IAVCEI 2013 Scientific Assembly - July 20 - 24, Kagoshima, Japan
Forecasting Volcanic Activity - Reading and translating the messages of nature for society

0P1_4E-O6   Room A3   Date/Time: July 20 15:45-16:00

IAVCEI 2013
Kagoshima

Eruption forerunners from multi-parameter monitoring and the corresponding predictability skills (Piton de la Fournaise)

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Volcanic eruptions impact on societal risk, and volcanic hazard assessment is a necessary ingredient for decision-makers. However, the prediction of volcanic eruptions remains challenging due to the complexity and the non-linearity of volcanic processes. Identified forerunners such as increasing seismicity or deformation or velocity changes within of the volcanic edifice prior to eruption are not deterministic. We analyzed the short-term (i.e. the inter-eruptive period) time series of the seismicity rate, the deformation and the seismic velocity changes (deduced from seismic noise cross-correlations) over the period 2000-2007, with two main goals. First, we characterize the average pre-eruptive time patterns before 23 eruptions using superposed epoch analysis for the three observables. Using daily rate values, we resolve (i) a velocity change within 100-50 days from the eruptions onsets, then a plateau value up to eruption onset; (ii) a power law increase in seismicity rate from noise level 15-10 days before eruption time; (iii) an increase of displacement rate on the eruption day. These results support a three steps mechanics leading to magma transfers towards the surface. Second we use pattern recognition techniques and the formalization of error diagrams to quantify the predictive power of each forerunners either as used independently or as combined to each others. We show that when seismicity rate alone performs the best in the failure to predict and alarm duration space, the combination of the displacement and seismicity data allows to reduce the false alarm rate. We further propose a tool which explores the prediction results in order to optimize prediction strategy for decision-makers, as a function of the risk value.