Large decrease in CH4 emissions due to the Mount Pinatubo triggered atmospheric CH_4 stabilization in the 1990s

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Atmospheric methane (CH_4) growth rates varied greatly in the past 3 decades, at about 12ppb/yr (range 8.8 –14.3 ppb/yr) increase during 1988-1991, 0-5 ppb/yr during 1992-2005, and 7 ppb/yr (range 4.5 –12.5 ppb/yr) during 2007-2016 (WMO bulletin, 2017). The causes of these variabilities still puzzling to the research communities. We use the MIROC atmospheric general circulation model (version 4.0; Watanabe et al., 2011) for simulating atmospheric CH_4 and other long-lived greenhouse gases. The MIROC-AGCM has a spectral dynamical core and uses a flux from the semi-Lagrangian scheme for the tracer advection. The simulations were conducted for the period of 1988-2016, after a spin-up for 29 years. The CH4 emissions consist of anthropogenic and animals (EDGARv4.3.2), wetland and rice paddies (VISIT terrestrial ecosystem model), and biomass burning (GFEDv4s; period: 1997-2016) and others (TransCom). Two different cases of a-priori emissions are discussed here for varied biogenic emission modeled by VISIT using CH4 emission schemes, Cao et al. (Cao) and Walter-Heimann (WH).

Both the model simulations show remarkable performance in reproducing the observations along with the year-to-year variability, in particular during the transient and constant period from 2000-2006. The model simulates more than 70% of the observed variability successfully over the southern and mid-latitudes (below 45°N). The Cao-scheme performs well in simulating the seasonal amplitude over the tropical sites (15°S-15°N), however, over the southern hemispheric sites (~ below 45°S), the WH-scheme performs better in simulating the amplitude compared to the emissions using the Cao scheme.

It was reported that a major difficulty in producing beginning of the reduction in CH_4 growth rate could only be overcome by a decrease in CH4 emissions (Ghosh et al., 2015). Here we show the VISIT model simulated a decrease in CH_4 emission by about 20 Tg/yr during June 1991 –May 1993, following the Mount Pinatubo eruption. Anomalous cooling over tropical (~20-25 °N) and extratropical (~60-65 °N) wetlands lead to more or less decrease in CH4 emission. Further, we investigate the sensitivity of CH4 concentrations to these emission perturbations during the pre- and post-Pinatubo eruption.

Keywords: Atmospheric Methane, MIROC model simulations, VISIT terrestrial ecosystem model, Mount Pinatubo eruption

