AFRL CALL FOR RESEARCH

1. Research Title: *Modeling for Sub Grid Turbulence in Combustion Flow Fields*

2. Individual Sponsor:

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3. Academic Area/Field and Education Level: Mathematics, Aerospace Engineering (Ph.D. level or masters level)

4. Objectives: The objective of this proposed 3-year DAGSI project is to develop a method for resolving sub-grid scale turbulence to Kolmogorov scales with minimal data values suitable for high speed combustion simulations.

5. Description: The Linear Eddy Model (LEM) has been shown to be effective for sub-grid scale modeling in Large Eddy Simulations (LES) of complex low speed combustion flow fields. See publications by Menon, S. and others dating from 1992. However, because of the range of scales of turbulence, the computational resources required for LEM modeling are still high. One possible solution to reduce the number of values required to resolve turbulence down to Kolmogorov scales is to use non-uniform data spacing in spectral space.

It is common practice when plotting turbulence quantities in frequency domain to use a logarithmic frequency axis. This compresses data in high frequency ranges. Also, for equilibrium turbulence the energy level reduces with frequency, making the high frequency information less significant. The cost of the high frequency information increases linearly with the frequency, so that in order to resolve three orders of magnitude in frequency scale would require in excess of 1000 data items per cell per equation. With 10 to 100 million cells and 20 equations for combustion flow simulations being common this would require 2 to 16 Tera-bytes of memory for each simulation.

A discrete Fourier transform where the frequency is an expanding geometric or Fibonacci series has the desired property that there are fewer data points in the higher frequencies. A growth factor of 1.6 can span 2 orders of magnitude with ten points and three orders with 15 points. A basis set thus constructed may be able to simulate several orders of magnitude of turbulent fluctuation with a practical number of data values. Alternatively, a similar set of wavelet basis functions with wider frequency spans at higher frequency levels may provide the desired efficiency. The higher frequency data points should incorporate information over a larger frequency band and not just skip frequency content. An initial investigation into feasibility and realizability for such methods in turbulence simulations and formulation of methods is underway. The numerical stability and accuracy of the methods should be considered.

6. Research Classification/Restrictions: U.S. Citizens only.

7. Interest in Summer USAFA Cadet: No

8. Eligible Research Institutions:

[X] Universities (DAGSI) [X] AFIT [ ] USAFA

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