HOBOware® Growing Degree Days Assistant White Paper

onset®

This white paper presents application and technical details for the Growing Degree Days (GDDA), a Post-Processor designed for use with HOBOware on the PC or Mac.

Post-Processors Overview

All available Post-Processors exist in the Processors directory in the HOBOware installation. All available Post-Processors are accessible from the Plot Setup Dialog in HOBOware. Each has a set of dependencies; channel-types it needs to become available when a particular dataset is displayed in the Plot Setup Dialog. A user can select a Post-Processor from the list and click the Process button, allowing them to progress through the logic contained in the Post-Processor. Upon completion of a Post-Processor, one or more new channels are added to the list of available channels to plot.

Application Details

The GDD processor generates Growing Degree Days based solely on a selected Temperature channel. GDD is a measure of heat where one GDD is equivalent to a 1 degree increase above a minimum threshold temperature for a period of one day. GDD can be used as a measure of crop maturity or pest development. Several well developed methods are available for calculating GDD. The GDDA generates a single datum for each full (midnight to midnight) day of temperature date. A day's datum is plotted at noon on that day.

The GDDA can be used with any Onset logger that measures Temperature for at least one contiguous day (midnight to midnight).

User Interface

This section includes details on how the user would be expected to prepare data for use with the Growing Degree Days Assistant. The details of how to use the assistant are left to the HOBOware Manual.
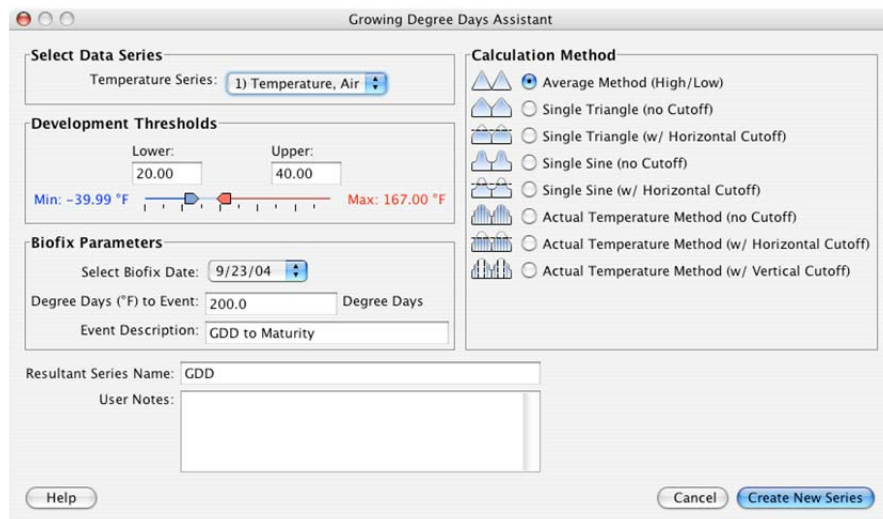
The user interface allows for choosing the following:

- The channel to be used for temperature

- Lower and Upper Development Thresholds (Upper thresholds are only available when the Average method or any method with horizontal/vertical cutoff are selected)

- Biofix Date

- Degree Days to Event and Event Description

- Calculation Method to determine GDD

- Series Name

- Series Notes

Technical Details

This section presents the details of how the Growing Degree Day values are computed, depending on the information supplied by the user. Where relevant to the discussion, equations are included.

Glossary of Terms

GDD Growing Degree Day value for a particular day

T_{high} High Temperature for the Day

T_{low} Low Temperature for the Day

TH_{high} High Temperature threshold

TH_{low} Low Temperature threshold

$m1$ Slope of linear equation for first half of day (for single triangle)

$m2$ Slope of linear equation for first half of day (for single triangle)

$b1$ Y-intercept of linear equation for first half of day (for single triangle)

$b2$ Y-intercept of linear equation for first half of day (for single triangle)

t Time in minutes after midnight on a given day

t_{log} Logging interval in seconds

i Index of time, measuring a particular number of 15 minutes intervals into the day

T_i Temperature at a given time (or index) in the day

T_{24} Total temperature (or heat) accumulated in a 24 hour period from midnight to midnight

Computation of Growing Degree Days

Calculation Methods

GDD can be calculated in several manners, each of which is described in this section.

Average Method
The following equation is used,

$$GDD = [(T_{high} + T_{low}) / 2] - TH_{low}$$

Where a temperature value below the low threshold is set to the low threshold, and a temperature value above the high threshold is set to the high threshold.

Single Triangle (No Cutoff)
The maximum and minimum temperatures are calculated and a set of two linear equations is computed to generate a triangle, one for the each half of the day. No upper threshold is used. The area under the curve and above the low threshold is used to compute GDD. Measuring time in minutes, the two linear equations are as follows:

$$m1 = (T_{high} - T_{low}) / 720$$

(720 min/half-day)

$$b1 = T_{low}$$

$$m2 = -1 * m1$$

$$b2 = 2\ T_{high} - T_{low}$$

Temperatures in every 15-minute interval are summed up to compute the cumulative heat per day. Before noon on a day, temperatures are computed as:

$$T_i = m1 * (i * 15) + b1$$

After noon, as:

$$T_i = m2 * (i * 15) + b2$$

$$T_{24} = \sum_{i=0}^{i<96}(T_i - TH_{low})$$

These temperature values are only added to the cumulative total for the day (T_{24}) if they are above the low threshold (TH_{low}). There are 96 15-minute intervals in a day, therefore the total *GDD* for the day is expressed:

GDD = T_{24}/96

Single Triangle (w/ Horizontal Cutoff)

This is computed the same as the Single Triangle method, except temperatures above the high threshold are set to the high threshold.

If $T_i > TH_{high}$,

$T_i = TH_{high}$

Single Sine (No Cutoff)

The maximum and minimum temperatures are calculated and a sine wave is computed assuming the low temp occurs at midnight and the high at noon. No upper threshold is used. The area under the curve and above the low threshold is used to compute *GDD*. The sine wave is expressed as:

$t = i * 15 * (0.125 °/min) * (0.0174532925$ radians$/°)$

$T_i = \sin(t)$

$$T_{24} = \sum_{i=0}^{i<96}(T_i - TH_{low})$$

Where *t* is in radians. These temperature values are only added to the cumulative total for the day (T_{24}) if they are above the low threshold (TH_{low}). There are 96 15-minute intervals in a day, therefore the total *GDD* for the day is expressed:

GDD = T_{24}/96

Single Sine (w/ Horizontal Cutoff)

This is computed the same as the Single Sine method, except temperatures above the high threshold and set to the high threshold.

If $T_i > TH_{high}$,

$T_i = TH_{high}$

Actual Temperature (No Cutoff)

Using the sampling interval of the temperature data, a numerical integration is performed to compute the area between the actual temperature curve and the low threshold. No upper threshold is used.

Temperatures are expressed as:

$$GDD = \sum_{i=0}^{i<t_{log}}[(T_i - TH_{low}) * t_{log}]$$

Where:

T_i = Logged value of temperature

Only values of T_i greater than are TH_{low} are included in the summation.

Actual Temperature (w/ Horizontal Cutoff)

This is computed the same as the Actual Temperature method, except temperatures above the high threshold and set to the high threshold.

If $T_i > TH_{high}$,

$T_i = TH_{high}$

Actual Temperature (w/ Vertical Cutoff)

This is computed the same as the Actual Temperature method, except temperatures above the high threshold are set to zero and do not factor into the daily value of GDD.

If $T_i > TH_{high}$,

$T_i = 0$

Plotted Values

Starting at the Biofix Date entered by the user, the GDD values are accumulated and plotted as the total GDD since the Biofix date. Additionally, a high alarm level is displayed at the value entered in the Degree Days to Event field.