CFD Modeling of Large Crown Forest Fire Behavior

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ABSTRACT

The computational fluid dynamics (CFD) modeling of large crown forest fire plumes has been carried out with the use of the general-purpose CFD software, PHOENICS, customized for such a modeling. The general 3D conservation equations (mass, momentum and energy conservation) are solved numerically under the input conditions specific for large crown forest fires. The standard high-Reynolds number k-ε model of turbulence has been applied and the atmospheric boundary layer has been introduced using the typical logarithmic profile. The input parameters of forest fire source (the vertical gas velocity and the fire temperature at the top crown surface) are defined based on the empirical correlations dependent of the forest fire intensity. The radiation heat transfer has been accounted for with the use of built-in PHOENICS IMMERSOL radiation model. A typical area of individual forest fire considered in this study is 100mx100m. The effects of atmospheric boundary layer parameters (wind speed, temperature stratification and ground surface roughness) on the behavior of multiple thermal plumes are analyzed. The hydrodynamic and thermal interactions between multiple plumes (potentially created by spotting) have been studied in detail. As a result of mathematical modeling, the steady-state 3D fields of gas velocity and temperature, smoke concentration and radiation fluxes have been obtained and analyzed while taking into account the mutual influence of the atmospheric boundary layer and the crown fire plume on each other. It has been concluded that the CFD modeling with the use of PHOENICS software could be systematically applied for investigating the dynamics of forest fire spread under the influence of various external conditions such as the meteorological conditions (air temperature, wind velocity, etc.), the terrain specific, the forest type (various kinds of forest combustible materials) and its state (load, moisture, etc.), in order to better understand the fundamental physical mechanisms, which control the forest fire initiation and spread, and develop the pragmatic (robust and user-friendly) physical-based forest fire behavior modeling tools.