

Using Cyberinfrastructure for Wildfire Resilience

- A Scalable Data-Driven Monitoring and Dynamic Prediction Approach -



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Good to be here!



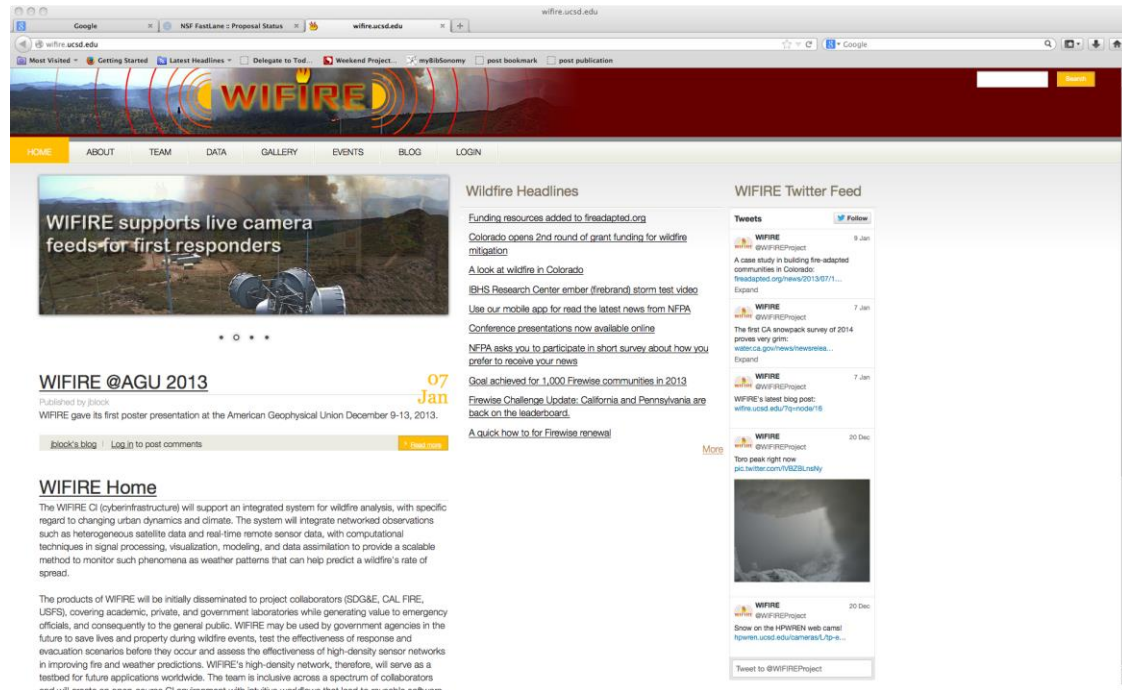
WIFIRE was funded by NSF

- WIFIRE is funded by NSF 1331615 under CI, Information Technology Research and SEES Hazards programs.
- NSF news release: http://www.research.gov/research-portal/appmanager/base/desktop?nfpb=true&pageLabel=research_news&nfls=false&noDePath=/researchGov/News/Common/InwakeofHurricaneSandyOklahomatornadoesNSFawards32millioninhazardssustainabilitygrants.html



WIFIRE is on the web!

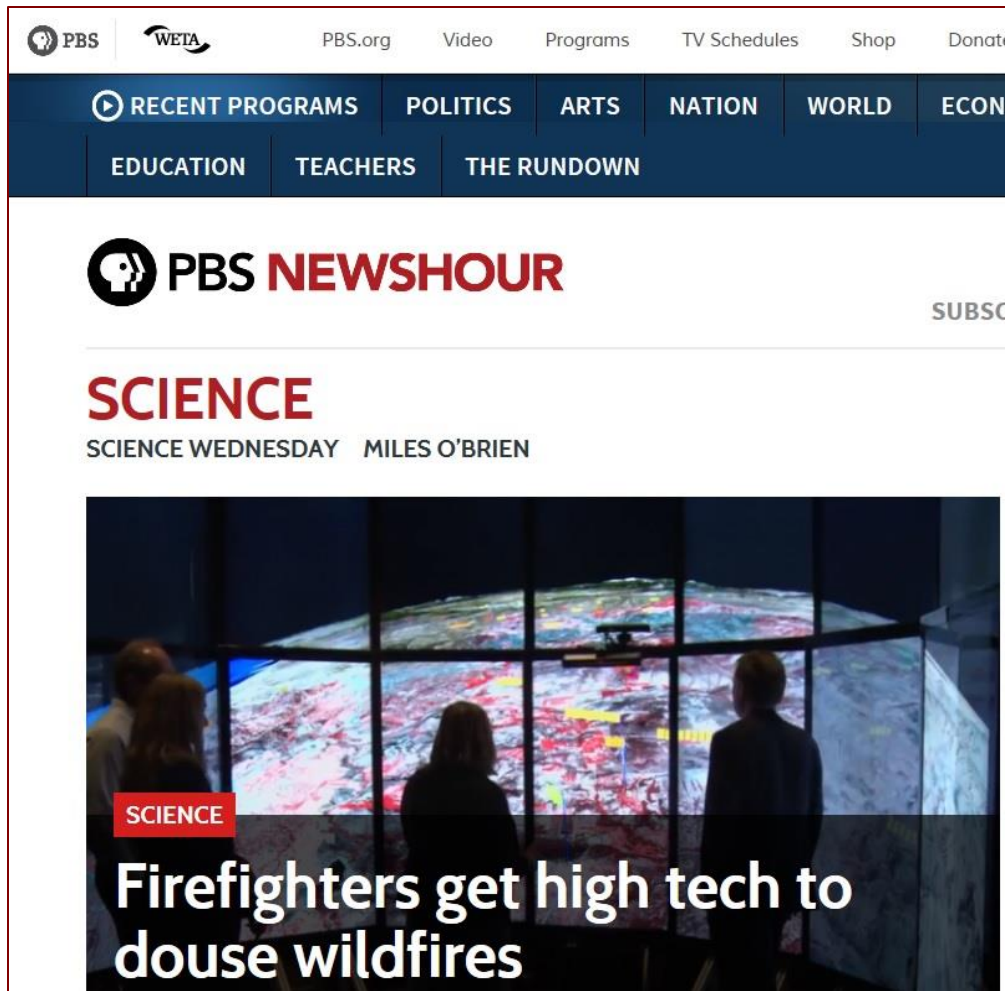
- Website:
<http://wifire.ucsd.edu>
- Twitter:
[@WIFIREProject](https://twitter.com/WIFIREProject)



What is WIFIRE?

A Scalable Data-Driven Monitoring, Dynamic Prediction and Resilience Cyberinfrastructure for Wildfires

(WIFIRE)

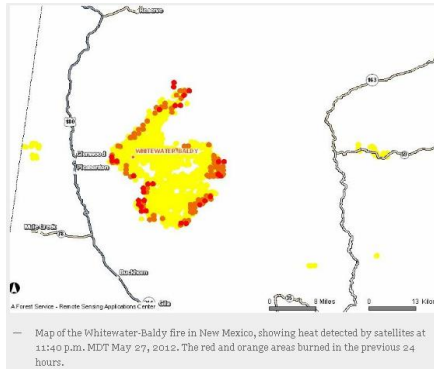


Development of:

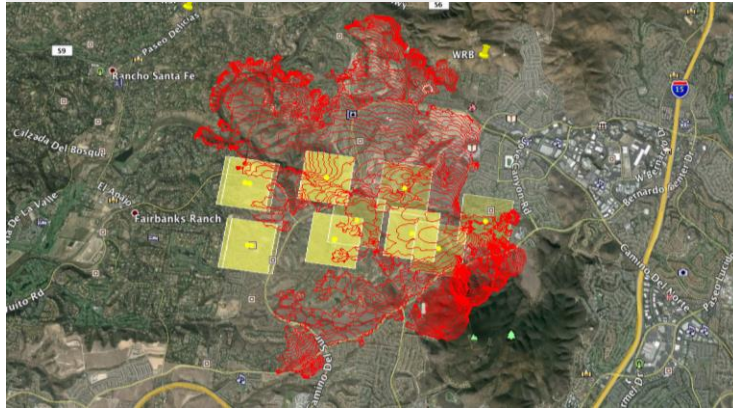
“cyberinfrastructure” for
“analysis of large
dimensional
heterogeneous real-time
sensed data” for fire
resilience *before, during*
and *after* a wildfire

Fire Data Today

Decision making for wildfire fighting and disaster management based on heterogeneous data:



Satellite data



Photograph by Mark Thiessen

Wildfire perimeter
Wind
Vegetation
Terrain



What is lacking in disaster management today is...

a system integration of real-time sensor networks, satellite imagery, near-real time data management tools, wildfire simulation tools, and connectivity to emergency command centers

.... before, during and after a firestorm.

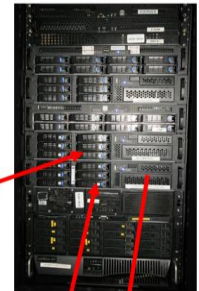
Wildland fire incident



Event-deployed networked sensors



Raw sensor data



Configuration of alert parameters

Computer-generated alerts

Notification to active firefighters about critical environmental changes



Command center



- How can **large dimensional heterogeneous sensor data** be analyzed systematically to a (lower dimensional) format useful for **information processing, real-time monitoring and visualization**?
- How can such data be **combined with existing scientific models** to allow for **prediction of propagating wildfires** and potential future events to **prepare fire fighters and the public** for regions of highest risk?
- What **quality** and **density** of real-time sensors is necessary to **improve both the predictive and preventative capabilities** of current fire models?
- How can such information processing be easily configured, programmed and computed by end-users with various skill levels to **formulate actual real-time data-driven environmental alerts**?

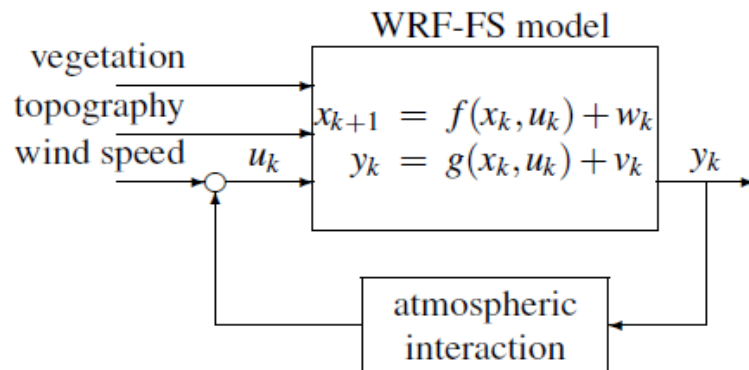
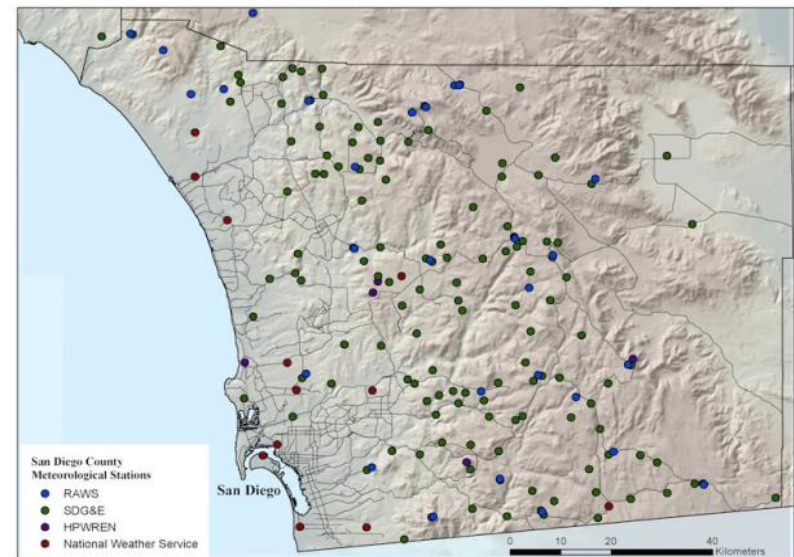


Data to Modeling in WIFIRE

Real-time remote data → Modeling, data assimilation and dynamic wildfire behavior prediction

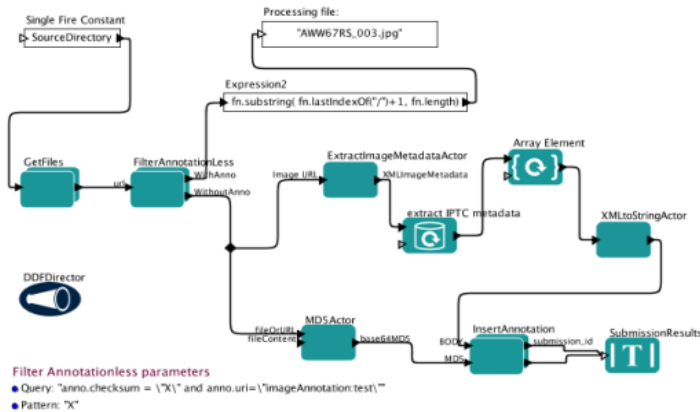
Sensors:

Remotely Sensed Data	Source	Resolution
WRF Atmospheric Model data	SDG&E/UCLA	1-3 km
Meteorological Sensors	SDG&E; HPWREN; RAWS	1/
Mountain-Top Web Cameras	HPWREN/UCSD	1/
MODIS Active Fire Data	USFS	2/
Active Fire Perimeters	US DOI	2/
UAV Imagery	SDSU	E ₂

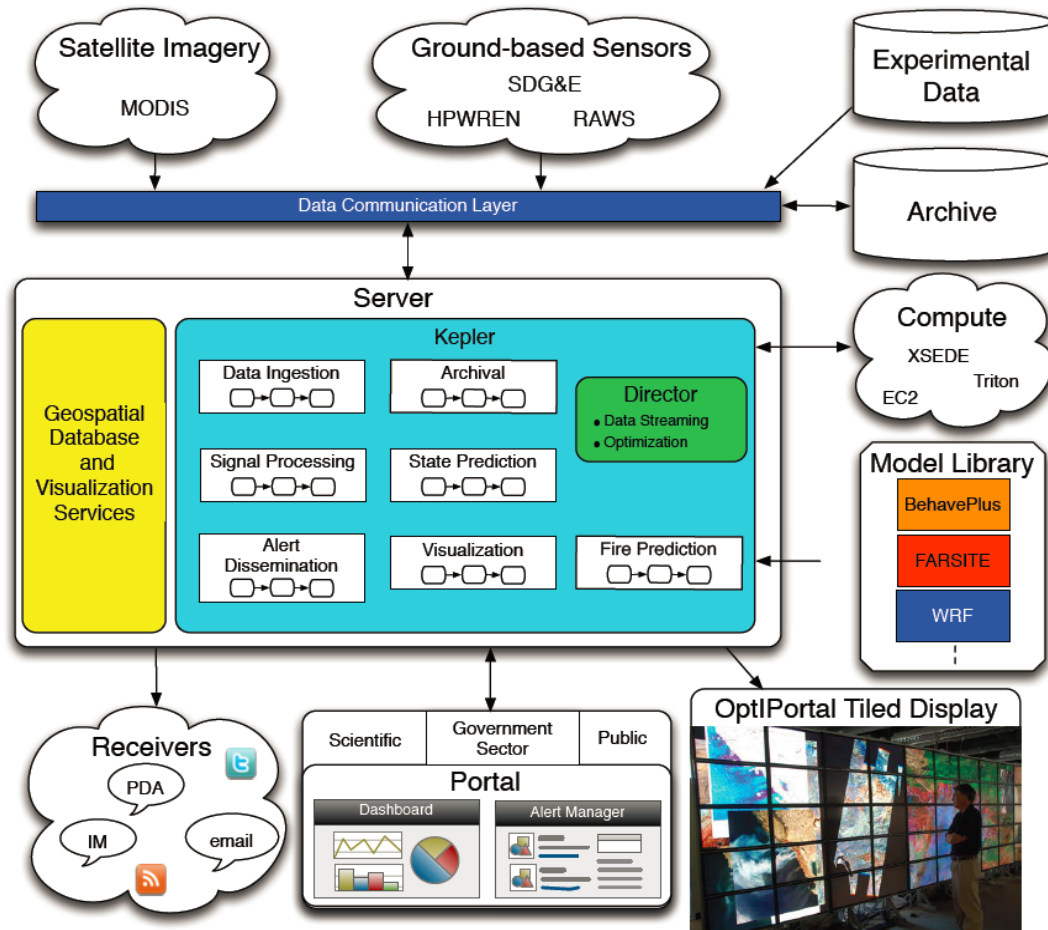


WIFIRE System Integration

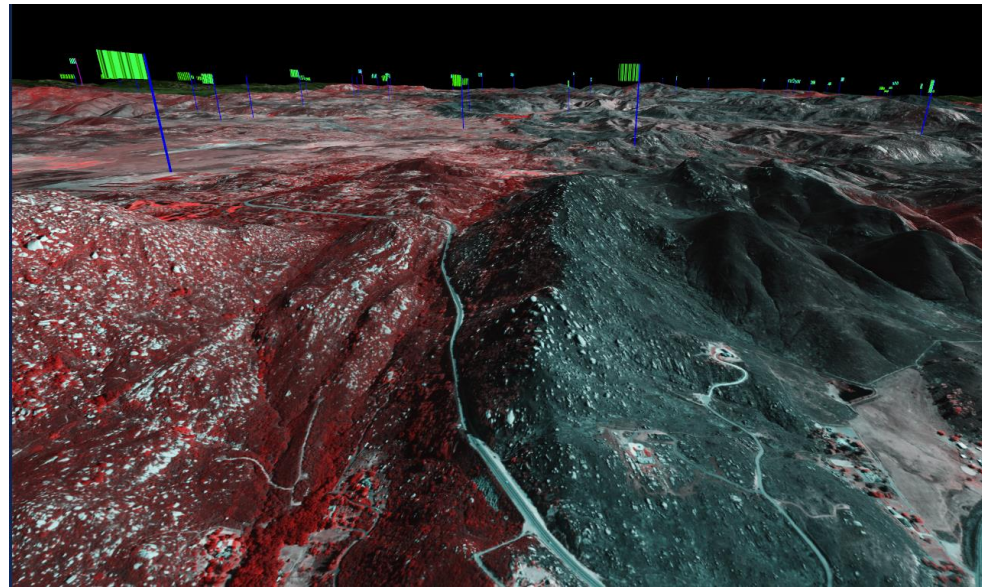
System Integration of sensor data, data assimilation, dynamic models and fire direction and RoS predictions (computations) is based on Scientific and Engineering Workflows (Kepler)



- Visual programming
- Scalable parallel execution
- Standardized data interfaces
- Reuse and reproducibility

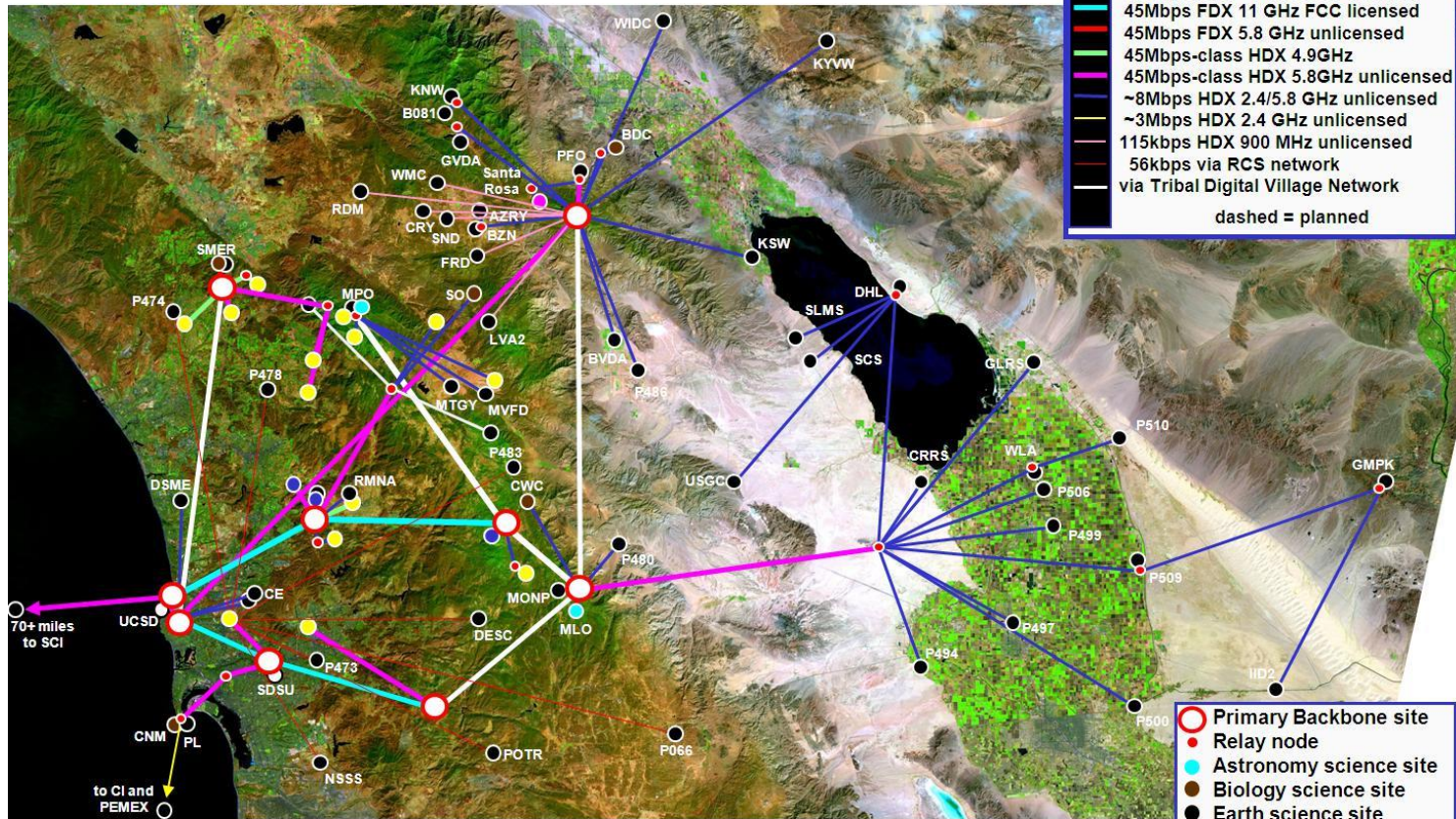


Data Visualization and Dissemination



High Performance Wireless Research and Education Network

HPWREN topology – January 2012



← approximately 50 miles: →

Note: locations are approximate

Ilkay Altintas
Jan. 22, 2015
<http://wifire.u>



Sensor Network

May 14: More than 1.8 million HTTP request from about 9,000 individual IP addresses

High Performance Wireless Research and Education Network

NOTE: Disclaimer and descriptions for contents of and access to this page.

Red Mountain (near Fallbrook) 360 degree panorama



Mount Woodson 360 degree panorama



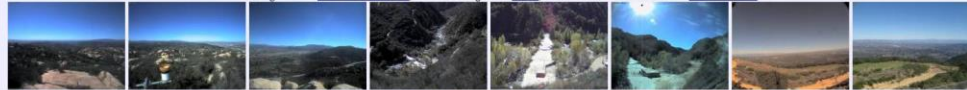
Mesa Grande 360 degree panorama, near North Peak 80+ degree cameras



Mt. Laguna 360 degree panorama, Lyons Peak 360 degree panorama



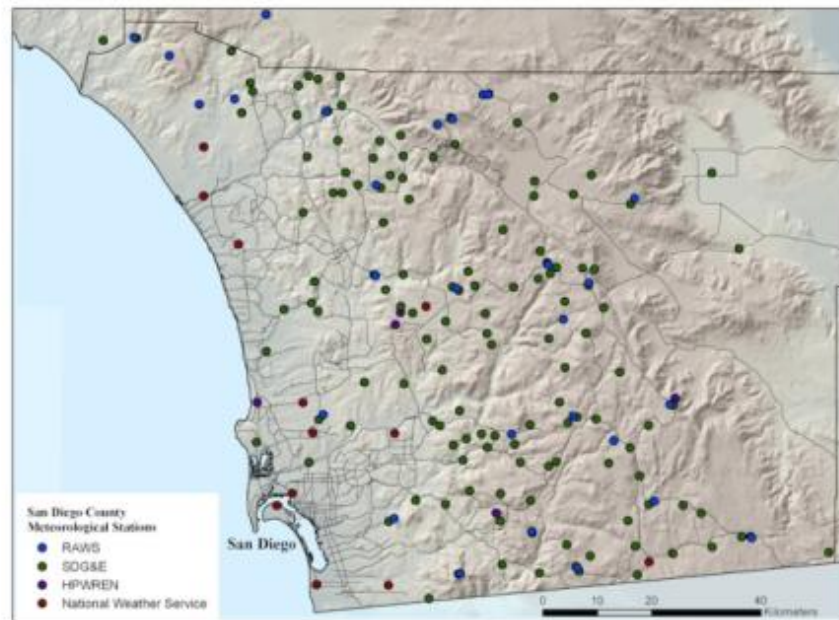
SMER highlands SW, NW, and NE, Santa Margarita river, Santa Monica Mountains Castro Peak



Cabrillo National Monument 80+ degree cameras, tidepools, Visitor Center skyline



Toro Peak W, Palomar Observatory 200", La Cima NW, Ramona CDP AAB SE, La Jolla coast NW, SDSC E, California Wolf Center



<http://hpwren.ucsd.edu/cameras/>

>160 Meteorological Sensors and Growing



May 14, 2014

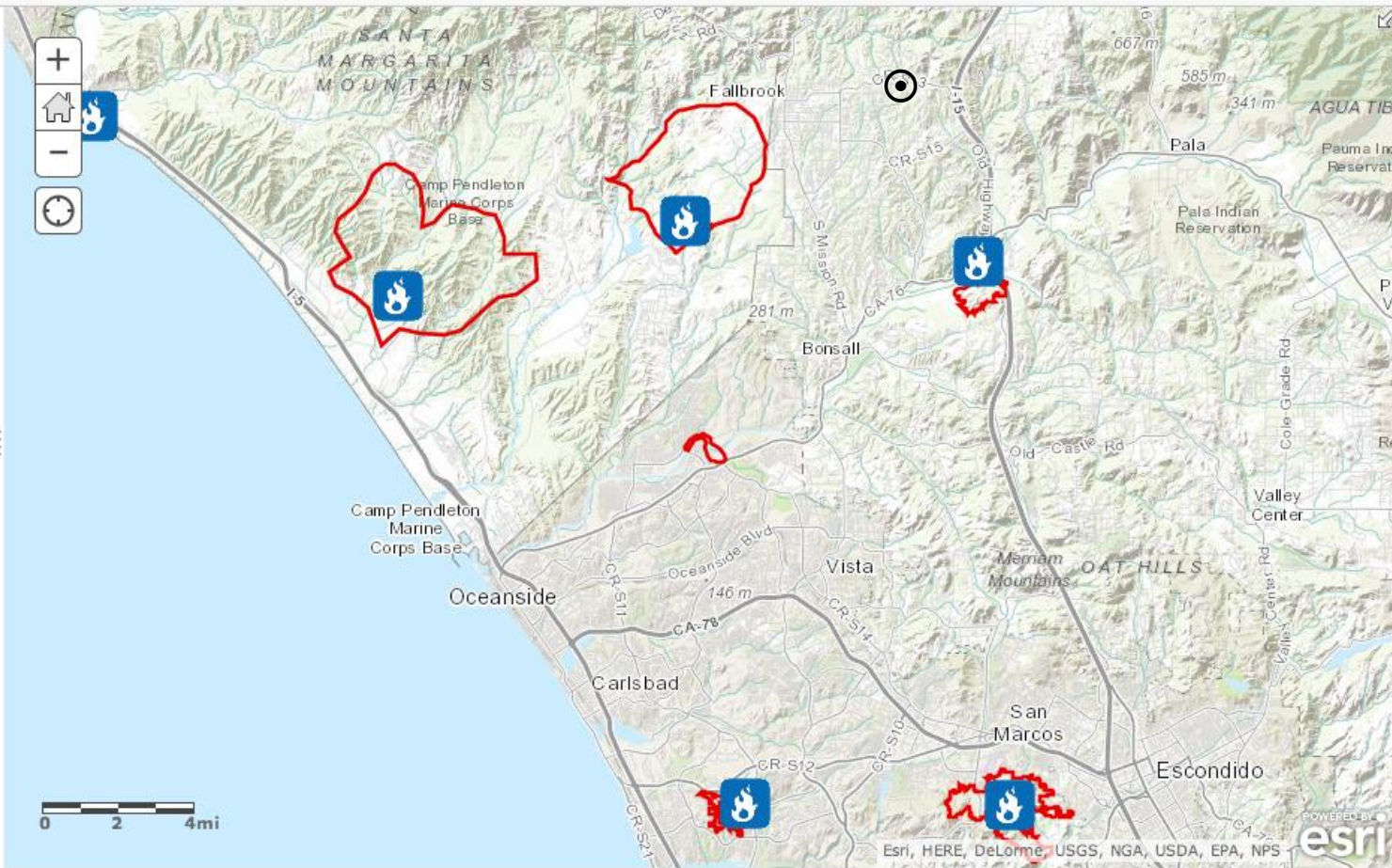
Legend

Localized Hazards

- Earthquake
- Epidemic
- Fire
- Flood
- General Hazard
- Hazardous Material
- Landslide
- Law Enforcement
- Tsunami
- Other

Traffic Control

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May 14th, 2014



- Red Mountain Cams
South (left) "Highway" Fire
SW (center rear) is the "Pointsettia" Fire
West (right) is the "Tomahawk" Fire

To summarize:

Effective systems for real-time acquisition and analysis of wildfire big data can make a huge impact on **wildfire resilience.**

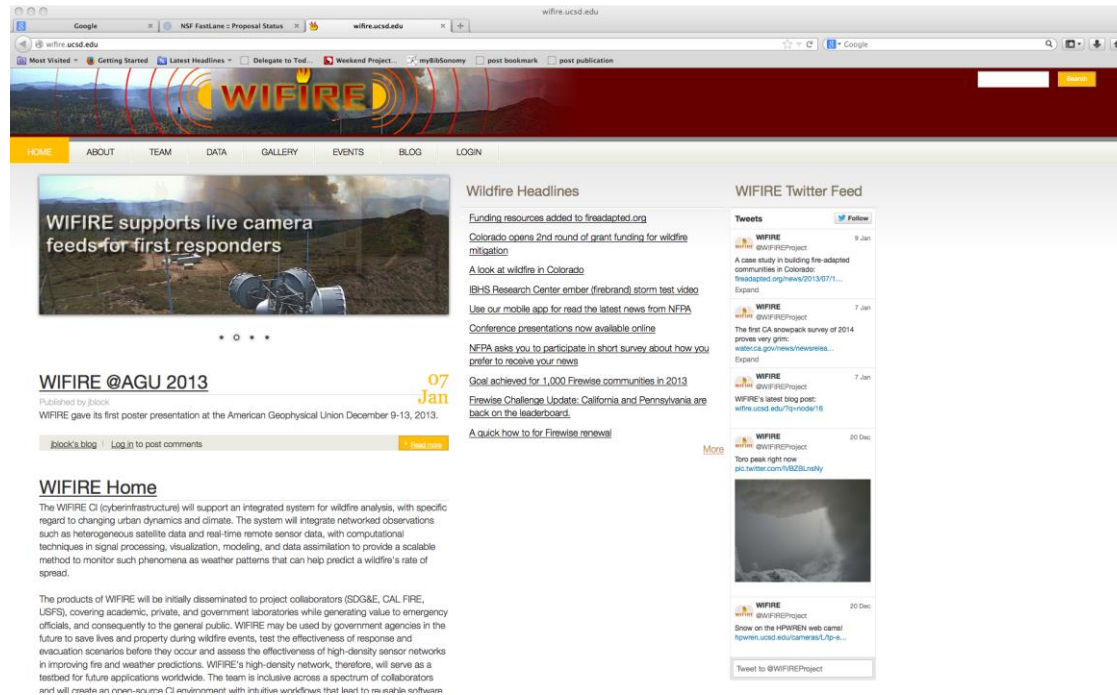
WIFIRE is on the web!

- Website:

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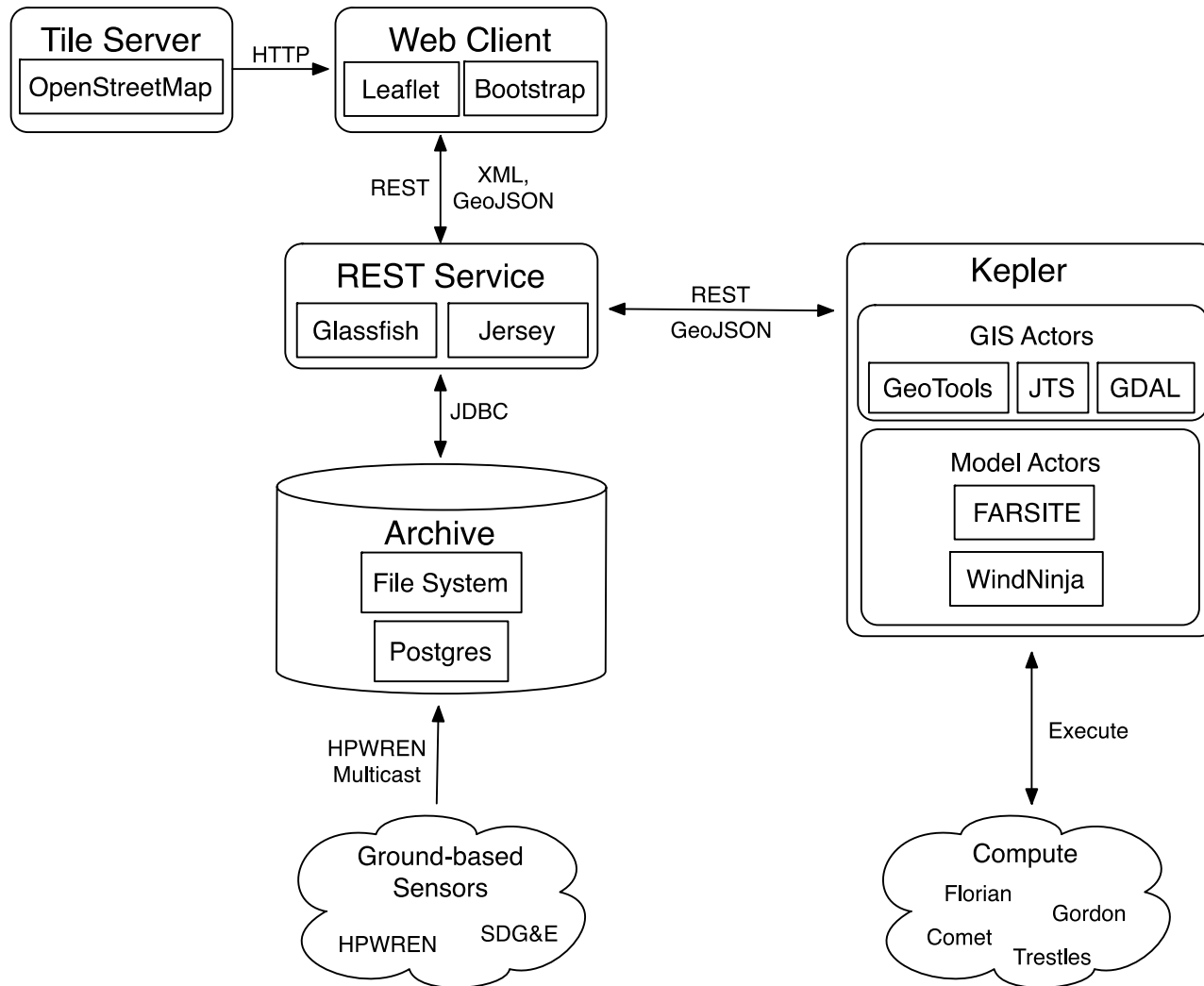
- Twitter:

@WIFIREProject



WIFIRE Architecture and Workflows

WIFIRE Architecture Year 1



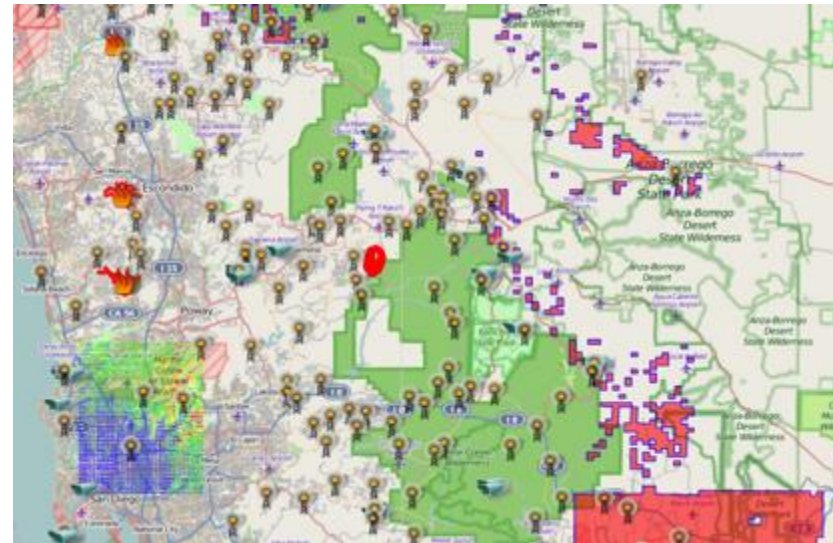
Progress to Date

- Data Catalog
 - Sources
 - Web UI to visualize data
- Use Case Applications
 - Santa Ana conditions
 - Fire growth models
- Modeling Workshop, Jan. 12-13, 2014



Data Integration and Access

- Data sources formally described using XML-based ontologies and cataloged
- Data merged from multiple sources into a single, unified model
 - Measurements from > 150 weather stations
 - Color and Near-IR images from > 100 cameras
 - Fire perimeters, e.g., InciWeb , GeoMac, SANDAG
 - Model output, e.g., FARSITE, Firefly, WindNinja
- Web-based access via REST
 - A unified interface for querying data
 - Offers multiple formats
 - XML
 - GeoJSON
 - WindNinja
 - FARSITE and Firefly (coming soon)



Data Communication Interface

- Data is
 - **extracted, quality-controlled, and stored**
 - available through REST-based **web service interfaces**
 - homogenously **integrated** from multiple sources
- Initial goal: Up-to-the-**minute** coverage availability
 - Up-to-the-moment coverage is a future goal.
- Proposed fire-modeling interface is uniform over modeled and real fires



Example Data Queries - Generalized

- A list of all sensor types
- Get metadata for specific sensor types
- A list of all data-sources (instances of sensor types)
- Get all data-sources within a bounding box, and observe air temperature, and a specific form of Average Wind Direction.



Example Queries – Specific to an Event

Q1: What is the current temperature at all the stations?

Q2: What was the temperature on Lyons Peak at 1:30pm on May 14, 2014?

Q3: What station is the closest to 32.614, -116.234?

Q4: What was the wind speed and direction for the station in Q3 in the WindNinja format?

Kepler Workflows for WIFIRE Use Cases

www.kepler-project.org

- Kepler is an open source, graphical environment for combining and automating Cyberinfrastructure components
 - Execute models
 - Read real-time and archived weather station measurements
 - GIS components to pre- and post-process data
 - Parallel execution
 - Provenance for execution history



Use Case: Santa Ana Conditions

- *Santa Ana* winds lead to dangerous fire conditions in San Diego County
 - Oct. 2003:
 - >700,000 acres burned
 - Oct. 2007:
 - >500,000 acres burned
- **Goal:** determine regions in San Diego County experiencing Santa Ana Winds
- **Solution:** Use *WindNinja* to compute wind conditions, post-process to find Santa Ana regions

Santa Ana defined by:

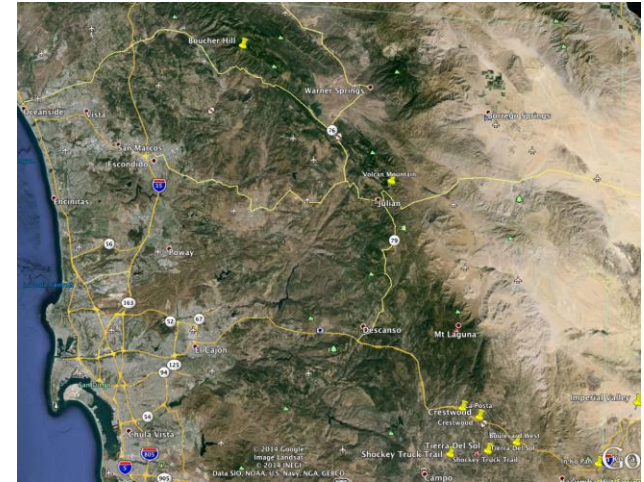
Wind direction $> 10^\circ$ and $< 110^\circ$

Wind speed $> 25\text{mph}$

Relative humidity $< 25\%$

HPWREN Real-Time Weather Alerts

- Weather stations measurements monitored Santa Ana conditions
- Alerts sent via email



Santa Ana condition real-time weather sensor alert
Santa Ana condition real-time weather sensor alert
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• Hans-Werner Braun	• 12/27/14 10:42 AM
• Hans-Werner Braun	• 12/27/14 10:52 AM
• Hans-Werner Braun	• 12/27/14 11:12 AM
• Hans-Werner Braun	• 12/27/14 11:22 AM
• Hans-Werner Braun	• 12/27/14 12:52 PM
• Hans-Werner Braun	• 12/27/14 1:13 PM
• Hans-Werner Braun	• 12/27/14 1:39 PM
• Hans-Werner Braun	• 12/28/14 7:20 AM
• Hans-Werner Braun	• 1/1/15 2:16 PM

From Hans-Werner Braun★

Subject Santa Ana condition real-time weather sensor alert

To l3@hpwren.ucsd.edu★



1/7/

BMR: RH=15.9 WD=93 WS=28 AT=62 20150107.070022 Big Black Mountain
More details at <http://hpwren.ucsd.edu/Sensors/>



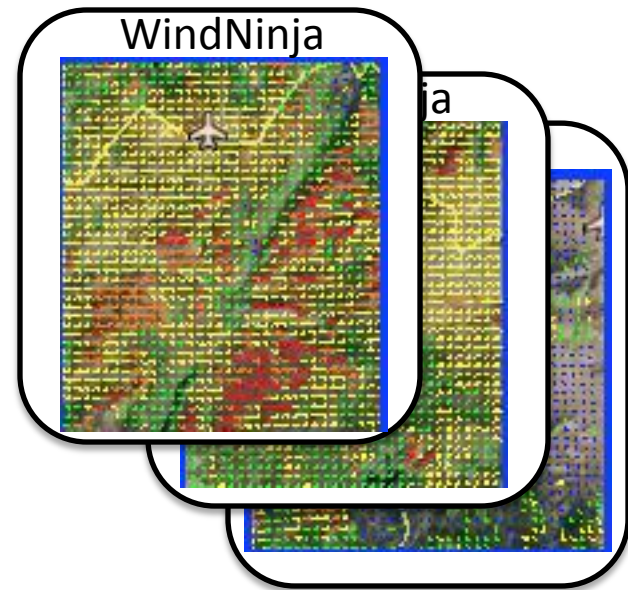
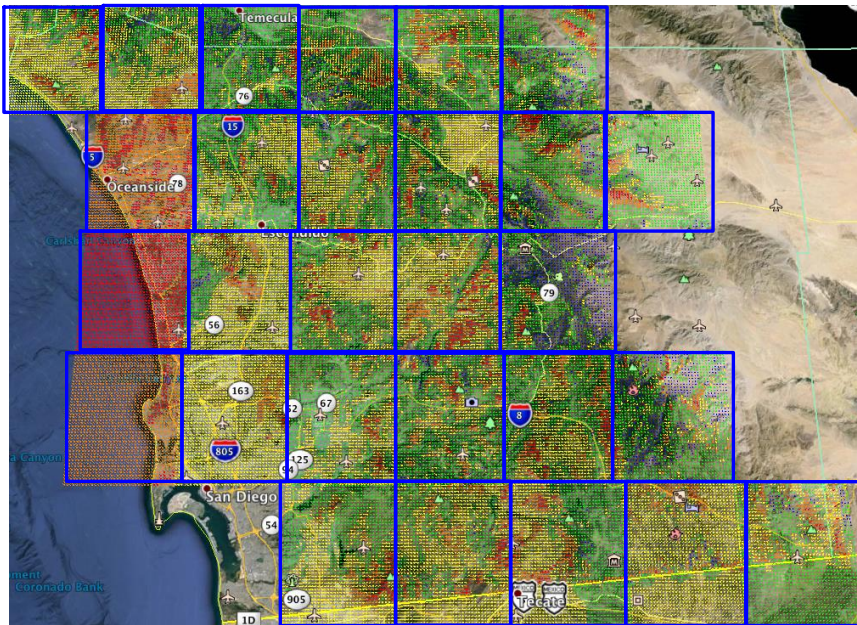
Wind Conditions Around Weather Stations

- Run WindNinja to model wind conditions
- Inputs:
 - Topography & vegetation
 - Weather station measurements
 - Spatial and temporal ranges
 - etc.
- Outputs:
 - Wind direction & speed over region



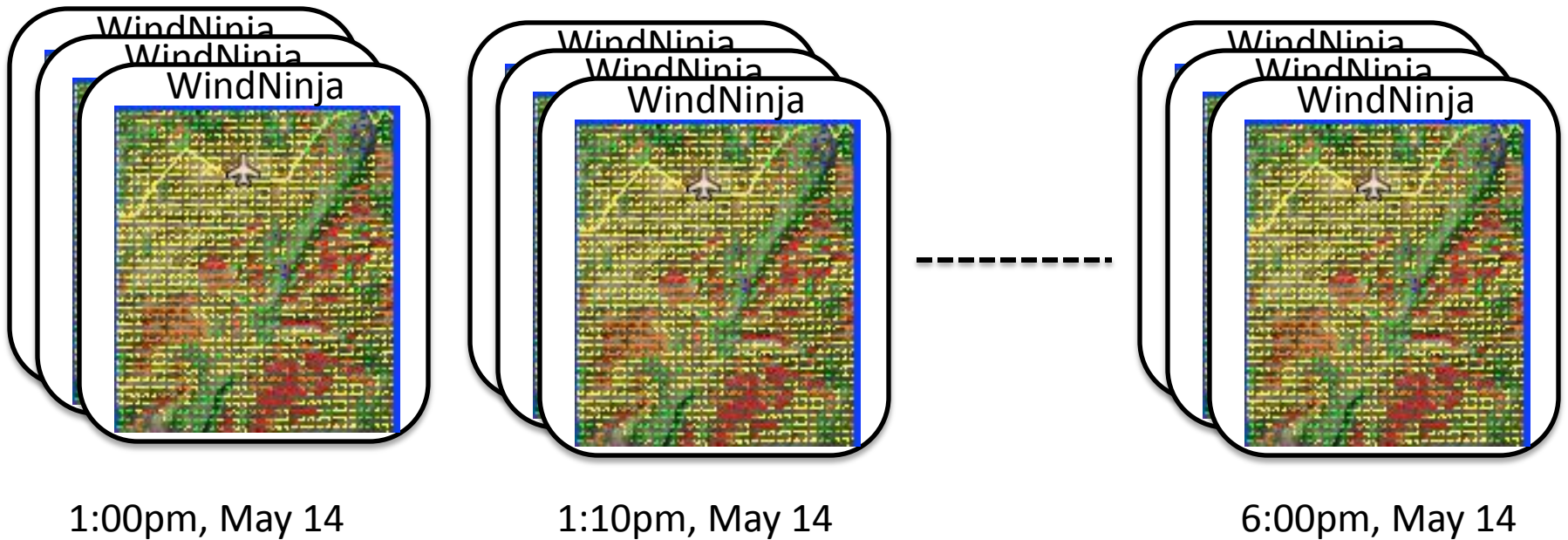
Spatial Coverage

- WindNinja run on domain size up to 50x50km
 - Split SD County into tiles
 - Run WindNinja for each tile



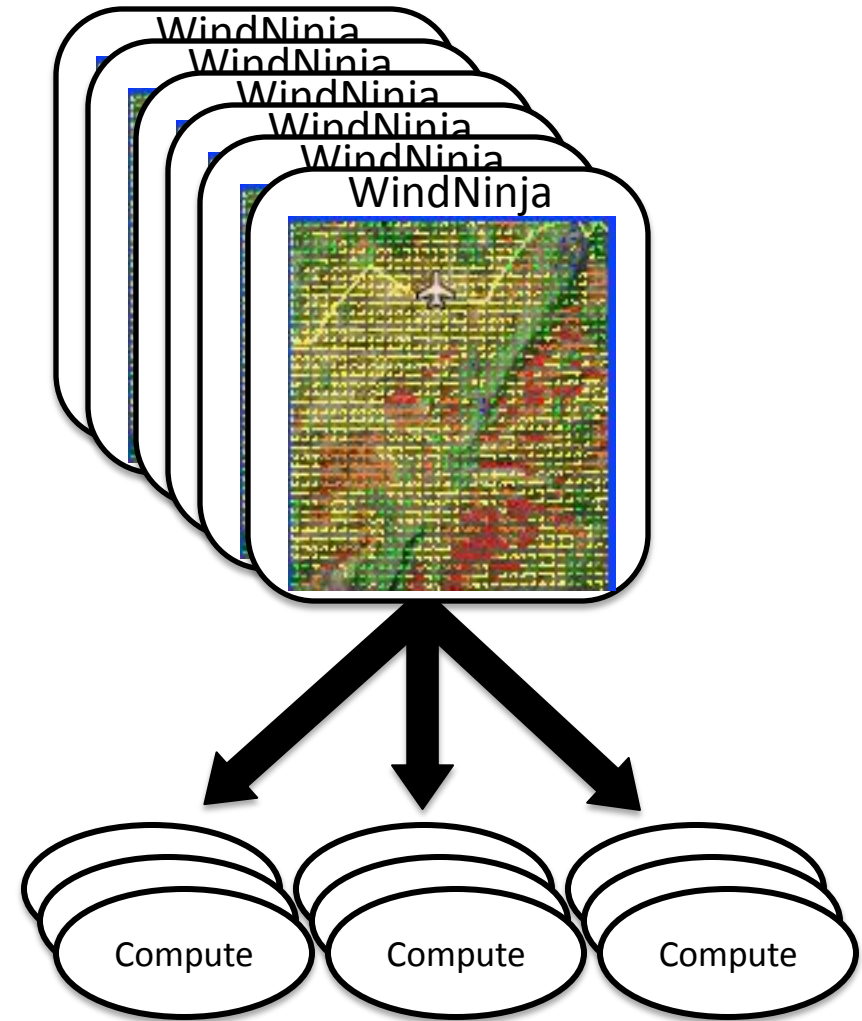
Temporal Coverage

- WindNinja calculates wind conditions for specific point in time
 - Run WindNinja for each timestamp



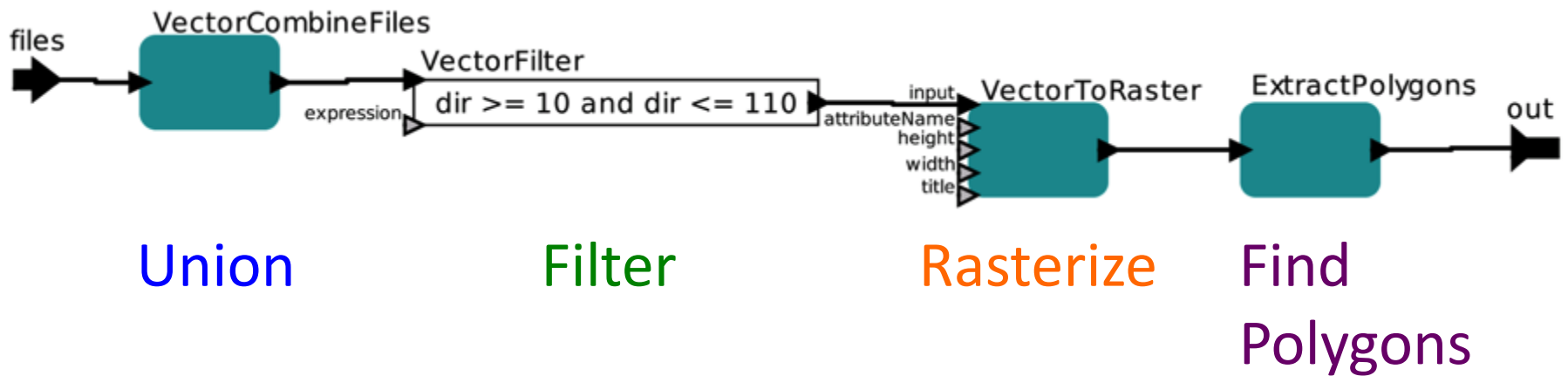
Execute in Parallel

- Run WindNinja for each tile
- Run WindNinja for each timestamp
- **Each execution is independent, so can be done in parallel**



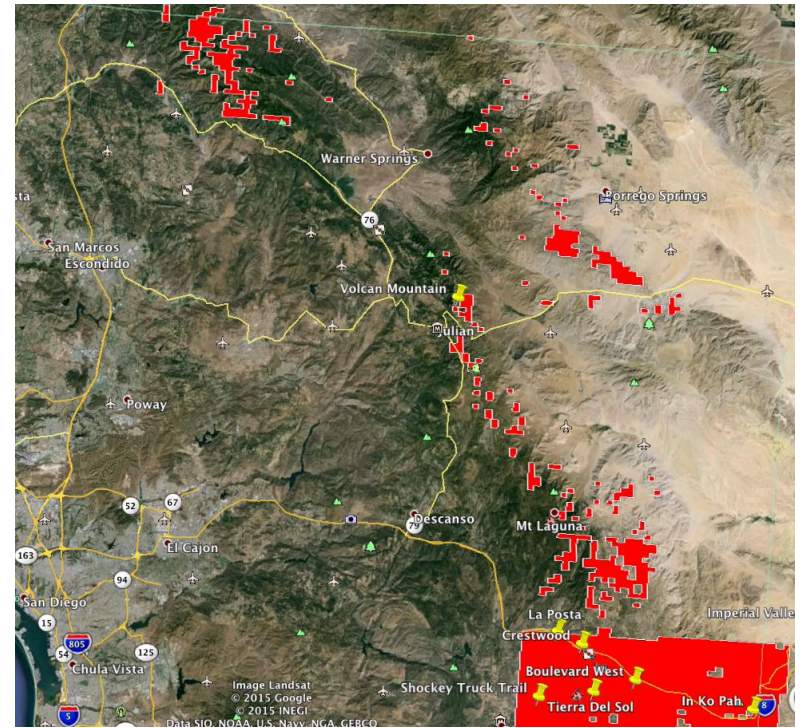
Post-Processing WindNinja Output

- WindNinja outputs wind direction and speed
- Process these outputs to find regions with Santa Ana winds



Application Outputs

- Output shows Santa Ana regions
- Often much larger area surrounding weather station



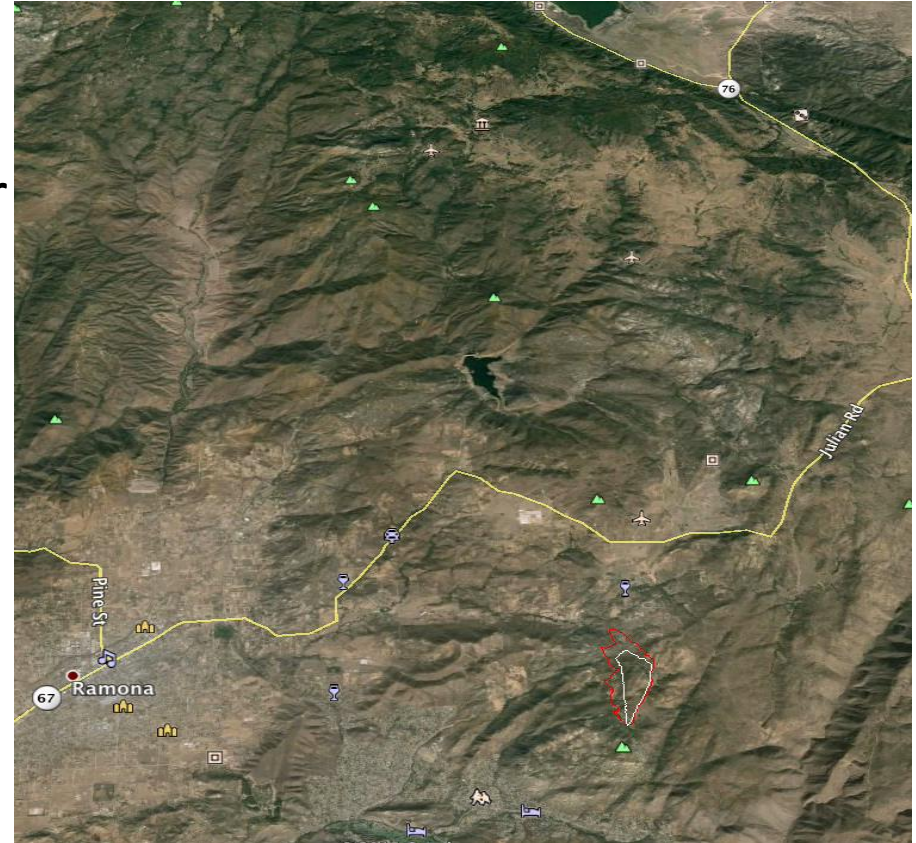
Use Case: Fire Growth

- *Goal:* Simulate fire growth in SD County
- Run FARSITE and Firefly
- Inputs:
 - Landscape (topography, fuel, etc.)
 - Weather (wind, temperature, humidity, etc.)
 - Ignition perimeter
- Outputs:
 - Fire perimeters
 - Intensity, flame length, spread rate, etc.

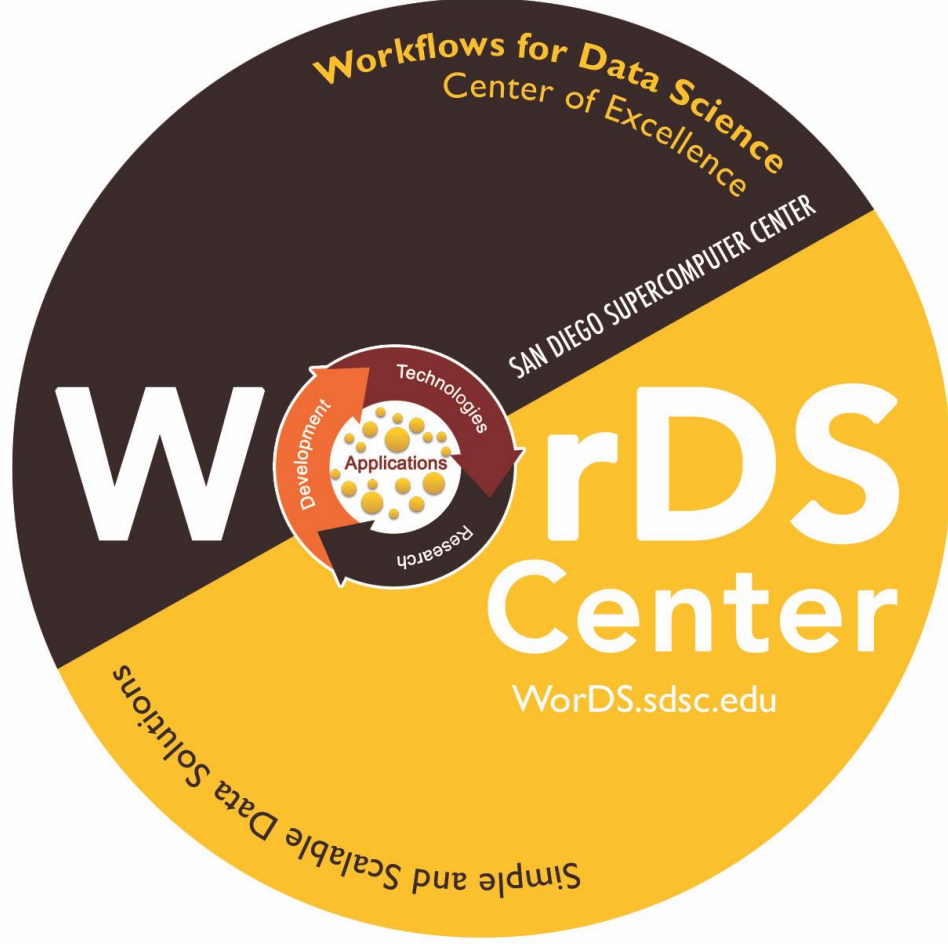


Example Output of Fire Perimeters

- Two simulations with different weather:
 - White is “normal” weather
 - Red is Santa Ana weather

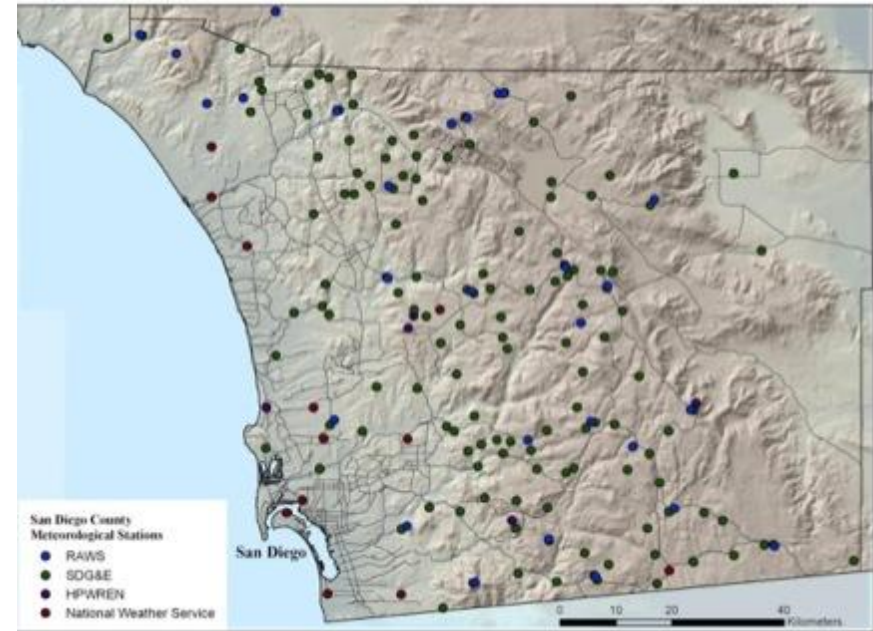


Questions?



Weather Stations

- Over 170 weather stations throughout San Diego County
 - HPWREN
 - SDGE
 - others
- ~20 types of measurements including temperature, wind & humidity
- Data frequency 1s to 10min
- Archive data back to 2007



Cameras



- Over 100 cameras
- Color and Near-IR Images
- Data is collected from HPWREN, SDG&E, NPS, and SDSU
- Data frequency is ~2min, faster during fires
- > 20TB archived images



Fire Perimeters

- Inciweb
- GeoMac
- SANDAG



Model Outputs

- Fire Perimeters
 - FARSITE
 - Firefly
- Wind conditions
 - WindNinja

