Supporting Information for "Revealing the intricate dune-dune interactions of bidisperse barchans"

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Introduction

This supplementary material presents a brief description of the employed methods, the layout of the experimental device, microscopy images of the used grains, additional graphics, and movies showing examples of interactions of bidisperse barchans. For the latter, we present top view movies for barchans consisting of (i) bidisperse mixtures of grains (file caseb.gif) and (ii) different monodisperse grains (one type for each barchan, file caseo.gif). We note that complete tables, individual images and movies used in the manuscript are available on Mendeley Data (http://dx.doi.org/10.17632/sbjtzbzh9k).

Methods

Preparation of experiments

The solid particles used in the experiments were glass spheres (see microscopy images in Figs. S2 to S4 below) with diameters 0.15 mm $\leq d_{s1} \leq$ 0.25 mm and 0.40 mm $\leq d_{s2}$ $\leq$ 0.60 mm (from Sigmund Lindner company). Prior to each test, they were separated and weighted with a precision scale with a resolution of 0.01 g in order to assure the right proportions of grains forming each initial pile, as well as the total mass of the initial pile. Once weighted, the samples were placed manually in the test section of the channel, already filled with water. With the piles placed on the bottom wall of the channel, a controlled flow of water was imposed and the piles deformed into two barchan dunes that interacted with each other. The desired water flow was fixed manually through globe valves, and the volumetric flow rate was measured with an electromagnetic flow meter (KROHNE, model Optiflux 2010C, 0.5 % uncertainty, maximum measurement capacity of 20 m3/h). A Nikon D7500 camera (which has maximum resolution of 1980 px $\times$ 1080 px at 60 Hz) with a lens of 18-140 mm focal distance and F2.8 maximum aperture was mounted on a traveling system and had a top view of the bedforms. The focus was adjusted manually and the pixel to millimeter conversion was carried out by placing a scale in the channel (filled with water) and acquiring a calibration image. In order to obtain the necessary light while avoiding beating with the camera frequency, two lamps of light-emitting diode (LED) with 100W each were used.

Image processing

Once the test run was concluded, the corresponding video file was cropped into frames that were saved as single image files by using functions existing in the Matlab software.

Because of the timescales involved, we processed images corresponding to every 1 s in all tests. The image processing began by converting RGB images in grayscale, and then, using a threshold adjusted manually, into binary images. In order to remove small objects and noise, Matlab built-in filters were used (namely the medfilt2 and bwareaopen functions). After that, some morphological information of identified objects, such as the area, width, length, and centroid positions, were obtained with the built-in function regionprops. Properties related to the interacting barchans, such as their width, total length, length of horns, instantaneous separation, etc., were computed with scripts written by ourselves. The process just described was performed inside a loop, which reads and stores the data of every processed image in vectors that are saved in mat files. Finally, mat files are post-processed in order to obtain time evolution of areas, lengths, celerities, etc.

Captions

Movie S1. caseb.gif Movie showing an exchange pattern for barchans consisting of bidisperse mixtures (case *b* in the main paper).

Movie S2. caseo.gif Movie showing a collision for barchans consisting of different monodisperse grains (one type for each barchan, case *o* in the main paper: the larger upstream barchan reaches the smaller downstream one.

Figures

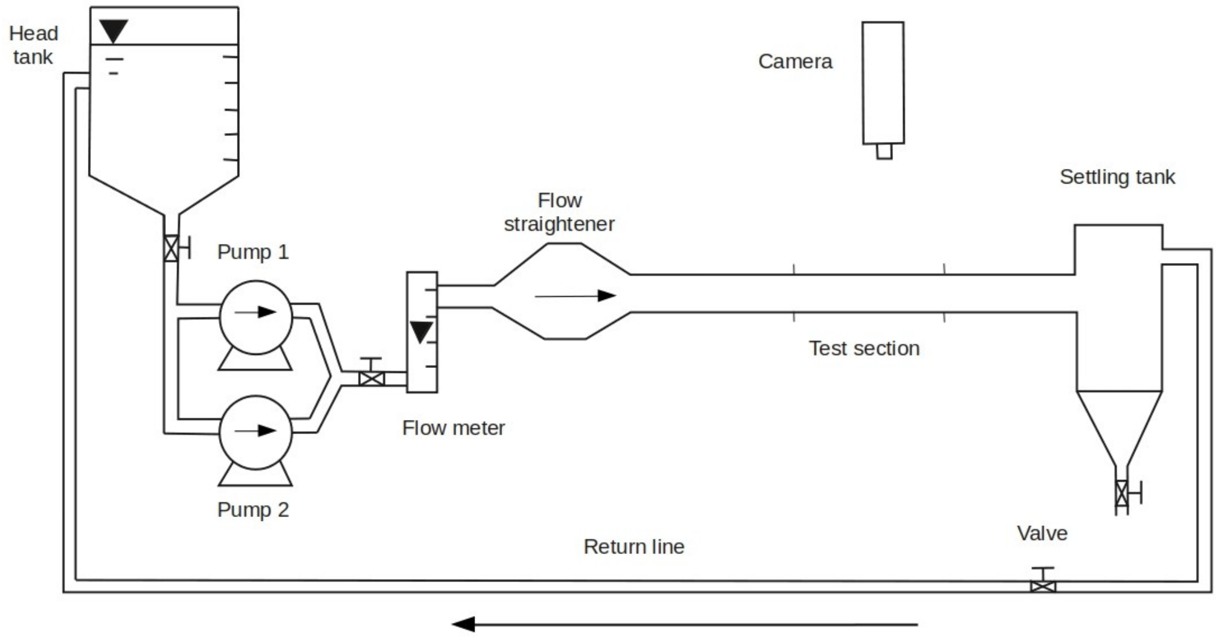

Figure S1. Layout of the experimental setup.

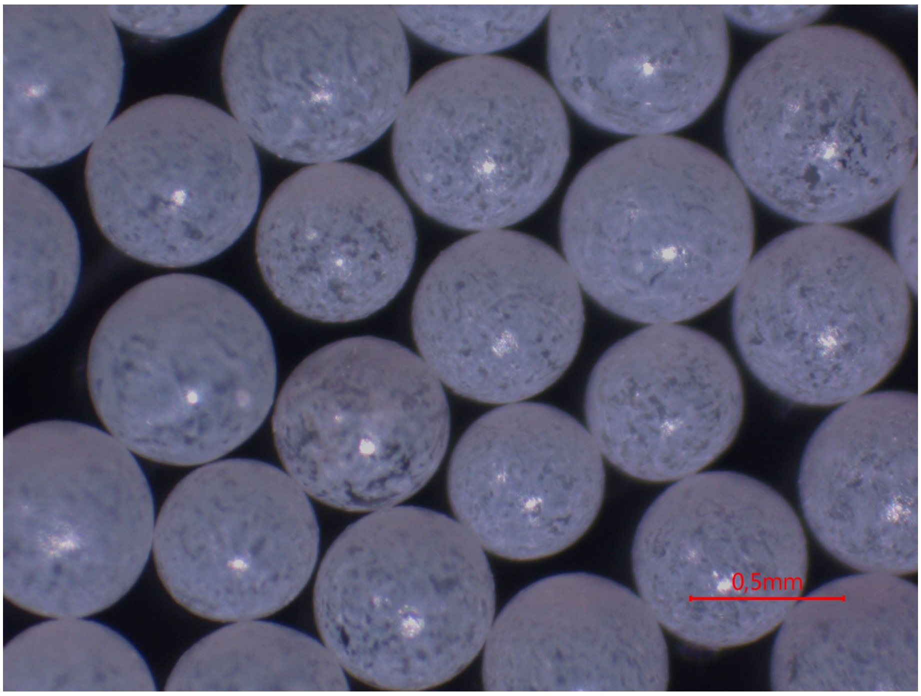

Figure S2. Microscopy image for the 0.40 mm $\leq d \leq$ 0.60 mm round glass beads of white color (species 2).

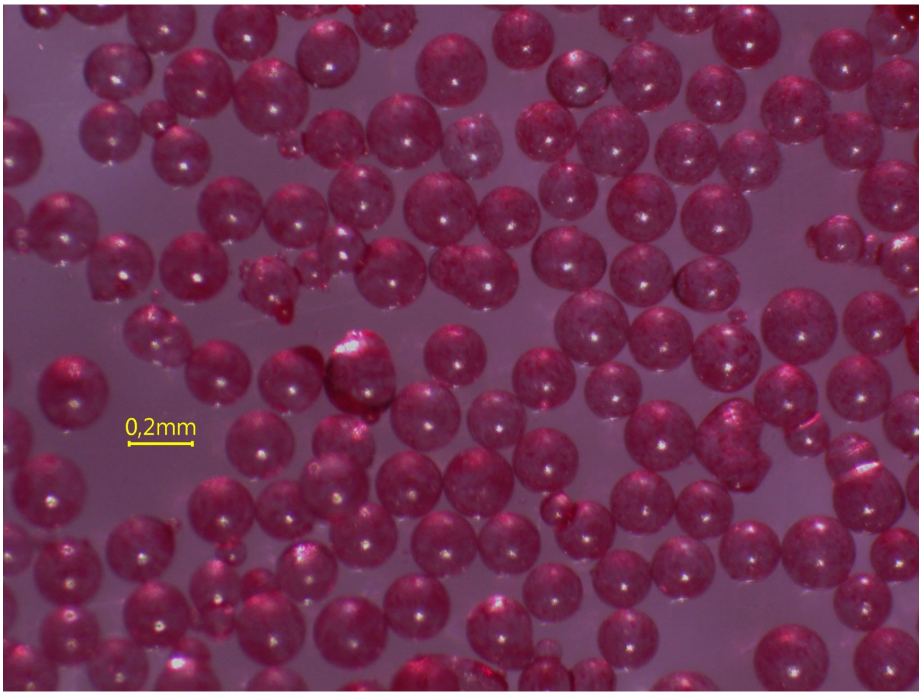

Figure S3. Microscopy image for the 0.15 mm $\leq d \leq$ 0.25 mm round glass beads of red color (species 1).

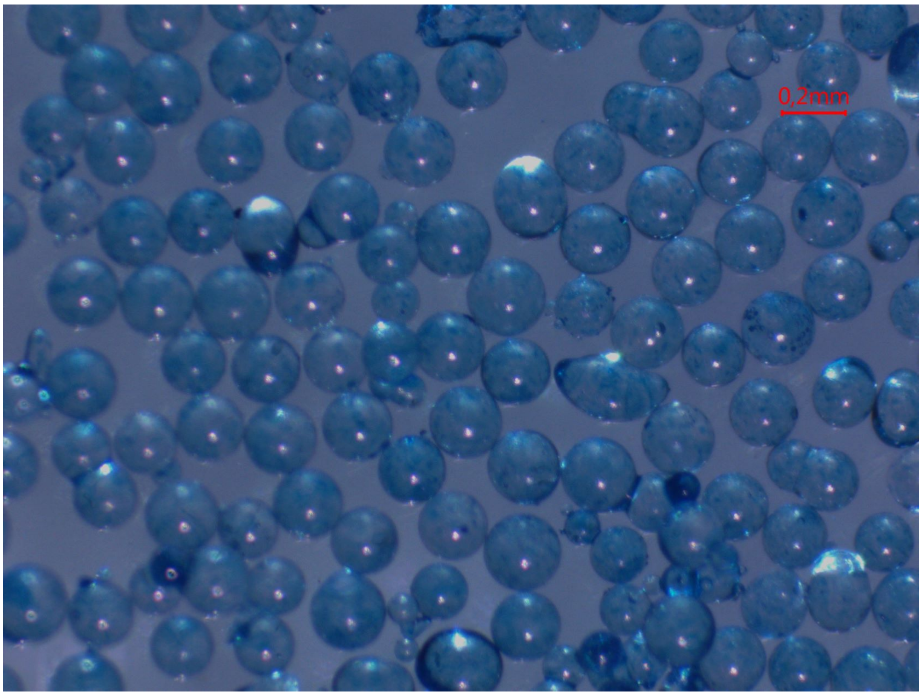

Figure S4. Microscopy image for the 0.15 mm $\leq d \leq$ 0.25 mm round glass beads of blue color (species 1).

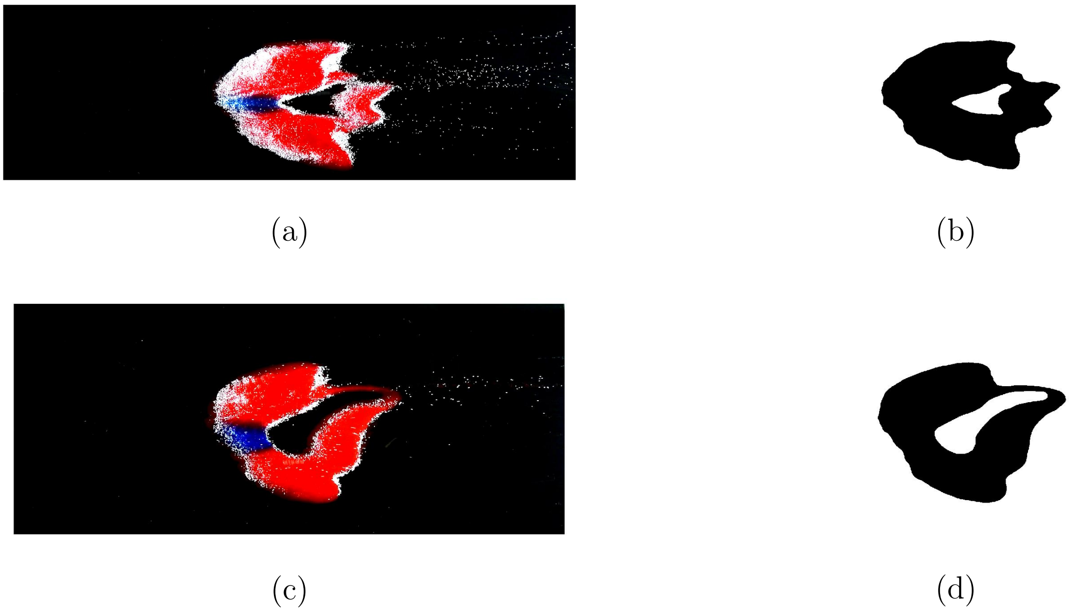

Figure S5. Void regions during the exchange processes for (a) and (b) $\phi_1 = \phi_2 = 0.5$ and (c) and (d) $\phi_1 \neq \phi_2$. Figures (a) and (c) are raw images and figures (b) and (d) binarized images.

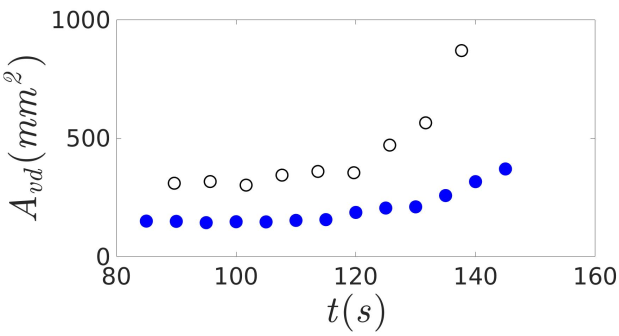

Figure S6. Area occupied by the void region A_{vd} as a function of time, in dimensional form, for the case of bidisperse piles (mixtures). Solid blue circles correspond to the exchange pattern when $\phi_1 = \phi_2 = 0.5$ and open black symbols when $\phi_1 \neq \phi_2$.

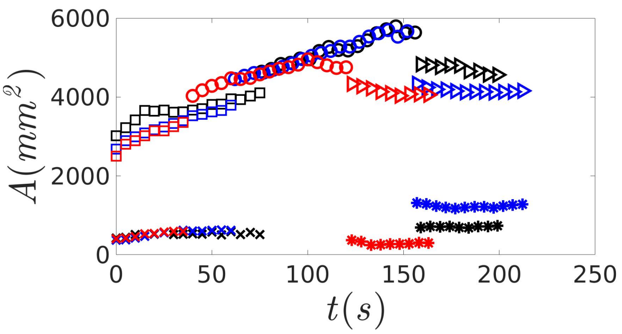

Figure S7. Projected areas, in dimensional form, of impact (x), target (□), merged (○), parent (▷) and baby barchans (*), respectively, as functions of time, for exchange processes with bidisperse piles (mixtures). Black, blue and red colors correspond to cases a, f and h.