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Climate and composition impacts of a net-zero anthropogenic methane future using an emissions-driven chemistry-climate model

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Methane (CH_4), the second most important greenhouse gas in terms of radiative forcing, is on the rise; but there are extensive opportunities for mitigation with existing technologies. Anthropogenic emissions account for around 60% of the global methane source, and the recent atmospheric methane growth rate puts us on a trajectory comparable to the most extreme future methane scenarios in the sixth Coupled Model Intercomparison Project (CMIP6).

We use a new methane emissions-driven configuration of the UK Earth System Model (UKESM1) to explore the role of anthropogenic methane in the earth system. The full methane cycle is represented, including surface deposition, chemistry and interactive wetland emissions. As a baseline scenario we used Shared Socioeconomic Pathway 3-7.0 (SSP3-7.0) – the highest methane emissions scenario in CMIP6. In an idealised experiment, all anthropogenic methane emissions were instantaneously stopped from 2015 onwards in a coupled atmosphere-ocean simulation running from 2015-2050, to make a net-zero anthropogenic methane emissions scenario.

Within a decade, significant changes can be seen in atmospheric composition and climate, compared to SSP3-7.0. The atmospheric methane burden declines to below pre-industrial levels within 12 years, and by the late 2030s reaches a constant level around 44% below that of the present day (2015). The tropospheric ozone burden and surface mean ozone concentrations decreased by 12% and 15% respectively by 2050 – key in terms of limiting global warming as well as improving air quality and human health.

By 2050 the net-zero anthropogenic methane scenario results in a global mean surface temperature (GMST) 1 °C lower than the baseline, a significant value in the context of climate goals such as the Paris Agreement. Through decomposition of the radiation budget, the change in climate can be directly attributed to the reduction in methane and indirectly to the resulting

changes in ozone, clouds and ozone precursors such as CO. In addition, the changes in climate result in impacts on the interactive wetland emissions via changes in temperature and wetland extent, highlighting the coupled nature of methane in the earth system.

Cessation of anthropogenic methane emissions has profound impacts on near-term warming and on tropospheric ozone, but ultimately cannot single-handedly achieve the necessary reductions for meeting Paris goals.