








Numerical Prediction of Wave Overtopping

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Aims

- Can we use a numerical tool to model overtopping?
- Wave by wave analysis with tides and surge
- Effect of beach profile
- EuroTop comparison
- Walcott and Blackpool case studies
- Input for flood inundation models

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Prediction of Wave Overtopping

Options

- Physical Models
- Empirical Tools
- Numerical Models?

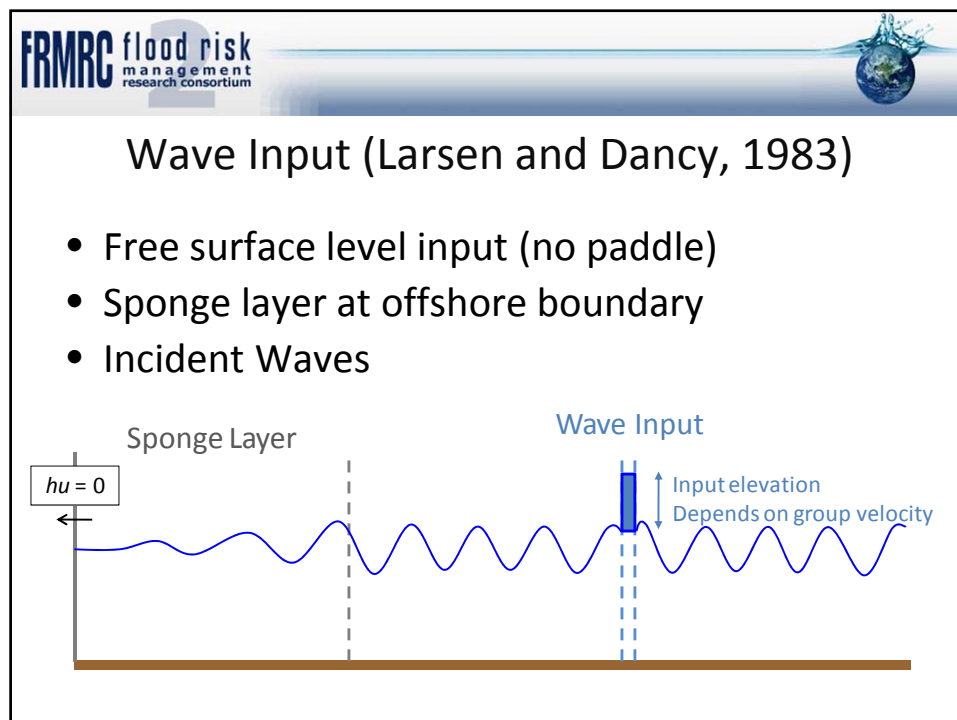
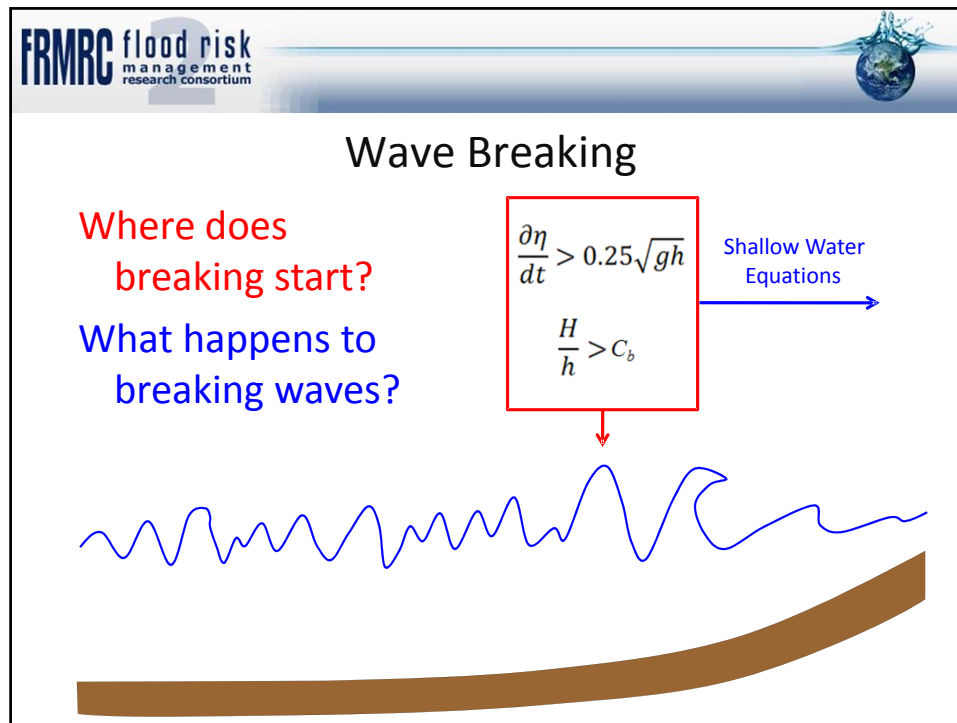
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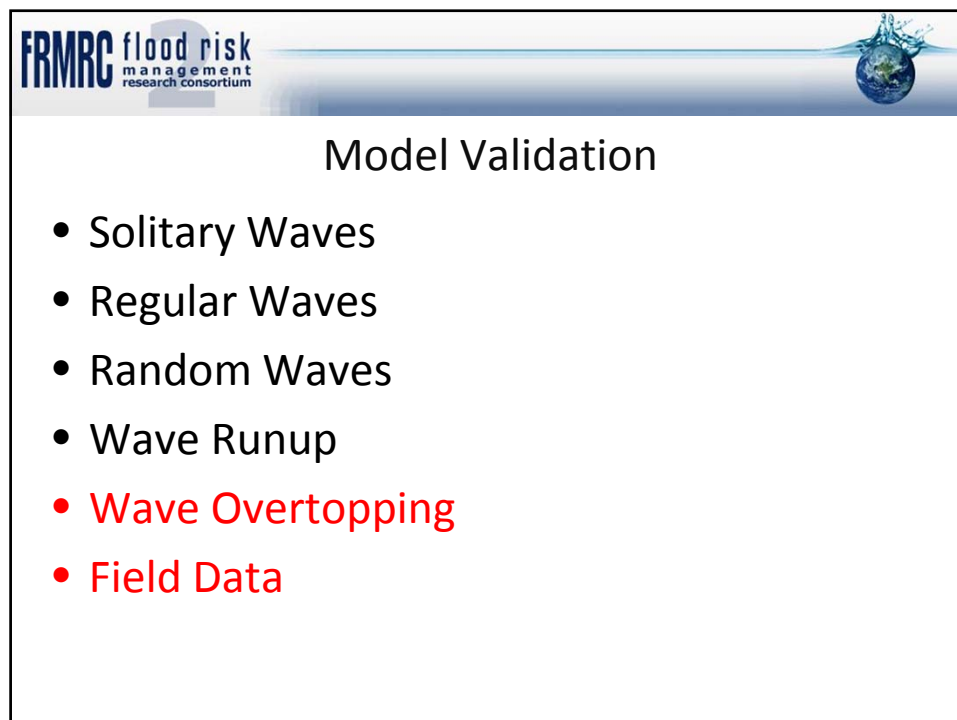
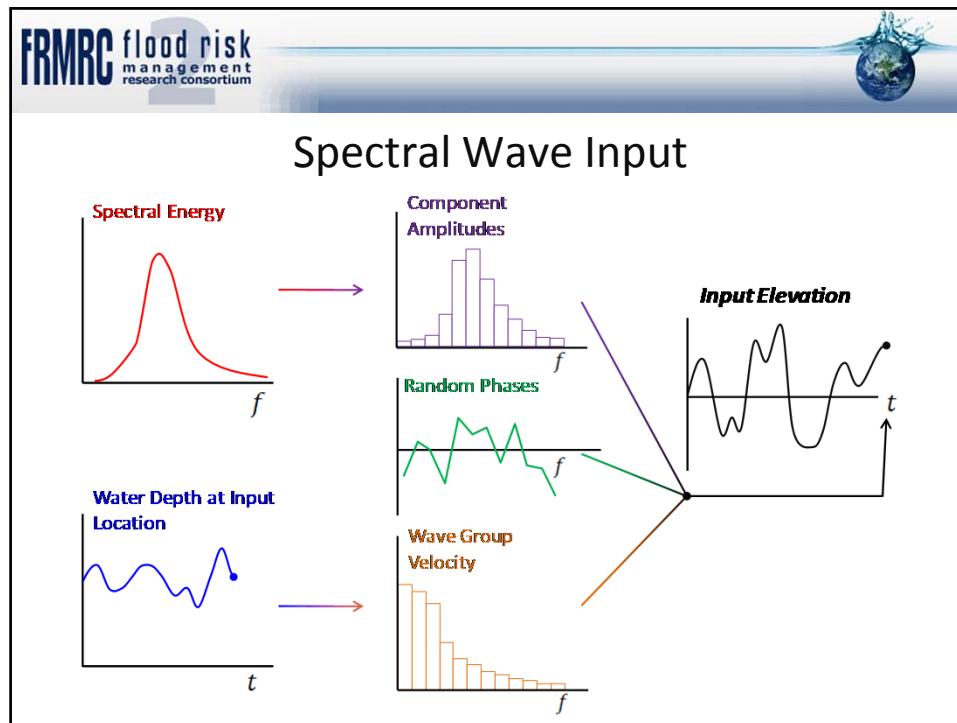
Nonlinear Shallow Water Equations

The diagram illustrates two models for shallow water flow over a wavy bed. On the left, the NLSW model is shown with a blue water column of height h moving with velocity u over a flat bed. The pressure distribution is linear, represented by a blue triangle with height p . The wave speed is given by $c = \sqrt{gh}$. On the right, the Boussinesq model is shown with a green water column of height h moving with velocity \hat{u} over a wavy bed. The pressure distribution is non-linear, represented by a green shape with height p . The wave speed is given by $c = f(h, T)$.

NLSW equations
Shallow water only

Boussinesq – type equations
Intermediate depths






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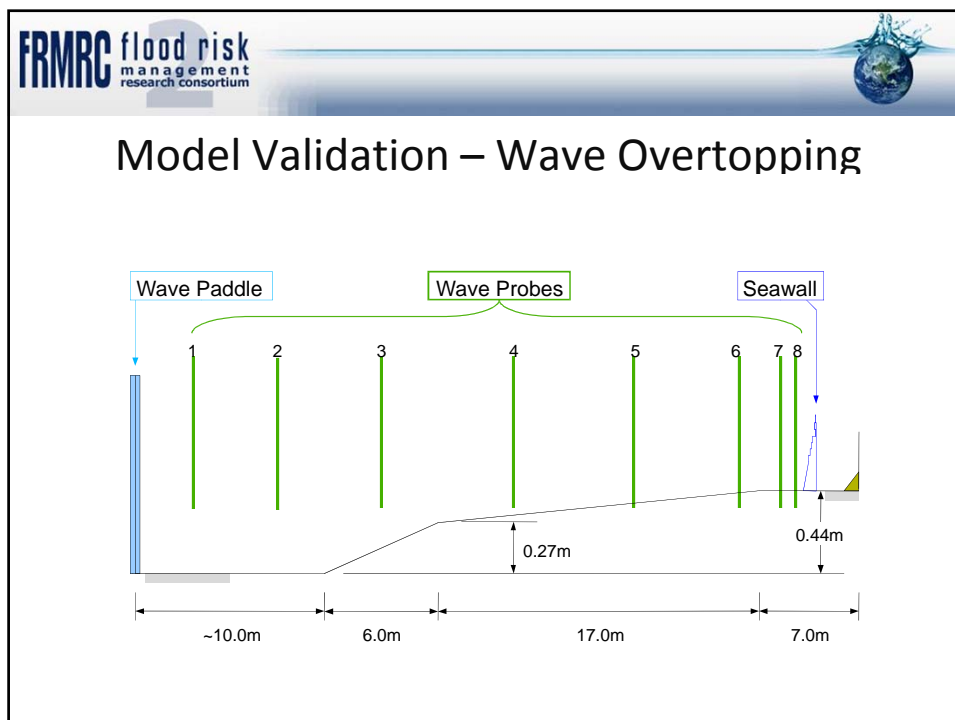
Model Validation – Wave Overtopping

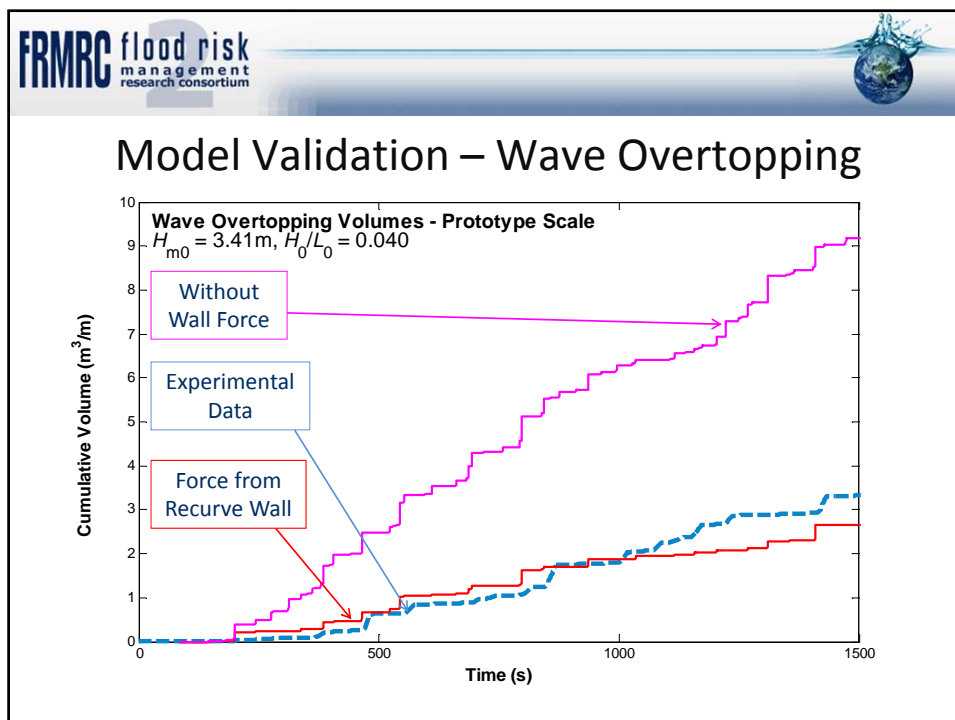
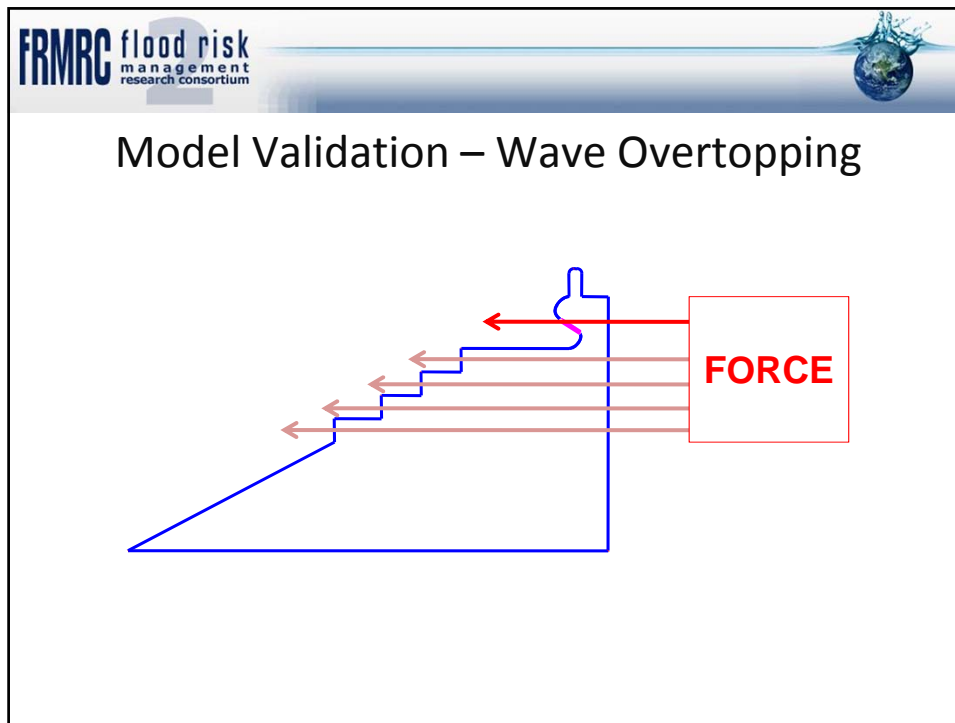
Anchorsholme Seawall
Blackpool

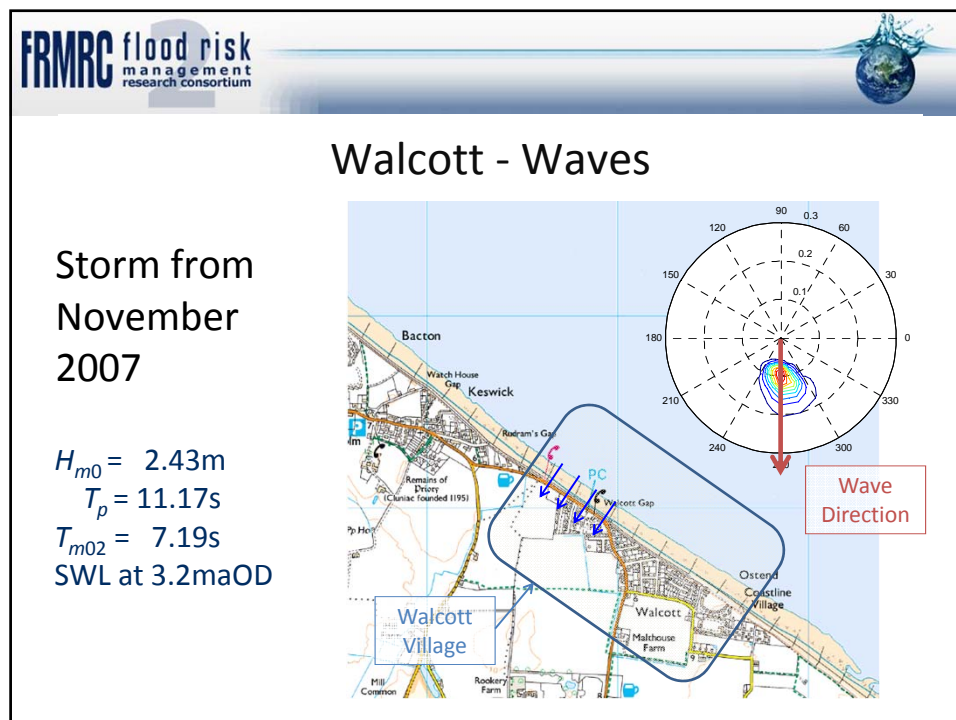
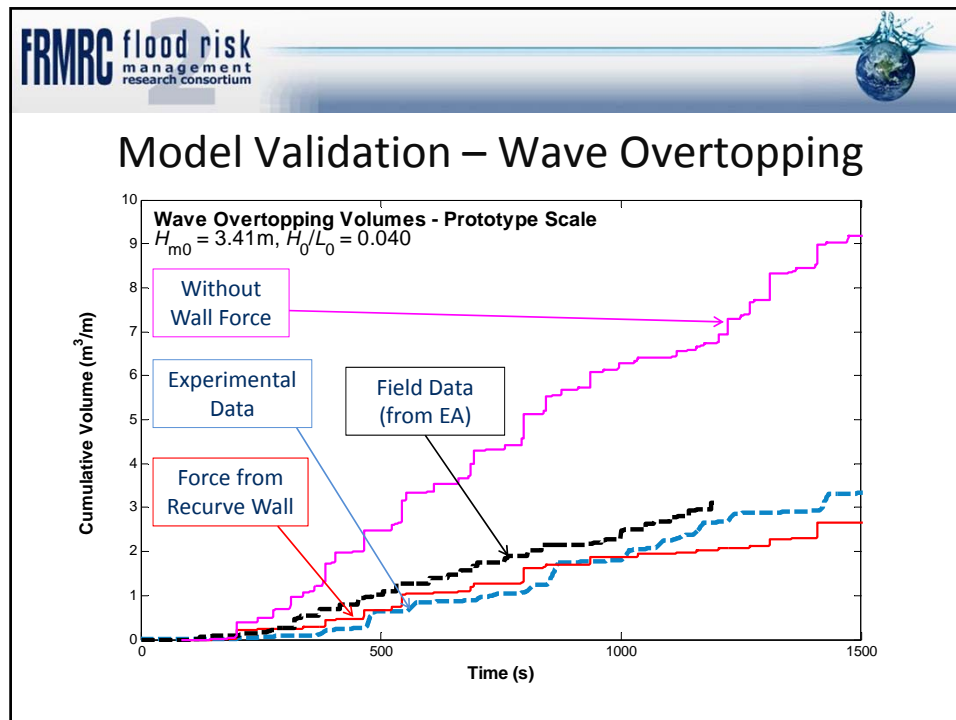
- Field data (HR Wallingford / EA)
- Physical model tests at HR Wallingford

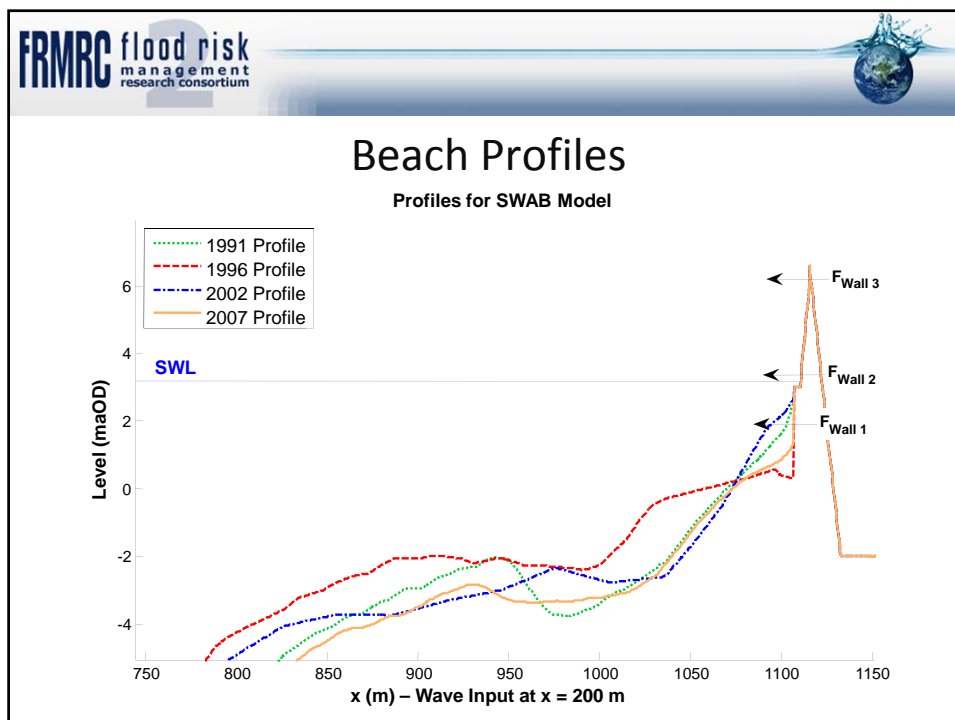
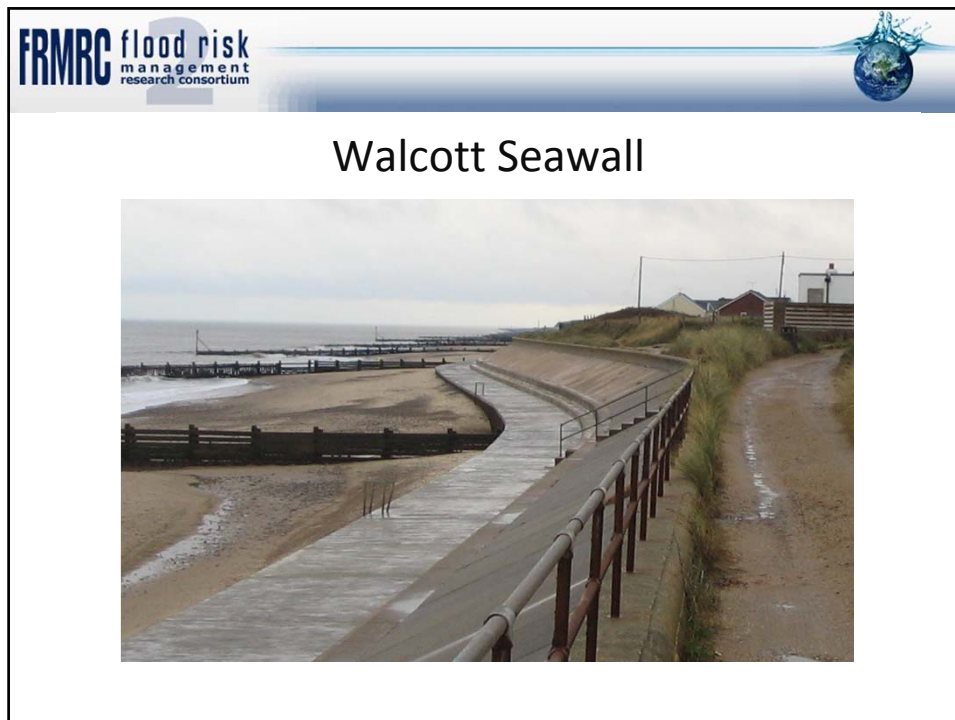


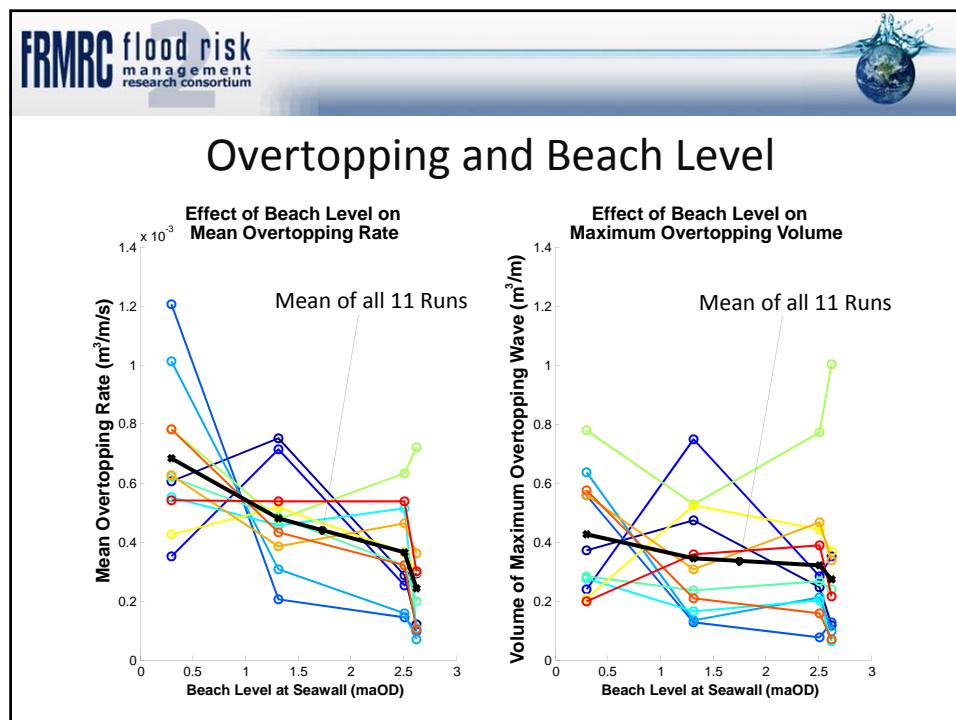
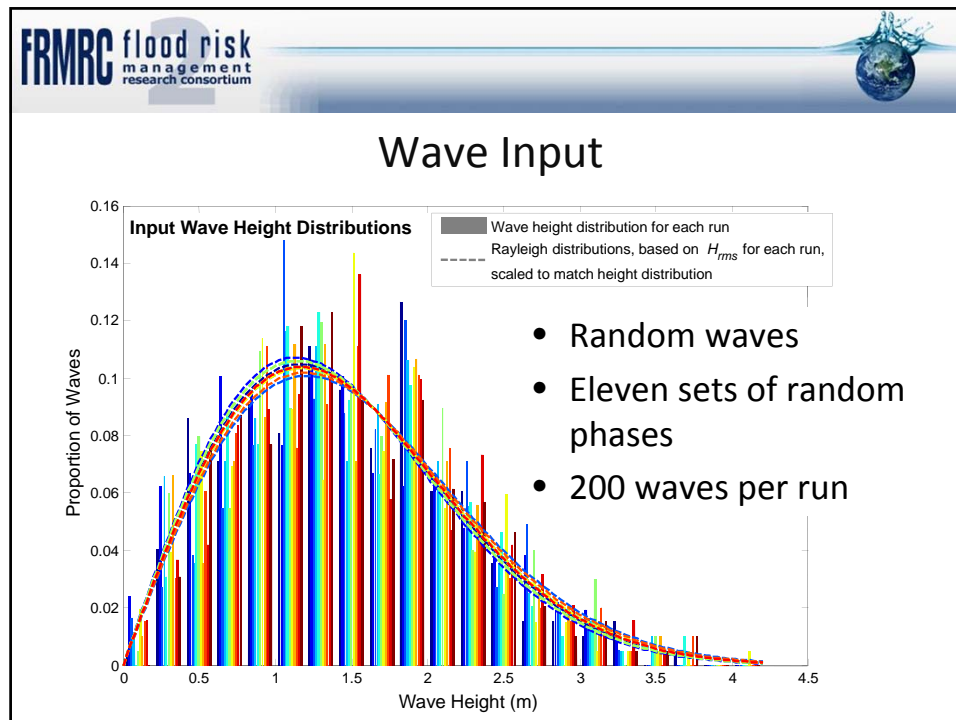
[Link to Movie](#)

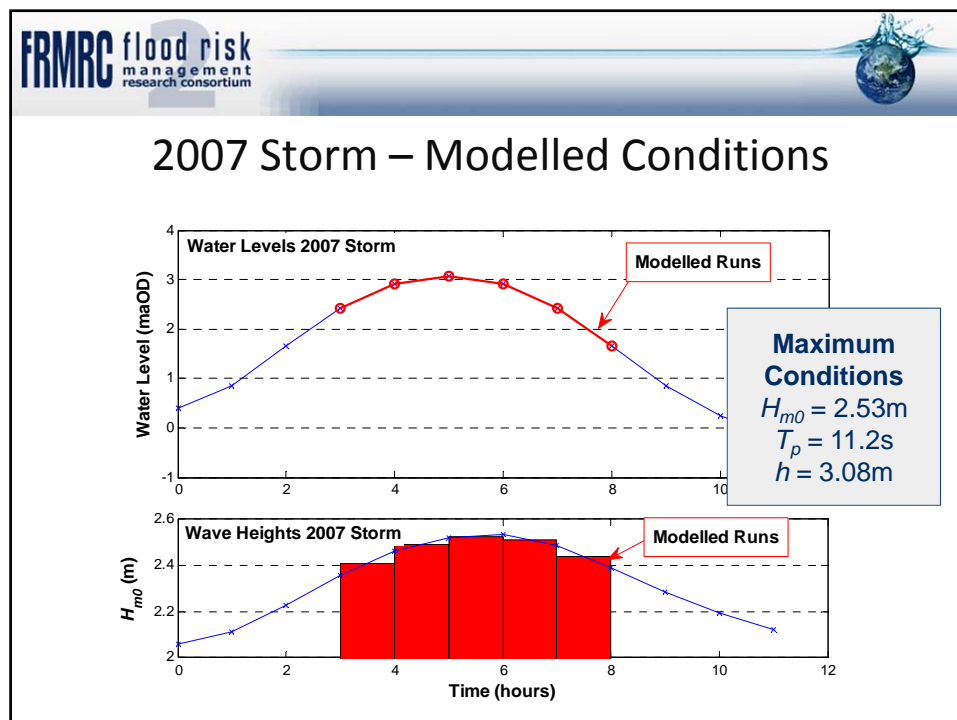
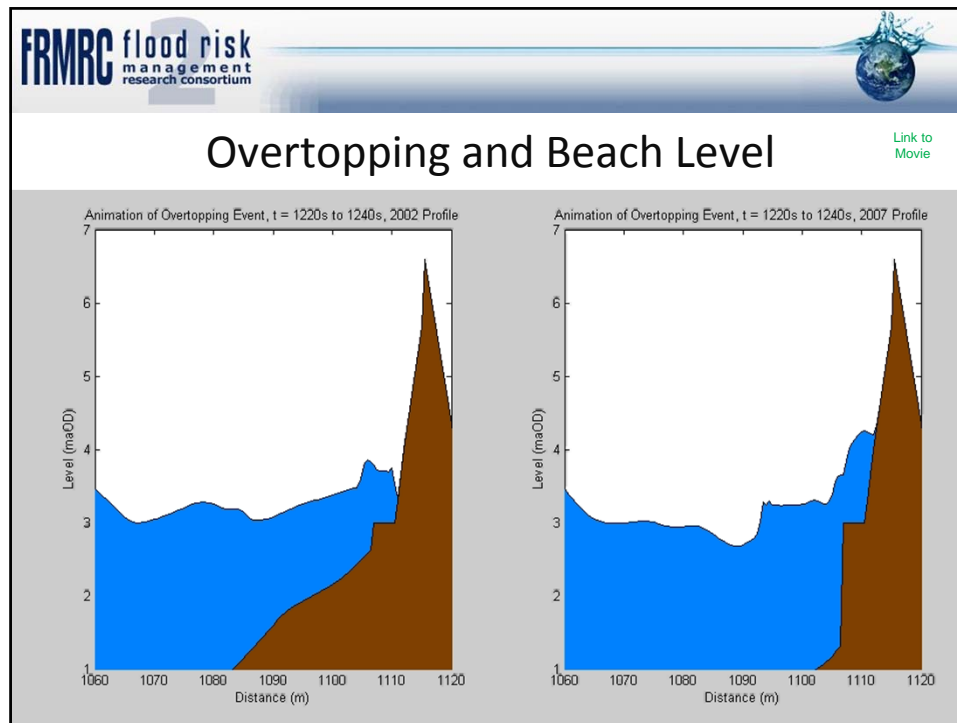


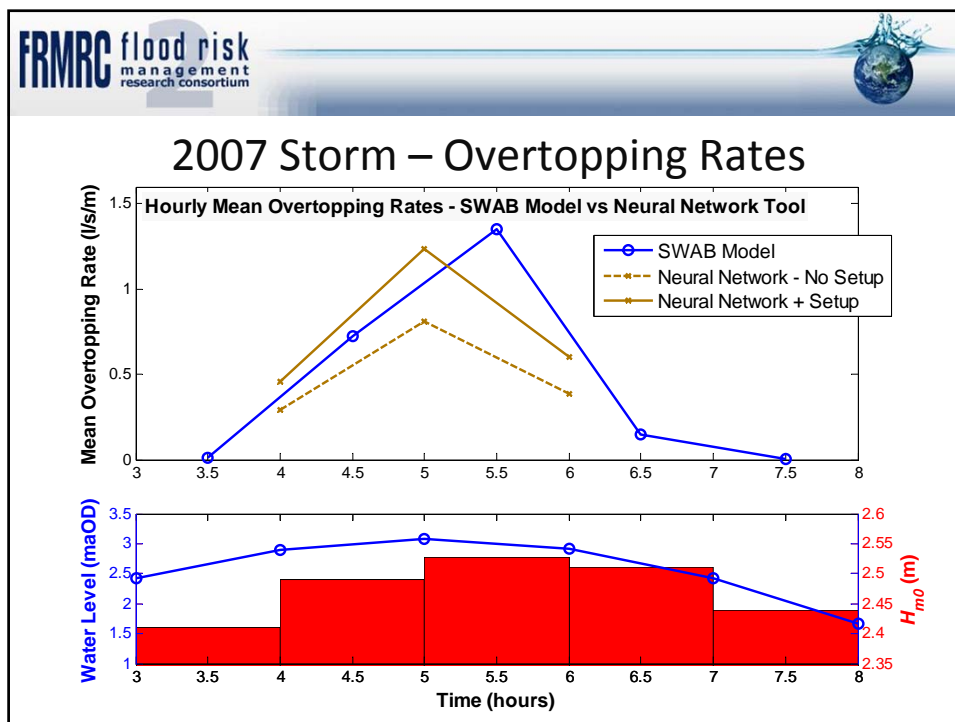
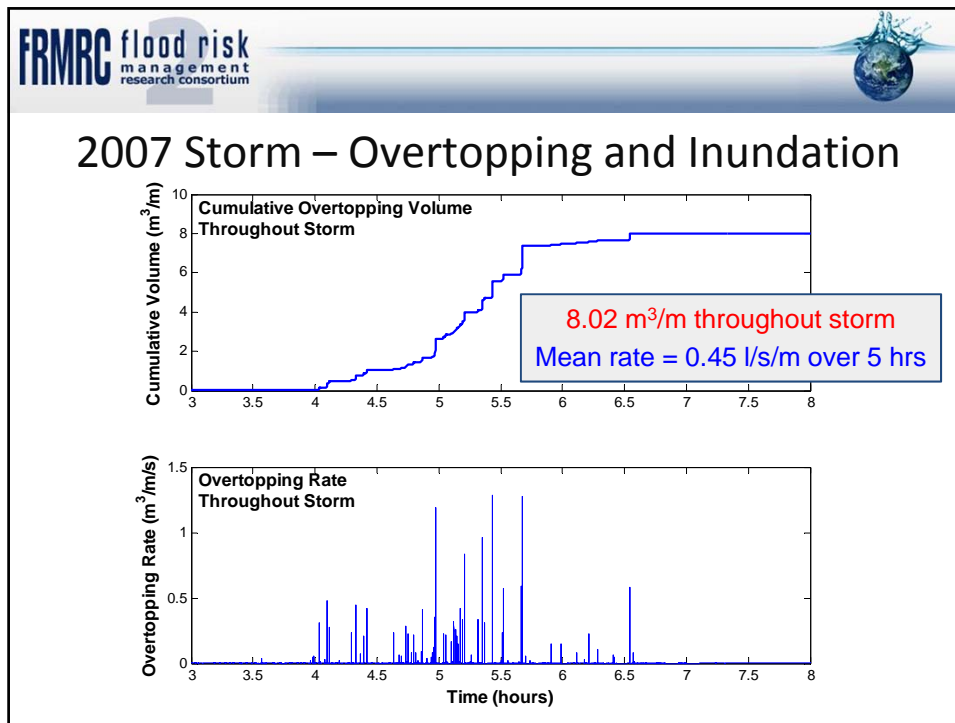


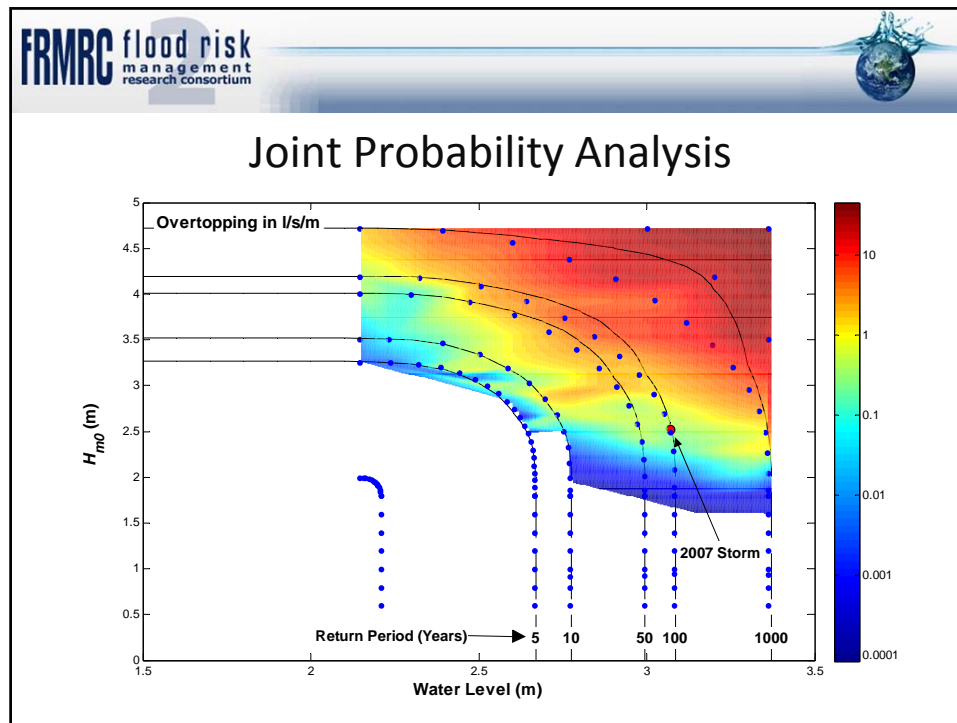












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Smoothed Particle Hydrodynamics (SPH)

Breaking waves on beaches

Plunger

Splash up

(Photo courtesy of F. Raichlen)

Overtopping, flooding and inundation

Water Particles

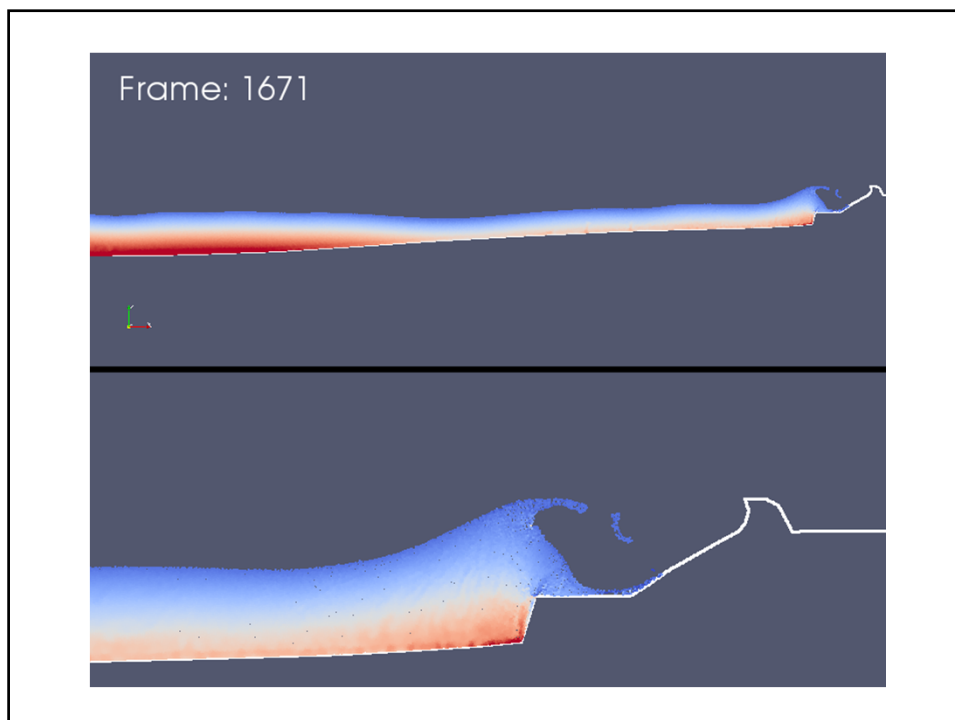
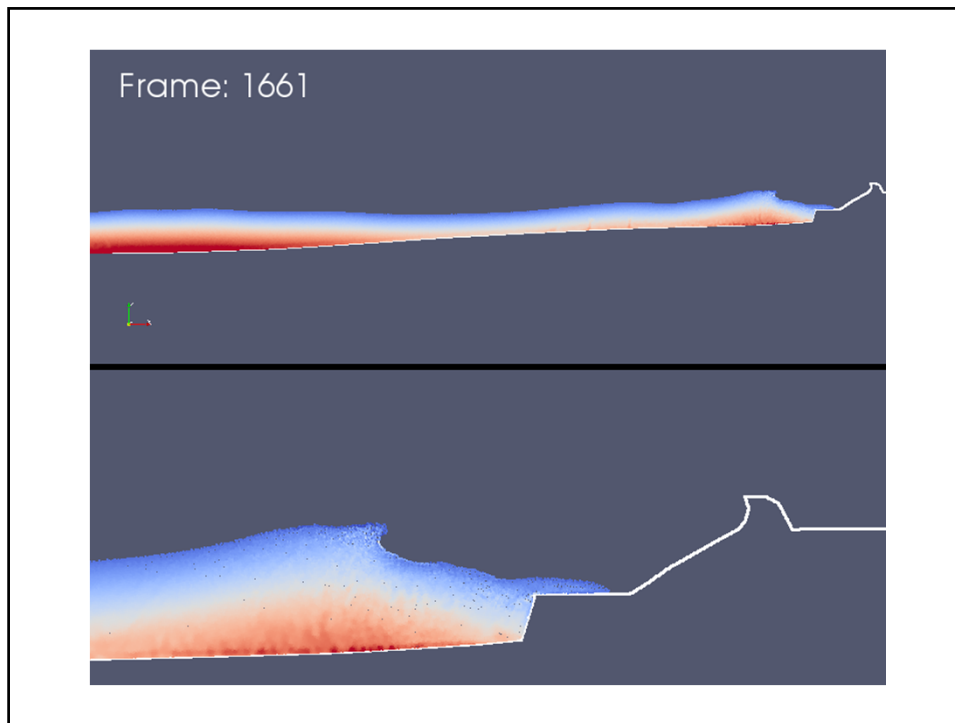
Radius of influence

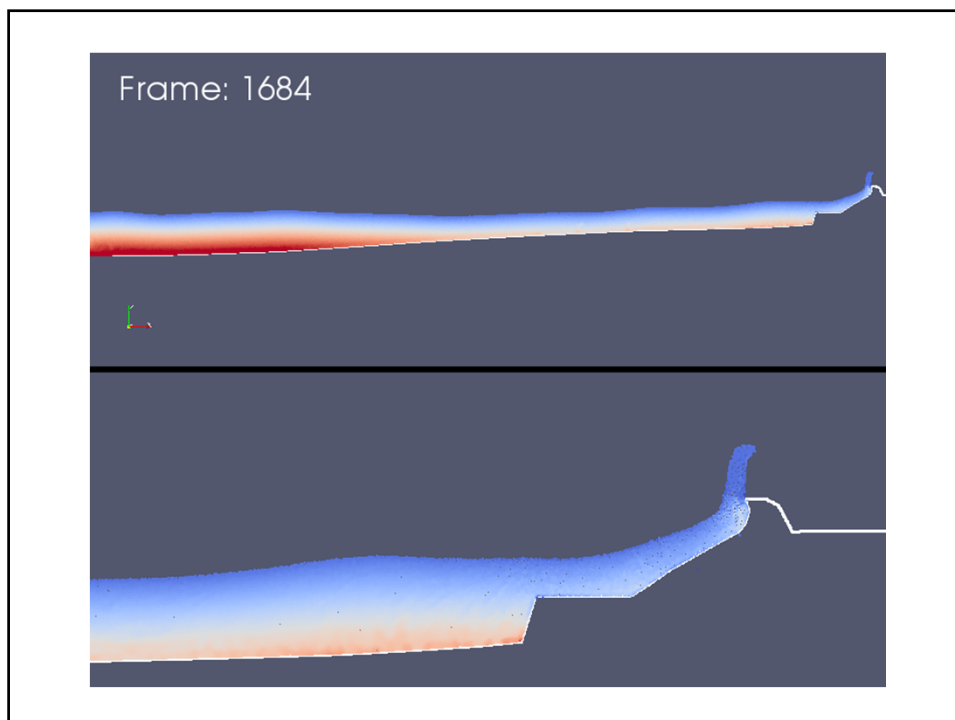
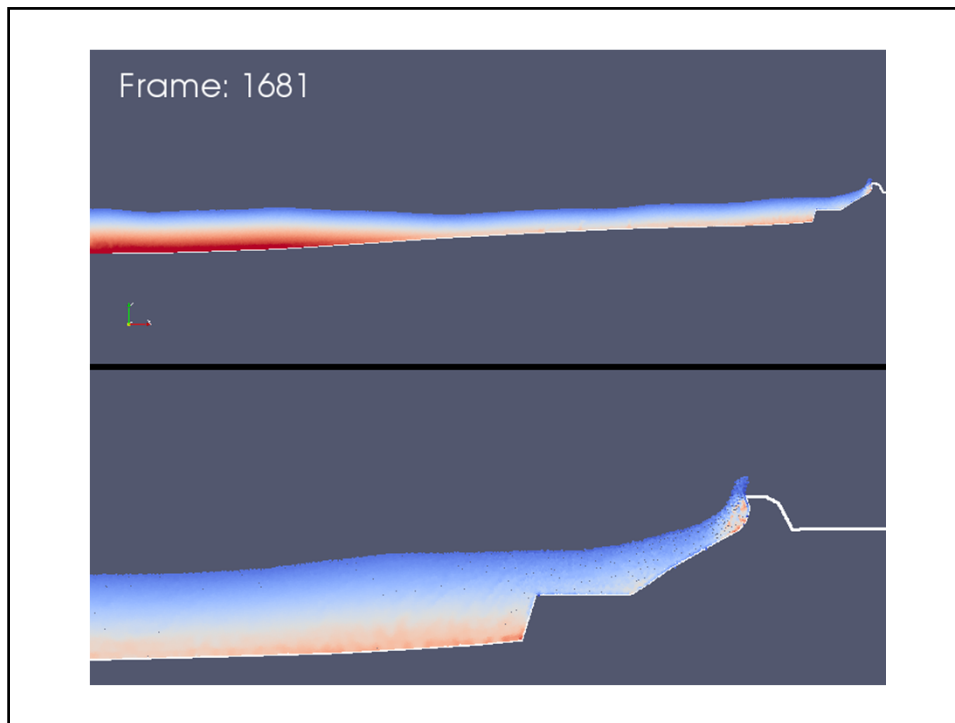
r

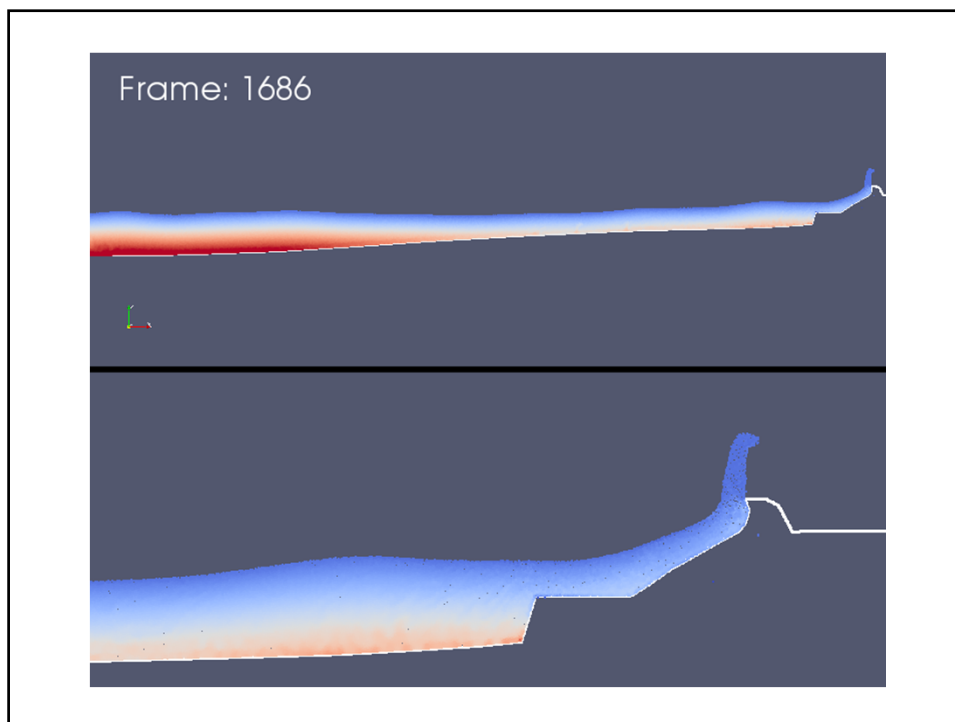
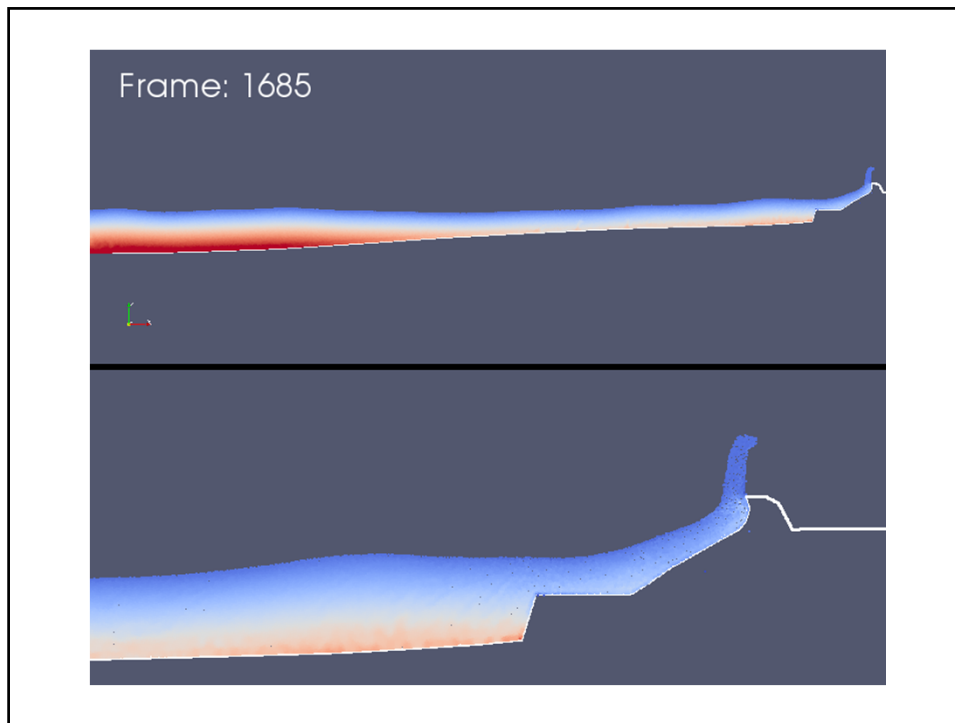
$2h$

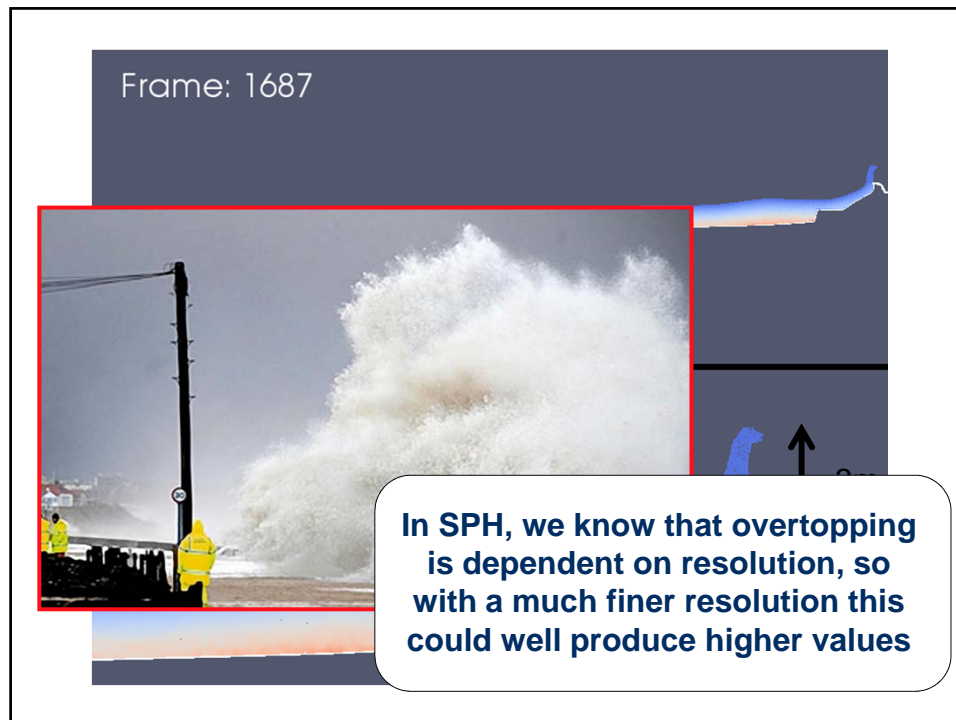
Very complex multi-phase multi-scale highly nonlinear problems

The figure illustrates the application of Smoothed Particle Hydrodynamics (SPH) to coastal flooding. It includes two photographs: one of a wave being generated by a plunger on a beach, and another of a large wave overtopping a structure. Below the photographs, a diagram shows water particles represented by blue dots. A central particle is surrounded by a circle of radius r , with a larger radius $2h$ indicating the radius of influence. A text box highlights that these are 'Very complex multi-phase multi-scale highly nonlinear problems'.









SPHysics



An international collaboration between 4 universities:

- The Johns Hopkins University (USA)
- Universidade de Vigo (Spain)
- University of Manchester (UK)
- University of Rome, La Sapienza (Italy)

Code has been released as free open-sourceware
<http://www.sphysics.org> (4000+ downloads)

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Conclusions

- Can we use a numerical tool to model overtopping? **YES**
- Wave by wave analysis with tides and surge
- Effect of beach profile
- EuroTop comparison **Same order of magnitude**
- Walcott and Blackpool case studies **Good results**
- Input for flood inundation models



Acknowledgement

The research reported in this presentation was conducted as part of the Flood Risk Management Research Consortium with support from the:

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- **Department of Environment, Food and Rural Affairs/Environment Agency Joint Research Programme**
- **United Kingdom Water Industry Research**
- **Office of Public Works Dublin**
- **Northern Ireland Rivers Agency**

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