

**Final Technical Report
South Carolina Seismic Network**

Cover Page

Cooperative Agreement Number: G10AC00073

Cooperative Agreement Start Date & End Date: 2/1/2010 – 1/31/2015

Project Title: Operation of the Mid-America Integrated Seismic Network – 2010-2014 - USC

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Abstract

The South Carolina Seismic Network includes the epicentral region of the 1886 Charleston, South Carolina earthquake, the most seismically hazardous region along the East Coast of the United States. In addition, sporadic earthquakes with intensity values up to VIII have occurred elsewhere in South Carolina in historic times. Felt earthquakes, including reservoir induced seismicity, are common throughout the state. Seven nuclear reactors at four sites are within the SCSN monitoring region. The SCSN provides raw and derived earthquake products to the ANSS system and provide local expertise on earthquake information, models, and methods. The University of South Carolina provides core operations and maintenance as well as locally specific tasks and expertise where appropriate. The South Carolina Seismic Network (SCSN; network code CO) is an ANSS Tier 2 seismic network that has undergone substantial changes beginning in 2008 when the USGS requested current network personnel take over management of what, at that time, was a largely inoperative network. In the 2010-2014 Cooperative Agreement, 100% of the stations the SCSN is charged with operating have been upgraded, two new broadband/strong motion USGS-supported stations have been installed (and 3 new broadband stations with support from the Savannah River Nuclear Solutions (SRNS), and operation of strong motion stations in Charleston area has been transferred from CERI to USC.

Main Body of the Report

This Cooperative Agreement was part of a joint effort to for operation and maintenance of regional seismic networks in the Mid-America region of the Advanced National Seismic System (ANSS). This is the largest ANSS region in the contiguous United States and includes the locations of the significant 1811-1812 New Madrid and the 1886 Charleston, South Carolina, earthquakes (Figure 1). The geographical delineation also includes similar geological features that affect ground motion, such as the deep sediment deposits near New Madrid and the coastal plains.

The Tier 1 regional monitoring partner is the Center for Earthquake Research and Information (CERI) at the University of Memphis. The regional seismic networks in the Mid-America Integrated Seismic Network (MAISN) provide raw and derived earthquake products to the ANSS system and provide local expertise on earthquake information, models, and methods. Each institution provides core operations and maintenance as well as locally specific tasks and expertise where appropriate.

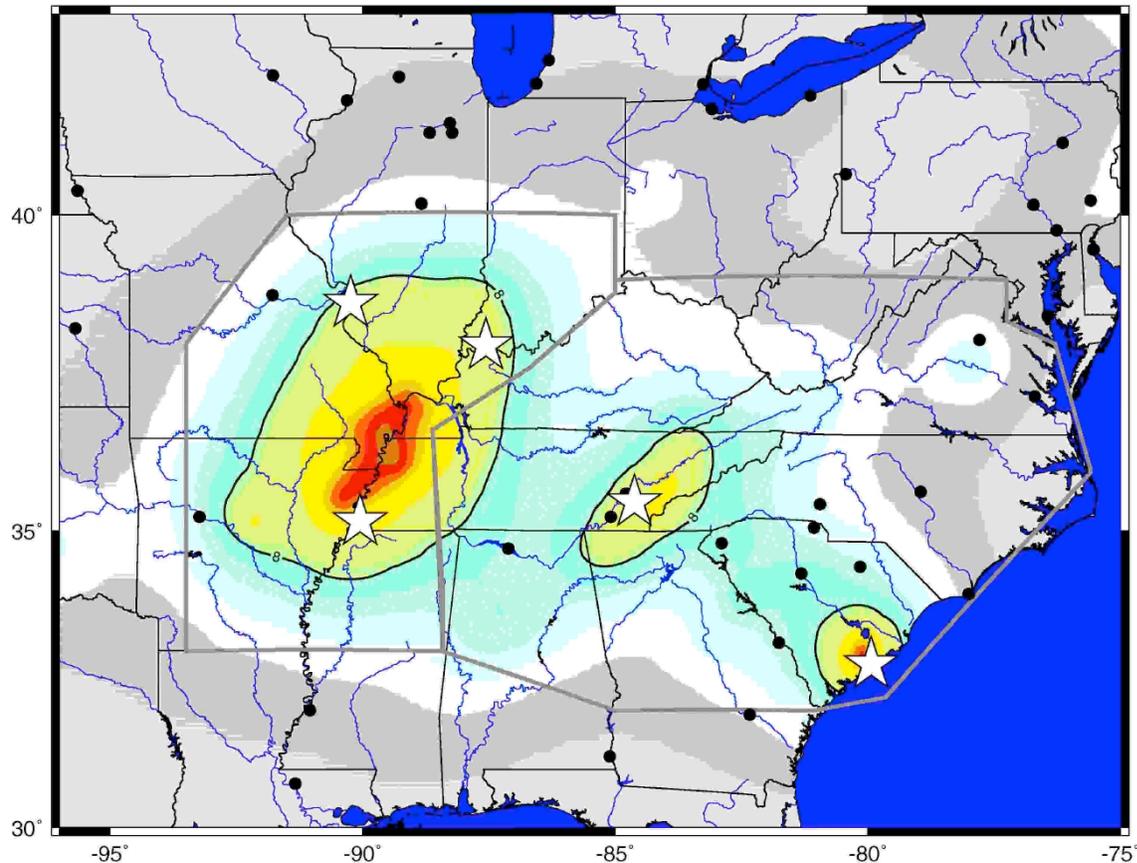


Figure 1. 2014 National Hazard Map. PGA, 10% probability of exceedance in 50 years for the NM and SE authoritative regions (gray polygons). Stars are urban monitoring targets from USGS Circular 1188 and black dots are Nuclear Power plants. The 8%g exceedance level is the line contour.

Figure 2 shows the current SCSN with site details in Table 1. We currently have primary operation and maintenance responsibility for 9 stations (RGR, CSB, JSC, CASEE, HAW and

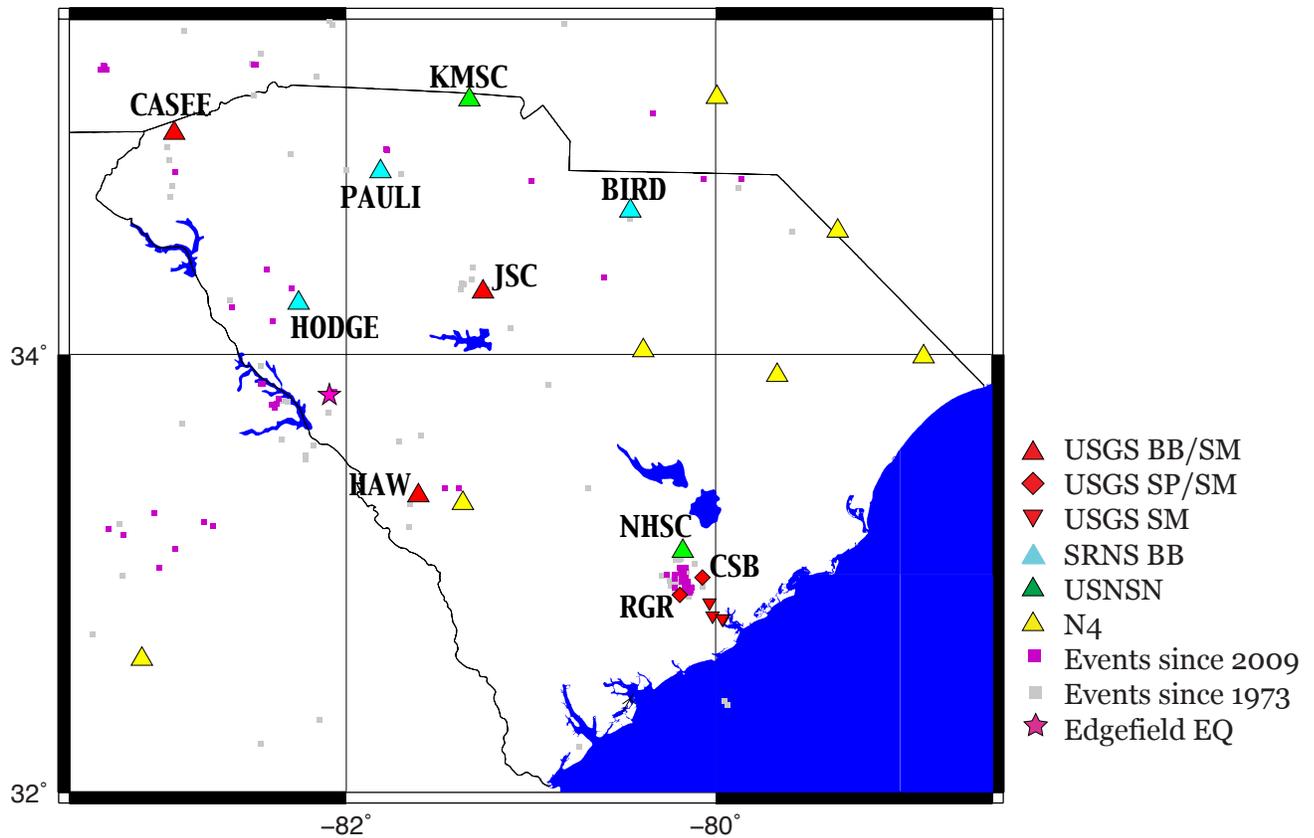
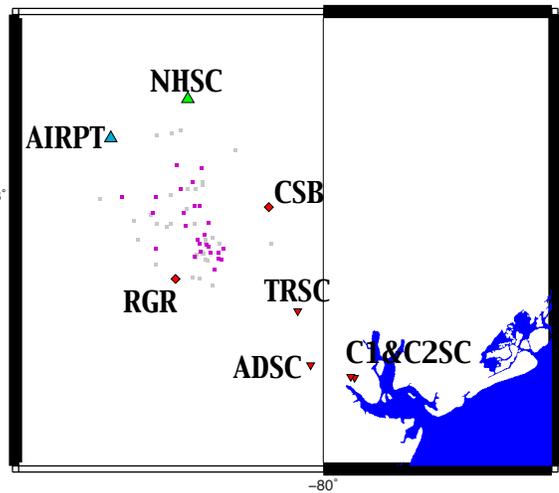


Figure 2. South Carolina Seismic Stations.

Red symbols denote stations of various types that the SCSN operates with support from the USGS via our Cooperative Agreement. Light blue symbols are other broadband stations operated by the SCSN with support from SRNS. The inset is an expanded view of the Charleston area. AIRPT is a new 100m borehole broadband site due for installation in Fall of 2014. Purple and gray squares show recent and older small earthquakes, respectively, located within the region. The purple star shows the location of the 2/15/14 Edgefield earthquake, $M \sim 4.1$. This is arguably the largest event within the State of South Carolina since the 1886 Charleston/-Summerville earthquake sequence. In Key: BB=Broadband, SP=Legacy Short Period, SM=Strong Motion.



strong motion stations ADSC, TRSC, and C1SC and C2SC). ADSC and TRSC were recently closed due to property sales and related renovations/use changes. We have installed Episensors at RGR and CSB to maintain coverage.

Table 1 – Stations operating under the CO Network Code

ADSC and TRSC are currently removed, pending site changes by landowners

BIRD, HODGE, & PAULI are operated and supported by the SRNS

Telemetry is by cell modem, except ADSC, C1SC, C2SC and TRSC, which are on the Internet

Station	Latitude (Degrees)	Longitude (Degrees)	Source of Support	Type	Hardware
CASEE	34.993	-82.931	USGS	Surface Broadband & Strong Motion	Q330, Trillium 120P, Episensor
HAW	33.360	-81.610	USGS	Borehole Broadband & Surface Strong Motion	Q330, Trillium BH-1, Episensor
JSC	34.282	-81.260	USGS	Surface Broadband & Strong Motion	Q330, Trillium 120P, Episensor
CSB	32.987	-80.072	USGS	Borehole Legacy Short Period & Surface Strong Motion	Q330, Sondi MB-1, Episensor
RGR	32.908	-80.194	USGS	Borehole Legacy Short Period & Surface Strong Motion	Q330, L-4?, Episensor
C1SC	32.798	-79.959	USGS	Surface Strong Motion	CMG5TD
C2SC	32.799	-79.964	USGS	Surface Strong Motion	CMG5TD
ADSC	32.812	-80.017	USGS	Surface Strong Motion	CMG5TD
TRSC	32.872	-80.034	USGS	Surface Strong Motion	CMG5TD
BIRD	34.645	-80.462	SRNS	Surface Broadband	Q330, Trillium 120P
HODGE	34.232	-82.259	SRNS	Surface Broadband	Q330, Trillium 120P
PAULI	34.821	-81.814	SRNS	Surface Broadband	Q330, Trillium 120P

The SCSN runs an EarthWorm v7.7.1 system under Linux. All Q330 stations send data via cell modem with standard earthworm modules. We archive data via Winston locally and export stations to several locations. All SCSN stations go to CERI and the IRIS DMC.

As configured, the network has reasonable location capabilities for felt earthquakes in the Charleston area, but only minimal capabilities outside the area. For instance, in February and March of 2009, over a dozen felt earthquakes occurred in Fairfield County within 10km of the VC Summer nuclear power plant site. Station JSC could detect these events, but only one was locatable using the current network. Similar problems exist elsewhere in South Carolina, where very shallow earthquakes are felt by nearby residents but are of insufficient size for location by the ANSS and regional networks. This is a scenario that is difficult to address in the ANSS earthquake monitoring framework, but the N4 network and our SRNS-supported sites certainly help.

On February 15, 2014, a $M \sim 4.1$ earthquake occurred near Edgefield, SC (Figure 2) and was well recorded by the SCSN (Figure 3). This event excited the public but did not cause damage. It is arguably the largest event within South Carolina since the 1886 Charleston/Summerville earthquake sequence. A slightly smaller event in the same area 40 years ago and the 1913 Union County earthquake may have been comparable in size. This illustrates the need for monitoring throughout the state and the capabilities of the combined USGS and SRNS supported stations in the upstate. Stations of the N4 network (Figure 2) should provide some capabilities in the relatively quiescent coastal plain area in northeastern SC.

SCSN is staffed part-time by 2 people. Dr. Thomas J. Owens, SCSN Director, and Dr. Philip Crotwell, SCSN Network Manager. Total effort is 0.375 FTE per year.

Field Operations Status

During the 2010-2014 Cooperative Agreement, all the stations in the network have been upgraded to improve vaults, solar power systems, and other “under the hood” elements of the stations that were in a state of dis-repair when Owens & Crotwell became involved in the network in 2009. We have established new USGS-funded stations at Hawthorne (on the Savannah River Site) and CASEE (in the Upstate) and added strong motion recording to all USGS-funded sites. All stations other than the strong motion stations at the Citadel have been standardized to Q330 digitizers, Trillium broadband seismometers, and Episensor strong motion seismometers. We took over operation of the Charleston area strong motion sites during this reporting period (formerly maintained by CERI) and have upgraded the communication with those sites via Raspberry Pi computers.

Uptime/data delivery has exceeded 95% and has on occasion had the highest rate of data return of all supported networks. We have also established good working relations with the South Carolina Emergency Management Division, who now host a backup server for our network.

All meta-data is up-to-date and shared with CERI, USGS, and IRIS.

Data Management Status

All of our data flows to the IRIS DMC in real-time. USGS-funded broadband and short-period stations averaged over 95% uptime. We work with CERI, our Tier 1 partner, on earthquake locations and rely on them make submissions to the catalogs. We have also established good working relations with the South Carolina Emergency Management Division, who now host a backup server for our network. Our current server at SCEMD, although up for 876 days continuously at one point, is not truly redundant as data still flows through USC. Philip Crotwell has served on the SIS TIC, which is working to improve metadata management.

ANSS Integration Status

As a Tier II Network, we send all waveform data in real-time to CERI, our mothership Tier I network. We do not perform any other real-time tasks. Earthquakes are located in collaboration with CERI. CERI posts all located events to the NEIC.

**FEB. 15, 2014 M~4.1 EARTHQUAKE NEAR EDGEFIELD
RECORDED BY THE SOUTH CAROLINA SEISMIC NETWORK**

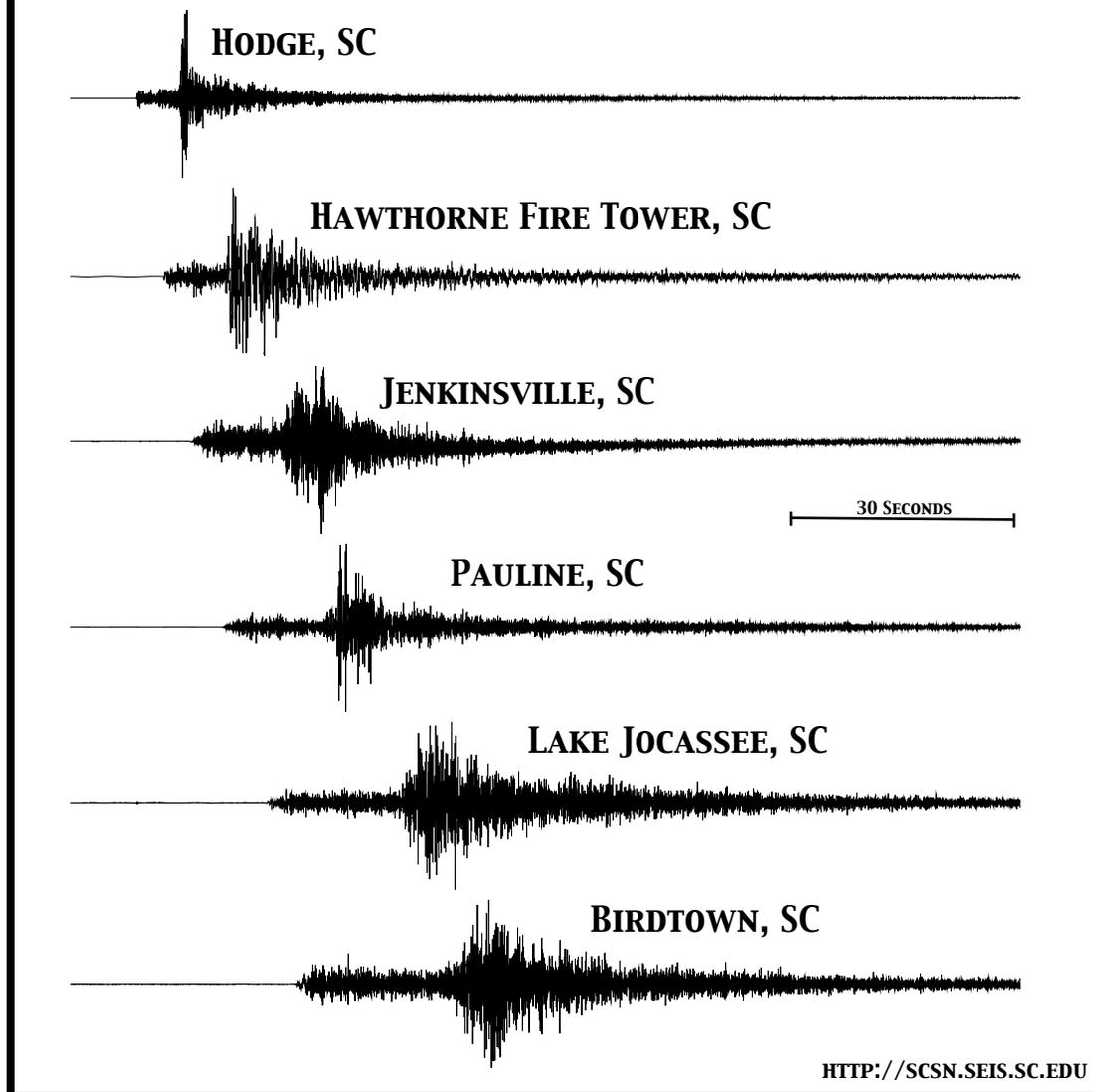


Figure 3. Edgefield Earthquake recorded by the SCSN. The 2/15/14 earthquake near Edgefield, SC is arguably the largest earthquake within South Carolina since the 1886 Charleston/Summerville earthquake sequence. This event, the 1913 Union County event, and another event near Edgefield in 1974 are all in the M~4 range. The 2/15 event caused no damage and only one recorded aftershock. Seismograms are plotted for viewing at the request of the South Carolina Geological Survey and are not all on the same amplitude scale.