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Combining ground- and ASTER- based thermal measurements to constrain fumarole field heat budgets: The case of Vulcano Fossa (2000-2015)

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Vulcano Fossa is the currently active volcanic site on the island of Vulcano in the Aeolian Arc, Italy. Vulcano's present activity is characterized by diffuse and fumarolic degassing, and shows extensive ground heating through near-surface condensation of steam that rises from depth. This volcano has been widely studied over many years through a variety of techniques and as such is commonly considered the model for a hydrothermal system. Satellite thermal monitoring is increasingly used to monitor such systems. In particular, the ASTER (Advanced Spaceborne Thermal Emission and Reflection Radiometer) instrument deployed aboard NASA's Terra satellite is of interest as it offers a relatively high spatial resolution of 90 m for the thermal infrared (TIR) bands and orbital period of 16 days which, typically, is sufficient for tracking thermal changes associated with hydrothermal system. The aim of our work is to combine satellite- and ground- based thermal measurements to observe heat-flux evolution along the period from 2000 to 2015. We use data collected over 13 field campaigns, integrating them with ASTER TIR images from the corresponding periods. The overall objective is to assess the time-varying partitioning of heat between vent flux (as measured by the field campaign) and geothermal flux (from ASTER), and to determine the implications for hydrothermal system dynamics.
To track heat flux at the fumarole field we developed a new methodology that converts ground-based vent temperature measurements to heat flux, and we obtained the geothermal heat flux from the ASTER data. We found that geothermal heat losses were typically 9 MW and vent heat losses were around 1 MW. This work highlights that the total heat flux was quite stable (at $\sim$10 MW) over the 2000-2015 period, although there was a marked increase (to 24 MW) in March 2002, and a steady increase since September 2017. Building on previous models, these results imply that the periodic changes are likely be caused by changes in ground permeability. This allows a more efficient transfer of heat from the source to the surface. We further propose that this validated model and methodology could be applied to other volcanoes such as Nisyros (Greece) or Campi Flegrei (Italy).