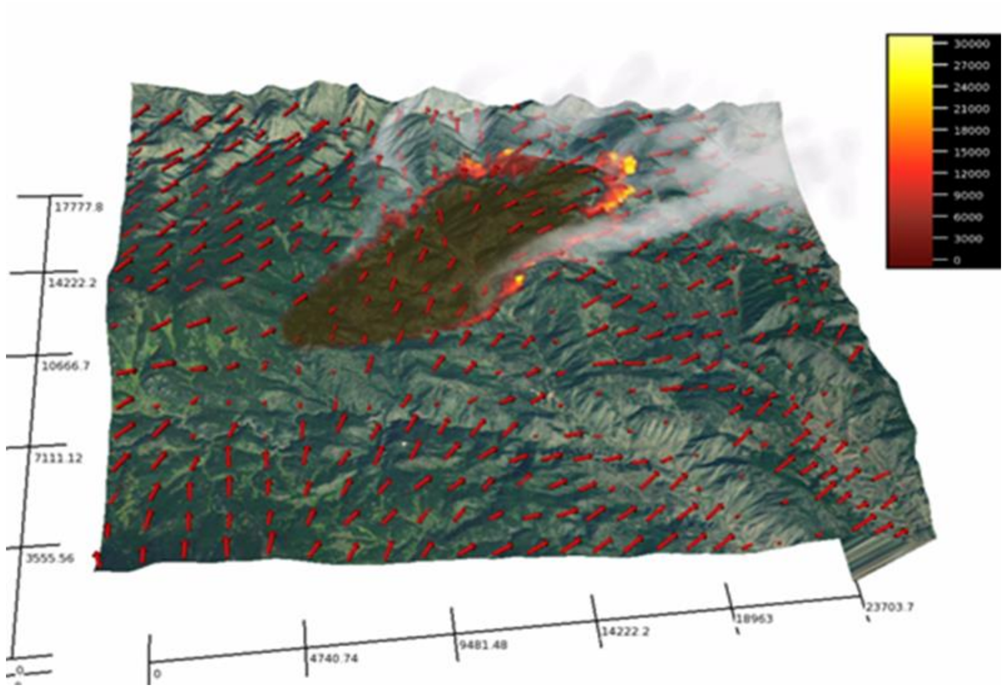
Colorado Decision Support System for Prediction of Wildland Fire Weather, Fire Behavior, and Aircraft Hazards



Kick-off Briefing
3 December 2015

Fire Prediction Technology Description

The CO-FPS will employ a sophisticated, coupled atmosphere - wildland fire model (e.g., CAWFE®), that generates a high-resolution 4D gridded weather simulation that allows for the production of reports (products) communicating fire behavior and aviation hazard forecasts.

Research-to-Operations (R2O) Process

Objective: To transition the CAWFE® research capability into a robust operational decision support system (e.g., CO-FPS) that can meet the needs of a broad group of Colorado decision makers.

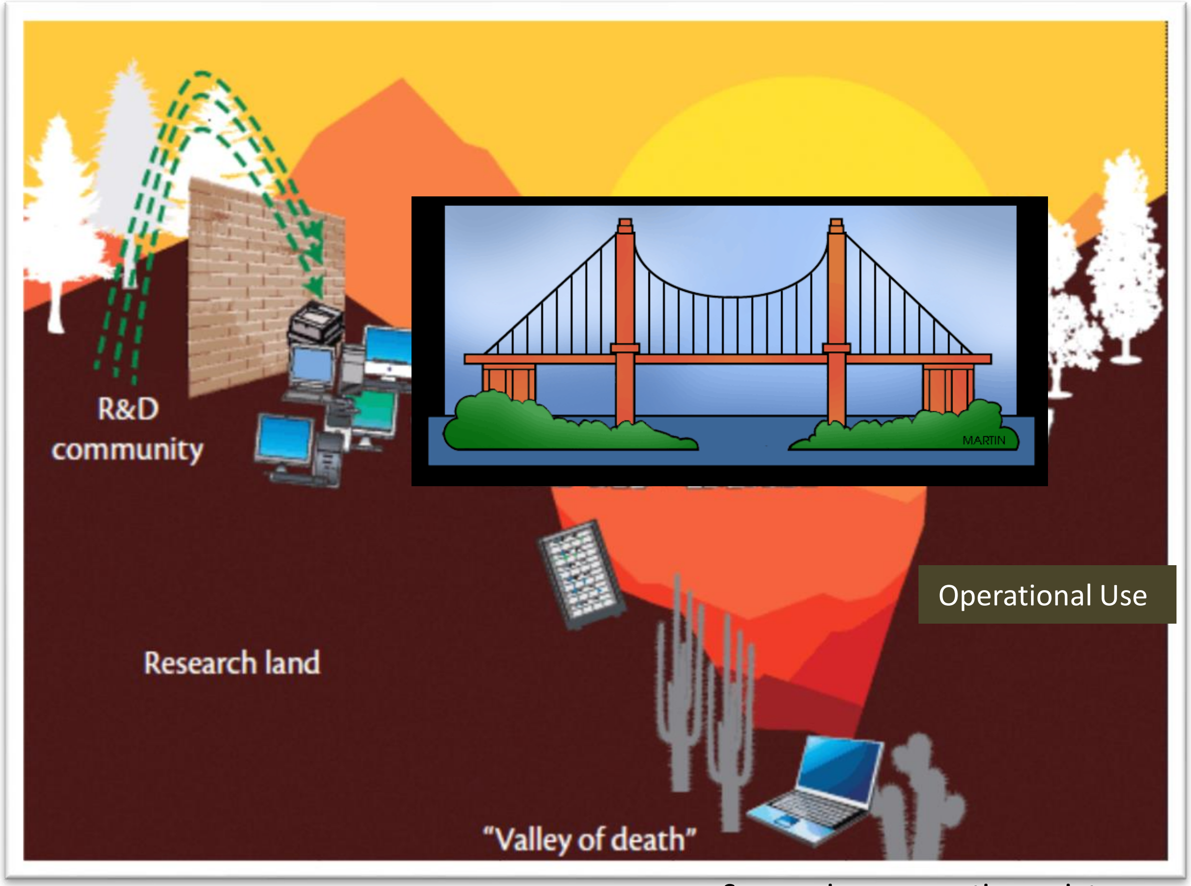
Testbed Definition

A framework for conducting rigorous, transparent, and replicable testing of scientific theories and new technologies.

The Technology “Valley of Death”

The “Valley if Death” is where good research goes to die because of the complexity of the transition process and lack of funding opportunities.

CAWFE® has been an R&D effort for 20 years. The CO Legislature and the State recognized the potential value of this technology and is leading the effort to operationalize it.



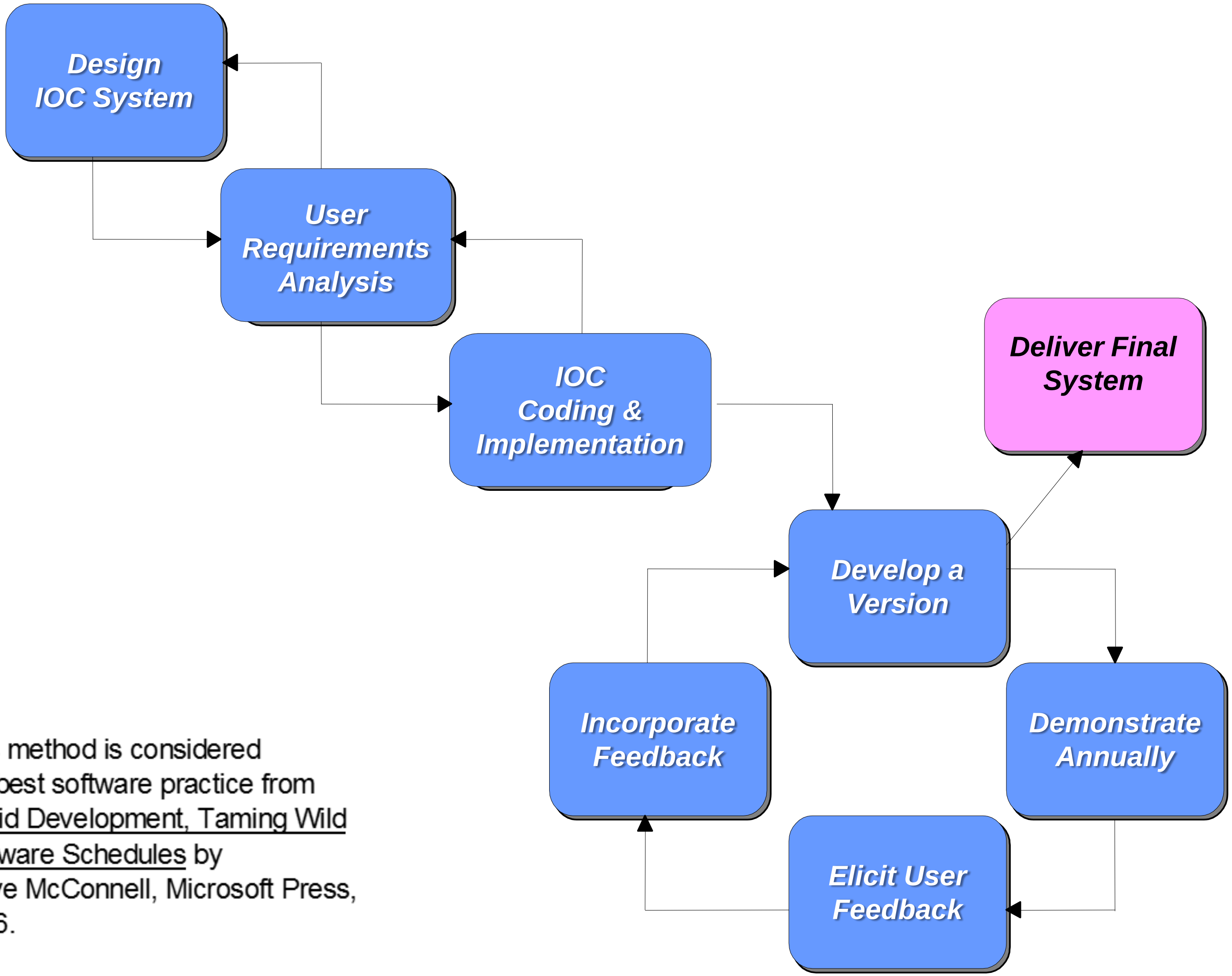
Source: ieeecomputingsociety.org

Development Approach

To reduce risk and ensure that end-user requirements are met throughout the course of the project, the system will be developed using an iterative approach.

This approach is consistent with the overall concept that NCAR and the DFPC are in a partnership and will work cooperatively to develop and evolve the system capabilities as the user requirements and science and technology evolve.

Evolutionary Development Process



November 2020

Initial Operating Capability Demo Sep-Oct-Nov 2016

This method is considered the best software practice from Rapid Development, Taming Wild Software Schedules by Steve McConnell, Microsoft Press, 1996.

Initial Operating Capability CO-FPS Products

18 hour predictions (at user defined increments) of:

- Fire extent
- Rate of spread
- Heat release
- Smoke concentration
- Significant fire phenomena

Fire behavior product group

- Turbulence intensity
- Downdraft and updraft regions
- Wind shear regions

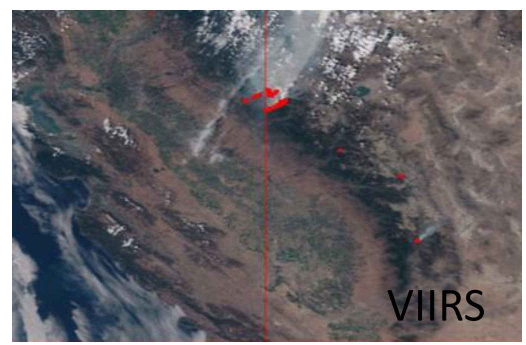
Aviation hazard product group

- Wind speed, direction, gustiness
- Surface air temperature
- Surface relative humidity

Fire weather product group

Planned System Attributes

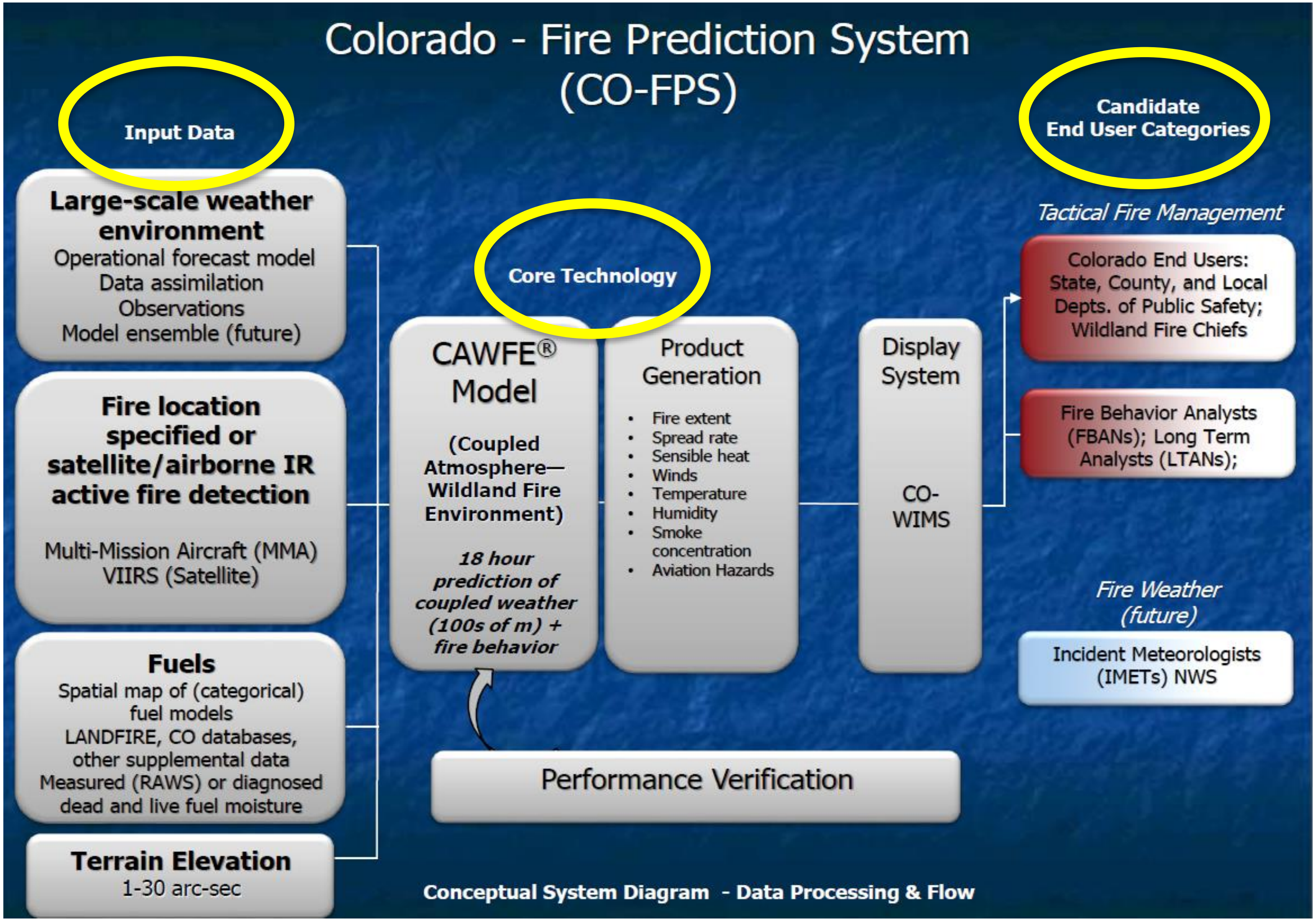
- Real-time data ingest of weather, fuel, and active fire detection data from the MMA and Visible Infrared Imaging Radiometer Suite (VIIRS)
- Multiple fire model cycles (runs) per day (utilizing updated weather and fire mapping data)
- User ability to select fire prediction location and size (via CO-WIMS)
- User ability to input ignition information (via CO-WIMS)
- Output customized and formatted to be displayed on CO-WIMS



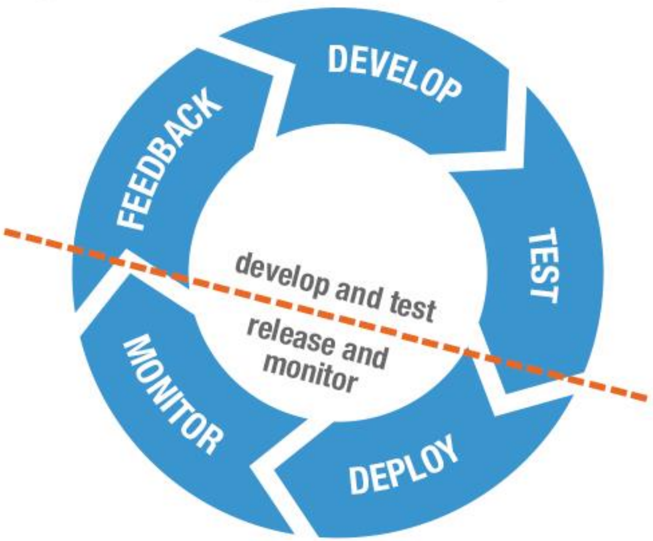
Rim fire in Central-East California. VIIRS active fire detection.

NASA, University of Maryland

System Concept Diagram

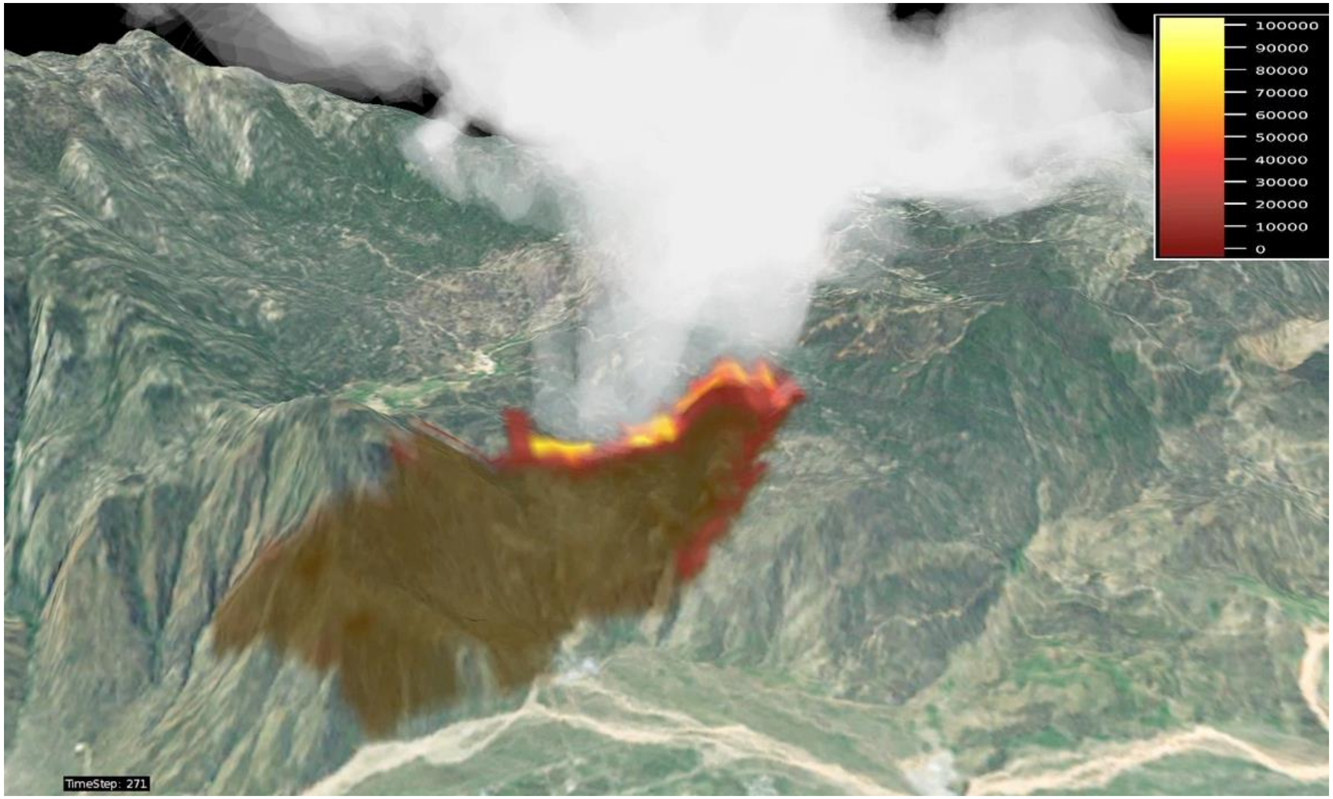


Setting Expectations



- The CO-FPS is not an off-the-shelf technology.
- The IOC version of the CO-FPS will be limited and perhaps not 100% robust.
- User feedback gathered this year will be used to improve the system capabilities, features, functions, and performance.
- We look forward to working with you on this effort.

CAWFE® Description

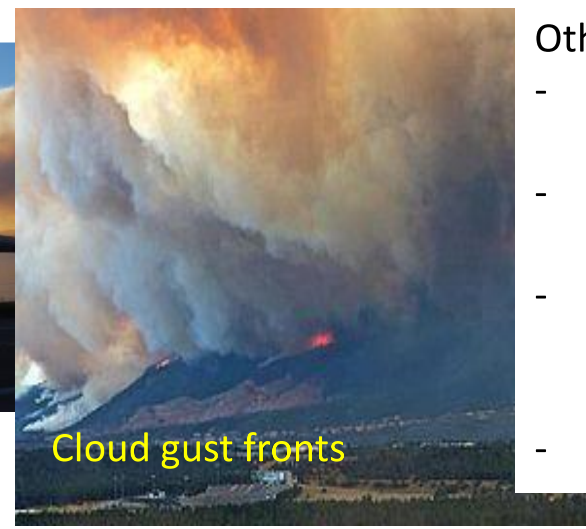


Dr. Janice Coen
Mesoscale & Microscale Meteorology Laboratory
NCAR

Status of operational fire behavior models

- Weather is the wildcard in a wildland fire event.
- Current models (FARSITE, NearTerm fire) similarly:
  - Estimate how fast the leading edge of the fire will spread, based on separate effects of wind speed, terrain, & fuel properties.
  - Use station measurements, simple approximations, or too coarse weather forecasts
  - Do not include how the fire creates its own weather
  - Frequently require calibrating inputs to get observed fire behavior
- Current tools are weak in these (and other) events:

Mountain airflows



Others:
- Fire whirls (Missionary Ridge)
- Backfires (Spade Fire)
- Splitting/fire-induced + wind-driven heads
- Chimney effect

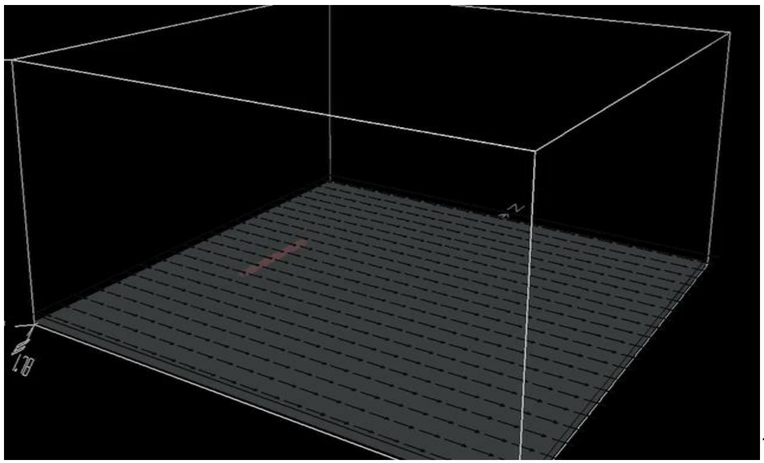
- More sophisticated tools are emerging from research for practical use

NCAR Wildland Fire Modeling Science

The CAWFE® (Coupled Atmosphere-Wildland Fire Environment) modeling system couples a 4-D numerical weather prediction model designed for high resolution (100s of m) simulations in complex terrain with a wildland fire behavior model to predict fire weather, fire behavior, and fire-weather interactions.

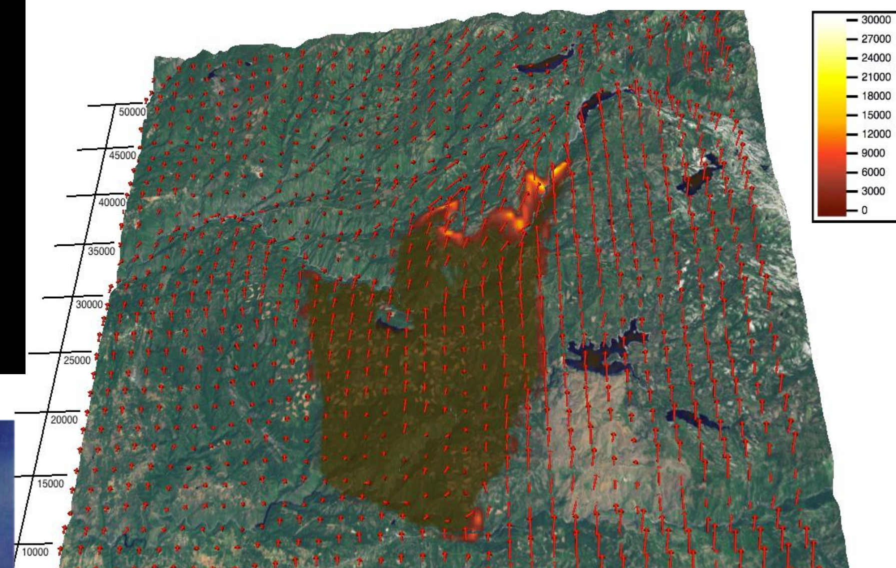
To understand fire behavior fundamentals…

CAWFE simulation: The "universal" fire shape and fire whirls evolve from fire-atmosphere interactions.



The Onion Fire, Owens Valley, CA (courtesy Chuck George USFS)

… and the unfolding of wildfire events

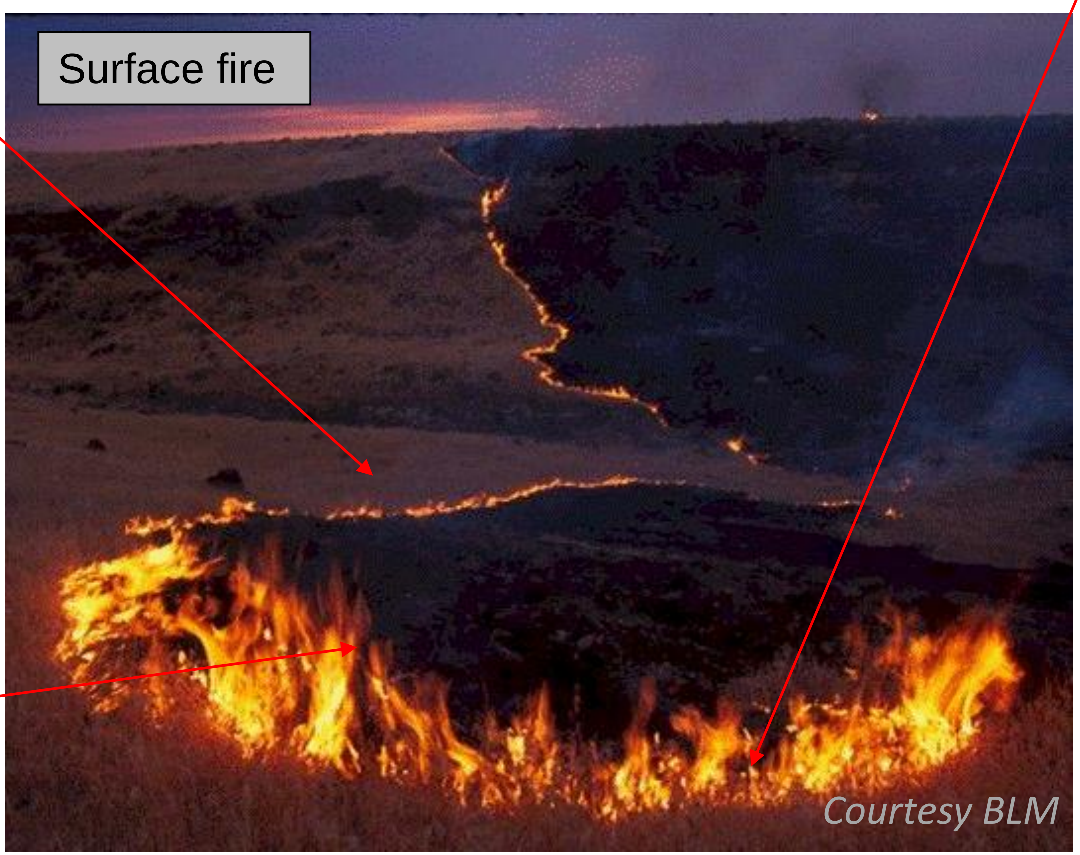


CAWFE simulation of the 2014 King fire showing the heat release rate produced by the fire and near ground wind speed and direction.

Fire Behavior Module

Overview of Components

1. Represent & track the (subgrid-scale) **interface** between burning and nonburning regions (the 'flaming front')



2. Rate of spread (ROS) of flaming front calculated as function of **fire-affected** wind, fuel, and slope using Rothermel (1972) semi-empirical equations

3. Post-frontal heat & water vapor release. Once ignited, the fuel remaining decays exponentially, acc. to lab experiments.

4. Heat, water vapor, and smoke released by surface fire into lowest layers of atmospheric model

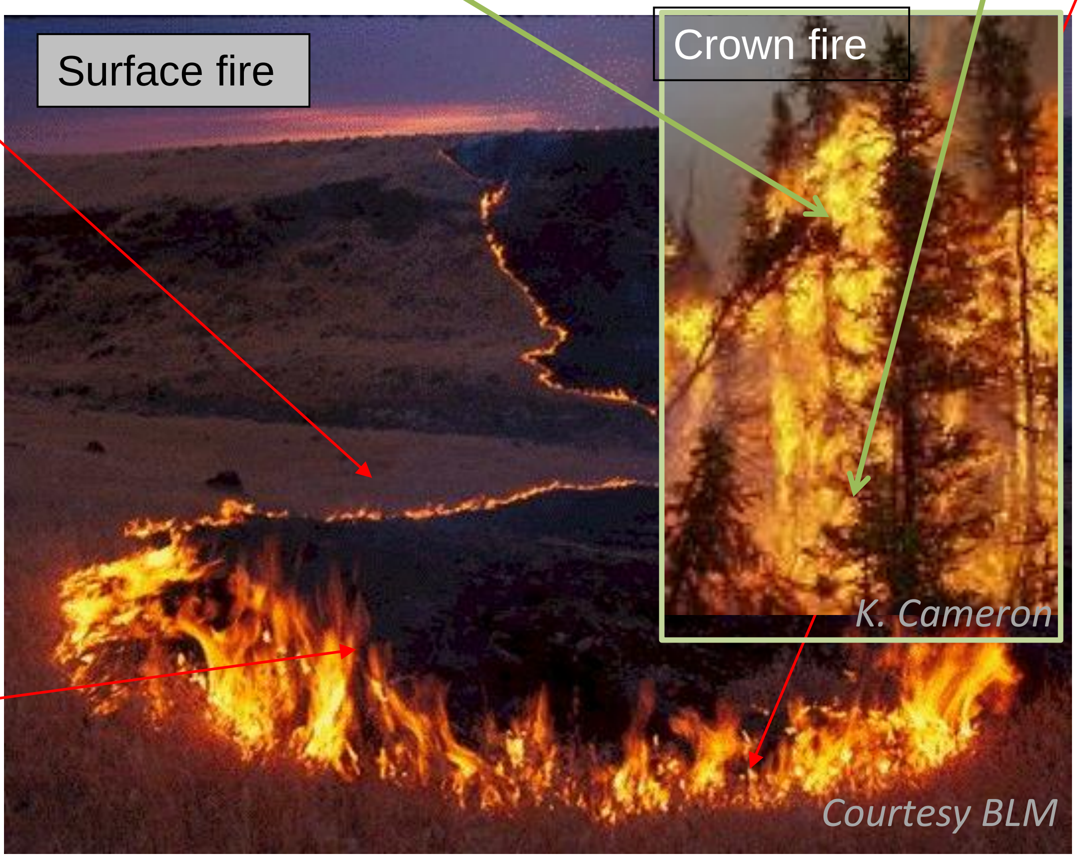
Fire Behavior Module

Overview of Components

6. Calculate the rate of spread of the crown fire using empirical relationships to surface fire ROS

5. Surface fire heats and dries canopy. Does the surface fire heat flux exceed the (empirical) threshold to transition into the tree canopy (if present)?

1. Represent & track the (subgrid-scale) **interface** between burning and nonburning regions (the 'flaming front')



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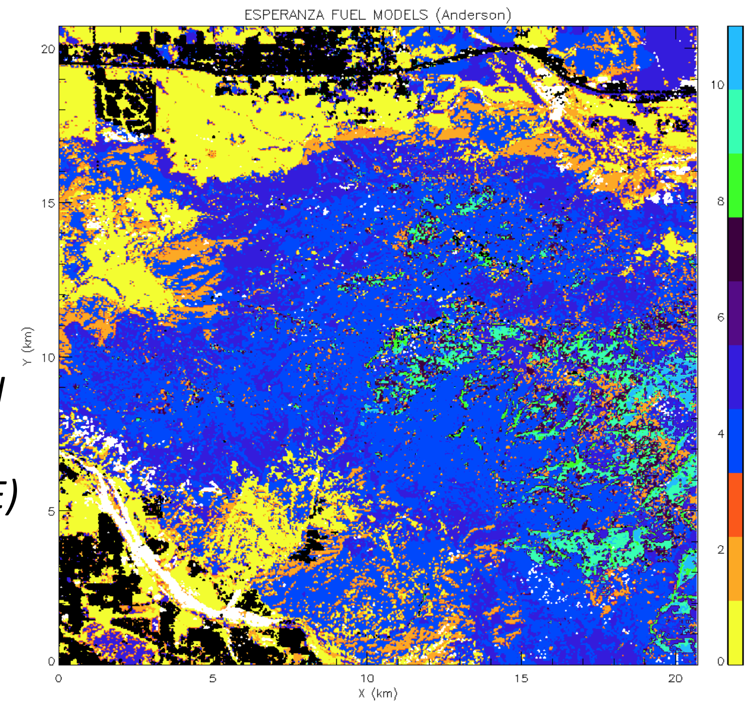
7. Heat, water vapor, and smoke released by crown fire into atmospheric model

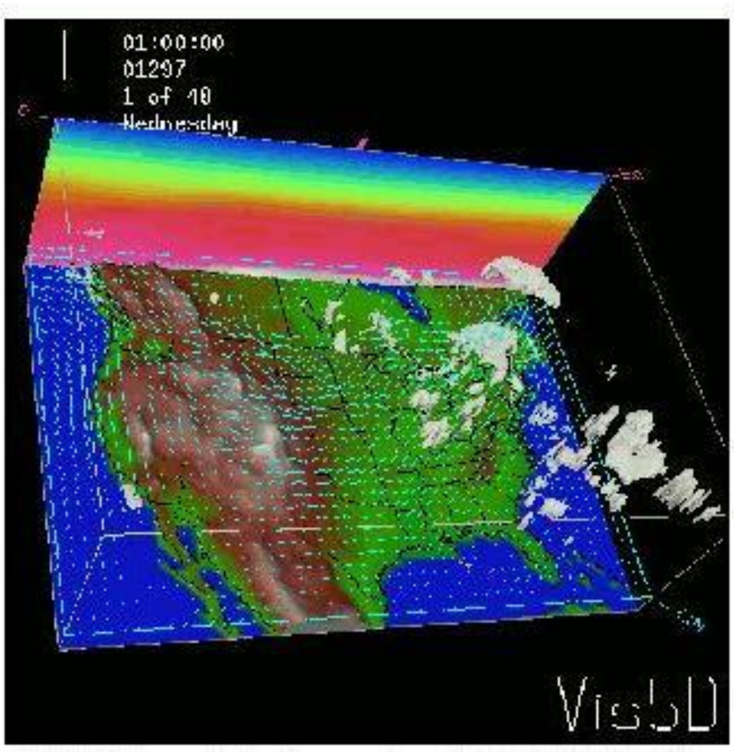
CAWFE® Model Configuration

INPUT DATA: (1) Gridded synoptic/global weather analyses or NWS model forecast

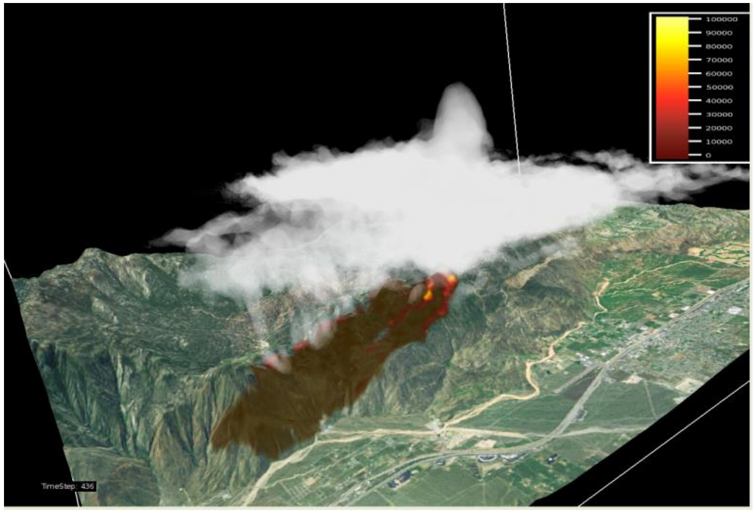
INPUT DATA: (2) terrain elevation data

INPUT DATA: (3) fuel model data (LANDFIRE)





Grid refinement

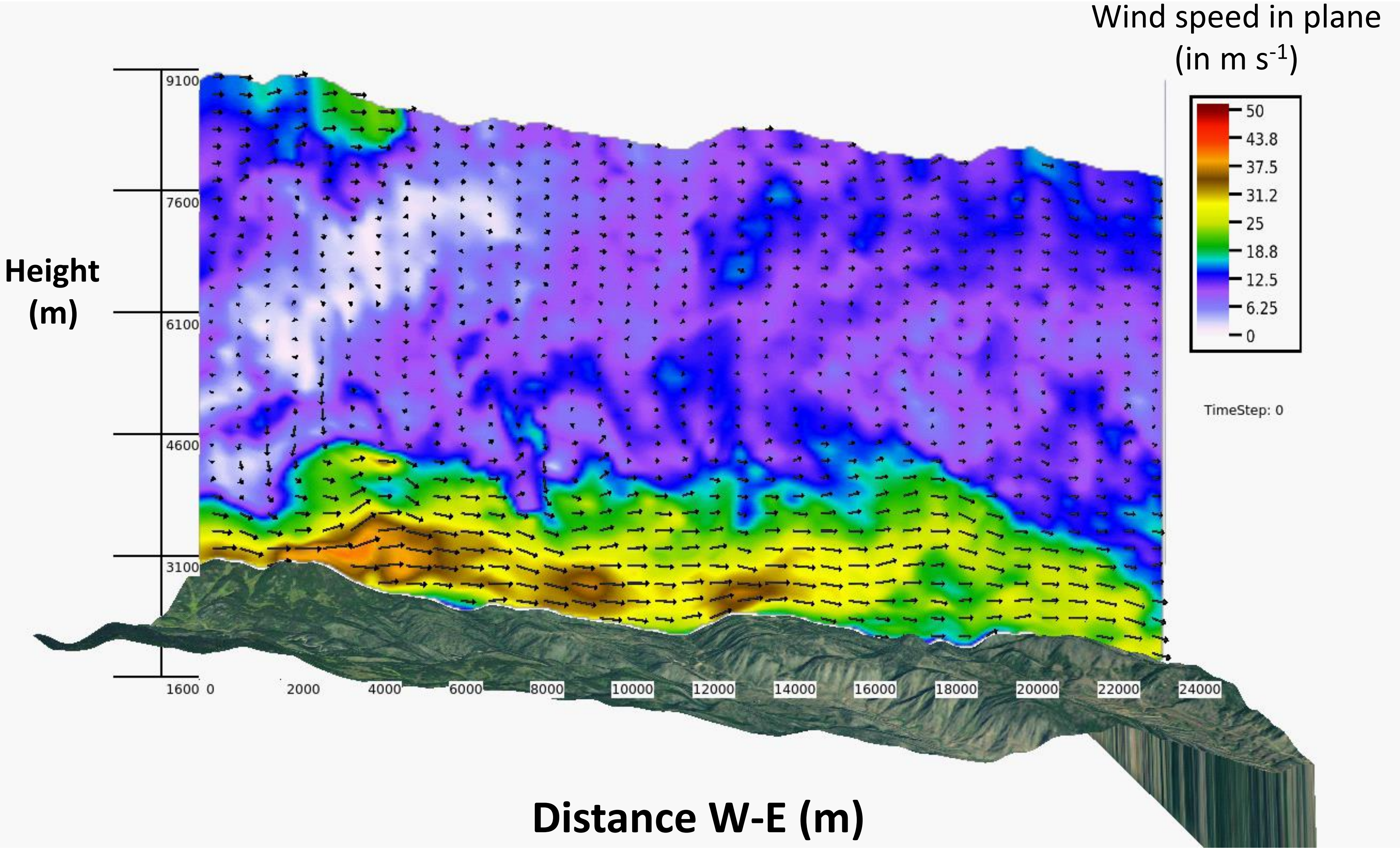


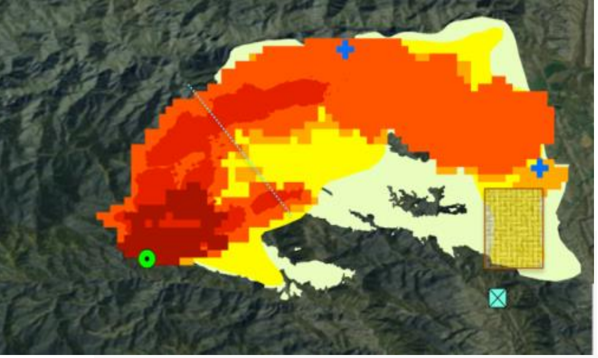
5 simultaneous nested weather modeling domains with horizontal grid spacing 10 km, 3.33 km, 1.11 km, 370 m, and 123 m telescope from a regional or national forecast…

…to, for example, a 25 km x 25 km area focusing on a fire.

Simulated wind in vertical slice through ignition

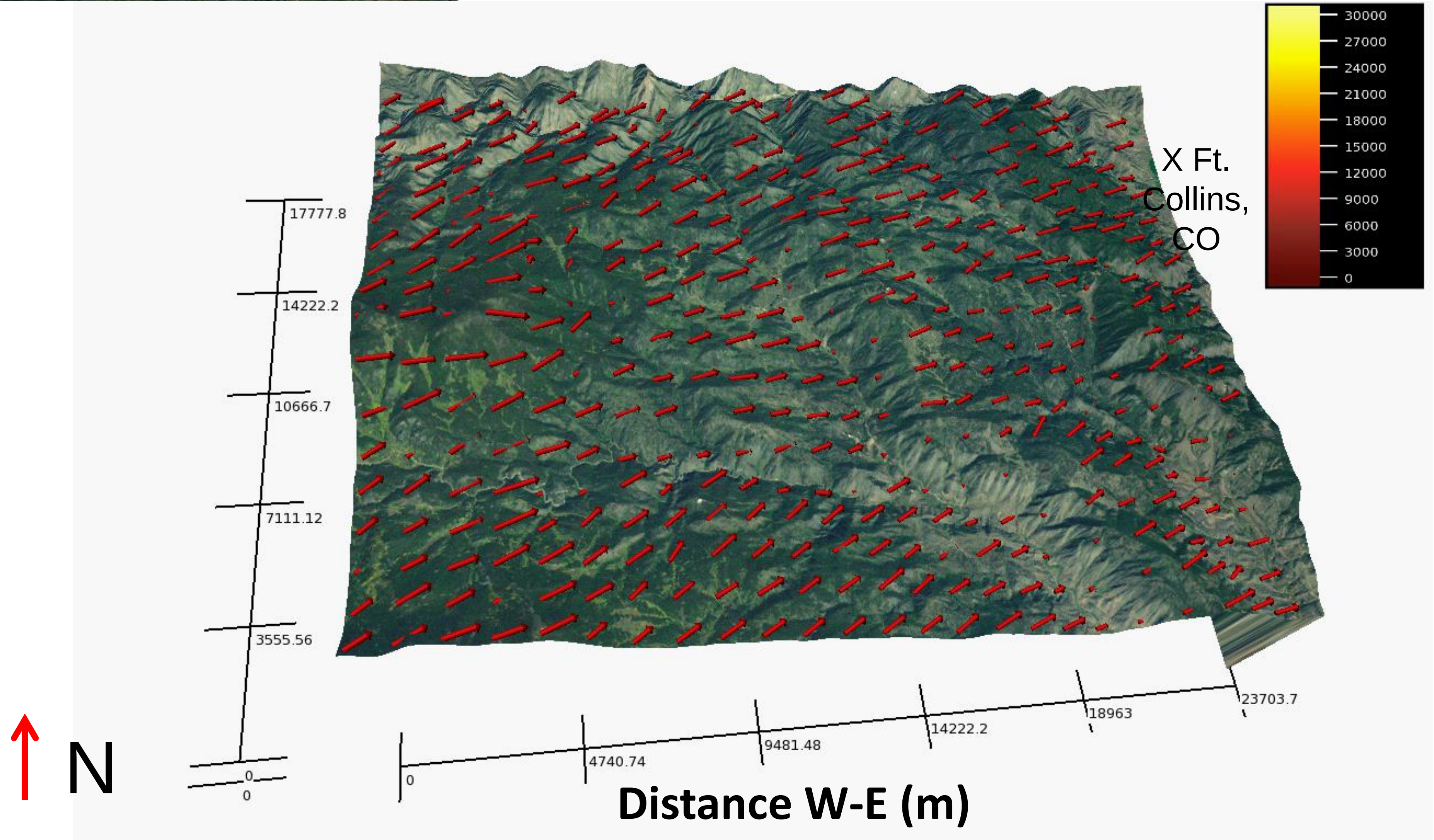
1 frame = 1 minute, beginning 5:45 a.m. 9 June





High Park Fire 6/9/12

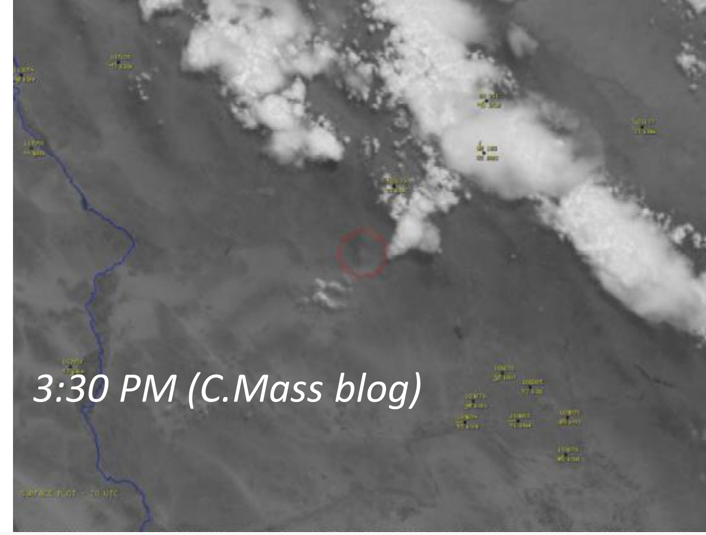
Period: 6/9 5:30 am – 6/10 2:58 am (21.5 hr). Each frame: 1 min. Animation: the rate the fire is releasing heat (inset color bar, W m^{-2}), burned area (dark brown), wind at 12 m (39 ft) above ground, and smoke.



Yarnell Hill Fire

Yarnell, AZ, 6/30/13

1 frame = 1 min



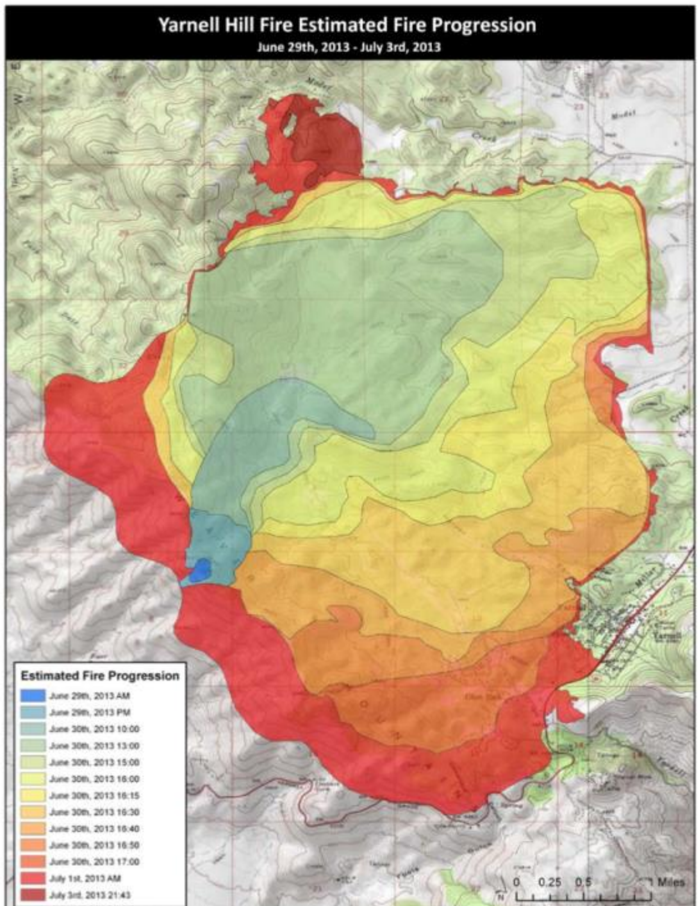
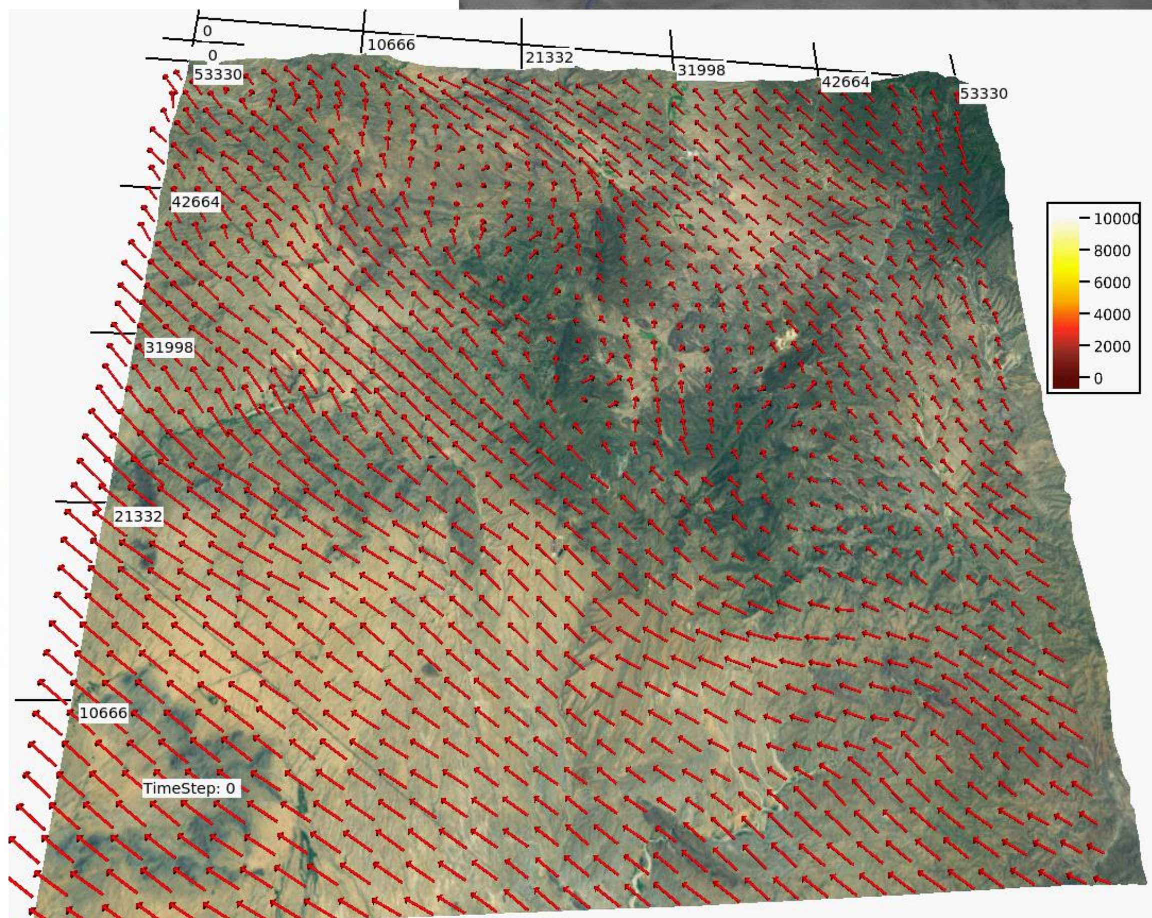


Figure 22. Yarnell Hill Fire Progression Map, June 29 through July 3, 2013.



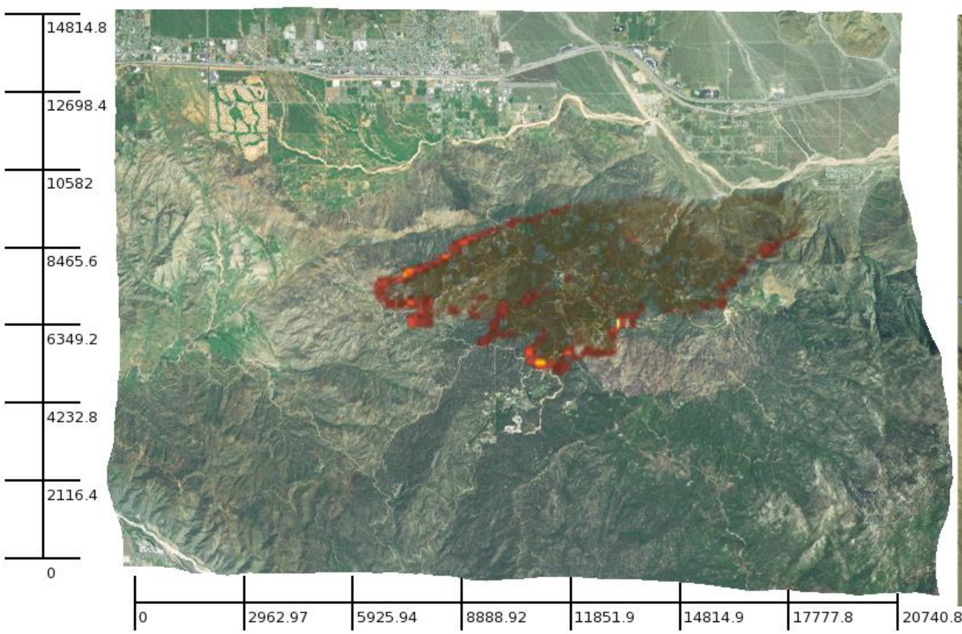
Testing and Verification Cases

Simulated large wildfires in many fuel & weather conditions:

- Little Bear Fire, NM
- High Park Fire, CO
- Esperanza Fire, CA
- Prototype real-time simulation of CO fires during 2004
- Simi Fire, CA
- Troy Fire, CA
- Spade Fire, MT
- Big Elk Fire, CO
- Hayman Fire, CO
- Yarnell Hill Fire, AZ
- King Fire, CA

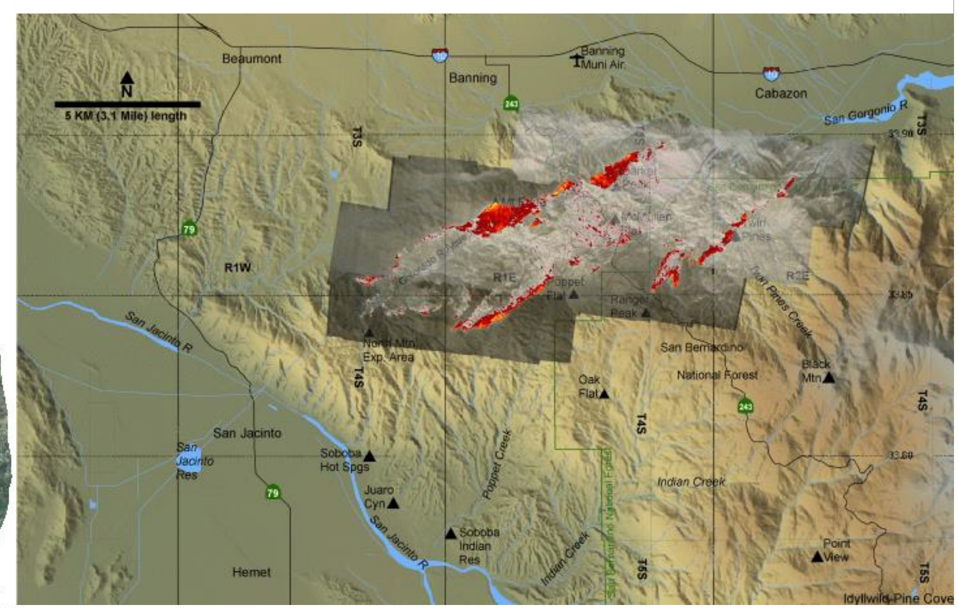
ESPERANZA WILDFIRE

CAWFE SIMULATION



INFRARED DATA

FireMapper, USDA Forest Service

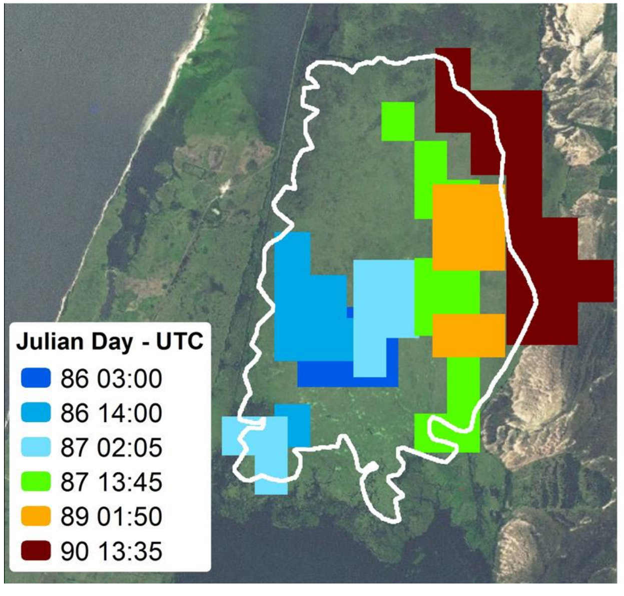


Modeled weather, fire extent, shape, intensity, and land surface effects can be validated. Airborne or space borne infrared data reveal fire properties through smoke.

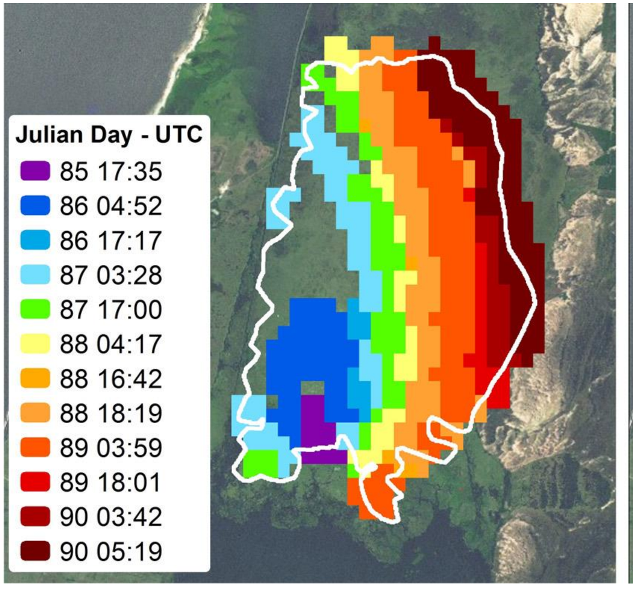
Satellite Active Fire Detection

The new Suomi-NPP sensor VIIRS provides (at least) twice-daily fire detection data at resolutions relevant for fire behavior

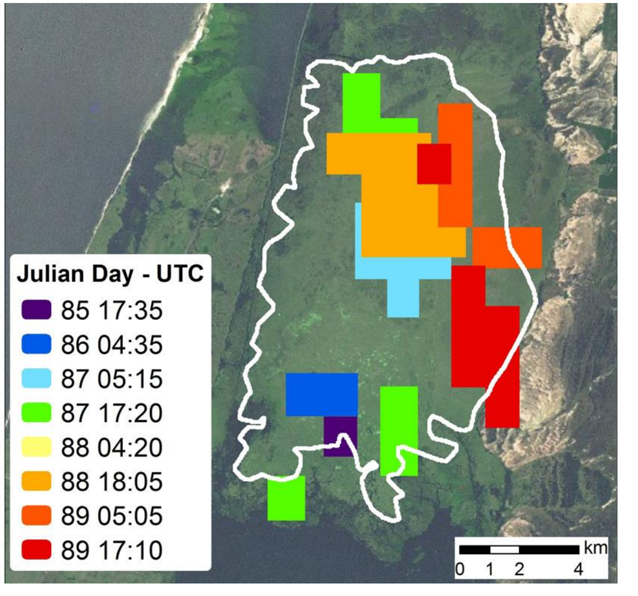
(old) Terra/MODIS 1km



(new) S-NPP/VIIRS 375m



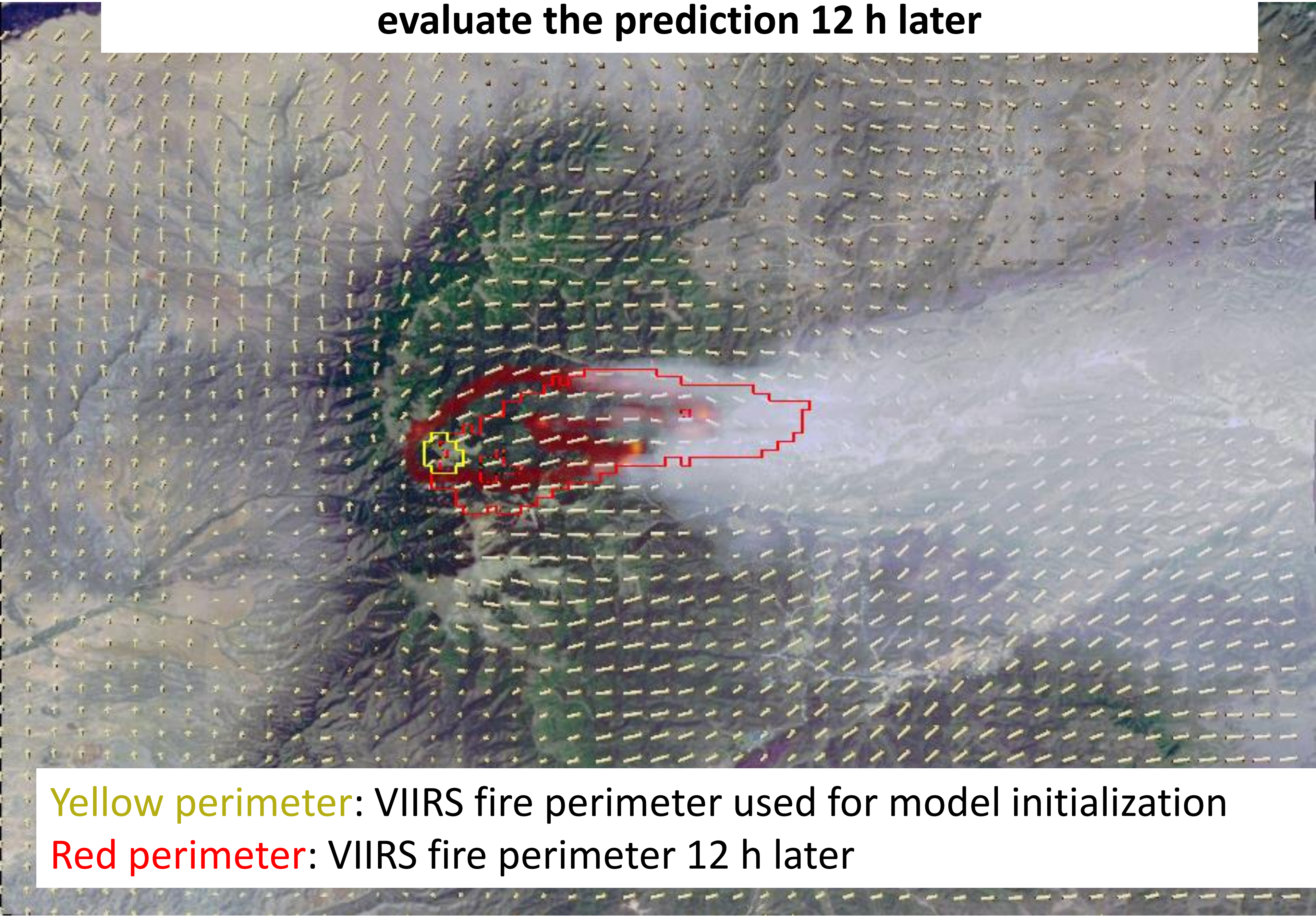
(old) Aqua/MODIS 1km



Wildfire in southern Brazil, March 2013

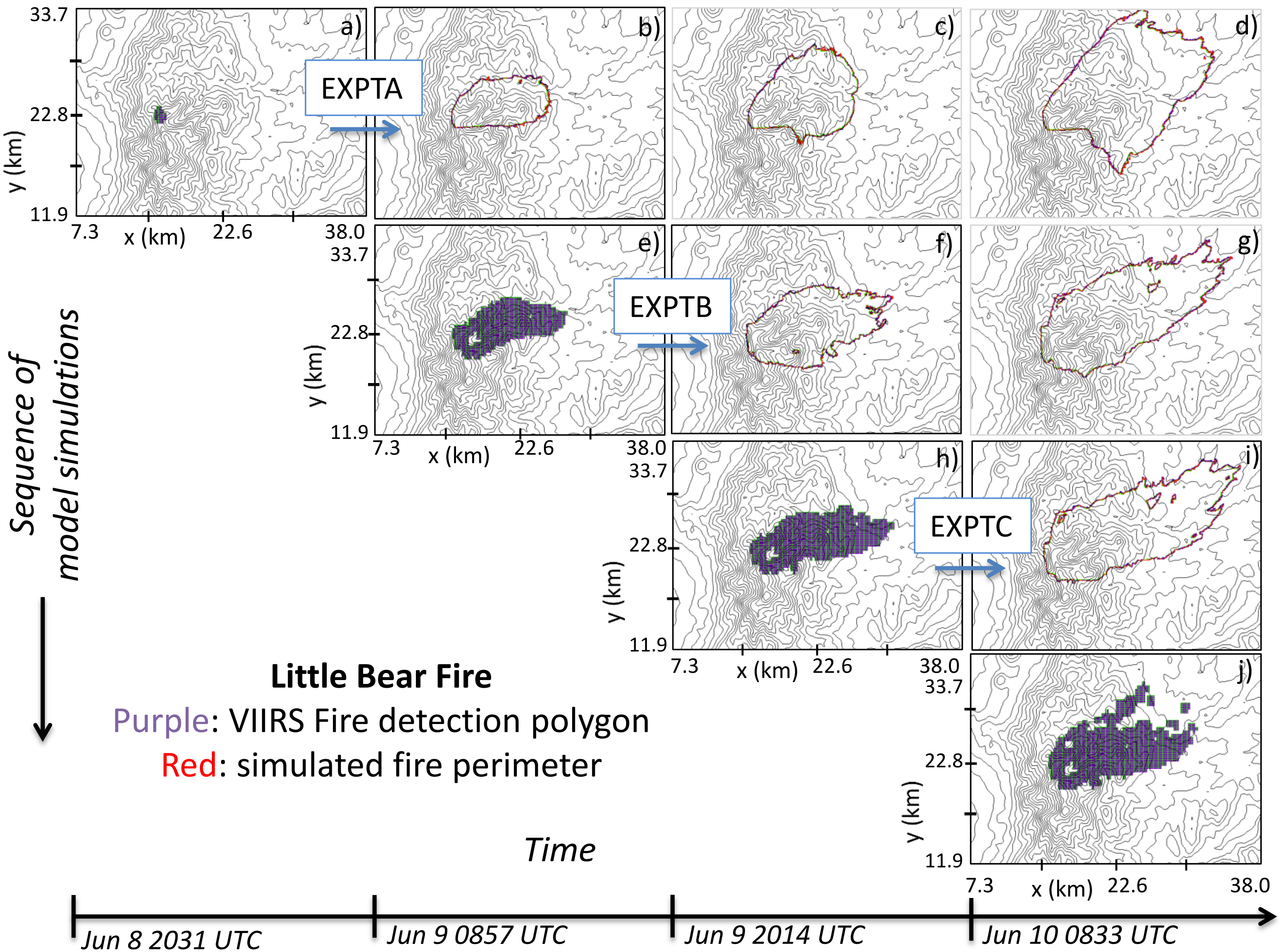
Courtesy W. Schroeder, Univ. of Maryland

VIIRS data can be used to start the fire 'in progress' and evaluate the prediction 12 h later



Yellow perimeter: VIIRS fire perimeter used for model initialization
Red perimeter: VIIRS fire perimeter 12 h later

Coen and Schroeder, 2013, Geophysical Research Letters



Fire Prediction Use Cases

Initial Focus

- High resolution fire weather products
- Management of individual fires – fire behavior
- Aviation weather hazard guidance (up/downdrafts, rotors, wind shear, turbulence)

Additional Candidate Applications

- Resource planning for regional operations
- Support for prescribed fire planning and execution
- Forest and rangeland management and planning
- Smoke impacts and air quality
- Firefighter safety & training
- Forensic evaluations of fire ignition and evolution

Questions?

- Janice Coen (janicec@ucar.edu)
- Bill Mahoney (mahoney@ucar.edu)
- Jim Cowie (cowie@ucar.edu)