Optimal Control of a Finite-Element Limited-Area Shallow-Water Equations Model

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Dedicated to Professor Neculai Andrei on the occasion of his 60th birthday.

Abstract: Optimal control of a finite element limited-area shallow water equations model is explored with a view to applying variational data assimilation(VDA) by obtaining the minimum of a functional estimating the discrepancy between the model solutions and distributed observations. In our application, some simplified hypotheses are used, namely the error of the model is neglected, only the initial conditions are considered as the control variables, lateral boundary conditions are periodic and finally the observations are assumed to be distributed in space and time. Derivation of the optimality system including the adjoint state, permits computing the gradient of the cost functional with respect to the initial conditions which are used as control variables in the optimization. Different numerical aspects related to the construction of the adjoint model and verification of its correctness are addressed. The data assimilation set-up is tested for various mesh resolutions scenarios and different time steps using a modular computer code. Finally, impact of large-scale minimization solvers L-BFGS is assessed for various lengths of the time windows.

Keywords: Variational data assimilation; Shallow-Water equations model; Galerkin Finite-Element; Adjoint model; Limited-area boundary condition.