A general class of scale-separating operators based on combined multigrid operators is proposed and analyzed in this work. The operators of this class are designed for variational multiscale large eddy simulation using a finite volume or finite element method. Two representatives are compared to discrete smooth filters, which are widely used in the traditional large eddy simulation literature; the comparison shows that they are not only theoretically different, but also yield considerable differences in the respective numerical results. Dynamic as well as constant-coefficient-based subgrid-scale modeling is used within the multiscale environment. All of the scale-separating operators are implemented in a second-order accurate energy-conserving finite volume method and tested for the case of a turbulent channel flow. One operator shows particularly remarkable results in the framework of the variational multiscale large eddy simulation, that is, profiles are obtained for velocity and kinetic energy which are considerably closer to the respective profiles from a direct numerical simulation than are the profiles resulting from the application of the other operators considered in the present study. Furthermore, this particular
operator proves to be very efficient with regard to the important aspect of computational cost, that is, a reduction in computing time ranging from about 25 The introduction of a substantial amount of subgrid viscosity to the small scales, particularly in the buffer layer of the channel, appears to be crucial for the good results achieved with this method.

Stichworte:
turbulence, large eddy simulation, variational multiscale method, scale separation, subgrid-scale modeling

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