A Long-Term Perspective on Recent Increases in Atmospheric CH_4 Abundance

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After CO_2, methane (CH_4) is the most important greenhouse gas influenced by human activities. Its chemistry results in additional indirect climate effects from production of tropospheric O_3, which also affects air quality, and stratospheric H_2O. Natural emissions of CH_4 from Arctic permafrost and hydrates are susceptible to changing climate. These sources recently received attention in the media because of their potential to cause strong positive climate feedbacks. But how much of this attention is warranted?

From 1999 to 2006, the global burden of atmospheric CH_4 remained nearly constant (red line, top panel of Figure 1). During 2007 and 2008, globally averaged CH_4 increased by ~13 ppb. Do these increases signal the start of increased emissions in the Arctic from permafrost or hydrates because of warming climate? We found that the likely drivers of these increases are greater than average wetland CH_4 emissions at high northern latitudes during 2007 because of exceptionally warm temperatures and in the tropics during 2007 and 2008 because of greater than normal precipitation in wetland regions during a La Niña. These increases result from interannual variations in temperature and precipitation (i.e., weather), which may be in part the result of long-term climate change, but there is yet no evidence for large permanent increases in CH_4 emissions. For 2009, our preliminary estimate of the global increase is ~4 ppb.

When evaluating these recent changes in atmospheric CH_4 burden, it is useful to consider the long-term behavior of CH_4. About a decade ago, we showed that if OH concentrations had been constant over the period of our observations, then total global CH_4 emissions had been constant. The observed decrease in CH_4 growth rate is consistent with a system approaching steady state, where the time constant of that approach is the CH_4 atmospheric lifetime (τ). Is this model of long-term behavior still consistent with the data today? The approach to steady state for this system, with zeroth-order source and pseudo-first-order loss, is given by: $[CH_4](t) = [CH_4]_{ss}-([CH_4]_{ss}-[CH_4]_0)e^{-t/\tau}$. By fitting this equation (**green line**) to the global averages, we find $[CH_4]_{ss} \approx 1799$ ppb and $\tau \approx 9$ yr. The lifetime determined from this fit is in good agreement with values determined independently based on methyl chloroform observations. For more than two decades, atmospheric CH_4 has looked like a system approaching steady state; super-imposed on the decline in growth rate are significant variations. Understanding the processes driving these variations will improve our ability to predict how CH_4 emissions in the Arctic will respond to changing climate. So far, the evidence suggests recent increases in CH_4 are part of natural climate variability and not evidence for strong climate feedbacks in the Arctic.

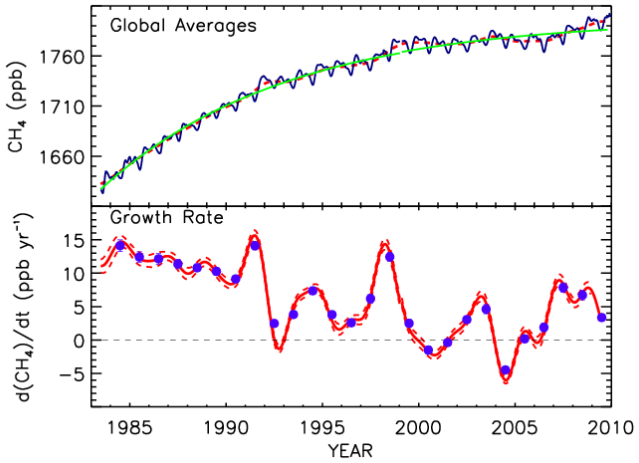

Figure 1. Globally averaged CH_4 mole fractions (blue), trend (red), and exponential fit (green; see text) (top panel); deseasonalized instantaneous growth rate (red) and annual increase (blue) (bottom panel). Results for 2009 are preliminary.