FVCOM Metadata for the ARCoES project

Keywords: FVCOM, residual circulation, Liverpool Bay, Irish Sea, UK shelf

FVCOM is the Finite Volume Community Ocean Model, developed at the University of Massachussets-Dartmouth by Prof Chen and colleagues in the Marine Ecosystem Dynamics Modeling Laboratory (MEDML). It comprises a baroclinic three-dimensional model which has the ability to run in regions which include both the deep ocean and the continental shelf, together with linked turbulence, wave, sediment and ecosystem models. The model is based on an unstructured (triangular) grid with terrain-following vertical coordinates. It can use variable resolution to achieve high-resolution coastal simulations. Wetting and drying of intertidal banks and beaches can be incorporated. The model can be run in Cartesian or spherical polar coordinates and solves the Boussinesq, hydrostatic equation of motion separated into depth varying and depth independent parts to allow time splitting between barotropic and baroclinic components. The total water depth (or free surface elevation), horizontal velocity components, temperature and salinity fields are calculated at each node of the computational mesh.

The EPSRC funded ARCoES project (research grant EPSRC EP/I035390/1) has made use of several implementations of the FVCOM model, some made at the National Oceanography Centre and one developed at the Plymouth Marine Laboratory:

- Scottish Shelf Model (SSM, developed for Scottish Government and managed by Marine Scotland Science).
- Irish Sea Model (ISM, developed in the EU FP7 FIELD_AC project)
- West coast shelf model (WCSM, developed at the Plymouth Marine Laboratory).

To obtain access to the FVCOM model code please get in touch with the developers http://fvcom.smast.umassd.edu/fvcom/ and make a request to join the registered user group. The model and documentation can then be downloaded.

To access the Scottish Shelf model implementation of FVCOM please contact Louise Campbell at Marine Scotland Science: l.campbell@marlab.ac.uk.

To access the Irish Sea model implementation of FVCOM please contact Judith Wolf at the National Oceanography Centre, Liverpool: jaw@noc.ac.uk

To access the West Coast shelf model implementation of FVCOM please contact Pierre Cazenave at the Plymouth Marine Laboratory: pica@pml.ac.uk

Application of FVCOM within ARCoES

FVCOM has been used by the National Oceanography Centre within the ARCoES project on 3 different grids (as above), and run for a typical year (2008). The main focus for ARCoES is on the Irish Sea.

The SSM has 267,744 nodes and 521,196 elements and was designed to cover the whole NW European shelf, with a resolution of O(1km) in Scottish Waters.

The IRS grid was designed to achieve the best (~200m) resolution in Liverpool Bay and has 88,477 nodes and 169,272 elements.

The WCSM grid covers the Irish Sea, extending to the Celtic Sea shelf edge in the SW, onto the Malin shelf in the NW and into the Southern North Sea. It has a higher coastal resolution than the other models, with fewer elements. The horizontal resolution increases towards the shore from O(10km) offshore to O(100m) in the coastal zone, with 58,558 nodes and 106,890 triangular elements. This grid was developed by Cazenave et al. (2016).

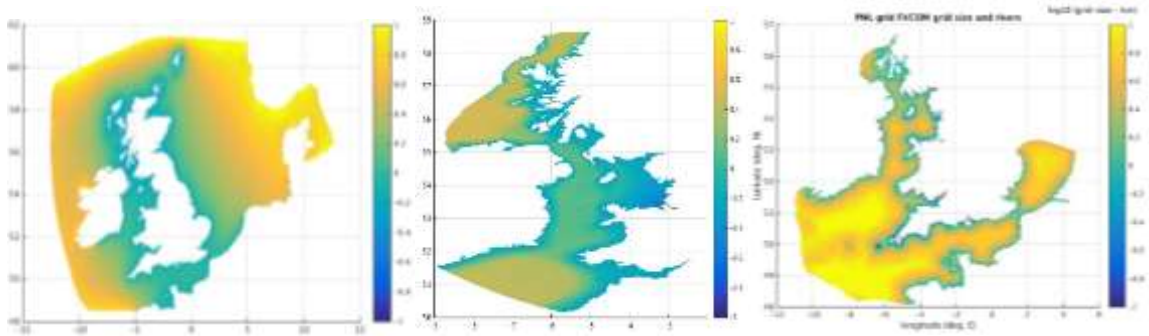

Figure 1: Grid size and extent of (left to right) SSM grid, ISM grid and WCSM grid in km on a logarithmic scale, river locations are marked with crosses in WCSM grid

The extent and grid size for each grid is compared in Fig. 1. It can be seen that the WCSM grid has the highest resolution at the coast but a steep gradient in resolution and thus a lower number of grid cells overall, thus is the most efficient to run. The minimum depth is 0.1m.

Although the IRS grid includes 73 rivers, these were not activated. The PML grid includes 99 rivers but does not include the Dee, Mersey or Ribble (it does include the Weaver, which discharges into the Mersey at Runcorn, the Alt, the Clwyd, the Conwy, rivers draining into Morecambe Bay and the Solway). The SSM only includes freshwater river discharges in Scottish waters, so no rivers are active in the Irish Sea.

The FVCOM model has been run for 3D baroclinic hydrodynamics only, no waves or sediment transport were calculated. The total current fields have been used to carry out particle tracking for the eastern Irish Sea. The outputs are 3D water level and current fields, salinity and temperature under 3 SLR scenarios for the WCSM model.

2014: represents present-day sea level

2050: 0.259m above present

2100: 1.9m above present

2500: 5.49m above present

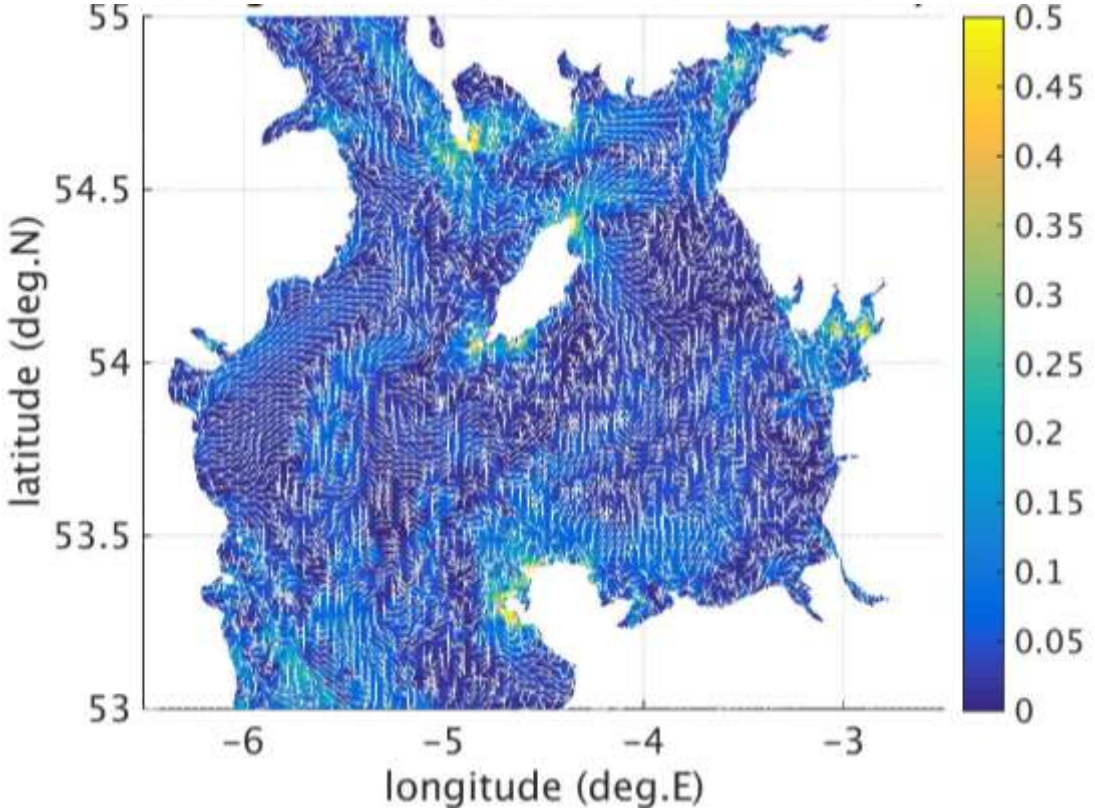

Figure 2: Surface residual current for 2008 from WCSM grid

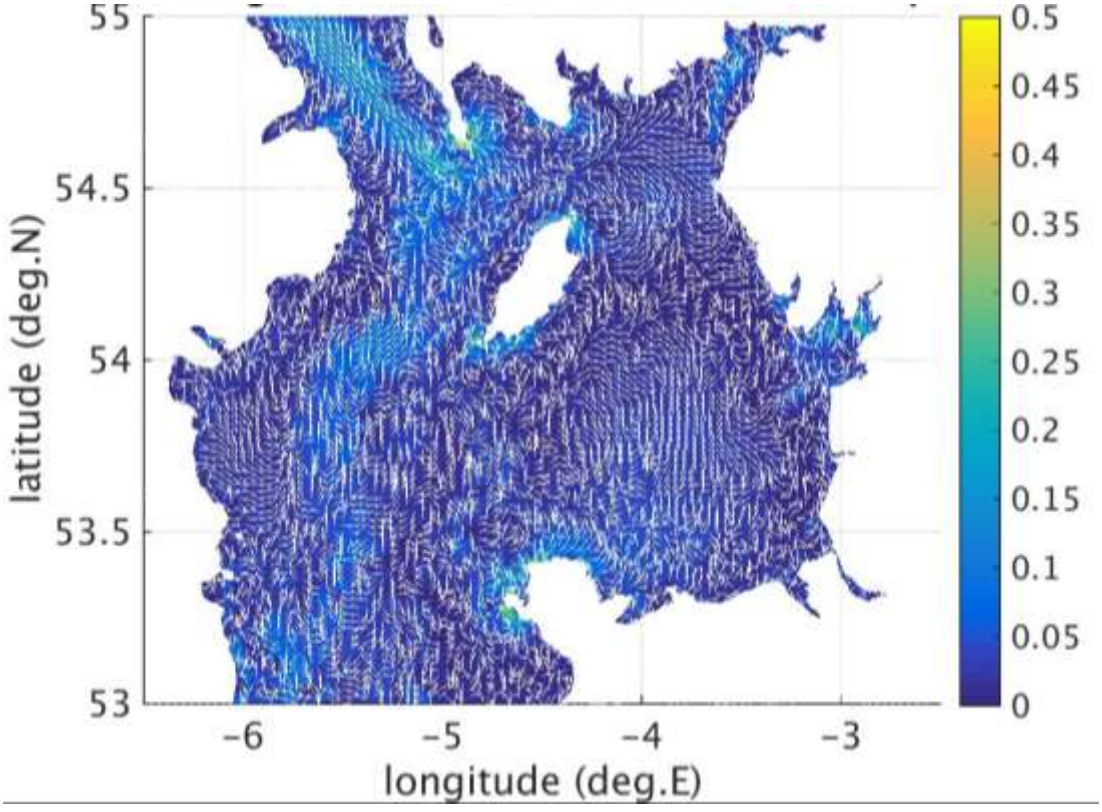

Figure 3: Bottom residual current for 2008 from WCSM grid

Particle tracking has been carried out using the offline particle tracking code available with FVCOM (with some modifications). Particles are released at surface and bottom from selected locations for a summer and a winter month for present and future sea level. 100 particles per release point are used to explore dispersion as well as advection. An example of the output for particles released near the mouth of the River Mersey is shown in Figure 3.

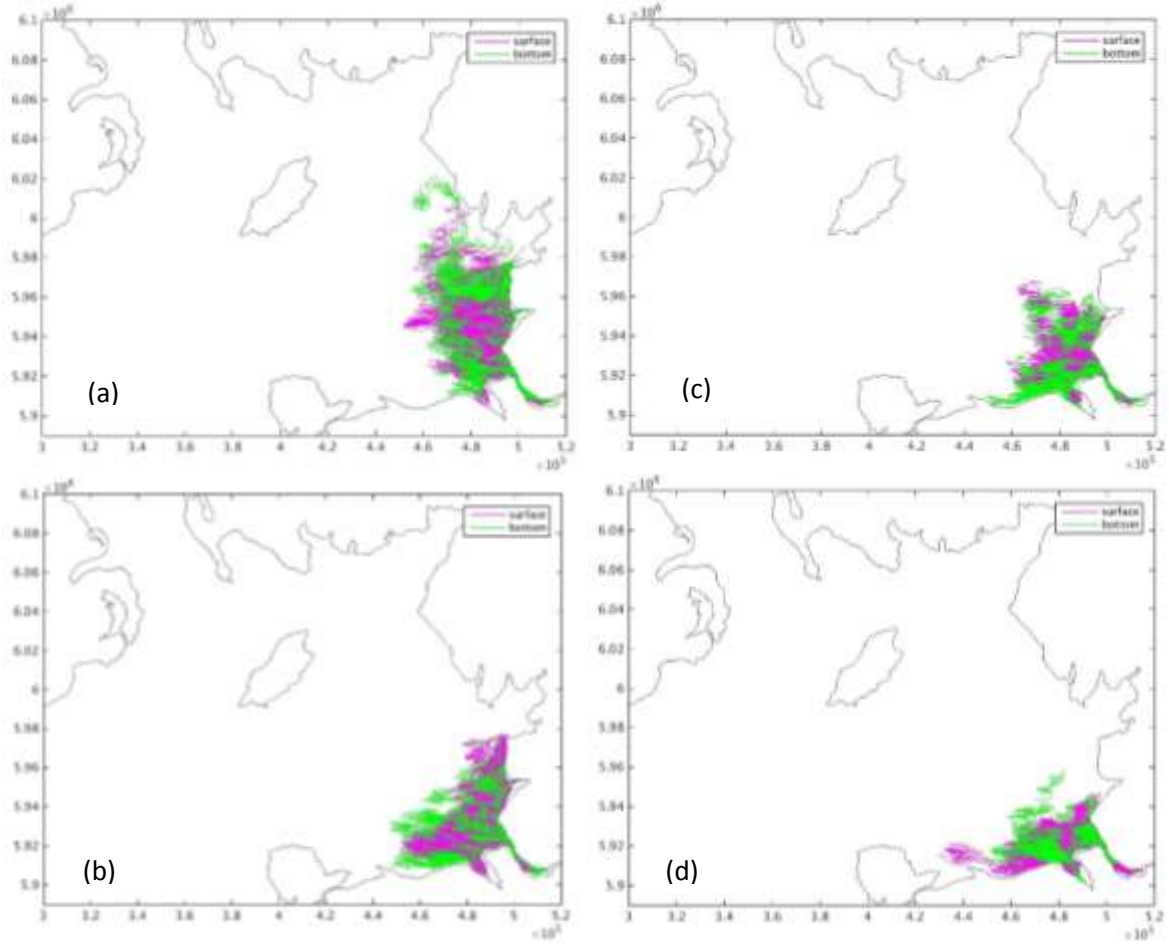

Figure 4: (a) January 2008 (b) June 2008 (c) January 2500 (d) June 2500

Data Archive

The model results for residual currents and accompanying matlab script below can be downloaded from the Liverpool University ARCoES repository:

http://datacat.liverpool.ac.uk

Parameters that are available in the *.mat files are the u- and v- components of the annual residual velocity.

- *Annual_mean_currents_2014.mat*
- *Annual_mean_currents_2050.mat*
- *Annual_mean_currents_2100.mat*
- *Annual_mean_currents_2500.mat*
- *Irish_Sea_residual_plot.m*

Model publications within ARCoES:

Wolf, J., Amoudry, K., Phillips, H. and Brown, J. (2017) Particle tracking in the eastern Irish Sea. Geophysical Research Abstracts, 19, EGU2017-17747, 2017 EGU General Assembly 2017, Vienna.