Component 2: Local heat monitoring and exposure assessment

This study component should be carried out in selected workplaces outdoors and indoors during the hot seasons, and if possible during cooler seasons as well. If the heat monitoring is carried out in the vicinity of an existing weather station, the new local measurements can be used to validate and improve heat exposure estimates based on weather station data,. The initial monitoring data covering only temperature and humidity can be converted, with some assumptions, to the heat stress index WBGT (for exposure indoors or in the shade) by mathematical formulas proposed by the Hothaps team in order to assess the potential health and work productivity impacts.

Where special WBGT monitoring equipment is available, more complete heat monitoring can be carried out, including WBGT measurements. In selected places with specialized research teams, such complete monitoring may be developed into a validation study (if interested, please contact the Hothaps team for further information). The cost of basic local heat monitoring should be very limited. (measurement and calculation of other heat stress indices may be included in Hothaps as well; currently under review)

1.1. Aims

The aim of these heat monitoring studies is to assess, under local circumstances, the extent of heat stress expressed either as a composite of temperature and humidity or as the heat stress index WBGT, in selected workplaces and during different seasons of the year.

1.2. Study design, study location

WBGT (Wet Bulb Globe Temperature) is a well established and widely used heat stress index that is associated with human physiological reactions to heat and the limits these reactions create for work intensity and workplace heat exposure levels. Special equipment is needed to measure WBGT according to standards (ISO, 1989). Each monitor can cost more than US$ 1,000. Such equipment has three thermometers measuring natural wet bulb temperature (Tnwb), globe temperature (Tg), and common air temperature (Ta). Tnwb is measured inside a water wetted small cloth sock, which simulates the heat exchange effect of evaporation from sweat covered skin. Tg is measured inside a black globe, which simulates the uptake of heat on the skin from heat radiation (e.g. solar radiation).

A heat monitoring study can avoid the cost of special equipment by using less advanced measurement equipment or data-loggers for temperature and humidity measurements, and then calculating the WBGT with mathematical formulas based on certain assumptions about the heat exposure situation (the formulas are based on the published work by Liljegren et al., 2008, and are available from the Hothaps team).

Equipment: low cost data logger

To measure temperature and humidity continuously for the study period we propose to use a data logger of the type shown in Figure 2.1, or any other brand of data logger for temperature and humidity. These cost approximately US$ 100 and can be purchased over the Internet (seek on Google: “temperature, humidity, data logger”).

The product description (Lascar EL-USB-2-LCD) on the Internet says:

This standalone data logger measures and stores up to 16,379 relative humidity and 16,379 temperature readings over 0 to 100%RH and -35 to +80°C (-31 to +176°F) measurement ranges. The user can easily set up the logger and view downloaded data by plugging the module into a PC's USB port and using the supplied software. Relative humidity, temperature and dew point (the temperature at which water vapour present in the air begins to condense) data can then be graphed, printed and exported to other applications. The high contrast LCD can show a variety of temperature and humidity information. At the touch of a button, the user can cycle between the current temperature and humidity, along with the maximum and minimum stored values for temperature and humidity. The data logger is supplied complete with a long-life lithium battery, which can typically allow logging for up to 1 year.

Figure 1. An example of a data logger for temperature and humidity measurement: Lascar EL-USB-2-LCD

Average temperature and humidity can be measured every hour (or half-hour, or 5 minutes, etc.) for a long time with this type of data logger: The battery can last many months for hourly measurements (according to the equipment specifications). Instant results are presented on a small LCD screen and a long series of recordings can be stored. When the data-logger is plugged into the USB port of a computer with EasyLog USB software installed, the detailed data is immediately available as time trend graphs and the data can be downloaded for analysis into any software (e.g. Excel). A guidance document on the use of this equipment for heat and health studies is available at the website of the journal Global Heath Action (paper by Byass et al., 2010).

Other data loggers will be tested and further advice will be provided. Different data loggers can be bought, for instance from the "Data logger store":

http://www.microdaq.com/data-logger/temperature/1.php

<u>Equipment: special WBGT monitor</u>

The three formal elements of the WBGT (Tnwb, Tg and Ta) should ideally be measured with specialized equipment. Such equipment can be found on the internet (Google "WBGT monitor"). For example, the Quest WBGT 34 monitor shown in Figure 2.2. These can cost as much as US$ 4,000 locally. The price in the USA was US$ 2,500 in 2009.

See: http://www.quest-technologies.com/PDFs/Brochures/Heat/PortableMonitors.pdf

Figure 2. A Quest technology WBGT monitor

Other WBGT monitors can be purchased from, for instance:

AFC International:
http://www.afcintl.com/other/rss214.htm

Shawcity.co.uk:
http://www.imageworksweb.co.uk/shawcity_web/heat-stress-wbgt-meters.html

Casella: http://casellausa.com/en/cas/microtherm.htm

It is important to note that WBGT measurement equipment that can be bought for less than US$ 200 is not designed to measure each of the three components of WBGT in a scientific manner, but uses calculation formulas that may create inaccurate WBGT estimates in a particular location. The results may therefore be less accurate. However, in our own tests of different equipment we have found that the variability of WBGT recordings at the same place at the same time can be up or down 0.5 – 1 °C, so absolute accuracy cannot be achieved with any type of equipment.

1.3. Placement of equipment and timing

The heat monitoring component of the Hothaps field study aims to record local heat exposure situations at regular intervals during a substantial period (a week, several weeks, the hot season, or a whole year). The focus is on heat exposure in places where many people work. For additional guidance, see Byass et al., 2010.

Placement: the data-logger (or WBGT monitor) should be in a place that represents the heat exposure that working people experience outdoors or indoors in this location (for instance in different workplaces in agriculture, resource extraction industry, manufacturing industry, transport industry, home businesses or service industry). Ideally, several data-loggers should be used to simultaneously measure heat exposures in several sites of the location, and indoors as well as outdoors at the same time.

See appendix xxx for detailed information about data logger placement.

One analysis in this study could be a comparison with local weather station data. In order to do this accurately, it would be desirable to place a data logger in the vicinity of the weather station. Where this is not possible, comparisons can be made between the data logger results and the nearest weather station data for temperature and humidity during the same hourly periods.

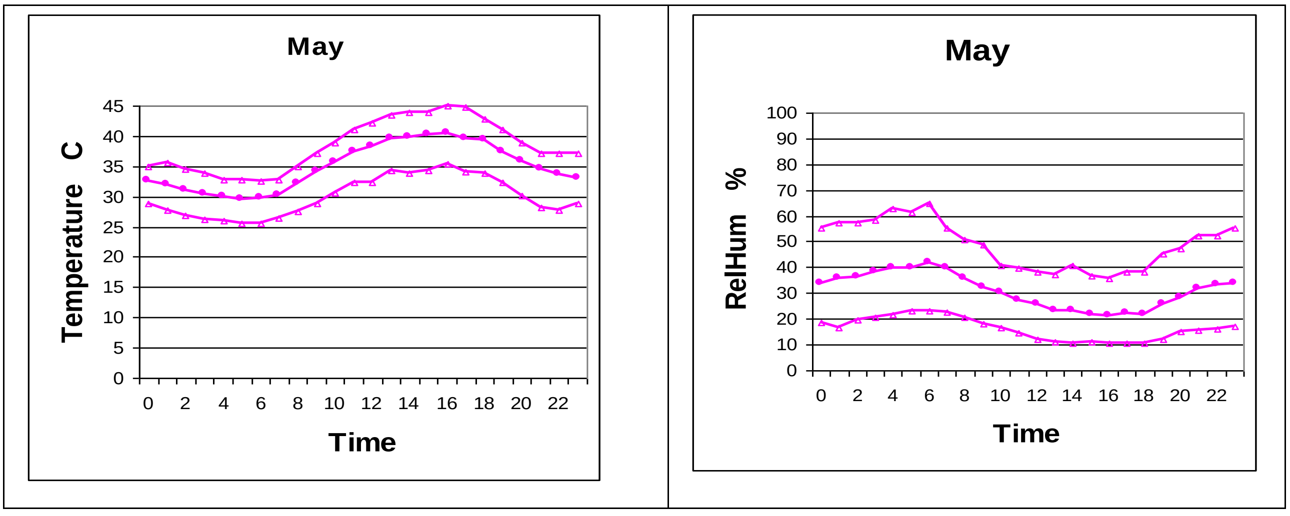
Timing: set the recording at 5 minute intervals or half hourly intervals depending on how long you want the data logger to run. Excel instructions are in appendix xxx on how to filter 5 minute and half hourly data to produce hourly data. If measurements are made continuously during both night and day there will be 24 hourly data-points each day. Graphic presentations of the type in Figure 3 can be produced from the data.

1.4. Data required

We recommend that at least one data logger be left in place to record hourly values for a month at a time during different times of the year. This allows calculation of monthly averages for every hour of the day (as in Figure 3.) With these data and assumptions about some other variables, the heat stress index at the location for different months of the year can be calculated. As environmental heat exposure is always highest during daylight hours, one may decide to measure only during the day-time if there are risks that the data loggers will be damaged or stolen during the night. The data logger can be locked up in a safe place during the night, if needed, and only the daytime data are used. The built in time and date data make it easy to later analyze just the time periods that are most relevant. It is important to keep a diary of where the data logger is during different time periods.

Figure 3. Average temperature and relative humidity in Delhi for each hour during May 1999.

(middle line shows averages at that hour based on data from Delhi airport. The upper and lower lines indicate the 5 and 95 percentiles of individual hourly data for this month)



1.5. Data collection

With a data logger of this type, the hourly results of measurements are automatically stored in a new file in the computer database for each download that is carried out and a time series graph is produced (Figure 4). It is necessary to keep records of when and where measurements were made and who carried them out, as shown in Table 1. The location is the town, village, or city part where the tests are taking place. Make sure your computer has the correct time set on it because the data logger will take the time off the computer. If using more than one data logger make sure they are set by the same computer. Day-light saving time can be an issue if your data logger time spans across a change from one time to another. Note this in your diary.

Start and end time for each data logger monitoring period are important to record because the data logger will keep recording when you transport it from the workplace to your computer. If you shift the data logger from one site to another make sure this is all recorded.. These computer files will have the date/time information for each hourly measurement automatically included. It is important to record the precise placement sites for each data-logger as more than one data-logger might be placed in the same town, village, etc. It is strongly advised that you name the data logger with a label and also give the data logger the same name electronically when you first set it up. The "type of work" indicates which work activity is carried out at the place where the data-logger was placed. The "person testing" refers to the person who actually places the data-logger and collects it for downloading of data. This is needed in order to keep track of who knows exactly where the data-logger was placed and any anomalies with the equipment. The downloaded file name is essential to record, so each set of data can be identified. For each measurement series the data collected can be summarized as in Table 2.

Figure 4. Time trend in data logger for a measurement in Nepal; temperature, humidity

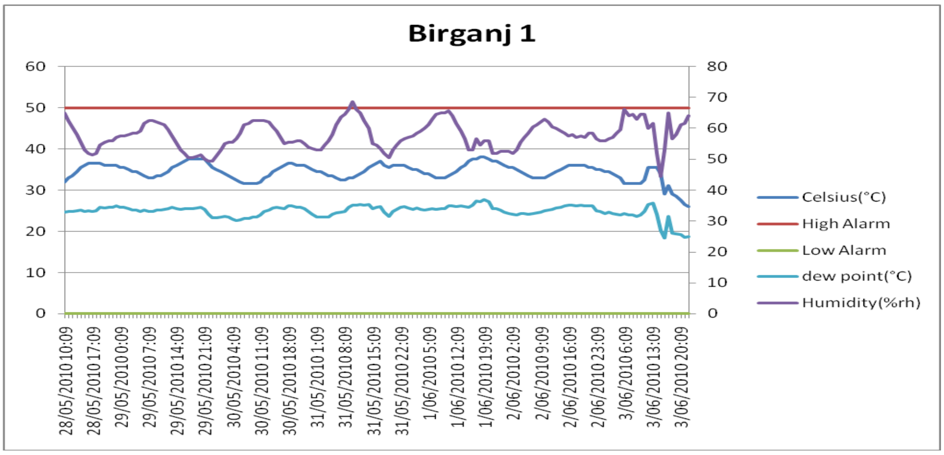


Table 1. Detailed recording of data-logger measurements carried out.

Location, site for measurements:					
Organization carrying out measurements:					
Measurement series Nr:	1	2	3	4	5
Start, date/time					
End, date/time					
Placement site					
Type of work at the site					
Person testing					
Downloaded file name					

For more details see appendix xx

1.6. Data analysis and reporting

The hourly data can be presented for short periods as time trend graphs based on individual hours, but our interest is mainly in the monthly averages at each hour and variability (standard deviations or 90% variation limits) of hourly data (as in Figure 3).

A standard method of summarizing the data in Excel (with calculation formulas included) is being prepared by the Hothaps team. Comparisons between months and locations can be made. Hourly WBGT will be based on actual WBGT measurements or calculated from the data logger measurements.

Results of heat exposure monitoring will be reported from each location and interpreted in relation to variations in results between different latitudes, altitudes and other geographic conditions. A combined publication summarizing results from a number of locations will be prepared and all scientists collecting local data will be invited to contribute data, ideas and text. In addition, the local scientists can publish their own datasets as they wish, for instance for national reporting in the local language.

These basic local heat monitoring studies will provide essential data allowing the best possible calculation of current heat exposure in workplaces at a population level; individual exposures may vary according to a number of factors: work type, clothing, local sources of heat and cold, etc. By using predicted future climate change in each location to calculate potential future hourly temperature and humidity distributions for each month, the future occupational heat stress can be estimated as a part of climate change and health analysis.

Table 2. Results of one series of measurements

	Date:				**Site:**				
Data from:	**Data logger1**			**Data logger 2**	**Wind speed estimate**	**Data from WBGT monitor**			
Hourly period	**Air Temp. °C (Ta)**	**Relative humidity % (RH)**	**Dew point °C (Td)**	**Globe temperature C (Tg)**	**Wind speed, m/s (V)**	**WBGT °C (WBGT)**	**Air Temp. °C (Ta)**	**Globe temp. °C (Tg)**	**Natural wet bulb temp. °C (Tnwb)**
00.00 – 00.59									
01.00 - etc.									
02.00 -									
03.00 -									
04.00 -									
05.00-									
06.00 -									
07.00 -									
08.00 -									
09.00 -									
10.00 -									
11.00 -									
12.00 -									

13.00 -									
14.00 -									
15.00 -									
16.00 -									
17.00 -									
18.00 -									
19.00 -									
20.00 -									
21.00 -									
22.00 -									
23.00 -									
Averages, 24 hours									