

Hydrodynamic modelling across spatial scales

From regional scale to tidal turbine scale

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marinescotland
science

Plan Options for Offshore Wind and Marine Renewable Energy and Planned developments in Scotland

Detail Key

Offshore Wind and Marine Renewable Energy

- Key:**
- 12 Nautical Miles
 - Sectoral Marine Plan Options
 - Offshore Wind Plan Options
 - Wave Plan Options
 - Tidal Plan Options

- Saltire Prize Identified Areas**
- Tidal
 - Wave

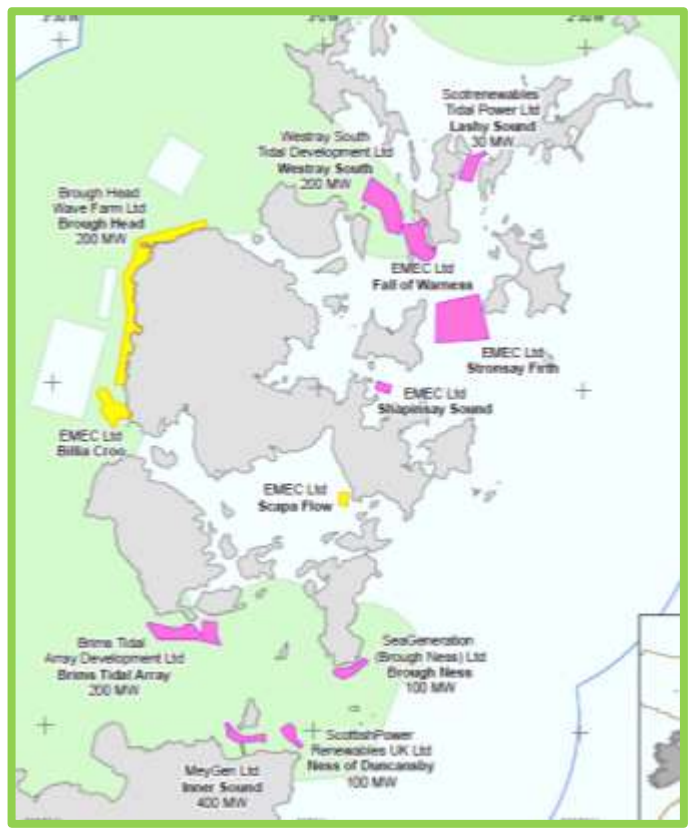
- Planned Developments**
- Scottish Territorial Waters offshore wind sites
 - Round 3 offshore wind zones
 - Test and Pilot offshore wind sites
 - Robin Rigg offshore wind demonstrator
 - Wave leases (The Crown Estate leasing round)
 - Tidal Leases (The Crown Estate leasing round)



Positions shown relative to British National Grid
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Map is indicative. An interactive version
 map can be found on NMPi. Upd
 sets will be added to NMPi when

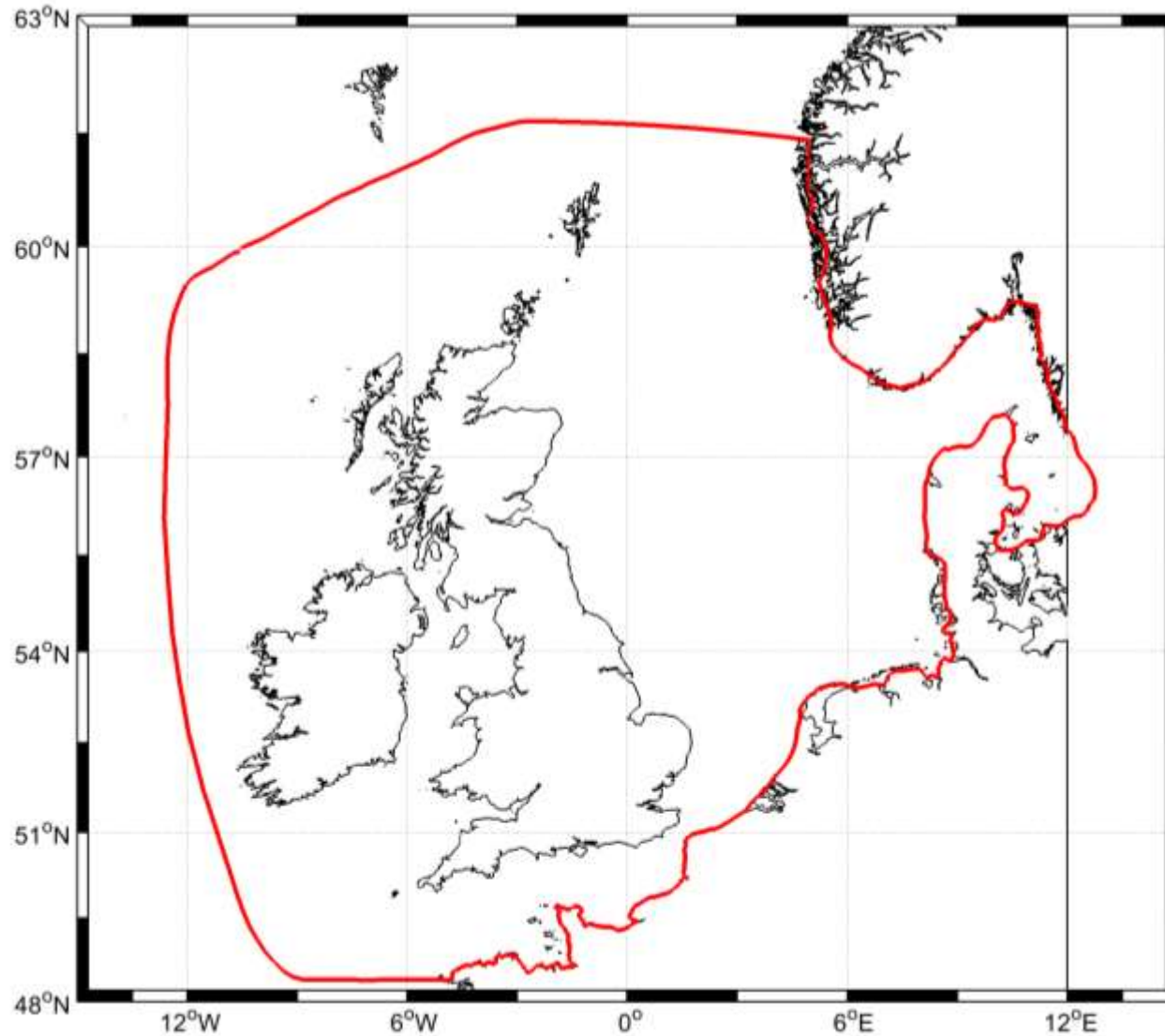
Plan Options for Offshore Wind and Marine Renewable Energy and Planned developments in Scotland



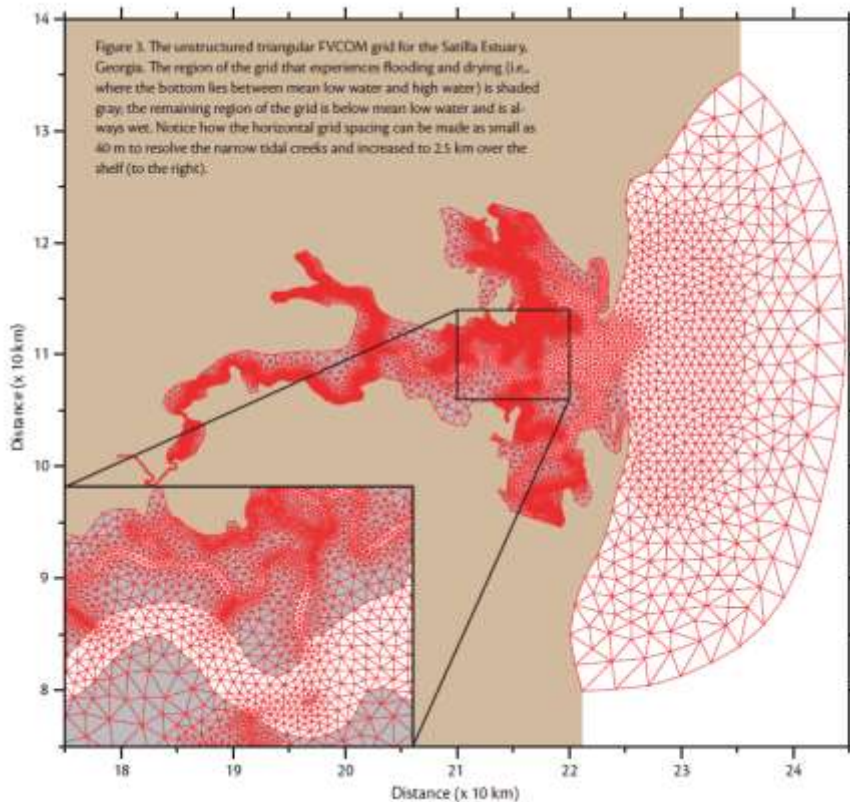
Range of scales:

- Scotland wide
- Regional – e.g. Orkney
- Specific sites – e.g. Pentland / Westray Firth, down to the Inner Sound of Stroma

The Scottish Shelf Model (SSM)



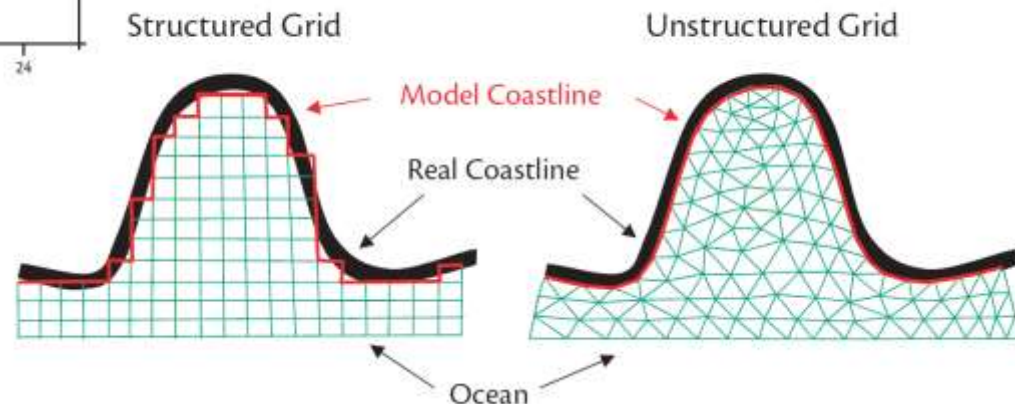
Finite Volume Community Ocean Model (FVCOM)



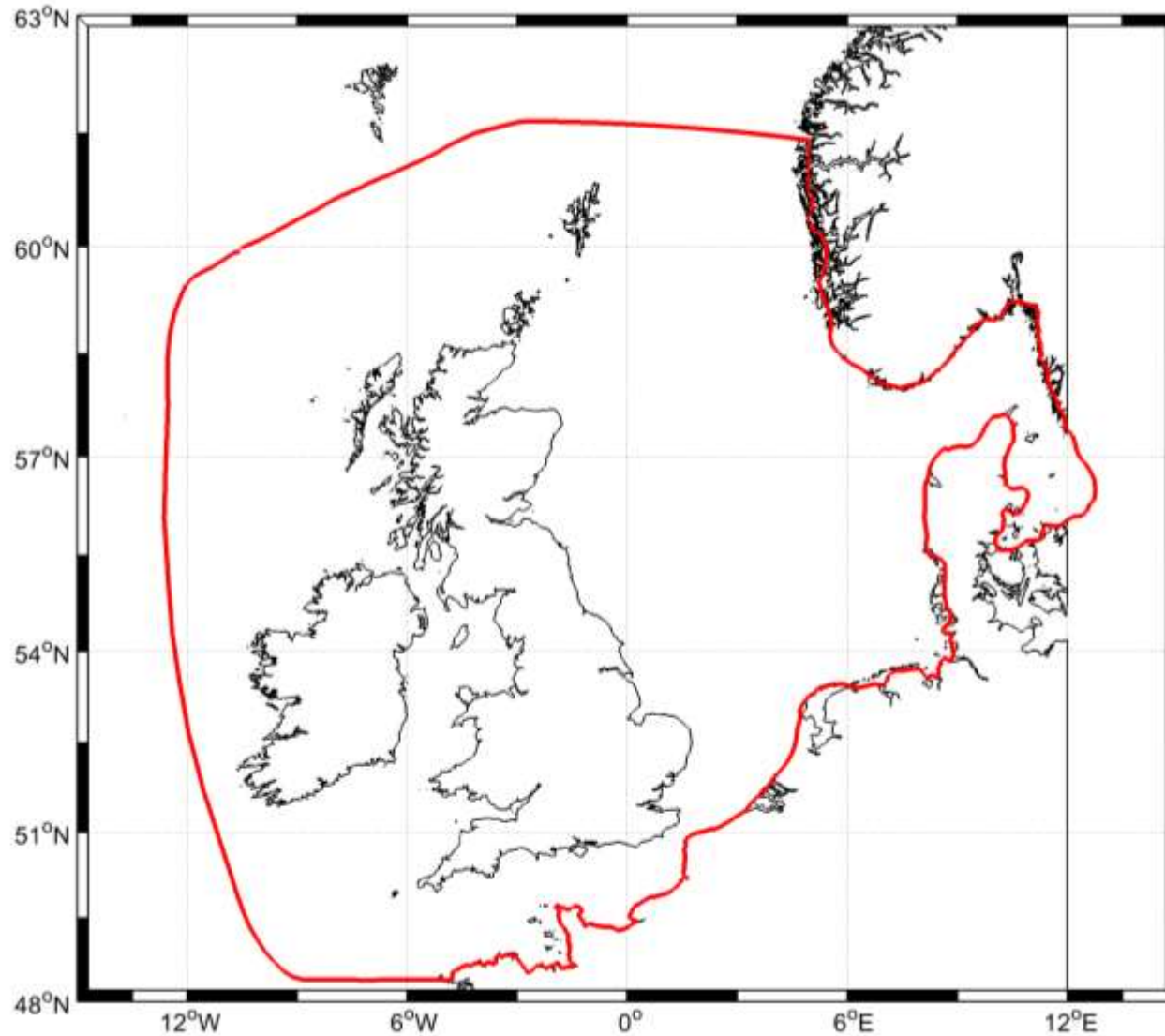
- Hydrodynamic model
- Finite volume
 - integral form of equations
 - Flux over mesh solved
- Unstructured grid
- Free surface
- 3D with multiple layers
- Modular structure
- Open source (Fortran 90)
- Parallel processing capabilities

- Typical outputs:

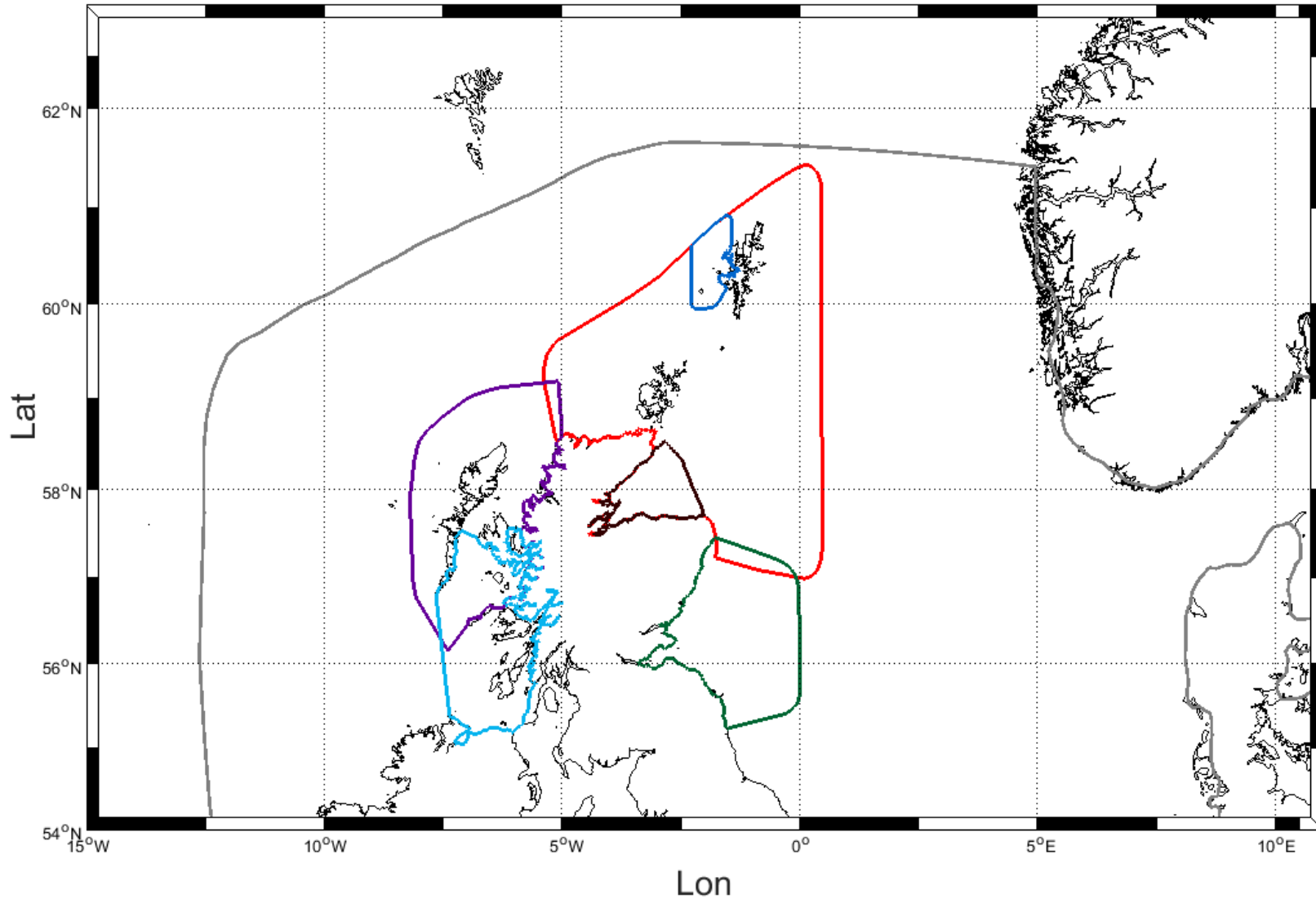
- Water levels
- Current speeds
- Temperature and Salinity



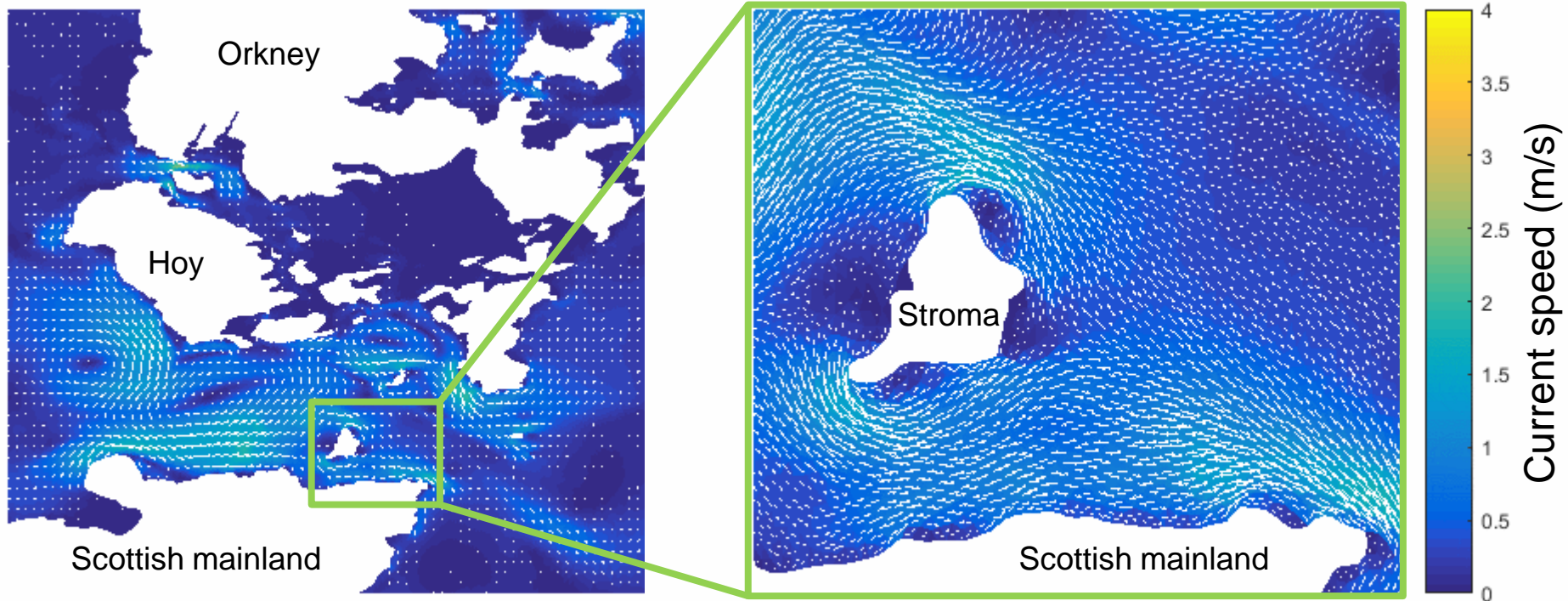
The Scottish Shelf Model (SSM)



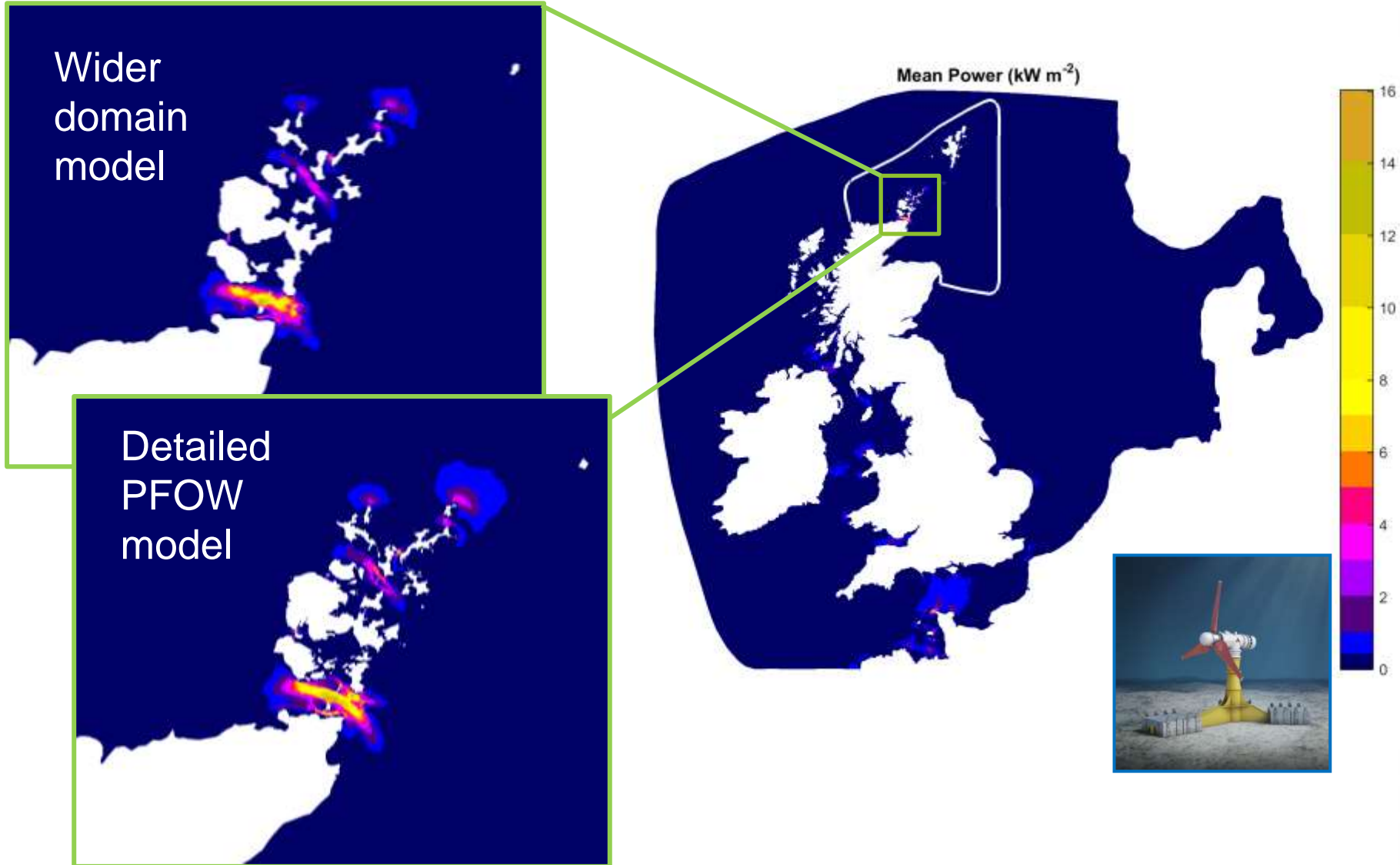
The SSM sub-models



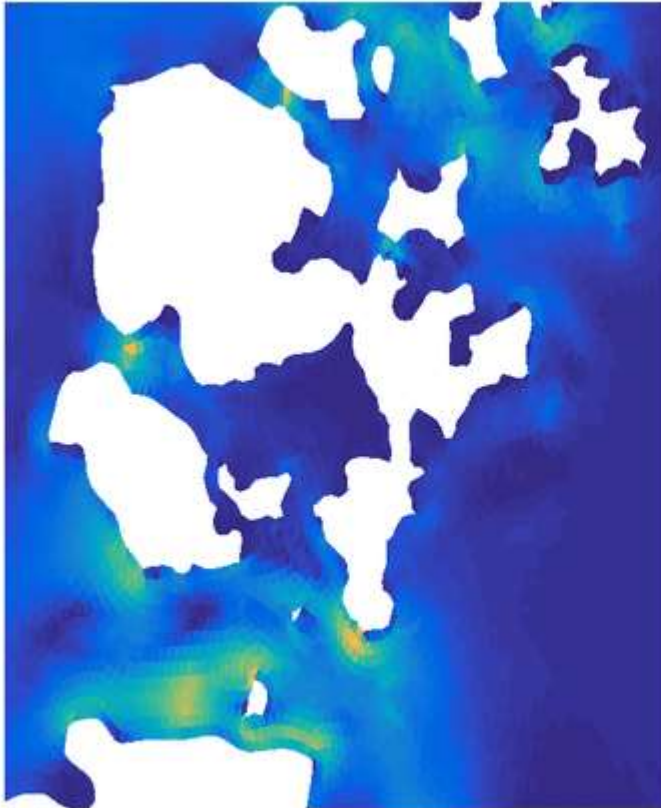
Modelled tidal currents from PFOW sub-model



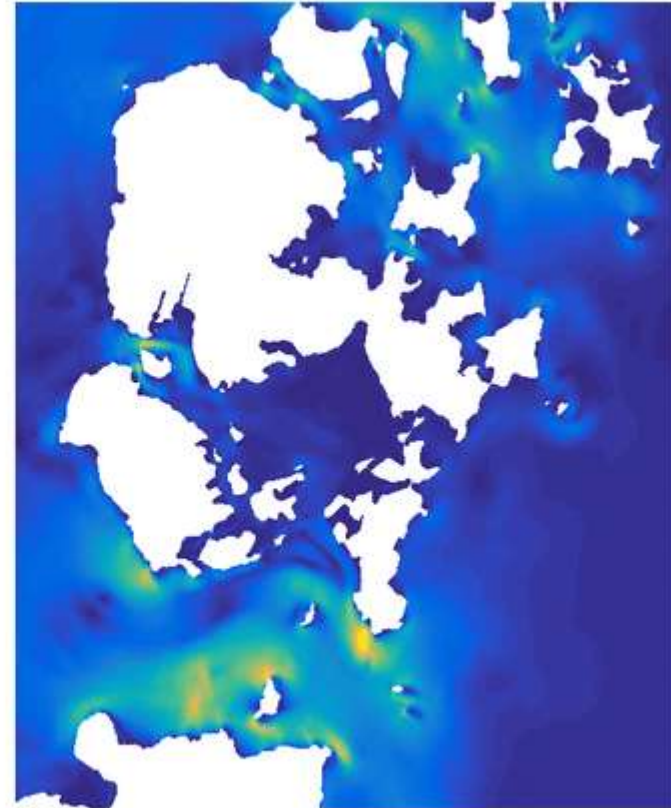
Tidal stream energy resource from the SSM



Speed comparison for Orkney

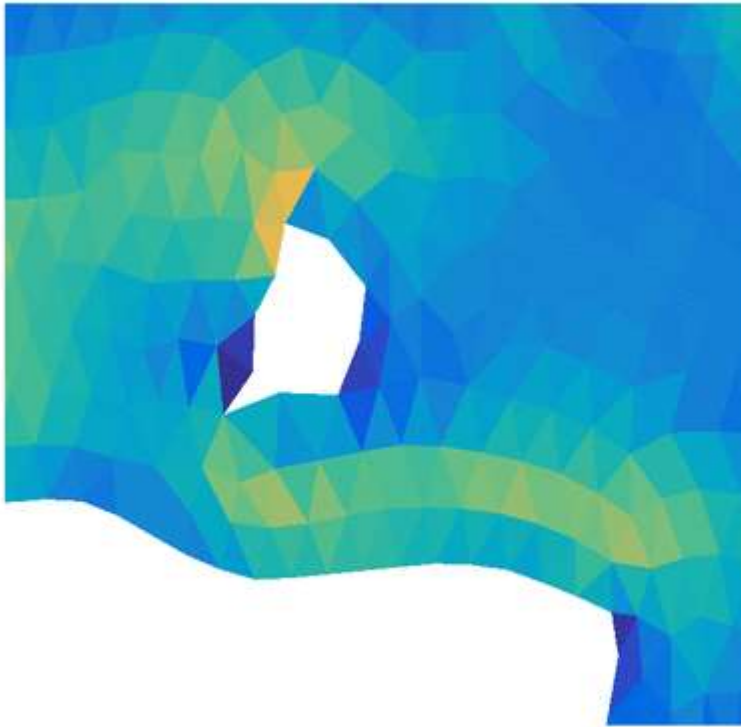


Wider SSM

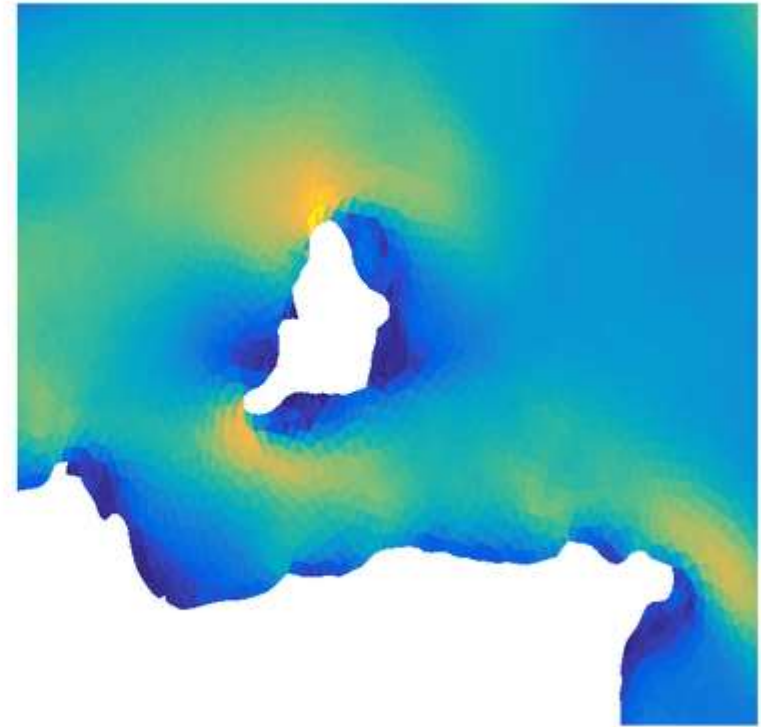


PFOW sub-domain

Speed comparison for Inner Sound

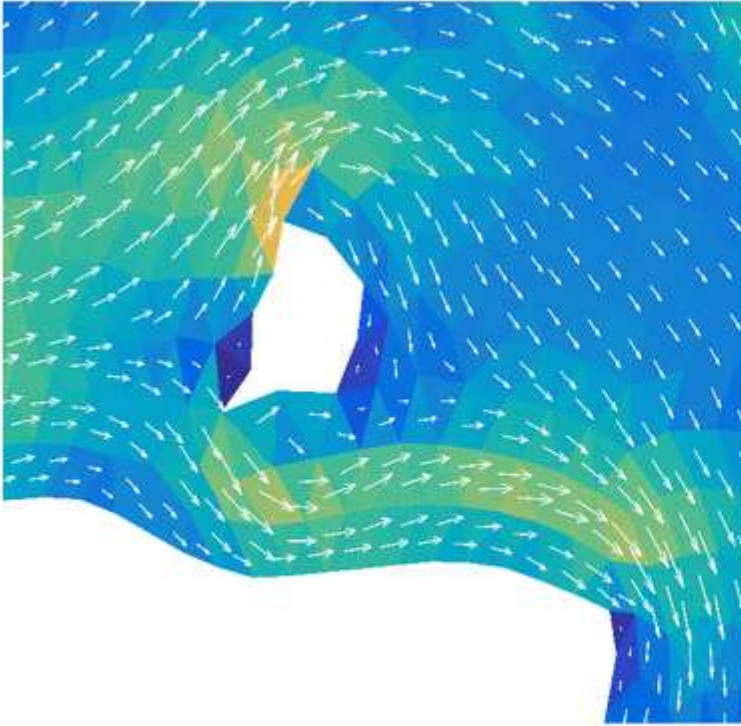


Wider SSM

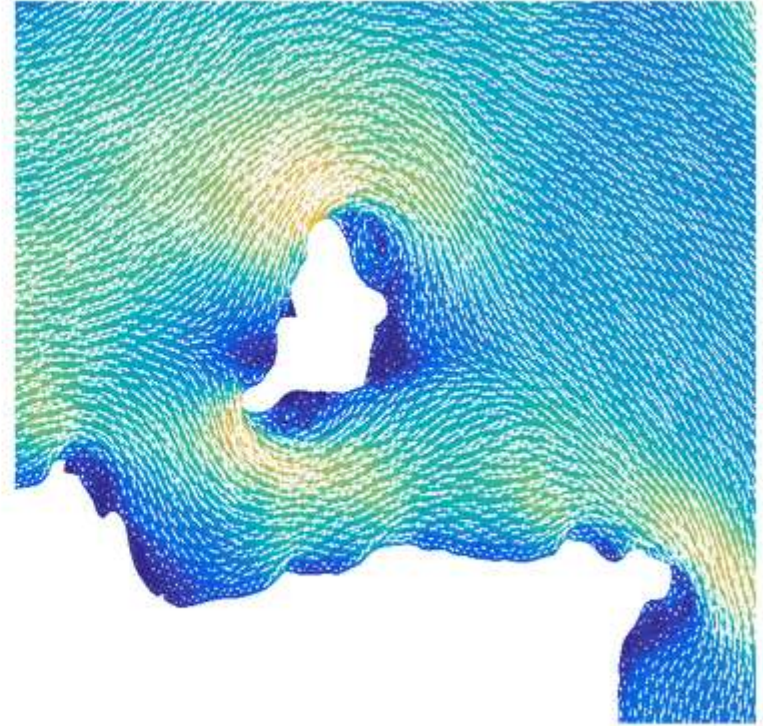


PFOW sub-domain

Speed comparison for Inner Sound



Wider SSM

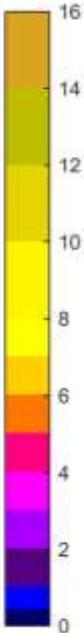
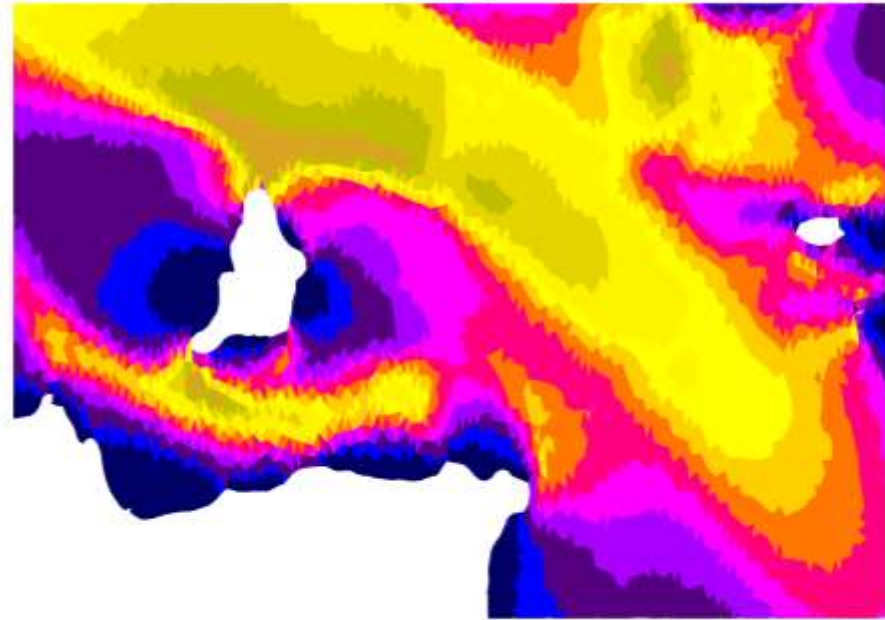
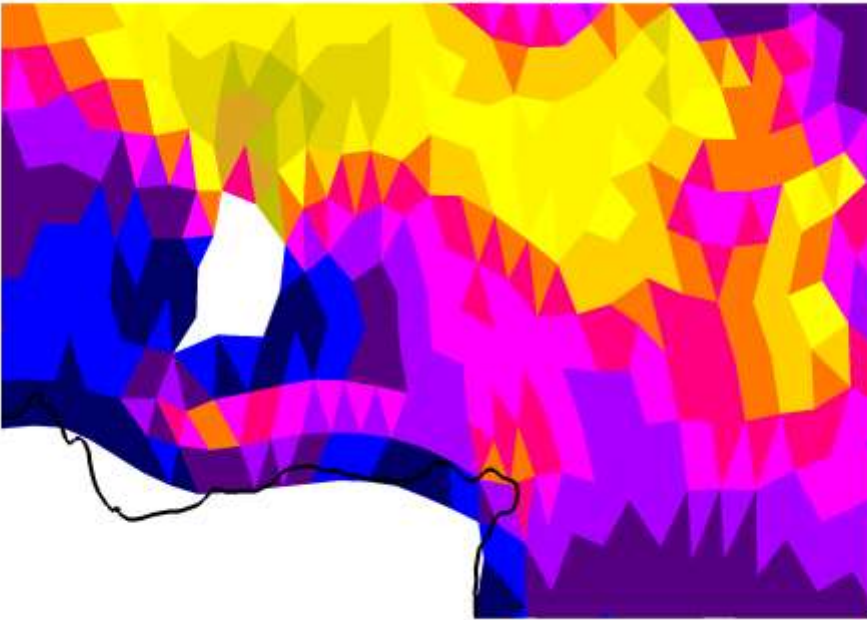


PFOW sub-domain

Power density comparison for the Inner Sound

Mean Power (kW m^{-2})

Mean Power (kW m^{-2})

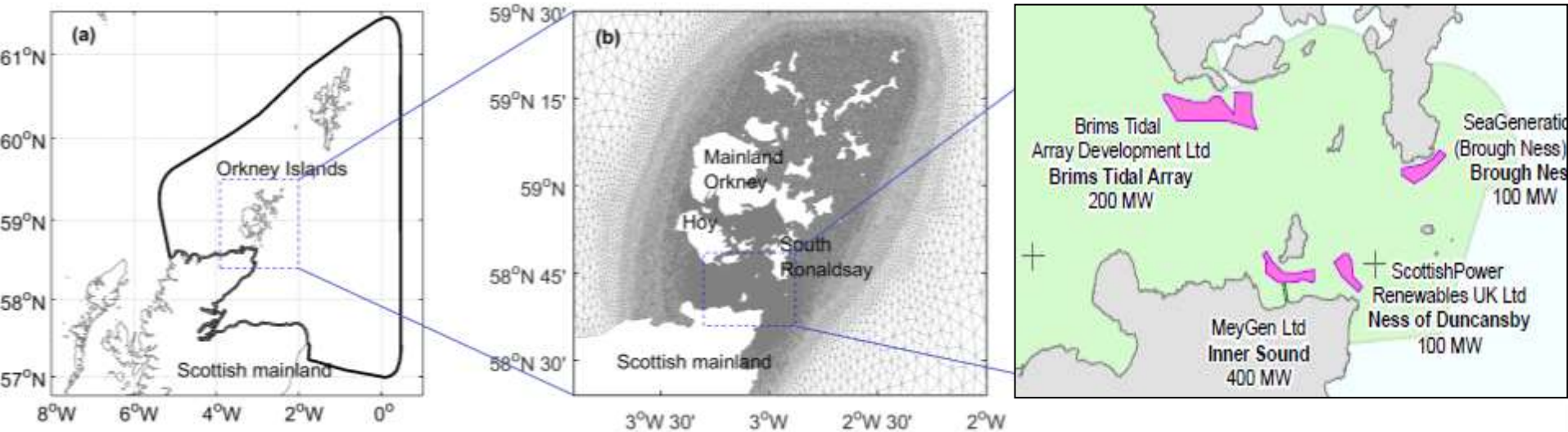


Wider SSM

PFOW sub-domain

- It is important to consider model resolution, and
- whether the appropriate processes are represented

Tidal turbines in the Pentland Firth



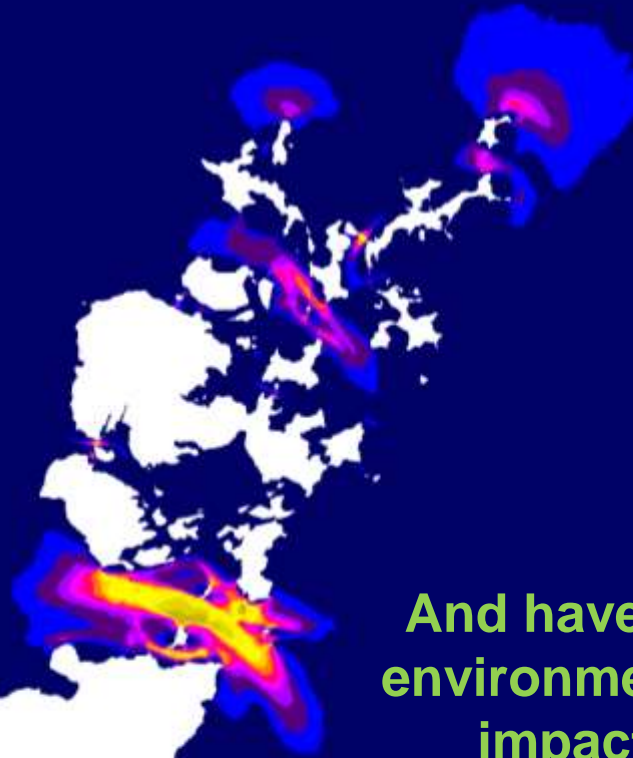
- How much power can be extracted ?
- How could the tide change as a result ?



Modelled tidal power density (baseline)

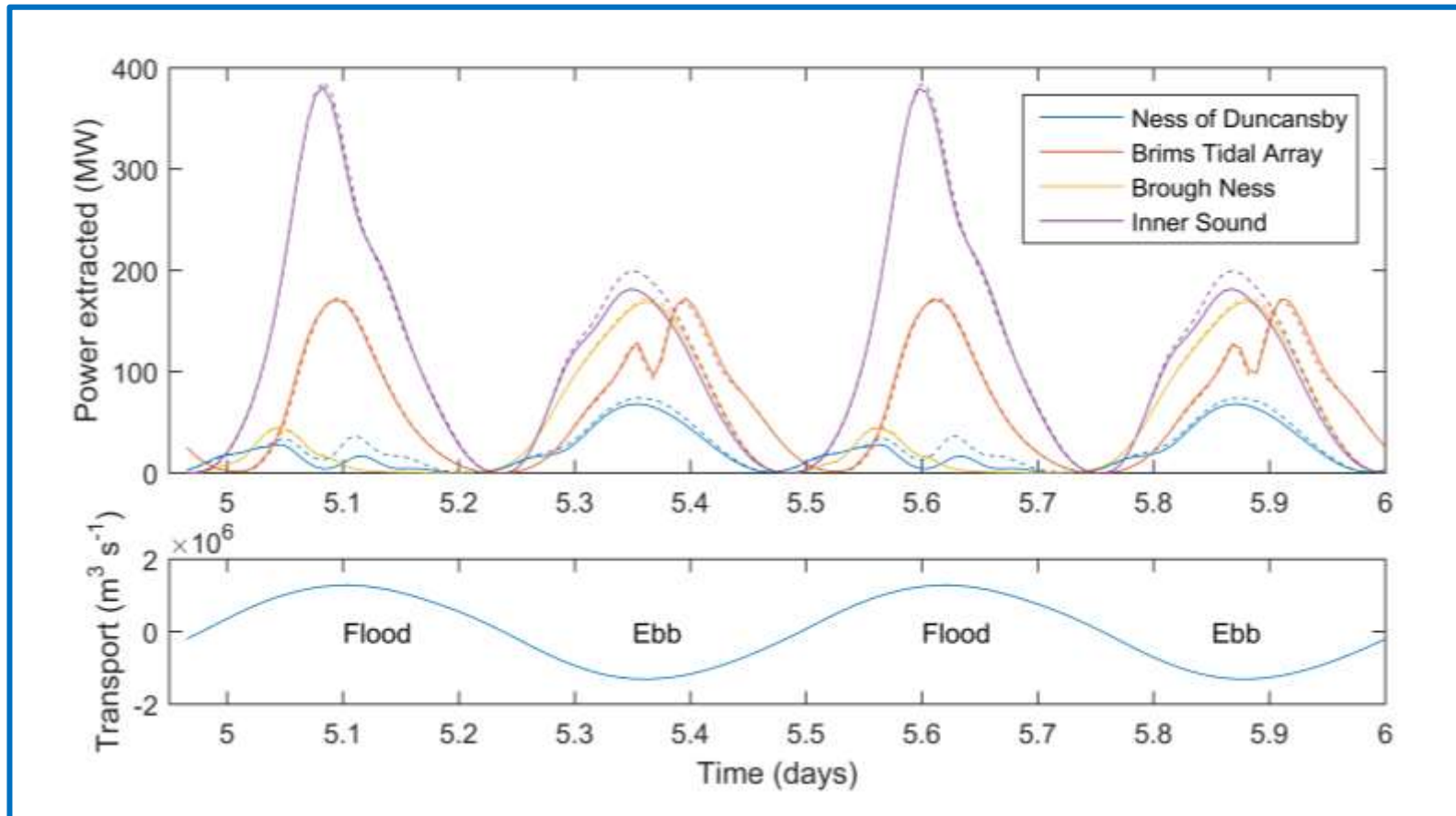


**Tidal turbines
will change this
resource**



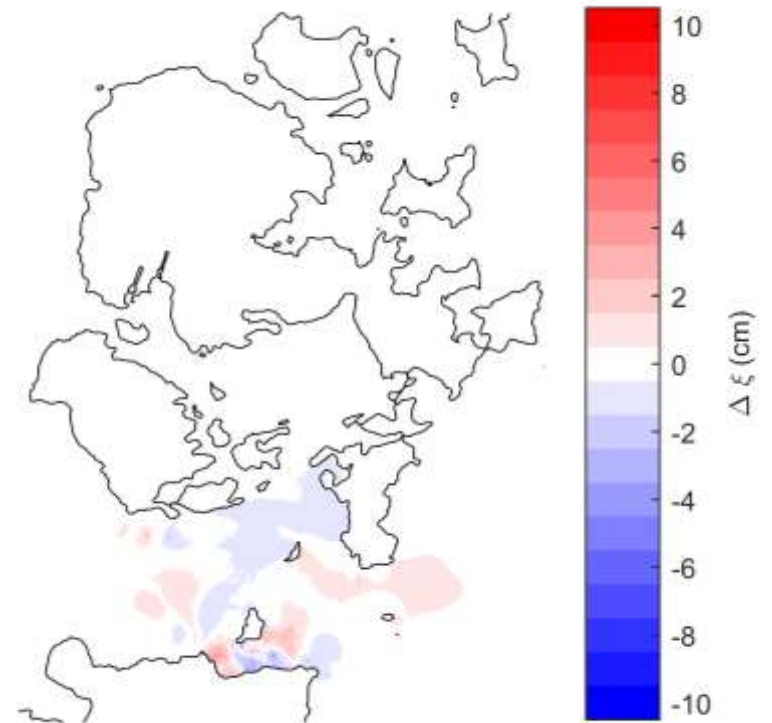
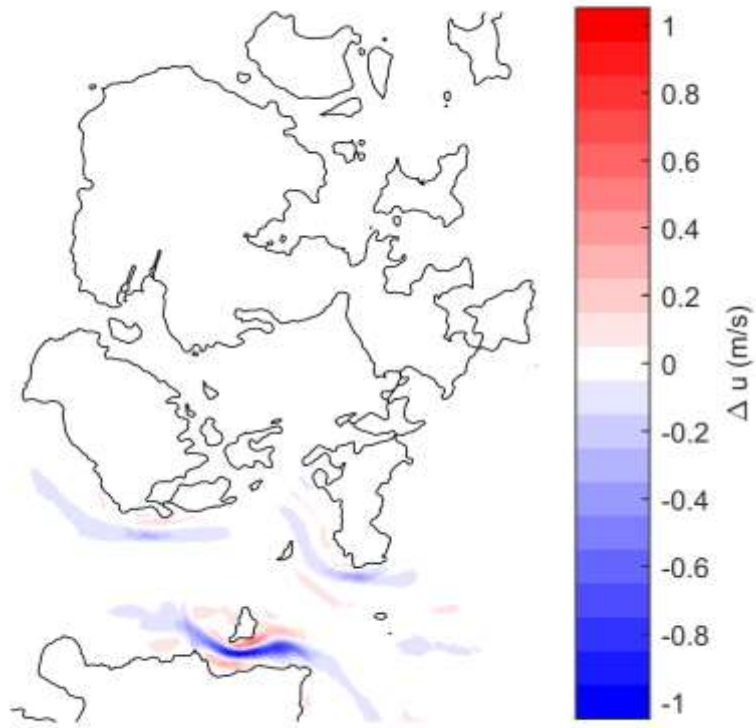
**And have an
environmental
impact**

How much power can be extracted ?



- Mean average combined power is 370 MW
- There are interactions between the arrays

How do the tides change ?

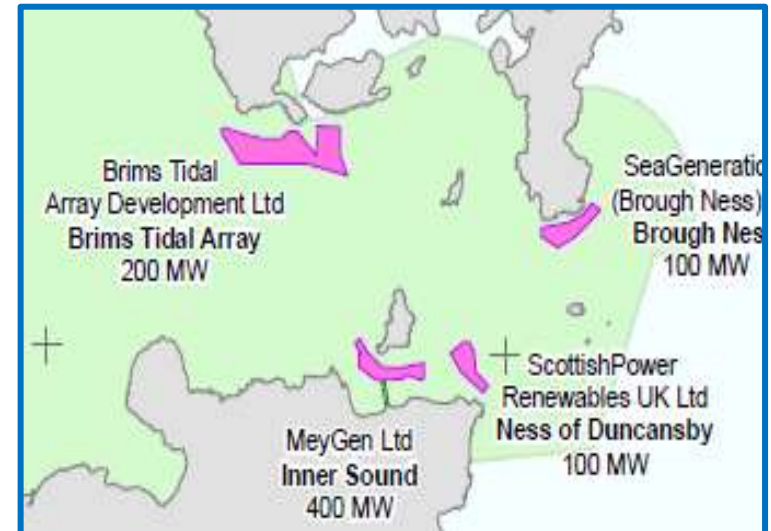
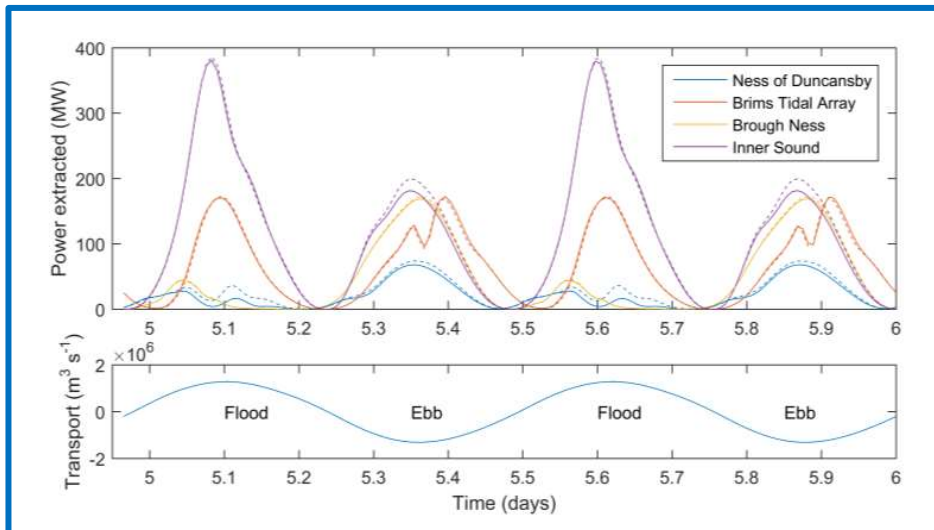


Conclusions

- **The SSM is a useful tool for regional scale resource assessment**
- **Different resolutions can produce different results**
- **What resolution should the model be for resource assessment ?**
 - Depends on who you are
 - Spatial planner (regional and array scale)
 - Developer (device scale)
 - It needs to resolve processes influencing the resource
 - Sensitivity analysis could *ideally* be conducted
- **The planned Pentland Firth arrays could change the tide a little and they could also interact with on another**

What next ?

- Include additional harmonic components
- Investigate asymmetry at the sites further
- Further refinements to the model, including further nesting
- Device scale interactions with FVCOM



What next ?

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