



Conserve O Gram

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Comparing Temperature and Relative Humidity Dataloggers for Museum Monitoring

Introduction

Datalogger refers to a battery powered device equipped with sensors and a microprocessor to monitor and record data such as temperature [T], relative humidity [RH], light, voltage, etc. Datalogging systems usually include proprietary software to initiate and set parameters for monitoring, downloading, viewing and analyzing data.

This *Conserve O Gram* (COG) compares several dataloggers and discusses selection criteria focusing on stand-alone loggers (each unit operating independently) rather than networked systems that provide real-time data using wireless or hard-wired technologies. Two accompanying tables list basic hardware specifications (Table 1), and software related issues (Table 2). It updates *COG 3/3 Datalogger Applications in Monitoring the Museum Environment, Part I: Comparison of Temperature Relative Humidity Dataloggers, 2001*. See also the NPS *Museum Handbook, Part I, 4, Museum Collections Environment* for other monitoring equipment options.

Methodology

The loggers discussed below are currently the most prevalent in the cultural heritage community. They were selected based on queries and responses posted on several preservation listservs, or were suggested in discussions with

manufacturers and distributors. Information was obtained from specification sheets or manufacturers and distributors. Manufacturers or distributors provided demonstration units of each logger. The loggers were run in a series of three environmental chambers at stable temperature with saturated salt solutions of low, mid and high RH. The data was used to evaluate the software and assess logger performance.

Datalogger Hardware Specifications (Table 1)

Table 1 compares hardware specifications for ten different dataloggers. How to evaluate these specifications is explained below.

Operating Range

The operating range of a datalogger is determined by sensor type and quality. Manufacturers specify range using different terms (e.g. operating, working, reading, or sensor range) but they are not necessarily synonymous. Specification sheets may use one term to indicate the physical limits to which a unit can be exposed, and another to indicate the working range for the sensor. All the loggers listed have functional ranges beyond the temperatures expected in a collection environment and may even function during heat or freeze treatments. A few do not function well at low RH (under 20%). None

are intended for outdoor environments or exposure to high RH for prolonged periods.

Accuracy

Accuracy is a function of the sensor type, quality and type of calibration and will greatly impact cost. Accuracy may differ across the functional range of the logger.

Calibration

Some loggers are given a basic, one point calibration, generally performed at room temperature and 50% RH, guaranteeing that the logger will be accurate at a mid-range RH. A logger calibrated at two or more points is checked at an additional low or high RH level and is more likely to take accurate readings across its range. Loggers arrive factory tested for accuracy within the manufacturer's specifications, which is generally sufficient for collections monitoring. Calibration to a traceable standard (e.g. National Institute of Standards and Technology [NIST]) may imply greater accuracy, but is rarely necessary for museums.

Electronic sensors are more durable and have faster response times than hair hygrometers or hygrometers but they also require periodic recalibration. Manufacturer recommended recalibration times range from 6 months to 3 years, with most advocating annual calibration. Some loggers allow the user to compensate for minor sensor drift by recalibrating the unit using accompanying software or adjusting the data in the software after download. Most, however, must be sent back to the manufacturer if they are not performing within their accuracy parameters. Factor the cost of factory recalibration into the lifetime cost of a logger.

Before returning a logger to the company, check the calibration of your unit using small chambers and saturated salt solutions. Use this procedure before installing newly purchased units. Discard inexpensive units that are found to be inaccurate, as recalibration is not cost efficient.

Power Source and Battery Life

Battery life is a function of battery type and the sampling rate. A logger set to read every five seconds will not last as long as one sampling every hour. Specifications are usually based on a moderate sampling rate (i.e., sampling every 20 - 30 minutes) as is generally recommended for long-term collections monitoring. Features such as Liquid Crystal Display (LCD) or Light Emitting Diode (LED) alarms also impact battery life. All loggers listed below have non-volatile memory, i.e., data is saved even if the battery is removed or dies. For general trend monitoring, a logger should have enough battery life to provide one full year of monitoring. A shorter battery life may be acceptable for special needs projects.

Memory Capacity and Run Time

Memory capacity is listed by the number of paired readings (T and RH readings) while others list the total number of individual readings. To compare these figures, divide this total by the number of operating channels, which is generally two: one for T and one for RH. Some loggers allow extra channels to be enabled for additional features (e.g. external probe) or other types of readings (e.g. light). If more channels are activated, fewer sets of readings will be collected. To facilitate comparison, all product specifications have been translated into the number of pairs of T and RH readings.

Memory capacity is impacted by the sampling rate (see below). To compare the combined impact of memory capacity and sampling rate, the loggers were launched for a 15-minute sampling period. The duration that the logger can run at this interval before reaching memory capacity is listed. Alternative data is provided for the few loggers where 15 minutes was not a selectable option.

Sampling Rate and Start/Stop Options

Most loggers allow the user to set the sample rate (how frequently a T and RH reading is taken) during the launch process. Intervals range from 1 second to 24 hours, lasting days or years. Users can also select various start and stop options during the launch. All loggers offered at least two of the following activation options:

- immediate launch
- delayed start: user sets date and time in the future
- trigger or push button: user activates logger or uses a magnet to trigger the logging process

Users can determine if the logger stops recording when the memory is full or overwrites earlier data to continue recording. If the former option is chosen, downloads should take place before the memory reaches capacity to ensure that there is no gap in monitoring. If the latter option is selected, download the logger regularly to ensure that data is not lost.

Alerts / Alarms

During the launch process, many loggers allow users to input upper and lower limits of a target range. If the parameters are exceeded, an alarm setting will be activated resulting in

a visible alert on either an LCD or LED. This feature indicates that an environmental event occurred and data should be downloaded and reviewed. Alarms negatively impact battery life.

Display

Several loggers offer a LCD for a visible display of real-time data. This is useful for checking current conditions without downloading data. However, if the logger is not in a readily visible or frequently accessed location, or real time readings are not needed, this feature may not be worth the corresponding drain on battery life.

Probes

External probes can be attached to some loggers. Probe sensors are smaller than the loggers. They can be placed into hard-to-access locations such as inside a sealed case with the sensor cable leading to the logger on the case exterior where it is accessible for downloading.

Size, Appearance, and Construction

Size may be a determining factor in monitoring inside vitrines, buffered frame enclosures, storage cases, and shipping crates. Casings are normally made of hard plastic but colors and shapes vary. Small loggers are unobtrusive, but larger loggers are more easily secured in place, a consideration when installed in public spaces. Consider mounting options such as magnetic backing, keyhole mounts, locking eyelet, and mounting brackets before purchase.

Data Retrieval, Viewing and Analysis (Table 2)

Table 2 evaluates factors that impact the user experience. A good piece of hardware can be rendered unappealing by poorly designed software. While software evaluation is subjective, good software will be easy to use and provide convenient data manipulation options.

Data Retrieval

Data on standalone loggers is retrieved by connecting *in-situ* to a laptop or bringing the unit to a desktop computer. If this is impractical, consider loggers that provide alternative download methods such as an option to download using a flash drive or proprietary data collection device. A few of the loggers listed in this COG have wireless functionality or related wireless models which is noted when applicable.

Software Platform

Confirm that the logger software is compatible with a Microsoft Windows platform. Software options for Mac users are limited. Most companies provide free software upgrades over time.

Data Formats

All logger software packages download data into a proprietary format and have basic export abilities. Some format directly to MS Excel and others to Comma Separated Value (CSV) or text format which can be imported into other software. A few allow data to be easily imported into the Image Permanence Institute's Climate Notebook or <www.pemdata.com software.> The ability to format a graph in one step for a report or email is a great convenience.

View Raw Data in Table Form

While all loggers allow for graphical representation of the data, several also allow viewing of the raw data in table form without exporting to a program like MS Excel. This is useful to identify specific problem in the raw data.

Download while Logging

This function allows for data backup or retrieval from the logger without re-launching. Monthly downloads on a logger without this capacity will result in 12 short graphs. Loggers that continue logging during the data retrieval process provide a single, long dataset. This avoids spending time organizing or combining multiple data sets.

Combining and Appending Data Sets

The ability to append data to combine short datasets into longer trends is useful if the unit cannot download while logging as discussed above.

Overlay Graphs for Comparison

This key feature allows for easy visual comparison of the conditions of different monitored spaces.

Ability to Modify and Print Graphs

Good software allows the user to modify, manipulate and print graphs. The table notes whether the software offers low, moderate or extensive options, including: changing graphics (line color, appearance, fonts, and background), selecting the range of axes, easily zooming in and out, adding or editing graph titles, and annotating the graph or specific data

points. The graph should display the time, date, and year of the readings and allow for setting printing options like portrait or landscape view.

Provides Statistics for Data and Subsets of Data

The software should clearly show basic statistics (high, low, mean, average readings, etc.) for the full dataset as well as data subsets.

View Target Ranges for Data

The ability to view graphically represented target ranges for data as noted in the section on Alerts/Alarms.

System Costs

Project budget is a driving force in product selection, but a system lacking needed features will be a poor investment over time. The unit price of the tested loggers ranged from \$68 - \$740 as of September 2011. Prices are subject to change. Some loggers will incur ancillary costs for a software, cables or a laptop computer or portable download unit, while others have a direct USB connection or free software eliminating extra charges. Check for volume discounts or kits that bundle loggers with software and accessories for additional savings.

Service and Technical Support

Consider company reputation, reliability, quality of service and technical support when making a purchasing decision. Many companies allow tests of their software via free Internet download.

Conclusion

All loggers listed in this COG are appropriate for monitoring environmental conditions in cultural institutions. Some are better suited to general long-term monitoring and others for special applications. Considering all the variables outlined in this COG should facilitate choosing a logger appropriate to your project needs.

Sources

Companies and distributors listed below supplied loggers used to develop this COG. Their participation is acknowledged with thanks.

- ACR, June Wheeler, Herzog/Wheeler & Associates, www.acrystems.com
- EasyLog, Dave Clark, CAS Dataloggers, www.dataloggerinc.com
- Hanwell, Greg Basso, Cascade Group, Inc., www.cascadegroup.com
- PEM2, Patricia Ford, Image Permanence Institute, www.imagepermanenceinstitute.org
- LogTag, Rich Woodfin, MicroDAQ www.microdaq.com
- Onset Hobos, Scott Ellis, www.onsetcomp.com
- T&D, Dave Clark, CAS Data Loggers, www.dataloggerinc.com and Steve Knuth T&D www.tandd.com
- Track-It, Rich Woodfin, MicroDAQ, www.microdaq.com
- Tinytag, Kathy Bryant and Doug Johnson, Micron Meters, www.micronmeters.com
- Veriteq –A Vaisala Company www.veriteq.com

References

Daly, Gregg M., and Hugh J. Flye. "Dataloggers Deliver." *Engineered Systems* 17, no. 8 (2000):84-89.

Morris, Patricia. "Setting Up an Environmental Monitoring Program". *Colorado Libraries* (2004): 31-33

National Park Service. *Museum Handbook*, Part I, Chapter 4: Museum Collections Environment (1999) <http://www.nps.gov/museum/publications/MHI/CHAPTER4.pdf>

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The series is distributed to all NPS units and is available to non-NPS institutions and interested individuals on line at <http://www.nps.gov/history/museum/publications/conservoogram/cons_toc.html>. For further information and guidance concerning any of the topics or procedures addressed in the series, contact NPS Park Museum Management Program, 1849 C Street NW (2265), Washington, DC 20240; (202) 354-2000.

Table 1: Datalogger Hardware Specifications (i)

Company Model Website <i>Listed in alphabetical order</i>	Operating Range	Accuracy <i>Generally assessed at room temperature</i>	Calibration: # of T or RH points <i>User calibratable</i>	Power Source Battery Life	Memory # of data sets (i.e. pair of Temp & RH readings) Run Time	Sampling Rate
ACR SmartReader 2 (SR-002) www.acrsystems.com	-40° to 158°F -40 to 70°C 0-95% RH	±0.2°C (0°C to 70°C) ±4% RH (10-90% RH)	Points: 3 point* Standard: NIST** User: Yes***	3.6 volt Lithium battery 10 years	16,383 data sets 15 mins = 170 days, 15 hours	User selectable 8 sec -5 days in 4 sec intervals
Gemini Tinytag View 2 TV-4500 www.gemindataloggers.com	-13° to 122°F -25° to 50°C 0-100% RH	±0.4°C (0°C to 50°C) ±3% RH at 77°F (25°C)	Points: 2 point * Standard: Factory** User: No** *	3.6 volt Lithium battery 1 year	15,000 data sets 15 mins = 161 days 19 hours.	User selectable 1 second to 10 days
Gemini Tinytag Ultra2 TGU-4500 www.gemindataloggers.com	-13° to 185°F -25° to 85°C 0-95% RH	±0.5°C or better (0 to 50°C) ±3% RH at 77°F (25°C)	Points: 2 point * Standard: Factory** User: No** *	3.6 volt Lithium battery 1 year	16,000 data sets 15 mins = 169 days 20 hours	User selectable 1 second to 10 days
Hanwell Temperature & Humidity ml4106 www.hanwellusa.com	32° to 149°F 0° to 65°C 0-100% RH	±0.1°C ±2% RH	Points: 3 points* Standard: OKED** User: Yes***	3.6 volt Lithium battery 3 years	50,000 data sets 15 mins = approx. 220 days	User selectable 10 seconds to 24 hours
Image Permanence Institute PEM2 www.imagepermanenceinstitute.org	-40° to 150°F -40° to 65°C 0-100% RH	0.5°C ±2RH (10%-90% RH) ±3.5% RH at extremities	Points: 5 points Standard: NIST* User: No	4 AA Lithium or alkaline batteries 10 years	350,400 data sets**	Fixed 30 minutes***
Monarch Instruments Track-It www.monarchinstrument.com	-4° to 185°F -20° to 85°C 0-100% RH	±0.1°C (0°C to 50°C) ±3% RH (20-80% RH)	Points: 1 point* Standard: None User: No	Lithium CR2032 1 year**	64,000 data sets 15 mins = 341 days, 8 hours	User selectable 2 seconds to 24 hours.
Lascar EasyLog EL-USB-2 www.lascarelectronics.com	-31° to 176°F -35° to 80°C 0-100% RH	0.5°C (20°C to 30°C) ±3RH (20%-80% RH) ±5% RH at extremes *	Points: 1 point Standard: None User: No	3.6 volt Lithium battery 1 year	16,382 data sets 5 mins = 56 days, 30 mins = 11 months	User selectable 10 sec – 12 hours (7 setting choices in that range)
LogTag HAXO-8 Humidity & Temp Logger www.logtagrecorders.com	-40°F to 185°F -40° to 85°C 0-100% RH	0.5°C (20°C to 30°C) ±3RH (20%-80% RH) ±5% RH at extremities	Points: 1 point Standard: None User: No*	3 volt Lithium 2-3 years**	8,000 data sets 15 mins = 83 days	User selectable 30 sec – 18 hours

Table 1: Datalogger Hardware Specifications (ii)

Company Model (continued)	Alarm LCD or LED	Display	Probe	Wireless / Realtime Capable	Size in. mm oz / g	Price as of 9/2011	Comments <i>Symbols (* or †) correspond to column entries</i>
ACR SmartReader 2 (SR-002)	No†	No	Yes††	No†	4.2 x 2.9 x 0.9 in. 107 x 74 x 22 mm 3.75 oz, 110 g	\$499	* Initial NIST factory calibration at 15, 50 & 80% RH at 77°F ** Factory recalibration \$150; sensor replacement \$275 † SRP-002-128 model, \$1,045 has extensive memory. can be networked for real-time data & alarms via phone or email †† Only unit where probe & logger measure concurrently
Gemini Tinytag View 2 TV-4500	LCD†	Yes	No††	No	3.5 x 2.6 x 1.4 in. 90 x 65 x 35 mm 3 oz. / 85g	\$275	* 0 and 30°C and 20 and 70%RH (at 25°C) ** NIST or UKAS traceable certificate at additional charge *** \$100 recalibration charge † Optional alarm box available for audible alarm †† Probe available on TV-4505 model
Gemini Tinytag Ultra2 TGU-4500	LED	No	No	No	2.8 x 2.4 x 1.3 in. 72 x 60 x 33 mm 1.94 oz / 55g	\$165	Tinytag Plus2 logger appropriate for outdoor use & extreme conditions * 0 and 30°C and 20 and 70%RH (at 25°C) ** NIST or UKAS traceable certificate at additional charge *** \$100 recalibration charge
Hanwell Temperature & Humidity ml4106	LCD	Yes	No†	No††	4.3 x 3.1 x 1.4 in. 110 x 80 x 35 mm 7.05 oz / 200g	\$599	* Factory calibrated at 33, 54 & 76% RH ** Traceable 3-point certificate \$140 *** Non-traceable single point calibration check \$75 † 43791-H & ML4102-457.6 units comes w/ remote probe †† Comparable ML4106-457.6 & ML4102-457.6 models works w/ Hanwell real time wireless monitors
Image Permanence Institute PEM2	No	Yes	No	No	2.9 x 3.8 x 1.5 in. 73 x 95 x 38 mm 7.03 oz, 199 g	\$349	* NIST certificate at no extra charge ** 20 years worth of data at set sampling rate *** Samples every 5 minutes averaged to 30 minute readings
Monarch Instruments Track-It	LED	Yes***	No	No	3.7 x .75 x 1.2 in. 93 x 19 x 30 mm 1.14 oz, 32 g	\$79	* NIST calibration available at extra cost ** Long-life battery EF651625 option provides 3 year battery life *** Also available w/o LCD
Lascar EasyLog EL-USB-2	LCD**	No**	No	No	4.0 x 1.0 x 1.0 in 103 x 26 x 26 mm 1.40 oz, 40 g	\$82***	* slightly increased accuracy on EL-USB-2+ & EL-USB-2-LCD+ models ** Displays on EL-USB2-LCD and LCD+ models *** 2+, LCD / LCD+ models priced between \$82-125
LogTag HAXO-8 Humidity & Temp Logger	LED	No	No	No	3.4 x 2.2 x .34 in. 86 x 55 x 8.6 mm 1.23 oz / 35 g	\$68	* Can add off-set value to exported data ** Non-replaceable sensor & battery. Discard unit upon battery depletion.

Table 1: Datalogger Hardware Specifications (iii)

Company Model Website <i>Listed in alphabetical order</i>	Operating Range	Accuracy <i>Generally assessed at room temperature</i>	Calibration: # of T or RH points <i>User calibratable</i>	Power Source Battery Life	Memory # of data sets (i.e. pair of Temp & RH readings) Run Time	Sampling Rate
Onset HOBO U10-011 www.onsetcomp.com	-4° to 158°F -20° to 70°C- 25 to 95% RH	± 0.5°C from 0° to 50°C (0.97°F from 32° to 122°F) ± 3.5% (25 to 85% RH) ±5% RH at extremities	Points: 1 point Standard: None* User: No**	CR2032 Lithium coin cell batteries 1 year	26,000 data sets 15 mins = 271.6 days	User selectable 1 second to 18 hours.
Onset HOBO U12-011 www.onsetcomp.com	-4° to 158°F -20° to 70°C 5% - 95% RH	± 0.35°C from 0° to 50°C (± 0.63°F from 32° to 122°F), ±2.5% from 10% to 90% RH ±3.5% at extremities	Points: 1 point Standard: None* User: No**	CR2032 Lithium coin cell batteries 1 year	21,500 data sets 15 mins = 226 days	User selectable 1 second to 18 hours
Onset HOBO U14-001 LCD Logger www.onsetcomp.com	-4° to 122°F -20° to 50°C 0 - 100% RH	±0.2°C from 0° to 50°C (±0.36°F from 32° to 122°F) ±2.5% from 10 to 90% RH	Points: 1 point Standard: None* User: No**	3 AAA Alkaline bat- teries 1 year	21,500 data sets 15 mins = 226 days	User selectable 1 second to 18 hours
TandD RTR-503 www.tandd.com	32° to 131°F 0° to 55°C 10 - 95% RH	±0.3°C across range (±0.32°F across range) ±5% at 25°C and 50% RH	Points: 2 points Standard: None User: Yes*	LS14250 Lithium battery** or AC adaptor 10 months***	8,000 data sets 15 mins = approx. 84 days	User selectable 15 choices from 1 sec to 60mins.
TandD TR-74Ui - Illuminance UV Recordert www.tandd.com	32° to 131°F 0° to 55°C 10 - 95% RH	±0.3°C across range (±0.32°F across range) ±5% at 25°C and 50% RH	Points: 2 points Standard: None User: Yes*	1 LR6 AA alkaline battery 6 months	8,000 data sets 15 mins = approx. 84 days	User selectable 15 choices from 1 sec to 60mins.
Veriteq Spectrum 2000-20R www.veriteq.com †	-31° to 185°F -35° to 85°C 0% to 100% RH	±0.15°C (-25 to 70°C) ±0.27°F (-13 to 158°F) ±1%RH from 10% to 90% RH at 20°C to 30°C	Points: 5 points* Standard: NIST** User: Yes***	3.6 Lithium battery 10 years††	61,098 data sets 15 mins = approxi- mately 183 days	User selectable 10 seconds to once a day in 10 second -increments

Table 1: Datalogger Hardware Specifications (iv)

Company Model (continued)	Alarm LCD or LED	Display	Probe	Wireless / Realtime Capable	Size in. mm oz / g	Price as of 9/2011	Comments <i>Symbols (* or †) correspond to column entries</i>
Onset HOBO U10-011	No	No	No	No	1.8 x 2.4 x 0.8 in. 45 x 60 x 20 mm 0.82 oz / 26 g	\$81	* NIST calibration on T only available at extra charge (\$70/point) ** Logger tune-up (\$84) checks T & RH calibration & replaces battery
Onset HOBO U12-011	No	No	No	No	2.3 x 2.9 x 0.9 in. 58 x 74 x 22 mm 1.6 oz / 46 g	\$115	U12-012 measures T/RH/lux & external channel for \$133 * NIST calibration on T only available at extra charge (\$70/point) * Logger tune-up (\$84) checks T & RH calibration & replaces battery
Onset HOBO U14-001 LCD Logger	LCD	Yes	No ***	No	4.9 x 3.6 x 1.2 in. 125 x 92 x 31 mm 6.0 oz /170 g	\$209	U10-003 model is lower cost but w/ narrower RH range * NIST calibration available at extra charge only on T (\$70/point) * Logger tune-up (\$84) checks T & RH calibration & replaces battery *** External probe available on U14-002 model.
TandD RTR-503	LED††	Yes	Yes	Yes	2.4 x1.9 x 0.7 in.† 62 x 47 x 19 mm 2.0 oz /56 g	\$299	* Adjustment tools software program ** Long life battery L series available fitted w/large capacity battery adaptor kit RTR-05B1 *** L series battery gives 4 year lifespan ††SMS text or email alarm capabilities if networked † Measurements excluding protrusions (e.g. probes). L type is 46.5 mm depth and 109g
TandD TR-74Ui - Illuminance UV Recorder†	LCD**	Yes	Yes	No***	2.2 x 3.1 x 0.7 in. 55 x 78 x 18 mm 2.2 oz /62 g	\$379	†Measures illuminance (lux) and UV intensity (mw/cm2) N.B. UV is not in mw/lumen as commonly expressed * Internal 2 Point Adjustment Function ** SMS text or email alarm if using RTR-574 *** RTR 574 is a wireless capable version \$449
Veriteq Spectrum 2000-20R	No†††	No	No	No†††	3.4 x 2.3 x 1 in. 85 x 59 x 26 mm 2.7 oz / 76g	\$740	† Company merged in 2010 w/Vaisala * 5 points on RH and 3 points on T ** NIST and A2LA standard on all units ***SCAL program can be purchased for user recalibration. Program cost depends on number of units. Factory recalibration \$285 †† Based on a 1 minute sampling rate ††† Hardwired or wireless option available w/alarm capabilities using Ethernet converter & viewLink software

Table 2: Data Retrieval, Viewing and Analysis (i)

Company Software Package Website <i>Alphabetical order</i>	Data Retrieval <i>Cable, flash drive, wireless, portable unit</i>	Software Platforms	Data Formats <i>Save as formats for raw data and graphs</i>	Raw Data viewable in table form	Download while logging	Combine/append data sets	Overlay graphs for comparison	Ability to modify & print graphs *
ACR TrendReader2 www.acrsystems.com	Cable (USB-Single prong or Serial to prong)*	Windows 2000 & up	Data: csv, proprietary, txt Graph: bmp, jpg, pdf	Yes	Yes	Yes	Yes	Extensive
Gemini Tinytag Explorer software SWCD-0040 www.gemini dataloggers.com	Proprietary USB or Serial Interface Cable CAB-0007	Windows 2000 & up	Data: csv, proprietary, xls, txt, Graph: png, bmp*	Yes	Yes	Yes	Yes	Moderate
Hanwell Temperature & W200 USB Logger Software www.hanwellusa.com	USB cable	Windows 2000 & up	Data: csv, proprietary Graph: bmp	Yes	Yes	Yes	Yes	Moderate
Image Permanence Institute www.mypemdata.com www.imagepermanenceinstitute.org	Portable flash drive	Web-based software viewable with internet connection	Data: Plain Text File ASCII Graph: pdf or right click to copy to Windows clipboard	No*	Yes	Yes	Yes	Limited
Monarch Instruments Track-It Software www.monarchinstrument.com	Direct USB connection	Windows XP and up	Data: csv, proprietary, xls Graph: None*	Yes	No	No	No	Limited
Lascar EasyLog USB Control software www.lascarelectronics.com	Direct USB connection or Portable EL-DataPad	Windows 2000 & up Mac compatible*	Data: txt Graph: None**	No***	No	No	No	Limited

Table 2: Data Retrieval, Viewing and Analysis (ii)

Company Software Package	Provides basic statistics for data and data subsets	Viewable data target ranges	Price for Accessories as of 5/2011	Notes
ACR TrendReader2	Yes	No	\$240 for both software and cable	* Features considered were the ability to change graphics (line color and appearance, fonts, background), change range of axes, zoom in and out, change titles, add notes and annotations, and modify print settings * The SRP-002-128 connects by network modem
Gemini Tinytag Explorer software SWCD-0040	Yes	Yes	\$90**	* Emails directly from software but only in proprietary format **when purchased as a kit
Hanwell Temperature & W200 USB Logger Software	Yes	Yes	\$110	
Image Permanence Institute www.mypemdata.com	Yes	Yes	Variable** Flash drive widely available	* not on pemdata.com but data file can be opened in any text or spreadsheet software (e.g. Excel) ** Tiered pricing depending on # of data sets. Free for few data sets. Data compatible with older IPI Climate Notebook software Will graph dewpoint
Monarch Instruments Track-It Software	Yes	Yes	Included in logger price	* screen capture is only option for saving graph
Lascar EasyLog USB Control software	No	No	Included in logger price EI-DataPad \$199	* Data can be transferred to Mac and viewed in Excel using the EI-DataPad ** screen capture is only option for saving graph *** not in software but can open file in Excel Will graph dewpoint

Table 2: Data Retrieval, Viewing and Analysis (iii)

Company Software Package Website <i>Alphabetical order</i>	Data Retrieval	Software Platforms	Data Formats	Raw Data viewable in table form	Download while logging	Combine/append data sets	Overlay graphs for comparison	Ability to modify & print graphs *
LogTag LogTag Analyzer www.logtagrecorders.com	Cable, flash drive, wireless, portable unit	Windows XP & up	Data: csv, proprietary, text (tab delim or mac), html Graph: copy to Windows clipboard	Yes	Yes	Yes	Yes	Extensive
Onset HOBOWare Pro www.onsetcomp.com	USB cable or HOBOW Shuttle Data Transporter U-DT-1	Windows XP & up Mac OS X	Data: csv proprietary* Graph: copy to Windows clipboard	Yes	Yes	Yes**	Yes**	Extensive
TandD RTR-500 for Windows www.tandd.com	Short Range Wireless or Optical	Windows XP & up	Data: proprietary, txt (comma, tab delim) Graph: None*	Yes	Yes	No	No	Limited
TandD Illuminance UV Recorder for Windows www.tandd.com	USB cable	Windows XP & up	Data: proprietary, txt (comma, tab delim) Graph: None*	Yes	Yes	No	No	Limited
Veriteq Spectrum software www.veriteq.com	USB cable†	Windows 2000 & up*	Data: csv, proprietary, txt** Graph: proprietary***	Yes	Yes	Yes	Yes	Moderate

Table 2: Data Retrieval, Viewing and Analysis (iv)

Company Software Package	Provides basic statistics for data and data subsets	Viewable data target ranges	Price for Accessories as of 5/2011	Notes
LogTag LogTag Analyzer	Yes	Yes	\$49	*Features considered were the ability to change graphics (line color and appearance, fonts, background), change range of axes, zoom in and out, change titles, add notes and annotations, and modify print settings
Onset HOBOWare Pro	Yes	Yes**	\$89 software \$10 cable \$260 shuttle	* Easy import into IPI pemdata.com website ** Available in Hoboware 3.0 and up Will graph dewpoint
TandD RTR-500 for Windows	Yes	No	RTR-500DC \$399 RTR-500NW \$449 RTR-500GSM \$549'	* Use w/ RTR-500DC Handheld Data Collector for portable collection, RTR-500NW Network Base Station if network is in place or RTR-500GSM – Mobile Base Station if no access to network or wifi is available. RTR 574 uses 500 series software
TandD Illuminance UV Recorder for Windows	Yes	No**		* Screen capture is only option **Additional functions such as target ranges and dewpoint are expected in new software update currently available in beta form
Veriteq	Yes	No††	\$185†	Will graph dewpoint †Hardwired or wireless option available using Ethernet converter and viewLink software. \$250 per logger unit plus software costs * viewLink software requires Windows XP & up ** Free Excel add in available for download on website *** Proprietary file must be saved as pdf for viewing w/o Spectrum software. †† Capability is expected in 2012 software update