Shallow Sand Equations: Real-Time Height Field Simulation of Dry Granular Flows

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Background

Granular media is the second-most-manipulated substance on Earth, second only to water. However, simulation of granular media is still challenging due to the complexity of granular materials and the large number of discrete solid particles.。
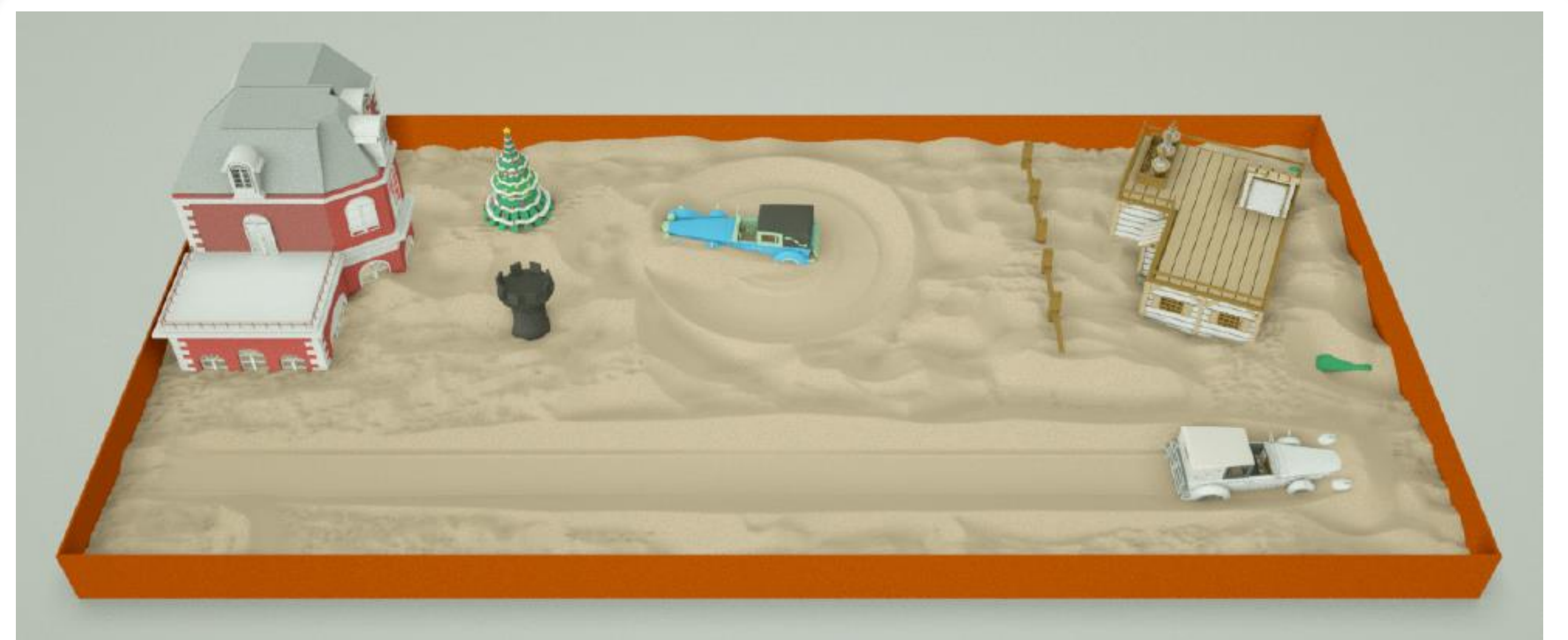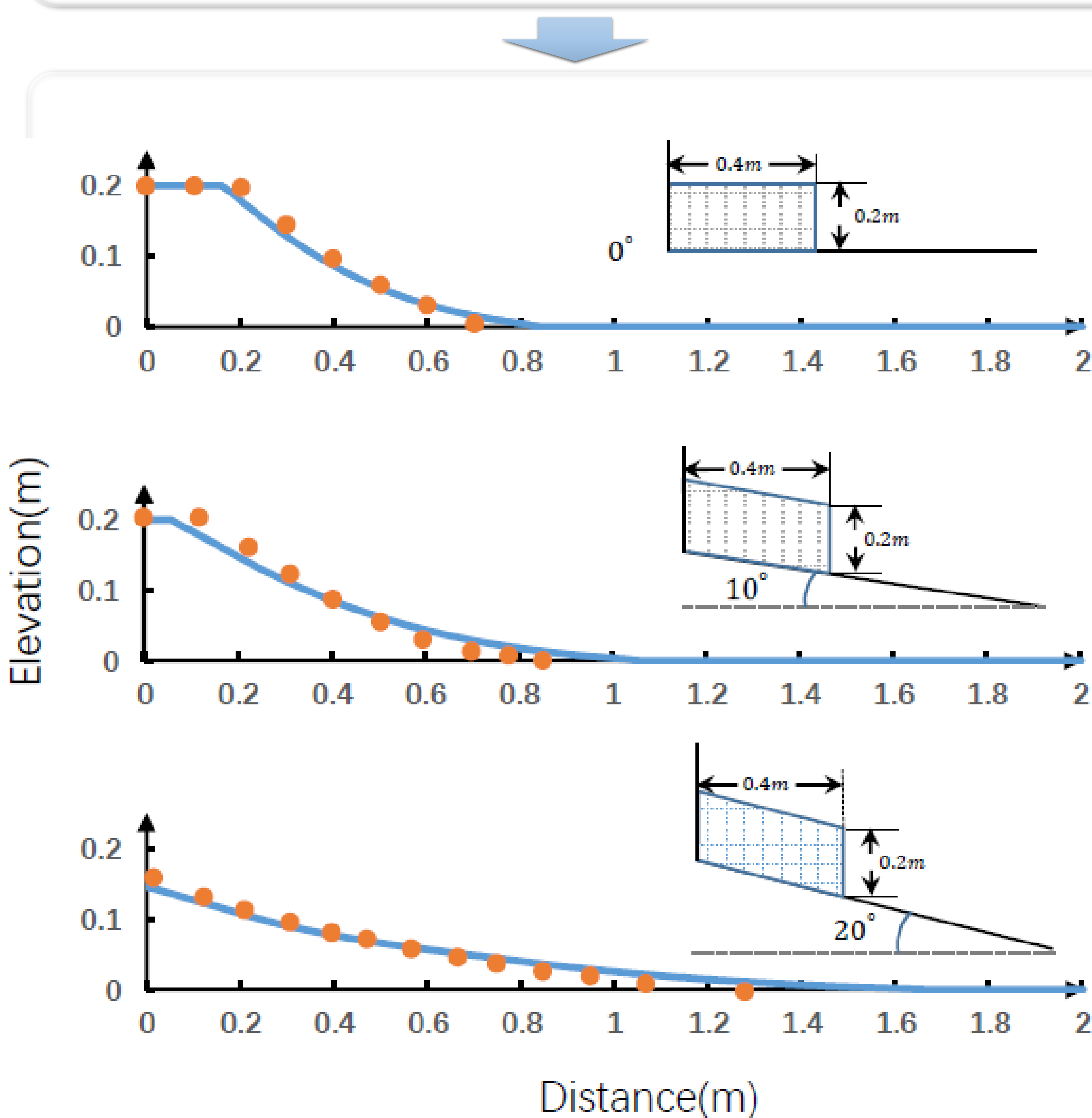
Our contributions

- A set of shallow sand equations that capture complex behaviors of dry granular flows
- A ray casting algorithm for efficient one-way solidfluid couplings
- A particle-based tracking method with adjustable resolution of particles
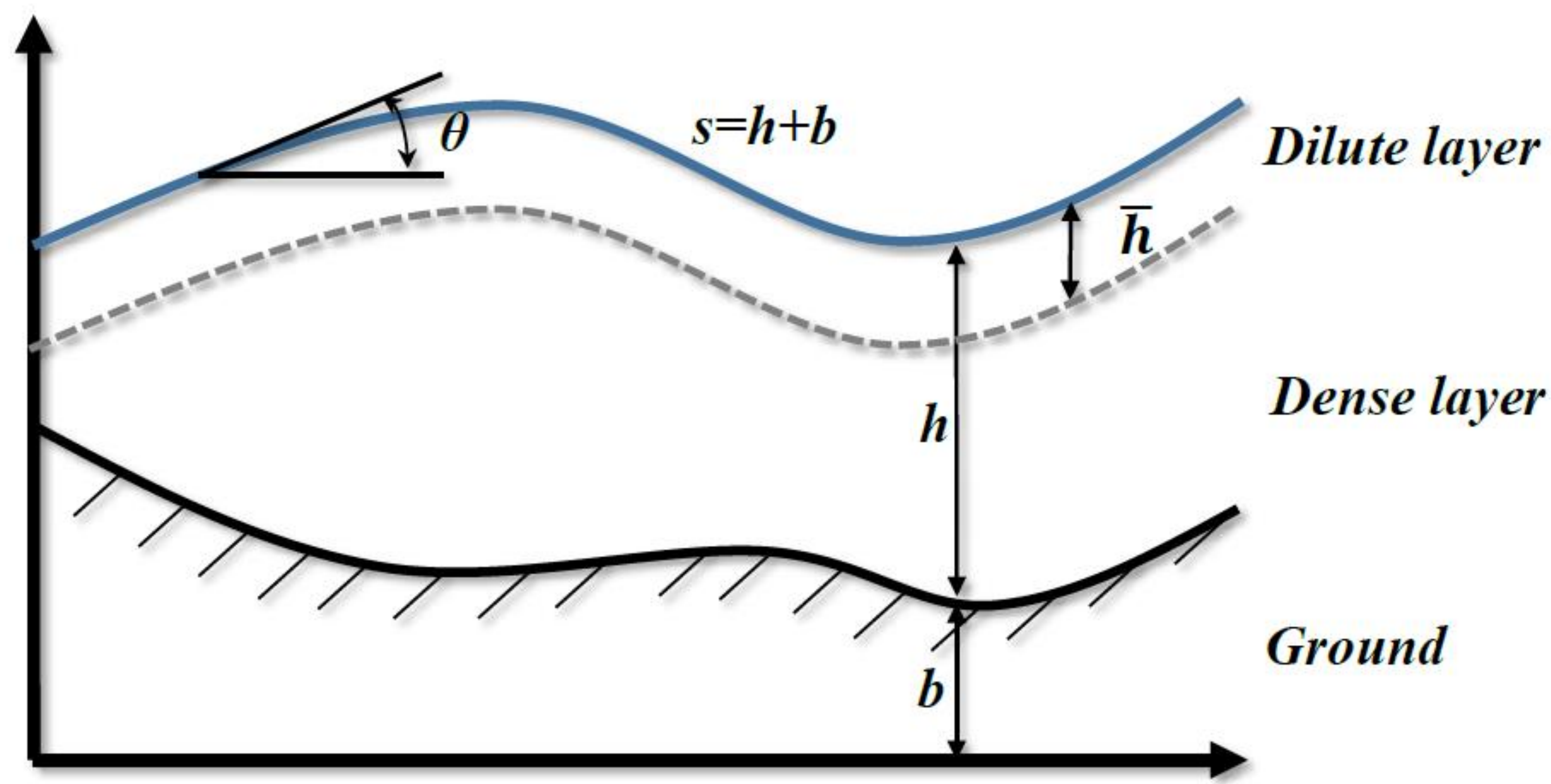
Shallow Sand Equations

$$\frac{\partial h}{\partial t} + \frac{\partial}{\partial x}(hu) + \frac{\partial}{\partial y}(hv) = 0$$

$$\frac{\partial}{\partial t}(hu) + \frac{\partial}{\partial x}\left(\frac{hu^2}{2}\right) + \frac{\partial}{\partial y}(huv) = -g\bar{h}\left(\frac{\partial s}{\partial x} + \mu \mathbf{m}_x\right)$$

$$\frac{\partial}{\partial t}(hv) + \frac{\partial}{\partial x}(huv) + \frac{\partial}{\partial y}\left(\frac{hv^2}{2}\right) = -g\bar{h}\left(\frac{\partial s}{\partial y} + \mu \mathbf{m}_y\right)$$

(a) Comparison of the final deposit profiles with experiments

Conclusion

- We proposed shallow sand equations for real-time simulation of dry granular flows