Impact of scale variation on watershed runoff concentrations in the Raritan River Watershed.

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Abstract

Watershed modelling tools like ArcSWAT, an ArcGIS extension of Soil and Water Assessment Tool (SWAT), are useful to watershed managers in many ways. One particular use is analyzing model outputs for decision making related to watershed restoration and mitigation, which is often undertaken to improve water quality in streams. The present study evaluates the use of digital elevation model (DEM) at 10 meter, 30 meter, and 100 meter pixel size on non-point runoff predictions for three sub-watersheds in Raritan River Basin in New Jersey. These three watersheds include: Bound Brook, Lamington River, and Lawrence Brook. ArcSWAT is utilized to investigate the difference due to DEM variation in predicting monthly estimates of pollutant loads including ammonium (NH4), nitrite (NO2) and sediment transported with water out of a watershed. Using land use/cover 2012, slope and soil data, monthly pollutant loads are calculated for each sub-basin in the watershed over a 10-year simulation period (2012-2022). Overall statistical and spatial results show that ArcSWAT results are sensitive to changes in DEM pixel size for watershed modeling. The results show that total sum of monthly runoffs including NH4, NO2 and sediment differ across the three different DEMs. Moreover, the spatial pattern of input (in sub-catchments) also changes among the three DEMs for most watersheds. This indicates that watershed managers need to supplement model predictions with field measurements before making substantial investments in stream restoration programs.

Methodology

Table 1. Variables and definitions of pollutant loads in ArcSWAT.

<table>
<thead>
<tr>
<th>Variables</th>
<th>Definition</th>
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<tbody>
<tr>
<td>NH4_OUT</td>
<td>Ammonium transported with water out of reach during time step (kg N)</td>
</tr>
<tr>
<td>NO2_OUT</td>
<td>Nitrite transported with water out of reach during time step (kg N)</td>
</tr>
<tr>
<td>SED_OUT</td>
<td>Sediment transported with water out of reach during time step (metric ton)</td>
</tr>
</tbody>
</table>

Statistical Analysis

Mean Difference (MD) = \( \frac{1}{n} \sum_{i=1}^{n} |Y_{i,30m} - Y_{i,10m}| \)

Mean Absolute Difference (MAD) = \( \frac{1}{n} \sum_{i=1}^{n} |Y_{i,30m} - Y_{i,10m}| \)

Root Mean Standard Deviation (RMSD) = \( \sqrt{\frac{1}{n} \sum_{i=1}^{n} (|Y_{i,30m} - Y_{i,10m}|)^2} \)

Conclusion

Simulation results over a 10-year time period showed that runoff predictions vary with variation in DEM pixel size. This shows that for small watersheds with little change in topography over the area with changing resolution up to 10 m DEM does affect the runoff production in ArcSWAT. Results show that such a noticeable impact of the DEM size are important for selection of parameters in hydrological models for watersheds that are small and have smooth topography. This new knowledge on the impact of the DEM size on NH4, NO2 and sediment levels should inform researchers in optimizing parameter generation and input data preparation as well as the efficiency of SWAT model with difference in data quality.

Spatial and Statistical Results

References


NJDEP (New Jersey Department of Environmental Protection), NJDEP 2012 Land Use/Land Cover.