Global Inventory of Natural Gas Geochemical Measurements for Improved Atmospheric Methane Modeling

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Introduction

Methane (CH_4)is a potent greenhouse gas (GHG) which accounts for ~20% of the GHG radiative forcing over the industrial era (Dlugokencky et al., 2011). The rise in atmospheric CH_4 has been non-linear, with a period of relative stability from 1997-2007, followed by a renewed increase since 2008 (Nisbet et al., 2014; Fig. 1). The reasons for these variations are not completely understood, partly because specific contributions from natural and anthropogenic sources remain unclear (Fig. 2).

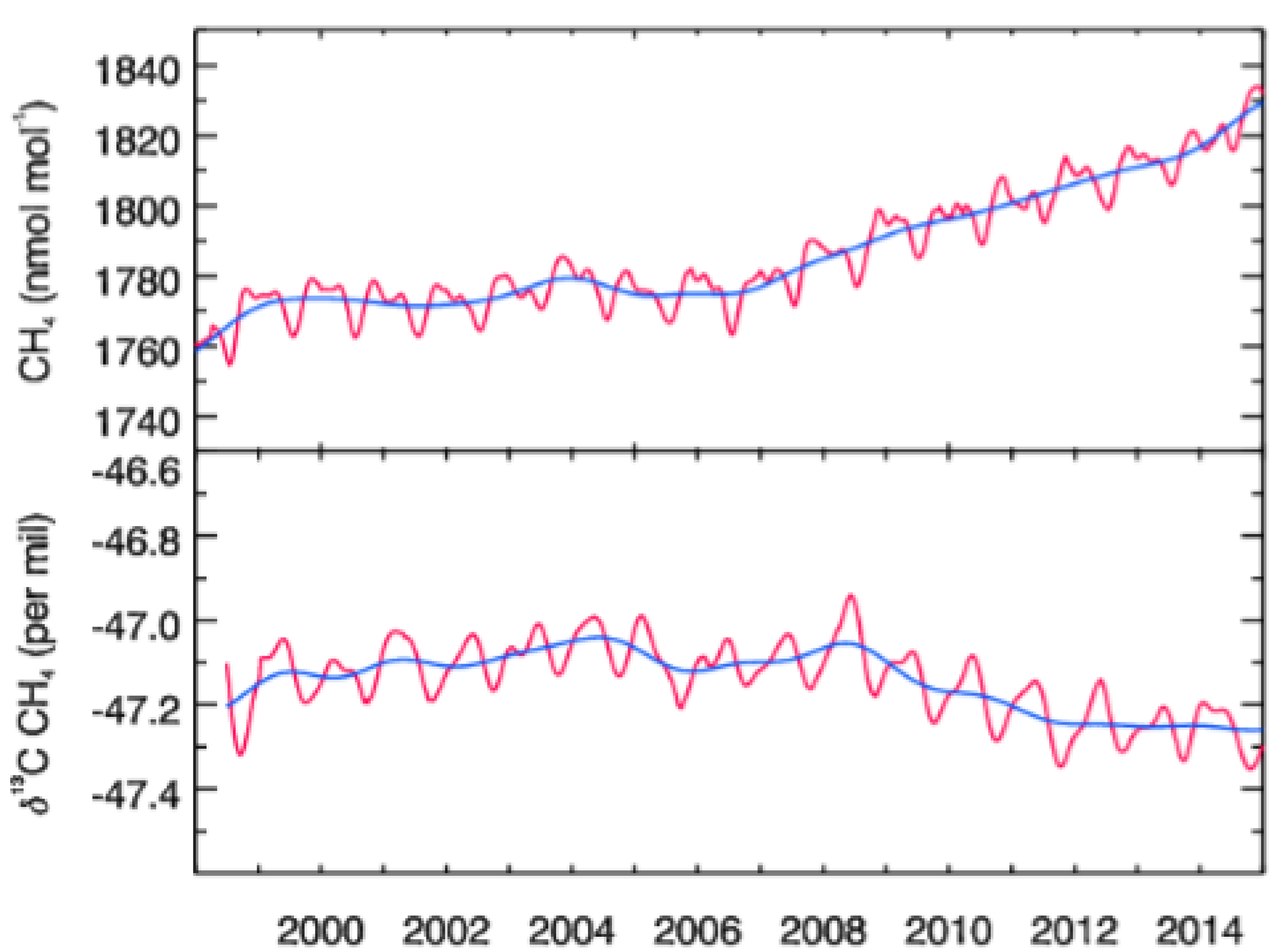

Figure 1: Global time series plots of CH_4 and $\delta^{13}C$ of CH_4 from 1999-2014. The recent rise in CH_4 is concurrent with a decrease in $\delta^{13}C$ of CH_4 .

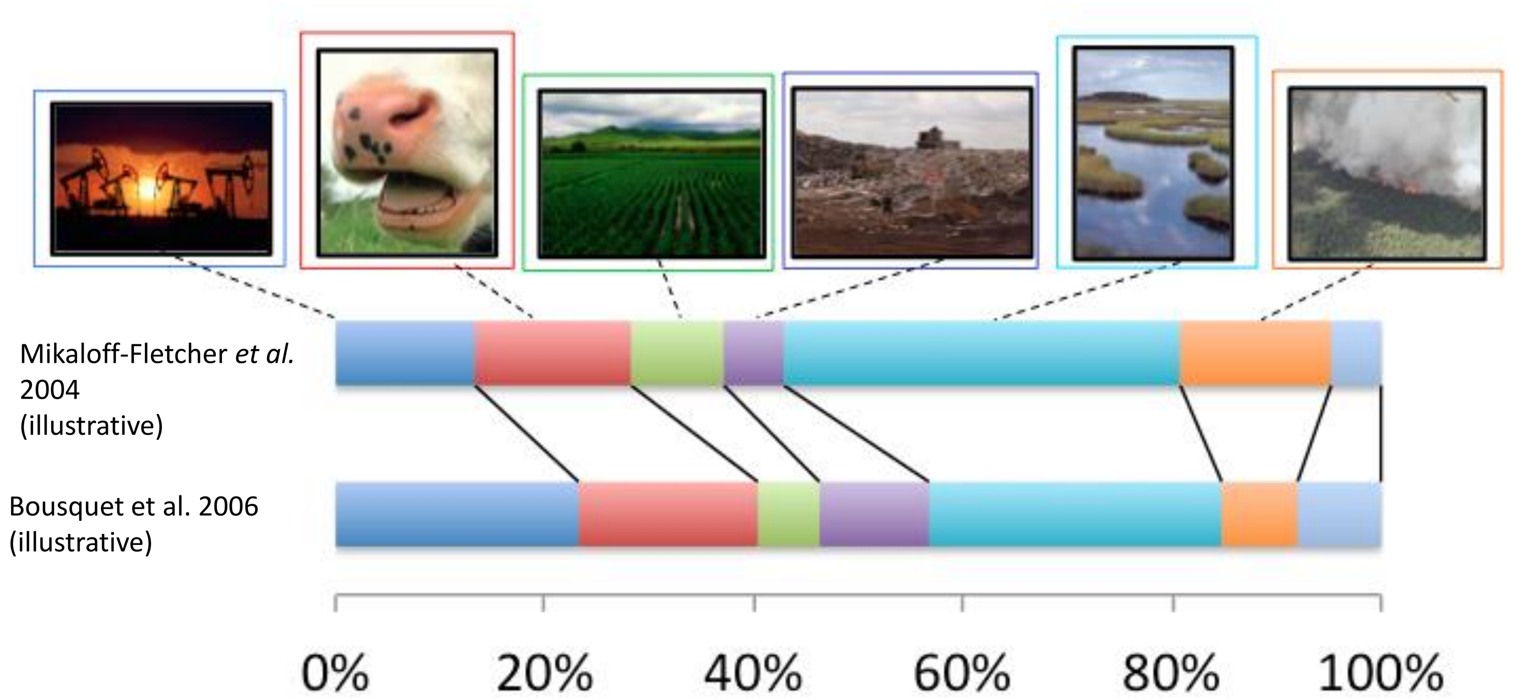

Figure 2: Illustration of uncertainties in attribution of global CH_4 sources. L to R: fossil fuels, ruminants, rice production, landfills, wetlands, and biomass burning.

Why $\delta^{13}C$ end-members?

Measurements of $\delta^{13}C$ can be used to constrain global methane sources (Fig. 1). However, the global-weighted end-member values are not well characterized. By knowing where the end-member values fall horizontally on the scale (Fig. 3), we can estimate how much each of the sources contribute to overall methane concentrations in the atmosphere.

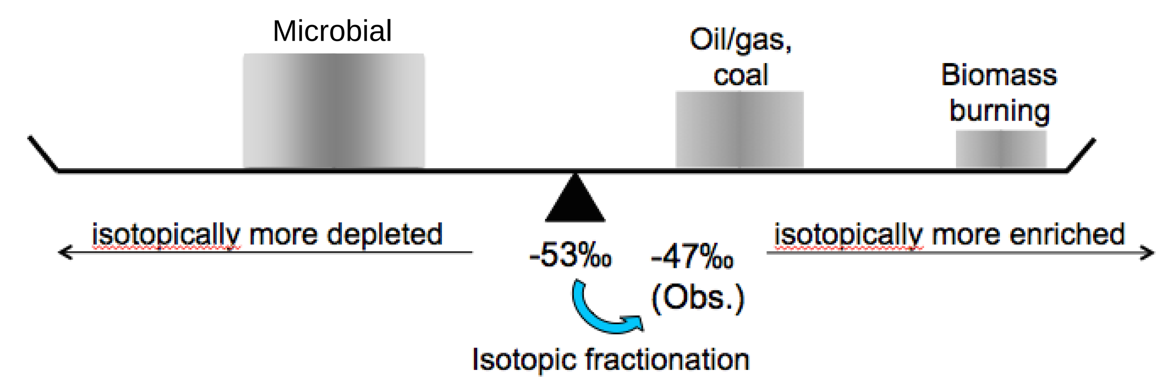

Figure 3: Mass balance of three CH_4 source categories. "Microbial" includes wetlands, ruminants, rice, landfills, and termites.

Database

We compiled a global inventory of natural gas molecular and istopic measurements from the peer-reviewed literature and government reports. The inventory contains data from 45 countries, 179 basins, 597 geological formations, and 10790 unique samples. On a country-level basis, the data represent 79% of world natural gas production.

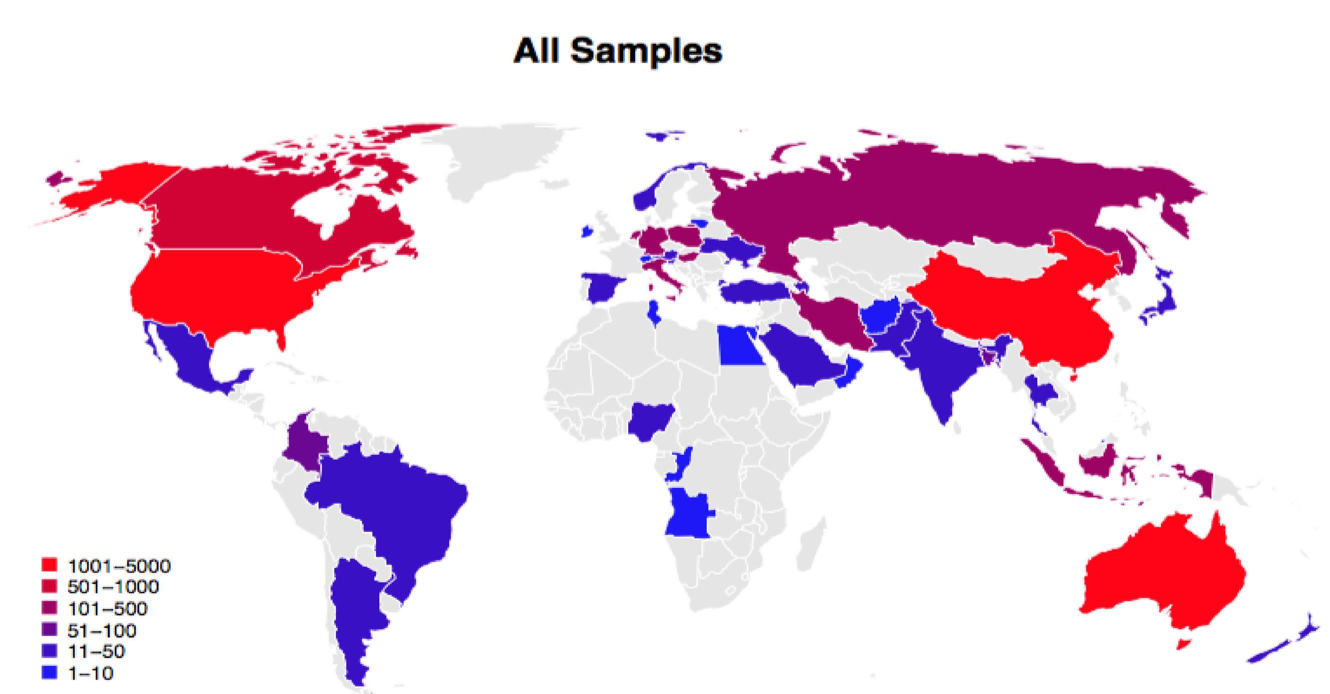

Figure 4: Global sample count of CH_4-$\delta^{13}C$ for all types of natural gas and coal production.

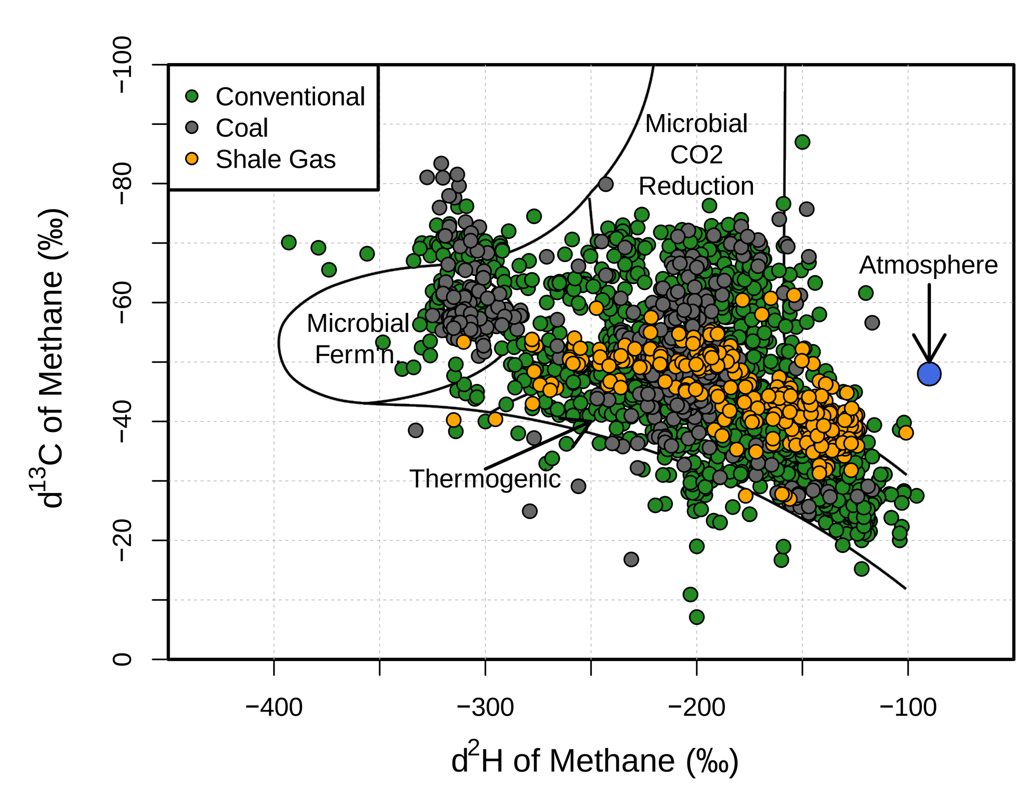

Figure 5: Generic classification of natural gases in the database, according to Whiticar (1999).

Results

Data for different types of natural gas production (conventional, coal and shale gas) are presented in Figs. 5 and 6. Note how CH_4-$\delta^{13}C$ values are skewed to more negative values, because of the importance of isotopically-depleted microbial gas. By weighting the data by continent-level gas production (BP, 2015) integrated over the years 2000-2014, we obtain a global, production-weighted average of -43.9 ± 0.3 ‰ (bootstrapped 95% confidence intervals) for the CH_4-$\delta^{13}C$ of conventional gas. This value is considerably lower than the value (-40 ‰) typically used in global, top-down models of the global CH_4 budget. This could have a major consequence in methane emissions estimates (Fig. 7)

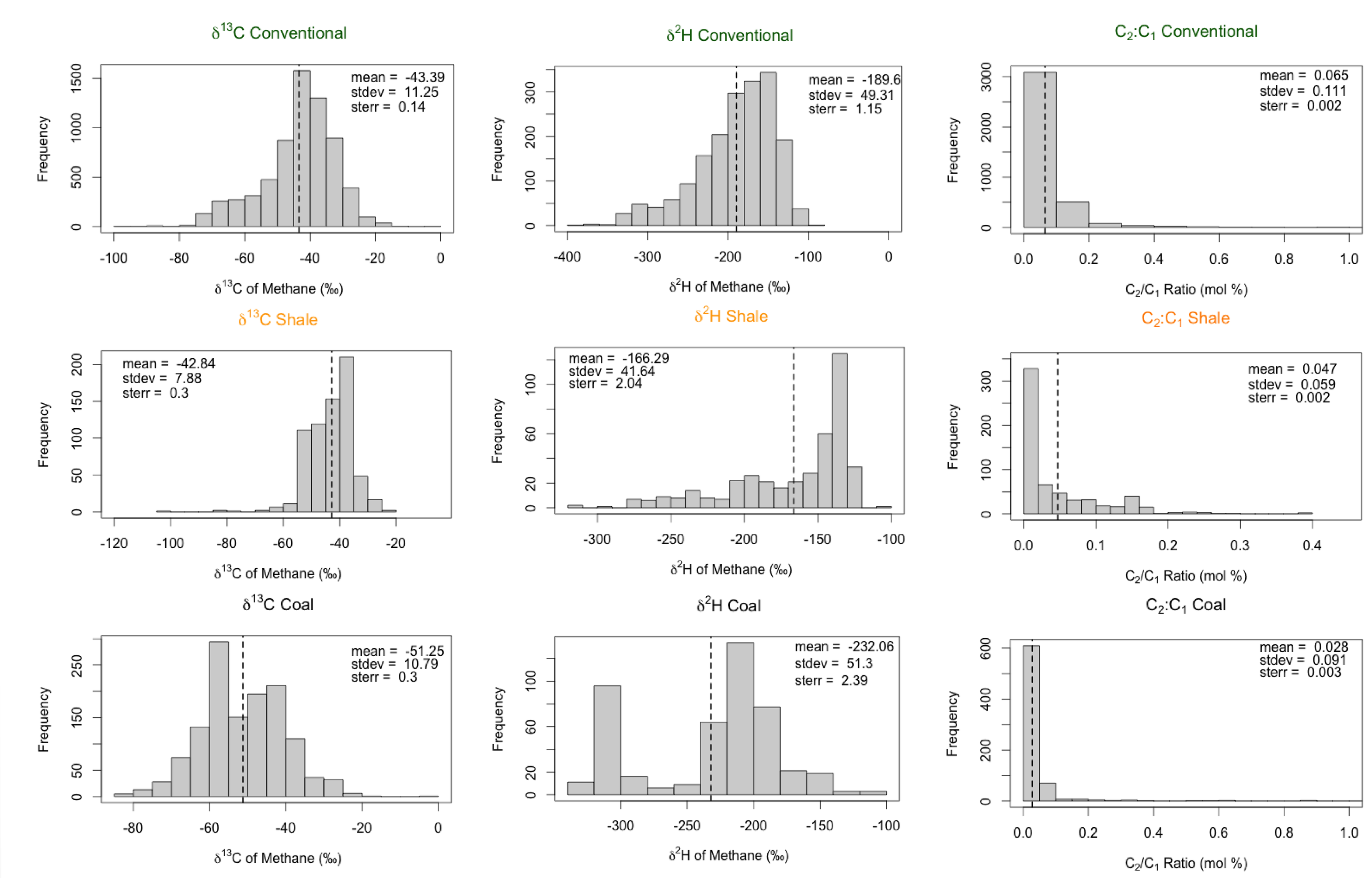

Figure 6: Visual representations of three analyzed parameters ($\delta^{13}C$, $\delta^{2}H$, and C_2:C_1) and three types of production (conventional, shale, coal) in the global database. Statistical weighting of the geochemical parameters by basin-level production is still in progress.

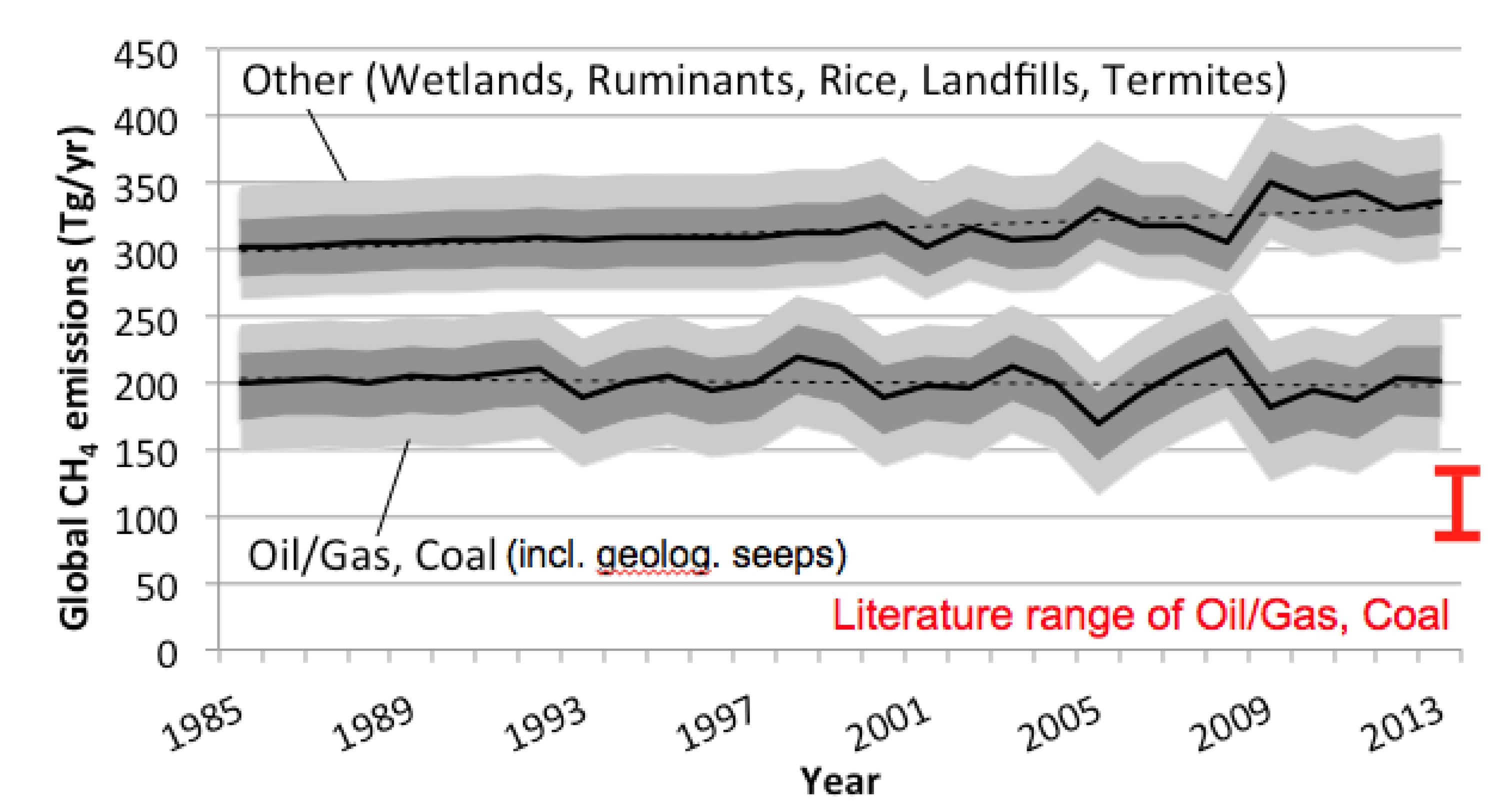

Figure 7: Time series plot of modeled CH_4 emissions from different sources. The recent increase in global CH_4 can be attributed primarily to microbial emissions. Model adapted from Schwietzke et al. (2014) assuming -45 ‰ as the vaue for integrated fossil fuel methane emissions.

References

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