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Bracketing the range of lake and wetland methane emissions rates in West Siberia using models, in situ observations, and remote sensing

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Large uncertainties exist in estimates of global lake and wetland methane emission rates, due in part to their large spatial and temporal heterogeneity and also due to the sparseness of in situ observations. This is especially true of lakes and inundated wetlands, for which ebullition is a major methane pathway. Here we use a large-scale coupled land-atmosphere model and remote sensing observations to bracket the range of possible emissions rates from lakes and wetlands in West Siberia. Our modeling framework consists of a large-scale hydrology model (Variable Infiltration Capacity; VIC), extended to handle carbon cycling and methane emissions, coupled to an atmospheric tracer-transport model (NIES Chemical Tracer Model; CTM) driven by NCAR/NCEP reanalysis fields. In the model, "permanent" lake areas are prescribed by the Global Lake and Wetland Database, bias-corrected to account for small lakes. Seasonal inundation of wetlands is dynamic and has been calibrated to match an inundation dataset derived from remote sensing (AMSR-E and Qscat). We calibrated the model's wetland methane emissions to match in situ observations from a large dataset collected in West Siberia between 2006 and 2010. Lake emission rates are prescribed in several scenarios that span the range of observed rates reported in the literature. We explore the relative sizes of various sources of uncertainty in simulated methane emissions: uncertainty in inundated area, parameter uncertainty in the methane emissions model, and the range of possible lake emissions rates. Using values from different ends of the spectrum of these uncertainty sources leads to markedly different spatial patterns of methane emissions across West Siberia. These emissions are ingested by the atmospheric tracer model to produce maps of atmospheric methane concentrations. We compare the resulting spatial patterns of methane concentrations with remotely-sensed observations from the AIRS and GOSAT satellite sensors and explore the implied likelihoods of the different lake and wetland emissions rates.

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