Identification of long- and short-term eruptive trends using satellite TIR records of Merapi Volcano, Java, Indonesia

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Merapi is a 2968 m high volcano located in the Central Java Province of Indonesia and one of the countrys most active volcanoes. Episodes of basaltic-andesite dome growth are periodically interrupted by explosive eruptions, which have caused at least 429 fatalities in the last 20 years alone. We use thermal infrared (TIR) images from the Moderate Resolution Imaging Spectrometer (MODIS) and Advanced Spaceborne Thermal Emission and Reflection Radiometer (ASTER) instruments to measure heat flux at Merapi Volcano over the time period from 2005-2012. We also estimate effusion rates at the vent from the heat flux values using the method of Harris and Ripepe (2007, Geophys. Res. Let. 34). Our data set includes over 1500 MODIS images and over 40 ASTER scenes that allow us to observe trends in volume flux at the vent over time. The result is an 8-year record of heat flux at Merapi that includes a typical Merapi-style, dome-building effusive eruption in 2006 and the explosive VEI 4 eruption of 2010. We are able to confirm the accuracy of heat flux measurements and effusion rate estimates from TIR data by comparison with a limited number of ground observations from the 2006 and 2010 eruptions. Nightly MODIS images create a dense record of heat flux that can show both long-term trends and the rapid onset of eruptions. Long-term trends include volume flux changes that may represent precursory events and post-eruption high-flux rebound, as well as background volume fluxes similar to previous studies (e.g. Siswowidjoyo, 2005, Bull. Volc. 57). The higher resolution ASTER images allow detection of source details that cannot be resolved in the lower-resolution MODIS images, such as differentiation between accelerated dome growth and dome collapses that create widely distributed hot pyroclastic deposits. We also demonstrate the limits of satellite TIR monitoring, which is primarily restricted by frequent cloud cover blocking the view of the volcano during the rainy season. Additionally, the presence of an ash plume during the 2010 explosive eruption severely limited our ability to observe that event. Satellite TIR monitoring of volcanic activity is best suited to observe ongoing effusive activity and to some extent, pre- and post- eruptive trends. The ability to correlate satellite TIR observations with specific events and types of activity at Merapi can be applied to other similar volcanic systems. More detailed interpretation of the TIR images captured by MODIS and ASTER can improve monitoring and hazard assessment at other potentially dangerous volcanoes that are not as well observed as Merapi.