How sensitive is electrical self-potential survey to groundwater flow along a slope?

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Self-potential (SP), nearly static electrical potential on and in the earth, is mainly generated by pressure gradient of pore water, especially in no volcanic and mine area, so that SP can be a useful tool to constrain and monitor groundwater flow. The relationship between SP and pressure gradient is clearly seen in laboratory experiments, and described with a linear equation in a hand-size sample. However, in many case studies, interpretations of groundwater flow based on observed SP distributions in field data are difficult. One reason comes from complex distribution of both groundwater flow and electrical resistivity of soil and rocks. Here, we try experiments of mountain-scale models numerically to discuss the relationship between SP and groundwater. The simultaneous simulations of both groundwater flow and resultant SP distribution are done by newly developed calculation codes. The groundwater calculation is done by MODFLOW, a well-known groundwater simulator. The calculated water head distribution by MODFLOW gives both position of electrical current sources and resistivity structure below the surface. Finally, we can obtain self-potential values at arbitrary points. We show the technical details of the simulation, and demonstrate how the groundwater flow can be interpreted from SP data qualitatively.