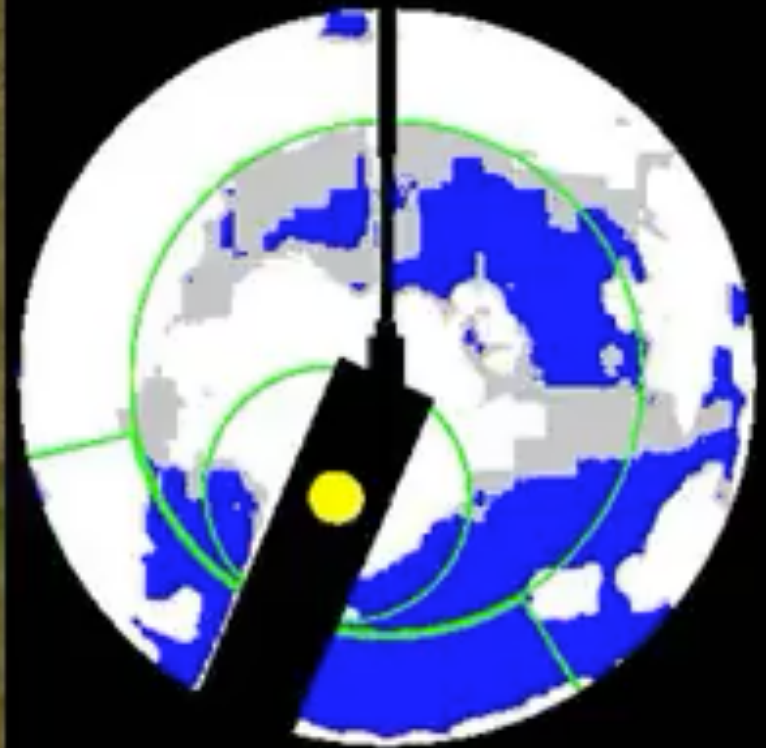


# *Weird* ways climate change will affect us that you probably didn't know

2019-07-05 12:46:00



Ankur Desai, UW-Madison, WN@TL, 21 Oct 2020

Climate Change Is Not The  
World's Biggest Problem



Terrorism

Lack of  
Education

Wealth  
Inequality

**Climate Change  
Makes These**

Water scarcity &  
pollution

Land  
Degradation

Rapid  
Urbanization

Natural  
Disasters

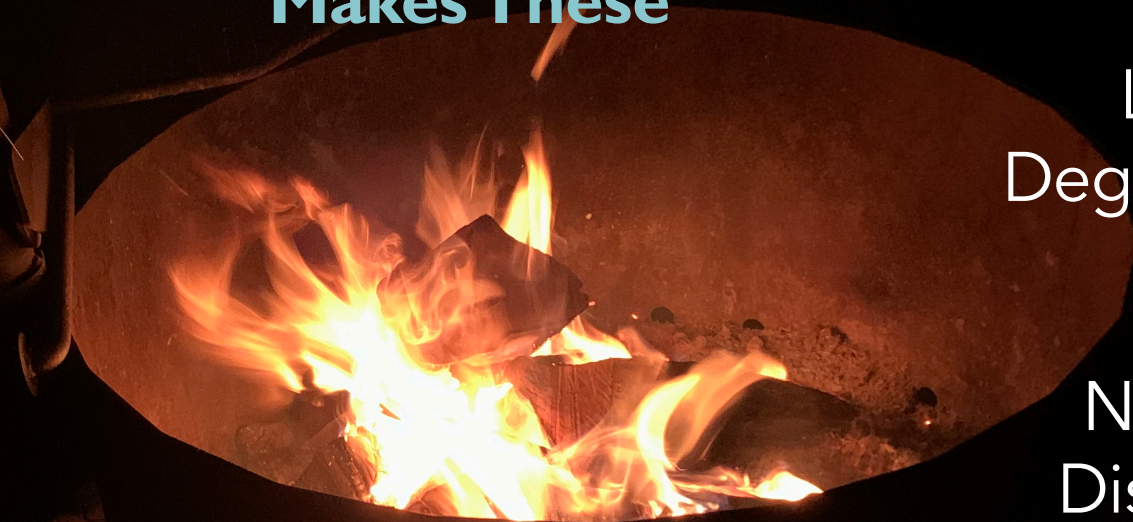
**Harder or More Expensive  
to Solve**

Oppression of  
minorities

Inadequate  
public health

Food  
Insecurity

Species  
Loss



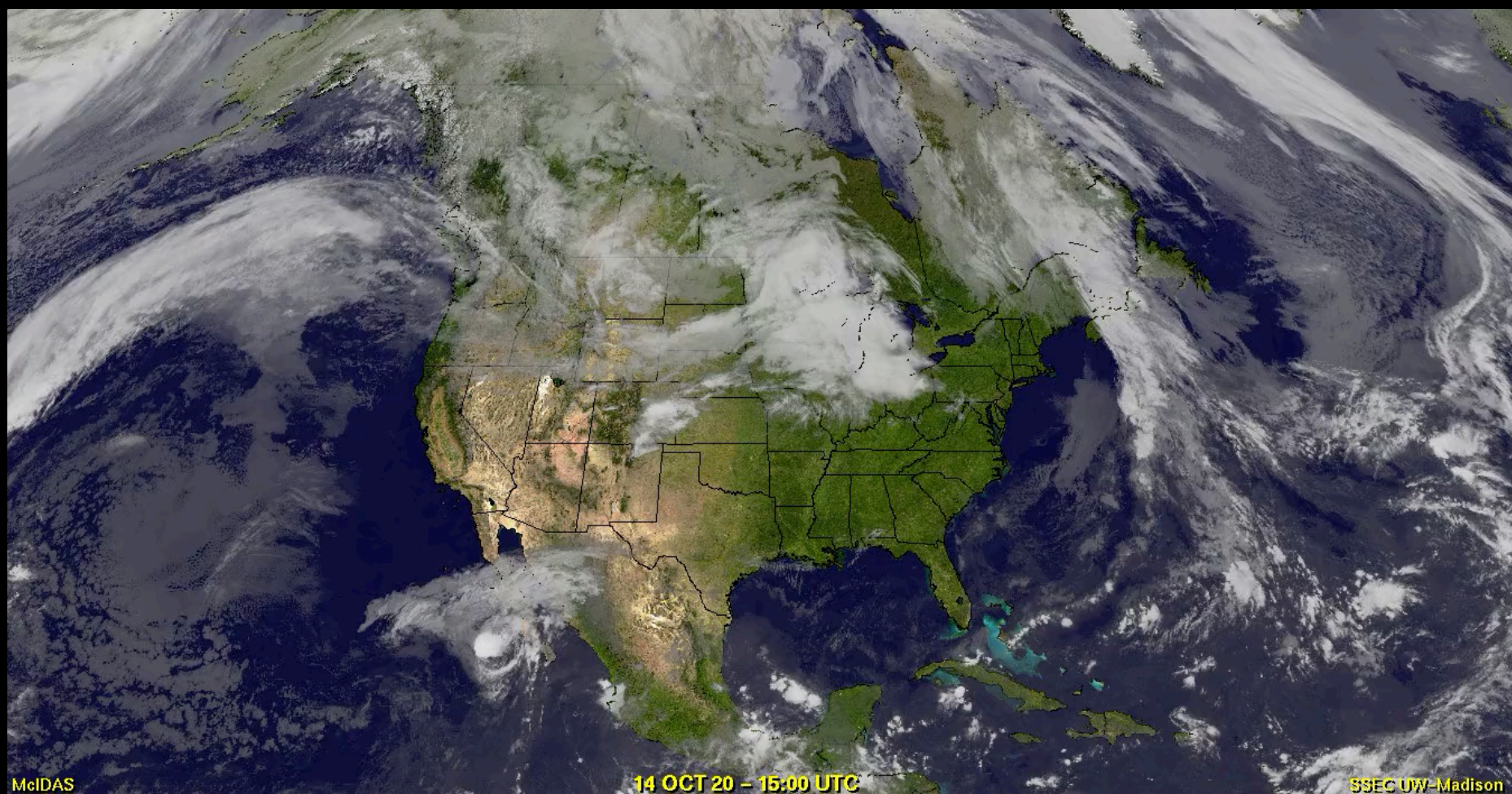


Can 2 degrees F do that?



How about 4-10 degrees F?





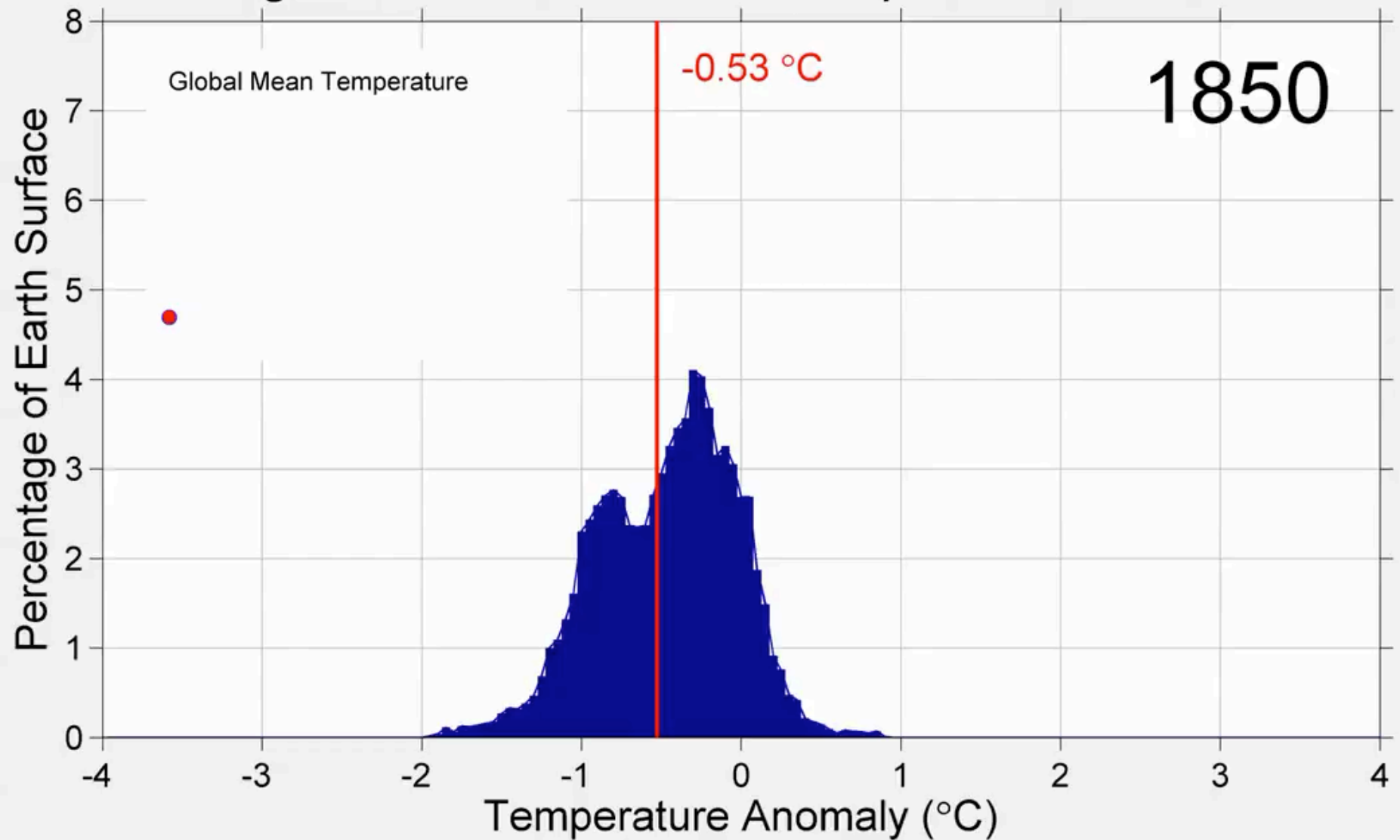
<https://www.ssec.wisc.edu/data/composites/satsfctemp/animation/>

Climate is your  
**personality**  
Weather is your  
**mood**

A portrait of Prof. J. Marshall Shephard, a Black man with a short haircut, smiling. He is wearing a dark suit jacket, a white shirt, and a red patterned tie. The background is a blurred outdoor scene with a blue sky and greenery.

Prof. J. Marshall Shephard  
U. Georgia

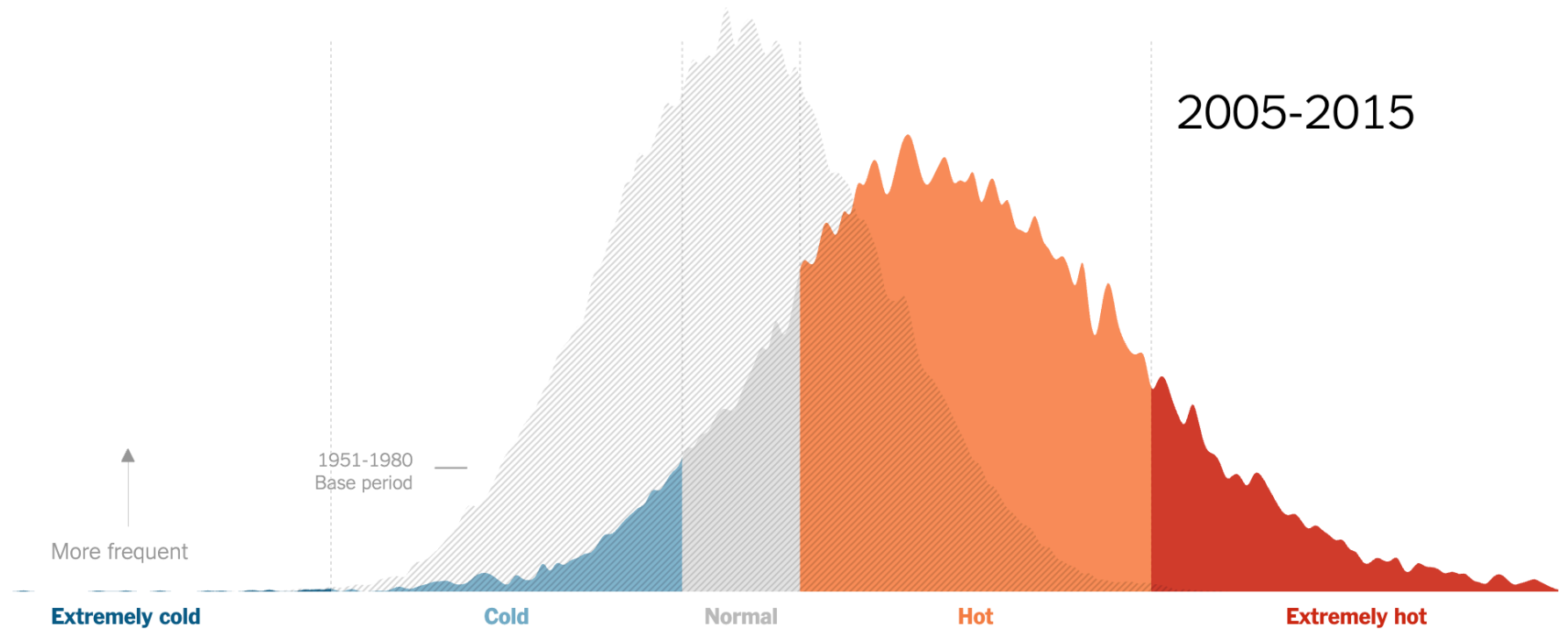
# Changes in Earth's Surface Temperature Distribution



Data Source: 12-month surface temperature anomaly distributions from Berkeley Earth, relative to 1951-1980 average



**Summer temperatures**  
in the Northern Hemisphere







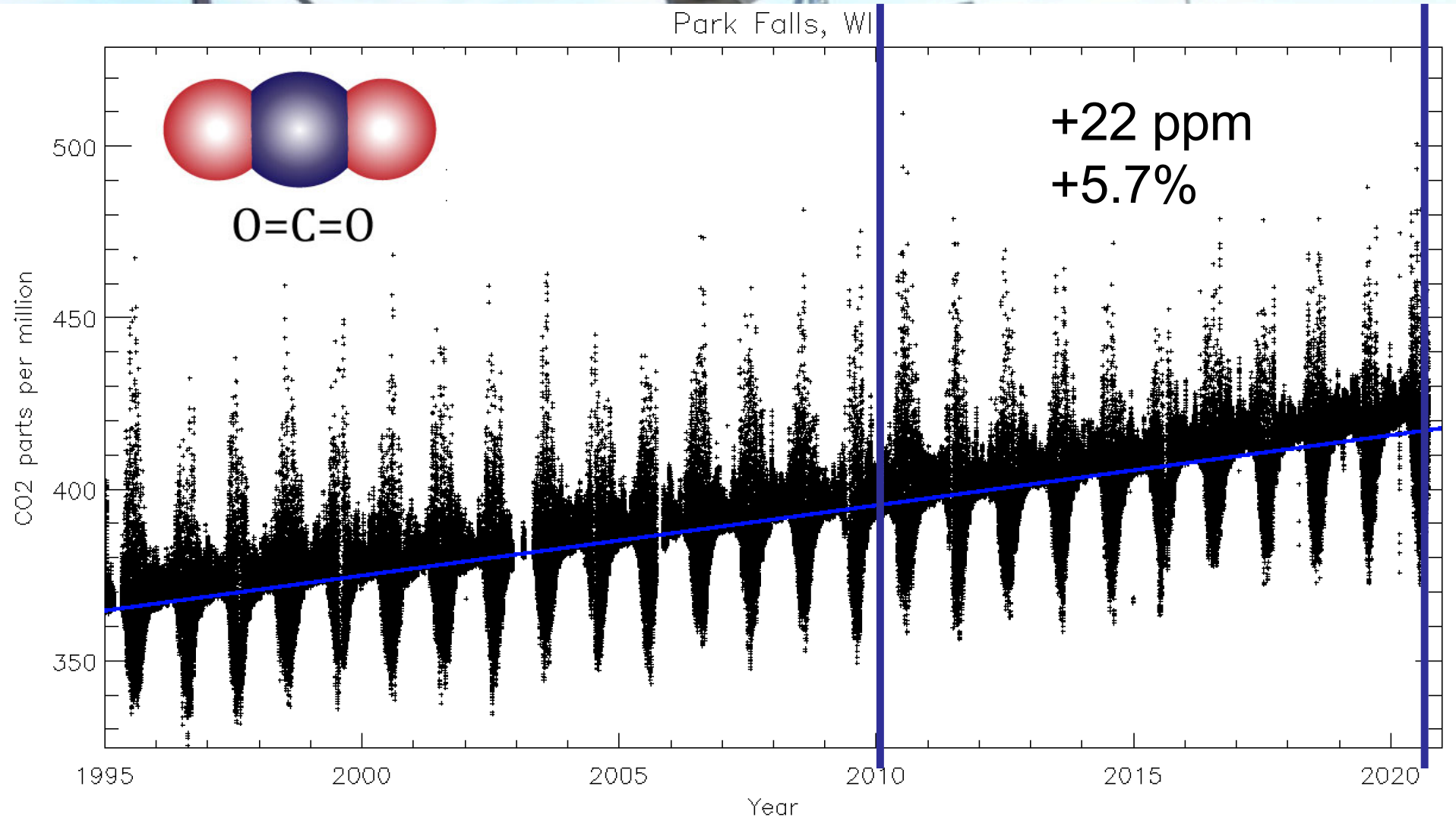
<https://www.nytimes.com/2020/01/10/world/australia/australia-wildfires-photos.html>





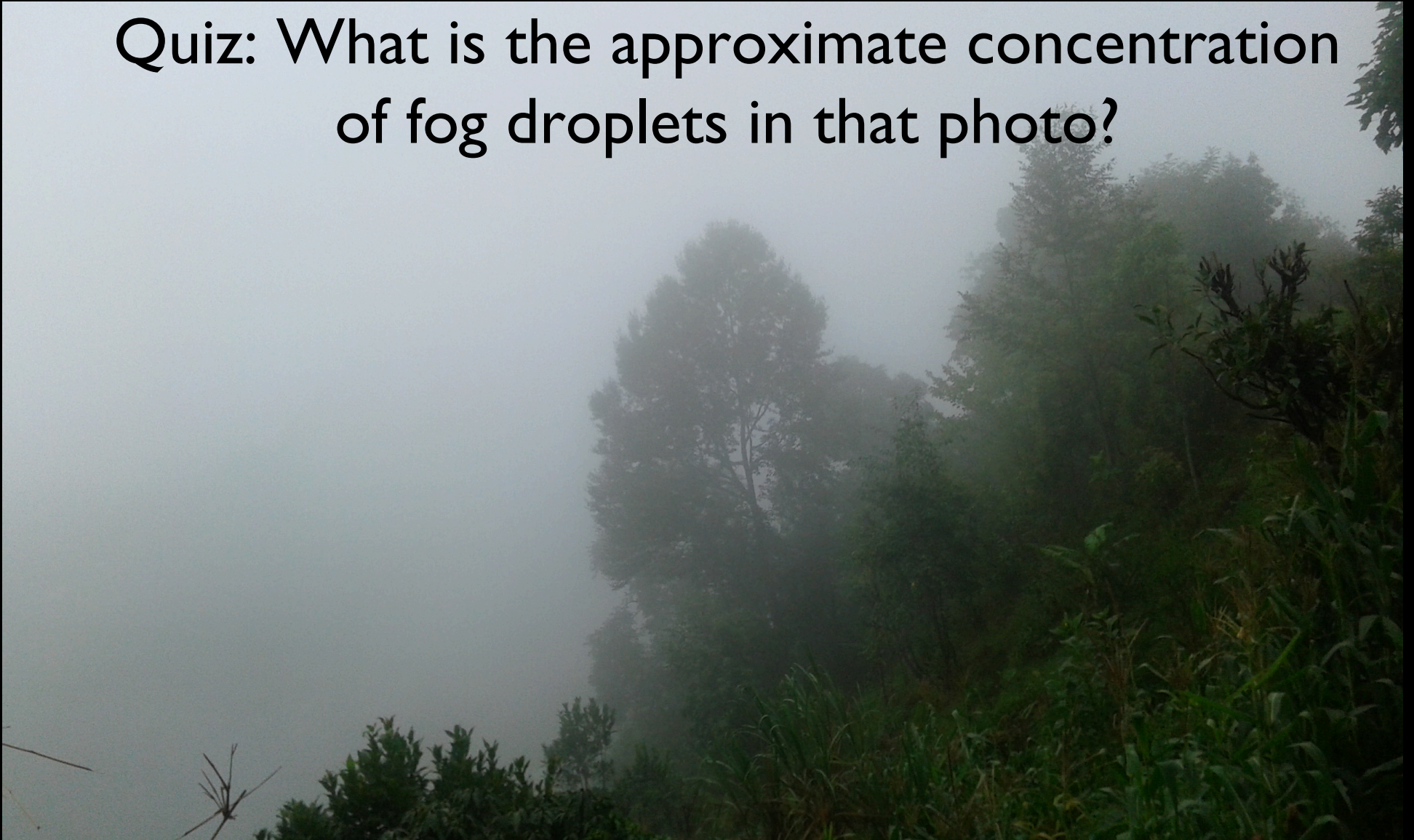
REUTERS

# And this is all caused by 0.04% of a gas?





Quiz: What is the approximate concentration of fog droplets in that photo?



[https://upload.wikimedia.org/wikipedia/commons/0/0a/Foggy\\_day.jpg](https://upload.wikimedia.org/wikipedia/commons/0/0a/Foggy_day.jpg)

Quiz: What is the approximate concentration of fog droplets in that photo?

- A. 50 parts per hundred (50%)
- B. 50 parts per thousand (5%)
- C. 50 parts per hundred thousand (0.05%)
- D. 50 parts per million (0.005%)
- E. 50 parts per 10 million (0.0005%)
- F. 50 parts per billion (0.000005%)

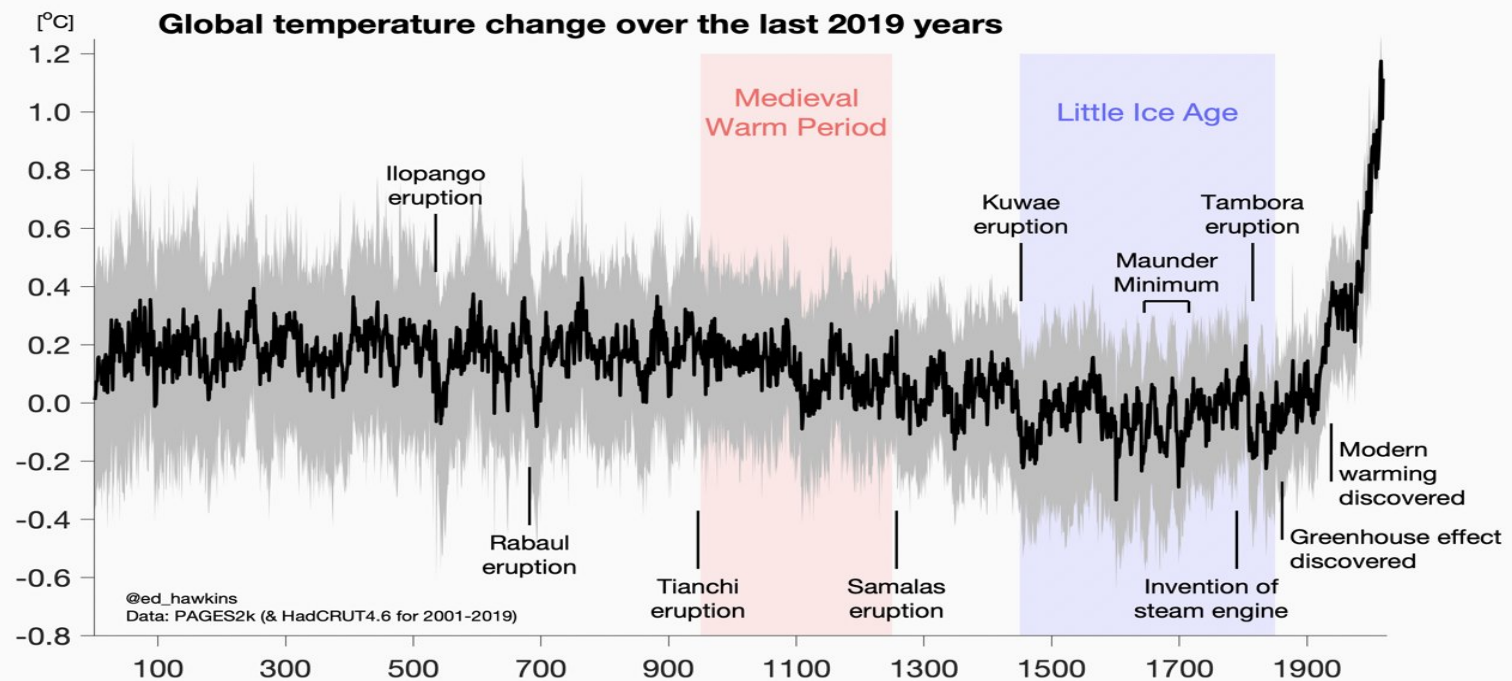
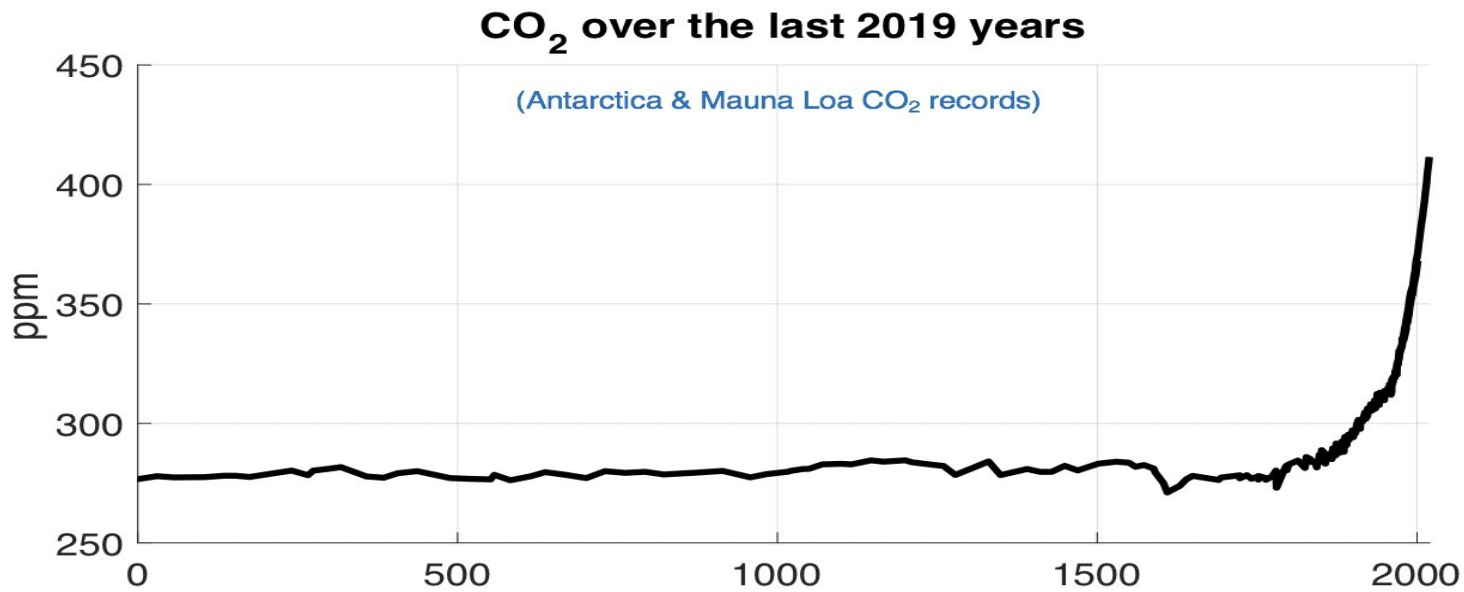
# Quiz: What is the approximate concentration of fog droplets in that photo?

- A. 50 parts per hundred (50%) *Probability my 11 yr old is wearing pants in virtual school*
- B. 50 parts per thousand (5%) *World record dewpoint water vapor concentration*
- C. 50 parts per hundred thousand (0.05%) *WI COVID case rate*
- D. 50 parts per million (0.005%) *~Cyanide fatal dose after ~ 1 hr*
- E. 50 parts per 10 million (0.0005%) *WI COVID death rate*
- F. 50 parts per billion (0.000005%)

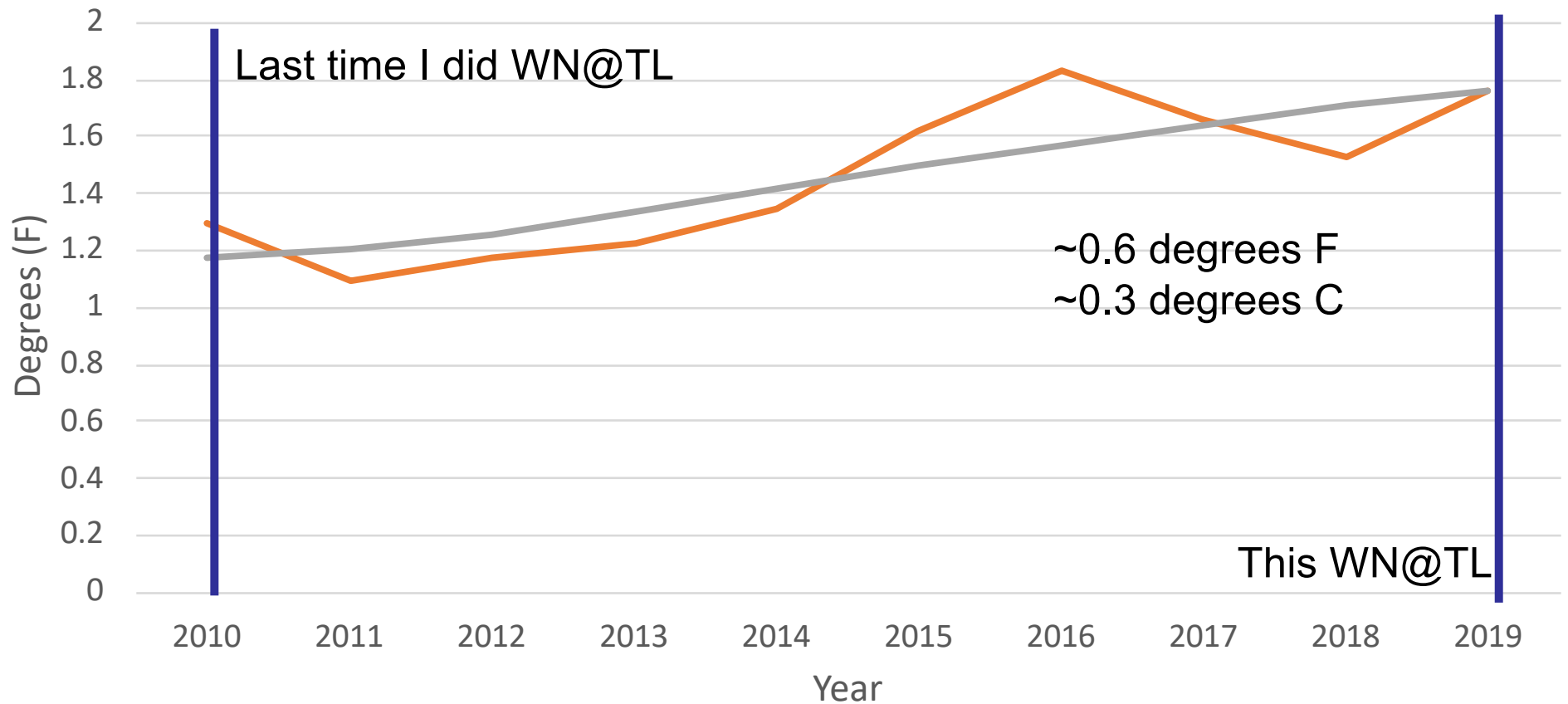
CO<sub>2</sub> in Earth's atmosphere has varied between 150-350 ppm for past 1,000,000 years, affecting comings and goings of glacial periods

Forecast: 450-910 ppm by 2100





## Global Temperature Difference from 1950-1980 (NASA GISS)



1.8 degree F per

100 ppm (20 yrs emissions)

— Anomaly

— Smoothed

# The Rodney & Otamatea Times

WAITEMATA & KAIPARA GAZETTE.

PRICE—10s per annum in advance

WARKWORTH, WEDNESDAY, AUGUST 14, 1912.

3d per Copy.

## Science Notes and News.

### COAL CONSUMPTION AFFECT- ING CLIMATE.

The furnaces of the world are now burning about 2,000,000,000 tons of coal a year. When this is burned, uniting with oxygen, it adds about 7,000,000,000 tons of carbon dioxide to the atmosphere yearly. This tends to make the air a more effective blanket for the earth and to raise its temperature. The effect may be considerable in a few centuries.

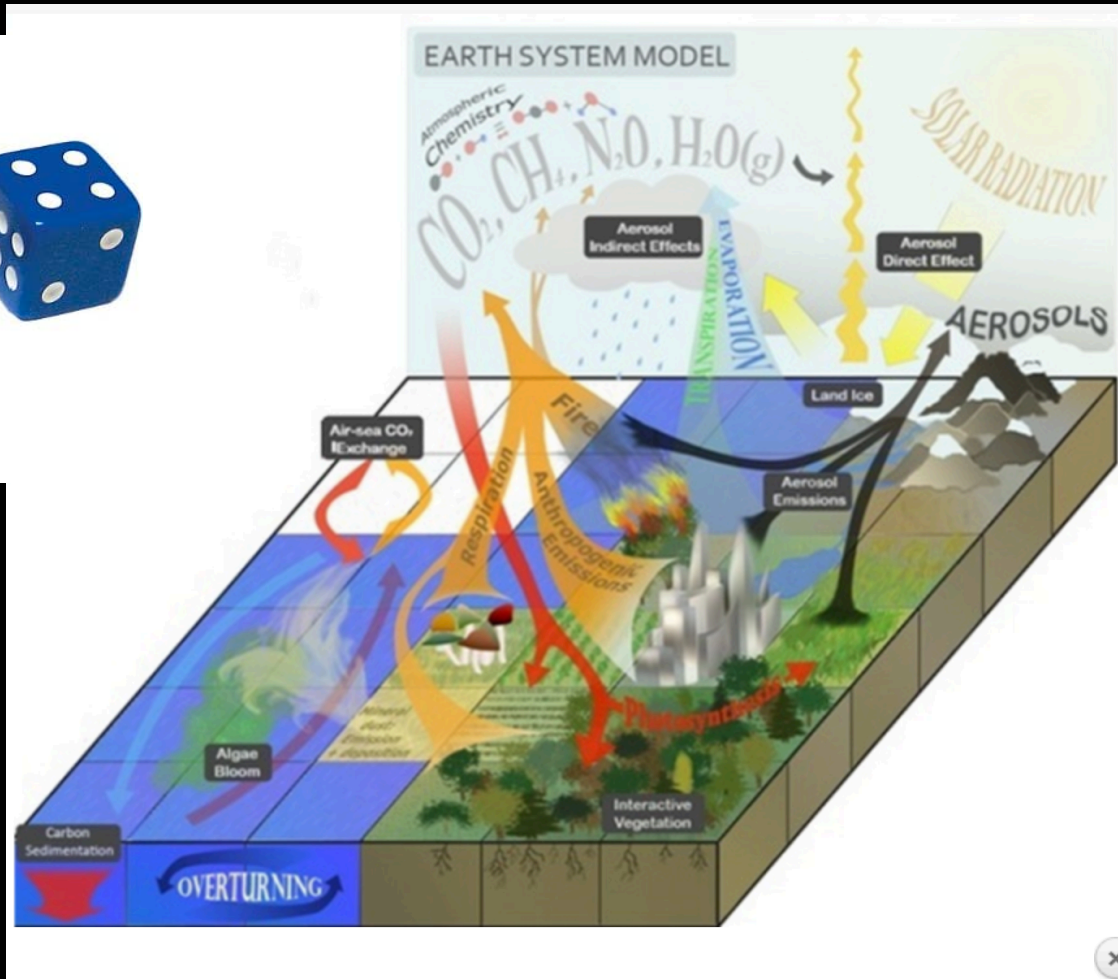








# So how does climate change make things weird?



<https://www.climateurope.eu/earth-system-modeling-a-definition/>

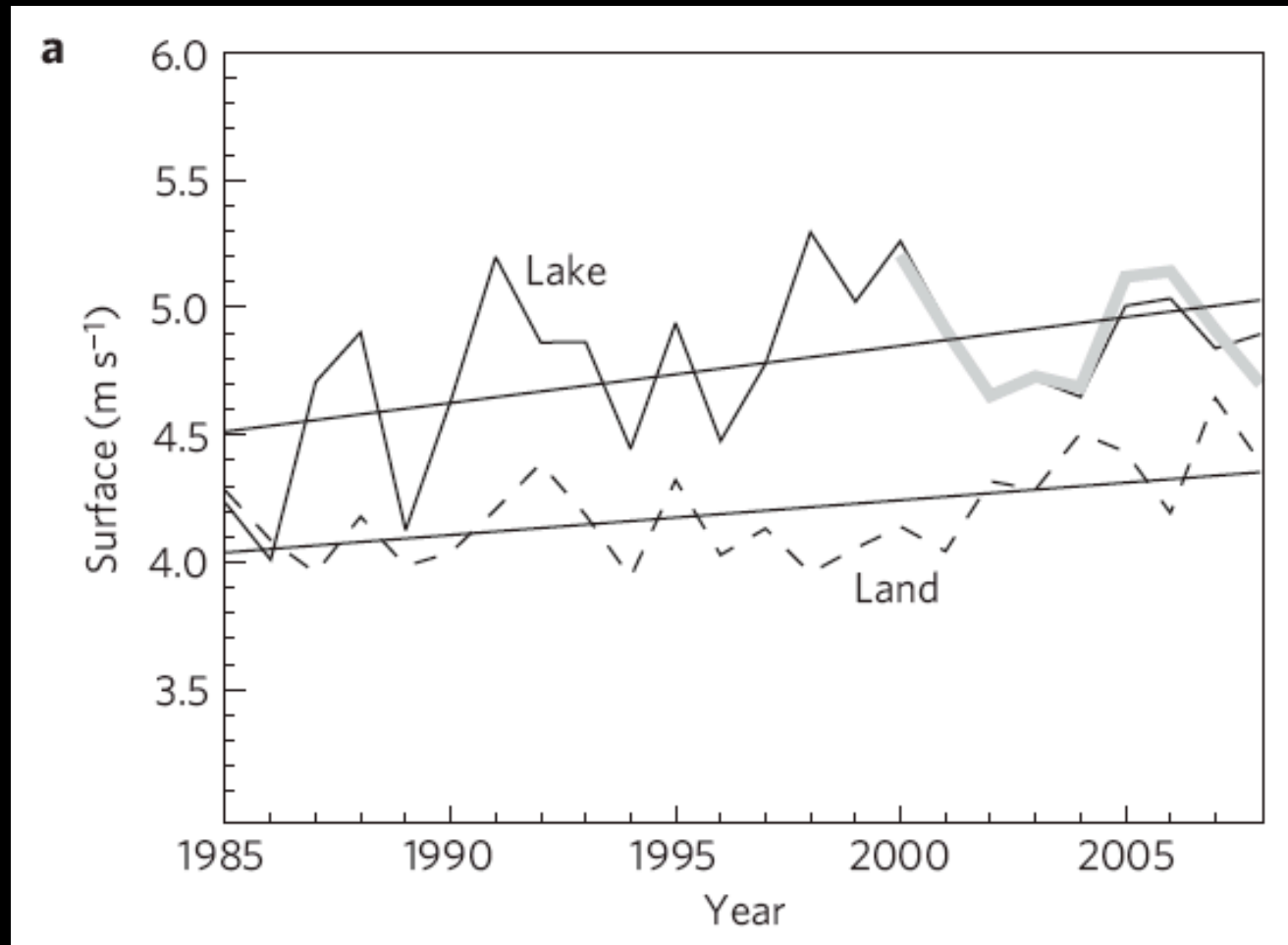




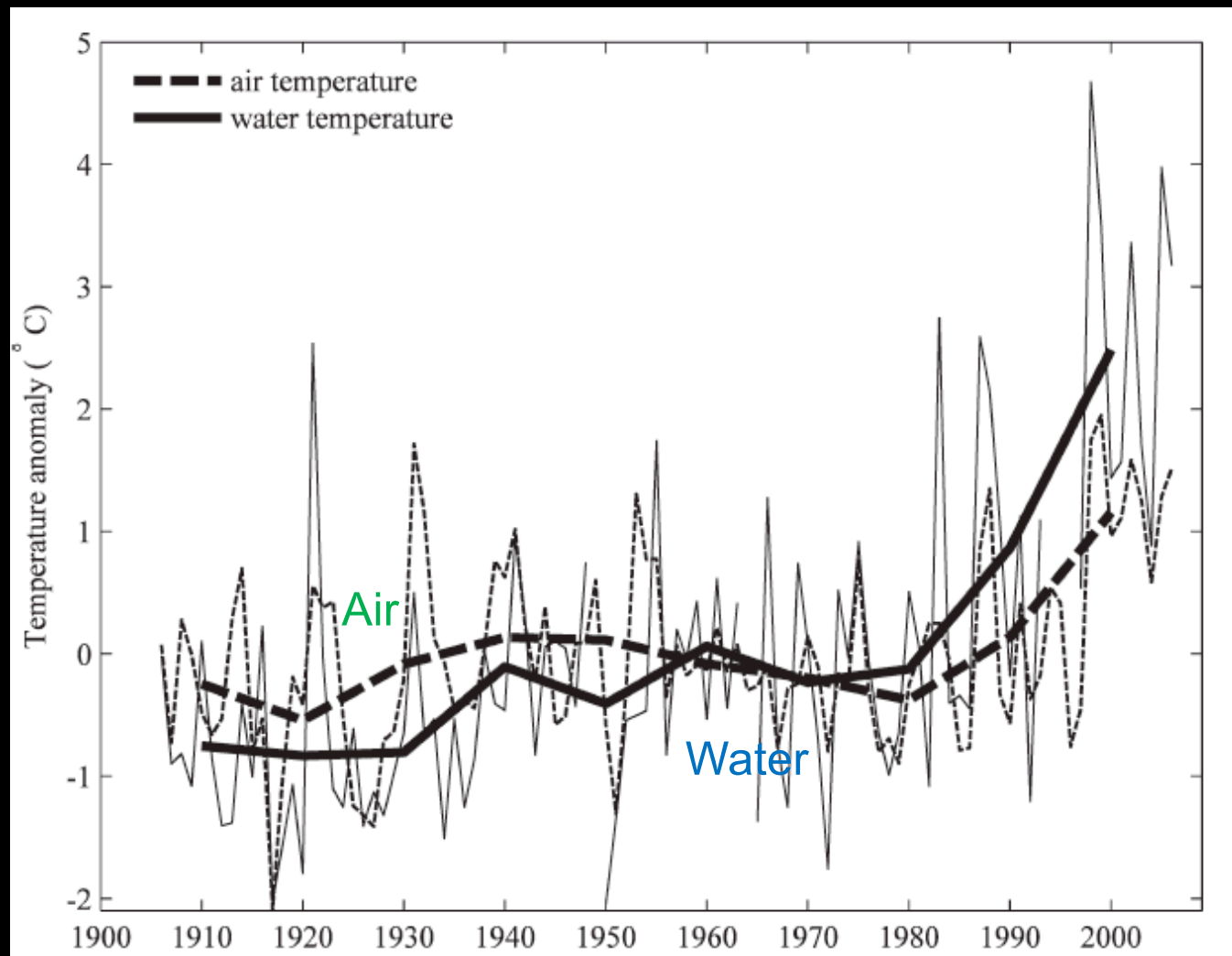


# It's Getting Windier Over Lake Superior

In Summer

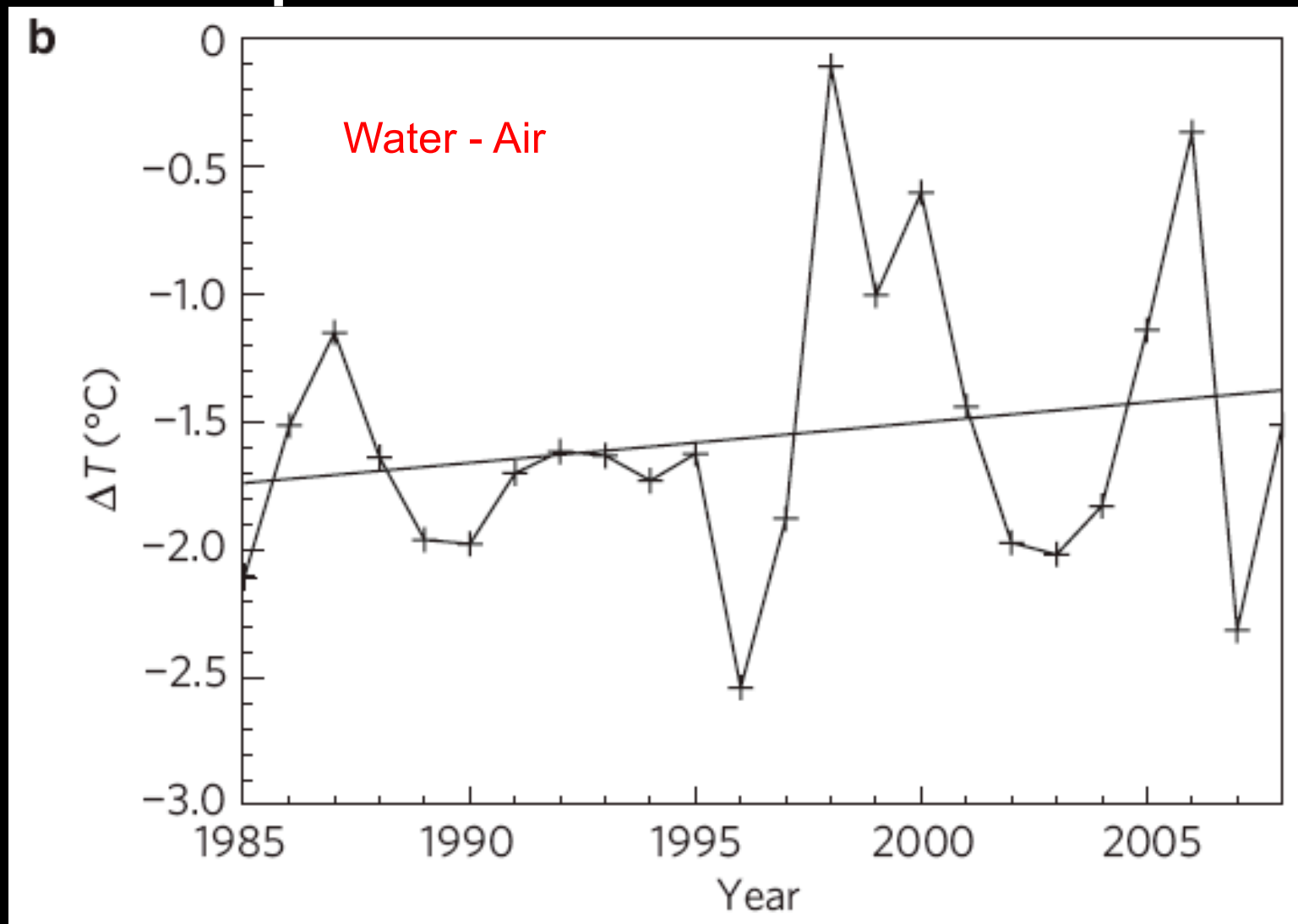


# Lakes are warming faster than air

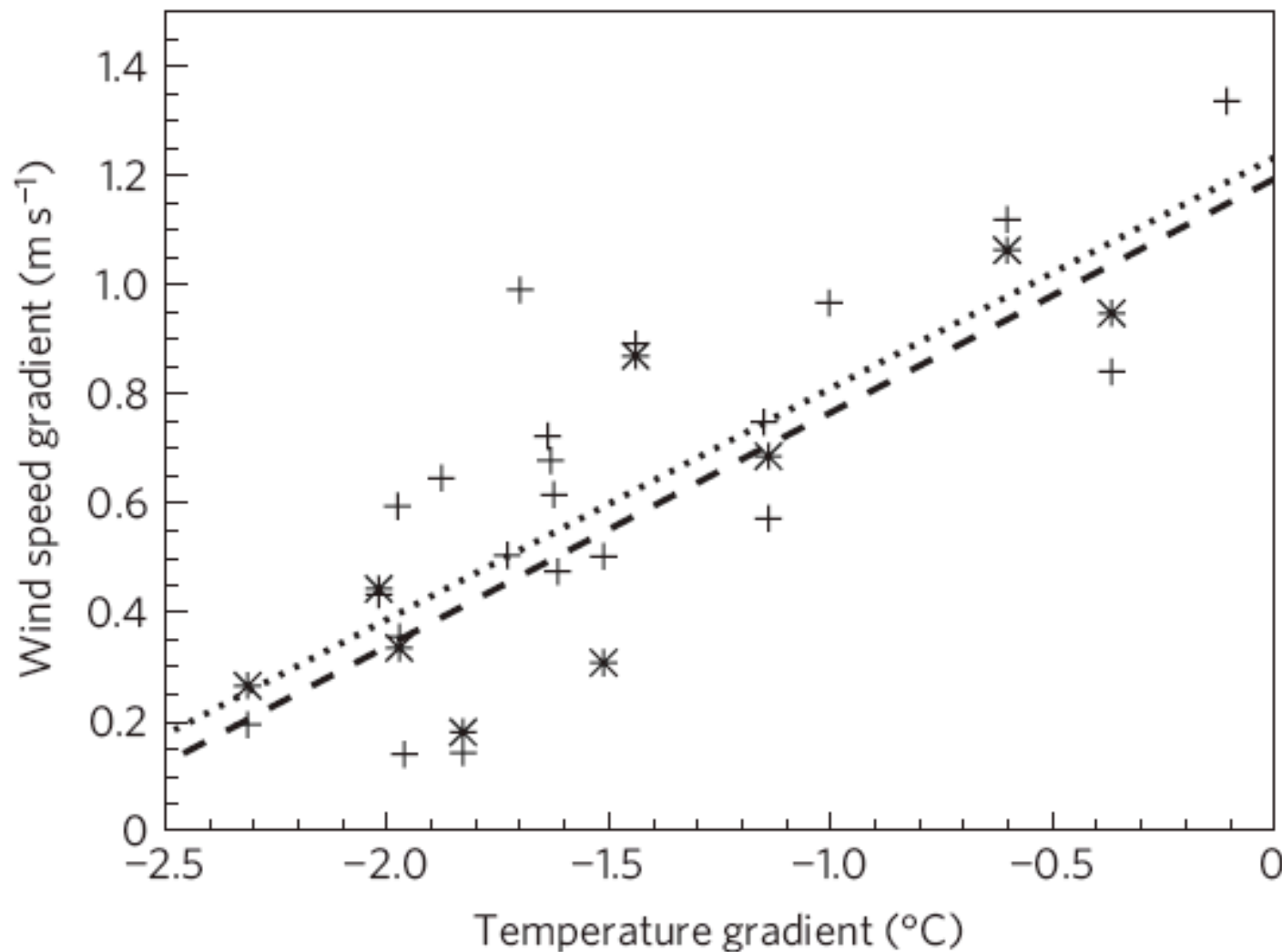


Austin and Colman (2008)

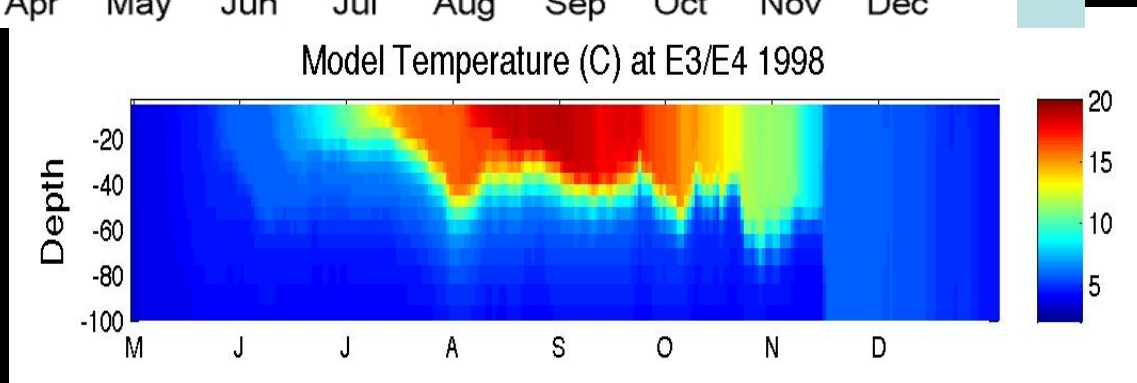
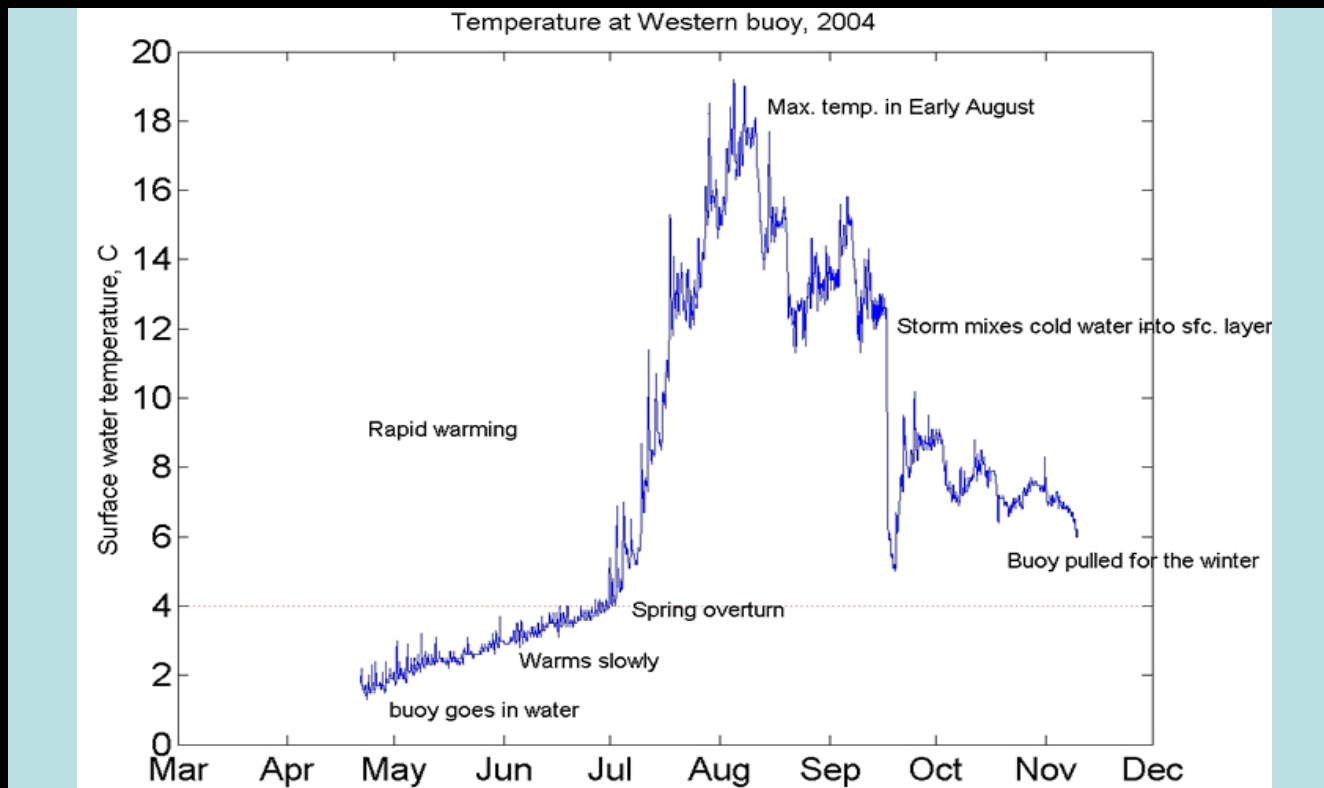
Which is decreasing the difference of temperature between the two



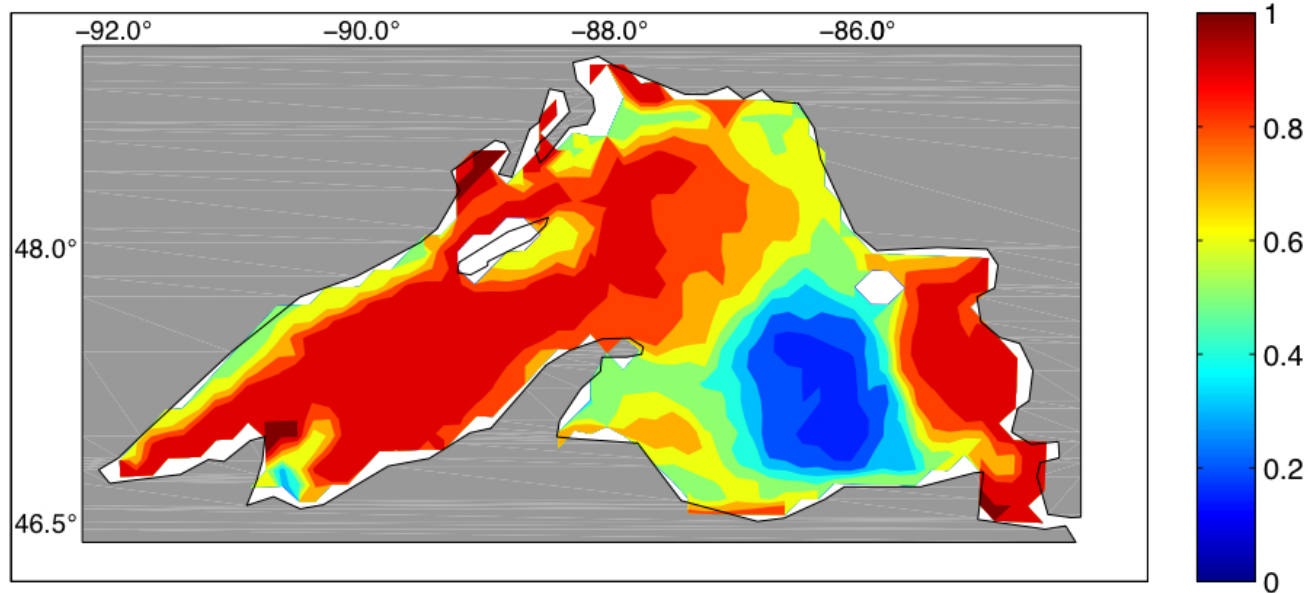
Smaller temperature difference  
decreases air stability, increasing winds



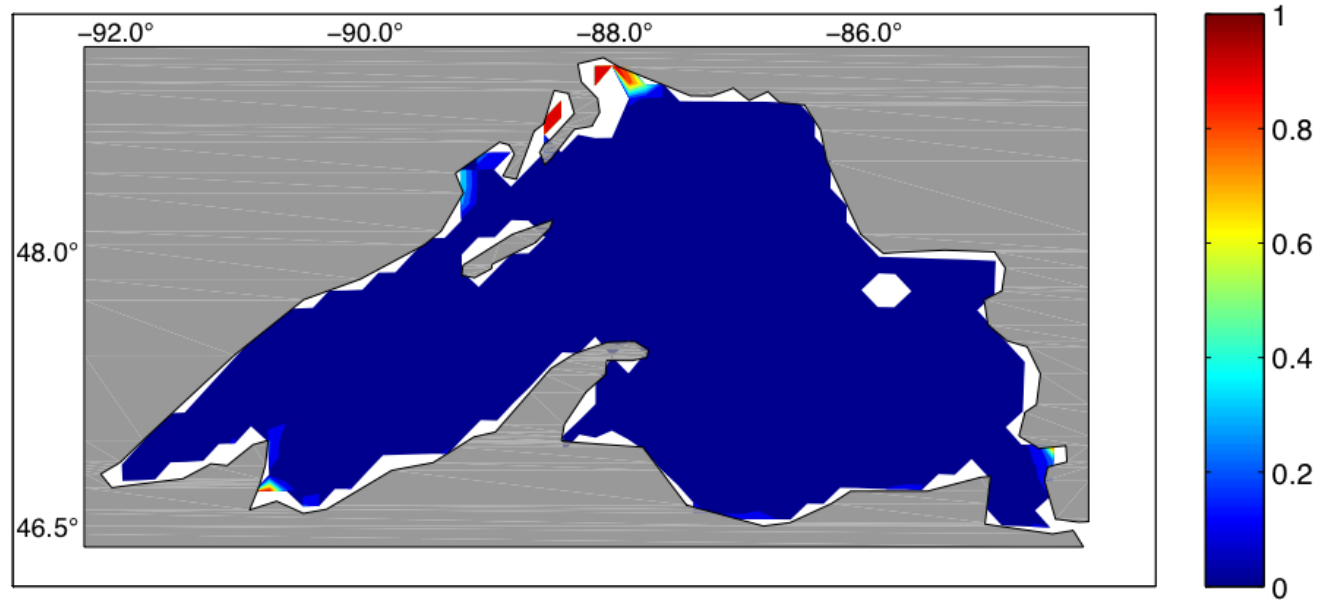
# How?



1997 February Ice Fraction



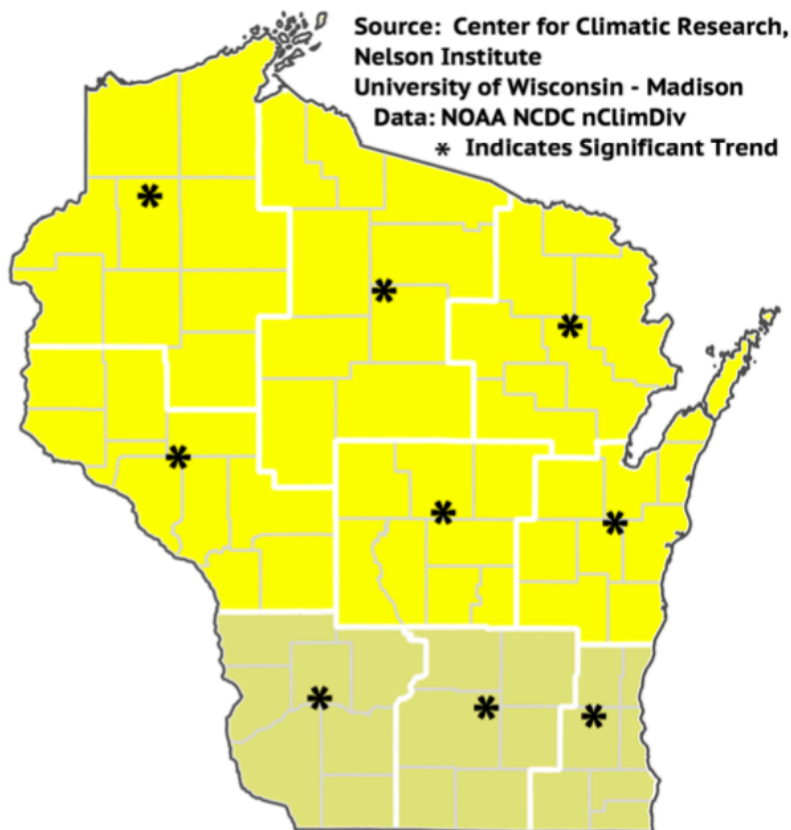
1998 February Ice Fraction



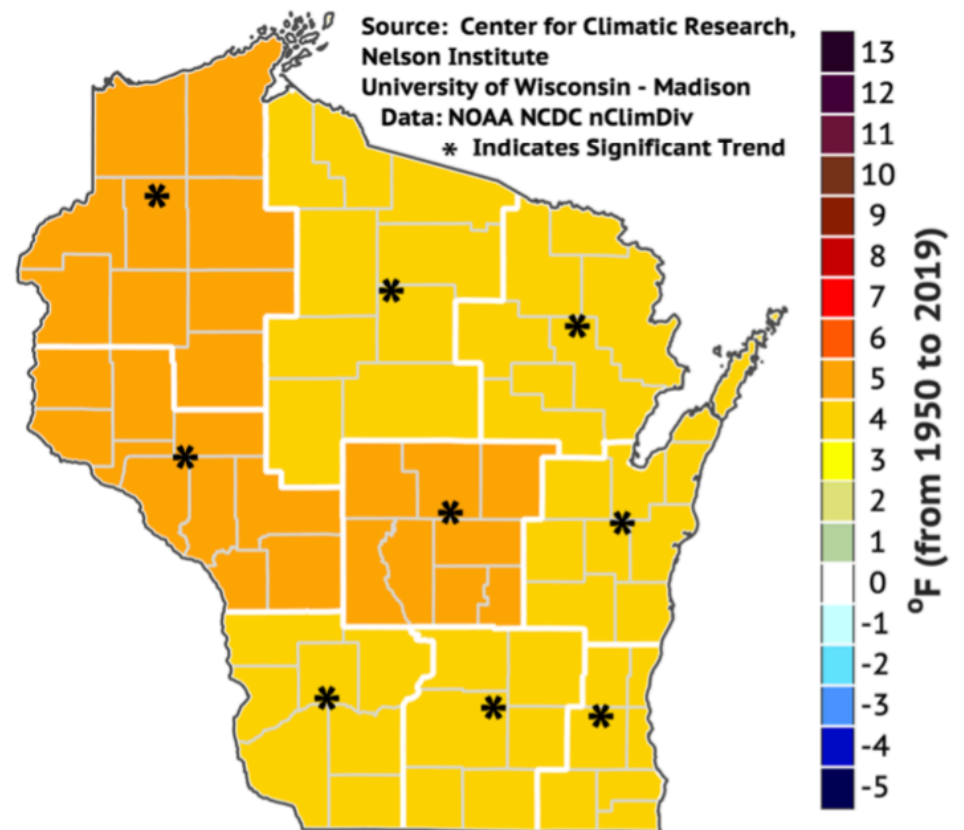


# Wisconsin is getting less cold

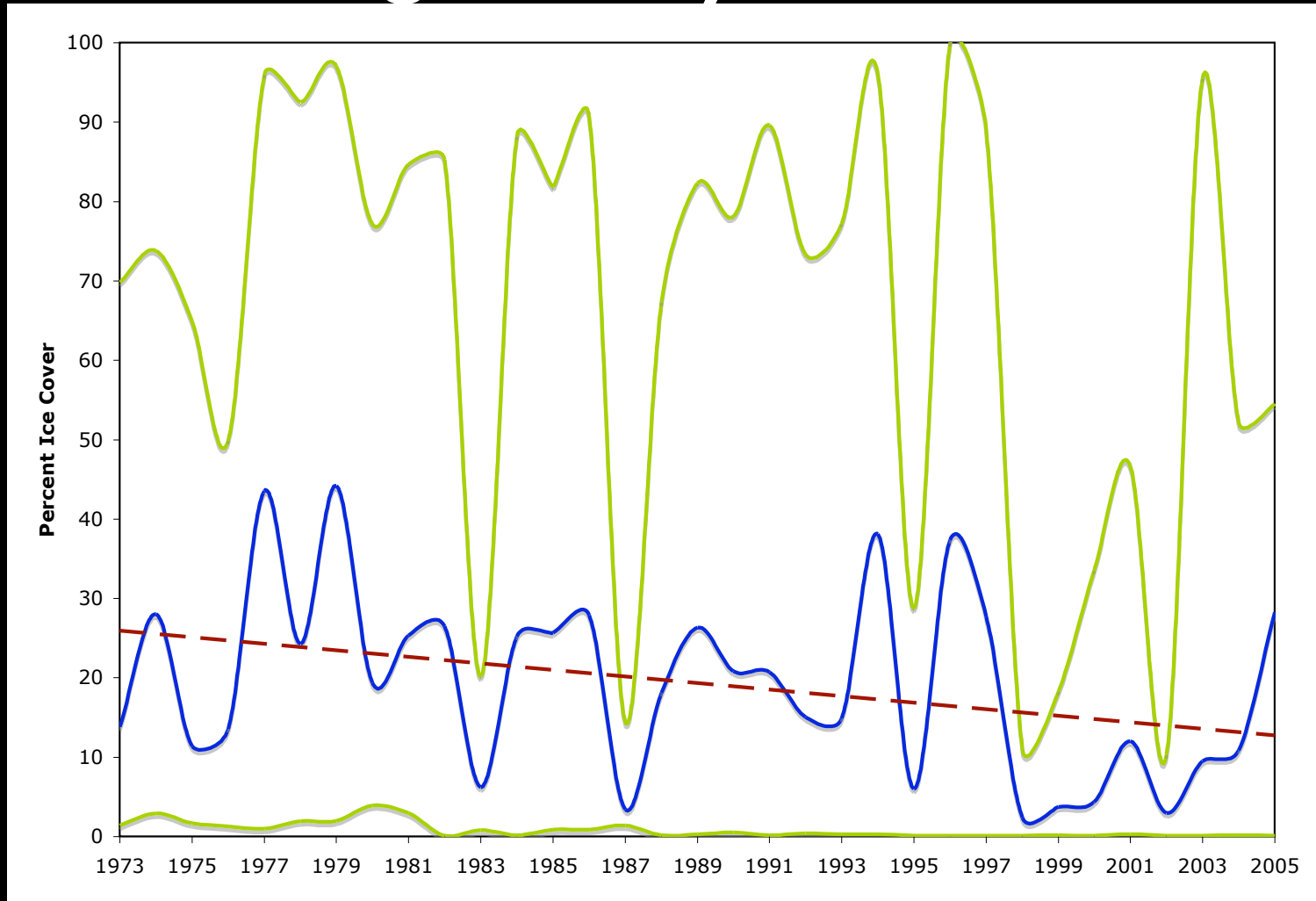
**Historical Change in Annual TMEAN  
from 1950 to 2019**



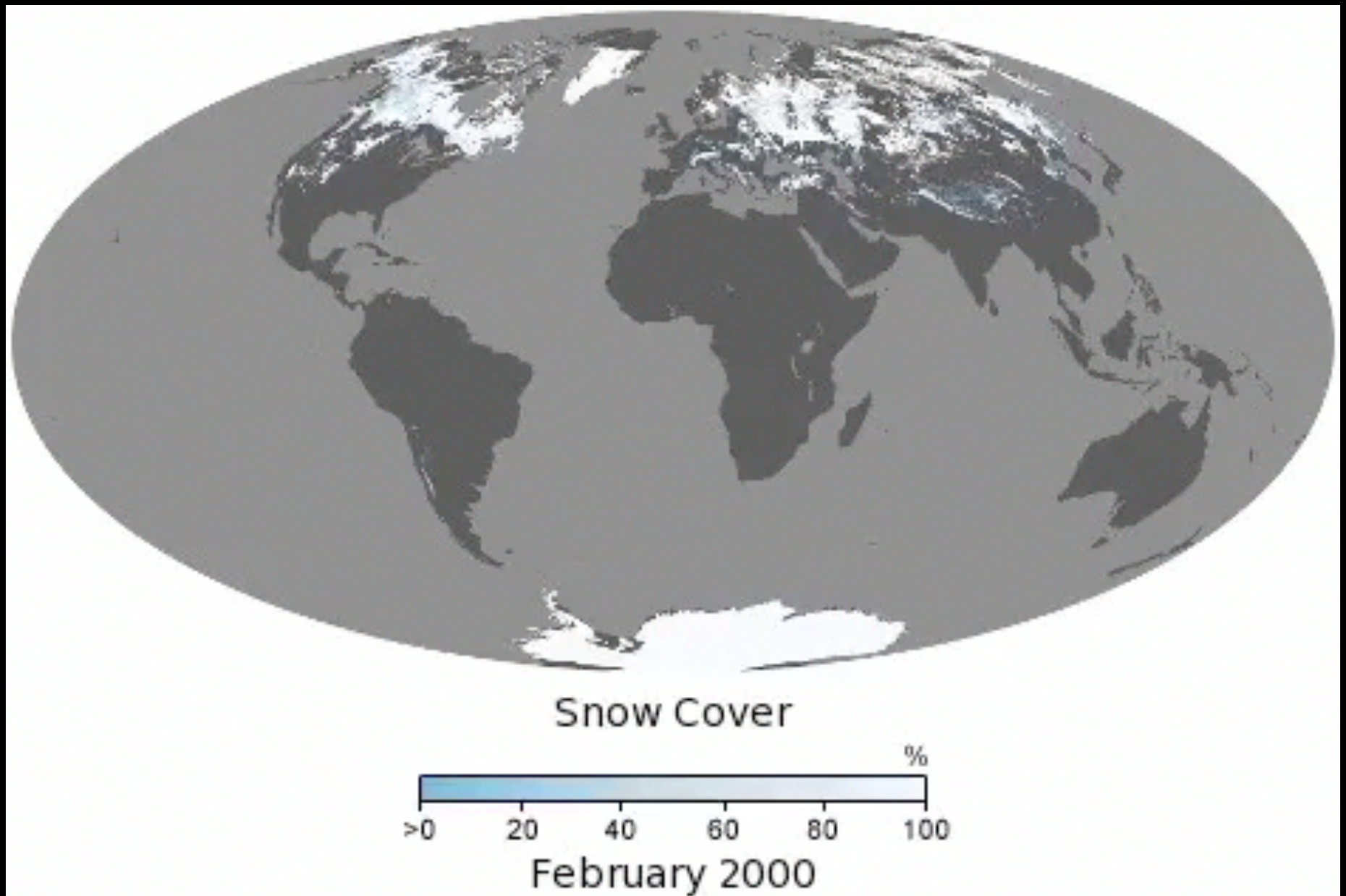
**Historical Change in DJF TMEAN  
from 1950 to 2019**



**Ice cover is declining = longer stratified  
season = faster warming water =  
decreasing stability = windier lake!**





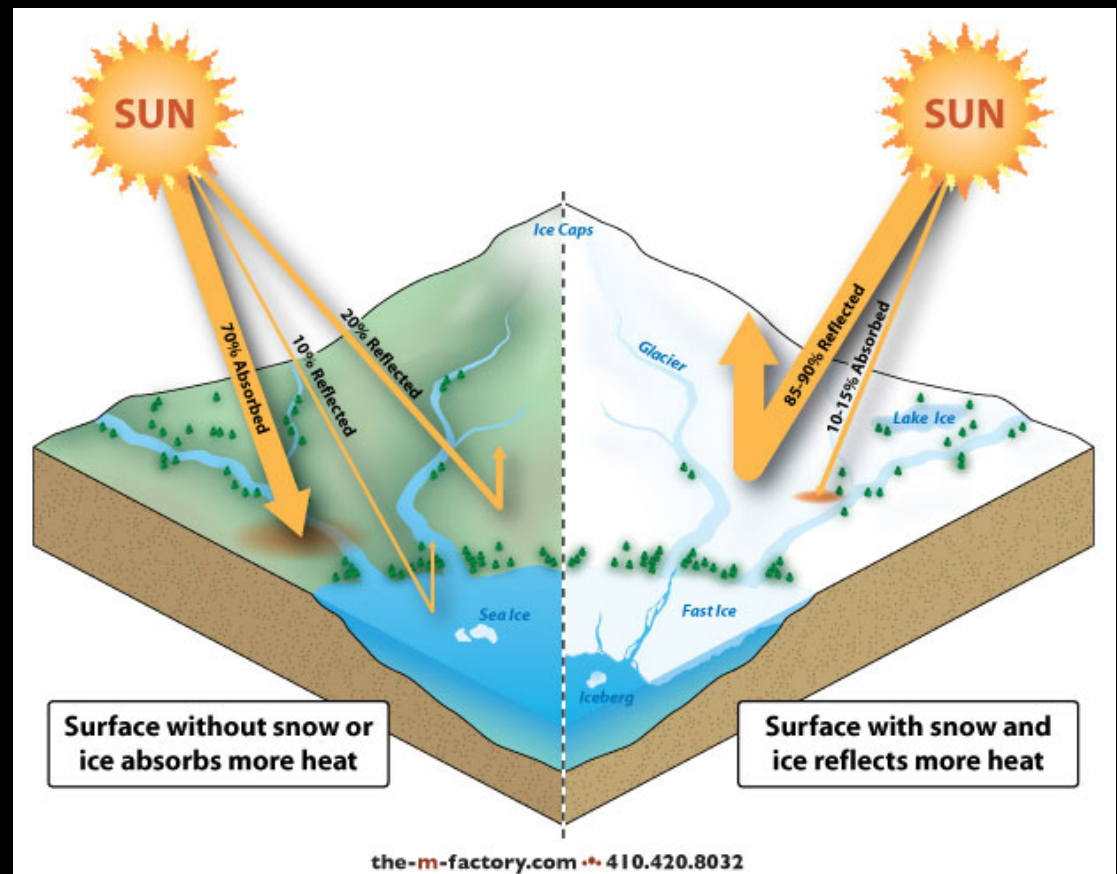
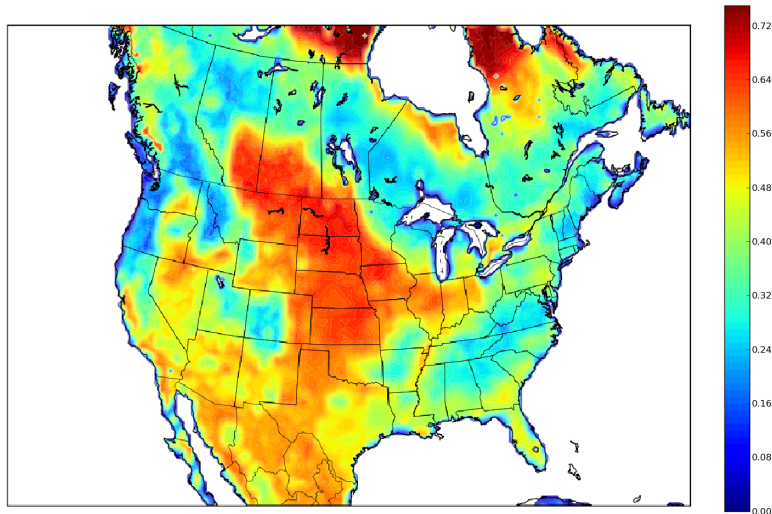


Rydzik *et al.*, 2014; Breeden *et al.*, 2020; Clare *et al.*, in review



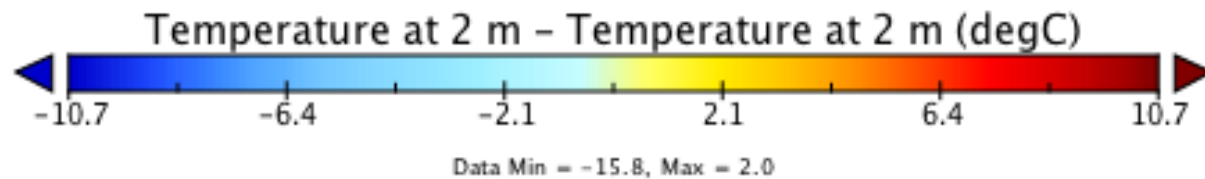
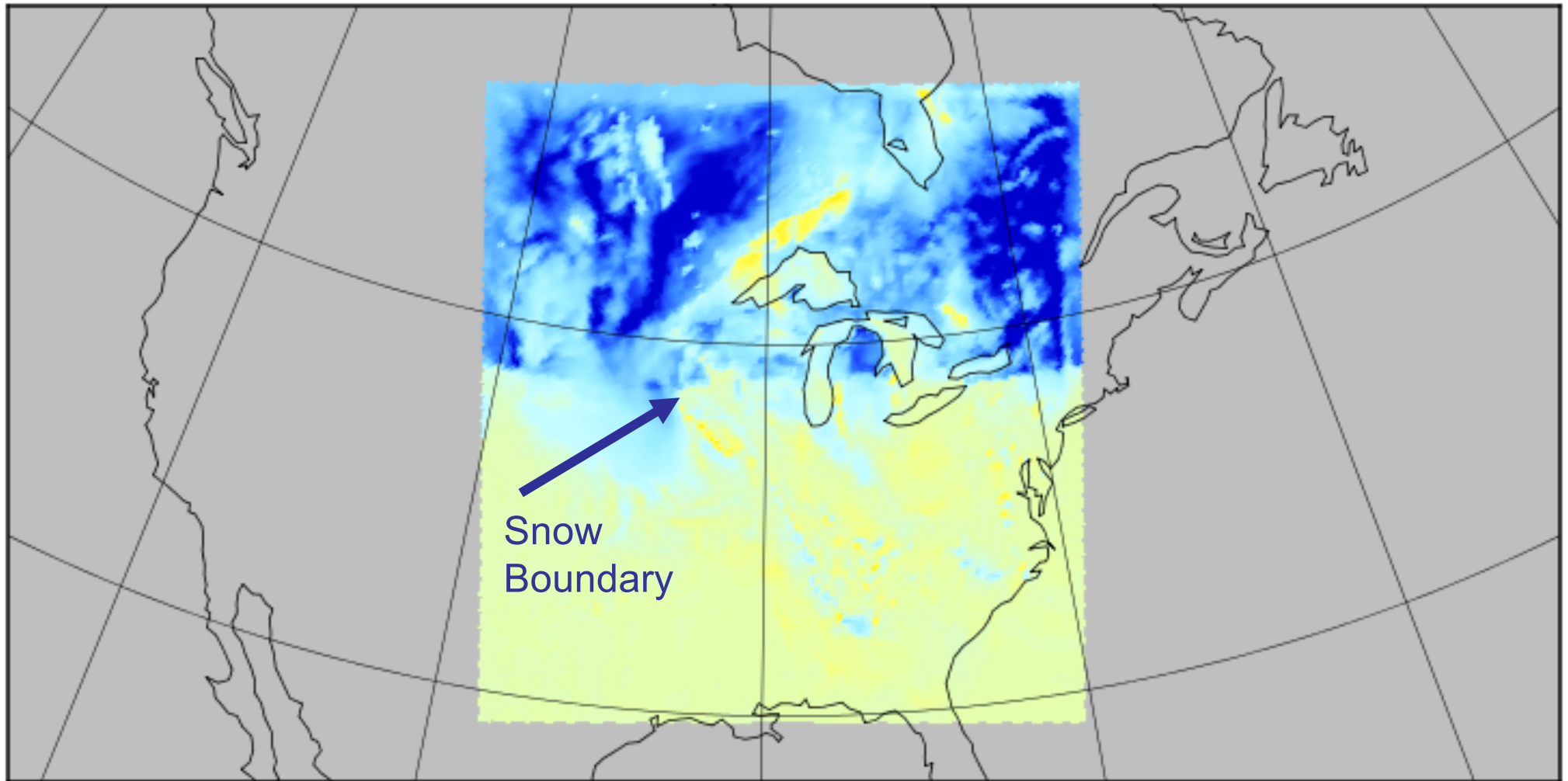
# Snow changes “albedo”, especially in the central USA

- 0% = dark, oceans, blacktop
- 100% = bright, mirror, ice
- Snow albedo exceeds 85%.
- Albedo gradients in winter exceeds 65% in winter.



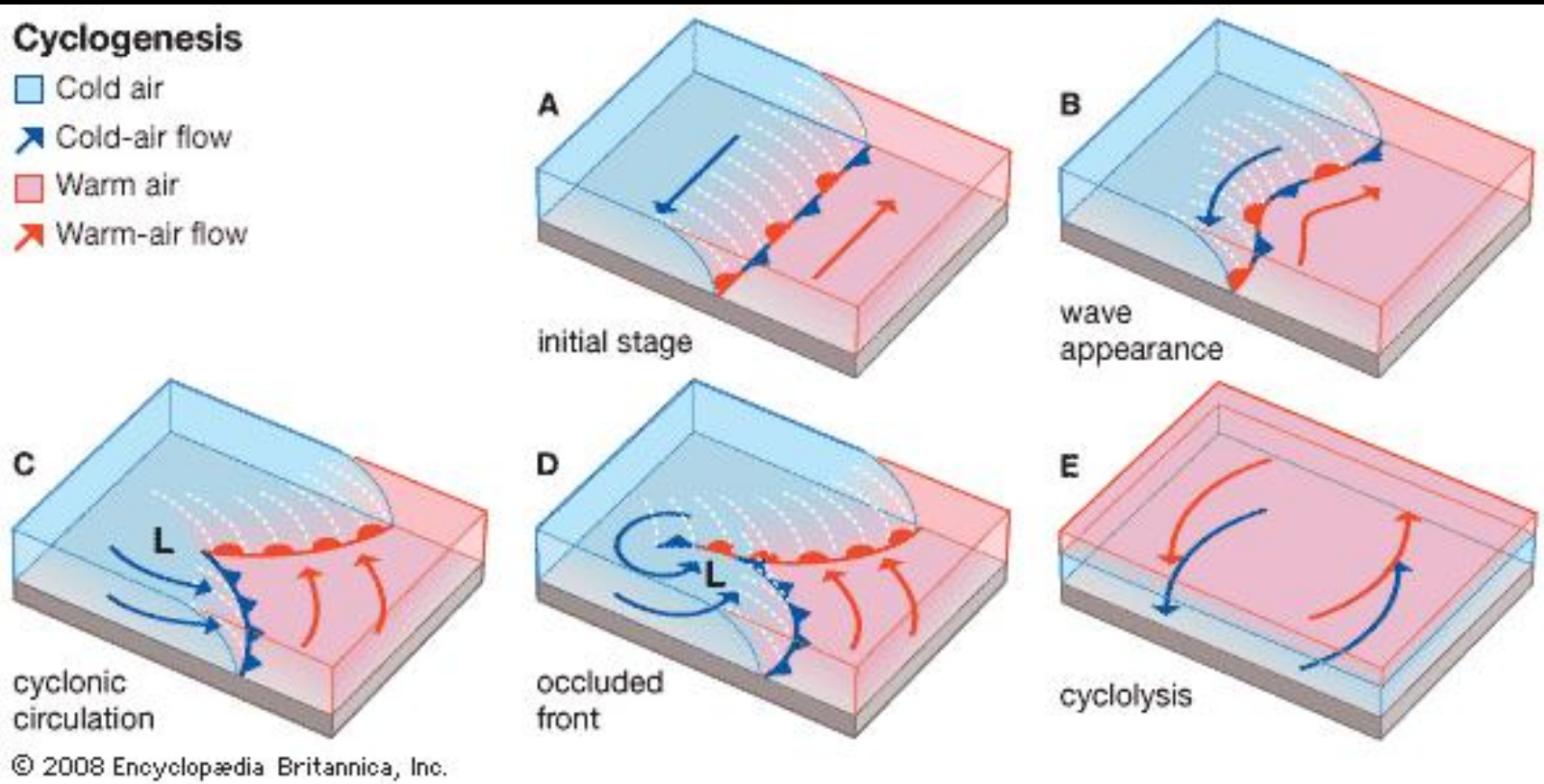
# Albedo influences surface temperature

Temperature at 2 m



G. Bromley  
R. Clare

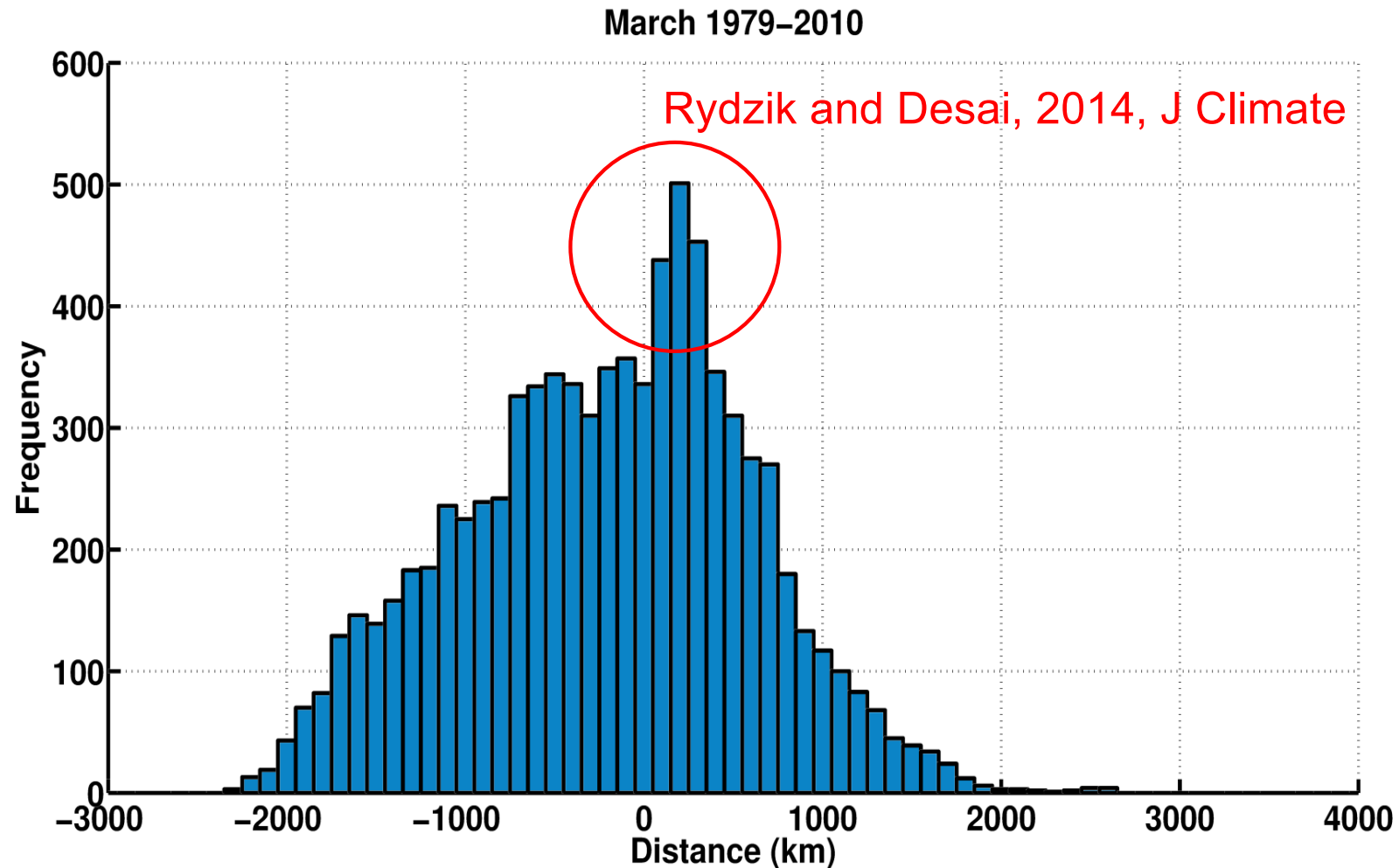
# Does it influence storms?



The Norwegian Model of  
"Mid-Latitude Cyclones"  
(Bjerknes and Solberg, 1922)



# Observations suggest it does



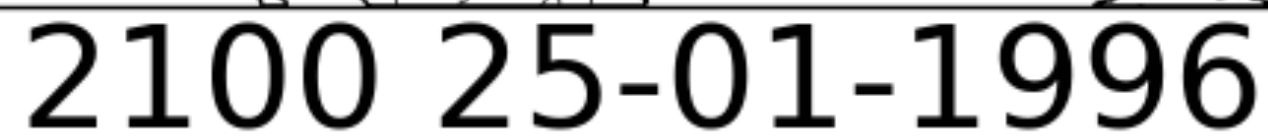
Snow

No Snow

# A trip back to Jan 25, 1996



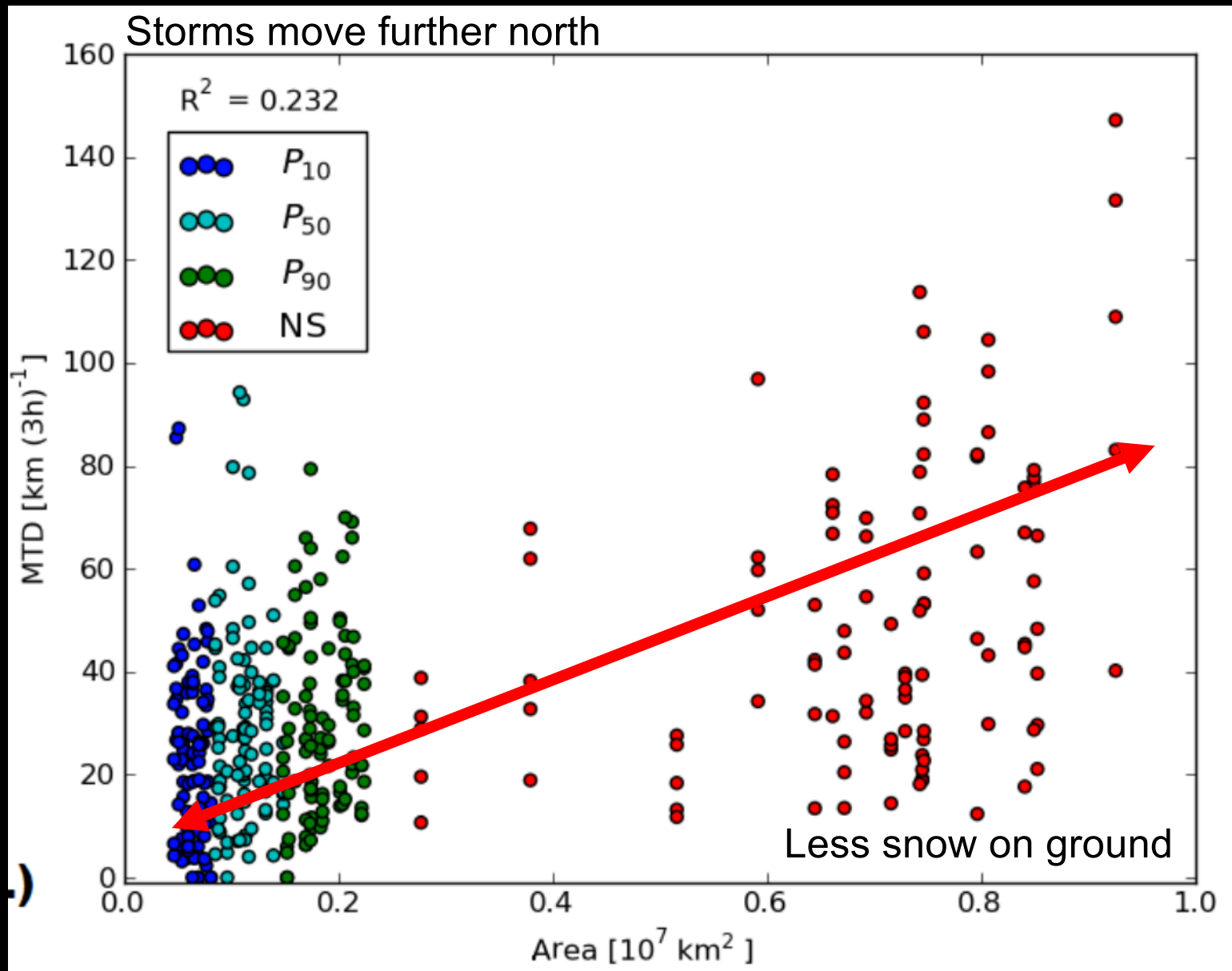
NWS LaCrosse



2100 25-01-1996

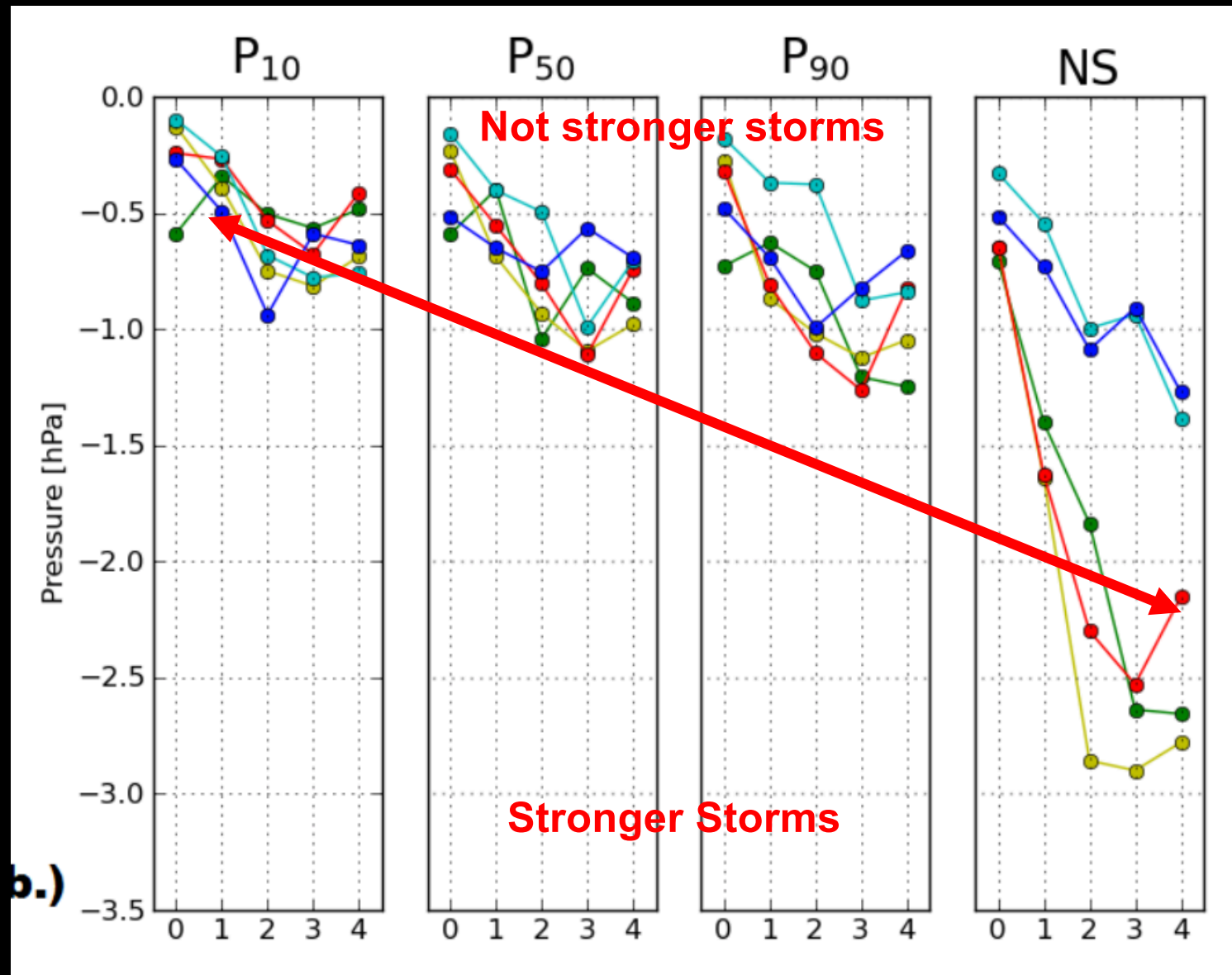


**Storms do follow snow cover,  
but only a little (~10 km per 10% reduction)**

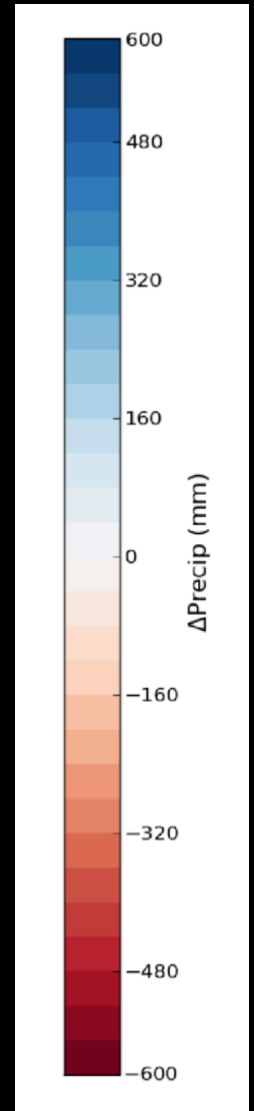
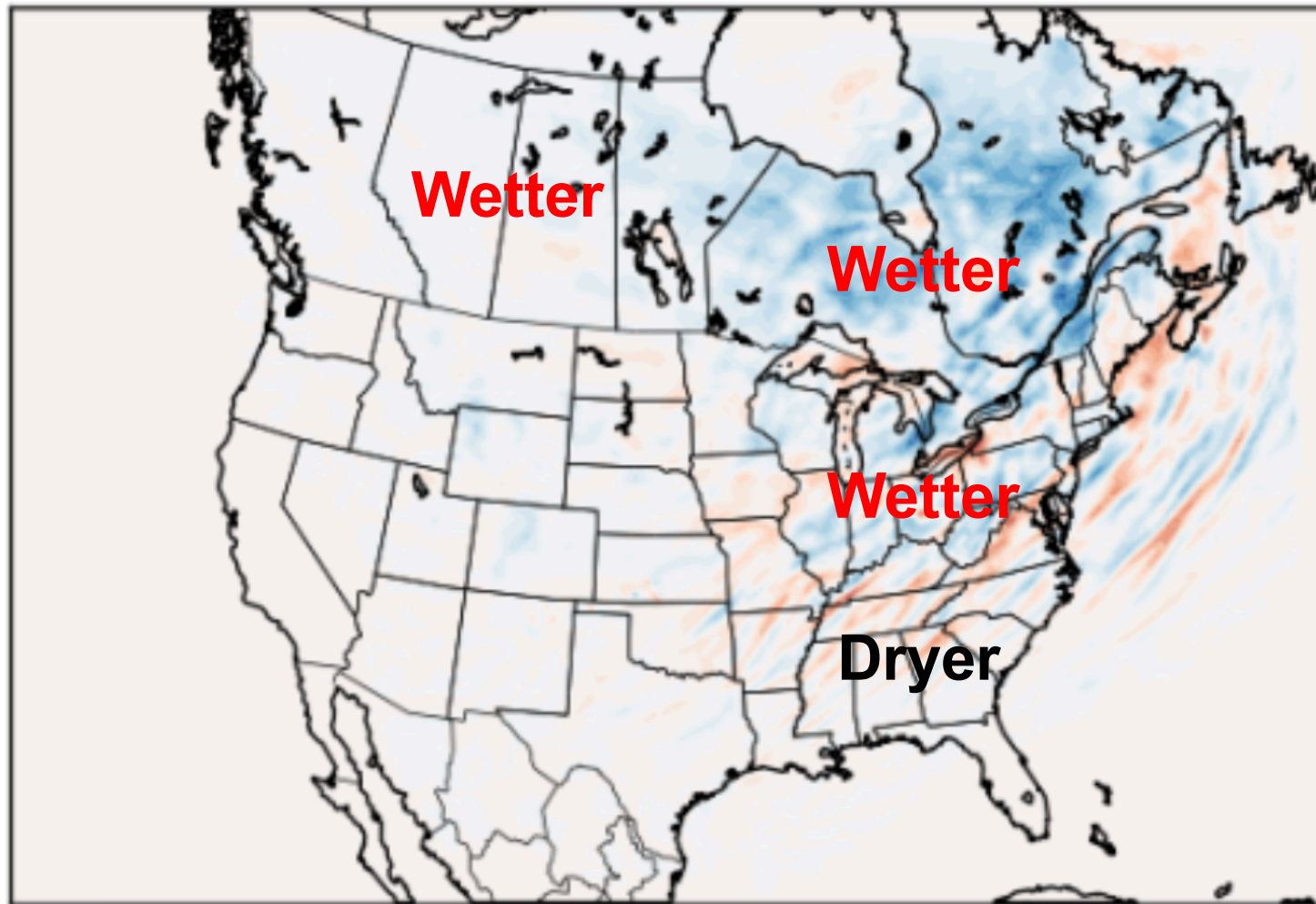


# Less snow = greater storm intensity

Less snow removed  $\longrightarrow$  All snow removed



**In most places, it gets wetter and rainier**

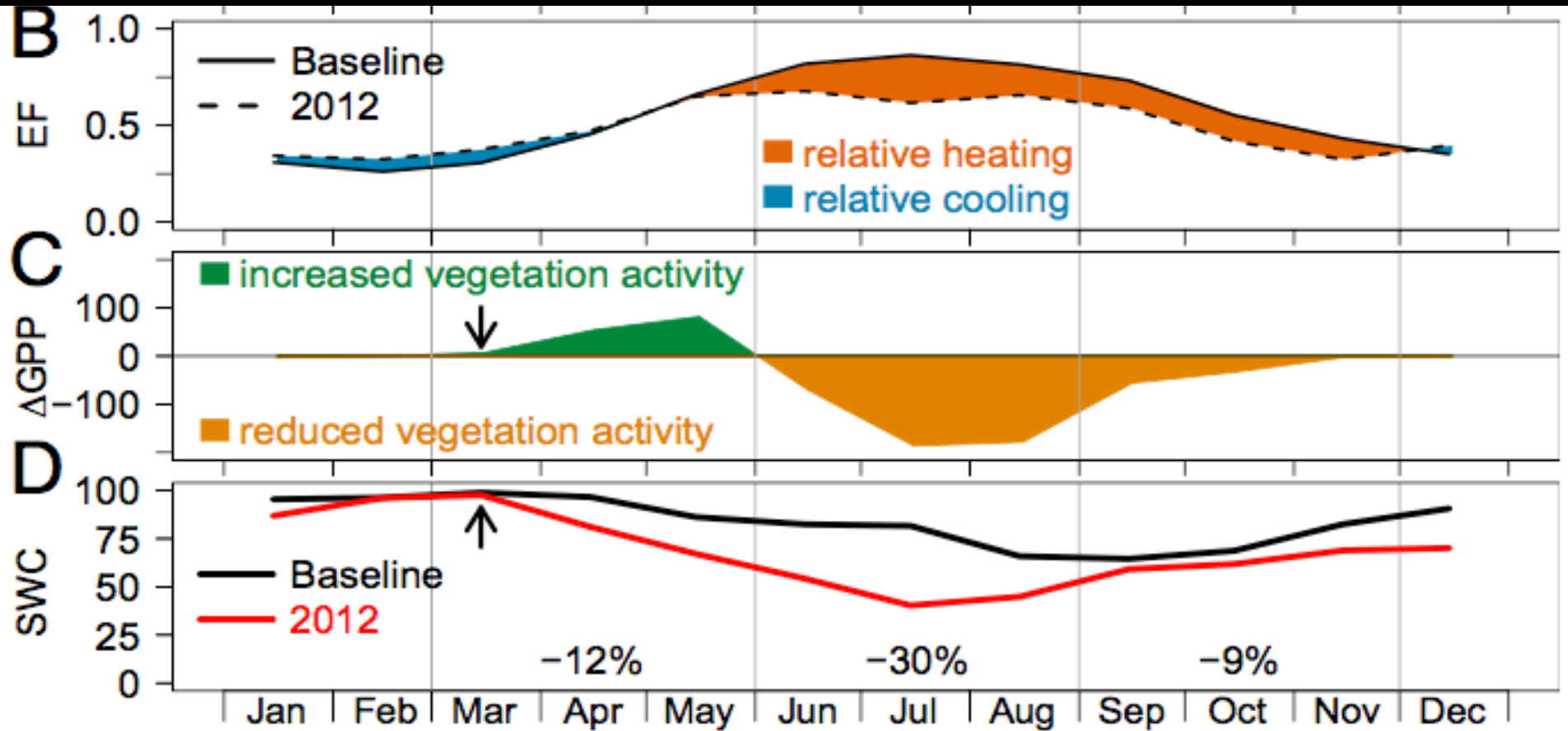






**What do shorter, wetter, rainier snow seasons imply?**

# Earlier growing seasons exacerbate summer droughts!

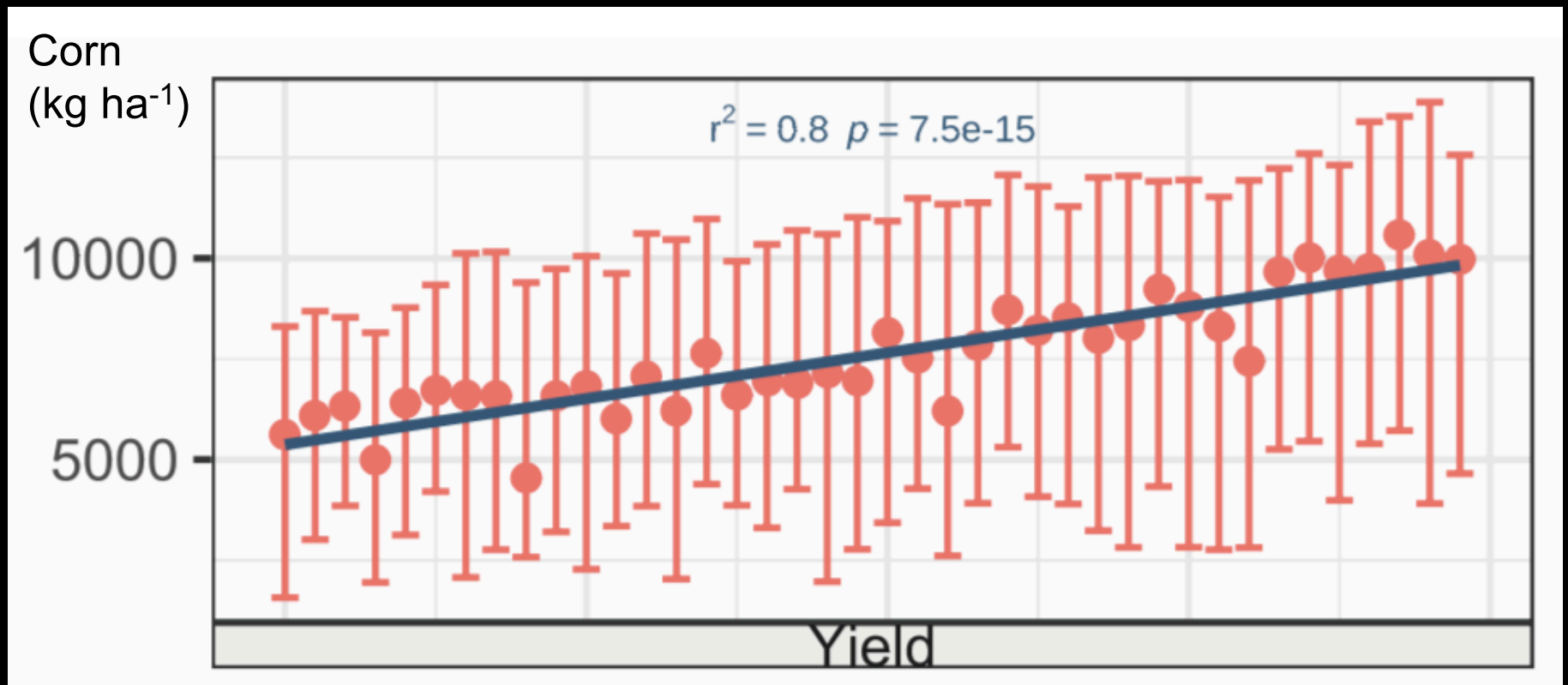






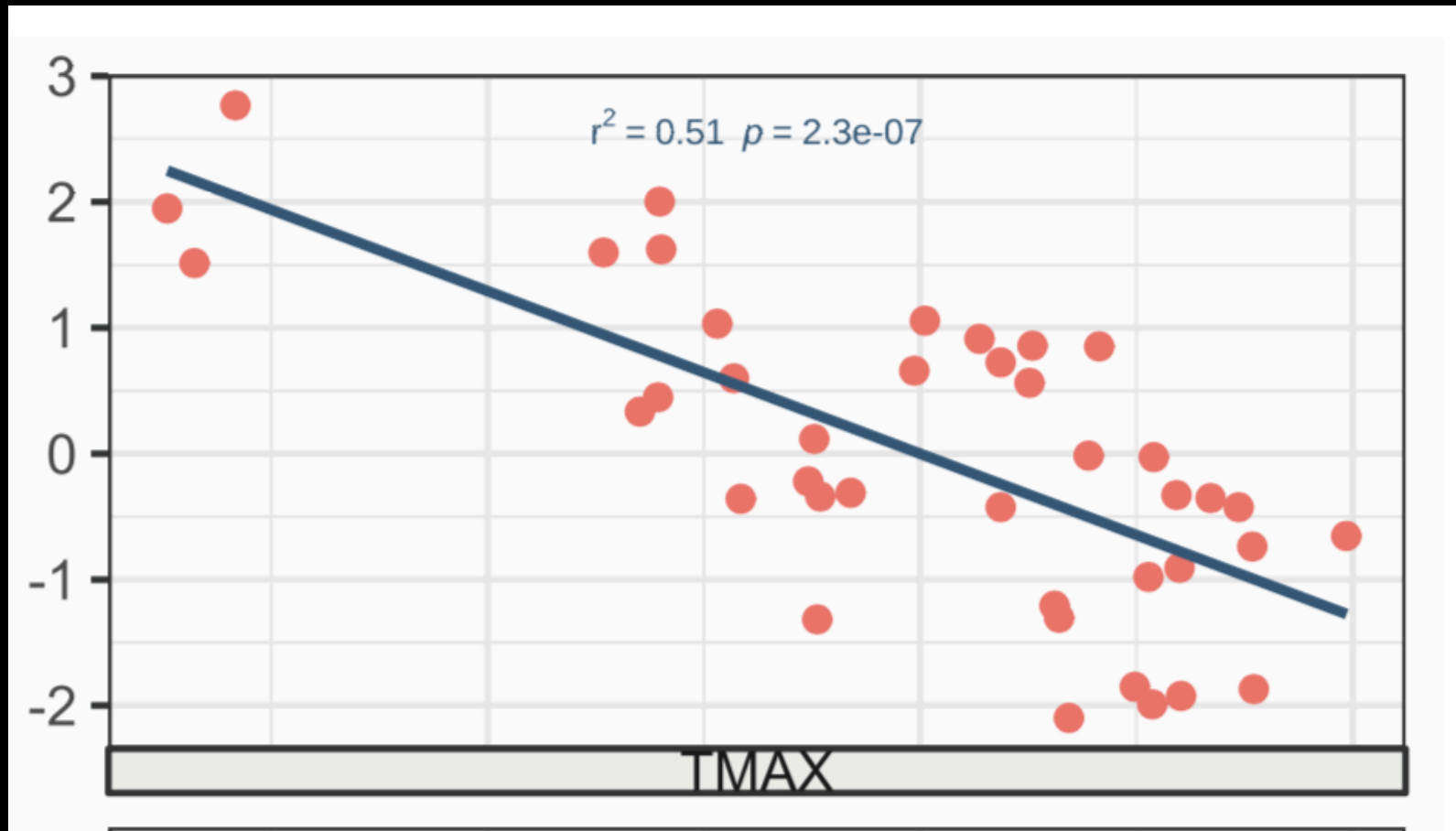


# American farmers are growing more food on less amount of land

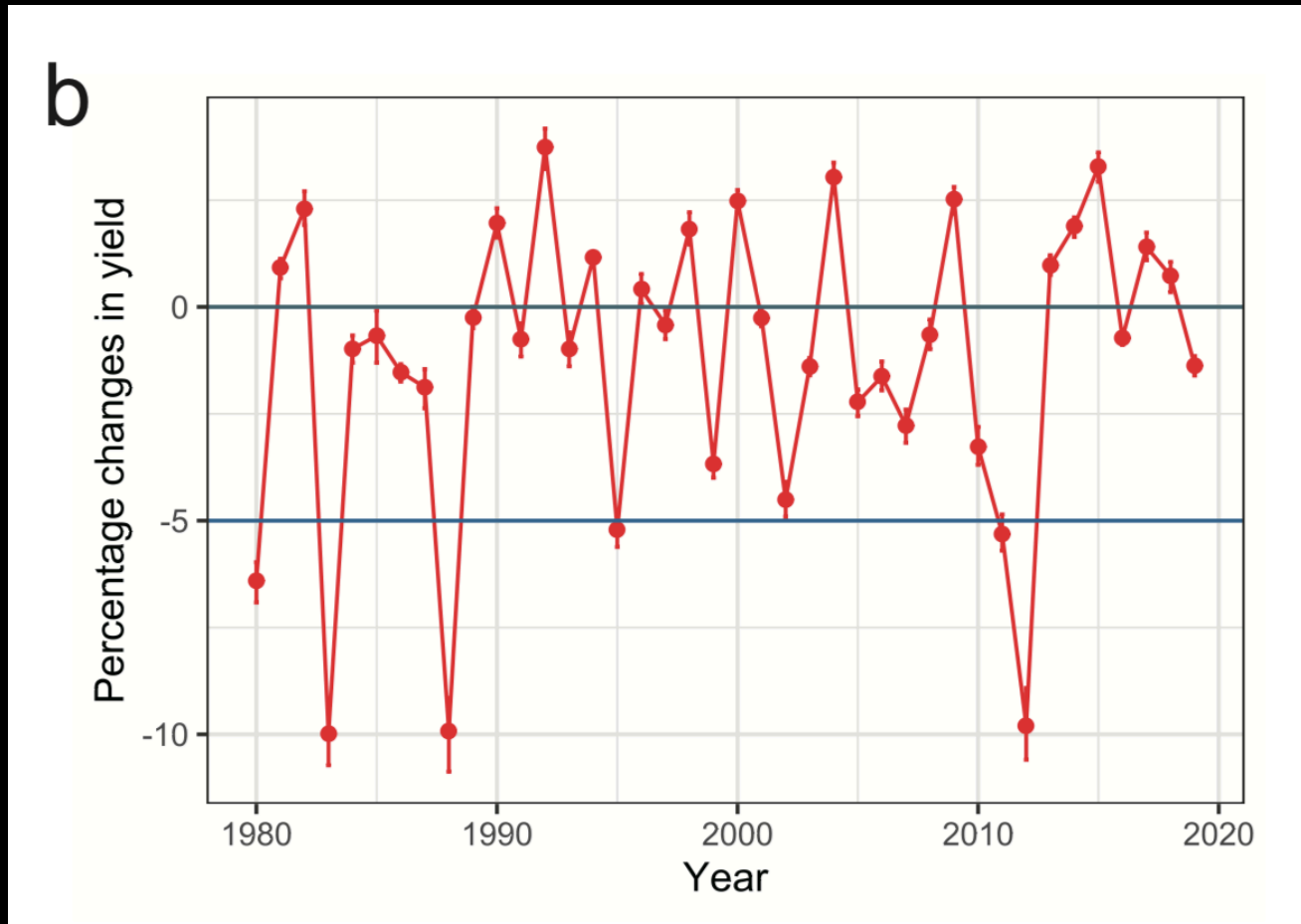


Liu and Desai, in review, Nature Comm.

# Yields are sensitive to climate



**But there is no consistent global warming signal on food security yet. Is something else happening?**





1975



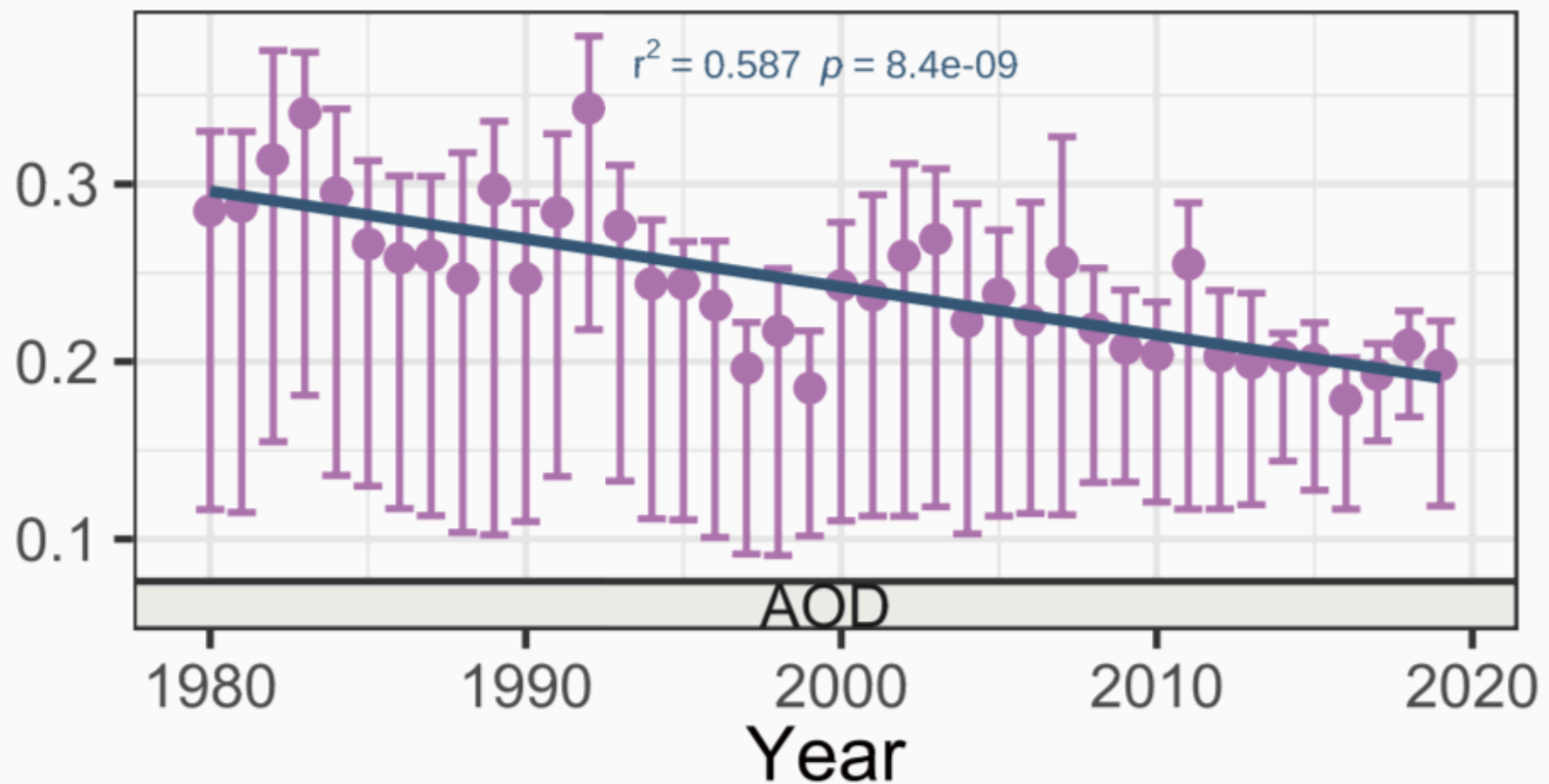
2020



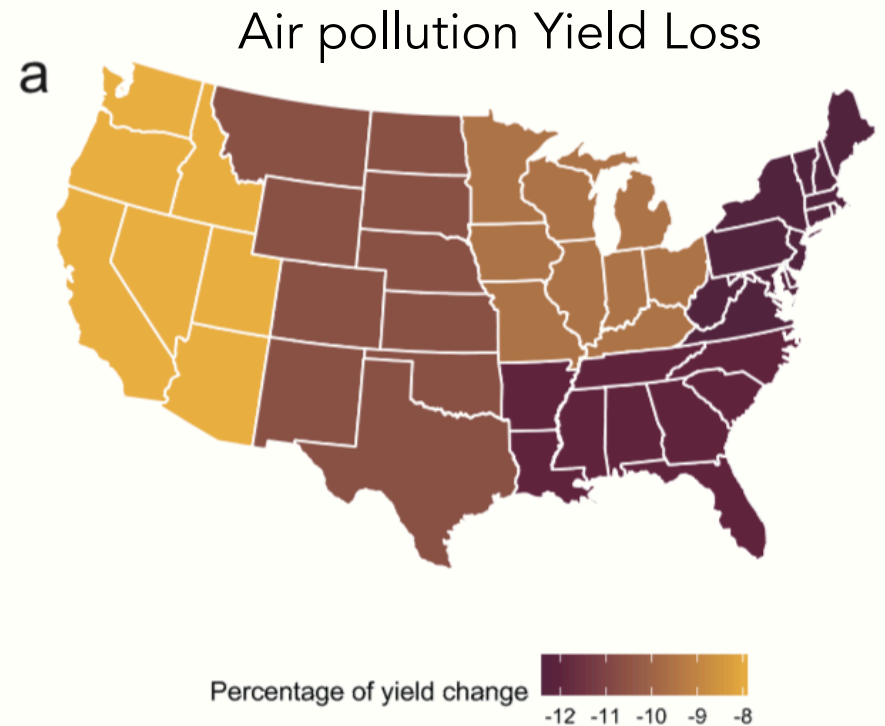
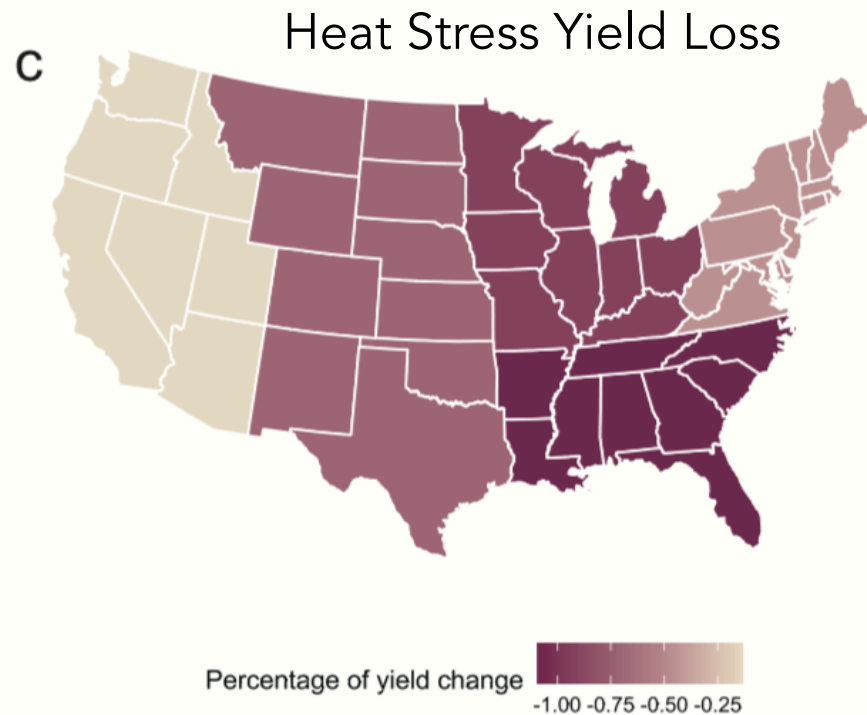
Top: <https://timeline.com/la-smog-pollution-4ca4bc0cc95d>

Bottom: Twitter / @MikeSington

# Turns out: air quality has gotten better

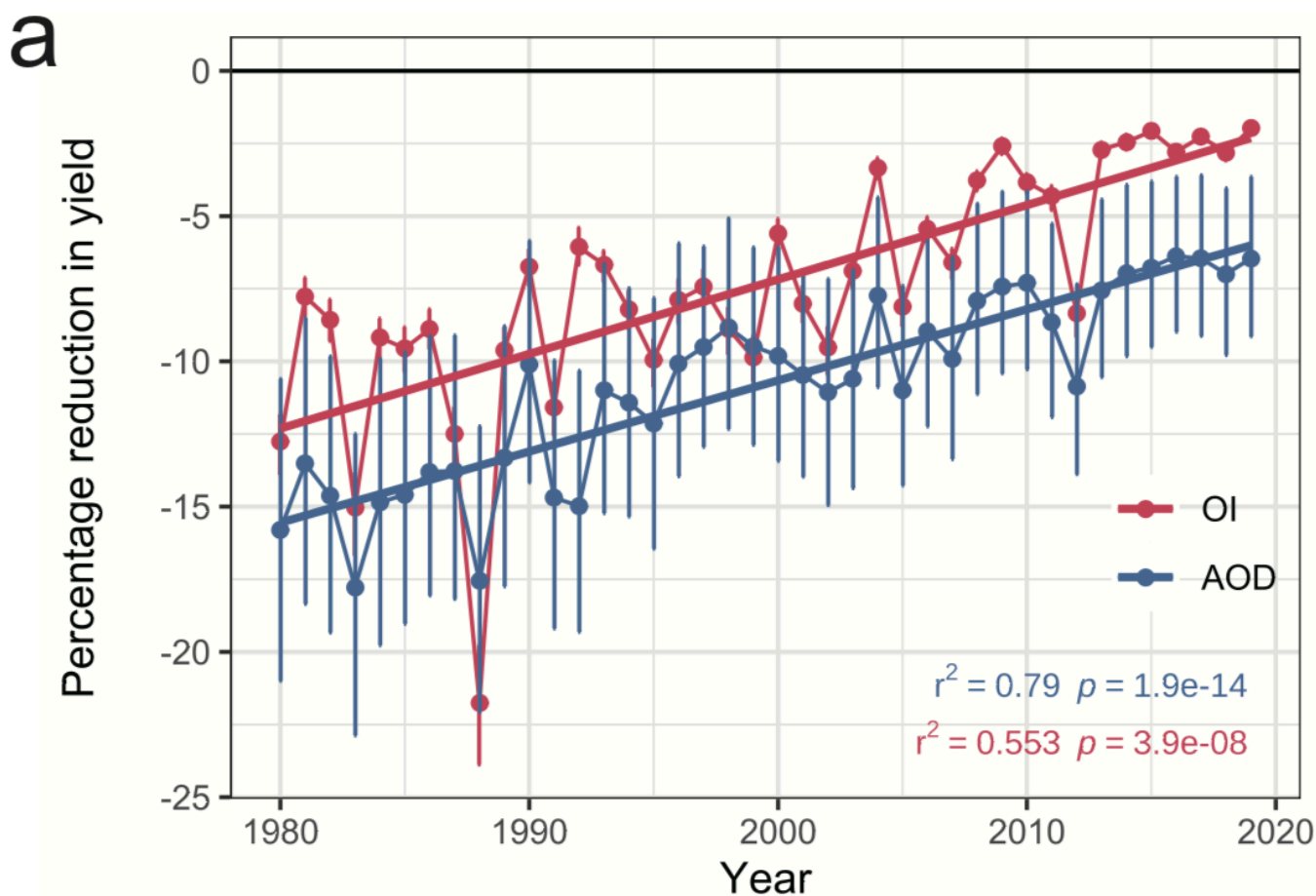


# Improving air quality more than offset heat/drought related yield losses

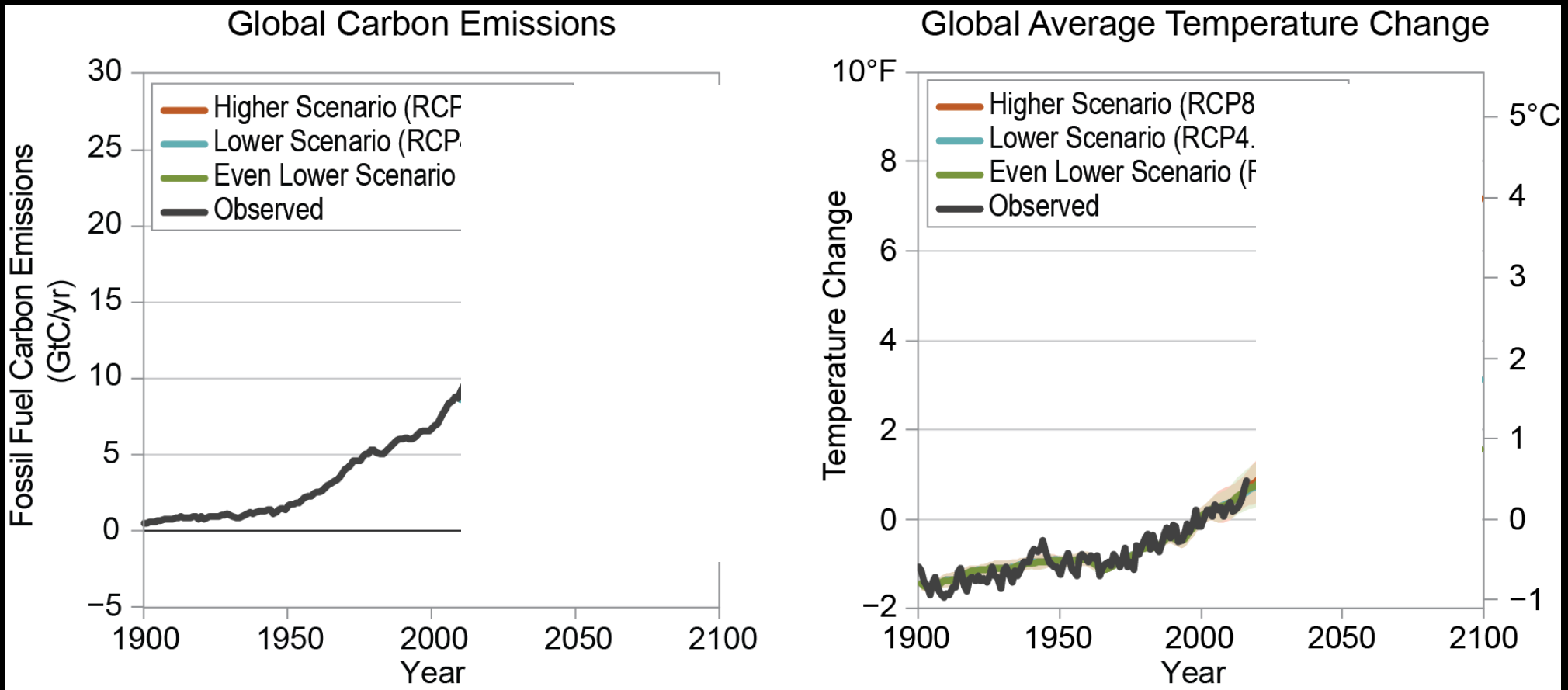




**And there is still some ways to go – we can further improve food security through air quality regulation**



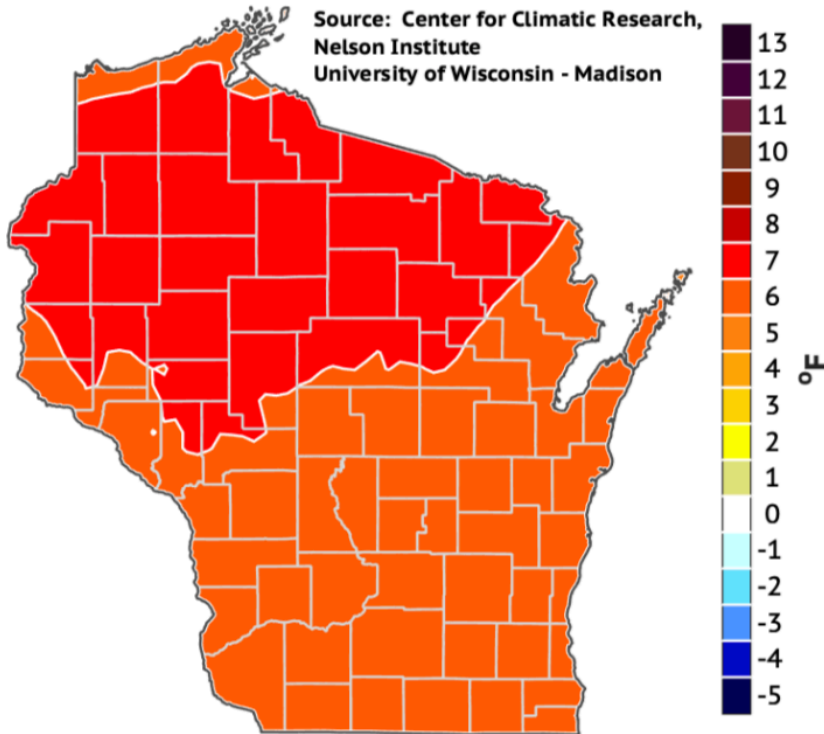
# Projecting into the future



# Future emissions makes a big difference

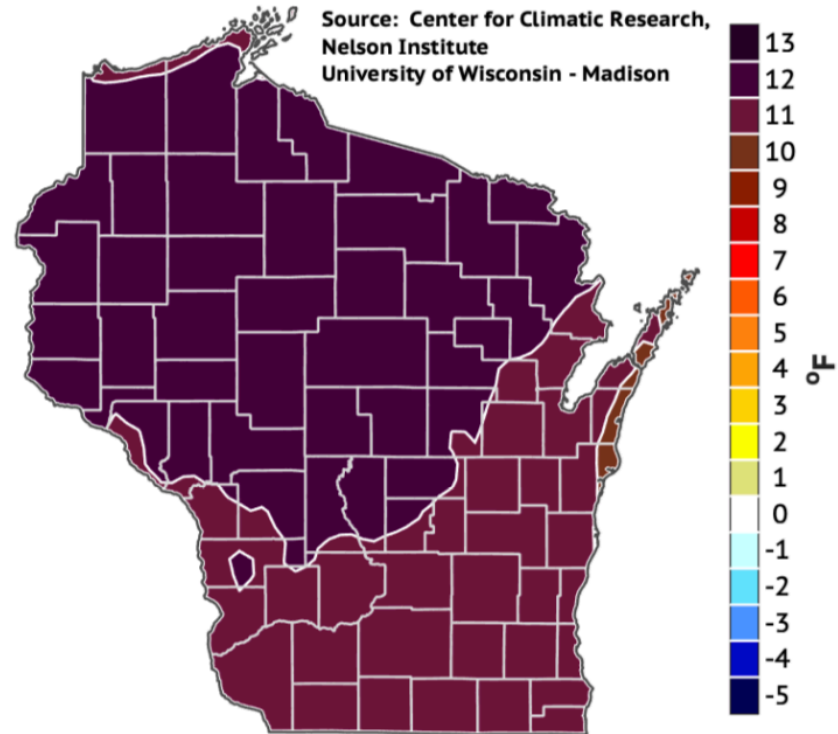
**Change in Annual TMEAN, RCP45:  
2081-2100 minus 1981-2010**

Source: Center for Climatic Research,  
Nelson Institute  
University of Wisconsin - Madison



**Change in Annual TMEAN, RCP85:  
2081-2100 minus 1981-2010**

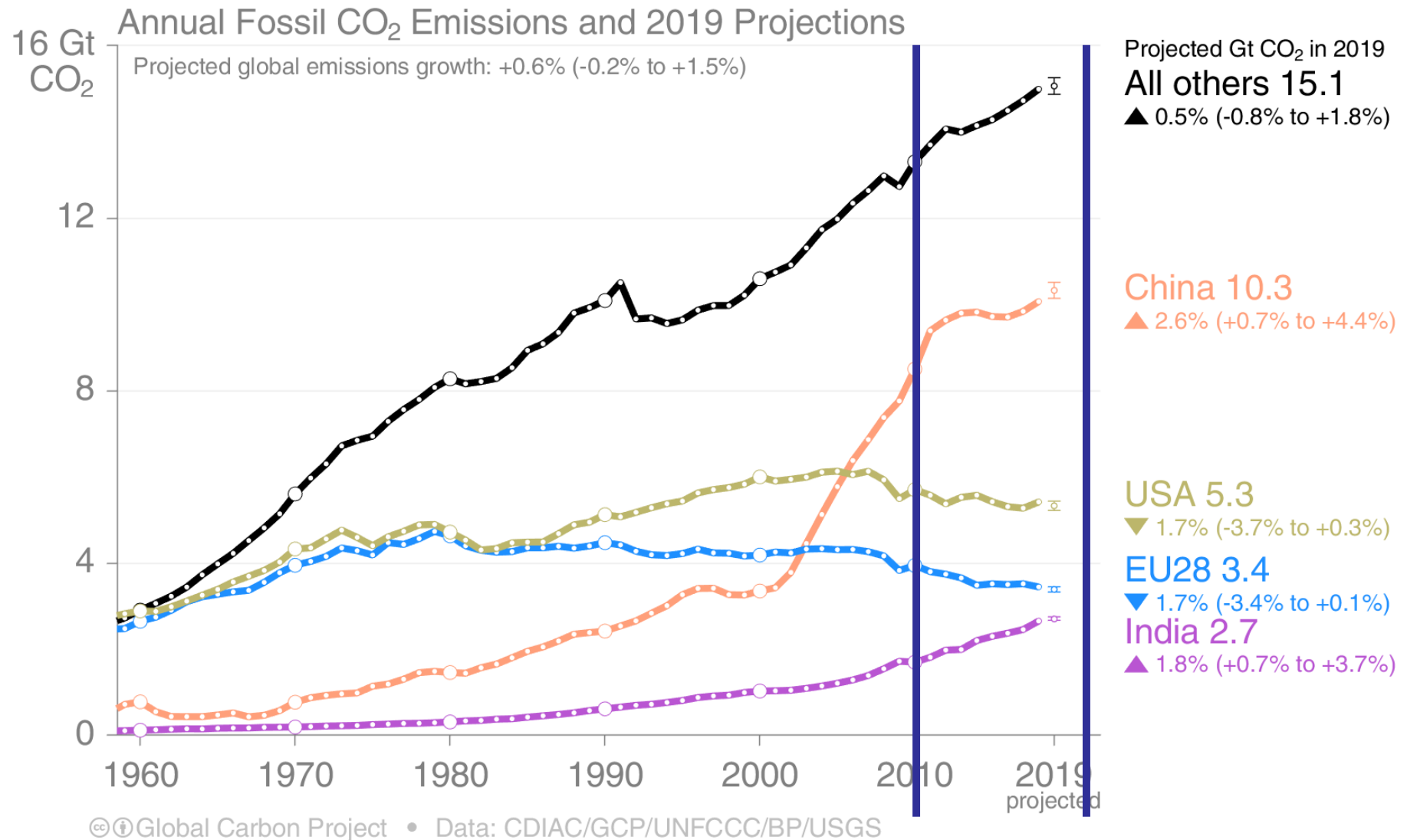
Source: Center for Climatic Research,  
Nelson Institute  
University of Wisconsin - Madison





# Aggressive fossil fuel emissions reductions are needed to avoid overloading the dice

## We've had some success, but it's not enough

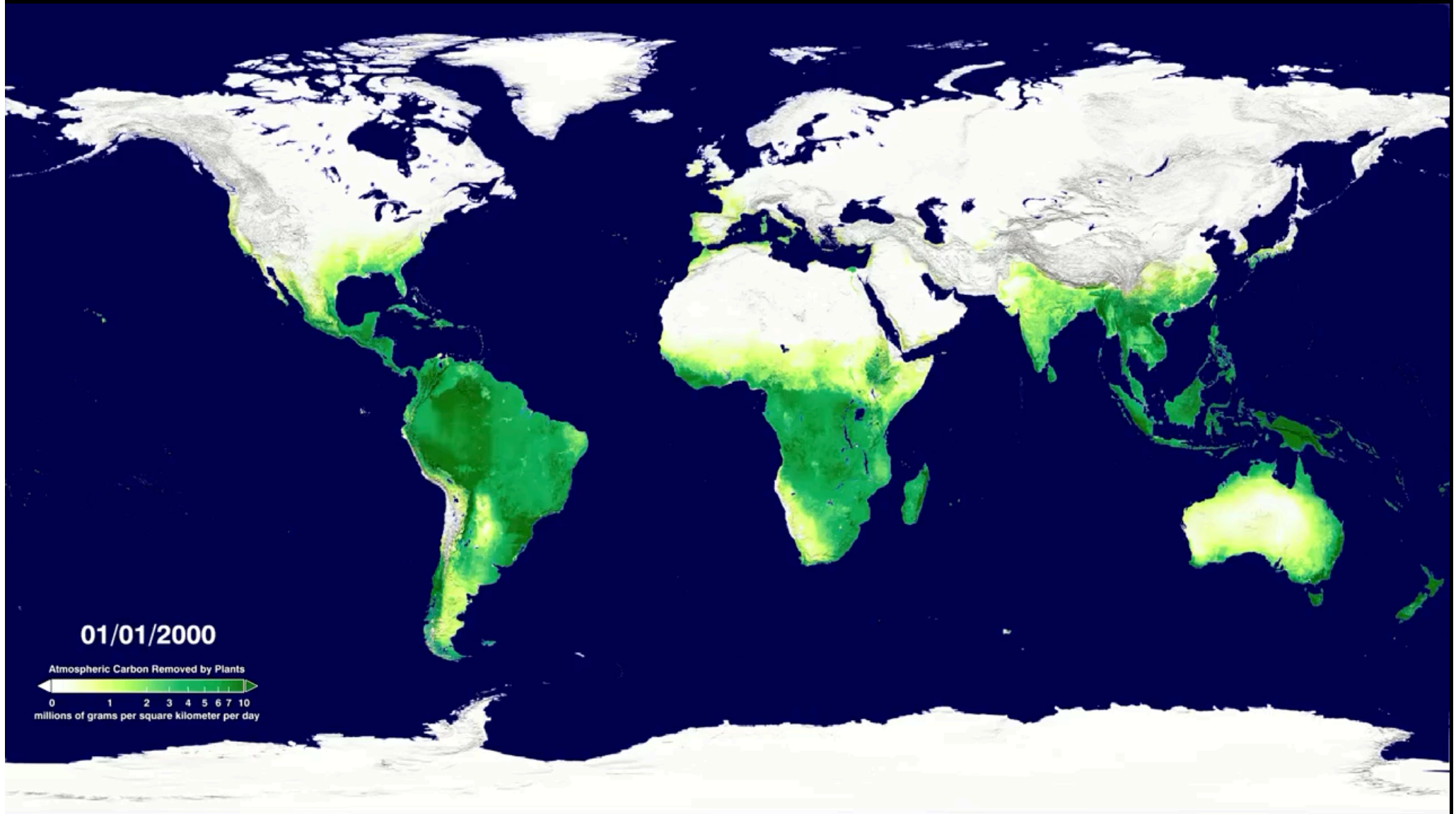


# Solutions are abundant

- <https://www.drawdown.org/solutions>

\* Gigatons CO2 Equivalent Reduced / Sequestered (2020–2050)

◆ SOLUTION	◆ SECTOR(S)	▼ SCENARIO 1 *	◆ SCENARIO 2 *
Reduced Food Waste	Food, Agriculture, and Land Use / Land Sinks	87.45	94.56
Health and Education	Health and Education	85.42	85.42
Plant-Rich Diets	Food, Agriculture, and Land Use / Land Sinks	65.01	91.72
Refrigerant Management	Industry / Buildings	57.75	57.75
Tropical Forest Restoration	Land Sinks	54.45	85.14
Onshore Wind Turbines	Electricity	47.21	147.72
Alternative Refrigerants	Industry / Buildings	43.53	50.53
Utility-Scale Solar Photovoltaics	Electricity	42.32	119.13
Improved Clean Cookstoves	Buildings	31.34	72.65
Distributed Solar Photovoltaics	Electricity	27.98	68.64
Silvopasture	Land Sinks	26.58	42.31
Peatland Protection and Rewetting	Food, Agriculture, and Land Use / Land Sinks	26.03	41.93
Tree Plantations (on Degraded Land)	Land Sinks	22.24	35.94
Temperate Forest Restoration	Land Sinks	19.42	27.85
Concentrated Solar Power	Electricity	18.60	23.96

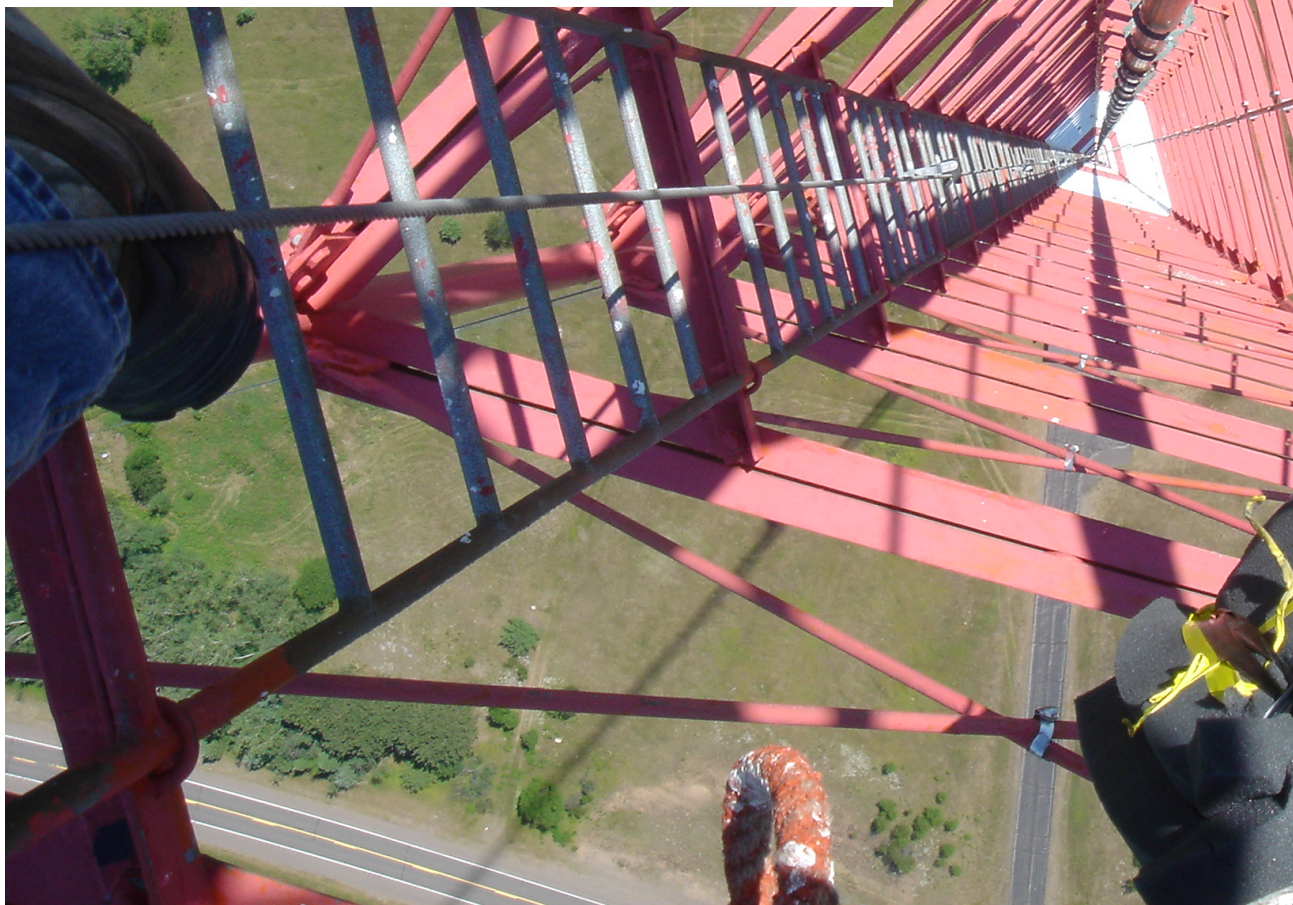


MODIS GPP (NASA)



# CHEESEHEAD 2019

*Chequamegon Heterogeneous Ecosystem  
Energy-balance Study Enabled by a High-  
density Extensive Array of Detectors*

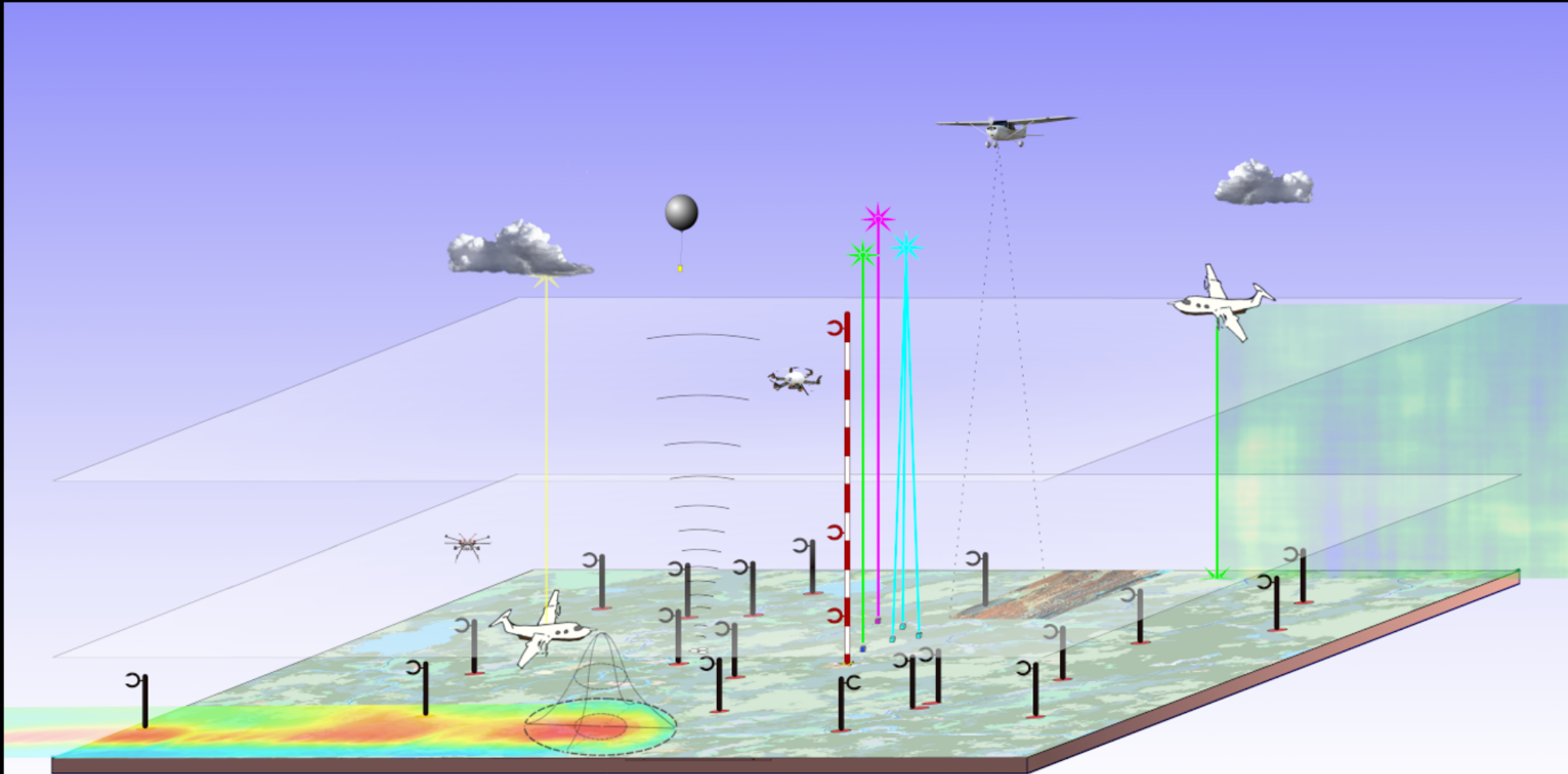








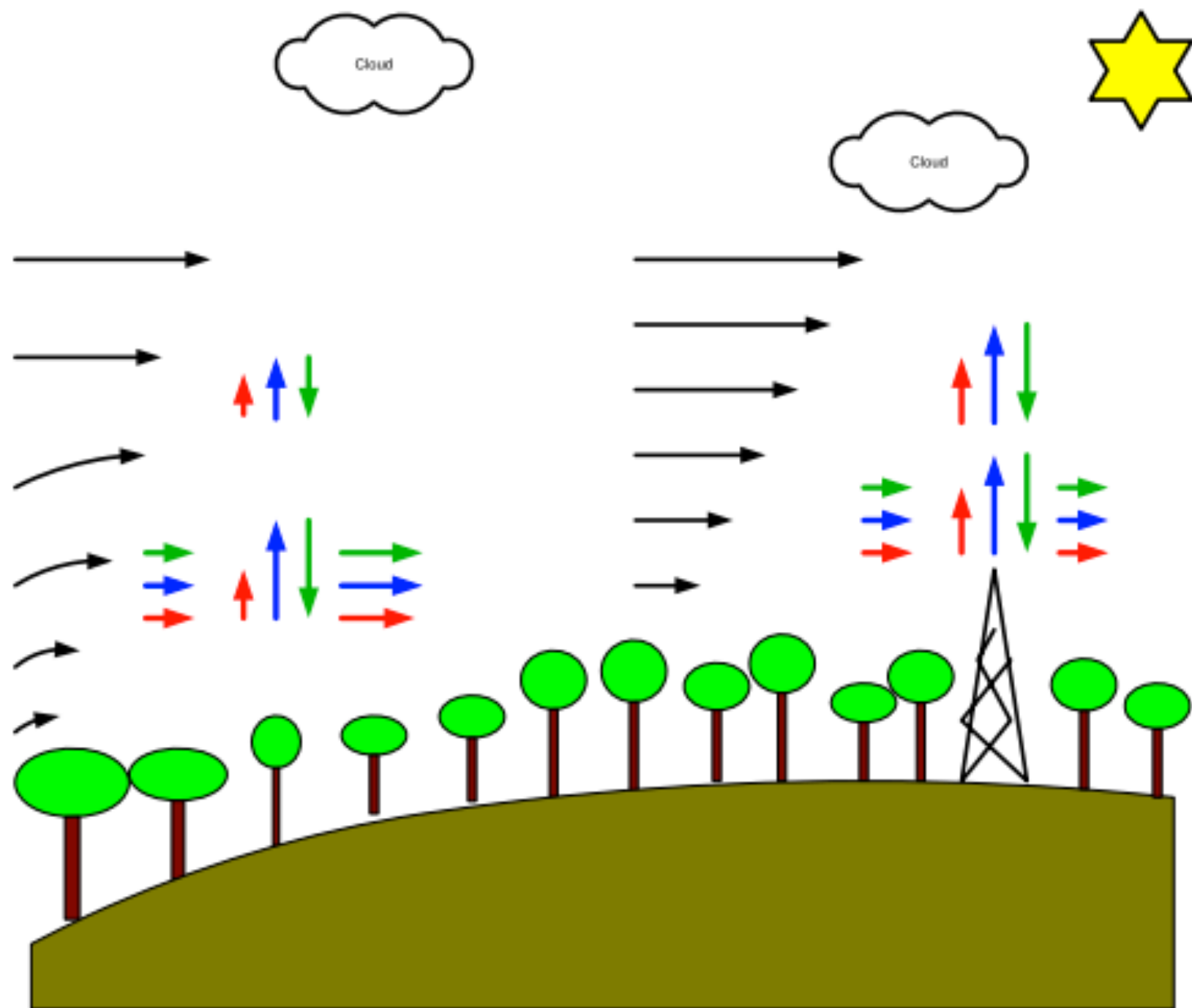
# Intensively sample air and ground of 35 square miles of Northern Wisconsin



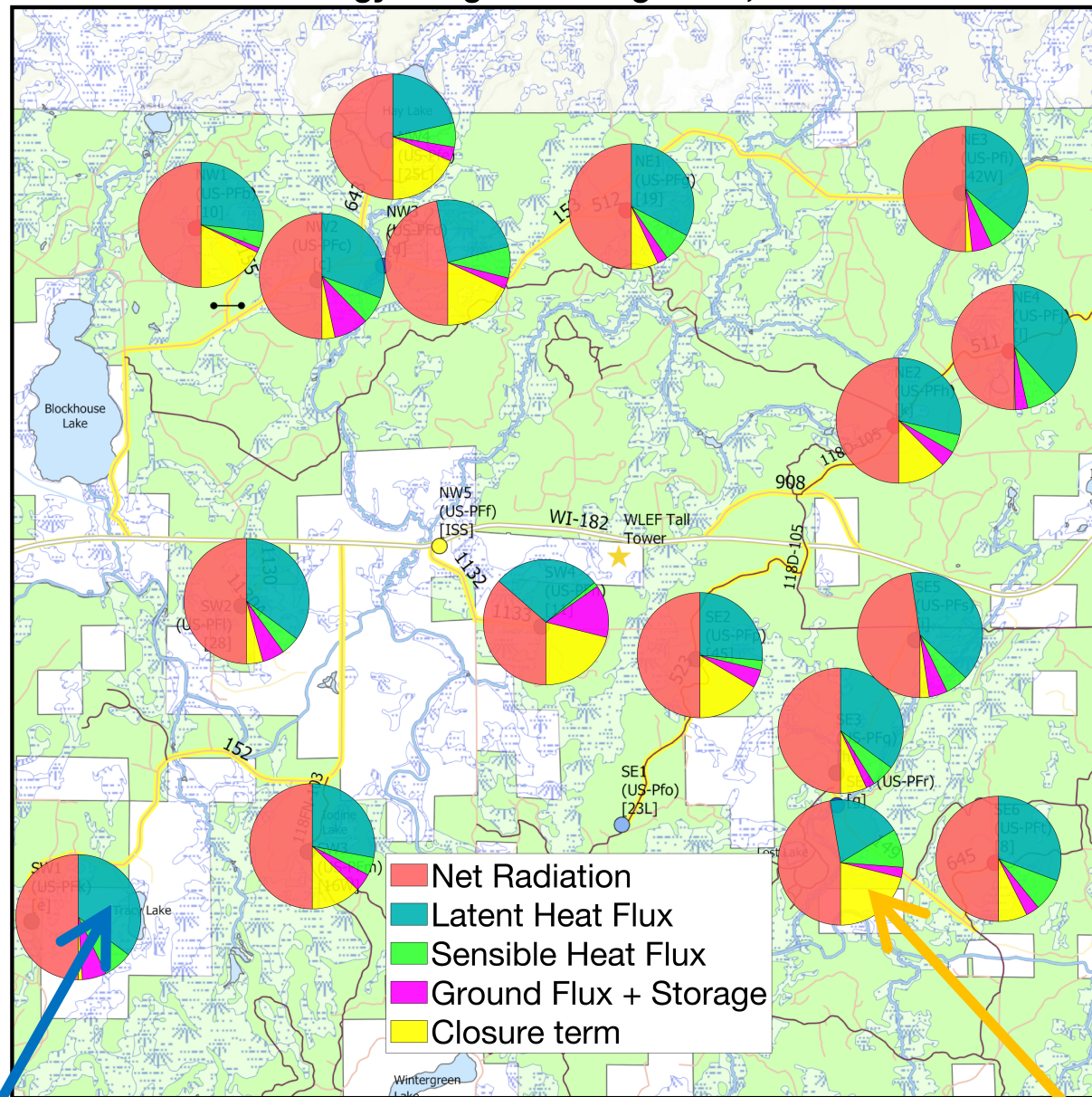








## Energy Budgets on August 22, 2019

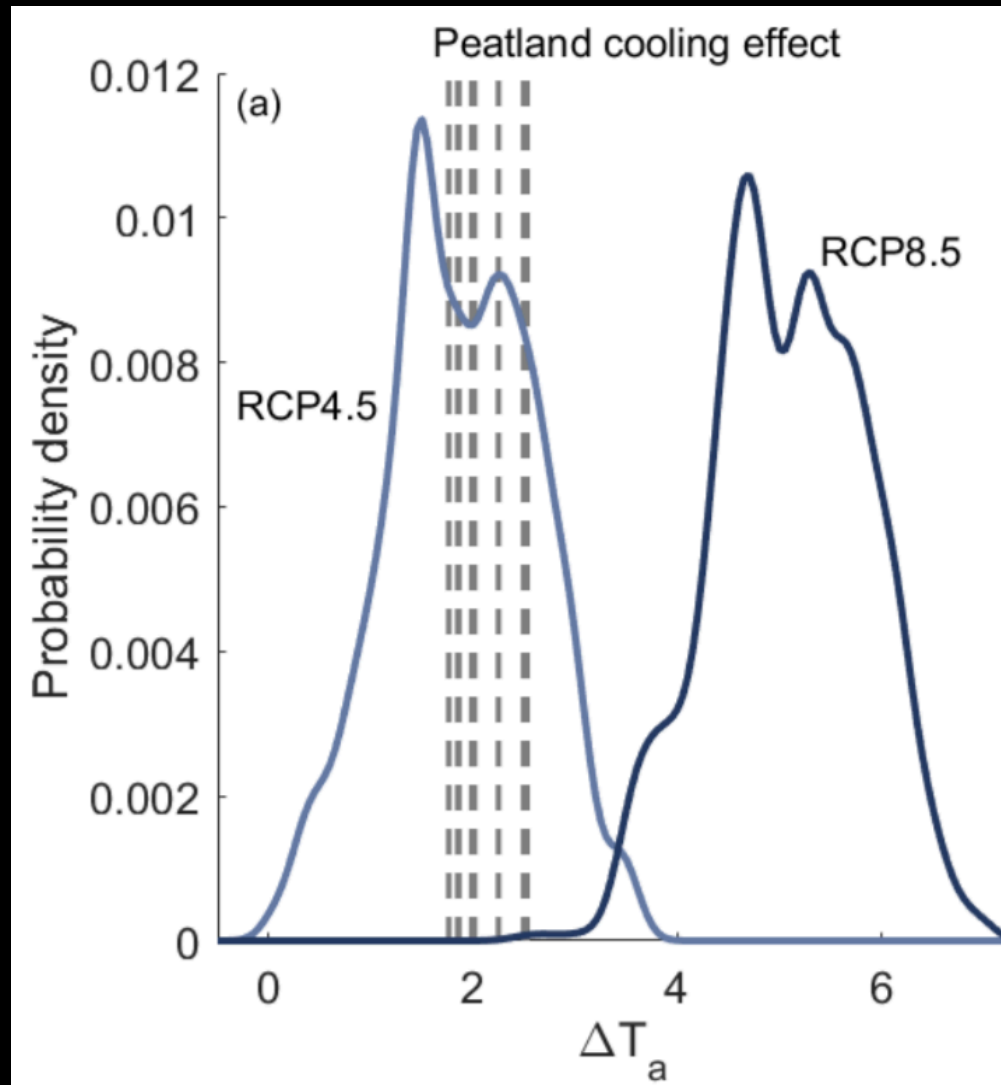


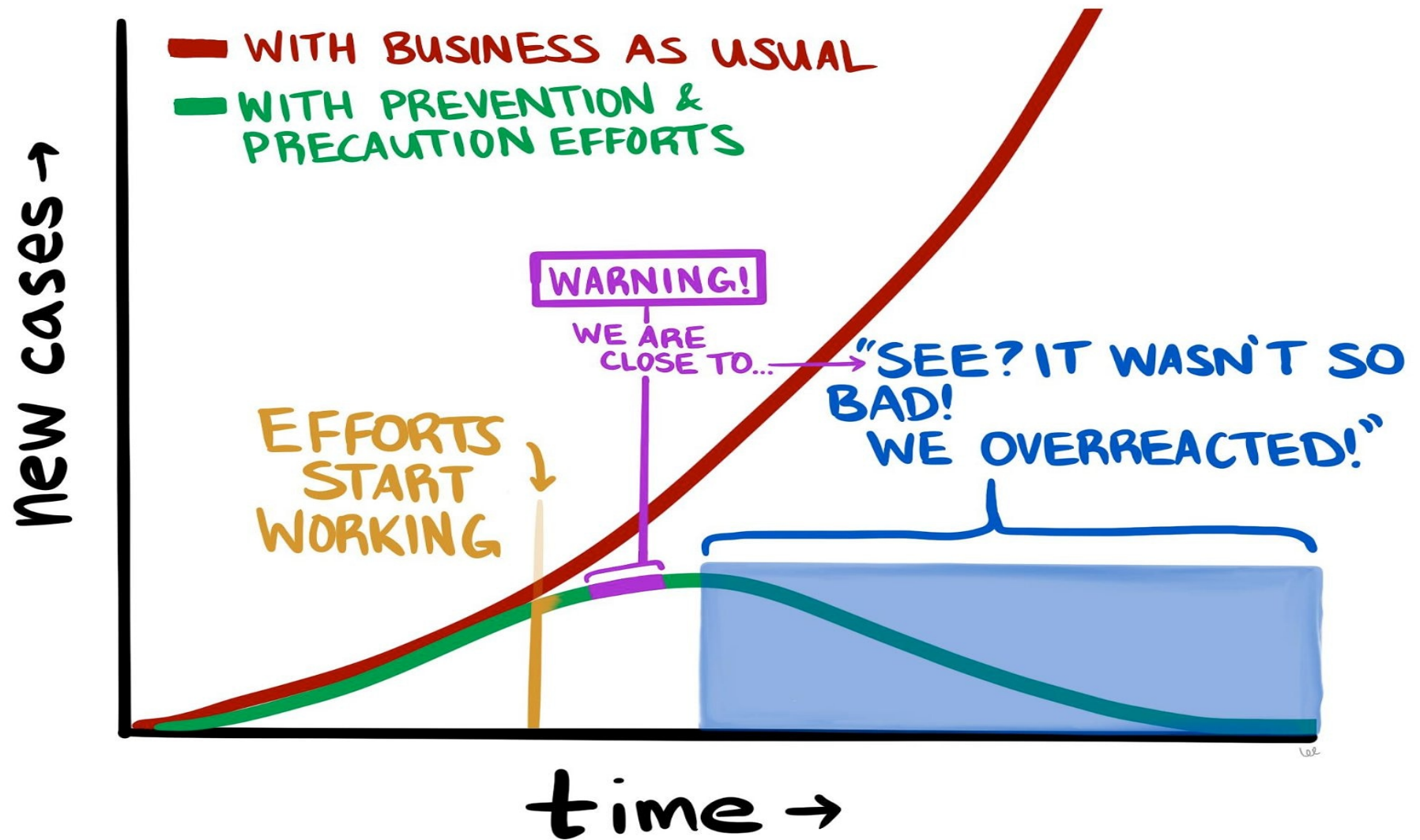
How much energy is used by plants to transpire water

Energy we don't know where it's going!



**Peatland wetlands, by having higher albedo (brighter), and begin windier, and wetter, use more energy to transpire water instead of heat air, and can offset local warming effects**







# DOWNTOWN MADISON INFORMATION

Love  
is greater than  
fear.

Please Respect  
This Space  
Reserved



# Thank you!

Ankur Desai

[desai@aos.wisc.edu](mailto:desai@aos.wisc.edu)

<https://flux.aos.wisc.edu>

@profdesai

Photo: A. Desai