NOAA GMD's Global Greenhouse Gas Reference Network Management, Logistics, and Importance

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1. Introduction

- Beginning in 1967, the NOAA Carbon Cycle Greenhouse Gases (CCGG) group's Global Greenhouse Gas Reference Network (GGGRN, Fig. 1) provides spatially and temporally consistent data for use by scientists worldwide.
- GGGRN focuses on the collection and analysis of background air samples for CO_2, CH_4, N_2O, SF_6, H_2, CO, stable isotopes of CO_2 and CH_4, and VOC's.
- The network includes semi-continuous measurements from 4 baseline observatories (Fig. 1, blue squares), background air samples collected by volunteers at ~60 sites (red dots), automated air samples at tall towers (green triangles), and vertical profile air samples via small aircraft across North America (blue stars).
- A network of this scale and complexity requires continuous management due to a variety of difficult logistical concerns and communication challenges.

2. Network Management/Operations

- GGGRN requires daily preparation and logistical planning, equipment management, and ongoing international communication.
- Equipment supply, equipment repair/turnaround, and targeted deployment all must be managed to mitigate equipment-related gaps in sampling.
- Communication with sample takers/site contacts as well as the various shipping entities are central to success.
- Air samples are collected in 2.5 liter glass flasks (Fig. 2) at surface sites with portable sampling units (PSU, Fig. 3) and in 0.7 liter automated glass flasks contained in Programmable Flask Packages (PFP, Fig. 4/6) at aircraft and tall tower network locations.


Fig. 3


Fig. 4

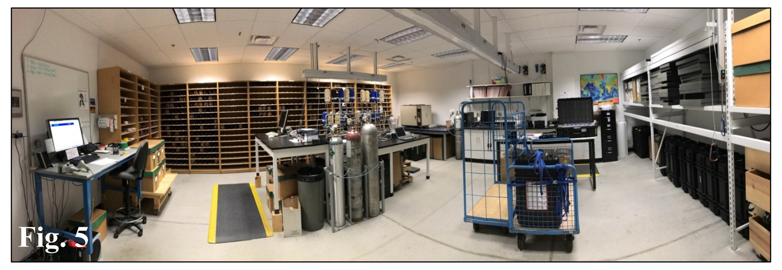


Fig. 5

- Daily operations and equipment preparation occurs in the Flask Logistics Lab (Fig. 5) . It is here where all of the ~16,000 yearly flask-air samples are received, cataloged, and routed to various analysis laboratories.
- Prepared flasks (Fig. 2) and/or PFP's (Fig. 6) are shipped to a site (Fig. 1), air samples are collected (Fig. 3), samples are returned to Boulder, Colorado for measurement (Fig. 7), and then prepped for reuse post-analysis (Fig. 8).
- All network flasks and equipment are managed with software called Operations Manager or OM which tracks location and status using numerical barcodes (Fig. 9/10) .

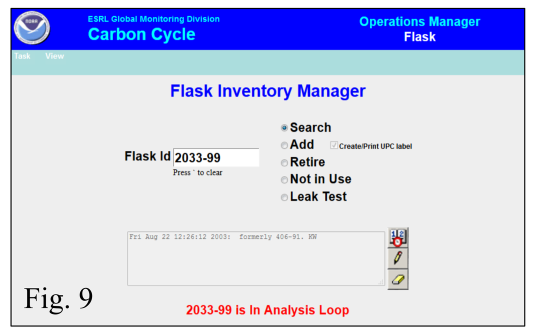


Fig. 9

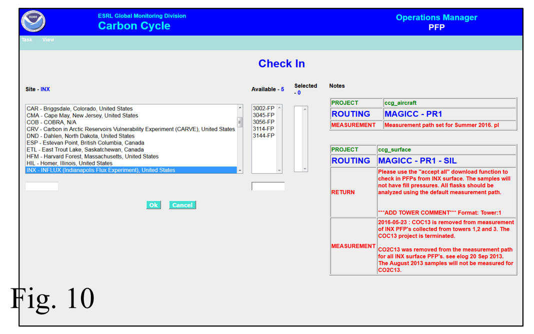


Fig. 10

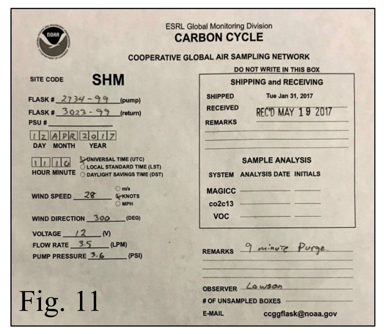


Fig. 11

- Samples are checked-in to OM and assigned a unique "event number" that defines each flask sample according to sample sheet info; date/time, meteorological/GPS data, and measurement path (Fig. 11) . The event data is saved in a relational database that allows for the storage of all sample info in one place, easy access by multiple labs, and quick cross-matching of results.
- Post-analysis, the flasks and PFP's are returned to the logistics lab to be evacuated/flushed and filled with an artificial gas with below ambient CO_2 and zero CH_4/SF_6 before reuse in the field (Fig. 8) .

Fig. 2

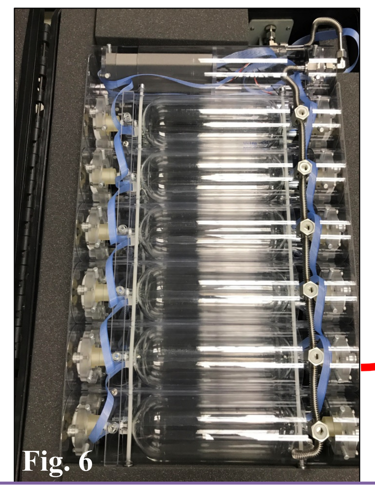


Fig. 6

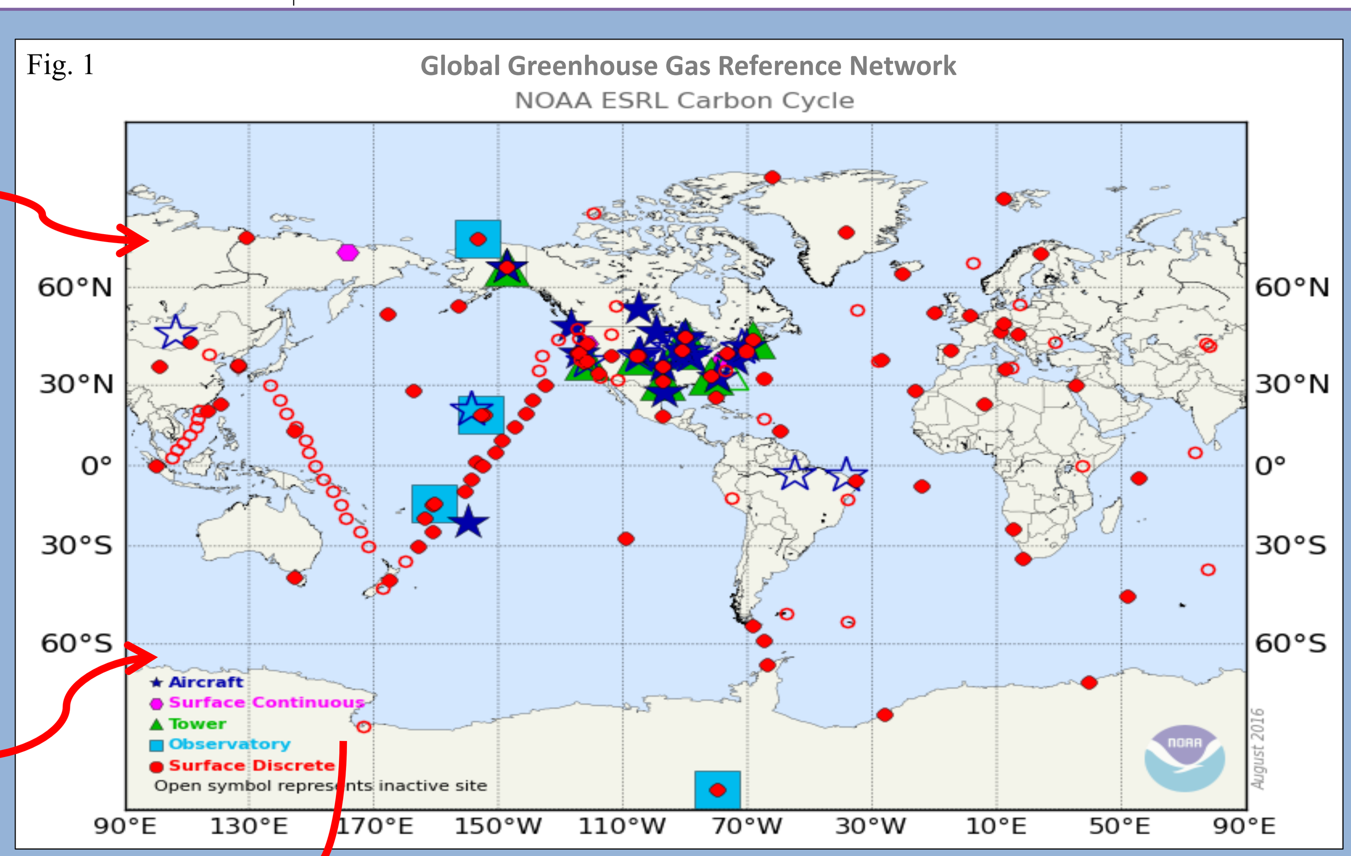


Fig. 1


Fig. 7


Fig. 8

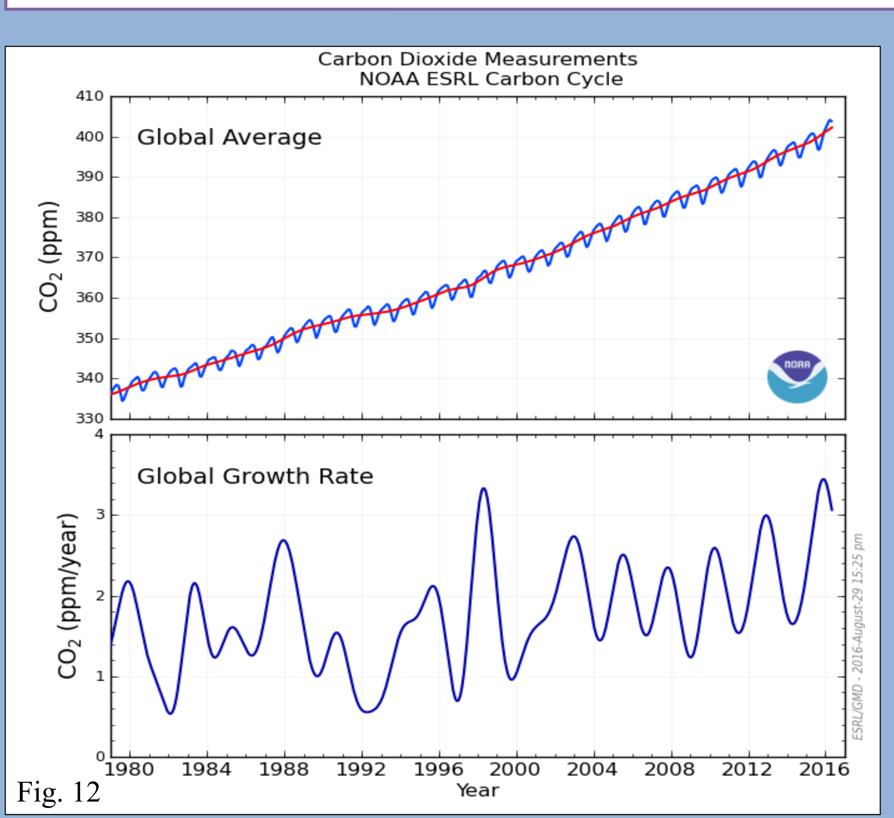


Fig. 12

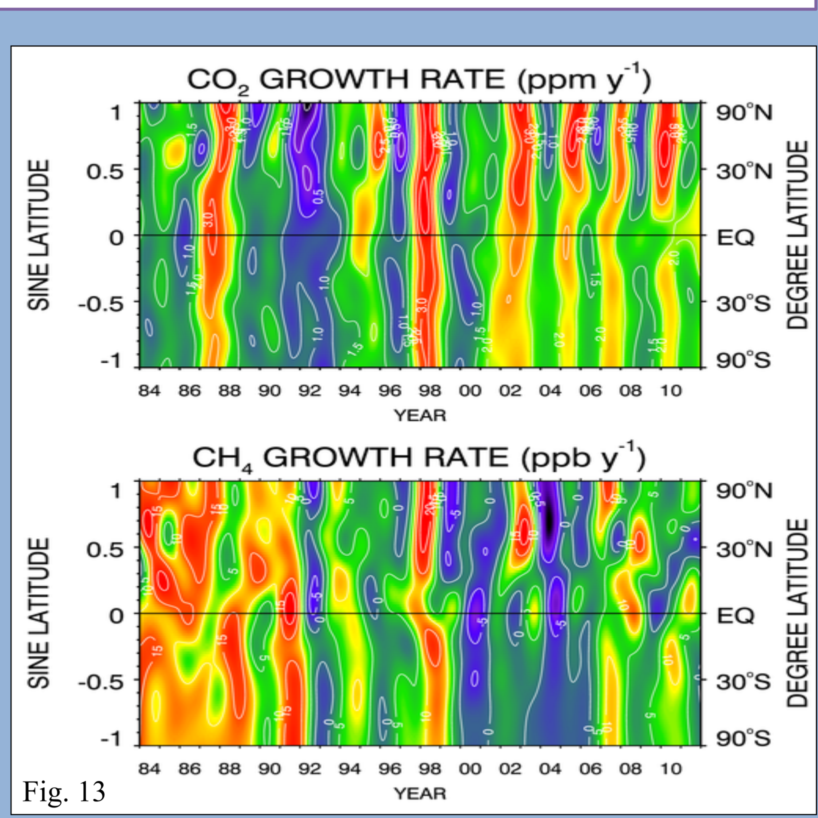


Fig. 13

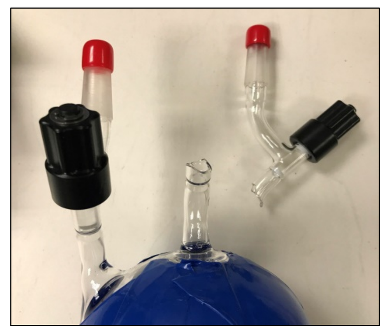
3. Logistics

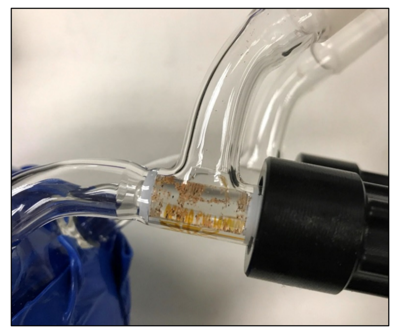
- Efficient, consistent, and affordable logistics are essential to the health of the reference network and to the success of the individual sites.

- When a flask or PFP is returned from the field, a replacement is sent out the next day. Exceptions include special research projects and remote locations, such as South Pole or Summit, Greenland, that require yearly shipments of flasks on barges or transport aircraft.
- We use US Embassies at seven of our international sites and 3rd party shipping (FedEx/UPS/DHL) for the rest.

Sites Utilizing Embassies		
EIC - Easter Island, Chile	HUN – Hegyhatsal, Hungary	PAL – Pallas, Finland
TAP – Tae-ahn Pen., Korea	USH – Ushuaia, Argentina	UUM – Ulaan Uul, Mongolia
WLG – Mt. Waliguan, China		

- Dealing with customs can be difficult and in some cases impossible. It often takes days or weeks to get shipments cleared.
- Special projects and campaigns puts stress on equipment supply causing flask and PFP shortages.
- Other common issues include adverse weather conditions restricting access to sites, flask breaks, boxes lost in transit, flask misplacement on site, environmental disasters, site relocation, both legal and illegal seizure of equipment, and changes/cuts in the funding of collaborating groups.


Broken Flask


Sand in flask valve, Namibia


PFP's in repair

4. Importance and Practical Applications

- GGGRN provides data used to identify long-term trends, seasonal variability, and spatial distribution of carbon cycle gasses to aid in our understanding of the global carbon cycle.
  - Fig. 12 - Top: Global average atmospheric carbon dioxide ratios (blue line) and long-term trend (red line). Bottom: Global average growth rate for CO_2.
  - Fig. 13 - CO_2 and CH_4 growth rates as a function of time and latitude.
- This information is crucial to enable governments, advocacy groups, and society in general to make informed decisions on energy policy, environmental policy, and social policy with the focus on mitigating climate change.
- GGGRN comprises ~half of the sites included in the Global Atmosphere Watch network of the World Meteorological Organization (WMO).
- The data from the network is freely available on the internet and widely used by scientists within NOAA and at other national and international institutions in studies of the carbon cycle and climate change.
- GGGRN measurements are used to create a variety of data products including CarbonTracker, ObsPack, GLOBALVIEW, and the NOAA Annual Greenhouse Gas Index.