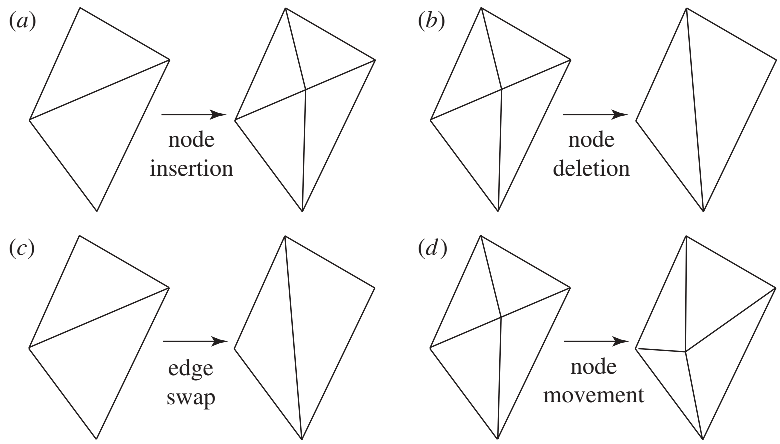

Figure 1. Local element operations used to optimize the mesh in two dimensions. (*a*) Node insertion or edge split. (*b*) Node deletion or edge collapse. (*c*) Edge swap. (*d*) Node movement.

barotropic gyre-based examples are presented to demonstrate the advantages that anisotropic variable resolution may deliver over the use of fixed uniform isotropic resolution. The paper concludes with a summary of the findings of this work and discussions on some of the extensions required for the use of mesh adaptivity on more complex real-world problems.

2. Optimization-based mesh adaptivity

(*a*) *Mesh optimization operations*

Given an unstructured mesh and information regarding the ideal shape and sizes of the elements making up the mesh, an optimization-based adaptivity algorithm can be formulated via the use of local topological operations that seeks to improve the quality of elements.

In the examples presented in this work, a two-dimensional mesh optimization algorithm (Agouzal *et al.* 1999; Vasilevskii & Lipnikov 1999) is used that employs the following local operations depicted in figure 1.

(i) *Node insertion or edge split*. Here a node is inserted on a pre-existing edge in the mesh so that the four new elements have improved shape/size characteristics compared with the original two; while the location of this new node along the pre-existing edge can be optimized, it is common to simply split it at its midpoint.

(ii) *Node deletion or edge collapse*. Here the inverse operation is performed whereby an edge in the mesh is collapsed, and consequently a node is deleted and two elements removed from the mesh.

(iii) *Edge swap*. Here an edge between two elements is removed and replaced with the only other possible configuration in two dimensions; the number of nodes and elements is preserved through the operation, but the edge lengths and element shapes are manipulated.