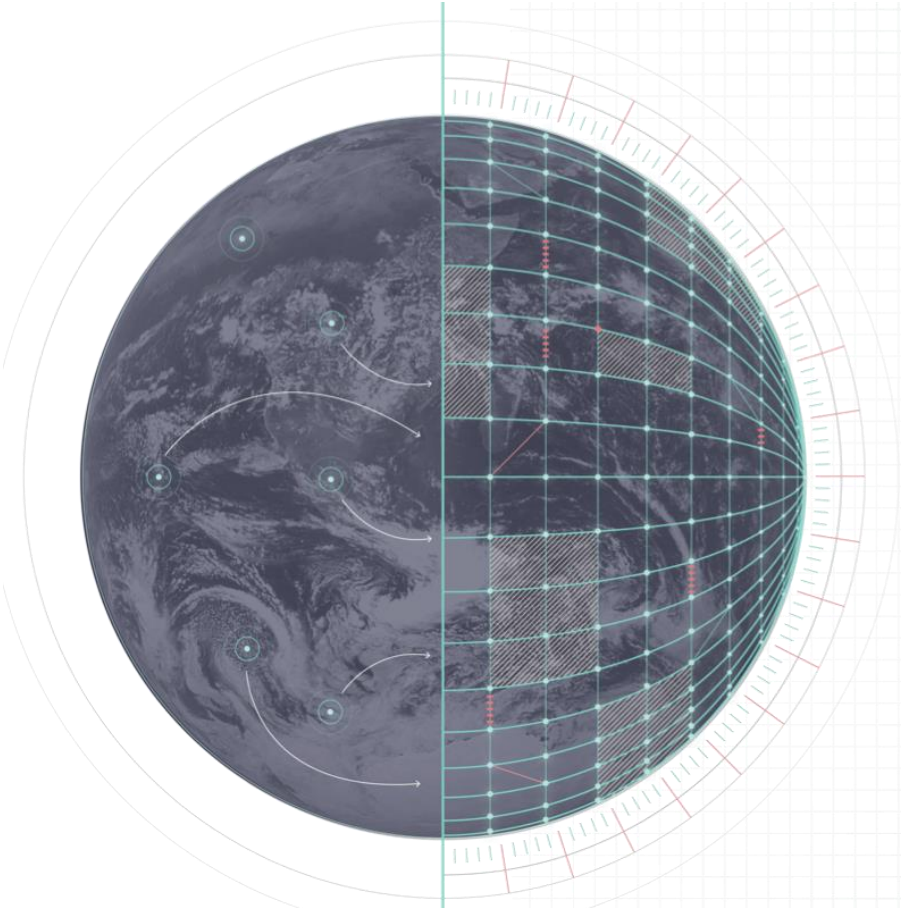


DESTINATION EARTH

URBAN HEAT USE CASE OVERVIEW

Nele Veldeman, Dirk Lauwaet, Filip Lefebre, Wim Peelaerts

VITO

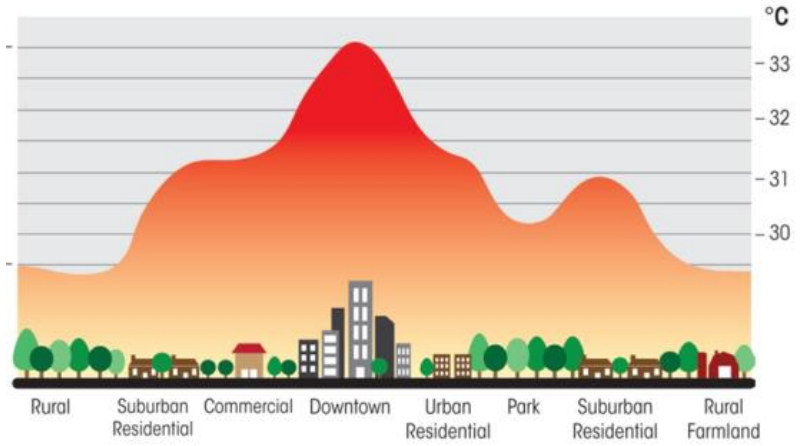
Funded by the European Union

Destination Earth implemented by ECMWF esa EUMETSAT

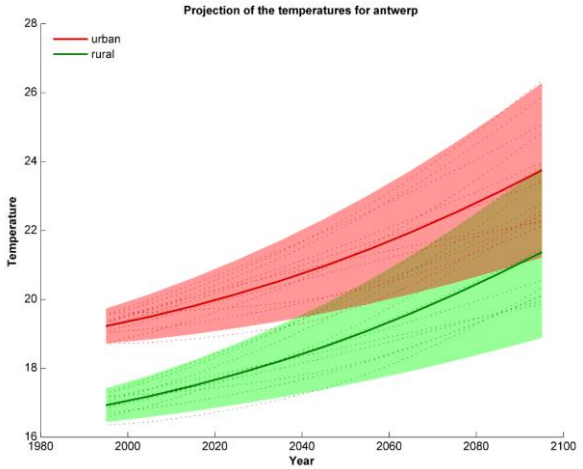
Urban Heat: Introduction

Background

- Climate change leads to increasingly frequent and intense heatwaves in Europe
- Cities are especially at risk because of the urban heat island (UHI) phenomenon



Late afternoon air temperatures across a city. Source: [web]



Projected average summer air temperatures [°C] for the city of Antwerp under the RCP8.5 climate scenario. Source: VITO.

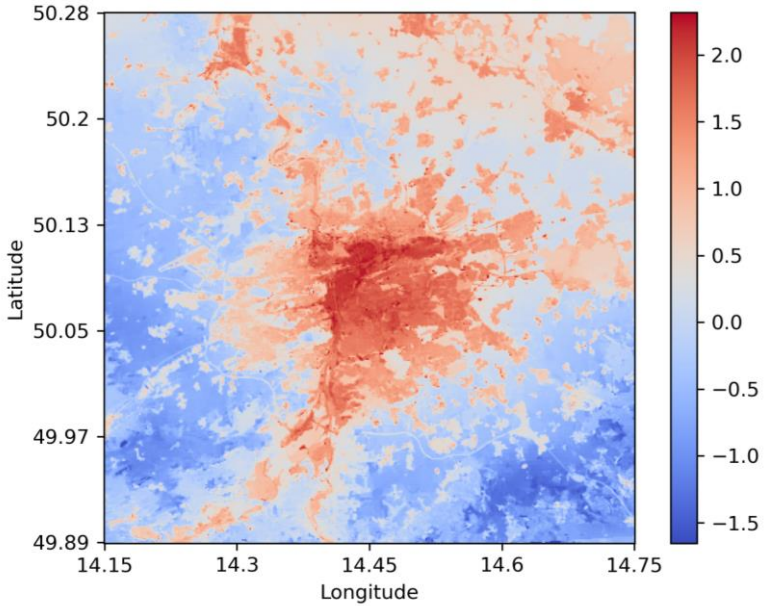
Urban Heat: Overview

Motivation

- Support EU adaptation policy intended to increase urban resilience against projected exposure to extreme heat
- **Support local administrations to take efficient heat stress adaptation measures at the most vulnerable locations**

Objectives

- Demonstrate added value of DestinE to tackle urban heat stress
- Deliver high-resolution urban heat maps for cities across Europe to underpin and motivate urban climate adaptation measures that are being developed



Example output map of VITO's UrbClim model, showing the average Urban Heat Island intensity [°C] of the city of Prague during the summer months. Source: VITO.

Urban Heat: Overview

Users involved

- Main users:
  - DG REGIO, **Demonstration cities** Prague and Lisbon
- Other stakeholders:
  - European Directorate-General's (DG's): CLIMA, ENV, EMPL, ECHO, SANTE;
  - European Institutes: Joint Research Centre (JRC), European Environmental Agency (EEA);
  - World Bank (WB);
  - City networks: ICLEI, EuroCities, Convenant of Mayors, Climate Alliance;
  - City supporting organisations: Tecnalia, Ramboll, RIVM;
  - Belgian/Flemish stakeholders: Flemish Environment Agency, Flemish Health Agency, Flemish Digital Administration, Belgian Climate Centre.

User engagement

- Telco's with main users
- User exchange workshop with broader stakeholder community

Urban Heat: Scoping the use case

Based on the **user requirements**, the following outline of this use case was decided:

- Heat stress calculations for 2011-2020 (ERA5) and 2020-2040/2050 (Climate DT) at 100m resolution
- Climate projections from DT Climate are compared to IPCC CMIP6 results
- Advanced heat stress variables (WBGT, UTCI, Tapp) are calculated
- Output indicators: Urban Heat Island intensity, Number of tropical nights, Number of health heatwave days, Exposure of the population to heatwaves, Heat-related mortality, Exceedances of health threshold levels, Lost working hours and Cool island identification
- Impact of climate adaptation measures are demonstrated offline for the demonstration cities
- Results are validated with local measurements

Potential urban heat stress adaptation measures. Source: Google images.

Urban Heat: Envisioned Technical Set-up

DE DT Climate

DE Data Lake

REST API
- Polytope access to DT data
- Harmonized access to other data

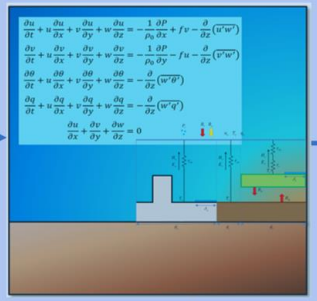
REST API

VITO hosted web platform

REST API

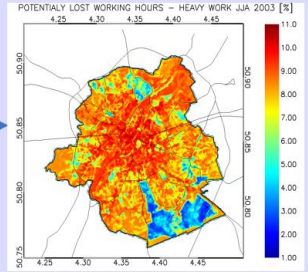
Python Preprocessor
- Meteorology
- Terrain

Docker container



The UrbClim® model

Python postprocessor
- Thermofeel package
- Indicator calculations



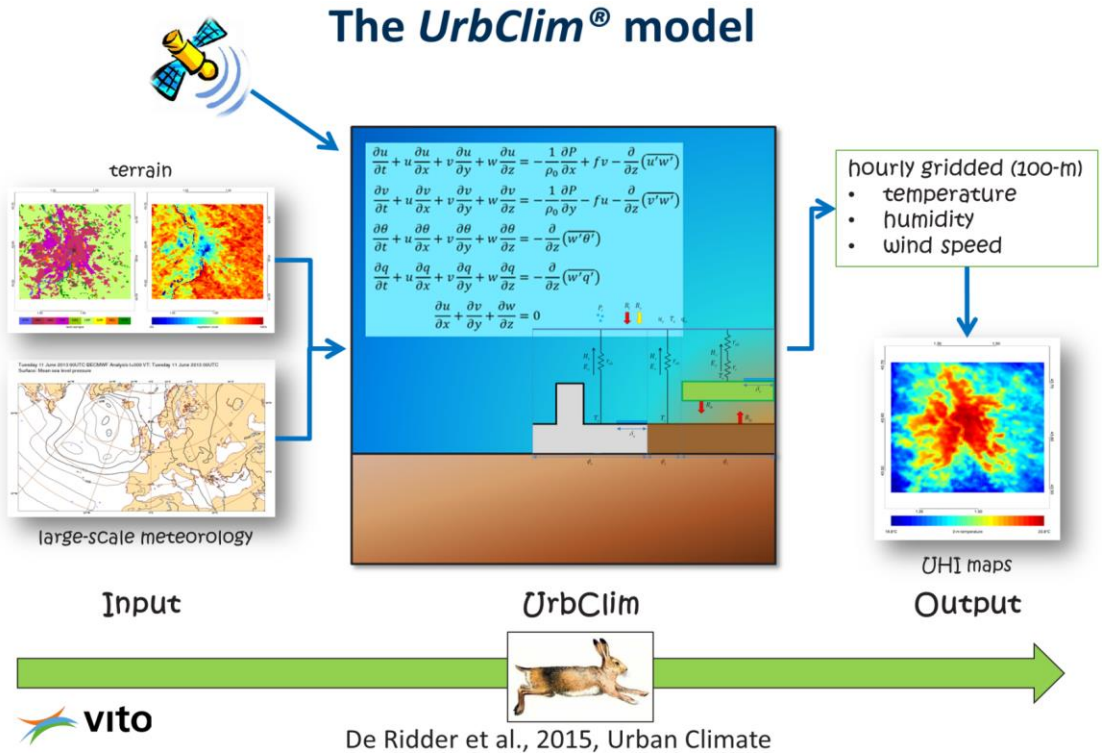
Heat stress indicator maps

REST API

DE Service Platform

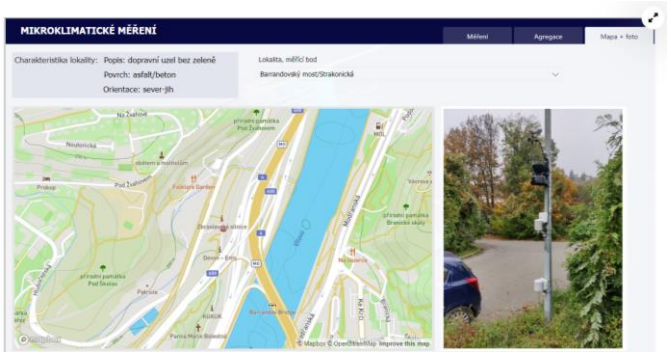
Urban Heat: Urban Climate Model

VITO has developed a high-resolution urban climate model that can cover entire urban agglomerations and can be easily set up for any city in Europe

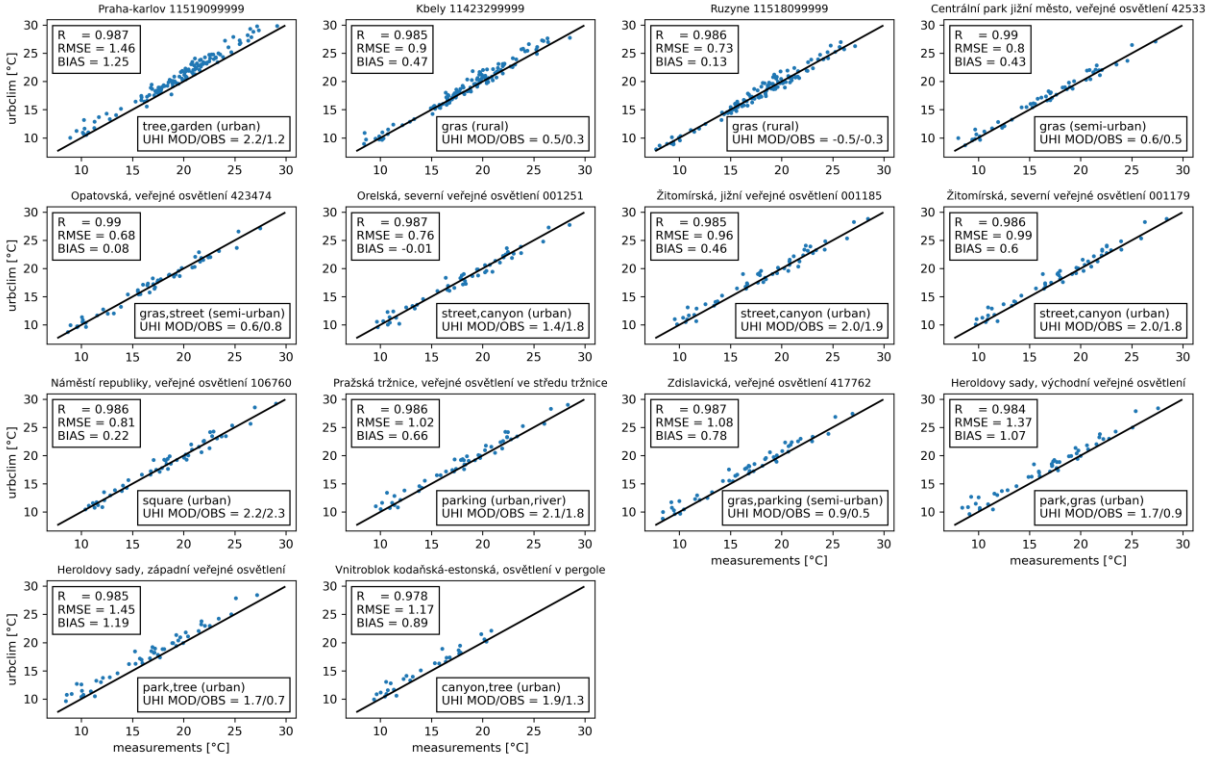


UrbClim validation

- UrbClim model results have been validated against 14 local measurement stations in Prague for the summer of 2022



https://golemio.cz/data/mikroklimaticke_parametry



Comparison between observed and modelled daily average 2m air temperatures. Source: VITO.

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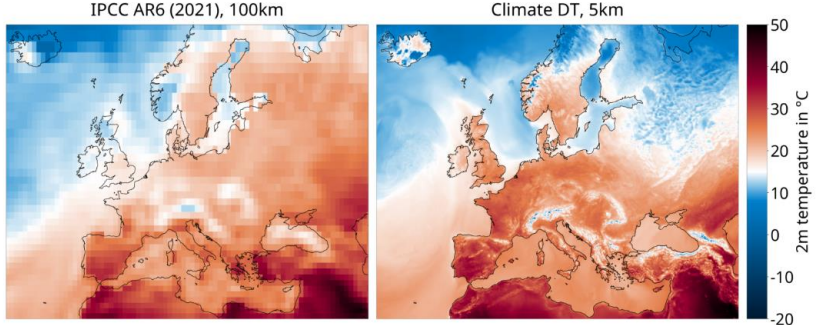
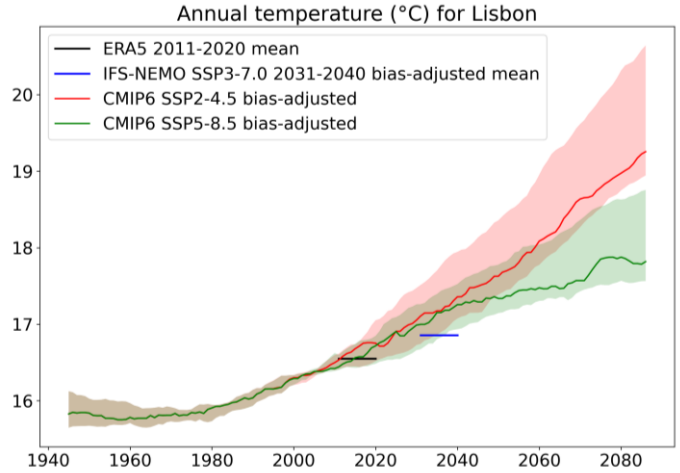
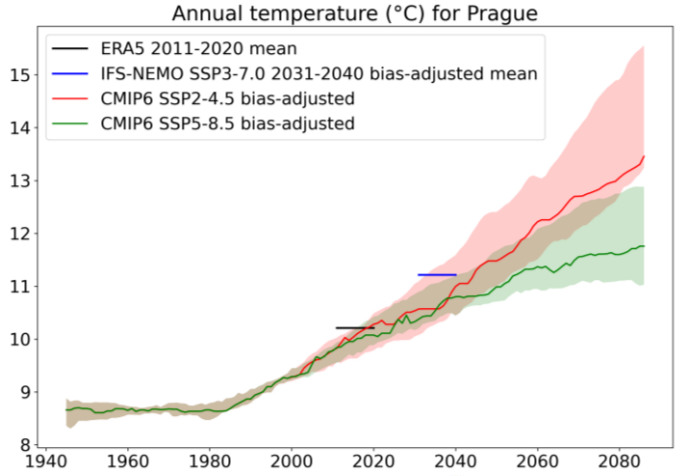
Climate DT projections

- The global climate models (3) of Destination Earth Climate DT run at an unprecedented spatial resolution of 5km
- Allow for flexible scenario calculations to study precise local impact
- For now only results for 1 model (IFS-NEMO) and 1 scenario (CMIP6 SSP3-7.0) available up to 2040
- For Lisbon: rather low impact compared to full CMIP6 ensemble
- For Prague: rather high impact compared to full CMIP6 ensemble



https://destine.ecmwf.int/news/climate-change-adaptation-digital-twin-a-window-to-the-future-of-our-planet





Adaptation measures

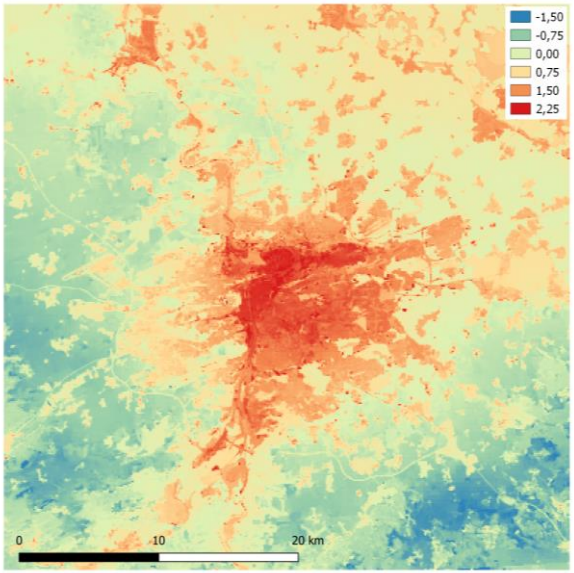
- The impact of 5 ambitious climate adaptation scenarios has been calculated
- Allowing to assess the maximal effect you can obtain with these types of measures and compare between them
- The measures are focused on the urban areas in the region and applied everywhere in an automated manner

  => Previous results have shown that only the wide-spread application of measures is effective to reduce the overall urban heat stress in a city

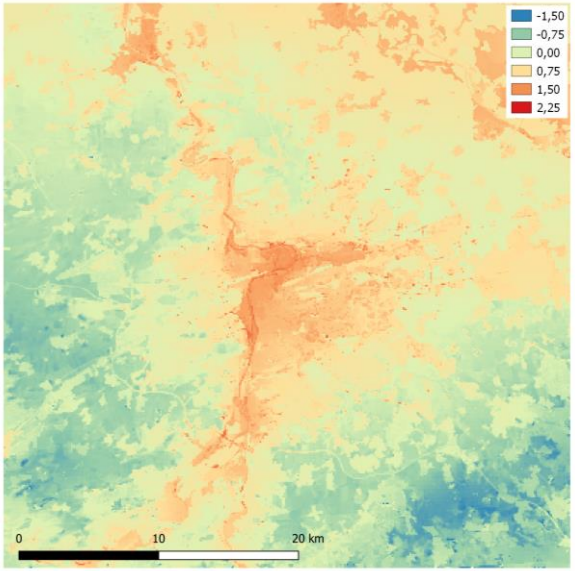
1. Green roofs: all the roofs in the city are converted to intensive green roofs
2. Light-colored materials: the albedo of all build-up areas is changed to 0.3 (realistic white)
3. Soil unsealing: 50% of all non-building urban areas are unsealed
4. Urban trees: 50% of all non-building urban areas are under tree crown cover
5. Combination of all of these: maximum impact scenario

Urban Heat: Result maps

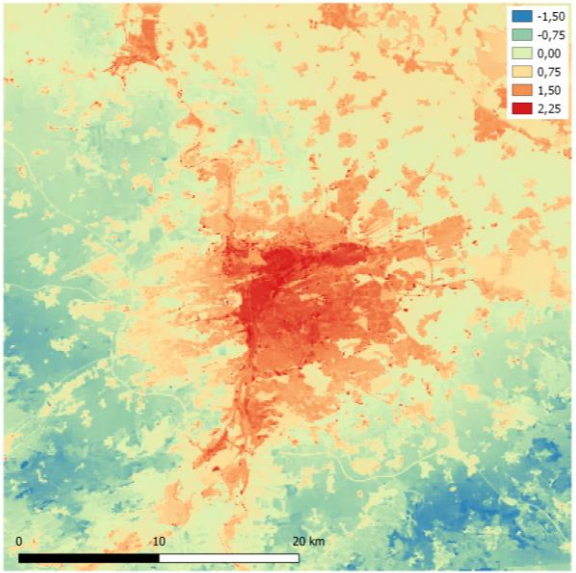
- The average UHI intensity [°C] is calculated by subtracting the average air temperature of all rural (non-water) grid cells from the 10-year average air temperature map for the summer season (JJA)



ERA5 2011-2020 Reference



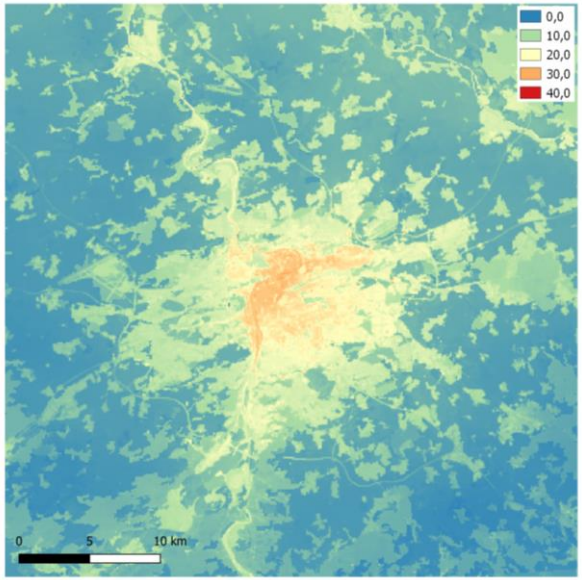
ERA5 2011-2020 MAX scenario



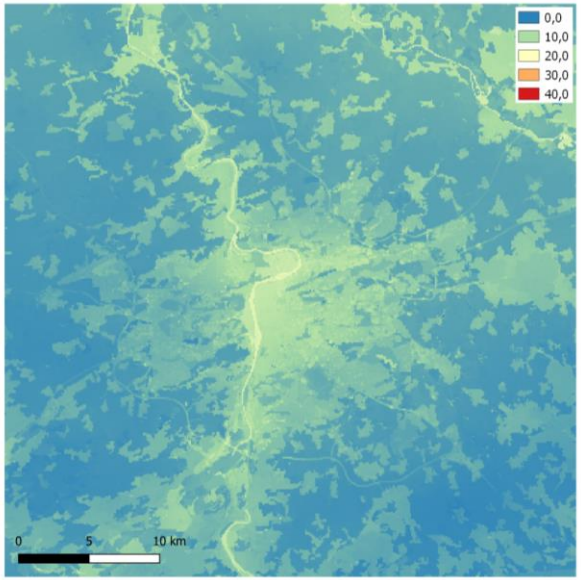
IFS-NEMO SSP3-7.0 2031-2040

Urban Heat: Result maps

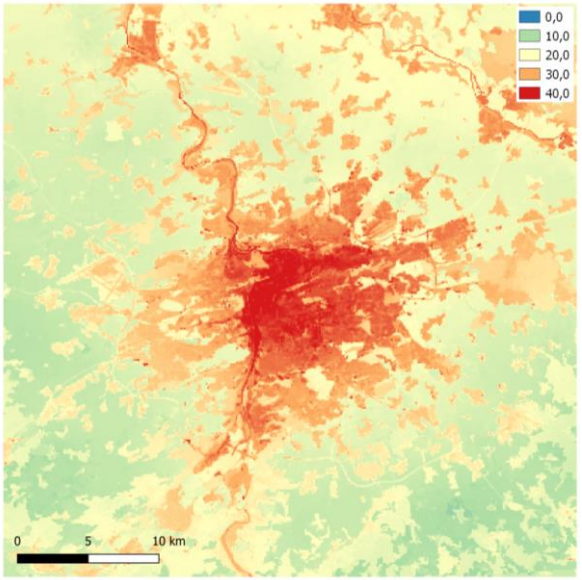
- The average number of tropical nights is calculated by counting the number of days during which the nighttime minimum air temperature is higher than 20°C



ERA5 2011-2020 Reference



ERA5 2011-2020 MAX scenario

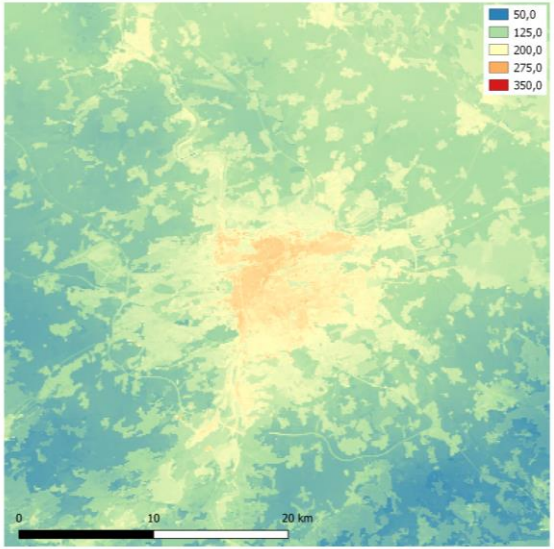


IFS-NEMO SSP3-7.0 2031-2040

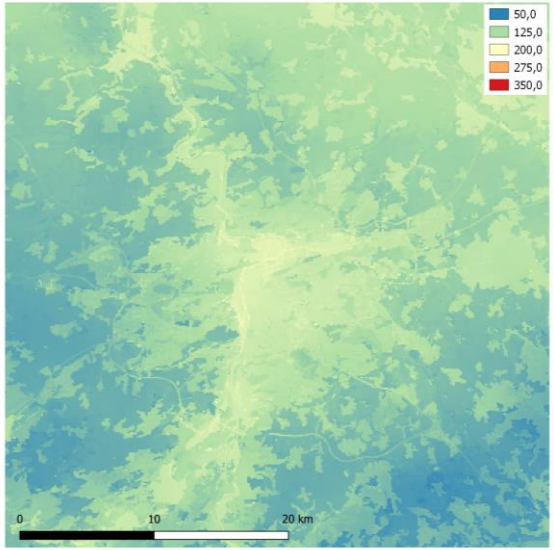
Urban Heat: Result maps

- Heat-related excess mortality is calculated based on the paper of Urban et al. (2022) where excess mortality in Prague is linked to daily average air temperatures
- On average 124 persons die from heat stress each summer in Prague during 2011-2020, increasing to 212 in the climate change scenario, decreasing to 95 in the MAX scenario

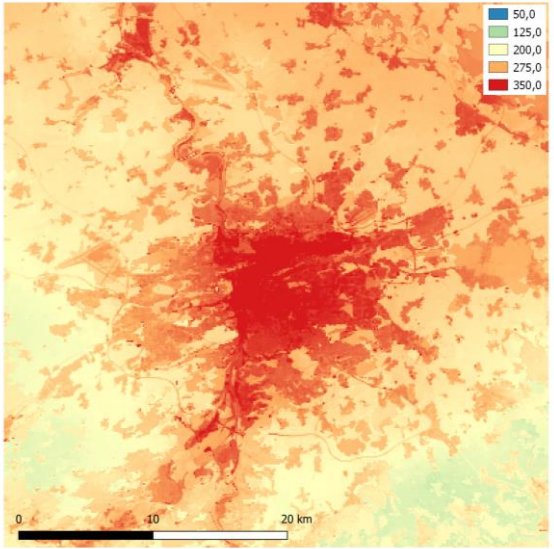
Number of days with Tmean > 20°C.



ERA5 2011-2020 Reference



ERA5 2011-2020 MAX scenario

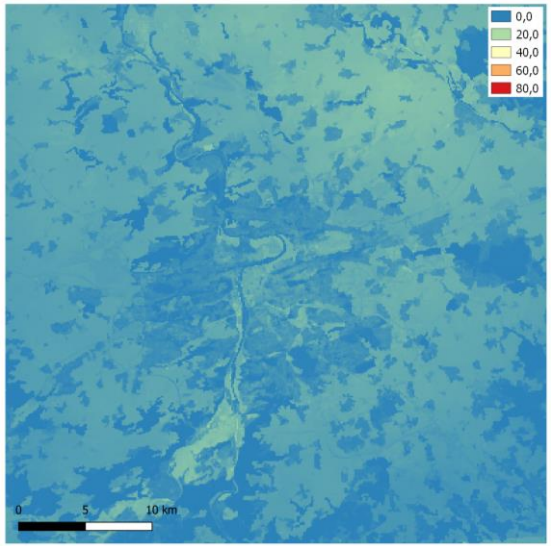


IFS-NEMO SSP3-7.0 2031-2040

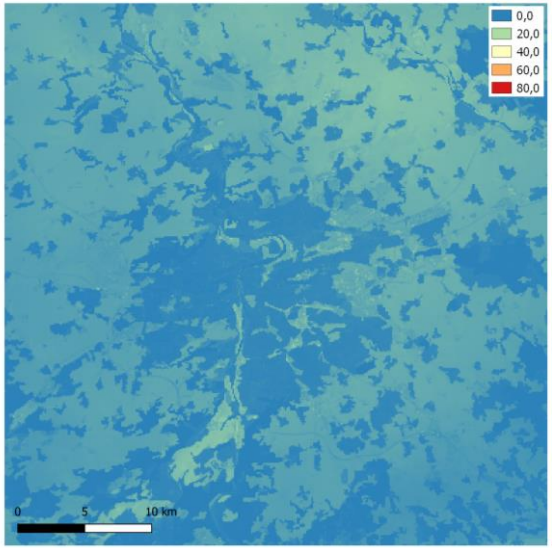
Urban Heat: Result maps

- The number of lost working hours is based on ISO 7243: Ergonomics of the thermal environment — Assessment of heat stress using the WBGT index (https://www.iso.org/standard/67188.html). They are calculated for intense, moderate and light manual work

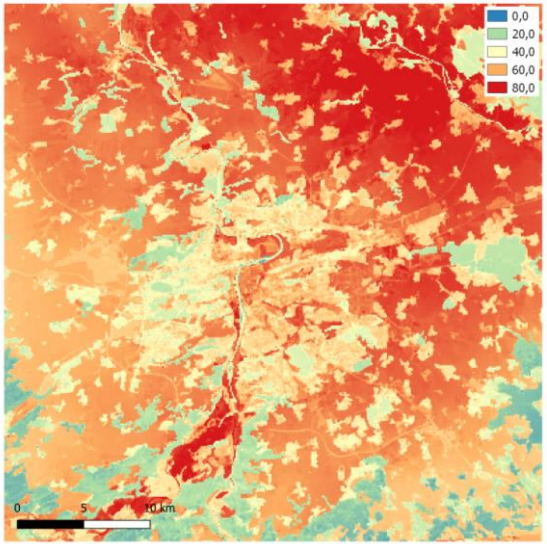
Average number lost working hours for intense manual work during the summer months. Source: VITO.



ERA5 2011-2020 Reference



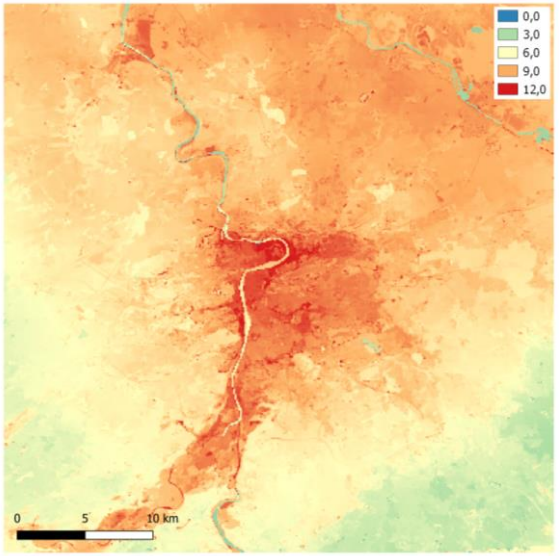
ERA5 2011-2020 MAX scenario



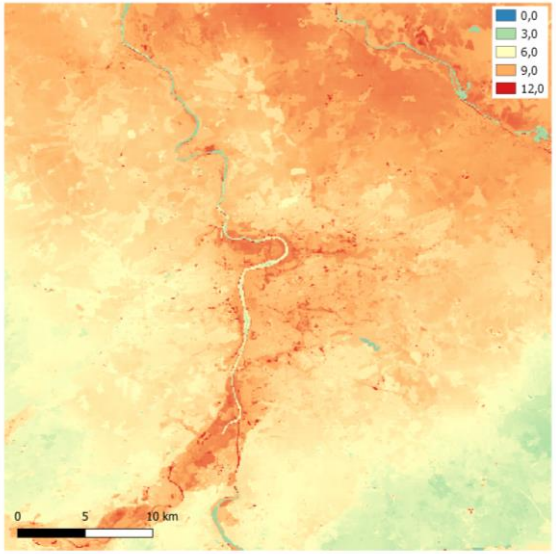
IFS-NEMO SSP3-7.0 2031-2040

Urban Heat: Result maps

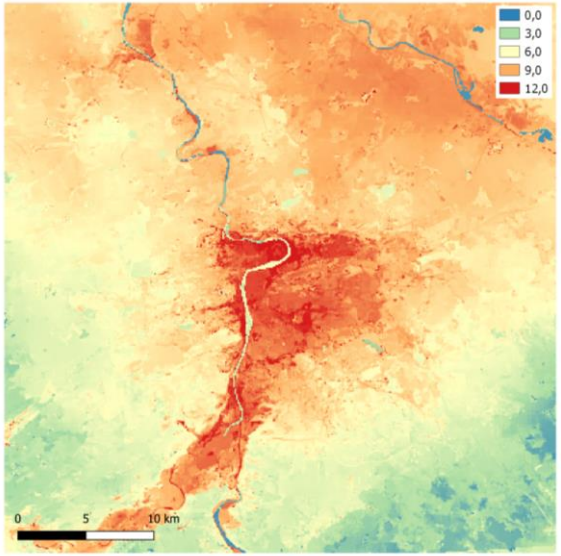
- A health-related heatwave is considered to be a period of at least 2 consecutive days on which the maximum apparent temperature (Tappmax) exceeds the 90th percentile of Tappmax and the minimum temperature (Tmin) exceeds the 90th percentile of Tmin (Romanello et al., 2022). Rural reference timeseries of Tappmax and Tmin are calculated by taking the average value of all grid cells with a rural (non-water) land cover.



ERA5 2011-2020 Reference



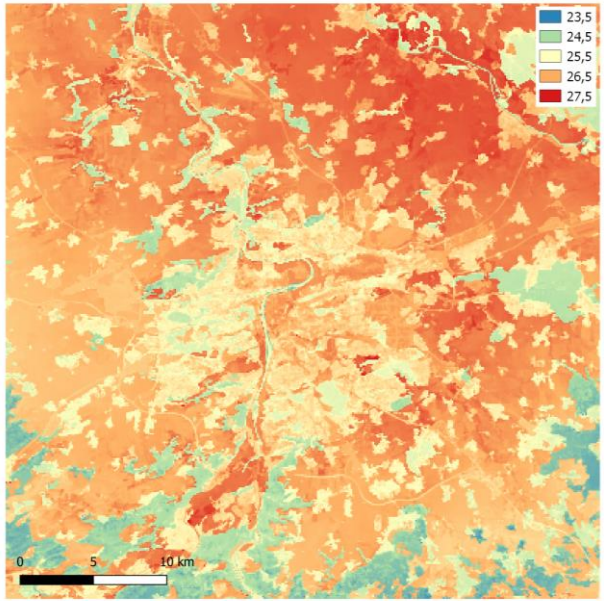
ERA5 2011-2020 MAX scenario



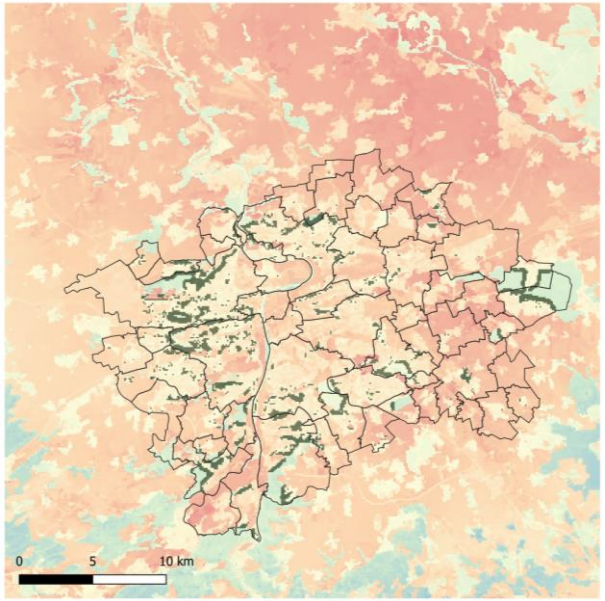
IFS-NEMO SSP3-7.0 2031-2040

Urban Heat: Result maps

- Cool area identification: based on daily maximum WBGT maps during heat wave days, the non-water areas that are below a threshold value (1.5°C below the spatial P90 value and less than 300m from an urban grid cell) are selected. The 1.5°C limit is taken as it is a very significant reduction of the WBGT, which can only be obtained in grid cells with a large tree cover. 300m is considered a doable walking distance for most people.



Average daily maximum WBGT during heatwave days [°C]. Source: VITO.



Identified cool areas. Source: VITO.

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Urban Heat: Results for Prague - overview

Impact of climate change

Prague city area - annual average values (urban areas only)			
Heat stress indicators	**Reference**	**2031-2040 SSP3-7.0 IFS-NEMO**	
			Relative change [%]
Urban Heat Island [°C]	1,29	1,29	0,00
Health Heat Wave Days	8,93	8,55	-4,27
Tropical Nights	16,18	31,44	94,36
Days with UTCI > 26°C	100,14	104,11	3,96
Days with WBGT > 25°C	5,69	21,51	277,71
Lost Working Hours for intense manual work	3,87	49,14	1170,72
Heat-related mortality	123,67	211,70	71,19

Impact of adaptation measures

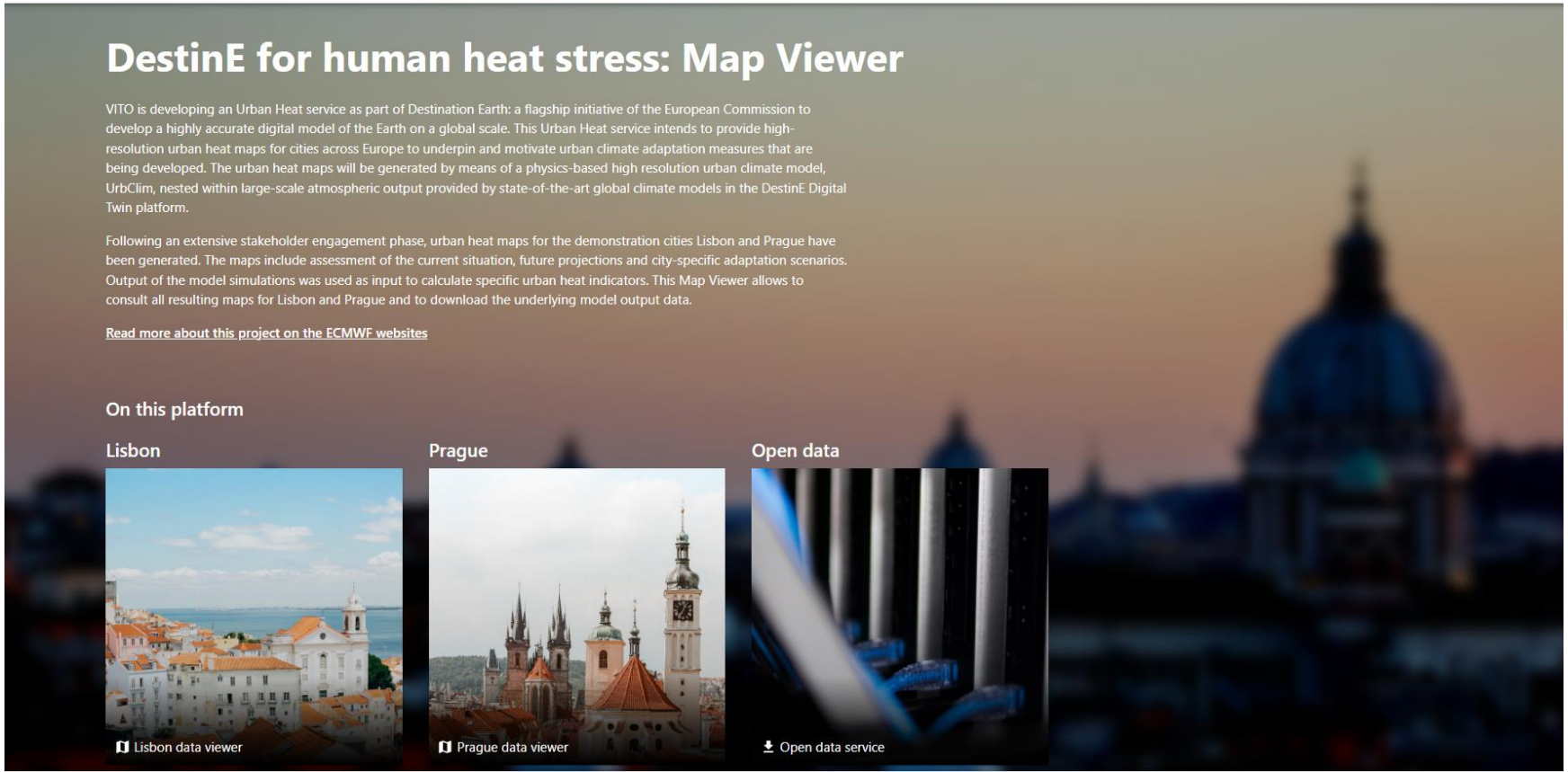
Prague city area - 2011-2020 annual average values (urban areas only)							
Heat stress indicators		**Adaptation scenarios**					
	Reference	**Green Roofs**	**Light-colored materials**	**Soil unsealing**	**Urban Trees**	**Combination of all**	**Max impact [%]**
Urban Heat Island [°C]	1,29	0,98	1,19	0,94	1,30	0,71	-44,96
Health Heat Wave Days	8,93	8,25	8,41	8,18	9,07	7,76	-13,11
Tropical Nights	16,18	11,37	15,44	11,81	16,11	8,11	-49,84
Days with UTCI > 26°C	100,14	80,74	101,13	94,16	88,63	72,22	-27,88
Days with WBGT > 25°C	5,69	4,58	5,39	5,56	4,92	4,31	-24,31
Lost Working Hours for intense manual work	3,87	1,94	3,37	3,61	2,77	1,45	-62,50
Heat-related mortality	123,67	107,40	116,78	107,21	123,53	95,16	-23,05

Urban Heat results for Prague: Conclusions

- Climate change will have a negative impact on most heat stress indicators, but the severity depends on which indicator you consider (air temperature and extreme event-related indicators are impacted the most)
- Keep in mind that the numbers presented here correspond to only one climate change scenario
- Locally applied adaptation measures can have a significant positive effect on (most) heat stress indicators
- There is no 1 ‘fit-for-all’ measure, the combination of measures generates the strongest overall response
- For some heat stress indicators, the impact of these (very ambitious) adaptation measures is expected to be able to compensate for the climate change impact up to 2040
- But (outdoor) adaptation measures are no magical solution, at some point climate change becomes too strong to keep the status-quo => also focus on building-level measures, cool shelters, heat action plans,…

Urban Heat: Web viewer

https://destinationearth.marvintest.vito.be/



Outlook

- Project ends next month
  - Finish web platform
  - Start onboarding this service in DestinE Service Platform
- Proposal to continue this work in new Destination Earth project
  - Make it a service (any city in the world, full automatization, further integration in DestinE, small cost for users,…)
  - Add user-requested functionalities (e.g. very high resolution heat stress maps, customized adaptation measures, customized input data selection, …)