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

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A new class of turbulence models has recently been derived by Lagrangian averaging (LA). 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. 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 modeling turbulence in geophysical applications, for example. LA is performed in a frame of motion that follows along with the main turbulent eddies, and thus the coherence of their spatio-temporal features is preserved.

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 report the results of a variety of tests of the $LANS{-}\alpha$ equations.

References

[1] B. J. Geurts and D. D. Holm, "Regularization modeling for large-eddy simulation," *Phys. Fluids*, v. 15, L13-L16, 2003.