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Raindrop Impact on Saturated Soil

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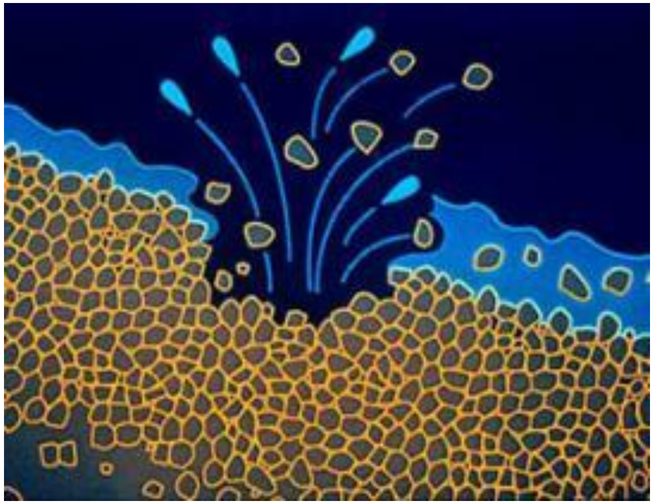
Water Erosion

Splash Erosion



http://www.montcalm.org/media/planningeduc/tn_raindrp.jpg

Rill Erosion

http://intechweb.wordpress.com/2011/11/30/
soil-erosion-raising-awareness-on-current-environmental-issues/

Gully Erosion

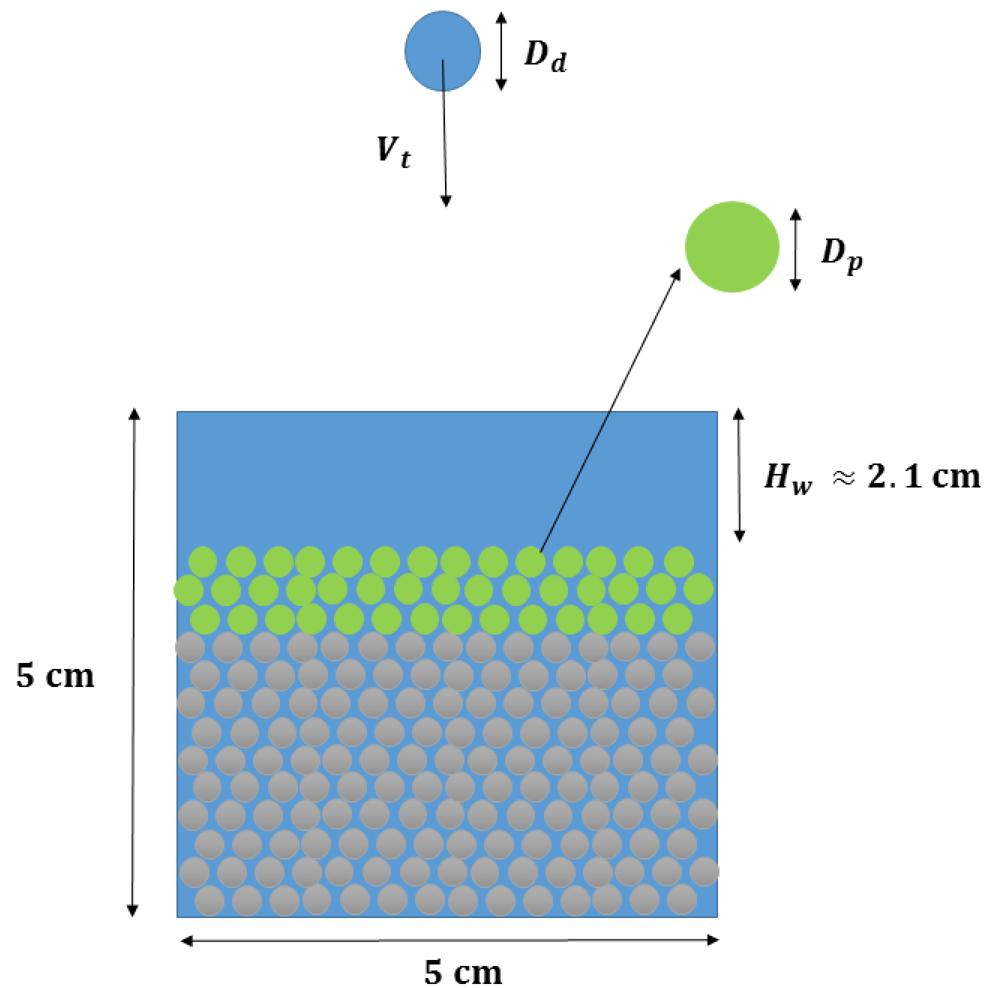
http://www.geo.uu.nl/landdegradation/Fieldwork.htm

Problem Definition

Terminal Velocity of Raindrop (V_t)

D_d = 2 mm → V_t = 2.36 ms^{-1}

D_d = 4 mm → V_t = 7.65 ms^{-1}



Discrete phase method

Particle size: 1 mm
Cohesion force: 0
youngsModulus 40e6;
poissonsRatio 0.35;

Drag model:
ErgunWenYuDrag

Collesion Model:

```
pairSpringSliderDashpotCoeffs
    {
        useEquivalentSize   no;
        alpha               0.02;
        b                   1.5;
        mu                  0.10;
        cohesionEnergyDensity 0.0;
        collisionResolutionSteps 12;
    };
```

Wall Model:

```
wallSpringSliderDashpotCoeffs
    {
        useEquivalentSize no;
        collisionResolutionSteps 12;
        youngsModulus   1e8;
        poissonsRatio   0.23;
        alpha           0.01;
        b               1.5;
        mu              0.09;
        cohesionEnergyDensity 0;
    };
```

Volume of Fluid method

phases

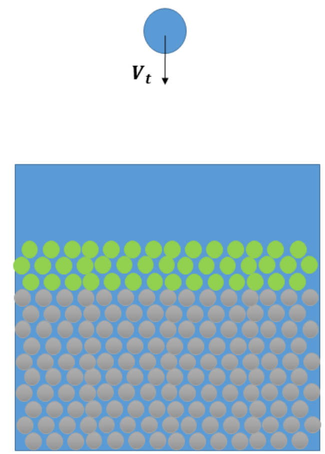
```
(
    water
    {
        transportModel Newtonian;
        nu nu [ 0 2 -1 0 0 0 0 ] 1e-06;
        rho rho [ 1 -3 0 0 0 0 0 ] 1000;
    }

    air
    {
        transportModel Newtonian;
        nu nu [ 0 2 -1 0 0 0 0 ] 1.48e-05;
        rho rho [ 1 -3 0 0 0 0 0 ] 1;
    }
);
```

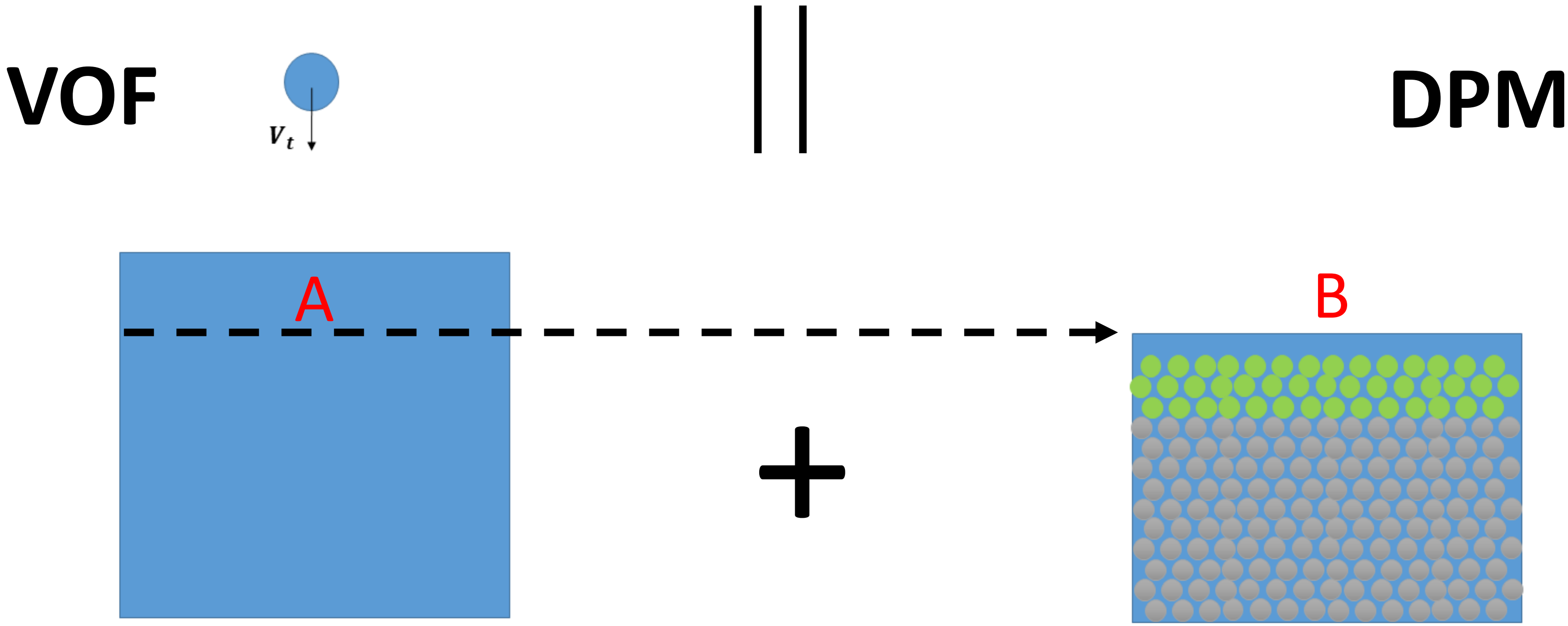
Sigma (surface tension)

```
(
    (air water)  0.07197
);
```

Simulation: outline

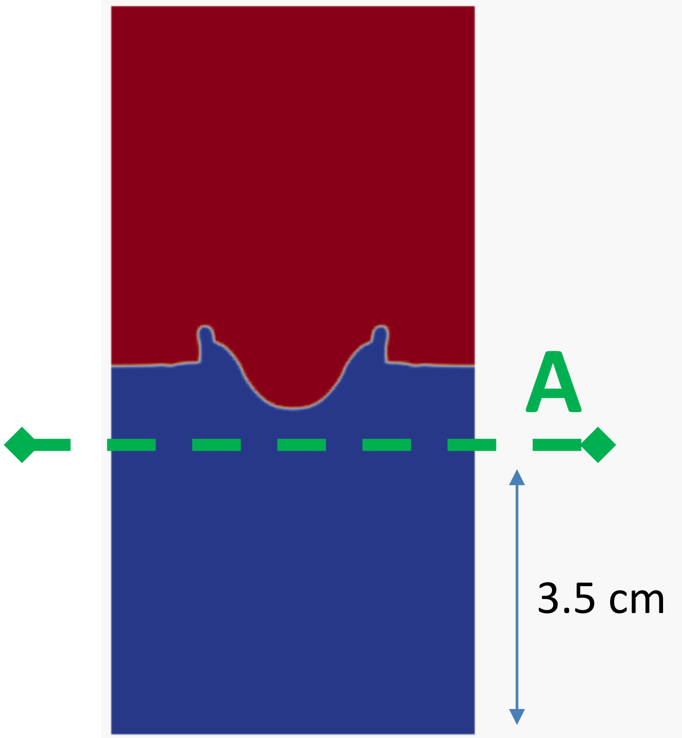


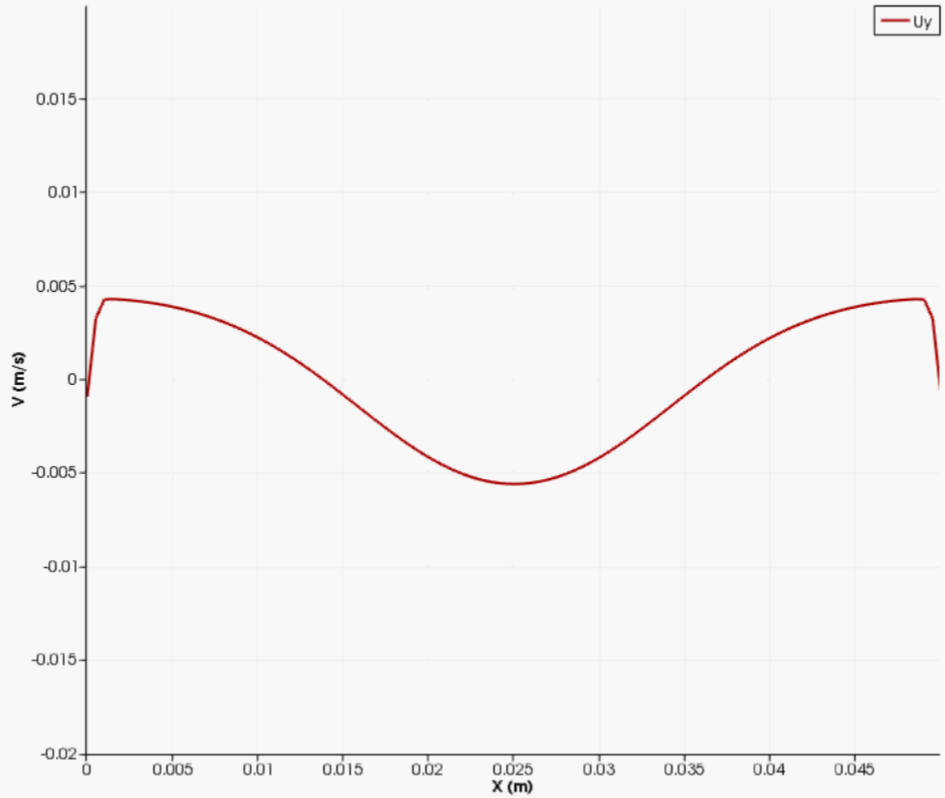
Velocity profile of section A is implemented as a boundary condition on surface B



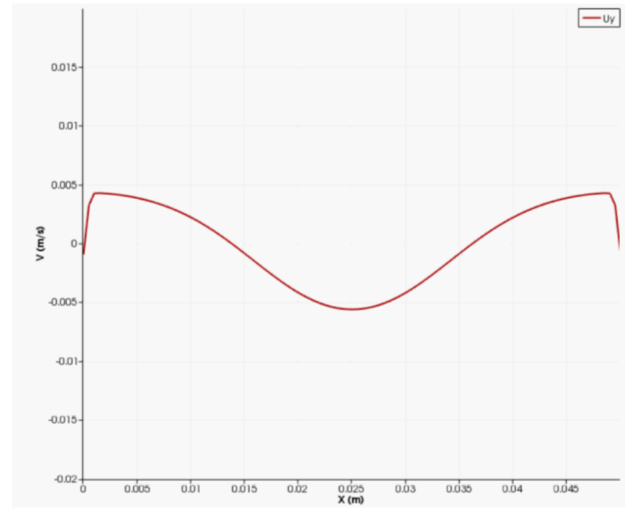
Simulation: VOF

Velocity profile along cross section A



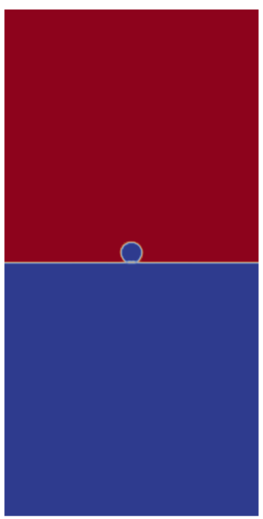


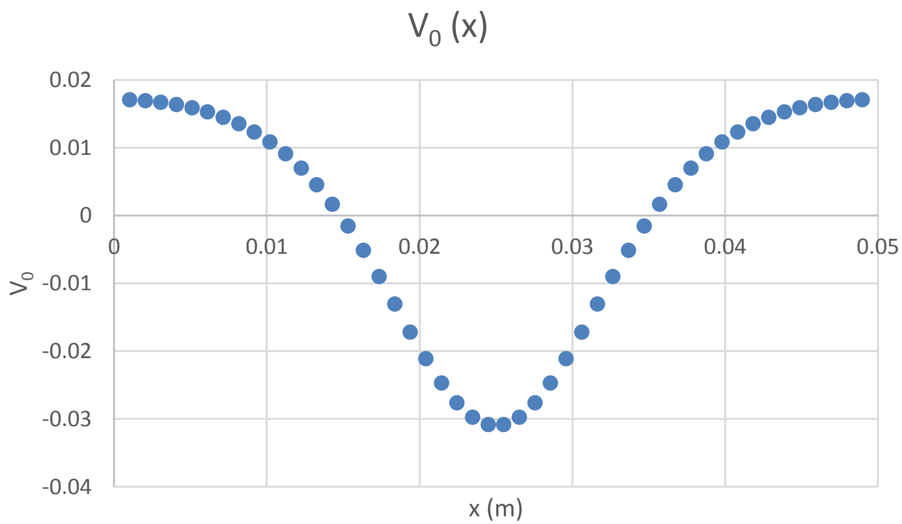
Simulation: VOF



$V(x, t) = V_0(x)\ f(t)$

$V_0\ (x)$ = Velocity Profile at the moment of collision

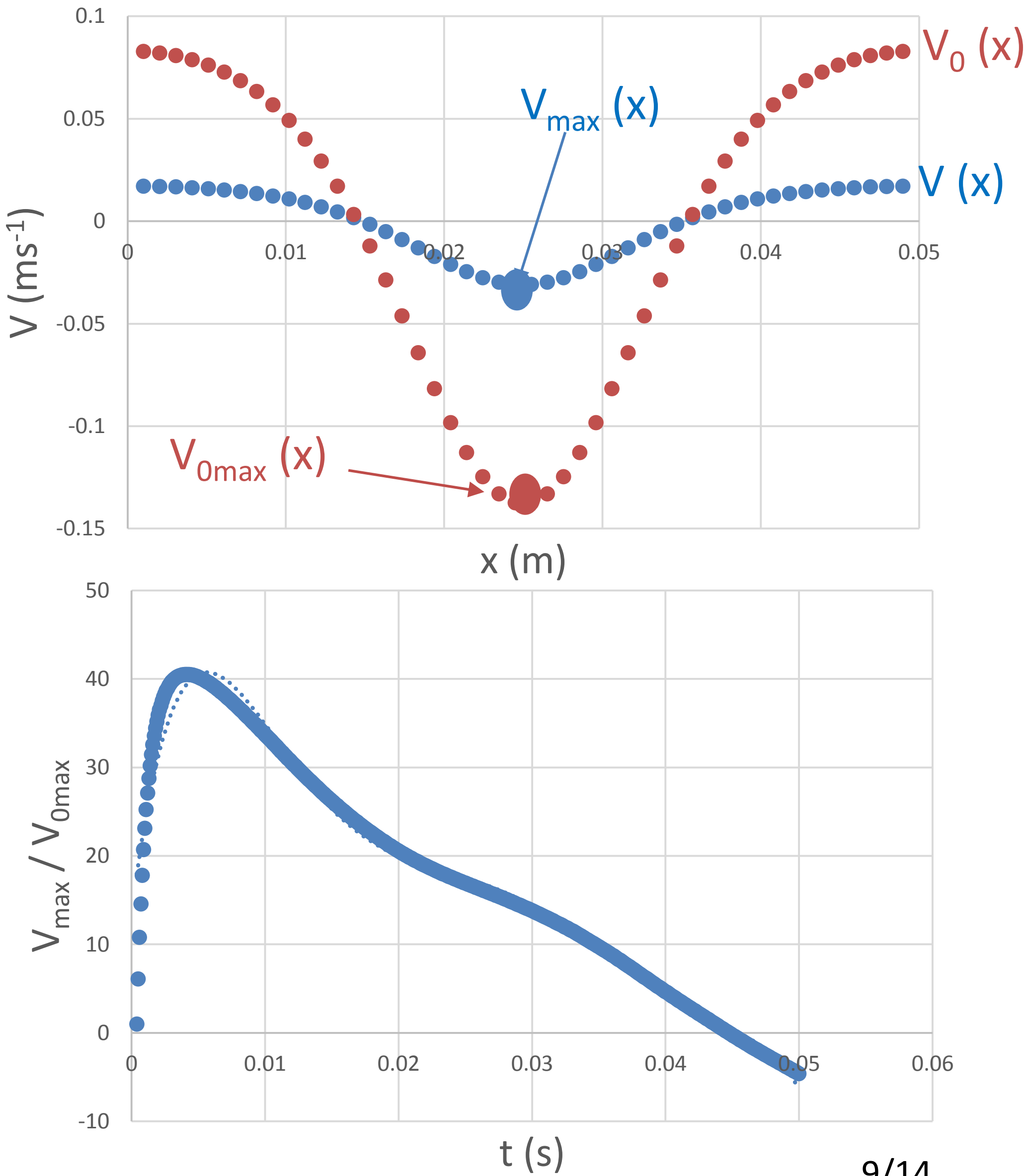




Simulation: VOF

$V(x, t) = V_0(x)\, f(t)$

V_0 (x): Velocity Profile at collision instant



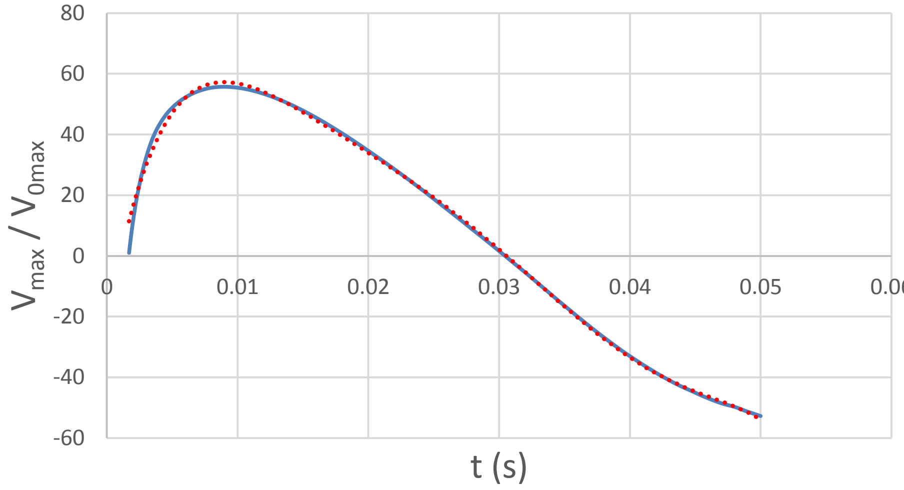
Simulation: VOF

$V(x,t) = f(t)V_0(x)$

2-mm Droplet:

$f(t) = -366443498336t^6 + 63529957792t^5$
$- 4342637831t^4 + 150446928t^3$
$-2829761t^2 + 25048t – 23$

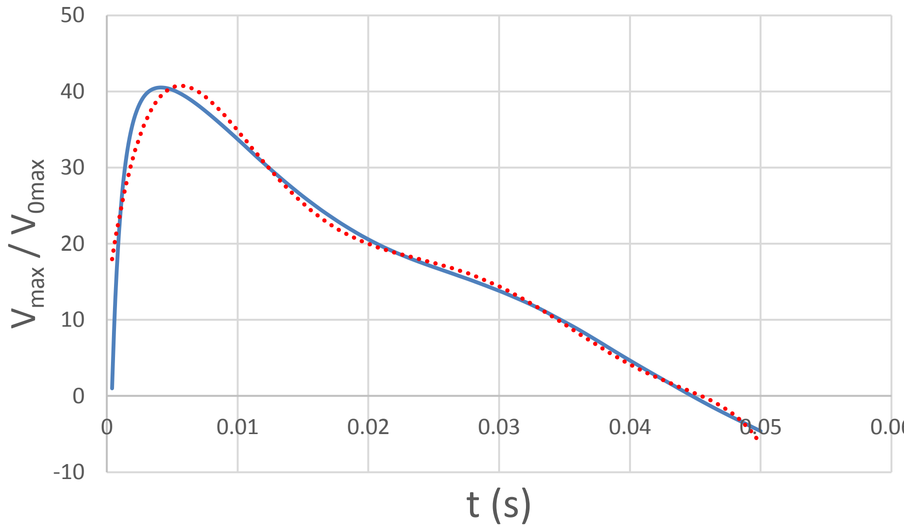
$R^2 = 0.999$



4-mm Droplet:

$f(t) = -305662395148t^6 + 52347905525t^5$
$3496475928t^4 + 114043721t^3$
$- 1846164t^2 + 12209t + 13$

$R^2 = 0.986$

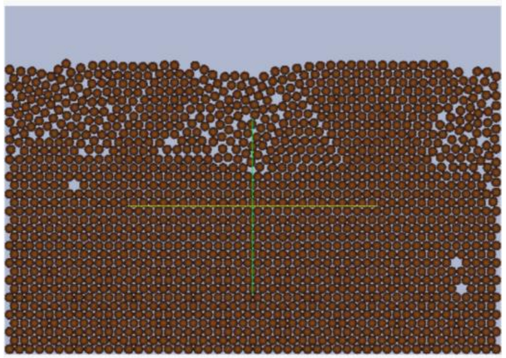


Results

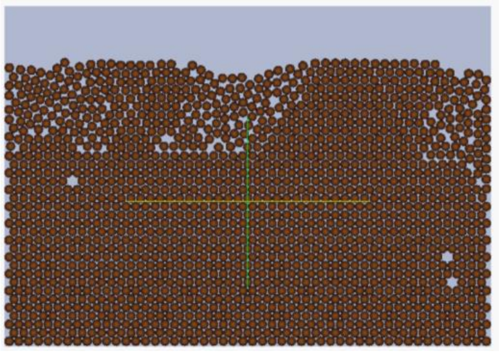
- **Droplet size: 2 mm (V_t = 2.36 ms^{-1})**
- **Particle size: 1 mm**

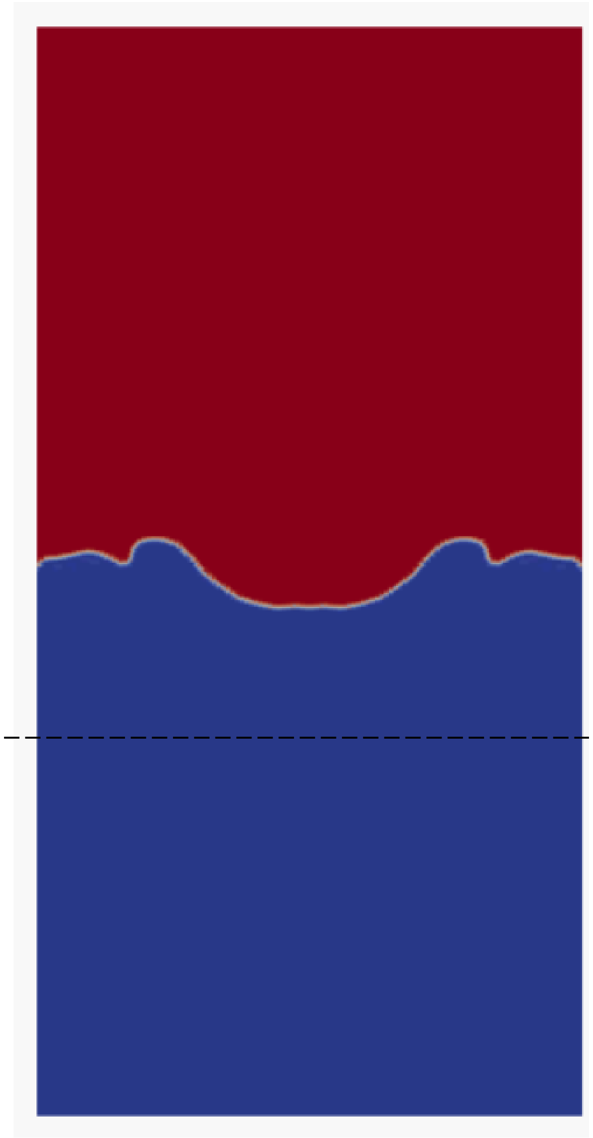
*Simulation for 50 ms splash

t = 0.00



t = 50 ms



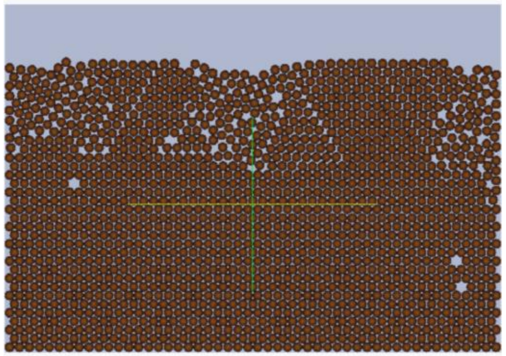


Results

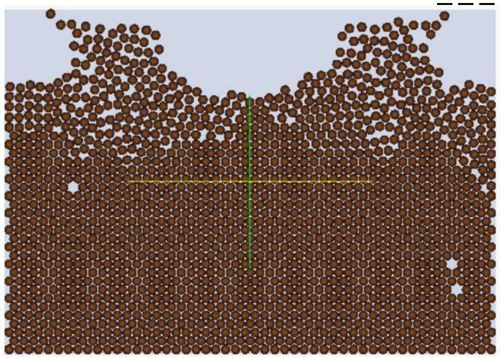
- **Droplet size: 4 mm (V_t = 7.65 ms^{-1})**
- **Particle size: 1 mm**

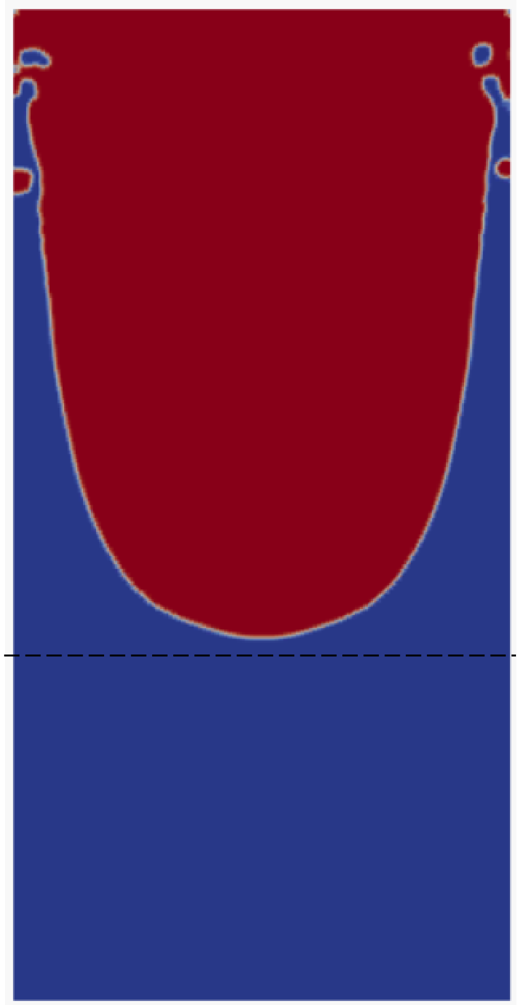
*Simulation is for 50 ms splash

t = 0.00



t = 50 ms





Conclusions:

- DPM method is able to simulate dense particles with the ErgunWenYu drag model
- Simulation of random droplets (as in rainfall) demands coupling of the DPM and VOF solvers
- This simulation was not verified or validated and a more precise VOF and LES simulation is needed in the future

Thank You

Questions?