BERAC Workshop on

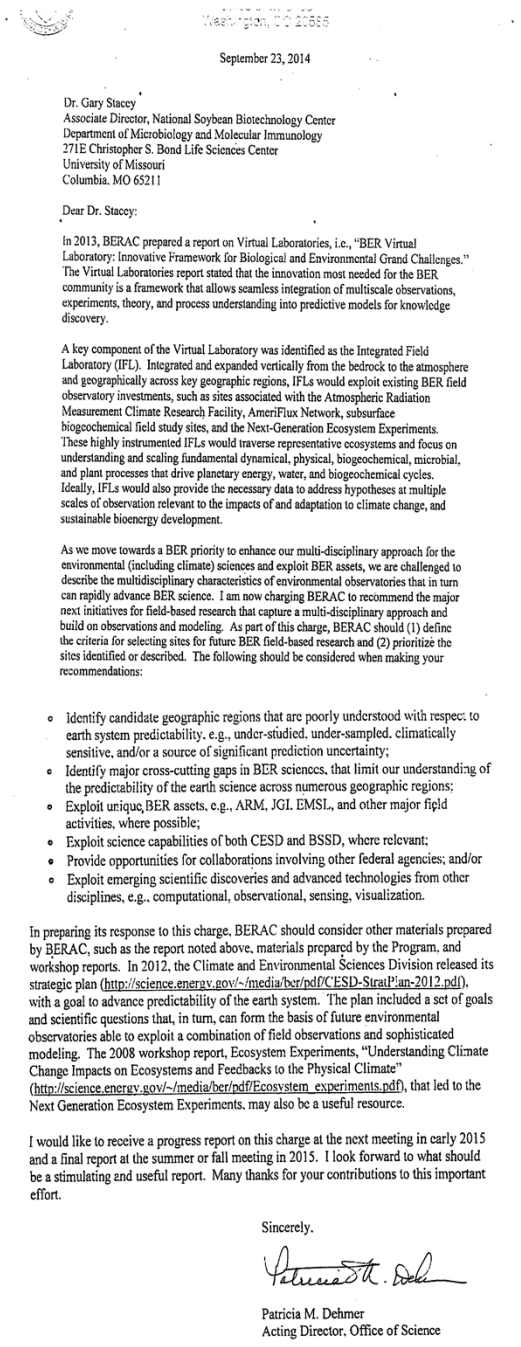
Development of an Integrated Field Laboratory

With a Focus Incorporating

Urban Systems as Part of Human – Earth System Interactions

January 29-30, 2015

Jim Ehleringer, Nancy Grimm, Lucy Hutyra,
Tony Janetos, and Ruby Leung



Washington, DC 20585

September 23, 2014

Dr. Gary Stacey
Associate Director, National Soybean Biotechnology Center
Department of Microbiology and Molecular Immunology
271E Christopher S. Bond Life Sciences Center
University of Missouri
Columbia, MO 65211

Dear Dr. Stacey:

In 2013, BERAC prepared a report on Virtual Laboratories, i.e., "BER Virtual Laboratory: Innovative Framework for Biological and Environmental Grand Challenges." The Virtual Laboratories report stated that the innovation most needed for the BER community is a framework that allows seamless integration of multiscale observations, experiments, theory, and process understanding into predictive models for knowledge discovery.

A key component of the Virtual Laboratory was identified as the Integrated Field Laboratory (IFL). Integrated and expanded vertically from the bedrock to the atmosphere and geographically across key geographic regions, IFLs would exploit existing BER field observatory investments, such as sites associated with the Atmospheric Radiation Measurement Climate Research Facility, AmeriFlux Network, subsurface biogeochemical field study sites, and the Next-Generation Ecosystem Experiments. These highly instrumented IFLs would traverse representative ecosystems and focus on understanding and scaling fundamental dynamical, physical, biogeochemical, microbial, and plant processes that drive planetary energy, water, and biogeochemical cycles. Ideally, IFLs would also provide the necessary data to address hypotheses at multiple scales of observation relevant to the impacts of and adaptation to climate change, and sustainable bioenergy development.

As we move towards a BER priority to enhance our multi-disciplinary approach for the environmental (including climate) sciences and exploit BER assets, we are challenged to describe the multidisciplinary characteristics of environmental observatories that in turn can rapidly advance BER science. I am now charging BERAC to recommend the major next initiatives for field-based research that capture a multi-disciplinary approach and build on observations and modeling. As part of this charge, BERAC should (1) define the criteria for selecting sites for future BER field-based research and (2) prioritize the sites identified or described. The following should be considered when making your recommendations:

- Identify candidate geographic regions that are poorly understood with respect to earth system predictability, e.g., under-studied, under-sampled, climatically sensitive, and/or a source of significant prediction uncertainty;
- Identify major cross-cutting gaps in BER sciences, that limit our understanding of the predictability of the earth science across numerous geographic regions;
- Exploit unique BER assets, e.g., ARM, JGI, EMSL, and other major field activities, where possible;
- Exploit science capabilities of both CESD and BSSD, where relevant;
- Provide opportunities for collaborations involving other federal agencies; and/or
- Exploit emerging scientific discoveries and advanced technologies from other disciplines, e.g., computational, observational, sensing, visualization.

In preparing its response to this charge, BERAC should consider other materials prepared by BERAC, such as the report noted above, materials prepared by the Program, and workshop reports. In 2012, the Climate and Environmental Sciences Division released its strategic plan (http://science.energy.gov/~/media/ber/pdf/CESD-StratPlan-2012.pdf), with a goal to advance predictability of the earth system. The plan included a set of goals and scientific questions that, in turn, can form the basis of future environmental observatories able to exploit a combination of field observations and sophisticated modeling. The 2008 workshop report, Ecosystem Experiments, "Understanding Climate Change Impacts on Ecosystems and Feedbacks to the Physical Climate" (http://science.energy.gov/~/media/ber/pdf/Ecosystem_experiments.pdf), that led to the Next Generation Ecosystem Experiments, may also be a useful resource.

I would like to receive a progress report on this charge at the next meeting in early 2015 and a final report at the summer or fall meeting in 2015. I look forward to what should be a stimulating and useful report. Many thanks for your contributions to this important effort.

Sincerely,

Patricia M. Dehmer
Acting Director, Office of Science

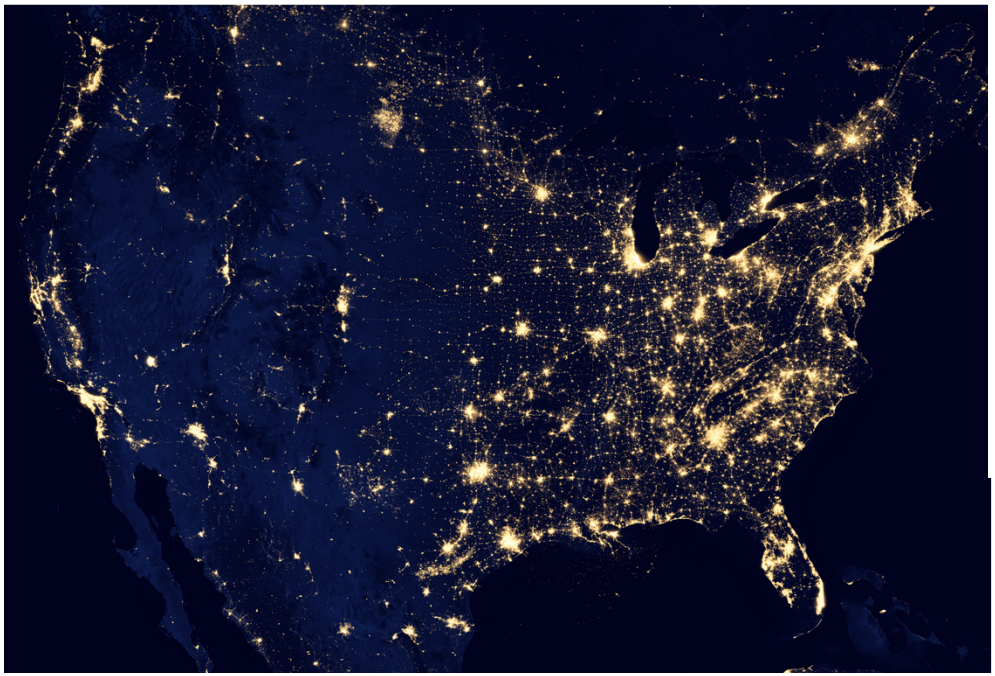
Charge to BERAC

- Expand on the IFL concept and provide recommendations on development of the IFL
- Identify major cross-cutting gaps in BER science that require development of IFLs
- Consider IFL as traversing representative ecosystems and building off existing BER investments
- Focus on understanding processes that drive energy, carbon, water, and biogeochemical cycles
- Address hypotheses relevant to impacts of and adaptation to climate change and sustainable bioenergy development
- Define criteria for selecting IFL sites and identify examples of possible IFL locations
- Provide opportunities for collaboration with other federal agencies

Initial BERAC Discussion

"… IFLs would be located in environments representative of large, rapidly changing regions or areas strategically important for the bioeconomy."

The BERAC discussion quickly focused on a consideration of couple natural-human systems, including urbanizing regions, as greatly understudied ecosystems where



http://www.nasa.gov/mission_pages/NPP/news/earth-at-night.html

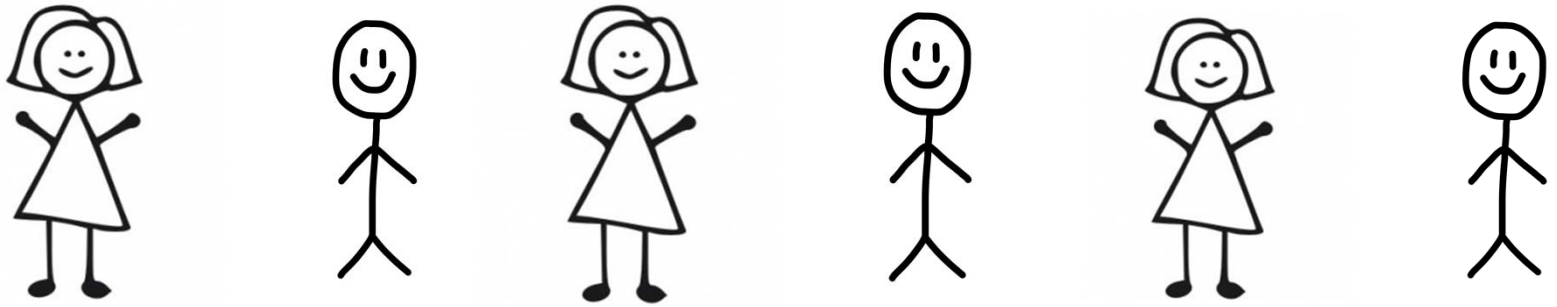
- Rapid land-use change
- Unpredictable future emissions
- Bi-directional connectivities between natural and human-built systems
- Impacts of future intensification of energy, carbon, and water cycles could lead to higher uncertainties in model predictions

BERAC Workshop

January 29-30, Germantown

Participants representing diverse perspectives, including

- BERAC
- Research universities
- National laboratories
- BER facilities
- Other federal agencies
- NSF long-term urban-related projects



Grand challenge questions central to the BER revolve around the concentrated use of energy in urban and surrounding areas, associated alterations in energy, water, materials, food, and other resources, and consequent influences on climate and energy systems of the future.

- What are the energy, water, and GHG flows of urban and adjacent systems in a changing environment?

- What are the drivers, controls, and feedbacks between the Earth System and humans systems from the global scale to finer grain scales more immediately relevant to the human experience?

- How can this knowledge inform Earth System communities?

- How can this information be used to inform stakeholders about ways to mitigate environmental impacts and lead to more resilient and sustainable urban systems?

These grand challenge questions lead to science questions that would drive research at an IFL, focusing on

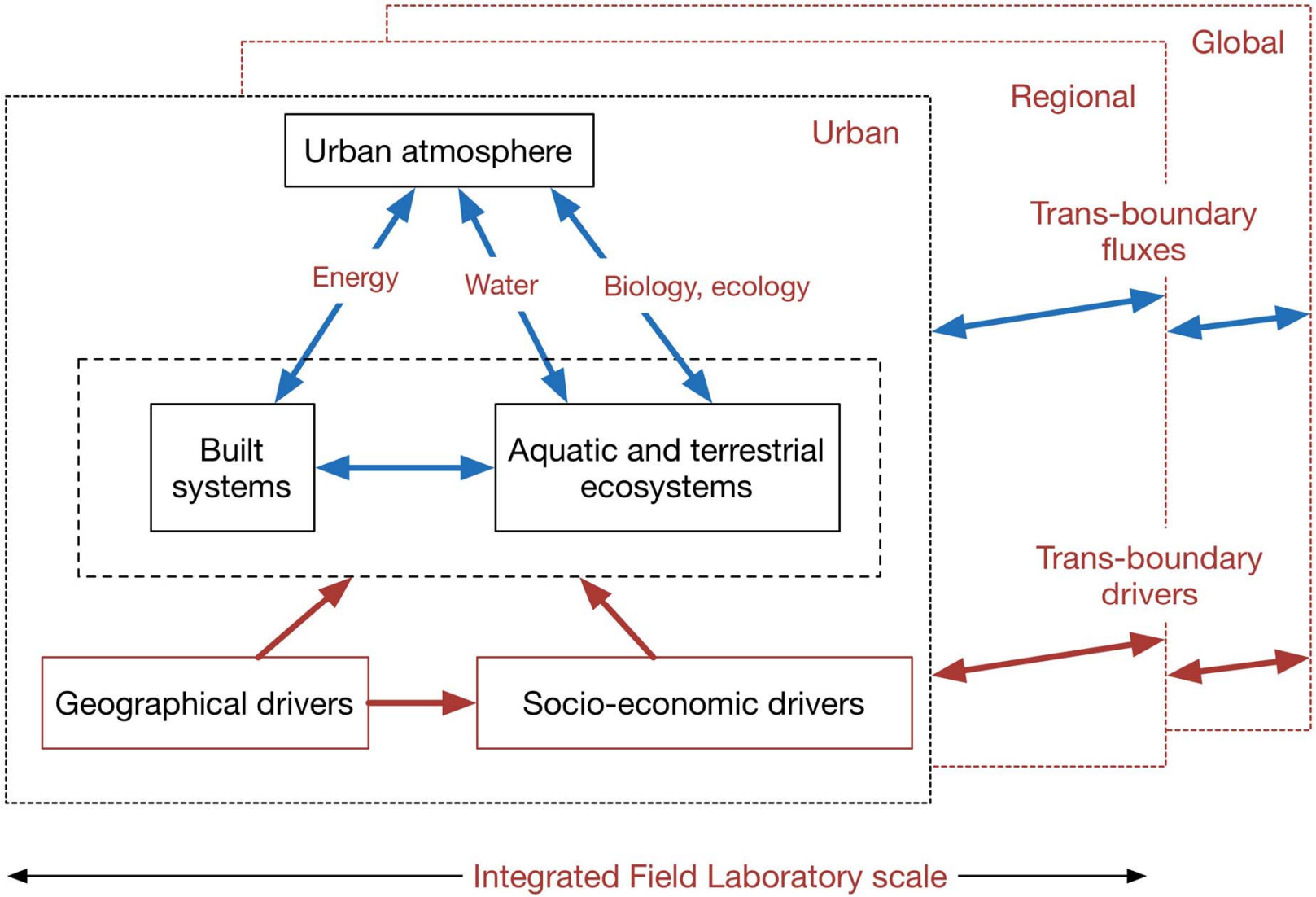
(a) mechanistic and core questions

(b) future thinking questions

Envisioning IFLs

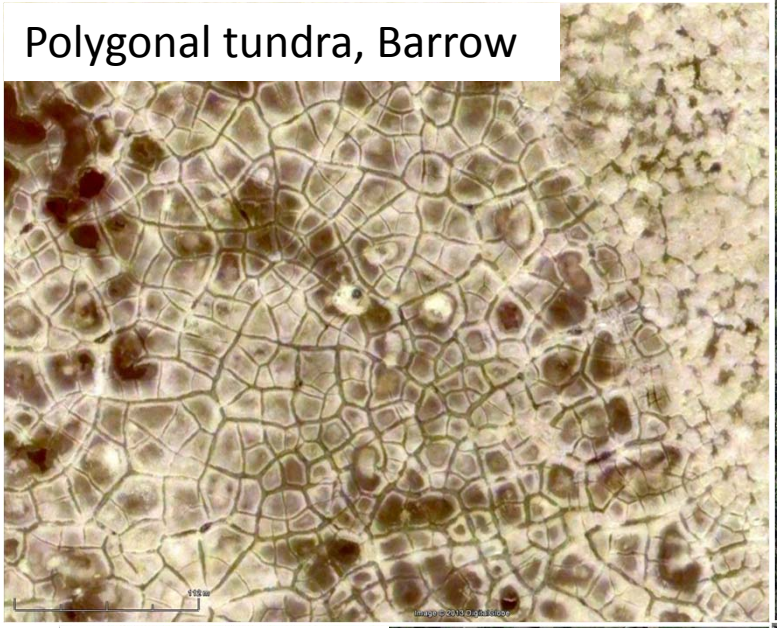
- A highly instrumented field-based observatory along a defined natural-through-urban gradient
- An integrated network of IFLs recognizing urban development and climate change as drivers
- A complement of observations, models and integrated analyses, and enabled by an end-to-end data and information management system and high-end computational capabilities
- Integrating with existing BER facilities is essential
- Strong relationships with local urban decision and policy-makers
- Strong relationships with resources of other federal agencies

Conceptual IFL

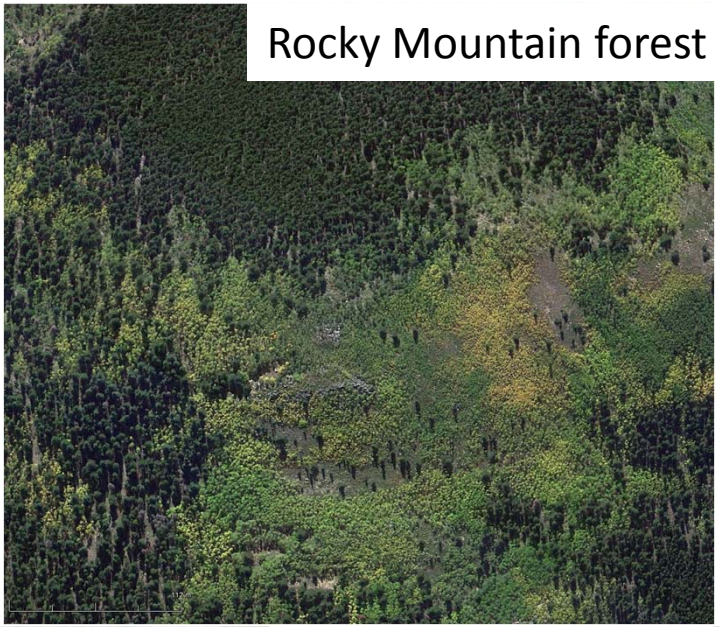


Heterogeneity is a central feature of urban and urbanizing landscapes, a feature also relevant to model development for natural systems

Polygonal tundra, Barrow



Rocky Mountain forest



West Knoxville

Downtown Knoxville

All images are on the same scale

Courtesy of Peter Thornton, ORNL

DOE leadership is essential

- An IFL is likely to integrate DOE activities and those of other federal agencies
- DOE has unique capacities and long-term commitments to lead development of an IFL infrastructure
- We expect the National Laboratories to play important roles in the management of IFLs with an urban focus

Implementation

- Implementation should take advantage of existing urban observation capacities and research efforts
- Implementation of IFL should represent a regionally-relevant theme and should take advantage of BER facilities and capacities
- Establishing partnerships with municipalities and local government institutions is essential
- Urban-to-natural transects present important scaling challenges for measurements and modeling

IFL Site Selection Criteria

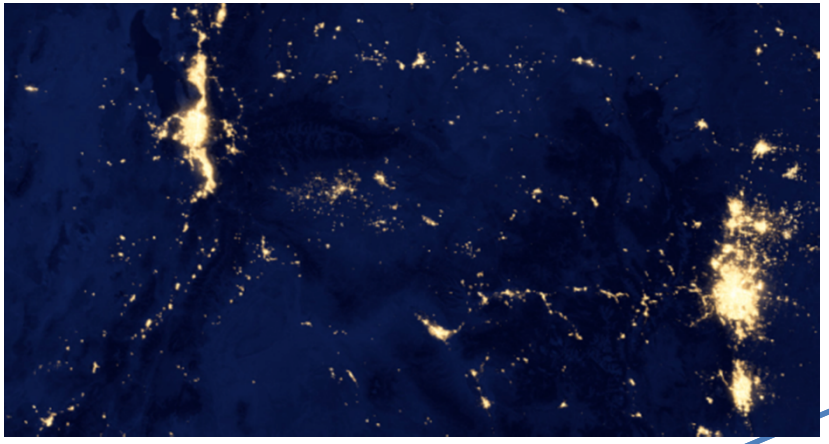
- Recognition of four different thematic considerations:
  - Climate and ecological factors
  - Social and institutional factors
  - Builds upon or complements both existing (BER) relevant research infrastructure and existing infrastructure from other federal agencies
  - The extent to which foundational data and studies exist to build upon in development of IFL

- No single site or transect is likely to be sufficient
  - Suggest 4-5 IFL sites/transects to form national network

- Most useful if site selection was coordinated with other Federal agencies and capitalized on their collaborative assets

- Specific IFL sites were not delineated in this workshop

Where to site IFL or IFL network?



courtesy NASA

Example

Consider realistic transects that include both natural and urban locations.

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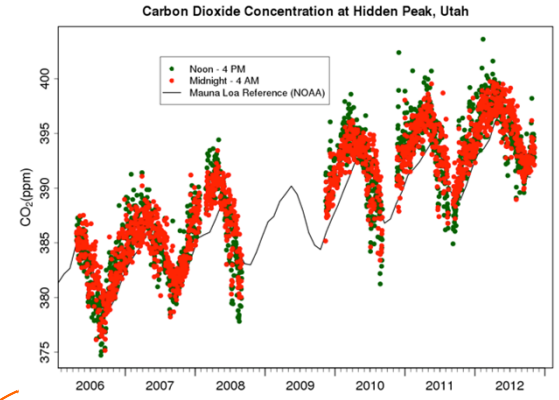

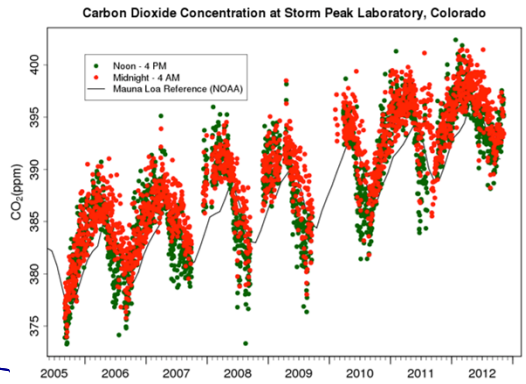

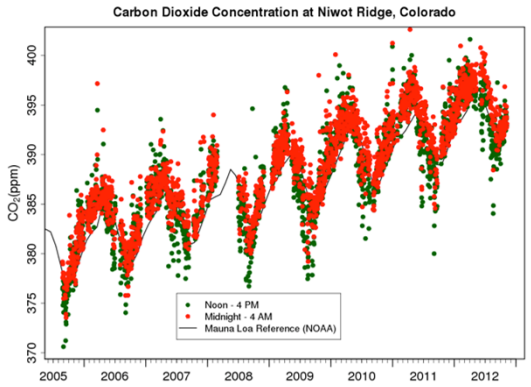

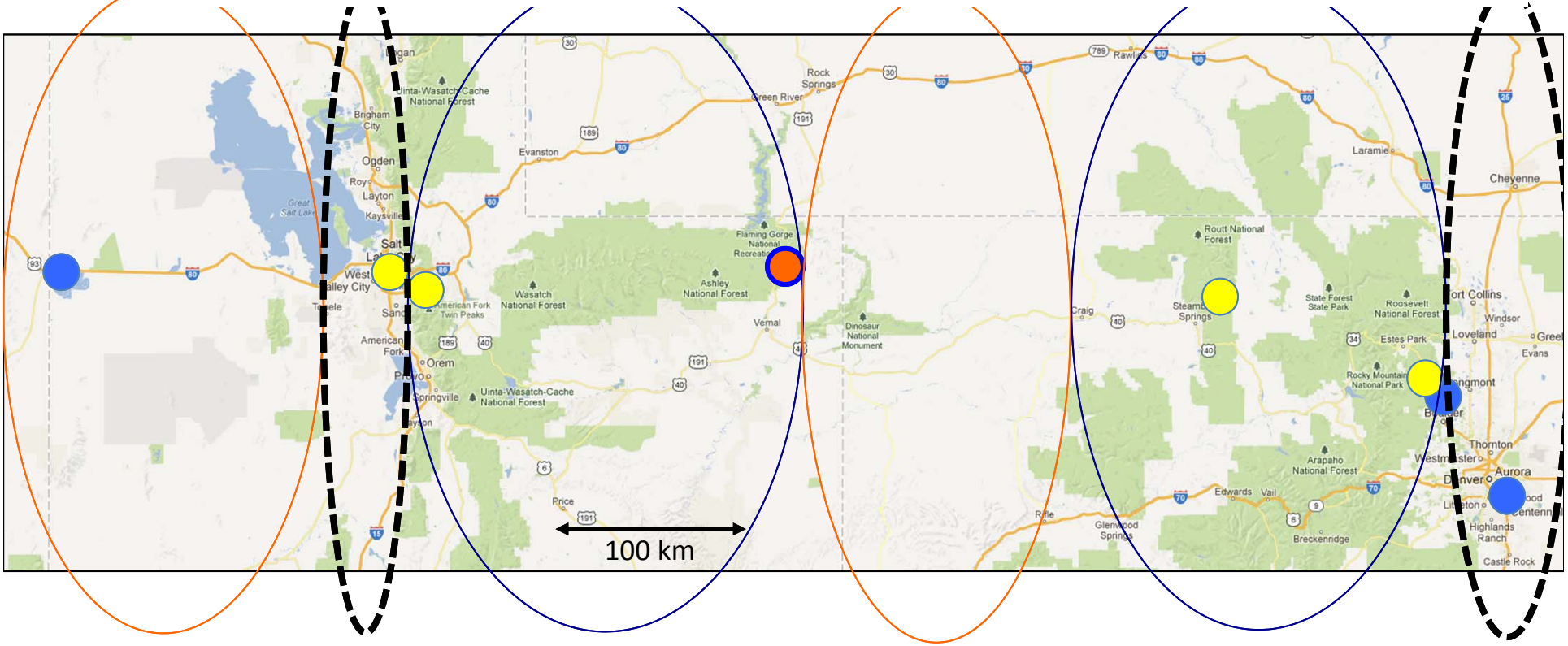

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http://www.esd.ornl.gov/~wmp/GPRA/

http://www.arm.gov/sites