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Better understanding of the climatic and environmental factors that affect soil carbon biodegradation and stabilization

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Introduction & Objectives

Understanding the dynamics of soil carbon is a major challenge, especially

as the IPCC pointed out the large uncertainty on soil carbon stock and its potential impact on future climate change. The increase in soil carbon stock is foreseen as a solution to mitigate global warming but this is relevant only if the storage is perennial. Therefore, ^{14}C content has to be used as an indicator of durability of soil carbon stock. Our aim in this study is to identify the climatic and environmental factors that affect the most the soil ^{14}C dynamics, although the many sources of uncertainty blurring the ^{14}C response. For this purpose, we investigate a statistical model selection procedure.

Materials & Methods

Our starting point is the Mathieu et al.'s (2015) profile, that describes the ^{14}C soil dynamics as a parametric function of depth (z):

$$^{14}C = \Theta_1 + \Theta_2 \exp(-\frac{z}{\Theta_3})^{\Theta_4} + \varepsilon$$

In this study, the estimation of the latent variables, Θ_i , is performed using Bayesian inference via MCMC algorithms. This approach has the advantage to take into account parameter uncertainties as well as experimental errors. We apply the Stochastic Search Variable Selection (SSVS) introduced by George and McCulloch, in order to define the probabilistic contribution of each of the 8 potentially explanatory variables (land use, soil type, temperature, precipitation, aridity, etc) on soil ^{14}C dynamics.

Results on radiocarbon data

Two major results: 1- the ^{14}C statistical model nicely reflects the observations and mimics the general shape of $^{14}C$with depth and 2- the selection algorithm highlights that soil type has an influence on the "deep"^{14}C, the topsoil $^{14}C$and the ^{14}Cincorporation with the following high inclusion probabilities (83%, 99%, 86%). Throughout climatic factors, there is a high probability that seasonal shift impacts all at once the first three latent variables as shown in Fig.1.

Fig.1: Posterior selection probability for the latent variables. The highest the probability is, the most the explanatory variable explains the ^{14}C fate.

Perspectives

Results on artificial data, show that SSVS in presence of categorical covariates such as soil type and land use may fail to detect the effect of some influential categorical covariates. Despite this weakness, SSVS does not consider a covariate is significant unless it is the case. Furthermore, cross validation shows that SSVS has a better adjustment and prediction level comparing with the full model containing all covariates. The issue of SSVS can be solved by using Bayesian selection approaches that are appropriate for categorical covariates. Several selection approaches such as Bayesian Sparse Group Selection, Bayesian Group Lasso and Bayesian Effect Fusion have been used in the literature as an alternative. Some of these techniques have a good performance selection not only at the group level but also within a group. Further results will be discussed at the conference.