1. Background
In areas influenced by backwater effect, a single-parameter rating curve techniques are often inapplicable. Recent developments allow flow velocity to be continuously monitored by the Horizontal Acoustic Doppler Current Profiler (H-ADCP).

2. Study area & data collection
The study is based on measurements carried out in the River Mahakam, East Kalimantan - Indonesia. The H-ADCP measurement station is located in Melak in the middle Mahakam area about 300 km from the delta apex. This area is an extremely flat lowland with about thirty lakes.

The H-ADCP discharge station was operational at a 250 m wide cross section of the river in March 2008 - August 2009. A 600 kHz H-ADCP was mounted on a solid jetty in the concave side of the river bend.

3. Method
We applied the semi-Deterministic semi-Stochastic Model (DSM)\(^\text{[3]}\) and the standard Index Velocity Method (IVM) to obtain a continuous discharge estimate from H-ADCP data. A stage-discharge relation using the Jones’ formula is also included.

1. DSM: Time-series of single point velocity \(u_z\), measured at the relative height \(\sigma_z\), are translated into depth-mean velocity \(U\) according to:

\[
U = F u_z
\]

\[
F = \frac{\ln \left( \frac{H}{\ln(\sigma_z)} \right) - \ln(\sigma_0)}{\ln(\sigma_z) - \ln(\sigma_0)}
\]

\(H\) is depth, \(\alpha\) is dip-correction factor, \(\sigma_0\) is the roughness length.

\[
\sigma_{\text{max}} = \frac{1}{\sqrt{\sigma_{\text{max}} - 1}}
\]

\(\sigma_{\text{max}}\) is the relative height where the maximum velocity occurs.

\[
\sigma_0 = \frac{H}{\exp \left( \frac{\sigma_{\text{max}}}{\sigma_{\text{max}} + 1 + \alpha} \right)}
\]

\(\kappa\) is the Von Karman constant and \(u_c\) is the shear velocity. Specific discharge \(q\) is obtained from:

\[
q = U H
\]

\(W\) is the river width, \(f(\beta)\) is constant amplification factor obtained from total discharge divided by \(Wq\) from ADCP campaigns.

2. IVM: The sectionally integrated velocity obtained from the boat-mounted ADCP is regressed against the width-averaged along channel velocity (i.e. the index velocity) obtained with the H-ADCP.

3. Jones’ formula:

\[
Q = Q_{\text{kin}} \left( 1 - \frac{\partial H}{c_S} \right)^{1/2}
\]

\(Q_{\text{kin}}\) is the kinematic discharge, \(c\) is wave celerity, \(S_o\) is bed slope, and \(\partial H/\partial t\) is rate of water level change in time.

4. Results & discussion
Referring to discharge from boat surveys, the DSM outperforms the IVM.

The range of discharges for a specific stage can span over more than 2000 m\(^3\)s\(^{-1}\), which is large in comparison with the maximum discharge of 3370 m\(^3\)s\(^{-1}\). Such variation can be considered far beyond the rising stage and falling stage explanation.

5. Conclusions
The stage-discharge model based on Jones’s formula captured only a small portion of the discharge dynamics, which was attributed to the invalidity of the kinematic wave assumption. A discharge range of about 2000 m\(^3\)s\(^{-1}\) was established for a particular stage in the recorded discharge series, which is about 60% of the peak discharge.

The large range of discharge occurring for a given stage was attributed to multiple backwater effects from lakes and tributaries, floodplain impacts and effects of river-tide interaction.

Reference, affiliation & funding

*Hydrology and Quantitative Water Management Group, Wageningen University, Wageningen, Netherlands.

Research Centre for Limnology, Indonesian Institute of Sciences, Cibinong, Indonesia.

Institute for Marine and Atmospheric Research Utrecht, Department of Physical Geography, Utrecht University, Utrecht, Netherlands.

Correspondence: hidayat.hidayat@wur.nl

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