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Development and validation of a finite element shallow-water model in spherical geometry

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We present a finite element model for the shallow water equations on the sphere and apply it to standard test cases as described by Williamson (1992). The method uses local Cartesian coordinates, allowing us to express the equations in a formalism applicable to both spherical and planar geometries. The first test case consists in advecting a cosine bell over the poles and shows the ability of our model to circumvent the singularity problems inherent to global coordinate systems typically encountered. The second test case checks the model's ability to maintain a global steady-state geostrophic flow and allows for conducting a convergence analysis of the numerical method. Another test case involves a zonal steady state geostrophic flow and illustrates the main advantage of finite element methods, namely the ability to locally increase the mesh resolution. Finally, it is shown that our method accurately represents the propagation of Rossby-Haurwitz waves, as compared with previously published result. This work is an important step forward for our project of developing the unstructured mesh OGCM SLIM as the method can be easily generalized in three dimensions.