# Ecole Doctorale des Sciences Fondamentales

## SUBJECT OF THE THESIS

**Title of the thesis:** ***Dynamics of volcanic plumes and their sedimentation: parameterization based on remote sensing measurements and modeling.***

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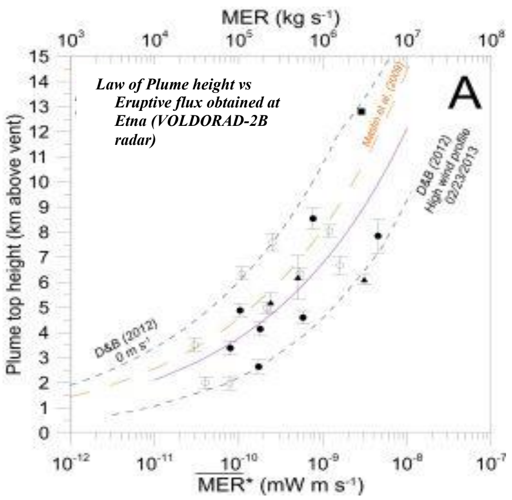
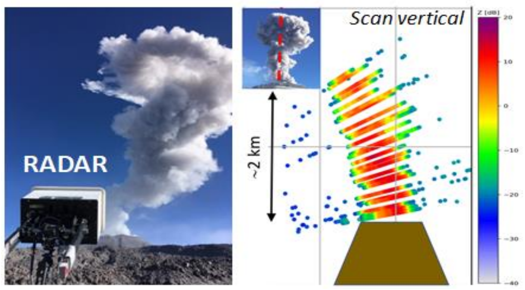
### Résumé :

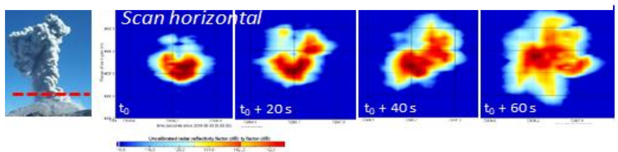
Volcanic ash plumes pose direct societal threats to populations (see Tajogaite 2021 eruption), air traffic, and the economy (see Eyjafjallajökull 2010, Etna). The main challenges in predicting their impact and mitigating the risks associated with ash dispersion and fallout are: (i) quantifying the eruptive parameters at the source that control plume behavior and are essential for initializing predictive models (height, flux, particle concentrations, particle size distribution, velocity field); (ii) understanding the spatiotemporal structure of the different plume regions (column, transition zone, umbrella, cloud) under the influence of wind; and (iii) establishing the interactions between internal plume dynamics and the mechanisms triggering sedimentation (i.e., collective, en-masse, or individual). The goal is to improve predictive models of ascent, dispersion, and ground accumulation, particularly for transient eruptive regimes that are poorly studied.
To meet these scientific objectives, which have significant operational and societal implications, powerful investigative instruments are available at the OPGC-LMV (Université Clermont Auvergne). These include a multi-frequency platform of portable Doppler radars well-suited for probing eruptive columns and plumes/clouds/ashfall[1-4], several proven disdrometers for the continuous measurement of ashfall[5-7] (https://opgc.uca.fr/volcanologie/voldorad), as well as various infrared imagers[8] and a microphysical analysis lab for sampled products. The framework for this thesis includes multi-year funding (ClerVolc Ambition project) and well-established international collaborations (INGV, CNR, University of Catania, Trento, University of Oregon) in volcanological monitoring, modeling, and fluid dynamics. The work will involve processing measurements already acquired with two radars in the column (λ=23.5 cm) and the plume (λ=3.2 mm), as well as new observations to be acquired depending on eruptive activity (e.g., Etna). It will aim to quantify eruptive parameters and then interpret the processes at work using available ascent-sedimentation models. The results will be correlated with the analysis and modeling of temporal dynamics and sedimentation rates observed by disdrometer, in relation to the collected samples. Depending on the opportunities, innovative measurements or in-situ drone sampling (UAR OPGC), as well as modeling of the atmospheric dispersion of products and their impact on air traffic, the environment, and climate, will usefully complement the study[9-10] (CNR, UnivPM, LaMP). In practice, we will continue our efforts to assess

the impact of variations in eruptive parameters measured at the base of the column on plume dynamics, particularly at Etna with our monitoring radar: correlation of the eruptive flux obtained by radar with the height and evolution of the umbrella11, multi-sensor intercomparison, spatio-temporal heterogeneity of the particulate load, and impact on the atmospheric dispersion of aerosols. Furthermore, we will utilize the 2D and 3D scanning capabilities of our high-resolution millimeter-wave radar to characterize the spatiotemporal evolution of the column and plume dynamic parameters, determining for the first time the structure of particle concentrations and internal velocities. The ash load can be deduced as a first approximation by comparing radar reflectivities with those calculated from disdrometer measurements. These detailed in-situ observations, directly compared to ascent/dispersion models, sedimentation rates, and ground deposition, allow us to understand the internal processes of the plume and their relationship to the triggering of sedimentation. Following the analysis of instrumental and field data, optimized acquisition and processing methodologies for obtaining eruptive parameters in real time will be developed for operational purposes.




***Reflectivity of an ash plume at Sabancaya volcano, 2018*** *(mm-wave radar VOLDORAD-3)*

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