Including stage-dependent roughness coefficient in algorithms to estimate river discharge from remotely sensed water elevation, width, and slope

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INTRODUCTION

• SWAT will measure ~10⁶ river reaches (~10 km in length). Most are ungauged or unshared [Pavelky et al., 2014]
• Methods to solve inverse problem to estimate river discharge from SWAT observations have been proposed and tested by Durand et al. [2016], a study known as the Pepsi Challenge (“PC16”)
• Six algorithms were applied to nineteen rivers. At least one algorithm to within ±35% relative RMSE
• Deficiencies in MetroMan algorithm improved in this poster
• Goal: Using ten “best” hydraulic models from PC16, improve algorithm to obtain globally deployable version of MetroMan (v3.2 using stage-varying roughness coefficient)
• Synthetic height, width, slope produced for each reach

METHODS

Stage-varying roughness coefficient

Manning’s equation as used for SWAT is:

\[ Q = \frac{1}{n} (\alpha_b + \beta) \frac{1}{3} W^{2/3} S^{1/2} \]

where \( Q \) is river discharge, \( \alpha_b \) is the effective roughness coefficient, \( A \) is the unobserved cross-sectional area, \( S \) is the observed change in area, the \( W \) is the river top width, and \( n \) is the roughness height, width, slope produced for each reach to be positive.

METHODS

Computing prior estimates for \( \alpha_b, a, \) and \( b \) from \( Q \)

• We begin with Water Balance Model [Wiser et al., 2010] simulations of long term mean annual flow (MAF) and assume it is ±35% accurate, with log-normal uncertainty
• We then use a simple Markov Chain Monte Carlo approach to estimate the distributions of \( A, a, \) and \( b \). Example below: River Severn, reach 3.

RESULTS

Inversion window used

<table>
<thead>
<tr>
<th>River</th>
<th>Garonne Downstream</th>
<th>Sacramento Downstream</th>
<th>Mississippi Downstream</th>
</tr>
</thead>
<tbody>
<tr>
<td>Run</td>
<td>RMSE (%)</td>
<td>NSE (%)</td>
<td>VE (%)</td>
</tr>
<tr>
<td>Gironde</td>
<td>5.1%</td>
<td>74%</td>
<td>48%</td>
</tr>
<tr>
<td>Garonne</td>
<td>7.1%</td>
<td>68%</td>
<td>32%</td>
</tr>
<tr>
<td>Mississipi</td>
<td>7.5%</td>
<td>81%</td>
<td>40%</td>
</tr>
<tr>
<td>Ohio</td>
<td>4.2%</td>
<td>74%</td>
<td>32%</td>
</tr>
<tr>
<td>Plata</td>
<td>6.9%</td>
<td>47%</td>
<td>33%</td>
</tr>
<tr>
<td>Sacramento</td>
<td>5.1%</td>
<td>71%</td>
<td>40%</td>
</tr>
<tr>
<td>Seine</td>
<td>8.1%</td>
<td>52%</td>
<td>30%</td>
</tr>
<tr>
<td>Severn</td>
<td>7.4%</td>
<td>52%</td>
<td>32%</td>
</tr>
</tbody>
</table>

\( n_Bias \) is calculated using MAF. A parameterized MAF is assumed (red line on right). A Markov Chain Monte Carlo approach to estimate the distributions of \( A, a, \) and \( b \). Example below: River Severn, reach 3.

• Results are improved (vs. v2.0). \( rRMSE \) is a better indicator of accuracy for Seine and Ohio, where low flows are poor but others are good
• Bias dominates the error in most cases

REFERENCES


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