

EGU2020-19135

<https://doi.org/10.5194/egusphere-egu2020-19135>

EGU General Assembly 2020

© Author(s) 2021. This work is distributed under the Creative Commons Attribution 4.0 License.



Bayesian spatio-temporal modeling of soil phosphorus in Brittany in western France (1995-2014) with INLA-SPDE

Bifeng Hu^{1,2}, Nicolas Saby², Hocine Bourennane¹, Thomas Opitz³, Pascal Denoroy⁴, Blandine Lemerrier⁵, and Zhou Shi⁶

¹URSOLS, INRAE, 45075 Orléans, France

²INRAE, Infosol, US 1106, Orléans 45075, France

³Biostatistics and Spatial Processes, INRAE, Avignon, France

⁴Voici: ISPA, Bordeaux Sciences Agro, INRAE, 33140, Villenave d'Ornon, France

⁵Unité Mixte de Recherche (UMR) Sol Agro et hydrosystème Spatialisation (SAS), INRAE, Agrocampus Ouest, Rennes 35042, France

⁶College of Environmental and Resource Sciences, Zhejiang University, Hangzhou 310058, China

Soil phosphorus (P) is one of the most critical elements for Earth's ecosystem. P is a component of the complex nucleic acid structure of plants, which regulates protein synthesis, plants deficient in P are stunted in growth and lead to diseases. In practice, P is most often the element responsible for eutrophication problems in freshwater meanwhile, and it is considered the macronutrient most frequently as the element limiting eutrophication because many blue-green algae are able to use atmospheric N₂. Since the Second World War overuse application of fertilizer P has led to lots of serious environmental problems such as eutrophication of water body.

Soil P was affected by several factors including climate, geology, time, anthropogenic activities (irrigation, industrial emission, fertilizer application, crop planting pattern etc.) and so on. This makes soil P varied in a very complex manner on both spatial and time dimension and thus increases the difficulty of estimating spatio-temporal variation of soil P. Therefore, a flexible framework is necessary for modelling spatio-temporal variation of soil P.

To explore spatio-temporal variation of soil available P, we propose a Bayesian hierarchical spatio-temporal model using Integrated Nested Laplace Approximation with Stochastic Partial Differential Equation approach (INLA-SPDE). The study was conducted on phosphorus measured by Olsen (P Olsen) and Dyer (P Dyer) methods in Brittany (western France) from 1995 to 2014 with data of more than 30,000 samples of France national soil test database (BDAT).

The INLA-SPDE method exploits the Laplace approximation in Bayesian latent-Gaussian models and does not require generating samples from the posterior distribution. Hence, it can often be used for quite large data sets at reasonable computational expense. It could provide approximate marginal (posterior) distributions over all states and parameters. In this study, the constructed model includes several components such as spatial varying trend, space varying temporal trend, effects of covariates, and residual with space-time dependent variation.

Regardless the method of quantifying phosphorus, the results indicated that the mean content of soil available P decreased between 1995 and 2014 in Britany. Our model explained 49.5% of variance of spatio-temporal variation of P Olsen in Britany in external validation dataset. For P Dyer, our model explained 50% of variance in external validation dataset. The purely spatial effects shown that the available P in west of Britany was higher than east part. Our study could contribute to better soil management and environmental protection. Further study still needed to include more related factors into the model to improve the model performance and detected more related factors (such as soil management measures) which have important effects on spatio-temporal variation of available P in soil.