Simulation of the Meadow Creek fire using WRF-Fire

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Goal

Use WRF-Fire to simulate a real wildland fire using standard data sources in order to evaluate its ability to predict a fire's propagation in real time.

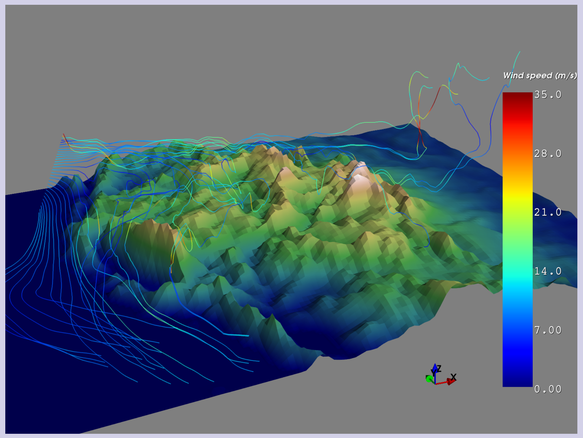
The Meadow Creek fire

- ignited by lightening in the mountainous region of Colorado on June 26, 2010 15:00 MDT
- burned nearly 6 km^2 in a month
- difficult to simulate in WRF-Fire due to size of the domain and the slope of the terrain
- data available from `www.inciweb.org`

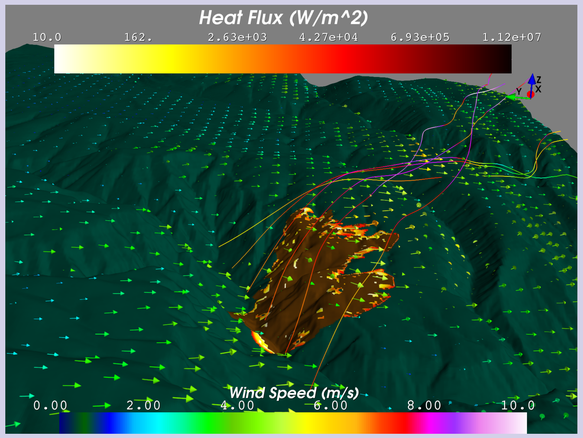
WRF-Fire [1]

- coupled atmosphere-fire model
- source code distributed with WRF [3]
- supported by an online community `http://www.openwfm.org`
- designed to work with data assimilation

3D visualization of the simulation with `mayavi2` [2]

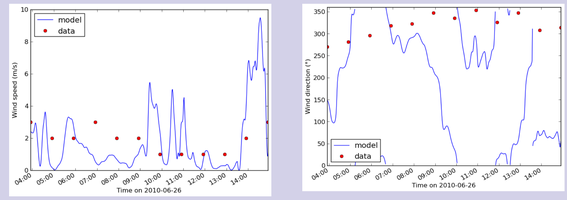


The top level domain 5 hours after ignition. Streamlines show the atmospheric winds blowing east, over the rocky mountains and south down the coast of California.



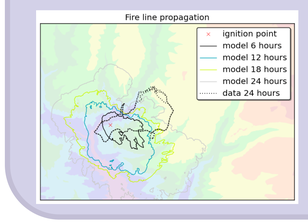
The finest domain 5 hours after ignition. Unburned fuel is displayed as green, burned fuel as brown. The heat flux from the fire appears near the fire line. Arrows indicate the surface winds, while streamlines show the atmospheric winds flowing over the fire region.

Results



(a) (b)

Comparing the modelled wind to the observed wind at the location of the Deep Creek weather station located near the fire. (`http://madis.noaa.gov`)

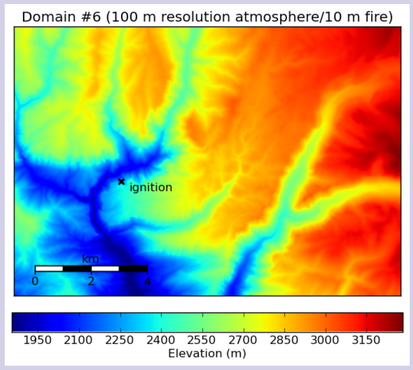


The observed fire line 24 hours after ignition to the modelled fire line at 6, 12, 18, and 24 hours.

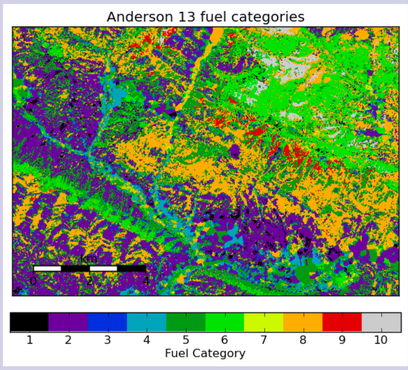
Conclusion

- WRF is not designed for microscale simulations, which leads to stability issues
- Nesting initial atmospheric conditions from 32 km to 100 m cannot capture accurate local atmospheric features. Data assimilation will be necessary for accuracy at this scale.
- The fire appears to propagate too fast compared to observations. Inclusion of more detailed fuel models (Scott-Burgan) and moisture content could alleviate this.

Data sources



(a)



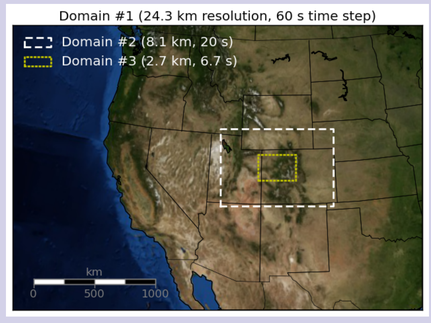
(b)

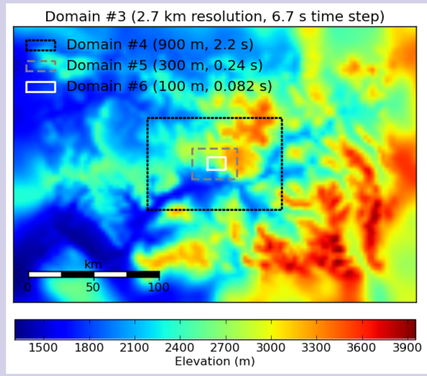
- Topography available from the National Elevation Dataset (NED) at up to 3 m resolution at `http://ned.usgs.gov`
- Fire fuel datasets available from Landfire at up to 10 m resolution at `http://landfire.cr.usgs.gov`

Atmospheric conditions initialized from the North American Regional Reanalysis (NARR).

- 32 km model grid covering North America
- 3 hour analysis cycle
- `http://www.emc.ncep.noaa.gov/mmb/rreanl`

Model domains





Six nested domains are required to scale the simulation down from the atmospheric initialization (32 km) to the fire grid resolution (10 m).

- cloud physics enabled in domains 1–3
- to maintain numerical stability:
  - smoothing of the atmospheric topography
  - choosing ideal time step; too large: instabilities due to topography and fire heat flux; too small: instabilities at boundaries
- 10x subgrid refinement ratio on finest domain for fire surface variables

References

[1] Mandel, J., Beezley, J.D., Coen, J.L., Kim, M. Data assimilation for wildland fires: Ensemble Kalman filters in coupled atmosphere-surface models. In *IEEE Control Systems Magazine 29, 47–65, 2009*

[2] Ramachandran, P., Varoquaux, G. The Mayavi data visualizer. `http://code.enthought.com/projects/mayavi`

[3] WRF Working Group Weather Research Forecasting (WRF) Model `http://wrf-model.org`

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