

# Wildfire, smoke, and river water temperatures in the Salmon River watershed

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# Water temperature matters!

*Ecology*, 85(7), 2004, pp. 1771–1789  
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## TOWARD A METABOLIC THEORY OF ECOLOGY

JAMES H. BROWN,<sup>1,2,4</sup>

with JAMES F. GILLOOLY,<sup>1</sup> ANDREW P. ALLEN,<sup>1</sup> VAN M. SAVAGE,<sup>2,3</sup> AND GEOFFREY B. WEST<sup>2,3</sup>

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AMER. ZOOL., 19:319-329 (1979).

## Physiological and Ecological Correlates of Preferred Temperature in Fish

THOMAS L. BEITINGER AND LLOYD C. FITZPATRICK

*Department of Biological Sciences and Institute of Applied Sciences, North Texas State University, Denton, Texas 76203*

## Climate, Population Viability, and the Zoogeography of Temperate Fishes

B. J. SHUTER

*Ontario Ministry of Natural Resources, Research Section, Fisheries Branch  
Post Office Box 5000, Maple, Ontario L6A 1S9, Canada*

J. R. POST

*Center for Limnology, University of Wisconsin–Madison  
Madison, Wisconsin 53706, USA*

## Thermal heterogeneity, stream channel morphology, and salmonid abundance in northeastern Oregon streams

Joseph L. Ebersole, William J. Liss, and Christopher A. Frissell



# Wildfires and water temperature



Combustion -> short term water temp increases (Hitt 2003; Beakes *et al.* 2014)



Reduced riparian cover -> increased solar radiation and summer water temps (Dunham *et al.* 2007; Isaak *et al.* 2009)

What about effects of wildfire smoke?



# Wildfires and water temperature continued

## Enhancement of Surface Cooling Due to Forest Fire Smoke

ALAN ROBOCK

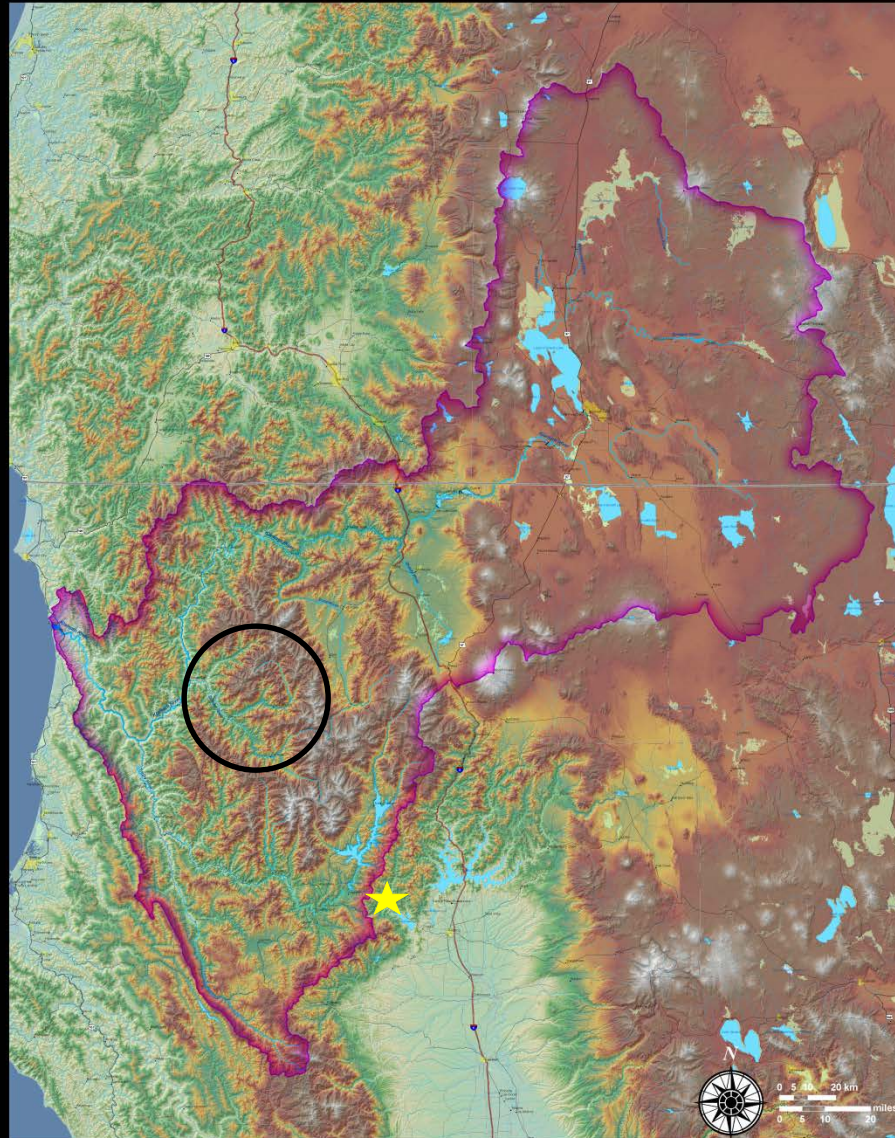
### Radiative impact of boreal smoke in the Arctic: Observed and modeled

R. S. Stone,<sup>1,2</sup> G. P. Anderson,<sup>2,3</sup> E. P. Shettle,<sup>4</sup> E. Andrews,<sup>1,2</sup> K. Loukachine,<sup>5</sup>  
E. G. Dutton,<sup>6</sup> C. Schaaf,<sup>7</sup> and M. O. Roman III<sup>7</sup>

1. Does wildfire smoke reduce solar radiation exposure to watersheds?
2. Does a reduction in solar radiation due to smoke result in reduced river water temps?
3. (Future) Do cooler water temps benefit salmonids and other cold-water adapted species?



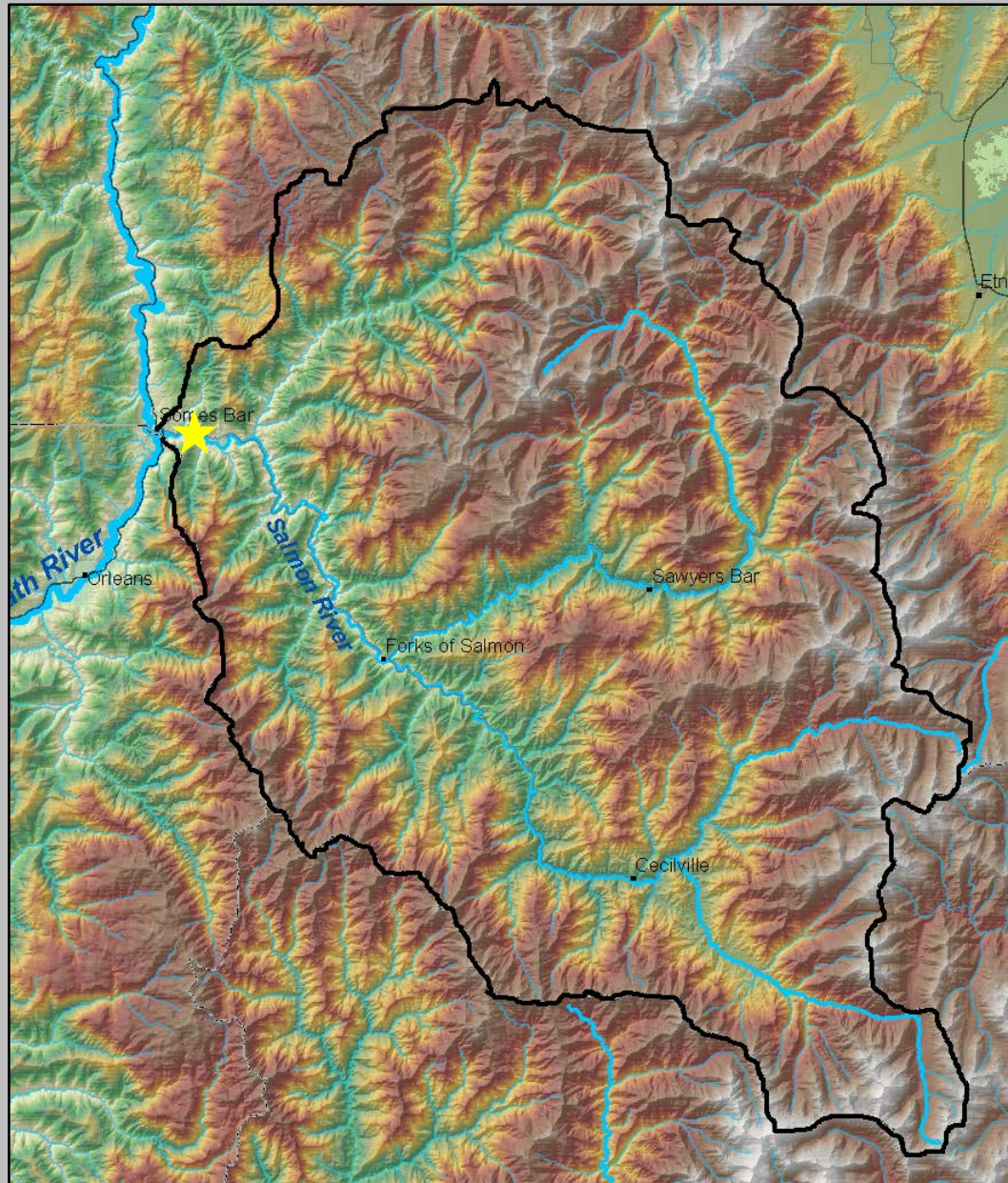




The Klamath Basin shaded relief was created from a Digital Elevation Model of Land surface.



# Salmon River watershed



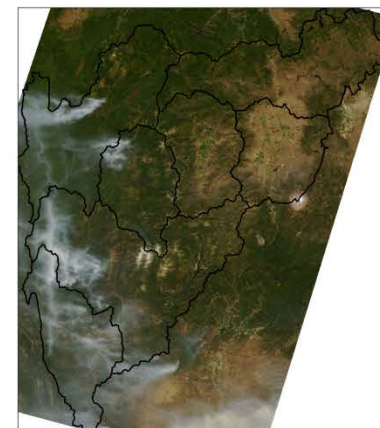
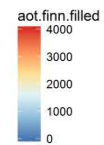
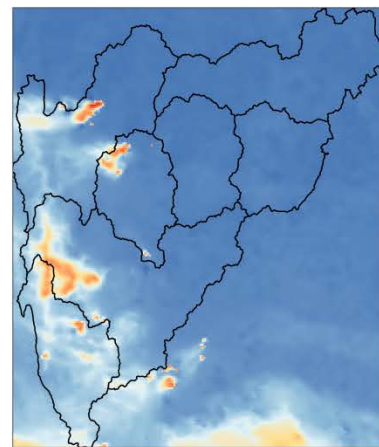
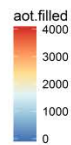
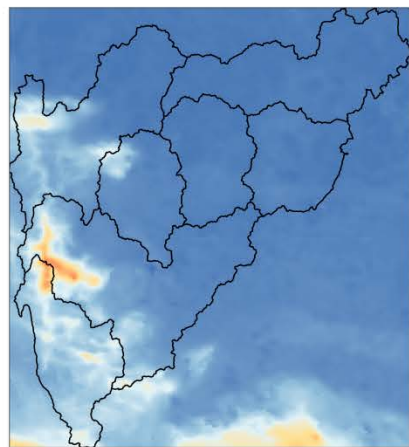
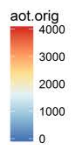
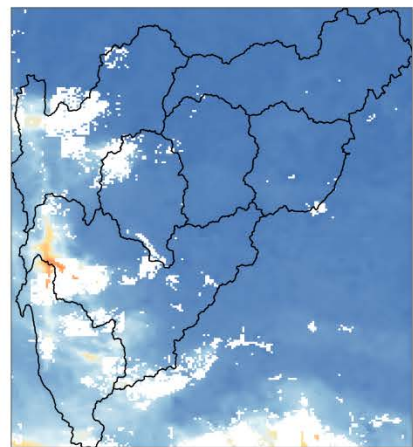


# Data sources

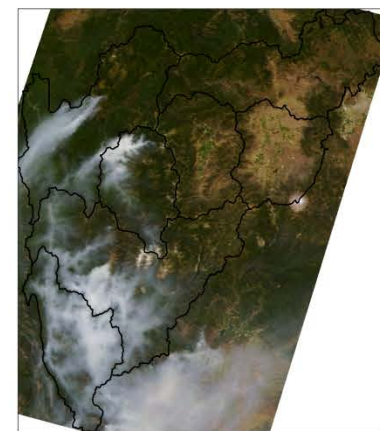
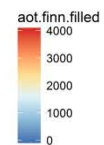
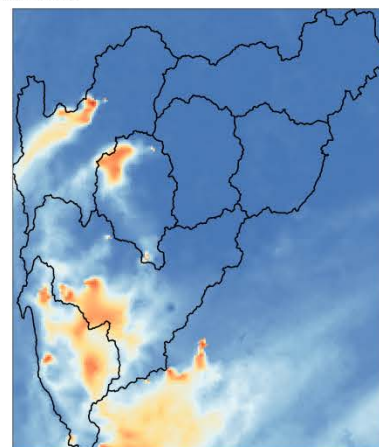
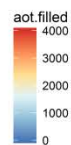
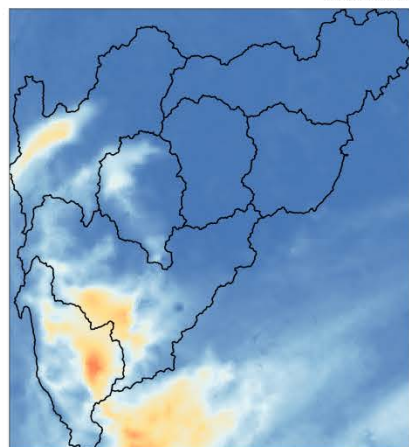
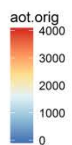
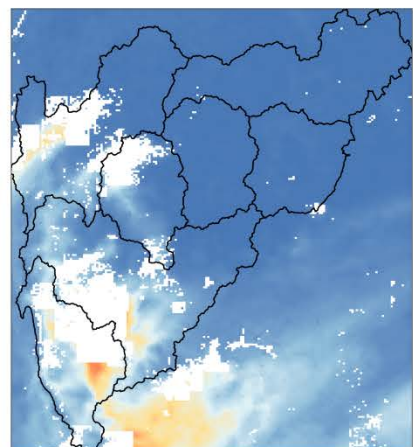
- Water temperature (daily maximum; 1997-2015)
- Gridded climate data (three day running mean):
  - Air temperature (Topo Weather)
  - Precipitation (Idaho Met Data)
- USGS river discharge (daily mean)
- Satellite-derived (MODIS) aerosol optical thickness (AOT) using the Multi-Angle Implementation of Atmospheric Correction algorithm (Lyapustin *et al.* 2011a,b)
- Fire INventory from NCAR (FINN) (Wiedinmyer *et al.* 2011)



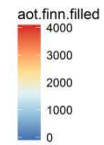
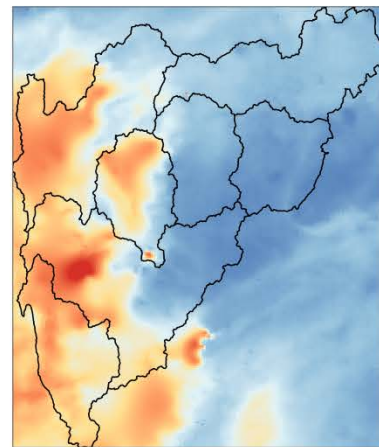
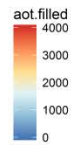
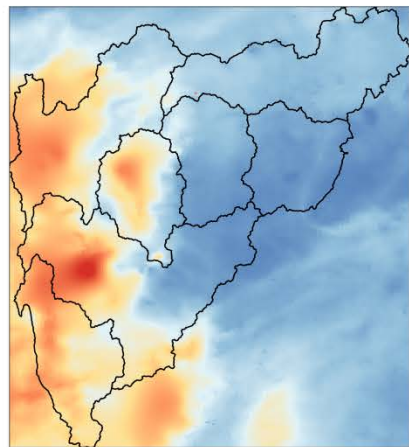
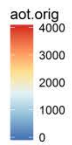
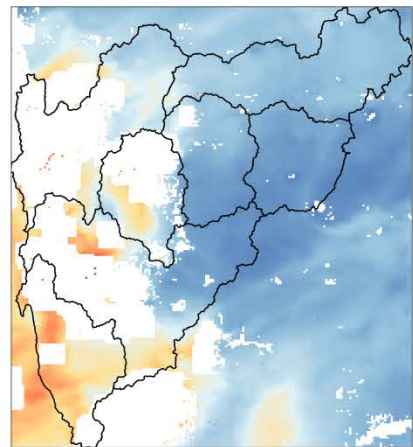
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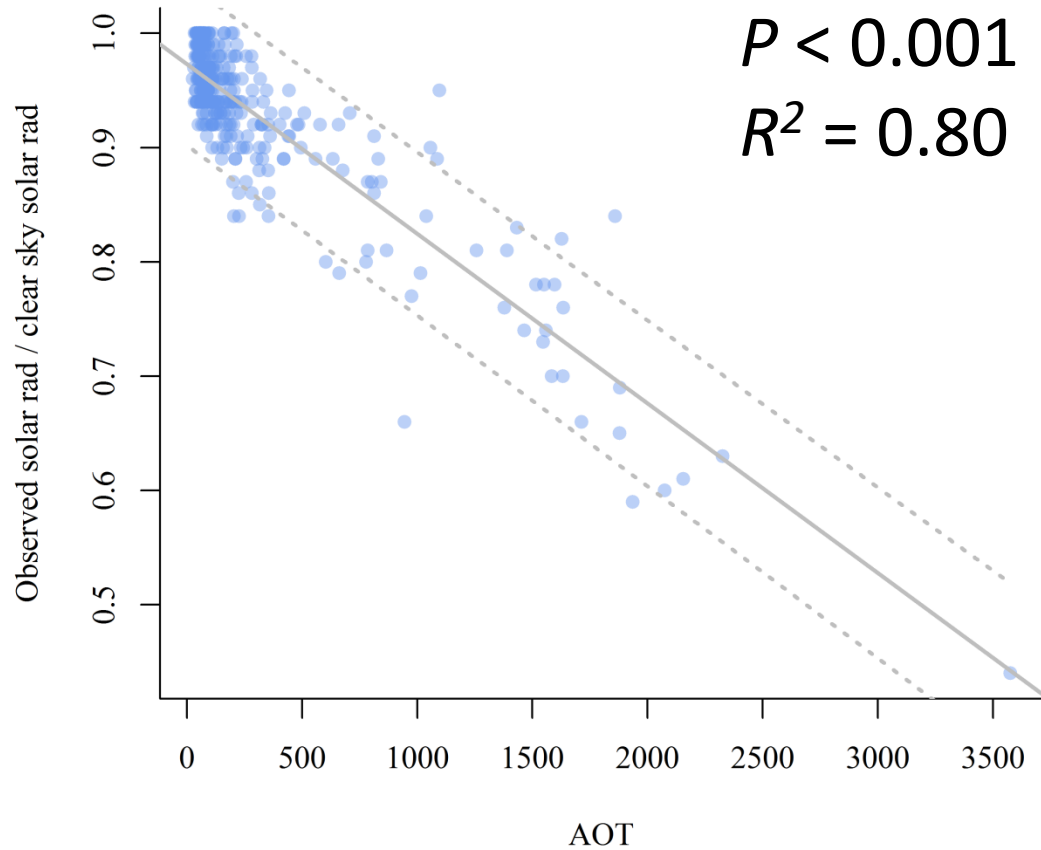




# Analysis

- Focused on 4 years: 2006, 2008, 2012, and 2013
- Effects of AOT (smoke) on solar radiation
- Effects of AOT (smoke), air temperature, precipitation, and river discharge on daily maximum water temperatures
  - Confined period of analysis to June 1 through Sept 30
  - GLS regression (AR-1 autocorrelation, nested with year)

# AOT (smoke) and solar radiation





# Water temp model

Water temperature ~	Effect (+ or -)	<i>t</i> value	<i>P</i> value
AOT (smoke)			
Air temperature			
Precipitation			
Discharge			
Discharge x air temperature			

# Water temp model

Water temperature ~	Effect (+ or -)	<i>t</i> value	<i>P</i> value
AOT (smoke)	-	-6.6	<0.001
Air temperature	+	10.0	<0.001
Precipitation	-	-2.7	0.007
Discharge	-	-0.8	0.443
Discharge x air temperature	+	0.2	0.843



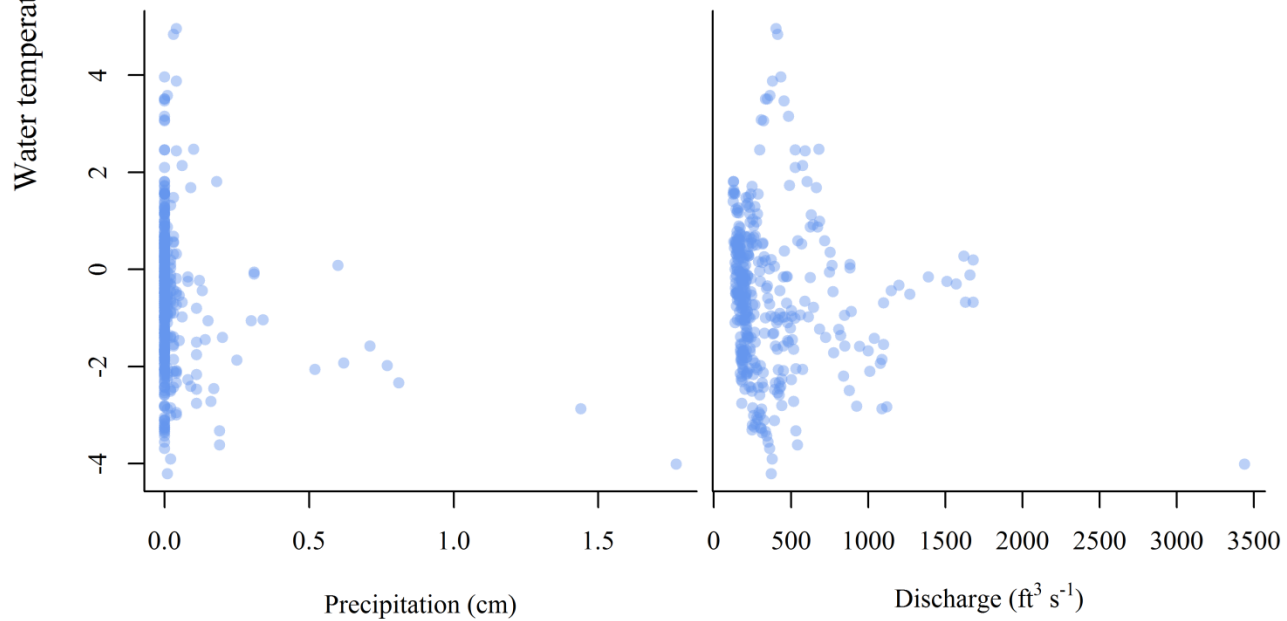
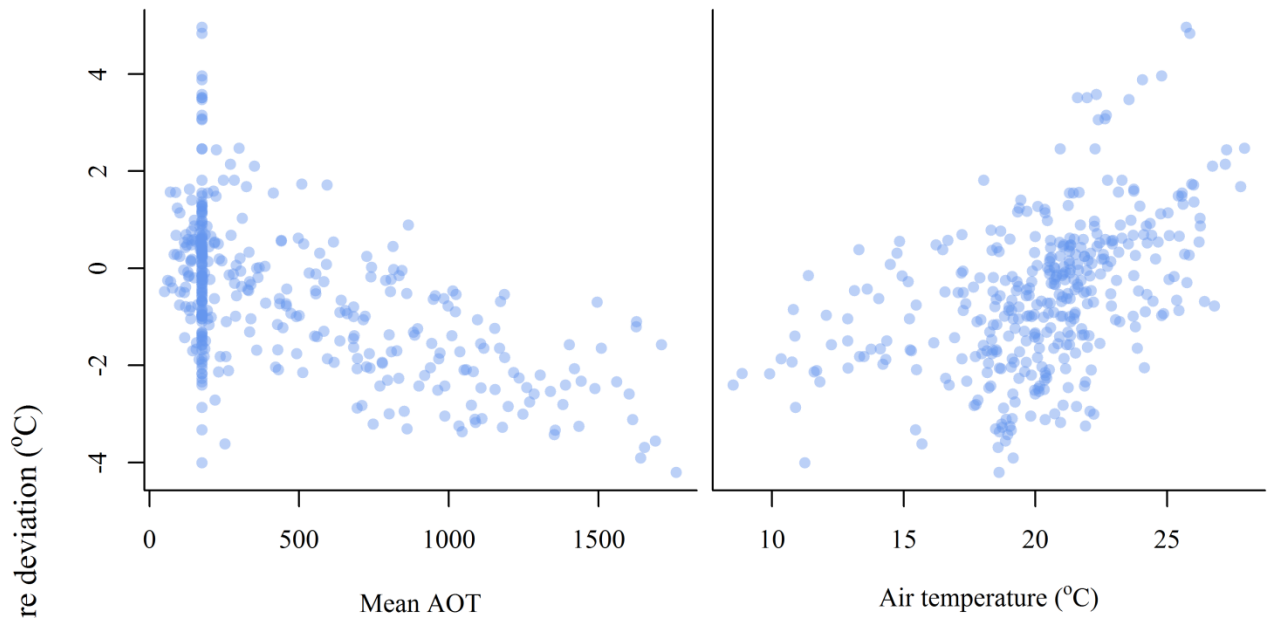
# Water temp model

Water temperature ~	Effect (+ or -)	t value	P value
AOT (smoke)	-	-6.7	<0.001
Air temperature	+	12.7	<0.001
Precipitation	-	-2.8	0.006
Discharge	-	-1.7	0.093
<del>Discharge x air temperature</del>			

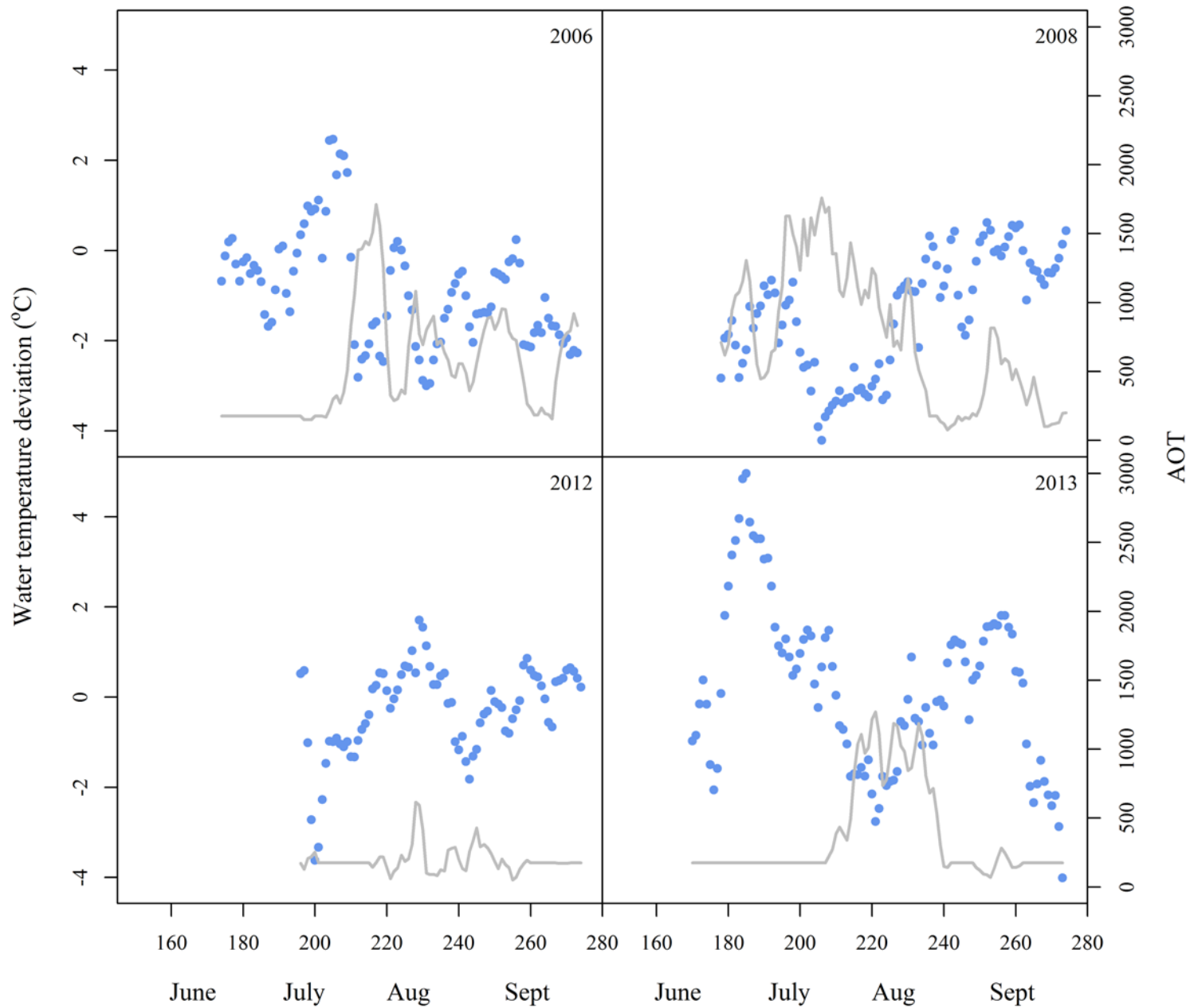
Light smoke = 0.6 °C decrease

Moderate smoke = 1.2 °C decrease

Heavy smoke = 1.8 °C decrease







# Conclusions

- Wildfire smoke (AOT) reduced the amount of solar radiation reaching the ground
- Wildfire smoke (AOT) had a modest negative effect on water temperatures
- We may be underestimating the effect of smoke because smoke may also affect air temperatures



# Conclusions

**“Particulates produced from annual prehistoric fires were substantial and may have moderated ground sunlight intensity by dispersing incoming radiation to space... Skies were likely smoky in the summer and fall in California before fire suppression.” (Stephens *et al.* 2007)**

# Future directions

- Incorporate 2014 and 2015 AOT data
- Expand analysis to 10-12 sub-watersheds within the lower Klamath basin
- Tease out the effects of smoke on air temps (if any)













Questions?

