

Uncertainty of modeled wetland area and methane emissions from HBL due to climatic noise

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The ensemble of numerical experiments with a joint model of the methane cycle and heat and moisture transport in soil was performed forced by data from the atmospheric general circulation model ECHAM5 for Hudson Bay Lowlands (HBL) region.

The wetland methane emission model consists of two modules. In the methane emission module, the flux of methane from the soil to the atmosphere is calculated using the parameterization of the temperature dependence of methane production by bacteria. It also takes into account the dependence of emissions on the amount of the carbon substrate in the active soil layer [1, 2]. Necessary physical characteristics of the soil are calculated in the module of heat and moisture transport, which can reproduce the dynamics of the soil temperature fields in case of alternating several boundaries of thawed and frozen layers [3]. In past similar experiments, the constant wetland mask [4] was used. Now the model is supplemented with an interactive scheme for calculating the area of the model cell occupied by the wetlands based on TOPMODEL [5].

An ensemble of 45 realizations of the multi-year data of meteorological variables at the land surface, calculated by the ECHAM5 for different initial and identical boundary conditions for a 34-year period (from 1.01.1979 to 31.12.2012) was specified as space-distributed input data. The initial conditions (the state of the atmosphere for January 1, 1979) were specified as instantaneous atmospheric conditions at various 12-hour intervals in December 1978. Averages and standard deviations of annual and monthly wetland area and emission values were estimated, and in case of monthly indicators only months with significant (>0.1 MtCH₄) emission, i.e., May-October were selected. The 95% confidence intervals of these estimates were calculated as indicators of the variability of the obtained estimates of mean values and standard deviation due to the internal variability of the climate system. When calculating the confidence intervals, it was assumed that the corresponding estimates were subject to a Gaussian distribution of probability. The ratio of half of the width of the 95% confidence interval of the corresponding estimate to its average value was considered to be the indicators of uncertainty of the calculated estimations.

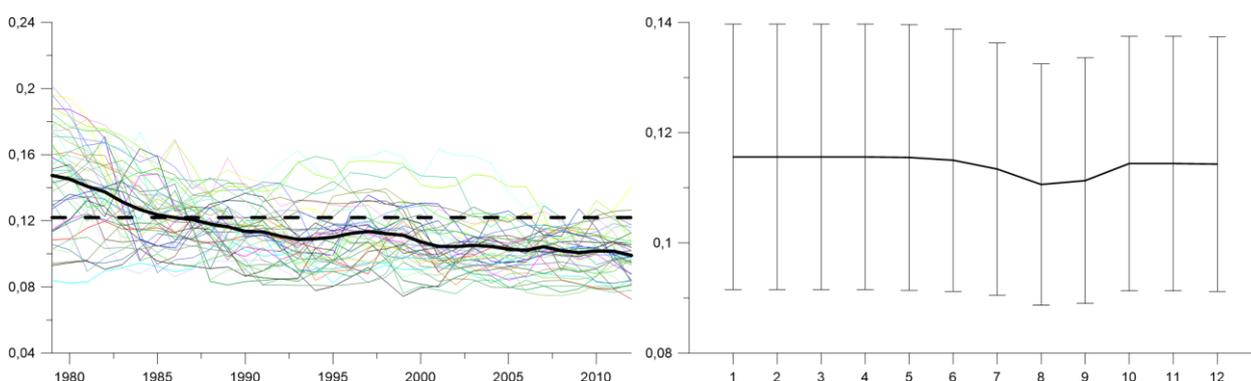


Fig.1 Simulated part of HBL region, covered by wetlands. Yearly means for each model realization (left) and monthly ensemble mean with standard deviation (right, month numbers on x axis). Thick line represents the ensemble mean, dashed line is the constant wetland mask data.

Wetlands are estimated to occupy 8-20% of HBL region area (Fig. 1). The ensemble average of yearly mean wetland area over the estimated period equals 11.4% (uncertainty index is 21%). The trend of wetland area equals $-0.1\%/yr$. In some years, the wetland area may differ more than twice for different model realizations. On average, modeled wetland area tends to

decrease slightly in the second half of summer and then recovers by the end of the year. For individual months, the uncertainty index of area remains within 21-22%.

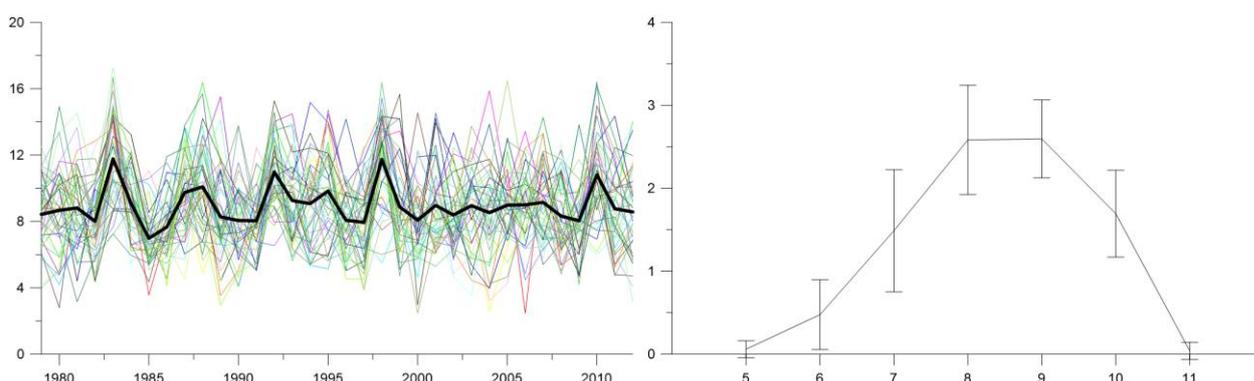


Fig.2 Modeled methane emissions [TgCH₄/yr] from HBL wetlands on yearly and monthly scale (month numbers on x axis) in experiments with constant wetland mask.

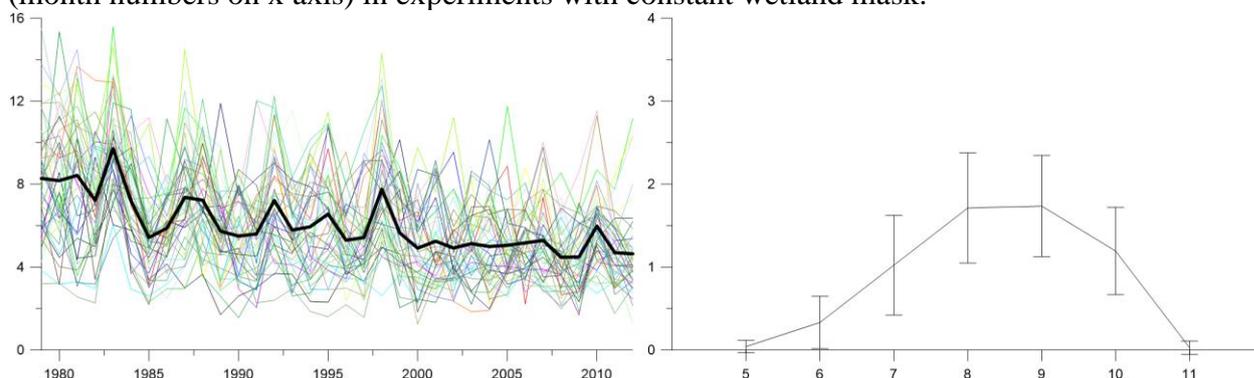


Fig.3 Modeled methane emissions [TgCH₄/yr] from HBL wetlands on yearly and monthly scale (month numbers on x axis) in experiments with interactively calculated wetland area.

Estimations of methane emissions from HBL wetlands for 1979-2012 periods were obtained (Fig. 2,3) both with constant wetland mask and interactively calculated wetland area. With constant wetland mask the ensemble average of annual emissions over the estimated period equals 8.9 TgCH₄ (uncertainty index is 11%). The trend of emissions is about 0.002 TgCH₄/yr. The interactive calculation of the wetland area changes the emission parameters (especially the uncertainty) significantly. In this case the ensemble average of annual emissions over the estimated period equals 6.1 TgCH₄ (uncertainty index is 32%). The trend of emissions is -0.1 TgCH₄/yr. Total annual emissions in individual years may differ by more than 5 times between different realizations of the model. The highest methane flux estimations (more than 2 TgCH₄) were obtained for August-September. For individual months, the uncertainty index of emission mean values equals 7-30% and 31-38% for constant and interactive wetlands correspondingly, and it is minimal for months with maximal emissions. The pronounced seasonal variability of uncertainty the emission values, inherent to calculations with constant wetland mask, mostly disappears in experiments with interactive wetlands.

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