ABSTRACT

Comparing Spatially Explicit Models of Fire Spread Through Chaparral Fuels: A New Algorithm Based Upon the Rothermel Fire Spread Equation

Marco Morais, Department of Geography, University of California, Santa Barbara, CA 93106, USA.

A new raster-based spatially explicit model of surface fire spread through chaparral, HFire (Highly Optimized Tolerance Fire Spread Model), is presented. The Rothermel fire spread equation is used to determine the direction and magnitude of the maximum rate of fire spread into a cell. One-dimensional predictions from the Rothermel equation are fit to two-dimensions using the solution to the fire containment problem and the empirical double ellipse formulation of Anderson. A new technique implemented in HFire, based upon finite fractional distances between cell centers, remedies the problem of distorted fire shapes previously identified as endemic to raster models of fire spread. Model accuracy, sensitivity to fuels, and sensitivity to data resolution were evaluated by measuring the coefficient of areal association (C_A) and the kappa coefficient (κ) for observed and predicted fire spread during two historical events, the 1996 Calabasas Fire and the 1998 Ogilvy Fire. Model accuracy for the reconstruction of the Santa-Ana driven 1996 Calabasas Fire was generally satisfactory and ranged from 0.7348 to 0.5774 (C_A) and 0.3960 to 0.1838 (κ). Model accuracy of the 1998 Ogilvy Fire, which burned under more moderate weather conditions, was more variable and ranged from 0.8461 to 0.0636 (C_A) and 0.1826 to 0.0019 (κ). Fire spread predictions of the extreme event were relatively insensitive to the quality of fuels information and data resolution. The opposite was true of the predictions for a fire that had burned under moderate conditions. This has important management implications for using any fire spread model based upon the Rothermel equation to predict fire behavior in chaparral. In addition, comparisons between HFire and the current US standard fire spread simulator, FARSITE, were also made. The HFire model produced patterns of fire growth that were similar but more accurate than FARSITE as measured by the C_A in 10 out of 12 trials and κ and in 9 out of 12 trials. The comparative speed and efficiency of the raster based code presented here puts into question the efficacy of using vector-based fire spread models based upon Huygens' Principle in the highly heterogeneous conditions experienced in Southern California chaparral.