Improving Global Methane Emissions by Combining TROPOMI Observations and In Situ Measurements

Nikolaos Daskalakis

Institute of Environmental Physics (IUP), University of Bremen, Germany

Author list (excluding presenting author)

Johann Rasmus Nüß, Nikos Daskalakis, Arjo Segers, Oliver Schneising, Michael Buchwitz, Mihalis Vrekoussis, Maria Kanakidou

Abstract

Reducing methane (CH_4) concentrations is fundamental to achieving climate change mitigation objectives of the Paris Agreement. Near-surface atmospheric methane has increased by a 2.7 factor, from 722 ppb (in the pre-industrial era) to 1932 ppb (in 2023). This rise in atmospheric methane concentrations has contributed roughly to 23% (~0.62 Wm^{-2}) of additional radiative forcing from 1750 to 2015. Persistent uncertainties in CH_4 sources and sinks exist due to limited knowledge of the underlying processes, resulting in inconsistencies between top-down and bottom-up flux estimates. Reducing these uncertainties could improve atmospheric modelling and climate change projections, along with inform policy-making. This study works towards such improvements by using an inverse modelling approach with high-resolution data from satellite observations and in-situ measurements from surface stations to optimise global methane emission fluxes. Different configurations of the inversion framework are tested by employing various combinations of satellite observations and surface measurements and evaluating variations in the resulting emissions. Our modelling framework is based on the TM5-MP atmospheric chemistry-transport model, utilising its adjoint within a four-dimensional variational (4DVAR) data assimilation system. Our study focuses on constraining global CH_4 emissions for 2019, initially at a spatial resolution of 3° × 2° (longitude × latitude) and, subsequently, enhancing the resolution to 1° × 1°. The tropospheric CH_4 mixing ratio product slated for assimilation was retrieved by applying a weighting function modified differential optical absorption spectroscopy (WFMD) algorithm to observations from the TROPOMI instrument onboard the Sentinel 5-P satellite. Compared to the operational product from ESA, this product provides improved coverage, particularly at higher latitudes. Near-surface CH_4 observations were taken from the NOAA global surface station network. We discuss the significance of both the resolution of the satellite observations and the type of assimilated data in terms of convergence and resulting optimised emissions.

Early Career Scientist

YES, I am an early career scientist.

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