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The state of greenhouse gases in the atmosphere using global observations through 2019

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We present results from the sixteenth annual Greenhouse Gas Bulletin (https://library.wmo.int/doc_num.php?explnum_id=10437) of the World Meteorological Organization (WMO). The results are based on research and observations performed by laboratories contributing to the WMO Global Atmosphere Watch (GAW) Programme (<https://community.wmo.int/activity-areas/gaw>).

The Bulletin presents results of global analyses of observational data collected according to GAW recommended practices and submitted to the World Data Center for Greenhouse Gases (WDCGG). Bulletins are prepared by the WMO/GAW Scientific Advisory Group for Greenhouse Gases in collaboration with WDCGG.

Observations used for the global analysis are collected at more than 100 marine and terrestrial sites worldwide for CO₂ and CH₄ and at a smaller number of sites for other greenhouse gases. The globally averaged surface mole fractions calculated from this in situ network reached new highs in 2019, with CO₂ at 410.5 ± 0.2 ppm, CH₄ at 1877 ± 2 ppb, and N₂O at 332.0 ± 0.1 ppb. These values constitute, respectively, 148%, 260% and 123% of pre-industrial (before 1750) levels. The increase in CO₂ from 2018 to 2019 (2.6 ppm) was larger than that observed from 2017 to 2018 and larger than the average annual growth rate over the last decade. For CH₄, the increase from 2018 to 2019 (8 ppb) was slightly smaller than that observed from 2017 to 2018 but still greater than the average annual growth rate over the last decade. For N₂O, the increase from 2018 to 2019 (0.9 ppb) was lower than that observed from 2017 to 2018 and practically equal to the average annual growth rate over the past 10 years. The National Oceanic and Atmospheric Administration (NOAA) Annual Greenhouse Gas Index (AGGI) shows that from 1990 to 2019, radiative forcing by long-lived greenhouse gases increased by 45%, with CO₂ accounting for about 80% of this increase.

The Bulletin highlights the potential impact of anthropogenic emission reductions due to COVID-19 lockdown measures on the levels of atmospheric concentrations of GHGs. These changes have been especially pronounced in urban areas and were visible in traditional pollutants as well as in greenhouse gases. However, the reduction in anthropogenic emissions due to confinement

measures will not have a discernible effect on global mean atmospheric CO₂ in 2020 as this reduction will be smaller than, or at most, similar in size to the natural year-to-year variability of atmospheric CO₂. Direct measurements of the CO₂ fluxes by ICOS directly demonstrated GHG emission reductions in a number of cities.

The Bulletin also describes the emission reduction opportunities related to methane. These opportunities are provided by emerging capabilities of methane observations from space and advances in transport modeling that allow for better source attribution and quantification. Globally averaged methane mole fraction has been increasing since 2007. Long-term observations and analysis of methane isotopic composition shed some light on this increase. The observed trend in $\delta^{13}\text{C-CH}_4$ is explained by a combined increase in microbial and fossil emissions. This trend points to the likely scenario that the methane increase is largely driven by the growing demand for energy and food.