Rating curve in the Amazon Basin combining altimetry-derived water stages and discharge propagated from remote in-situ stations

Leon, J-G\textsuperscript{1}; Seyler, F.\textsuperscript{2}; Bonnet, M-P\textsuperscript{2}; Calmant, S.\textsuperscript{3}

\textsuperscript{1}Univ. Nac. de Colombia;  
\textsuperscript{2}IRD/LMTG;  
\textsuperscript{3}IRD/LEGOS
Basins studied

Caqueta: ~1000 km / 200 000 km²
40 stations on the main river, only 6 still working (security pbs)... but 1 with discharges (at the mouth)

Negro: ~1900 km / 715 000 km²
only 7 gauges with discharges on the main river
Negro Basin

Uaracu
T178 7
T121 1

Taraqua
T579 1
T78 1
T35 1
T536 5

São Felipe
T536 4

Curicuriari

Cucúi

Serrinha

20 0 20 40 Kilometers
Time series at VS
(ICE-1 ENVISAT data)

Date

23/11/02  01/02/03  12/04/03  21/06/03  30/08/03  08/11/03  17/01/04  27/03/04

Height (m) (mean removed)

Sao Felipe measured water stage

T536_4 altimetry data
Estimating discharges at virtual stations

The Muskingum-Cunge model:
1D model
Based on Saint-Venant’s Equations

Coeff. K : Storage
Coeff. X : Atenuation

General equation:
$Q_{t+1} = C_0 I_{t+1} + C_1 I_t + C_2 O_t + C_3 Q_L$

Diagram showing the flow and storage at different stations:
- $Q_{in}$: Input flow at Station A
- $Q_{tr}$: Transmitted flow
- $Q_{o}$: Output flow at the end point

Wedge storage = $KX(t - Q)$
Prism storage = $KQ$
The reaches are delimited by the VS

The C coefficients are estimated for each reach between 2 in-situ stations from K & X values
Estimation des débits aux stations virtuelles
discharge and height séries at VS

Rio Negro

Caqueta

Figure 5
In-situ ADCP measurements

Uncertainty on the ADCP discharge evaluated at ~5%
(to be compared to the ~20% of uncertainty for the traditional measurements)

\[ \text{Mean } \sigma_{\text{ADCP depth}} = 3.73 \text{ m} \]

\(1.40 \text{ m} < \sigma < 7 \text{ m}\)
Rating curves at VS

Discharge (m³/s) vs. H-z (m) for various locations along the river network.

Locations shown include:
- Uaracu
- Sao Felipe
- Taraqua
- Curcuriari
- Cucui
- T949 1
- T536 1
- T536 2
- T89 22
- T951 1
- T254 22
- T247 1
- T407 1
- T908 1
- T450 1

Discharge values range from 1000 to 10490 m³/s, with corresponding H-z values ranging from 2.5 to 15.0 m.
Rio Caqueta Rating Curves
Evaluation of the rating curves at the SV

Usual power laws relating the discharge to stages in rating curves

\[ Q_t = aY_t^b \]

Power law modified for altimetric heights

\[ Q_t = a(h_t - z)^b \]

The minimum of the RMS always exist and is well defined

Reference surface (Ellipsoid....)

Figure 7
Height of the river bed
Profiles of river bed

Geoid altitude of zero flow (m)

Distance from outlet (km)

Geoid altitude of zero flow (m)

Distance from outlet (km)
Altitude Profile of the Caqueta River bed

Distance from outlet (km)

Geoid altitude of zero flow (m)
Conclusions

- Even with few in-situ series of discharge, we can propagate flow variations along-strike a river using the M-C model.
- Errors are of the order of 15% in the Rio Negro and 20% for the Caqueta.
- Realistic rating curves (i.e. comparable with traditional curves) can be derived by relating these propagated discharges to water height series provided by satellite altimetry.
- The typical size of the sub-basin delimited by this VS is ten times smaller than previously sized by the in-situ gauges.
- Altimetry also brings
  - Levelling of the in-situ gauges
  - Profiles of the river bed
3D Selection of ENVISAT Data for Improved Water Stage Times Series on the Rio Negro and Adjacent Wetlands (Amazon Basin)

Santos Da Silva, J.1; E. Roux 2; F. Seyler2; S. Calmant3; O. C. Rotunno Filho4
1UFRJ-LAHID; 2IRD-LMTG; 3IRD-LEGOS

PRINCIPLES OF THE DATA SELECTION

1: geographical selection    2: cross-section

1st Example: A –very- large river: the Rio Negro

2nd Example: A small river: the Rio Pardo

3rd Example: An inundated land: the Lago Capiranga