- Conduct field, laboratory, and modeling studies to improve understanding of the fundamental atmospheric processes associated with energy-related emissions and their effects on air quality and climate, and of the fundamental processes that control transport of energy-related pollutants out of the near-surface and transition boundary layers up to levels where they can be dispersed globally.

Global Carbon Cycle

The USGCRP budget includes $221 million in FY 2002 for research and observations related to understanding the global carbon cycle. Carbon is important as the basis for the food and fiber that sustain human populations, as the primary energy source that fuels human economies, and as a major contributor to the planetary greenhouse effect and the potential for climate change. Carbon dioxide (CO_2) and methane (CH_4) concentrations have been increasing in the atmosphere, primarily as a result of human use of fossil fuels and land clearing, and are now higher than they have been for at least 400,000 years.

Of the CO_2 emitted to the atmosphere, about half is currently taken up as part of the natural cycling of carbon into the ocean, and into land plants and soils. These reservoirs of carbon are known as carbon “sinks.” Changes in land management practices and the addition of CO_2 and nutrients are known to have the potential to enhance significantly the uptake of carbon, particularly by forests and croplands. Options for enhancing carbon sequestration in the oceans are also being considered. Uncertainties remain, however, about how much additional carbon storage can be achieved through improved management of ecosystems and other approaches, for how long the enhanced storage could be sustained, and just how vulnerable or resilient the natural carbon cycle is to manipulation of sources and sinks.

Successful carbon management strategies will need to be based on solid scientific information on the basic processes affecting the global carbon cycle, an understanding of long-term interactions of carbon dynamics with other aspects of the Earth system (such as climate variability and change and the global water cycle) and other environmental changes (such as nitrogen deposition), assessment of how management for maximizing carbon storage affects other uses of ecosystems, and the vulnerability of stored carbon to disturbance. In addition, knowledge of the carbon cycle, especially biological productivity, is essential for effective natural resource management and for maintaining the long-term sustainability of ecological goods and services.

The research community has developed a plan for enhancing understanding of the global carbon balance. Research progress is being stimulated by breakthroughs in the development of techniques for observing and modeling the atmospheric, terrestrial, and oceanic components of the carbon cycle. A concerted research effort is planned to identify, characterize, quantify, and project the major regional sources and sinks of CO_2. Key research topics will include the Northern Hemisphere terrestrial carbon sink; the oceanic carbon sink; the global distribution of carbon sources and sinks and their temporal dynamics; the effects of land use and land management on carbon sources and sinks; projecting future atmospheric CO_2 and related greenhouse gas concentrations; and scientific issues of carbon management.

Recent Accomplishments

- In 2001,the SeaWiFS satellite instrument marked its third anniversary of uninterrupted remote-sensing data set on ocean color. An instrument aboard the EOS Terra satellite also began producing a wide array of data products on marine ecosystems. Ocean color measurements can be converted into estimates of phytoplankton (or "plant") biomass in the ocean surface layer, and can indicate the presence of certain species. Phytoplankton are important to measure because they process carbon in the upper ocean, transforming carbon from dissolved form to particulate, and are therefore essential components of the ocean carbon cycle. Without phytoplankton living in the ocean's surface layer, atmospheric carbon dioxide levels would be many times higher than they are today.
- Uptake of carbon in North America and European ecosystems was demonstrated across a wide range of latitude locations. The rates of carbon storage range from near zero at high latitudes to 7.5 tonnes of carbon gain per hectare at southern latitudes in North America. Differences in the data between North American and European sites suggest that, at a given latitude, higher temperatures promote greater carbon uptake.
- Preliminary results from the ongoing Large-Scale Biosphere-Atmosphere Experiment in Amazonia have led to new insights into the complexity of carbon cycling in Amazonia, with significant implications for quantifying the global carbon budget and for how processes known to affect the cycling of carbon are represented in biogeochemical cycling models.

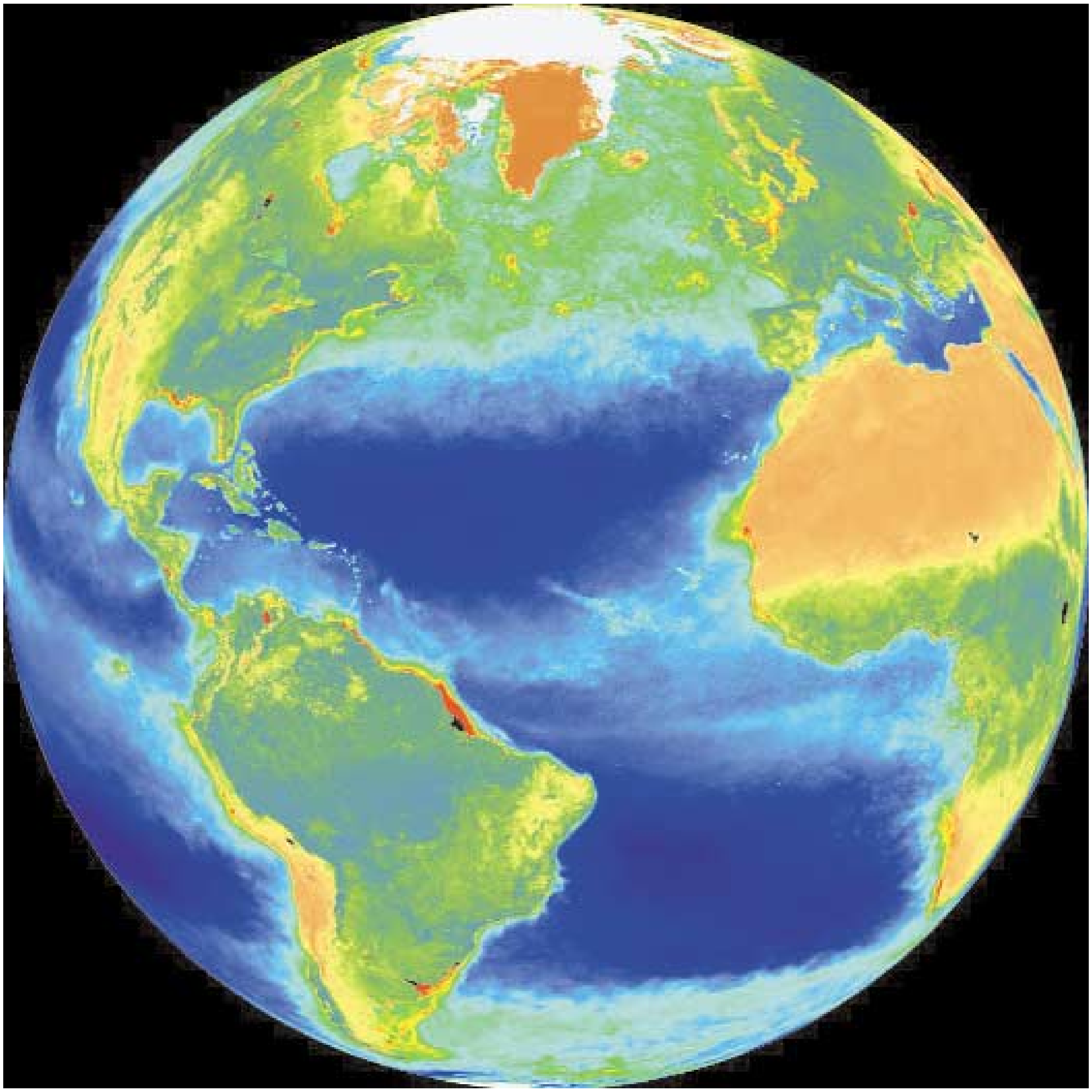

Figure 4. Plant Life on Earth as Observed From Space

False-color image of plant life on Earth as observed from space with the Sea-viewing Wide Field-of-view Sensor (SeaWiFS). On land, greens indicate abundant vegetation, and tans show relatively sparse plant cover. In the oceans, blue areas are the least biologically productive, whereas green, yellow, and red areas represent progressively greater productivity.

Source: SeaWiFS Project, NASA Goddard Space Flight Center and ORBIMAGE. See Appendix B for additional information.

Table 5
Global Carbon Cycle

FY 2002 Budget by Agency
(Discretionary budget authority in $millions)

Scientific Research	
DOC/NOAA	4.8
DOE	13.7
DOI/USGS	3.0
NASA	47.2
NSF	21.5
Smithsonian	0.3
USDA	14.8
Scientific Research Subtotal	**105.3**
NASA Space-Based Observations	111.6
NOAA Surface-Based Observations	4.2
Observations Subtotal	**115.8**
Global Carbon Cycle Total	**221.1**

FY 2002 Plans

The USGCRP will continue to focus on understanding and quantifying carbon sources and sinks, particularly in North America, and on filling critical gaps in understanding of the causes of carbon sinks on land as well as processes controlling the uptake and storage of carbon in the ocean. Key research goals for FY 2002 include:

- Quantify the amounts and changes in carbon storage in crop land and grazing land soils, as affected by management practices such as tillage, crop rotation, irrigation, and animal feeding, by expanding studies to agricultural systems used throughout the United States, as part of a five-year research effort. Because the values from individual practices are not simply additive, agricultural "systems" will be studied, in controlled experiments and on farms and ranches. The studies will lead to the development of decision-support tools and models that can enable land managers to project the amounts and changes in carbon storage in crop and grazing lands under different management practices, at spatial scales ranging from individual fields to large regions.
- Improve quantification of terrestrial biosphere carbon exchanges with the atmosphere and of global and regional carbon budgets, using ongoing acquisition of near-daily global measurements of the terrestrial biosphere from instruments on EOS

Terra (enhanced by new data from EOS Aqua after launch). The unprecedented calibration of EOS sensors and new, refined and validated algorithms will make improved quantification of productivity possible. These same data will make possible new, quantitative analyses of agricultural and forest productivity and enable early warning of regional food shortages and certain disease and pest outbreaks. Provision of timely data to U.S. and U.N. operational famine early warning programs focused on Africa and Latin America will yield more accurate forecasts of food shortages and disease/pest outbreaks. Early in FY 2002, "science quality" data will be released and end users, such as the U.N. Food and Agriculture Organization, will be able for the first time to integrate high-quality data from the MODIS instrument into their operational analyses.

- Complete an intercomparison of atmospheric transport models used to estimate carbon sources and sinks on a global scale. Transport models are a large source of uncertainty in locating and quantifying sources and sinks. Improvements in these models also will enable more accurate forecasts of weather and climate variability.
- Initiate a major ocean experiment and observations in the Southern Ocean around the Antarctic Polar Front Zone. This experiment will involve scientists from across the country in investigating: (1) the role of iron in the biological pump of carbon in silicate-rich versus silicate-poor High-Nutrient-Low Chlorophyll (HNLC) waters; (2) the ways in which iron mediates the differential drawdown of major nutrients; (3) iron limitation of carbon fixation and export from surface waters; (4) the biophysical response of primary producers to added iron; and (5) the potential effect of iron-induced carbon export on mid-water remineralization and denitrification processes. This effort will begin to provide a stronger scientific basis for discussions of the efficacy and efficiency of using the oceans to draw down atmospheric CO_2.
- Complete the field analysis phase of a unique collaborative study of gas exchange in the equatorial Pacific—the ocean's largest natural source region of CO_2. Preliminary results suggest that CO_2 fluxes across the sea-air interface are highly dependent upon the near-surface winds and local mixing processes in the top few meters of the water column. This study is contributing to our understanding of processes that control gas exchange at the surface of the ocean and will ultimately lead to an improved ability to parameterize gas exchange using remote sensing. Understanding gas exchange is essential for being able to estimate the amount of CO_2 that the ocean absorbs from or releases to the atmosphere.

Global Water Cycle

The USGCRP budget includes $309 million in FY 2002 for research and observations related to understanding the global water cycle. Providing adequate supplies of clean water and coping with extreme hydrologic events, such as floods and droughts, pose major obstacles to achieving social and economic goals, to sustaining essential ecosystems, and to managing natural resources effectively. During the 20th century, water systems and infrastructure were developed to reduce floods and store water for future distribution. Nonetheless, floods and water shortages still cause significant property damage, public health risks, loss of life, and impairment of agricultural, commercial, indus-