NOAA Satellites Track Trends in Greenhouse Gases

From Both Human and Natural Sources

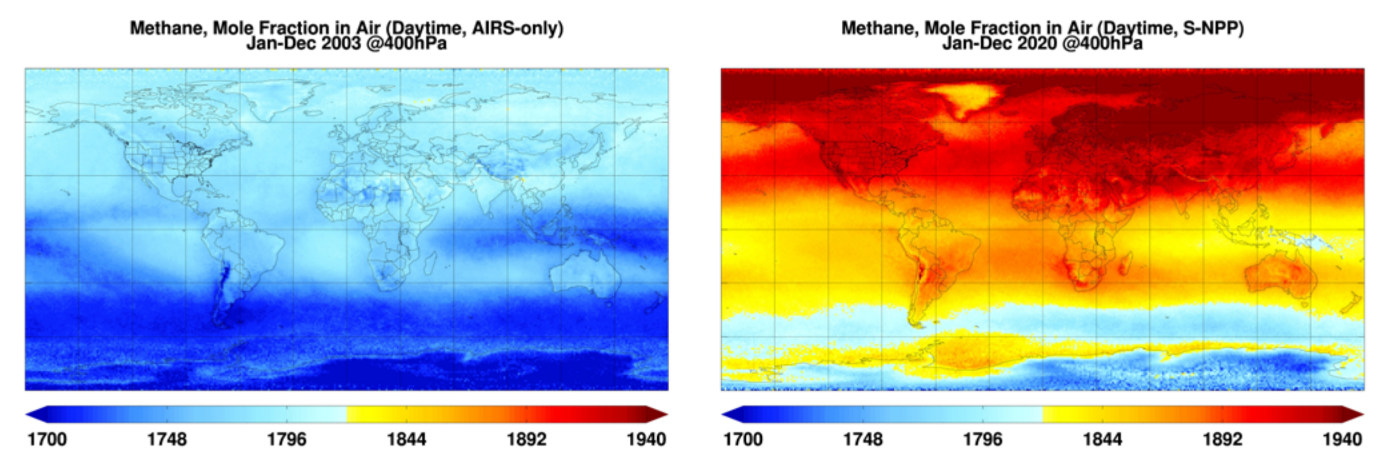
Earth science settled the question of whether and how greenhouse gases (GHGs) trapped in our planet's atmosphere are warming the planet. Science shows that human activities, such as deforestation and burning fossil fuels, contribute to the concentration of GHGs in the atmosphere. Earth science discoveries of the last two decades tell us that increasing GHGs in the atmosphere is driving other changes in our Earth system, such as increasing surface temperatures, rising sea levels, loss of polar sea and land ice, more frequent and more severe weather, and shifts in ecosystems and habitats.

To inform strategies for reducing GHGs, such as carbon dioxide (CO_2) and methane (CH_4), decision-makers need tools to track and monitor them. Since the greenhouse gas effect is a global phenomenon, those decisions are often made at the global level. For instance, the Paris Agreement adopted by 196 parties on Dec. 12, 2015, is an international treaty on climate change with the goal of limiting the temperature increase.

NOAA's CarbonTracker tool monitors global GHG concentrations using a measurement and modeling system that tracks sources (when carbon dioxide is emitted into the atmosphere) and sinks (when carbon dioxide is removed from the atmosphere). While NOAA developed CarbonTracker, its observations depend on a network of collaborators and a variety of sensors, from ground monitoring to NOAA's satellite systems.

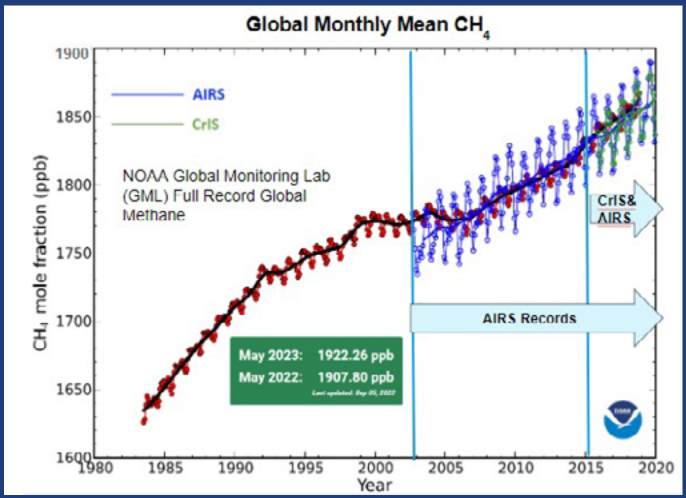
While ground-based sensors provide the most accurate measurements of GHGs, NOAA's Joint Polar Satellite System (JPSS) contributes to our understanding of how these gases are distributed across the globe. The JPSS sensors measure concentrations of GHGs like methane at different levels of the atmosphere, and can also detect and monitor what's contributing to GHGs, such as wildfires and agricultural burns.

NOAA's JPSS mission carries an instrument called the Cross-track Infrared Sounder (CrIS) that measures methane in the mid-to-upper troposphere—or about the midpoint of the atmosphere. CrIS continues the



The image on the left shows annual mean methane (CH_4) concentrations in 2003, as measured by NASA's AIRS sensor on the Aqua satellite. The image on the right shows the concentrations in 2020 as computed by the CrIS sensor onboard the S-NPP satellite. There is a significant increase in CH_4 in the atmosphere over this period of time.

legacy of measurements by a similar, earlier NASA instrument called the Atmospheric Infra-Red Sounder (AIRS). Figure 1 shows a side-by-side comparison of methane measured by AIRS in 2003 and by CrIS in 2020; there is a significant increase in methane in the atmosphere over this period of time.



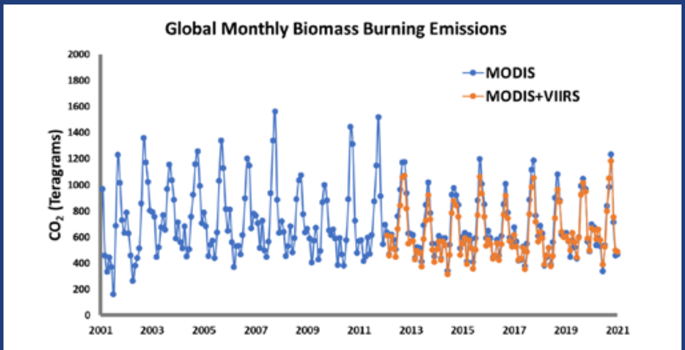
The red lines and circles are globally averaged monthly mean atmospheric CH_4 abundance determined from marine surface sites by NOAA Global Monitoring Lab. Monthly data transformed to 12-month running mean are shown with the black curve. The blue dots show CH_4 concentrations in units of parts per billion for 400 millibars in the atmosphere and the green dots are CH_4 concentrations from CrIS, also for 400 millibars in the atmosphere..

Remote-sensing observations confirm that atmospheric CH_4 resumed an increase after 2007 and has continued to increase since 2014. Our hyperspectral sounders provide high vertical resolution atmospheric information that can improve forecasts in numerical weather prediction (NWP) models. While in orbit the hyperspectral sounder can monitor atmospheric CH_4, but ground-level emissions are harder to detect from space.

Greenhouse gases are not all the same, and they have markedly different impacts on the atmosphere. Although atmospheric CH_4 is lower than CO_2, it is 25 times more potent than CO_2 because of its higher global warming potential, and it has a much shorter atmospheric lifetime (about a decade) than CO_2 (longer than a century).

Tools like CarbonTracker need the continuous monitoring of greenhouse gas emissions from sources like biomass (i.e. vegetation) burning—to accurately simulate the various greenhouse gas sources and sinks. In partnership with NASA, NOAA has been accumulating records of biomass burning since the 1999 launch of the Terra satellite carrying the Moderate Resolution imaging Spectroradiometer (MODIS). Today, NESDIS is capturing measurements with the Visible Infrared Imaging Radiometer Suite (VIIRS) instrument on NOAA's JPSS series and the NASA-NOAA pathfinder Suomi National Polar Partnership.

Measurements collected by NOAA's Earth observation satellites provide critical data and information to policymakers and decisionmakers. In 2020, NOAA estimated that global biomass burning released 7.9 gigatonnes of carbon, compared to 31.5 gigatonnes from burning of fossil fuels. In places like the western U.S., emissions from biomass burning are increasing at a rate of 214 teragrams per year—or more than 470 billion pounds—undoing years of air quality benefits the nation is experiencing from the Clean Air Act and regulations enforced by the Environmental Protection Agency.



Time series of CO_2 released into the atmosphere from biomass burning. Each data point is an annual total CO_2 for Canada. Terra and Aqua MODIS fire products were obtained from NASA, and NOAA's Global Biomass Burning Emissions algorithm was run on the data to calculate CO_2 emissions. Anthropogenic CO_2 emissions data was obtained from iea.org. Note Canadian anthropogenic CO_2 emissions data are not yet available for 2021-2023.

With the use of these greenhouse gas monitoring instruments and systems, NESDIS has provided a crucial contribution to the U.S. Climate Resilience Toolkit, a framework that helps agencies and individuals document climate hazards in near-real time. With continued research and innovation, NESDIS tools are vital to policymakers and communities in finding workable solutions to reduce climate-related risks now and in the future.