Lake Ontario, Niagara Falls area, and Attica, NY. NEOPSZ (northeastern Ohio – Pennsylvania seismic zone) has a cluster of seismicity around Ashtabula, Ohio, Painsville, Ohio and Pymatuning, Penn. The high level of seismicity in the northeastern corner of the map represents the Western Québec seismic zone. Seven earthquakes with known source mechanisms are plotted with beach-balls and their *P* axes orientations are plotted by a *solid bar* at their epicenters. A recent earthquake that occurred on Lake Ontario on 4 August 2004 is plotted by a *star* and the M 2.0 event on 08/22/2010 is plotted with a *solid star* near the station WVNY. The recent Mw 5.1 earthquake that occurred north of Ottawa, Canada (plotted on the upper right corner) also shows ENE-WSW (69°) trending *P*-axis.

Appendix 1. Earthquake Information reported by SOSN/GSC

Users can access the web site [<http://www.gp.uwo.ca/docs/eqlist.html>] of the Southern Ontario Seismic Network (SOSN) which is operated by the University of Western Ontario (Department of Earth Sciences) in Canada. User obtained the following earthquake information for the event on August 22, 2010.

Date: Aug 22 2010 Time: 20:41:47.000

Loc: [42.6900N 78.6500W](#)

Depth: 5.0* Km Magnitude: 2.3MN

Comment: 33 km SE from Fort Erie, Ontario.

Upon clicking coordinates of the event location, the web page displays a map showing its location in Erie-Ontario Lowlands as well as three-component seismic records at 10 stations in the region.

The location given by the web site of SOSN does not list more information, and its web page gives following note:

Events Recorded by the SOSN in Southern Ontario

- Most solutions are from the *Geological Survey of Canada* and are subject to change.

Staff at SOSN (Bill Dunn, bdunn@uwo.ca) confirmed (08/27/2010) that SOSN no longer locates earthquakes, but receives lists from GSC, Ottawa. Recent earthquake web page on GSC at URL http://earthquakescanada.nrcan.gc.ca/recent/maps-cartes/index-eng.php?tpl_region=son show following lists,

Note: The column titled F denotes events that were reported felt

Date	Time	Lat.	Long.	Depth	Mag.	F	Region
2010/08/23	05:31:30	44.98N	75.53W	18.0*	1.5MN		10 km SE from Kemptville, ON
2010/08/22	20:41:47	42.69N	78.65W	5.0*	2.3MN		33 km SE from Fort Erie, ON
2010/08/21	10:28:05	43.91N	78.55W	5.0*	2.4MN		17 km SE from Clarington, ON

More detailed information can be found from GSC's earthquake database, <http://earthquakescanada.nrcan.gc.ca/stndon/NEDB-BNDS/bull-eng.php>.

2010-08-22 20:41:47.94 42.6905 -78.6462 depth=5.00 km, RMS=0.20 sec, gap=251 degrees, mag=2.3MN, Dmin= 55.0 km, Nsta= 9, Nphase= 15, Standard deviation (Lat)=0.01 degree, S.D. (Long)=0.01 degree.

From these parameters, it is clear that GSC did not use U.S. stations other than MEDO (Medina, NY), since the event is in the United States.

Each morning GSC staff (Dr. Janet Drysdale) sends out earthquake information to LCSN (Won-Young Kim) via E-mail. Following is the e-mail message on 08/22 event sent on 08/25/2010.

From: Janet Drysdale <drysdale@seismo.nrcan.gc.ca>

Date: 08/25/2010 07:20 AM

To: wykim@ldeo.columbia.edu

new events SOUTHERN ONT - WEST QUE

2010/08/22 20:41:47 42.69N 78.65W 5.0G 2.3MN GSC 33 KM SE FROM

FORT ERIE, ON

--Date---Time-(UT)--Lat.---Long.---Z(km)-MAG.-SRC--Location -----

=====

new events QUE. AND ATALANTIC PROV.

Seismic bulletin for the 08/22/2010 shock from GSC.

H YyyyMmDd HhMm Ss.sssEqT-Lat-----Long-----Depth-kmMag--Magt DLSEAW

S 20100822 2041 47.936L 42.6905 -78.6462 5.00km 2.3MN FGA A

E RMS=0.20s, Lat error (s.d.)= 0.01 degree, Long error (sd)= 0.01 deg

M *MN 2.3 (0.1) 6

C 33 km SE from Fort Erie, ON

C EASTERN BACKGROUND SEISMIC ZONE.

F 33 km S-E de Fort Erie, ON

F ZONE SISMIQUE DE FOND DE L'EST DU CANADA.

H	Stn	Ch	Ph	UQHhmm	Ss.sssFm	TRes	Wt	Dst_km	Az	OcMag	UTp
P	MEDO	HHZPG	AB2041	56.800	L	-0.041	1.00	54.96	16.5N		X
P	MEDO	HHESG	AB2042	03.580	L	0.179	1.00	54.96	16.5N		X
P	MEDO	HHZTracYB2042	05.370	L				54.96	16.5N	2.5 MN	
P	EFO	EHZPG	AB2041	59.370	L	0.060	1.00	70.32	309.6NW		X
P	EFO	EHZSG	AB2042	07.960	L	0.271	1.00	70.32	309.6NW		X
P	EFO	EHZTracYB2042	08.870	L				70.32	309.6NW	1.9 MN	
P	TYNO	HHZPG	AB2042	05.840	L	0.197	1.00	109.66	294.6NW		X
P	TYNO	HHESG	AB2042	18.700	L	0.013	1.00	109.66	294.6NW		X
P	TYNO	HHZTracYB2042	20.760	L				109.66	294.6NW	2.6XMN	
P	DREO	HHNSG	AC2042	25.290	L	0.505	0.25	131.45	358.0N		X
P	WLVO	HHZPG	AB2042	10.290	L	-0.006	1.00	138.53	8.3N		X
P	WLVO	HHNSG	AB2042	26.730	L	-0.038	1.00	138.53	8.3N		X
P	WLVO	HHZTracYB2042	33.270	L				138.53	8.3N	2.2 MN	
P	PKRO	HHESG	AC2042	28.890	L	0.109	0.25	145.72	346.4N		X
P	ACTO	HHZPG	AB2042	12.830	L	0.051	1.00	153.93	312.0NW		X
P	ACTO	HHESG	AB2042	30.630	L	-0.450	1.00	153.93	312.0NW		X
P	ACTO	HHZTracYB2042	32.970	L				153.93	312.0NW	2.5XMN	
P	PECO	HHZPN	AC2042	17.880	L	-0.604	0.25	192.57	43.6NE		X
P	PECO	HHNSN	AC2042	41.170	L	0.070	0.25	192.57	43.6NE		X
P	PECO	HHZTracYB2042	45.030	L				192.57	43.6NE	2.6 MN	
P	SADO	BHZPN	AB2042	23.325	L	-0.257	1.00	234.51	350.4N		X
P	SADO	BHNSN	AX2042	51.075	L	1.080	0.00	234.51	350.4N		X
P	SADO	BHZTracYB2042	54.750	L				234.51	350.4N	2.2 MN	
P	KGNO	BHNSN	AX2042	54.050	L	2.002	0.00	244.03	44.8NE		X
P	BWLO	HHNSG	AX2042	57.950	L	-1.926	0.00	256.77	309.0NW		X
P	BWLO	HHZTracYB2042	59.110	L				256.77	309.0NW	2.5 MN	
Z	=====0=====0=====0=====0=====0=====0=====0=====0=====										

Appendix 2. Earthquake Information reported by LCSN/ANSS

The earthquake information for the same event is obtained from the LCSN (Lamont-Doherty Cooperative Seismographic Network) web site at URL <http://www.ldeo.columbia.edu/LCSN/recenteqs/>. This is known as “recent eq” page. Upon clicking a symbol for the earthquake (square), the web page displays a map with two epicenters and corresponding list.

<u>MAG</u>	<u>DATE</u> <u>y/m/d</u>	<u>LOCAL-TIME</u> <u>h:m:s</u>	<u>LAT</u> <u>deg</u>	<u>LON</u> <u>deg</u>	<u>DEPTH</u> <u>km</u>	<u>LOCATION</u>
2.0	2010/08/22	16:41:47	42.628N	78.606W	5.0	35 km SSE of Buffalo, NY
1.9	2010/03/03	00:32:44	43.377N	78.130W	5.0	46 km N of Dansville, NY

By clicking the event list, the web page shows more detailed earthquake parameters with explanations embedded in the parameter list.

Magnitude **2.0** - duration magnitude (Md)

Time Sunday, August 22, 2010 at 4:41:47 PM (EDT)

Sunday, August 22, 2010 at 20:41:47 (UTC)

Distance from Buffalo, NY - 35 km (22 miles) SSE (163 degrees)

Dansville, NY - 50 km (31 miles) SW (221 degrees)

Niagara Fall, NY - 60 km (37 miles) SSE (152 degrees)

Coordinates 42 deg. 37.7 min. N (42.628N), 78 deg. 36.3 min. W (78.606W)

Depth 5 km (3.1 miles)

Quality Fair

Location Quality Parameters Nst= 12, Nph= 23, Dmin=24.5 km, Rmss=0.15 sec, Erho=0.2 km, Erzz=0 km, Gp=115.2 degrees

Event ID# ld1026769

Additional Information map

Users of the earthquake information can assess overall quality of the solution by examining the listed earthquake parameters. The Location Quality Parameters have the following explanations.

Location Quality Parameters

These parameters provide information on the reliability of the earthquake location. Zero values usually indicate that the contributing seismic network did not supply the information.

Nst

Number of seismic stations which reported P- and S-arrival times for this earthquake. This number may be larger than Nph if arrival times are rejected because the distance to a seismic station exceeds the maximum allowable distance or because the arrival-time observation is inconsistent with the solution.

Nph

Number of P and S arrival-time observations used to compute the hypocenter location. Increased numbers of arrival-time observations generally result in improved earthquake locations.

Dmin

Horizontal distance from the epicenter to the nearest station (in km). In general, the smaller this number, the more reliable is the calculated depth of the earthquake.

Rmss

The root-mean-square (RMS) travel time residual, in sec, using all weights. This parameter provides a measure of the fit of the observed arrival times to the predicted arrival times for this location. Smaller numbers reflect a better fit of the data. The value is dependent on the accuracy of the velocity model used to compute the earthquake location, the quality weights assigned to the arrival time data, and the procedure used to locate the earthquake.

Erho

The horizontal location error, in km, defined as the length of the largest projection of the three principal errors on a horizontal plane. The principal errors are the major axes of the error ellipsoid, and are mutually perpendicular. Erho thus approximates the major axis of the epicenter's error ellipse.

Erzz

The depth error, in km, defined as the largest projection of the three principal errors on a vertical line. See Erho

Gp

The largest azimuthal gap between azimuthally adjacent stations (in degrees). In general, the smaller this number, the more reliable is the calculated horizontal position of the earthquake. Earthquake locations in which the azimuthal gap exceeds 180 degrees typically have large Erho and Erzz values.

Hence, in case of the event on August 22, the above list indicates that data from 12 stations were used (Nst=12) for locating this event. 23 P- or S-wave arrival times were (Nph=23) used, and that the nearest station is at 24.5 km (Dmin= 24.5 km) from the shock. The root mean squared error of the solution is 0.15 seconds (Rmss= 0.15 sec) with a horizontal location error of 0.2 km (Erho= 0.2 km) and the maximum azimuthal gap of the station coverage is 115.2 degree (Gp=115.2 degree).

LCSN Reviewed Event Bulletin

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evid=1018063 orid=1026769 Region: NEW YORK (LCSN)
8/22/2010 20:41:47.68 42.628 -78.606 h=5km fixed mc=2.0
STA DIST (km) AZ(deg) PHASE DATE TIME RESID
WVNY 24.574 179.00 P 8/22/2010 20:41:51.820 -0.060
WVNY 24.574 179.00 S 8/22/2010 20:41:55.010 0.060
MMNY 58.266 78.00 P 8/22/2010 20:41:57.150 0.020
MMNY 58.266 78.00 S 8/22/2010 20:42:04.040 0.010
MEDO 60.935 11.00 P 8/22/2010 20:41:57.000 -0.520
MEDO 60.935 11.00 S 8/22/2010 20:42:03.940 -0.760
EFO 77.169 312.00 P 8/22/2010 20:41:59.840 -0.360
EFO 77.169 312.00 S 8/22/2010 20:42:08.580 -0.760
TYNO 115.42 297.00 P 8/22/2010 20:42:05.880 0.130
TYNO 115.42 297.00 S 8/22/2010 20:42:19.090 0.150
DREO 138.66 356.00 S 8/22/2010 20:42:25.290 0.280
WLVO 145 6.00 P 8/22/2010 20:42:10.300 0.080
WLVO 145 6.00 S 8/22/2010 20:42:26.530 -0.140
PKRO 153.23 346.00 S 8/22/2010 20:42:28.940 0.120
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ACTO	160.9	313.00	P	8/22/2010	20:42:12.850	0.230
ACTO	160.9	313.00	S	8/22/2010	20:42:30.570	-0.260
PECO	195.15	41.00	P	8/22/2010	20:42:17.880	0.220
PECO	195.15	41.00	S	8/22/2010	20:42:39.780	0.240
SADO	241.85	350.00	P	8/22/2010	20:42:23.400	-0.040
SADO	241.85	350.00	S	8/22/2010	20:42:49.630	0.090

Reviewed by: Mitchell Gold
Comments:

Appendix 3. Lamont Cooperative Seismographic Network (LCSN)

Research into the causes and effects of intraplate earthquakes in the northeastern United States has been the primary reason for Lamont-Doherty's involvement in seismic monitoring in the eastern U.S. for over 35 years. Since the fall of 1999, the Lamont-Doherty seismic network became a cooperative seismographic network to promote active partnership with colleges, secondary schools and other educational organizations in the northeastern U. S. Continued seismic monitoring for improved delineation of seismogenic faults, evaluation of hazards associated with earthquakes and improved education and public outreach are the main operational objectives of the Lamont Cooperative Seismographic Network (LCSN). The configuration of the LCSN has evolved continuously for the past few years, and it now consists of 28 three-component, broadband seismographic stations. Stations covering New York, Connecticut, New Jersey, Pennsylvania, Delaware, Maryland and western Vermont are operated by 30 cooperating partners with Lamont-Doherty Earth Observatory (LDEO) of Columbia University serving as the lead institution (see Figure 4).

Partners include colleges and universities, community colleges, secondary schools, museums, state geological surveys, conservation organizations, research institutes, and a tourist attraction. The LCSN offers unique educational opportunities for students at a variety of levels, for public officials, and for the general public. Participation in the network provides valuable professional development opportunities for station operators, most of whom are not professional seismologists. The LCSN welcomes new partners, especially institutions interested in operating a station. The Network's web site is: <http://www.ldeo.columbia.edu/LCSN>. The backbone of the LCSN real time data acquisition for earthquake monitoring in the northeastern U.S. is the Internet based Earthworm system. Earthworm data acquisition software is installed at these organizations providing them with an ability to utilize the acquired data. These sites collect seismic data from a single 3-component, broadband seismograph and send the data in real time to the central processing facility at LDEO via Earthworm and the Internet. These cooperative efforts provide cost-effective earthquake monitoring capability in the region and facilitate data acquisition efforts of LCSN, and serve as an education and outreach program.

All seismogram data acquired by LCSN are sent to the IRIS-DMC² in Seattle, Washington in real time for archiving and further dissemination to users worldwide. Much of the earthquake

2 Incorporated Research Institutions for Seismology (IRIS) – Data Management Center (DMC)

data such as catalogs, maps, recent earthquakes, felt reports (Did-You-Feel-It?³), and waveform data are disseminated via the World Wide Web (WWW) which provides a cost efficient means to relay such information.

Lamont Cooperative Seismographic Network (LCSN) and Other Stations in Northeastern U.S.

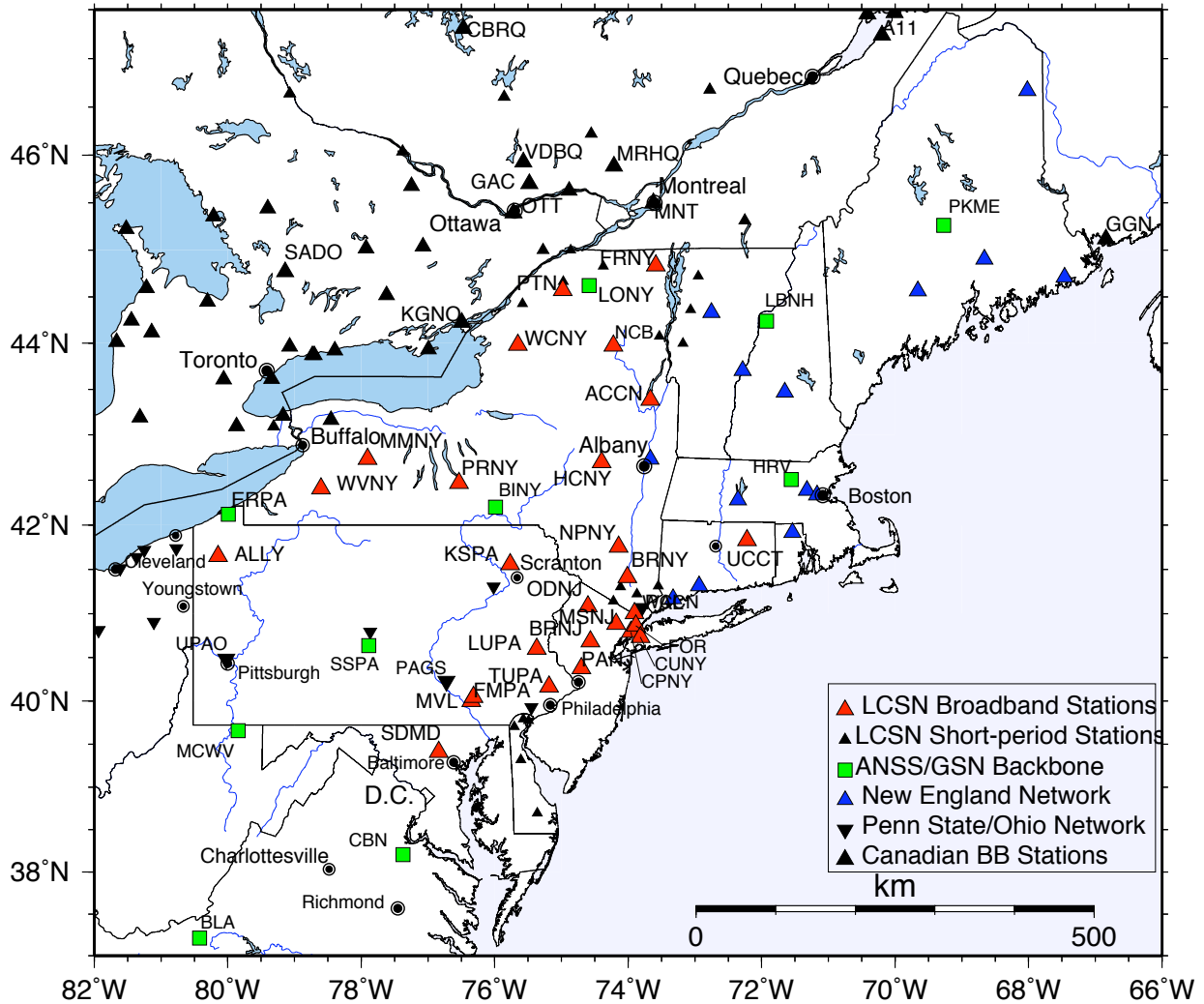


Figure 4. Map showing the overview of the broadband and short-period seismographic stations of Lamont Cooperative Seismographic Network (LCSN; *red triangles*), U.S. National Seismographic Network (*green squares*), New England Seismic Network (*blue triangles*) and Canadian National Seismic Network (*solid triangles*) in northeastern U.S. and southeastern Canada as of August 2010.

3 <<http://pasadena.wr.usgs.gov/shake/ne/>>