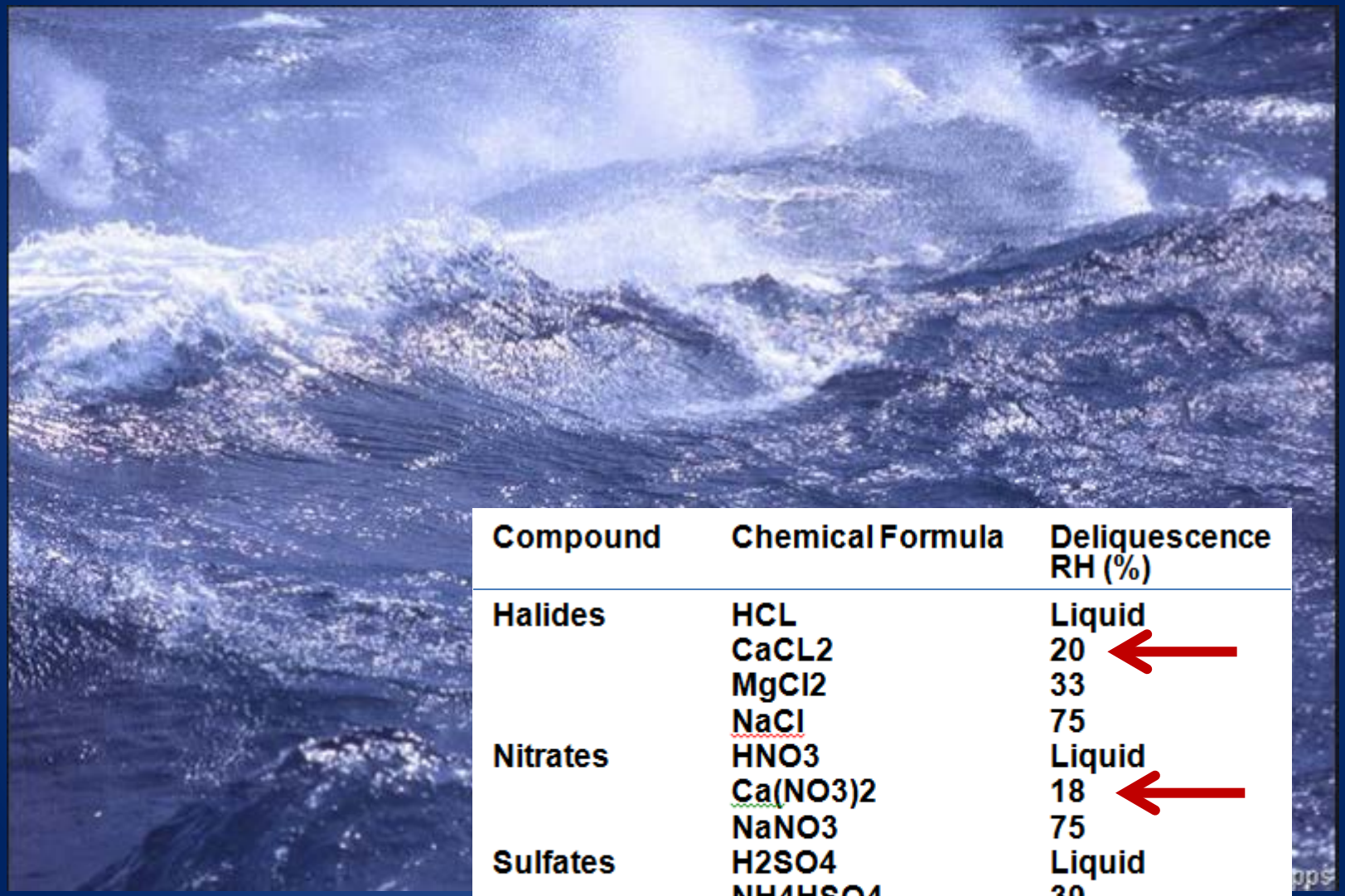

USGS
science for a changing world
Pacific Coastal Fog:
Ocean
Land
& Sky
Trends
= Foggy Results
CalEPA
Indicators of Climate Change in California
Alicia Torregrosa, USGS WGSC, June 16, 2015

TBC3 Terrestrial Biodiversity Climate Change Collaborative

USGS

Photo by Robert Cameron

Cloud Condensation Nuclei (CCN)



Compound	Chemical Formula	Deliquescence RH (%)
Halides	HCL	Liquid
	CaCL2	20
	MgCl2	33
	NaCl	75
Nitrates	HNO3	Liquid
	Ca(NO3)2	18
	NaNO3	75
Sulfates	H2SO4	Liquid
	NH4HSO4	39
	(NH4)2 SO4	80

Photo: Wayne Papps

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Cloud Condensation Nuclei (CCN)

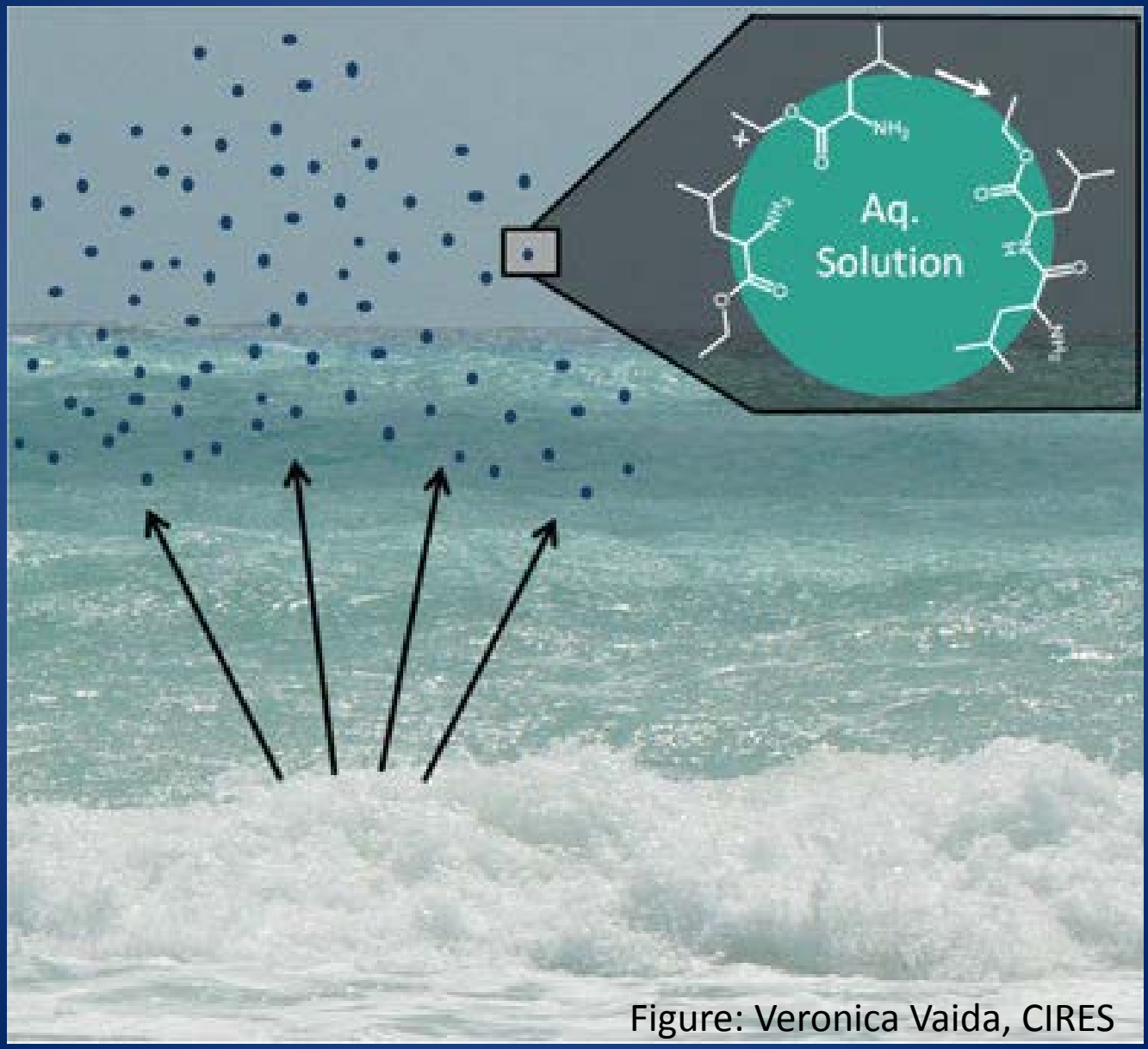

Figure: Veronica Vaida, CIRES

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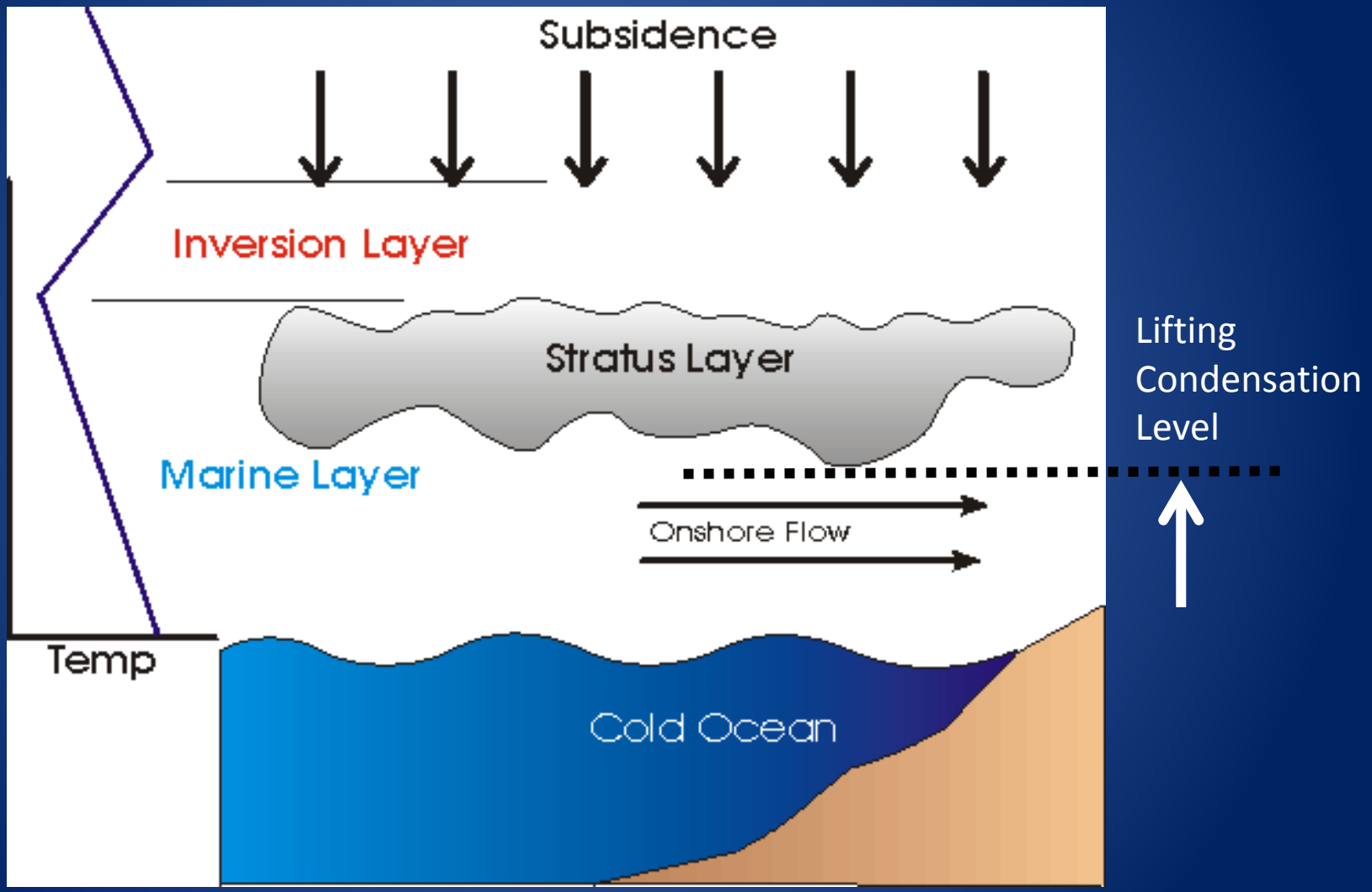
Marine Layer capped by Subsidence Inversion in Summer



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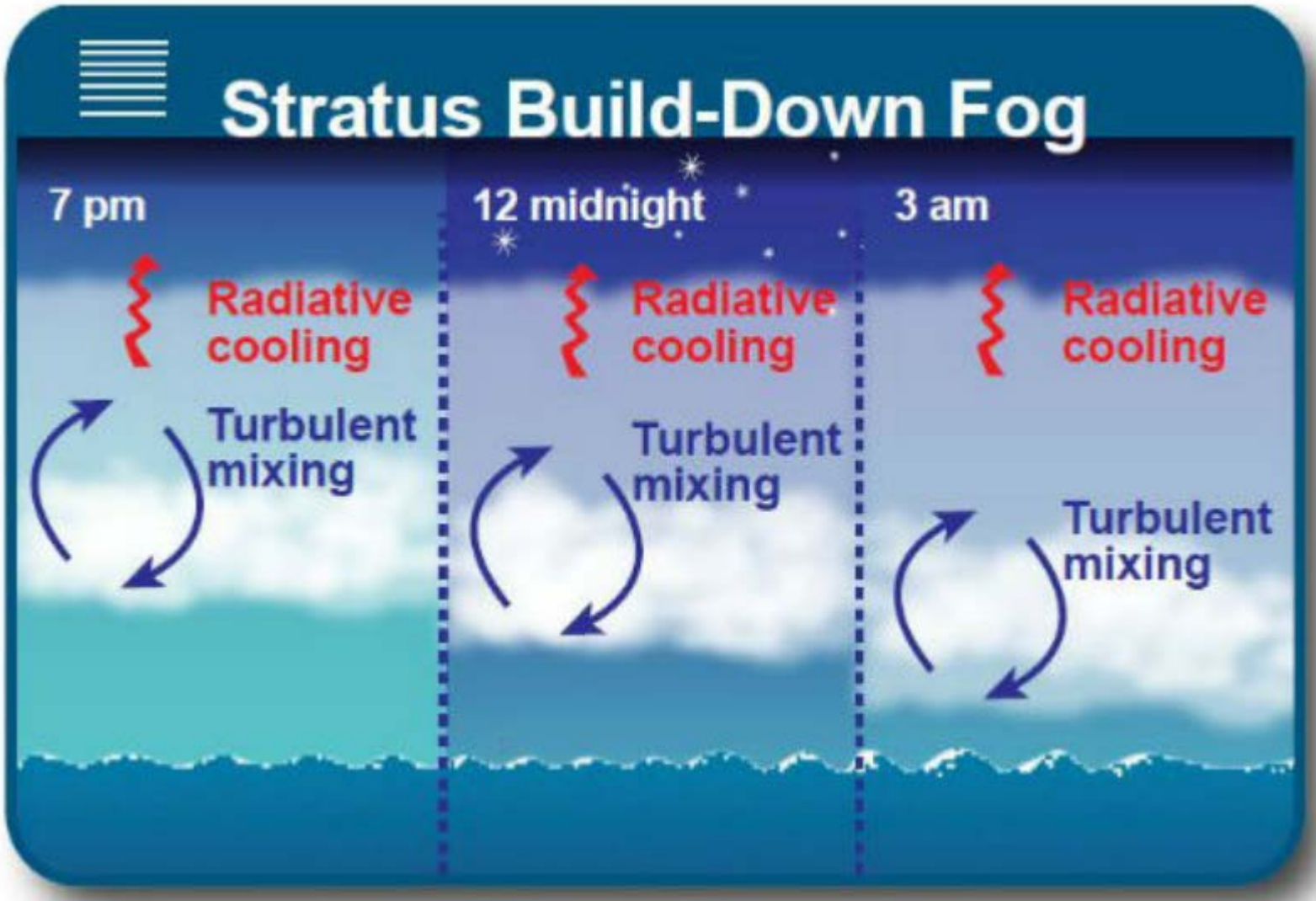
Prof Joel Michaelson, UCSB lecture notes



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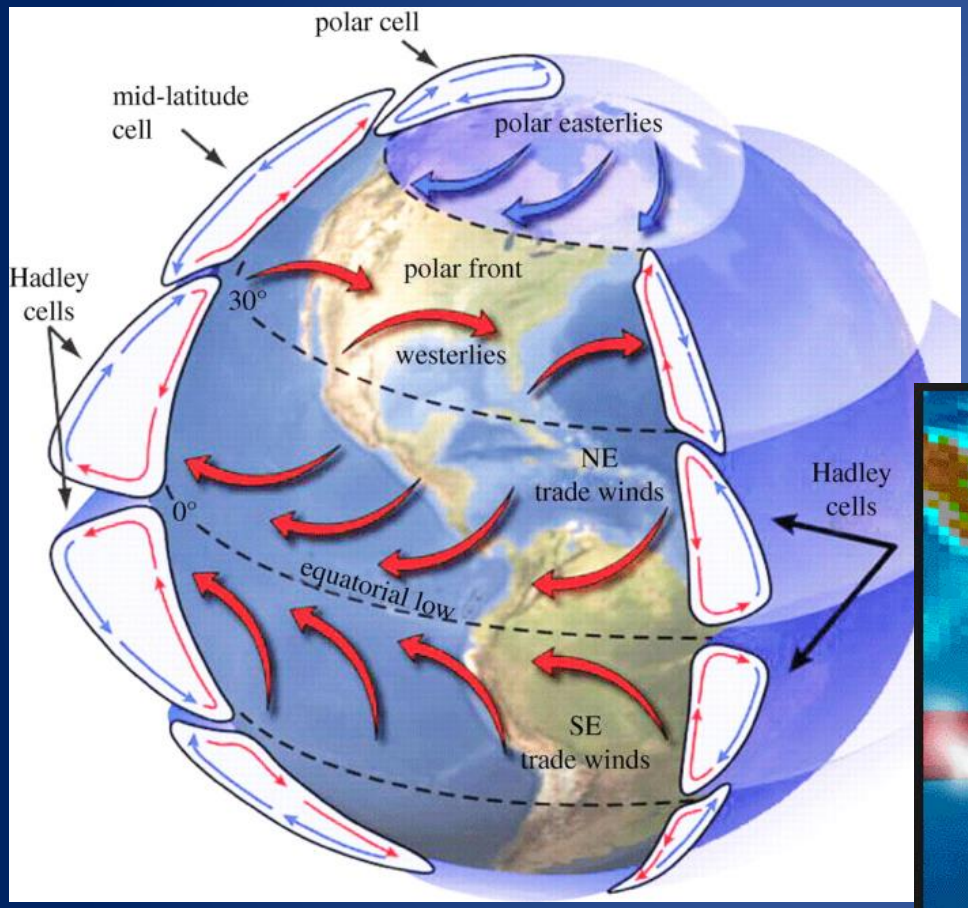
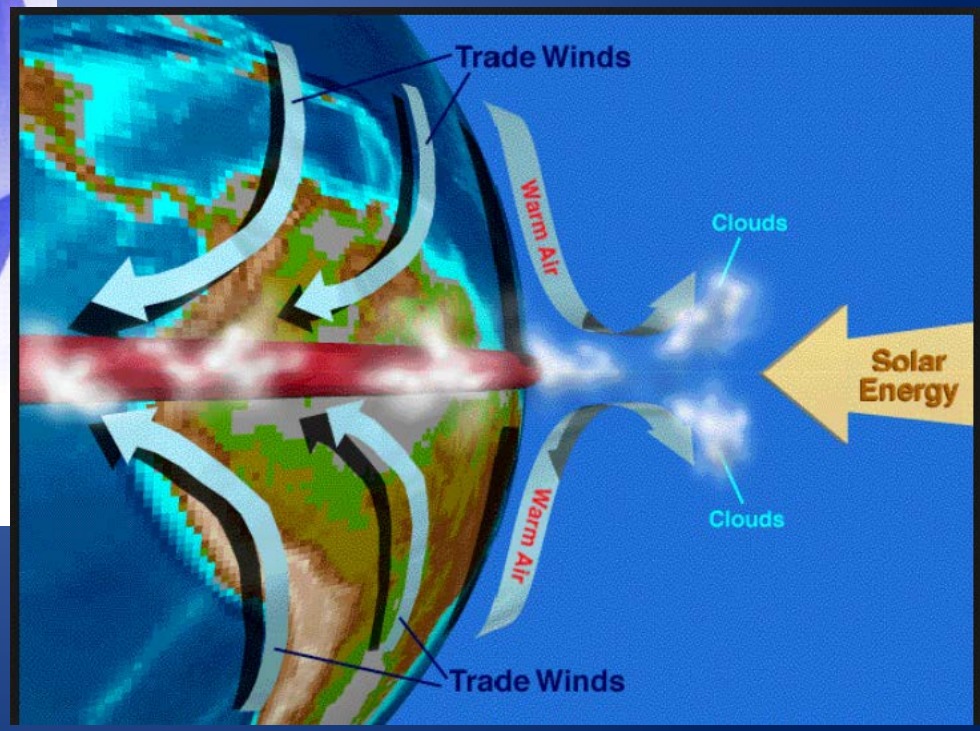
Government of Canada / Gouvernement du Canada
Environment Canada

Coastal Fog Drivers:
Subsidence
Ocean Condition
Cloud-top radiative cooling

Poleward Migration of Hadley Cells





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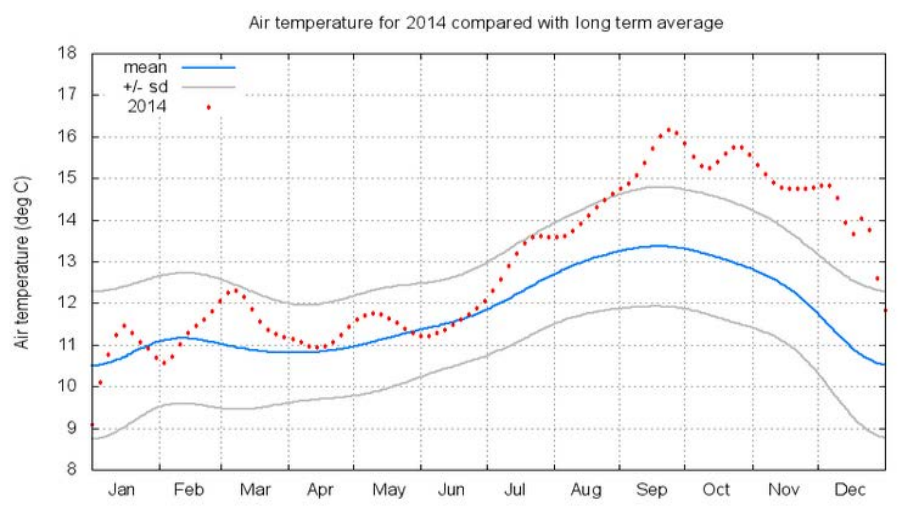
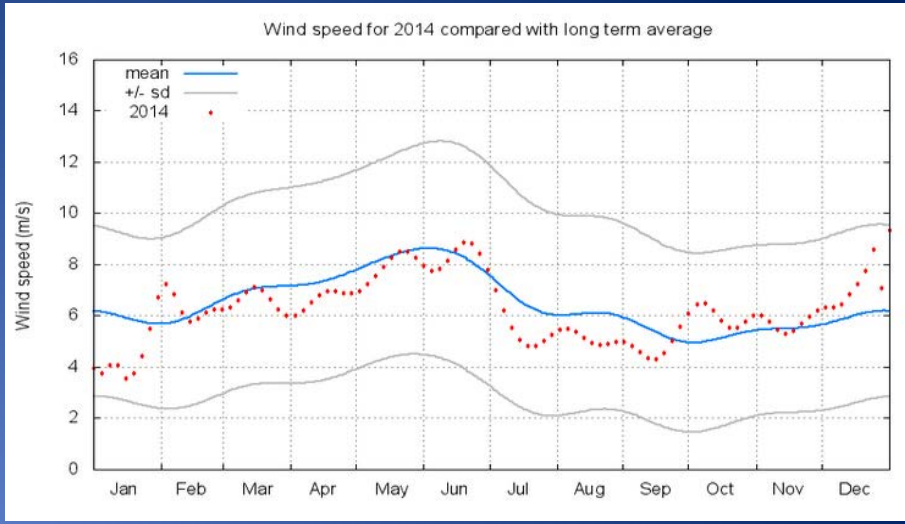
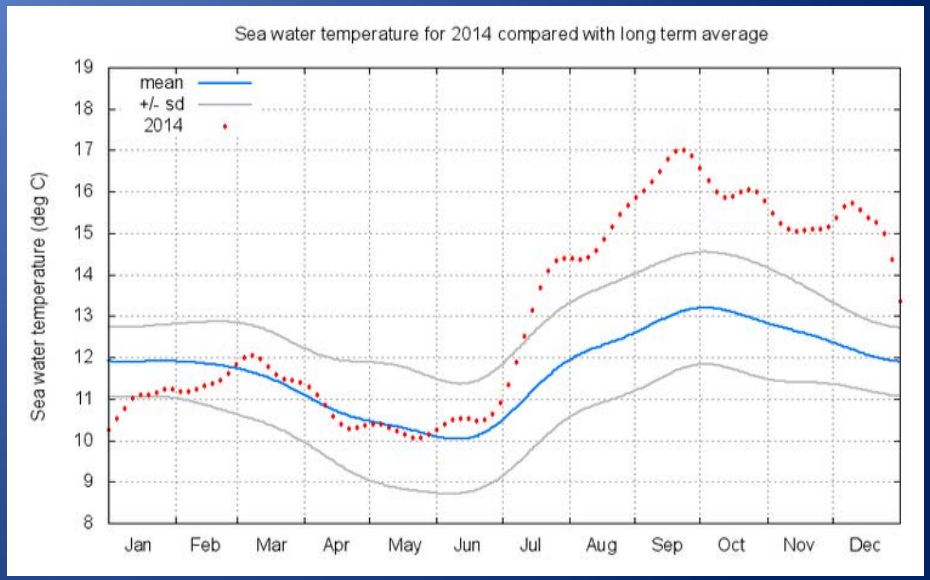
Wind and Waves

Air and Ocean Temperatures





Long term average air and seawater temperatures recorded from NOAA buoy 46013 over the period 1982-2007 are plotted for each day of the year and compared with current conditions.



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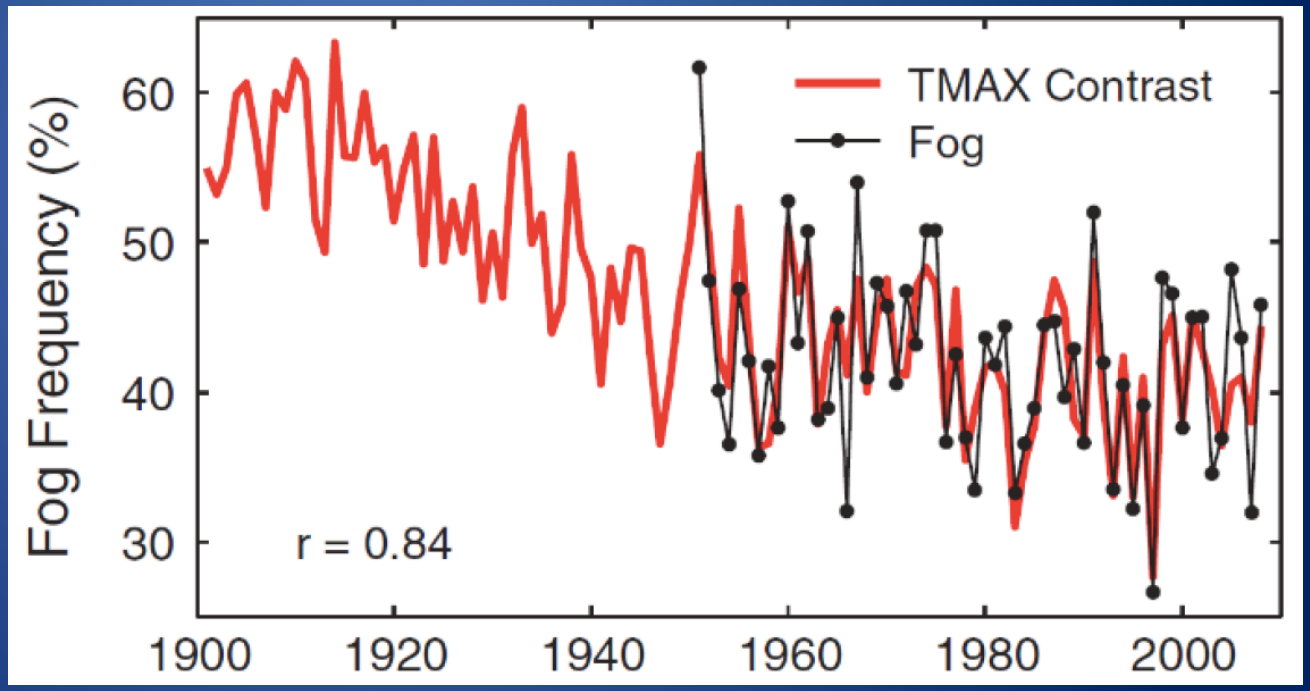
BOON
BODEGA OCEAN OBSERVING NODE

UCDAVIS
BODEGA MARINE
LABORATORY

What have we observed?

- Warming Ocean (+ 2 ^{o}F)
- Poleward expansion of Hadley Cells
- Less fog



Johnstone and Dawson, 2010

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What do climate models say about the future?

Slide courtesy of Travis O'Brien, LBL

- Weaker subsidence[1]
- Wetter upper atmosphere
- Warmer ocean[2]
- Less stratocumulus[3]
- Less fog[4]

[1] Details may vary regionally
[2] Current ocean models do not do well at upwelling
[3] Not all models agree on this
[4] **So far there has only been one model study**

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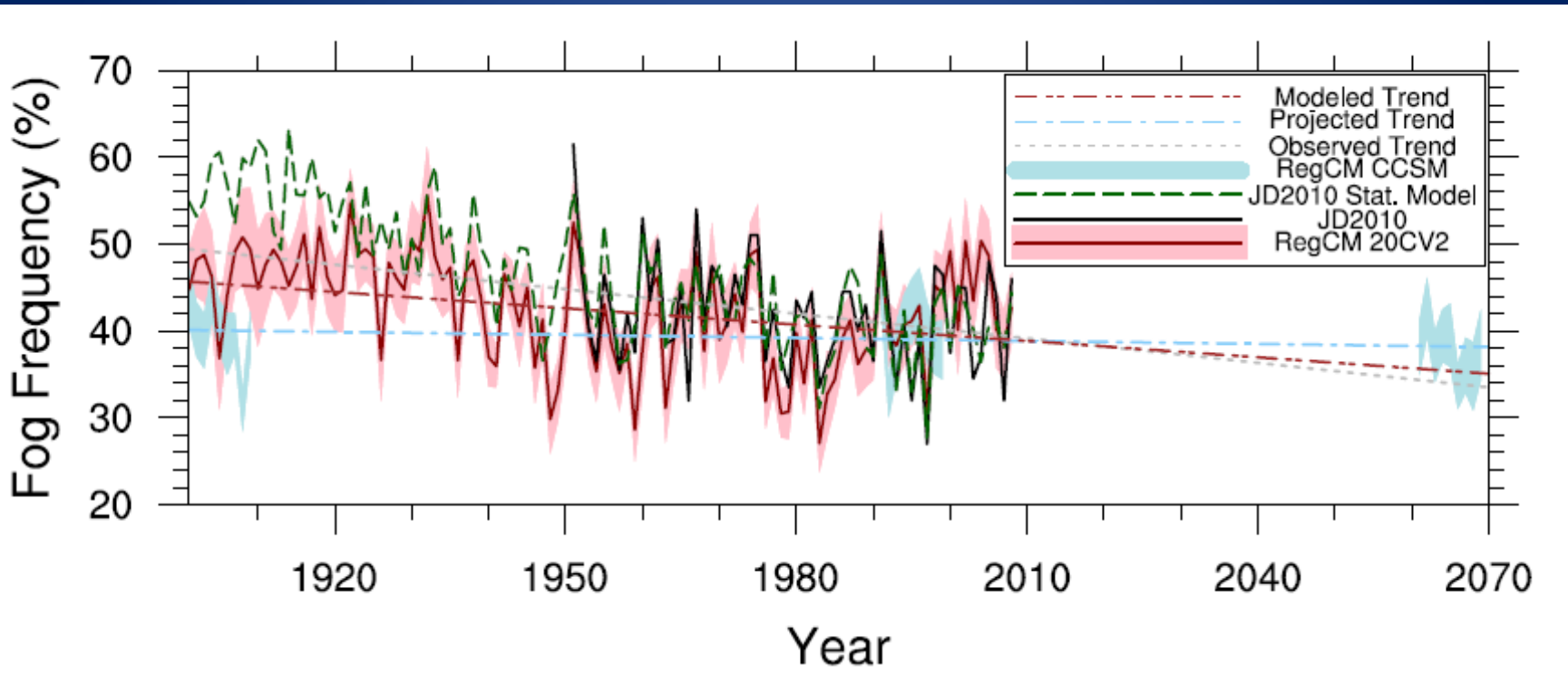
RegCM-UW Fog Model



Travis O'Brien's model results (2012) also show long-term declines in fog driven by 1) surface pressure that 2) increased off-shore flow, that 3) dries the marine boundary layer and 4) lifts the fog deck. Increasing SST from a would further reduce fog formation but perhaps be offset by Central Valley warming.

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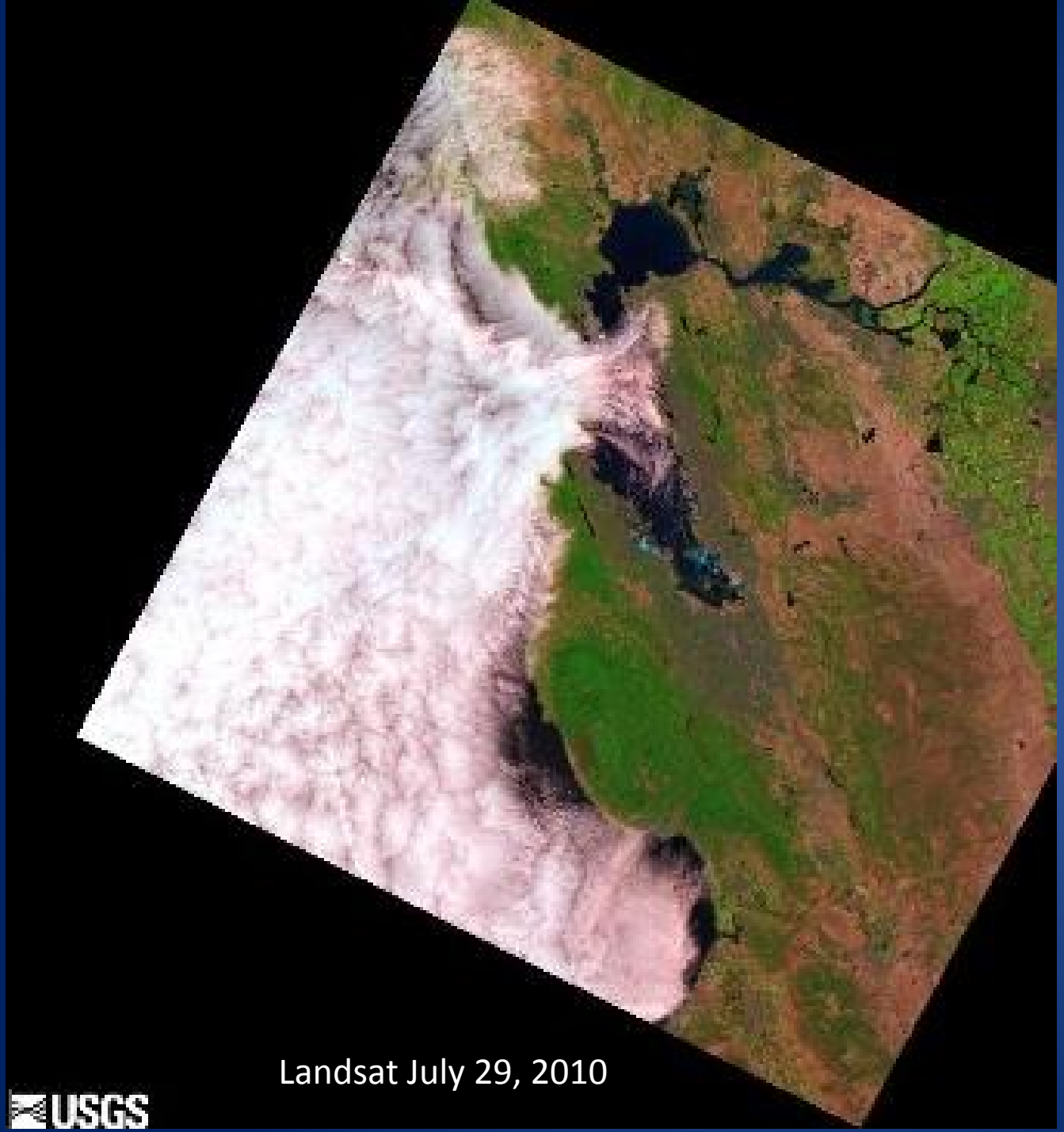
O'Brien et al (2012) www.geosci-model-dev.net/5/989/2012/
and O'Brien et al (2012) Climate Dynamics



Landsat July 29, 2010

Advection Fog

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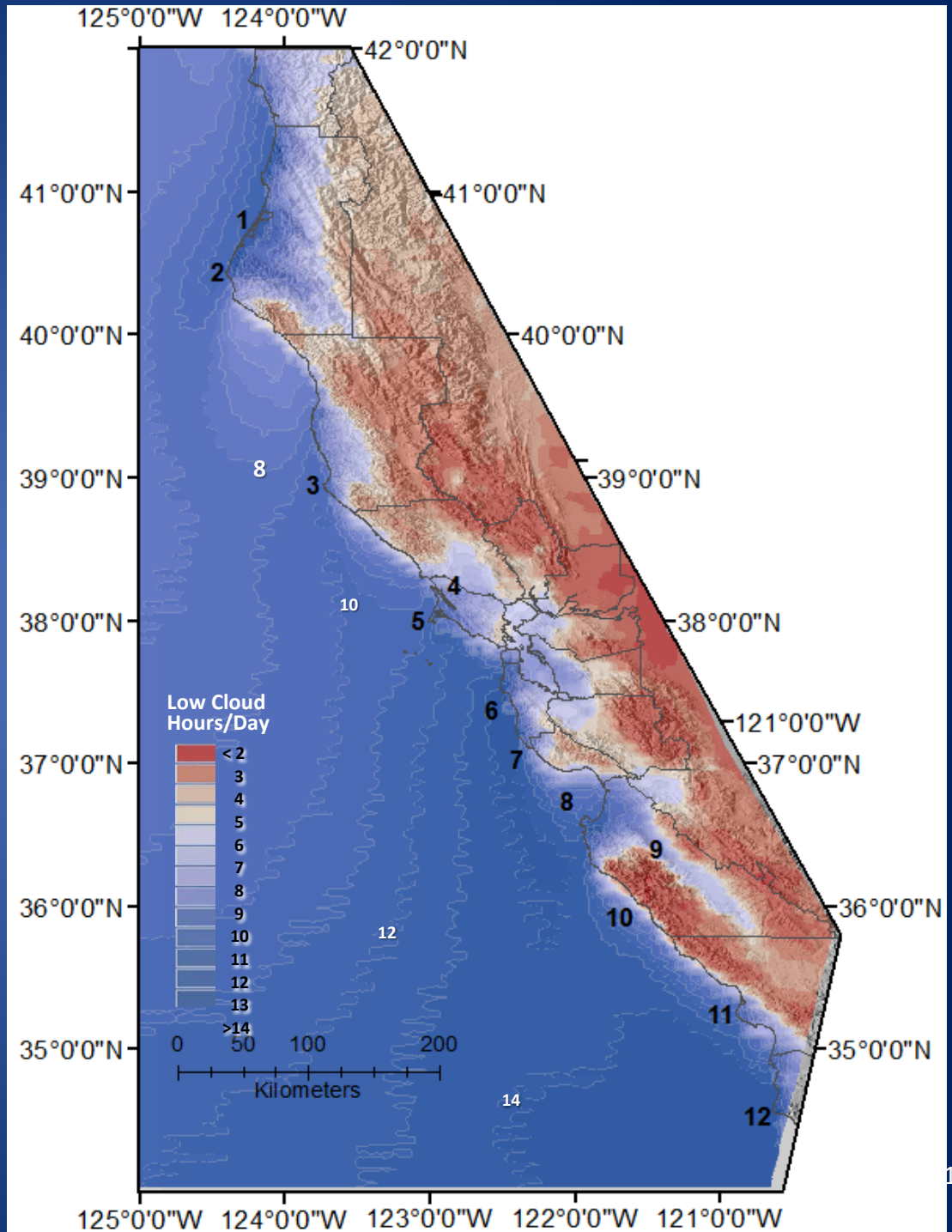
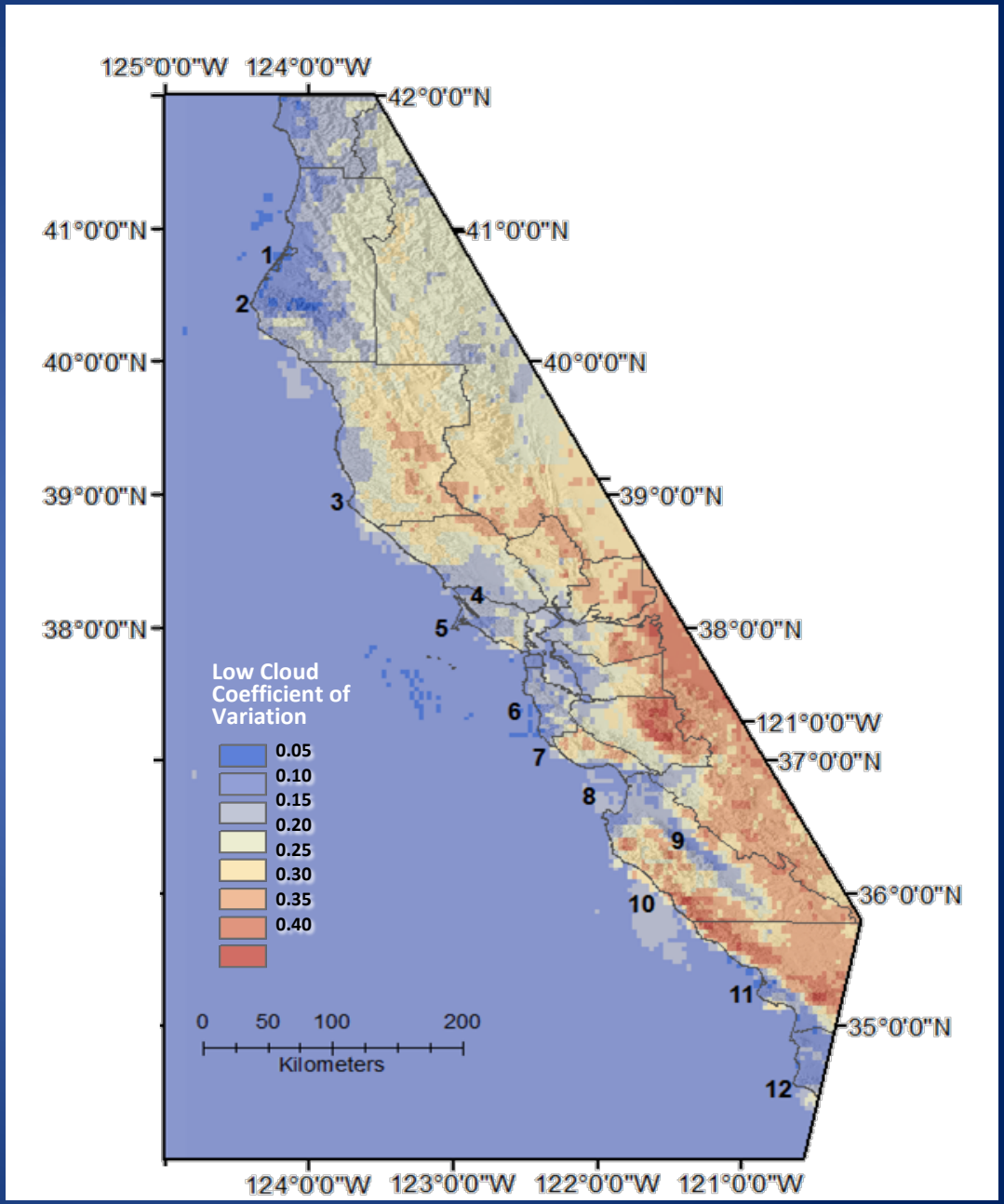
GOES-derived Fog and Low Cloud Frequency

1 – Eureka/ Humboldt Bay,
2 – Cape Mendocino,
3 – Pt Arena,
4 – Petaluma Gap,
5 – Pt. Reyes,
6 – Montara/ Half Moon Bay,
7 – Año Nuevo,
8 – Monterey Bay,
9 – Salinas Valley,
10 – Big Sur Coast,
11 – Pt. Arguello,
12 – Los Osos Peninsula



Coefficient of Variation

High Spatial Stability



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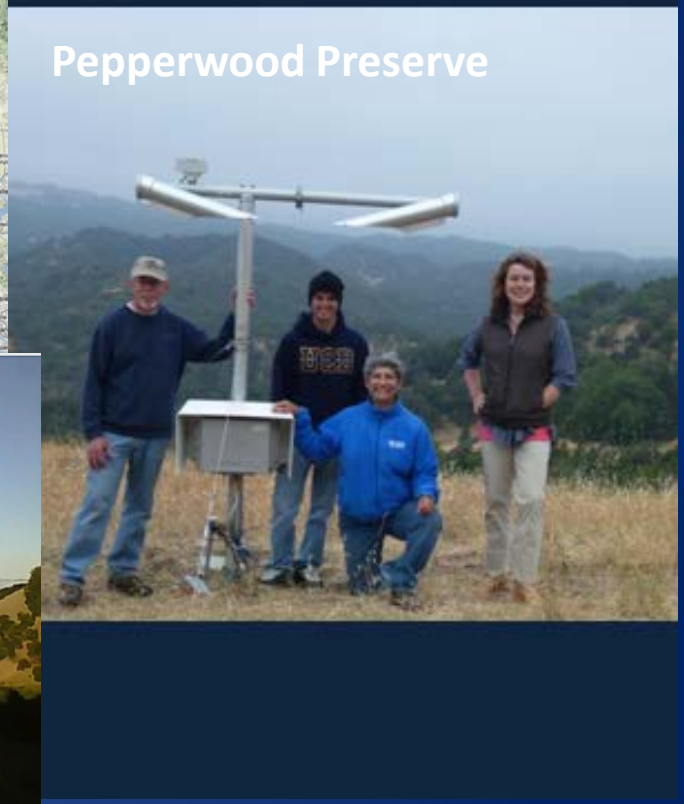
Torregrosa et al. in review

Bodega –Pepperwood Transect Summer 2012 Pilot



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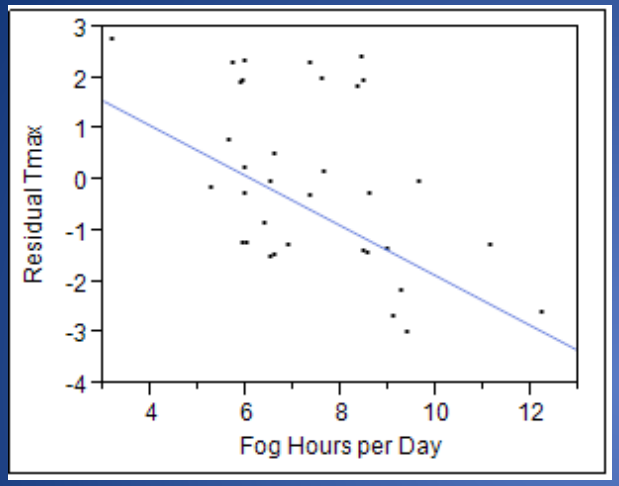
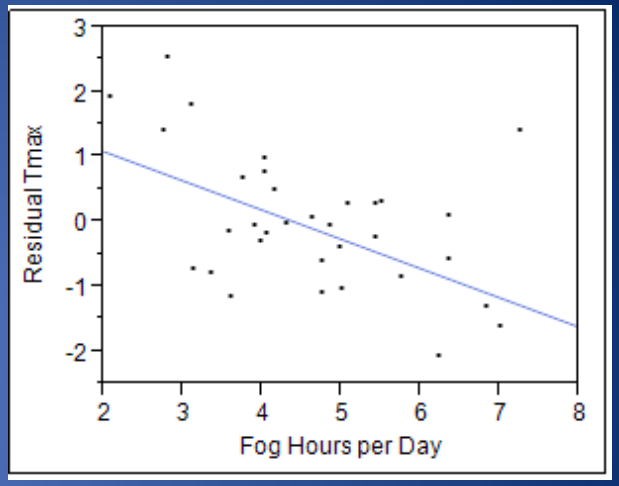
Quantifying Fog Impact on Monthly Temperature

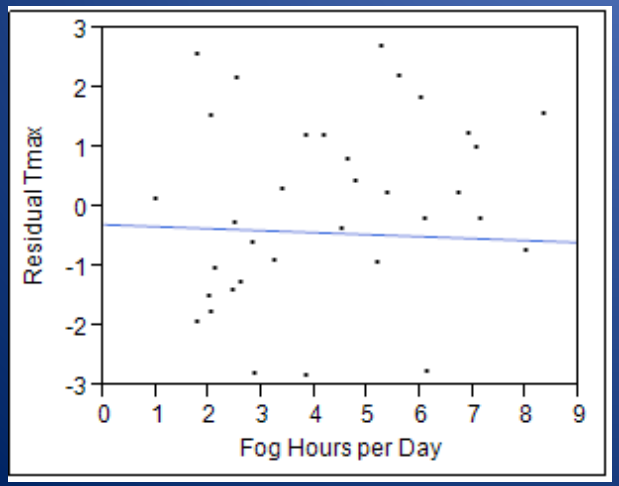
Tomales Bay $p < 0.001$



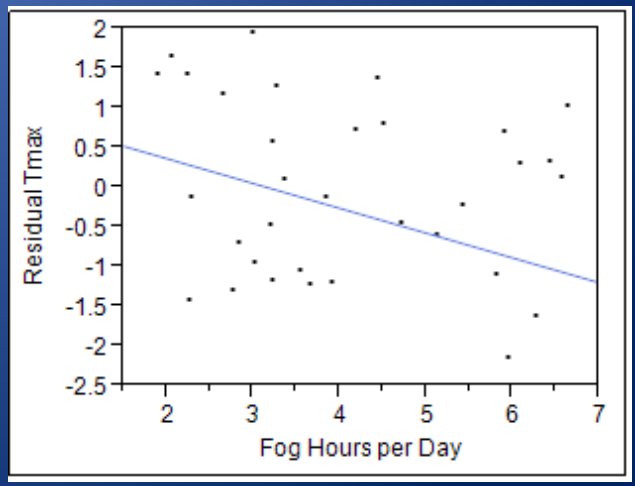
Cotati $p = 0.005$

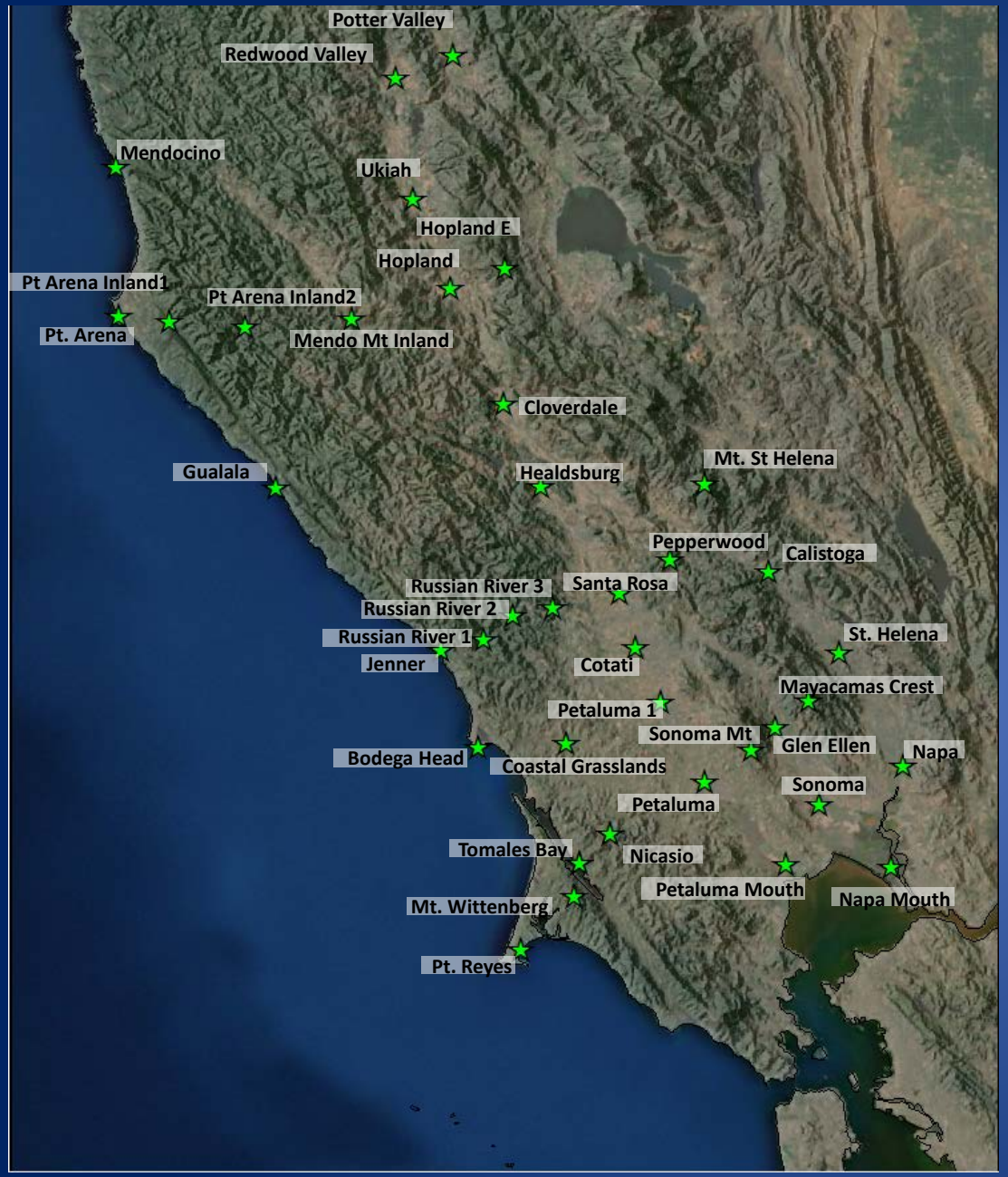


Jenner Not Sig.



Napa $p = 0.68$





Each additional fog hour per day equals a temperature decrease of 0.4°C, on average across sites. For Santa Rosa that's equal to 2100 projections.

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Prof. Dan Fernandez (CSU Monterey Bay) at the Big Sur fog collector site. Some fog events at this site produce 5 gallons of water per day per m^2

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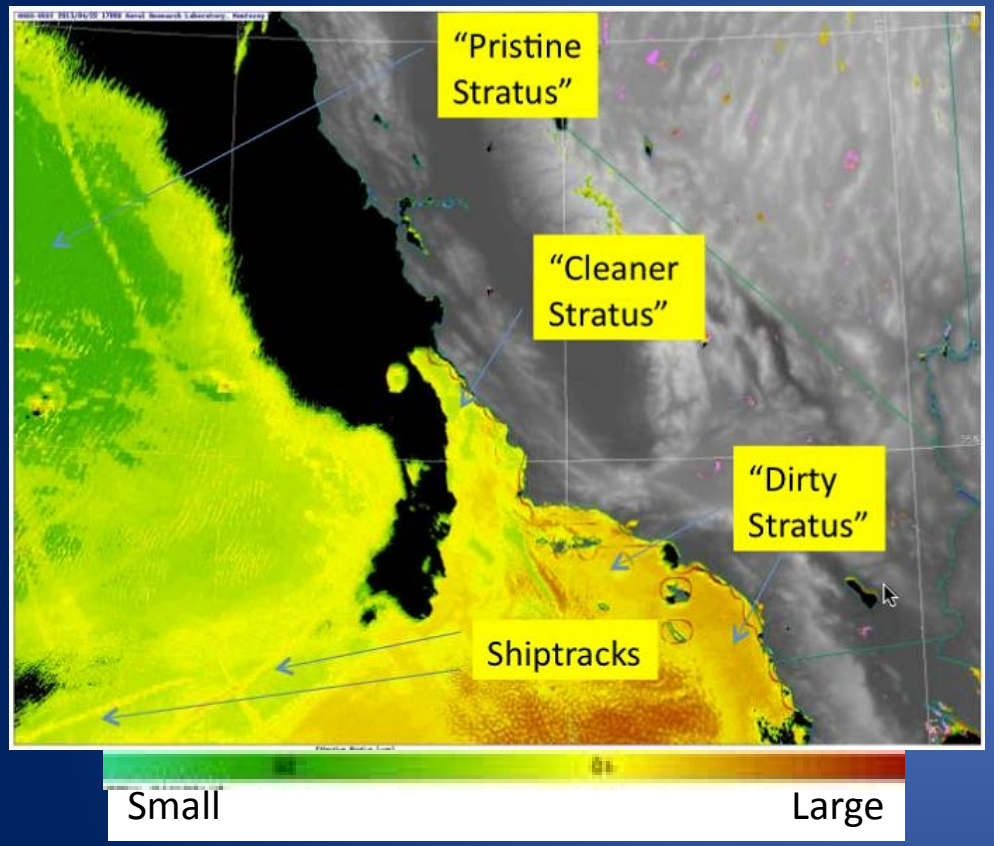
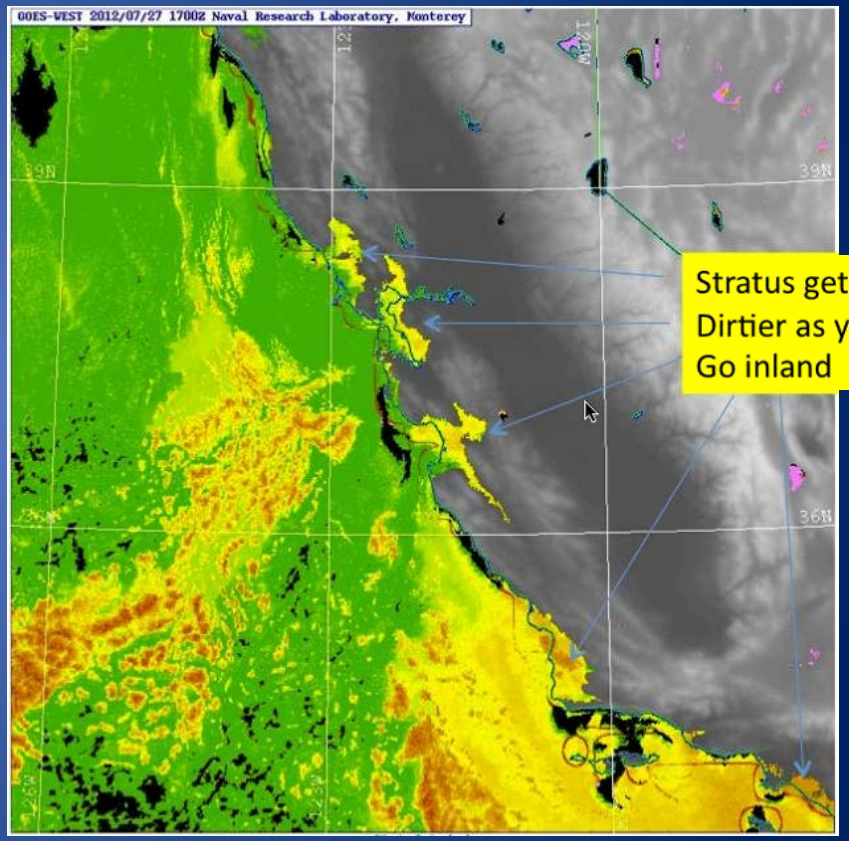
Fog Droplet Size



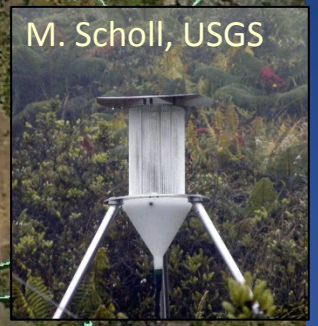
Large droplets form from brine cores becoming smaller after chemical reactions such as with sulfates and other combustion products



Tom Lee, Naval Research Lab, GOES derived fog size product.

USGS

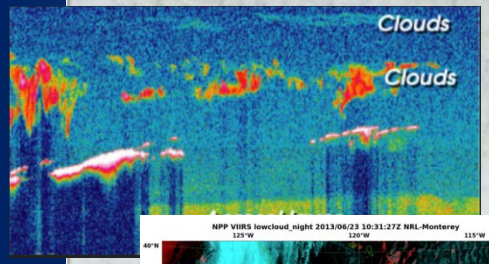
Fog Droplet Size and Number

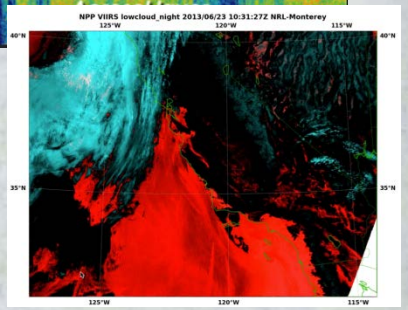


- Monitoring Sites/Partners

- USGS WGSC
- USGS Reston
- GSU
- Pepperwood
- CSUMB
- Naval RL
- UC Davis
- Bodega ML

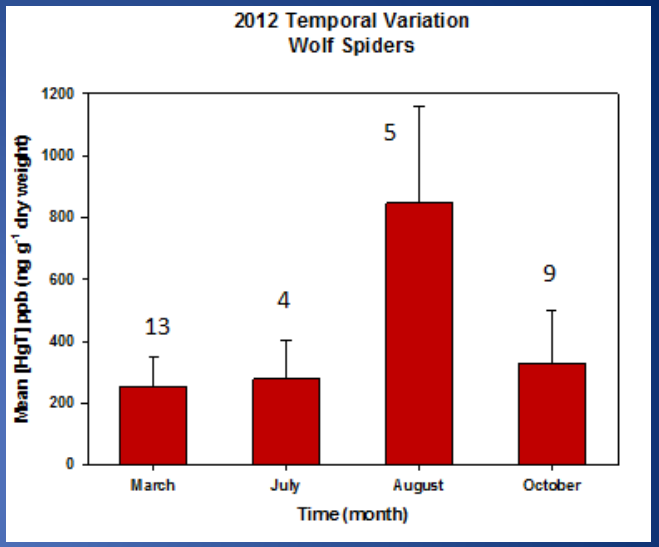
NRL

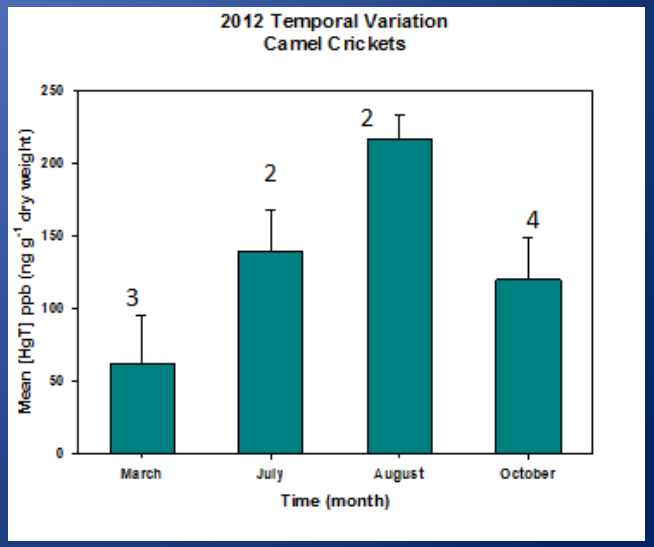




Measuring Mercury in Fog
Peter Weiss-Penzias

7 sites along CA coast from Trinidad Head to Big Sur





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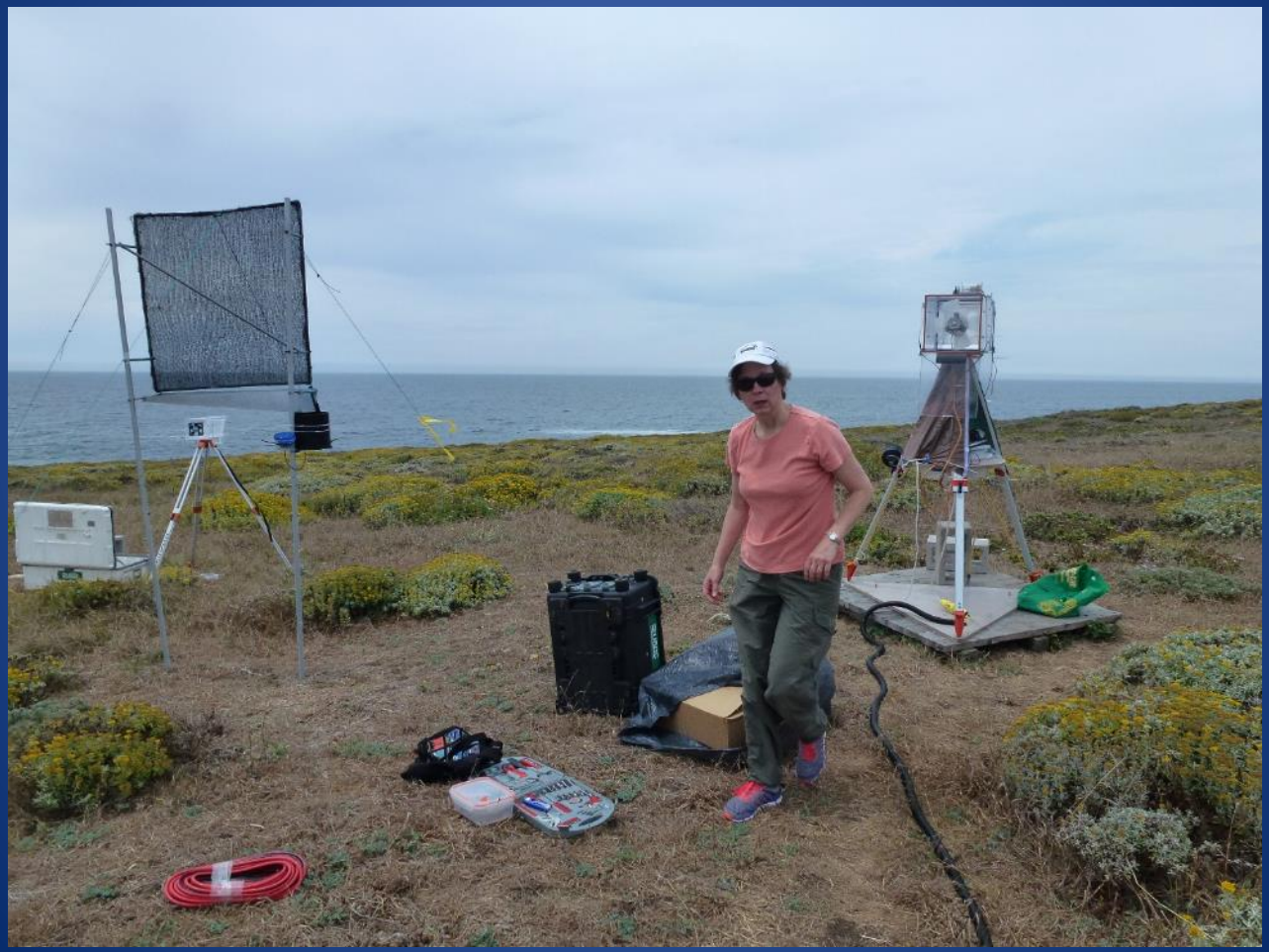
Liquid Water Content & Fog-Groundwater (using Isotopes)



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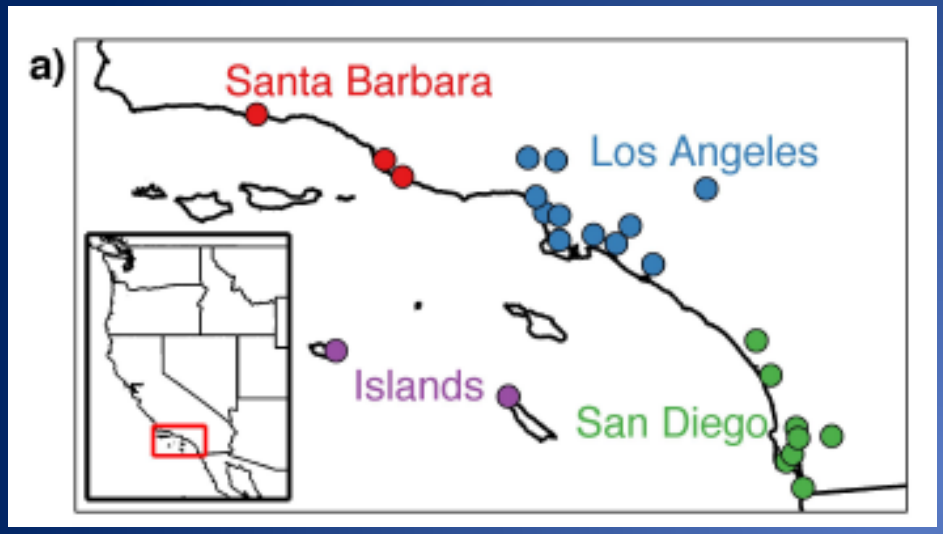
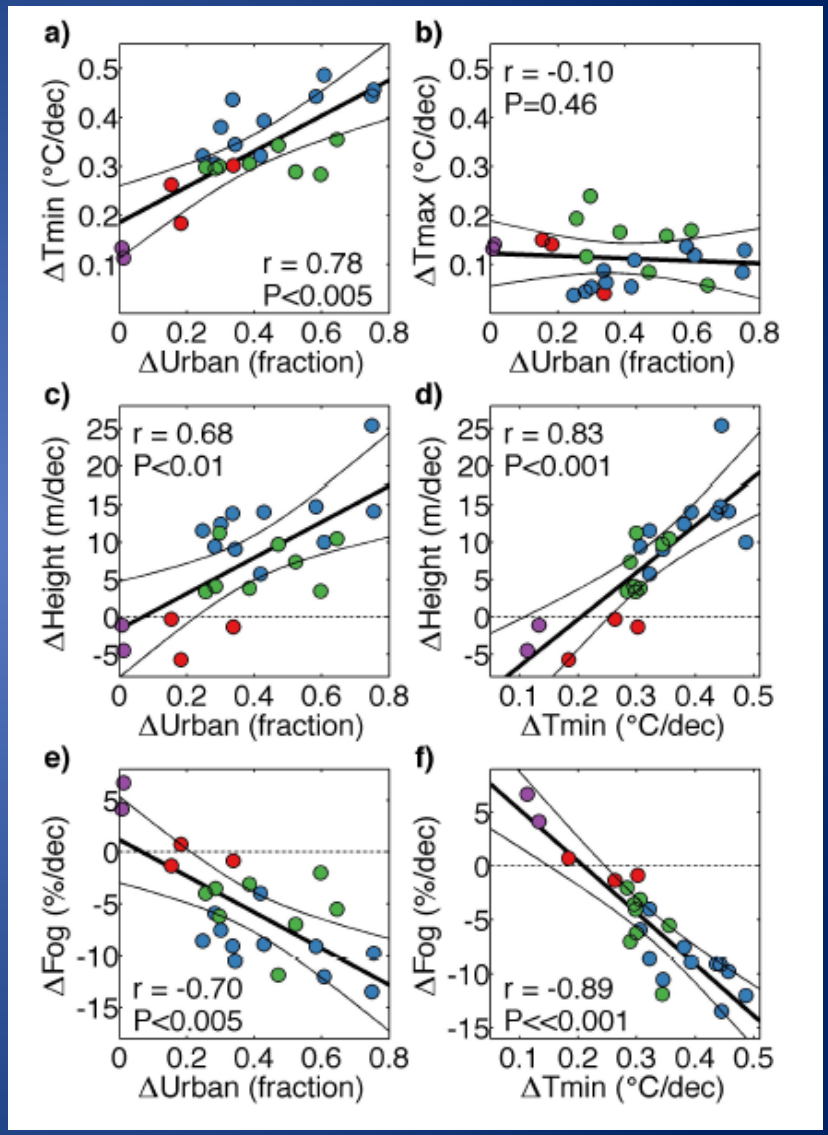
Urban effect on stratus



Urbanization causes increased cloud-base height and decreased fog in coastal southern California

A. Park Williams, Rachel E. Schwartz, Sam Iacobellis, Richard Seager, Benjamin I. Cook, Christopher J. Still, Gregory Husak, Joel Michaelsen



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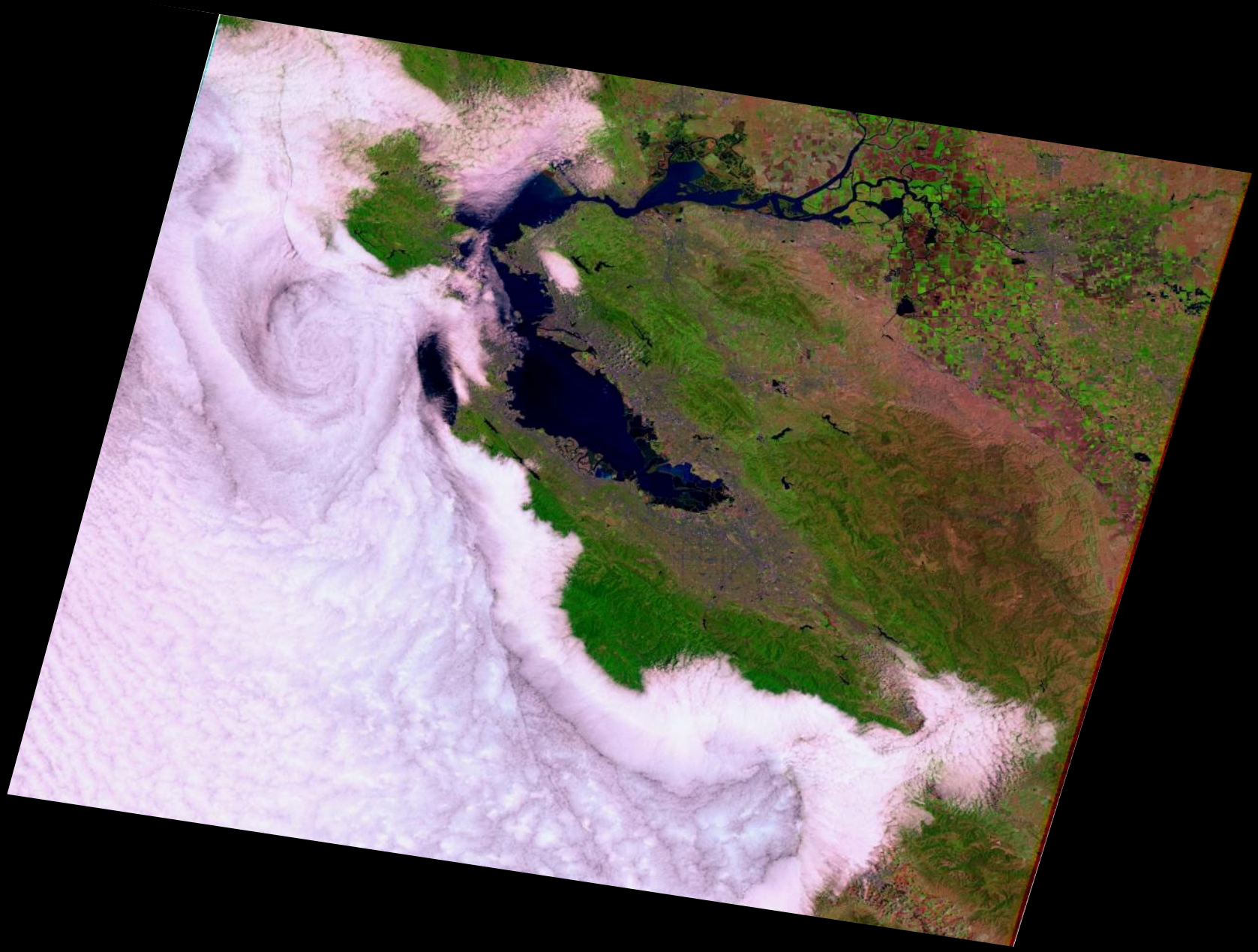
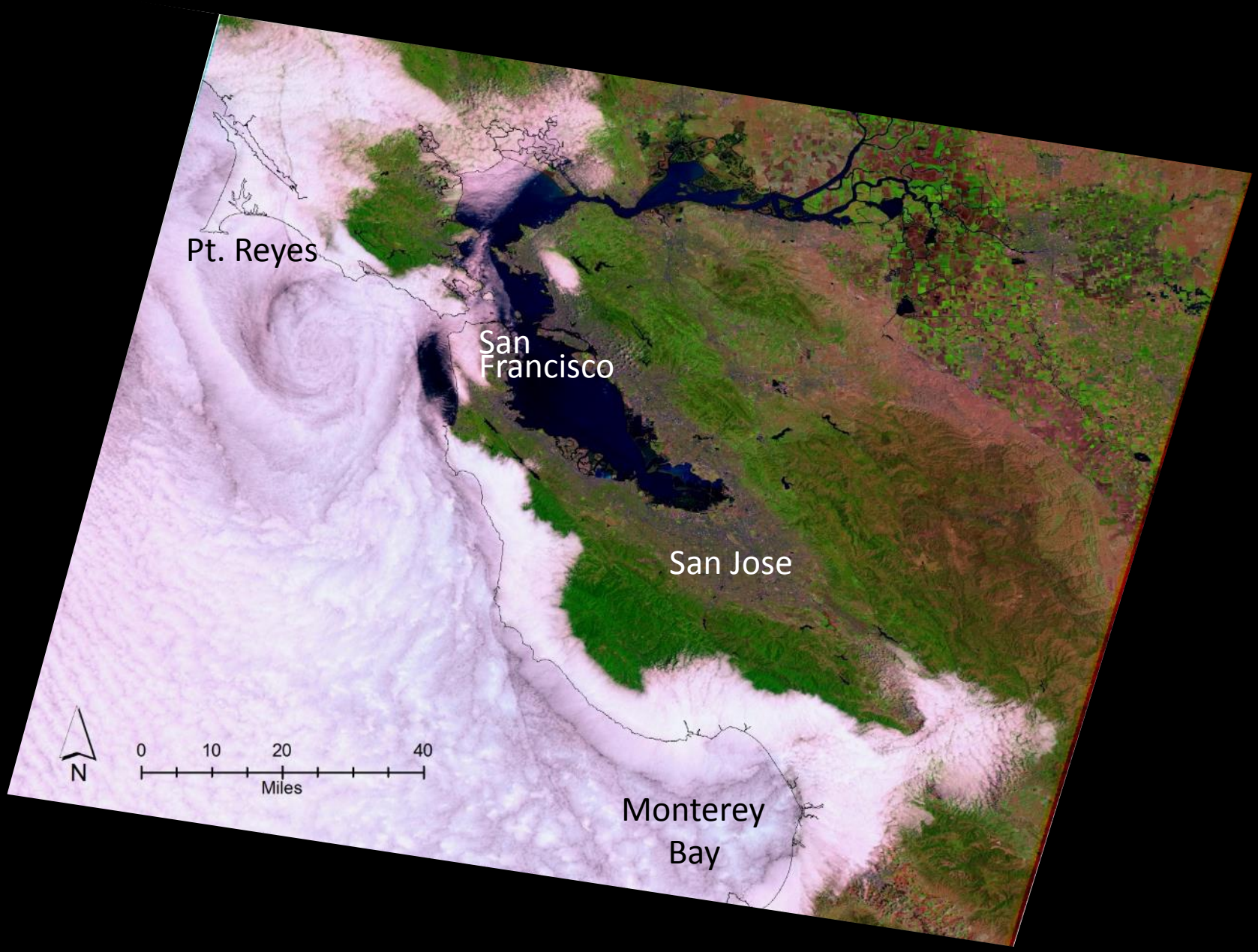


USGS Landsat May 22, 1991

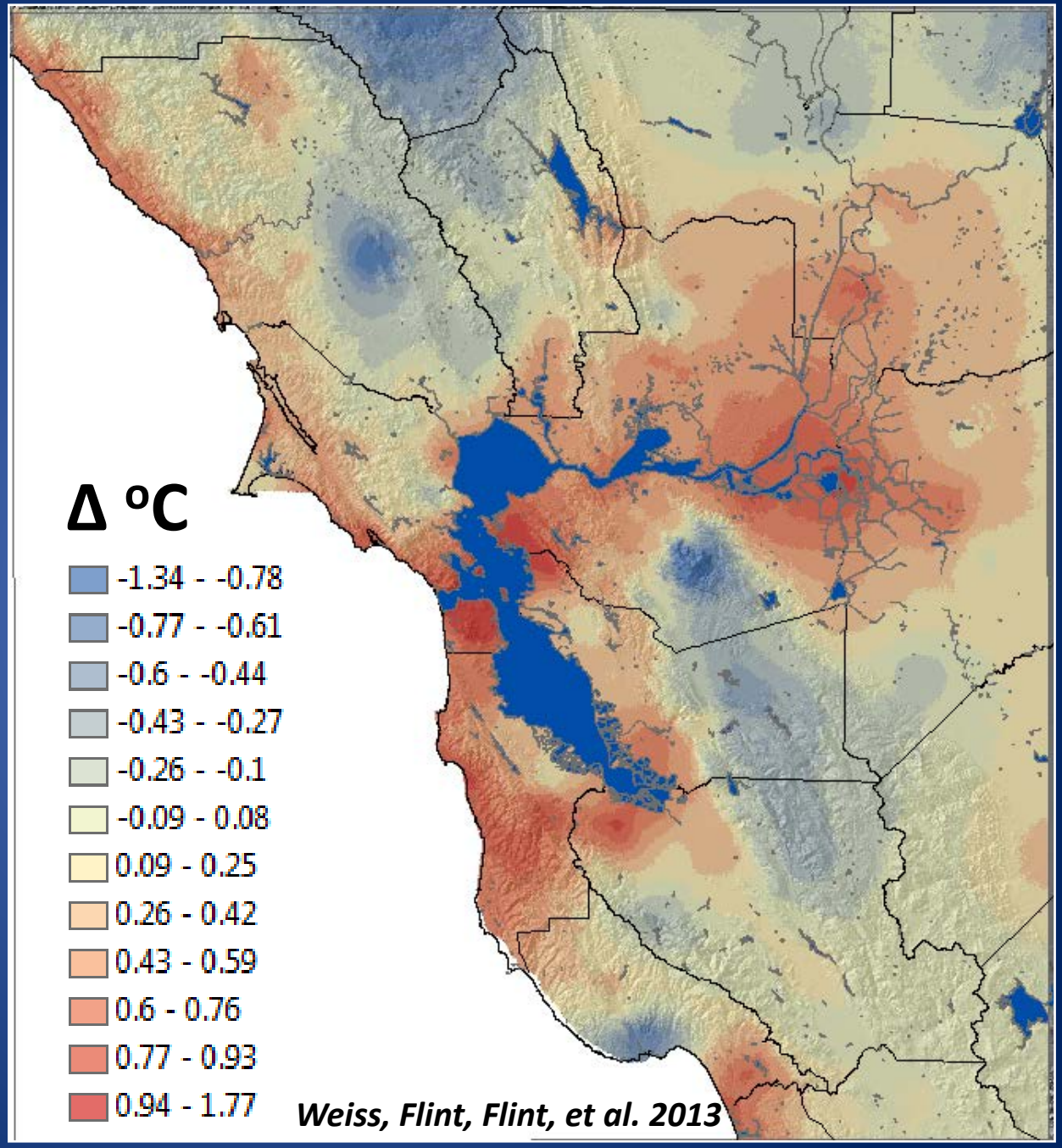


USGS Landsat May 22, 1991

USGS

Difference in Tmax between 30 year averages (1980 - 2009) minus (1950 - 1979)

Terrestrial Biodiversity Climate Change Collaborative (TBC3)



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Lives and Livelihood Threatened by Heat Waves

Heat-damaged Zinfandel clusters from the August 24-25 heat wave were in mid-veraison when the event occurred.

2006 July Heatwave

Number of deaths attributed to the 11-day-old heat wave, by county

Temperatures as of 4 p.m. Tuesday
80° 90° 100°

Authorities in Modesto found the bodies of two elderly men in separate apartments in the same housing complex.

In addition to the human toll, officials said the heat has killed thousands of dairy cows in the Central Valley, depressed milk production, and put crops such as walnuts and peaches at risk.

Source: County Coroners, FSA, USGS.

NEVADA

CALIFORNIA

Sacramento
San Francisco
Modesto
Santa Barbara
Los Angeles
San Bernardino
Riverside
San Diego

YOLO 1
3
CALAVERAS 1
13
STANISLAUS 3
MADERA 1
FRESNO 11
KINGS 1
KERN 1
SAN BERNARDINO 4
IMPERIAL 2

USGS

Chronicle graphic by Joe Shoulak

SFGate

Wine growers benefit

http://petalumagap.com/

Petaluma Gap Winegrowers Alliance

"From Wind to Wine"

Home | The Petaluma Gap | Growers | Wineries | Associates | Events | Membership | Blog | Contact Us

WELCOME TO THE PETALUMA GAP

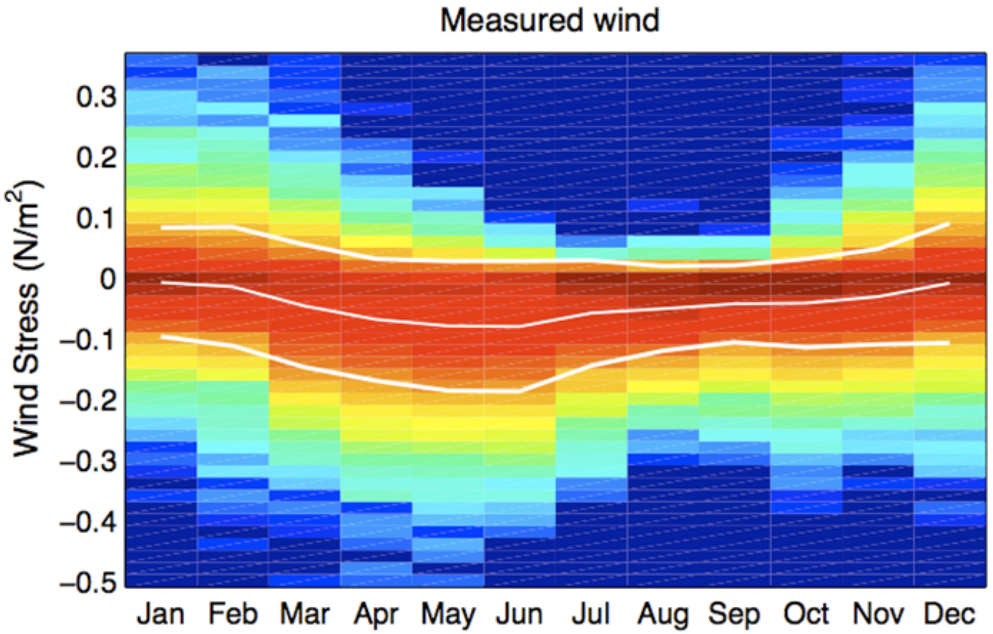
What is one of the best kept secrets of Sonoma County winemakers? The Petaluma Gap!

The Petaluma Gap is the gateway to the Sonoma Coast region. Although not a designated appellation, the Petaluma Gap is producing premium grapes that make the Sonoma Coast Appellation one of California's best areas to grow primarily Pinot Noir, Chardonnay, and Syrah grapes.

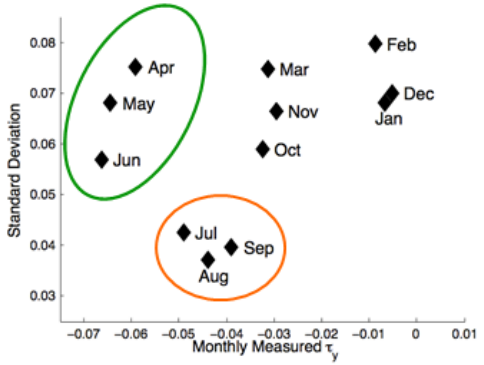
The wind and the fog are the Petaluma Gap's trademark. The "Gap" is actually a wind gap named after a coastal mountain opening that stretches east from the Pacific through the town of Petaluma and then roars south to San Pablo Bay.

USGS

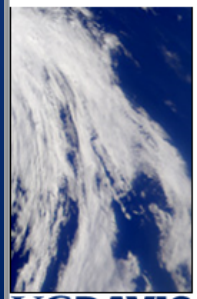
‘Summertime’ – Upwelling Season



upwelling – strong winds/high variability



relaxation – moderate winds/low variability



Annual trend of alongshore wind stress shows two distinct stages when considering both its strength and variability. Garcia-Reyes & Largier refer to AMJ – ‘upwelling’ vs. JAS – ‘relaxation’ seasons.

UCDAVIS UNIVERSITY OF CALIFORNIA