IMPLEMENTATION OF HYDROLOGICAL MODEL FOR FORECASTING PURPOSES IN UPPER MAGDALENA RIVER BASIN, COLOMBIA

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1. INTRODUCTION

Colombia has made great efforts to improve early warning system due to recent large flood, in particular, the last “la Niña Phenomena” causing country wide flooding. This disaster urges the need to have hydrologic forecasting capacity for producing early warnings with more time in advance and to allow the execution of operational strategies in order to reduce the adverse impacts. For this purpose multiple sources of model input data should be used, for examplethe real time information. However, there is not any conceptual framework that allows to generate the operational connection between available inputs (precipitation forecasting, satellite information, probabilistic precipitation forecasting, etc.) and hydrologic models for the major river basins in Colombia like upper Magdalena River Basin.

2. METHODOLOGY

The study basin is the upper part of Magdalena river basin in Colombia, It has a drainage area of 56.500 km^{2}.The average discharge at the Puerto Salgar Station is 1496m^3/s.

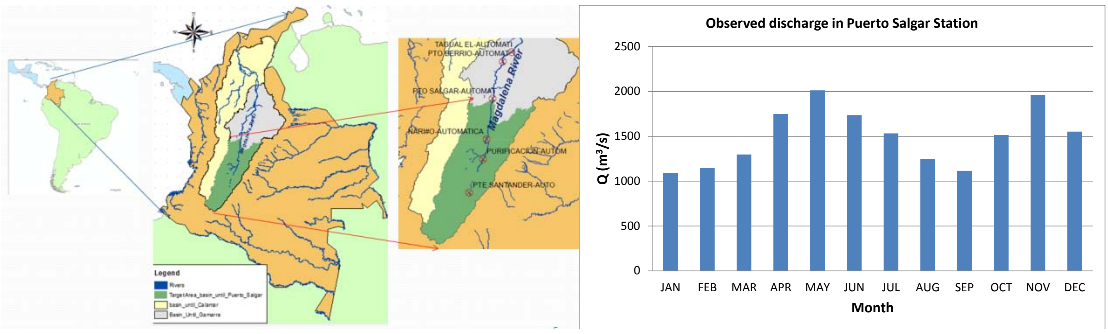

Fig. 1Target area, Upper Magdalena River basing and Observed Discharge at Puerto Salgar station in Magdalena river.

The hydrological response for large basins can be better simulated by distributed or semi distributed hydrologic models, particularly when the spatial distribution of precipitation hassignificant variability. In this context for distributed hydrological simulations of large river basins (10 000 – 100000km^2), the block - wise TOPMODEL(BTOP) was implemented in the upper part of Magdalena River Basin in Colombia, for hydrological forecasting purposes.

In the block – wise TOPMMODEL (BTOP) the basin is composed by blocks (sub basins) that are conformed by hillslopes and sub surface.Water is assumed to be shared into the block elements but not between blocks(Takeuchi, 2008). The effective rainfall discharges over a block as superficial flow in the cells, once the holding capacity has been filled and assuming steady state condition, or as sub surface flow to a local stream segment. In steady state, sub surface flow from each grid cell is equal to the recharge rate in a block times the effective contributing area of the grid cell i. This is defined as the product of total upstream area and the effective contributing area ratio. This concept allows to re-define (in relation with TOP model definition) the topographical index γ in the BTOP as expressed in Eq. (2).

$$q_{bi} = [a_i f(a_i) r_k]/a_{0i} \qquad (1)$$

$$\gamma_i = ln \frac{a_i f(a_i)/a_{0i}}{tan\,\beta_i} \qquad (2)$$

Where $\mathbf{q_{bi}}$ (m day-1) is the specific base flow of the grid cell i to the local stream segment per unit grid cell area, $\mathbf{r_k}$ (m/day^{-1}) is the spatially homogeneous recharge rate over the block *k*, $\mathbf{a_i}$ $\mathbf{f(a_i)}$ (m^2) is the effective contributing area of the grid cell and $\mathbf{a_{0i}}$ (m2) is the area of the grid cell *i*. Detailed description of BTOP model applications is presented in Takeuchi, (2008).

Keywords: hydrological forecast, BTOP model, Calibration

Daily precipitation values for a number of stations in the basin and three discharge stations located along the main channel (the discharge stations are presented in Fig 1) were used for model calibration purpose. The time period used for calibration purpose correspond to 1980 to 2000. For validation purpose the period 2001 to 2010 was used.

Model's Potential application for hydrological forecasting was made evaluating the hydrological responses using different forcing input data. The first one corresponds to the previous day precipitation from climatic stations available. The second involves the inclusion of three days forecasting by a global weather model. The third one correspond to simulations using ensembleslike NCEP Global Ensemble, this is generated by US National Weather Center. The use of this ensemble for hydrological forecasting is presented by Sadik (2010). NCEP Global Ensemble consists of 20 perturbed forecast runs, each one out to 16 days, but just the 3 first days were used. This work try to introduce the use of ensembles in hydrological forecast in Colombian basins, some considerations about the application and error evaluation are presented in Nester (2012).

3. RESULTS

The model calibration allows reproducing the discharge using precipitation station information. In this way, the model parameters were calibrated and compared with theoretical range. The hydrological response was evaluated comparing different model inputs simulations. The application of ensembles to hydrological forecast has been discussed in operational hydrological forecast systems like EFFS in Europe (Pappenberger, 2005).

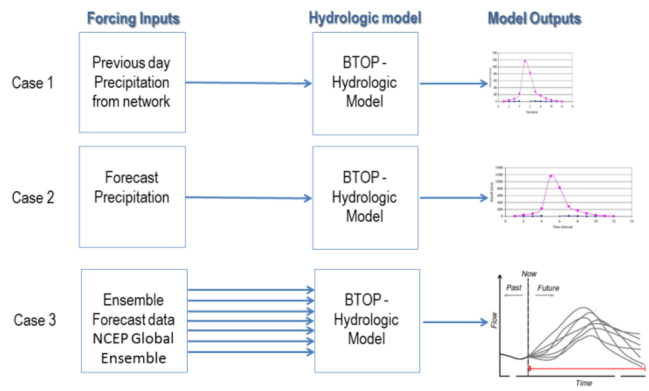

Fig. 2. Alternatives of model use for forecasting.

4. CONCLUSIONS

The skills of BTOP model for an operational hydrological forecasting system implementation are analyzed. Also the results show the potential use of ensembles like NCEP Global Ensemble, but considering the precipitation forecast estimator scale effect. Further work in the uncertainty reduction is necessary. Observing the discharge response dispersion by comparing one deterministic forecast simulation versus using ensemble precipitation inputs give some elements to improve the early warning generation process.

REFERENCES

Nester T. Et al. Flood Forecast errors and ensemble spread – A Case Study. Water Resources Research,2012

PappenbergerF., etal. Cascading Model Uncertainty from medium range weather forecast (10 days) through a rainfall-runoff model to flood Inundation predictions within European Flood Forecasting System (EFFS). Hydrology & Earth System Sciences 2005.

Sadik A, Hydrologic Ensemble Predictions Using Ensemble Meteorological Forecasts, Master Tesis. Mcmaster University. 2010

Takeuchi, K., Hapuraachchi P., Zhou Maichum, Ishidaira H and Magome J. A BTOP model to extend TOPMODEL for distributed hydrological simulation of large basins. Hydrological Processes 22, 3236 – 3251 (2008).

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