Designing data-driven modeling strategies for real-time wildfire spread forecasting

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ABSTRACT

Whether used as a planning tool prior to prescribed burning or as an operational tool to predict the growth of uncontrolled wildfires, the accuracy of wildfire spread models (e.g. FARSITE, PROMETHEUS, FOREFIRE) and their ability to provide useful information in a timely manner are of paramount importance. Available environmental data to parameterize these models are subject to large uncertainties and limited resolution, both spatially and temporally. A new approach to this problem is to take advantage of the recent advances in remote sensing technology to integrate real-time observations into existing models, with the objective of reducing the uncertainties in both model fidelity and input data and to produce improved forecasts of the system evolution. This approach is called data-driven modeling.

In this talk, we will demonstrate the benefits of data-driven modeling using ensemble-based data assimilation methods combined with sensor observations of the active burning areas. Our prototype called FIREFLY features the following components: a front-tracking fireline solver using a Rothermel-based description of the rate of spread (ROS) as a function of biomass fuel, topographical and meteorological properties; a series of observations mapping the active flame areas; and a data assimilation algorithm based on an ensemble Kalman filter (EnKF). Ensemble-based modeling generates hundreds of potential vegetation and weather scenarios, leading to the prediction of thousands of individual fires. The EnKF reduces the uncertainty in these scenarios by sequentially correcting ROS parameters and the fireline position, providing improved wildfire behavior forecasting. Results will be shown on the 2012 RxCADRE controlled fire and on the RIM fire hazard.

We will also present some of the challenges and opportunities data-driven modeling offers. The main challenge of real-time modeling is access to useful real-time data. Initial studies have all used the fireline location as observations; this necessitates remote sensing, particularly from airborne- or satellite-based sensors. Firelines with spatial resolution of approximately 10 m and temporal resolution of approximately 10 min would be ideal to achieve a reliable forecasting tool with accurate-enough predictions for fire behavior. Is this possible?

Keywords: Wildfire spread, Fire modeling, Data assimilation, Ensemble Kalman filter, Fireline observations