Observing Arctic Urban Climate

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More than 75% of Arctic population are leaving in 100 cities and towns. Arctic urban environment creates and maintains significant local climate anomalies with persistently warmer surface and air temperature (Esau et al., 2021), dryer and deeper active soil layer (Klene et al., 2013), modified biogeochemical cycles (Polyakov et al., 2018), and ecology (Korneykova et al., 2021). These climate anomalies induce impacts ranging from geotechnical hazards (Hjort et al., 2018), such as, e.g., collapse of oil reservoir in Norilsk in 2020, to grassroot social movements, such as those, e.g., pushing for urban sprawl and greenspace development (Stammler and Sidorova, 2015; Fedorov et al., 2021). Since the warmer urban climate anomalies or urban heat islands (UHIs) are rather significant, measuring on average from 1°C to 3°C (Miles and Esau, 2020), their monitoring is needed for providing high quality, safe and resilient environment for urban residents in the Arctic (Orttung et al., 2021).

Observing Arctic urban climate requires high spatial resolution satellite data and dense in situ urban observation networks. Unfortunately, the existing global datasets (Chakraborty and Lee, 2019) and ground-based meteorological observations (Lappalainen et al., 2016) are less specific and less accurate with respect to the urban Arctic needs. We manually developed a new remote sensing dataset based on MODIS to investigate different characteristics (temperature differences, NDVI, etc) of the surface UHIs in 118 cities north of 63°N. Figure 1 shows UHIs in our dataset (Miles, 2020). This dataset is complemented by in-situ UHIARC observational network in several Arctic cities (Konstantinov et al., 2018); more detailed urban climate studies were run in Apatity and Nadym, Russia. Figure 2 shows the vertical structure of the UHI in Nadym obtained through temperature profiling with drones.

Concentrated efforts of international teams have considerably improved our understanding and quantitative assessment of the Arctic UHIs. Furthermore, adjoint cross-disciplinary studies pointed out to socio-environmental impact of the physical climate anomalies. It has been discovered that urban climate factors in the Arctic cities are acting distinctly different to those in lower latitudes, e.g., a role of sand as ubiquitous building ground could be mentioned. Still, our knowledge of urban climate effects in the region remains fragmented. The biophysical processes in warmer urban soils are poorly understood; wider impact of urban climates is hardly known. A new fleet of ESA (e.g., Sentinel-series) and NASA (e.g., LandSat-series) satellites is potent to close the existing gaps in observations. Along with more accessible networks of amateur-quality meteorological and chemical sensors, the remote-sensing datasets will provide for implementation of urban integrated modeling systems – a WMO-GURME initiative – in the Arctic cities (Esau et al., 2021).

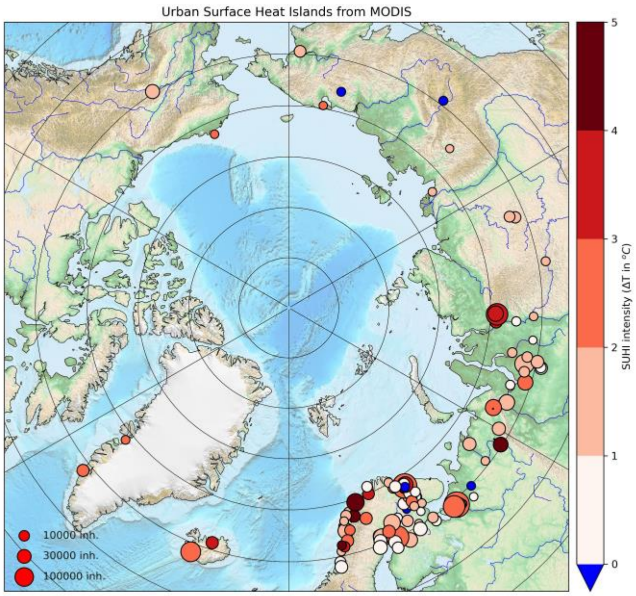

FIG 1. Surface UHI in 118 Arctic cities based on satellite remote sensing (MODIS) climatology for 2001-2018.

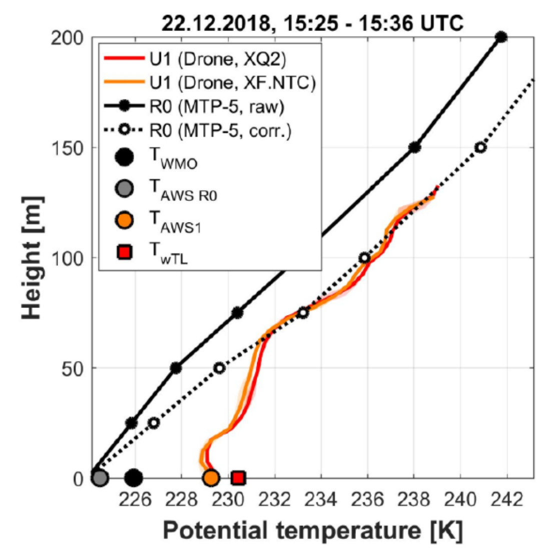

FIG 2. Vertical profiles of potential temperature obtained by drones (colored) in urban areas and the temperature profiler MTP-5 (b/w) at the airport, Nadym, Russia. Dots shows temperature at 2 m meters from relevant automated weather stations (AWSs).

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