SCIENCE NEWS of the week

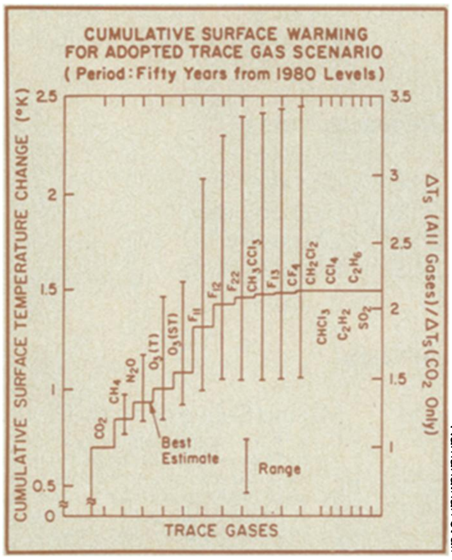
Greenhouse Gases En Masse Rival CO_2

In most people's minds the words "carbon dioxide" and "greenhouse effect" are practically synonymous. Scientists have worried for decades that the dramatic increases in atmospheric CO_2, brought on by the burning of fossil fuels over the last century, are warming the planet like hothouse glass and will eventually alter the climate, melt the ice caps and raise the sea level (SN: 10/22/83, p. 260).

Less well known to the public and even to many scientists is that there are dozens of other greenhouse trace gases that, taken together, could produce a global warming at least as great as that caused by CO_2 alone. Despite the work of a number of researchers on these trace gases over the last decade, "a lot of people who are climate experts and who have looked very carefully at the effect of CO_2 have no idea that the other trace gases could contribute anything like carbon dioxide," says Ralph Cicerone, director of the atmospheric chemistry division at the National Center for Atmospheric Research (NCAR). And, adds Jerry D. Mahlman, director of the Geophysical Fluid Dynamics Program at Princeton University, the magnitude of the heating due to other trace gases "has been a hard pill for some people to swallow because the amount of money spent on CO_2 research compared to this subject differs by a factor of 100 or so."

Now a new paper takes up the subject of trace gases again and underscores its importance. In an upcoming issue of the JOURNAL OF GEOPHYSICAL RESEARCH, Veerabhadran Ramanathan, a climate modeler at NCAR, Cicerone and co-workers present the most comprehensive catalog and analysis of greenhouse gases to date. The researchers assume that the present growth rates of these gases (as measured from 1970 to 1980) will remain the same over the next five decades. They conclude that by the year 2030, the combined effects of these gases would magnify the estimated 0.7-kelvin temperature rise due to just CO_2 by 1.5 to 3 times. "This is an unprecedented change in radiative heating, ... comparable, for the next 50 years, to making the sun shine brighter by one and a quarter percent," says Ramanathan.

In spite of their low abundances relative to CO_2, these trace gases are able to contribute to global heating because molecule for molecule they are much more effective at trapping the infrared energy escaping from the earth as it cools and reradiating that energy back to the planet to heat it up again. Most of the 30 or so trace gases studied by the researchers strongly absorb and emit radiation in a wavelength band from 7 to 13 micrometers (μm); CO_2 misses most of the infrared energy from earth by having absorption lines outside of this band, at 6 and 15 μm. Moreover, the atmosphere is now saturated with CO_2, so that a lot of the energy at 6 and 15 μm is already accounted for. The result is that adding, for example, one chlorofluorocarbon-11 (CFC-11) molecule to the present atmosphere is equivalent in terms of heating to adding 10,000 CO_2 molecules.



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This graph shows the projected change in surface temperature (T_s) caused by adding various gases, at their present emission rates, into the atmosphere during the next 50 years. The temperature effects of changing ozone levels differ in the troposphere (T) and stratosphere (ST).

Like other studies, the recent work indicates that the most important contributors to future temperature changes are methane, nitrous oxide, ozone, CFC-11 and CFC-12 — in part because these chemicals are generally detected at higher levels than the other trace gases studied. But Ramanathan's group also considered a number of gases, now found in tiny amounts, that could have as much of a heating effect as the more abundant gases should their concentrations approach 1 part per billion (ppb). Most of these currently exist at levels 10 to 100 times smaller than 1 ppb, but some have relatively rapid growth rates. Of most concern for the long term are a few of these gases — such as CFC-14 and CFC-116, by-products of the aluminum industry — that are unusually stable, hanging around the atmosphere for hundreds of years, long after most other gases have broken apart. If these gases continue to be emitted at their present rates, the atmosphere will eventually be full of them, with essentially no way to get rid of them, says Mahlman. "So what looks like a very benign and innocent effect could be an extraordinarily huge effect on the 1,000-year time scale," he says.

Unlike previous studies, the new paper also predicts an ozone profile that leads to warming rather than cooling. The researchers conclude that ozone in the upper stratosphere could drop, allowing more sunlight to reach the earth, while at lower altitudes, ozone increases will enhance greenhouse surface warming.

Many of the recent findings depend on the determination of growth rates for the gases, most of which have been introduced into the atmosphere only within the last two decades. Growth rates depend on new uses for chemicals, regulations and economic projections, none of which can be predicted with certainty. It's not surprising, then, that such projections have triggered some controversy.

Ramanathan's group assumed, for example, that CFC use would increase at 3 percent per year. While the United States banned aerosols with CFCs in 1978, other countries continue to use them. And worldwide a variety of other CFC uses, ranging from foam-blowing to cleaning semiconductors, have emerged. CFC use in refrigeration and air conditioning is also growing, especially in developing countries, says Cicerone.

CFC industrial representatives, however, contend that the 3 percent rate for the long-term projections is unrealistically high. "We cannot see in the future any expanded use of CFCs...that would tend to support this kind of number," says Kevin Fay of the Rosslyn, Va.-based Alliance for Responsible CFC Policy. According to Donald Strobach, science adviser to the alliance, a 3 percent growth rate compounded over 50 years would increase global levels 4 to 5 times, meaning that production capability would have to double every decade. "It's a risky projection," he says.

In addition to growth rate prediction, there are other uncertainties inherent in any study linking chemical emissions to atmospheric and climatic changes. The chemistry of the atmosphere is exceedingly complex, and temperature changes can cause all sorts of chemical responses that have yet to be adequately modeled. Moreover, translating heating into real temperature changes is complicated by the fact that oceans absorb "greenhouse-induced" heat, and clouds can change the radiative balance. Even less certain is how temperature changes alter climate.

"There are lots of uncertainties in the problem," says Mahlman. "But we can't think of any combination of scientific arguments or hand waving that will make [the warming effects of trace gases] go away."

—*S. Weisburd*