

Environmental System Science Program



The Environmental System Science program advances foundational ecological and hydro-biogeochemical process knowledge across scales to predictively understand Earth's terrestrial, watershed, and coastal systems.

The U.S. Department of Energy's (DOE) Environmental System Science (ESS) program supports research to improve foundational scientific understanding of physical, chemical, and biological processes of environmental systems and their interactions, with a particular focus on understudied regions and system interfaces.

Within DOE's Biological and Environmental Research (BER) program, ESS research seeks to deepen understanding of terrestrial ecosystems, watersheds, and coastal regions by investigating their interdependent microbial, biogeochemical, ecological, hydrological, and physical processes across space and time scales. This research also informs the development of improved scale-aware capabilities to predict these systems' behavior. These foundational insights and capabilities will help DOE and the nation plan and develop energy infrastructure, better manage natural resources, steward the environment, and identify equitable solutions to Earth's most vulnerable communities.

ESS BY THE NUMBERS | FY 2023



200
ESS Researchers
Supported at
100
Institutions



475+
Publications
Since
2022



1,035+
Public Datasets
in ESS-DIVE



More Information

Environmental System Science Program

ess.science.energy.gov



Earth and Environmental Systems Sciences Division
science.osti.gov/ber/Research/eessd

DOE Biological and Environmental Research Program
science.osti.gov/ber

DOE Office of Science
science.osti.gov

U.S. Department of Energy
energy.gov



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Key Environmental Science Domains

Interdisciplinary, multidomain science is a hallmark of ESS research, which is currently comprised of terrestrial, watershed, and coastal systems science. The program also has a growing focus on ecological and watershed processes in urban systems.



Watershed Sciences

Watershed sciences research seeks to advance a predictive understanding of how watersheds function as integrated hydro-biogeochemical systems and how they respond to disturbances, such as changes in water recharge, availability, and quantity; nutrient loading; land use; and vegetative cover. Current watershed sciences research funds three national laboratory–led Science Focus Areas (SFAs) that represent a network of complementary watershed testbeds within the contiguous United States. These SFAs enable national laboratory, university, and interagency partners to work in interdisciplinary teams to tackle a range of DOE energy and environmental challenges.



Terrestrial Ecology

Terrestrial ecology research seeks to improve representation of terrestrial ecosystems and their feedbacks and processes in predictive models by advancing understanding of ecosystems and ecological processes that are globally or regionally significant, sensitive to climate and environmental change, and insufficiently understood or inadequately represented in models. Current terrestrial ecology research includes three SFAs, the AmeriFlux Network, the Next-Generation Ecosystem Experiments (NGEE) projects in the Arctic and Tropics, and the Spruce and Peatland Responses Under Changing Environments (SPRUCE) project in northern Minnesota.



Coastal Systems

Coastal research seeks to address key uncertainties in the fundamental and predictive understanding of integrated coastal environmental systems and to improve their representation in Earth system models. Current coastal science research includes the Coastal Observations, Mechanisms, and Predictions Across Systems and Scales (COMPASS)–Field, Measurements, and Experiments program that focuses on field studies and associated process and ecosystem modeling of two coastal interfaces in western Lake Erie and the Chesapeake Bay.

Additional ESS Research Interests

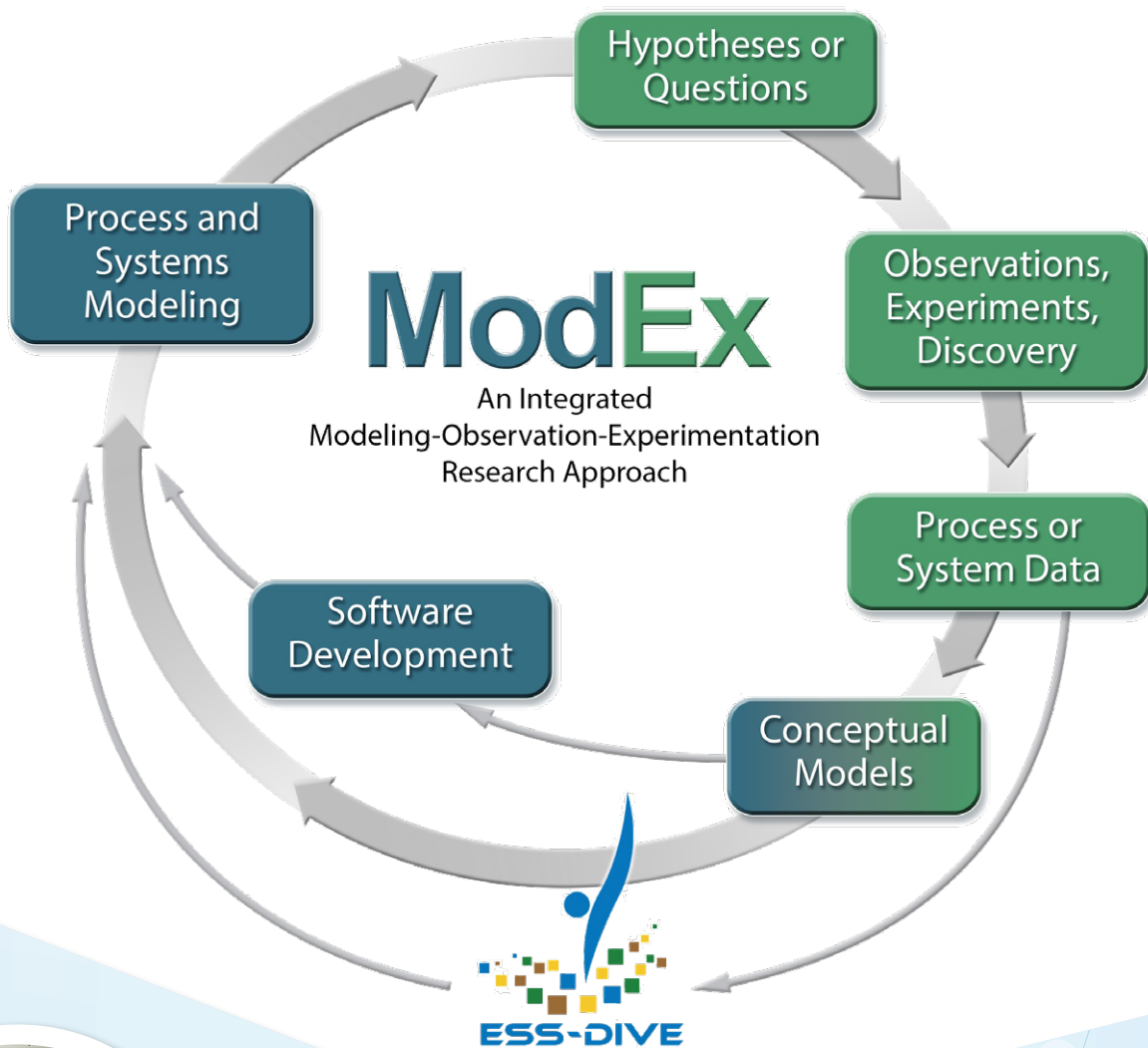
ESS is also invested in research that informs equitable climate and energy solutions across landscapes and in projects that promote climate resilience in areas historically underrepresented in climate science and decision-making.

Urban Integrated Field Laboratories are dedicated to developing the science framework, observational tools, and prediction capabilities needed to under-

stand how urban areas interact with the climate system.

Climate Resilience Centers (CRCs) will empower local universities to use DOE climate science, national laboratory capabilities, scientific user facilities, and research to help tackle problems posed by a changing climate. The CRCs will translate research results into practice among community stakeholders for improved local climate resilience.

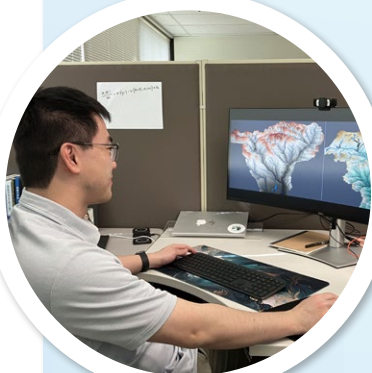




Research Approach

Through research that spans a wide range of disciplines, projects, and collaborative partnerships, ESS investigates inherent and emergent properties of changes to Earth and environmental systems across different spatial and temporal scales. This multifaceted research—which includes observation, experimentation, field manipulation, and simulation—produces new knowledge that enhances understanding of the current functioning and future dynamics of terrestrial processes. ESS research also leverages DOE and community capabilities, such as DOE user facilities like the Environmental Molecular Sciences Laboratory and Joint Genome Institute, the Energy Exascale Earth System Model (E3SM), and the Environmental System Science Data Infrastructure for a Virtual Ecosystem (ESS-DIVE).

Processes in terrestrial and watershed systems and their interfaces are difficult to represent in models because they exhibit considerable uncertainties in their functions, feedbacks, and dynamics. Using the coupled modeling-experimental (ModEx) approach, ESS research helps improve model representations of these processes to more accurately project how they will respond to a changing climate and environment. ModEx-inspired ESS research generates open-source and community models that incorporate state-of-the-science knowledge about critical systems. The resulting improved models can then be used to guide field- and laboratory-based research and inform future responses to complex energy and environmental challenges.



Community Resources



The AmeriFlux Network is a community of sites spanning different climates and ecosystems across the Americas that gathers and shares long-term carbon, water, and energy flux measurements and metadata.

ameriflux.lbl.gov



The Atmospheric Radiation Measurement user facility provides the research community with strategically located *in situ* and remote-sensing observatories for atmospheric and climate science.

arm.gov



The Environmental Molecular Sciences Laboratory makes multiple types of capabilities available to single investigators or multidisciplinary teams to study and model molecular to meso-scale hydro-biogeochemical processes.

www.emsl.pnnl.gov



ESS Cyberinfrastructure Working Groups strive to enable all ESS projects, big or small, university or DOE-led to utilize common cyberinfrastructure tools and workflows in a culture of open science.

esscommunity.org



The Environmental System Science Data Infrastructure for a Virtual Ecosystem (ESS-DIVE) is a data repository for Earth and environmental science data.

ess-dive.lbl.gov



The Energy Exascale Earth System Model (E3SM) is an ongoing, state-of-the-science Earth system modeling, simulation, and prediction project.

e3sm.org



The Joint Genome Institute user facility is the preeminent resource for sequencing plants, fungi, algae, microbes, and microbial communities foundational to energy and environmental research.

jgi.doe.gov



Research Philosophies

Open and Collaborative Research

The ESS program's open-science and open-data philosophy advances priority research areas by supporting a coordinated mix of investments, including university-led projects, NGEs, national laboratory-led SFAs, and observation networks that represent short-term projects, decadal experiments, and long-term studies.

Funding Opportunities

Early Career Research Program (ECRP)

energy.gov/science/listings/early-career-program

Established Program to Stimulate Competitive Research (EPSCoR)

epscorideaofoundation.org/about/agencies/doe-epscor

Office of Workforce Development for Teachers and Scientists (WDTS)

science.osti.gov/wdts

Additional BER Funding Opportunities

science.osti.gov/ber/funding-opportunities