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Parameter estimation in a large scale Dutch Continental Shelf Model by Proper Orthogonal Decomposition

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Accurate forecasting of the storm surges is very important in the Netherlands since large areas of the land lie below sea level. Timely water level forecasts are necessary to support the decision of the proper closure of the movable storm surge barriers. Dutch continental shelf model (DCSM), is a shallow sea model of the entire European continental shelf, which is used in the Netherlands to forecast the storm surges in the North Sea. The forecasts are necessary to support the decision of the timely closure of the moveable storm surge barriers to protect the land. The adjoint method has often been used for the calibration of the large scale numerical flow models. A number of unknown parameters is introduced into the numerical model. Using the given data these parameters are identified by minimizing a cost function that measure the difference between model results and data (observations). The drawback of the adjoint method is the programming effort required for the implementation of the adjoint model code. In this study, we have implemented a newly developed model calibration method MRVDA (model reduced variational data assimilation) for the estimation of the depth values for the model DCSM with approximately 10^6 operational grid points. The advantage of this method is that it shifts the minimization into lower dimensional space and avoids the implementation of the adjoint of the tangent linear approximation of the original nonlinear model. A number of calibration experiments is performed. The effectiveness of the algorithm is evaluated in terms of the accuracy of the final results as well as the computational costs required to produce these results. In doing so, comparison is made with a simultaneous perturbation stochastic approximation (SPSA) method. The main findings are: (1) A low dimensional model of much smaller size can be constructed as compared to the original model. (2) An overall improvement of more than 50% is obtained with respect to the initial DCSM. (3) The POD calibration approach efficiently solves the minimization problem without the burden of implementation of the adjoint code.