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A simple model for weathering front propagation and its potential use for mapping regolith geometry

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We present a new model of the evolution of the regolith thickness based on the assumption that the rate of propagation of the weathering front is linearly proportional to the velocity of the fluid in the permeable regolith. We compute the steady-state flow velocity assuming that the regolith has uniform hydraulic conductivity but is not fully saturated. This leads to a system of coupled equations that we solve numerically to predict the long-term (i.e. on geological time scales) evolution of the regolith geometry beneath a topographic feature (a hill) of set size and height. We show that the geometry of the regolith layer (i.e. its thickness) and its evolution through time are primarily controlled by the value of a dimensionless number that is itself function of the surface slope, the infiltration rate and the hydraulic conductivity of the regolith. In high slope environments, such as in tectonically active areas, the regolith layer is predicted to thicken towards the hill top, whereas in low slope environments, maximum thicknesses are predicted to occur at the base of the hill. We have compared these predictions to measurements of regolith thickness in a large variety of environments in an attempt to validate and calibrate our model, and more specifically to estimate the value of the parameter relating the weathering front velocity to the fluid velocity and the assumed mean hydraulic conductivity. We also show how this model can be used to improve mapping of the regolith layer at the catchment/basin scale, which is essential to build more complex and accurate models of the behavior of the critical zone and/or to integrate local studies at regional to global scales to improve our assessment of the effects of anthropogenic global change.