



Degree-days and Phenology Models

Evaluation of Several Degree-day Estimation Methods in California Climates*

Procedures for estimating degree-day accumulations are frequently used in the place of the more accurate method of calculating degree-days from hourly temperature data, and the UC IPM Web [degree-day calculator](#) uses several of the common estimation methods. However, the use of these methods requires that consideration be given to the time of year, geographical location, and biology of the organism under study.

[Roltsch et al.](#) analyzed seven methods of estimating degree-days for two years of air temperatures collected at each of nine California locations. The estimates, based on a lower temperature threshold of 50 F (10 C), were then compared by month to degree-day values calculated by hourly summation from the same locations and time periods. The findings are summarized below.

Summary of Results

Differences among similar methods. Degree-day estimates using seven methods were compared to hourly summations. The methods were [averaging](#), single sine ([1](#), [2](#)), [double sine](#), [single triangle](#), [double triangle](#), and corrected sine and triangle (these latter two were developed in-house at UC IPM).

- Sine methods. Double sine and corrected sine (corrected for day length) methods were nearly identical to those of the single sine method, which is commonly used or recommended by UC IPM.
- Triangle methods. Double triangle and corrected triangle methods produced very similar results to the single triangle method.
- Since no advantages were noted in the more complicated double and corrected methods, the single triangle and single sine methods are preferred since they are less complicated procedures.

Differences based on time of year. Degree-day estimates, based on a lower threshold of 50F (10C), were totaled for each month and compared to hourly sums for the same periods.

- Degree-day estimations from the late spring and summer months were more similar to one another for all estimation methods than those for the cooler months of the year.
- The single triangle and single sine methods estimate degree-days relatively well.
- From April through October, the single triangle and sine methods produced

similar results.

- Comparatively more errors were associated with the single sine method during the winter months from November to February, and at some locations, single sine error was also greater during March. Therefore, during months of the year, the triangle methods may be preferable over the sine or averaging method at many California locations.
- The averaging method's performance was the poorest among the three primary methods, having higher error for a greater portion of the year when temperatures are relatively cool.
- The threshold of 50 F was selected as being representative of a number of species, but note that for estimations using a significantly higher or lower threshold, results may differ.

Differences among climatic zones. Hourly air temperature data for nine stations in the [California Irrigation Management Information System](#) weather network were used to calculate the degree-day totals used as the standard for comparison. The stations were located in Brawley, Riverside, Salinas, Castroville, Watsonville, Five Points, Davis, Camino, and McArthur.

- Interior California. In the interior regions there is very little difference among approximation methods from mid-spring to fall. For organisms that are predominantly active during the warm periods of a year in the interior valleys, the error associated with the sine versus triangle methods may have little impact since the number of degree-days that accumulate during the cool months represent only a small proportion of the thermal units that would drive their development and population growth over the course of the season.
- Coastal California locations. For some locations along the coast (e.g., Salinas), none of the methods provide suitable estimates during most of the year. During spring and summer months, estimates for the Watsonville and Castroville locations were much closer to their respective hourly summation values than those calculated for Salinas.

Cutoff methods. High temperature threshold cutoff techniques were assessed to characterize their compatibility with the triangle and sine degree-day approximation methods. [Horizontal, vertical, and intermediate](#) cutoff methods, using thresholds of 80 F (26.7 C) and 89.6 F (32 C), were compared.

- None of the tested cutoff methods affected the error levels found when estimating degree-days using the sine method.
- Horizontal cutoff with the triangle method did not significantly increase the amount of error in the degree-day estimation.
- Intermediate cutoff and vertical threshold cutoff techniques used with the triangle method showed increased errors.

* Summary of results of a study reported in Roltsch, W. J.; Zalom, F. G.; Strawn, A. J.; Strand, J. F.; Pitcairn, M. J. 1999. Evaluation of several degree-day estimation methods in California climates. *Int. J. Biometeorol.* 42:169-176.

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