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Estimating Amazonian methane emissions through 4D-Var inverse modelling with satellite observations from GOSAT and IASI

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Abstract:
Methane (CH4) is emitted from a range of anthropogenic and natural sources, and since the industrial revolution its mean atmospheric concentration has climbed dramatically. CH4 produces a relatively high radiative forcing effect upon the Earth's climate, and its atmospheric lifetime of approximately 10 years makes it an appealing target for the mitigation of climate change.

However, the spatial and temporal variation of CH4 emissions are not well understood, though in recent years a number of top-down and bottom-up studies have attempted to construct improved emission budgets. However, some top-down studies suffer from poor observational coverage near the Amazon basin, particularly in the planetary boundary layer. Since emissions from this region, coming mainly from wetland and burning sources, are thought to be relatively high, additional observations in this region would greatly help to constrain the geographical distribution of the global CH4 emission budget. To this end, regular flask measurements of CH4 and other trace gases have been taken during flights over four Amazonian sites since 2010, as part of the AMAZONICA project. The GOSAT has been used to retrieve global column-average CH4 concentrations since mid-2009, whilst IASI, on-board Metop-A, has also been measuring atmospheric CH4 concentrations since its launch in 2006.

We present an assessment of Amazonian methane emissions for 2010 and 2011 using the TOMCAT Chemical Transport Model and the new variational inverse model, INVICAT. These models are used to attribute methane variations at each Amazon site to a source type and region. To assess the ability of our current CH4 flux estimates to reproduce these observations and to produce improved posterior emission estimates through assimilation of atmospheric observations. This study represents the first use of the INVICAT scheme to constrain emissions of any atmospheric trace gas. Whilst there is generally good agreement between the model and the observations prior to data assimilation, some high-methane events indicated by the observations are not captured by the model. We assimilate observations from the NOAA surface measurement network, from the AMAZONICA aircraft and from the GOSAT and IASI satellites, and find that tropical South American CH4 emissions approach 50 Tg(CH4)/yr.

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