5.090 Characterizing model errors in chemical transport modelling of methane: Using GOSAT XCH4 data with weak constraint four-dimensional variational data assimilation.

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Abstract:

Recently, there has been much effort focused on inverse modeling of surface emissions of CH_4 to better understand the observed changes in the atmospheric growth rate of CH_4. These inverse modeling analyses depend critically on the fidelity of the chemical transport models (CTMs) employed to relate the surface emissions to changes in the atmospheric distributions of CH_4. In particular, most inverse modeling schemes implicitly require that the CTMs are free of systematic errors, which can adversely impact the inferred emission estimates. However, until now, characterizing systematic model errors has been challenging. We introduce a new four-dimensional variational (4D-Var) data assimilation scheme, referred to as weak constraint 4D-Var, that provides a means of characterizing and mitigating systematic model errors in the context of 4D-Var data assimilation. We assimilate retrievals of column-averaged dry-air mole fractions of CH_4 (XCH_4) from the Greenhouse gases Observing SATellite (GOSAT) using weak constraint 4D-Var in the GEOS-Chem CTM to characterize systematic model errors. Specifically, we focus on characterizing model errors in the GEOS-Chem CH_4 simulation at the horizontal resolutions of 2° x 2.5° and 4° x 5°. We also assess the impact of these model errors on inferred CH_4 emission estimates. We find that the weak constraint 4D-Var scheme identifies biases in the model simulation of CH_4 associated with excessive mixing across the tropopause in the extratropical upper troposphere and lower stratosphere. The assimilation scheme also suggests that the model vertical transport in the troposphere at middle and high latitudes is too weak, particularly impacting upward transport of CH_4 over the source regions in eastern Asia and North America.