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Investigation of strongly enhanced methane Part I: Chemical feedbacks and rapid adjustments.

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Methane (CH_4) is the second most important greenhouse gas, which atmospheric concentration is influenced by human activities and currently on a sharp rise. We present a study with numerical simulations using a Chemistry-Climate-Model (CCM), which are performed to assess possible consequences of strongly enhanced CH_4 concentrations in the Earth's atmosphere for the climate.

Our analysis includes experiments with $2xCH_4$ and $5xCH_4$ present day (2010) lower boundary mixing ratios using the CCM EMAC. The simulations are conducted with prescribed oceanic conditions, mimicking present day tropospheric temperatures as its changes are largely suppressed. By doing so we are able to investigate the quasi-instantaneous chemical impact on the atmosphere. We find that the massive increase in CH_4 strongly influences the tropospheric chemistry by reducing the OH abundance and thereby extending the tropospheric CH_4 lifetime as well as the residence time of other chemical pollutants. The region above the tropopause is impacted by a substantial rise in stratospheric water vapor (SWV). The stratospheric ozone (O_3) column increases overall, but SWV induced stratospheric cooling also leads to enhanced ozone depletion in the Antarctic lower stratosphere. Regional patterns of ozone change are affected by modification of stratospheric dynamics, i.e. increased tropical up-welling and stronger meridional transport towards the polar regions. We calculate the net radiative impact (RI) of the $2xCH_4$ experiment to be 0.69 W m^{-2} and for the $5xCH_4$ experiment to be 1.79 W m^{-2}. A substantial part of the RI is contributed by chemically induced O_3 and SWV changes, in line with previous radiative forcing estimates and is for the first time splitted and spatially asigned to its chemical contributors.

This numerical study using a CCM with prescibed oceanic conditions shows the rapid responses to significantly enhanced CH_4 mixing ratios, which is the first step towards investigating the impact of possible strong future CH_4 emissions on atmospheric chemistry and its feedback on climate.