Are Recent Increases in Atmospheric Methane Related to Arctic Climate Change?

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Introduction

Measurements of atmospheric methane (CH_4) from air samples collected weekly at 46 remote surface sites show that, after a decade of near-zero growth, globally averaged atmospheric methane increased during 2007 and 2008. There is the potential for increased CH_4 emissions from strong positive climate feedbacks in the Arctic where there are huge stores of carbon in permafrost (Walter et al., 2007) and hydrates (Westbrook et al., 2009), so the causes of these recent increases must be understood. Emission rates from most anthropogenic sources would produce gradual changes in atmospheric methane which we do not see in the data. Other possible sources to investigate are biomass burning and wetlands, driven by natural variability in temperature and precipitation. Here we use atmospheric observations to investigate the causes of the increase in CH_4 growth rate during 2007 and 2008.

Recent Methane Trends

Figure 1

- Shows global averages and the growth rate for CH_4 from 1983 to 2009.
- From 1999 to 2006, CH_4 was relatively constant.
- CH_4 increased by 7.7±0.2 ppb in 2007 and 6.9±0.2 ppb in 2008.

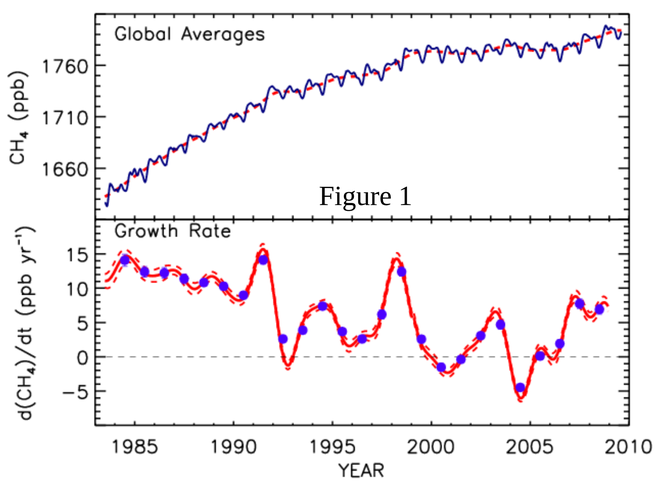


Figure 1

Figure 2

- Shows CH_4 growth rate distributed by latitude.
- The largest increase in 2007 was in the high northern latitudes.
- The largest increase in 2008 was in the tropics, while polar northern latitudes did not increase.

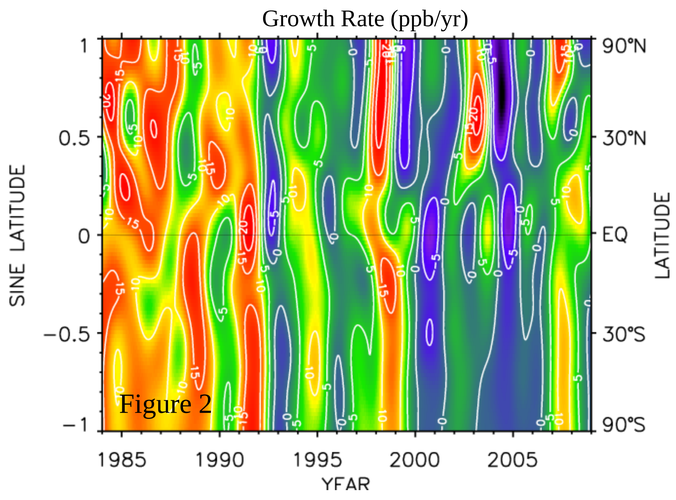


Figure 2

Wetlands - Arctic

- Methane mole fractions (a) and $\delta^{13}C$ (b) are plotted in Figure 5 for Alert, Canada (ALT).
- During summer 2007, CH_4 at ALT was ~12 ppb greater than during the previous few summers.
- In late-summer 2007, we also observed that $\delta^{13}C$ in CH_4 was the lowest during our period of record.
- The changes in $\delta^{13}C$ and CH_4 mole fraction from 2006 to 2007 during summer suggest increased emissions from a source with $\delta^{13}C \approx -66‰$; typical $\delta^{13}C$ from wetlands is -60‰ or lighter.
- The observed change in $\delta^{13}C$ (~-0.1‰ from 2006 to 2007) is too large to be consistent with potential changes in [OH] and in the wrong direction for a biomass burning source.
- The large increase in CH_4 at polar northern latitudes during 2007 compared to other latitude zones was coincident with anomalously high temperature (warmest year since 1980 for northern wetland regions).

Wetlands - Tropical

- 2007 had the 3rd-largest and 2008 the largest positive precipitation anomalies from 1986 to 2008 for all wetland grid cells between 17.5°S and 17.5°N (Schneider et al., 2008).
- In the tropics, precipitation is the dominant driver of wetland CH_4 emissions.
- Above-normal precipitation is typical in some parts of the tropics during La Niña events; La Niña conditions started in mid-2007 and intensified during the first half of 2008.
- CH_4 fluxes for a portion of the Amazon basin for 2007-2008 were 50% greater than fluxes in 2000-2006 (Figure 6).

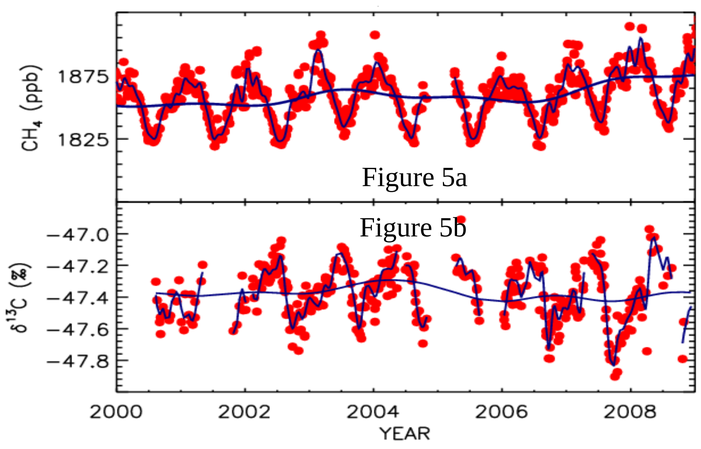


Figure 5a

Figure 5b

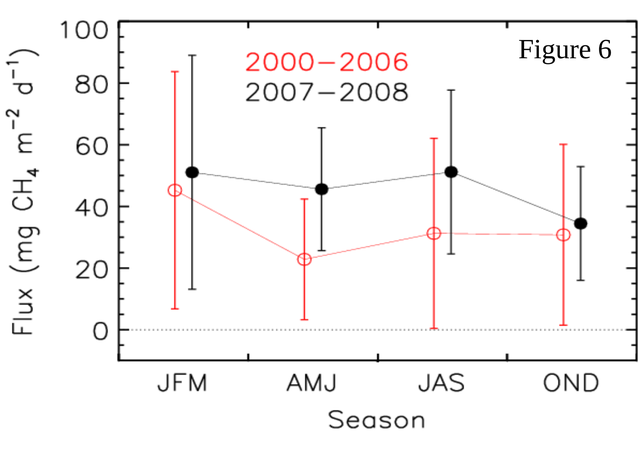


Figure 6

Conclusion

At least three factors contributed to the increase in CH_4 in 2007 and 2008. First, warm temperatures at polar northern latitudes during 2007 likely enhanced emissions from northern wetlands. Second, CO observations by MOPITT and NOAA are consistent with a contribution to CH_4 increases in the tropics by biomass burning, but the fraction of enhanced emissions from biomass burning was small. Third, positive anomalies in precipitation in the tropics, typical during La Niña events, may have driven increased emissions from tropical wetlands. We emphasize that, **although changing climate has the potential to dramatically increase CH_4 emissions from huge stores of carbon in permafrost and from Arctic hydrates, our observations are not consistent with sustained changes there yet.**

Biomass Burning

- We studied surface CO measured in the same samples that were analyzed for CH_4.
- Figure 3 shows CH_4 and CO residuals for northern polar latitudes (53° to 90°N, Figure 3a) and the tropics (Figure 3b).
- MOPITT (Measurements of Pollution in the Troposphere) satellite and in situ CO observations (NOAA CO data) suggest only a minor contribution to increased CH_4 from biomass burning during 2007/2008 (Figures 3 and 4).

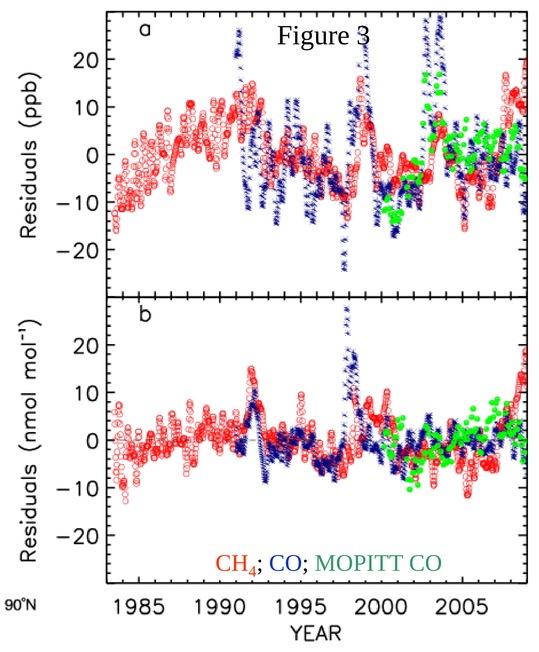


Figure 3

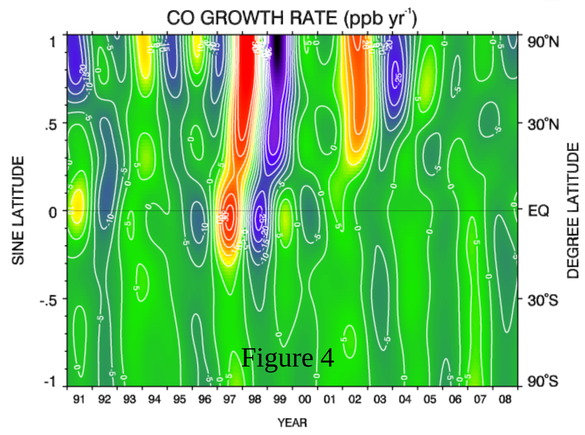
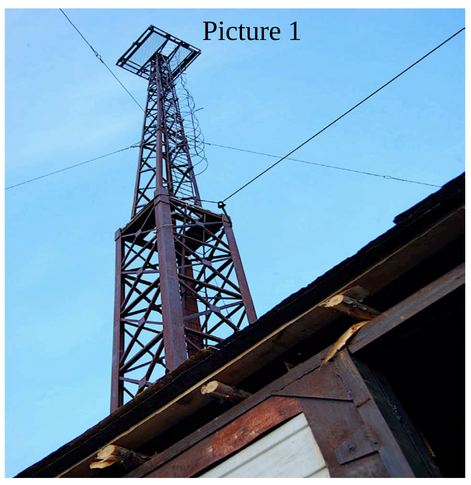


Figure 4

- Observations of ethane (Simpson et al., 2006) and CH_3Cl (lifetime ~1.5 yr), suggest a contribution of biomass burning to the CH_4 anomaly in the tropics during 2007 of ~1 ppb.

Future Work

To monitor carbon in the Arctic, we started continuous measurements of CH_4 at Cherskii, Siberia in summer 2008 (Pictures 1 and 2). Analysis of atmospheric CH_4 shows large increases during the summer when the wind is from wetlands located to the NW (Figure 7). This suggests emissions on order 40 mg $CH_4/m^2/d$.


Picture 1


Picture 2

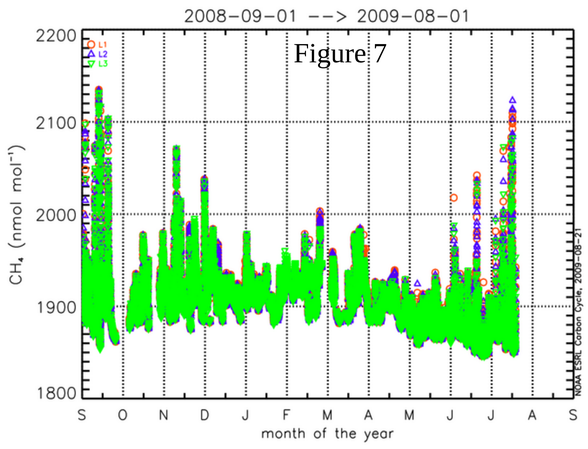


Figure 7

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