Geophysical Research Abstracts
Vol. 19, EGU2017-10294, 2017
EGU General Assembly 2017

Using cellular automata to simulate forest fire propagation in Portugal

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Wildfires in the Mediterranean region have severe damaging effects mainly due to large fire events [1, 2]. When restricting to Portugal, wildfires have burned over 1:4 million ha in the last decade. Considering the increasing tendency in the extent and severity of wildfires [1, 2], the availability of modeling tools of fire episodes is of crucial importance.

Two main types of mathematical models are generally available, namely deterministic and stochastic models. Deterministic models attempt a description of fires, fuel and atmosphere as multiphase continua prescribing mass, momentum and energy conservation, which typically leads to systems of coupled PDEs to be solved numerically on a grid. Simpler descriptions, such as FARSITE, neglect the interaction with atmosphere and propagate the fire front using wave techniques. One of the most important stochastic models are Cellular Automata (CA), in which space is discretized into cells, and physical quantities take on a finite set of values at each cell. The cells evolve in discrete time according to a set of transition rules, and the states of the neighboring cells.

In the present work, we implement and then improve a simple and fast CA model designed to operationally simulate wildfires in Portugal. The reference CA model chosen [3] has the advantage of having been applied successfully in other Mediterranean ecosystems, namely to historical fires in Greece. The model is defined on a square grid with propagation to 8 nearest and next-nearest neighbors, where each cell is characterized by 4 possible discrete states, corresponding to burning, not-yet burned, fuel-free and completely burned cells, with 4 possible rules of evolution which take into account fuel properties, meteorological conditions, and topography. As a CA model, it offers the possibility to run a very high number of simulations in order to verify and apply the model, and is easily modified by implementing additional variables and different rules for the evolution of the fire spread.

We present and discuss the application of the CA model to the “Tavira wildfire” in which approximately 24,800ha were burned. The event took place in summer 2012, between July 18 and 21, and spread in the Tavira and São Brás de Alportel municipalities of Algarve, a province in the southern coast of Portugal.

[1] DaCamara et. al. (2014), International Journal of Wildland Fire 23.
[2] Amraoui et. al. (2013), Forest Ecology and Management 294.
[3] Alexandridis et. al. (2008), Applied Mathematics and Computation 204.