Small Grant Report

SG2 : Implementation of SUNTANS model to Orkney Waters

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Overview

Funding from this grant has been used to buy a license for GAMBIT, the mesh generator software needed by SUNTANS, an advanced hydrodynamic model developed by Stanford University that is being implemented by ICIT for the Pentland Firth.

Benefits of this award

The mesh or grid of a numerical simulation is the geometric definition of the model domain. In the horizontal plan view meshes can be structured, which are compounded of rectangular cells with fix distances in x and y axis, or unstructured, i.e. triangular or hexagonal cells. The kind of mesh is inherent to the model since it describes where variables must be calculated. SUNTANS model [1] uses an unstructured grid, which have the advantage of providing a better representation of complex coastlines. Advanced numerical models require meshes to meet specific criteria for stability. Due to the complexity of unstructured topology appropriate mesh generator software is essential in order to avoid numerical instabilities as a consequence of bad mesh quality.

Implementation of the SUNTANS model for the Pentland Firth [2] has been successfully undertaken using an unstructured mesh, with an average resolution of 150 m, to solve Linear Shallow Water Equations (LSWE). However, once the non-linear terms of the ocean equations were activated simulations crashed because of discrepancies between the numerical scheme and the mesh configuration. Non-linear terms imply a stability limitation, which minimum distance between cells centres, maximum velocity and time step are related. Therefore generating a new mesh it was required.

This award and the acquisition of GAMBIT software have made possible the continuation of this research by allowing the creation of a new grid. Other open source software have been evaluated as potential candidates to create grids that the model could use, but model developers pointed out that GAMBIT is the most suitable mesh creator that they found, with any other alternative likely to increase the cost of the research as a time consuming learning and adaptive process.

Impacts and outputs related with the GAMBIT purchase

Modelling tidal energy extraction is essential for the future deployment of marine energy installations and requires advanced numerical tools in order to study potential environmental impacts, layout of the farms of devices and others concerns related to Marine Renewable Energy (MRE) development.

First step to achieve such goals is to have an accurate numerical tool with which to predict the complex hydrodynamics of the Pentland Firth and Orkney Waters. SUNTANS is an advanced coastal model designed for small scale physical processes such as upwelling and internal waves but it is also best suited for larger scale processes such as regional circulation. The smaller the scale of study the highest the grid resolution required.

Figure 1 shows the grid which the model using LSWE was implemented (left) and the new one (right), created with the GAMBIT software awarded by MASTS. As you can see the new one has a higher resolution to fulfil the numerical conditions required to include the non-linear terms of the equations in the model.

Other study areas will also be able to be modelled. Figure 2 shows the bathymetry interpolated into the grid for the northern islands of Orkney. Mesh generation is the first step in numerical modelling implementation therefore the award to purchase the GAMBIT software license has supported the further numerical modelling research that is being undertaken at ICIT using the SUNTANS model as well as the Pentland Firth implementation.
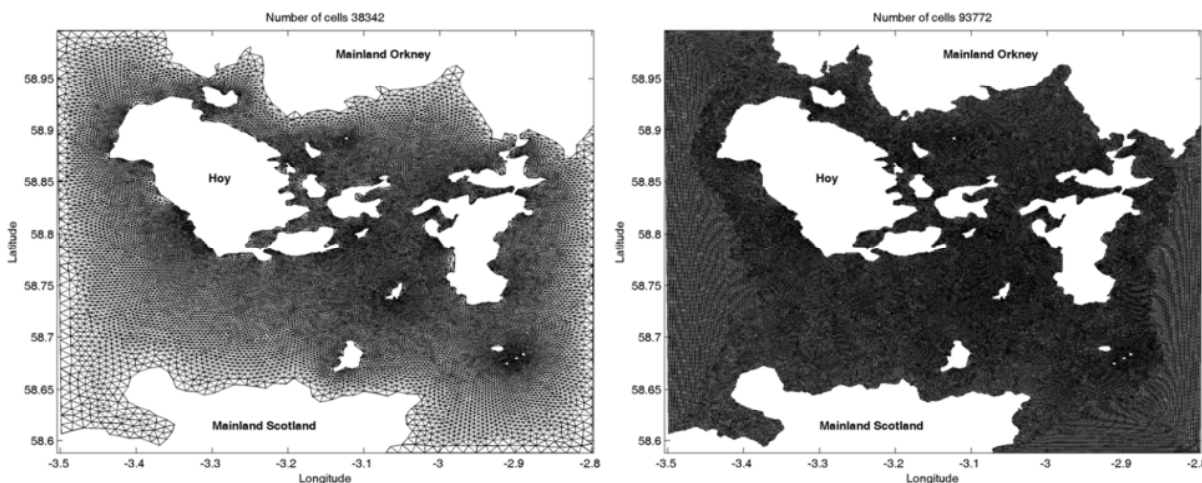

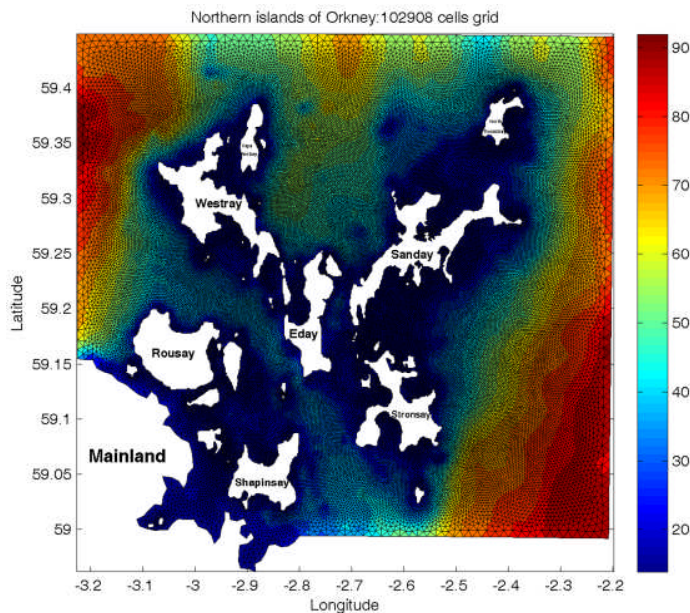**Figure 1: Original (left) and new (right) mesh for the Pentland Firth**

Figure 2: New grid to modelling the Northern islands of Orkney using SUNTANS model. Picture shows bathymetry (in m).

MASTS contribution

The Marine Alliance for Science & Technology for Scotland (MASTS) is becoming an essential support for Marine Science in Scotland. It is really helpful to have a funding body to which researchers can turn to solve problems that may emerge after the onset of a research project.

Numerical modelling is significantly linked to MRE development, a sector that Scotland is leading. MASTS is doing much to support research topics in this area. Present report is an example of how much helpful a small grant can become.