SENSITIVITY ANALYSIS FOR LARGE EDDY SIMULATION

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Numerical simulation of high Reynolds number flow in complex geometries is a computational challenge. Direct Numerical Simulation, aiming at resolving all the scales in the flow, is not feasible with today's computational resources for many turbulent flows of engineering or geophysical interest. Thus, Large Eddy Simulation (LES) has evolved as an enabling tool in this regard. The idea in LES is to develop evolution equations for the spatial average of (or filtered) flow, and model the important interaction between the small (unresolved) and large (resolved) scales. This sub-grid scale (SGS) modeling continues to be a highly researched area as are the specification of appropriate initial and boundary conditions.

In this research, we use sensitivity analysis to study a number of SGS and boundary condition models. Sensitivity analysis, in this case, seeks the influence of model parameters on the LES. We carry this out using both numerical approximation of implicitly differentiated LES model equations as well as automatic differentiation. The reliability of automatic differentiation allows us to concentrate on the "experimentation" with different strategies while giving us freedom to study arbitrary parameters of interest such as the filter width and filter shape.

To facilitate this study, we begin with Burgers equation. The simplicity of this model, as well as availability of closed-form solutions, allow us to prototype a variety of filters and boundary condition strategies, including differential filters and deconvolution-type methods for boundary treatment. To validate our LES models, we need to test them in realistic turbulent flow settings. We will use the three-dimensional flow over a backward-facing step, one of the most challenging tests for present LES models. In this setting we will also investigate new ideas, such as slip with friction boundary conditions.

References

[1] L. Berselli, G. P. Galdi, T. Iliescu and W. Layton, "Mathematical Analysis for a New Large Eddy Simulation Model," *Mathematical Methods and Models in the Applied Sciences*, v. 12, p. 1131-1152, 2002.