ASME, 2014. Modeling of Particle Wall Interaction and Film Transport using Eulerian Wall Film Model. R. Ingle

Natural Hazards and Earth System Sciences, 2011. Adaptive modelling of long-distance wave propagation and fine-scale flooding during the Tohoku tsunami. S. Popinet

The **Eulerian Wall Film** model is **similar to** our proposed model based on the **Saint-Venant** equation.

$$\frac{\partial h}{\partial t} + \nabla_s \cdot \left[h\vec{V}_l \right] = \boxed{\frac{\dot{m}_s}{\rho_l}}$$

$$\boxed{\frac{\partial h\vec{V}_l}{\partial t}} + \boxed{\nabla_s \cdot \left(h\vec{V}_l\vec{V}_l \right)} = \boxed{-\frac{h\nabla_s P_L}{\rho_l}} + \boxed{\left(\vec{g}_\tau \right) h} + \boxed{\frac{3}{2\rho_l}\vec{\tau}_{fs}} - \boxed{\frac{3\nu_l}{h}\vec{V}_l} + \boxed{\frac{\dot{q}}{\rho_l}}$$

Where

$$P_L = P_{gas} + P_h + P_\sigma$$

$$\boxed{P_h = -\rho h \left(\vec{n} \cdot \vec{g} \right)}$$

$$P_\sigma = -\sigma \nabla_s \cdot \left(\nabla_s h \right)$$

<u>RHS</u>

Gas-flow pressure, gravity normal to the wall (spreading) and surface tension; gravity parallel to the film; viscous shear at gas-film interface; viscous source in the film; droplet collection or separation.

$$\partial_t h + \partial_x (hu) + \partial_y (hv) = \cancel{0}$$

$$\boxed{\partial_t (hu)} + \boxed{\partial_x \left(hu^2 + \frac{1}{2} g h^2 \right) + \partial_y (huv)} = \cancel{-hg\partial_x z}$$

$$\partial_t (hv) + \partial_x (huv) + \partial_y \left(hv^2 + \frac{1}{2} g h^2 \right) = -hg\partial_y z$$

Multi-layer method and its normal boundary condition allow, respectively, film viscous shear modeling and gas-liquid viscous shear.

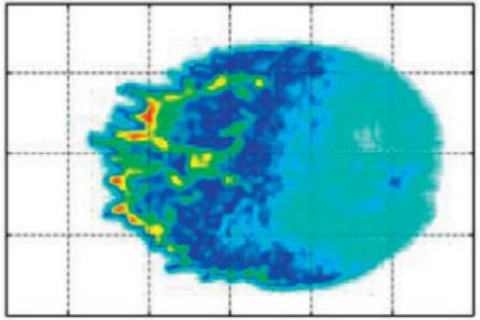
```
scalar hs[];
vector hus[];

advance_saint_venant ( ):
    ho[] = hold + dt*(dh[]+hs[]);
    uo.x[] = (hold*ui.x[] + dt*(dhu.x[]+hus.x[]))/ho[];
```

For while, just droplet collection is considered, since droplet separation (i.e. secondary spray from the film) need to be estimated based on experimental datasets and equations. The “mass conservation and momentum balance” source terms for the Saint-Venant equation is provided by the Basilisk setup as:

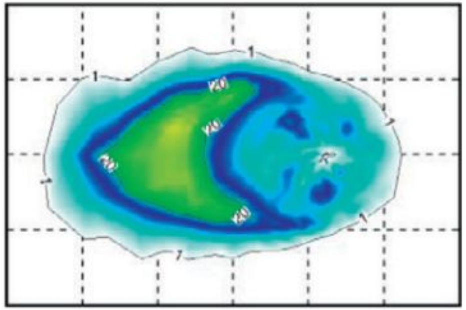
```
// Mass conservation source
hs[] = localThicknessSourceRate;

// Momentum conservation source
foreach_dimension()
    hus.x[] = hs[]*velocity.x[];
```

In the **Eulerian Wall Film model**, the film transport equation and the spray simulation are jointly solved. Therefore, each droplet is accounted to the film source terms at the time it reaches the wall. On the other hand, the **proposed model** get wall impact information during the spray simulation, treats this data, create a meta-model based on a machine or deep learning model, imports these information into the film source terms and runs a stationary film transport simulation based on the **Multi-Layer Saint-Venant equations**.

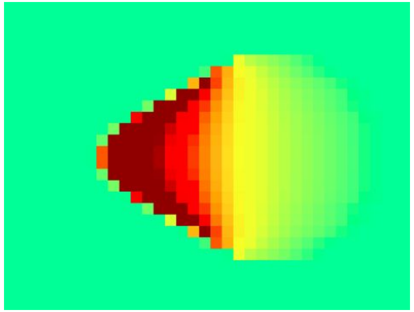
Qualitative comparison of a film thickness field.
Experiment
Eulerian Wall Film model (Zhang, 2016)
Saint-Venant based model (Current status)



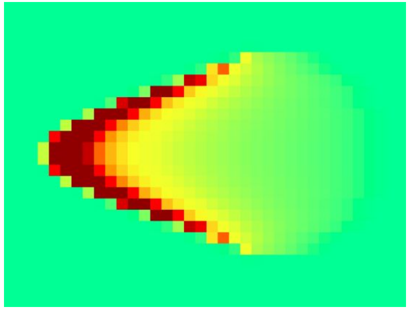
(a) Experiment



(c) OA model



During spray impact



After spray impact

Current challenges

- The liquid-wall split factor is unknown, but it greatly influences film front advance and, consequently, film thickness.

- The liquid film has been feeding with the same amount of experimental mass but it did not match experimental thickness yet.
  Experimental = 10 x Simulation.
  We have checked conservation issues.

- When we add a random noise to the feeding droplet velocity we can notice the same dendrite pattern as in the experimental film front. However it remains a challenge to properly set the impinging vertical velocity profile in order to provide a spreading effect in both directions (X and Y), though we understand the numerical reasons.

- Find more simple, but detailed, experimental/numerical works to validate our methodology.