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Understanding methane variability from 1980 - 2015 using inversions of methane, δ^{13}C and ethane

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Atmospheric methane (CH4) increased globally during the 20th century, from a pre-industrial value of approximately 722 ppb to 1773 ppb in 1999. The upward trend, however, was interrupted between 1999 and 2006, when the atmospheric growth rate of CH4 was close to zero. From 2007, atmospheric CH4 started to increase again and, in 2014, the growth rate was substantially faster (12.5 ppb/y) than in any other year since 2007. Changes in the atmospheric growth rate indicate changes in the balance of CH4 sources and sinks, however, the cause of the 1999-2006 stabilization and subsequent rise in atmospheric CH4, and its attribution to different sources is still not fully resolved. Various explanations have been proposed for the pause in the growth, including a reduction in fossil fuel and wetland emissions, and for its renewed increase, such as increasing emissions from wetlands, enteric fermentation, and fossil fuels, as well as a decline in the OH sink. To better constrain the sources and sinks of CH4, we have performed an inversion using the AGAGE 12-box model of the atmosphere using atmospheric observations of CH4, δ^{13}C, and of ethane. Using observations of these 3 atmospheric tracers simultaneously, a stronger constraint is placed on the different sources, as well as the principal atmospheric sink via oxidation by OH. In the model, we account for all emissions grouped into microbial, fossil fuel, biomass burning, landfill and ocean sources, as well as the soil oxidation sink. We also account for the atmospheric sink of CH4 and ethane via oxidation by OH and Cl radicals. The modelled lifetimes of CH4 and ethane were 8.2 years and 1.3 months, respectively. Inversions were also performed in which the OH sink was optimized simultaneously with the emissions. We find that fossil fuel emissions were underestimated in the northern mid to high latitudes in the 1980s but were overestimated from the mid 1990s onwards with respect to the prior (EDGAR-4.2), and that there is no evidence for a recent increase. For microbial emissions, we find an increase in emissions in the northern low and high latitudes from the early 2000s. The inversion also shifts microbial emissions from the northern to the southern low latitudes with respect to the prior (LPX-Bern for wetlands and EDGAR-4.2 for enteric fermentation). Finally, we do not find any evidence for a recent decrease in the OH sink.