# The United States Carbon Cycle Science Program: An Interagency Partnership

*Providing a coordinated and focused scientific strategy for conducting federal carbon cycle research*

## Introduction

The US Carbon Cycle Science Program is clarifying the changes, magnitudes and distributions of carbon sources and sinks, the fluxes between the major terrestrial, oceanic and atmospheric carbon reservoirs, and the underlying mechanisms involved including humans, fossil fuel emissions, land use, and climate. Program scientists are now beginning to reveal and quantify some of the intricate complexities and interactions between the Earth's carbon reservoirs and climate. The program engages numerous science disciplines and extends over a broad range of spatial and temporal scales.

## Mission and Vision

Carbon cycle science requires an unprecedented coordination among scientists and supporting government agencies. The nature of the carbon cycle demands this – carbon is exchanged among three major, active reservoirs (the ocean, the land, and the atmosphere) through a variety of physical, chemical, and biological mechanisms, and includes both organic and inorganic components. Because a large number of government agencies are involved in supporting research on the carbon cycle (ranging from data gathering to analysis and modeling), extraordinary value can be gained by coordinating research and encouraging disciplinary and organizational cross-fertilization through effective program integration. Thus the Carbon Cycle Science Program seeks to better understand past changes in atmospheric carbon dioxide, deliver credible predictions of future atmospheric carbon dioxide levels, and strengthen the scientific foundation for management decisions in numerous areas of great public interest.

## Scientific Questions

### Overarching Questions[1]


**The Carbon Cycle Science Program has two overarching questions at its core:**

1. What has happened to the carbon dioxide that has already been emitted through human activities (i.e., anthropogenic carbon dioxide)?
2. What will be the future atmospheric carbon dioxide concentrations resulting from both past and future emissions?

### Strategic Research Questions[2]

In order to both improve scientific knowledge and understanding of the carbon cycle and support application of this scientific knowledge to societal needs, **a number of strategic research questions are used to guide the efforts of the Carbon Cycle Science Program:**

7.1 What are the magnitudes and distributions of North American carbon sources and sinks on seasonal to centennial time scales, and what are the processes controlling their dynamics?

7.2 What are the magnitudes and distributions of ocean carbon sources and sinks on seasonal to centennial time scales, and what are the processes controlling their dynamics?

7.3 What are the effects on carbon sources and sinks of past, present, and future land-use change and resource management practices at local, regional, and global scales?

7.4 How do global terrestrial, oceanic, and atmospheric carbon sources and sinks change on seasonal to centennial time scales, and how can this knowledge be integrated to quantify and explain annual global carbon budgets?

7.5 What will be the future atmospheric concentrations of carbon dioxide, methane, and other carbon-containing greenhouse gases, and how will terrestrial and marine carbon sources and sinks change in the future?

7.6 How will the Earth system, and its different components, respond to various options for managing carbon in the environment, and what scientific information is needed for evaluating these options?

## Coordination

The Carbon Cycle Interagency Working Group (CCIWG) is composed of representatives from each of the ten federal agencies that participate in the Carbon Cycle Science Program. CCIWG is responsible for the programs, funds, development, coordination, and integration of carbon cycle research across the federal government.

The Carbon Cycle Scientific Steering Group (CCSSG) is a group of experts involved in carbon cycle research and applications from federal, state, university, and non-government organizations. The CCSSG provides input on the direction of the Carbon Cycle Science Program, its scientific content, and its relevance to the various stakeholder communities and helps to identify gaps and potential new areas of emphasis.

## North American Carbon Program

**http://www.nacarbon.org**

The North American Carbon Program (NACP) addresses strategic research question 7.1, and elements of questions 7.2 through 7.6, in the US Climate Change Science Program *Strategic Plan*.

**The NACP has three overarching goals[3]:**

- Develop quantitative scientific knowledge, robust observations, and models to determine the emissions and uptake of CO2, CH4, and CO, the 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
- Support long-term quantitative measurements of sources and sinks of atmospheric CO2 and CH4, and develop forecasts for future trends

In order to answer these questions, **the NACP is organized around four activities[4]:**

- *Diagnosis.* What is the carbon balance of North America and adjacent oceans? What are the geographic patterns of fluxes of CO2, CH4, and CO? How is the balance changing over time?
- *Attribution / Processes.* What processes control the sources and sinks of CO2, CH4, and CO, and how do the controls change with time?
- *Prediction.* Are there potential surprises?
- *Decision Support.* How can we enhance and manage long-lived carbon sinks and provide resources to support decision makers?

## Ocean Carbon and Climate Change

**http://us-ocb.org**

The Ocean Carbon and Climate Change (OCCC) program addresses Strategic Research Question 7.2, and elements of 7.1 and 7.3 through 7.6, in the *CCSP Strategic Plan*. **It is especially concerned with four fundamental science issues:**

- Anthropogenic $CO_2$ in the oceans
- Air-sea $CO_2$ flux
- Feedback mechanisms and climate sensitivities
- Ocean carbon mitigation strategies

**The implementation strategy for OCCC[5] consists of the following coordinated elements:**

- Enhancing the global ocean carbon observing network
- Conducting targeted, multidisciplinary process studies
- Integrating field observations, remote sensing, data synthesis and numerical modeling
- Accelerating enabling activities

OCCC works in cooperation with the Ocean Carbon & Biogeochemistry (OCB) program, which focuses more broadly on marine biogeochemistry and ecology. Members of the OCCC Scientific Steering Group are also a part of the OCB Scientific Steering Committee.

## International Cooperation

EARTH SYSTEM SCIENCE PARTNERSHIP

### Global Carbon Project (GCP)

The US Carbon Cycle Science Program Office serves as an affiliate program office of the Earth System Science Partnership Global Carbon Project (ESSP GCP), under the guidance of the CCIWG. As such, the office provides a single source of information about US activities to the global community and liaises with other GCP offices to promote integration of regional carbon programs into Earth system syntheses.

U.S. CLIMATE CHANGE BILATERALS

### Joint North American Carbon Program (JNACP)

The Joint North American Carbon Program is an international collaboration between Canada, Mexico, and the United States. The program fosters joint research on carbon cycle science for the North American continent and adjacent ocean basins and is currently in the process of developing a research strategy and establishing government coordination and scientific steering groups.

## State of the Carbon Cycle Report

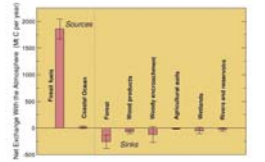
**http://www.climatescience.gov/Library/sap/sap2-2/final-report/default.htm**

The State of the Carbon Cycle Report (SoCCR), also known as Synthesis and Assessment Product 2.2 of the US Climate Change Science Program[6], is designed to provide accurate, unbiased, and policy-relevant scientific information concerning the carbon cycle to a broad range of stakeholders.

### Overarching Objectives

1. To summarize scientific knowledge about carbon cycle properties and changes; and
2. To provide scientific information for decision support and policy formulation concerning carbon.

### Major Findings




**North American carbon sources and sinks (million tons carbon per year).** Sources add carbon dioxide to the atmosphere (bars above the zero line); sinks remove it (bars below the zero line). Error bars indicate the uncertainty in that estimate. North America is currently a net carbon source (1330 ± 333 Mt C yr-1).[6]

*North America contributes about a quarter of global fossil-fuel emissions.*

Of the 27% of global emissions that North America emitted in 2003, approximately 85% of those were from the United States, 9% from Canada, and 6% from Mexico.

*The North American land surface removes carbon dioxide from the atmosphere – but not as much as it produces.*

In 2003, growing vegetation in North America removed approximately 30% of the fossil-fuel emissions produced from North America. The imbalance between the fossil-fuel source and the sink on land is a net release to the atmosphere.

*Forests play a critical role in removing carbon dioxide from the atmosphere.*

Approximately 50% of North America's terrestrial sink is due to the regrowth of forests in the United States on former agricultural land and on timberland recovering from harvest.

*Actions to reduce fossil-fuel emissions will likely be required.*

The large difference between current sources and sinks and the expectation that the difference could become larger suggests that addressing imbalances in the North American carbon budget will likely require actions focused on reducing fossil-fuel emissions.

## Future Priorities

In FY 2008, continuing integration within the NACP and the OCCC program will provide better estimates of the North American carbon budget including the roles of adjacent ocean basins. More comprehensive global and regional models and analyses, driven by improved *in situ* measurements and experiments, reservoir inventories, and remote sensing will provide better forecasts and understanding of critical carbon cycle dynamics.

In FY 2009, this focus will continue, along with new carbon cycle studies and observation networks in high latitude regions of the world that will provide critical information and improved estimates of the carbon sources and sinks of North America and adjacent coastal systems and ocean basins in the global carbon budget. With improved estimates and greater certainties of the major carbon reservoirs on Earth, scientists will have new insight into how Earth system functioned under past and present forcings and will be able to predict better how the system may respond to future climate forcings.

## References


[1] Sarmiento, J.L. and S.C. Wofsy. 1999. *A U.S. Carbon Cycle Science Plan*. Report of the Carbon and Climate Working Group for the U.S. Global Change Research Program. Washington, DC: U.S. Global Change Research Program.

[2] CCSP. 2003. *Strategic Plan for the U.S. Climate Change Science Program*. A report by the U.S. Climate Change Science Program and the Subcommittee on Global Change Research, Washington, DC.

[3] Wofsy, S.C. and R.C. Hariss. 2002. *The North American Carbon Program (NACP)*. Report of the NACP Committee of the U.S. Carbon Cycle Science Program. Washington, DC: U.S. Global Change Research Program.

[4] Denning, A.S. et al. 2005. *Science Implementation Strategy for the North American Carbon Program*. Report of the NACP Implementation Strategy Group of the U.S. Carbon Cycle Interagency Working Group. Washington, DC: U.S. Carbon Cycle Science Program.

[5] Doney, S.C. et al. 2004. *Ocean Carbon and Climate Change: An Implementation Strategy for U.S. Ocean Carbon Research*. Report of the Carbon Cycle Science Ocean Interim Implementation Group for the U.S. Carbon Cycle Scientific Steering Group and Inter-Agency Working Group. Washington, DC: U.S. Carbon Cycle Science Program.

[6] CCSP. 2007. *The First State of the Carbon Cycle Report (SOCCR): The North American Carbon Budget and Implications for the Global Carbon Cycle*. Anthony W. King, Lisa Dilling, Gregory P. Zimmerman, David M. Fairman, Richard A. Houghton, Gregg Marland, Adam Z. Rose, and Thomas J. Wilbanks, editors, 2007. A report by the U.S. Climate Change Science Program and the Subcommittee on Global Change Research, Washington, DC.


All documents are available from the Carbon Cycle Science Program website, http://www.carboncyclescience.gov/docs.




1717 Pennsylvania Ave. NW, Suite 250 · Washington, DC 20006 · http://www.carboncyclescience.gov