Title : Assimilation of geodetic data for risk assessment

Institutions :

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Beginning date and duration : according to the availability of the candidate, 4 – 6 months

Subject description :

This internship subject corresponds to a preliminary step of a Ph.D thesis to be started in October 2022. This subject is proposed along with the increasing and regular availability of the amount of remote sensing data and the response to the requirement of operational monitoring of natural hazards. The main objective is to improve the near-real-time integration of remote sensing data and dynamical geophysical models for the mitigation of natural hazards. The first application will be in volcanology with Interferometry SAR (InSAR) & GPS data, but the methodology can be easily utilized for other natural hazards (e.g. landslides, slow slip, etc.), as well as for anthropogenic hazards like forest fire.

In a perspective of volcanic hazard assessment, it is fundamental to be able to know, in advance, if magma that has started to propagate from a reservoir at depth will reach the surface, where and when. The propagation phase is generally rapid, lasting a few hours to a few months but it induces seismicity and deformation signals. These signals are recorded by continuous GPS and InSAR data whose temporal sampling frequency as well as latency have been greatly improved in recent years. In addition, we have dynamic magmatic intrusion propagation models that can be used to estimate the properties of the magma, the state of local stress, the magma's trajectory and propagation velocity. Data assimilation, a technique that combines a dynamic model with data observations at present and in the past in order to predict the future state of the observed system, is therefore an appropriate tool to respond to the need to be able to predict the position and timing of an eruption in volcanology.

In this work, we will develop an efficient data assimilation strategy exploring the Particle Filter that allows using timely available geodedic data to predict the location and timing of volcanic eruptions, with an application to Piton de la Fournaise volcano. This work will be based on the Ph.D thesis of our previous student Mary Grace Bato who successfully applied, for the first time, Ensemble Kalman Filter to volcanological problems focussing on the pressurization and rupture of magmatic reservoirs. This internship will benefit from the Franco-German ANR MagmaPropagator (ANR-18-CE92-0037, 2019-2022) project. There will also be the oppotunity to collaborate with Andy Hooper at University of Leeds in UK, who is developping new methods to automatically extract physical signals from InSAR time series.

Selected references :

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- Gaddes, M. E., Hooper, A., Bagnardi, M. (2019), Using machine learning to automatically detect volcanic unrest in a time series of interferograms, Journal of Geophysical Research : Solid Earth , 124(11), 12304–12322.
- Pinel V., Carrara A., Maccaferri F., Rivalta E., Corbi F., A two-step model for dynamical dike propagation in two dimensions: Application to the July 2001 Etna eruption, 2017, Journal of Geophysical Research, vol. 122, doi:10.1002/2016JB013630.
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- van Leeuwen P.J. Nonlinear data assimilation in geosciences : an extremely efficient particle filter, 2010, Quarterly Journal of the Royal Meteorological Society, vol. 136, pp. 1991-1999.