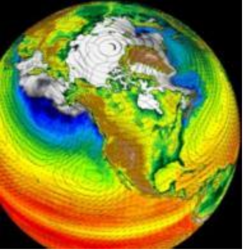
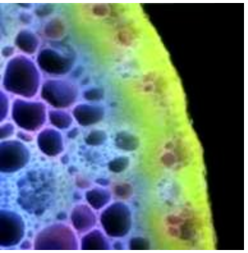
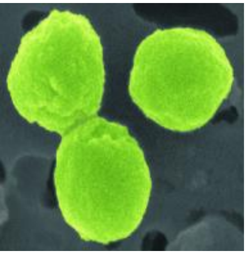


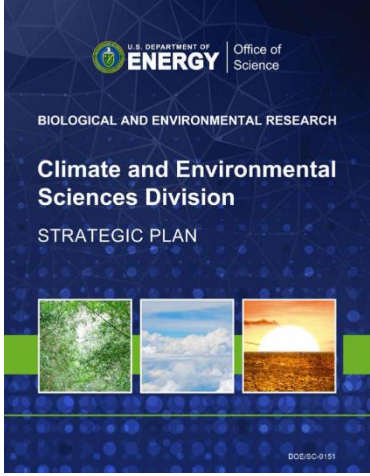
Climate and Environmental Sciences Division

Strategic Plan 2018 – 2023

Gary Geernaert, Ph.D.

U.S. DEPARTMENT OF
ENERGY

Office of Science



Office of Biological & Environmental Research
Climate & Environmental Sciences Division

Atmospheric Science

- Atmospheric System Research

Atmospheric Radiation Measurements Facility

Earth and Environmental System Modeling

- Model Development
- Model Analysis
- Multisector Dynamics
- Development-Validation

Environmental System Science

- Subsurface Biogeochemical Research
- Terrestrial Ecosystem Sciences

Environmental Molecular Sciences Laboratory

Data Management

Budget: $320M, divided roughly equally among the three groups

Plan Context and New Directions

Strategic Plan 2012: Focus was on innovative basic research based on individual program capabilities to improve climate predictability in support of energy mission

- **Greater coordination of activities with “ModEx” as standard element**
  In both atmosphere and land, there is tighter integration from field to process-research to global models, in order to understand, e.g. mesoscale convective storms and permafrost evolutions

- **Earth system focus**
  Earth system incorporates both climate and environment

- **New research directions**
  Integrated hydrological research; Multi-sectoral-impacts; Polar science; DOE-Earth system model; Data-management strategies

- **New connections within DOE**
  Collaborations with BSSD on microbial and genetic biology, crop research
  Energy sector resiliency and security, including issues around water, grid, extremes

Strategic Plan 2018: Focus on Grand Challenge Earth system science and energy research topics that require full breadth of BER capabilities

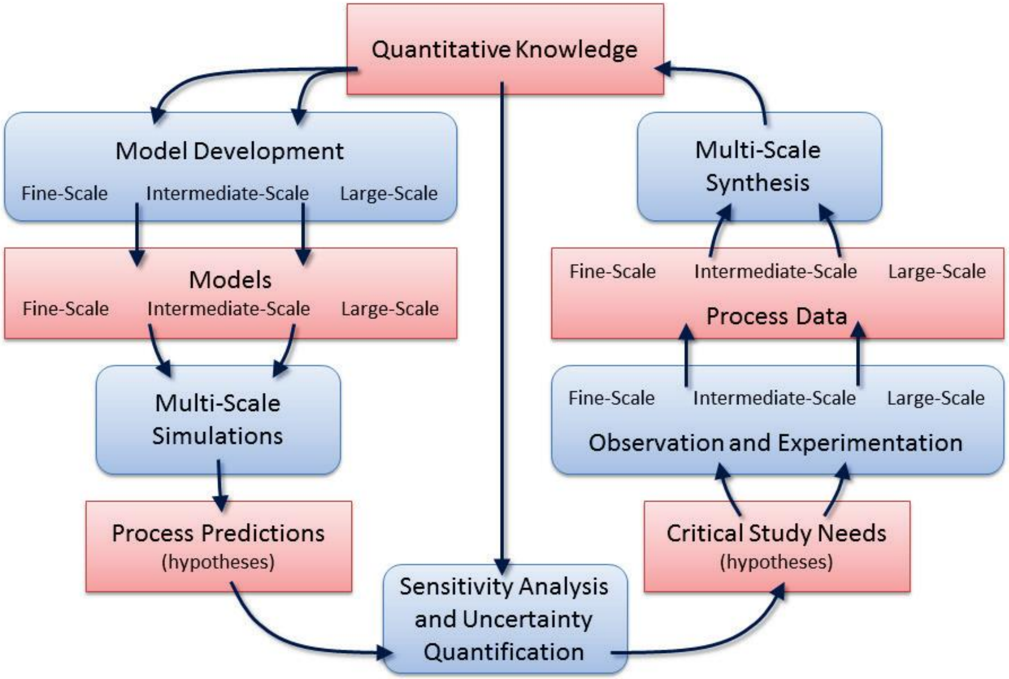
Mission and Vision

CESD's mission is to enhance the seasonal to multi-decadal scale predictability of the Earth system using long term field experiments, DOE user facilities, modeling and simulation, uncertainty characterization, best-in-class computing, process research, and data analytics and management in order to inform the development of advanced solutions to the Nation's energy challenges.

CESD's vision: An improved capability for Earth system prediction on seasonal to multi-decadal time scales to inform the development of resilient U.S. energy strategies.

CESD Scientific Grand Challenges

1. Integrated Water Cycle
2. Biogeochemistry
3. High Latitudes
4. Drivers & Responses in the Earth System
5. Observation-Model Integration



Grand Challenge 1 – Integrated Water Cycle

To advance understanding of the integrated water cycle by studying relevant processes involving all relevant Earth system components and their interactions across scales, thereby improving the predictability of the water cycle and reducing associated uncertainties in response to perturbations.

- **Hydrology statistics:** How are the frequency and intensity of precipitation and hydrological events affected by large-scale variability and change within the Earth system?
- **Clouds and precipitation:** How are atmospheric moisture, clouds, and precipitation influenced by atmospheric and surface processes, land-atmosphere coupling, heat and moisture transport, aerosols, and turbulence?
- **Riversheds:** How does the hydrological functioning of watersheds and river basins, including natural, managed and engineered components, respond to changes in precipitation, land use, vegetation cover, geomorphology, nutrient and contaminant loading, and compounding disturbances?
- **Energy:** How do energy, water, and land systems co-evolve in response to short- and long-term perturbations?
- **Local drivers:** To what extent do local-scale heterogeneities and anomalies, including both natural and anthropogenic system components, drive larger-scale hydrological processes and phenomena and how persistent and predictable are these interactions?

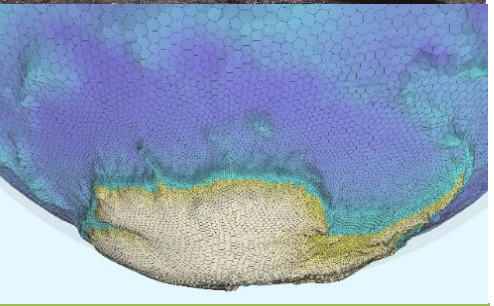
Grand Challenge 2 – Biogeochemistry

To advance a robust predictive understanding of coupled biogeochemical processes and cycles across spatial and temporal scales, by investigating natural and anthropogenic interactions and feedbacks, and associated uncertainties, within Earth and environmental systems.

- **Constraining Pools and Fluxes:** How to constrain biogeochemical cycles (and associated uncertainties) at global to local scales?
- **Interactions and Feedbacks**: How and which biogeochemical interactions/feedbacks improve Earth and environmental projections?
- **Perturbations and Thresholds:** How do compounding short and sustained changes across relevant spatio-temporal scales influence biogeochemical cycles and determine system thresholds?
- **Natural and Anthropogenic Changes:** How do changes in land cover/use affect biogeochemistry, especially at the land-water-atmosphere interface?
- **Scaling:** How do geochemical, genomic, and metabolic interactions influence environmental system dynamics from geophysical to watershed and global scales and models?
- **Hot Spots/Hot Moments:** What factors that create and sustain biogeochemical "hot spots and moments" and the importance of phenomena at different scales?.

Grand Challenge 3 – High Latitudes

To understand and quantify the drivers, interactions, and feedbacks both among the high-latitude components and between the high latitudes and the global system, in order to reduce uncertainties and improve predictive understanding of high latitude systems and their global impacts



- How will the surface energy budget be impacted by changes in high latitude atmospheric vertical structure, aerosols, and clouds?
- What are the critical coupled high-latitude biogeochemical processes that have implications for the global Earth system? How will these processes be impacted by high-latitude changes?
- How will the polar cryosphere change? What are the relevant processes, drivers, and feedbacks of these changes within the Earth system?
- To what extent are changes in the high latitude regions driven by local versus global influences? What are the impacts of high-latitude change on the lower latitudes?
- What are the uncertainties in global sea level rise projections due to high latitude processes? What are the associated coastal impacts? How do extreme events and other compounding factors interact with sea level rise?

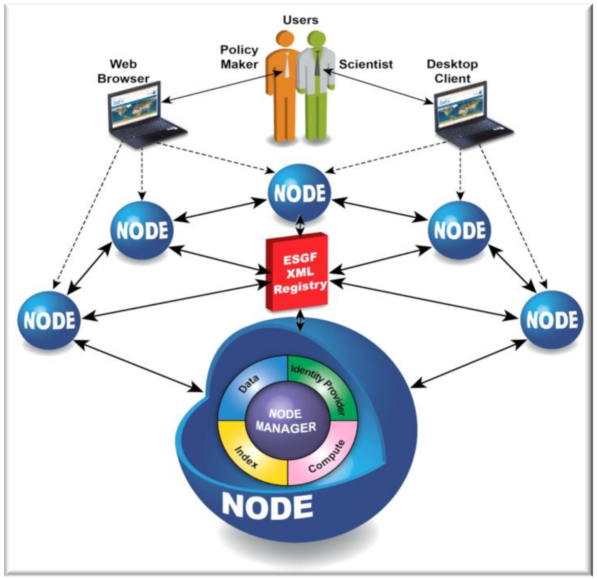
Grand Challenge 4 – Drivers & Responses in the Earth System

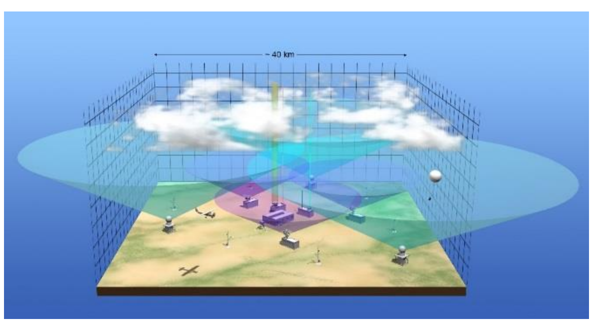
To advance next-generation understanding of the drivers of the Earth system and their effects on the integrated Earth-energy-human system.

- **Earth system drivers**: How do drivers of the Earth system such as atmospheric aerosols and gases, clouds, land use, land cover, ocean circulations, sea ice, and ice sheets interact with the coupled Earth system and how accurately can future interactions be predicted?
- **Confluence with natural variability:** How do timing, intensity, and location of drivers interact with natural variability and how do these affect extremes and potential tipping points across local, regional, and global scales?
- **Interactions with other challenges**: How do the hydrological cycle, the biogeochemical cycle, and the high latitude regions respond to specific natural and anthropogenic drivers?
- **Energy:** How may the responses of the integrated Earth system influence the accessibility, availability, location, distribution, and usage of U.S. energy supplies and connected infrastructure?

Grand Challenge 5 – Observation-Model Integration

To develop a broad range of interconnected infrastructure capabilities and tools that support the integration and management of models, experiments, and observations across a hierarchy of scales and complexity to address CESD scientific grand challenges.





- Provide an advanced and innovative cyberinfrastructure to ensure effective management of complex Earth system observational and simulation data and effective use of data for scientific discovery

- Develop and use innovative tools & metrics to integrate observation and simulation data and advance the validation of models and the characterization of uncertainty

- Enhance observation-model integration to improve the ability of experiments to inform model development and of simulations to inform needs for new observational efforts to address critical knowledge gaps

- Develop scalable and adaptable frameworks to allow effective utilization of a range of models and computational platforms to address CESD's scientific grand challenge

Implementation Strategy

Science-centric strategic approach:

- Utilize an integrated model-observational-experimental (ModEx) paradigm to rapidly incorporate knowledge into our predictive capabilities
- Develop decade-long, multidisciplinary, and collaborative research efforts
- Prioritize investments leading to improved spatial and temporal scale-aware processes
- Align National Laboratory and university investments with an integrated, team-based approaches, whereby:
  - National Labs (e.g.,SFA's, NGEE's, user facilities), will be the intellectual hubs and integrators of CESD scientific investments
  - Universities (via FOA's and CA's) will focus on shorter, targeted exploration of CESD discovery and scientific issues

Implementation of this plan requires:

- Exploiting capabilities at DOE User Facilities and community resources
- Embracing open-source, community cyberinfrastructure frameworks and data management
- Collaboration/coordination with federal partners
- Enabling transdisciplinary science through BSSD collaborations
- Coordinating emerging priorities, discoveries, and talent through community engagement and entrainment of early career scientists

What's New

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