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Simulating storm surge inundation and damage potential within complex port facilities

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Storm surge inundation of port facilities can cause damage to critical elements of infrastructure, significantly disrupt port operations and cause downstream impacts on vital supply chains. A tidal surge in December 2013 in the North Sea partly flooded the Port of Immingham, which handles the largest volume of bulk cargo in the UK including major flows of coal and biomass for power generation. This flooding caused damage to port and rail transport infrastructure and disrupted operations for several weeks. This research aims to improve resilience to storm surges using hydrodynamic modelling coupled to an agent-based model of port operations.

Using the December 2013 event to validate flood extent, depth and duration, we ran a high resolution hydrodynamic simulation using the open source Telemac 2D finite element code. The underlying Digital Elevation Model (DEM) was derived from Environment Agency LiDAR data, with ground truthing of the flood defences along the port frontage. Major infrastructure and buildings are explicitly resolved with varying degrees of permeability. Telemac2D simulations are run in parallel and take only minutes on a single 16 cpu compute node. Inundation characteristics predicted using Telemac 2D differ from a simple Geographical Information System 'bath-tub' analysis of the DEM based upon horizontal application of the maximum water level across the port topography. The hydrodynamic simulation predicts less extensive flooding and more closely matches observed flood extent. It also provides more precise depth and duration curves.

Detailed spatial flood depth and duration maps were generated for a range of tide and surge scenarios coupled to mean sea-level rise projections. These inundation scenarios can then be integrated with critical asset databases and an agent-based model of port operation (MARS) that is capable of simulating storm surge disruption along wider supply chains. Port operators are able to act on information from a particular flood scenario to perform adaptive responses (e.g. pre-emptive relocation of equipment), as well as estimate the likely duration of any disruption to port and supply chain operation. High resolution numerical inundation modelling, coupled to accurate storm surge forecasting and an agent based port operation model, thus has the potential to significantly reduce damage and disruption costs associated with storm surge impacts on port infrastructure and systems.