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Climate–methane cycle feedback in global climate model model simulations forced by RCP scenarios

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Methane cycle module of the global climate model of intermediate complexity developed at the A.M. Obukhov Institute of Atmospheric Physics, Russian Academy of Sciences (IAP RAS CM) is extended by coupling with a detailed module for thermal and hydrological processes in soil (Deep Soil Simulator, (Arzhanov et al., 2008)). This is an important improvement with respect with the earlier IAP RAS CM version (Eliseev et al., 2008) which has employed prescribed soil hydrology to simulate $\mathrm{CH_4}$ emissions from soil. Geographical distribution of water inundated soil in the model was also improved by replacing the older Olson's ecosystem data base by the data based on the SCIAMACHY retrievals (Bergamaschi et al., 2007). New version of the IAP RAS CM module for methane emissions from soil is validated by using the simulation protocol adopted in the WETCHIMP (Wetland and Wetland $\mathrm{CH_4}$ Inter–comparison of Models Project). In addition, atmospheric part of the IAP RAS CM methane cycle is extended by temperature dependence of the methane life–time in the atmosphere in order to mimic the respective dependence of the atmospheric methane chemistry (Denisov et al., 2012).

The IAP RAS CM simulations are performed for the 18th–21st centuries according with the CMIP5 protocol taking into account natural and anthropogenic forcings. The new IAP RAS CM version realistically reproduces pre–industrial and present–day characteristics of the global methane cycle including $\mathrm{CH_4}$ concentration $q_{\mathrm{CH_4}}$ in the atmosphere and $\mathrm{CH_4}$ emissions from soil. The latter amounts $150 - 160\ Tg\mathrm{CH_4}/yr$ for the late 20th century and increases to $170 - 230\ Tg\mathrm{CH_4}/yr$ in the late 21st century. Atmospheric methane concentration equals $3900\ ppbv$ under the most aggressive anthropogenic scenario RCP 8.5 and $1850 - 1980\ ppbv$ under more moderate scenarios RCP 6.0 and RCP 4.5. Under the least aggressive scenario RCP 2.6 $q_{\mathrm{CH_4}}$ reaches maximum $1730\ ppbv$ in 2020s and declines afterwards. Climate change impact on the methane emissions from soil enhances build up of the methane stock in the atmosphere by $10 - 25\%$ depending on anthropogenic scenario and time instant. In turn, decrease of methane life–time in the atmosphere suppresses this build up by $5 - 40\%$. The net effect is uncertain but small in terms of resulting additional greenhouse radiative forcing. This smallness is reflected in small additional (relative to the model version with both methane emissions from soil and methane life–time in the atmosphere fixed at their preindustrial values) near–surface warming which globally is not larger than $1\ K$, i.e, $\leq 4\%$ of warming exhibited by the model version neglecting climate–methane cycle interaction.

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