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Analysis of the meteorological impact on monitoring parameters from Merapi volcano

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Triggering of volcanic activity caused by rain events has been often postulated for different volcanoes whereas the underlying mechanisms are still under discussion. At Merapi Volcano (Indonesia) such a rain triggering of dome collapse events was recently assumed for several historical eruptions. In order to evaluate any possible type of meteorological influence on the dynamics of the volcanic system, it is certainly important to find further the meteorological perturbation on the monitoring parameters itself, which are used for describing the volcanic activity. Within this context, we present observations from a multi-parameter data set recorded at the monitoring network at Merapi Volcano and rain data from the Global Precipitation Center (GPCC). In particular, we use time series of seismic data, fumarole temperature, rain, air temperature and air pressure. Our aim is to distinguish between the meteorological perturbations on the monitoring parameters and the interaction of the meteorology and the volcano in terms of enhancing the volcanic activity status. Continuity, sampling rates and resolution vary considerably between the individual time series. The longest data sets consist of catalogues of daily seismic and monthly rain data which stretch over 19.5 years. Additionally, a detailed but shorter data set with daily resolution or even sampled with up to several Hz of all data types gives constraints how reasonable the different models for the underlying mechanisms are.

In doing so, we focus first on the joined analysis of seismic and precipitation data. A possible mechanism for rain fall induced seismic activity could be pressurisation in the upper most parts of the dome as discussed for Soufriere Hills, Montserrat, or tensile stress increase in deeper parts of the volcanic system as supposed for Piton

de la Fournaise, Reunion Island. At the present state of our analysis the correlation of the catalogues of classified seismic events for the time period 1983 up to present with rain amount at Mt. Merapi does not support any of the mentioned models. As reason we cannot exclude that the data set is too short to allow statistically reliable results: Less than ten times of high volcanic activity are observed. On the other hand, the meteorological influence on the eruptive behavior might be only pronounced if the volcano is already in a critical state and therefore very special circumstances are necessary to observe the interaction.

A test of models is not possible for the analysis results of the continuous records of fumarole temperature, rain rate, air temperature and air pressure data from Merapi Volcano with higher temporal resolution because there exist no models so far. This data set shows that single rain events cause a dramatic decrease in the fumarole temperature. Depending on the observation site the reaction in fumarole temperature differs. Theses differences can be ascribed to the degassing pathways of the two monitored fumarolic fields which show more or less intensive hydrothermal buffer signatures. Additional daily variations can be found in the fumarole temperature data which differ systematically for each site. The correlation of the fumarole temperatures with air pressure and air temperature is analyzed to test if these observed variations are related to solar irradiation or pressure variations. The correlation analysis between fumarole temperature and meteorological parameters shows that interaction between fumarolic gases and meteoric water takes place in the shallow subsurface. Based on the observations we discuss possible interaction models.