Key California Issues in a Changing Climate from a State Perspective

Climate Scenarios and Projections: the Known, the Unknown, and the Unknowable as Applied to California

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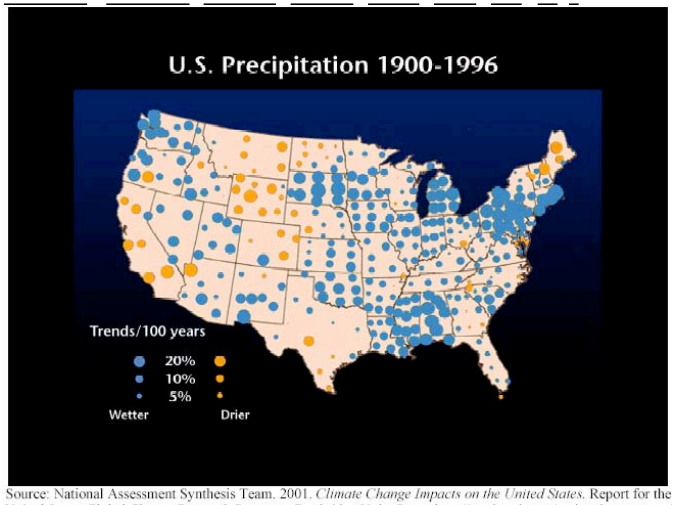
Outline

- Major Climatic Issues
- Other Factors
- A closer examination of two issues: Air Quality and Energy
- Conclusions

What are the Trends for Temperature and Precipitation in California?

- Temperature trends seem to be clear but we do not have a definitive answer as to the effect of urbanization and use of irrigation water.
- Precipitation trends are not clear

Grid Average Values



Source: National Assessment Synthesis Team. 2001. *Climate Change Impacts on the United States*. Report for the United States Global Change Research Program. Cambridge Univ. Press. http://prod.gcrio.org/nationalassessment/

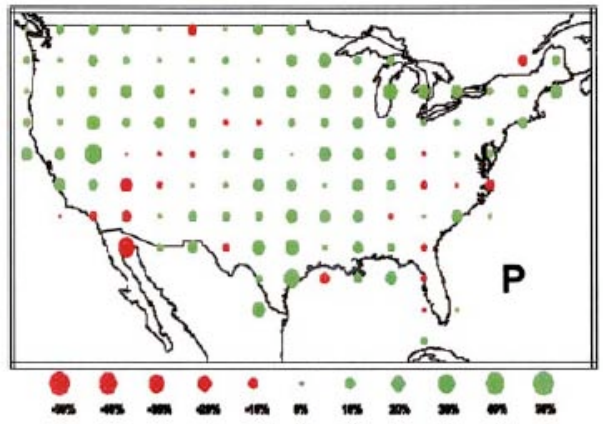
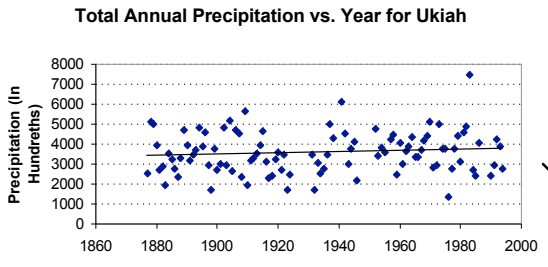
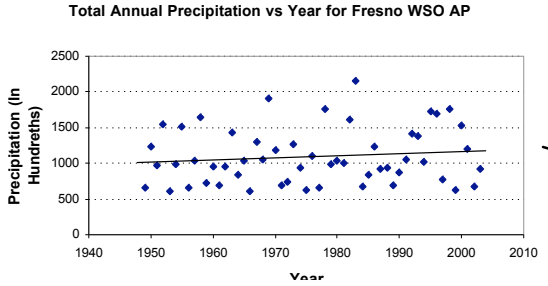


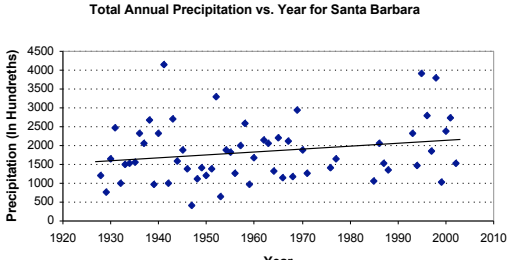
FIG. 6. Linear trends [% (100 yr)$^{-1}$] of annual precipitation (P; 1900–2002) over the contiguous United States. Individual trends from 1221 USHCN stations (Easterling et al. 1996) have been area averaged within a 2.5° × 3.5° grid. Green dots indicate increasing and brown dots decreasing trends. Updated and reformatted from Groisman et al. (2001a).

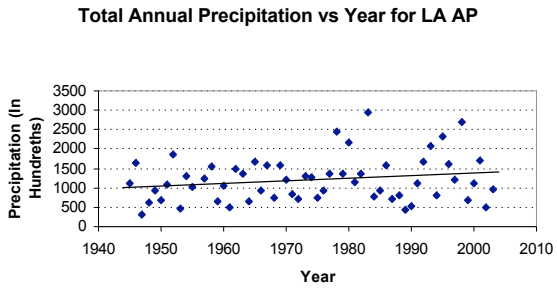
Source: Groisman et al.
Journal of Hydrometeorology. 2004

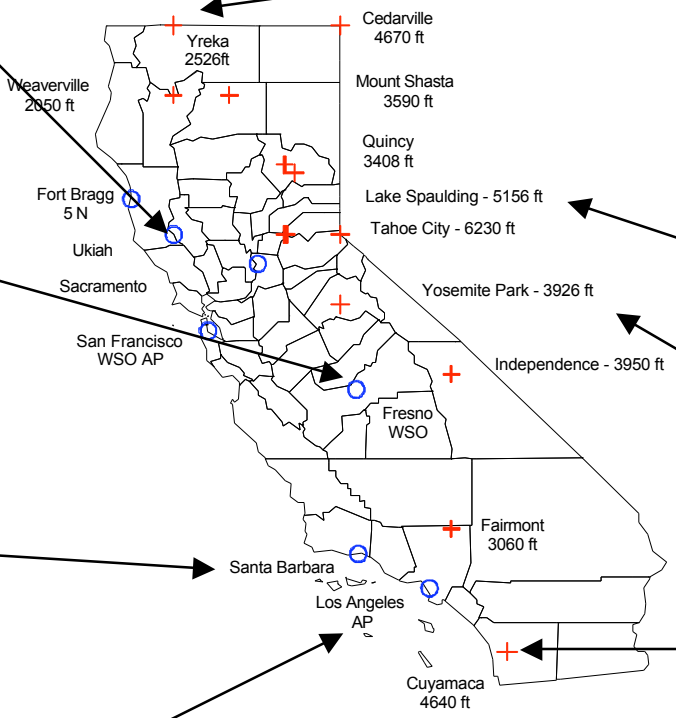
Precipitation Trends

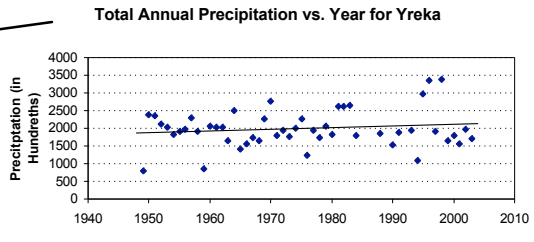


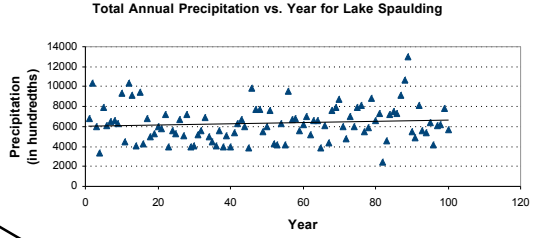


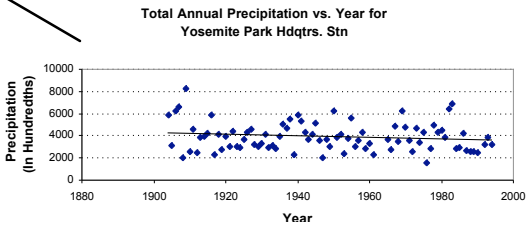


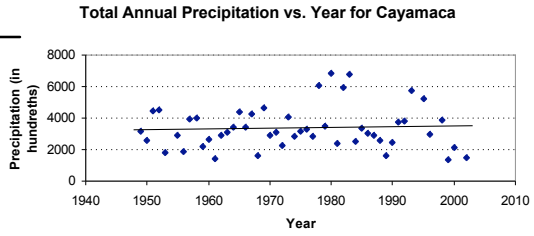












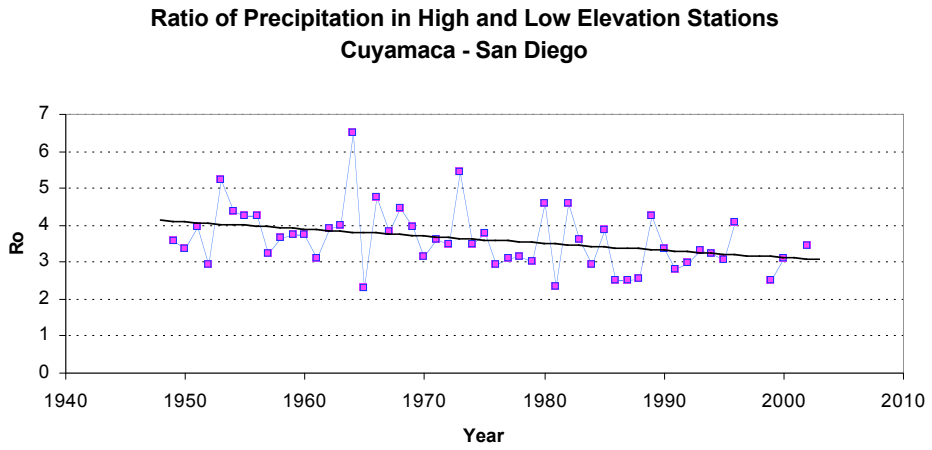
Low Elevation

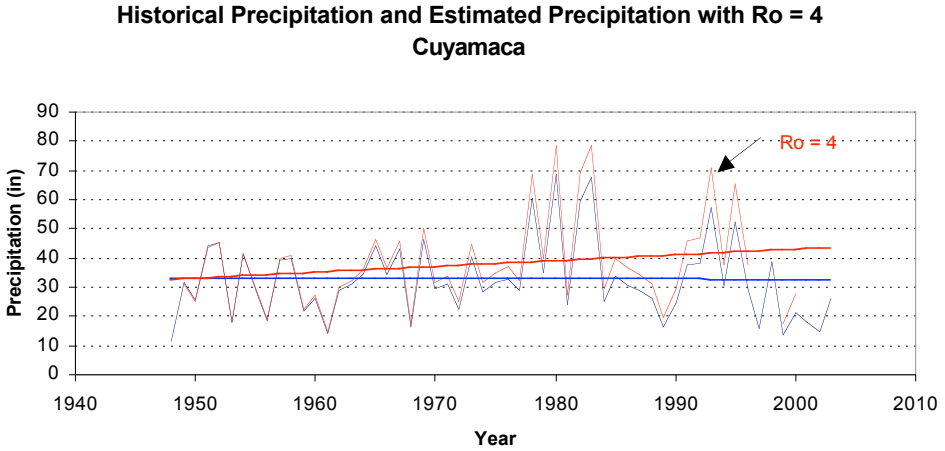
High Elevation

Source of Data: WRCC, USHCN

Are Aerosols Masking the Real Precipitation Trends in High Elevations?

- A new study by Amir Givati and Daniel Rosenfeld* strongly suggests that this is the case.
- Without aerosols the precipitation trends in high elevations would have been about 15 to 20 percent higher



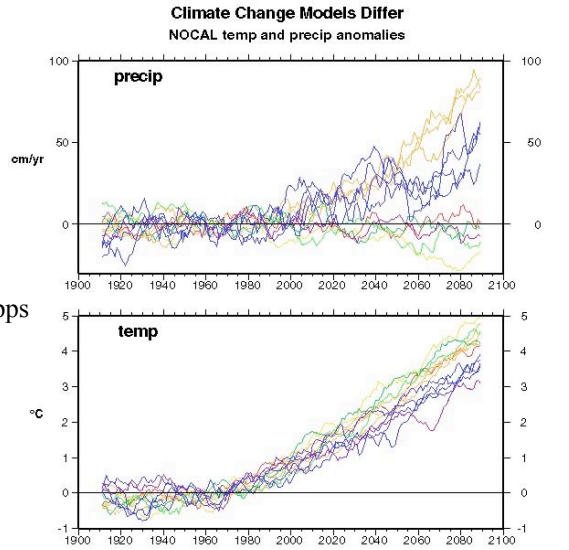


•Urban Aerosol-Induced Changes of Precipitation
Eos Trans. AGU, 84 (46) 2003

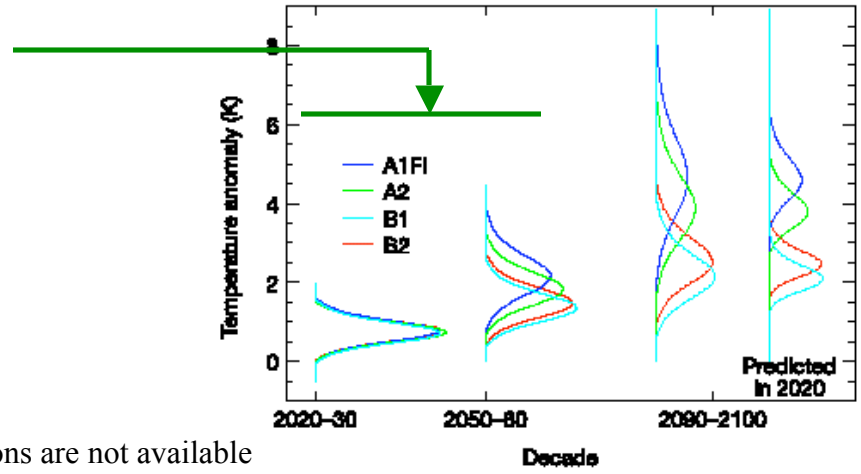
Data Source: Western Regional Climate Center (WRCC)

Projected changes of Temperature and Precipitation

- It is very difficult to develop robust adaptation strategies* when we do not know if it is going to be wetter or drier
- Are there at least relatively narrow probability bands for the next few decades?



Source: Scripps

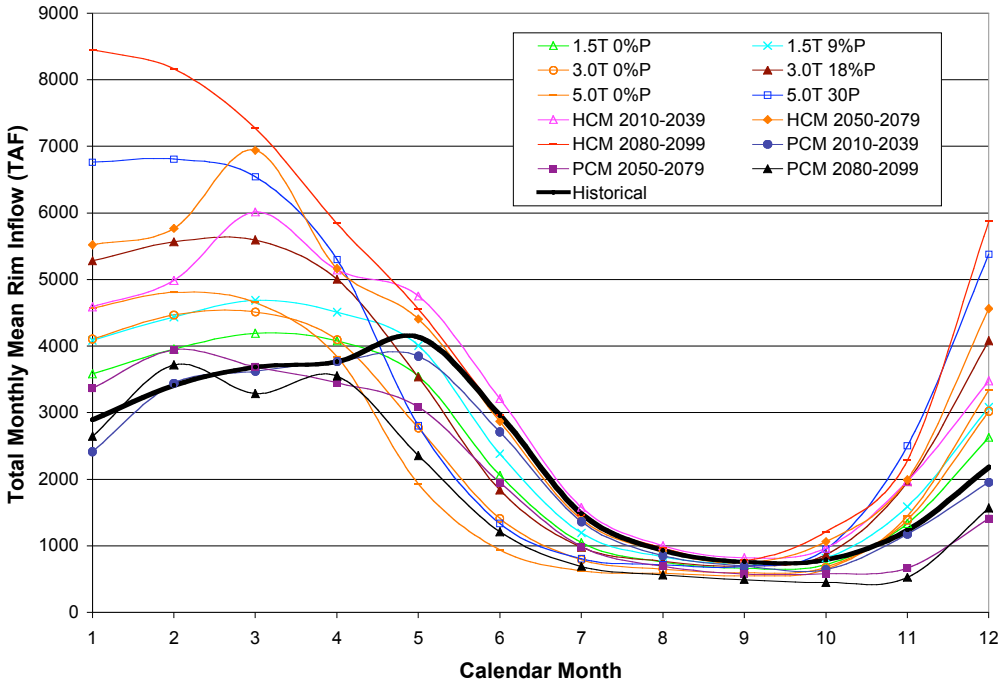


Source: Origins and estimates of uncertainty in predictions of twenty-first century temperature rise.Nature. Vol. 416. 18 April 2002

* Please note that this does not mean that "no regrets" options are not available

Stream Flow Timing

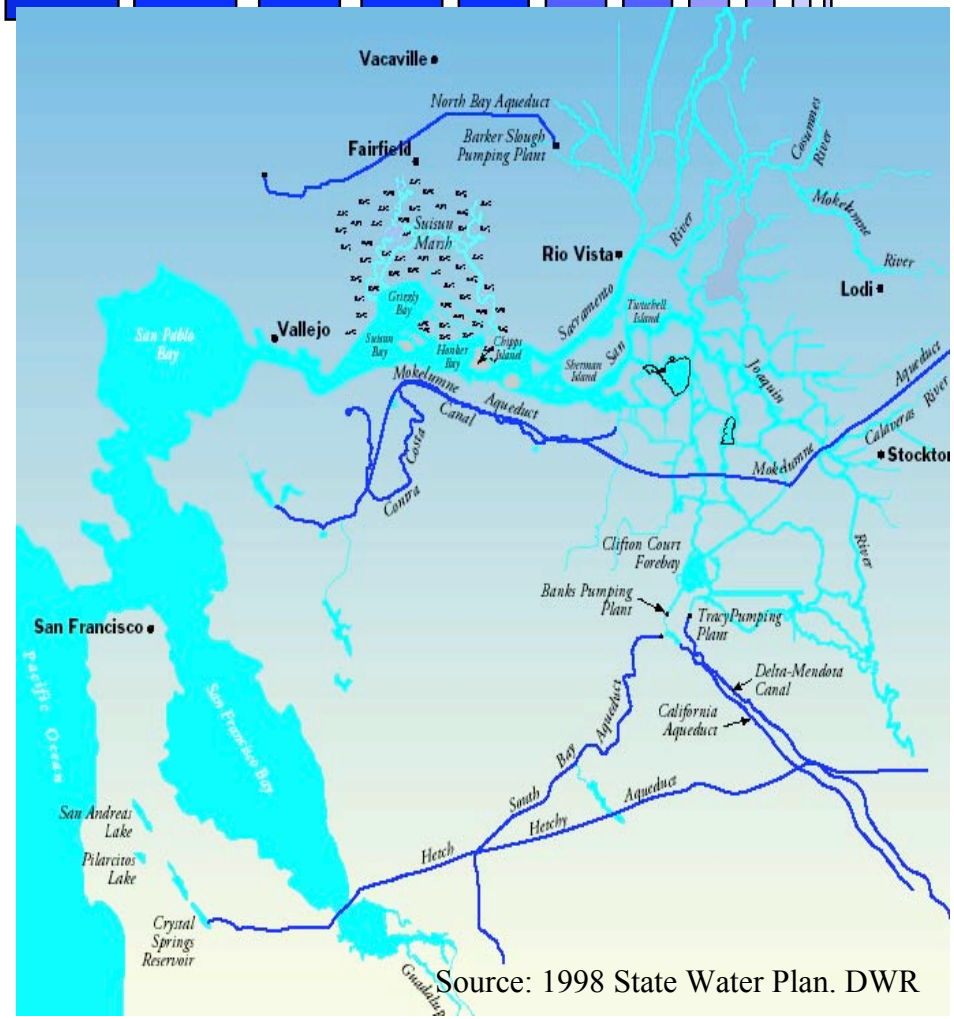
- Increased risk of floods in the winter season
- Reduced flows in the spring
- Less water available in the dry summer season



Source: Lund et al. 2003
PIER Report

Sea Level Rise

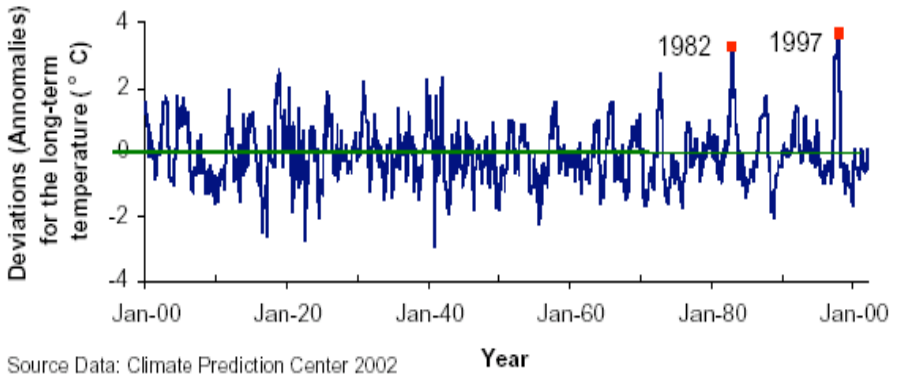
- Sea level rise could disrupt the conveyor system that brings fresh water from northern to southern California
- Increased sea water intrusion in coastal aquifers



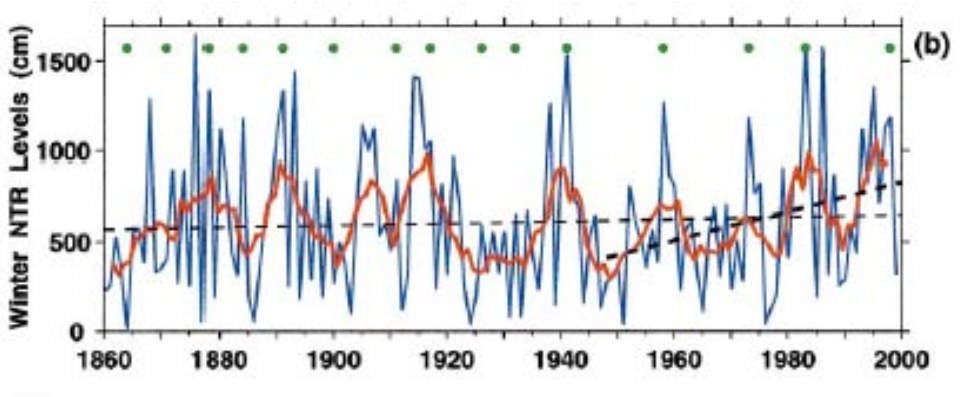
Source: 1998 State Water Plan. DWR

Potential changes in the frequency and amplitude of natural mode of climate oscillations

- Two of the strongest El Niño events in the last 100 years have occurred in the last decade.
- Would storminess increase in California?
- There is a danger of mal-adaptation if we confuse natural oscillations as a climate change signal.



Source Data: Climate Prediction Center 2002

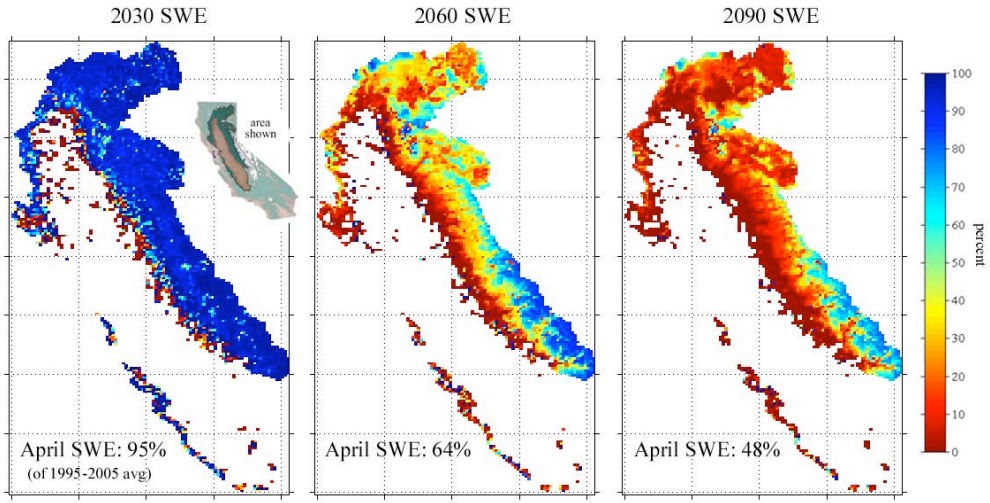


Source: Bromirski, Flick, and Cayan. 2003

Loss of water storage capacity in the Sierra

- On April 1st DWR determines how much water stored in snow is available for the dry season.
- Most studies estimate substantial reductions of April 1st snow cover.

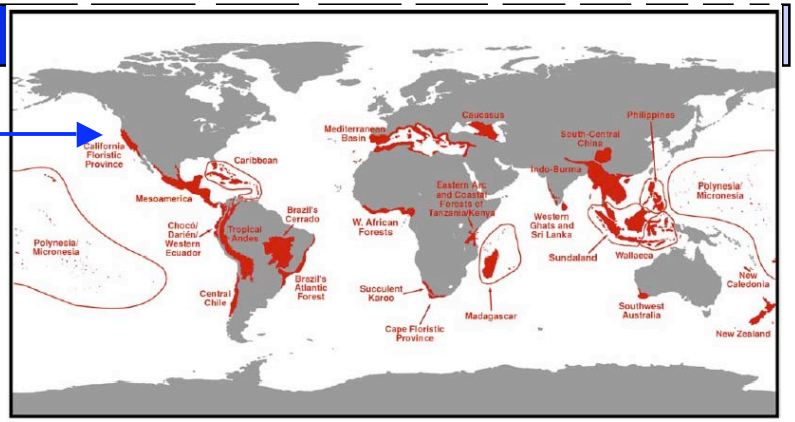
Snow Cover



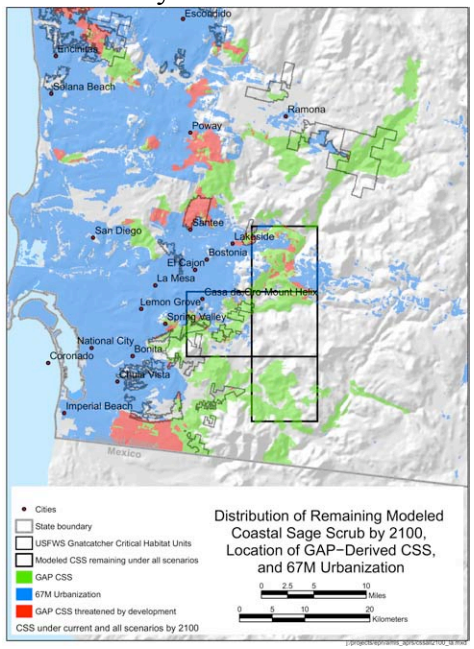
Source: Scripps

The potential ecological impacts are enormous

- California is a "hotspot" for biodiversity
- Some ecological systems (e.g., coastal sage scrub*) may only survive in a few places
- A preliminary PIER study** suggests that managed systems can adapt at cost but this may not be the case for ecosystems



Source: Myers et al. Nature Vol. 403. 2000



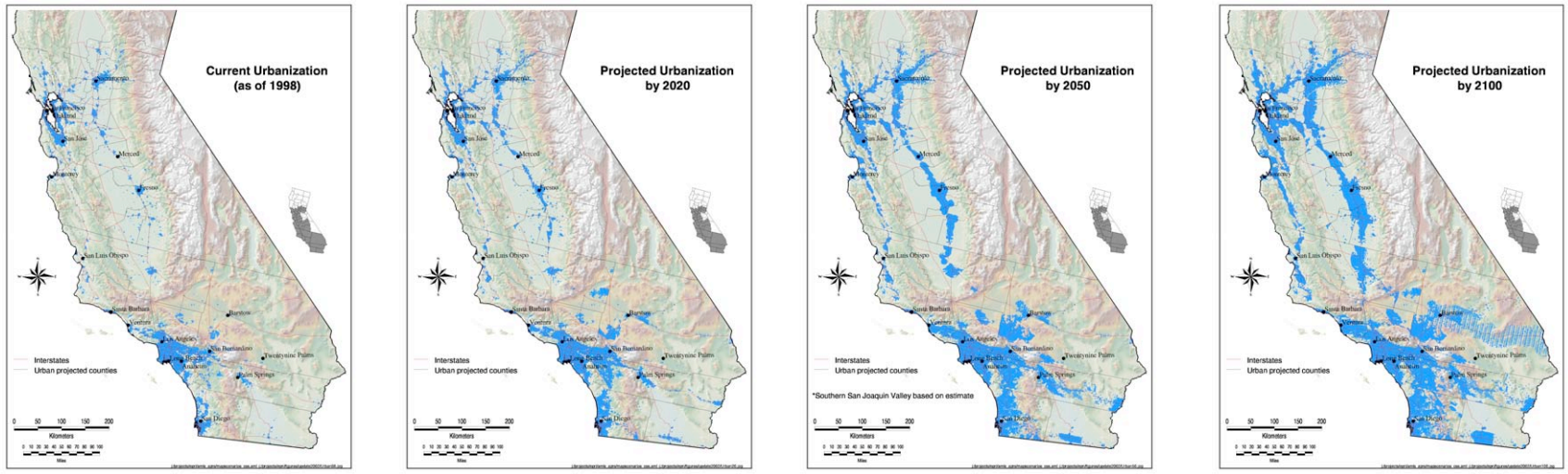
Source: Smith et al. 2003 PIER Report

*Home of about 100 endangered or potentially threatened species

** http://www.energy.ca.gov/pier/reports/500-03-058cf.html

Other Factors

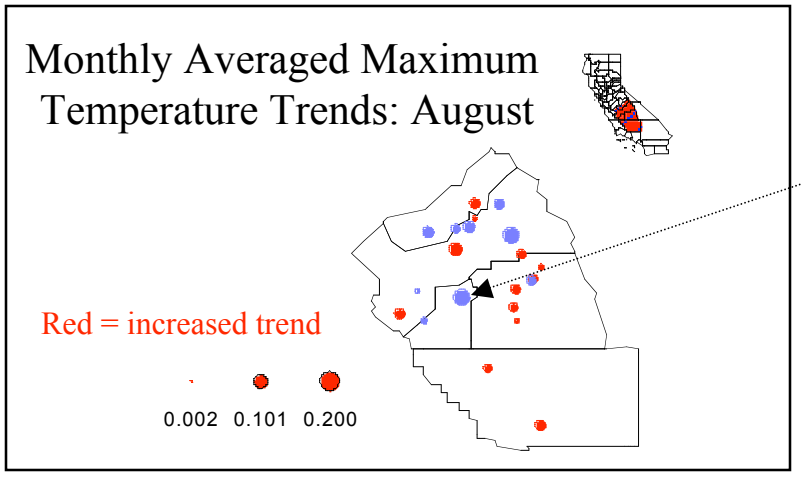
- Transport of air pollutants from Asia
- Urbanization
- Increased population
- Invasive species
- Surprises

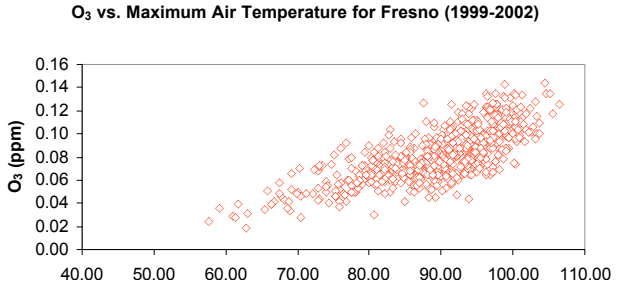


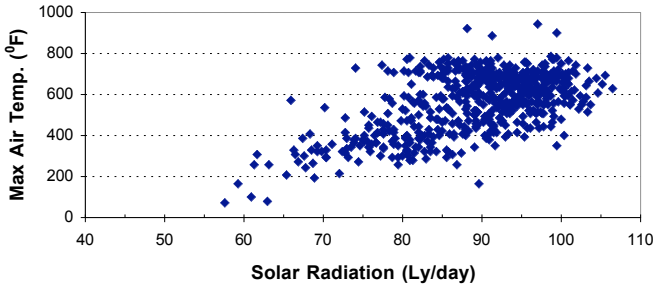
Landis et al. 2003
PIER Report

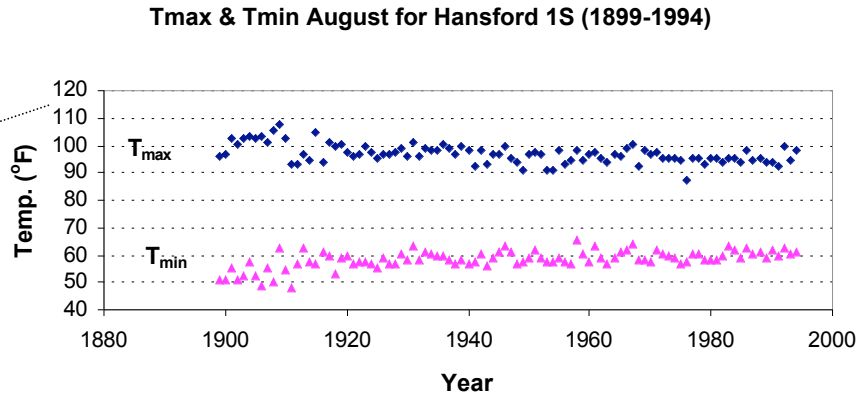
Air Quality: a Closer Examination (Ozone)

- We assume that higher temperatures will increase ozone levels but….
- Some Air Districts are reporting a trend towards more days conducive to ozone production.
- Would this create a problem achieving the national and state ambient air quality standards in the next 20 to 30 years?









Data Source: WRCC, ARB, and CIMIS

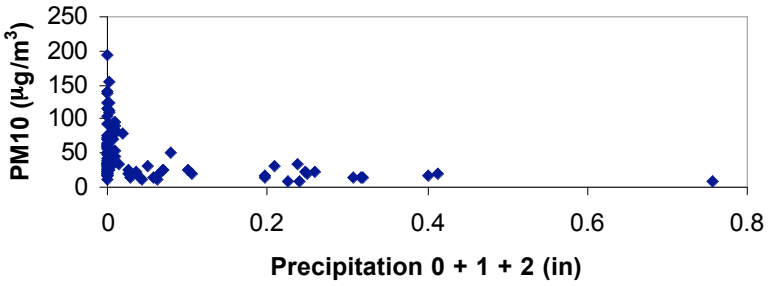
Air Quality: A Closer Examination (Particulate Matter)

- In California ammonium nitrate (NH_4NO_3) dominates wintertime PM levels
- Precipitation levels have a strong influence on measured PM levels
- Nitrates go down with increased ambient temperatures

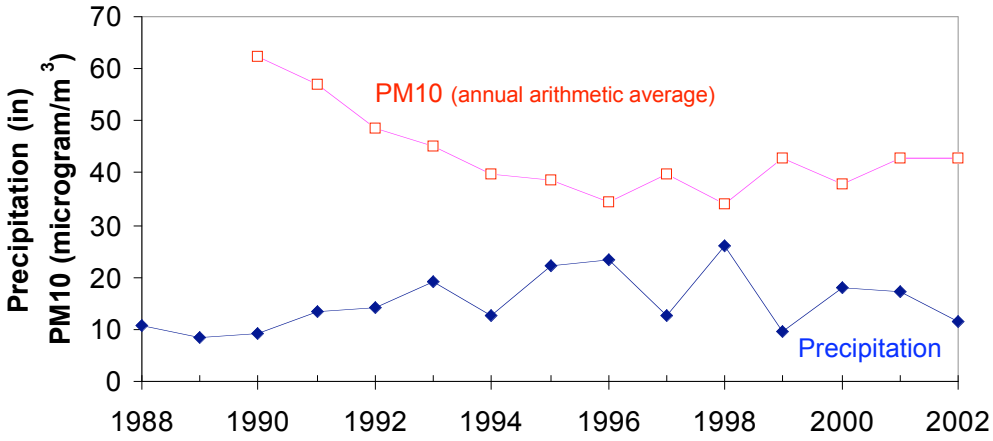
$$NH_3(g) + HNO_3(g) \rightleftharpoons NH_4NO_3(s)$$

Temperature

PM10 vs Precipitation for Fresno (1999-2002, Nov-Mar)



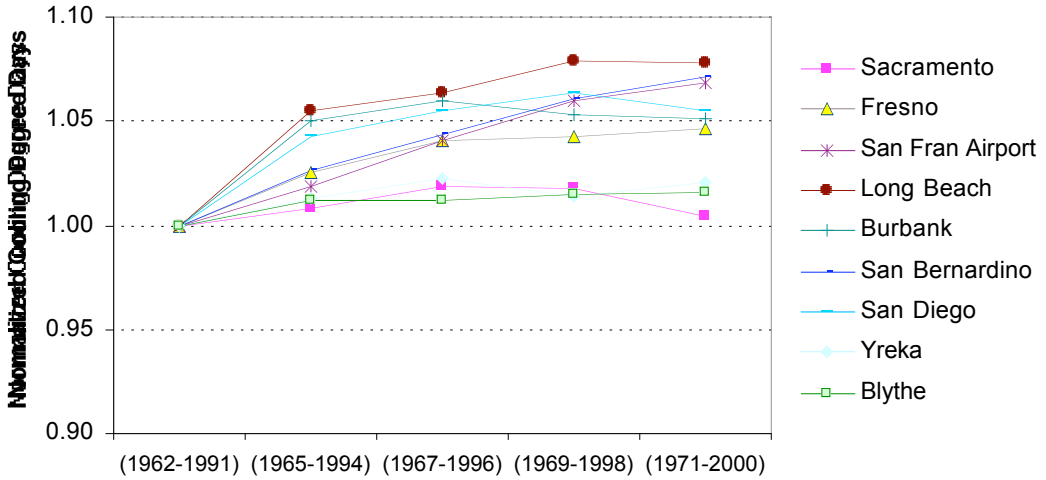
Average Precipitation and Particulate Matter: San Joaquin, Stanislaus, Merced, and Fresno Counties



Data Source: ARB, WRCC

Energy: A Closer Examination

- The urban "heat-island" effect may be as important as climate change for energy demand.
- Most studies use projected average temperatures or CDD/HDD to estimate energy demand. This is problematic due to the expected asymmetric changes in diurnal temperature profiles



Data Source: NOAA

$$CDD = \_[(Tmax+Tmin)/2 - 65°F]$$

Where: $(Tmax + Tmin)/2 > 65°F$

Conclusions

- Retrospective analyses are extremely important.
- We need data at adequate temporal and geographical resolutions compatible with the analysis in hand.
- Probabilistic regional climate projections will help state planners.
- Uncertainty will remain with us for a long time

Quantitative Knowledge useful for planning in California

* To be discovered with further research in the next few years