Estimation of methane emissions from wetlands of Western Siberia and their uncertainty 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.

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 and diagnose the formation of intermediate non-freezing zones (taliks) for several years [3].

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. Mean values and standard deviations of annual and monthly emission indices were estimated. The 95% confidence intervals were calculated as indices of the variability (due to the internal variability of the climate system) of the mean value estimates and the standard deviation. These indices were calculated under assumption of corresponding estimates to obey the Gaussian probability distribution. The uncertainty of the estimates (mean value and standard deviation) was considered to be the ratio of half the width of the 95% confidence interval of the corresponding estimate to its average value.

Estimations of methane emissions from wetlands in Western Siberia for 1979-2012 periods were obtained (Fig. 1). The ensemble average of annual emissions over the estimated period equals 3.8 TgCH4 (uncertainty index is 10%). Highest methane flux estimations (more than 2 TgCH4) obtained for August-September (Fig. 2). The trend of emissions equals about 0.02 TgCH4/yr. Total annual emissions in individual years may differ by more than 3 times between different realizations of the model. For individual months, the uncertainty index of emission mean values equals 7-35%, and it is minimal for months with maximal emissions. It is concluded that the uncertainty of methane emission mean values due to climatic noise decreases with the growth of the averaging time interval. The uncertainty of the estimates for the emission mean values on the monthly scale has a pronounced seasonal variability. The uncertainty index of the standard deviation estimates for both annual and monthly emission values is 25-26% and has negligible seasonal variability.

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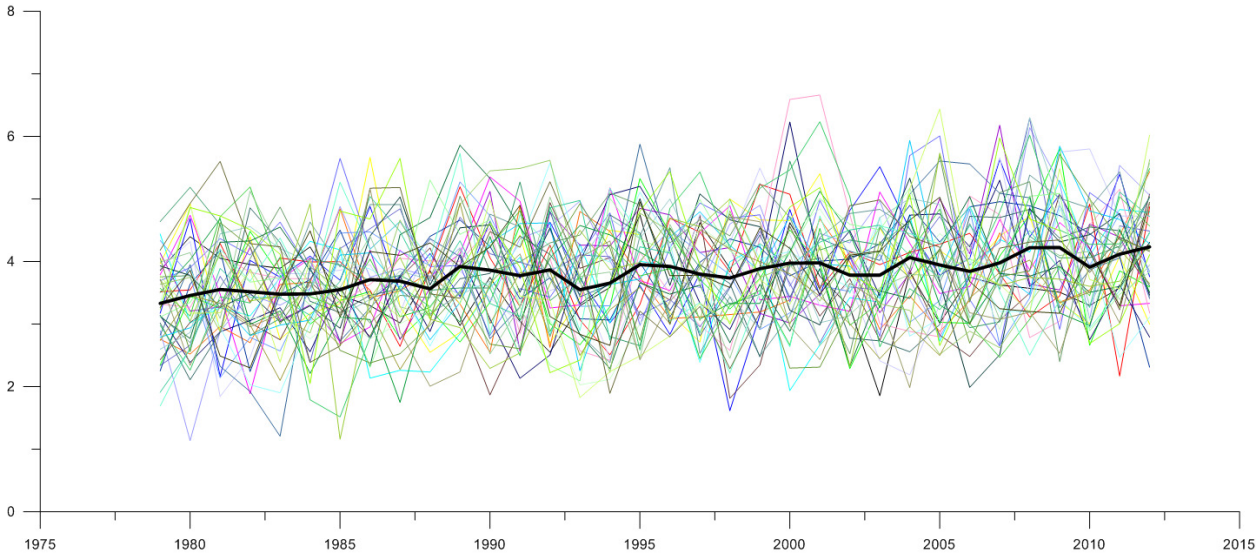

Fig.1 Methane emissions [TgCH4/yr] from Western Siberian wetlands (thick line is the ensemble mean)

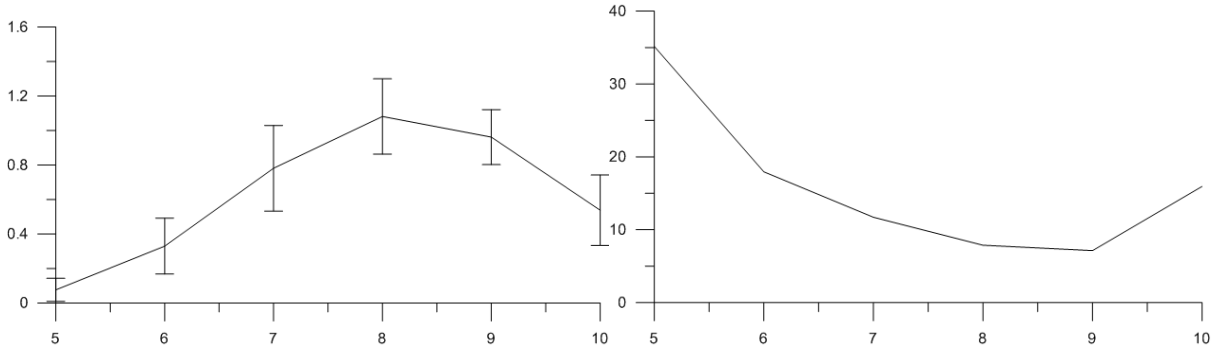

Fig.2 Modeled mean methane emissions [TgCH4/yr] and uncertainty index [%] on monthly scale (month numbers on y axis)

References

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