Supplementary Information

Supplementary Table 1. Parameters used for computing the advection length-scale in Figure 4 of main text.

Name of phenomenon	L [m]	u [m s^{-1}]	h [m]	q [m^2 s^{-1}]	r_0 [-]	D_{50} [mm]	w_s [mm s^{-1}]	u_* [mm s^{-1}]	Reference
Step-pools	0.6-1.0	-	-	0.4-0.66	10	21	1021	185.3-225.8	(1)
Gravel cluster	0.4-0.7	0.02-1.23	3.12-22	0.4-3.85	9.25-9.98	45-105	1388-2112	606-881.4	(2)
Alternate bars	1.2-3.8	0.68-0.97	0.01-0.035	0.0067-0.0349	9.99	1.3	225.3	34.6-45.3	(3)
Pool-riffle	6.7	1.8	3	5.39	10	60	1579	230.0	(4)
Cyclic step[c]	2000-6100	3.5	20	70	1.97[a]	0.07	5.8	-	(5)
Subaqueous bedforms	0.5-6	0.36-0.64	0.4-0.95	0.13-0.97	8.2-9.8	0.12-0.24	25-41	17.4-31.3	(6)
	0.71-1.5	0.5-0.75	0.15-0.9	0.075-0.54	6.2-9.7	0.43-0.86	76-148	48.5-157.2	(7)

	0.2-0.3	0.33-0.435	0.13-0.2	0.0435-0.087	8.25-9.45	0.37	64.4	37.4-54.2	(8)
Megaripples	27-290	20	300	6000	10	1000	21850	171.6	(9)
Hydraulic jump	1.0	-	-	3.3×10^{-3}	1.0	$0.005-0.07\times10^{-3}$	0.02-3.7	4-16	(10)
Plunging plumes	0.5	-	-	$10^{-3} – 4\times10^{-3}$	1.5[a]	$6.7-10.4\times10^{-3}$	0.44	-	(11)
Washed-out ripples	0.10 – 0.14	0.74-0.85	0.39-0.40	0.30-0.33	2.0-2.8[a]	0.108	8.2	-	(12)
Meanders	3.0	0.22	0.015	3.3×10^{-3}	9.97	0.51	92.7	28.4	(13)
	5.6	0.236	0.019	4.5×10^{-3}	9.96	0.5	90.7	29.3	(14)
Wave ripples	0.07-0.13	0.15-0.22	0.3	0.045-0.066	4.6-20[a]	0.07	5.8	47.9-106.1	(15)
High-density suspension	4.9[d]	0.15-0.22	0.3	0.045-0.066	1.4-6[a]	0.026	0.94	47.9-106.1	(15)
Floodplain[f]	-	1	3-5	3-5	1	0.05	3.2	3.43	(16)

Wind dunes[b]	40-100	-	-	-	-	-	-	-	(17)
Dunes, Mars[b]	200	-	-	-	-	-	-	-	(17)
Dunes, Titan[b]	2300-3300	-	-	-	-	-	-	-	(17)
Dunes, Venus[b]	500	-	-	-	-	-	-	-	(17)
Draas, Earth[b]	2000	-	-	-	-	-	-	-	(17)
Mississippi delta	490000	-	-	44.61	7[e]	0.3	49.9	49.9	(18, 19)
Parana delta	210000			17.95	7[e]	0.37	64.4	64.4	(18, 20)
Nile delta	210000			36.67	7[e]	0.2	29.3	29.3	(18, 21)
Orinoco delta	78000			12.275	7[e]	0.6	110.1	110.1	(18, 22)
Amazon delta	404000			15.93	7[e]	0.1	1.2	1.2	(18, 23)

[a]Calculated from reported vertical profiles of sediment concentration. All other values of r_0 were computed assuming a Rouse profile.

[b]Advection length scale was assumed to be equal to the saltation length scale reported by *Grotzinger et al.*[17].

[c]Hydraulic parameters correspond to the numerical model of *Fildani et al.*[5].

[d]Length of the experimental flume was used as the length scale of interest *L*.

[e]The ratio u_*/w_s was assumed to be equal to 1 for all the deltaic systems, which yielded a r_0 value of ~7.

[f]Because of the lack of a periodic length scale, the length of the landform for the floodplains was arbitrarily chosen to be a very small value, which was plotted at the left most end of the x-axis on Figure 4.

Supplementary note 1

The analysis presented in the main text is limited to depositional landforms and alluvial beds that are not limited by sediment supply, where equation (1a) is a common approximation for modeling bedload transport at scales much larger than the saltation hop length[24]. For depositional systems $q_s > q_{sc}$ (equation 1) and, therefore, given some bound on q_s from upstream, q_{sc} cannot get infinitely large as l_a increases. In contrast, for erosional systems $q_s < q_{sc}$ (equation 1) and q_{sc} may grow with increasing l_a, and depending on the degree of linearity between q_{sc} and l_a, q_{sc} may not be equal to q_{s0} for infinitely large l_a. Thus, our analysis is limited to depositional systems, and may not necessarily apply to erosional systems (this scaling will depend on the actual entrainment law and its relation to l_a for erosional systems).

To provide a historical context, Exner[25, 26] was the first to develop equation (1a) where he assumed that deposition and erosion rates are a function of the gradient in fluid velocity and it was not until Einstein[27] that equation (1b) was developed. Equation (1b) is an exact form of mass balance while equation (1a) is an approximation and until now the choice of between equations (1a) and (1b) was made rather arbitrarily – with equation (1a) usually applied to bedload transport problems and equation (1b) used for suspension load. Our analysis suggests that the approximation of equation (1a) is only valid over length scales larger than the advection length-scale l_a.

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