Simulation and validation of long-term ground surface subsidence in continuous permafrost, western Arctic Canada

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Ground surface subsidence caused by the melt of excess ice is a key geomorphic process in permafrost regions. Subsidence can damage infrastructure, alter ecology and hydrology, and influence carbon cycling. The Geological Survey of Canada maintains a network of thaw tubes in northwestern Canada, which records annual thaw penetration, active-layer thickness, and ground surface elevation changes at numerous sites. Measurements from the early 1990s from 17 sites in the Mackenzie Delta area have highlighted persistent increases in thaw penetration in response to rising air temperatures. These increases in thaw penetration have been accompanied by significant ground surface subsidence (~5 to 20 cm) at 10 ice rich sites, with a median subsidence rate of 0.4 cm a\(^{-1}\) (min: 0.2, max: 0.8 cm a\(^{-1}\)). Here we present preliminary results comparing these long-term field data to simulations for two observation sites using the Northern Ecosystem Soil Temperature (NEST) model. NEST has been modified to include a routine that accounts for ground surface subsidence caused by the melt of excess ground ice. The excess ice content of upper permafrost in the simulations was estimated based on ratios between thaw penetration and subsidence measured at each thaw tube. The NEST simulations begin in 1901, and there is little ground surface subsidence until the 1980s. The simulated rate of ground surface subsidence increases in the 1990s. The modelled ground surface subsidence is in good agreement with the measured annual magnitudes and longer-term patterns over the measurement period from 1992 to 2017. This preliminary assessment indicates that the modified NEST model is capable of predicting gradual thaw subsidence in ice-rich permafrost environments over decadal timescales.