University of Brasilia - Brazil
Department of Civil and Environmental Engineering
Postgraduate Programme in Environmental
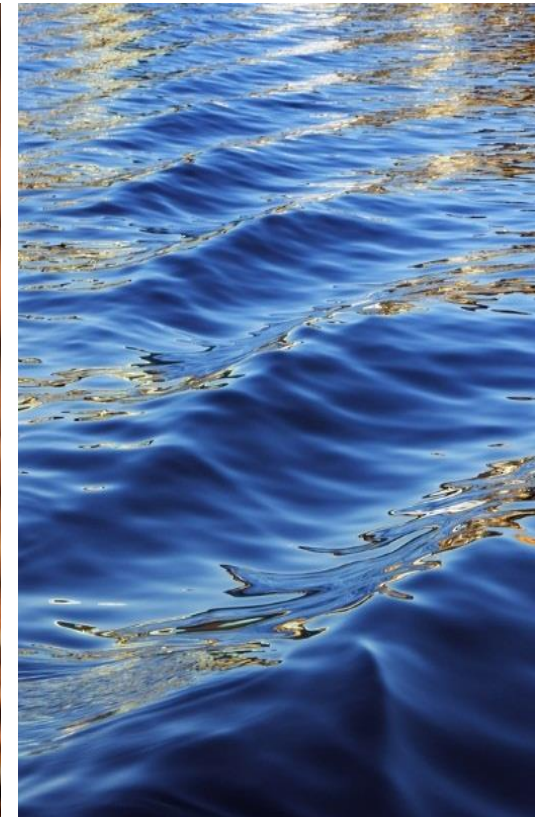**Technology and Water Resources**

Assessment of the applicability of the SWAT model to simulate the streamflow in a rural catchment in the Federal District (Brazil)

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Ricardo Tezini Minoti
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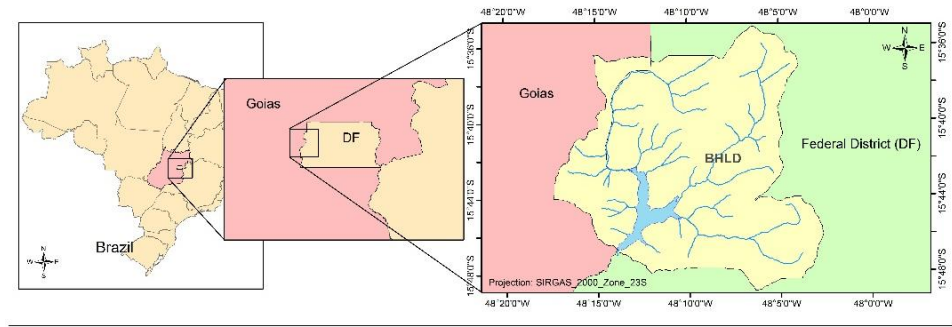**Sergio Koide**

July 30, 2014

Background

## Descoberto Lake Catchment

- Federal District
    - Cerrado (Brazilian Savanna), in the highest region of the central plateau
    - Tropical region
    - Upstream region of 3 major basins
    - DF is among the 5 units of the Federation with less hydric availability *per capita*

- Descoberto Lake Catchment
    - It is responsible for 63% of the water supply of the DF
    - Catchment drainage area - 452 km²
    - It is divided into 11 sub-basins
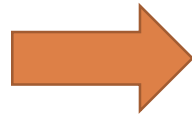   - Main concern is diffuse pollution
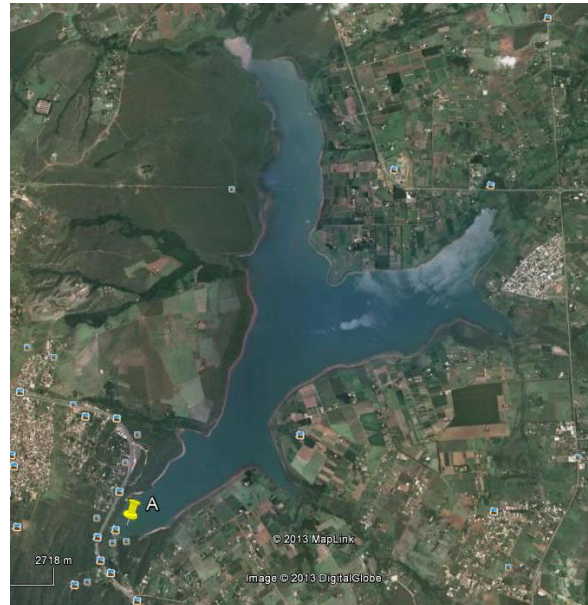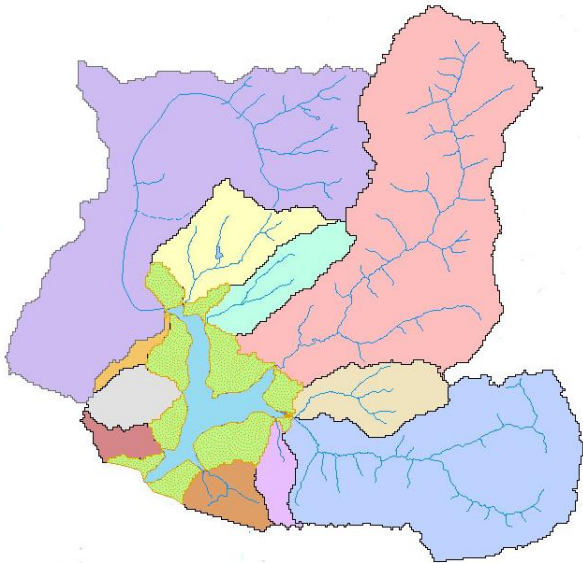
WATER QUALITY

Background

- Analyze the hydrological behavior is a complex task - understand and predict hydrological impacts

Hydrological Modelling ➡️ **SWAT**

- Structure the catchment information and hydrological simulation
- Local scale
- Small sub-basins (<500 km²)
- Accurate results

- Descoberto Lake Catchment – UnB/PTARH:

Barnez (2004), Avila (2005), Bicalho (2006), De Vito (2007), Fragoso (2008), Silva (2009), Lopes (2010), **Sarmento (2010)**, Santos (2012), **Ferrigo (2011), Ferrigo *et al.* (2011, 2012 and 2013), Ferrigo (2014)**

- Sensitivity analysis, calibration and validation

- Sediment modelling

- Response of four different multi-criteria methods for SWAT model calibration

- Regionalization of SWAT Model Calibration for all the Descoberto Lake Catchment sub-basins

Objectives

- Evaluate the applicability of SWAT model in simulating the daily stream flow in Descoberto Upper Sub-basin
  (11 sub-basins of the Lake Descoberto catchment)

- Analyze the efficiency and relative errors of the model to simulate the flow in the rainy and dry seasons

INTRODUCTION

Study Area

- Descoberto Upper Sub-basin
- The total catchment area is 114 km²
  - 38% - preserved areas
  - 16% - urbanized areas
  - 18% - agricultural areas
- The remaining areas - wetlands, grasslands, bare soil and forests
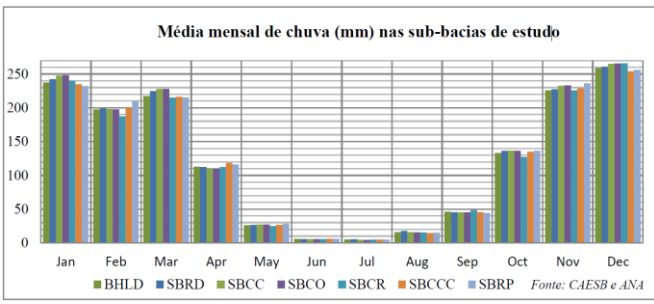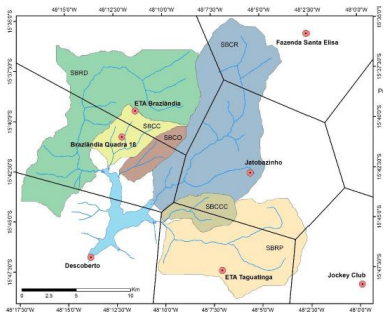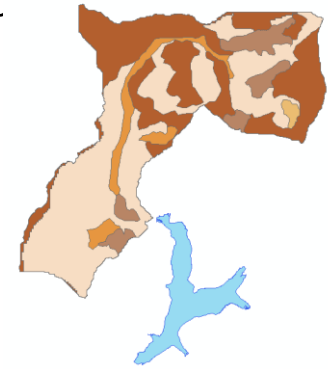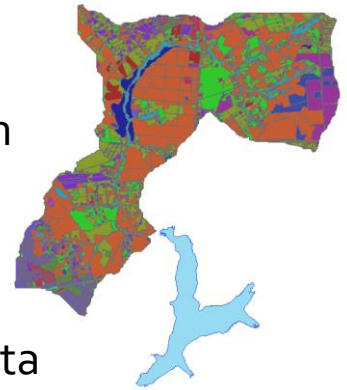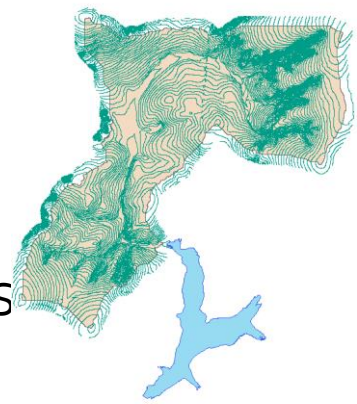- 2 Stream gauges (Capão da Onça Creek and Descoberto River)
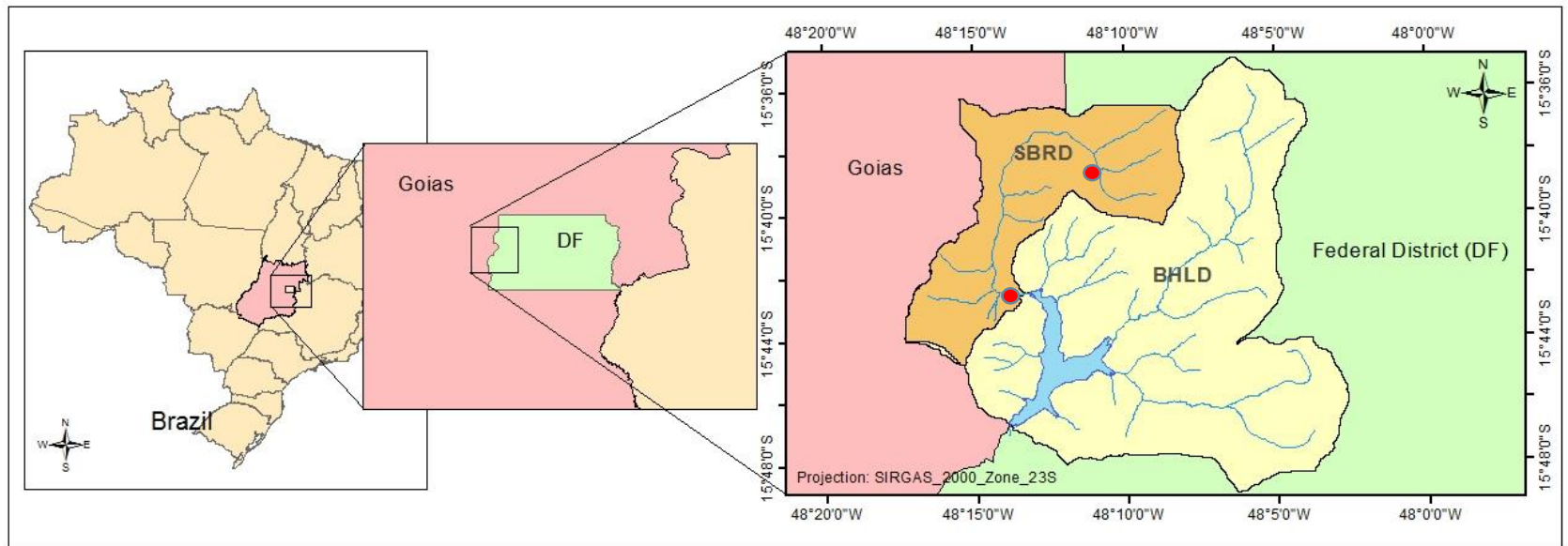
- **Model Description:**
  - ArcSWAT version 2012
- **Data sources:**
  - DEM - generated contour line map (Terracap - spaced at 5m)
  - Land use map - was drawn manually on the scale of 1:3.000 using ArcGIS 10.1 software (Orthophoto Terracap – 24 cm spatial resolution)
  - Soil data - Embrapa (Reatto et al., 2003) on a scale of 1:50.000.
  - The historical series of 45 years at the daily basis of 3 rain gauges (CAESB)
  - Climatic data - solar radiation, wind speed, relative humidity, maximum and minimum temperatures (INMET)
  - Soil parameterization - Lima et al. (2013) $\Rightarrow$ database of soils from the Cerrado Biome for application in the SWAT model
  - Land use parameterization – SWAT data base and regional scientific data base
    - The values of CN were adapted to the hydrologic classification of Brazilian so (Sartori et al, 2005;. Sartori et al, 2005b and Sartori, 2010)

Média mensal de chuva (mm) nas sub-bacias de estudo

BHLD SBRD SBCC SBCO SBCR SBCCC SBRP *Fonte: CAESB e ANA*

- **Sensitivity analysis, calibration and validation processes**

  - The selection of the parameters for sensitivity analysis and calibration:
    - Evaluation of initial modeling
    - Several studies on the influence of each parameter in the hydrological cycle (Arnold et al, 2012;. Pechlivanidis et al, 2011; Griensven van et al, 2006; etc.)
    - Previous studies in one of the sub-basins of Lake Descoberto Catchment (Ferrigo, 2011;. Ferrigo et al, 2011; Ferrigo et al, 2012;. Ferrigo et al, 2013)
  - The sensitivity analysis and calibration was performed with SWAT-CUP software version 2009 4.3.7.1.
  - Automatic calibration – stream flow daily data - hydrological years (October-September) 2005-2010
  - Optimization algorithm SUFI-2
  - Validation - stream flow daily data - hydrological years (October-September) 2010-2013
  - The coefficients of efficiency NSE and determination R^2 were evaluated
  - Periods of the rainy and dry seasons were evaluated separately. Efficiency ratings and error analysis were made individually
    - The computed errors were:
      - absolute error (difference in magnitude between observed and simulated values)
      - relative error (ratio of the absolute error and the value of flow observed)
      - percentage error (percentage representation of the relative error)

Results

- **Model Calibration**
  - Automatic calibration of the 14 chosen parameters (SOL_K, CN2, SOL_AWC, SHALLST) was performed with 1020 interactions within the ranges adopted in the sensitivity analysis.
  - Calibration was made for:
    - 1766 daily values observed at the point near the stream flow basin (Descoberto river)
    - 638 daily values observed at the point upstream in the basin, along the (Capão da Onça creek)
  - This result indicates statistically the evolution of the values obtained without calibration
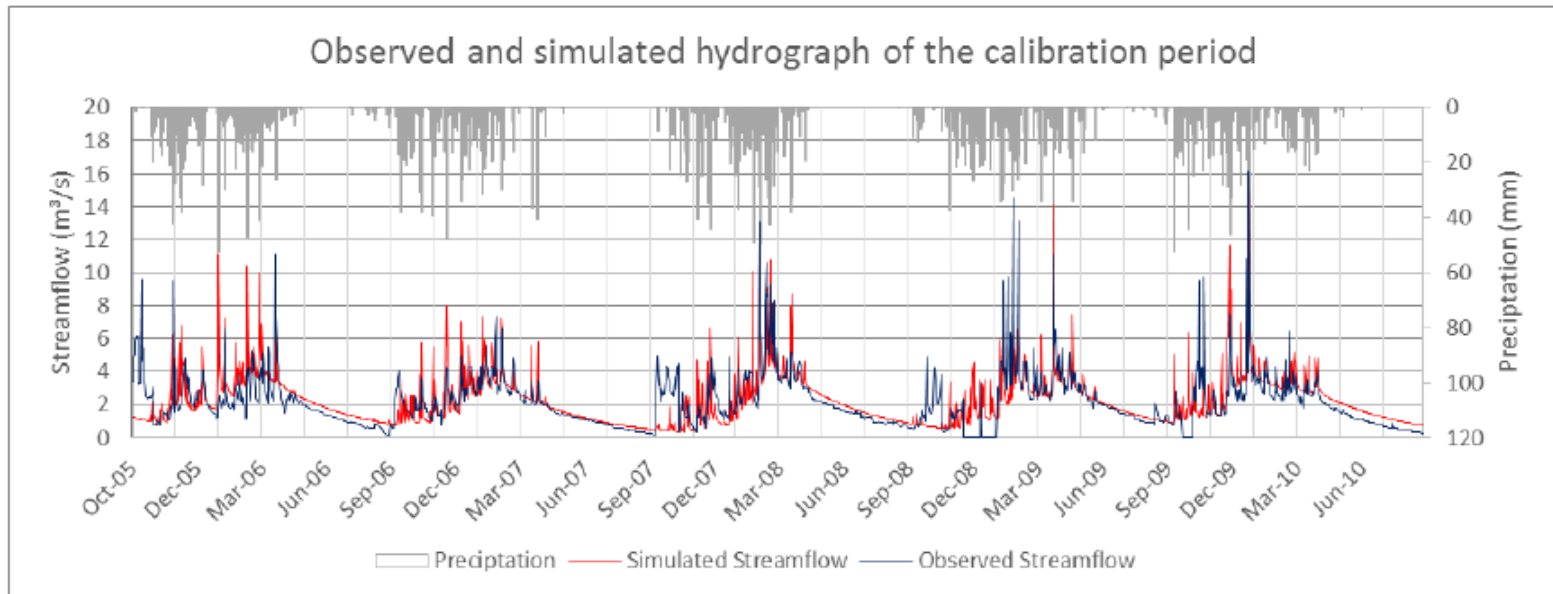
  ➢ Descoberto River   ➢ Capão da Onça Creek
      NSE = -0.57   NSE = 0.40   NSE = 0.51
      R² = 0.44   R² = 0.24   R² = 0.44
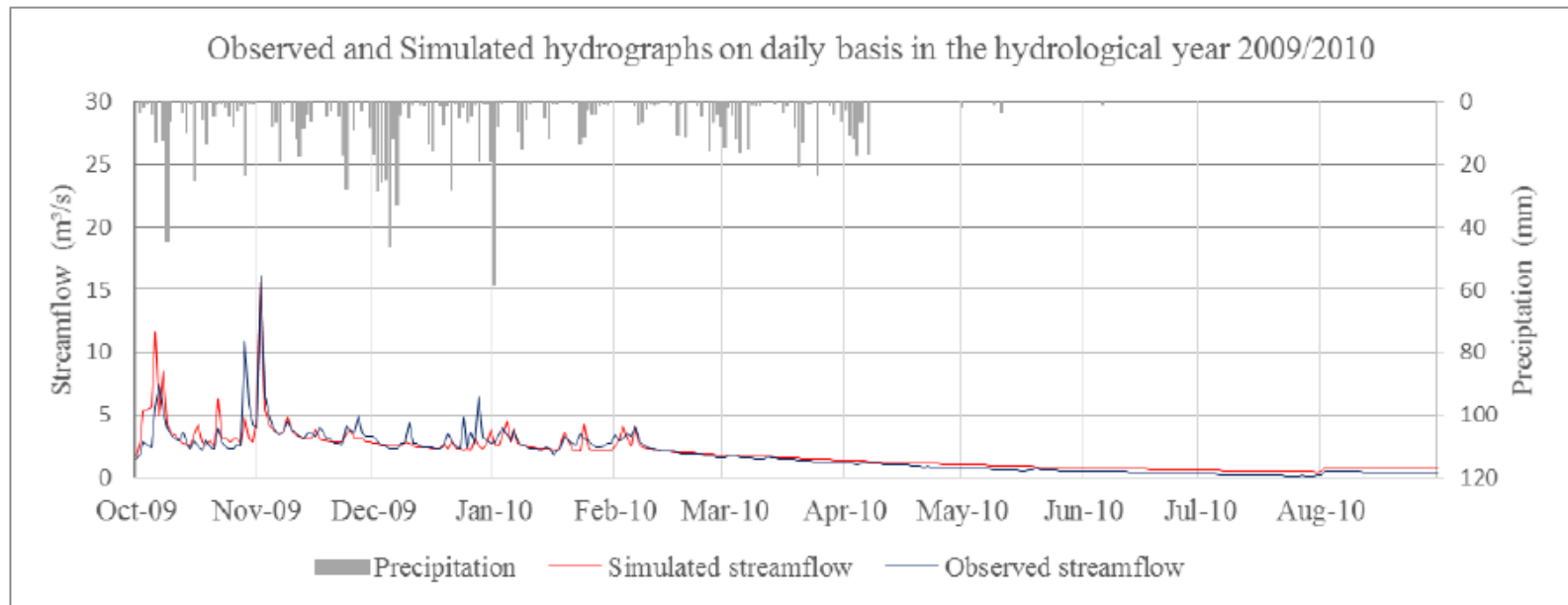

Observed and simulated hydrograph of the calibration period

Results

- **Model Calibration**
  - The NSE of daily basis simulation in hydrological year (2009/2010) was 0.78, while the R² was 0.79

Observed and Simulated hydrographs on daily basis in the hydrological year 2009/2010

Results

- **Error Analysis**
  - With the aim to evaluate the behavior of SWAT after calibration – Scatter diagram of percentage errors relating to observed stream flows
  - The mean absolute error was 0.74 m³/s, while the average percentage error relative to the observed flow rate was 41.6%.
 - Significant error in the lower flow rates

Scatter Diagram of Percentages Errors Relating to Observed Streamflow in Full Simulation Period
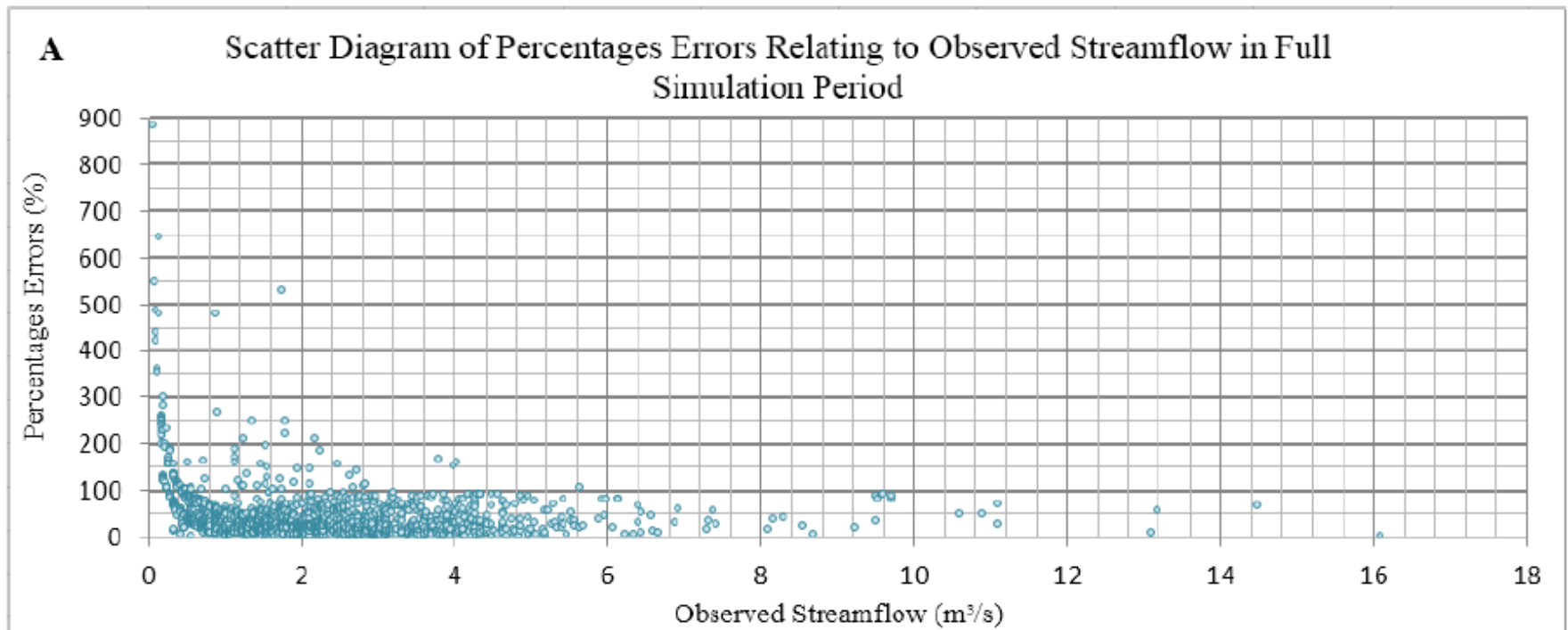
Results

- **Error Analysis – Rainy period**
  - Mean flow observed = 2.89 m³ / s
  - Simulated flow = 2.90 m³ / s.
  - NSE = 0.28 and R² = 0.42
  - Average percentage relative error was 35%

- **Error Analysis – Dry period**
  - The assessment of dry periods resulted in 25 underestimated values and 586 overestimated values.
  - NSE = 0.39 and R² = 0.74
  - Average percentage relative error was 56%

B Scatter Diagram of Percentages Errors Relating to Observed Streamflow in Rainy Period

C Scatter Diagram of Percentages Errors Relating to Observed Streamflow in Dry Period
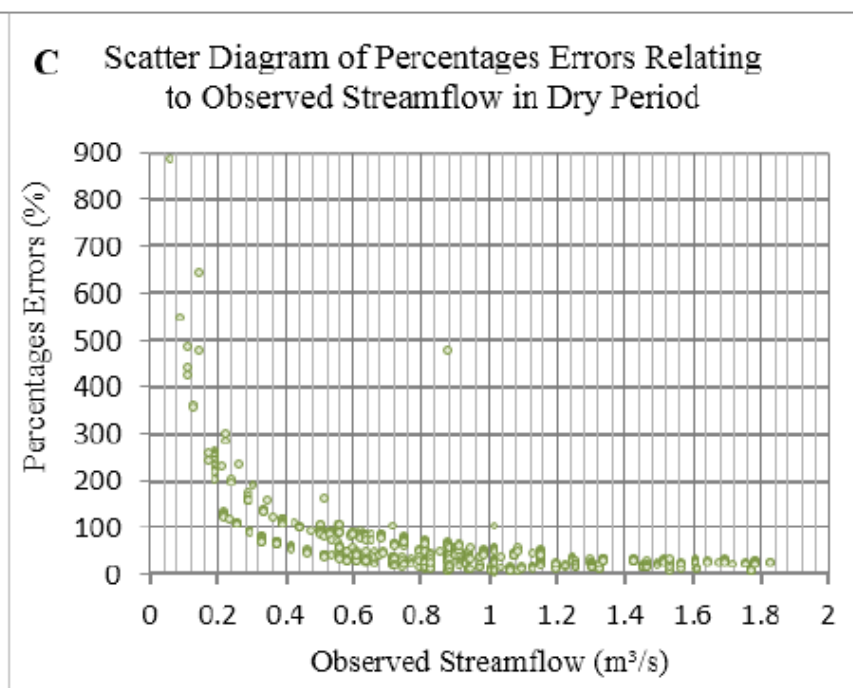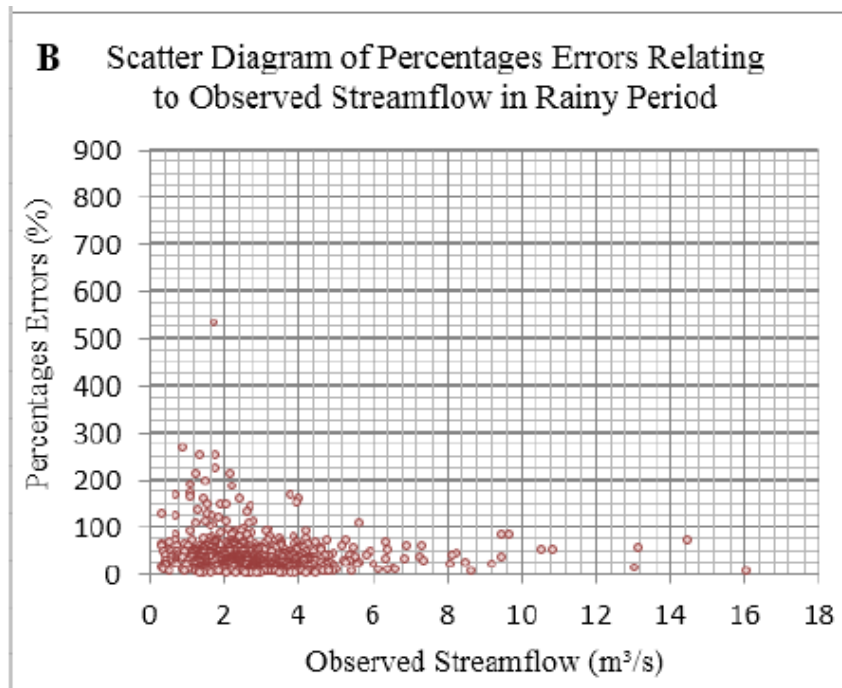
Results

- **Model Validation**
  - NSE = 0.48 and R² = 0.46.
  - These results indicate a good result of the daily values simulation in the SWAT model.

Observed and simulated hydrograph of the vaidation period
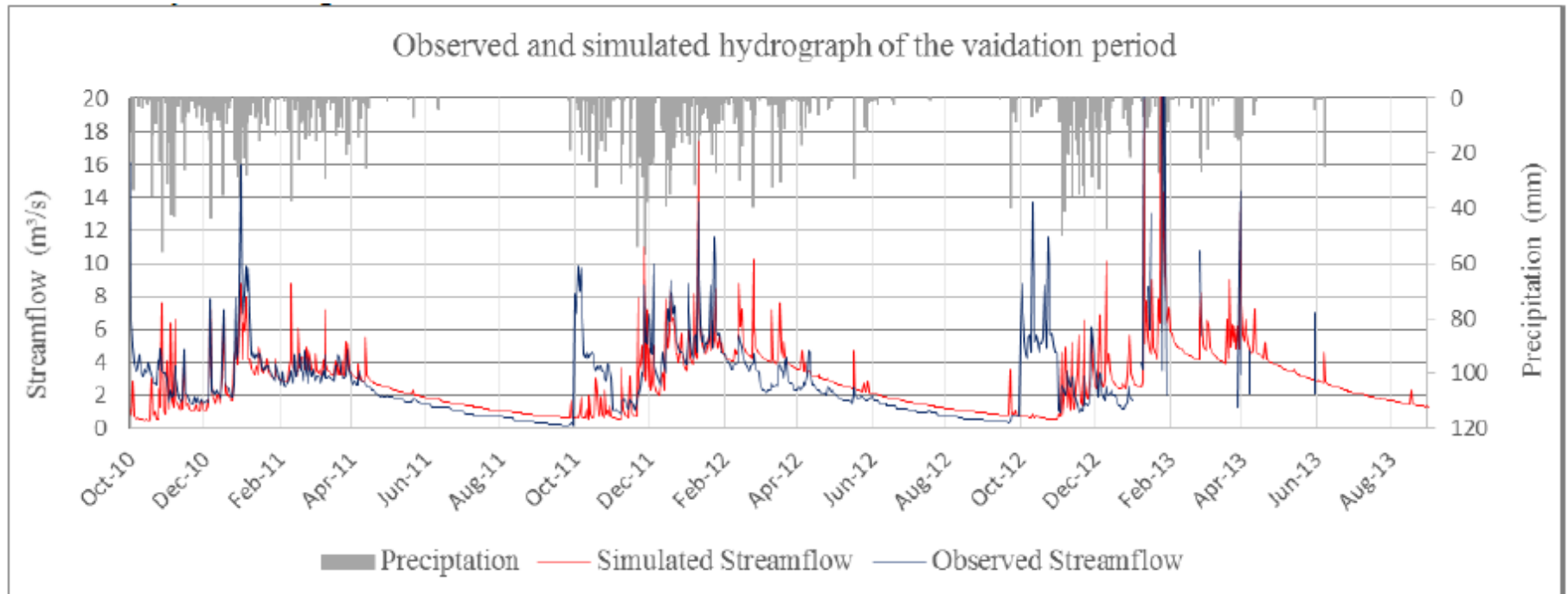
Concluding Remarks

- The characterization of sub-basins, including the parameterization of the SWAT model for adaptation to the study area was performed

- The initial performance of the SWAT model was evaluated in order to verify certain difficulties in simulating hydrological processes

- Model calibration was performed at the daily basis for a period of 5 hydrological years and validated for a period of 3 hydrological years

- Hydrological modelling showed satisfactory results in daily calibration (5 years)

- Consistent results were found during the validation period (3 years)

- The error analysis showed the importance of the use of different methods to the SWAT model validation

- Further tests are being conducted to adapt the SWAT model to the dry period in the Sub-basins of Descoberto Lake Catchment in order to improve the reliability in modelling processes

- Further studies should be extended to the model calibration and influence of different parameters on the simulation of water quality

Thank you!