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Deep neural network for cosmic-ray neutron sensors calibration

Content

The current approach for calibrating Cosmic Ray Neutron Sensors (CRNS) for area-wide soil moisture is based on time-consuming and labor-intensive sample collection. In addition, depending on the land use, plant sampling may also be required for calibration, for example, due to significant crop biomass water interference. Finally, the current calibration method includes corrections considering several parameters influencing neutron counts, the proxy for soil moisture, such as soil lattice water and organic carbon content. The main objective of this study was to investigate and develop an alternative calibration method to the currently available field calibration method. To this end, a Deep Learning model architecture under the TensorFlow machine learning framework was used to calibrate the CRNS. A deep neural network (DNN) model is built with more than 8 years of CRNS data from Petzenkirchen (Austria) and consists of four hidden layers with activation function and a succession of batch normalization and drop-out layers. Prior to build the DNN, data analysis consisting of pertinent variables selection was performed with multivariate statistical analysis of correlation. Among nine features, five were effectively pertinent and included in the machine learning artificial neural network architecture. The five input variables were the raw neutrons counts (N1 and N2), air humidity (H), air pressure (P4) and temperature (T7). To train the DNN model, 80 % of the data from CRNS between 2017-2020 were used and 20 % for validation. The DNN model was characterized by a coefficient of determination of 0.94 and the model predicted the soil moisture with less than 1% error (MAE=0.08). These preliminary results are encouraging and proved that a machine learning-based method could be a valuable alternative calibration method for CRNS against the current field calibration method. More investigation will be performed to test the model under different agroecological conditions, such as Nebraska, USA, in the West-Africa Region and the East and South Africa CRNS network. Further, additional input variables will be considered in the development of machine learning-based models, to bring in agro-ecological information, such as crop cover, growth stage and precipitation related to the CRNS footprint.

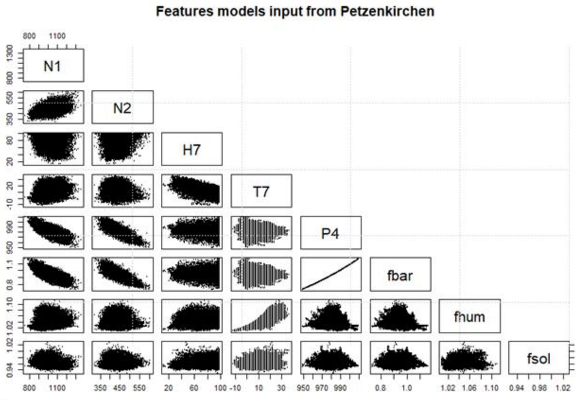


Fig.1: distribution and relation of all hydrological and soil variable which are fed to the deep learning model.

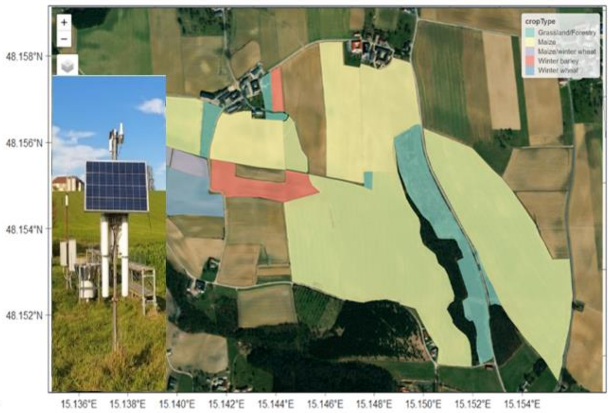
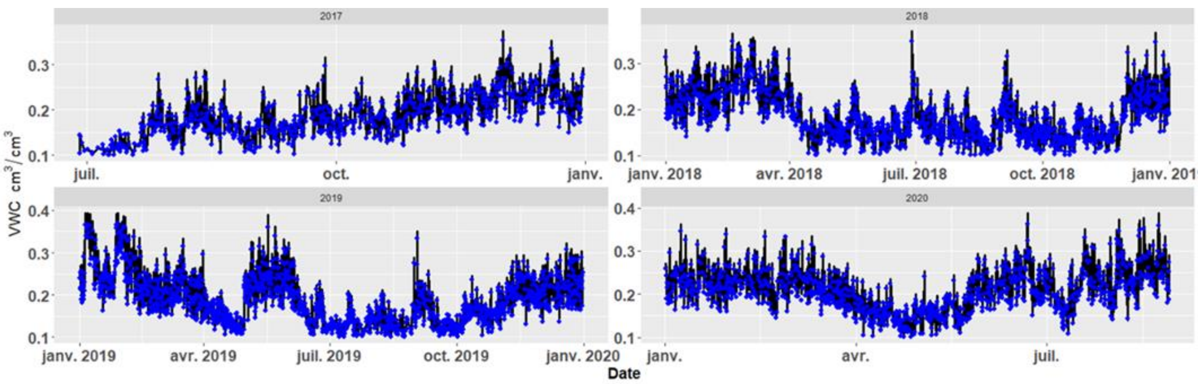


Fig.2: location of CRNS in Petzenkirchen in Vienna Austria

***Fig.3**: Results of the application of deep learning predictive model to calibrate cosmic-ray neutron sensors. Black lines are measured soil moisture using the CRNS and the blue lines are the predictive output based on the deep learning model. The model can accurately produce hourly soil moisture prediction*



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