Consensus Modified Mercalli Intensities for the 1811-1812 New Madrid, Central United States, Mainshocks and Dawn Aftershock

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Abstract.

The 1811-1812 New Madrid, central United States earthquake sequence included three principal mainshocks and a large aftershock that were widely felt throughout the mid-continent. The macroseismic effects of these earthquakes, documented in archival sources, provide the most direct constraint on the magnitudes of these events. To interpret macroseismic effects, a key first step is to assign modified Mercalli intensity (MMI) values to each account. MMI assignments had been done previously for the four principal 1811-1812 earthquakes by individual researchers or teams of researchers. To explore the degree of variability associated with individual assessments, and to develop a set of consensus intensity values for extant accounts of the 1811-1812 earthquakes, we determine values based on independent assessments by four researchers. The resulting values are lower than those determined by previously published studies.

Introduction

The 1811-1812 New Madrid earthquake sequence included three well-documented mainshocks that have been described and analyzed in considerable detail, plus a large aftershock that is considered the fourth principal event in the sequence (e.g., *Mitchill*, 1815; *Fuller*, 1912; *Nuttli*, 1973; *Penick*, 1981; *Street*, 1982, 1984; *Johnston*, 1996b; *Hough et al.*, 2000, *Bakun and Hopper*, 2004). The three principal mainshocks occurred at approximately 02:15 local time (LT) on 16 December, 1811; around 09:15 LT on 23 January, 1812, and approximately 03:45 LT on 7 February, 1812 (henceforth NM1, NM2, and NM3, respectively). The so-called dawn aftershock, on 16 December 1811, occurred at 7:15 am LT on 16 December 1811 (henceforth NM1A). Published magnitude estimates of the four principal events range from ~7 to over 8 (e.g., *Nuttli,* 1973; *Johnston*, 1996b; *Newman et al*., *1999*; *Hough et al.*, 2000, *Bakun and Hopper*, 2004). Although magnitudes can be estimated from the size and extent of liquefaction features, and from scaling relations given inferred rupture parameters, the most direct constraint on the magnitudes of the four principal 1811-1812 events comes from macroseismic effects as documented in archival sources.

The earliest effort to compile written accounts of the 1811-1812 earthquakes was undertaken immediately after the sequence (*Mitchill*, 1815; Appendix A). This account provides a valuable overview: the author was in a position to consider multiple accounts and ascertain the reliability of accounts by considering the consistency of independent observations. The initial modern archival search was undertaken by *Nuttli* (1973) and expanded by *Street* (1982, 1984). In this study we use the compilation of *Street* (1982, 1984), augmented by a small number of additional archival sources.

Modified Mercalli Intensities

Intensity values for the principal 1811-1812 earthquakes were originally determined by *Nuttli* (1973) and later reinterpreted by *Street* (1982, 1984) and *Hough et al*. (2000). Although all of the studies used the same basic formulation of the modified Mercalli intensity scale, the *Hough et al.* (2000) assignments were guided by recently developed insights regarding the nature of macroseismic effects. Any number of studies have discussed the issues that must be considered carefully in the interpretation of macroseismic data (e.g., *Ambraseys*, 1983; *Ambraseys and Bilham*, 2003) *Hough et al.* (2000) revisit the archival accounts of the earthquakes and conclude that many of the initial intensity assignments were too high, including a few outright transcription errors and a greater number of values that are higher than would be assigned given present-day understanding of macroseismic effects. For example, although the principal 1811-1812 events caused dramatic secondary effects in the Mississippi River Valley, recent studies (e.g., *Ambraseys and Bilham*, 2003) have shown that such effects are not reliable indicators of overall shaking intensity. Further, while, according to traditional intensity scales, MMI IV-V shaking is required to awaken many or most sleepers, reliably determined “Did You Feel It?” (*Wald et al.*, 1999) intensities reveal that during large regional earthquakes, sleepers are generally awakened by MMI III-IV shaking.

Although the intensity values determined by *Hough et al.* (2000) are justified in detail, they are themselves subjective. In an effort to explore the consequences of subjective individual intensity assignments, in this study we develop a set of consensus intensities values for the four principal New Madrid earthquakes based on independent assessments by multiple experts.

To explore the variability associated with individual intensity assignments, and to develop a set of consensus intensities, intensity values were assigned independently by four researchers with experience in historical earthquake research. Most of the accounts are from the compilation of *Street* (1982, 1984), supplemented by a small number of additional sources. Additionally, photographs are included to provide an indication of typical historical structures from the era, including a number of buildings that pre-date the 1811-1812 sequence. The photographs and archival sources are including in Appendix B and C.

It was left to the discretion of the individual researchers whether an individual account include sufficient information to infer an intensity value. This determination is itself subjective. The individual researchers were in agreement that dramatic near-field accounts did not provide the basis for reliable intensity determination. For some of the other accounts, individual researchers reached different conclusions. For NM1 and NM3, which occurred at night, an assignment of “felt” is interpreted as MMI 3.5; for NM1A and NM2, which occurred when many or most people would have been awake, a “felt” is interpreted as MMI 3. Consensus intensities were determined for those accounts for which there were at least 3 individual intensity values. The number of consensus intensities for each of the principal events is therefore lower than the number of accounts of each earthquake: a total of 86 for NM1 and 45-50 for NM2, NM3, and the dawn aftershock. The values are shown in Figure 1 and are available as an electronic supplement.

The individual intensity assignments for the four principal events are shown in Figures 2-5. The individual assignments reveal no glaring systematic differences, but individual intensity values do vary considerably, spanning a range of at least 1 full MMI unit for most of the accounts (Figure 6). A similar degree of variability is found for the other three events.

Figure 1.

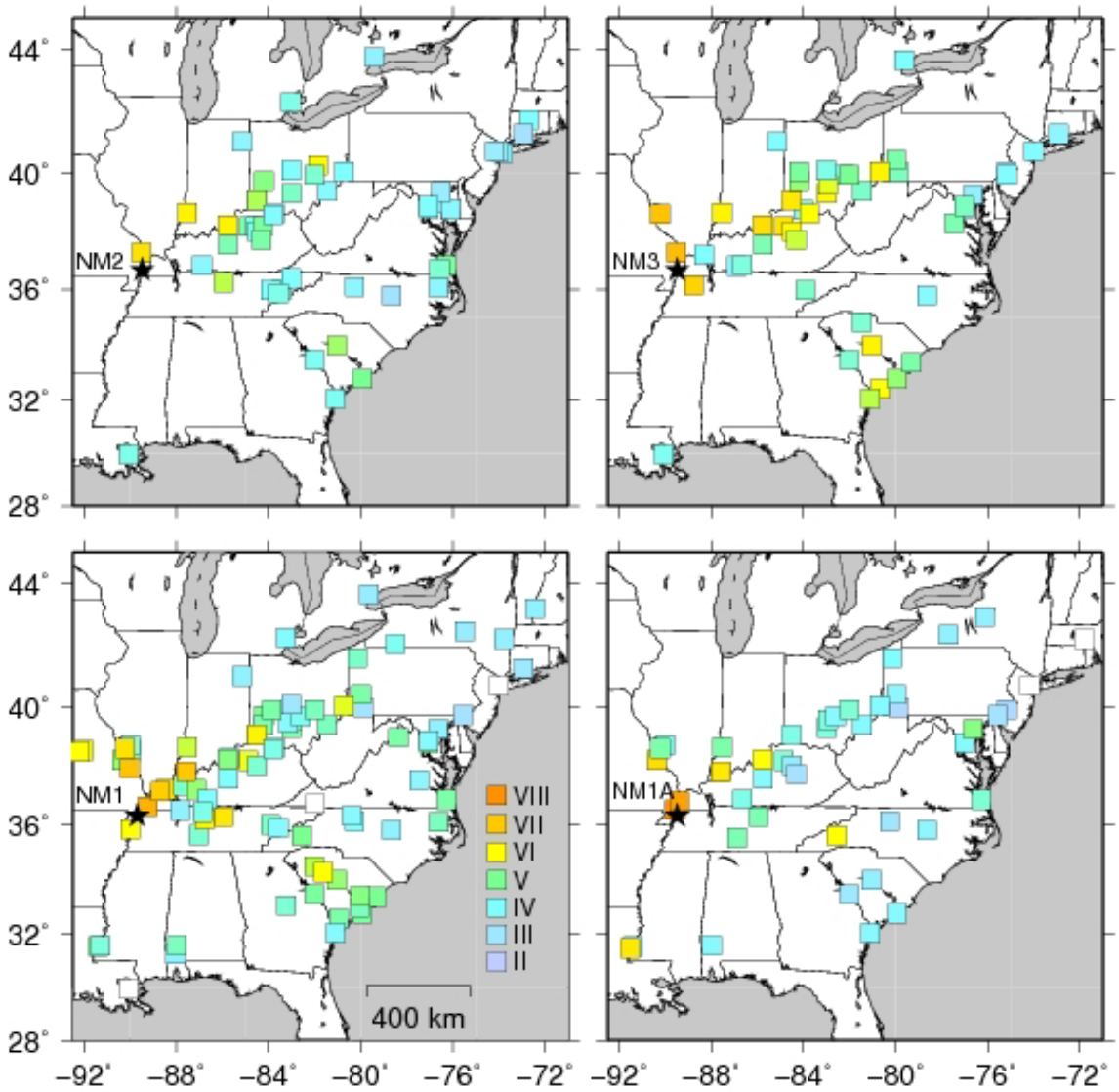

Figure 1. Consensus intensity values for NM1 (top left), NM1A (top right), NM2 (bottom left), and NM3 (bottom right). The magnitude estimates correspond to the average of the results using the two attenuation models (see text). Stars indicate assumed location; for NM2, two candidate locations are shown along with the corresponding magnitude estimates.

Figure 2.

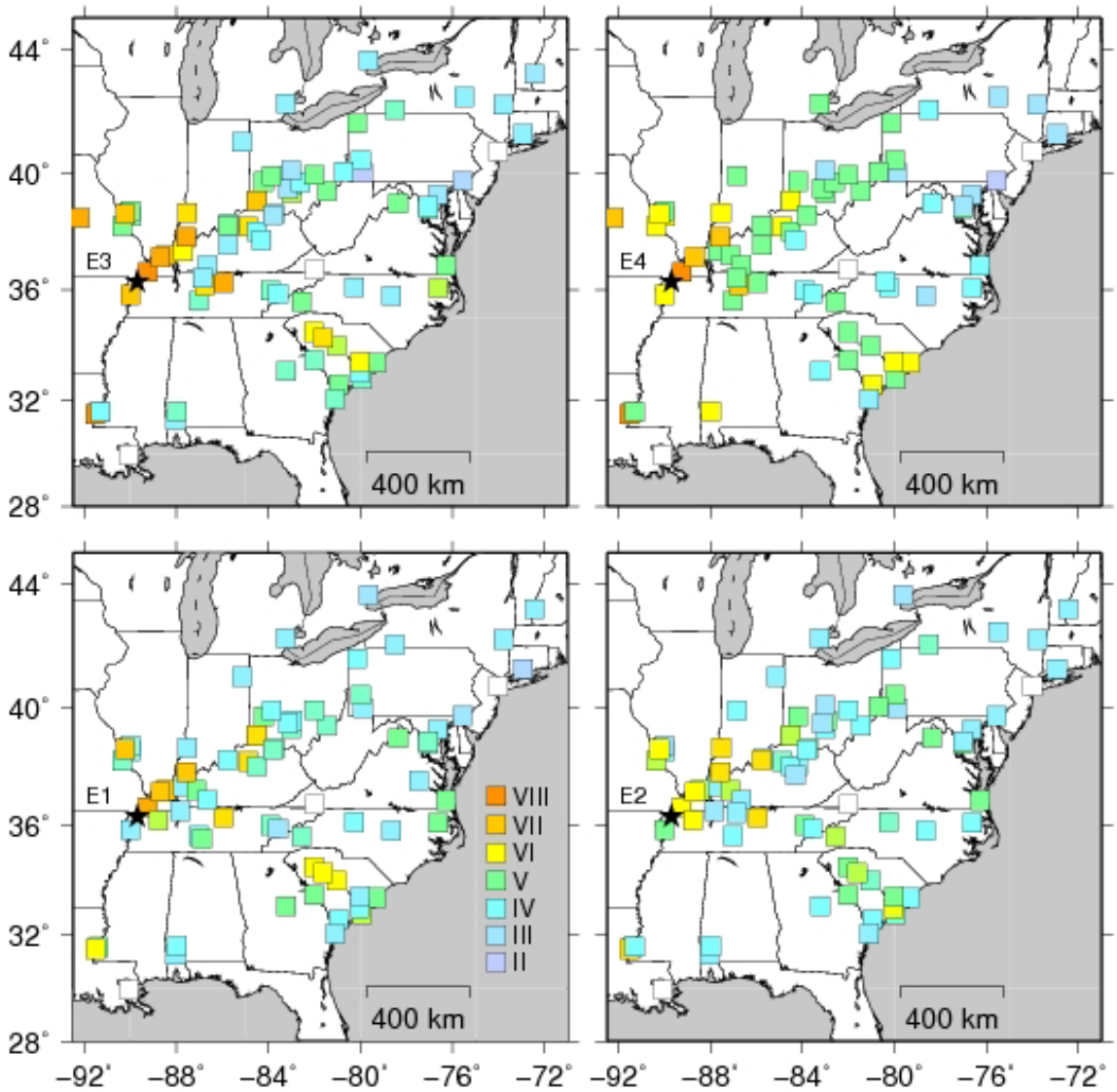

Figure 2. Intensity assignments for NM1 from the four individual experts.

Figure 3.

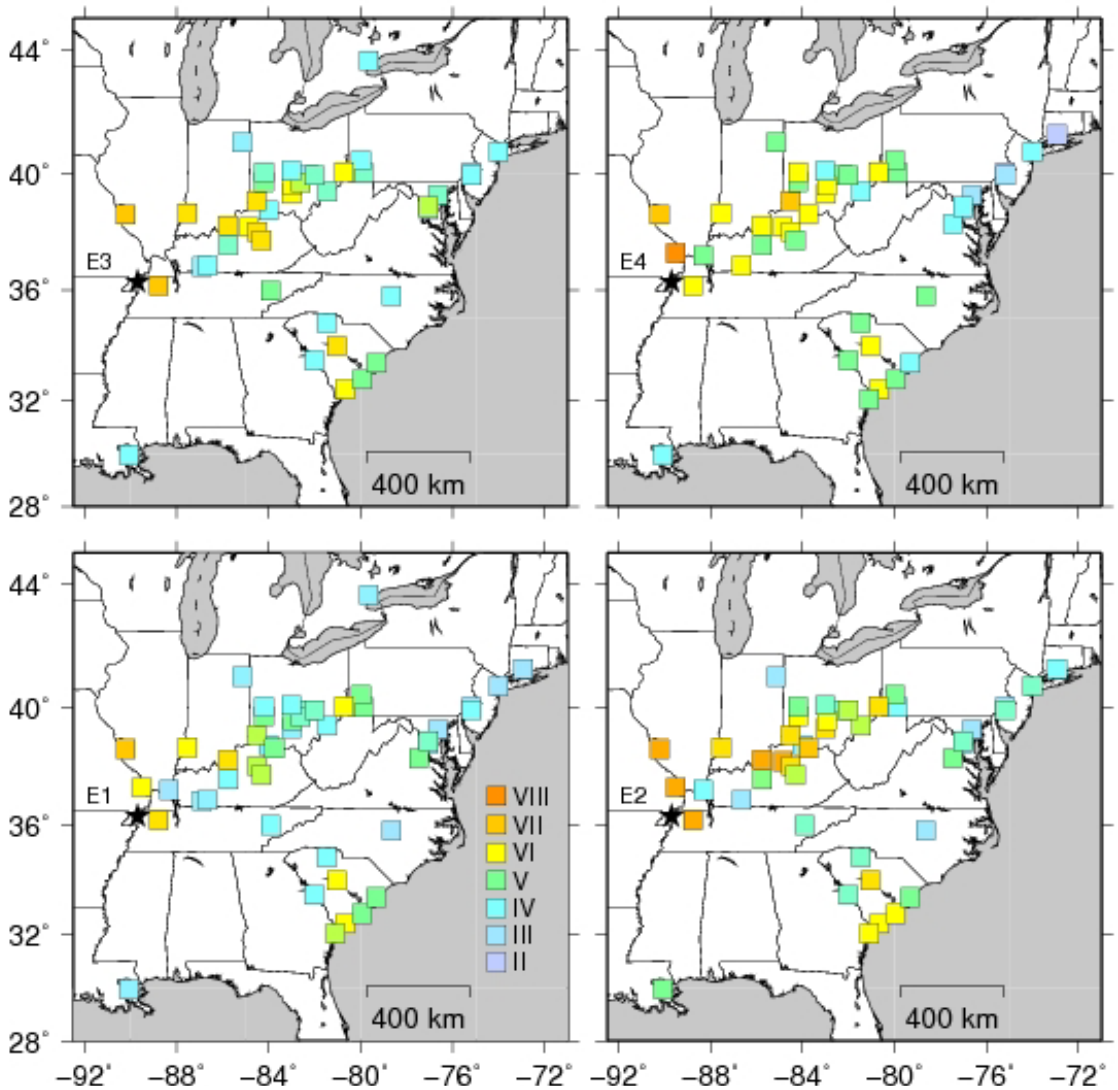

Figure 3. Intensity assignments for NM1A from the four individual experts

Figure 4.

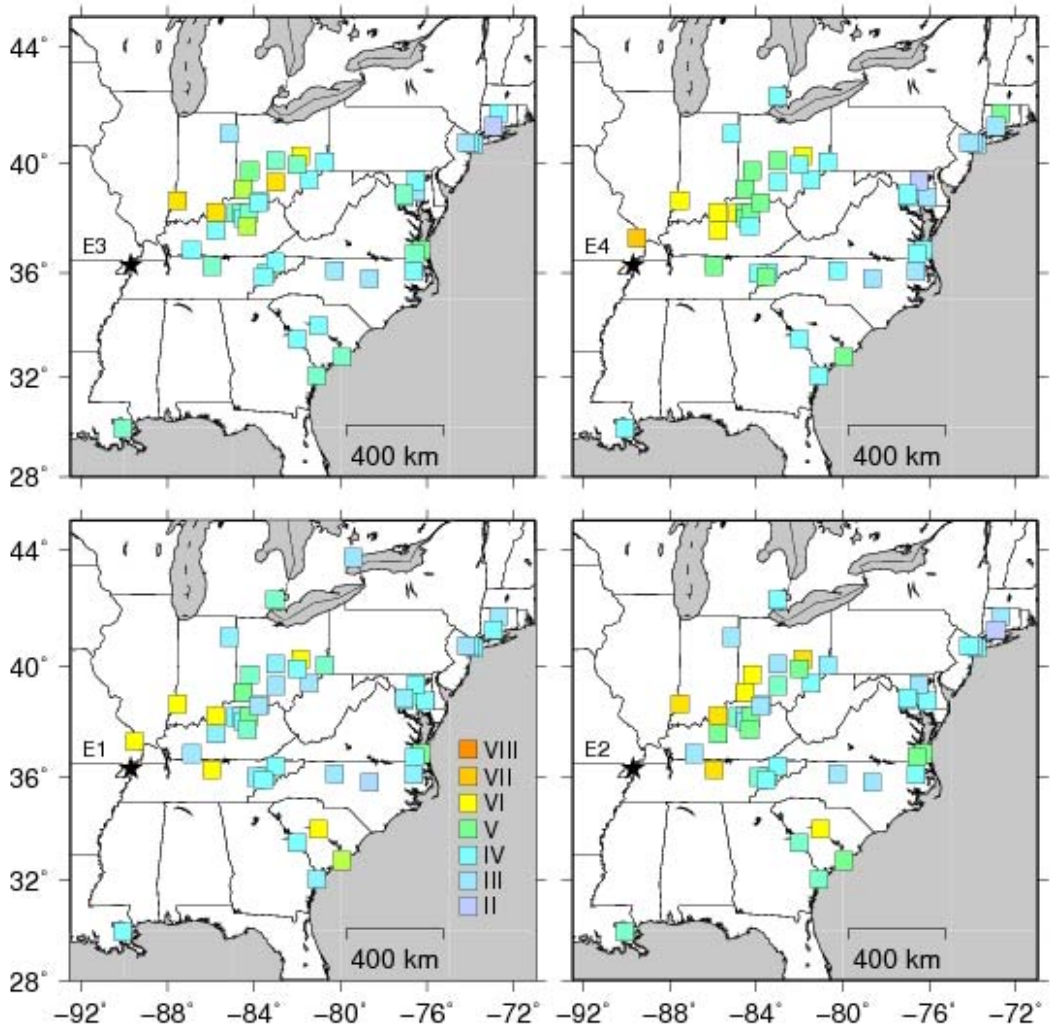

Figure 4. Intensity assignments for NM1A from the four individual experts

Figure 5.

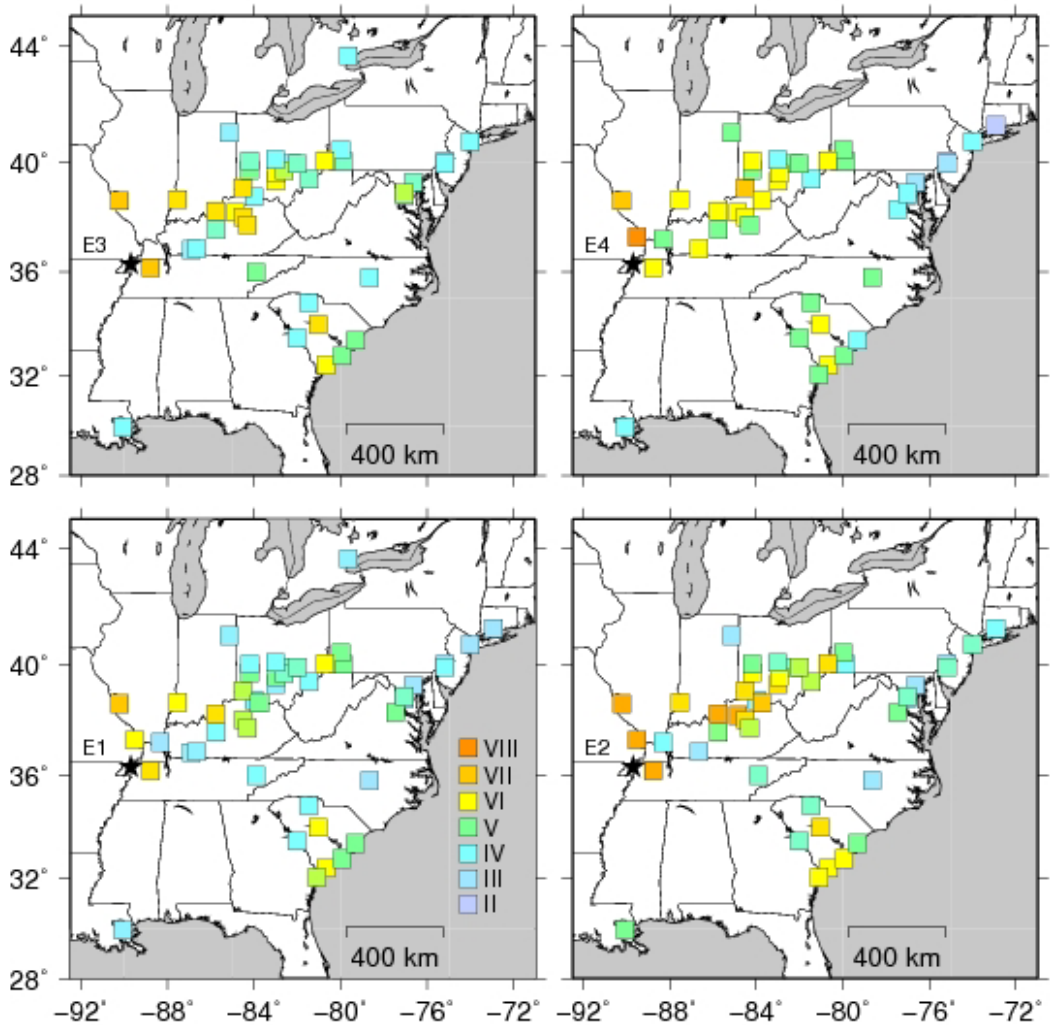

Figure 5. Intensity assignments for NM3 from the four individual assessments.

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Table 1.

Location (State)	Long.	Lat.	MMI 1	MMI 2	MMI 3	MMI 4
Abingdon, VA	-81.981	36.708	NF	NF	NF	NF
Alexandria, VA	-77.044	38.812	4.5	5.0	4.5	5.0
Allegany, NY	-78.494	42.090	3.1	4.5	4.5	4.0
Asheville, NC	-82.564	35.593	4.5	5.5	5.0	5.0
Augusta, GA	-81.994	33.470	5.0	5.0	4.5	5.0
Baltimore, MD	-76.626	39.287	F	F	F	F
Birdsville, KY	-88.450	37.220	7.0	5.5	7.0	NA
Brownsville, PA	-79.889	40.020	F	3.0	2.0	3.0
Carthage, TN	-85.955	36.263	6.5	6.5	7.5	5.0
Charleston, SC	-79.940	32.798	5.5	4.5	4.5	5.0
Charleston, NH	-72.423	43.238	F	F	F	NA
Chillicothe, OH	-82.985	39.330	4.5	4.0	5.5	5.0
Cincinnati, OH	-84.517	39.103	6.5	5.5	6.0	5.0
Circleville, OH	-82.949	39.594	4.0	5.0	4.5	NA
Clarksburg, OH	-83.153	39.506	4.0	3.0	3.0	5.0
Clinton Hill IL	-89.989	38.551	4.0	4.0	4.5	6.0
Columbia, TN	-87.035	35.617	4.0	4.0	4.5	5.0
Columbia, SC	-81.040	34.000	6.0	4.5	5.5	5.0
Coosawatchie SC	-80.939	32.588	4.0	4.0	5.0	6.0
Dayton, OH	-84.188	39.739	5.0	5.0	5.0	5.0
Dorena, MO	-89.240	36.617	7.5	6.0	8.0	8.0
Dover, TN	-87.842	36.488	F	F	NA	NA
Edenton, NC	-76.602	36.066	5.0	4.0	5.5	4.0
Fort Massac, IL	-88.687	37.143	7.0	6.0	7.5	7.0
Fort Osage, MO	-92.032	38.553	6.5	4.5	6.5	6.0
Frankfort, KY	-84.881	38.205	6.5	4.5	6.5	6.0
Ft. Dearborne	-83.244	42.305	F	F	F	5.0
Ft. Pickering	-90.000	35.830	F	5.0	7.0	6.0
Ft. Stoddart AL	-88.050	31.270	F	F	F	NA
Ft. Wayne, IN	-85.150	41.051	F	F	F	NA
Ft. Stephens `	-87.980	31.600	4.0	4.0	4.5	6.0
Georgetown, SC	-79.308	33.382	5.0	4.0	5.0	6.0
Goose Creek, SC	-80.047	33.000	4.0	5.9	4.0	NA
Goshen, IL	-90.000	38.739	4.0	3.0	5.0	5.0
Henderson Cty	-87.594	37.837	6.0	6.0	6.5	7.0
Herculaneum MO	-90.379	38.226	4.5	5.5	5.0	6.0

Hodgenville KY	-85.750	37.57	NA	3.5	3.5	5.0
Hopkins Cty	-87.700	37.350	F	F	6.0	5.0
Hudson, NY	-73.794	42.255	F	F	F	3.0
Jeffersonville	-85.730	38.310	NA	3.0	3.0	5.0
Knoxville, TN	-83.920	35.978	4.5	5.0	4.5	4.0
Lancaster, OH	-82.599	39.714	4.0	3.5	4.0	5.0
Laurens, SC	-82.020	34.504	6.0	5.0	6.0	5.0
Lebanon, OH	-84.210	39.430	NA	4.5	4.5	5.0
Lexington, KY	-84.508	38.041	4.5	4.0	4.0	5.0
Louisville, KY	-85.777	38.251	4.0	6.5	5.0	5.0
Marietta, OH	-81.455	39.417	4.5	4.0	5.0	5.0
Maysville, KY	-83.744	38.636	4.5	5.0	3.1	NA
Meadsville, PA	-80.144	41.647	4.0	4.0	5.0	5.0
Milledgeville	-83.237	33.087	5.0	4.0	4.5	4.0
Muhlenberg Cty	-87.150	37.220	5.0	5.5	NA	5.0
Nashville, TN	-86.784	36.166	5.5	6.0	6.5	7.0
Natchez, MS	-91.402	31.562	5.0	5.0	F	6.0
Natchitoches,LA	-93.101	31.760	4.5	5.0	6.0	6.0
New Bourbon MO	-90.021	37.950	6.0	6.5	8.0	8.0
New Haven, CT	-72.930	41.304	2.5	F	F	3.0
New Orleans, LA	-90.069	29.971	NF	NF	NF	NF
New York, NY	-73.996	40.728	NF	NF	NF	NF
Newberry, SC	-81.614	34.283	6.0	5.5	6.5	NA
Newport, KY	-84.496	39.090	6.5	5.5	7.0	6.0
Norfolk, VA	-76.277	36.849	5.0	5.0	5.0	4.0
Norwich, NY	-75.490	42.510	NA	3.5	3.5	3.0
Ozark Vill. AR	-92.200	38.500	F	6.0	7.5	7.0
Pineville, SC	-80.029	33.428	F	5.0	6.0	6.0
Pittsburgh, PA	-79.983	40.440	4.5	5.0	4.5	5.0
Raleigh, NC	-78.647	35.791	3.5	4.0	3.5	3.0
Red Banks, KY	-87.593	37.838	7.0	6.5	7.5	7.0
Richmond, VA	-77.470	37.530	F	3.0	4.0	4.0
St. Louis, MO	-90.217	38.631	7.0	6.0	7.0	6.0
Salem, NC	-80.260	35.102	4.0	4.5	3.5	X.X
Savannah, GA	-81.091	32.064	3.5	3.5	4.5	3.5
Sevierville, TN	-83.574	35.865	3.0	4.0	4.0	4.0
South Union, KY	-86.657	36.876	4.0	F	3.5	5.0
Springfield OH	-83.844	39.931	5.0	4.0	5.0	5.0
Springfield TN	-86.870	36.420	5.0	3.5	3.5	5.0

Stokes Cty NC	-80.400	36.300	NA	F	F	4.0
Strasburg, WV	-78.365	38.994	5.0	5.0	5.0	4.0
Vincennes, IN	-87.525	38.679	F	6.5	6.5	6.0
Washington DC	-77.026	38.891	4.5	F	4.0	3.0
Washington KY	-83.812	38.611	4.5	4.0	F	5.0
Washington MS	-91.300	31.580	NA	4.0	4.0	5.0
Wheeling, WV	-80.721	40.064	NA	5.0	4.0	5.0
Wilmington, DE	-75.547	39.746	3.0	F	2.5	2.0
Worthington, OH	-83.018	40.093	NA	3.0	3.0	3.0
York, ONT, CA	-79.630	43.68	3.0	F	F	NA
Zanesville, OH	-82.013	39.940	4.5	4.0	5.0	5.0

Table 2. Intensity assignments for Dawn aftershock (7:XXam LT, 16 December 1811)

Alexandria VA	-77.044	38.812	NA	4.5	4.5	3.0
Arkport NY	-77.697	42.395	4.5	2.5	9.9	3.0
Asheville NC	-82.564	35.593	5.5	5.0	6.5	7.0
Augusta GA	-81.994	33.470	F	F	F	NA
Baltimore MD	-76.626	39.287	NA	NA	F	3.0
Brownsville PA	-79.889	40.020	NA	2.0	F	9.9
Carthage TN	-85.955	36.263	NA	6.0+	F	5.0
Charleston SC	-79.940	32.798	F	5.0	F	NA
Chillicothe OH	-82.985	39.330	F	5.0	4.0	5.0
Cincinatti OH	-84.517	39.103	F	5.5	F	5.0
Circleville OH	-82.949	39.594	4.0	4.5	4.5	NA
Columbia SC	-81.040	34.000	3.0	3.0	4.0+	NA
Ft.St.Stephens	-87.98	31.60	NA	4.5	F	NA
Frankfort KY	-84.873	38.201	NA	5.1	F	5.0
Goshen IL	-90.000	38.739	NA	5.0	4.5	3.0
Henderson TN	-87.594	37.837	4.0	7.5	7.0	7.0
Herculaneum MO	-90.379	38.226	6.0	7.5	6.0	7.0
Hodgenville KY	-85.740	37.574	F	5.1	F	NA
Lancaster OH	-82.609	XXX	F	3.5	4.0	4.0
Lexington KY	-84.508	38.041	F	F	3.0	4.0
Little Prairie MO	-89.60	36.50	10.0	NA	NA	7.0
Louisville KY	-85.777	38.251	NA	7.0	7.0	4.0
Marietta OH	-81.455	39.417	NA	F	4.5	NA
Meadville PA	-80.144	41.647	F	4.5	4.0	4.0
Natchez MS	-91.402	31.562	4.0	F	3.0	NA
Natchitoches LA	-93.101	31.760	F	F	3.5	NA
New Bourbon MO	-91.525	31.488	5.0	7.5	7.0	6.0
New Madrid MO	-89.40	36.80	NA	7.0	NA	9.0
Newark NJ	-74.172	40.736	1.0	1.0	NA	NA
Norfolk VA	-76.277	36.849	4.0	5.0	4.5	4.0
Onondaga V. NY	-76.141	42.975	F	NA	NA	4.0
Philadelphia PA	-75.164	39.952	3.0	F	2.0	2.0
Pittsburgh PA	-79.983	40.440	4.0	3.5	3.0	4.0
Raleigh NC	-78.647	35.791	3.0	4.5	4.0	3.0
Red Banks KY	-87.593	37.838	4.0	7.5	7.0	7.0
Richmond VA	-84.310	37.746	F	F	2.0	3.0
Saint Louis MO	-90.217	38.631	NA	4.5	4.0	6.0
Salem NC	-80.260	36.102	F	F	3.0	3.0
Savananah GA	-81.091	32.064	F	4.5	4.0	3.0

South Union KY	-86.657	36.876	F	4.5	4.0	5.0
Springfield TN	-86.891	35.502	F	5.0	5.5	5.0
Vincennes IN	-87.525	38.679	NA	6.5	F	NA
Wheeling KY	-80.721	40.064	4.0	3.5	NA	4.0
Wilmington DE	-75.547	39.746	F	2.5	NA	3.0
Worcester MA	-71.802	42.262	1.0	1.0	NA	NA
Zanesville OH	-82.013	39.94	3.0	5.0	NA	5.0

Table 3. Intensity assignments for 23 January 1812 mainshock

Alexandria VA	-77.044	38.812	3.5	3.5	4.5	4.0
Annapolis MD	-76.492	38.978	4.5	3.5	3.0	3.0
Augusta GA	-81.994	33.470	4.0	4.5	4.0	4.0
Cape Girardeau MO	-89.518	37.306	6.0	9.9	9.9	7.0
Carthage TN	-85.955	36.263	6.0	6.5	4.5	5.0
Charleston SC	-79.940	32.798	5.5	5.0	4.5	5.0
Chillicothe OH	-82.985	39.330	3.5	4.5	6.5	4.0
Cincinatti OH	-84.517	39.103	4.5	6.0	4.0	5.0
Columbia SC	-81.040	34.000	6.0	6.0	4.0	9.9
Coshockton OH	-81.86	40.272	6.0	6.5	6.0	6.0
Dandridge TN	-83.415	36.015	4.0	4.5	4.5	4.0
Dayton OH	-84.188	39.739	4.5	5.9	5.0	5.0
Detroit MI	-83.046	42.331	4.5	4.0	9.9	4.0
Easton MD	-76.076	38.774	4.0	4.0	9.9	3.0
Edenton NC	-76.602	36.066	3.5	4.0	4.0	3.0
Ft. Wayne	-85.150	41.051	3.1	3.1	3.1	4.0
Frankfort KY	-84.873	38.201	4.0	4.5	4.5	6.0
Georgetown KY	-84.559	38.21	3.1	3.1	4.5	5.0
Hartford CT	-72.685	41.764	3.1	3.1	4.0	5.0
Hodgenville	-85.740	37.574	3.5	5.1	4.0	6.0
Jamaica NY	-73.806	40.691	3.5	4.0	3.0	3.0
Knoxville	-83.920	35.978	3.5	4.5	9.9	4.0
Lexington	-84.508	38.041	4.0	3.5	4.0	5.0
Louisville	-85.777	38.251	6.0	6.5	6.5	6.0
Lower Canada	-79.42 43.77	3.0	3.1	9.9	9.9	
Marietta	-81.455	39.417	3.0	4.0	4.0	4.0
Maysville	-83.744	38.636	3.1	3.1	3.1	9.9
New Haven	-72.930	41.304	4.0	2.0	2.0	3.0
New Orleans	-90.069	29.971	4.0	4.5	4.5	4.0
New York	-73.996	40.728	4.0	3.1	4.0	3.0
Newark NJ	-74.172	40.736	3.0	4.0	3.0	3.0
Newport	-84.496	39.090	5.0	6.0	5.5	5.0
Norfolk	-76.277	36.849	5.0	5.0	5.5	4.0
Nottingham	-76.490 39.386	4.0	3.0	4.0	2.0	
Paris KY	-84.253	38.210	5.0	5.0	4.5	5.0
Raleigh	-78.647	35.791	2.5	3.0	3.0	3.0
Richmond	-84.310	37.746	4.5	5.0	5.5	4.0
Rogersville	-83.016	36.402	4.0	4.0	4.0	9.9
Russellville	-86.892	36.845	3.1	3.1	4.0	9.9
Salem	-80.260	36.102	3.1	3.1	3.1	4.0

Savananah	-81.091	32.064	3.5	4.5	4.5	4.0
Sevierville	-83.574	35.865	4.0	4.0	4.0	5.0
Suffolk VA	-76.584	36.726	4.0	5.0	4.5	4.0
Vincennes	-87.525	38.679	6.0	6.5	6.5	6.0
Washington DC	-77.026	38.891	3.5	4.0	4.5	4.0
Washington KY	-83.812	38.611	3.0	3.1	4.0	5.0
Wheeling KY	-80.721	40.064	4.5	3.5	4.0	4.0
William NY			3.1	3.1	4.0	9.9
Worthington OH	-83.018	40.093	3.5	3.0	4.5	5.0
Zanesville OH	-82.013	39.94	4.0	5.0	4.5	4.0

Table 4. MMI assignments for 7 February 1812 mainshock

Alexandria	-77.044	38.812	3.5	3.5	3.0	3.0
Augusta GA	-81.994	33.470	4.0	4.5	4.0	5.0
Augusta KY	-84.002	38.769	3.5	4.0	4.0	NA
Baltimore MD	-76.626	39.287	3.0	3.0	4.5	3.0
Beaufort SC	-80.670	32.432	6.0	6.0	6.0	6.0
Brownsville OH	-82.256	39.946	4.5	4.5	3.0	5.0
Brownsville PA	-79.884	40.024	5.0	4.0	4.5	5.0
Cape Girardeau MO	-89.418	37.306	6.0	7.5	NA	8.0
Charleston SC	-79.940	32.798	5.0	6.0	5.0	5.0
Chillicothe OH	-82.985	39.330	3.1	6.5	6.0	6.0
Cincinatti OH	-84.517	39.103	5.5	6.5	6.5	7.0
Circleville OH	-82.949	39.594	5.0	6.0	6.0	6.0
Columbia SC	-81.040	34.000	6.0	6.5	6.5	6.0
Dayton OH	-84.188	39.739	5.0	6.0	5.0	5.0
Ft. Wayne IN	-85.150	41.051	F	F	F	5.0
Frankfort KY	-84.873	38.201	NA	7.5	6.0	6.0
Fredericksburg	-77.461	38.303	5.0	5.0	9.9	4.0
Georgetown SC	-79.308	33.382	5.0	5.0	5.0	4.0
Germantown	-75.180	40.043	3.0	3.0	3.0	2.0
Hodgenville KY	-85.740	37.574	4.0	5.0+	4.5	5.0
Knoxville TN	-83.920	35.978	4.0	4.5	5.0	NA
Lancaster PA	-82.609	82.611	4.5	5.5	5.5	6.0
Lexington KY	-84.508	38.041	5.5	6.5	6.5	6.0
Livingston Cty	-88.330	37.220	3.0	4.0	NA	5.0
Louisville KY	-85.777	38.251	6.5	7.5	6.5	6.0
Marietta OH	-81.455	39.417	4.0	5.5	4.5	4.0
Maysville OH	-83.744	38.636	5.0	7.0	9.9	6.0
Nashville TN	-88.786	36.162	6.5	7.5	7.0	6.0
New Haven CT	-72.930	41.304	3.0	4.0	NA	2.0
New Orleans LA	-90.069	29.971	3.5	5.0	4.0	4.0
New York NY	-73.996	40.728	3.0	4.5	4.0	4.0
Philadelphia PA	-75.164	39.952	4.0	4.5	4.0	3.0
Pinckneyville	-81.468	34.843	4.0	4.5	4.0	5.0
Pittsburgh PA	-79.983	40.440	5.0	5.0	4.0	5.0
Raleigh NC	-78.647	35.791	3.0	3.1	4.0	5.0
Richmond VA	-84.310	37.746	5.5	5.5	6.5	5.0
Saint Louis MO	-90.217	38.631	7.0	7.5	7.0	7.0
Savananah GA	-81.091	32.064	5.5	6.0	NA	5.0
South Union	-86.657	36.876	F	F	4.0	6.0
Troy OH	-84.203	40.039	4.0	5.0	4.5	6.0
Vincennes IN	-87.525	38.679	6.0	6.5	6.5	6.0
Washington DC	-77.026	38.891	4.5	4.5	5.5	4.0

Wheeling KY	-80.721	40.064	6.0	6.5	6.0	6.0
Worthington OH	-83.018	40.093	4.0	4.5	4.0	4.0
Zanesville OH	-82.013	39.94	4.5	5.5	4.5	5.0

Appendix A. A Detailed Narrative of the Earthquakes which occurred on the 16th day of December, 1811*

(Transactions of the Literary and Philosophical Society of NY, vol. 1, pp. 281-307)

Samuel L. Mitchill, Representative in Congress
Transcription and notes, Susan E. Hough, U.S. Geological Survey, Pasadena (May, 2000).

*Full title: A detailed narrative of the earthquakes which occurred on the 16th day of December, 1811, and agitated the parts of North America that lie between the Atlantic Ocean and Louisiana; and also a particular account of the other quakings of the earth occasionally felt from that time to the 23d and 30th of January, and the 7th and 16th of February, 1812, and subsequently to the 18th of December, 1813, and which shook the country from Detroit and the Lakes to New-Orleans and the Gulf of Mexico. Compiled chiefly at Washington, in the district of Columbia.

[Read before the Society on the 14th of April, and the 12th of May, 1814]

The beautiful comet which travelled through the northern celestial hemisphere during 1811, had offered itself plainly to view until the approach of the following year. Its elements, as calculated by Nathaniel Bowditch, Esq. and his learned associates, have already been placed before the public eye.

The tremendous storm from the northeast, near the end of December, 1811, began to leeward, near Cape Hatteras, and swept the American coast to the banks of Newfoundland, doing great damage to navigation, and exhibiting some curious facts in the history of the atmosphere. The particulars of this furious and memorable tempest have been collected by myself; and are in readiness to be offered to the society at the first convenient time.

My present intention is to read to you the information I have gathered on another occurrence of those portentous days. I mean the phenomena of the earthquakes, which terrified the country about the same period, and which continued a long time afterwards.

On the morning of Monday, the 16th of December, 1811, several shocks of earthquakes were felt at the city of Washington. The first of these happened at three o'clock; and in some houses was considerable enough to shake the doors and windows, and wake persons from their sleep. There were successive tremors. Tassels of curtains were seen to move; and pitchers of washing-stands were heard to rattle upon their basins. The sound was very distinguishable, and was believed by many to pass from southwest to northeast. The alarm was so

great in some families, that searches were made from room to room, to discover the robbers who were imagined to have broken into the houses.

A second shock, though lighter, was experienced about six o'clock, and a third about eight.

A gentleman standing in his chamber at his desk and writing, in the third story of a brick house, upon the Capitol Hill, suddenly perceived his body to be in motion, vibrating backward and forward, and producing dizziness. Not suspecting the moment that the uncomfortable sensation was caused by an earthquake, he examined his desk to know whether it stood firm. Finding that it did, he dropped his pen; and turning his eyes upward, discerned that the looking-glass, and other things hanging near him, were in a similar motion.

Another person was near a table placed beneath a mirror. Feeling a giddiness come upon him, he seized the table for support. The general agitation of the chamber and house ceased in about a minute; but the looking-glass, which was suspended in the usual manner, continued to swing for some seconds longer. These observations, made by Messrs. Bigelow and Mosely, may serve as specimens of a multitude of phenomena of those kinds.

The atmosphere seemed to forebode some unusual occurrence. One of my most correct and respectable friends, declared in conversation, and stated to me in writing, that he made an observation of the sky about ten o'clock that night. It was quite calm. There was not a breath of wind stirring. The air was perfectly clear and free from clouds. Nevertheless, it was uncommonly dark, and the stars which appeared in every part through the gloom, were lurid and dim, and afforded little light.

In Richmond the signs of an earthquake were witnessed by many persons. At three o'clock on the same morning, (the 16th of December,) there were said to be three successive shocks; another about six; and a third about eight. Several people were impressed with a belief that thieves had entered their dwellings; and in one of the most elevated mansions, the bells were set a ringing in both the upper and lower rooms. The noise and concussion were supposed by some to proceed from east to west.

It was stated at Norfolk that two very distinct shocks were felt in that town and in Portsmouth; to wit, at three and eight o'clock in the morning of the 16th. Some clocks were reported to have stopped; the doors rattled; and articles hanging from the ceilings of shops and houses, swung to and fro, although a perfect calm prevailed.

At Raleigh (N.C.) several slight earthquakes were felt on the morning of the 16th December. The first happened between two and three o'clock, and was distinctly perceived by all who were awake at the time. Two others were reported to have

occurred between that time and seven o'clock, but were not plainly observed, except by some members of the legislature, who were in the state-house, and were considerably alarmed at the shaking of the building.

From Georgetown, (S.C.) it was told, that several shocks had been experienced between the hours of three and eight, on the morning of the 16th. The inhabitants were much alarmed. The shocks were so considerable, that the parade-ground of the fort was said to have settled from one to two inches below its former level. A tub of water, standing upon a table in the barracks, was reported to have been overset by the jarring of the building. Another severe shock was felt two days afterwards, at noon.

At Columbia, (S.C.) the inhabitants were alarmed by repeated shocks. The first took place at half after two in the morning of Monday, which was represented as shaking the houses as if rocked by the waves of the sea. It was followed, after the cessation of a minute, by three slighter ones. At eight o'clock two others took place, and at ten, some slight ones. The South Carolina college appeared to rock from its foundation, and a part of its plaster fell; which so alarmed the students, that they left the chambers without their clothes. It seemed as if all the buildings would be levelled. The dogs barked; fowls made a racket; and many persons ran about with lights, not knowing where to go, so great was their terror. During the first agitation, it was observed, that the air felt as if impregnated with a vapour, which lasted for some time.

On Tuesday, at a quarter after twelve, another smart shock was experienced. At Laurens and Newbury, in the interior districts, it was so violent as to crack and start several chimnies.

At Charleston (S.C.) the sensation was of considerable strength. One account stated; that on the morning of the 16th, at a few minutes before three o'clock, a severe shock of an earthquake was felt. Its duration conjectured to ahve been between two and three minutes. For an hour previous, though the air was perfectly calm, and several stars visible, there was, at intervals of about five minutes, a rumbling noise like that of distant thunder; which increased in violence of sound just before the shock was felt. The vibrations of St. Philip's steeple caused the clock bell to ring about ten seconds. Two other shocks were felt afterwards, one a little before eight, and the other about a quarter of an hour after. Both these were slighter and shorter than the first. Many of the family clocks were stopped by the concussions. In many wells the water was considerably agitated. From another source it was related that Charleston was shaken by an earthquake severely, at the time before specified. This was preceded by a noise resembling the blowing of a smith's bellows. The agitation of the earth was such that the bells in the church steeples rang to a degree indicative of an alarm for fire. The houses were so much moved that many persons were induced to rise from their beds. The clocks generally stopped. Another slight shock was experienced about fifteen minutes after; and yet

another at eight o'clock. This last one produced a considerable rattling among glass, china, and other furniture. A looking-glass hanging against a west wall was observed to vibrate two or three inches from north to south.

The ingenious writer of the meteorological observations for Charleston during December, 1811, has noticed these occurrences in a manner too interesting to be omitted. According to his remarks, there were seven shocks during the month, having a vibratory motion from east to west. In many persons the motion produced nausea. All the shocks, except the last, were preceded by noises resembling the rattling of a carrage over a pavement. There had been less thunder during the preceding season than usual. THe days of thunder amount annually to about sixty; but this year there were no more than thirty-eight. The beautiful comet was visible in the northwest during the whole month.

The inhabitants of Savannah were sensible of four earthquakes. The first was on the morning of the 16th December, between two and three o'clock. It was preceded by a flash of light, and a rattling noise, resembling that of a carriage passing over a paved road. It lasted about a minute. A second soon succeeded, but its duration was shorter. A third happened about eight o'clock; and a fourth about noon on the 17th. Persons who experienced the hardest shock, were made to totter, as if on shipboard. Its course was believed to be from southwest to northeast.

It was observed, by Dr. Macbride of Pineville, (S.C.) that the earthquake terrified the inhabitants exceedingly. It was accompanied by several appearances that countenances the theory of this phenomenon, which brings in the agency of the electric fluid. 1. The unfrequency or absence of thunder storms; that is, they were much less frequent this year than usual, especially in the autumn. 2. Immediately before the earthquake, a red appearance of the clouds, which had much darkened the water for twenty-four hours immediately before the shock; and 3. The loudness of the thunder, and the number of the peals within twenty-four hours after the first shock, and but a few hours before the last, which was felt before he wrote. Such thunder was very unusual at that season.

At Natchez, the occurrences, as related by a careful observer, were as follow: Four shocks were felt on the morning of the 16th. The principal one was at tem minutes after two, A.M. There was no noise, except in a few situations. Several clocks were stopped. Articles, in some instances, fell from shelves. Plastered walls were sometimes cracked. The Mississippi was agitated as if the banks were falling in. The trees in the forests waved their tops. Many houses were shaken considerably. And things suspended on nails or pins swung backwards and forwards.

Information was forwarded from Tennessee, that the earth quaked so violently, as to throw down chimnies, in some places. Eighteen or twenty acres of land, adjacent to Piney river, suddenly fell down, and sunk so low, that the tops of the

trees were on a level with the surrounding earth. Four other shocks were experienced on the 17th, and one or more continued daily until the 30th.

At Knoxville, the quaking of the earth on the 16th was represented to have lasted more than three minutes. The rattling of the windows and furniture of the houses were such as to awaken almost every family. This was about two in the morning. It was followed, in half an hour, by another, which continued half a minute. Between sunrise and breakfast, three others were felt, of only a few seconds in duration. At the end of the first and longest shock, there were, in a direction due north, two flashes of light, at the interval of about a minute, very much like distant lightning.

At Columbia, in Tennessee, between two and three o'clock on the morning of the 16th December, the inhabitants were suddenly alarmed by a voilent agitation in the earth. It was accompanied by a peculiar sound, proceeding from southwest to northeast. Immediately after the shock had ceased, a very large volume of something like smoke was discovered to rise in the quarter whence the sound appeared to come; and pursuing nearly the same course, finally settled in the north, exhibiting the appearance of a black cloud. The shock was computed to have continued from ten to fifteen minutes.

At Louisville, (Ken.) near the falls of the Ohio, on Monday morning about three o'clock, a violent shock of an earthquake was felt. It was judged to have continued about three minutes. This was followed by three or four others of less violence. A number of houses suffered considerable damage; the chimnies having been so much cracked as to require repairs by the mason. On the evening previous to the shock, there was a gentle rain, such as we have in April; and the night was rather close and dark; but at the termination of the first shock, it was light enough to enable a pin to be seen.

By information from Jeffersonville, in the Indiana Territory, on the opposite side of the Ohio, it was understood that the shocks were reiterated, and the writer of the account I am now copying, declares that the table was in motion from the earthquake, while he was employing his pen to describe the phenomena. The day preceding was extremely dark and gloomy there, and warmth and smokiness distinguished the weather for some time after.

At Vincennes, the earthquake occurred about two o'clock on the morning of the 16th December. Other shocks of less violence followed it for several days. It was so severe that the inhabitants were greatly concerned for the safety of their houses.

At the Reb Banks, one hundred and fifty miles below Louisville, it was stated in a letter to my friend, the hon. Anthony New, dated January 4, 1812, "that there had been from twenty to thirty shocks of earthquakes at that place. They begun on the morning of December 16, at about half after two o'clock. The first one, and

another at sunrise the same morning, were most violent indeed. We had to flee from our houses. Several chimnies were thrown down, and many others so wrecked and cracked as to be very dangerous. The noise which accompanied the several shocks is said to have come from the west."

The town of St. Louis, in Louisiana, experienced a full proportion of the commotion. Mr. Riddick, being at St. Louis, near the Mississippi, observed to me, that the shocks were preceded by a remarkable calm. The atmosphere was of a dingy and lurid aspect, and gleams and flashes of light were frequently visible around the horizon, in different directions, generally ascending from the earth. Sometimes sounds were heard, like wind rustling thorugh the trees, but not resembling thunder.

The first earthquake was felt aobut a quarter of an hour after two in the morning of the 16th. It roused persons from their sleep, by the clatter of windows, doors, and furniture, in tremulous motion. There was a rumbling distant noise, resembling a number of carriages passing over a pavement. In a few seconds the motions and noises had considerably increased. The sky was obscurred by a thick and hazy fog, without a breath of wind. The weather was moderate, with the mercury about eight degrees above the freezing point. At forty-seven minutes after two, a second shock was felt. At thirty-four minutes after three, a third came; which was as tremulous as the first, but not followed by so much noise. A little after daylight, there was a fourth; at eight, a fifth; and at half past eleven, a sixth; several persons felt, or imagined, others. They were of different lengths, from two minutes to a few seconds. No lives were lost; some chimnies were thrown down; and a few stone houses split. The morning was observed to be very hazy, and unusually warm for the season. The houses and fences seemed to be covered with a white frost; but on examination, this appearance was illusive. A vapour hovered over every thing, and shrouded the morning in awful gloom.

At Lebanon, in Ohio, the alarm was so great, that many persons forsook their houses. The vibration of the shocks seemed to be from east to west.

At Circleville on Monday morning between one and two o'clock, many of the inhabitants were considerably alarmed by a sudden and violent trembling of their houses, which was supposed to have proceeded from an earthquake. Many persons, affrighted, leaped out of bed. Another was felt at eight; but there was no explosion.

A letter from Kentucky to my friend, the hon. John Talliaferro, informed him that on the night between the 15th and 16th December, 1811, the shock of an earthquake was sensibly and alarmingly felt. The shakings continued, in greater or less degrees, through night and day, up to the 30th of the same month, when a more severe shock than any preceding one occurred. It overturned almost every brick or stone chimney in Henderson county, or the region thereof, situated on Green river, down to its confluence with the Ohio.

The editor of the Western Spy, a newspaper printed at Cincinnati, in Ohio, after writing an intelligent account of the phenomena of the earthquake, gave a valuable summary from the gazettes of the occurrences in other places along the western waters.

By the intelligence from Detroit, from Judge James Witherall, it appears that Michigan was agitated by the same subterranean power. A small shock was felt at Detroit on the 17th December. The atmosphere was serene, but cold. Thirty miles northwest of that village is a lake about nine miles in circumference, of an oval form, and which is supposed to have communication under ground with Lake Sinclair. In the centre of this lake there is an island of perhaps three miles in circumference, inhabited only by Indians. They relate, that on the said 17th December the waters of the lake appeared to tremble, and boil like a great pot over a hot fire; and immediately a vast number of large tortoises rose to the surface, and swam rapidly to the shore, where they were taken for food.

The testimony of Colonel Samuel Hammong, in a letter of the 6th February, 1812, which I received from him, was to the following effect. He confined himself strictly to what he know from personal observation. The first shock he witnessed was on the 15/16th of December last. He was then at Herculaneum in Louisiana. A few seconds before the motion was felt, he and others heard a considerable roaring or rumbling noise, resembling a blaze of fire acted upon by wind. The motion of the frame of the house on which he stood was tremulous. It began instantly after to rock pretty violently. This continued, as he thought, about ten to twelve minutes. The vibrations of the chimney were, perhaps, about three or four inches each way, and were in the direciton of southeast and northwest nearly. The noise which preceded the shock was from the northwest. Its commencement was about two o'clock in the morning. One hour after there was a second, which was light, and of very short duration. No houses or chimnies were thrown down by either of those. The motion was very much like the first, but of short duration. This injured several brick and stone chimneys. Its duration between one and a half and two and a half minutes. About sunrise the same morning there was a fourth shock. The vibrations of the chimneys at twenty-five feet from the ground, were at least four inches each way. The direction was the same as the first. The motion of the earth was very perceptible. Cradles rocked, and the church bells rang. Several chimnies were cracked to their bases, and some were broken off as low as the stem or funnel. In this last shock, the water in the river Mississippi was thrown into commotion, bubbling like boiling water; and, in a few minutes, the whole atmosphere was filled with smoke or fog, so that a boat could not be seen within twenty paces from the water's edge; and the houses were so shrouded as not to be seen fifty feet; this smoke continued all the forepart of that day.

In passing along upon his journey, he found the effects had been pretty uniform, and their occurrence and duration nearly the same, as far as Carthage, in the state of Tennessee. There were one or more shocks every twenty-four hours,

from the first-mentioned one, until the night of January 1, 1812. Then, at about half after three in the morning, being at Carthage, he felt a severer shock. It threw bricks from a chimney which had been previously broken by the first shock; he found, on inquiry, that the motion was considerably greatest near the large water courses. The court-house at Carthage is a large brick edifice, and was cracked to its foundation, and considerably damaged. Several chimnies had been cast down, by the shock of the 16th of December. Everywhere it was stated to him by those who witnessed the motions, that they were from the south of west, to the opposite point, or vice versa. In the county of Christian, (Kentucky,) af fine and fresh spring was observe to run very muddy for several hours. On examining it, after the feculence had settled, he found it to be so strongly impregnated with sulphur; so much so that it was spoiled for domestic uses; indeed it had been converted to one of the strongest brimstone springs he ever met with.

But considerable as these operations were, they were surpassed by others which took place along the river Mississippi; indeed, the strata underlying the bed of this stream appear to have been the principal seat of the commotion or, at least, the place where it was most considerable. The phenomena were described in the most fearful and alarming strains by several writers. Much exaggeration was interwoven with some of the narratives. Some, indeed, were tinctured with fable and burlesque. Among the various recitals it became exceedingly difficult to find out the true, or even the most probable, account. Five or six witnesses, who seem to have been wholly unknown to each other, agree in so many particulars, that their united evidence may be considered to approach as near to the truth as we can expect to arrive.

First, the writer of a letter from the Chicasah Bluffs, dated December 21st, to his correspondent in Cincinnati, stated many particulars from his personal observation. The first shock happened at thirty minutes after two, on the morning of the 16th, and was followed by many more within a few days. The boat was acted upon by the water in such a manner as to induce a belief that she had grounded; but upon sounding, he could find no bottom. The current, at the place where he was at the time of the occurrence, (eighty-seven miles below the mouth of the Ohio,) acquired three times its former velocity, and the river rose six feet upon its former level; the trunks of trees, bedded in the bottom, suddenly rose in great numbers to the surface; the banks tumbled down at an alarming rate; and the land was rent by cracks and fissures.

Secondly, a writer from New Madrid, in a communication to a friend in Lexington, dated 16th December, describes a tremendous noise as rousing the family from their sleep, rocking the house, throwing down the chimney, and terrifying them so, that they passed the remainder of the morning, from two o'clock, when the shock was felt, in the open air. During the time of the shock, the heavens were very clear and serene; there being not a breath of air stirring; but in five minutes it became very dark; and a vapour which seemed to impregnate the atmosphere,

had a disagreeable smell, and produced a difficulty of breathing. This darkness continued until nearly the break of day. During its continuance there were six more shocks. About half after six it cleared up. However, the danger was increased by another shock, which racked the houses violently, and threw down the chimneys. The darkness returned, and it was accompanied by loud noises, and a bounding motion up and down. Many persons were so alarmed that they formed encampments in the fields. The shocks were repeated from time to time, until the 28th, and then amounted to sixty-seven.

Accounts from Little Prairie (note 1) stated that ponds had been converted to upland, and dry land to lakes; that the banks of the river had sunk and fallen in to great extent; that cracks had been formed in the earth; that water had gushed out; and that there was a strange and chaotic mixture of the elements. In some places, sand, mud, water, and stone-coal were reported to have been thrown up thirty yards high.

Thirdly; a more full and circumstantial history of those eruptions and commotions was drawn up by Mr. William Leigh Pierce, who, at the time of their occurrence, was passing down the Mississippi in a boat.

After having described the occurrences of the 16th, 17th, and 18th, up to the 19th, he wrote from the Big Prairie, under date of December 25th, to his acquaintance in New-York, a very circumstantial account, which was published in the journals of the time. His narrative abounds with facts showing the irresistible and ruinous effects of the commotion, which he thinks might have been considered as protracted to the surprising length of one hundred and seventy-eight hours.

Fourthly; to these I subjoin another respectable communication, from Mr. Joseph Ficklin of Russelville, (Ken.) who thus describes the earthquakes, in a letter dated February 5, 1812: "The shocks continue. The accounts that you will see in the Nashville and Lexington papers may be confided in. I have conversed with several persons from New Madrid, all of whom confirm the above. The bottom of the Mississippi river, two under miles west of this place, was cracked in some places fifteen feet in width, and cast up *warm* water sufficient to inundate the settlement from one to two feet. In this situation, the poor inhabitants sought for the highest ground, where some remained for seventeen days, looking for the earth to swallow them up. Indians who were two hundred and fifty miles beyond the Mississippi, and about five hundred miles west of this place, relate sights of horror, in the tumbling down of rocks, the fall of trees, and the lights of fire; which prove to my satisfaction that the cause of this alarm lies in the mountains or hills which are between the head of the Arkansaw river, and the waters of the Missouri, not more than six hundred miles from this place, a little south of west. The shocks are much more severe one hundred and fifty miles west of this than they are here. Fortunately, there are no brick or stone houses near the seat of danger to destroy the people. The Indians cannot have suffered much in their

tends and bark houses. But the United States will suffer in the sales of their public lands west of the Mississippi for an age. At least the present generation must be buried before the spirit of wandering, in that direction, revives; and may it not be an advantage that some power exists to fix a boundary for our fellow citizens; for my own part, I am pleased in viewing the benefits which my country will derive from this great shock. We had one last night."

Fifthly: there is further information contained in a letter from a gentlement at the mouth of the Cumberland river to his friend in Woodford county, Kentucky, dated February 10, 1812: it was published in the newspapers of that state, and corroborates substantially the recitals of the other witnesses.

Sixthly; Daniel Bedinger, Esq. who was passing down the Mississippi, in a boat, at the very time, was a witness of the occurrences, near him; and he described them in his journal, dated at New-Orleans, January 15, 1812: He bears witness of the noises that attended the shocks; the froth that formed on the surface of the river from the bursting of air bubbles; and of the elevation of innumerable logs and trees from the bottom of the Mississippi. Cracks and rents in the earth and the falling of banks were frequent and terrible.

The earthquakes were not felt quite so strongly at or below New-Orleans.

In all these shakings of the ground it is particularly to be observed, that there were but slight indications of them at Baltimore, or in any place to the eastward or northward. The evidence from Philadelphia and New-York was of a dubious character; though some persons at the latter place, and at Newark, assured me they felt several small concussions. It seemed, however, as if the Maryland side of the Potomac and the ridge of the Alleghany, might almost be deemed the limits of their extension; the more considerable proofs of their power having been to the westward of the latter, and to the southward of the former, of those boundaries.

On the 23d of January, the earthquakes were renewed, to greater extent than before, and in some places with increased violence.

One was felt at Washington, about nine A. M., and the witnesses of the concussion were very numerous. The phenomena very much resembled that of the 16th of December. A few recitals will answer all the purposes of information.

At Nottingham, in Maryland, the shock was alleged to have happened twenty minutes after nine, and to have lasted a minute. The writer of the account was sitting in a room with two other persons, occupied in reading, when it was asked by one of them what made the chamber shake so? This called the attention of them all to the movement, which they described as having the same effects as the rolling of a vessel on an agitated sea.

The inhabitants of Richmond (Va.) felt it severely at half after none. Like the former, it was more sensible on Shockoe and Richmond hills, than in the lower parts of the city. In some instances, books were nearly thrown from their shelves, and many persons at breakfast precipately left the tables.

At Cashockton, in the state of Ohio, on the morning of the 23d of January, at Georgetown, Louisville, Chilicothe, Paris, Washington, and Frankfort, the shocks excited a great share of attention.

At Charleston, (S.C.) on the same morning, to wit, of the 23d of January, at fifteen minutes after nine o'clock, the vibratory shock on an earthquake was felt more severely than on the former occasions.

This was said to have been more extensive than the preceding ones, inasmuch as the newspapers stated that it was felt at New York.

Another was experienced in Kentucky, on the 30th of January. It was described in a letter from Louisville to Stephen Ormsby, Esq. as having proceeded from the west, about the same time of night with that of December 29. It was not near so violent. The relater was waked from sleep by a noise like that of a carriage, which was followed by a shake. About six minutes before the shock, the whole heavens appeared to be illuminated, and darkness immediately afterwards ensued. No damage was done.

These commotions were renewed in February, as appears by the intelligence from Michigan, written to me by Judge Witherall:

"The earthquakes continue to visit us. On the 3d instant, fourteen minutes past 4 P. M., a small shock was felt; the mercury low, but not quite in the ball; it had risen very considerably a few hours previous to the shock. On the 7th, at 4 P. M., the weather continuing moderate, the shock was strong, nearly equalling the one I previously mentioned to you, and continued about ninety seconds; on the same evening, at half past seven, another small shock; at fifty-five minutes past nine, the same evening, another small shock; at eleven, another, and at 2 A. M. of the 8th, one which seemed to produce a different motion; that is, like pounding up and down, instead of oscillating.

On the 7th of February several shocks occurred at Pittsburgh. These were most extensively felt, and by no means confined to that region. They began about four in the morning. Many persons were so much alarmed as to rise from their beds and run out of doors, screaming with affright. Flashes of light similar to those seen on the 16th of December were perceived toward the southwest. The last concussions were greater than any that had been experienced before. There was another shake between ten and eleven that night.

Being on horseback in Livingston County, Kentucky, Mr. Riddick, on the morning of the 8th of February, was sensible of the earthquake. His horse refused to proceed, and bracing himself on his legs, stood still. The atmosphere was remarkably luminous for some time prior to the shaking of the ground. There was no moonshine; and yet objects could be seen to a considerable distance. On this occasion the brightness was general and did not proceed from any point or spot in the heavens. It was broad and expanded, reaching from the zenith, on every side, toward the horizon. It exhibited no flashes, nor coruscations; but, as long as it lasted, was a diffused illumination of the atmosphere on all sides; but no noise was distinguished until the shaking of the earth began; then the usual rumbling sound was heard.

William W. Worsely, Esq. of Lexington, (Ken.) on the 29th of February, reported the particulars at large, and published them in the newspapers.

Thomas Crawford, jun. of Louisville, (Ken.) published an account of the terrestrial commotions in very emphatical terms at Russelville, (Kentucky.)

Mr. Mathias M. Speed wrote to his friend, Thomas Speed, Esq. of Bardstown, an account of the earthquake of February 7, and the following days, in a communication dated March 3, 1812. He states the appearance of frequent lights during the commotions, and that from one of the low islands in the Mississippi, where he was, sand, coal, and warm water were ejected from holes in the earth.

Some of the coal was collected by Mr. Pierce, and transmitted to me. About the 1st of May, 1812, I made a few experiments upon it at the city of Washington. I found it to be very inflammable; it consumed with a bright and vivid blaze. A copious smoke was emitted from it, whose smell was not at all sulphureous, but btuminous in a high degree. Taken out of the fire in its ignited and burning state it did not immediately become extinct; but continued to burn until it was consumed. While blowed upon, instead of being deadened, it became brighter by the blast. The ashes formed during the combustion were of a whitish colour; and when put into water, imparted to it the quality of turning to a green the blue corolla of a phlox whose juice was subjected to its action. By this, and other tests, the alkalinity of the residue was fully acertained.

The Hon. Israel Pickens of Buncombe county, (N. C.) received a letter from the Rev. John Carrigan, dated 28th of February, and containing the following information:

"During my travels lately to and from the state of Georgia, I made it a part of my business to obtain the most accurate accounts of the present shaking of the earth, from all parts. I have found that in all parts of the continent the motion of the earth has been the same, and its partiality remarked in the same neighborhoods. In this country, the first rocking (as it is generally called) was perceived on the 23d of December, a little before daylight. Since that time it has

been observed almost every week through South Carolina and parts of Georgia. Several persons in those states have told me that they had felt it almost every day since. No damages have arisen, more than a few bricks shaken off some chimneys. There is no truth in the report in circulation respecting the fall of the Painted Rock, and other extraordinaries in Buncombe county. (note 2) I gave my friend, Colonel Freeman, (in Georgia,) a call, who informed me that he had particularly noticed some tall poplers in his lane during the time of the second shock, rocking with equable motion from northeast to southwest, which I have found to be general. On the 7th and 16th instant the shaking has been general here. I do not consider it an earthquake proceeding form the usual causes."

"Captain Robert Alexander, of Lincoln, (N. C.) gave me a most alarming account of a phenomenon which was generally seen on the night of the 20th instant. Three large extraordinary fires, in the air, one appeared in an easterly direction, one in the north, and one in the south. Their continuance was several hours; their size as large as a house on fire; the motion of the blaze quite visible, but no sparks appeared."

"Another phenomenon appeared on the 22d of November, of which I was a spectator. About 2 o'clock P. M. a meteor took fire in the air, attended with a fulminating noise, and bore a southeast direction; and however unaccountable, it is a fact, that about the same instant, a whitish substance, resembling a duck in size and shape, detached itself, and descended with a swift motion, from the cloud of smoke that was formed, and was beheld at my house, and fifteen miles due north of it, and twenty-three miles west of it, at the same instant."

"Whether these things are ominous or not, one thing is certain, this is a time of extraordinaries."

To these curious notices, I add the communication from New-Orleans, of William Shaler, Esq. dated March 23d, 1812.

"Dear Sir,"

"Knowing the interest you take in all natural events, I do myself the pleasure to communicate to you the following simple account of the late earthquake, as I received it from the patron of a Kentucky boat lately arrived here. On the 7th of last February, at 3 A. M., being moored to the bank of the Mississippi, about thirteen miles above New Madrid, he was awakened by a tremendous roaring noise, felt his vessel violently shaken, and observed the trees over the bank falling in every direction, and agitated like reeds on a windy day, and many sparks of fire emitted from the earth. He immediately cut his cable and put off into the middle of the river, where he soon found the current changed, and the boat hurried up, for about the space of a minute, with the velocity of the swiftest horse; he was obliged to hold his hand to his head to keep his hat on. On the current's running its natural course, which it did gradually, he continued to proceed down

the river, and at about daylight he came to a most terrific fall, which, he thinks, was at least six feet perpendicular, extending across the river, and about half a mile wide. (note 3) The whirls and ripplings of this rapid were such that the vessel was altogether unmanageable, and destruction seemed inevitable; some of the former he thinks were, at least, thirty feet deep, and seemed to be formed by the water's being violently sucked into some chasm in the river's bottom. He and his men were constantly employed in pumping and bailing, by which, and the aid of Providence, he says, he got safe through! As soon as he was able to look round, he observed whole forests on each bank fall prostrate, to use his own comparison, like soldiers grounding their arms at the word of command. On his arrival at New-Madrid he found that place a complete wreck, sunk about twelve feet below its level, and entirely deserted; its inhabitants, with those of the adjacent country, who had fled thre for refuge, were encamped in its neighbourhood: he represents their cries as truly distressing. A large barge loaded with five hundred barrels of flour, and other articles, was split from end to end, and turned upside down at the bank. Of nearly thirty loaded boats only this and one more escaped destruction; the water ran twelve feet perpendicular, and threw many of them a great many rods on shore; several lives were lost among the boatmen. Another fall was formed about eight miles below the town, similar to the one above, the roaring of which he could distinctly hear at New-Madrid. He waited five days for the fall to wear away; during that time the earth was constantly trembling, at intervals of about five minutes. He observed many fissures in the earth below the town, five or six feet wide, extending in length out of sight, and one side several feet lower than the other. On the fifth day he passed the lower fall which had worn away to a practicable rapid. He felt a succession of shocks of earthquake until he came down to Flam Island. He spoke of many physical changes in the river, particularly a great multiplication of sawyers, but he does not describe them with sufficient accuracy to enable me to give you an account of them."

"I have also seen several persons who passed New-Madrid on the 20th of February; they report that the earth still continues to tremble there, at that time. The falls had worn away to smooth rapids."

"With very great respect and esteem I am, Dear Sir, your very humble servant,"
"The Hon. Samuel L. Mitchill

W.SHALER."

The information contained in a description, forward to William Duane, Esq. by one of his correspondents at St. Genevieve, in Louisiana, shows the state of opinion in the mind of the sensible writer, there, about the 1st of April, 1812, on the subjects of the earthquakes at New-Madrid, and the surrounding region. This may be found on the pages of his Aurora.

A.B. Woodward, Esq. one of the judges of Michigan Territory, in his letter of the 7th of April, 1812, wrote thus, "We have had nine shocks of the earthquake here, of which I have an exact memorandum for eight, and have somehow entirely lost the time of the other. I felt four myself. I know only one person, a French lady, who felt the whole; speaking here of the eight." And in a letter dated June 23d, the same gentleman observes that "in a late journey to the *Riviere aux Tranches*, in Upper Canada, I found the number of shocks of the earthquake felt there, was exactly the same as here, that is, *nine*.

Dr. Robertson, the enterprising traveller to the sources of the Arkansaw River, by order of the government, in 1806, witnessed the phenomenona of these earthquakes, very particularly at St. Genevieve, where he resided during their occurrence. He travelled with me from Washington to Fredericktown, on the 3d of July, 1812, and parted with me at that place on the morning of the 4th, he journeying to the westward by the way of Hagerstown, and I proceeding southwestwardly to Harper's Ferry, and its vicinity. This gentleman, among other matters, declared to me, that the had kept a record or memorandum of the shocks of these earthquakes, until they exceeded *five hundred* , and then ceased to note them any more, because he became weary of the task.

The commotions, however, did not end here. They were renewed from time to time. My correspondent, Peter H. Cole, wrote me, in a letter dated at Clarksville, in Montgomery county, Tennessee, under date of December 15, 1812, as follows: "The earthquakes continue to visit us. We had a tolerably severe one on the morning of the 14th instant. The 16th instant will make one year since they commenced. They have destroyed a number of chimneys in this state, and terrified many of the inhabitants."

So, on the 24th of November, 1812, a shock was again felt in the morning, near Russelville, in Kentucky.

The same gentleman afterwards, in a communication from the same place, of January 26, 1813, furnished additional facts, "In the month of September," he stated, "I visited a spring of about the distance of fourteen miles from my residence. It was situated on the bank of a creek that issued forth strong sulphureous water. The smell was evident to a considerable distance. It received its sulphureous impregnation from a very heavy earthquake that occurred in January. Before that event it was a limestone water. On that occasion a new limestone spring broke out about twenty feet above the original spring; and to this day, the respective fountains pour forth their calcarious and sulphureous waters, in distinct currents. Some springs ceased to run for some time; and others ran muddy several hours after the earth had been convulsed. The earthquakes appeared to affect very sensibly both the body and mind of human beings. In some instances, where individuals had been deprived of their usual sleep, through fear of being ingulfed in the earth, their stomachs were troubled with nausea, and sometimes even vomiting. Others complained of debility, tremor,

and pain in the knees and legs. The shocks seemed to produce effects resembling those of electricity. We have had a very wet spring, summer, and autumn, with a loaded atmosphere; and I have no doubt much impregnated with sulphureous particles. Sickness was much more prevalent last winter, spring, summer, and fall, than ever was known in this country; and, no doubt, the state of the atmosphere was the principal cause."

Nor had those subterranean tumults ceased at the close of 1813. For two shocks were felt at Russelville, on the 5th of December, one at ten o'clock in the morning, and the other four in the afternoon.

They were repeated in the Illinois Territory about the same time. Stanley Griswold, Esq. gave an account of them in a short narrative of December 18th. This was printed in the gazettes of the time. They were particularly severe at the salt works belonging to the United States; and but moderate at a short distance off. In the 16th volume of the Medical Repository, P. 304, there are other sensible observations of the same ingenious gentleman.

And on the 29th of December Mr. Hempstead, the delegate in congress from the Missouri Territory, moved for the consideration of a proposition relative to an additional judge in that quarter. He said he has been instructed by the legislature of the territory to bring the measure forward. The settlement of Arkansas, for which the new judge was asked, was situated two hundred miles from New-Madrid, where the courts were then held, and since the late earthquakes, the road had become so nearly impassable, that a circuit of three hundred miles was required to go from one place to the other. So great a distance from the seat of justice, obviously amounted, in many cases, to a denial of the benefits of the judiciary, and called loudly upon the legislature for a remedy.

After this minute, reiterated, and, perhaps, tedious detail of facts, it will be rational to attempt some deductions. When I engaged the task of collecting the evidence on these curious and interesting phenomena, I was in expectation that physical occurrences so immediately before our eyes and under our feet, would have qualified me to form something like a tolerable theory of earthquakes. I must own, however, that after all the information I have collected, I have not been enabled to offer a solution, by any means satisfactory to myself. But, although materials may yet be wanting for a perfect theory, it is a matter of some consolation to have assembled into one body, the phenomena of the most memorable earthquakes that ever agitated these parts of North America, and to have made a record of them for my sagacious and fortunate successors.

1. The trembling of the earth was felt from the Atlantic Ocean to the regions far beyond the Mississippi. The accounts given by the Indians uniformly stated that the shocks had been very frequent and violent, to a great distance up the Arkansaw. They appear to have been felt very little to the north of the Potomac, and east of the Alleghany.

2. Though the commotions were of great extent, it was not possible to assign a priority to any place. Though the earthquakes were not equally violent or extensive, yet in those of the widest diffusion or circuit, there was no method of tracing a succession; on the contrary, the shocks in the most distant situations were synchronous, or nearly so.

3. Air was produced below, and extricated into the atmosphere.

4. This, when it passed through water, produced bubbles and froth, and after their extrication, formed visible vapour, obscuring the atmosphere.

5. Hot water was ejected with considerable force.

6. Coal or carbonated wood was thrown up in a similar manner, and about the same time.

7. Light, in some cases, was extricated, and from the circumstances of its appearance, may be considered, not as an accidental coincidence of the earthquake, but as a natural and necessary accompaniment. But, in most places, there was no luminous appearance.

8. Sounds were sometimes heard, but by no means uniformly or steadily. In very many cases there was no noise at all.

9. The gas (3. and 4.) the hot water (5.) and the coal (6.) lead conclusively to the existence of subterranean fire; and the light (7.) and sound (8.) induce the same belief. (note 4)

10. But, after all, it is not very evident what kindles the flame beneath; by what means it is supported by air, and kept from extinction by water; how deep it lies; how it convulses the superincumbent strata, and communicates its tremors instantaneously, for several hundred miles. Nor am I able to explain to my satisfaction, why a certain part of the bed of the Mississippi was its focus; nor why it happened during the winter season.

I console myself, however, that the history which I have written will give valuable information to the curious on these subjects, and assist some more happy inquirer into nature, to deduce a full and adequate theory of earthquakes.

Let me, nevertheless, before I lay down my pen, request the reader to consider this paper as a sequel to the history of the earthquakes in New-England, as has it been written by the learned and ingenious Samuel Williams, LL. D. and published in the transactions of the American Academy of Arts and Sciences at Boston.

Permit me also to observe, that contemporaneous earthquakes have agitated other regions of the globe. Terrible commotions were experienced among the

Azores in 1808 and 1811; and in Venezuela and St. Vincents in 1812. I have collected the facts into distinct histories, which I intend at convenient times to offer to this society.

The favourers of the several hypotheses invented to explain the awful phenomena of earthquakes, may all find arguments to support them, in the preceding recitals. The *mechanical* reasoner will find the great strat of the earth falling in some places, rising in others, and agitated everywhere. The *chemical* expositor will discover evidence enough of subterranean fire in the coal, hot water, vapour, and air bubbles which were ejected and extricated. The *electrical* philosopher will deduce from the lights, the noises, and the velocity of their motions, conclusions favourable to the origin of earthquakes from electron, that subtile and universal agent. Even the believer of the conversion of metallic potassium, by rapid inflammation, into common potash in the deep recesses of the earth, will find in the salt-petrous sandstone of the western states, a better argument than any I am acquainted with, to countenance the *alkaline* system of earthquakes. And yet, these various expositions, plausible, in some respects, as each of them is, are deficient in that general character and universal application which ought to pervade scientific researches.

Appendix B. Historical Structures

The following nine pages present photographs of structures that either pre-date the 1811-1812 New Madrid sequence, or provide examples of representative construction from that era. Where available, accounts of the earthquakes' effects are included.

Page 1. St. Charles, Missouri, and Smithson, Kentucky

Examples of brick houses that pre-date the 1811-1812 sequence in St. Charles, Missouri (left), and Smithson, Kentucky (right). Cracks in the house at left were caused by later moderate earthquakes in the region; there is no original account of damage in either St. Charles or Smithson.

Reference:

Kochkin, V.G. and J.H. Crandell, Survey of Historic Buildings Predating the 1811-1812 New Madrid Earthquakes and Magnitude Estimation Based on Structural Fragility, Seismological Research Letters, 75, 22-35, 2004.

Page 2. Cahokia, Illinois

Post-on-sill construction in Cahokia, Illinois: Holy Family church (top left) and Old Court House (top right and bottom left), house (bottom right). There are no records indicating that either of the above structures were damaged by the earthquake, and the church, which is next door to the Jarrot Mansion, which did sustain some damage, shows no evidence of damage/repair. The reconstructed Old Court House (bottom left) reveals the original construction style: mortise-and-tenon joints between posts and the wood sill were secured with wood pegs.

General account from Cahokia: “A great many houses have been badly damaged, but no one was killed. The earth opened in many places, especially about three miles from the monastery. Only sand and water came from the opening. Fortunately our poor cabins of wood and sand can withstand a great deal of shaking without much danger. Their undress logs piled one on top of another can be separated only by considerable force. Some stone and brick houses have had to be abandoned.” (see Appendix C)

McDermott, J.F., Old Cahokia, Found in: The St. Louis Historical Documents Foundation, St. Louis, Missouri, 316-320, 1949.

Page 3. Cahokia, Illinois: Jarrot Mansion

Jarrot, a fur trader and land speculator, built his house of hand-made brick (probably made by slave labor) strong enough to withstand several remodeling jobs, including one in the Parks ownership period. The 1811 earthquake at New Madrid, MO, cracked the back wall and broke two of the chimneys.

The hand-made bricks are of a Flemish bond pattern across the back and west sides of the house with almost-black banding (created by over-firing the bricks) and with haphazard brick courses on the other two sides. Logs were cut from groves nearby for the woodwork and floor boards, including pine plank flooring of the ballroom.

Exterior walls and interior partitions are 16 inches thick; the door frames, of walnut, are doweled and tenoned together with oak, pegs, and the windows are 12-paned throughout.

Reference: Flannery, Toni, Two Illinois houses, one restored, one in the raw, 1972. http://cusd187.stclair.k12.il.us/Tricentennial/Records/

St. Clair County court records corroborate the above account. A case for for Jarrot vs. Hicek (1813) contains an invoice dating from the approximately period of the earthquakes, which itemizes repair work on one of the chimneys. The date of other damage is more difficult to substantiate.

Reference: Restoration Inventory, Nicholas Jarrot House, Illinois Dept. of Conservation, Historic Sites Division, Springfield, Illinois, June 14, 1982

Page 4. Cahokia, Illinois (continued)

Historical Sketch (date unknown) showing Jarrot Mansion (towards left), Holy Family Church (middle), and houses that are no longer standing.

Page 5. Lincoln log cabins

Few if any traditional Lincoln log cabins dating back to the time of the earthquake sequence have survived. These structures were prone to rot. The earliest frontier cabins were also very modest structures ("starter homes") that were cannibalized and/or incorporated into later, larger structures. The small handful of surviving cabins from the early 19th century generally survived by virtue of having been cocooned inside later, larger structures.

Historical photographs (top left, top middle) reveal log cabins constructed circa 1840. The cabin in the right photograph, now cocooned in a barn, is probably older; the age of the structure is unknown but, as was typical for the earliest frontier cabins, the structure has only a single small door and no windows.

Few historical accounts of the New Madrid sequence describe damage to Lincoln log cabins other than damage to chimneys. An account of the 1/23/1812 mainshock by George Heinrich Crist in Nelson County in Kentucky, near present-day Louisville, states, "We lost our Amandy Jane in this one – a log fell on her." (This is one of the very few clear, specific accounts of a fatality during the sequence.) The details of damage are not clear from this account, but a later account from Crist states that people in Pigeon Roost (southern Indiana near present-day Henryville) "felt the ground move and shake but it did not destroy cabins and trees like it did in Kentucky." (See Appendix C)

Page 6. Fort des Chartres, Prairie du Rocher, Illinois

Fr. Benedict Roux described the effects of the earthquakes in Kaskaskia, Illinois. "In 1811, Kaskaskia underwent one of the most dreadful earthquakes ever felt by mortals - earth waves came several times this year - the steeple of the church bending like a reed, here and there stone and brick chimneys fell down, cattle themselves siezed with fear, were running to and fro. The earth cracked so deeply along one of the streets that they could never sound the bottom of this crevice. There must have been similar effects in Prairie du Rocher."

Second account:

Prairie du Rocher houses many historical buildings and artifacts — the most popular being Fort de Chartres. The fort was built in the mid-1700s and now boasts Illinois' oldest building, the Powder Magazine.

The New Madrid earthquakes of 1812 brought most of the fort to the ground. But the Powder Magazine survived, apparently by virtue of its arch-shaped roof.

Photo above: historical sketch (date unknown) of ruined fort and powder magazine.

Reference: Historical sketch is from the Fort de Chartres museum. The account of damage is local lore; the original source is unknown.

Page 7. Reelfoot Lake, Tennessee

Reelfoot lake, widely believed to have been created by vertical motion on the Reelfoot fault during the 2/7/1812 mainshock and possibly the 12/16/1811 dawn aftershock. The fault runs along the southwest edge of the lake. Photo shows Bald Cypress trees, which grow in swampy conditions but cannot germinate under water. Submerged trees along the western and southern edges of Reelfoot Lake are thus inferred to have been submerged during the 1811-1812 sequence.

Account: The site of this town [New Madrid] was evidently settled down at least fifteen feet, and not more than a half a mile below the town there does not appear to be any alteration on the bank of the river, but back from the river a small distance, the numerous large ponds or lakes, as they are called, which covered a great part of the country were nearly dried up. The beds of some of them are elevated above their former banks several feet, producing an alteration of ten, fifteen to twenty feet, from their original state. And lately it has been discovered that a lake was formed on the opposite side of the Mississippi, in the Indian country, upwards of one hundred miles in length, and from one to six miles in width, of the depth of ten to fifty feet. It has communication with the river at both ends, and it is conjectured that it will not be many years before the principal part, if not the whole of the Mississippi, will pass that way.

Reference:

Eliza Bryan, published in “Lorenzo Dow’s Journal,” published by Joshua Martin, printed by John B. Wolff, pp 344-346, 1849.

Page 8. Sainte Genevieve, Missouri

Structures in Ste. Genevieve, Missouri, all predating 1811-1812 New Madrid sequence. Top left: The Old Brick House is the first brick house built west of the Mississippi River (Mr. Potato Head postdates 1811-1812); top right, masonry house; bottom, post-on-sill construction.

Account:

Immediately following the Great Comet, on December of that year 1811, shocks of earthquakes, which had created such remarkable convulsions of nature at New Madrid and its neighborhood, were sensibly felt at St. Genevieve, though no material damage was done by them.

Reference: Rozier, F.A., Rozier's *History of the Early Settlement of the Mississippi Valley*, G.A. pierrot and Son, St. Louis, 1890.

Page 9. Sainte Genevieve, Missouri (continued)

Ste. Genevieve, Missouri (continued): early wood frame house (top left), early stone house (top right), traditional Lincoln log cabin cocooned in later structure (bottom.) The top two houses predate the 1811-1812 earthquakes.