Water Vapor Protocol

Classroom Preparation Guide

This section includes a detailed step-by-step discussion about how to collect water vapor data, with information about and explanations for each step. The data collection steps are keyed to the *Water Vapor Protocol Data Collection Field Guide*, in which the same steps are listed, without explanation.

Tasks

- Record a set of maximum voltage readings obtained by pointing your water vapor instrument at the sun.
- Record the precise time of your measurements.
- Observe and record meteorological, cloud, and sky conditions.

What You Need

- ❑ GLOBE/GIFTS water vapor instrument
- ❑ *Water Vapor Data Sheet*
- ❑ Watch, preferably digital, or GPS receiver
- ❑ Digital hygrometer or sling psychrometer
- ❑ Pen or pencil
- ❑ GLOBE Cloud Chart
- ❑ Barometer
- ❑ Thermometer
- ❑ Field Guides for *Cloud Cover*, *Cloud Type*, *Air Temperature*, *Sling Pyschrometer*, *Digital Hygrometer Protocols* and *Barometric Pressure Protocol*

Getting Ready To Make Measurements

Site Description (see the Instrument Construction, Site Selection and Set-Up Protocol)

In order to report water vapor measurements you must have a defined atmosphere site at which to make observations. If your school has not established an *Atmosphere Study Site*, you will need to define one following the *Instrument Construction, Site Selection, and Set-Up Protocol*.

The site description needs to be done only once unless, of course, you change the location of the site or add an additional site. Interpretation of your measurements requires knowledge of the longitude, latitude, and elevation of your observing site.

The basic condition for taking water vapor measurements is that you must have an unobstructed view of the sun and a view of the sky that allows you to make reasonable cloud cover and type estimates. These measurements can be done in an urban setting.

Metadata

Metadata are data about data and supplement your actual data. They are important because they help scientists interpret your measurements. Some of the metadata (such as barometric station pressure) can be collected in the classroom just before or after your measurements.

Types of Metadata:

1. Barometric pressure (*Barometric Pressure Protocol* **available**)
Accurate barometric pressure values are important. Sources for barometric pressure are, in order of preference:

1. Online or broadcast data from a nearby official weather station.
2. Printed values from a reliable source.
3. Measurements from a classroom barometer.

Note: If you use option #1 or option #2 then **do not** enter the value in the "Barometric Pressure" field on the *Water Vapor Data Sheet*, instead report this value in the Comments section of the Data Sheet. If option #3 is used the relative humidity value should be entered in the "Barometric Pressure" field on the *Water Vapor Data Sheet*.

In many parts of the world, accurate barometric pressure values are readily available online, and are therefore preferable.

Many U.S. newspapers publish a daily weather almanac that gives weather information for the previous day, including barometric pressure. Use the value closest to the time of your data collection. For example, if barometric pressure is given at noon, this would be the value to use for most water vapor measurements. Depending on whether pressure is rising, steady or falling, it is reasonable to interpolate between noontime and early morning or late afternoon values (6:00 am and 6:00 p.m. local time are often given in addition to 12:00 noon).

In the U.S., the pressure may need to be converted from inches of mercury to millibars (hectopascals), which is the international and GLOBE standard:

pressure (mbar or hectopascals) = pressure (inches of Hg) * 33.864 (mbar/inch of Hg)

It is sufficient to report barometric pressure to the nearest millibar.

2. Current air temperature (*protocols* **available**)
Because the electronics in your GLOBE water vapor instrument, and especially its detectors, are temperature-sensitive, the Science Team asks that you report air temperature along with your water vapor measurements. GLOBE provides four ways to measure current air temperature.

1. *Digital Multi-Day Max/Min Current Temperature Field Guide*
2. Steps 1-5 of the *Maximum, Minimum and Current Temperature Protocol Field Guide*
3. Steps 1-4 of the *Digital Single-Day Maximum and Minimum Temperature Protocol Field Guide*
4. *Current Air Temperature Protocol Field Guide*

3. Temperature inside your water vapor instrument case
In terms of instrument performance, what really matters is not the outside air temperature itself, but the temperature inside the instrument case. Your water vapor instrument is fitted with an electronic temperature sensor that is located next to the sunlight detectors. You can display the voltage reading from this sensor by selecting the "T" position for the rotary switch. The output from the sensor is 10 mV per degree C. So, the temperature is 100 times the "T" voltage reading. For example, if the reading is 0.224 V, then the temperature inside the case is 22.4 ˚C. You should record this value once at the beginning of a set of measurements and again at the end.

For the most accurate measurements, it is important to maintain the air inside the case at approximately room temperature — in the low 20's. There are some simple steps you can take to minimize temperature sensitivity problems. Keep your water vapor instrument inside and bring it outside only when you are ready to take measurements. In the winter, transport it to the observing site under your coat or in an insulated bag. In the summer, transport it in a small picnic cooler. You can construct an insulating shell for your instrument from rigid foam plastic sheets (Styrofoam) held together with aluminum tape. Especially in the summer, keep your instrument shielded from direct sunlight whenever you are not actually taking a measurement.

4. Time

It is important to report accurately the time at which you take measurements because calculations of solar position at your site depend critically on time. The GLOBE standard for reporting time is always UT, which can be calculated from local clock time, your time zone and time of year (required for areas that implement daylight sayings time). It is essential to convert local time to UT correctly. Be especially careful if you switch from standard to daylight savings time, or vice versa. For example, you must add 5 hours to convert Eastern Standard Time (EST) to UT, but only 4 hours to convert Eastern Daylight Time (EDT) to UT. A one-hour error can produce results that look OK but that are, wrong. If you have a GPS receiver, you can obtain UT directly from it.

Time should be reported to an accuracy of no less than the nearest 30 seconds. A digital watch or clock that displays seconds is easier to use than an analog one, but in either case you must set your timepiece against a reliable standard. Even an analog wristwatch can be read to the nearest 15 seconds if it has one-minute marks on its dial. The time accuracy requirements for this and the related *Aerosols Protocol* are stricter than for most other GLOBE protocols.

It is not difficult to set your clock or watch accurately enough to meet the standards required for this protocol. You can get time online or from a handheld GPS receiver. In many parts of the world, you can buy a clock that sets itself automatically by detecting a radio signal from an institution that maintains a reference clock.

It may be tempting to use the clock maintained by your computer as a standard. However, this is not a good idea, as computer clocks are often inaccurate, and they should be reset periodically according to a reliable standard. Note that modern computer operating systems will automatically switch your computer clock back and forth between standard and daylight savings time.

Water vapor measurements can be taken any time during the day. Indeed, it is an interesting project to study the variation of water vapor during the day. However, the water vapor instrument will give the most reliable readings when you take measurements between mid-morning and mid-afternoon. In temperate and higher latitudes, with low maximum solar elevation angles, you should take measurements near solar noon if possible, especially in the winter.

If you are taking measurements that correspond to satellite overflights, then the times of those overflights determine when measurements should be taken. How closely must your measurements match the time of the overflight to be useful? This is a question that should be discussed with scientists working with the space-based instruments. In general, the times should match within just a few minutes. However, it is always better to collect data than not, even if you cannot time the measurements precisely with satellite overflights.

5. **Relative humidity** (*Relative Humidity Protocol* **available**)

Relative humidity is reported as a whole number, in percent. Relative humidity and temperature are used to calculate the dewpoint temperature, which is empirically related to PW. (See *Looking at the Data*.) There are two options for reporting relative humidity, with the first being highly preferred:

1. Obtain a relative humidity reading by doing the *Relative Humidity Protocol*. Report this reading in the "Relative Humidity" field on the *Water Vapor Data Sheet*.
2. If you do not have access to a digital hygrometer or sling psychrometer that meets GLOBE specifications, you may obtain a relative humidity reading from an online or broadcast source. In this case **do not** fill in the "Relative Humidity" field on the *Water Vapor Data Sheet*. Instead report this value in the *Comments* section of the *Data Sheet*.

6. Cloud observations (*Cloud Protocols* **available**)
Water vapor measurements can be interpreted properly only when the sun is not obscured by clouds. This does not mean that the sky must be completely clear, but only that there must be no clouds in the vicinity of the sun. This may not always be a simple determination. It is easy to determine whether low- and mid-altitude clouds are near the sun, but cirrus clouds can pose a challenge. They are often thin and may not appear to block a significant amount of sunlight. However cirrus clouds can affect PW measurements even when they are invisible to the human eye. Remember that the water vapor instrument detects light in the infrared part of the solar spectrum, so the fact that cirrus clouds may be only faintly visible to humans does not mean they are not absorbing infrared sunlight.

Another difficult situation occurs in typical summer weather, especially near large urban areas. In this environment, polluted skies and humid conditions may make it difficult to distinguish cloud boundaries. It is important to describe such conditions whenever you report measurements. Observing the sky (away from the sun!) through orange or red sunglasses or a plastic filter will make cloud boundaries easier to see.

Whenever you try to determine cloud conditions in the vicinity of the sun, you must block the sun itself with a book, a sheet of paper, a building or tree, or some other object. A sensible rule is that if you can see even faint shadows on the ground, you should not try to look directly at the sun. If in doubt, or if you believe you cannot determine sky conditions near the sun, then do not take a measurement.

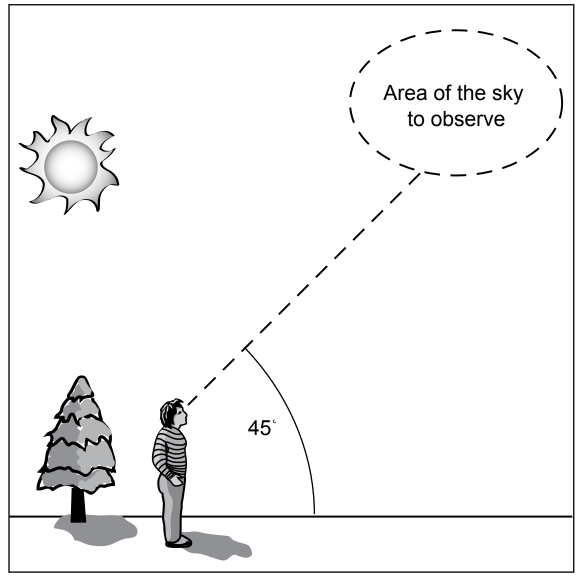
Safety Reminder: Never look directly at the sun, even through colored sunglasses or plastic filters. This can seriously damage your eyes!

Cloud condition reports should follow the Cloud Protocols. The categories given on the *Water Vapor Data Sheet* are described in these protocols.

7. Sky conditions
Sky conditions include sky color and clarity. These are subjective observations but, with practice, you can learn to be consistent in your interpretations. For example, you can easily learn to recognize the clear deep blue sky that is associated with clean air and low relative humidity. With higher humidity and increasing pollution, the sky color changes to a lighter blue. It may appear milky rather than clear. In some places, especially in and near urban areas, the sky can have a brownish or yellowish tint due to air pollution (primarily particulates and NO_2).

To determine sky color, look at the sky in a direction *away* from the sun. That is, your shadow should be directly in front of you. Sky color is generally lighter near the horizon. For this reason, you should be consistent about basing your observation on the sky at an elevation angle of about 45° above the horizon. If this part of the sky is cloudy, use the nearest part of the sky for which you can determine the color.

Figure AT-WV-6: Area of the Sky to Observe



You can determine sky clarity by using a distant object – a tall building or mountain range, for example – as a reference. When this object appears sharply defined in its natural colors, then the sky is clear. As the object becomes less distinct, then there are probably more water vapor and aerosols in the atmosphere. However, please note that this method of determining haziness is more directly related to horizontal visibility, which may not always be an accurate indicator of the condition of the atmosphere above your site.

When there are obvious reasons for unusual sky conditions, the users of your data need to know about them. Urban pollution, dust, and smoke are examples of conditions that need to be reported in the *Comments* section of the *Data Sheet*.

8. Spacecraft overflight information

Collecting data during satellite overpass, when available, can add relevency to student field work. The S'COOL overpass calculator (http://scool.larc.nasa.gov/en_rover_overpass.html) will allow the user to calculate satellite overpass for Aqua and NPP, both very relevant to water vapor measurements. Because the water vapor measurement involves viewing the Sun, only daytime overflights are of interest. When you are taking a measurement to correspond with a satellite overflights, please record the Satellite/instrument name, time of overflight, and any additional information on your *Water Vapor Data Sheet*.

In the Classroom

You should be familiar with the parts of the GLOBE/GIFTS Water Vapor Instrument, as shown in Figure AT-WV-7. Make sure you have all required materials and, if you are working as a team, that each team member understands her or his role. This is especially important if several different students participate in these measurements on a rotating basis. Information about using the computer interface can be obtained from the Science Team.

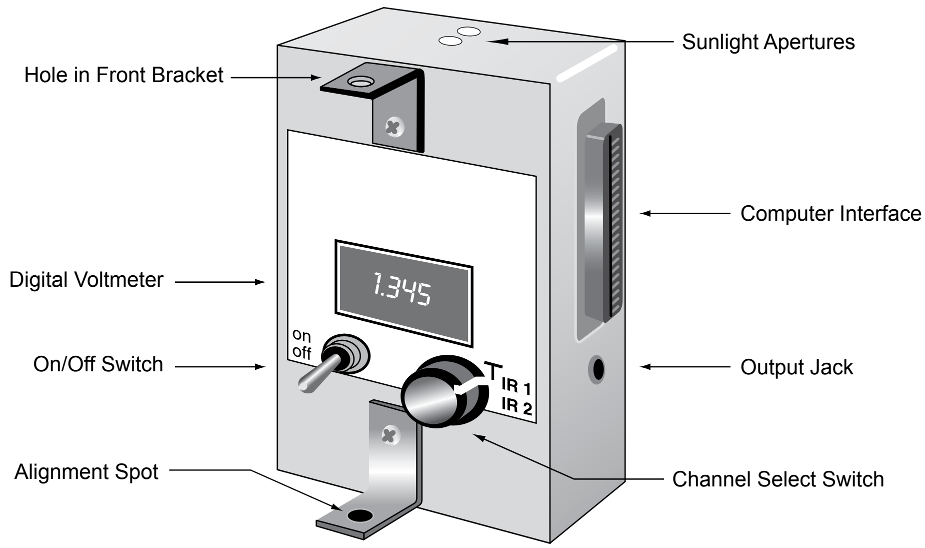
Practice runs can be made inside by pointing your instrument at the sun through a window – even a closed window. (Actual measurements should not be made through a closed window!) The water vapor instrument should be at room temperature – about 20-25° C – before collecting data. Place the instrument in an insulated container before you take it outside.

In the Field

It is easier for two people to collect these data than it is for one person working alone. If you are not familiar with this protocol, divide up the tasks and go through several practice runs outside before you start recording real data with your water vapor instrument. Remember that these practice runs may result in your instrument being exposed for a relatively long time to hot or cold weather. Before you take "real" measurements, you must be sure your instrument

Data Collection

Figure AT-WV-7: Parts of the GLOBE/GIFTS Water Vapor Instrument



has returned to room temperature, as described in item 3 in the Metadata section of *Getting Ready To Take Measurements*.

Explanation of Field Guide Steps for Data Collection:

1. Turn your instrument on.
2. Hold the instrument in front of you in a position where you can read the digital voltmeter and can comfortably keep the sun spot shining through the front alignment bracket aligned on the rear alignment dot.

   It will be helpful to brace the instrument against your knees, a chair back, railing, or some other fixed object.
3. Set the rotary switch to T, read the voltage, multiply this reading by 100, and record the value under “case temperature” on your *Water Vapor Data Sheet*.

   This reading represents the air temperature near the LED detectors inside your instrument. For the most accurate results, this temperature should be in the range 20-25˚ C.
4. Set the rotary switch to IR1.

   The *Data Entry Form* asks for measurements in the order IR1 then IR2. Always take measurements in this order.
5. Adjust the pointing of your instrument until the spot of sunlight coming through the front alignment bracket is centered on the colored alignment spot on the rear bracket.

During the next 10-15 seconds, observe the voltage displayed on the meter and record the maximum voltage in the “sunlight voltage” column of your *Data Sheet*. The voltages will fluctuate by a few millivolts even when you hold your instrument perfectly steady. This is due to real fluctuations in the atmosphere. Do not try to “average” these fluctuating voltages. Also, be sure to record all the digits displayed on the meter: 1.732 rather than 1.73, for example.

6. Record the time at which you took the measurement as accurately as possible.

   Include seconds. An accuracy of 15-30 seconds is required. This is possible even with an analog watch that has been set to a reliable standard.

7. While still pointing your instrument at the sun, cover the sunlight apertures with your finger to block all light from entering the case. Record this reading in the “dark voltage” column on the *Data Sheet*.

8. Select the IR2 channel and repeat steps 5-7.

9. Repeat steps 4-8 at least two and as many as four more times.

   This will give between three and five pairs of IR1/IR2 measurements. Remember that it is important to be consistent about the order in which you collect these data: IR1, IR2, IR1, IR2, IR1, IR2. The time between measurements is not critical as long as you record the time accurately. However, especially in hot or cold weather, it is important to minimize the total measurement time in order to keep the temperature inside your instrument case close to room temperature. A set of up to five pairs of measurements should take no longer than two or three minutes to collect (20-30 seconds per voltage value). The *Water Vapor Data Sheet* has space for up to five pairs of measurements; taking more than three pairs is helpful, but not required.

10. Set the rotary switch to T, read the voltage, multiply this reading by 100, and record the value under “case temperature” on your *Water Vapor Data Sheet*.

11. Turn off your water vapor instrument.

12. Note any clouds in the vicinity of the sun in the Comments section of your *Water Vapor Data Sheet*. Be sure to note the type of clouds by using the *GLOBE Cloud Chart*.

13. Do the *Cloud Protocols* and record your observations on the *Water Vapor Data Sheet*.

14. Read and record the current air temperature to the nearest 0.5˚ C following one of the air temperature protocols. Be careful not to touch or breathe on the thermometer.

    Use one of the protocols listed in item 2. in the first part of this *Classroom Preparation Guide*.

15. Perform the *Relative Humidity Protocol* and record the results on the *Water Vapor Data Sheet*.

    If you do not have an acceptable digital hygrometer or sling psychrometer available, then do not fill in the “Relative Humidity” fields on your data *Water Vapor Data Sheet*. Instead report a relative humidity value from a reliable online source in the Comments section of the *Water Vapor Data Sheet*.

16. Complete the *Water Vapor Data Sheet*.

    This includes reporting a barometric pressure value (preferably from an online source reported in the *Comments* section) as described above, and filling in any additional comments.