



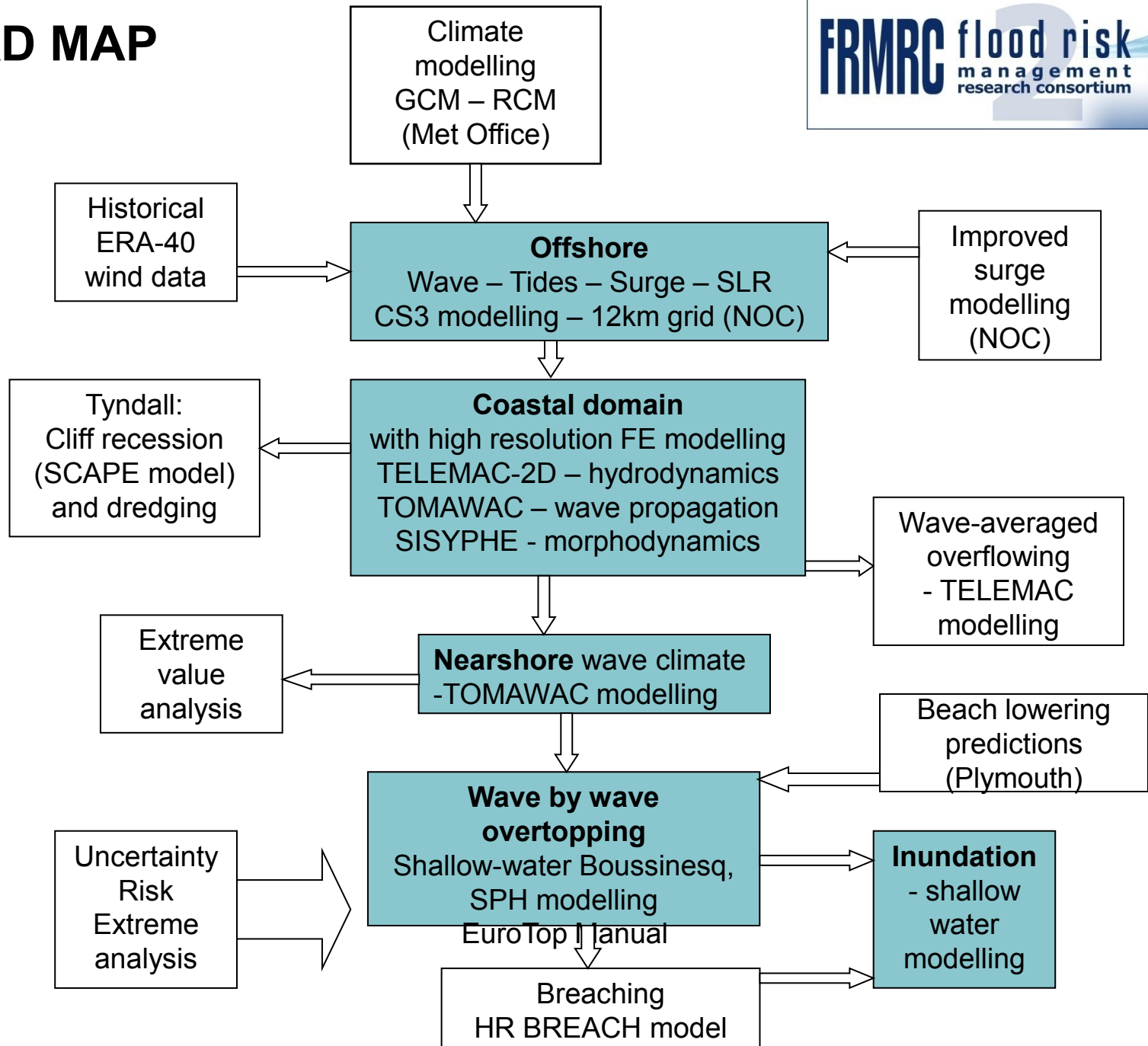
Super Work Package 2

Coastal Flooding

EPSRC Grant: EP/FP202511/1



ROAD MAP





GENERAL METHODOLOGY

Tested on storm at Walcott, Norfolk, England 9th November 2007

OVERTOPPING

Measured at Anchorsholme, Blackpool, in January 2008

by HR Wallingford for the Environment Agency -

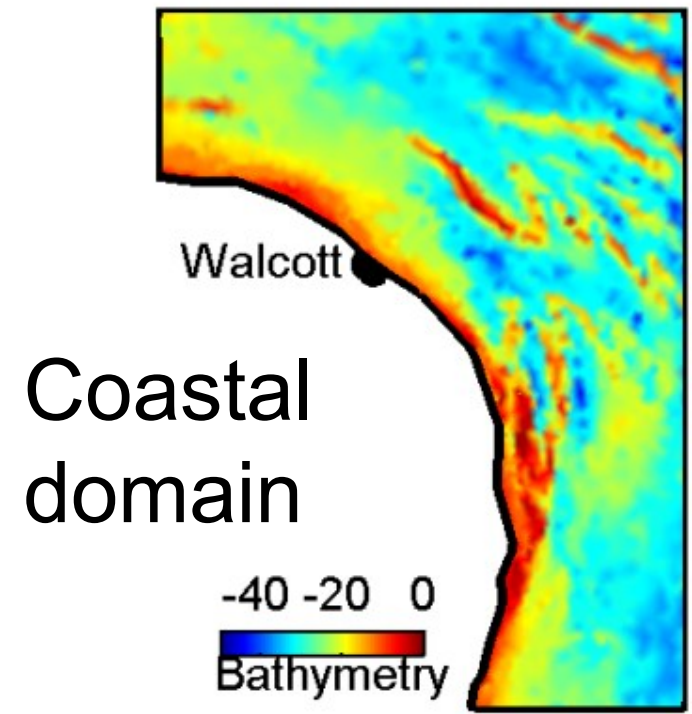
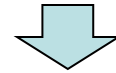
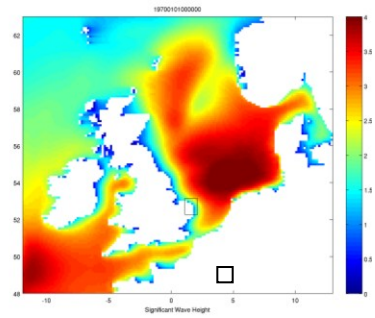
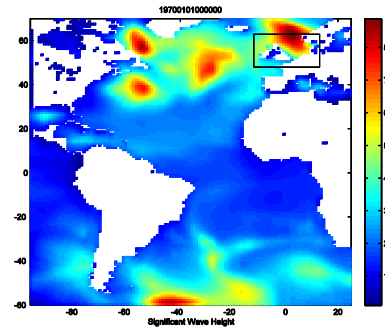
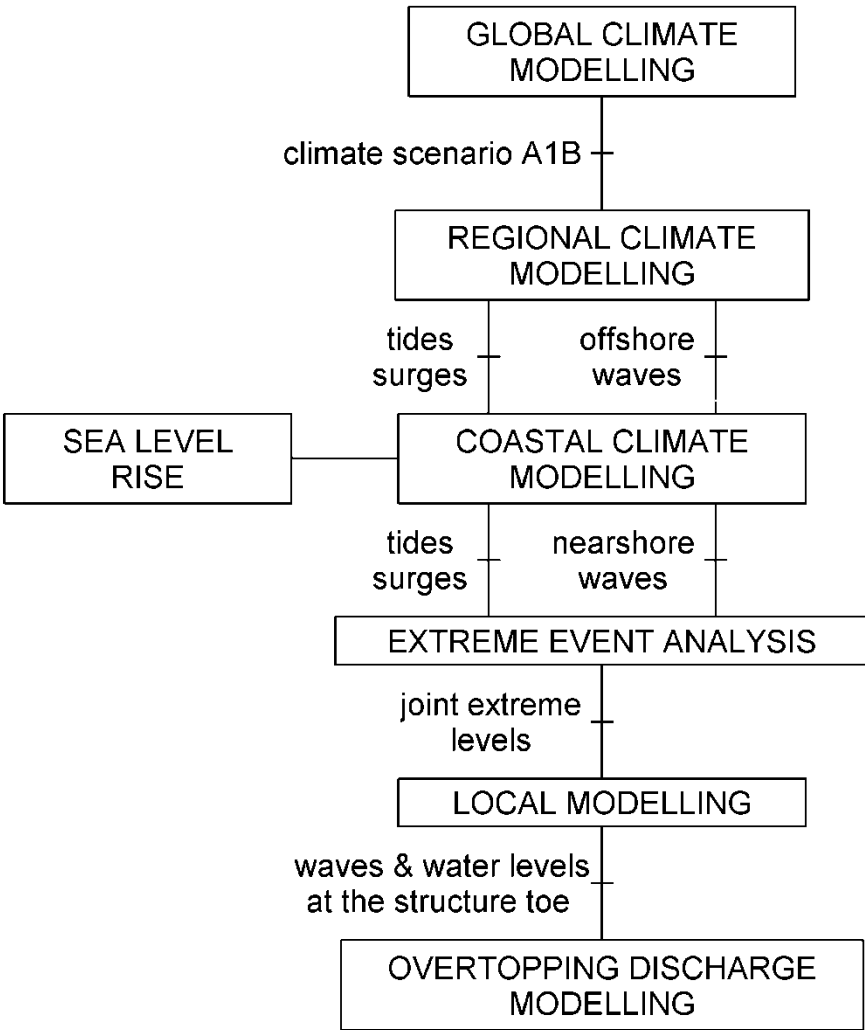
Laboratory tests, Shallow-Water And Boussinesq (SWAB) and

SPH modelling for great detail

FIELD-LABORATORY-MODELLING

AIMS

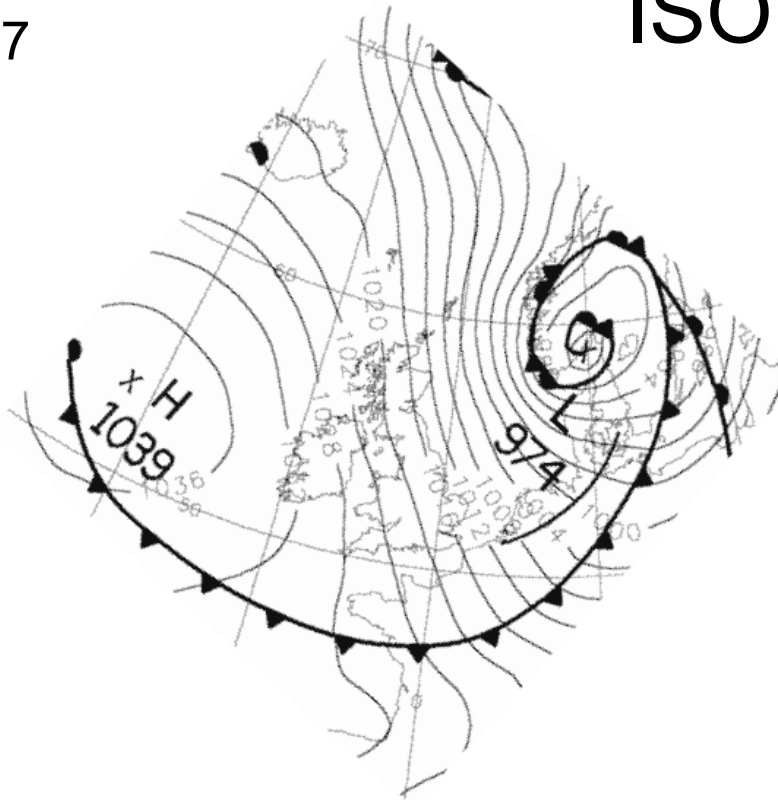
- Predict inundation accurately from offshore conditions
- Predict statistics of overtopping/inundation with climate change and sea level rise
- Analyse uncertainty





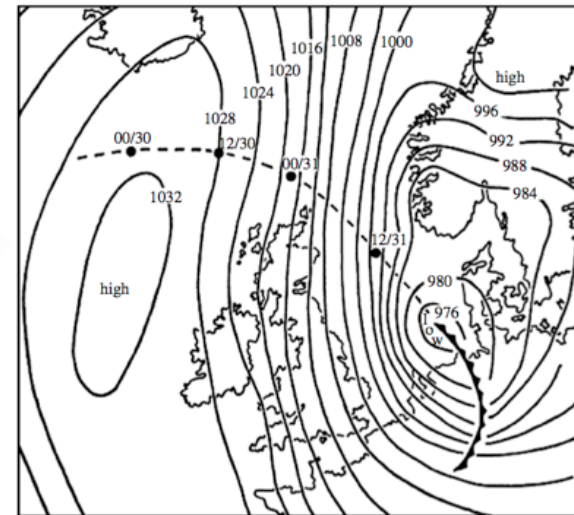
Walcott flood
9th Nov 2007
(from NOC)

ISOBARS



**Surface pressure analysis
at 00:00 GMT, 9th Nov. 2007**

from Horsburgh et al. (2008)



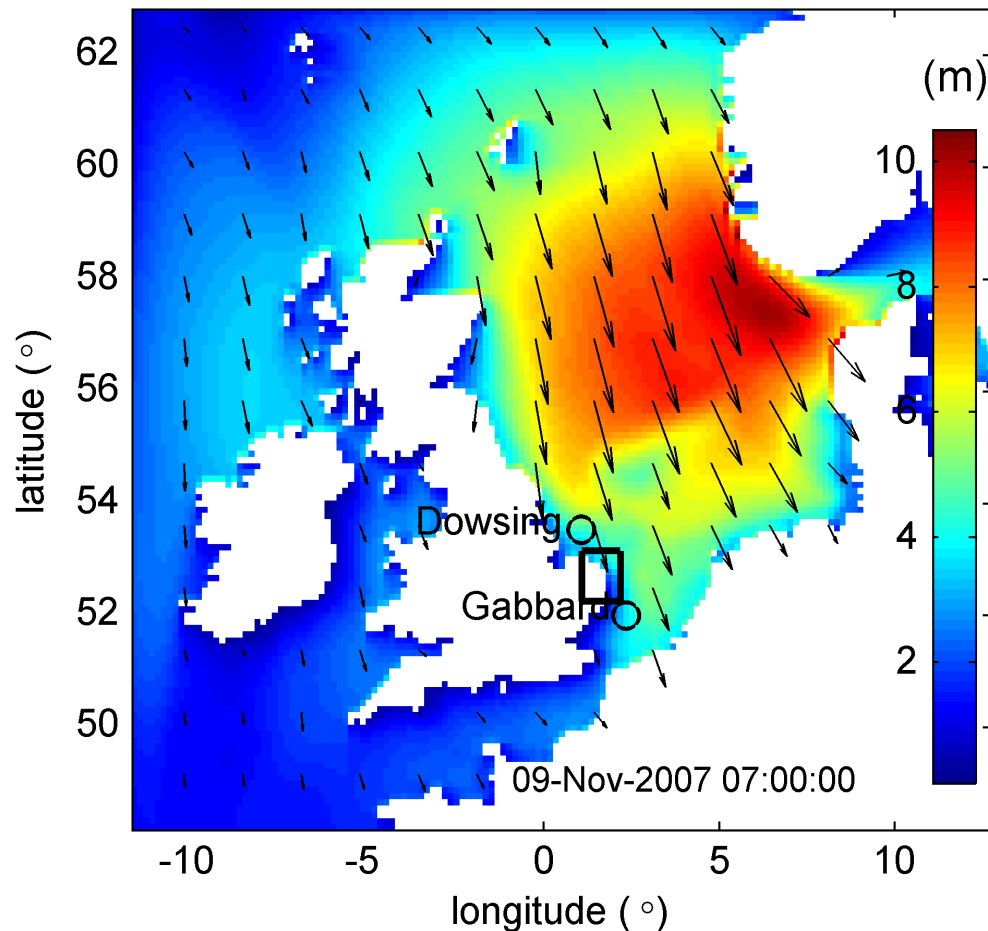
**Surface pressure analysis
at 00:00 GMT, 1st Feb. 1953**

from Wolf and Flather (2005)



Walcott flood
9th Nov 2007
(from NOC)

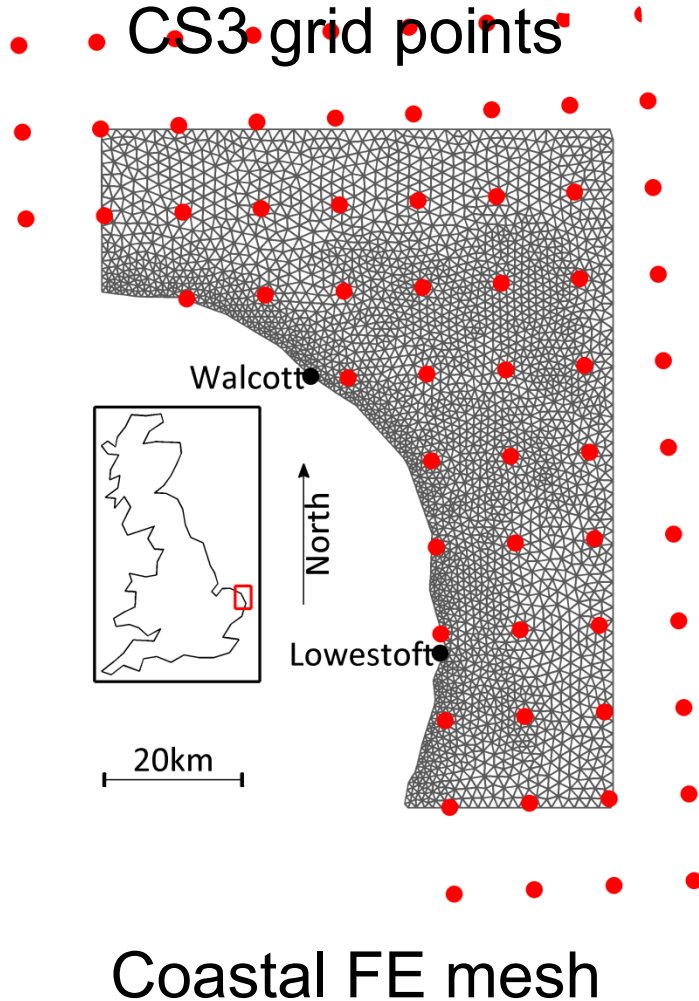
WAVE HEIGHTS



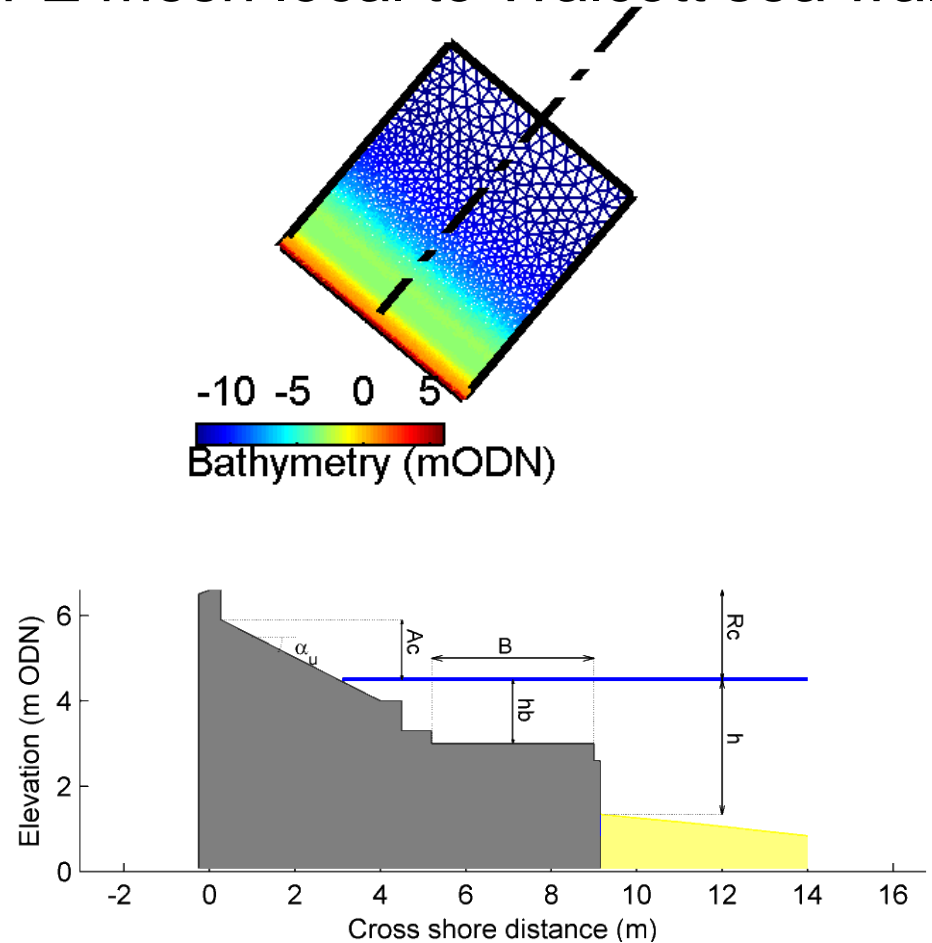
Significant wave height from the wave model at 07:00 on 9th November 2007.
The colour bar shows the wave height in metres.
The arrows show the peak wave direction at that time.



From regional to coastal modelling



FE mesh local to Walcott sea wall



Coastal wave modelling

POLCOMS-WAM

Including :

→ bathymetric wave breaking

→ shoaling

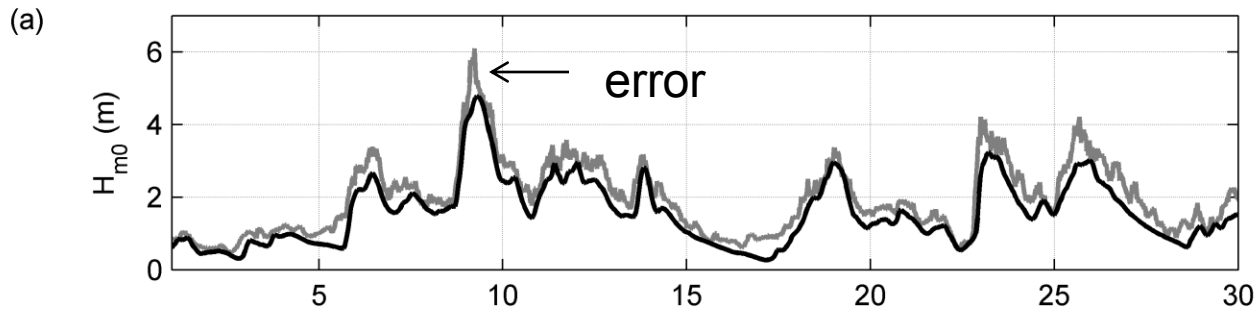
→ bottom friction

→ Wave-wave non linear interaction

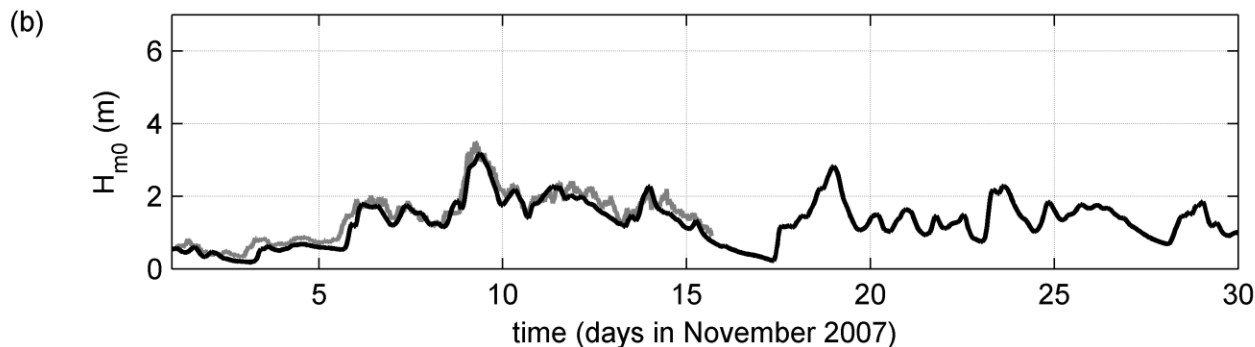
→ bathymetric refraction

→ water depth variation due to tides and surges

Significant wave height at Dowsing (a) and Gabbard (b).

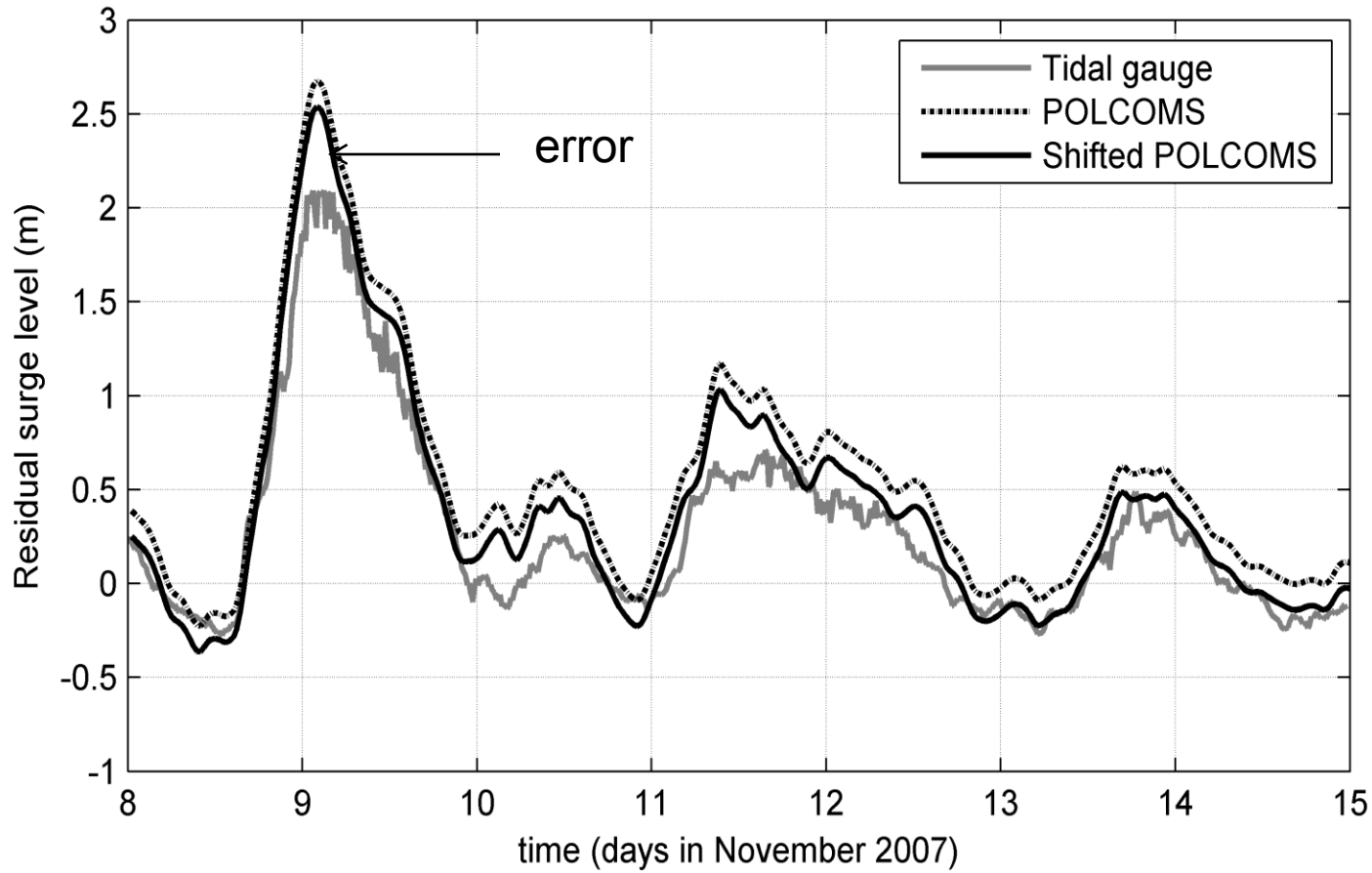


Black – model
Grey - buoy



Coastal tide-surge modelling

Residual surge from model and observations from Lowestoft

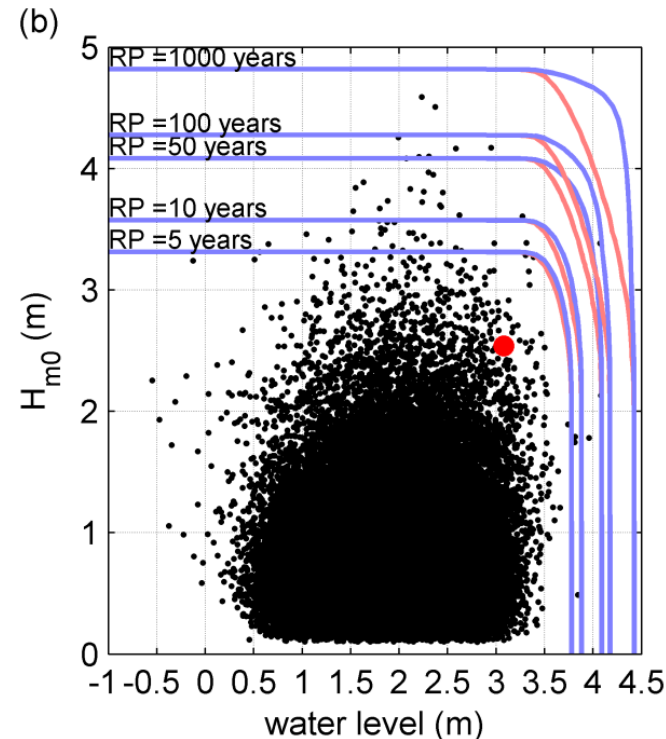
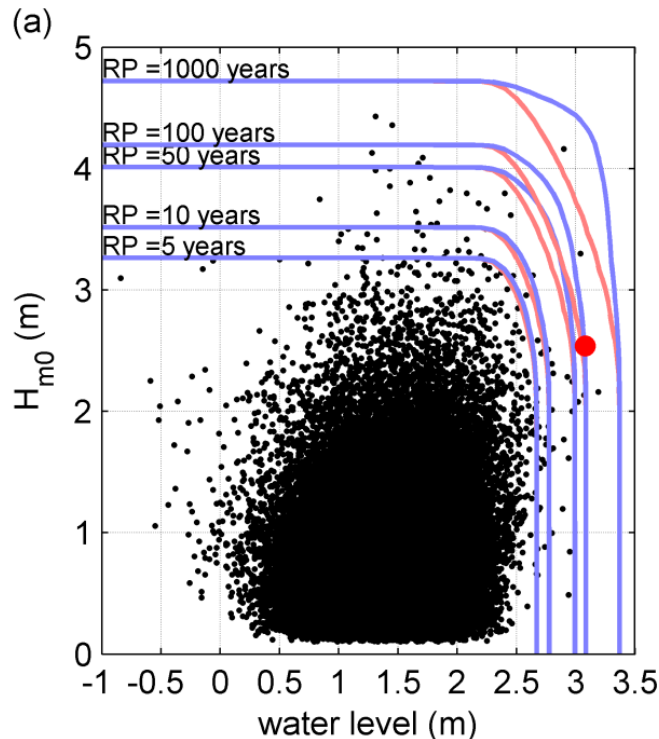


Extreme value joint probability analysis :1960-2100

No SLR

1m SLR in 2100

Return
Period



Scatter plot of semi-diurnal maxima of significant wave height vs water level
Red – independent ; blue – dependent.

The red dot shows the location of the Nov 2007 event



OVERTOPPING SEA WALL

Anchorholme, Blackpool
data 28th January 2008.

Flume tests at HR Wallingford.

Overtopping field tests – EA data

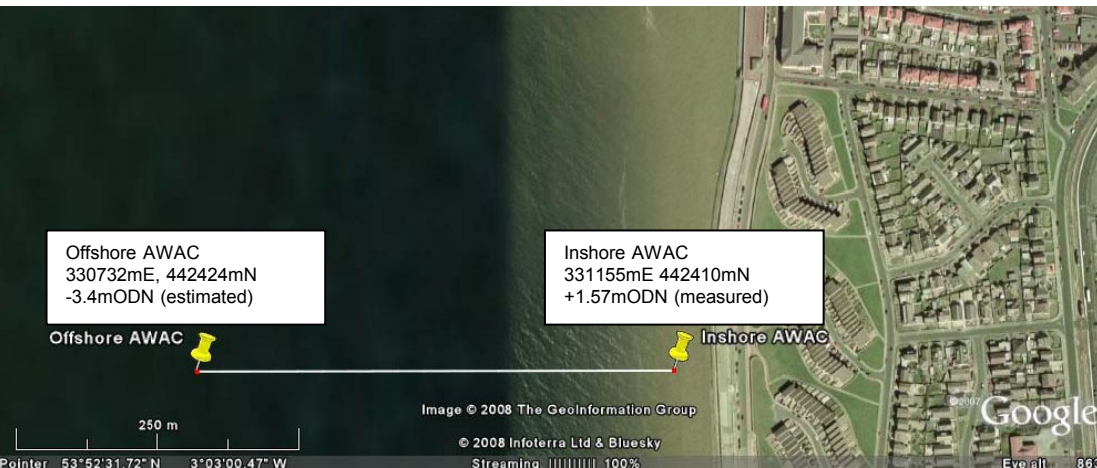
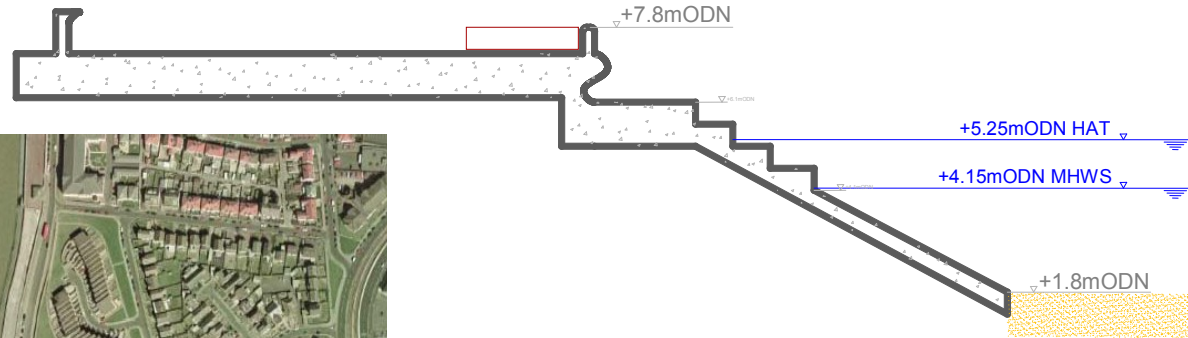


Image © 2008 The GeoInformation Group

© 2008 Infoterra Ltd & Bluesky

Streaming 100%

Google

Everall 833



Physical Model Comparison

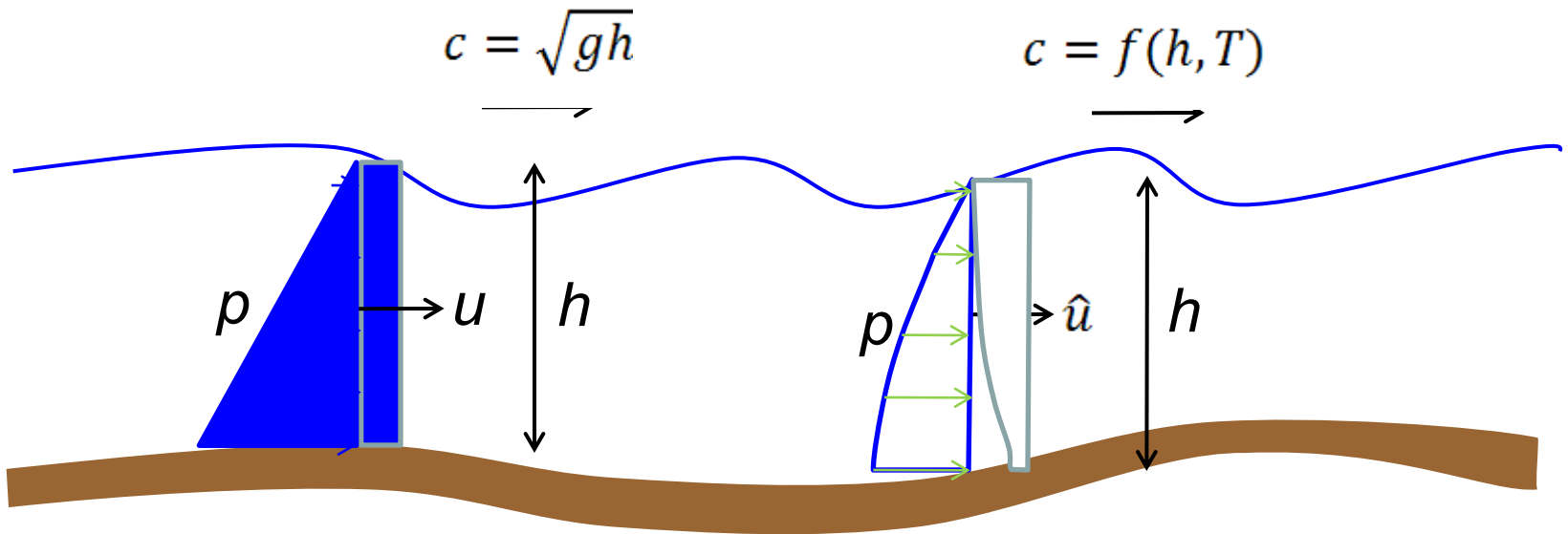
HR Wallingford
tests



[Link to
Movie](#)

Shallow Water And Boussinesq (SWAB) Model

Depth averaged – 1-D time stepping

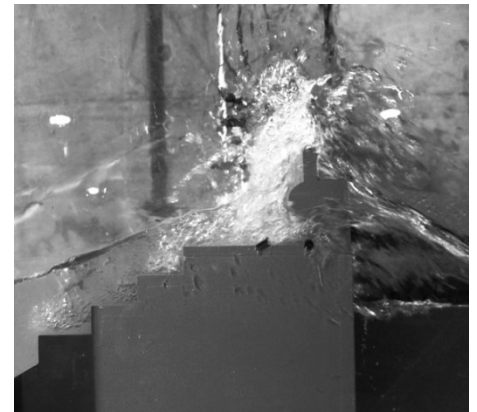


Shallow water equations
Shallow water only

Boussinesq equations
Intermediate depths

- Boussinesq works well on mild slopes without breaking **SWAB**
- *New breaker algorithm* based on old concept – ratio of wave height to depth limit for individual waves
- *New algorithm for breaker impact* – momentum reversal
- Surface elevation input only
- Executable and manual available

Recurve

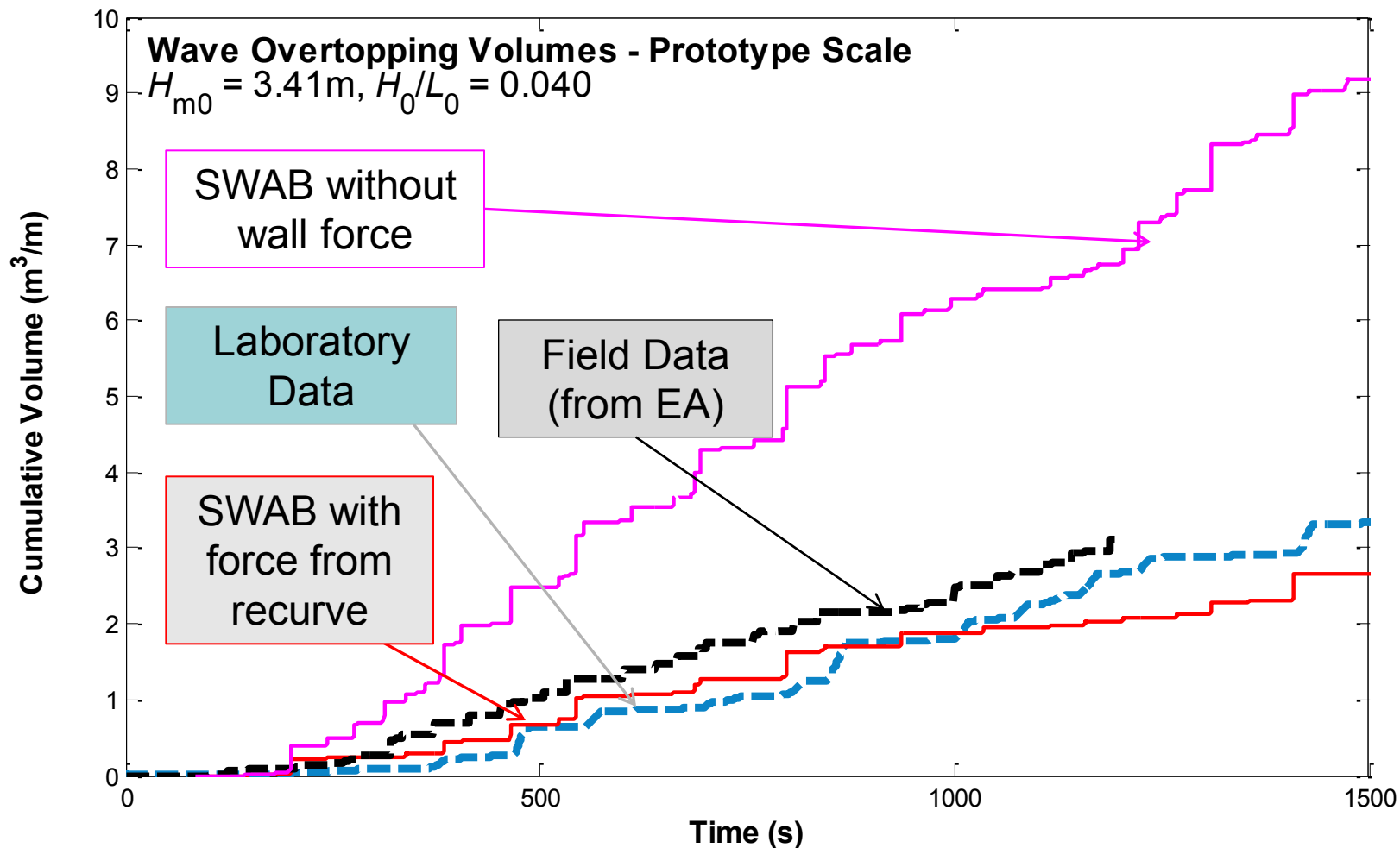


ADVANTAGES

- Easy to use and fast
- Less uncertainty over input than EuroTop
- Breakers switch on/off automatically – suited to waves propagation over reefs



Shallow Water And Boussinesq (SWAB) model validation against field and lab data





Walcott - Waves

Storm from
November

$H_{m0} = 2.43\text{m}$
 $T_p = 11.17\text{s}$
 $T_{m02} = 7.19\text{s}$
 SWL at 3.2maOD





Walcott Seawall





courtesy Sylvia Andrews WEVA

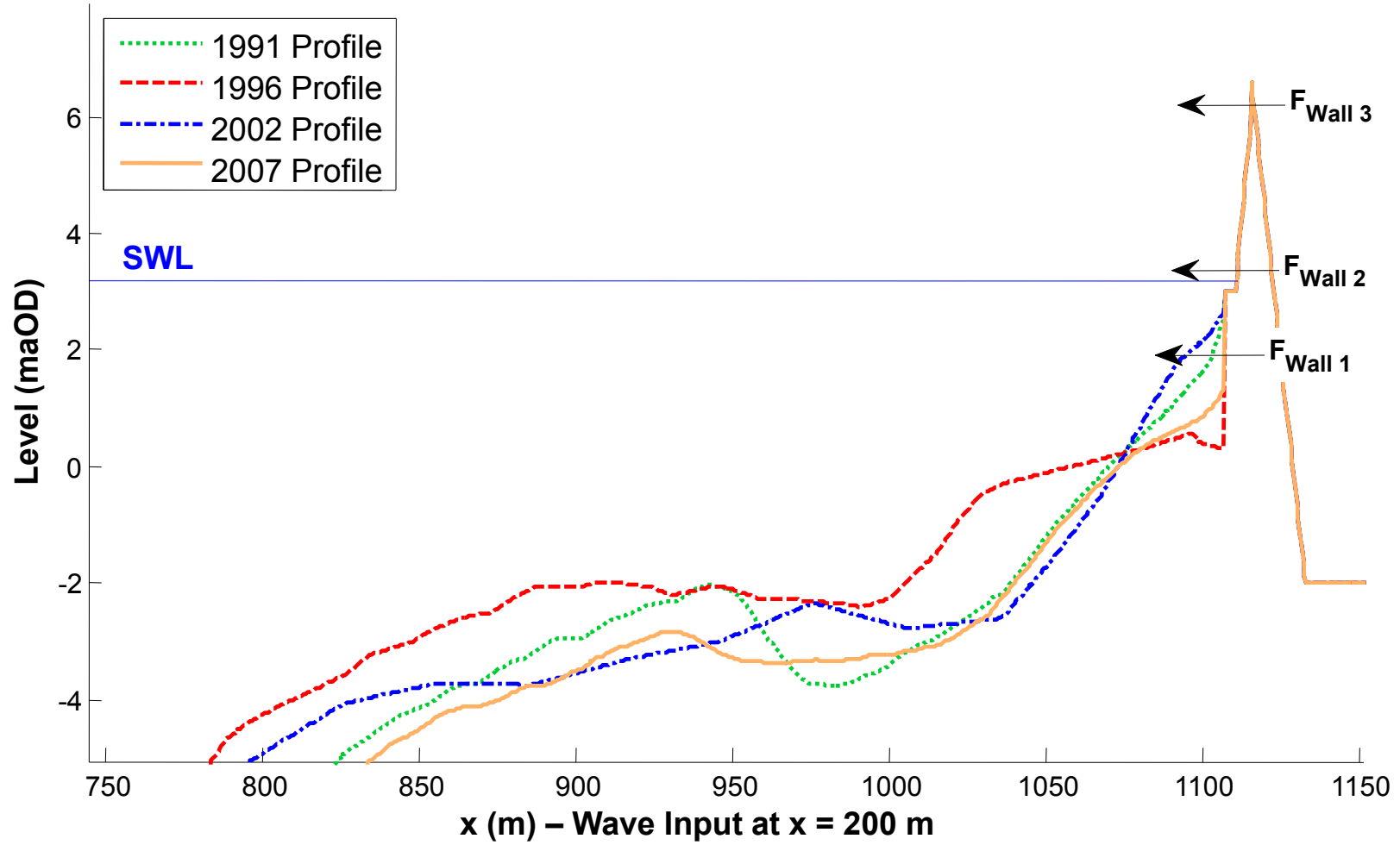


courtesy Sylvia Andrews WEVA



Beach Profiles

Profiles for SWAB Model



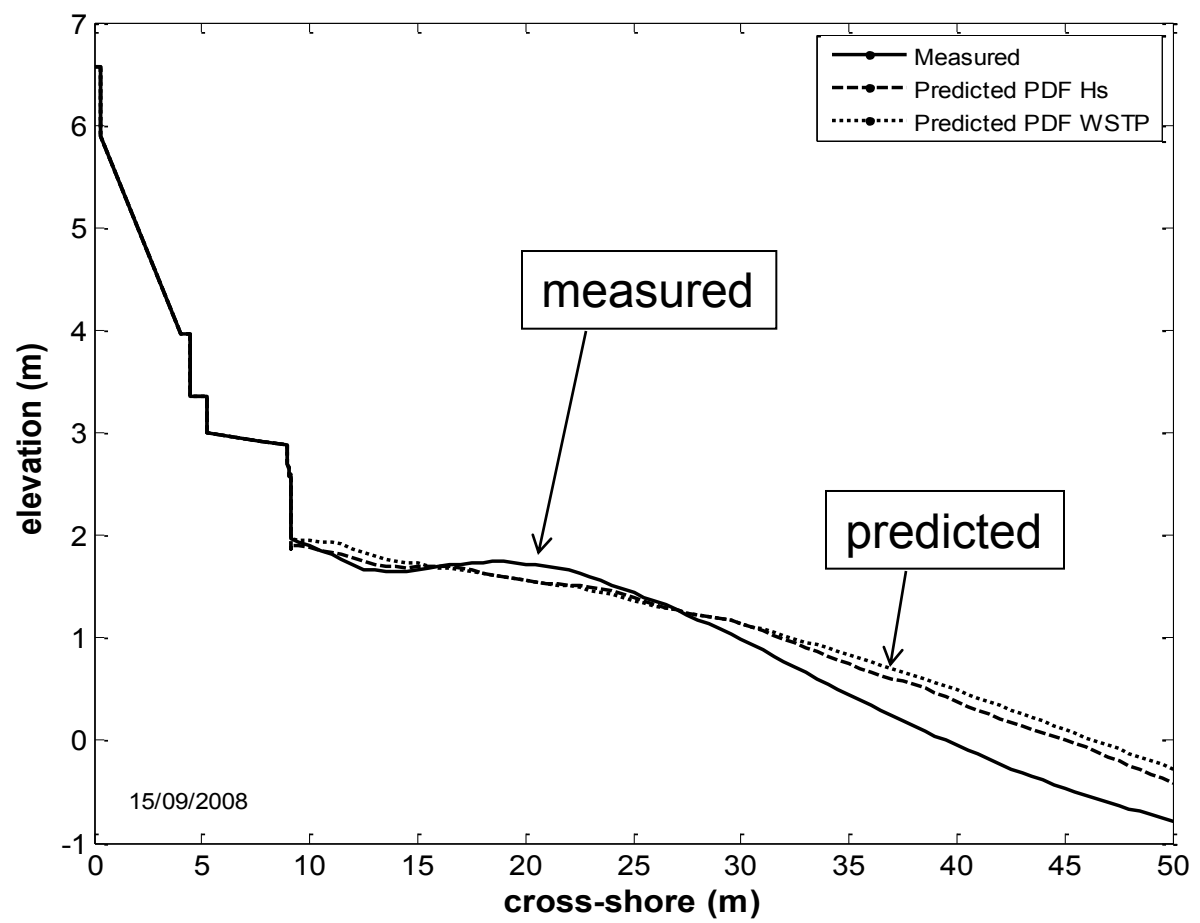


BEACH PROFILE PREDICTION by Canonical Correlation Analysis (CCA) (Reeve – Plymouth now Swansea)

CCA – a data-driven statistical analysis - is useful for analysing beach profile response to waves if there is strong correlation between the two variables (beach profiles and wave height distributions).



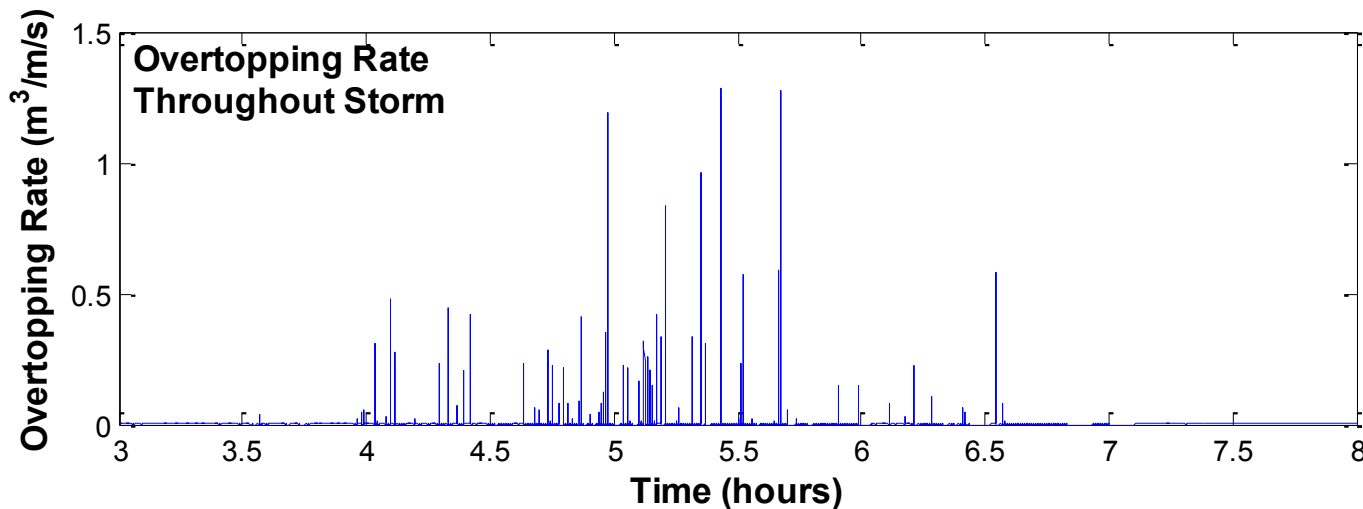
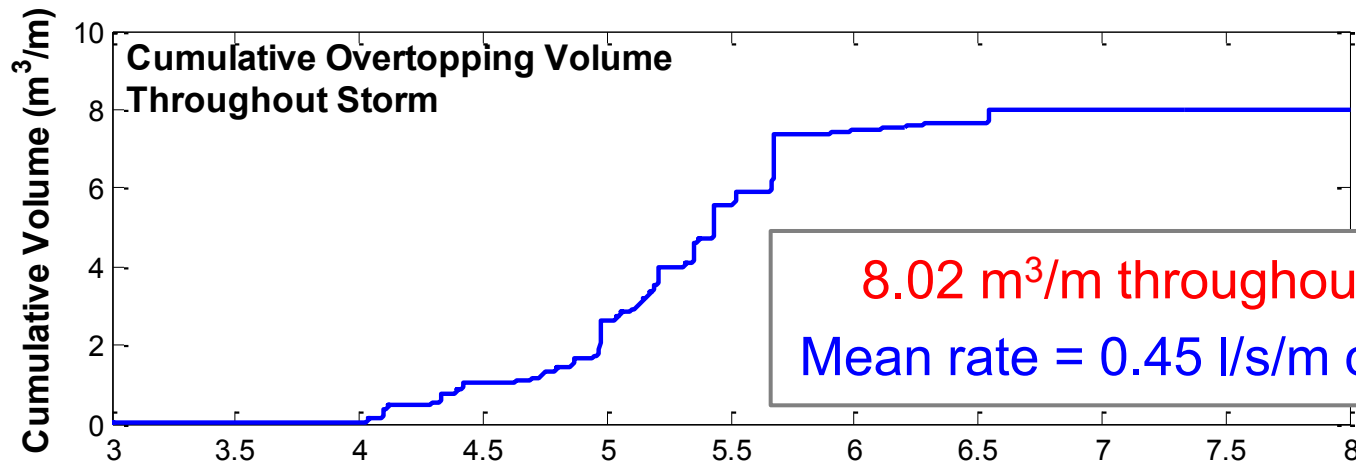
Predictions using CCA against profile measured on 15th Nov 2008



Measured profile and predictions using wave height and wave steepness based on regressions determined from data up to August 2003.



2007 Storm – Overtopping Volumes





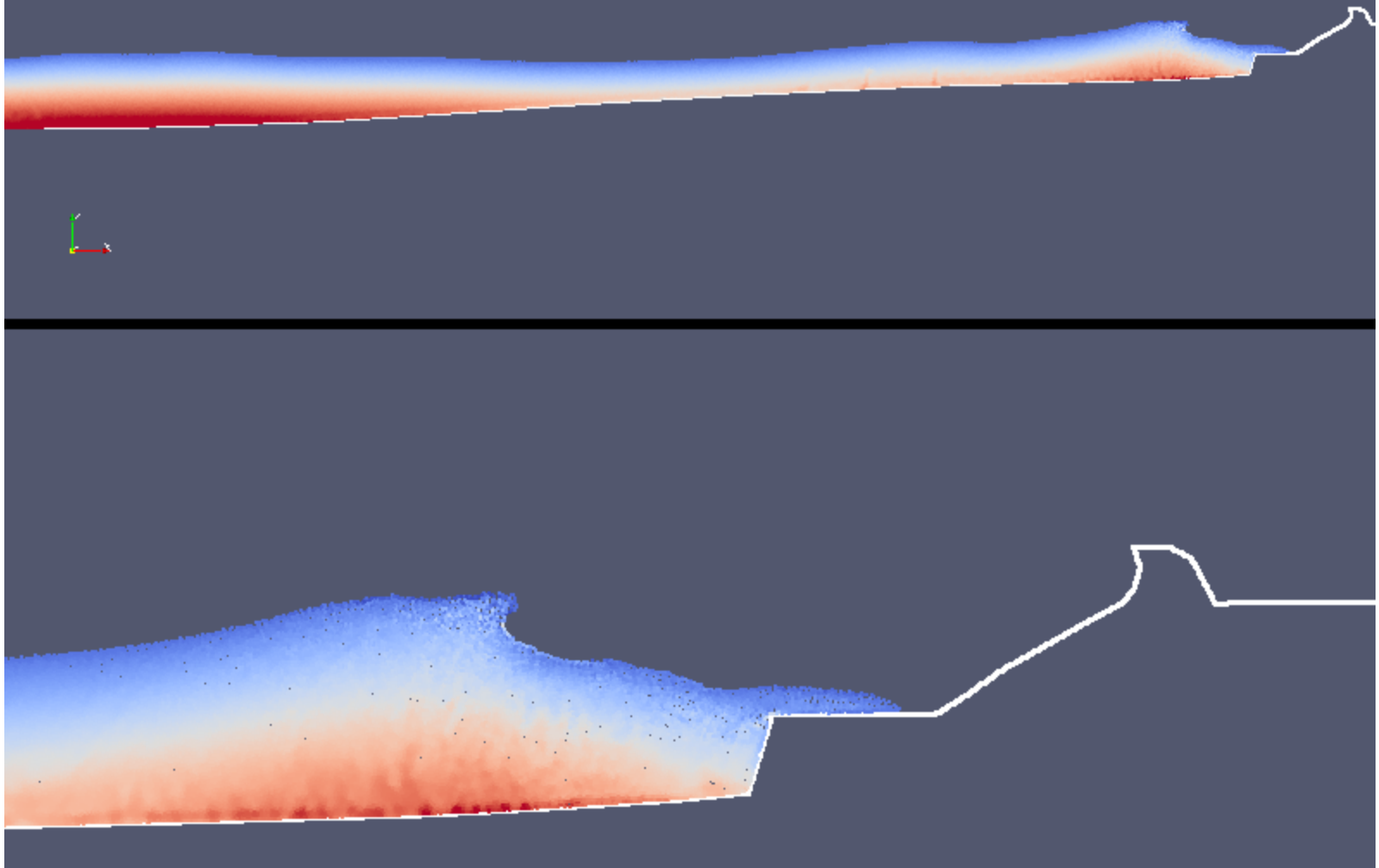
SPHysics open source code

An international collaboration between 4 universities:

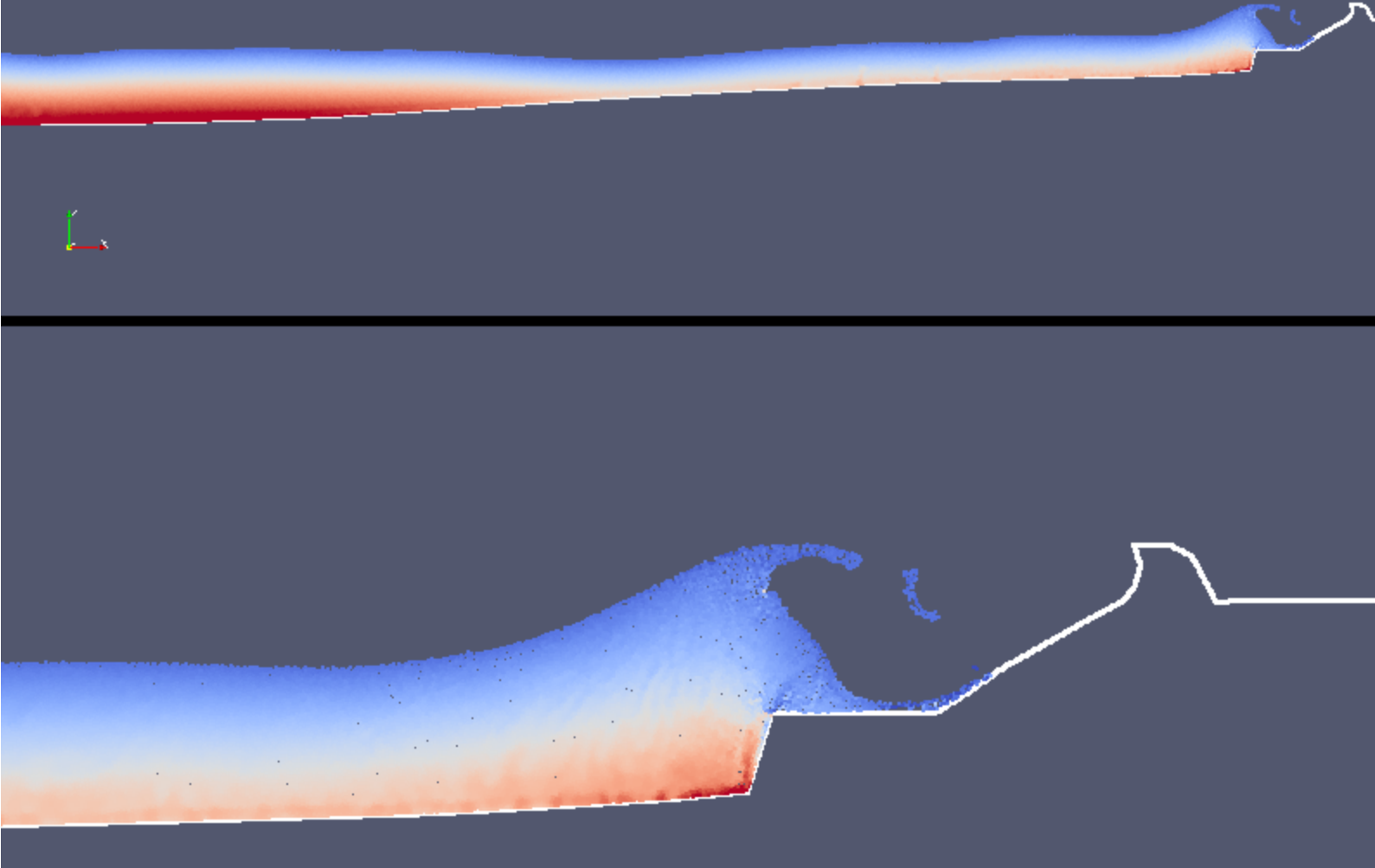
- The Johns Hopkins University (USA)
- Universidade de Vigo (Spain)
- University of Manchester (UK)
- University of Rome, La Sapienza (Italy)
- Code has been released as free open-sourceware
<http://www.sphysics.org> (4000+ downloads)

The screenshot shows the SPHysics website home page. At the top right, there is a 'Log in / create account' link. The main content area is titled 'SPHysics Home Page' and 'SPHysics - SPH Free-surface Flow Solver'. Below this, it states 'Open-Source Smoothed Particle Hydrodynamics code' and 'v2.0 UPDATE RELEASED: JANUARY 2010'. A list of 13 links is provided, including 'Welcome to SPHysics', 'Developers (photos) and Contributors', 'Code Features', 'Downloads (serial, parallel, GPU, hybrid-coupling)', 'Documentation', 'SPHysics FAQ', 'SPHysics Forum', 'Visualization: Images & Videos', 'Code History & Fixed Bugs (UPDATES)', 'Future Developments & Releases', 'Publications using the SPHysics code', 'How to reference SPHysics', and 'Help and Info about SPHysics website'. A video player is embedded on the right side of the page, showing a 3D visualization of a flow simulation. The left sidebar contains a navigation menu with links to 'SPHysics Home', 'Developers', 'Downloads', 'SPHysics FAQ', 'SPHysics Forum', 'Visualization', 'Code History', 'Future Developments', 'Contributors', and 'Recent changes'. There is also a search bar and a status message at the bottom: 'Waiting for wiki.manchester.ac.uk...'.

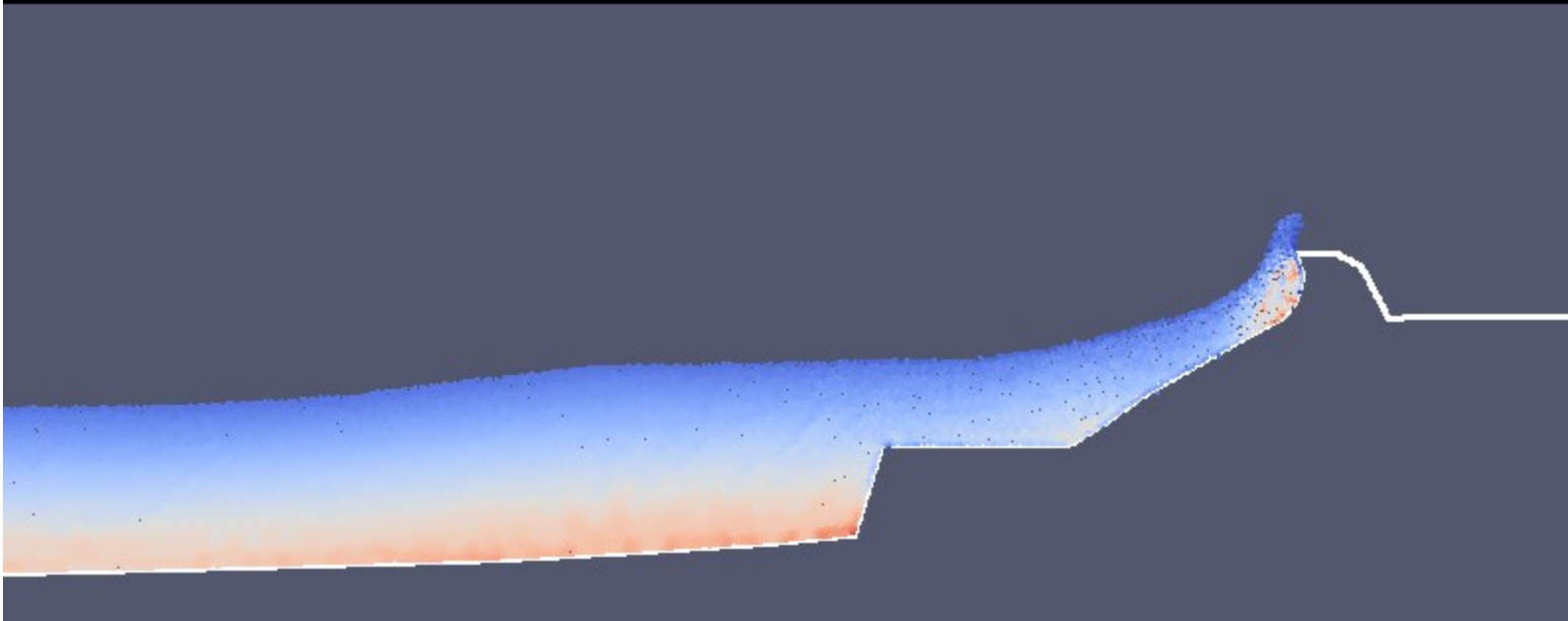
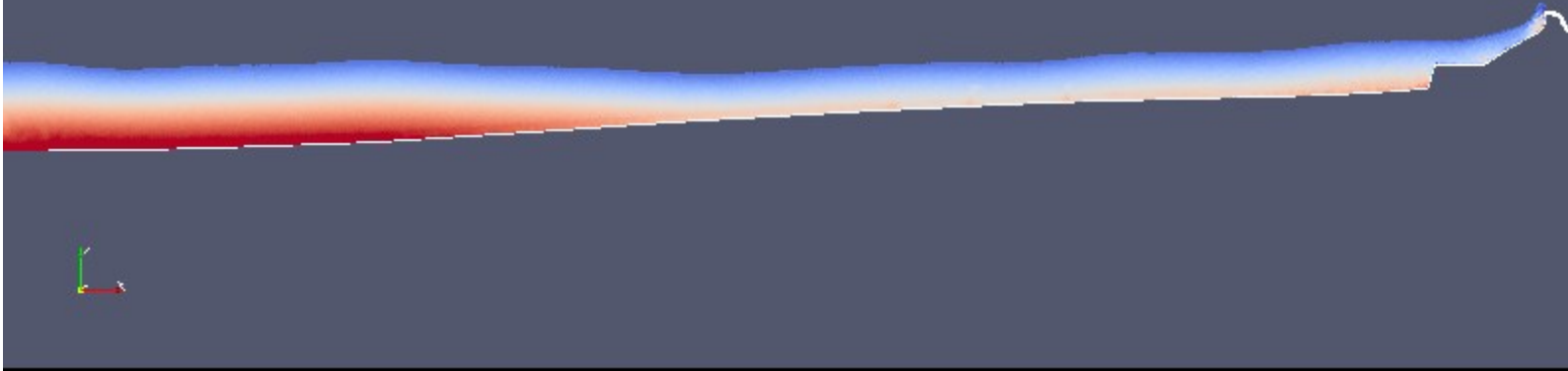
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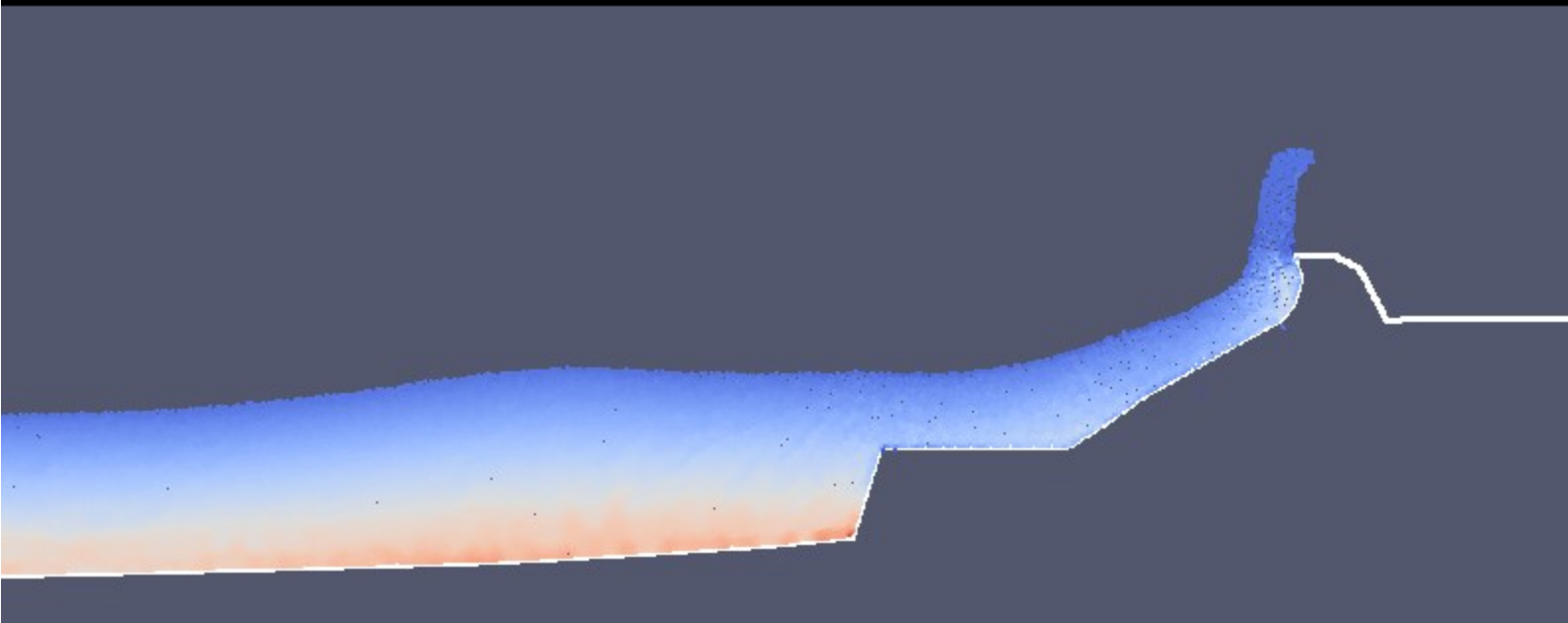
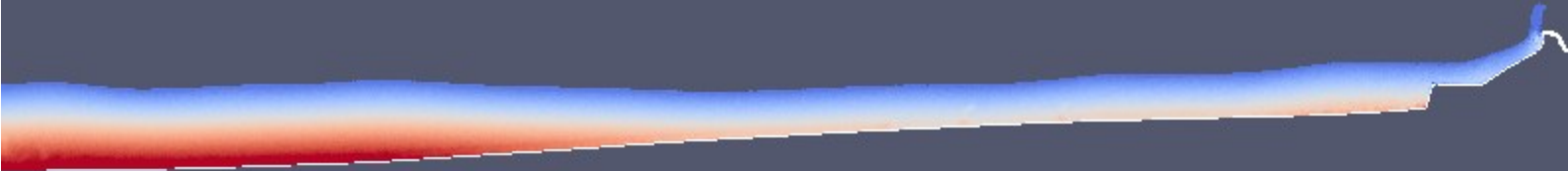
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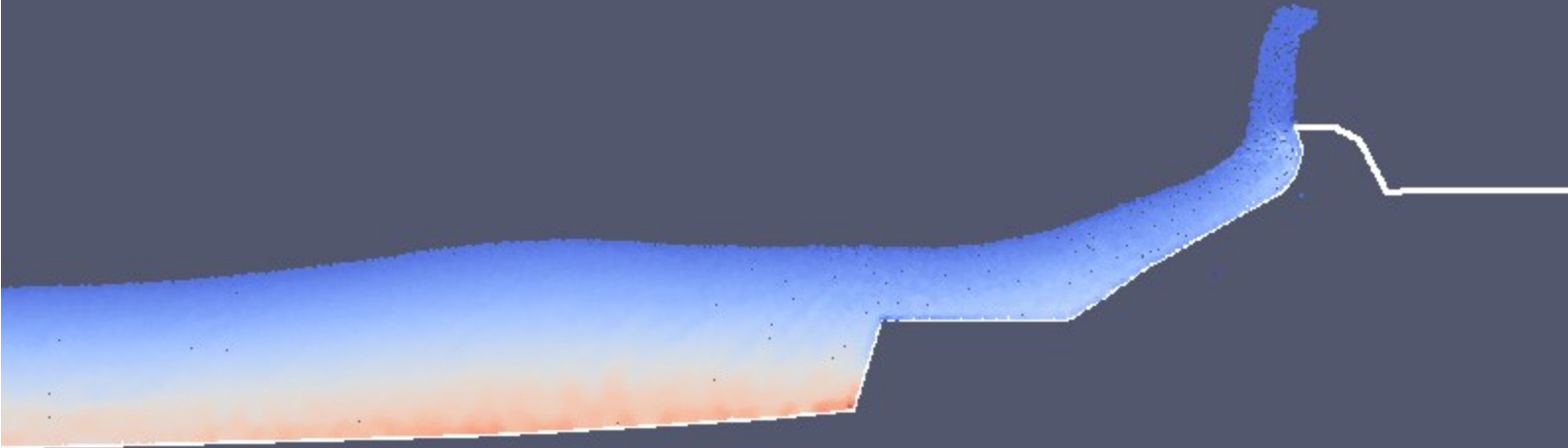
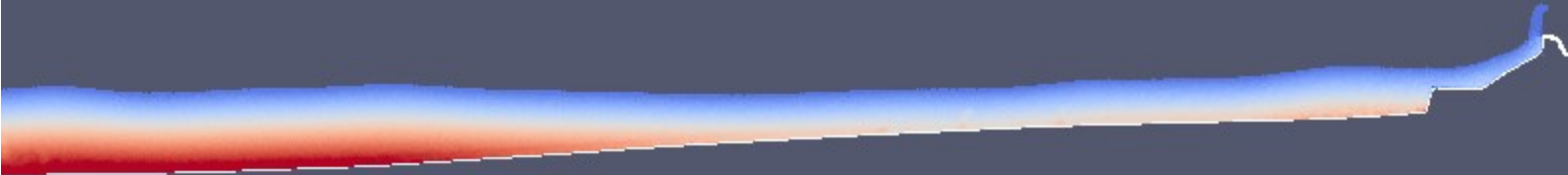
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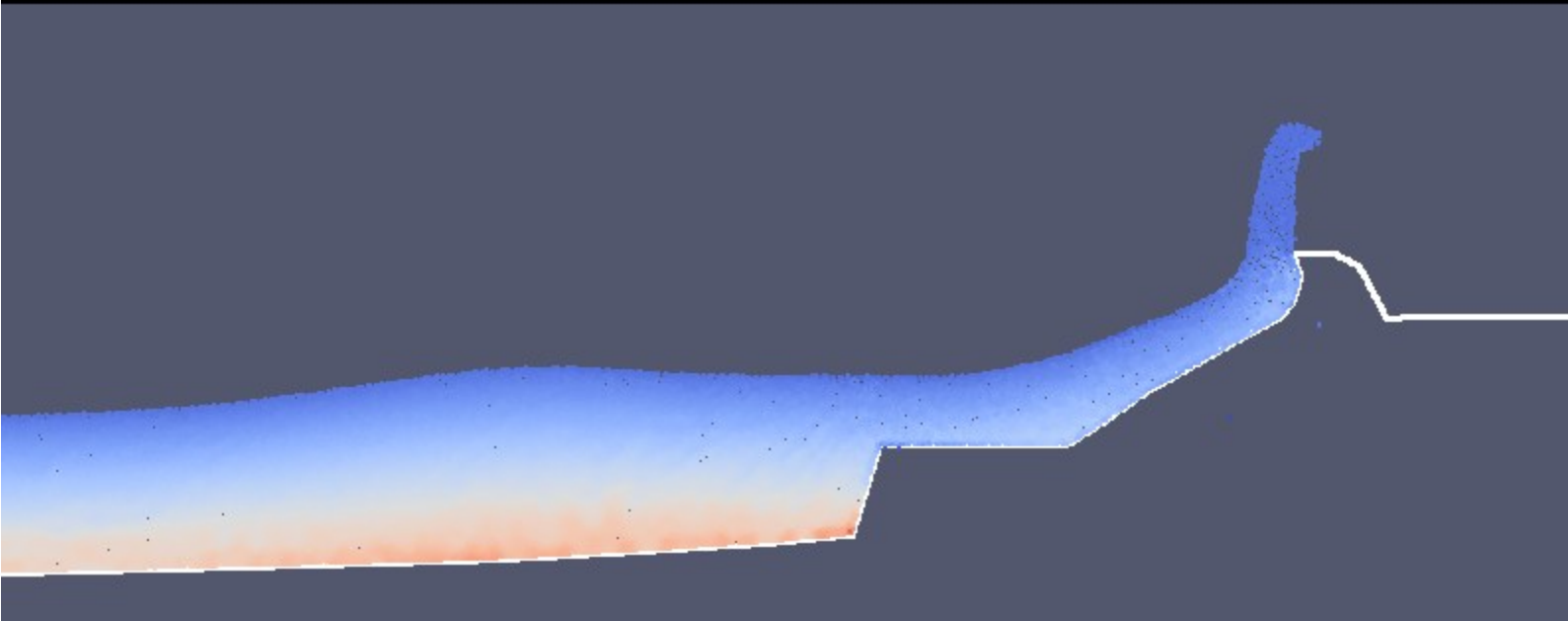
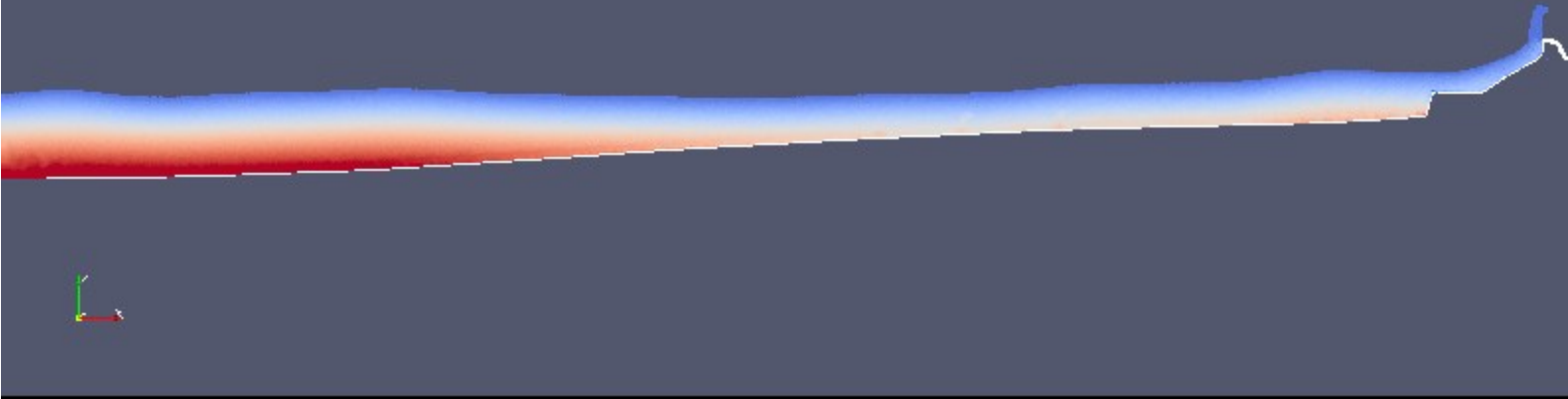
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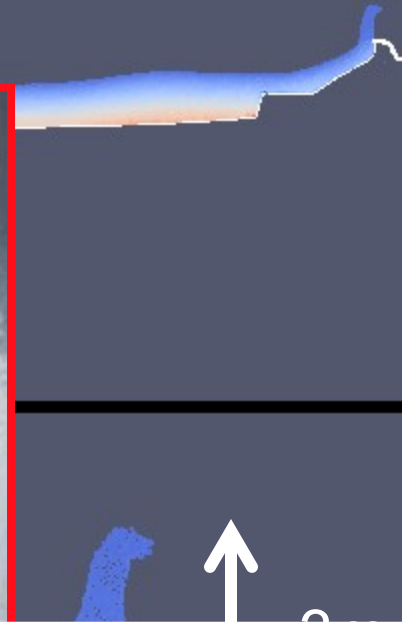
Frame: 1685



Frame: 1686



Frame: 1687

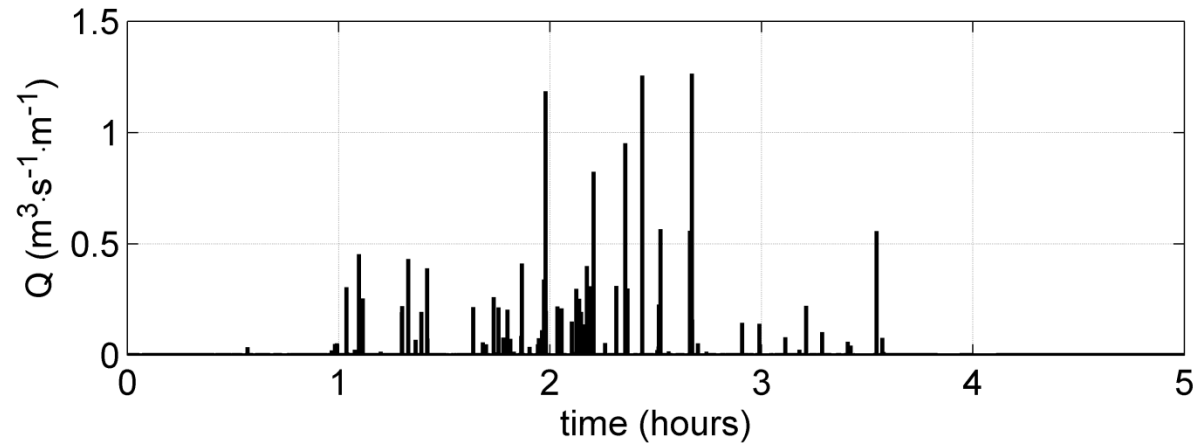


In SPH, we know that overtopping is dependent on resolution, so with a much finer resolution this could well produce higher values

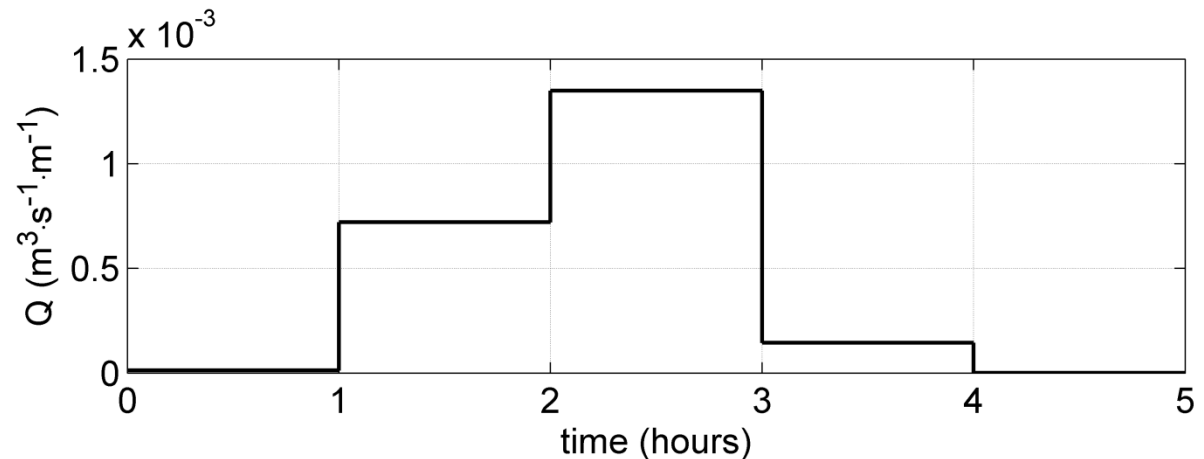


Overtopping discharge for inundation

Wave by wave input

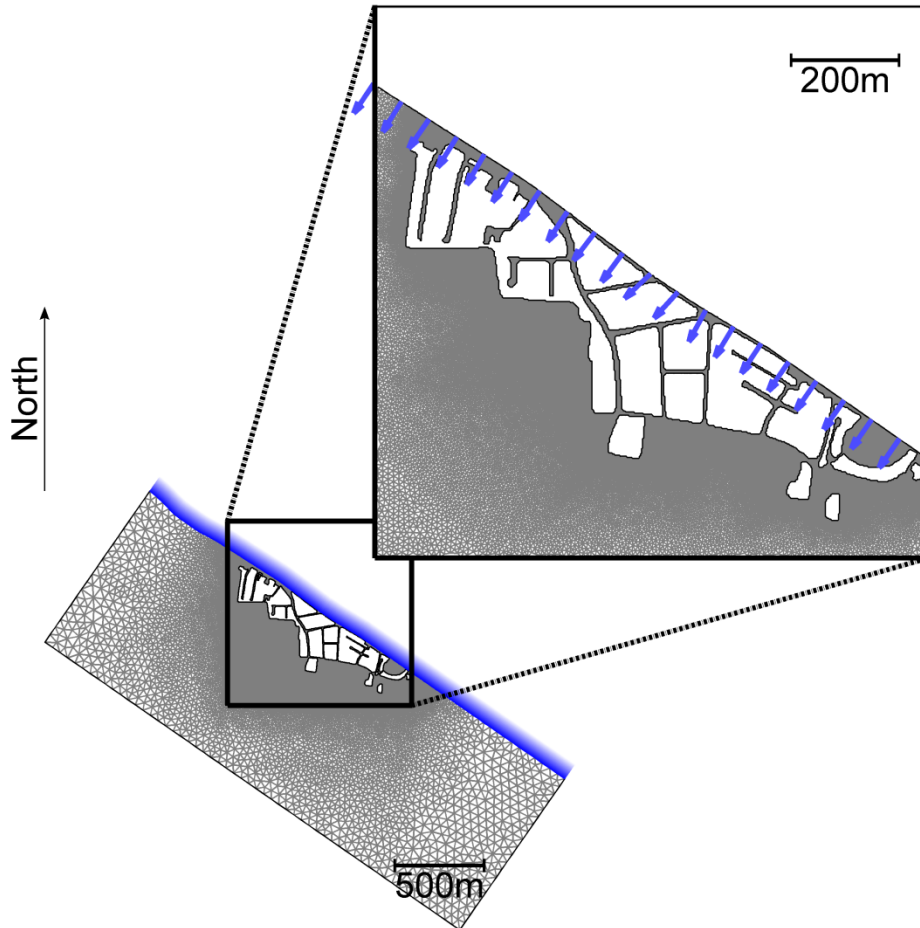


Hourly averaged input





Inundation model- Telemac-2D

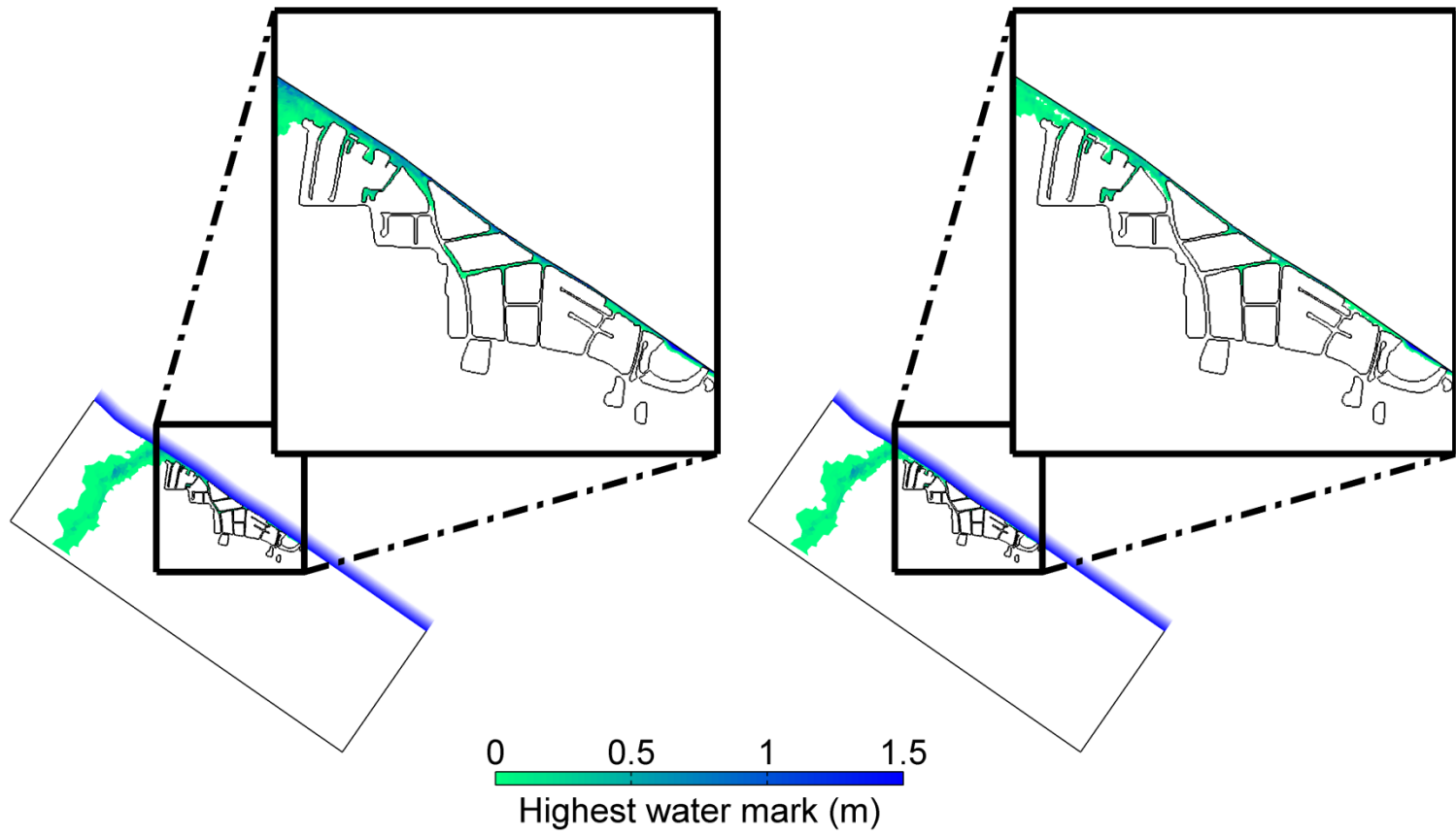


- Unstructured mesh
90102 triangular elements
resolution from 50m to 1m
- Bathymetry: LIDAR 2m resolution (EA),
filtered by Kuo (2011)
- Blocks represented as islands with a sliding
conditions at their boundaries
- Treatment for non-positive depths
- Overtopping discharge rates represented
as sources terms and imposed at each
node of a seawall 1260m long
- Time step : 0.1s
- Bottom friction : Manning's $n=0.036\text{s/m}^{1/3}$



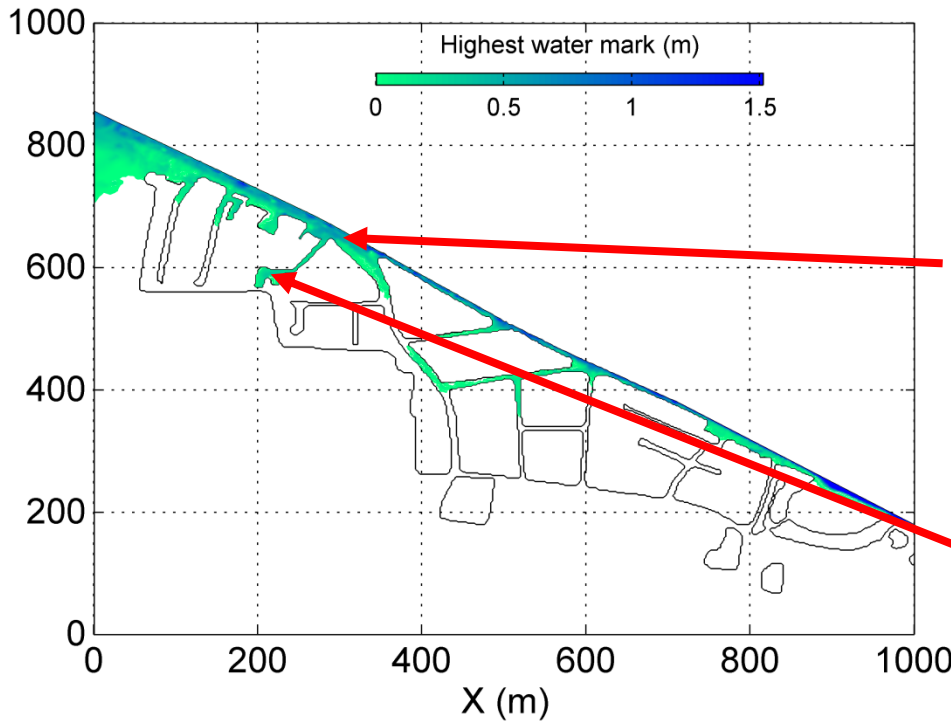
Wave by wave input

Hourly averaged input





Comparison with collected information



Ph 16:
Mean SWAB = 0.44m
SWAB series = 0.65m

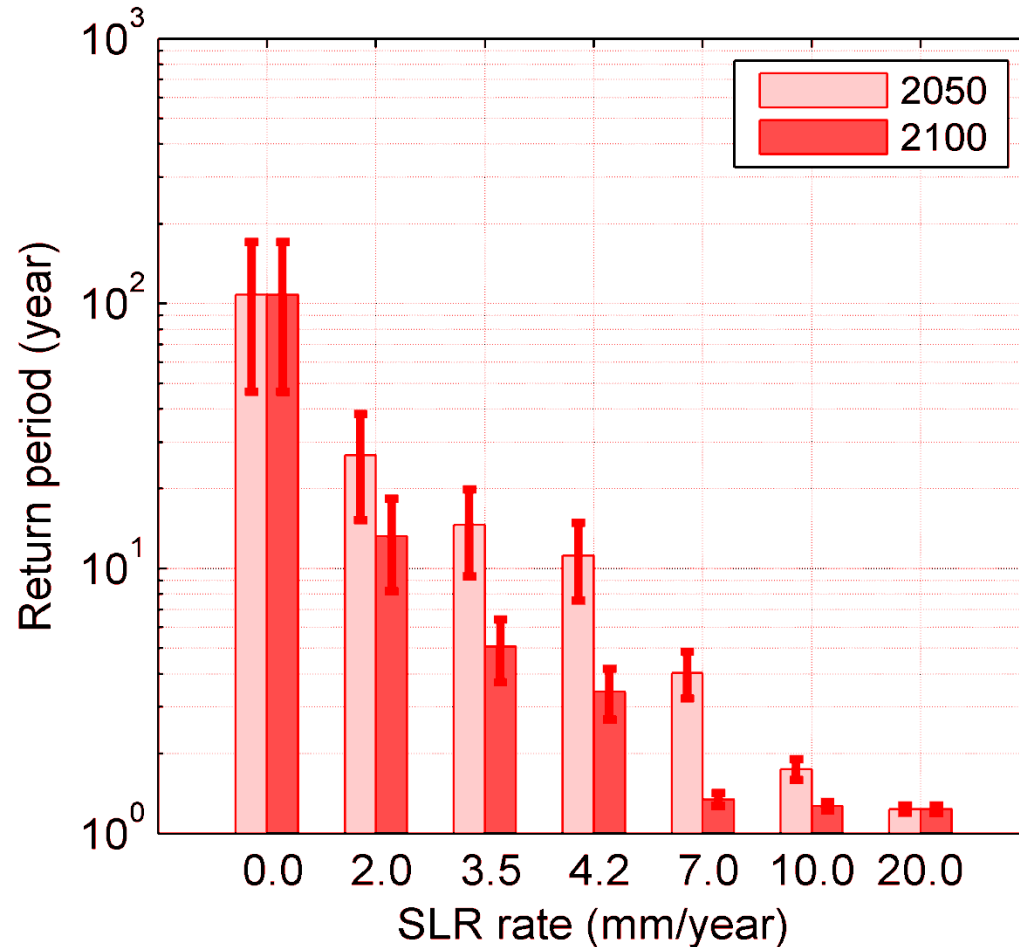
Ph 13
Mean SWAB = 0.31m
SWAB = 0.36m



courtesy Maurice McCabe
and Brian Farrow

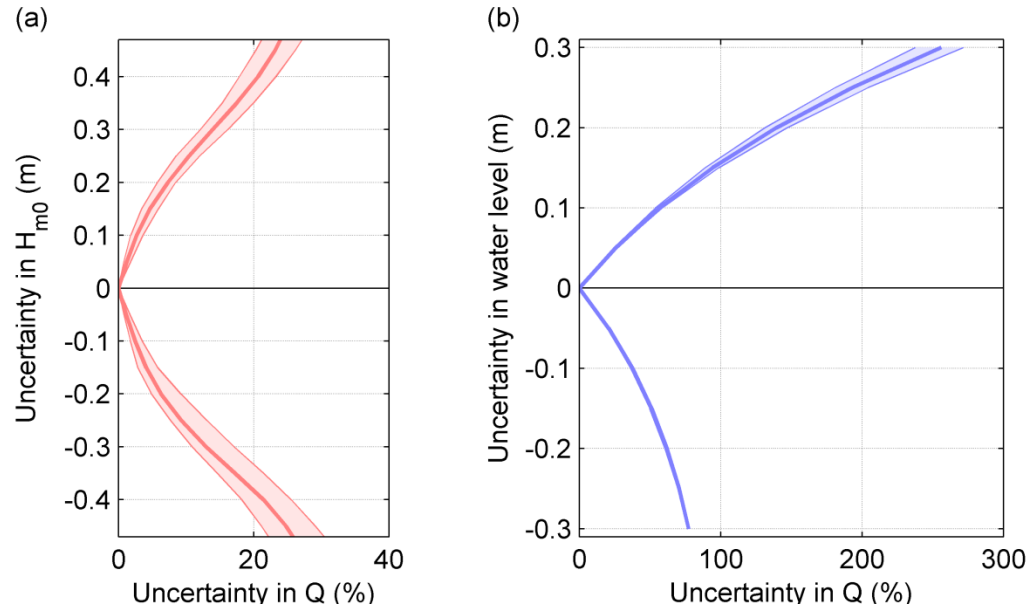
SEA LEVEL RISE

Change in return period of Walcott event due to sea level rise



UNCERTAINTY

In mean overtopping due to error in nearshore wave height and water level



Error of 0.1m in H_s gives 3% error in Q

Error of 0.1m in water level gives 50% error in Q

WATER LEVEL DOMINATES



PEOPLE

Nicolas Chini (Tyndall and FRMRC funded, Manchester)	
Maurice McCabe (EPSRC standard studentship, Manchester)	
Ben Rogers (RCUK Fellow and part FRMRC funded, Manchester)	6
Renato Vacondio (PhD visitor, Manchester)	
Rui Xu (PhD MACE scholarship, Manchester)	
David Apsley (Manchester Lecturer)	
Alistair Borthwick (Oxford Professor)	
Kuo Yan (PhD FRMRC funded, Oxford)	3
Myron van Damme (PhD FRMRC funded, Oxford)	
Dominic Reeve (Plymouth Professor)	
Jose Horrillo-Caraballo (FRMRC funded, Plymouth)	2
Kevin Horsburgh (POL)	
Chris Wilson (FRMRC funded, POL)	3
Judith Wolf (POL, part Tyndall funded)	—
	14



Acknowledgement

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

- **Engineering and Physical Sciences Research Council**
Grant: EP/FP202511/1
- **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**

Data were provided by the EA and the Ordnance Survey.





Thank you for your attention

Questions?