Biological and Environmental Research
Funding Profile by Subprogram and Activity

(dollars in thousands)

	FY 2012 Current	FY 2013 Annualized CR*	FY 2014 Request
Biological Systems Science			
Genomic Science			
Foundational Genomics Research	63,632	—	76,341
Genomics Analysis and Validation	10,000	—	10,000
Metabolic Synthesis and Conversion	19,122	—	19,462
Computational Biosciences	16,395	—	16,395
Bioenergy Research Centers	75,000	—	75,000
Total, Genomic Science	184,149	—	197,198
Mesoscale to Molecules	0	—	9,680
Radiological Sciences			
Radiochemistry and Imaging Instrumentation	19,410	—	11,400
Radiobiology	15,528	—	7,898
Total, Radiological Sciences	34,938	—	19,298
Biological Systems Facilities and Infrastructure			
Structural Biology Infrastructure	14,895	—	14,895
Joint Genome Institute	68,500	—	69,800
Total, Biological Systems Facilities and Infrastructure	83,395	—	84,695
SBIR/STTR	0	—	10,195
Total, Biological Systems Science	302,482	—	321,066
Climate and Environmental Sciences			
Atmospheric System Research	26,278	—	26,392
Environmental System Science			
Terrestrial Ecosystem Science	40,193	—	45,001
Subsurface Biogeochemical Research	27,404	—	27,380
Total, Environmental System Science	67,597	—	72,381
Climate and Earth System Modeling			
Regional and Global Climate Modeling	28,345	—	28,159
Earth System Modeling	35,336	—	35,569
Integrated Assessment	9,958	—	9,853
Total, Climate and Earth System Modeling	73,639	—	73,581

(dollars in thousands)

	FY 2012 Current	FY 2013 Annualized CR*	FY 2014 Request
Climate and Environmental Facilities and Infrastructure			
Atmospheric Radiation Measurement Climate Research Facility	67,908	—	71,199
Environmental Molecular Sciences Laboratory	50,324	—	46,671
Data Management	3,205	—	3,496
General Purpose Equipment (GPE)	300	—	500
General Plant Projects (GPP)	700	—	500
Total, Climate and Environmental Facilities and Infrastructure	122,437	—	122,366
SBIR/STTR	0	—	9,561
Total, Climate and Environmental Sciences	289,951	—	304,281
Total, Biological and Environmental Research[a]	592,433	613,287	625,347

*FY 2013 amounts shown reflect the P.L. 112-175 continuing resolution level annualized to a full year. These amounts are shown only at the "congressional control" level and above; below that level a dash (—) is shown.

[a] SBIR/STTR funding:
- FY 2012 Appropriation: SBIR $15,092,000 and STTR $2,032,000 (transferred out of BER in FY 2012 Current column)
- FY 2014 Request: SBIR $17,287,000 and STTR $2,469,000

Public Law Authorizations

Public Law 95-91, "Department of Energy Organization Act", 1977
Public Law 102-468, "Energy Policy Act of 1992"
Public Law 109-58, "Energy Policy Act of 2005"
Public Law 110-69, "America COMPETES Act of 2007"
Public Law 111-358, "America COMPETES Reauthorization Act of 2010"

Overview

The Biological and Environmental Research (BER) program supports fundamental research and scientific user facilities to address diverse and critical global challenges. The program seeks to understand how genomic information is translated to functional capabilities, enabling more confident redesign of microbes and plants for sustainable biofuels production, improved carbon storage, or contaminant bioremediation. BER research advances understanding of the roles of the earth's biogeochemical systems (the atmosphere, land, oceans, sea ice, and subsurface) in determining climate so we can predict climate decades or centuries into the future, information needed to plan for future energy and resource needs.

BER research uncovers nature's secrets from the diversity of microbes and plants to understand how biological systems work, how they interact with each other, and how they can be manipulated to harness their processes and products. By starting with the potential encoded by organisms' genomes, BER scientists seek to define the principles that guide the translation of the genetic code into functional proteins and the metabolic/regulatory networks underlying the systems biology of plants and microbes as they respond to and modify their environments.

BER plays a unique and vital role in supporting research on atmospheric processes, climate change modeling, interactions between ecosystems and greenhouse gases (especially carbon dioxide [CO_2]), and analysis of impacts and interdependencies of climatic change with energy production and use. BER contributes toward understanding the earth's radiant energy balance associated with clouds, aerosols, and atmospheric

greenhouse gases, the three factors contributing the most uncertainty in global climate change models. BER also supports research to understand the impacts of climatic change—warmer temperatures, changes in precipitation, increased levels of greenhouse gases, changing distributions of weather extremes—on different ecosystems such as forests, grasslands, and farmland. Finally, BER research seeks understanding of the critical role that biogeochemical processes play in controlling the cycling and mobility of materials in the earth's subsurface and across key surface-subsurface interfaces in the environment.

BER's scientific impact has been transformative. Efforts to map the human genome, primarily the U.S. supported international Human Genome Project, which DOE formally began in 1990, initiated the era of modern biotechnology and genomics-based systems biology. Today, with its Genomic Sciences Program and the DOE Joint Genome Institute (JGI), BER researchers are using the powerful tools of plant and microbial systems biology to pursue fundamental breakthroughs needed to develop cost-effective cellulosic biofuels. Our three DOE Bioenergy Research Centers lead the world in fundamental biofuels relevant research.

Since the 1950s, BER has been a critical contributor to climate science research in the U.S., beginning with atmospheric circulation studies that were the forerunners of modern climate models. Today, BER research contributes to the Community Earth System Model, a leading U.S. climate model, and addresses two of the most critical areas of uncertainty in contemporary climate science—the impact of clouds and aerosols—through support of the Atmospheric Radiation Measurement Climate Research Facility (ARM), which is used by hundreds of scientists worldwide. BER has been a pioneer of ecological and environmental studies in terrestrial ecosystems. BER's Environmental Molecular Sciences Laboratory (EMSL) provides powerful suites of instruments and computers to characterize biological organisms and molecules.

Basic and Applied R&D Coordination

BER research underpins the needs of DOE's energy and environmental missions. Basic research on microbes and plants provides fundamental understanding that can be used to develop new bioenergy crops and improved biofuel production processes that are cost effective and sustainable. This research is relevant to other agencies, including DOE's Office of Energy Efficiency and Renewable Energy and the U.S. Department of Agriculture. Coordination with other federal agencies on priority science needs occurs through the Biomass Research and Development Board, a congressionally mandated interagency group created by the Biomass Research and Development Act of 2000, as amended by the Energy Policy Act of 2005, and under the Office of Science and Technology Policy.

BER research to understand and predict future changes in the Earth's climate system provides important tools that link climate predictions to evaluations of new energy policies and help guide the design criteria for next generation energy infrastructures. BER research on the transport and transformation of energy-related substances in subsurface environments provides understanding that can enable DOE's Office of Environmental Management (EM) to develop new strategies for the remediation of weapons-related and other contaminants at DOE sites. DOE program managers have established formal technical coordination working groups that meet on a regular basis to discuss R&D programs with wide applications for basic and applied programs, including the Office of Environmental Management. In general, BER coordinates with DOE's applied technology programs through regular joint program manager meetings, by participating in their internal program reviews, by participating in joint principal investigator meetings, and by conducting joint technical workshops. In FY 2014, SC and EM will also implement new platforms for coordination such as workshops and formal technical coordination working groups, which have been used to effectively improve coordination between basic research and applied programs in DOE.

Program Accomplishments and Milestones

Advancing the science needed for next-generation biofuels. The DOE Bioenergy Research Center (BRC) researchers have developed new approaches for engineering non-food plant biomass that can be more easily and efficiently digested for conversion into biofuels. These include increasing easily-digestible starch levels in the candidate biofuels crop switchgrass and discovering new lignin subunits within plant biomass that could be future engineering targets to make it easier to process into liquid fuel. They have also identified specific genes that enable biofuel-producing microorganisms to

cope with toxic and inhibitory chemical components produced during biomass pretreatment processes, avoiding the expense of removing residual toxic chemicals from pretreated biomass.

Genome-based studies to address global carbon cycling processes. Researchers at the DOE Joint Genome Institute recently discovered novel groups of methane-producing microbes in climate-sensitive environments such as Arctic permafrost by directly sequencing genomes from soil samples. Understanding genome-encoded metabolic properties of environmental microbes underpins the development of detailed metabolic models of key organisms involved in globally significant carbon cycling. These models enable a more predictive understanding of how microorganisms impact global carbon flux.

Observations, new data, and science teams advance climate predictions. A team of national laboratory scientists collected new observations to produce a sophisticated aerosol microphysical model that more accurately resolves aerosol sizes and mixing states, and implemented these into the Community Earth System Model. A second team of national laboratory, university, and private research scientists used the Environmental Molecular Sciences Laboratory (EMSL) to show that secondary organic aerosols have much longer lifetimes than previously predicted. A third team of academic scientists advanced a submodel that combines photosynthetic activity with atmospheric solar radiation availability. National laboratory researchers used this collective set of achievements to demonstrate that the improved atmospheric and ecology components of the Community Earth System Model lead to improved confidence in climate predictions.

Atmospheric Radiation Measurement (ARM) facility advances both cloud modeling and NASA satellite capabilities. A research team involving scientists from DOE and NASA laboratories participated in a joint DOE-NASA experiment conducted in 2012 at the Oklahoma ARM site. The ARM facility's three dimensional, high resolution observations represent the only data set that combines a long time series with sequences of severe and extreme thunderstorms impacting the central U.S. Early results are extending capabilities of the Community Earth System Model to accurately represent extreme events (e.g., heat waves, droughts, and storms), and the same data extended the range of applicability of NASA satellite sensors to map two-dimensional global aerosol and cloud fields.

Milestone	Date
All Systems Biology Knowledgebase infrastructure is installed and operational, with initial full public release to enable key scientific objectives in plant and microbial research: integration of data to reconstruct and predict metabolic and gene expression regulatory networks for up to 1,000 microbes and integration of phenotypic and experimental data for bioenergy plants to predict manipulation of biomass properties. (Genomic Science)	2nd Qtr, FY 2013
Use new climate model simulations to quantify the interactions between clouds and climate changes. (Climate and Earth System Modeling)	4th Qtr, FY 2013
The average achieved operation time of the BER scientific user facilities as a percentage of the total scheduled annual operating time is greater than 98%. (Supporting Information/ Facilities Users and Hours)	4th Qtr, FY 2013

Program Planning and Management

BER uses broad input from scientific workshops[a] and external reviews, including those performed by the National Academies, to identify current and future scientific and technical needs and challenges in current national and international research efforts, as well as for program evaluation, consistent with the President's management agenda.[b] BER also receives advice from the Biological and Environmental Research Advisory Committee (BERAC) on the management of its research programs (through Committee of Visitors [COV] reviews), on the direction and focus of its research programs, and on strategies for long-term planning and development of its research activities.

In FY 2011, BERAC issued a report on an overall strategy to inform a long-term vision for BER. A key emphasis of the report was the identification of the greatest scientific challenges in biological, climate, and environmental systems science that BER should address in the long-term (20-year horizon) and how BER should be positioned to

[a] BER scientific workshop reports are available at http://science.energy.gov/ber/news-and-resources.
[b] http://www.whitehouse.gov/sites/default/files/omb/memoranda/2012/m-12-14.pdf

address those challenges; the continued or new fields of BER-relevant science that DOE will need to pursue to achieve its future mission challenges; and the future scientific and technical advances needed to underpin BER's complex systems science. The report, "Grand Challenges for Biological and Environmental Research: A Long-Term Vision"[a] identified grand challenges in complex systems and synthetic biology, climate modeling and climate-related ecosystem science, energy sustainability, computing, and training and workforce development. In 2013, BERAC prepared a companion strategy report, "BER Virtual Laboratory: Innovative Framework for Biological and Environmental Grand Challenges" to inform the technology and facilities priorities to meet an ambitious long-term vision for BER research.

BER supports research at universities, research institutes, private companies, and DOE national laboratories. All BER-supported research undergoes regular peer review and merit evaluation based on procedures established in 10 CFR 605 for the external grant program and using a similar process for research at the national laboratories. BERAC conducts COV reviews of the merit evaluation conducted by BER subprograms every three years. Results of these reviews and BER responses are posted online.[a] The Climate and Environmental Sciences Division will undergo a COV review in FY 2013. A COV will be assembled in 2014 to review the Biological System Science Division.

Every three years, BER also conducts consolidated onsite merit, operational, management, and safety reviews of each of its user facilities. Results of these reviews are used to address management, scientific, operational, and safety deficiencies. The BER program is coordinated with activities of over 14 other federal organizations supporting or conducting complementary research. BER Climate Change Research is coordinated with the U.S. Global Change Research Program (USGCRP), an interagency program codified by Public Law 101–606 and involving other federal agencies and departments.

Program Goals and Funding

Office of Science performance expectations (and therefore funding requests) are focused on four areas:

Research: Increase our understanding of and enable predictive control of phenomena in complex biological, climatic, and environmental systems sciences.

Facility Operations: Maximize the reliability, dependability, and availability of the SC scientific biological, climatic, and environmental user facilities.

Future Facilities: Build future and upgrade existing facilities and experimental capabilities to ensure the continuing value of the SC scientific user facilities. All construction projects and MIEs are within 10% of their specified cost and schedule baselines.

Scientific Workforce: Contribute to the effort aimed at ensuring that DOE and the Nation have a sustained pipeline of highly skilled and diverse science, technology, engineering, and mathematics (STEM) workers.

[a] http://science.energy.gov/ber/berac/reports/Science/

Goal Areas by Subprogram

	Research	Facility Operations	Future Facilities	Scientific Workforce
Biological Systems Science	72%	28%	0%	0%
Climate and Environmental Sciences	60%	40%	0%	0%
Total, Biological and Environmental Research	66%	34%	0%	0%

Performance Measures

Performance Goal (Measure)	**BER Climate Model**—Develop a coupled climate model with fully interactive carbon and sulfur cycles, as well as dynamic vegetation to enable simulations of aerosol effects, carbon chemistry, and carbon sequestration by the land surface and oceans and the interactions between the carbon cycle and climate		
Fiscal Year	**2012**	**2013**[a]	**2014**
Target	Demonstrate coupled climate models at 20-kilometer resolution	Use new climate model simulations to quantify interactions between clouds and climate changes	Use global models to estimate most sensitive elements of terrestrial carbon to climate change for tropics, mid-latitudes, and polar regions
Result	Met		
Endpoint Target	BER supports the Community Earth System Model, a leading U.S. climate model, and addresses two of the most critical areas of uncertainty in contemporary climate science—the impact of clouds and aerosols. Delivery of improved scientific data and models (with quantified uncertainties) about the potential response of the Earth atmosphere system to more accurately predict the Earth's future climate is essential to plan for future energy needs, water resources, and land use. DOE will continue to advance the science necessary to further develop predictive climate and earth system models at the regional spatial scale and decadal to centennial time scales, involving close coordination with the U.S. Global Change Research Program and through the international science community.		

Performance Goal (Measure)	**BER Facility Operations**—Average achieved operation time of BER user facilities as a percentage of total scheduled annual operation time		
Fiscal Year	**2012**	**2013**[a]	**2014**
Target	≥ 98%	≥ 98%	≥ 98%
Result	Met		

[a] 2013 targets reflect DOE's FY 2013 Budget Request to Congress. FY 2013 target updates can be found in the upcoming FY 2012–2014 Annual Performance Plan and Report.

Endpoint Target	Many of the research projects that are undertaken at the Office of Science's scientific user facilities take a great deal of time, money, and effort to prepare and regularly have a very short window of opportunity to run. If the facility is not operating as expected the experiment could be ruined or critically setback. In addition, taxpayers have invested millions or even hundreds of millions of dollars in these facilities. The greater the period of reliable operations, the greater the return on the taxpayers' investment.

Explanation of Funding and Program Changes

Biological and Environmental Research will support key core research areas and scientific user facilities in bioenergy, climate, and environmental research. Increased investments target the development of biosystems design tools and the development of integrative analysis of experimental datasets to examine cross-scale (mesoscale to molecular) relationships among biological processes. Core research in foundational genomics, including the DOE Bioenergy Research Centers, will provide the fundamental biological system science to underpin advances in bioenergy production, carbon cycling in the environment and bioremediation processes. While overall funding for radiological sciences is decreased as funding for activities on human nuclear medicine is completed and radiation studies shift toward linking laboratory-based research with epidemiological research on low dose radiation effects, targeted investments will be made in specific radiological sciences activities to develop radiotracer imaging techniques for bioenergy and environmental processes, and epidemiological research on low dose radiation effects in large populations.

Climate and Environmental Research activities will conduct preliminary scientific analysis of the sensitivity and uncertainty of climate predictions to examine climate sensitive geographies not represented by the Next Generation Ecosystem Experiment (NGEE) Arctic and Tropics studies. New observations of clouds, aerosols, and sensitive ecosystems will address uncertainty in climate models. There will be reduced investment in running climate projections that support global and regional climate assessments as the Intergovernmental Panel on Climate Change (IPCC) Assessment Report 5 (AR 5) will be completed in FY 2013. Terrestrial Ecosystem research will increase to characterize the complex interdependent processes and interrelationships between climate change and tropical ecosystems.

(dollars in thousands)

	FY 2012 Current	FY 2014 Request	FY 2014 Request vs. FY 2012 Current
Biological Systems Science	302,482	321,066	+18,584

Investment in Foundation Genomics increases in the development of biosystems design tools and biodesign technologies and integrative analysis of experimental genomic science datasets to examine cross-scale relationships among biological processes. New activities exploit the powerful tools of the physical sciences to facilitate understanding of organisms from the molecular to mesoscale cellular organization. While overall funding for Radiological sciences research decreases, activities will enhance development of radiotracer imaging techniques for bioenergy and environmental processes, and efforts to link laboratory-based research with epidemiological studies on low dose radiation effects in large populations.

(dollars in thousands)

	FY 2012 Current	FY 2014 Request	FY 2014 Request vs. FY 2012 Current
Climate and Environmental Sciences	289,951	304,281	+14,330
BER observational efforts to describe the interrelationships between climate change in Arctic, midlatitude, and tropical ecosystems will deliver new data and more sophisticated multi-scale parameterizations in order to advance earth system models. Modeling efforts will emphasize the interdependencies involving global scale dynamics and higher resolution scale interactions for regions that are of primary interest to both the scientific community and stakeholders. New observations of clouds, aerosols, and sensitive ecosystems will address uncertainty in climate models.			
Total, Biological and Environmental Research	592,433	625,347	+32,914

Biological Systems Science
Funding Profile by Activity

(dollars in thousands)

	FY 2012 Current	FY 2013 Annualized CR	FY 2014 Request
Genomic Science			
Foundational Genomics Research	63,632	—	76,341
Genomics Analysis and Validation	10,000	—	10,000
Metabolic Synthesis and Conversion	19,122	—	19,462
Computational Biosciences	16,395	—	16,395
Bioenergy Research Centers	75,000	—	75,000
Total, Genomic Science	184,149	—	197,198
Mesoscale to Molecules	0	—	9,680
Radiological Sciences			
Radiochemistry and Imaging Instrumentation	19,410	—	11,400
Radiobiology	15,528	—	7,898
Total, Radiological Sciences	34,938	—	19,298
Biological Systems Facilities and Infrastructure			
Structural Biology Infrastructure	14,895	—	14,895
Joint Genome Institute	68,500	—	69,800
Total, Biological Systems Facilities and Infrastructure	83,395	—	84,695
SBIR/STTR	0	—	10,195
Total, Biological Systems Science[a]	302,482	—	321,066

[a] SBIR/STTR funding:
- FY 2012 Appropriation: SBIR $8,070,000 and STTR $1,087,000 (transferred out of BER in FY 2012 Current column)
- FY 2014 Request: SBIR $8,921,000 and STTR $1,274,000

Overview

Biological Systems Science is unique in the U.S. science enterprise in integrating discovery- and hypothesis-driven science with technology development on plant and microbial systems relevant to DOE bioenergy mission needs. Systems biology is the multidisciplinary study of complex interactions specifying the function of entire biological systems—from single cells to multicellular organisms—rather than the study of individual components. The Biological Systems Science subprogram focuses on utilizing systems biology approaches to define the functional principles that drive living systems, from microbes and microbial communities to plants and other whole organisms.

Key questions that drive these studies include:

- What information is encoded in the genome sequence?
- How is information exchanged between different subcellular constituents?

- What molecular interactions regulate the response of living systems and how can those interactions be understood dynamically and predictively?

The subprogram builds upon a successful track record in defining and tackling bold, complex scientific problems in genomics—problems that required the development of large tools and infrastructure; strong collaboration with the computer sciences community and the mobilization of multidisciplinary teams focused on plant and microbial bioenergy research. The approaches employed include genome sequencing, proteomics, metabolomics, structural biology, high-resolution imaging and characterization, and integration of information into computational models that can be iteratively tested and validated to advance a predictive understanding of biological systems from molecules to mesoscale.

The subprogram supports operation of a scientific user facility, the DOE Joint Genome Institute (JGI), and use of structural biology facilities through the development of instrumentation at DOE's national user facilities. Support is also provided for research at the interface of the biological and physical sciences and instrumentation for radiochemistry to develop new methods for real-time, high-resolution imaging of dynamic biological processes.

Explanation of Funding Changes

(dollars in thousands)

	FY 2012 Current	FY 2014 Request	FY 2014 Request vs. FY 2012 Current
Genomic Science	184,149	197,198	+13,049
Genomic Science research remains a priority activity, with Foundational Genomics Research increasing for the development of biosystems design tools and biodesign technologies for plant and microbial systems relevant to bioenergy production, carbon and nutrient cycling, and environmental change. Targeted research in Metabolic Synthesis and Conversion on cellulosic ethanol and biohydrogen continues to be de-emphasized. Genomic Analysis and Validation continues. The DOE Bioenergy Research Centers will conduct research on advanced renewable biofuels. Computational Biosciences will advance the Systems Biology Knowledgebase tools and integrative analyses of plant and microbial functional genomics experimental datasets.			
Mesoscale to Molecules	0	9,680	+9,680
The properties of many complex systems at one observational scale cannot be extrapolated accurately from processes at another scale because the nature of the scaling relationships is unknown. New funding is provided for integrated experimental and computational approaches to investigate the scaling properties of processes occurring from the molecular to the mesoscale and multicellular organization. Identifying scaling relationships allows accurate representation of functional relationships within the cell, facilitating improved predictions of multicellular interactions and biological organism behavior with respect to energy and the environment			

(dollars in thousands)

	FY 2012 Current	FY 2014 Request	FY 2014 Request vs. FY 2012 Current
Radiological Sciences	34,938	19,298	-15,640
Radionuclide imaging research for real-time visualization of dynamic biological processes in energy and environmentally-relevant contexts continues, while concluding training activities in nuclear medicine research. Further decreases in radiobiology reflect a shift towards bioenergy and environmental research within the Biological Systems Science portfolio. Ongoing efforts in radiobiology emphasize a systems biology approach to understanding the subtle effects of low dose radiation on cell processes and epidemiological studies to evaluate statistically significant effects of low dose radiation exposure in large populations.			
Biological Systems Facilities and Infrastructure	83,395	84,695	+1,300
Funding will support large-scale, complex genome sequencing and analysis at the Joint Genome Institute, with increasing emphasis on understanding comparative or community-scale plant and microbial genomics. Support continues for the development of instrumentation at SC's synchrotron light sources, neutron sources, and next-generation user facilities for analyzing biological structure-function relationships. Increases will support refreshment of equipment at the Joint Genome Institute.			
SBIR/STTR	0	10,195	+10,195
In FY 2012, $8,070,000 and $1,087,000 were transferred to the Small Business Innovation Research (SBIR) and Small Business Technology Transfer (STTR) programs, respectively. SBIR/STTR funding is set at 2.95% of non-capital funding in FY 2012 and 3.2% in FY 2014.			
Total, Biological Systems Science	302,482	321,066	+18,584

Genomic Science

Overview

The Genomic Science activity supports research aimed at identifying the fundamental principles that drive biological systems relevant to DOE missions in energy, climate, and the environment. These principles guide the translation of the genetic code into functional proteins and the metabolic/regulatory networks underlying the systems biology of plants, microbes, and communities. Advancing fundamental knowledge of these systems will enable new solutions to national challenges in sustainable bioenergy production, understanding the fate and transport of materials such as nutrients and contaminants in the environment, and developing new approaches to examine the role of biological systems in carbon cycling, biosequestration, and global climate.

The major objectives of the Genomic Science activity are to determine the molecular mechanisms, regulatory elements, and integrated networks needed to understand genome-scale functional properties of microbes, plants, and communities; develop "-omics" experimental capabilities and enabling technologies needed to achieve a dynamic, system-level understanding of organism and community functions; and develop the knowledgebase, computational infrastructure, and modeling capabilities to advance predictive understanding, manipulation and design of biological systems. Research efforts in biosystems design, including environmental, ethical, legal, and societal impacts, are coordinated across the Federal Government.

The Systems Biology Knowledgebase is designed to be an integrated experimental framework for accessing, comparing, analyzing, modeling, and testing large scale Genomic Science data. The team-based multi-institutional DOE Bioenergy Research Centers focus on innovative research to achieve the basic science breakthroughs needed to develop sustainable and effective methods of producing cellulosic biofuels.

Funding and Activity Schedule

Fiscal Year	Activity	Funding (dollars in thousands)
FY 2012	Supported core research activities in plant and microbial systems-level functional genomics and for the three Bioenergy Research Centers, including the development of new synthetic toolkits and testbeds to facilitate biosystems design engineering applications in bioenergy production, environmental remediation, and carbon cycling. This new activity was informed by the 2011 Biosystems Design Workshop report.[a] Computational Biosciences further developed a Systems Biology Knowledgebase to integrate microbial community genomic, proteomic, and transcriptomic experimental data sets from research conducted at the DOE Bioenergy Research Centers, the Joint Genome Institute, and the Genomic Science supported activities.	184,149

[a] http://science.energy.gov/ber/news-and-resources/

Fiscal Year	Activity	Funding (dollars in thousands)
FY 2013	The FY 2013 Request proposed $188,149,000 for investment in the development of biosystems design tools, biodesign technologies, and integrative analysis of experimental genomic science datasets. The resulting new molecular-level insight into the design, function, and regulation of plants, microbes, and biological communities contributes to cost-effective production of next generation biofuels as a major secure national energy resource. Support continues for core research activities in plant and microbial systems-level functional genomics and networks, with completion of Metabolic Synthesis and Conversion targeted research on cellulosic ethanol and biohydrogen. The three DOE Bioenergy Research Centers begin a renewal funding period in FY 2013, continuing research on advanced biofuels. Computational Biosciences supports the Systems Biology Knowledgebase effort to develop predictive simulation efforts in microbial community interactions. The first phase of the knowledgebase effort becomes fully operational in FY 2013 with the integration of plant and microbial experimental and genomic sequencing datasets.	—
FY 2014	Increased investment will advance core research areas in Foundational Genomics Research with emphasis on continued development of biosystems design tools and biodesign technologies for bioenergy research, integrative analysis of large experimental genomic science datasets, and efforts to gain a predictive understanding of carbon cycling in the environment. The research portfolio will stress the integration of genome science with experiment and computational modeling to advance a predictive understanding of the design, function and regulation of plants, microbes, and biological communities contributing to the cost-effective production of next generation biofuels as a major secure national energy resource. At least 5% of the funding for biodesign efforts will be used to study the environmental, ethical, legal, and societal impacts. Support will provide for core research activities in plant and microbial systems-level functional genomics and networks, with completion of Metabolic Synthesis and Conversion targeted research on cellulosic ethanol and biohydrogen. Research efforts at the Bioenergy Research Centers will advance biofuels development from foundational biological systems science. Computational Biosciences will advance the Systems Biology Knowledgebase effort to develop predictive simulation efforts in plant and microbial community interactions.	197,198

(dollars in thousands)

	FY 2012 Current	FY 2013 Annualized CR	FY 2014 Request
Foundational Genomics Research	63,632	—	76,341
Genomics Analysis and Validation	10,000	—	10,000
Metabolic Synthesis and Conversion	19,122	—	19,462
Computational Biosciences	16,395	—	16,395
Bioenergy Research Centers	75,000	—	75,000
Total, Genomic Science	184,149	—	197,198

Mesoscale to Molecules

Overview

BER approaches to systems biology have focused on the rich terrain between genotype and phenotype—from the genome up through the mechanisms that power living cells, communities of cells, and whole organisms. But there is also a need to explore the terrain between the mesoscale structures within living cells and the molecular effects in biological macromolecules. The Mesoscale to Molecules activity will encourage joint efforts between systems biologists and physical scientists and engineers, to focus on fostering interdisciplinary approaches and leveraging tools and resources at the national scientific user facilities to solve DOE mission needs in energy and environment.

Funding and Activity Schedule

Fiscal Year	Activity	Funding (dollars in thousands)
FY 2012	There is no funding for this activity in FY 2012.	0
FY 2013	There is no funding for this activity in FY 2013.	0
FY 2014	Research is initiated to understand the genomic and physical rules that govern the formation and architecture of subcellular organelles in biological systems. The relationship between composition and function will be explored, leveraging imaging tools and resources at the national scientific user facilities.	9,680

Radiological Sciences

Overview

Radiological Sciences supports radionuclide synthesis and imaging research for real-time visualization of dynamic biological processes in energy and environmentally relevant contexts. The activity has significantly transitioned from its historical focus on nuclear medicine research and applications for health to focus on real-time, whole organism understanding of metabolic and signaling pathways in plants and nonmedical microbes. Radionuclide imaging continues to be a singular tool for studying living organisms in a manner that is quantitative, three dimensional, temporally dynamic, and non-perturbative of the natural biochemical processes. The instrumentation research focuses on improved metabolic imaging in the living systems, including plants and microbial-communities, relevant to biofuels production and bioremediation of interest to DOE. The activity also supports fundamental research on integrated gene function and response of biological organisms to low dose radiation exposure, through systems genetics analysis in model systems and epidemiological studies. This activity contributes a scientific foundation for informed decisions regarding remediation of contaminated DOE sites and for determining acceptable levels of human health protection, for both cleanup workers and the public, in the most cost-effective manner.

Funding and Activity Schedule

Fiscal Year	Activity	Funding (dollars in thousands)
FY 2012	Core research activities in radiotracer synthetic chemistry and complementary imaging instrumentation continued. Additional activity included nuclear medicine research with human application and research to help determine health risks from exposures to low levels of ionizing radiation, as well as studies of health impacts at and around the Fukushima Daiichi nuclear plant as directed by Congress (in the FY 2012 Energy and Water Development Appropriations conference report [H. Rpt. 112-331]). Research is completed for integrated training in radiotracer synthetic methodology and in vivo imaging and detection relevant to nuclear medicine applications.	34,938
FY 2013	The FY 2013 Request proposed $28,160,000 to continue core research activities in radiotracer synthetic chemistry for real-time visualization of dynamic biological processes in the energy and environmentally-relevant contexts. Research is completed for the development of a limited number of systems genetic reference mouse populations. Priority research begins to address integration of mechanism-based models that incorporate both radiobiology and epidemiology.	—
FY 2014	Core research activities will emphasize radiotracer synthetic chemistry for real-time visualization of dynamic biological processes in the energy and environmentally-relevant contexts. Funding is decreased as human nuclear medicine research is transitioned to integrative training opportunities in nuclear medicine. Opportunities to transition nuclear medicine training activities to agencies with a human-health focus mission will continue to be explored. Decreases in radiobiology research reflect an emphasis on bioenergy and environmental missions within the Biological Systems Science portfolio and emphasize a systems biology approach to understanding the effects of low dose radiation on cellular processes and epidemiological studies to uncover statistically significant effects of low dose radiation in large populations.	19,298

(dollars in thousands)

	FY 2012 Current	FY 2013 Annualized CR	FY 2014 Request
Radiochemistry and Imaging Instrumentation	19,410	—	11,400
Radiobiology	15,528	—	7,898
Total, Radiological Sciences	34,938	—	19,298

Biological Systems Science Facilities and Infrastructure

Overview

Biological Systems Science supports unique scientific facilities and infrastructure related to genomics and structural biology that are widely used by researchers in academia, the national laboratories, and industry. The DOE Joint Genome Institute (JGI) is the only federally funded major genome sequencing center focused on genome discovery and analysis in plants and microbes for energy and environmental applications. High-throughput DNA sequencing underpins modern systems biology research, providing fundamental biological data on organisms and groups of organisms. By understanding shared features of multiple genomes, scientists can identify key genes that may link to biological function. These functions include microbial metabolic pathways and enzymes that are used to generate fuel molecules, affect plant biomass formation, degrade contaminants, or capture CO_2, leading to the optimization of these organisms for biofuels production and other DOE missions.

The JGI is developing aggressive new strategies for complex genome assembly using next-generation sequencing platforms and genomic analysis tools. The JGI also performs metagenome (genomes from multiple organisms) sequencing and analysis from environmental samples and is developing single cell sequencing techniques on hard-to-culture cells from environments relevant to the DOE missions.

BER also supports development and use of specialized instrumentation for biology at major DOE user facilities, such as synchrotron light sources and neutron facilities, in collaboration with the other SC program offices. These research facilities enable science aimed at understanding the structure and properties of biological systems at resolutions and scales not accessible with instrumentation available in university, institute, or industrial laboratories. This information is critical in contributing to our understanding of the relationship between genome, biological structure, and function, leading to practical applications of this knowledge for energy and the environment.

Funding and Activity Schedule

Fiscal Year	Activity	Funding (dollars in thousands)
FY 2012	JGI supported the large-scale genome sequencing data acquisition and analysis needs of the scientific user community and the DOE Bioenergy Research Centers with a greater emphasis on metagenome expression and sequencing of environmental microbial communities and functional analysis and verification of genome-scale models. JGI initiated efforts to transform its capabilities and provide functional genomic interpretations of biological systems in large scale multi-disciplinary environmental and targeted systems biology studies while maintaining operating performance at 98% of scheduled operating time. Support continued for research at established structural biology instrumentation at the synchrotron light sources and neutron facilities, informed by the report of the 2011 workshop on "Applications of new DOE National User Facilities in Biology."[a]	83,395

[a] http://science.energy.gov/ber/news-and-resources/

Fiscal Year	Activity	Funding (dollars in thousands)
FY 2013	The FY 2013 Request proposed $84,082,000 to supports a greater JGI emphasis on functional genomics analysis for plants and microbes combining massive sequencing capability with high performance computing for data management, integration, and analysis in conjunction with BER's Systems Biology Knowledgebase effort. JGI continues to utilize new technologies for higher-throughput genome analysis and integration with other proteomic and metabolomic datasets and develop new high-throughput sample processing to ease pre-sequencing sample preparation bottlenecks to large scale sequencing projects. JGI sequencing capabilities also support biosystems design efforts. Support continues to develop structural biology instrumentation and end stations and new research capabilities at the synchrotron light sources and neutron facilities.	—
FY 2014	JGI will emphasize large scale, complex sequencing of plants and microbial communities in support of fundamental research for DOE bioenergy and environmental missions. JGI will facilitate genome science through its massive sequencing capability coupled with high performance computing for data management, integration, and analysis. JGI activities are closely coordinated with BER's Systems Biology Knowledgebase effort and will seek opportunities to integrate high-throughput technologies that can bring added functional understanding to the genome sequences generated. The priority needs for these technologies are informed by the report from the community workshop, "JGI Strategic Planning for the Genomic Sciences," held in FY 2012. JGI sequencing capabilities also support biosystems design efforts. Support continues to develop new instrumentation and end stations for structural biology and new research capabilities at the Office of Science synchrotron light sources and neutron facilities.	84,695

(dollars in thousands)

	FY 2012 Current	FY 2013 Annualized CR	FY 2014 Request
Structural Biology Infrastructure	14,895	—	14,895
Joint Genome Institute	68,500	—	69,800
Total, Biological Systems Facilities and Infrastructure	83,395	—	84,695

Climate and Environmental Sciences
Funding Schedule by Activity

(dollars in thousands)

	FY 2012 Current	FY 2013 Annualized CR	FY 2014 Request
Atmospheric System Research	26,278	—	26,392
Environmental System Science			
Terrestrial Ecosystem Science	40,193	—	45,001
Subsurface Biogeochemical Research	27,404	—	27,380
Total, Environmental System Science	67,597	—	72,381
Climate and Earth System Modeling			
Regional and Global Climate Modeling	28,345	—	28,159
Earth System Modeling	35,336	—	35,569
Integrated Assessment	9,958	—	9,853
Total, Climate and Earth System Modeling	73,639	—	73,581
Climate and Environmental Facilities and Infrastructure			
Atmospheric Radiation Measurement Climate Research Facility (ARM)	67,908	—	71,199
Environmental Molecular Sciences Laboratory	50,324	—	46,671
Data Management	3,205	—	3,496
General Purpose Equipment (GPE)	300	—	500
General Plant Projects (GPP)	700	—	500
Total, Climate and Environmental Facilities and Infrastructure	122,437	—	122,366
SBIR/STTR	0	—	9,561
Total, Climate and Environmental Sciences[a]	289,951	—	304,281

[a] SBIR/STTR funding:
- FY 2012 Appropriation: SBIR $7,022,000 and STTR $945,000 (transferred out of BER in FY 2012 Current column)
- FY 2014 Request: SBIR $8,366,000 and STTR $1,195,000

Overview

The Climate and Environmental Sciences subprogram supports fundamental science and research capabilities that enable DOE leadership in climate-relevant atmospheric-process and ecosystem research and modeling. This includes research on clouds, aerosols, and the terrestrial carbon cycle; large-scale climate change modeling; experimental research on the effects of climate change on ecosystems; integrated analysis of climate change impacts; and advancing fundamental understanding of coupled physical, chemical, and biological processes controlling contaminant mobility in the environment. This integrated portfolio of research of molecular-level to field-scale studies emphasizes multidisciplinary experimentation and advanced computer models and is aimed at developing predictive, systems-level understanding of the fundamental science associated with climate change. The Department will continue to advance the science necessary to further

develop predictive climate and earth system models at the regional spatial scale and decadal to centennial time scales, involving close coordination with the U.S. Global Change Research Program (USGCRP) and the international science community.

The subprogram supports three primary research activities and two national scientific user facilities. The two user facilities are the Atmospheric Radiation Measurements Climate Research Facility (ARM) and the Environmental Molecular Sciences Laboratory (EMSL). ARM provides unique, multi-instrumented capabilities for continuous, long-term observations needed to develop and test understanding of the central role of clouds and aerosols on the earth's climate. EMSL provides integrated experimental and computational resources needed to understand the physical, chemical, and biological processes that underlie DOE's energy and environmental mission.

Explanation of Funding Changes

(dollars in thousands)

	FY 2012 Current	FY 2014 Request	FY 2014 Request vs. FY 2012 Current
Atmospheric System Research	26,278	26,392	+114
Research will continue to improve formulations for aerosols, clouds, and aerosol-cloud-precipitation interactions in order to improve estimates of how these feedbacks have and will impact climate.			
Environmental System Science	67,597	72,381	+4,784
The activity will support new experimental field activities at the tropics Next-Generation Ecosystem Experiment (NGEE) to study and contribute to predictive models that characterize the relationships between various tropical ecosystems and climate change. Terrestrial modeling activities are integrated into the Climate and Earth System Modeling portfolio to promote stronger model research coordination. Subsurface biogeochemical research continues to focus on environmental research across scales as a continuum of complex interdependent processes, while reducing emphasis on contaminant mobility and on geologic barriers to groundwater contaminant transport.			
Climate and Earth System Modeling	73,639	73,581	-58
Investments continue to evolve climate modeling capabilities using more flexible and adaptive software to support new physics and be compatible with next generation high performance computing assets. Basic research will focus on the science underpinning high-resolution predictability and uncertainty quantification using adaptive grids.			

(dollars in thousands)

	FY 2012 Current	FY 2014 Request	FY 2014 Request vs. FY 2012 Current
Climate and Environmental Facilities and Infrastructure	122,437	122,366	-71
Funding is increased for ARM to support both initiation of long term measurements at Oliktok, AK, and the Azores Islands, and the increased analysis of data collected from those sites; corresponding decreases occur in ARM capital equipment. ARM will support its approximately 1,000 users. EMSL funding for operations increases to support approximately 750 users who will access the facility's suite of instruments for research on biological interaction and dynamics; geochemistry and biogeochemistry of subsurface science; and science of interfacial phenomena. EMSL funding decreases overall as funding for the Mass Spectrometer MIE was completed in FY 2012.			
SBIR/STTR	0	9,561	+9,561
In FY 2012, $7,022,000 and $945,000 were transferred to the Small Business Innovation Research (SBIR) and Small Business Technology Transfer (STTR) programs, respectively. SBIR/STTR funding is set at 2.95% of non-capital funding in FY 2012 and 3.2% in FY 2014.			
Total, Climate and Environmental Sciences	289,951	304,281	+14,330

Atmospheric System Research

Overview

Atmospheric System Research (ASR) is the primary U.S. activity addressing the two major areas of uncertainty in climate change model projections: the role of clouds and the effects of aerosols on precipitation and the atmospheric radiation balance. ASR coordinates with the ARM facility, utilizing the facility's continuous long-term datasets that provide three dimensional measurements of radiation, aerosols, clouds, precipitation, dynamics, and thermodynamics over a range of environmental conditions at climatically diverse locations. The long-term observational datasets are supplemented with laboratory studies and shorter-duration ground-based and airborne field campaigns to target specific atmospheric processes under a diversity of locations and atmospheric conditions. ASR research results are incorporated into earth system models developed by Climate and Earth System Modeling to both understand the processes that govern atmospheric components and to advance earth system model capabilities with greater certainty of predictions. Finally, ASR seeks to develop integrated, scalable test-beds that incorporate process-level understanding of the life cycles of aerosols, clouds, and precipitation into dynamic models.

Funding and Activity Schedule

Fiscal Year	Activity	Funding (dollars in thousands)
FY 2012	ASR used data from the new instruments at the ARM sites specifically supporting research on the development of three-dimensional representation of clouds in climate models. Research continued on marine boundary layer clouds, Arctic clouds and their interactions with aerosols, and processes and atmospheric transformations involving biogenic aerosols.	26,278
FY 2013	The FY 2013 Request proposed $26,392,000 for ASR process studies and modeling efforts to emphasize developing improved formulations for aerosols, clouds, and aerosol-cloud interactions in order to improve estimates of how these feedbacks have and will impact the climate. Specific focuses include Arctic and tropical aerosol-cloud-precipitation interactions, and high altitude (cirrus) clouds and their life cycles and impacts on radiation budget.	—
FY 2014	ASR focuses on process studies and modeling efforts that improve formulations of aerosols, mixed phase clouds, and precipitation process interdependencies, in order to improve estimates of feedbacks on climate in mid-latitude, tropical, and Arctic regions. Specific focuses include the description of aerosol-cloud-precipitation interdependences during larger scale dynamical events, such as those that occur in the tropics and mid-latitudes.	26,392

Environmental System Science

Overview

Environmental System Science supports research that provides scientific understanding of the effects of climate change on terrestrial ecosystems, the role of terrestrial ecosystems in global carbon cycling, and the role of subsurface biogeochemical processes determining flow and transport in the subsurface and how the subsurface and above ground environments interact.

A significant fraction of the carbon dioxide (CO_2) released to the atmosphere during fossil fuel combustion is taken up by terrestrial ecosystems, but the impacts of the timing and magnitude of climatic change, particularly warming, on the uptake of CO_2 by the terrestrial biosphere remain poorly understood. The significant sensitivity of climate models to terrestrial carbon cycle feedback and the uncertain signs of that feedback make resolving the role of the terrestrial biosphere on the carbon balance a high priority. The research focuses on understanding, observing, and modeling the processes controlling exchange rates of greenhouse gases, in particular CO_2 and methane (CH_4), between atmosphere and terrestrial biosphere, evaluating terrestrial source-sink mechanisms for CO_2 and CH_4, and improving the representation of terrestrial ecosystems in coupled earth system models.

Subsurface biogeochemical research supports integrated research, ranging from molecular to field scales, to understand and predict the role that biogeochemical processes play in controlling the cycling and mobility of materials in the subsurface and across key surface-subsurface interfaces in the environment, including environmental contamination from past nuclear weapons production.

Funding and Activity Schedule

Fiscal Year	Activity	Funding (dollars in thousands)
FY 2012	Research focused on potential effects of warming, changes in rainfall, and increasing concentrations of atmospheric CO_2 on terrestrial ecosystems and the terrestrial carbon cycle. A shift in emphasis focused on a new next-generation ecosystem-climate change experiment to predict changes in Arctic permafrost. Research efforts continue to test and evaluate computer models describing subsurface mobility of radionuclides and nutrients. In addition, experimental research at the three Integrated Field Research Challenge (IFRC) sites emphasized sites where there are biological and biogeochemical process controls over heavy metal and radionuclide flow and transport, reducing activities at two of the sites.	67,597
FY 2013	The FY 2013 Request proposed $79,337,000 to support the Arctic Next Generation Ecosystem Experiment (Arctic NGEE) to improve the representation of the major carbon sinks associated with changes in Arctic permafrost ecosystems in earth system and regional climate models. A second NGEE is initiated to address poorly understood ecosystem processes that govern biogenic aerosol emissions to the atmosphere in the tropics. Focusing on one of the most climatically-sensitive tropical regions, the tropics NGEE experiment examines the role of rainfall stress on Amazonian ecosystems and the resulting shifts in released aerosols that serve as cloud condensation nuclei.	—

Fiscal Year	Activity	Funding (dollars in thousands)
	Subsurface Biogeochemical Research continues support to advance the predictive understanding of processes controlling the mobility of radionuclides and nutrients in the environment, including field-based activities at one IFRC site. The focus of the multi-disciplinary field-based investigations retains a focus to advance a science-based general modeling framework, based on a shift to larger system scales as recommended in the 2010 workshop report, "Complex Systems Science for Subsurface Fate and Transport."[a]	
FY 2014	The research will emphasize the Arctic and tropics Next Generation Ecosystem Experiments (NGEE) and AmeriFlux to improve the representation of the major carbon sinks associated with changing climates. Specific tropics NGEE field studies will be conducted based on the recommendations provided during the NGEE Tropics Workshop held in FY 2012. Support for terrestrial modeling activities will be shifted to Climate and Earth System Modeling portfolio, to promote stronger model research coordination and cost efficiencies. In addition, more efficiency will be gained by consolidating investments in terrestrial and subsurface biogeochemistry, nutrient flow, and soil science.	72,381

(dollars in thousands)

	FY 2012 Current	FY 2013 Annualized CR	FY 2014 Request
Terrestrial Ecosystem Science	40,193	—	45,001
Subsurface Biogeochemical Research	27,404	—	27,380
Total, Environmental System Science	67,597	—	72,381

[a] http://science.energy.gov/ber/news-and-resources/

Climate and Earth System Modeling

Overview

Climate and Earth System Modeling develops physical, chemical, and biological model components, including the interactions of human and natural earth systems, needed to simulate climate variability and change from decades to centuries at regional and global scales. The research specifically focuses on quantifying and reducing the uncertainties in earth system models based on more advanced model development, diagnostics, and climate system analysis. Priority model components include the ocean, sea-ice, land-ice, aerosols, atmospheric chemistry, terrestrial carbon cycling, multi-scale dynamical interdependencies, and dynamical cores.

A unique objective of the BER Climate and Earth System Modeling investments is the study and modeling of both historical and current climate change, with an objective to validate and improve future climate projections based on the prediction successes using existing data testbeds. To rapidly and efficiently advance model capabilities, BER supports a unique and powerful inter-comparison resource, the Program for Climate Model Diagnosis and intercomparison (PCMDI), for global climate model development, validation, diagnostics, and outputs, using all 23 world-leading climate models. This ensures BER can exploit the best available science and practice within each of the world's leading climate research programs.

BER and the National Science Foundation (NSF) support the Community Earth System Model which is designed by the research community with open access and broad use by climate researchers worldwide. This model provides a critical capacity for regional climate projections, including information on how the frequency of occurrence and intensity of storms, droughts, and heat waves will change as climate evolves. Demonstrating the critical linkages between DOE's climate modeling investments, the scientific priorities for improvement of the community model are based on the outputs of the intercomparison and validation resource. DOE has also provided computational power and expertise to the Earth System modeling community, through its internal partnership between BER and the Office of Science's Advanced Scientific Computing Research program, innovating code design for optimal model computation on its petascale computers. Climate modeling tools are essential for informing investment decision-making processes for infrastructures associated with future large-scale deployment of energy supply and transmission.

Funding and Activity Schedule

Fiscal Year	Activity	Funding (dollars in thousands)
FY 2012	Model enhancements focused on adding additional representations of processes within the coupled models while improving understanding and representations of complex systems dynamics. For example, ice sheet and ocean models were coupled in the Community Earth System Model to be capable of projecting sea-level rise, and systems dynamics were explored within and among earth system and integrated assessment models. Additional work centered on development of a variable grid coupled climate model, able to produce predictions at 20 km resolution by the 4th quarter of FY 2012. Tools for the dissemination of climate model output in support of the Intergovernmental Panel on Climate Change (IPCC) Assessment Report 5 (AR 5) were implemented.	73,639

Fiscal Year	Activity	Funding (dollars in thousands)
FY 2013	The FY 2013 Request proposed $78,450,000 for research focusing on the development of an enhanced validation and verification capability to compare models and measurements with common framework and sophisticated software tools. A framework to use ARM measurements to validate the clouds and terrestrial carbon measurements to validate the land model will be included in this toolbox. The toolbox will be used on new climate model simulations to quantify the interactions between clouds and climate changes. Research is increased to enhance resolution of climate models operating on regional scales, and to expand model diagnostics, databases, and intercomparison studies. Funding is provided to augment the data and diagnostic technical and analysis capabilities within the national laboratories so that climate projections are carried out in support of the IPCC AR5 and completed.	—
FY 2014	Research on climate model development and analysis will focus on the science underpinning high-resolution predictability using adaptive grids and uncertainty characterization. Emphasis will also be placed on regional predictions for the Arctic and tropics that map into extended Community Land Model capabilities using data from the NGEE experiments. In addition, understanding dynamical interdependencies that describe larger scale variabilities (such as El Niño) that influence regional climate predictability will be prioritized.	73,581

(dollars in thousands)

	FY 2012 Current	FY 2013 Annualized CR	FY 2014 Request
Regional and Global Climate Modeling	28,345	—	28,159
Earth System Modeling	35,336	—	35,569
Integrated Assessment	9,958	—	9,853
Total, Climate and Earth System Modeling	73,639	—	73,581

Climate and Environmental Facilities and Infrastructure

Overview

Climate and Environmental Facilities and Infrastructure includes two scientific user facilities, climate data management for the climate science community, and general purpose equipment and plant projects for the Oak Ridge Institute for Science and Education (ORISE). The scientific user facilities—the Atmospheric Radiation Measurement Climate Research Facility (ARM) and the Environmental Molecular Sciences Laboratory (EMSL)—provide the broad scientific community with technical capabilities, scientific expertise, and unique information to facilitate science in areas integral to BER's mission.

ARM is a multi-platform multi-site national scientific user facility, providing the world's most comprehensive continuous field measurements of climate data to promote the advancement of atmospheric process understanding and climate models through precise observations of atmospheric phenomena. ARM currently contains four fixed long-term measurement facility sites (in Oklahoma, Alaska, the Azores, and the western Pacific), three mobile facilities, and an airborne research capability that operates at sites selected by the scientific community. The ARM fixed sites and mobile measurement campaigns are distributed around the world in locations where we most critically need data to incorporate into climate models and improve model performance and predictive capabilities. Each of the ARM sites contains scanning radars, lidar systems, and in situ meteorological observing capabilities; the sites are additionally used to demonstrate technologies as they are developed by the community. ARM experiments to study the impact of evolving clouds, aerosols, and precipitation on the earth's radiative balance and rate of climate change address the two most significant scientific uncertainties in climate research. BER is also maintaining the exponentially increasing data archive to support enhanced analyses and model development. The data extracted from the archive are used to improve climate projections at higher resolution, greater sophistication, and lower uncertainty, all to better specify tipping points associated with permafrost thaw and other patterns of extreme events.

Data sets generated by ARM and other DOE and Federal earth observing activities, as well as from earth system modeling activities, are large. The information in earth observations data can be used to achieve broad benefits ranging from natural disaster impact mitigation to commercial supply chain management to natural resource management. Access to and use of these data are fundamental to supporting decision-making, scientific discovery, and technological innovation. DOE's data management activities will be coordinated with the Big Earth Data Initiative in the President's FY 2014 Budget, which invests in standardizing and optimizing the management of data from Federal earth observations systems. Interagency coordination for this effort will be accomplished through the USGEO Subcommittee of the National Science and Technology Council (NSTC), led by the Office of Science and Technology Policy (OSTP), and in coordination with the USGCRP Observations Working Group. This research will be in collaboration with the Office of Science's Advanced Scientific Computing Research program.

EMSL provides integrated experimental and computational resources for discovery and technological innovation in the environmental molecular sciences. With more than fifty leading-edge instruments, EMSL enables users to undertake molecular-scale experimental and theoretical research on aerosol chemistry, biological systems, biogeochemistry, and interfacial and surface science. EMSL thus provides a unique opportunity to use multiple experimental systems to provide fundamental understanding of the physical, chemical, and biological processes that underlie DOE's energy and environmental mission areas, including alternative energy sources, improved catalysts and materials for industrial applications, insights into factors influencing climate change and carbon sequestration processes, and subsurface biogeochemical drivers at contaminated sites.

Funding and Activity Schedule

Fiscal Year	Activity	Funding (dollars in thousands)
FY 2012	ARM continued its long-term measurements for users to address key scientific uncertainties with a goal to achieve 98% of scheduled operating time. Mobile facilities supported the India experiment as well an experiment on the Madden Julian Oscillation on Gan Island in the Indian Ocean. Instrumentation was obtained and site preparation was initiated for the mobile facility at Oliktok Point, AK for three dimensional measurements of cloud and aerosol properties over land, sea, and ice and the ARM fixed site in the Azores for observations of marine clouds and aerosols. EMSL supported facility operations that underpin user research to obtain a fundamental understanding of the physical, chemical, and biological processes and a goal to achieve 98% of scheduled operating time. Funding was completed for the High Magnetic Field Mass Spectrometer. Data management activities continue.	122,437
FY 2013	The FY 2013 Request proposed $122,018,000 for ARM support of long-term measurements at fixed and mobile facilities for users to address key scientific uncertainties. The ARM measurements at Oliktok Point, AK and the Azores are fully operational. EMSL supports facility operations that underpin user research to obtain a fundamental understanding of the physical, chemical, and biological processes. The focus is to provide users with enhanced access to new capabilities in molecular beam epitaxy and nano-secondary ion mass spectrometry. Data management activities continue for data-intensive science. The activities advance the use of ARM data to inform and validate the earth system model development.	—
FY 2014	ARM will fully support its long-term measurements at fixed sites, and the mobile facilities will be deployed to three climate-sensitive regions demanding targeted measurements: the Amazon Basin; Oliktok, Alaska; and Finland. These observations are key to reducing the earth system model uncertainties attributed to clouds and aerosols. EMSL will support facility operations that underpin user research to obtain a fundamental understanding of the physical, chemical, and biological processes that map to DOE mission needs. New capabilities of the Radiological Annex, including X-ray photo emission spectrometers, electron microscopy, electron probe microanalyzer, transmission electron microscopy and scanning electron microscopy, come on line in FY 2014 to study contaminated materials, and examine radionuclides and chemical signatures. BER will participate in the Big Earth Data initiative to adapt the ARM data archive and other DOE Earth data sets to specifications aimed at increasing interoperability and consistent with the needs of the scientific community. In addition, ARM will continue to format its databases in order to conform to the needs of the evolving climate modeling community.	122,366

(dollars in thousands)

	FY 2012 Current	FY 2013 Annualized CR	FY 2014 Request
Atmospheric Radiation Measurement Climate Research Facility	67,908	—	71,199
Environmental Molecular Sciences Laboratory	50,324	—	46,671
Data Management	3,205	—	3,496
General Purpose Equipment (GPE)	300	—	500
General Plant Projects (GPP)	700	—	500
Total, Climate and Environmental Facilities and Infrastructure	122,437	—	122,366

Supporting Information

Capital Operating Expenses

Capital Operating Expenses Summary

(dollars in thousands)

	FY 2012 Current	FY 2013 Annualized CR	FY 2014 Request
Capital equipment over $500,000, including major items of equipment (MIEs)	25,134	—	7,467
General plant projects (GPP) (under $10 million)	2,183	—	500
Total, Capital Operating Expenses	27,317	—	7,967

Capital Equipment over $500,000 (including MIEs)

(dollars in thousands)

	Total	Prior Years	FY 2012 Current	FY 2013 Annualized CR	FY 2014 Request
Major items of equipment (TEC over $2 million)					
Atmospheric Radiation Measurement Climate Research Facility (ARM)					
Dual-Frequency Scanning Cloud Radar for Oliktok, Alaska ARM Site (TEC/TPC)	3,500	0	3,500	—	0
Dual-Frequency Scanning Cloud Radar for ARM Azores Climate Activity (TEC/TPC)	3,070	0	3,070	—	0
Environmental Molecular Sciences Laboratory (EMSL)					
Next Generation, High Magnetic Field Mass Spectrometer (TEC/TPC)	17,500	10,250	7,250	—	0
Total, Major items of equipment, TEC/TPC			13,820	—	0
Other capital equipment projects under $2 million TEC			11,314	—	7,467
Total, Capital equipment			25,134	—	7,467

Atmospheric Radiation Measurement Climate Research Facility

Dual-frequency scanning cloud radar for the ARM Arctic Climate activity. This instrument will provide the capability to measure cloud properties in a volume and will provide three-dimensional cloud properties at Oliktok, Alaska: essential data for developing high-resolution climate models.

Dual-frequency scanning cloud radar for the ARM Azores Climate activity. This instrument will provide the capability to measure cloud properties in a volume and will provide three-dimensional cloud properties in the Azores: essential data for developing high-resolution climate models.

Environmental Molecular Sciences Laboratory

Next Generation, High Magnetic Field Mass Spectrometer system is a world-leading system to measure and characterize complex mixtures of intact proteins and other biomolecules, aerosol particles, petroleum, and

constituents from other types of fluids. The Total Project Cost (TPC) was reviewed and approved at CD-2/3a, Approve Performance Baseline and Authorization to Award Magnet Procurement Contract, on August 30, 2011. The system will enable world-leading proteomics, metabolomics, and lipidomics with application to bioenergy, as well as provide insights relevant to climate science, fossil fuel processing, and catalysis.

General Plant Projects (GPP) (TEC under $10 million)

(dollars in thousands)

	Total	Prior Years	FY 2012 Current	FY 2013 Annualized CR	FY 2014 Request
Other general plant projects under $5 million TEC	n/a	n/a	2,183	—	500

Other Supporting Information

Funding Summary

(dollars in thousands)

	FY 2012 Current	FY 2013 Annualized CR	FY 2014 Request
Research	389,806	—	402,026
Scientific user facilities operations and research	187,807	—	202,565
Major items of equipment	13,820	—	0
Other[a]	1,000	—	20,756
Total, Biological and Environmental Research	592,433	613,287	625,347

Scientific User Facilities Operations and Research

(dollars in thousands)

	FY 2012 Current	FY 2013 Annualized CR	FY 2014 Request
Biological Systems Science			
Structural Biology Infrastructure	14,895	—	14,895
Joint Genome Institute	68,500	—	69,800
Total, Biological Systems Science	83,395	—	84,695
Climate and Environmental Sciences			
Atmospheric Radiation Measurement Climate Research Facility	67,908	—	71,199
Environmental Molecular Sciences Laboratory	50,324	—	46,671
Total, Climate and Environmental Science	118,232	—	117,870
Total Science user facilities operations and research	201,627	—	202,565

[a] Includes SBIR, STTR, GPE, and non-Facility related GPP.

Facilities Users and Hours

	FY 2012 Current	FY 2013 Annualized CR	FY 2014 Request
Joint Genome Institute[a]			
Achieved operating hours	8,544	—	N/A
Scheduled operating hours	8,316	—	8,616
Optimal hours	8,316	—	8,616
Percent of optimal hours	102.7%	—	100.0%
Unscheduled downtime hours	0	—	N/A
Number of users[b]	992	—	940
Atmospheric Radiation Measurement Climate Research Facility (ARM)[c]			
Achieved operating hours	8,198	—	N/A
Scheduled operating hours	7,906	—	7,906
Optimal hours	7,906	—	7,906
Percent of optimal hours	103.7%	—	100.0%
Unscheduled downtime hours	0	—	N/A
Number of users[d]	1,231	—	1,000

[a] JGI scheduled and optimal hours are based on being open 24 hours a day, 7 days a week (less holidays, planned downtime for maintenance, installation of new instrumentation, etc.) Actual hours can differ when maintenance and instrument upgrades, etc. take more or less time than planned.

[b] All JGI users are remote. Primary users are individuals associated with approved projects being conducted at the JGI in a reporting period. Each user is counted once per year regardless of how many proposals their name may be associated with. Additionally, different users reflect vastly differing levels of JGI resources.

[c] ARM scheduled and optimal hours are base on the average over the fixed sites. The hours are estimated based on planned downtime for maintenance, installation of new instrumentation, weather history of each site, etc. Actual hours can differ when maintenance and instrument upgrades, weather related downtime, etc. take more or less time than planned.

[d] ARM users are both onsite and remote. A unique scientific user is defined by the use of an ARM Facility's on-site assets, off-site services, or data services during the defined reporting period. Prior to FY 2013 an ARM user could be counted more than once by using multiple ARM capabilities. This change reduces the FY 2013 ARM user count.

	FY 2012 Current	FY 2013 Annualized CR	FY 2014 Request
Environmental Molecular Sciences Laboratory[a]			
Achieved operating hours	4,265	—	N/A
Scheduled operating hours	4,296	—	4,272
Optimal hours	4,296	—	4,272
Percent of optimal hours	99.3%	—	100.0%
Unscheduled downtime hours	31	—	N/A
Number of users[b]	718	—	750
Total Facilities			
Achieved operating hours	21,007	—	NA
Scheduled operating hours	20,518	—	20,794
Optimal hours	20,518	—	20,794
Percent of optimal hours (funding weighted)	102.2%	—	100.0%
Unscheduled downtime hours	31	—	N/A
Number of users	2,941	—	2,690

Structural Biology Infrastructure activities are at Basic Energy Sciences user facilities and the user statistics are included in the BES user statistics.

[a] EMSL scheduled and optimal hours are generalized to 12 hours a day, seven days a week (4,380 hours), less holidays (96 hours), because some capabilities are available 24/7 while others require EMSL staff assistance. Leap years, as well as planned downtime for maintenance, installation of new instrumentation, etc. can also modify the hours available. Actual hours can differ when maintenance, instrument upgrades, etc. take more or less time than planned.

[b] EMSL users are both onsite and remote. Individual users are counted once per year. On-site users are individuals who are physically present using an EMSL capability at least once during the reporting period as part of an active project. Remote users are members of an approved research project team who remotely access and operate EMSL capabilities; reduce, collate or otherwise modify project data; modify open source codes originally developed by EMSL; and send or receive materials/samples. Individual users are counted once per year.

Scientific Employment

	FY 2012 Actual	FY 2013 Estimate	FY 2014 Estimate
Number of university grants	470	—	480
Average size per year	$340,000	—	$340,000
Number of laboratory projects	195	—	200
Number of permanent Ph.D.'s[a]	1,500	—	1,515
Number of postdoctoral associates[b]	345	—	350
Number of graduate students[b]	495	—	500
Number of Ph.D.'s awarded[c]	110	—	115

[a] The number of permanent Ph.D.s is estimated. Information is not readily available on the total number of permanent Ph.D. scientists associated with each research project. In addition to the principal investigator for each research project funded by BER, individual projects typically have between 1 and 20 additional Ph.D.-level scientists who are funded collaborators. Information on scientific collaborators is not routinely tracked.

[b] The number of Postdoctoral Associates and graduate students is estimated for national laboratory projects.

[c] The number of Ph.D.s awarded is estimated. Information is not available on the number of Ph.D.s awarded as a result of BER funded research at universities or national laboratories.