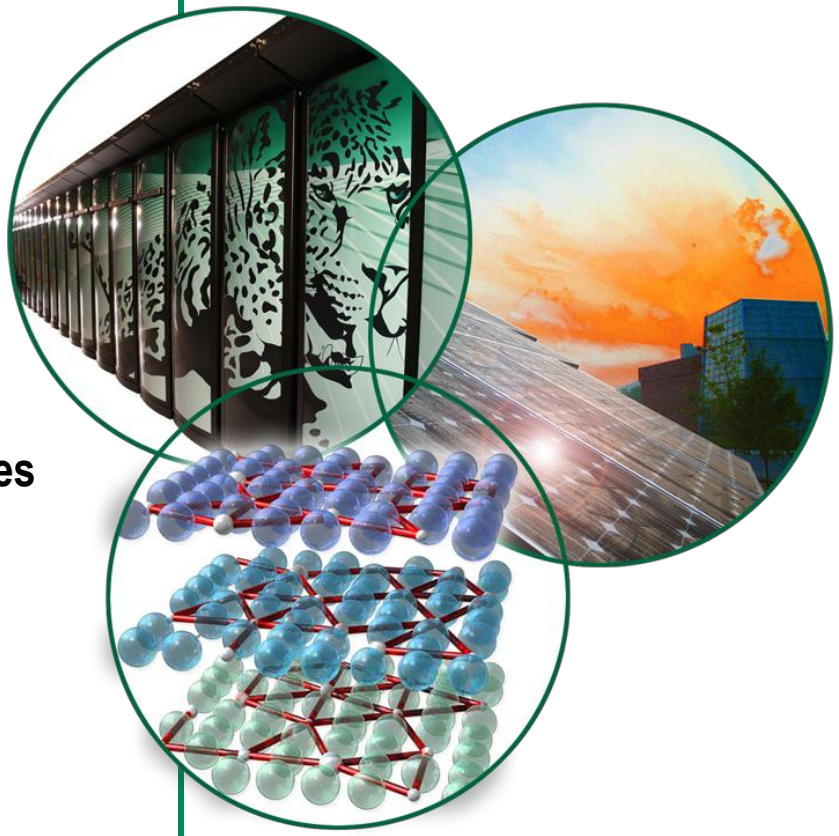
Panel on Accelerating Atmospheric, Ocean, and Sea Ice Models



James J. Hack
Director, National Center for Computational Sciences
Oak Ridge National Laboratory

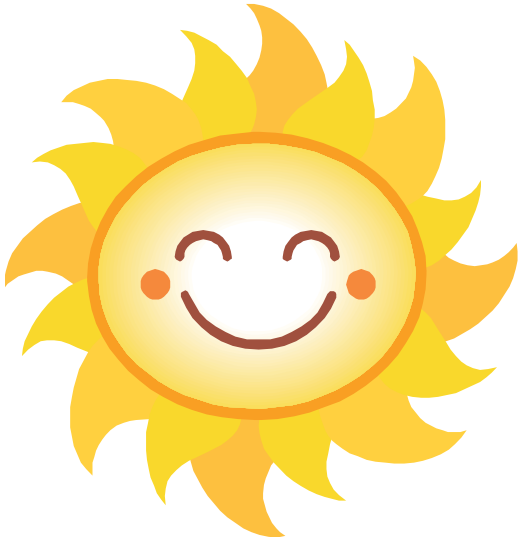
Accelerating Computational Science Symposium 2012

Washington, DC

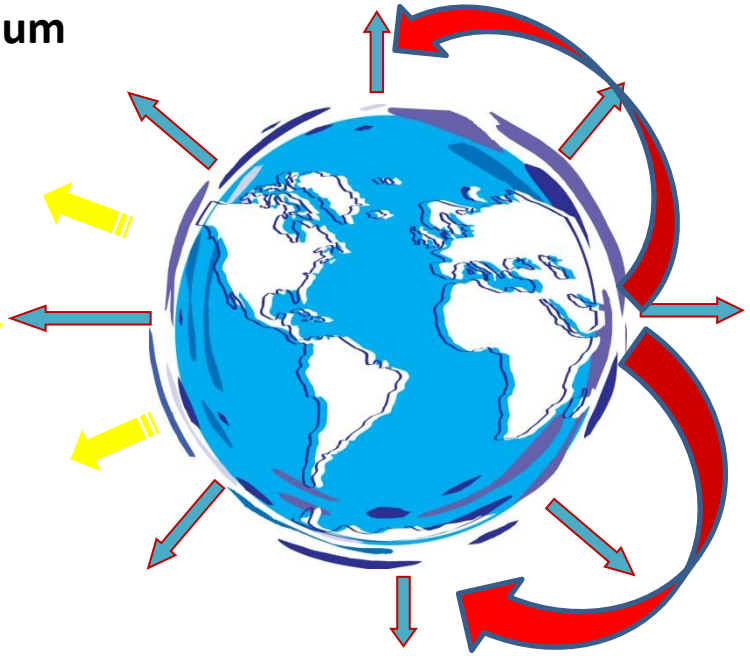
29 March 2012

Cartoon Climate 101

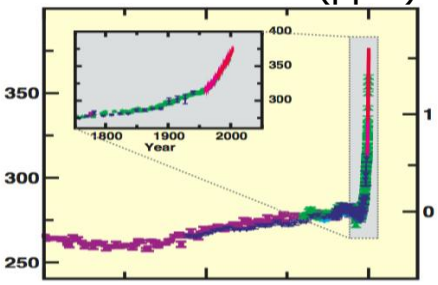
The Concept of a Forced System
In Radiative/Energy Equilibrium



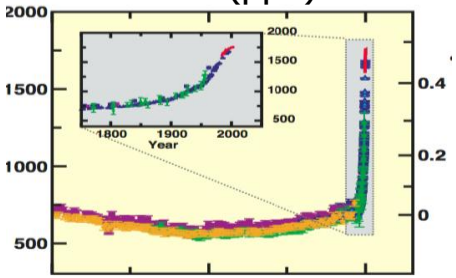
Solar Radiation



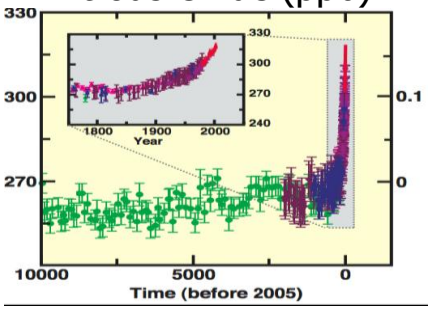
Carbon Dioxide (ppm)



Methane (ppb)



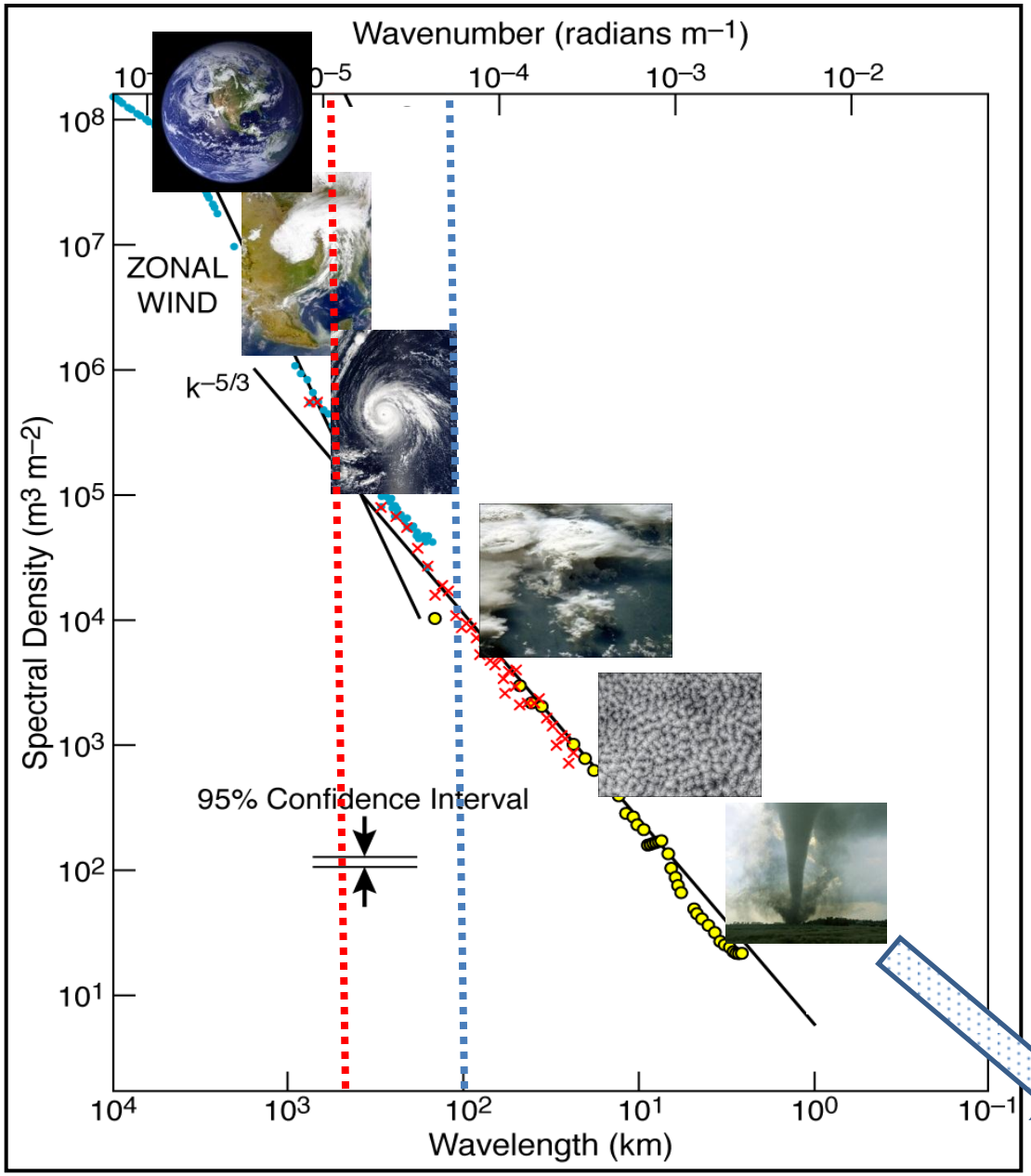
Nitrous Oxide (ppb)

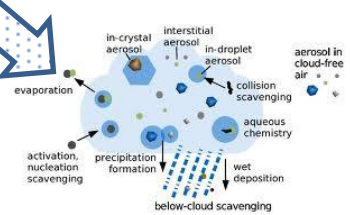


Terrestrial Radiation

$\varepsilon\sigma T^4$

Kinetic energy spectra from aircraft





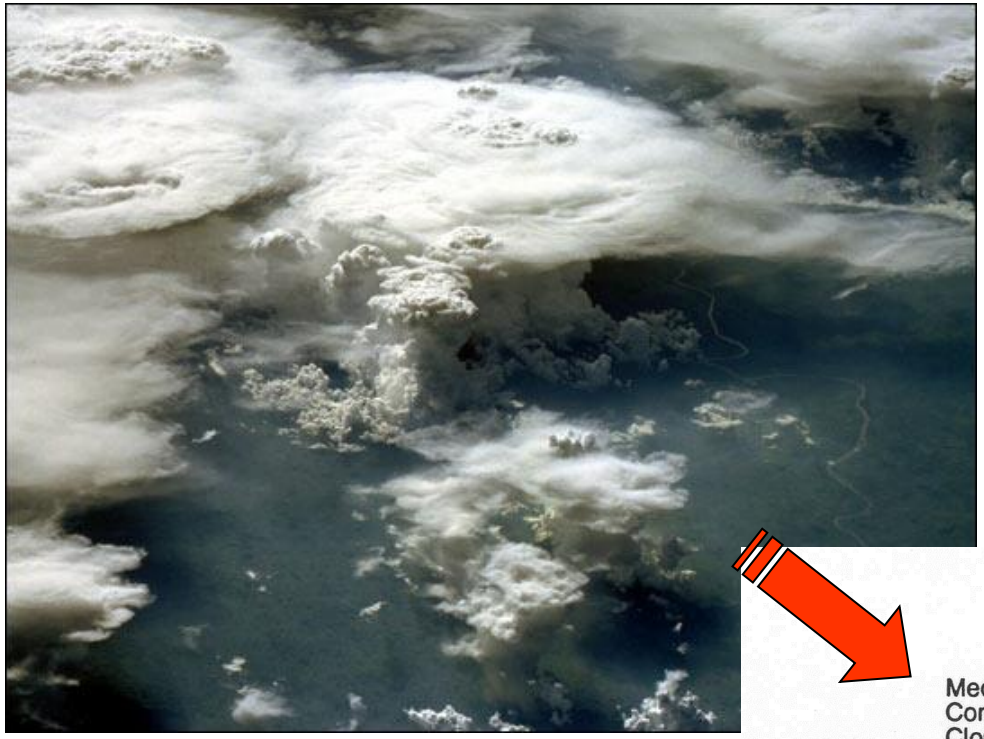
Atmosphere and Ocean exhibit a continuum of motion scales

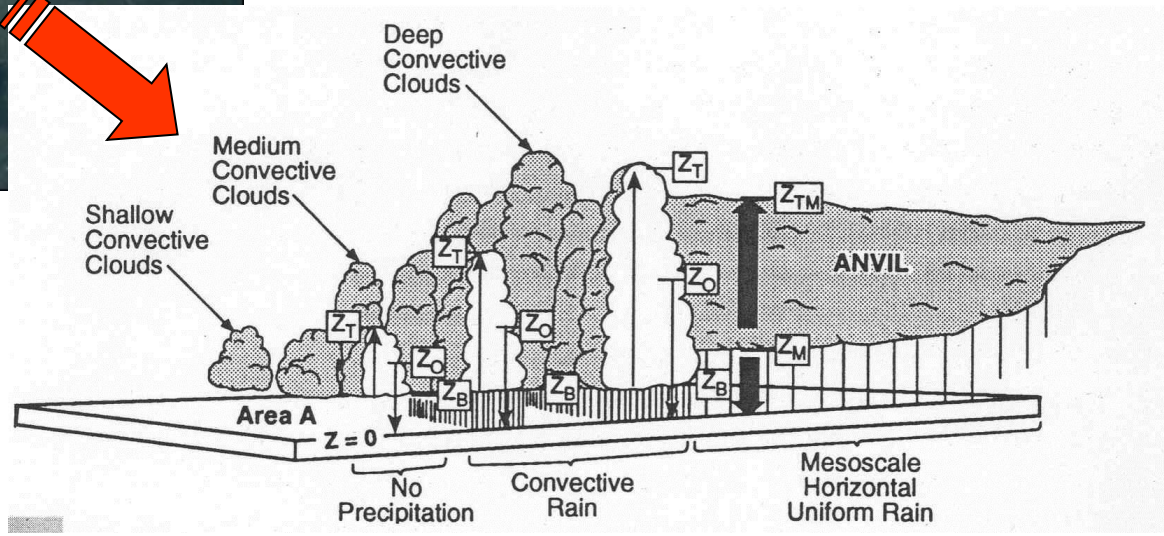
- Resolved scale treatment formulated on first principles conservation laws (energy, mass, momentum)
- Unresolved scales represented using parameterizations based on highly-detailed process models formulated in statistical equilibrium with resolved scale motion field

Nastrom and Gage, 1985

Process Models and Parameterization

The other enduring frontier





Examples of climate consequences questions

- **Water Resources**
  - management and maintenance of existing water supply systems, development of flood control systems and drought plans
- **Agriculture and food security**
  - Erosion control, dam construction (irrigation), optimizing planting/harvesting times, introduction of tolerant/resistant crops (to drought, insect/pests, etc.)
- **Human health**
  - Public health management reform, improved urban and housing design, improved disease/vector surveillance and monitoring
- **Terrestrial ecosystems**
  - Improvement of management systems (deforestation, reforestation,…), development/improvement of forest fire management plans
- **Coastal zones and marine ecosystems**
  - Better integrated coastal zone planning and management
- **Human-engineered systems**
  - Better planning for long-lived infrastructure investments

Reducing uncertainty

Climate Science for a Sustainable Energy Future (CSSEF)

- Accelerate incorporation of new knowledge, including process data and observations, into climate models
- Develop new methods for rapid evaluation of improved models.
- Develop novel approaches to exploit computing at the level of tens of petaflops in climate models

Identify the most important unresolved processes

Identify critical underutilized datasets

Develop comprehensive testbeds

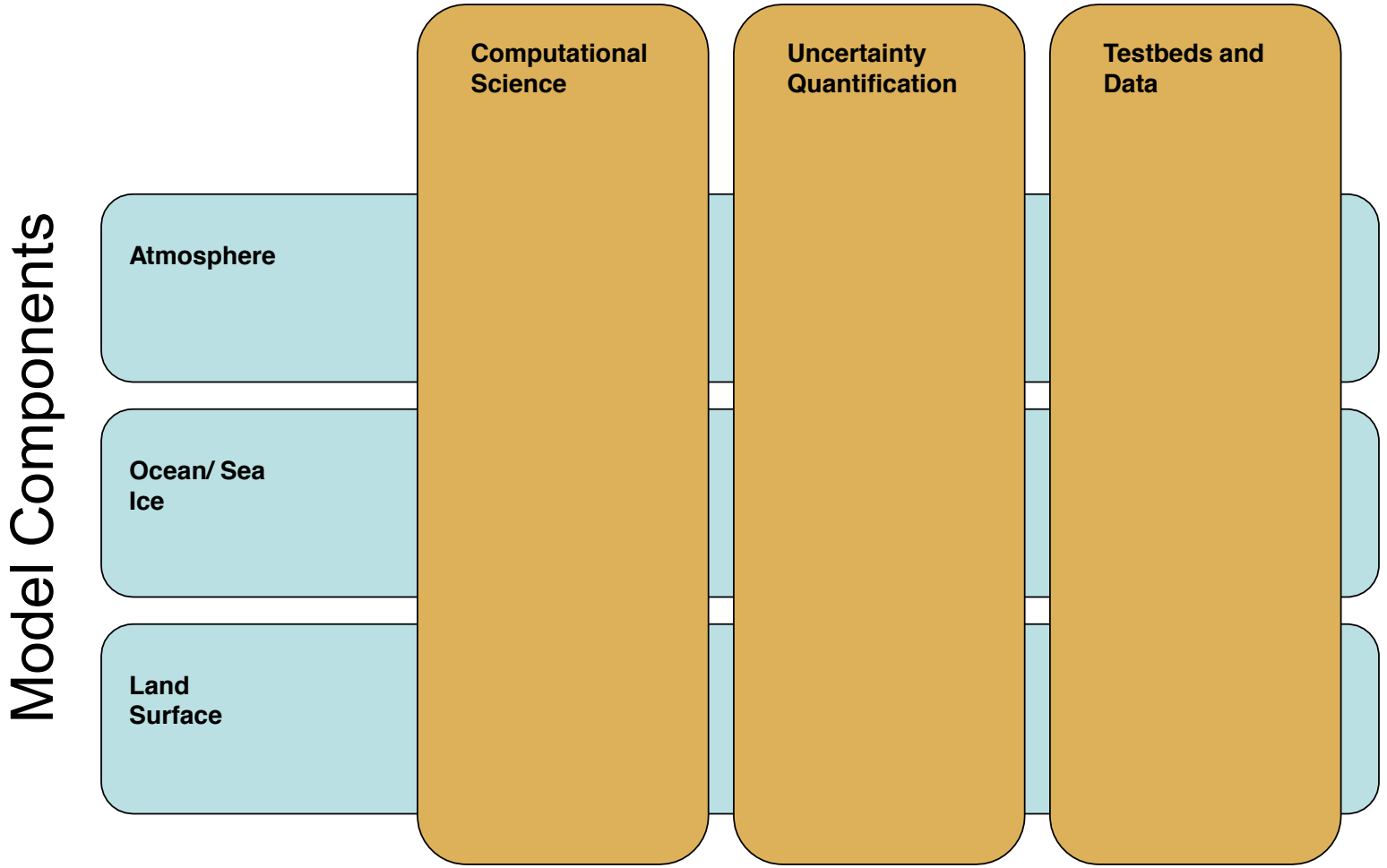
Formal incorporation of uncertainty quantification

comprehensive multi-variate optimization, with formal parametric uncertainty estimates and characterization of error propagation

Reducing uncertainty

Climate Science for a Sustainable Energy Future (CSSEF)

Research Elements



New Scientific Opportunities

Continued scientific and computational science research coupled with advances in computational technology opens new opportunities

Exploring population dynamics in the context of adaptation to water availability, coastal vulnerability using Landscan population dataset