15 Measurement Protocols

The Measurement Protocols tab is where the majority of the configurations settings for the PSY1 are made.

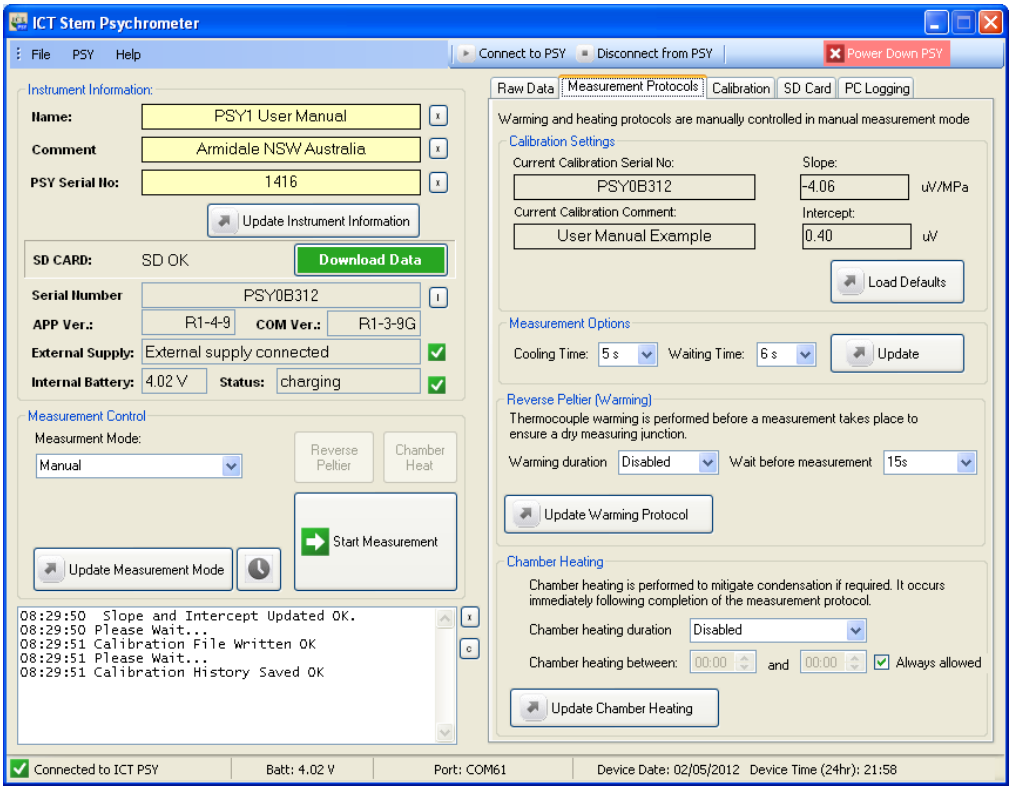

Figure 23: The Measurement Protocols are situated on a dedicated tab in the software.

15.1 Calibration Settings

This is an instant reference of the calibration slope and intercept that will be applied to the raw Psychrometric Wet Bulb Depression to convert it to Water Potential in MPa. The actual calibration file is stored on the MicroSD card using the four digit serial number of the psychrometer chamber that was calibrated.

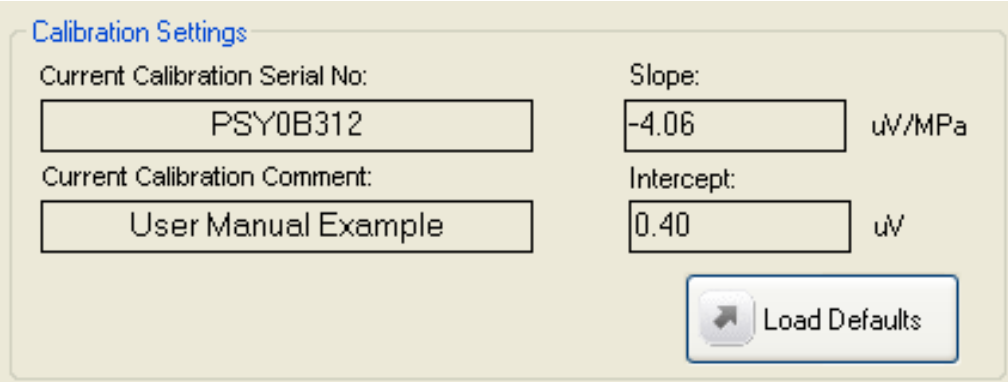

Figure 24: Summary listing of the calibration settings applied to the PSY1.

The calibration file contains the serial number of the PSY1 that was used to perform the calibration along with a user comment to reference the time or reason the calibration was performed. This information is read from the cal file and displayed in this window.

After calibration of a psychrometer the new calibration slope and intercept will automatically be updated in this field. Before it is written to firmware the user is prompted to accept or decline the new slope & intercept. The calibration process is covered in detail in the Calibration section of the manual.

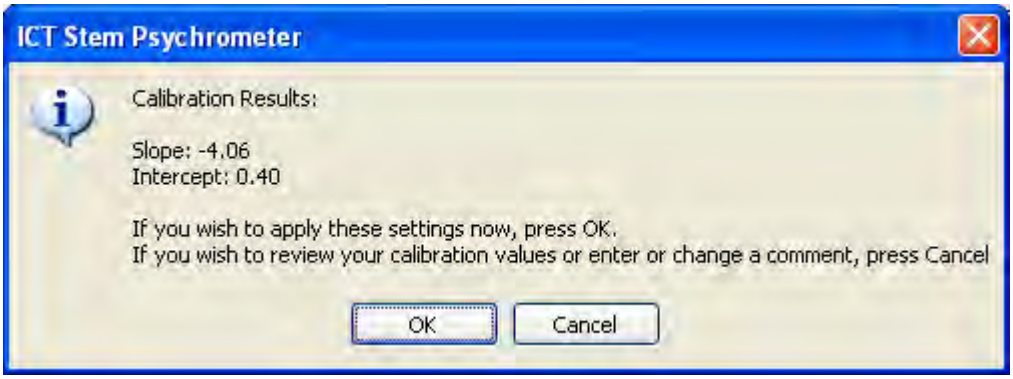

Figure 25: Confirmation Window before writing PSY1 Calibration settings to firmware.

15.2 Measurement Options

Measurement Options deal specifically with the duration of the Peltier Cooling Pulse and sampling point at which the Psychrometric Wet Bulb Depression is read after the end of cooling. When a change is made to either parameter it is necessary to confirm this change and write it to firmware by clicking the Update icon. If the change is not updated, then no change is made to firmware and the next time the software is opened or the instrument connected, the previous settings will remain.

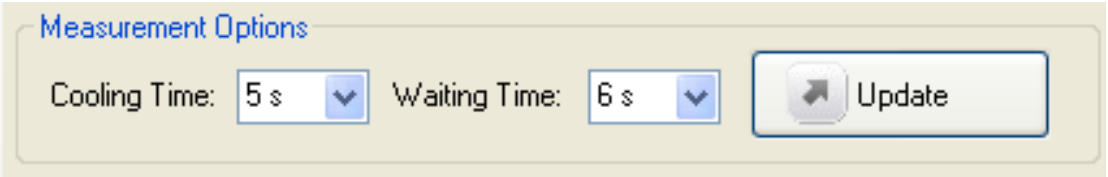

Figure 26: Drop down boxes to adjust the duration of the Peltier cooling time and sampling point.

15.2.1 Cooling Time:

The length of the Peltier cooling pulse will determine the volume of water that is condensed onto Thermocouple-C. A short cooling time will result in a small volume of water that will quickly evaporate back into the atmosphere of the chamber. Conversely, a long cooling time will condense a large volume of water, and slowly evaporate back into the atmosphere of the chamber.

The volumes of water and the times taken to change from liquid to vapour phase will be determined by the vapour pressure within the chamber which is in equilibrium with the plant. It should be

understood that as conditions become more negative it may be necessary to increase the cooling time to ensure a sufficient volume of water is condensed onto Thermocouple-C to generate a Psychrometric Wet Bulb Depression. If insufficient water is condensed in a “dry” environment (very negative water potentials) the cooling effect and hence the plateau will not remain for the necessary 6 seconds in order to record a measurement, and instead generate a false reading, or most commonly no reading at all.

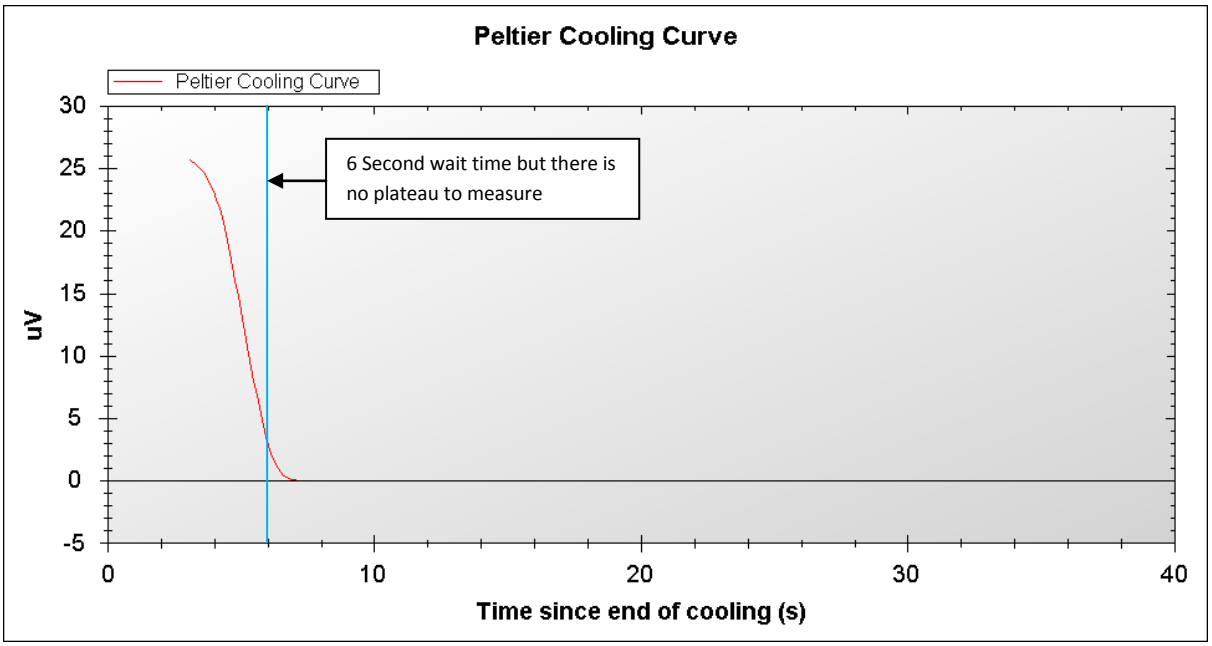

Figure 27: Peltier cooling curve with insufficient cooling time.

Conversely, if the cooling time is too long in a “wet” environment (values close to zero MPa) then it may be that the time interval for absorption of the condensed water back into the atmosphere is so long that the minimum 10 minute logging interval cannot be used. This situation can be identified by reviewing the Peltier cooling pulse. If the temperature of Thermocouple-C is failing to return to zero by the end of the 40 second sampling window, then the logging interval should be reviewed.

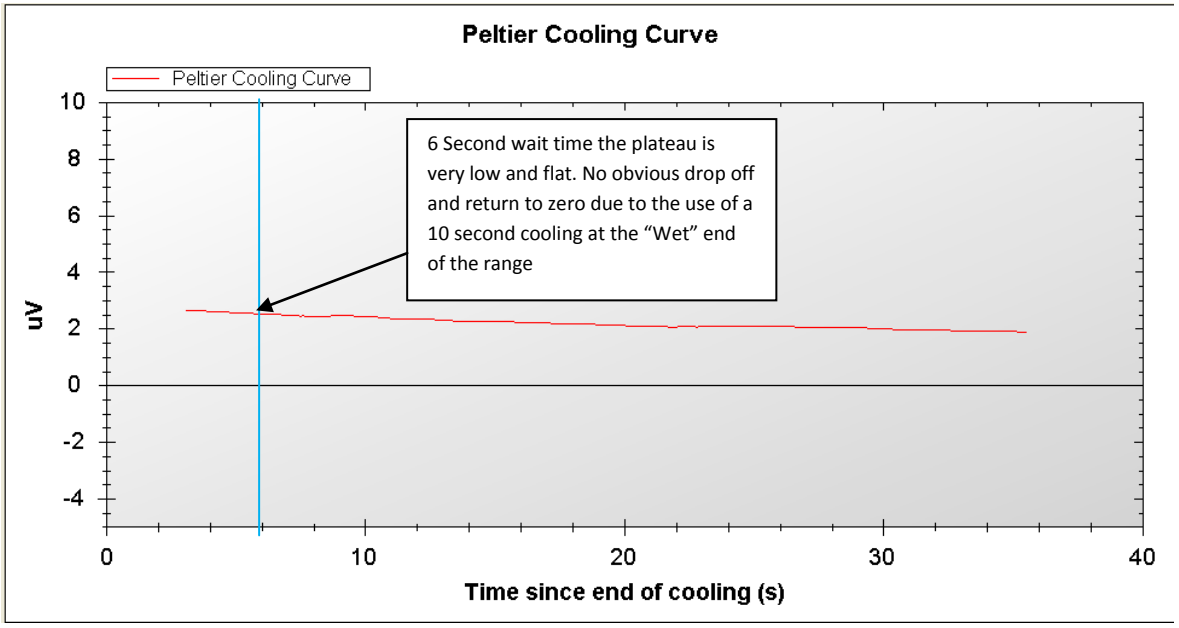

Figure 28: Peltier cooling curve with an excessive cooling time relative to the water potential of the sample resulting in a much longer time required for Thermocouple-C to return to zero reference. This sample was taken on *Sequoia sempervirens* (Coast Redwood) and the measured water potential (-0.76 MPa) was simultaneously verified against a Scholander pressure bomb (-0.73MPa)

It is important to note that the length of the Peltier cooling pulse does not affect the measured water potential. It will only affect the duration of the Psychrometric Wet Bulb depression. This is best demonstrated by performing a calibration measurement using a 1.0 Molal solution on a filter paper placed in the calibration lid. Place the PSY1 in Manual mode and set the Peltier cooling time to 5 seconds. Then commence a reading. For a clean psychrometer the response will be in the range of 19 µV and the duration will be approximately 10 seconds before a sharp drop back to zero reference.

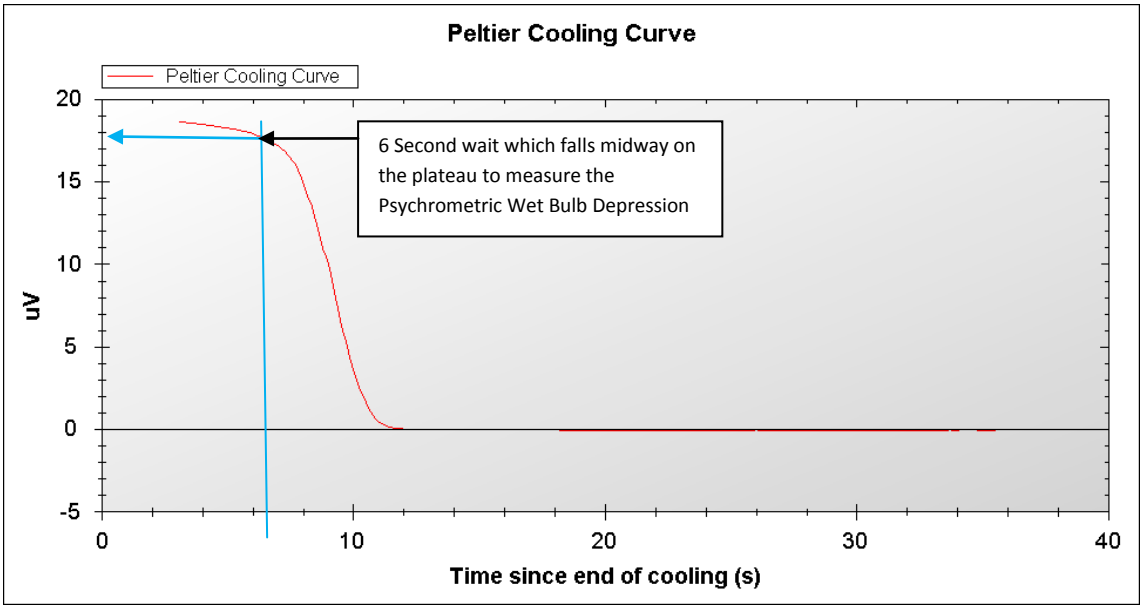

Figure 29: Peltier Cooling Curve produced with a 5 second cooling time. The plateau extends to 10 seconds before returning to zero reference.

Now wait a few minutes (preferably 10 minutes to allow the vapour pressure to return to equilibrium within the chamber) and repeat the measurement, but this time increase the cooling time from 5 seconds to 10 seconds. There will be negligible (if any) difference in the measured µV output of the Psychrometric Wet Bulb Depression, but the Peltier cooling curve will be approximately twice as long as the previous measurement extending to approximately 20 seconds before sharply dropping and returning to zero reference. This clearly demonstrates the Psychrometric principle that the Wet Bulb Depression is the temperature at which water condensed on the Thermocouple-C cools the thermocouple as it evaporates. It also shows the independence of the measurement to the volume of water condensed on the Thermocouple, yet the significance this can have on the temporal logging interval. If measuring well hydrated plants in the "wet" end of the plant water potential range (close to zero) it may not be possible to measure at 10 minute logging intervals, instead 15 to 30 minute intervals may yield better results.

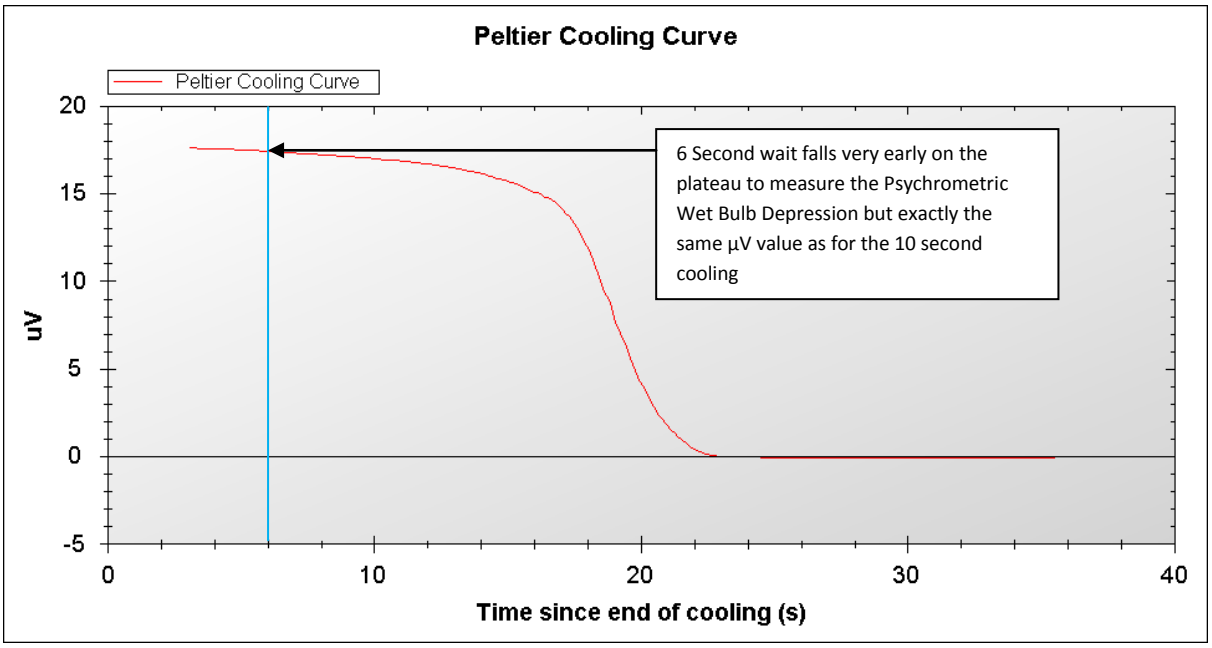

Figure 30: Peltier Cooling Curve produced with a 10 second cooling time the plateau extends to almost 20 seconds before returning to zero reference.

NOTE 25: Do not attempt to repeat manual measurements sequentially without allowing equilibration time, typically 10 minutes, between each reading. It is necessary to allow vapour pressure between the chamber and the stem to return to equilibrium after having first condensed water from the atmospheric vapour of the chamber and subsequently allowing it to be evaporated it back into vapour. Failure to allow this time will result in disequilibrium between the atmosphere and the stem, create a compounding affect in the measurement and seemingly the sample will continue to become wetter or less negative (closer to zero) which is not a true representation of the plant's water potential.

15.2.2 Wait Time:

The Wait time is an empirically derived interval. It has been determined over years of empirical observations and comparisons against sophisticated algorithms to fit tangents to the curve of the Peltier cooling curve. Whilst such sophisticated algorithms are possible these tend to introduce variability into the results that do not appear by opting for a fixed time period upon which to always make the Psychrometric Wet Bulb Depression measurement.

15.3 Reverse Peltier (Warming)

The reverse Peltier Current or "warming" is used to dry off any microscopic beads of water that may remain on the thermocouple following a measurement. You can automate this to provide a user defined temporal interval for warming of Thermocouple-C prior to taking a measurement. There is also a user adjustable wait time which prevents a measurement from being taken to allow the thermal gradients (small though they are) to dissipate from the chamber before the next measurement.

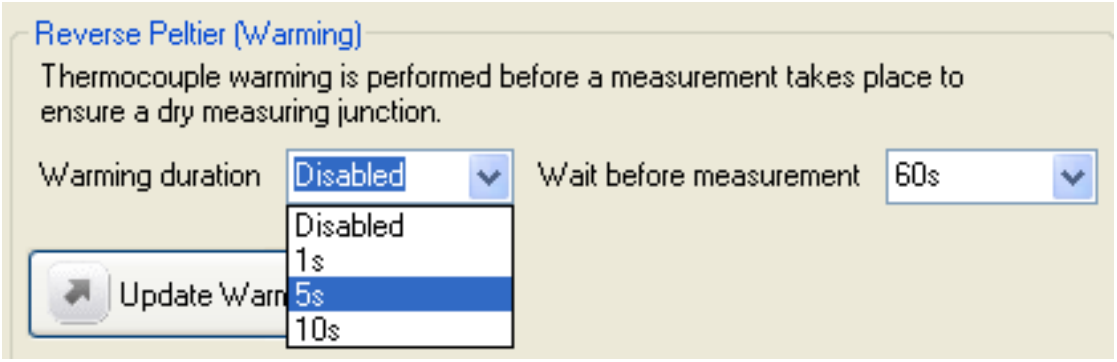

Figure 31: Reverse Peltier (Warming) settings.

15.4 Chamber Heating

Under environmental conditions that favour undesirable temperature gradients (i.e., the chamber is colder than the stem) the heater can be used to mitigate these problems. A 12V (DC) resistive heater is integrated into the back of the chamber and controlled by the PSY1. The chamber heater can be set to automatically turn on immediately following the completion of a measurement. The duration of the chamber heating can be set by selecting the desired time period from the drop down box. The exact duration for every installation will be specific to the ambient conditions and the plant being monitored. It may be necessary to trial a range of chamber heating durations between the ranges of 15 seconds to 2 minutes until the ideal protocol for the prevailing conditions is determined.

NOTE 25: The appropriate chamber heating protocol is one which maintains conditions such that condensation will not occur on the chamber walls (i.e. the chamber is warmer than the sample).

Chamber heating can be continuously employed, but this has the potential to cause artificial drying of the stem if employed when undesirable temperature gradients are not present. As a broad guideline the most likely period for condensation to occur inside the chamber, due to the chamber being colder than the stem, is between 5:00AM to 10:00AM.

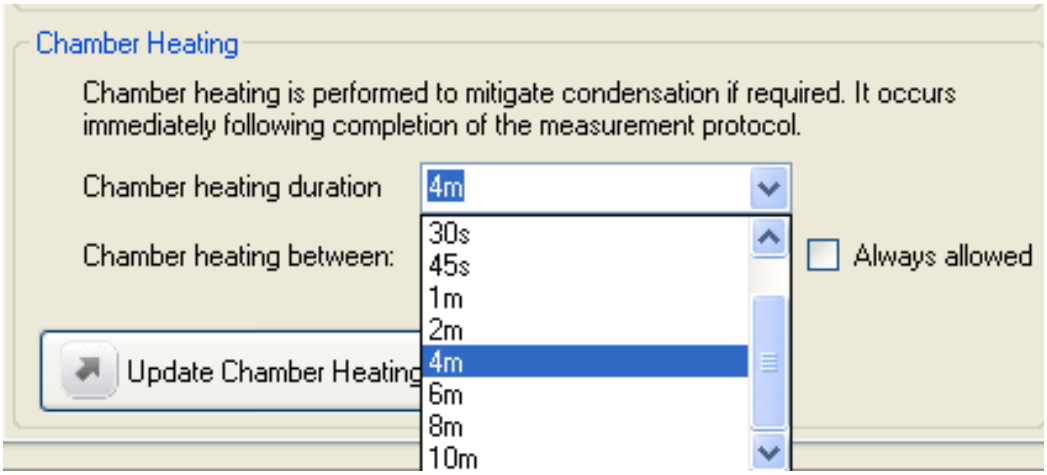

Figure 32: Chamber Heating Duration drop down box, heating duration can be set from 15 seconds to 10 minutes.

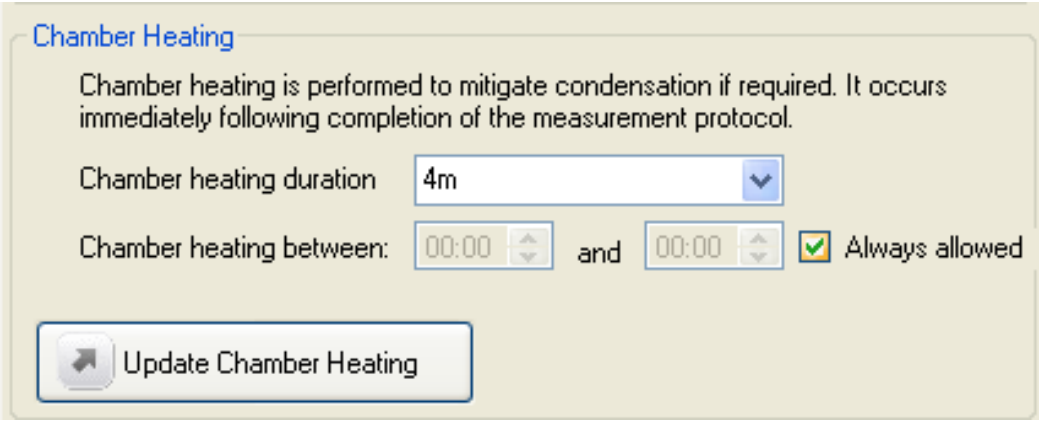

Figure 33: Chamber Heating can be set to be always active after each measurement.

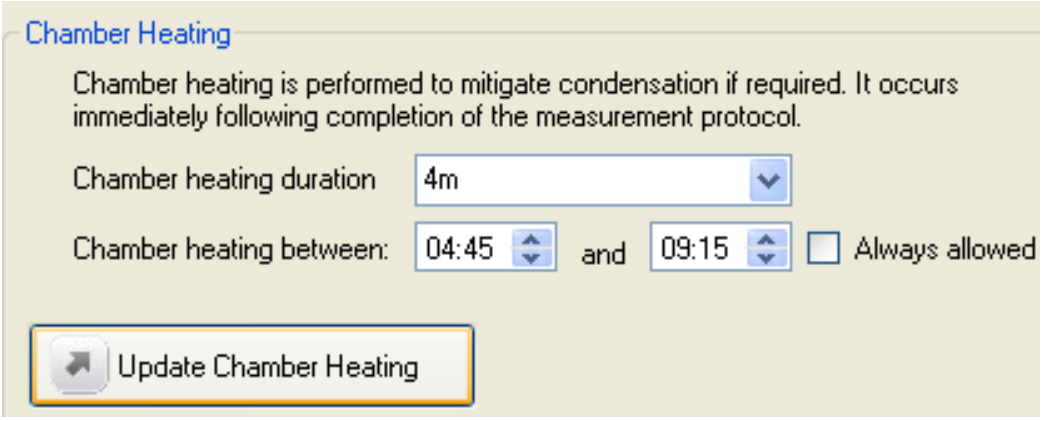

Figure 34: Chamber Heating should be set only to operate within the early hours of the morning when conditions are assessed to be most conducive to condensation.

NOTE 26: The Live Mode function can be used to evaluate the heat ring down in the chamber to empirically set the temporal interval between heating and measurements for each installation. Set the PSY1 to Manual Mode and activate Chamber heating. Set the heating duration and update these settings to firmware. Then start Live Mode logging and set the logging interval to 1 second. Now when a manual is made the dT, Chamber Temperature and Thermocouple-C values will be logged every second during and after the measurement until logging is stopped. This will record the effect of chamber heating on the Thermocouple output and the period of time required for this effect to dissipate can be determined. This data can then be used to develop the specific chamber heating protocol for the experiment.