NOAA Earth System Research Laboratory
Global Monitoring Division
Carbon Cycle Greenhouse Gases (CCGG) Group

Issue 4: February 2018

Aircraft Air Sampling Network Newsletter

Welcome to the fourth issue of the NOAA Carbon Cycle Greenhouse Gases Group's newsletter for the pilots and collaborators in our aircraft sampling network. We appreciate your continued efforts to collect quality data for use in valuable climate-related research. Thank you!

Figure 1 shows a map of our current and past aircraft sampling sites in North America. In addition we have one site in Rarotonga in the South Pacific.

With this newsletter, we are including an updated plot with data from the air samples collected at your site, from the start of sampling flights through the present, with more recent data being preliminary. The black diamonds represent the date and altitude of samples. The colors represent the concentrations of carbon dioxide (CO_2) in parts per million (ppm), with CO_2 values being interpolated between sampling altitudes. We are also including a figure showing the average annual climatology of CO_2 for the North American sites. This allows a look at seasonal differences across the continent.

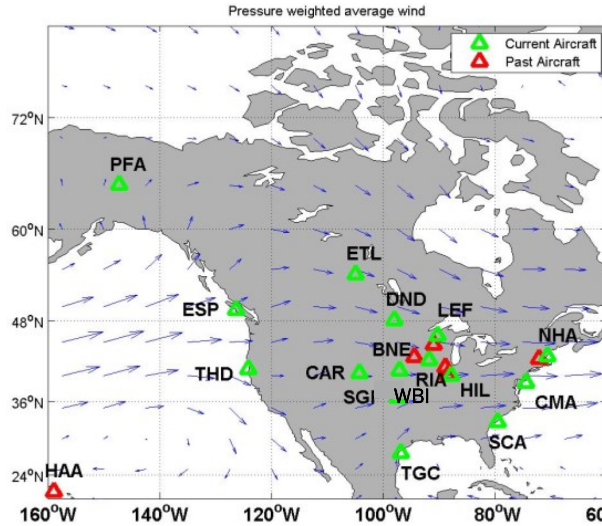

Figure 1: Aircraft network in North America

What is the Carbon Cycle?

Of the greenhouse gases, CO_2 is of greatest concern because it contributes the most to the greenhouse effect and climate change. For this reason, scientists at NOAA and elsewhere have been studying this molecule carefully and attempting to quantify its abundance in the atmosphere in order to track how and why it changes. The CO_2 molecule is involved in a complex series of processes called the carbon cycle, where the carbon atom within the molecule moves between many different natural reservoirs (e.g. the terrestrial biosphere, the atmosphere, and the oceans). As carbon is transferred between reservoirs, processes that release CO_2 into the atmosphere are called sources, and processes that remove CO_2 from the atmosphere are called sinks.

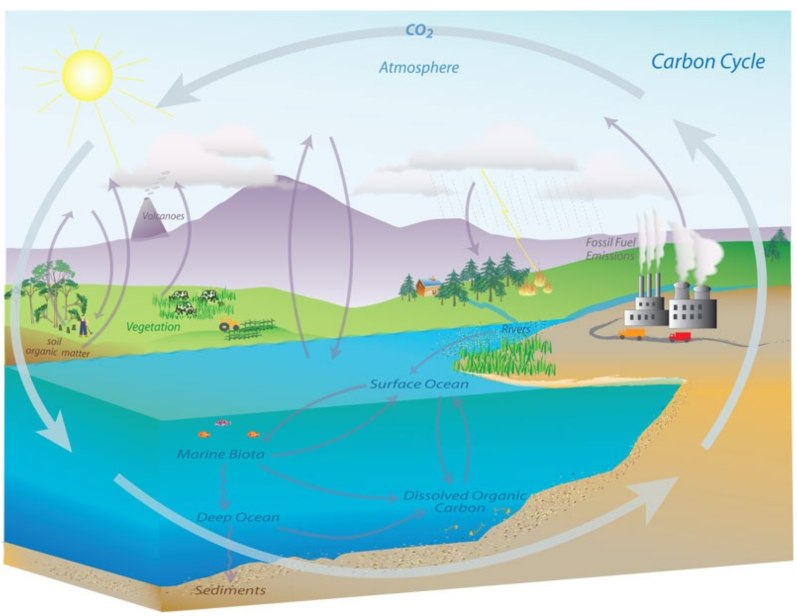

Figure 2: The Carbon Cycle

Carbon is continuously exchanged and recycled among the reservoirs through natural processes. These processes occur at various rates ranging from short-term fluctuations, which occur daily and seasonally, to very long-term cycles, which occur over hundreds of millions of years. For example, there is a clear seasonal cycle in atmospheric CO_2. As plants photosynthesize during the growing season, they remove large amounts of CO_2 from the atmosphere. Respiration from plants and animals and decomposition of leaves, roots and organic compounds release CO_2 back into the atmosphere. On a scale spanning decades to centuries, CO_2 levels fluctuate gradually between the ocean and atmospheric reservoirs as ocean mixing occurs between surface and deep waters and the surface waters exchange CO_2 with the atmosphere. Much longer cycles occur, on the scale of geologic time, due to the deposition and weathering of carbonate and silicate rock.

Measuring CO_2 and understanding the carbon cycle has become increasingly important over the last few decades because of climate change. Thanks to all your efforts we are able to track and document the long-term trends of CO_2 and other greenhouse gases.

NOAA Twin Otter Projects

In addition to CCGG's network of aircraft sites that conduct regular, long-term air sampling, the group also participates in short-term, intensive campaigns to study smaller areas in greater detail. Over the past few years, we have partnered with NOAA's Aircraft Operations Center to research methane (CH_4) emissions. Although it is much less abundant in the atmosphere (~1.8 ppm CH_4 vs ~400 ppm of CO_2), CH_4 is a much more potent greenhouse gas. Global Warming Potential (GWP) is a relative measure of how much heat a certain mass of gas traps in the atmosphere compared with the same mass of CO_2. The GWP of CH_4 over a 20-year timespan is ~80 times greater than that of CO_2., which is why CH_4 emissions are of interest for climate research. Studies of smaller areas help answer larger questions of how much CH_4 the U.S. is emitting from specific sources and how it is changing over time.

View from the NOAA Twin Otter over the Bakken Shale region in North Dakota

Sampling fleet in the 4 Corners methane campaign

Our recent CH_4 emissions studies have been carried out with the help of NOAA's fleet of Twin Otters in a variety of locations with varying instrumentation. Most of the projects have focused on emissions from oil and gas production, including one in the San Juan Basin of the Four Corners region after that area had been identified by satellite as a CH_4 hotspot. Funding from NOAA and the Bureau of Land Management brought four aircraft and two surface mobile laboratories from NOAA, NASA, CU-Boulder, and UC-Davis / Scientific Aviation to the Four Corners area in May 2015 with a mission to validate and quantify the satellite observations, as well as separate out what portion of the CH_4 emissions come from oil, gas and coal production vs natural geologic seeps. Measurements showed that most of the CH_4 emissions are the result of leakage from oil and gas production activities.

Preparing for a flight over Marcellus Shale in Pennsylvania
(Photo: M. Nance, Philadelphia Inquirer)

Smaller-scale flight campaigns were carried out with a NOAA Twin Otter in the Bakken Shale region of North Dakota in May 2014 and over the Marcellus Shale area of Pennsylvania in June 2015. These missions aimed to verify reported emissions from gas production processes. The Bakken study showed very high levels of ethane (a component of natural gas) emissions, enough to account for a significant fraction of a recent increase of global ethane levels.

A summer 2016 project had a slightly different focus. The Twin Otter was again outfitted with instruments to measure CH_4, but with more of an eye toward emissions from the Alaskan tundra. Temperatures in the Arctic are on the rise, as are concerns about increased CH_4 emissions from melting permafrost. The study showed that northern Alaska's emissions are mainly from natural sources, with the exception of the oil and gas activities in the Prudhoe Bay area. These contributions are significant, though not large relative to other production basins.

The Alaskan Arctic tundra as seen from the NOAA Twin Otter

This spring we will again partner with a NOAA Twin Otter on the East Coast Outflow (ECO) project. These flights will focus on quantifying CO_2 and CH_4 emissions from major urban centers in the northeastern U.S.

Shipping
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Please include the following information on all your invoices:
1) Flight date **2)** Flight hours **3)** Tail number **4)** Name(s) of pilot(s)
5) If samples weren't collected because of equipment failure or similar.

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To learn more about GMD's projects, please visit these Web links:
GMD home page: www.esrl.noaa.gov/gmd   CCGG: www.esrl.noaa.gov/gmd/ccgg
Aircraft Air Sampling Network: www.esrl.noaa.gov/gmd/ccgg/aircraft
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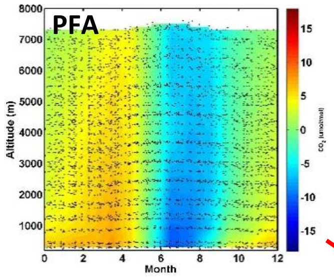
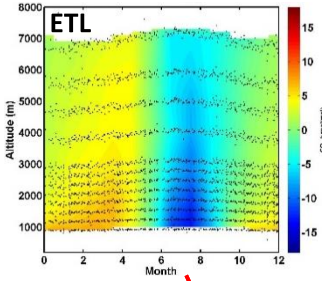
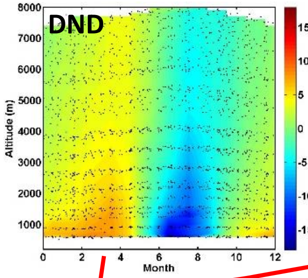
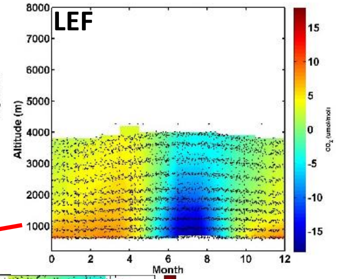
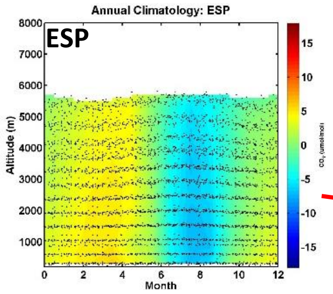
Annual Average Carbon Dioxide Climatology from NOAA/GMD Aircraft Air Sampling Network

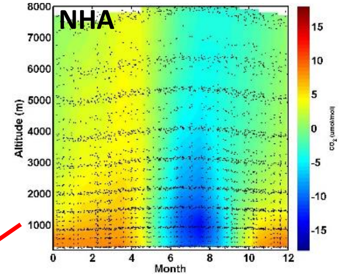


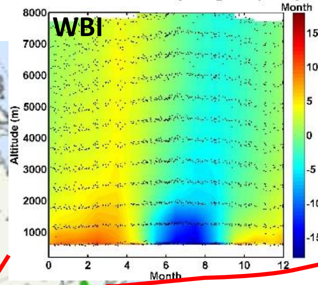


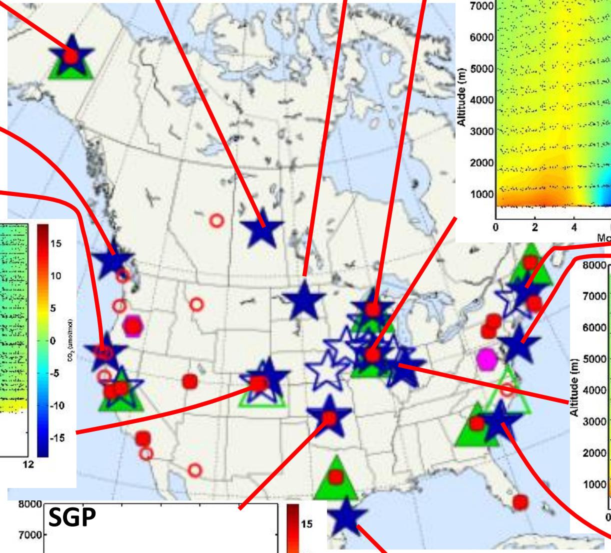


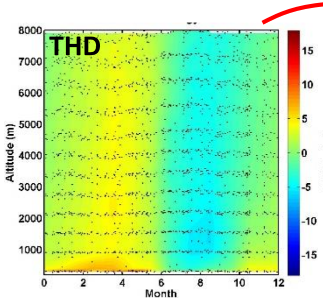


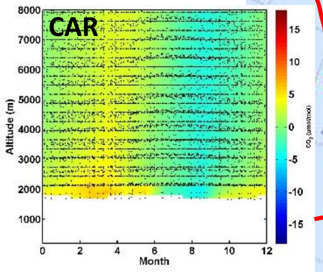


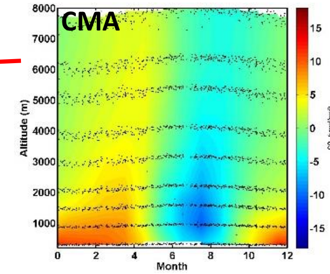


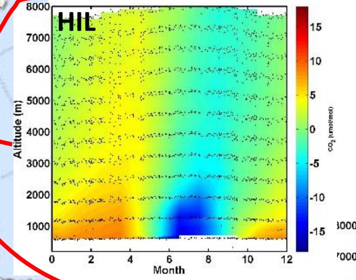




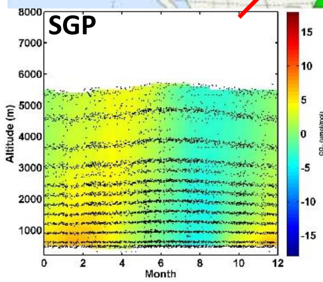


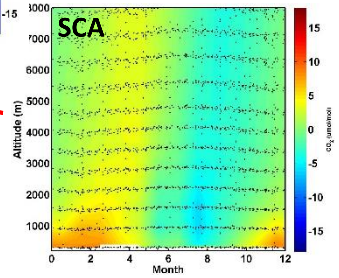


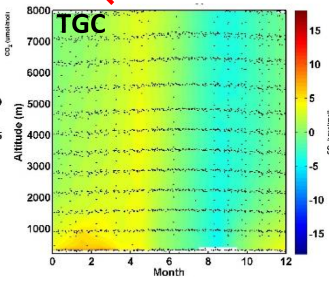




Plots show average annual carbon dioxide (CO_2) climatology at each aircraft site using data collected since the start of sampling at each site. All the data were binned by month, detrended and then adjusted to one common year by normalizing them with surface measurements from the NOAA Mauna Loa Observatory. Plots are arranged by approximate latitude / longitude, so it's easy to compare the horizontal and vertical distribution of CO_2 throughout a climatological year.

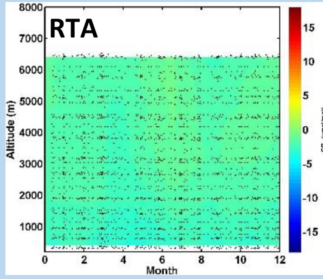






The farther north we get from the equator, the more pronounced the CO_2 seasonal cycle is. Judging by the limited stratification in CO_2 at the high latitude west coast sites, it is likely that most of the seasonal cycle is not driven by local processes near the sites but biological processes upwind of these sites on the Asian continent.

And far off in the South Pacific (-21.25 / -159.83)



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