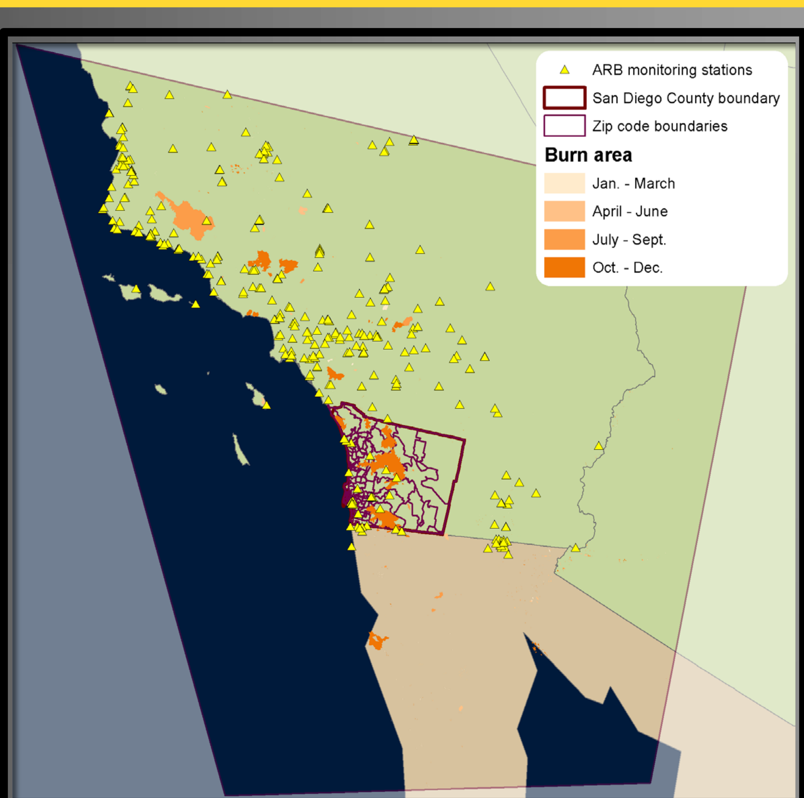
Respiratory Health Impacts of Wildfire Particulate Emissions under Climate Change Scenarios

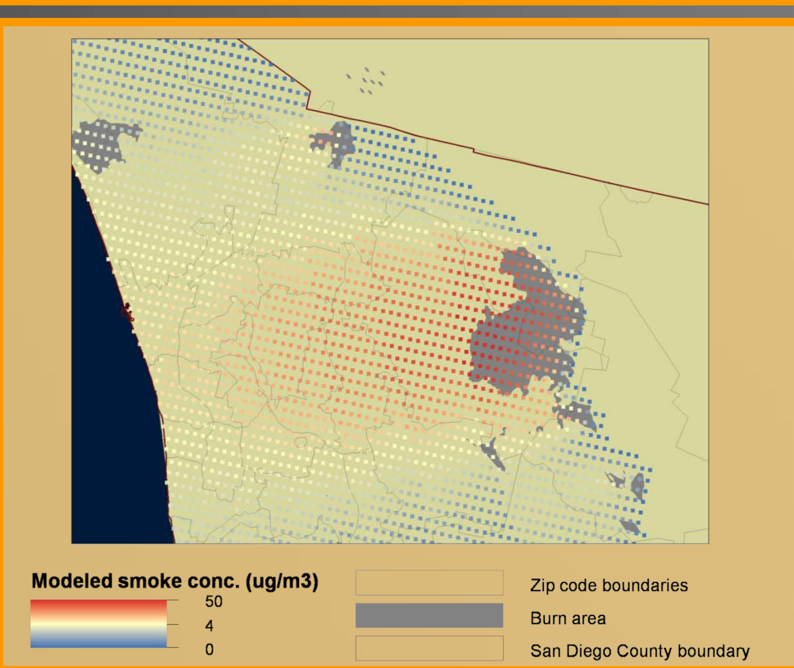
Presented by N.H.F French at the 3rd IAWF Human Dimensions of Wildland Fire, Seattle, WA, April 2012



Study Area

The study area shown is used to model the smoke impacting San Diego County. The comparison of the smoke concentration maps to health data is for zip codes within San Diego County, shown in purple. Future fire is modeled for the entire region to gauge the impacts of climate change on fire and health outcomes.

Smoke Concentration Mapping



Transport of particulate matter (PM) emissions from wildland fires in San Diego County were modeled using the HYbrid Single Particle Lagrangian Integrated Trajectory (HYSPLIT) model. Fire PM sources (2.5 and 10) were estimated using a statistical, empirically-based fuel consumption and emission model (CONSUME) parameterized using weather data and fuel loadings from the Fuel Characteristics Classification System (FCCS).

HYSPLIT Model Parameters and Assumptions

- The model was run in the dispersion mode, which most accurately simulates the deformation of pollution plumes.
- PM assumed to be a purely passive tracer, without reaction or deposition applied.
- PM modeled for 3 days after emission.
- Simulations driven with meteorological data from the NAM (Eta) Data Assimilation System (EDAS) with a 40 km horizontal resolution, 26 vertical levels, and output every 3 hrs.
- Particle-only and hybrid puff-particle simulations were tested to optimize model performance (based off comparisons with surface measurements) and computational resources.

Project Motivation & Research Objectives

The goal of this research

is to better understand how to approach forecasting and preparedness for fire-driven air pollution events.

The project objectives

are to develop methods to connect wildfire occurrence to health outcomes and to better understand how climate change will affect wildland fire air quality conditions detrimental to respiratory health.

Station Fire in La Crescenta, California (AP Photo/Jae C. Hong)

Chaparral Vegetation, San Diego, California

Syndromic Surveillance Health Data

San Diego County utilizes a locally developed syndromic surveillance system called San Diego Aberration Detection and Incident Characterization (SDADIC).

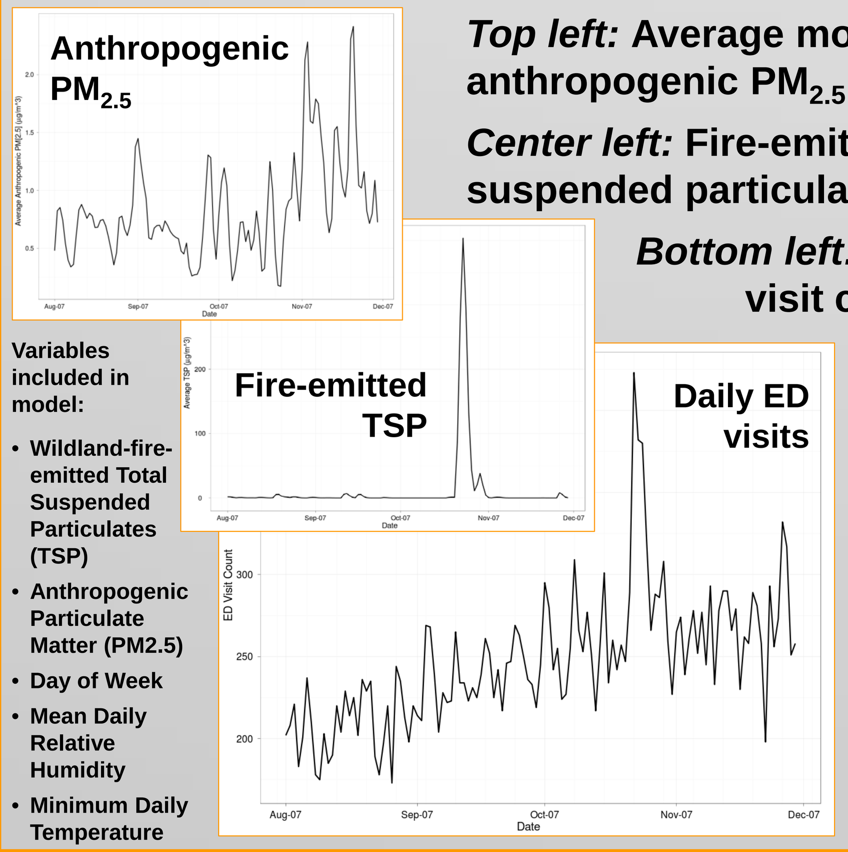
- SDADIC system has been in operation for over 10 years.
- Ten hospital emergency departments currently participate representing about 60% of the county-wide encounters in a population of 3.2 million with system enhancements in progress to include four more hospitals and real-time HL7 ADT data transfer.
- The County monitors 24 distinct syndromes daily that enable an all-hazards detection capability.
- Automated alerts are generated for statistical findings.
- For this project, data on 8 wildfire respiratory syndromes are included (respiratory, hazardous/toxic, respiratory/chest pain, eye irritation, COPD, burns, difficulty breathing, cardiac problems).
- Data cover 2003 to 2008 inclusive from up to 16 hospitals.

Sample summary of health data for three of the six years used in this study. 2007 was a high wildfire year.

	2008	2007	2006
Time Period	Aug - Dec	Aug - Dec	Aug - Dec
Hospitals reporting	13	16	13
Emergency Patient Encounters	193,458	232,626	198,494
Percent of Total Encounters represented in data set	64.2%	86.6%	77.4%

- This project demonstrates the value of syndromic surveillance data collection and analysis capabilities that are rapidly being developed across the US.
- The project has advanced collaboration between public health and environmental health to better understand determinants of health during a disaster.

Data Assessment & Model Development

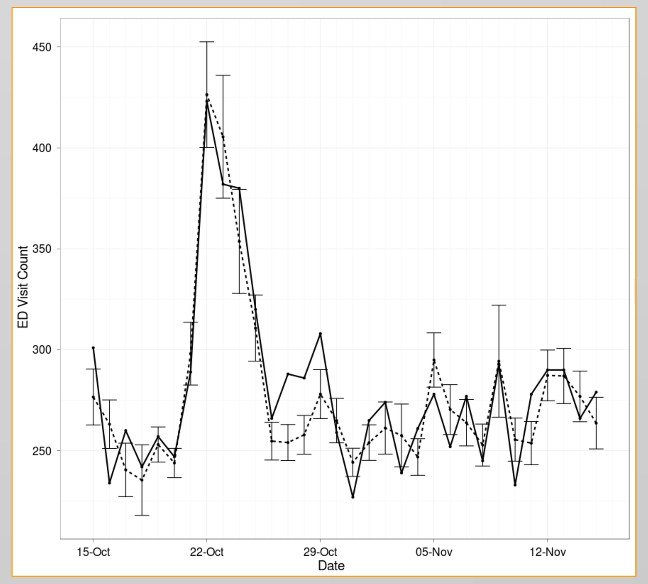


Top left: Average modeled anthropogenic $PM_{2.5}$

Center left: Fire-emitted total suspended particulates (TSP).

Bottom left: Daily ED visit counts for reporting hospitals in San Diego County

Below: Observed ED visit counts (solid line) shown with model predictions (dashed line). Standard error for the prediction are shown as error bars.

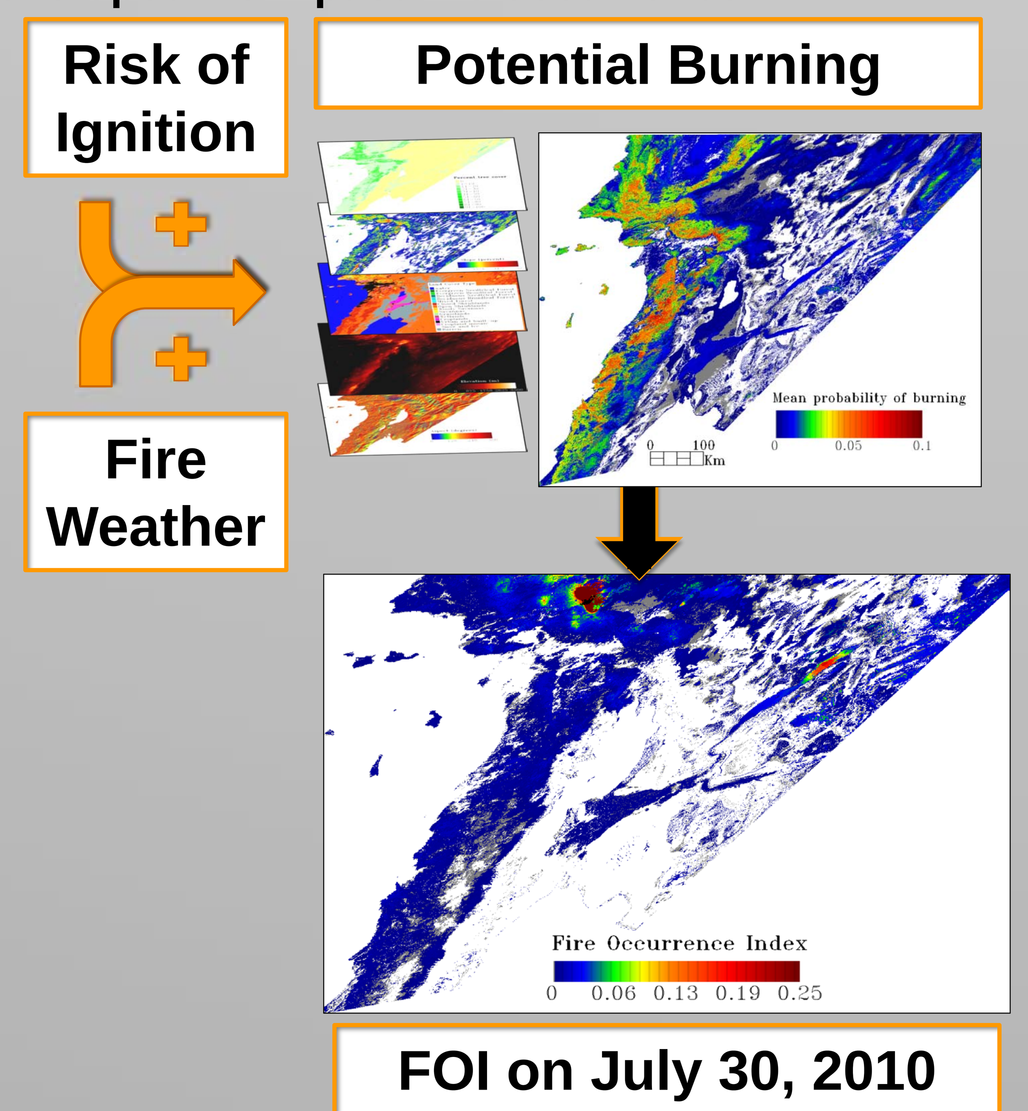


- The coupled statistical and process-based modeling demonstrates an end-to-end methodology for generating reasonable estimates of wildland fire particulate matter concentrations and health effects at resolutions compatible with syndromic surveillance data.
- Model coefficients and functional estimates are specific to San Diego County, but the method has applicability to other regions and syndromic responses.
- Statistical modeling occurred at two levels of spatial aggregation: (1) San Diego County (shown) and (2) Subregional Areas of San Diego County grouped by zipcode. The sub-region approach allows for additional demographic variables to be included.
- Model results show that at peak fire particulate concentrations the odds of a person seeking emergency care is increased by approximately 50% compared to non-fire conditions.

Predicting Future Fire & Health Outcomes

Fire Occurrence Index (FOI)

calculated daily from mapped Risk of Ignition (ROI), Potential Burning (PB), and Fire Weather (FW) developed from past fire occurrence

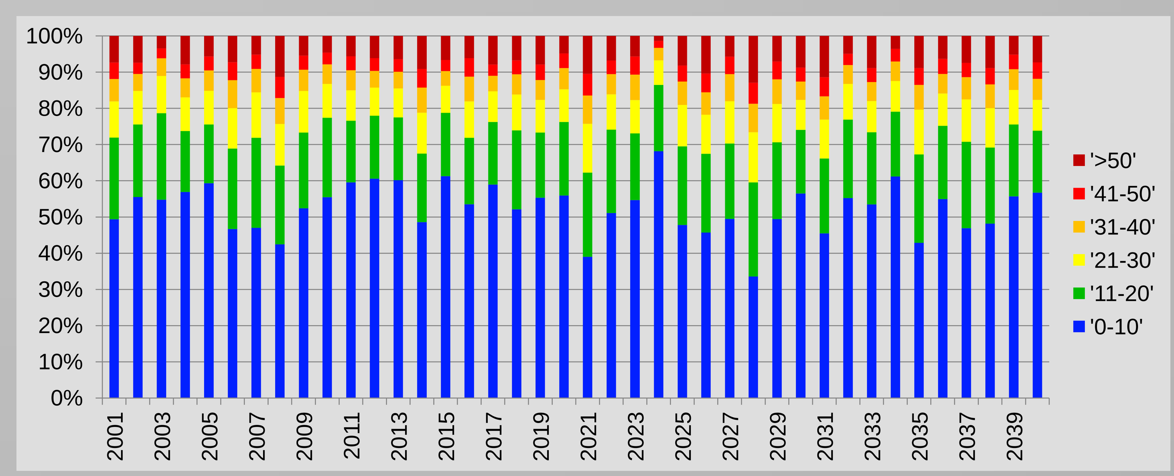


FOI on July 30, 2010

Future Climate-Induced Change in Fire Occurrence

Canadian Fire Weather index was calculated for the study area using the weather conditions produced by the Regional Climate Model (RegCM Version 4.1)[1] over 2001-2040.

- At the decadal scales the RegCM produced comparable conditions as those observed during 2001 – 2010 (two years of elevated climatological fire danger during 2004 and 2008 which correspond to the actual observed years of catastrophic fire occurrence during 2003 and 2007 seasons).
- Based on this finding we compared changes in RegCM-generated Fire Weather Index during 3 decades in the future (2011-2020, 2021-2030, and 2031-2040) to the simulated conditions during 2001-2010.



- Future weather conditions, modeled at 25 km resolution using the Regional Climate Model (RegCM Version 4.1)[1] do not project a noticeable change in frequency of high fire weather conditions, compared to the 2001-2010 period.
- Results show it is likely that San Diego County will experience approximately two extreme fire seasons each decade by 2040 (see graph below).

[1]Pal, J. S., et al. (2009), The ICTP RegCM3 and RegCNET: Regional Climate Modeling for the Developing World, Bull. Amer. Meteo. Soc., 88, 1395.

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Funding provided by the National Institute of Environmental Health Sciences, a part of the National Institutes of Health, under the NIEHS Interagency Working Group on Climate Change and Health Initiative.

Implications of this Research

The research activities of this project have substantially advanced the sciences of syndromic surveillance, wildfire PM concentration mapping, connecting fire events to health outcomes, and modeling of future fire occurrence.

Conducting such interdisciplinary science can be challenging, so these successes are vital for applying cutting-edge science and social science research for societal benefit.