Data collection protocol

TROPENBOS SURINAME

UNIVERSITY OF TWENTE. | ITC

Collecting temperature and humidity transect data in Paramaribo

Contents

1. Introduction

Urban green areas such as forests, parks and gardens and other green infrastructure provide manifold benefits to the urban population, often referred to as "urban ecosystem services" (Haase et al. 2014). One of these services is urban microclimate regulation, which can also reduce the urban heat island effect. The urban heat island effect is about the temperature difference between urban and nearby rural areas, with urban areas typically being warmer than their rural surroundings (Arnfield 2003). There are many reasons for cities being warmer than their surroundings, and one of them is the relative lack of green spaces in cities compared to rural areas (Arnfield 2003).

The scientific evidence for the role of urban green for the urban climate comes mainly from studies conducted in cities in subtropical or temperate climates (Roth 2007). Comparatively few studies so far have investigated that relationship for tropical cities (recent review by Giridharan & Emmanuel 2018). The dry and wet seasons and the high relative humidity in the tropics lead to different temperature patterns, both in air and surface temperatures and, thus, making this an interesting and challenging research field (Giridharan & Emmanuel 2018).

This data collection protocol is about collecting temperature and humidity transect data in the field, i.e. with mobile measurements. The transect data were collected by walking along routes in Paramaribo, Suriname. This research has been conducted within the project "Towards a Green and more Liveable Paramaribo", funded by UTSN (groenparamaribo.org). The aim of the transect walks is to determine for each of the selected urban green spaces the so-called cooling distance and maximum cooling effect (e.g. Jaganmohan et al., 2016). The cooling distance is the distance until when a cooling effect stemming from an urban green space can still be measured in its surroundings, determined from the border of the urban green space. The maximum cooling effect is the maximum temperature difference between the urban green space and its surroundings.

2. Measurement devices and setup

Mobile measurements of air temperature and humidity variables are conducted with Kestrel Heat Stress trackers (version 5400). These trackers can be programmed to automatically log this data in a given time frame. However, they do not log GPS coordinates. Thus, the heat stress trackers are combined with tablets running the app Locus Map.

2.1 Kestrel heat stress tracker

2.1.1 Programming the heat stress tracker

Table 1 provides the settings for the heat stress trackers and where in the manual to find instructions on how to set these values. Date and time will be automatically synchronised with the device (here: tablet) used for programming the tracker.

Important! Since the time stamp will later be used to combine the heat stress tracker readings and the GPS coordinates, it is important to check beforehand whether the time logged is indeed synchronised!

Table 1: Settings for the heat stress trackers.

Setting	Value	Manual page #
Name	Heat#	(via App)
Altitude*	3m	14
Time and date	(Check values)	12
WBGT settings	outdoor	11
Auto shutdown	Off	12
Units	Global – metric	12
System – Measurements	Turn on all variables that shall be monitored.	12
Memory options – Auto store	**On – the tracker will start logging at pre-defined rate** **Off – the tracker will stop**	17
Memory options – store rate	10 seconds	17
Memory options – overwrite	On	17

* Even after setting the value of altitude, the logger will record slightly changing altitude readings due to changes in air pressure (https://kestrelmeters.com/pages/adjusting-the-pressure-altitude-adjusting-the-pressure-altitude-on-your-kestrel).

During the measurement, the tracker should be carried at least 1.25 m above the ground and as vertically as possible.

2.1.2 Transferring data from the heat stress tracker

Two data transfer cables are available for connecting the trackers a laptop. The software to download the data, program the tracker and update software on the trackers can be downloaded from

https://kestrelinstruments.com/faqs/question/view/id/89/

Rename the file using the same pattern, for instance:
Tracker_rawdata_[ID of tracker]_[date of measurement in YYYYMMDD format].csv

2.2 Recording GPS coordinates

The Kestrel tracker cannot log GPS coordinates. Thus, it is important to also carry a tablet while doing mobile measurements. The tablet can log GPS coordinates through the app “Locus Map” (https://www.locusmap.eu).

2.2.1 Programming Locus Map

To **record GPS coordinates**,

- Open Locus Map,
- Tap in the upper right corner on the REC symbol,
- Select the recording profile: “Transects”,
- Hit the green arrow to start recording,
- When done, hit the red button to stop.

Should this profile called “Transects” not be available, create a new recording profile with that name. Use the following settings:

- Preferred folder: “Recorded”
- Auto-save after stop: on
- Distance interval: 1000 meters
- Time interval: 10 seconds
- Trackpoint condition: one

With this profile, GPS coordinates will be locked exactly once every ten seconds.

2.2.2 Exporting and sharing Locus Map data

To **export the data**:

- In the upper left menu, tap on tracks,
- The last track appears in the folder “Recorded”,
- Select the track you want to export,
- In the lower right corner, tap on the arrow facing up,
- Tap “Export”,
- Choose a name for the file to be exported,
- Select KML/KMZ as file type,
- Store the data on the internal SD card, folder Locus,
- Repeat the process and store as csv file.

To **share the data**:

- Open the app “My files”,
- Navigate to the internal storage, folder Locus,
- Select the KML file(s) you want to share,
- Share it/them, for instance via Bluetooth

2.3 Determining the routes

The routes can be prepared already in a GIS and uploaded on the tablets (Locus app).

Where to start the transect?
Start in the centre of the urban green space (if possible).

How far to walk from the edge of the green space into the surroundings?
The transect walks shall determine for each of the selected urban green spaces the so-called cooling distance and maximum cooling effect. Thus, the distance to be covered needs to be larger than the expected cooling distance. In urban climate studies, the so-called park-width distance is considered to be the maximum distance to which an urban green space can cool its surroundings (Spronken-Smith 1994). The park width distance is the square root of the area of the green space (measured in m^2). Thus, it is recommended to at least take measurements for that distance, ideally 300m more to be on the safe side.

When to take the measurements?
It is recommended to take measurements on clear, sunny days with little wind.

Where to walk?
Even when a specific route is defined, there is often a choice to be made with respect to where to walk exactly (e.g. which side of the street). For instance, one side could be more shaded than the other. It is important to do this as consistently as possible across all transects. For replicable air

temperature measurements, the shaded side is preferable, since it is recommended to shield temperature loggers from direct sunlight.

How often to walk?
It is recommended to walk the transect twice, i.e. once out of the urban green space and then return. That ensures that the effect of sudden wind gusts and other disturbances can be accounted for later.

2.4 Documenting the transect walks

For all mobile measurements, the following information should be recorded to be able to put the data into context later on:

- Weather conditions during the measurement
  - Average wind speed
  - Rainfall
  - Cloud cover
- Date
- Start and end time of the measurement

3 Data preparation

3.1 Combining heat stress tracker data and GPS coordinates

The weather data need to be combined with the GPS coordinates via the time stamp recorded. This can be done in any basic office program such as Open Office Calc or Microsoft Excel.

Note for Excel users: Do not open files in Excel by double-clicking on the csv file itself. Excel tries to "help" and automatically converts time and date formats, which means it can lose a part of the information needed later. Thus, the preferred way is to open a blank work book in Excel and then navigate to Data | From Text/CSV. This allows specifying how date and time data should be imported.

3.2 Calculating Euclidean distance to UGS

To determine how far the cooling effect of urban green spaces reaches into the surroundings, the Euclidean distance from each measurement point to the urban green space needs to be calculated. This can be done in any GIS system such as QGIS or ArcGIS.

As a first step, the csv file with GPS points needs to be imported into the GIS system. The GPS points are recorded in WGS 84 and need to be converted into UTM 21N for Suriname.

Then, the Euclidean distance to the urban green space can be calculated and exported for further analysis (e.g. as spreadsheet).

3.3 Correcting temperature measurements

Depending on the time spent for walking along the transects, temperature and relative humidity can also change not only due to gradient effects, but also due to changes diurnal changes, i.e. changes because of the daily weather cycle. Therefore, the raw measurement values need to be adjusted accordingly:

- For the start and end time of the transect walk (which should be at the same location): calculate the mean values for temperature and relative humidity for the first/last three measurements.
- Calculate the difference between the mean first and mean last measurements.
- Increase/decrease the raw measurements to adjust for diurnal effects across all measurement points.

A simple example: The mean temperature at the beginning is 22.3, the mean temperature at the end of the walks – on the same spot – is 23.3. This amounts to an increase in temperature of 1K over the time spent walking back and forth. For 100 measurement points in total, the values up to the end of the measurements are adjusted as follows:

T corrected (time = n) = T raw (time = n) + T difference / 100 * (100-n)

Leading to:
T corrected (time = 0) = 22.3 + 1/100 * 100 = 23.3
T corrected (time = 1) = 22.1 + 1/100 * 99 = 23.1
…
T corrected (time = 100) = 23.3 + 1/100 * 0 = 23.3

4 Determining maximum cooling effect and cooling distance

The maximum cooling effect and cooling distance can be either estimated statistically (e.g. Jaganmohan et al., 2016) or determined visually. Here, we determine these values visually.

4.1Visualising the data

For each transect, temperature and humidity changes are visualised twice, namely once for the forward and once for the backward measurement (Figure 1). The x-axis shows the Euclidean distance from the urban green space. The y-axis shows the temperature (or relative humidity) change compared to the measurements in the middle of the urban green space.

Note that we use the graphs for relative humidity here only to select a transect (next section).

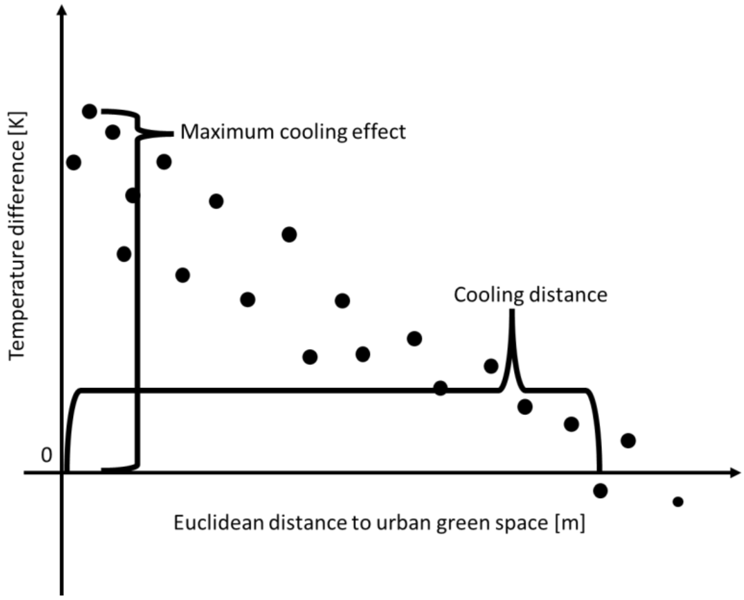

Figure 1: Visualising temperature difference for a transect

4.2 Selecting a transect direction

For each transect, only one direction (either forward or backward walking) is selected for determining the cooling effect and cooling distance. The direction is chosen based on:

- Stable relative humidity
- Low wind speed
- Avoiding sudden changes of temperature during measurement (e.g. because of starting rainfall)
- Consistent surface coverage (in case forward and backward walk followed different sides of the street, for example).

4.3Determining cooling distance

The cooling distance is the distance at which the cooling effect levels off. This is where the temperature difference visualised in the graph approaches or crosses the x-axis for the first time (Figure 1).

4.4 Determining maximum cooling effect

The maximum cooling effect is the maximum temperature difference between the urban green space and its surroundings. It is the maximum value of temperature difference in the graph within the cooling distance (Figure 1).

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