Analysis of SWAT Model and SNTHERM Model to Improve Stream Flow and Snow Pack Evolution Simulations

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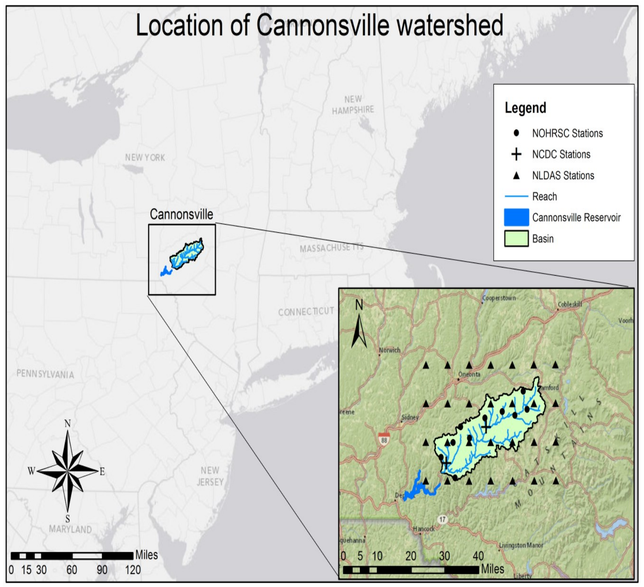
Abstract

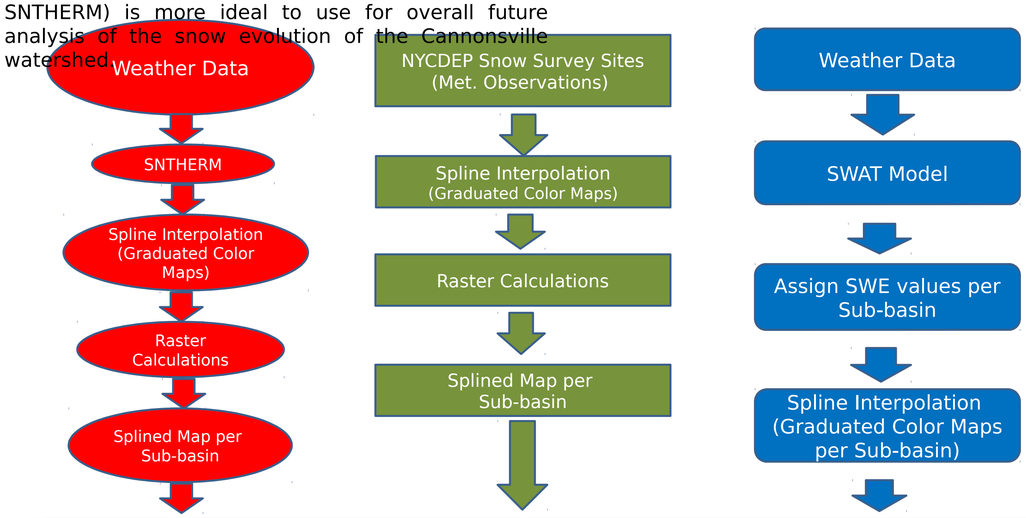
Estimating stream flow from snow melting processes is vital to predicting floods. According to observations, rapid snow melt has contributed floods. Thus, it is essential that snow pack properties are accurately measured and estimated in order to provide an accurate prediction of disaster that floods can cause. The Snow Thermal Model (SNTHERM) is a one-dimensional model that analyzes the snow pack properties given the climatological states of a specific area. Using Remote sensing data and in-situ observations, snow water equivalent and snow melt estimations will be acquired. The Soil and Water Assessment Tool (SWAT) is a hydrological model that is able to predict the quality and quantity of runoff, and the quality of a watershed provided its hydrological and physical properties. The results from SNTHERM and SWAT will provide a sufficient comparison of which model is better at simulating runoff during snow melt. This project aims to improve the estimation and simulation of snow melting processes by measuring snow water equivalent (SWE) in order to better predict floods and estimate stream flow. Surprisingly, despite SNTHERM's more detailed components it takes into consideration (thermodynamics and fluid dynamics), according to the results, SWAT is the better model. This may be due to the fact that it has the capability of executing calculations of the watershed's physical and hydrological properties. Its analysis, directly

Introduction

- Estimating stream flow from snow melting processes is vital to predicting floods. Thus, it is important that snow pack properties are accurately measured to ensure a better prediction of disasters caused by floods.
- The Snow Thermal Model (SNTHERM) analyzes the snow pack properties given the climatological states of a specific area. Using Remote sensing data and in-situ observations, snow water equivalent calculations will be acquired.
- The Soil and Water Assessment Tool (SWAT) predicts the quality and quantity of runoff, and the quality of a watershed provided its hydrological and physical properties.
- The results from SNTHERM and SWAT will provide a sufficient comparison of which model is better at simulating runoff during snow melt. This project aims to compare the results of the simulations of SWAT and SNTHERM to the in-situ meteorological data and analyze which model is better for the task of efficiently estimating river discharge in order to better predict floods and estimating stream flow.
- Using the Spline interpolation method and the measurements from SWAT, SNTHERM, and the New York City Department of Environmental Protection snow survey sites on the Cannonsville watershed, it would be possible to identify which model (SWAT or SNTHERM) is more ideal to use for overall future analysis of the snow evolution of the Cannonsville watershed.



Methodology



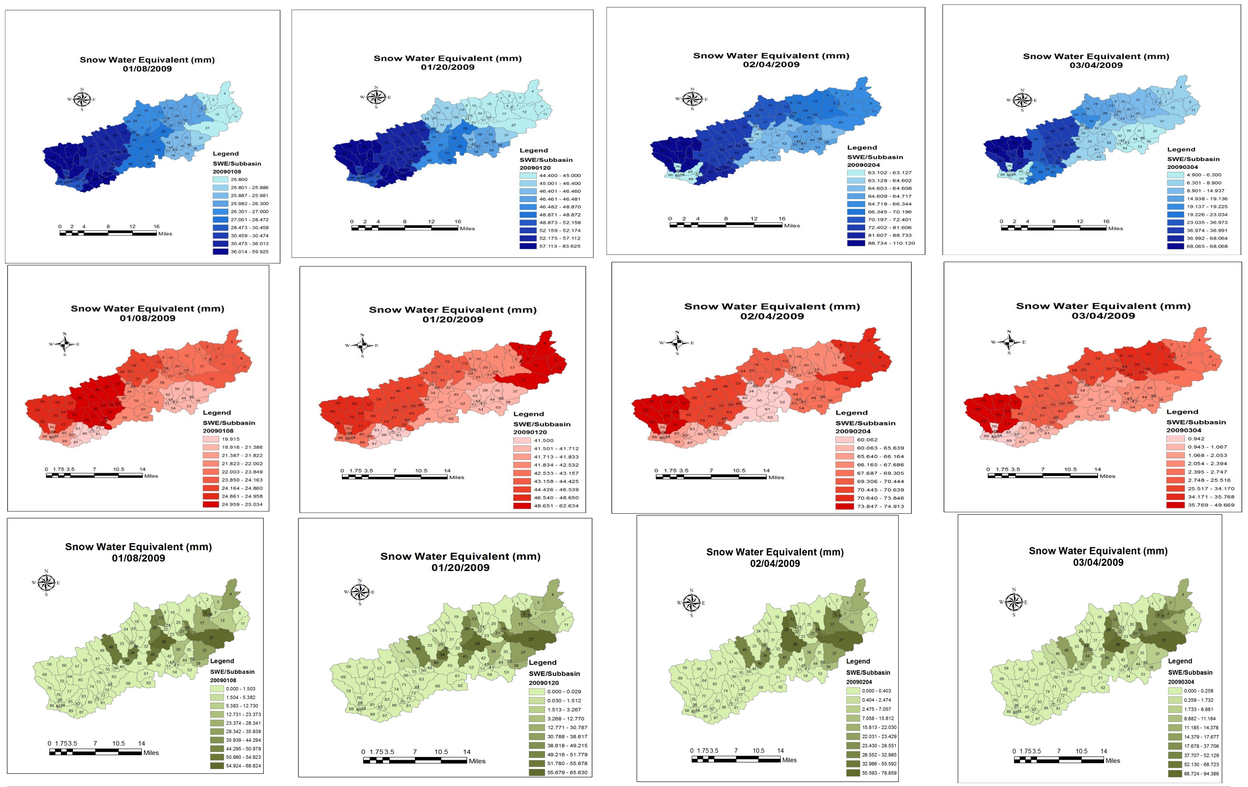
Statistical Analysis

$$RMSE = \sqrt{\frac{\sum \left(Y_{obs} - Y_{sim}\right)^2}{n}}$$

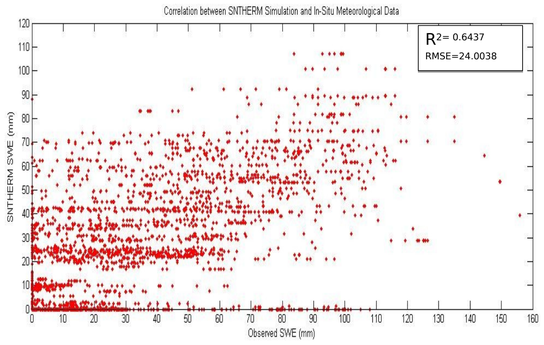
$$R^2 = \frac{\left[\sum \left|\left(Y_{obs} - \bar{Y}_{obs}\right) \cdot \left(Y_{sim} - \bar{Y}_{sim}\right)\right|\right]^2}{\sum \left(Y_{obs} - \bar{Y}_{obs}\right)^2 \cdot \sum \left(Y_{sim} - \bar{Y}_{sim}\right)^2}$$

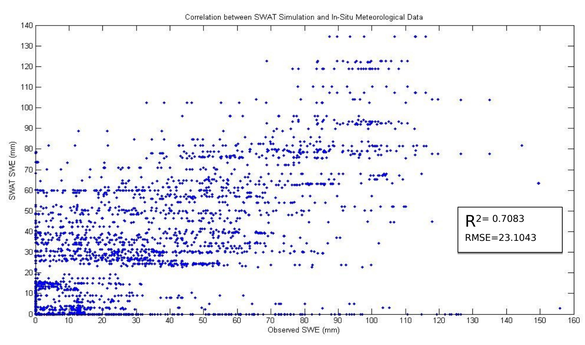
RMSE: Root Mean Square Error
R^2:Correlational Coefficient
n: Number of Observations
y_{obs}: Observed Variable
y_{sim}: Simulated Variable
$\bar{y}_{sim}$: Average Simulated Variable
$\bar{y}_{obs}$: Average Observed Variable

Data Sets from SWAT, SNTHERM, and In-Situ Observations



SWAT and SNTHERM Statistical Analysis





Conclusions and Future Work

According to the results, the SWAT model is the better model for analyzing future stream flow, runoff, and snow pack evolution simulations. When comparing the correlations between each model's measurements of SWE and the observed SWE from the snow survey sites, the correlation between SWAT and the observed data proved be closer to 1 (0.7083) than the latter correlation (0.6437). In addition, when calculating the magnitude of possible error using the RMSE formula, SWAT also proved to have a smaller RMSE (23.1043) than SNTHERM (24.0038). However, despite the SWAT model's better performance it still does not 100% accurately simulate the evolution of the snow pack. In fact, the SNTHERM model was only out performed by 0.0646.

Perhaps, in the future, both models can be integrated into a single system of models that takes the qualities of both models in order to increase the accuracy of estimating snow melting processes, which can, in turn, improve scientists' capabilities of predicting floods. Some examples of how to improve SNTHERM are to take into account

References

1. Arnold, J. G., Moriasi, D. N., Gassman, P. W., Abbaspour, K. C., White, M. J., Srinivasan, R., ... Jha, M. K. (2012). SWAT: Model use, calibration, and validation. ASABE, 55(4), 1491–1508.
2. Jordan, R. (1991). A One-Dimensional Temperature Model for a Snow Cover: Technical Documentation for SNTHERM.89. CRREL Special Report, 91(16), 61.
3. Moriasi, D. N., & Arnold, J. G. (2007). Model evaluation guidelines for systematic quantification of accuracy in watershed simulations. ASABE, 50(3), 885–900. Retrieved from http://swat.tamu.edu/media/1312/moriasimodeleval.pdf

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