Unlike carbon dioxide and nitrous oxide, methane has not experienced a continuous rise over the last several hundred years. The data shown here, by Rigby and coworkers from the AGAGE network for several different sites, shows seasonal-- that is to say natural-- variability. But there is no long term increase.

There is a more recent increase in methane. The reasons for this hiatus in methane increase is still being researched.

We now return to our discussion of global warming potential. Global warming potential, or GWP, allows us to compare the radiative impact of different greenhouse gases by relating them to CO2 over a specific time. We can think of this as an integral of radiative forcing of a gas over a chosen time horizon. Gas lifetime must be accounted for, since a short-lived species may not be present over the entire period of our time horizon.

Using methane-- which has a 12-year lifetime-- as an example, a GWP over 100 years would take into account little original methane present at the end of that period. Thus, radiative forcing, gas lifetime, and the time period all affect global warming potential.

Again, using methane-- which has a shorter lifetime than carbon dioxide by almost an order of magnitude-- we see that the global warming potential falls for time horizons of 20, 100, and 500 years. This is also true of some CFCs with lifetimes shorter than CO2.

The reverse is true for long-lived species such as CF4 and SF6. We note that the Kyoto Protocol adopted a 100-year time horizon for discussions of global warming potential and greenhouse gas emissions. Scientifically, we can see that the choice of a time horizon influences how we view global warming potential, especially for species with a lifetime dissimilar to CO2.

Nitrous oxide represents a special case, where the lifetime of the gas is almost equivalent to that of CO2. Although the lifetime of carbon dioxide is often stated as 100 years, it is more complex. Recall the various forms of carbon-- biomass, atmosphere, ocean, and sediments-- that we discussed in the last lecture.

Carbon dioxide can be removed from the atmosphere mainly through reaction with water in the ocean.

This forms carbonic acid, which then can dissociate. It is noteworthy that excess CO_2 uptake by the oceans has resulted in an increase in ocean acidity. This is known as acidification.

It is also noteworthy that as the ocean relaxes to a new, higher carbon dioxide level, excess CO_2 can only be removed by reaction with rocks, and these processes have time scales of thousands to hundreds of thousands of years. Thus, unlike the exponential decay of other greenhouse gases, substantial CO_2 can persist for centuries after the originally stated lifetime of 100 years.

This can be visualized as the warming effect of the greenhouse gases carbon dioxide, nitrous oxide, and methane. The model runs shown here were presented by Solomon and coworkers. In this model, the greenhouse gases are allowed to rise until 2050. And then the anthropogenic emission is stopped. Whereas methane and nitrous oxide effects-- in blue and green-- decay over a 1,000 year horizon, a substantial portion of the carbon dioxide effect does not.