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Quantitative morphological description of pingos (permafrost hills) using high-resolution DEMs from UAV and satellite photogrammetry

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Permafrost dynamics, related to ice aggradation and thawing, are effective climatic indicators. Pingos (conical ice-cored hills) concentrate large amounts of ice near the surface and, hence can be sensitive to environmental changes. Thus, the dynamics of pingos can be used to monitor the effects of climate change over many regions in the Artic. To use pingos for environmental monitoring, we need to quantify the relationship of pingos morphology with its origin and permafrost conditions, and to monitor pingo dynamics (growth, stability or collapse) effectively. Artic permafrost ice-landforms and pingos are characterized with small reliefs. Particularly, pingo elevations are usually less than 40 m, with an average of 4.8 m. Current topographic databases are of sufficient quality to identify many pingos, but are completely inadequate to quantitatively measure the morphology of the vast majority of pingos, which prevent from a rigorous morphometric classification and monitoring.

In this work, we present a quantitative morphological description of pingos located in the Tuktoyaktuk Coastal Plain area, Northwest Territories, Canada. During the summer of 2017, we collected relevant very-high-resolution topographic data using UAVs drones, and satellite tri-stereo optical photogrammetric data from the Pleaides satellite constellation. We compare and validate our results with the newly available ArcticDEM [https://www.pgc.umn.edu/data/arcticdem/]. The quantitative relationships derived from this very-high-resolution topographic dataset will allow to numerically described pingo morphologies, and contribute to establish rigorously its origin and dynamic processes, with the overall aim to fully exploit its potential as climate indicators.

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