Digital Multi-Day Max/ Min/Current Air and Soil Temperatures Protocol

Purpose

To record daily measurements of maximum, minimum, and current air and soil temperatures at a common site

Overview

One temperature probe is placed inside the instrument shelter while another is installed at a 10 cm depth in the soil. A digital thermometer is used to measure current temperatures as well as daily minimum and maximum temperatures. The daily minimum and maximum temperatures are stored by the instrument for a period of six days and need to be read and recorded within this span of time.

Student Outcomes

Students gain insight into the relationships between air and soil temperatures over time and learn to use a digital thermometer.

Science Concepts

Earth and Space Science

- Weather can be described by quantitative measurements.
- Weather changes from day to day and season to season.
- Weather varies on local, regional, and global spatial scales.

Geography

- The variability of temperature of a location affects the characterization of Earth's physical geographic system.

Enrichment

- Soil temperature varies with air temperature.
- Soil temperature varies less than air temperature.

Scientific Inquiry Abilities

- Use a digital max/min thermometer.
- Identify answerable questions.
- Design and conduct scientific investigations.
- Use appropriate mathematics to analyze data.
- Develop descriptions and explanations using evidence.
- Recognize and analyze alternative explanations.
- Communicate procedures and explanations.

Time

10 minutes per measurement set

Level

All levels

Frequency

At least once every six days

Materials and Tools

- Digital multi-day max/min thermometer
- Instrument Shelter installed on a post
- Digging tools (site setup only)
- Calibration thermometer
- Soil probe thermometer

Preparation

Set up the instrument shelter.

Calibrate and install the digital max/min thermometer.

Reset the digital max/min thermometer.

Review the *Soil Temperature Protocol*.

Prerequisites

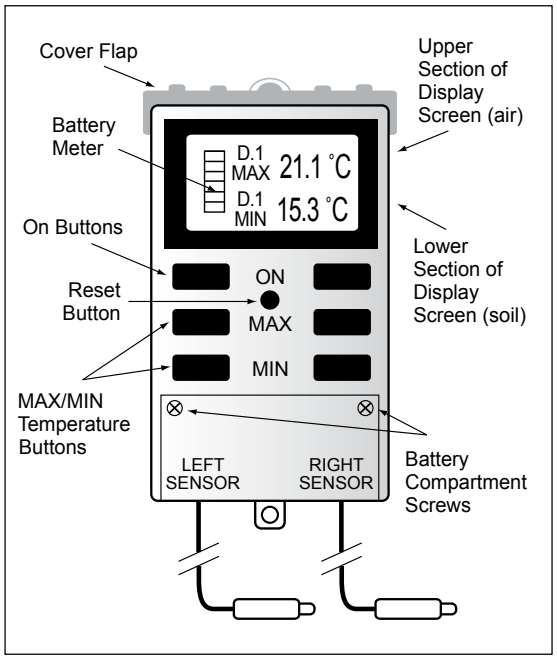
None

Digital Multi-Day Max/Min Thermometer Introduction

The digital multi-day max/min thermometer is an electronic instrument used to measure the current temperature and record the maximum and minimum temperatures reached during multiple 24- hour periods. It has two identical temperature probes. One probe is used to measure air temperature and the other to measure soil temperature.

The instrument records and stores the highest and lowest temperatures reached over six successive 24-hour periods. The start and end times for these periods correspond to the time of day at which the instrument was initially reset by the user (*the time of reset*). The instrument is reset once when it is first setup and again whenever the battery is changed. For use in GLOBE, the *time of reset* should be as close as possible to local solar noon, thereby causing each 24-hour period to span from approximately local solar noon to local solar noon of consecutive days. The thermometer displays the maximum and minimum temperatures for the current day as well as for the previous five days as long as it is read at a time which is later than the time that the thermometer was initially reset (*time of reset*). If the thermometer is read after the *time of reset*, it will display the maximum and minimum temperatures for the previous six days.

Figure AT-MU-1: Multi-Day Digital Max/Min Thermometer



The digital multi-day max/min thermometer is capable of measuring temperatures down to -20˚ C when run on a standard alkaline AA-size battery. Substitution of a lithium AA-size battery will allow the instrument to handle lower temperatures. Also, at low temperatures the digital display screen may become too dim to read, while the instrument is still recording temperatures.

Temperature Probes

The multi-day digital max/min thermometer has two sensor probes. Normally one probe will be used to measure air temperature while the other will be used to measure soil temperature. For the sake of consistency the probes should be placed as follows:

Left Sensor – air temperature,

Right Sensor – 10 cm depth in soil.

The display areas for the two sensors are labeled on the right side of the digital display screen for the instrument. The upper display area (which is for the left sensor) is labeled ‘LF’, while the lower display area (which is for the right sensor) is labeled ‘RT’.

Hint: To help prevent confusion, label these display areas as ‘air’ and ‘soil’ respectively. This can be done by writing on a piece of tape attached to the left of the display screen.

Instrument Maintenance

The instrument shelter should be kept clean both inside and outside. Dust, debris, and spider webs should be removed from the inside of the shelter with a clean, dry cloth. The outside of the shelter may be lightly washed with water to remove debris, but try to avoid getting water inside the shelter. If the outside of the shelter becomes very dirty, it should be repainted white.

When the battery in the thermometer becomes low on power a low battery symbol will light. This symbol is located along the left side of the

display screen and is shaped like a AA-size battery. Once this symbol becomes visible it is time to replace the battery. Follow the *Changing the Battery in the Digital Multi-Day Max/Min Thermometer Field Guide*.

Teacher Support

The instructions given in this protocol are specific to one brand of digital thermometer. They may be adapted to other equipment that meets the same specifications. If you have questions or require assistance with adapting these instructions to other instruments, contact the GLOBE Help Desk. The essential elements of this protocol, which must remain the same regardless of the equipment model, are the placement of the temperature probes and the +/- 0.5˚ C precision and accuracy of the temperature sensors.

Instructions for using alternative types of max/min thermometers are given in the *Single-Day Maximum, Minimum, and Current temperature Protocol*. The thermometers used in that protocol do not log data, so they need to be read and reset every day.

If your instrument shelter is in a location that makes it difficult to measure soil temperatures, or if you are only interested in taking air temperature measurements, it is acceptable to only take air measurements. To do so simply skip the portions of each field guide that pertain to the soil sensor.

Measurement Logistics

1. Review background in Atmosphere and Soil chapters.
2. Check a calibration thermometer following the *Thermometer Calibration Lab Guide*.
3. Calculate sensor correction offsets following the *Digital Multi-Day Max/Min Thermometer Sensor Calibration Field Guide*.
4. Install your digital multi-day max/min thermometer following the *Digital Multi-Day Max/Min Thermometer Installation Field Guide*.
5. Establish your time of reset by resetting the thermometer within one hour of local solar noon following the *Digital Multi-Day Max/Min Thermometer Reset Field Guide*.
6. Record current maximum and minimum temperatures following the *Digital Multi-Day Max/Min Temperature*

Protocol Field Guide at least once every six days.

7. Record current temperatures following the Digital Multi-Day Thermometer Current Temperature Protocol Field Guide as desired.
8. Report your data to GLOBE.
9. Every six months, or whenever the battery is changed, check the accuracy of the soil probe following the Digital Multi-Day Max/Min Thermometer Soil Sensor Error Check Field Guide. If the magnitude of the soil sensor error that you calculate is two degrees Celsius or more, dig out the soil sensor and recalibrate both the soil and air sensors following the Digital Multi-Day Max/Min Thermometer Sensor Calibration Field Guide. If the magnitude of the soil sensor error that you calculate is less than two degrees Celsius, leave the soil sensor buried and recalibrate just the air sensor.
10. Engage students in looking at their data.

Calibration

Your digital thermometer must be calibrated before initial use. Every six months after installation and whenever the battery is changed the air sensor will need to be recalibrated and the soil sensor readings will need to be checked to see if the soil sensor needs to be dug out and recalibrated. These calibrations and checks are performed by comparing temperatures read by the two probes with readings from a calibration thermometer and the soil probe thermometer. See the Soil Temperature Protocol.

Helpful Hints

The goal of the calibrations is to obtain air and soil sensor correction offsets that account for differences between measured and actual temperatures. When you report your calibration data to the GLOBE database, the database automatically calculates these values and reports them to you. After you have completed your calibration and start entering temperature data to GLOBE, the database will automatically account for your correction offsets as your measurements are entered into the database. So, all the data in the GLOBE database have effectively been calibrated. However, take caution in accounting for the correction offsets when analyzing data not obtained from the GLOBE database (including data you have collected). DO NOT APPLY THE OFFSETS TO DATA REPORTED TO GLOBE.

Questions for Further Investigation

Which season has the greatest range of temperatures? Why?

How does the soil temperature range compare with the air temperature range?

What are the latitudes and elevations of other GLOBE schools with atmosphere and soil temperatures similar to yours?

What soil temperatures signal a new growing season in your area, as evidenced by new grass, weed growth and germination, or budburst?

Is your local environment affected more by average temperature or temperature extremes?

How does soil character affect soil temperature?

Thermometer Calibration
Lab Guide

Task

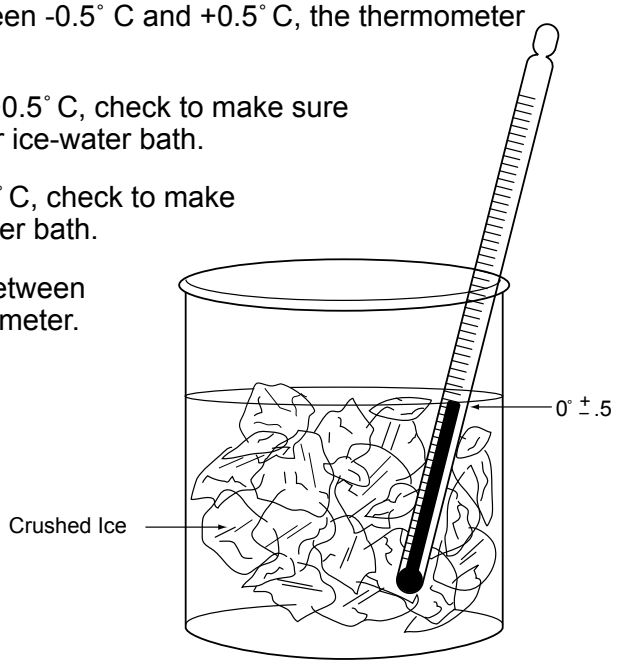
Check the calibration of the calibration thermometer.

What You Need

- ❑ Calibration thermometer
- ❑ Clean container at least 250 mL in size
- ❑ Crushed ice
- ❑ Water (distilled is ideal, but the key is that the water is not salty)

In the Lab

1. Prepare a mixture of fresh water and crushed ice with more ice than water in your container.
2. Put the calibration thermometer into the ice-water bath. The bulb of the thermometer must be in the water.
3. Allow the ice-water bath and thermometer to sit for 10 to 15 minutes.
4. Gently move the thermometer around in the ice-water bath so that it will be thoroughly cooled.
5. Read the thermometer. If it reads between -0.5˚ C and +0.5˚ C, the thermometer is fine.
6. If the thermometer reads greater than +0.5˚ C, check to make sure that there is more ice than water in your ice-water bath.
7. If the thermometer reads less than -0.5˚ C, check to make sure that there is no salt in your ice-water bath.
8. If the thermometer still does not read between -0.5˚ C and +0.5˚ C, replace the thermometer.

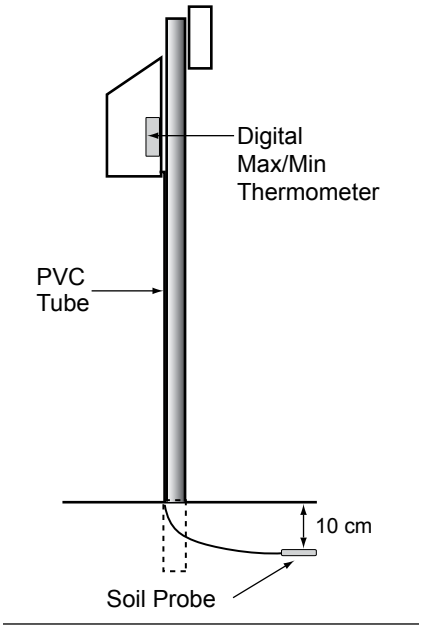


Digital Multi-Day Max/Min Thermometer Installation

Field Guide

Task

Install the digital thermometer at your Atmosphere Study Site.



What You Need

- ❑ Drill with 12 mm spade bit (if doing soil measurements)
- ❑ Digging tools (if doing soil measurements)
- ❑ String or wire ties
- ❑ GLOBE instrument shelter (specifications are given in the *GLOBE Instrument List* in the *Toolkit* section)
- ❑ 120 cm x 2.5 cm PVC pipe (optional)

In the Field

1. Mount the digital thermometer housing to the rear wall of your instrument shelter. The housing should be placed so that the digital display may be read easily.
2. Hang the probe labeled *Left Sensor* so that no part of it contacts the walls and there is airflow all around it. This can be done simply by hanging the rolled-up cable for this sensor from the top of the shelter, with the probe itself hanging below.
3. If you will not be taking soil measurements, store the right sensor and it's cable neatly in a corner of the shelter where it will be out of the way and skip the following steps.
4. If necessary drill a 12 mm hole, using a drill with a spade bit, in the bottom of the instrument shelter, near the back. Feed the right sensor probe through the hole, leaving as much cable as possible inside the shelter. You may wish to feed the sensor and wire through a thin PVC pipe that will then serve to protect the wire.
5. Choose a site to place the soil temperature probe nearby on the equatorward side (sunny-side) of the instrument shelter mounting post. Data collected from soil in unshaded locations are preferred. Comments in your site definition should include the amount of shade that the soil surface above the probe will experience during a year.
6. Dig a hole to a depth of a little over 10 cm at the chosen location.
7. Push the probe horizontally into the side of the hole at a depth of 10 cm. Use a nail or steel pin, with a slightly smaller diameter than the probe, to pilot an opening for the probe if needed.
8. Refill the hole with the soil that you removed.
9. Neatly secure all extra cable for the soil sensor using string or wire ties. Keep as much of the excess cable as possible within the shelter.

Digital Multi-Day Max/Min Thermometer Reset

Field Guide

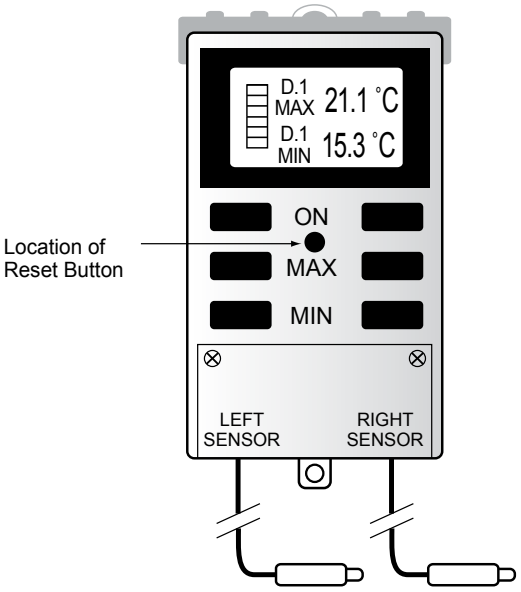
Task

Reset the digital multi-day thermometer to establish the time of reset, which serves as the starting and ending time for the 24-hour intervals over which the instrument records maximum and minimum temperatures.

Note: The thermometer should only be reset when it is setup, when the battery is changed, or if your *time of reset* becomes more than one hour from local solar noon.

What You Need

- ❑ Pen or nail
- ❑ *Site Definition Sheet*
- ❑ An accurate watch or other device that tells time



In the Field

1. Determine an appropriate *time of reset* that corresponds to the average time of local solar noon for your area. It is important that the *time of reset* is within one hour of local solar noon for every day that you will be taking measurements. If you find that this is not the case, then a new *time of reset* will need to be chosen and the instrument reset.
2. Go to the instrument shelter a little before your desired *time of reset* and open up the instrument shelter and the cover flap of the digital max/min thermometer.
3. At your desired time of reset, use a nail or the tip of a pen to press in and release the reset button, located as shown above.
4. The digital display screen will briefly flash and then begin reading the current temperature. The instrument has now been reset. Record the exact time of day, in the *Time of Reset* section of the *Site Definition Sheet*. This is your time of reset.
5. Report your *time of reset* by clicking on Edit Site, clicking on Reset Thermometer and indicating the date and time of reset in UT time.

Digital Multi-Day Current Temperature Protocol

Field Guide

Task

Measure the current air temperature.

Measure the current soil temperature.

What You Need

- ❑ A properly sited instrument shelter
- ❑ A properly calibrated and installed digital multi-day max/min thermometer
- ❑ An accurate watch or other device that tells time
- ❑ Pen or pencil
- ❑ *Digital Multi-Day Max/Min Thermometer Data Sheet*, *Integrated 1-Day Data Sheet*, *Aerosols Data Sheet*, *Ozone Data Sheet*, or *Water Vapor Data Sheet*

In the Field

1. Open the instrument shelter and the cover flap of the digital max/min thermometer being careful not to breathe on or touch the air temperature sensor.
2. Record the time and date on your *Data Sheet*.
3. Turn the air temperature display on by pressing the air sensor ON button (upper left button labeled ON on the front of the instrument casing).
4. Read the current air temperature shown in the upper section of the digital display. Record this temperature on your *Data Sheet*.
5. If soil measurements are being taken, turn the soil temperature display on by pressing the soil sensor ON button (upper right button labeled ON).
6. Read the current soil temperature from the lower section of the digital display. Record this temperature on your *Data Sheet*.
7. After all measurements have been taken close the cover flap of the instrument. It will shut off automatically after a short time.

Digital Multi-Day Maximum and Minimum Temperature Protocol

Field Guide

Task

Measure the daily maximum and minimum air temperatures for the past six days.

Measure the daily maximum and minimum soil temperatures for the past six days.

What You Need

- ❑ A properly sited instrument shelter
- ❑ A properly calibrated and installed digital multi-day max/min thermometer
- ❑ Pen or pencil
- ❑ An accurate watch or other device that tells time
- ❑ *Digital Multi-day Max/Min Thermometer Data Sheet*

In the Field

1. Maximum and minimum readings should be taken at least five minutes after your *time of reset*.
2. Open the instrument shelter and the cover flap of the digital max/min thermometer being careful not to breathe on or touch the air temperature sensor.
3. Record the time and date on your *Data Sheet* in both local and UT time. **Note:** GLOBE data entry should be UT time.
4. Turn the air temperature display of the thermometer on by pressing the air display ON button (upper left button labeled ON). **Note:** The temperature displayed will be the current air temperature.
5. Press the air sensor MAX button (middle left button labeled MAX) *twice*.
   Note: The reading that appears after you press the MAX button once is the highest temperature that has occurred since the last *time of reset*, and is not for a full 24-hour period. It should not be recorded.
6. You should see the MAX symbol displayed on the digital display screen to the left of the temperature reading with the symbol D.1 displayed above. Record this temperature on your *Data Sheet*.
7. Press the air sensor MAX button again. The symbol D.2 should now be displayed in place of D.1. Record the accompanying temperature on your *Data Sheet*. Repeat this procedure to record data for as many of the past six days (D.1 – D.6) as needed.
8. To record minimum air temperatures repeat steps 5-7 pressing the air sensor MIN button (bottom left button labeled MIN) instead of the MAX button.
9. For the soil temperatures, repeat the above steps using the soil buttons on the right side and reading from the lower section of the display screen.
10. After all measurements have been taken close the cover flap of the instrument. It will shut off automatically after a short time.

Changing the Battery in the Digital Multi-Day Max/Min Thermometer

Field Guide

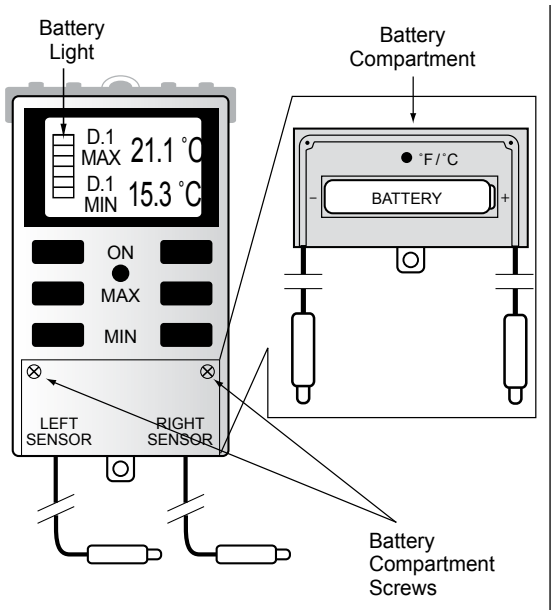
Task

Change the battery in the digital multi-day max/min thermometer.

What You Need

- ❑ A new AA-size battery
- ❑ A small Phillips head screwdriver

In the Field



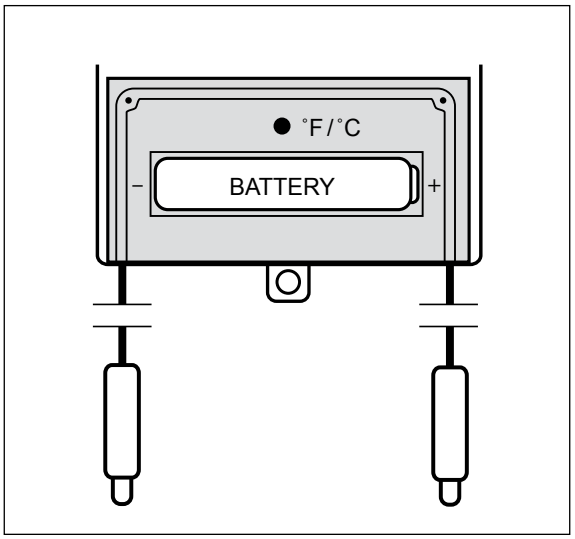
1. The battery is in the battery compartment in the lower section of the instrument casing.
2. Remove the two little screws located at the upper corners of the compartment cover and lift off the cover.
3. Change the battery, taking care to ensure correct polarity (negative end of battery contacting the spring).
4. Replace the compartment cover and secure with the two screws. After the battery has been changed be sure to recalibrate the instrument.
5. Recalibrate the air and soil sensors following the *Digital Multi-Day Max/Min Thermometer Sensor Calibration Field Guide*.
6. Reset the instrument using the *Resetting the Digital Multi-Day Max/Min Thermometer Field Guide*.

Frequently Asked Questions

1. What should I do if my digital max/min thermometer is reading temperatures in degrees Fahrenheit instead of Celsius?

You can change the units by pressing a small button located in the battery compartment. Open the battery compartment following the instructions given in the Changing the Battery in the Digital Multi-Day Max/Min Thermometer Field Guide. You should see a small round button, marked ˚F/˚C (see figure below). Turn on at least one of the sensors and press this button. You will see the measurement units change from Fahrenheit to Celsius. Close the battery compartment. Be sure always to have your instrument in Celsius mode when taking GLOBE measurements!

Figure AT-MU-2: Multi-Day Digital Max/Min Thermometer Battery Compartment with cover removed.



2. What if I find that as the time of local solar noon varies over the year it no longer is within an hour of my time of reset?

For your maximum and minimum temperature readings to be valid it is necessary for the time of reset to be within one hour of local solar noon. Reset your instrument using the Digital Multi-Day Max/Min Thermometer Reset Field Guide as close as possible to the time of local solar noon (within 15 minutes).

3. If I miss reading my maximum and minimum temperatures, can I still get the readings the next day?

The max/min temperatures stored in the instrument are updated every 24 hours at the *time of reset*. Therefore, these temperature values can be collected anytime from about 5 minutes after the *time of reset* on the desired day until 5 minutes before the *time of reset* on the next day. If you wait until after the *time of reset* on the 7th day, one day's data will be lost. However, if they are read on the next day, care must be taken to match temperatures read from the instrument to the days to which they correspond. Maximum and minimum temperatures displayed along with the D.1 symbol on the instrument display screen correspond to the current day when readings are being taken after *time of reset* (as recommended) and to the previous day when readings are being taken before the *time of reset*. See the following tables for clarification:

Readings taken AFTER time of reset (as recommended).

Digital Display			
Symbol:	D.1	D.2	D.3
Reading Corresponds to 24-hours Ending:	Today	Yesterday	2 days ago

Readings taken BEFORE time of reset

Digital Display			
Symbol:	D.1	D.2	D.3
Reading Corresponds to 24-hours Ending:	Yesterday	2 days ago	3 days ago

4. Can I read the thermometer in the morning before the time of reset?

If the thermometer is read in the morning, at least 5 minutes before the time of reset, it is possible to read the max/min temperatures for the past six days. However, the max/min temperatures for the current day cannot be read.

5. When I first press a MAX or MIN button, the instrument displays a reading which I am not supposed to record; what is this reading?

The reading displayed when you press a MIN or MAX button for the fist time is the minimum or maximum temperature for the on-going 24-hour period. Since this period is not finished, the reading may not be the final maximum or minimum temperature for the 24-hours. While it is not a valid data measurement that you report to GLOBE, it can be used for your own inquiry purposes.

6. How does the digital thermometer work?

The thermometer works by measuring the change in current running through a constant-voltage circuit in which the sensor probe serves as a resistor. As the temperature of the sensor changes, it's resistance changes. The change in current in the circuit is inversely proportional to the change in the sensor's resistance as described by Ohm's Law which explains that current is equal to voltage divided by resistance. So by measuring the current going through the circuit, and knowing the voltage, it is possible to calculate the resistance of the sensor. This is done by the instrument, which then reports the probe temperature corresponding to that level of resistance.