# Chapter 2

# Deconvolution Methods for Subgrid-Scale Approximation in LES

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**Abstract** We review the development and the recent progress of deconvolution modeling to account for the subgrid-scale effects in Large-Eddy Simulations. Models based on eddy-diffusivity assumptions do not optimally exploit information contained in the resolved scales. This is indicated by low correlations of modeled and exact subgrid-scale stresses. An attempt to extract more information for an improved subgrid-scale modeling from the resolved scales led to the formulation of dynamic eddy-viscosity models. The first subgrid-scale models to use deconvolution of filtered quantities are the expansion-deconvolution model (at lowest non-trivial order often called the tensor diffusivity model) of Leonard (1974) and the scale-similarity model of Bardina (1983). Since the filter operation is singular, deconvolution can only be performed approximately, and the inverse operation requires regularization. Discrete-kernel regularizations were proposed by Shah and Ferziger (1995) and Geurts (1997). Domaradzki & Saiki (1998) developed a regularized deconvolution approach by subgrid-scale estimation. Stolz & Adams (1999,2000) introduced a deconvolution method which is based on a truncated series expansion of the kernel in terms of multiple filter operations. Previous models such as the expansion deconvolution model or the scale-similarity model can be formulated as subsets of this more general methodology. Without another secondary level of regularization, deconvolution models in general do not provide a proper amount of subgrid-scale dissipation, For this purpose deconvolution models are mostly combined with (dynamic) eddy-viscosity regularizations, which annihilates some of the advantages of the primary model. A relaxation regularization can be constructed by employing a secondary filter operation. This approach is used by Stolz & Adams (1999,2000) in combination with the approximate deconvolution model, and by Adams & Leonard (1999,2000) in employing regularized deconvolution for the computation of discontinuous solutions of conservation laws.

## 2.1 Introduction

The development of large-eddy simulation (LES) dates back to Smagorinsky [42] and Deardorff [9], who exploited the formal analogy of the unclosed subgrid-scale stresses in LES with the unclosed Reynolds stresses in the Reynolds-averaged Navier-Stokes equations (RANS). Early modeling closures where therefore based on closure-ideas for RANS, up to the point of using