Big Data and the Earth Sciences
Board on Earth Sciences and Resources

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President Designate, University of Illinois
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Introduction

Compelling requirements

National and International Efforts

Obstacles and Needs
Background

- Professor of Atmospheric, Oceanic, and Science Sciences, University of Michigan
  - Satellite remote sensing PI; Developed interdisciplinary global change minor
- Director of NCAR
  - Petascale computing, Earth system modeling, global observations, GIS and IPCC
- Assistant Director of NSF for the Geosciences
  - Ocean, Atmosphere, Earth, Large facilities (OOI, Earthscope), cyberinfrastructure (EarthCube)
- President, SUNY Research Foundation
  - Nanotechnology, biomedical research, hospitals, energy (Brookhaven), Computer science, Hurricane Sandy Response Commission; New York State's Data-Enabled Science, Technology strategy
- President-Designate of the University of Illinois
  - National Center for Supercomputing Applications; CyberGIS, National Data Service

Lots of reflections, where to start?
Interagency Partnerships: $2.6B/yr
Land & Ocean Temperature Percentiles Mar 2015
NOAA’s National Climatic Data Center
Data Source: GHCN–M version 3.2.2 & ERSST version 3b
Arctic Sea Ice Decline
Arctic Ice-Melt Cost Seems Equal to Year of World Economic Output

-July 24, 2013, Bloomberg Businessweek
A model international partnership, Canada and the US, led by EPA
Approx. 60 jurisdictions

Significant progress in key clean up priority areas

All lakes considered to be deteriorating, except Lake Superior

Opportunities for citizen science

Little or no ecosystem services economic impact component
Some major global societal issues

- Environmentally sustainable development
- Need for renewable energy sources
- Information and communications technology
- Universal access to education
- Poverty and economic opportunity
- Technology-based manufacturing and jobs
- Intellectual property rights
- Terrorism
- International security
- Natural disasters
- Science and technology capacity building
- Vaccines and medical therapies against infectious diseases
- Quality and accessibility of health care
interactions between climate, human and natural systems

barriers, limits and costs of adaptation

Renewable energy supply technology

Sustainability literacy

effects of lifestyle and behavioral changes on energy consumption and climate

interactions between socio-economic factors and the evolution and utilization of adaptive and mitigating strategies;

impacts of ice sheets dynamics on climate change and sea level rise

creating the Energy Internet (merge IT and ET – Smart Grid)

Systems / interdisciplinary approach to sustainable energy economy and supporting technology

regional climate change and causes

Sustainability literacy

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Sustainability literacy
Observing the Complex Ocean System

Era of Observation: Major Facilities
e.g., Coastal Cabled Observatory – Pacific Northwest

Cascadia and Other Areas
Era of Observation: National Ecological Observatory Network
Cyber-Enabled Networks

Made possible by more than three decades of float technology research.
Cyber-Enabled Networks

More than 50 NSF awards related to the network and its results...
Growth of Climate Modeling

New Era of Simulations

Atmospheric/Land Surface/Vegetation

Ocean

Coupled Climate Model

Sea Ice

Sulfate Aerosol

Biogeochemical Cycles

Carbon Cycle

Ice Sheet

Marine Ecosystems

60s 70s 80s 90s 00s 10s

NCAR-Wyoming Supercomputer Center
Opened June 2012
>1 Petaflop, 150 Petabyte, LEED Gold
An Example: End-to-End

- Linking models to assess climate change impacts on food availability (Mark W. Rosegrant, International Food Policy Research Institute)

  - GCM climate scenarios
    - NCAR (wetter) and CSIRO (drier) using SRES A2

  - DSSAT crop model
    - Biophysical crop response to temp and precipitation

  - ISPAM
    - Spatial distribution of crops based on crop calendars, soil characteristics, climate of 20 most important crops

  - IMPACT2009
    - Global food supply demand modeling to 2050 with global hydrology
Change in Precipitation, 2000-2050

CSIRO, A2, AR4

delta_annual_prec_csiro_mk3_0_sresa2_run1
@world_bank_climate_diff
Change from 2000 to 2050: annual prec csiro mk3_0_sresa2_run1

-400
-300
-200
-100
0
100
200
300
400

Map showing change in precipitation from 2000 to 2050 using data from CSIRO, A2, and AR4 models.
Change in Precipitation, 2000-2050
NCAR, A2, AR4

delta_annual_prec_ncar_cesm3_0_sresa2_run4
@world_bank_climate_diff
Change from 2000 to 2050: annual prec ncar cesm3_0_sresa2_run4
Climate Induced Percentage Change in Production in 2050: **Irrigated Rice**

Global production = -27%
Impacts

International Food Prices

Childhood Malnutrition
International Partnerships
Who is Collaborating with Who?
Most of Africa’s collaboration is with G20 countries, but South-South collaboration is a growing trend, the US could amplify.

- Egypt and Sudan – important bridges
- Kenya and South Africa - important hubs
An International Alliance to Create a 10-year Earth System Global Sustainability Initiative
Belmont Forum
Collaborative Research Actions

2013-2014 Priorities (under discussion)

- Food security and energy usage - (Brazil)
- Arctic Science - (Canada)
- Rural to urban transition (Japan)
- Data fusion and cyberinfrastructure (US)
Goal: To transform the conduct of research in Earth System Sciences through community-based cyberinfrastructure

- More than 900 expert participants working on social media site
- More than 100 white papers
- First awards underway: total of ~$2m; next year >$20m
- Community designed, owned and governed
- An open cyberinfrastructure, a 10-year building effort
Why data MATTERS

On a smarter planet, everything from traffic to utilities to healthcare information can be monitored and analyzed for insight.

Find out how IBMers are harnessing the power of data
The Future: Discovery and Innovation Across Boundaries, Disciplines and Information-space
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WHY GEO? WHY NOW?
NEW ERA OF DISCOVERY AND INNOVATION

- Observing the Complex Ocean System
- Coastal Cabled Observatory – Pacific Northwest
- Cyber-Enabled Networks
- New Era of Simulations
- Combustion, Aerosols and Nanoparticles
- New Sea-Based Asset: R/V Siqualiaq
- Paleoclimate: CO₂ coupling in deep time
- Fossil Microorganisms
- Paleoclimate: 1000+ years of El Niño
- El Niño Changes Affect U.S. Weather and Climate
- “Global Warming Preceded by Increasing CO₂…”
- Deepwater Horizon Oil Spill
- Earthquakes
- Volcanic Eruptions
- Solar Eruptions
- Cascadia: A U.S. Earthquake and Tsunami?
- Life
- Marcellus Shale Horizontal Fracking
- Water: Prediction of Precipitation Change
- Water Sustainability
- GEO and SEES
- Coastal Vulnerability: A Delta Dynamics Collaboratory
- The Belmont International Opportunities Fund
- The Alliance and Future Earth
- Interagency Leadership
- CubeSats
- SOARS/RESESS/MS PHD’s
- Ocean Leaders
- Diversity, Accessibility and Technology
- EarthCube
Obstacles and Needs

- Overwhelmingly Tribal Expertise
- Unstructured Data Fusion very challenging
- Automated ontologies
- “Big Collaboration” technologies
- “Big” Public-Private-Governmental partnering for scaled up, end-to-end work

- Open Community Governance
- Integrated “Big Compute”
- “Big Social Science” (esp. economics)
- University Leadership
- Address major societal challenges (trans-national funding)
“We are drowning in information while starving for wisdom. The world henceforth will be run by synthesizers, people able to put together the right information at the right time, think critically about it, and make important choices wisely.”

-- E.O. Wilson
Thanks

A sustainable world is one in which human needs are met without harm to the environment, and without sacrificing the ability of future generations to meet their needs - NSF SEES