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BurnPro 3D

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CALFIRE Smoke and Fire Modeling for Prescribed Fire in Napa

Ilkay Altintas and Leticia Lee

Presentation for 7NRP, San Diego
May 7, 2026

SCIL
Societal Computing and Innovation Lab

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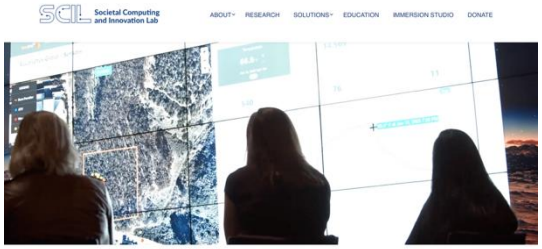

- The Societal Computing and Innovation Lab (SCIL) is led by Dr. Ilkay Altintas and powered by a dedicated team of over 50 students, scientists, engineers, technologists, and practitioners.
- It is housed at the San Diego Supercomputer Center at the Halicioğlu School of Data Science and Computing.
- Informed by cutting-edge scientific discoveries, SCIL pioneers innovation pathways to address complex societal challenges.
- At the heart of SCIL's approach, is a commitment to moving from use-inspired problems to scalable, real-world solutions.

UC San Diego
SCHOOL OF COMPUTING, INFORMATION AND DATA SCIENCES

SAN DIEGO SUPERCOMPUTER CENTER

SCIL'S WIFIRE Program

WIFIRE Program

- Co-develop solutions with the fire management community
- Advance technologies using cutting-edge science and data
- Deliver tools that match the scale and complexity of wildland fire

BurnPro3D

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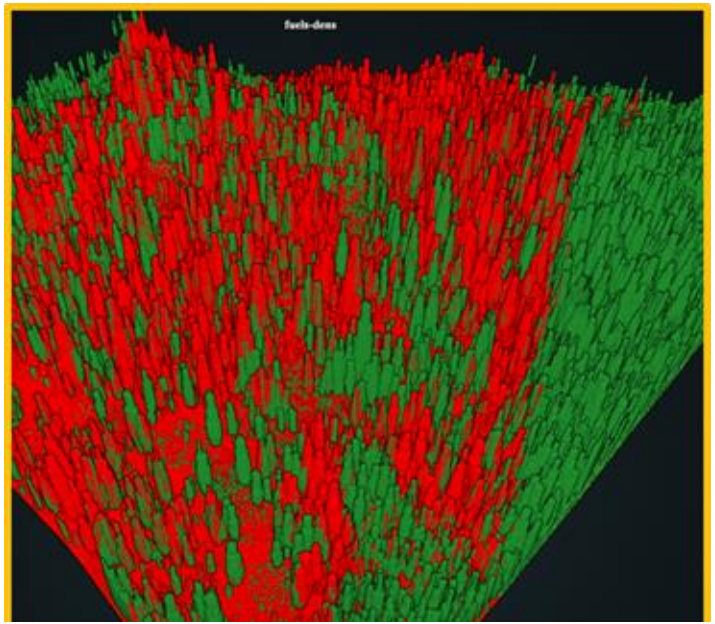
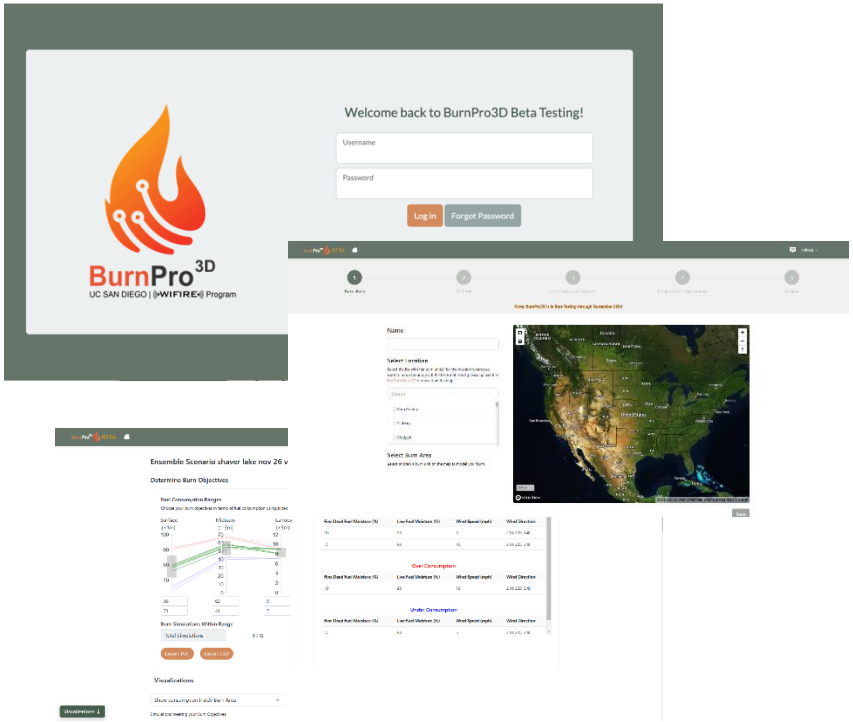


The BurnPro3D platform is designed to give users easy access to next-generation fire science to plan and implement prescribed burns at scale.

BurnPro3D partners and funders



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USGS science for a changing world

FOREST SERVICE US DEPARTMENT OF AGRICULTURE

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BurnPro3D Workflows on NRP

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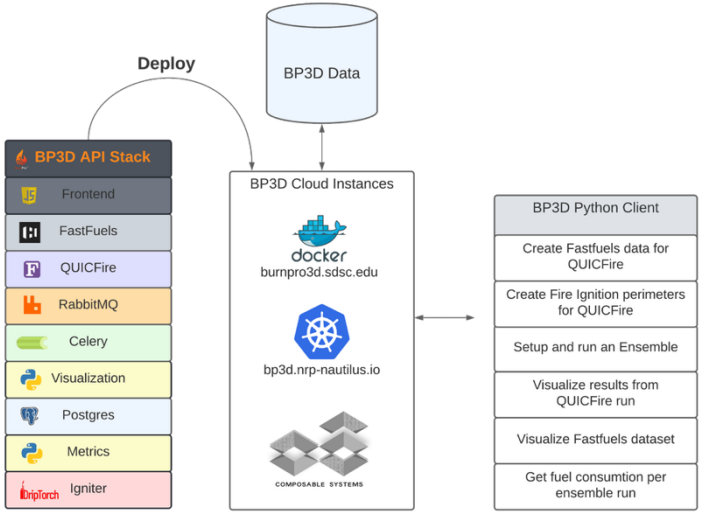
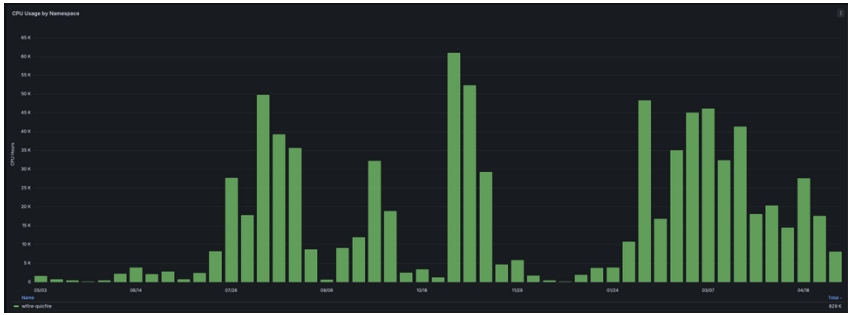


wifire-quicfire - 900K CPU hours over the last 12 months



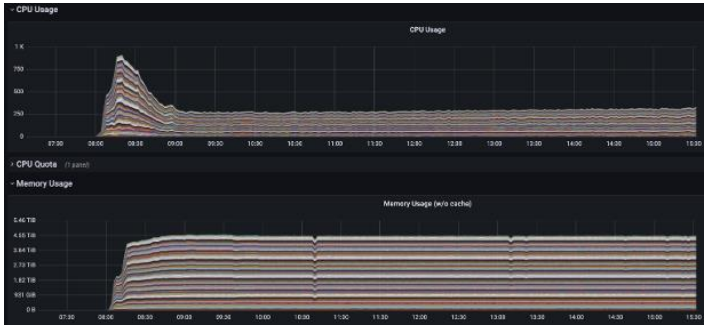
1.28 M CPU hours since 2023

High-throughput ensemble modeling to evaluate ignition, weather, fuel, and operational scenarios simultaneously.

- Dynamic bursty workloads 100s of concurrent jobs across distributed 100s-1000s CPU cores
- Mix of long-running and short-running ensemble simulations with different scheduling and orchestration requirements
- Memory-intensive workloads reaching multi-terabyte RAM scale (~5–6 TB)
- Network and data intensive requiring high-bandwidth (~1.8 GB/s sustained storage bandwidth)
- Simulation campaigns that generate large intermediate and output datasets requiring efficient caching, staging, and data lifecycle management
- Interactive and operational downstream uses, including visualization, prescribed fire planning, and agentic AI.

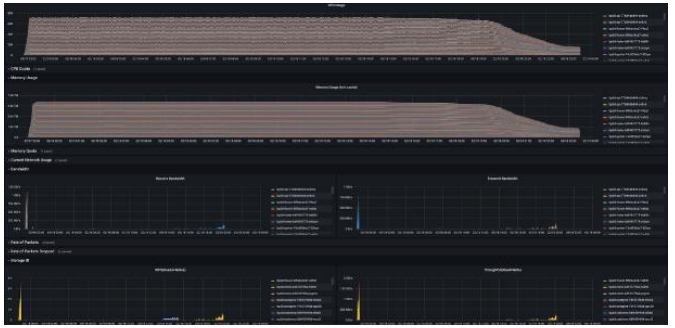
Example Workloads on Nautilus

Heterogenous 3D Fuels Data



- Stress test with representative long running simulations
- 210 concurrent runs
- CPUs: ~1k Cores
- RAM: ~5TB
- 24hrs to complete

Uniform Fuels



- Stress test with short running simulations
- 720 concurrent runs
- CPUs: 700 cores
- RAM: ~6TB
- Bandwidth: ~1GB/s
- Storage I/O Bandwidth: ~1.8GB/s
- 1hr to complete

Using BurnPro3D for Prescribed Fire and Smoke Modeling New Vineyards

Wildfire Damage on Wineries

Understanding smoke taint

- Wildfires cause destruction of crops, vineyards, tasting rooms, and barns
- Wildfires release volatile organic compounds (VOCs) that can damage grapes leading to “smoke taint” in wines
- In 2020, wildfires in California caused $3.7 billion (estimated) in losses to the wine industry

Photo credit: The New York Times

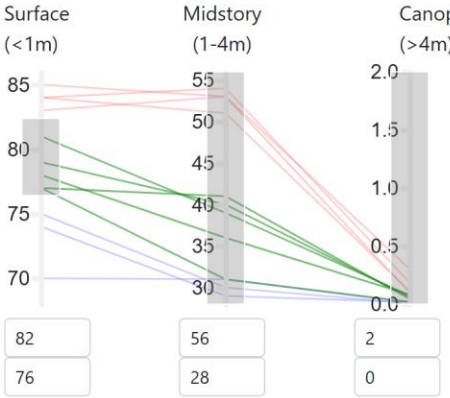
Vineyards as fire breaks?

- Prescribed fires can be used to mitigate wildfires and subsequent damage to the wine industry
- An effective communication and planning tool is needed so CALFIRE and growers can work together to reduce wildfire risk and protect crops
- BurnPro3D and QUIC-smoke could be used to plan prescribed burns so that the prescribed fire smoke will not affect the grapes

Credit: Jane Tyska/Digital First Media/East Bay Times via Getty Images

Ensemble Scenario Los Posadas

Determine Burn Objectives



Burn Simulations Within Range

Total Simulations 5 / 12

Export PDF Export CSV

Environmental Conditions

Consumption Meeting Objectives

Fine Dead Fuel Moisture (%)	Live Fuel Moisture (%)	Wind Speed (mph)	Wind Direction
6	120	1, 3	225
8, 10, 12	120	3	225

Over Consumption

Fine Dead Fuel Moisture (%)	Live Fuel Moisture (%)	Wind Speed (mph)	Wind Direction
6, 8, 10, 12	120	5	225

Under Consumption

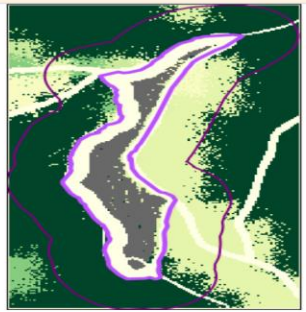
	Burn Outputs			Burn Inputs		
		Surface	Midstory	Canopy	Fine Dead Fuel	Live Fuel	Wind

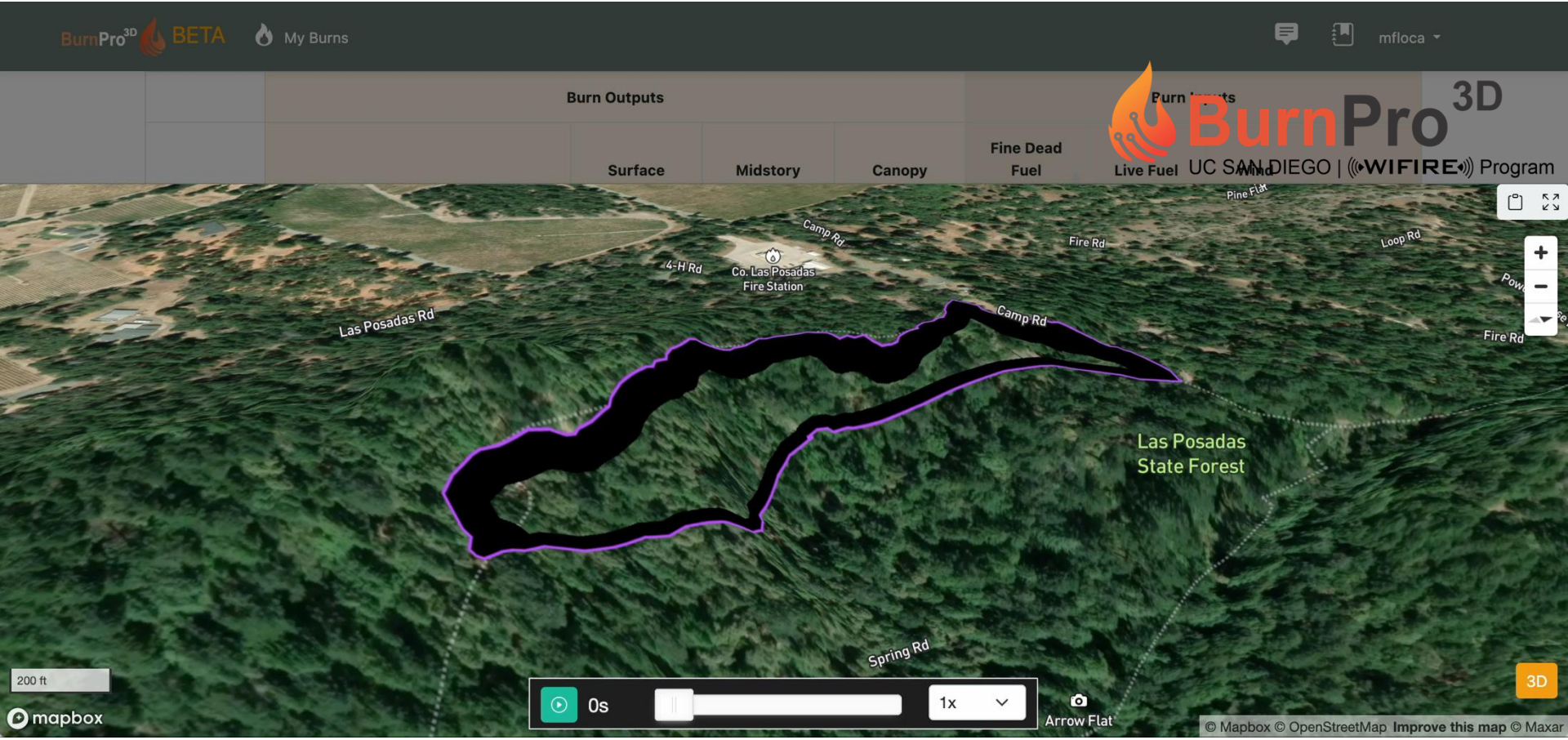
Outputs

burnpro3d.sdsc.edu/u/ensemble.html?ensemble=87e2b05a-5d0e-4b53-ade3-a9fe567e875c

School | Action required

BurnPro3D BETA | My Burns | mfloca

	Burn Outputs				Burn Inputs			
	Fire Perimeter	Surface Consumed (%)	Midstory Consumed (%)	Canopy Consumed (%)	Fine Dead Fuel Moisture (%)	Live Fuel Moisture (%)	Wind Speed (mph)	Wind Direction
Create Plots / View Timelapse / Create 3D Fuels		77	31	0	6	120	1	225
Create Plots / Create Timelapse / Create 3D Fuels		83	53	0	12	120	5	225


BurnPro3D BETA
My Burns
mfloca
Burn Outputs
Surface
Midstory
Canopy
Fine Dead Fuel
Live Fuel
BurnPro 3D
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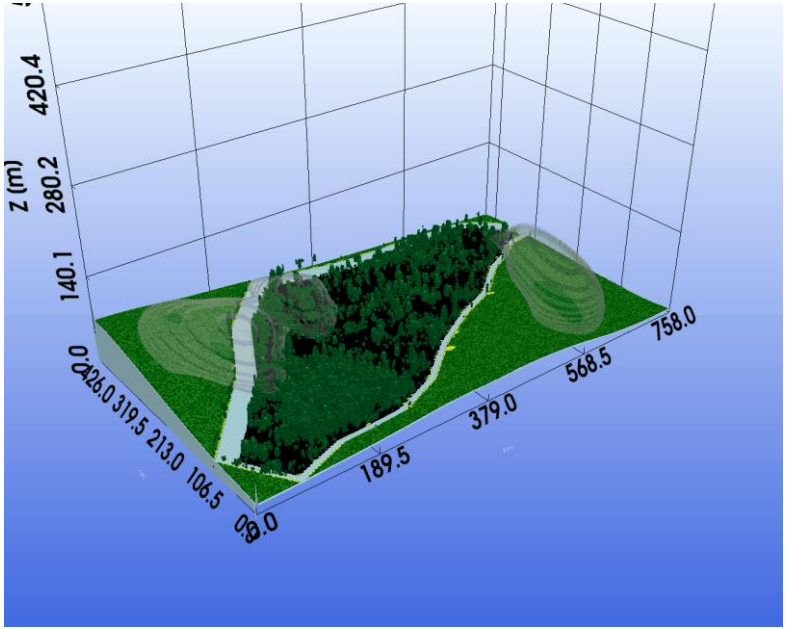
Pine Flat
Camp Rd
Fire Rd
Loop Rd
4-H Rd
Co. Las Posadas Fire Station
Las Posadas Rd
Camp Rd
Fire Rd
Las Posadas State Forest
Spring Rd
200 ft
mapbox
0s
1x
Arrow Flat
3D
© Mapbox © OpenStreetMap Improve this map © Maxar

Smoke Calculations using QUIC-SMOKE

- Lagrangian random walk model
- Atmospheric and fire-induced turbulence
- Dispersion of gasses (CO, water) and particulate ($PM_{2.5}$)
- Gravitational settling for particulate
- Varying (time and space) winds and emissions from QUIC-Fire
- Nested domain capability (high-resolution for burn plot, lower out to 100 km)



Napa Case Study

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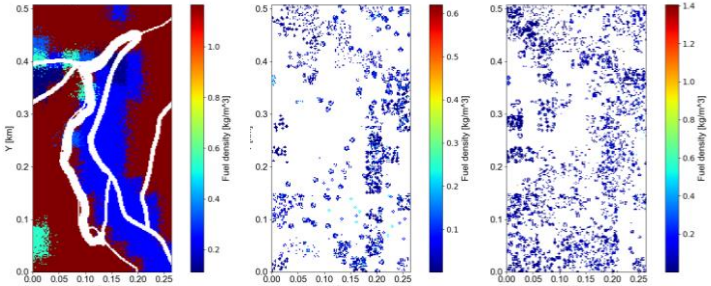
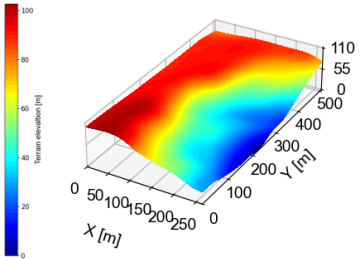
3D Fuels

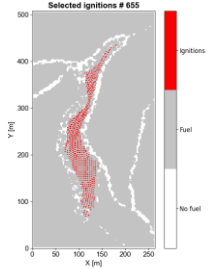
(density, moisture, drag)
changes with space and height



0-1 m 2-3 m 4-5 m

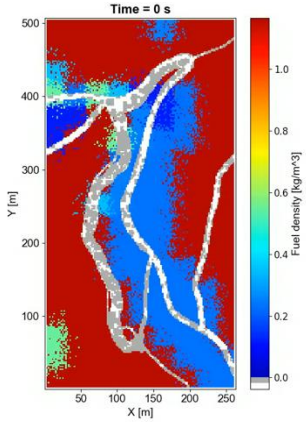
Topography and Ignitions



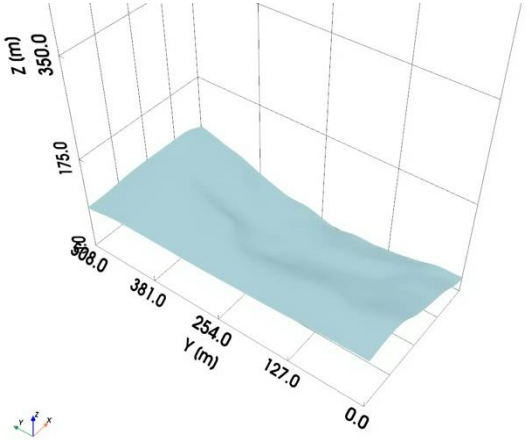


Simulation Results

Fuel Consumption



Updrafts

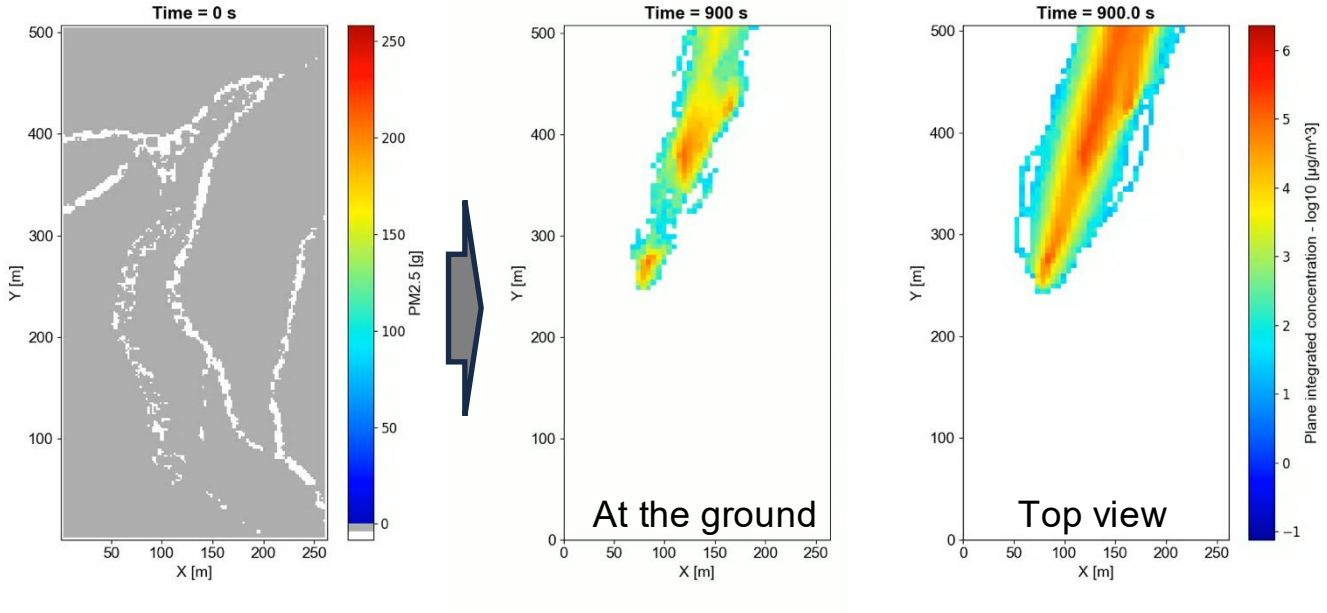


Resolves evolving (space and time) updrafts that modify winds and carry emissions downwind.

Emissions – $PM_{2.5}$

Amounts generated

Smoke transport



No need to specify mean emitted amounts

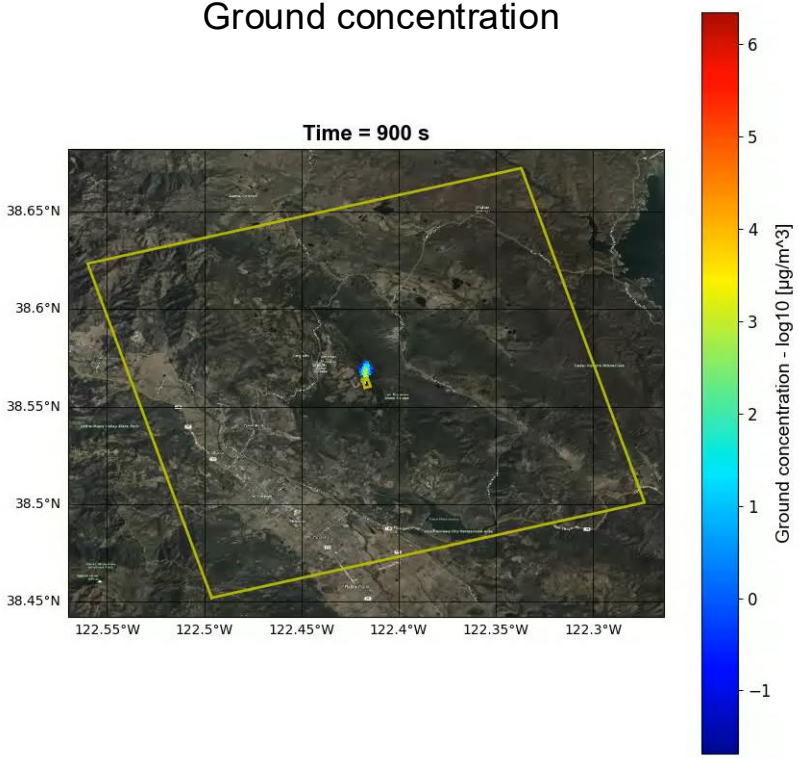
Includes transients

Winds: 1.34 m/s 225 deg @20 ft

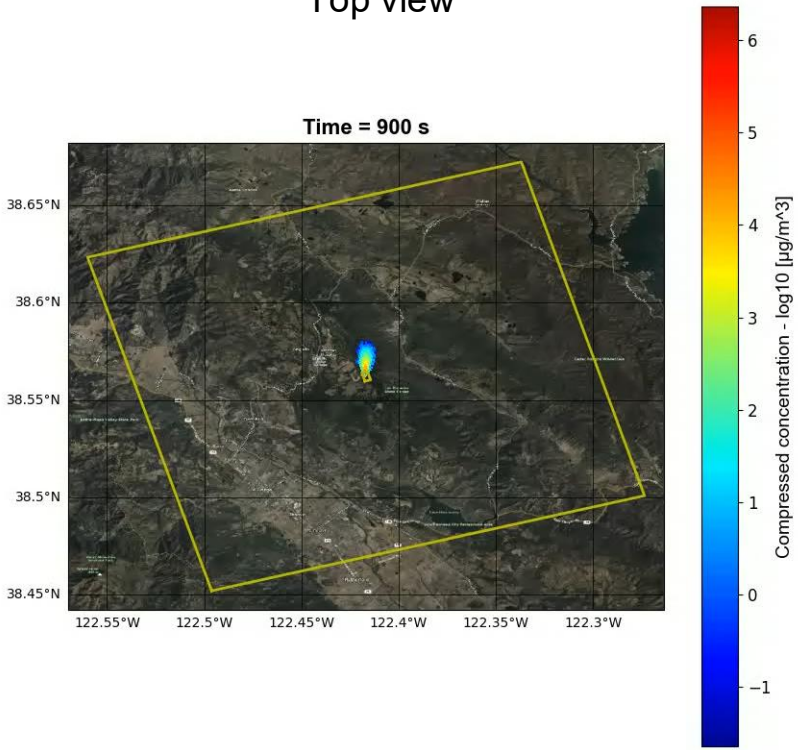
Slide from Sara Brambilla,
Los Alamos National Laboratory

Smoke Dispersion: Outside the burn unit

Ground concentration



Top view



Slide from Sara Brambilla,
Los Alamos National Laboratory

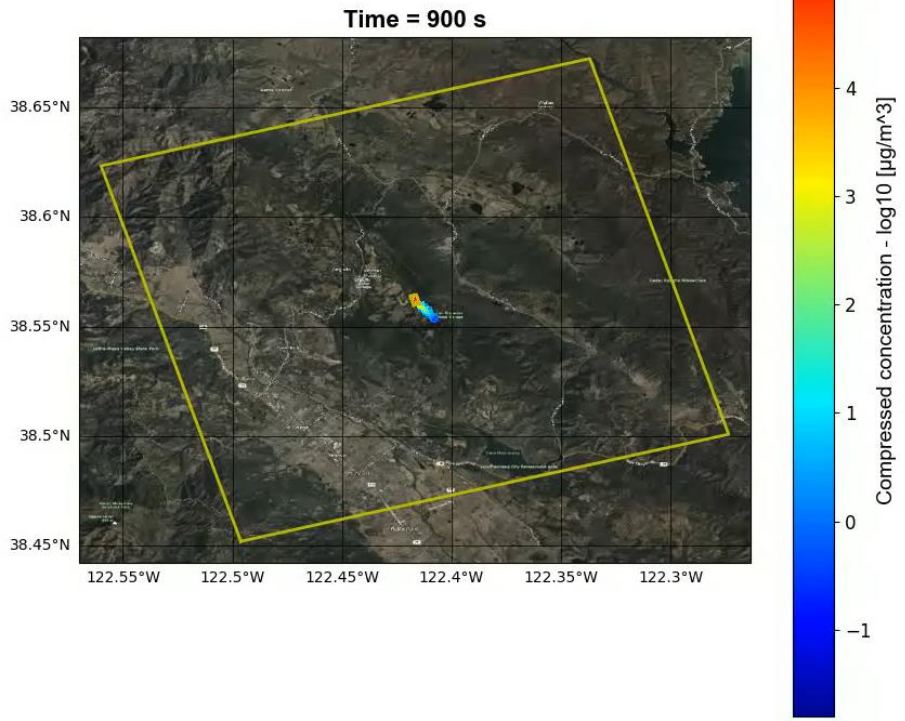
https://meteologix.com/mw/satellite/liberty/satellite-smokecheck-superhd-5min/20220302-

Smoke Dispersion with Real Measurements

RAWS measurements

Local time	Wind speed	Wind direction
10:00	1.34 m/s	3 deg
11:00	1.79 m/s	46 deg
12:00	1.34 m/s	28 deg
13:00	0.9 m/s	27 deg
14:00	1.34 m/s	51 deg
15:00	0.9 m/s	7 deg

Top view



Lessons Learned and Next Steps

Lessons Learned

- **NRP enabled operational-scale ensemble fire modeling** capacity necessary to support large ensemble workflows at practical time scales.
- **Elastic infrastructure** was critical for dynamic bursty wildfire workloads.
- **Large-memory workflows became feasible** to orchestrate at scale, making high-resolution 3D fire and smoke modeling operationally viable.
- **High-bandwidth data movement** was essential for outputs that required network throughput at GBs.
- **NRP supported heterogeneous workflow patterns**, useful for both research and production use.
- **Containerized services improved portability and reproducibility.**
- **NRP accelerated innovation to operations transition** for BurnPro3D in applications with CAL FIRE and vineyard stakeholders.
- **Integrated AI-ready infrastructure matters** for BurnPro3D workflows increasingly combining simulation outputs, visualization systems, and emerging agentic AI approaches.

Future Work

- **Turning BurnPro3D into an operational tool**
  - BurnPro3D is evolving toward workflows that combine simulation, visualization, operational planning, and agentic AI systems into integrated decision-support environments
  - Using the models and visualizations to help practitioners and inform stakeholders
  - Practitioner facing features and workflows involving agentic assistants for burn planners, incident personnel, growers, and dther stakeholder
- **Continuing to use NRP for research and development**
  - Ongoing model development aims to improve fire behavior representation, smoke transport accuracy, fuel characterization, andoperational reliability
  - Advancing high-resolution 3D fuels workflows
  - Testing efficacy of visualizations and outputs
  - Scalability and infrastructure-level intelligence, e.g., BanditWare →

Taina Coleman, Hena Ahmed, Ravi Shende, Ismael Perez, and Ilkay Altintas. 2025.
BanditWare: A Contextual Bandit-based Framework for Hardware Prediction.
In Proceedings of the 34th International Symposium on High-Performance Parallel and Distributed Computing (HPDC '25). Association for Computing Machinery, New York, NY, USA, Article 40, 1–6.
https://doi.org/10.1145/3731545.3743643

- **Expanding smoke-impact applications**
  - Current vineyard smoke-taint studies illustrate a broader direction toward operational smoke forecasting and community impact modeling.

Thank you!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