FINAL REPORT PROGRAM LEFE

Program LEFE-CHAT	Project Title: Research on Sulfated Aerosols, Temperature and Volcanism (RASTA-VOLC)	Years 2019 – 2021
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Context :

Volcanic aerosol emissions have a potential impact on the surrounding environment (acid rain), on the weather (cloud formation) and on the global climate. It is thus crucial to improve our knowledge of the processes of formation / transformation / transport of volcanic aerosols.

Objectives / scientific questions :

The project initially aimed to build a methodology for the study of high temperature physico-chemical processes in the near volcanic field by numerical modeling and experimental probing of the proximal component of volcanic aerosols followed by physico-chemical analyzes in the laboratory.

Immediately, from the start of the project, the objectives were revised: changes in LaCy laboratory personnel and expertise made the numerical modeling difficult to undertake. The experimental field part of the project was built around the acquisition of a high-tech field instrument for aerosols probing which was not funded, and the OVPF team needed to reprioritize their activities because of the 2018 eruption of the Fani Maoré volcano close to Mayotte island. For these reasons, we focused on the characterization of OPC-N3 low-cost aerosols counters in collaboration with the LASIR from Lille University.

Main results :

The planned strategy was a calibration of the low-cost instrumentation's answer with machine learning. A set of measurements in various natural environments were simultaneously performed with a set of 7 OPCN3 aerosols counters and a high-tech Mini Wrass portable aerosols counter (see Figure 1). Next, a calibration procedure was built using principal component analysis pre-processing, and assessment of linear, multi-linear, random forest and neural network regression algorithms.

From this calibration work, the efficiency of low-cost (350 €) aerosols counters was validated compare to the high-tech instrument (30 k€) under the conditions that the calibration time is long enough and to use a set of low-cost instruments instead of an isolated one. This type of low-cost aerosol counter is currently used as embedded instrumentation for sea campaigns of the Marion Dufrene.

Figure 1: Calibration hardware

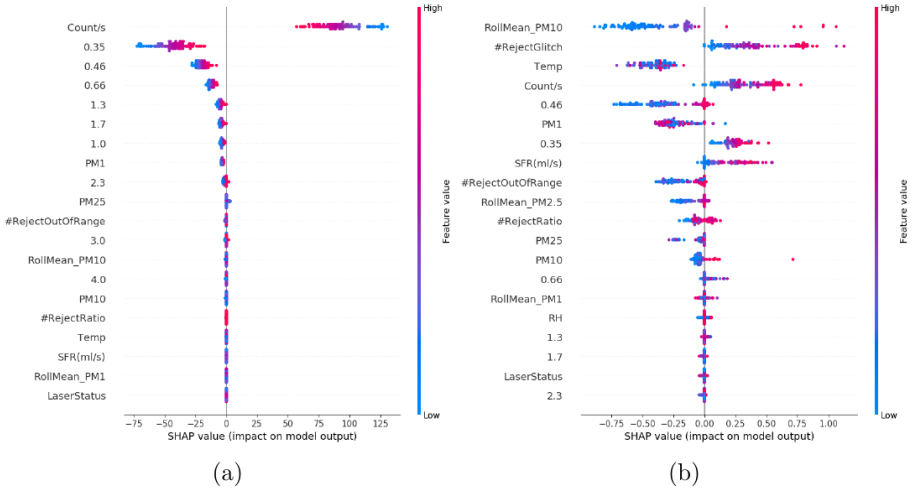

Figure 2: Highest 20 SHAP values of Multilinear regression (a) and random forest (b) models for PM2.5 prediction

The multivariate models showed similar performances, and it is interesting to check whether these similarities translate in their working principles. An original approach to investigate and interpret the outputs of black box models was inspired by the game theory: The SHAP values (SHapley Additive exPlanations) compute the average of the marginal contributions across all feature permutations. They were applied for the full time series to interpret variables of importance in the output. The Figure 2 shows that the regressions have no physical coherence between target value (PM2.5) and predictors.

Future of the project :

The original project on volcanic aerosols is not continued, given the difficulties encountered and the PI has changed research topic. The revised project has resulted in the following deliverables and future perspectives: Low-cost OPCN3 counters are embedded for sea campaigns of the Marion Dufrene. The calibration of OPC counters by supervised learning worked well, and provides numerous valuable insights on: stability of the instruments, importance of linear and non-linear corrections, etc. These results are currently used by the team in charge of the aerosol counters on board the Marion-Dufresne.

Number of publications, communications and theses

2020 – G. Feger, *Study of natural aerosols by low-cost instrumentation calibrated with machine learning*. Defense Master 2 Water Air Pollution Energy – Ecole Polytechnique, Palaiseau.

Data availablility

Data stored on local personal computers. For more information please contact the project PI (C. Guimbretiere).