# NASA—Carbon Simulation

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**SPONSOR:** National Aeronautic and Space Administration (NASA)

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**PARTNERS:** NASA Godard Space Flight Center

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## PROJECT DESCRIPTION

The attribution of the Earth surface sources of atmospheric $CO_2$ is of critical importance to the study of the carbon cycle and climate. $CO_2$ moves between the ocean, land and atmosphere in a variety of natural cycles that have existed for millions of years. Over the past several hundred years, the combustion of fossil fuels and other human related activities have resulted in a steady increase in the atmospheric concentration of $CO_2$. It is a critical research need to understand global carbon cycle dynamics in the context of global change. NASA is launching a satellite (OCO-2) in January 2013 that will make global measurements of atmospheric $CO_2$. The numerical modeling of the atmospheric circulation and the sources and sinks of $CO_2$ (land, ocean, fossil fuel combustion) provide the fundamental underpinning to place the NASA satellite measurements in context.

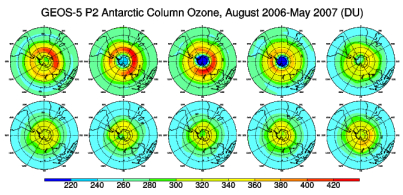
The goal of this project is to port, run and evaluate various instantiations of the Global Earth Observing System (GEOS-5) numerical model. ORNL assisted in the port of the GEOS-5 code and configuration to the Jaguar supercomputer. As the simulations complete, ORNL has been working with Steven Pawson, Lesley Ott and E. Nielson on the analysis of gravity wave simulation, carbon cycle ($CO_2$) simulations and analysis. The approach is to use the GEOS-5 model on Jaguar as a tool to study various source-sink estimates of $CO_2$ , including monthly anthropogenic $CO_2$ emissions and various aspects of the physical parameterizations such as gravity wave-$CO_2$ concentration interactions.

## SIGNIFICANCE

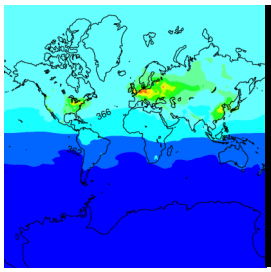
One of the primary areas of research in climate science is the understanding the global carbon cycle and how carbon in the atmosphere interacts with atmospheric radiation with implications for time trends in global and regional temperature, precipitation and extreme event frequency. This project lays the groundwork for the use of remotely sensed (satellite) measurements of atmospheric $CO_2$ distributions. The GEOS-5 $CO_2$ simulations are being analyzed, and various gradients are being evaluated. A variety of surface CO2 fluxes are implemented (i.e., time varying anthropogenic CO2 fluxes) and the computed 3-D time varying atmospheric $CO_2$ distributions are computed. This project implements and exercises a NASA based modeling framework that is unique in simulating a variety different approaches to estimating atmospheric $CO_2$ concentrations and trends on DOE/National Center for Computational Sciences computational platforms.

## INTERESTING FINDINGS

There are several ongoing synthesis projects within this project. They include an analysis of different gravity wave treatments on $CO_2$ and $O_3$ tracer distributions in GEOS-5 and the impact f vertical transport on atmospheric $CO_2$ concentrations. The impact of monthly anthropogenic $CO_2$ emissions (as opposed to annual means) also yield some new and interesting results that are still under analysis.




*Evolution of the Antarctic ozone hole and the destruction of the polar vortex for the period August 2006 – May 2007. Simulation performed on ORNL Jaguar XT4 by Eric Nielsen, GFSC, NASA .*



*One result from an eight-member ensemble of NASA GEOS-5 simulations of January, 2000 anthropogenic CO2 emissions (informed by observations). Simulation performed on ORNL Jaguar XT4 by Leslie Ott, GFSC, NASA*