Analysis of spatial distribution of observed ground-based data and large scale modelling of the Paraná River Basin

Sameh A. Abou Rafee[1], Anderson Rudke[2], Thais Fujita[2], Marcos Morais[2], Eliane Santos[1], Ricardo Hallak[1], Rodrigo Souza[3], Leila Martins[2], Jorge Martins[2], Edmilson Freitas[1]

[1]Department of Atmospheric Sciences, University of São Paulo, São Paulo, Brazil, [2]Federal University of Technology – Parana, Londrina, Brazil, [3]Amazonas State University – Amazonas, Manaus, Brazil

1. INTRODUCTION

Several studies have demonstrated a significant increase in stream flow in Paraná River Basin (PRB) in the last decades (e.g. Camilloni & Barros, 2003). However, some regions of the basin have witnessed severe hydrological droughts. PRB has a great importance in the economy and development of Brazil, which contributes to agricultural and livestock development, public and industrial supply, and mainly in hydroelectric power generation (see Figure 01). Given the importance of this watershed for Brazil, the main objective of this work was to evaluate the spatial distribution of climate variables that constitute the most important driving input data of watershed models, as well as modelling the stream flow of PRB.

2. MATERIALS AND METHODS

2.1 Study area

The study area comprises the PRB with the drainage area of around 900,480 km^2. PRB is one of the largest watersheds in Brazil located in center-south region, which covers six Brazilian states (São Paulo, Paraná, Mato Grosso do Sul, Minas Gerais, Goiás and Santa Catarina) and Federal District (Figure 01). Currently, PRB has an estimated population more than 60 million inhabitants, with 93% of its population living in urban areas. The region has the highest demand for water resources in Brazil equivalent to 736 m^3 s^{-1}, where most are used for agricultural (42%) and industrial (27%) activities.

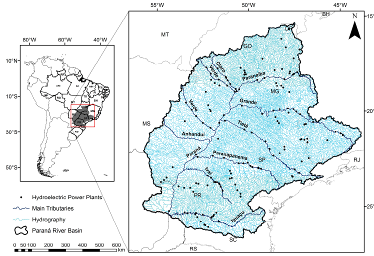

Figure 01. Geographic location of the study area. Blue lines show the hydrography and main tributaries, and black circles show the hydroelectric power plants over PRB.

2.2 Model and input data

In this study, the stream flows were simulated by using the 2012 version of Soil and Water Assessment Tool (SWAT) model with an ArcGIS interface. SWAT is a semi-distributed model developed to assess the impact of land management practices on hydrologic and water quality under different climate and land use change scenarios (Arnold et al., 1998).

The model was run during the period Jan 1984 to Dec 2013 with five years of warm-up. Climate data observed by the National Water Agency (ANA), Department of Water Electrical Energy (DAEE), National Electrical System Operator (ONS) and National Institute of Meteorology (INMET) were used. For the simulated period were found 1,129 rain gauges, however, the majority located in the left margin of the basin (Figure 2a). On the other hand, only 41 weather stations are available.

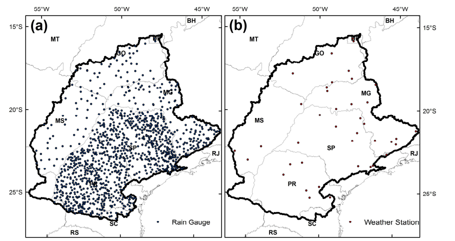

Figure 02. Spatial distribution of rain gauges (a) and weather stations (b).

A digital elevation map at 30-meter resolution was obtained from the Shuttle Radar Topography Mission. In relation to soil characteristics, were based from the Harmonized World Soil Database (HWSD) developed by the Food and Agriculture Organization of the United Nations (FAO-UN), which has a spatial resolution of 1 km. For land use and land cover, spatial data from the combination of Moderate-resolution Imaging Spectroradiometer (MODIS, 2013) and Brazilian Institute of Geography and Statistics (IBGE, 2014) was used. Seven major classes were identified, which the dominant categories are Pasture (52%) and Agriculture Land-Generic (27%). The urban areas represent 1.6 % of the region area, where the majority located at left basin margin (Figure 4).

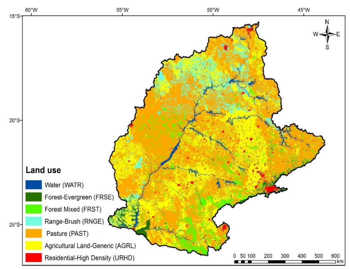

Figure 03. Land use and land cover map from IBGE and MODIS.

The PRB was divided into 1587 sub-watersheds of an average size of 567 km^2 (Figure 04). The resulting sub-watersheds were defined using the dominant combinations of soil, land use types, and slope. Moreover, we selected an outlet of the basin to verify how the model predict the discharge over the Paraná river.

3. RESULTS

Figure 04 shows the comparison between the observed and simulated values (Jan 1989 to Dec 2013) for daily outlet discharge located over Paraná river after the confluence of Grande and Paranaiba rivers. Overall, the model has provided a satisfactory representation of the temporal evolution of daily discharge with 0.89 of correlation coefficient. However, the model tends to overestimate the values observed and the most significant differences are in the peak daily values.

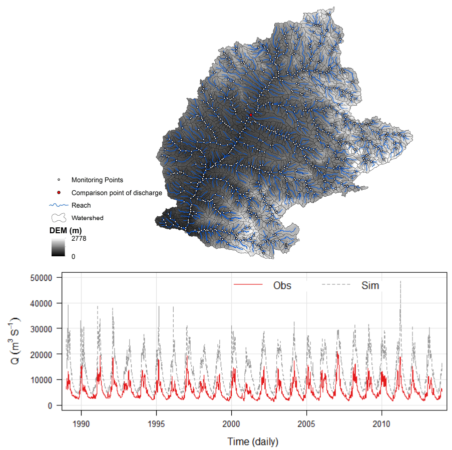

Figure 04. Model set up, in addition comparison of simulated and observed daily outlet discharge located over Paraná river.

4. CONCLUDING REMARKS

We presented here the spatial distribution of long time series of climate data and the ability of the model to represent discharge over PRB. The proposed of this work was organize the input database for SWAT model and its initial response, which was satisfactory. The next step will be calibrate and validate the outlets of the PRB which have a observed data, as well as apply climate and land use change scenarios.

ACKNOWLEDGEMENTS

The authors would like to gratefully acknowledge CAPES (Coordenação de Aperfeiçoamento de Pessoal de Nível Superior) and XXXXX for their financial support.

REFERENCES

Camilloni, I. A., and Barros, V. R. **Extreme discharge events in the Paraná River and their climate forcing**. Journal of Hydrology, 278 (1), 94-106, 2003.

Arnold, J.G., Srinivasan, R., Muttiah, R.S., Williams, J.R.. **Large area hydrologic modeling and assessment. Part 1. Model development.** Journal of the American Water Resources Association 34 (1), 1–17, 1998.