USGS Global Change Research

U.S. DEPARTMENT OF THE INTERIOR — U.S. GEOLOGICAL SURVEY

"Global Change" means changes in the global environment (including alterations in climate, land productivity, oceans or other water resources, atmospheric chemistry, and ecological systems) that may alter the capacity of the Earth to sustain life.

--- Global Change Research Act of 1990

Understanding natural change and the effects of human activities on environmental systems

The Earth's global environment--its interrelated climate, land, oceans, fresh water, atmospheric and ecological systems--has changed continually throughout Earth history. Human activities are having ever-increasing effects on these systems. Sustaining our environment as population and demands for resources increase requires a sound understanding of the causes and cycles of natural change and the effects of human activities on the Earth's environmental systems.

The U.S. Global Change Research Program was authorized by Congress in 1989 to provide the scientific understanding necessary to develop national and international policies concerning global environmental issues, particularly global climate change. The program addresses questions such as: what factors determine global climate; have humans already begun to change the global climate; will the climate of the future be very different; what will be the effects of climate change; and how much confidence do we have in our predictions? Through understanding, we can improve our capability to predict change, reduce the adverse effects of human activities, and plan strategies for adapting to natural and human-induced environmental change.

The Department of the Interior manages public lands and other resources across the United States and its territories. Today, a major concern of resource managers is how natural and cultural resources are affected by environmental change, whether it is caused by natural variation or human activities. Department of the Interior research, including studies by the U.S. Geological Survey (USGS), into the effects of global change on sensitive environments and resources provides information necessary for decisions on a variety of environmental issues, including water supplies, ecological systems, and biological diversity.

The USGS studies terrestrial and marine processes and the natural history of global change, including the interactions between climate and the hydrologic system. It is an international source for ground-based and remotely sensed earth science data and information used by global change researchers and contributing to assessments of the potential effects of global change on society. USGS global change research complements research and observations on oceanic, atmospheric, and biological processes in other Federal agencies.

Goals of USGS global change research

- Improve our understanding of land-atmosphere and land-ocean exchanges of water, energy, carbon, and nutrients
- Describe past and contemporary states and changes in the Earth's environment
- Facilitate access to, and use of, global change data and information for research, resource management, education, and policy decisions

Water, energy, carbon, and nutrients

Predicting future global change depends on understanding contemporary earth processes. We know that certain gases in the atmosphere called greenhouse gases (carbon dioxide and methane, for example) absorb heat radiated from earth and, in turn, radiate energy to the land and lower atmosphere, trapping heat in a manner similar to warming in a greenhouse. Many scientists believe that increases in atmospheric concentrations of greenhouse gases caused by human activities will increase the "greenhouse effect" in the atmosphere, leading to global warming.

The amount of carbon dioxide produced each year by human activities (mainly the use of fossil fuels and destruction of forests) exceeds our best estimate of the combined amount of carbon dioxide absorbed each year into the atmosphere and oceans by about 2 billion tons. Locating this missing carbon dioxide and understanding the role of natural additions and subtractions in the global carbon budget are critical requirements for developing realistic policies to regulate human emissions of greenhouse gases.

Scientists have only known about the missing carbon for a few years, and current theory suggests that this carbon is being stored on land. USGS scientists study the movement of carbon between land and atmosphere and between land and oceans, as well as in sediments, water, and soil to help determine what happens to the greenhouse gases produced by humans. Much of this research involves monitoring and experiments at several geographically distributed Water, Energy, and Biogeochemical Budget study sites. Established sites represent alpine, forested upland, temperate lake, and tropical rain forest environments.

Past and contemporary states and changes in the Earth's environment

It is vital to view possible future climate changes in the context of past climate changes and contemporary climate variation. Knowledge of past climates provides the basis for distinguishing changes caused by human activities from natural climate variation. Information about current Earth systems is equally critical to predicting future changes.

USGS scientists assemble comprehensive pictures of worldwide climates, environments, and ecological systems during specific times in the past using fossils and a variety of other geologic information. Understanding the climates of the past helps us to assess the causes, consequences, and extremes of past climate changes, and thus gain insights into possible future changes. Using climate history, we test the ability of computer models to simulate known climate conditions, thereby improving our ability to model and predict the effects of future global change.

USGS scientists also assemble a variety of data and information about the modern Earth to give us comprehensive pictures of variation and changes in contemporary environmental systems. The combined use of satellite and land-based data describing climate, vegetation, land use, topography, geology, soils, ice, snow, and water allows more accurate representation of terrestrial environmental systems in computer models of global climate.

The USGS studies effects of global change in sensitive environments. For example, ecology, soils, and water resources in arid and semi-arid lands are extremely sensitive to changes in land use, wind, and precipitation. USGS scientists study relations between climate, vegetation, geology, and hydrology to understand causes and effects of climate change in arid lands. They study past episodes of desert formation to understand their causes and effects and to identify areas that are susceptible to desertification.

Many scientists believe that climate changes, and their effects, are more pronounced at high latitudes. Because of this sensitivity, the study of cold regions is important to the early detection of global change. Climate change in cold regions could trigger processes causing further environmental change. For example, arctic environments are a potential natural source of large volumes of methane. Under warmer conditions or higher sea levels, stored methane could be released, increasing the concentration of greenhouse gases in the atmosphere. The USGS studies methane produced in arctic wetlands and frozen as gas hydrates in permafrost and marine sediments to assist in estimating potential methane release in response to environmental change. The USGS also monitors glaciers and sea ice and studies processes that lead to the advance and retreat of glaciers. It measures temperature profiles in permafrost as a record of recent climate change, and monitors change in permafrost distribution.

Global change data and information

The complexity of global change requires many types of data and information from many scientific disciplines. Large amounts of data must be assembled, documented, archived, and distributed. Research results must be communicated outside the scientific community to decision makers and educators.

The USGS is working with other agencies to establish the Global Change Data and Information System, which will better organize and improve access to global change data and information. As part of this effort, the USGS has developed the Global Land Information System, an on-line computer-based directory and inventory that provides a user-friendly, interactive source for information about land-related data. The Global Land Information System contains information about data from Landsat and meteorological satellites, as well as land use, land cover, soils, terrain, and cartographic data. Global Land Information System users can interconnect with other systems, including the interagency Global Change Master Directory. Other information systems also are being developed to provide access to the entire range of USGS global change data.

The USGS has been designated by Congress as the National Satellite Land Remote Sensing Data Archive. As such, the USGS is preserving, archiving, and distributing Landsat data, approximately one million scenes representing more than 20 years of observations essential for studying global change.

In addition, USGS scientists participate in international assessments of global change, providing information needed by decision makers to establish environmental policy. The USGS also creates educational materials to inform students about global change issues.

Predicting Global Change

Improved understanding of the Earth's environmental systems increases our capacity to anticipate future environmental change. Scientists are using computer models to simulate such changes and their potential effects on the Earth. The USGS aids in developing and improving these models (General Circulation Models, for example) by providing earth science data, participating in simulations of past climates, and developing better representations of hydrologic processes and terrestrial environmental systems.

Improved predictions of the effects of climate change on humans and ecological systems will also require better model simulations at scales important to resource managers--geographic regions, watersheds, and ecosystems. USGS researchers are developing improved analytical methods and modeling procedures for evaluating the sensitivity of land and water resources to global change. These techniques help in assessing the possible effects of change and have already been used in solving water management problems in the western United States. The USGS is participating in the development of a multiagency laboratory for Terrestrial Ecosystems Regional Research and Analysis. Researchers at this laboratory are developing analytical techniques to incorporate land and natural resource management considerations realistically into computer models that represent terrestrial ecosystems.

The USGS is contributing information needed to assess the causes and consequences of global change through a balanced program of ground-based observations and remote sensing, data management, process studies, and modeling, grounded in long-term experience in Earth Science research.

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