

Historical Soil Moisture Index (HSMI)

What is HSMI?

The Historical Soil Moisture Index (HSMI) puts current soil moisture into a historical context. Rather than looking only at the amount of water in the soil, HSMI answers: "*How unusually wet or dry is the soil compared with what has historically been observed at this location and time of year?*" HSMI uses KY Mesonet soil moisture observations with at least 5 years of data to account for the natural differences in soil moisture between **locations, seasons,** and **soil depths.**

Important distinction

HSMI compares conditions relative to a site's own history—it does not represent an absolute amount of water in the soil.

A soil moisture value of 25% may be extremely dry at one station but relatively wet at another. HSMI accounts for these differences by asking how unusual that value is for that particular station, depth, and time of year.

How is it Calculated?

1. Calculate the historical climatology

For each station, depth, time of year, and time of day, historical soil moisture is used to establish a typical range. The median represents the typical soil moisture condition.

2. Calculate the standardized anomaly

Current soil moisture is compared with its historical climatology:

$$std_{anom} = \frac{soil\ moisture\ - median_{climo}}{Inner\ Quartile\ Range\ (IQR)}$$

The IQR (interquartile range) represents the typical spread of historical observations.

- Negative values → drier than typical
- Positive values → wetter than typical
- Values near 0 → close to typical

3. Rank the anomalies

An empirical cumulative distribution function (ECDF) ranks the standardized anomaly from 0–100% based on its historical distribution, with 0% representing the driest conditions and 100% the wettest.

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How to Interpret HSMI

HSMI is a **historical percentile.** HSMI can be interpreted as the percentage of historical conditions that were drier than the current condition.

HSMI Percentile	General Interpretation
0-20%	Very Dry
20-30%	Below Typical/Dry
30-70%	Near Typical
70-80%	Above Typical/Wet
80-100%	Very Wet

These categories are intended as general guidance rather than formal drought classifications.

For example, an HSMI of 10% means current soil moisture is wetter than only about 10% of historical conditions—or, equivalently, about 90% of historical conditions were wetter.

Comparing Across Depths

HSMI is calculated for each soil moisture depth (2", 4", 8", 20", 40").
This allows users to see where dryness or wetness is occurring within the soil profile.
For example:

2" HSMI = 15%
8" HSMI = 45%
20" HSMI = 65%

This indicates that the **shallow soil is unusually dry**, while d**eeper soil remains normal to wetter than typical**.
This can help distinguish short-term surface dryness from deeper, longer-lasting soil moisture deficits.

Comparing Across Sites

Because HSMI is based on each station's own historical distribution, it can be used to compare the relative wetness or dryness of different stations.
For example:

Station A: HSMI = 12%
Station B: HSMI = 48%

Even if the two stations have different average soil moisture values or different soil characteristics, **Station A is experiencing more historically unusual dryness than Station B**.

Method modified from**:** Leeper, R. D., J. E. Bell, and M. A. Palecki, 2019: A description and evaluation of U.S. Climate Reference Network standardized soil moisture dataset. J. Appl. Meteor. Climatol., 58, 1417–1428, https://doi.org/10.1175/JAMC-D-18-0269.1.

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