Fourth Paradigm: Area 1: Environmental Sciences

Three Phases

- Phase 1: largely discipline-oriented: geology, atmospheric chemistry, ecosystems
- Phase 2: study of interacting element earth sciences and systems: Complex systems and models for explaining these systems emerged; knowledge developed for scientific understanding
- Phase 3: knowledge developed for practical decisions and actions
- This new knowledge endeavor is termed “Science of environmental sciences”

Knowledge and Queries

- “With the basic understanding now well established, the demand for climate applications knowledge is emerging.
- How do we quantify and monitor total forest biomass so that carbon markets can characterize supply?
- What are the implications of regional shifts in water resources for demographic trends, agricultural output, and energy production?
- To what extent will seawalls and other adaptations to rising sea level impact coasts?”
- These questions and additional issues need applications to built around this basic knowledge
- Integration of knowledge from many disciplines: physics, biogeochemical, engineering, and human processes (demographics, practices).
- Snow-melt problem affects 1 billion people in the world: it is discussed in detail.
- Models have to consider interactions among various systems: traditional approaches may not suffice. My opinion: We may need a compendium of methods.

Consideration for designing models

- Need driven vs. curiosity driven
- Externally constrained
- Consequential and recursive (knowledge generates more knowledge)
- Useful even when incomplete
- Scalable
- Robust
- Data-intensive

Development of New Knowledge Types and Tools

- For acquiring knowledge multiple sources: satellite imagery, energy-balancing reconstruction, etc.
- Practical answers, intellectually captivating models, knowledge for policy making, etc.
- Equally important is using this knowledge in everyday lives: esp. with the availability of mobile devices and the Internet. Ex: Hurricane Irene models, knowledge and consequences

Simple Example

- Figure 1:
- Sierra Nevada and Central Valley of CA geography image
- NASA satellite images at various spectral bands
- Use these two collection to arrive at the snow cover model
- Something of a scientific “mashup”

Ecological Sciences Systems (p.24..)

- Navigating the ecological cloud flood
- Step1: in ecological scientific analysis is data discovery and harmonization…sources, conversions, scrapping, web services, RSS, namespace mediation, search portals, wikipedia, …
- Step 2: Moving ecological synthesis into the cloud: CSV MATlab ready data files from hundreds of sites; analysis on the cloud; SQL Server Analysis Data Cube on the cloud;

Ecological Sciences Systems (contd.)

- Step 2 (contd.): analysis will download 3 terabyte of imagery, 4000 CPU hours, and generate < 100MB results.
- Challenges: complex visualization, diversity of the data set, data semantics, data publisher, meta data, collaboration tools.
- So you think these are NOT CSE problems, take a look at this:http://climatechange.cs.umn.edu/