Abstract

Lakes and wetlands are important sources of the greenhouse gases CO2 and CH4, whose emission rates are sensitive to climate. The northern high latitudes, which are especially susceptible to climate change, contain about 50% of the world’s lakes and wetlands. With the predicted changes in the regional climate for this area within the next century, there is concern about a possible positive feedback resulting from greenhouse gas emissions (especially of methane) from the region’s wetlands and lakes. To study the climate response to emissions from northern hemisphere lakes and wetlands, we have coupled a large-scale hydrology and carbon cycling model (University of Washington’s Variable Infiltration Capacity model; VIC) with the atmospheric chemistry and transport model (CTM) of Japan’s National Institute for Environmental Studies and have applied this modeling framework over the Pan-Arctic region. In particular, the VIC model simulates the land surface hydrology and carbon cycling across a dynamic lake-wetland continuum. The model includes a distributed wetland water table that accounts for microtopography and simulates variations in inundated area that are calibrated to match a passive microwave based inundation product. Per-unit-area carbon uptake and methane emissions have been calibrated using extensive in situ observations. In this paper, the atmospheric methane concentrations from a coupled run of VIC and CTM are calibrated and verified for the Pan-Arctic region with satellite observations from Aqua’s Atmospheric Infrared Sounder (AIRS) and Envisat’s Scanning Imaging Absorption Spectrometer for Atmospheric Cartography (SCIAMACHY) instruments. We examine relative emissions from lakes and wetlands, as well as their net greenhouse warming potential, over the last half-century across the Pan-Arctic domain. We also assess relative uncertainties in emissions from each of the sources.

1. Research Domain

Northern High Latitudes: 45N-80N, 180W-180E

2. Modeling Framework

1. Simulate land surface hydrology and carbon cycle using Variable Infiltration Capacity (VIC) model
2. VIC’s dynamic lake-wetland continuum
3. Linkages among models
   - VIC Land Surface Model
   - VIC’s dynamic lake-wetland continuum
   - Water-Heinmann Infiltration models
3. Wetland CH4 emissions
4. Transport Model

3. Model Calibration – over West Siberia

SCIAMACHY kernel: sensitive to lower atmospheric methane concentration, most sensitive to near surface concentration
AIRS kernel: sensitive to upper layer atmospheric methane concentration
Note: for current simulation, wetlands methane emission is mainly from West Siberia

4. Wetland Methane Emissions over West Siberia

Glagolev et al. (2011): 3.9 +/- 1.4 Tg CH4/y
Our Estimate: 3.6 Tg CH4/y

5. Simulated Atmospheric Concentrations over W. Siberia

Simulated emissions computed in section 4 (above) are input to the CTM model
CTM’s lake CH4 based model (% of total CH4 emissions)

6. Surface Methane Concentration

Comparison of AIRS and Scinacyma kernels

7. Conclusions

1. VIC model successfully reconstructed lake and wetlands topography, and gave reasonable variation of water tables over the whole Pan-Arctic region
2. CTM model reproduced the lower atmospheric methane concentration patterns well. Coupling of hydrological model (VIC) and atmospheric model (CTM) could show atmospheric methane concentration well where hydrological cycle and carbon cycle are highly integrated
3. Future work: 1) Analysis of satellite observation of methane, finding a better way of deriving near surface methane concentration from observations; 2) Conduct CTM runs using surface methane emissions from all possible source from VIC output (i.e. West Siberia and northern Canada)