1 Introduction

The costs of a wildland fire can be measured in terms of the burned acreage, destroyed infrastructure, quantity of released CO_2, lives lost, and the monetary cost of controlling its spread. In recent years we have been experiencing longer fire seasons with both more and larger wildland fires. Given this, it is more important than ever that fire managers have access to real-time fire behavior data, and high quality predictive models.

Current operational speed models, those that simulate fire behavior faster than real-time, are empirically based on data obtained from laboratory experiments and small scale experimental fires. This is a flaw because large scale fires behave differently than small scale fires (e.g. they generate their own weather). Thus operational models for large scale wildland fires may be improved by the incorporation of data from fires of equal scale.

In order for operational speed models to produce actionable fire spread predictions, they need up to date inputs. Data on active fire progression is currently acquired via aerial infrared sensors. However, this data is not operationally actionable due to both its high temporal and sptial resolultion. An automated GIS image analysis pipelines is needed to make this data operationally actionable.

I propose to develop two fire behavior softwares: a fire behavior model that derives its rate of spread parameters from sequences of large-scale historical fire perimeters, and an automated real-time GIS Image Analysis pipeline for infrared imagery of active fires.

2 Methods

In order to develop a fire spread model based upon large scale fire behavior, I will obtain sequences of historical fire perimeters from (insert source) spaced at approximately 24 hour intervals. Due to the low temporal resolution of this data I will need to approximate the path of the fire between successive perimeters.

In order to approximate these paths I will first numerically solve a two dimensional steady state heat equation with boundary conditions defined by the historical fire perimeters. Given the numerical solution, I will be able to approximate the path of the fire between boundaries by particle tracing according to its gradient.

Once I have obtained the approximate paths of the fire, I will be able to associate them with the terrain, fuel types, and historical weather that they passed through. This data combined with the length of the path, and the time interval between successive perimeters, will inform the parametrization of rate of spread in my fire spread model.

I will validate my model against known sequences of historical fire perimeters. My model validation will exclude data used in its formation. I will then compare the results of my fire simulations against those of other operational models.

In order to determine the perimeter of fires from infrared imagery in real-time, I will first pre-process the imagery with a blurring filter. Next, I will make

the image binary according to a temperature threshold to establish locations that are actively burning against those that are not. Finally, I will convert the image to a shape file according to the boundary between areas that are actively burning and those that are not. This should result in data compression of about two orders of magnitude.

3 Intellectual Merit

My work contributes to the field of fire science by modeling fire behavior based upon large-scale fire dynamics. This is a current hole in the field for operational speed models. My approach to path approximation based upon the solution to a steady state heat equation may also be novel and have implications to model building across fields.

4 broader impacts

My work will directly impact wildland fire management. It has the potential to improve both wildland fire suppression efficacy and wildland firefighter safety. My real-time GIS image analysis pipeline will provide fire managers with accurate current fire behavior information, and my operational fire model will provide them with a better prediction of future fire behavior. These will combine to allow fire managers to make well-informed decisions, resulting in increased fire suppression efficacy and firefighter safety.