COOL TOWNS MEASUREMENT CHECKLIST

Introduction

The Cool Towns Heat Stress Measurement Protocol delivers guidance for conducting a full Thermal Comfort Assessment (TCA) at street-level to determine where, on a specific site, heat stress is likely to be experienced. It provides practical support in identifying areas that could be affected, and for proposing effective heat mitigation measures to incorporate in future plans. To examine the thermal comfort of an urban space and the influence of heat mitigating features, a combination of three complementary methods is used: site characterization, a questionnaire, and measurement of PET.

Thermal Comfort Assessment

The TCA begins with describing the character of the place, the arrangement and type of building and streets along with recording features, such as green and blue infrastructure, and how the site is being used. This is documented by taking photographs, including with a thermal camera and a fish-eye lens.
A questionnaire asking users of the site how they feel about the thermal environment and how comfortable they are can provide insight into need for improvement in this respect.

In order to measure PET, various combinations of points of interest are monitored simultaneously to investigate the microclimate and the potential cooling influence of an intervention or existing green or blue features. All the measurement points associated with specific features require a corresponding reference point nearby against which the heat mitigating influence can be compared. Physiological Equivalent Temperature (PET) parameters (air temperature, radiation, wind speed and humidity) are measured simultaneously for 15 minutes at each measurement point, to allow time for the weather station to equilibrate.

The combination of these three complementary methods will provide information on the potential benefit- in terms of heat stress mitigation - people may gain from interventions at the site.

Working conditions

Those carrying out this fieldwork may themselves be affected by heat stress as may those interviewed. Adequate preparations for extreme working conditions are required such as hats, sunscreen, drinking water, and a parasol to provide shade for questionnaire respondents. If necessary, pause or postpone the fieldwork rather than risk any damage to health.

Policy regarding privacy

Take notice of the local policies or regulations that apply to taking photographs and conducting the questionnaires. Comply with the local legislation (e.g. General Data Protection Regulation, GDPR, in the EU, or Algemene Verordening Gegevensbescherming (AVG) in The Netherlands).

Preparations

Equipment

A checklist of all the equipment required. It is important that at least one member of the team has read and understands the operating manual of any unfamiliar equipment, such as the weather station and thermal camera before any work on site is undertaken.

Equipment

- ☐ Mobile weather stations
- ☐ Thermal (infrared) camera
- ☐ Camera (with fisheye lens)
- ☐ Timekeeping device (e.g. watch or cell phone)
- ☐ Tape measure
- ☐ Spare batteries (for each part of equipment)

Manuals

- ☐ This document
- ☐ Measurement plan of the pilot site
- ☐ Measurement protocol (Cool Towns)
- ☐ Manual of the Mobile weather stations
- ☐ Manuals of other equipment (e.g. Thermal camera)

Forms and Questionnaires

- ☐ Measurement forms
- ☐ Questionnaires
- ☐ Clipboards
- ☐ Pens or pencils

Personal

- ☐ Cap or hat
- ☐ Sunscreen
- ☐ Drinking water

Promotion material

- ☐ Promotional Flyer
- ☐ Cool Towns Fan
- ☐ Cool Towns Banner/Parasol

Setting up the equipment

Mobile weather station

Check the manual for your mobile weather station if necessary. Perform the following steps:

☐ Check memory and battery status	Optimal: Full memory available and full battery	
☐ Set time and date correctly	To local time by cell phone	
☐ Set measurement parameters and units as indicated in the next columns	Air temperature	°C
	Globe temperature	°C
	Relative humidity	%
	Wind speed	m/s
	Wind direction	° (degrees)
☐ Set logging interval	10 seconds	
☐ Start the measurement and make sure it can only be stopped manually	Optimal: Start now and stop only at the end of the day. Write down the start and end time, they are essential.	
☐ Level tripods, anemometers and wind vanes and open pro- or impeller lids	Check your mobile weather station manual for the specific instructions.	
☐ Ensure sensors are 1.1 m above the ground	Use tape measure (±1-2 cm is okay)	
☐ Perform calibrations if necessary	Check your mobile weather station manual for specific instructions.	

Thermal camera and regular camera (with fisheye lens)

Check the manual of the thermal camera if necessary. Perform the following steps:

☐ Check memory and battery status	Optimal: Full memory available and full battery
☐ Set time and date correctly	To local time by cell phone

Fieldwork

The measurements on the site must be carried out between 12:00 pm and 4:00 pm local time. Depending on the number of interventions, measurements, and sites, the first round, for example, could take place between 12:00 pm and 2:00 pm, the second round for example, can then take place between 2:00 pm and 4:00 pm.

During the measurement period, the questionnaire is used to interview a minimum of 16 (but preferable 25) people using the site. During the measurement period, the regular and thermal photographs can also be taken; the fisheye photographs must be taken above every weather station immediately before the start of each measurement.

Note that both the point(s) of interest and reference point(s)/site(s) need to be measured simultaneously. A control measurement point is continuously monitored on one spot during the entire measurement period.

Site characterization

Start the fieldwork by completing the list of site characteristics (see cooltowns.eu/protocol). This is supplemented by regular and thermal photographs to provide visual evidence on the spatial configurations, thermal conditions and the existing feature(s) or intervention measured at the site.

Regular photographs

Make sure:

- to take pictures of every single existing heat mitigation feature or installed intervention measured. This can be done before, during or directly after the measurements;
- record the number/filename of each photo (on the measurement form of the point of interest);
- photographs are taken from an eye-level perspective and from all directions: north, east, south, and west;
- photographs cover the area of influence of the intervention, for example, edges of the warmer/sunny and cooler/shaded surface;
- the reference point is included in one of the photographs. If this is not possible it should be photographed separately;
- photographs comply with privacy legislation; if people are included either their consent should be recorded or faces blurred to make them unrecognizable
- the photographs are appealing and informative.

Thermal photographs

Make sure:

- the sun is behind you except when photographing a green wall, when you stand at right angles to the wall;
- photographs are taken from an eye-level perspective;
- the intervention and the edges of the warmer/sunny and cooler/shaded surface are included (see fig. 16 in the Cool Towns Heat Stress Measurement Protocol);
- the reference point is included in the photograph. If this is impossible a separate photograph according to the above requirements should be taken. See figure 16 in the Cool Towns Heat Stress Measurement Protocol to make sure it meets all the requirements.

Fisheye lens photographs

Refer to figure 17 in the Cool Towns Heat Stress Measurement Protocol and make sure:

- to take the photograph before the start time of the measurement (to avoid influencing the sensors and so the measurement);
- to take the photograph just above the sensor (see fig. 18 in the Cool Towns Heat Stress Measurement Protocol);
- the camera lens is horizontal;
- you are not visible on the photograph (kneel down).

Questionnaire

The questionnaire (see cooltowns.eu/protocol) is carried out at the same time as the weather station measurements by other team members. The users of the site are questioned in both shaded and sunny parts of the site. Experience during the Cool Towns project has found each questionnaire takes about 15 minutes.

Interviewers should briefly introduce themselves, explain the research project and why people are being interviewed. If appropriate, shade (parasol) can be offered, it could be suggested that they move into the shade or take a seat. Be able to provide background information about the Thermal Comfort Assessment as people are generally interested in activity concerning their environment.

After this introduction the time, location, and interviewer's name are recorded followed by the subject's clothing and activity, as these may influence perception of thermal comfort; participants should be informed that this is being done. If clothing does not exactly match any of the descriptions tick the most similar one in the list. Some participants may prefer not to answer all questions (e.g. gender or age range), please continue with the questionnaire. Please write down the respondent's answers and avoid making any interpretation of their thermal experience.

Measurement of PET parameters

These are measured with the mobile weather stations: wind speed, radiation (by black globe temperature), relative humidity, air temperature. The sensors should be placed at 1.1 m above the ground. One measurement consists of one station positioned at a point of interest while another station is positioned at a reference point always measuring simultaneously. If there is a weather station at the control point, then this will need to remain positioned continuously monitoring during the entire measurement period. should be set up to record constantly during the entire time measurements are being made on the site. This should be set up first and removed after all other measurements have ended.

The measurements at the point(s) of interest and corresponding reference point(s) are measured twice, in two rounds, on the same day, preferably in the same order, but at least one hour apart. Each time the measurement should run for 15 minutes (as it takes time for the black globe to equilibrate) with the weather station set up with a logging interval s of 10 seconds or shorter. The start and end time of each measurement period must be noted.

Measuring different intervention categories

These may have several cooling mechanisms so these must be measured separately. For more details on how to position the mobile weather stations in this case please refer to the site Measurement Plan and the Cool Towns Heat Stress Measurement Protocol. General advice follows:

- always use one mobile weather station for points of interest and another for the reference points.
- make sure the weather stations sensors are 1.1 m above ground level (use the tape measure).
- ensure mobile weather stations are at least 2 meters away from any factors that could influence accuracy (e.g. cars, engines, walls (except when measuring green walls), air conditioners, people (including yourself) or any other heat source.
- shadows move so position the mobile weather station in the middle of the current shade area of trees or other shade structures.
- make sure the wind speed sensor is exposed and facing the direction of the wind or breeze so air can pass over it. Make sure the wind vane or anemometer can rotate, is not blocked by anything and is horizontal.
- make sure that the temperature and humidity sensors are never exposed to direct sunlight.
- mark any changes in locations that, due to unforeseen circumstances, need to be redefined on the site map.
- update the start time if measurement has to be paused when a cloud passes over, restarting for a new 15-minute period when it has gone.

Measurement form

This must be completed for each measurement of each installed intervention or existing heat mitigation feature (see cooltowns.eu/protocol). All the information in the list below is essential - without it the data cannot be used.

Location	The site name where measurement is taken
Point of interest	The point to be measured to determine the heat mitigation. This can be a tree, a shade structure, a green wall, a water feature, a cool surface, or any other cooling features.
Name	Your name
Date	Date of the measurement
Start time	The time (hours and minutes) when all the mobile weather stations are in position and begin measuring.
End time	The time (hours and minutes) when measurement stops. This must be at least 15 minutes after the start time.
UI point of interest, UI reference, UI control point	Unique identifier (UI) is a serial number, name or colour, assigned to each individual mobile weather station. This is to ensure that measurement data recorded can be linked to the location where the weather station was positioned (at the point of interest, reference point, or control point). This is important for analysis.

Point of interest description

Fill in the appropriate column to identify the point of interest. The column headers are "Tree", "Shade Structure", "Green Wall", "Water feature" and "Cool surface".

Filenames for illustrations

The photograph filenames are noted according to whether they are regular, thermal, or fisheye.