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PREFACE

Volume XIII of the South Carolina Seismic Network (SCSN) Bulletin describes the seismicity in the state in 2003. The largest event with a magnitude M_L 3.1 occurred on May 5, 2003 near Summerville. Seismicity continued at a low level near Monticello Reservoir where 12 events were located (Table 4). Seismicity was recorded in the Middleton Place Summerville Seismic Zone (MPSSZ) where a total of 23 events were located (Table 2). Three events were located near Columbia (Table 3) and two of them were felt. The seismic network near Lakes Jocassee and Keowee was intermittently operational during the first half of 2003 and was permanently disconnected as of May 22, 2003. No events recorded from that region during 2003.

The South Carolina Seismic Network website lists historical and instrumental seismicity in South Carolina and details of the location of the current seismicity. The website address is http://scsn.seis.sc.edu.

In 2003, the SCSN continued routine digital recording of seismicity in the state. The data from Coastal Plain stations surrounding MPSSZ are recorded in an event triggered format at Charleston Southern University (CSU) near Summerville, and accessed via the Internet from the University of South Carolina (USC), where other digital data are recorded.

Successful operation of the SCSN is due in part to the support from the U.S. Geological Survey and Westinghouse Savannah River Company. This bulletin is the result of the efforts of the staff and students at USC.

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I. INTRODUCTION

Volume XIII of the South Carolina Seismic Network (SCSN) Bulletin covers the period from January to December, 2003. This issue presents the details concerning the observed seismicity and network operation in the state during 2003.

We observed an higher level of seismicity in the Middleton Place Summerville Seismic Zone (MPSSZ) during the year compared to 2002. Twenty-three earthquakes were located in 2003 compared to seventeen earthquakes in 2002. The largest event during 2003 was a M_L 3.1 that occurred on May 5, 2003. Among the earthquakes located in 2003, 13 were of $M_L \geq 2.0$, and 2 events were of $M_L \geq 3.0$.

Seismicity at Monticello Reservoir was significantly lower in 2003 compared to over one-hundred events in 2002 and five events with $1.5 < M_L \leq 2.3$ (12 events were located near the reservoir area, with the largest magnitude a M_L 1.1). Seismicity near Lakes Jocassee and Keowee was not recorded in 2003 due to in-operational status of the network during the first half of 2003 and then permanent disconnection of the network on May 22, 2003.

Three events with magnitudes from M_L 1.4 to 1.5 were located in areas outside the MPSSZ, and Monticello Reservoir. These events were located near Columbia and two of them were associated with felt reports.

In 1987 the SCSN began digital recording of seismicity in the state, but only for the stations telemetered to USC. The digitizing of data from Coastal Plain stations surrounding MPSSZ started in 1995 and are recorded in an event triggered format at Charleston Southern University (CSU) near Summerville, and accessed via the Internet from the University of South Carolina (USC), where other digital data are recorded in triggered mode and continuously.

The bulletin is arranged in four sections. The next section deals with the network operations, current methods of data acquisition, retrieval and processing. An analysis of the

seismicity of the state in 2003 is presented in the third section. Future plans of the SCSN, (http://scsn.seis.sc.edu), are presented in the last section.

II. SOUTH CAROLINA SEISMIC NETWORK OPERATION - 2003

II.1. Station Locations

In 2003, the SCSN consisted of sixteen stations. These included three stations in the "main net", eight stations in the Coastal Plain network and five stations in the Monticello Reservoir sub-network. The present configuration of the seismic network is shown in Figure 1. The stations of the "main" SCSN (JSC, LHS) cover the area in the lower Piedmont and (COW) covers the upper Coastal Plain. Data from these stations are telemetered and recorded at the USC. The Coastal Plain Seismic Network consists of three bore-hole stations, CSB, RGR, and HBF, and six surface stations, CSU, DRC, MGS, SVS, TWB and WAS. These cover the meizoseismal area of the 1886 Charleston earthquake (Figure 2). Data from these stations are telemetered and recorded at Charleston Southern University and also transmitted to USC.

The configuration of stations in the vicinity of Monticello Reservoir area is shown in Figure 3. Data from the five station Monticello Reservoir sub-network (Figure 3) are telemetered and recorded at the USC Seismic Laboratory in Columbia.

II.2. Recording Facilities

Digital data are recorded continuously at USC on PC-based system at 50 samples/second. To facilitate easier storage of the continuous data being recorded at USC, a DAT tape drive was installed on our PCSUDS analysis workstation. This tape drive can store approximately 2 gigabytes of data on a single tape. Accumulating data at the rate of 288 Mb per day, the new tape drive has given us the ability to mass dump data each morning from hard disk to tape. A backlog of 60 days data is maintained at the present time.

At USC data are also recorded on two Helicorders. Of these, one is used to record data from stations in the Coastal Plain, and one is dedicated to data from the induced seismicity sub-network. Data from the Coastal Plain stations are recorded on the three Helicorders at CSU.

In October of 1998, the USGS initiated a new phase of cooperative seismic monitoring. The recording operations of both the Charleston Southern University and USC facilities were augmented with the installation of "Earthworm". Earthworm is a PC-based, event triggered and short term continuous data recording system that utilized the Internet for data transfer and sharing. This allows data from the SCSN to be shared with networks at CERI (Memphis) and the USGS in Golden, Colorado as part of the Advanced National Seismic System (ANSS) for the Central and Southeast US region. It also gives the main data analysis group at USC the ability to import data from stations throughout the southeast, thereby enhancing our event detection and location capabilities.

II.3. Operational Status

Yearly operational status of the stations of the main SCSN in 2003 is shown in Figure 5. Most of the stations were completely operational throughout the year. The downtime ranges from 0% to ~11%.

The yearly operational status of the sub-net at Monticello Reservoir is shown in Figure 6. The Monticello sub-net's downtime ranges from 0% to 5% in general with the exception of Station MR05 which was inoperational in 2003.

II.4. Data Analyses

Data are analyzed at the USC's seismological laboratory. Identification of blasting activity, documentation of regional and teleseismic events, location and analyses of local earthquakes form a part of the routine analyses. The present configuration of triggering operators consists of six separate triggering parameters encompassing the several sub-

networks and the main network and some combinations. This increased triggering capability has allowed for the recording and locating of events of $M_L \leq 1.0$. Examples of the system digital playbacks are shown in Figures 7a to 7c. These include the M_L 3.1 event in MPSSZ on May 5, 2003 (Figure 7a), the M_L 1.2 Monticello Reservoir event on June 21, 2003 (Figure 7b), and the M_D 3.9 Georgia event on March 18, 2003 (Figure 7c).

The ability to store data on 8 mm digital tapes is an added advantage of using a digital recording system. The data are processed using the Seismic Analyses Code (SAC program on the Sun workstations. Hypocentral locations are obtained using HYPO71 and HYPOELLIPSE programs with an appropriate velocity model for each region. Format of the HYPO71 output is given in Table 1. Event magnitudes are determined using the following relation:

$$M_L = -1.83 + 2.04 \log D$$

where D is the signal duration in seconds.

The results of seismic monitoring in the state during 2003 is presented in the next section.

III. SOUTH CAROLINA SEISMICITY: 2003

Seismic activity continued in the MPSSZ (23 located events) and Monticello Reservoir (12 events) (Figures 2 and 3). Seismicity in the different regions (Figure 8) is discussed below, first tectonic seismicity is presented (Sections III.1 and III.2) and then the induced seismicity (Section III.3).

III.1. Middleton Place Summerville Seismic Zone

The MPSSZ continued to be the most active (non reservoir induced) seismic source zone in the Coastal Plain in 2003 (Figures 2 and 9). Seismic activity was higher in MPSSZ

during 2003 compared to that in 2002 when 17 events were located. Twenty three events were located during 2003 with magnitudes ranging between M_L = 0.9 and M_L = 3.1 at depths shallower than 12 km (Table 2, Figure 2). Most of the seismicity was located in a cluster in MPSSZ with the exception of three events which were located about 5 – 10 miles west, north, and southeast of the cluster respectively (Figure 2). Based on the locations of these events, there is a likelihood of them being associated with the northern and southern legs of the ~N15°E trending Woodstock fault. Temporally, the seismicity was distributed throughout the year (Figure 10).

III.2. Other Tectonic Activity

Three events of M_L 1.4 – 1.5 were located outside the MPSSZ, and Monticello Reservoir in 2003 (Table 3, Figure 4). These events were located near Columbia and two of them were felt.

III.3. Reservoir Induced Seismicity

III.3.1. Monticello Reservoir

The seismic activity near Monticello Reservoir reduced drastically during 2003 compared to that in 2002. Twelve earthquakes were located near Monticello Reservoir area during 2003 (Table 4, Figure 3) compared to 115 earthquakes in 2002. All of the earthquakes in 2003 had a $M_L < 1.2$. Except for two events, which had depths of ~3.5 and 7.9 km, all depths were shallower than 3 km. The monthly distribution of the earthquakes around Monticello Reservoir is given in Figure 11.

III.3.2. Lakes Jocassee, Keowee, and Bad Creek

The local seismic network at lakes Jocassee and Keowee was inoperational during the first half of 2003. It was permanently disconnected on May 22, 2003. Hence no local event was recorded from the region in 2003.

IV. RECORDING FACILITIES AND DIGITAL UPGRADE AT THE SCSN

The location of stations of the SCSN in 2003 are shown in Figure 1. Data from stations of the Monticello Reservoir network are now telemetered to the USC via dedicated phone line after the loss of the Parr radio tower in early 2002 (Figure 12). Data from the stations in the MPSSZ are telemetered and recorded at CSU (Figure 13). We continue to record analog data on two Helicorders at USC. The instrument acquisition and deployment history is given in earlier bulletins of the SCSN. Analog data are recorded on three Helicorders at CSU.

IV.1. Future Plans

We hope to bring the bore hole stations at TWB online in 2004.

V. SCSN Web Page

We have established a SCSN Web Page. It can be accessed at http://scsn.seis.sc.edu. The historical and instrumental data are displayed on the web site. We also maintain an updated list, and locations of current seismicity.

TABLE 1

HYPO71/HYPOELLIPSE FORMAT

Column	1	Date
Column	2	Origin time (UTC) h.m.sec.
Column	3	Latitude (N) degrees, min.
Column	4	Longitude (W) degrees, min.
Column	5	Depth (km)
Column	6	Local duration magnitude.
Column	7	No. of station readings used to locate event. P and S arrivals from same stations are regarded as 2 readings.
Column	8	Largest azimuthal separation in degrees between stations.
Column	9	Epicentral distance in km to nearest station.
Column	10	Root mean square error of time residuals in sec. RMS = Ri2/No, where Ri is the time residual for the ith station.
Column	11	Standard error of the epicenter in km*.
Column	12	Standard error of the focal depth in km*
Column	13	Quality of the epicentral location.

* Statistical interpretation of standard errors involves assumptions which may not be met in earthquake locations. Therefore standard errors may not represent actual error limits.

Note: If ERH or ERZ is blank, this means that it cannot be computed, because of insufficient data.

Table 2

Locations of events in the MPSSZ during 2003

DATE	ORIGIN	LAT N	LONG W	DEPTH	MAG	NO	GAP	DMIN	RMS	ERH	ERZ	Q
20030201	06 49 11.13	32-55.88	80-09.26	5.51	2.1	12	117	4	0.06	0.3	0.7	A
20030226	09 42 39.34	32-56.15	80-09.41	7.92	2.1	12	122	4	0.06	0.4	0.6	A
20030228	07 02 36.52	32-55.90	80-09.01	4.33	2.6	12	117	4	0.03	0.3	0.6	A
20030302	17 18 26.49	32-55.87	80-09.90	6.53	2.9	14	093	4	0.08	0.3	0.5	A
20030315	09 02 24.44	32-55.07	80-09.61	5.76	0.9	10	104	3	0.09	0.3	0.5	A
20030315	15 56 48.91	32-56.21	80-08.24	5.43	2.3	12	136	4	0.04	0.3	0.7	A
20030315	16 24 54.73	32-56.31	80-08.26	5.33	1.9	12	134	5	0.07	0.3	0.7	A
20030430	03 54 24.77	32-54.55	80-09.72	6.58	1.6	10	120	2	0.07	0.6	0.5	A
20030505	10 53 49.87	33-03.31	80-11.38	11.40	3.1	10	123	10	0.07	0.3	0.7	A
20030612	23 33 17.27	32-58.35	80-13.67	10.24	2.6	16	140	2	0.05	0.3	0.5	A
20030719	14 22 21.31	32-55.42	80-08.22	5.70	2.5	12	146	3	0.04	0.7	0.7	A
20030924	10 31 29.88	32-53.86	80-08.89	4.89	1.0	9	155	1	0.07	0.5	0.4	A
20031012	09 07 43.49	32-49.31	80-05.30	11.90	2.9	10	274	10	0.37	1.7	1.7	B
20031014	10 45 38.62	32-56.75	80-10.59	7.22	2.5	14	135	5	0.09	0.3	0.6	A
20031020	05 59 32.01	32-55.51	80-09.46	7.01	1.4	10	102	3	0.05	0.6	0.6	A
20031022	23 36 27.90	32-58.99	80-09.93	7.49	2.4	13	078	8	0.07	0.3	0.7	A
20031028	16 42 43.51	32-55.60	80-10.17	7.39	1.7	10	149	3	0.05	0.8	0.6	A
20031118	06 49 13.75	32-52.40	80-09.77	3.39	1.1	8	217	3	0.05	0.5	0.7	A
20031201	09 18 19.62	32-56.35	80-08.36	8.44	2.2	8	175	5	0.04	0.9	0.7	A
20031202	21 21 31.11	32-55.66	80-08.96	5.40	1.4	10	118	3	0.05	0.6	0.9	A
20031222	07 32 12.52	32-55.72	80-09.73	10.16	1.8	8	181	4	0.05	1.0	0.6	A
20031222	23 50 26.04	32-55.44	80-09.44	5.60	3.0	14	103	3	0.07	0.3	0.6	A
20031222	23 53 59.94	32-54.26	80-09.06	6.71	1.5	12	113	1	0.08	0.6	0.4	A

Table 3

Locations of events outside MPSSZ, and Monticello Reservoir during 2003

DATE	ORIGIN	LAT N	LONG W	DEPTH	MAG	NO	GAP	DMIN	RMS	SEH	SEZ	Q
20030404	23 01 46.59	33-59.17	81-01.91	0.46	1.4	17	165	6	0.07	0.3	1.4	B
20030508	11 33 05.99	33-59.31	81-03.15	0.89	1.5	10	355	28	0.07	4.2	99	D
20031211	20 00 52.16	33-59.80	81-02.77	1.11	1.5	10	354	28	0.07	5.4	99	D

Table 4

Locations of events at Motnicello Reservoir during 2003

DATE	ORIGIN	LAT N	LONG W	DEPTH	MAG	NO	GAP	DMIN	RMS	ERH	ERZ	Q
20030114	04 27 49.42	34-18.06	81-19.31	3.43	0.8	10	195	4	0.06	0.7	1.0	A
20030115	04 49 16.09	34-20.87	81-20.87	0.83	0.8	10	248	1	0.06	0.8	0.8	A
20030120	14 36 16.70	34-20.18	81-19.65	1.34	0.7	8	136	1	0.04	0.4	0.7	A

20030617	10 49 22.21	34-19.70	81-18.49	1.49	0.9	8	149	1	0.03	0.7	0.8	A
20030621	23 40 06.85	34-20.80	81-19.36	0.90	1.2	10	128	2	0.04	0.3	0.8	A
20030622	23 09 56.92	34-20.51	81-20.78	0.62	0.9	8	260	1	0.01	0.7	0.6	A
20030827	05 10 23.93	34-20.36	81-09.85	7.89	0.2	6	294	11	0.45	5.5	7.6	D
20030926	23 35 58.71	34-20.57	81-20.55	1.31	0.7	8	318	1	0.06	0.6	0.6	A
20030927	15 03 58.12	34-20.25	81-20.58	0.89	0.9	8	311	1	0.06	0.6	0.5	A
20030930	08 34 49.03	34-20.44	81-20.62	1.03	0.3	8	315	1	0.06	0.6	0.5	A
20031125	18 53 52.80	34-21.43	81-20.46	0.64	0.0	7	230	2	0.04	1.1	1.5	B
20031218	05 51 31.96	34-20.57	81-19.18	0.69	0.7	9	127	2	0.03	0.4	0.7	A

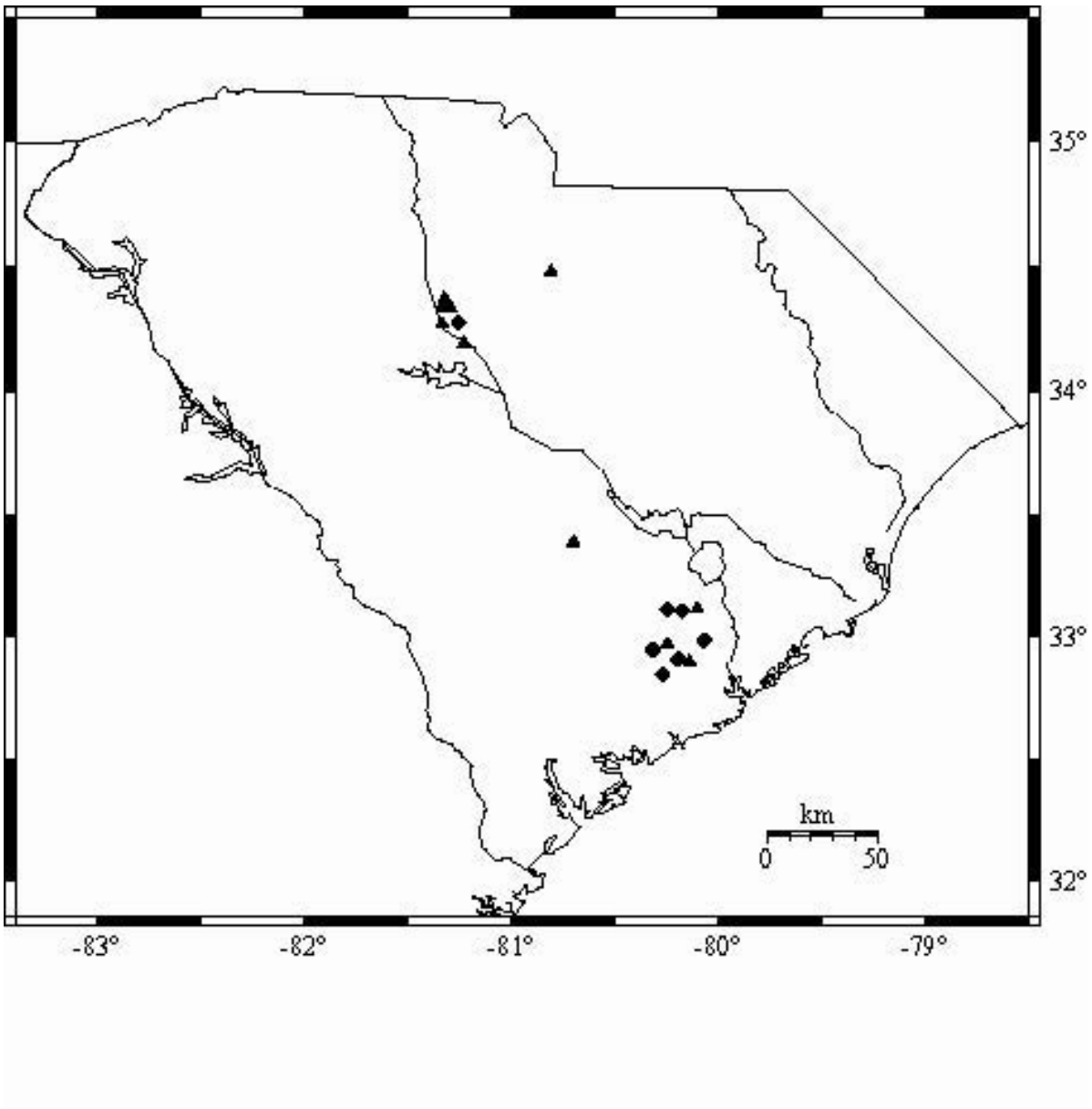

Figure 1: Distribution of stations/subnets of the South Carolina Seismic Network during 2003. Triangles (▲) represent single component stations while diamonds (♦) represent three component stations.

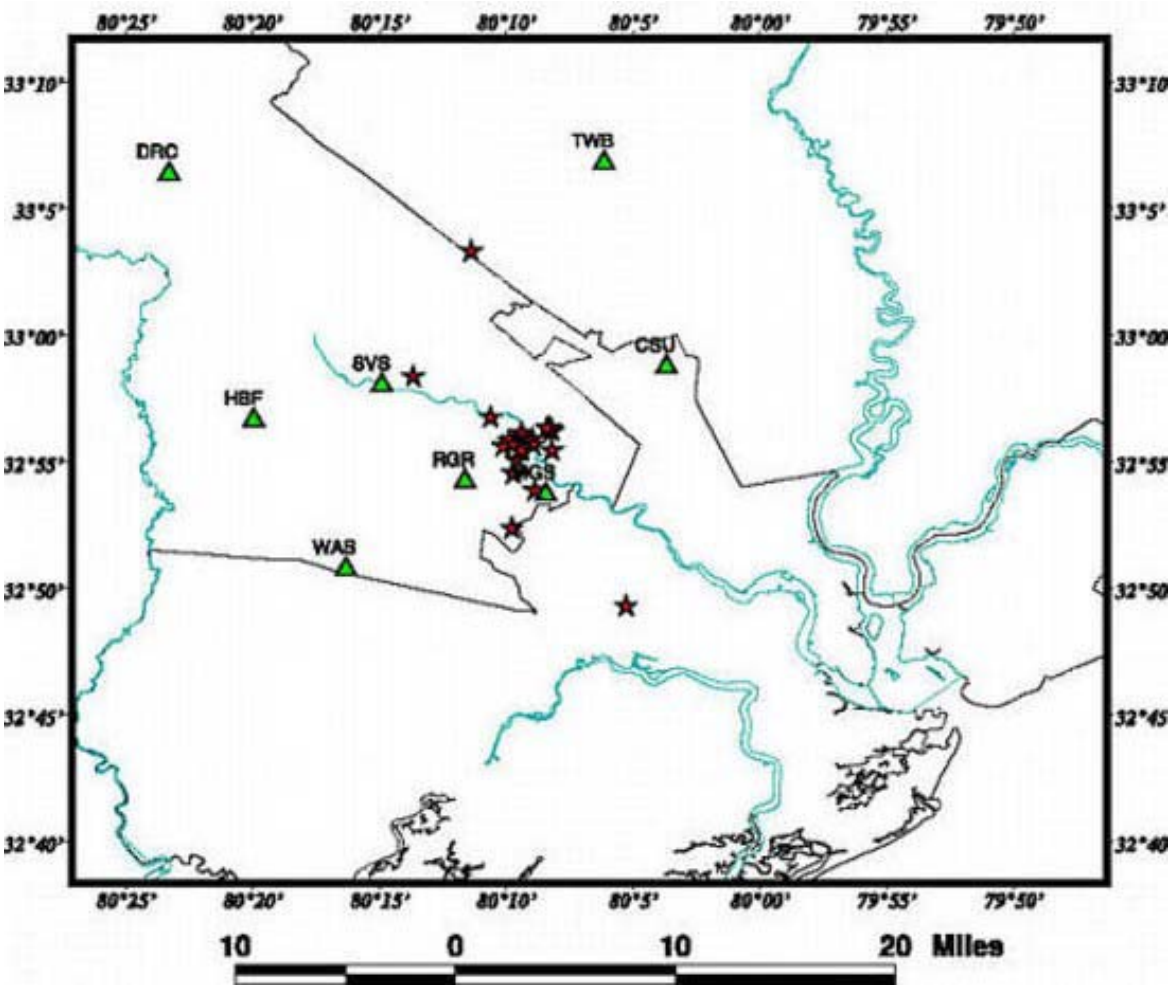

Figure 2: All earthquakes located in the MPSSZ during 2003 (*). Solid green triangles (▲) show the locations of the SCSN stations in the MPSSZ.

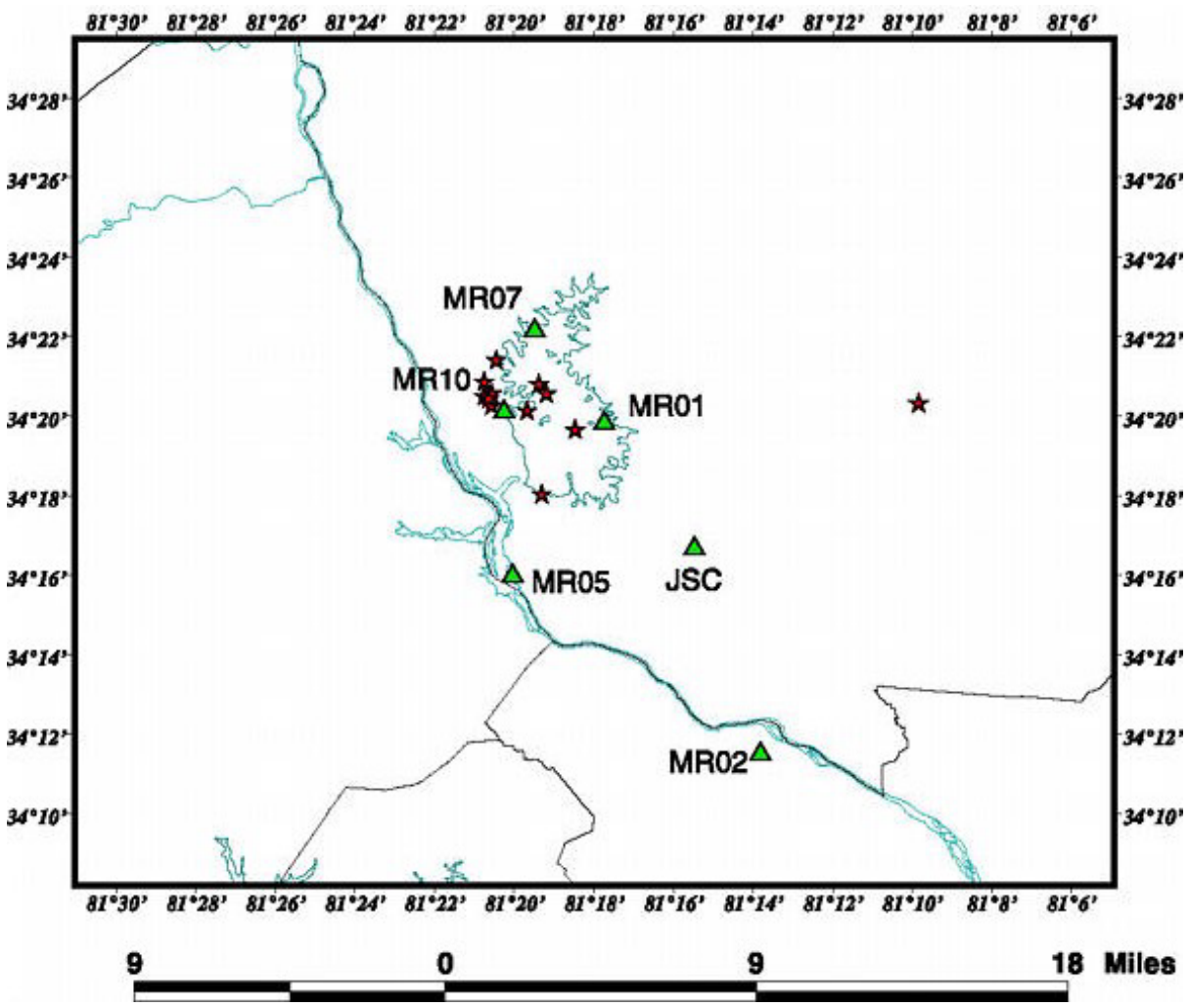

Figure 3: All events located near the Monticello reservoir during 2003 (*). Solid green triangles (▲) show station locations of the Monticello Reservoir subnetwork.

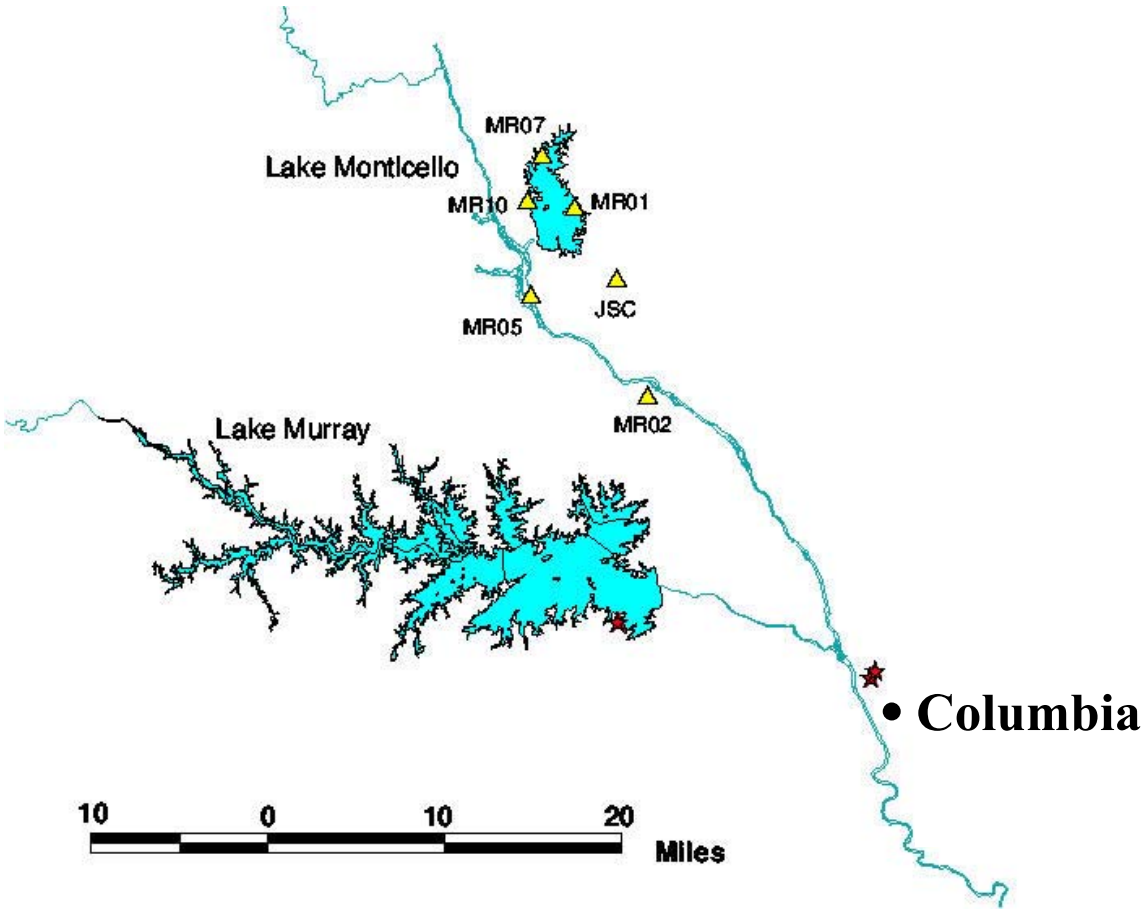

Figure 4: All events located outside of MPSSZ and Monticello Reservoir during 2003 (*). Station locations of the Monticello Reservoir sub-network (▲).

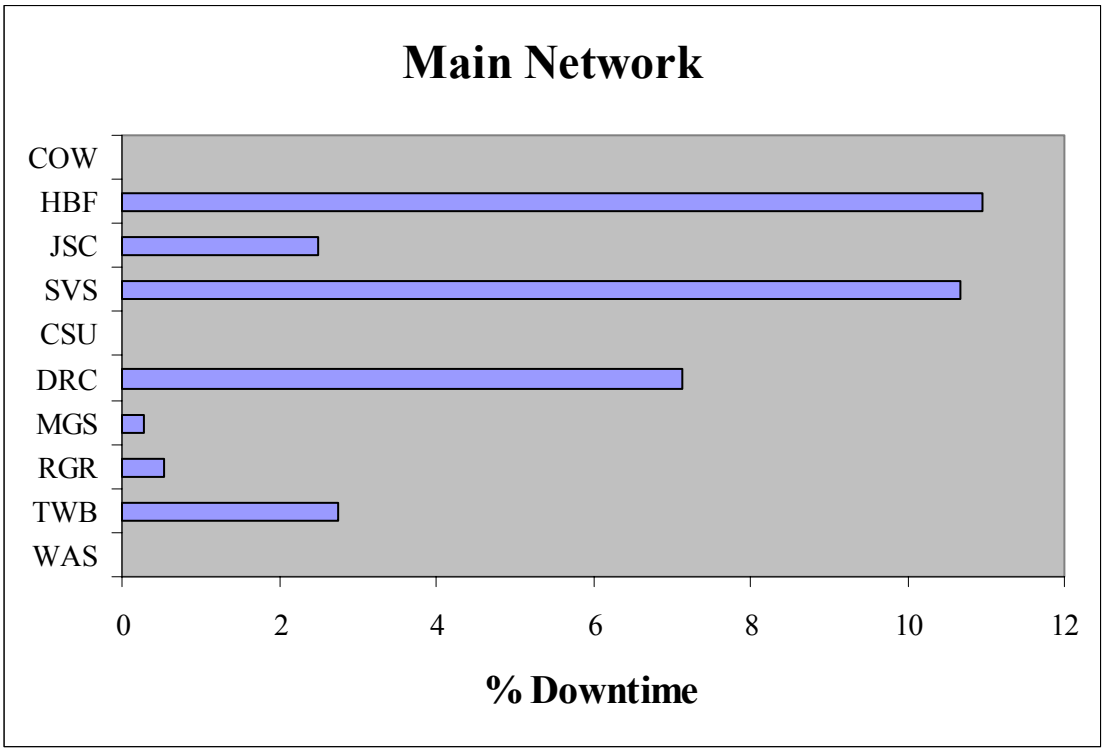

Figure 5: Operational status of the main network of the SCSN during 2003.

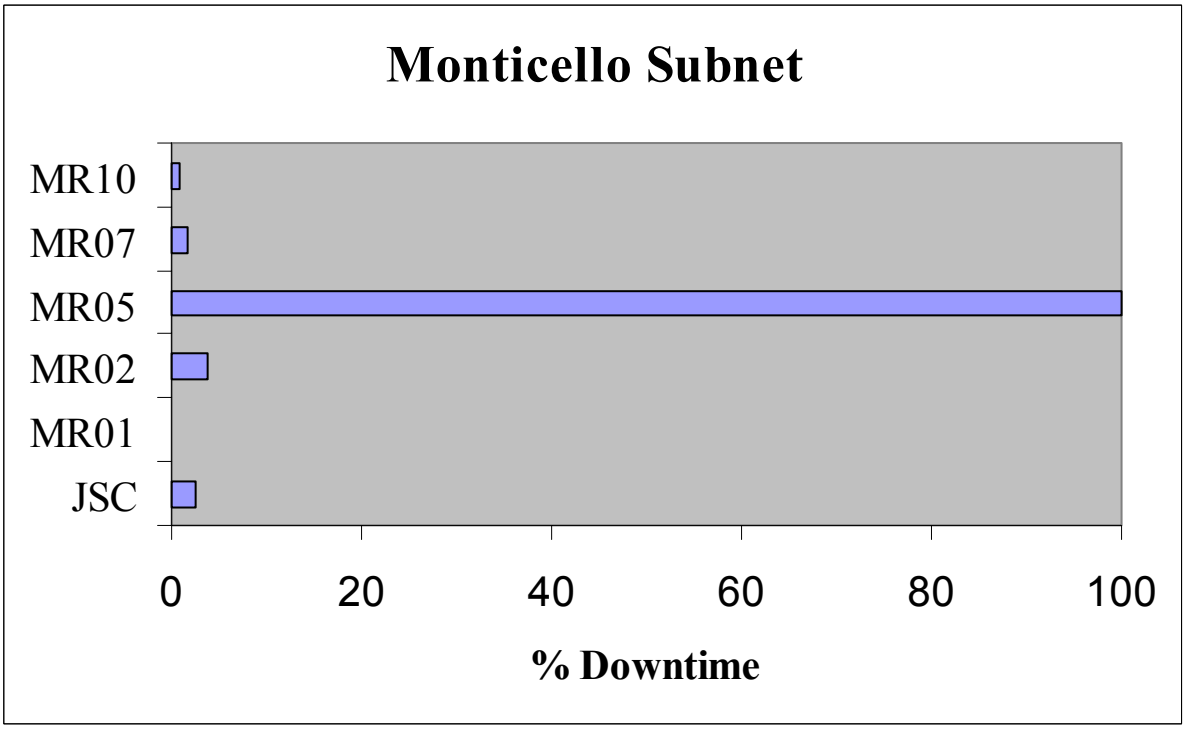

Figure 6: Yearly operational status of the Monticello Reservoir subnetwork during 2003.

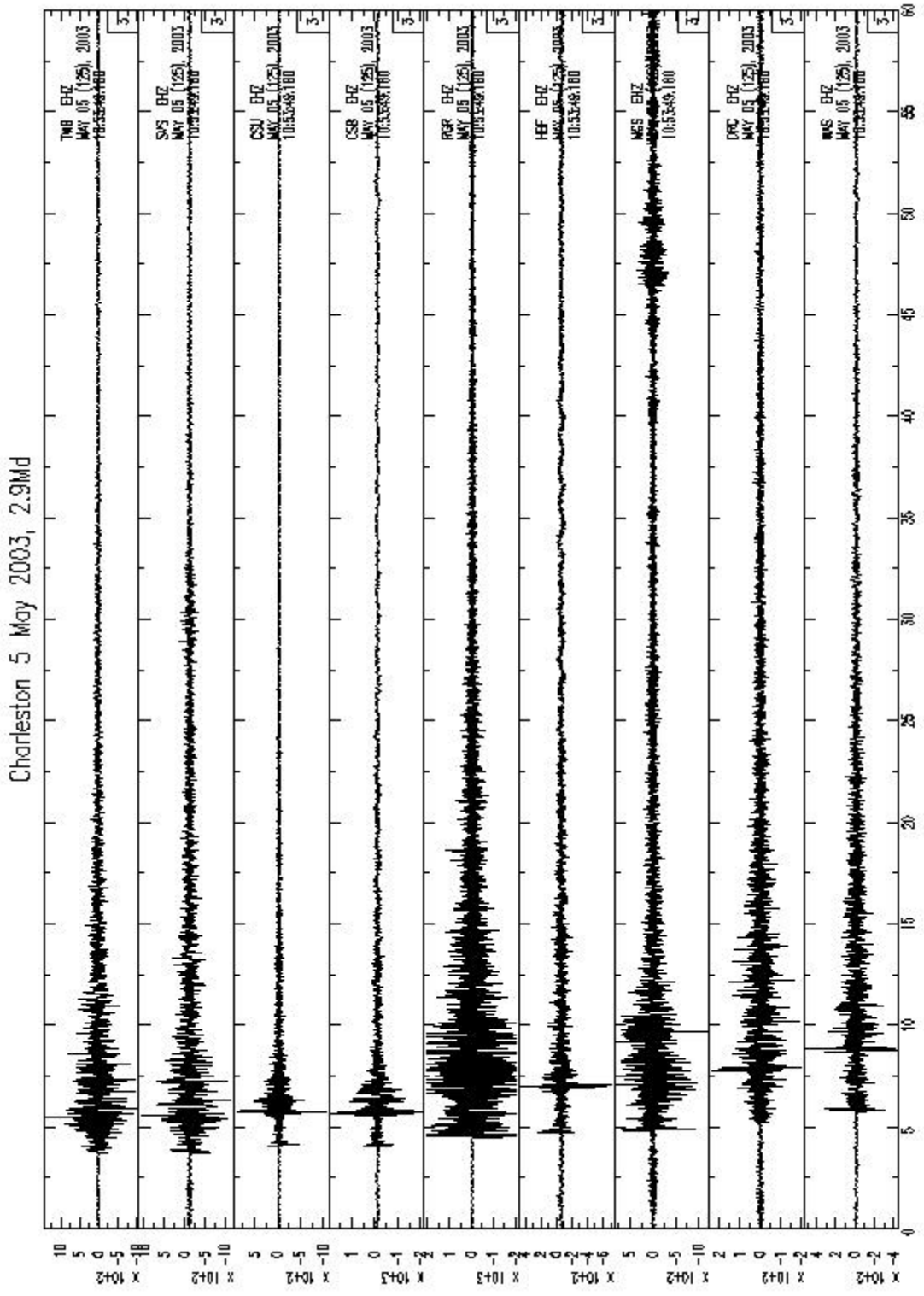

Figure 7a: Digital playback of M_L 3.1 event in MPSSZ on May 5, 2003.

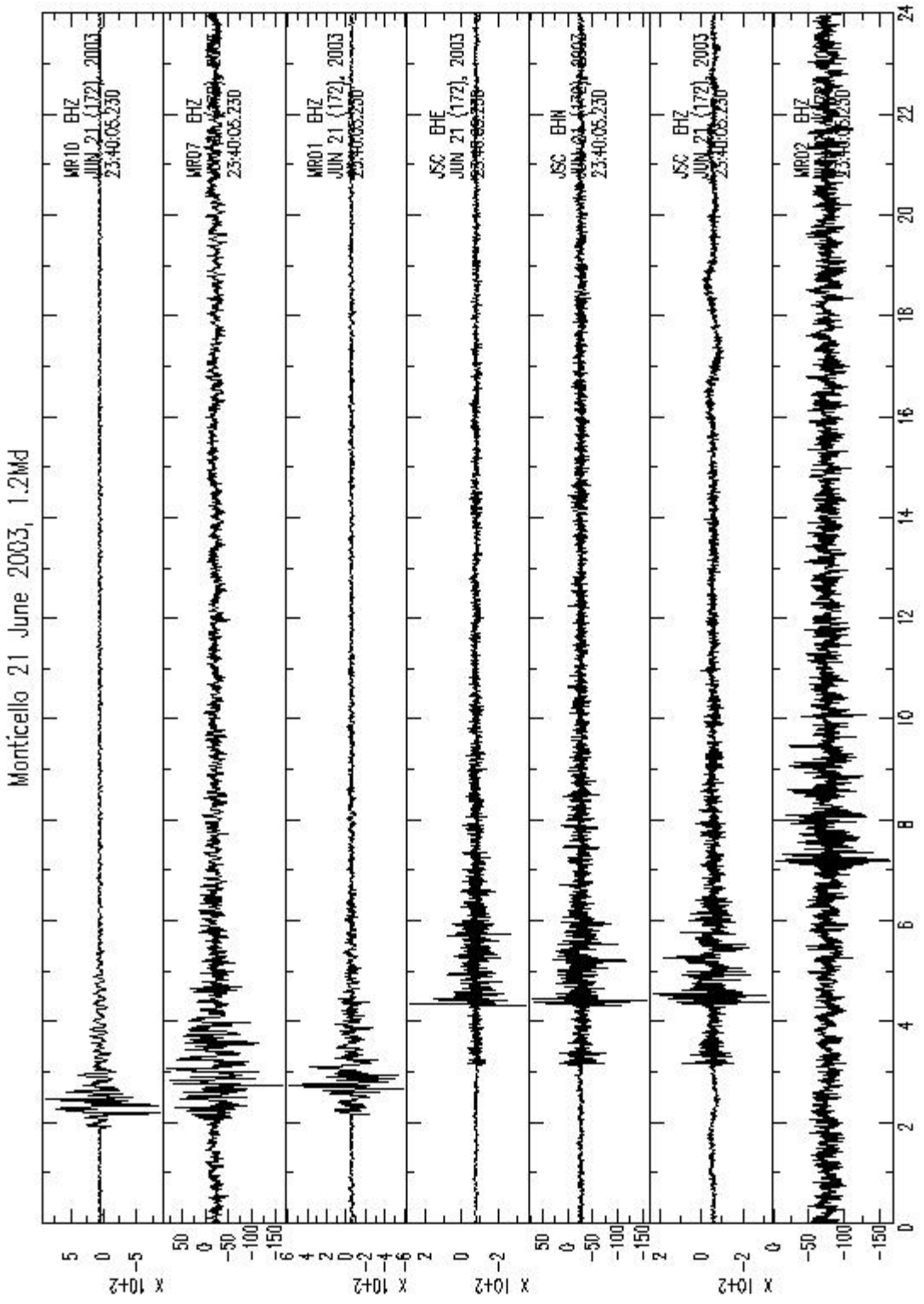

Figure 7b: Digital playback of M_L 1.2 Monticello Reservoir earthquake on June 21, 2003.

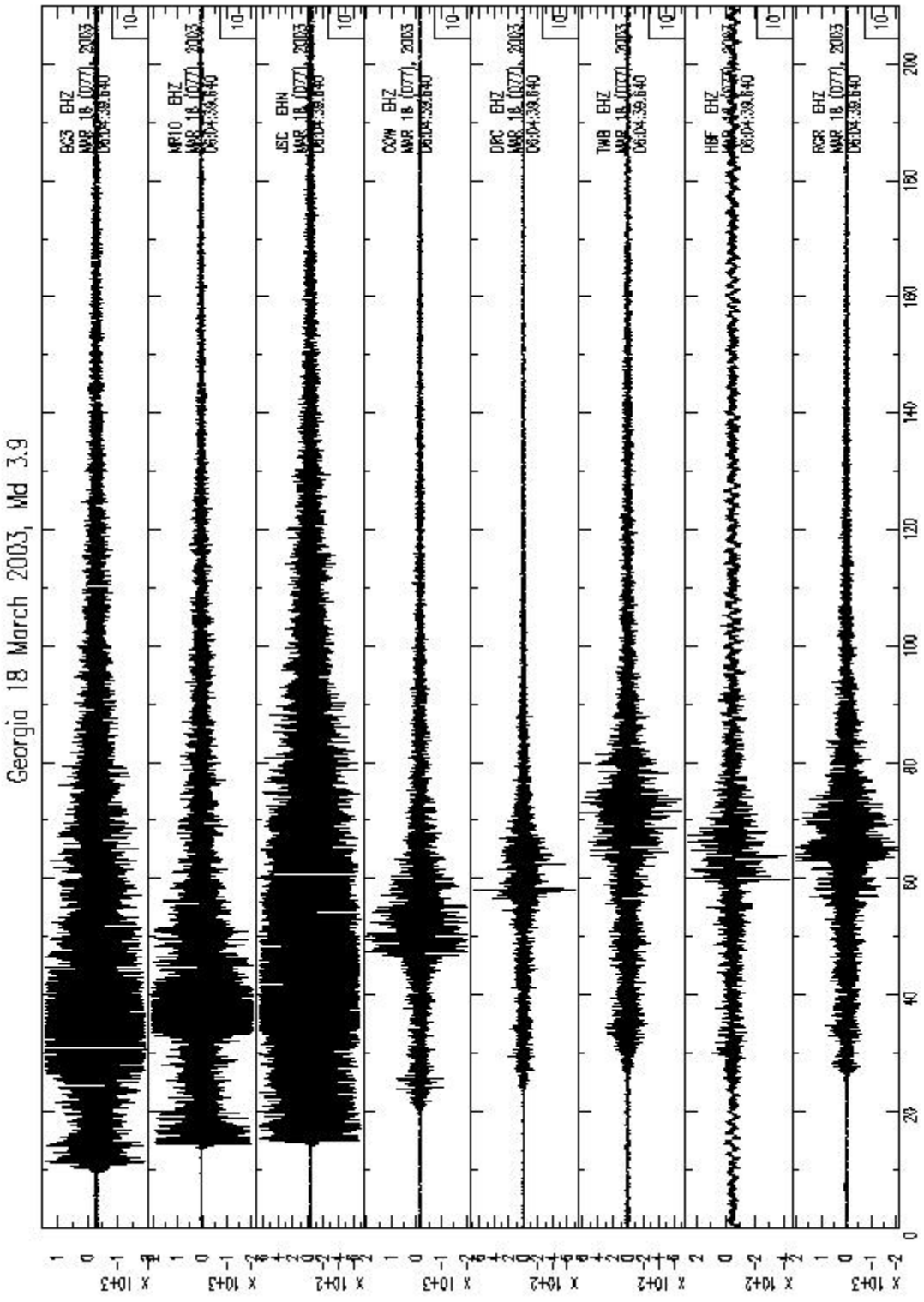

Figure 7c: Digital playback of M_D 3.9 event in Georgia state on March 18, 2003.

Earthquakes in South Carolina in 2003

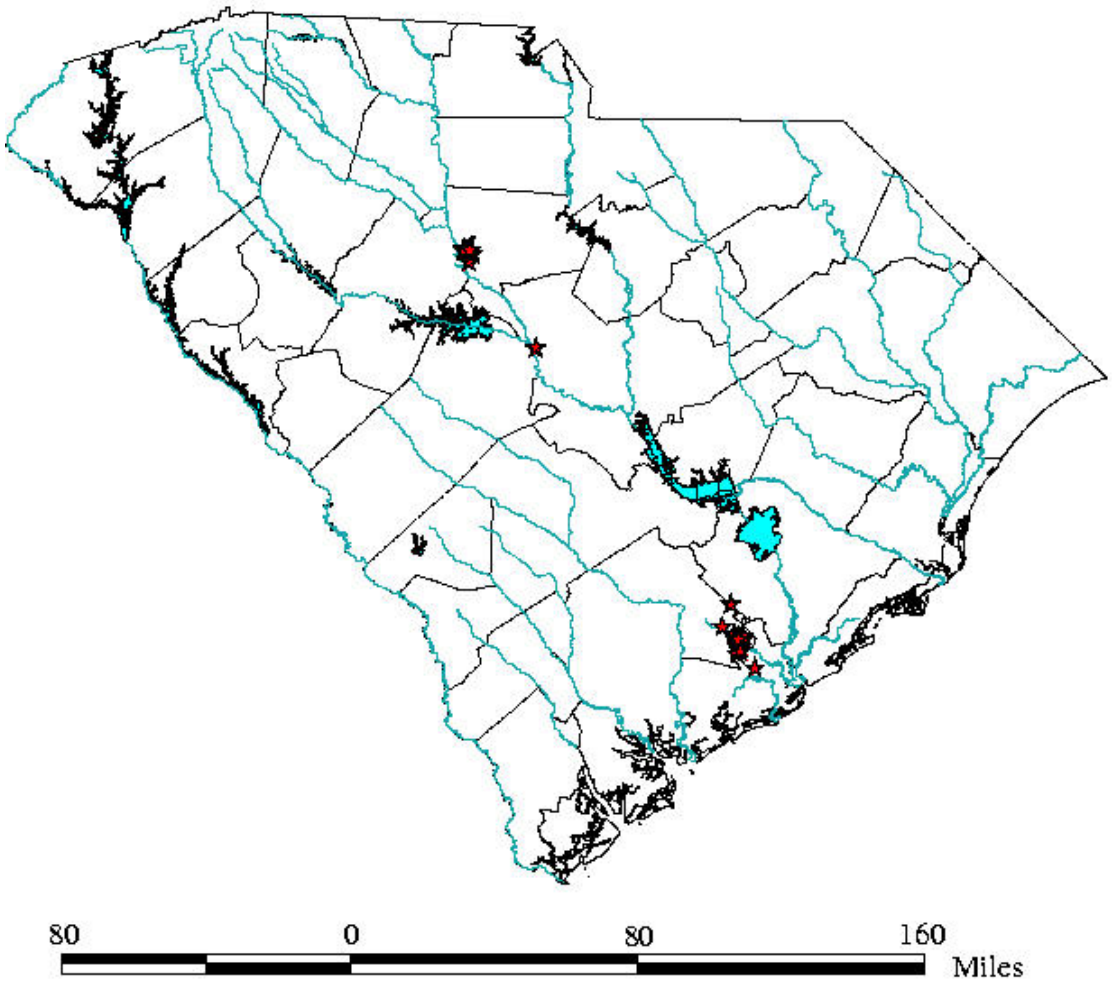

Figure 8: Cumulative seismicity in South Carolina during 2003 (*).

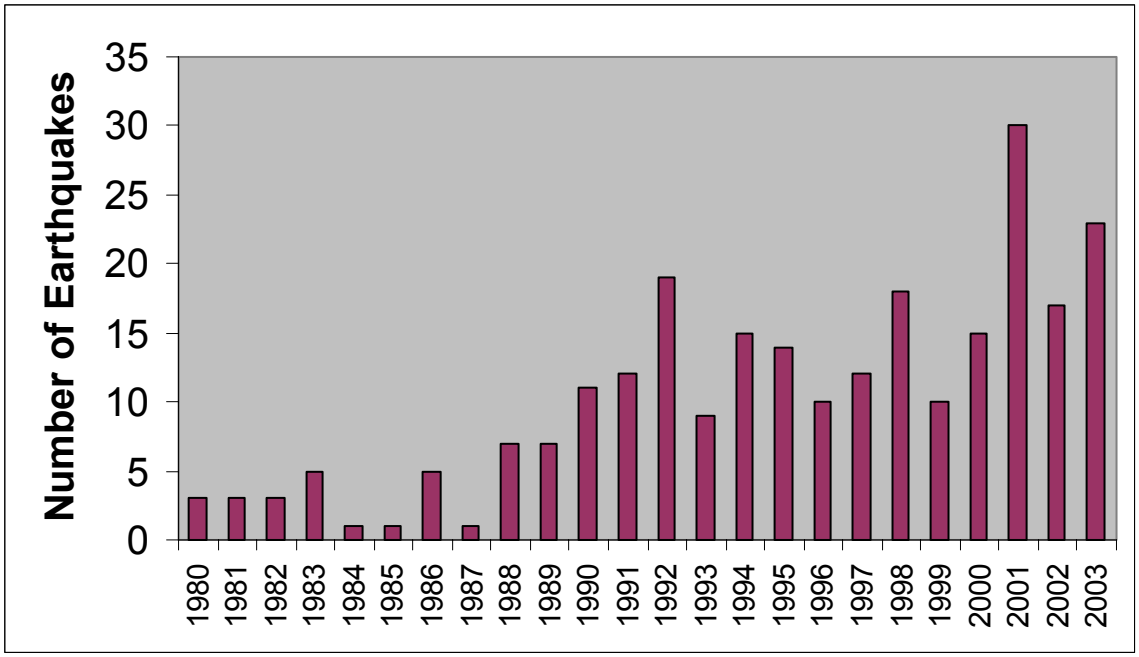

Figure 9: Number of located earthquakes in MPSSZ with magnitudes >0.6 for the period 1980-2003.

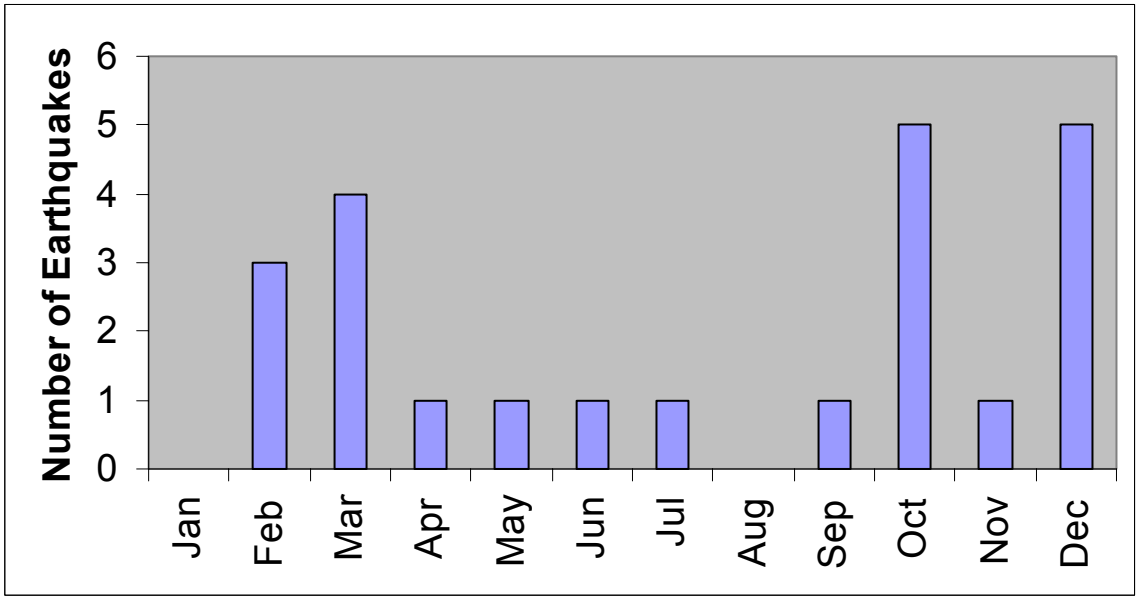

Figure 10: Monthly distribution of earthquakes located in MPSSZ during 2003.

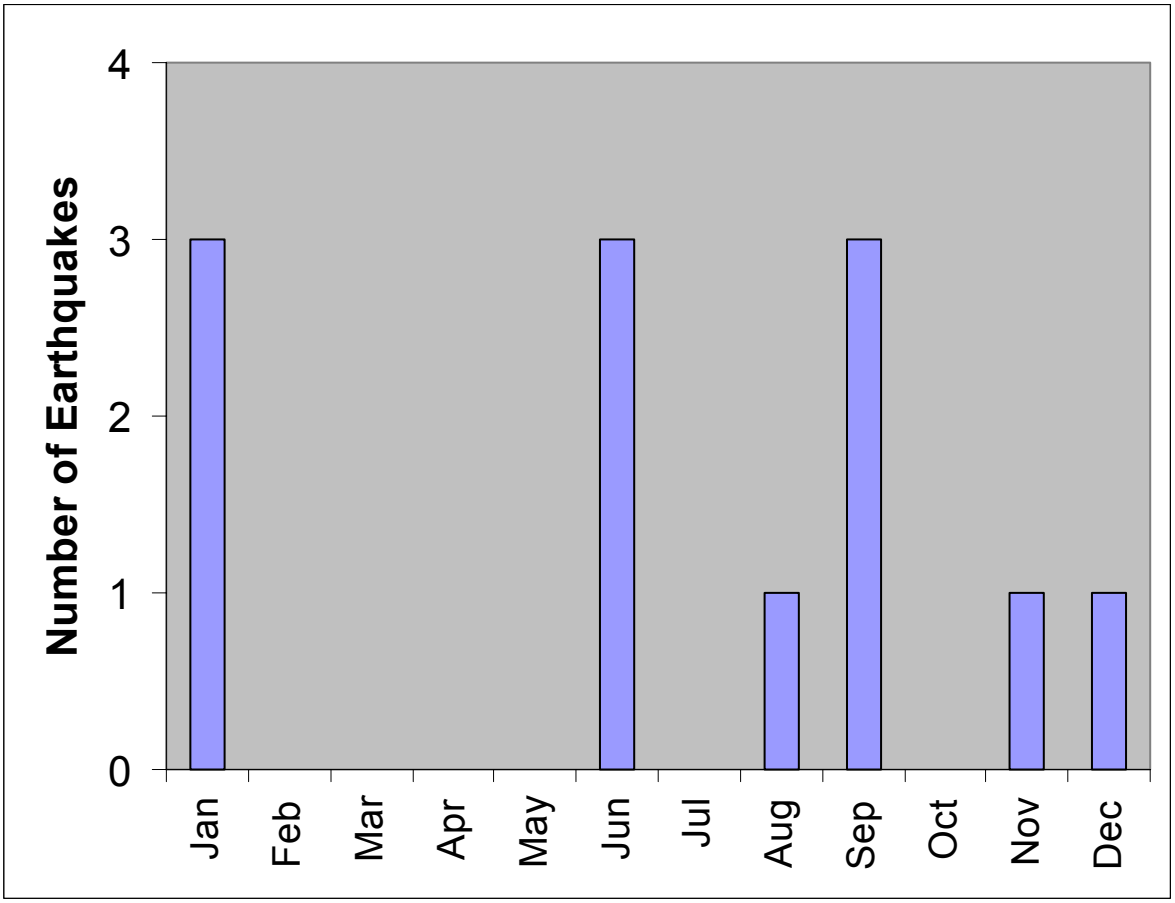

Figure 11: Monthly distribution of located earthquakes at Monticello Reservoir during 2003.

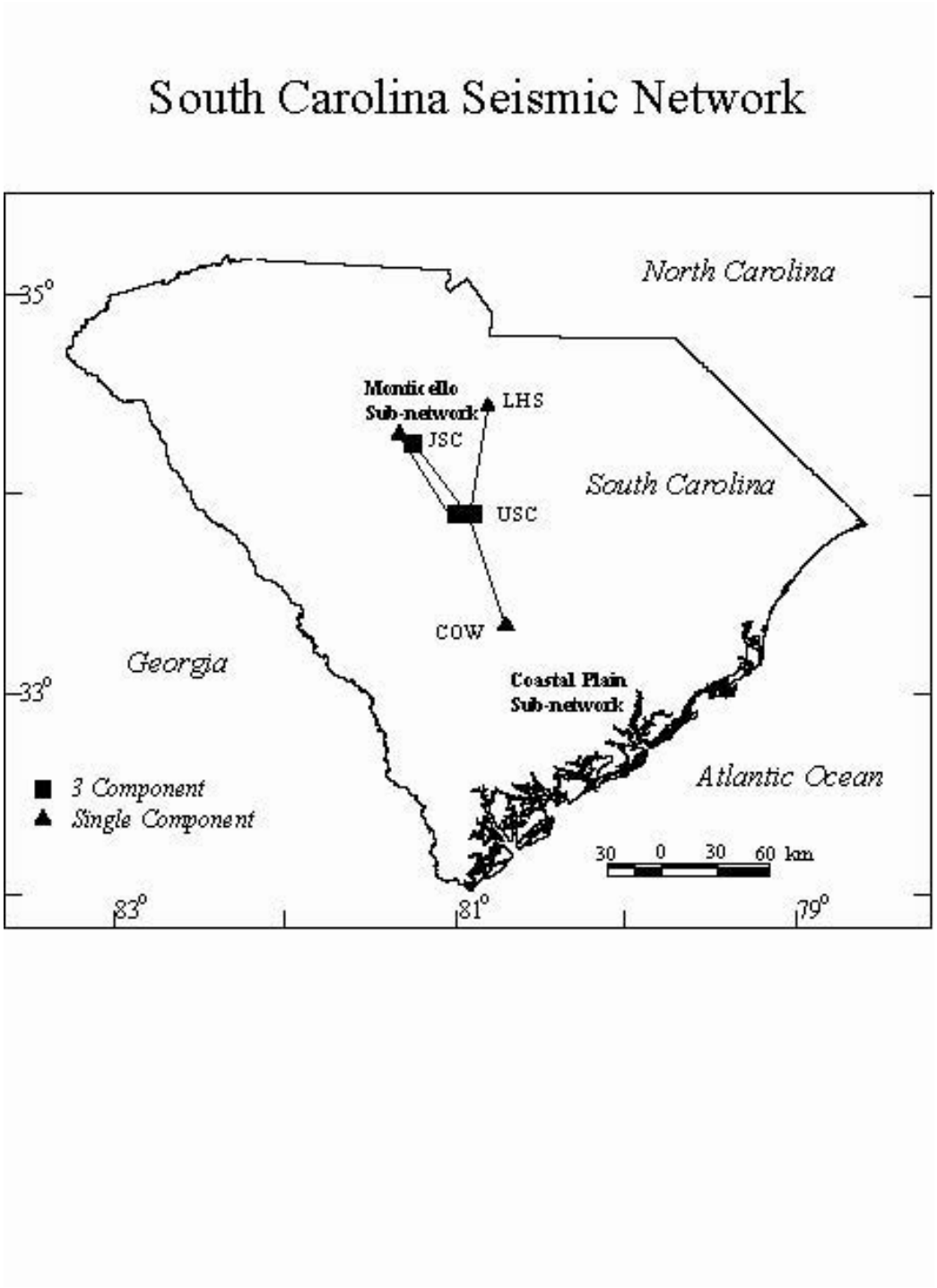

Figure 12: Telemetry routes for seismic data transmitted to USC.

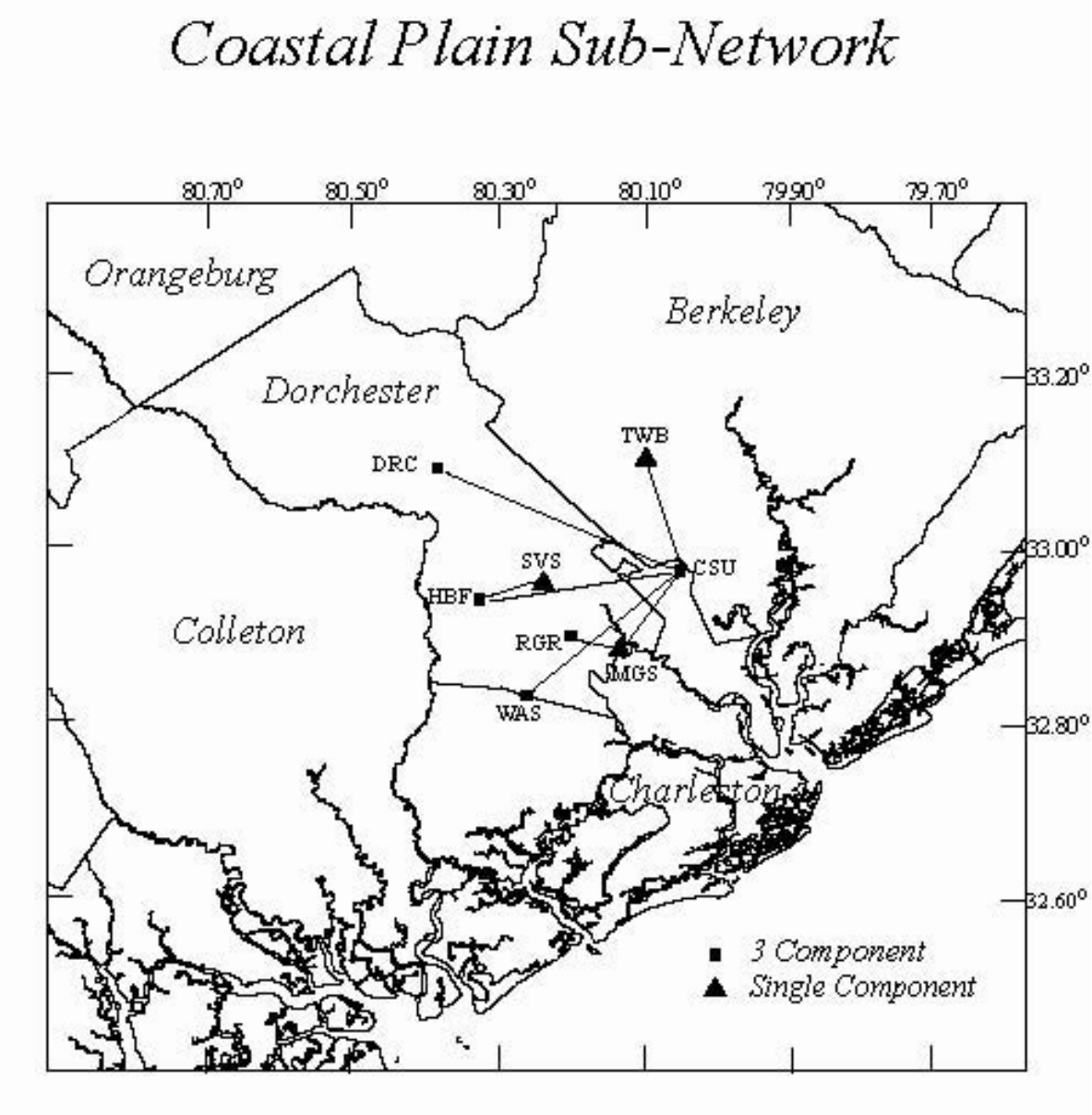

Figure 13: Telemetry routes for seismic data to Charleston Southern University.