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Titel des Beitrags: An algebraic variational multiscale-multigrid-multifractal method (AVM^4) for large-eddy simulation of turbulent variable-density flow at low Mach number
Abstract: An algebraic variational multiscale-multigrid-multifractal method is proposed for large-eddy simulation of turbulent variable-density flow at low Mach number. In the multifractal subgrid-scale modeling approach, the subgrid-scale quantities are explicitly evaluated from a multifractal description of associated gradient fields. The multifractal subgrid-scale modeling approach is embedded into a residual-based form of the variational multiscale method. A particular feature of the proposed form of the multifractal subgrid-scale modeling approach is scale separation by level-transfer operators from plain aggregation algebraic multigrid methods to identify the required smaller resolved scales. In this study, we introduce a novel development of the multifractal subgrid-scale modeling approach for application to turbulent variable-density flow at low Mach number. Based on the physical background, we derive a variable-density extension of the multifractal subgrid-scale modeling approach to recover the subgrid-scale velocity and temperature field. The proposed
method is validated via two numerical test cases. First, turbulent flow in a channel with a heated and a cooled wall is considered for two different temperature ratios. Second, turbulent flow over a backward-facing step with heating is investigated. The results obtained with the algebraic variational multiscale-multigrid-multifractal method are compared to results obtained with the widely-used dynamic Smagorinsky model and a residual-based variational multiscale method. Particularly the results obtained for turbulent flow in a channel with a heated and a cooled wall indicate the excellent prediction quality achievable by the proposed method for turbulent variable-density flow at low Mach number.

**Stichworte:**
- large-eddy simulation
- turbulent variable-density flow
- low-Mach-number flow
- multifractal subgrid-scale modeling
- variational multiscale method
- algebraic-multigrid scale separation
- turbulent channel flow
- backward-facing step

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