WORLD METEOROLOGICAL ORGANIZATION
GLOBAL ATMOSPHERE WATCH

WMO GREENHOUSE GAS BULLETIN

The State of Greenhouse Gases in the Atmosphere Based on Global Observations through 2024

No. 21 | 16 October 2025

ISSN 2078-0796

The levels of the three most abundant long-lived greenhouse gases (LLGHGs), carbon dioxide (CO_2), methane (CH_4) and nitrous oxide (N_2O), reached new records in 2024. From 2023 to 2024, CO_2 in the global surface atmosphere increased by 3.5 ppm,(1) the largest one-year increase since modern measurements began in 1957. This increase was driven by continued fossil CO_2 emissions, enhanced fire emissions and reduced terrestrial/ocean sinks in 2024, which could signal a climate feedback. Given the dominant role of increasing atmospheric CO_2 in global climate change [1], achieving net-zero anthropogenic CO_2 emissions must be the focus of climate action. Sustaining and expanding greenhouse gas monitoring is critical to supporting such efforts.

Carbon dioxide is the dominant LLGHG driving global climate change today and has been throughout Earth's history [1]. Atmospheric CO_2 continued to increase in 2024, with no sign of slowing down. Globally averaged CO_2 at the Earth's surface reached 423.9 ppm in 2024. CO_2 growth rates accelerated significantly from an average of 0.8 ppm per year in the 1960s to 2.4 ppm per year in the decade from 2011 to 2020 (Figure 1), a direct response to increasing human emissions. From 2023 to 2024, CO_2 in the global surface atmosphere increased by 3.5 ppm; this was the largest one-year increase in the modern measurement record, exceeding the previous record of 3.3 ppm from 2015 to 2016 and surpassing the increase of 2.4 ppm from 2022 to 2023 by a large margin.

Atmospheric CO_2 levels result from the net difference between cumulative carbon emissions to the atmosphere and temporary removals by terrestrial ecosystems and the oceans. Since 1960, humans have emitted 500 ± 50 gigatons of carbon (GtC) to the atmosphere through

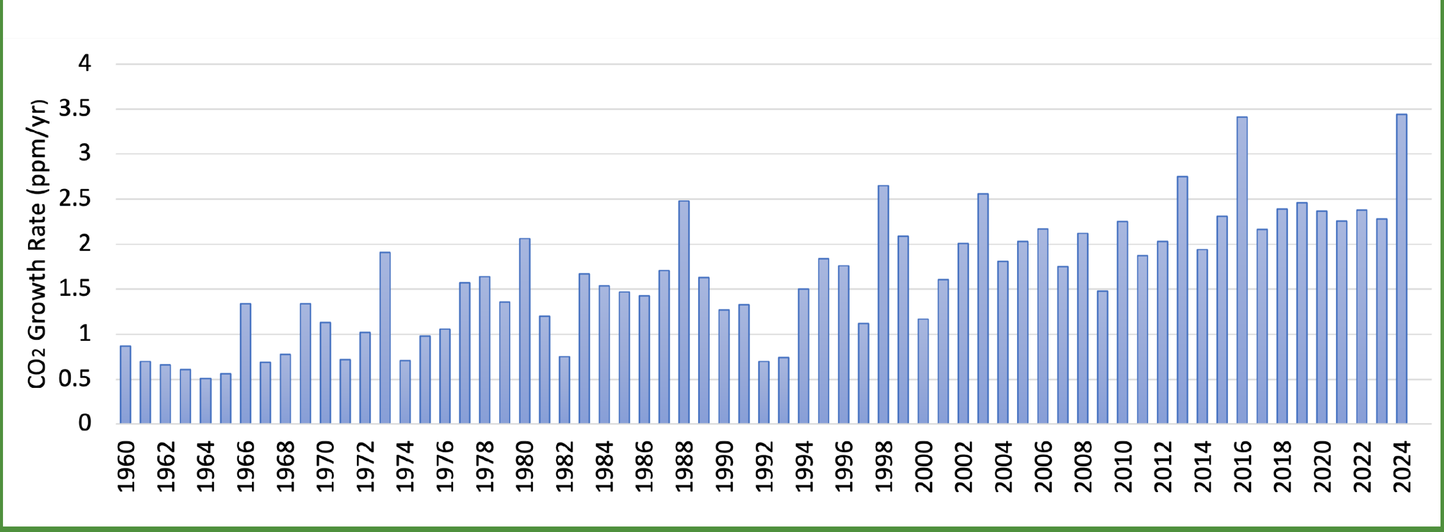

Figure 1. Increases in successive annual means of atmospheric CO_2, calculated from observations from the National Oceanic and Atmospheric Administration (NOAA) network (a subset of the remote marine surface sites of the WMO Global Atmosphere Watch (GAW) network) for the period 1980–2024 [2] and from Scripps Institution of Oceanography (SIO) Mauna Loa and South Pole measurements for the period 1960–1979 [3]. The 0.1 ppm/yr difference between WMO's (3.5 ppm/yr) and NOAA's (3.4 ppm/yr) CO_2 growth rates for 2023–2024 reflects differences in station selection and averaging approach.

fossil fuel burning [4]. About half of the total carbon dioxide emitted to the atmosphere has been transferred to the Earth's land ecosystems and oceans; however, this storage is not permanent. As global temperatures rise, the oceans absorb less CO_2 because of decreased solubility at higher temperatures [5]. Extreme droughts may become more frequent and put global forests and grasslands under stress, which can also reduce net CO_2 uptake [6, 7].

Global fossil CO_2 emissions were almost static during 2023–2024 at the record level of 10.2 ± 0.5 GtC/yr [4]. The global terrestrial ecosystems and global oceans are likely responsible for the additional 1.1 ppm/yr (equivalent to 2.34 GtC) in CO_2 growth compared to 2022–2023. The global temperature in 2024 was the highest recorded in the observational record dating back to 1850, breaking the record previously set in 2023. For the first time, it passed the significant 1.5 °C mark relative to the pre-industrial period, a result of long-term global warming combined with additional heat from the El Niño event in 2023–2024 [8]. El Niño is the warm phase of the El Niño–Southern Oscillation (ENSO) weather pattern, often associated with abnormal weather, such as strong storms in some regions and droughts or flooding in others. These changes alter regional temperature and precipitation patterns, which in turn influence photosynthetic CO_2 uptake, respiratory CO_2 release and the frequency and magnitude of fires [9, 10]. The oceans may account for a small fraction of the additional carbon dioxide in 2024, on the order of 0.3 GtC [5], as record-breaking sea-surface temperatures in 2023 persisted into 2024. However, the majority of the 2024 anomaly arose from decreased net ecosystem carbon uptakes and increased fire emissions, as estimated by the preliminary 2025 analysis using the 14 global inverse models included in the 2025 Global Carbon Budget [4], which use CO_2 measurements, including those from the GAW Programme. The Amazon and Southern Africa experienced record-high fire activities in 2023–2024, as drought conditions were severe in several land regions (see the discussion of fire carbon emissions in 2024 in the insert). There is a significant concern that terrestrial and ocean CO_2 sinks are becoming less effective, which will increase the fraction of anthropogenic CO_2 that stays in the atmosphere, thereby accelerating global warming. Sustaining and enhancing greenhouse gas monitoring is even more critical now to understand these feedbacks and to provide the information needed to inform and monitor climate action.

Current CO_2 emissions to the atmosphere not only impact the global climate today but will continue to do so for millennia, and ongoing CO_2 emissions will ensure that warming continues indefinitely. The removal of anthropogenic CO_2 from the atmosphere depends on exchanges among reservoirs on timescales ranging from years (surface ocean) to hundreds of thousands of years (weathering). The slowed uptake of anthropogenic CO_2 emissions within the global carbon cycle is exacerbated by the slow uptake of heat by the deep oceans [11], so once CO_2 is emitted to the atmosphere, it affects climate indefinitely [12]. This is different from methane (CH_4), whose atmospheric lifetime is about nine years due to its removal by chemical oxidation. While reducing CH_4 emissions is useful and necessary, climate action urgently needs to focus on reducing fossil fuel CO_2 emissions, which represent the vast majority of overall greenhouse gas emissions.

Executive summary

The latest analysis of observations from the WMO Global Atmosphere Watch (GAW) in situ observational network shows that the globally averaged surface concentrations(2) for carbon dioxide (CO_2), methane (CH_4) and nitrous oxide (N_2O) reached unprecedented highs in 2024, with CO_2 at 423.9±0.2 ppm, CH_4 at 1942±2 ppb(3) and N_2O at 338.0±0.1 ppb. These values constitute, respectively, 152%, 266% and 125% of pre-industrial (before 1750) levels. The record increase in CO_2 from 2023 to 2024 was most likely due to a combination of natural variability and continued emissions of fossil fuel CO_2. For CH_4, the increase from 2023 to 2024 was lower than that observed from 2022 to 2023 and also lower than the average annual growth rate over the last decade (2014–2023). For N_2O, the increase from 2023 to 2024 was lower than that observed from 2022 to 2023 and slightly lower than the average annual growth rate over the last decade. The National Oceanic and Atmospheric Administration (NOAA) Annual Greenhouse Gas Index (AGGI) [13] shows that from 1990 to 2024, radiative forcing by long-lived greenhouse gases (LLGHGs) increased by 54%, with CO_2 accounting for about 81% of this increase.

Overview of observations from the GAW in situ observational network for 2024

This twenty-first annual WMO Greenhouse Gas (GHG) Bulletin reports atmospheric abundances and rates of change of the most important LLGHGs – carbon dioxide, methane and nitrous oxide – and provides a summary of the contributions of other greenhouse gases. CO_2, CH_4 and N_2O, together with dichlorodifluoromethane (CFC-12) and trichlorofluoromethane (CFC-11), account for approximately 96%(4) [13] of radiative forcing due to LLGHGs (Figure 2).

The WMO GAW Programme coordinates systematic observations and analyses of GHGs and other trace species. Sites where greenhouse gases have been measured in the last decade are shown in Figure 3. Measurement data are reported by participating

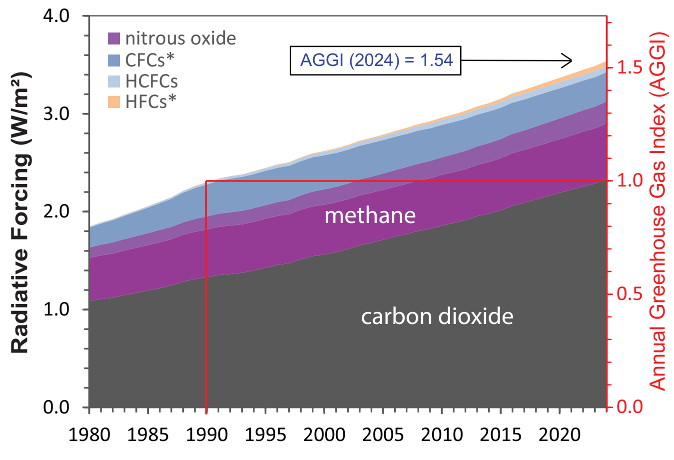

Figure 2. Atmospheric radiative forcing, relative to 1990, by LLGHGs corresponding to the 2025 update of the NOAA AGGI [13]. The chlorofluorocarbons ("CFCs*") grouping includes some other long-lived gases that are not CFCs (for example, CCl_4, CH_3CCl_3 and halons); however, CFCs account for the majority (95% in 2024) of this radiative forcing. The hydrochlorofluorocarbons ("HCFCs") grouping includes the three most abundant of these chemicals (HCFC-22, HCFC-141b, and HCFC-142b). The hydrofluorocarbons ("HFCs*") grouping includes the most abundant HFCs (HFC-134a, HFC-23, HFC-125, HFC-143a, HFC-365mfc, HFC-227ea and HFC-152a) and sulfur hexafluoride (SF_6) for completeness, although SF_6 only accounted for a small fraction of the radiative forcing from this group in 2024 (13%).

countries and archived and distributed by the World Data Centre for Greenhouse Gases (WDCGG) at the Japan Meteorological Agency.

The results reported here by WMO WDCGG for the global average and growth rate are slightly different from the results reported by NOAA for the same years [2] due to differences in the stations used and the averaging procedure, as well as a slight difference in the time period for which the numbers are representative. WMO WDCGG follows the procedure described in detail in [14] and [15]. Additional information related to the analysis presented in this Bulletin is available at https://gaw.kishou.go.jp/publications/summary_figures.

The table provides globally averaged atmospheric abundances of the three major LLGHGs in 2024 and changes in their abundances since 2023 and since 1750.

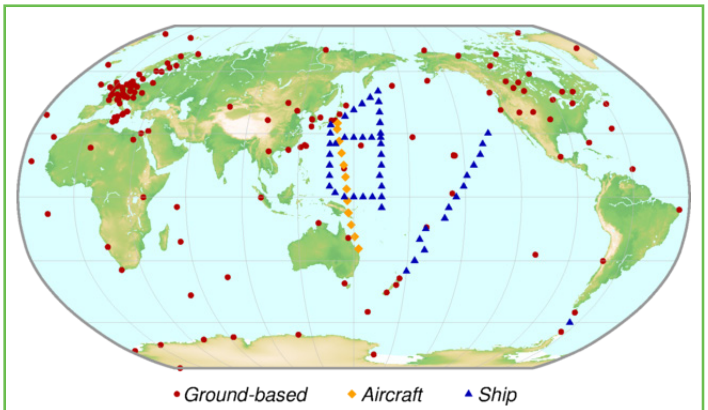

Figure 3. The GAW global network for CO_2 in the last decade. The network for CH_4 is similar. The in situ network for N_2O and other LLGHGs is far less dense.

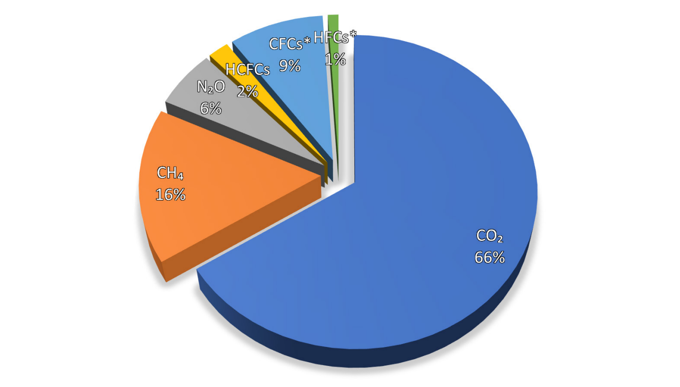

Figure 4. Contribution of the most important long-lived greenhouse gases to the increase in global radiative forcing from the pre-industrial era to 2024 [13]

The three GHGs shown in the table are closely linked to anthropogenic activities and interact strongly with the biosphere and the oceans. Predicting the evolution of the atmospheric content of GHGs requires a quantitative understanding of their many sources, sinks and chemical transformations in the atmosphere, as well as climate predictions. Observations from GAW provide invaluable constraints on the budgets of these and other LLGHGs. They are increasingly used to improve emission estimates and to evaluate satellite retrievals of LLGHG column averages. The Integrated Global Greenhouse Gas Information System (IG³IS) provides further insights on the sources of GHGs at the national and sub-national, especially urban [16], scales.

The NOAA AGGI measures the increase in total radiative forcing due to all LLGHGs since 1990 [13]. The AGGI reached 1.54 in 2024, representing a 54% increase in total radiative forcing[4] from 1990 to 2024 and a 1.5% increase from 2023 to 2024 (Figure 2). The relative contributions of other gases in the total radiative forcing since the pre-industrial era are presented in Figure 4.

Table. Global annual surface mean abundances (2024) and trends of key greenhouse gases from the GAW in situ observational network for GHGs. The units are concentrations in dry air, and the uncertainties are 68% confidence limits. The averaging method is described in [14].

	CO_2	CH_4	N_2O
2024 global mean abundance	423.9±0.2 ppm	1942±2 ppb	338.0±0.1 ppb
2024 abundance relative to 1750[a]	152%	266%	125%
2023–2024 absolute increase	3.5 ppm	8 ppb	1.0 ppb
2023–2024 relative increase	0.83%	0.41%	0.30%
Mean annual absolute increase over the past 10 years	2.57 ppm yr^{-1}	10.6 ppb yr^{-1}	1.07 ppb yr^{-1}

[a] Based on pre-industrial mole fractions of 278.3 ppm for CO_2, 729.2 ppb for CH_4 and 270.1 ppb for N_2O. The number of stations used for the analyses was 179 for CO_2, 171 for CH_4 and 123 for N_2O.

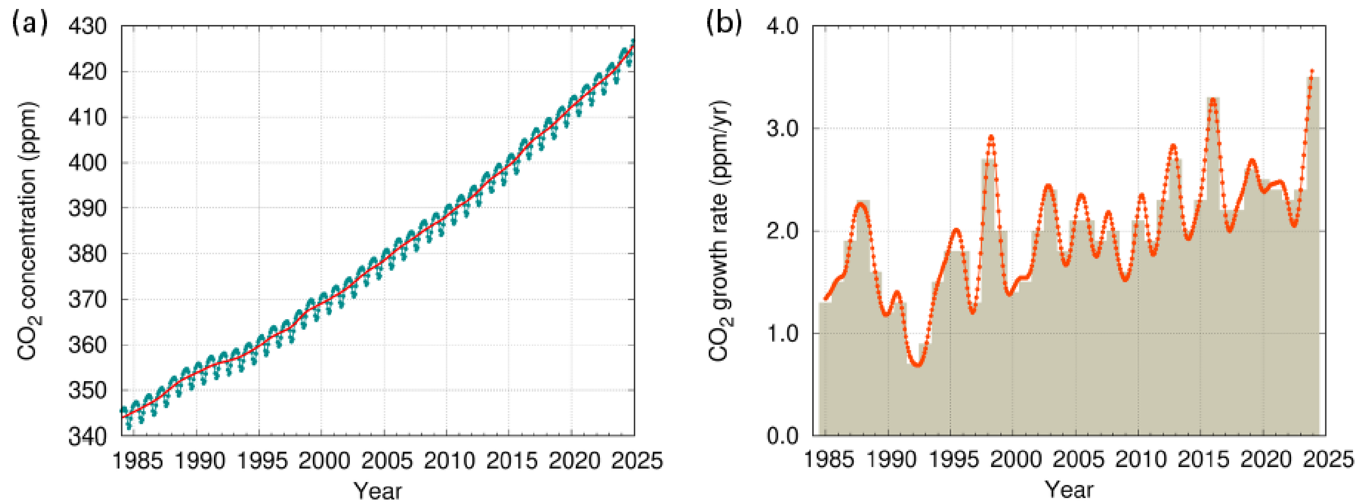

Figure 5. Globally averaged CO_2 concentration (a) and its growth rate (b) from 1984 to 2024. Increases in successive annual means are shown as the shaded columns in (b). The red line in (a) is the monthly mean with the seasonal variation removed; the blue dots and blue line in (a) depict the monthly averages. Observations from 179 stations were used for this analysis.

Carbon dioxide (CO_2)

Carbon dioxide is the single most important anthropogenic greenhouse gas in the atmosphere, accounting for approximately 66%(4) of the radiative forcing by LLGHGs. It is responsible for about 79%(4) of the increase in radiative forcing over the past decade. The pre-industrial level of 278.3 ppm represented a balance of fluxes among the atmosphere, the oceans and the land biosphere. The globally averaged CO_2 concentration in 2024 was 423.9±0.2 ppm (Figure 5a), 152% of the pre-industrial level. The increase in the annual mean from 2023 to 2024, 3.5 ppm (Figure 5b), was the highest in the recent history of observations, higher than the 2.4 ppm increase from 2022 to 2023 by large margin and higher than the average growth rate for the past decade (2.57 ppm yr^{-1}). The increase in the growth rate reflects a combination of the continued increase in fossil fuel emissions and reduced CO_2 sink fluxes, as described in the cover story.

Of the total emissions from human activities during the 2014–2023 period, about 53% accumulated in the atmosphere, 26% in the ocean and 21% on land, with no unattributed imbalance [4]. The portion of CO_2 emitted by fossil fuel combustion that remains in the atmosphere (the airborne fraction, (AF)), varies inter-annually due to the high natural variability of (mainly terrestrial) CO_2 sinks, although there is little evidence for a long-term AF trend (see the cover story in WMO Greenhouse Gas Bulletin No. 17).

Methane (CH_4)

Methane accounts for about 16%(4) of the radiative forcing by LLGHGs. Approximately 40% of methane is emitted into the atmosphere by natural sources (for example, wetlands and termites), and about 60% comes from anthropogenic sources (for example, ruminants, rice agriculture, fossil fuel exploitation, landfills and biomass burning) [17]. The globally averaged CH_4 concentration calculated from in situ observations reached a new high of 1942 ± 2 ppb in 2024, an increase of 8 ppb with respect to the previous year (Figure 6a). This increase is lower than both the increase of 11 ppb from 2022 to 2023 and the average annual increase of 10.6 ppb over the past

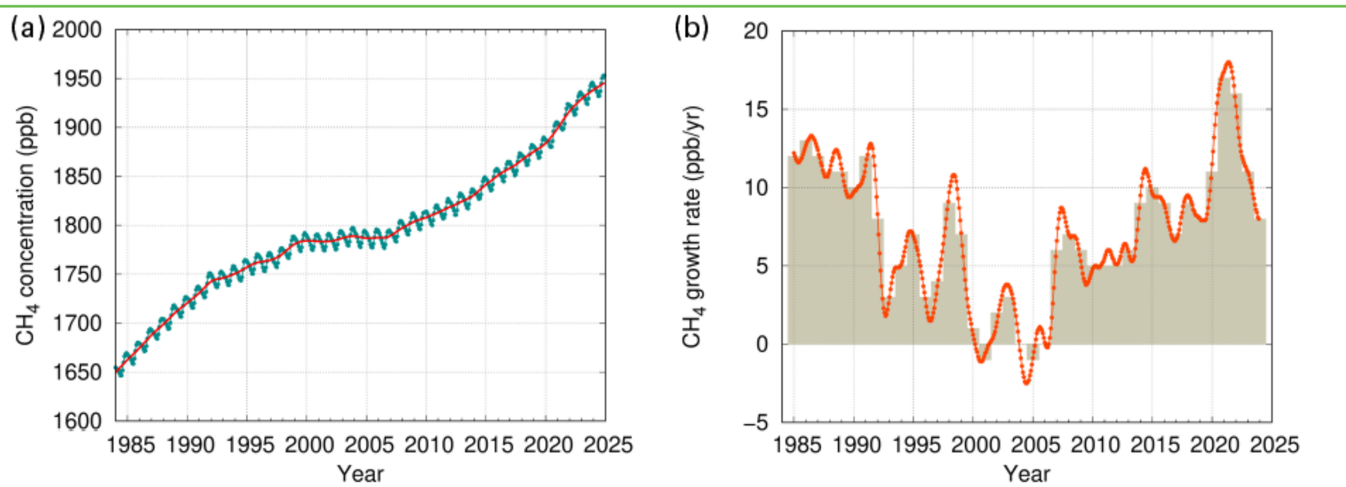

Figure 6. Globally averaged CH_4 concentration (a) and its growth rate (b) from 1984 to 2024. Increases in successive annual means are shown as the shaded columns in (b). The red line in (a) is the monthly mean with the seasonal variation removed; the blue dots and blue line in (a) depict the monthly averages. Observations from 171 stations were used for this analysis.

Impact of global fire emissions in 2024 on the increase in atmospheric CO_2

In 2024, atmospheric carbon monoxide (CO) levels showed an anomalously high seasonal peak in remote southern hemisphere surface GAW stations (Figure 9), mainly due to exceptionally high fire emissions in South America. CO is a product of incomplete combustion and a key indicator of atmospheric pollution and wildfire smoke due to its photochemical lifetime of several weeks. The CO emitted by wildfires is oxidized to produce CO_2. In addition, most wildfire carbon emissions are in the form of CO_2, so the intensity of the fires had a sizable impact on the CO_2 budget and growth rate in 2023–2024 and will significantly influence its future growth because of the impact of fires on land use, which in turn will affect the net CO_2 land sink.

Wildfire emissions in the Americas reached historic levels in 2024. In South America, the Plurinational State of Bolivia especially experienced unusually intense fires throughout most of the year, with monthly total emissions the highest for every month except December. The Brazilian states of Amazonas and Mato Grosso do Sul also experienced their highest annual total emissions, and emissions for the Brazilian Amazon were among the highest in the past two decades. In North America, the annual total estimated wildfire emissions for Canada were not as high as the record year of 2023 but were significantly higher than any other year since 2003.

CO data from the Copernicus Atmosphere Monitoring Service (CAMS) global atmospheric composition reanalysis [21] for September 2024 showed positive anomalies relative to the 2003–2022 average throughout most of the tropics and the southern hemisphere, with the strongest positive anomalies in a wide band extending from the tropical Pacific to the southern tropical Atlantic and centred on South America, as shown in Figure 10. Overall, the annual mean CO for South America was the highest in the 22 years of the CAMS dataset, while the global annual mean was the highest since the large-scale biomass burning emissions from Indonesia during the El Niño of 2015 [22]. The scale and intensity of the fires resulted in large-scale smoke plumes throughout much of the fire seasons in the Americas, with significant impacts on regional air quality and several episodes of long-range transport, in addition to increased CO_2 emissions.

Amazonia fire CO_2 emissions

Over the past 15 years, the Amazon has been significantly impacted by deforestation, biomass burning and the degradation of forest climate conditions. Forest loss causes a reduction in precipitation and an increase in temperatures, intensifying dry-season climate stress and causing increasingly drier and hotter conditions that extend over increasingly longer periods of time. This process is making the forest increasingly flammable, and fire has become a significant risk. Starting in 2023, severe drought conditions in the Amazon led to an exceptional increase in fire emissions, estimated on the basis of bimonthly vertical profile measurements at four Amazonia sites in the Long-term Study of the Amazon Carbon Balance (CARBAM) project, operated by the National Institute for Space Research (INPE) in Brazil since 2010.

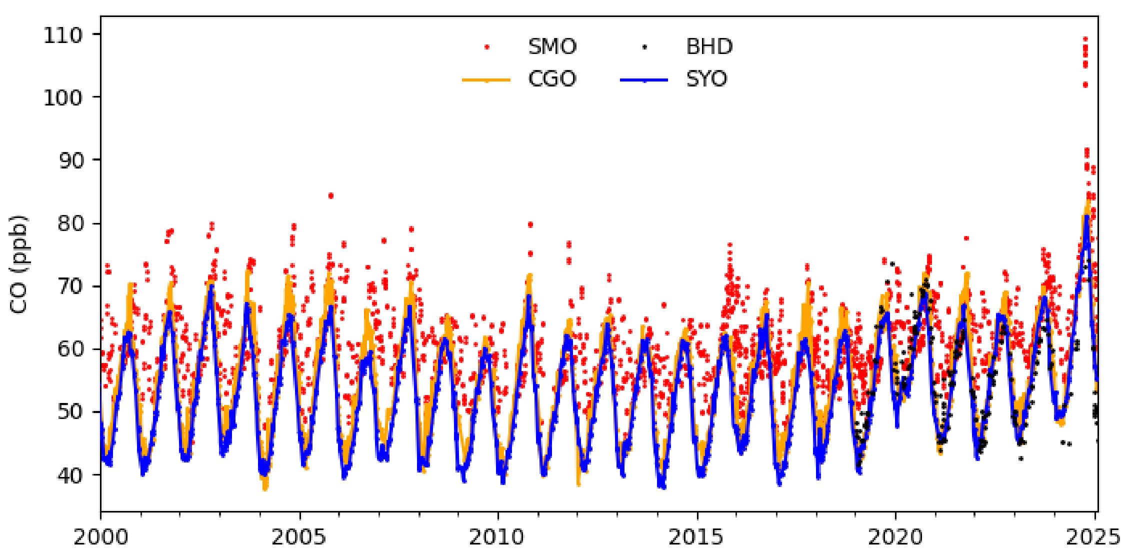

Figure 9. Atmospheric CO levels observed at American Samoa Observatory (SMO – American Samoa), Cape Grim Observatory (CGO – Australia) and Syowa Station (SYO – Antarctica), from the NOAA network [20], and at Baring Head Station (BHD – New Zealand), from Earth Science New Zealand (formerly NIWA), representing a subset of the remote southern hemisphere sites of the WMO GAW network

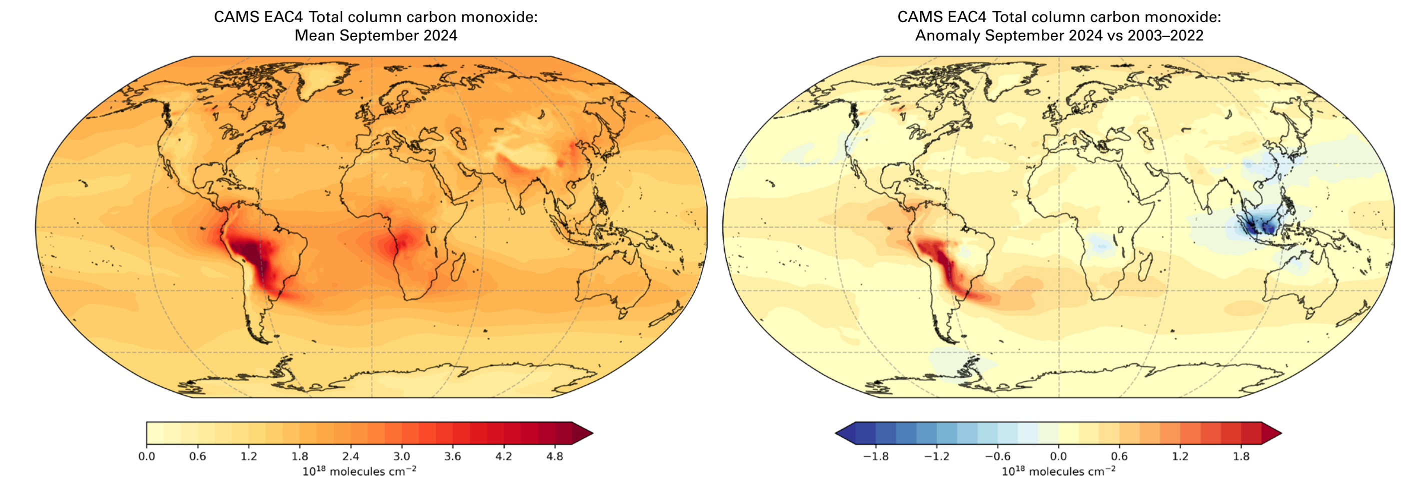

Figure 10. Monthly mean total column carbon monoxide (left) and anomalies relative to the 2003–2022 average (right) for September 2024
Source: CAMS global reanalysis (EAC4) monthly averaged fields

Total CO_2 emissions, fire CO_2 emissions and net biome exchange (NBE) were estimated from these 15-year observations [23–25]. Both total and fire CO_2 emissions in the Amazon were the highest in 2024, associated with low-precipitation and high-temperature conditions (Figure 11). The variability of carbon emissions and NBE in the Amazon was strongly driven by the El Niño pattern and the North Atlantic Ocean high-temperature anomaly, which caused extreme droughts and high temperatures. These resulted in higher CO_2 emissions in 2010, 2015–2016 and 2024.

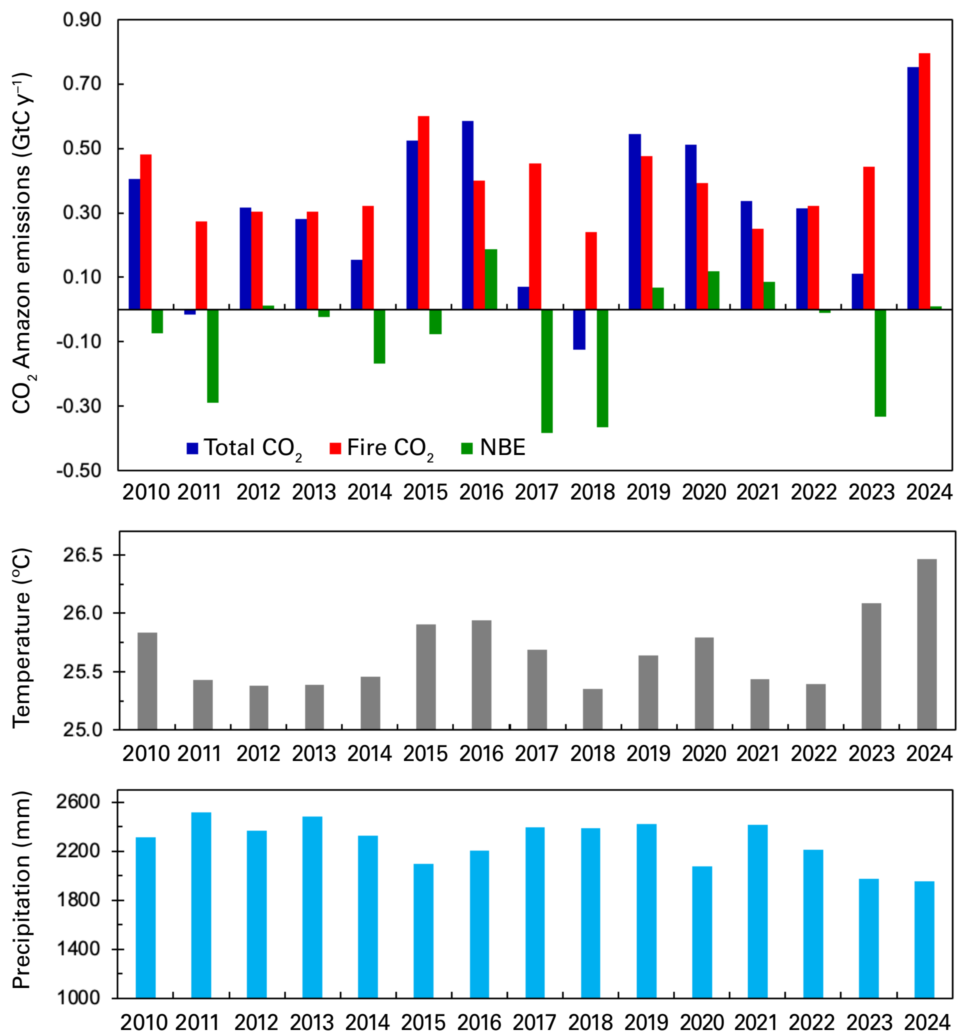

Figure 11. Changes in CO_2 emissions and anomalies in meteorological conditions in the Amazon between 2010 and 2024

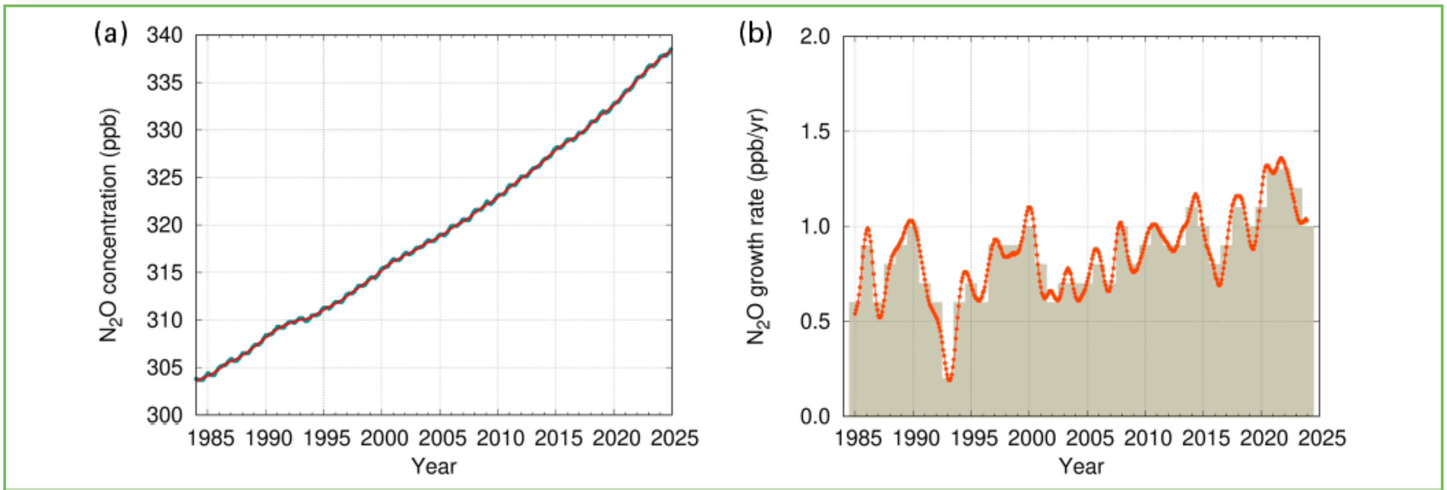

Figure 7. Globally averaged N_2O concentration (a) and its growth rate (b) from 1984 to 2024. Increases in successive annual means are shown as the shaded columns in (b). The red line in (a) is the monthly mean with the seasonal variation removed; in this plot, the red line overlaps the blue dots and blue line that depict the monthly averages. Observations from 123 stations were used for this analysis.

decade. The mean annual increase of CH_4 decreased from approximately 12 ppb yr^{-1} during the late 1980s to near zero during 1999–2006 (Figure 6b). Since 2007, average atmospheric CH_4 has been continuously increasing. It reached 266% of the pre-industrial level in 2024. It is critical to remember that unlike the case with CO_2, anthropogenic sources of CH_4 are not dominated by fossil fuel-related emissions; agricultural and waste sources play the most important role. Studies using GAW CH_4 measurements indicate that increased CH_4 emissions from wetlands in the tropics and from anthropogenic sources at the mid-latitudes of the northern hemisphere are the likely causes of this recent increase since 2007 (see WMO Greenhouse Gas Bulletin No. 20).

Nitrous Oxide (N_2O)

Nitrous oxide accounts for about 6%[(4)] of the radiative forcing by LLGHGs. It is the third most important individual contributor to the combined forcing. N_2O is emitted into the atmosphere from both natural sources (approximately 57%) and anthropogenic sources (approximately 43%), including oceans, soils, biomass burning, fertilizer use and various industrial processes. The globally averaged N_2O concentration reached 338.0 ±0.1 ppb in 2024, which is an increase of 1.0 ppb with respect to the previous year (Figures 7a and 7b) and 125% of the pre-industrial level (270.1 ppb). The annual increase from 2023 to 2024 was lower than the increase from 2022 to 2023 and slightly lower than the mean growth rate over the past 10 years (1.07 ppb yr^{-1}). Global human-induced N_2O emissions, which are dominated by nitrogen additions to croplands, increased by 30% over the past four decades to 7.3 (range: 4.2–11.4) teragrams of nitrogen per year. This increase was mainly responsible for the growth in the atmospheric burden of N_2O [18].

Other greenhouse gases

Stratospheric ozone-depleting CFCs, which are regulated by the Montreal Protocol on Substances that Deplete the Ozone Layer, together with minor halogenated gases, account for approximately 12%[(4)] of the radiative forcing by LLGHGs. While CFCs and most halons are decreasing, some HCFCs and HFCs, which are also potent greenhouse gases, are increasing at relatively rapid rates; however, they are still low in abundance (at ppt[(5)] levels). Although at a similarly low abundance, SF_6 is an extremely potent LLGHG. It is produced by the chemical industry, mainly as an electrical insulator

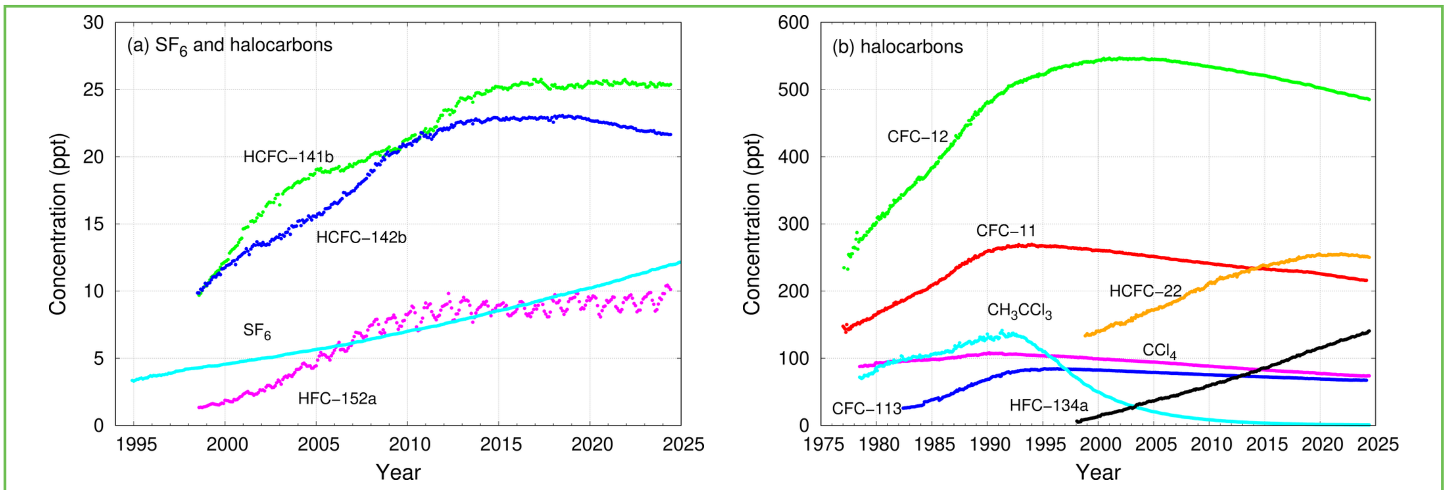

Figure 8. Monthly mean concentration of sulfur hexafluoride (SF_6) and the most important halocarbons: (a) SF_6 and lower mole fractions of halocarbons and (b) higher halocarbon concentration. For each gas, the number of stations used for the analysis was as follows: SF_6 (93), CFC-11 (27), CFC-12 (28), CFC-113 (23), CCl_4 (25), CH_3CCl_3 (26), HCFC-141b (12), HCFC-142b (16), HCFC-22 (16), HFC-134a (13), HFC-152a (12).

in power distribution equipment. Its concentration is rising at a quite constant rate and is now more than twice the level observed in the mid-1990s (Figure 8a).

This Bulletin primarily addresses long-lived greenhouse gases. Relatively short-lived tropospheric ozone has a radiative forcing comparable to that of the halocarbons [19]; because of its short lifetime, its horizontal and vertical variability is very high and global means are not well characterized with a network such as that shown in Figure 3. Many other pollutants, such as carbon monoxide, nitrogen oxides and volatile organic compounds, although not referred to as greenhouse gases, have small direct or indirect effects on radiative forcing. Aerosols (suspended particulate matter) are short-lived substances that alter the radiation budget. All the gases mentioned in this Bulletin, as well as aerosols, are included in the observational programme of GAW, with support from WMO Member countries and contributing networks.

Acknowledgements and links

Fifty-six WMO Members contributed CO_2 and other greenhouse gas data to the GAW WDCGG. Approximately 42% of the measurement records submitted to WDCGG were obtained at sites of the NOAA Global Monitoring Laboratory cooperative global air-sampling network. For information about the GAW GHG network and methodologies, see GAW Report No. 292. The Advanced Global Atmospheric Gases Experiment also contributed observations to this Bulletin. The GAW observational stations that contributed data to this Bulletin, shown in Figure 4, are included in the list of contributors on the WDCGG web page. They are also described in the GAW Station Information System (GAWSIS), supported by MeteoSwiss, Switzerland. The present Bulletin has been prepared under the oversight of the GAW Scientific Advisory Group on Greenhouse Gases.

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Notes:

(1) ppm = the number of molecules of a gas per million (10^6) molecules of dry air

(2) The scientifically correct term to use for the abundance in the atmosphere of compounds such as carbon dioxide and other (greenhouse) gases is dry air **mole fraction**, expressed as the number of moles of each gas per mole of dry air, often with units of ppm(1) or ppb(3). However, in the GHG Bulletin, we use the more popular term **concentration** to avoid possible confusion for the public.

(3) ppb = the number of molecules of a gas per billion (10^9) molecules of dry air

(4) This percentage is calculated as the relative contribution of the mentioned gas(es) to the increase in global radiative forcing caused by all long-lived greenhouse gases since 1750. Radiative forcing is the perturbation to the Earth's energy budget resulting from the increased burdens of greenhouse gases since the pre-industrial (1750) period after allowing stratospheric temperature to quickly adjust. "Effective" radiative forcing also includes fast tropospheric adjustments. Note that the numbers presented here account only for the direct radiative forcing of CH_4 and CO_2, as opposed to the emission-based forcings used in the IPCC AR6 WG1 report, which include estimated indirect forcings due the atmospheric chemistry of CH_4, influencing other atmospheric constituents.

(5) ppt = the number of molecules of a gas per trillion (10^{12}) molecules of dry air

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ENVIRONMENT AND CLIMATE CHANGE CANADA'S GREENHOUSE GAS MONITORING NETWORK

Fifty years of monitoring atmospheric greenhouse gases in Canada

In the summer of 1975, Environment and Climate Change Canada (ECCC) started the regular collection of air samples at Alert, Nunavut in the High Arctic (82.451°N, 62.507°W) and on Sable Island, Nova Scotia (43.933°N, 60.007°W), in the Atlantic Ocean, ideal locations for tracking changes of carbon dioxide levels in background air. Over the last 50 years, ECCC has seen annual average carbon dioxide mole fractions measured at Alert increase from 334 to 425 ppm. Today, the Dr. Neil Trivett Global Atmosphere Watch Observatory at Alert is one of three WMO GAW GHG intercomparison sites.

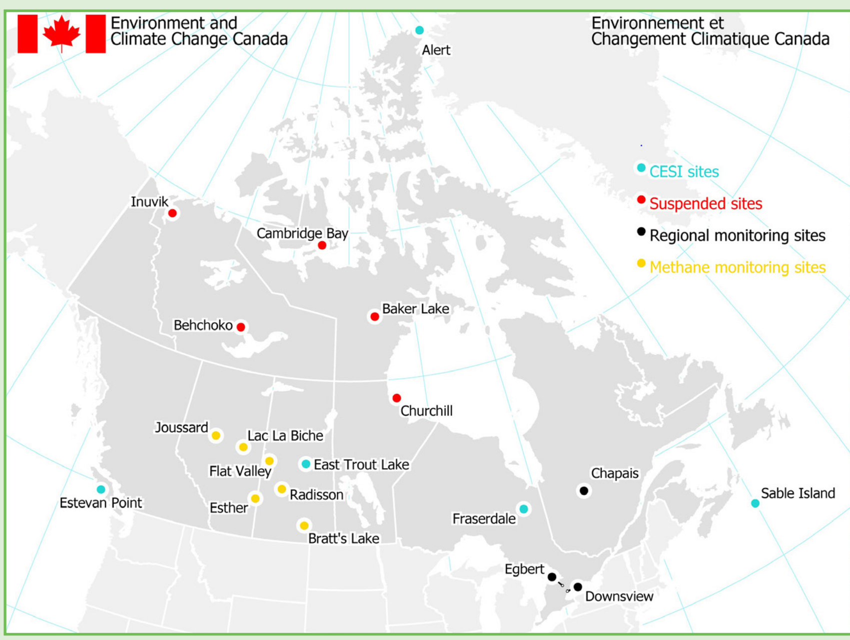
In the 1980s, a new monitoring station was added on the Pacific coast and ECCC's methane monitoring programme began. As measurement technology advanced and understanding greenhouse gas emissions and uptake became a focus of policymakers, ECCC expanded its network between 2000 to 2020 to add more regions across Canada. At its peak, the GHG monitoring network included sites in the boreal forest, in the sub-Arctic and Arctic, near major wetlands, in urban areas, as well as in the Western Canadian Sedimentary Basin (WCSB), where most of Canada's oil and gas extraction industry is located. These greenhouse gas measurements are frequently used and included in global data products and reported to the WMO World Data Centre for Greenhouse Gases (WDCGG), from which they are downloaded several thousand times per month.

Today, the five core sites (cyan) provide information on changes in atmospheric greenhouse gas levels from coast to coast to coast; these data are reported biannually as one of the Canadian Environmental Sustainability Indicators (CESI).

As atmospheric modelling tools have improved, ECCC's long-term high-precision observations have come to be used not only for research purposes, but also to support core government policies, such as Canada's Methane Strategy. The atmospheric monitoring sites in the WCSB (yellow) allow the tracking of changes in methane emissions from oil and gas operations, which decreased by about 30% from 2010 to 2022 (about –1 MtCH_4 per year). Additionally, these atmospheric data can improve quantification of methane emissions from Canada's oil and gas industry. Using additional atmospheric observations, ECCC's inventory group developed a new hybrid approach to tracking methane emissions, which has increased the accuracy of emission reporting.

Recently, data previously collected at Canadian sub-Arctic and Arctic sites (red) was used in multiple studies to investigate natural methane emissions from these regions. The observations revealed regional changes in natural methane emissions in response to increasing temperatures of up to 1 MtCH_4 (28 MtCO_2e) per year for each 1 °C of change. Furthermore, these observations have been used extensively in comparisons with state-of-the-art wetland and ecosystem models, which are continually being improved to better predict future climate change impacts.

As climate change continues to affect the carbon cycle, and as national as well as international policies are implemented to mitigate emissions and achieve climate goals such as net zero, the data collected by ECCC's GHG monitoring network will continue to provide crucial information for scientists, policymakers and civil society.




Alert, Nunavut


Sable Island, Nova Scotia