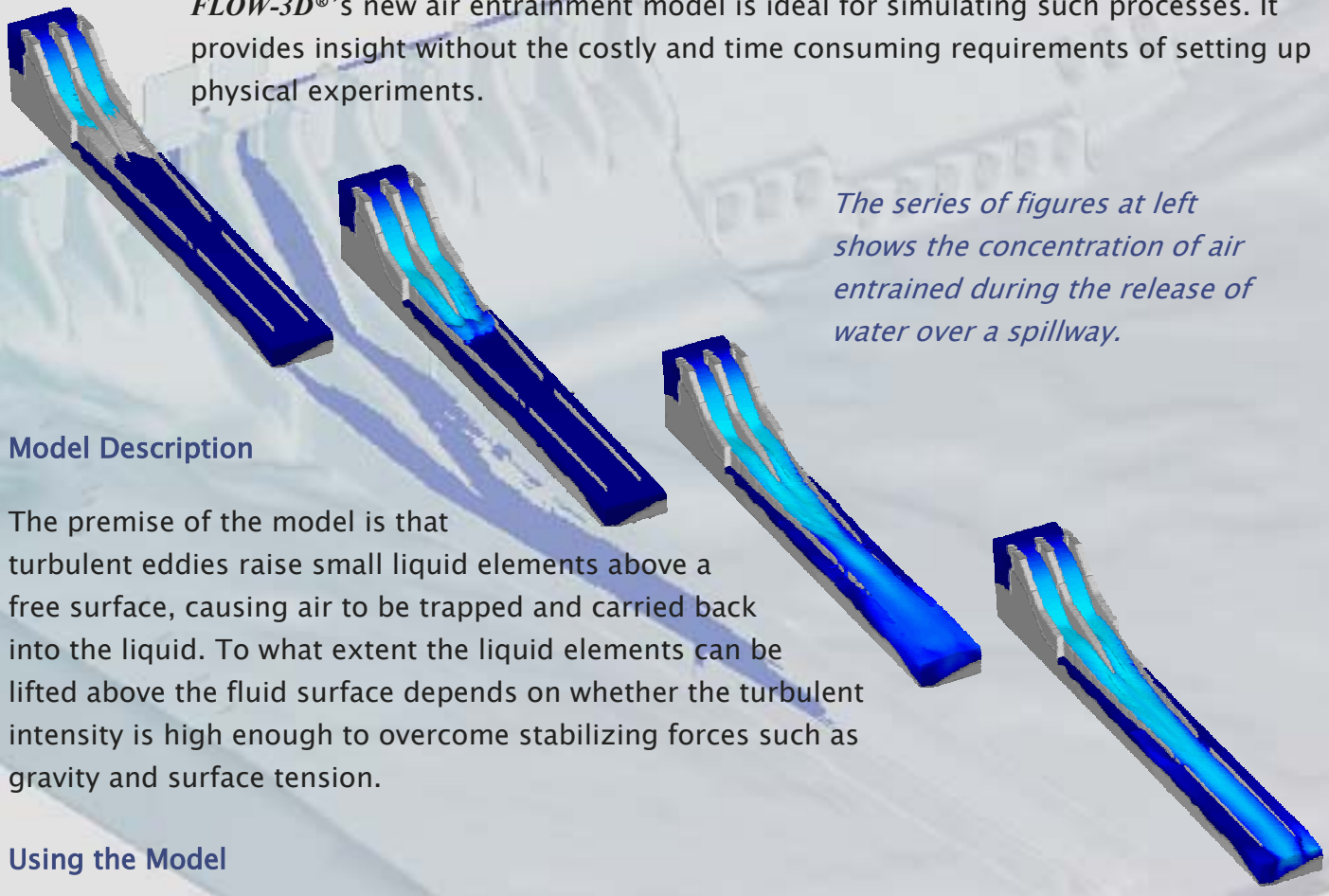
Modeling Air Entrainment with *FLOW-3D®*

Understanding the entrainment of air into water is important for many reasons. In water treatment, entrained air helps to sustain microorganisms for water purification. In rivers and streams, maintenance of a healthy fish population requires air to be entrained in the water. In dealing with spillway flows, knowing the quantity of air entrained is important for reducing the possibility of cavitation damage on the catch chute and determining the amount of bulking that may occur, thus impacting downstream structures.

FLOW-3D®'s new air entrainment model is ideal for simulating such processes. It provides insight without the costly and time consuming requirements of setting up physical experiments.



The series of figures at left shows the concentration of air entrained during the release of water over a spillway.

Model Description

The premise of the model is that turbulent eddies raise small liquid elements above a free surface, causing air to be trapped and carried back into the liquid. To what extent the liquid elements can be lifted above the fluid surface depends on whether the turbulent intensity is high enough to overcome stabilizing forces such as gravity and surface tension.

Using the Model

The model can be applied two different ways, depending on whether bulking effects are important. If bulking is negligible, the air concentration can be treated as a scalar quantity that does not change the fluid volume, thus requiring less computational overhead. If bulking is important, ***FLOW-3D®***'s variable density model can be activated to increase volume according to the air concentration.

Flow Science, Inc. www.flow3d.com cfd@flow3d.com (505) 982-0088

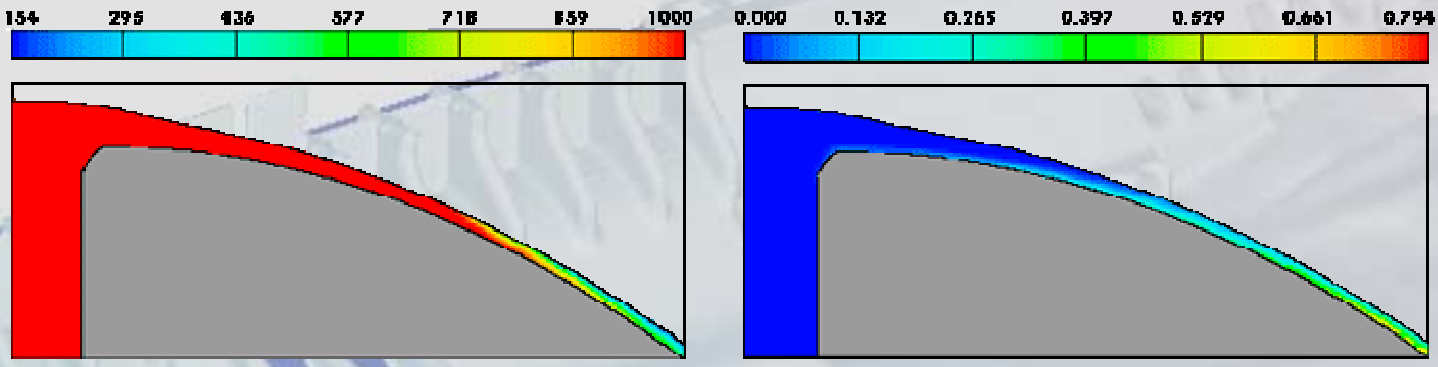
Excellence in Flow Modeling Software

Validations

The Air Entrainment model in ***FLOW-3D***® has been validated against a number of experimental results, including flow over a spillway and a hydraulic jump in a conduit.

Spillway

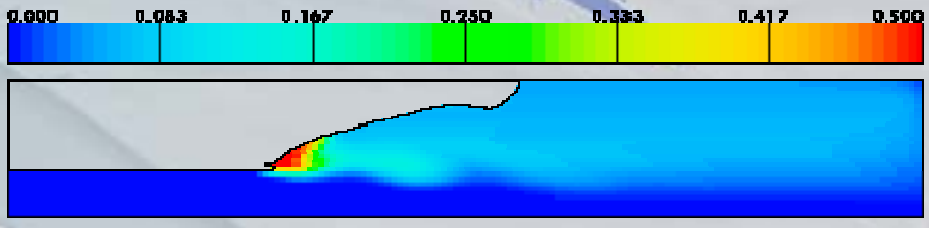
This validation looks at a spillway with a parabolic surface. The air/water ratio was compared to experimental data at various elevations normal to the surface relative to a normalized distance between the spillway surface and the water surface. It was found that the maximum error is about 8 percent.



Reference: "Air Entrainment in Free-Surface flows" written by I.R. Wood in the IAHR Monograph, "Hydraulic Design Considerations," published by Balkema, Rotterdam, 1991.

Hydraulic Jump in a Conduit

In this experiment, the air/water volumetric flow rate ratios versus the Froude (Fr) number of incoming flow were compared in a conduit with a 10% slope. The computational results were about



Reference: "Closed Conduit Flow," by Kalinske, A.A. and Robertson, J.M., published paper in the unknown Symposium proceedings is based on doctoral work of Robertson submitted on the U. of Iowa August, 1941.

For a complete details and more validations, refer to Tech Note FSI-03-TN61 found on our web site under the Publications/Technical Notes section.