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Land2Sea database of river drainage basin sizes, annual water discharges, and suspended sediment fluxes

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[1] The Land2Sea database contains data on the sizes of 1519 exorheic river drainage basins (79% of the exorheic land area), annual suspended sediment fluxes (593 rivers, 63% of the exorheic land area), and water discharges (1272 rivers, 76% of the exorheic land area) that have been compiled from a variety of sources. The database extends earlier compilations, such as GEMS/GLORI. The river basins are grouped into 19 large-scale drainage regions to investigate the regional variability in freshwater and sediment fluxes to various ocean basins. The annual suspended sediment flux to the coastal ocean ($\sim$18.5 $\times$ 10^9 tons) is dominated by east Asia (6.1 $\times$ 10^9 tons); Arabia, India, and southeast Asia (4.3 $\times$ 10^9 tons); and eastern South America (2.4 $\times$ 10^9 tons). Small topical islands of Oceania support the highest annual sediment fluxes per drainage area ($\sim$9650 t km^{-2} a^{-1}). Annual freshwater discharge to the coastal ocean ($\sim$38,857 km^3) is dominated by runoff from eastern South America (11,199 km^3); east Asia (7114 km^3); and Arabia, India, and southeast Asia (4384 km^3). The empirical data agree well with results from global models (ART and BQART) that have been trained on a subset of the data compiled here.

Components: 5768 words, 5 figures, 2 tables.

Keywords: river; database; water discharge; runoff; suspended sediment; drainage basin area.

Index Terms: 1819 Hydrology: Geographic Information Systems (GIS); 1836 Hydrology: Hydrological cycles and budgets (1218, 1655); 1860 Hydrology: Streamflow; 1862 Hydrology: Sediment transport (4558); 1879 Hydrology: Watershed.

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1. Introduction

[2] This data compilation (Land2Sea, version 1.0) aims at providing the community with a digital database of important physical characteristics of rivers draining into the ocean. It builds upon existing digital (e.g., World River Sediment Yields Database that is maintained by the FAO of the United Nations and the River Database by the Center for Sustainability and the Global Environment (SAGE) at the Gaylord Nelson Institute for Environmental Studies of the University of Wisconsin–Madison) and analog databases (e.g., GEMS/GLORI [*Meybeck and Ragu*, 1996], Global Composite Runoff Fields [*Fekete et al.*, 2000], BQART database [*Syvitski and Milliman*, 2007], and various Land-Ocean Interactions in the Coastal Zone (LOICZ) reports and studies). The lack of a comprehensive, publicly

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accessible, digital database of important physical parameters leads to wasteful duplication of efforts by other researchers to create useful compilations of data on water discharge and suspended sediment flux to the coastal ocean. Such data are needed to estimate fluxes of land-derived constituents to the coastal ocean. In contrast to some other databases (e.g., World River Sediment Yields Database that is maintained by the FAO of the United Nations) only rivers draining into the oceans and large inland seas (Caspian Sea, Aral Sea) are included in this compilation.

2. Data

[3] Data on 1527 rivers (1519 exorheic) have been compiled from primary as well as secondary [e.g., *Meybeck and Ragu*, 1996; *Syvitski and Milliman*, 2007] sources. A number of online resources (e.g., the eAtlas, Watersheds of the World (http://multimedia.wri.org/watersheds_2003/index.html); the Norway River Report (http://www.nve.no); and the regional maps of UK gauging stations compiled by the Center for Ecology and Hydrology (http://www.nwl.ac.uk/ih/nrfa/station_summaries/map.html)) have been scrutinized for data. All data are referenced to the respective sources, but no effort has been made to trace the data to the original source. The same original estimate therefore may be cited more than once. Whenever possible, predam and postdam estimates are included in the compilation. However, for the estimation of fluxes predam estimates are used whenever possible. No effort other than using available predam estimates has been made to correct for anthropogenic modification of fluxes [e.g., *Hooke*, 2000; *Syvitski et al.*, 2005; *Chao et al.*, 2008; *Syvitski and Kettner*, 2008].

[4] The country where the mouth of the river is located is listed, as is the large-scale drainage region [*Graham et al.*, 1999, 2000] the respective river basin belongs to. The *Graham et al.* [1999, 2000] data provide 5-min (2160 × 4320 grid units) delineations of large-scale drainage basins as Cartesian Geodetic grids, derived from a 5-min global digital terrain model [*Row et al.*, 1995] and additional information from the CIA World Data Bank II [*Gorny and Carter*, 1987]. This data has been used previously to investigate the bedrock geology of the continental surface [*Peucker-Ehrenbrink and Miller*, 2007].

[5] The spelling of names varies significantly for a number of rivers (see *Meybeck and Ragu* [1996] for a discussion). Variations in spelling are indicated with parenthesis. For instance, the Irrawaddy is also known as Ayeyarwady, and the Incomati in Mozambique is also known as Imkomati, Imcomati and Inkomati.

[6] The river mouths are not yet tagged with geographic coordinates. It is therefore possible that a few rivers that are known under very different names are listed more than once.

[7] Sizes of river drainage basins are given in km^2, annual water discharge (runoff) is given in cubic kilometer per year ($km^3\ a^{-1}$) and suspended sediment flux is listed in million metric tons per year ($Mt\ a^{-1}$). The large-scale drainage basins are numbered consecutively from 1 (Russian Arctic) to 19 (Hudson Bay) following the nomenclature of *Graham et al.* [1999, 2000].

3. Results

[8] The full compilation of data and corresponding source references are listed in Data Set S1 and the readme, respectively, in the auxiliary material.[1] Data for the individual drainage regions are summarized in Table 1. If more than one estimate exists for drainage basin area, annual water discharge or annual suspended sediment flux, the respective median values have been used here to estimate regional and global average fluxes, unless predam (natural) estimates are available.

[9] The 1527 drainage basins cover 90,732,057 km^2, equivalent to 75.2% of the total surface area of the 19 large-scale drainage regions. The total exorheic drainage (i.e., drainage to the ocean, without glaciated regions) area based on the *Graham et al.* [1999, 2000] data is 110,095,498 km^2. This value is slightly larger than the exorheic drainage area of 106×10^6 km^2 that *Syvitski et al.* [2005] estimate. Some of the differences may be accounted for by the various corrections made to the drainage area to account for endorheic drainage areas (see Table 1 for details), as well as differences in the delineation of the drainage areas. The 1519 rivers that drain the continents to the ocean cover 86,567,535 km^2 or 78.6% of the exorheic drainage area (Figure 1). *Syvitski et al.* [2005] estimate that 4464 river basins larger than 100 km^2 drain the continents to the sea. This indicates that the 2945 river basins >100 km^2 that are not included in this compilation cover only ~21%, or about 23.5×10^6 km^2 of the global exorheic drainage area. The database is clearly

[1] Auxiliary materials are available at ftp://ftp.agu.org/apend/gc/2008gc002356.

Table 1. Land2Sea Database Summary for 19 Large-Scale Drainage Regions[a]

ID	Drainage Region	A_{dr} (km^2)	A_d (km^2)	N	C_A (%)	S_d (Mt a^{-1})	N	C_S (%)	S_b (Mt a^{-1})	T (Mt km^{-3})	Q_d (km^3 a^{-1})	N	C_Q (%)	Q_b (km^3 a^{-1})	R (cm a^{-1})
1	Russian Arctic	13,087,208	11,444,776	40	87.5	100	22	84.8	118	0.042	2,472	37	87.3	2,833	21.6
2	North American Arctic	3,577,966	2,830,837	18	79.1	335	10	70.1	478	0.552	663	15	76.6	866	24.2
3	eastern North America	9,325,220	7,667,969	107	82.2	491	38	65.2	753	0.272	2,246	96	81.3	2,762	29.6
4	western Europe	1,998,839	1,585,093	246	79.3	32	34	49.1	65	0.077	633	234	74.6	848	42.4
5	eastern South America	16,369,568	14,083,468	100	86.0	1,841	55	77.4	2,378	0.212	9,599	90	85.7	11,199	68.4
6	West Africa	11,261,691	9,712,254	69	86.2	256	24	72.7	352	0.140	2,077	49	82.2	2,510	22.3
7	East Africa	5,701,908	4,823,881	58	84.6	167	12	39.9	419	0.927	359	51	79.4	452	7.9
8	Arabia, India, and SE Asia	9,590,213	5,991,365	62	62.5	2,424	31	56.3	4,304	0.982	2,668	51	60.9	4,384	45.7
9	east Asia	14,073,715	9,585,259	204	68.1	3,563	85	58.5	6,089	0.856	4,629	166	65.1	7,114	50.5
10	western North America	5,405,659	3,806,397	94	70.4	562	57	58.3	965	0.563	1,197	81	69.8	1,715	31.7
11	western South America	1,220,853	661,283	86	54.2	55	6	4.7	1,171	0.925	597	72	47.2	1,266	103.7
12	Australia-NZ	4,701,839	3,744,781	207	79.6	214	92	40.4	530	0.937	369	125	65.1	566	12.0
13	Antarctica (≥60°S)	1,523,722													
14	Mediterranean	5,726,983	4,108,421	123	71.7	442	80	64.7	683	1.217	386	100	69.3	561	9.8
15	Caspian Sea	8,049,943	4,164,523	8	51.7	192	6	39.6	486	0.486	508	6	50.8	1,000	12.4
16	Black Sea	2,453,129	2,175,984	25	88.7	184	19	88.2	209	0.505	365	19	88.2	414	16.9
17	Red Sea	935,189													
18	Baltic Sea	1,846,881	1,553,992	56	84.1	5	24	65.0	7	0.014	426	62	79.8	534	28.9
19	Hudson Bay	3,753,826	2,792,775	24	74.4	2	4	6.5	26	0.032	619	24	74.4	833	22.2
Sum		120,604,352	90,732,057	1527	75.2	10,865	599	60.6	19,034	0.438	29,816	1278	73.0	39,857	32.9
Sum exorheic		110,095,498	86,567,535	1519	78.6	10,673	593	63.4	18,548		29,308	1272	76.2	38,857	35.3
With Oceania islands			86,683,498		78.7	11,820									

[a] Abbreviations are as follows: A_{dr}, total area, in square kilometers, of the respective exorheic drainage region (area 5 has been corrected by subtracting the endorheic drainage area of Lake Titicaca and Salar de Uyuni, area 6 has been corrected by subtracting 2/3 of the endorheic area of North Africa [*Peucker-Ehrenbrink and Miller*, 2007], area 7 has been corrected by subtracting the Okavango drainage area, area 8 has been corrected by subtracting the difference between the endorheic areas of central Asia [*Peucker-Ehrenbrink and Miller*, 2007] and the Caspian Sea (area 15), area 12 has been corrected by subtracting the endorheic areas of central Australia [*Peucker-Ehrenbrink and Miller*, 2007], and area 14 has been corrected by subtracting 1/3 of the endorheic area of North Africa [*Peucker-Ehrenbrink and Miller*, 2007]); A_d, total area of all river drainage basins within the respective drainage region on which the database contains data ($A_d = A_1 + A_2 + \ldots + A_n$); N, number of river basins within the respective drainage region for which the database contains estimates of drainage basin size, annual suspended sediment flux, or annual water discharge (runoff); C_A, percent of total area of drainage region for which the database contains information on drainage basin size ($C_A = A_d/A_{dr}*100$); S_d, best estimate of annual suspended sediment flux, in million metric tons per year, usually the median flux of all individual flux estimates, except when "natural," i.e., prehuman or predam, estimates are available; C_S, percent of total area of drainage basins (A_{dr}) for which the database contains information on annual suspended sediment flux (usually some fraction of A_d); S_b, best estimate of annual suspended sediment flux ($S_b = S_d/C_S*100$); T, turbidity, i.e., concentration of suspended sediment in water, in millions of tons of suspended sediment per cubic kilometer of water ($T = S_b/Q_b$); Q_d, best estimate of annual water discharge (runoff), in cubic kilometers per year, usually the median flux of all individual flux estimates, except when "natural," i.e., prehuman or predam, estimates are available; C_Q, percent of total area of drainage basins (A_{dr}) for which the database contains information on annual water discharge (usually some fraction of A_d); Q_b, best estimate of annual suspended sediment flux ($Q_b = Q_d/C_Q*100$); R, runoff, in cm per year ($R = Q_b/A_{dr}*10^6$). Oceania islands are small islands in the western Pacific for which the Land2Sea database contains sediment fluxes from the entire island, not individual river basins on the islands (lines 927–974 in Data Set S1).

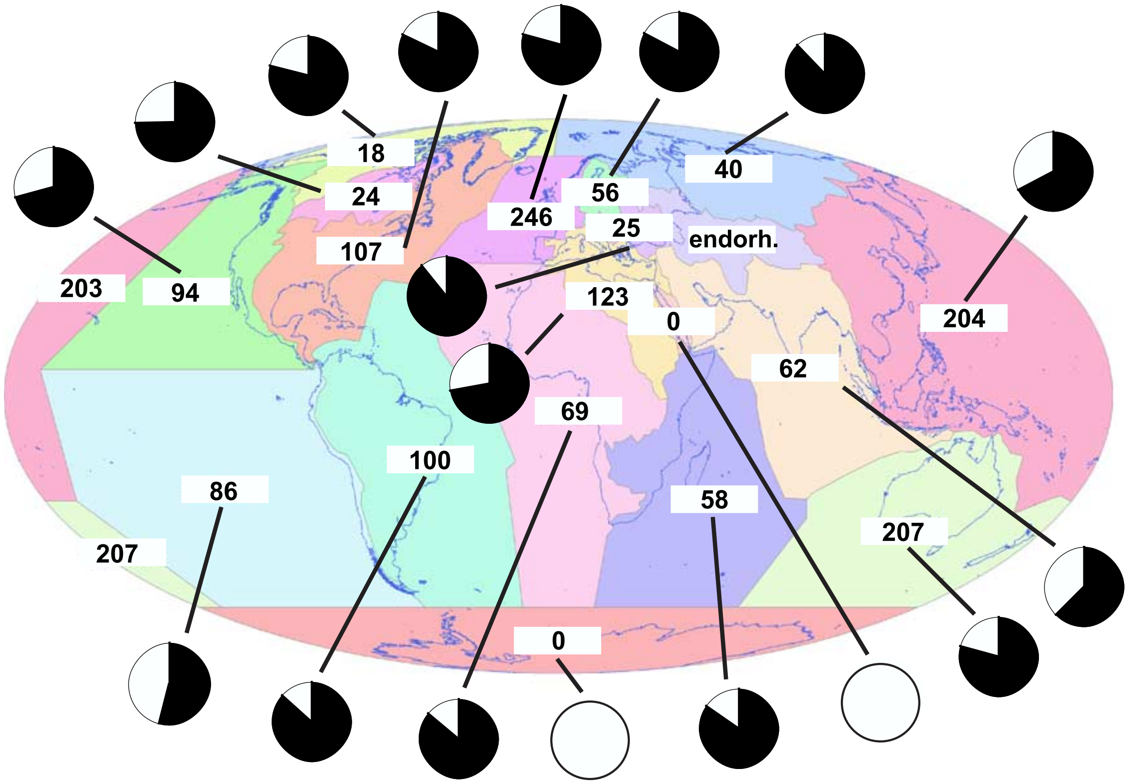

Figure 1. Shown (in color) are the 19 large-scale continental drainage regions including the ocean basins they drain into. The pie diagrams indicate the fraction of the total land area within each drainage region that is covered by river basins listed in the database. For instance, about 88% of the total land area draining the Russian Arctic (medium blue drainage region) is covered by river basins that are part of the database. In contrast, only slightly more than 50% of the area draining the western side of South America into the Pacific Ocean (light blue drainage region) is covered by river basins that are listed in the database. The total number of rivers (1527) included in the database per drainage region is shown.

biased in favor of large drainage basins, whereas small basins draining coastal areas are underrepresented. The regional variations in the degree of completeness of the data are shown in Figure 1 for the 19 large-scale drainage regions.

[10] The 1278 rivers (1272 exorheic drainages) for which the database contains data on annual water discharge (runoff) cover 88,001,591 km^2 (83,913,219 km^2), or 73.0% (76.2%) of the continental drainage. The completeness of the area coverage in each of the 17 drainage regions for which data on water discharge exist (not considering Antarctica and the Red Sea drainage for which the database contains no entries) varies from a minimum of 47.2% (western South America) to a maximum of 88.2% (Black Sea). The number of exorheic river basins that characterize water discharge from each region varies from 15 for the North American Arctic to 234 for Western Europe (Figure 2).

[11] The 599 (593 exorheic) drainages for which the database lists estimates of the annual suspended sediment fluxes cover 73,042,176 km^2 (69,854,441 km^2) or 60.6% (63.4%) of the continental drainage. Regional area coverage varies from only 4.7% for western South America to 88.2% for the Black Sea drainage. The number of rivers that characterize suspended sediment fluxes from each drainage region varies from 4 for the Hudson Bay to 92 for Australia and New Zealand (Figure 3).

4. Discussion: Global and Regional Estimates of Runoff and Suspended Sediment Load

[12] The data is used to reassess the total fluxes of river water and suspended sediment from land to sea. This is done by assuming that the data for each drainage region is representative of the total surface area of the respective drainage region. The annual

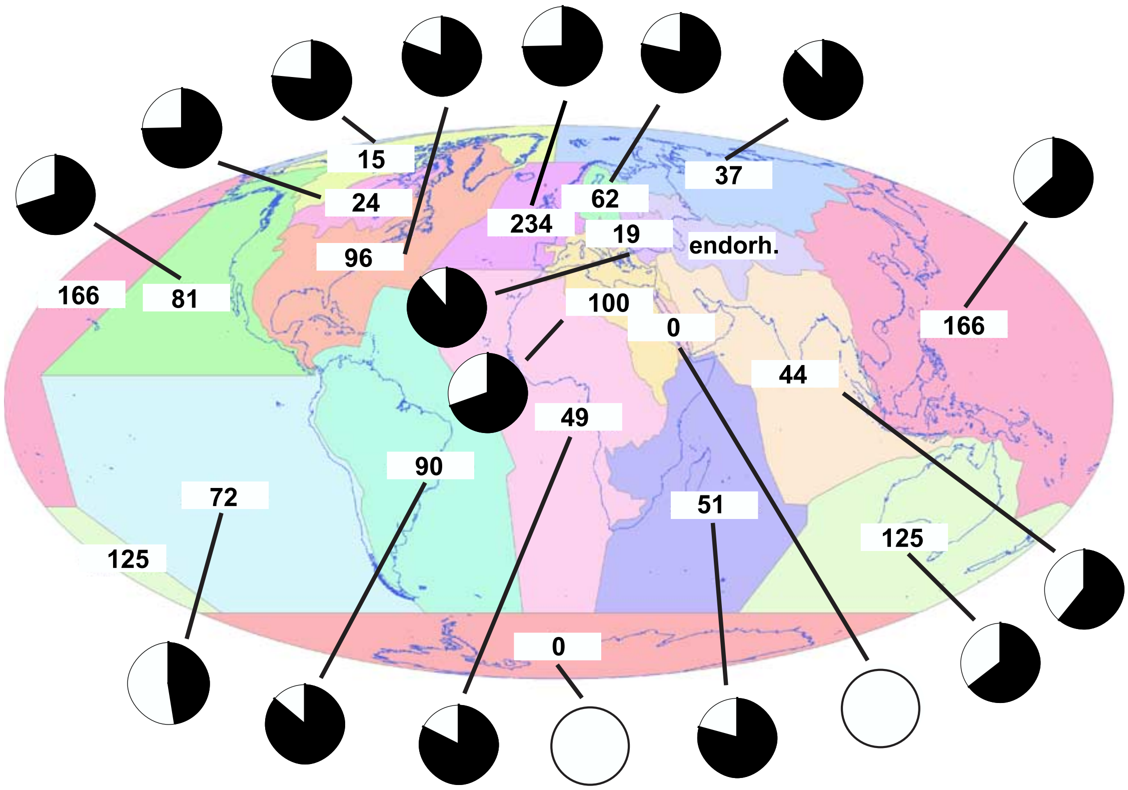

Figure 2. Shown is the fraction of the total area of each drainage region that is covered by river basins that have been characterized with respect to annual runoff. The total number of rivers (1278) with data on annual runoff is shown. While runoff from many regions is well characterized, the database contains runoff information on less than 50% of the area draining the western side of the Andes. No information is available for runoff into the Red Sea. The total annual runoff from each drainage region is shown in Figure 4.

water discharge and suspended sediment flux for the fraction of the total drainage area for which the database contains estimates is extrapolated to the total area of the respective drainage region (see Table 1 for details). The extent of the extrapolation depends on the fraction of the drainage regions that has been characterized with respect to water discharge (see Figure 2) and suspended sediment flux (see Figure 3).

[13] The annual water discharge from each drainage region is shown in Figure 4. These estimates do not include subterranean influx of freshwater from the continents into the coastal oceans [*Moore*, 1996]. The global water discharge is dominated by runoff from eastern South America (11,199 km^3 a^{-1}); east Asia (7114 km^3 a^{-1}); and Arabia, India, and southeast Asia (4384 km^3 a^{-1}). Regional variations in runoff range from 7.9 cm a^{-1} (East Africa) to 103.7 cm a^{-1} (western South America). Of the annual global river water discharge of 39,857 km^3, 38,857 km^3 reach the ocean.

[14] The annual suspended sediment flux from each drainage region is shown in Figure 5. These estimates do not include the bed load for which the database contains no estimates. On the basis of the study by *Syvitski and Saito* [2007] bed load accounts for about 6.6% of the total sediment flux. Of the 19,034 Mt a^{-1} suspended sediment, 18,548 Mt a^{-1} reach the coastal oceans. Sediment input is dominated by erosion from east Asia (6089 Mt a^{-1}); Arabia, India, and southeast Asia (4304 Mt a^{-1}); and eastern South America (2378 Mt a^{-1}). The sediment yield (flux per area) is highest for the small tropical islands of Oceania (9646 t km^{-2} a^{-1}) that are not included in the suspended sediment flux estimate for drainage region 9 (east Asia). It should be noted that the data used for Oceania are identical to that of *Kjerfve et al.* [2002], which are based on data from *Asquith et al.* [1994]. However, the definition of Oceania used here does not include the mainland provinces of Papua New Guinea. It should also be noted that for some areas (Hudson Bay, western South America) the extrapolations

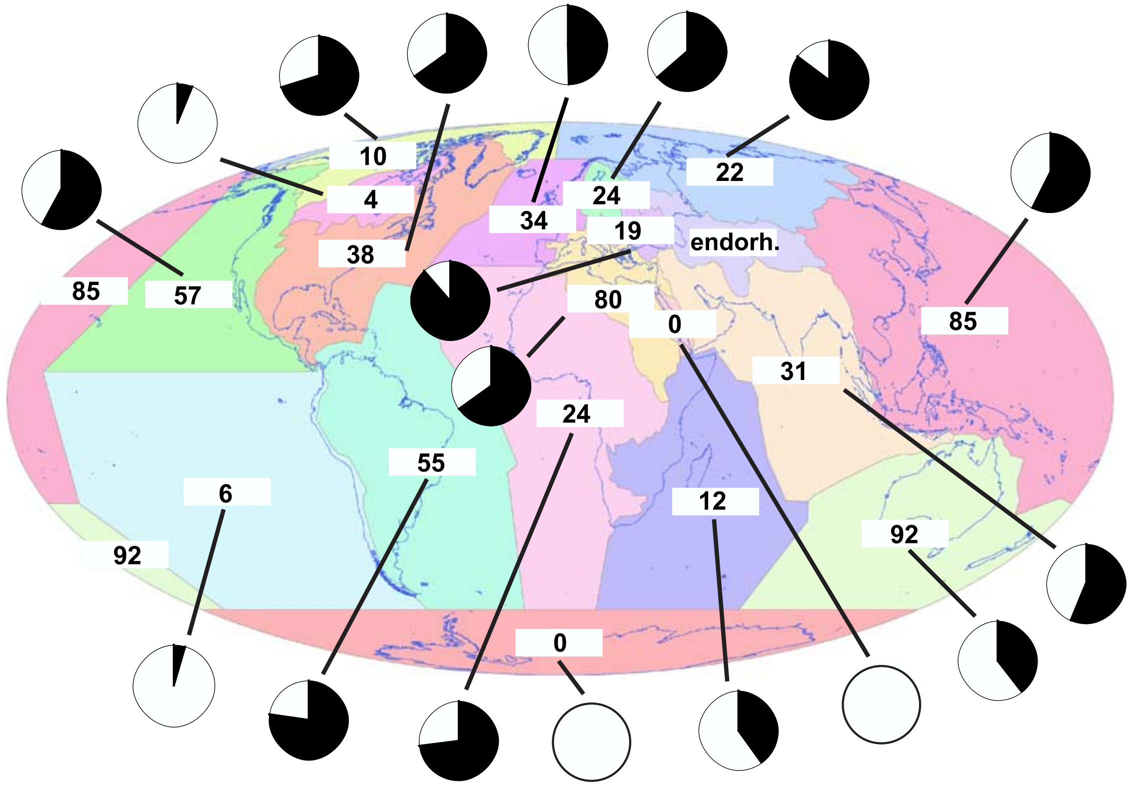

Figure 3. The database contains data on the annual suspended load of 599 rivers, i.e., not quite 40% of the rivers in the database. Accordingly, the regional data coverage is uneven. The pie diagrams show the fraction of the area of each drainage region that is characterized with respect to annual suspended sediment load. While suspended sediment delivery to the Russian Arctic is well characterized (medium blue region), detrital sediment input from the western slopes of the Andes into the eastern Pacific Ocean (light blue region) is based on data from only six rivers. Similarly, detrital sediment input into the Hudson Bay (pink area) is based on estimates from only four rivers.

made using the above approach are large. For instance, the documented sediment flux from western South America is based on only six rivers that yield 55 Mt a^{-1}. Assuming that these six river basins are representative of runoff from western South America, the total flux calculated for this region is 1171 Mt a^{-1}, equivalent to an average suspended sediment yield of 959 t km^{-2} a^{-1}. Although more estimates are needed for this (and some other) drainage regions, the sediment yield for western South America is comparable to the value of 1260 t km^{-2} a^{-1} that *Restrepo and Kjerfve* [2000] estimated for the Colombian Andes. It is unclear whether the bias against small coastal drainage basins introduces systematic bias in sediment flux estimates: one could argue that such rivers are mostly low-lying and lacking steep upland terrains that are particularly productive in generating suspended sediment, causing extrapolated sediment fluxes to be too high. However, small coastal basins also dominate smaller, high-standing ocean islands and active margins that generate prodigious amounts of sediment. Missing data for 2945 river basins that cover ~21% of the exorheic land area may thus not significantly bias estimates of the suspended sediment flux to the coastal oceans. Regional suspended sediment yields vary from ~4 t km^{-2} a^{-1} (Baltic Sea) to ~959 t km^{-2} a^{-1} (western South America), with an average (exorheic) value of 168 t km^{-2} a^{-1}. Assuming a bedrock density of 2.5 g cm^{-3}, such yields correspond to physical (suspended sediment only) denudation rates between 1.6 m Ma^{-1} (Baltic Sea) and 384 m Ma^{-1} (western South America), with a global (exorheic) average value of 67 m Ma^{-1} that is two to three times as high as the Phanerozoic average [cf. *Wilkinson*, 2005].

[15] The results obtained using the above approach can be compared with estimates that are derived from models of water discharge and suspended sediment flux that have been trained on observed runoff and sediment flux data [*Syvitski et al.*, 2005; *Syvitski and Milliman*, 2007; *Syvitski and Kettner*, 2008].

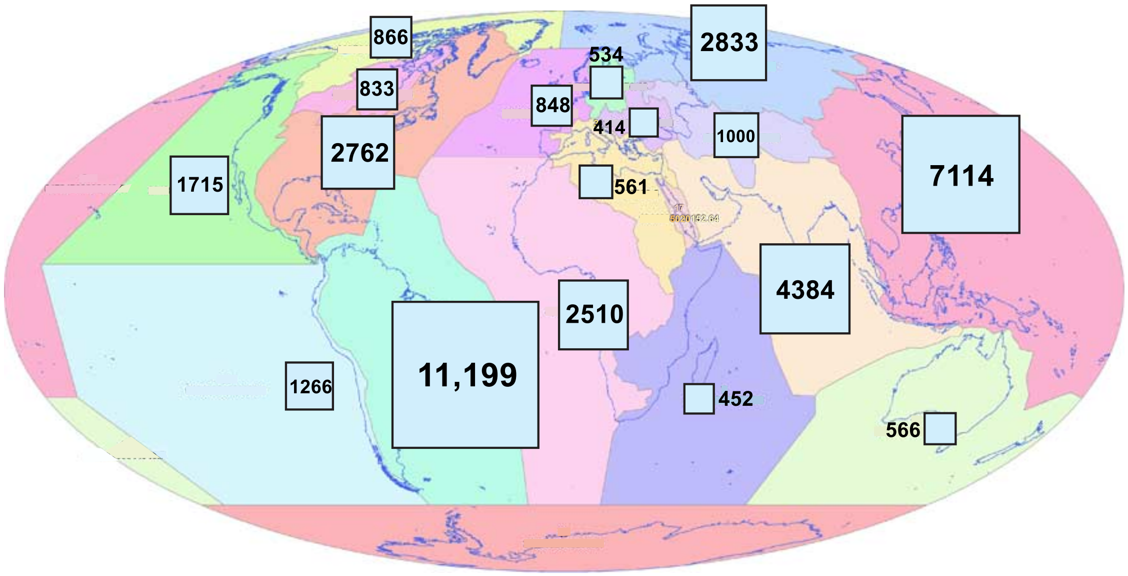

Figure 4. The global annual runoff into the oceans ($\sim$38,500 km^3) is dominated by runoff into the South Atlantic from eastern South America (11,119 km^3), into the western Pacific from east Asia (7114 km^3), and into the Indian Ocean from Arabia, India, and southeast Asia (4384 km^3). The sizes of the boxes are proportional to the fluxes. Depending on the estimate, the Amazon River alone accounts for 15–18% of the annual freshwater runoff into the oceans. Not shown are intra-annual variations in runoff that are substantial for high-latitude rivers (Russian and American Arctic, Hudson Bay, and Baltic Sea) and regions dominated by strong seasonal precipitation (e.g., monsoon).

The recently updated Simulated Topological Network at 30 min resolution (STN-30p) provides the terrain database for the *Syvitski et al.* [2005] ART model and the expanded BQART model of *Syvitski and Milliman* [2007] and *Syvitski and Kettner* [2008]. The water balance and transport model (WBM/WTM) that has been developed at the University of New Hampshire has been used by these models to estimate discharge. The models have been trained and optimized on empirical data from 663 gauging stations from the archive of the Global Runoff Data Center (GRDC). These stations characterize 76,000,000 km^2 of the exorheic drainage. Details on the method for calculating terrestrial sediment fluxes are given in the online supporting material of *Syvitski et al.* [2005] and *Syvitski and Milliman* [2007] as well as *Syvitski and Kettner* [2008]. A significant fraction of the data used in those studies has been included in the Land2Sea database, resulting in a significant overlap in the physical databases used here and by *Syvitski et al.* [2005], *Syvitski and Milliman* [2007], and *Syvitski and Kettner* [2008]. Owing to the different definition of large-scale drainage regions in this and the modeling studies, several large-scale drainage regions used in this study have to be combined in order to approximate some of the definitions used by *Syvitski et al.* [2005]. For instance, the landmass of North America [*Syvitski et al.*, 2005; *Syvitski and Kettner*, 2008] is compared to the sum of drainage regions 2 (North American Arctic), 3 (eastern North America), 10 (western North America) and 19 (Hudson Bay). Similarly, the landmass of South America [*Syvitski et al.*, 2005; *Syvitski and Kettner*, 2008] is compared to the sum of drainage regions 5 (eastern South America) and 11 (western South America). The landmass Australasia [*Syvitski et al.*, 2005; *Syvitski and Kettner*, 2008] is assumed to be identical to drainage region 12 (Australia–New Zealand). These matches are not necessarily perfect, as indicated by the difference in total surface area listed in Table 2, but they are reasonably similar to allow a general comparison between this data compilation and model results [*Syvitski et al.*, 2005; *Syvitski and Milliman*, 2007; *Syvitski and Kettner*, 2008].

[16] The results of the comparison are shown in Table 2. The exorheic suspended sediment flux calculated here (18,548 Mt a^{-1}) is slightly lower than the previous estimate of 20,000 Mt a^{-1} by *Milliman and Syvitski* [1992]. However, it is higher than the estimate for a modern, dam-free world of 16,200 Mt a^{-1} (17,800 Mt a^{-1} including bed load), and a prehuman estimate of 14,030 Mt a^{-1} [*Syvitski et al.*, 2005]. Using the BQART model, *Syvitski and Kettner* [2008] estimate modern and prehuman global suspended sediment fluxes at 12,838 and 20,617 Mt a^{-1}. The total annual exorheic water

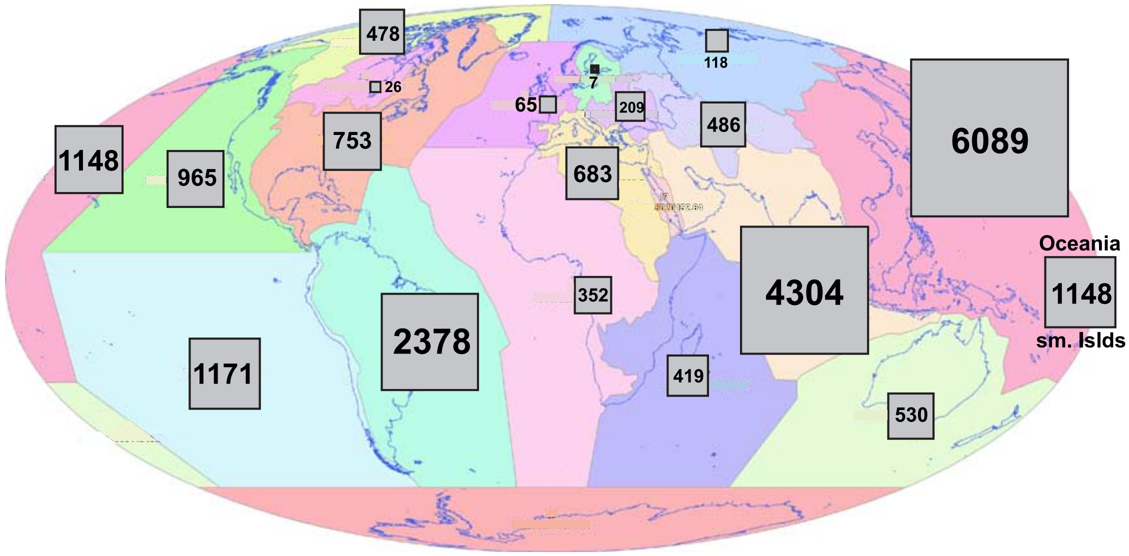

Figure 5. The global input of suspended sediment to coastal oceans is dominated by input from east Asia into the western Pacific (6089 million tons (Mt)), followed by input from Arabia, India, and southeast Asia into the Indian Ocean (4304 Mt). Normalized to drainage basin area, suspended sediment yields are highest for high-standing tropical ocean islands of Oceania (9650 t km^{-2} a^{-1} [*Asquith et al.*, 1994]). The sizes of the boxes are proportional to the fluxes.

discharge of 38,857 km^3 estimated here is virtually identical to the values of 38,540 km^3 and 38,510 km^3 estimated by *Syvitski et al.* [2005] and *Syvitski and Kettner* [2008], respectively. The degree of agreement between basin area, water and sediment fluxes estimated here with those of *Syvitski et al.* [2005] and *Syvitski and Kettner* [2008] varies between regions. For instance, while the agreement is good for the water discharge into the Arctic Ocean (drainage regions 1 and 2), agreement is poor for the modern sediment fluxes from South America (drainage regions 5 and 11) and Australasia (drainage region 12). The eastern side of the South American drainage is well characterized in

Table 2. Comparison of Fluxes Estimated Using the Land2Sea Database and Recent Flux Models[a]

Drainage Region	A_{dr} (10^6 km^2)	Q_b (km^3 a^{-1})	S_m (Mt a^{-1})	S_p (Mt a^{-1})	S_b (Mt a^{-1})	Reference
Australasia	4	610	390 ± 40	420 ± 100		*Syvitski et al.* [2005]
		608	225	300		*Syvitski and Kettner* [2008]
Region 12	4.7	566			530	this study
North America	21	5,820	1910 ± 250	2350 ± 610		*Syvitski et al.* [2005]
		5,819	1357	2130		*Syvitski and Kettner* [2008]
Regions 2, 3, 10, and 19	22.1	6,247			2222	this study
South America	17	11,540	2450 ± 310	2680 ± 690		*Syvitski et al.* [2005]
		11,529	2738	5582		*Syvitski and Kettner* [2008]
Regions 5 and 11	17.6	12,464			3549	this study
Arctic Ocean	17	3,570	420 ± 60	580 ± 120		*Syvitski et al.* [2005]
Regions 1 and 2	16.7	3,699			596	this study
Mediterranean and Black seas	8	710	480 ± 60	890 ± 280		*Syvitski et al.* [2005]
Regions 14 and 16	8.2	975			892	this study
Global	106	38,540	12,610	14,030		*Syvitski et al.* [2005]
Global		38,510	12,838	20,617		*Syvitski and Kettner* [2008]
Global					20,000	*Milliman and Syvitski* [1992]
Global, without reservoirs			16,200			*Syvitski et al.* [2005]
All regions except 13, 15, and 17	110.1	38,857			18,548	this study

[a] *Syvitski et al.* [2005] and *Syvitski and Kettner* [2008]. Abbreviations used are identical to those in Table 1 except for the following: S_m, "modern" estimates of *Syvitski et al.* [2005]; S_p, "prehuman" estimates of *Syvitski et al.* [2005]; S_b, the "best" flux estimate determined by extrapolating data from the Land2Sea database to the entire surface area of the respective large-scale drainage region (A_{dr}).

this database (Figures 2 and 4). It is thus probable that the observed bias is caused by the overestimation of the suspended sediment flux from western South America, for which data on only six rivers draining the wetter central and southern Chile as well as the Colombian Andes is included in the database. These six rivers cover less than 5% of the drainage region and are used to characterize the entire drainage area of western South America. In general, sediment flux estimates calculated here are more similar to the prehuman suspended sediment fluxes of *Syvitski et al.* [2005] and *Syvitski and Kettner* [2008].

[17] The generally good agreement between this empirical data set and previous model results is reassuring. It is therefore informative to also evaluate important geologic parameters that have been determined for the 19 large-scale drainage regions, particularly the age of the bedrock [*Peucker-Ehrenbrink and Miller*, 2007]. The age estimates derived with an exponential age model are used for this comparison, because for digital maps of lower resolution such as the digital geologic map of the world used here [*Commission for the Geologic Map of the World*, 2000] the "exponential" age estimates agree better with the "linear" age estimates that have been derived from higher-resolution digital geologic maps [*Peucker-Ehrenbrink and Miller*, 2007]. The mean "exponential" age of continental bedrock (without Antarctica and the Red Sea drainage), weighted according to land area, is 445 Ma. If the mean bedrock ages of the large-scale continental drainage regions are weighted according to the area of river basins that are included in the Land2Sea database the mean bedrock age is 453 Ma. The good agreement between these age estimates is another indication that the Land2Sea database does not suffer from large regional biases.

[18] If the mean bedrock ages of the large-scale drainage regions are weighted according to the respective annual water discharge from each drainage region (Q_b in Table 1), the mean age of the bedrock is 394 Ma compared to a nonweighted mean bedrock age of 445 Ma. The offset of ~50 Ma to younger ages suggests that there is only a slight preference for younger bedrock with respect to water discharge from the continents. In contrast, if the ages of the large-scale drainage regions are weighted according to their respective annual suspended sediment flux (S_b in Table 1), the mean age of the eroding surface is 320 Ma, more than 120 Ma younger than the area-weighted mean bedrock age of the nonglaciated continental surface. This age bias of detrital matter transported by rivers to the sea reflects the disproportionate delivery of detrital matter from young terrains, such as active continental margins and ocean islands. The mean "bedrock age" (i.e., stratigraphic age of sediments, intrusive age of plutonic rocks, eruptive age of volcanic rocks, and the age of the last major metamorphic overprint of metamorphic rocks) of the suspended sediment that is being delivered to the ocean is likely significantly younger than 320 Ma, because young sedimentary and volcanic rocks that make up significant fractions of the large-scale drainage regions weather more easily than igneous and metamorphic rocks. As we lack quantitative data on preferential weathering of certain lithologies, this effect has not been taken into account in the calculation of mean bedrock ages of suspended particulate matter.

5. Summary

[19] The good agreement between estimates of water discharge and suspended sediment flux that are based on this compilation of empirical data with those that are based on global flux models [*Syvitski et al.*, 2005; *Syvitski and Milliman*, 2007; *Syvitski and Kettner*, 2008] emphasizes the value of this database for estimating fluxes of elements and their isotopes to the coastal ocean. In addition to providing digital data on river basin size, annual water discharge and suspended sediment flux, this compilation identifies regions that are not adequately characterized with respect to water discharge and/or suspended sediment flux (e.g., Hudson Bay, western South America). The difference in mean bedrock ages between the dissolved and detrital loads implies that chemical and isotopic tracers of the dissolved and particulate river loads carry different, but complementary information on continental bedrock that supplies material to the coastal oceans.

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