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# The Holy Grail for unstructured grid ocean modelling: a finite element pair on triangles without spurious modes

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We present a new finite element discretisation for triangle-based horizontal meshes in unstructured mesh ocean models. The horizontal velocity is represented on the linear Brezzi-Douglas-Marini element, enriched with a particular choice of vector-valued quadratic bubble functions; the pressure is represented by linear discontinuous elements. The method is second-order accurate in space, with slightly less degrees of freedom that the triangular C-grid on a mesh with edge lengths halved. When applied to the linear rotating shallow-water equations, this new discretisation shares a number of favourable properties with the Arakawa C-grid on quadrilaterals, which is the preferred horizontal discretisation in most structured mesh ocean models. These properties are (1) energy is conserved (this property is shared by all correctly formulated finite element discretisations); (2) there are no spurious pressure modes (oscillatory patterns of pressure which have discrete gradient equal to zero); (3) geostrophic states are exactly steady on the f-plane; (4) there are no spurious inertia-gravity modes (unlike the C-grid on triangles or the Raviart-Thomas element pair on triangles); (4) there are no spurious Rossby modes on the beta-plane (unlike the C-grid on hexagons); and (5) there are no spurious inertial oscillations (unlike the P0-P1 or P1(DG)-P2 finite element pairs on triangles). All of these properties hold on arbitrary triangular meshes, and are all based on the existence of a discrete Helmholtz decomposition with an equal number of divergent and rotational components (just like the C-grid on quadrilaterals). This combination of properties means that ocean models constructed using this discretisation will not suffer non-physical wave propagation. This talk will briefly review and explain all of these properties.