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Stochastic modeling of fire at daily time steps from mesoscale meteorology

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Significant changes in fire severity and fire size are predicted for many ecosystems as a result of land-use change, climatic change, and fire exclusion. In many ecosystems, warmer temperatures and associated drought are significantly related to increased fire. Statistical models can predict annual or seasonal averages of fire extent at scales from watersheds to ecoregions, but both fire forecasting and estimation of fire effects such as smoke production, carbon release, and air-quality reduction require daily or hourly time steps to be useful. We present a Fire Scenario Builder (FSB) that uses a simultaneous weighting of known influences on fire occurrence to create mapped distributions of fire probabilities, including both the likelihood of a fire occurring and the probabilistic distribution of fire sizes. Key input layers are mesoscale meteorology (MM5) at scales from 12-36 km, atmospheric stability indices (CAPE) and fuel moistures (from NFDRS), and mean-field estimates of seasonal area burned at the same scale as the meteorology. Combining these influences into a probabilistic model produces downscaled (to daily) estimates of fire-occurrence probability and fire sizes. We present the results of simulations at 12-km for the Pacific Northwest and 36-km for the western United States, using simulated meteorology for both current (1990-1999) and future (2045-2054) decades. We show two applications of the FSB in conjunction with other models: continental-scale increases in fire emissions from the 36-km simulations and visibility reductions over national parks and wilderness areas in the Pacific Northwest and northern Rocky Mountains. The FSB provides a partly mechanistic alternative to probabilistic estimates of fire frequency or natural fire rotation from historical fire-regime statistics, and is best used at intermediate scales between those associated with global vegetation models and those associated with landscape fire succession models.