Goal oriented adaptivity for tropical cyclones

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Many meteorological and environmental phenomena are influenced by processes on a large range of scales in space and time. For such multi-scale problems the numerical modelling and solution is challenging since not all scales can be resolved adequately due to memory or CPU time restrictions. Often a certain physical quantity of the solution is of interest. In such cases goal oriented adaptivity is a promising approach as only features that are relevant for the determination of the quantity of interest – described by some goal functional J – need to be considered.

By means of the dual-weighted residual method (DWR) ([EEHJ95] and [BR03]) the error in J can be estimated and the mesh can be adapted accordingly. The sensitivity information with respect to the goal functional required for the error estimator is obtained as solution of a so-called dual problem. In a time-varying context the dual problem is posed backward in time and requires the solution of the original problem in each time step. Therefore the estimation of the error and adaption process is expensive in terms of memory consumption and CPU time. The recently proposed local dual-weighted residual method [Huertas08] is suitable for a certain class of goal functionals and presents a compromise between classical error estimators and the DWR method.

In this paper we present specific adaptive schemes based on goal oriented adaptivity techniques for the simulation of tropical cyclones. It turns out that the definition of goal functionals for meteorological applications is a non-trivial task. In this contribution we propose adaptive methods based on several goal functionals which lead to economical meshes with error control both in space and time. We further address the issue of the efficient computation of the dual problem by means of interpolated higher-order solutions.

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