Estimating Fire Spread Rates From Discreet Fire Perimeter Observations

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Accurate fire perimeter maps are essential for suppression operations and retrospective modeling; however, existing remote sensing platforms struggle to provide both high spatial and high temporal resolution needed for in-depth research cases. Satellites are often constrained by relatively infrequent revisit rates (for polar-orbiting platforms like MODIS) or coarse spatial detail (for geostationary platforms like GOES) for such cases, while aerial mapping faces operational limitations during active suppression operations. To resolve these temporal data gaps, this study is working toward a novel boundary evolution method to interpolate high-resolution fire perimeters between known intervals of mapped data. Given an initial perimeter at T=0 and a subsequent perimeter at T=1, the geometric boundaries are converted into continuous Signed Distance Functions (SDFs). An intermediate evolving SDF is initialized at T=0 and algorithmically propagated toward the known state at T=1. This propagation is constrained to only expand outward, to prevent the "unburning" of previously burned areas and must converge exactly with the final perimeter at T=1. Current efforts are focused on evaluating multiple algorithmic drivers for this evolution, comparing physically based models utilizing the Rothermel rate of spread, purely mathematical approaches like the exact Euclidean distance transform, and hybrid frameworks. In this study we apply these approaches to synthetic cases as well as real-world fire perimeter observations. Ultimately, this ongoing research aims to generate temporally dense, high-resolution fire spread datasets without the computational overhead of solving full dynamical models. These continuous fire spread data sets can then be used to constrain numerical simulations in coupled fire-atmosphere models, amongst other applications.