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Empirical low-dimensional manifolds in composition space[1] YUE YANG, STEPHEN B. POPE, Cornell University, JACQUELINE H. CHEN, Sandia National Laboratories — To reduce the computational cost of turbulent combustion simulations with a detailed chemical mechanism, it is useful to find a low-dimensional manifold in composition space that can approximate the full system dynamics. Most previous low-dimensional manifolds in turbulent combustion are based on the governing conservation equations or thermochemistry and their application involves certain assumptions. On the other hand, empirical low-dimensional manifolds (ELDMs) are constructed based on samples of the compositions observed in experiments or in direct numerical simulation (DNS). Plane and curved ELDMs can be obtained using principal component analysis (PCA) and multivariate adaptive spline regression (MARS), respectively. Both PCA and MARS are applied to the DNS datasets of a non-premixed CO/H2 temporally evolving jet flame (Hawkes et al., 2007) and an ethylene lifted jet flame (Yoo et al., 2011). We observe that it requires very high dimensions to represent the species mass fractions accurately by a plane ELDM, while better accuracy can be achieved by curved ELDMs with lower dimensions. In addition, the effect of differential diffusion on ELDMs is examined in large-eddy simulations with PDF modeling.

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