Characterization by Image Analysis of the 3D Propagation of Dense Gravity Currents over the bottom of a Bassin of Static Fresh Water

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Extended abstract

This paper explores the 3D propagation of dense gravity currents (salty water) in a rectangular basin containing static ambient fresh water. The salty water (coloured with Rhodamine B dye) was injected into the basin via a transparent horizontal plastic square channel at the horizontal bottom surface made of a smooth white plastic. When the injection orifice opens, instantly, the two fluids with different densities come in contact and a non-equilibrium condition occurs. A light source made of 50 Hz-500w projector lamp was placed in front of the basin.

A video sequence with a frequency of 38 frames per second was considered for each experiment. An observation system consisting of one camera (type: Photron Fastcam) taking 190 images per second with a resolution of (1024x1024 Pixels) was consider as well. The camera was placed 1m above the water surface of the basin. The pictures observed by the camera are captured at a frequency of 38 Hz owing to a system of image consisting of a PC equipped with a Pentium IV processor (2.6 GHz) of a 1024 Mb random-access memory.

An image analysis technique was applied to assess the two-dimensional planar view of the gravity current flow. Using the ImageJ image processing software allowed, the video images to be captured directly from the camera during the experiments. Using the captured video tapes allowed the analysis of the experiments results as shown in Fig. 3.2. ImageJ is written in Java, which allows it to run on Linux, Mac OS X or Windows, in both 32-bit or 64-bit modes. ImageJ and its Java source code are freely available in the public domain, where no license is required. ImageJ can calculate area and pixel value statistics of user-defined selections. It can measure distances and angles. It can create density histograms and line profile plots.

It supports standard image processing functions such as contrast manipulation, sharpening, smoothing, edge detection and median filtering. ImageJ can be zoomed up to 32:1 and down to 1:32. All analysis and processing functions are available at any magnification factor. The program supports any number of windows (images) simultaneously, limited only by the computing available memory. ImageJ supports 8-bit, 16-bit and 32-bit (real) grayscale images and 8-bit and 32-bit color images. 8-bit images are represented using unsigned integers in the range 0 to 255. 16-bit images use unsigned integers (0 to 65,535) and 32-bit grayscale images use floating-point numbers.

The 3D propagation propagation of the dense gravity current was characterized in a range of Reynolds numbers and Richardson numbers that had not been investigated in earlier studies. The experimental measurements showed that the maximum velocity is located at Z0.5 wher Z0.5 is the height at which the mean velocity is equal to the half of the maximum velocity. The excess-density shows a radial symmetry close to the inlet and asymmetry far from the inlet. The local gradient Richardson number shows that the maximum of the turbulent mixing occurs at Z=Z0.5 in the first stage of the gravity current close to the inlet and it collapses far from the inlet. By analyzing the turbulent mixing in a 3D configuration, the mixing turbulent zone increases close to the inlet jet and decreases far from the inlet. In this case, the mixing estimated by the entrainment at different values of the iso-density threshold is found independent on Reynolds number between 2222 and 3889.

References

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