# Application of HYPE Model in Simulating River Discharge and Suspended Sediment Concentration at Upper Srepok River Basin in Vietnam

Authors:
Thao Bui Thi Phuong, Kawamura Akira, Thi Nuong Bui
Co-authors:
Tien Thuy Le Du, Du Duong Bui , René Capell , Amaguchi Hideo, Leyland Julian , Manh Hung Le, Thi Ngoc Nguyen , KANTOUSH SamehAhmed , Darby Stephen , Johan Strömqvist

## 1. INTRODUCTION

Vietnam has been facing many challenges related to water resources, such as transboundary water resources management, increasing water demand, degradation of water quality and quantity due to climate change and human activities, among others. One of the most crucial transboundary river basins in Vietnam is the Srepok River Basin (NCWRP, 2010). We focus our study on the Upper Srepok River Basin (USRB), which is the portion of the Srepok River Basin located within the jurisdiction of Vietnam as shown in **Fig. 1**. One of the most crucial issues in this USRB is the brought by human activities, such as watershed deforestation and construction of hydroelectric power plants, which can cause excessive sediment transport due to erosion and runoff. In effect, excessive sediment transport can lead to poor water quality, algal bloom, and sediment built-up. Hence, in this study, we attempt to simulate the river discharge and the suspended sediment concentration (SSC) within the USRB using Hydrological Predictions for the Environment (HYPE) model. The HYPE model is an open-source model that simulates hydrological processes and water resources development, such as reservoir operation, irrigation, water use, and wastewater discharge in a river basin (Lindström, G. et al., 2010). The HYPE model has not yet been considered for SSC simulation in USRB, as far as the authors know.

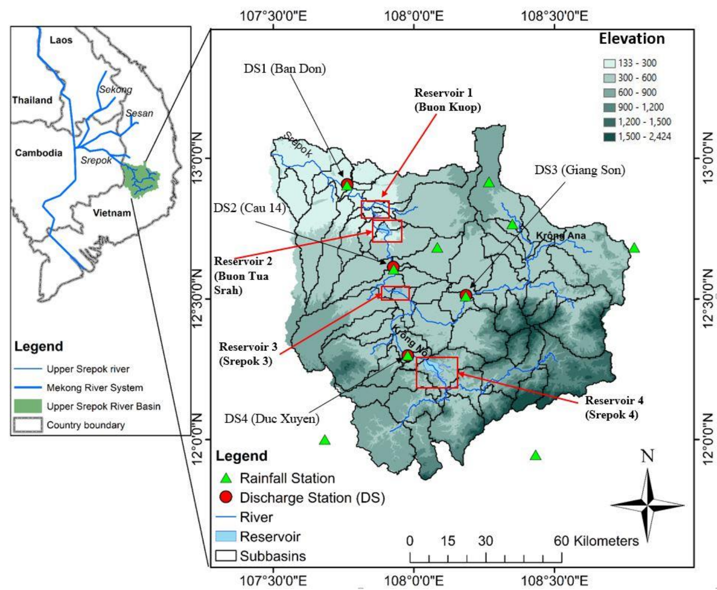


**Fig. 1** Location map of Upper Srepok River Basin

## 2. METHODOLOGY

### 2.1. Hydrological Predictions for the Environment (HYPE) Model

The HYPE model was developed and maintained by the Swedish Meteorological and Hydrological Institute (SMHI) in 2003. It is a semi-distributed dynamic model that integrates rainfall-runoff and nutrient transfer by modeling the flow and transformation of water, nutrients, and organic carbon in soil, lake, and river. In this model, each river basin is divided into subbasins, and each subbasin is further divided into hydrologic response units (HRUs). The model calculation starts at HRUs, and then aggregated to the subbasin level. HYPE calculates flow in the soil based on evapotranspiration, surface runoff, infiltration, tile drainage, and outflow to the stream from soil layers when the water content is above field capacity. The runoff from the land classes is then routed through the network of rivers and lakes to generate river flow, which could be dampened due to the effect of reservoirs. HYPE Model can also simulate sediment using the Morgan-Morgan-Finney (MMF) soil erosion model, which calculates mobilized particles as functions of rainfall energy, surface runoff, and catchment properties (slope, soil erodability, etc.).

### 2.2 Data Input

The HYPE model was set up from 1980 to 2015 for the river discharge simulation and from 2001 to 2002 for the SSC simulation. The required input data include average air temperature and 35-year daily rainfall data from 1980 to 2015, collected from the 10 rainfall stations shown in **Fig 1**. The input data for simulating SSC include the digital elevation model, land use type, the cohesion of soil surface, and observed rainfall. We also utilized 30×30m DEM obtained from U.S. Geological Survey (USGS) and soil type and land use data from ESA Climate Change Initiative – Land Cover project (ESA). The total volume of four reservoirs within USRB is also included in simulating the river discharge in HYPE.

### 2.3. Parameter Setup

For river discharge simulation, the parameters for field capacity (*wcfc*), effective porosity (*wcep*), and parameters related to the process like Evaporation (alfapt) and Recession (*rrcs1, rrcs2*) were set and calibrated. Meanwhile, there are nine parameters necessary for the MMF-based erosion model, which include general parameters (*Sreroexp, Pprelmax, Pprelexp*), soil independent parameters for each soil type (*Soilerod, Macrofilt, Soilcoh*), and parameters related to land use (*Innerfilt, Otherfilt, bufferfilt*). The description of these parameters can be found on the HYPE website (http://www.smhi.net/hype/wiki/par.txt). Some data for the soil type and land use parameters in USRB are not available, so the default value is used instead. The HYPE model start-up guide provided a first guess range for some parameters.

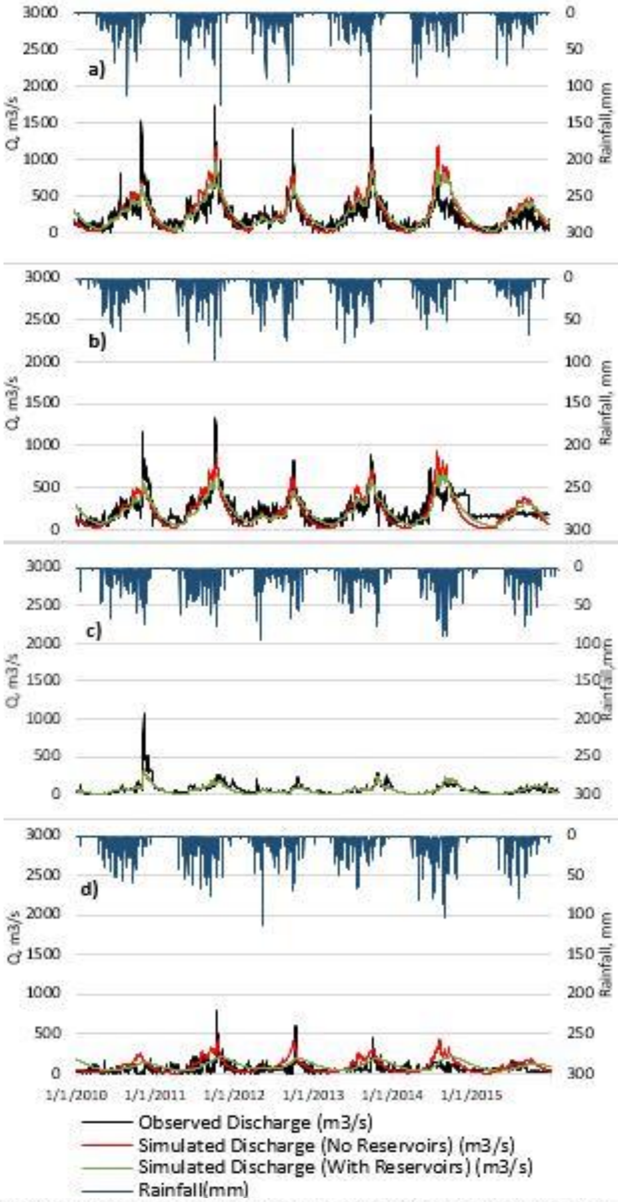


**Fig.2** Simulated River Discharge in two cases with and without reservoir at 4 station a) DS1 b) DS2 c) DS3 and d) DS4

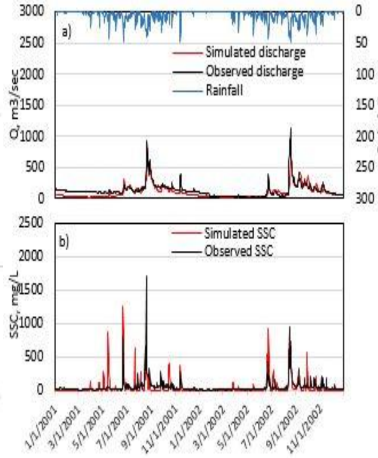


**Fig. 3** Observed and simulated discharge a) and SSC b) for DS1

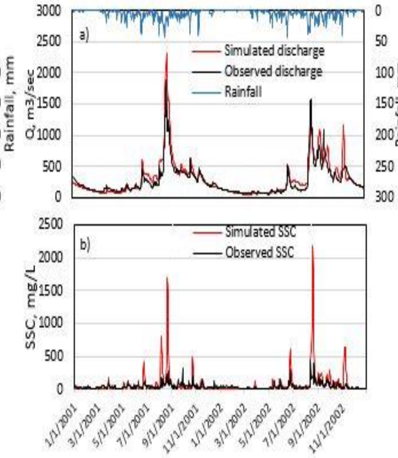


**Fig. 4** Observed and simulated discharge a) and SSC b) for DS4

**Table 1** Model evaluation for river discharge in two case with and without reservoir

| RMSE index (m3/s) | | | | |
|---|---|---|---|---|
| Discharge Station | DS1 | DS2 | DS3 | DS4 |
| Case 1. No reservoir | 144.1 | 124.4 | 46.4 | 87.4 |
| Case 2. With reservoir | 93.2 | 80.3 | 46.4 | 57.3 |

**Table 2** Model evaluation for Discharge and Suspended Sediment Concentration

| Station | Discharge | | SSC | |
|---|---|---|---|---|
| | CC | RMSE($m^3$/s) | CC | RMSE(mg/L) |
| DS1 | 0.69 | 65.2 | 0.569 | 118.42 |
| DS4 | 0.72 | 120.5 | 0.583 | 171.78 |

## 3.RESULTS AND DISCUSSION

Firstly, the daily discharge in USRB was simulated without reservoirs (Case 1) using the HYPE model. The observed and simulated discharge at four discharge stations from DS1 to DS4 is shown in **Fig.2**. By visual inspection, the simulated flows in DS1, DS2, and DS4 vary with the observed flow, while the simulated flow in DS3 shows relatively closer results with the observed discharge. The root means square error (RMSE) for these simulations was also calculated in **Table 1**. The results show that DS1 has the highest RMSE while DS3 station has relatively good results. The information on the four reservoirs within the USRB was not yet included in the model simulation, which caused high RMSE in DS1, DS2, and DS4. Meanwhile, the RMSE in DS3 is low because there is no reservoir upstream of this discharge station. Then, simulation of the discharge with reservoirs (Case 2) is also carried out in this study. The simulations from Case 2 show better results than Case 1, and the RMSE is lower, as shown in Table 1. Secondly, the HYPE model was applied to estimate SSC in DS1 and DS4 because we have only available observation data at these stations from 2001 to 2002. **Figs. 3** and **4** show the results of the daily discharge and SSC estimation from 2001 to 2002 at DS1 and DS4, respectively. **Table 2** shows the model evaluation for the discharge and SSC by Pearson correlation coefficient (CC) and RMSE. From **Figs. 3** and **4**, the SSC estimations do not show good results compared with the discharge estimation, especially for DS4. RMSE for SSC of DS4 is much higher than DS1, while CC is almost the same, as shown in **Table 2**.

## 4. CONCLUSION

This study shows the potential of the HYPE model in estimating the river discharge and the SSC in the USRB. However, there is still a need to improve the model further in terms of parameter setting to achieve higher model accuracy. We should improve the model performance so that HYPE can be applied in locations with less observed data since this model has the potential for predicting hydrologic data in ungauged basins

## REFERENCE


1) Lindström, G., Pers, C., Rosberg, J., Strömqvist, J., and Arheimer B.: Development and test of the HYPE (Hydrological Predictions for the Environment) model – A water quality model for different spatial scales. Hydrology Research, 41 (3–4), 2010, pp. 295–319.
2) National Center for Water Resources Planning and Investigation Project (NCWRP), 2010, "Setting up planning task for the Srepok River Basin" (Vietnamese)