

# **NORTH AMERICAN CARBON PROGRAM**

*Continental carbon budgets, dynamics, processes, and management.*



**Program Overview and Progress**



# NACP Questions

1. What is the carbon balance of North America and adjacent oceans? What are the geographic patterns of fluxes of CO<sub>2</sub>, CH<sub>4</sub>, and CO? How is the balance changing over time?  
(**Diagnosis**)
2. What processes control the sources and sinks of CO<sub>2</sub>, CH<sub>4</sub>, and CO, and how do the controls change with time?  
(**Attribution/Processes**)
3. Are there potential surprises (could sources increase or sinks disappear)? (**Prediction**)
4. How can we enhance and manage long-lived carbon sinks ("sequestration"), and provide resources to support decision makers? (**Decision support**)

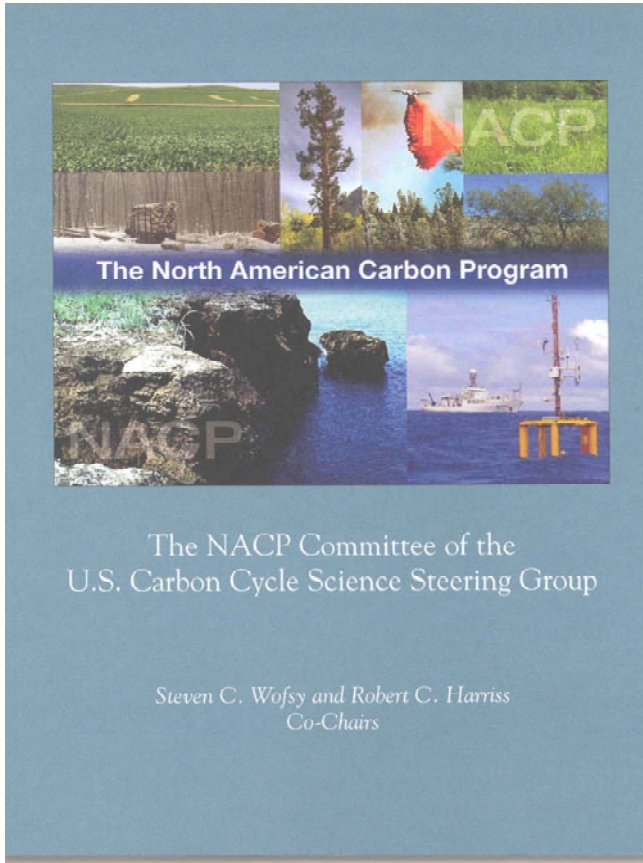


# NACP Goals

- Develop quantitative scientific knowledge, robust observations, and models to determine the **emissions and uptake of CO<sub>2</sub>, CH<sub>4</sub>, and CO, changes in carbon stocks, and the factors regulating these processes** for North America and adjacent ocean basins.
- Develop the scientific basis to implement **full carbon accounting on regional and continental scales**. This is the knowledge base needed to design monitoring programs for natural and managed CO<sub>2</sub> sinks and emissions of CH<sub>4</sub>.
- Support **long-term quantitative measurements of fluxes, sources, and sinks of atmospheric CO<sub>2</sub> and CH<sub>4</sub>, and develop forecasts for future trends**.



# Science Plan

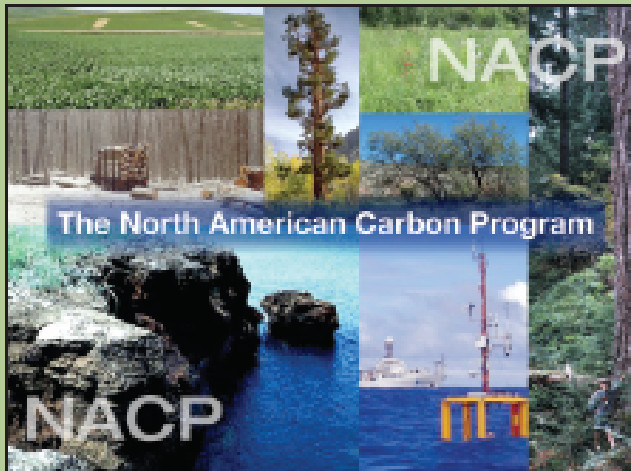


- **Published in 2002**
- **Prepared by the U.S. Carbon Cycle Science Steering Group**
- **Steven Wofsy and Robert Harriss, Co-Chairs**
- **Describes a broad science questions, goals, and a framework for a North American Carbon Program.**



# Science Implementation Strategy

Science Implementation Strategy  
for the North American Carbon Program



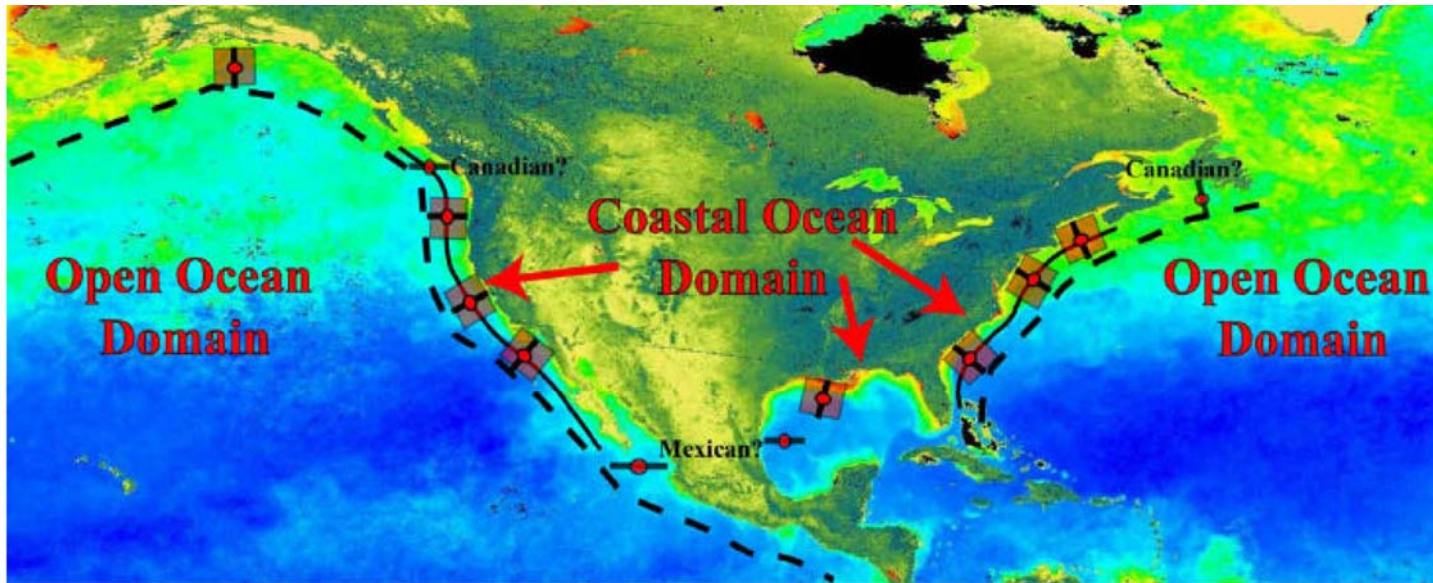
*Prepared for the  
U.S. Carbon Cycle Scientific Steering Group  
and Interagency Working Group  
by the  
North American Carbon Program Implementation Strategy Group*

*A. Scott Denning  
Chair and editor*

- **Published in July, 2005**
- **Overall strategy for synthesis and integration**
- **Phasing of NACP research**
  - ⇒ **Diagnosis**
  - ⇒ **Process/Attribution**
  - ⇒ **Prediction**
  - ⇒ **Decision Support**
- **Data and information management**



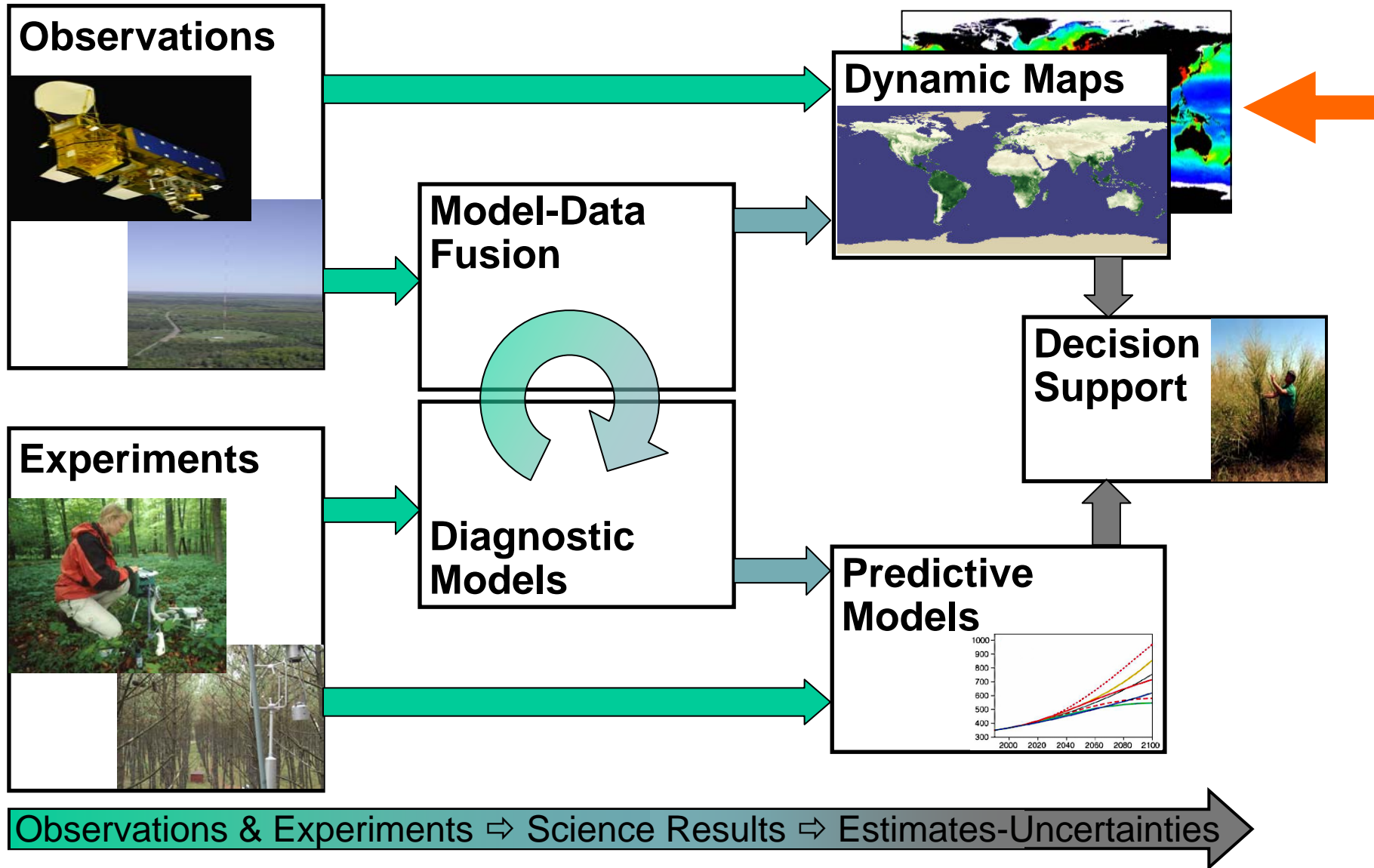
# NACP Ocean Observations and Modeling



- Adjacent open oceans are major sources and sinks for carbon transported across North America through the atmosphere.
- River-dominated margins and coastal upwelling regions merit special attention due as boundaries on North America.
- **Coordination with Ocean Carbon and Climate Change Program (OCCC).**



# NACP Approach





# North American Carbon Program

The central objective of the North American Carbon Program is to measure and understand carbon stocks and the sources and sinks of CO<sub>2</sub>, CH<sub>4</sub>, and CO in North America and in adjacent ocean regions.

- Approaching 120 projects.
- Involving more than 200 investigators.
- About 10 major observation & experimental networks.
- A focus for remote sensing observations and research.
- Developing collaboration with Mexico & Canada.



## **NACP Science Steering Group**

**Scott Denning, Colorado State University, Chair**

**John Baker, USDA Agriculture Research Service**

**Bob Cook, Oak Ridge National Laboratory**

**Linda Heath, USDA Forest Service**

**Eileen Hofmann, Old Dominion University**

**Bev Law, Oregon State University**

**Brent McKee, Tulane University**

**Jeff Morisette, NASA Goddard Space Flight Center**

**Rich Norby, Oak Ridge National Laboratory**

**Steve Ogle, Colorado State University**

**Mac Post, Oak Ridge National Laboratory**

**Greg Reams, USDA Forest Service**

**Chris Sabine, NOAA Pacific Marine Environmental Laboratory**

**Pieter Tans, NOAA Climate Monitoring & Diagnostics Laboratory**

**Peter Thornton, National Center for Atmospheric Research**

**Margaret Torn, Lawrence Berkeley National Laboratory**



# NACP Hierarchical Measurements Over Land



## Continental “wall-to-wall” by remote sensing



- 80 projects involving satellite and aircraft remote sensing
- NASA supports 65



## Extensive inventories (FIA and NRI)

- More than 170,000 sites at 5-10 yr intervals
- Improved sampling for carbon



## Intermediate intensity with systematic sampling

- Pilot Forest Service projects
- Potential NEON contributions
- Requires substantial additional funding



## Very intensive process investigations

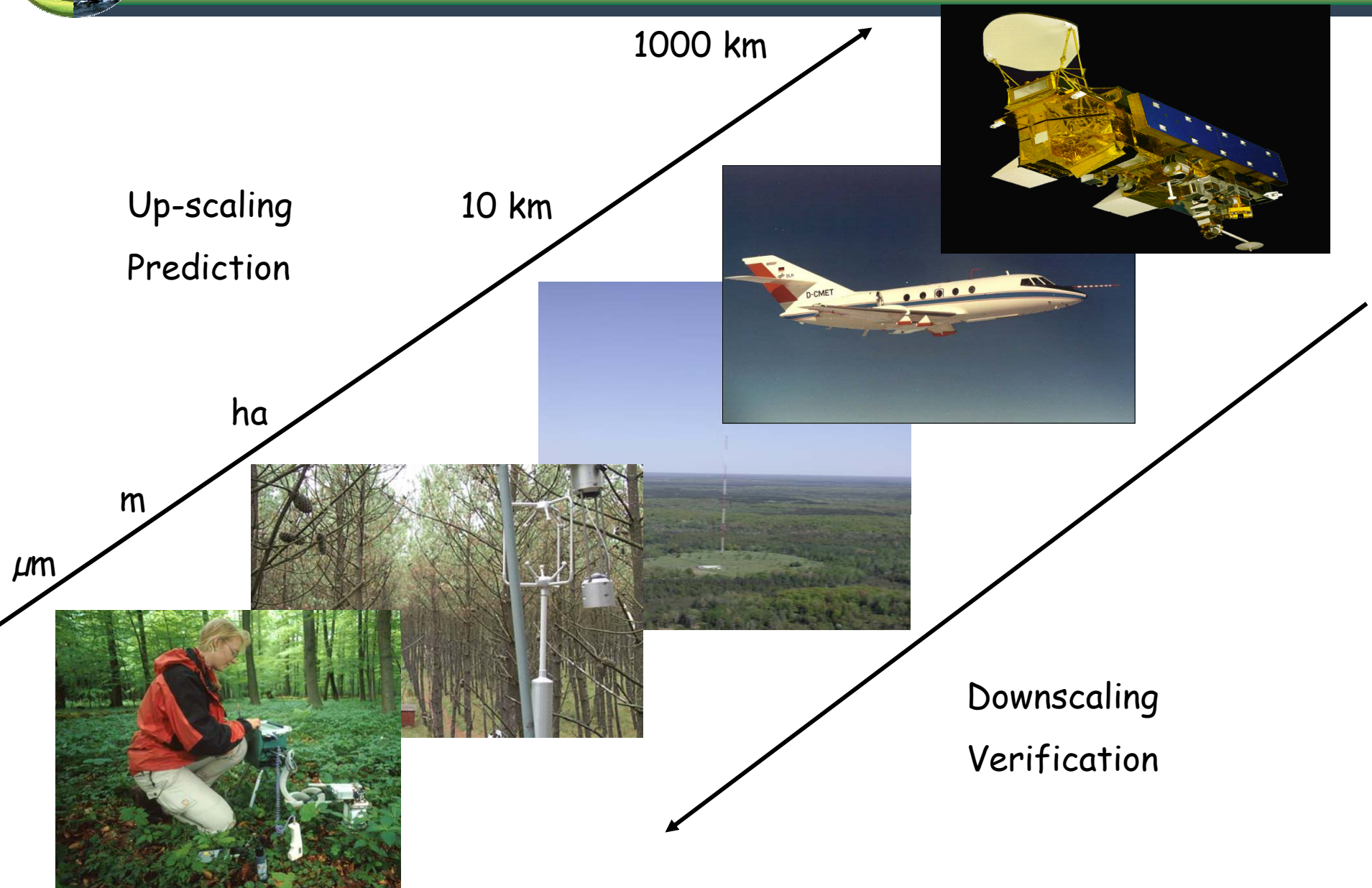


- ~100 AmeriFlux, Agriflux, LTER, and similar sites





# Multiple-Scale Observations and Experiments



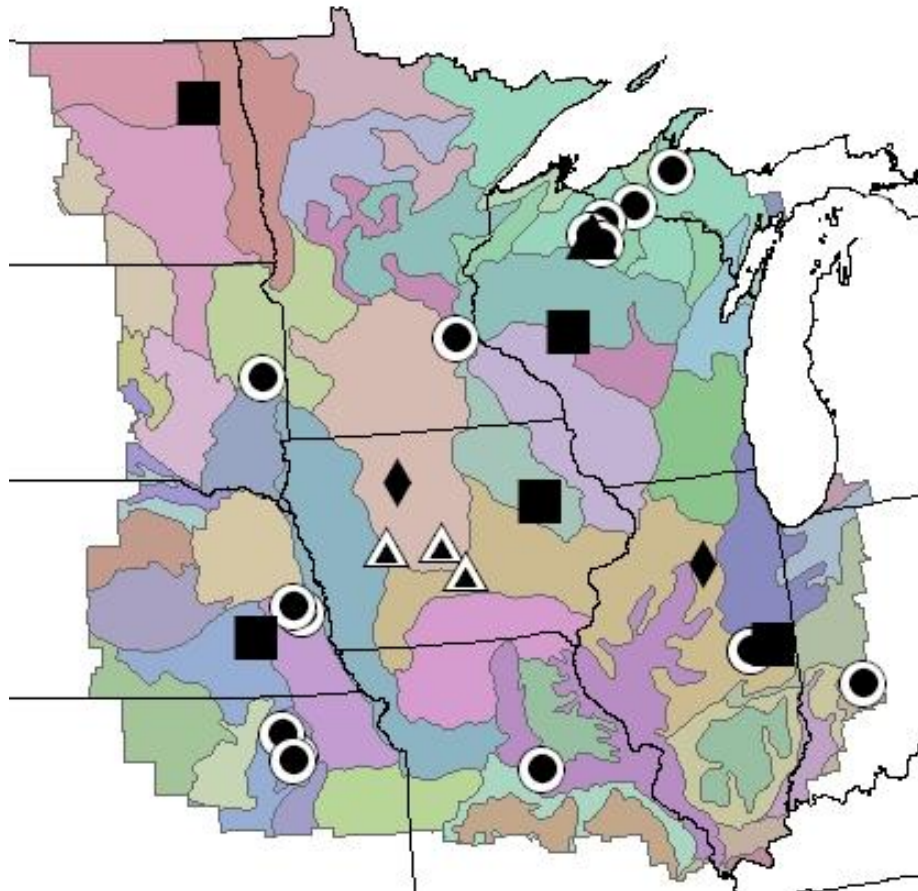


# NACP Intensive Campaigns

- **The North American Carbon Program (NACP) conducts intensive experimental and field campaigns to:**
  - **Address specific science issues, questions and hypotheses;**
  - **Reduce specific, major uncertainties;**
  - **Develop and test methods and models;**
  - **Calibrate and validate remote sensing observations relevant to NACP objectives; and**
  - **Produce critical data or analyses.**
- **NACP intensive campaigns may focus on a specific region or regions within North America.**
- **But the NACP is not a collection of intensive campaigns.**



# Mid-Continent Geographic Domain



## Tall Tower Sites

- ▲ Existing
- Planned
- ◆ Alternate

## Flux Tower Sites


- Ameriflux
- ▲ USDA

USDA Natural Resources Conservation Service (NRCS) Major Land Resource Areas summarize distributions of climatic conditions and soil characteristics across the region.



# Mid-Continent Intensive Campaign

Proposed by Pieter Tans, NOAA-CMDL

- Develop optimized **sampling schemes for field and atmospheric measurements** to efficiently monitor regional carbon stocks and fluxes.
- Use **top-down approaches to provide a region-level estimate of net carbon fluxes** during short periods (weeks) with an accuracy of 10% by increasing spatial and temporal coverage of atmospheric measurements and by enabling improvements in the parameterization of transport/mixing processes in the lower atmosphere.
- Use a variety of **bottom-up techniques to provide daily to annual estimates of carbon stocks and fluxes** over a region by improving process model structure and parameterization. A hierarchy of field and remote sensing observations should be used for model testing, development of data assimilation techniques, and model parameterization. 
- **Compare the top-down and bottom-up approaches** and iteratively improve the independent approaches on daily to annual time scales.
- Produce carbon stock and flux maps at various levels of spatial and temporal detail, and compare the results of the top-down and bottom-up approaches to diagnose methods.



## Mid-Continent Campaign Tasks

- Long-Term Atmospheric Monitoring
- Aircraft Measurements
- Biological Measurements at Intensive Sites
- Long-Term Biological Measurements at Sites Intermediate to Inventories and Intensive Sites
- Inventories of Carbon Stocks
- Bottom-Up Models ←
- Transport Models
- Land-Use and History ←
- Fossil Fuel Inventory



## Mid-Continent Campaign Status

- **Constraints on NOAA's FY 2006 budget delayed the instrumentation of tall towers to measure of atmospheric CO<sub>2</sub> and other trace gas concentrations and greatly reduced aircraft measurements, at least for the time being.**
- **The NACP also intends to develop bottom-up estimates of changes in carbon stocks, sources, and sinks that can be reconciled with the top-down estimates and provide insights about the mechanisms involved, and field measurements are planned to provide the data required by the bottom-up analysis. This field work has been slow to develop.**
- **At this point, the mid-continent science team is planning for field work during the growing season of 2006. Recognizing that the top-down NOAA effort may not be restored until FY 07, the group expects a far more substantial and coordinated effort during the growing season of 2007.**



# Mid-Continent Intensive Studies Task Force

**Stephen Ogle (Co-Coordinator) – Ecosystem modeling**

**Ken Davis (Co-Coordinator) – Flux measurements & analysis**

**Bob Cook – Data management**

**Tim Parkin – Agri-ecosystem flux measurements**

**Shashi Verma – Agri-ecosystem flux measurements**

**Arlyn Andrews – Atmospheric measurements & analysis**

**Steve Wofsy – Aircraft measurements**

**Kevin Gurney – Data assimilation & fossil fuel emissions**

**Tris West – Ecosystem modeling**

**Jeff Morisette – Remote sensing**



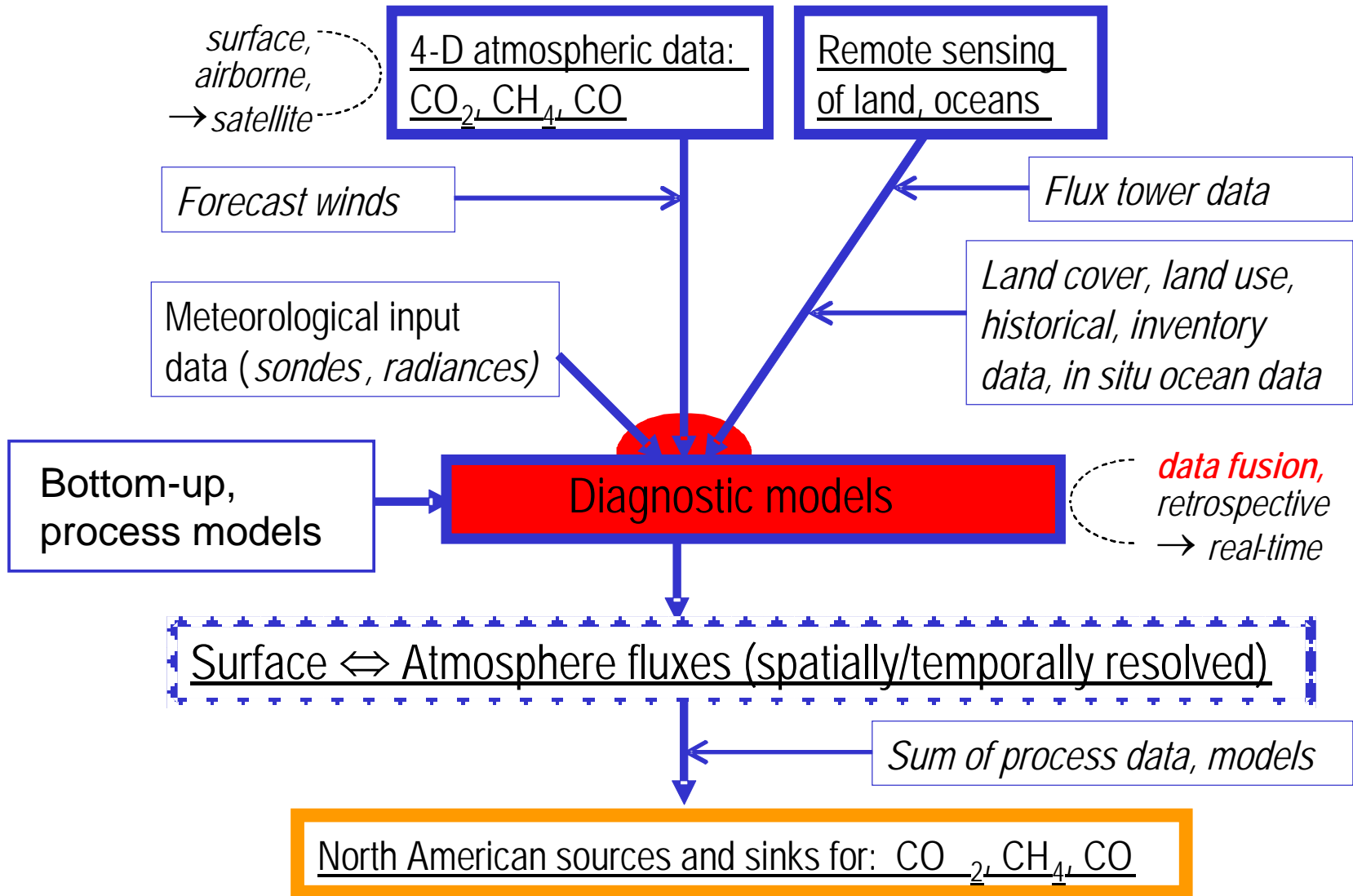
## **NACP Meetings & Workshops**

- **NACP SSG Meeting, Washington, DC, May 18-19**
- **Joint NACP Planning Workshop (with Mexico & Canada), Summer, 2006**
- **NACP SSG Meeting, Washington, DC, November, 2006**
- **NACP Investigators Meeting, January 2007**
- **Joint (Canada-Mexico-U.S.) NACP Science Meeting, January 2007**





# NACP Framework





# North American Carbon Program

Continental Carbon Budgets, Dynamics, Processes, and Management...

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Welcome to the North American Carbon Program website!

The central objective of the North American Carbon Program is to measure and understand carbon stocks and the sources and sinks of carbon dioxide (CO<sub>2</sub>), methane (CH<sub>4</sub>), and carbon monoxide (CO) in North America and in adjacent ocean regions.

### Specific Program Goals

Develop quantitative scientific knowledge, robust observations, and models to determine the emissions and uptake of CO<sub>2</sub>, CH<sub>4</sub>, and CO, changes in carbon stocks, and the factors regulating these processes for North America and adjacent ocean basins.

Develop the scientific basis to implement full carbon accounting on regional and continental scales. This is the knowledge base needed to design monitoring programs for natural and managed CO<sub>2</sub> sinks and emissions of CH<sub>4</sub>.

Support long-term quantitative measurements of fluxes, sources, and sinks of atmospheric CO<sub>2</sub> and CH<sub>4</sub>, and develop forecasts for future trends.

### News & Updates

**April 3, 2006:** We have added an announcement for a conference on "Carbon Management at Urban and Regional Levels: Connecting Development Decisions to Global Issues". For more information, please visit the [Meetings](#) page.

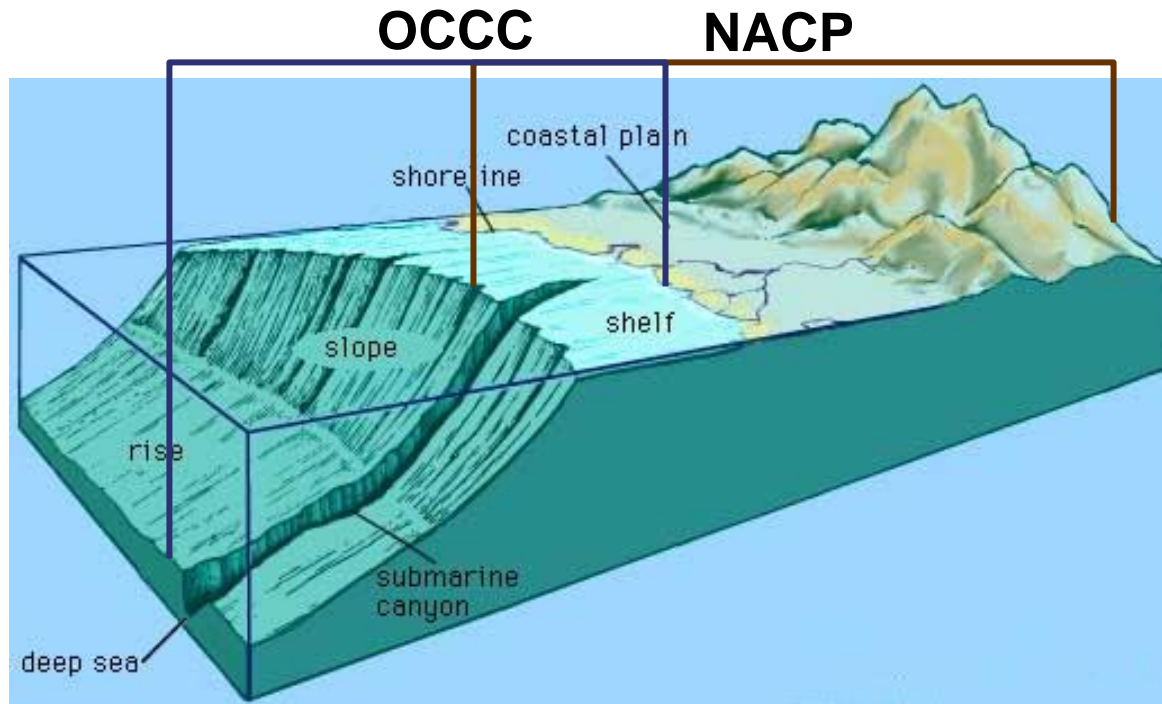
**March 21, 2006:** Registration is now open for the MODIS Vegetation Workshop III. For more information, please see the [Meetings](#) page.



END



# NACP — OCCC Relationships

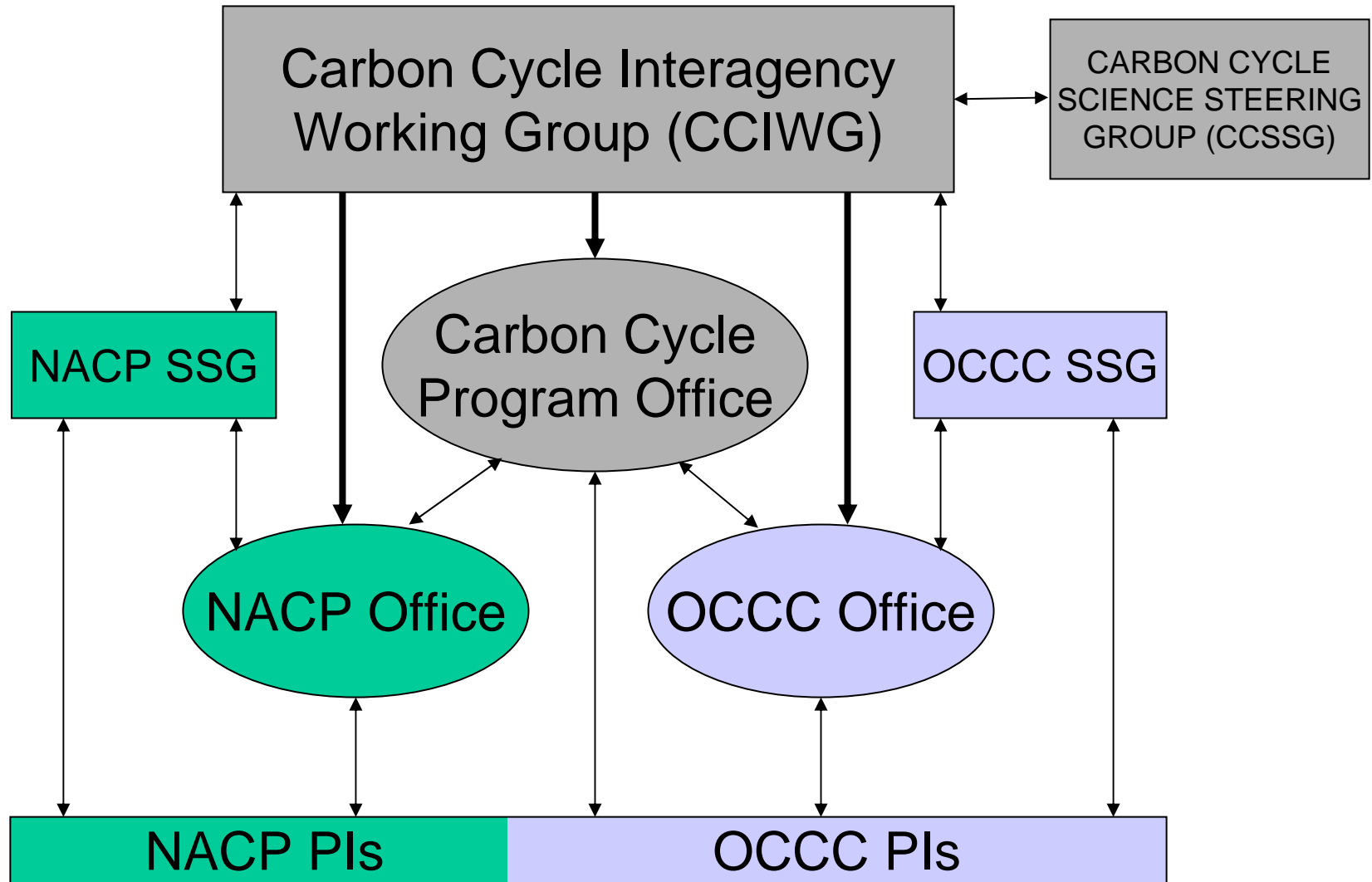


**NACP and OCCC will coordinate to cover a continuum from dry land to open ocean.**

- NACP is responsible for land-ocean exchanges.
- Both programs consider shelf processes.
- OCCC has primary responsibility for shelf-open ocean exchanges.



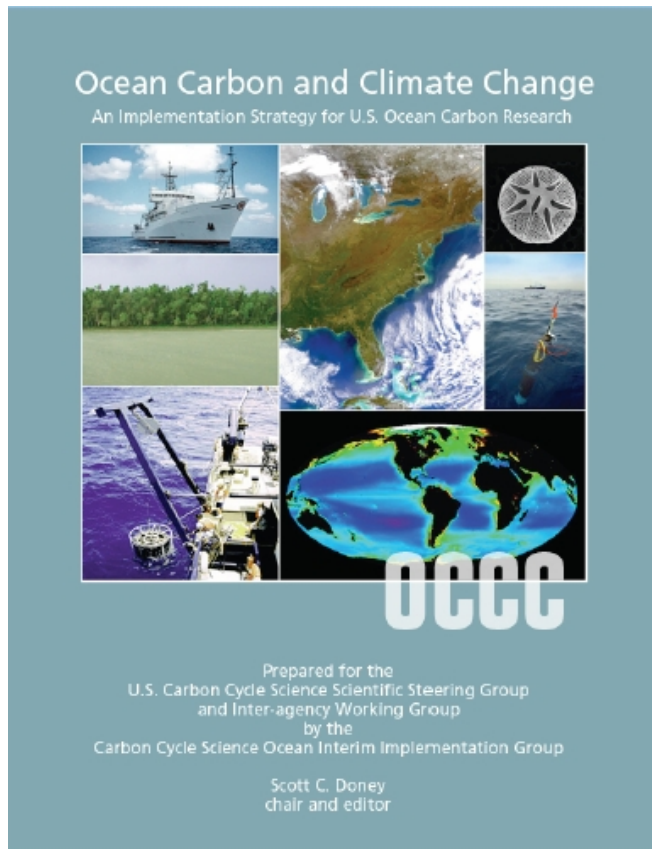
# U.S. Carbon Cycle Science Coordination





# U.S. Ocean Carbon and Climate Change Program

## Role of the ocean on regulating atmospheric CO<sub>2</sub> levels.



- Ocean natural and anthropogenic CO<sub>2</sub> inventory.
- Magnitude and variability of air-sea CO<sub>2</sub> flux.
- Feedback mechanisms and climate sensitivities for ocean carbon storage.
- Scientific basis for mitigation strategies.