Performance evaluation and uncertainty analysis of SWAT model for simulating hydrological processes in an agricultural watershed of India

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Balanced ecosystems are essential for the survival and welfare of humankind. The ecosystems have been disturbed in the past due to over exploitation of our natural resources in many parts of the world, including some parts of India.

- **The resulting imbalance in the ecosystem is revealed through degradation of soil surfaces and frequent occurrence of intense floods etc.**
- **Excessive erosion of soil from upstream watershed can impair a stream's water quality and cause excess biological growth.**
- **In India, 53% of the total land area is prone to soil erosion. It has been reported by CWC (2001) that the rate of sedimentation in some of the Indian reservoirs is higher than the design rate assumed at the planning stage.**

- **Damodar Valley Corporation (DVC), Hazaribagh, India has taken several initiatives to restore and improve the hydrology, reduce sediment loads and nutrient concentrations, and improve habitat along the upper Sewani River and its watershed where erosion is a severe problem.**

- **Nagwa watershed is one of the watersheds which are being monitored by DVC for stream flows and sediment loads only for rainy seasons i.e. June to October. Proper understanding of the hydrology of the watershed is important for guiding and evaluating the impacts of proposed or ongoing soil and water conservation measures.**

Objectives

- **To develop, calibrate and validate a model for estimating stream flow and sediment yield from Nagwa watershed using Soil Water Assessment Tool (SWAT).**

- **Uncertainty analysis of SWAT model output by using SUFI-2 algorithm.**

Study area

- **The Nagwa watershed is located in the Upper Damodar Valley in the Damodar Valley Corporation, Hazaribagh, Jharkhand, India and is approximately 92.46 km2 in area of which about 30-40% is under shrubs and forest and the remaining under cultivation.**
- **The average elevation of the command is 540 m from the mean sea level.**
- **The topography of the watershed is undulating with flat land in major parts.**
- **The average annual rainfall of the area is 1200mm of which more than 80% occurs during the monsoon months from June to October and the rest in the winter months (December and January). The daily temperature ranges from a maximum of 42.50C (1st May, 1999) to a minimum of 2.50C (18th January, 1999).**
- **The overall climate of the area is classified as sub-humid sub-tropical.**

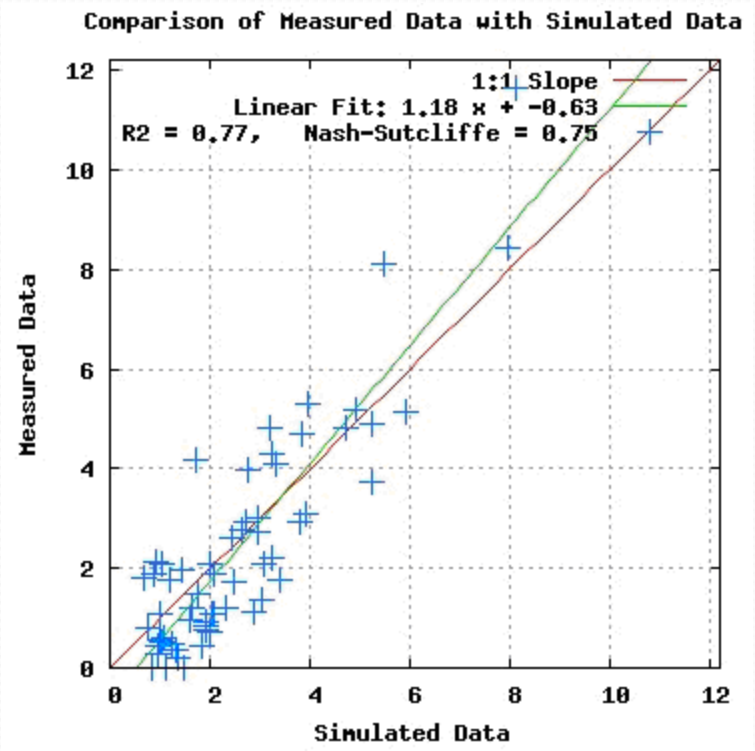
Model development

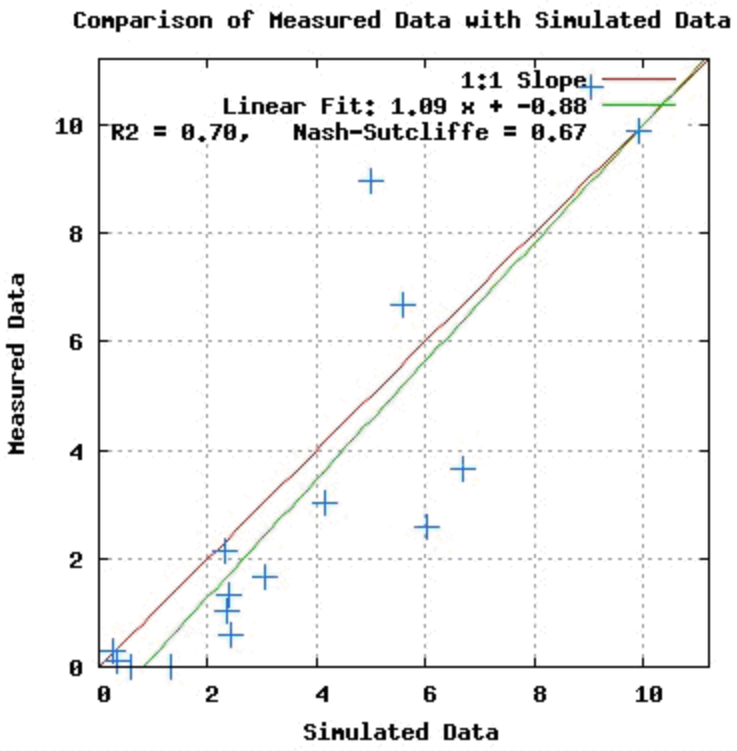
- **SWAT model was calibrated for the period 1991-2004 (1991 & 1992 as warm up periods) and validated for 2005-2007 to simulate monthly stream flow and sediment yield.**
- **The Hargreave method of evapotranspiration computation and Muskingum method of routing were found to give best performance under sub-humid region.**
- **The major parameters affecting stream flow and sediment yield were modified to increase agreement between the simulated and observed values.**

Results

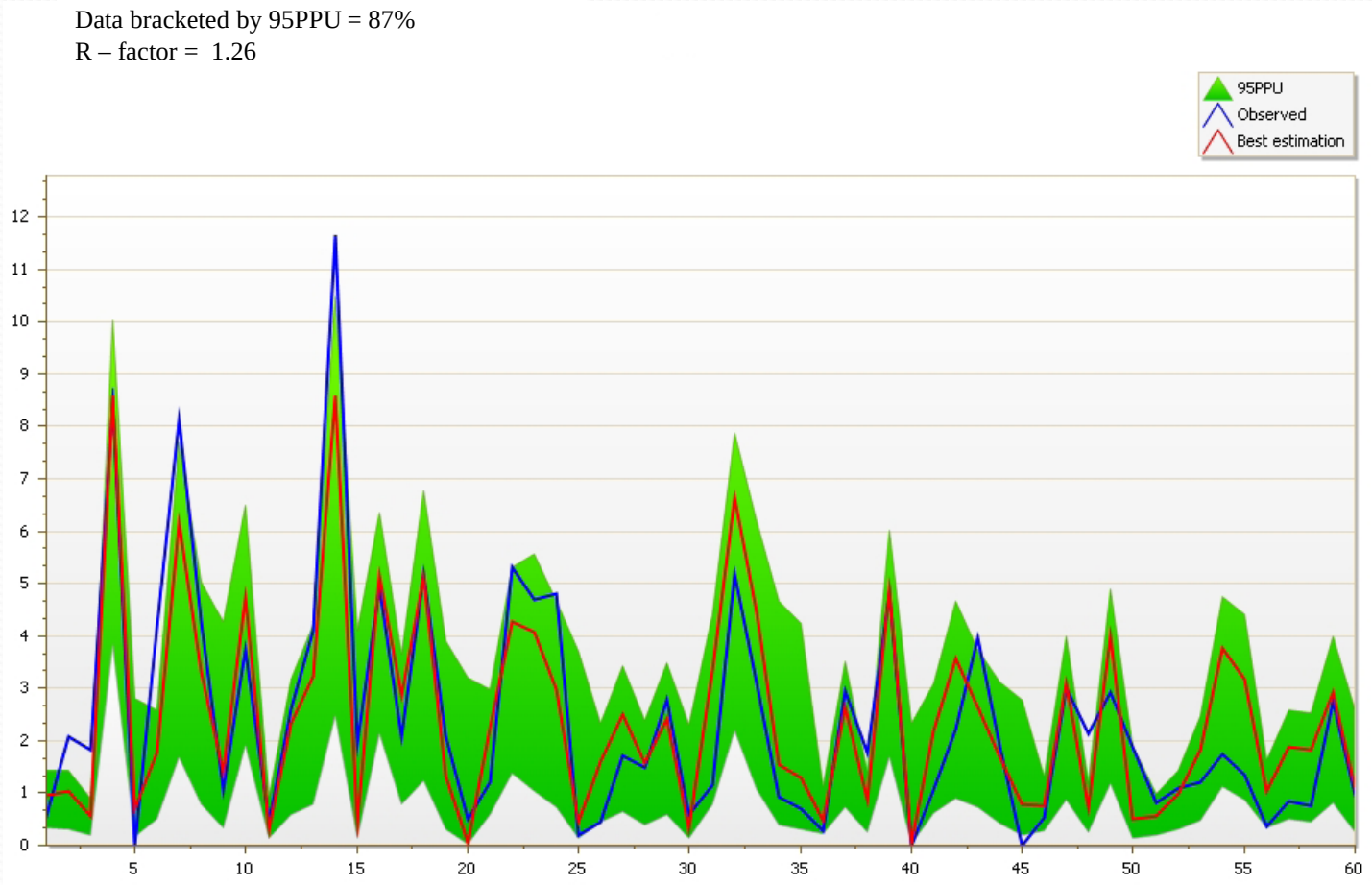
- The parameters were adjusted in such a way that they could represent the characteristics of the existing land use and topographic condition of the watershed. The final calibrated values were obtained.

Calibration and validation of stream flow

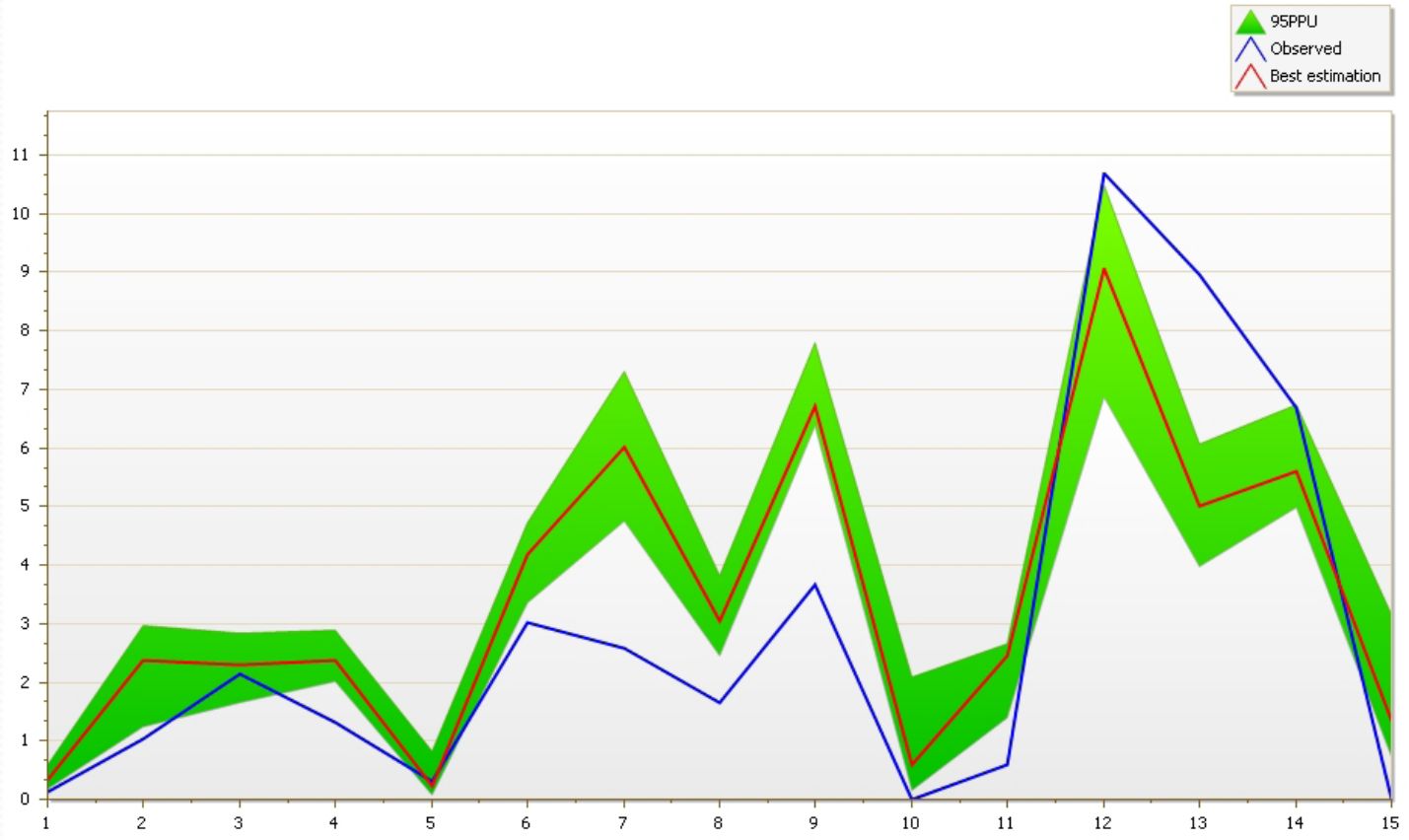




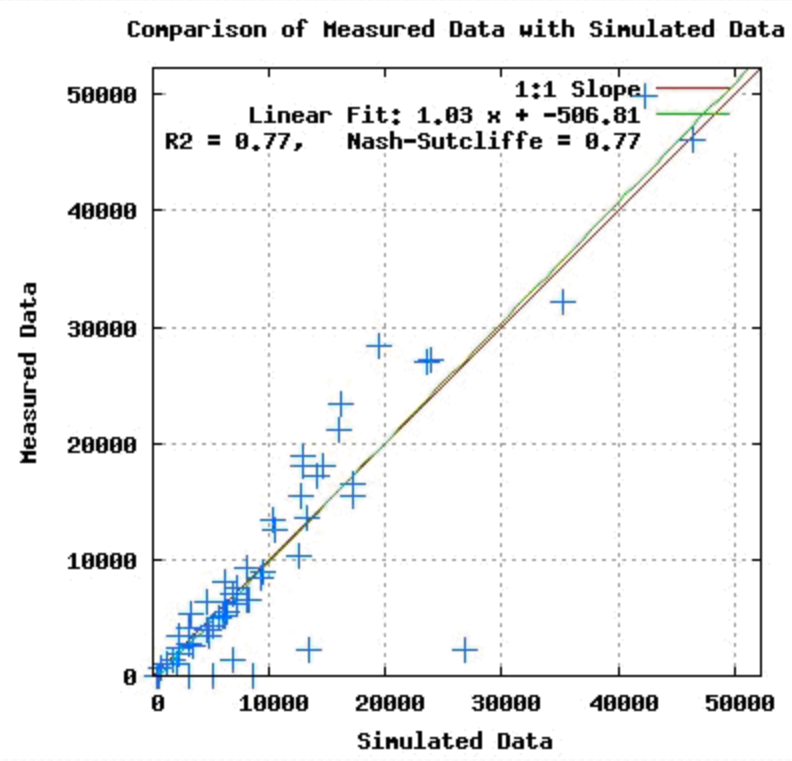
95% prediction uncertainty intervals along with the measured and simulated stream flow for SWAT Model during calibration (top) and validation (bottom) periods.

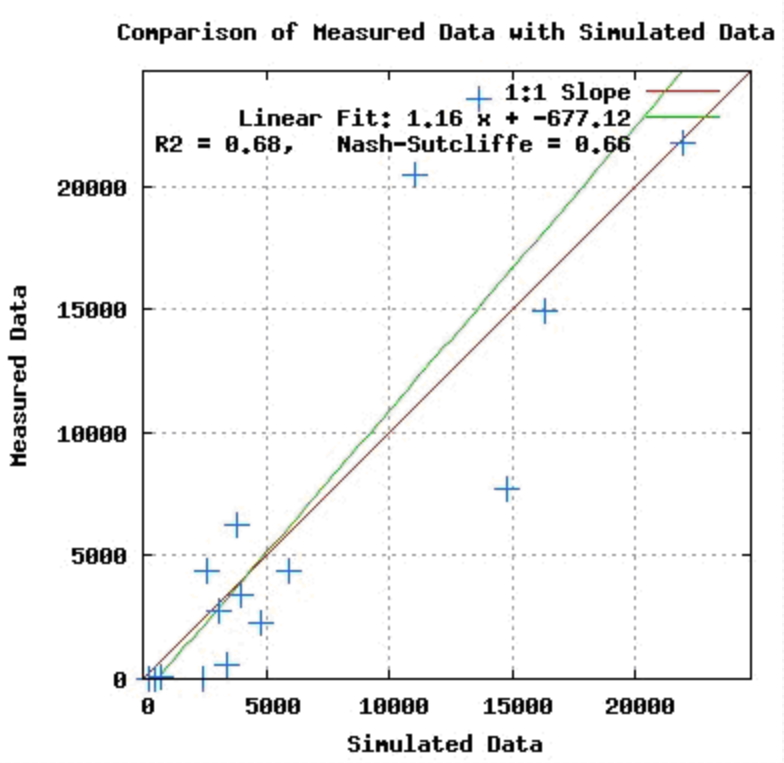


Data bracketed by 95PPU = 27%
R – factor = 0.51

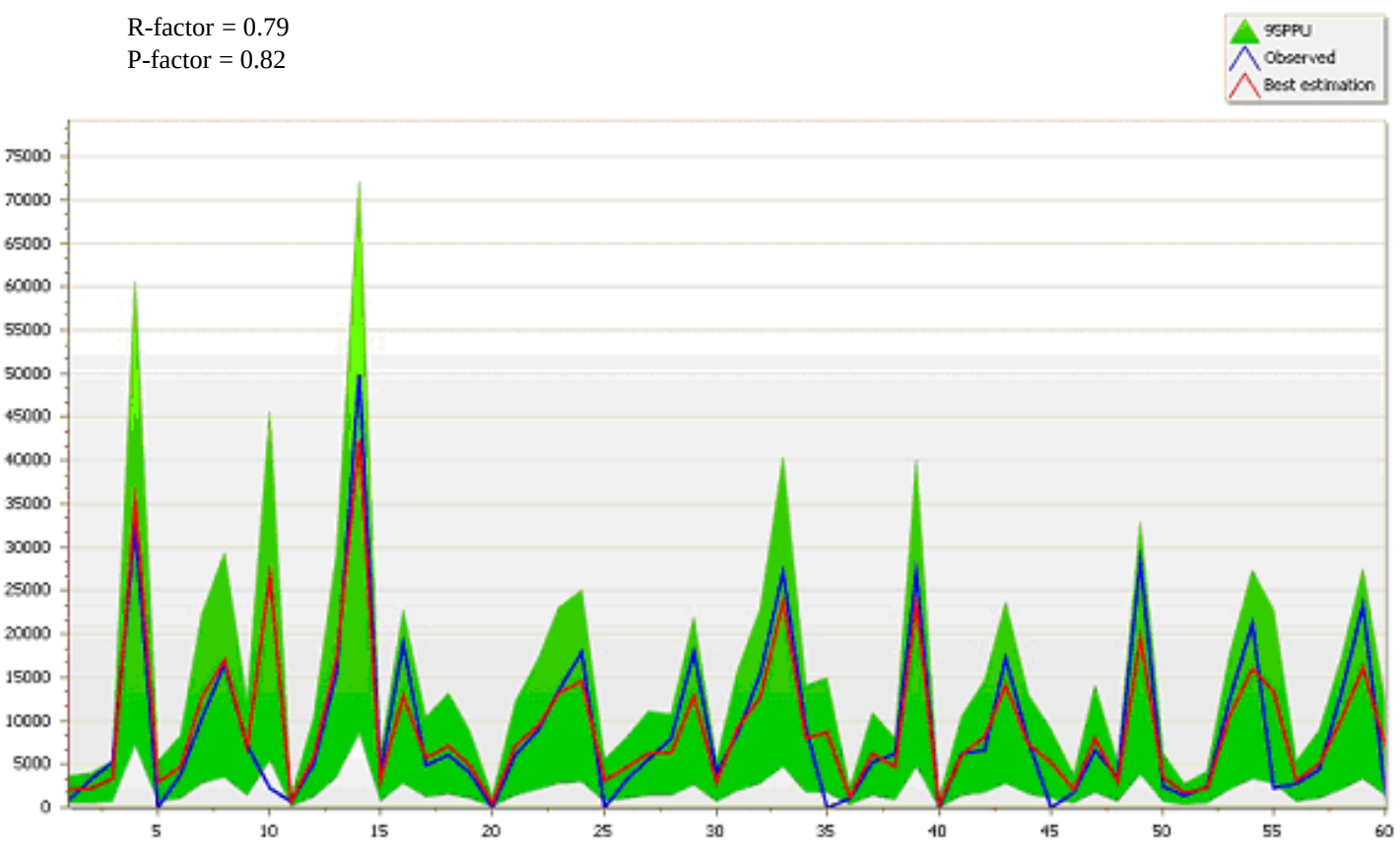


Scatter plots of monthly measured and SWAT simulated sediment yield (ton) for calibration (top) and validation (bottom) periods

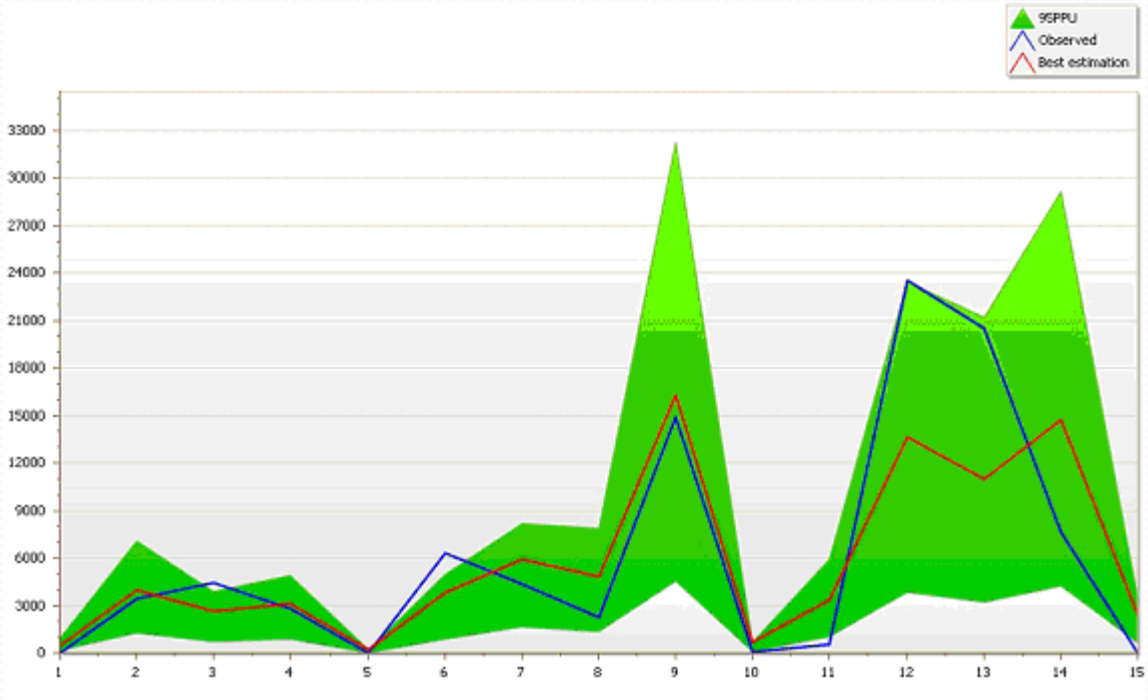




95PPU for observed and SWAT simulated monthly sediment yield (ton) at the watershed outlet during calibration periods (1993–2004) and validation periods (2005–2007) shown above and bottom.



R-factor = 0.88
P-factor = 0.67



Conclusions

- Monthly simulations show good agreement between measured and simulated values of stream flow and sediment yield.
- Overall, the SWAT model offers the most comprehensive representation of hydrological processes that can be of great help in taking decisions on the land use management alternatives impacting downstream water quality.
- SWAT model predictions were quite good keeping in view the approximations and spatial variability involved in simulating the complex hydrological processes.

Thank you