

Vis-NIR Spectroscopy for the Assessment of Soil Quality in Grassland

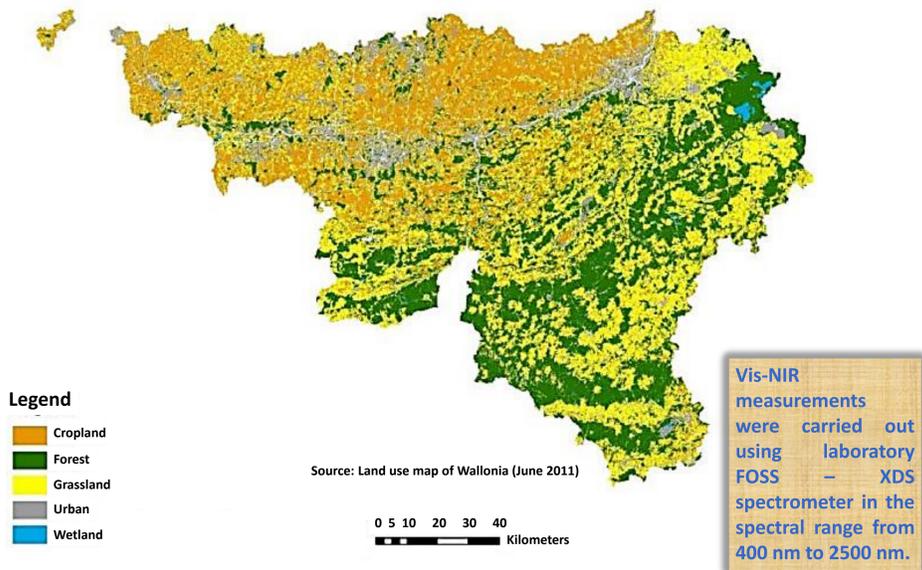
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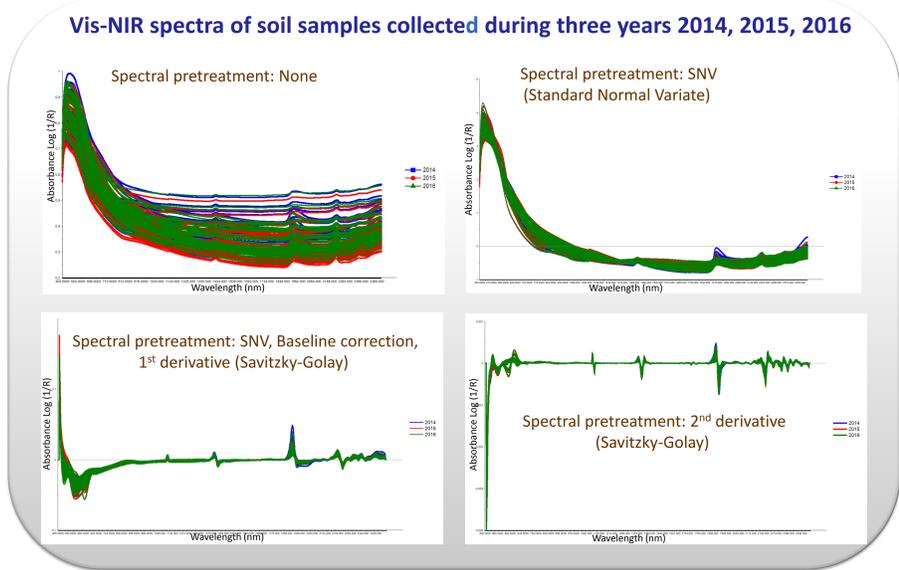
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Today, the challenge of agriculture is not only to ensure food security, but also to have sustainable management of agricultural ecosystems that protects our natural resources which resist to mitigate climate change effect, and emit less greenhouse gas. BIOECOSYS* project deals with the development of a methodology, that allows an evaluation of the ecosystem services supplied by grasslands according to its management and its territorial situation.

The study area is located in 3 pedoclimatic regions of the Walloon territory (Belgium): Ardennes, Famenne and Pays de Herve. The grasslands were chosen because this ecosystem represents up nearly half of Wallonia's agricultural land area. Different types and various management systems were sampled: permanent, lay, grazed, mowed which are likely to produce a large range of soil properties. We collected 150 surface soil samples (0–20 cm) over three years (2014, 2015 and 2016) to cover soil heterogeneity and seasonal variations. The samples were air-dried and ground for spectral measurements. They have been analyzed by NIR, chemical and biological activity methods.



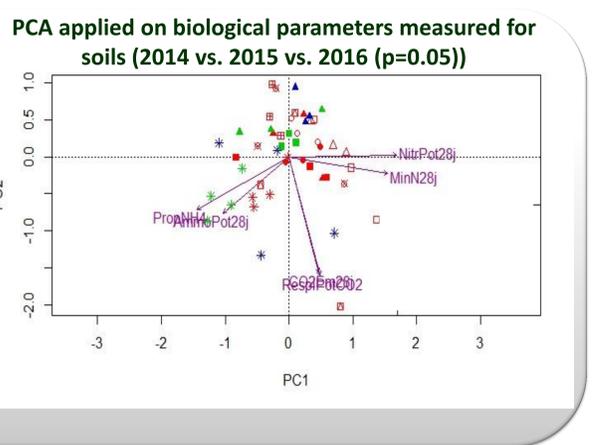
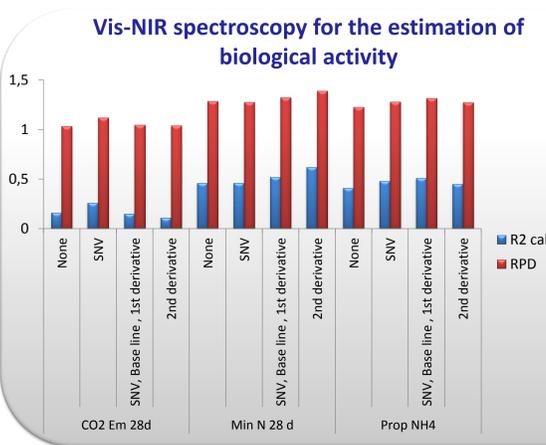
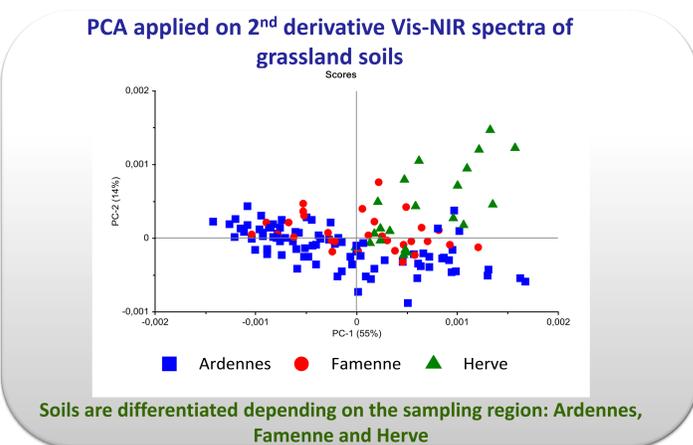
Vis-NIR measurements were carried out using laboratory FOSS – XDS spectrometer in the spectral range from 400 nm to 2500 nm.



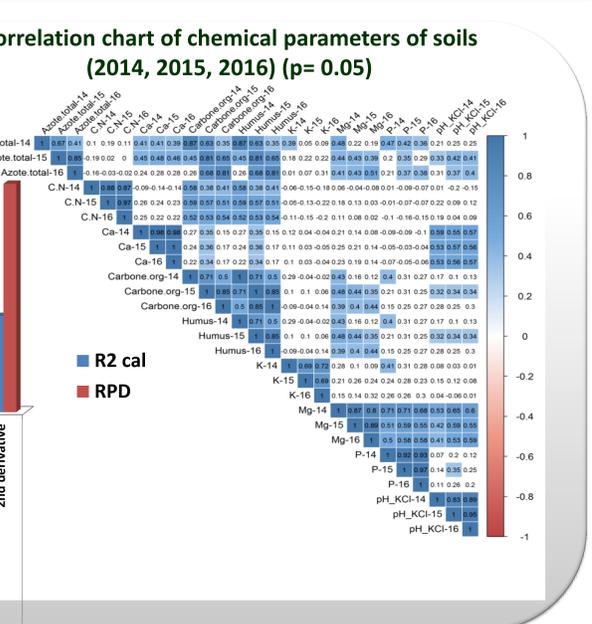
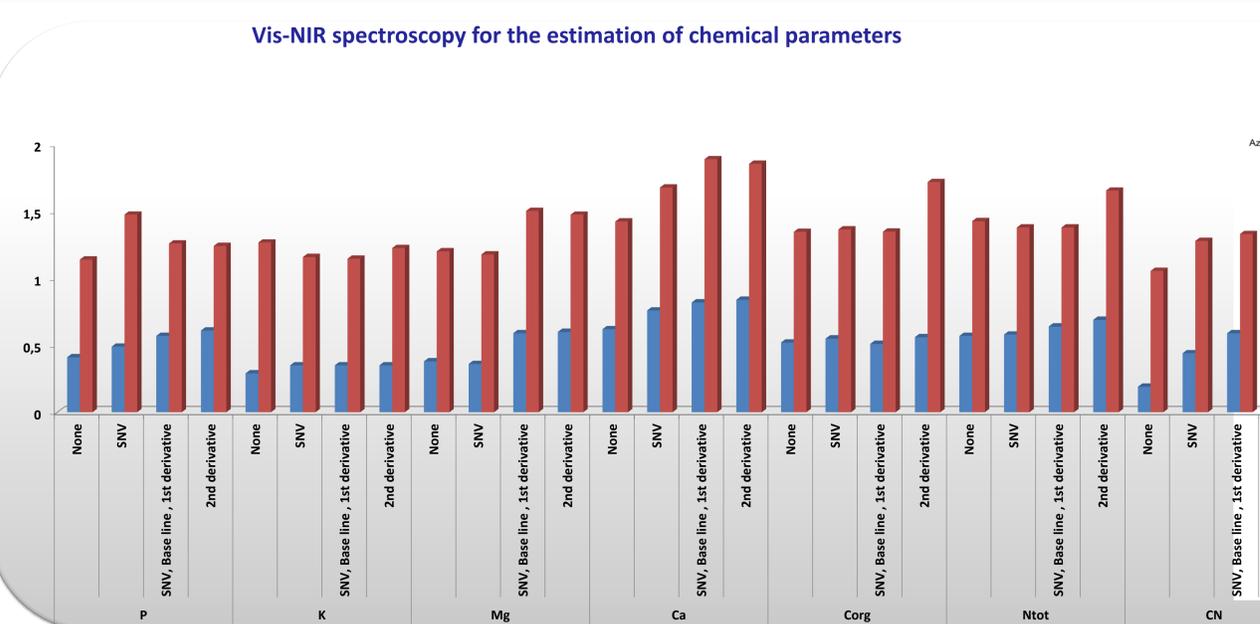
Testing different pretreatments was the strategy followed to optimize RPLS models built with VIS-NIR spectra of soils from grassland. We aimed to estimate chemical and biological properties to assess soil quality.

PCA (Principal Component Analysis) was applied in order to observe any grouping related to the region, the grassland type or management systems. Differentiation according to grassland types / management systems was not possible due to their high number and their high diversity comparing to the number of samples collected from each region. However, discrimination according to regions was possible as presented here.

The microbial biomass is responsible of 80-90 % of biochemical transformations in the soil**. It is essential to carbon, nutrient cycling and energy flow in soil systems. PLS (Partial Least Square) regression models (with random cross-validation) built between Vis-NIR spectra and biological activity parameters not correlated (CO₂ emitted during 28 days (CO₂ Em 28d), proportion of N-NH₄⁺ (PropNH₄), mineralized N (Min N 28d)) show that is difficult to estimate these properties whatever the pretreatment applied (R² < 0.65 and RPD*** < 1.5). Vis-NIR spectroscopy seems not to be able to predict biological activity of studied grassland soils.



Predictions of soil chemical properties are by far the most common attributes reported in the literature. R² and RPD values are presented for prediction of phosphore (P), potassium (K), magnesium (Mg), calcium (Ca), organic carbon (Corg), total nitrogen (Ntot), carbon nitrogen ratio (CN) by applying different pretreatments. Correlation chart of chemical properties permitted us to select ones not correlated which makes it easier to test models build on data submitted to different pretreatments. Calibration models (with random cross-validation) for predicting chemical properties show that the 2nd derivative pretreatment permits to obtain the highest values of R² and RPD. Values of R² of Ca, Ntot and CN are equal or higher than 0.7 while their RPD values (in addition to Corg) are included between 1.5 and 2 revealing that the prediction error has decreased to half the original one. That means it is only possible to separate between high and low values. The values for the other parameters indicate that the calibration is not usable.



→ PCA applied on Vis-NIR spectra has not permitted to differentiate management systems neither grassland types.
 → PLS-R models confirms that Vis-NIR spectroscopy could be used to predict soil organic matter (Ntot and CN) by separating high and low values, but it is not possible to predict biological activity.

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*** RPD = ration of performance-to-deviation, calculated as RPD=SD (Standard deviation) /RMSECV (root-mean-square error of cross-validation)

** Nannipieri et al., Eur. J. Soil Sci., 54:655-670 (2003)