Studying Intrusive Flows in Two Ambient Fluids

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Common Examples of Intrusive Flows

SOURCE: Weather Wiz Kids

SOURCE: National Wildfire Coordinating Group

SOURCE: Farmer’s Almanac
Understanding Intrusive Flows Can Prepare for Disasters

SOURCE: United States Geologic Survey
Intrusive Flows in Volcanic Plumes as an Example

SOURCE: United States Geologic Survey
How Are Intrusive Flows Created?

SOURCE: United States Geologic Survey
Fitting a Theoretical Model to Volcanic Plumes

**For these low speeds, air can be considered a fluid**

SOURCE: United States Geologic Survey
Two Ways to Model Intrusive Flows

Mathematical Approximation

Simulation
Make Quantitative Measurements to Compare

Mathematical Approximation

Simulation

\[ \rho_C \quad \rho_U \quad \rho_L \]

\[ \rho_C \quad \rho_U \quad \rho_L \]
Comparison Verifies Mathematical Models

Mathematical Predictions

Computer Simulation Data

Comparison
Model Includes Heights of Flows

Intrusive Flow Model in Two Ambient Fluids
Velocities are Equal

Measuring Velocities

Intrusive Flow Model in Two Ambient Fluids
Time: 0.2 s
Equilibrium Depends on Density of Current

\[ \rho_C = \frac{\rho_U d_U + \rho_L d_L}{d_U + d_L} \]

Equilibrium

\[ \rho_C \neq \frac{\rho_U d_U + \rho_L d_L}{d_U + d_L} \]

Non-Equilibrium
Using Conservation Laws to Calculate $u_C$

Five Unknowns
$u_L$, $u_U$, $u_C$, $h_L$, $h_U$

Five Equations
Mass,
Vertical Momentum,
Horizontal Momentum

Way to Calculate $u_C$
**Speed Depends on Density**

All Three Flow Speeds are the Same

\[ u_U = u_L = u_C \]

Speeds of Flows Depend on Density

\[ u_C^* = \frac{1}{2} \sqrt{\rho_c^*(1 - \rho_c^*)} \]
Non-Dimensional Variables Apply to Any Scale

\[ \rho_c \] 50% off
Simulation Data Matches Prediction Model

Experimental Data Points

Prediction Curve

\[ u_c^* \]

\[ \rho_c^* \]
Asymmetrical Models More Accurately Model Inconsistent Air Densities
Time: 0.0
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