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National Oceanic and Atmospheric Administration

Greenhouse Gases

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What are greenhouse gases?

Many chemical compounds present in Earth's atmosphere behave as 'greenhouse gases'. These are gases which allow direct sunlight (relative shortwave energy) to reach the Earth's surface unimpeded. As the shortwave energy (that in the visible and ultraviolet portion of the spectra) heats the surface, longer-wave (infrared) energy (heat) is reradiated to the atmosphere. Greenhouse gases absorb this energy, thereby allowing less heat to escape back to space, and 'trapping' it in the lower atmosphere. Many greenhouse gases occur naturally in the atmosphere, such as carbon dioxide, methane, water vapor, and nitrous others are synthetic. Those that are man-made include the chlorofluorocarbons (CFCs), hydrofluorocarbons (HFCs) and Perfluorocarbons (PFCs), as well as sulfur hexafluoride (SF₆). Atmospheric concentrations of both the natural and man-made gases have been rising over the last few centuries due to the industrial revolution. As the global population has increased and our reliance on fossil fuels (such as coal, oil and natural gas) has been firmly solidified, so emissions of these gases have risen. While gases such as carbon dioxide occur naturally in the atmosphere, through our interference with the carbon cycle (through burning forest lands, or mining and burning

occurs in the NH spring and summer as plants convert CO₂ to plant material through photosynthesis. It is then released again in the fall and winter as the plants decompose.

Methane

Methane is an extrememly effective absorber of radiation, though its atmospheric concentration is less than CO_2 and its lifetime in the atmosphere is brief (10-12 years), compared to some other greenhouse gases (such as CO_2 , N_2O , CFCs). Methane(CH₄) has both natural and anthropogenic sources. It is released as part of the biological processes in low oxygen environments, such as in swamplands or in rice production (at the roots of the plants). Over the last 50 years, human activities such as growing rice, raising cattle, using natural gas and mining coal have added to the atmospheric concentration of methane. Direct atmospheric measurement of atmospheric methane has been possible since the late 1970s and its conentration rose from 1.52 ppmv in 1978 by around 1%/year to 1990, since when there has been little sustained increase. The current atmospheric concentration is ~1.77 ppmv, and there is no scientific consensus on why methane has not risen much since around 1990.

Tropospheric Ozone

Ultraviolet radiation and oxygen interact to form ozone in the stratosphere. Existing in a broad band, commonly called the 'ozone layer', a small fraction of this ozone naturally descends to the surface of the Earth. However, during the 20th century, this tropospheric ozone has been supplemented by ozone created by human processes. The exhaust emissions from automobiles and pollution from factories (as well as burning vegetation) leads to greater concentrations of carbon and nitrogen molecules in the lower atmosphere which, when it they are acted on by sunlight, produce ozone. Consequently, ozone has higher concentrations in and around cities than in sparsely populated areas, though there is some transport of ozone downwind of major urban areas. Ozone is an important contributor to photochemical smog. Though the lifetime of ozone is short, and is therefore not well-mixed through the atmosphere, there is a general band of higher ozone concentration during NH spring and summer between 30 N and 50 N resulting from the higher urbanization and industrial activity in this band. Concentrations of ozone have risen by around 30% since the pre-industrial era, and is now considered by the IPCC to be the third most important greenhouse gas after carbon dioxide and methane. An additional complication of ozone is that it also interacts with and is modulated by concentrations of methane.

Nitrous Oxide

Concentrations of nitrous oxide also began to rise at the beginning of the industrial revolution and is understood to be produced by microbial processes in soil and water, including those reactions which occur in fertilizer containing nitrogen. Increasing use of