

Urban heat island in Northern Eurasian cities: Climatic overview

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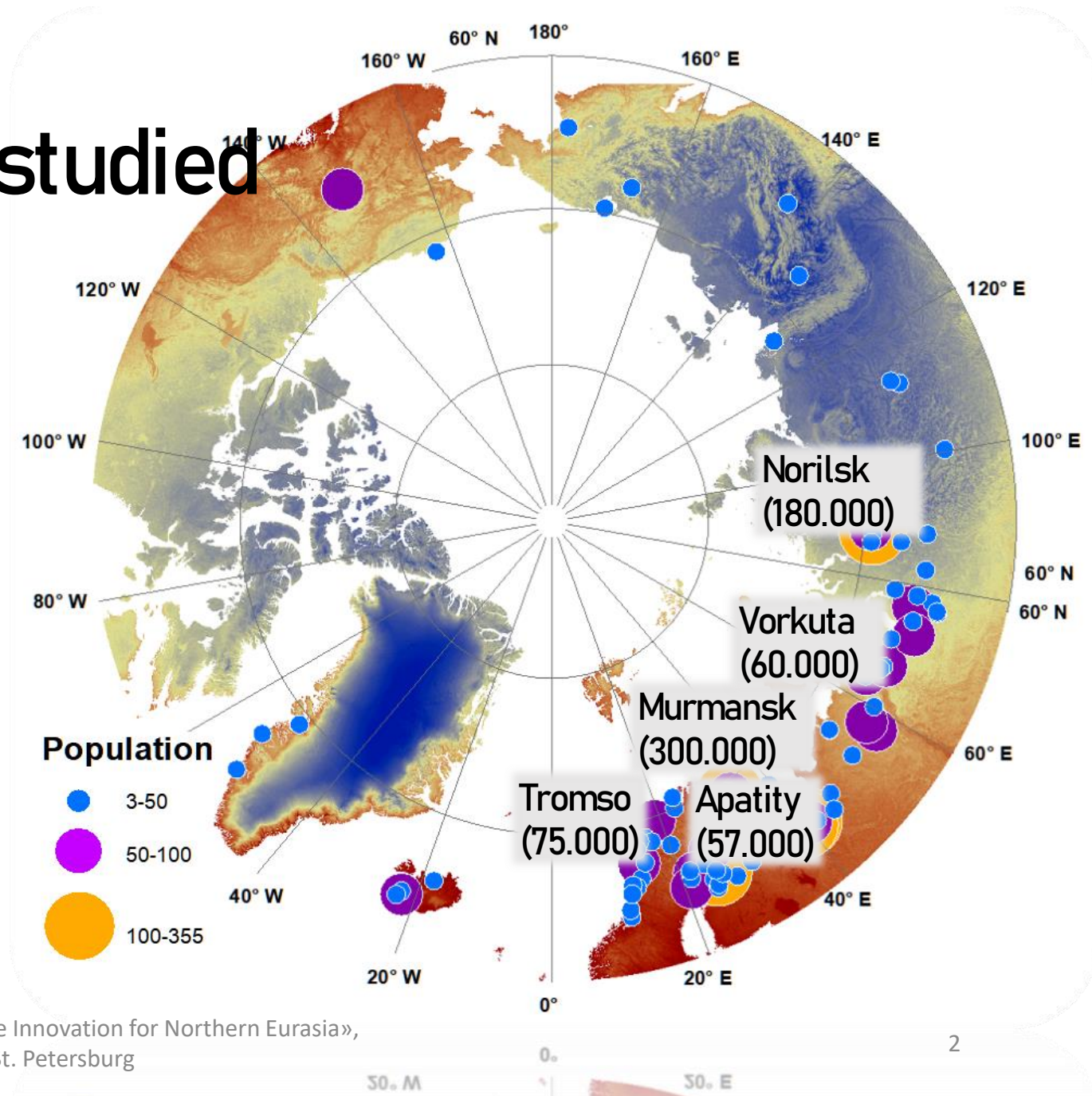
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Nadym, Photo by M. Varentsov

The Urban North: 118 urban settlements studied

Arctic population >4,000,000

85 % of Arctic population lives in a cities



FAIRBANKS

Natural Resilience

UHI, permafrost, ecosystems

Social Resilience

LIK, migration, education

Knowledge Asset

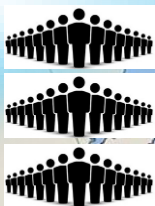
Social data, Remote Sensing

Infrastructure

Air quality, AHF



FAIRBANKS



SERUS

GWU
(USA)

NERSC
(NORWAY)

UTMN
(RUSSIA)

NADYM

UHI, permafrost, ecosystems

Natural Resilience

LIK, migration, education

Social Resilience

Land values, Observations

Knowledge Asset

AHF, new materials

Infrastructure



City population (thousands)

Infrastructure, scenario, new materials

Field Work
 Interview and work with stakeholders

LONGYEARBYEN

Natural Resilience

UHI, snow cover

Social Resilience

Migration, education, tourism

Knowledge Asset

Air quality, Climate change

Infrastructure

Air quality, power generation

LONGYEARBYEN



APATITY



UHI, ecosystems

Natural Resilience

Migration, education

Social Resilience

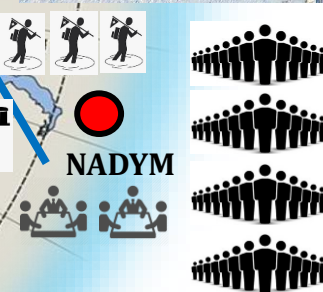
Air quality, AHF, Observation

Knowledge Asset

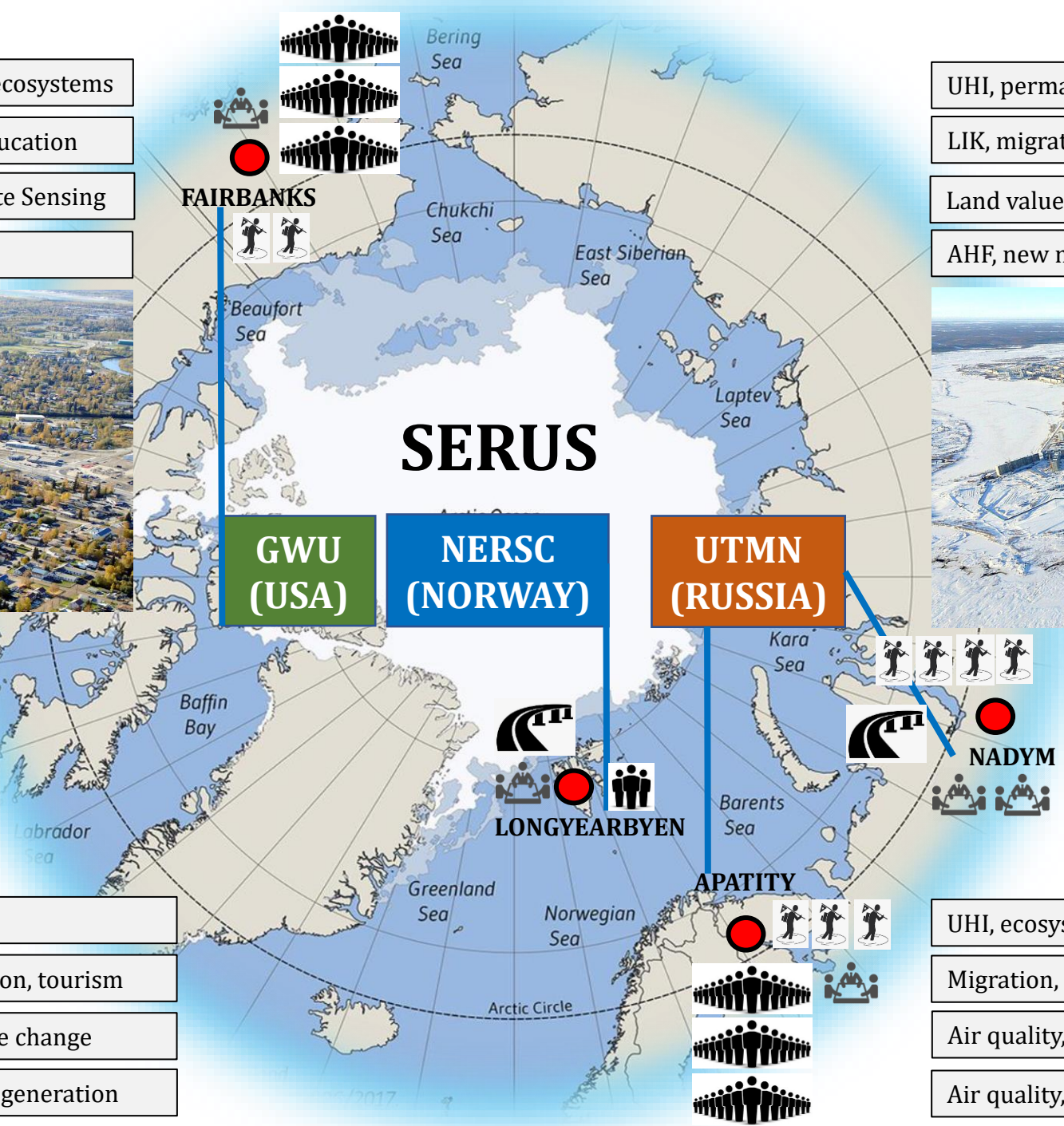
Air quality, dust, AHF

Infrastructure

APATITY



NADYM



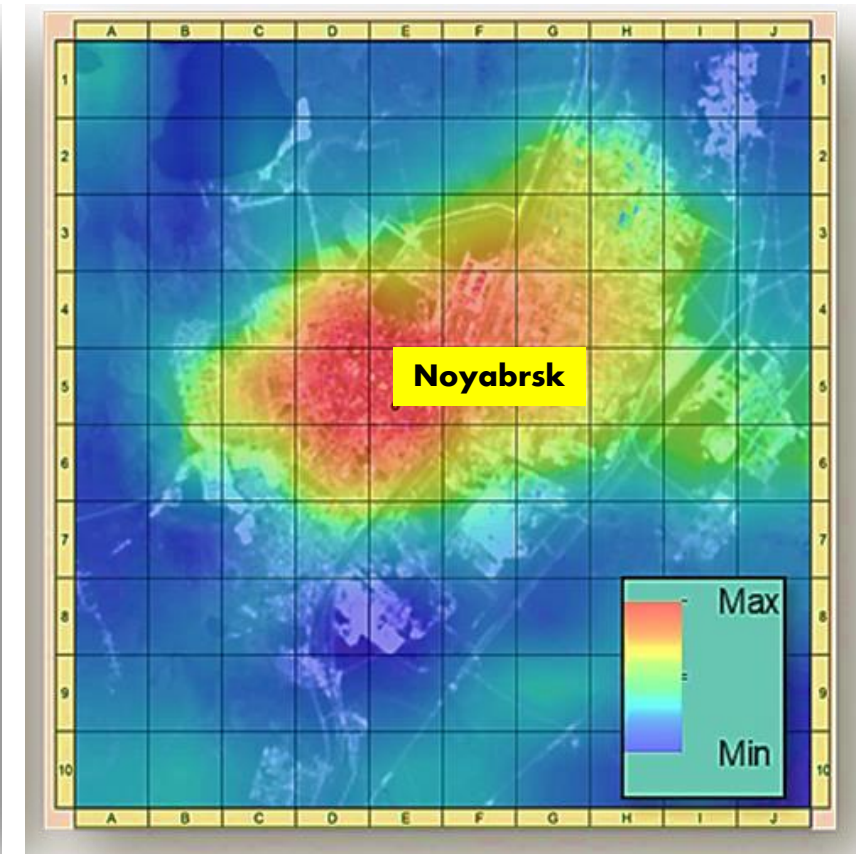
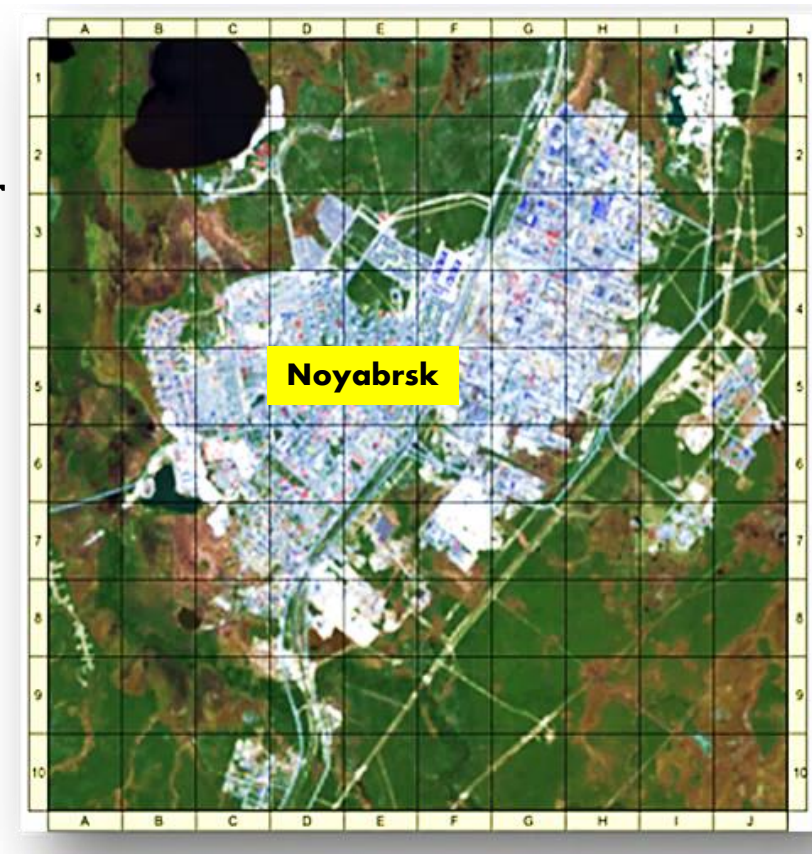
Cities – Climate change agents on local scales

Urban areas are warming significantly more rapidly than their natural background

Urban Heat Island

- Modified land use – land cover
- Anthropogenic heat release
- Modified surface structure

*Example of strong the mean **winter** urban land surface temperature anomaly in Noyabrsk, West Siberia*



Wider Anthropogenic Impact on Environment

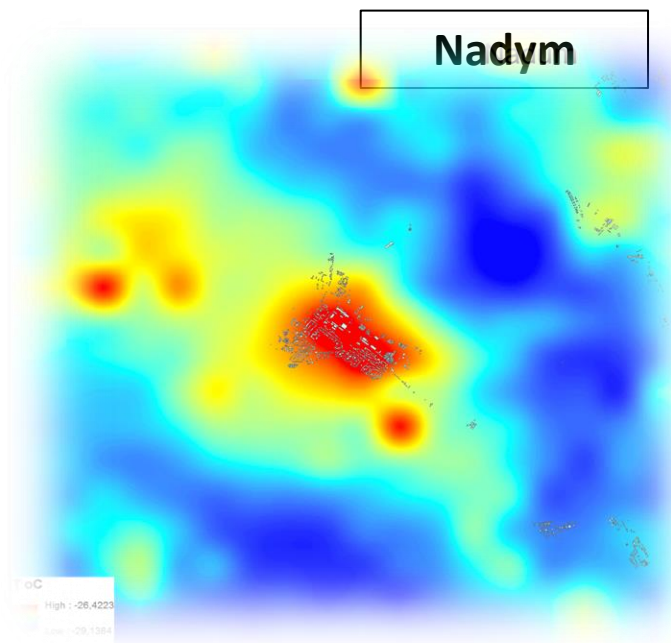
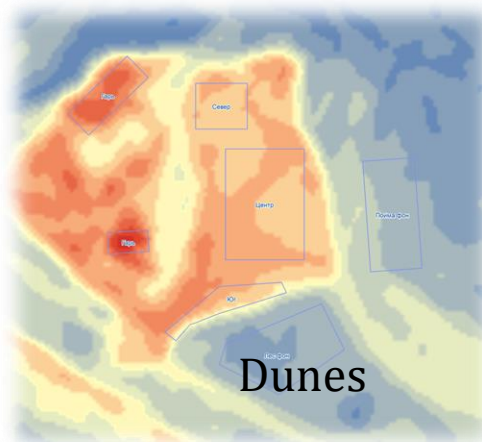
Long time, aggregated

Short time, detailed

0.1 – 10 m
Plant response physiology:
 Controlled Arctic Tundra Warming Experiments (Elmendorf et al. 2012)



10 – 1000 m
Habitat response:
 Natural plant refugia observations (Sizov et al. 2016)



1 – 100 km
Eco-systemic response with interacting plant communities:
 Local climate hot spots (Srodnykh et al. 2008)

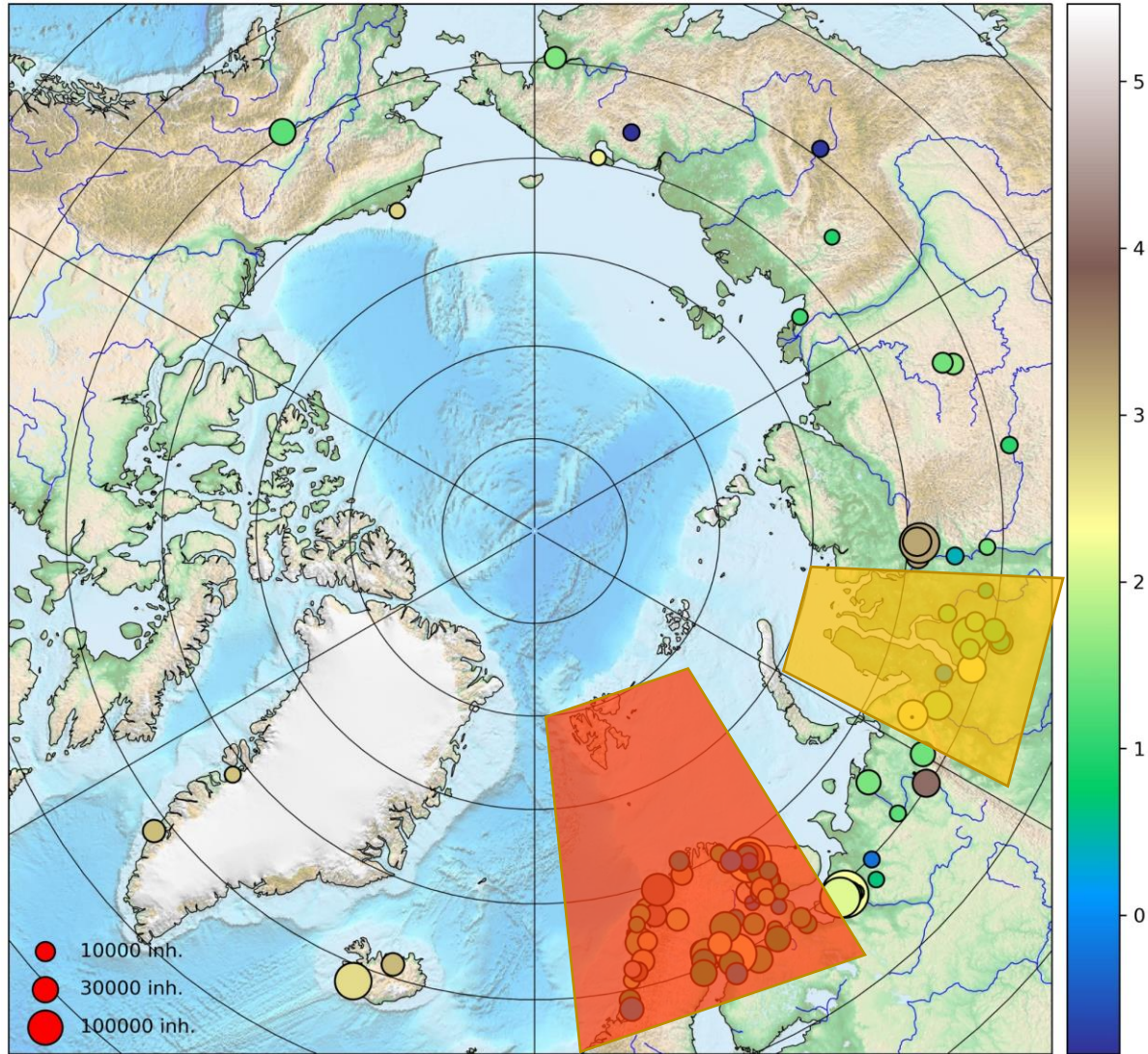
Micro-scale

Meso-scale

Large-scale

Regional-scale

Urban Heat Islands



The West Siberian cluster

The Fennoscandian cluster

Data and method:

MODerate Resolution Imaging Spectroradiometer (MODIS) collection 5 MOD 11A2 product based on 8-days composites over 2000 (Dec) – 2018 (Dec)

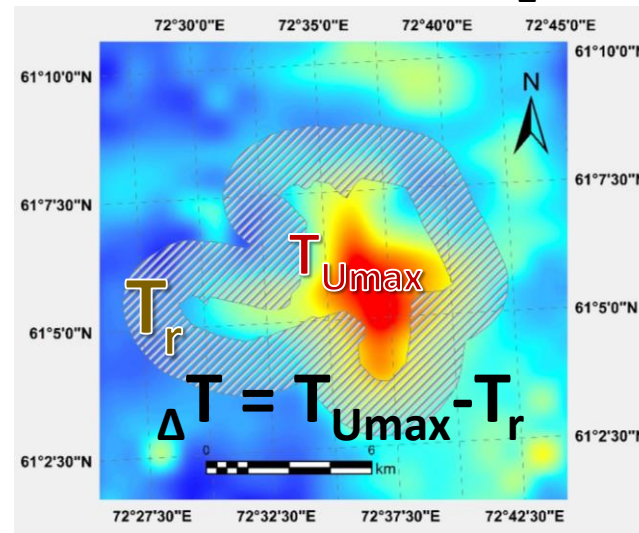
MODIS LST

- 1000 m spatial resolution,
- 8-day composites

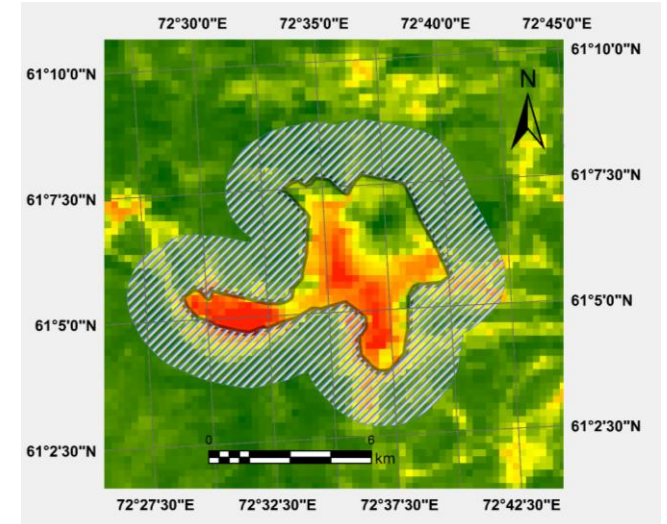
MODIS NDVI

- 250 m spatial resolution
- 16-day composites

Urban Heat Island UHI (ΔT)



Normalized Difference Vegetation Index (NDVI)



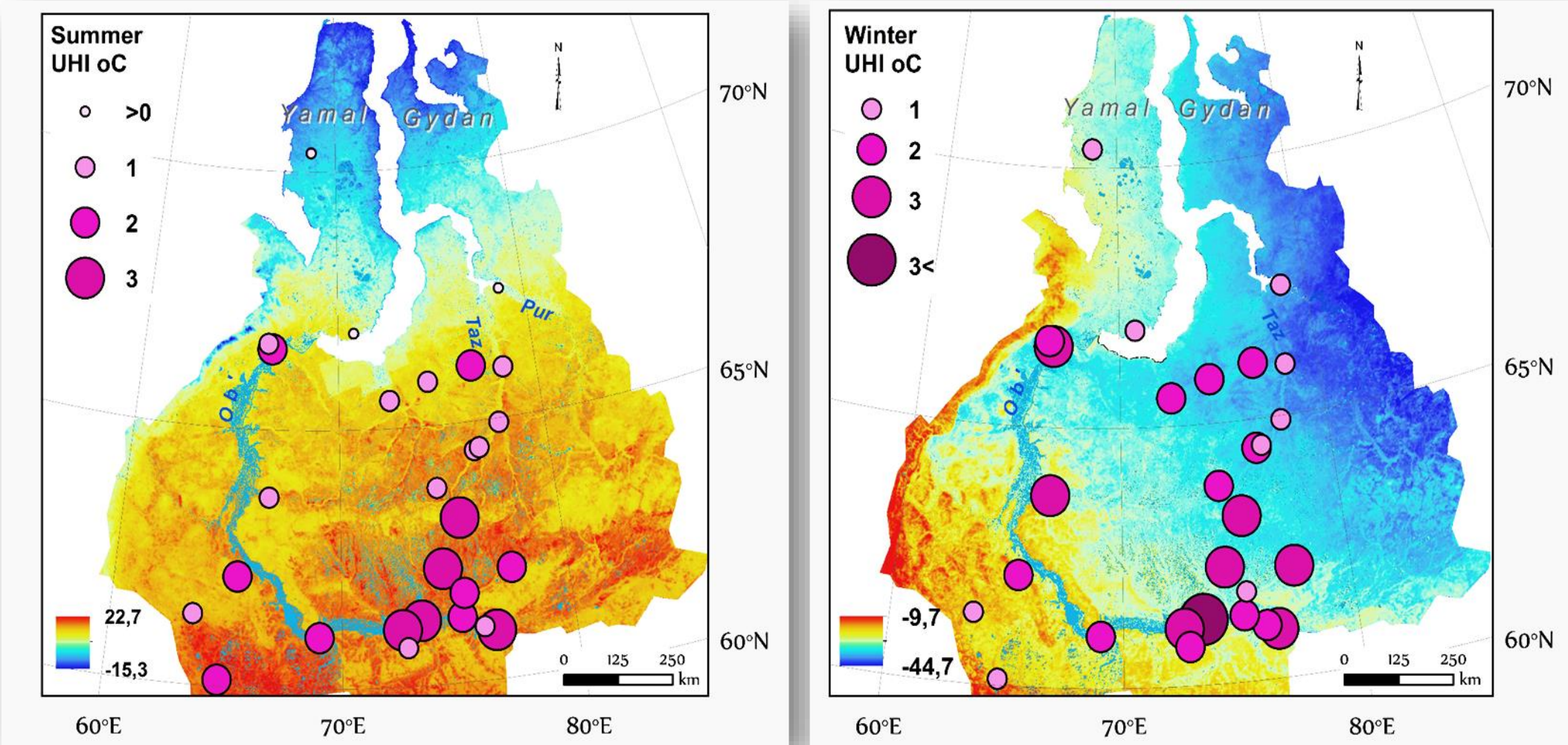
Urban polygon and 2 km boundary buffer

T_{Umax} – *maximum* urban pixel temperature

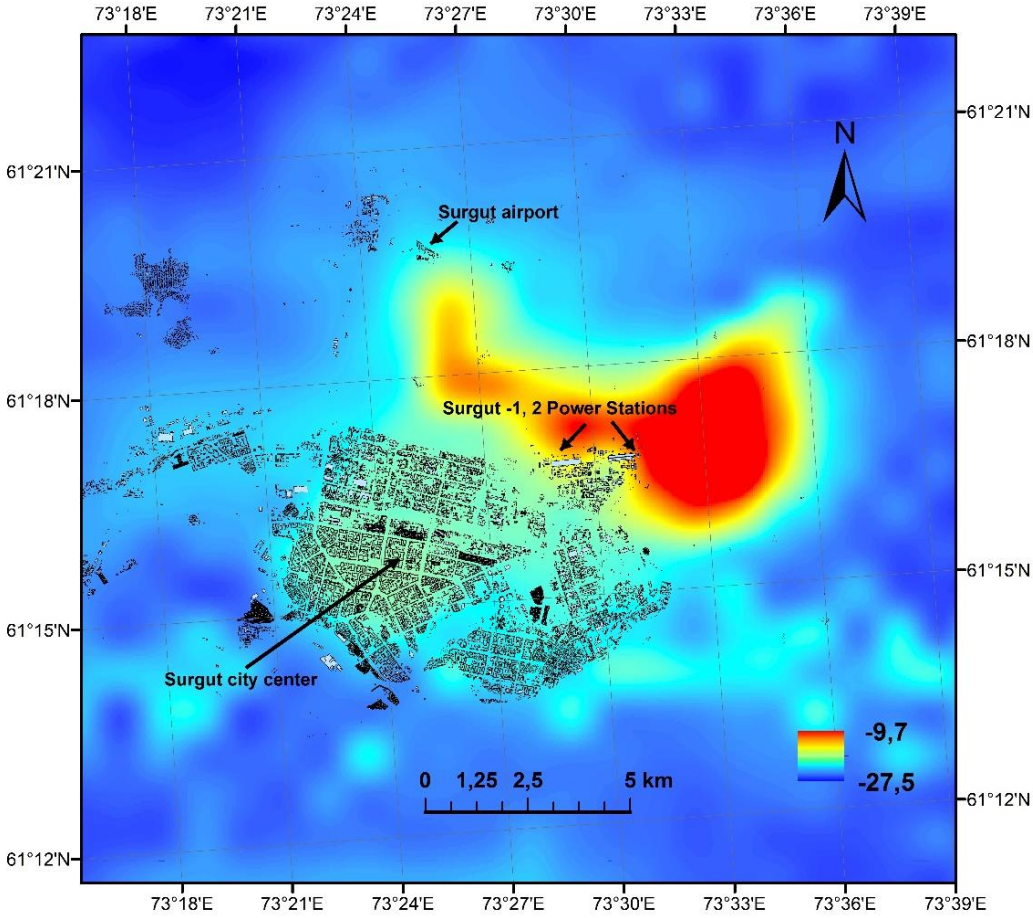
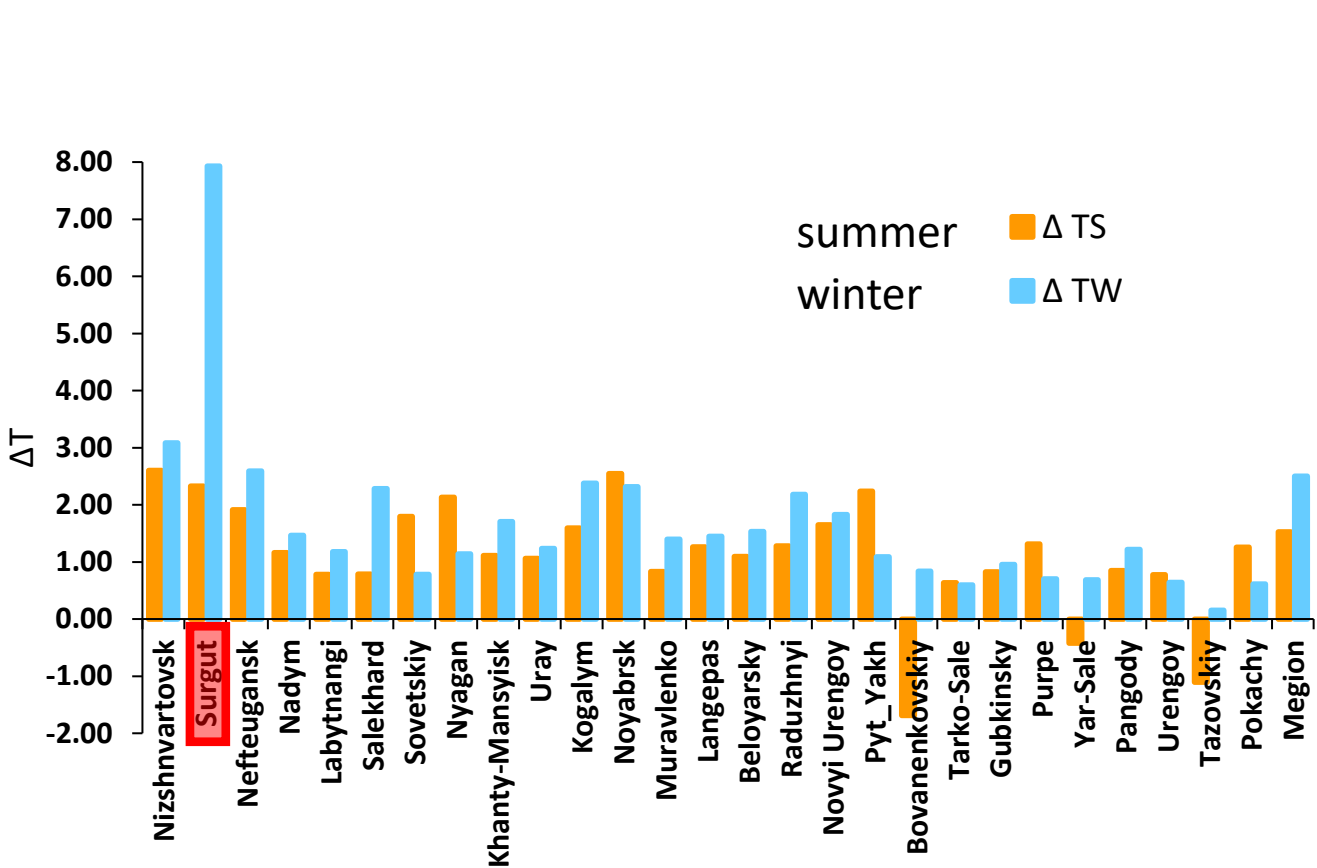
T_r – *mean* rural buffer temperature

Urban Heat Island in 28 Siberian Cities

Miles V. and I. Esau, 2017, *Remote Sensing*, 9(10), 989, doi:10.3390/rs9100989

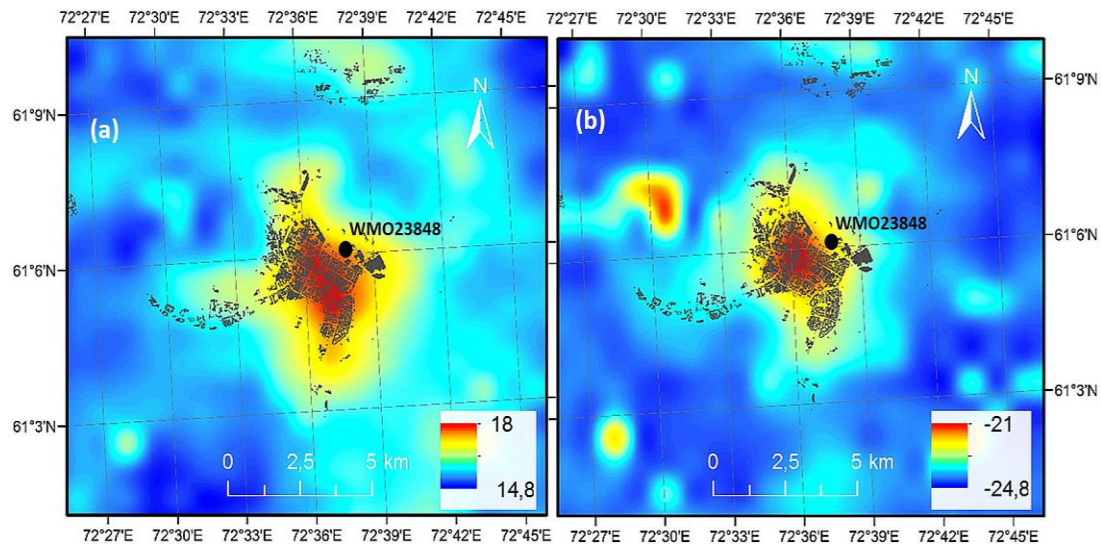


Urban Heat Island in 28 Siberian Cities

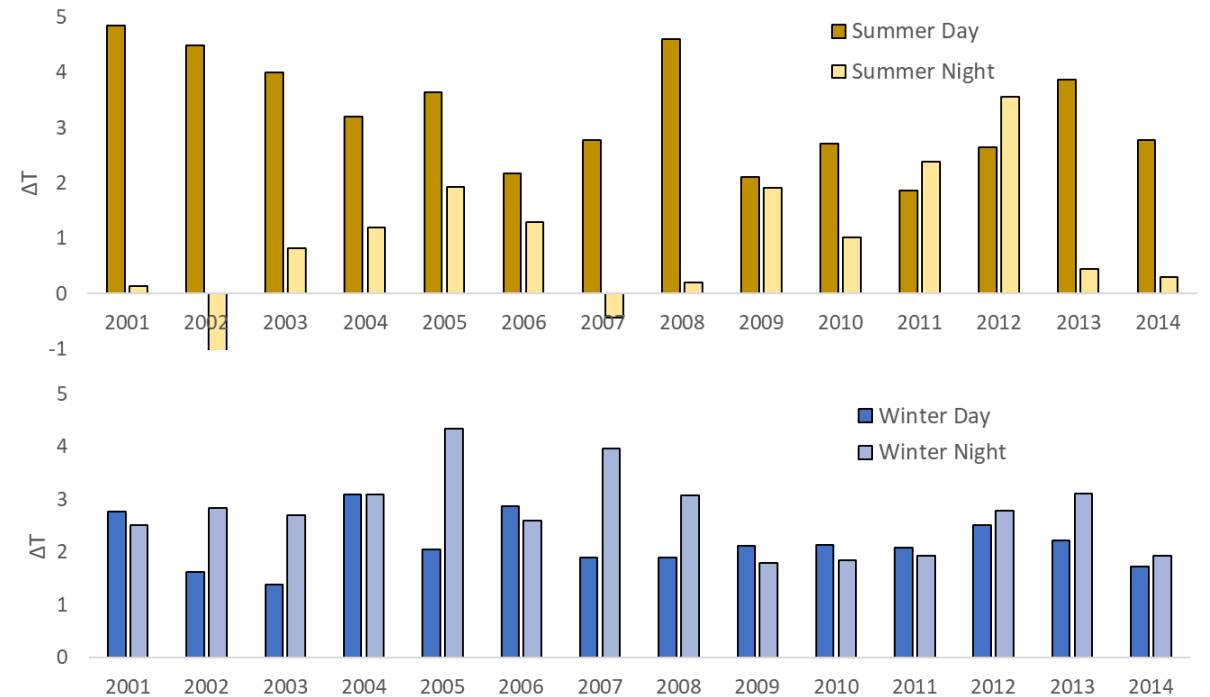


Miles & Esau, 2017

Surface UHI: Variations in the Nefteyugansk case study

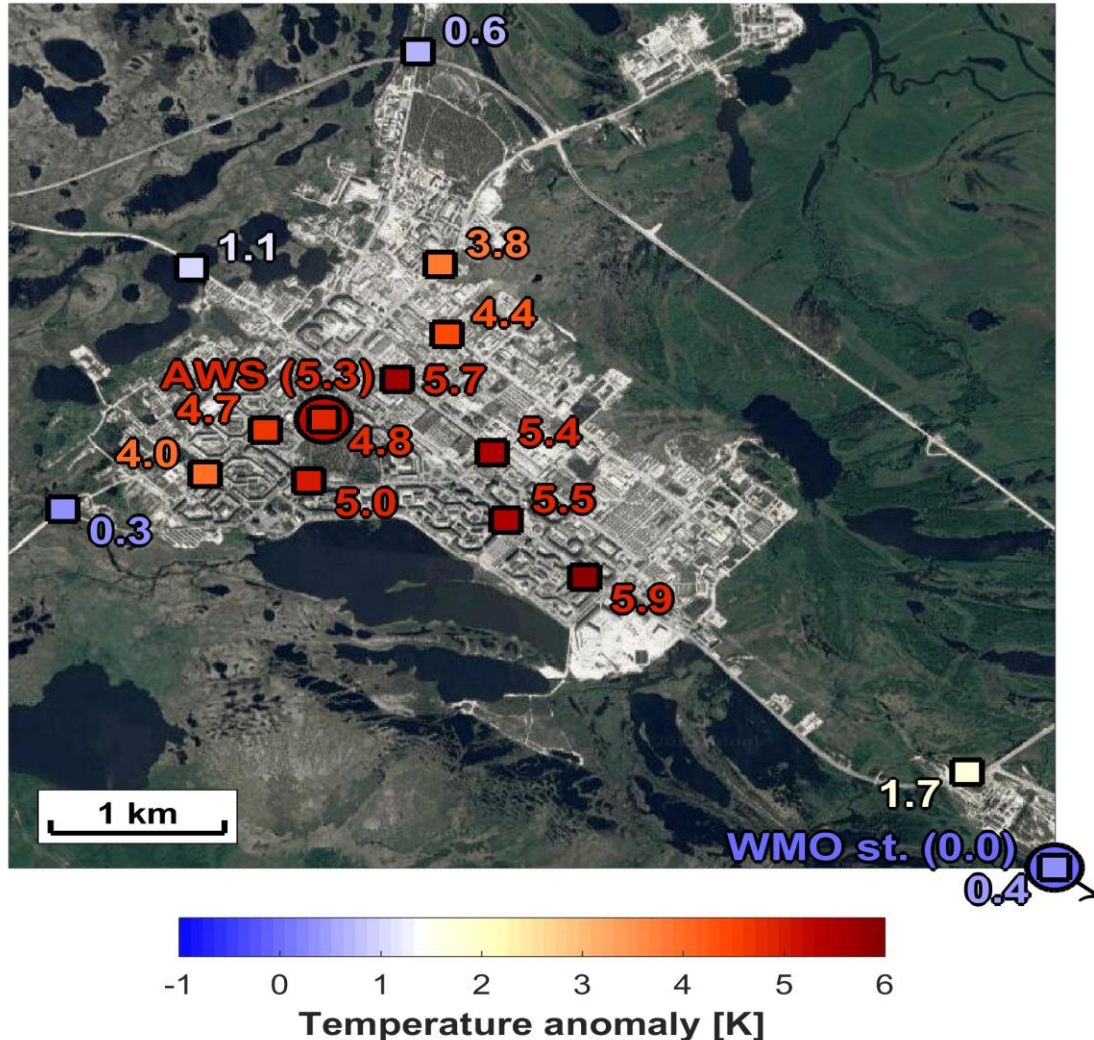


The 14 years (2001-2014) climatology of the MODIS LST in Nefteyugansk for (a) summer and (b) winter seasons. A black dot -the location of the WMO station.



Nefteyugansk , Summer & Winter SUHI (ΔT Day, ΔT Night)

Urban Heat Island in 11 High Arctic Cities



In situ Arctic urban climate studies with UHIARC observational network:

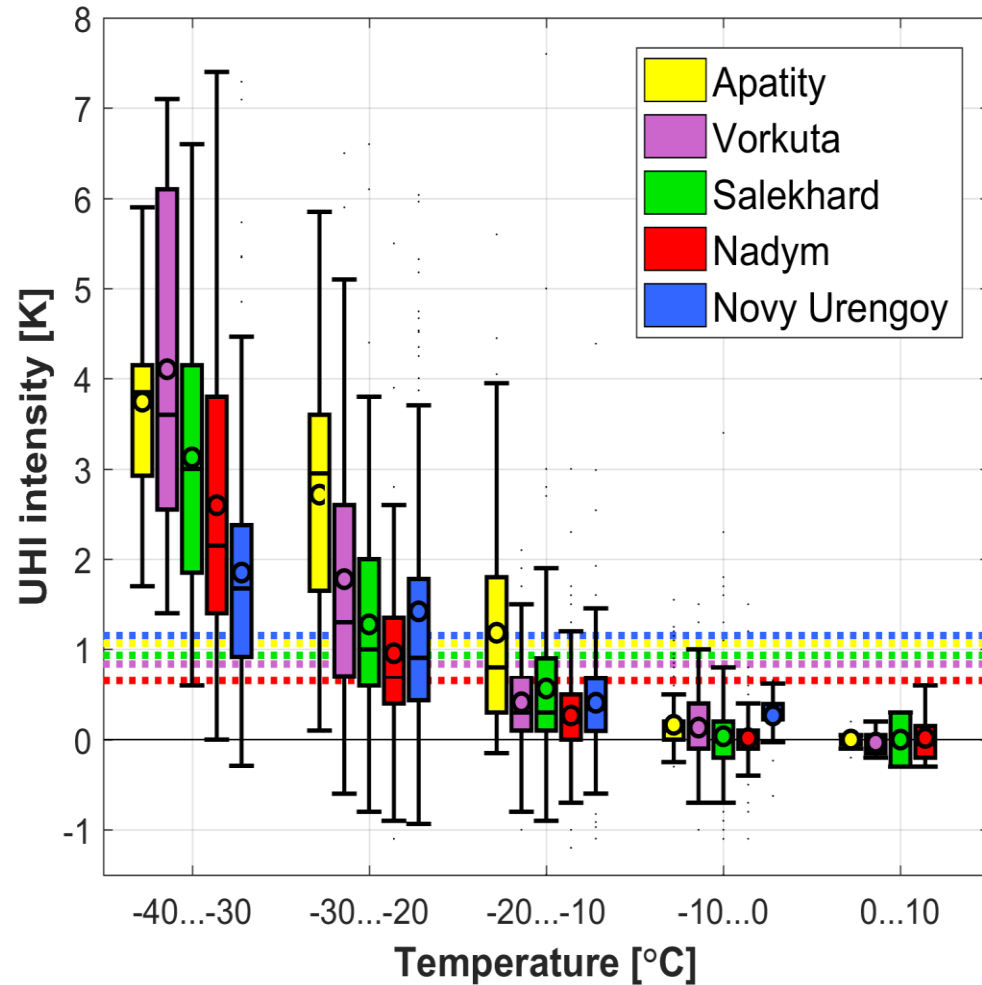
- In 6 cities (Apatity, Vorkuta, Nadym, Novy Urengoy, Murmansk, Norilsk)

A review of 4 cities is published in Konstantinov P, Varentsov M, Esau I, 2018, *Environmental Research Letters*, 13, doi: 10.1088/1748-9326/aacb84

The review of 11 high Arctic Siberian cities

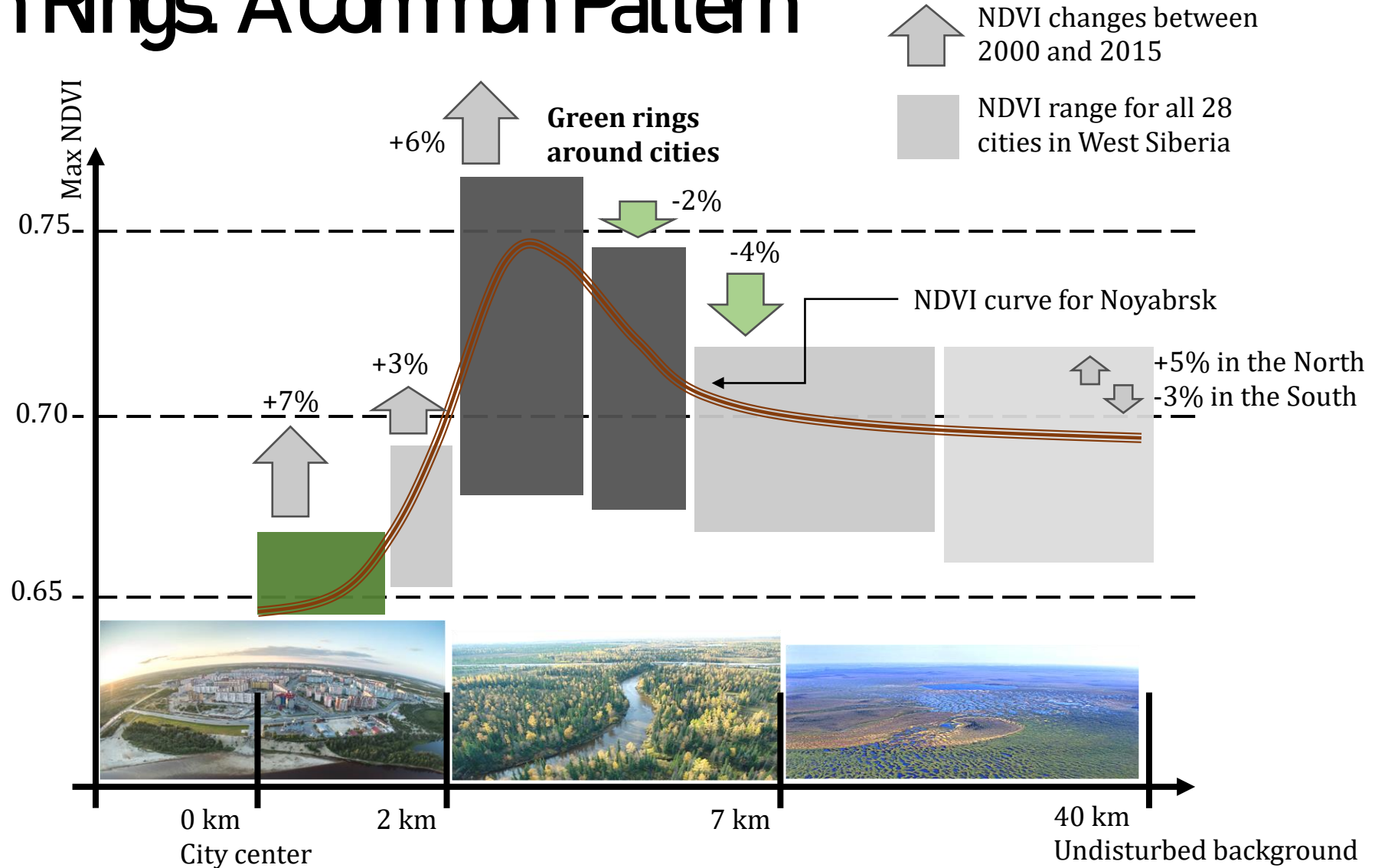
Esau I, Varentsov M, Laruelle M, Miles M.W., Konstantinov P, Soromotin A, Baklanov A. A. and Miles V. V., 2020: Warmer Climate of Arctic Cities, in the monography "The Arctic: Current Issues and Challenges", Pokrovsky O., et al. (Eds), NOVA Publishers, ISBN: 978-1-53617-306-2

Urban Heat Island in 11 High Arctic Cities

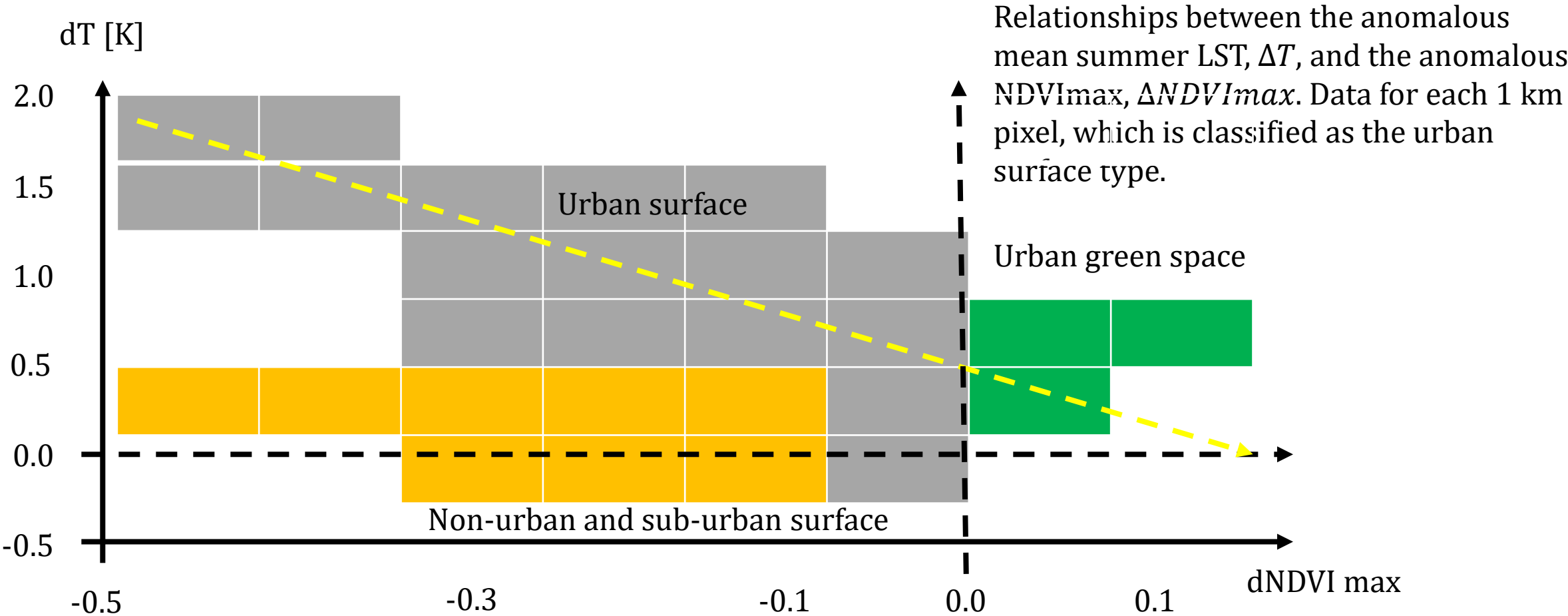


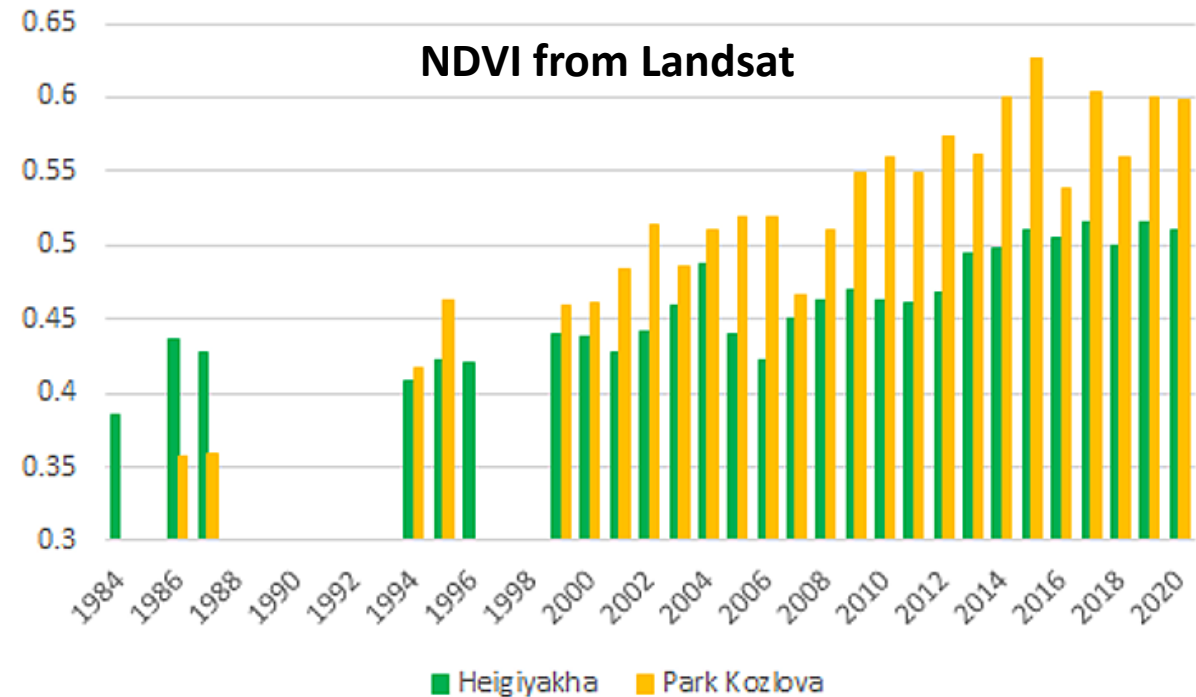
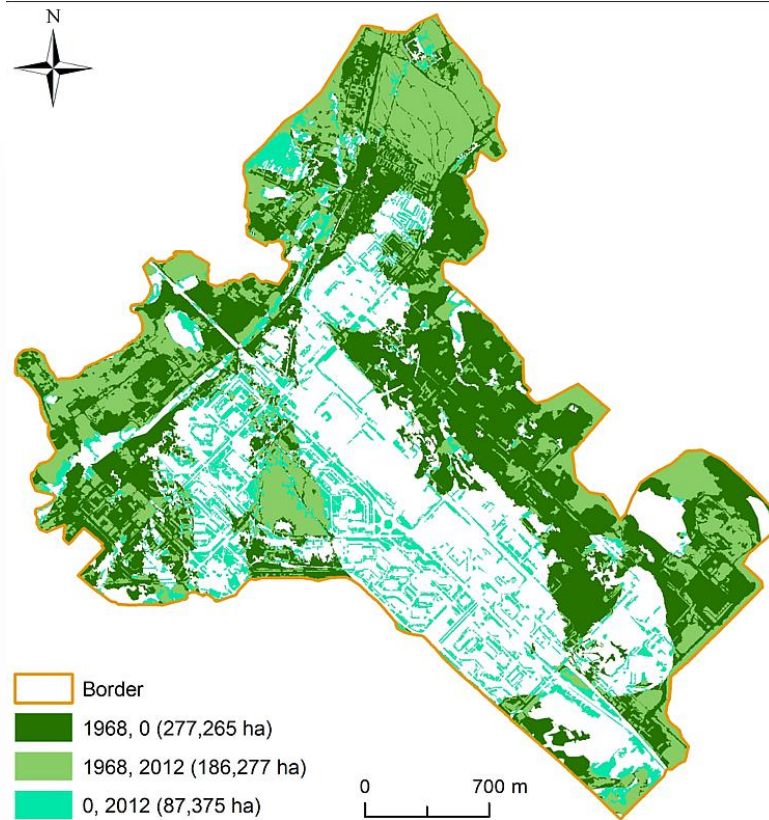
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Green Rings: A Common Pattern



Urban footprint and vegetation response





Зелёные пространства

Опрос субъективного мнения экспертов:

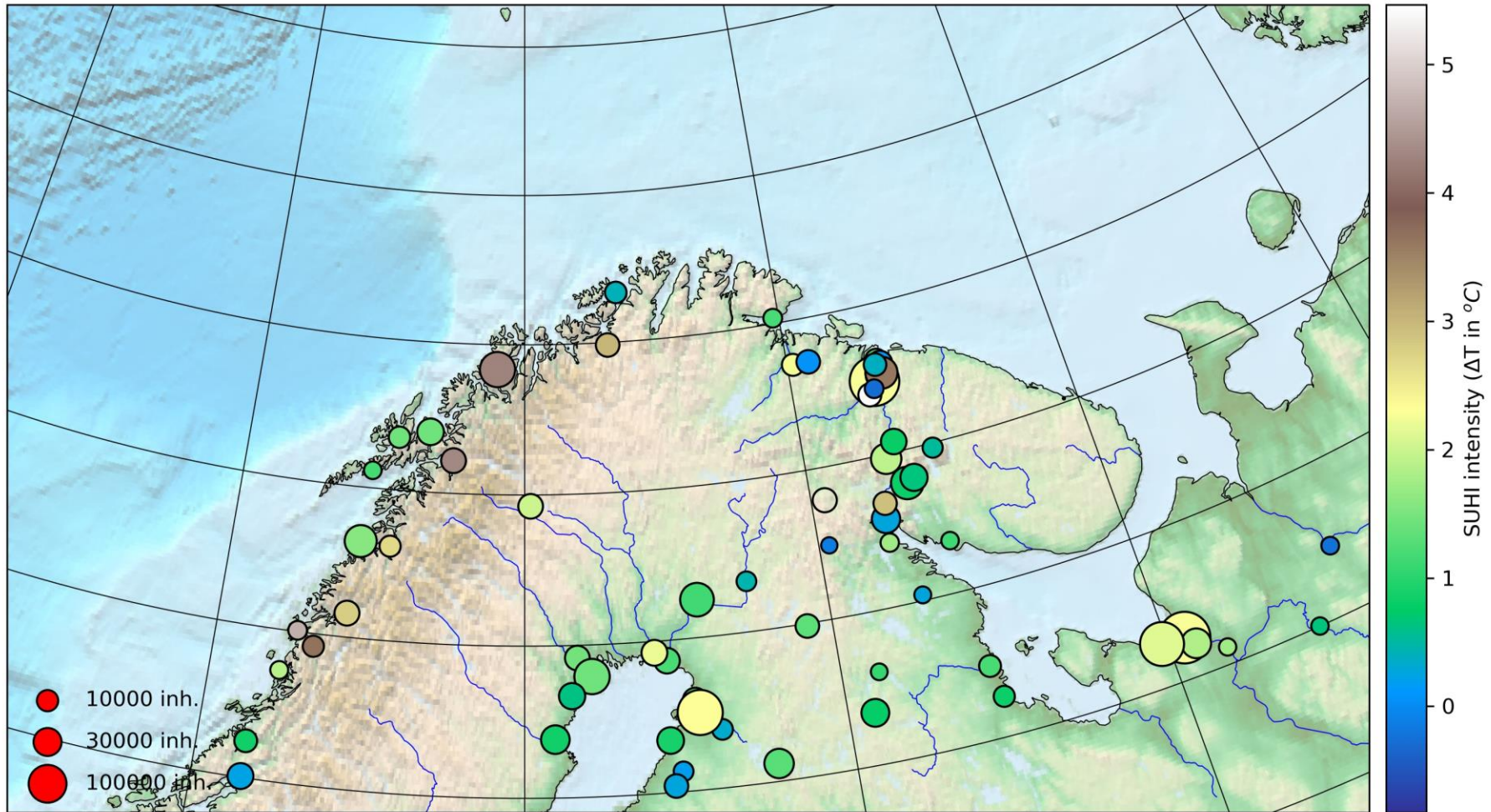
- Повышенное внимание к озеленению и поддержанию зелёных пространств
- Сохранение элементов природных ландшафтов

Анализ объективных параметров:

- Более быстрый рост биологической продуктивности и её более высокие значения в городской среде
- Расширение площади неспецифических экосистем

Противоречие: Культурная ценность городских зелёных пространств не соответствует их практической ценности (использование и очистка воздуха)

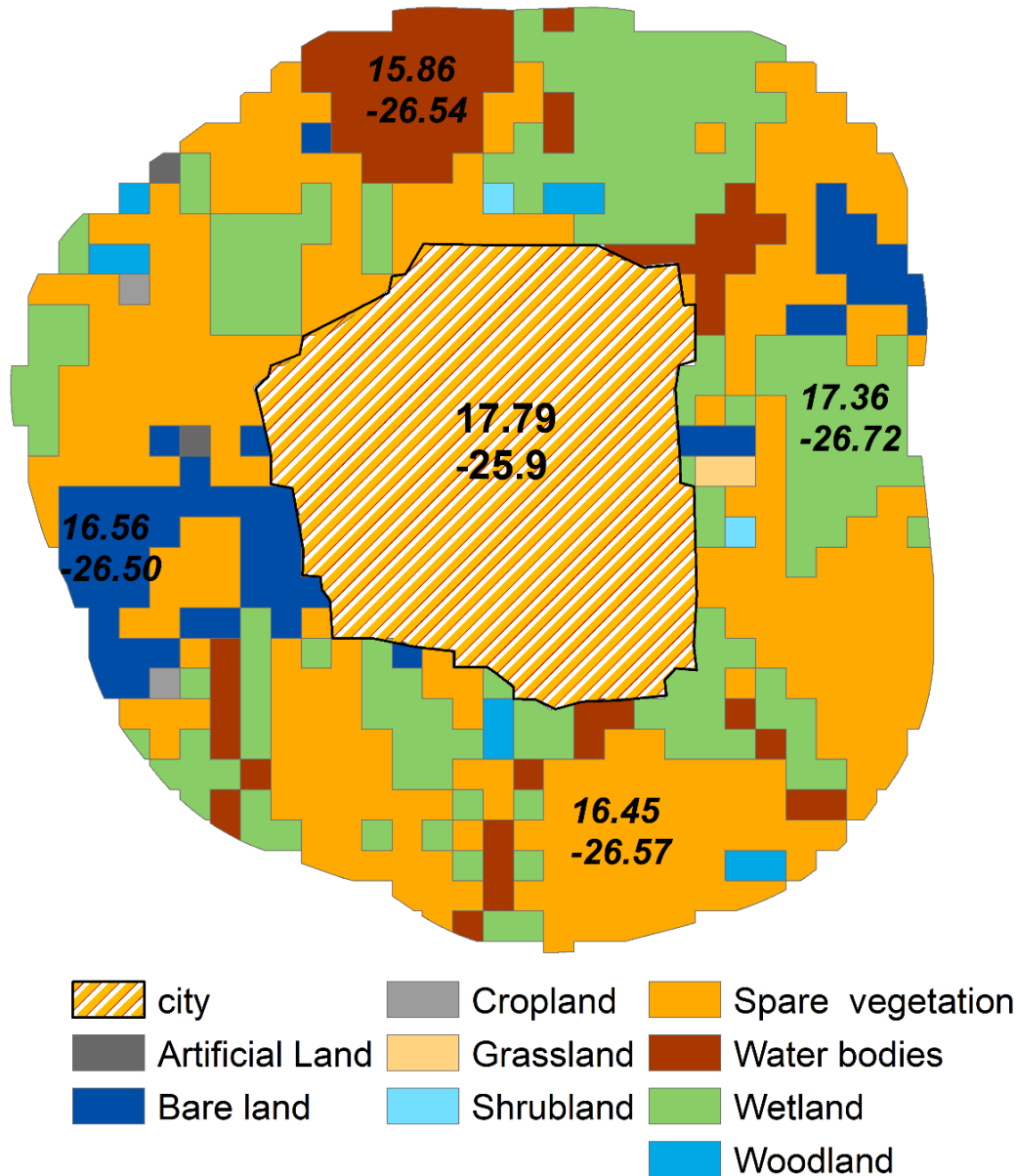
Urban Heat Islands



Exogenous LULC drivers: Example of Pokachy

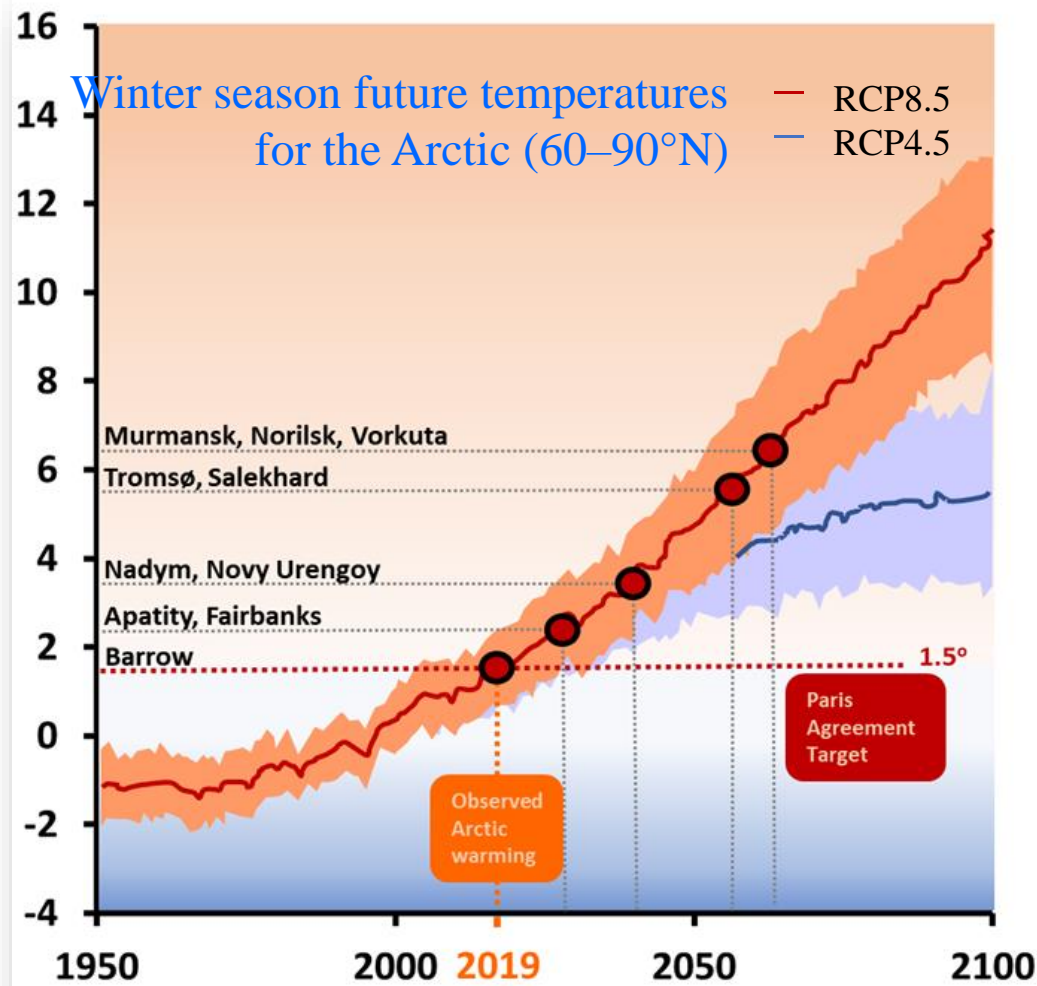
Example of the Pokachy city polygon and 2-km buffer polygon.

Urban pixels were allocated to the city polygon and surrounding land in a 2-km buffer was considered as rural. The buffer polygon combined different land cover (LC) polygons. The land cover was extracted from LC CCI raster and converted to polygons. LC CCI original classes were joined into 9 new classes. The numbers represent mean LST for different LC classes in the buffer. The upper numbers are summer LST and the lower numbers are winter LST.



Connecting Local and Global Scales:

Urban Arctic climate is a harbinger of future Arctic warming



«Swimming resort» in Norilsk – world`s northernmost large city
[69°20'N 88°13'E](#)



- 40% to 80% of infrastructure in the Arctic cities has been already damaged
- Soil bearing capacity has decreased by 30%

D. Streletsky and N. Shiklomanov (2016) in Earth's Cryosphere

Conclusions

- Northern cities reveal large UHI (SUHI)
 - Related to the heat trapping in stably-stratified PBL
- Temporal and spatial patterns are diverse
- Northern UHIs might have a pronounced socio-environmental impact

Driving/scaling factors:

Population is the most important

City area and density are less influential

Counterintuitive – Urban green spaces induce warming (not cooling) effects – subject of studies in the Belmont Forum project SERUS (Nansen Center in Norway, George Washington University in USA, Tyumen State University in Russia)

The role of local green space and small-scale relief in cold climate cities: Khanty-Mansiysk

«Green and Blue Urban Infrastructure Innovation for Northern Eurasia», 19.04 - 20.04, St. Petersburg

