

In-situ and ground based observations/ data in support SES (from Arctic zone to Moscow)



¹Konstantinov P.I., ^{2,3} Varentsov M.I., Varentsov A.I., ¹Semenova A.A., ¹Vorotilova P.G., ⁴Esau I.N., ⁵Baklanov A.A.



¹Lomonosov Moscow State University, Moscow, Russia

²Lomonosov Moscow State University, Research Computing Center, Moscow, Russia

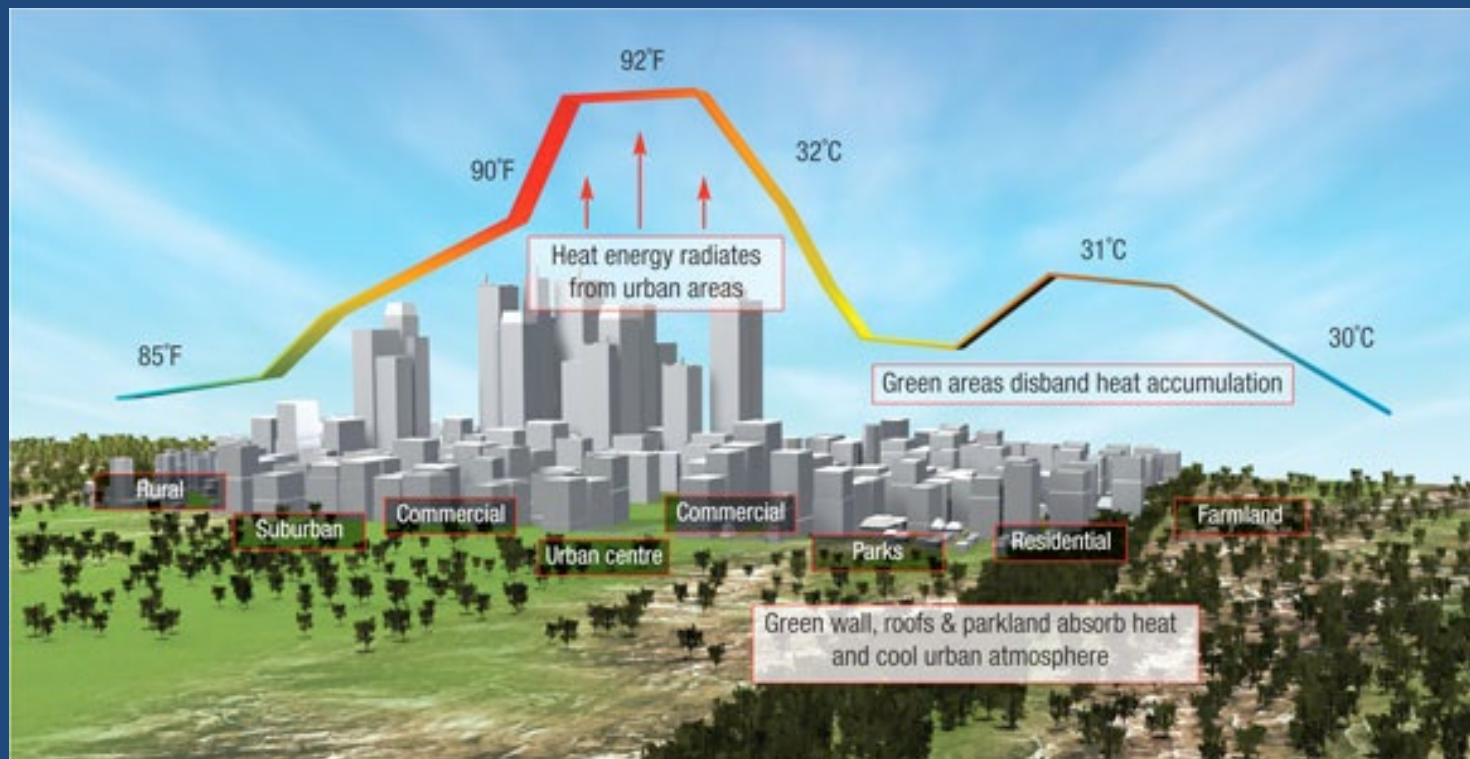
³A.M. Obukhov Institute of Atmospheric Physics RAS, Moscow, Russia

⁴Nansen Environmental and Remote Sensing Center/Bjerknes ⁵Center for Climate Research, Bergen, Norway

⁵World Meteorological Organization (WMO), Genève, Switzerland

Now we use special Arctic Network: UHIARC

Urban Heat Island Arctic Research Campaign

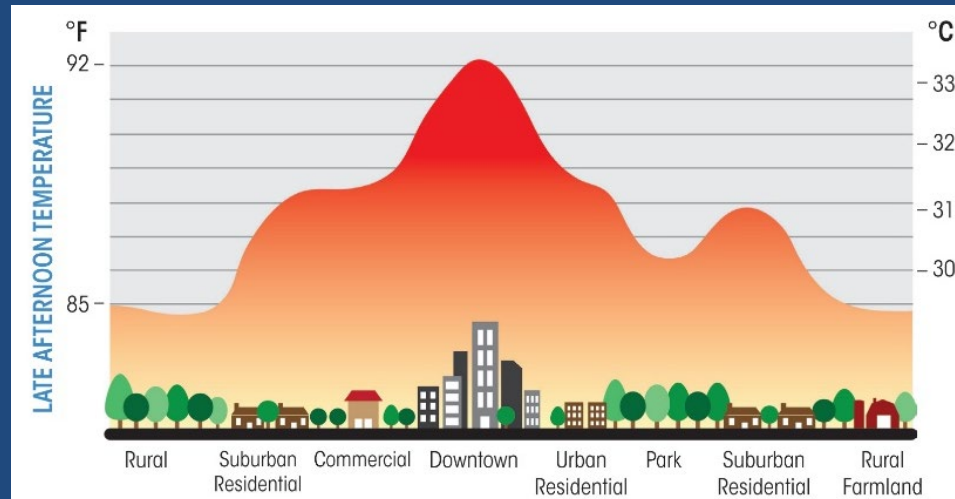


Urban Heat Island has influence on:

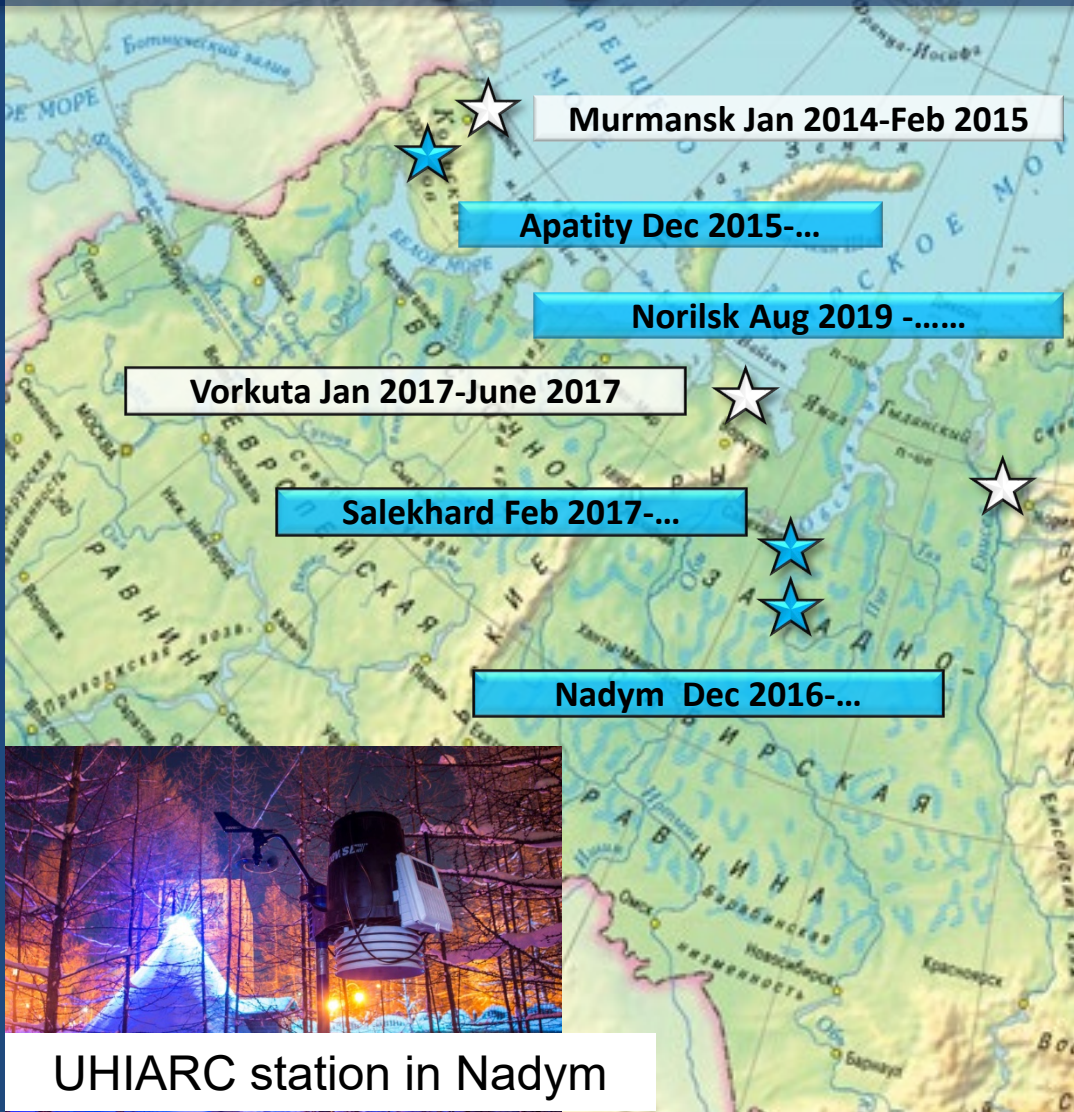
1. House heating systems
2. Human health
3. Air quality
4. Permafrost melting



Luke Howard
(1772-1864)



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



- ★ Now operating sites
- ★ Now disabled sites

Lomonosov MSU students mounting UHIARC station in Vorkuta, Feb 2017



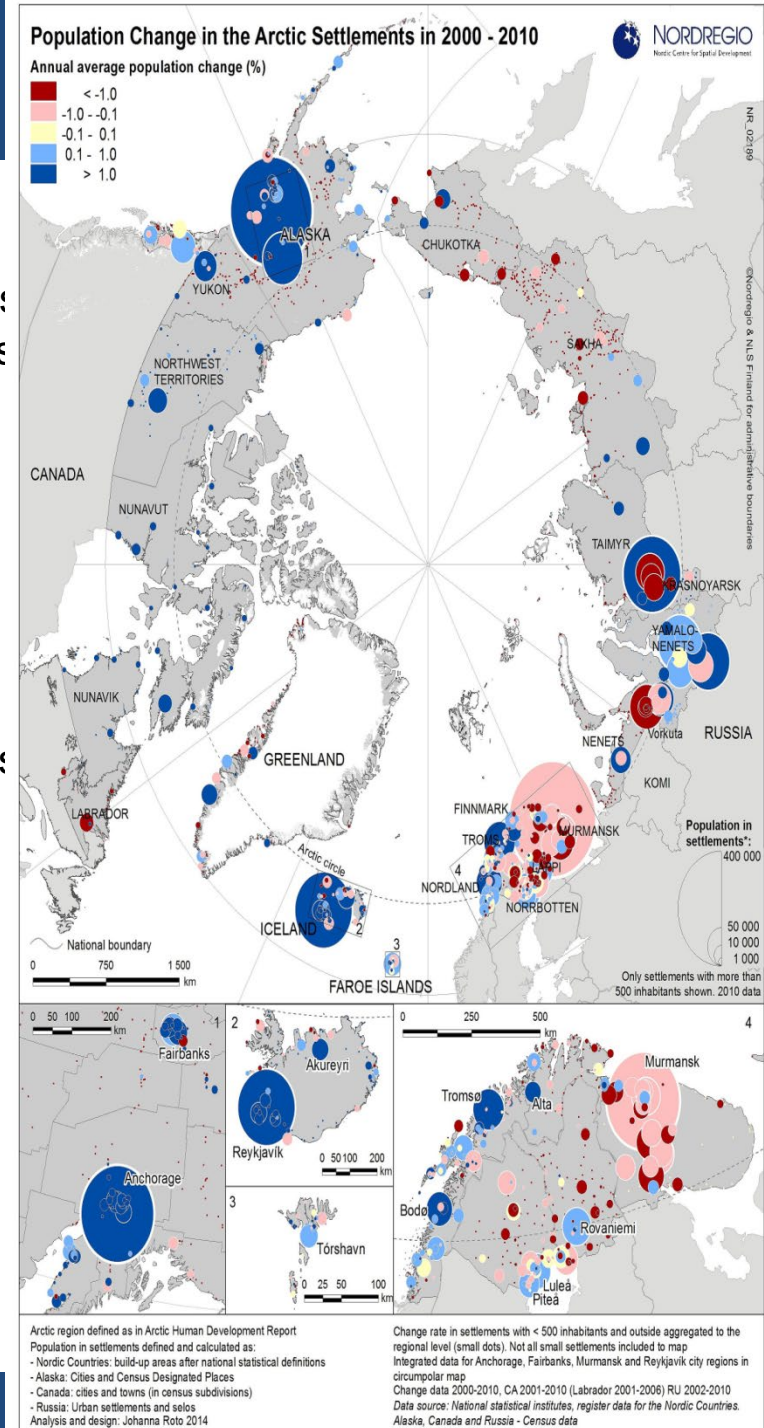
UHIARC station in Nadym



Northern Urbanization

Arctic and Northern PEEEX region is characterized by:

- Much **lower population density** and not fast growing
- **Highly urbanized** with $\approx 90\%$ 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 services
 - 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



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

1. Polar day in summer and polar night in winter
2. Polar urban planning strategies

1



(c) www.bergan.ru

2



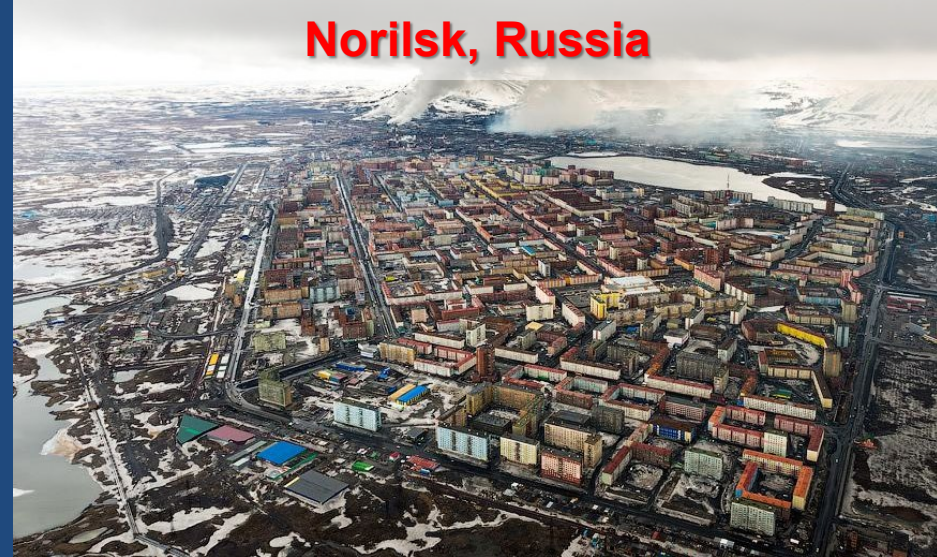
<http://www.languagesoftheworld.info/>

Urban landscapes of the Arctic cities

Fairbanks, Alaska, USA



Norilsk, Russia



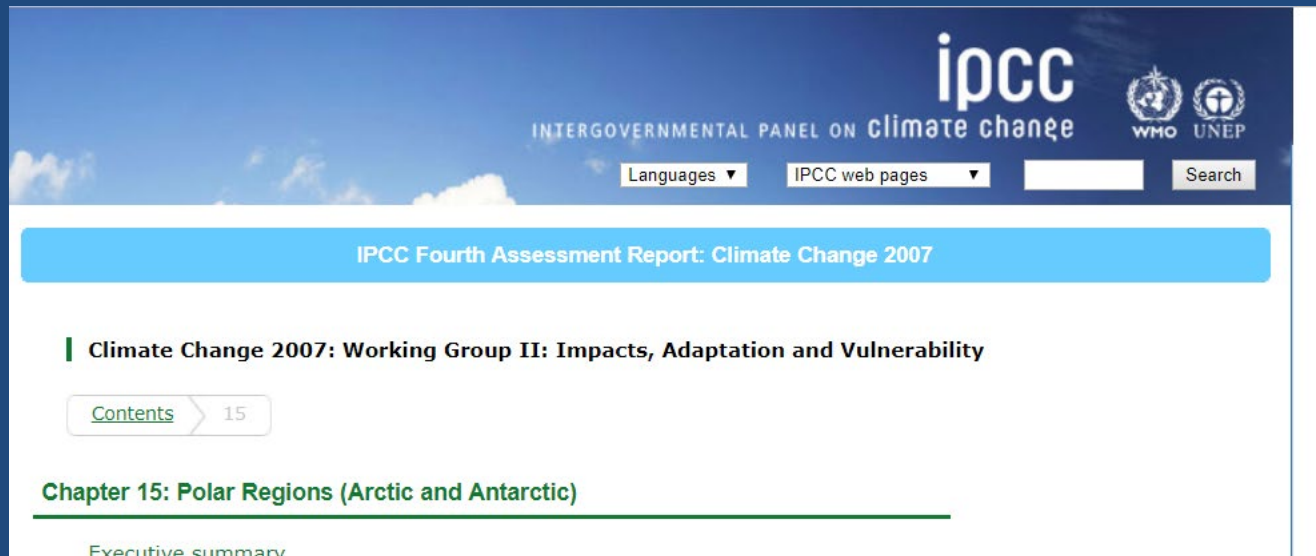
Tromsø, Norway



Apatity, Russia



Primary target: fill the “Arctic gap” in Global Urban Climatology and its SE-connections

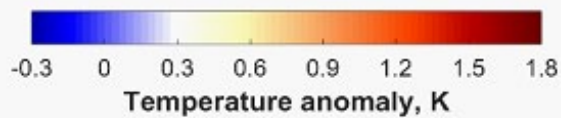
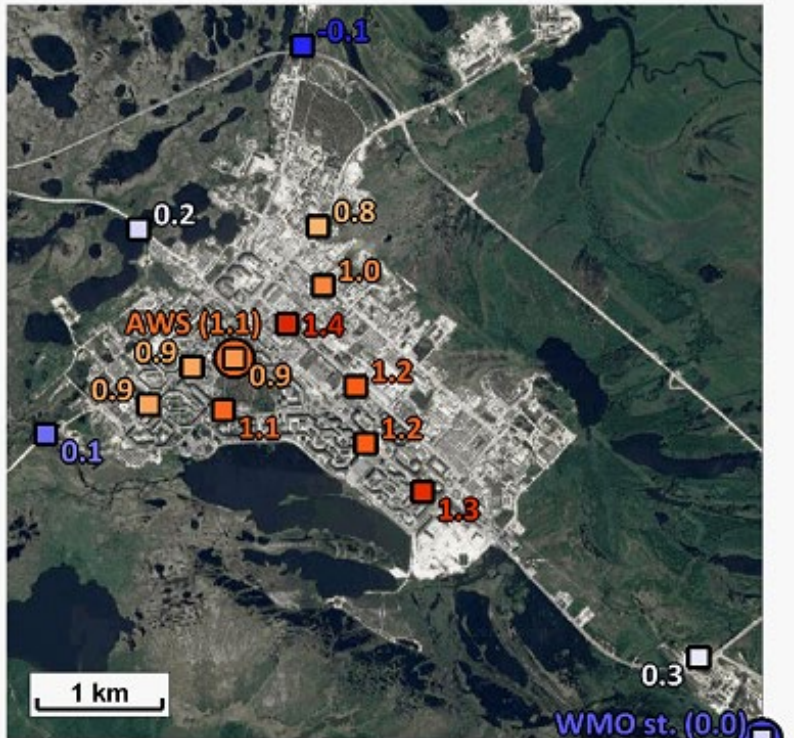


The image is a screenshot of the IPCC website. At the top right, the IPCC logo is displayed, along with the text "INTERGOVERNMENTAL PANEL ON climate change" and the logos for WMO and UNEP. Below the logo, there are navigation options: "Languages" with a dropdown arrow, "IPCC web pages" with a dropdown arrow, a search box, and a "Search" button. A blue banner across the middle of the page reads "IPCC Fourth Assessment Report: Climate Change 2007". Below this banner, the text "Climate Change 2007: Working Group II: Impacts, Adaptation and Vulnerability" is shown. Underneath, there is a "Contents" button with a right-pointing arrow and the number "15". Below the contents button, the text "Chapter 15: Polar Regions (Arctic and Antarctic)" is displayed, followed by a horizontal line. At the bottom left, the text "Executive summary" is visible.

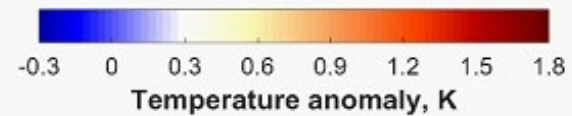
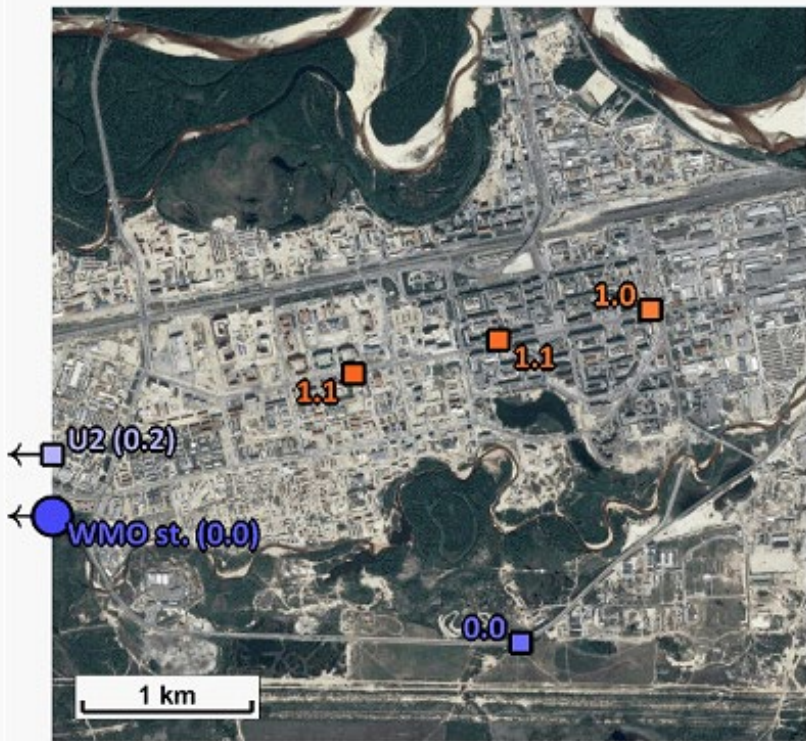
First UHIARC's long-term measurement system results

UHI in Nadym & Novy Urengoy

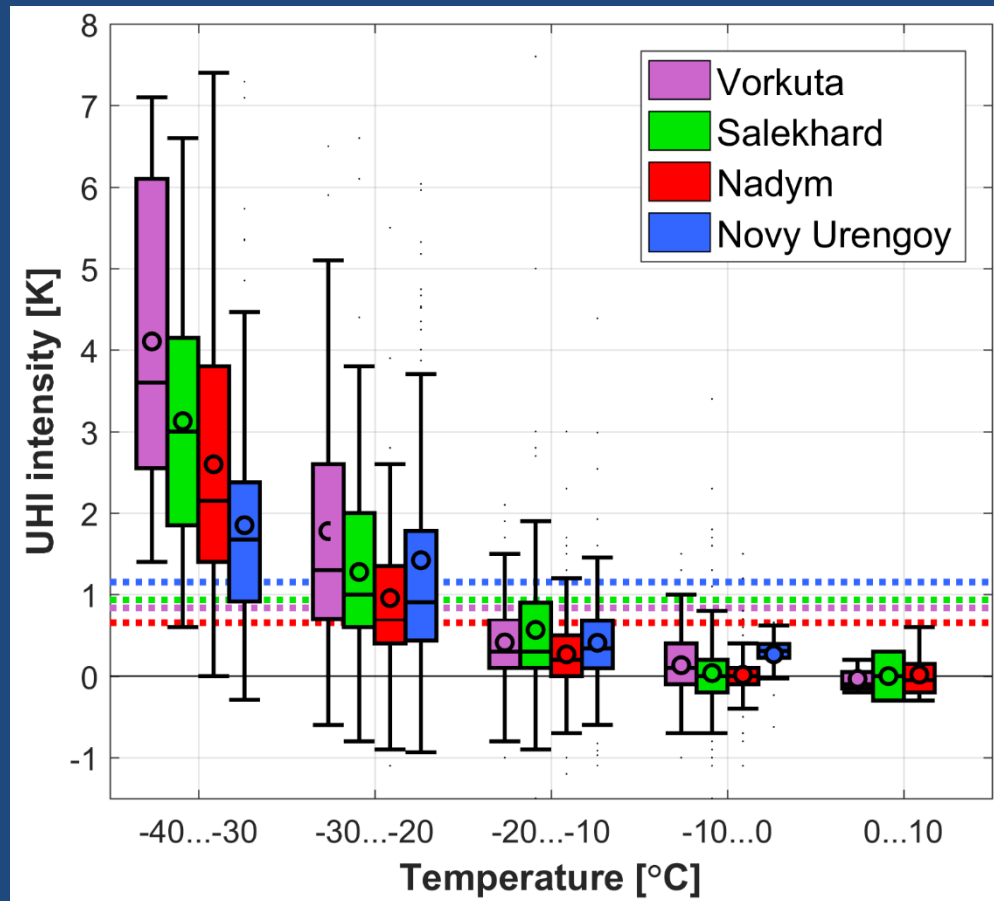
(c) Nadym



(d) Novy Urengoy



UHIARC results for Ural-Siberia Arctic region



Dependence between UHI intensity and air temperature

**OK, UHIs exist in the Arctic cities in winter,
and we know their typical features.**

What's next?

Ground-level thermal Inversions monitoring

Nadym



Apatity

Intensive campaign in Nadym

Location: Nadym, Russia, 65.3N, 73E

Period: 18-27 December 2018

Lowest observed temperature: $-46\text{ }^{\circ}\text{C}$



Intensive campaign in Nadym

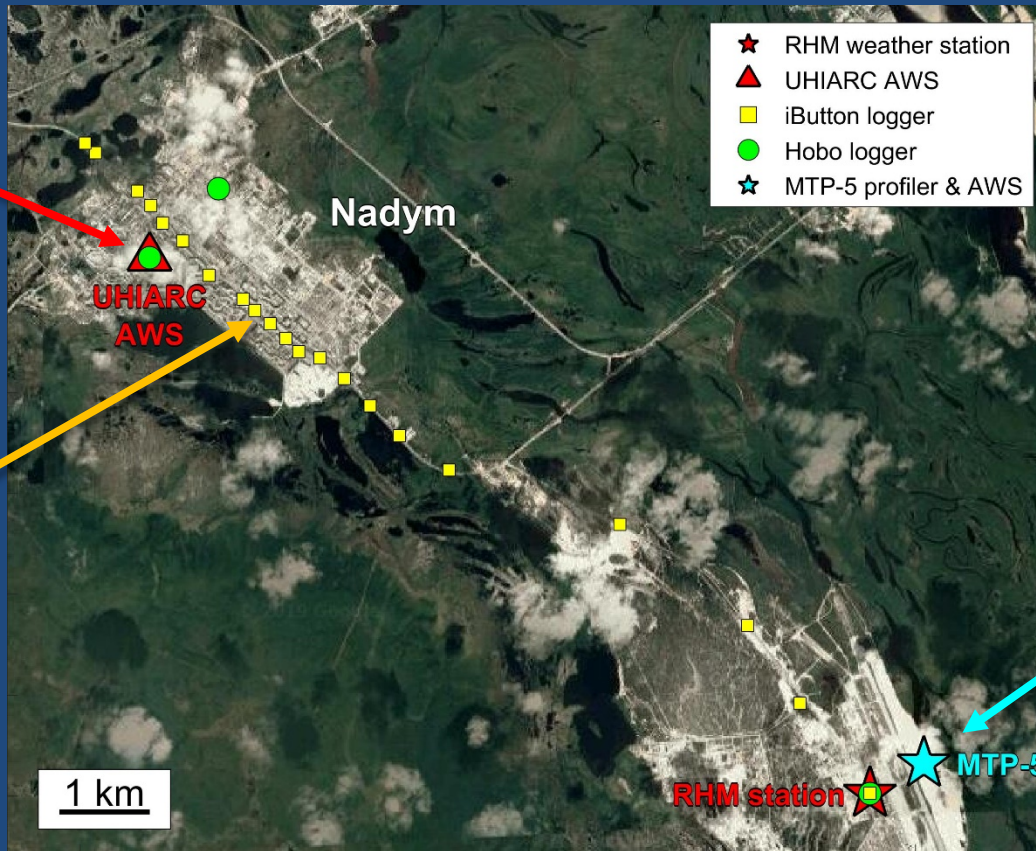
Aim of the research is to investigate the ABL behavior over the Arctic city in winter, under strongly stable atmospheric stratification



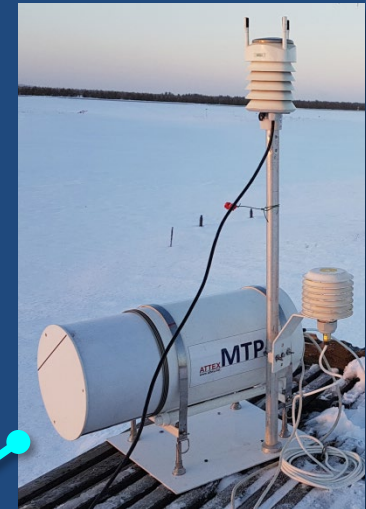
UHIARC AWS in the city center



Quadcopter-based vertical temperature sounding over the city



22 iButton & Hobo temperature loggers



MTP-5 microwave temperature profiler

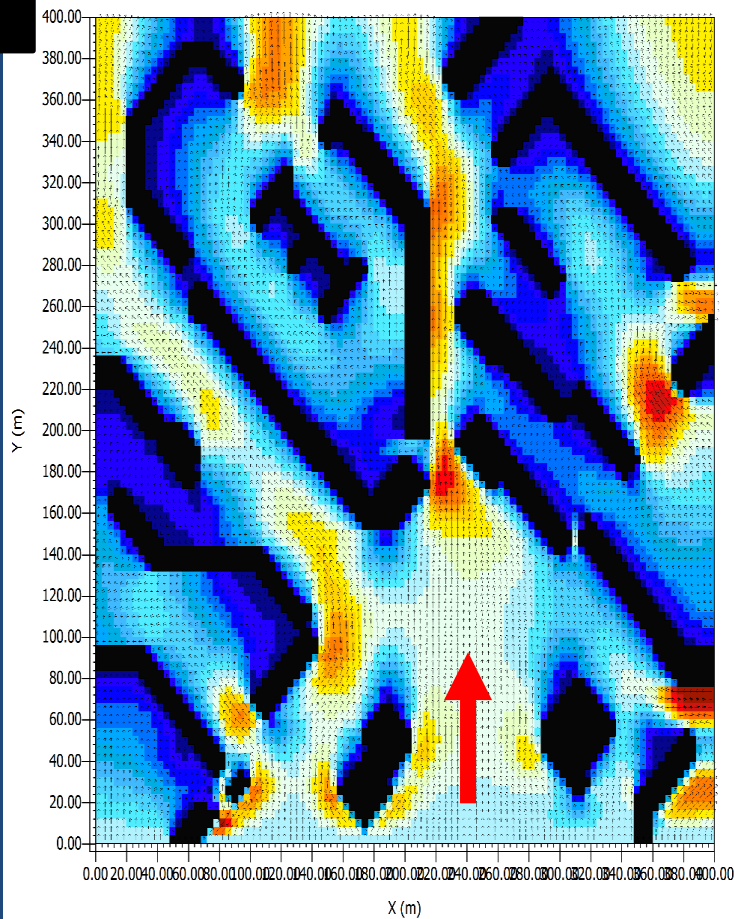
Intensive campaign in Nadym

Quadcopter-based measurements at $-42\text{ }^{\circ}\text{C}$

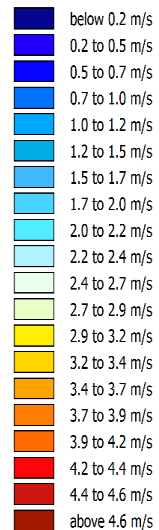


Air quality modeling (largangian aerosol modeling)

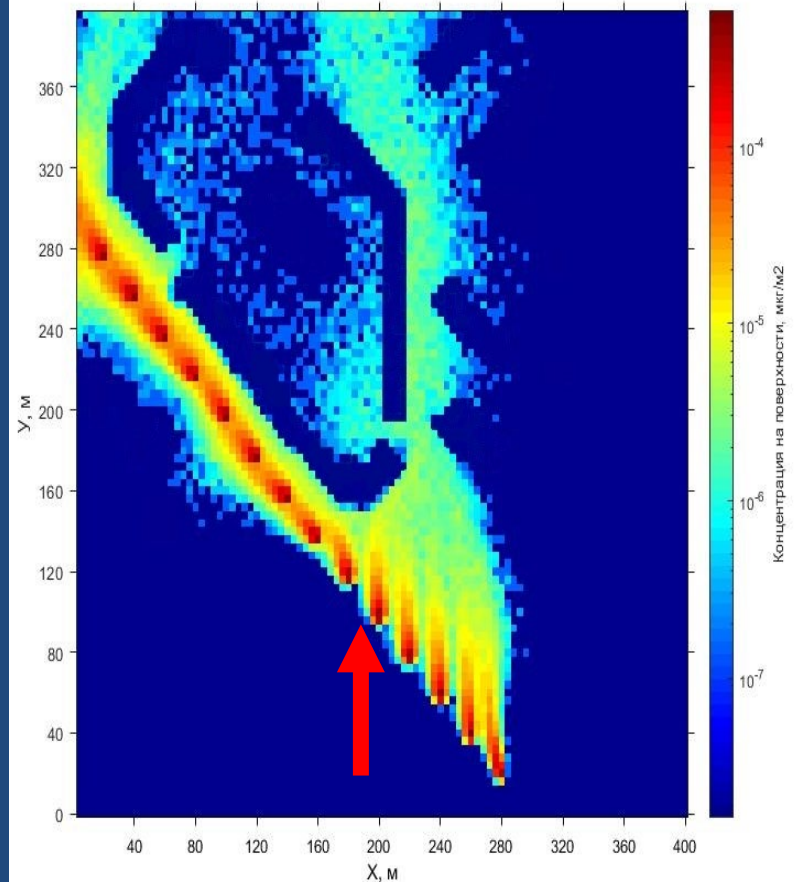
Wind speed 1.2 m



Скорость ветра на 1.2 м



Concentrations



Концентрация на поверхности, мкг/м³

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



Photo by: O. Anisimov, SGI

Thermokarst

Cherskij, 2002

Photo by: V. Romanovki, SGI



J.Doboliubova, 2015

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



Thermal Comfort measurements and modeling

Thermal comfort

Thermal comfort is a parameter of the feeling of comfort. In this condition the thermoregulatory system is at rest.

A human feels comfortable. He is neither cold, nor hot. (Isaev, 2003)

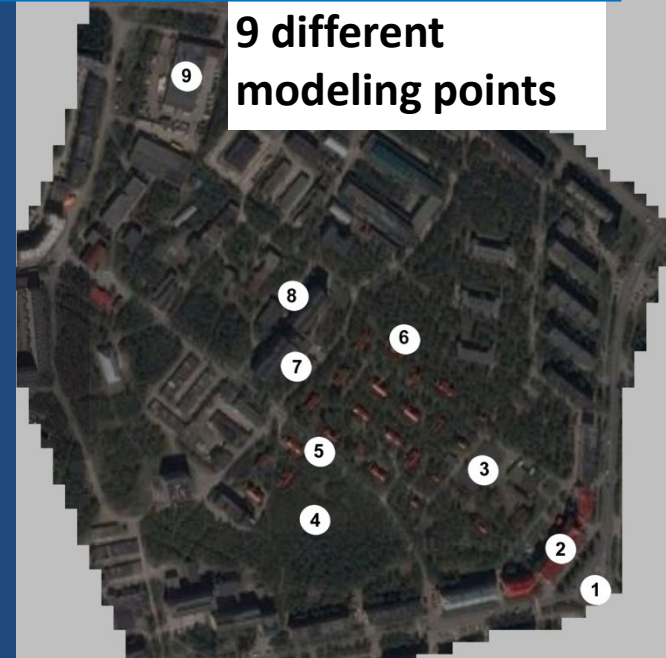
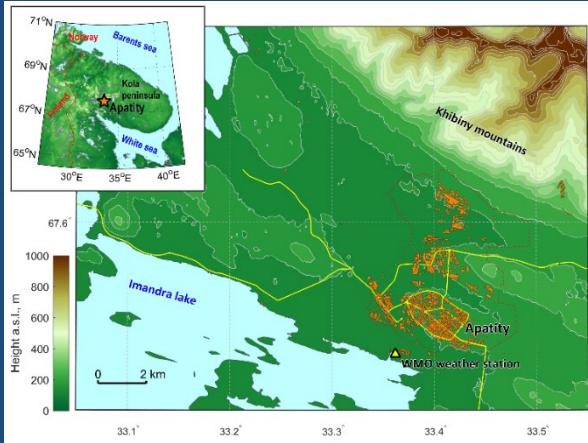
Factors affecting thermal comfort

- **meteorological parameters:** air temperature, wind speed, air humidity
- **metabolic rate** (depends on human physiological parameters: height, weight, age)
- **the level of physiological activity**
- **thermo-insulating properties of clothing**

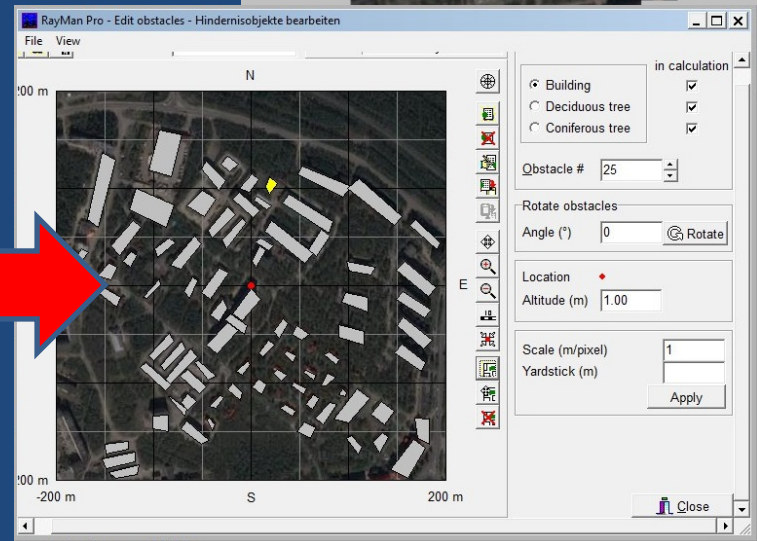
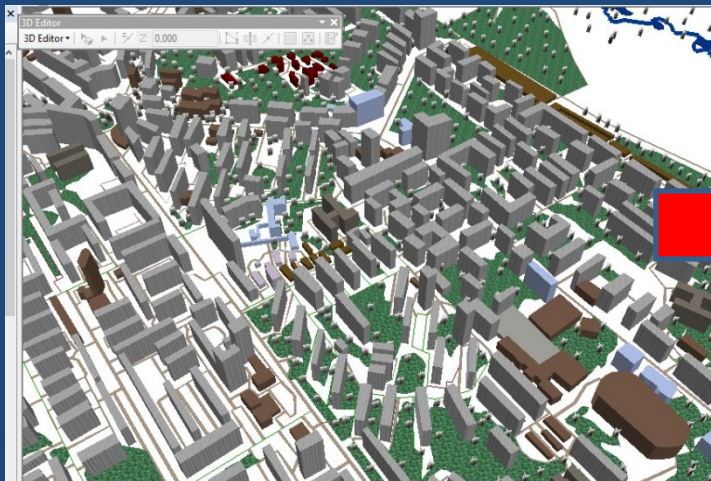


Thermal Comfort // Innova Air Tech
Instruments A/S, 2002

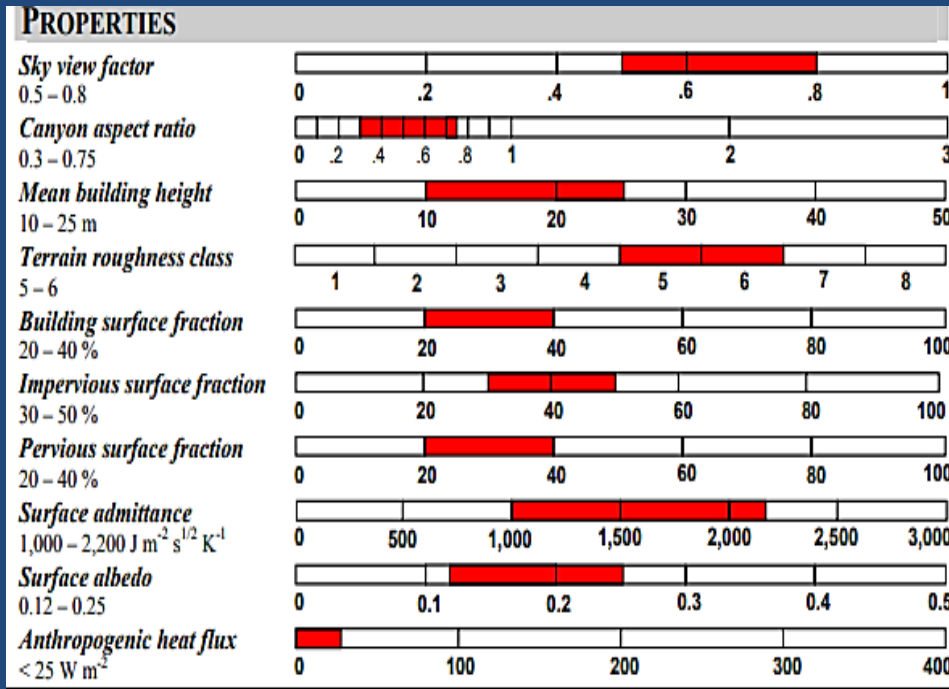
It is possible to meet with thermal stress during last summer in Arctic latitudes?



9 different modeling points

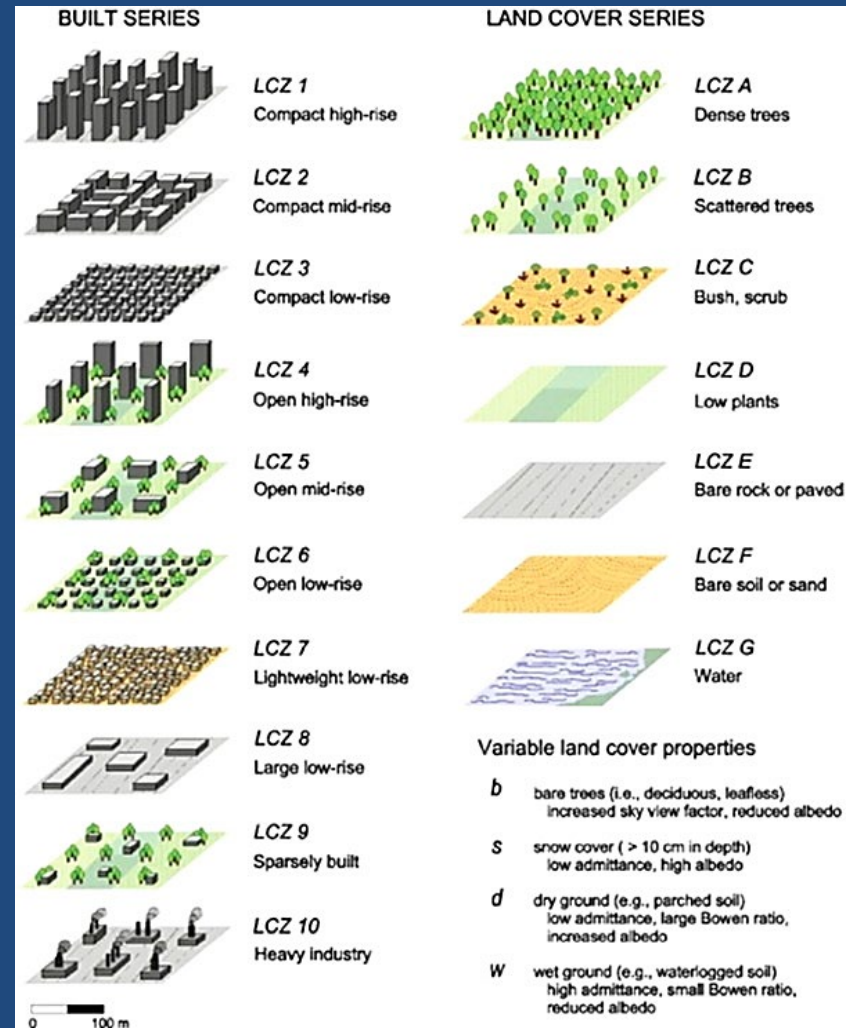


Regionalization of cities by LCZ



Local Climate Zones -
these areas have relatively uniform surface coverage:

- height and building density,
- the number of green spaces
- building materials surfaces
- the nature of human activity

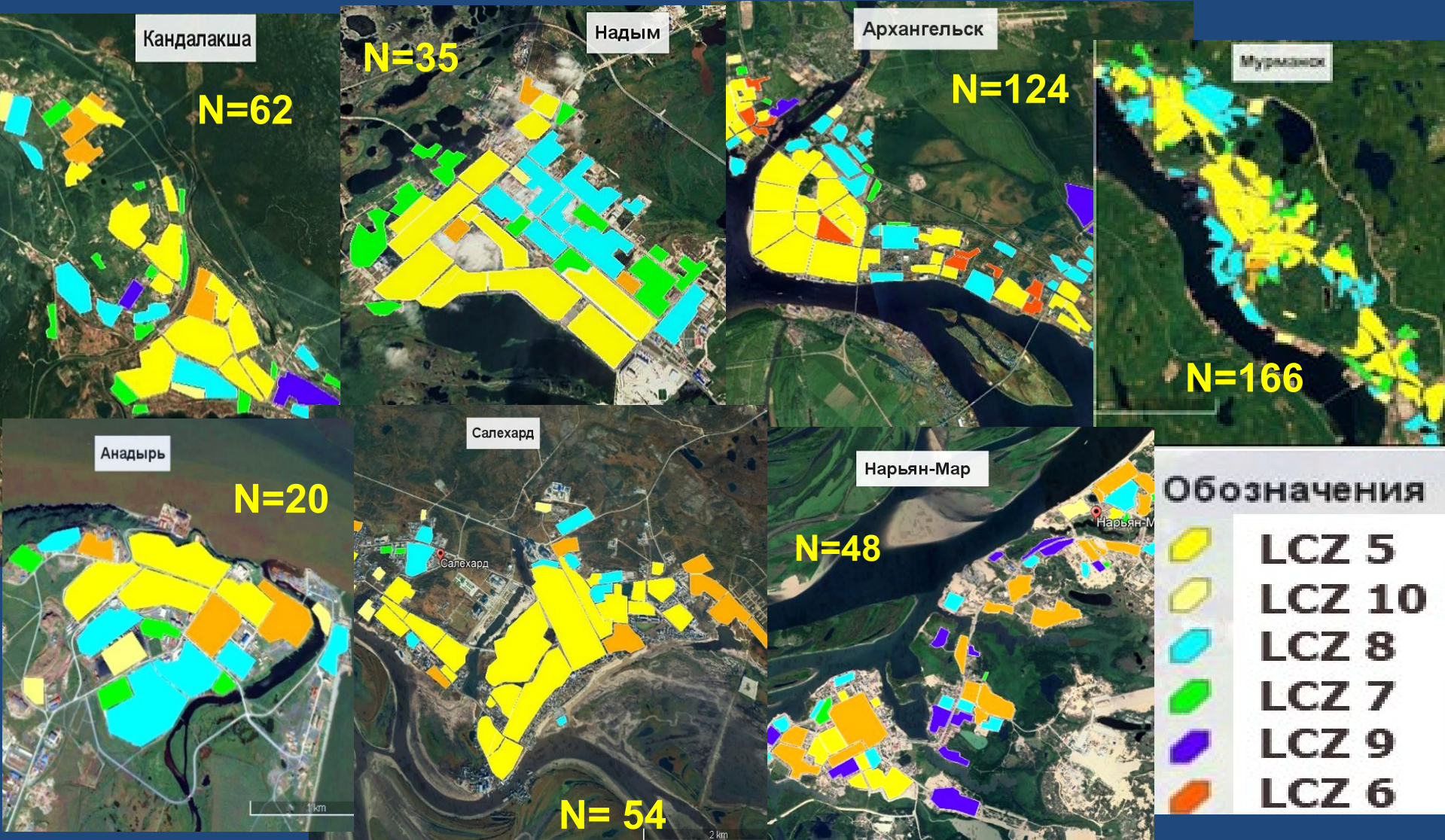


Iain Stewart and Tim Oke

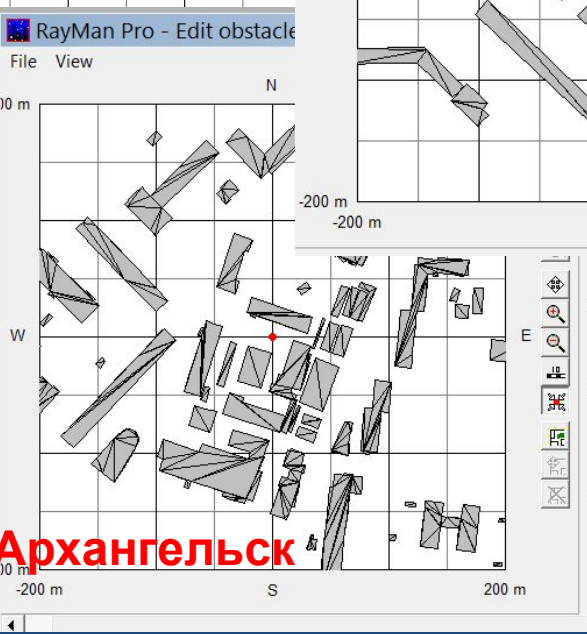
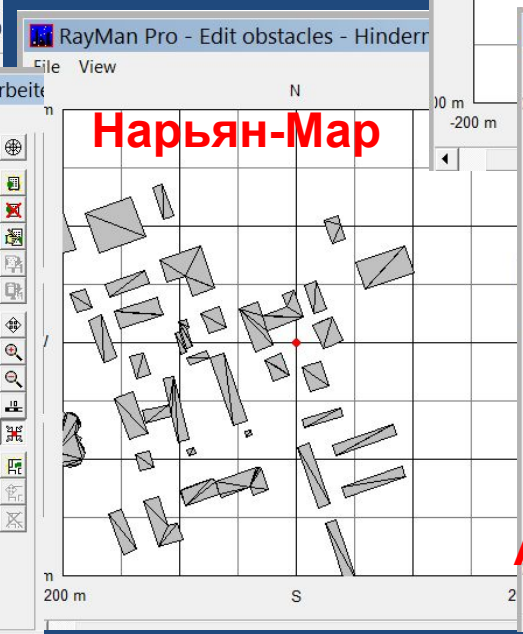
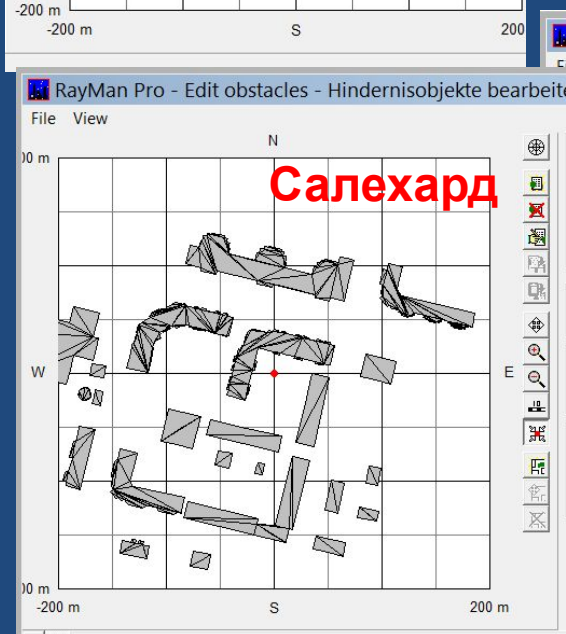
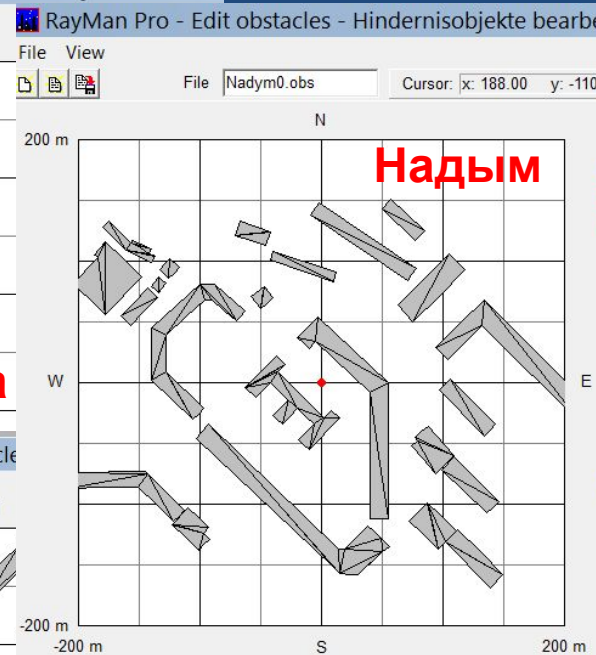
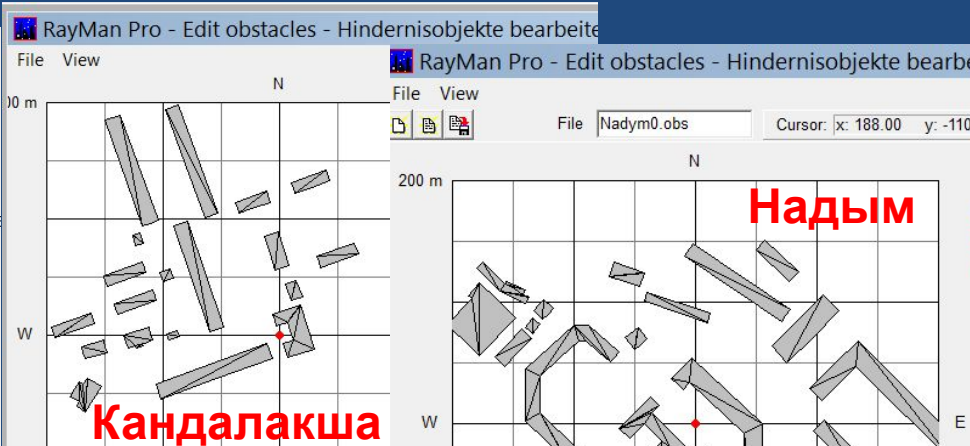
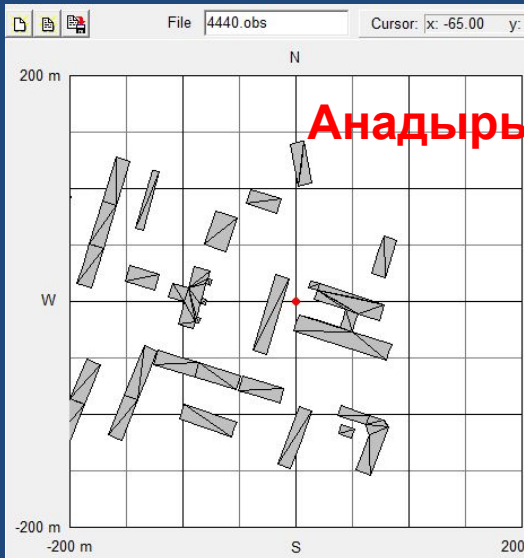
Department Geography
University of British Columbia
Vancouver CANADA

Regionalization of cities by LCZ

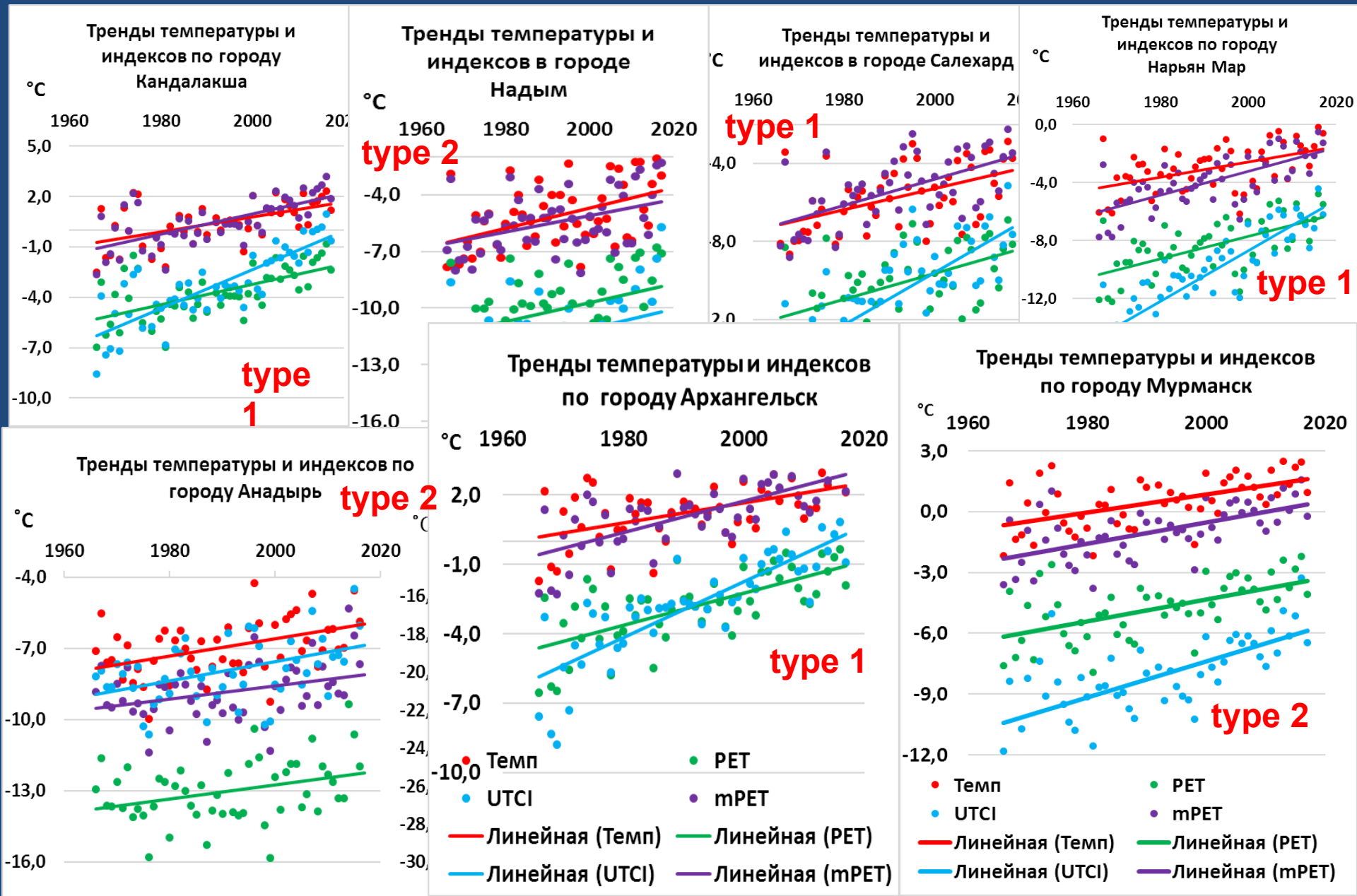
N – number of polygons



Selected urban areas



Model experiment results



Thermal comfort trends /10 years

Город	ΔT	ΔPET	$\Delta mPET$	$\Delta UTCI$	$\Delta Wind\ Chill$
Murmansk	0.45	0.54	0.53	0.68	0.60
Kandalaksha	0.45	0.61	0.61	1.10	0.65
Arkhangelsk	0.45	0.69	0.67	1.22	0.72
Narjan Mar	0.52	0.78	0.83	1.68	0.93
Salekhard	0.53	0.67	0.68	0.82	0.41
Nadym	0.54	0.50	0.43	0.47	0.60
Anadyr	0.36	0.30	0.28	0.29	0.56

Thermal Comfort and Urban Planning

Microscale evaluation of urban planning

Figure 1: EcoHack_19.10.00
13.07.2010_GRAY
x/y Cut at k=0 (z=1.0000 m)
Min: 23.80 °C
Max: 49.20 °C

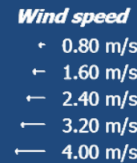
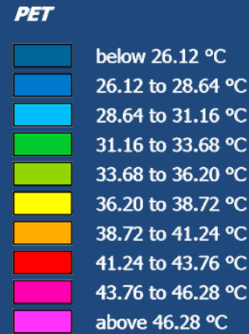
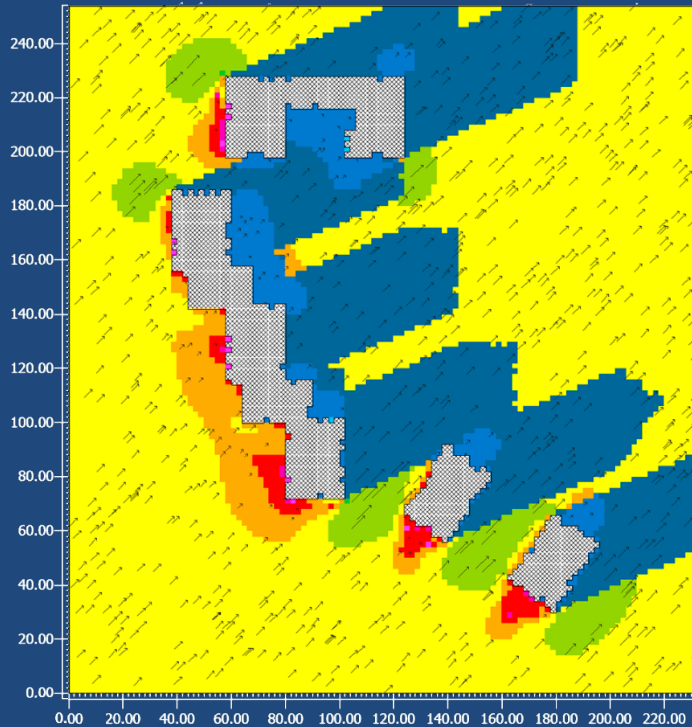
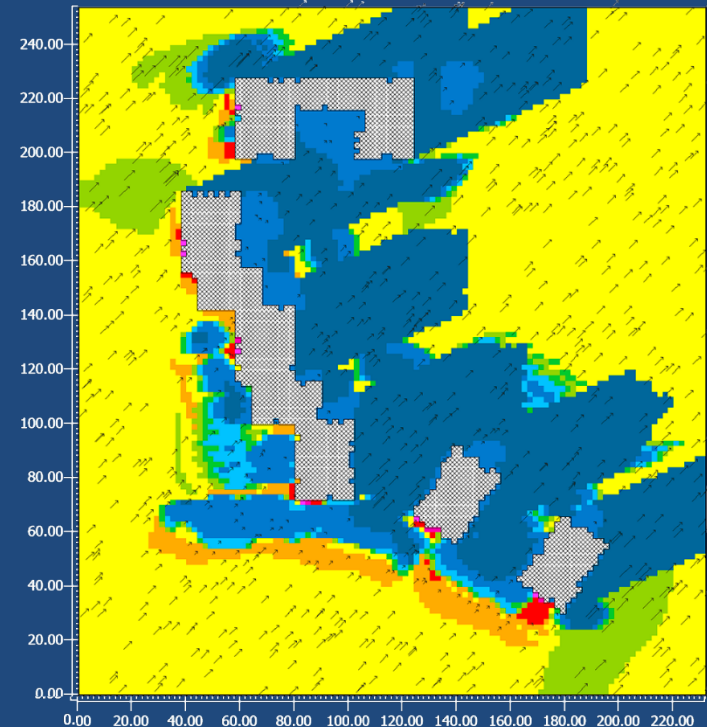


Figure 1: EcoHack_19.10.00
13.07.2010_GREEN
x/y Cut at k=0 (z=1.0000 m)
Min: 23.60 °C
Max: 48.80 °C

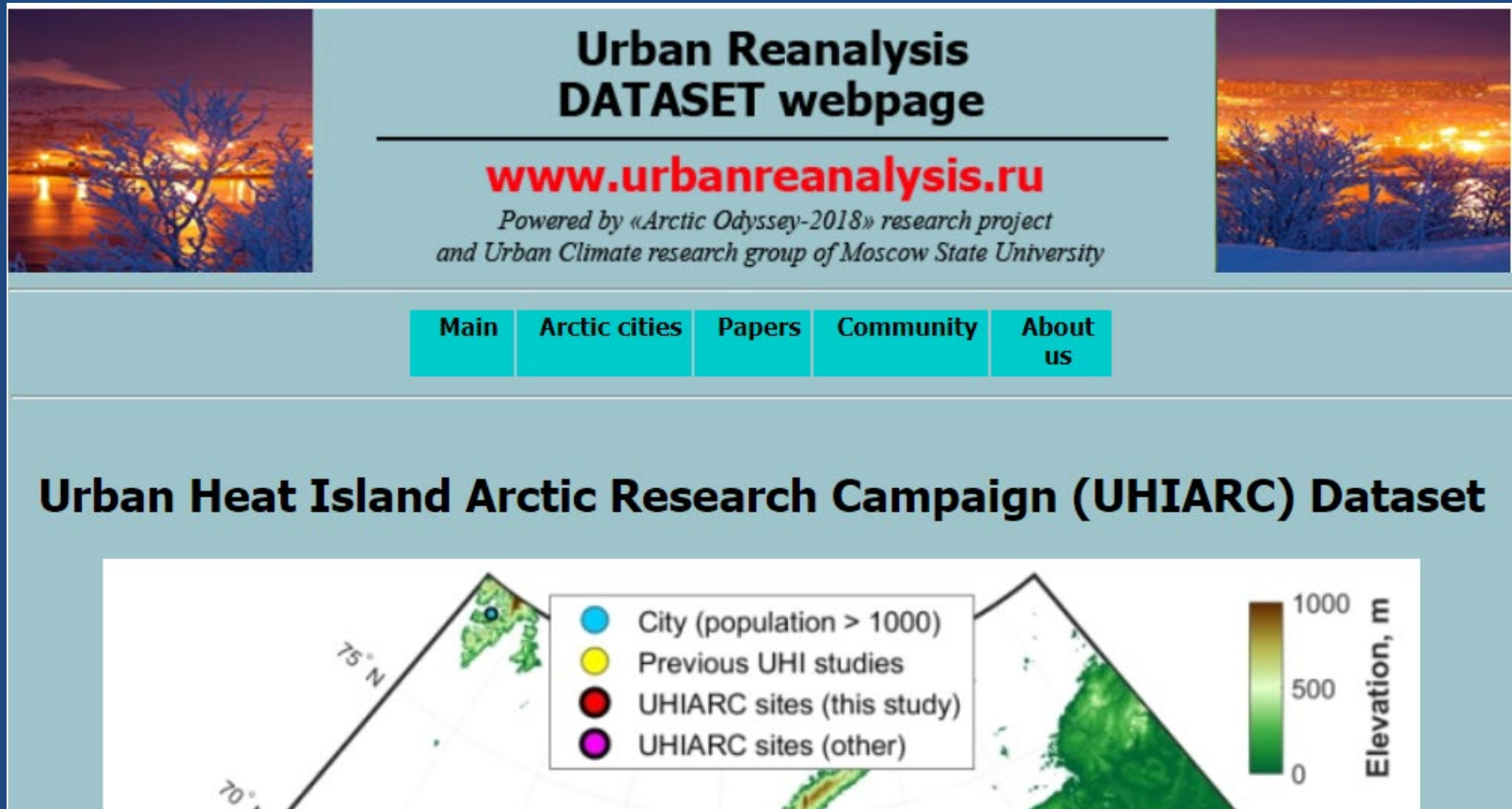


Design building experimental site, GREEN (with trees) vs GRAY (without trees) cases
Trees help to decrease thermal stress

Since July 2018 UHIARC AWS

dataset is **available online:**

<http://urbanreanalysis.ru/uhiarc.html>



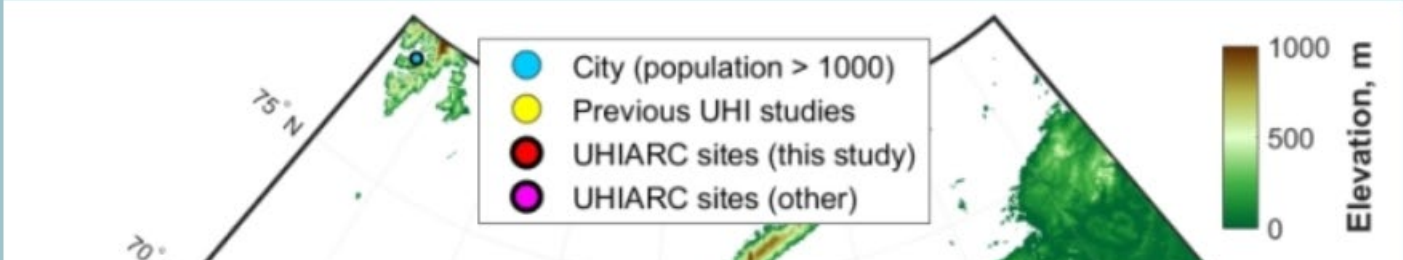
**Urban Reanalysis
DATASET webpage**

www.urbanreanalysis.ru

*Powered by «Arctic Odyssey-2018» research project
and Urban Climate research group of Moscow State University*

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Urban Heat Island Arctic Research Campaign (UHIARC) Dataset



- City (population > 1000)
- Previous UHI studies
- UHIARC sites (this study)
- UHIARC sites (other)

Elevation, m

1000
500
0

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. <https://doi.org/10.1088/1748-9326/aacb84>