ÉCOLE DOCTORALE
SCIENCES DE LA TERRE ET DE L'ENVIRONNEMENT
ET PHYSIQUE DE L'UNIVERS, PARIS

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**Subject title: Towards an integrated warning system for volcanic crisis management: the challenges of linking research, monitoring and communication**

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Host lab/ Team : **IPGP- Team Volcanic Systems – UMR7154**

Financing: Doctoral contract with or without teaching assignment

## *Presentation of the subject:* (Maximum 2 pages)

Disaster risk reduction is one of the major challenges of the 21st century. The Sustainable Development Goals (SDGs) note increasingly frequent and intense natural disasters (Article 14) and call for the development and implementation of comprehensive disaster risk management at all levels in accordance with the Sendai Framework (Goal 11). There is an urgent need to develop appropriate responses to anthropogenic risks such as climate change. But it is important to keep in mind that some natural phenomena, such as earthquakes, cyclones and volcanic eruptions, combine with anthropogenic threats in certain territories and are likely, because of their suddenness and intensity, to affect human development very severely and durably, with long-term repercussions on poverty, inequality, human health (particularly mental health) and more broadly the well-being of individuals and communities. However, there is still a long way to go in improving the understanding and management of these phenomena, which are often not studied in an "integrated" way.

This PhD project is part of the work of the joint international laboratory France/Indonesia SIR of the IRD, which aims to develop an integrated and multi- hazard approach to hazards related to the presence of a subduction zone whose activity is characterized by earthquakes, tsunamis, active volcanism, and land movements, in a context of climate change and significant demographic pressure. Created in 2022, this young laboratory associates researchers in geosciences and humanities and social sciences and deals in particular with the issue of warning. The objective of this PhD is to contribute to the reflection on integrated warning systems which, although called for by the international community, remains a real challenge in terms of scientific monitoring as well as civil security response. It will contribute to developing links between the different actors of the risk chain and thus to strengthening the institutional response to disasters.

The approach adopted is interdisciplinary and should allow to reinforce the articulation between research, monitoring and information sharing with different communities (authorities, media, populations) in the context of volcanic risks, but with lessons for other territories and other types of risks. Indeed, the volcanic phenomenon is an extremely complex phenomenon which is, by essence, "multi-risk".
On the "hard sciences" side, the PhD will adopt a deterministic approach based on instrumental geophysical data and numerical modeling to define which thresholds to use to support the change

of alert levels. Indeed, the detection and operational exploitation of observations as geophysical signals precursors of eruptive phenomena require a quantitative interpretation of internal processes in order to evaluate them in terms of hazard (seismic energy, lava volumes and temporal delays between signs and surface phenomena). For this, the thesis will explore in particular the method of monitoring ground deformations through Bayesian inversions of pressure sources during internal magmatic fluid movements (Beauducel et al., 2020). It will be applied to several active volcanoes equipped with GNSS networks and for which we have other observables during the last eruptive crises. In addition to the definition of thresholds, the thesis will also take seriously the treatment of associated uncertainties. On the humanities side, it will explore the effects of different ways (textual and graphical) of representing scientific results and uncertainties on the communities concerned by the risk: scientists, authorities, media, populations. Beyond the choice of communication media, the different representations of the alert within the communities concerned will be analyzed: what is the understanding of a change in alert level? what are the expected/observed effects in terms of individual and institutional response? does it depend on the ways of representing the alert? on the representations of the alert of other more common phenomena in the territory (cyclone, earthquakes, lahars, etc.)?
These different elements will allow the development of an in-depth reflection on the interest and limits of integrated warning systems, which could be applied to French volcanoes and other volcanoes in the world, but also to other multirisk contexts.

In practice, the candidate is expected to conduct the following works:

- study existing precursor signals on different volcanoes (seismicity, gas, deformation), interpretation models and their use in scientific crisis management
- test deformation models on different data sets and develop a methodology to determine robust thresholds, independent of instrumental artifacts
  familiarize with the existing volcanic warning systems in the world, and their limits in terms of monitoring and crisis management, through a study of the literature in volcanology, in social volcanology and through interviews with scientists in charge of the monitoring of different volcanoes in France and in the world
- familiarize with the problems of communication of uncertainties and perception of the alert by a study of the literature in risk perception, risk communication, and the contributions of the social sciences of the disaster (disaster studies) on various fields and in various contexts
- carry out a sociological survey (participant observation, free and semi-directive interviews) on the representations of warning and warning levels among the communities concerned, focusing on a field already well known by the laboratory's researchers (the Merapi volcano) and with the help of Indonesian researchers familiar with the cultural specificities of the territory (stay of several months to be planned).

The thesis will be directed by François Beauducel, a geophysicist researcher at IPGP, with experience in monitoring Indonesian and French volcanoes, and Maud Devès, a researcher specialized in disaster risk reduction, doubly affiliated to IPGP and to a laboratory of psychology and clinical sociology of the Institut Humanités Sciences et Société (CRPMS). This double supervision will ensure an effective interdisciplinarity. The candidate will also be well supported by the French and Indonesian researchers of the SIR laboratory. During her stay in Indonesia, she will be hosted by the director of the Merapi Volcano Observatory, an Indonesian scientist responsible for the scientific management of the alert, and accompanied by these supervisors for shorter periods.