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Three decades of methane sources and sinks: budgets and variations

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The importance of understanding the global budget and variability of atmospheric methane (CH_4) can be viewed from many different perspectives. The atmospheric CH_4 concentration has rapidly increased – nearly tripled – since 1850, mostly due to human activity and climate change. Methane is an important atmospheric greenhouse gas because of its contribution to the direct radiative forcing, but also its indirect effects through the role of CH4 in the oxidizing capacity of the troposphere, and the production of tropospheric ozone. At the same time, CH_4 is an attractive target for emissions reduction and mitigation due to its relatively short atmospheric life time, and to some extent already existing technological solutions. Controlling climate change on the long term calls for a stabilization of atmospheric carbon dioxide (CO_2) concentrations. However, only by mitigating CH_4 and black carbon emissions (on the short term) together with CO_2 emissions (on the long term) will we be able to stay below the 2°C target of global warming.
Notwithstanding its importance, large uncertainties remain about the process behavior of atmospheric CH_4. Several scenarios, sometimes contradictory, have been published to explain the recent stabilization of CH4 in the atmosphere observed over the last two decades, and the following increase since 2007. Reasons for the large observed interannual variability of atmospheric CH_4, and the relative contributions of the sources and sinks, is still debated (as for instance seen, most recently in 2011, in the Kai et al. and Aydin et al. Nature publications). Finally, no synthesis budget has been aggregated for atmospheric CH_4 as for CO_2.
A comprehensive synthesis of the global CH_4 budget must bring together the different approaches used to estimate CH_4 sources and sinks, so as to fully shed light on their strengths, to close the budget and estimate variability and uncertainties. Atmospheric inversion is a powerful tool to infer the time-varying distribution of regional sources and sinks of CH4. However, as with most top-down approaches, atmospheric inversions provide limited insights on the underlying processes causing the emissions. The existence of several satellites measuring CH_4 columns from space (SCIAMACHY, GOSAT, IASI) with reasonable precision (e.g. ±2%) and global coverage is unique and offers a valuable complement to high precision (e.g. ±0.1‰ but unevenly spaced surface networks. Bottom-up ecosystem models computing wetland or fire CH_4 emissions incorporate knowledge of small-scale processes, but often need additional constraints to project their local estimates to regional and global scales to produce large-scale emission estimates that are compatible with global atmospheric signals. Emissions inventories are based on various economical statistics, and provide yearly estimates of the different anthropogenic emissions at global and country scales. Finally, many minor sources for which only limited quantitative global estimates are available can together make a significant contribution to the global source mix.
Here we show a synthesis of the global CH_4 budget for the past three decades by consolidating the available knowledge from the above approaches: atmospheric inversions, bottom-up land surface models, and emission inventories. With support from the Global Carbon Project, we have been bringing together most of the scientific teams working on estimating CH_4 sources and sinks from regional to global scales. We will present a complete synthesis of the decadal CH_4 budget for the past three decades, the regional CH_4 budget, the interannual variability of atmospheric CH_4, and the remaining uncertainties in the knowledge of the CH_4 cycle.