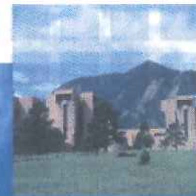
NCAR

Wildland Fire Modeling: Capabilities and Applications



Janice Coen
William Mahoney

National Center for Atmospheric Research

Problem Statement

Suppression costs are increasing

- building in the WUI
- fire exclusion
- combinations of climate and weather

Losses due to a fire continue for decades

- 10-50 times suppression costs

Wildland fires are exceedingly complex phenomena

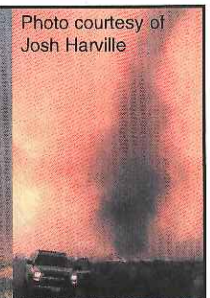
- Humans cannot integrate all the interacting factors
- Simple operational tools estimate how fast the leading edge of the fire will spread, based on wind speed, terrain, and fuel properties.
- More sophisticated tools are needed

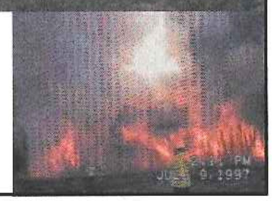
Complexity

Wildland fires produce extreme fire behaviors such as:

- **fire whirls and 'firenadoes'**
- **horizontal roll vortices**
- **fire winds 10 times stronger than ambient wind speeds**
- **bursts of flame shooting ahead of the fire line**
- **blow-ups and firestorms**
- **pyrocumulus**
- **flank runs**
- **splitting or merging**

These all result from dynamic interactions between a fire and its environment.



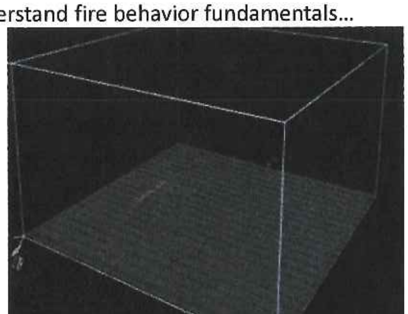


NCAR Wildland Fire Modeling Science

For more than 20 years, NCAR has worked with federal, university, and international partners to develop technologies such as the Coupled Atmosphere-Wildland Fire Environment (CAWFE) model and more recently, the Weather Research & Forecasting (WRF) model that couple numerical weather prediction with wildland fire models to predict fire behavior.

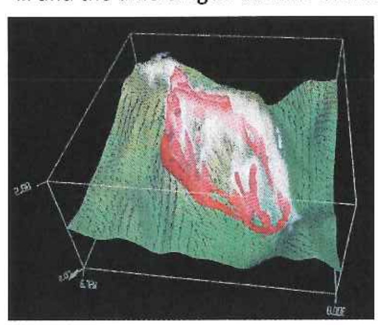
To understand fire behavior fundamentals...

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



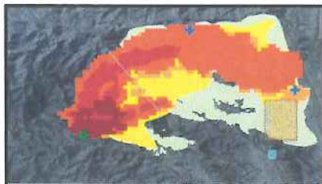
The Onion Fire, Owens Valley, CA (courtesy Chuck George)

... and the unfolding of wildfire events



Simulation of the 2002 Big Elk Fire showing the heat produced by the fire, near ground wind speed and direction, and smoke plume.

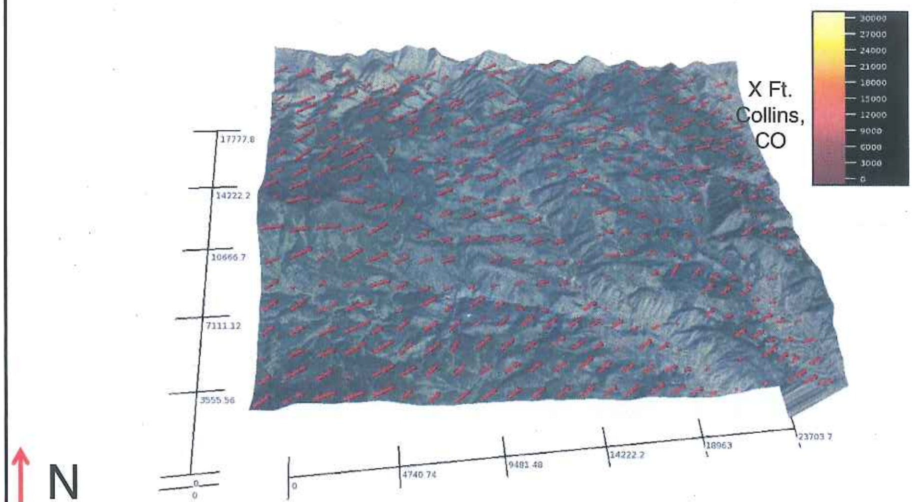
3



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 above ground, and smoke.



Yarnell Hill Fire

Yarnell, AZ, 6/30/13

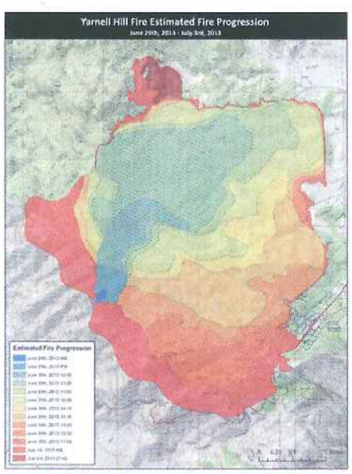


Figure 22. Yarnell Hill Fire Progression Map, June 29 through July 3, 2013.

Testing & Verification

Simulated landscape-scale fires in many fuel & weather conditions:

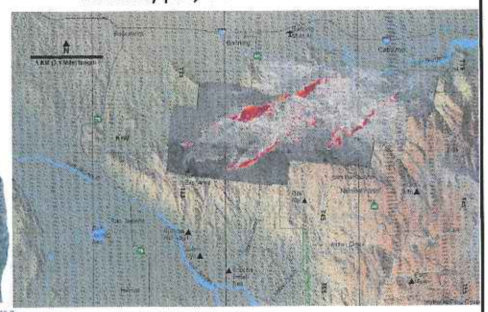
- Little Bear Fire, NM
- Simi Fire, CA
- Big Elk Fire, CO
- High Park Fire, CO
- Troy Fire, CA
- Hayman Fire, CO
- Esperanza Fire, CA
- Spade Fire, MT
- Yarnell Hill Fire, AZ
- Done faster than real-time on CO fires during 2004

ESPERANZA WILDFIRE

CAWFE SIMULATION

INFRARED DATA

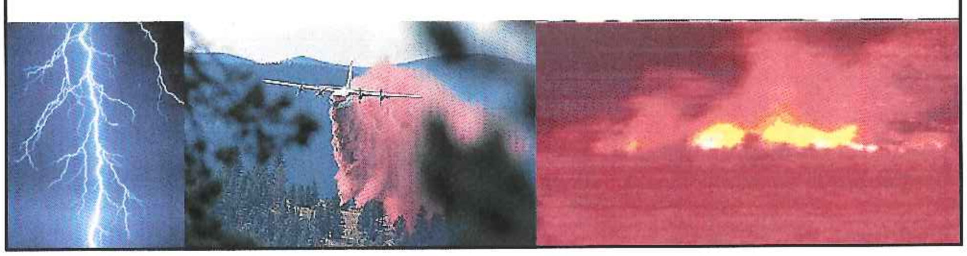
FireMapper, USDA Forest Service



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

Wildland fires as a weather forecasting problem:

- Following a lightning strike, a fire may
  - smolder for several days without growing, until dry, windy weather occurs and experience lulls for several days in between growth periods
  - continue for weeks or months.
- Weather forecast skill deteriorates with time, particularly small features
  - A forecast initialized at ignition would lose most of its accuracy by the time of fire growth.
  - A single forecast cannot cover a fire's lifetime accurately.
- Models cannot foresee everything:
  - Firefighting could be affecting fire growth
  - Unpredictable processes such as spotting could create new fires

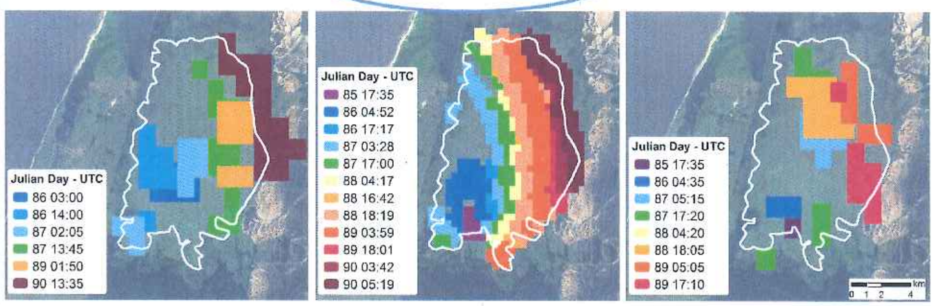


JLC2

The new satellite based sensor provides twice-daily fire detection data at resolutions relevant for fire behavior

NPP- Land Product Evaluation and Testing Element
VIIRS Land Product Quality Assessment

(old) Terra/MODIS 1km | (new) S-NPP/VIIRS 375m | (old) Aqua/MODIS 1km



Wildfire in southern Brazil, March 2013 *courtesy of W. Schroeder*

8

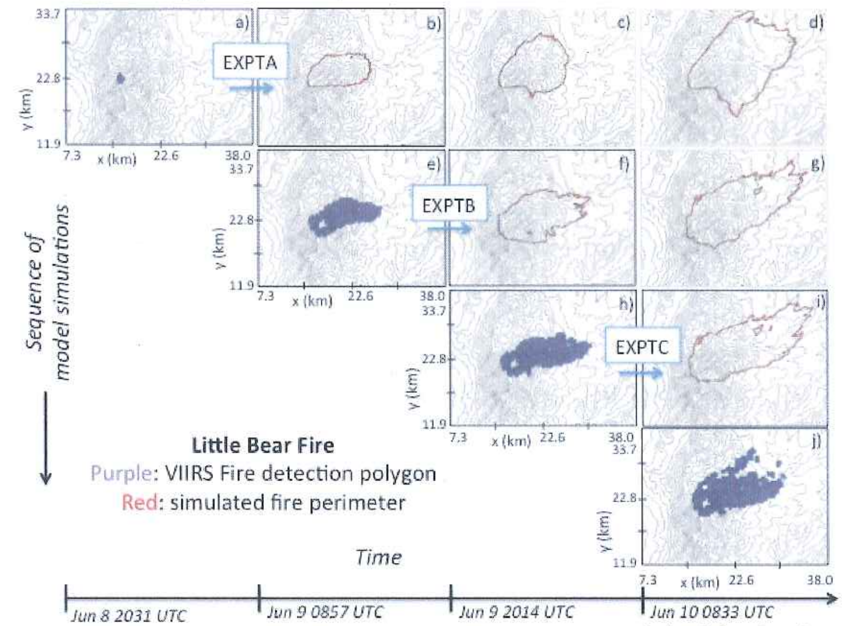
VIIRS data can be used to start the fire 'in progress' and evaluate the prediction 12 h later

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

Slide 9

JLC2 Janice Coen, 4/16/2013

Coupled Weather-Fire Modeling by CAWFE Using Satellite-Observed Initial Fire Conditions



Coen and Schroeder [2013] Geophys. Res. Letter.

Moving These Emerging Capabilities Forward

We need to provide 21st century technologies for the wildland fire community to support user decisions such as:

- **Management of individual fires**
- **Resource planning for regional operations**
- **Support for prescribed fire planning and execution**
- **Land management and planning**
- **Smoke impacts and air quality**
- **Firefighter safety & training**




Research to Operations Transition Goal

- To transition the coupled weather-wildland fire modeling capability into a robust operational decision support system that can meet the needs of a broad group of end users such as
    - Incident Meteorologists (IMETs)
    - Fire Behavior Analysts (FBANs) & Long Term Analysts (LTANs)
    - State and County Fire Chiefs
    - Interagency Geographic Area Coordination Centers and Predictive Services Personnel
    - Other end users

Opportunity

- The State of Colorado would benefit by supporting the research-to-operations process by establishing a collaborative wildland fire prediction testbed where fire practitioners would work with researchers to operationalize this technology for the benefit of Coloradans and society as a whole.


Waldo Canyon Fire – Pueblo Chieftain

NCAR

Thank you.

For more information:
janicec@ucar.edu (303)497-8986
mahoney@ucar.edu (303)-497-8426

This material is based upon work supported by the National Science Foundation (NSF), NASA, and FEMA

NCAR is sponsored by the National Science Foundation

NCAR Mission:

- To understand the atmosphere and related physical, biological, and social systems
- To support, enhance, and extend the capabilities of the university community and the broader scientific community, nationally and internationally
- To foster the transfer of knowledge and technology for the betterment of life on Earth

Supplemental Slides

Over 30 invited briefings have been given:

Elected Officials
- Western Governor's Assn. Annual Mtgs.
- CO State Rep. Dickey Hullinghorst
- CO State Rep. Kraft-Tharp
- CO State Rep. KC Becker
- CO State Rep. Jonathan Singer
- CO Sen. Rollie Heath
- US Congressman Polis (CO)
- US Senator Udall (CO) & staff
- US Senator Bennett (CO) & staff
- Gov. Hickenlooper & staff
- US Rep. Lummis (WY) & Gov. Mead (WY) staff

(Fire) Weather Agencies
- NOAA Office of Science and Technology
- National Interagency Fire Center, Predictive Services
- Drs. Louis Uccellini (Dir. Natl. Weather Service), Ed Johnson, John Murphy (Dir. NWS Office of Science and Technology
- 4 Colorado Incident Meteorologists

State Fire Agencies
- Colorado Division of Homeland Security and Emergency Management & Division of Fire Prevention and Control (CO DFPC)
- CO DFPC Advisory Committee on Wildfire and Prescribed Fire Matters (members from fire agencies across CO)

NGOs with Fire Management teams
- The Nature Conservancy

National Wildland Fire Decision Support Technology
- Wildland Fire Management Research, Development, and Application team

Wildland Fire Training Curriculum /Technology Adopting Committees
- Natl. Wildfire Coordinating Group, Fire Environment Committee, Fire Behavior Subcommittee

Research-to-Operations Program Components

- Support further coupled fire model development
- Conduct detailed user requirements analysis
- Develop user relevant performance metrics
- Build a robust engineering framework around the coupled fire model using evolutionary development
  - Develop automated data ingest and QC capabilities (weather, fuel data, active fire detection data, etc.) for multiple of use cases
  - Develop user interfaces (including mobile devices)
  - Identify additional observational data needed to improve predictions (remote and in-situ) – observations are critical!
  - Prepare system documentation
  - Transition to an operational environment
- Demonstrate and implement capability in operational environment