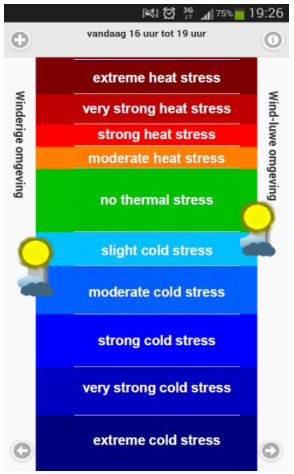
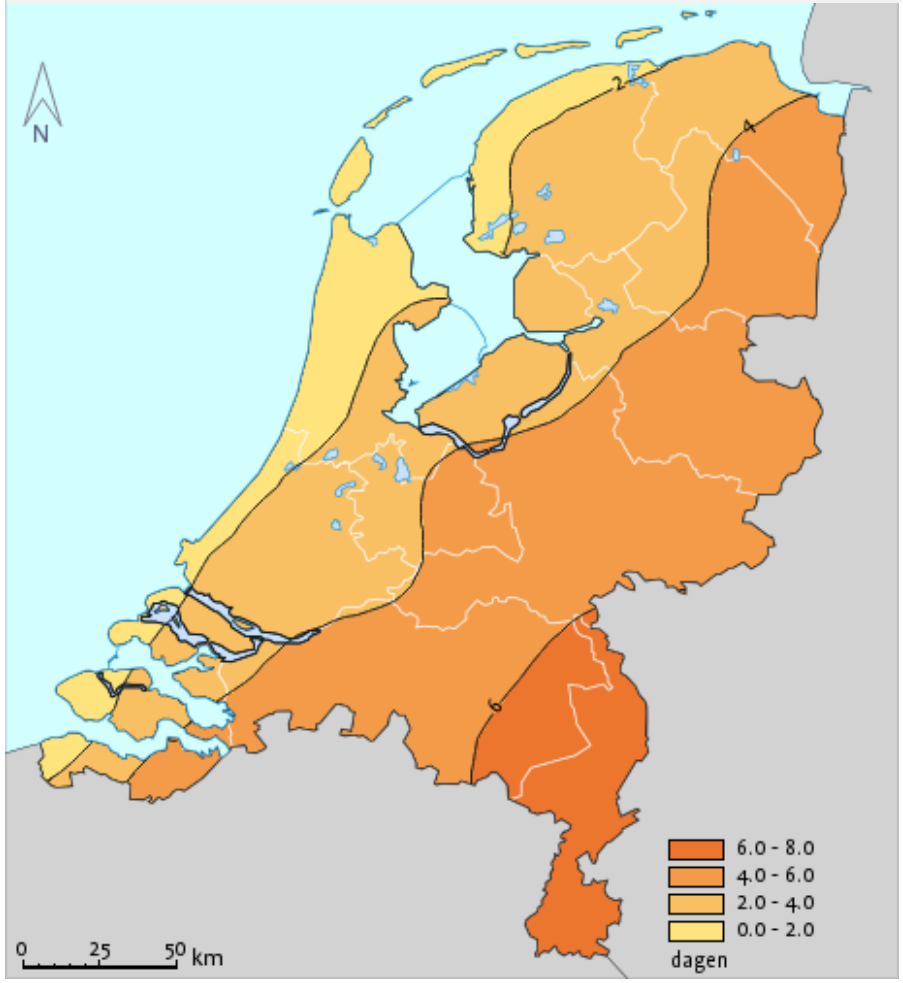
Innovative observations and analysis of human thermal comfort in Amsterdam

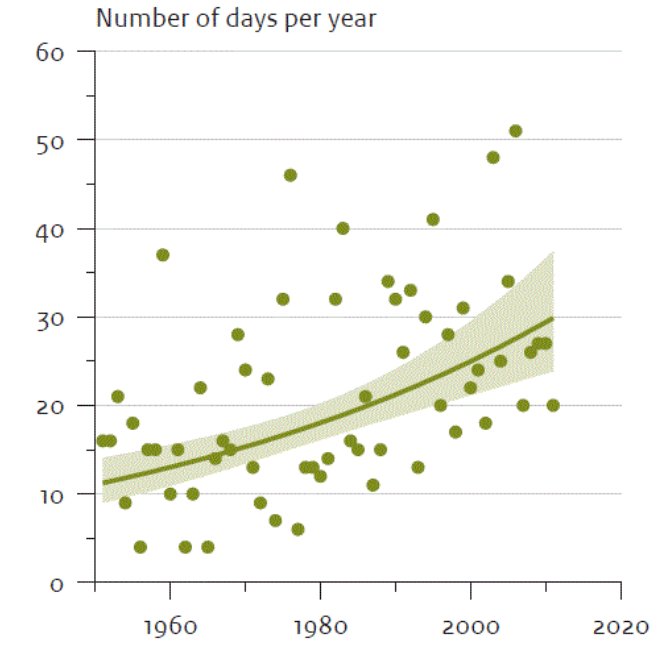
Bert Heusinkveld, Gert-Jan Steeneveld, Reinder Ronda, Jisk Attema and Bert Holtslag



Number of tropical days (left) and trend in Summer days in NL (right)

Annual average 1981-2010
Number of days with a max. temperature of 30C





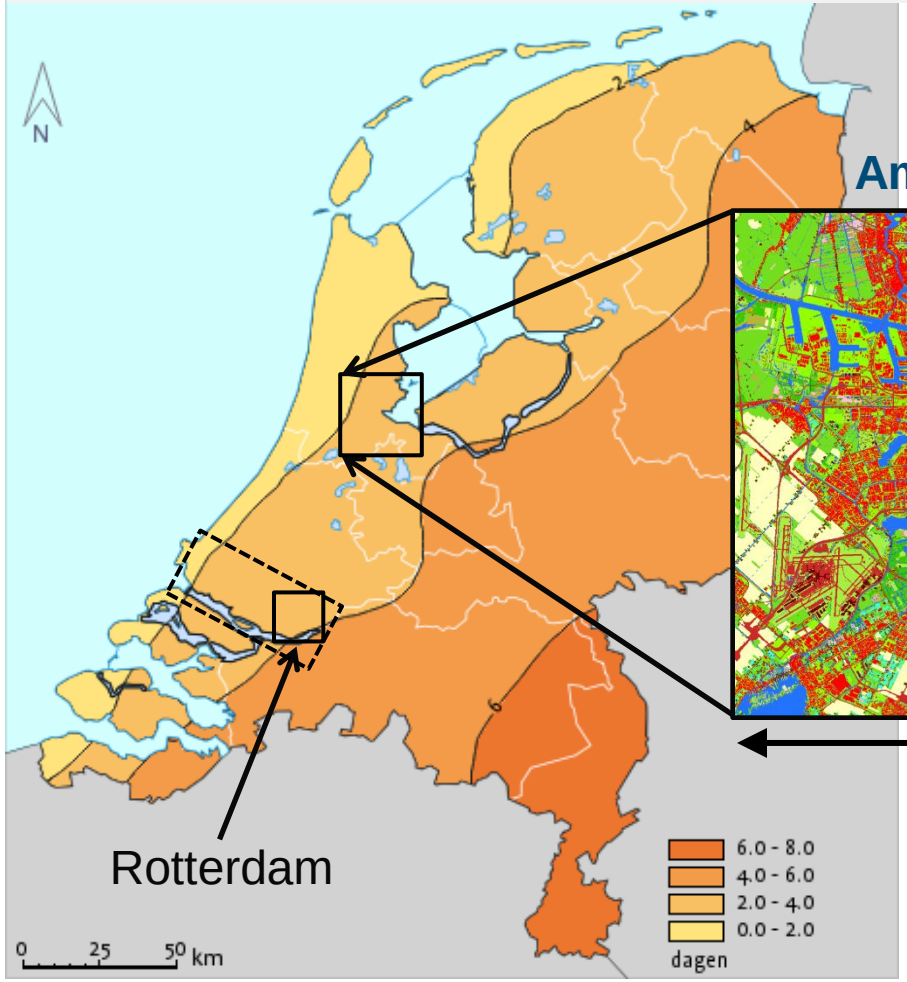
Maximum temperature of 25 °C or higher

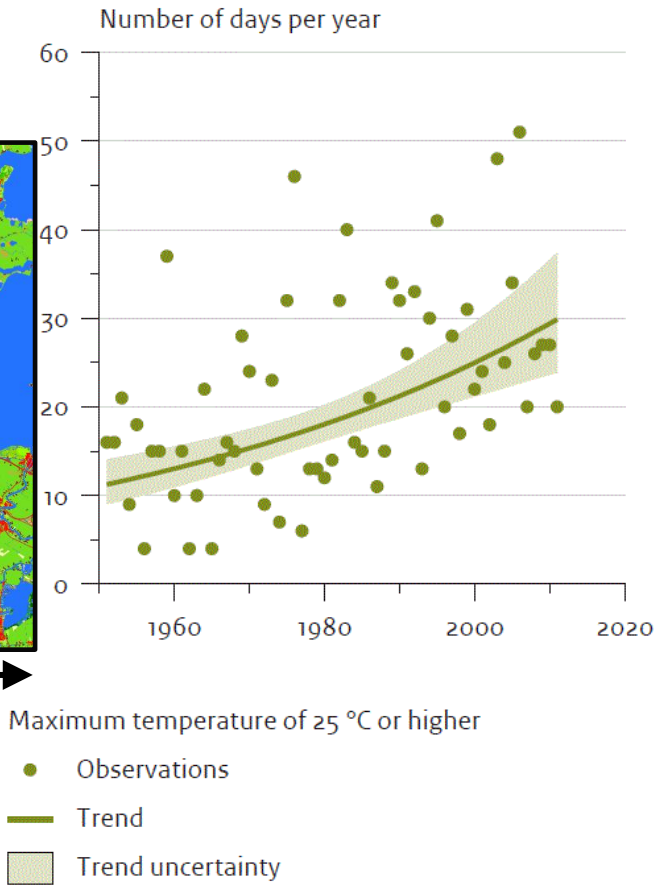
- Observations
- Trend
- Trend uncertainty

Source: KNMI (2011)

Number of tropical days (left) and trend in Summer days in NL (right)

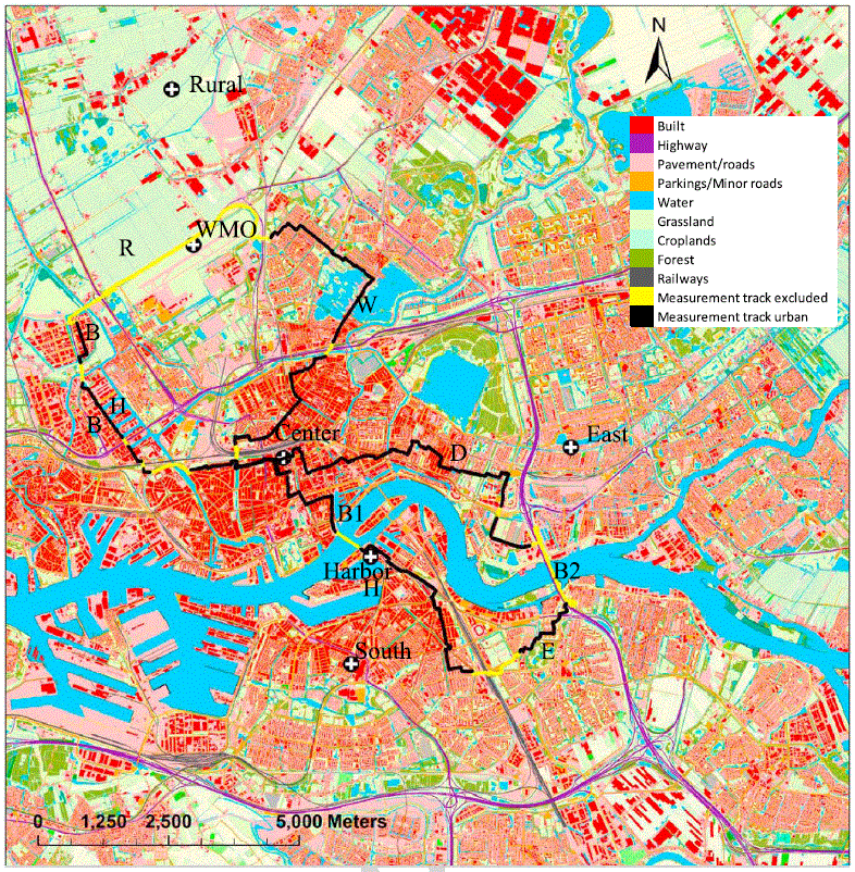
Annual average 1981-2010
Number of days with a max. temperature of 30C

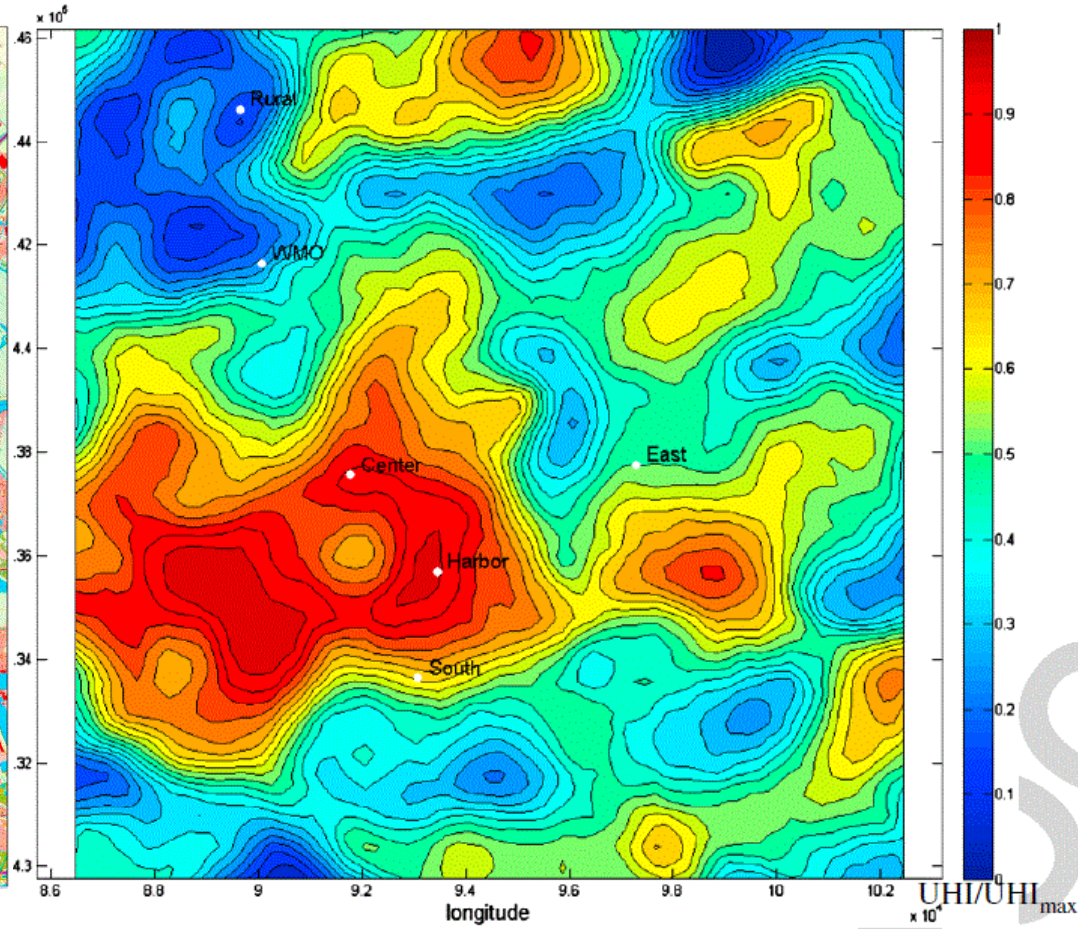




Source: KNMI (2011)

Big cities are urban heat islands (UHI), recent example: Rotterdam





Summer UHI max ~8K

Spatial variability of the Rotterdam urban heat island as influenced by urban land use

Bert G. Heusinkveld,[1] G. J. Steeneveld,[1] L. W. A. van Hove,[1,2] C. M. J. Jacobs,[2] and A. A. M. Holtslag[1]

JOURNAL OF GEOPHYSICAL RESEARCH: ATMOSPHERES, VOL. 118, 1–14, doi:10.1002/2012JD019399, 2013

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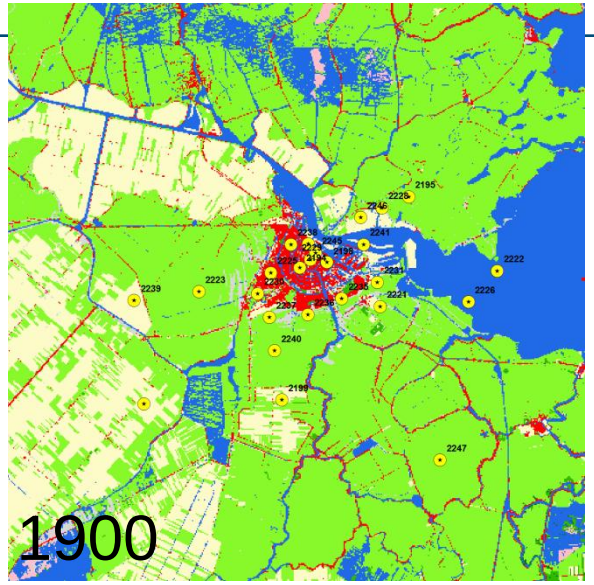
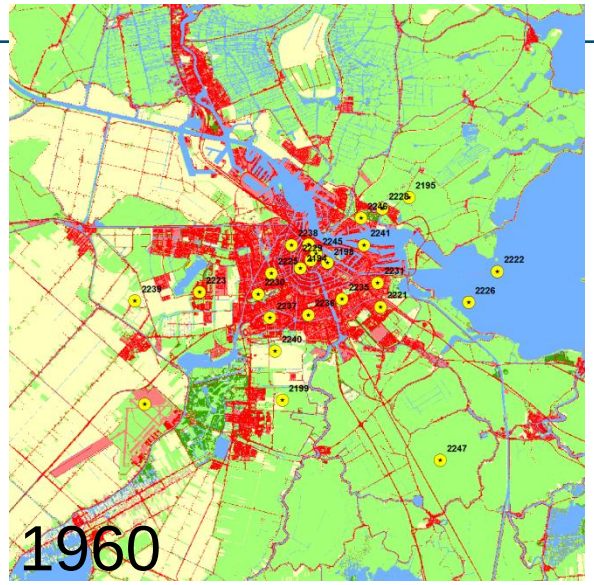
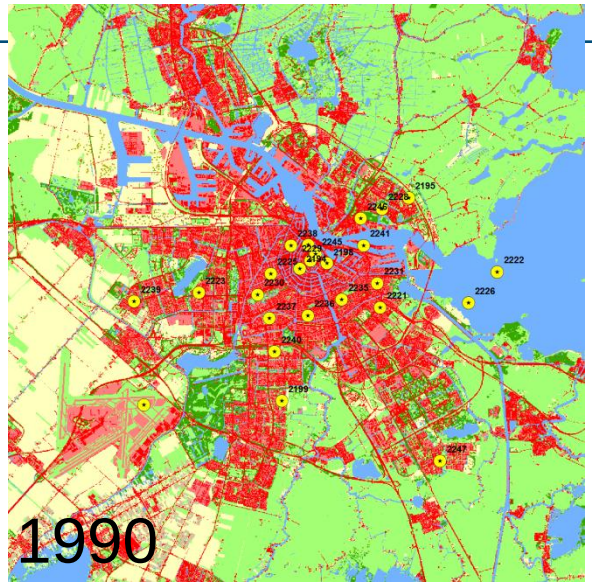
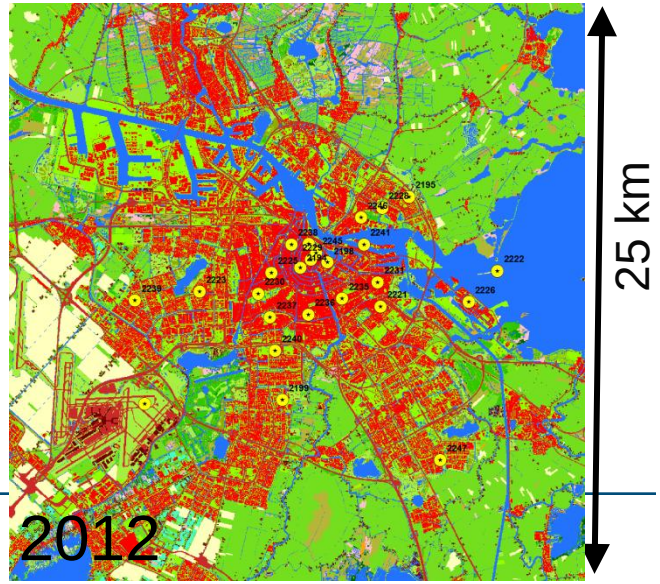
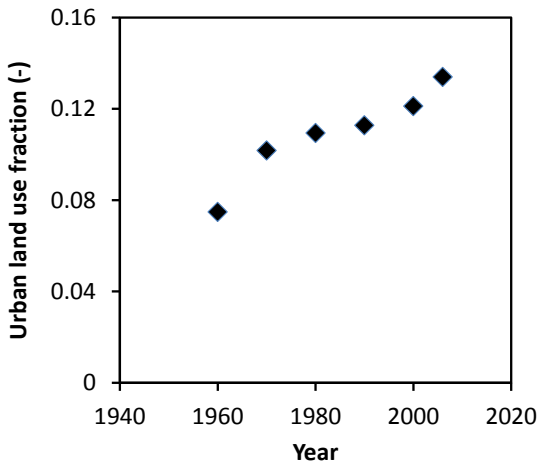
Urbanization Amsterdam











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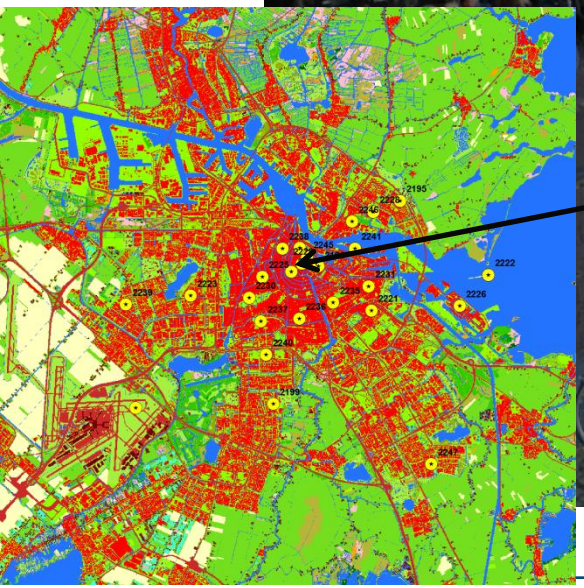
Maps: Land use maps from Kramer H., Hazeu, G., Wageningen UR - Alterra

24 Urban weather stations



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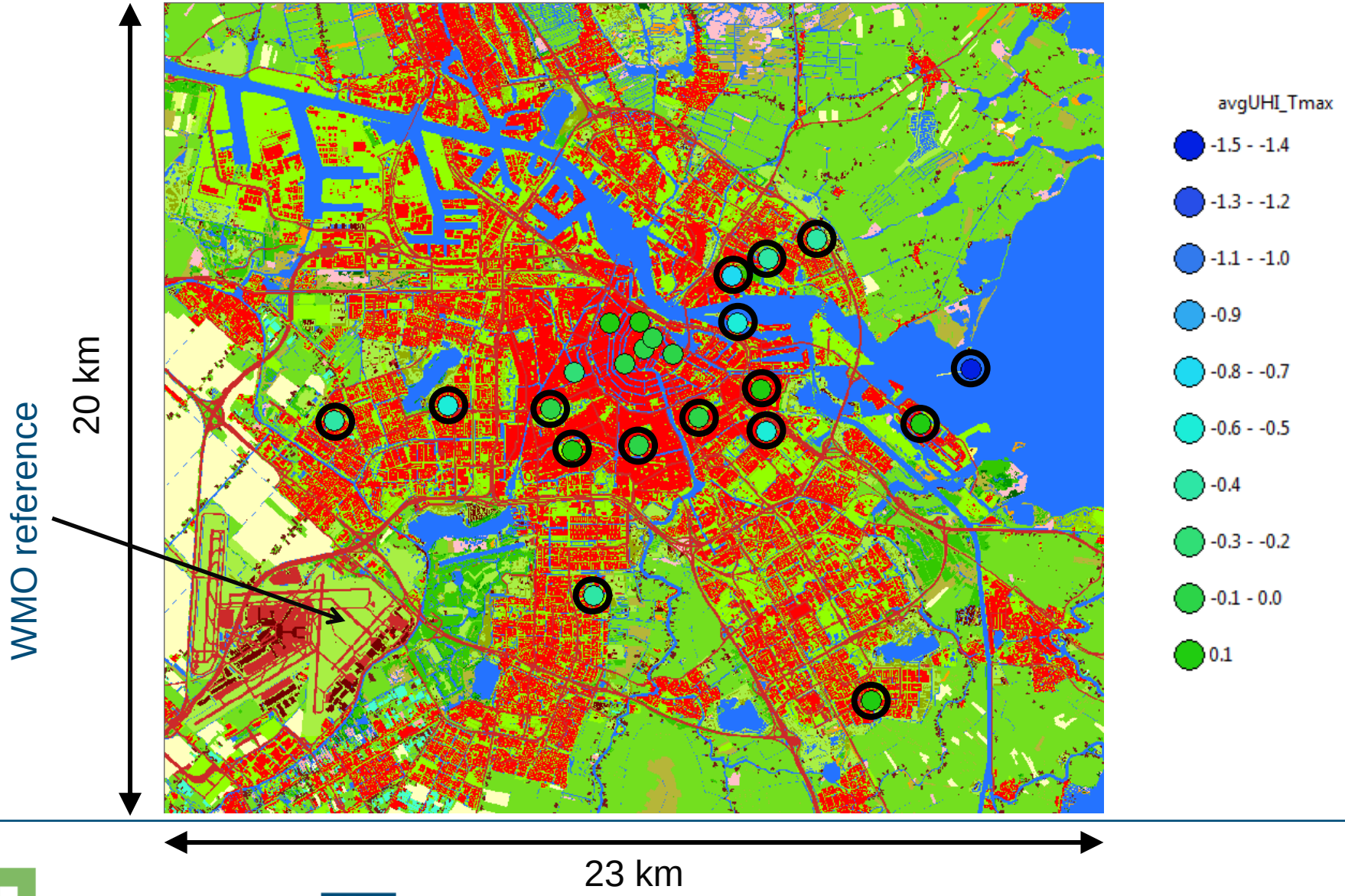
Urban Heat Islands or Urban Cool Islands?

Summer 2014, $\overline{T_{max_urban} - T_{max_wmo}}$



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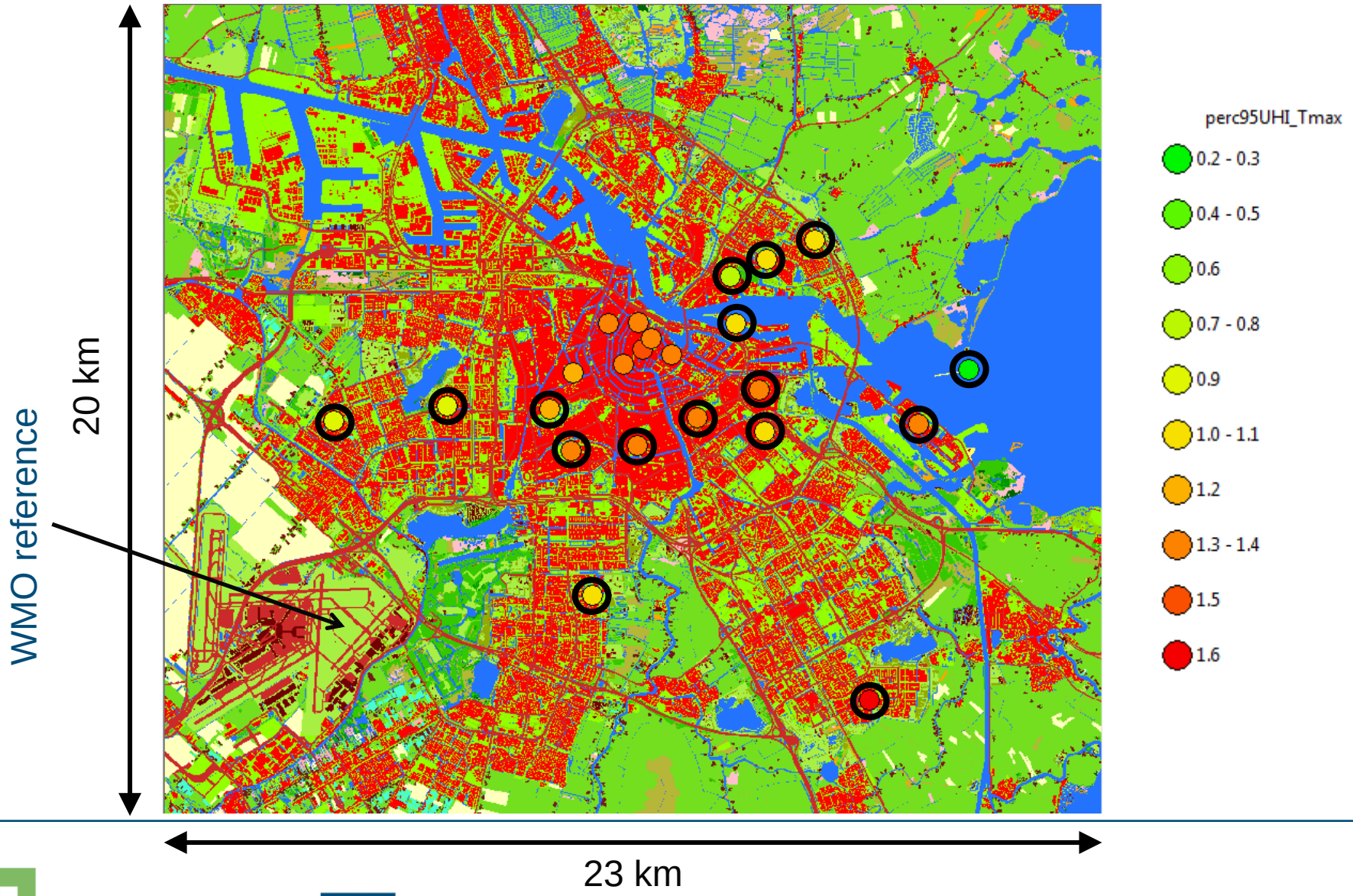
Landuse maps LGN7, 2012, Alterra

Urban Heat Islands or Urban Cool Islands?

Summer 2014, 95percentile(T_{max_urban}-T_{max_wmo})



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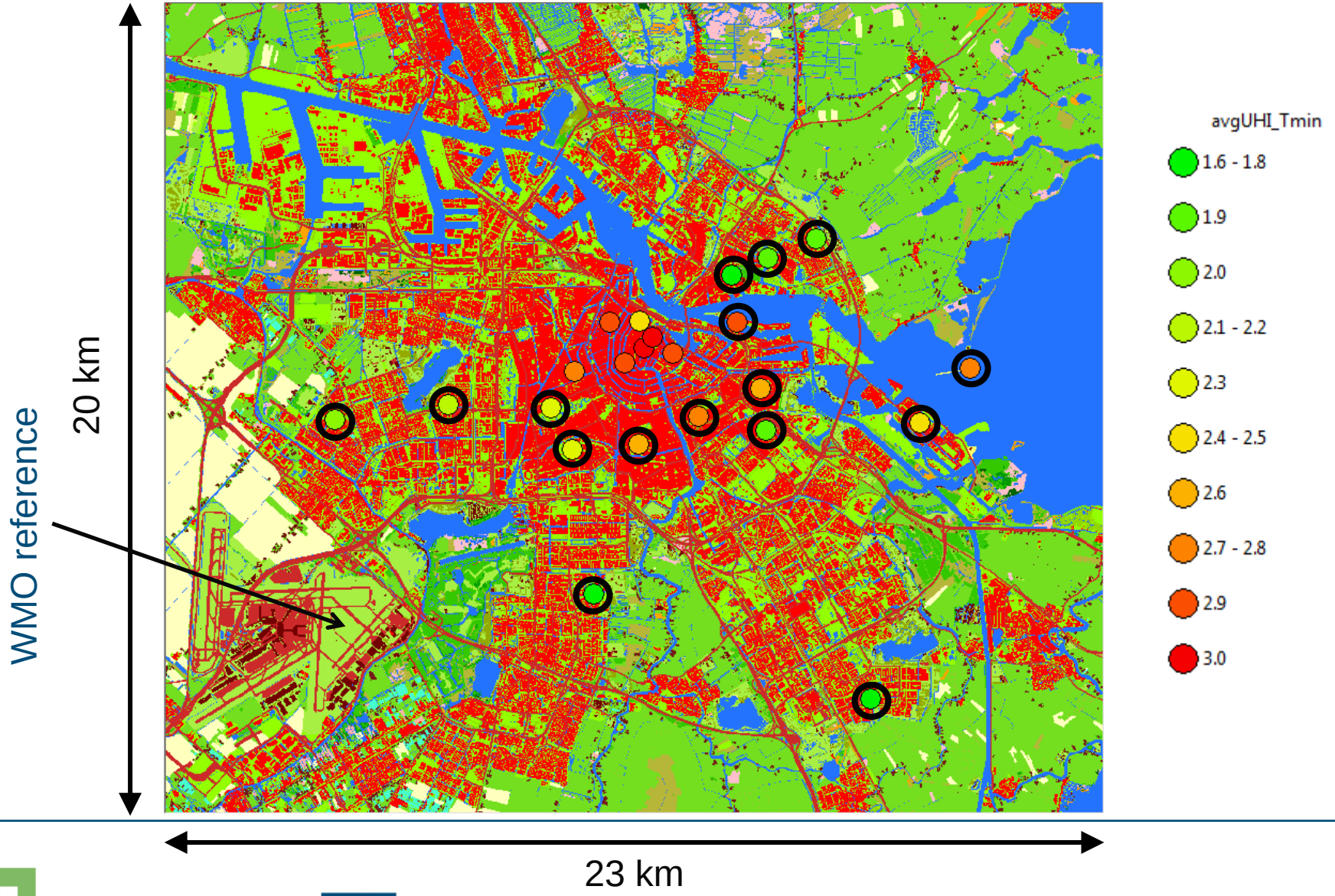
Landuse maps LGN7, 2012, Alterra

Urban Heat Islands or Urban Cool Islands?

Summer 2014, $\overline{T_{min_urban} - T_{min_wmo}}$



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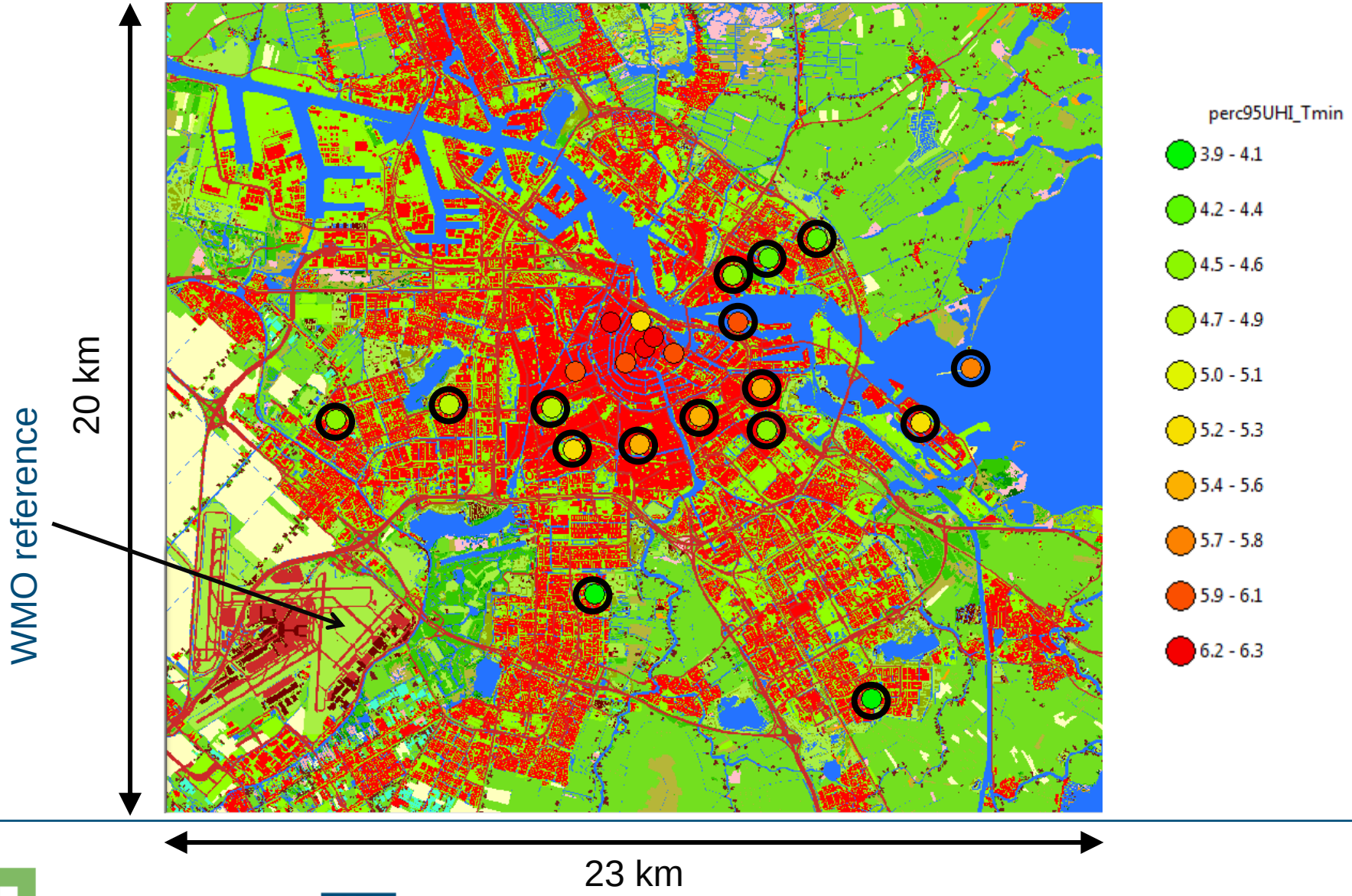
Landuse maps LGN7, 2012, Alterra

Urban Heat Islands

Summer 2014, 95percentile(T_{min_urban}-T_{min_wmo})



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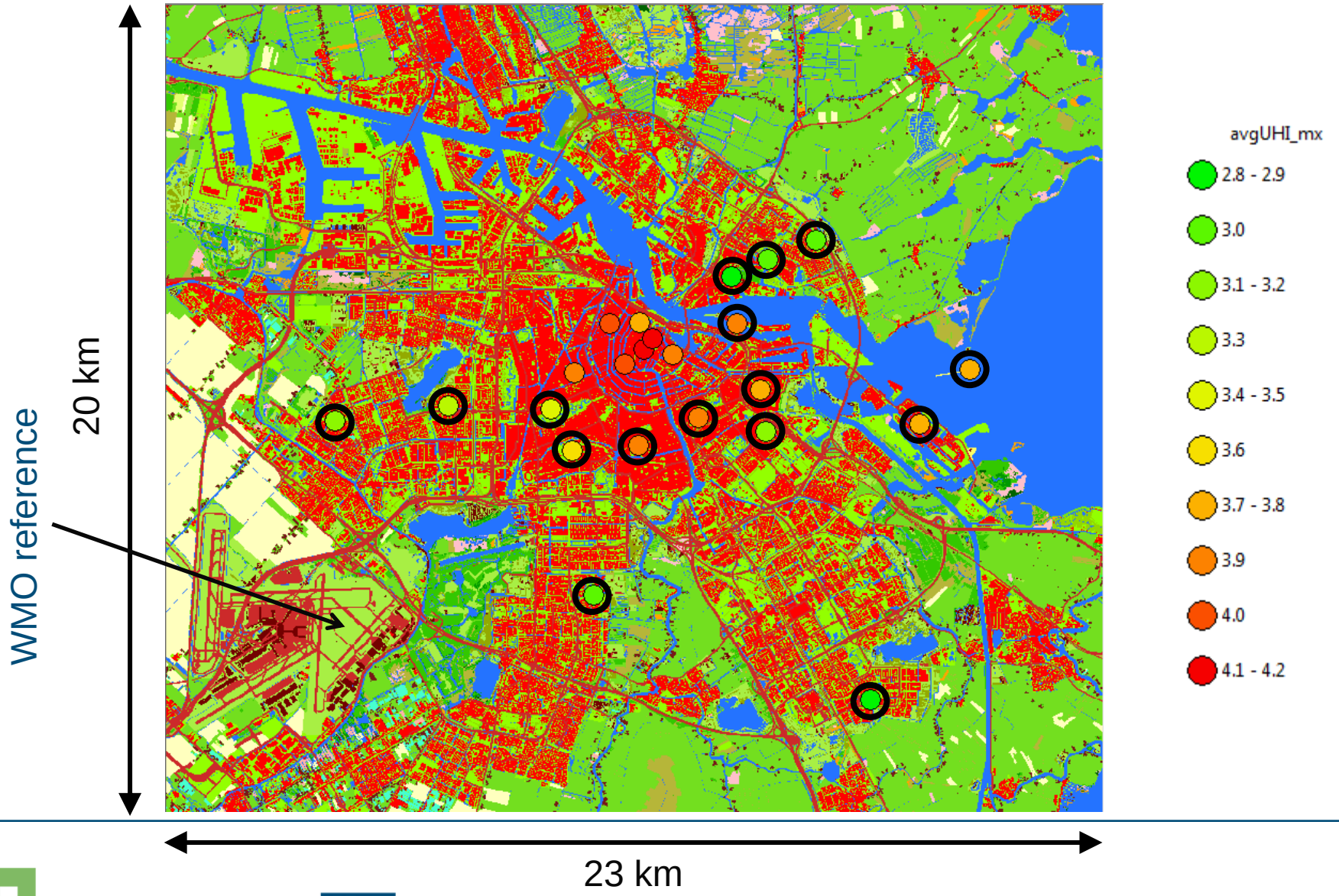
Landuse maps LGN7, 2012, Alterra

Nocturnal Urban Heat Islands

Summer 2014, daily_maximum($\overline{T_{urban}-T_{wmo}}$)



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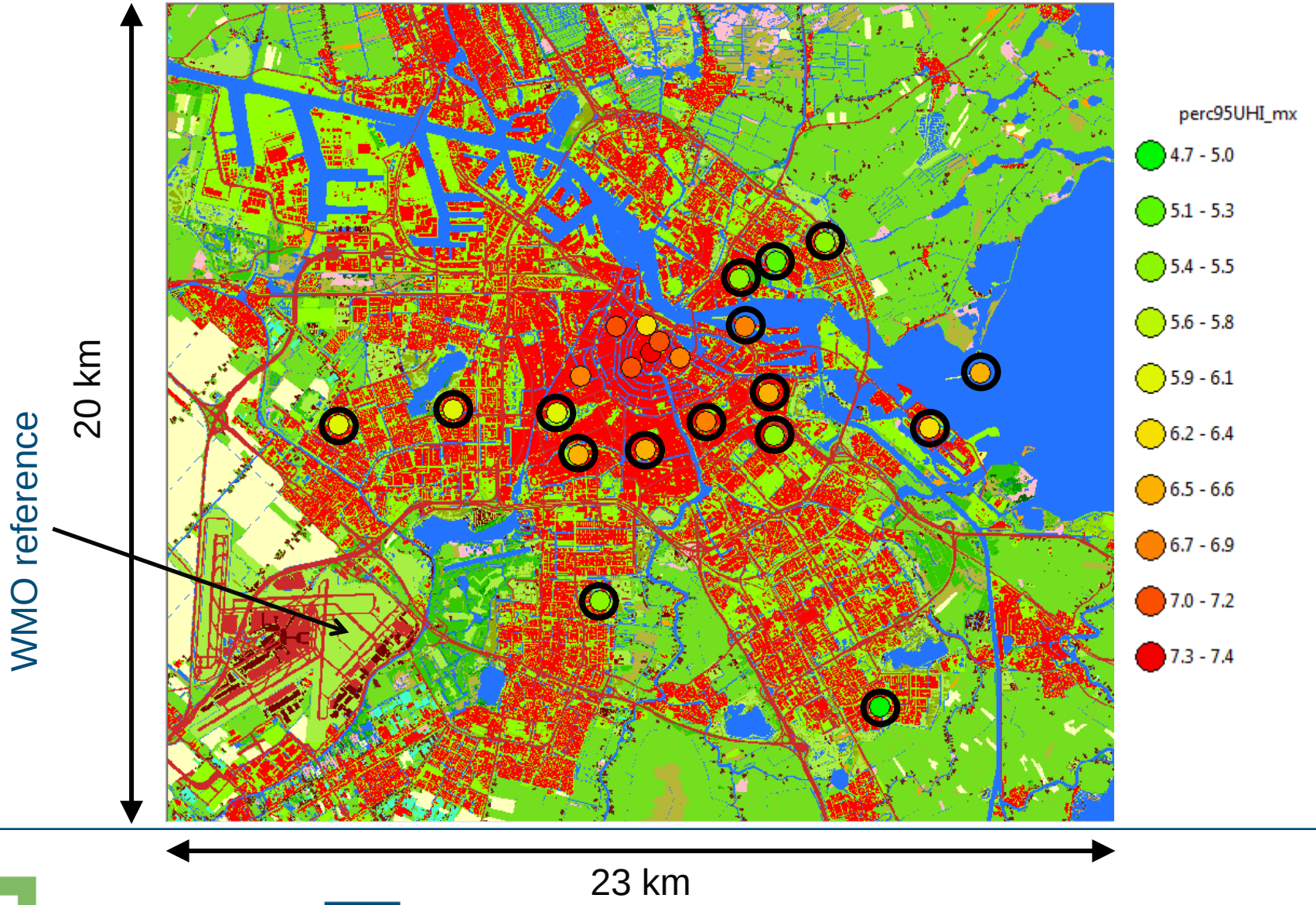
Landuse maps LGN7, 2012, Alterra

Nocturnal Urban Heat Islands

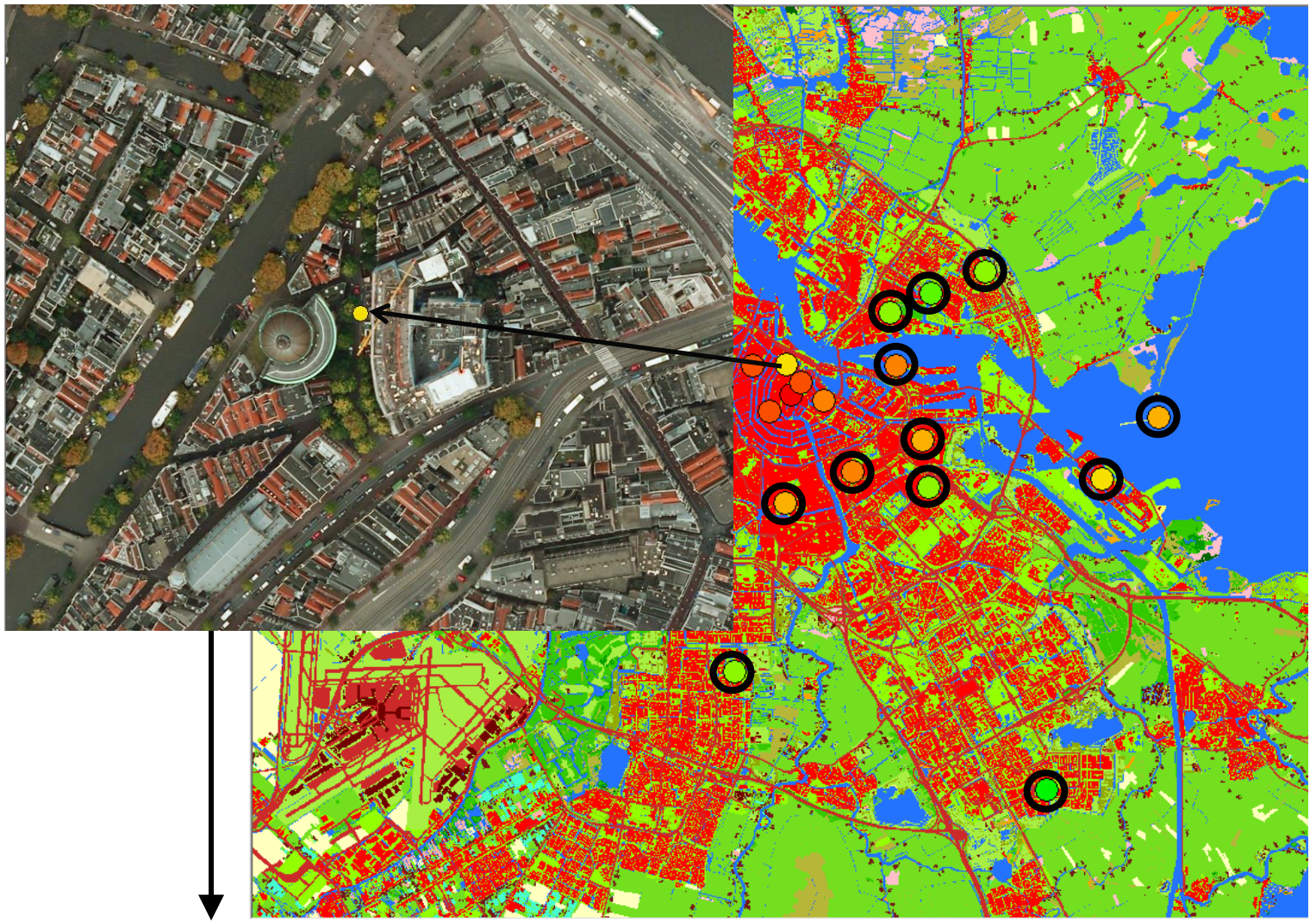
Summer 2014, 95percentile(daily_maximum(T_{urban}-T_{wmo}))



Landuse maps LGN7, 2012, Alterra

Nocturnal Urban Heat Islands

Summer 2014, 95percentile(daily_maximum(T_{urban}-T_{wmo}))



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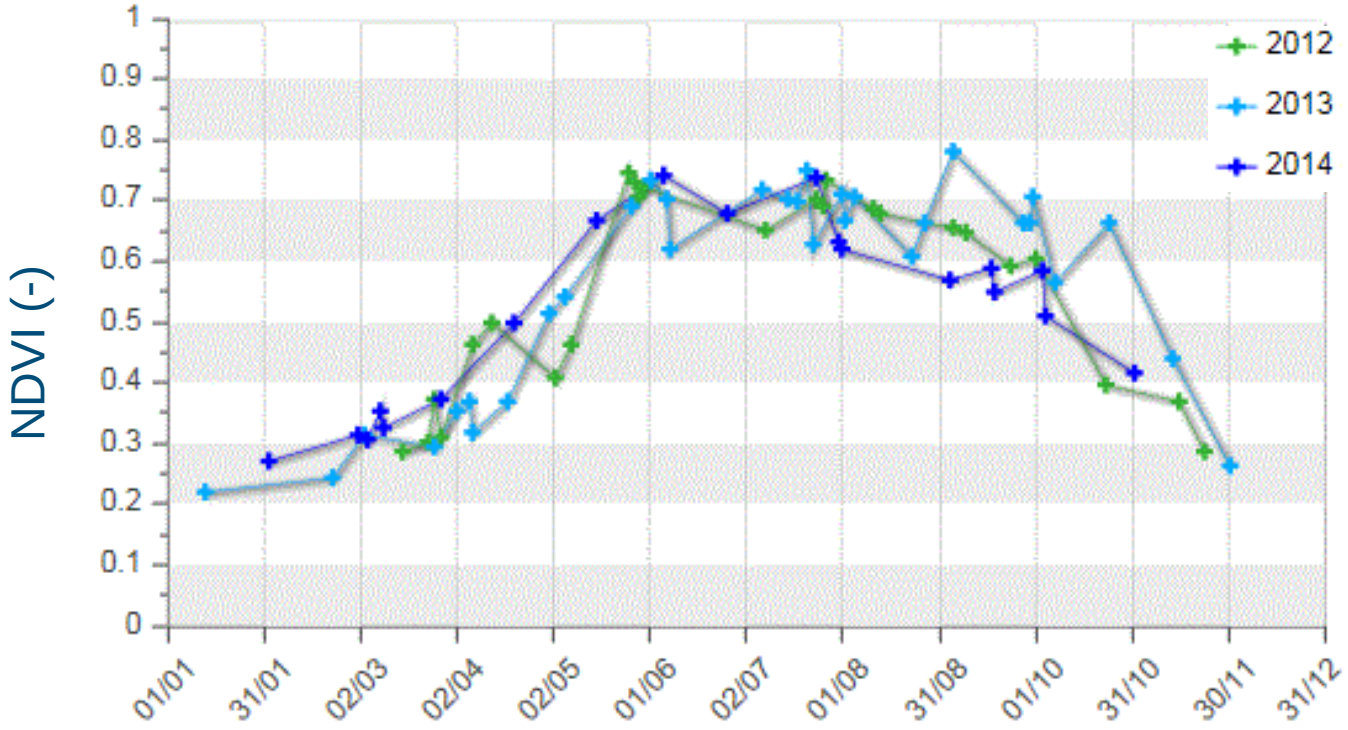
Landuse maps LGN7, 2012, Alterra

Fenology of vegetation, detection from space to quantify urban vegetation



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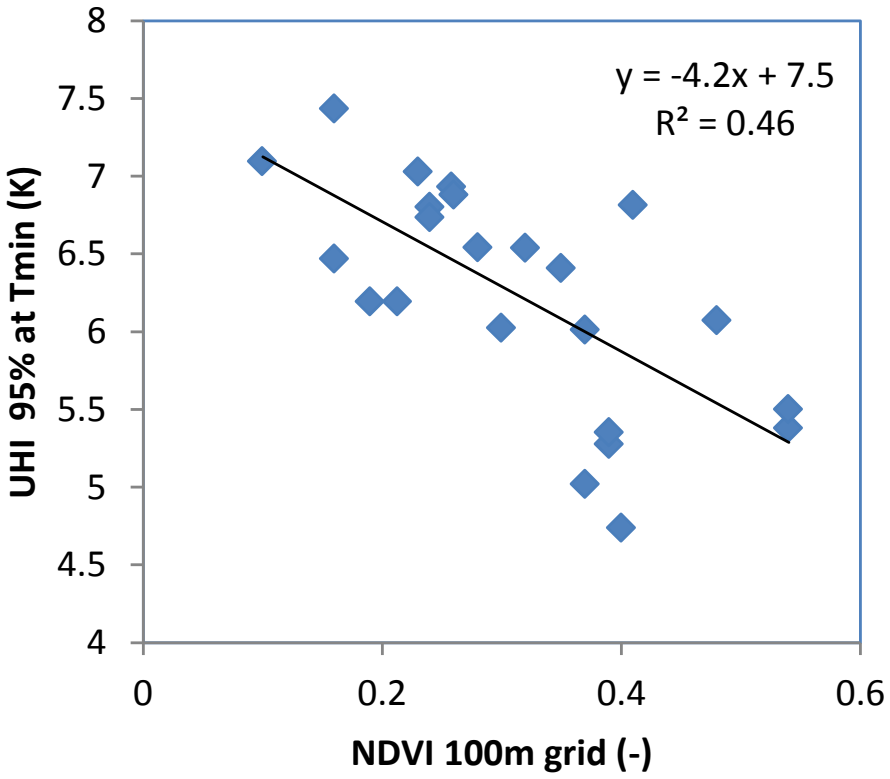
"Groenmonitor", initiative of Alterra, Wageningen UR, the Netherlands. Gerbert Roerink & Sander Mucher,
Satellites: Formosat (8m), DMC (22m), Landsat7-ETM

Land-use and nocturnal UHI in Amsterdam



Cargo bicycle measures human thermal comfort, importance of radiation (direct measurement of T_{mrt})

Air temperature, humidity (aspirated screen)

GPS: location, time, speed

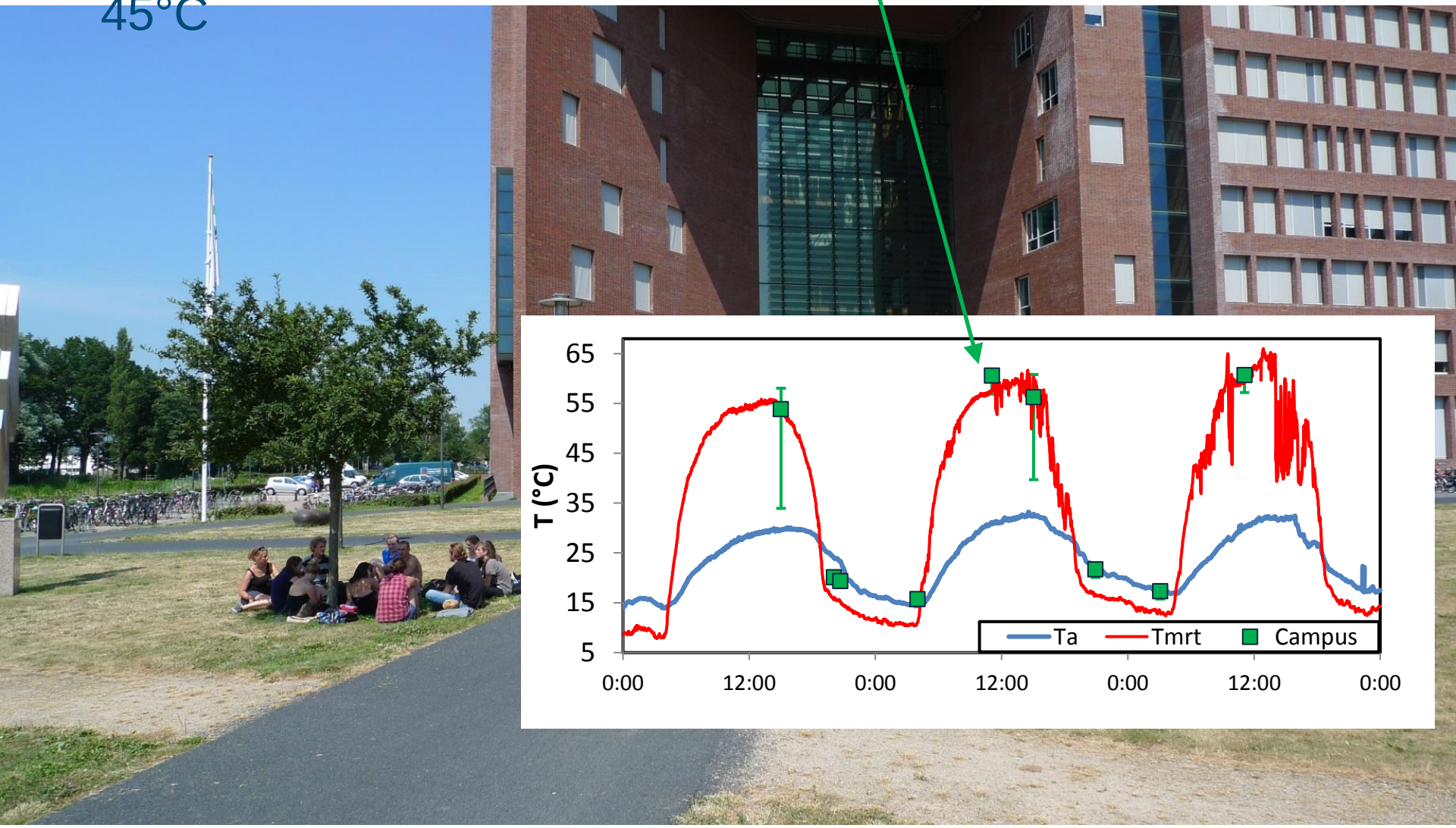
Wind speed, -direction

Radiation

Radiation

Wheel speed

Campus at 22 July 2013, 11 UTC: T_{mrt}: 62°C, PET: 45°C



Similar values at Campus and rural station, but not the extremes

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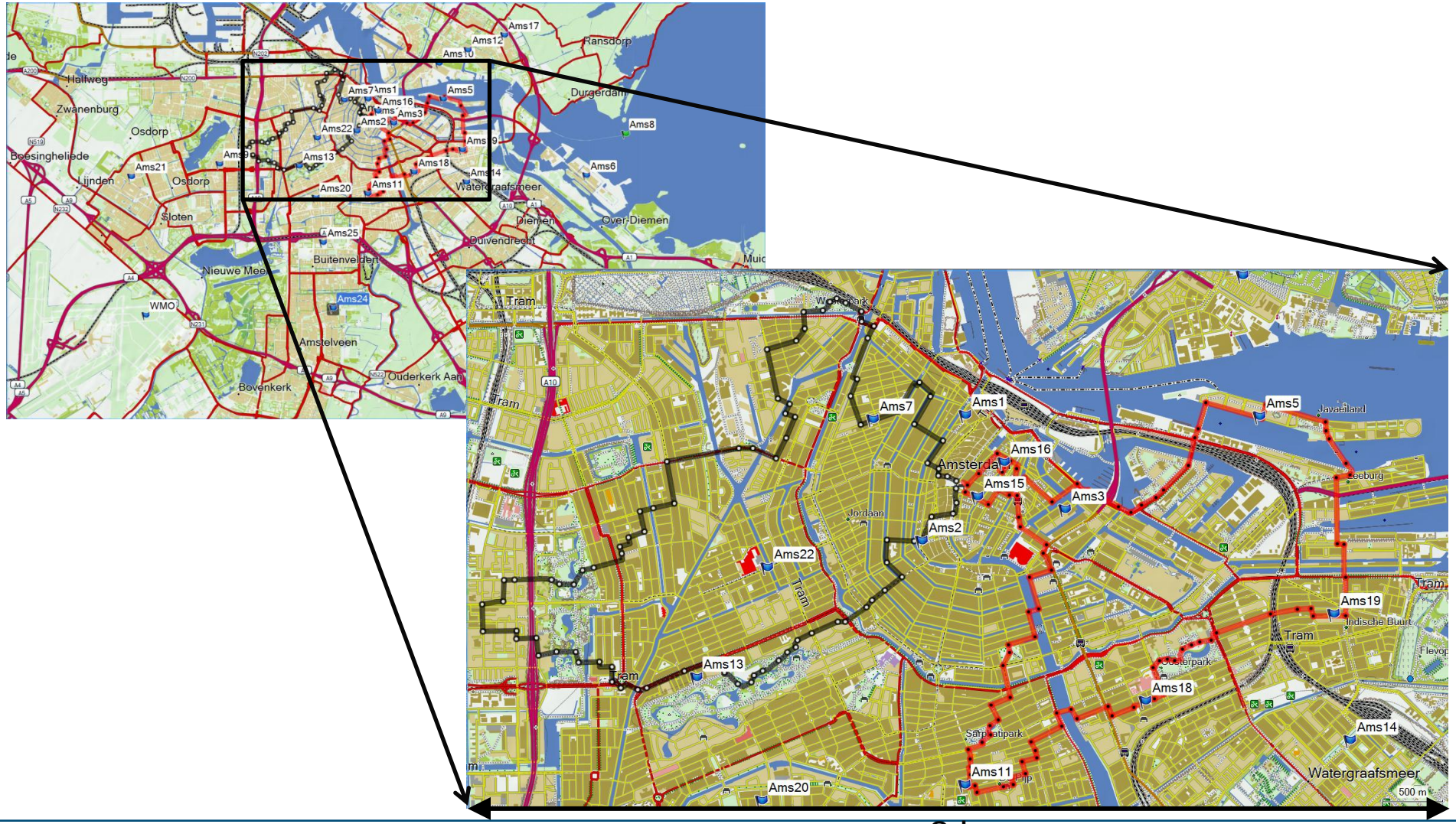
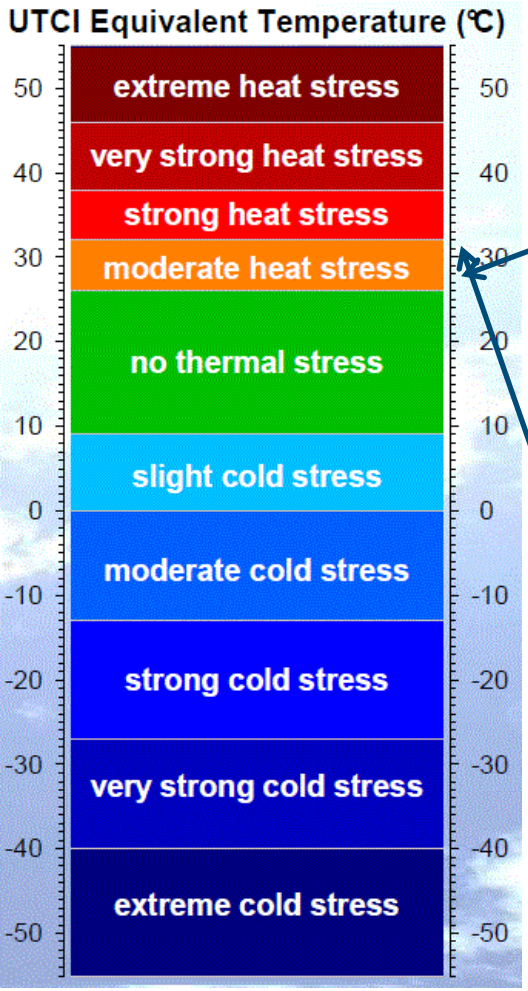
2 bicycle measurement tracks



Real-time thermal comfort measurements in Amsterdam



Universal Thermal Climate Index (UTCI) scale: www.utci.org

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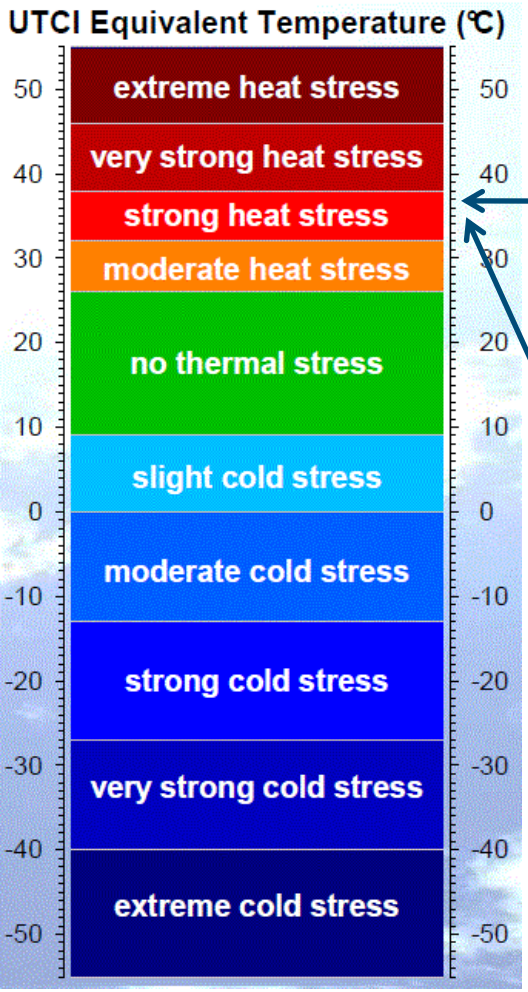
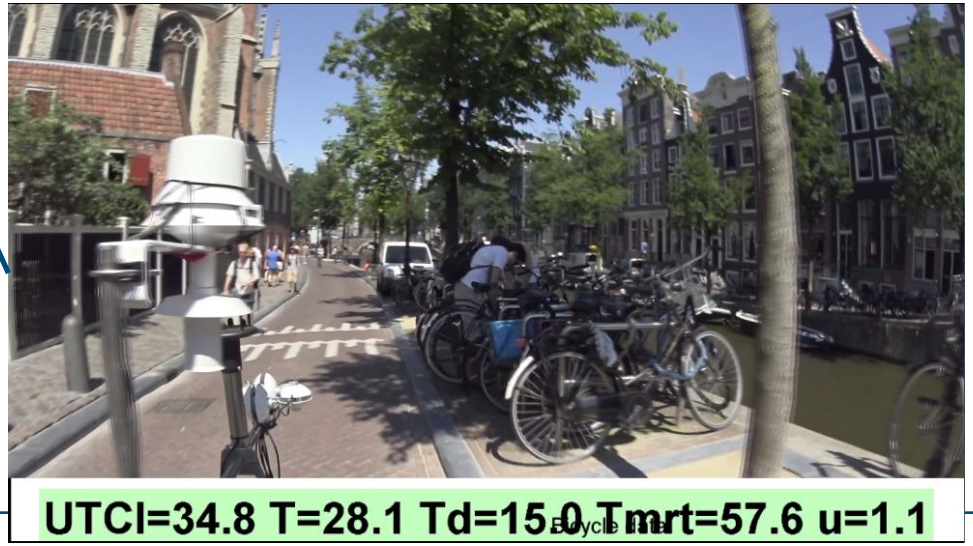
Real-time thermal comfort measurements in Amsterdam





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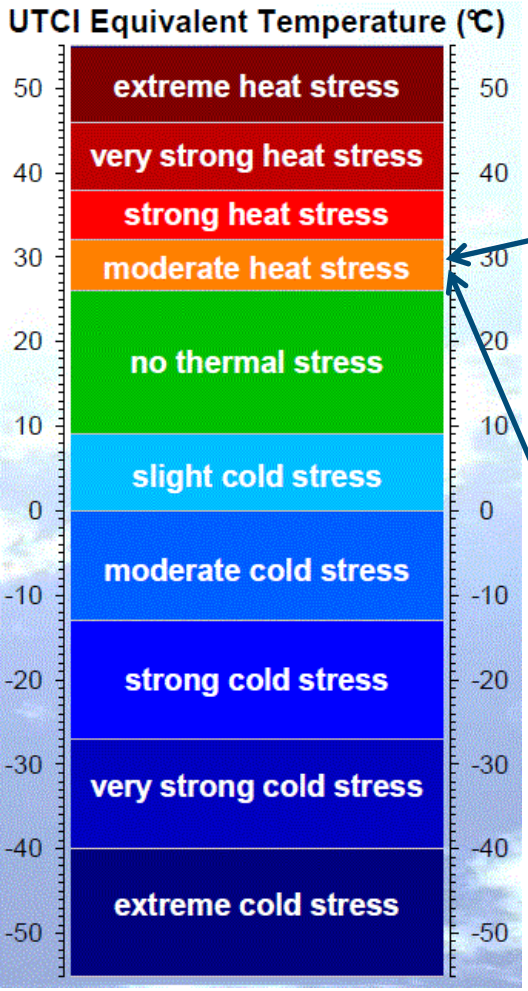
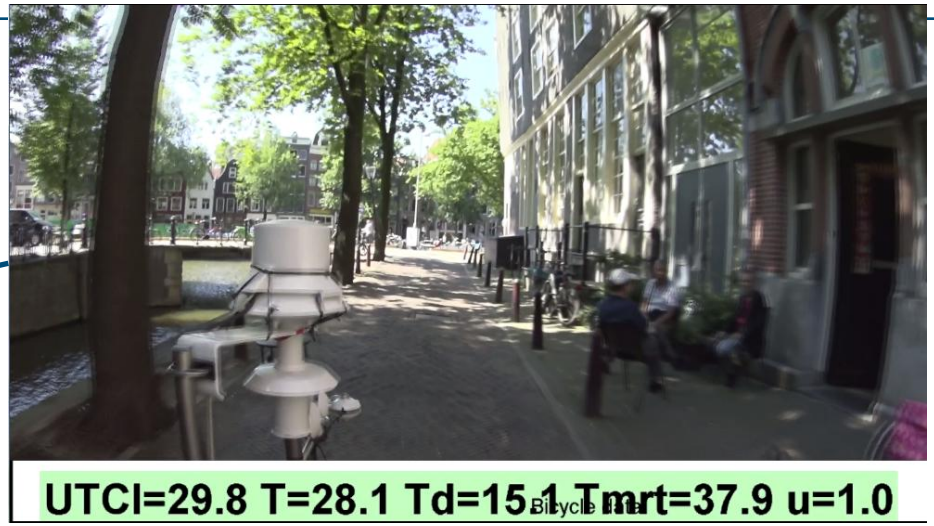
Real-time thermal comfort measurements in Amsterdam





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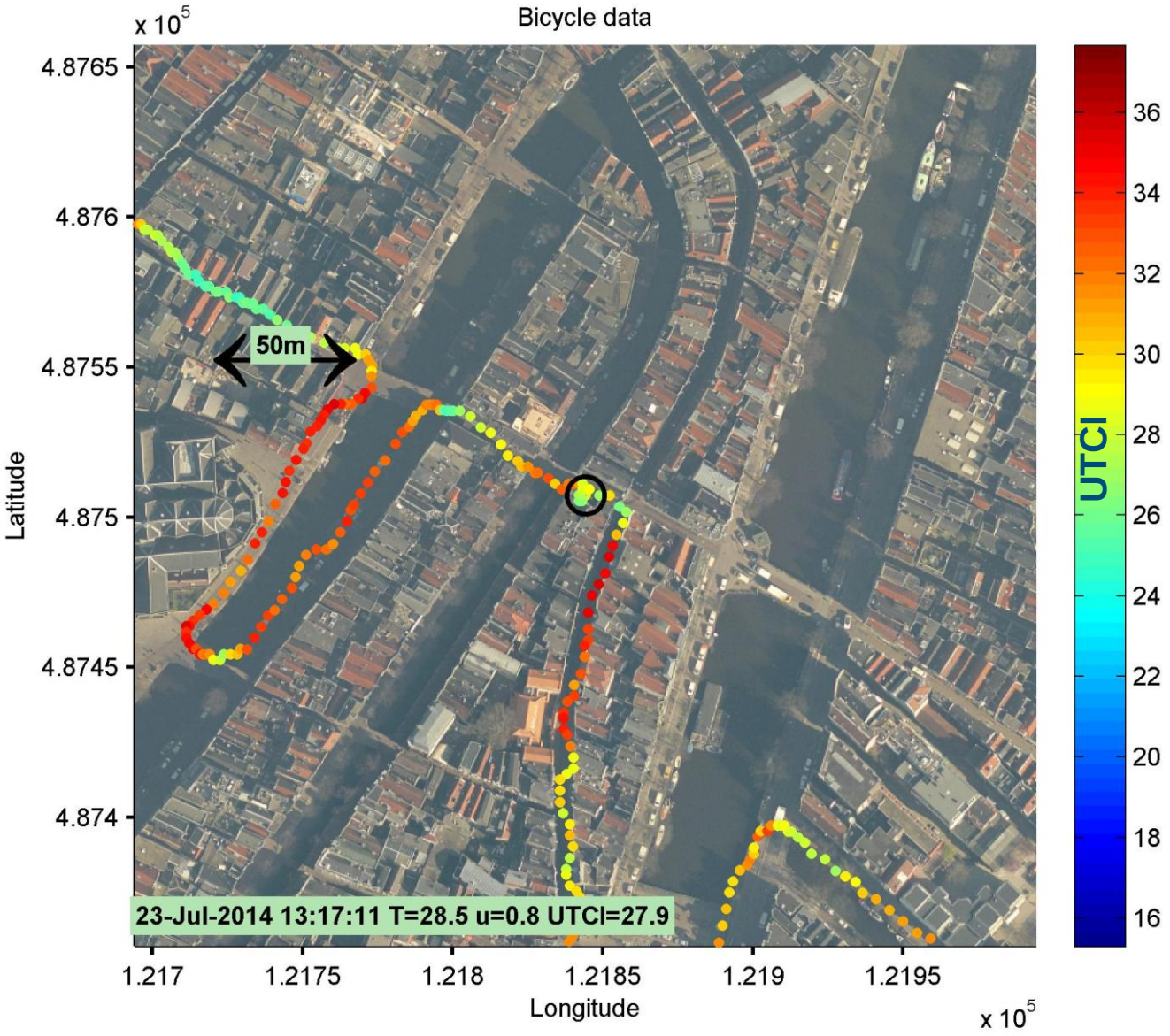
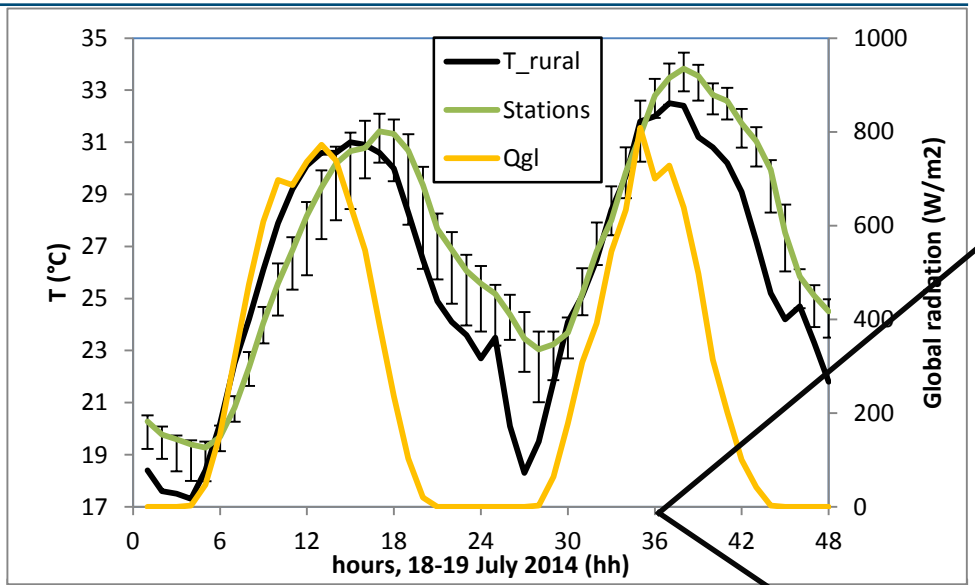
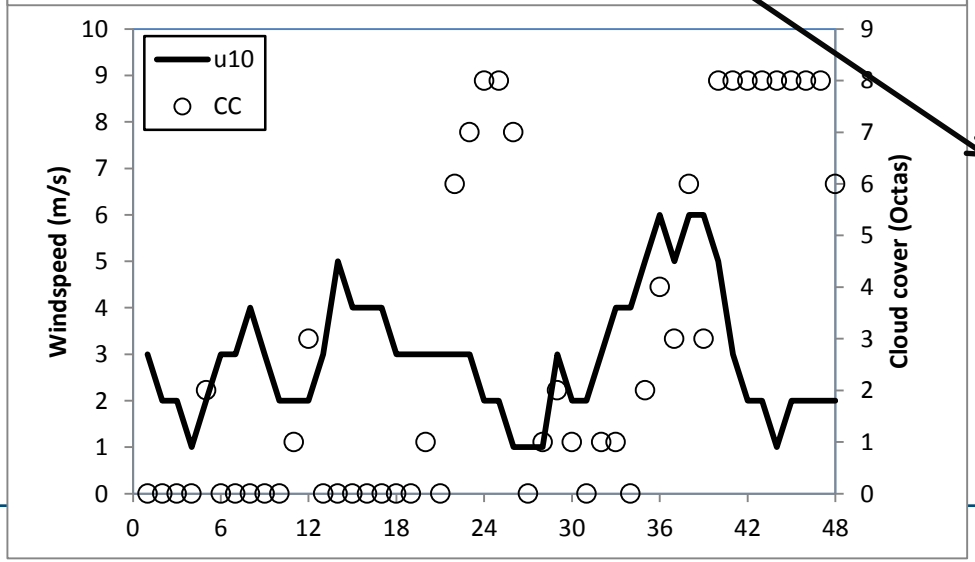
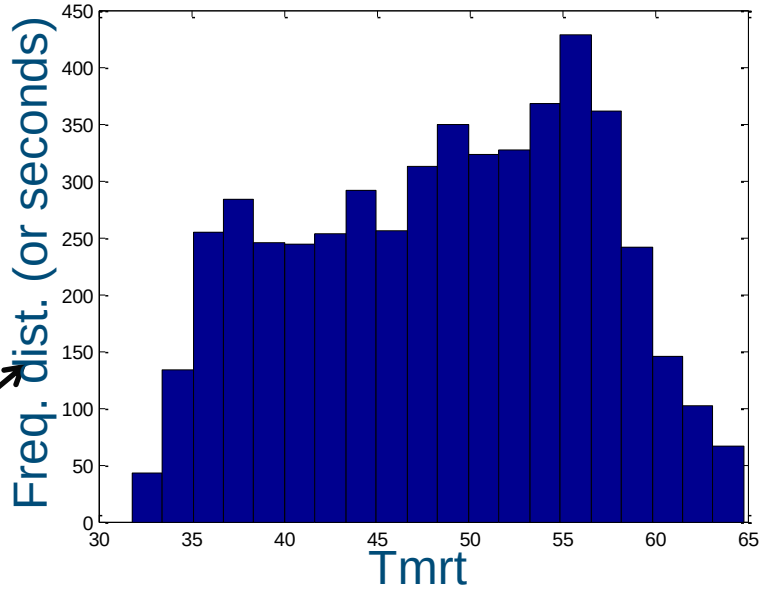
Real-time thermal comfort measurements in Amsterdam

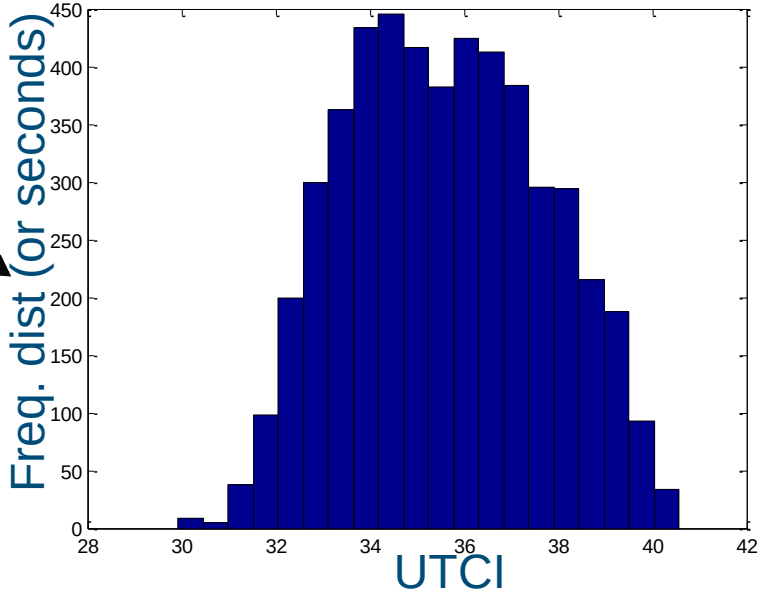


Amsterdam (18-19 July 2014)









19 July 11:00-12:22
(Moderate to very strong heatstress)

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App development: Forecasting Thermal comfort in a complex environment

The idea is to present a location specific 3 h weather forecast of human thermal comfort up to 36 h ahead.

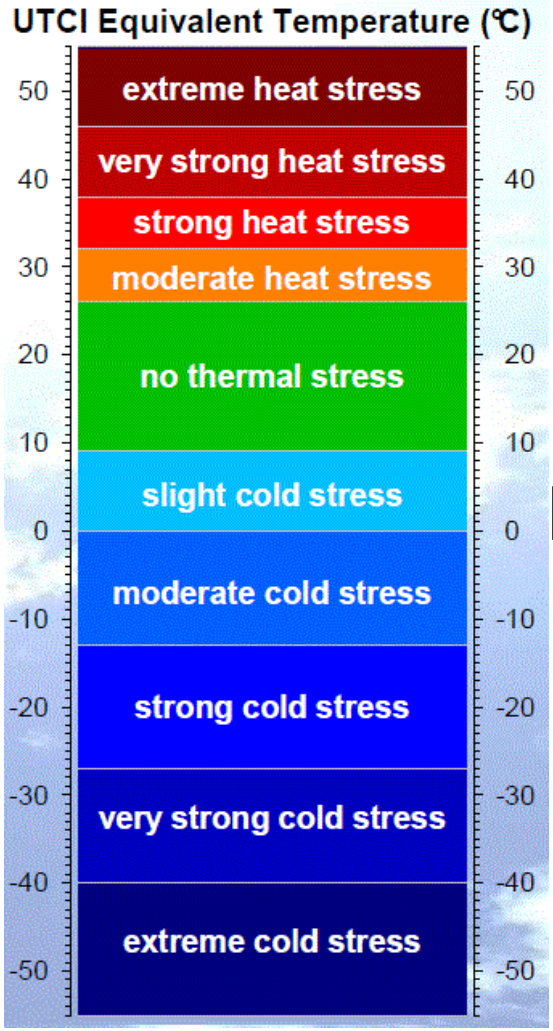
Requirements:

- Use of a modern thermal comfort scale:
  UTCI (Universal Thermal Climate Index)
- No numbers (only a colour scale)
- Thermal stress levels as text (UTCI scale)
- Includes land-use effects (temperature, wind speed, radiation)

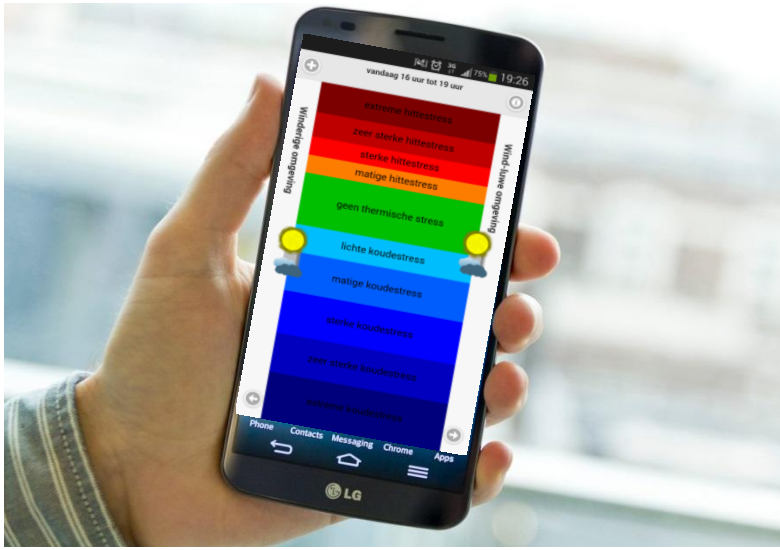
Based on:

- Thermal comfort measurements/analysis: Bert Heusinkveld, session NONTM11
- WRF simulation: Reinder Ronda, session TUKUP4
- Land-use map 25 m resolution: Jisk Attema, session GD5
- Global model forecast: GFS, NCEP, U.S.A.
- Technical realisation: Master student Gert Sterenborg

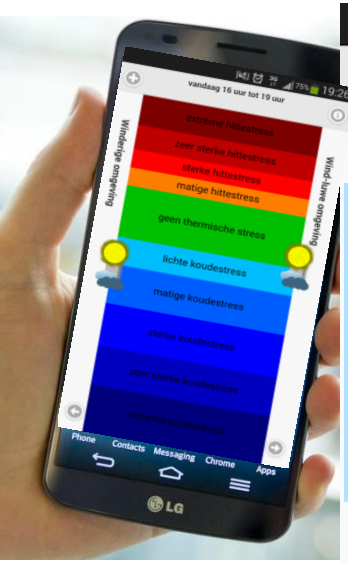
App Thermal comfort

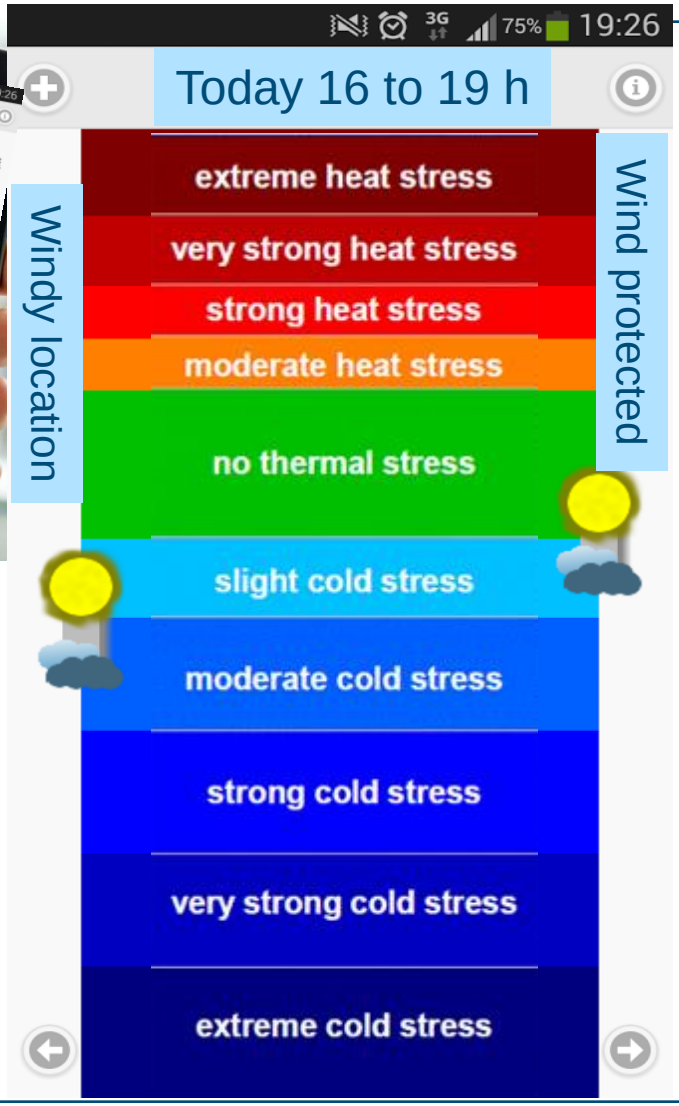


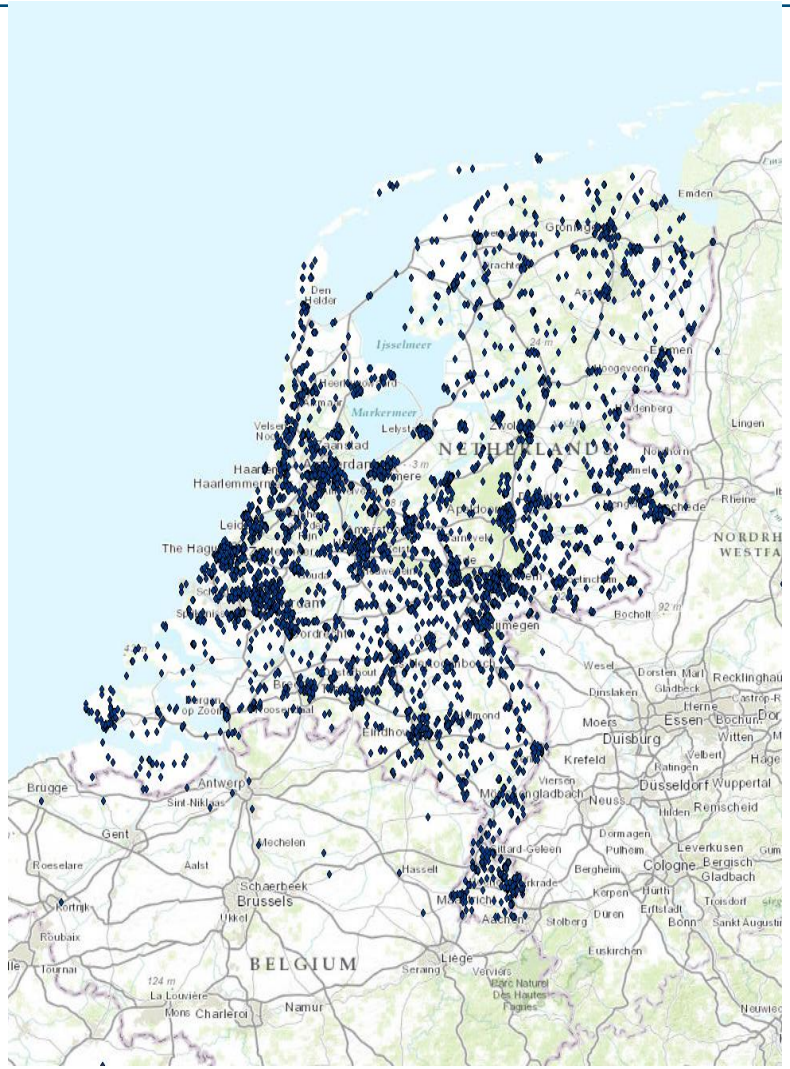
1. Use location data Smartphone
2. Download forecast
3. Display forecast
   - Add symbol sun
   - Wind/obstructed



App: Thermal comfort







Concluding remarks

Urban space during heat wave conditions:

- *Amsterdam has a substantial nocturnal urban heat island effect (canals don't help)*
- *Thermal comfort varies strongly among built up areas*
- *Parks with short vegetation are urban hot spots (during daytime)*
- *Narrow street canyons can be more thermally comfortable than a WMO weather station location (air temperature and UTCI)*

Thank you for your attention!

BERT.HEUSINKVELD@WUR.NL

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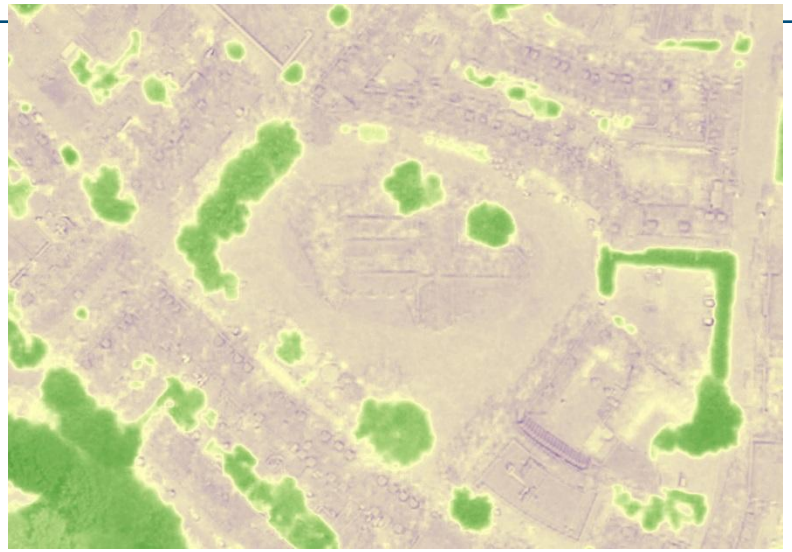
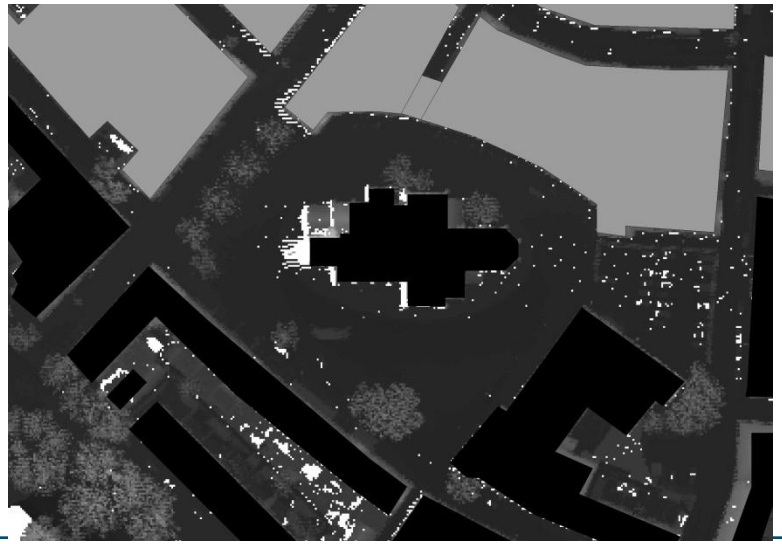
Very detailed geographical data available

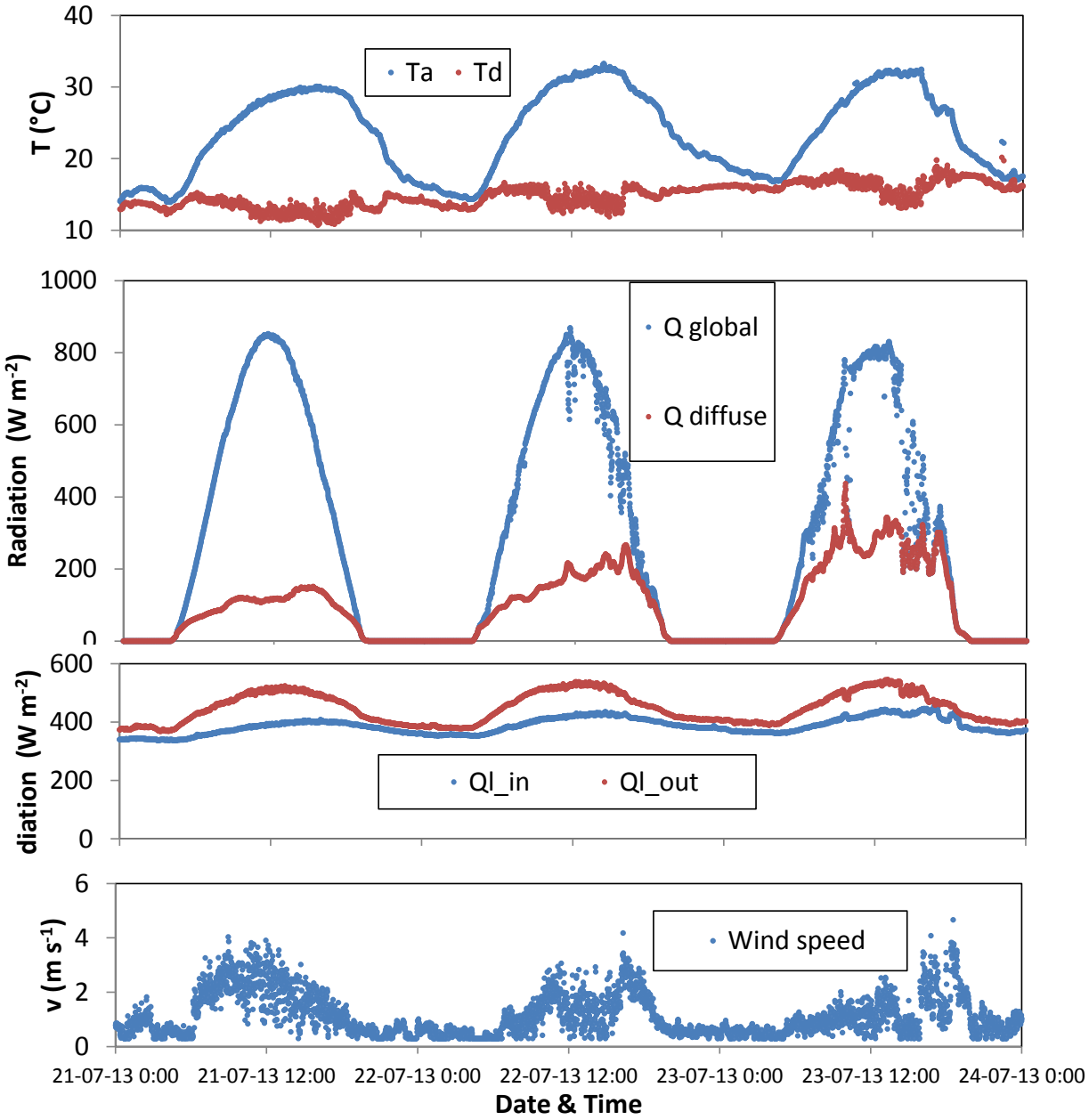




Lidar altimetry map: Waterschapshuis Rijkswaterstaat the Netherlands
Aerial photographs: Aerodata

Heat wave July 2013

Observations Rural station



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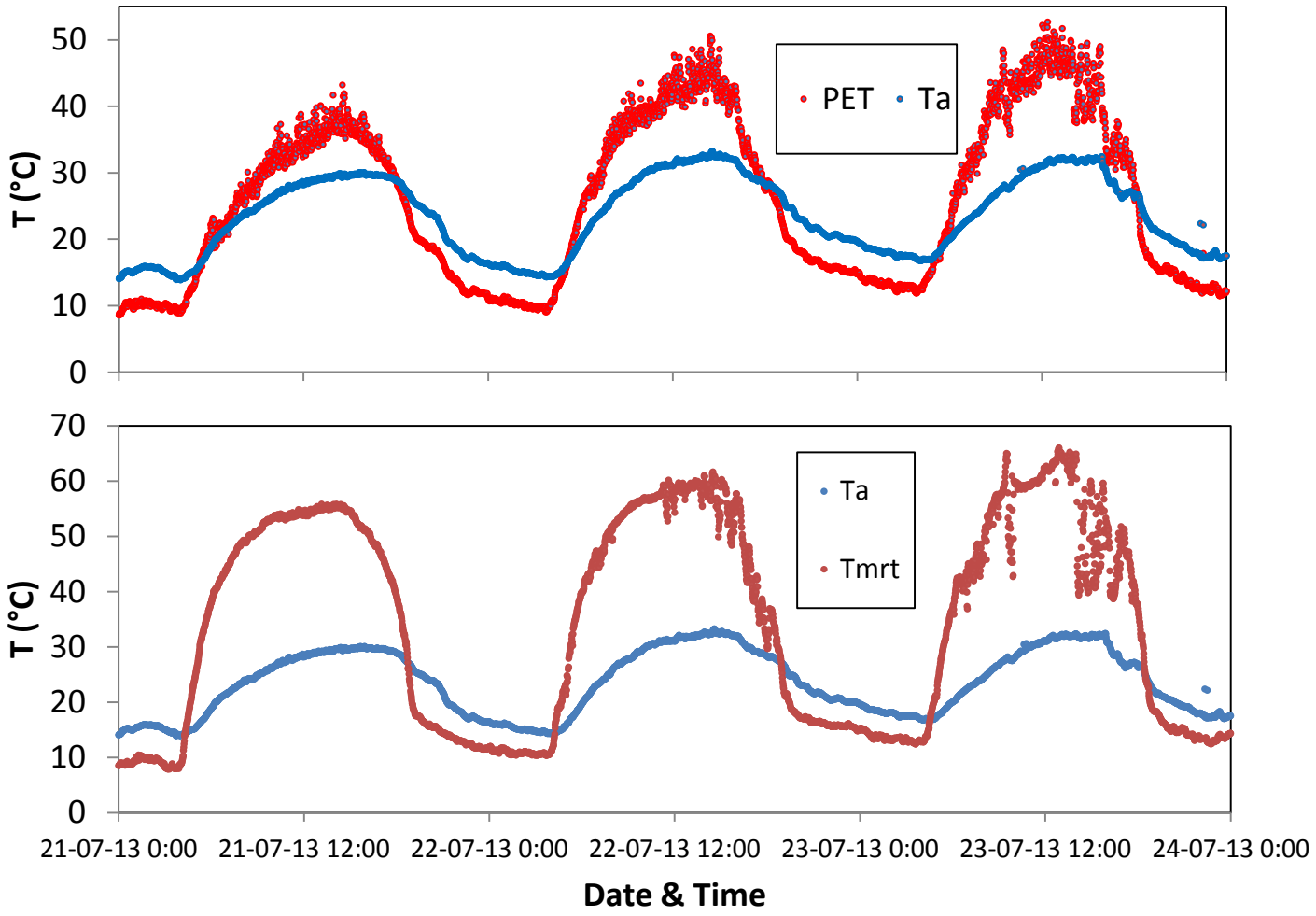
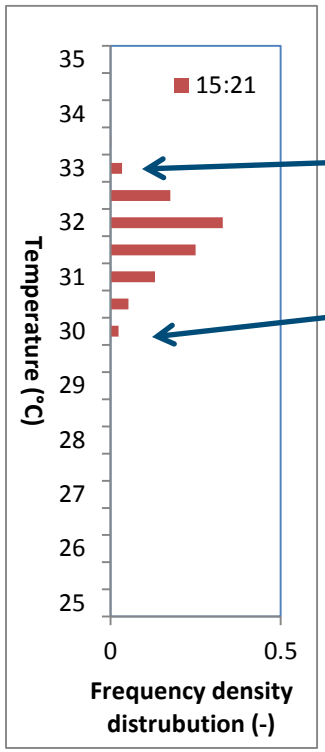
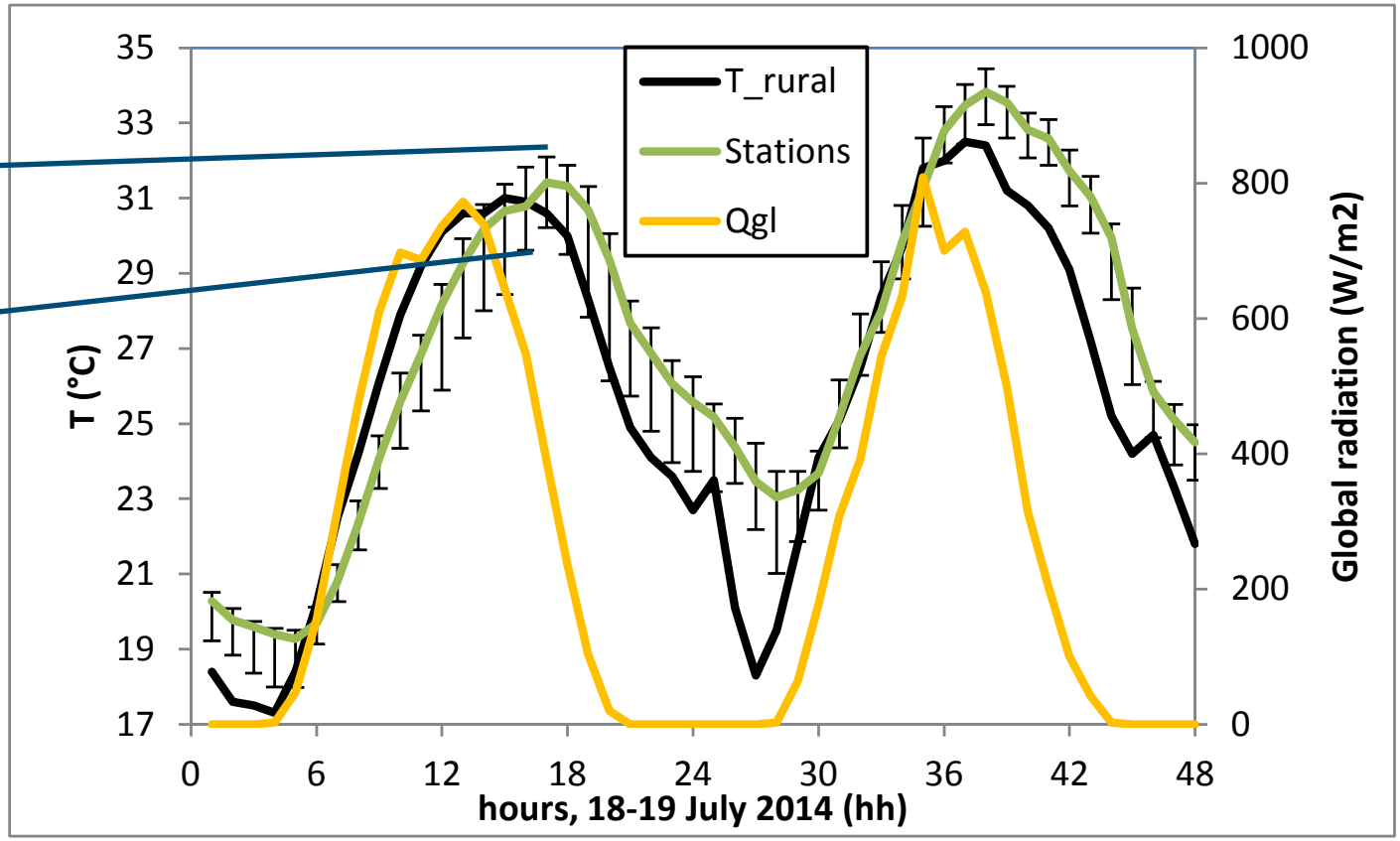
Mean radiant temperature and PET, rural station



PET: Calculated with a human thermal energy balance model Rayman (Matzarakis et al.)

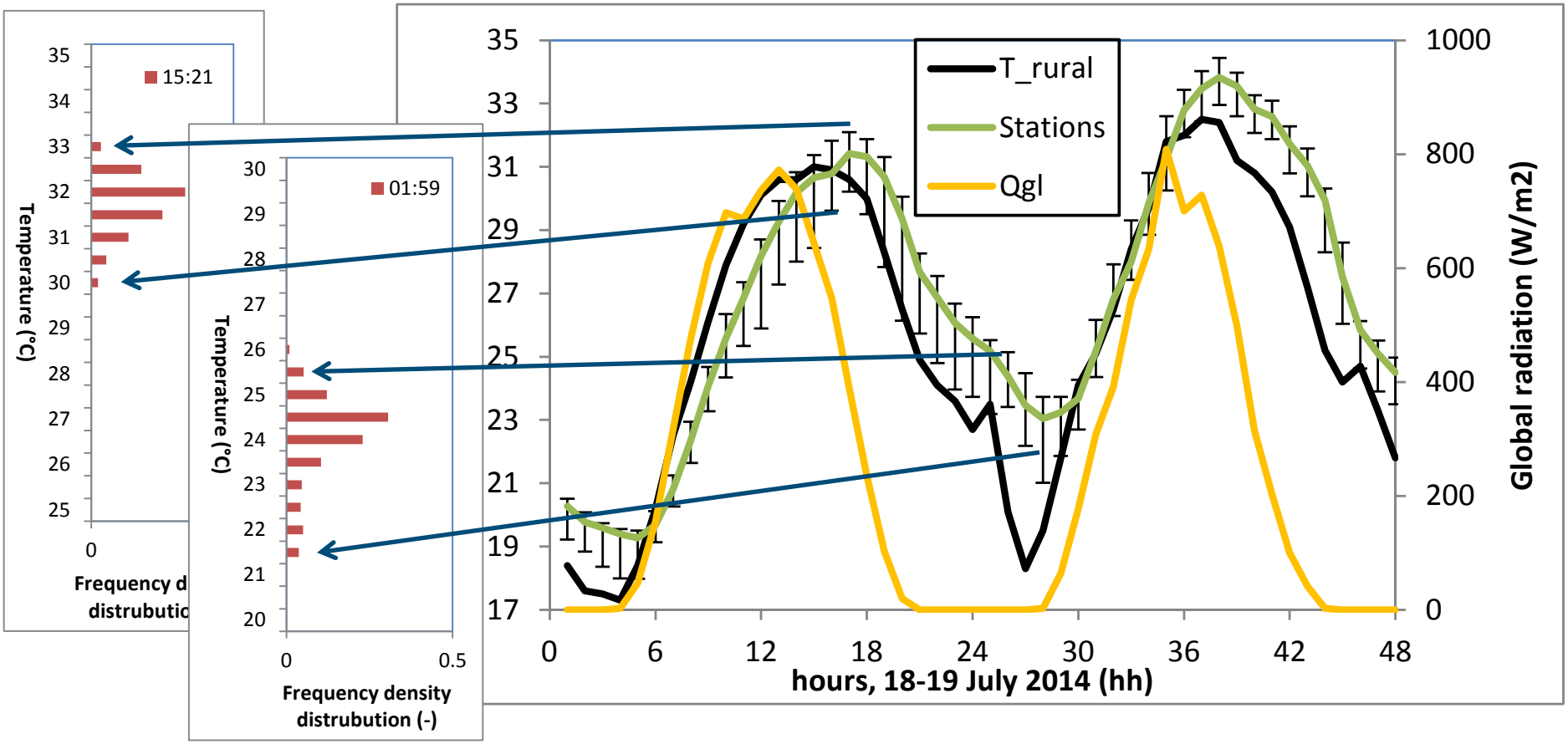
Realtime thermal comfort measurements in Amsterdam





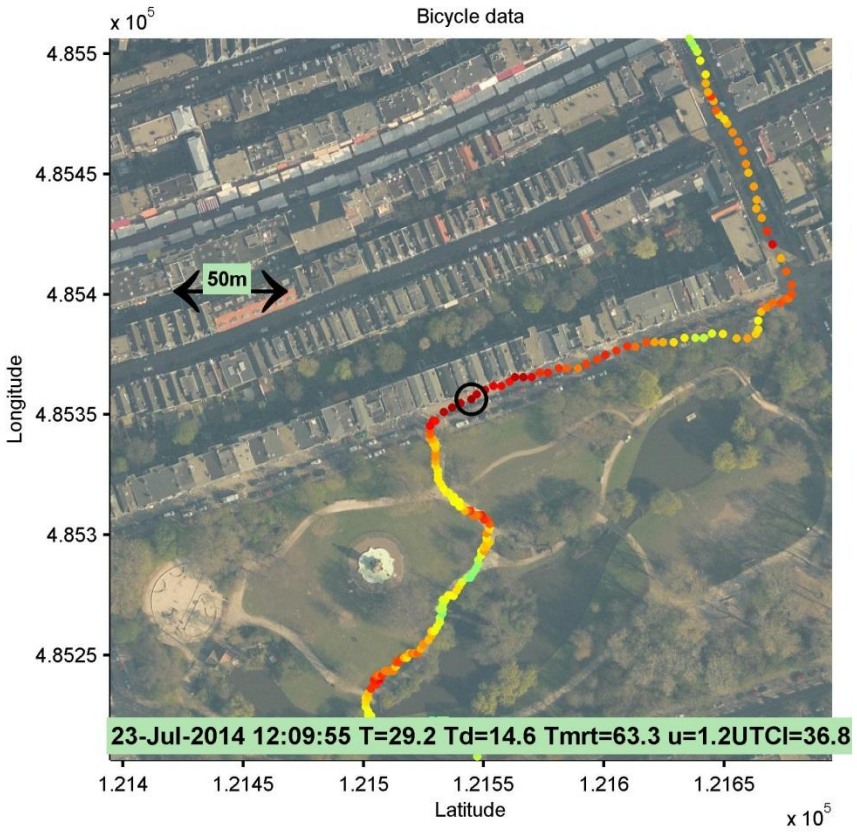
Error bars: 95percentile of a 1 hour measurement of 24 stations

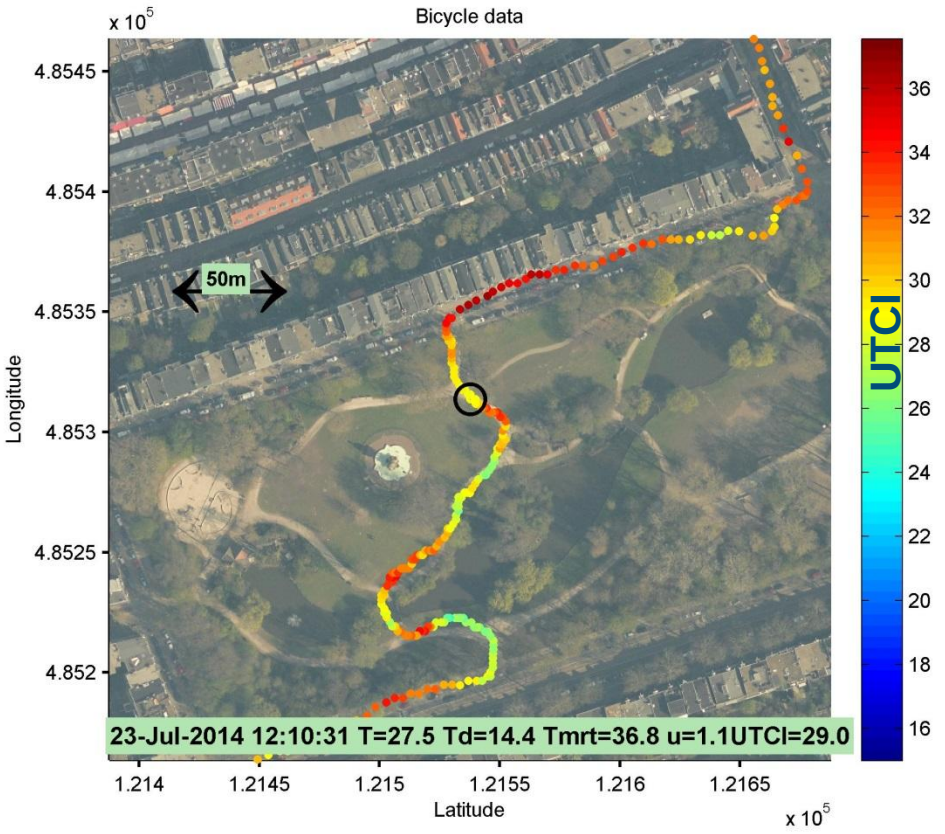
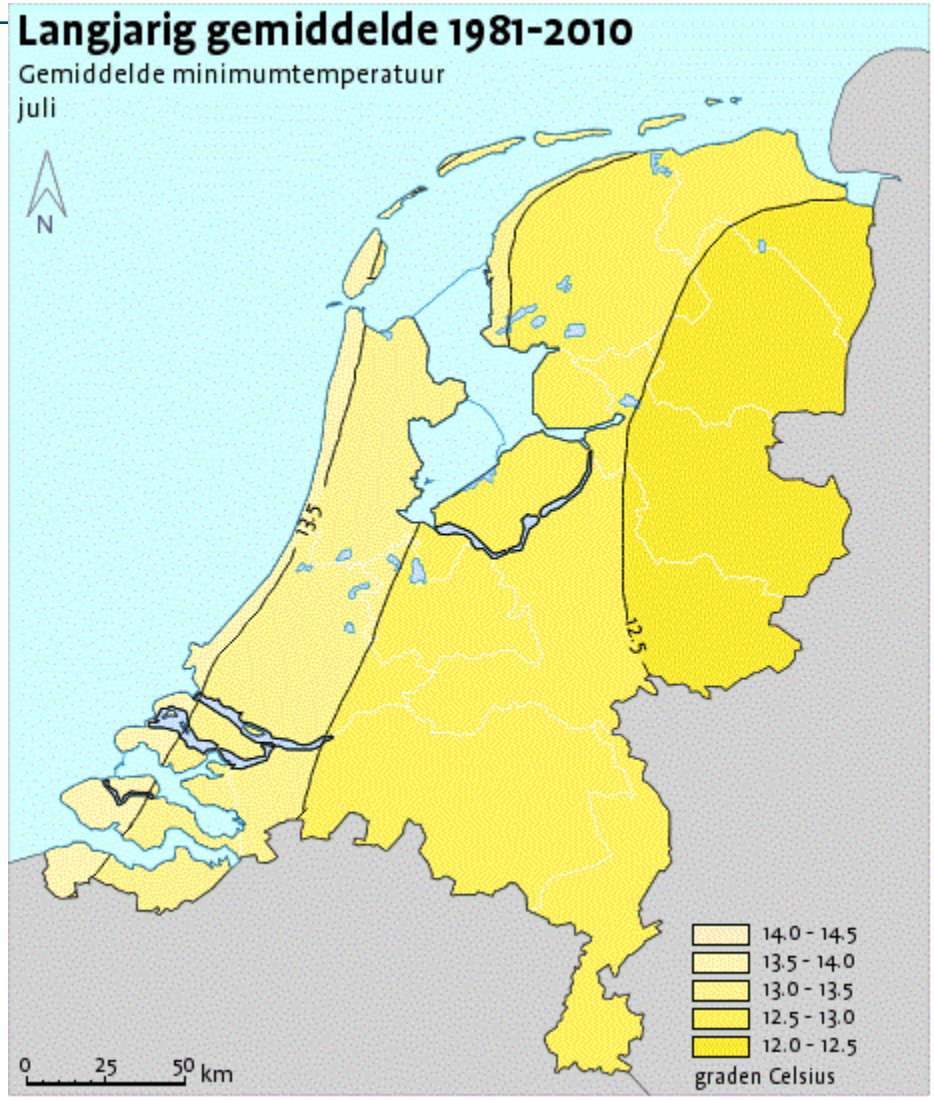
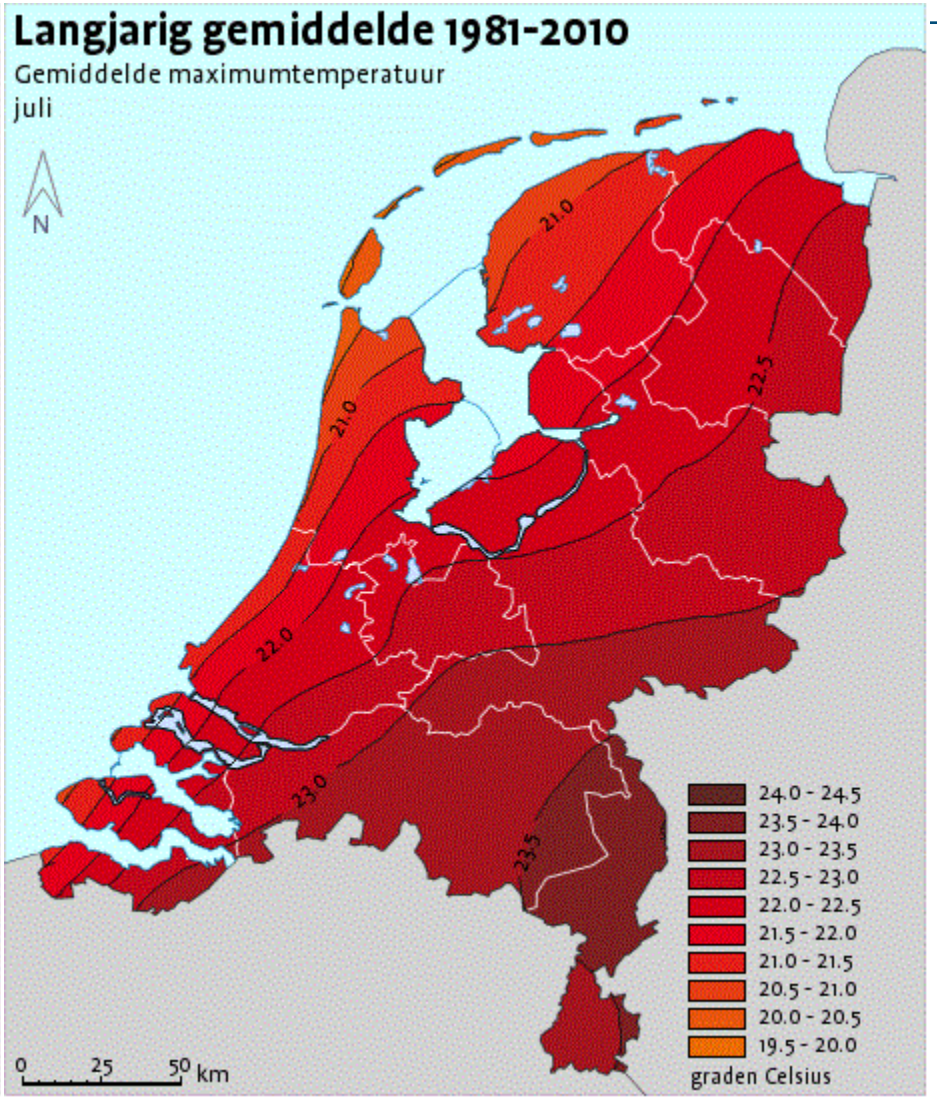
Urban heat island Amsterdam



Error bars: 95-percentile of a 1 hour measurement of 24 stations

Measured variation in thermal comfort





Urban heat islands (UHI) on climate maps?