Quantifying Coastal Fog for Management Actions

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Climate-Smart from Watershed to Sea

4th Ocean Climate Summit

May 17, 2016

Fog is a Dominant Meteorological Feature of Coastal California

Photo Credit
Robert Cameron

Science <<-- -->> Action
Three Examples

- Land Acquisition and Restoration
- Prioritizing Watersheds for Coho Restoration
- Fog Water Harvesting

USGS

Science <<-- -->> Action
Central Science Questions

- *Locate fog → when does it come & go?*
- *Quantify what fog brings into coastal ecosystems -> how much water, nutrients, biogenic STUFF ?*
- *What will happen to fog with future warming?*

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Coastal Fog and Low Clouds

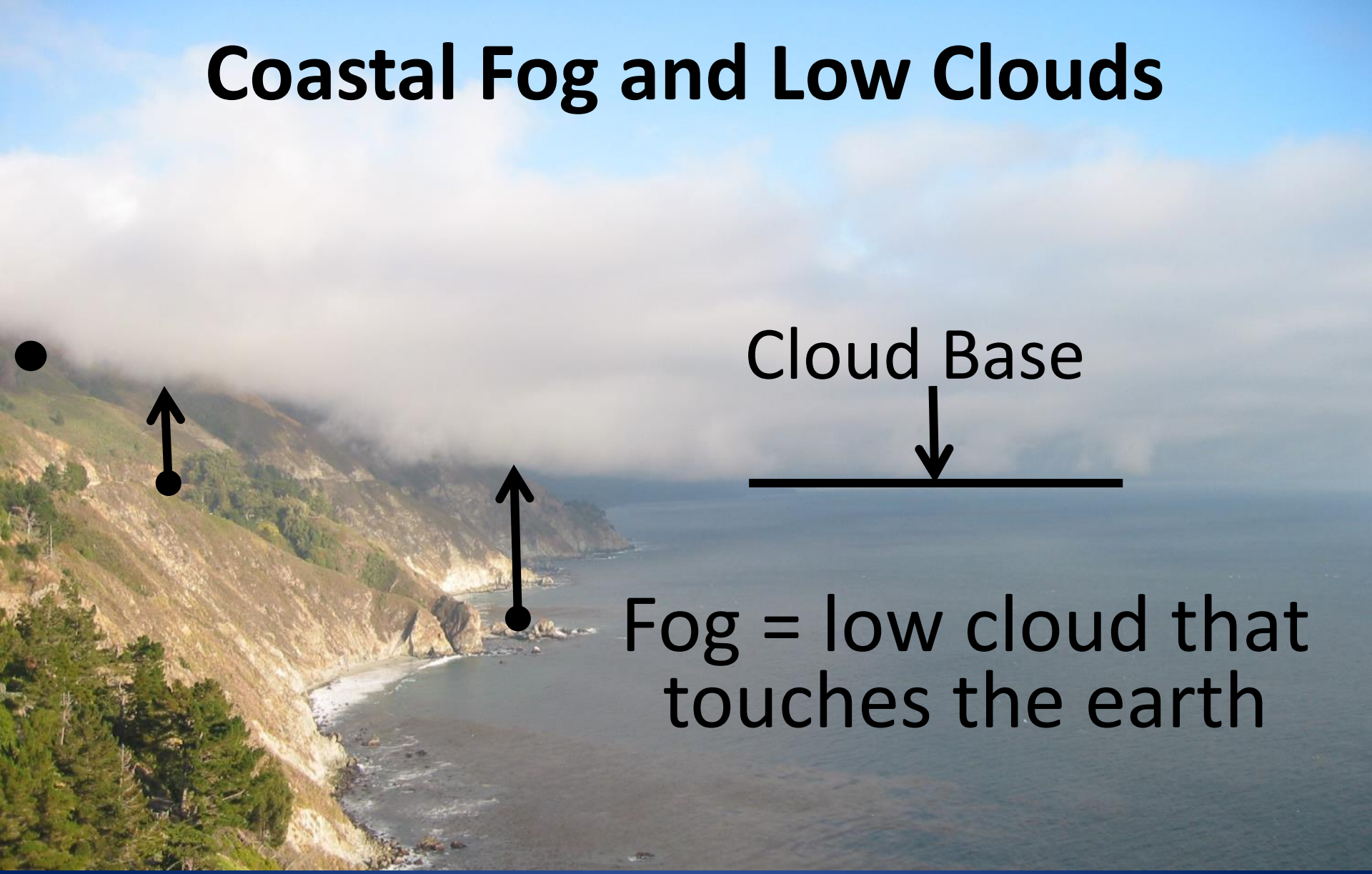

Photo Credit: Ian Faloona

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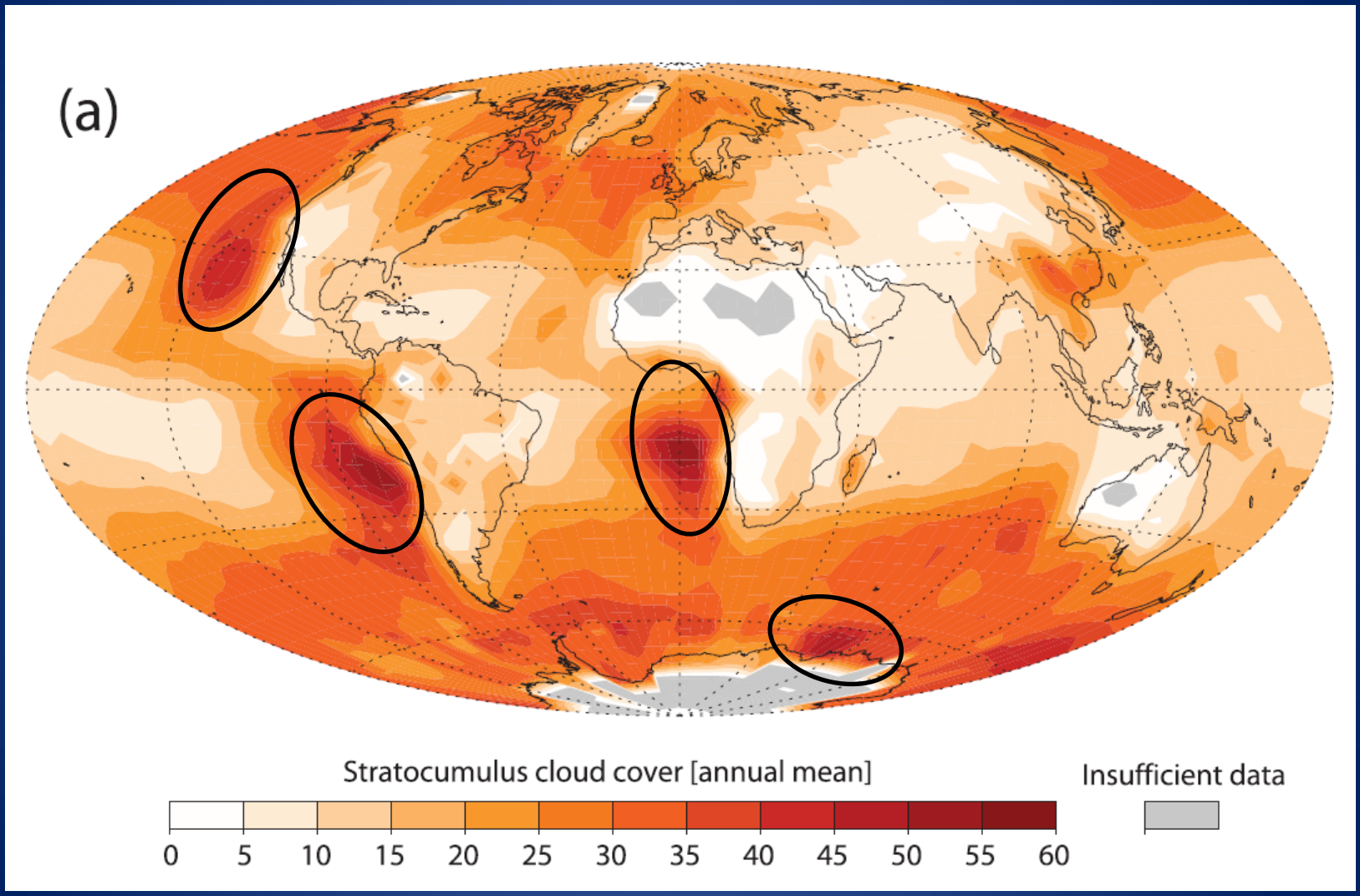
Coastal Fog Hotspots



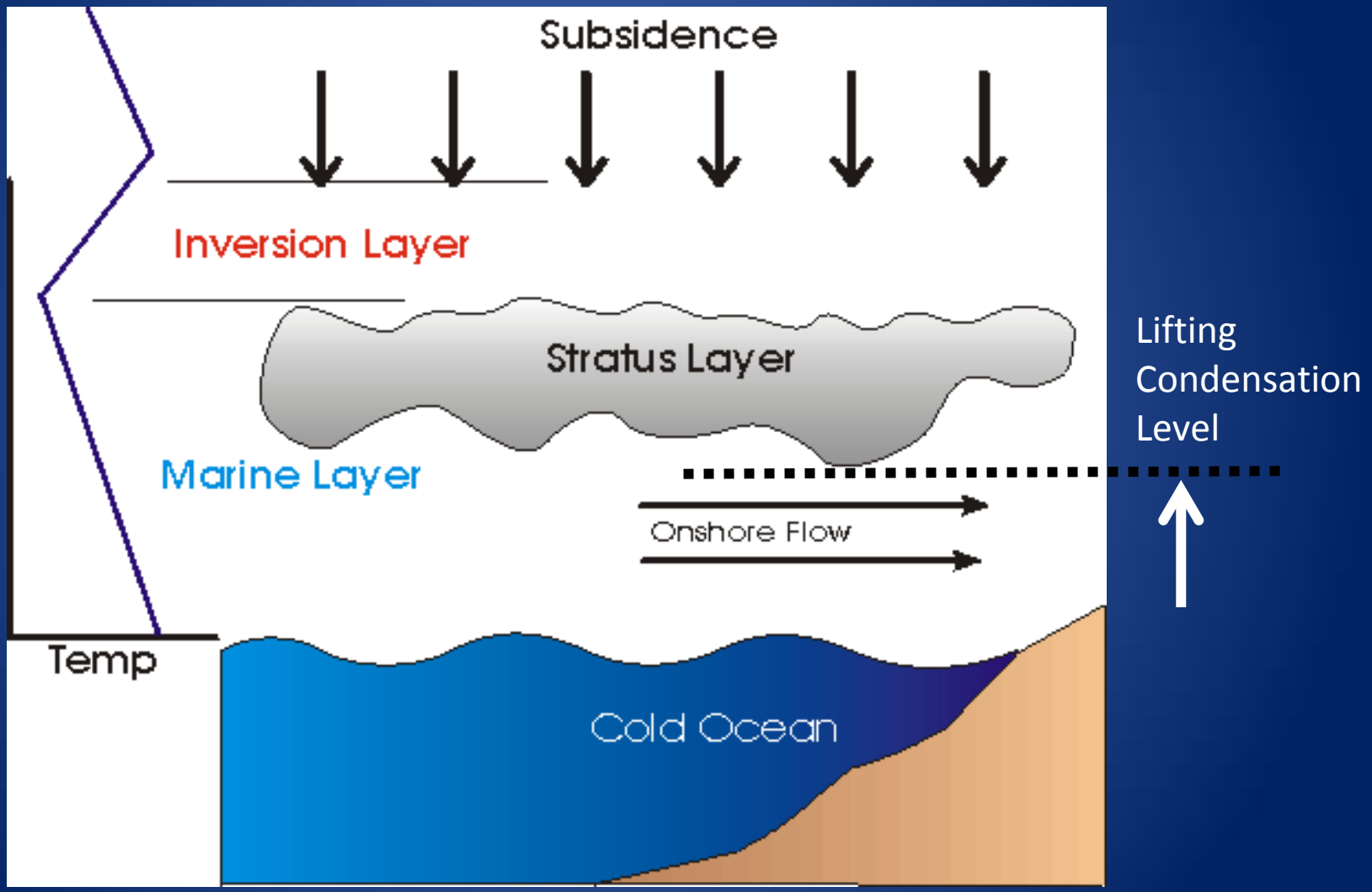
Wood (2012) Stratocumulus Clouds, MWR, v 140

USGS

Land Acquisition and Restoration

USGS

Mechanistic Approach to Locating Marine Stratus



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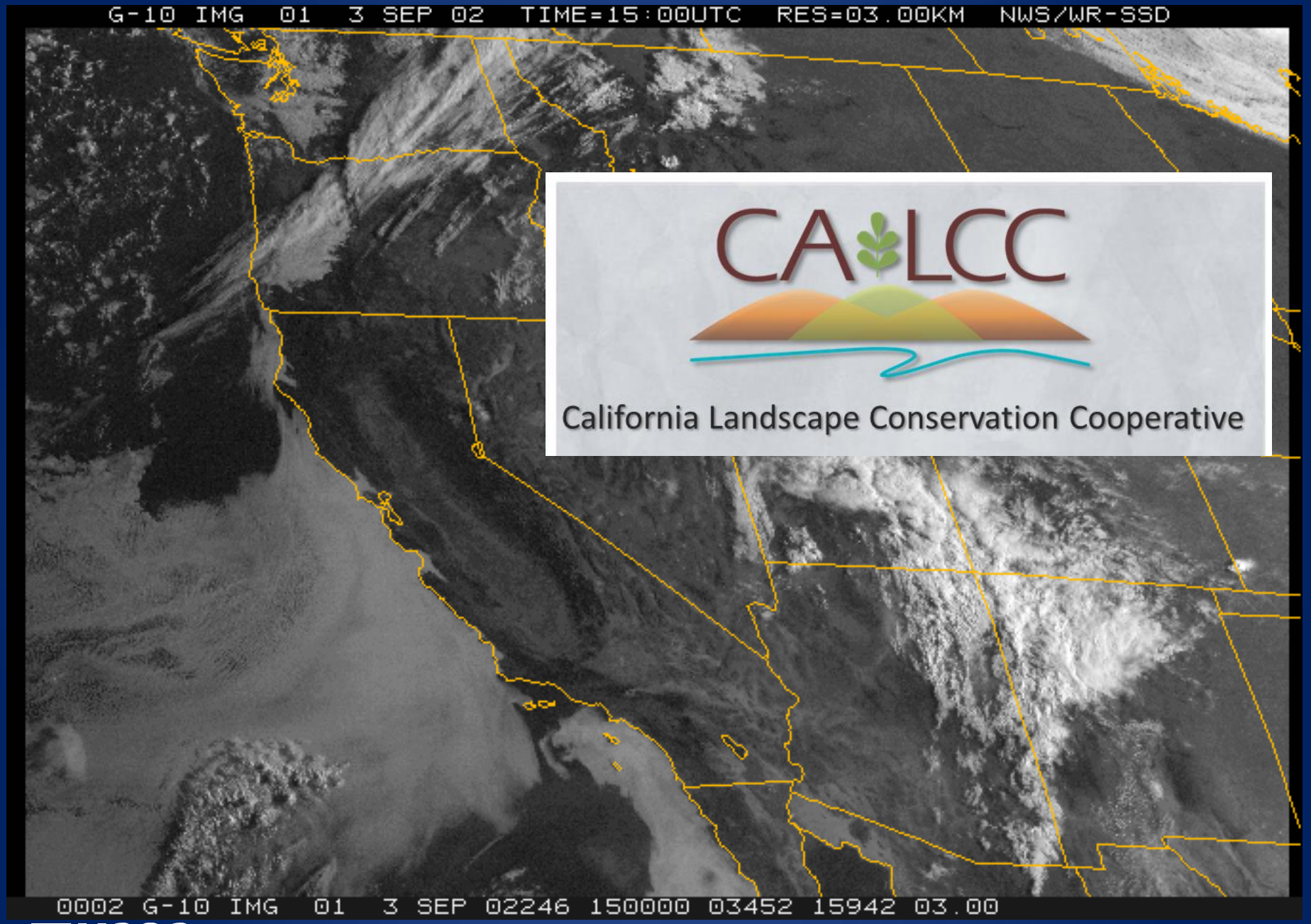
Prof Joel Michaelson, UCSB lecture notes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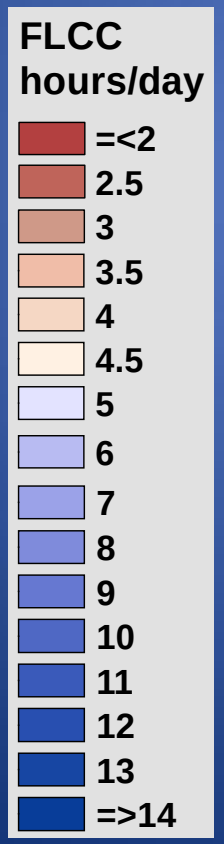
CA LCC
California Landscape Conservation Cooperative
0002 G-10 IMG 01 3 SEP 02246 150000 03452 15942 03.00

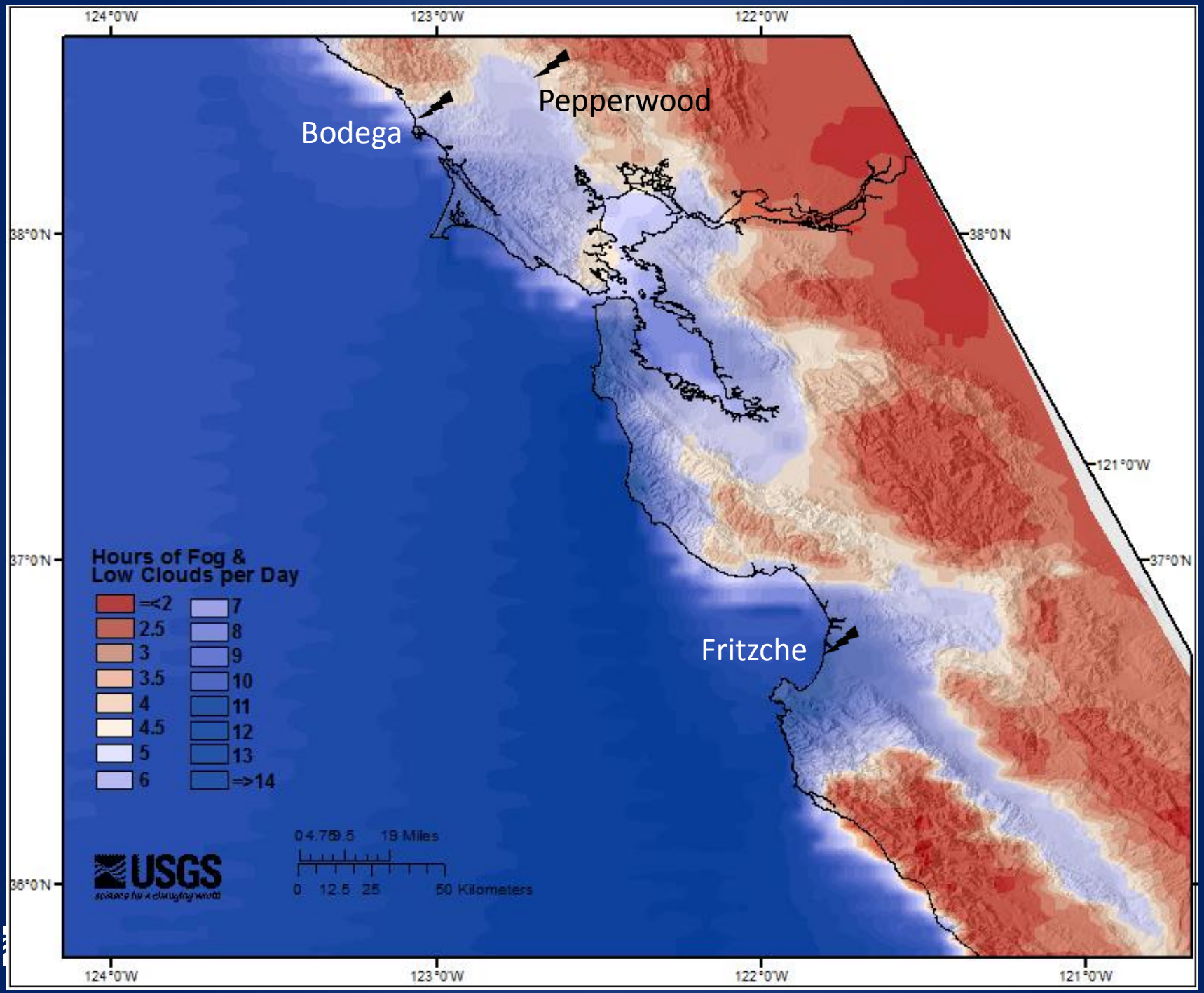
USGS

Decadal Fog and Low Cloud Index

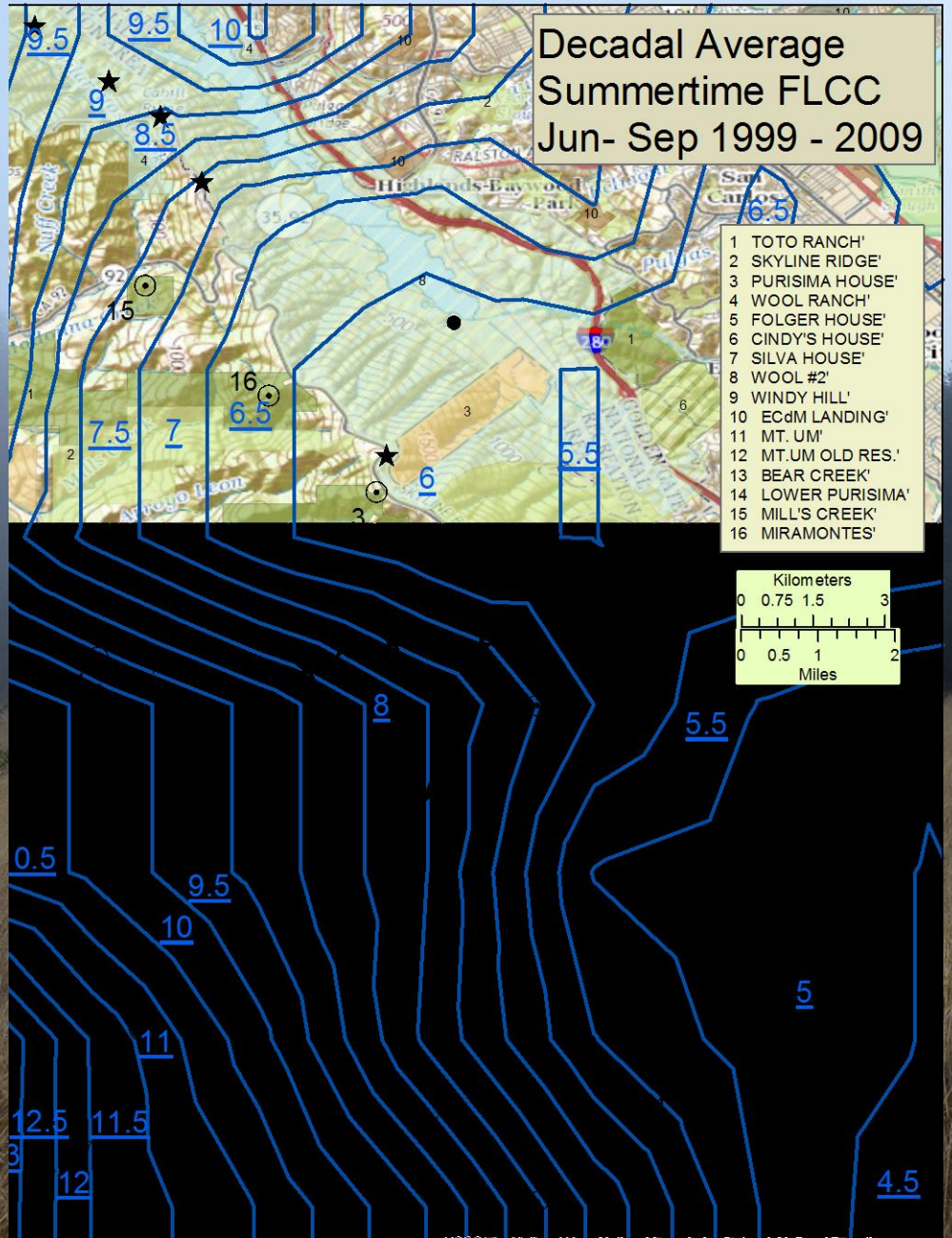
~30,000 hourly GOES-derived summertime (June – Sept 1999 - 2009) cloud maps



USGS


124°0'W
123°0'W
122°0'W
121°0'W
38°0'N
37°0'N
36°0'N
Bodega
Pepperwood
Fritzche
Hours of Fog &
Low Clouds per Day
=<2
2.5
3
3.5
4
4.5
5
6
7
8
9
10
11
12
13
=>14
USGS
0 4.7 9.5 19 Miles
0 12.5 25 50 Kilometers

Midpeninsula Regional Open Space District

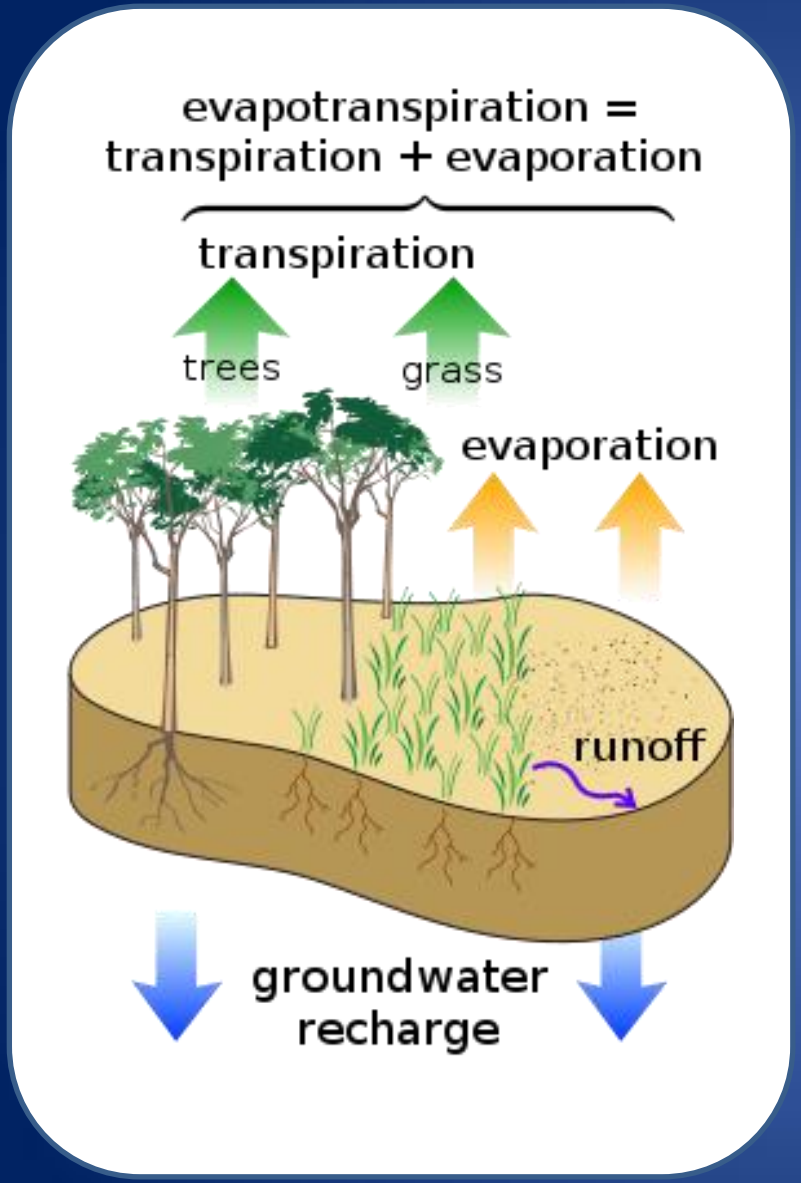


How Prioritizes fog in Watersheds of Coastal California?

Photo: Mel Wright, www.spawnusa.org

Fog = 200 % increase in streamflow (Sawaski and Freyburg 2014)

USGS



Fog lowers the evaporative demand by lowering temperature and increasing humidity

USGS

Fog in Groundwater

- *Bodega groundwater mixing model analysis of **30%** fog water shows fog events are plausible recharge sources for shallow unsaturated zone*
- ***Pepperwood fog** is isotopically depleted compared to previous studies, probably due to higher elevation, but **isotopically enriched compared to rain***
- *Fog may be a component of groundwater in Pepperwood area, but uncertainty is high.*

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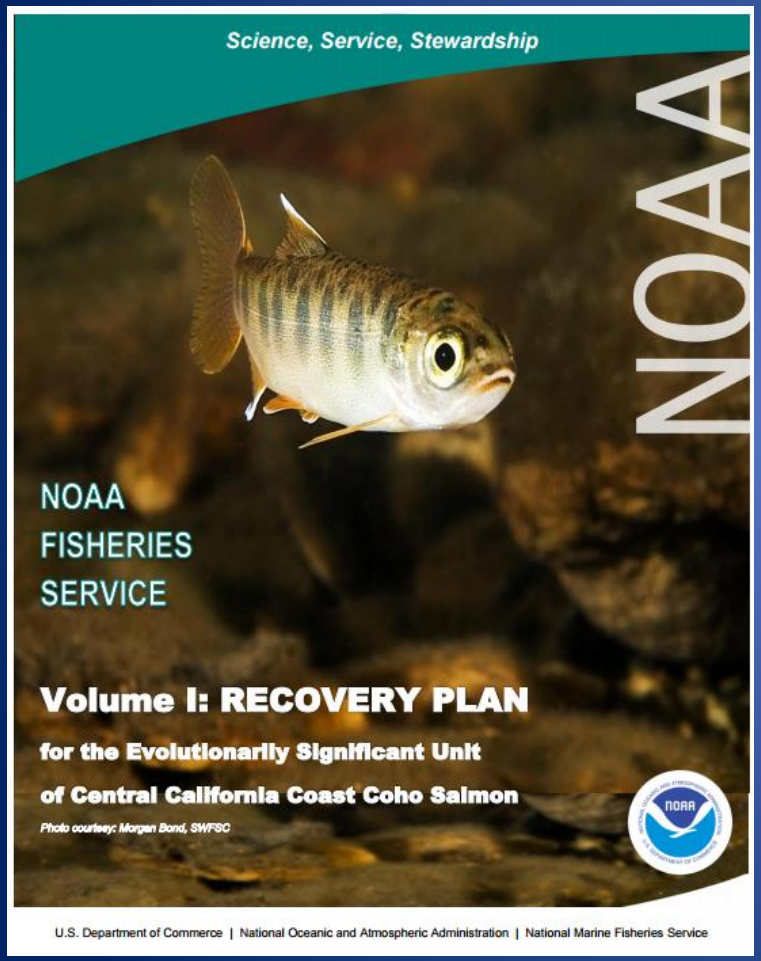
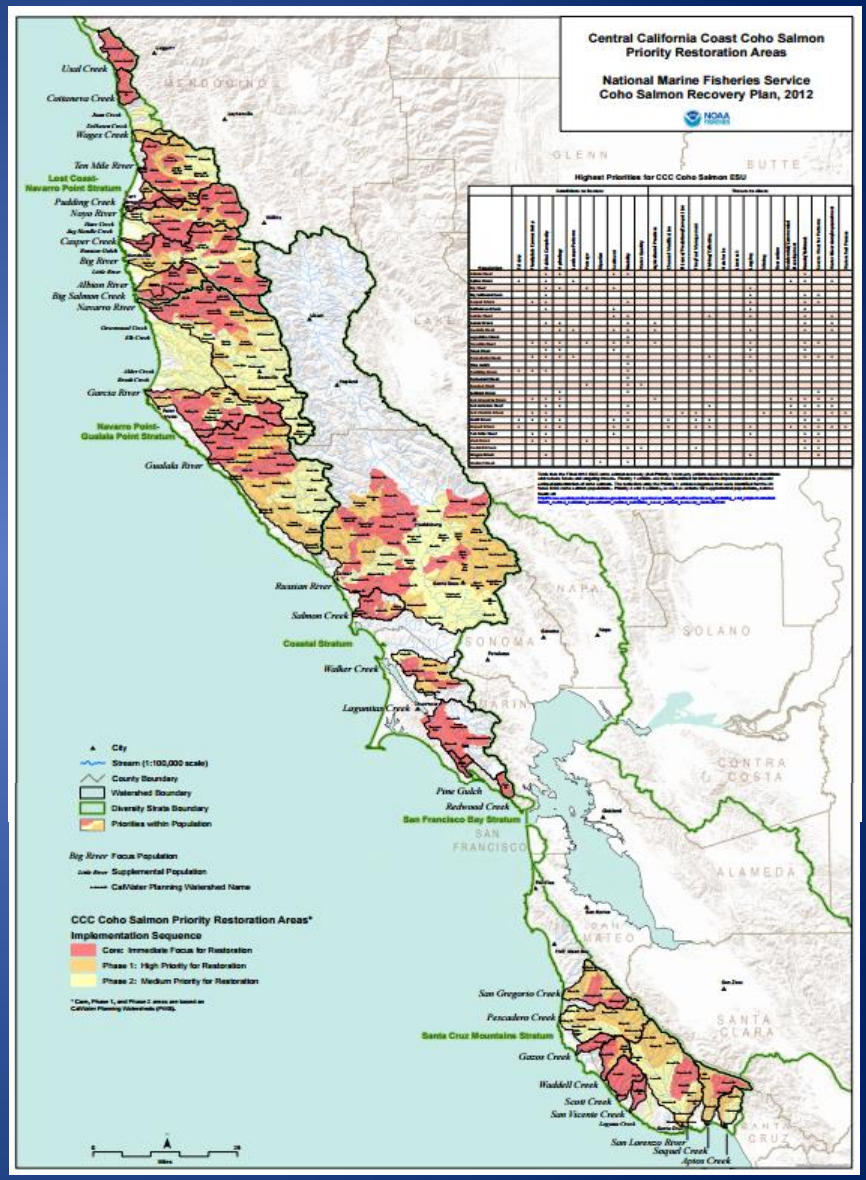
Fog, Water Balance and Coho





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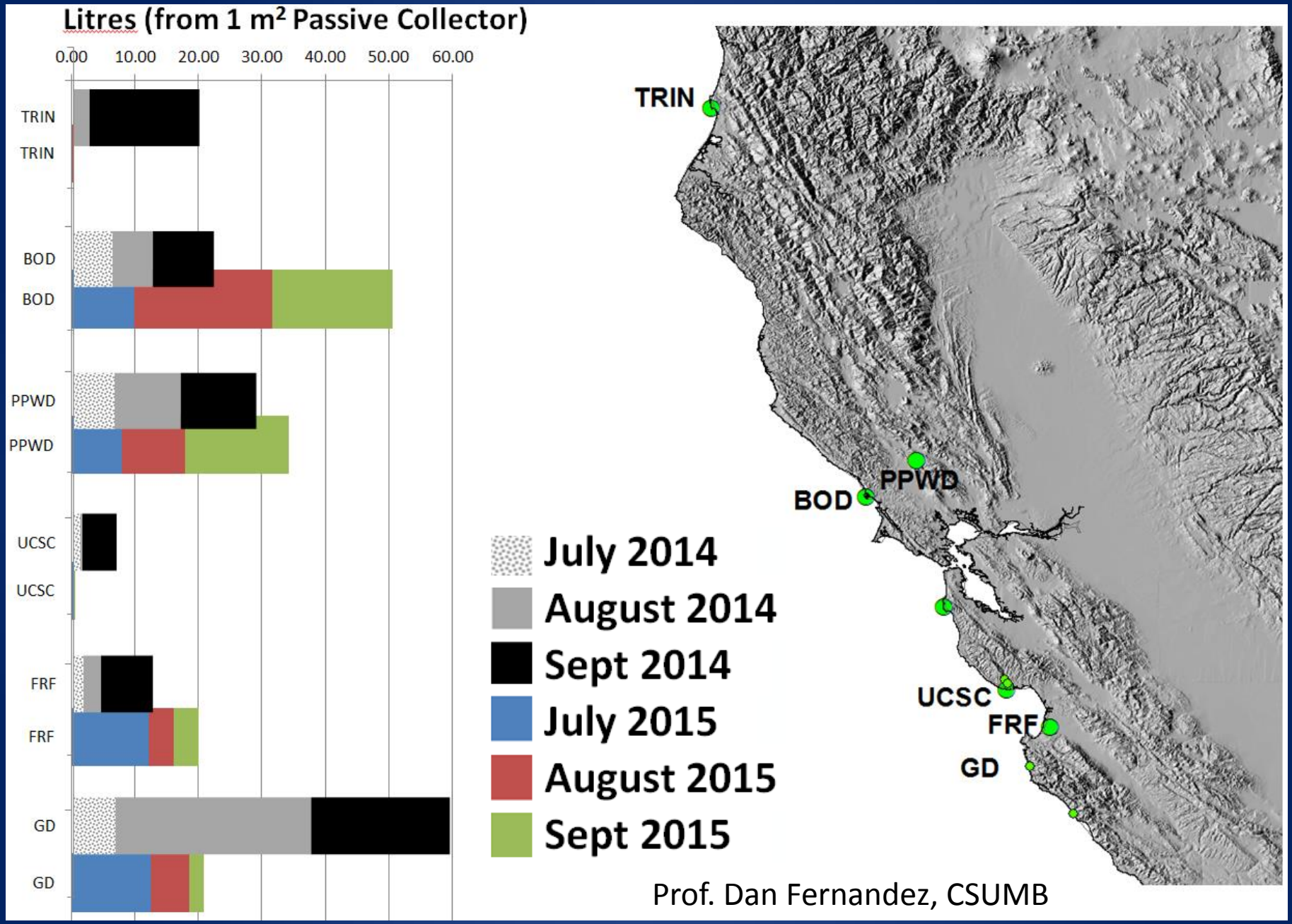
Fog Water Harvesting



Prof. Dan Fernandez, CSUMB

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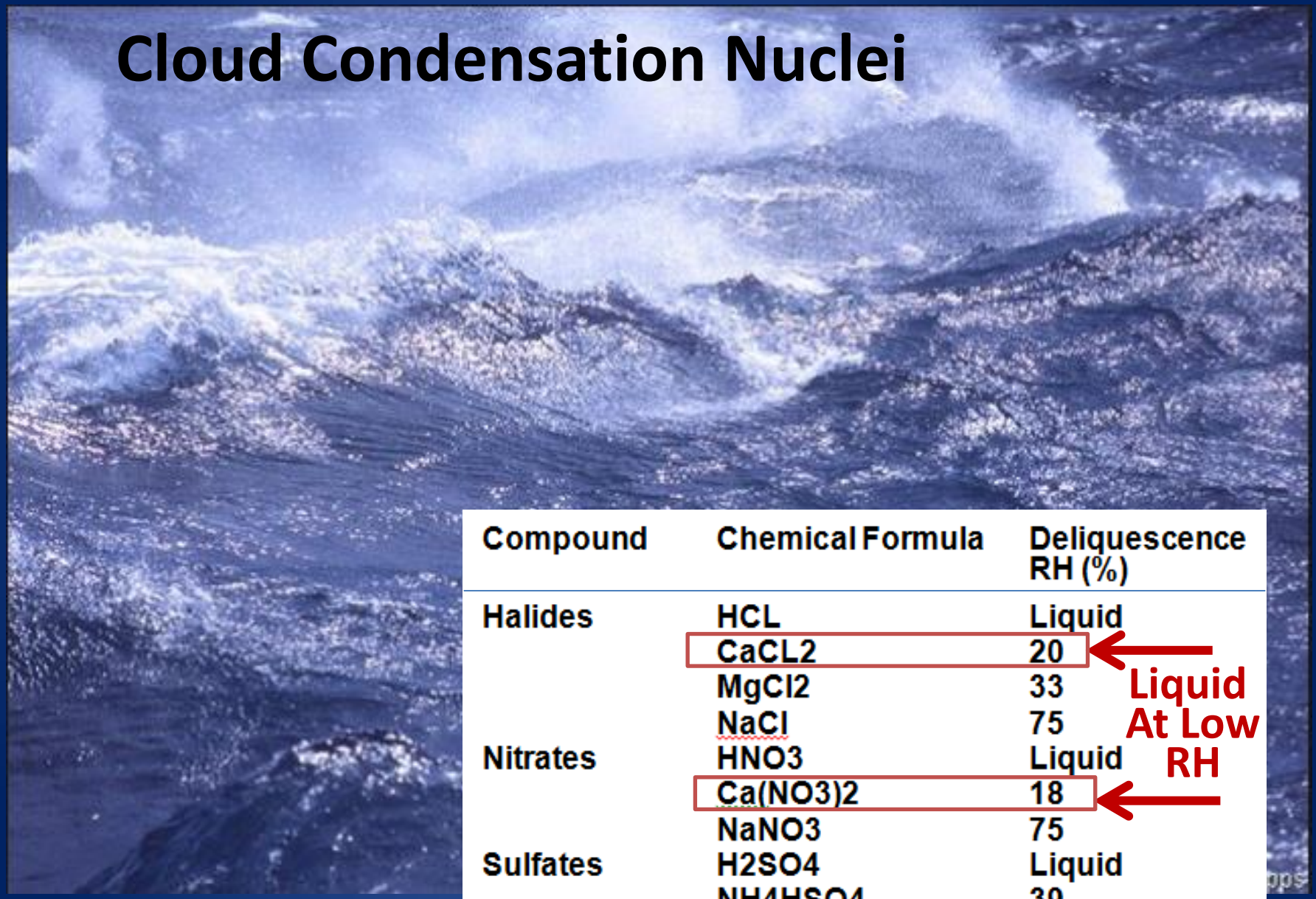
Cloud Condensation Nuclei



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

Liquid At Low RH

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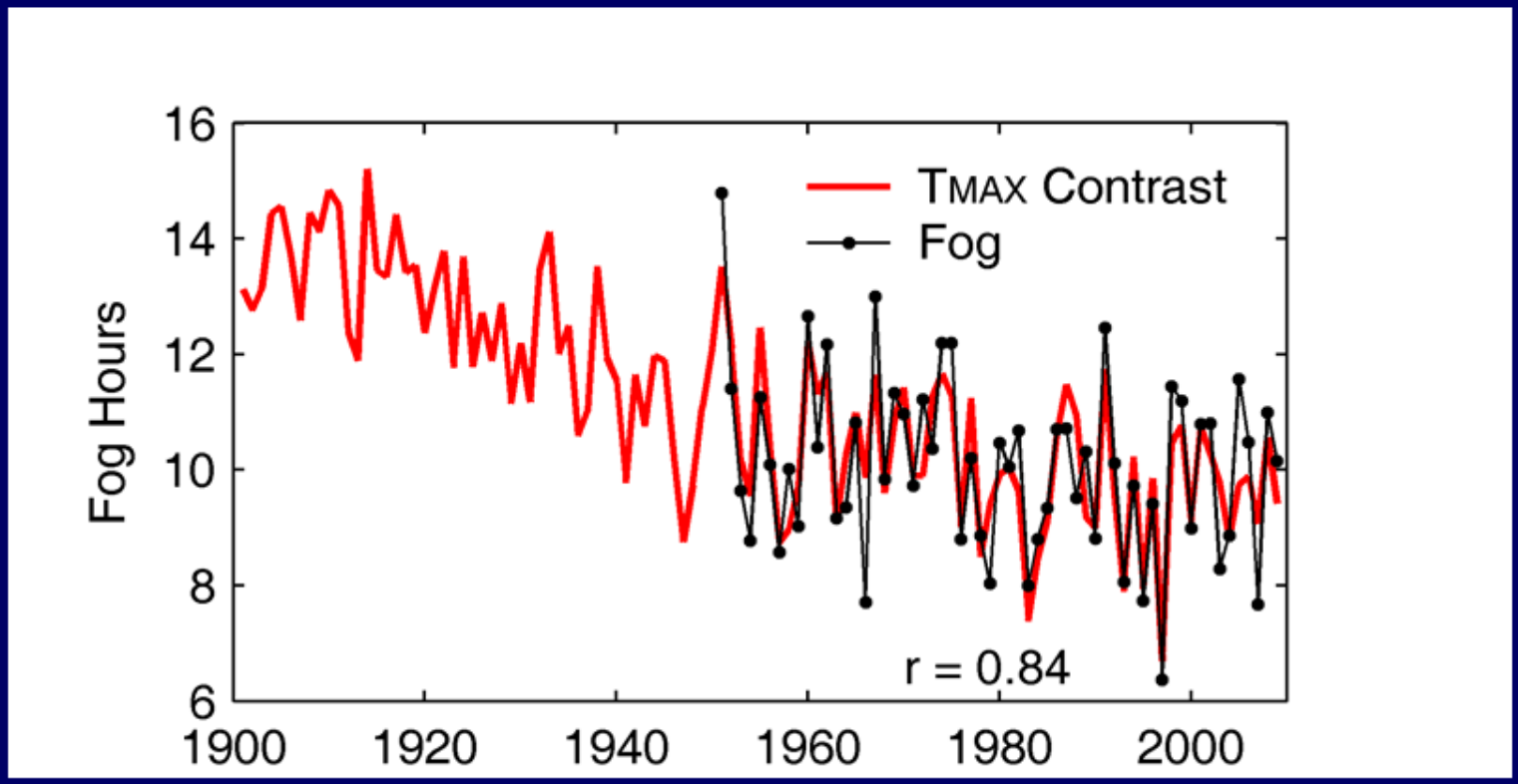
What is the future of fog?

T_{max} Inland-Coast Contrast 1901-2008



Johnstone & Dawson (PNAS 2010) suggest summertime fog duration is ~3 hrs less (-33%) than in early 20th century

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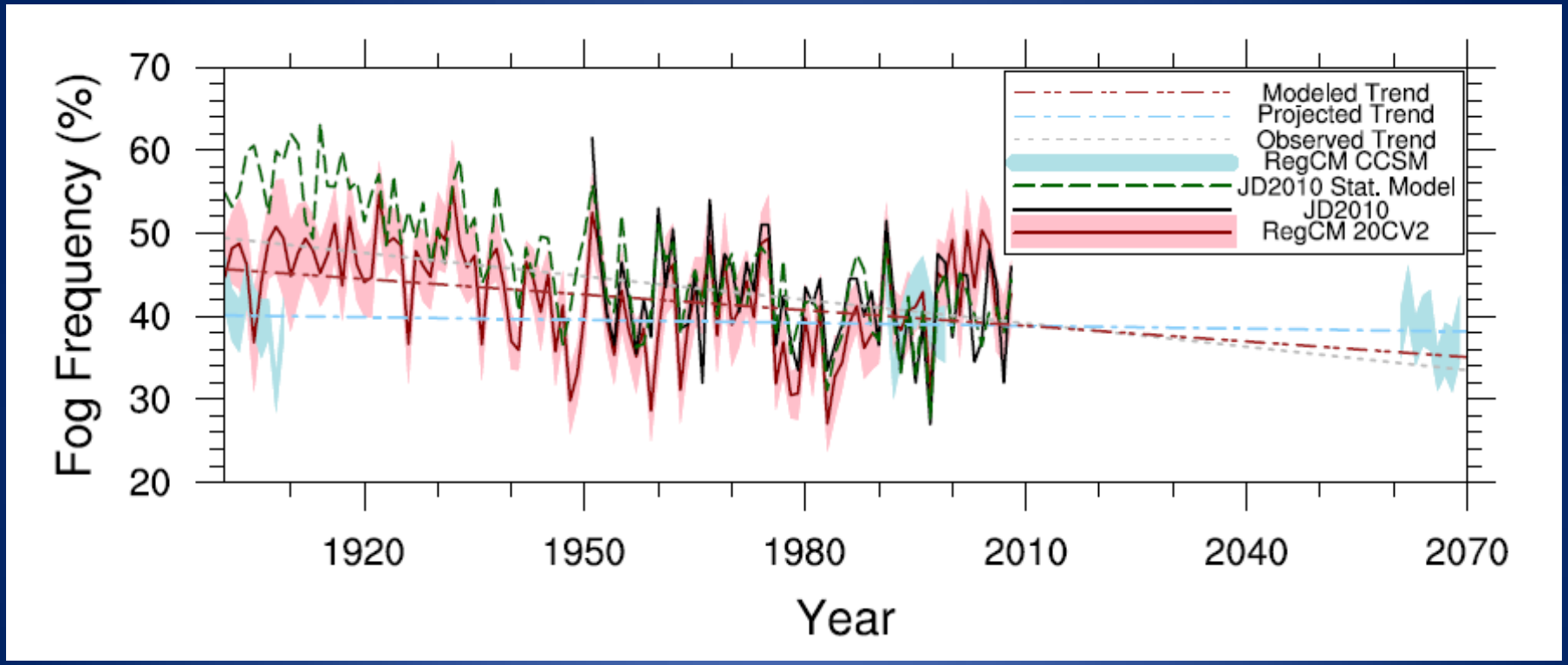
RegCM-UW Fog Model

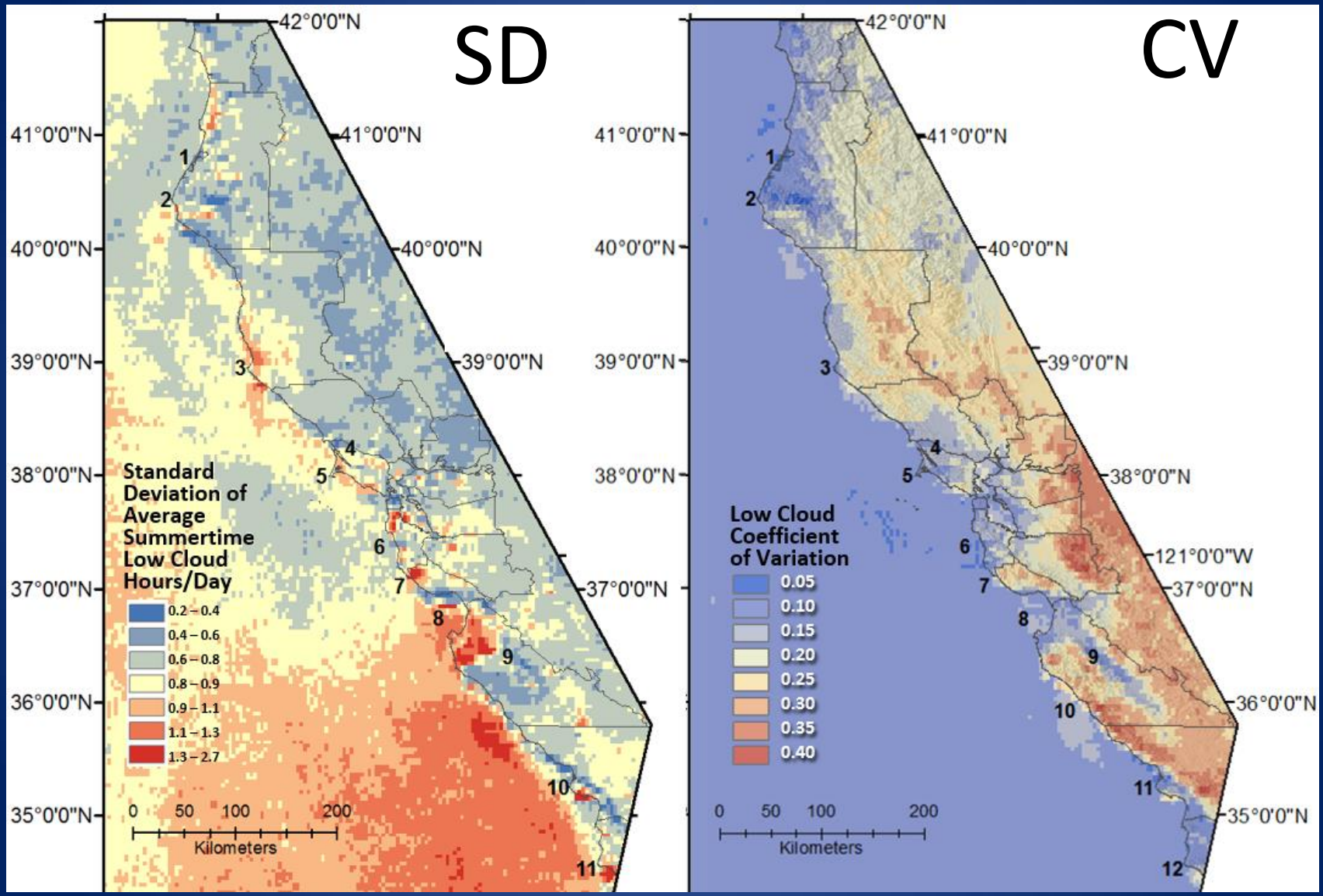


Travis O'Brien's model results (2012) also show long-term declines in fog driven by 1) surface pressure that 2) increased off-shore flow, that 3) dries the marine boundary layer and 4) lifts the fog deck. Increasing SST would further reduce fog formation but perhaps be offset by Central Valley warming.

USGS

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

Patterns of Stability, Climate Refugia



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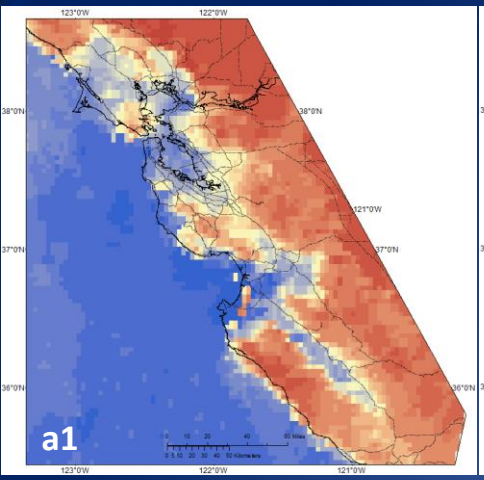
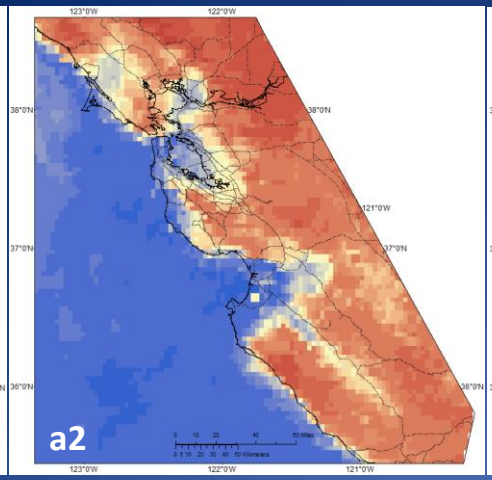
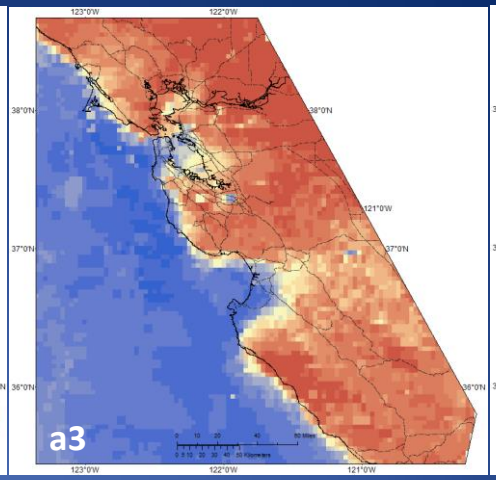
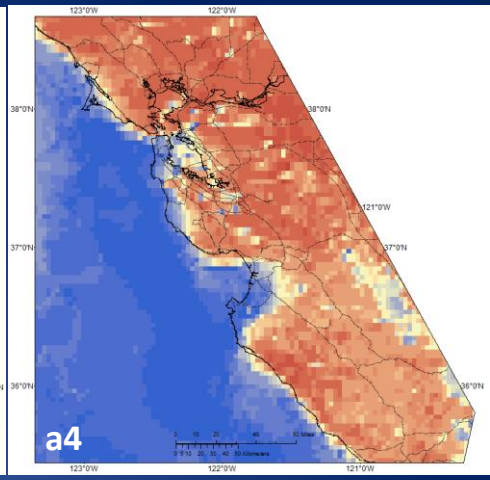
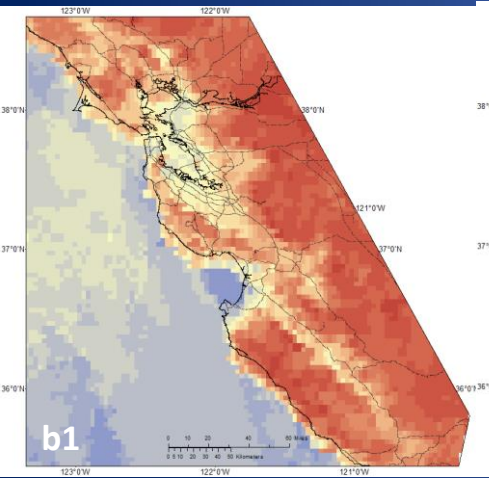


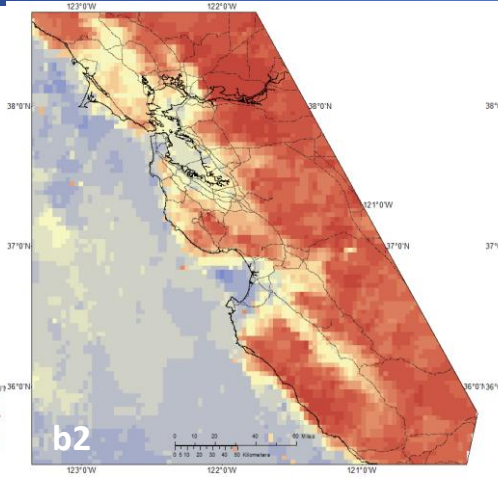


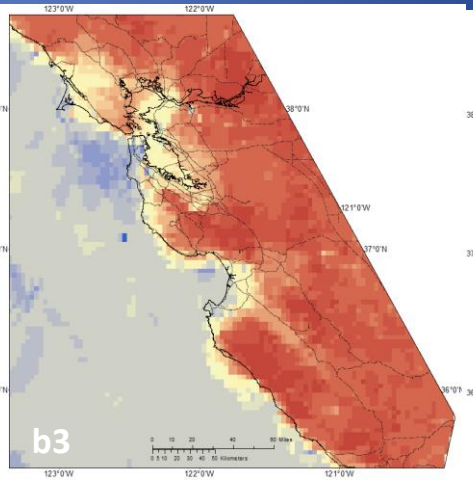


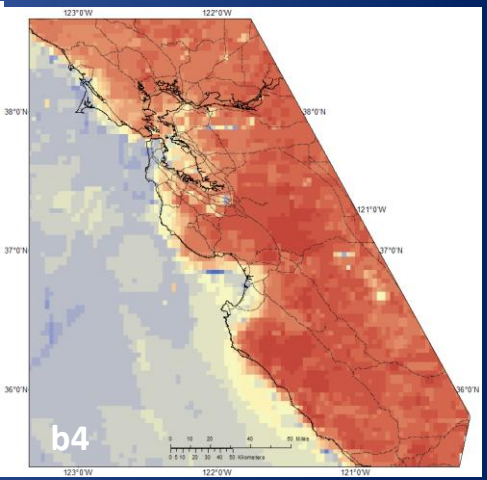


July 2001 ------ 8 am ---------- 9 am ---------- 10 am ---------- 11 am





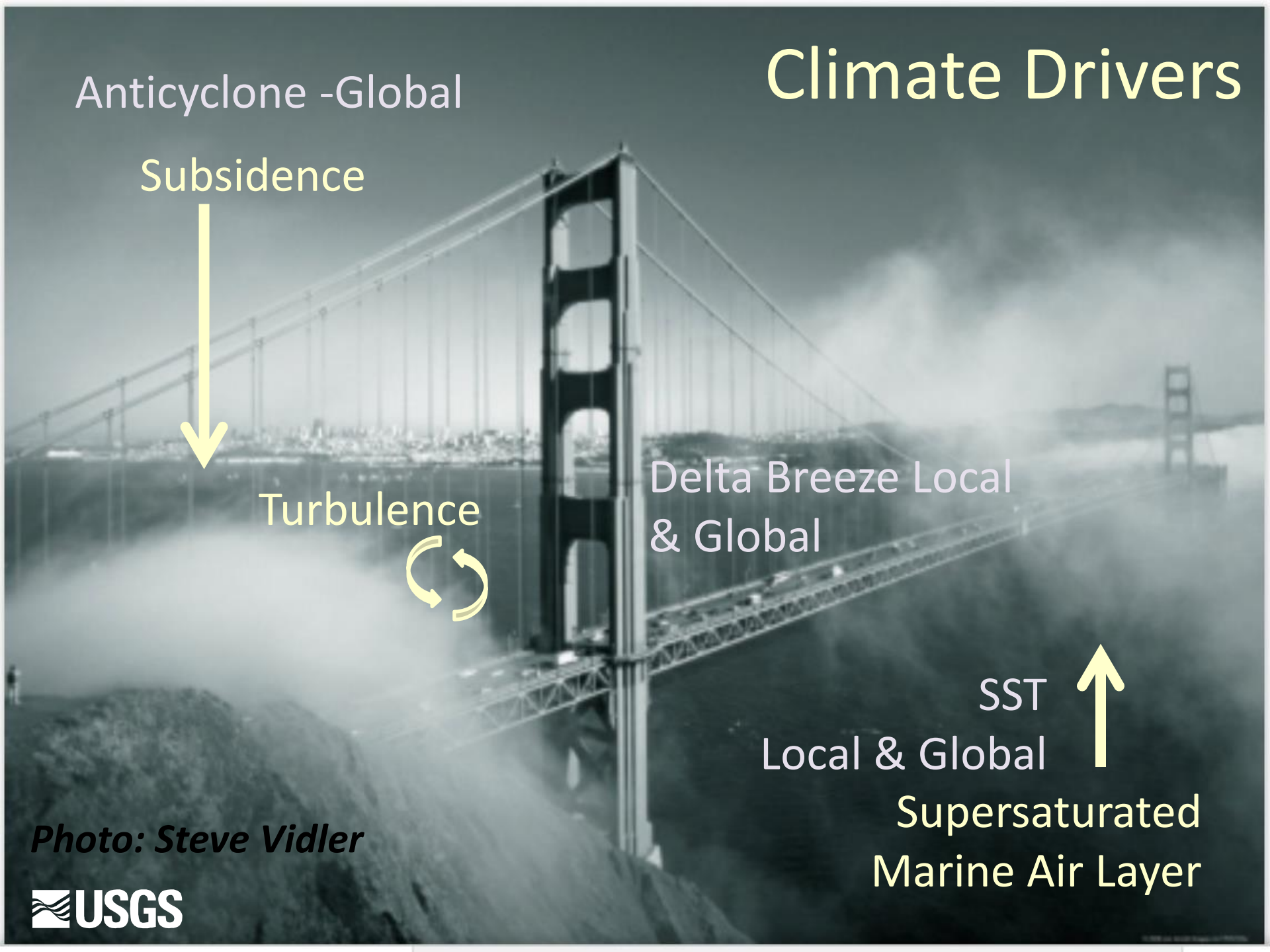


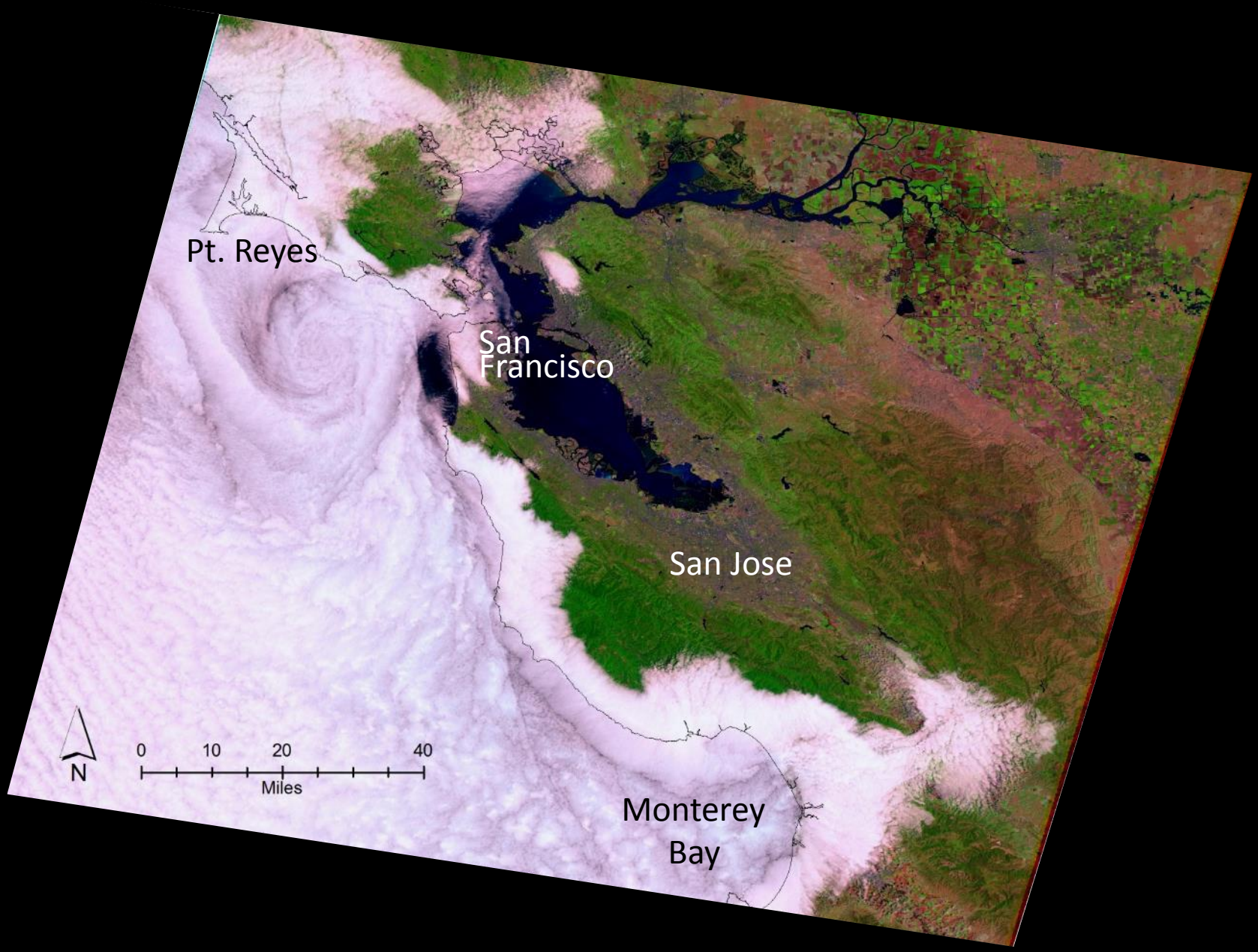


Sept 2001 ------ 8 am ---------- 9 am ---------- 10 am ---------- 11 am

<5 5 10 15 20 25 30 35 40 45 50 55 65 70 75 80 85 90 95 100

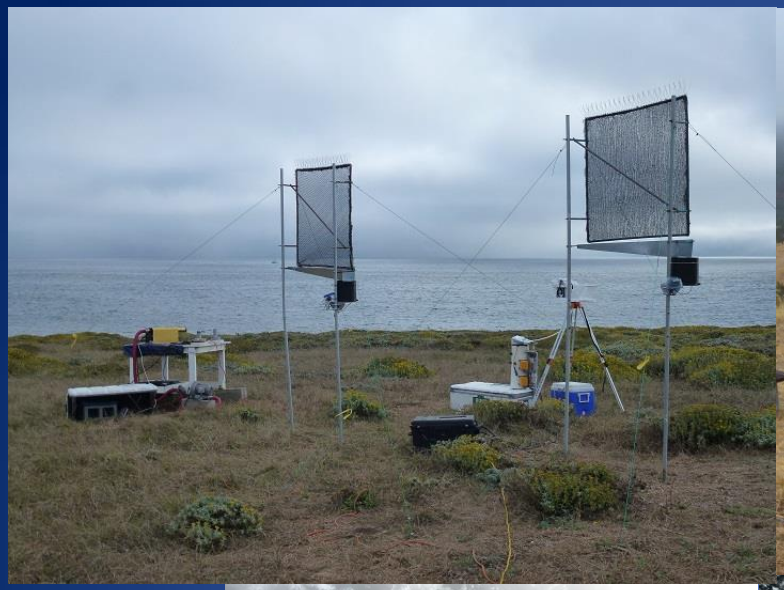
Percent of the Month with Fog and Low Cloud Cover at the Specified Hour


Climate Drivers
Anticyclone -Global
Subsidence
Turbulence
Delta Breeze Local
& Global
SST
Local & Global
Supersaturated
Marine Air Layer
Photo: Steve Vidler
USGS



USGS Landsat May 22, 1991

Fog Monitoring Network



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Questions?

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