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Multi-gauge Calibration Comparison For Simulating Streamflow Across the Major River Basins In Madagascar: SWAT+ Toolbox, R-SWAT, and SWAT+ Editor Hard Calibration

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ABSTRACT: This study aims to improve the Soil and Water Assessment Tool (SWAT) model performance across the Major River Basins in Madagascar (MRBM), specifically for SWAT simulation located in relatively dry zones in the western and southern parts of the country. A multi-gauge calibration was carried out to compare the performance of SWAT+ Toolbox, and R-SWAT, SWAT+ Editor Hard calibration on a monthly time step for the periods 1982–1999. We found that the SWAT+ model generated greater surface runoff, while the SWAT model resulted in higher groundwater flow in both CSFR and CHIRPS datasets. It has been demonstrated that the SWAT+ Toolbox had more potential in calibrating runoff across the MRBM compared to R-SWAT. Calibration in both methods led to a reduction in surface runoff, percolation, water yield, and curve number but increased the lateral flow, evapotranspiration (ET), and groundwater flow. The results showed that the multi-gauge calibrations did not significantly enhance simulation performance in the MRBM compared to single-site calibration. The performance of the SWAT+ model for runoff simulation within the SWAT+ Toolbox and R-SWAT was unsatisfactory for most basins (NSE<0) except for Betsiboka, Mahavavy, Tsiribihina, Mangoro, and Mangoky basins (NSE=0.40–0.70; R^2=0.45–0.80, PBIAS ≤ ±25), whether considering the CHIRPS or CSFR datasets. Further study is still required to address this issue.

1 INTRODUCTION

- **SWAT model:** a semi-distributed river basin model, widely used in water resources assessment and climate change impact studies.
- **Rainfall input data:** plays a crucial role in simulating streamflow in hydrological modeling.
- **Challenge:** data scarcity and climatic variability across regions.

2 OBJECTIVES

- To improve the Soil and Water Assessment Tool (SWAT) model performance across the Major River Basins in Madagascar (MRBM), specifically in the Manambolo, Onilahy, Mananara, and Mandrare basins.
- To assess the effectiveness of SWAT+ Toolbox, R-SWAT, and SWAT+ Editor Hard calibration for multi-gauge calibration.

3 METHOD

- **Precipitation Data:** CSFR and CHIRPS datasets;
- **Model set-up:** SWAT 2012 and SWAT+ Model;
- **Calibration Methods:** SWAT+ Toolbox, R-SWAT and SWAT+ Editor;
- **Calibration and Validation Period:** 1982–1999.

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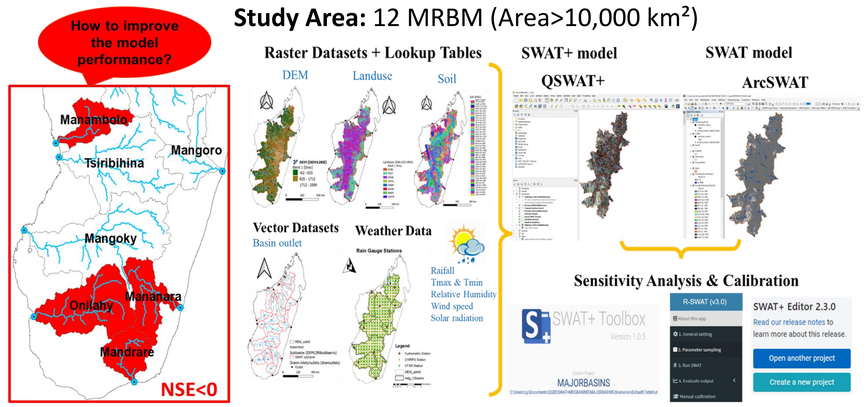
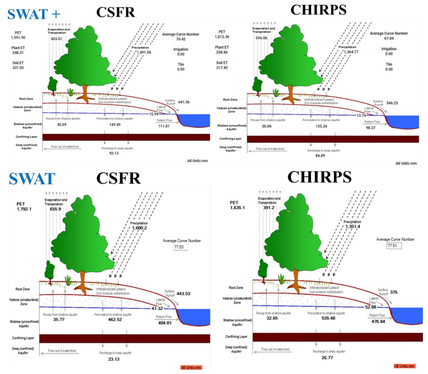


4 RESULTS AND DISCUSSIONS

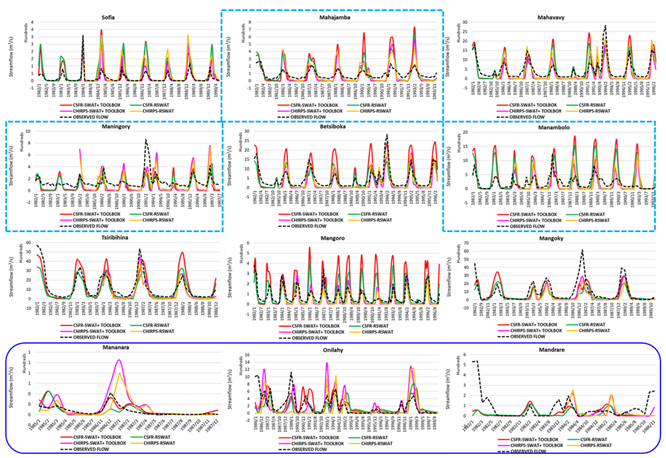
Comparison of the water balance ratios



SWAT 2012 vs. SWAT+ Model:
- SWAT+ produced greater surface runoff.
- SWAT 2012 resulted in higher groundwater flow.

Data Impact:
- CSFR data exhibited higher precipitation compared to CHIRPS.
- Better performance noted with CHIRPS data.

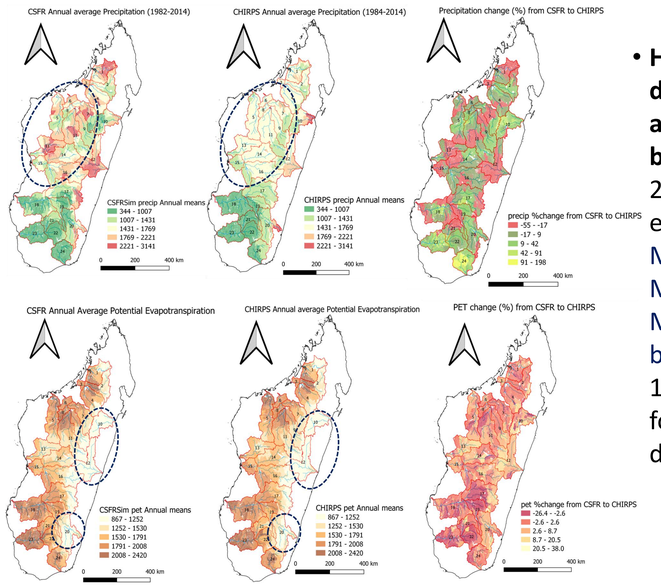
Comparison of calibrated streamflow across the MRBM



- **CHIRPS data:** exhibited a capability to simulate peak flow.
- **SWAT+ Toolbox:** showed greater potential in runoff calibration.

- **SWAT+ model performance:** was satisfactory for Betsiboka, Mahavavy, Tsiribihina, Mangoro, and Mangoky basins (NSE = 0.40–0.70; R^2 = 0.45–0.80) but unsatisfactory for most basins (NSE < 0).
- **Multi-gauge calibration:** did not significantly enhance simulation performance compared to single-site calibration.

Annual average precipitation and PET in SWAT+



- **High PET in the downstream area of most basins** (1530 - 2420 mm/yr) except for the Maningory, Mangoro, and Mananara basins (867 - 1252 mm/yr) for both datasets.
- **Northern and Eastern basins:** abundant precipitation (1769- 3141 mm/yr) for both CFSR and CHIRPS data.
- **Southern basins:** less precipitation (344 - 431 mm/yr for both datasets.
- **Western basins:** CSFR data showed a high value of precipitation (1007- 3141 mm/yr).

5 CONCLUSIONS

The model performance depends on several factors such as SWAT/SWAT+ uncertainties, discrepancy in estimating precipitation, input data uncertainties, choice of calibration methods and algorithms, availability of observed discharge data, objective function, and influential parameters.

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