California Heat Waves
(implications for public health)

Alexander (Sasha) Gershunov
Climate Research Division
Scripps Institution of Oceanography
La Jolla, California
THE GLOBAL VIEWPOINT

Variations of the Earth’s surface temperature
Departures in temperature in °C (from the 1990 value)

- The observed global warming is consistent with the anthropogenic signal
- It can be expected to continue
- Much of this warming will be in higher latitudes and in winter/spring
- The rate of future warming depends on future emissions

Projections
Proxy
Instrument
During recent history, temperature changes in west U.S. have tracked those in global temperature.
Although not as large as in winter and spring, observed summer warming is also significant.

Summer temperature changes:
1965-2005

How does summer warming play out regionally?
What is natural and what is anthropogenic?

- Data source: (Jones and Moberg 2003). Processed by the U.S. NOAA NCDC Global Climate at the Glance Mapping System.
PRELUDE TO THE SUMMER:
In the West, Spring has come earlier since the mid-1970’s: snowmelt and plant blooms have advance by 1-3 wks

Dan Cayan et al, 2001

Spring temperatures, lilac bloom dates and streamflow pulse dates
Western United States

Dan Cayan et al, 2001

broad footprint of change across the West

Early March 2007
California **summer** temperatures: can we already detect a change?

JJA Tmax (**Daytime**) linear trend (°C/decade)  
JJA Tmin (**Nighttime**) linear trend (°C/decade)

Ambient day and nighttime temperature trends

This is consistent with climate change

Is this related to heat wave activity?
Quantifying Californian Heat Waves

• Heat Wave Index, related to impacts:
  MAGNITUDE = intensity + duration + spatial extent
• Day and nighttime heat waves
• Trends
• Spatial patterns
• July 2006 and other extremes

Late September 2006: Lassen Volcanic
Working definition of extreme heat: **Intensity**

**Sacramento Tmax**

- Locally extreme temperature exceeding a high percentile threshold $t^*$ (e.g. 99%-ile)

99th percentile thresholds

99th percentile in °C of JJA Tmax over the base period 1950 – 1999. Temperatures have a climatological 0.01 probability of exceeding these thresholds and should be considered locally extreme. Crosses mark the hottest thresholds.
Working definition of extreme heat: **Intensity**

**Sacramento Tmin**

- Locally extreme temperature exceeding a high percentile threshold \( t^* \) (e.g. 99%-ile)

![Graph showing temperatures and percentile thresholds](image)

99\(^{th}\) percentile in °C of JJA Tmin over the base period 1950 – 1999. Temperatures have a climatological 0.01 probability of exceeding these thresholds and should be considered locally extreme. Crosses mark the hottest thresholds.
Daily magnitude and spatial extent

Tmax daily magnitude

Max magnitude

Max spatial extent

Mean spatial extent
Nightly magnitude and spatial extent

Tmin nightly magnitude

Max magnitude

Max spatial extent

Mean spatial extent
Great daytime heat waves:
timing and regional magnitude

Diagram showing the temperature variations from June 1 to August 1 with peaks in July for different years such as 1972, 2002, 1981, 2006, 1961, and 1960.
Great nighttime heat waves

timing and regional magnitude

Diagram showing temperature variations over months with peaks in July.
GREAT HEAT WAVES AND THEIR OVERALL REGIONAL MAGNITUDES
Local intensity + duration + spatial extent
Composite Circulation and Moisture anomalies with respect to JJA mean

Peak daytime events

Peak nighttime events
Circulation aloft: 500 millibar geopotential height over the northwest

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Surface circulation and pressure gradient (MSLP Great Plains – CA shore)

Precipitable Water
Precipitable water animation
July 14 – August 1, 2006

July 14, 2006, PRWTR as % of JJA average
DAILY REGIONAL MAGNITUDE
2006 and composite

TOTAL LOCAL MAGNITUDE
PER EVENT
Trends in Atmospheric Moisture?

[Graph showing trends over the years with different markers for JJA and Day Night]
Conclusions

In California:

- Great heat waves are primarily day or nighttime events
- 2006 – humongous nighttime heat wave that had a great daytime signature as well

What caused it?

- Synoptic dynamics, timing, and moisture availability
- Trends!

Global warming vs. regional extremes…