A Spatially Consistent Account of Infrastructure across the Entire Arctic

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Infrastructure and anthropogenic impacts are expanding across the Arctic. A consistent record is required in order to quantify the changes and to assess climate change impacts, including permafrost thaw, on the communities.

Satellite data offer spatially continuous coverage, but the separation of infrastructure from natural environments is challenging due to spatial resolution and spectral similarities with natural features. Sentinel-2 provides an advance in this context compared to Landsat (10m versus 30m). We used Sentinel-1 (Synthetic Aperture Radar) in combination with Sentinel-2 (multispectral) observations covering the entire Arctic coastal region to identify areas impacted by humans. Machine learning techniques are implemented in a first step. Manual post-processing has been carried out for two different classification type results and eventually they have been merged. Due to the size of the study area, several editors have been involved in the manual postprocessing step. To evaluate the comparability of the results, the performance of individual editors has been assessed through a benchmarking exercise.

Mapped objects include roads, buildings, and other areas such as gravel pads or open pit mining areas. These represent only part of relevant infrastructure for Arctic communities, but a consistent database can be obtained. In total, 0.02% of the land area within the 100-km buffer was identified as human-impacted.

As an example, results are combined with ground temperature trends derived from the ESA CCI+ Permafrost time series (1997-2019). If trends continue as observed during this time period, the majority of areas with human presence will be subject to thaw by mid-21st century.

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Early Warning Frost Detection System*

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Occurrence of freeze/thaw conditions in rural roadway subgrades over the years resulted in significant labor efforts by Whatcom County Public Works engineers to monitor and evaluate conditions for implementing road restrictions. Extended periods of frost conditions followed by warmer temperatures can result in extensive damage to the road system if restrictions are not applied. Previously, manual subsurface temperatures were measured at various locations throughout the county to assist with evaluation of roadway conditions. Recently, a network of automated measurement and remote communication systems was designed and implemented to facilitate improved monitoring and response for the County engineers. Sixteen remote monitoring locations were selected throughout the county and at each site a 1-meter-long tube with 18 thermistors at 50 mm spacing was installed into the roadway subgrade. Additional instrumentation at each site included ambient air temperature sensors and moisture sensors for the datalogger enclosures. Data is collected and transmitted to a web-based data management system for county personnel to access. The data also provides alarm notifications to county personnel with indications as to when temperature thresholds are exceeded. Having the automated system allows the county to monitor the thaw process more accurately and be more confident in when road restrictions are applied and the duration. The current monitoring system has increased the effectiveness and efficiency of the county's rural roadway management process during freeze/thaw cycles, resulting in significant savings in operating and maintenance costs.

***For full text, see *Permafrost 2021: Merging Permafrost Science and Cold Regions Engineering*, American Society of Civil Engineers. https://ascelibrary.org/doi/epdf/10.1061/9780784483589**