National Remote Sensing Centre

Indian Space Research Organisation, Government of India, Hyderabad.

Science Story

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Monitoring atmospheric Green House Gases (GHGs)

Climate Research Lab for atmosphere (CRLA), NRSC established instrument network which includes greenhouse gas analyser (GGA) and Isotopic analyzer to measure concentrations of atmospheric GHGs in India.

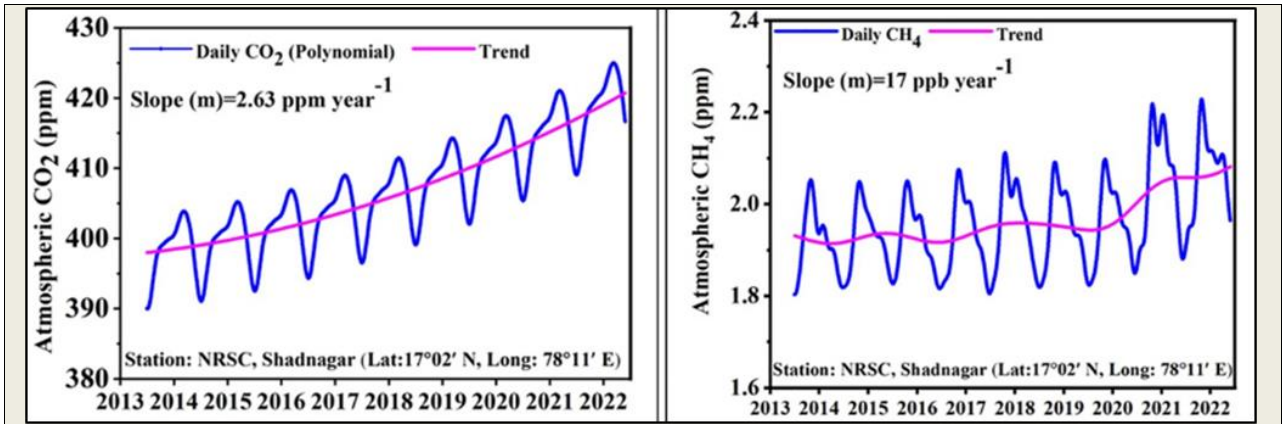
GreenHouse Gases (GHGs) are gases in atmosphere that trap and retain heat from the sun, which leads to the greenhouse effect. While the greenhouse effect is essential for maintaining a habitable climate on Earth, developmental and human activities have been increasing the concentration of these gases, intensifying the greenhouse effect and causing global warming.

Carbon dioxide (CO_2) is the most important greenhouse gas released through various human activities, such as burning fossil fuels (coal, oil, and natural gas), deforestation, and certain industrial processes. It accounts for approximately 75% of the total greenhouse effect. Increased CO_2 levels have been the primary driver of global warming. **Methane (CH_4)** is another important greenhouse gas which is released during the production and transportation of coal, oil, and natural gas, as well as from livestock and other agricultural practices. Methane is a significant contributor to global warming.

Monitoring greenhouse gases is essential to understand their concentrations in the atmosphere, track their sources and sinks, and assess their impact on climate change. Scientists adopt various methods to monitor greenhouse gases.

Ground-based monitoring stations are established to measure greenhouse gas concentrations. They use instruments such as gas chromatographs, spectrometers, and gas analyzers to collect air samples and analyze the levels of greenhouse gases present.

NRSC collected systematic measurements of atmospheric CO_2 and CH_4 concentrations for about a decade period. Inter annual variations of CO_2 and CH_4 were studied during 2013 to 2022 period, over the suburban city of Shadnagar, near Hyderabad, India. Observations on atmospheric CO_2 and CH_4 concentration are continued to measure at the Shadnagar site to understand the regional carbon cycle, which resembles the CO_2 Keeling curve.



Decadal time series of seasonal atmospheric a CO_2 and b CH_4 concentrations

Atmospheric CO_2 concentration increased at the rate of 2.63 ppm/year over the period 2013 to 2022 at Shadnagar, Hyderabad. The atmospheric CO_2 concentrations from seven sites collected during different time periods are analysed to understand the role of biospheric, fossil fuel fluxes on diurnal and seasonal variations of atmospheric CO_2. The study also examines the impact of land use/land cover on the variability of atmospheric CO_2 concentration. The observed CO_2 is further compared with satellite retrieved XCO_2 and the simulations from atmospheric chemistry-transport model. The model is able to capture the observed seasonal cycle all over the study locations.

The diurnal variation refers to the daily fluctuations in the atmospheric concentrations of these greenhouse gases over a 24-hour period. Several natural and human-related factors contribute to these variations.

Diurnal Variation of CO_2 : During the daytime, photosynthesis in plants absorbs CO_2 as they convert carbon dioxide into carbohydrates and oxygen. This process is very active during day due to sunlight, leading to a decrease in CO_2 levels in the atmosphere. Conversely, during the night, photosynthesis stops, and plants continue to respire, releasing CO_2, which leads to an increase in atmospheric CO_2 concentrations.

Diurnal variation of atmospheric CO_2 and its driving factors are studied using high-precision in-situ mixing ratio measurements and stable carbon isotopic CO_2 (δ13C-CO_2).

High-precision in-situ mixing ratio measurements refer to the accurate and detailed measurements of the concentrations of greenhouse gases in the atmosphere at a given location.

Stable carbon isotopic CO_2, represented as δ13C- CO_2, refers to the measurement of the stable carbon isotope composition of carbon dioxide molecules in the atmosphere. Carbon consists of three stable isotopes: carbon-12 (12C), carbon-13 (13C), and a small amount of carbon-14 (14C). The majority of carbon atoms are 12C, with a natural abundance of about 98.9%. 13C makes up around 1.1% of carbon atoms. The δ13C value is a measurement of the relative abundance of 13C compared to a reference standard, expressed in per mil (‰) notation.

The annual mean mixing ratios of atmospheric δ13C- CO_2 is -11.19±1.63 ‰. To characterize the atmospheric CO_2 sources, the Miller-Tans model was implemented by separately using the CO_2 and its δ13C- CO_2 isotopic data during day and night. A strong source signature of δ13C-CO_2 was observed during the night-time of summer monsoon. The source identified indicates probable emissions from fossil fuel combustion.

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1. https://link.springer.com/article/10.1007/s12524-023-01718-9
2. https://doi.org/10.1016/j.atmosres.2023.106785
3. https://agupubs.onlinelibrary.wiley.com/doi/10.1029/2022JD036472