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Groundwater circulations within a tropical humid andesitic volcanic watershed using the temperature as a tracer

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Groundwater flow within volcano-detritic environment, is of prime importance to many human needs and activities, from the supply of clean drinking water to the extraction of hydrocarbons or geothermal energy. However, the heterogeneity of the geological formations makes difficult to quantify the groundwater spatial distribution. Moreover, its temporal variation in tropical humid regions is sometimes poorly known.

For instance, the surronding of the Merapi volcano, in Central Java, Indonesia, is an area of high but seasonal rainfall, and extensive crop irrigation. It has a large population and a need to increase food and potable water supplies depending upon exploiting groundwater ressources. The stress on these resources increases with the intensification of the demography, the agricultural practices and the industrial exploitations. In order to implement a sustainable management of the water resources, the description of the groundwater circulations and the quantification of the resources is needed.

A mutidisciplinary approach has been performed at the watershed scale, including geology, hydrogeochemistry and long term hydrogeological monitoring. The data synthesis and constisency have been confirm with a numerical model of physical processes.

Based on a geological and geomorphological study, the hydrogeological watershed on the Eastern flank of the Merapi volcano is composed by an alternation of aquitards (mainly ashes, tuffs and clay) and aquifers (sand, gravel and boulders). The deep aquifers are agenced in conduit following the burried channel of the paleo-rivers. The eastern flank of Merapi provides excellent example of a volcanic-sedimentary environment.

From 20 cold springs of 3 spring zones, sampled on 2 hydrological years (2011 to 2013), the study of the transfer into the saturated zone from upstream to downstream, given the geological context and topography, allows to estimate the role of supply from high and low altitudes to the recharge processes. The water temperature has been used as a tracer to understand the pattern of groundwater flow and to determine the mean recharge elevation for springs. Inferences from standard oxygen and hydrogen isotopic measurements are compared with temperature measurements made at the springs to confirm the recharge elevation estimation and whether groundwater circulates to shallow or deeper depths.

The METIS model, coupling groundwater flow and heat transport simulations in 2D steady flow regime, has been used in order to confirm the findings of the temperature and mean flow rate analysis and to characterize the regional flow of the multi-layered aquifer system.

This approach provides methodological insights into characterization of the groundwater pathway within complex porous media in tropical humid regions. This study enable us to provide guidance on the required level of model complexity as well as on the amount and type of observations data required.