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RESEARCH ARTICLE

Coupling Normalization with Moving Window in Backpropagation Neural Network (BNN) for Passive Microwave Soil Moisture Retrieval

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Abstract

A common practice to capture the non-stationary characteristics of the time series data in Artificial Neural Network (ANN) is by randomly dividing the whole set of available data into training, validation and testing, i.e. the data in validation and testing are represented in the training data. Consequently, the usability of the developed model on data not represented by the training data used during the network model development process is always doubtful. In this work, we present a backpropagation neural network (BNN) model trained using one-day history data to predict soil moisture data at 1 km resolution for two future dates. Specifically, high soil moisture values were observed in the training data while the testing data were characterized by drier conditions due to minimal or no rainfall. Our model uses separate mean and standard deviation statistics values from the training and testing data, respectively, to the z-normalized data. With data pre-processed using this method, the BNN model next uses a moving window of size 4 km × 4 km to capture the spatial variability of the soil moisture throughout the 40 km × 40 km study area. The coupling of the normalization and moving window method managed to achieve average soil moisture with Root Mean Square (RMSE) of 3.67% and correlation coefficient, R^2 of 0.89. By only using the suggested normalization without the moving window method, the BNN model managed to achieve an average RMSE of barely 5.82% with $R^2 = 0.83$. When comparing with the normal practice of using the same mean and standard deviation statistics of the training data in the testing data, the retrieval accuracy of the BNN model deteriorates to 8.86% with $R^2 = 0.32$. The experiment results demonstrated that the proposed coupling method performed better in terms of both RMSE and R^2 for soil moisture retrieval.

Keywords Backpropagation · Neural network · Normalization · Passive microwave · Soil moisture

1 Introduction

Surface soil moisture content is a critical parameter for various disciplines. Therefore, accurate large-scale estimation of the value is vital in improving hydrology and climatic modeling and prediction [1, 2]. Due to the high spatial–temporal variability of the surface soil moisture [3], monitoring surface soil moisture over big areas is a tough task as accurate soil moisture values will need to be obtained at fine resolution. Low frequencies microwave remote sensing has shown to be the best performing approach among the different satellite remote sensing methods for large areas integration information on soil moisture [4–6]. Among the active and passive microwave data, soil moisture is successfully retrieved from passive microwave sensors [7]. The most particular benefit of passive microwave sensors is that, on the received signal, in the lack of substantial vegetation cover, soil moisture has the dominant effects [8].

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