National Aeronautics and Space Administration

Advanced Wildfire Mapping and Modeling Tools

NASAfacts

User Requirements

The demand for timely, consistent, and quality wildfire information is high and peaks each summer when interagency fire operations and resource requests are maximized in response to multiple large wildfires. Wildfire response at all government levels requires current and predictive fire information for tactical firefighting, evacuation, and strategic planning to avert or mitigate impacts. Remote sensing active fire datasets, fire modeling tools, and associated geospatial products are essential to interagency fire operations. They provide critical support to fire managers and help inform the public in areas threatened by wildfires.

Recent advances in satellite-based fire detection and mapping, airborne fire mapping and measurement, and coupled weather-wildland fire modeling present a new opportunity to routinely map fire extent and progression, examine active fire areas in greater detail, and predict fire growth, intensification, and extreme behaviors of wildfires lasting several days.

Active Fire Mapping

Currently two NASA/NOAA Visible Infrared Imaging Radiometer Suite (VIIRS) instruments provide environmental monitoring parameters over the entire globe every 12h or less at spatial resolutions of 375 m and 750 m. Compared to previous coarser resolution products, the VIIRS 375 m active fire detection data enables early detection of small fires and improved mapping of large wildfires (Fig. 1). In addition to VIIRS, USGS/Landsat-8 and ESA/Sentinel-2 data now provide detailed wildfire spatial information at significantly lower revisit times with great potential to complement on-demand airborne mapping services (e.g., USDA Forest Service NIROPs and FireMapper) that are engaged during large incidents. Together, these remote sensing assets deliver routine fire mapping information of unmatched temporal frequency and spatial detail.

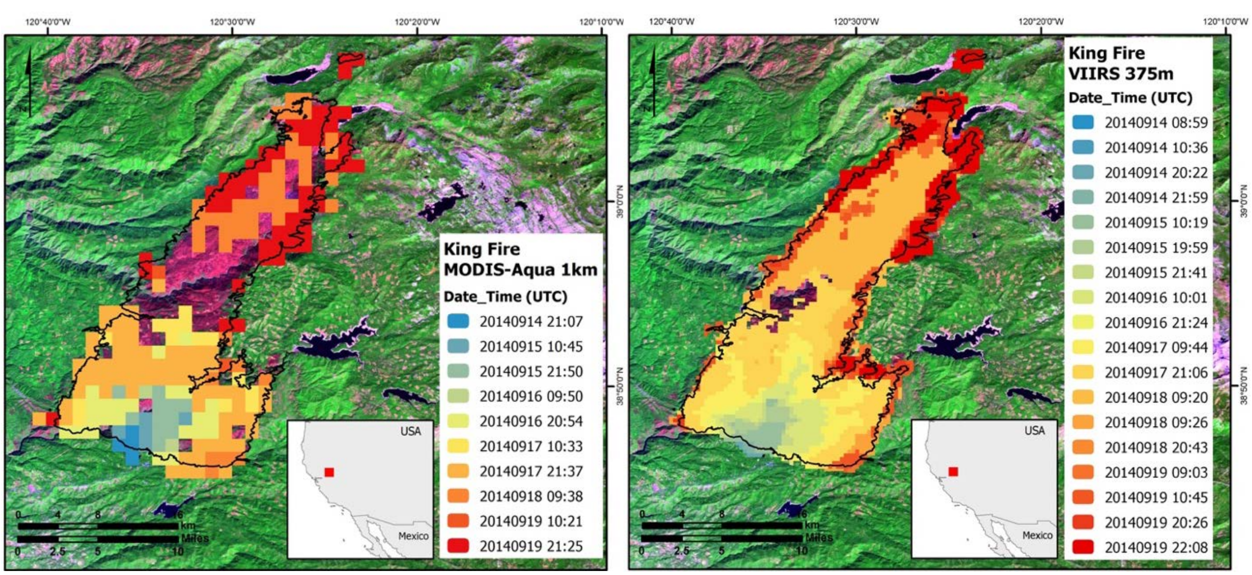

Figure 1. Aqua/MODIS 1 km (left) and near-coincident Suomi-NPP/VIIRS 375 m (right) mapping of fire progression during the 2014 King Fire event in California. Colored polygons describe the active fire pixel footprints of MODIS and VIIRS. The black polygon outlines the fire-affected area mapped using the background Landsat-8/OLI image acquired on 05 October 2014.

Coupled Weather - Fire Modeling

NCAR's CAWFE®(Coupled Atmosphere-Wildland Fire Environment) model couples a numerical weather prediction model with wildland fire behavior algorithms to simulate fire behavior. These not only predict a fire's shape and extent but extreme behaviors such as fire whirls, blow-ups, flank runs, and pyrocumulus, all resulting from a fire's interaction with its environment, i.e. how the fire 'creates its own weather'. CAWFE was evaluated on numerous cases capturing overall unfolding of events, locations where fires intensified and accelerated, splitting of the head, and flank runs. CAWFE has been successfully initialized and validated using the new VIIRS 375 m fire data, enabling accurate simulation of complex fire behavior during long-lasting wildfires, demonstrating improved simulation in conditions not captured well with operational tools: plume-driven fires, fires driven by complex mountain airflows, and transient behavior from wind shifts like gust fronts (Fig. 2).

Sequences of 1-2 day CAWFE simulations combined with fire detection data can be applied to accurately predict fire growth from first detection until containment. Speed depends on the configuration but computations for the Tubbs Fire (Fig. 3) predict the 4-dimensional weather preceding the fire, its spread, fire phenomena, smoke production and transport at speeds of 4 times faster than real time on a single computer processor at horizontal grid spacing of 370 m. Decision support applications include managing wildland fires, estimating emissions of carbon, trace gases, and particulates, and anticipating and mitigating air quality, watershed, and land surface impacts.

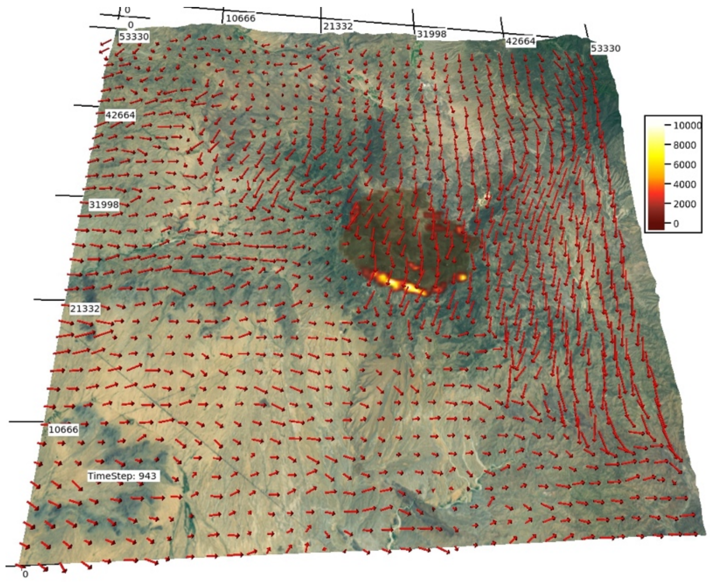

Figure 2: CAWFE simulation of the Yarnell Hill Fire on June 30, 2013. Arrows indicate near surface wind strength and direction. Heat flux of the fire is shown, according to the color bar at right (W m^{-2}).

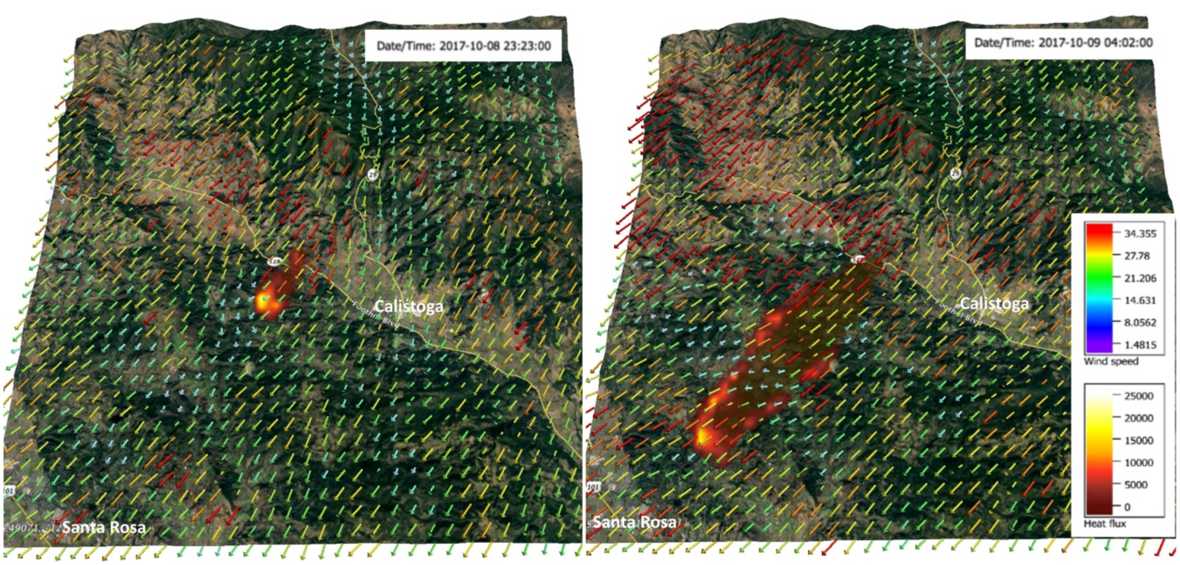

Figure 3: CAWFE forecast of the 2017 Tubbs fire near Calistoga and Santa Rosa, CA. Shown are near-surface winds (colored according to upper color bar) and fire heat flux (colored according to lower color bar) at 11:23 PM PDT Oct 8 and 4:02 AM PDT Oct 9. Forecasts can be used to predict where a fire will spread, especially when dangerous behavior like blow-ups and wind shifts will occur, and which locations will be impacted by smoke.

NASA Applied Sciences Program
Wildfires program area

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Select Publications

Coen, J., and Schroeder, W. (2013). Use of spatially refined satellite remote sensing fire detection data to initialize and evaluate coupled weather-wildfire growth model simulations. Geophysical Res. Letter, doi: 10.1002/2013GL057868.

Schroeder, W., Oliva, P., Giglio, L., and Csiszar, I. (2014). The new VIIRS 375 m active fire detection data product: Algorithm description and initial assessment. Remote Sensing of Environment, 143, 85-96.

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