Using CFD to Studying Coupled Atmospheric Phenomena such as Wildfire Behavior

Understanding and attempting to predict wildfire behavior is particularly difficult scientific problem, since the length scales of the physics range from those of flame sheets to fire and topography influenced atmospheric dynamics. Wildfires are driven by very complex processes ranging from combustion of complex natural fuels to local meteorology and depend heavily on the coupling between a range of chemical and physical processes. HIGRAD is coupled to a wildfire behavior model FIRETEC to produce a coupled atmosphere/wildfire behavior model and is based on conservation of mass, momentum, species, and energy. HIGRAD/FIRETEC is a transport formulation that uses a compressible-gas formulation to couple its physics-based wildfire model with the motions of the local atmosphere. HIGRAD/FIRETEC is an attempt to capture the combined essence of the driving physical processes that control a wildfire while simulating fire behavior on landscape scales (1000s of meters.) This objective precludes the use of existing simplified empirical wildfire models because they do not predict general fire behavior and high-fidelity combustion models because of the multiple meter resolution that is frequently used. A multiphase approach together with ensemble averages and probability distribution functions are used in an attempt capture the combined effects of the unresolved details of the fuel bed and many fine-scale processes. Currently, a three-dimensional version of HIGRAD/FIRETEC is being used to study the interaction between nonhomogeneities in vegetation, topography, and atmospheric conditions. Examples of the types of physical phenomenon of interest are the effects of transient wind conditions, the effects of nonhomogeneous terrain, and the effects of nonuniform fuels (patchy distributions) on fire behavior.