Investigating the Cause for the Increase in the Atmospheric Methane Burden from 2007 to Present

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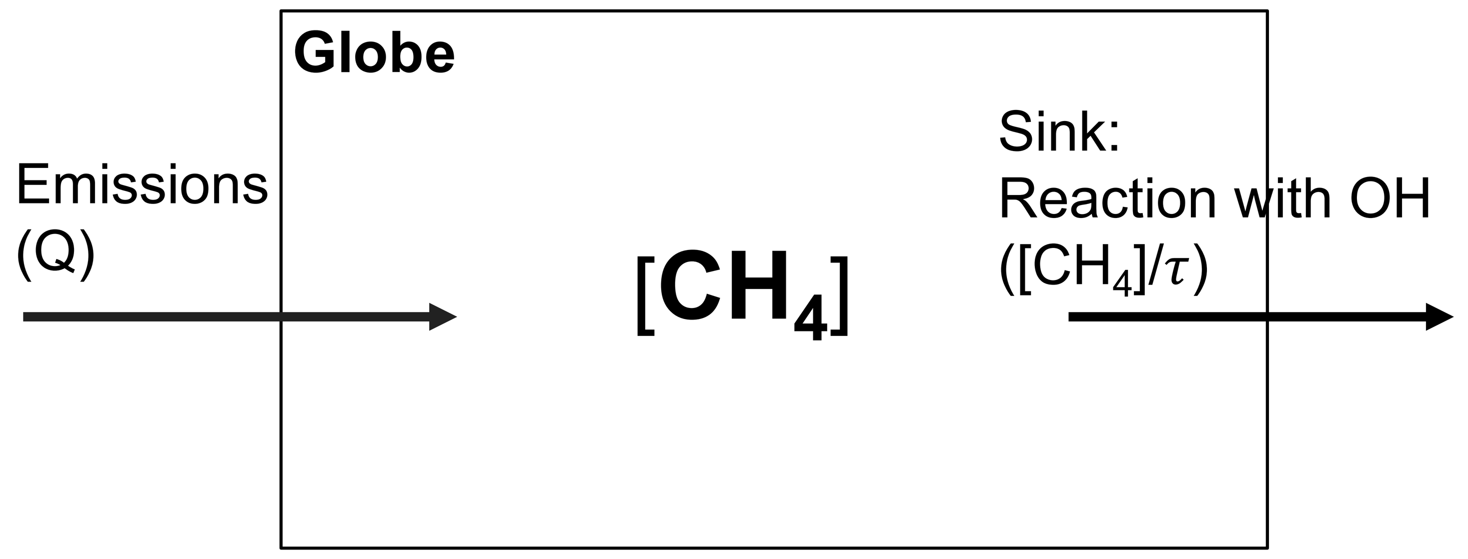
1.0 Objective

The global atmospheric methane burden approached equilibrium from 1983 until 2006, after which atmospheric CH_4 increased because of increased emissions, decreased sink, or both.[1] Here we attempt to determine whether atmospheric CO records are consistent with the hypothesis that the recent increase in atmospheric CH4 is entirely due to a decreased sink.

2.0 Methods

- CO and CH_4's primary sink is the same: reaction with OH radical. If there was a change in the sink for CH_4, there would be a corresponding change in the behavior of CO observations.
- A one-box, global model was employed to model an approach to steady-state for the time period up to 2007 with the assumptions of a lifetime of 9.1 years[1] and constant emissions. How the lifetime would need to change in order to match global observations for 2007 to present was then calculated using the same constant emissions.

CH_4 One Box Model:



$$\frac{d[CH_4]}{dt} = Q - \frac{[CH_4]}{\tau}$$

- Where $[CH_4]$ is the burden (determined from measurements of its atmospheric mole fraction), Q is emissions, and τ is the lifetime

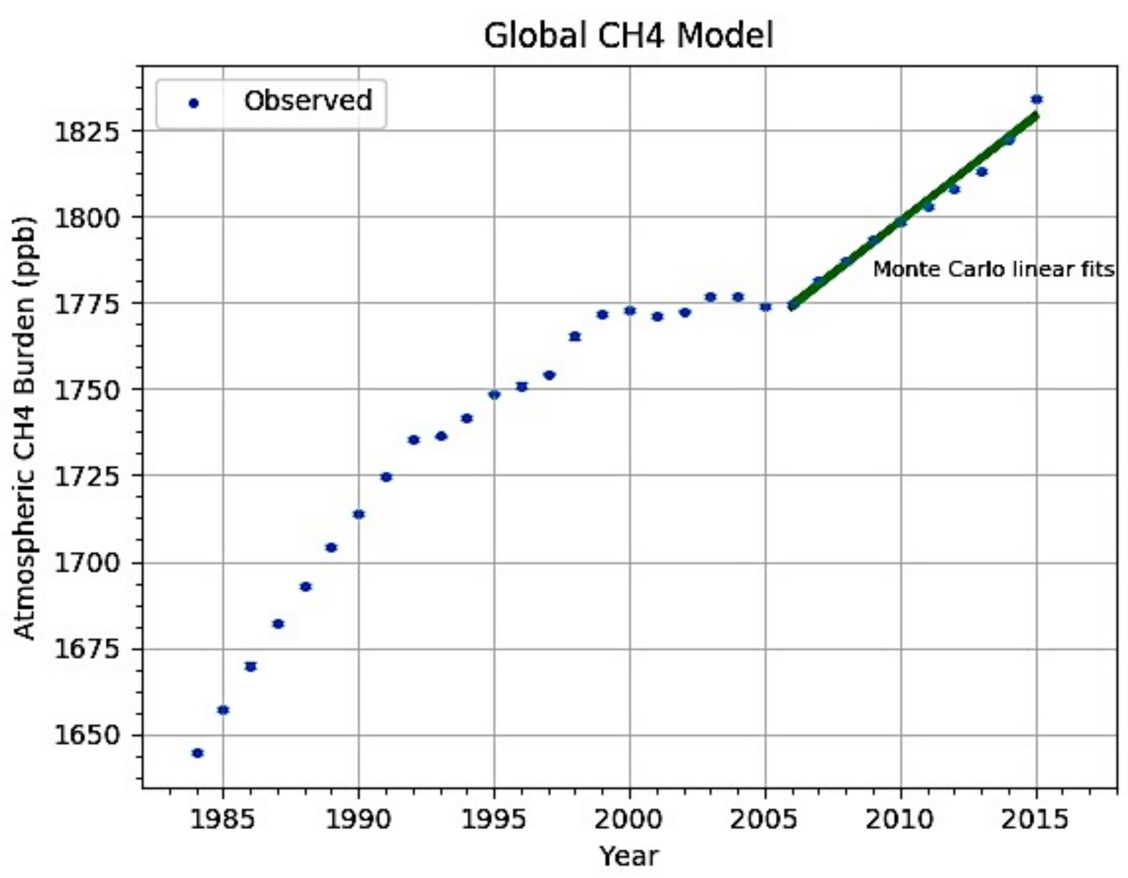
2.1 Methods

- Many linear fits were made to fit methane observations for the time period from 2007 to present, using a Monte Carlo method: taking random samples with a standard normal distribution from the ranges of uncertainty of the observed data.
- Each linear fit corresponds to a different constant rate of change in the lifetime of CH_4 from year to year.

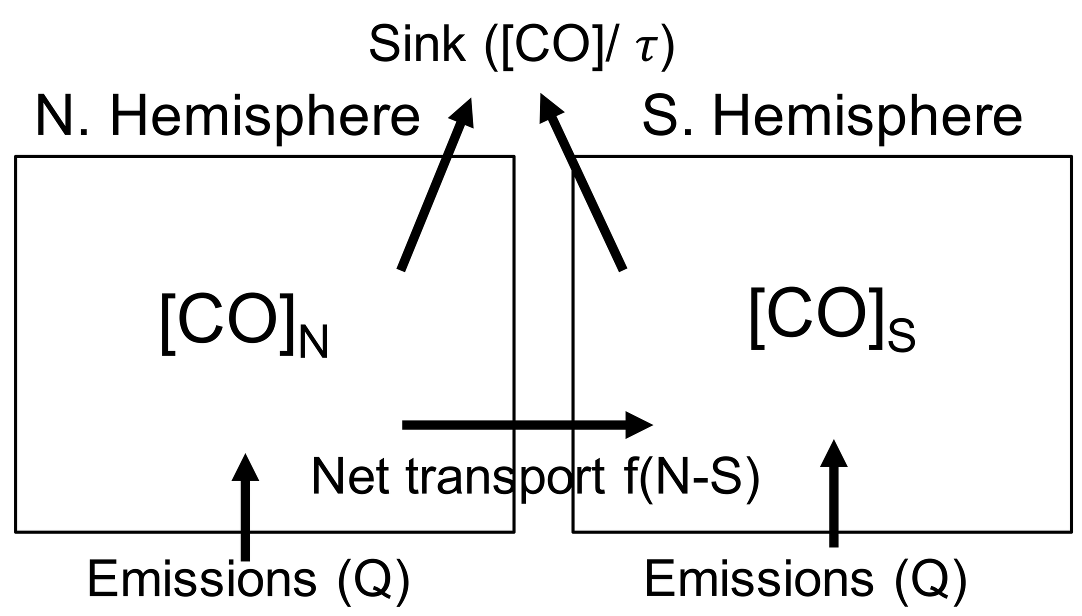
2.2 Methods

- These rates of change were then applied to the lifetimes of CO in a a two-box model using the following conversion.

$$\frac{\Delta\tau_{CH4}}{\tau_{CH4}} = \frac{\Delta\tau_{CO}}{\tau_{CO}}$$



2.3 Methods, CO Two Box Model:

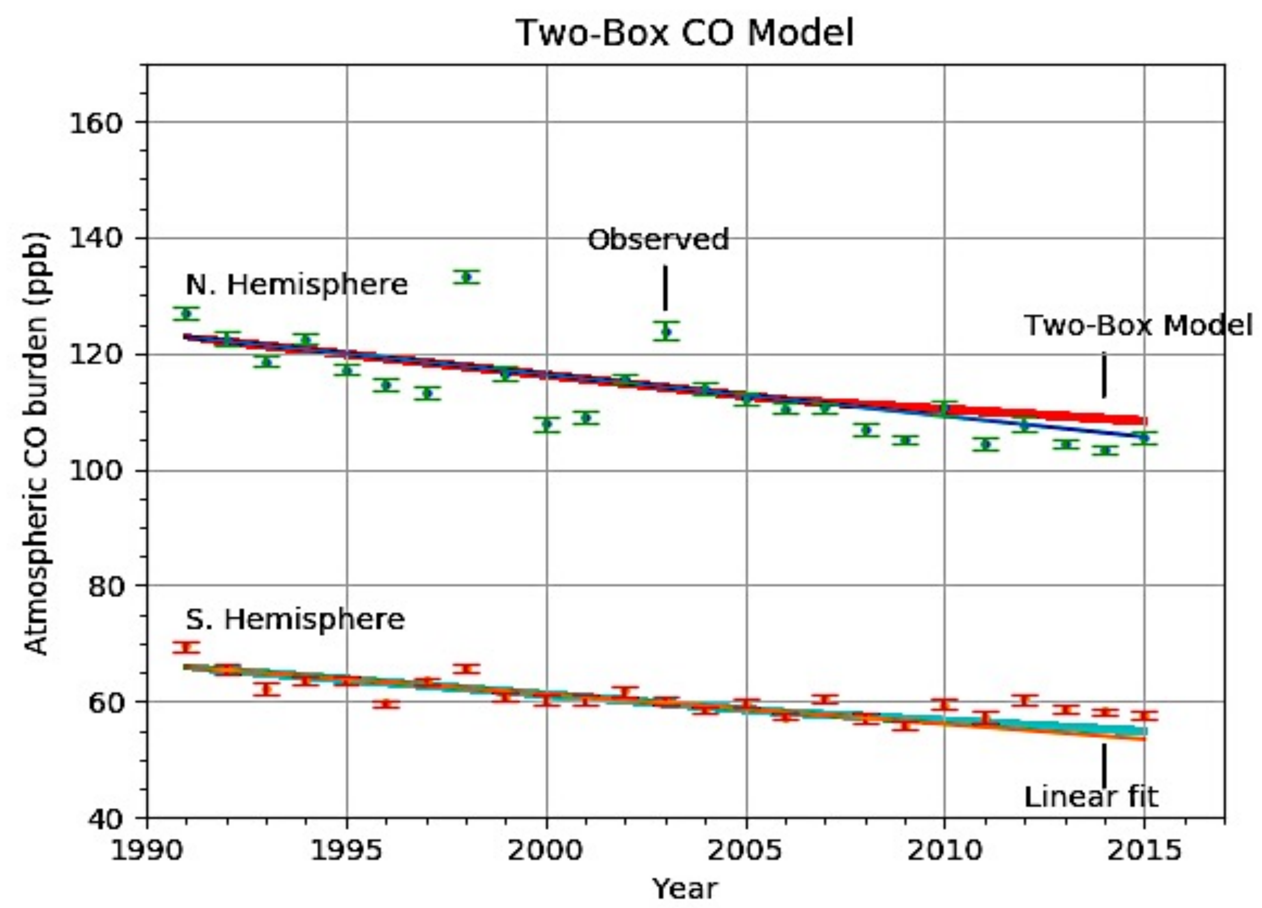


- Where Q is emissions, [CO] is the concentration of CO, τ is the lifetime, f is the interhemispheric exchange constant, and N-S is the difference between Northern and Southern Hemisphere CO.

$$\frac{d[CO]_N}{dt} = Q - \frac{[CO]_N}{\tau} - \mathrm{f(N-S)}$$

2.4 Methods

- Linear fits were calculated for up to 2007 by using an assumed constant lifetime of 0.18 years and finding the consequent trend in emissions for 1991-2006.
- This resulting linear fit was extrapolated through 2007-2015, to model no change.
- Curves calculated from the two-box model vary the time for interhemispheric transport by 3%, and annual lifetimes in accordance with modeled CH_4 lifetime changes



3.0 Results

- The two-box CO model results calculated with perturbed lifetimes to match CH_4 deviate only minimally from the linear trends – largely within the variability of the observed data.
- Based on our analysis of CO, it is inconclusive whether a change in lifetime was the sole cause for the increase in atmospheric CH_4 since 2007.

4.0 Bibliography

[1]Dlugokencky, E. J., Masarie, K. A., Lang, P. M. & Tans, P. P. Continuing decline in the growth rate of the atmospheric methane burden. *Nature* **393,** 447–450 (1998).

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