Sustainability: NSF Center Programs

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National Academies Roundtable on Science and Technology for Sustainability

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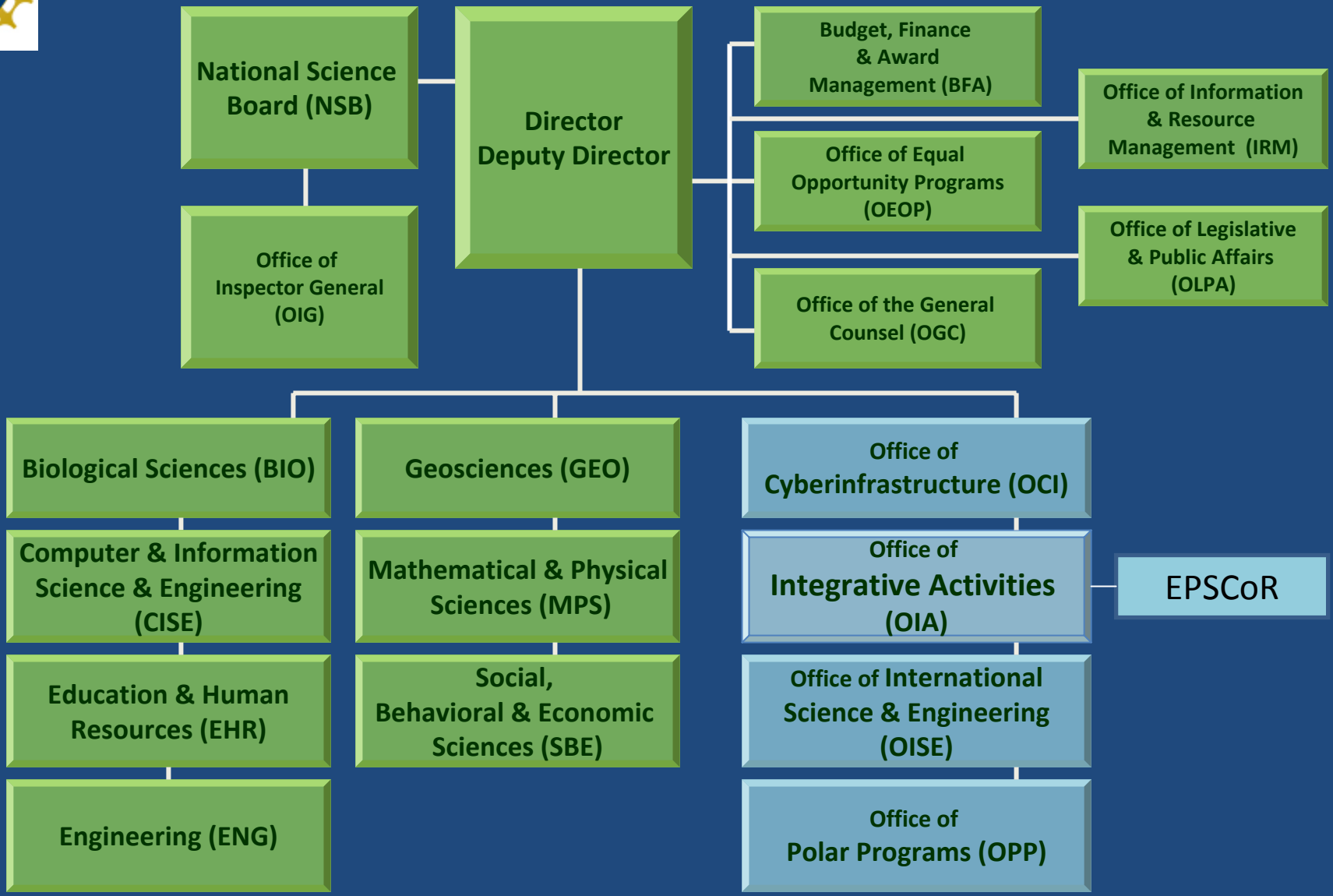
Outline

- NSF center programs relating to sustainability
  - some examples of research agendas
- Major NSF facilities/networks relating to sustainability
  - examples: OOI, NEON, NCAR
- Virtual centers
  - examples from the NSF EPSCoR program

The NSF Vision

Advancing discovery, innovation and education beyond the frontiers of current knowledge, and empowering future generations in science and engineering

NSF Organization



NSF Center Programs

- **Science and Technology Centers (17)**
  - all areas of NSF
- **Engineering Research Centers (15)**
  - all areas of engineering
- Materials Research Science and Engineering Centers (28)
- Nanoscale Science and Engineering Centers (19)
- Science of Learning Centers (6)
- Centers for Analysis and Synthesis (4)
- Centers for Chemical Innovation (9)

Science and Technology Centers

- Open competitions, currently 17 Centers, all areas of NSF
- Each STC is an extended partnership led by one institution
- **Many of the STCs focus on sustainability themes**
  - National Center for Earth-Surface Dynamics - 2002
  - **Center of Advanced Materials for the Purification of Water with Systems - 2002**
  - Center for Remote Sensing of Ice Sheets - 2005
  - Center for Multi-Scale Modeling of Atmospheric Processes - 2006
  - Center for Coastal Margin Observation and Prediction - 2006
  - Center for Microbial Oceanography Research and Education - 2006
  - Center for Dark Energy Biosphere Investigations - 2010
  - **Center for Energy Efficient Electronics Science - 2010**

Energy Efficient Electronics Science STC

UC Berkeley and partners

The amount of power required by electronics will continue to grow dramatically unless we make some fundamental changes to the physics, chemistry, and materials and device science that underlie information processing technologies

To reduce the energy requirement of electronics, researchers will focus on the basic logic switch, the decision-maker in computer chips. The logic switch function is primarily performed by transistors, which demand about 1 volt to function well.

"The transistors in the microprocessor are what draw the most power in a computer. When you feel the heat from under a laptop, blame it on the transistors" – *Eli Yablonovitch*

It's Time to Reinvent the Transistor!

Thomas N. Theis* and Paul M. Solomon

IBM Research, T. J. Watson Research Center, Post Office Box 218, Yorktown Heights, NY 10598, USA.

Energy Efficient Electronics Science STC

UC Berkeley and partners

Develop the device science and technology that will reduce energy consumption in electronic systems by orders of magnitude.

An electronic circuit could operate well on as little as a few millivolts.
A thousand-fold reduction in voltage requirements translates into a million-fold reduction in power consumption.

Four themes for the research:

- ***Nanoelectronics:*** Develop semiconductor millivolt switching
- ***Nanomechanics:*** Develop low voltage nanomechanical switches
- ***Nanomagnetics:*** Use the technology of nanomagnets to create low energy logic switches
- ***Nanophotonics:*** Develop optical communication that relies on only a few photons per bit

STC – WaterCAMPWS

University of Illinois and partners

est 2002

- **Advance the fundamental understanding of the interaction of materials with water and its constituents:** adsorption and binding of contaminant molecules and foulants on surfaces; energetics and transport of water, ions, and organic molecules through material systems; and reactions of inorganic, organic and biological compounds on catalysts and substrates

- **The grand challenge:** use this enhanced understanding of aqueous interfaces to guide the development of new materials and systems and inspire revolutionary new approaches for water purification

STC – WaterCAMPWS

University of Illinois and partners

New water purification technologies focused on the nexus between **Water and Energy** and **Water and Health** have the potential to reduce the quantities of energy and chemicals now used to treat water and can create new methods to desalinate, reuse, decontaminate, and disinfect waters, enabling nations to gain new waters for human use from different types of source waters, including those that are not now considered usable.

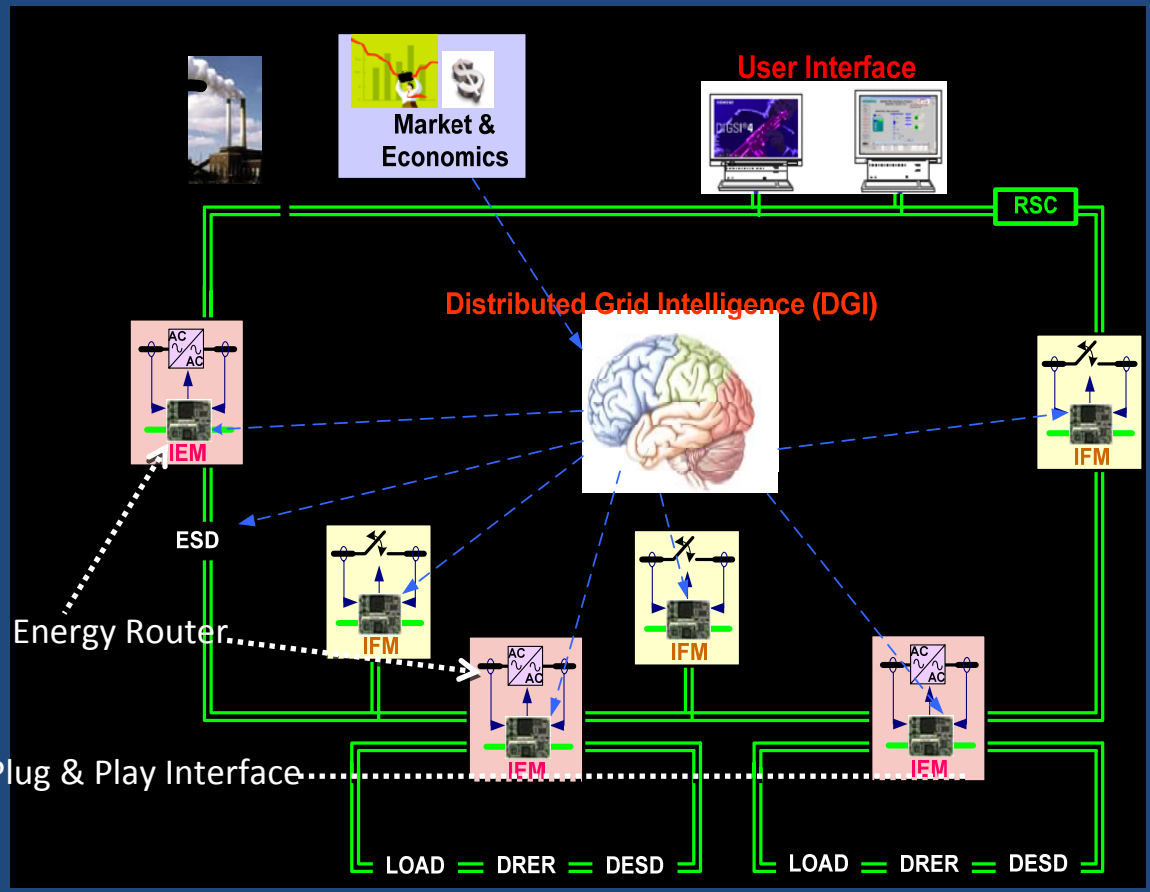
[Source: Shannon, M. A., P. W. Bohn, M. Elimelech, J. G. Georgiadis, M. J. Mariñas, and A. M. Mayes, "Science and Technology for Water Purification in the Coming Decades," Nature 452, 301-310, 2008.]

Engineering Research Centers

- Currently 15 ERCs
- 4 ERCs address energy, sustainability, & infrastructure
  - ***Biorenewable Chemicals***
    Iowa State University partnering with Rice University, the University of California, Irvine, the University of New Mexico, the University of Virginia, and the University of Wisconsin-Madison
  - ***Compact and Efficient Fluid Power***
    University of Minnesota, Minneapolis, partnering with Georgia Institute of Technology, Purdue University, the University of Illinois at Urbana-Champaign, and Vanderbilt University
  - ***Future Renewable Electric Energy Delivery and Management***
    North Carolina State University partnering with Arizona State University, Florida State University, Florida A&M University, Missouri University of Science and Technology
  - ***Smart Lighting***
    Rensselaer Polytechnic Institute partnering with Boston University and the University of New Mexico

Future Renewable Electric Energy Delivery and Management (FREEDM) System ERC

- "Energy Internet" concept to enable every citizen to participate in energy production, conservation and utilization
- Develop plug-and-play infrastructure to enable the use of distributed renewable energy resources



NC STATE UNIVERSITY

ASU Arizona State University

Florida State University

Florida A&M University

Missouri S&T

RWTH Aachen University

ETH Eidgenössische Technische Hochschule Zürich Swiss Federal Institute of Technology Zurich

Future Renewable Electric Energy Delivery and Management (FREEDM) System ERC

- The backbone of the center's work is developing and demonstrating technology that actively controls, distributes and stores electric power. Today’s grid needs an upgrade to handle the flood of new intelligent devices.

- Revolutionize the nation's power grid and speed renewable energy technologies into every home and business.

- Develop and demonstrate the new system in a 1-megawatt micro-grid that will power the center's new headquarters, the Keystone Science Center on Centennial Campus.

ERC for Biorenewable Chemicals

CBiRC
NSF Engineering Research Center for Biorenewable Chemicals

- Transform the chemical industry by integrating biological and chemical catalysis to create a generalized framework for producing biorenewable chemicals – a more sustainable source of carbon for industrial chemicals

- Provide educational programs which attract a diverse set of students into the engineering field, and produce a new cadre of globally-competitive college graduates capable of designing integrated chemical/biological processing systems

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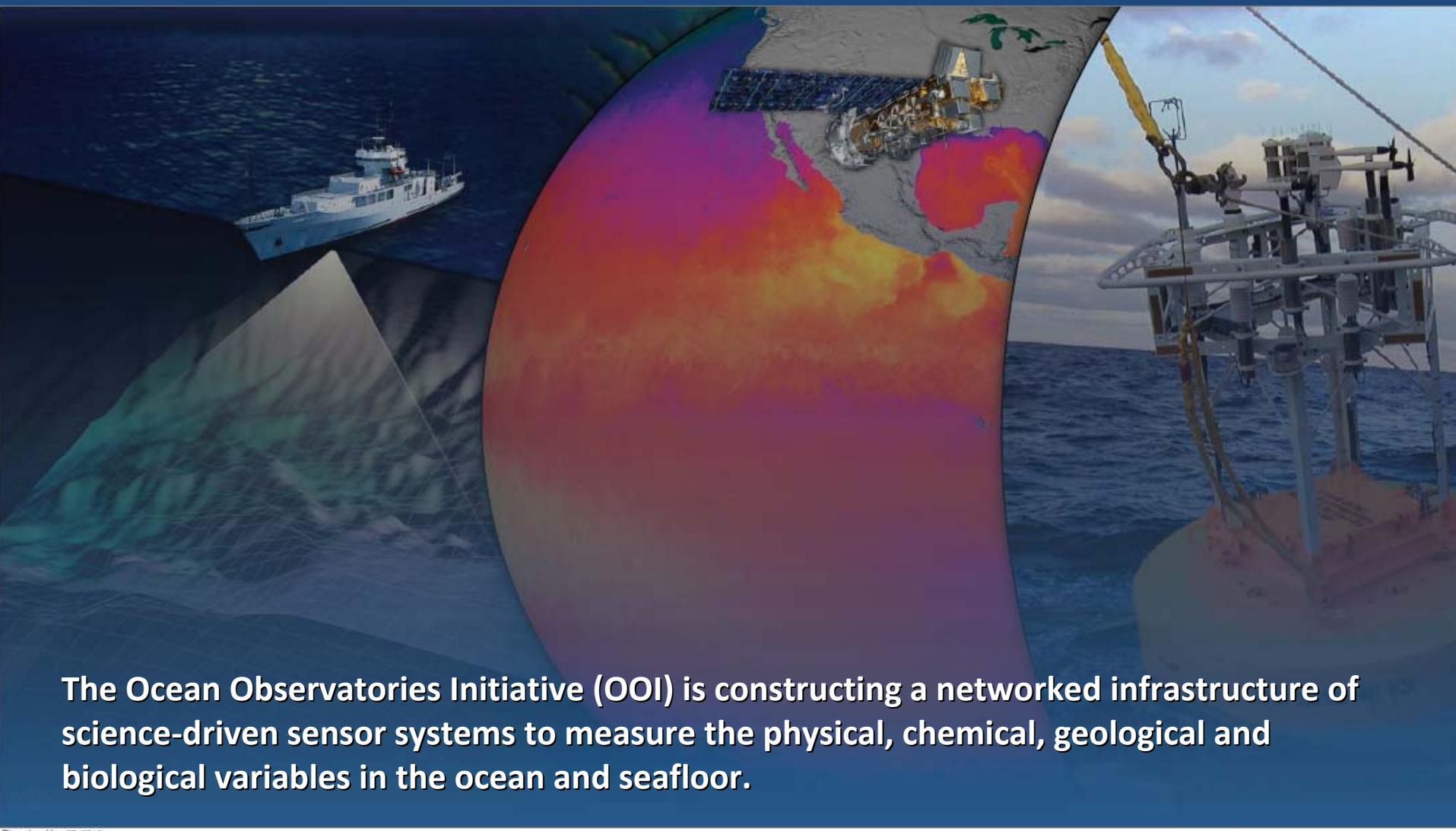
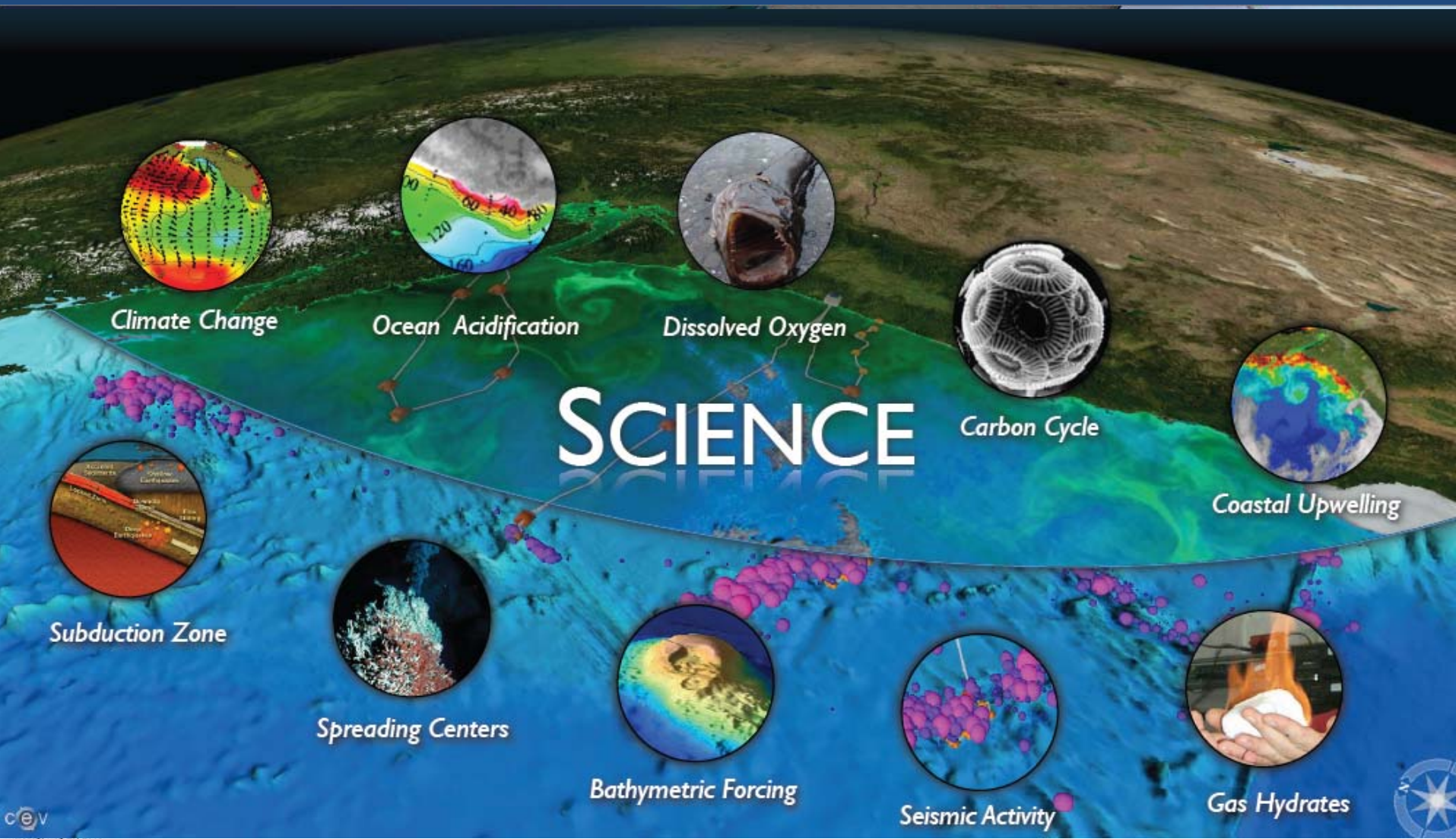
Ocean Observatories Initiative



The Ocean Observatories Initiative (OOI) is constructing a networked infrastructure of science-driven sensor systems to measure the physical, chemical, geological and biological variables in the ocean and seafloor.

Ocean Observatories Initiative



Design Elements

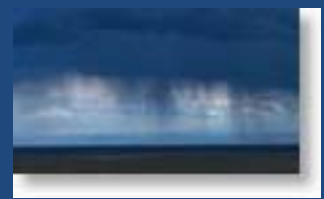
- Global Scale
- Regional Scale in the NE Pacific
- Coastal Scale: Mid-Atlantic Pioneer Array, PNW Endurance Array
- Fixed and mobile assets
- Cyberinfrastructure: data access, integration, adaptive sampling, analysis & visualization
- Interfaces for education users

National Center for Atmospheric Research (NCAR)

- Focal point for research in the atmospheric sciences
- Located in Boulder, CO; approximately 750 staff
- Consortium of 68 universities
- Facilities include supercomputer resources and services for the development and production of large models and for archiving, manipulating, and visualizing large data sets







- Research programs focus on:
  - large-scale atmospheric and ocean dynamics that contribute to an understanding of past and present climate processes and global change, including interactions with other environmental systems
  - global and regional atmospheric chemistry including geochemical and biogeochemical cycles
  - the variable nature of the Sun; physics of the corona
  - the physics of clouds, thunderstorms, precipitation formation, and the interactions and effects on larger-scale weather
  - **the examination of human society's impact on and response to global environmental change**

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  - research-based awards to build capacity in human resources, physical and cyberinfrastructure

EPSCoR program - Maine

Sustainability Science

- Expand capacity to understand and respond to sustainability challenges; coupled dynamics of social-ecological-systems (SES) and the use of SES in decision-making

- Potentially transformative, integration of natural and social science; model for sustainability research that could be adapted for other ecologically sensitive systems

EPSCoR program - Hawaii

Ecosystem Sustainability

- Understand and predict how invasive species, anthropogenic activities, and climate change impact biodiversity, ecosystem function and use of Hawaiian endemic species
- A vibrant indigenous understanding, perspective, and history of the islands is embedded in the research, education, and outreach components
- Contribute to understanding the impacts of human activities on tropical ecosystems world-wide

YSI Water Quality Sonde

EPSCoR

Western Tri-State Collaboration: Nevada, New Mexico, Idaho

Impacts of Climate Change

- Effects on water resources, ecosystems, and environment
- Seeded by science needs
- Model interoperability for the region
- Shared data models and metadata for additional data sharing

More Information

- NSF http://nsf.gov/
- STCs http://nsf.gov/dir/index.jsp?org=OIA
- ERCs http://www.erc-assoc.org/centers.htm
- OOI http://www.oceanleadership.org/
- NCAR http://ncar.ucar.edu/home
- EPSCoR http://nsf.gov/dir/index.jsp?org=OIA

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