


Transforming Our Ability to Predict Climate Change and its Impacts

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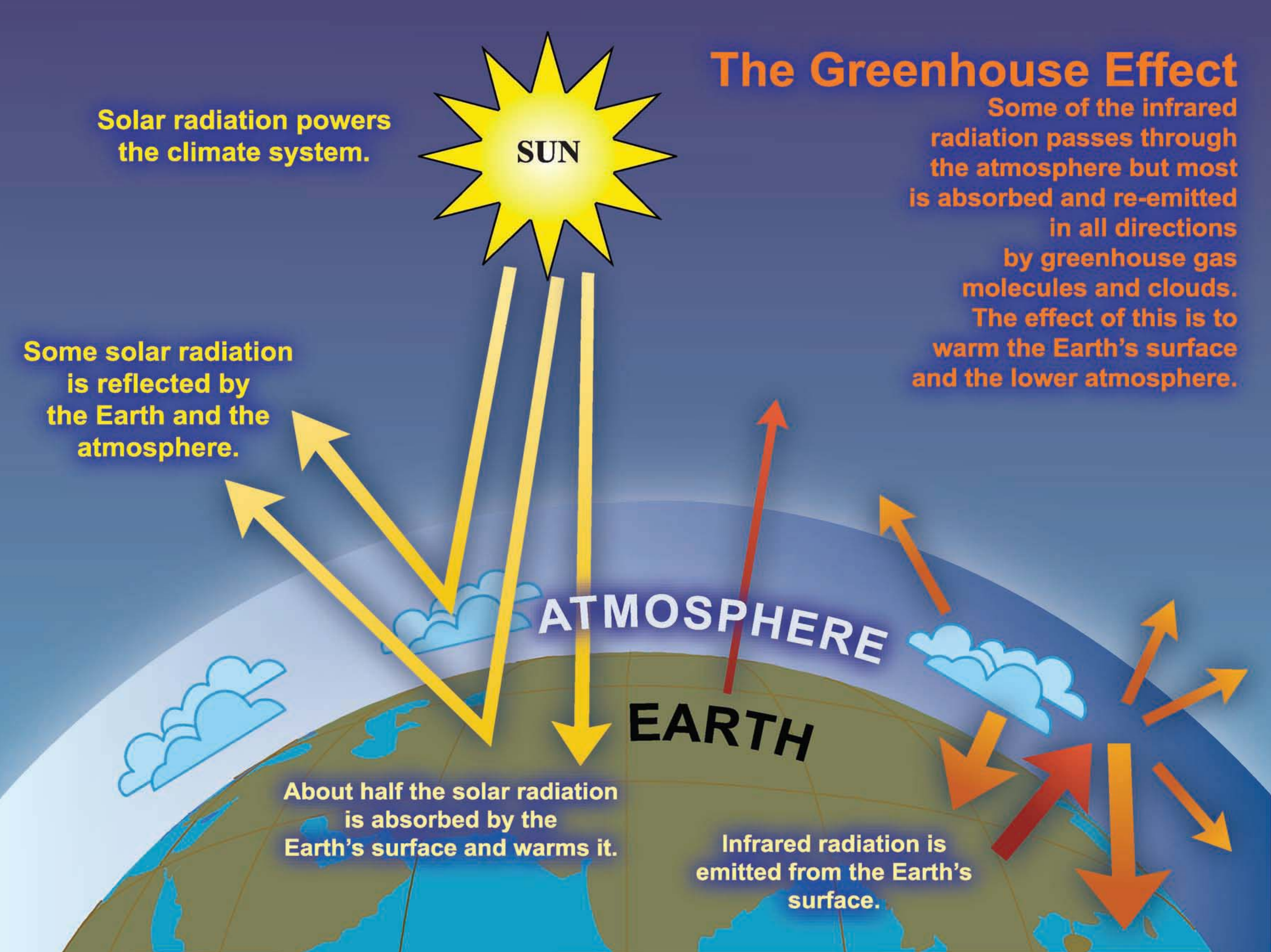
What We Know

- Warming of the climate system is unequivocal
- Many natural systems are being affected by regional climate change
- Global GHG emissions due to human activities have increased 70% between 1970 and 2004
- Altered frequencies and intensities of extreme weather, together with sea level rise, are expected to have mostly adverse effects on natural and human systems

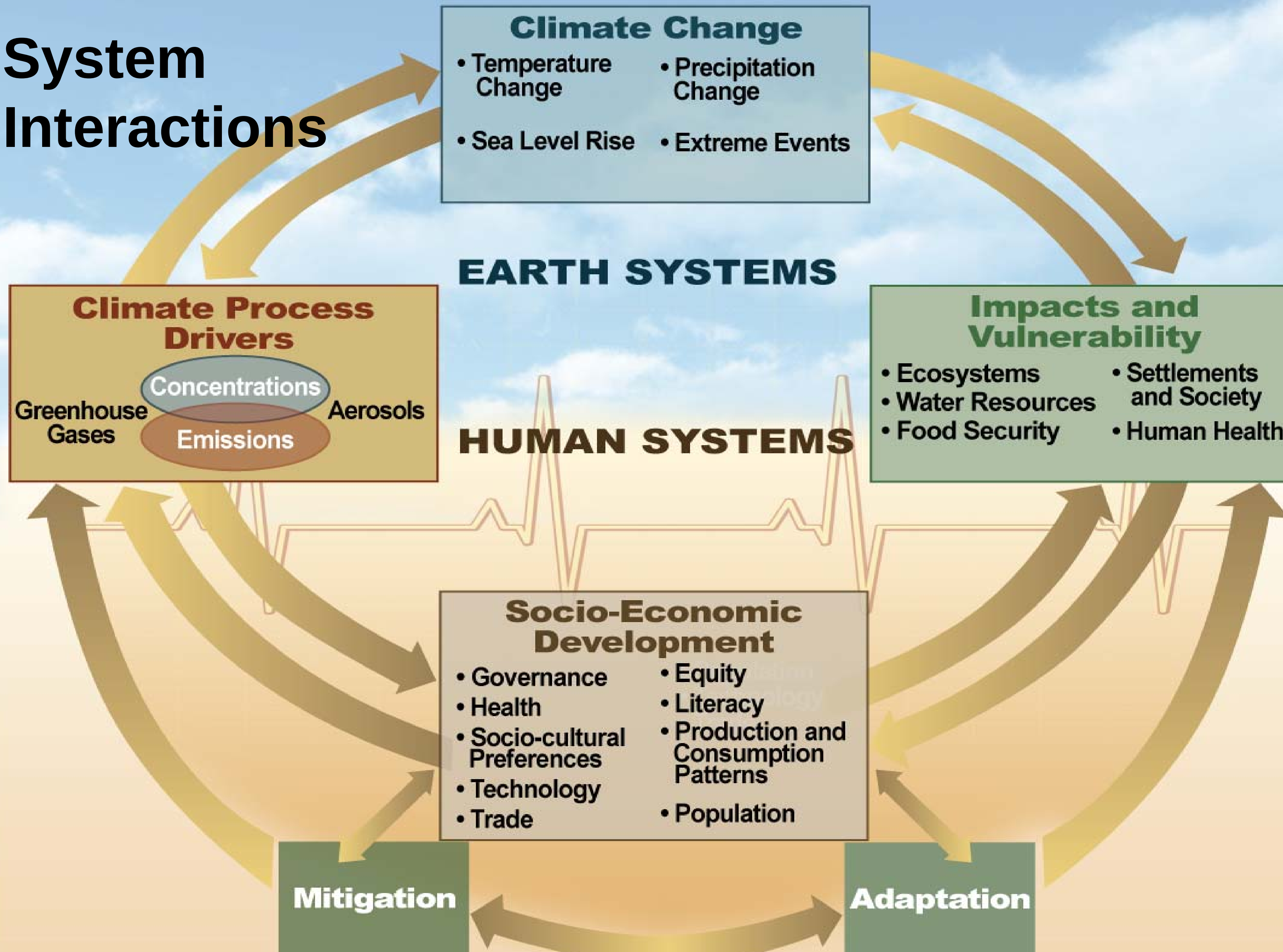
From: IPCC Fourth Assessment Report. Climate Change 2007: Synthesis Report Summary for Policymakers

What We Really Want to Know

- **Energy and water**
  - How will climate change impact our energy security?
  - What effects will climate change have on water supply and management challenges?
  - Will droughts become more intense and frequent?
- **Ecosystems**
  - How rapidly will ecosystems change, and will there be tipping points in their responses?
- **Agriculture:**
  - What effects will climate change have on water resources, growing seasons, and our food supply?
  - How will a biofuels industry impact land use and climate?
- **Public Infrastructure:**
  - What are the implications of abrupt and severe climate events? How can we predict and prepare for these?

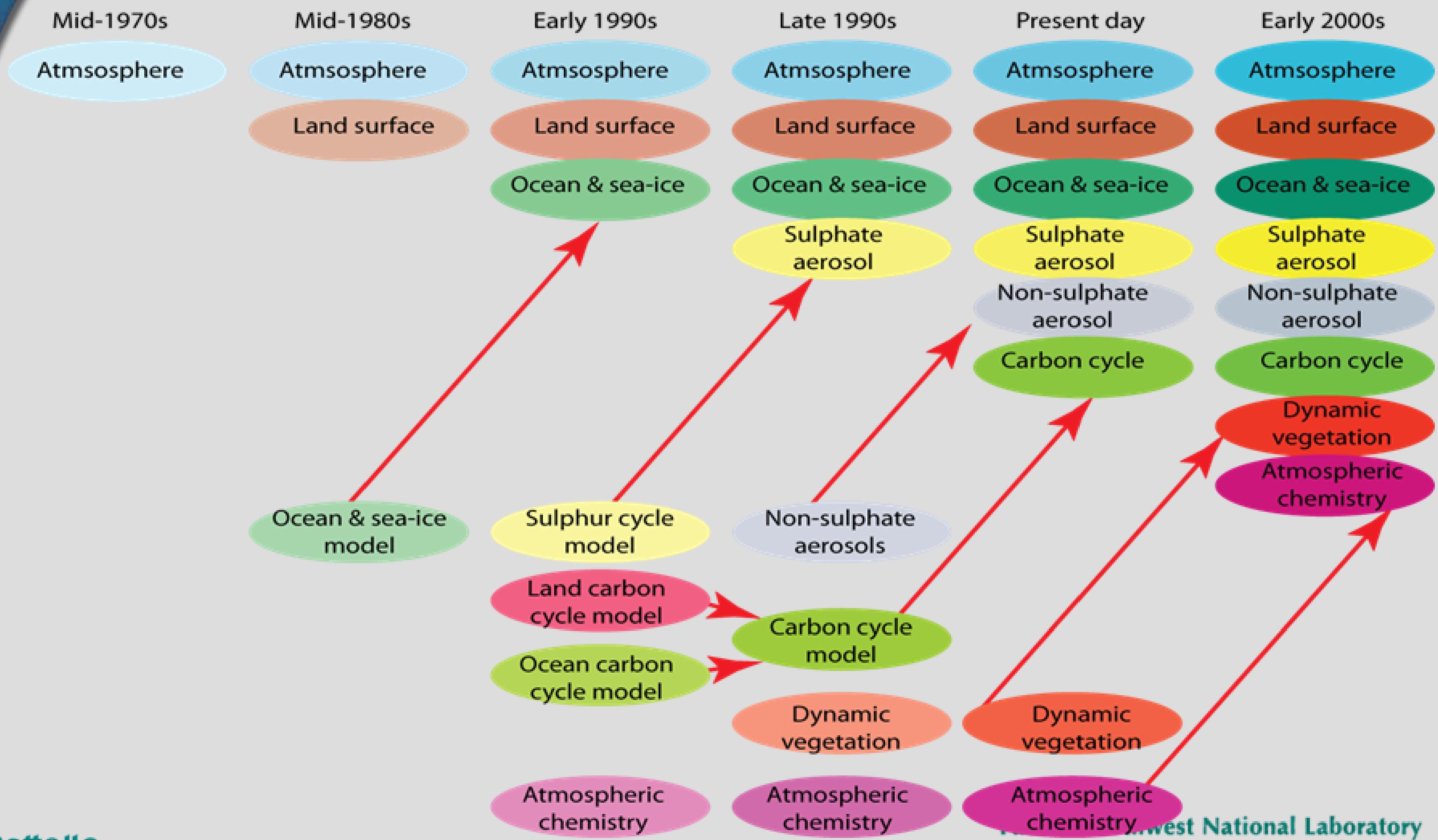

The Greenhouse Effect
Solar radiation powers the climate system.
SUN
Some of the infrared radiation passes through the atmosphere but most is absorbed and re-emitted in all directions by greenhouse gas molecules and clouds. The effect of this is to warm the Earth's surface and the lower atmosphere.
Some solar radiation is reflected by the Earth and the atmosphere.
ATMOSPHERE
EARTH
About half the solar radiation is absorbed by the Earth's surface and warms it.
Infrared radiation is emitted from the Earth's surface.

System Interactions

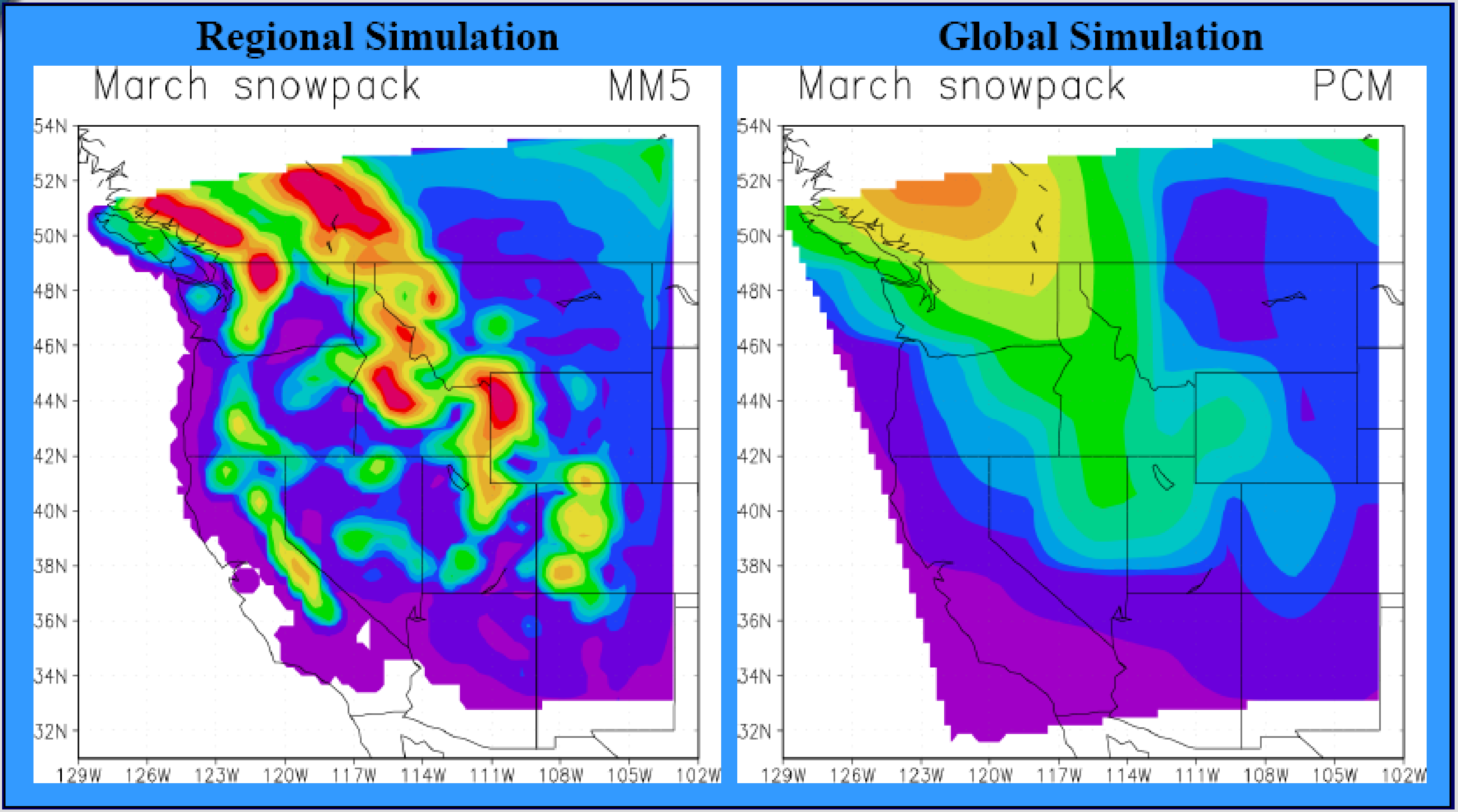


The Development of Climate Models-- Past, Present, and Future

Our ability to more fully represent the dynamics of our environment is increasing – but interactions among model elements are still problematic



Higher Resolution is Required to Understand and Predict Regional Impacts



Global models under-predicted and misplaced snow

Predictions at a Regional Scale, in a Global Context, are Required for Managing Resources and Risks

- Changes in precipitation (soil moisture, snowpack, river runoff) -- affect water resources (including hydropower), agriculture and ecosystems
- Changes in extreme events (e.g., hurricanes, heat waves, floods/droughts, heavy snowfall) – affect water resources, human health, agriculture, vegetation, forest fires
- Changes in meteorology (circulation/winds, sunshine/clouds, storm frequency/intensity, frost, hail/snow) – affect air quality, energy (winds, solar), crops
- Sea level rise (melting of sea ice) – affects coastal regions

What We Need to Do…..

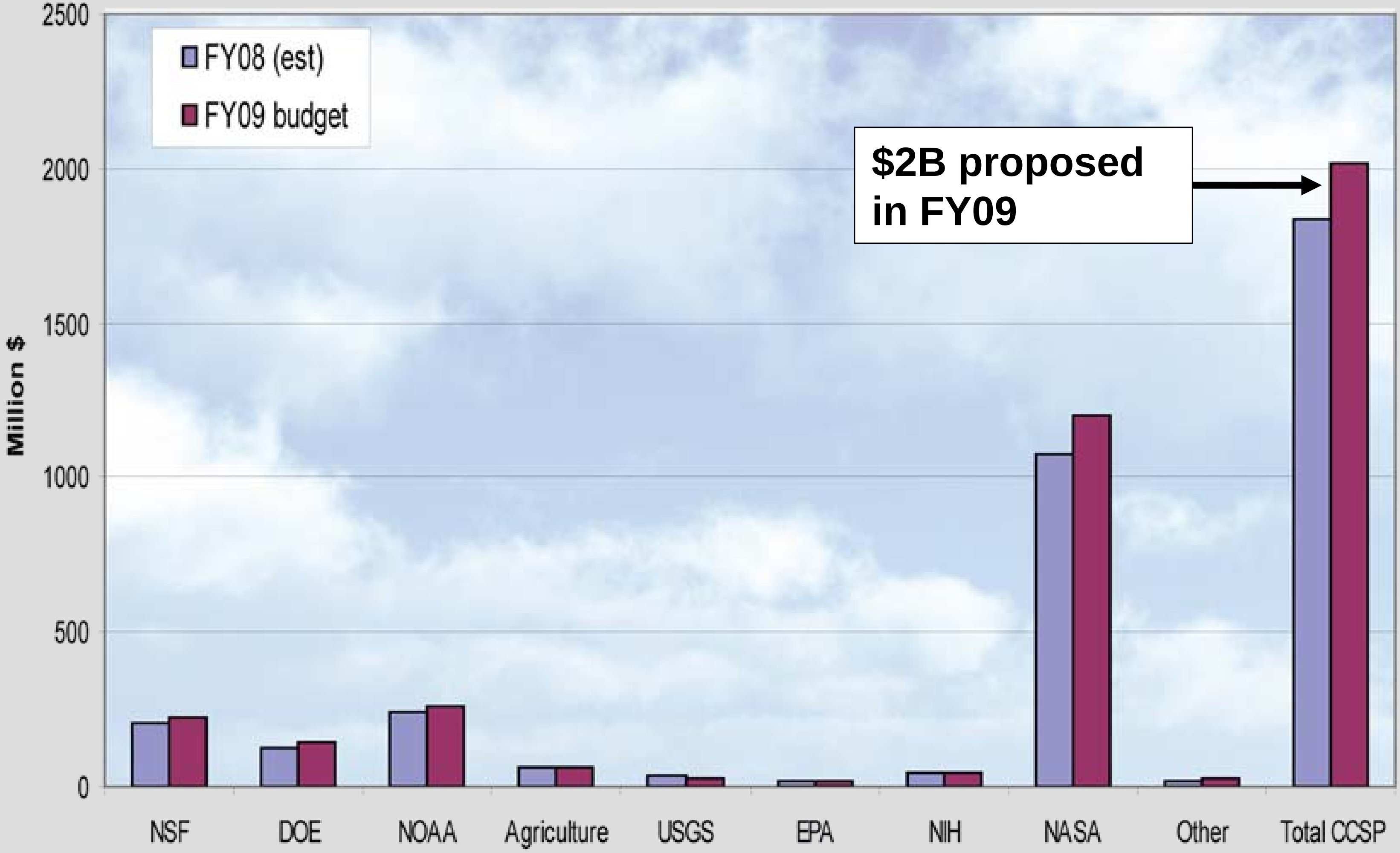
- Take accurate and consistent environmental measurements to understand climate change effects and validate models
- Obtain understanding from petabytes of data to enable coupling of atmospheric, terrestrial, and ocean models at high resolution
- Develop fully coupled, dynamic climate and Earth system models that incorporate adaptation and mitigation options and project responses to climate forcing at regional and global scales over decades

Who is Working on the Problem?

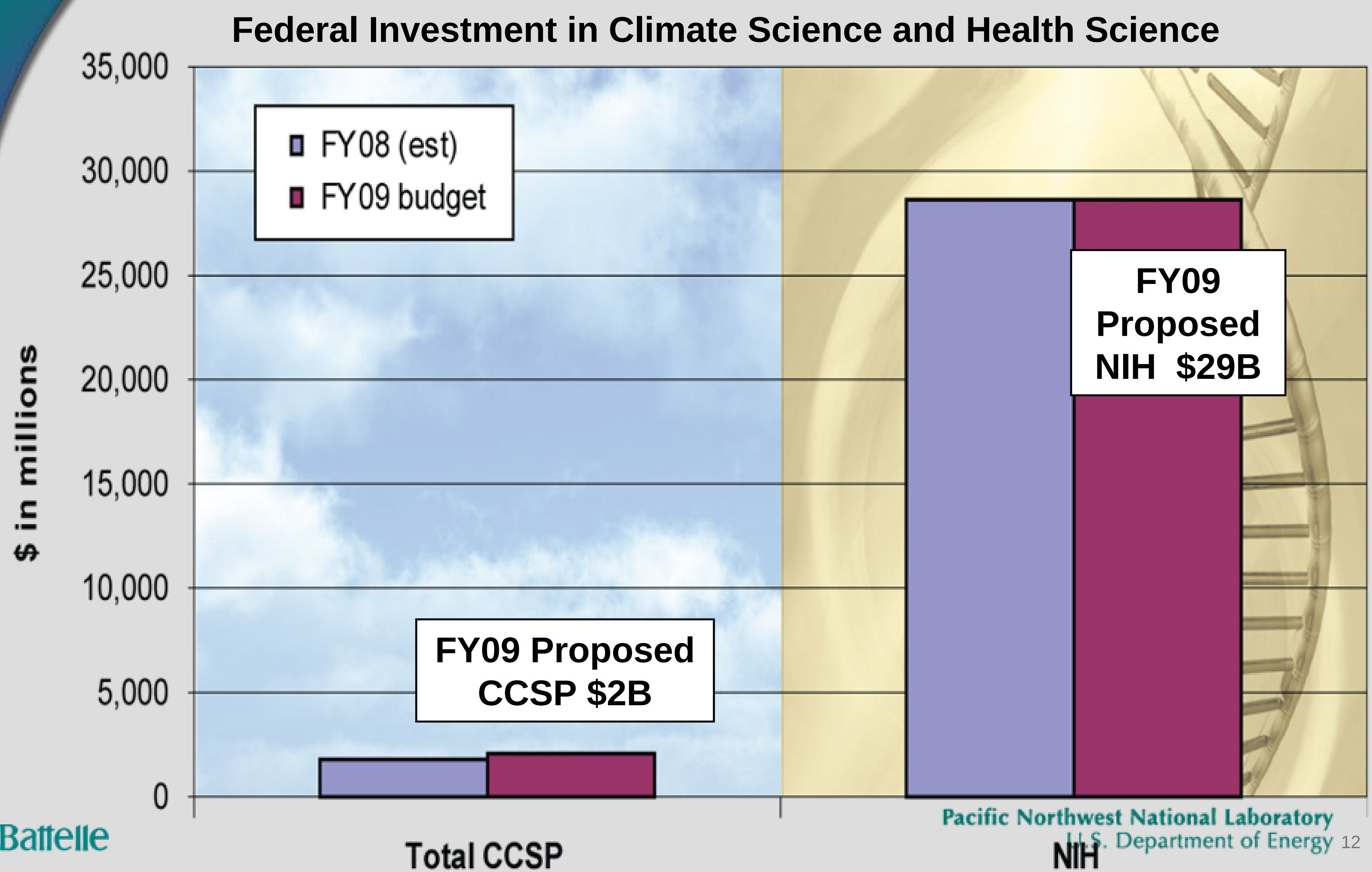
- The Climate Change Science Program (CCSP) integrates federal research on climate and global change
  - **Involves 13 federal agencies**
  - Oversight conducted by Office of Science and Technology Policy, the Council on Environmental Quality, the National Economic Council and the Office of Management and Budget
- Over **$20B** (cumulative) invested over the last thirteen years
- Baseline programs and related capabilities contribute to progress
  - DOE and computation
  - NASA and technology development

US Climate Change Science Program
www.climatescience.gov

Federal Investment in Climate Science is Primarily through the Interagency Climate Change Science Program (CCSP)



Proposed NIH budget is over 14 times that of Climate Change Science Program (CCSP)



We Need a Transformational Approach to Climate Science

- A targeted climate science agenda that includes
  - Laboratory Measurements
  - Observations
  - Modeling
- Coupled models are required to move us toward an integrated earth system perspective
- Model complexity is increasing without the associated increase in measurements and observations (data) for validation

Advances in Scientific Instrumentation and Computational Power make this Transformational Approach Possible

- Ability to accurately measure and observe at a variety of scales, in labs and in native environments
  - From single particle to cloud level measurements
  - Monitoring and evaluation of regional ecosystems
  - Global imaging and satellite data systems
- Enormous increases in computational power and capability enables consideration of complex system runs
- Advanced sensors and monitoring systems can deliver near real-time geophysical parameters

What it All Means: A Summary

- Natural systems are already being affected by climate change
- For highest value, climate science must focus on answers decision makers need about energy and water, ecosystems, agriculture, and public infrastructure
  - Aim for predictions at a regional scale, in a global context, to enable management of resources and risks
- Needed: Transformational approaches and tools
  - A targeted climate science agenda that includes **measurements, observations, and modeling**
  - Coupled, **high-resolution climate and Earth system models**, including adaptation and mitigation, at regional and global scales
  - Strategic use of emerging **scientific instrumentation** and **computational power**
- Financial **investments** and effective, integrated **partnerships** are required to accelerate and enable transformational approaches, tools, and results

Where Do We Go from Here?

- Aligning Integrated Assessment Research to be Responsive to the Emerging Needs of Climate Change Decision Makers
  - **Robert Vallario**,US Department of Energy, Washington, DC
- Climate Change Impacts and Adaptation
  - **Anthony Janetos**, Pacific Northwest National Laboratory, Joint Global Change Research Institute, College Park, MD
- From Emissions to Impacts: Insights from and Advances in Atmospheric Chemistry
  - **Thanos Nenes**, Georgia Institute of Technology, Atlanta, GA
- Effects of Climate Change on Atmospheric-Hydrologic Cycle
  - **Tom Ackerman**, University of Washington, Seattle, WA
- Computational Challenges for Dynamic Earth System Models
  - **Bill Collins**, Lawrence Berkeley National Laboratory and UC Berkeley, Berkeley, CA