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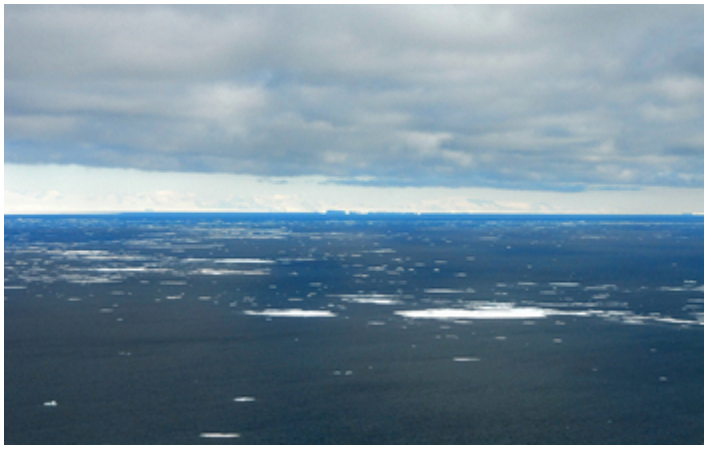
Flying lab to investigate Southern Ocean's appetite for carbon

ORCAS field campaign will help scientists predict future climate



The Southern Ocean is unique among Earth's oceans.

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A team of scientists supported by the National Science Foundation (NSF) will launch a series of research flights over the remote Southern Ocean this month to better understand just how much carbon dioxide its icy waters can lock away.

The ORCAS field campaign -- led by the National Center for Atmospheric Research (NCAR) -- will give scientists a rare look at how the air and seas surrounding Antarctica exchange oxygen and carbon dioxide. The data they collect will help illuminate the role the Southern Ocean plays in soaking up excess carbon dioxide humans emit into the atmosphere.

"If we want to better predict the temperature in 50 years, we have to know how much carbon dioxide the oceans and terrestrial ecosystems are going to take up," said NCAR scientist Britton Stephens, co-lead principal investigator for ORCAS. "Understanding the Southern Ocean's role is important because ocean

circulation there provides a major opportunity for the exchange of carbon between the atmosphere and the vast reservoir of the deep ocean."

Carbon dioxide, the main greenhouse gas that contributes to human-caused global warming, moves continually back-and-forth among the atmosphere, plants on land and the oceans. As the burning of fossil fuels releases more carbon dioxide into the atmosphere, the oceans have absorbed more of it. But it's unclear whether oceans can keep pace with continued emissions.

Studies disagree about whether the Southern Ocean's ability to absorb carbon dioxide is speeding up or slowing down. Measurements and air samples collected by ORCAS -- which stands for the O_2/N_2 Ratio and CO_2 Airborne Southern Ocean Study -- will give scientists critical data to help clarify what's actually happening in the remote and difficult-to-study region.

NSF's Division of Polar Programs funds ORCAS through the U.S. Antarctic Program. That program supports researchers, coordinates all U.S. government research on Antarctica and provides the necessary logistical support for scientists.

"Building on decades of U.S. Antarctic Program research, new questions of global significance continue to emerge," said Peter Milne, program director of Ocean and Atmospheric Sciences in the Division of Polar Programs. "ORCAS addresses one of those questions: how the Southern Ocean affects global climate by storing, or releasing, carbon dioxide, water vapor and heat."

Tracking carbon

The ORCAS field campaign will operate out of Punta Arenas, near the southern tip of Chile. The researchers plan to use the NSF/NCAR HIAPER research aircraft to make 14 flights across parts of the Southern Ocean between Jan. 15 and Feb. 28. A suite of instruments on a modified Gulfstream V jet will measure the distribution of oxygen and carbon dioxide, as well as other gases produced by marine microorganisms, aerosols, and cloud characteristics in the atmosphere.

The flights also will observe the ocean color -- which can indicate how much and what type of phytoplankton is growing in the water -- using NASA's Portable Remote Imaging Spectrometer (PRISM). NASA funded the addition of the PRISM instrument to the ORCAS campaign.

Stephens and NCAR scientist Matthew Long are leading the science campaign. Other principal investigators include Elliot Atlas (University of Miami Rosenstiel School of Marine and Atmospheric Science), Michelle Gierach (NASA's Jet Propulsion Laboratory), Ralph Keeling (Scripps Institution of Oceanography), Eric Kort (University of Michigan), and Colm Sweeney (Cooperative Institute for Research in Environmental Sciences). CIRES is a partnership of the National Oceanic and Atmospheric Administration and University of Colorado Boulder.

NCAR is also managing the field campaign, which includes logistics support, such as obtaining diplomatic clearances from multiple countries to fly through their airspace and providing housing and work space for the project'a scientists in South America.

Carbon, oxygen and phytoplankton

Measuring oxygen alongside carbon dioxide can give scientists a clearer picture than they would get from measuring carbon dioxide alone.

"The air-sea exchange of carbon dioxide is controlled not just by physics but also by biology," Long said. "There's a nice relationship between the fluxes of oxygen and the fluxes of carbon dioxide that can be exploited to gain insight into these processes."

If scientists know how the two gases' concentrations change relative to one another with location and time, they can disentangle how biology and physics each affect the ocean's ability to absorb carbon dioxide.

Physics and biology affect the ratio of carbon dioxide to oxygen in the air in different ways. In the Southern Hemisphere's austral spring, the warmth of the returning sun drives both carbon dioxide and oxygen out of the Southern Ocean surface and into the atmosphere.

But the sunlight also triggers the growth of phytoplankton in the water. As organisms flourish, they take in carbon dioxide and release oxygen, causing the relative amounts of those two gases in the atmosphere to shift in opposite directions. Observations of these shifts can ultimately tell scientists how much carbon is going where and, more importantly, why.

A window into the deep ocean

The Southern Ocean is unique among Earth's oceans. Unimpeded by continental landmasses, and driven by a westerly wind, the Southern Ocean is able to form a circular current around Antarctica. This huge flow, the largest current on the planet, connects the adjacent Atlantic, Pacific and Indian oceans.

The complex interactions between this Antarctic Circumpolar Current and currents flowing in from other ocean basins creates an overturning circulation that brings deep water to the surface, where it can exchange gases with the atmosphere before it returns to depth.

Once that surface water heads toward the ocean floor, it can stay sequestered in the deep ocean for hundreds or even thousands of years -- along with any carbon it carried. Data the ORCAS flights collect will help determine how much carbon dioxide goes along for the ride.

"The Southern Ocean provides a window into the deep ocean, but it's a difficult system to simulate in our Earth system models," Long said. "It's remote, and so there has been a paucity of observations that can be used to improve the models we have."

The ORCAS team will use data generated during the field campaign to improve global computer models so they do a better job representing the Southern Ocean's complexities. The NCAR-managed data set will be publicly available.

While the measurements made during the ORCAS campaign will help scientists fine-tune what they know so far about the Southern Ocean, the project could also bring to light entirely new aspects of how the ocean works.

"The Southern Ocean is very inaccessible and existing measurements are from ships or surface stations that represent only a few tiny dots on a huge map," Stephens said. "The airborne measurements we take will be helpful in terms of understanding the system better. And because we're doing something that no one's ever done before, we're likely to find things that we aren't expecting."

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Related Websites

The ORCAS field campaign: http://www.eol.ucar.edu/field_projects/orcas (/cgi-bin/good-bye?http://www.eol.ucar.edu/field_projects/orcas)

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