Investigation of microclimate, groundlevel inversions and human thermal comfort conditions in Arctic cities of Russian federation (based on UHIARC observations)





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What do we know about Urban Heat Island in Arctic?

The Second UCCRN Assessment Report on Climate Change and Cities (ARC3.2)



Northern Urbanization

Arctic and Northern PEEX region is characterized by:

- Much lower population density and not fast growing
- Highly urbanized with ≈ 90% of population living in cities
- Small size cities are dominating, but not less problems
- About **100** urban settlements with > 5000 inhabitants
- Much higher vulnerability and lower sustainability
- Cold climate is a dominant environmental factor
- Urban nexus includes:
 - Snow impact on management and planning
 - Frozen soil & permafrost infrastructure stability
 - Frozen surface water water supply and sewage
 - Dormant vegetation reduced ecosystem service:
 - Stagnant atmosphere air pollution and urban heat island
 - Low temperatures health issues and working routines -
 - high energy consumption
- Migration is a dominant societal factor in the region
 - More than 60% of urban population are 1st generation migrants
 - High skills but little sense-of-place
 - External, unsustainable development agenda



What are the "Arctic cities"

City	Reference
Apatity	Konstantinov et al.
	(2015a,b)
Barrow	Klene et al. (2013)
	Hinkel & Nelson (2007)
Fairbanks	Magee et al. (1999)
Nadym	Esau and Miles (2016)
Norilsk	Varentsov et al. (2014)
	Telyatnikov et al. (2014)



North-Eurasian Arctic is the most urbanized part of whole Arctic

WMO ground stations



Tedesco, M.; Jeyaratnam, J. A New Operational Snow Retrieval Algorithm Applied to Historical AMSR-E Brightness Temperatures. *Remote Sens.* **2016**, *8*, 1037

Problem with WMO stations in "Urban landscape"



Urban climate studies



Why can UHI properties in Arctic be different from other cities?

Polar day in summer and polar night in winter
Polar urban planning strategies



http://www.languagesoftheworld.info/

(c) www.bergan.ru

Urban landscapes of the Arctic cities



Norilsk, Russia



Apatity, Russia



World's biggest polar cities (top-5) (To the North of the Arctic Circle):

MURMANSK (RUSSIA)
NORILSK (RUSSIA)
TROMSO (NORWAY)
VORKUTA (RUSSIA)
APATITY (RUSSIA)

295 000 people 179 000 people 75 000 people 58 000 people



Primary target: fill the "Arctic gap" in Global Urban Climatology

INTERGOVERNM	IPCC IN Climate change
Languag	ages ▼ IPCC web pages ▼ Search
IPCC Fourth Assessment Repor	rt: Climate Change 2007
Climate Change 2007: Working Group II: Impacts, Ad	daptation and Vulnerability
Chapter 15: Polar Regions (Arctic and Antarctic)	

That's how it began... (Step 1. 2013-2015)



First case-study of 4 biggest Arctic cities:

- 1. First complex experimental study of temporal and spatial characteristics of Urban Heat Island in 4 biggest polar cities in the world (in Russia).
- 2. We used 3 different measurements techniques for obtaining good data quality,
- **3.** Evaluation of possible economical effect of UHI at polar city heating system

Research area (5 expeditions)



Measurement techniques:



Measurement techniques:



Measurements network:

Apatity (2014)

Apatity, thermal sensors and automatic weather station



0,5

Automatic weather station

Murmansk, thermal sensors and automatic weather stations



- Automatic weather station
- Thermal sensors

Murmansk

Field campaign in 2014: Apatity

5-days average

Case with max. UHI (1-hour average)



Spatial distribution of **the temperature anomaly** - deviation from mean value at background points (Meteo station and AWS located outside of the map border). Solid isotherms go every 1 °C

Mobile measurements

VS

stationary sensors



UHI formation in Apatity

31 Jan 00:00 Pressure at meteo station 1020 1015 1010 1005 1000 8 995 6 990 AWS forest 985 4 980 2 Temperature at meteo station 0 -2 -10 -15 -20 Aeteo station -25 -30

Permanent on-line measuring system (Step 2. 2015- until today)

Step 2.1 Permanent network for Apatity



Step 2.2 New cities (Ural-Siberia Artic region)



UHIARC in Vorkuta & Salekhard

(a) Vorkuta

(b) Salekhard



UHIARC in Nadym & Novy Urengoy

(c) Nadym

(d) Novy Urengoy



First UHIARC's long-term measurement system results

UHI in Salekhard & Vorkuta



UHI in Nadym & Novy Urengoy

(c) Nadym

(d) Novy Urengoy



UHIARC results for Ural-Siberia Artic region



Dependence between UHI intensity and air temperature



Ground-level thermal Inversions monitoring



2 ext temp log

Nadym







First results from winter 2018-19 Nadym (Western Siberia)





The consequences of antropogenic heat load and Urban Heat Island in Arctic:



РРЭЦ ЭКОЛОГИЧЕСКИЙ ЦЕНТР

<u>Thermokarst</u> Cherskij, 2002 Photo by: V. Romanovki, SGI

Norilsk, 2006 г., Photo by V.Konischev, MSU



June 05 2019 UHIARC: state of art

UHIARC- Urban Heat Island Arctic Research Campaign: science and education





Lomonosov MSU students mounting UHIARC station in Vorkuta, Feb 2017

Since July 2018 UHIARC AWS dataset is available online: http://urbanreanalysis.ru/uhiarc.html



Main Arctic cities Papers Community

nity About

Urban Heat Island Arctic Research Campaign (UHIARC) Dataset



Pavel Konstantinov, Mikhail Varentsov, and Igor Esau. A high density urban temperature network deployed in several cities of Eurasian Arctic. Environmental Research Letters, 13(7), 2018.

Outlook:

1. Establish long-term measuring system in





Fairbanks, Alaska, USA

Norilsk, Russia

2. Upgrade UHIARC by Alphasense gas sensors





... UHI research in cold climate reveals warm feelings [generally] ③



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Thank you for your attention!

