COMMUNICATIONS IN SOIL SCIENCE AND PLANT ANALYSIS
2023, VOL. 54, NO. 3, 408–430
https://doi.org/10.1080/00103624.2022.2116032

The Estimation of Monthly Mean Soil Temperature at Different Depths in Sivas Province, Turkey by Artificial Neural Networks

Cahit Gurlek

Mechanical Engineering Department, Sivas Cumhuriyet University, Sivas, Turkey

ABSTRACT
In this study, soil temperature of Sivas province was estimated by the artificial neural networks (ANNs) method using data obtained from five different meteorological measurement stations situated in provincial borders. Nineteen years of (2000–2018) monthly mean air temperature data obtained from five different soil depths (5, 10, 20, 50 and 100 cm) was used for ANN analysis. Predicted and measured soil temperatures were strongly correlated with determination coefficient (R^2) values ranging between 0.9767 and 0.9941. Mean Absolute Error (MAE) ranged from 0.532°C to 1.381°C, while Mean Absolute Percentage Error (MAPE) ranged from 5.692% to 16.263% and Root Mean Squared Error (RMSE) ranged between 0.694°C and 1.666°C. It was found that the predicted values are in good agreement with the measured data. However, there was a tendency to underestimate the soil temperature.

ARTICLE HISTORY
Received 7 April 2022
Accepted 15 August 2022

KEYWORDS
Air temperature; artificial neural networks; Sivas province; soil temperature

Introduction

Soil temperature is an essential parameter for many agricultural, meteorological and engineering applications, like belowground plant activity, numerical weather prediction and ground source heat pump systems (Albergel et al. 2015; Kozlowski and Pallardy 1997; Xing and Spitler 2017). Variation of soil temperature regime is dependent on several parameters: physical conditions of soil such as texture and structure, meteorological factors such as solar radiation, air temperature, sunshine duration, cloudiness and wind velocity and terrain variables such as elevation, slope and aspect (Kang et al. 2000). Therefore, different parameters and models (energy balance, regression, machine learning, etc.) have been used for predicting spatial and temporal variation of soil temperature by different authors.

Zheng, Hunt, and Running (1993) used daily mean air temperature data from 6 climate regions across the United States to estimate daily mean soil temperature at a depth of 10 cm using linear regression. The values of R^2 between observed and predicted soil temperatures ranged from 0.85 to 0.96 with standard errors from 1.5 to 2.9°C. They concluded that their method may be appropriate for predicting daily soil temperature at large scales. Kang et al. (2000) developed a hybrid soil temperature model based on heat transfer physics and the empirical relationship between air and soil temperature. The hybrid model using a minimum set of variables (air temperature, satellite imagery and digitized elevation maps) gave a better prediction of daily soil temperature than the empirical model of Zheng, Hunt, and Running (1993). Paul et al. (2004) designed an empirical model for predicting the seasonal variation of daily average temperature within surface soil layers for a range of forest types. They indicated that according to the sensitivity analysis, the most important input data required were air temperature, leaf area index and soil depth. García-Suárez and Butler (2006) successfully reconstructed winter soil temperatures at 30 and 100 cm depth using air temperature data from the

CONTACT Cahit Gurlek cgurlek@cumhuriyet.edu.tr Mechanical Engineering Department, Sivas Cumhuriyet University, Sivas, Turkey

This article has been republished with minor changes. These changes do not impact the academic content of the article.