Journal of Agricultural Sciences (Tarim Bilimleri Dergisi) 2023, 29 (1) : 221 - 238 DOI: 10.15832/ankutbd.997567

Journal of Agricultural Sciences
(Tarim Bilimleri Dergisi)

J Agr Sci-Tarim Bili
e-ISSN: 2148-9297
jas.ankara.edu.tr

JAS

Machine Learning Approaches for One-Day Ahead Soil Temperature Forecasting

Mehmet BILGILI[a], Şaban ÜNAL[b*], Aliihsan ŞEKERTEKIN[c], Cahit GÜRLEK[d]

[a]*Department of Mechanical Engineering, Ceyhan Engineering Faculty, Cukurova University, Adana 01950, TURKEY*

[b]*Department of Mechanical Engineering, Engineering Faculty, Osmaniye Korkut Ata University, Osmaniye 80000, TURKEY*

[c]*Igdir University, Vocational School of Higher Education for Technical Sciences, Department of Architecture and Town Planning, Igdir, TURKEY*

[d]*Department of Mechanical Engineering, Engineering Faculty, Sivas Cumhuriyet University, Sivas 58140, TURKEY*

ARTICLE INFO

Research Article

Corresponding Author: Şaban ÜNAL, E-mail: saban.unal@osmaniye.edu.tr

Received: 19 September 2021 / Revised: 26 March 2022 / Accepted: 03 April 2022 / Online: 18 January 2023

Cite this article

BİLGİLİ M, ÜNAL Ş, ŞEKERTEKİN A, GÜRLEK C (2023). Machine Learning Approaches for One-Day Ahead Soil Temperature Forecasting. *Journal of Agricultural Sciences (Tarim Bilimleri Dergisi),* 29(1):221-238. DOI: 10.15832/ankutbd.997567

ABSTRACT

Present study investigates the capabilities of six distinct machine learning techniques such as ANFIS network with fuzzy c-means (ANFIS-FCM), grid partition (ANFIS-GP), subtractive clustering (ANFIS-SC), feed-forward neural network (FNN), Elman neural network (ENN), and long short-term memory (LSTM) neural network in one-day ahead soil temperature (ST) forecasting. For this aim, daily ST data gathered at three different depths of 5 cm, 50 cm, and 100 cm from the Sivas meteorological observation station in the Central Anatolia Region of Turkey was used as training and testing datasets. Forecasting values of the machine learning models were compared with actual data by assessing with respect to four statistic metrics such as the mean absolute error, root mean square error (RMSE), Nash−Sutcliffe efficiency coefficient, and correlation coefficient (R). The results showed that the ANFIS-FCM, ANFIS-GP, ANFIS-SC, ENN, FNN and LSTM models presented satisfactory performance in modeling daily ST at all depths, with RMSE values ranging 0.0637-1.3276, 0.0634-1.3809, 0.0643-1.3280, 0.0635-1.3186, 0.0635-1.3281, and 0.0983-1.3256 °C, and R values ranging 0.9910-0.9999, 0.9903-0.9999, 0.9910-0.9999, 0.9911-0.9999, 0.9910-0.9999 and 0.9910-0.9998 °C, respectively.

Keywords: ANFIS, Daily soil temperature, LSTM, Elman neural network (ENN), Feed-forward neural network

1. Introduction

Annual, monthly, daily, and hourly meteorological data are among the most critical atmospheric parameters for many engineering systems and agricultural activities. As one of these meteorological parameters, soil temperature (ST) has crucial importance in distinct disciplines, including soil science, meteorology, agronomy, environmental studies, atmospheric, hydrological, and agricultural numerical models, ecological applications, and agricultural management (Mehdizadeh et al. 2017). Also, ST is a significant meteorological factor for agricultural activity, solar energy technologies, geothermal energy systems, ground source heat pumps, etc. The chemical structure of the soil and organic components are highly affected by ST. The soil heats inwards from the surface and cools by losing heat from inside to outside (Feng et al. 2019). Therefore, daily and seasonal temperature changes are high, although not as high as air. These changes decrease towards the depths, and the temperature remains constant after a certain level. Although the effects of the surface, in general, affect up to 10 m depth, temperature changes are negligible at depths more than 1.5~2 m. For these reasons, many studies have focused on ST forecasting and modeling (Araghi et al. 2017; Shahabi et al. 2021).

Meteorological parameters are measured at meteorological stations located at specific points in many parts of the world. ST measurements are generally made with soil thermometers and soil thermographs at depths of 5, 10, 20, 50, and 100 cm. Many meteorological and atmospheric variables are more easily measured than ST, and therefore more widely accessible. Measuring the ST of a specific location when needed is not as easy as measuring the air temperature of that point. Therefore, estimating ST based on various meteorological parameters, which can be measured much more quickly, has facilitated many engineering problems (Xing et al. 2018).

The thermal changes and energy balances between the soil and ground surface at a certain depth are highly affected by the ST (Araghi et al. 2019). Accurate ST forecasting is recognized as crucial information and foresight for this reason (Zeynoddin et al. 2019). Various studies have recently been conducted on short and mid-term ST forecasting (Penghui et al. 2020). In the first category, statistical approaches such as numerical weather prediction (NWP) methods are used, assuming that future