Breakout Session IV - CC&E Contributions Towards Analyzing Impacts and Consequences of Global Change

Report for

Challenges of Scale

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(Additional figures are given in the accompanying Power Point document from the full presentation in the breakout session)

The charge questions for this breakout session, in the context of the challenges of scale, were:

- What research can we conduct to better address the impacts and consequences of global change?
- What actions would be most useful to or supportive of future assessments?
- What are the greatest challenges and opportunities?

Discussion began by giving several examples of recent scaling studies and by reviewing the foci addressed in IPCC Working Group 2 (see items 1-7 below), as they apply directly to impacts and consequences of global change. It was noted that, with the exception of sea level rise, aquatic systems were not well represented by the IPCC list. Therefore, Oceans and Freshwater Systems were added as an eighth item to the list.

1. NPP and the Carbon Cycle
2. Wildfire
3. Crop and Forest Pests
4. Biodiversity
5. Agriculture and Land Use
6. Sea Level Rise
7. Storms and Extreme Events
8. Oceans and Freshwater systems

This was followed by explicit examples of issues of scale, noting the overarching concept of the tradeoffs associated with scale:

Spatial Scale

<u>Sample questions:</u> *plant species migration; invasive species; selective logging; coral bleaching; coastal eutrophication.*

Temporal Scale

<u>Sample Issues:</u> *Changes in phenology, diurnal cycles, longer-term change and data continuity.*

Scales of Complexity (Scaling laws)

<u>Sample questions:</u> *Species to functional groups and biomes. Food webs to ecosystems. Spectral resolution.*

Overarching Questions and Concepts
Is there an inherent tradeoff in the importance of spatial versus temporal scale among gas (atmosphere), liquid (aquatic) and solid (terrestrial) phase systems?

Other examples of ecosystem responses to climate change that involve challenges of scale were discussed, including:

- *Plant species migration* #*
- *invasive species**
- *selective logging**
- *coral bleaching**
- *coastal eutrophication* #*
- *expansion of tropical gyres**
- *algal bloom dynamics #**
- *algal bloom dynamics in response to sea ice retraction #*
- *pollutant plumes and responses*
- *Vegetation phenology #*
- *Phenology and Foodweb dynamics #*
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*Greatest challenge: * Spatial, #Temporal*

The work of Downing et al. 2006 (Figure 1) served as a salient example of the inherent challenges of scale, demonstrating that water bodies smaller in size than a Landsat pixel represent an enormous fraction of the global freshwater surface area; the largest of the size classes in Figure 1. These small ponds and impoundments have very high surface area to volume ratio and are of tremendous importance to global biogeochemistry, but go largely undetected by conventional remote sensing analyses.

Much of the discussion was organized into a SWOT (Strengths, Weaknesses, Opportunities, and Threats) analysis framework in order to summarize the issues discussed above:

Strengths:

- *Excellent multi-scale data capture (e.g., MODIS, MISR, Seawifs, Landsat, EO-1, AVIRIS).*
- *Ton of existing data and validation opportunities.*

Weaknesses:

- *Relating measurements and processes across scales <u>still</u> represents a huge challenge.*
- *Wealth of data, but insufficient people-hours to fully analyze them.*
- *Still difficult to pull together multiple-scale data sources for a single analysis.*

Opportunities:

- *Investing in people to conduct multi-scale analyses represents an enormous opportunity, given the already paid costs of instruments and data acquisition.*
- *Aircraft have multiple-scale capabilities that can compliment satellites, and allow for explicit data scaling. Advantages of airborne sensor data include flexibility in targeting and spatial resolution likely outweigh the weaknesses of temporal) repeatability and flight restrictions.*
- *Treatment of "Scaling" as a fundamental science issue can lead to significant breakthroughs in understanding impacts.*

Threats:

- *Continued underutilization of existing investments*
- *Lack of data continuity for detecting longer-term impacts from global change.*

The following additional suggestions, observations, and comments were discussed:

- NASA may no longer be pushing the envelope as far as development of future missions that will ensure data continuity.
- Developing tools and explicit methods for scaling using existing multi-sensor data sets—identify a key question or important parameter, define a methodology, and develop the global measurement strategy. This may involve, for example, identifying emergent fine-scale spectral properties that can be used to interpolate to broader spectral features.
- A request for information may be a useful tool to address the question of what minimum scale is *required* (vs. *desired*) to answer science questions—i.e., what scale can you "get away with"? This is dependent on the question you're trying to address
- Geostatistical data (e.g., semi-variograms) could be key to pre-mission or pre-proposal efforts in this regard. These data could assist in elucidating fundamental laws of scaling that could be applied to existing datasets.
- The combination of multi-scale data from the EO-1 platform (Hyperion and ALI) is seen as an underutilized strength. A graduate student commented on wanting to use these data, but not having the funds to purchase them. Should NASA consider investing in additional data buys to increase the use of these instruments?
- Collaboration between scientists and engineers could assist in determining what scales are relevant to what impacts.

The discussion consistently came back to the question of determining what scale is most appropriate to answer specific science questions; hence the conclusion that ***scaling itself as a fundamental science issue could lead to significant breakthroughs in understanding impacts and consequences of global change***.

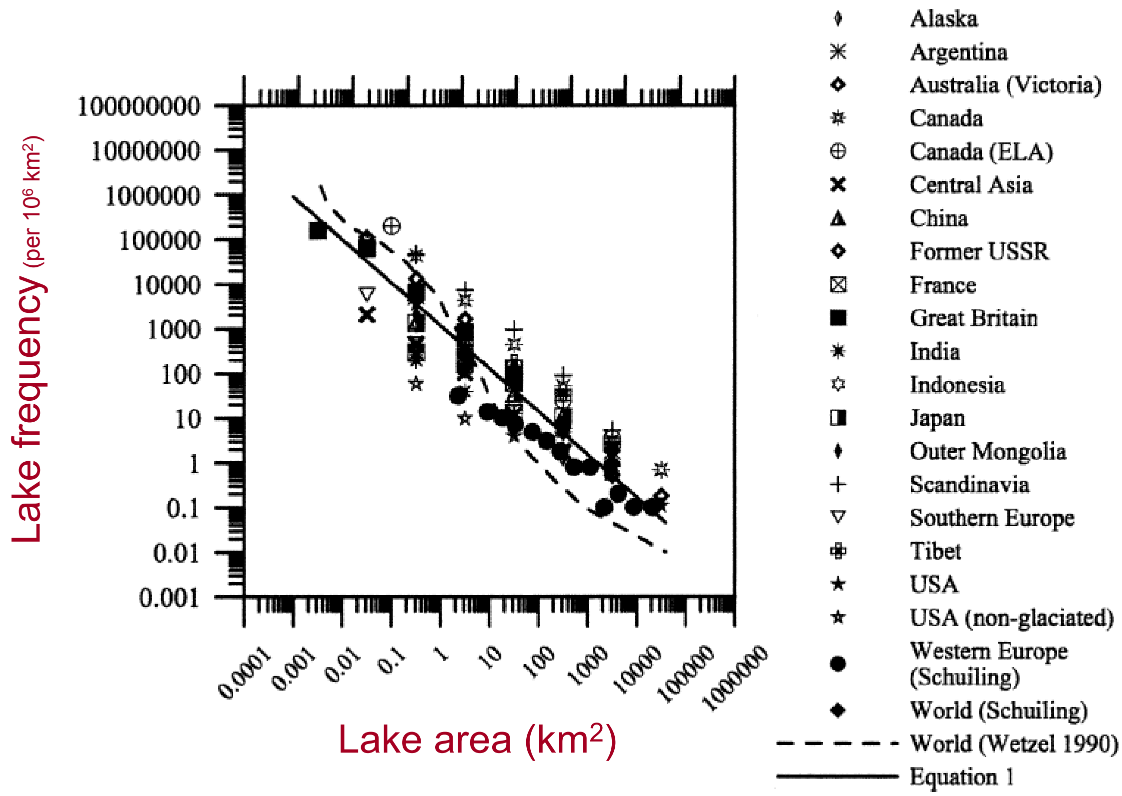

Figure 1. Area versus Frequency of Lakes and Ponds (Downing et al. 2006).