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Flood forecasting in Ruvubu River Basin using TRMM data

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The paper presents the scientific challenges of hydrological modelling of data-scarce catchments with particular reference to the Ruvubu River Basin in Burundi. The runoff in the Ruvubu River Basin responds to seasonal rainfall with a peak flow between March-May and a smaller peak in November-December. The Ruvubu River drainage area is around 10547 km2. In order to build a catchment model the HEC-HMS tool with the soil moisture accounting (SMA) model was selected to simulate the catchment response to a series of wet and dry periods. Based on the availability of data a daily simulation time step was considered. The daily simulation time step allows for building models to study catchment characteristics, particularly over a long period of time, but building a model to predict the catchment response within a short period of time (in hours) is not possible. The recent availability of rainfall estimates from Tropical Rainfall Measuring Mission (TRMM) provides new sources of more frequent rainfall data. Recent research has shown the possibility of using this data in flood forecasting in ungauged basins.

There are several TRMM rainfall products available by combining measurements from different sensors in the estimation algorithm. The real-time 3 hourly TRMM Multi-satellite Precipitation Analysis (TMPA) was shown by the International Precipitation Working Group (IPWG) to be an accurate high resolution satellite-based rainfall estimate for operational use by making comparisons over Australia, the US, and the North-western Europe. In these studies the spatial resolution of TMPA (0.25o X 0.25o) was considered to capture the hydro-meteorological heterogeneity of the study region. The coarse resolution of satellite estimates may be a limitation for some hydrological applications, but its temporal frequency and global coverage are characteristics that make TPMA worth pursuing.

In this research the 3-hourly TRMM rainfall estimates for the period 1998 to 2006 was acquired. When compared to the in-situ measurements the accuracy of rainfall estimates from TRMM is still a major issue. The 3 hourly rainfall estimates from TRMM was converted to a daily time series. This time series when compared to the time series from raingauges showed low correlation coefficient (for instance 0.55 over Ruvyironza sub-basin during the period 1999 to 2005). The R2 for Ruvyironza sub-basin during the period 1999 to 2005 was 0.3. A set of linear models was developed to disintegrate the daily rainfall time series to 3-hourly time series using the TRMM data. After adopting the conversion based on the developed linear models the R2 was 0.9. The scope of using more complex and non-linear modelling (such as using an ANN) was explored.

The generated 3-hourly rainfall data was used to predict flood in Ruvubu basin (only with a 3-hourly forecast). The monthly peak and average discharge data were only available for a comparison with the simulated values. From the observed data, the monthly peak flow in December 1999 was 42.5 m3/s while in May 2003 it was 48 m3/s. The peak simulated flood was 44.2 and 45.6 m3/s respectively. The simulated peaks were quite close to the observed peaks, however, no information was available about the time of occurrences.

In general, it is concluded that the TRMM data provides new opportunities for hydrological studies in ungauged basins.

Keywords: Ruvubu, Burundi, HEC-HMS, TRMM, rainfall disintegration, rainfall-runoff modelling, data-scarce catchment.