Mathematical modeling of the impact of forest fires on buildings and structures

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The protection of buildings and structures in a community from destruction by forest fires is a very important concern. This paper addresses the development of a mathematical model for fires in the wildland-urban intermix. The forest fire is a very complicated phenomenon. At present, fire services can forecast the danger rating of, or the specific weather elements relating to, forest fire. There is need to understand and predict forest fire initiation, behavior and impact of fire on the buildings and constructions. This paper's purposes are the improvement of knowledge on the fundamental physical mechanisms that control forest fire behavior. The mathematical modeling of forest fires actions on buildings and structures has been carried out to study the effects of fire intensity and wind speed on possibility of ignition of buildings. It is assumed that the forest during a forest fire can be modeled as 1) a multi-phase, multistoried, spatially heterogeneous medium; 2) in the fire zone the forest is a porous-dispersed, two-temperature, single-velocity, reactive medium; 3) the forest canopy is supposed to be non – deformed medium (trunks, large branches, small twigs and needles), which affects only the magnitude of the force of resistance in the equation of conservation of momentum in the gas phase, i.e., the medium is assumed to be quasi-solid (almost non-deformable during wind gusts); 4) let there be a so-called "ventilated" forest massif, in which the volume of fractions of condensed forest fuel phases, consisting of dry organic matter, water in liquid state, solid pyrolysis products, and ash, can be neglected compared to the volume fraction of gas phase (components of air and gaseous pyrolysis products); 5) the flow has a developed turbulent nature and molecular transfer is neglected; 6) gaseous phase density doesn't depend on the pressure because of the low velocities of the flow in comparison with the velocity of the sound. The modeling approach is based on the use of standard non-stationary three-dimensional conservation equations that are solved numerically under the input conditions specific for crown forest fires. It is considered the effect of forest fire front on the building which is situated near from the forest. The results of calculations can be used to evaluate the thermal effects on the building, located near from the forest fires. The model proposed there gives a detailed picture of the change in the velocity, temperature and component concentration fields with time. It allows to investigate the dynamics of the impact of forest fires on buildings under the 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.). The calculations let to get the maximum distance from the fire to the building in which the object possible ignition. The paper was supported from RFBR (project code: № 16-41-700022 p_a) and within the framework of Tomsk Polytechnic University Competitiveness Enhancement Program grant.