Regional methane emission estimation based on observed atmospheric concentrations (2002–2012)

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Methane (CH_4) is one of the most important short-lived climate forcers (SLCFs) due to its dual roles as a strong greenhouse gas and in air pollution chemistry. A better understanding of the regional (country-level) emissions is required for effective policymaking for emission mitigation as well as for evaluating progress of the committed INDCs (Intended Nationally Determined Contribution) at the Conference of the Parties (COP21) in Paris in 2015. An atmospheric chemistry-transport model (i.e., JAMSTEC's ACTM) has been developed to simulate greenhouse gases and ozone depleting substances. With atmospheric CH_4 lifetime being ~10 years, accurate knowledge of the transport and chemistry are established first for monitoring and verification of CH_4 emissions using atmospheric data by inverse modeling (referred to as top-down method). We have performed an ensemble of 7 inversions, by varying the bottom-up emissions for top-down estimation of CH_4 emissions from 53 partitions of global land using the ACTM forward simulations and atmospheric measurements at 39 surface sites. Our top-down results show that CH_4 emissions for the East Asian and Tropical regions are overestimated, up to about 20 Tg/yr (1Tg = 10^{12}g) each, by the bottom-up method. In contrast, top-down estimation for the southern extratropics is about 10 Tg/yr higher CH_4 emissions compared to the bottom-up method. Furthermore, the emission increase between 2002 and 2012 is also overestimated by the bottom-up method for East Asia. We use additional observational evidences to show that CH_4 emissions from coal burning is overestimated from the East Asia (China) region, and the emissions from enteric fermentation (livestock farming) is increasing in the tropical countries. We determine the tropical CH_4 emissions increase is due to livestock farming, based on an analysis of observed carbon isotopes of CH_4 ($\delta^{13}C$) by Tohoku University and animal population from Food and agriculture organization (FAO) statistics.
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