

# Chapter 16

## Numerical effects contaminating LES; a mixed story

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**Abstract** We consider direct and large-eddy simulations of turbulent flow in a mixing layer to identify the role of the numerical method in relation to LES predictions. The main quantity that determines the quality of the solution is next to the filterwidth  $\Delta$  itself the ratio between the filterwidth and the grid-size  $h$ . If  $\Delta/h$  is large then numerical effects are comparably small but the computational cost for capturing scales up to order  $\Delta$  is comparably large. If this ratio is small then a potentially large amount of physical detail is contained in the LES solution at comparably small computational cost, but the solution may be substantially contaminated by numerical effects. The total numerical and modeling effects on mean, fluctuating and instantaneous solution properties differ considerably. When numerically resolving LES solutions well below the filter-width by considering large ratios  $\Delta/h$ , nearly grid-independent solutions to the LES equations can be obtained. We report computations of a mixing layer using a fourth order method at constant  $\Delta$  with gradually increased resolution. These computations are contrasted with grid refinement at fixed ratio  $\Delta/h$ . The respective properties of these two approaches are discussed and the computational cost is highlighted.

### 16.1 Introduction

The intricate nature of high Reynolds number turbulent flow has to date proven to defy detailed rigorous analysis or direct numerical simulation (DNS) and, consequently, has given rise to a number of modeling strategies. Such strategies are aimed at reducing the complexity of the underlying system of equations while retaining sufficient information to reliably predict the flow phenomena of interest in an application. These two conflicting requirements are prominent in large-eddy simulation (LES) which involves a desire of coarsening the description while trying to capture the generic

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