Urban scale measurements

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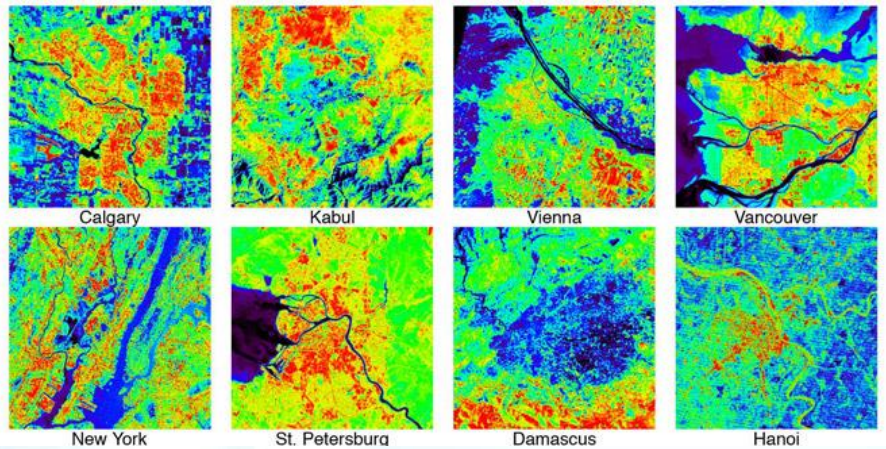
Moscow State University, Research Computing Center & Faculty of Geography

**mikhail.varentsov@srcc.msu.ru*

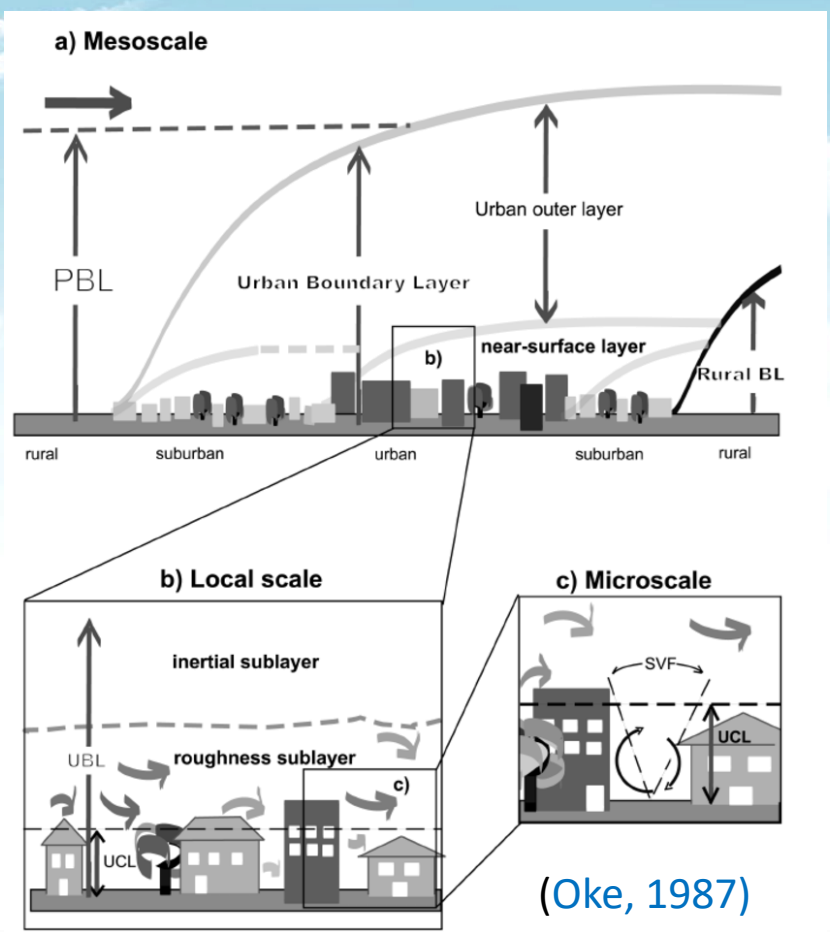
Challenges of urban climatology

Spatial heterogeneity



Variety of urban forms and land cover types

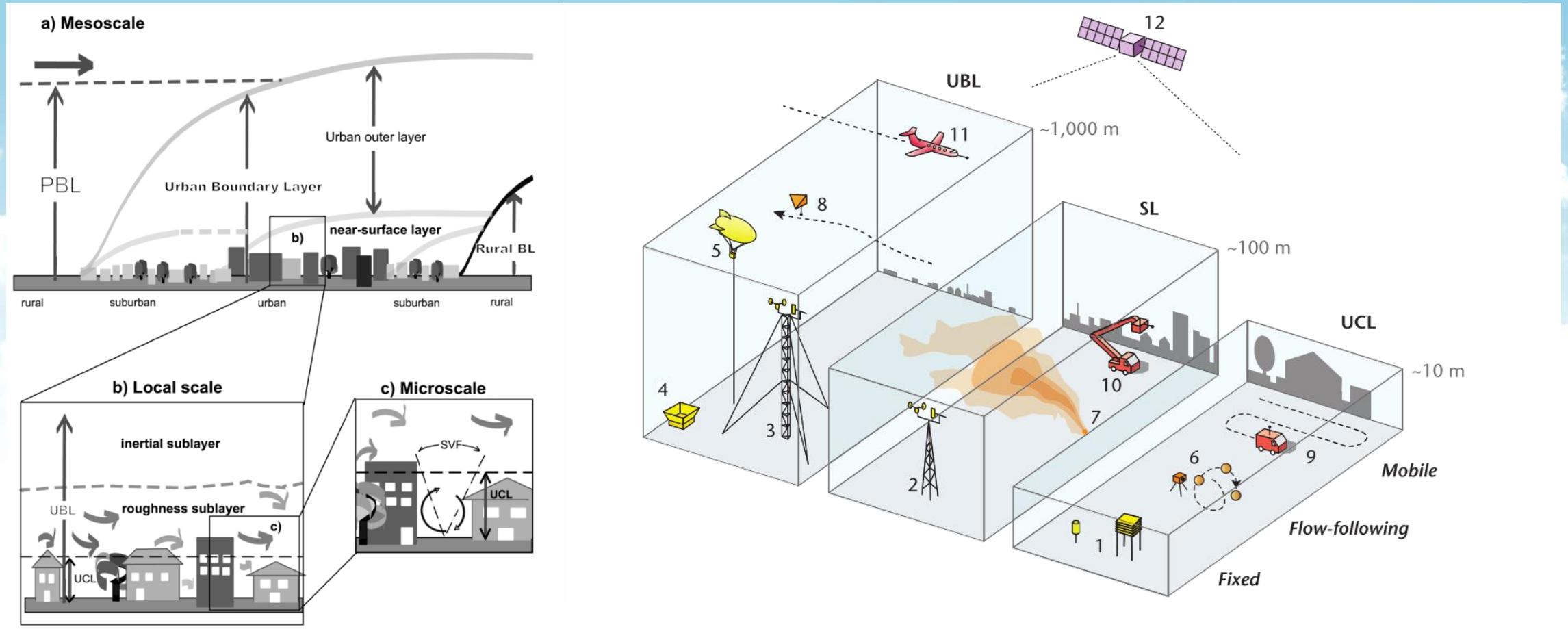
Complexity of scales



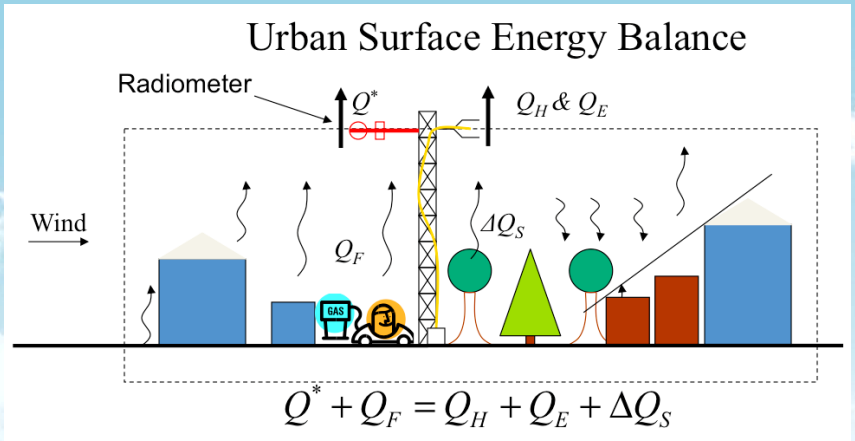
(Oke, 1987)

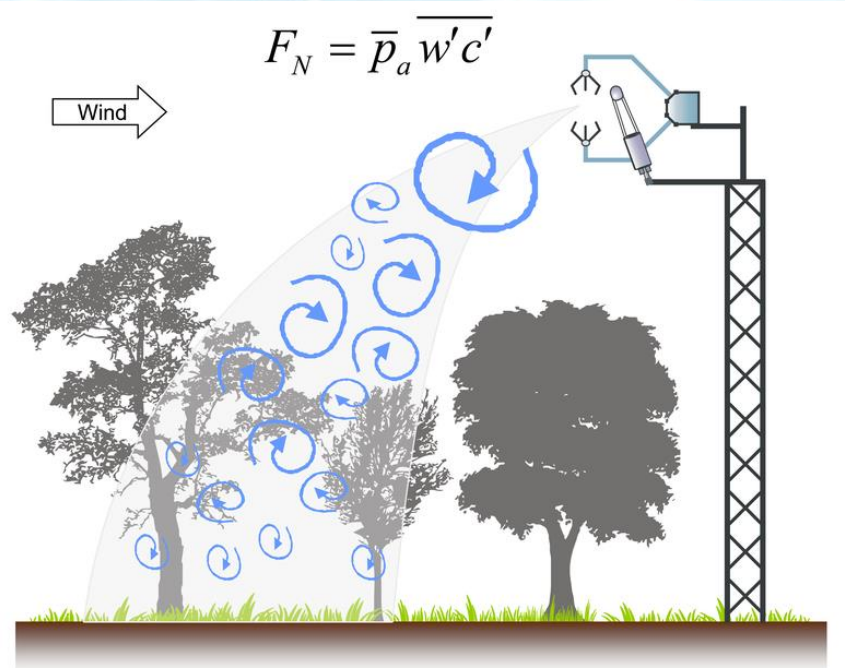
Lack of observational data

Variety of scales and measurements

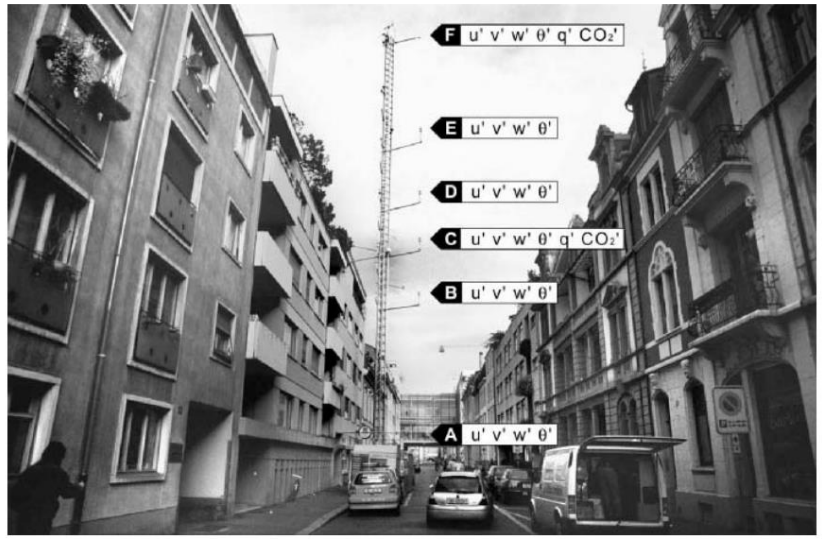


Urban flux measurements





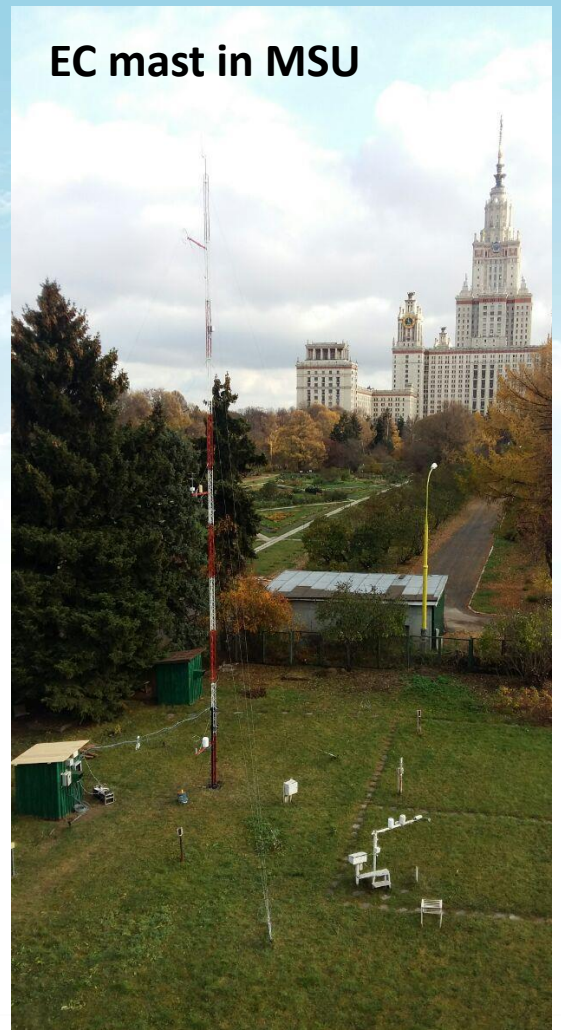
- To understand, what's going with microclimate, we need to know energy fluxes between the surface and atmosphere, including the turbulent fluxes
- Basic theories of atmospheric turbulence (e.g. Monin-Obukhov theory) have strong limitations for heterogeneous urban areas)
- **Eddy covariance method** allows to measure heat, moisture and other fluxes through high-frequent (20 Hz) observations of wind speed, temperature, etc.
- Such measurements are needed both inside and above urban canopy, so we need high and expensive masts

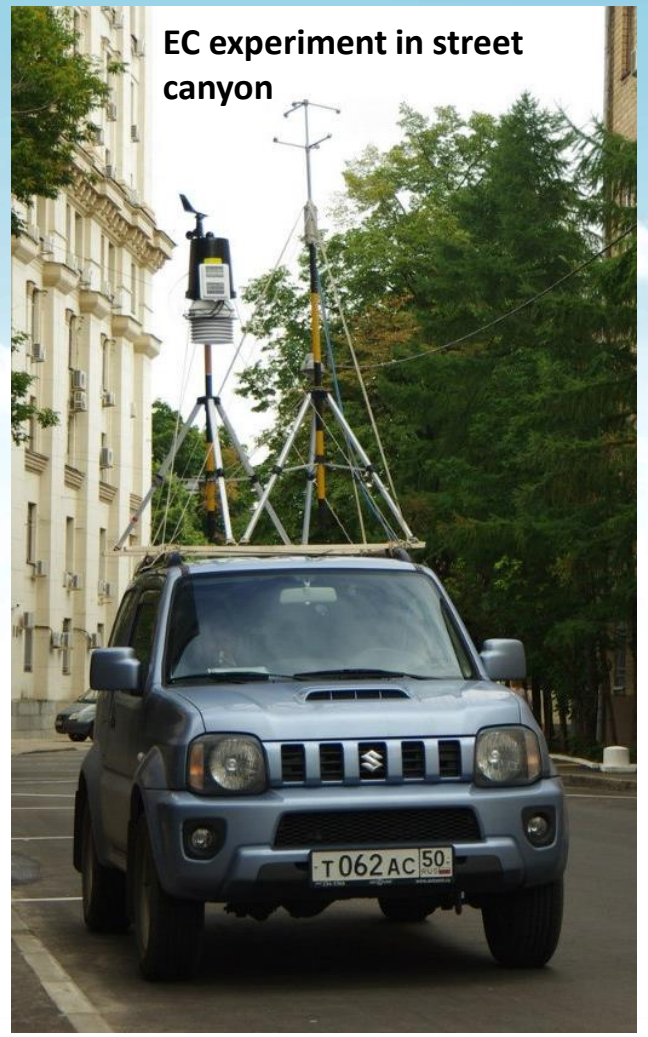


Urban Boundary Layer Measurements in Basel (BUBBLE, Rotach et al., 2005)

Urban flux measurements


EC equipment in field cross-validation tests

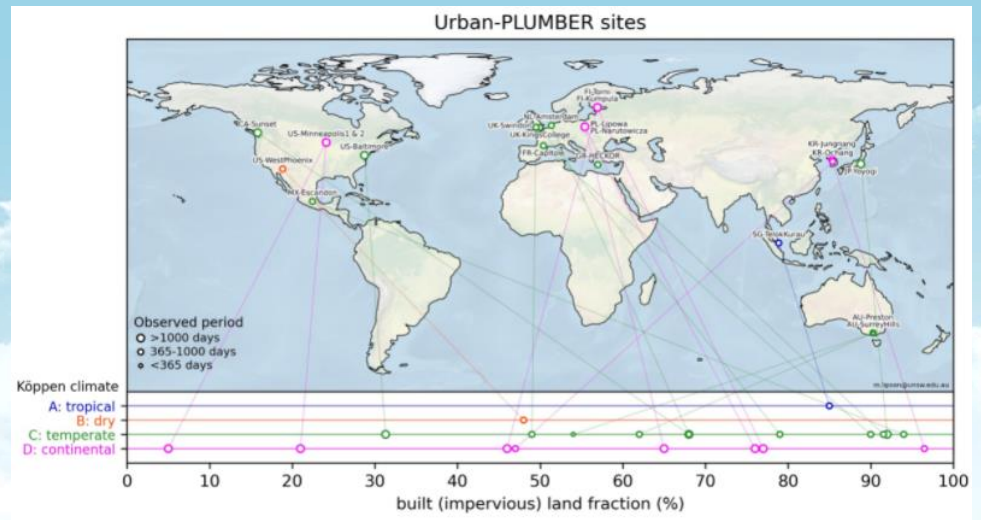

EC mast in MSU

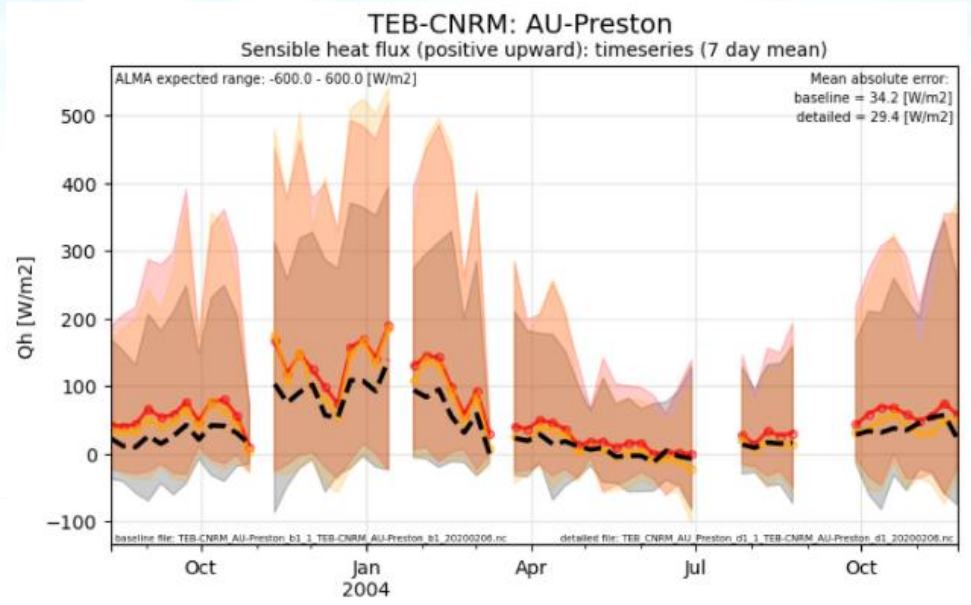


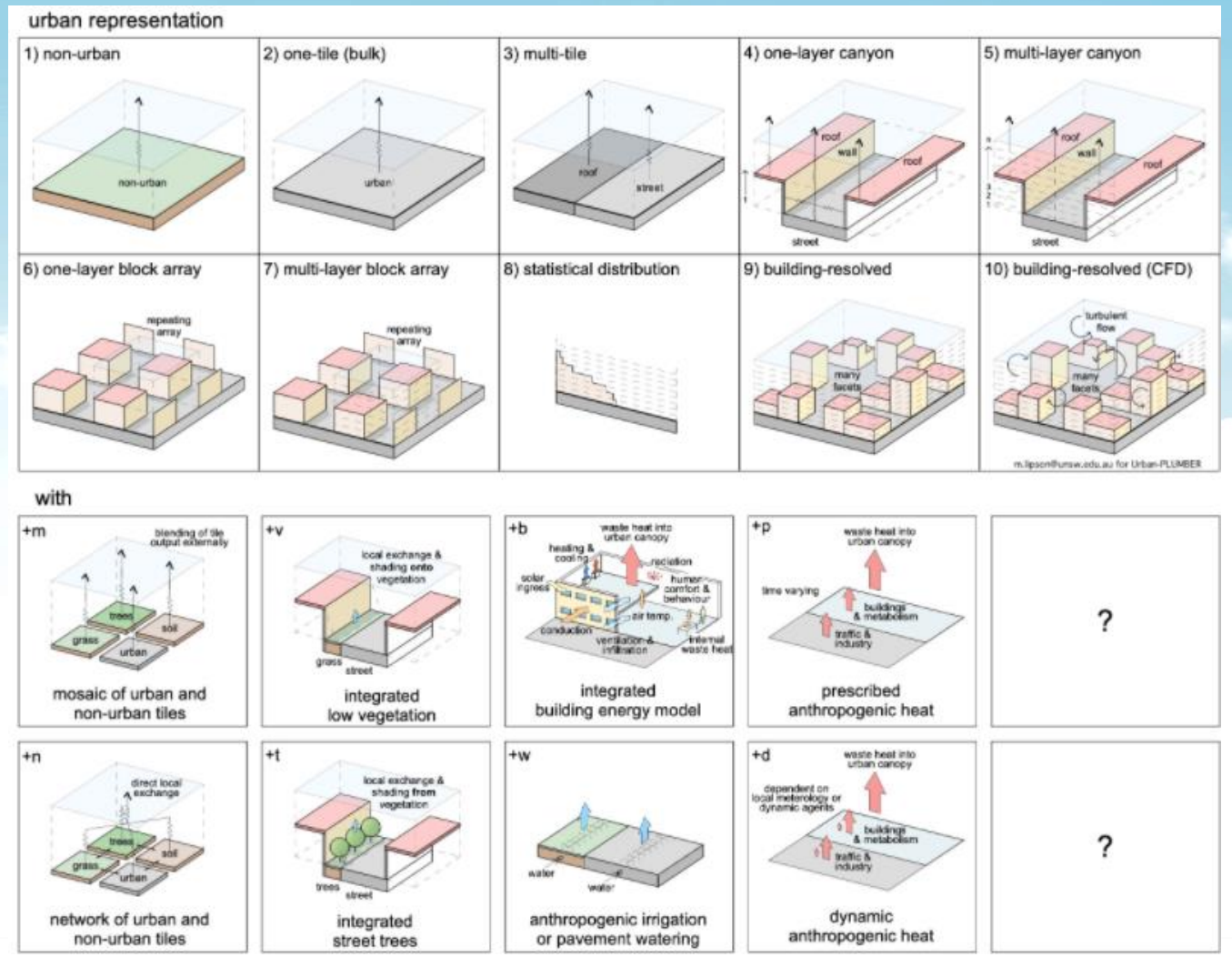
EC experiment in street canyon


SMEAR III urban mast in Helsinki, Finland

Flux data for model development

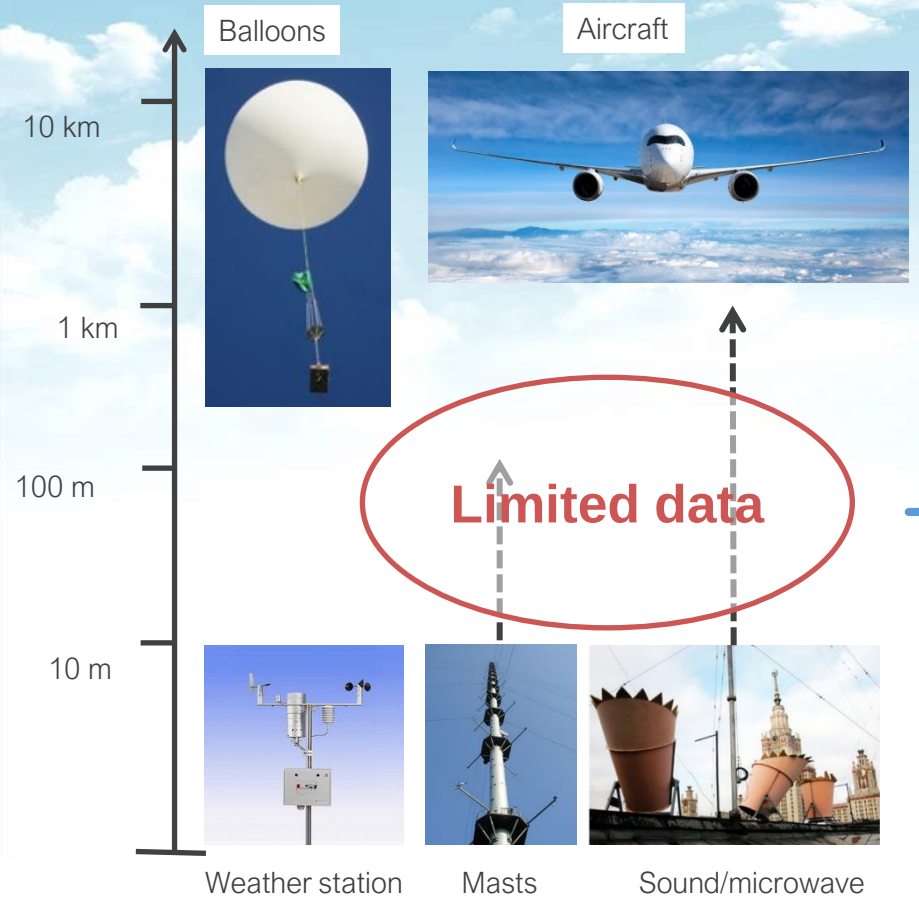


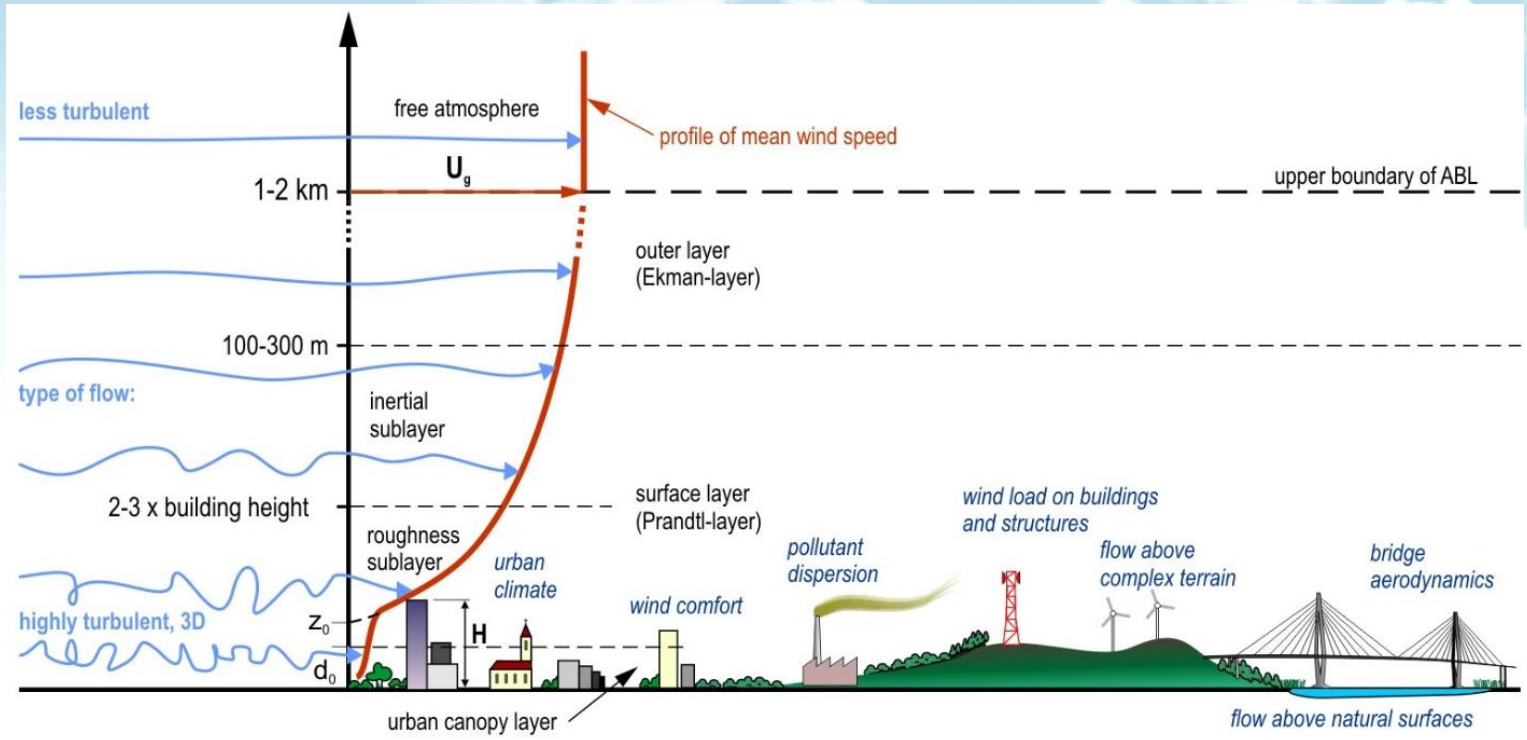




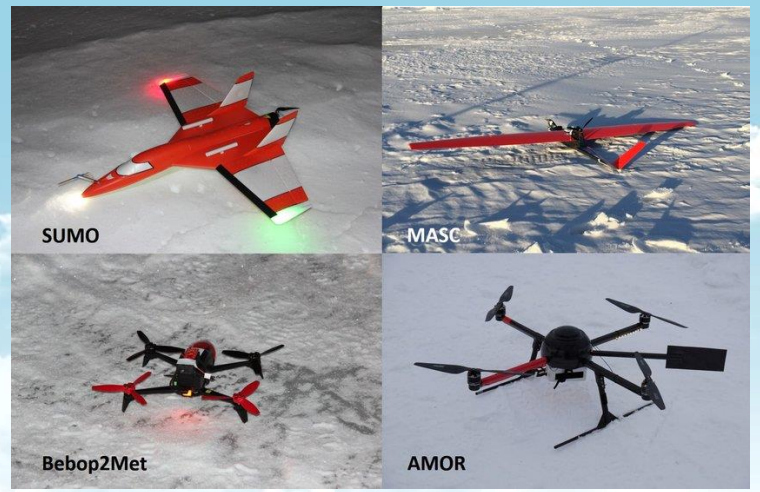
Boundary layer measurements

Lack of the data above the “roof level”





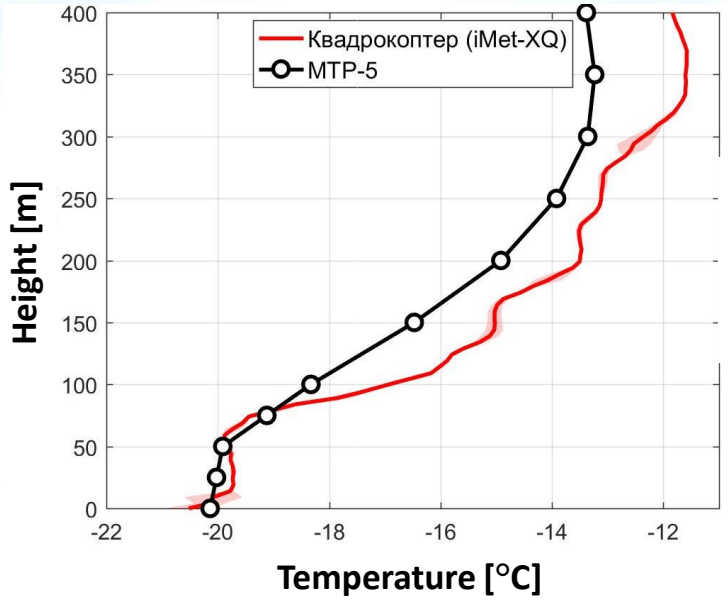
New age of ABL studies with drones

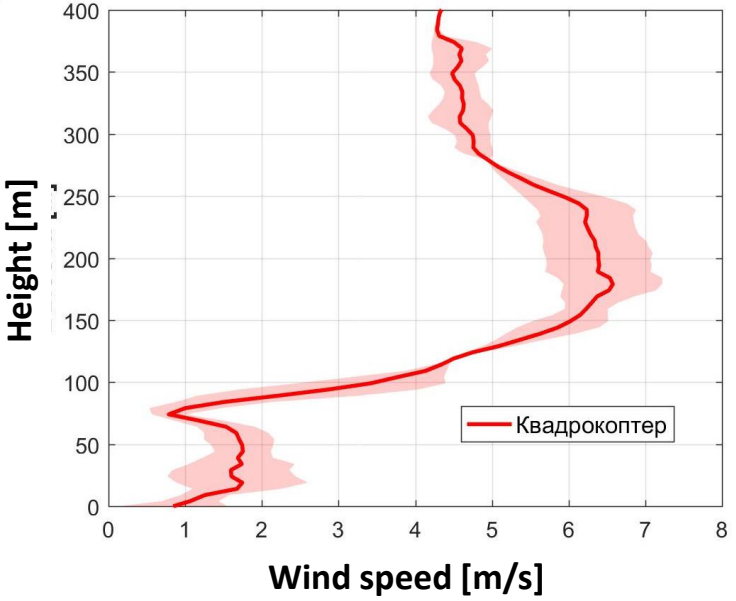


CopterSonde (Segales et al., 2020)

Meteodrone
(www.meteomatics.com)

Measurements with mass-market DJI drones
by MSU and IAP team





New age of ABL studies with drones

meteomatics

	Meteodrone SSE	Meteodrone MM-670	Meteodrone MM-670 ML
Number of engines	6	6	6
Take-off weight	ca. 1.1 kg	ca. 4.9 kg	ca. 5.0 kg
Dimensions	40 x 40 cm	70 x 70 cm	70 x 70 cm
Max. climb rate	10 m/s	10 m/s	10 m/s
Max. wind speed	100 km/h	92 km/h (50 knts)	92 km/h (50 knts)
Max. flight altitude*	1'500 m	6'000 m AMSL (20'000 ft)	6'000 m AMSL (20'000 ft)
Max. flight duration	ca. 12 min	ca. 30 min	ca. 30 min
Measured parameters:			
- Sample rate	250 ms	250 ms	250 ms
- Temperature	✓	✓	✓
- Wind speed	✓	✓	✓
- Wind direction	✓	✓	✓
- Dew point	✓	✓	✓
- Air pressure	✓	✓	✓
Optional parameters:			
- Particular matter/ black carbon	✗	✓	✓
- Ozone	✗	✓	✓
- Radioactivity	✗	✓	✓

MeteoBase – a remote platform

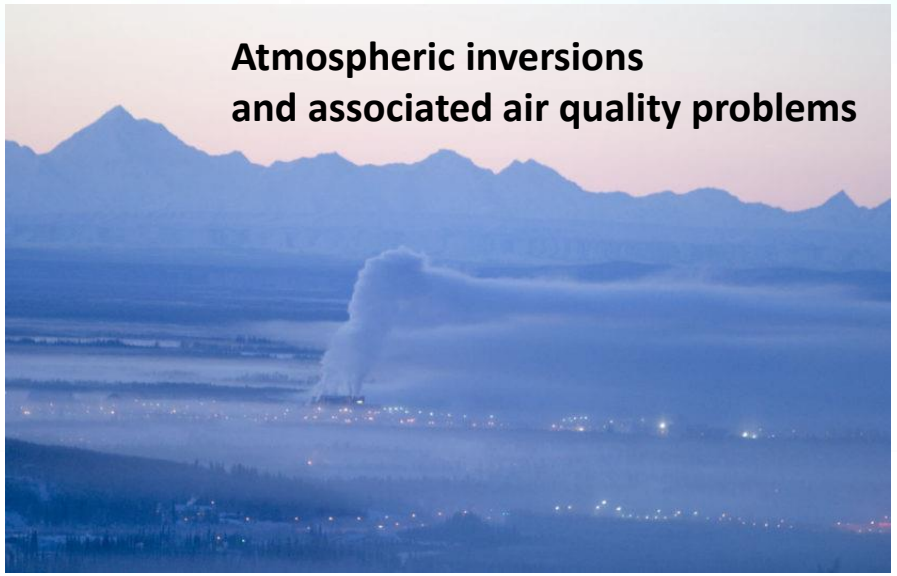
Our flight operations center

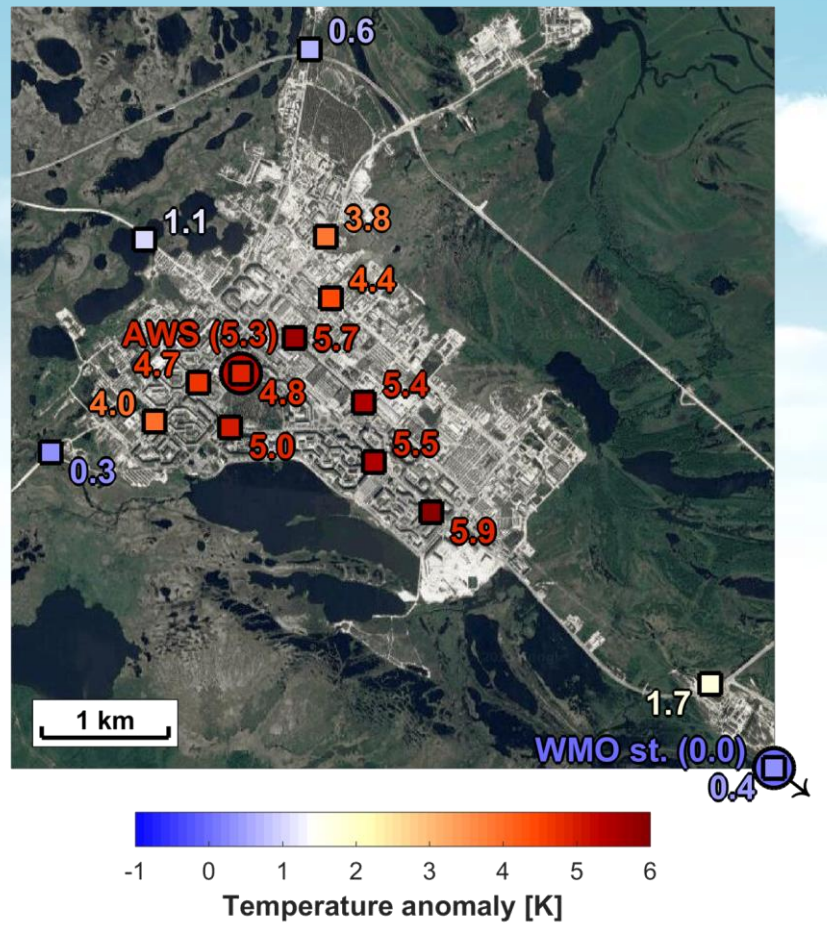
https://www.meteomatics.com/

UBL studies in Arctic cities

Lack of urban climate studies in high latitudes

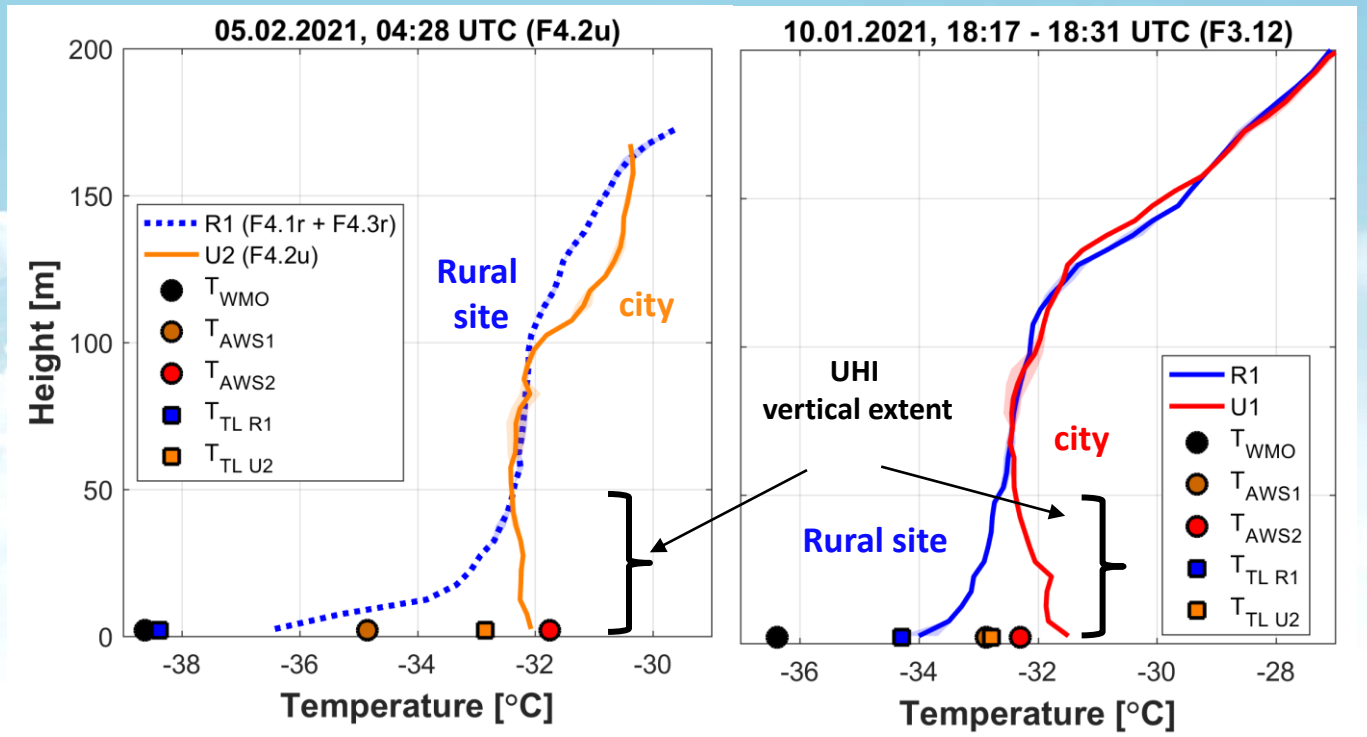
(UCCRN, 2018)

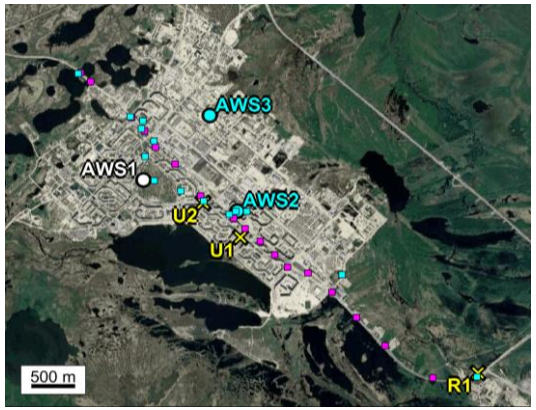




Urban heat island in Nadym (Siberia) according to ground-based measurements (Konstantinov et al., 2018)

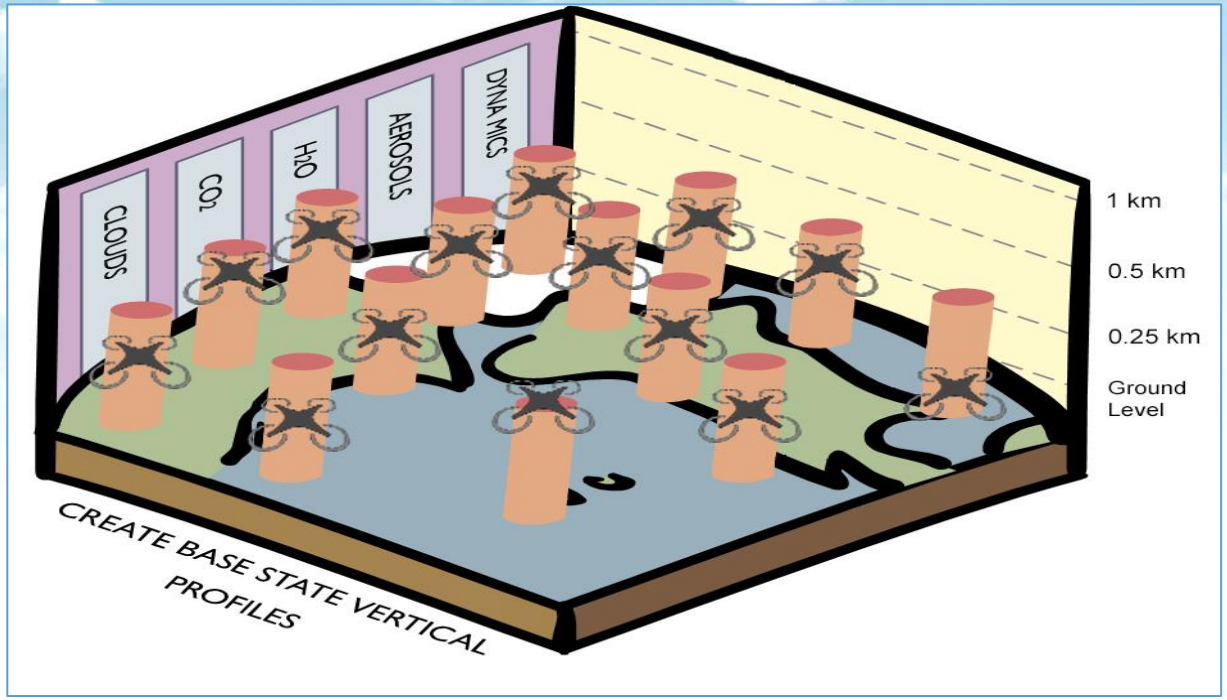
UBL studies in Arctic cities



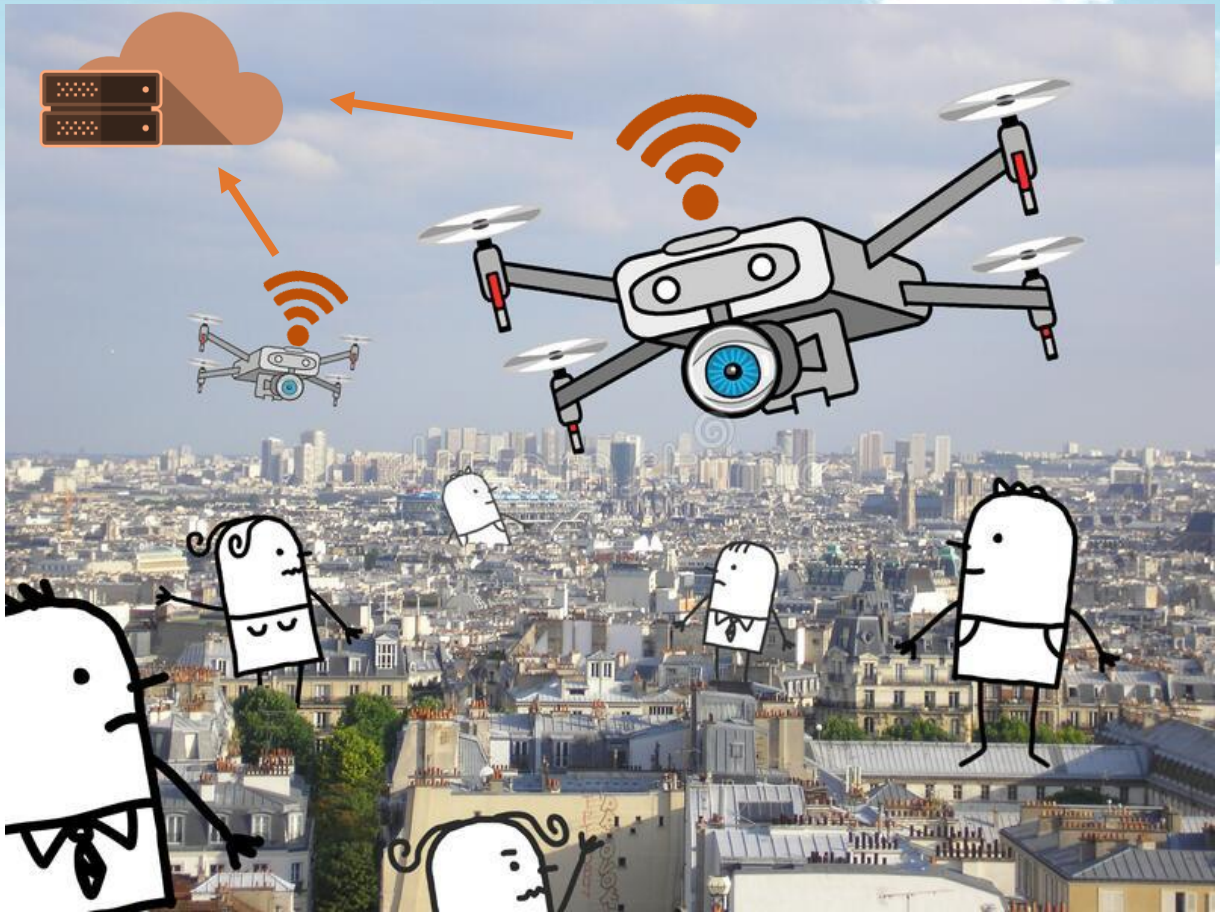


Dreams about the future

Drone-based 3D networks



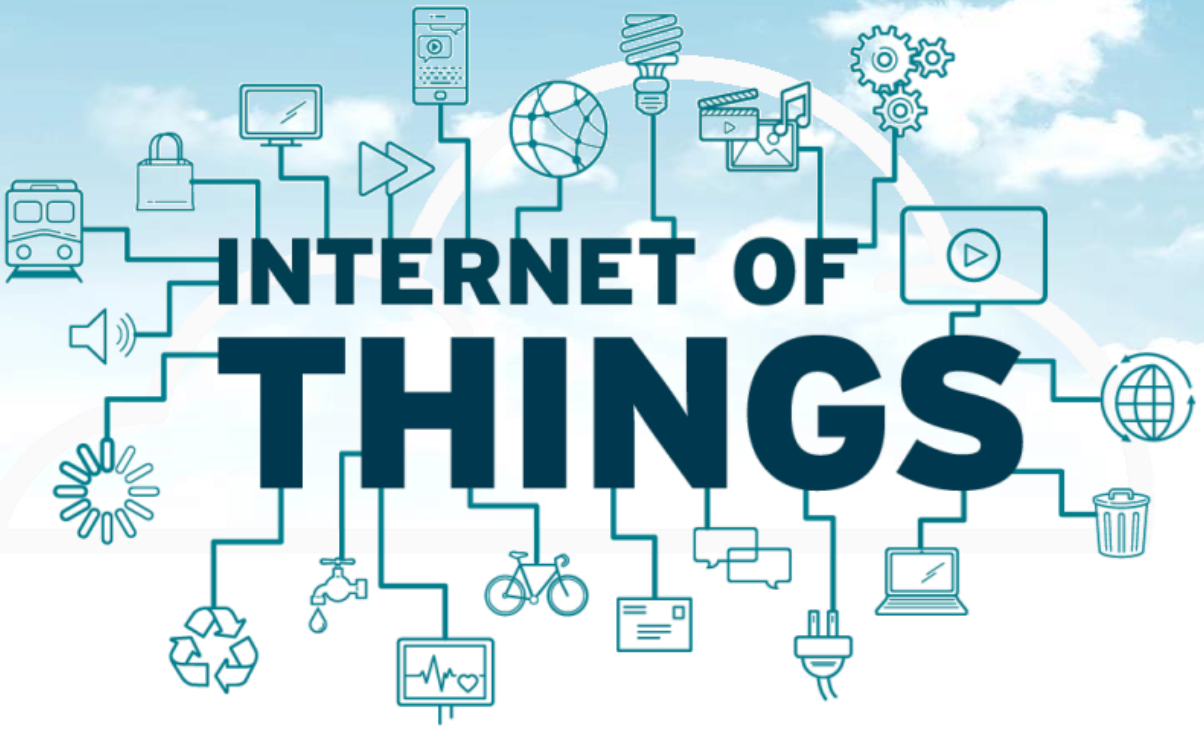
Passing measurements from drones (like AMDAR from commercial planes)



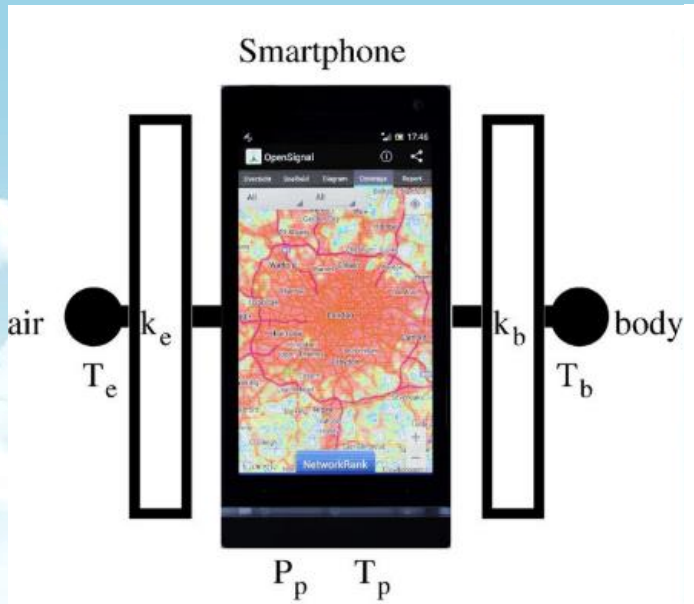
Non-traditional data sources

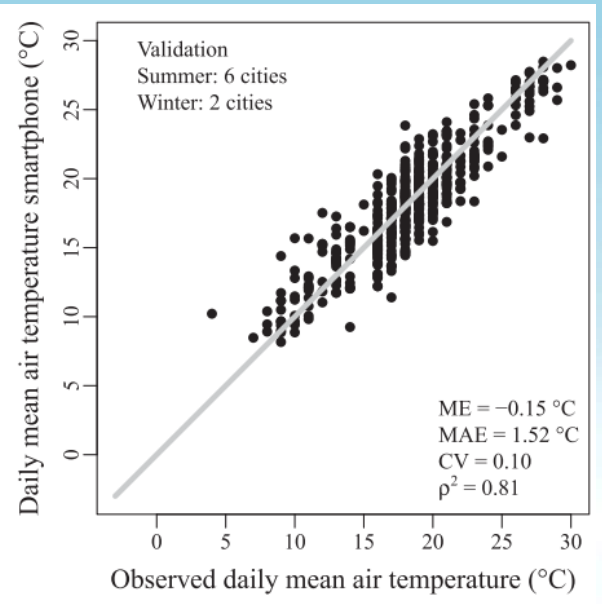
Crowdsourcing

IoT



Smartphones and wearables





The Potential of a Smartphone as an Urban Weather Station—An Exploratory Analysis

Aly Noyola Cabrera[1], Arjan Droste[1,2], Bert G. Heusinkveld[1] and Gert-Jan Steeneveld[1]*

[1]Meteorology and Air Quality Section, Wageningen University, Wageningen, Netherlands, [2]Hydrology and Quantitative Water Management Group, Wageningen University, Wageningen, Netherlands

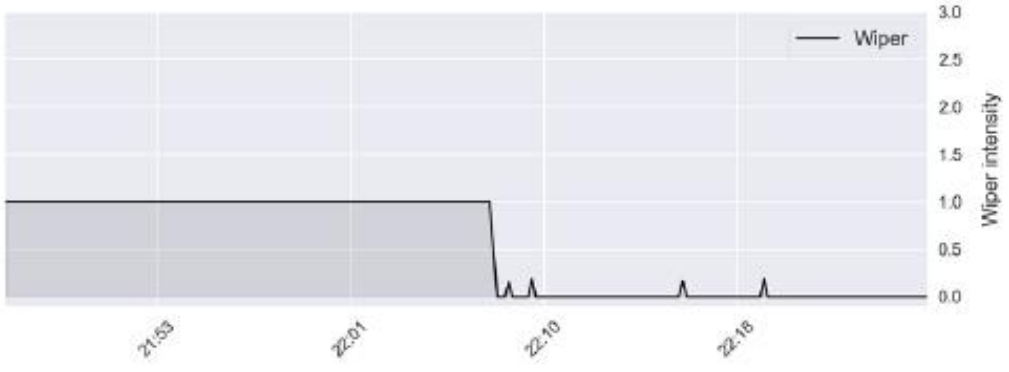
Crowdsourcing urban air temperatures from smartphone battery temperatures

A. Overeem,[1,2] J. C. R. Robinson,[3] H. Leijnse,[2] G. J. Steeneveld,[4] B. K. P. Horn,[5] and R. Uijlenhoet[1]

Project Coolbit: can your watch predict heat stress and thermal comfort sensation?

Negin Nazarian[1,2,15,*], Sijie Liu[1,2], Manon Kohler[3,4], Jason K W Lee[5,6,7,8,9], Clayton Miller[3], Winston T L Chow[4], Sharifah Badriyah Alhadad[9,14], Alberto Martilli[13], Matias Quintana[3], Lindsey Sunden[10] and Leslie K Norford[11,12]

Smart cars ~~and cats~~

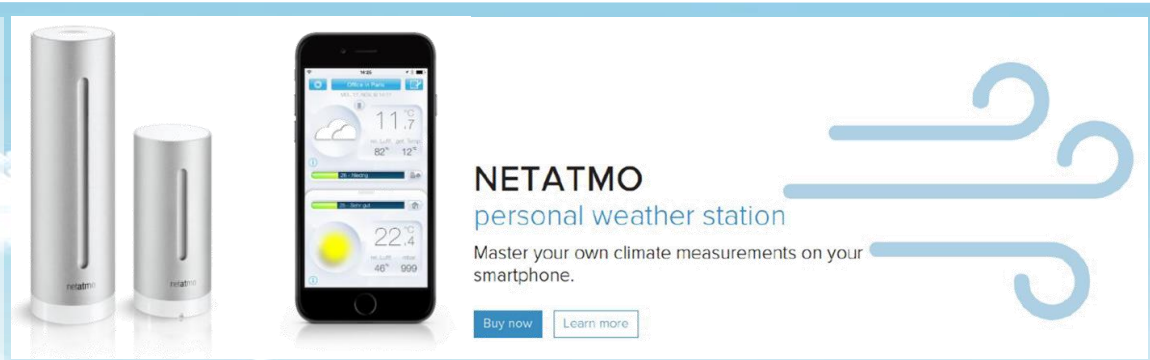


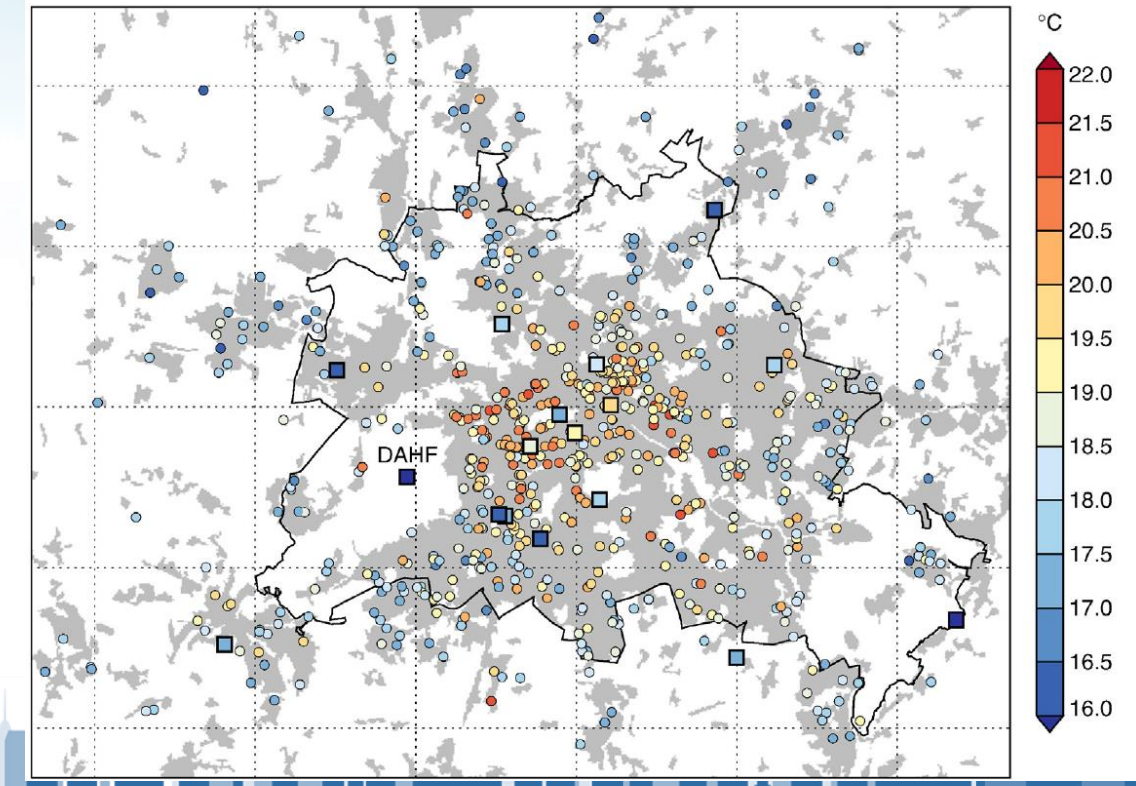
Windshield wipers on connected vehicles produce high-accuracy rainfall maps

Matthew Bartos[1], Hyongju Park[2], Tian Zhou[2], Branko Kerkez[1] & Ramanarayan Vasudevan[2]

Citizen weather stations (CWSs)

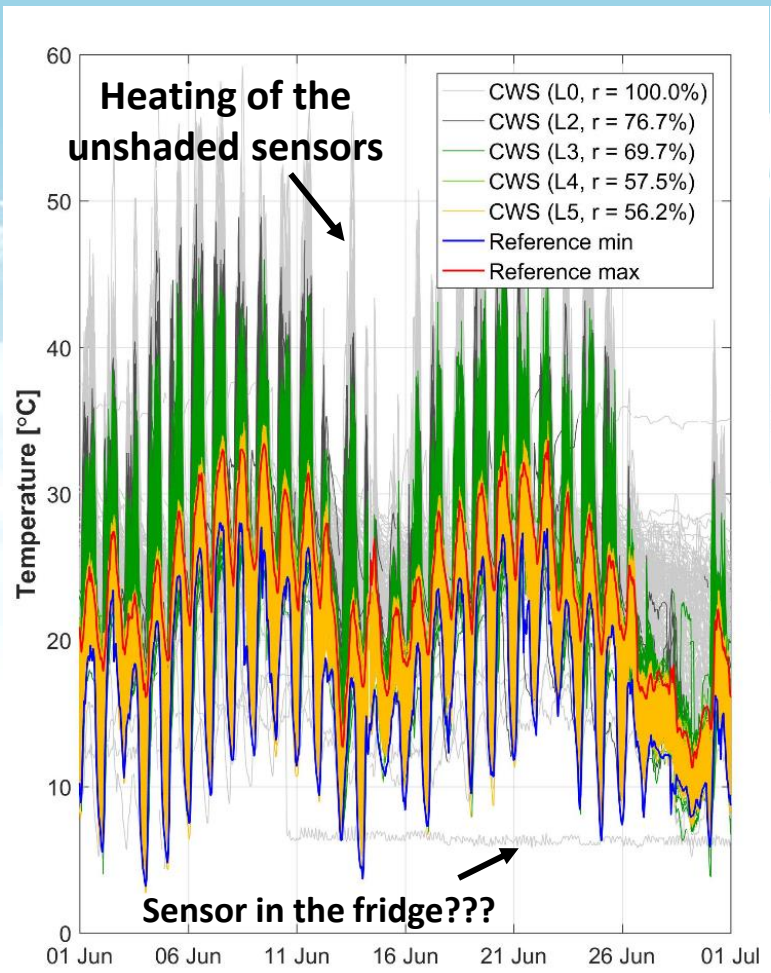
- **Citizen weather stations are becoming popular IoT gadgets**
- **The world's largest network Netatmo (www.netatmo.com)**
- **Data is used for urban climate studies** (Chapman et al., 2017; Fenner et al., 2017; Meier et al., 2017) **and weather forecast improvement** (Nippen et al., 2020)

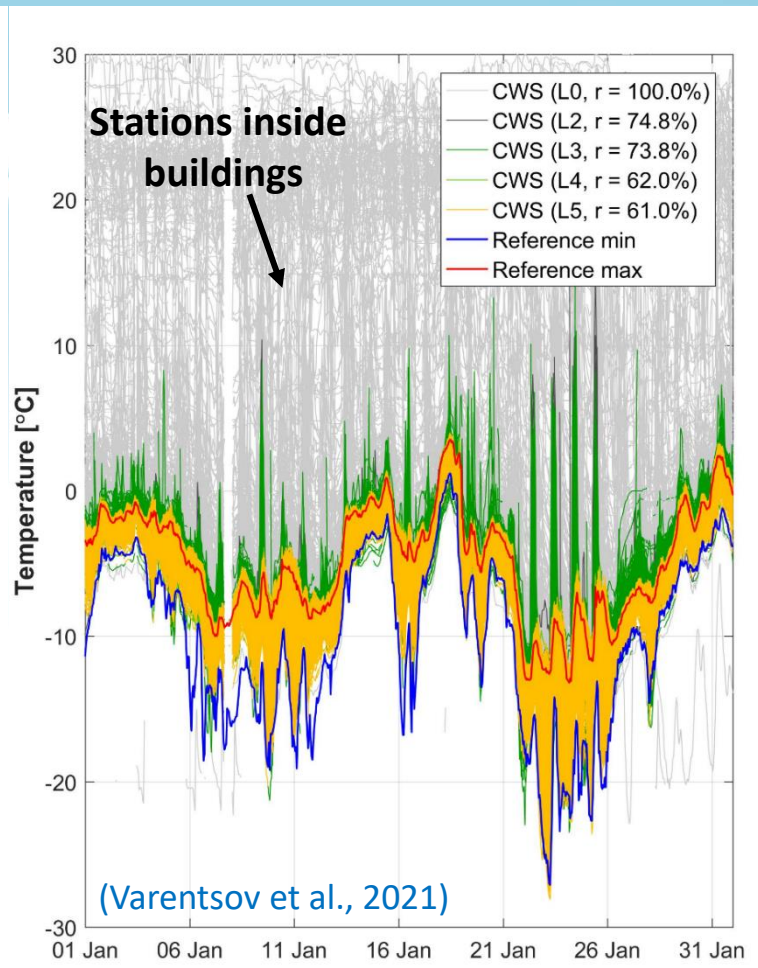


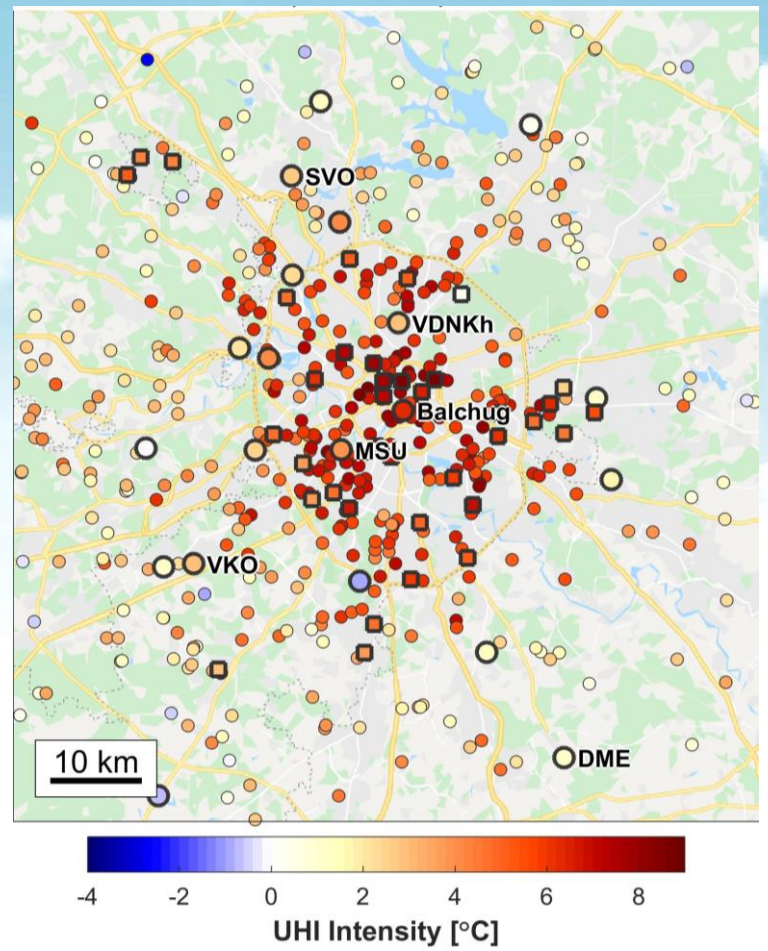


City	# CWS June 2018
Basel	940
Berlin	2100
Bern	650
Gothenburg	410
Hamburg	1190
Lisbon	150
London	830
Moscow	730
Paris	6380
Toulouse	720
Stuttgart	840
Atlanta	90
New York City	210
Phoenix	160
Santiago de Chile	130
Vancouver	150
Seoul	20

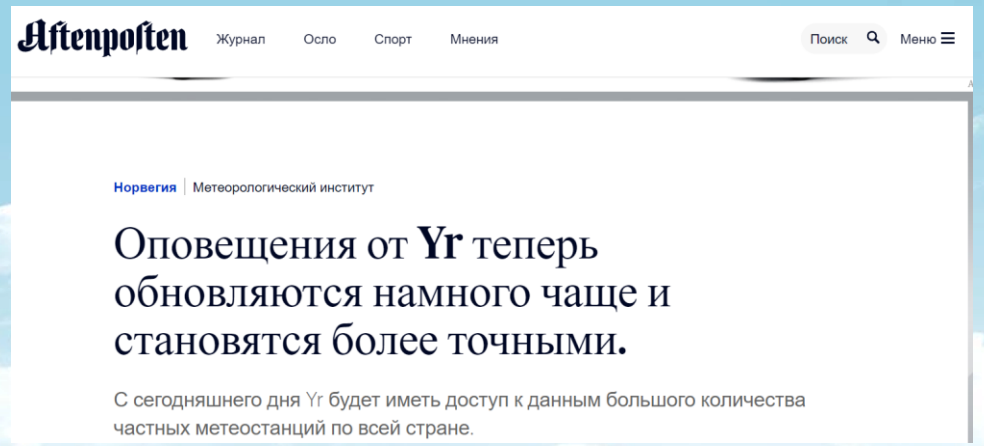
Citizen weather stations (CWSs)

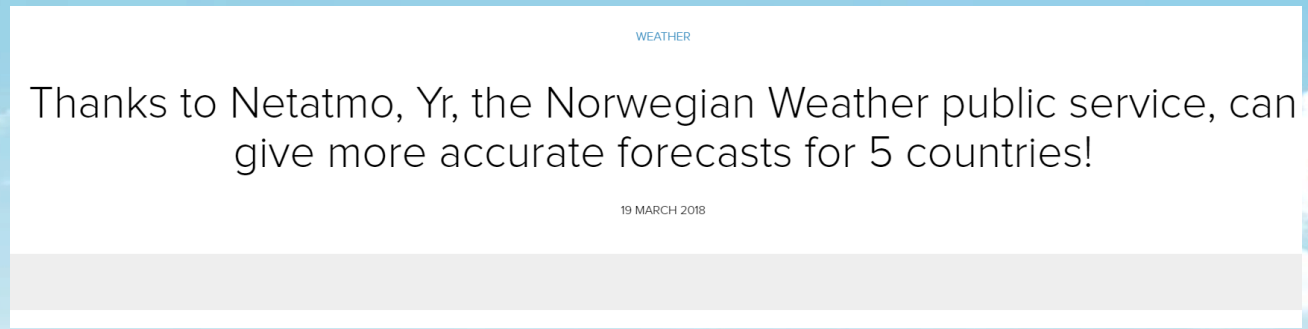


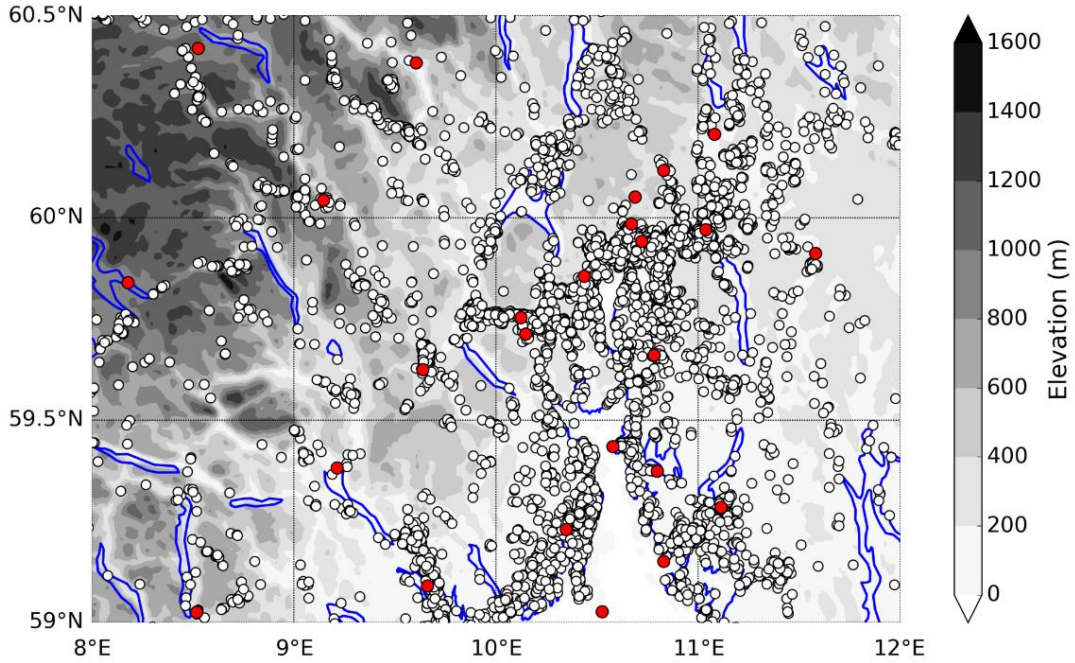


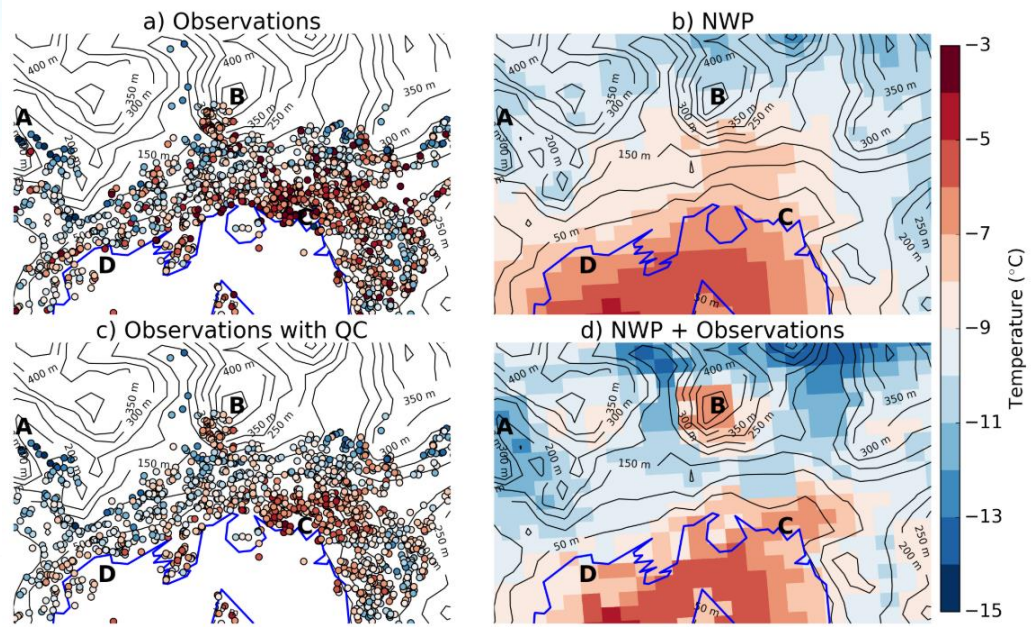


CWSs for better weather forecasts



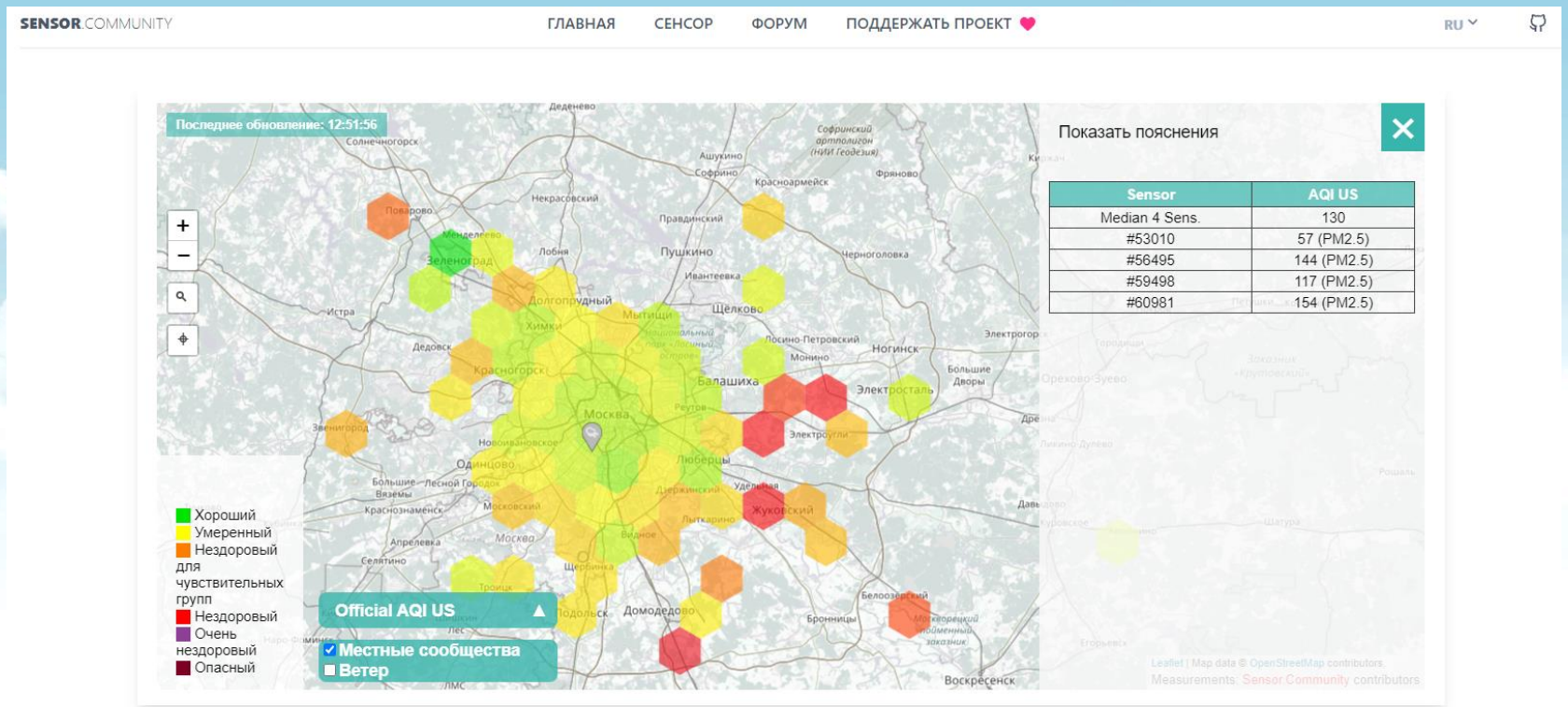






(Nipen et al., 2020)

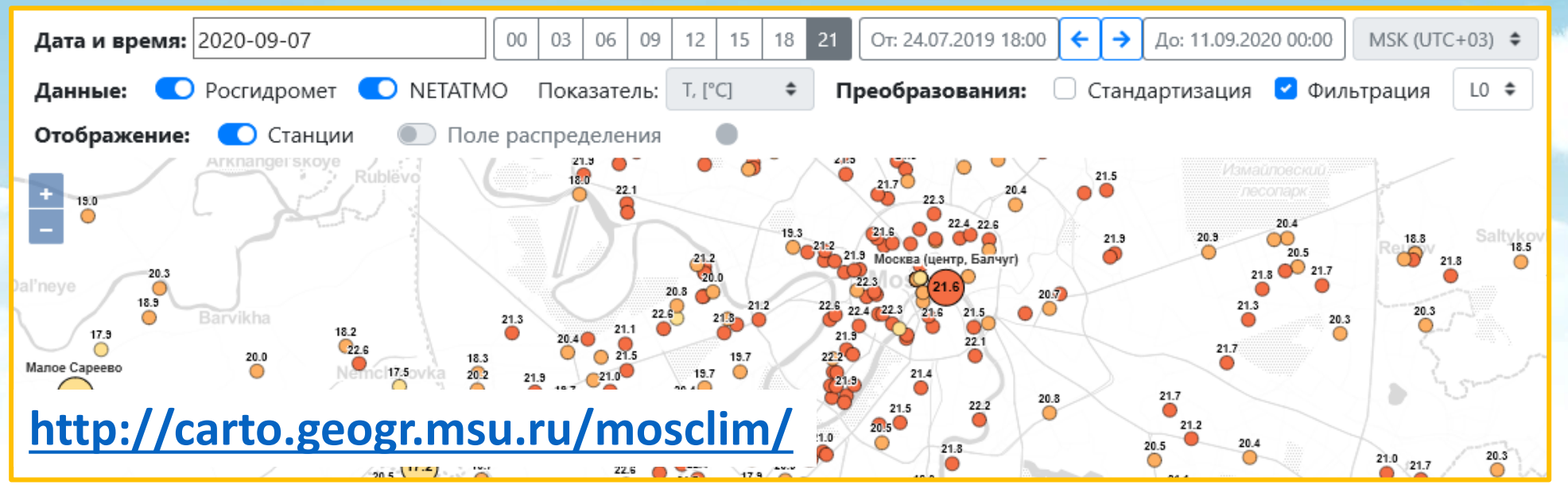
Citizen air quality monitoring



Sensor.Community это всемирная сеть сенсоров
информация с которых доступна в виде открытых данные
об окружающей среде.

Breathe.Moscow & Sensor.Community

CWS data for urban climate services

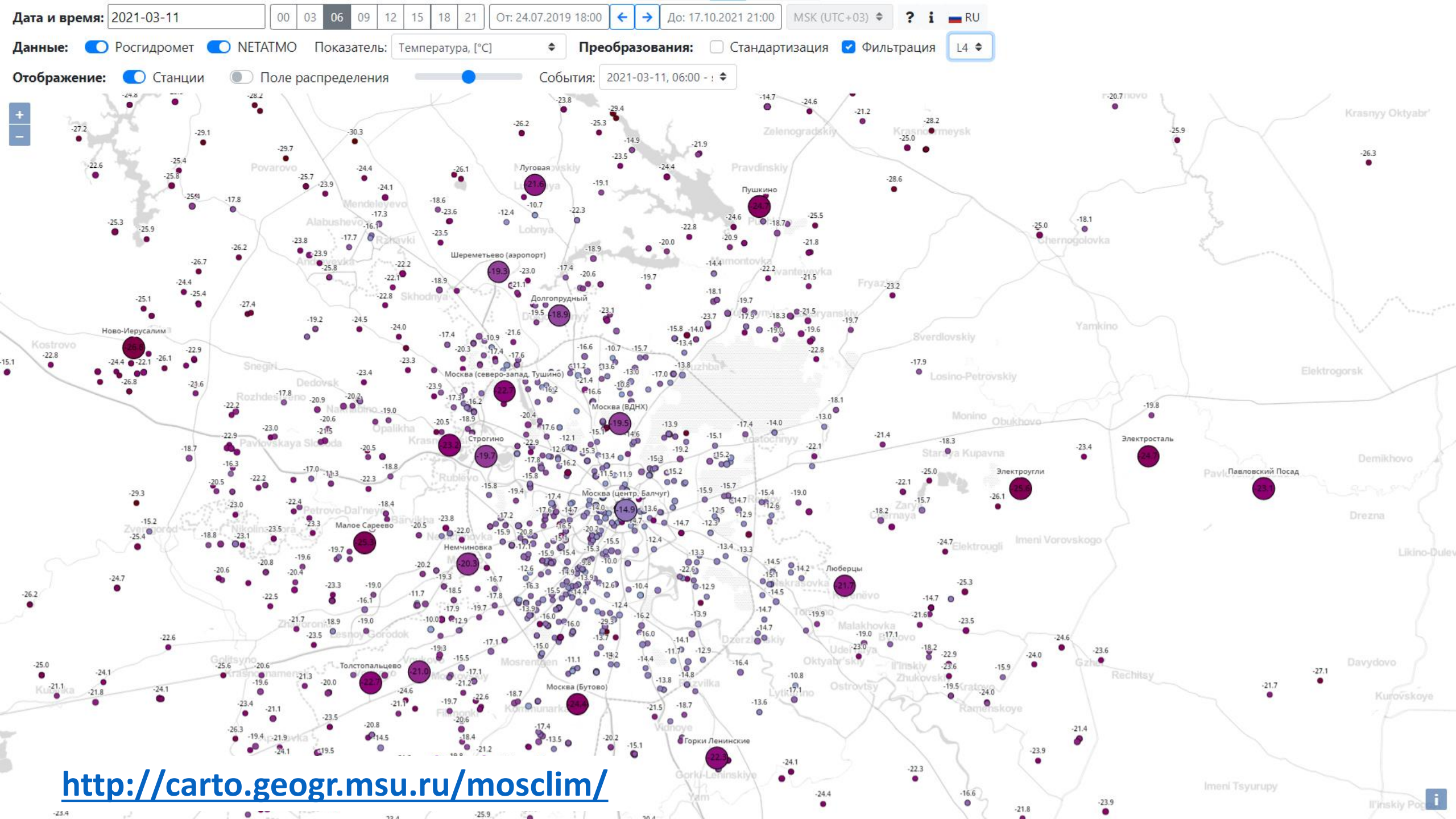


http://carto.geogr.msu.ru/mosclim/

РУССКОЕ ГЕОГРАФИЧЕСКОЕ ОБЩЕСТВО
* ОСНОВАНО В 1845 г. *

ПРАВИТЕЛЬСТВО МОСКВЫ

РФФИ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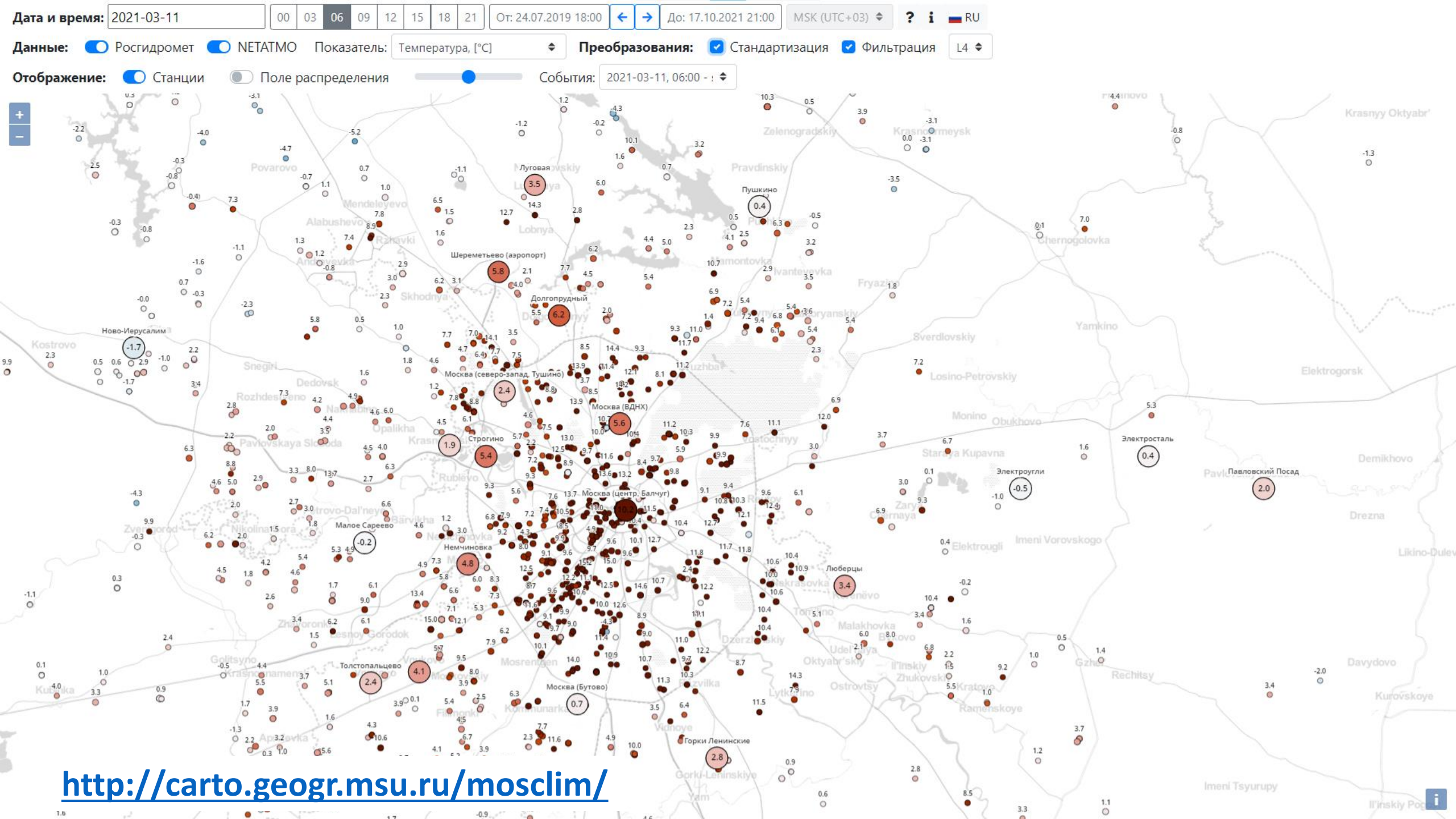
От: 24.07.2019 18:00
До: 17.10.2021 21:00
MSK (UTC+03)
RU
Данные: Росгидромет NETATMO
Показатель: Температура, [°C]
Преобразования: Стандартизация Фильтрация L4
Отображение: Станции Поле распределения
События: 2021-03-11, 06:00 - :
Луговая
Пушкино
Шереметьево (аэропорт)
Долгопрудный
Ново-Иерусалим
Москва (северо-запад, Тушино)
Москва (ВДНХ)
Строгино
Москва (центр, Балчуг)
Малое Сареево
Немчиновка
Толстопальцево
Москва (Бутово)
Горки Ленинские
Люберцы
Электросталь
Электроугли
Павловский Посад
http://carto.geogr.msu.ru/mosclim/


Дата и время: 2021-03-11
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От: 24.07.2019 18:00
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L4
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События: 2021-03-11, 06:00 - :
Луговая
Пушкино
Шереметьево (аэропорт)
Долгопрудный
Ново-Иерусалим
Москва (северо-запад, Тушино)
Москва (ВДНХ)
Строгино
Москва (центр, Балчуг)
Малое Сареево
Немчиновка
Толстопальцево
Москва (Бутово)
Горки Ленинские
Электроугли
Электросталь
Павловский Посад
Люберцы
http://carto.geogr.msu.ru/mosclim/

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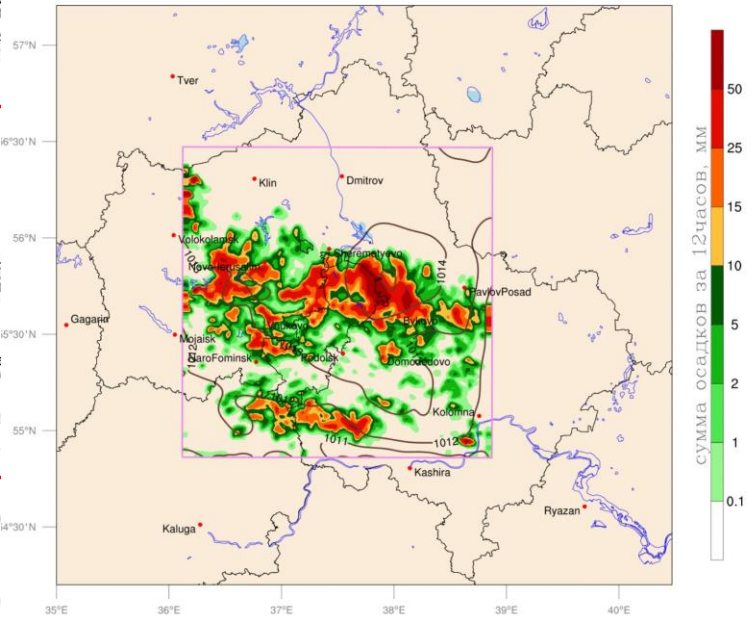
15:00 20июн2020(UTC): Prec12h+PMSL



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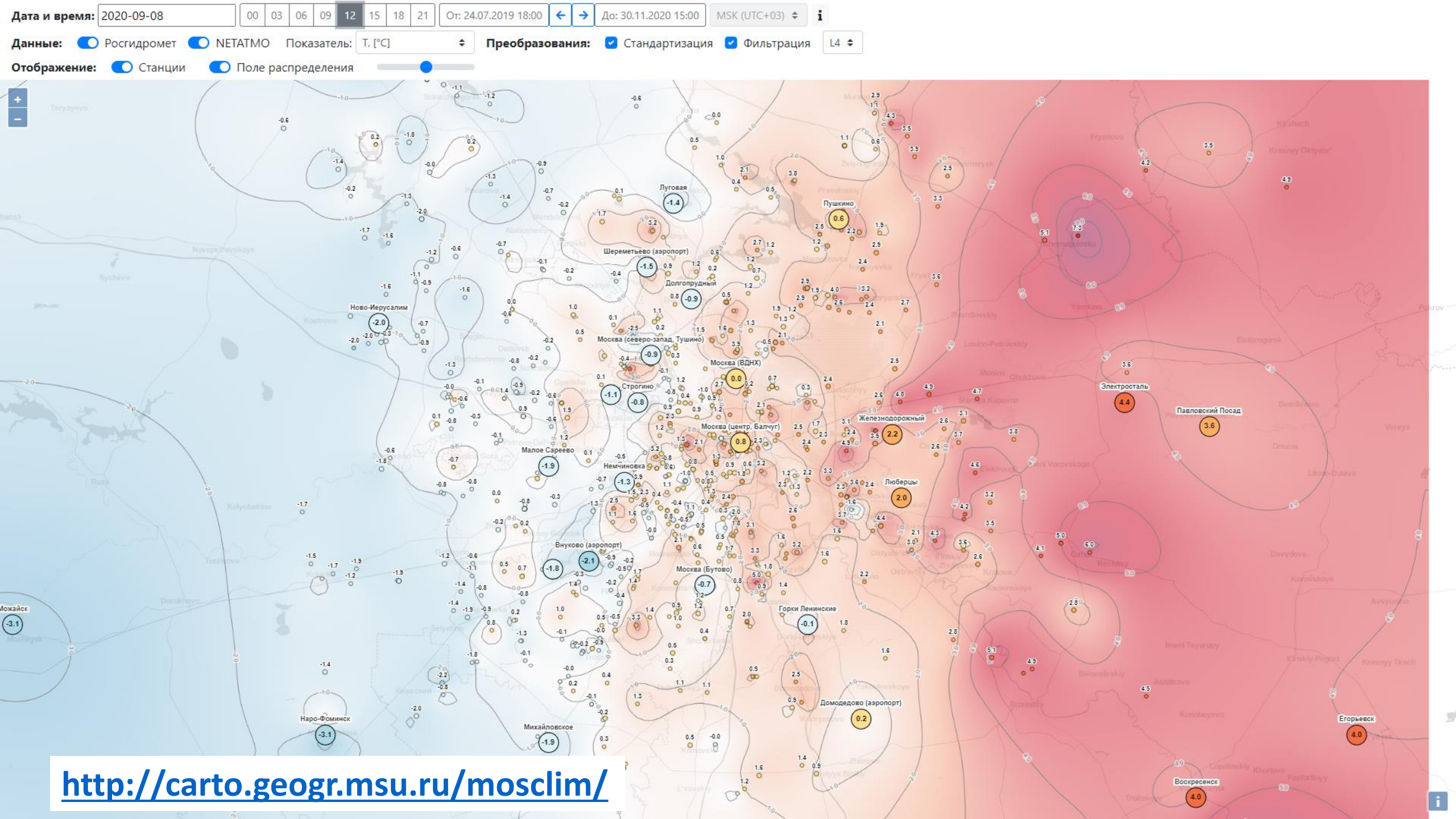
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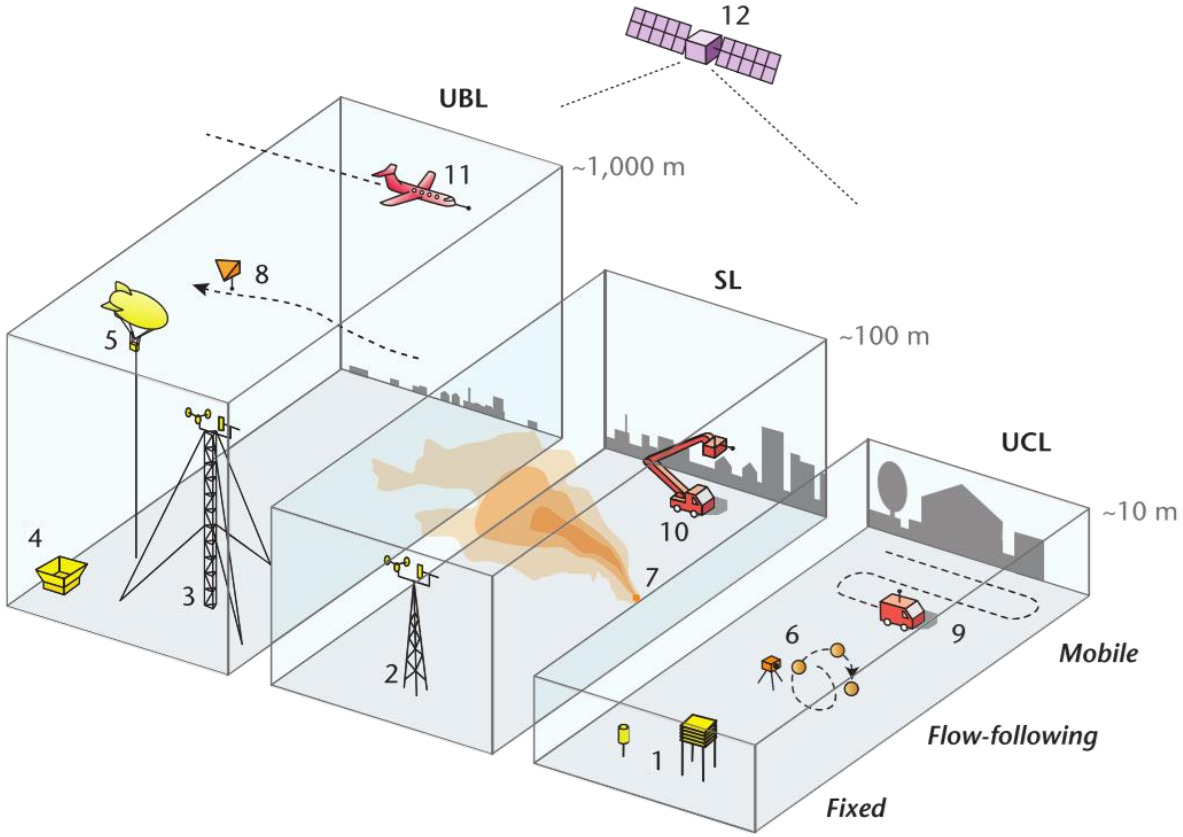
Преобразования: Стандартизация Фильтрация L4
Отображение: Станции Поле распределения
Луговая
Пушкино
Шереметьево (аэропорт)
Долгопрудный
Ново-Иерусалим
Москва (северо-запад, Тушино)
Москва (ВДНХ)
Строгино
Электросталь
Железнодорожный
Павловский Посад
Москва (центр, Балчуг)
Малое Сареево
Немчиновка
Люберцы
Внуково (аэропорт)
Москва (Бутово)
Горки Ленинские
Можайск
Домодедово (аэропорт)
Наро-Фоминск
Михайловское
Егорьевск
Воскресенск
http://carto.geogr.msu.ru/mosclim/

Summary



- Urban meteorological networks for regular monitoring, research and human thermal stress warning *(more insides will come from Pavel)*
- High-quality eddy covariance measurements from masts for comprehensive studies on urban energy exchange and model development
- Drones and ground-based remote sensing for urban boundary layer studies and also for model development
- Crowdsousing data at the forefront of spatially-resolving urban studies, weather forecast improvement and new-generation public services