Reconstruction of Inundation and Greenhouse Gas Emissions from Siberian Wetlands over the Last Half-Century

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Abstract

Changes in greenhouse gas emissions such as methane (CH4) and carbon dioxide (CO2) from high-latitude wetlands is a warming transient mechanism for projections of global warming, due to the large amounts of carbon stored in high-latitude soils and the high greenhouse warming potential of methane. As much as 1/3 of global natural methane emissions come from wetlands. Hence, it is important to quantify the effects of errors in the TOPMODEL parameterization, and uncertainty in model parameter values, on simulated inundation and greenhouse gas emissions. For each ROI, we aggregated to 2700 m resolution, computing the fraction of 30 m DEM pixels having wetness index >-mean(fraction_inundated). We then selected the top 10000 most varied pixels for each ROI. We used these data to calibrate the model and produce time series of inundation and methane emissions at each grid cell. We then used the calibrated model to explore the interannual variability of inundation and methane emissions.

1. Modeling Approach

1.1 Land Surface Hydrology Model

• Variable Importance (VIC) Model (Liang et al., 1996)
• Water and energy balance closure
• Macroscopic grid cells range from 10 to 100 km
• Physically-based parameterizations of sub-grid variability in soil moisture, land cover, and topography
• Water balance at each grid cell is computed as the difference between precipitation and potential evapotranspiration

1.2 Model Calibration

• Gridded meteorological forcings supplied by the SRTM3 DEM
• VIC model driven by (1) gridded meteorological forcings and (2) wetness index distribution from SRTM3 and NPP

2. Study Domain

The study domain is the West Siberian Lowlands, home to a large portion of the world’s wetlands. We chose the Chayabasin basin, located in the Western Siberian Lowlands, to represent the inundation and methane emissions processes. The Chayabasin basin is the largest wetland in the world and is characterized by permafrost, which is key to understanding the effects of climate change on wetland ecosystems.

3. Model Calibration

3.1 Topography (SRTM3 DEM)

• Topographic wetness index formulation from TOPMODEL (Beven and Kirkby, 1979)

3.2 Soil Respiration Model

• Based on LPJ model (Sitch et al., 2003)

4. Intensural Variability

4.1 Systematic Analysis

• The strong correspondence between the spatial distributions of simulated and observed inundation is evident.

4.2 Methane Model

• Walter and Heimann (2000) with modifications described in Walter et al. (2001a)
• Methane production rate controlled by soil temperature and NPP

5. Spatial Variability of Inundation and Methane Emissions

5.1 Methane Emissions

• Responses of CH4 Emissions to T and P

6. Conclusions

• The VIC model is able to simulate the spatial distribution of inundation, and the associated methane emissions.

7. Future Work

• The VIC model is a valuable tool for understanding the effects of climate change on wetland ecosystems.

References

1. Liang et al., 1996
2. Sitch et al., 2003

Figures

Fig. 1. VIC overview and the VIC lake and wetland algorithm schematic.

Fig. 2. Focus area (Chayabasin) for inundation.

Fig. 3. Simulated and observed inundation from ROIs in Figure 2.

Fig. 4. Annual time series of relevant variables, Chayabasin, 1948-2007.

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