LAGRANGIAN AVERAGED NAVIER-STOKES-ALPHA ($LANS-\alpha$) EQUATIONS FOR MODELING TURBULENCE

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Lagrangian averaging (LA) is producing new ideas and methods for the construction of novel subgrid models for momentum, energy and scalar transport in turbulence. LA is applied at fixed Lagrangian fluid label, rather than at fixed spatial location, as in Eulerian averaging and filtering for RANS and LES equations, respectively. Instead, LA is performed in a frame of motion that follows along with the main turbulent eddies. The LA process commutes with the advective time derivation; so LA fluid equations have their own circulation theorem, potential vorticity conservation, and other Lagrangian transport invariants of importance in applications. Thus, LA produces a new class of turbulence models that preserve the coherence of spatio-temporal flow features.

Although, the LA turbulence equations are formally similar to LES turbulence equations, they arise from different principles. Formally, LA produces equations that embody a "regularization principle," involving an explicit filter and its inversion. This regularization principle allows a systematic derivation of the implied subgrid-model, which resolves the closure problem. Hence, both the interpretation of $LANS-\alpha$ predictions in terms of direct simulation results, as well as the corresponding subgrid closure are specified by the filter appearing in these equations. However, the $LANS-\alpha$ equations cannot be obtained by directly applying the LES filtering method. This is because the theoretical basis for obtaining this alternative to the LES approach is Lagrangian averaging, *not* spatial filtering. We emphasize that Lagrangian averaging is a closely related *alternative* to the LES and RANS approaches, not a subset of them.

We shall report the results of a variety of tests of the $LANS-\alpha$ equations. These tests include comparisons with data from pipe and channel experiments, with results of direct numerical simulations of turbulence decay and with results of competing LES models, such as the dynamic model, for shear-driven mixing.

References

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