Internship at IFP Energies nouvelles, Paris area, France

Statistical tools for interpreting thermal decomposition signals from biomass samples: application to the agronomic valorization of soils

Scope. For several decades, Rock-Eval® (RE) thermal analysis has demonstrated its adaptability to a wide range of applications for the quantitative and qualitative characterization of carbon. In the field of soil science, the growing number of publications in recent years confirms the potential of this fast, unprocessed method for studying and monitoring soil carbon evolution. Recently, given the triple challenge presented by food, environment and climate strategies discussed by the European Commission, the use of products derived from biomass is becoming a solution of the future, where the RE method is also proving its ability to characterize their carbon pools (labile and stable) and to provide information on their agronomic interest (soil amendment or carbon storage).

The principle underlying the Rock-Eval® method is based on a first pyrolysis under inert gas (nitrogen) and a second one under oxidizing conditions (air) under the action of different temperature cycles (ranging approximately between 150 °C and 1000 °C). The effluents released continuously as a function of temperature during the two stages are detected by a flame ionization detector (FID) for hydrocarbons and an infrared CO_2 and CO detector during pyrolysis under nitrogen, and by only an infrared CO_2 and CO detector during oxidation under air. This results in five analog signal profiles as a function of time and temperature, which can be converted into quantities for different RE descriptors. However, interpreting these signals is complex and time-consuming.

Objectives. We wish to provide numerical solutions to facilitate and accelerate the interpretation of the numerous RE thermograms (five per sample). Using signal processing and machine-learning techniques, this amounts to proposing algorithms capable of processing these thermograms altogether and classifying them by properties, e.g., by sample type, agronomic interest (amendment, carbon storage), or carbon pools (labile and stable). Ultimately, we want to create a database of RE data on a variety of products derived from biomass together with their properties.

To meet these objectives, this internship will be based on the following elements:

- A database of Rock-Eval® raw analysis files containing time and temperature data associated with intensity values of various signals (FID, CO_2 and CO) obtained for a large number of biomass samples.
- A table containing the parameters calculated (e.g., TOC, MinC, HI, OI, I, R) from the signals, enabling us to propose an interpretative framework for the data.
- For some samples, a database of agronomic parameters (e.g., ROC% and biochemical composition of biomass).

Requested profile. We are looking for a final-year master's student with the following attributes:

- Fluency in mathematics (real and complex analysis, linear algebra, probability).
- Solid grounding in signal processing and statistics, especially machine learning.
- Strong object-oriented programming skills (Python or C++).
- Strong interest in soil science or agronomy.
- Ability to thrive in a research environment: curiosity, autonomy, initiative.

Practical information.

Address: IFP Energies nouvelles, 1 & 4 avenue de Bois Préau, 92852 Rueil-Malmaison, France

Departments: Soil and Subsoil Sciences and *Applied Mathematics*

Level: Final year of master's degree

Duration: 5 months, starting from February 2025

Supervisors: Francesco Patacchini, Antoine Bouziat, Isabelle Kowalewski

To apply, please send a CV and a cover letter to Francesco Patacchini at francesco.patacchini@ifpen.fr