CLIMATE PROGRAM OFFICE

Earth System Science

How can we understand and anticipate the global and regional impacts of climate variability and change?

What knowledge do we need to improve climate models and predictions?

NOAA

ESS supports field campaigns, such as the CalNex Mission, during which hundreds of researchers take to the land, sea, and air to measure and track greenhouse gases and air pollutants. The top photo shows the NOAA's WP-3D Orion, a premier research aircraft often used in field campaigns. The bottom photo was taken during CalNex. It shows a view of hazy skies over Los Angeles, often an indication of poor air quality.

The Earth System Science (ESS) program, managed by the NOAA Climate Program Office, supports research aimed at providing process-level understanding of the climate system through observation, modeling, analysis, and field studies. This vital knowledge is needed to improve climate models and predictions so that scientists can better anticipate the impacts of future climate variability and change.

To achieve its mission, the ESS Program supports research carried out at NOAA and other federal laboratories, NOAA Cooperative Institutes, and academic institutions. The Program also coordinates its sponsored projects with major national and international scientific bodies including the World Climate Research Programme, the International Geosphere-Biosphere Programme, and the U.S. Global Change Research program.

ESS Objectives

- Understand the dynamics of, and sources of predictability in, the coupled ocean-atmosphere-land-ice system across all climate time scales
- Improve our ability to understand and predict future atmospheric CO_2 concentrations
- Understand the forcing of the climate system by aerosols and greenhouse gases

ESS's Approach

The ESS Program funds research that leads to new discoveries and refines our knowledge of many aspects of the climate system. ESS supports NOAA mission-critical research, modeling, analysis, and data collection aimed at gaining a better understanding of the processes associated with climate phenomena. These activities are essential steps toward delivering climate prediction and assessment products for risk management and decision-making.

ESS-funded researchers improve our understanding of how greenhouse gases and aerosols behave in the atmosphere and how they impact society. Our researchers measure and model a range of atmospheric species that affect climate.

Earth System Science

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ESS's Approach (cont.)

For example, anthropogenic and natural aerosols can both have a large effect on air quality and climate, and are sources of uncertainty in climate research. Studies addressing emissions of aerosol precursors, aerosol formation, and aerosol-cloud interactions address critical questions at the nexus of air quality and climate. While aerosols contribute negatively to air quality, their effect on climate is less certain. The complicated relationship between aerosols and clouds can lead to increased, decreased, delayed, intensified, or otherwise altered precipitation, making weather and hydrological cycle processes much less predictable.

Researchers also continue to monitor, diagnose, and predict the variability of the global carbon cycle and its impact on climate. ESS research plays a vital role in efforts to monitor, report, and verify regional emissions, including those from fossil fuel use, to provide an independent check on emissions accounting based on economic inventories.

ESS Highlights

By Air, Land, and Sea: Exploring the Mysteries of the MJO

The Indian Ocean is one of Earth's most sensitive regions because the interactions between ocean and atmosphere there have a discernable effect on global climate patterns. The tropical weather that brews in that region can move eastward along the equator and reverberate around the globe, shaping weather and climate in far-off places. The vehicle for this variability is a phenomenon called the Madden-Julian Oscillation, or MJO.

The MJO, which originates over the Indian Ocean roughly every 30 to 90 days, is known to influence the Asian and Australian monsoons. It can also enhance hurricane activity in the northeast Pacific and Gulf of Mexico, trigger torrential rainfall along the west coast of North America, and affect the onset of El Niño.

State-of-the-art global climate models are currently limited in their ability to simulate the MJO, which can degrade their seasonal to interannual predictions and future climate projections. In order to improve climate prediction and assessment products for risk management and decision-making, ESS-funded scientists participated in a field campaign called the Dynamics of the Madden-Julian Oscillation (DYNAMO) in 2011-2012. Results from this international campaign are expected to improve researcher's insights into this influential phenomenon.


NOAA

The DYNAMO field campaign gathered observation data from ships, a network of buoys, and land-based radar systems in the Indian Ocean. Radars provide information about the microphysics inside clouds and rainstorms that lead to the development of the MJO.

Reducing Uncertainties about CO_2 Exchange in the Terrestrial Biosphere

ESS-funded scientists used the Princeton-NOAA Geophysical Fluid Dynamics Laboratory global land model to examine how interactions between land use changes, atmospheric nitrogen deposition, and climatic conditions govern terrestrial ecosystems' responses to CO2 in the atmosphere. The project brought together a group of experimental, theoretical, and modeling scientists with the goal of improving simulations of terrestrial carbon exchange.

The team conducted their study in the forests of Barro Colorado Island in collaboration with the Smithsonian Tropical Research Institute in Panama. These forests represent an ideal model system for lowland tropical forecasts. By applying the longest and most complete record of forest growth and watershed nutrient dynamics available worldwide to this system, the team was able to better understand the influence of climate change and land disturbance on the nitrogen cycle. This project's findings demonstrate that feedbacks between the carbon and the nitrogen cycles and interactions with land may constrain carbon uptake in terrestrial ecosystems.