

**Center for Earthquake Research and Information
(CERI)**

<http://www.memphis.edu/ceri/>

University of Memphis
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Leadership

Charles A. Langston, Director
Michelle Smith, Assistant Director for Administration and Finance
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Mitch Withers, Director of Seismic and IT Networks (mwithers@memphis.edu)
Gary Patterson, Director for Education and Outreach (glptrsn@memphis.edu)
Christine Powell, Graduate Program Coordinator (capowell@memphis.edu)

Mission

CERI, established in 1977 as the Tennessee Earthquake Information Center, is a Tennessee Center of Excellence at the University of Memphis devoted to understanding the causes and consequences of earthquakes and the structure and evolution of the continental lithosphere. CERI addresses these needs through cutting-edge research, comprehensive graduate student education, operation of state-of-the-art seismic and GPS networks, and dissemination of technical and practical information to the private and public sectors.

BUDGET INFORMATION

	Current Org Budget/Revenue	FY '20 Actual Expenses
Revenue		
Grants and Contracts		
Research:		
<i>NSF (Oklahoma Arrays)</i>	9,444.00	8,679.00
<i>NSF (Geodynamics and Ice Sheets 2)</i>	25,626.00	25,468.00
<i>NSF (Role of Circumpolar Current)</i>	9,468.00	6,571.00
<i>NSF (Continental Dynamics Southern Andes)</i>	7,396.00	7,396.00
<i>NSF (GPS Array for Mid-America)</i>	52,359.00	12,793.00
<i>NSF (Workshop Proposal: Analog Modeling)</i>	9,094.00	3,728.00
<i>NSF (Magmatic and Tectonic Processes)</i>	28,344.00	28,344.00
<i>USGS (Intraplate Seismic Zones)</i>	45,060.00	54,736.00
<i>USGS (GPS Array for Mid-America)</i>	57,254.00	57,254.00
<i>USGS (Seisnet 2020)</i>	675,000.00	300,328.00
<i>USGS (Operation/Mid America Seismic Network)</i>	150,835.00	183,234.00
<i>USGS (Operation Mid Amer Seismic Network)</i>	387,048.00	393,309.00
<i>USGS (Charleston Area EQ Hazards)</i>	27,699.00	26,802.00
<i>Regents of University of California (Powell Dynamic Rupture Models Subduction)</i>	52,821.00	4,013.00
<i>HUD (HazMe)</i>	209,584.00	234,171.00
<i>HUD (HazMe)</i>	326,299.00	330,037.00
<i>US Air Force (Partitioning Signals and Noise)</i>	47,164.00	60,649.00
<i>SCEC (SCEC5)</i>	30,000.00	25,945.00
<i>DOE (DOE Subaward)</i>	41,485.00	16,002.00
Public Service:		
<i>Arkansas Geo Survey (Op and Maint of Ark Seismic Networks)</i>	54,000.00	45,648.00
Fellowships:		
<i>CERI - Carnegie 1 Fellowships</i>	54,257.00	54,523.00
State Appropriations:		
<i>COE - Earthquake</i>	1,113,925.00	1,076,641.00
<i>West TN Seismic Safety Commission</i>	65,000.00	107,385.00
U of M Contributions:		
<i>CERI</i>	634,273.00	619,658.00
<i>CERI- Cost Share</i>	131,007.00	130,227.00
<i>FRG - Powell</i>	6,581.00	5,718.00

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<i>Startup - Kyriakopoulos</i>	74,000.00	65,787.00
<i>Startup - Goebel</i>	64,000.00	10,119.00
IDCR:		
<i>Department</i>	271,144.00	270,696.00
<i>Faculty</i>	90,590.00	76,755.00
	\$4,750,757.00	\$4,242,616.00

PERFORMANCE NARRATIVE

Primary Goals and Purpose of CERI

CERI is a Tennessee Center of Excellence created to perform state-of-art scientific research into the nature of earthquakes in continental interiors, monitor earthquakes within the central and southeastern United States, and to serve the public and educational institutions of the State of Tennessee in providing accurate information on earthquake effects and hazards. CERI faculty members administer the Geophysics Concentration for the MS and PhD Earth Science graduate program at the University of Memphis and the interdisciplinary program in Engineering Seismology with the Civil Engineering Department.

CERI is an entity of the State of Tennessee that is reauthorized every 4 to 8 years by the legislature and governor. This occurred in the 2015-2016 legislative session when CERI was reauthorized under State Sunset Laws to June 30, 2022 (SB 1510 and HB 1608). Preparation for the next reauthorization will occur in early 2021.

CERI has additional direct ties to the State through the West Tennessee Seismic Safety Commission (WTSSC). The WTSSC 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. The WTSSC 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. The WTSSC was created through the Tennessee Code Annotated, Title 58, Section 4. CERI (created by Tennessee Code Annotated, Section 49-8-602) is authorized and directed to provide any information or services requested by the commission to achieve its goals. Gary Patterson, Director for Education and Outreach at CERI, is the Executive Director for the WTSSC.

Thus, through State of Tennessee mandates, CERI addresses a wide range of scientific and public outreach activities in addition to University academic matters.

A primary function of CERI is maintaining a large seismic network in the central and southeastern United States to monitor earthquakes. CERI technical staff operate and maintain over 144 seismic stations in 10 states in the region from Arkansas to Virginia. This seismic network is part of the Advanced National Seismic System (ANSS) through our partner, the U.S. Geological Survey. CERI personnel analyze earthquakes that occur within CERI's area of

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influence to determine and distribute earthquake locations and magnitudes. The raw waveform data and data products are then sent to national data centers in Seattle (Incorporated Research Institutions in Seismology – IRIS) and to the U.S. Geological Survey in Golden, Colorado, and become available to the public through USGS, IRIS, and CERI websites. Much research at CERI concerns earthquake hazards within the central and southeastern U.S. region and is helped by data collected by the seismic network. ***Goals of the network include continual upgrade of hardware and software facilities to more efficiently and accurately determine the parameters of earthquakes within the region.***

CERI's research mission into the causes and effects of earthquakes is greatly enhanced by participation in graduate programs in Earth Sciences and Civil Engineering. In Fall 2015 the CERI faculty was given full responsibility for administering the Geophysics Concentration for the MS and PhD in Earth Sciences. At the same time, CERI and the Civil Engineering Department started an interdisciplinary program in Engineering Seismology that has resulted in cross listing many CERI and Civil graduate courses. ***Goals for the Earth Sciences Geophysics Concentration include:***

- ***High quality graduate student training resulting in refereed student publications and exceeding yearly graduation quotas for PhD (3) degrees;***
- ***Focus on PhD program and reduce emphasis on MS program to address the University strategic goal of attaining Carnegie R1 status;***
- ***Maintain current state of the Engineering Seismology interdisciplinary program with Civil Engineering.***
- ***Provide a high-quality learning environment for the graduate students including good office space and laboratory facilities.***

CERI offers the faculty the full spectrum of support systems needed for success in research and education. Faculty and research staff members are provided office and lab space for their research, support staff for IT systems, liberal start-up funds for computers and other equipment, and administrative support for submitting grants and contracts to external sponsors as well as for day-to-day contract administration. Governance of all academic matters is done democratically and faculty and research staff input are required for decisions concerning graduate student admissions. An annual, all-hands, meeting is held in the third week of September each year to review accomplishments and plans for the upcoming year; all faculty, staff, and students attend. In addition, the Graduate Coordinator and Director for Administration and Finance facilitate all needed activities for proper functioning of the graduate programs

Membership/Affiliate Criteria

CERI operates as an autonomous educational and research unit within the University of Memphis. The criterion for membership is primarily based on source of support for CERI faculty, staff, and graduate students (i.e., whether personnel are on CERI budgets). There are no formal criteria for defining a CERI affiliate. However, a small number of faculty members from other departments routinely sit on student graduate committees and CERI standing committees. These "Friends of the Center" are de facto CERI affiliates.

Activity Targets, Outcome Objectives, and Metrics Associated with Achieving Progress

Activity Targets:

- Maintain seismic, GPS, and IT networks
- Attain/exceed graduation rate of 3/year for the PhD degree in Earth Sciences

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- Maintain the interdisciplinary Engineering Seismology program with Civil Engineering
- Construct a Research Laboratory in Fault Mechanics
- Construct a Research and Outreach Laboratory in Scientific Visualization and High Performance Computing
- Construct a Research Laboratory in Field Seismic Instrumentation
- Maintain a high level of externally funded research and scholarship
- Maintain vigorous Education and Outreach Program

Evidence of Progress Made during 2019-2020 Towards Goals and Objectives

Activity Targets:

- *Maintain seismic, GPS, and IT networks:* This is a principal task for network personnel and has been ongoing. A staff of 7 is organized and routinely given tasks by the Director for IT and Seismic Networks. A large number of technical improvements have been made to the seismic and GPS networks. Congressional increases given to the U.S. Geological Survey in FY20 have resulted in significant supplementary funds being awarded to CERI faculty members (Withers and Smalley) for upgrading equipment in both networks.
- *Attain/exceed graduation rate of 3/year for the PhD in Earth Sciences:* Two PhD students graduated between September 2019 and August 2020 (Y. Yang and C. Liu). However, we have an unprecedented class of 8 senior PhD students who will be defending in Fall 2020 and Spring 2021. This is a direct contribution to the University goal of attaining Carnegie I research university status in 5 years. In response to budget pressures since 2014, CERI has had to cut back on admission of graduate students to the Geophysics concentration. This, and the Universities strategic goal of attaining Carnegie R1 status has led the faculty to focus on recruiting PhD students at the expense of the Masters program. Unfortunately, the global pandemic and U.S. Government restrictions on visas have forced 4 of our highly qualified new graduate students to defer admissions until Spring 2021 when conditions may be better for obtaining a student visa. It is not clear how this hiatus in student admissions will affect the graduation rate in future years, but it probably is not a positive indicator.
- *Maintain the interdisciplinary Engineering Seismology program with Civil Engineering:* Primary evidence for program success is the cross listing of 9 CERI graduate courses in Civil Engineering. We have maintained our connection with the Civil Engineering Department primary through joint research programs between Cramer, Pezeshk, and Arellano. We routinely have Civil Engineering graduate students in our courses on Signal Analysis, Earthquake Hazards, Inversion Methods, and Global Seismology.
- *Construct a Research Laboratory in Fault Mechanics:* New Assistant Professor Thomas Goebel is building a laboratory to investigate the physics of faulting in 3892 Central Ave. He has designed the equipment which is currently being constructed by a geophysical company in Northwestern Arkansas. His research will investigate the physical parameters of friction, pore pressure, and rock strength that control earthquake fault ruptures. Construction of the laboratory should be complete in AY21.
- *Construct a Research and Outreach Laboratory in Scientific Visualization and High Performance Computing:* New Assistant Professor Christos Kyriakopoulos has

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constructed a laboratory for scientific visualization in 3876 Central Ave. Through the use of high-end computers and visualization equipment students and faculty can immerse themselves into complex geometries of faulting and rendering of geophysical fields. In addition, Dr. Kyriakopoulos has set up a computer cluster at the Fedex Institute of Technology for dedicated computations of numerical fault rupture models.

- *Construct a Research Laboratory in Field Seismic Instrumentation:* Director Langston is constructing a laboratory in 3892 Central Ave. dedicated to industry-standard three-component nodal seismometers that will be used in various seismic deployments. 60 instruments have been purchased along with associated peripheral charging and data-handling equipment. In addition, CERI has purchased a new type of seismometer that measures 3 axis ground rotation to be used in field arrays to be deployed with the Czech Academy of Sciences in the New Madrid Seismic Zone and elsewhere. Several new proposals have been written to external programs that propose to use this equipment.
- *Maintain a high level of externally funded research and scholarship:* 19 proposals for external grants and contracts were submitted by Center faculty and staff between September 2019 and August 2020. Notably, Professor Withers won a 5-year \$4.2M contract from the U.S. Geological Survey for CERI seismic network operations. In addition, there were at least two ~\$100K additions for network maintenance. This was a significant accomplishment since the U.S.G.S. has been reducing its network support for other national networks. In September 2019, I accompanied Prof. Withers to Albuquerque, New Mexico, for a meeting at the U.S.G.S. facility to explore the new level of commitment that the U.S.G.S. was displaying by its support. Additional funds for new seismic upgrades and sensors became available as a result of this meeting.
- *Maintain vigorous Education and Outreach Program:*
CERI's Education and Outreach (E&O) Program continued its mission in 2019-early 2020 to transfer technical and non-technical earthquake information to public and private sector groups in the Central and Eastern US, especially in the Greater Memphis Area. Over its 43-year history, CERI has grown to become an annual destination for dozens of area schools, non-governmental organizations, and professional groups seeking earthquake information. Non-technical information transfer at CERI includes activities for K-12 teachers and students, public service announcements, public meetings for earthquake safety, and museum display development. CERI E&O's frequent technical interaction with state and local governments has naturally led to development of multidisciplinary applied research projects that address gaps in community preparedness, such as school structural safety evaluations. Gary Patterson is Director for Education and Outreach and Kent Moran is a research associate handling outreach events and CERI webmaster.

The use of the CERI web page in conjunction with Facebook and Twitter to provide notices and information on local seismic events has helped to address our goal of educating the public about earthquake hazards. CERI social media resources are routinely used and promoted by local media. There are approximately 52,000 hits on the CERI webpages per month and 1200 hits per month on the CERI facebook page.

However, the pandemic has effectively shut down physical visits to CERI from local schools. We had hoped that the Visualization Laboratory would become a destination for K-12 science groups this year.

Identification of Special Achievements and/or Challenges During the Prior Year

Achievements:

- Monitoring Earthquakes in the Central United States: Maintaining our relationship with the U.S.G.S. as a network partner was a significant achievement in the current climate of increased scientific funding pressures.
- Two Tenure-track Faculty Hires: We successfully searched for and then hired our top two candidates for our open faculty positions. We had an uncommonly large field of about 70 serious applicants to choose from. Both Thomas Goebel and Christos Kyriakopoulos arrived in Fall semester 2019 and have become active contributors to the Center. In particular, Kyriakopoulos arrived with ~\$83K in funding and Goebel ~\$77K.
- Grants/Contracts Submitted: Center faculty and staff have submitted \$2.6M in proposed projects in 2019-2020. \$951K have been declined at this point leaving ~\$1.5M in review.
- CERI Becomes a Voting Board Member of the Southern California Earthquake Center: As part of the hiring negotiations for the new CERI faculty members, we requested and were granted entrance to the Board of Directors of the Southern California Earthquake Center (SCEC). The University of Memphis is now a valued part of the SCEC team that will guide the scientific program of SCEC through its next 5 year funding cycle with NSF. Christos Kyriakopoulos is the University's representative on the SCEC Board. Membership in SCEC is not a prerequisite for acquiring SCEC research funds, but it does substantially increase chances for success. Currently, both Kyriakopoulos and Goebel have SCEC grants that support their external research programs. In the past, Choi has also had SCEC funding. Being a member of SCEC will significantly increase the research network of the CERI faculty and students in the Earthquake scientific community.

Challenges:

Our major challenge is the common national challenge of dealing with the pandemic and associated recession. Restrictions caused by embassy closings have forced 4 of our new graduate students (2 from Iran, 1 from Nepal, 1 from Mexico) to defer coming to the University until, at least, January 2021. This may have a significant damping effect on producing timely PhD graduates 4 to 5 years from now. It is also impacting our course offerings this semester since many courses will have significantly reduced numbers of students.

I am also worried about how the freshly minted recommendations from the University Budget Committee will impact the Center depending on how deep the budget crisis may go. The national mood for science seems to be at an all-time low just when science is needed the most to solve our problems. It is not clear at all how Federal science funding will improve even if the current administration is changed; the nation has accumulated massive deficits from dealing with the recession. It is also not clear how State funding for the University will change if the recession turns into a depression. The University has done well so far, but further and likely State budget deficits will be hard to take.

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Plans for the Upcoming Academic Year Including Goals and Expected Achievements

Based on CERI's unusual position in the University as a graduate research center, our task is clear. The CERI faculty and scientific staff will need to strive to become more financially independent through winning higher levels of extramural funding. Budget cuts seem inevitable and can only be alleviated by new research revenues under the SRI model of CERI being a research center without having direct contributions to the undergraduate programs of the University.

There are some hopeful indicators, however. I was involved in recruiting Carl Herickhoff into Biomedical Engineering this Spring and Summer. Carl is a University strategic hire from Stanford who will be bringing expertise in acoustic ultrasound imaging. There is a possibility for CERI faculty to branch out into completely new fields of medical imaging. Theory for wave propagation in the human body is not too different from wave propagation in the Earth and it is simpler in some respects. Carl will be arriving in Memphis in November and I look forward to seeing what can develop.

Center status as a "State entity" will be reviewed in 2021 under the State of Tennessee Sunset Law. The expectation is that there will be a request from the Commerce, Labor, Transportation and Agriculture Joint Subcommittee to supply testimony for the Sunset review in June, 2021. The University and CERI has used CERI's State entity status to justify the West Tennessee Seismic Safety Commission and connections with other State agencies such as the Tennessee Emergency Management Agency. It is not clear how State entity status is related to the Tennessee Center of Excellence (COE) program which is administered through the Tennessee Higher Education Commission; there probably is no relationship. Nevertheless, having CERI be a State entity has allowed it to participate in State emergency exercises and seemed to be a factor in winning the large HUD grant a few year ago. Maintaining State entity status will allow the University to have deeper relationships with State government.

In summary, the CERI faculty will be asked once again to carefully review their research programs and to make strategic decisions for applying to new funding programs. The upcoming year will be one of dealing with what comes from the uncertain financial, political, and health situation of the country. CERI will also be reviewed by the State as a State entity under Tennessee Sunset Law.

CERI Personnel 2019-2020

FACULTY

CHOI, Eunseo	Associate Professor
CRAMER, Chris H.	Research Professor
GOEBEL, Thomas	Assistant Professor
KYRIAKOPOULOS, Christos	Assistant Professor
LANGSTON, Charles	Professor, Director
POWELL, Christine	Professor/Graduate Coordinator
SMALLEY, Robert	Research Professor
WITHERS, Mitch	Associate Research Professor, Director IT and Seismic Networks

POST-DOCTORAL FACULTY

CUNNINGHAM, Erin	Post-Doctoral Fellow
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EMERITI FACULTY

DORMAN, Jim	Director/Professor
JOHNSTON, Arch	Director/Professor
CHIU, Jer-Ming	Professor

VISITING FACULTY

SHEEN, Dong Hoon	Associate Professor, Chonnam National University
TAN, Handong	Professor, China University of Geosciences

STAFF

BOLLWERK, Jim *	Seismic Network Engineer
BREWER, Steve *	Digital Seismic Systems Supervisor
DAVIS, James *	Local Tech Support Provider I
DEBULA, Robert	Local Technical Support Provider II
HORTON, Steve	Research Scientist
MARSHALL, Deshone	Local Technical Support Provider I
MORAN, Nathan Research	Associate II – Physical Science
PARKER, John *	Research Assoc. Tech
PATTERSON, Gary	Director Education & Outreach
SHIVERS, Patrick*	Research Equipment Technician II
SMITH, Michelle	Assistant Director Adm. & Finance
STEINER, David *	Research Equipment Technician II
WITHERS, Holly *	Research Associate II

*seismic and gps networks staff

GRADUATE STUDENTS

AL NOMAN, Md. Nayeem	Graduate Research Assistant
AUSBROOKS, Scott	Graduate Research Assistant
BHATTARAI, Roshan	Graduate Research Assistant
BOLARINA, Oluwaseyi	Graduate Research Assistant
FADUGBA, Oluwaseun	Graduate Research Assistant
GENG, Yu	Graduate Research Assistant
HUDA, Md. Monsurul	Graduate Research Assistant
ISLAM, S. M. Ariful	Graduate Research Assistant
KOIRALA, Roshan	Graduate Research Assistant
LIU, Chunyu	Graduate Research Assistant
LU, Hao	Graduate Research Assistant
MARLOW, Christopher	Graduate Research Assistant
MAHANAMA, Anuradha	Graduate Research Assistant
NOOR, Samia	Graduate Research Assistant
PANDEY, Kiran	Graduate Research Assistant
SARKAR, Kaushik	Graduate Research Assistant
SAXENA, Arushi	Graduate Research Assistant
TAN, Jiayan	Graduate Research Assistant
YANG, Yang	Graduate Research Assistant
ZHANG, Jia	Graduate Research Assistant
ZHANG, Yixin	Graduate Research Assistant