



Use of pore-water pressure and discharge data as orthogonal information in the calibration and validation of a distributed hillslope model for landslide prediction

Sekhar Lukose Kuriakose (1), Victor Jetten (1), L.P.H van Beek (2), C.J van Westen (1), and G Sankar (3)

(1) UNU-ITC School for DGIM/Department of Earth Systems Analysis, Faculty of the Geoinformation Science and Earth Observation (ITC), University of Twente, Enschede, Netherlands (lukose11753@itc.nl, +31534874336), (2) Department of Physical Geography, Utrecht University, The Netherlands (r.vanbeek@geo.uu.nl), (3) Geoscience Division, Centre for Earth Science Studies, Thiruvananthapuram, India (sankarazhakath@gmail.com)

The plateau margins of highland Kerala (The Western Ghats), India is conducive to slope failures. A slope hydrology coupled slope stability model named STARWARS+PROBSTAB capable of predicting the spatio-temporal probabilities of shallow landslide initiation was identified and used for the region in a data poor environment (Kuriakose et al., DOI:10.1002/esp.1794). The study revealed that a detailed characterization of the slope hydrological response of the region such as transient ground water level (TGWL), discharge (Q) and base flow (BF) is necessary to calibrate the slope hydrology model, outputs of which could be used as inputs in the stability model for the accurate prediction of space and time of occurrence of shallow landslides in the region.

A catchment named Aruvikkal (upstream of Meenachil River, in the district of Kottayam) measuring 9.35 km² was instrumented in 2007 with an automated weather station (Vantage Pro2 Plus), 13 piezometers (Keller DCX 22AA) measuring the TGWL and a stage height (SH) gauge at the outlet of the catchment. A rating curve was prepared based on velocity measurements at the outlet and subsequently the Q was calculated. BF was separated from the Q data using a master recession curve filtering approach of USDA (Arnold et al., 1995).

The TGWL, Q and BF were subjected to a time series analysis (cross correlation; CC) with the rainfall (RF). The Q response of the catchment to RF was very rapid that a peak CC of 0.45 was observed within a lag of 1 to 2 hrs. The existence of a significant BF component was also noticed which had a peak CC of 0.21 exists at a lag time of 17 hrs. Of the TGWL data from thirteen piezometers nine showed acceptable cross correlations of >0.21 (the peak CC of BF). The rainfall-TGWL-Q-BF response lags do not show very significant seasonal variability except in terms of its absolute cross correlation coefficients. The strongest relationships were observed during the SW monsoon seasons.

The analysis indicated that data from 2007 North East monsoon (1 October) season to the end of 2008 South-West monsoon (SWM) season (30 September) and the 2009 pre-monsoon (January to May) season are suitable and consistent enough for the calibration and validation of slope hydrology models. The observed average peak CC of TGWL to rainfall during the calibration and validation period was about 0.32, with seven of the nine piezometers showing more than 0.21 and only two having more than 0.55. The relative location of the instruments with respect to the rain gauge and the variability in the terrain conditions explains this variability in cross correlations.

Based on this analysis STARWARS was parameterized with a 6 hrs time step rainfall and evapotranspiration data and was calibrated using PEST for the period of Pre monsoon (PM) season (January to May) and SWM of 2008 with TGWL at nine of the thirteen piezometers as the calibration target. This calibration is expected to reflect the spatial and temporal hydrological response persistence and peaks of the region such that the space and time of occurrence of shallow landslides can be accurately predicted. The model was validated with the 2007 NEM TGWL data at the selected piezometers. The calibration resulted in an average agreement of 0.37 (Coefficient of

Determination) with a maximum of 0.6 at 3 piezometer locations. The model performance when considering Q and BF was about 0.6 and 0.8 (Coefficient of Determination). Much of the error in predictions was due to the uncertainty in the estimate of soil depth and the lack of soil properties data in the B and C soil horizons.

The STARWARS predicted TGWL and volumetric moisture content of the year 2001 was used as inputs in the slope stability model. The landslide inventory of the year was used to validate the model. The model over predicted the unstable area, while successfully predicted the date of the landslide events as with the peak instability conditions. All the five recorded landslide locations were predicted as failed. The calibrated and validated models were applied to assess the spatio-temporal probabilities of shallow landslide in the catchment over a century of rapid land use changes (reported in the session GM6.1, EGU 2010).