CALIFORNIA'S FOURTH CLIMATE CHANGE ASSESSMENT:
OVERVIEW OF PROPOSED ENERGY SECTOR STUDIES, PART A

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Environmental Area (EA)
Energy Generation Research Office
Research Division
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Proposed Studies

PART A (this presentation)

- Socioeconomic and urban projections for the energy sector
- Climate, hydrological, and sea-level rise scenarios to support energy sector planning and management (*ongoing research*)
- Wildfires and the transmission and distribution system
- Sea-level rise and electricity infrastructure

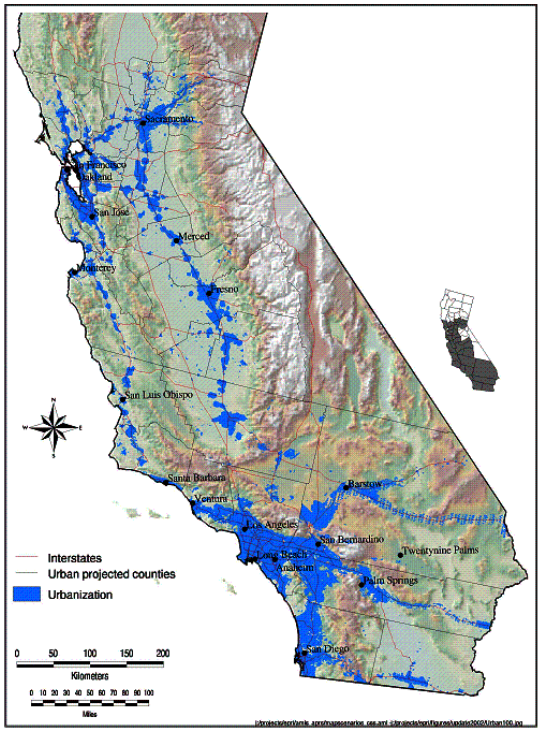
PART B (to be discussed in the next presentation)

- Long-term scenarios for the energy sector
- Improved characterization of the urban heat islands
- Regional adaptation studies for the natural gas sector
- Electricity sector strategies to foster resilience
- Related studies supported by the CEC

Socioeconomic and urban projections for the energy sector

Susan Wilhelm, Sonya Ziaja

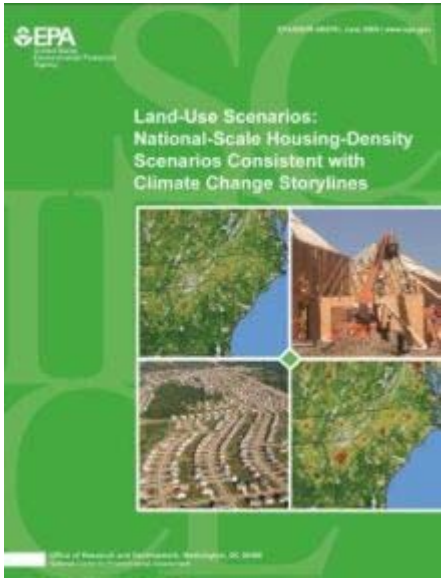
- **Objective:** Develop enhanced socioeconomic and land use scenarios for California to support energy sector planning and management.
- **Prior work:** Prior work (Landis and Reilly 2003, ICLUS 2009, UPLAN 2012) demonstrated the importance of considering urban, suburban, and ex-urban projections to estimate risks to ecological systems, energy demand, and the reliability of the electricity system. Prior studies have the following limitations:
  - "Old" information, data
  - Assumption of static general plans
  - Some models do not enable examination of relationships between fiscal policies and other planning decisions



J. Landis and M. Reilly, 2003.
source:
http://www.energy.ca.gov/reports/500-03-058/2003-10-31_500-03-058CF_A03.PDF

Proposed work:

- Use socioeconomic projections produced by the Dept. of Finance and enhance this work as needed to make it more responsive to the needs of the energy sector (e.g., finer spatial resolution vs. county-level data).
- Leverage on-going work with USGS and/or USEPA. USEPA could share early results of ongoing efforts designed to improve the Integrated Climate and Land Use Scenarios (ICLUS) model.
- Consider opportunities to coordinate with and enhance related work such as OEHHA's CalEnviroScreen tool and local general development plans.
- Develop different urban, suburban, and ex-urban projections using alternative assumptions about drivers of growth.
- Identify specific parameters or model scenarios needed by stakeholders.



2050 Impervious Surface: A2 scenario

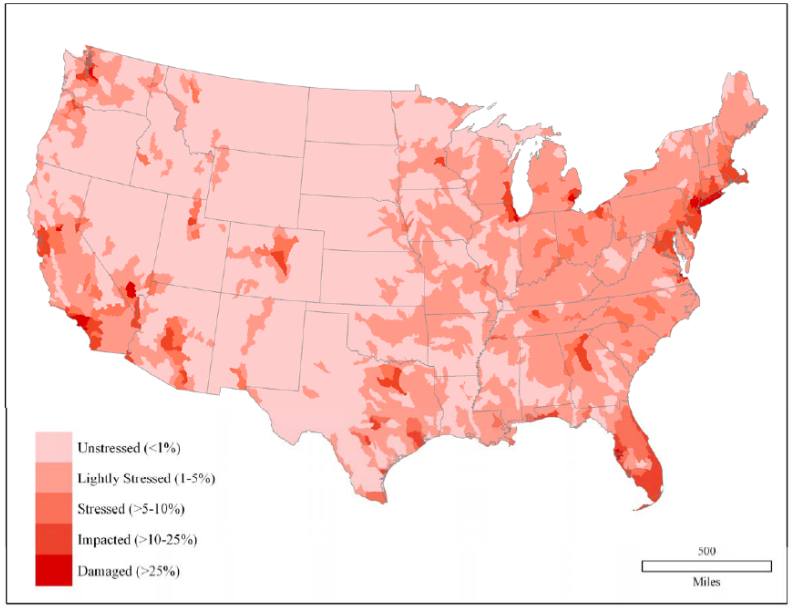


Figure 5-21. 2050 impervious surface, A2 storyline.

Climate, hydrological, and sea-level rise scenarios for the energy sector

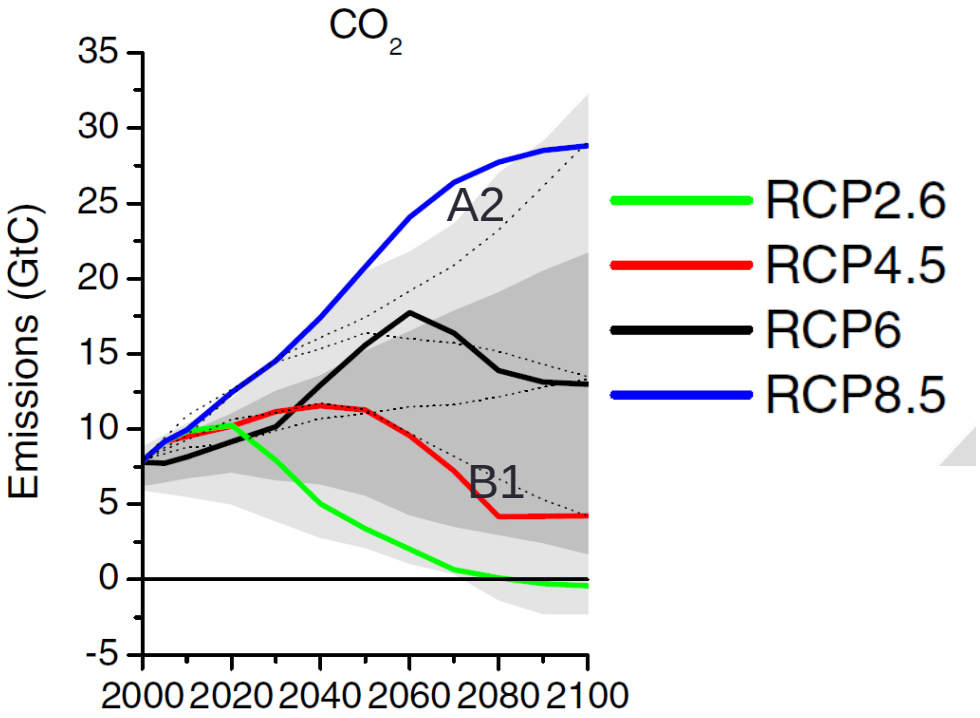
Guido Franco

- **Objectives:** 1) Develop new state-of-the art/science climate scenarios for the energy system using the outputs from the recent IPPC global climate models; 2) Use the VIC hydrologic model to estimate changes in stream flows affecting hydropower generation, and risk of inland flooding; and 3) Develop "probabilistic" sea-level rise scenarios.
- **Prior-work:** California is one of the national leaders in this field. However, CEC sponsored evaluation work of downscaling techniques (e.g., 2012; Pierce et al., 2013) and others (e.g., Zhang et al., 2012), have discovered some deficiencies such as the underestimation of extreme events and unrealistically homogeneous precipitation fields.
- **Proposed work:** Because these scenarios are needed ASAP, we will use new tools that have been developed by Scripps and UCLA. General characteristics of the proposed work:
  - Use the new LOCA downscaling technique developed by Scripps. The daily T and P fields would be available by December 2014 including "probabilistic" projections. Resolution of about 6 km (3.5 miles) for RCP 8.5 and RCP 4.5.
  - Hydrologic projections using the VIC model (first quarter in 2015).
  - Other fields (relative humidity and wind fields) may be available in 2015.
  - Use the dynamic projections being developed by Prof. Alex Hall from UCLA using the WRF model (time slices for a historical period and middle and end of this century). This work is not funded by the CEC.
  - Use expert elicitation techniques to develop probabilistic sea-level rise projections for California.

- Pierce, D.W., et al, 2013: Probabilistic estimates of future changes in California temperature and precipitation using statistical and dynamical downscaling. *Climate Dynamics*, **40**, 839-856. doi:10.1007/s00382-012-1337-9.
- Zhang, F. and A.P. Georgakakos, 2012. "Joint Variable Spatial Downscaling," *Climatic Change*, **111**(3), 945-972.

New Global Emission Scenarios

- Representative Concentration Pathways (RCPs) replacing the SRES scenarios
- RCP 8.5 similar to A2
- RCP 4.5 similar to B1
- "Continuity" from past CA assessments that used the A2 and B1 scenarios
- Are other groups downscaling different scenarios?



van Vuuren et al., 2011. The representative concentration pathways: an overview. *Climatic Change.*

Preliminary Selection of GCMs for the representative climate scenarios for CA

- Work done in collaboration with DWR through their Climate Change Technical Advisory Group with support from CEC, NOAA, and Southwest Climate Science Center.

Change in JJA Temperature (ºF) and Water Year Precipitation (inches): 2070-99 vs. 1961-1990, Sacramento Region

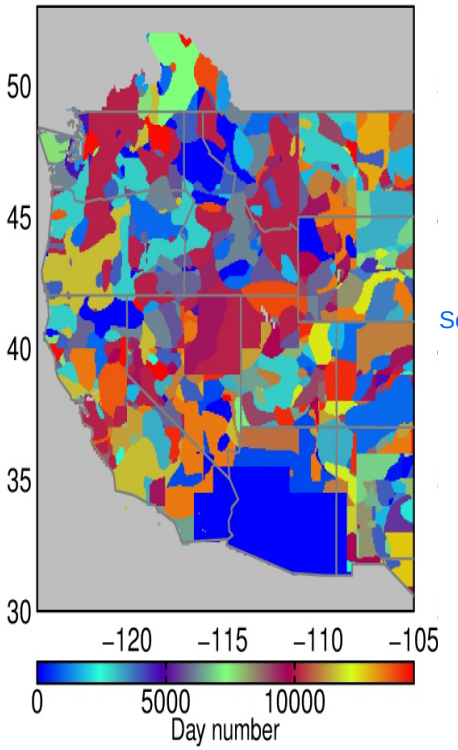
rm#	model name	JJA 2070-2099 minus 1961-1990		WY 2070-2099 minus 1961-1990	
		rcp 4.5	rcp 8.5	rcp 4.5	rcp 8.5
	ACCESS-1.0	6.13	9.39	0.79	-5.08
2	CCSM4	4.38	7.62	0.19	0.62
5	CESM1-BGC	4.12	7.68	3.91	12.12
	CMCC-CMS	5.39	9.95	3.04	-0.99
3	CNRM-CM5	5.24	8.51	9.98	10.37
4	CanESM2	6.96	12.07	3.87	7.31
15	GFDL-CM3	7.47	10.33	-0.60	-3.55
10	GFDL-ESM2M	4.72	7.95	-3.12	-4.85
11	HadGEM2-CC	5.61	9.69	0.03	-1.59
8	HadGEM2-ES	6.57	10.39	0.31	3.35
1	MIROC5	5.67	7.46	-4.57	-1.36

DRAFT

source: Dan Cayan, Scripps Institution of Oceanography

Statistical downscaling: with LOCA

- **Validation**: Comparison of simulations with observations is very good. More realistic spatial distribution of T and precipitation, and improved simulation of extreme events.
- **Ongoing**: Federal agencies will support application of LOCA at the national level.
- **Need**: Selection of appropriate, regionally representative scenarios.



Downscaling with Localized Constructed Analogues (LOCA)

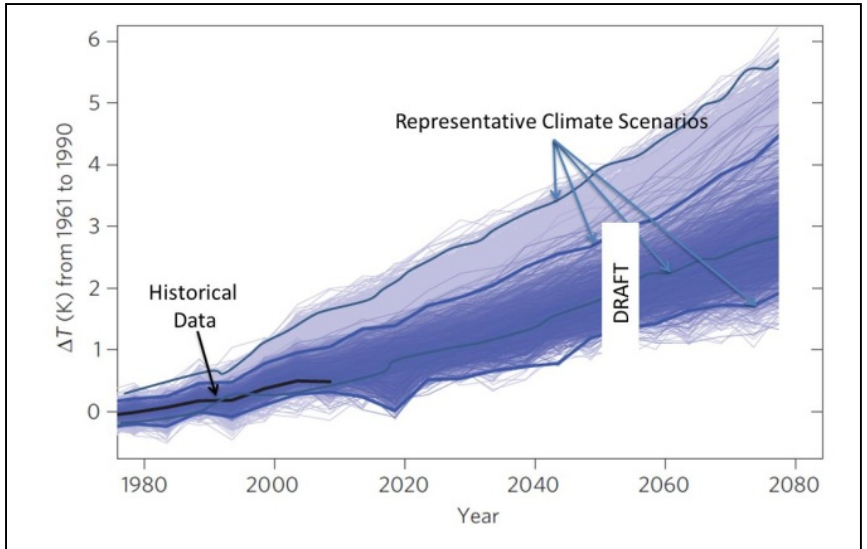
David Pierce and Dan Cayan

Scripps Institution of Oceanography

CEC webinar 2013-12-03

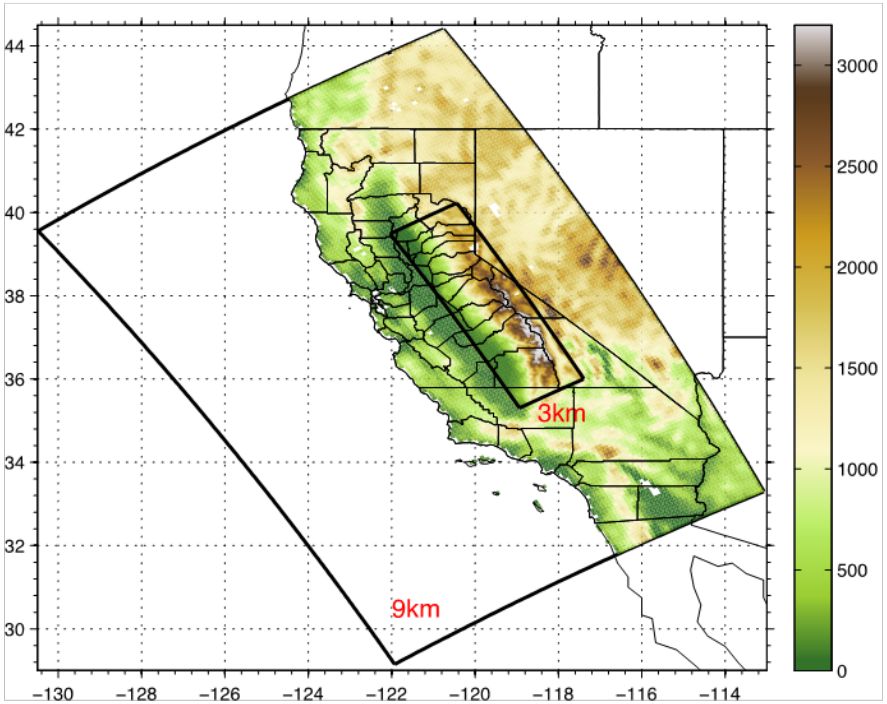
Work sponsored by

The California Energy Commission



Dynamic Downscaling

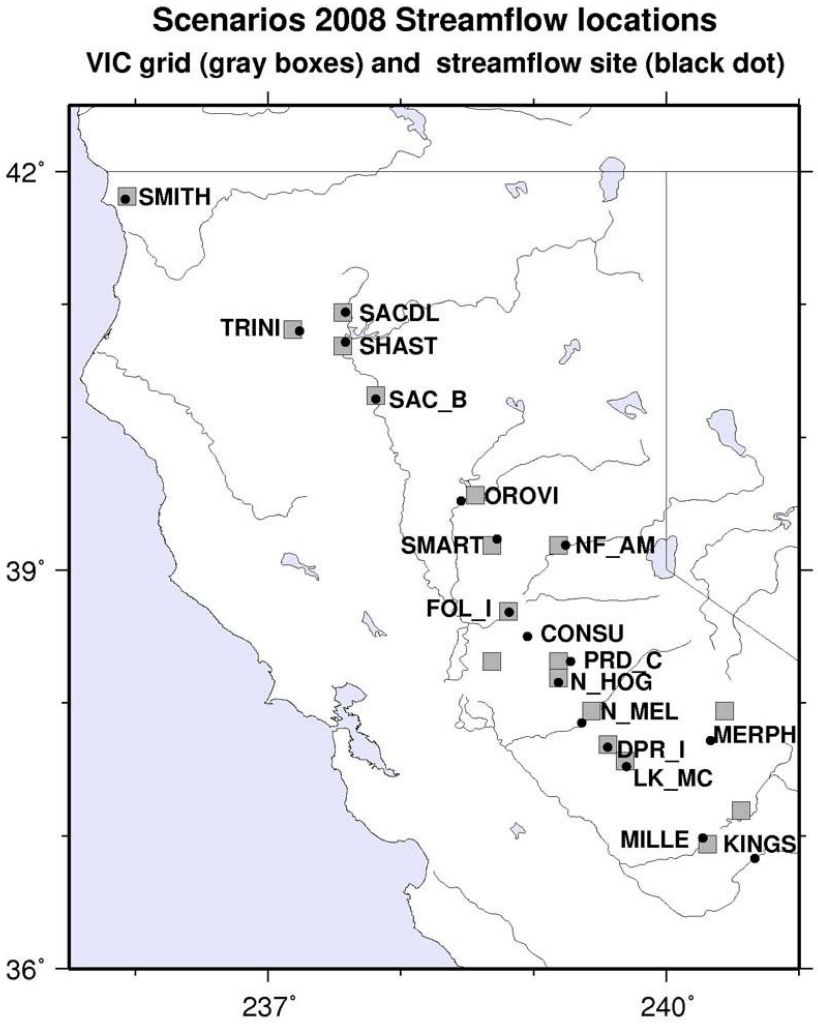
- Prof. Alex Hall from UCLA using the WRF model forced with NARR data to create baseline simulation for 1991–2010
- WRF forced with output from 5 GCMs to produce future projections for 2081–2100 under RCP8.5
- 9-km resolution over California; 3-km resolution over Sierra Nevada Mountains
- Data include full suite of meteorological variables, e.g.:
  - 2-dimensional temperature, water vapor, cloud
  - 3-dimensional winds
  - Surface variables such as snow, heat fluxes



source: Professor Alex Hall, UCLA

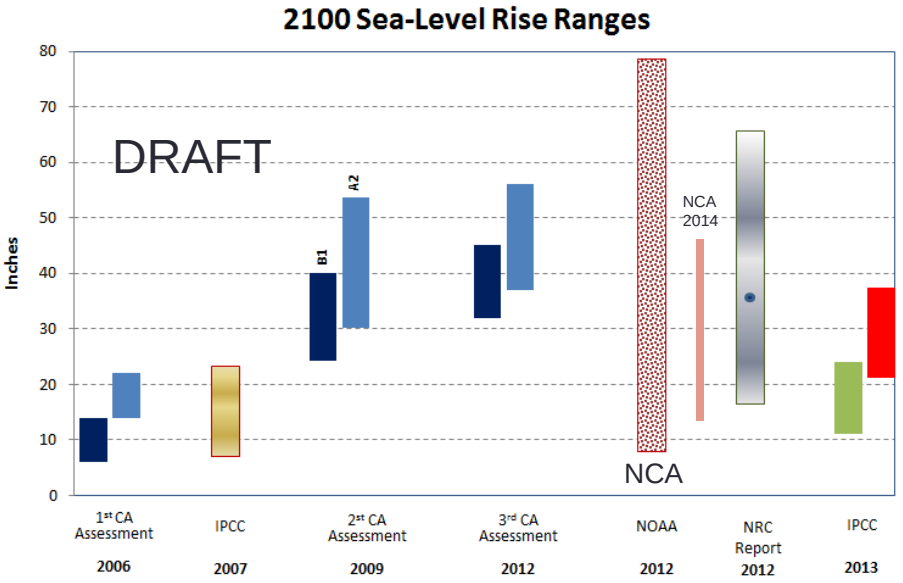
Streamflow locations used to validate hydrological modeling

- Stream gage locations in the Variable Infiltration Capacity (VIC) hydrologic model.
- In the past they have been used as “indicator” gages.
- Do we need more locations?

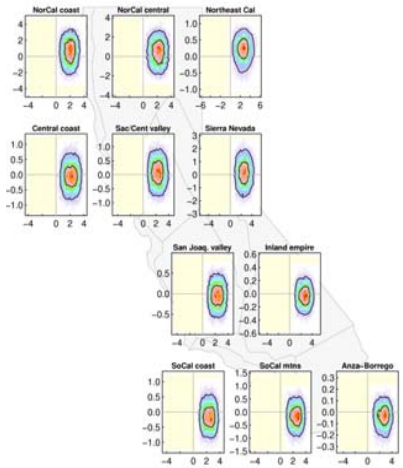


Do we need “probabilistic” projections?

- Reporting ranges may be misleading because it suggests that extremes are as likely as other potential outcomes.
- Pierce et al. 2013 explored the development of “probabilistic” climate projections for CA.
- “Probabilistic” projections could include extreme cases (e.g., long-lasting droughts) with low probability of materializing but with high consequences. Surprises, however, cannot be ruled out.

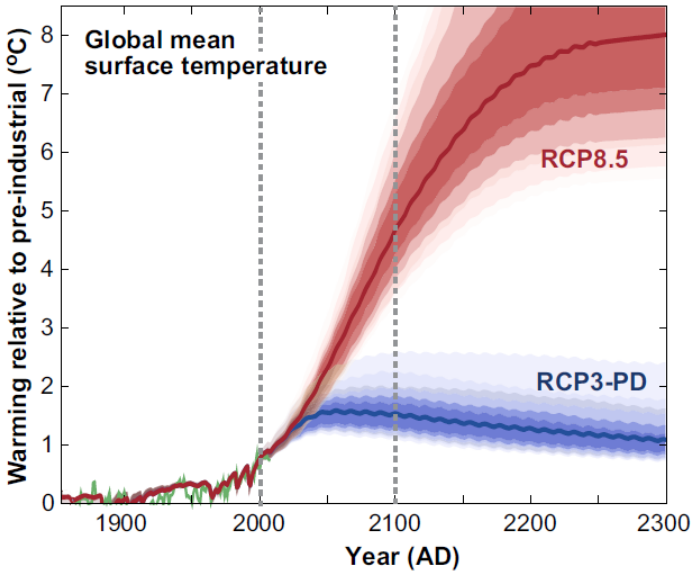


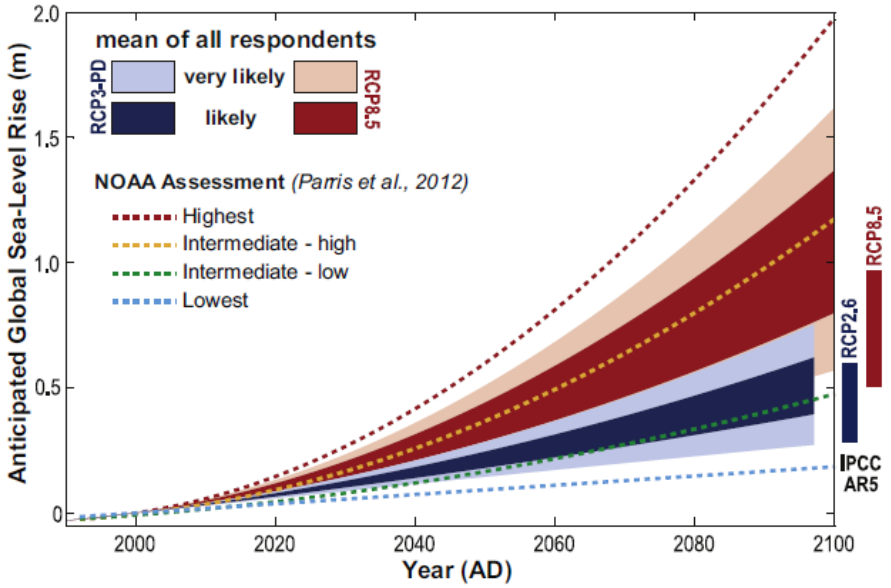
source: Franco, Oliver, Wilhelm, 2013



Pierce et al., 2013

Do we need “probabilistic” projections? (cont.)





Studies are available reporting sea-level rise “probabilities” but they are not specific to CA, do not cover the RCPs that CA will use, and involve no formal quantitative analyses. Moreover, scenarios must be updated to reflect rapidly advancing science.

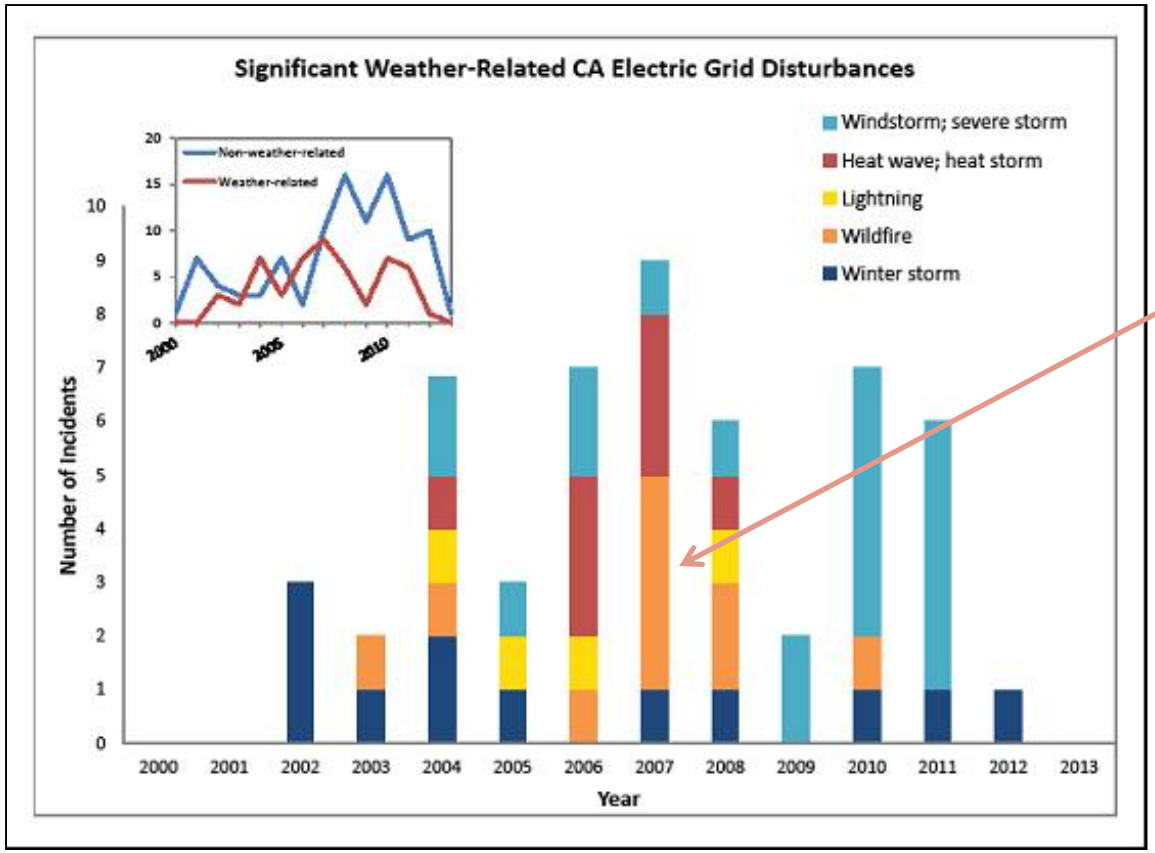
Horton et al., 2014

Any concerns with the use of “probabilistic” projections? When possible, should this work be complemented with robust decision analyses?

Wildfires and the transmission and distribution system: vulnerabilities and exploration of adaptation options

David Stoms

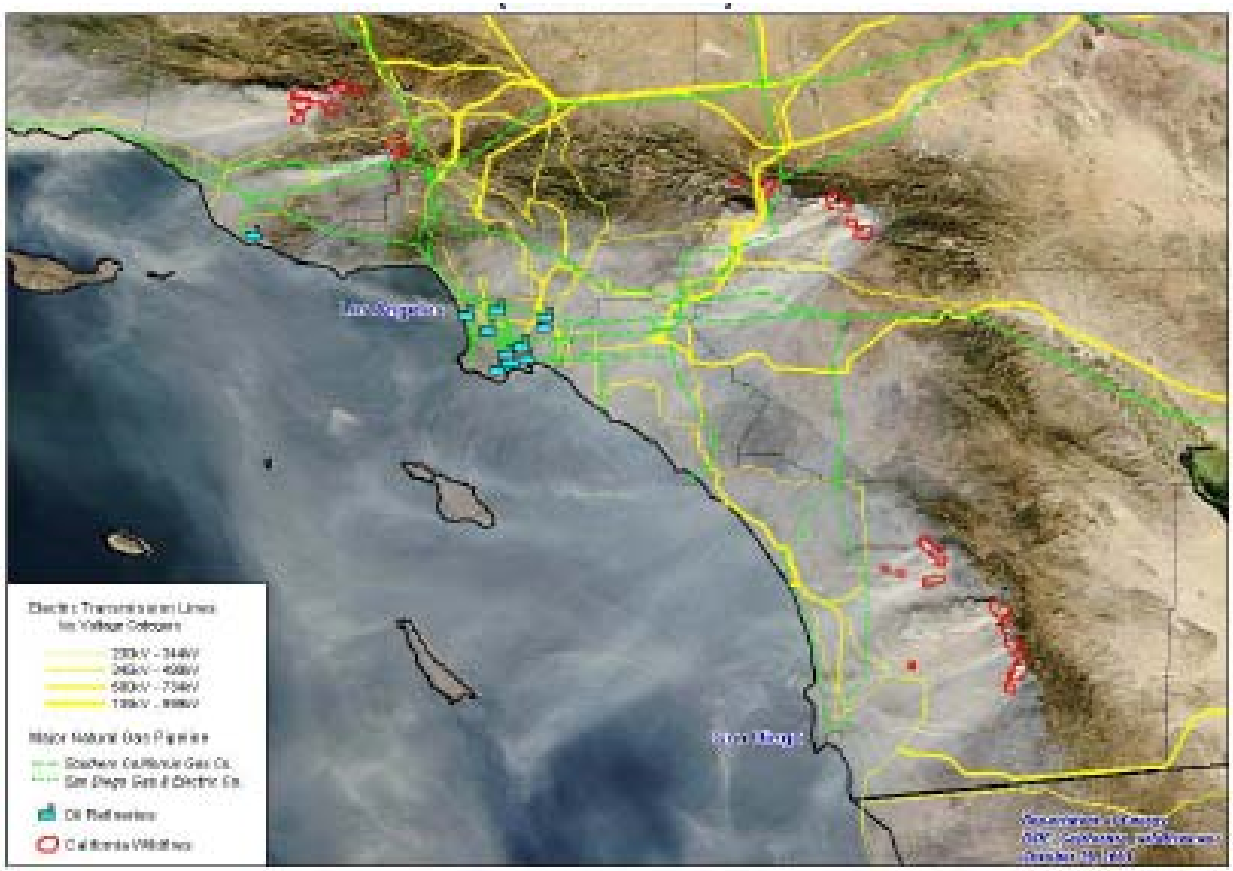
Wildfires are a significant source of weather-related disturbances



G. Franco, L. Oliver, 2013

Data Source: U.S. Energy Information Administration, http://www.oe.netl.doe.gov/OE417_annual_summary.aspx

Energy infrastructure issues due to 2003 wildfires in Southern California



The picture above shows electric transmission lines, major natural gas pipelines, oil refineries, and the locations of the wildfires as of Monday, October 28, 2003. The heavy smoke from the fires appears as white clouds in this image.

source: http://www.oe.netl.doe.gov/docs/ca_wildfires_103003.pdf

Energy infrastructure issues due to 2003 wildfires in Southern California, *continued*

Electricity

- 58,700 customers of Southern California Edison and San Diego Gas and Electric without power for several days.
- Four major transmission lines in Southern California had outages over several days (including two 500 kilovolt lines).
- California ISO reported that all customer outages were due to loss of low voltage distribution lines.
- SDG&E lost about 700 utility poles and transmission lines; SCE lost 800.
- Two 775-megawatt power plants in Ventura County offline for at least one day.
- With conservation efforts and reduced demand due to evacuations, California electricity peaked at approximately 2/3 of its expected peak.

Petroleum (*note*: EPIC and Natural Gas funds **cannot** cover this sector)

- There were no fires near refineries.
- But two refineries that were in the vicinity of the fires were in great danger of a shutdown: the large ExxonMobil refinery in Torrance, and the large Tosco refinery in Carson.
- No problems were reported with the petroleum product pipelines serving Southern California.
- Some petroleum distribution problems (delivering products from petroleum terminals) were reported due to temporary highway closures on highways I-8, I-10, and I-15.

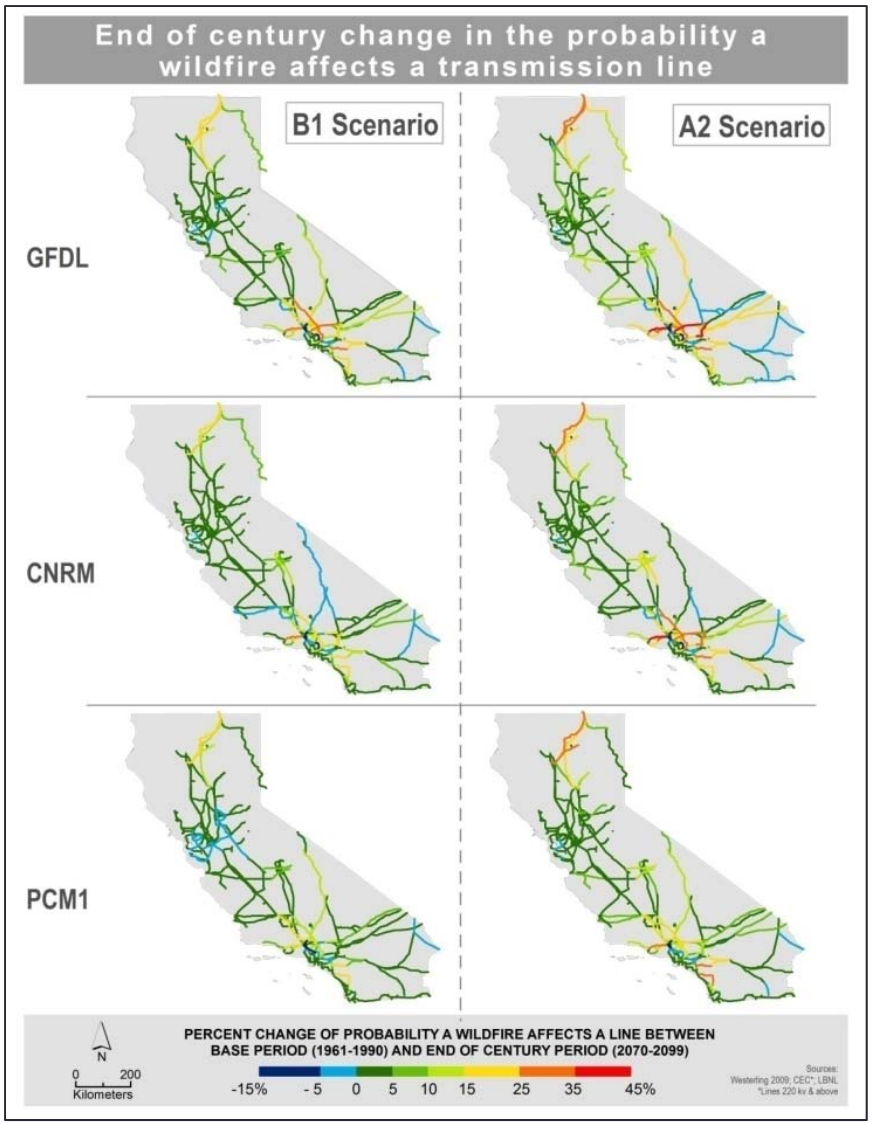
Natural Gas

- No major gas line outages were reported.
- Approximately 1,000 customers in San Diego County were without natural gas service and were in danger of being without for as long as a week as of the Oct. 29, 2003 report.

Adapted from http://www.oe.netl.doe.gov/docs/ca_wildfires_103003.pdf

source: Dept. of Fish and Wildlife, https://www.dfg.ca.gov/rap/socal-fire.html

- **Objective:** Model the exposure and sensitivity of existing transmission and distribution lines to projected wildfire as well as implications of wildfire risks in areas that are candidates for new transmission capacity.
- **Prior work:** LBNL study suggested that the increased risk of wildfires will affect the reliability of the transmission system.
- **Gap**: The distribution system was not analyzed.
- **Coordination**: New wildfire scenarios would become available for the non-energy sector research of California's 4th Assessment.



source: Sathaye et al., 2012. CEC 500-2012-057. http://www.energy.ca.gov/2012publications/CEC-500-2012-057/CEC-500-2012-057.pdf

- **Proposed work:** Due to funding limitations, one or two regional studies may be selected. The following factors would be considered in this study:
  - Assess sensitivity of distribution circuits based on factors such as load and characteristics (e.g., materials, equipment, and age).
  - Consider the number of customers and key assets (e.g., hospitals, dispatch centers) that could be affected by an outage in determining risk.
  - Project how sensitivity may change as the grid evolves and adapts (e.g., energy storage, distributed generation, demand response, smart grid with two-way flows, and microgrids).
  - Identify the range of potential exposure of the existing or proposed T&D infrastructure to greater climate-induced wildfire threat.
  - Use the projected rate of change in wildfire threat to model timescales associated with the transition of individual transmission line segments or distribution circuits into “high-risk” status with respect to wildfire.
  - Explore adaptation options at least a preliminary way.

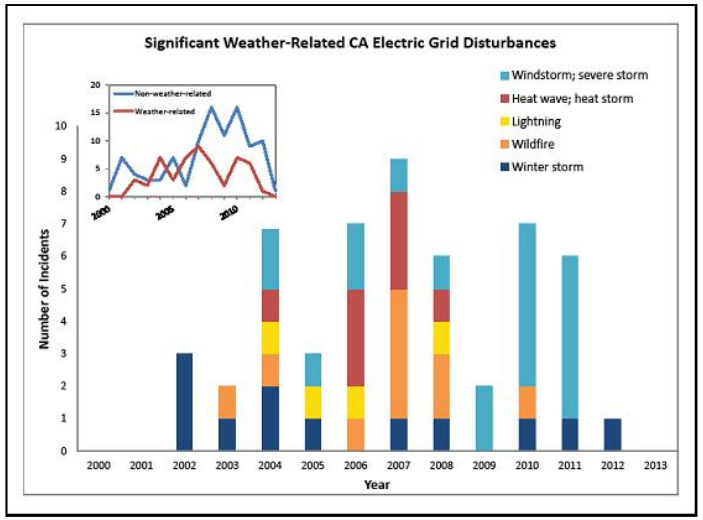
Sea-level rise and other weather-related risk factors and electricity infrastructure

Janna Franks, Guido Franco

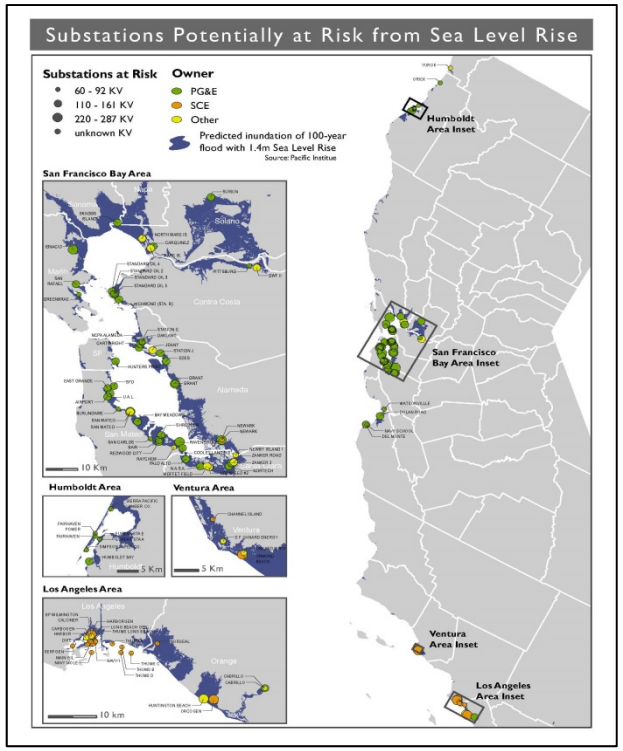
- **Objective:** Investigate extreme weather-related factors that may challenge the reliability of the electricity system.
- **Prior work:** Work done by UC Berkeley (Auffhammer et al., 2012) and LBNL (Sathaye et al., 2012) has shown that the electricity system is vulnerable. In some case (e.g., risk to coastal facilities from sea-level rise) the work only identified potential risk *exposure*.
- **Proposed work**: This would be an open area of research seeking innovative ideas. For example, this work may include more realistic analysis of sea-level rise-related risks and adaptation options for coastal electricity units.
- <u>Due to funding limitations, one or two regional analyses would be funded</u>. Hydropower units are addressed in other studies.

Sathaye et al, 2012, *Estimating Risk to California Energy Infrastructure from Projected Climate Change*. CEC-500-2012-057.
Auffhammer and Aroonruengsawat, 2012, *Hotspots of Climate-Driven Increases in Residential Electricity Demand*. CEC-500-2012-021.

G. Franco, L. Oliver, 2013



Sathaye et al, 2012



Discussion Questions

Part “A” Research:

- Are these high priority climate research areas for the energy sector?
- What coordination with utilities is needed to help leverage EPIC and Natural Gas funds and/or support production of “actionable” results?
- Are there security/confidentiality issues that would preclude in-depth studies of the electricity/natural gas system?
- Should other potential stressors should be considered for the different studies? For instance, some believe that poles loaded with communication-related equipment are at greater risk of toppling.
- Other comments?

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