Workshop, San Diego, 5-7 August 2013

Measuring, Quantifying, and Reporting Drought Impacts

Remote Sensing and Wildfires

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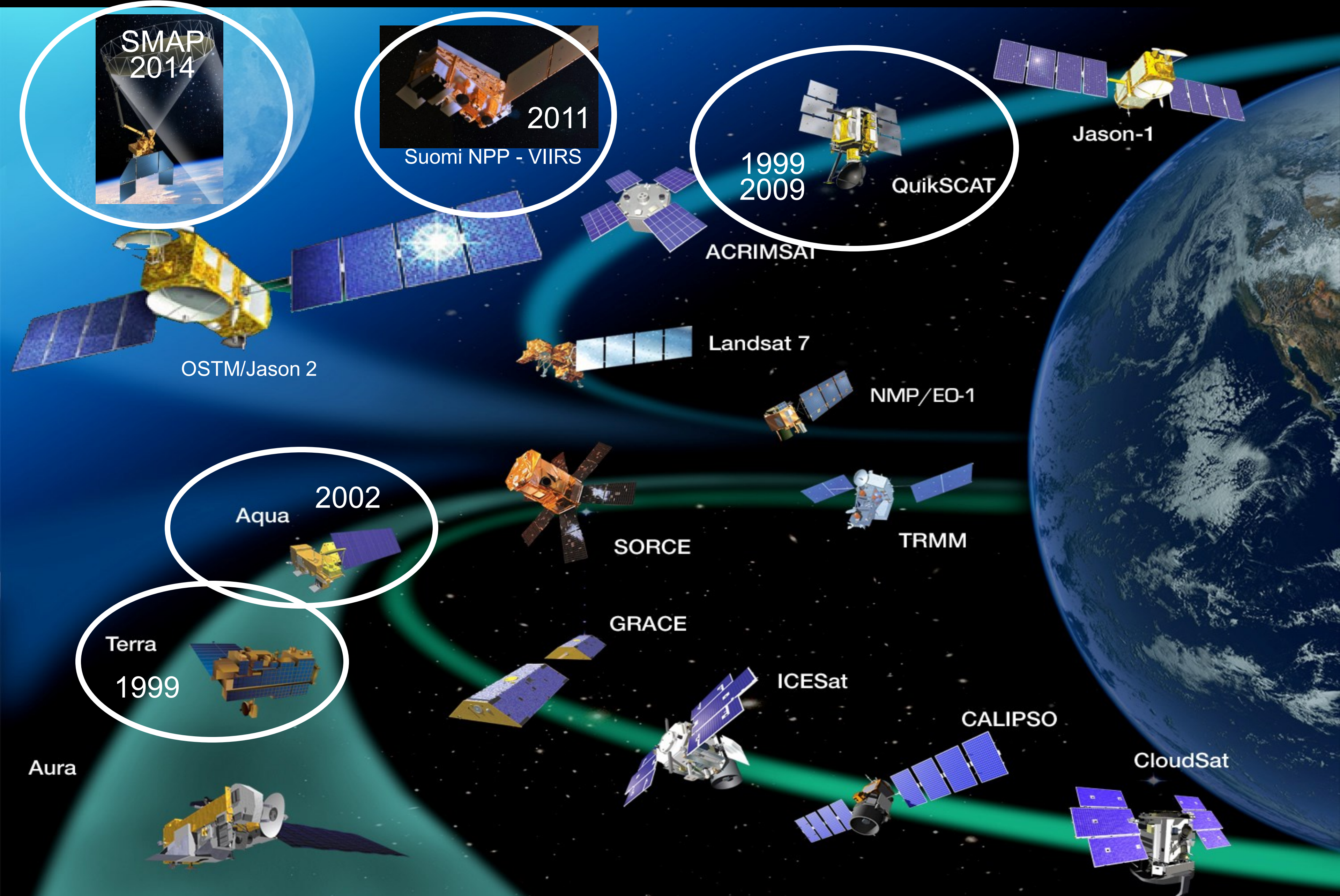
Background: NASA Earth Satellite Missions

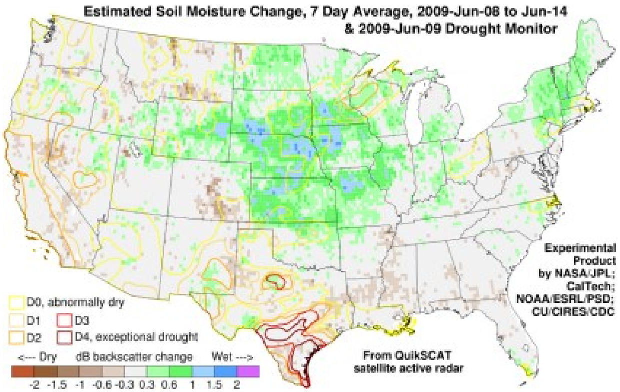


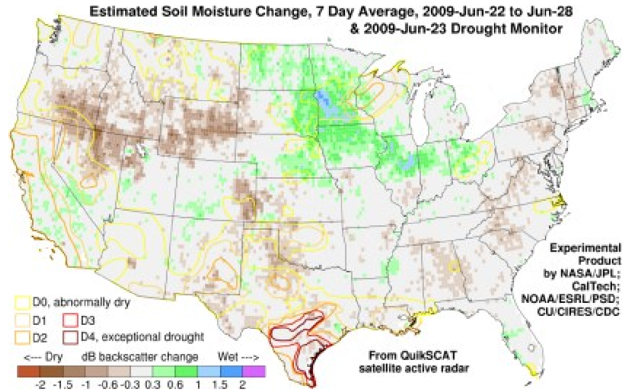
Background - Drought Monitoring NASA Drought Application Project

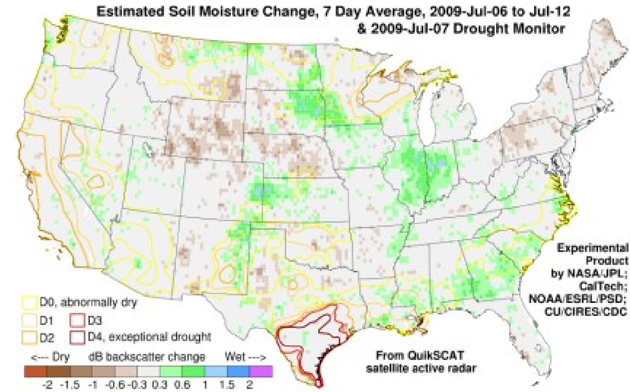
- PI: Jet Propulsion Laboratory (Nghiem)
- U.S. Geological Survey (Verdin)
- National Drought Mitigation Center (Wilhite)
- NOAA Physical Science Division (Dole)
- NOAA Climate Prediction Center (Le Comte)
- Dartmouth College (Brakenridge)

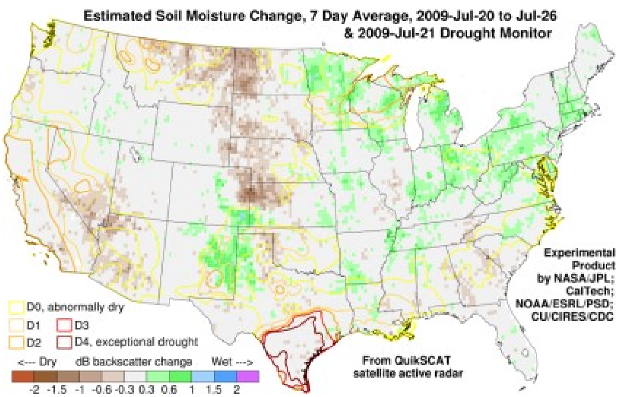
Advisory Board: D. Entekhabi (MIT), D. Hall (NASA GSFC), P. Houser (George Mason U.), A. Huete (U. Arizona), G. Leshkevich (NOAA GLERL), K. Steffen (U. Colorado/CIRES), and P. Whung (USDA).

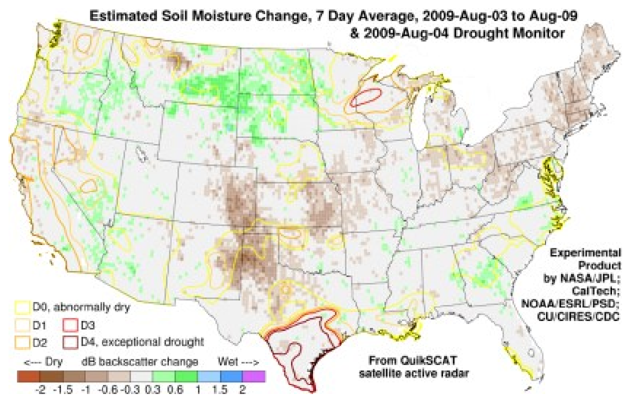
Background: Drought Monitoring Prototype

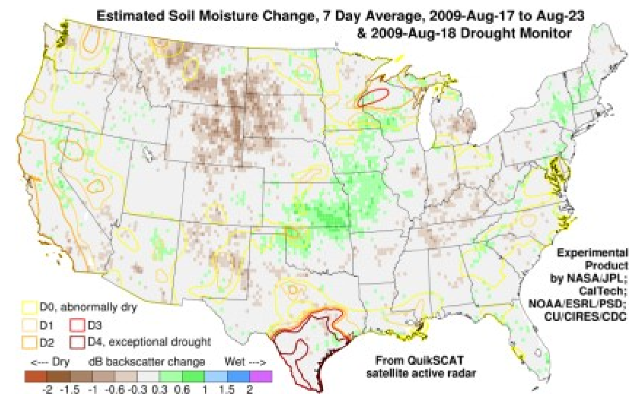


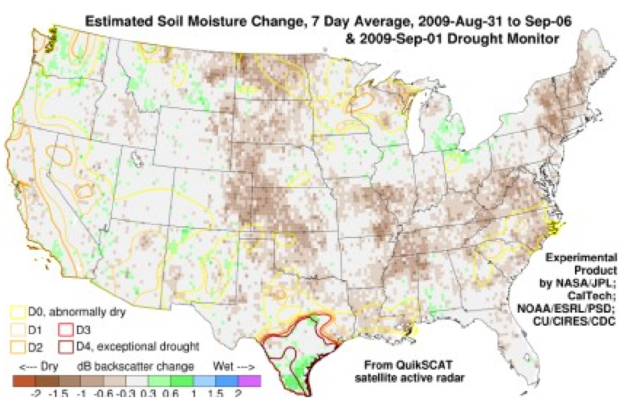


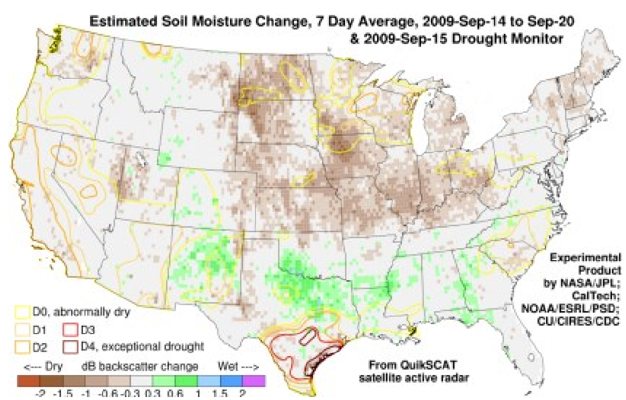


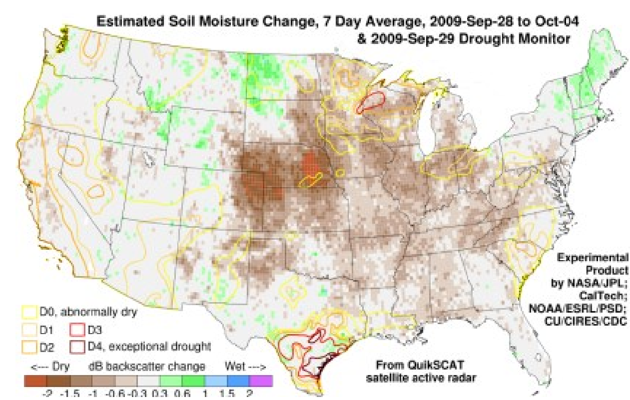












NASA Wildfire Feasibility Project

- **Objective:** Investigate the feasibility of using satellite measurements of soil moisture and vegetation; models (RAMS, FARSITE) for wildfire applications.
- **Investigators:** NASA/JPL (Nghiem, PI), Chapman University (Kafatos, Co-PI), NOAA National Weather Service, USFS.
- **Collaborators:** Los Angeles County Fire Department, Ventura County Fire Department, Orange County Fire Authority, and JPL Fire Department.

NASA Terra satellite image of San Diego wildfires. Red pixels indicate fire activity; black horizontal line indicates the U.S.-Mexico border. (Oct. 23, 2007 at 11:25 a.m. PDT) Image credit: NASA/MODIS Rapid Response.

However, it's a little too late when things go up in smoke!

We have a proactive focus:

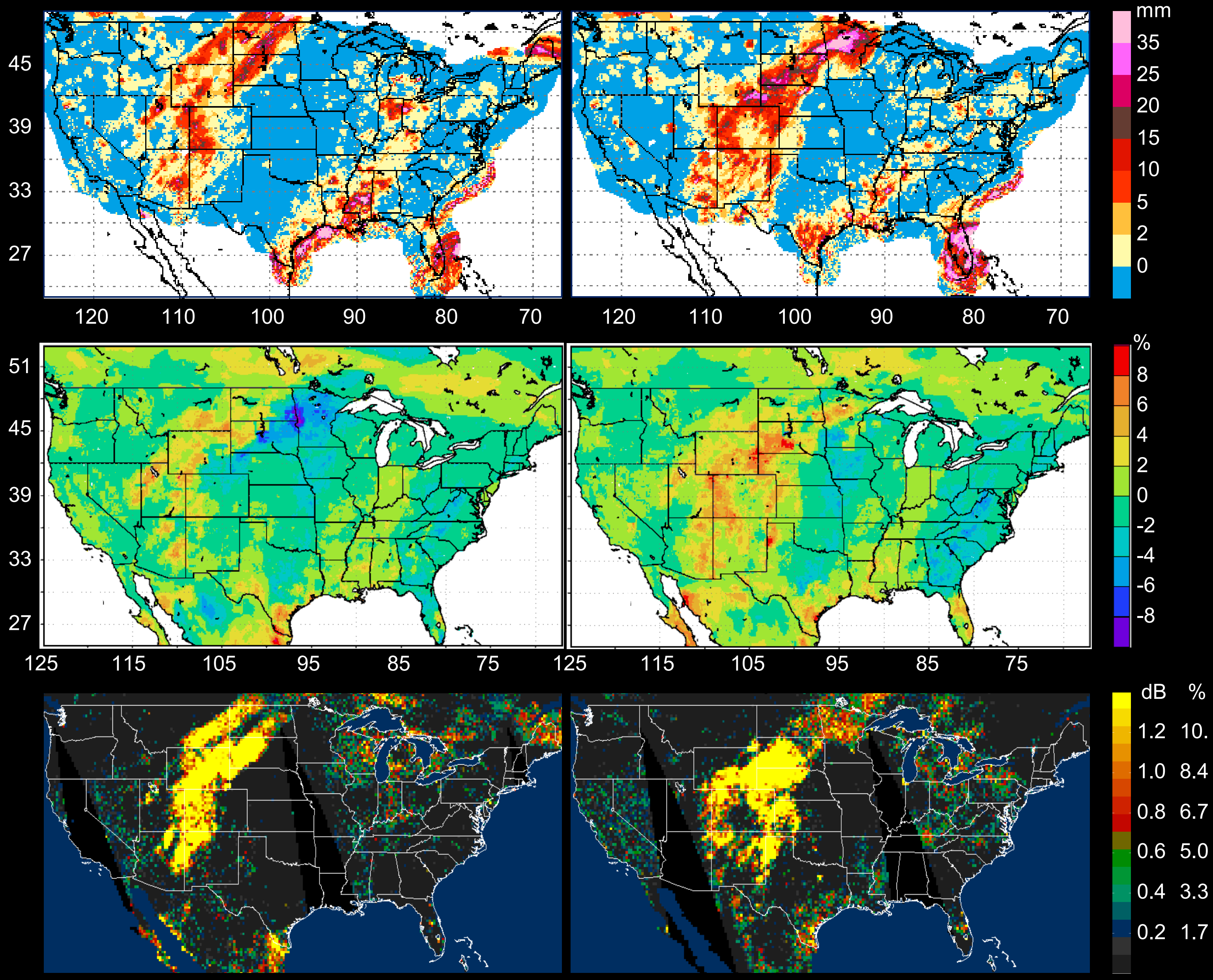
Assessment of fire danger before fires occur by enhancing: FWW, RFW, NFDRS, WFDSS

Soil Moisture Change

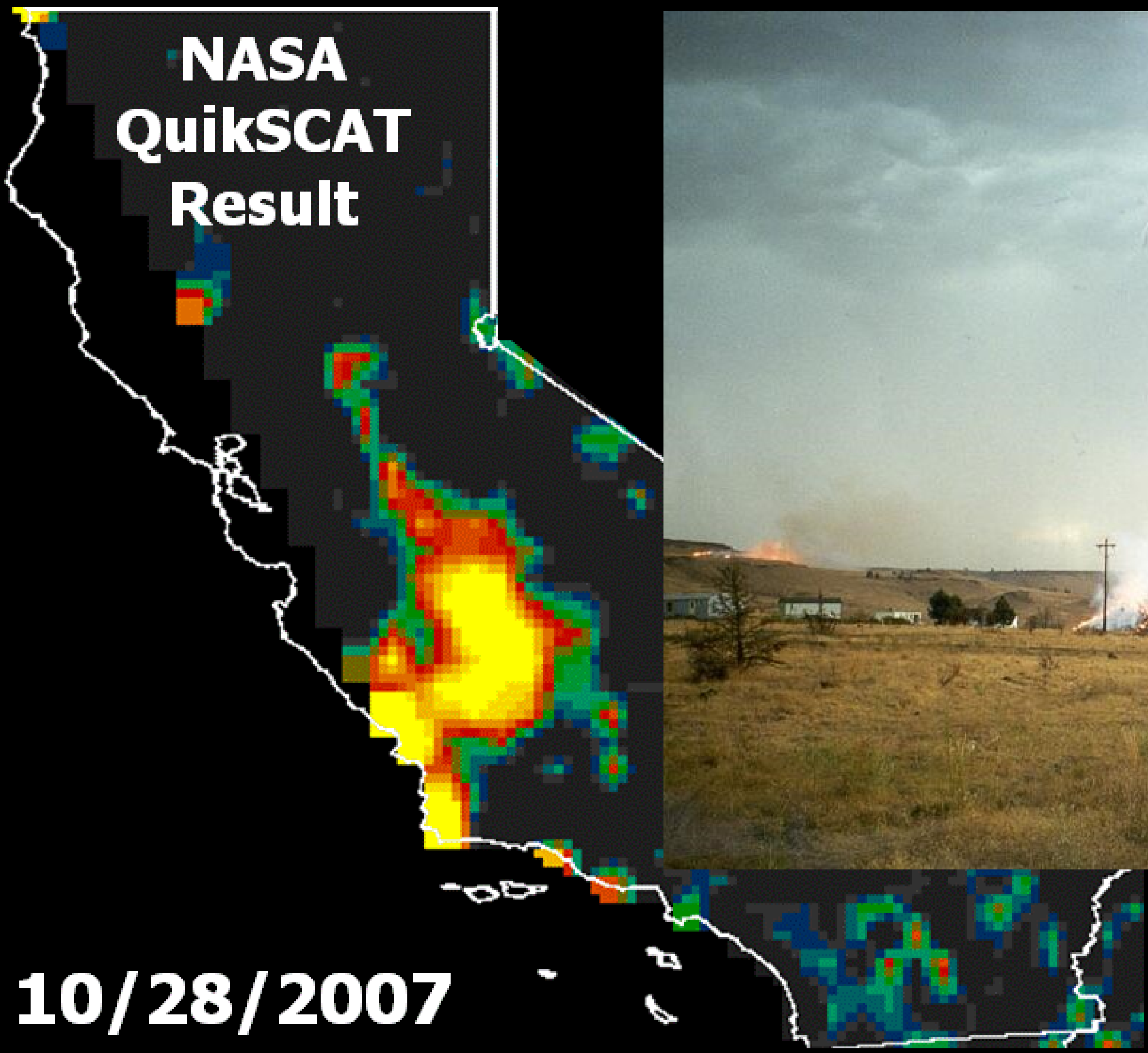
Precip

AMSR-E SMC

QSCAT SMC

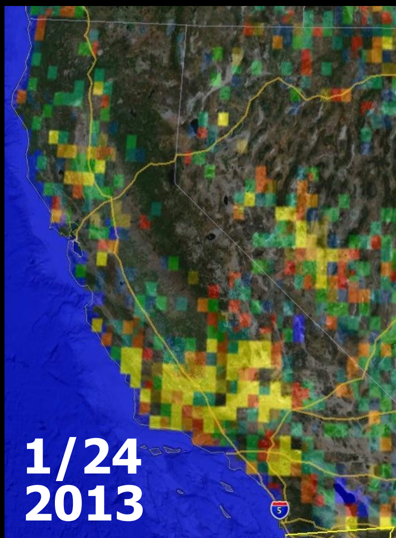


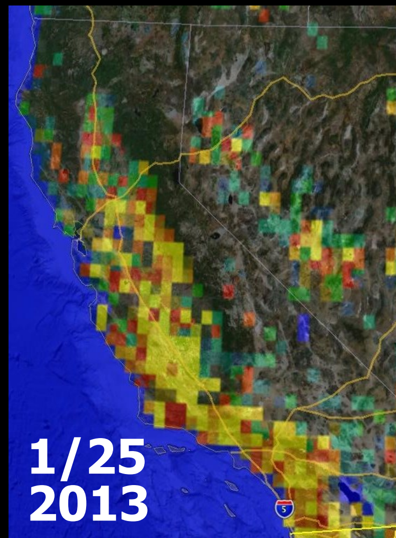
Virga - Dry Thunderstorm

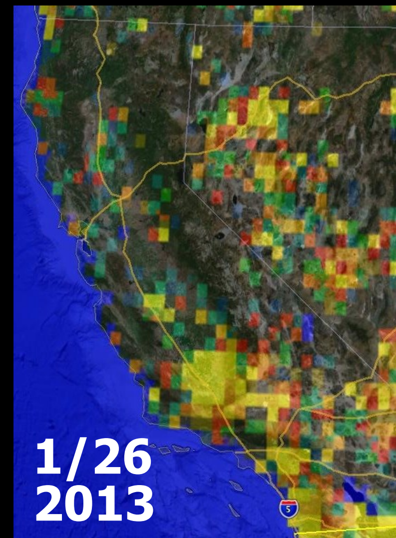


10/28/2007

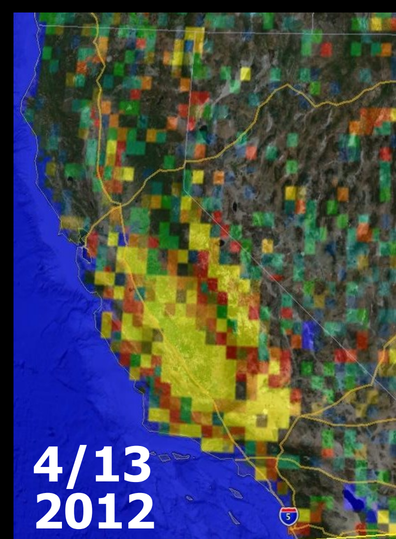
Soil Moisture Change in 2013 and 2012







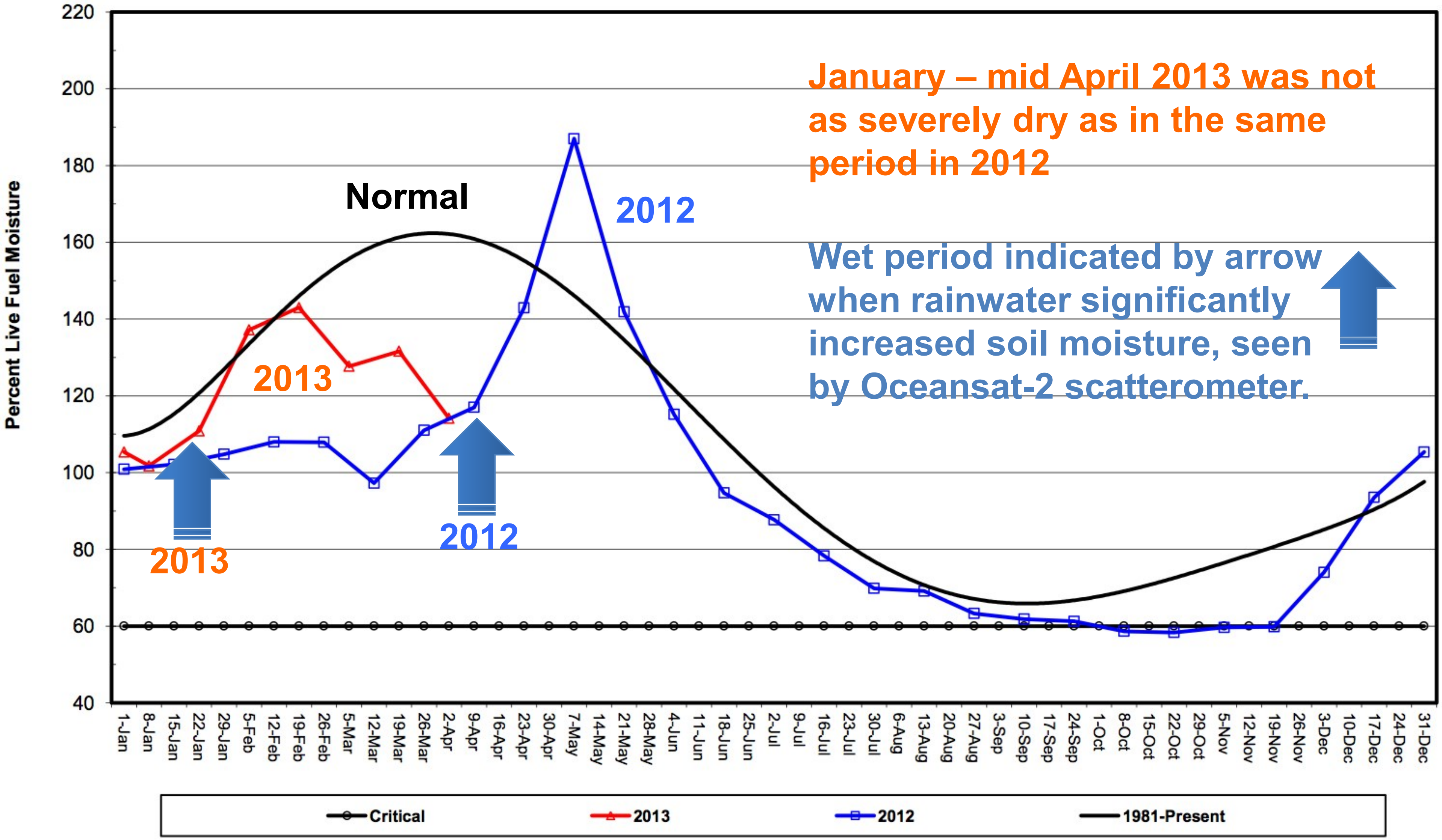
2013: Significant soil moisture increase in late January from rainwater at the onset of the growth season of vegetation.



2012: Significant soil moisture increase in the 2nd week of April from rainwater that enhanced live fuel moisture later than normal.

Vegetation Management Program
Live Fuel Moisture 1981-2013

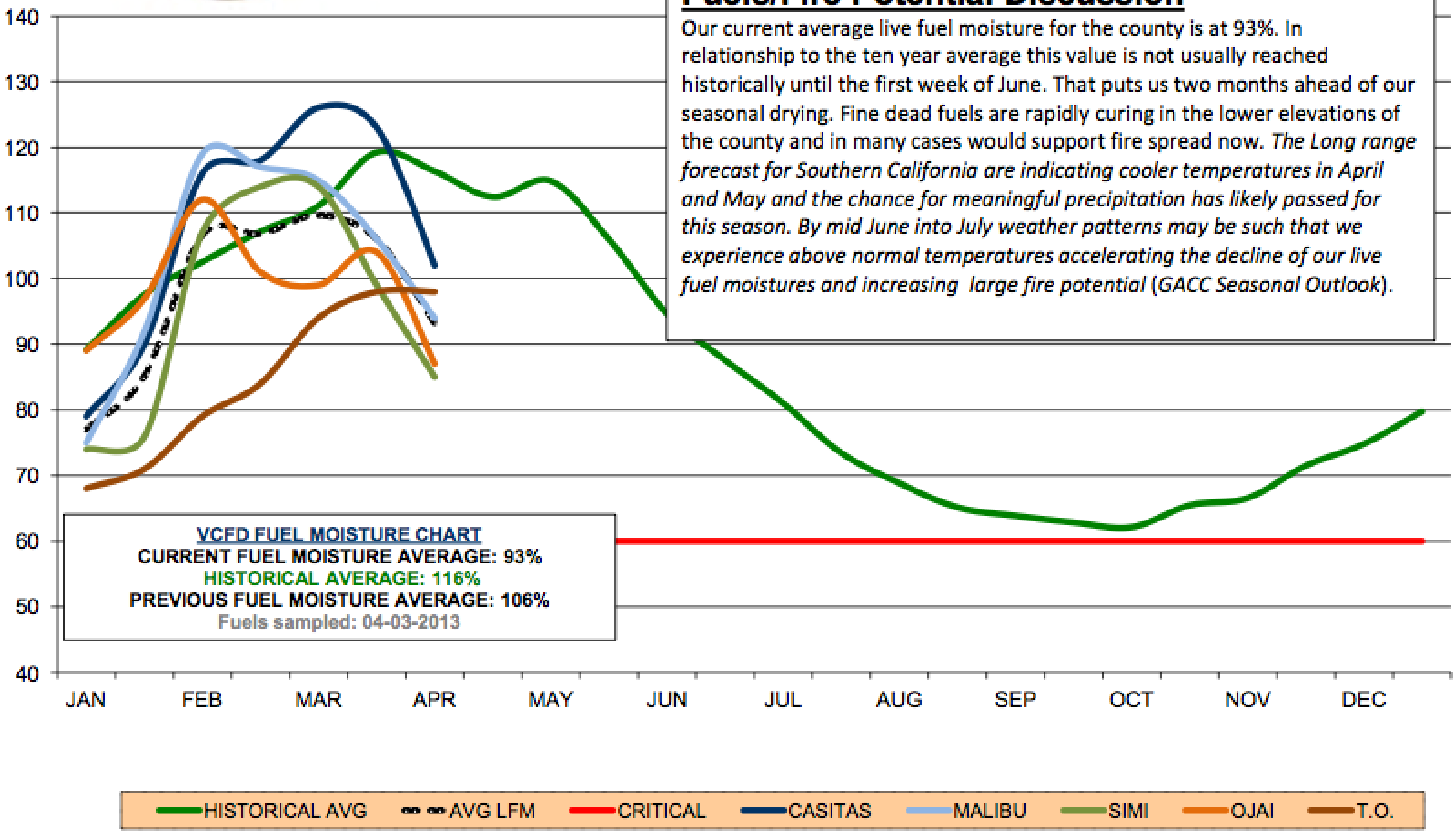
All Areas, All Fuels - Chamise, Ceanothus, Sages, Sagebrush



VENTURA COUNTY FIRE DEPARTMENT
LIVE FUEL MOISTURE 2013
ALL FUEL BEDS - CHAMISE

Ventura County
Fuels/Fire Potential Discussion

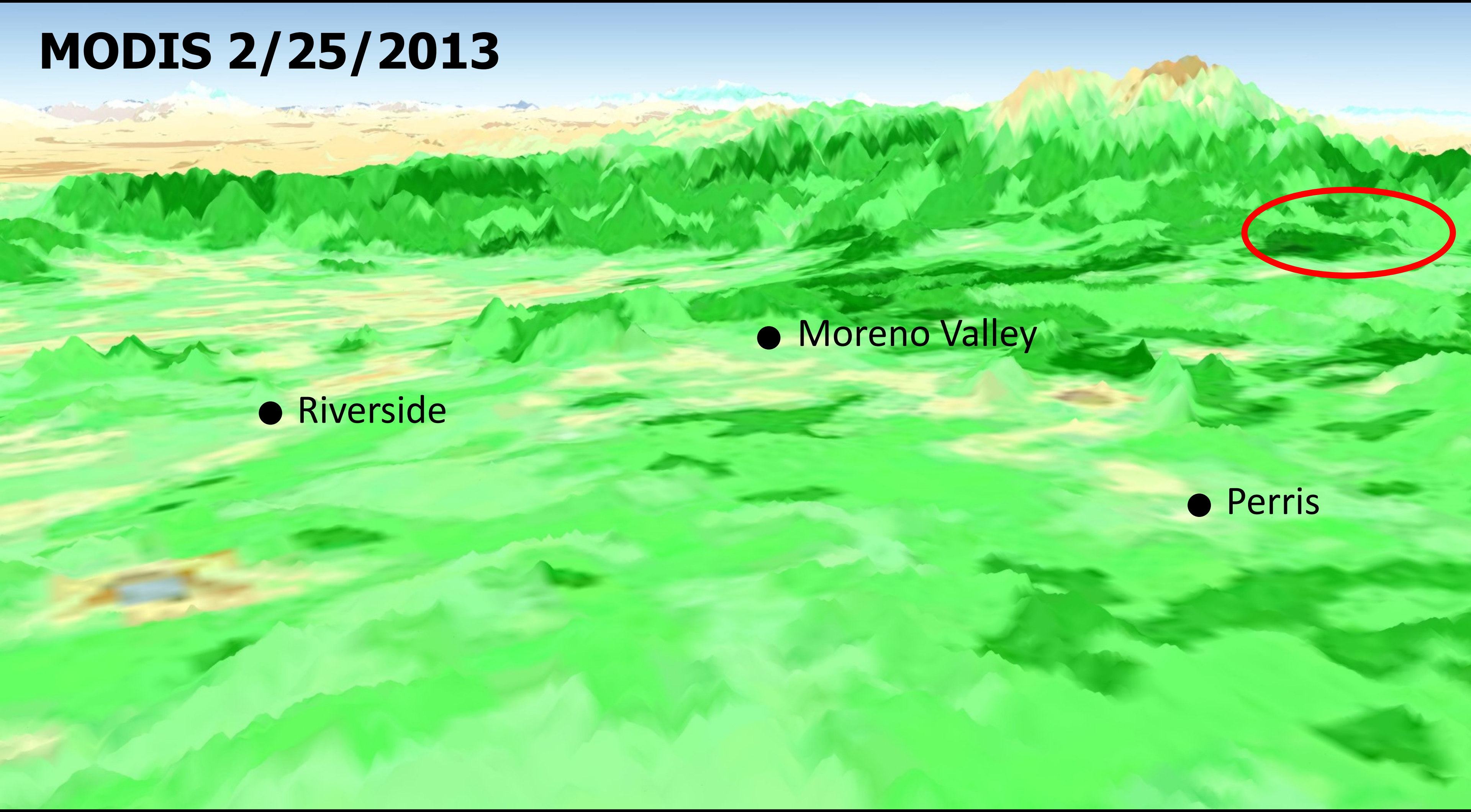
Our current average live fuel moisture for the county is at 93%. In relationship to the ten year average this value is not usually reached historically until the first week of June. That puts us two months ahead of our seasonal drying. Fine dead fuels are rapidly curing in the lower elevations of the county and in many cases would support fire spread now. *The Long range forecast for Southern California are indicating cooler temperatures in April and May and the chance for meaningful precipitation has likely passed for this season. By mid June into July weather patterns may be such that we experience above normal temperatures accelerating the decline of our live fuel moistures and increasing large fire potential* (*GACC Seasonal Outlook*).



Life Fuel Moisture Sampling – Black Star Canyon, OC, April

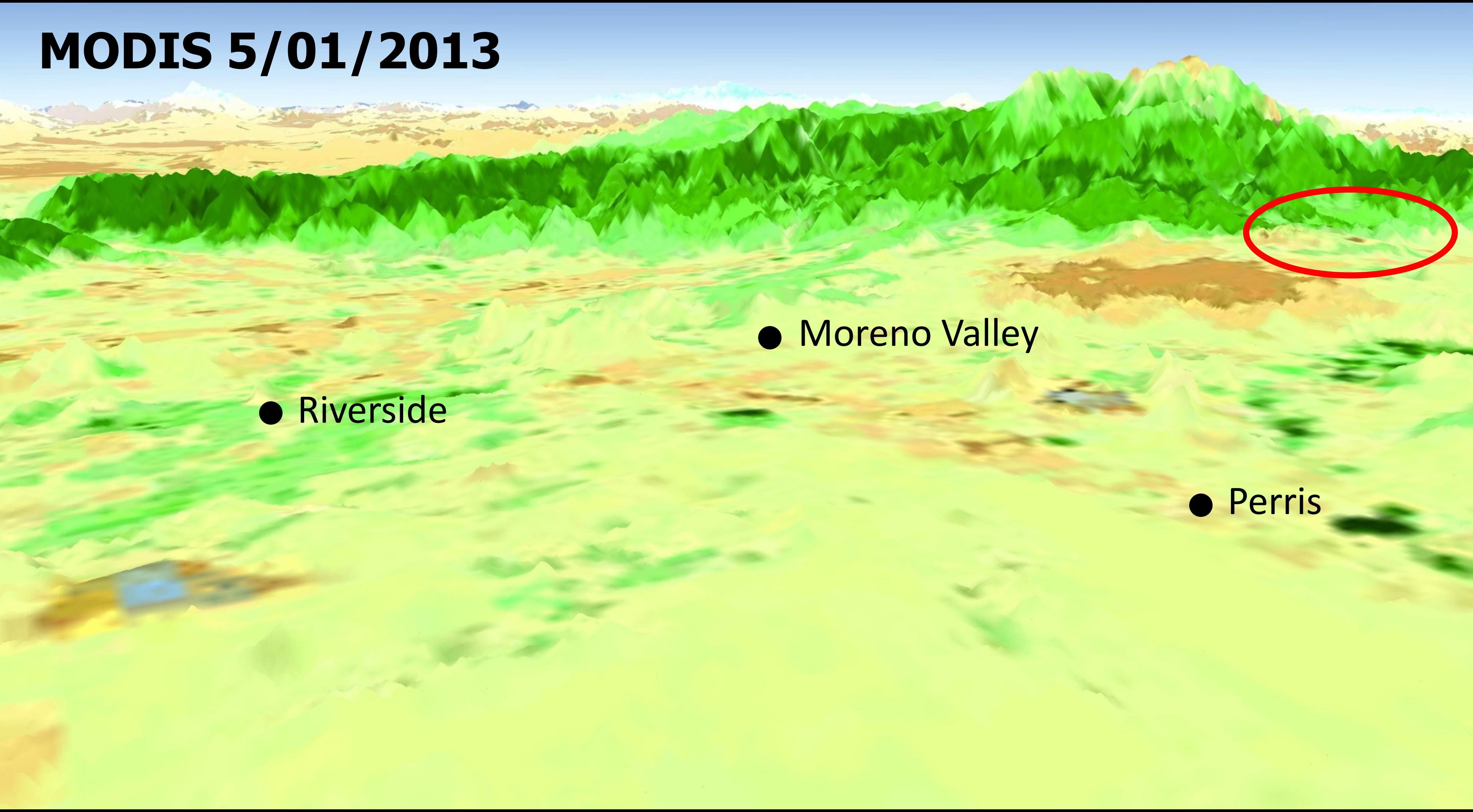
NDVI from MODIS Aqua

Vegetation conditions one month after January rains



NDVI from MODIS Aqua

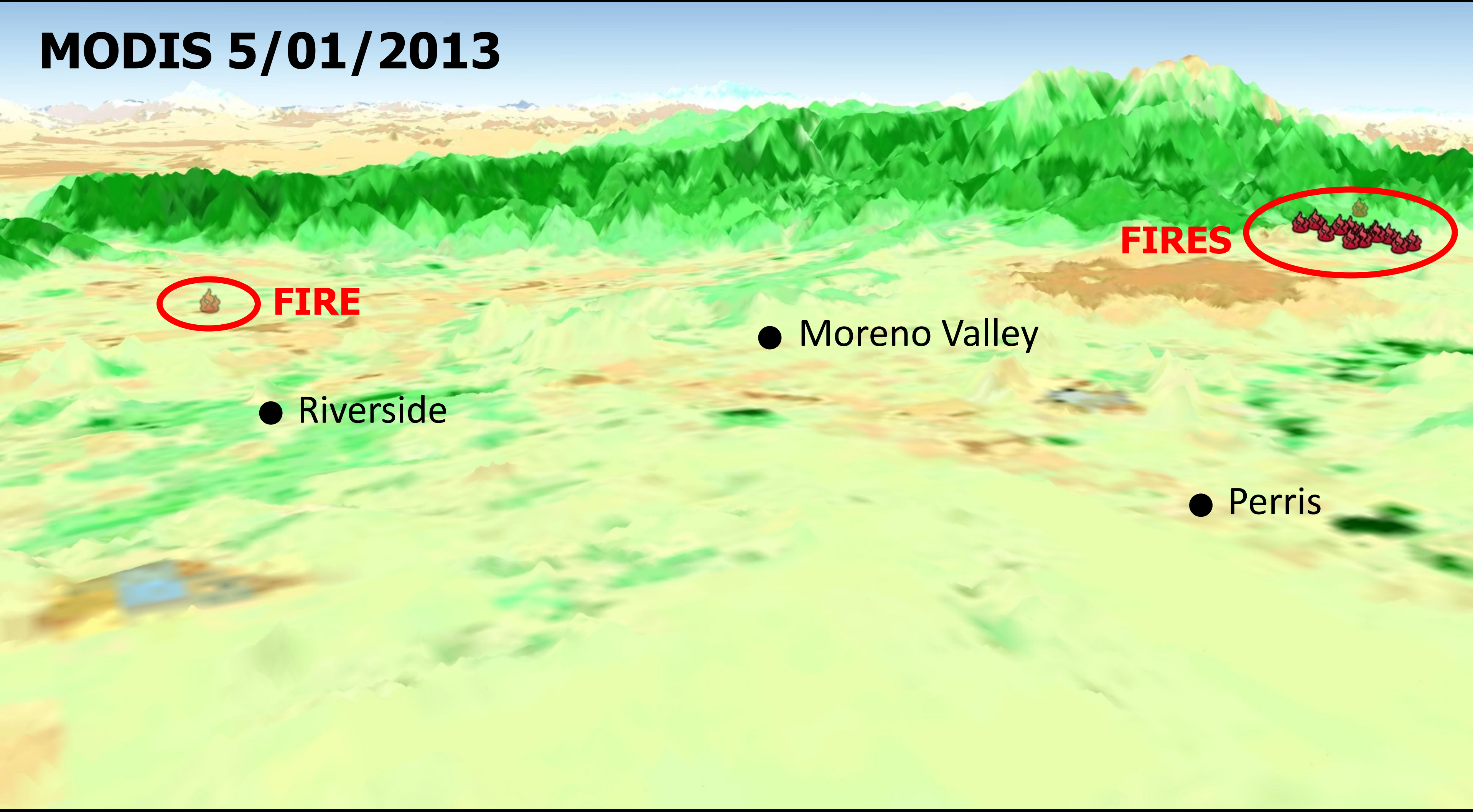
Vegetation conditions at the nominal start of fire season



Rapid and severe dry-out of vegetation

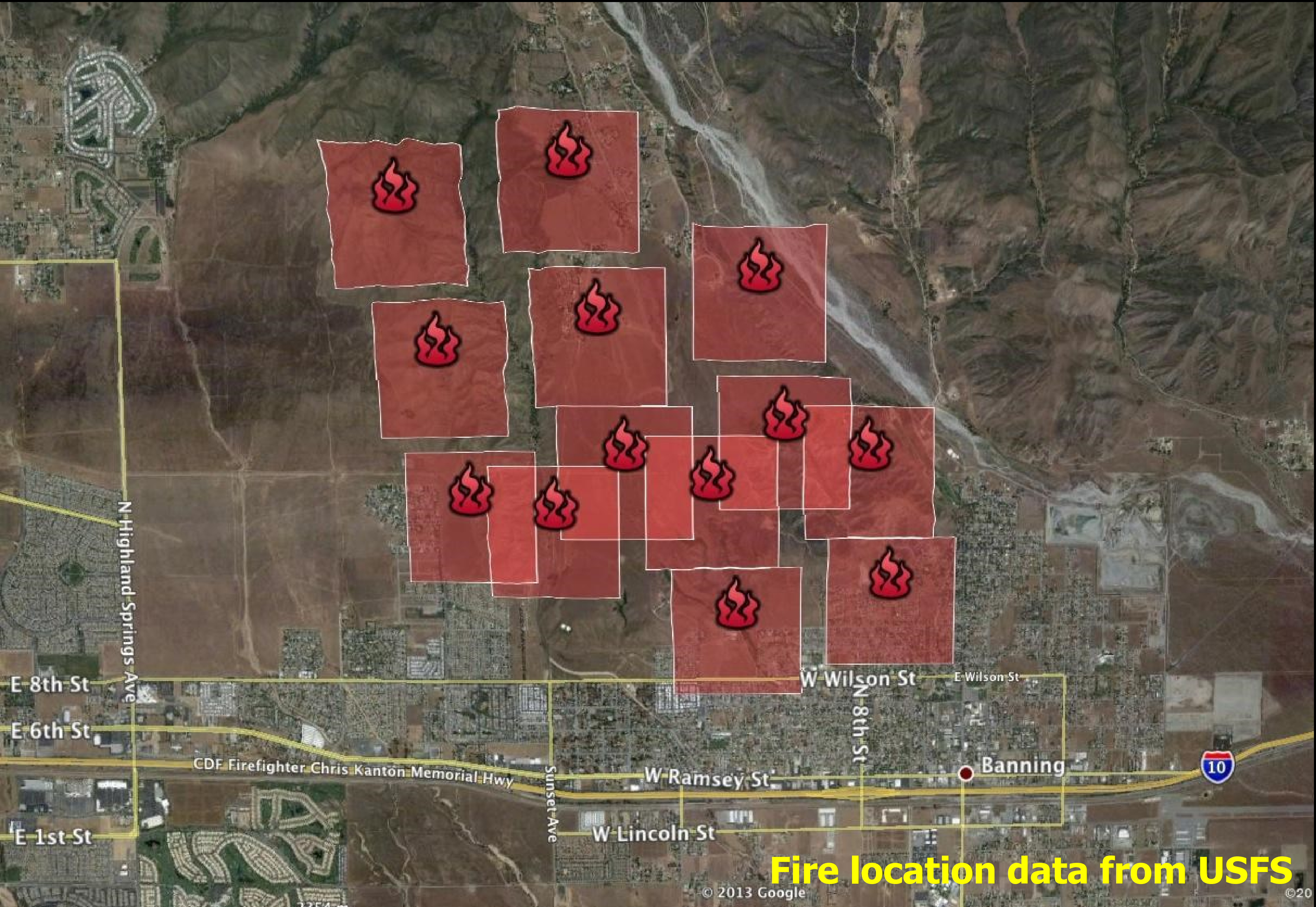
NDVI from MODIS Aqua

Vegetation conditions at the nominal start of fire season

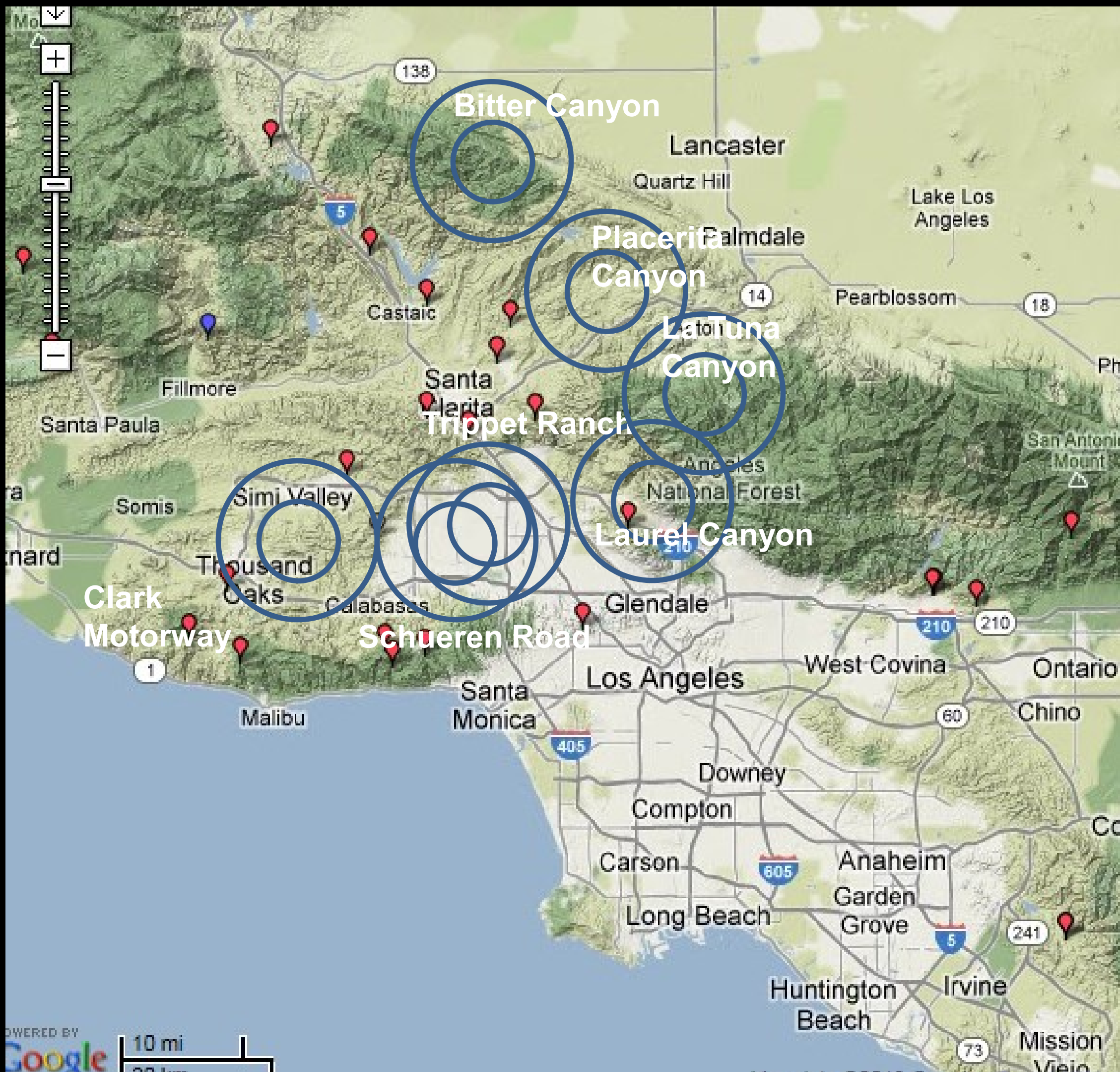


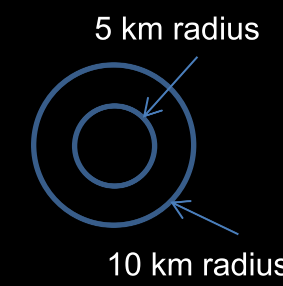
Wildfires broke out at multiple locations

Wildfires near Banning 5/1/2013

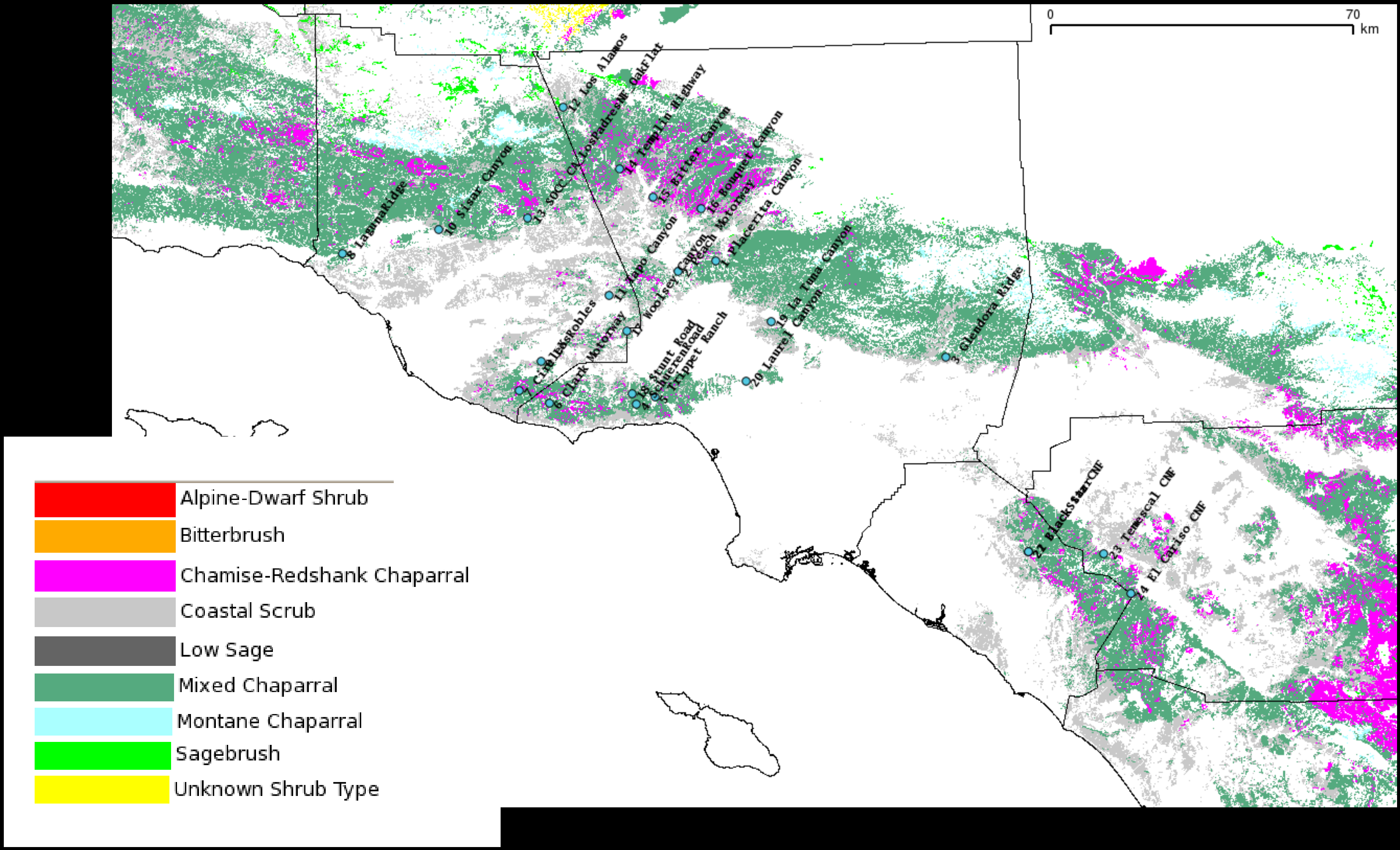


Can satellite replicate Life Fuel Moisture?
Site information

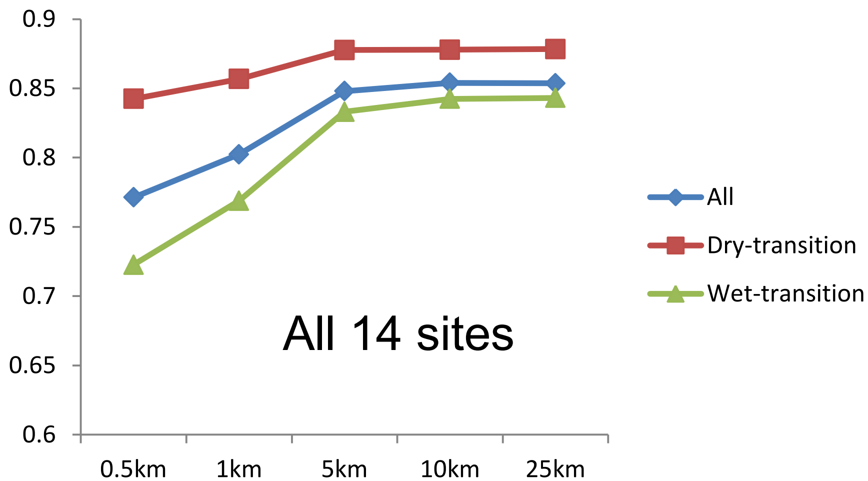


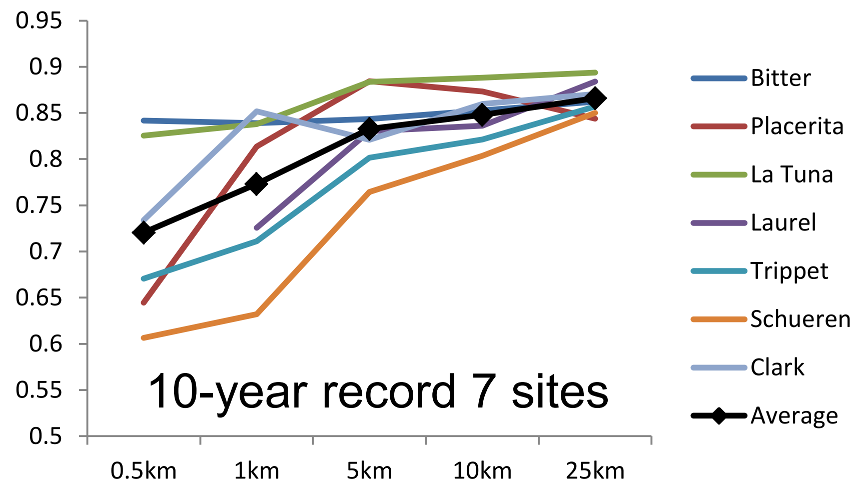


Shrub+Coastal Scrub masking using FRAP data



Result of correlation with different radii





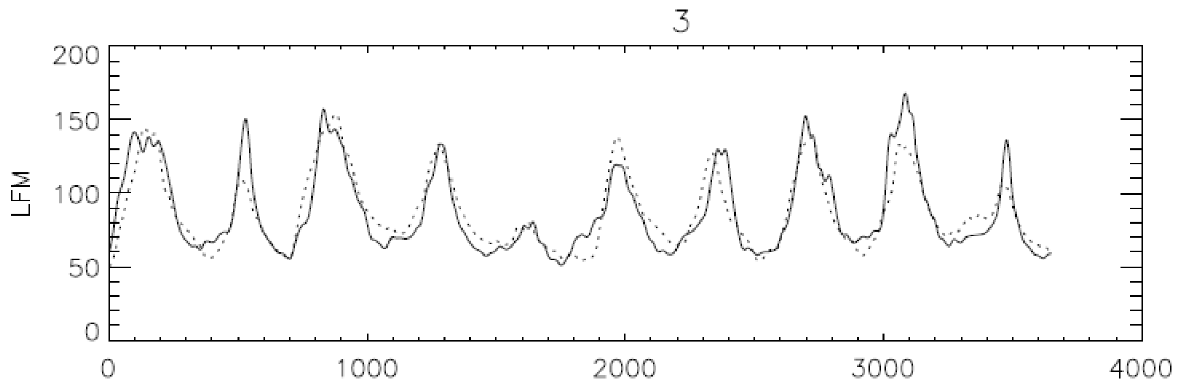
- Increasing trend of correlations from 0.5km to 5km and a saturation beyond 5km (blue color). (At 0.5km and 1km resolutions, seasonal cycles are less pronounced, which diminishes their correlations)
- Dry-transition season (Apr-Sep, red color) has higher correlation than wet-transition season (Oct-Mar, green color).
- Among the long-record sites, the highest correlation occurs at 25km except Placerita.

Strong cross-correlations of LFM among the sites

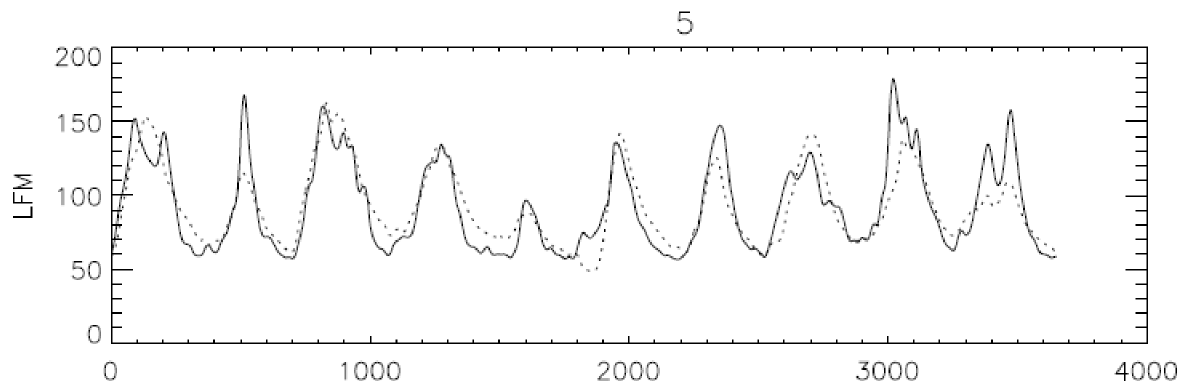
	Bitter	Placerita	La Tuna	Laurel	Trippet	Schueren	Clark
Bitter	1.0	0.934	0.932	0.893	0.847	0.840	0.868
Placerita		1.0	0.949	0.891	0.825	0.861	0.885
La Tuna			1.0	0.928	0.872	0.910	0.917
Laurel				1.0	0.895	0.906	0.896
Trippet					1.0	0.936	0.922
Schueren						1.0	0.942
Clark							1.0

Estimation of LFM by EVI (linear regression model)

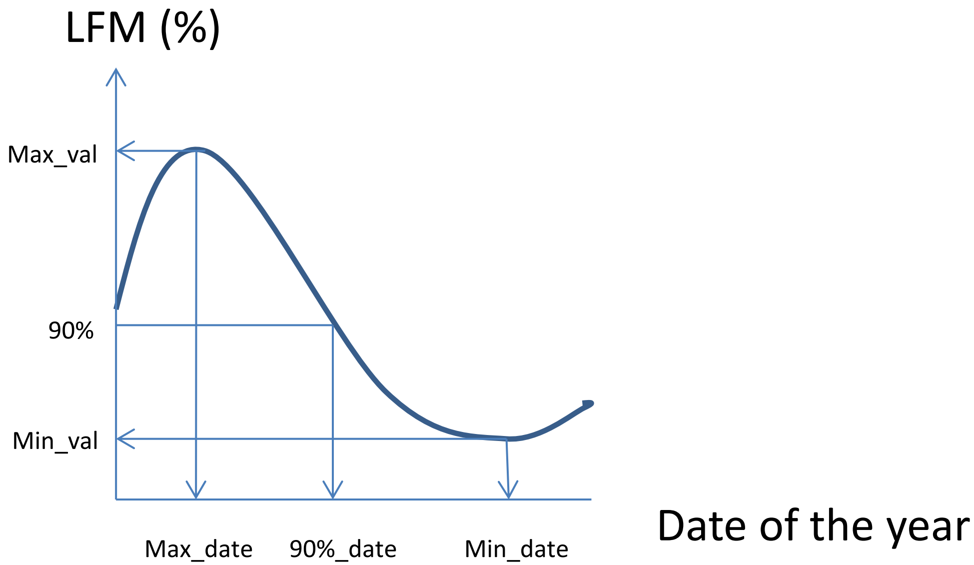
5km	coeff	constant	r
Bitter	450.04	2.52	0.86
Placerita	617.27	-36.77	0.90
La Tuna	534.02	-40.86	0.89
Laurel	500.02	-40.31	0.85
Trippet	505.73	-41.16	0.78
Schueren	510.37	-47.22	0.81
Clark	562.50	-56.74	0.83



25km	coeff	constant	r
Bitter	561.68	-25.30	0.87
Placerita	565.60	-24.28	0.85
La Tuna	493.52	-27.08	0.90
Laurel	435.43	-14.81	0.89
Trippet	490.53	-26.39	0.86
Schueren	494.57	-26.65	0.87
Clark	485.00	-24.07	0.88



Decadal Characteristics



	Max_value	Min_value	Max_date	90%_date	Min_date
10yr mean LFM	143.30	65.14	106.24	197.16	296.66
10yr mean Estimation	131.12	65.04	94.88	186.64	298.76
Interannual correlation	0.46	0.36	0.03	0.62*	0.10

Decadal Characteristics at Each Site

Bitter	Max_value	Min_value	Max_date	Min_date	90%_date
10yr mean LFM	142.556	60.6482	91.6	293.9	169.778
10yr mean Estimation	125.814	62.2825	90.9	311.3	171
Interannual correlation	0.837344	0.324666	0.454536	0.566356	0.850038

Placerita	Max_value	Min_value	Max_date	Min_date	90%_date
10yr mean LFM	160.953	62.9776	106	299.7	191.111
10yr mean Estimation	140.428	64.8618	89.8	310	184.222
Interannual correlation	0.792778	0.721821	0.189458	0.689614	0.715616

La Tuna	Max_value	Min_value	Max_date	Min_date	90%_date
10yr mean LFM	136.967	58.9674	94.7	274.7	181
10yr mean Estimation	126.219	60.0061	95.8	303.5	177.875
Interannual correlation	0.6607	0.479561	0.628794	0.336792	0.611139

Laurel	Max_value	Min_value	Max_date	Min_date	90%_date
10yr mean LFM	140.57	61.3591	86.9	281	178.778
10yr mean Estimation	127.06	61.8678	83.9	307.9	173.222
Interannual correlation	0.702027	0.423605	0.817162	0.123813	0.784021

Trippet	Max_value	Min_value	Max_date	Min_date	90%_date
10yr mean LFM	146.124	59.4381	77.4	283.3	178.5
10yr mean Estimation	130.748	63.6786	82.6	306.1	187.75
Interannual correlation	0.438933	0.528796	0.816926	0.422253	0.692624

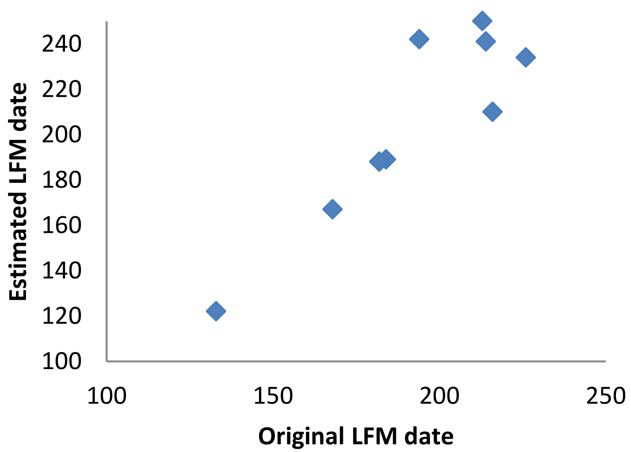
Schueren	Max_value	Min_value	Max_date	Min_date	90%_date
10yr mean LFM	148.51	58.1413	95.3	262.9	176.6
10yr mean Estimation	131.79	65.2038	88.6	305.6	178.1
Interannual correlation	0.274611	0.628762	0.714379	-0.20336	0.79743

Clark	Max_value	Min_value	Max_date	Min_date	90%_date
10yr mean LFM	148.173	62.2676	84.7	296.6	190
10yr mean Estimation	132.746	67.9526	96.7	299	185.1
Interannual correlation	0.351412	0.778831	0.687216	0.689591	0.872015

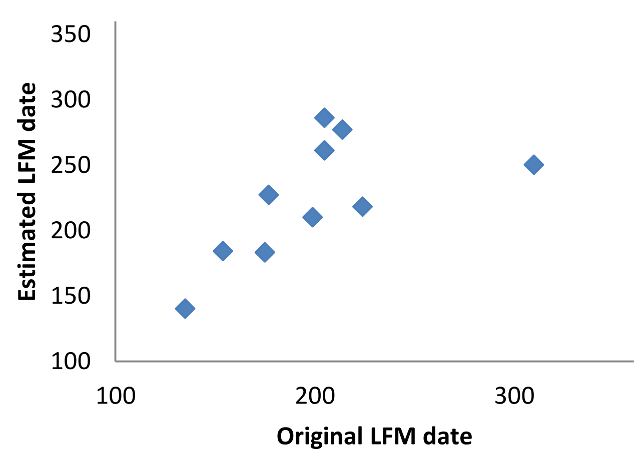
Correlations with different thresholds (will be better with temperature correction; e.g., 0.73 for Schueren)

	100%	90%	80%	70%
Bitter	0.78	0.85	0.81	-0.03
Placerita	0.64	0.72	0.68	0.90
La Tuna	0.58	0.61	0.78	0.60
Laurel	0.62	0.78	0.68	0.40
Trippet	0.68	0.69	0.80	0.69
Schueren	0.67	0.80	0.59	-0.29
Clark	0.91	0.87	0.92	0.64

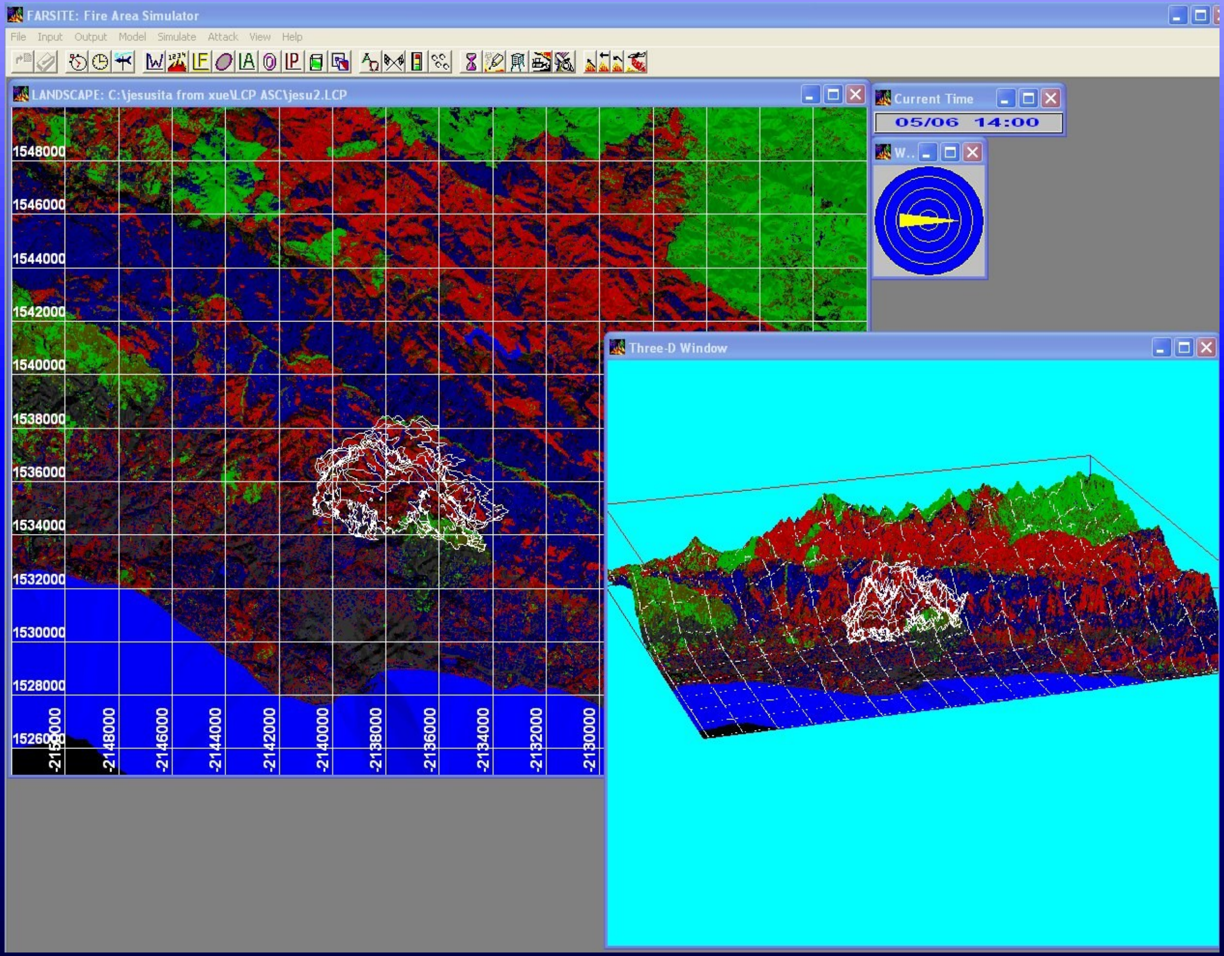
10-year dates of 75% (La Tuna)



10-year dates of 75% (Laurel)

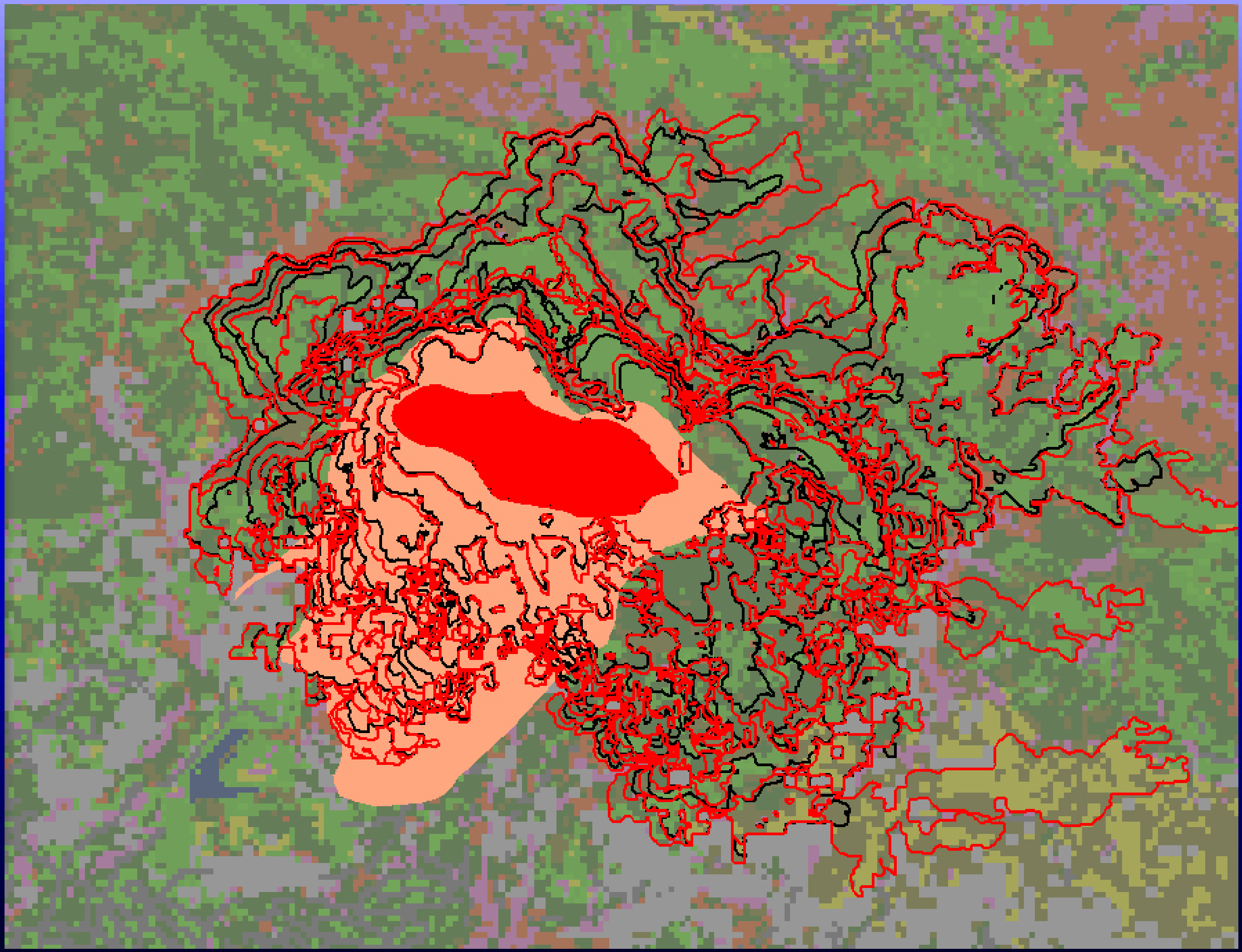


Jesusita Fire (5/2009), Farsite3 Model

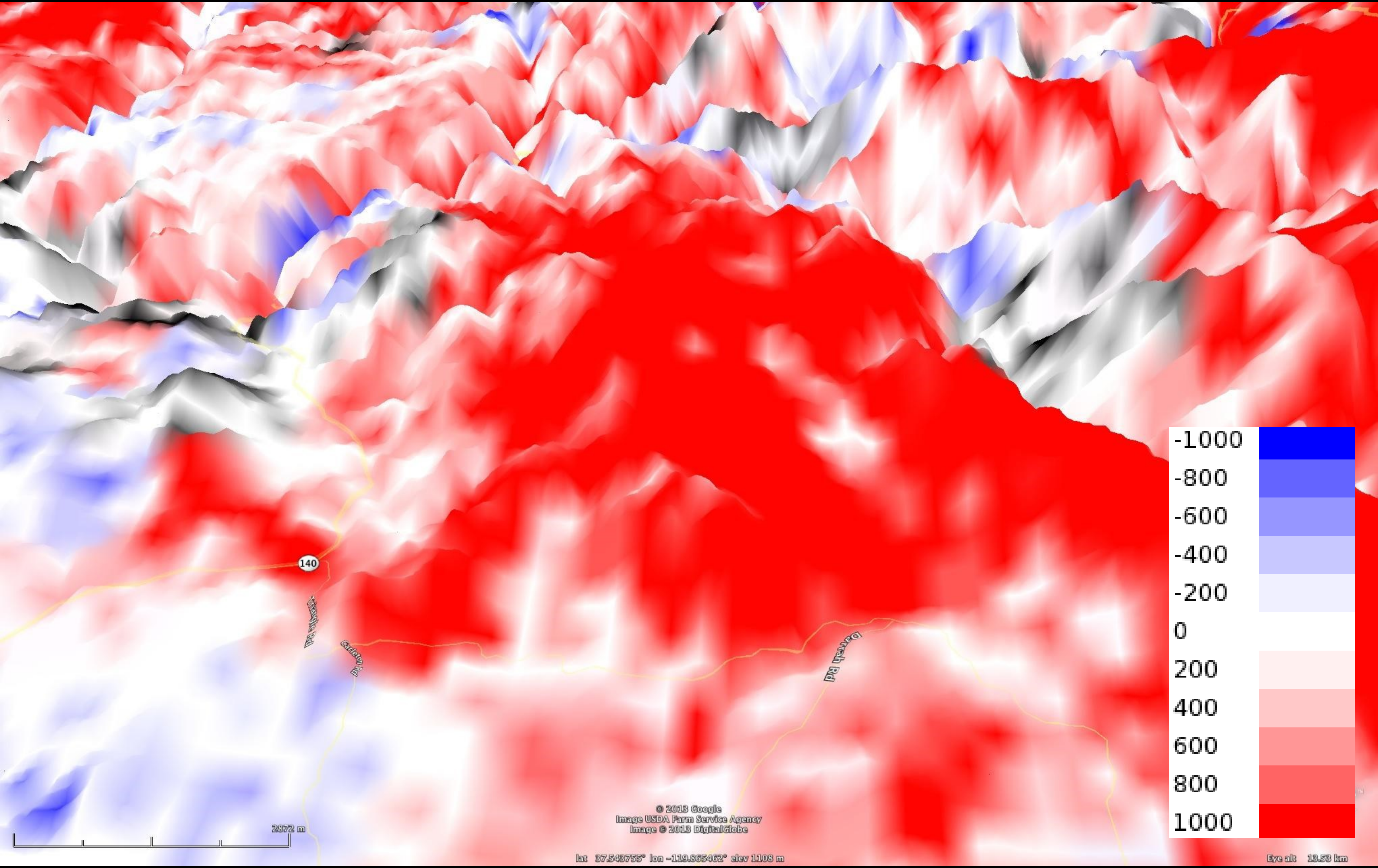


Will eventually use gridded winds, relative humidity, temperature, cloud cover, precip

Jesusita Fire with ±10% LFM (Liu)

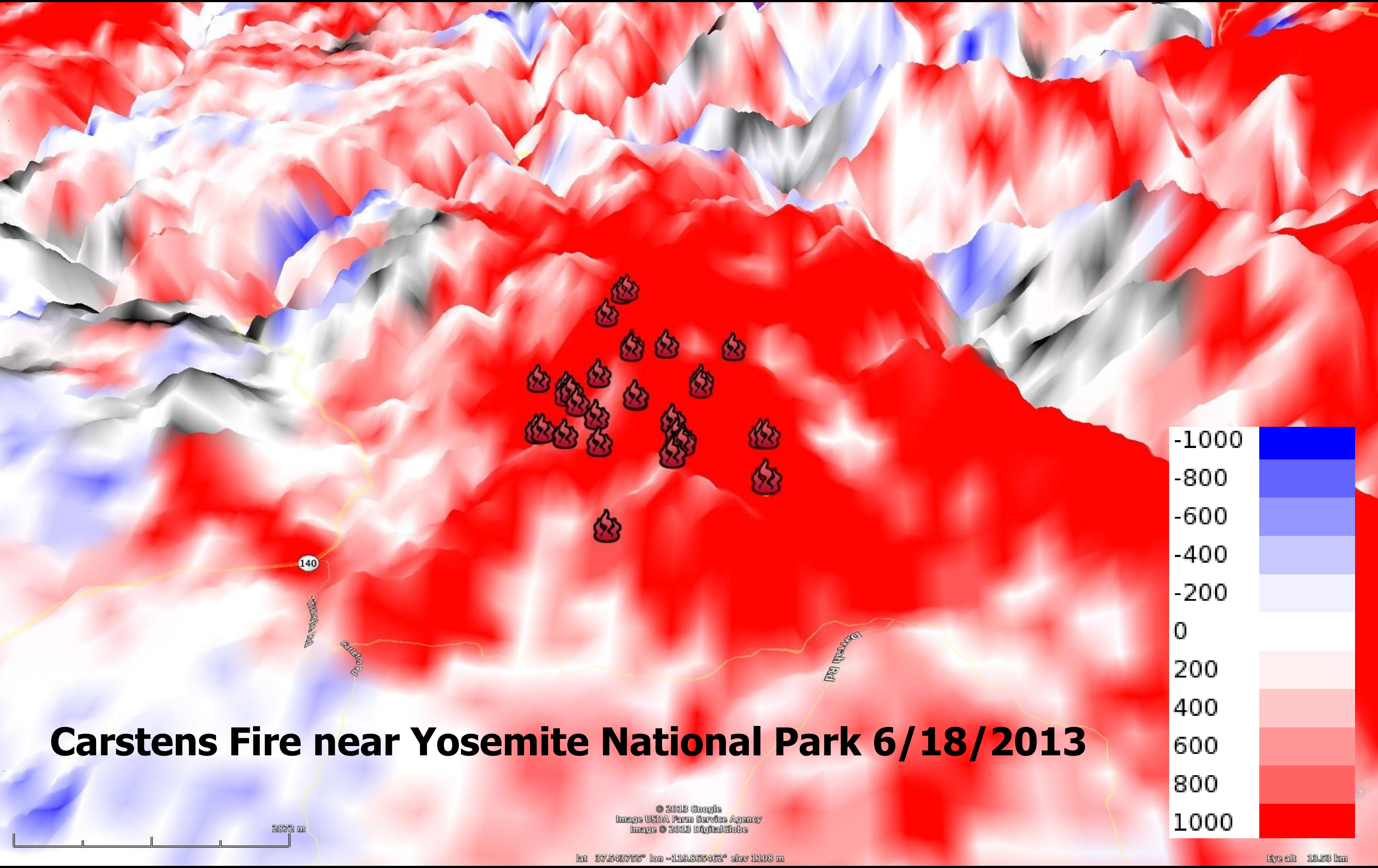


Fuel Dryness Map from MODIS EVI



Map by Son V. Nghiem from JPL using MODIS EVI data from Chapman University.

Fuel Dryness Map and USFS Fires 6/18



Map by Son V. Nghiem from JPL using MODIS EVI data from Chapman University. Fire location data from US Forest Service.

Summary and Conclusions

- **Impacts of drought strongly depend not only on rainwater quantity but also on timing of water excess or deficit.**
- **Satellite data for soil moisture and vegetation can track drought conditions and impacts.**
- **Satellite data can provide quantitative assessment of drought impacts on fire danger (e.g., 2 months early in 2013).**
- **Meteorological and fire behavior models need input from satellite for full spatial and temporal characterization.**