The Barrow Atmospheric Baseline Observatory

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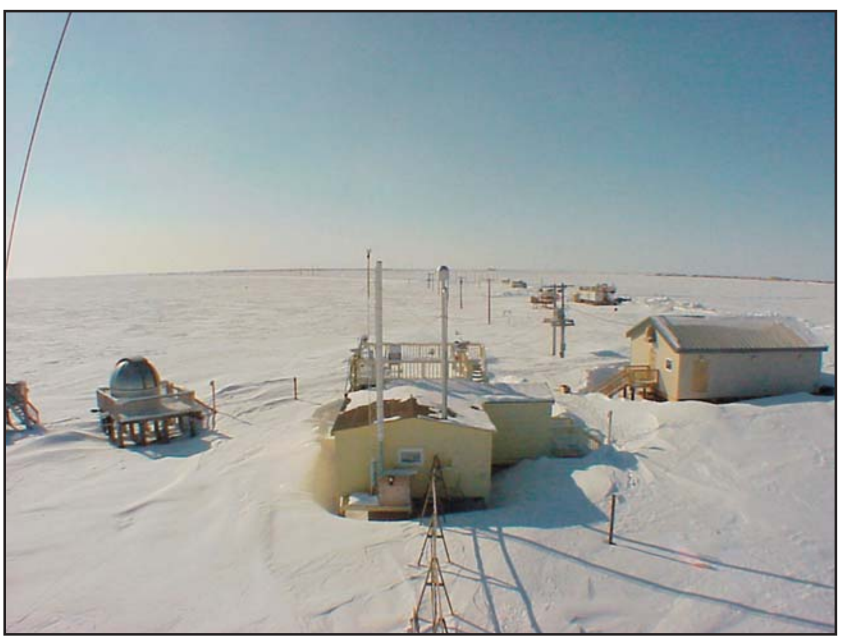
NOAA's Climate Monitoring and Diagnostics Laboratory (CMDL) operates the manned Atmospheric Baseline Observatory six miles east of Barrow, Alaska (71.3°N; 156.6°W). The observatory measures changes in atmospheric climate forcing agents such as carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), sulfur hexafluoride (SF_6), climate-forcing and stratospheric-ozone-depleting chlorofluorocarbons, air pollution from Eurasia known as Arctic Haze, and solar radiation, to name only a few of the more than 200 measurements conducted at the facility. NOAA established the observatory in 1973 in an 800-ft^2 building in use today. In recent times the observatory has taken on the support of 16 cooperative research projects from other agencies and universities, with a concentration of projects from the University of Alaska. Two permanent CMDL staff operate the facility.



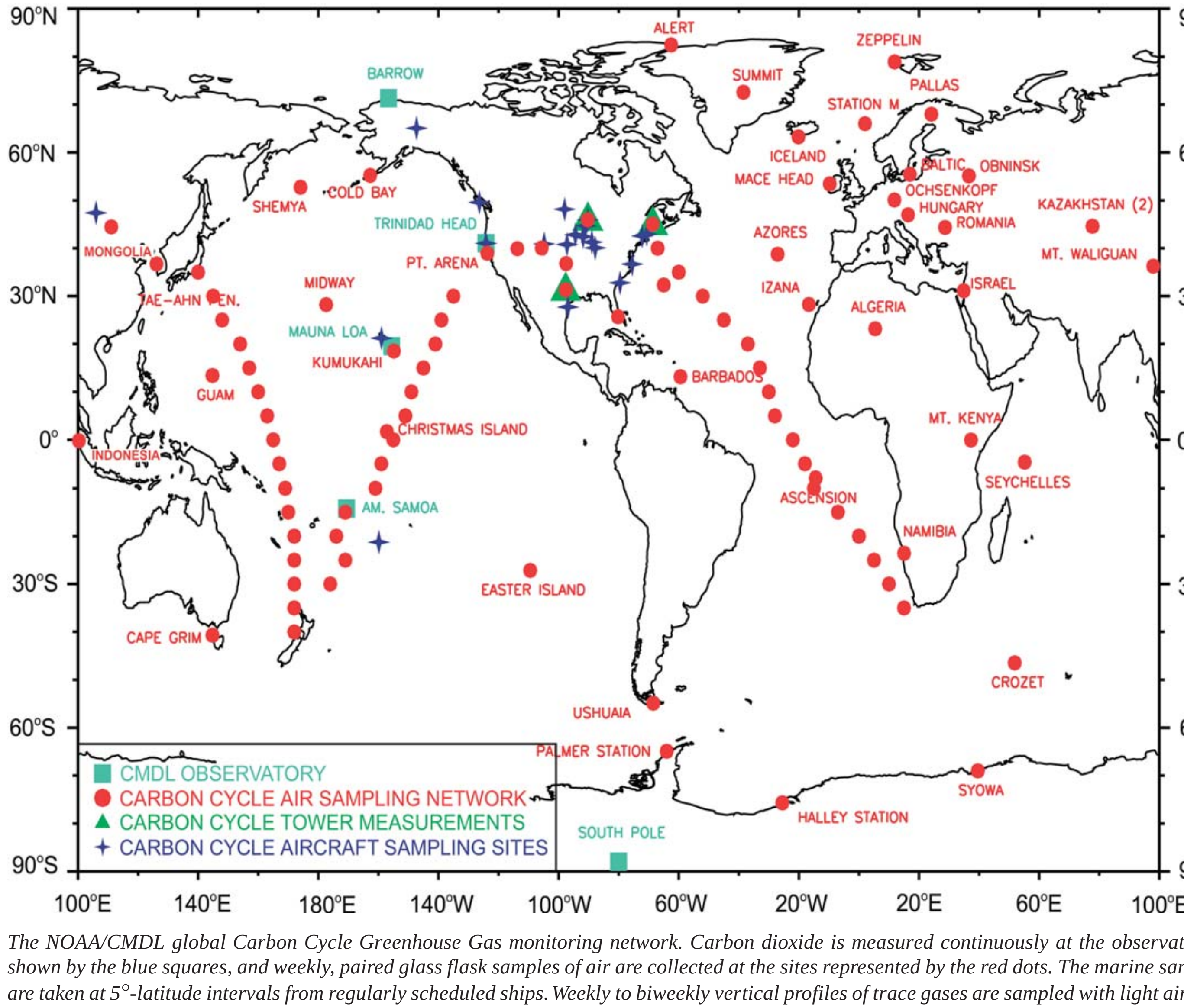
NOAA/CMDL Barrow Atmospheric Baseline Observatory, viewed from the east near the base of the 20-m sampling tower. The former Naval Arctic Research Laboratory is on the upper right horizon. The DOE ARM facilities are above and to the left of the garage (center right), with the USGS Magnetic Observatory above and to the left of the white DOE building. The Barrow Atmospheric Baseline Observatory is in the center of the view, and the Dobson ozone spectrophotometer dome is at center left. Winds persistently blow from the point of the photograph towards the main observatory building.

The observatory is situated near the center of an 80-acre parcel of Federal land one mile south of a DOD radar facility, through which the observatory access road passes. The CMDL acreage is bounded on the west by an 80-acre parcel of Federal land that is home to the U.S. Geological Survey's Barrow Magnetic Observatory and on the south and east by the 7,500-acre Barrow Environmental Observatory (BEO), land preserved for scientific research. Adjacent to the main building is a two-vehicle garage with gas cylinder storage space. Additional facilities consist of a 60-ft-tall walk-up sampling tower, three elevated platforms for instrument support, and a number of smaller towers and instrument installations on the tundra. The observatory site is host to a Department of Energy Atmospheric Radiation and Monitoring (ARM) facility, two NOAA National Environmental Satellite, Data, and Information Service (NESDIS) polar-orbiting satellite downlink antennas, and a NOAA Climate Reference Network (CRN) station.

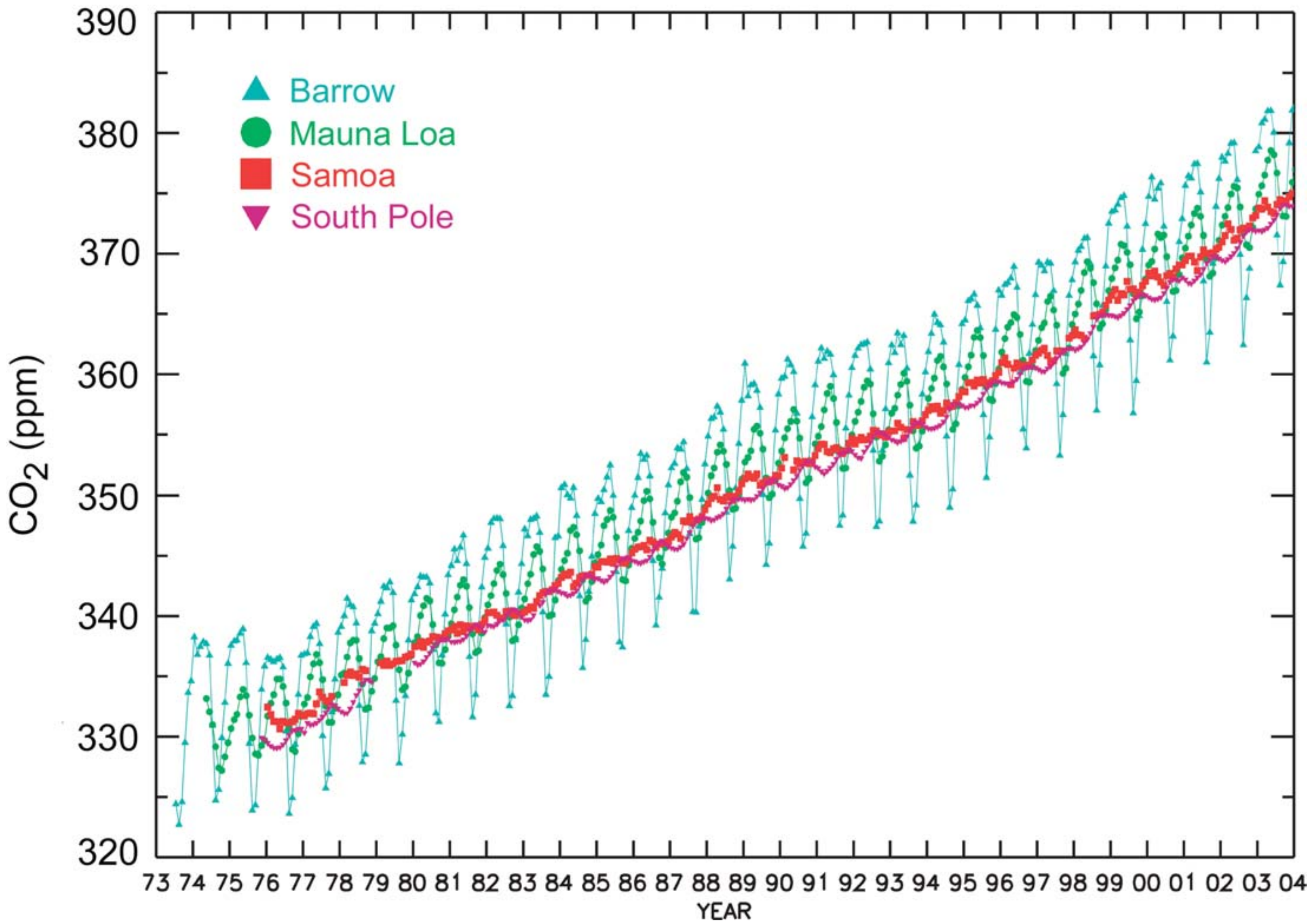
The observatory facility does not have any internal combustion sources or volatile chemicals that might contaminate the trace gas measurements conducted within the facility. Vehicle traffic near the station is controlled, and there are no roads upwind of the observatory. Some observatory measurements require a view of the natural surface that is unaffected by anthropogenic influences and will be maintained in such a state for at least a century or more. The upwind clean-air sector (45° through 100°) is expected to remain a clean-air sector in perpetuity unless oil production facilities are installed in the Arctic Ocean within a 100-mile radius upwind of Barrow.

The Barrow Atmospheric Baseline Observatory is the farthest north of the five manned observato-

NOAA National Environmental Satellite, Data, and Information Service (NESDIS) 3-m (left) and 4-m (right) High Resolution Picture Transmission (HRPT) downlink antennas for the NOAA Polar Operational Environmental Satellite (POES) at the observatory site. These antennas allow for near-real-time downloads of ice and cloud conditions over the Arctic Ocean.



The NOAA/CMDL global Carbon Cycle Greenhouse Gas monitoring network. Carbon dioxide is measured continuously at the observatories shown by the blue squares, and weekly, paired glass flask samples of air are collected at the sites represented by the red dots. The marine samples are taken at 5°-latitude intervals from regularly scheduled ships. Weekly to biweekly vertical profiles of trace gases are sampled with light aircraft at the blue- starred locations.



Monthly mean carbon dioxide concentrations determined from continuous analyzers at four NOAA/CMDL baseline stations. Note the large relative amplitude of the CO_2 cycle at Barrow, which is a combination of transport of fossil fuel combustion effluents from lower latitudes and high primary productivity in the northern hemisphere and mid-latitude forests and agricultural regions.

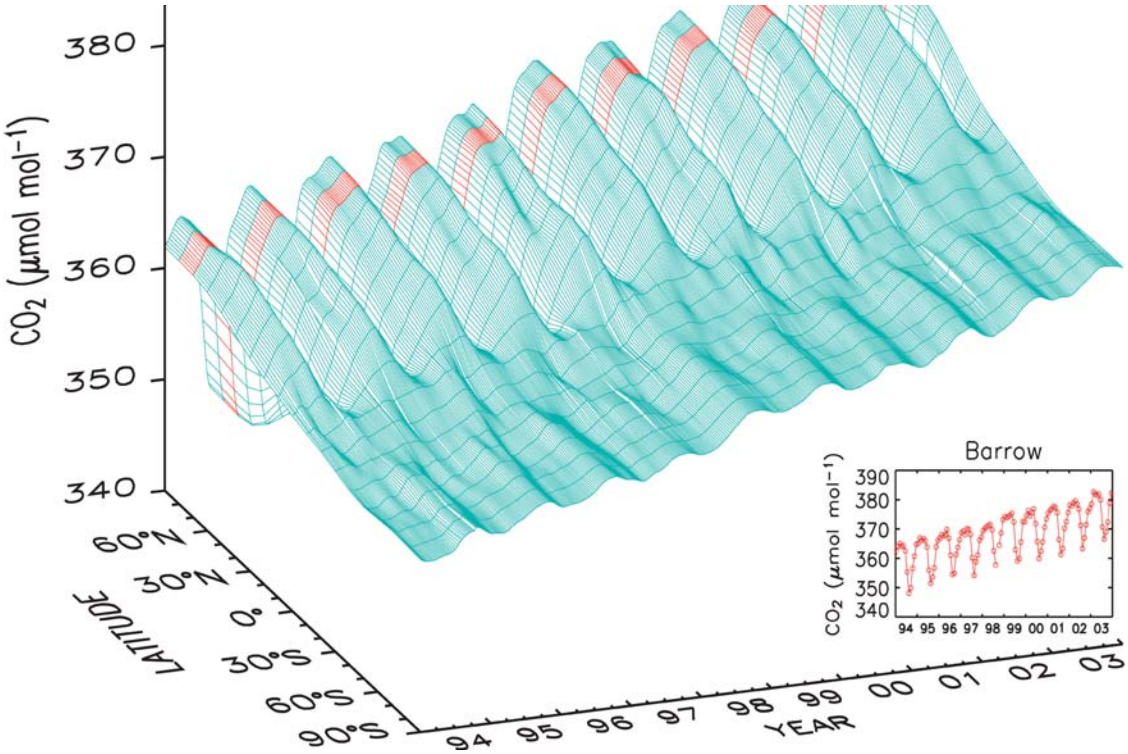
ries operated by CMDL; the others are at Trinidad Head, California; Mauna Loa, Hawaii; American Samoa; and South Pole. Carbon dioxide has the largest total cumulative direct radiative climate forcing in the atmosphere—about three times greater than CH_4, six times greater than the CFCs, and 15 times greater than N_2O. Sulfur hexafluoride (SF_6), although a strong greenhouse gas and increasing in the atmosphere, is present in low concentrations and has a much smaller net effect on total radiative forcing than the other greenhouse gases.

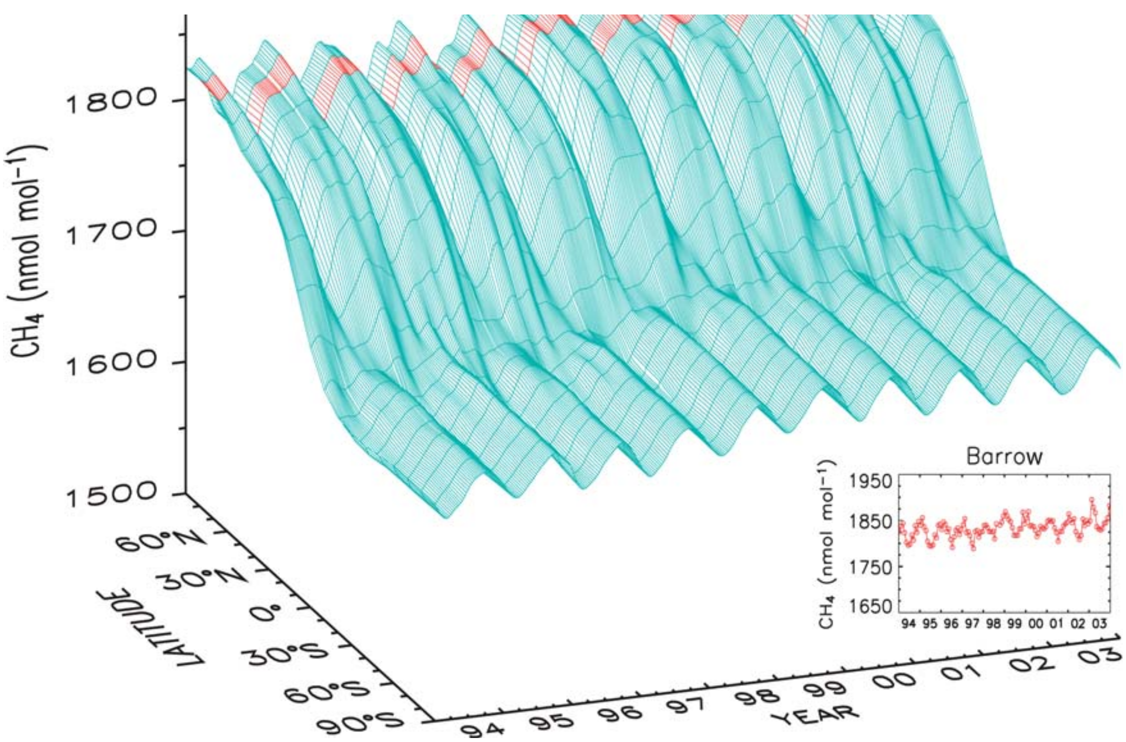
Carbon Dioxide and Methane Measurements

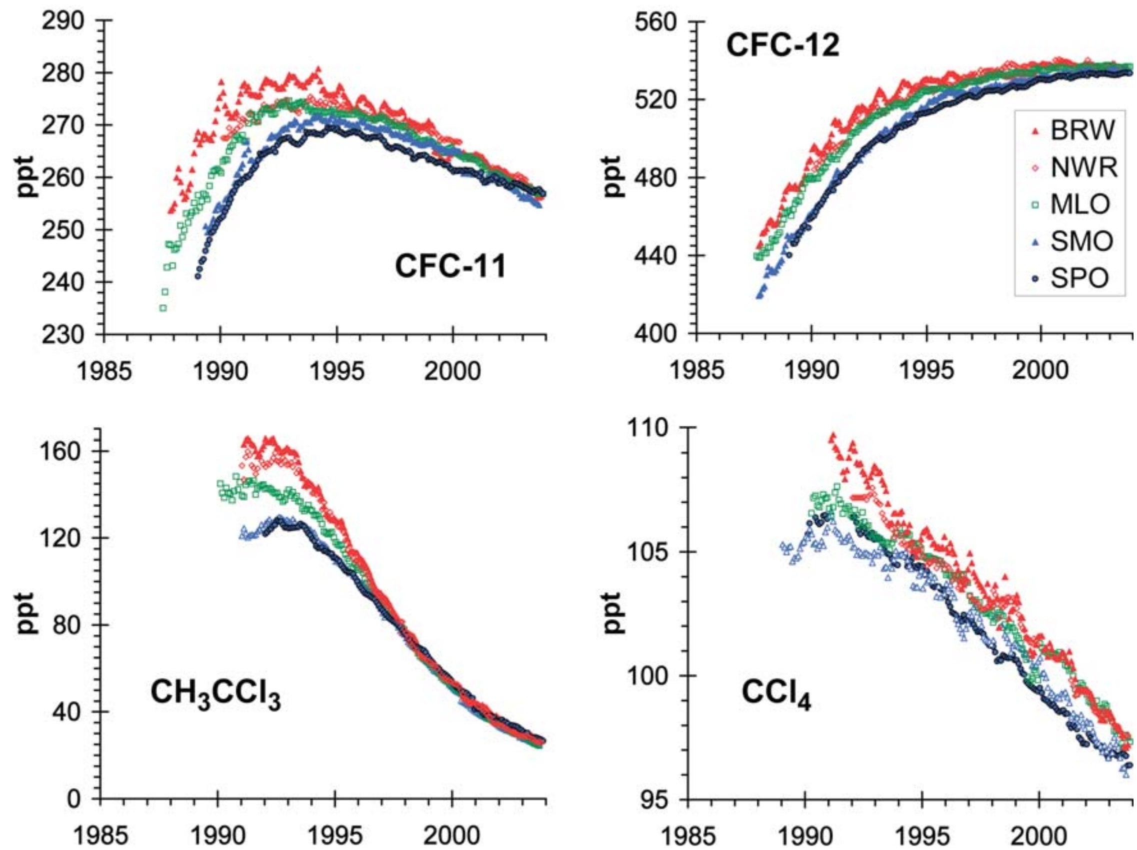
Most of the landmass on earth is in the northern hemisphere, as is vegetation and the human population. Anthropogenic activities at lower latitudes produce combustion effluents that result in high background CO_2 concentrations at Barrow and other locations in the Arctic thousands of kilometers north of the sources because of northward transport of the gases. Similarly, even though Barrow has very low annual plant growth, forests and agriculture in regions such as in Russia and Canada, well south of the latitude of Barrow, dominate the summer CO_2 drawdown in the high Arctic. Combined, these factors produce the largest annual background CO_2 cycle on earth.

Methane measurements at Barrow show that the Arctic also has the highest annual CH_4 cycle amplitude on earth, as well as the highest winter concentrations of the gas compared to lower northern latitudes and the southern hemisphere. This is caused by complex interactions between CH_4 sources and sinks and transport of mid-latitude air into the Arctic. Global average atmospheric CH_4 concentrations increased from 1625 ppb during 1984 to 1751 ppb during 1999 and then have remained essentially constant for the past five years. This is a large decrease in the methane growth rates compared to 1983, when the growth

Three-dimensional views of the global distribution of carbon dioxide (top) and methane (bottom) over time, showing the large amplitude of both cycles in the northern hemisphere. The 10°-latitude band that encompasses the Barrow data is indicated in red on the three-dimensional graph.







Concentrations in tropospheric mixing ratios of the chlorofluorocarbons (CFCs) controlled by the Montreal Protocol and measured at five CMDL measurement sites from Barrow, Alaska, in the Arctic to South Pole, Antarctica. Note that the Barrow concentrations, shown in red, are for the most part higher than measurements at lower latitudes.

rate was 13.5 ppb. It is not yet known if this change in the atmospheric methane growth rate is a temporary pause or a new, and as yet unexplained, steady state.

CFCs, Nitrous Oxide, and Sulfur Hexafluoride

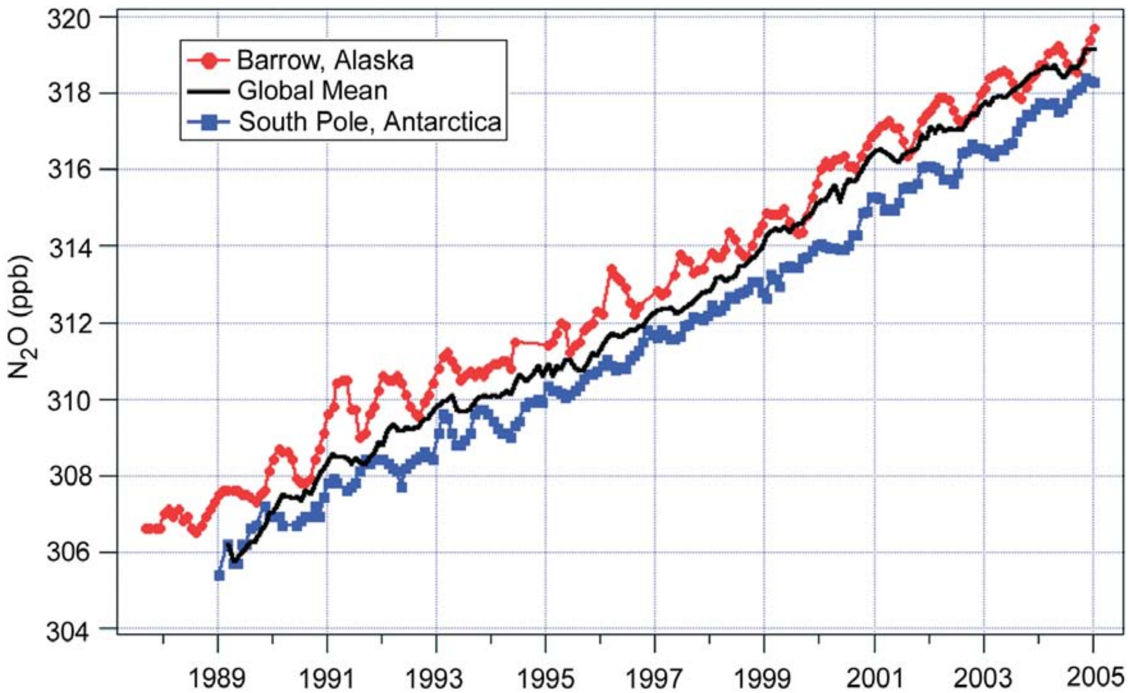
Concentrations of anthropogenic chlorofluorocarbon-11 (CFC-11), CFC-12, methyl chloroform (CH_3CCl_3), and carbon tetrachloride (CCl_4) in the atmosphere have decreased since 1991 in response to the international treaty known as the Montreal Protocol to Reduce Chemicals that Deplete the Ozone Layer and its subsequent amendments. The amount of the decrease for each compound, after production was reduced or ceased, is related to how quickly the compound is naturally destroyed in the atmosphere; methyl chloroform has an atmospheric lifetime of 5.5 years and is decreasing fast compared to CFC-11, which has a lifetime of 45 years, and CFC-12, with a lifetime of about 100 years. The Arctic typically has higher levels of these anthropogenic gases than at lower latitudes, as atmospheric transport moves air pollution from heavily populated northern mid-latitudes into the Arctic, where the gas concentrations build up, especially in winter.

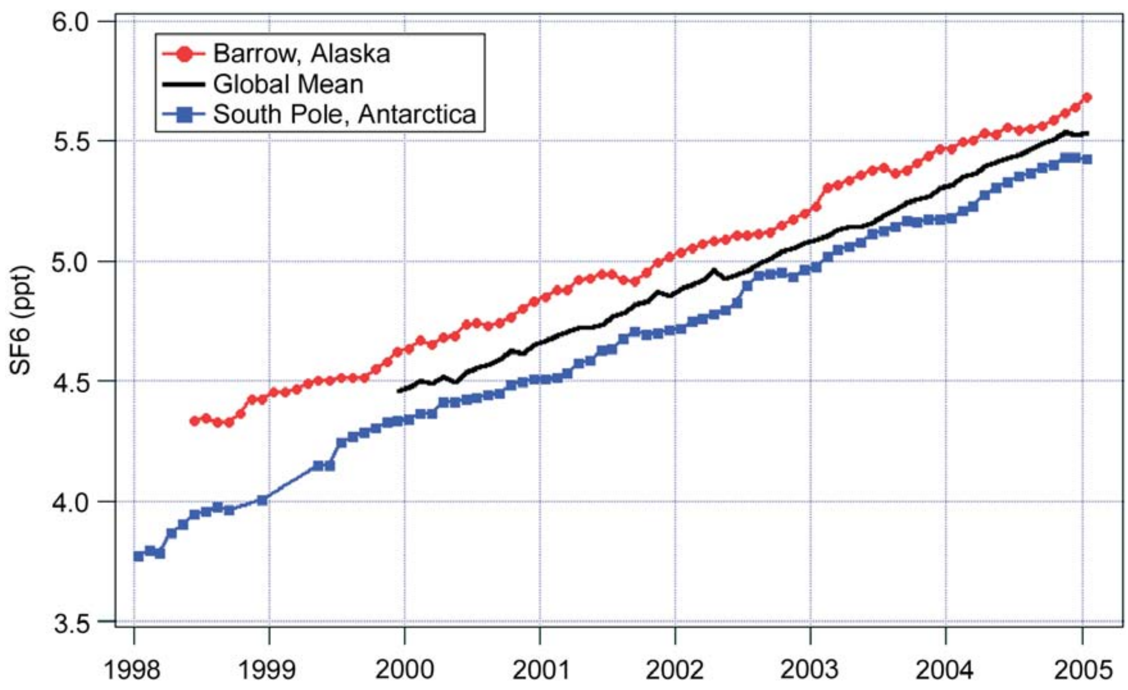
The concentrations of nitrous oxide and sulfur hexafluoride at Barrow continue to grow. Nitrous oxide is produced in conjunction with fossil fuel combustion and oxidation of agricultural fertilizers, whereas sulfur hexafluoride is produced by a limited number of manufacturers mainly supplying the electricity transmission industry. N_2O has a seasonal cycle at Barrow, with a clear wintertime peak in February. SF_6 is steadily increasing in the atmosphere at a rate of 5% per year, and its sources are in the northern hemisphere.

Advance of Snowmelt Date and Springtime

The date on which the last snow melts in the Barrow area, defined as the last day when one inch of snow can no longer be measured, has been monitored by the National Weather Service (NWS) since 1940 and by CMDL since 1986. The snowmelt date at the Barrow Atmospheric Baseline Observatory has advanced by 10.2 days in 64

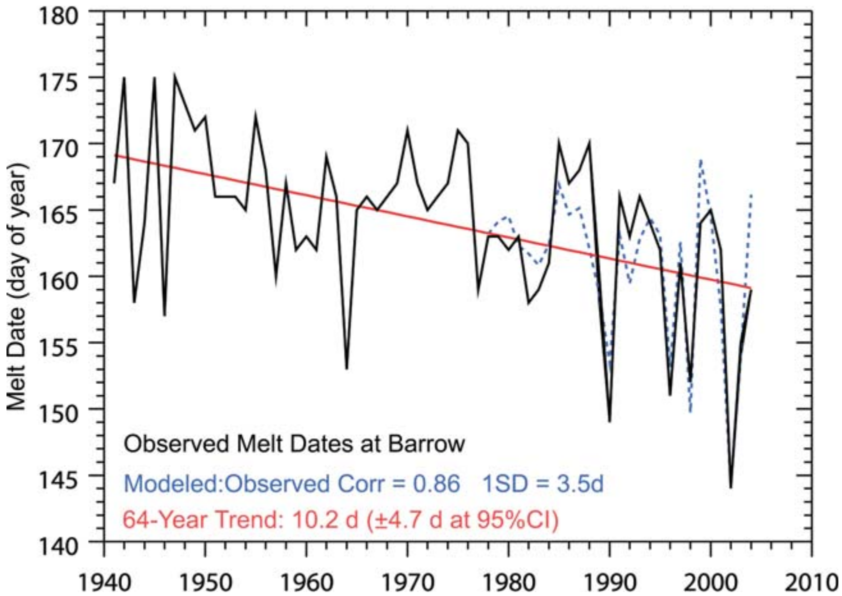
Global tropospheric mixing ratios for N_2O (top) and SF_6 (bottom). Global means were determined from measurements made by on-site instrumentation and from air collected in flasks in the NOAA cooperative sampling network that were subsequently analyzed by NOAA/CMDL in Boulder, Colorado.





years. This is a significant advance at the beginning of the snow-free period, which is in the range of 85–135 days in Barrow. The causes for this increase in snowmelt date are believed to be a combination of decreased snowfall in winter and higher spring temperatures brought on by changes in both winter and spring Arctic air-flow patterns.

Whatever the causes of the advancing snowmelt date, one species of bird that nests on the observatory property is taking advantage of the earlier spring. In the summer of 2002, snow buntings raised two clutches of chicks in the Barrow area, the first time this has ever been observed, according to the local Inupiat hunters and elders.



Observed dates of snowmelt at Barrow, showing an advancing trend over the past 64 years.

Baby snow bunting (top) hatched near the Barrow observatory and a parent (bottom) looking for insects to feed this second-hatch chick. In 2002 the early spring and consequent longer summer allowed snow buntings to successfully raise two sets of fledglings on the North Slope tundra, the first time this has been observed in Barrow in living memory.

References

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