NOAA Earth System Research Laboratories
Global Monitoring Laboratory
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The Cooperative Global Air Sampling Network Newsletter

Another Volcanic Disruption in Hawai'i

NOAA's Mauna Loa Observatory (MLO) is located in Hawai'i on the north flank of Mauna Loa Volcano. At 3397 meters above sea level, MLO protrudes through the region's strong marine temperature inversion layer, which separates the more polluted lower portions of the atmosphere from the much cleaner free troposphere. The undisturbed air, remote location, and minimal influences of vegetation and human activity make MLO ideal for monitoring climate change constituents in the atmosphere.

MLO has been in operation since the 1950s, and measurements have paused only a few times: for 3 months in 1964 because of federal budget cuts; for a month in 1984 when the volcano last erupted and cut off power; and now. At 11:30pm on Nov 27, 2022, Mauna Loa volcano began erupting. The observatory and staff were safe, but before the end of the day on Nov 28, lava had crossed the access road and cut power.

Sections of MLO access road covered by new lava

As was the case in 2018 when the eruption of Kilauea volcano cut off access to the sampling site at Cape Kumukahi ('KUM', see 2020 newsletter), the MLO staff once again had to find an alternate sampling site. Through an emergency agreement with the University of Hawaii, a new site was established at 4,210 masl at the nearby Mauna Kea Astronomical Observatory (MKO), and by Dec 7, air samples and associated *in situ* CO_2 measurements were being collected. While these represent a small subset of the full MLO measurement suite, they help minimize a greenhouse gases data gap.

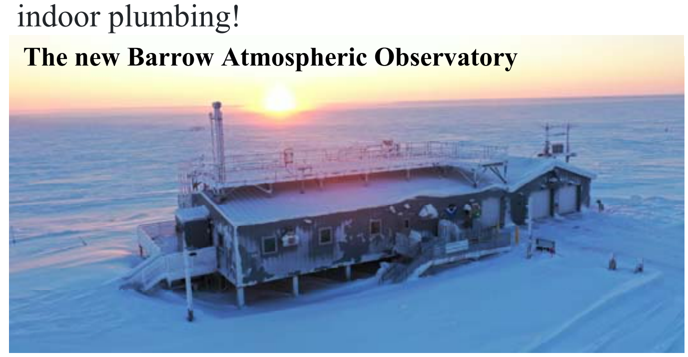
NOAA's Aidan Colton collecting flask samples at the new MKO site

Mauna Loa stopped erupting on Dec 13, and a week later two MLO engineers accessed the site to survey the facilities and collect air samples with a battery-powered portable sampling unit. There was no physical damage to the observatory but good road access will be slow to return. MLO has solar panels but did not have on-site power storage. Now, plans are underway to install batteries to harness the solar energy locally, thus allowing some projects to come back on line until grid power is eventually restored to the observatory. Staff will continue to collect weekly samples at the MKO alternative site, at MLO whenever possible and, of course, weekly samples at the current KUM site.

Finally, indoor plumbing!

In a completely different climate zone, at the northernmost tip of the United States, the Barrow Atmospheric Baseline Observatory (BRW) in Utqiaġvik, Alaska, sits on a point of land jutting into the Beaufort Sea. Like MLO, BRW is well-positioned to sample air and make other baseline climate measurements in a place minimally influenced by local or regional air pollution sources.

Cooperative network air samples were first collected at this location in 1971 so were one of the earliest BRW projects. The cramped observatory building, established in 1973, was intended to be a temporary facility. Nearly half a century later, the 'temporary' nature of the original facility finally came true in 2020 when the staff and instrumentation moved out of the old building and into a new facility. NOAA and a host of other research organizations make more than 200 measurements at BRW, including the original cooperative network greenhouse gas samples, ozone-depleting chemicals, air pollution events from Eurasia known as Arctic Haze, advancing snowmelt dates, lengthening of summers along Alaska's North Slope and more. The facility also includes more space to house new research opportunities. As an added bonus for staff and visitors, the building now includes indoor plumbing!



The new Barrow Atmospheric Observatory

Institute of Arctic and Alpine Research - Stable Isotope Lab

The Stable Isotope Lab (SIL) at the Institute of Arctic and Alpine Research, part of the University of Colorado, has been measuring stable isotopes of greenhouse gases in cooperation with NOAA's Global Monitoring Laboratory since 1990. Stable isotopes provide useful information about the sources of these gases, as well as the processes that remove them from the atmosphere. Isotope observations can be used with models to study the carbon cycle and how it might be changing.

What are stable isotopes?

Stable isotopes are relatively rare atoms with molecules that contain extra neutrons. For example, the most common form of carbon has 12 neutrons, but approximately 1% of carbon atoms naturally contain 13 neutrons - not so many that they are radioactive, but nonetheless, slightly heavier, which causes them to react at different rates in chemical, physical, and biological processes. There are several ways to measure stable isotopes, but the most accurate and precise is to use an isotope ratio mass spectrometer. Molecules of CO_2 and CH_4 are trapped from the air samples, ionized and sent through a magnetic field in a vacuum chamber. The different isotopes are then separated by mass, detected, and compared to calibrated gas standards of known isotopic ratios.

How are they useful?

As atmospheric concentrations of CO_2 have increased, the amount of ^{13}C relative to ^{12}C has decreased - on the delta isotope scale, which is the relative difference of heavy to light isotopes compared to a standard (Fig 1). This is one line of evidence that demonstrates the increase in CO_2 comes from fossil fuel burning, since fossil fuels have a very negative $\delta^{13}C$ value. Also, the seasonal cycle of the $^{13}C\text{-}CO_2$ isotope is out of phase with the cycle of CO_2 concentration. This is due to the fact that when vegetation assimilates carbon during photosynthesis, the $^{12}C\text{-}CO_2$ molecules are preferred relative to the $^{13}C\text{-}CO_2$ molecules. Therefore, when plants take up CO_2 from air, more of the ^{13}C molecules remain in the atmosphere. This gives scientists a way to determine how much CO_2 is taken up by the biosphere relative to the oceans.

Stable isotopes of methane are also useful because different sources of this important greenhouse gas have different isotopic values. Since 2007, CH_4 concentration has been increasing rapidly, and $\delta^{13}C\text{-}CH_4$ has decreased (Fig 2). We can use this observation to test hypotheses about where that increase has come from - and studies suggest that the increase is primarily from a biogenic source, like wetlands or agriculture, though fossil fuel sources may also play a smaller role. We hope to expand our measurements of CH_4 isotopes in order to understand this better.

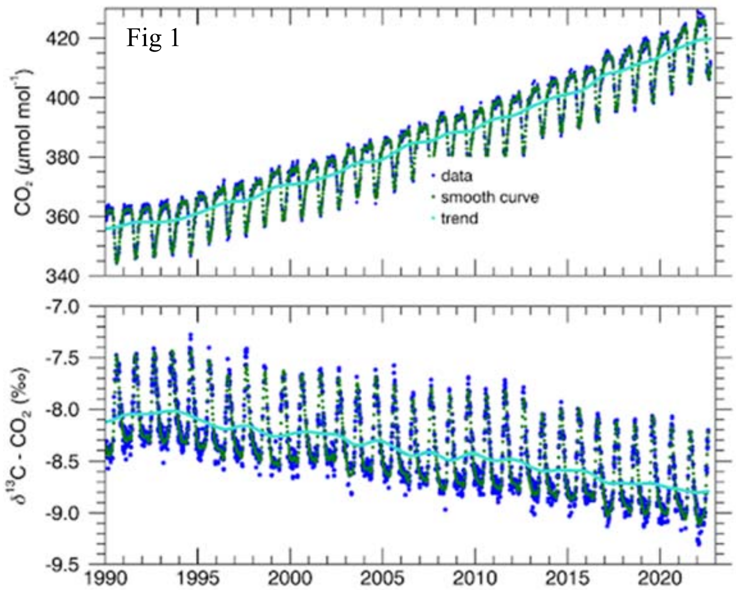
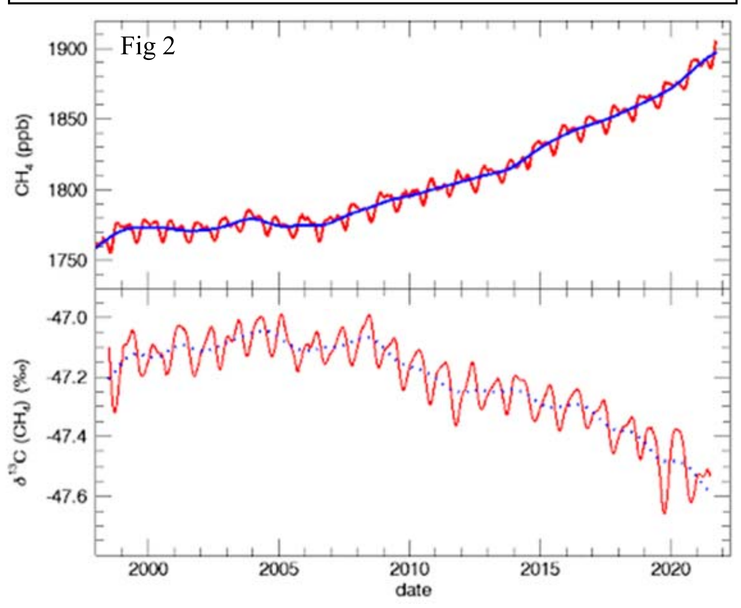


Fig. 1 (above): CO_2 and $\delta^{13}C\text{-}CO_2$ at Barrow, Alaska (blue dots), smooth curves (green) and trends (light blue). As CO_2 increases, the relative amount of ^{13}C compared to ^{12}C decreases due to the addition of fossil fuels. The seasonal cycle shows the effect of plants, which discriminate against the heavy isotopes.

Fig. 2 (below): Globally averaged CH_4 and $\delta^{13}C\text{-}CH_4$ (red) and trends (blue). The change in the isotopes as CH_4 increases suggests an increase in primarily biogenic sources of methane.



Institute of Arctic and Alpine Research - Stable Isotope Lab (cont.)

The NOAA/INSTAAR measurement record is the largest collection of stable isotopes of greenhouse gases in the world. Technicians at the Stable Isotope Lab work hard to maintain their fleet of mass spectrometers, striving to keep up with the huge flux of flasks that come through the lab (~ 15,000 per year). They also dedicate themselves to ensuring the data quality is good enough to detect small changes in seasonal cycles and latitudinal gradients. We hope that this collaboration also will capture successful mitigation efforts for greenhouse gases in the future.

Stable Isotope Lab Scientists (from left to right): Reid Clark, Chloe Brashear, Taline Leon, Sylvia Michel, John Ortega

State of the Network

This past year has brought continued challenges from COVID-19, but we are also seeing a little bit of normalcy come back to our lab. Our staff is mostly back in the office at least in a part-time capacity, allowing us to return to our lab work and collaborate away from the computer screen. We hope that most of you are also getting back to a new normal.

Operational highlights:

- There was a slight decrease in the number of flask samples collected in 2020 & 2021. This was due to pandemic related issues like shipping delays, lockdowns, and staffing problems. Overall, the cooperative network was quite resilient and we thank everyone for their sustained efforts and contributions.

Science highlights:

- Global mean CO_2 increased by about 2.5 ppm and reached 415 ppm in 2021. In the past decade, we observed the fastest sustained rate of CO_2 increases in the atmosphere from our record. In 2021, global CO_2 emissions from fossil fuel burning increased by 5.1% relative to 2020, bouncing back to pre-COVID 2019 levels.
- A 1% increase in global fossil CO_2 emissions is projected for 2022 by Global Carbon Project (Friedlingstein et al. 2022: https://doi.org/10.5194/essd-14-1917-2022), reaching 37.5 Gt CO_2.
- Global mean CH_4 increased by 18 ppb in 2021, the largest annual increase in the global cooperative network record. A few recent studies suggest a dominant contribution from increased wetland emissions for the record high CH_4 growths in 2020 and 2021 (Feng et al., 2022: https://doi.org/10.5194/acp-2022-425; Peng et al. 2022: https://doi.org/10.1038/s41586-022-05447-w).
- Radiative forcing quantifies the energy imbalance due to the perturbation of added GHGs to Earth's atmosphere. During 2021, CO_2 was responsible for 64% of the forcing by all GHGs; its rate of increase during the last five years accounts for 78% of the total increase in GHG forcing (https://gml.noaa.gov/ccgg/ghgpower/).

Reminders… please:

- Return broken flasks and parts
- Use oldest flasks first
- Double check that sample information is complete on sample sheets
- Make sure to check appropriate time and date units on sample sheets: Coordinated Universal Time (UTC), Local Standard Time (LST) or Daylight Saving Time (DST))
- Connect lower flask number first (pump) and higher flask number second (return)
- Record pump unit # on the sample sheet
- Contact us if you have any questions, flask supply issues or equipment problems

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