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Automated adjoints: towards a robust method for generating adjoint ocean models

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The problem of generating and maintaining adjoint models is sufficiently difficult that typically only the most advanced and well-resourced community ocean models achieve it. There are two current technologies which each suffer from their own limitations. Automatic differentiation is employed by models such as the MITGCM and the Alfred Wegener Institute model FESOM. This technique requires frequent manual intervention and is often defeated by modern software constructs such as derived data types. Since automatic differentiation produces a discrete adjoint model, it has difficulties coping with non-differentiable discretisations even where the underlying continuous system is differentiable.

An alternative is to formulate the adjoint differential equation and to discretise this separately. This approach, known as the continuous adjoint, has the disadvantage that two different model code bases must be maintained and manually kept synchronised as the model develops.

The alternative presented here is to formulate the flow model in the high level language UFL (Unified Form Language) and to automatically generate the model using the software of the FEniCS project. In this approach it is the high level code specification which is differentiated, a task very similar to the formulation of the continuous adjoint. However since the forward and adjoint models are generated automatically, the difficulty of maintaining them vanishes and the software engineering process is therefore robust.

In this poster, a proof of concept study for this approach will be presented in which a shallow water model is formulated along with its adjoint model using this technique.