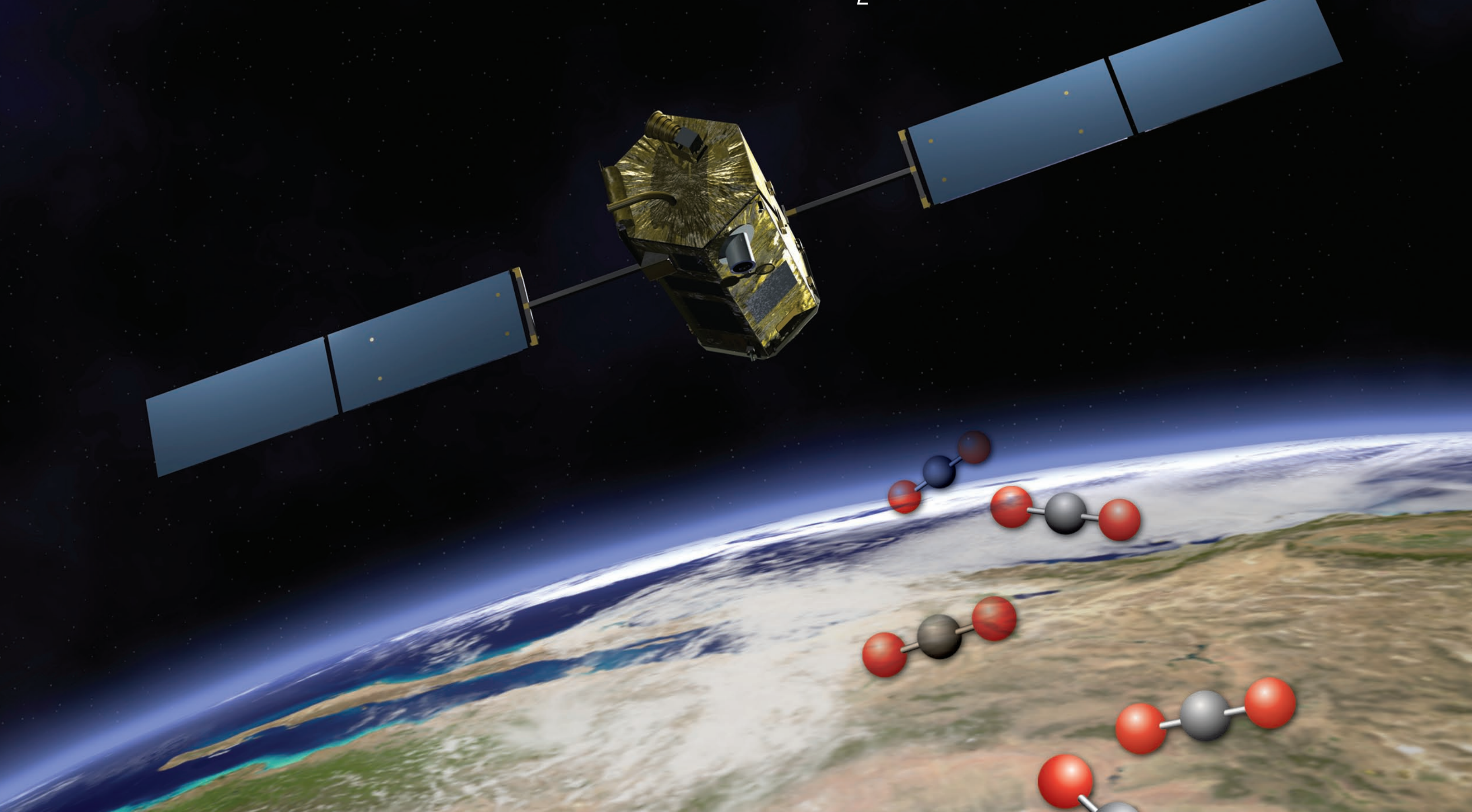
National Aeronautics and Space Administration

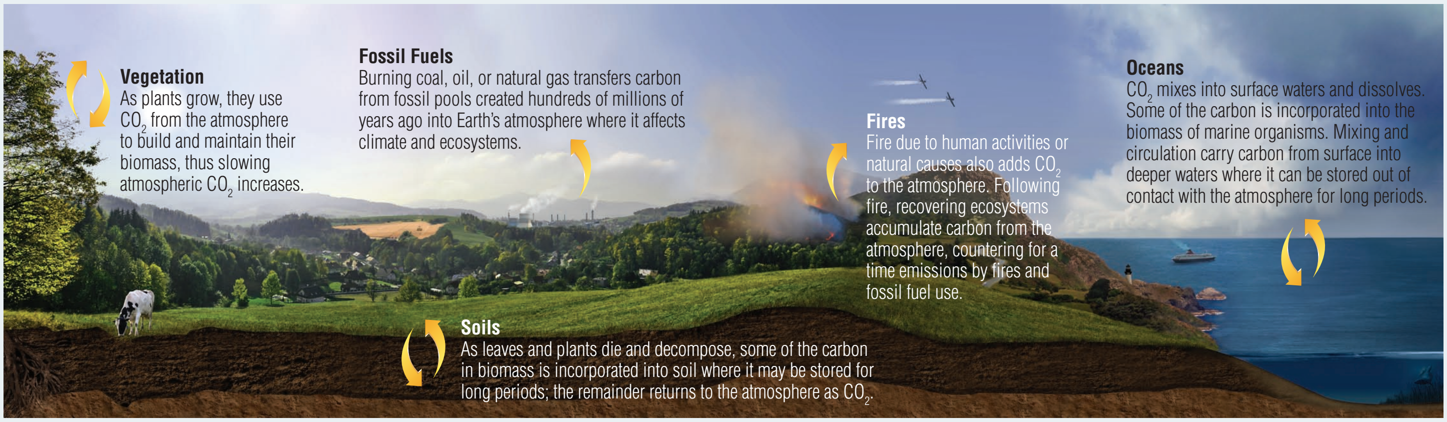
Orbiting Carbon Observatory (OCO)

Watching the Earth Breathe…Observing CO_2 from Space

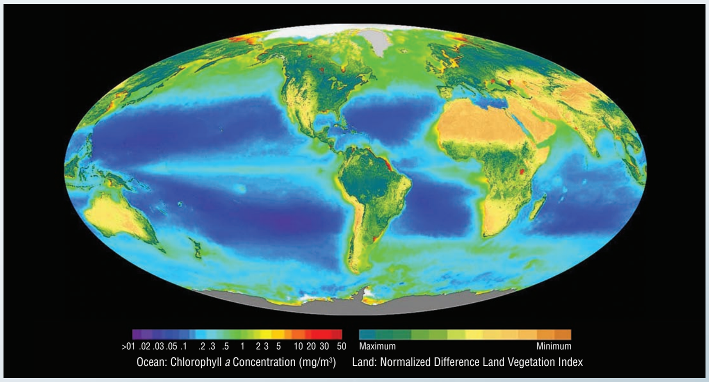


OCO is a new mission in NASA's ongoing study of the global carbon cycle. OCO will make the first space-based measurements of atmospheric carbon dioxide (CO_2) with the precision, resolution, and coverage needed to accurately map the geographic distribution of CO_2 sources and sinks. This information will be used to improve our understanding of the processes that control atmospheric concentrations of this potent greenhouse gas and will lead to improved predictions of future climate.

The Carbon Cycle



The global carbon cycle comprises the major reservoirs of carbon and the exchanges between them. The reservoirs most relevant to future climate are the atmosphere, terrestrial biosphere, oceans and geologic fossil fuel reserves. The atmospheric reservoir has steadily increased since the beginning of the industrial age because of anthropogenic emissions from fossil fuel burning and deforestation. The rate of atmospheric increase, however, has been ameliorated by the uptake of CO_2 by the ocean and terrestrial biosphere. Based on surface measurements of atmospheric CO_2 and economic data on fossil fuel use we know that on average only about 50% of emissions from human activities each year remains in the atmosphere and that carbon uptake by terrestrial and oceanic sinks absorbs the rest. Today's CO_2 levels of about 380 ppm would be about 100 ppm higher were it not for these natural sinks for atmospheric CO_2.

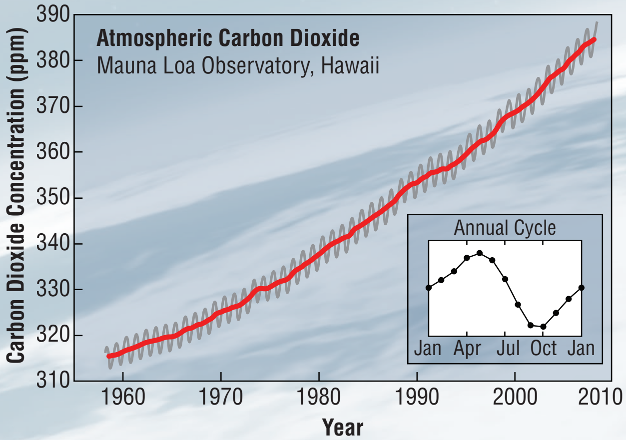


Data from the Sea-viewing Wide Field-of-view Sensor (SeaWiFS) aboard the OrbView-2 satellite are helping to define the role the ocean plays in the global carbon cycle. Ocean color data aid scientists in identifying "hot spots" of biological activity, measuring global phytoplankton biomass, and estimating the rate of oceanic carbon uptake.

Where and how these natural sinks operate is highly uncertain. They tend to show high interannual variability—in some years most of fossil fuel emissions are absorbed by the sinks while in others virtually none is absorbed and the atmospheric CO_2 increases at rates equivalent to fossil fuel emissions. Will these sinks continue to operate in the future, will they strengthen, or will they reverse, exacerbating the greenhouse warming of the planet? To predict the future behavior of these sinks it is necessary to locate them, quantify them, and understand their underlying processes.

Our understanding is currently limited to a large extent by our ability to measure atmospheric CO_2 at finer temporal and spatial scales. Current measurements are largely limited to the surface at about 100 sites globally. Atmospheric transport of CO_2 rapidly mixes the signals of the various sources and sinks, making it impossible to locate and quantify these processes at sufficient resolution to understand them beyond a rudimentary level.

The OCO mission is aimed at measuring full atmospheric column CO_2 levels globally, providing unprecedented data densities that will allow modelers to locate and identify surface sources and sinks for CO_2. The resulting improved understanding will allow more accurate predictions of how theses sources and sinks will respond in the future to climate change and human activities.

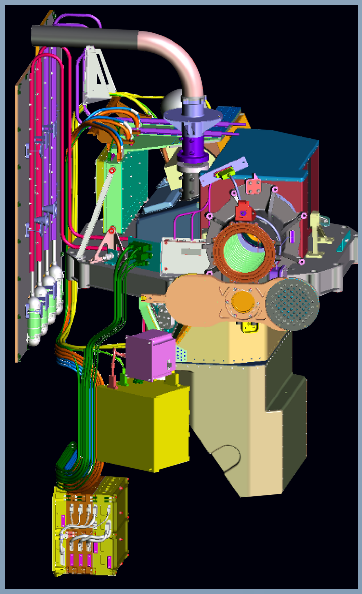


Atmospheric CO_2 concentration measurements at Mauna Loa Observatory in Hawaii, begun by Charles David Keeling, Scripps Institution of Oceanography, and continued by the National Oceanic and Atmospheric Administration.

The OCO Instrument

OCO will measure spatial variations in the column average dry air CO_2 mole fraction (X_{CO2}) with three near-infrared spectrometers that measure the absorption of reflected sunlight from the Earth's surface. Two spectrometers measure the absorption by CO_2 at wavelengths where CO_2 is the dominant absorbing atmospheric constituent (~1.6 and 2.1 μm). Surface sources and sinks for CO_2 produce atmospheric CO_2 column density variations on the order of 1 to 10% of background levels. Variations in terrain height and meteorologically driven changes in atmospheric pressure can produce variability in column CO_2 density that are larger than the contributions of surface CO_2 sources and sinks. Expressing atmospheric CO_2 amounts in terms of mole fraction of the atmosphere corrects for variations in atmospheric pressure. For this reason OCO will also measure the column density of the atmospheric O_2, whose mole fraction is known to be relatively constant, with a third spectrometer that measures absorption in the spectral range dominated by O_2 (~0.765 μm). The ratio of measured CO_2 to O_2 densities yields X_{CO2} .

OCO will acquire a large number of densely spaced samples to ensure that there are still many measurements that sample the full atmospheric column, even in the presence of interference from clouds and aerosols. The X_{CO2} data measured by OCO will then be used in computer-based data assimilation models to infer the locations of CO_2 sources and sinks.



3-channel Grating Spectrometer

- O_2 0.765 μm band, Resolving Power = 18,000
- CO_2 1.61 μm band, Resolving Power = 21,000
- CO_2 2.06 μm band, Resolving Power = 21,000

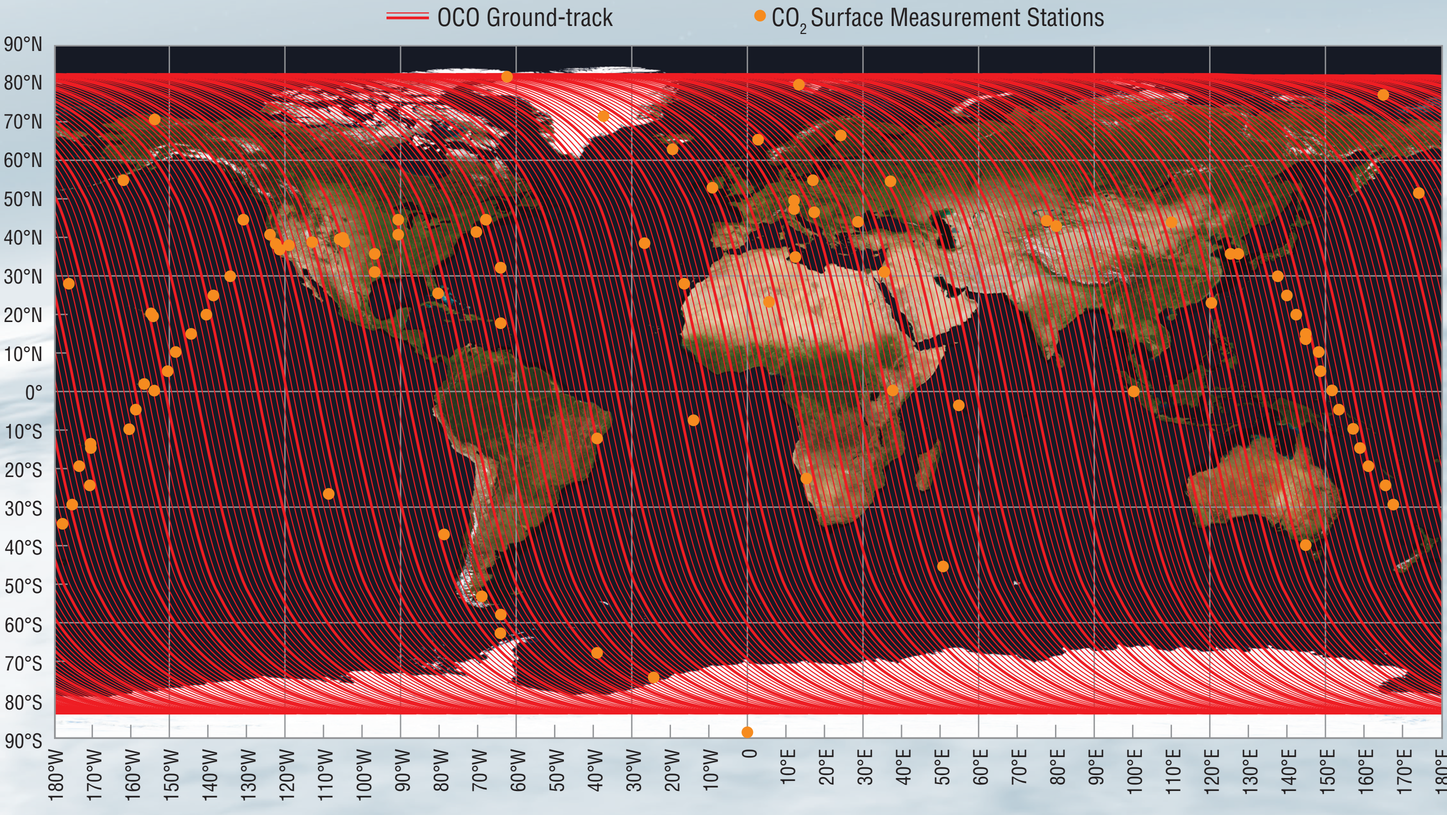
Field of View: 1.3 x 2.3 km/footprint

NADIR Ground Swath: 10.4 x 2.3 km (8 footprints)

Sampling Rate: 3 Hz

Mass: 135 kg

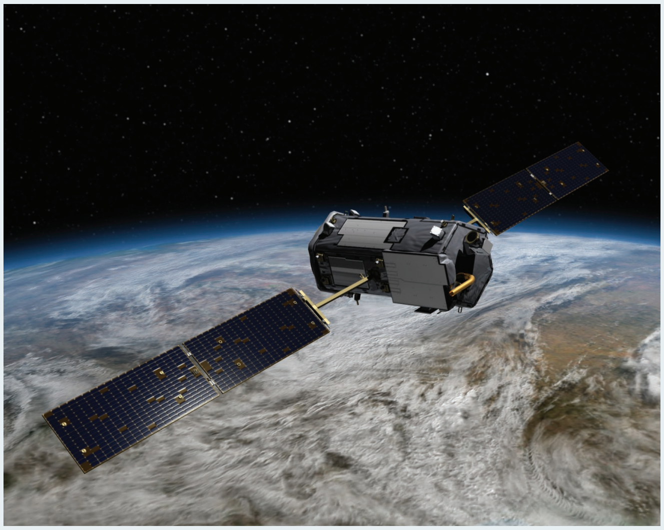
Power: 120 W



OCO will provide global coverage of the sunlit hemisphere with a 16-day (233 orbit) ground-track repeat cycle.

The OCO Spacecraft

OCO will launch from California's Vandenberg Air Force Base in early 2009 aboard a *Taurus 3110* launch vehicle. The spacecraft bus, based on the successful Solar Radiation and Climate Experiment (SORCE) and Galaxy Explorer (GALEX) missions, weighs approximately 975 lb (442 kg). An *S-band* antenna and *X-band* transmitter allow the spacecraft to send and receive information. The spacecraft's location data is provided by a Global Positioning System (GPS) receiver onboard.

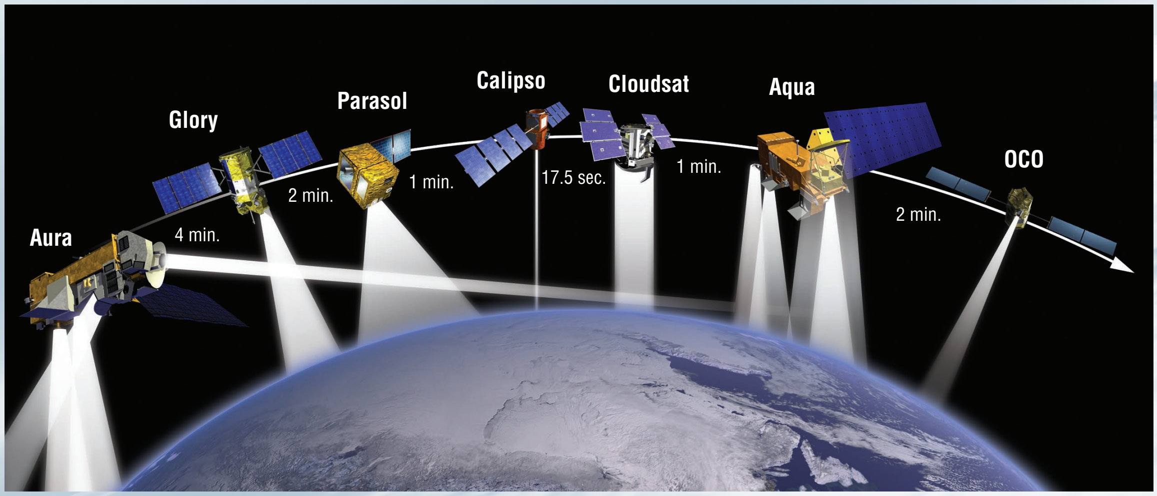


OCO will fly in a near-circular, 438 mi (705 km) altitude, near-polar, sun-synchronous orbit that provides global coverage of the sunlit hemisphere with a 16-day ground-track repeat cycle. Flying in the Earth Observing System (EOS) Afternoon Constellation (A-Train) of satellites, OCO will share its ground track with the Aqua satellite. The orbit's 16-day ground repeat cycle facilitates monitoring X_{CO2} variations over the entire sunlit hemisphere on semi-monthly intervals. OCO has a planned lifespan of two years.

OCO's Place in the Study of the Global Carbon Cycle

Previous NASA satellite missions have sought to reveal the dynamics of the global carbon cycle using observations of land and ocean surfaces from space. The Landsat series of satellites, first launched in 1972, has supplied continuous data on deforestation, urban growth, and other land-use practices. Data from the SeaWiFS instrument, launched aboard the OrbView-2 satellite in 1997, have been used to produce maps of oceanic uptake of CO_2 by biological primary productivity. These ocean data are augmented by the Moderate Resolution Imaging Spectroradiometer (MODIS) instrument on the Terra and Aqua satellites launched in 1999 and 2002, respectively. The MODIS instruments also provide information regarding the state of the terrestrial carbon cycle.

OCO measurements will be used in conjunction with satellite data from Terra as well as Aqua, Aura, CloudSat, and other A-Train satellites to comprehensively study the Earth's atmosphere and the influence of greenhouse gases on climate change. OCO will contribute to NASA's study of the global carbon cycle by supplementing the current CO_2 measurement network with information on the regional abundance and distribution of CO_2. Models that show the distribution and variability of CO_2 sources and sinks will facilitate more accurate predictions of how changes to the carbon cycle effect climate.



OCO will fly at the head of the A-Train, 2 minutes ahead of the Aqua platform. 438 mi (705 km) altitude sun synchronous, 98.2° inclination, 98.8 minute period.

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