

# An integrated approach for estimation of methane emissions from wetlands in high latitude regions

C. Chiu<sup>a</sup>, L. C. Bowling<sup>a</sup>, E. Podest<sup>b</sup>, T. J. Bohn<sup>c</sup>, D. P. Lettenmaier<sup>c</sup>, R. Schroeder<sup>d</sup>, K. C. McDonald<sup>b</sup>



<sup>a</sup>Department of Agronomy, Purdue University, West Lafayette, IN, USA

<sup>b</sup>Water and Carbon Cycles Group, Jet Propulsion Laboratory, California Institute of Technology, Pasadena, California, USA

<sup>c</sup>Department of Civil & Environmental Engineering, University of Washington, Seattle, WA, USA

<sup>d</sup>University of Hohenheim, Institute of Botany and Botanical Gardens (210), Garbenstrasse 30, 70599 Stuttgart, Germany



## Introduction

In recent years, there has been increasing evidence of significant alteration in the extent of lakes and wetlands in high latitude regions due in part to thawing permafrost, as well as other changes governing surface and subsurface hydrology. Changes in surface water extent, and the associated subsurface anaerobic conditions, are important controls on methane emissions in high latitude regions.

In this study, we investigate the variability of methane emissions with northern wetland extent using an integrated assessment approach based on remote sensing image classification, a biogeochemical model and a macroscale hydrological model with a parameterization of sub-grid water table depth. There are three objectives to this study:

- ❖ Utilize remotely sensed wetland extent and topographic data for parameterizing a lake and wetland algorithm in the hydrologic model
- ❖ Evaluate the simulated change in lake and wetland extent with respect to remotely-sensed inundation products.
- ❖ Utilize simulated water table depth and soil temperature to evaluate variability in methane emissions in Eurasian wetland regions.

## Study Areas

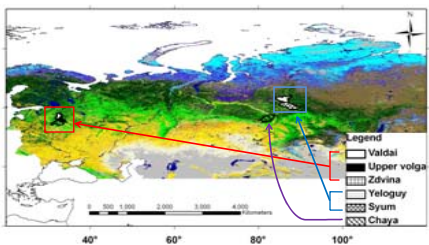


Figure 1. Three study regions with land cover of the NEESPI domain (source: Bartalev et al. 2003)

❖ As shown in Figure 1, our preliminary investigation was carried out over three regions:

- ❖ Region 1: Yelogy and Syum River basins
- ❖ Sporadic permafrost
- ❖ Region 2: Zapadnaya Dvina, Lake Valdai, and Upper Volga River basins
- ❖ Seasonal soil frost
- ❖ Region 3: Chaya River basin
- ❖ Sporadic permafrost

## Methodology and Model Description

- ❖ Landcover classification from L-band JERS-1 SAR (100m) and ALOS PALSAR (~30m) was used to generate a wetland mask in each region.
- ❖ A 100m resolution Digital Elevation Model (DEM) interpolated from the GTOPO30 was used to generate the topographic wetness index distribution for wetland areas.
- ❖ This is used to parameterize the Variable Infiltration Capacity (VIC) land surface model (Liang et al. 1994) lake and wetland algorithm at 25 km x 25 km resolution (see below).
- ❖ The VIC model-simulated soil temperature at different depths and water table position are used to simulate daily methane emissions using the Walter and Heimann (2000) model.

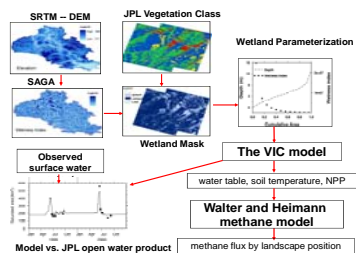


Figure 2. Schematic diagram of remote sensing technique, VIC model, methane model

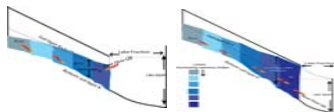
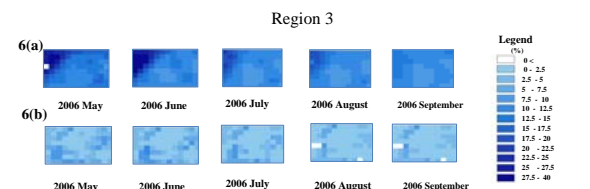
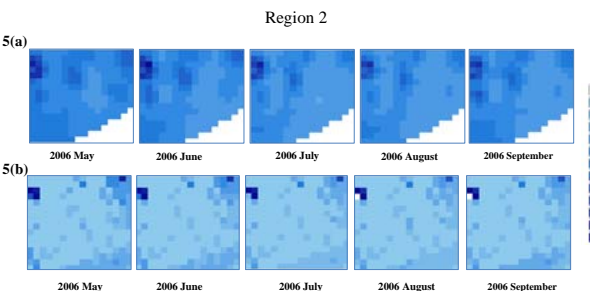
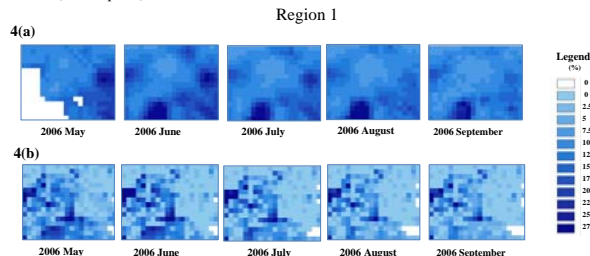


Fig 3. Distributed water table resulting from the fractional area topographic index curve in the VIC model, allowing surface and subsurface water exchange.

- ❖ A recent modification to the VIC wetland algorithm allows the exchange of surface and subsurface moisture and sub-grid variability in the water table position, through use of the topographic index.

## Variation in Open Water Extent

- ❖ The VIC model was applied to each of the three test regions at 25 km resolution (EASE grid). For each region, the panels illustrate:
  - ❖ 25 km resolution inundation products developed from combined QuickSCAT, AMSR-E and MODIS data sets in 2006 (top panel).
  - ❖ The temporally-variable inundation extent simulated by the VIC lake model (bottom panel).



## Methane Emissions

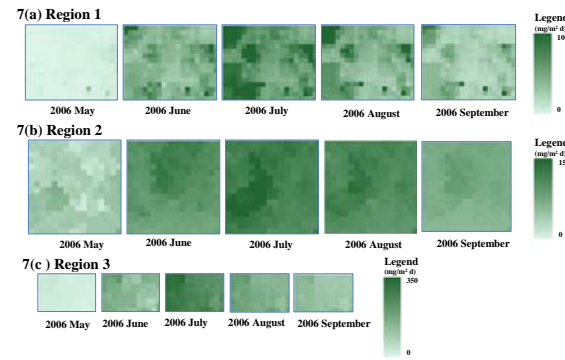


Figure 7. Simulated monthly methane emissions (25 km resolution) using the VIC grid cell average water table as input to the Walter and Heimann (2000) methane model from May to October in 2006.

Table 1. Arctic and subarctic methane emissions from remote sensing technique, field measurement and model simulation results:

	Location	Vegetation	Growing season mg m <sup>-2</sup> d <sup>-1</sup>	Annual mg m <sup>-2</sup> yr <sup>-1</sup>	
Landsat 7 ETM+ (1999-2006)	Lena River Delta, Russia (72-73.8°N, 122.0-129.5°E)	Tundra	10.35 <sup>a</sup>	972.14	Schneider et al., 2009
SPOT HRV and NOAA AVHR (1994)	Plotnikovo, Russia (57°N, 82°E)	Forested and open bog	83 <sup>b</sup>	NA	Takeuchi et al., 2003
Field observations	Plotnikovo, Russia (57°N, 82°E)	Peatland	182-465 <sup>c</sup>	13,900 - 43,400	Panikov and Dedysh 2000
Field observations	E. Bakchar Bog near Plotnikovo, West Siberia (56°51'N, 82°58' E)	Bog	136 <sup>d</sup>	26,000	Friborg et al., 2003
PEATLAND-UV model	Kyralyk, NE Siberia (70°N, 147°E)	Peatland	30.96 - 50.16	NA	Petrescu et al., 2008

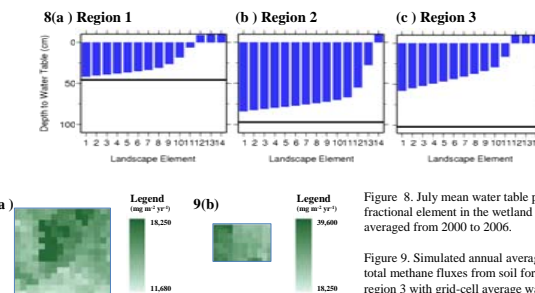
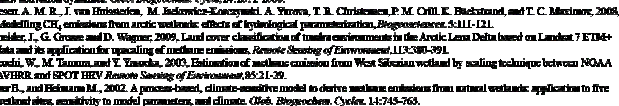


Figure 8. July mean water table position for each fractional element in the wetland landscape averaged from 2000 to 2006.

Figure 9. Simulated annual average (2000-2006) total methane fluxes from soil for (a) Region 2 (b) region 3 with grid-cell average water table (VWT).



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