

# **OBJECTIVES**

- Link laboratory models and numerical models of landslide tsunamis to the characteristics of historical landslides and tsunamis.
- Design a joint numerical modeling and experimental program based on wellconstrained real-world landslide generated tsunami and near-source runup scenarios.
- Validate physical, analytical and numerical models using the measured landslide and tsunami characteristics.

## **EXPERIMENTAL SETUP**

- A novel pneumatic landslide tsunami generator was deployed to generate tsunamis.
- Granular material is used to model deformable landslides.
- The camera setup provides measurements of landslide motion on the hill slope, impact at water surface and under water deformation.
- The resistance wave gages are used to measure the wave properties.
- These measurements are used to relate the generated wave properties with the source landslide parameters.



Fig. 1.(a) Experimental setups superimposed for the two case scenarios of landslide generated tsunamis in a fjord with a straight opposing coastline and a headland with a 90° bend facing the landslide axis. (b) Experimental setup with a conical island.

#### **EXPERIMENTAL PROCEDURE**



Fig. 2.(a) LTG experimental cycle. (b) LTG launching the gravel slide off the conical island configuration.

# **NEESR-CR: Tsunami Generation by Landslides: Integrating Laboratory Scale Experiments, Numerical Models and Natural Scale Applications** HINSDALE **CMMI 0936603** Georgia Institute of Technology

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**EXPERIMENTAL RESULTS** 



Fig. 3. (a) Landslide surface velocity above water surface using particle image velocimetry (PIV). (b) Landslide shape for slide volume,  $V_s = 0.756 \text{ m}^3$  and box velocity,  $v_{\rm h}$  = 3.8 m/s.



Fig. 4. (a) Wave gauge comparison for fjord (—) and basin wide propagation(--cases at r/h=6.9,  $\theta$  = 0°. (b) Lateral wave runup profile comparison for fjord (headland (-----) and basin wide propagation (----) cases at r/h=6.3.

# **EXPERIMENTAL CONCLUSIONS**

- Predictive empirical equations have been produced for the mostly nonlinear wave amplitudes which are primarily dependent on the landslide Froude number and the impact slide thickness.
- The fjord setup traps the wave energy between the two slopes and funnels it laterally through the fjord channel.
- The wave runup on the hill slope can be amplified due to the trapped energy by the wave reflection from the fjord or the headland slopes.
- The headland configuration traps only part of the wave energy in the channel and leaks the rest of the energy into the open basin.
- There is an amplification of the wave profile close to the headland curve when compared with the wave propagation in the absence of such a feature.
- Trapped edge waves on the conical island propagated around both sides of the island, collided on the rear side of the island, thereby locally amplifying the wave runup.

- Tsunami Solution Using Navier-Stokes Algorithm with Multiple Interfaces (TSUNAMI3D) simulation software has been developed by the University of Alaska Fairbanks and Texas A&M University-Galveston. - FLOW-3D is a general purpose computational fluid dynamic simulation software package based on the algorithms for simulating fluid flow. -TSUNAMI3D numerical tools are improved by tuning the landslide internal friction by means of the slide eddy viscosity and by considering the additional friction mechanisms in the model, e.g., the no-slip condition.

-The landslide viscosity and density are calculated as functions of the mud concentrations according to their magnitude in the FLOW-3D simulation. In this study the deformable slide is represented by suspended mud which advects and drifts according to the local fluid pressure gradient.



Fig. 5. (a) Comparison at wave gauge r/h=6.3,  $\theta=90^{\circ}$  in the fjord configuration for the experiment (....), TSUNAMI3D (—) and FLOW-3D (—). (b) Comparison at wave gauge r/h=6.9,  $\theta$  = 0° in the basin wide propagation configuration for the experiment (....), TSUNAMI3D (----) and FLOW-3D (----).

### REFERENCES

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### NUMERICAL MODEL RESULTS