'Unified' ocean-land-river modelling using compatible unstructured meshes

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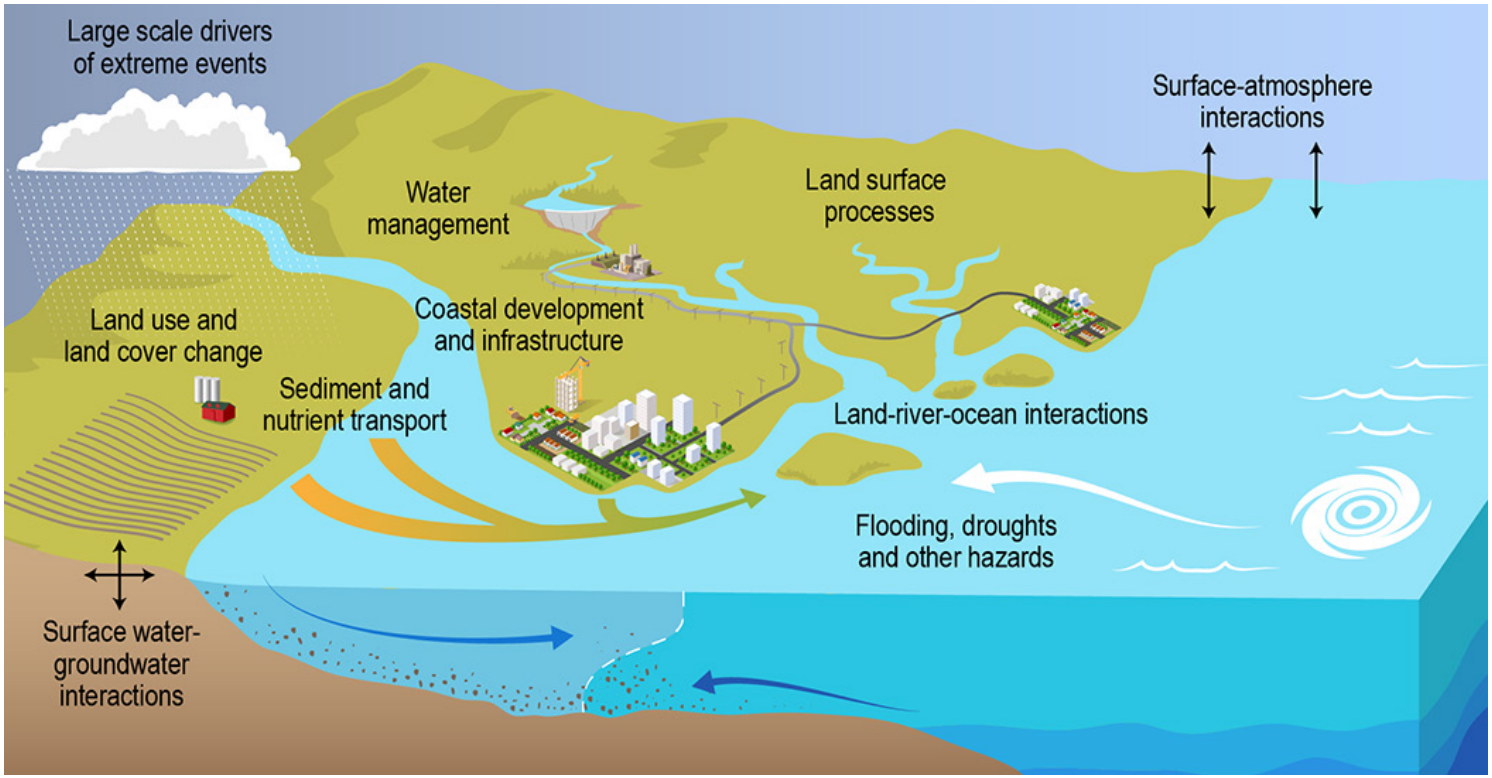
ESMD Meeting: October, 2020

‘Unified’ coupled modelling in ICoM

Coupling between the ocean, land and river components will be significantly enhanced in the ICoM (Integrated Coastal Modelling) project.

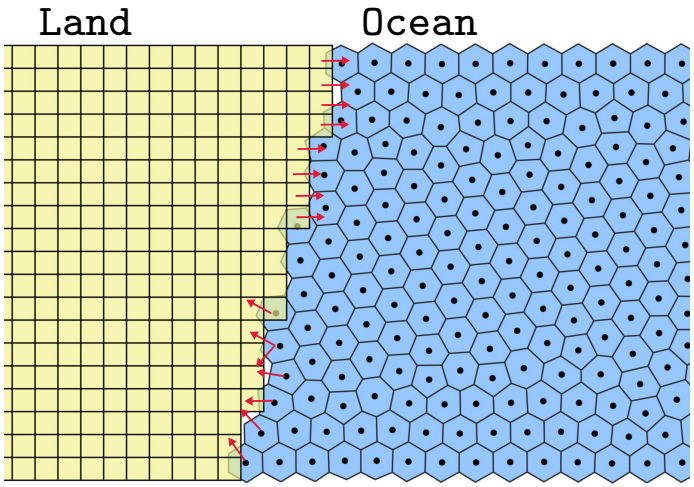


Aim to achieve dynamic, two-way exchange of state + fluxes between all model components: **ocean-river**, **ocean-land**, **land-river dynamics**, **BGC tracers**, **sediment**, etc!

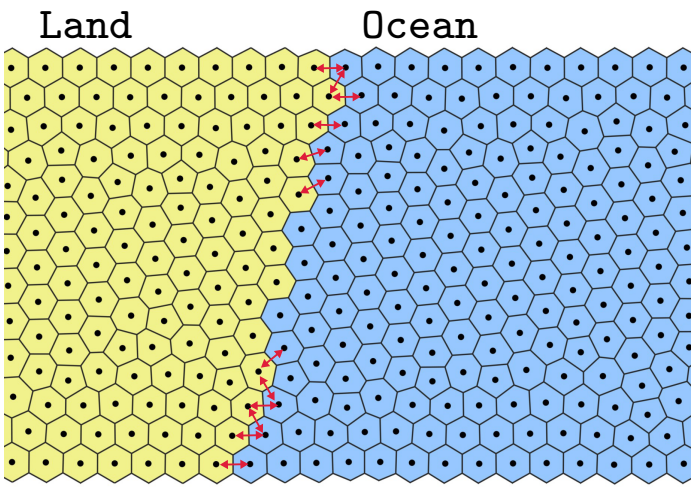
ICoM vs E3SM coupling strategy

To enable this tight coupling, the ocean, land and river models are placed onto a **common 'unified' discretisation / unstructured mesh**.

E3SM v1: (mixed meshes)



ICoM v0: ('unified' mesh)



Issues at component 'boundaries':

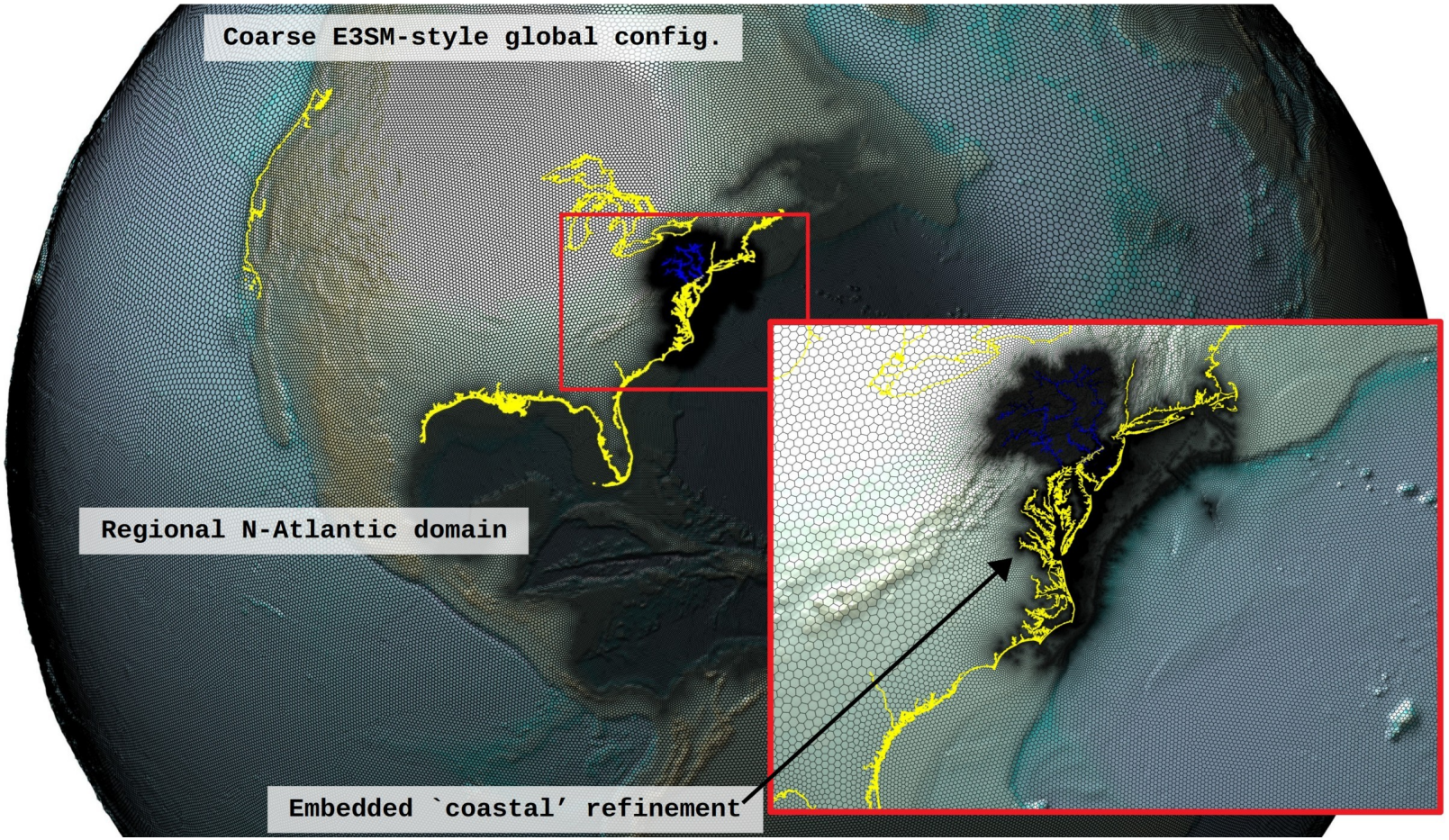
- Flux coupling requires interpolation → conservation challenges.
- Model-components cannot 'coexist' per grid-cell → ocean cannot flood land, etc.
- One-way coupling → ocean cannot flux 'up' rivers, etc.

Direct one-to-one coupling possible:

- Fluxes between components over common cell edges → no interpolation.
- Model-components can 'stack' in mesh cells → dynamic flooding, etc.
- Align mesh with ocean, land & river boundaries + resolution constraints.

‘Unified’ unstructured meshes: global-to-local refinement

Use the ‘unified’ approach to construct high-resolution ocean/land/river configurations for coupled coastal environments (e.g. mid-Atlantic region).



Enables seamless transitions between global and local domains, without complications of nested boundary conditions. Couples global + local dynamics.

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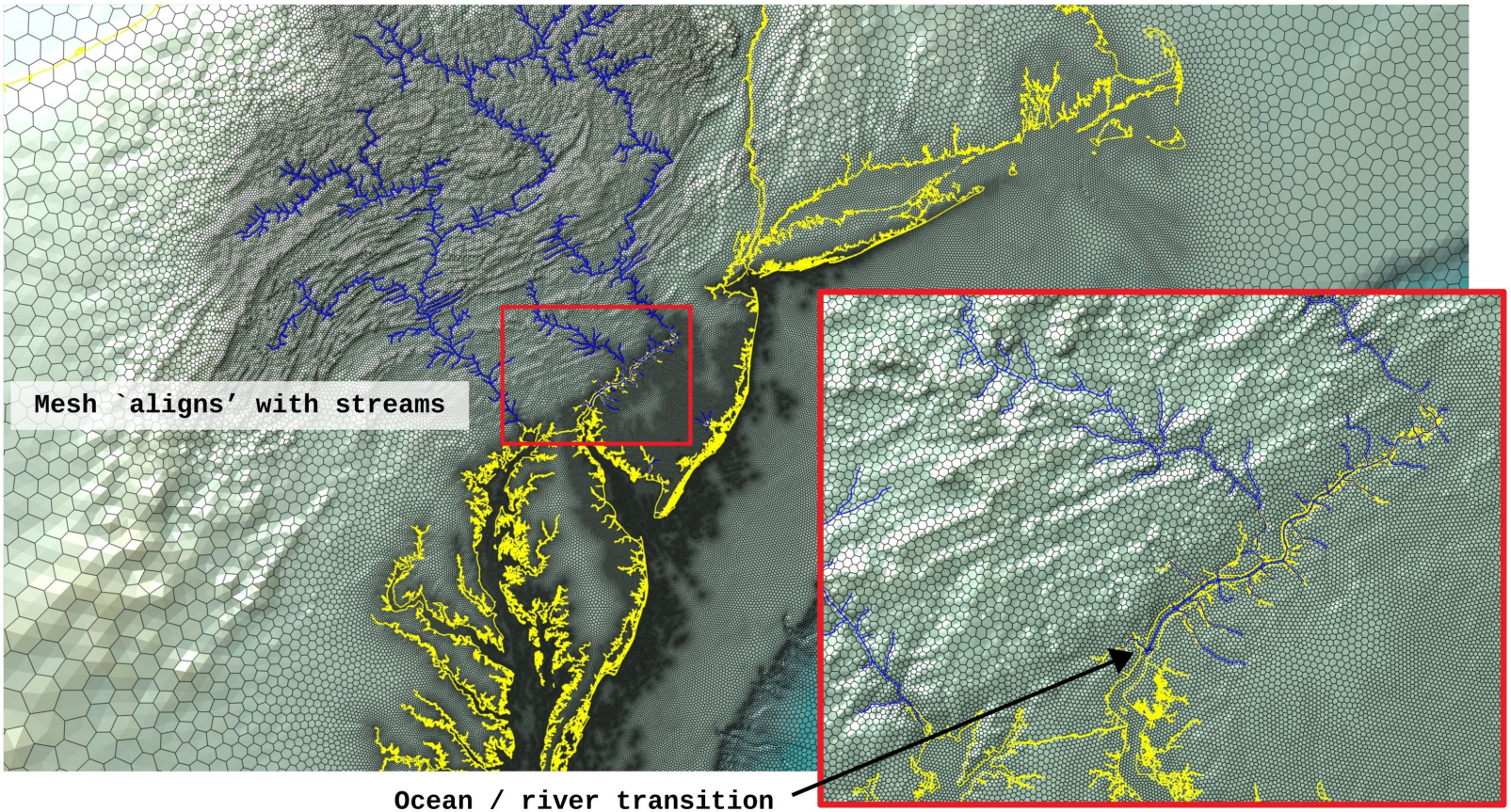


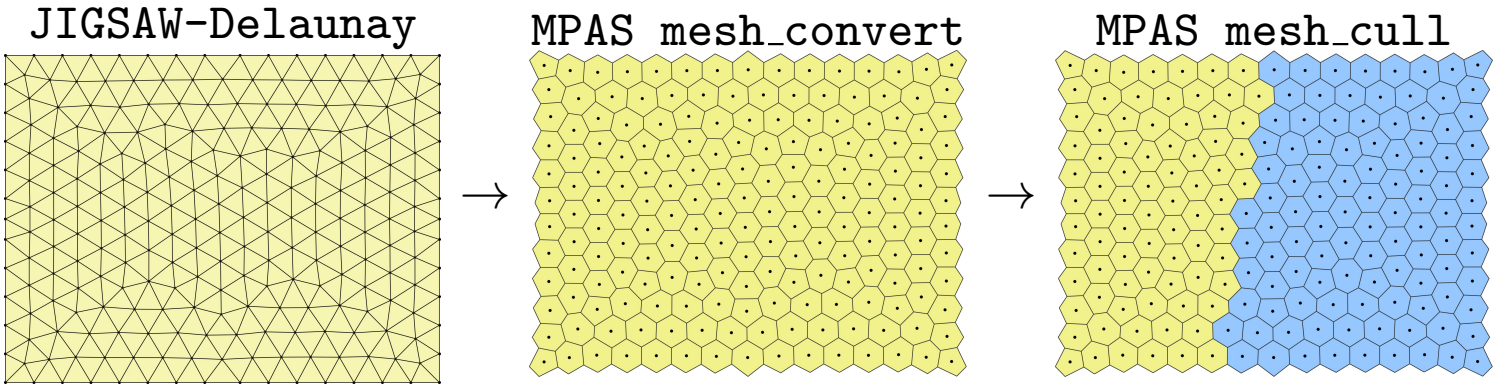
Supports ‘aggressive’ use of variable resolution to capture coastal ocean, land + watershed domains, as well as alignment with embedded ‘boundaries’ (coastlines, stream networks, etc).

Unstructured meshing workflow

Workflow combines the JIGSAW meshing library with the MPAS-Tools adapted from MPAS-E3SM v1:

- A C++ and Python library designed for Delaunay + Voronoi mesh generation. https://github.com/dengwirda/jigsaw
- Python tools for creating + manipulating 'MPAS format' mesh descriptions. https://github.com/MPAS-Dev/MPAS-Tools

Generates netCDF files for land + ocean according to MPAS data structures.



**JIGSAW-GEO (1.0): locally orthogonal staggered unstructured grid generation for general circulation modelling on the sphere (Engwirda, 2017).

**MPAS mesh specification v1

(https://mpas-dev.github.io/files/documents/MPAS-MeshSpec.pdf).