ESSIC is a joint center of the University of Maryland Departments of Meteorology, Geology, and Geography and the Earth Sciences Directorate of the NASA/Goddard Space Flight Center. The center seeks to better understand how the atmosphere-ocean-land-biosphere components of Earth interact as a coupled system and how human activities influence this system. To accomplish this, ESSIC studies the interaction between the physical climate system (e.g., El Niño) and biogeochemical cycles (e.g., greenhouse gases, changes in land use and cover).

The center concentrates on four major research areas: climate variability and change; atmospheric composition and processes; the global carbon cycle (including terrestrial and marine ecosystems/land use/cover change); and the global water cycle. Research is conducted through in situ and remotely sensed observations, together with component and coupled ocean-atmosphere-land modeling. This multi-pronged approach provides a foundation for understanding and forecasting changes in the global environment and regional implications. Data assimilation and regional downscaling are used to link the observations and models, enabling us to study the interactions between the physical climate system and biogeochemical cycles from global to regional scales.

**Climate Variability and Change.** Societies around the world expect, and depend upon, a stable, though seasonally variable, climate. Climatic events such as the El Niño/Southern Oscillation (ENSO) disrupt the normal seasonal cycle, heightening awareness that, in reality, climate can vary dramatically from year to year and significantly affect society. Over the past two decades, research has demonstrated that ENSO is an intrinsic oscillation of the coupled ocean-atmosphere system. Other, more sustained, climatic variabilities are known but not well understood, such as the changes in annual rainfall in the African Sahel on decadal and longer time scales; lengthy droughts in the Nordeste region of Brazil; and the 1930s dust bowl in the United States. The rise in atmospheric concentration of greenhouse gases, and predictions of global warming and regional climate change are also relevant to studies of climate variability. Taken together, these examples demonstrate the need for better understanding of the coupled climate system, its natural variability, and its susceptibility to human influences, such as increases in radiatively active gases and atmospheric aerosols.

- ESSIC’s research is oriented toward understanding, monitoring, and predicting the physical processes responsible for climate variability and predictability on seasonal, interannual, decadal, and centennial time scales.
Atmospheric Composition and Processes. The atmosphere links the components of the Earth System, including the oceans, geosphere, terrestrial and marine biospheres, and cryosphere. As a result, the atmosphere is the conduit for change on a local, regional and global scale. Natural events and human activities can change atmospheric composition, which in turn alters Earth’s radiative balance. Subsequent responses by the climate system and the stratospheric ozone layer can influence both natural systems and the biosphere. The atmosphere represents the fast response of the coupled Earth System. Given the rapid and often global dispersal of chemical emissions into the atmosphere, the importance of atmospheric observation as an indicator of global change is evident.

- ESSIC’s research is oriented toward understanding, monitoring, and predicting the interrelationships of changes in atmospheric composition, climate, ozone-layer depletion, and surface-level chemical and radiative exposure.

Global Carbon Cycle (terrestrial and marine ecosystems; land use/cover change). Recent developments in science, resource management, and public policy have intensified interest in the global carbon cycle. Carbon is important as the basis for the food that sustains human populations, and as the primary energy source that fuels human economies. It also significantly contributes to the planetary greenhouse effect and the potential for climate change. Fossil fuel consumption and land clearing over the past 150 years have caused atmospheric carbon dioxide and methane concentrations to increase to a level higher than it has ever been in over 400,000 years. Changes in land management practices and CO₂ and nutrient additions can also significantly enhance carbon “sinks.”

- ESSIC’s research is oriented toward understanding, monitoring, and predicting the global carbon cycle, including the role and variability of terrestrial and marine ecosystems, land use, and land cover.

Global Water Cycle. The behavior of water in the Earth System is central to nearly every aspect of the global climate and crucial to human welfare. Interannual changes in precipitation and evaporation are associated with droughts and floods that threaten the lives and livelihood of millions of people. Evidence indicates that the global hydrological cycle is accelerating, resulting in an increasing number of extreme precipitation events. Improving our understanding of the ways that water influences, and is influenced by, the integrated Earth System is a critical component of our ongoing effort to predict climate variations and anticipate global climate change.

- ESSIC’s research is oriented toward understanding, monitoring and predicting the global water cycle, including precipitation, evaporation, storage and transport, on time scales from weeks to centuries.