

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

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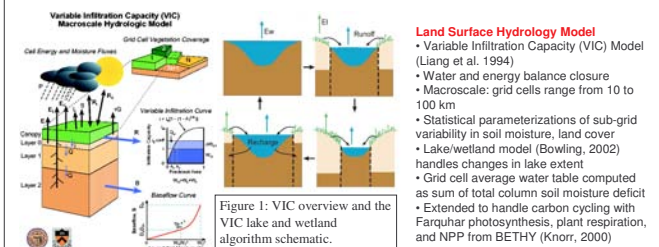
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Abstract

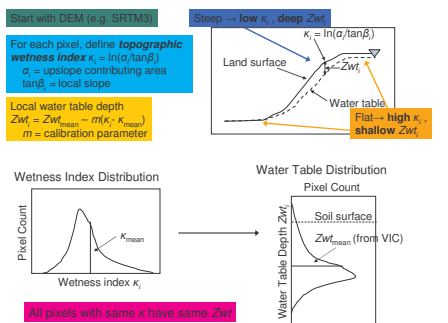
Changes in greenhouse gas emissions such as methane (CH₄) and carbon dioxide (CO₂) from high-latitude wetlands in a warming climate may have important implications for projections of global warming, due to the large amounts of carbon stored in high-latitude soils and the high greenhouse warming potential of methane. As much as 1/3 of global natural methane emissions come from high latitudes. Efforts to monitor high-latitude greenhouse gas emissions are hampered by the sparseness of in situ data at high latitudes, especially in Northern Eurasia. While biogeochemical modeling can provide estimates of greenhouse gas emissions in such areas, the lack of in situ measurements also makes it difficult to constrain these models. Fortunately, emissions of greenhouse gases, especially methane, are sensitive to hydrologic variables such as inundation that now can be observed via passive microwave and synthetic aperture radar remote sensors. Here we apply a combination of large-scale hydrologic/biogeochemical models and remote sensing observations across the West Siberian lowlands to estimate soil moisture, inundation, and greenhouse gas fluxes. Our modeling framework consists of the Variable Infiltration Capacity macroscale hydrological model (VIC), extended to include carbon cycling and coupled to a methane emissions model. In particular, our modeling framework includes a parameterization of the spatial distribution of soil moisture, which allows us to compare our simulated emissions to both large-scale remote sensing observations and point-scale in-situ observations. We have calibrated this framework using observed streamflow, inundation products derived from PALSAR and AMSR-E, and in situ water table and greenhouse gas emissions observations. Using the calibrated model, we examine the interannual variability of simulated inundation and greenhouse gas emissions across W. Siberia for the period 1948-2007.

1. Modeling Approach



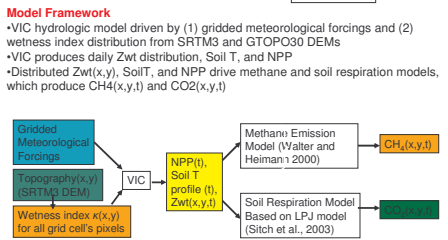
Sub-grid Variability of Water Table and Inundation

- Uses topographic wetness index formulation from TOPMODEL (Beven and Kirkby, 1979)
- Relates local water table position to local topography and the average water table depth of the region



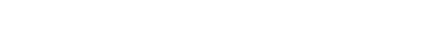
Methane Model

- Walter and Heimann (2000) with modifications described in Walter et al (2001a)
- soil methane production, and transport of methane by diffusion, ebullition, and through plants modeled explicitly
- methane production occurs in the anoxic soil from the bottom of the soil column to the water table
- methane production rate controlled by soil temperature and NPP (both from VIC)
- methane oxidation also taken into account



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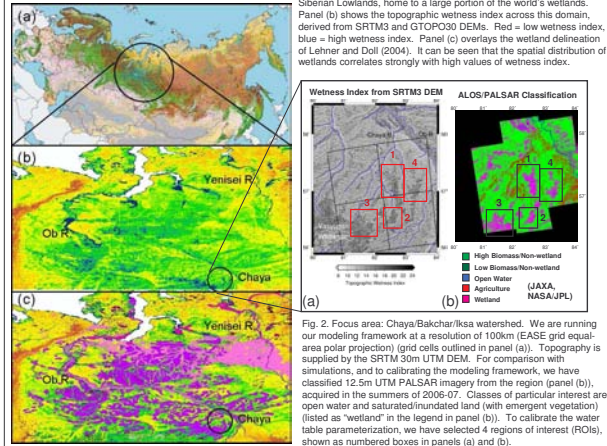


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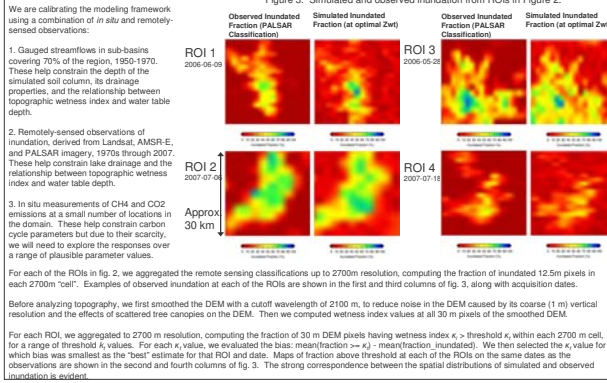
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2. Study Domain



3. Model Calibration



6. Conclusions and Future Work

Conclusions

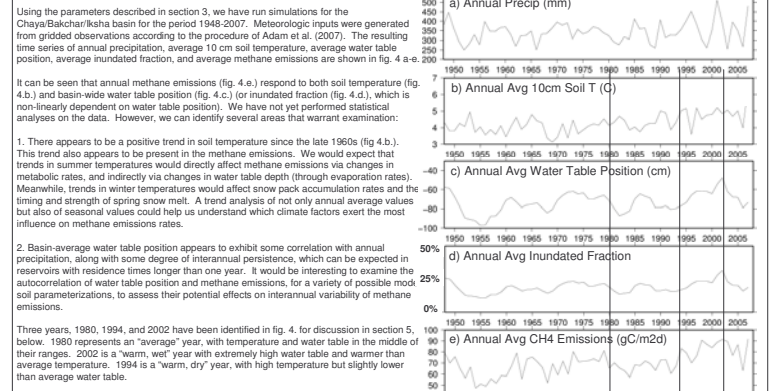
- The TOPMODEL approximation gives a good fit to the spatial distribution of wetlands, offering a relatively inexpensive method for increasing the accuracy of methane emissions estimates from global large-scale models
- One benefit of the distributed water table parameterization is that it allows us to convert simulated water table depth into inundated extent, which can be observed by satellite
- Predicted methane emissions and greenhouse warming potential are very sensitive to how the water table varies across the landscape; models using uniform water table likely overestimate the response of wetland methane emissions
- Combining remote sensing data and models allows us to better understand the behavior of wetlands across vast, relatively inaccessible areas
- The ability to validate with remote sensing offers possibility of data assimilation schemes to enhance real-time monitoring

Future Work

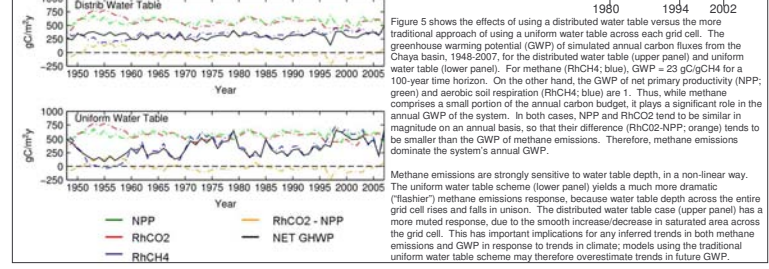
- Explore the effects of errors in the TOPMODEL parameterization, and uncertainty in model parameter values, on simulated inundated extent and CH₄ emissions
- Explore the statistical relationships among T, P, Zwt, inundation, and CH₄ emissions over the period 1948-2007, including trend analysis and persistence
- Explore spatial variation in sensitivity of methane emissions to climate factors and parameter uncertainty, and identify areas where future observations might be most beneficial
- Extend analysis to all of West Siberian Lowlands

* References available upon request

4. Interannual Variability



5. Spatial Variability of Inundation and Methane Emissions



5. Spatial Variability of Inundation and Methane Emissions

