Improved water discharge predictions in *WBMsedv2.0*, a Global riverine Sediment Flux model

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Introduction

- *WBMsed* is a spatially and temporally explicit global riverine model predicting sediment fluxes based on the *WBMplus* (Wisser et al., 2010) water balance and transport model (part of the *FrAMES* biogeochemical modeling framework).
- The prediction of fluvial sediment fluxes is highly dependent on how well river water discharge is simulated.
- Our analyses indicate that average water discharges are well predicted but daily predictions are often over or under estimated by up to an order of magnitude (Cohen et al., 2011).
- To improve daily discharge predictions *WBMsedv2.0* incorporate a floodplain reservoir component, storing overbank water flow, later returned to the river when water level subside.
- Here we compare two methods for determining overbank flow:
  (1) Log-Pearson III flood frequency analysis;
  (2) CaMa-Flood model.

Methodology

When daily river discharge, Q_i, is higher then bankfull discharge, Q_{bf}, excess water are removed from the river flow ($Q_i = Q_{bf}$) and stored in a virtual infinite floodplain reservoir, Q_{fp}, (Fig. 1)

$$Q_{fp} = Q_{fp} + (Q_i - Q_{bf}).$$

When the water level recedes water are injected back to the river from the floodplain reservoir

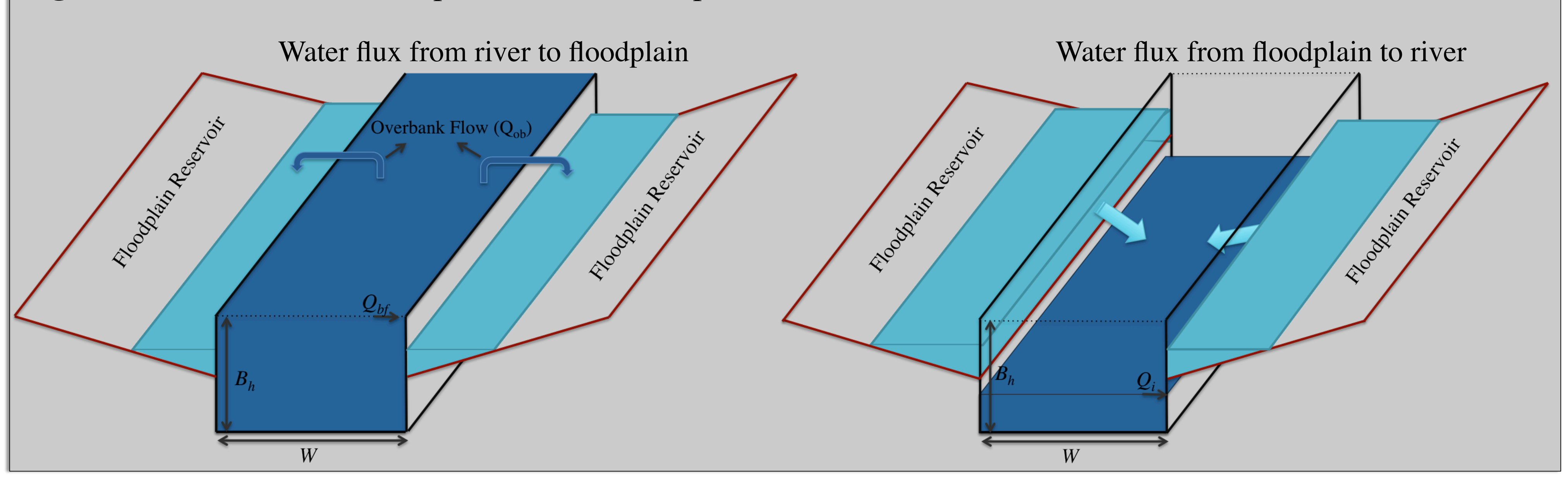
$$Q_i = Q_i + b(Q_{bf} - Q_i)Q_{fp}$$

and

$$Q_{fp} = Q_{fp} - b(Q_{bf} - Q_i)$$

where b is a daily delay fraction of water flow from the floodplain to the river, $b=1$ translate to no delay (open flow).

Fig. 1: Schematics of the floodplain reservoir component in *WBMsedv2.0*.



Determining Bankfull Discharge (Q_{bf})

***Method 1:* Log-Pearson III flood frequency analysis**

A statistical distribution method. Standard practice for estimating annual probability of exceedance of peak flows.

$$log(Q_{bf_n}) = \overline{Q}_{my} + K_n \cdot S$$

where Q_{bf} is bankfull discharge for yearly recurrence n, $\overline{Q}_{my}$ is the river log mean maximum discharge, S is standard deviation of the river maximum discharge timeseries and K_n is a frequency factor – we used a 4th order polynomial equation based on Haan (1977) skew coefficient table (w). For 5 years recurrence (used in here) it is

$$K_5 = 0.004w^4 + 0.0014w^3 - 0.0319w^2 + 0.0477w + 1.2832$$

***Method 2:* CaMa-Flood model**

Modified from a river morphology module in the CaMa-Flood model (Yamazaki et al., 2011)

$$Q_{bf} = BWV_{bf}$$

where B is bank height

$$B = Max[0.5\,\overline{Q}^{0.3}, 1.0]$$

where $\overline{Q}$ is long term average discharge, W is channel width

$$W = Max[15\,\overline{Q}^{0.5}, 10.0]$$

and V_{bf} is bankfull flow velocity

$$V_{bf} = n^{-1}S^{-1/2}B^{2/3}$$

where n is Manning's roughness coefficient (=0.03) and S, slope, is assumed here to be constant (=0.001).

References:

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WBMsed specs.

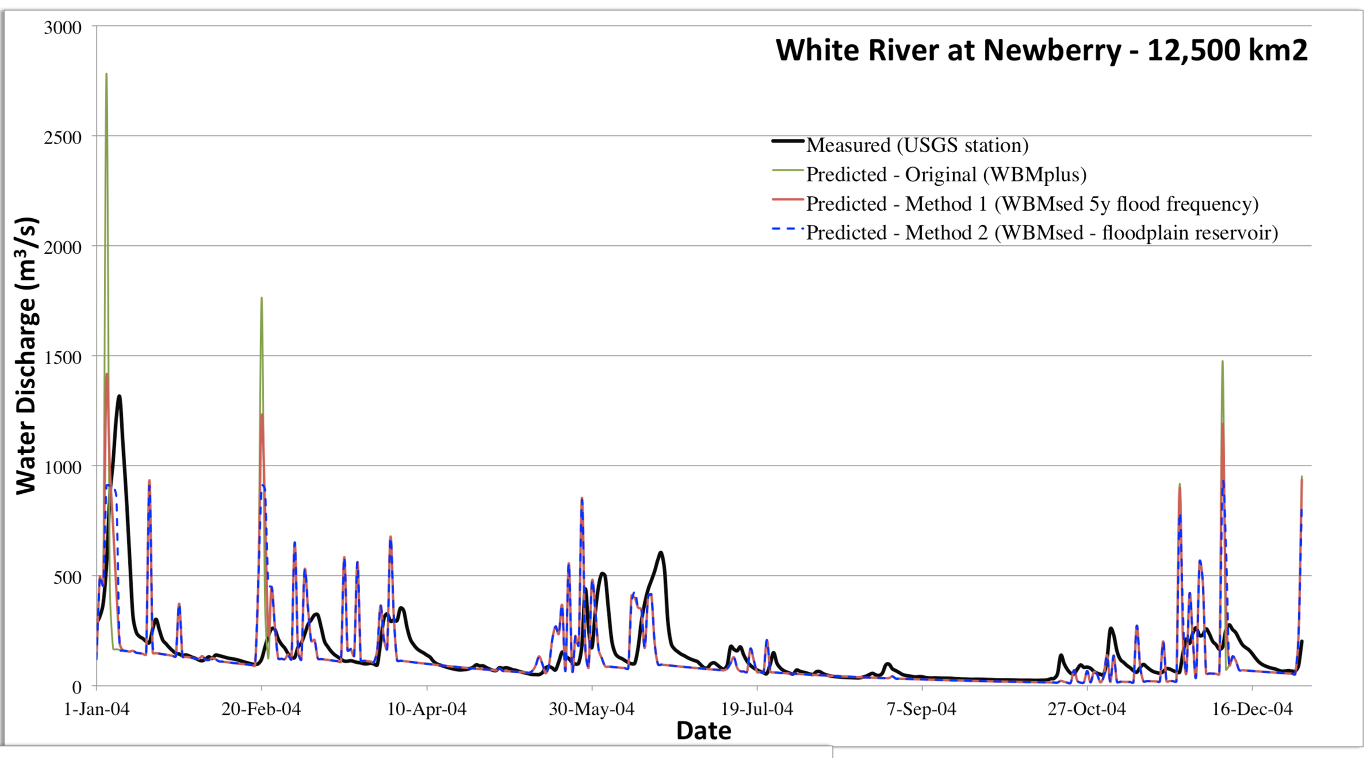
Time Frame: Several Decades;
Time Steps: Daily;
Simulated domain: Continental – Global;
Pixel size: 6 – 30 arc min. (approx. 10 –50 km).

Selected Results

The two methodologies are evaluated by comparing *WBMsedv2.0* predicted discharge to measured discharge (from a USGS gaging stations) and to the original *WBMplus* predicted discharge (without a floodplain reservoir component) for two rivers (White and Mississippi).

For the smaller **White River** differences between the predicted timeseries was only apparent for peek discharge events (Fig. 2). **Method 2** better correspond to measured discharge.

For the **Mississippi River** the differences between the three predicted timeseries differ even for low flow periods due to cascading effects downstream. Here too **Method 2** better corresponds to measured discharge.



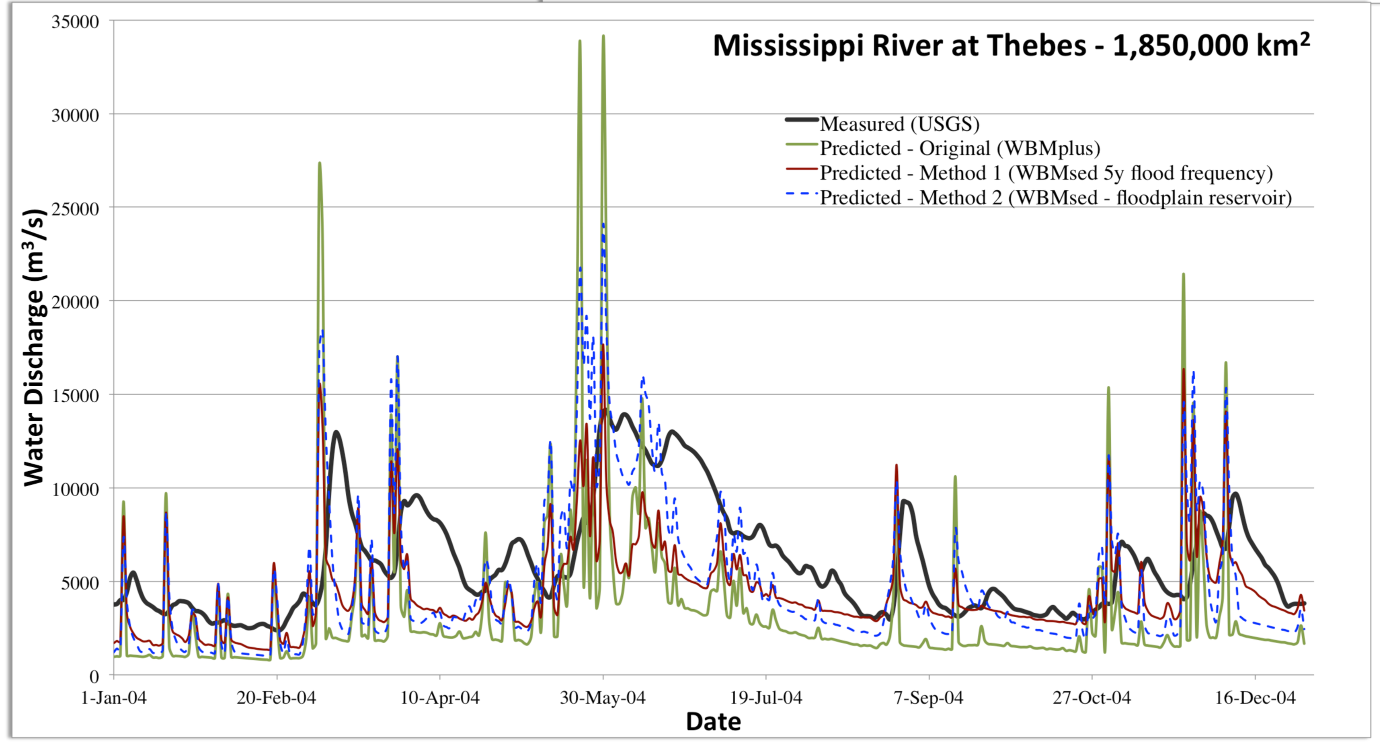


Fig. 2: Daily timeseries of model predicted and measured (USGS gaging station) water discharge.

Conclusions

Initial results indicate that introducing a floodplain reservoir component improved the model discharge predictions, particularly for peek discharge events.

Of the two methodologies for determining overbank discharge, Method 2 better corresponds to measured discharge.

This is a promising result as Method 2 is physically-based (Method 1 is purely statistical) and can be improved even further.

Future work

- Conduct a large validation study using a global daily discharge database (Fig.3) ranging over a 100 years for some sites.
- Test the effect of *WBMsedv2.0* improved discharge prediction on its sediment flux predictions.
- Continue *WBMsed* development toward a more explicit sediment dynamics model.

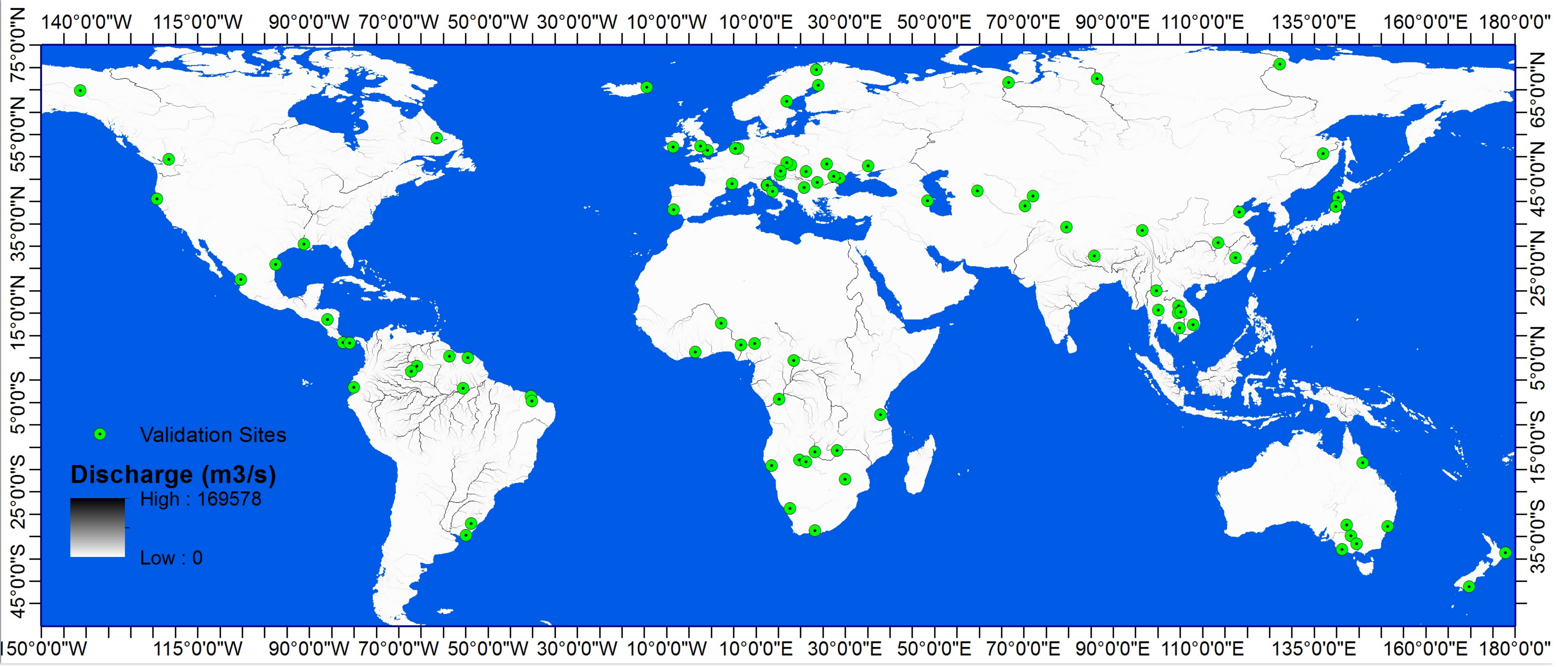


Fig. 3: Global discharge database for 92 river locations overlaying a *WBMsed* predicted water discharge map (average discharge in 2010)

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