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## *Coupled Weather-Fire Modeling of Landscape-Scale Wildland Fires: Understanding & Prediction*

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Large wildfires can cover hundreds of thousands of acres and continue for months, varying in intensity as they encounter different environmental conditions, which may vary dramatically in time and space during a single fire. They can produce extreme behaviors such as fire whirls, blow-ups, bursts of flame along the surface, and winds ten times stronger than ambient conditions, all of which result from the interactions between a fire and its atmospheric environment and are beyond the capabilities of current operational tools.

Coupled weather-wildland fire models tie numerical weather prediction models to wildland fire behavior modules to simulate the impact of a fire on the atmosphere and the subsequent feedback of these fire-induced winds on fire behavior, i.e. how a fire “creates its own weather”. The methodology uses one such coupled model, the Coupled Atmosphere-Wildland Fire Environment (CAWFETM) Model, which contains two-way coupling between two components: (1) a numerical weather prediction model formulated for and with numerical methods optimized for simulating airflow at 100s of m in complex terrain, and (2) a wildland fire component that is based upon semi-empirical relationships for surface fire rate of spread, post-frontal heat release, and a canopy fire model. The fire behavior is coupled to the atmospheric model such that low level winds drive the spread of the surface fire, which in turn release sensible heat, latent heat, and smoke fluxes into the lower atmosphere, in turn feeding back to affect the winds directing the fire. CAWFE been used to explain basic examples of fire behavior and, in retrospective simulations, to reproduce large wildland fire events. Over a wide range of conditions, model results show rough agreement in area, shape, and direction of spread at periods for which fire location data is available; additional events unique to each fire such as locations of sudden acceleration, flank runs up canyons, and bifurcations of a fire into two heads; and locations favorable to formation of phenomena such as fire whirls and horizontal roll vortices.

The duration of such events poses a prediction challenge, as meteorological models lose skill over time after initialization, firefighting may impact the fire, and processes such as spotting, in which burning embers are lofted ahead of the fire, are not readily represented with deterministic models. Moreover, validation data for such models is limited and fire mapping and monitoring has been done piecemeal with infrared imaging sensors producing 6-hourly maps of active fires with nominal 1 km pixels, complemented by sub-hourly observations from geostationary satellites at coarser resolution and other valuable but non-routine tools such as airborne infrared mapping. Thus, CAWFE has been integrated with spatially refined (375 m) satellite active fire data from the Visible Infrared Imaging Radiometer Suite (VIIRS), which is used for initialization of a wildfire already in progress in the model and evaluation of its simulated progression at the time of the next pass.

Case studies of landscape-scale wildland fires will be presented to illustrate our current capability to model the unfolding of large fire events -- foremost for research and understanding, but also to assess their suitability as a predictive tool. Results show that using a cycling forecasting approach, in which a sequence of CAWFE simulations initialize the fire 'in progress' with VIIRS data and updated atmospheric analyses can overcome several forecasting issues and allow good representation of fire growth from first detection until extinction.

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Refreshments 3:15 PM  
NCAR-Foothills Laboratory  
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Bldg 2 Main Auditorium, Room 1022

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