Theme B: Functions & values of soil-water systems; understanding of processes
Lecture Session (LeS): B.1 Climate change: adaption and research

MODELLING THE LOCAL SPATIAL VARIABILITY OF THE FOREST SOIL MINERALIZATION PROCESS OVER EUROPE

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1. Objectives

As an indicator of the soil mineralization processes, the Carbon/Nitrogen (C/N) ratio of the forest soils is one of the best predictors for evaluating soil functions such as biomass production, carbon storage capacity of forest soils. When integrated to risk assessment, these functions can serve for modeling scenarios of soil sustainability with climate change issues (gas fluxes emissions, biofuel production). For instance, for a soil having a relative high C content, if the C/N ratio is high, the mineralization is high and the gas fluxes emission is high.
The C/N ratio is very dependent on the forest management and on environmental factors. Furthermore, since the forest management is done locally, the variability of the C/N ratio has to be analysed locally. Thus, the final objective is to model and quantify the local spatial distribution of the soil forest C/N ratios for the entire Europe.

2. Case Study

3340 C/N ratios are available as point measurements and are described according to 3 strata: the litter, the topsoil horizon (0-10 cm) and lower horizons (>10 cm). For this study, we focus only on the litter dataset. Information on neighboring tree species, number of trees per species and percentage of defoliation is given at the same location,. Since this information on forest is composed by 120 categories of tree species, it has been transformed into 15 classes of tree densities using a supervised classification by Maximum Likehood.
In order to predict the C/N ratios of the litter at unsampled locations, around 150 spatially continuous variables are considered: climate (annual mean temperature, mean diurnal range of temperature, temperature seasonality, isothermicity, annual rainfall, ombrothermic index), population density, relief (altitude, slope, aspect and wetness index), parent material, potential evapotranspiration, the average activity of the vegetation derived by the average Fraction of Absorbed Photosynthetically Active Radiation between 1990 and 2000 acquired every 15 days.

3. C/N Ratio Modeling

Due to the complexity of the phenomenon, a geostatistical approach is suggested for the spatial modeling of the C/N ratio. It is composed by three steps:

1. The reduction of the number of predictors assuming they are spatially autocorrelated. In this step, the Min/Max Autocorrelation Factors (MAF) approach is used to reduce the number of predictors. This approach is a generalization of the classical Principal Component Analysis (PCA) to the case of spatially correlated variables.
2. The prediction of the C/N ratio measurements from the resulting MAF factors using two different techniques:
    a. neural network: this two-stage classification approach comprises a set of nonlinear equations that predict the C/N ratio from the MAF predictors in a flexible way using layers of linear regressions and S-shaped (exponential) functions.
    b. kriging with external drift: this non stationary geostatistical approach decomposes the C/N ratio into a trend (derived from the predictors) and residuals around the trend. The trend can be locally derived from the predictors.
3. Validation: the prediction quality is assessed using an independent C/N ratio dataset.

The plausibility and consistency of results are then discussed on several critical areas over Europe.