

# **ENSEMBLE BASED UNCERTAINTY QUANTIFICATION FOR NOWCASTING AND FORECASTING EXTREME COASTAL FLOODING**

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**Flood Risk from Extreme Events (FREE)**

**EPIRUS – Ensemble Prediction of  
Inundation Risk and Uncertainty arising  
from Scour**



# Introduction

- *UK assets at risk from coastal flooding = £130bn <sup>1</sup>*
- *England and Wales properties at risk = 4 million <sup>1</sup>*
- *Future projections of:*
  - *sea level rise*
  - *increase in intensity and frequency of severe storms*

<sup>1</sup> Office of Science and Technology 2004. Foresight Flood and Coastal Defence Project – Executive Summary, 59.

# Introduction

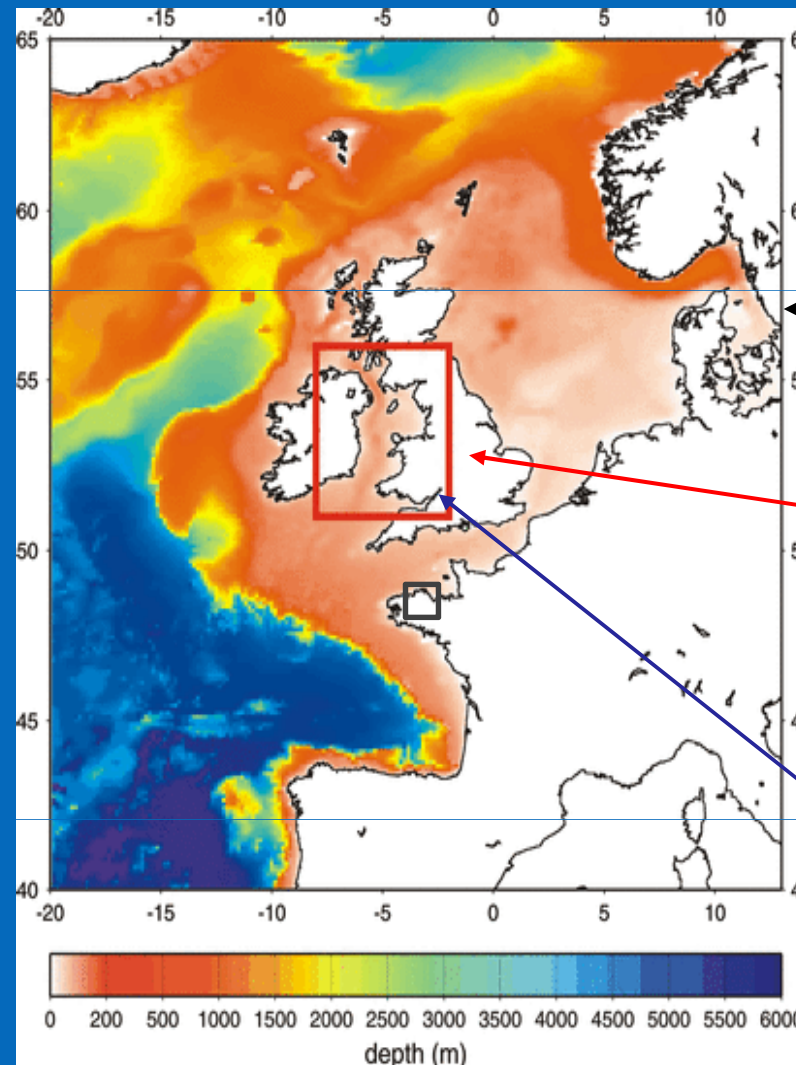
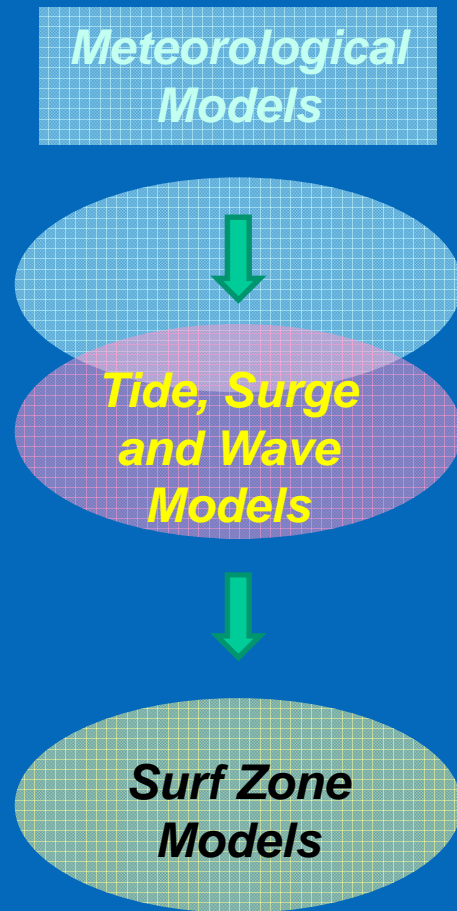
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  - *sea level rise*
  - *increase in intensity and frequency of severe storms*

*→ Integrated “clouds-to-coast” model framework to simulate surge and wave heights*

*→ Quantify uncertainty in model cascade*

<sup>1</sup> Office of Science and Technology 2004. Foresight Flood and Coastal Defence Project – Executive Summary, 59.

# Tide, Surge & Wave Modelling Framework



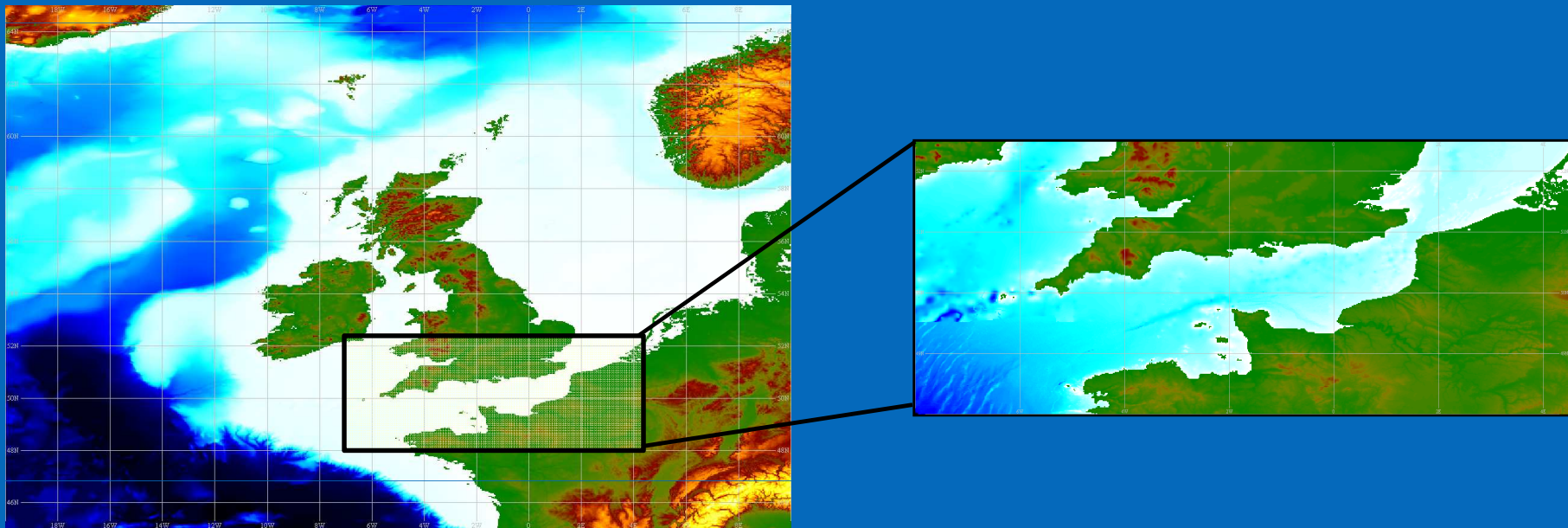
**Continental Model  
WAM**  
[Grid size ~ 12km]

**Regional Model  
POLCOMS**  
[Grid size ~1.8km]

**Coastal Zone  
Model COAST2D**  
[Grid size ~250m]

# Model Framework

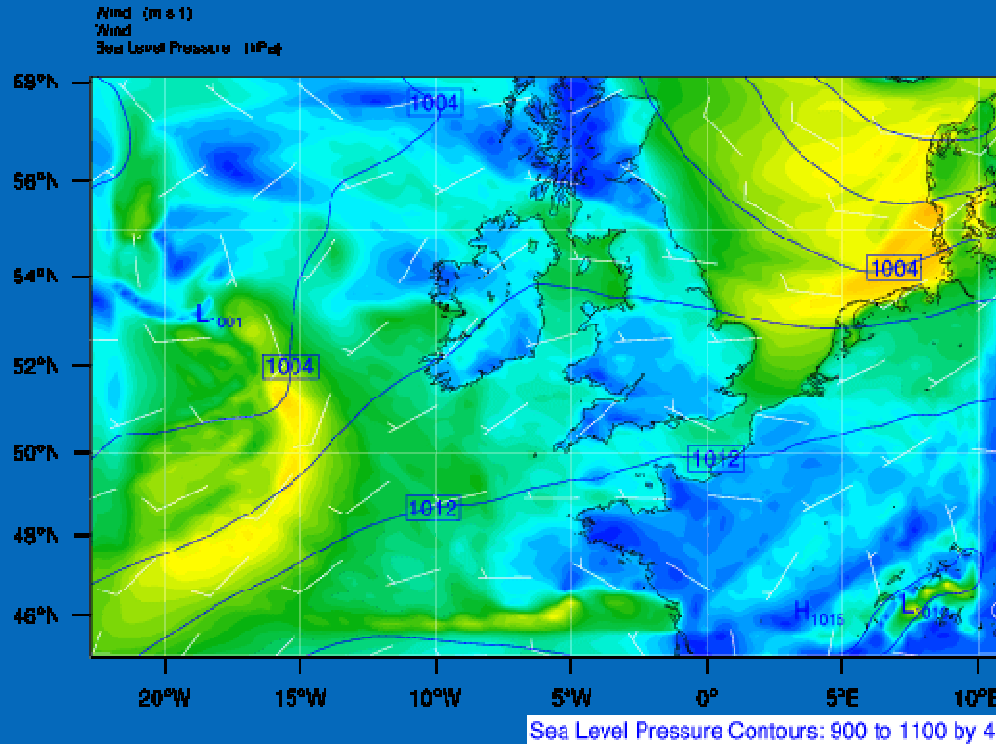
- *Domains*



# October 2004 Case Study

25<sup>th</sup> – 30<sup>th</sup> October 2004

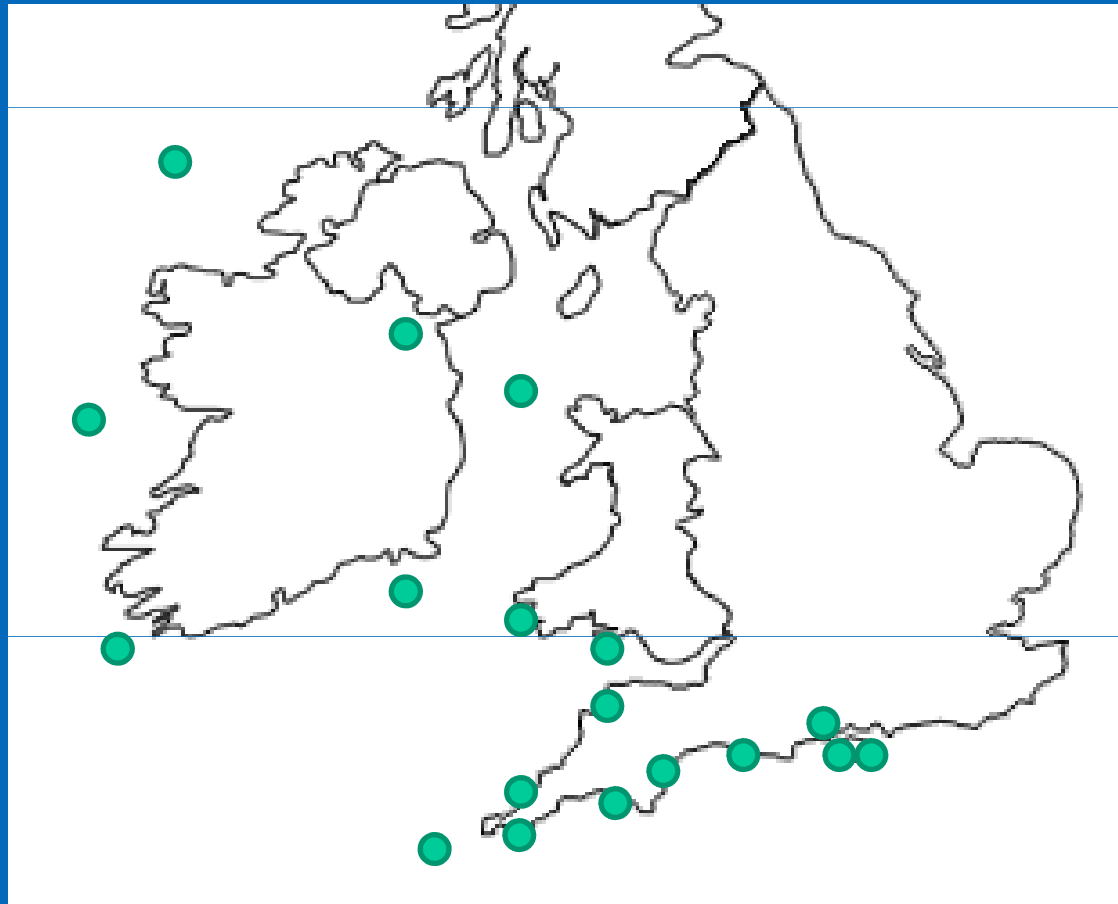
Inj: 2004-10-25 00:00:00  
Veld: 2004-10-25 24:00:00



- 1<sup>st</sup> Oct – 7<sup>th</sup> Nov 2004
- WRF boundary conditions:  
ECMWF ERA Interim

# October 2004 Case Study

- Validation (WRF)
  - Windspeed



- 1<sup>st</sup> Oct → 7<sup>th</sup> Nov

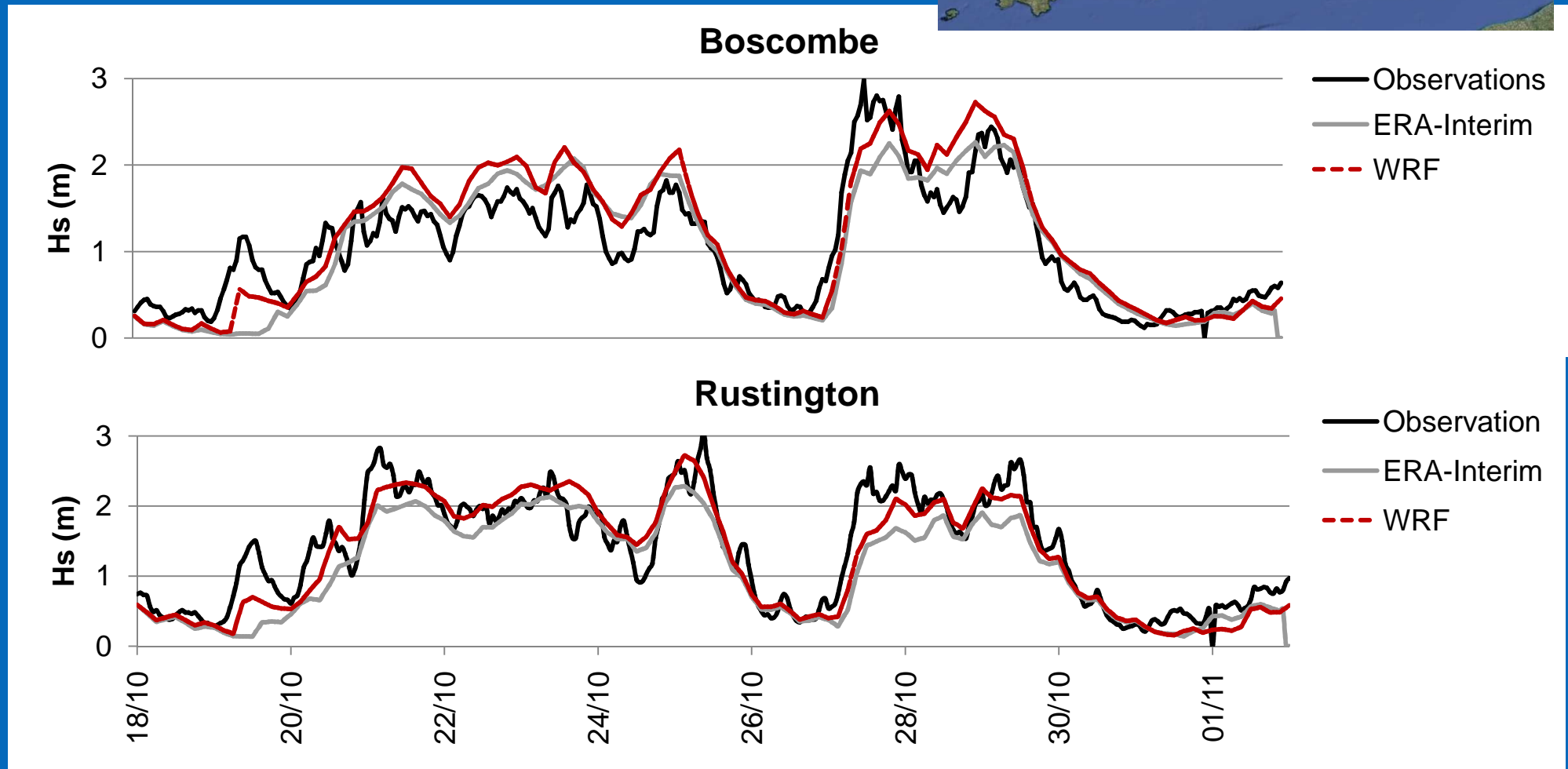
	ERA Interim	WRF Downscaled
R <sup>2</sup>	0.78	0.81
Bias (ms <sup>-1</sup> )	+1.02	+0.57

- 24<sup>th</sup> Oct → 2<sup>nd</sup> Nov

	ERA Interim	WRF Downscaled
R <sup>2</sup>	0.80	0.82
Bias (ms <sup>-1</sup> )	+0.95	+0.67

# October 2004 Case Study

- Validation (ProWAM)
  - Significant Wave heights

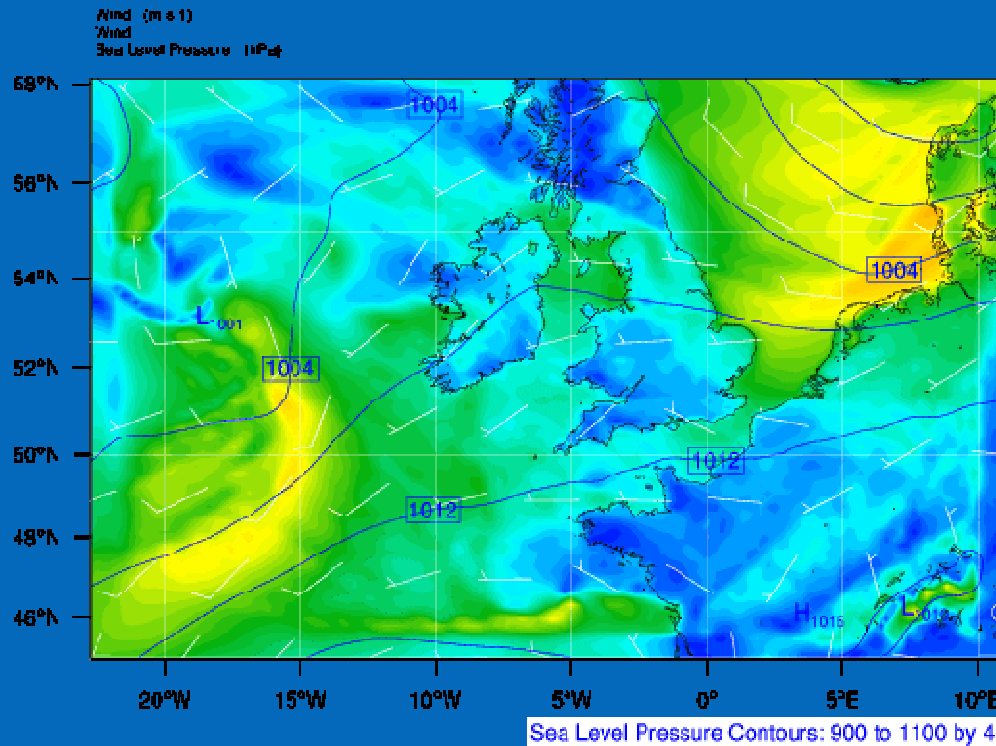




# October 2004 Case Study

25<sup>th</sup> – 30<sup>th</sup> October 2004

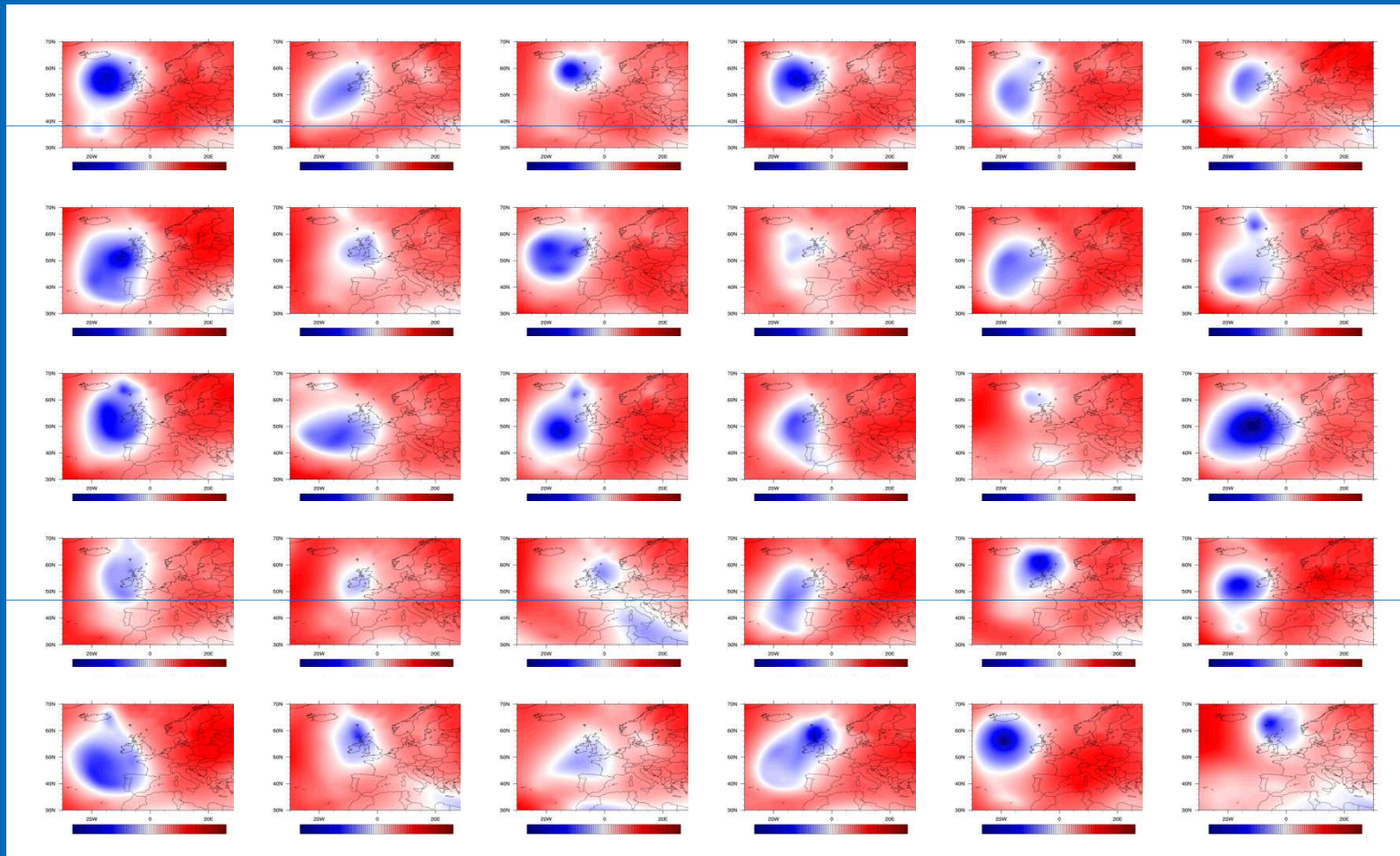
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Veld: 2004-10-26 00:00:00



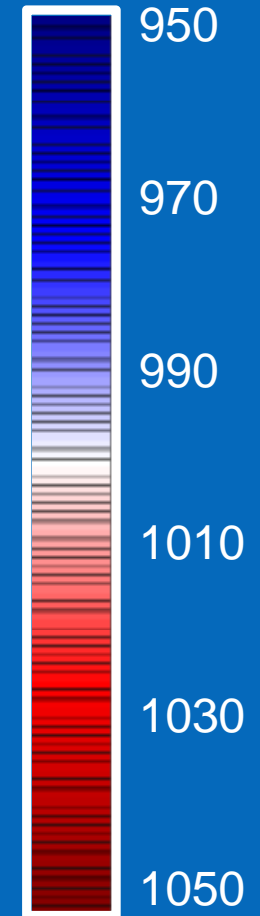
- *Model spin-up*  
Oct 16<sup>th</sup> - 26<sup>th</sup>
- *Ensemble forecast*  
Oct 26<sup>th</sup> – Nov 4<sup>th</sup>
- *WRF boundary conditions:*  
*ECMWF EPS 10 day forecast*

# October 2004 Case Study

- 60-hour forecast,
- valid at 12:00, 28 Oct 04

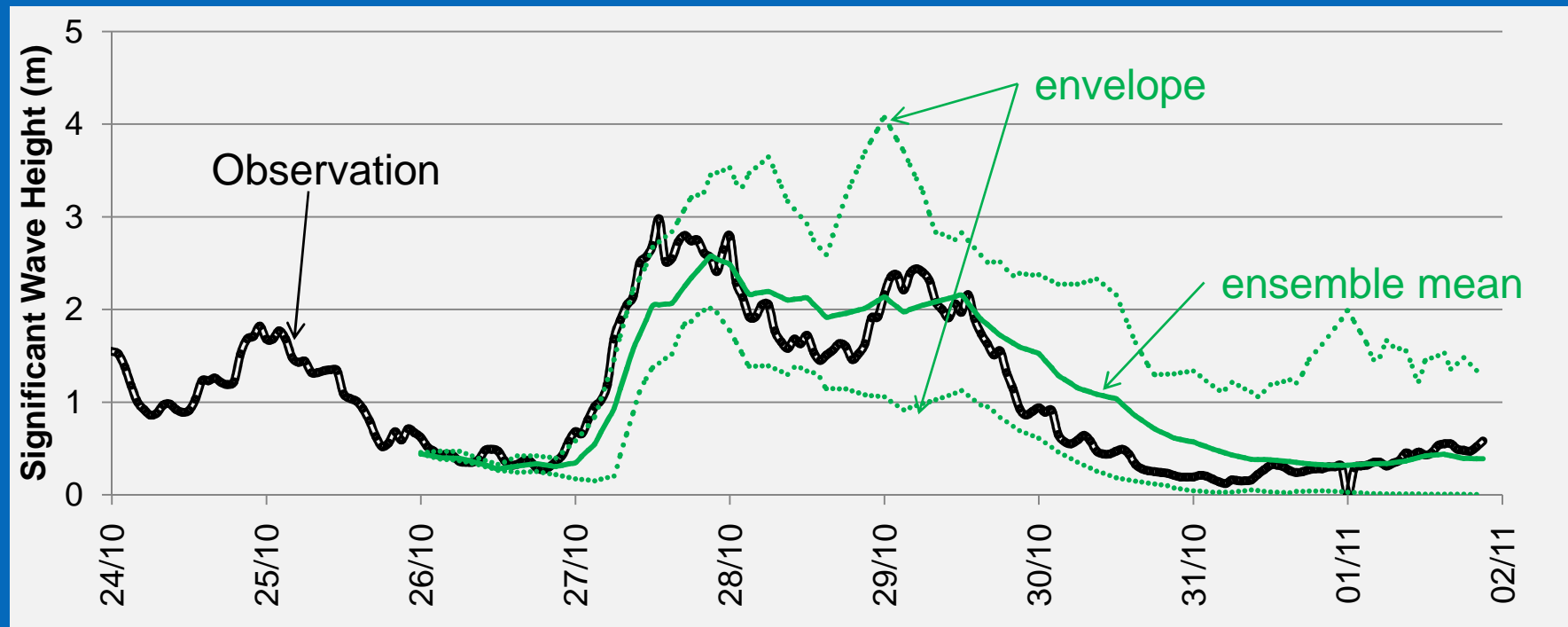


Pressure (hPa)



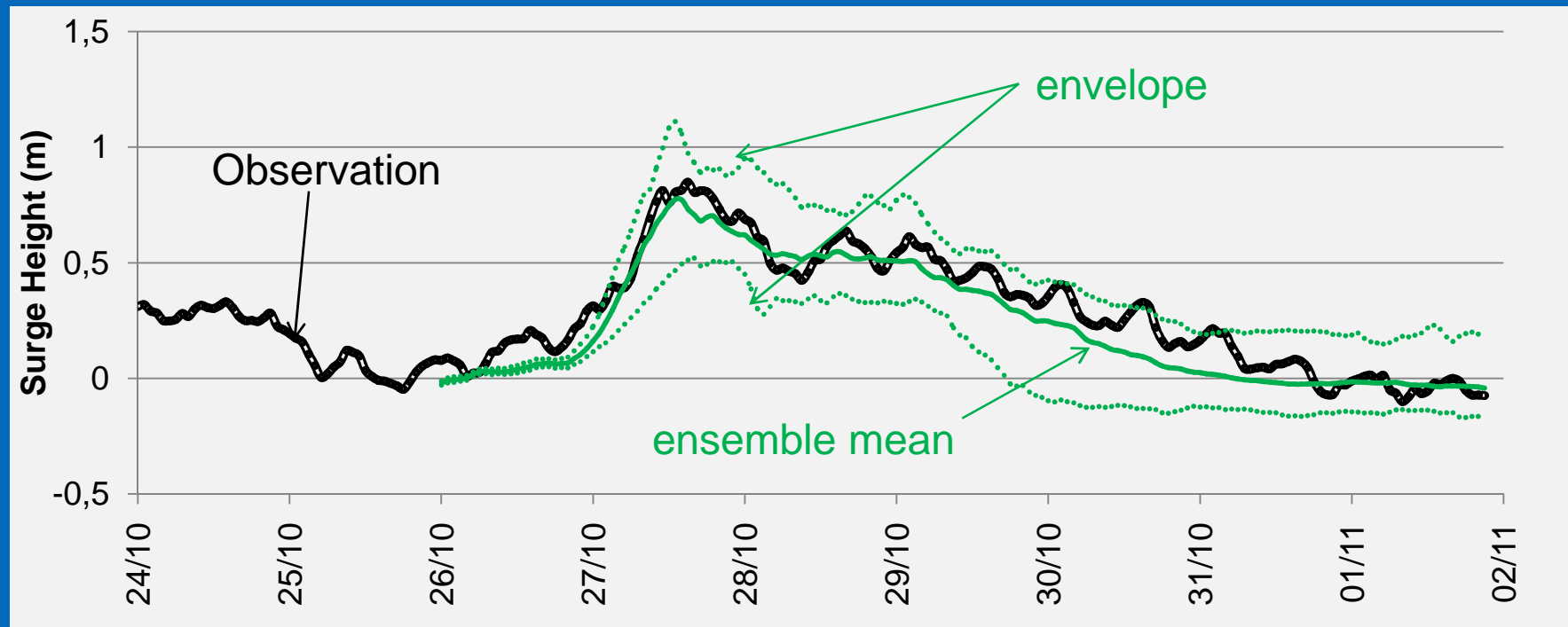
# October 2004 Case Study

## Significant Wave Height



# October 2004 Case Study

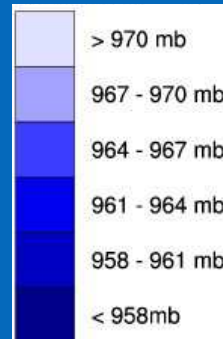
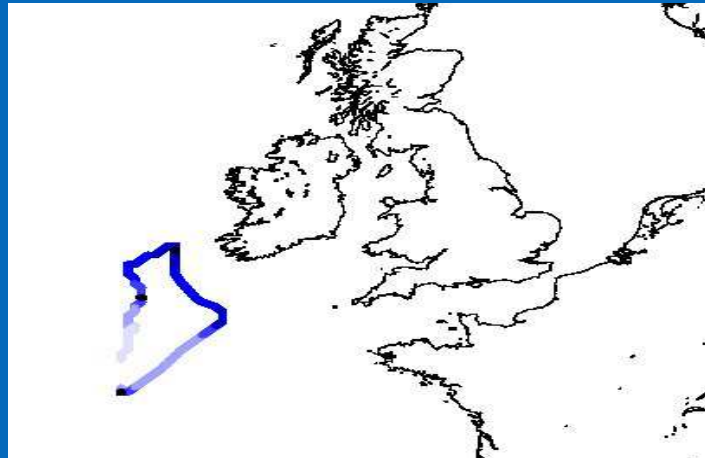
## Surge Height



# October 2004 Case Study

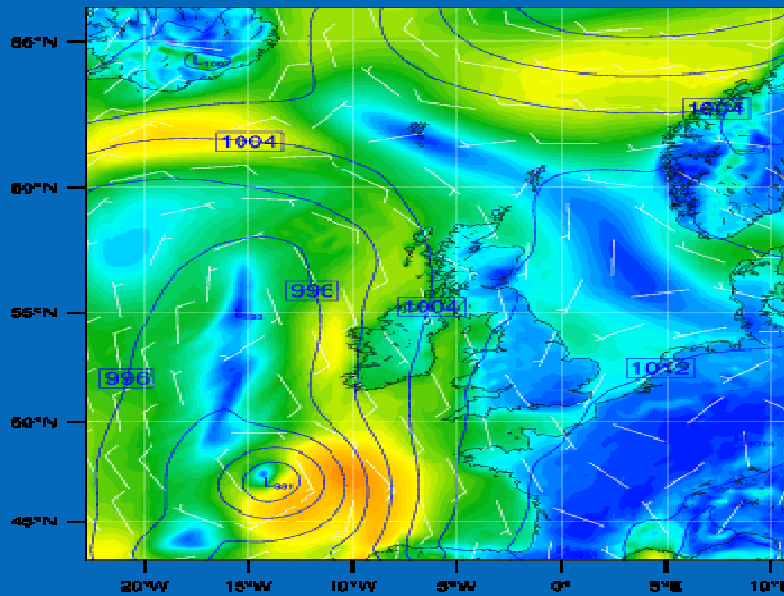
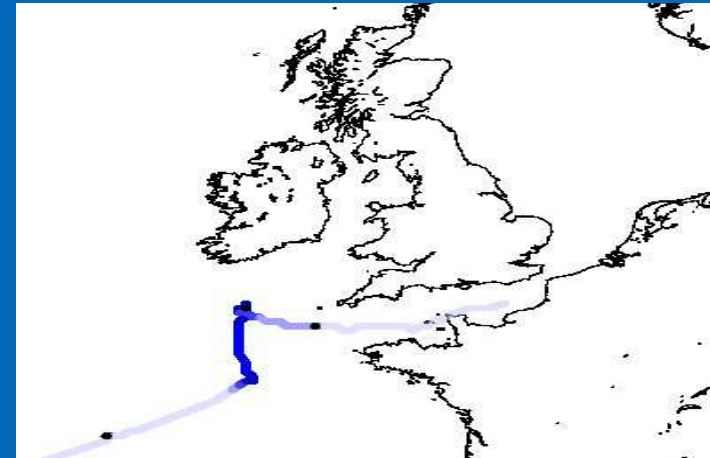
Member 16

High surge and wave heights

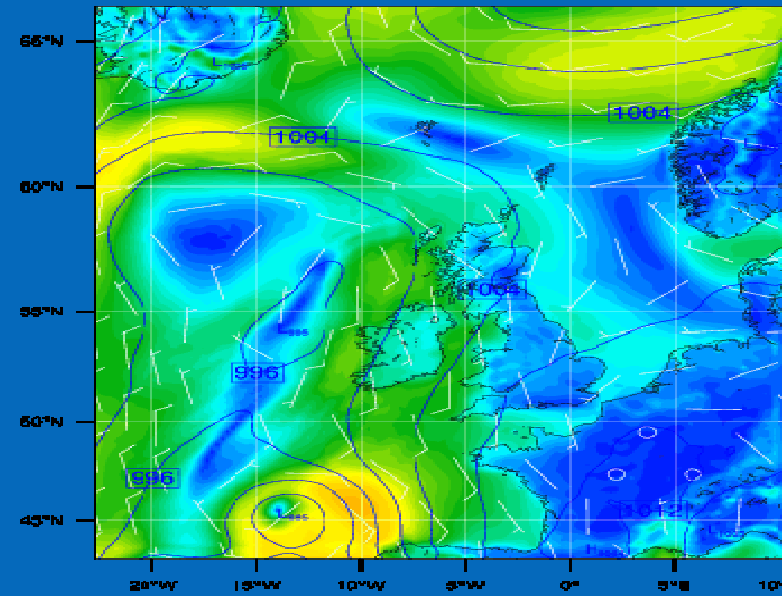


Member 08

Low surge and wave heights



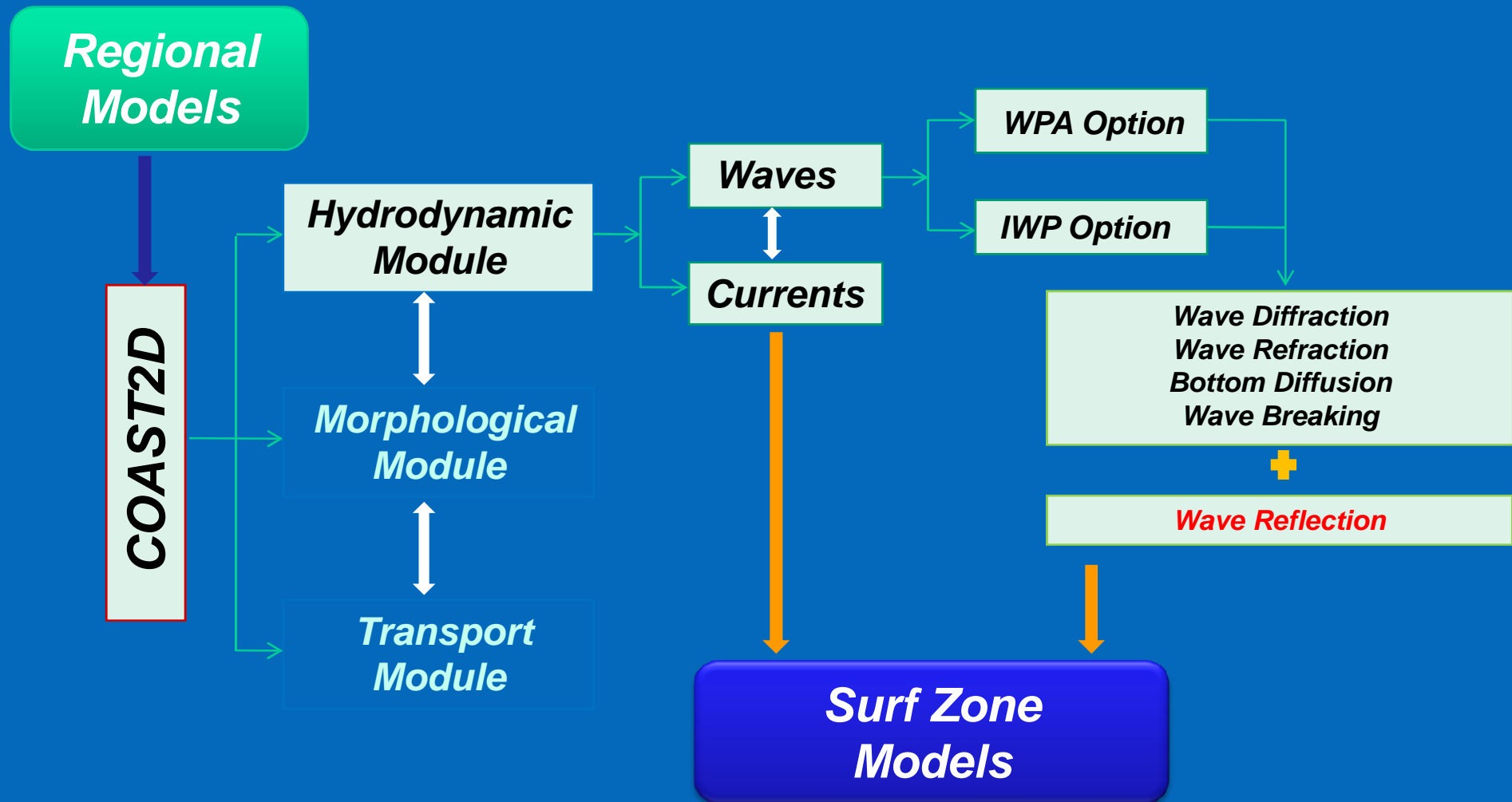
Sea Level Pressure Contours: 900 to 1100 by 4  
Wind speed (ms<sup>-1</sup>)

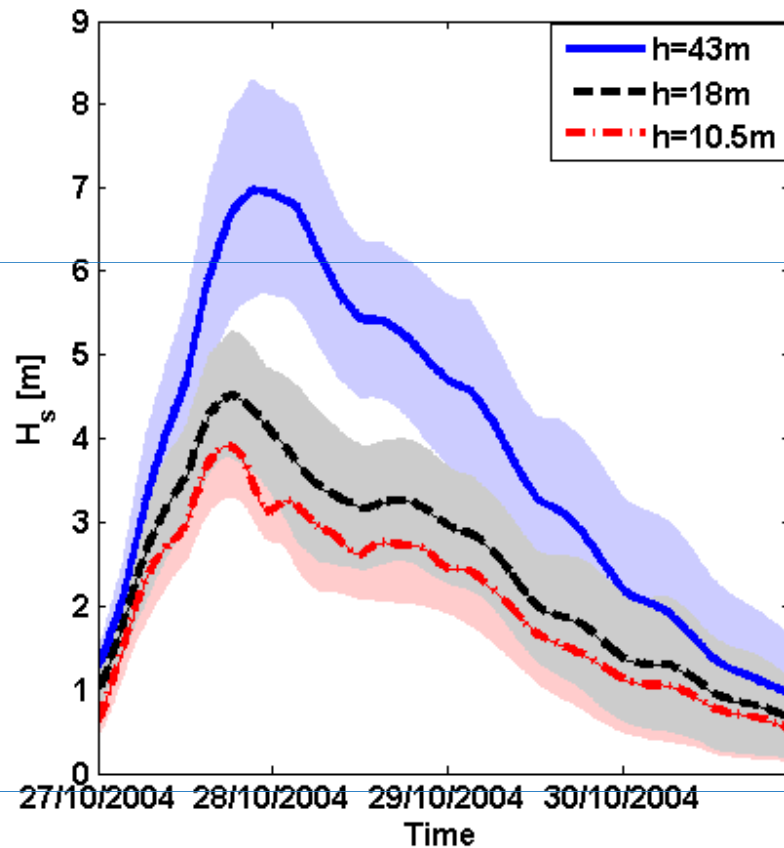


Sea Level Pressure Contours: 900 to 1100 by 4  
Wind speed (ms<sup>-1</sup>)

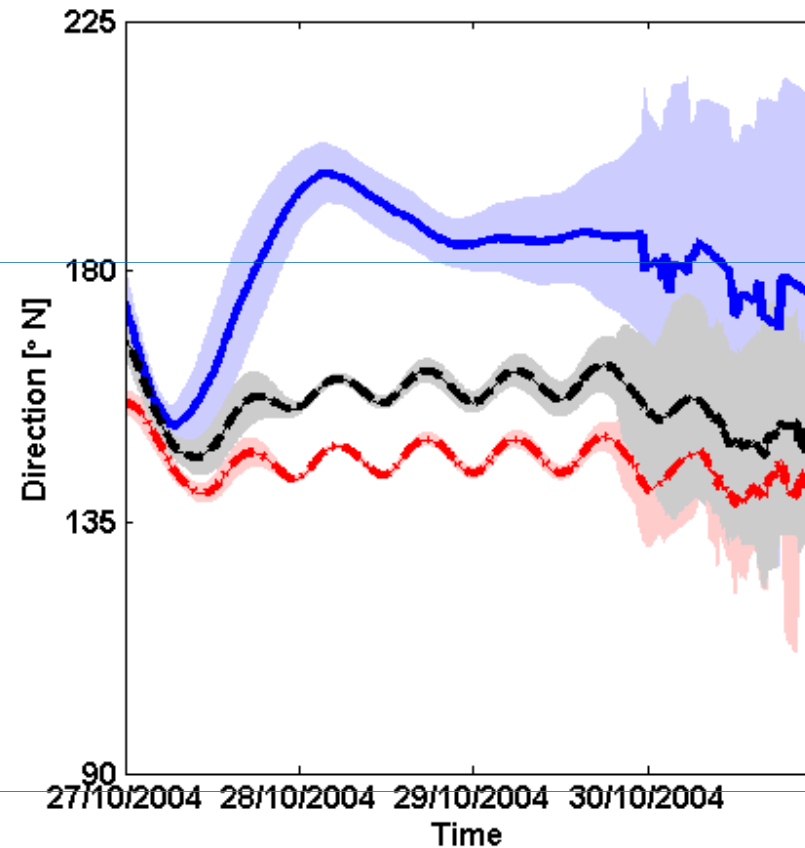


# Coastal Zone Model – COAST2D





*Wave Height at Water Depth  $h$*



*Wave Direction at Water Depth  $h$*

# SEVERN TIDAL BARRAGE

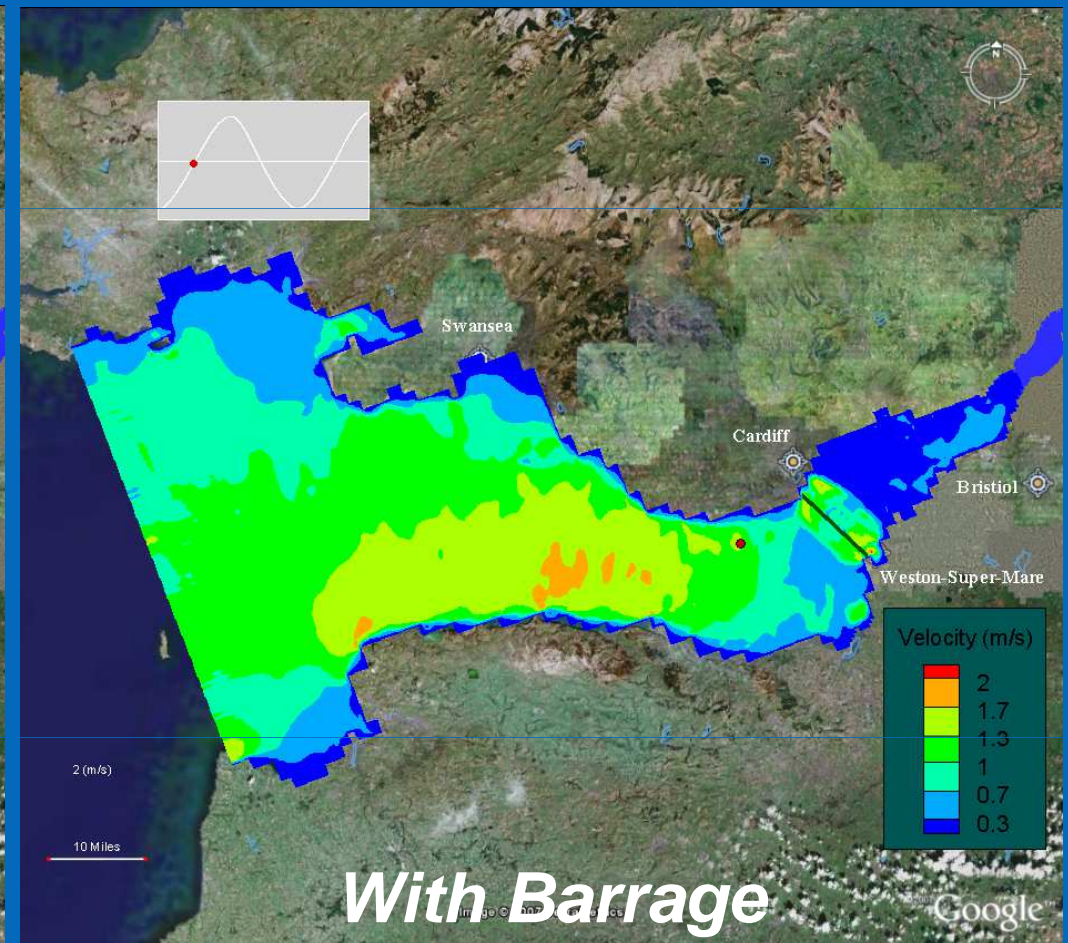
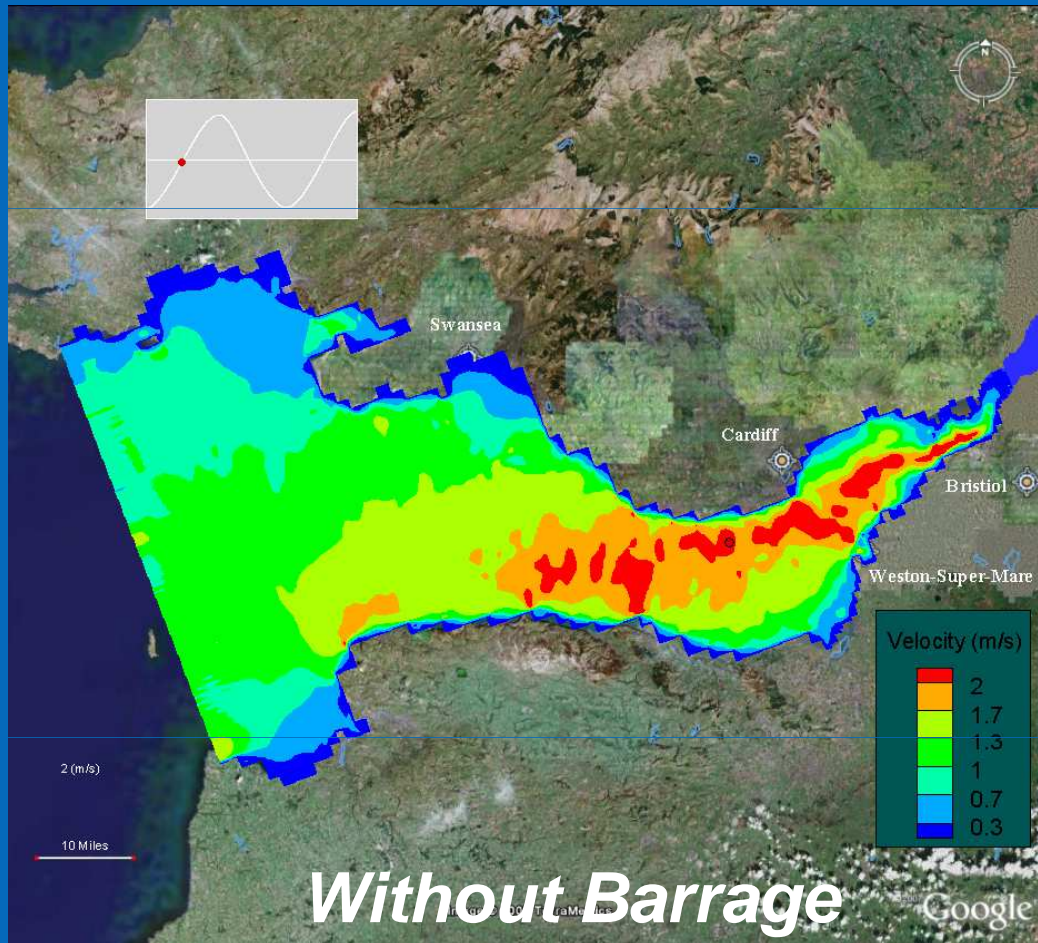


**>14m Tidal Height Range**  
**8.6GW – 3 Nuclear Power Stations**  
**18 Km, 214+ Turbines, £40B**  
**5 to 8% UK National Energy**



# Tidal Current Modelling

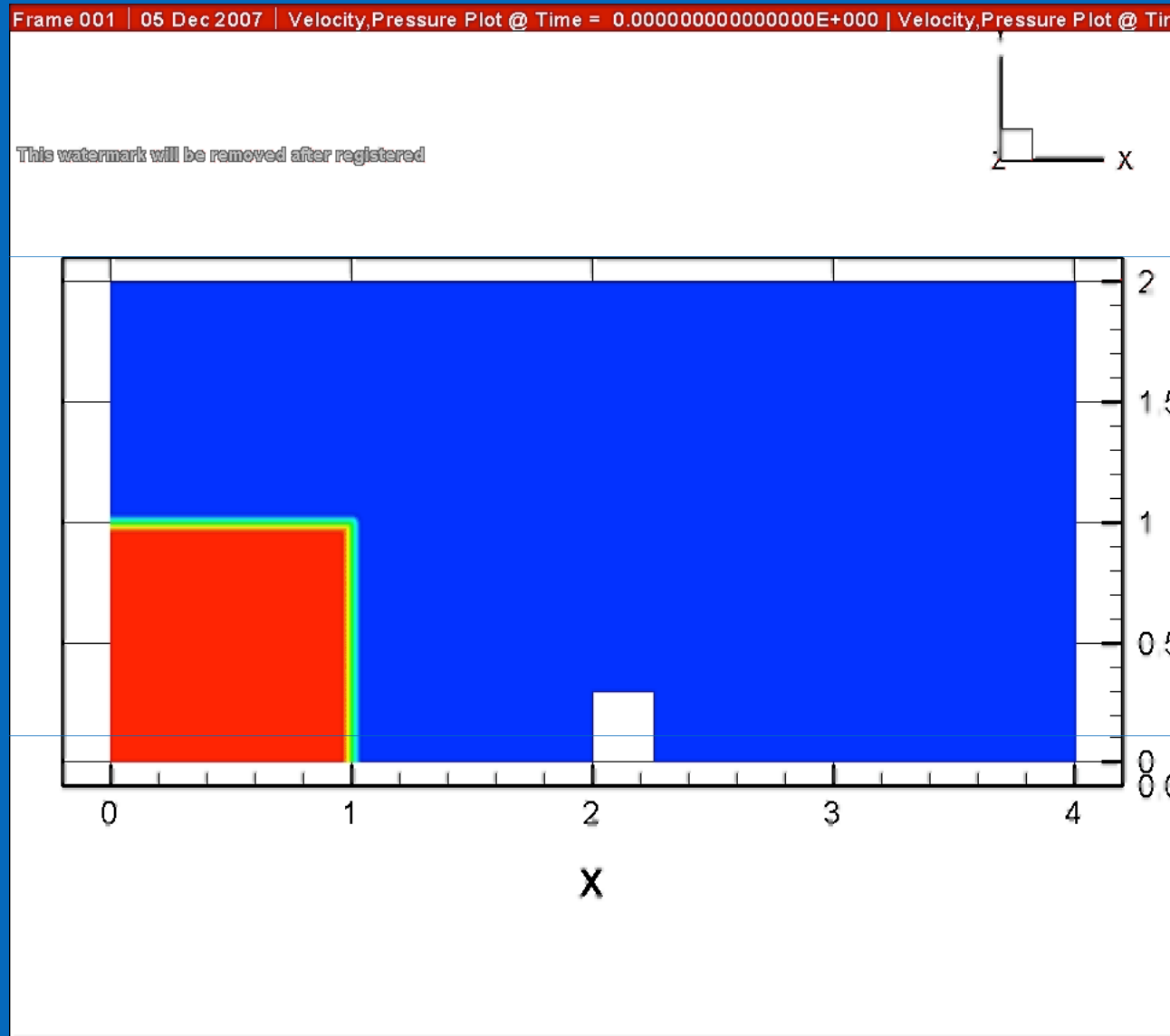
Source: Falconer, HRC, Cardiff



*Mean Flood - Spring Tide*

# Wave Structure Interaction

Source: Reeve, Swansea  
NERC FREE



# Summary and Future Work

- *Integrated model framework developed for assessing surge and wave heights*
- *Dynamical downscaling produces more accurate wind and pressure fields*
- *Divergence of ensemble members as a proxy for uncertainty*

# Summary and Future Work

- *Integrated model framework developed for assessing surge and wave heights*
- *Dynamical downscaling produces more accurate wind and pressure fields*
- *Divergence of ensemble members as a proxy for uncertainty*
  
- *On-going work:*
  - *Hindcasting of other historic events*
  - *Climate change impacts*
  - *Utilise future High-Res Version of UK UM*

**- Future is in IMPACT!**

An aerial photograph of a coastal town and harbor. In the foreground, a large, white, abstract sculpture made of thin poles and flat panels is situated in the water. The harbor is filled with several sailboats. The town is built on a peninsula with green hills and a sandy beach. The sky is bright and hazy.

*QJRMS Paper!*

**Thank you for  
Listening!**