SUNSET PUBLIC HEARING

before the

Commerce, Labor, Transportation and Agriculture Joint Subcommittee

for the

Center for Earthquake Research and Information

The University of Memphis

16 June 2015

This report was prepared by the
Center for Earthquake Research and Information

Sunset Public Hearing Questions for
Center for Earthquake Research and Information
Created by Section 49-8-602, Tennessee Code Annotated

Before the Commerce, Labor, Transportation and Agriculture Joint Subcommittee
June 16, 2015

THE UNIVERSITY OF MEMPHIS
CENTER FOR EARTHQUAKE RESEARCH AND INFORMATION

1. ***Provide a brief introduction to the center, including information about its purpose, statutory duties, staff, and administrative attachment.***

The Center for Earthquake Research and Information (CERI) is a Tennessee Center of Excellence at the University of Memphis. At present, it has a staff of 53 consisting of 6 tenure track faculty, 3 research track faculty, 2 emeriti faculty, 17 scientific, technical and clerical staff members, and 25 Masters and PhD students (Attachment 1). CERI is the successor of the Tennessee Earthquake Information Center chartered in 1977 by the Tennessee Legislature to conduct research on the causes and consequences of earthquakes and to provide seismic safety and mitigation information to citizens and government units (Attachment 2). CERI's mission consists of research, education, and public service.

As part of the University of Memphis, CERI has become an academic unit offering Master of Science and Doctoral degrees in Earth Sciences with a Concentration in Geophysics. CERI also has strong ties with the Herff College of Engineering at the University, hosting a faculty member in the Civil Engineering Department and participating in the Engineering Seismology graduate program between Civil Engineering and CERI. CERI faculty mentor graduate students, teach graduate courses in their specialties, and maintain externally funded, internationally recognized research programs. Faculty and scientific staff at the Center have averaged over $1.6M per year in external grants and contracts over the past 3 years (Attachment 3).

As a partner with the US Geological Survey, CERI maintains and operates the seismic network within the Central Region of the Advanced National Seismic System (ANSS). ANSS is a national program designed to provide the United States with definitive information about the occurrence of earthquakes within its territories. CERI's seismic network spans 10 states and is comprised of over 144 seismic stations that are serviced by CERI technical staff. Data from an additional 200+ stations operated by the USGS are also transmitted to CERI's campus and are used by technicians in determining definitive locations and magnitudes of earthquakes throughout the region.

The seismic network is a focal point for a vigorous education and outreach program that serves the public of Tennessee and surrounding states. CERI outreach staff members have a busy schedule of speaking to numerous public school and general citizen groups throughout the region. CERI faculty and graduate students

also participate in outreach activities by giving presentations and serving as science fair judges.

CERI has formed working relationships with other state entities to serve the public more effectively. In particular, the executive director of the West Tennessee Seismic Safety Commission (WTSSC) is also the Director of CERI's education and outreach program. The WTSSC was formed in 2006 by the Tennessee Legislature through TCA Title 58, Section 4, to initiate a comprehensive program to prepare the state's response to a major earthquake. The WTSSC and CERI often leverage costs of public activities such as with important scientific workshops and special events like the annual Great Central US Shakeout. CERI also interacts with the Tennessee Emergency Management Agency (TEMA) for earthquake related matters and recently has been working with the Tennessee Department of Economic and Community Development (TDECD) in preparing a $50M HUD proposal for community disaster resiliency in northwest Tennessee.

Administratively, CERI is both a research center and an academic unit within the College of Arts and Sciences at the University of Memphis. The Director is supervised by the Dean of Arts and Sciences. CERI has an Assistant Director for Administration who maintains all budgets, a Director of Education and Outreach, a Director for Seismic and Information Technology Networks, and a Graduate Program Coordinator who oversees the graduate program. Promotion and Tenure is evaluated within the Center for all faculty including one faculty member who is associated with the Civil Engineering Department. CERI is housed in 4 remodeled residential buildings and in a large prefabricated building across from the northwest corner of campus. Total space is approximately 22,500 square feet.

2. ***What were the center's revenues (by source) and expenditures (by object) for fiscal years 2013 and 2014 and to date in 2015?***

Funding sources for CERI in this time frame are summarized in the following table. The greatest change in funding (-32%) has occurred in the contribution from the University of Memphis in the current fiscal year.

CERI Funding Sources:

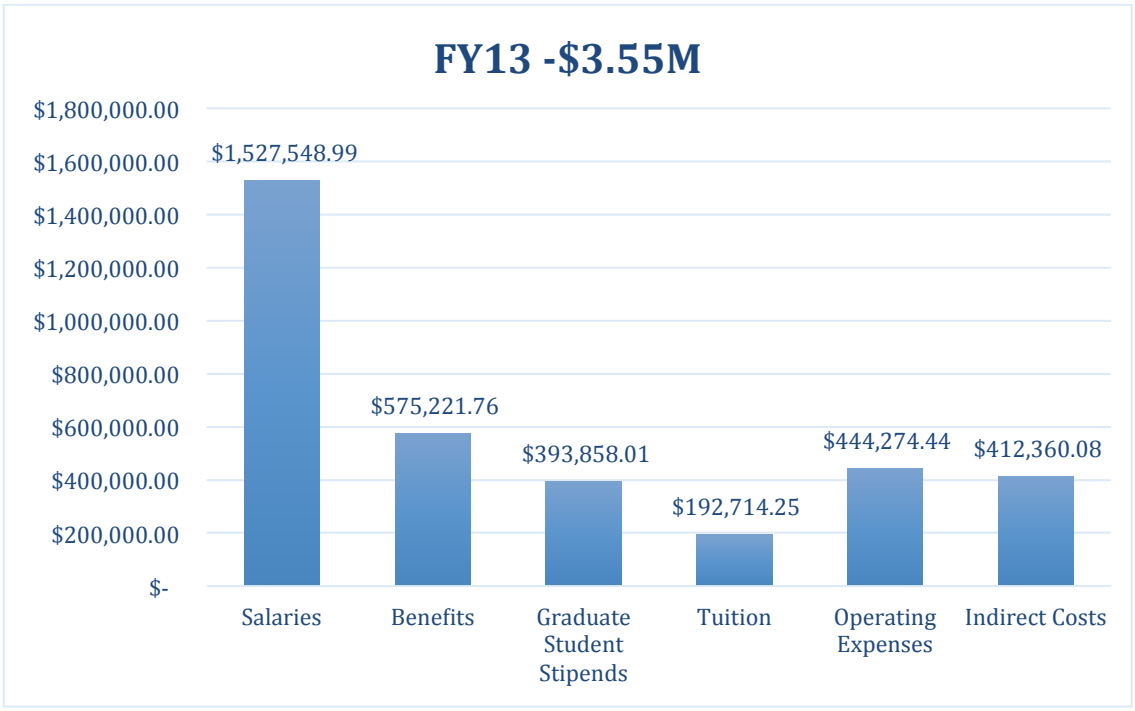
	FY '13	**FY '14**	**Current**
UoM Base/Coe Match	780,966	850,603	581,196
Center of Excellence	977,100	1,014,500	991,600
Externally Sponsored Programs	1,792,908	1,620,858	1,453,020
Gifts Foundation	1,730	6,397	13,578
Total:	3,552,704	3,492,358	3,039,394

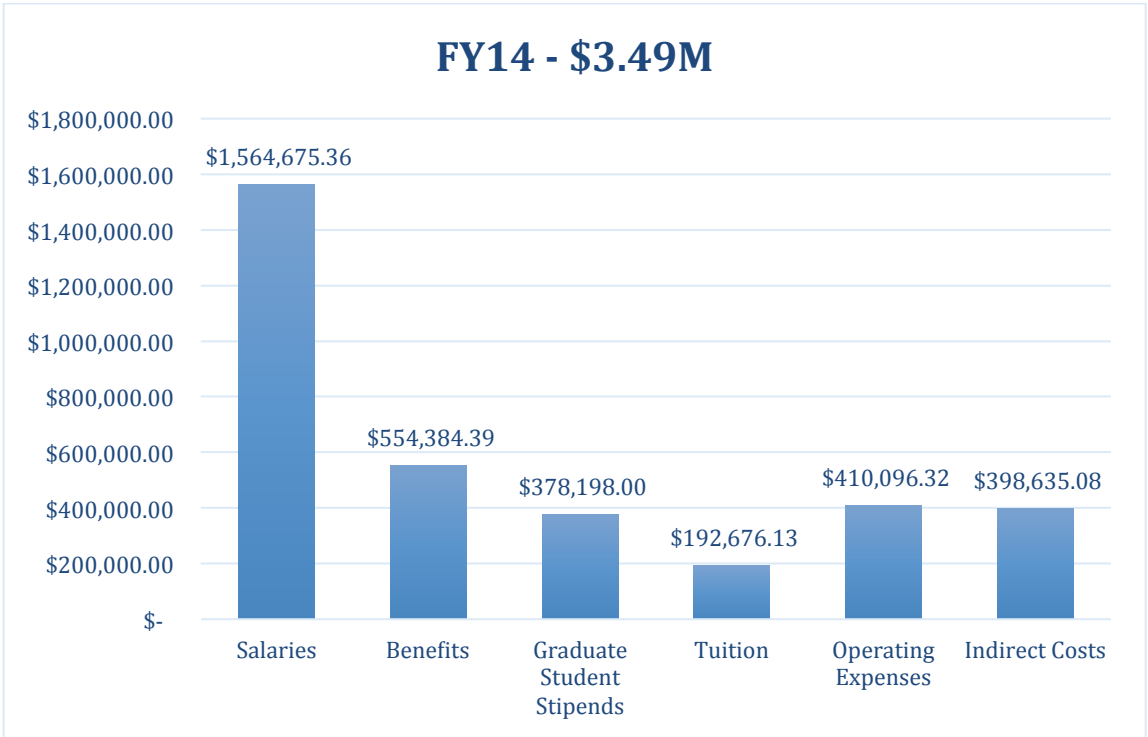
Detail for CERI Funding Sources by Fiscal Year:

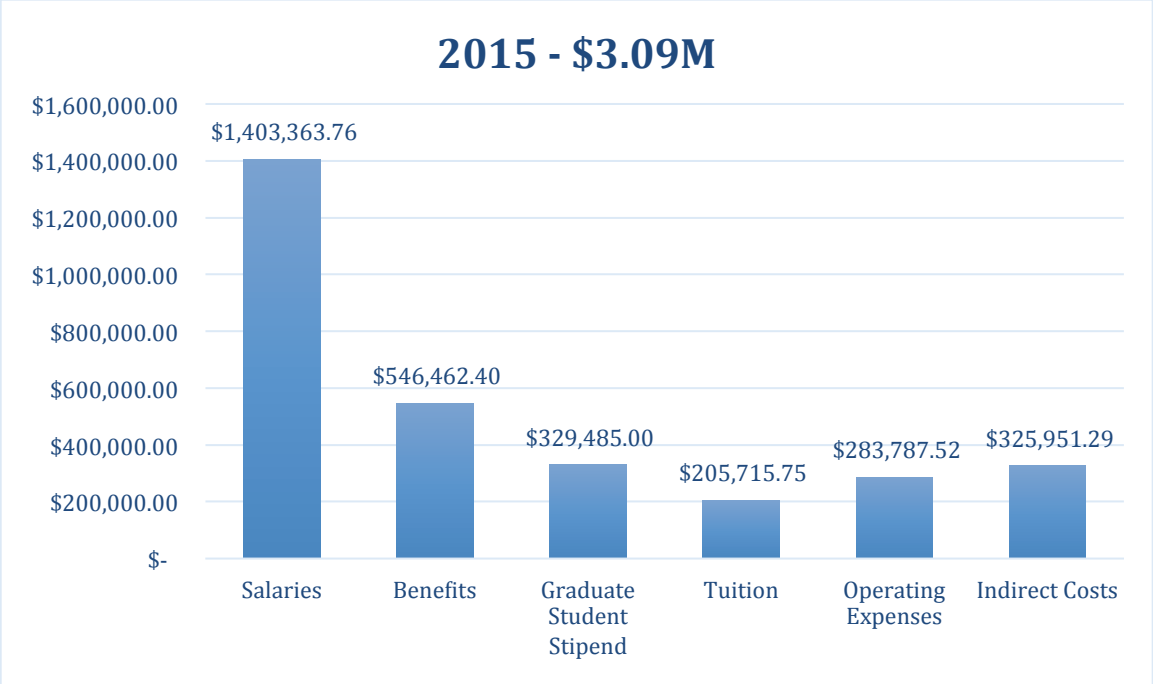
	2013	2014	2015
GENERAL STATE APPROPRIATIONS	660,615*	730,252*	460,845*
CENTER OF EXCELLENCE			
University Match	120,351	120,351	120,351
State Appropriation	977,100	1,014,500	991,600
SPONSORED PROGRAMS			
U.S. Geological Survey	1,059,343	994,792	822,182
National Science Foundation	603,794	501,955	379,510
Arkansas Geological Survey	30,501	34,890	20,831
M. Tuttle and Associates	2,767	9,857	4,248
State Farm Insurance	1,730		13,576
North Carolina Central University	19,774	2,742	
Shaw Group	23,358	68,881	105,040
State of Tennessee	53,371		
Tennessee Emergency Management Agency		7,741	32,616
University of Southern California			55,559
University of Colorado			33,036
TOTALS	3,552,704	3,492,358	3,039,394

*As part of overall UoM Appropriations

Expenditures by object for each fiscal year are shown in the following bar graphs:


FY13 -$3.55M
$1,800,000.00
$1,600,000.00
$1,400,000.00
$1,200,000.00
$1,000,000.00
$800,000.00
$600,000.00
$400,000.00
$200,000.00
$-
$1,527,548.99
$575,221.76
$393,858.01
$192,714.25
$444,274.44
$412,360.08
Salaries
Benefits
Graduate Student Stipends
Tuition
Operating Expenses
Indirect Costs


FY14 - $3.49M
$1,800,000.00
$1,600,000.00
$1,400,000.00
$1,200,000.00
$1,000,000.00
$800,000.00
$600,000.00
$400,000.00
$200,000.00
$-
$1,564,675.36
$554,384.39
$378,198.00
$192,676.13
$410,096.32
$398,635.08
Salaries
Benefits
Graduate Student Stipends
Tuition
Operating Expenses
Indirect Costs



3. ***Please describe what policies and procedures the center has in place to address potential conflicts of interest by center staff and employees.***

CERI follows all policies and procedures established by the University of Memphis to address potential conflicts of interest by Center staff and employees. University policy can by found at the following link:

http://umwa.memphis.edu/umpolicies/UM1692.htm .

4. ***What reports does the center prepare concerning its activities, operations and accomplishments? Who receives copies of these reports? Please attach copies of any such reports issued during fiscal years 2013 and 2014 and to date in fiscal year 2015.***

The Director prepares an annual summary of the Center's accomplishments and plans each year for oral presentation to the CERI community and to the University administration at the annual September CERI "Research and Outreach" meeting. Attachment 4 is a copy of the presentation for the 22 September 2014 meeting. Included within it are summaries of the 2013 and 2014 budgets, a history of funding since 2008, as well as information on the health of the graduate program.

In 2010, the Tennessee Board of Regents requested a "Centers of Excellence and Centers of Emphasis Survey". Our response was a comprehensive listing of research grants and contracts, publications, and faculty vitae for fiscal years 2008 and 2009. The University administration or TBR has not requested reports since 2010.

In 2010, the Director requested and received permission from the university administration to initiate an external review of the Center. This was done to assess the results of CERI's strategic plan proposed for 2006 through 2009 and to identify

strengths and weaknesses of the Center. A visiting committee of 3 prominent scientists was invited to participate and they provided an invaluable perspective on CERI's strengths and weaknesses (Attachment 5). The committee addressed a particularly vexing problem in academic administration concerning CERI's role as a research center but with faculty associated with other academic departments. This problem was solved in Spring 2014 with the signing of a Memorandum of Understanding between the Department of Earth Sciences and CERI that allowed CERI to become its own academic unit (Attachment 6). The external review committee also made important suggestions for strategic planning, particularly in hiring of new faculty, that were used to justify our last 3 hires.

5. ***What were the center's major accomplishments during fiscal years 2013 and 2014 and to date in 2015? Specifically, describe the nature and extent of center activities as defined in Section 49-8-602, Tennessee Code Annotated.***

There are several measures that define the accomplishments of the Center. These include scientific publications in peer-reviewed journals by the faculty, staff, and students as well as presentations at scientific meetings (Attachment 7) and successfully funded grants and contracts (Attachment 3). The CERI faculty and staff have been prolific in writing grant proposals. As of 1 June 2015 there is a total of $3.7M in pending proposals written to the National Science Foundation, US Geological Survey National Earthquake Hazards Reduction Program, the Southern California Earthquake Center, Arkansas Geological Survey, and State of Louisiana. In addition, CERI and the University of Memphis have been assisting the Tennessee Department of Economic Community Development in developing a $50M proposal to HUD; this project is at the "Phase 1" or pre-proposal stage. If successful, HUD will allow a full proposal to be prepared by the State of Tennessee to aid communities in NW Tennessee that have bee affected by the floods of 2011. CERI became involved at the invitation of TDECD since earthquake hazards also impact community resiliency in that part of the state.

CERI was heavily involved in public education and outreach as well as governmental agency interactions during the bicentennial of the New Madrid earthquakes in 2011 and 2012. CERI produced a video "New Madrid: The earthquakes of 1811-1812" that attained national exposure with 63 million potential viewers and a 2012 Bronze "Telly" award for documentaries. In addition, CERI Education and Outreach produced a series of short video public service announcements during 2011-2012 for the bicentennial and in 2013 and 2014 for the Central U.S. "Shakeout" events. These videos were broadcast throughout the region on local television channels.

Scientifically, CERI and the Memphis, TN, area were also showcased by hosting the highly successful 2011 national meeting of the Seismological Society of America. Earthquake scientists from all over the world converged on Memphis to present their latest scientific results and to commemorate the 1811-1812 New Madrid earthquakes. CERI also organized 2 important USGS scientific workshops in 2013 and 2014 where scientists from all parts of the country came to Memphis to discuss the problems of

earthquake hazards in the central U.S. Clearly, CERI has had positive economic impact for western Tennessee.

Here are responses to the specific questions.

a. ***accurate, immediate reports for individuals, government agencies, and the news media on the occurrence of earthquakes;***

CERI is a national resource for disseminating timely research and response information following an earthquake. Although most efforts are related to the New Madrid seismic zone (NMSZ), CERI also provides information and research on the eastern Tennessee, Wabash, and Southern Appalachian seismic zones. Significant earthquakes in any of these zones could impact Tennessee. Following an earthquake, CERI serves as a clearinghouse of information to the media, scientists, emergency managers, engineers, and other local and state officials. The Center also cooperates with other networks to provide comprehensive 24/7/365 regional coverage and is the Tier 1 processing center for the 26-state Mid-America region of the Advanced National Seismic System. Email is provided within several minutes after an event to more than 100,000 recipients using the U.S. Geological Survey Earthquake Notification System (http://earthquake.usgs.gov/ens). Text-based notifications are also automatically generated for mission-critical staff members and for emergency management control rooms in Tennessee and Arkansas through the CERI managed Automated Seismic Alert Project (ASAP). CERI interactive Web-based maps and lists have become a primary information source for rapid earthquake information available within minutes to tens of minutes following an event, depending on the event size. CERI's real time, internet-based "Recent EQ's **(**http://folkworm.ceri.memphis.edu/REQ3/html/index2.html**)** website is an interactive map database of earthquakes and related information. This website received over 41 million hits in the last year. Permanent catalog archives are electronically available covering regional seismicity from 1627 to present. These archives are merged continuously with the composite Advanced National Seismic System.

As a primary source of earthquake information, CERI responds to media requests on a daily basis. For example, interviews were provided for these significant earthquakes since 2013 that may have been felt in Tennessee:

2013/02/23 M3.7 south of Maple Grove, AR
2013/03/31 M3.4 west of Shadyside, WV
2013/05/22 M3.4 east of Saint Vincent, AR
2013/05/24 M3.4 east of Saint Vincent, AR
2013/07/17 M3.2 southeast of Promised Land, AR
2013/08/12 M3.3 east of Elbridge, TN
2014/02/15 M4.1 west of Brunson Crossroad, SC
2014/04/07 M3.1 northeast of Cat Corner, TN
2014/05/15 M3.1 west of Spoonerville, MO
2014/05/22 M3.1 northwest of Hideaway Lake, VA
2014/06/04 M3.8 north of Whispering Springs, AR
2015/02/28 M3.1 northwest of Marston, MO

2015/02/28 M3.1 northwest of Marston, MO
2015/04/02 M3.6 west of Cooter, MO

CERI routinely communicates with emergency managers in all Central US states to announce or confirm earthquake occurrence and to plan for future earthquakes. Our partnership with the Tennessee Emergency Management Agency is particularly strong with daily interaction and input to local, regional, and state planning and mitigation efforts. As noted above, the ASAP project was specifically designed to rapidly provide earthquake information to TEMA's emergency response control room in Nashville. ASAP was funded outside of the state budget with external funds from the National Earthquake Hazard Reduction Program and the insurance industry. ASAP is an example of the rapid earthquake information tools that can be developed by academia to assist emergency managers in the distribution of resources in the aftermath of a large quake.

b. ***background information on earthquakes for individuals, civic groups, schools, governmental agencies, the news media and others;***

Over the last 3 1/2 decades, CERI has grown to become a reliable source of earthquake information for the general public, civic groups, professional development groups, schools, government agencies and the news media using every form of oral, written and electronic communication.

CERI continues to provide significant focus on community earthquake preparedness. Meetings of this nature have been held in Ripley, Covington, Dyersburg, Union City, Ridgely, Jackson, and other communities in west TN since 2009. Most recently on March 31, 2015 CERI partnered with the WTSSC and the City of Millington to organize "Millington Get Ready" (http://millington-news.com/2015/04/09/millington-gets-ready/), which was a community disaster preparedness meeting featuring exhibits, speakers, and first response vehicles. Over 125 attendees were present at this meeting.

Perhaps the most impactful of CERI's recent outreach efforts has been the production of public service announcements (PSA), social media videos, and digital animations to increase awareness of Mid South earthquake hazards. This outreach effort has benefitted greatly by the active partnership of key policy makers and state agencies in funding, producing, narrating, and distributing video products (recent examples listed below). Senator Lamar Alexander, Shelby County Mayor A.C. Wharton, and TEMA Director James Bassham have contributed significant time and influence as narrators of past CERI-produced PSA's. PSA's and social media videos have been primarily developed to support the Great Central US Shakeout (www.shakeout.org), which is a national earthquake drill held on October 16 each year involving millions of Americans. CERI promotion of the Shakeout through PSA production and distribution helped bring the event registration to over 2.19 million across the region in 2014 with 542,763 registrants in Tennessee. CERI continues to reach thousand of K-12 students and teachers with on-site and off-site presentations and programs. For example, in 2014 CERI partnered with the WTSSC, State Farm

Insurance, and local and state emergency management to sponsor the Shelby County Science Fair Earthquake Awareness Poster Contest (Item #3 below).

CERI also produced a documentary in 2012, "New Madrid: The earthquakes of 1811-1812" (Item # 6 below). To date, the potential viewing audience for this documentary has reached over 63 million viewers in the U.S (Figure below) and went on to win a National Telly Award in the documentary category.

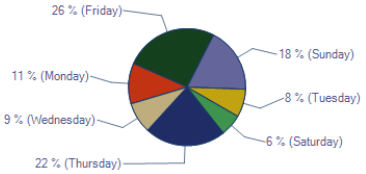
1. CERI Earthquake Safety Awareness video promoting Shakeout: https://www.youtube.com/watch?v=PBKvxMRRNUk
2. 2013-2014 Shakeout PSA: https://www.youtube.com/watch?v=pGG5D6rEfP0
3. 2014 Shelby County Schools Earthquake Poster Contest, Documentation Video: https://www.youtube.com/watch?v=t6srFjYotYs
4. 2013 Shakeout Video for Social Media: https://www.youtube.com/watch?v=c2xy-O89b08
5. 2013 USGS/FEMA/CERI public meeting, "Building Resiliency in the Face of Earthquake Risk"…Lessons from Christchurch. (1 of 6 presentations/panel discussions) https://www.youtube.com/watch?v=AdDmQC0e0uc
6. 2012 New Madrid Bicentennial Documentary (National Telly Award Winner in the Documentary Category): http://vimeo.com/38864818
7. 2011 Shakeout : https://www.youtube.com/watch?v=BVDVf5JTV1c
8. 2011 Shakeout PSA for children: https://www.youtube.com/watch?v=n2pCGzcDu7U

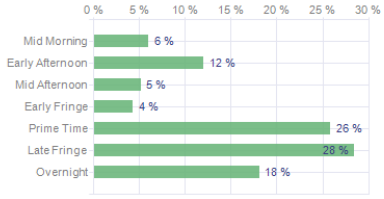
TRAC media services

Carriage Summary
New Madrid: The Earthquakes of 1811-1812
6/1/2012 - 4/25/2013

	Telecasts	Channels	Markets	States	% Coverage
All Channels	116	59	38	18	21.73 %
Main Channels	55	31	25	12	14.15 %
Primary Channels	29	17	17	10	6.05 %
Metered Channels	41	16	13	12	16.07 %
Sub Channels	61	28	22	11	9.95 %
Secondary Channels	87	42	30	15	18.22 %

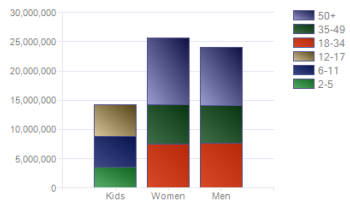
Distribution of Airings by Day and Daypart





Demographic Information of Potential Audience

Demo Group	Men	Women	Total
People 2+			63,996,673
DMA Households			24,806,790
Kids 2-5			3,575,860
Kids 6-11			5,272,940
Kids 12-17			5,414,677
Adults 18-34	7,629,438	7,583,918	15,213,356
Adults 35-49	6,407,801	6,638,050	13,045,851
Adults 50+	9,975,040	11,498,949	21,473,989



This Figure shows the carriage report for the NEHRP-sponsored New Madrid Bicentennial documentary, "New Madrid: The earthquakes of 1811-1812" for the period 6/1/2012 – 4/25/2013 with a potential viewing audience of 63 million Americans in 18 states. This video received a National Telly Award (Bronze) in 2012 in the documentary category.

c. ***research related to the causes and consequences of local earthquakes, to develop such information as the precise locations of earthquakes, magnitude-frequency relationships, magnitude-duration relationships, source spectra studies, attenuation studies, bedrock structure studies, and behavior of foundation material studies;***

CERI faculty members and staff concentrate on research involving the NMSZ and the potential impact of damaging earthquakes upon the region. We also monitor and study the active eastern Tennessee seismic zone. Major externally funded research projects conducted from 2013 to present in 2015 include (see Attachment 3 for details):

- Improving Regional Ground Motion Attenuation Boundaries and Models Using Earthscope US Array Data for Use in the National Seismic Hazards Mapping Project
- Professional Seismic Services to Review Nuclear Site Applications
- GPS Array for Mid-America monitoring deformation in the New Madrid Seismic Zone
- Collaborative Research: Great Earthquakes, Megathrust Phenomenology and

Continental Dynamics
- Collaborative Research: Deformation Processes in the Central Andaman Islands
- Collaborative Research: Northern Embayment Lithosphere Experiment (NELE)
- Toward an Understanding of the long-term deformation in the Mississippi embayment (Phase II)
- Paleoliquefaction Studies in Moderate Seismicity Regions with a History of Large Events: NUREG Report, Training Workshop and Research
- Collaborative Research: Examining the variation in earthquake parameters along the Nicaragua and Costa Rica subduction zone using onshore and offshore seismic data
- Monitoring of the Bayou Corne, LA seismic network
- Seismic Hazard from Induced Earthquakes in Arkansas
- Operation of the Mid-America Integrated Seismic Network
- Evaluation of Attentuation Models (Q-Vs Relationships) used in Physics-Based Ground Motion EQ Simulation through Validation with Data and Comparisons with NGA
- Evaluation of CVM-SI.26 Perturbations Integration Involving Undergraduate Computer Science and Graduate Earth Sciences and Engineering Students
- Validating site response predictions in physics-based ground motion simulations
- 2013 TEMA/CERI EQ Public Service Announcements
- CERI "Partners in Outreach and Preparedness" (POP) Program
- Developing Empirical Ground Motion Prediction Equations for Eastern North America based on the WGA East ground motion database and additional M6-7 ground motion estimates from historical earthquake intensifies
- Support of the St. Louis Area Earthquake Hazards mapping projects: Completion of the final 12 SLAEHMP Seismic and liquefaction hazards maps
- Charleston, SC area earthquake hazards mapping project (CAEHMP) workshop and pilot study: Collaborative Research with the College of Charleston and University of Memphis
- EarthCube Building Blocks: Earth System Bridge: Spanning Scientific Communities with Interoperable Modeling Frameworks
- Evaluation of the Southern California Seismic Velocity Models Through Ground Motion Simulation and Validation of Past Earthquakes
- Improving Regional Ground Motion Attenuation Boundaries and Models in the CEUS and Developing a Gulf Coast Empirical guide using EarthScope USArray Data for use in the National Seismic Hazards Mapping Project
- Collaborative Research: Role of the Central Scotia Sea Floor and North Scotia Ridge in the Onset and Development of the Antarctic Circumpolar current

d. ***studies of the desirability of earthquake resistant construction;***

CERI works on a regular basis with private sector and academic engineers to promote earthquake resistant construction. Most of these efforts since 2012 have been held in concert with the WTSSC and under the guidance of the TN State Fire Marshall's Office. For example, in 2013 the WTSSC and CERI commissioned the

West TN Structural Engineers Association to compare the relative costs of different residential seismic codes in Shelby County Tennessee. Although the report is still in progress, the project has generated widespread debate and understanding among government officials and the engineering and earthquake science communities with respect to the earthquake safety of buildings. In December 2014, the Shelby County Government adopted the 2012 International Building Code for commercial buildings without waiver or provision. This is the first time in history that Shelby County has adopted commercial seismic building codes without modification as recommended by the State Fire Marshall's Office.

CERI is also and active member of the Earthquake Engineering Research Institute (EERI) with a mission to reduce earthquake risk by (1) advancing the science and practice of earthquake engineering, (2) improving understanding of the impact of earthquakes on the physical, social, economic, political, and cultural environment, and (3) advocating comprehensive and realistic measures for reducing the harmful effects of earthquakes. CERI faculty and staff serve routinely on panels related to the earthquake safety of buildings. Most recently CERI provided a panel expert at the EERI National Meeting in Boston (2015): INVENTORYING AND PRIORITIZING ACTIONS TO REDUCE RISK OF OLDER STRUCTURES (http://new-england.eeri.org/wp-content/uploads/2015/01/2015_AM_Brochure_3R.pdf). This expert panel focused on the methods of inventorying, classifying and setting priorities for addressing risk in older building stock. Distinctions between historically significant structures and other building stock as well as regional issues (Memphis, Charleston, and Boston) were addressed through panelist expertise.

Another example of CERI's interest in earthquake resistance and emergency response planning began in 2011 as a partner with the WTSSC, the Shelby County Emergency Management Agency, the American Red Cross, and the Assisi Foundation of Memphis to identify over 300 potential mass shelter facilities in the Greater Memphis Area. These facilities were analyzed for earthquake resistance and documented according to emergency housing needs such as food preparation ability, number of restrooms and parking spaces, available sleeping area, etc. The project provides critical data for emergency sheltering needs that may arise from any catastrophic weather or earthquake event, and also better prepares the state to house victims of large-scale coastal storms.

e. ***advice to governmental bodies, insurance groups and others on the methods and feasibility of reducing earthquake damage;***

The CERI Director gave testimony to a meeting at the State Fire Marshall's office in Nashville on 10 July 2014 with Memphis homebuilders, lobbyists and members of the State Legislature that resulted in the Tennessee Legislature eliminating legislation that would allow Tennessee municipalities to adopt building codes that did not meet or exceed state standards. Results of the meeting also led to the successful adoption of the 2012 suite of International codes by Memphis and Shelby County in October 2014. This effort was championed by the CERI E&O Director over a period of 2 years in collaboration with several agencies of the city, county, and state and by a number of legislators.

CERI faculty and staff provide advice to governmental bodies, insurance groups, and professional development groups on a regular basis through research, presentations, meetings, and workshops. Since 2006 CERI has focused its efforts to reach these groups through partnership with the WTSSC, which was created in 2006 through the Tennessee Code Annotated, Title 58, Section 4 and has been tasked to initiate, with the assistance of state, federal, and local government agencies, a comprehensive program to prepare the state for responding to a major earthquake. The WTSSC is a twelve (12) member board appointed as follows: two (2) members chosen by the Speaker of the House of Representatives, two (2) members chosen by the Speaker of the Senate and eight (8) members appointed by the governor to represent the following professional areas: architecture, fire protection, public utilities, engineering, geology or seismology, local government, insurance, business, emergency health services, nonprofit emergency assistance, local education and emergency management. CERI is authorized and directed to provide any information or services requested by the commission to achieve its goals. The commission is currently chaired by Gary Graves, Millington TN Fire Chief.

CERI also interacts on a regular basis with insurance companies and the National Association of Insurance Commissioners (NAIC). CERI researchers are primary contributors to earthquake hazard mapping in Shelby County Tennessee http://earthquake.usgs.gov/hazards/products/urban/memphis/). These data are important to land use officials, city planners, emergency responders, engineers, and the public who seek to identify areas that may undergo increased levels of earthquake damage due to soil consistency and water content.

CERI has sought to develop ways to understand complex earthquake hazard issues through the development of short digital animations. One such visualization was presented to the NAIC in 2014 to identify areas in Shelby County Tennessee that are prone liquefaction from earthquakes
(https://www.youtube.com/watch?v=ovXvk9Vqd3U).
Liquefaction results in the inability of sediments to support loads uniformly and can cause structural building damage. Hazard zonation is shown in the following video:
https://www.youtube.com/watch?v=q_7dOPUizIk

f. ***and earthquake prediction.***

A large part of CERI's research is devoted to probabilistic seismic hazard evaluation. Relevant research includes statistical studies of an accumulating catalog of regional earthquakes, detailed studies of fault movements by seismic network monitoring, a search for geological evidence of pre-historic earthquakes, studies of earth deformation over geologic time by surface and subsurface geologic methods, regional measurement of slow non-seismic strain by GPS, compilation of geologic and liquefaction susceptibility maps, and determination of site and path effects on propagating seismic energy. CERI has made significant advances in all of these research areas during the last fiscal year. In addition, CERI has made advances in forecasting the ground motions that will occur in and around the NMSZ following a significant earthquake.

6. ***How accurate are current methods in predicting when and where earthquakes will occur? Are there any developments expected in the near future that are likely to increase the accuracy of earthquake forecasting?***

Current methodology does not allow accurate prediction of earthquake location, occurrence, or magnitude. Of more certain and immediate value are the results of CERI studies which can delineate the specific nature of earthquake motion in the NMSZ and how it relates to soil conditions, geologic structure, distance from the event, etc, and its effects on lifelines and buildings. This research provides a steadily improving focus on what to expect and what to prepare for even though we cannot tell when or how intense the event may be.

Only the long-term probabilities of future earthquakes can be estimated according to a slowly changing best-available statistical model based on earth physics and earthquake history. The New Madrid statistical model, a mathematical equation expressing earthquake probability as a function of earthquake magnitude and time, is used by the Center. The 'build-up theory' of this model says that the longer the elapsed time since the last large earthquake, the more likely is another large earthquake within a specified future time interval. All such models must extrapolate from experience with small earthquakes to predictions regarding large earthquakes, since the historic record is too brief to include a rich sample of large earthquakes. The probability prediction is periodically updated with more recent earthquake data. The probability of a magnitude 6 earthquake within the next 50 years is between 15% to 40%.

Around the world, professionals working at least part time on earthquake prediction number perhaps more than a thousand. Several hundred in the United States work in university laboratories like CERI and in the U.S. Geological Survey. The scientific problem is much more difficult than that of predicting the time and location of rain or severe weather or of finding a cure for cancer. Reliable earthquake prediction, if ever achieved, will require a detailed understanding of the dynamics of the earth's interior, which actively turns heat into motion, and thus would involve the findings of additional thousands of earth scientists and specialists working in related fields. Most believe that significant progress, more certain by decades than by years, is being made toward a method or methods of earthquake prediction.

Recent advances in long-term earthquake forecasting have occurred in the fields of crustal strain monitoring using GPS and modeling of earthquake-induced stress fields using Coulomb Failure stress theory after large earthquakes. GPS observations have illuminated areas of the earth, such as southern and northern California, that are actively deforming from plate motions. These areas of slow ground deformation are places where the crust of the earth is storing large amounts of crustal strain and stress, which are expected to lead to large future earthquakes. The cumulative amounts of crustal strain are proportional to expected earthquake sizes. GPS methods are also providing strong constraints to the type of crustal deformation that is occurring in the NMSZ and show that the NMSZ is fundamentally different than areas on the west coast.

Coulomb Failure theory has been used in studies of recent large earthquakes to show that fault motions from large earthquakes can either reduce or increase stress in

areas adjacent to the earthquake. Areas where stress increases have produced large aftershocks or additional future large earthquakes. Areas where stress decreases after a large earthquake produce few aftershocks and this explains why there have been few large earthquakes in the historical past for some regions. For example, the 1906 San Francisco earthquake released a large amount of crustal strain in the San Francisco Bay area causing a long period of seismic quiescence there. In addition, there have been advances in the study of seismicity catalogs using non-linear dynamics and catastrophe theory, which forecast the occurrence of large earthquakes based on the rate and size of small earthquakes occurrences. These forecasts provide probabilities of occurrence on the time scale of decades.

7. ***Where does the center feel the next serious earthquake in Tennessee will be most likely to occur, and what measures has the center taken to inform the public in those areas about such possible danger and how to deal with it?***

Based upon the past occurrence of damaging earthquakes in the region, we anticipate that the next serious earthquake to effect Tennessee will occur somewhere in the NMSZ. The NMSZ has a well-documented history of generating damaging earthquakes. Only a portion of the NMSZ lies in Tennessee but a large earthquake occurring anywhere in the zone will result in significant damage and will have long-term socioeconomic impact both locally and regionally. A serious earthquake is not necessarily one of large magnitude; earthquakes as small as magnitude 5.6 have caused serious damage in areas with structures lacking earthquake resistant design. We must also recognize that the eastern Tennessee seismic zone has the spatial dimensions to generate a large, damaging earthquake. Cities at risk from the eastern Tennessee seismic zone include Knoxville, Chattanooga and Oak Ridge. All TVA dams and nuclear power facilities are also at risk.

The Center takes a variety of approaches to inform the public about earthquake risks and the importance of preparedness. Specifically, CERI has responded directly to earthquake information requests from Chattanooga and from dozens of communities across west Tennessee. Although scientists believe that the next major quake in the central US will occur in the NMSZ, no one knows exactly where or when. However, a large earthquake (M 7.0 to M 7.8) occurring anywhere in the NMSZ would heavily impact all of west Tennessee.

The education and outreach activities associated with the bicentennial of the New Madrid earthquakes in 2011-2012 mentioned above were a major activity for all at the Center during this critical time period for informing the public about earthquake dangers. Personnel at the Center continue to give requested presentations to school and public groups. The following are examples of activities in 2013 and 2014 addressing how we generally inform the public and organizations on earthquake hazards.

- CERI-organized Meeting with the Rotary and Emergency Management in Union City, Tennessee. 45 attendees.
- Coordination meeting with TEMA West in Jackson, TN.
- Meetings with International Paper, Memphis Area Homebuilders Association, Shelby County Mayor, State Farm Insurance, Federal Reserve Bank, Ducks

Unlimited workshop for Garden Club of America, Jackson TN Exchange Club, President of MLGW, Evangelical Christian School, Shelby County Office of Preparedness, International Facility Managers Association, West TN Chapter of the Association of General Contractors, Berkeley Insurance, US Corps of Engineers, all on earthquake hazards and preparedness.

8. ***What is the center's role once an earthquake occurs?***

The answer to this question depends upon the location, size, and character of the earthquake but we generally have three duties:

(1) Determine physical characteristics of the earthquake in coordination with the National Earthquake Information Center,
(2) Inform the public and response community, and
(3) Coordinate scientific response

In the aftermath of an earthquake, CERI enters rapid response mode that addresses both scientific and public information needs. Deploying our portable seismic arrays to the epicenter region to monitor aftershock activity is an important role. For example, we deployed instruments following the August 23, 2011 earthquake (M 5.8) near Mineral, Virginia. This earthquake was felt widely in east Tennessee. We use information gathered by the permanent seismic network and geological field studies to determine main shock characteristics. Due to our expertise in seismic monitoring and public information, CERI has become a resource for the eastern US for all aspects of post earthquake response.

Informing the community and serving as an interface between science and the public is critical. Following an earthquake, CERI serves as a clearinghouse for information to the media, scientists, emergency managers, engineers, and other local and state officials. This includes acquiring felt and damage information collected from the public and communicating this to the appropriate agencies. The Center also cooperates with other networks and organizations to provide comprehensive regional coverage and consistent information to the media. For larger damaging earthquakes, we focus on informing emergency response workers where damage is likely, and the possibility of damaging aftershocks. Email is provided within minutes after an event to more than 100,000 recipients (http://earthquake.usgs.gov/ens). Interactive Web-based maps and lists are also available within minutes to tens of minutes following an event depending on its size. A critical part of our task is addressing the fears the public has about earthquakes and their consequences. The Center responds to dozens of media requests, hundreds of telephone calls and written requests for information following each felt earthquake in the region, with the express purpose of not only communicating appropriate scientific, risk and preparedness information but also of calming the fears and reducing the apprehension of a public with little or no first-hand experience of earthquake occurrence and the frequency and duration of aftershocks. Our web site commonly takes 10,000 to 150,000 thousand hits immediately following a felt event and serves as very valuable resource to the public.

Coordinating scientific response is especially critical in the central US, where

each sizeable earthquake can teach us something fundamental about the local hazard. Recent earthquakes, like the M5.8 event in central Virginia (August 23, 2011) alarmed Tennesseans across the state, and generated scientific aftershock instrument deployments and information clearinghouse applications from CERI. Over 144,000 individuals, many in Tennessee, reported the felt effects of the August 23 earthquake to the CERI and USGS web pages. For larger earthquakes that could occur, where our portable arrays are insufficient to cover the affected area, there could potentially be dozens of national institutions contributing instrumentation and personnel to study the earthquake, using seismology, geology, and geodesy. Because of our central role in the region, we will provide information exchange mechanisms and coordination, so that scientific work proceeds efficiently.

9. ***Describe any items related to the center that require legislative attention and your proposed legislative changes.***

There are two scientific developments that have occurred since 2008 that impact earthquake safety for citizens of Tennessee that should be brought to the attention of Tennessee Legislators. These include Earthquake Early Warning (EEW) systems being developed in California, Oregon, and Washington and the occurrence of man-made, induced earthquakes associated with hydrocarbon exploration in the nearby states of Arkansas, Oklahoma, Texas, and Kansas.

The State of Oklahoma has become the most seismically active area in the United States, even more active than California, since 2008 when shale-gas and shale-oil exploration significantly increased within the state. According to USGS studies, the rate of occurrence of magnitude 3.0 and greater earthquakes has increased by a factor of 5 in the central and eastern US over the past 4 years compared to earthquakes occurring in the same region before 2000. We now observe over 100 M3 or greater events per year compared to 20 per year in the past. These "extra" earthquakes are believed to be occurring mostly because of the pumping of wastewater from hydrocarbon "fracking" operations deep into the Earth where the increase in fluid pressure lubricates existing faults causing earthquakes.

CERI has been working with the Geological Survey of Arkansas to monitor induced events near Conway, AR. On 4 March 2011 the Arkansas Oil and Gas Commission issued an emergency order to shut down two wastewater injection wells near Guy, AR. This was done because of the evidence that CERI staff had uncovered showing that a deep fault was being activated by the pumping. The area experienced a swarm of thousands of earthquakes near the wells and a M4.7 earthquake occurred a week before. Induced earthquakes are still occurring in Arkansas based on our latest studies.

The occurrence of these events has raised the earthquake hazard over the entire region. It is notable that the largest, probably induced earthquake was M5.6. This occurred in central Oklahoma and caused significant damage to nearby homes. An earthquake of this size occurring in central/eastern Arkansas would likely cause damage to cities in western Tennessee. The 1976 Marked Tree earthquake that led to the creation of CERI was only M5 and caused moderate damage in Memphis.

Although earthquake prediction is still an infant science, seismic networks, communication, and information systems can effectively be used to warn areas farther from an earthquake that strong shaking will occur within seconds to a minute of the start of an earthquake. Seismic waves responsible for earthquake damage travel at speeds of about 120 miles per minute. If a nearby seismic sensor can detect the onset of an earthquake, then a warning can be broadcast electronically to great distance. Given only a few seconds, businesses and utilities could automatically shut down sensitive machinery and energy systems. Larger warning times could be useful for the population at large to prepare for shaking (drop, cover, and hold on!) and for utilities to monitor dams and power stations for damage.

EEW systems have been developed in several countries like Japan and Mexico and are starting to being developed on the U.S. west coast. The cost of these systems is justified on the basis of the estimated annualized loss from earthquakes. In the central U.S., the annualized loss from earthquakes is estimated to be $380M per year. As a recent Mid America Earthquake Center report showed, much of this loss would occur in Tennessee in the case of a large New Madrid earthquake. Work on EEW is proceeding in the western U.S. because the annualized loss is 10 times greater in California alone. Nevertheless, the annualized loss in the central U.S. is significant. This is also compounded by the fact that strong ground motions propagate to greater distances in the central U.S. than in the west because of the nature of the crustal rocks. In principle, EEW systems in the central U.S. could warn at greater distances and with longer times than possible in the western U.S.

Because of CERI's seismic network facilities and scientific expertise, we are ideally positioned to address both the problem of induced seismicity and development of EEW systems within Tennessee and in the greater central U.S. Tennessee is vulnerable from induced earthquakes in adjacent states that are undergoing hydrocarbon exploration. CERI's network is also the necessary backbone for an EEW system for detecting strong ground motions within our two major seismic zones, New Madrid and eastern Tennessee, as well as detecting waves from earthquakes outside the seismic zones. Although one scientist and three graduate students at CERI are studying EEW and induced seismicity in their research, embarking on study of these two important societal concerns for the State requires some direction and resources to become effective. CERI and the University of Memphis are available to interested Legislators for facilitating the necessary legislation to address the problem of induced earthquakes and initiate EEW.

10. ***Should the center be continued? To what extent and in what ways would the absence of the center affect the public health, safety, or welfare?***

CERI's progenitor, the Tennessee Earthquake Information Center, was created in 1977 in recognition of the danger posed by the NMSZ. Recognized was the need to 1) inform the public and appropriate agencies about the potential hazard, 2) conduct basic research involving the causes and consequences of local earthquakes, 3) provide basic studies involving earthquake resistant construction, and 4) advise governmental and other agencies on the methods and feasibility of mitigating seismic hazard. The NMSZ and the comparably dangerous eastern Tennessee seismic zone still pose a

significant threat and the need for the Center to continue its work as a clearinghouse of information and as a research organization is more important than ever. Clearly, the danger posed by the two active seismic zones increases as population density increases and urban infrastructure grows. We request that CERI be maintained as an agency of the state. CERI benefits greatly from this status and in return, the state benefits from our activities.

The loss of state agency status upon CERI's ability to serve the state is difficult to assess. Certainly, loss of agency status would not be looked upon favorably by TBR or THEC and could put continued existence of the Center at risk in these times of tight budgets. Loss of agency status could also affect interaction with other state and national agencies such as the Tennessee Emergency Management Agency, the Federal Emergency Management Agency, the Central U.S. Earthquake Consortium, the Tennessee National Guard, the U.S. Army Corps of Engineers, and the Tennessee Department of Transportation.

To understand the impact of the loss of the Center on public safety and welfare, consider that CERI meets the information needs of over 100,000 people annually through its comprehensive website, answering individual information requests, and responding to presentation requests. Specific technical information is developed and transferred to emergency managers, engineers, politicians, city planners, fire departments, and the military. The Center provides specific technical information to local, state, and federal emergency response agencies and provides targeted information to engineers and engineering groups in order to facilitate the adoption and implementation of appropriate building codes. Research conducted at CERI quantifies the earthquake hazard posed to major urban areas across the state and the Center provides technical research on the vulnerability of schools, utility lifelines, transportation networks, hospitals, and fire departments to various levels of earthquake-induced ground motion. State agencies as well as officials from other states at risk from New Madrid and eastern Tennessee earthquakes, benefit from earthquake information processed and delivered rapidly from CERI's seismic networks.

Clearly, CERI plays a vital role in the safety and welfare of the people of Tennessee, a state containing two active seismic zones. CERI's status as a state agency assists us in our ability to carry out our critical mission. We request the state agency status be continued.

11. ***Has the center developed and implemented quantitative performance measures for ensuring it is meeting its goals? (Please answer either yes or no). If the center has developed and implemented quantitative performance measures, answer questions 12 through 19. If the center has not developed quantitative performance measures, proceed directly to question 20.***

Yes.

12. ***What are your key performance measures for ensuring the center is meeting its goals? Describe so that someone unfamiliar with the program can understand what you are trying to measure and why it is important to the operation of your program.***

Fundamentally, CERI is an academic research center with responsibilities to the citizens of the State of Tennessee. The faculty, staff, and graduate students are here to perform cutting edge scientific research and to add the results of that research to the scientific body of knowledge and present it to the public. A key performance measure is the amount of externally funded research that the faculty and staff contribute to the Center. External research funds generate graduate student stipends and tuition as well as providing faculty salary release that can be used for general Center expenditures. General expenditures include providing educational programs to the public. Because of this, Center faculty are encouraged to obtain at least $120K/year in external funds.

Another key measure is the number of graduates that the Center produces for the University. A larger number of graduates increases the viability of the graduate program since new students replace those graduating as faculty increase their national and international reputation for doing important research. Since 2008, we have been working to attain TBR quotas for numbers of MS and PhD graduates per year of 5 and 3. For the next 4 years we will be exceeding the PhD quota (see Attachment 4) with the present student body. Becoming our own academic unit has also allowed us to make innovative changes to the curriculum so that we can also award Masters degrees to nearly all PhD students on their way to obtaining the PhD degree. This will allow us to attain the TBR quota of 5 Masters graduates per year.

There are other performance measures that are examined each spring when the Director evaluates the faculty and staff through University of Memphis formal evaluation procedures. For faculty, progress is judged on the basis of performance in research funding, scholarly activity, teaching, and professional service. For staff, progress is judged based on specific job descriptions. In all cases, productivity evaluations are in line with Center objectives that also include seismic monitoring progress and Education and Outreach activities. In addition, the Director is also evaluated each year by the Center faculty and the Dean of Arts and Sciences. This process involves the faculty answering questions about the Director's job performance and administrative style in a confidential on-line survey. The Dean gives the results of the survey to the Director and makes his own summary. The Director is then required to discuss the results of his evaluation with the faculty in a faculty meeting. This produces useful dialog for improvement if improvement is needed.

13. ***What aspect[s] of the program are you measuring?***

These measures gauge the economic, academic, and public service vitality of the program.

14. ***Who collects relevant data and how is this data collected (e.g., what types information systems and/or software programs are used) and how often is the data collected? List the specific resources (e.g., report, other document, database, customer survey) of the raw data used for the performance measure.***

The data are easily available through University of Memphis accounting, academic, and research software systems. The data are collected each year, usually by the Assistant Director for Finance and the Graduate Program Coordinator.

15. ***How is the actual performance measure calculated? If a specific mathematical formula is used, provide it. If possible, provide the calculations and supporting documentation detailing your process for arriving at the actual performance measure.***

By examining totals.

16. ***Is the reported performance measure result a real number or an estimate? If an estimate, explain why it is necessary to use an estimate. If an estimate, is the performance measure result recalculated, revised, and formally reported once the data for an actual calculation is available?***

The performance measures are real numbers.

17. ***Who reviews the performance measures and associated data/calculations? Describe any process to verify that the measure and calculations are appropriate and accurate.***

The CERI Director, Assistant Director for Finances, and Graduate Program Coordinator. Numbers are compared to those available in the Deans office.

18. ***Are there written procedures related to collecting the data or calculating and reviewing/verifying the performance measure? Provide copies of any procedures.***

No. The measures are simple.

19. ***Describe any concerns about the center's performance measures and any changes or improvements you think need to be made in the process.***

The process is working well.

20. ***Please list all center programs or activities that receive federal financial assistance and, therefore are required to comply with Title VI of the Civil Rights Act of 1964. Include the amount of federal funding received by program/activity.***

CERI programs and activities do not receive direct federal financial assistance. However, as a unit of the University of Memphis, CERI complies with Title VI of the Civil Rights Act of 1964.

21. - 26. N/A

27. ***Please provide a breakdown of current center staff by title, ethnicity, and gender.***

Please see Attachment 1.

28. ***Please list all center contracts, detailing each contractor, the services provided, the amount of the contract, and the ethnicity of the contractor/business owner.***

The Center does not contract to individuals or businesses.

Attachment 1

CERI Personnel 2013-2015

by Title, Ethnicity and Gender

	Personnel	Title	Ethnicity	Gender
Faculty				
	Boyd, Oliver	Adjunct Research Professor	White	Male
	Chiu, Jer-Ming	Professor	Asian	Male
	Choi, Eunseo	Assistant Professor	Asian	Male
	Cramer, Chris	Research Associate Professor	White	Male
	Daub, Eric	Assistant Professor	White	Male
	Langston, Charles	Professor/ Director	White	Male
	Powell, Christine	Professor/Graduate Coordinator	White	Female
	Smalley, Robert	Research Professor	White	Male
	Taborda, Ricardo	Assistant Professor	Hispanic	Male
	Withers, Mitchell	Research Professor/Director for Seismic and IT Networks	White	Male
Professional Staff				
	Bollwerk, James	Seismic Networks Engineer	White	Male
	Brewer, Steve	Seismic Systems Supervisor	White	Male
	Broadbent, Tanya	Design Drafter I	White	Female
	Chiu, Christy	Research Associate	Asian	Female
	Davis, James	LTSP I	White	Male
	Debula, Robert	LTSP II	White	Male
	Horton, Stephen	Research Scientist	White	Male
	Lane, Pat	Hourly Temp	White	Male
	Marshall, Deshone	LTSP I	Black	Female
	McGoldrick, Gerrit	Research Equip Tech II	White	Male
	Moran, Nathan	Research Associate II	White	Male
	Parker, John	Research Associate II	White	Male
	Patterson, Gary	Director- Education and Outreach	Asian	Male
	Puchakayala, John	Research Scientist	Asian	Male
	Smith, Michelle	Assistant Director-Administration	Black	Female
	Spikes, Virginia	Administrative	White	Female

		Associate I – ended 06/30/2013		
	Steiner, David	Research Equip Tech II	White	Male
	Tucker, Kathleen	Technical Info Specialist	White	Female
	Withers, Holly	Research Associate II	White	Female
Graduate Research Assistants				
	Ahamed, Sabber	PhD	Asian	Male
	Al Noman, Nayeem	PhD	Asian	Male
	Amosu, Adewale	PhD	Black	Male
	Aslam, Khurram	PhD	Asian	Male
	Ausbrooks, Scott	MS	White	Male
	Basu, Urbi	PhD	Asian	Female
	Bisrat, Shishay	PhD	Black	Male
	Bockholt, Blaine	PhD	White	Male
	Clark, Evan	MS	White	Male
	Christianson, Ryan	MS	White	Male
	Dangkua, Donny	PhD	Asian	Male
	Davis, James	PhD	White	Male
	Dhar, Mahesh	PhD	Asian	Male
	Doan, Hieu	MS	Asian	Male
	Driskell, Melissa	PhD	White	Female
	Gomez, Demian	PhD	Hispanic	Male
	Guo, Lei	PhD	Asian	Male
	Hao, Yanjun	PhD	Asian	Male
	Huda, Monsurul	PhD	Asian	Male
	Jamerson, Leonard	PhD	Black	Male
	Kelemencky, Sara	MS	White	Female
	Kendall, Lauren	PhD	White	Female
	Khoshnevis, Naeem	PhD	Asian	Male
	Kutliroff, Jerome	PhD	White	Male
	Liu, Chunyu	PhD	Asian	Male
	Meredith, John	PhD	White	Male
	Mostafanejad, Akram	PhD	Asian	Female
	Mousavi, S. Mostafa	PhD	Asian	Male
	Nyamwandha, Cecilia	PhD	Black	Female
	Ogwari, Paul	PhD	Black	Male
	Ogweno, Luke Philip	PhD	Black	Male
	Roodpish, Shima	PhD	Asian	Female
	Satterfield, Trevor	MS	White	Male
	Shahjouie, Alireza	MS	Asian	Male

	Tian, Xiaochuan	MS	Asian	Male
	Tovar, David	MS	White	Male
	Yang, Yang	PhD	Asian	Male
	Young, Brian	PhD	White	Male

Attachment 2

TCA 49-8-602: Center for Earthquake Research and Information.

(a) There is established the Tennessee Center for Earthquake Research and Information, which shall operate as a division of the University of Memphis, to provide services such as the following:
   (1) Accurate, immediate reports for individuals, governmental agencies and the news media on the occurrence of earthquakes;
   (2) Background information on earthquakes for individuals, civic groups, schools, governmental agencies, the news media and others.
   (3) Research related to the causes and consequences of local earthquakes, to develop the information as the precise locations of earthquakes, magnitude-frequency relationships, magnitude-duration relationships, source spectra studies, attenuation studies, bedrock structures studies and behavior of foundation materials studies.
   (4) Studies of the desirability of earthquake resistant construction.
   (5) Advice to governmental bodies, insurance groups and others on the methods and feasibility of reducing earthquake damage; and
   (6) Earthquake prediction.

(b) The university is authorized to accept for the establishment, maintenance or operation of the center gifts, grants, funds and other assistance from any agency of state, federal or local governments, or private entities and individuals, and to use or spend the same on behalf of the center.

Attachment 3

CERI External Grants and Contracts 2013-2015

SPONSORING AGENCY	P.I.	GRANT TITLE	PROJECT PERIOD	GRANT BUDGET
USGS Nehrp	Cramer	Improving Regional Ground Motion Attenuation Boundaries and Models Using Earthscope USArray Data for Use in the National Seismic Hazards Mapping Project	01/01/2013 - 12/31/2013	$ 53,000.00
USGS	Cramer	Professional Seismic Services to Review Nuclear Site Applications	08/01/2012 - 07/31/2013	$ 24,812.00
USGS	Langston, Charles	CERI Annual Support	02/01/2012 - 01/31/2013	$ 50,000.00
USGS	Smalley/ Puchakayala	GPS Array for Mid-America monitoring deformation in the New Madrid Seismic Zone	03/01/2013 - 05/31/2013	$ 10,608.00
NSF	Smalley	REU: Collab Res: Great Earthquakes. Megathrust Phenomenology and Continental Dynamics in the Southern Andes	05/01/2013 - 04/30/2014	$ 9,604.00
USGS	Smalley/ Puchakayala	GPS Array for Mid-America monitoring deformation in the New Madrid Seismic Zone (Supplement)	06/01/2013 - 02/28/2014	$ 35,392.00
AR Geo Survey	Horton, S.	Operation and Maintenance of the Arkansas Seismic Network	07/01/2012 - 06/30/2013	$ 36,000.00
NSF	Puchakayala	Collaborative Research: Deformation Processes in the Central Andaman Islands	07/01/2013 - 06/30/2014	$ 91,434.00
State of TN	Patterson, Gov't Relations	West TN Seismic Safety Commission	07/01/2013 - 06/30/2014	$ 65,000.00
USGS	Withers, M.	Bayou Corne Monitoring: Supplement to Operation of the Mid-America Integrated Seismic Network 2010 -2014 - CERI	08/01/2012 - 01/31/2013	$ 16,860.00
USGS	Withers, Mitchell	Continued Bayou Corne Monitoring: Supplement to Operation of the Mid-America Integrated Seismic Network 2010-2014 - CERI	10/15/2012 - 01/31/2013	$ 18,372.00
NSF	Langston, Powell, Horton, Deshon	Collaborative Research: Northern Embayment Lithosphere Experience (NELE)	06/01/2013- 05/31/2014	$ 192,489.00
NSF	Magnani, Waldron	Toward an Understanding of the long-term deformation in the Mississippi embayment (Phase II) - Year 3	07/01/2012 - 06/30/2013	$ 83,794.00
NSF	Puchakayala	Collaborative Research: Deformation Processes in the Central Andaman Islands	07/01/2012 - 06/30/2013	$ 88,724.00
NSF	Smalley	Collaborative Research: Great Earthquakes, Megathrust Phenomenology and Continental Dynamics in the Southern Andes	09/01/2012 - 08/31/2013	$ 110,001.00
M. Tuttle & Associates	Powell, C.	"Paleoliquefaction Studies in Moderate Seismicity Regions with a History of Large Events: NUREG Report, Training Workshop and Research"	09/01/2012 - 12/31/2012	$ 5,675.00
NSF	Powell, C.	Collaborative Research: Examining the variation in earthquake parameters along the Nicaragua and Costa Rica subduction zone using onshore and offshore seismic data	09/15/2012 - 08/31/2012	$ 17,732.00

Shaw Group	Horton, S.	Monitoring of the LA seismic network	02/27/2013 - 03/01/2014	$	133,333.00
USGS Nehrp	Horton, S.	Seismic Hazard from Induced Earthquakes in Arkansas	06/01/2013 - 05/31/2014	$	58,001.00
USGS	Withers	Operation of the Mid-America Integrated Seismic Network 2010-2014- CERI (Year 4)	02/01/2013 - 05/31/2013	$	208,695.00
USGS	Withers	Operation of the Mid-America Integrated Seismic Network 2010-2014- CERI (Year 4)	06/01/2013 - 01/31/2014	$	469,985.00
			Total Awarded 2013 Funding	**$**	**1,779,511.00**
USGS	Withers	Operation of the Mid-America Integrated Seismic Network 2010-2014- CERI (Year 5)	02/01/2014 - 01/31/2015	$	669,857.00
SCEC	Taborda, R.	Evaluation of Attenuation Models (Q-Vs Relationships) used in Physics-Based Ground Motion EQ Simulation through Validation with Data and Comparisons with NGA	02/01/2014 - 01/31/2015	$	20,000.00
SCEC	Taborda, R.	Evaluation of CVM-SI.26 Perturbations Integration Involving UG Computer Science and Graduate Earth Sciences and Engineering Students	02/01/2014 - 01/31/2015	$	20,000.00
SCEC	Taborda, R.	Validating site response predictions in physics-based ground motion simulations	02/01/2014 - 01/31/2015	$	10,844.00
TEMA	Patterson, G	2013 TEMA/CERI EQ Public Service Announcements	05/01/2013 - 10/31/2013	$	7,741.00
State Farm Insurance	Patterson, G	CERI "Partners in Outreach and Preparedness" (POP) Program	07/01/2013 - 06/30/2014	$	20,000.00
TEMA	Patterson, G	CERI "Partners in Outreach and Preparedness" (POP) Program	07/01/2013 - 06/30/2014		
USGS Nehrp	Cramer, C.	Developing Empirical GMPEs for Eastern North America based on the WGA East ground motion database and additional M6-7 ground motion estimates from historical earthquake intensifies	06/01/2013 - 05/31/2014	$	59,751.00
Ark Geo Survey	Horton, S.	Operation and Maintenance of the Arkansas Seismic Network	07/01/2013 - 06/30/2014	$	36,000.00
NSF	Smalley	Collaborative Research: Great Earthquakes, Megathrust Phenomenology and Continental Dynamics in the Southern Andes	09/01/2013 - 08/31/2014	$	109,872.00
M. Tuttle & Assoc	Powell, C.	Paleoliquefaction Studies in Modern Seismicity Regions with an History of Large Events: NUREG Report, Training Workshop, and Research	09/01/2013 - 05/12/2014	$	8,553.00
USGS	Langston, C.	CERI Annual Support	09/01/2013 - 08/31/2014	$	28,260.00
USGS	Smalley/ Puchakayala	GPS Array for Mid-America monitoring deformation in the New Madrid Seismic Zone	03/01/2014 - 02/28/2015	$	46,000.00
NSF	Langston, Powell, Horton, Deshon	Collaborative Research: Northern Embayment Lithosphere Experience (NELE)	06/01/2014- 05/31/2015	$	169,484.00
NSF	Smalley	REU: Collab Res: Great Earthquakes. Megathrust Phenomenology and Continental Dynamics in the Southern Andes	05/01/2014- 08/31/2015	$	10,355.00

USGS Nehrp	Cramer, C.	A proposal in support of the St. Louis Area Earthquake Hazards mapping projects: Completion of the final 12 SLAEHMP Seismic and liquefaction hazards maps	07/01/2013 - 06/30/2015	$	58,013.00
USGS Nehrp	Cramer, C.	Charleston, SC area earthquake hazards mapping project (CAEHMP) workshop and pilot study: Collab Res with the College of Charleston and University of Memphis	01/01/2014 - 12/31/2014	$	28,968.00
USGS	Smalley/ Puchakayala	GPS Array for Mid-America monitoring deformation in the New Madrid Seismic Zone	03/01/2014 - 02/28/2015	$	48,331.00
NSF Earth Cube	Choi, E.	EarthCube Building Blocks: Earth System Bridge: Spanning Scientific Communities with Interoperable Modeling Frameworks	10/01/2013 - 09/30/2014	$	55,896.00
USGS	Taborda, R	Evaluation of the Southern California Seismic Velocity Models Through Ground Motion Simulation and Validation of Past Earthquakes	04/01/2014 - 03/31/2015	$	67,000.00
USGS Nehrp	Cramer, C.	Improving Regional GMA Boundaries and Models in the CEUS and Developing a Gulf Coast Empirical guide using EarthScope USArray Data for use in the National Seismic Hazards Mapping Project	06/01/2014 - 05/31/2015	$	61,025.00
NSF	Smalley, R.	GPS observations of co- and post-seismic deformation in the Argentine Puna from the 1 Apr 2014, Mw 8.2, Pisagua, Chile, earthquake sequence	06/01/2014 - 05/31/2015	$	33,880.00
			Total Awarded 2014 Funding	**$**	**1,569,830.00**
CB & I	Horton, S.	Monitoring of the LA Seismic Network	03/01/2014 - 02/28/2015	$	141,021.00
USGS	Cramer, C.	A proposal in support of the St. Louis Area Earthquake Hazards mapping projects: Completion of the final 12 SLAEHMP Seismic and liquefaction hazards maps- Supplement	07/01/2014 - 12/31/2014	$	27,316.00
NSF	Smalley, R.	Collaborative Research: Role of the Central Scotia Sea Floor and North Scotia Ridge in the Onset and Development of the Antarctic Circumpolar current	09/01/2014 - 08/31/2015	$	15,301.00
NSF Earth Cube	Choi, E.	EarthCube Building Blocks: Earth System Bridge: Spanning Scientific Communities with Interoperable Modeling Frameworks	10/01/2014 - 09/30/2015	$	62,046.00
USGS Nehrp	Cramer, C.	Improving Regional GMA Boundaries and Models in the CEUS and Developing a Gulf Coast Empirical guide using EarthScope USArray Data for use in the National Seismic Hazards Mapping Project	06/01/2015 - 05/31/2016	$	62,431.00
NSF	Langston, C.	GOALI: Application of wave gradiometry to exploration seismology	07/01/2014 - 06/30/2015	$	64,971.00
USGS Nehrp	Cramer, C., Arellano, D.	Updating Liquefaction Probability Curves, Seismic Hazard Model, and Urban Seismic Hazard Maps with Public Outreach for Memphis and Shelby County, TN	08/01/2014 - 07/31/2015	$	81,126.00

NSF	Smalley	Collaborative Research: Great Earthquakes, Megathrust Phenomenology and Continental Dynamics in the Southern Andes	09/01/2014 - 08/31/2015	$	110,000.00
NSF	Puchakayala, J	Measuring and modeling postseismic deformation processes in Andaman Islands	08/01/2014 - 07/31/2015	$	108,725.00
Ark Geo Survey	Horton, S.	Operation and Maintenance of the Arkansas Seismic Network	07/01/2014 - 06/30/2015	$	36,000.00
USGS	Withers, M.	Operation of the Mid-America Integrated Seismic Network 2015-2019 - CERI	02/01/2015 - 01/31/2020	$	675,000.00
USGS	Smalley, R.	GPS Array for Mid-America - monitoring deformation in the New Madrid Seismic Zone	03/01/2015 - 02/28/2016	$	42,000.00
SCEC	Daub, E.	Effective Friction Laws for Fault Scale Earthquake Rupture and Ground Motion	02/01/2015 - 01/31/2016	$	15,000.00
SCEC	Taborda, R.	A Technical Activity Group on Geotechnical Layer Modeling and Integration in SCEC Ground Motion Simulations	02/01/2015 - 01/31/2016	$	5,000.00
SCEC	Taborda, R.	Toward a Framework for Ground Motion Simulation Validation using Attenuation Relationships. Part 1: Calibration between NGA-West2 Predictions, Physics-Based Synthetics, and Data	02/01/2015 - 01/31/2016	$	20,000.00
Shaw Group	Horton, S.	Bayou Corne Seismic Network Monitoring	03/01/2015 - 09/30/2015	$	50,620.00
NSF	Taborda, R.	SI2-SSI: Community Software for Extreme-Scale Computing in Earthquake System Science	06/01/2015 - 5/31/2018	$	168,000.00
CIT	Taborda, R.	Three-Dimensional nonlinear site effects at US strong motion stations	05/15/2014 - 05/14/2015	$	4,500.00
			Total Awarded 2015 Funding	**$**	**1,684,557.00**

Attachment 4

Copy of Powerpoint given by the Director, Staff, and Graduate Students at the 22 September 2014 CERI general meeting.


CERI Research and Outreach Meeting
September 22, 2014
By PresenterMedia


Agenda
Director's Report
Langston
Academic Programs
Powell
Education & Outreach
Patterson
IT & Seismic Networks
Withers
Student Chapter of the SEG
Bockholt

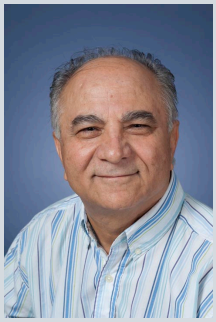
Director's Report

Personnel

Budget

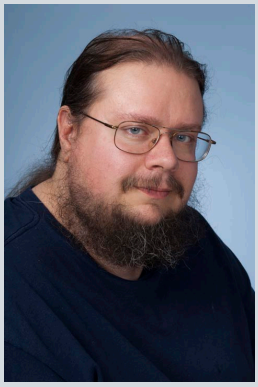
Academic Year Priorities

Personnel - Partings



Al Segadat
(Network Staff)

Personnel – New (sort of)

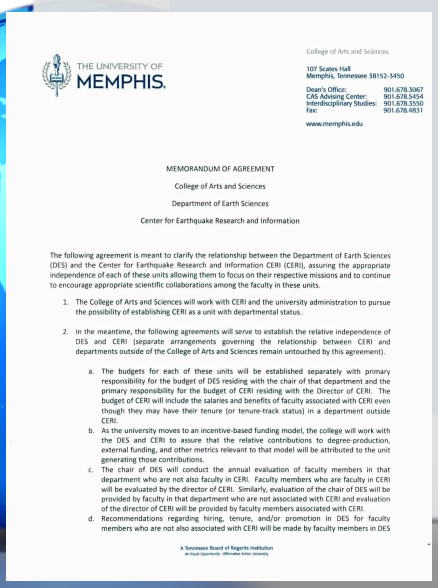


James Davis
(network staff)

Personnel – Faculty

Eric Daub
(Assistant Professor,
Earth Sciences)

Academic Department Status – the most significant change for CERI in the past decade



THE UNIVERSITY OF MEMPHIS.

College of Arts and Sciences

107 Scates Hall
Memphis, Tennessee 38152-3450

Dean's Office: 901.678.3067
CAS Advising Center: 901.678.5454
Interdisciplinary Studies: 901.678.3550
Fax: 901.678.4831

www.memphis.edu

MEMORANDUM OF AGREEMENT

College of Arts and Sciences

Department of Earth Sciences

Center for Earthquake Research and Information

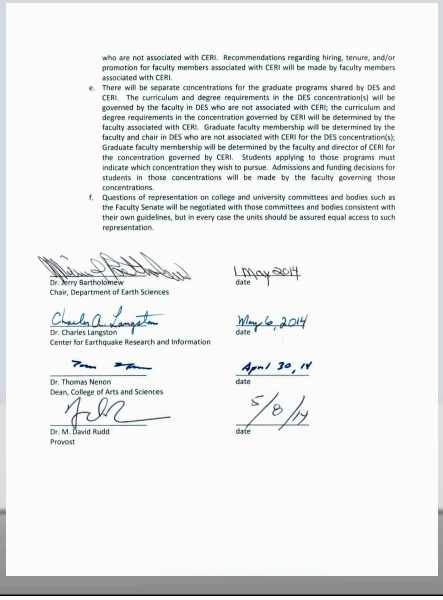
The following agreement is meant to clarify the relationship between the Department of Earth Sciences (DES) and the Center for Earthquake Research and Information CERI (CERI), assuring the appropriate independence of each of these units allowing them to focus on their respective missions and to continue to encourage appropriate scientific collaborations among the faculty in these units.

1. The College of Arts and Sciences will work with CERI and the university administration to pursue the possibility of establishing CERI as a unit with departmental status.

2. In the meantime, the following agreements will serve to establish the relative independence of DES and CERI (separate arrangements governing the relationship between CERI and departments outside of the College of Arts and Sciences remain untouched by this agreement).

   a. The budgets for each of these units will be established separately with primary responsibility for the budget of DES residing with the chair of that department and the primary responsibility for the budget of CERI residing with the Director of CERI. The budget of CERI will include the salaries and benefits of faculty associated with CERI even though they may have their tenure (or tenure-track status) in a department outside CERI.
   b. As the university moves to an incentive-based funding model, the college will work with the DES and CERI to assure that the relative contributions to degree-production, external funding, and other metrics relevant to that model will be attributed to the unit generating those contributions.
   c. The chair of DES will conduct the annual evaluation of faculty members in that department who are not also faculty in CERI. Faculty members who are faculty in CERI will be evaluated by the director of CERI. Similarly, evaluation of the chair of DES will be provided by faculty in that department who are not associated with CERI and evaluation of the director of CERI will be provided by faculty members associated with CERI.
   d. Recommendations regarding hiring, tenure, and/or promotion in DES for faculty members who are not also associated with CERI will be made by faculty members in DES

A Tennessee Board of Regents Institution
An Equal Opportunity, Affirmative Action University



who are not associated with CERI. Recommendations regarding hiring, tenure, and/or promotion for faculty members associated with CERI will be made by faculty members associated with CERI.

e. There will be separate concentrations for the graduate programs shared by DES and CERI. The curriculum and degree requirements in the DES concentration(s) will be governed by the faculty in DES who are not associated with CERI; the curriculum and degree requirements in the concentration governed by CERI will be determined by the faculty associated with CERI. Graduate faculty membership will be determined by the faculty and chair in DES who are not associated with CERI for the DES concentration(s); Graduate faculty membership will be determined by the faculty and director of CERI for the concentration governed by CERI. Students applying to those programs must indicate which concentration they wish to pursue. Admissions and funding decisions for students in those concentrations will be made by the faculty governing those concentrations.

f. Questions of representation on college and university committees and bodies such as the Faculty Senate will be negotiated with those committees and bodies consistent with their own guidelines, but in every case the units should be assured equal access to such representation.

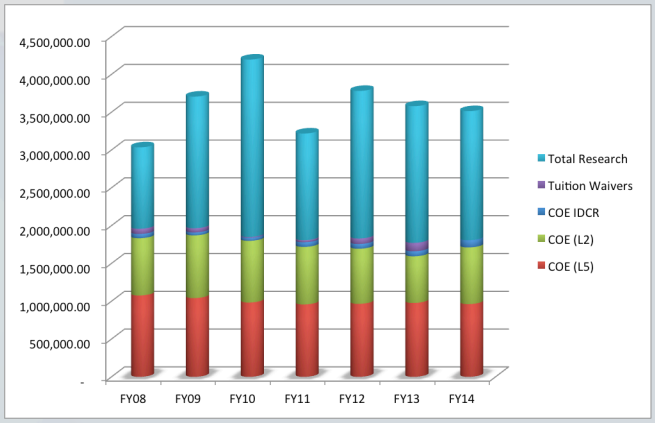
Dr. Jerry Bartholomew
Chair, Department of Earth Sciences
date: 1 May 2014

Dr. Charles Langston
Center for Earthquake Research and Information
date: May 6, 2014

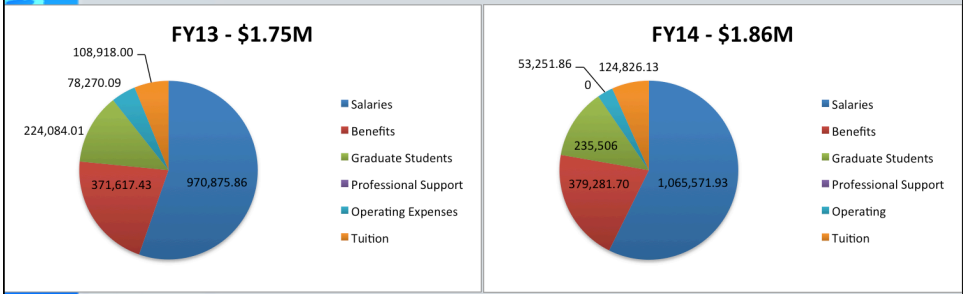
Dr. Thomas Nenon
Dean, College of Arts and Sciences
date: April 30, 14

Dr. M. David Rudd
Provost
date: 5/8/14

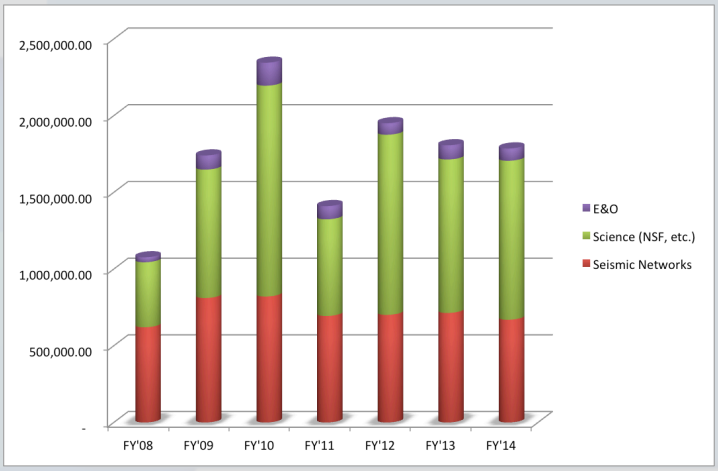
Budget – COE, Research, and University Match



COE Pieces of the Pie - Costs (with research salary recovery added)

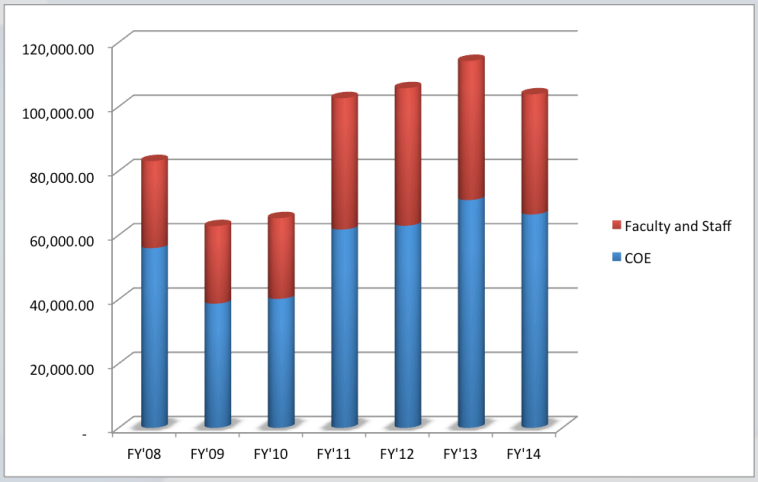


Research



$8.4M in pending proposals!

Indirect Cost Recovery



2013-2014 Priorities (Director's Agenda from last year's meeting)

- Responsibility Center Management (RCM) and University Reorganization
  - Ongoing with Major Implications
- External Advisory Committee
  - Delayed because of CERI departmental status
- Undergraduate and Graduate Progam Initiatives
  - CERI Transition to an Academic Department
- Website Revision
  - Completed

2014-2015 Priorities

- Departmental Transition
  - P&T
  - PhD concentration in Geophysics, Earth Sciences
  - MS concentration in Geophysics, Earth Sciences
- External Advisory Committee

2014-2015 Priorities

- **The Dean's SRI Challenge**

$700K → $400K in University Match

2014-2015 Priorities

- **Response**

Increase PhD Graduation Rate
Increase MS Graduation Rate
(MS-on-the-way-to-PhD)
Increase External Funding

Academic Programs

Chris Powell

Geophysics Graduate Program

Update on Academic Transition

Our proposal to create a Concentration in Geophysics within the Earth Sciences major was approved unanimously by the CAS Graduate Council.

We are requesting that the 4000 level geophysics courses be deleted. We may not be able to list them as CERI courses because we do not have an undergraduate program. Enrollment in these courses is very low.

Our proposed changes to the 7000 courses will go before the CAS Graduate Council next month.

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Geophysics Graduate Program

Present Status: Students Under CERI Support
23 Ph.D.
5 M.S.

Growth of the program over the last three years – trends:
-Increased number of applicants

-Increased interest in engineering aspects of the program

-Increased percentage of geophysics students admitted into the PhD program

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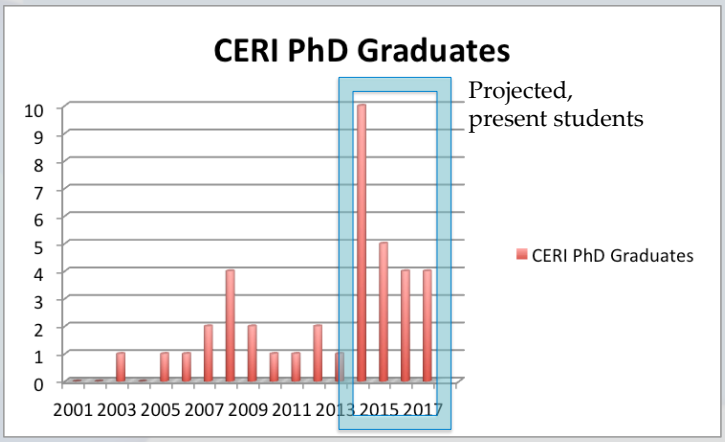
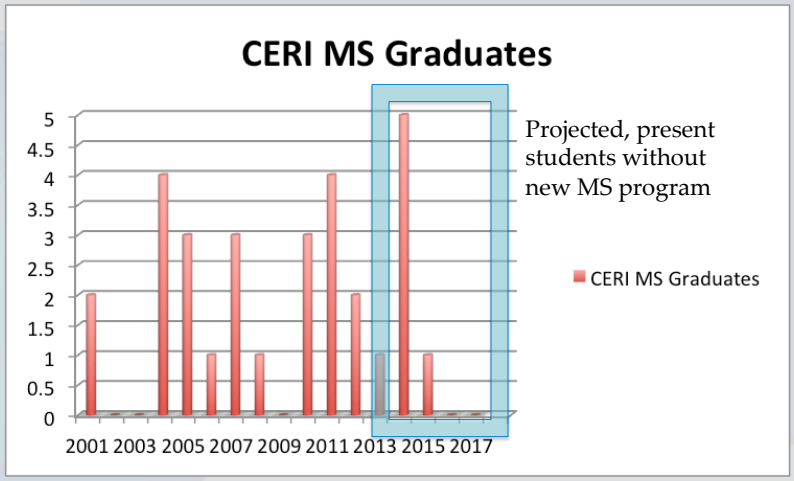
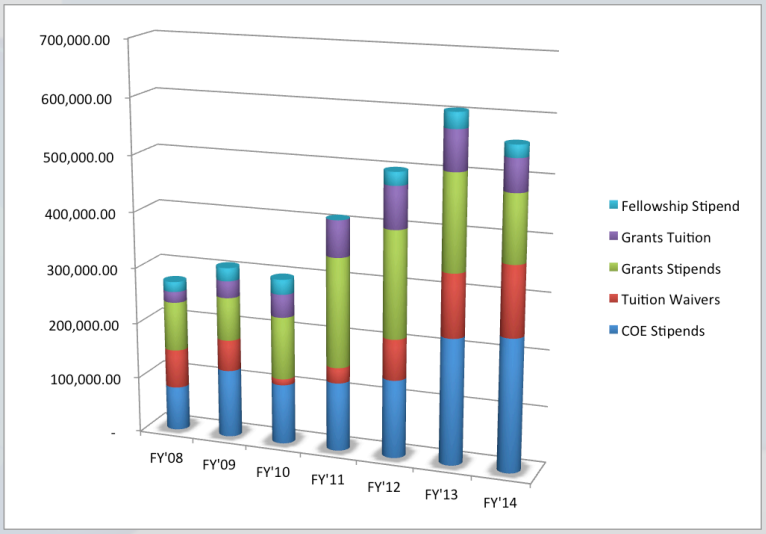
PhD Program



M.S. Program



Program(stipends and tuition)



Stipends

$18K – M.S.

$20K – PhD

$22K – Palisades Fellowship

12 month RA support; nationally competitive

Recruitment

Former students are our best ambassadors
Contact colleagues; attend student posters
Higher visibility

In Process ~~Needs~~:

Online Admissions Process
MS-on-the-way-to-PhD Program
Greater visibility

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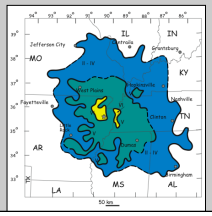
Center for Earthquake Research and Information

CERI Education and Outreach Program

CERI was originally created through the efforts of State Representative Brad Martin in 1977 following a M 5.0 earthquake that caused minor damage in Memphis. Mr. Martin was concerned about the limited information that was available following this quake and the lack of public EQ preparedness . The TEIC was created by House Bill 1149 to provide the following:

1. Provide accurate, immediate reports for the public, media, and governmental agencies
2. Provide background information on Eq's for the same groups
3. Research related to the causes and consequences of EQ's
4. Advice to government, insurance groups, and others on the methods and feasibility of reducing EQ damage



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Center for Earthquake Research and Information

West Tennessee EARTHQUAKE AWARENESS WEEK

2014 Science Fair: co organized by CERI

Poster contest for grades 4-6 in West TN

- Sponsored by State Farm Insurance and the TN Emergency Mgmt. Agency
- See www.ceri.memphis.edu and itmattersareyouprepared.org for details
- Contact: Gary Patterson, The Center for Earthquake Research and Information glpttrsn@memphis.edu

STATE FARM INSURANCE

poster contest winners

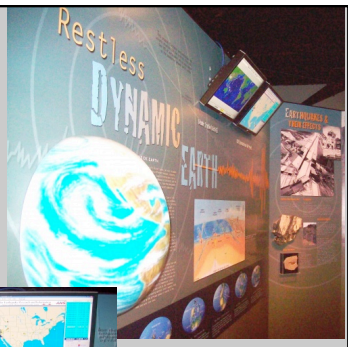
WEST TENNESSEE SEISMIC SAFETY COMMISSION

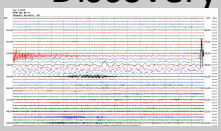
TENNESSEE DEPARTMENT OF EDUCATION

THE UNIVERSITY OF MEMPHIS
Center for Earthquake Research and Information

Museum Displays

- Memphis Pink Palace Museum
- Reelfoot Lake Visitors Center
- New Madrid Museum
- Discovery Museum





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CERI Partners in Preparedness Program

Private sector and agency donations help support CERI E & O program and special projects

2008 – $32,000
2009 - $35, 000
2010 - $30,000
2011 - $41,000
2012 - $30,000
2013 - $27, 500
2014 - $15,000

STATE FARM INSURANCE
Auto Life Fire

acp Mid-South

MLGW

1811-2011 Bicentennial New Madrid Earthquakes
EARTHQUAKES OF THE PAST
SCIENCE OF THE PRESENT
UNDERSTANDING IN THE FUTURE

West Tennessee Seismic Safety Commission

TENNESSEE.GOV

As proposed by Collierville Legislator Mark Norris, Tennessee House Bill 2192/Senate Bill 3068 (TCA Title 58, Section 4) established the West Tennessee Seismic Safety Commission to "prepare Tennesseans for the next large earthquake."
-Commissioners are appointed by the Governor, Lt. Governor, and Speaker of the House
-U of M serves as fiduciary agent
-CERI is mandated to provide an organizational framework for the WTSSC

2013-14 Chair, Elaine Clyburn
Vice Chair, Gary Graves
Mike Molder (Fire)
Elly Jones (Insurance)
Cliff Deberry (Utilities)
Steve Horton (Seismology)
Barry Moore (Public Health)
Bob Nations (EMA)
Mike Walker (Architecture)
John Bucy (Policy)

Executive Director: Gary Patterson
Itmattersareyouprepared.org

State funding since 2006
-$555,000
External research support to date
-$310,00 (2010 Assisi Foundation)
Direct CERI staff support
-$28,000 per year

Networks Report

Mitch Withers

CERI General Meeting

September 22, 2014

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Seismic Network

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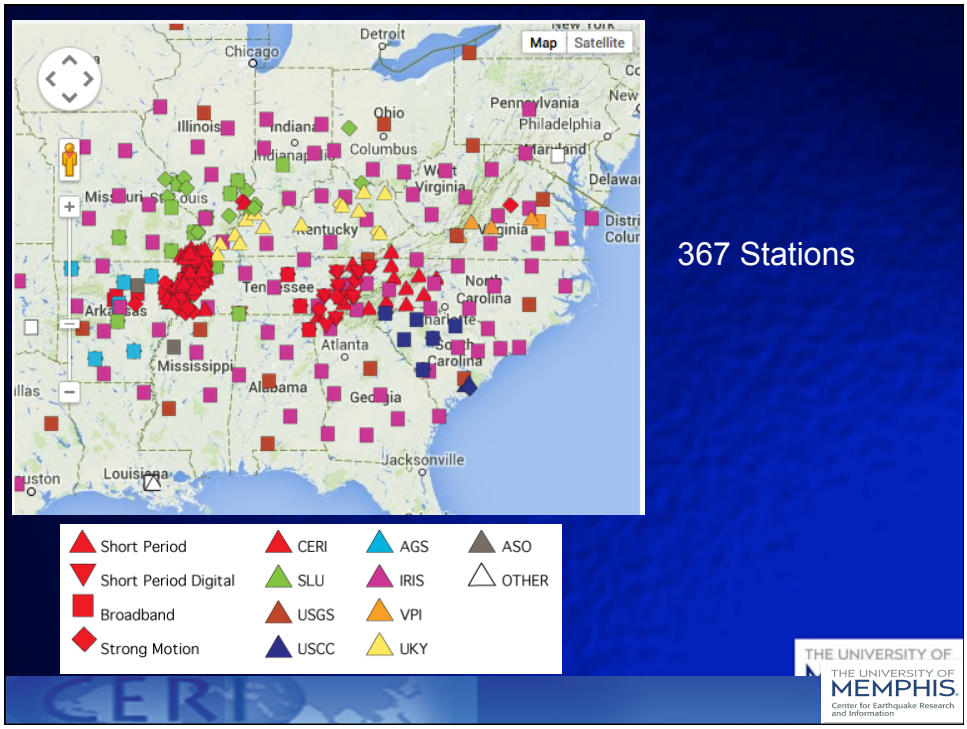
Map
Satellite
Chicago
Detroit
Illinois
Indiana
Ohio
Columbus
Pennsylvania
Philadelphia
Kentucky
Tennessee
Mississippi
Alabama
Atlanta
Georgia
Jacksonville
Louisiana
Carolina
Short Period
Short Period Digital
Broadband
Strong Motion
CERI
SLU
USGS
USCC
AGS
IRIS
VPI
UKY
ASO
OTHER
367 Stations
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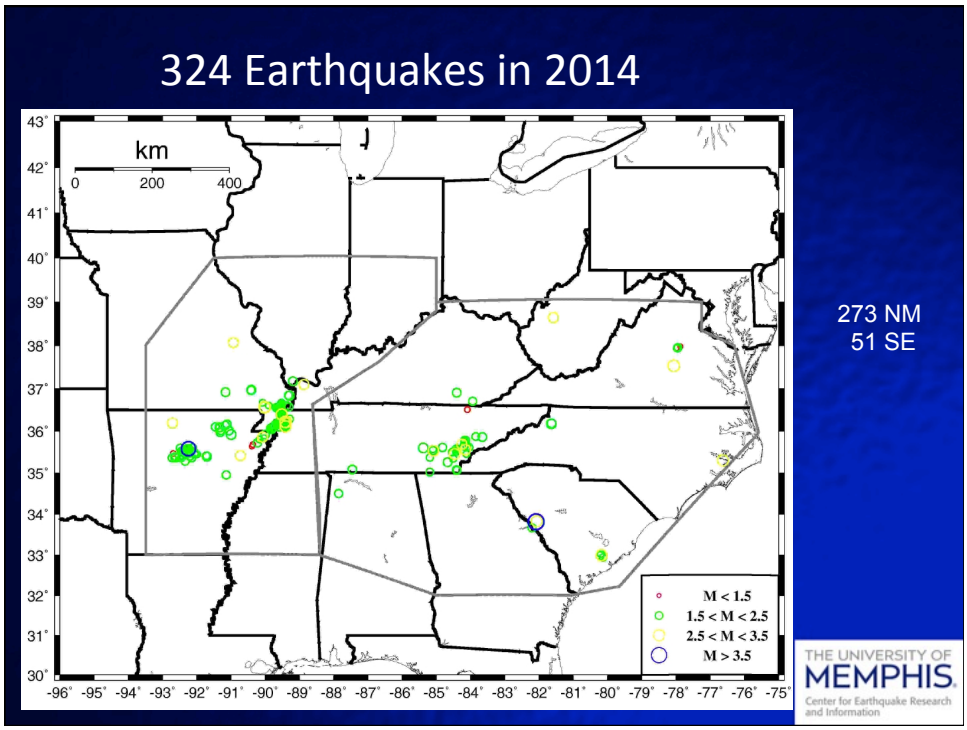
Center for Earthquake Research and Information


324 Earthquakes in 2014
km
0
200
400
M < 1.5
1.5 < M < 2.5
2.5 < M < 3.5
M > 3.5
273 NM
51 SE
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Center for Earthquake Research and Information

Two Largest Events

Origin Time: 2014/02/15 03:23:38.15
Magnitude: 4.1 Mwr
Hypocenter: 33.8167 -82.0920
Depth: 5.18
3.94 km west of Brunson Crossroads, SC (Edgefield)

950 km apart (590 miles) Distance between SF and LA is about 381 miles.

Origin Time: 2014/06/04 21:19:24.33
Magnitude: 3.8
Hypocenter: 35.5795 -92.2450
Depth: 0.08 km
3.07 km north of Whispering Springs, AR

THE UNIVERSITY OF MEMPHIS
Center for Earthquake Research and Information

2014 Funding: $713,038 Authorized, $669,856 Appropriated

Proposed Budget next funding cycle

2015	2016	2017	2018	2019	Total
730,545	751,654	773,377	795,728	818,730	3,870,034

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ToDo

- Complete DBB move
- NC reconfig
- SP upgrades
- AQMS Post-processing
- Solaris->Linux
- Sundry requirements in RFP

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Center for Earthquake Research and Information

Computer Network

THE UNIVERSITY OF MEMPHIS
Center for Earthquake Research and Information

Server name	Primary Contact	IP addresses (if static)	O/S	Location
throy.ceri.memphis.edu	Robert DeBula	141.225.157.106	Solaris 10 x86	3904 Central Rm 218
enigma.ceri.memphis.edu	Robert DeBula	141.225.157.75	Solaris 10 Sparc	3904 Central Rm 218
galileo.ceri.memphis.edu	Robert DeBula	141.225.157.76	Solaris 10 Sparc	3904 Central Rm 218
ceridsm.ceri.memphis.edu	Robert DeBula	141.225.157.82	Mac OS X Server 10.6	3904 Central Rm 218
ceridsr1.ceri.memphis.edu	Robert DeBula	141.225.157.103	Mac OS X Server 10.6	3892 Central Rm 115
ceridsr2.ceri.memphis.edu	Robert DeBula	141.225.157.104	Mac OS X Server 10.6	3904 Central Rm 213
mudbug.ceri.memphis.,edu	Robert DeBula	141.225.157.83	Solaris 9 Sparc	3904 Central Rm 218
crawdad.ceri.memphis.edu	Robert DeBula	141.225.157.84	Solaris 9 Sparc	3904 Central Rm 218
shelob.ceri.memphis.edu	Robert DeBula	141.225.157.24	Solaris 9 Sparc	3904 Central Rm 218
araminta.ceri.memphis.edu	Robert DeBula	141.225.157.36	Unix undetermined	3904 Central Rm 218
cadwal.ceri.memphis.edu	Robert DeBula	141.225.157.40	Solaris 10 x86	3904 Central Rm 218
bbking.ceri.memphis.edu	Robert DeBula	141.225.157.44	Ubuntu Linux	3904 Central Rm 213
atreides.ceri.memphis.edu	Robert DeBula	141.225.157.52	Solaris 9 Sparc	3904 Central Rm 218
packrat.ceri.memphis.edu	Robert DeBula	Not yet available	Unix undetermined	Destined for 3892 Central Rm 115
miai.ceri.memphis.edu	Robert DeBula	141.225.157.72	Solaris 9	3904 Central Rm 218
marco.ceri.memphis.edu	Robert DeBula	141.225.157.51	RHE 5.6 Linux	3904 Central Rm 218
polo.ceri.memphis.edu	Robert DeBula	141.225.157.74	RHE 5.6 Linux	3904 Central Rm 218; Destined for 3892 Central Rm 115
sabaki.ceri.memphis.edu	Robert DeBula	141.225.157.59	Windows 2003 Server	3904 Central Rm 218
smeagol.ceri.memphis.edu	Robert DeBula	141.225.156.70	Solaris 9 Sparc	3904 Central Rm 218
clavdivs.ceri.memphis.edu	Robert DeBula	141.225.157.48	RHE 5.6 Linux	3904 Central Rm 218
cirith.ceri.memphis.edu	Robert DeBula	141.225.157.54	Solaris 10 Sparc	3904 Central Rm 218

Bob's toys that make your life easier

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Center for Earthquake Research and Information

For Next Year

- Power Outage post mortem
- Harden server room
- Populate backup rack in 3892
- Meet with Computer Committee

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Questions and Suggestions?

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University of Memphis Society of Exploration Geophysicists Student Chapter

CERI Department Meeting
Fall 2014

Officers

- Blaine Bockholt- President
- Naeem Khoshnevis- Vice-President
- Yang Yang- Secretary
- Brain Young- Secretary

Members

- 29 Members
  - CERI
  - DES
  - Civil Engineering
- Website

  https://umdrive.memphis.edu/g-SEG/index.html

Goals

- REACH SUMMIT LEVEL!!!!!!

How high can you climb?

Got what it takes to reach the top? Float your mouse over the different Student Chapter Rankings above to find out.

The journey of a Student Chapter is like climbing a mountain: you start out as merely a group of like-minded individuals who share the same hope, passion, and ambition. But if you find the right path, you can achieve a position of leadership and achievement to last you the rest of your life. SEG invites you to take that challenge - and we will help you chart your progress along the way!

Criteria

- Serve
  - SEG boards or committees
- Organize
  - Student Activities
- Get Involved
  - Education and Outreach
- Participate
  - SEG Student Programs
- Submit
  - Annual Report
- Mentor
  - Other Student Chapters

What We Have Done 2013

- Outreach Programs
  - Hutchison Girls School "How to be a women scientist"
  - First Lego League Competition
  - Helped with NELE
- Meetings
  - Dr. Nick Moldaveanu and Dr. Linda Kah Lectures

What We Have Done 2013

- Social Events
  - Pumpkin Carving
- SEG Student Programs
  - SEG/ExxonMobil Student Education Program
    - Adewale Amosu
  - Chevron Student Leadership Symposium
    - Blaine Bockholt
  - AAPG/SEG Student Expo
    - John Meredith
    - Matt Cooley
    - Adewale Amosu
    - Paul Ogwari
    - Donny Dangkua

What We Are Working On

- Outreach Programs
  - Science Fair Judges
  - First Lego League
- Education Programs
  - CERI Colloquium Series
    - Dr. Clifford Frolich (UT Austin)
    - Dr. Hugues Djikpesse (Schlumberger)
    - Dr. Dan Hollis (Nodal Seismic)
    - Phil Bording Short Course (Alabama)
    - Dave Hale (SEG Distinguish Lecturer)
    - Lijun Liu (UIUC)
    - Fan-Chi Lin (UofU)

What We Are Working On

- Student Chapter Sponsored Field Trip
- More Social Activities
- SEG Student Programs
  - SEP (Denver 2014)
    - Blaine Bockholt
    - Naeem Khoshnevis
    - Yang Yang
  - SLS (Denver 2014)
    - Akram Mostafanejad

Attachment 5

Report of the CERI External Review Committee 2011

United States Department of the Interior

U.S. GEOLOGICAL SURVEY
EARTHQUAKE SCIENCE CENTER

June 7, 2011

Dr. Henry Kurtz, Dean of the College of Arts and Sciences
University of Memphis
107 Scates Hall
Memphis, TN 38152

Dear Dean Kurtz,

The enclosed is the report of the External Review Committee for the Center for Earthquake Research and Information at the University of Memphis.

We wish to express our thanks to everyone that we met with during our visit to the campus on April 25- 26, 2011, and for the extensive preparations that went into our visit.

The Committee strongly believes in the CERI mission and hopes that this report will help CERI continue to grow and prosper at the University of Memphis. If we can be of further assistance please don't hesitate to call or contact us.

Sincerely your,

William L. Ellsworth

Dr. William L. Ellsworth
U. S. Geological Survey

Professor Stephen P. Grand
University of Texas at Austin

Steven Malone

Professor Emeritus Stephen D. Malone
University of Washington

Report of the External Review Committee
for the Center for Earthquake Research and Information
University of Memphis
June 7, 2011

Introduction.

The University of Memphis appointed an external committee to review the Center for Earthquake Research and Information (CERI) and requested a frank assessment of the strengths and weaknesses of the Center. The Committee was composed of Dr. William L. Ellsworth (chair, U. S. Geological Survey), Professor Stephen P. Grand (University of Texas at Austin) and Professor Emeritus Stephen D. Malone (University of Washington). The Committee met in Memphis on April 25 and 26, 2011. Over the course of 1 ½ days we met with the Provost; Vice Provost for Research; Dean of the College of Arts and Sciences and Associate Dean for Graduate Studies and Research; the Director, faculty, graduate students and staff of CERI; and the Chair and faculty of the Department of Earth Sciences.

The Committee was charged with reviewing and making recommendations in five key areas: research, academics, seismic networks, education and outreach and institutional relations. The materials we were provided and the preparations for our visit by all of the participants in the review were very thorough and extremely helpful. We also deeply appreciate the time and thought that everyone we spoke with put into our meetings and the frank and open discussions we had with them. We are also indebted to the CERI staff, who arranged our visit and schedule. We felt that we made very efficient use of our time during our brief visit to the campus. Following our visit, the Committee met by conference call on several occasions to prepare our recommendations. This document constitutes the report of the Committee.

Executive Summary.

The Center for Earthquake Research and Information at the University of Memphis has an excellent reputation in the international seismological community for its many contributions to the understanding of the causes and consequences of earthquakes. It has also been a leader in the U.S. Advanced National Seismic System and carries major responsibilities for earthquake reporting as a Tier 1 network. The Education and Outreach programs at CERI have had a major impact on awareness of earthquake hazards in the State of Tennessee and surrounding region. CERI has also been growing a graduate degree program in recent years that has begun to produce a steady stream of M.S. and Ph.D. degrees in geophysics.

CERI has a well-defined Mission with clear statements of its Vision and Core Values contained in the CERI Handbook. The success of the academic program has permitted CERI to expand its already strong program of research to better address this component of the Vision of solving key problems in continental geology and natural hazards. We believe that the other half of the Vision that covers the academic program can be

improved by using the Core Values to guide interactions between faculty and student, and between the CERI Directors of the five principal activity areas and the faculty and staff. Ongoing attention needs to be paid to transparency in decision-making, free and open discourse, and scientific and professional integrity.

It is evident to the committee that there is a serious disconnect between CERI and the Department of Earth Sciences (DES). While some of the problems can be blamed on differences in the primary goals of the two groups and their physical separation, the controversies over seemingly minor issues have developed into long standing and debilitating animosities.

Because of institutional metrics established by the Tennessee Board of Regents we see no reasonable restructuring of CERI's overall relationship with DES that would not do one or the other, or probably both entities, serious damage. Thus within the current structural framework we suggest the following actions:

At the College/University level we suggest a committee be formed to draft a Memorandum of Agreement (MOA) containing specific written guidelines to help with the apparent incompatibilities between CERI and DES. The commendable policy of encouraging collegial discussions and consensus building that seems to have worked very well between the disciplines of geology, geography and archeology is not working in CERI's case. Leadership from above is needed to help set specific policies and procedures. Clarity from above is now critical.

At the departmental level we suggest that written policies be developed to the committee level and that committee and general faculty meetings have and retain written minutes. We trust that the serious understaffing issues at DES of the past year will change soon with the hiring of at least one new staff member. Having faculty do lots of clerical work when they already have a tremendous teaching load is bound to create problems.

At the CERI level, recognize the important role of undergraduate education at U of M and in DES and try to help support that role. The University of Memphis is a commuter, primarily teaching university, not a major research university. While excellent research is done both in CERI and DES, quality and appropriate teaching is paramount and CERI must contribute to that effort. Recognize that DES has been woefully understaffed thus patience and respect is needed by CERI when common academic procedures are involved.

CERI students need to have a broader graduate student experience. Those coming from a physics/math/engineering background should be allowed if not required to take some basic geology and those coming from a geology background should be allowed if not required to take some math/physics outside of CERI. Students should also be more involved with routine CERI tasks such as seismic analysis, field installations and repair, and education and out-reach. CERI should continue working on developing a service geophysics course for DES students who don't have the math/physics to handle the fundamental theory.

Research at CERI.

The Committee was asked to examine the research program at CERI and to make recommendations about the staffing balance, new activities that it might pursue to increase its impact, and the potential benefits of one or two faculty hires for new or existing research areas. The committee met with the CERI faculty, students, and seismic network and E&O staff during our visit, and gained a valuable perspective from each group about current activities, gaps and opportunities.

In general, we were impressed with the breadth of the research program, which covers many key areas in earthquake science, particularly as it applies to the questions of intra-continental seismicity. This program also provides a broad foundation for the education of graduate students in geophysics.

Staffing

The tenure track faculty currently consists of four full professors. The five non-tenure-track research professors hold ranks that are distributed between assistant and full professor. All have their academic home in the Department of Earth Sciences. In addition, there is one CERI faculty associate from DES, and one adjunct professor from the USGS.

In general, we found the balance between tenure track and research faculty to be appropriate. The research specialties of the research faculty also complement those of the tenured faculty, adding needed breadth to the CERI teaching and research program. We also note that the tenured faculty are all senior, which raises the issue of their replacements as retirements approach or occur.

CERI has lost significant capability in the past 5 years or so through the resignation of faculty and relocation of USGS researchers. Fields that have been most impacted include paleoseismology, tectonic geomorphology and earthquake mechanics. It would seem prudent for CERI, in cooperation with the DES faculty, to develop a strategic staffing plan that identifies needed capabilities and anticipates the filling of openings as they arise. Overlap with current faculty would be desirable.

Our meeting with the CERI graduate students left us with the clear impression that they valued the education and working environment at CERI. The students told us that they had no concerns about access to their advisors or other CERI faculty, indicating that the faculty/student ratio is not a concern at the present time.

The 50+ members of CERI are supported by a staff of three with responsibilities for administration, finances and academic services. CERI's large number of external contracts, responsibilities to the State of Tennessee as a state agency, responsibilities as an ANSS Tier 1 network, and graduate student population of 20 suggest to us that these staff positions are essential to the smooth operation of the Center.

Activities to Increase CERI's Impact

Because the fundamental reason for CERI is the earthquake hazard in Tennessee and more broadly the mid-continent, research that bears on improving the understanding of the hazard and approaches to reduce the risk should continue to be at the center of CERI's research agenda. Here, we list several research areas that we believe should be (or continue to be) central components in CERI's portfolio:

- Mechanics of intracontinental deformation.
- Hazards of triggered and induced seismicity.
- Physics-based approaches to probabalistic seismic hazards in the central and eastern U.S.
- Ground motion equations for engineering applications based on physics of wave propagation and continental structure.
- Research in the interface between hazards and risk; structural vulnerability and loss estimation.

Strategic Hires

Based upon all of the input that we received, and in consideration of the scope of CERI's mission and its current capabilities, we identified several areas where the Center's core competency could be strengthened or broadened. These suggestions are ours alone. We offer these suggestions as areas to be considered as CERI considers a strategic staffing plan.

- Paleoseismology/Geomorphology
- Continental dynamics/geodynamics/lithospheric studies
- Earthquake Physics
- Earthquake Engineering
- Risk Assessment and Mitigation

We listed paleoseismology/geomorphology at the top of our list for several reasons. First, this has long been one of the most important research areas at the University of Memphis, involving CERI, DES and USGS. Although a DES faculty member is currently a CERI Associate, we were told that this arrangement was unlikely to be renewed. Coupled with the loss of Mike Ellis from the CERI faculty, and departure of Buddy Schweig and Tish Tuttle from the USGS office in Memphis, we are concerned that research in this vital area may lose momentum at a time when the debate over the hazard has never been sharper. New technologies, such as LIDAR have important potential for expanding the geographic scope of paleoseismic investigations, just as they proved essential for revolutionizing the understanding of active faulting in the Pacific Northwest.

The other four suggestions are also directly linked to the long-term goal of building hazard models that are based on a physical understanding of the Earth systems and applying that understanding to mitigate the risk.

Academic Program.

The committee was asked to examine the academic program at CERI and to make recommendations about DES-CERI relations, the appropriate role of CERI in undergraduate education, and the role research professors in the graduate program. The committee met with CERI faculty and DES faculty separately. The committee also met with CERI graduate students in an open and enjoyable discussion.

The Department of Earth Science has four groupings, Geography, Archeology, Geology, and Geophysics. CERI comprises the Geophysics group within DES. It was clear to the committee that that are severe frictions between CERI and the other parts of DES. We address this issue in a later part of the report but here we will focus on specific issues.

Undergraduate Program

CERI has relatively little involvement with the undergraduate program of the DES. DES, on the other hand, is strongly committed to undergraduate education with heavy teaching duties. Undergraduate geophysics degrees are uncommon in the United States and with the state responsibilities of CERI as a research center the committee felt it is not necessary that CERI take on responsibility for an undergraduate option in geophysics. The committee did feel, however, that CERI could participate in undergraduate education through offering appropriate courses such as a general geophysics course or natural hazards course at the upper division level for DES majors and graduate students (see below).

Graduate Program

Overall the committee was impressed by the CERI graduate program with the students showing a high level of excitement and satisfaction with their research and interaction with CERI faculty. CERI graduate students are given strong direction by a supervisor and committee. Student research projects are significant and well defined and the students seemed enthusiastic and content. CERI offers an excellent range of graduate level courses for their students directly related to CERI research interests. This is positive but the committee felt that it is also important for graduate students to broaden their options and to take courses in math, physics, geology and/or engineering outside of CERI. We had the impression, however, that students were sometimes being denied permission to take courses outside of CERI that they believed would strengthen or broaden their skills. It was unclear to us how such decisions are appealed but we encourage CERI to allow more flexibility in taking outside courses.

The committee felt that it would be useful for DES to offer a graduate level geology course for geophysics students without a geology background (not atypical of geophysics graduate students). Conversely, the committee felt that CERI should offer at least one survey course in geophysical methods that could be taken by non-geophysics DES graduate students and perhaps upper division undergraduate students. Graduate student TA experience is also valuable and not offered by CERI. Having a service geophysics

course may allow such a TA experience. It was also noticed that few if any current students were listed in the 2009 – 2010 publication list of CERI. PhD students should be strongly encouraged to publish their research as part of obtaining a PhD degree.

Concern was raised about the graduate admissions policy of DES by CERI faculty. Both CERI and DES seem committed to developing stronger PhD programs, which the committee strongly endorses. High quality graduate students are critical to this. The current environment is such that there is strong competition for top graduate students in geophysics across the country. Therefore the committee strongly endorses the recruiting efforts for graduate students by CERI and encourages a flexible graduate admission process. The DES admissions committee meets once a week during the heavy admission time period and this seems reasonable. All graduate students are admitted through DES and thus rules developed by DES for graduate admissions should be followed including respect for the position of graduate coordinator. Issues that have arisen seem to be due to a lack of communication between DES and CERI regarding student admission. The committee encourages DES with CERI participation to develop written rules for graduate admissions including communication protocols for rapid dissemination of information on admission to all interested faculty. CERI, as well as other faculty, should be able to, at least informally contact graduate students quickly upon the admission decision without waiting for formal admissions letters to be written and need to be informed of admission decisions promptly.

Another concern mentioned by CERI faculty was the lack of a web presence on the DES webpage. Indeed, in discussions with the CERI graduate students, not one discovered CERI through the DES webpage. All graduate programs including Geophysics through CERI should be prominent on the DES webpage. DES is understaffed and CERI has the resources to help with the webpage. The committee encourages collaboration between DES and CERI to improve their webpage specifically regarding the presence of the CERI program.

Research Professors

The committee was asked to consider a fair method for promotion and attainment of graduate faculty status for research professors. The committee feels that research professors should play an active role in the graduate program including supervising students. They add breadth to the opportunities available for graduate student research and having graduate faculty status makes the position more attractive which is important for recruiting and retaining high quality candidates. It is clear to the committee that the CERI Director must have a primary role in hiring and promoting research professors yet, due to their role in education, DES must also have some role in evaluating them. A clear policy on evaluation and promotion must be written. We suggest a committee from DES and CERI attempt to write these guidelines but if a mutually agreed upon set of guidelines cannot be reached by the committee then it is imperative that the Dean take a strong role in writing such guidelines.

One suggestion might be to have a DES faculty member included on future CERI

research professor searches to give DES a voice in the process while CERI retains overall control. Graduate faculty status could then be accomplished at the hiring stage. Perhaps promotion could be handled similarly. The guidelines should also address the opportunity for movement from the research to tenure track. We understand that there is an option for research faculty to request transfer to the tenure track within the first three years of their appointment. Perhaps this process is well-defined by university policy, but if not, we felt that it should also be considered in the guidelines, as when vacancies among the tenure track faculty arise it is natural to first look inside. In general, we believe that the university will be better served by an open, national search.

Seismic Networks.

The committee was asked to review the CERI seismic network for it meeting the goals of ANSS and the local user communities. We were also to look for any specific areas where improvements could be made and also if there were gaps in staffing or expertise that was needed to improve operations.

The CERI seismic network carries major operational responsibilities in the U.S. Advanced National Seismic Network (ANSS). Successful operation of the network requires a broad set of skills ranging from the siting and installation of stations, to the planning and implementation of telemetry systems, to construction and maintenance of central computer facilities, to the analysis of the data and to the public dissemination of results. The very wide geographic span of the network, mix of instrumentation including stations operated by cooperating networks and ongoing seismic activity near Guy, Arkansas present significant challenges to the staff as they work to meet their responsibilities as a Tier 1 network in the ANSS .

Based on a meeting with most of the operations staff, reviewing documents related to operations and plans, the CERI web pages, data products found at IRIS DMC and discussions with others both in and outside of ANSS we have the following observations and recommendations:

The network staff is obviously a very professional, high functioning group with dedication to operating a diverse set of instruments and processing facilities to produce products, generally inline with ANSS objectives. The collegial nature of the group, the semi-informal managerial style, the review and reporting procedures and the apparent ownership of maintaining quality data seems to empower the engineering staff resulting in a seismic network of high technical quality. The following list of suggestions are ordered in priority and schedule.

Station meta-data - Of highest priority and needing immediate attention is the generation of station-channel metadata in dataless SEED format and submission to NEIC and IRIS DMC. It appears that all the needed information exists (the hard part) but producing the properly formatted files is stuck somewhere. Generating such SEED files is not trivial but once learned is straightforward if somewhat tedious. Get PDCC-3.7 from IRIS and Appendix-C of SEED manual. IRIS personnel are good at telephone consulting when

stumped.

ShakeMap - Arrangements with NEIC to actually produce ShakeMaps for the region are good; however CERI must provide appropriate parametric data from it's own stations quickly after an earthquake. This depends on having good meta-data (see above) and an analysis program. While the new AQMS system has such a module included it is not likely that it will be implemented at CERI in less than a year (see below). An interim solution is to provide the waveform data from broad-band and strong-motion stations and meta-data to the NEIC for them to generate such event parameters.

GPS operations - Using a talented and skilled senior graduate student to run the GPS network is obviously not sustainable. Probably additional cross training of other technical staff for field operations is needed. The faculty scientist should probably take over the data quality control and analysis duties from the grad student. Longer term sustainability might require at least a part of another technical person.

Adaptation of AQMS - The proposed plan submitted to the USGS for switching to AQMS from the current analysis system is very optimistic at current staffing levels. While a full DBMS administrator is not needed in-house (USGS-ANSS can provide such help remotely through Pasadena) knowledge and experience with database systems (SQL) is required. We recommend that either an existing software engineer receive some serious training in SQL or better yet, hire an experience database person for a year to help get everything going and train all in-house personnel in DMS/AQMS use. Schedule an ISTI site visit but only after you have good meta-data (dataless-SEED) for (almost) all channels.

Station expansion/upgrades - We highly support the efforts underway currently with ARRA funding to upgrade legacy analog stations to full digital ones and the desire to phase out the older analog, particularly gain-ranging stations. We understand some of the reticence of including the temporary USArray TA stations into routine processing; however, we strongly recommend that you include a larger subset than planned. Even though these stations will exist for not much more than 18 months, they provide a very inexpensive sampling of seismicity in many areas with little or no previous monitoring and can greatly improve, albeit temporary, the detection and location of seismicity in known areas. For strong-motion stations we recommend that you exploit the knowledge and experience other regional networks have developed for the deployment of NetQuakes instrumentation.

Operational personnel - The one seismic analyst seems very good and quite dedicated. Normal seismicity is such that one analyst, even with somewhat inefficient processing software (SAC) is a reasonable number. However, during seismic crisis (swarm such as at Guy, AK) this is a heavy load. We suggest more cross-training for analysis duties. Train and involve other faculty and staff and some senior grad students for both their education and for emergency help. This might apply to the "Duty Seismologist" role also. A rotating schedule of several people who are trained to respond at any time of day or night to felt earthquakes and/or simple automatic computer problems should be set up.

This task should not fall only to one or two people. For really significant events or problems not solvable by this duty person others can be called in for help. NEIC should be considered backup, not in place of this.

Strategic evolution - While the seismic network's role is primarily that of being the Tier-1 part of the ANSS covering the central and southern US, it also has a role in providing data for local research projects, for the training of students and leadership in seismic monitoring for a significant part of the US. It is our perception that it is fulfilling its primary role quite well, but we saw less evidence of significant involvement in the other roles. Regarding broadening its activities within CERI we have suggested some ideas in bullets above. The coordination between CERI and other regional sub-networks seems adequate at the purely technical operation level but we suggest that CERI consider meetings among the other sub-network operators on a broader set of topics. For example once a month (or more often) conference calls or maybe even skype or webcast sessions could be held where all local networks would be invited to participate. Sessions should have a limited time period for operational issues and another for reviewing some science topic of current interest related to network data (such as the Guy earthquake swarm).

Education and Outreach.

The committee was asked to review the effectiveness of the E&O effort and give feedback on the balance between political and general outreach activities and the relevance of other CERI personnel to E&O activities. We received a detailed presentation by the E&O director and then a short Q&A with him and other staff. We also reviewed WEB pages and other handout material.

The E&O activities are an impressive array of diverse efforts touching on almost all aspects of earthquake hazard information distribution. Recipients of these efforts go from K-12 presentations and materials all the way to personal briefings at high levels of government. The variety of approaches for "getting the word out" is laudable as is the variety of funding sources utilized to support these activities. The support staff seems talented and very appropriate and their availability to others in CERI is a wise use of resources.

Having a broad base of funding support is generally a good thing but it also implies more clients to satisfy. Expanding on the example of the State Farm Insurance support might be advisable; however, one must be careful that such fund raising efforts don't take more staff time than the funds they bring in.

It appears that the E&O group is very good at supporting the rest of CERI activities in the region following a seismic event of public interest and the committee commends this effort. We do recommend that the E&O effort make more use of materials and help available through IRIS and EarthScope, particularly as the USArray experiment moves through the region.

It was not clear to us if students (either from CERI or others from the university) were

used to help with E&O activities. We encourage using students, particularly undergrads, when possible. Maybe hire work-study geology students. While there is some effort to do training it should be more than made up for by their help. Also, it can be an important part of their education. We understand there was an unfortunate incident when an unprepared student was caught by the press and quoted saying something inappropriate. These things happen and it shouldn't mean that they can not still be used, with proper cautions given.

Partnerships.

The committee was asked to comment on the prospects of improving the current situation of a greatly reduced presence of the USGS in Memphis. We understand that CERI enjoyed a good working relationship with the local USGS scientists in past years and is missing the breadth of interests and close collaboration those scientists represented. Like you we feel that a USGS presence in Memphis is critical to the ultimate goals of NEHRP in the central US. However, given the tight budget constraints the USGS is under we understand it is not likely that these positions will be replaced with USGS personnel in Memphis without making a very strong case for specific needs that only a USGS person could fulfill.

The committee was asked to suggest new partnerships that could increase CERI's national and international impact. Our review of the research and outreach components of CERI suggests that there are strengths that are relevant to several types of new partnerships. Because of CERI's unique position both physically (in an intra-continental tectonic area with unusually high seismic hazard) and its strong showing in recruiting international graduate students we think CERI might look into expanding partnerships with international seismological institutions similarly located and interested in intra-continental tectonics. CERI's somewhat unique position of having both a strong research program and E&O program is likely to encourage collaboration with international institutions with similar problems and may also allow for funding sources through international organizations such as the UN or NGOs interested in reducing earthquake hazards in developing countries.

A separate area of potential increased collaboration is within the central and southeastern US. The committee was not made aware of any significant, on-going, scientific collaboration with other institutions in the region other than routine collaboration through the seismic network. It seems to us that this existing technical infrastructure could be used to take a leadership role in research topics of interest in the region. As an early step to these ends we suggest organizing in-person workshops or regular "Webinars" (teleconferences) on topics of current and future interest. With the arrival of USArray stations in the region this is a perfect time to engage your fellow institutions to the east that will soon see the Transportable Array stations.

University Relations.

This section of our report covers the most contentious and difficult issues that we were asked to examine: the relations between CERI and DES. In the course of our visit, we met separately with DES faculty and the CERI faculty. Our meetings with both groups were very cordial and we greatly appreciated the thought and preparation that each put into our discussions. Through these meetings we gained some appreciation of the underlying sources of conflict, as well as a strong sense of the directions that DES and CERI would like to move to strengthen their programs. We also heard repeatedly from both groups that they got along well with the faculty of the other on an interpersonal basis. The problems arise instead at the institutional points of contact between the organizations.

Both CERI and DES are organized units of the College of Arts and Sciences (CES) and the head of each reports to the Dean of CES. CERI has other institutional roles as well, as it is an Agency of the State of Tennessee. Because CERI is a Center as opposed to a Department in CES, its students and teaching faculty must be affiliated with a degree-granting organization in the University of Memphis. Currently, all of the CERI students and faculty are also members of DES. The CERI graduate program forms the geophysics curriculum in DES.

This creates a complex set of interdependencies between CERI and DES that we perceive to be the primary source of the friction between the two organizations. Members of both CERI and DES expressed frustration with their interactions concerning admission of graduate students, web presence, the curriculum, and hiring and promotion of research faculty.

Part of the friction between CERI and DES is likely due to physical separation as well as a history of relatively minor conflicts growing to an unnecessary confrontational atmosphere. It is our impression that some of the friction between CERI and DES also arises out of a lack of written procedures that govern their interactions. One model that we were presented for resolving the conflicts would separate them completely by either affiliating CERI with a different department or making CERI a Department of Geophysics. Another model that we were presented would place CERI entirely inside of DES and eliminate its direct reporting to the Dean.

We do not believe that either model is viable at the University of Memphis. TBR rules would make it difficult for the two programs to survive independently and the responsibilities of the CERI Director to the state preclude the CERI Director reporting directly to the Department Chair. We do believe, however, that degree programs in all of the focus areas of DES at both the undergraduate and graduate level are very much in the interest of both parties. Both DES and CERI share the goal of creating a vibrant graduate program focused on high quality research and we see real potential for growing and expanding these programs.

It is not uncommon for two organizations to have areas of shared responsibility. Unless these areas are well-defined, misunderstandings and mistrust can arise. One way of

minimizing the potential for problems is to create a Memorandum of Agreement (MOA) between the two organizations that spells-out the rights and responsibilities of both parties and their members. Ideally, this type of MOA covers not only the areas of shared responsibility but also the areas that are unique to each unit. Of particular importance are the rules governing research professors. The committee feels the CERI director must maintain a primary role in the hiring and promotion of research faculty in order to fulfill the research mission of CERI, yet DES certainly has a role to play in evaluating research professors due to their teaching and graduate student advising duties. Clear guidelines must be set on evaluation and promotion procedures for research professors and their role in the graduate program. Such rules are essential for recruitment and retention of young research professors who are critical to the success of CERI.

Since both the CERI Director and DES Chair report to the Dean of CES, it would seem logical to us for the Dean to charge a committee with drafting the MOA and appoint its chair and members. The committee would be the interface to the full faculty of CERI and DES and would be tasked with drafting language that was acceptable to both groups. If all parties could not come to agreement on the contents, it would be the responsibility of the Dean to settle the disputes.

Attachment 6

Memorandum of Understanding allowing CERI to become a separate academic department at the University of Memphis.

THE UNIVERSITY OF MEMPHIS.

College of Arts and Sciences

107 Scates Hall
Memphis, Tennessee 38152-3450

Dean's Office: 901.678.3067
CAS Advising Center: 901.678.5454
Interdisciplinary Studies: 901.678.3550
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www.memphis.edu

MEMORANDUM OF AGREEMENT

College of Arts and Sciences

Department of Earth Sciences

Center for Earthquake Research and Information

The following agreement is meant to clarify the relationship between the Department of Earth Sciences (DES) and the Center for Earthquake Research and Information CERI (CERI), assuring the appropriate independence of each of these units allowing them to focus on their respective missions and to continue to encourage appropriate scientific collaborations among the faculty in these units.

1. The College of Arts and Sciences will work with CERI and the university administration to pursue the possibility of establishing CERI as a unit with departmental status.

2. In the meantime, the following agreements will serve to establish the relative independence of DES and CERI (separate arrangements governing the relationship between CERI and departments outside of the College of Arts and Sciences remain untouched by this agreement).

    a. The budgets for each of these units will be established separately with primary responsibility for the budget of DES residing with the chair of that department and the primary responsibility for the budget of CERI residing with the Director of CERI. The budget of CERI will include the salaries and benefits of faculty associated with CERI even though they may have their tenure (or tenure-track status) in a department outside CERI.
    b. As the university moves to an incentive-based funding model, the college will work with the DES and CERI to assure that the relative contributions to degree-production, external funding, and other metrics relevant to that model will be attributed to the unit generating those contributions.
    c. The chair of DES will conduct the annual evaluation of faculty members in that department who are not also faculty in CERI. Faculty members who are faculty in CERI will be evaluated by the director of CERI. Similarly, evaluation of the chair of DES will be provided by faculty in that department who are not associated with CERI and evaluation of the director of CERI will be provided by faculty members associated with CERI.
    d. Recommendations regarding hiring, tenure, and/or promotion in DES for faculty members who are not also associated with CERI will be made by faculty members in DES

who are not associated with CERI. Recommendations regarding hiring, tenure, and/or promotion for faculty members associated with CERI will be made by faculty members associated with CERI.

e. There will be separate concentrations for the graduate programs shared by DES and CERI. The curriculum and degree requirements in the DES concentration(s) will be governed by the faculty in DES who are not associated with CERI; the curriculum and degree requirements in the concentration governed by CERI will be determined by the faculty associated with CERI. Graduate faculty membership will be determined by the faculty and chair in DES who are not associated with CERI for the DES concentration(s); Graduate faculty membership will be determined by the faculty and director of CERI for the concentration governed by CERI. Students applying to those programs must indicate which concentration they wish to pursue. Admissions and funding decisions for students in those concentrations will be made by the faculty governing those concentrations.

f. Questions of representation on college and university committees and bodies such as the Faculty Senate will be negotiated with those committees and bodies consistent with their own guidelines, but in every case the units should be assured equal access to such representation.

Dr. Jerry Bartholomew
Chair, Department of Earth Sciences

1 May 2014
date

Dr. Charles Langston
Center for Earthquake Research and Information

May 6, 2014
date

Dr. Thomas Nenon
Dean, College of Arts and Sciences

April 30, 14
date

Dr. M. David Rudd
Provost

5/8/14
date

Attachment 7
CERI Refereed Journal Articles and Conference Presentations
2013-2015

Refereed Journal Articles

Bockholt, B. M., C. A. Langston, H. R. DeShon, S. Horton, and M. Withers. 2014, Mysterious tremor-like signals seen on the Reelfoot fault, Northern Tennessee. Bull. Seism. Soc. Am., **104**,2194-2205. doi: 10.1785/0120140030.

Boyd, O. S., and C. H. Cramer. 2013, A new macroseismic intensity prediction equation and magnitudes of the 1811-1812 New Madrid and 1886 Charleston, South Carolina, earthquakes. Seis. Res. Lett., **84**, no. 2,377.

Boyd, O. S., and C. H. Cramer. 2014, Estimating earthquake magnitudes from reported intensities in the central and eastern United States. Bulletin of the Seismological Society of America, **104**,1709-1722.

Choi, E., W. R. Buck, L. L. Lavier, and K. D. Petersen. 2013, Using core complex geometry to constrain fault strength. Geophysical Research Letters, **40**, no. 15,3863-3867. doi: 10.1002/grl.50732.

Choi, E., E. Tan, L. L. Lavier, and V. M. Calo. 2013, DynEarthSol2D: An efficient unstructured finite element method to study long‐term tectonic deformation. Journal of Geophysical Research: Solid Earth, **118**, no. 5,2429-2444. doi: 10.1002/jgrb.50148.

Cramer, C. H., and O. S. Boyd. 2014, Why the New Madrid Earthquakes are M 7–8 and the Charleston earthquake is~ M 7. Bulletin of the Seismological Society of America, **104**,2884-2903.

Cramer, C. H., R. B. Van Arsdale, M. S. Dhar, D. Pryne, and J. Paul. 2014, Updating of urban seismic-hazard maps for memphis and shelby county, Tennessee: geology and Vs observations. Seis. Res. Lett., **85**,986-996.

Daub, E. G., D. Klaumünzer, and J. F. Löffler. 2014, Effective temperature dynamics of shear bands in metallic glasses. Physical Review E, **90**, no. 6.

Dunn, M., H. DeShon, and C. Powell. 2013, Imaging the New Madrid seismic zone using double-difference tomography. Journal of Geophysical Research, **118**,5404-5416. doi: 10.1002/jgrb.50384.

Graw, J. H., C. A. Powell, and C. A. Langston. 2014, Crust and mantle velocity structure in the vicinity of the eastern Tennessee seismic zone based upon radial P wave transfer functions. Journal of Geophysical Research Solid Earth, **119**. doi: 10.1002/2014JB011516.

Horton, S. P., W. L. Ellsworth, J. Rubinstein, and M. Withers. 2013, Seismological Observations Associated with the Development of a Sinkhole near the Napoleonville Salt Dome, Louisiana. Seis. Res. Lett., **84**,833-873.

Horton, S. P., P. Ogwari, and S. Ausbrooks. 2013, Naturally Occurring and Induced Earthquakes in Central Arkansas. Seis. Res. Lett., **85**,214-241.

Isbiliroglu, Y., R. Taborda, and J. Bielak. 2013, Coupled soil-structure interaction effects of building clusters during earthquakes. Earthquake Spectra.

Johnson, G. A., S. P. Horton, M. Withers, and R. Cox. 2014, Earthquake focal mechanisms in the New Madrid Seismic Zone. Seismological Research Letters, **85**,257-267.

Kim, K. H., K. C. Chen, and J. M. Chiu. 2013, Three dimensional structure of Vp, Vs, and Vp/Vs beneath the active collision bounday of eastern Taiwan. Geophys. J. Int. doi: 10.1093/gji/ggt397.

Langston, C. A. 2014a, Coherence of teleseismic P and S waves across the transportable array. Bull. Seism. Soc. Am., **104**,2253-2265. doi: 10.1785/0120140075.

Langston, C. A., and S. P. Horton. 2014, Three-dimensional seismic-velocity model for the unconsolidated Mississippi embayment sediments from H/V ambient noise measurements. Bull. Seism. Soc. Am., **104**,2349-2358. doi: 10.1785/0120140026.

Lin, Y. N. N., A. Sladen, F. Ortega‐Culaciati, M. Simons, J. P. Avouac, E. J. Fielding, and A. Socquet. 2013, Coseismic and postseismic slip associated with the 2010 Maule Earthquake, Chile: Characterizing the Arauco Peninsula barrier effect. Journal of Geophysical Research: Solid Earth, **118**, no. 6,3142-3159.

Lingling, Y., T. Lay, K. D. Koper, R. Smalley, L. Rivera, M. G. Bevis, A. F. Zakrajsek, and F. N. Teferle. 2014, Complementary slip distributions of the August 4, 2003 Mw 7.6 and November 17, 2013 Mw 7.8 South Scotia Ridge earthquakes. Earth and Planetary Science Letters, **401**, no. 1,215-226. doi: 10.1016/j.epsl.2014.06.007.

Logan, L., G. Catania, L. Lavier, and E. Choi. 2013, A novel method for predicting fracture in floating ice. Journal of Glaciology, **59**, no. 216,750-758. doi: 10.3189/2013JoG12J210.

McNamara, D. E., H. M. Benz, R. B. Herrmann, E. A. Bergman, P. Earle, A. Meltzer, and M. Chapman. 2013, The Mw 5.8 mineral, Virginia, earthquake of August 2011 and aftershock sequence: Constraints on earthquake source parameters and fault geometry. Bulletin of the Seismological Society of America, **104**. doi: 10.1785/0120130058.

Mousavi, S. M., C. H. Cramer, and C. A. Langston. 2014, Average QLg, QSn, and observation of Lg blockage in the Continental Margin of Nova Scotia. Journal of Geophysical Research: Solid Earth, **119**, no. 10,7722-7744.

Powell, C., M. Withers, R. Cox, G. Vlahovic, and P. Arroucau. 2014, Crustal velocity structure associated with the eastern Tennessee seismic zone: Vp and Vs imaged based upon local earthquake tomography. Journal of Geophysical Research, **119**,1-26. doi: 10.1002/2013JB010433.

Rivet, D., M. Campillo, M. Radiguet, D. Zigone, V. Cruz-Atienza, N. M. Shapiro, and E. Daub. 2014, Seismic velocity changes, strain rate and non-volcanic tremors during the 2009–2010 slow slip event in Guerrero, Mexico. Geophysical Journal International, **196**, no. 1,447-460.

Taborda, R., and J. Bielak. 2013, Ground‐motion simulation and validation of the 2008 Chino Hills, California, earthquake. Bulletin of the Seismological Society of America, **103**, no. 1,131-156.

Conference Presentations

Ahamed, M. S., and E. Choi. 2014, Incorporating elastic and plastic work rates into energy balance for long-term tectonic modeling. In CIG Mantle and Lithospheric Dynamics Workshop, Joint with the Canadian Geophysical Union. Banff, Canada.

Ahamed, M. S., and E. Choi. 2015, Incorporating elastic and plastic work rates into energy balance for long-term tectonic modeling. In AGU Fall Meeting. San Francisco, CA.

Ahamed, M. S., D. Hossain, and E. Choi. 2013, Basement-surface soupling of northwest Bengal Basin. In AGU Fall Meeting. San Francisco.

Al Noman, M. N., and C. H. Cramer. 2014a, Empirical ground motion prediction equations for eastern North America with the addition fo intensity observations. In Eastern Section SSA Annual Meeting. Charleston, SC.

Al Noman, M. N., and C. H. Cramer. 2014b, Initial ENA empirical GMPEs using the NGA East databse. In Seis. Res. Lett.

AMOSU, A. M., and R. SMALLEY. 2014, Crustal Deformation from Surface Loading in the Great Salt Lake Region. In Seis. Res. Lett.

Arroucau, P., A. P. Kuponiyi, G. Vhahovic, and C. A. Powell. 2013, A shallow S-wave model for the eastern Tennessee seismic zone from Rayleigh wave ambient noise. In Seism. Res. Lett.

Assimaki, D., J. Shi, and R. Raborda. 2013, Nonlinear site response: validation exercises on site-specific and regional scalses. In SCEC ANnu. Meet. Palm Springs, CA.

Assimaki, D., J. Shi, and R. Taborda. 2014, Site-specific response in validation studies of physics-based earthquake simulations. In SSA Annu. Meet. Anchorage, Alaska.

Ausbrooks, S., and S. Horton. 2015, Characterization and Classification of Discrete Clusters of Earthquakes from 2008-2015 in North-Central Arkansas, Natural or Induced: Illustrating Their Influence on the National Seismic Hazard Maps. In SSA Annual Meeting.

Azzizadeh-Roodpish, S., N. Khoshnevis, and R. Taborda. 2014, Evalutaion of the southern californa velocity models throught simulation and validation of multiple historical events. In SCEC Annu. Meet. Palm Springs, CA.

Bielak, J., D. L. Restrepo, and R. Taborda. 2014, Effects of Topography on Ground Motion in Southern California and the Wasatch Front Regions. In AGU Fall Meeting. San Francisco.

Bockholt, B. B., and C. A. Langston. 2014a, Local-magnitude and anomalous amplitude distance decay in the eastern Tennessee seismic zone. In Annual Meeting of the Eastern Section of the SSA. Charleston, SC.

Bockholt, B. M., and C. A. Langston. 2014b, Surface wave gradiometry of the US Transportable Array. In SEG/AGU Summer Research Workshop. Vancouver, Canada.

Buck, W. R., E. Choi, and X. Tian. 2014, Development of Core Complex Domes Due to Along-Axis Variation in Diking. In AGU Fall Meeting. San Francisco, CA.

Chiu, J. M., Seismic monitoring systems and their applications to seismological research, energy resources and study of regional tectonic structures. In seismology seminar. National Chin-Hwa University.

Chiu, J. M. 2013, Earthquake sciences from our backyard - the New Madrid Seismic Zone in the central USA. In invited talk. memphis Rotary Club Meeting.

Chiu, J. M. 2014a, Energy resources and earthquake. In seismology seminar. Institute of Earth Science, Acadamia Sinica, Nakang, Taipei.
Chiu, J. M. 2014b, Energy resources and earthquake - special workshop on energy resources. In seismology seminar. National Chin-Hwa University.
Chiu, J. M. 2014c, Lessons we have learned from seismological observations in the Taiwan region. In seismology seminar. Institute of Earth Science, Acadamia Sinica, Nakang, Taipei.
Chiu, J. M. 2014d, Propagation of high-frequency seismic waves from intermediate depth earthquakes - implications for slab's internal structure and regional tectonics. In seismology seminar. Institution of Geology and Geophysics, Chinese Academy of Sciences, Beijing.
Chiu, J. M. 2014e, Seismological research from land to ocean. In seismology seminar. Institute of Earth Science, Acadamia Sinica, Nakang, Taipei.
Chiu, J. M. 2014f, Volcano earthquake. In Workshop for Tatung Volcano Earthquake. Central Weather Bureau.
Chiu, J. M. 2014g, Volcano earthquakes and significance of lateral variations of topograph and near-surface strucutres on earthquake location and structure imagess. In seismology seminar. Institute of Earth Science, Acadamia Sinica, Nakang, Taipei.
Chiu, J. M., and S. C. Chiu. 2013, Past, current, and future prospects of conventional and unconventional energy resources - what a geophysicist should know. In invited seminar. Institute of Earth Science, Academia Sinica, Taipei, Taiwan.
Choi, E. 2014, DynEarthSol3D: An Unstructured-Mesh Finite Element Solver for Long-Term Tectonic Deformations Involving Strain Localization. In CIG Crustal Deformation Modeling Workshop. Stanford University, CA.
Choi, E., A. Kelbert, and S. Peckham. 2014, Linking Tectonics and Surface Processes through SNAC-CHILD Coupling: Preliminary Results Towards Interoperable Modeling Frameworks. In AGU Fall Meeting. San Francisco, CA.
Choi, E., M. Tominage, M. G. Baker, D. May, and E. Fujita. 2013, Numerical investigation of the morphological transitionn of submarine lave flow due to slope change. In AGU Fall Meeting. San Francisco.
Cooley, M., C. A. Powell, and E. Choi. 2014, A new set of focal mechanisms and a geodynamic model for the eastern Tennessee seismic zone. In AGU Fall Meeting. San Francisco, CA.
Cooley, M. T., and C. A. Powell. 2014, A new set of focal mechanisms for the eastern Tennessee seismic zone. In Seism. Res. Lett.
Cramer, C. H. 2013a, Developing ground motion estimates from M>6.0 earthquake intensity observations for use in ENA empirical GMPEs. In Eastern Section SSA Annual Meeting. Charlevoix, Quebec, Canada.
Cramer, C. H. 2013b, Ground motion database for SCRs: Development, attributes, and products. In SMiRT-22 conference. San Francisco.
Cramer, C. H. 2013c, New seismic and liquefaction hazard maps. In Memphis Area Earthquake Hazards Mapping Workshop. Memphis, TN.
Cramer, C. H. 2013d, Project overview. In Memphis Area Earthquake Hazards Mapping Workshop. Memphis, TN.

Cramer, C. H. 2014a, Developing ground motion estimates from M>6.0 earthquake intensity observations for use in ENA GMPEs. In Seis. Res. Lett.
Cramer, C. H. 2014b, Dmpirical ENA model: an update. In NGA East SSHAC Workshop 3a. Berkeley, CA.
Cramer, C. H. 2014c, Earthquake hazard in the Memphis area. In Civil Engineering Seminar. Memphis, TN.
Cramer, C. H. 2014d, Ground motion and source properties of natural vs. induced earthquake. In USGS Induced Seismicity Workshop. Oklahoma City, OK.
Cramer, C. H. 2014e, Magnitude dependent site amplification seismic hazard calculation outside the hazard integral for St. Louis, MO. In Seis. Res. Lett.
Cramer, C. H. 2014f, NGA East ground motion database: data collection. In NGA East workshop. Berkeley, CA.
Cramer, C. H., M. N. Al Noman, P. Ogwari, and S. M. Mousavi. 2014, CMPEs, Q and NGA East. In USGS/CERI CEUS Research Workshop. Memphis, TN.
Cramer, C. H., and O. S. Boyd. 2013, Magnitude estimates of M7.3-7.8 for the 1811-1812 New Madrid and M7.0 for the 1886 Charleston Earthquakes from a Monte Carlo analysiss of mean MMIs. In Seis. Res. Lett.
Cramer, C. H., and M. S. Dhar. 2013, Memphis urban seismic hazard mapping update: new geology vs. shear-wave velocity observations. In Eastern Section SSA Annual Meeting. Charlevoix, Quebec, Canada.
Cramer, C. H., S. Jaume, N. Levin, A. Braud, and M. Chapman. 2014, Urban hazard map pilot study for the Charleston, SC quadrangle. In Eastern Section SSA Annual Meeting. Charleston, SC.
Cramer, C. H., and M. N. A. Noman. 2013, Investigating Q boundary transitions and regional Q(f) using NGA East and USARRAY data. In Seis. Res. Lett.
Dangkua, D. T., and C. H. Cramer. 2013, Magnitude estimates of M7.3-7.8 for the 1811-1812 New Madrid and M7.0 for the 1886 Charleston Earthquakes from a Monte Carlo analysiss of mean MMIs. In Seis. Res. Lett.
Dangkua, D. T., C. A. Langston, and C. H. Cramer. 2013, Wave gradiometry using a three-dimensional array of experimental MEMS-based accelerometers. In Seis. Res. Lett.
Dangkua, D. T., C. A. Langston, and C. H. Cramer. 2014, A wave gradiometry application in engineering seismology: field measurement of nonlinear soil behavior in the near surface. In Seism. Res. Lett.
Daub, E. G. 2014a, Can we detect clustered megaquakes? In AGU Fall Meeting. San Francisco.
Daub, E. G. 2014b, Can we detect clustered megaquakes? In Southern California earthquake Center Annual Meeting. Palm Springs, CA.
Daub, E. G. 2014c, Monitoring Nonlinear Elastic Behavior of Rocks in the Earth's Crust. In International Conference on Nonlinear Elastic Materials. Frejus, France.
Dhar, M. S., C. H. Cramer, R. B. V. Arsdale, D. Pryne, J. Paul, and G. L. Patterson. 2013, MAEHMP: Updating the Memphis area seismic and liquefaction hazard maps. In Seis. Res. Lett.
Durand, M., L. Lenzano, G.Lenzano, and R. Smalley. 2014, Investigación sobre la respuesta de los procesos tectónicos a partir de los cambios experimentados por los glaciares en el campo de hielo patagónico sur argentino por medio de técnicas

geomáticas. In XXVII Reunión Científica de la Asociación Argentina de Geofísicos y Geodestas. San Juan, Argentina.
Feng, L., E. Choi, and M. Bartholomew. 2013a, Effects of flat length on deformation around a ramp-flat-ramp thrust system: A numerical approach. In GSA Annual Meeting.
Feng, L., E. Choi, and M. Bartholomew. 2013b, Modeling the evolution of a ramp-flat-ramp thrust system: A geological application of SynEarthSol2D. In AGU Fall Meeting. San Francisco.
Feng, L., E. Choi, and M. Bartholomew. 2014, Modeling the evolution of a thrust system: a geological application of DynEarthSol2D. In CSDMS Annual Meeting. Boulder, Colorado.
Gill, D., P. Small, P. Maechling, T. Jordan, S. J. H., A. Plesch, C. P., L. E. J., R. Taborda, O. K. B., and S. Callagham. 2014, UCVM: open source software for understanding and delivering 3d velocity models. In AGU Fall Meeting. San Francisco, CA.
Gill, D., P. Maechling, T. Jordan, A. Plesch, R. Raborda, S. Callagham, and P. Small. 2013, UCVM: An open source framework for 3D velocity model research. In SCEC Annu. Meet. Palm Springs, CA.
Gill, D., P. Small, P. Maechling, T. Jordan, S. J., A. Plesch, C. P., L. E. J., R. Taborda, and S. Callagham. 2014, UCVM: open source software for understanding and delivering 3d velocity models. In SCEC Annu. Meet. Palm Springs, CA.
Gill, D., P. Small, P. Maechling, T. Jordan, A. Plesch, R. Taborda, and S. Callagham. 2014, UCVM: Open source software framework for 3D seismic velocity models. In SSA Annu. Meet. Anchorage, Alaska.
Gill, D., P. Small, R. Taborda, E. J. Lee, O. K.B, P. Maechling, and T. Jordan. 2015, Standardized access to seismic vlocity models using the unified community velocity model (UCVM) software. In SSA Annu. Meet. Pasadena, CA.
Gomez, D. D., C. A. Langston, and R. Smalley. 2014a, A Linear Formulation for Earthquake Location in a Homogeneous Half-Space Based on the Bancroft Algorithm Developed for GPS Location. In Seis. Res. Lett.
Gomez, D. D., C. A. Langston, and R. Smalley. 2014b, A linear formulation for earthquake location in a homogenous half-space based on the Bancroft algorithm developed for GPS location. In Seism. Res. Lett.
Gómez, D. D., R. Smalley, D. A. Piñón, and S. R. C. p. Mínimos. 2014, Cuadrados de la deformación co-sísmica del sismo de maule, chile 2010: estimación de observaciones mínimas. In XXVII Reunión Científica de la Asociación Argentina de Geofísicos y Geodestas. San Juan, Argentina.
Goulet, C. A., C. H. Kishida, C. H. Cramer, R. B. Darragh, and W. J. Silva. 2013, The NGA-East Database: development challenges and products. In Eastern Section SSA Annual Meeting. Charlevoix, Quebec, Canada.
Guangliang, W., L. Lavier, and E. Choi. 2013, Modes of extension in collapsing orogens. In GSA Annual Meeting.
Horton, S., S. Ausbrooks, M. Withers, and P. Ogwari. 2014, Managing Seismic Hazard Due to Induced Earthquakes in Central Arkansas through Partnership between Scientific and Regulatory Agencies. In SSA Annual Meeting Anchorage, Alaska.

Horton, S. P. 2014a, Overview of Induced Earthquakes in Central and Eastern North America. In CEUS Earthquake Hazards Workshop Memphis, TN.
Horton, S. P. 2014b, Overview of Induced Earthquakes in Central and Eastern North America. In CEUS Earthquake Hazards Workshop. Memphis, TN.
Huda, M. M., and C. A. Langston. 2014, Coherence and variability of ground motion over 600m of the nonvolcanic tremor array site at Mooring, TN. In AGU Annual Fall Meeting. San Francisco, CA.
Isbiliroglu, Y., R. Taborda, and J. Bielak. 2014a, Multiple structure-soil-structure interaction and coupling effects in building clusters. In 10th National Conf. Earthq. Eng. Anchorage, Alaska.
Isbiliroglu, Y., R. Taborda, and J. Bielak. 2014b, Multiple structure-soild-structure interaction and coupling effects in building clusters. In SCEC Annu. Meet. Palm Springs, CA.
Kelemencky, S., C. Powell, and M. Lamontagne. 2013, New 1-D and 3-D velocity models for the Charlevoix seismic zone. In Seism. Res. Lett.
Kendall, L., and C. A. Langston. 2014, Seismic-wave gradiometry applied to a small-scale exploration dataset. In Seism. Res. Lett.
Khoshnevis, N., and R. Taborda. 2014a, Sensitivity of ground motion simulation validation criteria to filtering. In SSA Annu. Meet. Anchorage, Alaska.
Khoshnevis, N., and R. Taborda. 2014b, Sensitivity of ground motion simulation validation to signal processing and GOF criteria. In SCEC Annu. Meet. Palm Springs, CA.
Khoshnevis, N., and R. Taborda. 2015, Evaluation of attenuation modelss used in physics-based gound-motion earthquake simulation. In SSA Annu. Meet. Pasadena, CA.
Konfal, S. A., T. J. Wilson, M. G. Bevis, E. C. Kendrick, I. W. Dalziel, R. Smalley, and D. A. Wiens. 2013, GPS observations of glacial isostatic adjustment into the Antarctic Interior. In AGU Fall Meeting. San Francisco.
Konfal, S. A., T. J. Wilson, M. G. Bevis, E. C. Kendrick, I. W. D. Dalziel, R. S. Jr, M. J. Willis, D. Heeszel, D. A. Wiens, and T. P. Team. 2014, GPS Measurements of Crustal Motion Indicate 3D GIA Models are Needed to Understand Antarctic Ice Mass Change. In AGU Fall meeting. San Francisco.
Langston, C. A. 2013a, Doing some new things with EarthScope data. In National Meeting of the EarthScope project. Rayleigh, NC.
Langston, C. A. 2013b, Empirical constraints on broadband array designs. In IRIS workshop on arrays in global seismology. Raleigh, NC.
Langston, C. A. 2013c, Using Integral and Differential Arrays to Determine Wave Field Composition. In IAHS - IAPSO - IASPEI Joint Assembly. Gothenburg, Sweden.
Langston, C. A. 2014b, From Large N to point arrays and back again. In SEG/AGU Summer Research Workshop. Vancouver, Canada.
Langston, C. A. 2014c, Lg wave propagation and ground motions. In Central and Eastern U.S. Earthquake Hazards Research Review and Planning Workshop for the USGS. Mmephis, TN.
Langston, C. A. 2014d, Seismo-acoustics of space shuttle N-waves across the New Madrid Cooperative Seismic Network. In Annual Meeting of the Eastern Section of the SSA. Charleston, SC.

Langston, C. A., and S. P. Horton. 2013, 3D Seismic Velocity Model for the Unconsolidated Mississippi Embayment Sediments from H/V Ambient Noise Measurements. In Fall Annual meeting of the Eastern Section of the Seismological Society of America. Charlevoix, Canada.

Levine, N., S. Jaume, A. Braud, and C. H. Cramer. 2014, Developing uncertainty estimates for sub-surface mapping used in the Charleston urban seismic study. In Eastern Section SSA Annual Meeting. Charleston, SC.

Logan, E., L. Lavier, E. Choi, E. Tan, and G. Catania. 2014, DynEarthSol3D: numerical studies of basal crevasses and calving blocks. In AGU Fall Meeting. San Francisco, CA.

Meredith, J., and C. A. Langston. 2013, Wave gradiometry using a broadband aftershock array in southern Illinois. In Seis. Res. Lett.

Meredith, J. A., and C. A. Langston. 2014, Earthquake locations using a wave gradiometer in southern Illinois. In Seism. Res. Lett.

Mostafanejad, A., and C. A. Langson. 2014, P wave transfer functions for the northern Mississippi embayment: a different approach. In Seism. Res. Lett.

Mostafanejad, A., and C. A. Langston. 2013, The teleseismic P-wave palindrome for average P and S sediment velocity: H/V VH power spectral ratios. In Seis. Res. Lett.

Mostafanejad, A., and C. A. Langston. 2014, Average shear wave velocity for the Mississippi embayment sediment inferred from teleseismic P-wave spectral ratios. In Annual Meeting of the Eastern Section of the SSA. Charleston, SC.

Mostafanejad, A., C. A. Powell, and C. A. Langston. 2013, Variation of seismic b-value in the New Madrid seismic zone: evidence that the Northern Reelfoot fault is creeping. In Seis. Res. Lett.

Mousavi, S. M., and C. H. Cramer. 2013, Frequency-dependent Lg attenuation across easternmost Canada. In Eastern Section SSA Annual Meeting. Charlevoix, Quebec, Canada.

Mousavi, S. M., and C. H. Cramer. 2014, Lg propagation and attenuation across continental margins, Scotia Basin. In Seis. Res. Lett.

Mousavi, S. M., and S. Horton. 2015, An update of Microseismic Monitoring at The Napoleonville Salt Dome, Louisiana. In SSA Annual Meeting.

Noman, M. N. A., and C. H. Cramer. 2013, Initial ENA empirical GMPEs using the NGA-East database. In Eastern Section SSA Annual Meeting. Charlevoix, Quebec, Canada.

Nyamwandha, C. A., C. A. Powell, and C. A. Langston. 2014a, Crust and upper mantle velocity structure of the New Madrid seismic zone,. In AGU Annual Fall Meeting. San Francisco, CA.

Nyamwandha, C. A., C. A. Powell, and C. A. Langston. 2014b, A joint local, regional, and teleseismic tomography study of the New Madrid seismic zone. In Seism. Res. Lett.

Ogwari, P., and C. H. Cramer. 2014a, Comparing the CENA GMPEs using NGA East ground motion database. In Seis. Res. Lett.

Ogwari, P., and C. H. Cramer. 2014b, Regression relations between modified Mercalli intensities and ground motion parameters. In Eastern Section SSA Annual Meeting. Charleston, SC.

Ogwari, P., C. H. Cramer, and M. N. A. Noman. 2013, Comparison of current ENA GMPEs with the NGA East Ground Motion Database using model bias residual analysis. In Seis. Res. Lett.

Ogwari, P. O., and S. P. Horton. 2013, Using induced earthquakes to estimate hydraulic properties of subsurface reservoirs in central Arkansas. In SSA Annual Meeting Salt Lake City, UT.

Ogwari, P. O., and S. P. Horton. 2015, A 3D Model of Pore Pressure Diffusion Associated with Induced Seismicity in Guy, Arkansas. In SSA Annual Meeting.

Ogwari, P. O., S. P. Horton, and S. M. Ausbrooks. 2014, Characteristics of Induced/Triggered Earthquakes During The Guy-Greenbrier Earthquake Sequence (2010-2011) in North-Central Arkansas. In SSA Annual Meeting Anchorage, Alaska.

Oldham, H. R., H. R. DeShon, C. A. Langston, and S. Horton. 2014, Noise analysis of the Northern Mississippi Embayment. In AGU Annual Fall Meeting. San Francisco, CA.

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