8 Supplementary Material

- Supplementary Table 1 - List of experiments and experimental settings (SupplementaryMaterialExperimentListOUAU.xlsx)

Supplementary Information - "The dynamics of CO_2-driven granular flows in gullies on Mars
List of experiments and experimental settings
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Notes:
Only experiments presented in the manuscript are presented here.
Experiments were numbered based on the order of execution but are organised here in logical order concerning the tested parameter space.
Not all experiments that were executed are presented in the manuscript, therefore some numbers are "missing" in this list.
The small-scale and large-scale experiments were numbered seperately.

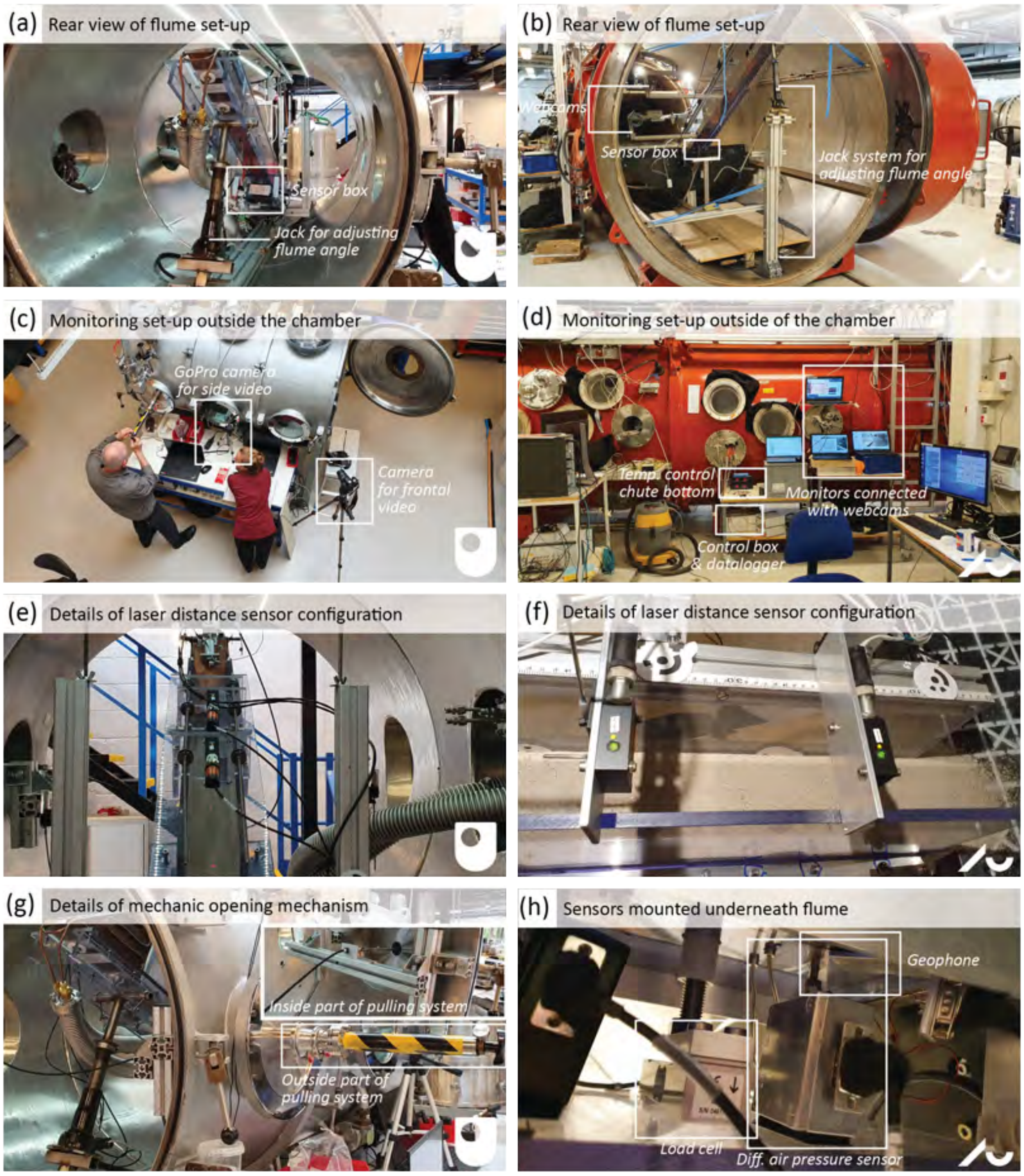
Small scale experiments - Open University, Milton Keynes, United Kingdom

date	exp nr.	CO2 ice volume (m3)	CO2 ice weight (kg)	Sediment volume (m^3)	Sediment weight (kg)	Volume frac CO2	Total volume (m3)	Total weight (kg)	Chamber pressure (mbar)	Temp chute bottom	Flume angle (degrees)	Silver sand (kg)	Builders sand (kg)	Slope chute (de	Slope outflow plain (deg	Notes
Different CO2 fractions																
28-9-2021	18	0.00000	0.00	0.00038	1	0.00	0.00038	1.0	7-8.3	20	30	0.6	0.4	30	12	
6-10-2021	51	0.00000	0.00	0.00038	1	0.00	0.00038	1.0	7-8.3	20	30	0.6	0.4	30	12	Triggered record to early, so no channel data
6-10-2021	52	0.00000	0.00	0.00038	1	0.00	0.00038	1.0	7-8.3	20	30	0.6	0.4	30	12	
24-9-2021	9	0.00006	0.10	0.00038	1	0.14	0.00044	1.1	7-8.3	20	30	0.6	0.4	30	12	
24-9-2021	10	0.00006	0.10	0.00038	1	0.14	0.00044	1.1	7-8.3	20	30	0.6	0.4	30	12	
27-9-2021	11	0.00006	0.10	0.00038	1	0.14	0.00044	1.1	7-8.3	20	30	0.6	0.4	30	12	
28-9-2021	20	0.00006	0.10	0.00038	1	0.14	0.00044	1.1	7-8.3	20	30	0.6	0.4	30	12	
15-10-2021	73	0.00013	0.20	0.00038	1	0.25	0.00050	1.2	7-8.3	20	30	0.6	0.4	30	12	Slope heaters were off, and no frontal movie
15-10-2021	74	0.00013	0.20	0.00038	1	0.25	0.00050	1.2	7-8.3	20	30	0.6	0.4	30	12	
15-10-2021	75	0.00013	0.20	0.00038	1	0.25	0.00050	1.2	7-8.3	20	30	0.6	0.4	30	12	
15-10-2021	76	0.00013	0.20	0.00038	1	0.25	0.00050	1.2	7-8.3	20	30	0.6	0.4	30	12	
29-9-2021	22	0.00019	0.30	0.00038	1	0.33	0.00056	1.3	7-8.3	20	30	0.6	0.4	30	12	
24-9-2021	7	0.00019	0.30	0.00038	1	0.33	0.00056	1.3	7-8.3	20	30	0.6	0.4	30	12	
24-9-2021	8	0.00019	0.30	0.00038	1	0.33	0.00056	1.3	7-8.3	20	30	0.6	0.4	30	12	
15-10-2021	77	0.00025	0.40	0.00038	1	0.40	0.00063	1.4	7-8.3	20	30	0.6	0.4	30	12	
15-10-2021	78	0.00025	0.40	0.00038	1	0.40	0.00063	1.4	7-8.3	20	30	0.6	0.4	30	12	Forgot to take photos, so no T1
18-10-2021	79	0.00025	0.40	0.00038	1	0.40	0.00063	1.4	7-8.3	20	30	0.6	0.4	30	12	
18-10-2021	80	0.00025	0.40	0.00038	1	0.40	0.00063	1.4	7-8.3	20	30	0.6	0.4	30	12	
18-10-2021	81	0.00031	0.50	0.00038	1	0.45	0.00069	1.5	7-8.3	20	30	0.6	0.4	30	12	
18-10-2021	82	0.00031	0.50	0.00038	1	0.45	0.00069	1.5	7-8.3	20	30	0.6	0.4	30	12	
18-10-2021	83	0.00031	0.50	0.00038	1	0.45	0.00069	1.5	7-8.3	20	30	0.6	0.4	30	12	
18-10-2021	84	0.00031	0.50	0.00038	1	0.45	0.00069	1.5	7-8.3	20	30	0.6	0.4	30	12	
27-9-2021	12	0.00038	0.60	0.00038	1	0.50	0.00075	1.6	7-8.3	20	30	0.6	0.4	30	12	
27-9-2021	13	0.00038	0.60	0.00038	1	0.50	0.00075	1.6	7-8.3	20	30	0.6	0.4	30	12	
27-9-2021	14	0.00038	0.60	0.00038	1	0.50	0.00075	1.6	7-8.3	20	30	0.6	0.4	30	12	
Different chute slopes																
30-9-2021	27	0.00019	0.30	0.00038	1	0.33	0.00056	1.3	7-8.3	20	20	0.6	0.4	20	12	No videos from front
30-9-2021	28	0.00019	0.30	0.00038	1	0.33	0.00056	1.3	7-8.3	20	20	0.6	0.4	20	12	
30-9-2021	29	0.00019	0.30	0.00038	1	0.33	0.00056	1.3	7-8.3	20	20	0.6	0.4	20	12	
5-10-2021	40	0.00019	0.30	0.00038	1	0.33	0.00056	1.3	7-8.3	20	25	0.6	0.4	25	12	
5-10-2021	41	0.00019	0.30	0.00038	1	0.33	0.00056	1.3	7-8.3	20 surf		0.6	0.4	25	12	
5-10-2021	42	0.00019	0.30	0.00038	1	0.33	0.00056	1.3	7-8.3	20	25	0.6	0.4	25	12	
Earth atmospheric conditions																
28-9-2021	16	0.00000	0.00	0.00038	1	0.00	0.00038	1.0	1022	20	30	0.6	0.4	30	12	
28-9-2021	17	0.00000	0.00	0.00038	1	0.00	0.00038	1.0	1022	20	30	0.6	0.4	30	12	
29-9-2021	21	0.00000	0.00	0.00038	1	0.00	0.00038	1.0	1022	20	30	0.6	0.4	30	12	
29-9-2021	23	0.00006	0.10	0.00038	1	0.14	0.00044	1.1	1022	20	30	0.6	0.4	30	12	
29-9-2021	24	0.00006	0.10	0.00038	1	0.14	0.00044	1.1	1022	20	30	0.6	0.4	30	12	
28-9-2021	15	0.00019	0.30	0.00038	1	0.33	0.00056	1.3	1022	20	30	0.6	0.4	30	12	
28-9-2021	19	0.00019	0.30	0.00038	1	0.33	0.00056	1.3	1022	20	30	0.6	0.4	30	12	
29-9-2021	25	0.00038	0.60	0.00038	1	0.50	0.00075	1.6	1022	20	30	0.6	0.4	30	12	
29-9-2021	26	0.00038	0.60	0.00038	1	0.50	0.00075	1.6	1022	20	30	0.6	0.4	30	12	
Other sediments																
8-10-2021	57	0.00019	0.30	0.00038	1	0.33	0.00056	1.3	7-8.3	20	30	0	1	30	12	
8-10-2021	60	0.00019	0.30	0.00038	1	0.33	0.00056	1.3	7-8.3	20	30	0	1	30	12	
11-10-2021	61	0.00019	0.30	0.00038	1	0.33	0.00056	1.3	7-8.3	20	30	0	1	30	12	
7-10-2021	56	0.00019	0.30	0.00038	1	0.33	0.00056	1.3	7-8.3	20	30	1	0	30	12	
8-10-2021	58	0.00019	0.30	0.00038	1	0.33	0.00056	1.3	7-8.3	20	30	1	0	30	12	
8-10-2021	59	0.00019	0.30	0.00038	1	0.33	0.00056	1.3	7-8.3	20	30	1	0	30	12	

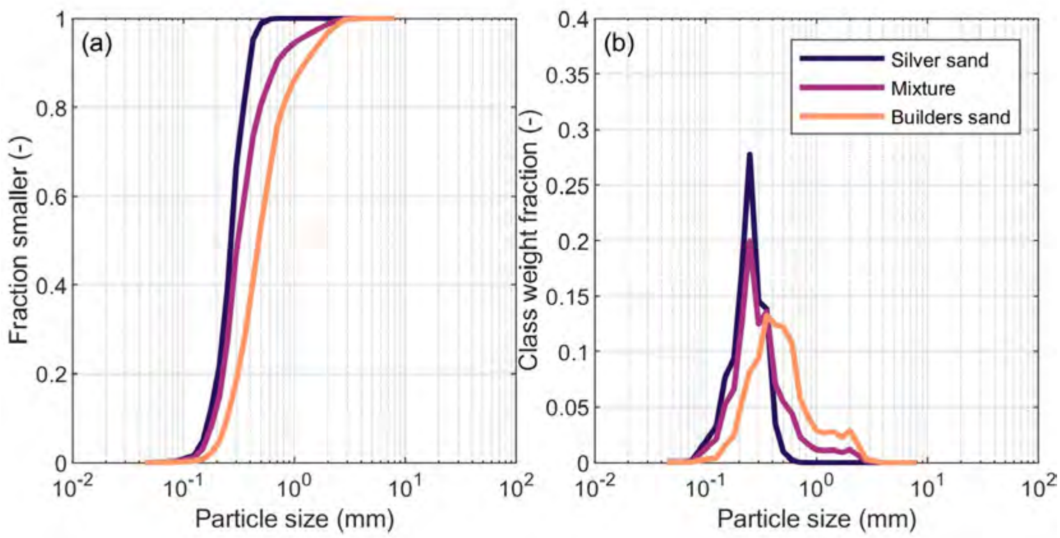
Large scale experiments - Aarhus University, Aarhus, Denmark

date	exp nr.	CO2 ice volume (m3)	CO2 ice weight (kg)	Sediment volume (m^3)	Sediment weight (kg)	Volume frac CO2	Total volume (m3)	Total weight (kg)	Chamber pressure (mbar)	Temp chute bottom	Flume angle (degrees)	Silver sand (kg)	Builders sand (kg)	Slope chute (de	Slope outflow plain (deg	Notes
Different CO2 fractions																
11-10-2022	15	0.0000	0	0.00302	8	0.00	0.00302	8.0	8	20	30	4.8	3.2	30	10	
6-10-2022	5	0.0010	1.6	0.00302	8	0.25	0.00402	9.6	8	20	30	4.8	3.2	30	10	
13-10-2022	21	0.0010	1.6	0.00302	8	0.25	0.00402	9.6	8	20	30	4.8	3.2	30	10	
17-10-2022	25	0.0010	1.6	0.00302	8	0.25	0.00402	9.6	8	20	30	4.8	3.2	30	10	
13-10-2022	20	0.0015	2.4	0.00302	8	0.33	0.00452	10.4	8	20	30	4.8	3.2	30	10	
17-10-2022	24	0.0015	2.4	0.00302	8	0.33	0.00452	10.4	8	20	30	4.8	3.2	30	10	
17-10-2022	26	0.0015	2.4	0.00302	8	0.33	0.00452	10.4	8	20	30	4.8	3.2	30	10	
5-10-2022	2	0.0015	2.4	0.00302	8	0.33	0.00452	10.4	8	20	30	4.8	3.2	30	10	No high speed footage
7-10-2022	7	0.0020	3.2	0.00302	8	0.40	0.00502	11.2	8	20	30	4.8	3.2	30	10	
7-10-2022	8	0.0020	3.2	0.00302	8	0.40	0.00502	11.2	8	20	30	4.8	3.2	30	10	
14-10-2022	23	0.0020	3.2	0.00302	8	0.40	0.00502	11.2	8	20	30	4.8	3.2	30	10	
Different chute slopes																
18-10-2022	28	0.0015	2.4	0.00302	8	0.33	0.00452	10.4	8	20	20	4.8	3.2	20	10	
12-10-2022	18	0.0015	2.4	0.00302	8	0.33	0.00452	10.4	8	20	25	4.8	3.2	25	10	
13-10-2022	19	0.0015	2.4	0.00302	8	0.33	0.00452	10.4	8	20	25	4.8	3.2	25	10	
17-10-2022	27	0.0015	2.4	0.00302	8	0.33	0.00452	10.4	8	20	25	4.8	3.2	25	10	

- **Supplementary videos**
- Can be downloaded under this link:
- https://filesender.surf.nl/?s=download&token=110d4f61-f624-406b-a23c-3cb3a66b5ef0

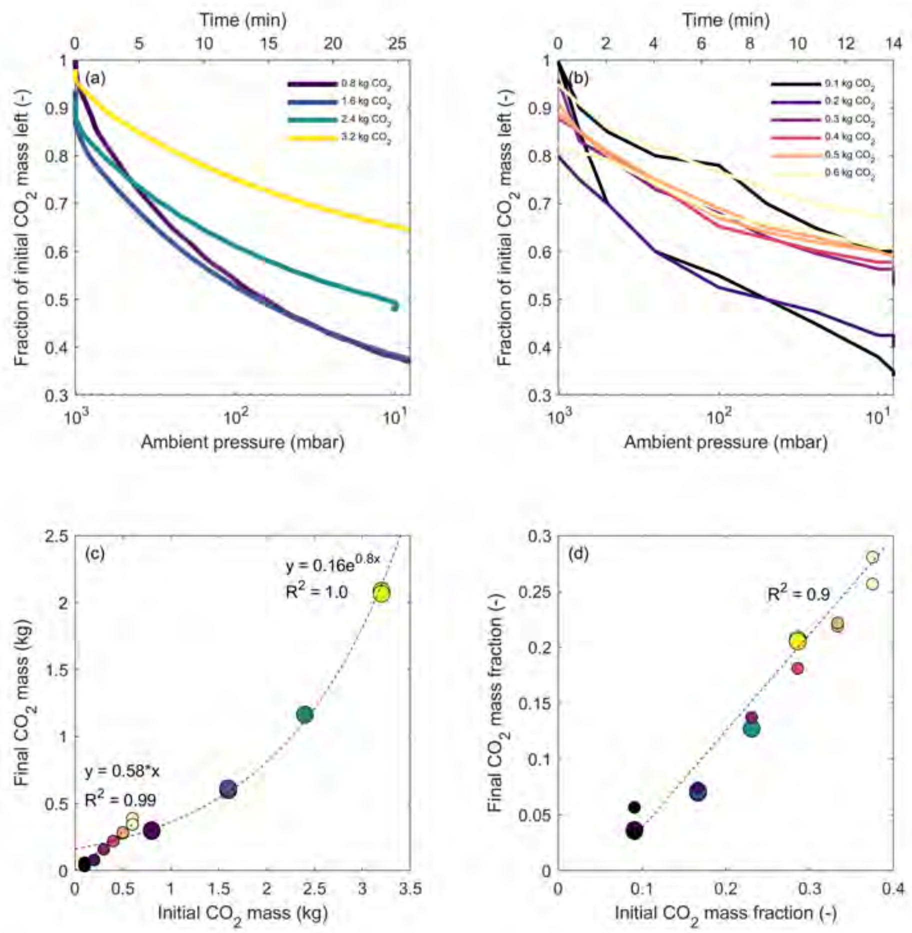


Supplementary Figure 1. Photos showing important details of the flumes. The details of the small-scale experiments conducted in the Mars chamber at the Hyper Velocity and Impact lab (HVI) of the Open University (UK) are shown in panels (a), (c), (e), and (g). The details of the large-scale experiments conducted in the Mars Simulation Wind tunnel at Aarhus University (Denmark) are shown in panels (b), (d), (f), and (h). Note that the sensors depicted in panel (h) are used in both flumes.

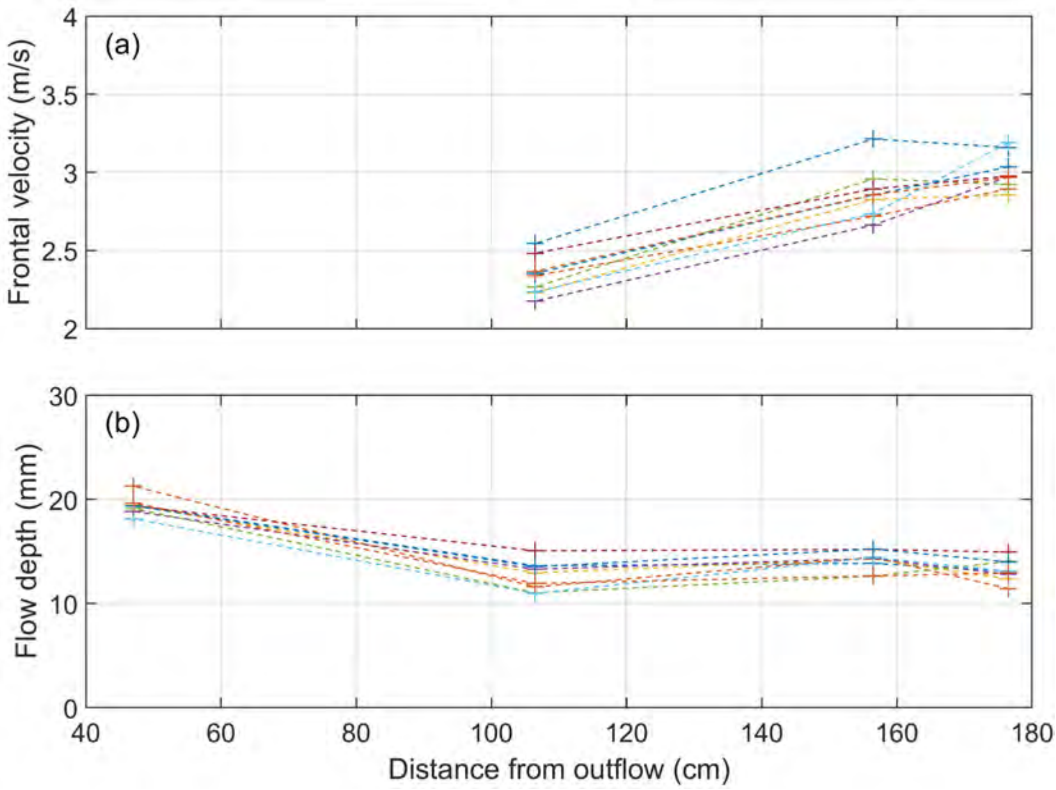


Supplementary Figure 2. Grain size distributions of the three different sands used; (a) frequency distribution, (b) cumulative particle-size distribution. Note that the mixture is used for all experiments in the main manuscript, this mixture comprises for 60% of silver sand and 40% builders sand.

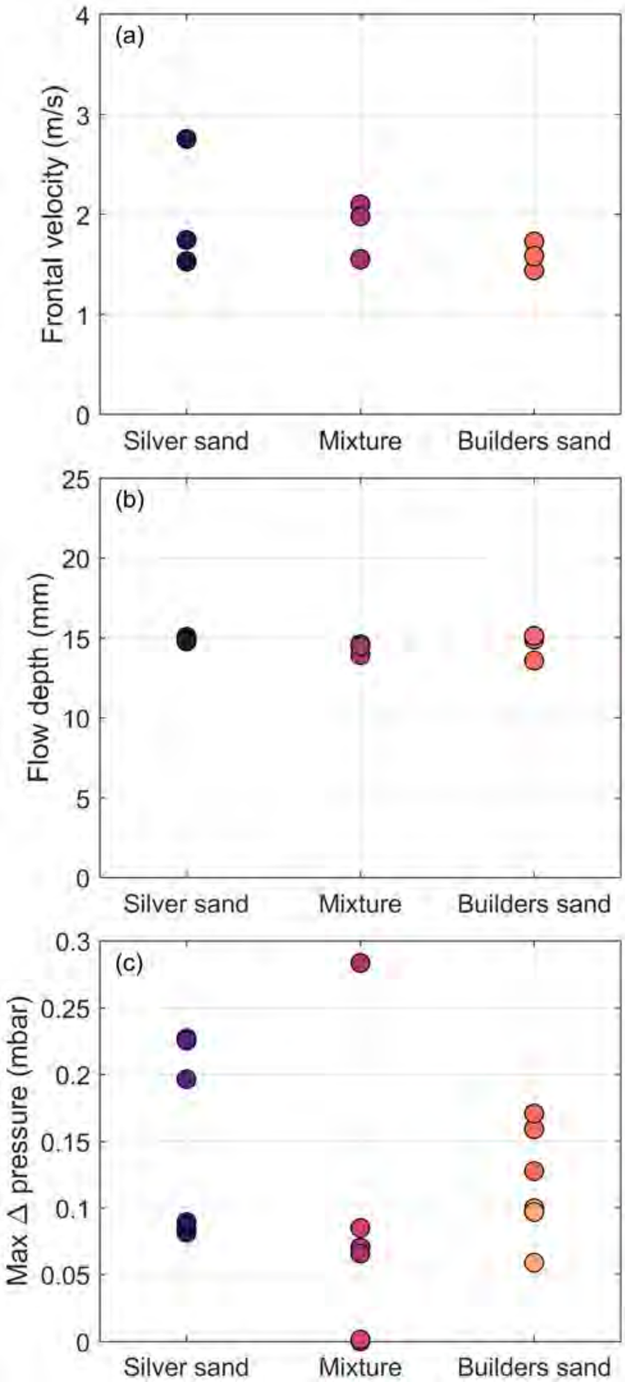
Supplementary Figure 3. Photos showing important details of the experimental routine, from storing the CO_2 ice (a-b) to the loading of the material before an experiment (g-h). The experimental routine for the small-scale and large-scale experiments are mostly similar. The most important differences are depicted in this figure. For the small-scale experiments, the CO_2 ice was crushed by hand (c), whereas for the large-scale experiments a grain mill was used (d). The resulting grain size of the ice is similar for both methods (see insets of (c) and (d)). In the small-scale experiments, the sediment-ice mixture was poured into the reservoir and the reservoir was loaded into the flume, whereas in the large-scale experiments, the sediment-ice mixture was directly poured into a reservoir permanently connected to the flume.



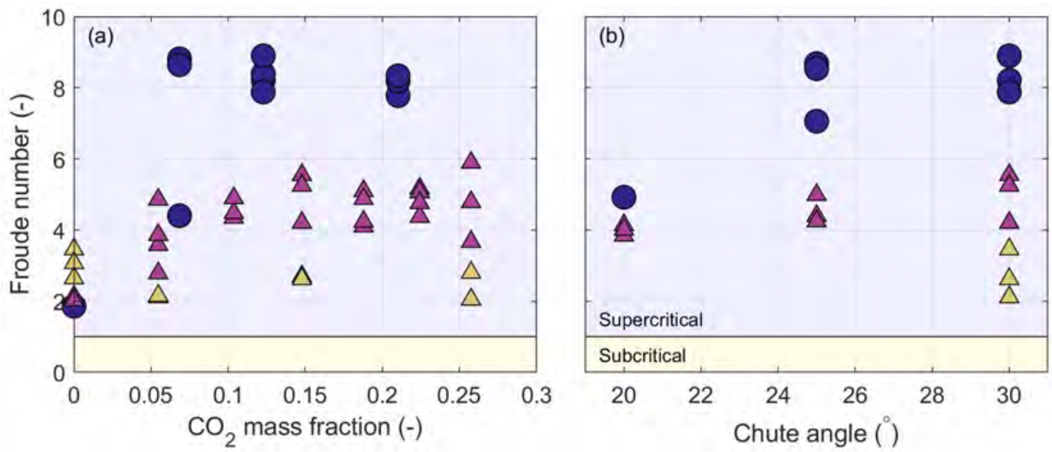
Supplementary Figure 4. Results of the CO_2 sublimation tests. With these tests, we quantified the loss of CO_2 during depressurization and determined the amount of CO_2 ice in the sediment-ice reservoir at the start of an experiment. In panels (a) and (b) the fraction of CO_2 relative to the initial CO_2 mass is given over time and pressure, for the large-scale set-up and the small-scale set-up respectively. In panel (c) the final CO_2 mass in the sediment-ice reservoir, when reaching a chamber pressure of 8 mbar, is plotted against the initial CO_2 mass. Panel (d) shows the final CO_2 mass fraction against the initial CO_2 mass fraction. Note that for the large-scale set-up, we used a digital lab scale and automatically recorded the weight at a frequency of 1 Hz, whereas for the small-scale set-up, we used simple analog kitchen scales and wrote down the remaining weight every minute.



Supplementary Figure 5. Frontal flow velocity (a) and maximum flow depth (b) for the large-scale experiments over the distance along the flume, seen from the outflow point. The experiments shown are conducted under a chute angle of 30° with varying CO_2 mass fractions. Colors correspond to individual experiments. Note that the flow velocity is calculated from the difference in arrival times of the flow front at two consecutive locations. Therefore, the flow velocity depicted here is an average velocity over a certain distance. For the locations in the flume where the flow is still accelerating, this means that the depicted velocity is likely lower than the actual velocity at that location in the flume. This is the case for the flow velocities depicted at 106.5 cm from the outflow point.



Supplementary Figure 6. Frontal flow velocity (a), maximum flow depth (b), and maximum differential pore pressure of the two different sensors (c) for the small-scale (S) experimental flows with three different sand types; 1) silversand, 2) a mixture of silver sand and builder sand and 3) builders sand. The mixture is used for all other experiments presented in the main text. All experiments presented in this plot are conducted under a chute angle of 30° with a CO_2 mass fraction of 0.15 at the beginning of the experiment, which is derived from data presented in Supplementary Figure 4.



Supplementary Figure 7. Froude numbers for the granular flows in the large-scale and small-scale experiments conducted with different CO_2 mass fractions (left column) and under different chute angles (right column). The horizontal lines indicate the transition from subcritical to supercritical flow.