WRF-Fire: A coupled atmosphere/fire model

1) Sensitivity analyses of an ideal fire (Kara Yedinak)
2) NASA feasibility study: WRF-Fire in AIRPACT (Steve Edburg et al)

Weather

Research

Forecasting model

Latent and Sensible Heat

Wind Speed and Direction

Weather Research and Forecasting (WRF) – Fire
Ideal WRF in Large Eddy Simulation (LES) mode

Stability Defined by
- Surface heating
  - Unstable case = 100 W m^{-2}
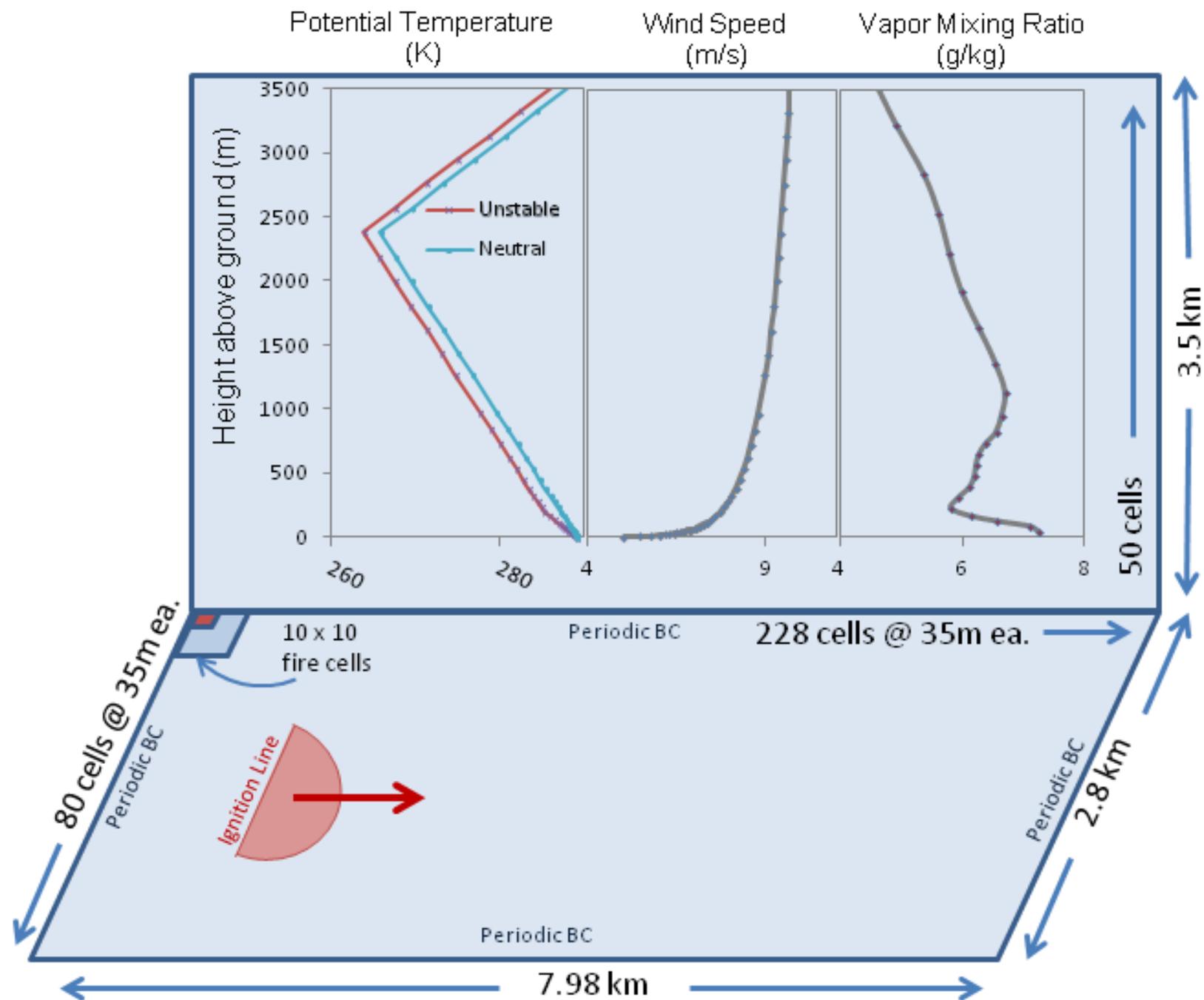 - Neutral case   = 0 W m^{-2}
- Potential temperature profiles

Idealized WRF domain
- No topography
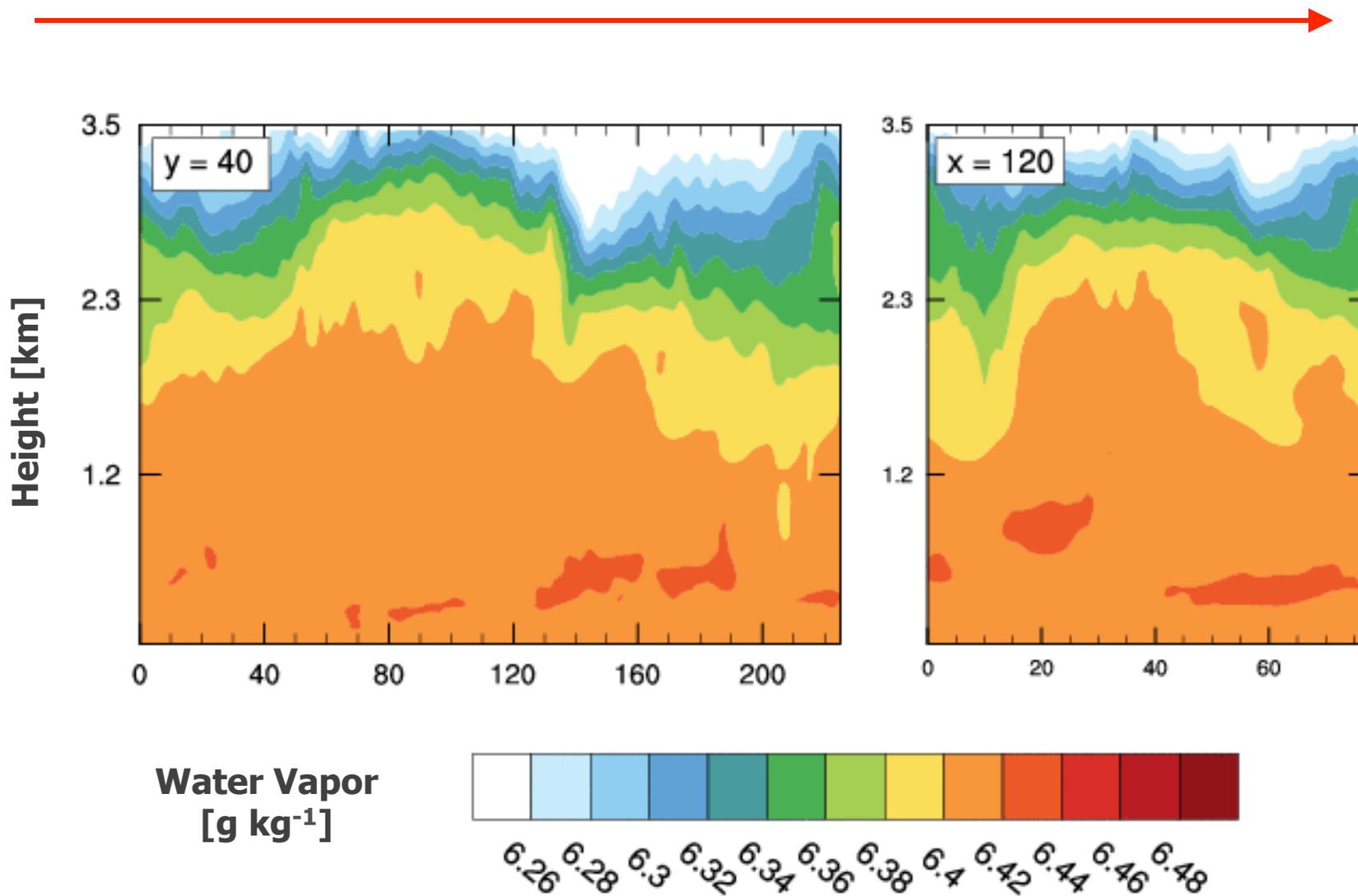- Homogenous vegetation
- No influences from synoptic flow

Empirical fire behavior model
- No resolution of combustion kinetics
- "mid-flame-length" is assumed to be 6 m AGL
- Rate of Spread (ROS) is only dependant on:
  - vegetation characteristics
  - Slope (zero for this study)
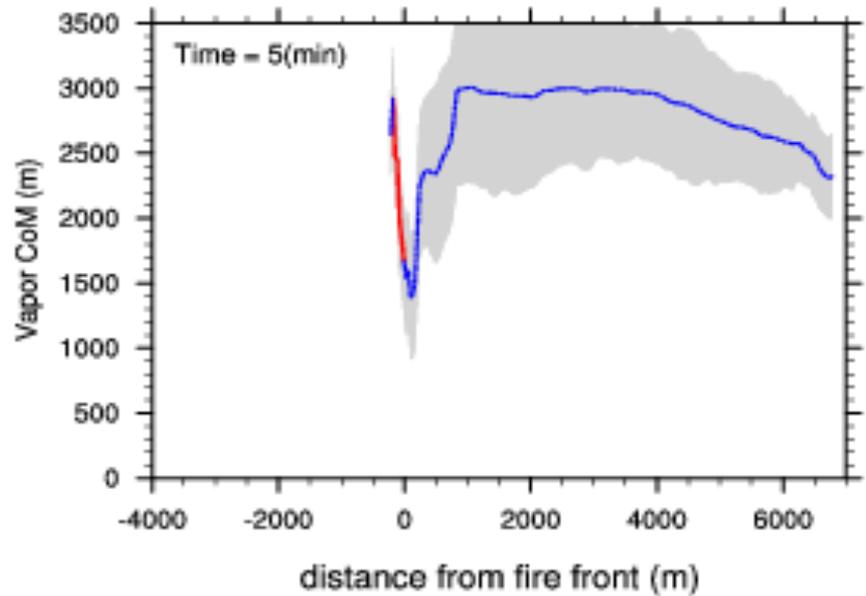 - Surface wind speed

Potential Temperature (K)

Wind Speed (m/s)

Vapor Mixing Ratio (g/kg)

Height above ground (m)

Unstable

Neutral

3.5 km

50 cells

228 cells @ 35m ea.

Periodic BC

10 x 10 fire cells

80 cells @ 35m ea.

Periodic BC

Periodic BC

2.8 km

Ignition Line

Periodic BC

7.98 km

Water Vapor

Water Vapor
[g kg^{-1}]
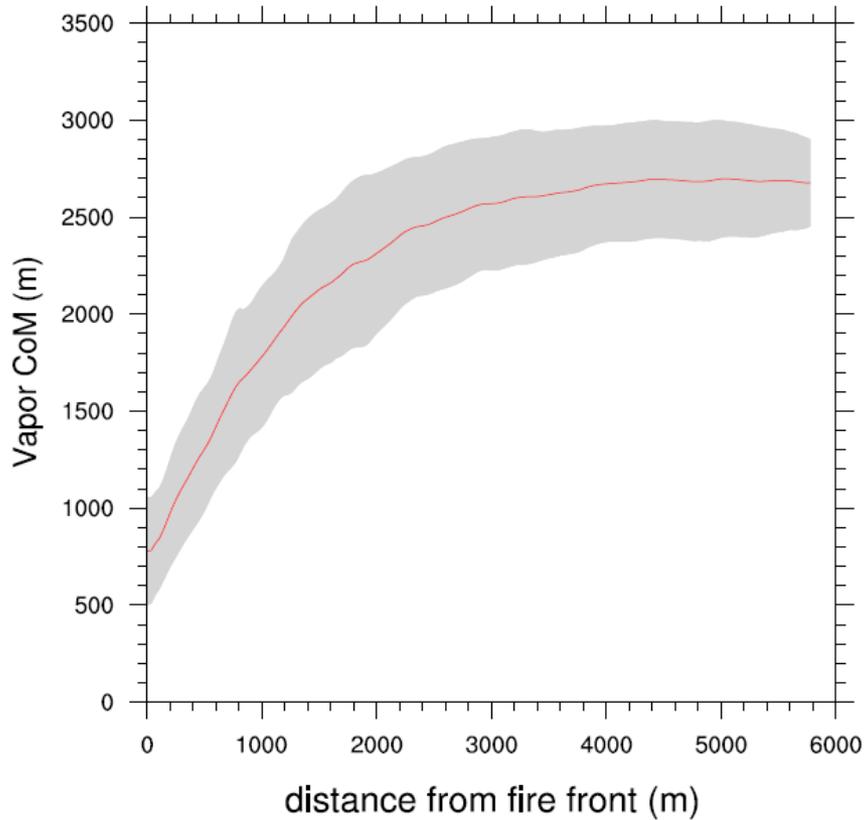
Calculating the plume center-of-mass

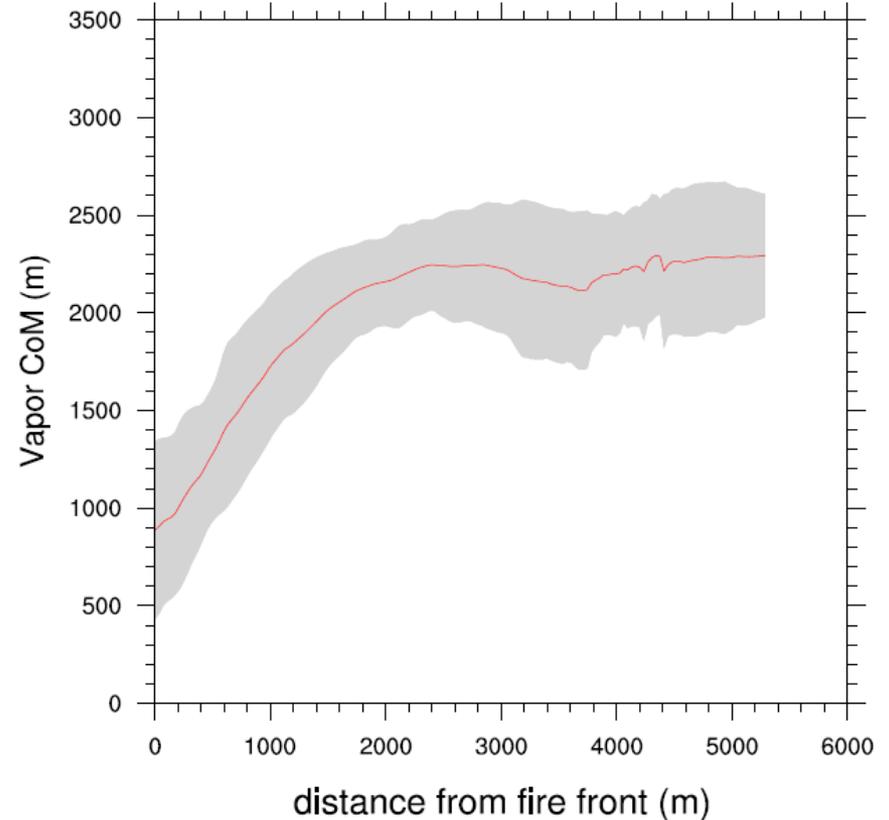$$H = \frac{\sum z\overline{Q}dz}{\sum \overline{Q}dz}$$

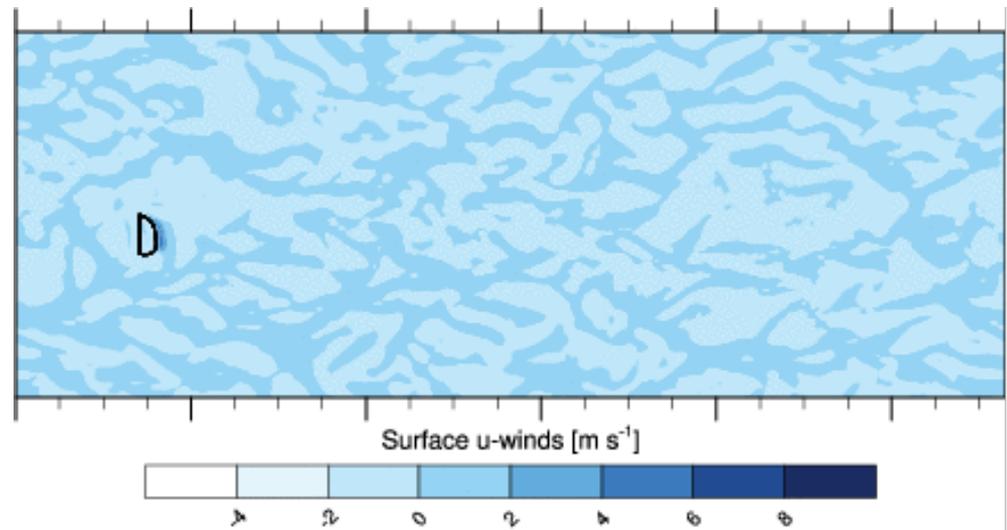# Results from six 10 minute averaged vapor center-of-mass calculations

Unstable

Neutral

Calculating Rate of Spread

Surface u-winds [m s⁻¹]
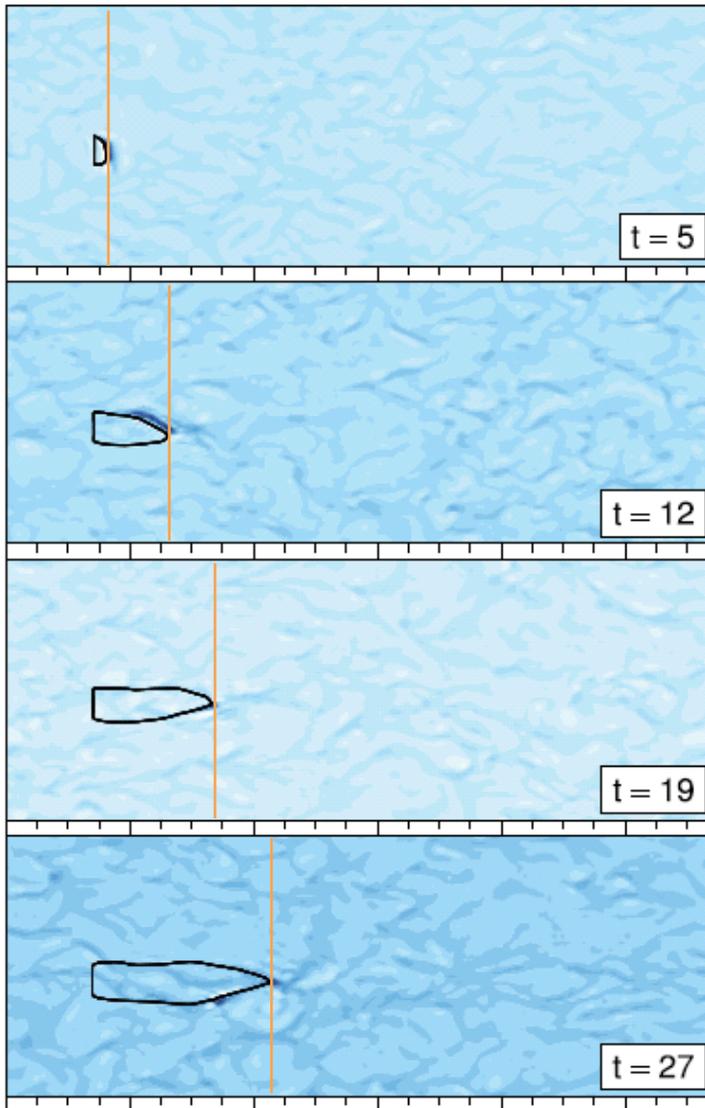
Rate of Spread (ROS) results

Red = unstable
Blue = neutral
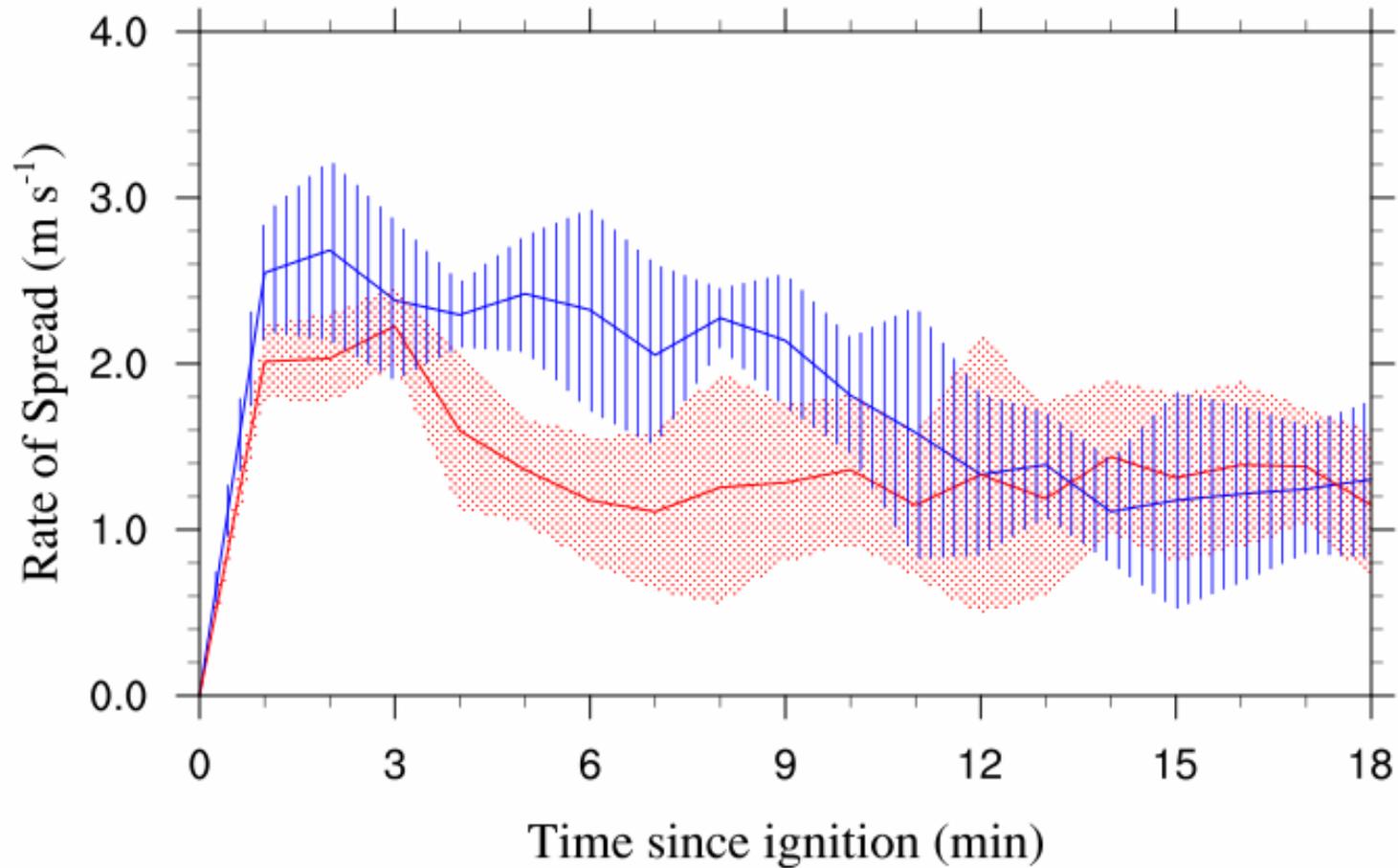
Summary

Neutral case average ROS was 0.2–1.0 m s^{-1} higher than that of the unstable case

Neutral case plume rise was 500 m lower than that of the unstable case

Neutral case:
lack of background surface heating lead to surface flows dominated by background wind speeds

Unstable case:
subject to a uniform surface heating that amplified vertical mixing and surface turbulent kinetic energy

Dominant forcing of plume rise for both cases appears to be the location of the thermal inversion which denotes the top of the CBL

Daily Forecasts of Wildland Fire Impacts on Air Quality in the Pacific Northwest: Enhancing the AIRPACT Decision Support System

S. Edburg, B. Lamb, J. Vaughan, A. Kochanski, M.A. Jenkins, J. Mandel, N. Larkin, S. O'Neill, T. Strand, and R. Mell

Objective: Feasability study to incorporate WRF-Fire with AIRPACT for improved treatment of wildfire impacts on Air Quality

Real WRF-Fire:
Witch and Guejito fires
October 21 – October 23, 2007
near Ramona California
Kochanski et al.,2013

Image of the Witch fire on October 22, 2007 from the Quick Bird satellite

Images © DigitalGlobe

Smoke from multiple fires as well as dust stirred up during a Santa Ana wind event on October 22nd, 2007 as seen from the Aqua satellite.
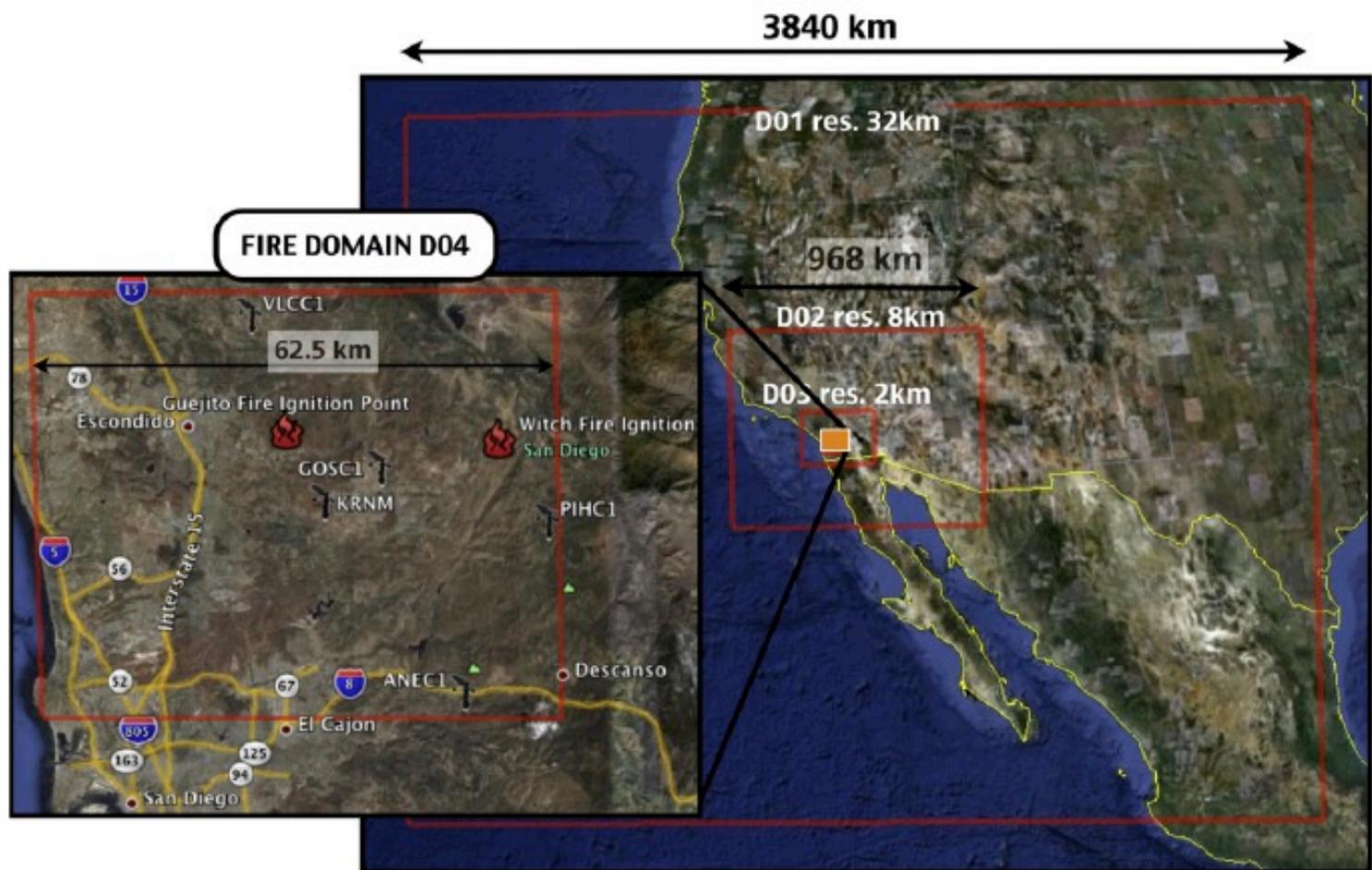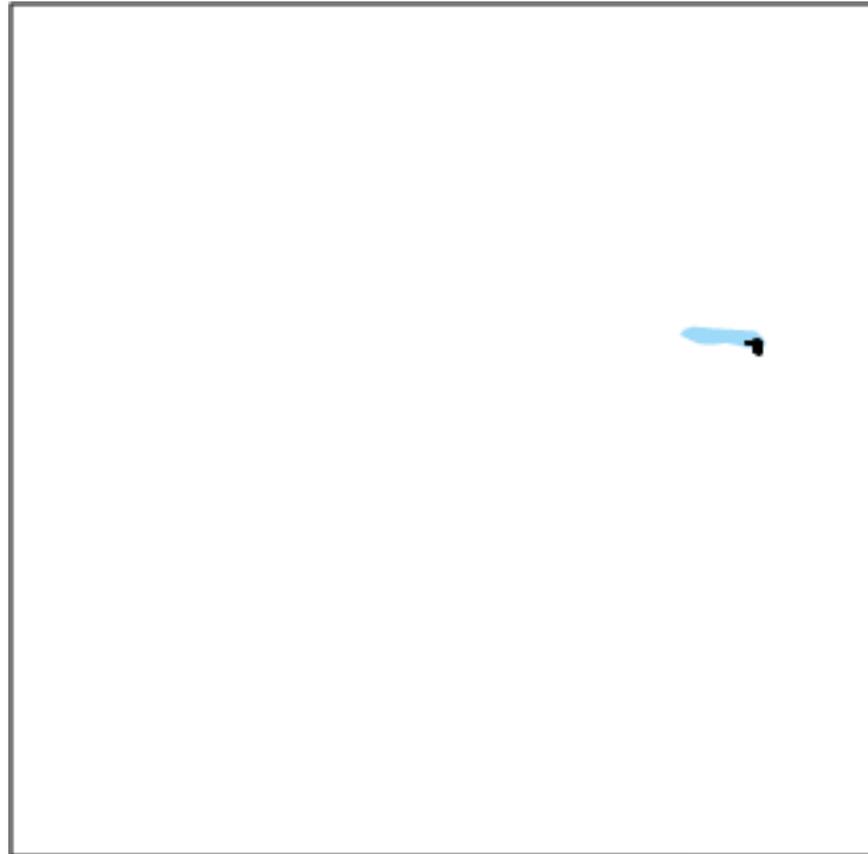
Fig. 2. The multi-scale WRF setup in this study, with locations of fire origins and local meteorological stations used for model validation. Horizontal domain resolutions vary from 32 km (D01) to 500 m (D04).

Table 1
Details of the WRF–Sfire setup.

Domain	Atmospheric domain size $X \times Y \times Z$	Atmospheric horizontal resolution $\Delta X \times \Delta Y$	Atmospheric vertical grid resolution ΔZ (m)	Fire domain size $X_f \times Y_f$	Fire domain resolution $\Delta X_f \times \Delta Y_f$
D01	$120 \times 96 \times 37$	32 km $\times$ 32 km	20–2000	–	–
D02	$121 \times 97 \times 37$	8 km $\times$ 8 km	20–2000	–	–
D03	$137 \times 105 \times 37$	2 km $\times$ 2 km	20–2000	–	–
D04	$125 \times 105 \times 37$	500 m $\times$ 500 m	20–2000	3125×2625	20 m $\times$ 20 m

Kochanski et al.,2013, Real time simulation of 2007 Santa Ana fires, Forest Ecology and Management (294) 136-149

Total PM [mg m^{-3}]

2 4 6 8 10 12 14

Date: 2007-10-21
Time = 19:30:00

Plume Height [m]

25 50 75 100 125 150 175 200 225 250 275 300 325
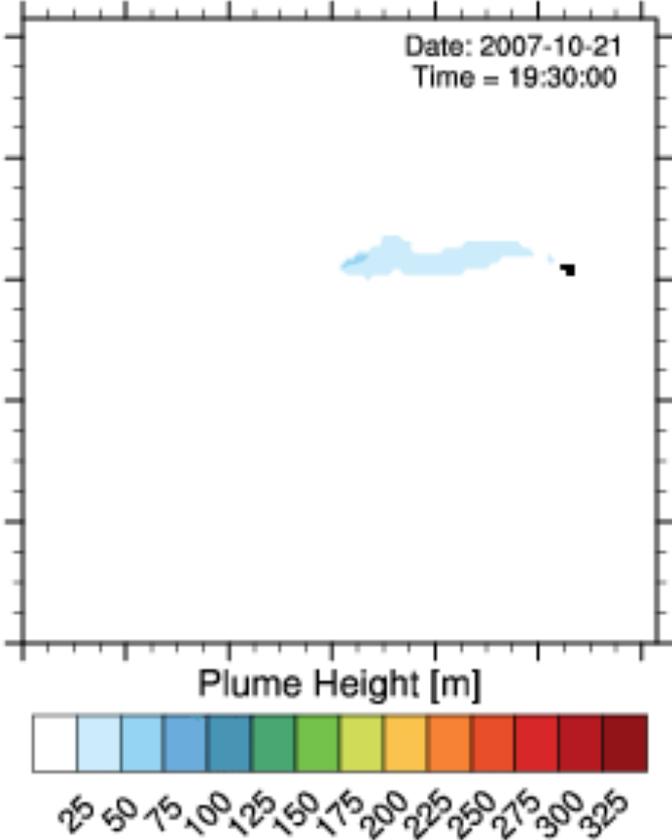
Next Steps

- Run Barker Canyon Fire
- Integrate WRF-Fire into Bluesky
  - Fire area burned prediction
  - Plume height prediction (could be stage 2)
- Run AIRPACT framework w/ and w/o WRF-Fire mods
- Evaluate with Satellite observations
- Repeat steps 1-4 for a forest fire (Table Mtn)

Stage 2 (requires competitive proposal and user cost share)

- Incorporate nesting from UW WRF to WRF-Fire
- Develop scripts to automate WRF-Fire runs within AIRPACT domain in near real time
- Use smartfire to locate real time fires and run WRF-Fire