Sonoma Technology

Smoke Transport and Fire Weather Climatology Dashboard for California

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Acknowledgment

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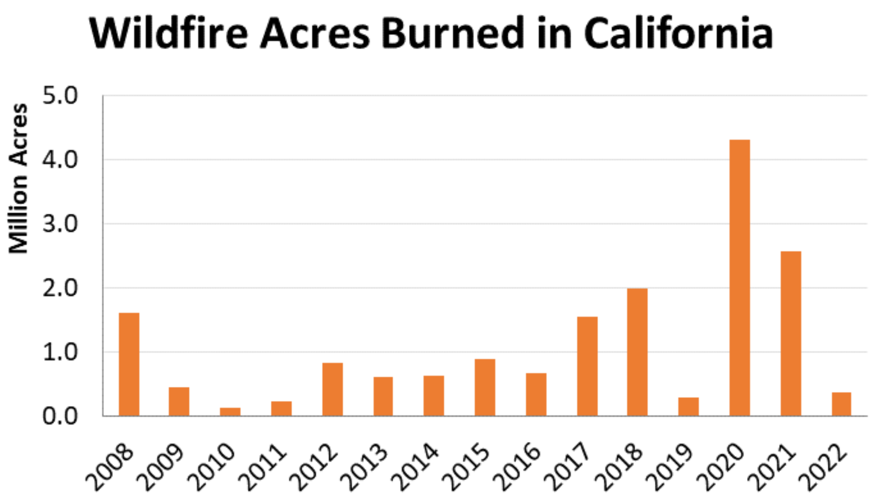
- Project Team
  - Desert Research Institute (DRI)
  - Sonoma Technology
  - California and Nevada Air and Smoke Committee (CANSAC)

Background

- Growing wildfire crisis due to past fire exclusion, climate change, and human footprint expansion
- Prescribed fire is an effective treatment to reduce fuels (vegetation) and mitigate wildfire risks
- Statewide plan sets acreage targets of beneficial fires at 400K-500K acres annually by 2025*
- Smoke management for prescribed fires is needed to minimize smoke impacts on downwind air quality



CAL FIRE Statistics

*California Wildfire & Forest Resilience Task Force. (2022). California's Strategic Plan for Expanding the Use of Beneficial Fire.

Purpose and Objectives

Purpose: Develop air transport and fire weather climatology data to support prescribed fire planning and smoke management in California

Project objectives:

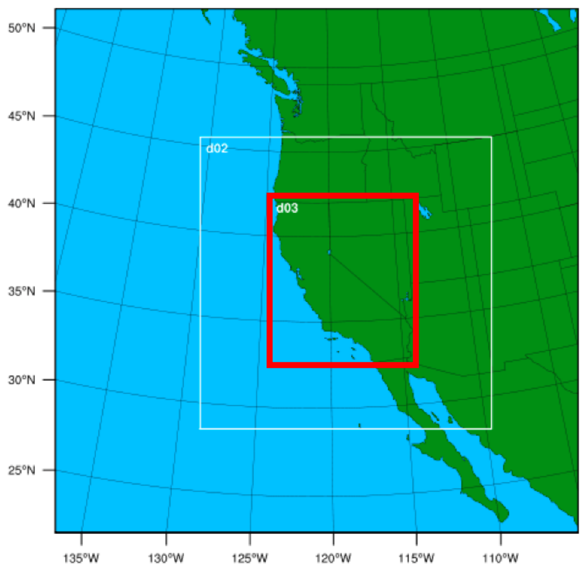
- Generate high-resolution transport probability
- Establish fire weather climatology
- Develop an online dashboard for convenient data access
- Conduct a training workshop for land and air managers

Methods – Data

- Foundational dataset: CANSAC 20-year, 2-km, hourly weather reanalysis for 2001-2020 from the Weather Research and Forecasting (WRF) model.
- Stakeholder input:
  - A short survey on fire weather data and needs was sent to 25 land and air managers in California in March 2023.
  - Priority fire weather metrics identified by nine respondents from local, state, and federal organizations.
- Receptor Data:
  - Education and healthcare facilities point data from Homeland Infrastructure Foundation-Level Data (HIFLD) national dataset.*
  - California ZIP code polygons with population data from the 2020 U.S. Census.

*https://hifld-geoplatform.opendata.arcgis.com/

WPS Domain Configuration



Priority Fire Weather Variables	
Variable	**% of Respondents**
Relative Humidity	100%
Wind Direction	100%
Wind Speed	100%
Temperature	89%
Mixing Height	67%
Transport Wind	67%
Soil Moisture	56%
Ventilation Index	44%
Vapor Pressure Deficit	33%

Methods – Transport and Fire Weather

- Transport modeling
  - HYSPLIT trajectory model with CANSAC reanalysis meteorology
  - 11.5K origin points over land (6-km spacing – every 3rd cell horizontally from the 2-km CANSAC grid)
  - Every day for 2001-2020
  - Four starting times per day (00, 06, 12, and 18 hours local time) at four heights (10%, 50%, 80%, and 200% mixing height)
  - 72-hour simulation per run

1.3 billion HYSPLIT trajectory runs!

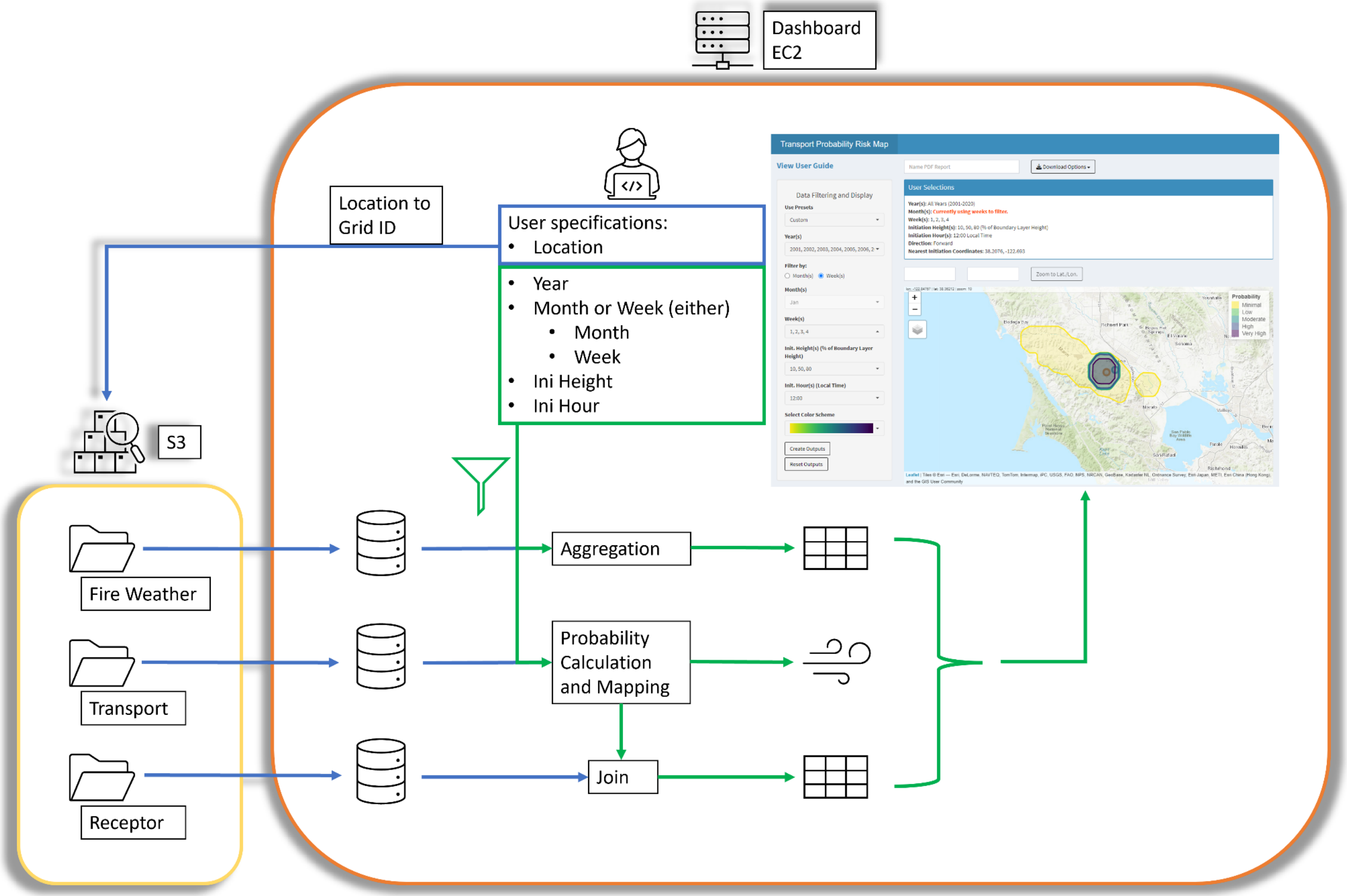
- For every origin and every year-week
  - The count of the trajectory points is calculated per pixel, starting time, and starting height
  - The average values are calculated for fire weather variables from the CANSAC reanalysis: wind speed (m/s), wind direction (degrees), relative humidity (%), temperature (°F and °C), soil moisture (kg/m^2), a.m. mixing height (m), p.m. mixing height (m)

Methods – Probability of Impacts

For a given origin point and data selection…

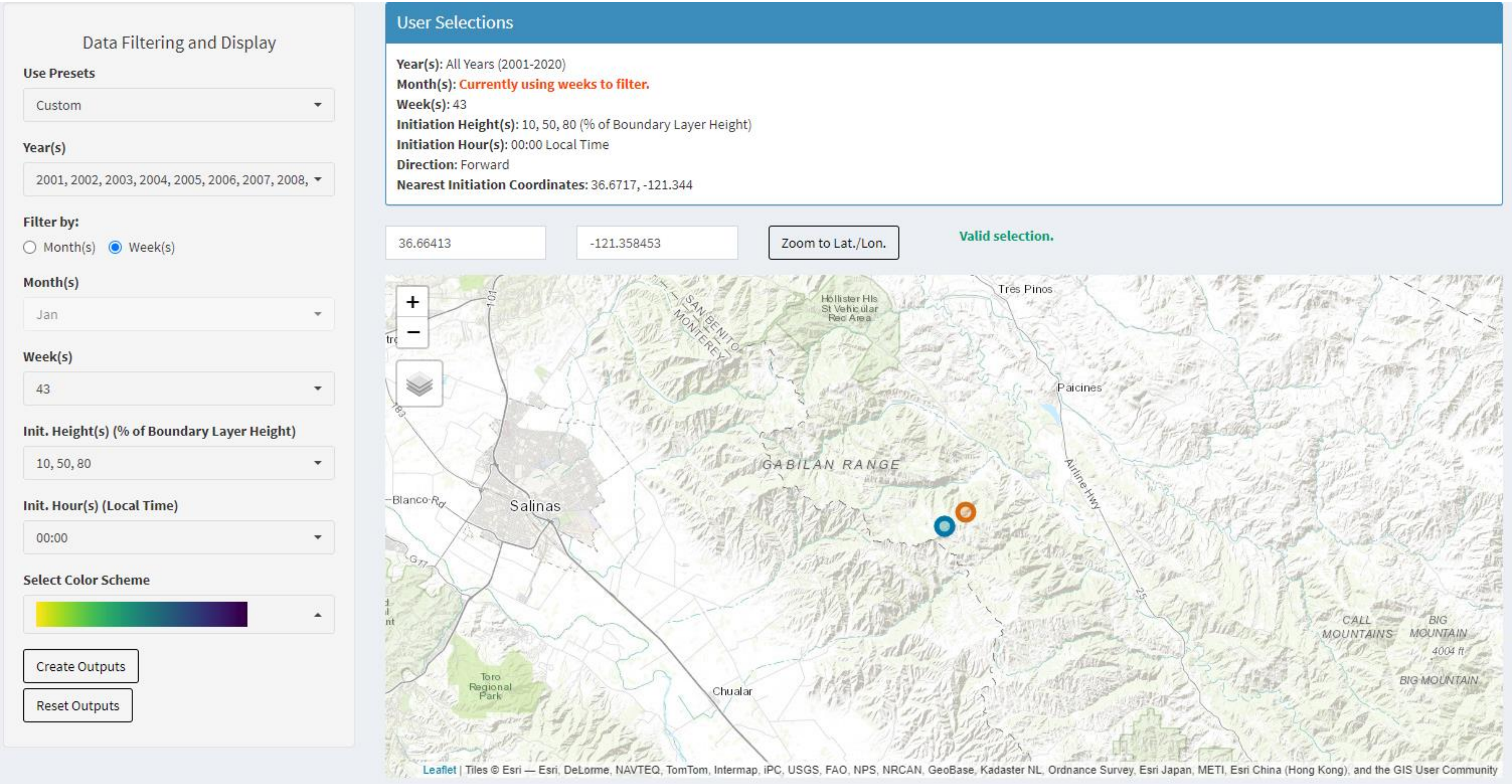
1. Transport probability is calculated for each downwind grid cell on a 2-km grid by dividing the count of trajectory points by the maximum possible count, followed by normalizing by the maximum probability (i.e., 100%)
2. Gridded transport probability is converted to contours representing multiple probability levels: 1-5% (minimal), 5-10% (low), 10-25% (moderate), 25-75% (high), and >75% (very high)
3. Receptor data are spatially joined with transport probability contours to identify and summarize receptors at risk of smoke exposure

Methods – Data Dashboard Schema



Results – Example 1: Data Dashboard

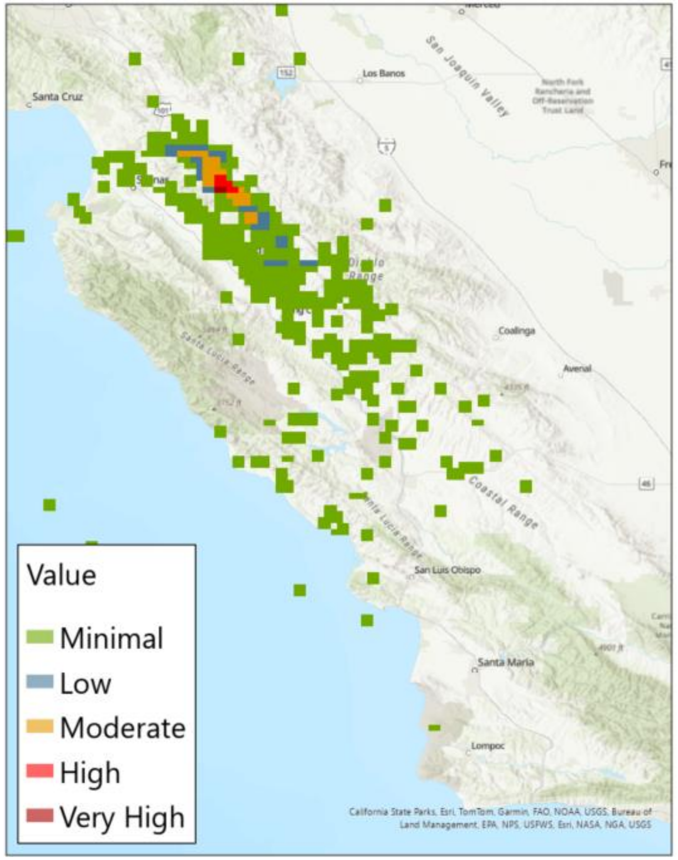
Data Selection: All Years | Week 43 | Height=10, 50, 80% | Time=00:00 PST



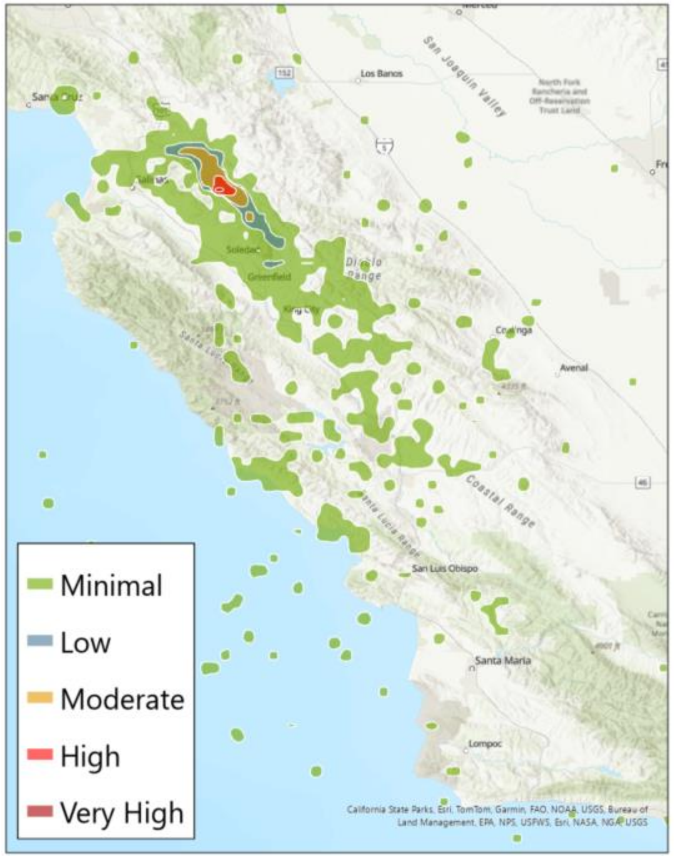
Results – Example 1: Output

Transport probability data processing

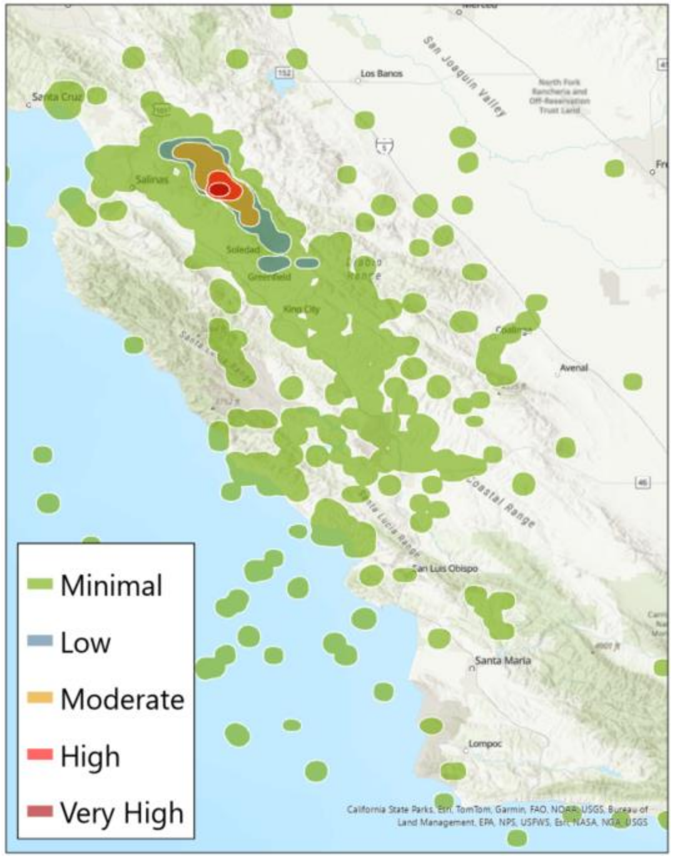
Transport probability raster



Contour



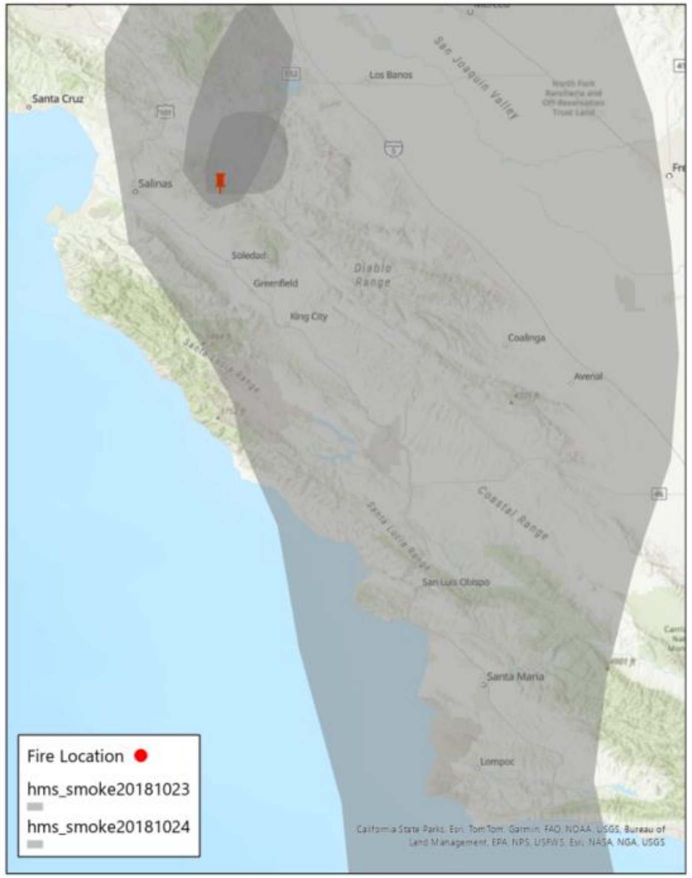
2-km buffer



Results – Example 1: Comparison

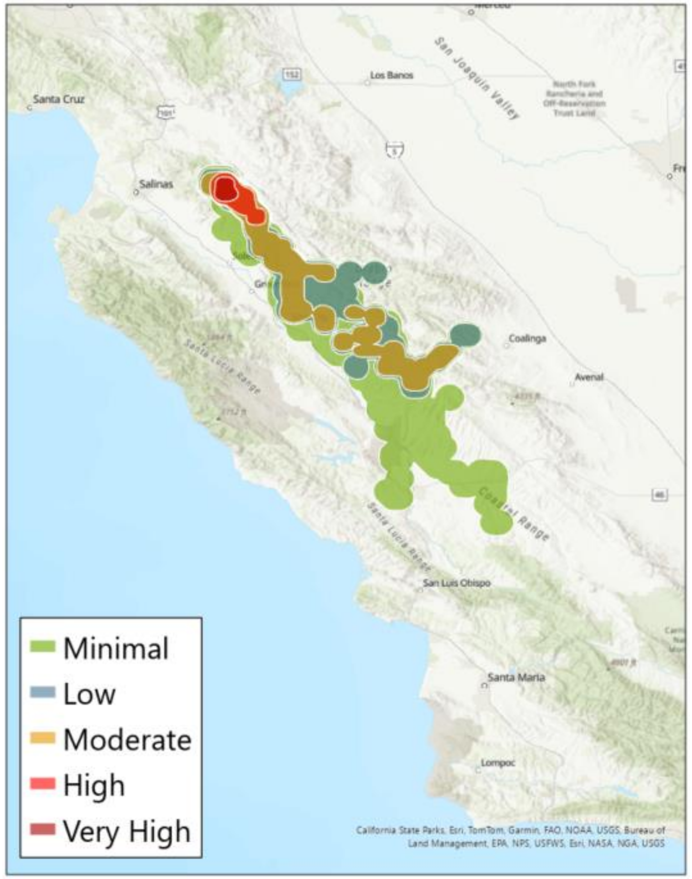
Observed prescribed fire with NOAA HMS smoke

10/23/2018 10:30 Z



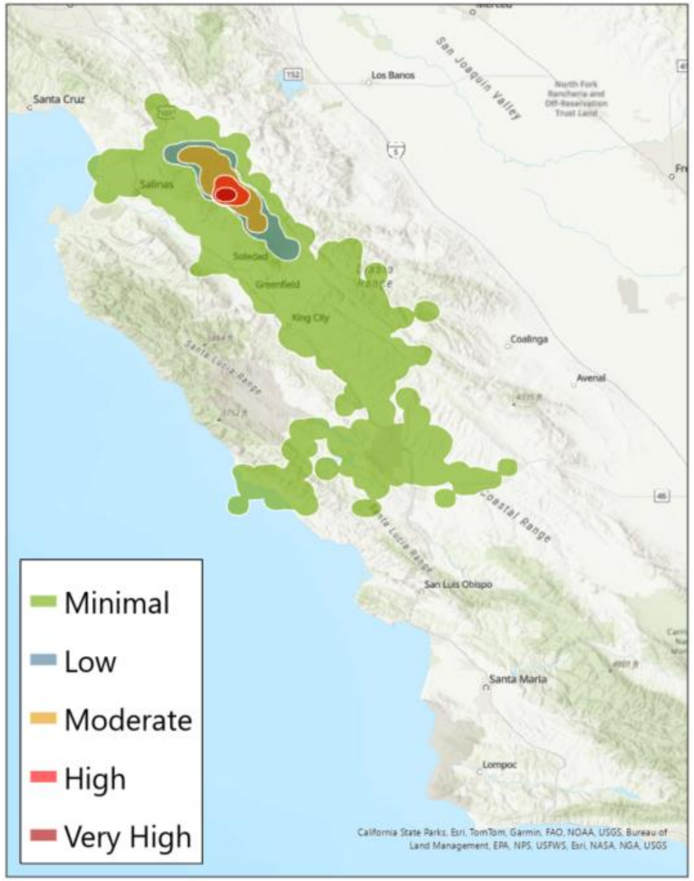
Transport probability for the week of the actual prescribed fire event

Data Selection: 2018 | Week 43 | Height=10, 50, 80%
Time=00:00 PST



Transport probability for the same week from 15 years

Data Selection: All Years | Week 43
Height=10, 50, 80% |Time=00:00 PST

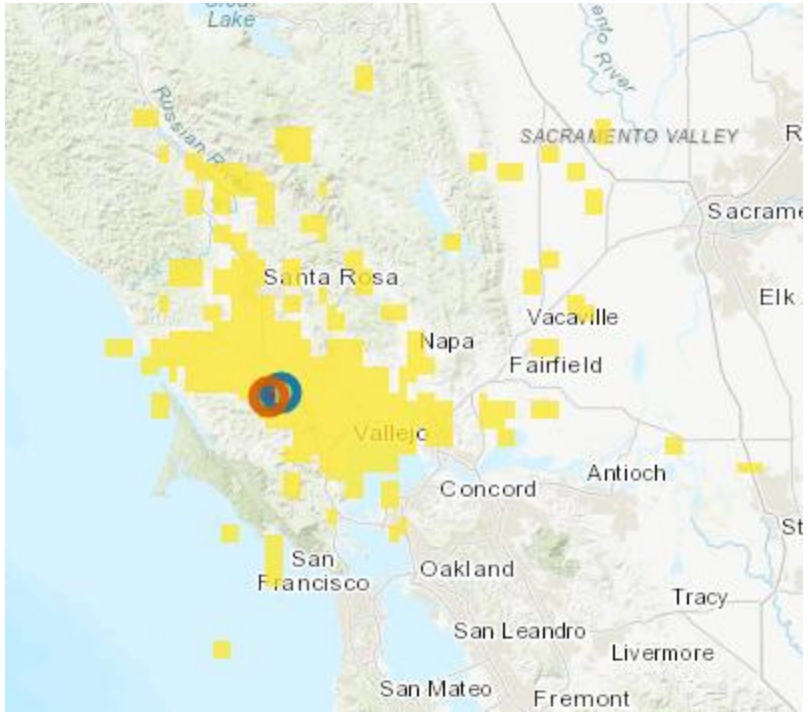


Observed transport in general agreement with modeled transport from the same week and from 15 years of data

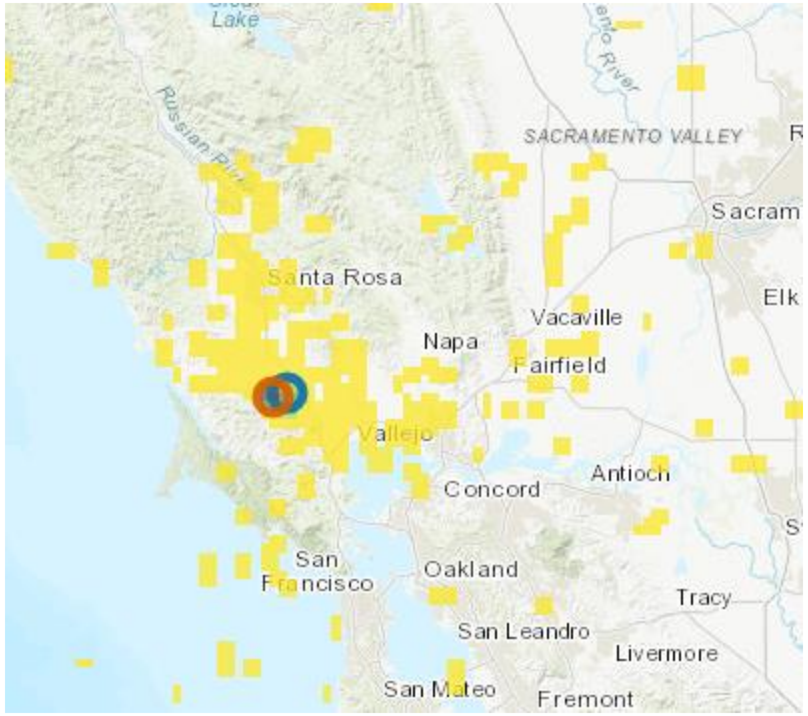
Results – Example 2: Time Comparison

Data Selection: 2014-2020 | Weeks 45, 46, 47 | Height=10%

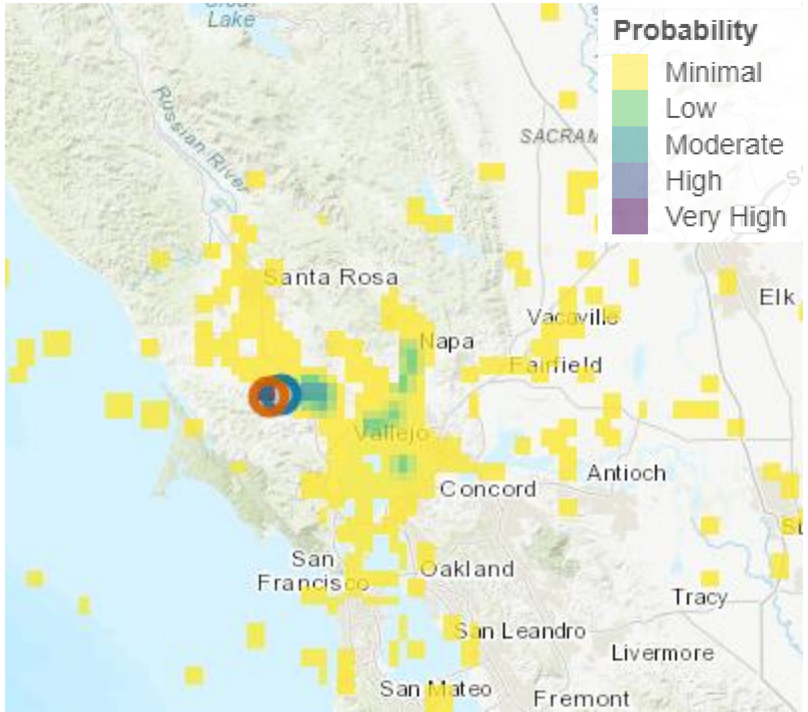
Starting Time=06:00 PST



Starting Time=12:00 PST



Starting Time=18:00 PST



This example demonstrates the use of the dashboard to examine the effects of the time of day on transport, where transport probability late in the day is elevated in downwind locations, including Vallejo and Napa, CA (far right).

Summary

- Based on the CANSAC reanalysis meteorology:
  - 20-year, 2-km transport modeling completed for the entire state of California
  - 20-year fire weather climatology available
- The online climatology data dashboard offers:
  - Instant access to long-term, high-resolution transport probability visualization and fire weather data for prescribed fire planning
  - Summary of receptors at risk of smoke exposure
  - A playground for gaining insights on transport patterns and variability for any time of year for any location in California

What's Next

- Finish trajectory data postprocessing (5 more years of data)
- Perform case studies by air basin for:
  - Data validation
  - Trajectory cluster analysis
- Refine and finalize data dashboard:
  - Transport probability data visualization (e.g., binning, color scheme)
  - Usability
  - User guide
- Conduct a workshop for land and air managers
- Publication

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Learn more about
Sonoma Technology's
Wildland Fire & Smoke
Program:
https://www.sonomatech.com/services/firesmoke

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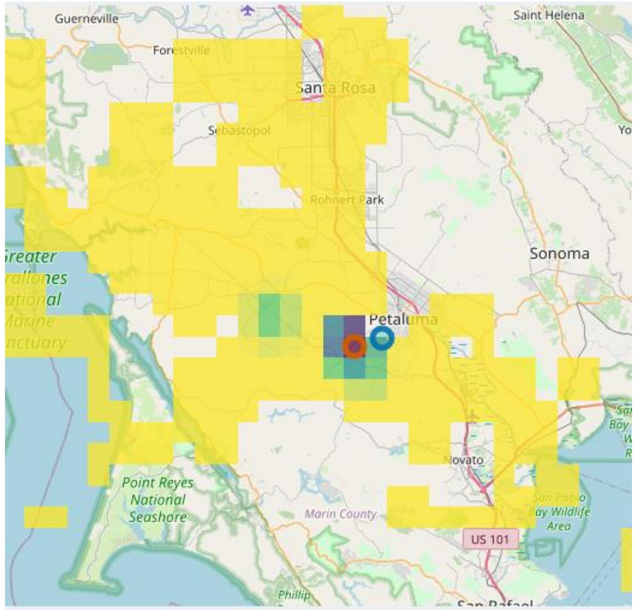
Extra slides

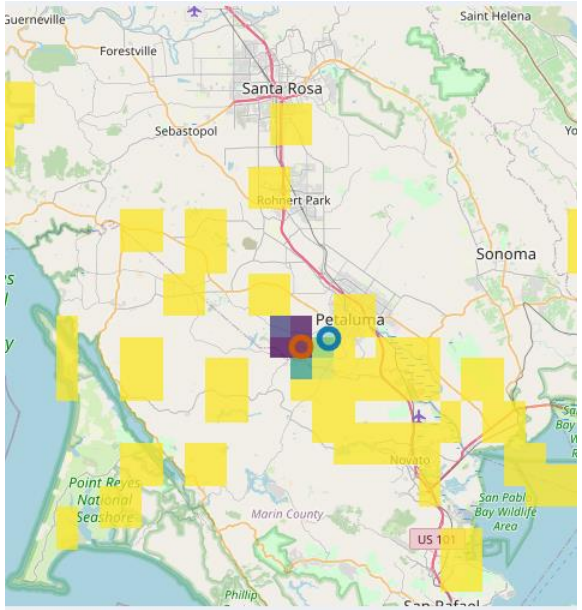
Results – Example 3: Height Comparison

Data Selection: 2014-2020 | Weeks 3, 4, 5 | Time=12:00 PST

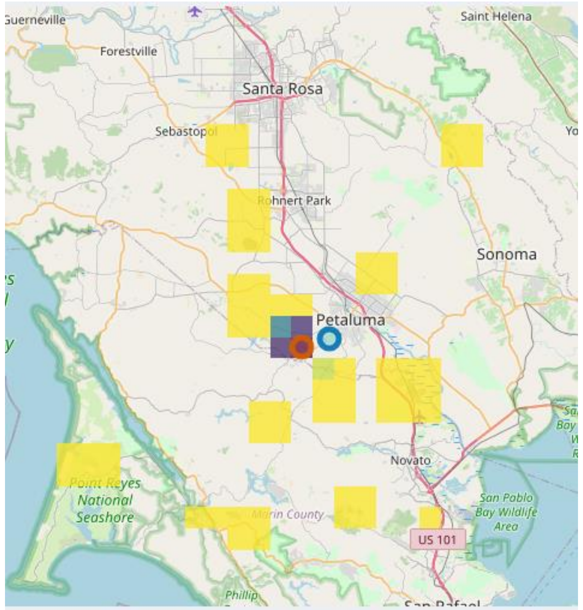
Height=10%



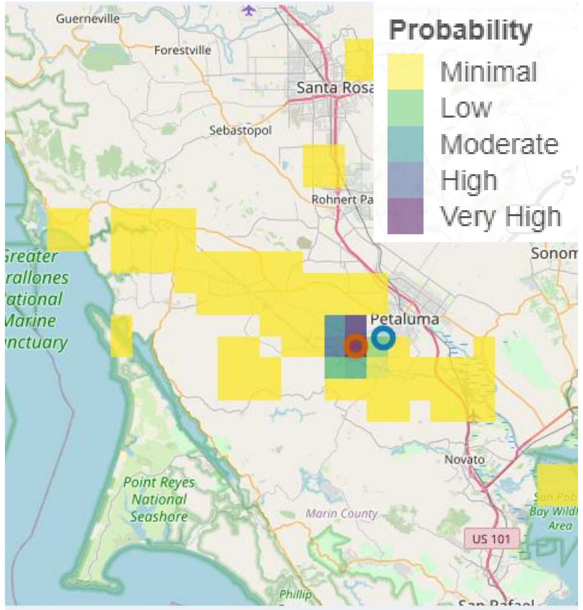
Height=80%



Height=200%



Height=All



This example demonstrates the use of the dashboard to examine the effects of starting height (i.e., plume height) on transport, where the lowest height (far left) results in the highest transport probability locally to the origin.