Discussions

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The basis of this paper is a model of flow in catchments. The model applies to a shallow soil layer atop an impermeable barrier. In a practical application, the catchment is divided into a group of plates with little or no surface curvature. The model then applies in each of the plates, with the proviso that the side boundaries of the plates are impermeable. The model, as given by equation (1), divides each plate into differential slices perpendicular to the slope, i.e., the slices are defined by elevation contours. The model becomes less accurate with increasing topographic irregularity because the water flux becomes increasingly a function of position along a contour. The water flux at the soil surface (precipitation less evapotranspiration) is treated as areally-averaged over the entire catchment. It is apparent that the model can be extended, without any increase in the complexity of the calculations, by treating the surface moisture flux as a function of distance, as well as time, i.e., by replacing $p(t)$ and E_a (t) by $p(y,t)$ and $E_a(y,t)$, respectively. Spatial variation of factors affecting surface flux, e.g., vegetation, could be partially accounted for in this way.

The authors derive analytical solutions to the model by linearizing the hydraulic conductivity function $K(\theta)$ (symbols correspond to paper). The linearized $K(\theta)$ is matched with the "true", nonlinear $K(\theta)$ so that the former will be most accurate for near-saturated conditions. The main analytical solution, given by equation (17), is valid for $y > tK_c \sin\phi$. It would useful to have the corresponding solution for the case $y < tK_c \sin\phi$.

Some important model results are presented in discretized, rather than analytical, form. For example, the runoff function, r, can be written

$$r(y,t) = H[\theta(y,t) - \theta_s][\theta(y,t) - \theta_s]\, W(y)$$

where the first term on the right-hand side is the Heaviside step function. The total hillslope runoff is defined by

$$R(t) = \int_0^L r(y,t)\, dy$$

In practice, knowledge of the total runoff at a particular location is necessary, i.e., R(t) is more useful if generalized to R(y,t). The above equation then can be simple generalized to

$$R(y,t) = \int_0^y r[y',t(y')]\, dy'$$

Where the function t(y) is specified according to some overland flow model. In the most simple case, one makes the assumption that excess water moves with a constant velocity, v, downslope. Assuming, additionally, that runoff does not re-enter the soil profile, then the total runoff at L is given by

$$R(L,t) = \int_0^L r[y,t - (L-y)/v]\, dy$$

Model predictions are compared for converging, diverging, and parallel hillslopes. [Note that the equations (32)-(34) defining W(y) describe only the right side of the hillslope geometries. The left side is a reflection about the y coordinate axis. Additionally, the right side of each equation must be multiplied by B(y) = 0.5 m.] Although each geometry has the same volume, their centroids ($\bar{y}$) are unique. It may be verified that $\bar{y}$ (diverging) $> \bar{y}$(parallel) $> \bar{y}$ (converging). Because the mean travel distance of the water to the hillslope end is different in each case, interpretation of the presented results regarding topography types is somewhat difficult.

In conclusion, principle features of the model are its parsimonious nature and apparent ease of application. As demonstrated here, extensions to the model can be incorporated in a straightforward way. I look forward to the forthcoming publication of the model results for actual catchment data.