(38-240329-B) **New Insights Into the Global Methane Budget from Measurements of Atmospheric δD-CH_4**

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Extensive measurements of the ^{13}C-to-^{12}C ratio of atmospheric CH_4 (expressed as $\delta^{13}C$-CH_4) have helped to quantify the role of different sources in the ongoing and rapid increase in atmospheric CH_4 abundance. However, incomplete understandings of the spatiotemporal variability in the $\delta^{13}C$-CH_4 of major CH_4 source types and atmospheric sink characteristics both add considerable uncertainty to interpretations of $\delta^{13}C$-CH_4. The D-to-H ratio in atmospheric CH_4 (δD-CH_4) is uniquely sensitive to aspects of the CH_4 budget, but it's measurement has received significantly less attention. Although several laboratories now make routine measurements of atmospheric δD-CH_4, these data have seldom been used to improve constraints on the global CH_4 budget.

Here, we examine two global, high-resolution datasets of δD-CH_4: One measured by the INSTAAR Stable Isotope Laboratory from 2005 to 2009 using air samples collected within NOAA's Global Greenhouse Gas Reference Network, and the other measured by the Max Planck Institute from 2011 to present. With these data, we observe robust latitudinal, seasonal, and interannual variability in δD-CH_4. Specifically, we observe a ~10 ‰ latitudinal gradient during NH summer that increases to 18 ‰ during NH winter, reflecting a combination of seasonal variability in the regional strength of microbial emissions and the OH sink. Using an atmospheric one-box model framework, we find that the most recent top-down estimates of the CH_4 budget are consistent with the observed negative trend in δD-CH_4 beginning in 2010 (Figure 1).

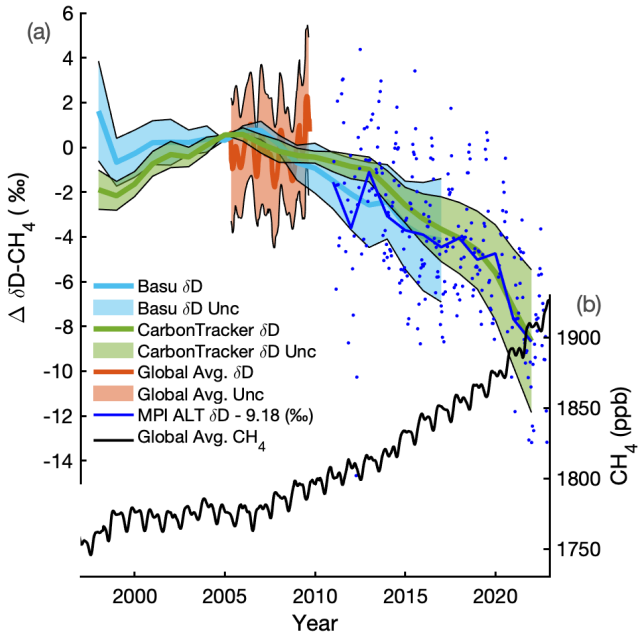

Figure 1. Trends in δD-CH_4. (a) Change in δD-CH_4 relative to 2005, when data begins. Global annual mean δD-CH_4 and uncertainty from the GML/INSTAAR dataset (orange). MPI raw data and annual average δD-CH_4 from ALT, with 9.18 ‰ subtracted to represent global annual mean (Blue line and points). Box modeled relative change in δD-CH_4 from 2005 and uncertainty generated using budget estimates from Basu et al., 2022 (light blue) and CarbonTracker-CH_4 (green). (b) Global average CH_4 mixing ratio (NOAA GML).