AGU PUBLICATIONS

Water Resources Research

Supporting Information for

Sediment flows in South America supported by daily hydrologic-hydrodynamic modeling

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Introduction

This supporting information presents a detailed description of the MGB-SED model (Text S1), developed by Buarque (2015) and complementary results to those presented in the main text: the value of C-factor used in the sediment modeling (Figure S1); the sites used in the comparisons between MGB-SED AS model and other studies (Figure S2); model performance using KGE, $DCPerm$ and $RMSErel$ metrics (Figure S3); Detailed view of the MGB-SED AS performance in terms of r, $BIAS$ and NSE (Figures S4-S6); Scatter plot using all observed values against simulated values in the same days (Figure S7); number of samples for each in-situ sediment station (Figures S8-S9); values of suspended sediment discharge from MGB-SED AS and other studies for specific sites (Table S1 and S2); errors of model sediment balance (Table S3); Ranking of of South American rivers with highest annual QSS (Table S4); and performance analysis considering temporal and spatial extrapolations (Table S5).

Text S1. MGB-SED Equations

Basin Module

The Modified Universal Soil Loss Equation (MUSLE, Williams, 1975) is given by:

$$Sed = \alpha.(Q_{sur} * q_{peak} * A)^{\beta}.K.C.P.LS_{2D} \tag{1}$$

where Sed[t/day] is the sediment yield, Q_{sur}[mm/day] is the specific runoff volume, q_{peak}[m^3/s] is the peak runoff rate, A[ha] is the unit catchment area, K[0.013.t.m^2.h./m^3.t.cm] is the soil erodibility factor, C[-] is the cover and management practices factor, P[-] is the conservation practices factor, LS_{2D}[-] is a bidimensional topographic factor; and α and β are the fit coefficients of the equation (which are calibrated afterward), whose values originally estimated by Williams (1975) were 11.8 and 0.56, respectively.

The q_{peak} is estimated as a function of the area A and of the daily runoff volume Q_{sur}:

$$q_{peak} = \frac{Q_{sur}.A}{86400} \tag{2}$$

The K factor is estimated from equation proposed by Williams (1995) (Equation 3), which is detailed in Buarque (2015):

$$K = Fag.Fcs.Forg.Fa \tag{3}$$

, where Fag is a factor that gives low soil erodibility factors for soils with high coarse-sand contents and high values for soils with little sand, Fcs is a factor that gives low soil erodibility factors for soils with high clay to silt ratios, $Forg$ is a factor that reduces soil erodibility for soils with high organic carbon content, and Fa is a factor that reduces soil erodibility for soils with extremely high sand contents. These factors are calculated by Williams (1995):

$$Fag = 0.2 + 0.3 \cdot exp\left[-0.0256 \cdot SAN \cdot \left(1 - \frac{SIL}{100}\right)\right] \tag{4}$$

$$Fcs = \left(\frac{SIL}{ARG + SIL}\right)^{0.3} \tag{5}$$

$$Forg = 1 - \frac{0.25 \cdot orgC}{orgC + exp(3.72 - 2.95 \cdot orgC)} \tag{6}$$

$$Fa = 1 - \frac{0.7 \cdot \left(1 - \frac{SAN}{100}\right)}{\left(1 - \frac{SAN}{100}\right) + exp\left[-5.51 + 22.9 \cdot \left(1 - \frac{SAN}{100}\right)\right]} \tag{7}$$

, where SAN, SIL, ARG and $orgC$ are the percentages of sand, silt, clay and organic carbon, respectively.

To compute LS_{2D} factor, a routine was created by Buarque (2015). For each pixel $k\langle l, c\rangle$ of Digital Elevation Model (DEM), LS is computed automatically. The L factor is obtained based on Desmet & Govers (1996), using the unit contributing area concept (Kirkby & Chorley, 1967). This two-dimensional approach explicitly considers the convergence of the flow and, based on field observations, and it was able to consider not only the processes of erosion in the rill and interrill, but also the erosion in ephemeral ravines (Desmet & Govers, 1997). The L factor equation applied for each DEM pixel $k\langle l, c\rangle$ is:

$$L_k = \frac{\left(Am_k + Lp_k^2\right)^{m+1} - Am_k^{m+1}}{Lp^{m+2} \cdot Xdir_k^m \cdot (22{,}13)^m} \tag{7}$$

, where L [-] is the length factor of pixel k; Am [m^2] the accumulated drainage area in the pixel entrance; Lp [m] the pixel width; $Xdir$ [-] is an aspect direction factor for the pixel; m [-] is the exponent of the slope length. The direction factor $Xdir$ correspond to the distance between two neighboring pixels, defined as 1 when the direction between them is orthogonal or $\sqrt{2}$ when the direction is diagonal. The m index is acquired by expressions bellow:

$$m = \begin{vmatrix} 0{,}2 & se & Sf < 1 \\ 0{,}3 & se & 1 \le Sf < 3 \\ 0{,}4 & se & 3 \le Sf < 5 \\ 0{,}5 & se & Sf \ge 5 \end{vmatrix} \tag{8}$$

,where Sf [%] is the pixel slope. The Sf measure the rate of change of the elevation in the direction of the highest slope and is computed in the model for each pixel using the z [m] elevations of the four neighbors in the orthogonal directions, following the equation 9 (Wilson & Gallant, 2000):

$$Sf = \sqrt{\left(\frac{\partial z}{\partial x}\right)^2 + \left(\frac{\partial z}{\partial y}\right)^2} \tag{9}$$

,where $\partial z/\partial x$ e $\partial z/\partial y$ are the first-order partial differential that describes the rate of local variation of elevation z [m] against the orthogonal distances x and y. These differentials are calculated using finite centered difference:

$$\frac{\partial z}{\partial x} \approx \frac{z_l^{c+1} - z_l^{c-1}}{2 \cdot Lp}, \frac{\partial z}{\partial y} \approx \frac{z_{l+1}^{c} - z_{l-1}^{c}}{2 \cdot Lp} \tag{10}$$

$$\frac{\partial z}{\partial y} \approx \frac{z_{l+1}^{c} - z_{l-1}^{c}}{2 \cdot Lp} \tag{11}$$

,where l and c are the row and column that determine the pixel position in the matrix $k\langle l, c\rangle$. Pixel slope also can be estimated using the modified method proposed by Pradhan et al. (2006), based on the scaling of the slope, estimated from fractal theory, proposed by Zhang et al. (1999). More details see Naipal et al. (2015).

The slope factor S is computed using the equation proposed by Wischmeier & Smith (1978):

$$S_k = 65{,}41 \cdot \sin^2(\theta_k) + 4{,}56 \cdot \sin(\theta_k) + 0{,}065 \tag{12}$$

, where θ is the value of Sf in degrees.

The total volume of sediment generated in each Hydrological Response Unit (HRU) and stored in the linear reservoir is computed as follows:

$$SED_{i,j}^{t} = VSED_{i,j}^{t-1} + \sum_{k=1}^{NP_j} SED_{i,j}^{k} \tag{13}$$

,where $VSED$[t] is the volume in sediment reservoir of j HRU of i unit catchment, NP is the number of pixels of HRU, the indexes t and $t-1$ designate the current and previous time steps.

The total load discharge QS [t/s] of linear reservoir output is computed as a linear function of the respective stored load and delay time ҍ [s] of the surface reservoir. QS is computed by equation 14:

$$QS_{i,j}^{t} = \frac{1}{ҍ} VSED_{i,j}^{t} \tag{14}$$

The total sediment delivered in each unit catchment is divided into three fractions: silt, clay and sand. Each one is defined according to its percentage in the upper layer of each HRU soil type. The delivery of the three classes of particles each unit catchment to the stream network is calculated by:

$$SEDsil_i^t = \sum_{j=1}^{N_{URH}} \left(QS_{i,j}^t \cdot FRAC_{i,j}^t \cdot SIL_j\right) \cdot \Delta t \qquad (15)$$

$$SEDarg_i^t = \sum_{j=1}^{N_{URH}} \left(QS_{i,j}^t \cdot FRAC_{i,j}^t \cdot ARG_j\right) \cdot \Delta t \qquad (16)$$

$$SEDsan_i^t = \sum_{j=1}^{N_{URH}} \left(QS_{i,j}^t \cdot FRAC_{i,j}^t \cdot SAN_j\right) \cdot \Delta t \qquad (17)$$

,where $SEDsil$ [t], $SEDarg$ [t] and $SEDsan$ [t] are the load of silt, clay and sand, respectively, leaving the sediment reservoir and reaching the stream network in each time step Δt. The $FRAC$ term (equation 18) corresponds to the fraction of the sediment volume in each reservoir of each HRU .

$$FRAC_{i,j}^t = \frac{VSED_{i,j}^t}{\sum_{j=1}^{N_{URH}} VSED_{i,j}^t} \qquad (18)$$

River module

The transport of the suspended loads (silt and clay) in the river network considers an unsteady flow approach, in which the flow velocity and advective processes are dominants. The transport equation, in this case, is given by:

$$\frac{\partial AC}{\partial t} + \frac{\partial AUC}{\partial x} = q_{sm} - q_{sfl} \qquad (19)$$

where A [m^2] is the cross-section wetted area; C [t/m^3] is the sediment mean concentration, U [m/s] is the mean flow velocity in the cross-section; x [m] is the distance in the flow direction; t [s] is the time; q_{sm} [t/(m.s)] is the catchment lateral sediment supply; and q_{sfl} [t/(m.s)] is the discharge of sediment exchange between the river and floodplain, considered different of zero only when the hydrodynamic routing is used.

The equation 19 is solved numerically for each suspended particle fraction using a progressive implicit scheme in time and space, which is applied reach to reach, from upstream to downstream:

$$C_i^t = \frac{\theta \cdot Q_{i-1}^t \cdot C_{i-1}^t - (1-\theta)\left(Q_i^{t-1} \cdot C_i^{t-1} - Q_{i-1}^{t-1} \cdot C_{i-1}^{t-1}\right)}{\frac{Vol^t}{\Delta t} + \theta \cdot Q_i^t} + \\ + \frac{\frac{Vol^{t-1}}{\Delta t} \cdot C_i^{t-1} + {QS_m}^t - {QS_{fl}}^t}{\frac{Vol^t}{\Delta t} + \theta \cdot Q_i^t} \quad (20)$$

, where Q [m^3.s-1] is water discharge; the indexes $i-1$ and i refer to the river cross-section upstream and downstream; $t-1$ and t refer to initial and final time step; Δt [s] is calculation time step; θ is the weight of the temporal terms, whose value varies between 0 and 1; $Vol = A \cdot \Delta x$ [m^3] is mean water volume in the river reach; Δx [m] is the length of the catchment river reach; $QS_m = q_{sm} \cdot \Delta x$ [t/s] is sediment load (silt or clay) from the catchment to the river reach; and $QS_{fl} = q_{sfl} \cdot \Delta x$ [t/s] is a sediment load exchange between the river and floodplain.

The cross-section wetted areas (A), related to the respective Q, are calculated using two approaches: (i) for Muskingum-Cunge method, values are calculated for a rectangular channel by multiplication of river width B by water depth h, estimated by Manning equation considering that hydraulic radius Rh is equal h; (ii) in reaches with hydrodynamic flow routing, the h is estimated by the model, and the area A can be directly obtained from Manning equation.

Equations used to represent transport, erosion and deposition of coarse particles (sand) are not presented here, since our study is focused on suspended sediment (silt and clay). For further details the reader is referred to Buarque (2015).

Floodplain module

MGB-SED approach considers that in the floodplains: (i) there are only fine sediments; (ii) sediments are well-mixed and, therefore, concentrations are constant; (iii) longitudinal flow velocity is zero, which allows only lateral exchanges; (iv) floodplains works as fine sediment storage areas. If the net flow of river-plain exchange q_{sfl} [m^3/s] is positive; the water inflow to floodplain will have the same suspended sediment concentration (C) of the river reach. For this case, the solid discharge of river-plain exchange QS_{fl} [t/s] is estimated using equation 21. If q_{sfl} is negative the water outflow from floodplain to the river will have the same suspended sediment concentration of the floodplain (C_{fl} [t/m^3]). For this case, solid discharge QS_{fl} is estimated by equation 22.

$$QS_{fl}{}^{t} = q_{sfl}{}^{t} \cdot \Delta x = q_{fl}{}^{t} \cdot \left(\frac{C_i^t + C_{i-1}^t}{2}\right) \cdot \Delta x \tag{21}$$

$$QS_{fl}{}^{t} = q_{sfl}{}^{t} \cdot \Delta x = q_{fl}{}^{t} \cdot C_{fl}{}^{t} \cdot \Delta x. \tag{22}$$

The sediment concentration in the floodplain is estimated using a time mass balance equation, which is solved numerically for each fraction of particles. For this solution, an implicit scheme progressive in time (equation 23) was used.

$$C_{fl}^{*\,t} = \frac{C_{fl}{}^{t-1} \cdot V_{fl}{}^{t-1} + \left(\frac{q_{fl}{}^{t-1} + q_{fl}{}^{t}}{2}\right) \cdot \Delta x \cdot \Delta t}{V_{fl}{}^{t}} \tag{23}$$

, where V_{fl} [m^3] is the water volume in the floodplain, given by the product between average water depth H_{fl} [m] and flooded area A_{fl} [m^2], estimated by the hydrodynamic model. The percentage of sediments deposited in the floodplain is computed by comparing the H_{fl} with the average vertical distance traveled by each particle in the time step, which is a function of its falling velocity ω_s [m/s]. The volume deposited and the sediment concentration at the end of the time step is estimated using equations 24 and 25, respectively.

$$DEP_{fl}{}^{t} = C_{fl}{}^{t} \cdot V_{fl}{}^{t} \cdot \left(\frac{\omega_s \cdot \Delta t}{H_{fl}}\right) \tag{24}$$

$$C_{fl}{}^{t} = C_{fl}^{*\,t} - \frac{DEP_{fl}{}^{t}}{V_{fl}{}^{t}} \tag{25}$$

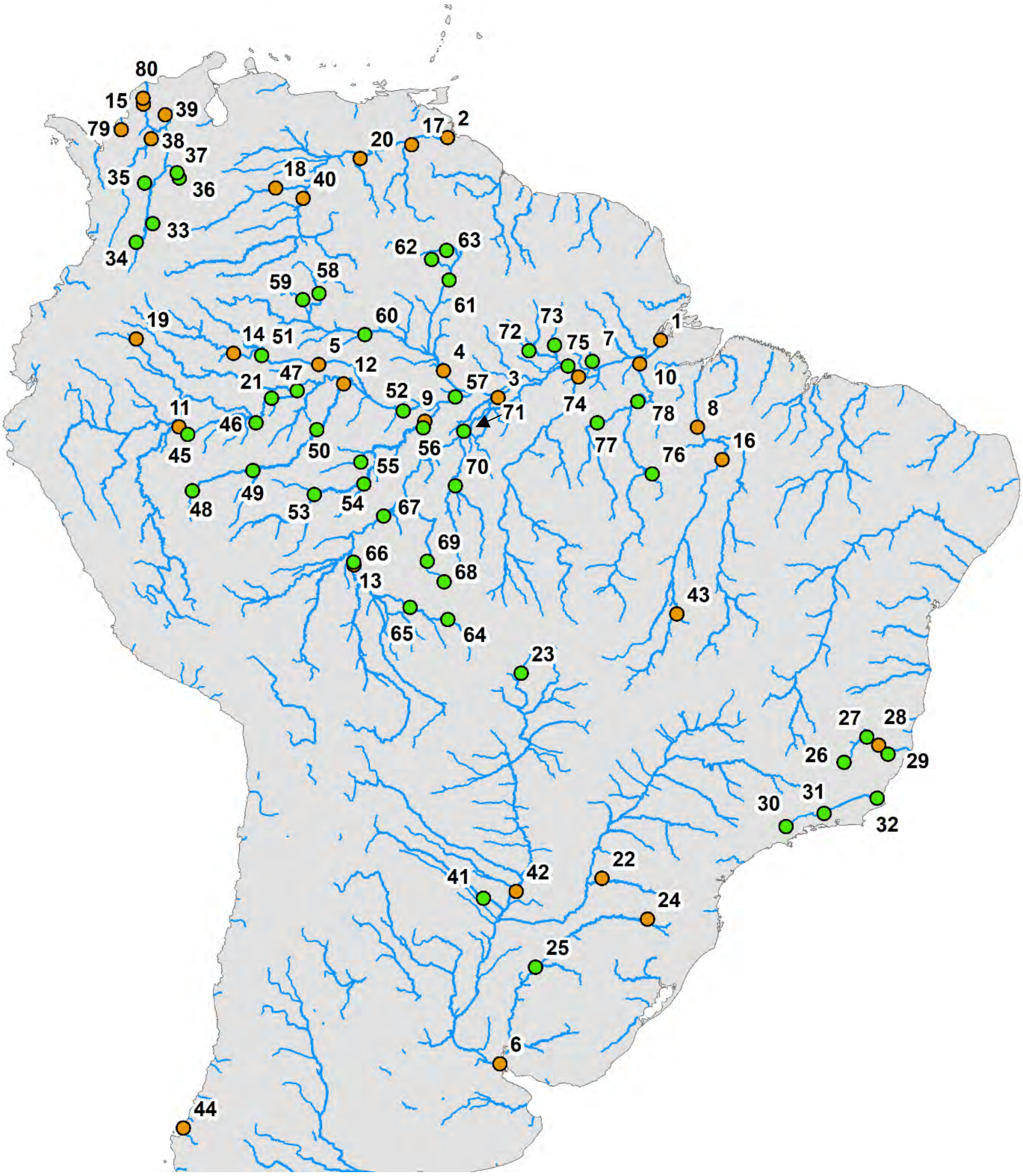

Figure S2. Sites (orange and green) where MGB-SED AS and regional studies data were compared. Numbers are related to ID in Table S1. The Green dots refer to specific sites where comparisons between MGB-SED and WBMsed were made.

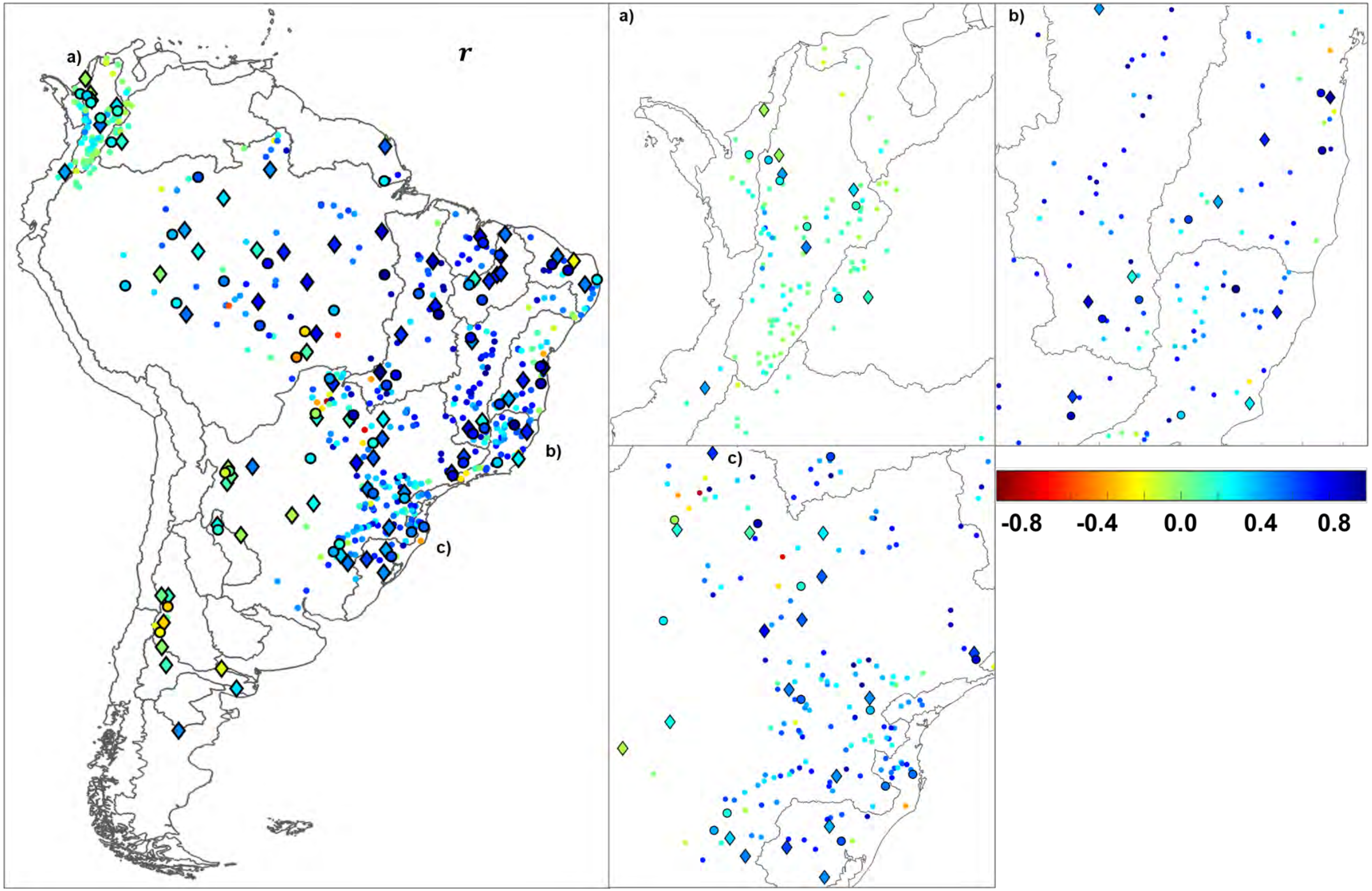

Figure S4: MGB-SED AS performance. Detailed view of Pearson correlation coefficient (r).

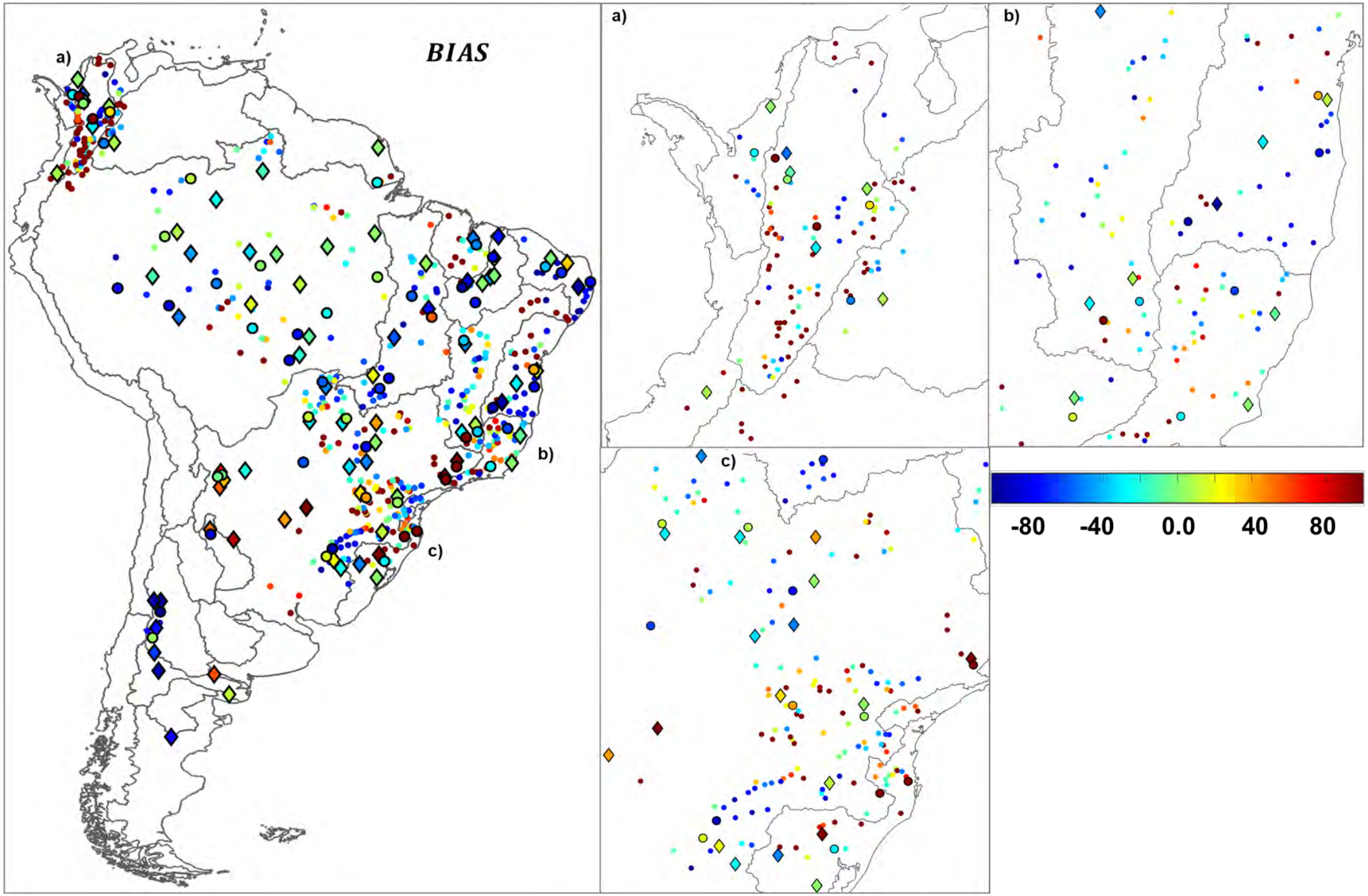

Figure S5: MGB-SED AS performance. Detailed view of $BIAS$.

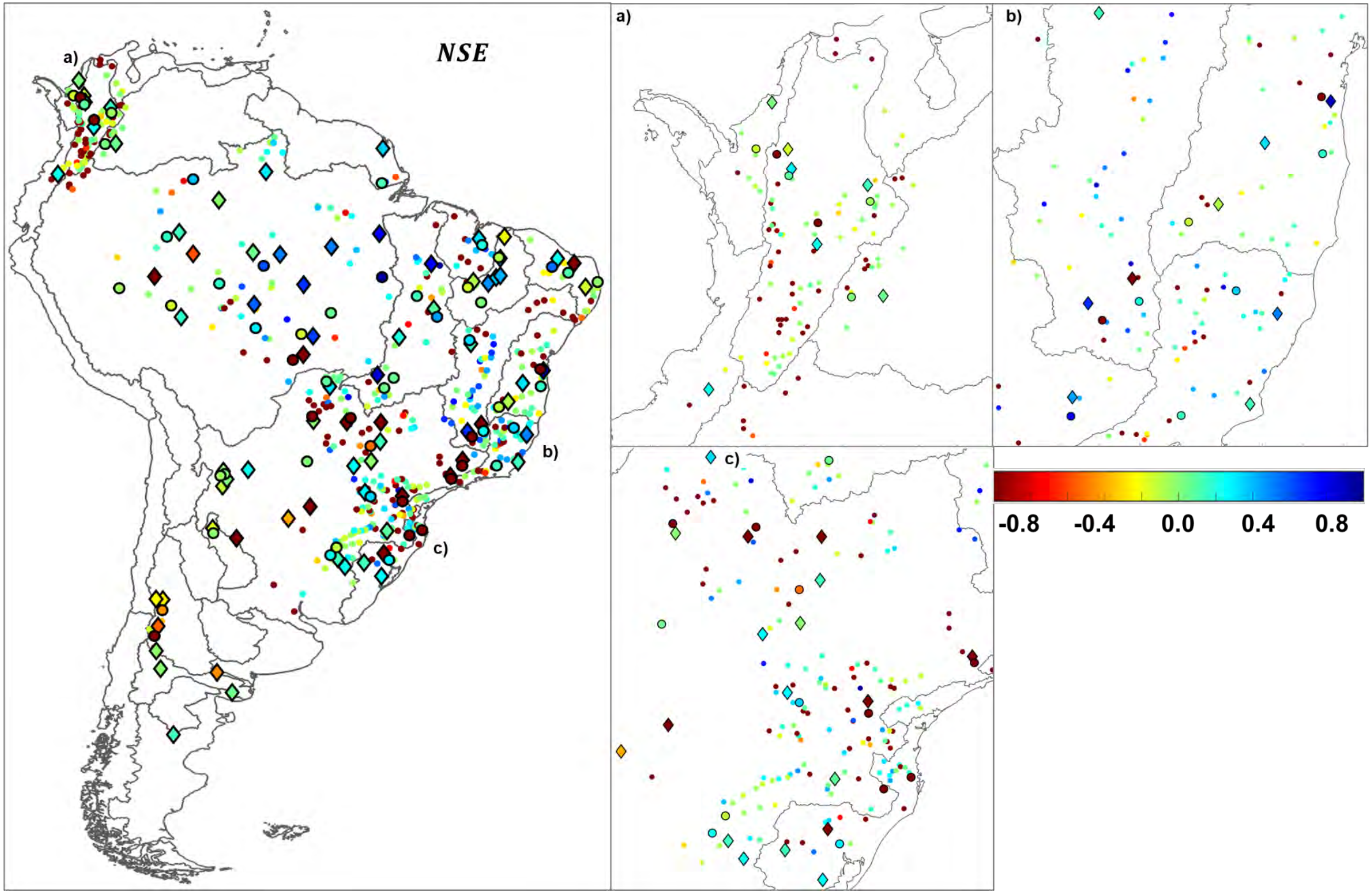

Figure S6: MGB-SED AS performance. Detailed view of NSE.

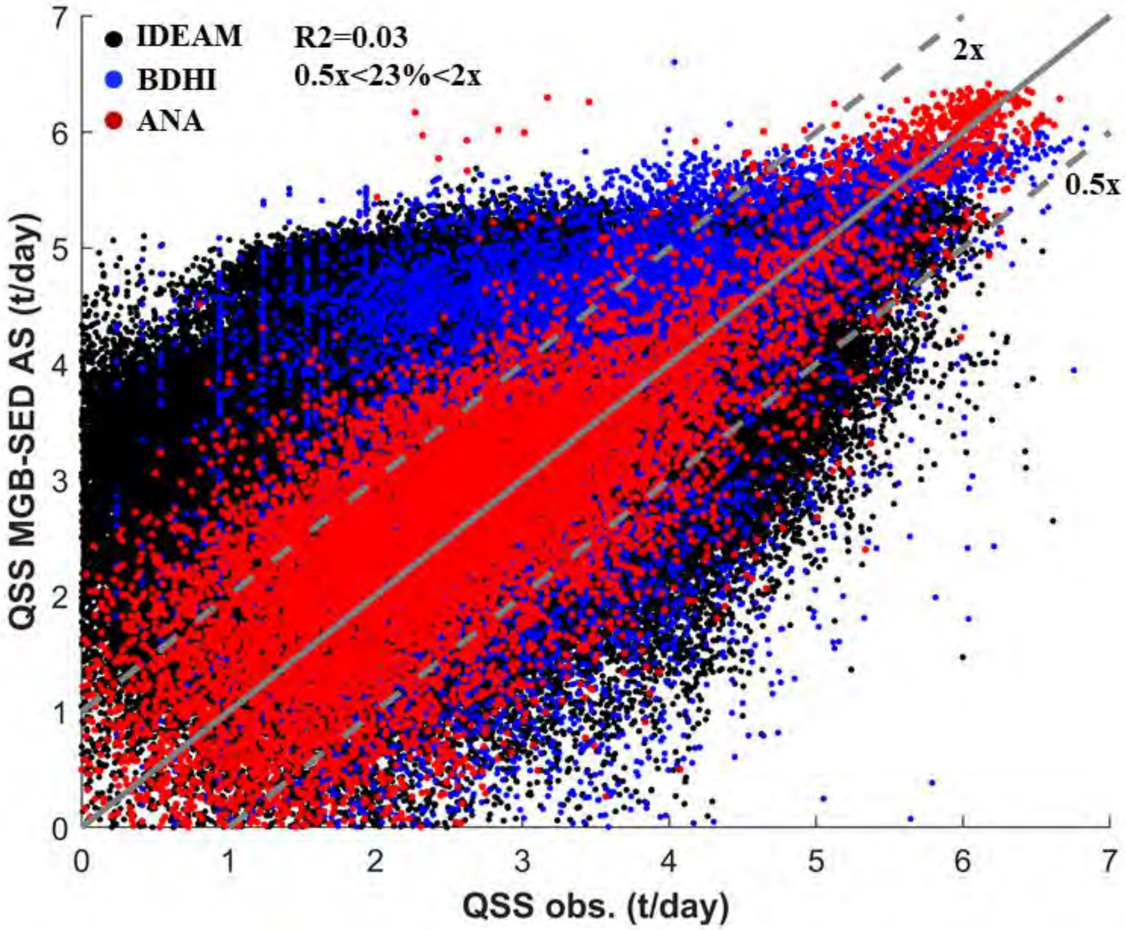

Figure S7: Comparison between all daily observed and simulated QSS.

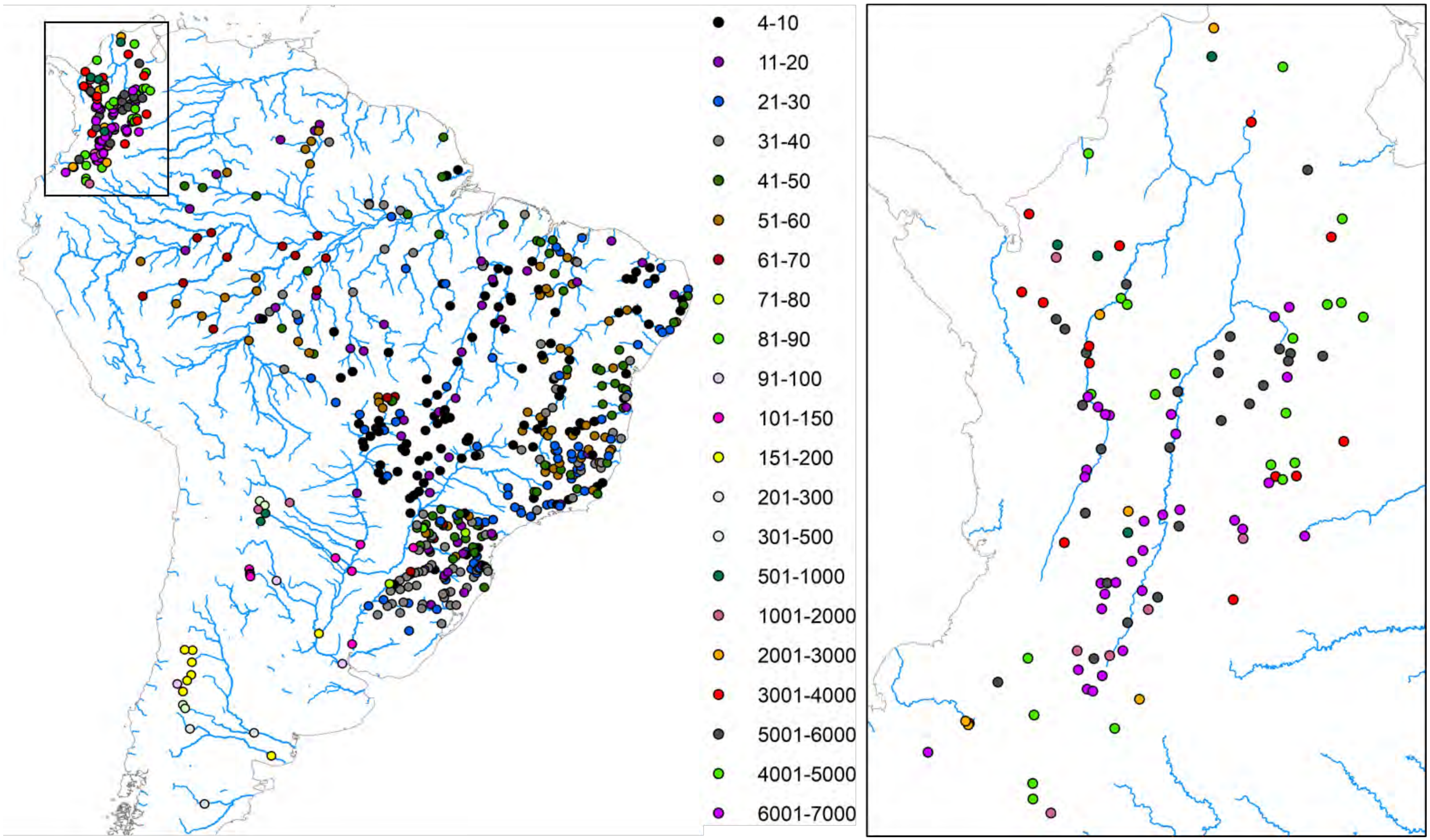

Figure S8: number (n) of discharge of suspended sediment for each station from ANA, IDEAM and BDHI.

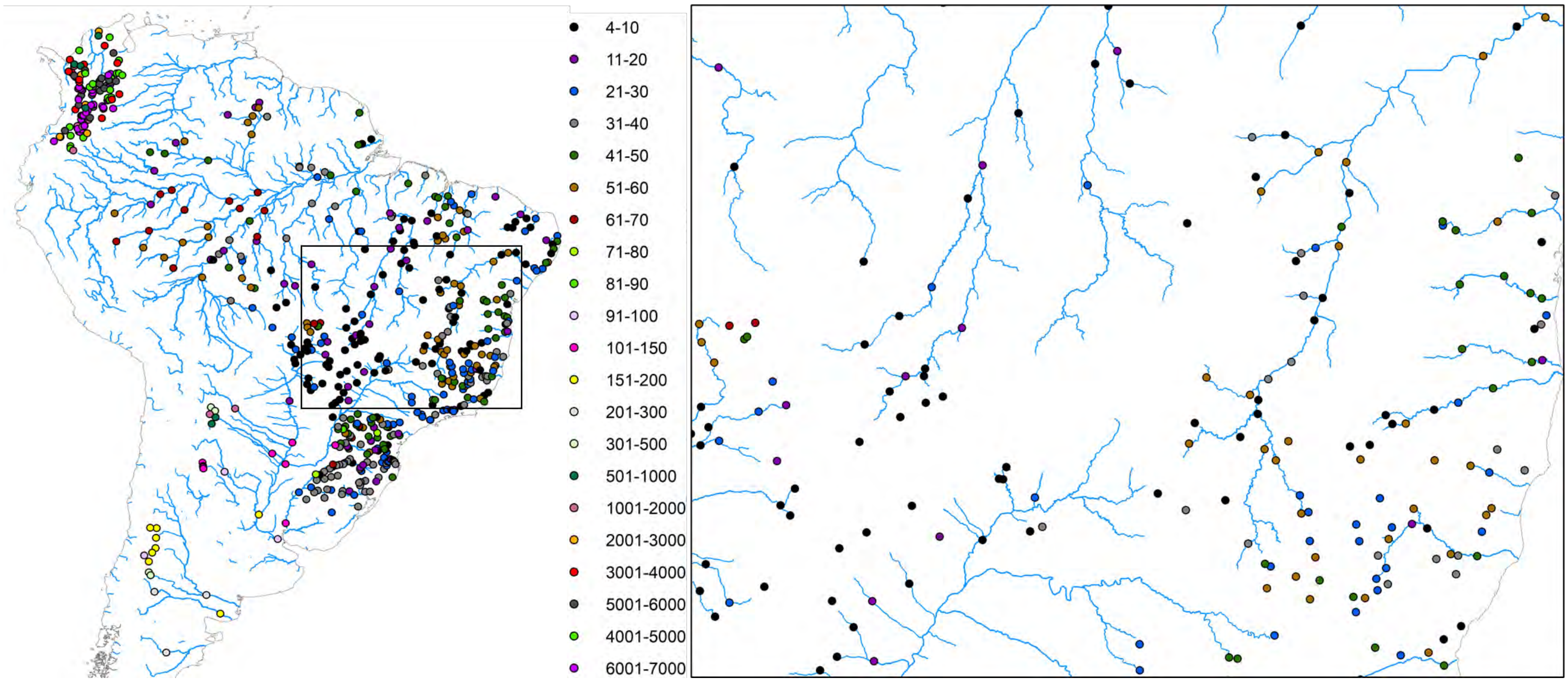

Figure S9: number (n) of discharge of suspended sediment for each station from ANA, IDEAM and BDHI.

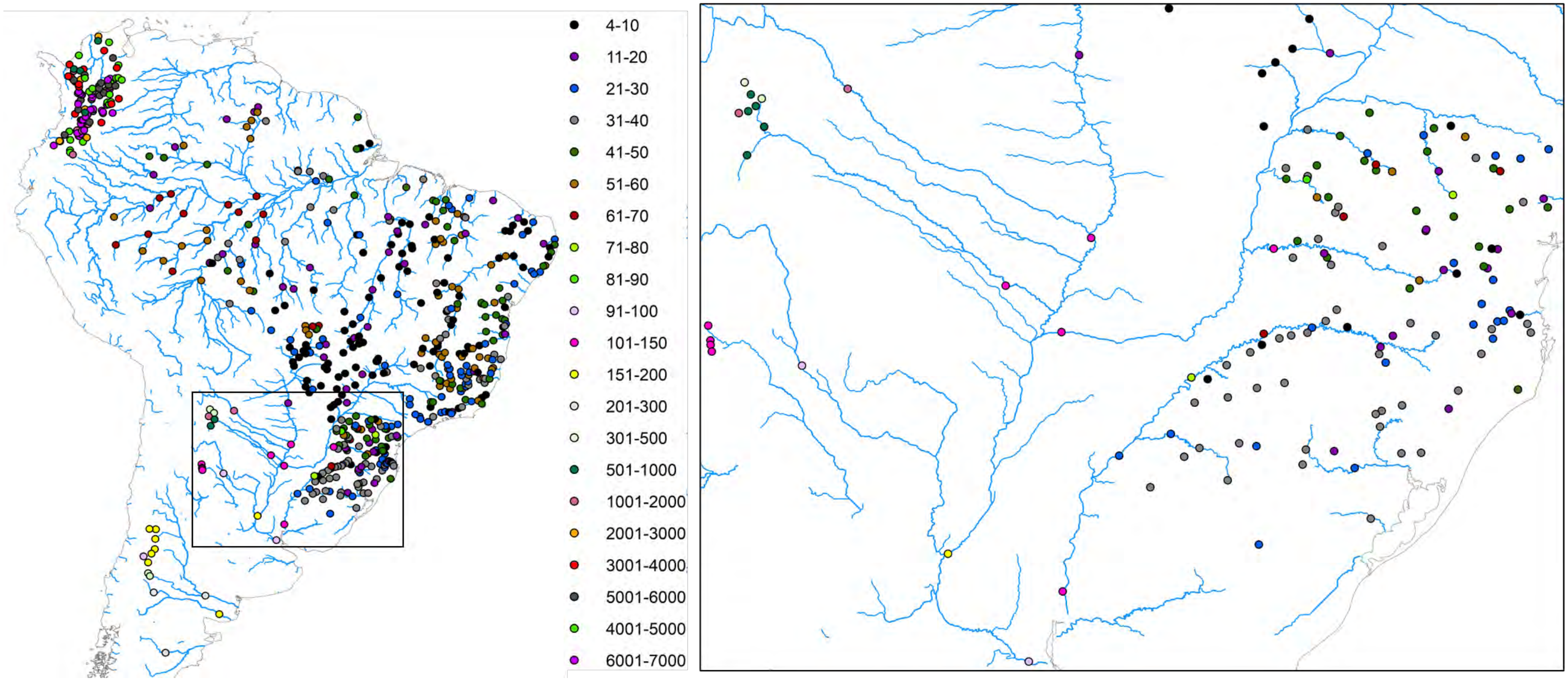

Figure S10: number (n) of discharge of suspended sediment for each station from ANA, IDEAM and BDHI.

Table S1. Summary of water and sediment suspended discharges used to comparison between regional studies and outputs from MGB-SED AS

			Regional Studies				MGB-SED AS				*Diff (%)*
ID	**Source**	**River**	**A (km^2)**	**Q (m^3/s)**	**QSS (Mt/year)**	**QSS (t/year.km^2)**	**A (km^2)**	**Q (m^3/s)**	**QSS (Mt/year)**	**QSS (t/year.km^2)**	
1	Filizola[1]	Amazonas	6.00E+06	2.09E+05	1.00E+03	1.67E+02	5.93E+06	2.03E+05	4.37E+02	7.37E+01	-56
2	Meade[2]	Orinoco	9.50E+05	3.50E+04	1.50E+02	1.58E+02	9.41E+05	3.45E+04	1.37E+02	9.46E+01	-9
3	Filizola[1]	Madeira	1.36E+06	3.20E+04	4.50E+02	3.30E+02	1.37E+06	2.91E+04	2.13E+02	1.55E+02	-53
4	Filizola[1]	Negro	6.96E+05	2.84E+04	8.00E+00	1.15E+01	6.99E+05	3.40E+04	7.29E+00	1.04E+01	-9
5	Filizola[1]	Japura	2.48E+05	1.86E+04	3.30E+01	1.33E+02	2.50E+05	1.46E+04	1.86E+01	7.45E+01	-44
6	Amsler[3]	Paraná	2.60E+06	1.80E+04	1.12E+02	4.30E+01	2.60E+06	2.26E+04	1.10E+02	3.95E+01	-2
7	Filizola[1]	Tapajós	4.90E+05	1.35E+04	6.00E+00	1.22E+01	4.95E+05	1.52E+04	3.63E+00	7.33E+00	-39
8	Latrubesse[4]	Tocantins	7.57E+05	1.18E+04	5.80E+01	7.66E+01	7.56E+05	1.32E+04	7.42E+00	9.82E+00	-87
9	Filizola[1]	Purus	3.70E+05	1.10E+04	3.00E+01	8.10E+01	3.72E+05	1.09E+04	1.90E+01	5.11E+01	-37
10	Filizola[1]	Xingu	5.04E+05	9.70E+03	9.00E+00	1.78E+01	5.12E+05	1.37E+04	3.06E+00	5.99E+00	-66
11	Gibs[5]	Ucayali	4.06E+05	9.54E+03	1.25E+02	3.07E+02	3.55E+05	1.03E+04	1.54E+02	4.33E+02	23
12	Filizola[1]	Jurua	1.85E+05	8.44E+03	3.50E+01	1.89E+02	1.82E+05	5.81E+03	2.20E+01	1.21E+02	-37
13	Filizola[1]	Mamore	5.90E+05	8.26E+03	8.00E+01	1.36E+02	5.98E+05	7.08E+03	8.92E+01	1.49E+02	12
14	Nordin[6]	Guaviare	1.14E+05	8.20E+03	3.00E+01	6.78E+02	1.19E+05	7.03E+03	2.86E+01	2.40E+02	-5
15	Milliman[7]	Magdalena	2.57E+05	7.20E+03	1.44E+02	5.45E+02	2.58E+05	7.51E+03	3.32E+01	1.29E+02	-77
16	Latrubesse[4]	Araguaia	3.77E+05	6.10E+03	1.80E+01	4.77E+01	3.77E+05	6.12E+03	2.33E+00	6.18E+00	-87
17	Milliman[7]	Caroni	9.35E+04	5.00E+03	2.00E+00	2.13E+01	9.23E+04	4.18E+03	1.27E+01	3.78E+01	537
18	Milliman[7]	Meta	1.05E+05	4.60E+03	8.00E+01	7.59E+02	1.05E+05	3.98E+03	3.00E+01	2.85E+02	-62
19	Latrubesse[4]	Napo	1.22E+05	4.60E+03	2.24E+01	1.84E+02	1.24E+04	8.58E+02	5.59E+00	4.50E+02	-75
20	Milliman[7]	Caura	4.73E+04	4.00E+03	2.00E+00	4.22E+01	4.75E+04	2.26E+03	1.00E+01	6.11E+01	401
67	Lima[8]	Madeira	9.54E+05	1.93E+04	2.43E+02	2.54E+02	9.82E+05	1.62E+04	2.90E+02	2.96E+02	20
71	Lima[8]	Madeira	1.32E+06	3.06E+04	2.38E+02	1.80E+02	1.32E+06	2.67E+04	2.24E+02	1.70E+02	-6
21	Lima[8]	Solimões	9.91E+05	4.72E+04	3.43E+02	3.46E+02	1.00E+06	4.21E+04	4.00E+02	3.98E+02	17
57	Lima[8]	Solimões	2.15E+06	1.02E+05	4.52E+02	2.11E+02	2.20E+06	9.26E+04	3.55E+02	1.61E+02	-22

74	Lima[8]	Amazonas	4.68E+06	1.81E+05	5.67E+02	1.21E+02	4.70E+06	1.68E+05	4.31E+02	9.17E+01	-24
78	Lima[8]	Xingu	4.46E+05	7.75E+03	3.43E+00	7.70E+00	4.49E+05	1.13E+04	2.59E+00	5.77E+00	-25
22	Lima[8]	Iguaçu	6.32E+04	1.77E+03	2.23E+00	3.53E+01	6.42E+04	1.71E+03	5.15E+00	7.61E+01	131
23	Lima[8]	Paraguai	3.28E+04	5.33E+02	1.26E+00	3.85E+01	3.28E+04	4.88E+02	9.69E-01	3.34E+01	-23
24	Lima[8]	Uruguai	4.13E+04	8.96E+02	1.03E+00	2.49E+01	4.21E+04	1.24E+03	3.03E+00	7.18E+01	194
25	Lima[8]	Uruguai	1.64E+05	4.69E+03	3.59E+00	2.20E+01	1.89E+05	5.49E+03	5.91E+00	3.12E+01	65
26	Lima[8]	Doce	1.01E+04	1.61E+02	1.00E+00	9.96E+01	9.94E+03	1.63E+02	8.52E-01	8.57E+01	-15
27	Lima[8]	Doce	5.54E+04	7.17E+02	6.21E+00	1.12E+02	5.52E+04	7.25E+02	3.51E+00	6.35E+01	-44
28	Lima[8]	Doce	6.16E+04	6.39E+02	6.28E+00	1.02E+02	6.18E+04	7.80E+02	3.86E+00	6.25E+01	-39
29	Lima[8]	Doce	7.58E+04	9.21E+02	1.12E+01	1.48E+02	7.60E+04	9.13E+02	4.68E+00	6.16E+01	-58
30	Lima[8]	Paraíba do Sul	9.58E+03	1.55E+02	2.20E-01	2.25E+01	9.61E+03	1.88E+02	2.88E-01	3.00E+01	31
31	Lima[8]	Paraíba do Sul	1.76E+04	2.73E+02	1.38E+00	7.83E+01	1.81E+04	3.29E+02	5.75E-01	3.18E+01	-58
32	Lima[8]	Paraíba do Sul	5.55E+04	7.91E+02	4.35E+00	7.85E+01	5.62E+04	9.04E+02	2.18E+00	3.87E+01	-50
33	Restrepo[9]	Bogotá	5.54E+03	3.90E+01	1.30E+00	2.39E+02	5.50E+03	5.45E+01	2.28E-01	4.15E+01	-82
34	Restrepo[9]	Saldaña	7.01E+03	3.20E+02	8.90E+00	1.27E+03	6.51E+03	2.44E+02	4.54E+00	6.98E+02	-49
35	Restrepo[9]	Nare	5.71E+03	3.96E+02	2.60E+00	4.52E+02	5.70E+03	2.88E+02	1.32E+00	2.31E+02	-49
36	Restrepo[9]	Suárez	9.31E+03	3.00E+02	3.40E+00	3.67E+02	1.02E+04	2.90E+02	1.81E+00	1.77E+02	-47
37	Restrepo[9]	Sogamo	2.15E+04	4.88E+02	1.12E+01	5.22E+02	2.13E+04	4.89E+02	5.20E+00	2.43E+02	-54
38	Restrepo[9]	Cauca	5.96E+04	2.37E+03	4.91E+01	8.23E+02	5.96E+04	2.39E+03	2.00E+01	3.36E+02	-59
39	Restrepo[9]	Cesar	1.67E+04	5.30E+01	2.00E-01	1.00E+01	1.69E+04	2.02E+02	1.30E+00	7.66E+01	549
40	Meade[2]	Orinoco	-	1.57E+04	3.20E+01	-	3.42E+05	1.66E+04	4.15E+01	5.32E+01	30
41	Alarcon[10]	Bermejo	-	-	1.09E+02	-	1.06E+05	5.10E+02	2.56E+01	3.08E+02	-77
42	Alarcon[10]	Paraguay	-	-	5.20E+00	-	9.72E+05	3.88E+03	3.09E+01	3.89E+01	495
43	Carvalho[11]	Araguaia	-	3.64E+03	5.53E+00	-	1.18E+05	1.73E+03	1.33E+00	1.13E+01	-76
44	Aros[12]	Bio Bio	2.43E+04	1.00E+03	5.94E+00	2.45E+02	2.44E+04	1.08E+03	4.18E+01	1.52E+03	603
45	Filizola[13]	Javari	1.20E+04	6.40E+02	1.34E+00	1.12E+02	1.68E+04	5.65E+02	1.01E-01	6.01E+00	-92
46	Filizola[13]	Solimões	9.83E+05	4.42E+04	4.35E+02	4.42E+02	9.95E+05	4.16E+04	4.01E+02	4.03E+02	-8
47	Filizola[13]	Solimões	1.14E+06	5.49E+04	4.73E+02	4.17E+02	1.14E+06	5.04E+04	4.14E+02	3.62E+02	-13

48	Filizola[13]	Juruá	3.90E+04	9.10E+02	1.23E+01	3.15E+02	3.82E+04	9.48E+02	5.35E+00	1.40E+02	-56
49	Filizola[13]	Juruá	7.70E+04	1.78E+03	1.18E+01	1.53E+02	7.73E+04	2.21E+03	8.42E+00	1.09E+02	-29
50	Filizola[13]	Juruá	1.62E+05	4.75E+03	2.55E+01	1.57E+02	1.65E+05	5.05E+03	2.25E+01	1.36E+02	-12
51	Filizola[13]	Japurá	1.97E+05	1.37E+04	2.64E+01	1.34E+02	2.08E+05	1.24E+04	3.00E+01	1.44E+02	14
52	Filizola[13]	Solimões	1.77E+06	8.40E+04	5.10E+02	2.88E+02	1.79E+06	7.99E+04	4.46E+02	2.50E+02	-13
53	Filizola[13]	Purus	1.53E+05	3.65E+03	1.03E+02	6.71E+02	1.54E+05	3.84E+03	1.51E+01	9.78E+01	-85
54	Filizola[13]	Purus	2.20E+05	5.52E+03	6.84E+01	3.11E+02	2.28E+05	6.00E+03	1.84E+01	8.07E+01	-73
55	Filizola[13]	Cuniua	3.80E+04	1.49E+03	7.44E+00	1.96E+02	3.84E+04	1.26E+03	1.29E+00	3.37E+01	-83
56	Filizola[13]	Purus	3.60E+05	1.07E+04	2.47E+01	6.85E+01	3.69E+05	1.07E+04	1.90E+01	5.16E+01	-23
57	Filizola[13]	Solimões	2.15E+06	9.88E+04	4.03E+02	1.88E+02	2.20E+06	9.26E+04	3.55E+02	1.61E+02	-12
58	Filizola[13]	Negro	6.20E+04	4.84E+03	9.70E-01	1.56E+01	7.43E+04	4.23E+03	1.04E+00	1.41E+01	8
59	Filizola[13]	Içana	2.20E+04	1.88E+03	2.70E-01	1.23E+01	2.37E+04	1.67E+03	1.47E-01	6.20E+00	-45
60	Filizola[13]	Negro	2.80E+05	1.61E+04	3.89E+00	1.39E+01	2.98E+05	1.81E+04	2.85E+00	9.58E+00	-27
61	Filizola[13]	Uraricoera	3.80E+04	1.02E+03	1.00E+00	2.63E+01	3.67E+04	1.15E+03	1.13E+00	3.08E+01	13
62	Filizola[13]	Mucajai	1.40E+04	2.80E+02	3.40E-01	2.43E+01	1.21E+04	3.46E+02	2.73E-01	2.26E+01	-20
63	Filizola[13]	Branco	1.25E+05	2.90E+03	2.74E+00	2.19E+01	1.26E+05	3.62E+03	3.46E+00	2.75E+01	26
64	Filizola[13]	Guaporé	3.00E+03	6.00E+01	2.40E-01	8.00E+01	5.48E+04	5.19E+02	8.50E-01	1.55E+01	254
65	Filizola[13]	Guaporé	1.10E+05	9.10E+02	1.40E-01	1.27E+00	1.10E+05	1.17E+03	1.14E+00	1.04E+01	717
66	Filizola[13]	Mamoré	5.89E+05	8.40E+03	5.65E+01	9.58E+01	6.15E+05	7.45E+03	8.93E+01	1.45E+02	58
67	Filizola[13]	Madeira	9.54E+05	1.94E+04	2.77E+02	2.91E+02	9.82E+05	1.62E+04	2.90E+02	2.96E+02	5
68	Filizola[13]	Pimenta Bueno	1.20E+04	2.10E+02	1.30E-01	1.08E+01	1.01E+04	2.22E+02	2.03E-01	2.01E+01	56
69	Filizola[13]	Jiparana	3.30E+04	7.20E+02	1.53E+00	4.64E+01	3.33E+04	7.54E+02	4.73E-01	1.42E+01	-69
70	Filizola[13]	Aripuanã	1.09E+05	3.38E+03	2.57E+00	2.36E+01	1.31E+05	3.68E+03	8.46E-01	6.44E+00	-67
71	Filizola[13]	Madeira	1.33E+06	3.13E+04	2.44E+02	1.84E+02	1.32E+06	2.67E+04	2.24E+02	1.70E+02	-8
72	Filizola[13]	Mapuera	2.60E+04	7.30E+02	6.00E-01	2.31E+01	2.58E+04	5.91E+02	4.70E-01	1.82E+01	-22
73	Filizola[13]	Erepecuru	3.50E+04	5.20E+02	1.80E-01	5.14E+00	3.48E+04	7.30E+02	3.54E-01	1.02E+01	97
74	Filizola[13]	Amazonas	4.62E+06	1.69E+05	5.56E+02	1.20E+02	4.70E+06	1.68E+05	4.31E+02	9.17E+01	-22
75	Filizola[13]	Maicuru	1.30E+04	1.20E+02	1.20E-01	9.23E+00	1.26E+04	2.12E+02	1.78E-01	1.42E+01	48

76	Filizola[13]	Fresco	4.20E+04	8.30E+02	1.37E+00	3.26E+01	4.25E+04	1.04E+03	6.25E-01	1.47E+01	-54
77	Filizola[13]	Iriri	1.24E+05	2.69E+03	2.56E+00	2.06E+01	1.23E+05	3.79E+03	6.23E-01	5.07E+00	-76
78	Filizola[13]	Xingu	4.46E+05	8.72E+03	5.80E+00	1.30E+01	4.49E+05	1.13E+04	2.59E+00	5.77E+00	-55
79	López[14]	Sinú	1.47E+04	-	3.02E+00	2.05E+02	9.84E+03	5.60E+02	1.76E+00	1.79E+02	-42
80	López[14]	Magdalena	2.57E+05	-	1.41E+02	5.47E+02	2.59E+05	7.51E+03	3.30E+01	1.27E+02	-77

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Table S2. Summary of water and sediment suspended discharge used to the comparison between regional studies and outputs from MGB-SED AS

		WBM-SED[1]	MGB-SED AS	*Diff (%)*	*Daily BIAS (%)*
ID	**River**	**QSS (Mt/year)**	**QSS (Mt/year)**		
67	Madeira	2.43E+02	2.90E+02	-44	-52
71	Madeira	2.38E+02	2.24E+02	-71	-3
21	Solimões	3.43E+02	4.00E+02	-35	5
57	Solimões	4.52E+02	3.55E+02	-76	8
74	Amazonas	5.67E+02	4.31E+02	-83	32
78	Xingu	3.43E+00	2.59E+00	-96	0
23	Paraguai	1.26E+00	9.69E-01	-74	-40
25	Uruguai	3.59E+00	5.91E+00	-73	-7
26	Doce	1.00E+00	8.52E-01	-32	-11
27	Doce	6.21E+00	3.51E+00	-40	-65
29	Doce	1.12E+01	4.68E+00	-45	-8
30	Paraíba do Sul	2.20E-01	2.88E-01	-74	14
31	Paraíba do Sul	1.38E+00	5.75E-01	-81	23
32	Paraíba do Sul	4.35E+00	2.18E+00	-77	1
33	Bogotá	1.30E+00	2.28E-01	-92	-43
34	Saldaña	8.90E+00	4.54E+00	-25	132
35	Nare	2.60E+00	1.32E+00	-21	60
36	Suárez	3.40E+00	1.81E+00	-70	30
37	Sogamo	1.12E+01	5.20E+00	-71	6
41	Bermejo	1.09E+02	2.56E+01	5	42
45	Javari	1.34E+00	1.01E-01	-94	-95
46	Solimões	4.35E+02	4.01E+02	-34	2
47	Solimões	4.73E+02	4.14E+02	-43	8
48	Juruá	1.23E+01	5.35E+00	92	-72
49	Juruá	1.18E+01	8.42E+00	7	-12
50	Juruá	2.55E+01	2.25E+01	58	-44
51	Japurá	2.64E+01	3.00E+01	-82	0
52	Solimões	5.10E+02	4.46E+02	-63	29
53	Purus	1.03E+02	1.51E+01	19	-69
54	Purus	6.84E+01	1.84E+01	14	-47
55	Cuniua	7.44E+00	1.29E+00	31	72
56	Purus	2.47E+01	1.90E+01	-33	-10
58	Negro	9.70E-01	1.04E+00	-97	10
59	Içana	2.70E-01	1.47E-01	-94	-47
60	Negro	3.89E+00	2.85E+00	-97	-25
61	Uraricoera	1.00E+00	1.13E+00	-90	-18
62	Mucajai	3.40E-01	2.73E-01	-90	-49
63	Branco	2.74E+00	3.46E+00	-90	-1
64	Guaporé	2.40E-01	8.50E-01	-84	173
65	Guaporé	1.40E-01	1.14E+00	-90	304
66	Mamoré	5.65E+01	8.93E+01	-71	91
68	Pimenta Bueno	1.30E-01	2.03E-01	-77	-7
69	Jiparana	1.53E+00	4.73E-01	-87	-29
70	Aripuanã	2.57E+00	8.46E-01	-94	-65
72	Mapuera	6.00E-01	4.70E-01	-91	-5
73	Erepecuru	1.80E-01	3.54E-01	-92	66
75	Maicuru	1.20E-01	1.78E-01	-94	-8
76	Fresco	1.37E+00	6.25E-01	-87	21
77	Iriri	2.56E+00	6.23E-01	-95	-17

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Table S3. QSS (Mt/year) for the main South America rivers. Bold values refers to rivers reaching the Ocean.

River	QSS (Mt/year)
Amazon	**436.83**
Madeira	213.40
Marañon	202.12
Ucayali	153.68
Orinoco	**136.97**
Prata	**111.76**
Beni	110.32
Madre de Dios	91.11
Mamoré Grande	84.59
Magdalena	**32.59**
Pilcomayo	25.66
Grande	25.58
Bermejo	24.36
Juruá	22.03
Purus	18.75
Tietê	16.94
Paranaíba	15.68
São Francisco	**7.46**
Tocantins	**7.44**
Negro (Amazon)	7.25
Uruguai	**5.88**
Paraná-Panema	5.53
Iguaçu	5.27
Doce	**5.04**
Guaporé	4.72
Jacuí	**3.70**
Tapajós	3.63
Xingu	3.04
Araguaia	2.44
Paraíba do Sul	**2.15**
Parnaíba	**1.23**
Negro	**0.64**
Salado	**0.55**
Jequitinhonha	**0.54**
Colorado	0.37
Desaguadero Salado	**0.07**

Table S4. Sediment balance for the whole South America and simulation time (1990-2009)

	Input	Deposition	Storage in river reaches	Output	Error (%)
Silt	1.54E+12	1.89E+09	5.16E+07	1.54E+12	5.62E-02
Clay	3.32E+12	2.11E+09	1.53E+08	3.32E+12	2.59E-02

Table S5. Performance analysis for MGB-SED AS for calibration (2002-2009) and non-calibration period (1992-2001), considering temporal and spatial extrapolations. #1 refers to calibration step with selected stations. #2 refers to temporal extrapolation with selected stations of #1 with available data in interval of #2. #3 refer to spatial extrapolation considering selected station of validation step in calibration period. #4 refer to all simulation period with calibration stations. #5, #6 and #7 represent spatial, spatial and temporal and global assessments of MGB-SED AS performance. Many stations do not have data in all simulation period. Results were summarized using median values.

#	Interval	*r*	*NSE*	*BIAS*	Notes
1	2002-2009	0.54	0.02	-11.79	Calib. (77 stations)
2	1992-2001	0.51	0.01	-10.47	Temporal extrap. (65 stations)
3	2002-2009	0.65	-0.03	-35.90	Spatial extrap. (47 stations)
4	1992-2009	0.54	0.08	-2.89	All simulation period (77 stations)
5	2002-2009	0.57	-0.13	-0.04	Spatial extrap. (515 stations)
6	1992-2001	0.49	-0.07	-0.06	Spatial and temporal extrap. (488 stations)
7	1992-2009	0.50	-0.05	-0.76	All simulation period (595 stations)