Mesonet First Hollow Stem Advisor
Technical Description and Equations

Projected Soil Heat Units (Early Varieties)

through February 27, 2014
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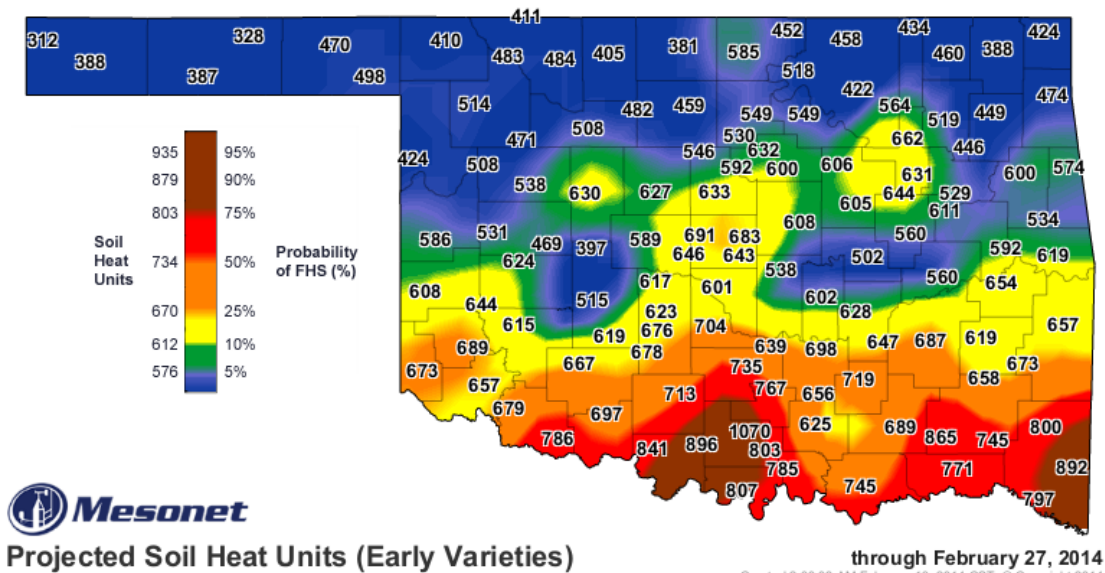
Overview

First hollow stem (FHS) is the growth stage in ungrazed winter wheat at which cattle need to be removed from nearby grazed wheat fields to prevent deterioration in wheat yield.

The First Hollow Stem Advisor was developed by J. D. Carlson (OSU Biosystems & Agricultural Engineering) in conjunction with Gene Krenzer and Jeff Edwards (OSU Plant and Soil Sciences); base level model programming was done by Rafal Jabrzemski (Oklahoma Mesonet). The FHS Advisor consists of three soil temperature based "models". Wheat varieties fall into one of three categories (Early, Middle, or Late), based on when they reach first hollow stem. There is one model for each category.

The three models use daily average 4-inch soil temperatures under vegetative cover (SAVG) as measured by the Oklahoma Mesonet and are based on soil degree-day accumulations (heat units) from specific start dates (SDATE) and with specific low temperature thresholds (TLOW).

Probability levels for FHS as a function of accumulated soil degree days have been calculated for each model based on the log-logistic distribution fitted to the observed FHS data used in the research.

Calculated daily soil degree days (SDD) at each Mesonet station for the current FHS season are utilized to give current SDD accumulations, and pre-calculated 14-year historical average daily soil degree days at each Mesonet station are used to project the SDD accumulations two weeks into the future to provide lead time to wheat/cattle producers for scouting and cattle removal activities.

For all the years (1995-2012) and varieties included in this research, the earliest FHS date that was observed was February 2 and the latest, March 29. The FHS data used in the research came from the Marshall and Stillwater research stations for fall-planted wheat.

Soil Degree-Day Parameters for the Three Models

> **EARLY model:**   **TLOW = 31F;**   **SDATE = December 22**
>
> **MIDDLE model:**   **TLOW = 31F;**   **SDATE = December 22**
>
> **LATE model:**   **TLOW = 34F;**   **SDATE = January 1**

As can be observed, the daily SDD calculations and accumulations will be identical for the EARLY and MIDDLE models, since they have the same parameters, but different for the LATE model. The daily SDD calculations include those occurring on the SDATE (e.g., December 22 is the first day of SDD used for the early and middle models).

Calculation of Daily Soil Degree Days

Daily soil degree days (SDD) at each Mesonet site are calculated from the daily average 4-inch soil temperature under vegetative cover (SAVG):

$$\text{SDD} = \text{SAVG} - \text{TLOW}$$

If SAVG < TLOW for a given day, that day's SDD is set to 0.

In other words, SDD is always >= 0.

Accordingly,

> **SDD_31F = SAVG – 31F**   *(Early and Middle models)*
>
> **SDD_34F = SAVG – 34F**   *(Late model)*

Calculation of Accumulated Observed Soil Degree Days

Daily measured SDD values from the Oklahoma Mesonet are calculated for the current FHS season beginning with the start date (SDATE) and then summed up as the calendar progresses. The daily updating of accumulations occurs in the early morning hours (after midnight) after the past calendar day's data has completely arrived and SAVG values for that day are available.

Accumulated soil degree days (ASDD) are based on observed Mesonet soil temperatures and calculated as follows:

> **ASDD_31F = sum [SDD_31F] from Dec. 22 through current date (yesterday)**
>
> **ASDD_34F = sum [SDD_34F] from Jan. 1 through current date (yesterday)**

Two-Week Projections: Historical Average Daily Soil Degree Days

The three models use daily soil degree days averaged over a 14-year period (2000-2013) to project accumulated soil degree days two weeks into the future. These historical average daily soil degree days have been calculated for every current Mesonet station. If the station did not exist during all of the 14-year period, then interpolation from existing stations was used for the time periods the station was not there.

Thus, for each current Mesonet site there are pre-calculated historical average daily soil degree days (HSDD) for each calendar date (mo/day):

HSDD_31F (calendar date) *(Early and Middle models)*

HSDD_34F (calendar date) *(Late model)*

As an example of how observed and historical average soil degree days are used in projecting two weeks into the future, let's consider the Early FHS variety model and assume the current day is December 27. The Mesonet-based accumulated soil degree days (ASDD) are from the start date (December 22) through December 26. To get the projected soil degree day totals two weeks from December 27 (January 10), the following methodology is used (specific to each Mesonet station):

ASDD_31F (Dec. 27) = ASDD_31F (Dec. 26) + HSDD_31F (Dec. 27)

ASDD_31F (Dec. 28) = ASDD_31F (Dec. 27) + HSDD_31F (Dec. 28)
....
....
ASDD_31F (Jan. 10) = ASDD_31F (Jan. 9) + HSDD_31F (Jan. 10)

Probability Tables and Functions (Log-Logistic Distribution)
for the Three First Hollow Stem Models

EARLY Model (TLOW = 31F; SDATE = Dec. 22)

Probability of FHS Occurring [Prob (FHS)]	Accumulated SDD_31F Value [ASDD_31F]
2.5%	543
5.0%	576
10.0%	612
25.0%	670
50.0%	734
75.0%	803
90.0%	879
95.0%	935
97.5%	991

The equation below gives the accumulated SDD_31F value, ASDD_31F, for a specified level of cumulative probability Prob (FHS) in %.

$$ASDD\_31F = \frac{733.73}{\{\,[100/Prob(FHS)] - 1\,\}^{0.08218}}$$

Example: for the 75% FHS probability level, what would be the value of ASDD_31F ?

$$ASDD\_31F = 733.73 \,/\, \{\,[100/75] - 1\,\}^{0.08218}$$

$$= 733.73 \,/\, \{\,1.333 - 1\,\}^{0.08218}$$

$$= 733.73 \,/\, 0.91360 = 803.12$$

which matches the above table value of 803 for the 75% level.

NOTE: *This and the other corresponding two equations for the Middle and Late models blow up if Prob (FHS) = 0% or 100% is used. However, this equation is not used in the First Hollow Stem Advisor.*

To calculate the cumulative FHS probability level in %, Prob (FHS), for a given ASDD_31F value, we use the following equation, which is the inverse of the one above:

$$\text{Prob (FHS)} = 100 \times \left\{ \frac{1.0}{[1.0 + (733.73/\text{ASDD\_31F})^{12.169}]} \right\}$$

Example: for an ASDD_31F value of 803, what is the probability of FHS occurring ?

$$
\begin{aligned}
\text{Prob (FHS)} \quad &= \quad 100 \times \{ 1.0 / [1.0 + (733.73/803)^{12.169}] \} \\
&= \quad 100 \times \{ 1.0 / [1.0 + 0.3336] \} \\
&= \quad 100 \times 0.74985 \quad = \quad 74.985\%
\end{aligned}
$$

which matches the above table value of 75% for an ASDD_31F value of 803.

This equation (and its counterparts for the Middle and Late models) is used in the First Hollow Stem Advisor.

MIDDLE Model (TLOW = 31F; SDATE = Dec. 22)

Probability of FHS Occurring [Prob (FHS)]	Accumulated SDD_31F Value [ASDD_31F]
2.5%	702
5.0%	731
10.0%	763
25.0%	812
50.0%	864
75.0%	920
90.0%	980
95.0%	1022
97.5%	1065

The equation below gives the accumulated SDD_31F value, ASDD_31F, for a specified level of cumulative probability Prob (FHS) in %.

$$ASDD\_31F = \frac{864.5}{\{\,[100/Prob(FHS)] - 1\,\}^{0.05688}}$$

To calculate the cumulative FHS probability level in %, Prob (FHS), for a given ASDD_31F value, we use the following equation, which is the inverse of the one above:

$$Prob\ (FHS) = 100\ \times\ \left\{\ \frac{1.0}{[1.0 + (864.5/ASDD\_31F)^{17.581}]}\ \right\}$$

LATE Model (TLOW = 34F; SDATE = Jan. 1)

Probability of FHS Occurring [Prob (FHS)]	Accumulated SDD_34F Value [ASDD_34F]
2.5%	511
5.0%	539
10.0%	571
25.0%	620
50.0%	674
75.0%	732
90.0%	796
95.0%	842
97.5%	889

The equation below gives the accumulated SDD_34F value, ASDD_34F, for a specified level of cumulative probability Prob (FHS) in %.

$$ASDD\_34F = \frac{673.86}{\{\,[100/Prob(FHS)] - 1\,\}^{0.07566}}$$

To calculate the cumulative FHS probability level in %, Prob (FHS), for a given ASDD_34F value, we use the following equation, which is the inverse of the one above:

$$Prob\,(FHS) = 100\ \times\ \left\{ \frac{1.0}{[1.0 + (673.86/ASDD\_34F)^{13.217}]} \right\}$$

2015 Variety List and Associated FHS Category

Below is the list of varieties for 2013 in the First Hollow Stem Advisor and their associated FHS category.   E = Early; M = Middle; L = Late.

Wheat Variety (alphabetical)	FHS Category
2174	L
Above	E
AP503CL2	L
Armour	E
Bill Brown	E
Billings	E
Brawl CL+	L
Byrd	M
Centerfield	L
Chisholm	L
CJ	M
Custer	M
Cutter	E
Deliver	L
Doans	M
Doublestop CL Plus	L
Duster	M
Endurance	L
Everest	M
Fannin	E
Fuller	E
Gallagher	E
Garrison	M
Greer	E
Hatcher	E
Iba	L
Jackpot	E
Jagalene	E
Jagger	E
Karl 92	E
LCS Mint	L
LCS Wizard	M
Lockett	E
Mace	L
OK Bullet	E
Overley	E

Pete	M
Ripper	E
Ruby Lee	M
Santa Fe	E
Sy Llano	E
T153	E
T154	E
T158	L
TAM 110	E
TAM 111	L
TAM 112	E
TAM 113	M
TAM 203	M
TAM 304	M
TAM 401	E
Triumph 64	L
WB Cedar	E
WB4458	E
WB-Duece CL+	E
WB-Redhawk	E
Winterhawk	L
Unlisted Variety (EARLY)	E
Unlisted Variety (MIDDLE)	M
Unlisted Variety (LATE)	L