Estimating controlling factors of the CH4 changes/variability observed in 2000-2020: a global modeling study with CHASER/VISIT

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Methane (CH_4) is one of the most important greenhouse gases. CH4 has a wide variety of natural and anthropogenic sources, including wetlands, termites, coal mining, livestock, and rice paddies. Although the sources and sinks of CH_4 have been identified, there is still a large uncertainty in estimating their relative contributions to atmospheric CH_4 concentrations and budgets (Kirschke et al, 2013). In this study, in the framework of the chemical climate model CHASER, we investigate global changes in CH_4 concentrations and budgets during the years 2000 to 2020 focusing on the roles of emissions from wetlands and rice paddies, which are the largest natural sources of atmospheric CH_4 accounting for 20-40% of global CH_4 source. In the CHASER simulation, we use the latest EDGAR inventory (V6.0) for industrial emissions. For the emissions from wetlands and rice paddies, we use different sets of simulations by the terrestrial ecosystem model VISIT (Ito and Inatomi, 2012). The CHASER/VISIT simulations are analyzed to evaluate the factors of the CH_4 seasonal/interannual variability and long-term trend for 2000-2020 along with the comparison and verification with the satellite and ground observation data.

Validation using the data from the GOSAT satellite observations and ground-based observations by WDCGG shows that the introduction of the VISIT emissions into CHASER improves the reproducibility of the CH_4 simulations in CHASER, mainly due to the improved estimation of wetland emissions in the Northern Hemisphere mid-high latitudes in the summer and fall seasons.

We also conduct sensitivity simulations on the effects of seasonal variation and interannual variability of the wet-land and rice-paddy emissions on CH_4. It is shown that the seasonality in wetland emissions largely enhances the seasonal amplitude of the global mean atmospheric methane concentration by about 20%, suggesting that the seasonality of wetland emissions can be an important factor in the atmospheric methane response. It is also indicated that the increase in global CH_4 concentration over the past 20 years is largely contributed from wetlands and rice paddies emissions as well as other types of emissions (mainly industrial). Our simulation also shows that the interannual variability of the observed CH_4 growth rate is substantially controlled by emissions from wetlands and rice paddies; in particular, there is a considerably high correlation for the interannual variation of the growth rate between the GOSAT observation and the wetland/rice-paddy driven component in the simulation.

Furthermore, the simulation results suggest that about 50% of the increase in global mean CH_4 observed from 2019 to 2020 can be explained by the increase in emissions from wetlands and rice paddy (mostly from wetlands).

Keywords: methane, land ecosystem, chemistry climate model, CHASER, VISIT

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