Numerical solution of three dimensional conjugate problems of forest fires spread

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The mathematical model simulating the heat and mass transfer processes taking place during the crown forest fire spread is developed to take into account atmosphere boundary layer. The aim of the present paper is to solve the system of three dimensional non-stationary equations describing the behavior of crown forest fires propagating through crown canopy and to study the mutual influence of crown forest fires and boundary layer of atmosphere using numerical simulation with a physics-based model. It is a coupled atmosphere/crown fire behavior model and is based on the laws of conservation of mass, momentum, species and energy. The paper gives a new mathematical setting and method of numerical solution to this problem. The three-dimensional Reynolds equations are solved numerically for turbulent flow using diffusion equations for chemical components and equations of energy conservation for gaseous and condensed phases. The method of finite volume is used to obtain discrete analogies. Using finite volume method, the solution domain is subdivided into a finite number of small control volumes by a grid. The grid defines the boundaries of the control volumes while the computational node lies at the center of the control volume. The advantage of finite volume method is that the integral conservation is satisfied exactly over the control volume. The boundary-value problem is solved numerically using the method of splitting according to physical processes. In the first stage, the hydrodynamic pattern of flow and distribution of scalar functions was calculated. The system of ordinary differential equations of chemical kinetics obtained as a result of splitting was then integrated. Difference equations that arise in the course of sampling were resolved by the method of SIP [6]. The accuracy of the program was checked by the method of inserted analytical solutions. The time step was selected automatically. This approach allows investigating dynamics of forest fire initiation and spreading under influence of various external conditions: a) meteorology conditions (air temperature, wind velocity etc.), b) type (various kinds of forest combustible materials) and their state (load, moisture etc.). Fields of temperature, velocity, component mass fractions, and volume fractions of phases were obtained numerically. The results of calculation are agreed with the laws of physics and experimental data.