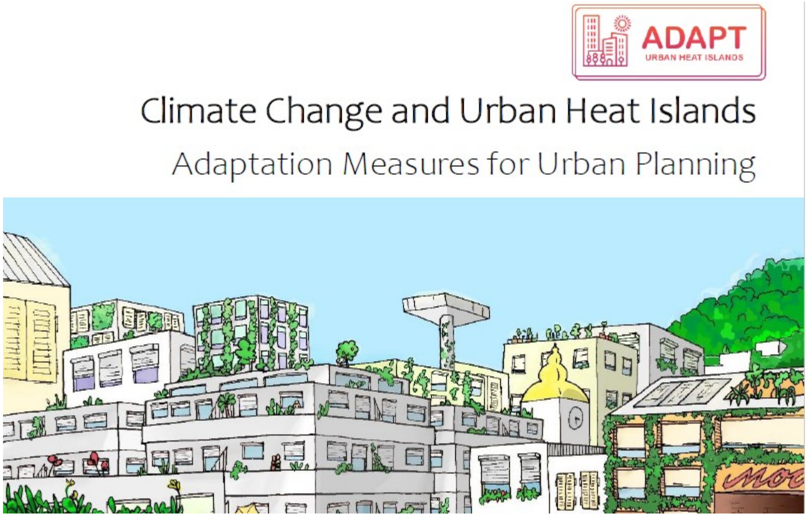
- Presentation of Your LCZ mapping exercise will start on **Monday, December 4th at 1:00 PM, Z7 lecture room**
- To save time and avoid technical problems, please upload your presentation before the date indicated to IS:

  ***Study materials – Homework vaults – LCZ_mapping_exercise***
- Or you can send me your presentation via e-mail

# URBAN CLIMATOLOGY

## X. Adaptation and mitigation

## Paper to read




https://is.muni.cz/auth/el/sci/podzim2024/ZA311/um/67875456/10_ADAPT_UHI_Brochure_EvaluationMeasures.pdf

## Some expected climate changes in cities

- Rising temperatures and higher intensity of Urban Heat Island
- Higher frequency and longer duration of heat waves
- Changes in precipitation distribution during a year
- More frequent occurrence of high precipitation totals of short duration, higher probability of local floods
- Higher frequency of drought periods without precipitation

**Negative effects prevail**
**Heat load is increasing**

**Survive New York's Heat Waves**
**Stay cool during your trip to New York**
(http://www.frenzytours.com)

## From understanding to some action

Physical processes well understood

Main drivers of negative impacts are known

We know that we can either **adapt** or **mitigate**

Numerous solutions already exist

↓

Realizations are not adequate in many cases

What are the main reasons/problems?

Is there any analogy with the global climate change?

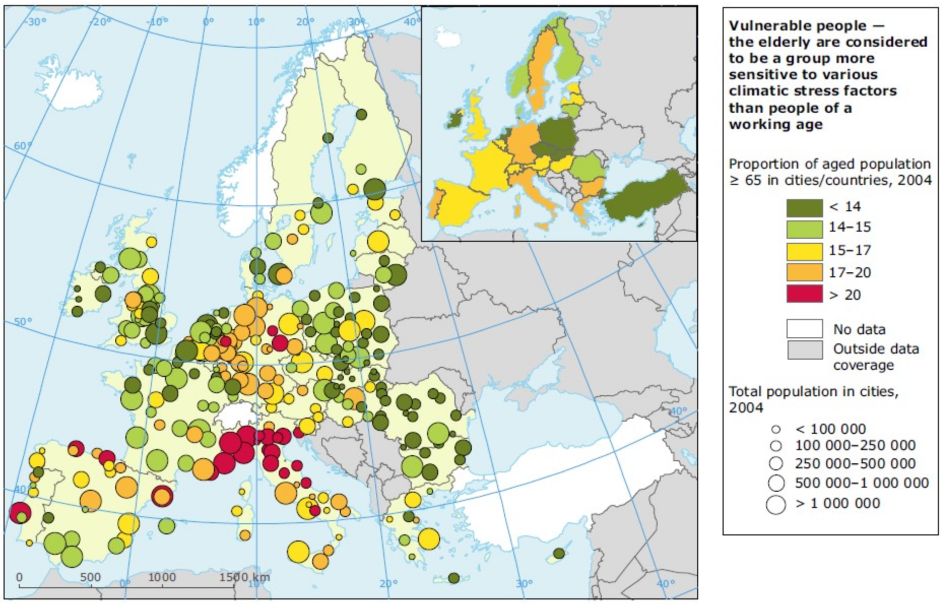
## Adaptation and mitigation in urban climatology

- Besides „physical controls" urban climatology has also „human / social controls"

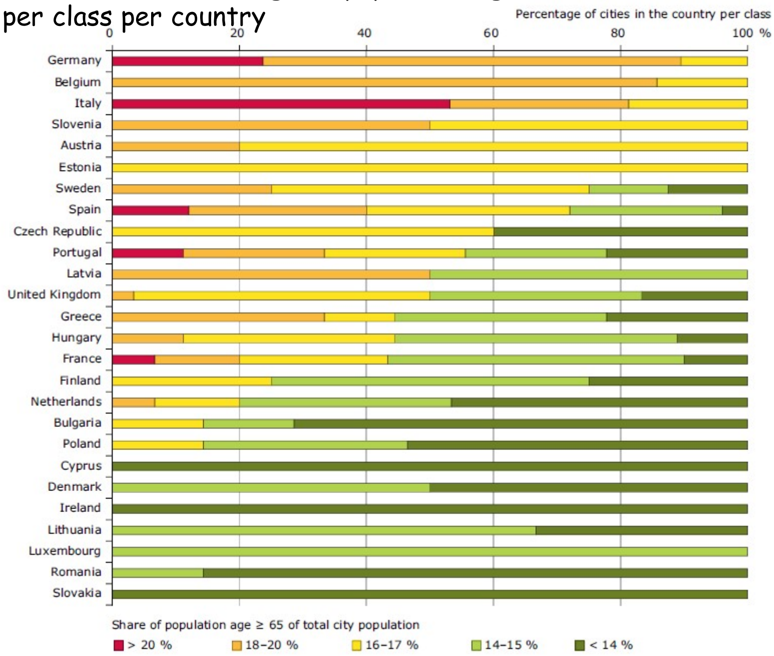
https://jpi-urbaneurope.eu

- In cities climate change is **strongly intertwined** with other **socio-economic changes**: demographic trends, higher proportion of older people, urbanization, competing demand for water, etc.
- These socio-economic changes **increase the vulnerability** of people, property and ecosystems under current climate conditions as long as no adaptation measures are taken.
- Negative impacts of climate change in cities require various **actions**, strategies, technologies that help inhabitants **to adapt or mitigate**.

**Human controls** — the elderly are considered to be a group more sensitive to various climatic stress factors than people of a working age
*(Urban adaptation to climate change in Europe, EEA Report 2012)*

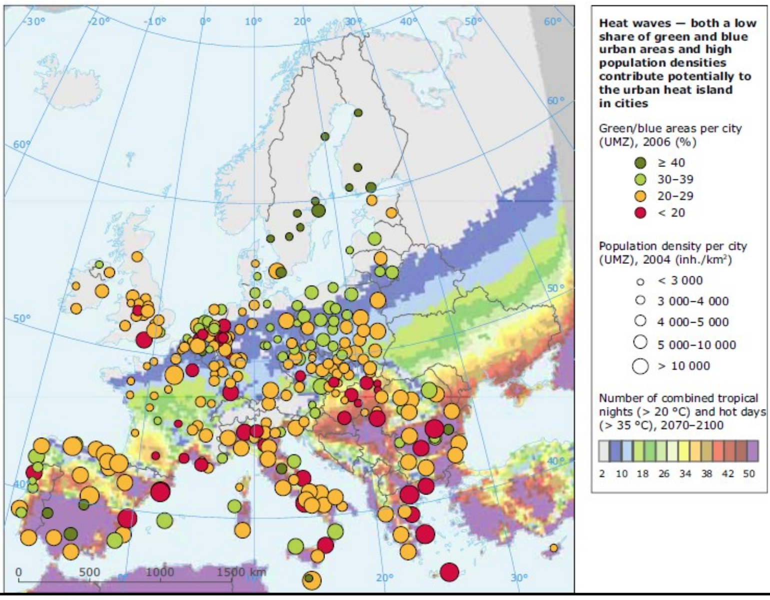



**Human controls** - Percentage of population aged ≥ 65 — share of cities per class per country

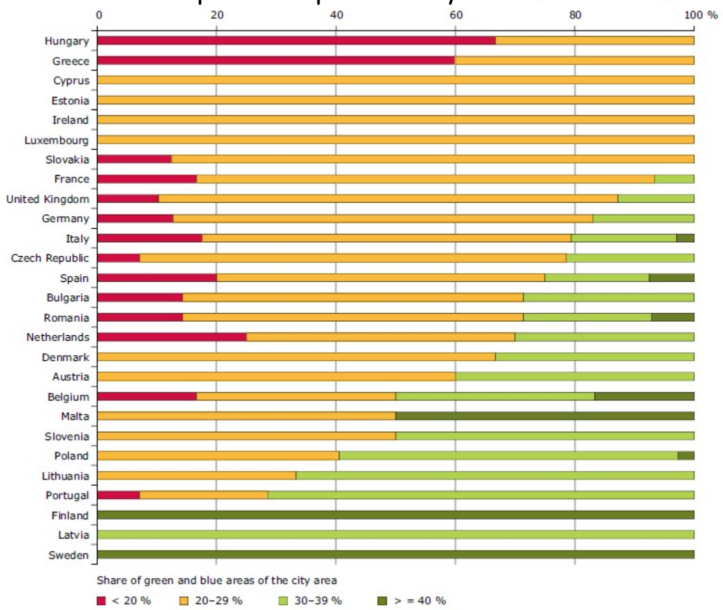



*(Urban adaptation to climate change in Europe, EEA Report 2012)*

**Human and geographical controls -** Low share of green and blue urban areas and high population densities can contribute to the urban heat island effect in cities *(Urban adaptation to climate change in Europe, EEA Report 2012)*




**Human and geographical controls -** Percentage of green and blue urban areas — share of cities per class per country




*(Urban adaptation to climate change in Europe, EEA Report 2012)*

## Adaptation and mitigation - terminology

**Adaptation** to climate change is the adjustment in urban areas in response to actual or expected effects of adverse climate. It moderates harm or exploits beneficial opportunities of climate change.

**Mitigation** of climate change is an anthropogenic intervention to reduce the anthropogenic forcing of the climate system. It includes strategies to reduce greenhouse gas sources and emissions and enhancing greenhouse gas sinks.

**Vulnerability** is the degree to which a system is susceptible to, and unable to cope with, adverse effects of climate change, including climate variability and extremes.

**Resilience** is the ability of a social or ecological system to absorb disturbances while retaining the same basic structure and ways of functioning, the capacity for self-organization and the capacity to adapt to stress and change.

## Causes of urban warming and mitigation strategies (Grimmond, 2007)

| Urban heat island causes | Mitigation strategy |
|---|---|
| *Increased surface area* | |
| Large vertical faces | |
| Reduced sky view factor | |
| Increased absorption of shortwave (solar) radiation | High reflection building and road materials, high reflection paints for vehicles |
| Decreased longwave (terrestrial) radiation loss | |
| Decreased total turbulent heat transport | Spacing of buildings |
| Reduced wind speeds | Variability of building heights |
| *Surface materials* | |
| *Thermal characteristics* | |
| Higher heat capacities | Reduce surface temperatures (changing albedo and emissivity) |
| Higher conductivities | |
| Increased surface heat storage | Improved roof insulation |
| *Moisture characteristics* | |
| Urban areas have larger areas that are impervious | Porous pavement |
| Shed water more rapidly – changes the hydrograph | Neighbourhood detention ponds and wetlands which collect stormwater |
| Increased runoff with a more rapid peak | |
| Decreased evapotranspiration (latent heat flux, $Q_E$) | Increase greenspace fraction<br>Greenroofs, greenwalls |
| *Additional supply of energy – anthropogenic heat flux – $Q_F$* | |
| Electricity and combustion of fossil fuels: heating and cooling systems, machinery, vehicles. | Reduced solar loading internally, reduce need for active cooling (shades on windows, change materials) |
| 3-D geometry of buildings – canyon geometry | District heating and cooling systems<br>Combined heat and power systems<br>High reflection paint on vehicles to reduce temperature |
| *Air pollution* | |
| Human activities lead to ejection of pollutants and dust into the atmosphere | District heating and cooling systems<br>Combined heat and power or cogeneration systems |
| Increased longwave radiation from the sky | |
| Greater absorption and re-emission ('greenhouse effect') | |

# Adaptation measures (approaches) in cities

1. **'Grey' infrastructure approaches** - physical interventions or construction measures and using **engineering services** to make buildings and infrastructure essential for the social and economic well-being of society more capable of withstanding extreme events.
2. **'Green' infrastructure approaches -** contribute to the increase of ecosystems resilience and can halt biodiversity loss, degradation of ecosystem and restore water cycles. At the same time, green infrastructure uses the functions and services provided by the ecosystems to achieve a more cost effective and sometimes more feasible adaptation solution than grey infrastructure.
3. **'Soft' approaches** - include policies, plans, programs, procedures, information dissemination and economic incentives to reduce vulnerability, encourage adaptive behavior. They are related to **behavioral changes**, emergency systems and the adequate provision of information to vulnerable groups.

# Adaptation approaches and measures

Overview on grey, green and soft adaptation measures to heatwaves
*(Urban adaptation to climate change in Europe, EEA Report 2012)*

| Grey measures | Green measures | Soft measures |
|---|---|---|
| • Building insulation to keep the inside cool<br>• Blinds to provide shade<br>• Passive cooling of buildings<br>• Urban designs providing shade<br>• Ventilation of urban space by intelligent urban design<br>• Emission reduction of air pollutants | • Boosting green infrastructure, such as green urban areas, trees, green walls and roofs where possible, but ensuring sustainable watering<br>• Ensuring that fresh air from green areas outside the city can flow in | • General awareness raising and ensuring broad participation<br>• Mapping of urban heat island as well as cool places<br>• Identification of vulnerable groups and their distribution as basis for targeted action<br>• Warning systems<br>• Heat action plans including appropriate institutional structures<br>• Preparedness of health and social care system<br>• Information on adapting behaviour during heatwaves in particular to the vulnerable<br>• Adapting building codes to include insulation and shadowing to cope with heatwaves<br>• Consider reducing heatwave impacts through urban renewal projects and urban planning<br>• Transport management to reduce air pollutants |

# Adaptation measures (approaches)

Resilient cities


"green" city


"blue" city


"white" city

**Further possibilities:**

- Energy saving and passive houses
- Warning systems and disaster risk management programs
- Urban adaptation relies on action beyond cities' borders (flooding due to inappropriate land use and flood management in upstream regions) and incudes reducing cities' dependency on external services

# Examples of adaptation measures


Shading effect, evaporation of water into the atmosphere and its storage in soil

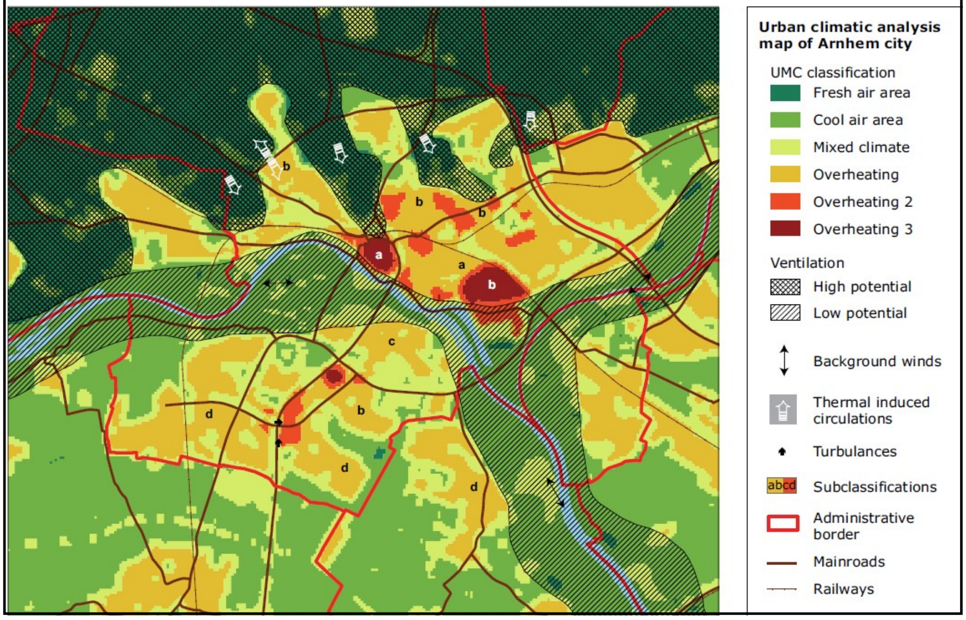

Green tram tracks (Mulhouse, France)


Grey measure - shading of a public square in Benicassim, Spain (© urbadis)


Soft measure – change in our mind (© projectADAPT-UHI(KR17AC0K13693)

## Urban climate analysis map for the city of Arnhem, the Netherlands

*(Urban adaptation to climate change in Europe, EEA Report 2012)*

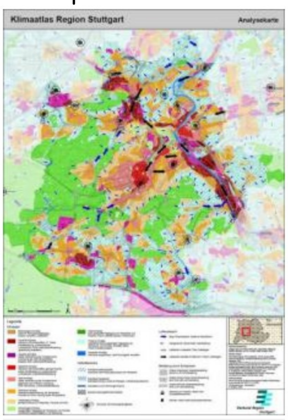



## Climate planning strategy, Stuttgart (Germany)

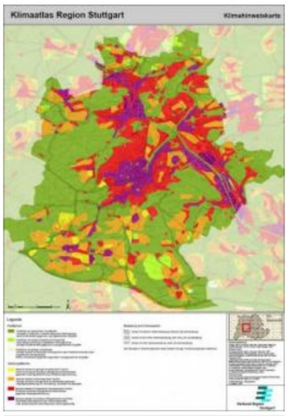
*(Urban adaptation to climate change in Europe, EEA Report 2012)*

An excellent example of urban heat island management. The city of Stuttgart has been designed to not only respect and protect nature, but to exploit how natural **wind patterns** and **dense vegetation** can actively help the city to reduce its problems of overheating and air pollution.

At night cool air sweeps down from the surrounding hills and runs through a series of 'ventilation-corridors' which have been kept open as wide, tree-flanked arteries within the city's street infrastructure.




Klimaanalysekarte Stuttgart

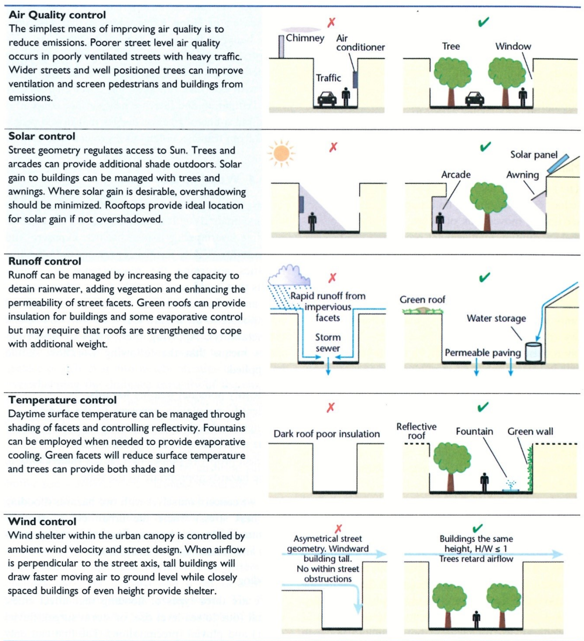



Planungshinweiskarte Stuttgart

*http://www.stadtklima-stuttgart.de*

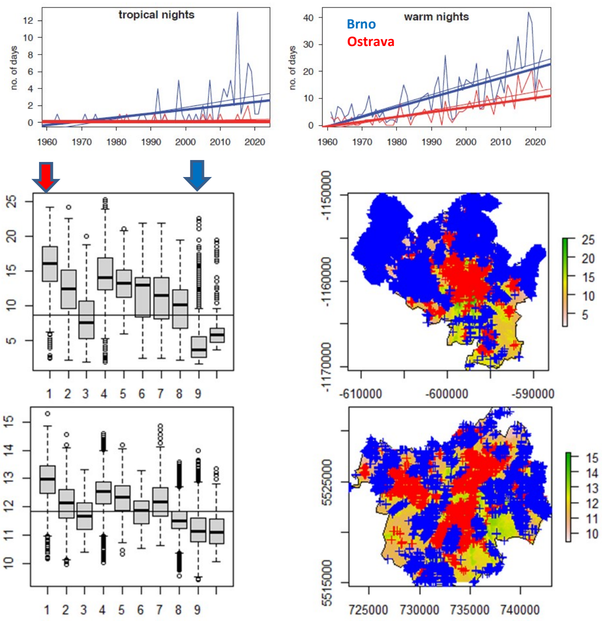
# Climate sensitive design (resilient cities)

- Cities are efficient in their use of resources
- Cities are designed to improve local climate and microclimate
- Inhabitants and infrastructure are well protected from extreme weather events



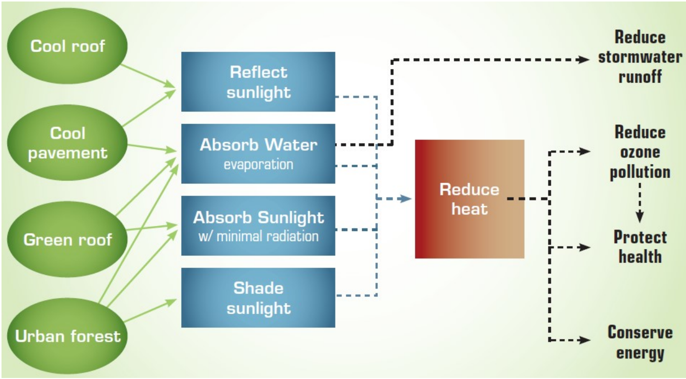

Examples of poor and good practices in street design (Oke et al. 2017)

# Climate sensitive design




Spatial distribution of LCZs that contribute the most and the least to the heat stress

# Benefits of the complex approaches




Source: Harrison Institute for Public Law, 2012.

"Climate sensitive design"

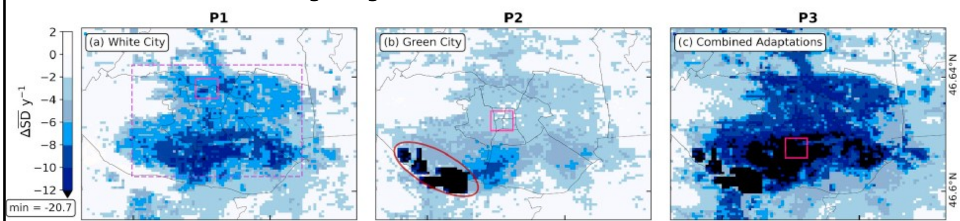
# Effectiveness of adaptation strategies

Oswald et al. 2020 – Klagenfurt (Austria)

**Two adaptation strategies:**

(i) **White** city - an increase in the albedo values of sealed areas (i.e., roofs, walls and streets)

(ii) **Green** city - an increase in green surfaces (i.e., lawns on streets and at roof level) and high vegetated areas (i.e., trees).




Evaluation of the different climate adaptation measures for the urban area of Klagenfurt. difference in the average number of summer days per year ( SD y 1) compared to the reference simulation for the time period 1981–2010.

- Some climate adaptation measures show higher potential in mitigating hot days than others, varying between reductions of 2.3 to 11.0%.
- An overall combination of adaptation measures leads to a maximum reduction of up to 44.0%

# Weather extremes and the effectiveness of soft measures

An example from extreme flood events in CR

| Soft measures |
|---|
| • General awareness raising and ensuring broad participation |
| • Identification of vulnerable groups and their distribution as basis for targeted action |
| • Warning systems |
| • Preparedness of health and social care system |
| • Information on adapting behaviour in particular to the vulnerable |

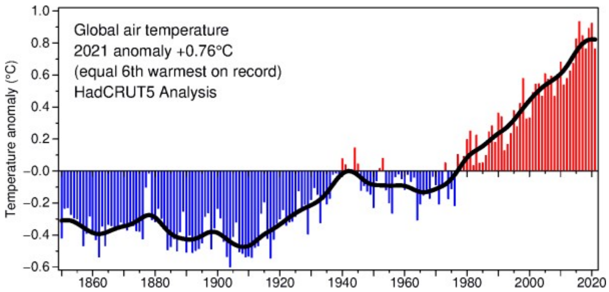
The weather forecast called for 400 mm of rainfall over three days.

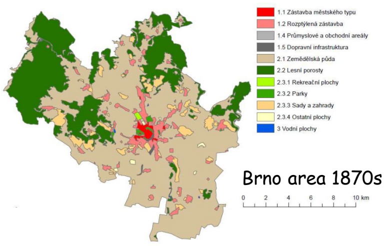
**Moravia and Silesia in July 1997**
52 victims - material damage
63 billions of Czech crowns

**Bohemia in August 2002**
19 victims - material damage
73 billions of Czech crowns

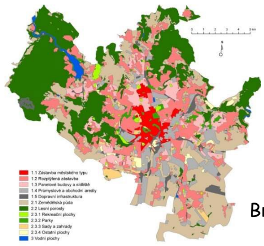
**Moravia and Silesia in September 2024**
13 victims - material damage
10s billions of Czech crowns

# Urban climate and recent global warming



Brno area 1870s

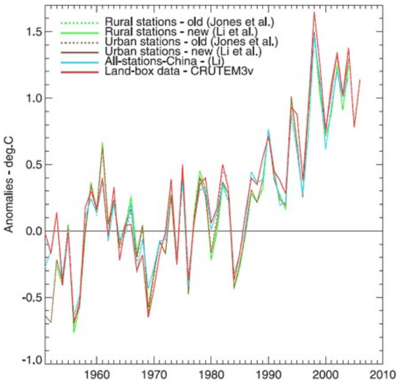


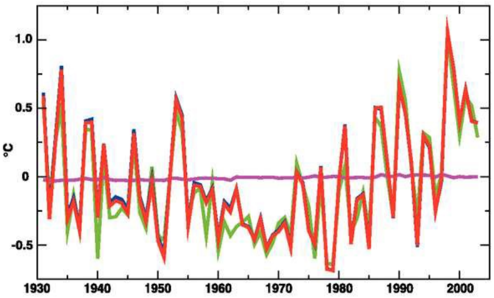
Brno area 2010s

A paper by McKitrick & Michaels (2004) concluded that half of the global warming trend from 1980 to 2002 was caused by Urban Heat Island – not proved

## UHI and recent global warming

Urban and rural regions show the same warming trend.

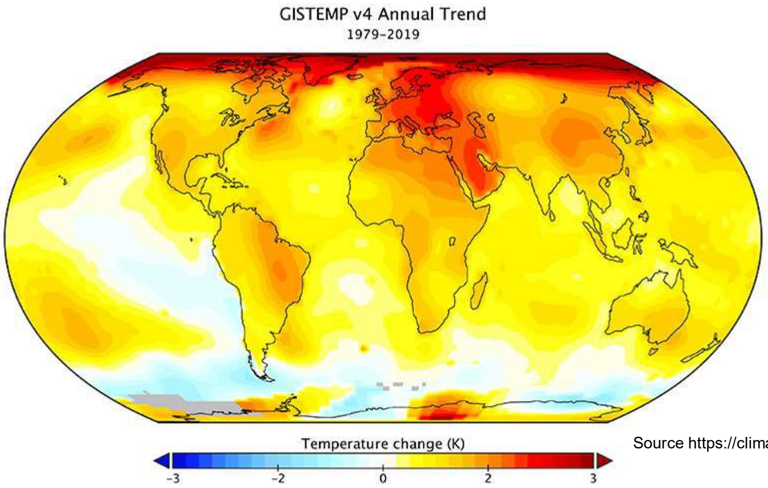



Anomaly (°C) time series relative to the 1961 to 1990 mean of the full US Historical Climatology Network (USHCN) data (red), the USHCN data without the 16% of the stations with populations of over 30,000 within 6 km in the year 2000 (blue), and the 16% of the stations with populations over 30,000 (green). The full USHCN set minus the set without the urban stations is shown in magenta. Source IPCC 2007

Parker (2004, 2006) noted that warming trends in night minimum temperatures over the 1950-2000 period were not enhanced on calm nights, which would be the time most likely to be affected by urban warming.

## UHI and recent global warming




Source https://climate.nasa.gov

Due to the polar amplification The greatest difference in temperatures for the long term averages where across Russia, Alaska, far north Canada and Greenland and not where major urbanization has occurred.

## Final remarks and questions

Mills (2006) - the sustainable city is the new urban *utopia*

1. What is the role of geographers in the adaptation process of cities to climate change?