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

Welcome to the 2020 NOAA Cooperative Global Air Sampling Network newsletter. We thank all co-operating partners and network affiliates for their continued support. This newsletter comes to you as the world continues to grapple with the global COVID-19 pandemic. Through this crisis, our work documenting the main drivers of climate change remains important. At NOAA, many of us are working remotely, but so far we have been able to maintain essential staff at our facilities in Boulder and at the Observatories to keep the measurements going as regularly as possible. We are doing our best to adjust the network logistics. In the weeks or months ahead, however, there may be disruptions to shipping and receiving air sample flasks that are out of our control. As always, please reach out to us at ccggflask@noaa.gov if you have any questions.

Our long-term flask-air measurements have been instrumental in documenting the global rise in the major long-lived greenhouse gases (LLGHGs) responsible for climate change. Figure 1 on page 4 shows globally averaged CO_2, CH_4, N_2O, and SF_6 determined from measurements from the air samples you collect for us. As described in previous newsletters, these observations are used in our “Trends” webpages to keep the public informed on how rapidly atmospheric greenhouse gas burdens are increasing. These observations are also used to calculate the contribution of LLGHGs to climate forcing from the pre-industrial era to modern times (3.18 W m^{-2} in 2018). In the next section of this newsletter, we give some examples of ways to think about this enormous amount of energy being added to our climate system.

New Annual Greenhouse Gas Index

Quantifying natural and anthropogenic changes to the flow of energy in and out of Earth’s climate is fundamental to understanding global climate change. Our Annual Greenhouse Gas Index (AGGI) webpage (https://www.esrl.noaa.gov/gmd/aggi/) focuses on the role of long-lived greenhouse gases (LLGHGs) in changing climate forcing since the start of the industrial revolution. This year, we are revising our AGGI webpage to present it in a broader context by indexing it to the percent increase in energy absorbed by the climate system due to LLGHGs compared to pre-industrial times. We quantify the change in climate forcing (also called radiative forcing) by determining the atmospheric increase in LLGHG global mean burdens from pre-industrial times until today. Preindustrial values are determined from measurements of air bubbles extracted from ice cores drilled in very old ice sheets in Greenland and Antarctica. In 2018, LLGHGs were responsible for 3.181 W m^{-2} additional climate heating (Fig. 2). This is 1.347% more energy trapped by the atmosphere than during the preindustrial era. How can we visualize that much energy? Multiplying that additional climate forcing by the surface area of Earth gives 1622 terawatts (one terawatt = 10^{12} watts). That is equivalent to the energy produced 24/7 by 1.6 million large (~1,000 megawatt) power plants. In terms of Earth’s climate, it is enough energy to melt about 5% of Greenland’s ice cap in one year, raising sea level by 37 cm. It is also enough energy to heat up, then evaporate, all the water in the North American Great Lakes (22600 km^3 of water) in about 14 months. And because some of the CO_2 and other LLGHGs emitted today will still be in the atmosphere hundreds of years from now, today’s emissions will continue to impact climate well into the future. https://www.eia.gov/energyexplained/electricity/electricity-in-the-us-generation-capacity-and-sales.php

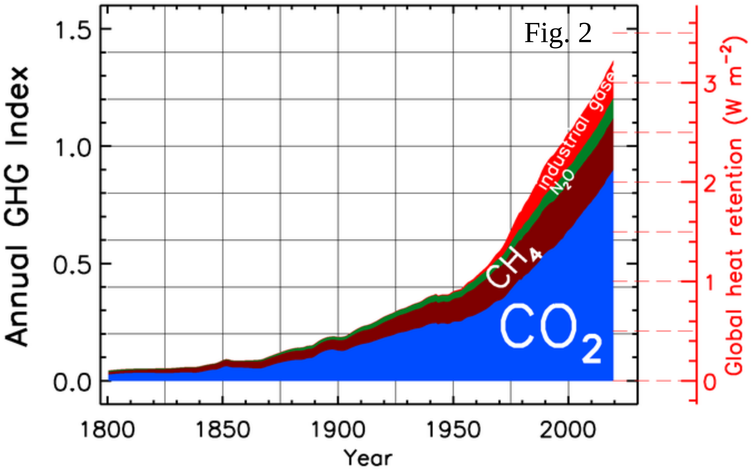
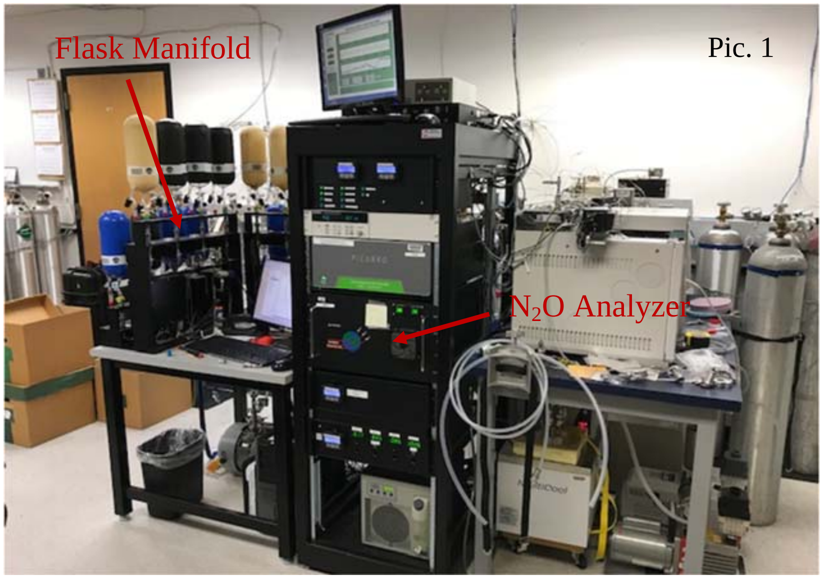


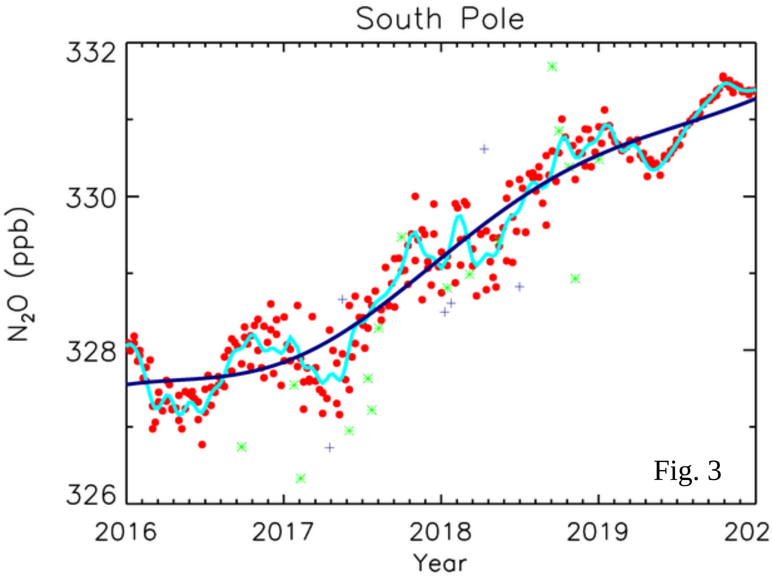
Fig. 2: Annual GHG Index climate heating from LLGHGs.

New Carbon Cycle Measurement System in the Boulder Labs

Our goal at NOAA is to make as many high-quality measurements as possible from the air samples collected by our Cooperative Global Air Sampling Network partners. Until August, 2019, we were using decades-old commercial technology to make the flask-air measurements: gas chromatographs, non-dispersive infrared analyzers, and similar technologies. About 15 years ago, new commercial analyzers based on highly-sensitive laser spectroscopic methods came to market for CO_2 and CH_4, and more recently for N_2O and CO. These extremely precise instruments work best for applications where gas can flow continuously through the analyzer, so we needed to design a system that utilized their excellent stability without using too much of our precious air sample. Once funds were available to purchase two new analyzers, it took 2 years of development and extensive testing by Andrew Crotwell, an internationally recognized expert in building systems to measure greenhouse gases and related species. Andrew made other improvements to gas handling, allowing us to seamlessly transition among different air sample types (e.g., flasks and tanks). While the precision improved for all four gases measured with this new generation of analyzers (CO_2, CH_4, N_2O, and CO), the largest improvement was for N_2O, where it was most needed. N_2O has a lifetime in the atmosphere of about 300 years and its emissions are relatively small. As a result, its spatial variations, north-to-south, east-to-west, and vertically are small, on the order of 1 ppb or less in the background atmosphere. The better we can resolve these differences in our measurements, the better we can assess N_2O emissions and how they change with time, especially those changes related to climate change. We began using this new system (MAGICC-3: Measurement of Gases that Influence Climate Change version 3) for all flask-air measurements in late-summer, 2019 (Pic. 1). Figure 3 shows N_2O at South Pole, Antarctica, and the reduced scatter starting in 2019 is readily apparent.



Pic. 1 (above): The new MAGGIC-3 system for measuring discrete flask-air samples.
Fig. 3 (below): Time series of atmospheric N_2O at South Pole, Antarctica measured with our older analytical system (sample dates 2016 to Jan 2019) and new Magicc-3 system (Feb to Dec 2019). Precisions have improved from ~ 0.4 ppb to ~ 0.05 ppb.



Introducing….
In April 2020, NOAA's Global Monitoring Division (GMD) became the new Global Monitoring Laboratory (GML). GML maintains its mission to monitor aspects of the global atmosphere linked with climate forcing, air quality and the recovery of the ozone layer.

Cape Kumukahi, Hawaii Site - Volcanic Disruption

While we track important changes in our atmosphere, Hawaii changes her landscape right beneath our feet. For more than 40 years NOAA staff at the Mauna Loa Observatory have collected network air samples from the lighthouse at Cape Kumukahi on the "Big Island" of Hawaii (site code 'KUM'). The eastern most point of Hawaii, this location is ideal for sampling background Pacific Ocean trade winds. In May 2018 Kilauea volcano erupted (not for the first time) in a residential area not far from the lighthouse. Within a week there were multiple fissures, requiring evacuation of the area. By the end of May the lava flow had blocked access to the lighthouse, and the lava continued to flow until September 4th. The lighthouse is still standing, but access is cut off by nearly 200 meters of rugged lava (Pic. 2); and beyond the lava it is still 3 kilometers to the lighthouse. The observatory staff collected one last sample pair from the Cape on May 15, 2018.

The staff searched carefully along the eastern coast of the island for a reasonable alternative sampling location. This was not easy since most of the coast is rugged and covered in vegetation. Ironically, one of the reasons the Cape is a great sampling site is that previous lava flows reduced the coastal vegetation to a minimum in the vicinity of the lighthouse. The staff identified two alternative, but less ideal, sampling locations. Since late May 2018 the observatory staff have been choosing one of these sampling locations weekly, based on wind direction and other practical considerations, to collect the KUM air samples. In addition to our normal network samples the staff collects samples for other projects as well, and the logistical needs of these projects are challenging to meet at these alternative locations - but crossing 200 meters of rough lava is not easy either. We hope to collect samples from Cape Kumukahi again one day, but we are not aware of a definite plan to restore road access to the lighthouse.


Pic. 2

Pic. 2: The beginning of 200 meters of lava flow blocking access to Cape Kumukahi, Hawaii.

Pat Lang's Retirement

In 1984 Patricia (Pat) Lang was waffling between accepting a job offer as a university soccer coach and another opportunity in a laboratory making measurements of atmospheric air samples. Last April, Pat retired from our lab as lead of operations for the MAGICC lab. Yes, after almost 35 years dedicated to measuring samples from the networks of surface, aircraft and tall tower sites around the world, she was ready for something else. We calculated that she had measured and quality-controlled approximately 450,000 samples, a significant percentage of all the samples collected throughout the history of the lab. Staying mostly behind-the-scenes, Pat made an enormous contribution to the world's understanding of global greenhouse gases. We miss her! But we do wish her well. She's moved on to more travels, outdoor adventures, time with family, and rowing with her crew team.

Contact Information:
Molly Crotwell: 303-497-4728
Eric Moglia: 303-497-3988
Don Neff: 303-497-4271
Sonja Wolter: 303-497-4801

Fax: 303-497-6290

E-mail: ccggflask@noaa.gov

Shipping Address:
Attn: Prep Lab, Rm GD305
NOAA/GML-1
325 Broadway
Boulder, CO 80305
USA

Interested in learning more? Check out these links:
GML home page: www.esrl.noaa.gov/gmd/
CCGG home page: www.esrl.noaa.gov/gmd/ccgg/
Cooperative Network: www.esrl.noaa.gov/gmd/ccgg/flask.php

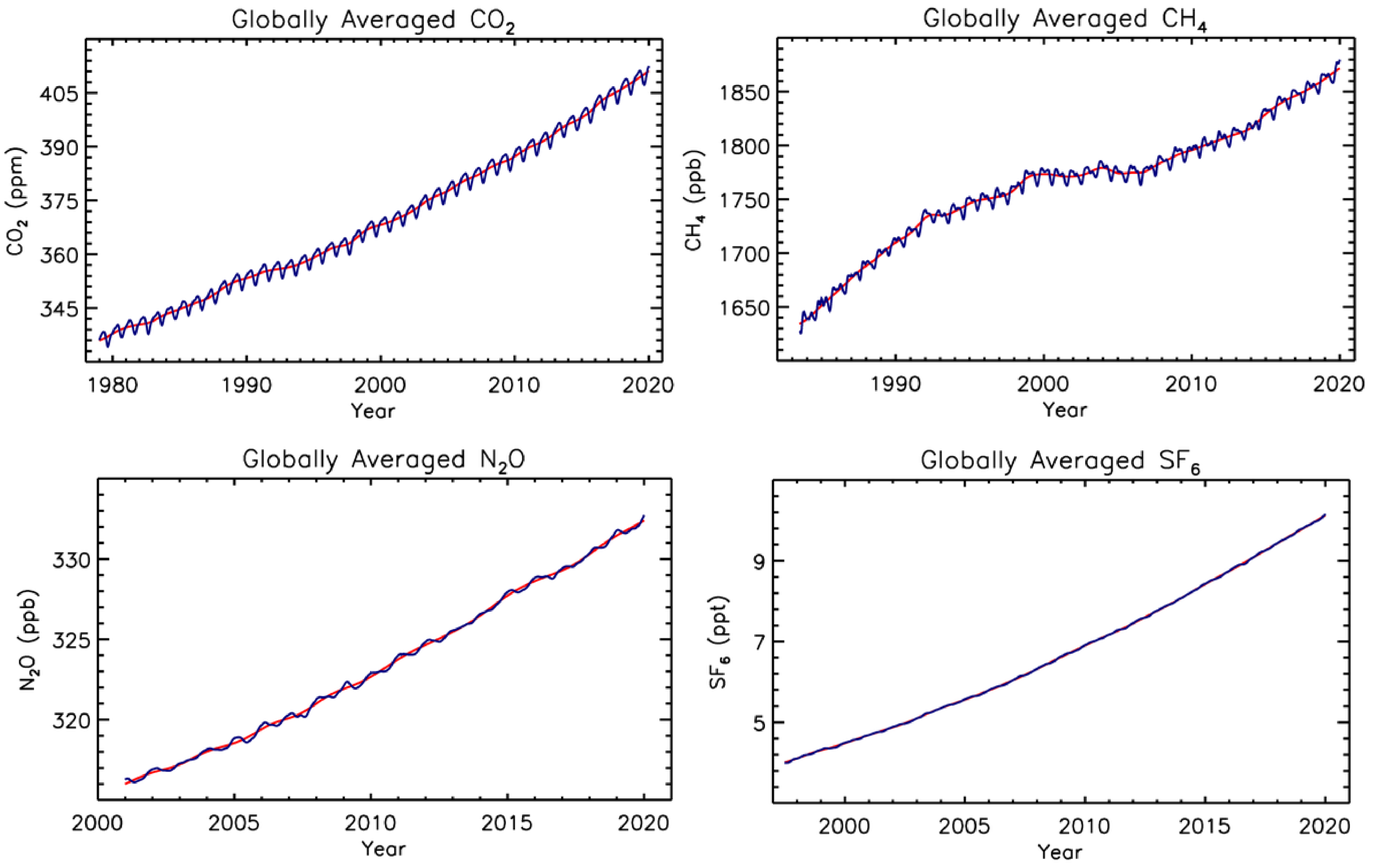


Figure 1: Globally-averaged monthly mean carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O) and sulfur hexafluoride (SF_6) over marine surface sites (see https://www.esrl.noaa.gov/gmd/ccgg/mbl/ for more information). The blue line represents the monthly mean values, centered on the middle of each month. The red line represents the same, after correction for the average seasonal cycle.