

## Description of Additional Supplementary Files

File Name: Supplementary Data 1

Description: AThaw and CLM4.5BGC model emissions (annual and cumulative since 2010) and associated radiative forcing (RF). Model results under Representative Concentration Pathway (RCP) 4.5 and RCP8.5 climate scenarios are shown in *a* and *b*, respectively. AThaw emissions are the median and 68% uncertainty range (in parentheses) from a 500-member AThaw model ensemble, which considers uncertainty in 18 key model parameters containing critical factors that influence AThaw modeled emissions.

File Name: Supplementary Data 2

Description: Radiocarbon dates of CH<sub>4</sub> and CO<sub>2</sub> in thermokarst lake bubbles. <sup>14</sup>C-depleted CH<sub>4</sub> values correspond to <sup>14</sup>C-depleted permafrost soil organic carbon values in the study lake regions<sup>21</sup>. The δ<sup>13</sup>C of CH<sub>4</sub> ranged from -55‰ to -82‰ (mean ± standard deviation: -69‰ ± 5‰), indicating a microbial methane source.