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Near infrared spectroscopy to estimate the temperature reached on burned soils: strategies to develop robust models.

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The temperature reached on soils is an important parameter needed to describe the wildfire effects. However, the methods for measure the temperature reached on burned soils have been poorly developed. Recently, the use of the near-infrared (NIR) spectroscopy has been pointed as a valuable tool for this purpose. The NIR spectrum of a soil sample contains information of the organic matter (quantity and quality), clay (quantity and quality), minerals (such as carbonates and iron oxides) and water contents. Some of these components are modified by the heat, and each temperature causes a group of changes, leaving a typical fingerprint on the NIR spectrum. This technique needs the use of a model (or calibration) where the changes in the NIR spectra are related with the temperature reached. For the development of the model, several aliquots are heated at known temperatures, and used as standards in the calibration set. This model offers the possibility to make estimations of the temperature reached on a burned sample from its NIR spectrum. However, the estimation of the temperature reached using NIR spectroscopy is due to changes in several components, and cannot be attributed to changes in a unique soil component. Thus, we can estimate the temperature reached by the interaction between temperature and the thermo-sensible soil components. In addition, we cannot expect the uniform distribution of these components, even at small scale. Consequently, the proportion of these soil components can vary spatially across the site. This variation will be present in the samples used to construct the model and also in the samples affected by the wildfire. Therefore, the strategies followed to develop robust models should be focused to manage this expected variation.

In this work we compared the prediction accuracy of models constructed with different approaches. These approaches were designed to provide insights about how to distribute the efforts needed for the development of robust models, since this step is the bottle-neck of this technique. In the first approach, a plot-scale model was used to predict the temperature reached in samples collected in other plots from the same site. In a plot-scale model, all the heated aliquots come from a unique plot-scale sample. As expected, the results obtained with this approach were deceptive, because this approach was assuming that a plot-scale model would be enough to represent the whole variability of the site. The accuracy (measured as the root mean square error of prediction, thereinafter RMSEP) was 86ºC, and the bias was also high (>30ºC). In the second approach, the temperatures predicted through several plot-scale models were averaged. The accuracy was improved (RMSEP=65ºC) respect the first approach, because the variability from several plots was considered and biased predictions were partially counterbalanced. However, this approach implies more efforts, since several plot-scale models are needed. In the third approach, the predictions were obtained with site-scale models. These models were constructed with aliquots from several plots. In this case, the results were accurate, since the RMSEP was around 40ºC, the bias was very small (<1ºC) and the R2 was 0.92. As expected, this approach clearly outperformed the second approach, in spite of the fact that the same efforts were needed. In a plot-scale model, only one interaction between temperature and soil components was modelled. However, several different interactions between temperature and soil components were present in the calibration matrix of a site-scale model. Consequently, the site-scale models were able to model the temperature reached excluding the influence of the differences in soil composition, resulting in more robust models respect that variation. Summarizing, the results were highlighting the importance of an adequate strategy to develop robust and accurate models with moderate efforts, and how a wrong strategy can result in deceptive predictions.