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The response of methane hydrate offshore Svalbard to ocean warming during the next three centuries

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Large-scale rapid release of methane from hydrate may have contributed to past abrupt climate change inferred from the geological record. The discovery in 2008 of numerous plumes of methane gas escaping from the seabed of the West Svalbard continental margin at ∼400 m water depth, and the increase in the temperature of the West Spitsbergen current over the latter part of the 20th century, suggest that hydrate is dissociating in this region. We evaluate the possible effect on this system of future climate change, using output from a range of established climate models to drive a hydrate system model. We model the dynamic response of hydrate-bearing sediments to predicted seabed temperature changes, over the range of water depths for which hydrate destabilisation may be occurring and the periods for which climate model output is available, using the TOUGH + HYDRATE (T+H) v1.2 code. We constrain the present-day sub-seabed distribution of gas and hydrate by using seismic data that image the BSR in water depths of more than 580 m and the upper limit of gas-related reflectors in shallower water. We "grow" this initial distribution by running the T+H model over the past 2 kyr, driven by a model of changing ocean temperature, to provide a present-day sub-seabed distribution of gas and hydrate that is close to that indicated by the seismic data. Our results suggest that the active dissociation area between latitudes of 78°26'N-78°40'N (∼25 km length) will extend to ∼480 m water depth by 2100 CE and to ∼550 m by the 2300 CE. Over the next century, 3.9-6.9 Gg yr-1 of methane may be released on the West Svalbard margin, and over the next three centuries 5.3-29 Gg yr-1. Emissions increase with time because the area over which they occur grows over time. The time of first methane emission at a given water depth is controlled by the rate of warming of the overlying ocean. The methane flux until 2050 CE is relatively insensitive to choice of climate model or scenario, but there is greater sensitivity during 2050-2100 CE.