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# Added value of InSAR derived displacements through combination with in situ observations over continuous permafrost, central Yamal

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The Vaskiny Dachi research station was established in 1988 and is situated on the central Yamal Peninsula in a system of highly dissected alluvial lacustrine-marine plains and terraces. It is located within a region of continuous permafrost where tundra lakes and river flood plains are the most prominent landscape features. Active layer thickness ranges between 40 cm in peat and up to on average 120 cm on sandy, poorly vegetated surfaces. Depths of more than 170 cm can occur.

Satellite observations from synthetic aperture radar data including displacements derived using interferometry (InSAR) and surface soil saturation from backscatter information collected from X-, C- and L-band observations (COSMO Skymed, TerraSAR-X, Sentinel-1, ALOS-2 PALSAR-2) are available for 2016 to 2018 through the ESA DUE project GlobPermafrost. Active layer thickness modeled from TerraSAR-X backscatter is also available from a preceding study for this region.

The snow free season on Central Yamal has been longer than average on central Yamal in 2016. This is reflected in in situ measurements, including active layer thickness. Further available in situ measurements include ground temperature and subsidence. Air temperature data are available from the meteorological station Mare-Sale.

All available years of satellite data have been analyzed to quantify the impact of the 2016 warming. The overall magnitude of subsidence is in the order of in-situ measurements, but it is in general underestimated possibly because space-based observation cannot sense the period right after start of ground thaw and their spatial sampling is not sufficient to capture local scale effects. An offset correction regarding start and magnitude of displacement using in situ measurements is required for interpretation of the InSAR measurements. Results of the modified records show that two phases of thaw and subsequent subsidence can be observed in 2016, what agrees with air temperature observations. Late summer thaw patterns, as enabled in 2016, relate also to surface wetness conditions and increased active layer involving thaw of perennial ice at the top of permafrost.

The suggested approach of combining in situ and space based observations may allow for evaluation of the seasonal evolution of modeled thaw depth time series over larger regions, as e.g. anticipated within the framework of the ESA CCI+ Permafrost initiative.