Santa Ana Wildfire Threat Assessment

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1 Introduction

- The "Santa Ana" is a dry, sometimes hot, offshore wind directed from the Great Basin and Mojave Desert over the mountains and through the passes of Southern California. **See Figure 1(a).**
- Its season extends from September to April, and the winds evince terrain amplication of the mountain gap and downslope varieties.
- Fast winds combine with low relative humidities to produce large and destructive fires when an ignition occurs. Such fires happened in 1993, 2003, 2007, 2008, etc.
- The Santa Ana Wildfire Threat (SAWT) index categorized Santa Ana winds event with respect to large fire potential and acticipated fire threat.

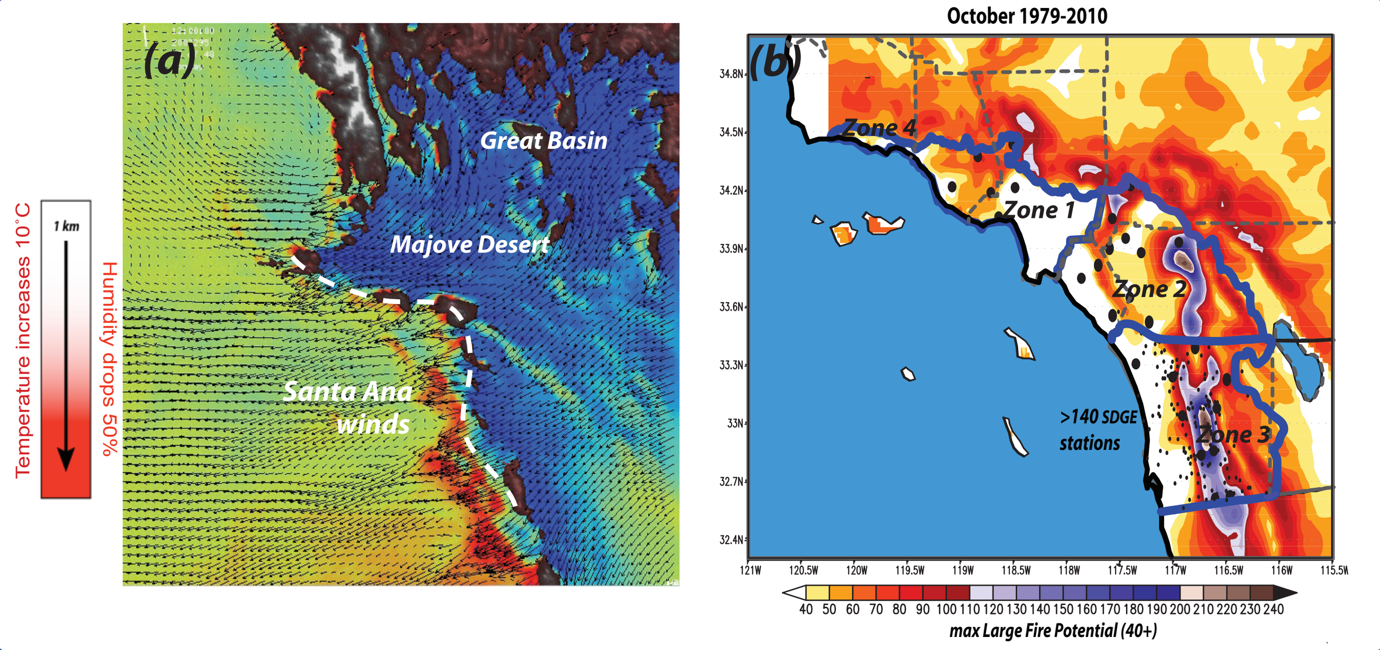


Figure 1:
(a) Simulation of 850 mb temperature (shaded) and winds (arrows). Cold colors denote relatively cold air temperature and warm colors denote relatively warm temperature. The Los Angeles and San Diego areas are separated from the Mojave and Colorado Deserts by the imperfect curtain of mountains. (b) Composite maps showing the maximum LFPw value for each grid point for Oct 1979-2010. Zone boundaries are shown on the map. Large black dots indicate RAWS stations. Small black dots show SDGE network.

2 Methodology

- Factors contributing to large fire potential during Santa Ana winds are ***Wind Speed, Humidity*** and ***Fuels Conditions.***
- Our **Large Fire Potential (LFP)** index is expressed by:

$$LFP = LFPw \times FM = (W_s^2 D_d) \times \left\{\frac{1}{10}\left[\left(\frac{DL}{LFM} - 1\right) + G\right]\right\}^{1.7}$$

- **LFPw** is the weather-only component of LFP.
  Ws=surface wind speed, Dd=dew point depression.
- **FM** is formulated as $\{[(DL/LFM-1)+G]/10\}^{1.7}$, where
  - -DL = Dryness Level index consisting of the Energy Release Component (ERC) and ten hour dead fuel moisture timelag.
  - -LFM = Live Fuel Moisture, a sampling of live chamise cuttings.
  - -G = Greenness of the annual grass, a categorization of NDVI.
- **Santa Ana Wildfire Threat (SAWT)** index is a categorization system of LFP, which conveys anticipated fire danger and activities to the public. **(Figure 7)**

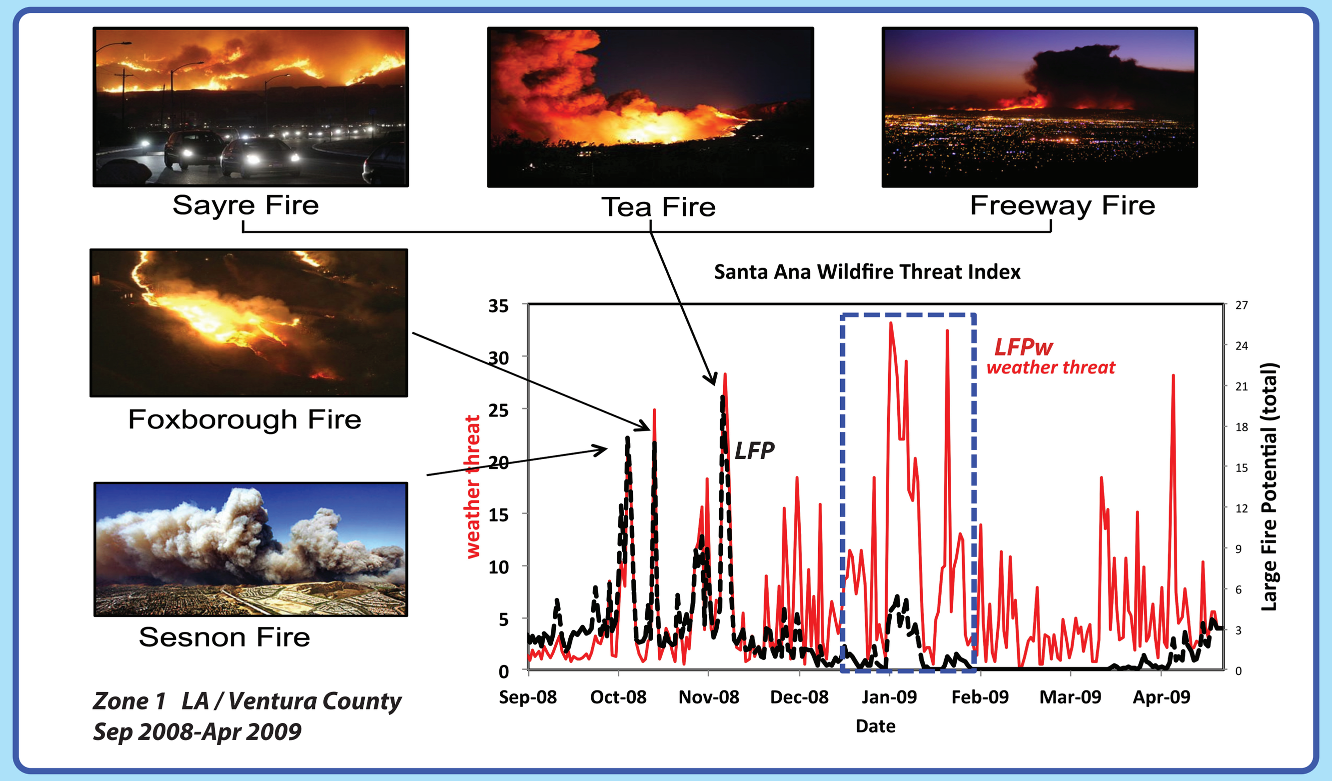


Figure 2:
Validation of LFP = LFPw x FM against observed fire activities between Sep 2008-April 2009. LFPw (red line) is the weather component of the total LFP (black dotted line). LFPw values are scaled by a factor of 0.001.

3 LFP Weather Component and Fuel Component

- LFPw is calculated as 6m wind speed (mph) times surface dew point depression(˚F). The zones **(Figure 1b)** used to calculate LFPw were chosen mainly based on the different offshore flow characteristics that occur across the region.
- The composite image **(Figure 1b),** made from 6km resolution WRF reanalyses, show the 30 year historical maximum LFPw map, were used to define what are called Santa Ana regions (boxes) within each zone. LFPw was calculated from grid points only within the boxes. The final LFPw is the spatial average over each box.
- **Figure 2** shows the significant role fuels play in affecting the overall fire potential during a Santa Ana event.
- Seasonal varibilities of dead, live fuel moisture and greenness are indicated in **Figure 3**, and were calculated at each grid point within the hatched regions.

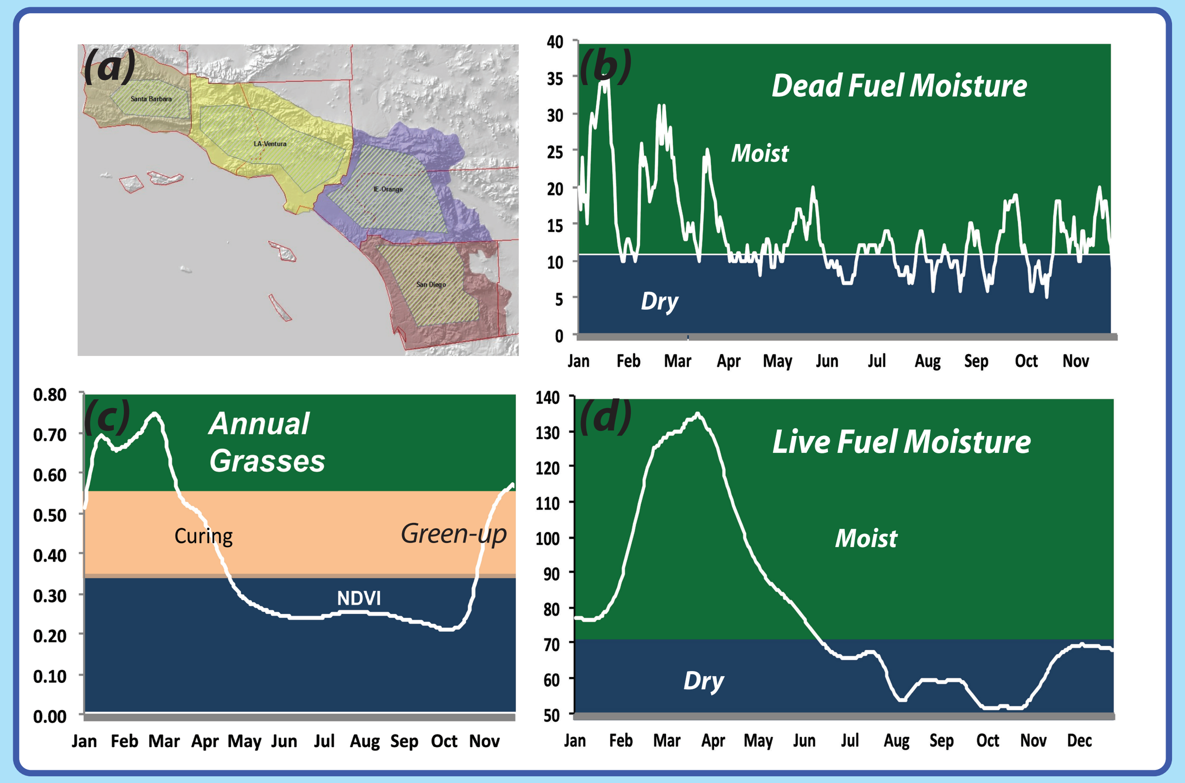


Figure 3:
(a) Fuel component is calculated within the hatched areas in each zone. (b)-(d) Time series showing the seasonal varibilities of dead fuel moisture, greenness and live fuel moisture.

4 Greenness Modeling

- Utilized "random forest" and stepwise linear regression method to create a universal equation to all zones. Satellite observations from 19 stations (**Figure 4a**) are used as the dependent variable.
- Selected independent variables include cosine of day of year, accumulated rainfall, 30-day average RH, root zone (40-100cm) soil moisture (from NLDAS) and surface vegetation fraction.
- NDVI formula is $NDVI = -0.31 + 0.11 \times \cos\left(\frac{2\pi \times day}{365}\right) + 1.44^{-5} \times rain_{accu} + 0.0036 \times \overline{RH}_{30days} + 0.91 \times veg + 0.0024 \times soilm$ and a validation example of station Witch Creek is shown in **Figure 5(a)**.
- **Figure 4(b)** shows a real time NDVI prediction for 06 Mar 2014 .

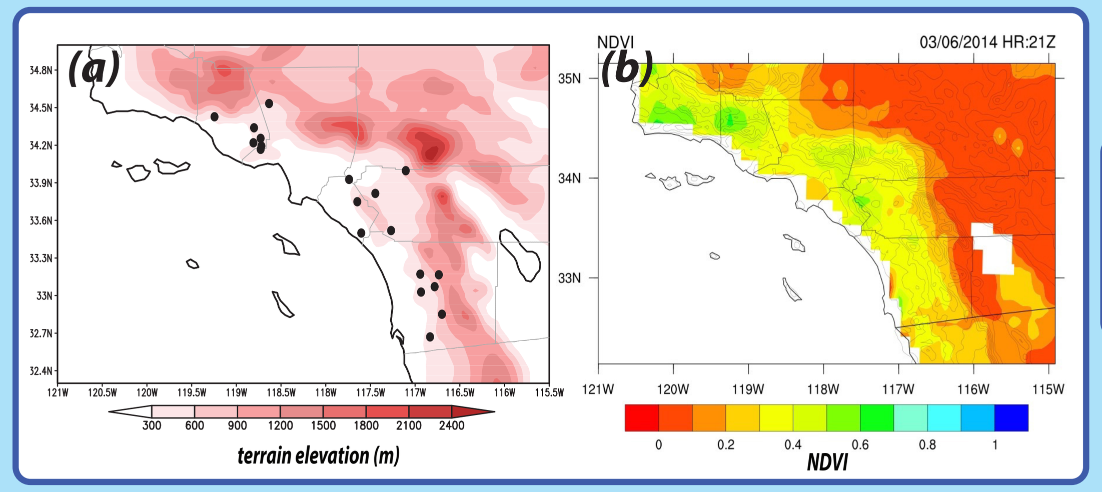
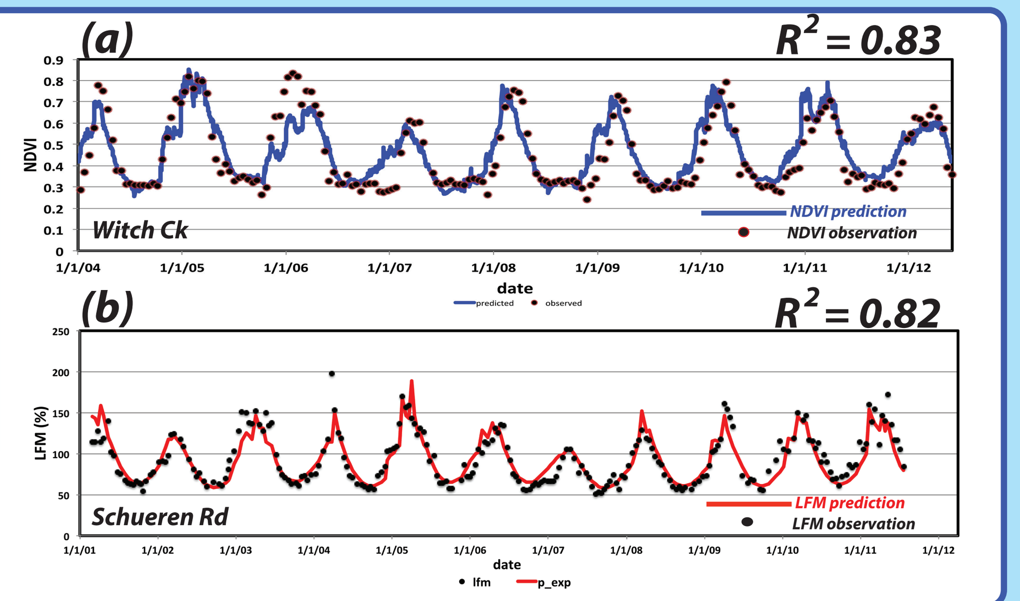


Figure 4:
(a) 19 NDVI observation stations, with topography shaded.
(b) NDVI real time forecast of 2100 UTC 6 Mar 2014.

Figure 5:
(a) Time series showing NDVI prediction (blue line) versus observations (black dots) for Witch Ck.
(b) Time series showing LFM prediction (red line) versus observations (black dots) for Schueren Rd.



5 Live Fuel Moisture Modeling

- Aim to predict Chamise (new growth) LFM using model forecast and/or reanalysis data. Utilized observations from 28 stations (**Figure 6a**) as the dependent variable.
- Modeled with root-zone soil moisture (from NLDAS) and a time function.
  - Soil moisture is LAGGED and/or AVERAGED.
  - Emphasis on seasonal ramp-ups and ramp-downs.
- LFM formula is $\log LFM = a + b1 \times \sin\left(\frac{2\pi \times day}{365}\right) + b2 \times \cos\left(\frac{2\pi \times day}{365}\right) + b3 \times \ln(soilm\_lag41) + b4 \times \left[\ln(soilm\_lag41)\right]^2$ and a validation example of station Schueren Rd is shown in **Figure 5(b)**.
- **Figure 6(b)** shows a real time LFM prediction for 06 Mar 2014 .

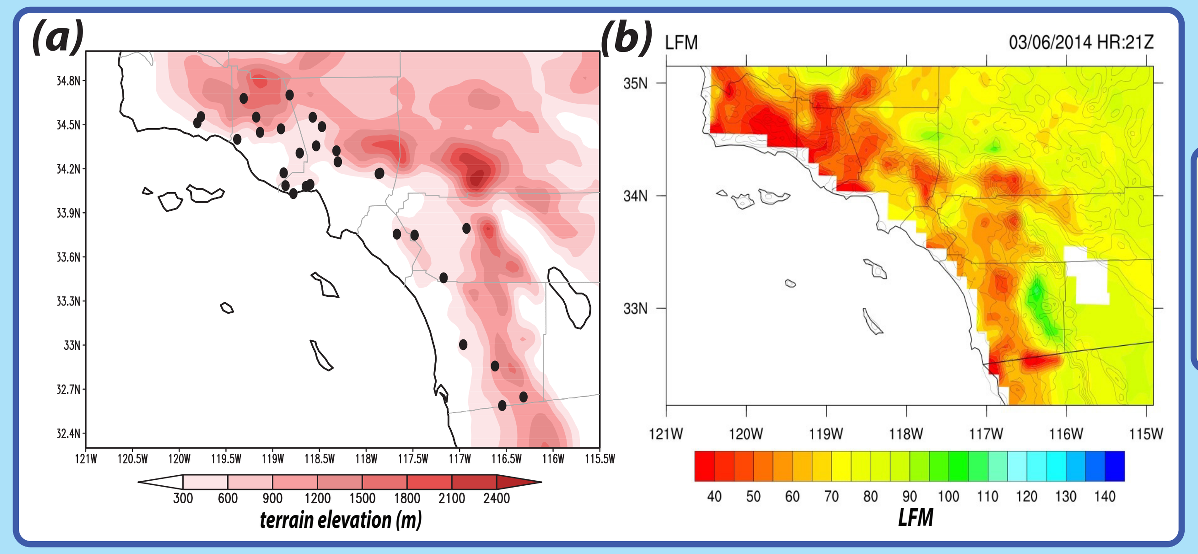


Figure 6:
(a) 28 LFM observation stations, with topography shaded.
(b) LFM real time forecast of 2100 UTC 6 Mar 2014.

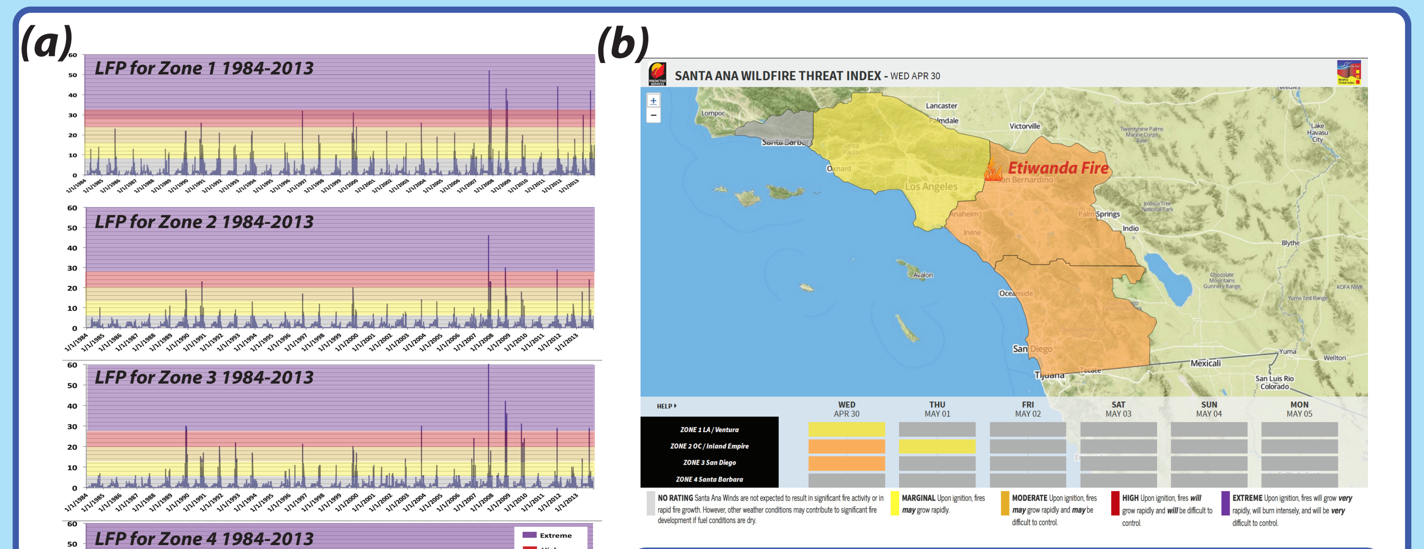


Figure 7:
(a) Time series showing the historical LFP over four zones for the past 30 years. Shading denotes fire threat severity. (b) Main page of Santa Ana Wildfire Threat Index on 30 Apr 2014, with location of Etiwanda Fire overlayed.

6 Conclusions

- Winds, low level dryness, and fuel conditions are the determining factors for how severe the Santa Ana event will be in terms of its impact upon the fire environment.
- Santa Ana Wildfire Threat (SAWT) index is a useful tool to categorize Santa Ana winds with respect to the anticipated fire environment.
- A climatology of Santa Ana wind events is developed based on this index which can be used in future research involving seasonal outlook predictions.

Related Work

- Fovell, R. G., 2012: Downslope windstorms of San Diego county: Sensitivity to resolution and model physics. 13th WRF Users Workshop, June 2012.
- Rolinski,T., B.D'Agostino, and S.Vanderburg, 2013: Categorization of Santa Ana Winds with respect to Large Fire Potential. 93rd American Meteorological Society Annual Meeting, January 2013.
- Cao, Y., and R.G.Fovell, 2013: Predictability and Sensitivity of Downslope Windstorms in San Diego County. 15th Conference on Mesoscale Processes, August 2013.
- Fovell, R. G.and Y. Cao, 2014: Wind and gust forecasting in complex terrain. 15th Annual WRF Users' Workshop, June 2014.

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