UNC RESEARCH

UNIVERSITY Research WEEK

Lunch & Learn

Health and Heat

Presented by the Office of the Vice Chancellor for Research and UNC Gillings School of Global Public Health

Health and Heat Panel

Panel Emcee: Rebecca Fry

Chair (Interim), and Carol Remmer Angle Distinguished Professor in Children's Environmental Health, Department of Environmental Sciences and Engineering, UNC Gillings School of Global Public Health; Director, Institute for Environmental Health Solutions, UNC Gillings School of Global Public Health

Jason West

Professor and Director of Graduate Studies, Department of Environmental Sciences and Engineering, UNC Gillings Schools of Global Public Health

Noah Kittner

Assistant Professor, Department of Environmental Sciences and Engineering, UNC Gillings School of Global Public Health

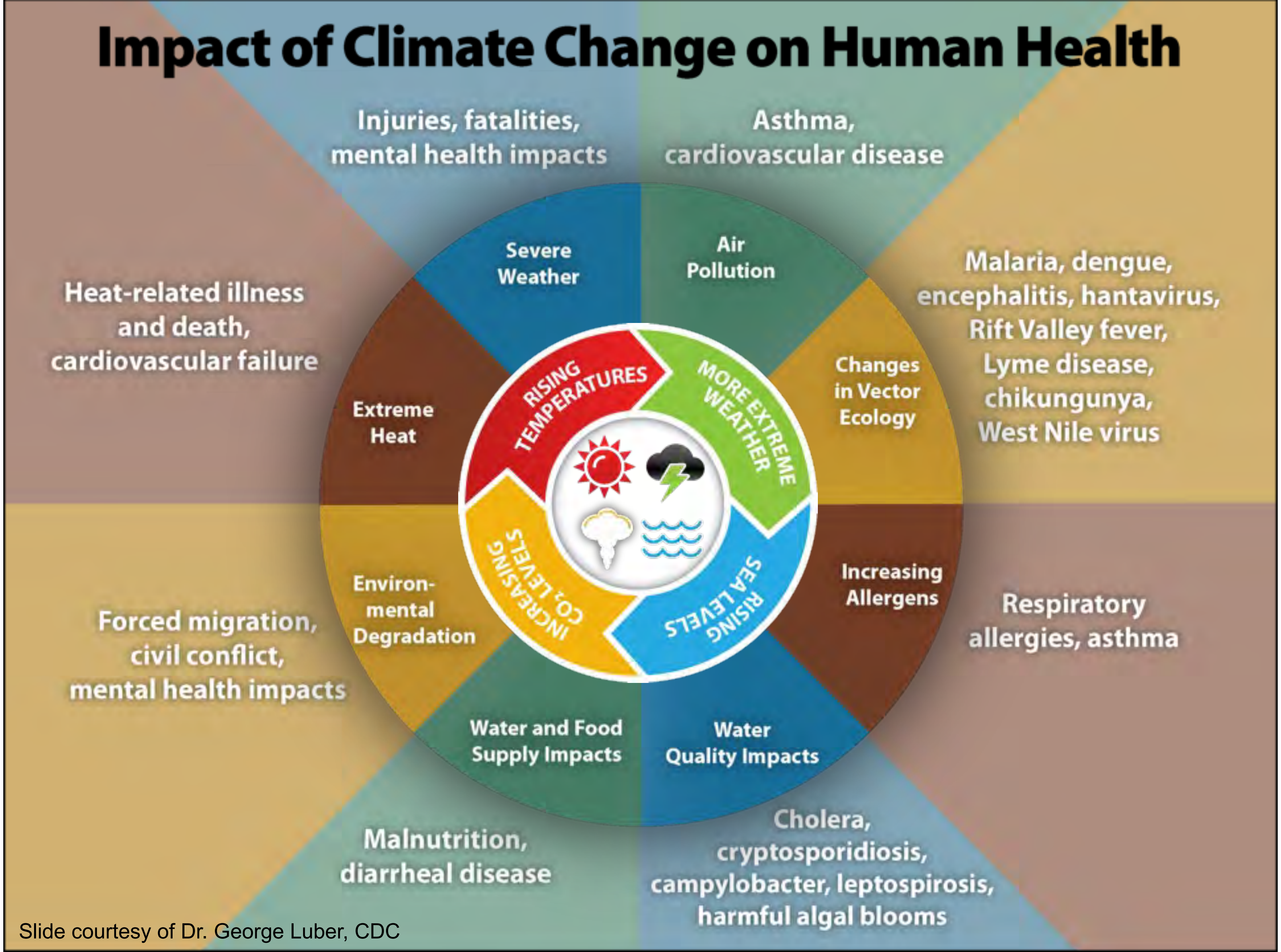
Hans Paerl

Professor, Department of Environmental Sciences and Engineering, UNC Gillings School of Global Public Health; Professor, Department of Marine Sciences, UNC College of Arts and Sciences; W.R. Kenan Jr. Distinguished Professor, UNC Institute of Marine Sciences

Lunch & Learn

Jason West

Professor and Director of Graduate Studies, Department of Environmental Sciences and Engineering, UNC Gillings Schools of Global Public Health



Slide courtesy of Dr. George Luber, CDC

Lunch & Learn


THE LANCET

"Climate change is the biggest global health threat of the 21st century."

2009:
"Climate change is the biggest global health threat of the 21st century"

"More challenging to public health than the polio epidemics… This is a new kind of threat" – US Surgeon General Vivek Murthy, 2016

Global Burden of Disease of Air Pollution (2019)

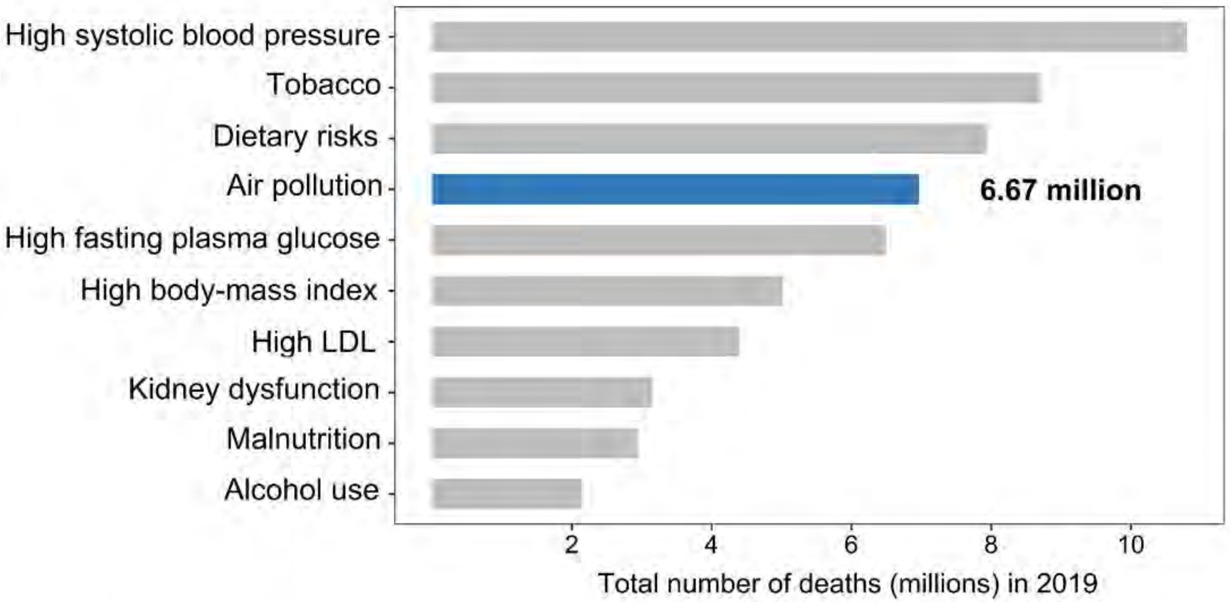
Global Deaths per Year

Ambient $PM_{2.5}$ pollution: 4.1 million

Ambient ozone pollution: 0.37 million

Household air pollution from solid fuels: 2.3 million

1 of every 8.5 deaths globally!



Global ranking of risk factors by total number of deaths from all causes in 2019.

GBD 2019 Team, *Lancet*, 2020

UNC RESEARCH

Global deaths from air pollution in 2019: 6.7 million (1 of every 8.5 deaths)

Compare to:

Diabetes

All transportation accidents

Tuberculosis

HIV

Breast cancer

Malaria

Prostate cancer

Global deaths from air pollution in 2019:
6.7 million (1 of every 8.5 deaths)

Compare to:

Diabetes	1.55 million
All transportation accidents	1.28 million
Tuberculosis	1.18 million
HIV	0.86 million
Breast cancer	0.70 million
Malaria	0.64 million
Prostate cancer	0.49 million
	6.7 million

Connections Between Air Pollution and Climate Change

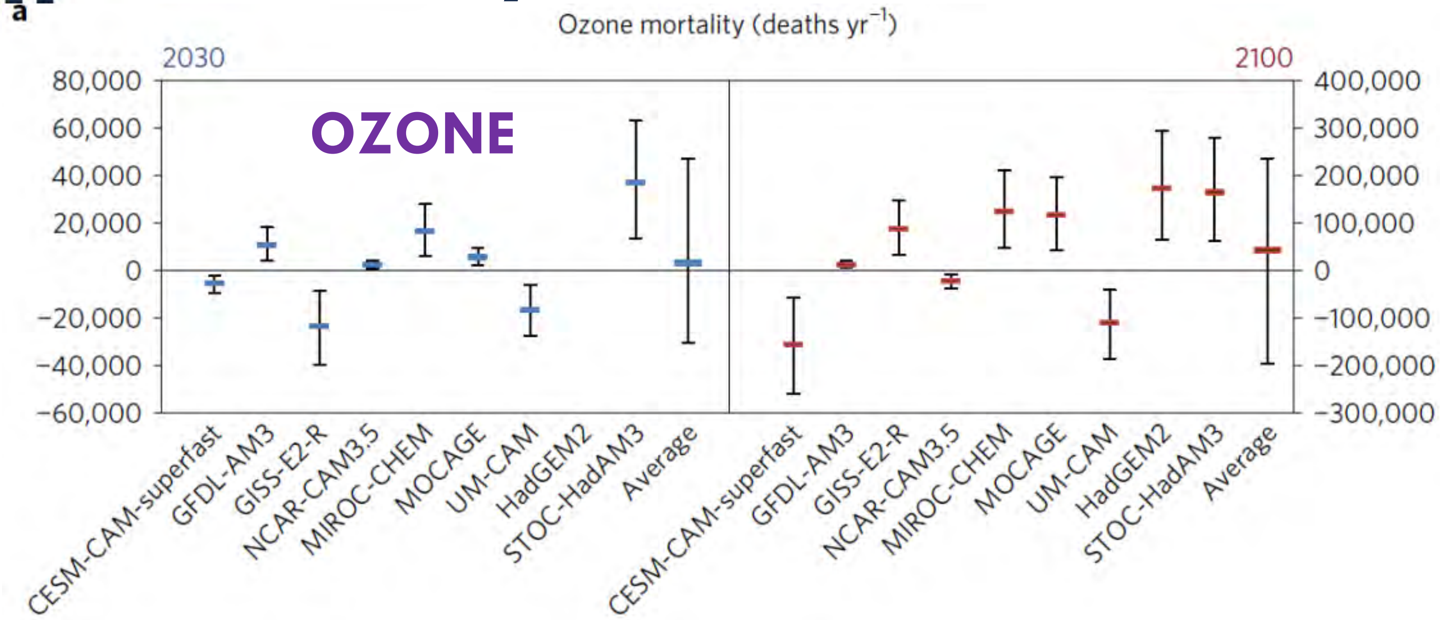
1) Several air pollutants affect climate
   - Ozone (O_3) is a greenhouse gas (GHG)
   - Aerosols scatter and absorb sunlight, and affect clouds.

2) Changes in climate may affect air quality (of O_3, PM, or other pollutants).

3) Sources of air pollutants and GHGs are shared – fossil fuel combustion.

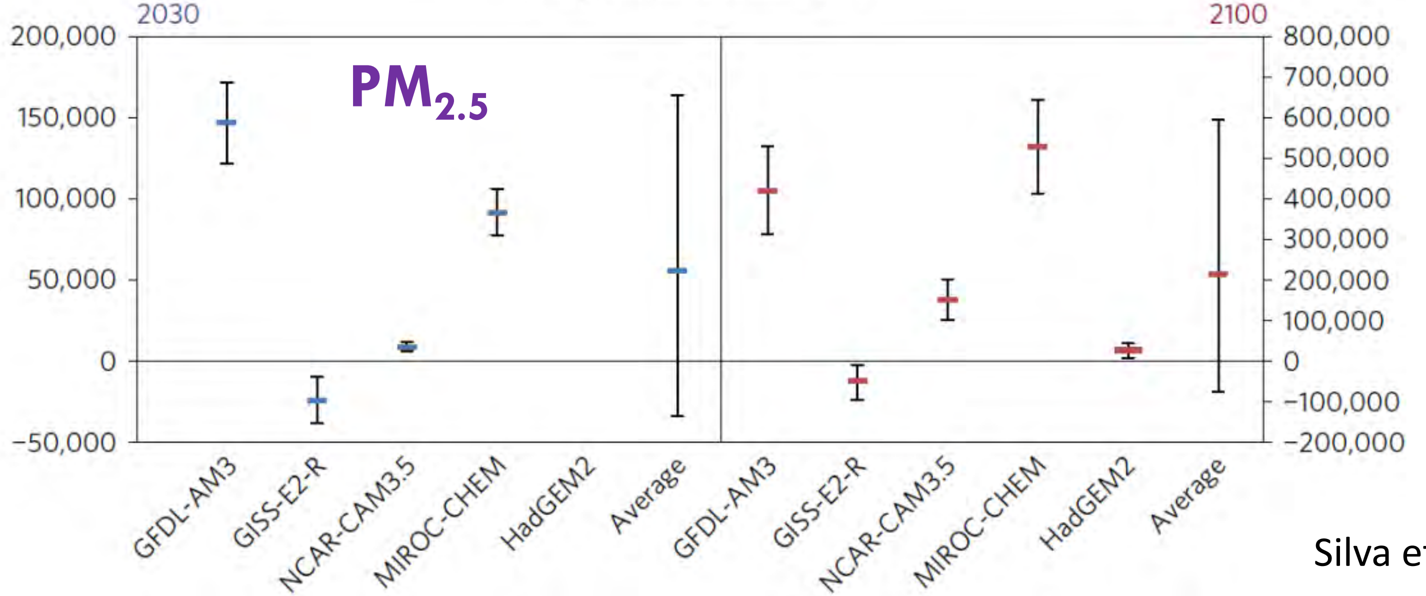
4) Climate change may influence demands for energy, and therefore emissions.

Impact of Climate Change on Global Air Pollution Mortality



Mean (95% CI) (deaths yr^{-1})
2030
3,000
(-30,000, 47,000)
2100
44,000
(-195,000, 237,000)

For RCP8.5 climate change



Mean (95% CI) (deaths yr^{-1})
2030
56,000
(-34,000 , 164,000)
2100
215,000
(-76,000 , 595,000)

Silva et al. *Nat Clim Ch*, 2017

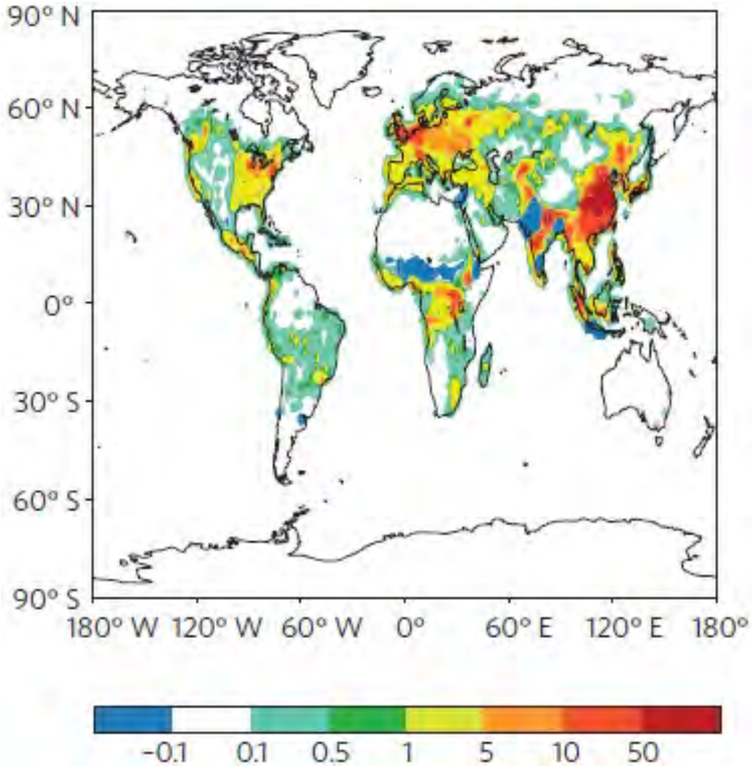
Lunch & Learn

University Research Week

UNC Research

Co-benefits of Global GHG Mitigation for Air Quality & Health

Avoided air pollution-related deaths from global GHG reductions:



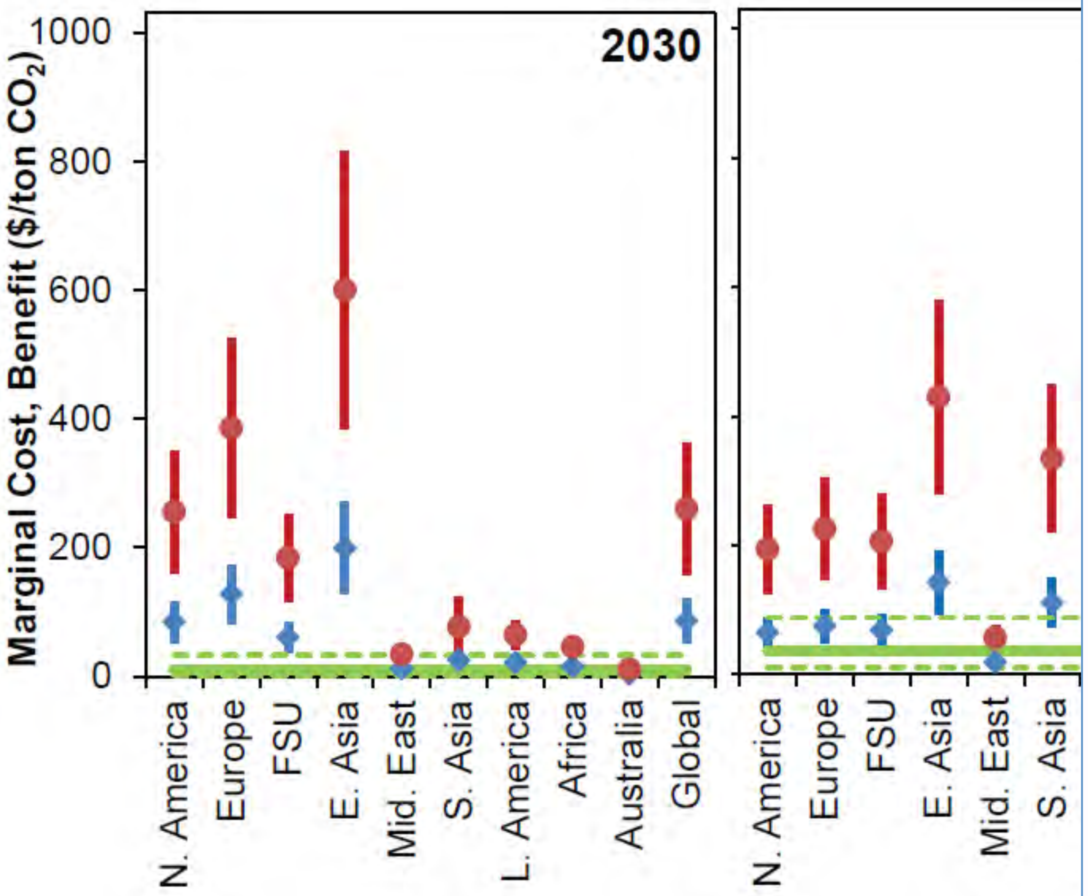
Projection of global population and baseline mortality rates from International Futures.

$PM_{2.5}$ co-benefits
(CPD + lung cancer mortality)
2030: 0.4±0.2 million yr^{-1}
2050: 1.1±0.5
2100: 1.5±0.6

Ozone co-benefits
(respiratory mortality)
2030: 0.09±0.06
2050: 0.2±0.1
2100: 0.7±0.5

West et al. *Nat Clim Ch* 2013

Co-benefits of Global GHG Mitigation for Air Quality & Health



Health benefits in 2030 (per ton CO_2):

USA:	$70 to $480
China:	$130 to $840
World:	$60 to $370

Costs of control in 2030:

$0 to $33

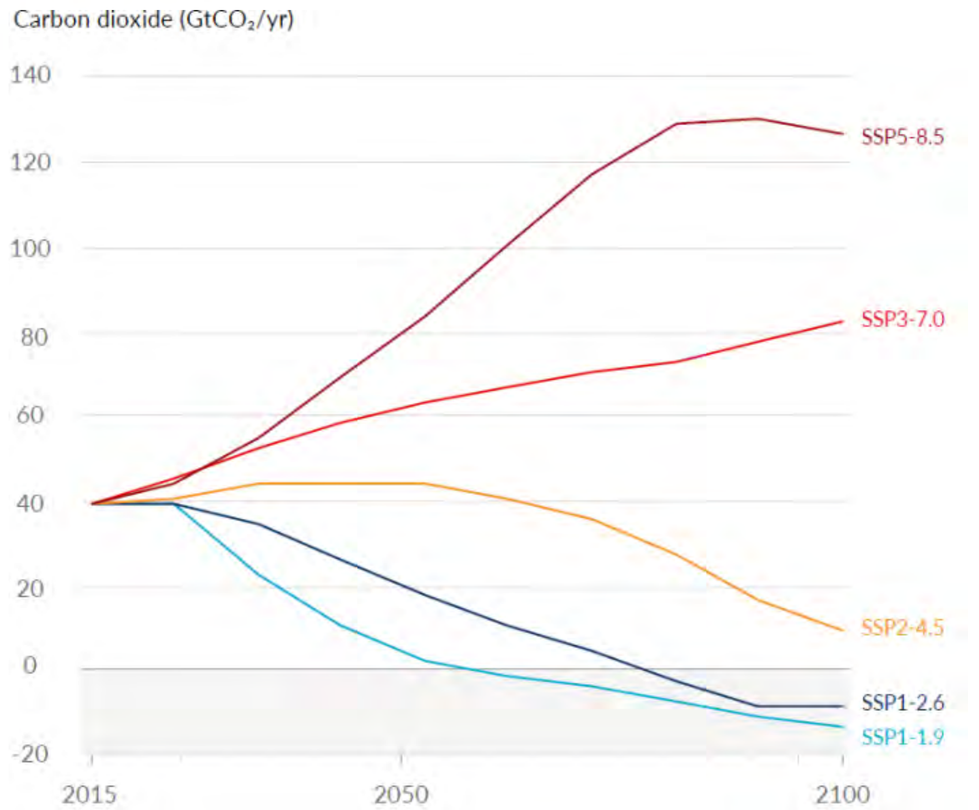
Red: High valuation (2030 global me

Blue: Low valuation (2030 global me

Green: Median and range of global C price (13 models)

West et al. *Nat Clim Ch* 2013

Opportunity to plan for Climate and Air Quality goals simultaneously



Climate change:

Reduce GHG emissions to near zero this century

Air pollution:

New WHO guidelines likely can not be met with much fossil fuel use

Lunch & Learn

Thank you!

Contact Jason West at
jjwest@email.unc.edu
Website: west.web.unc.edu
Twitter/X: @ProfJasonWest

Lunch & Learn

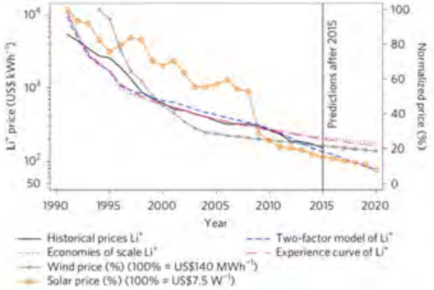
Noah Kittner

Assistant Professor, Department of Environmental Sciences and Engineering, UNC Gillings School of Global Public Health

Lunch & Learn

Sustainable and Resilient Energy Group

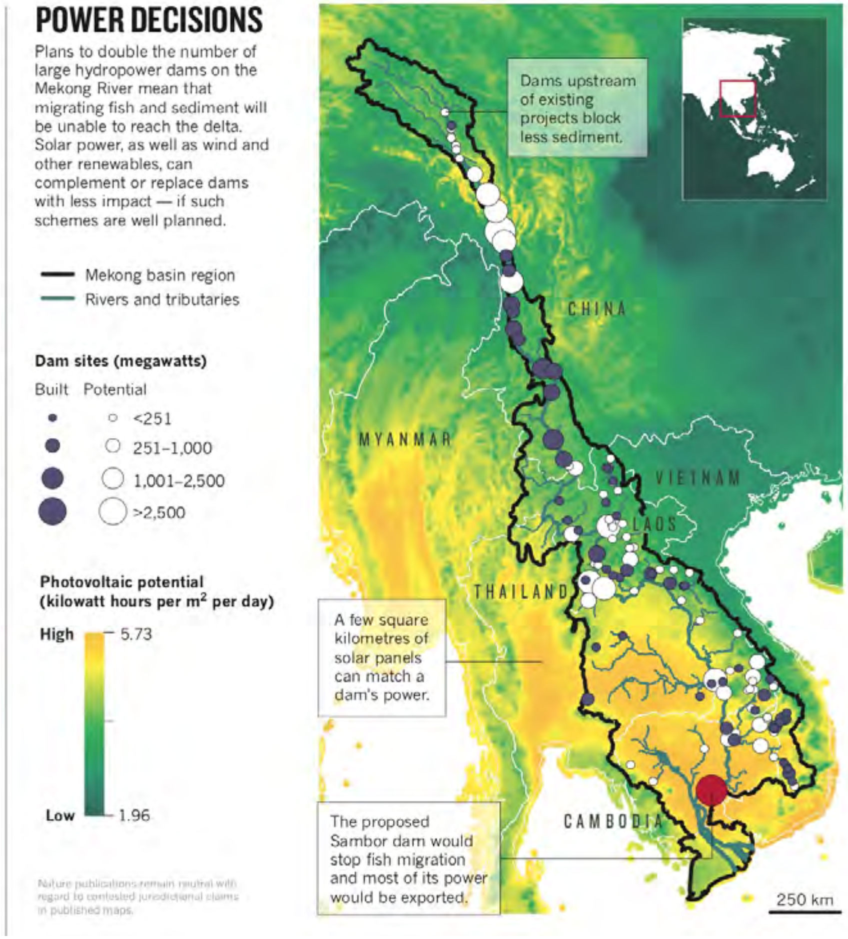
Dr. Noah Kittner



Planning for low-carbon, healthy, resilient energy systems

Distributed solar energy and electric vehicle modeling – cost, sustainability, systems integration, climate, health

Innovation for decarbonization and a just transition



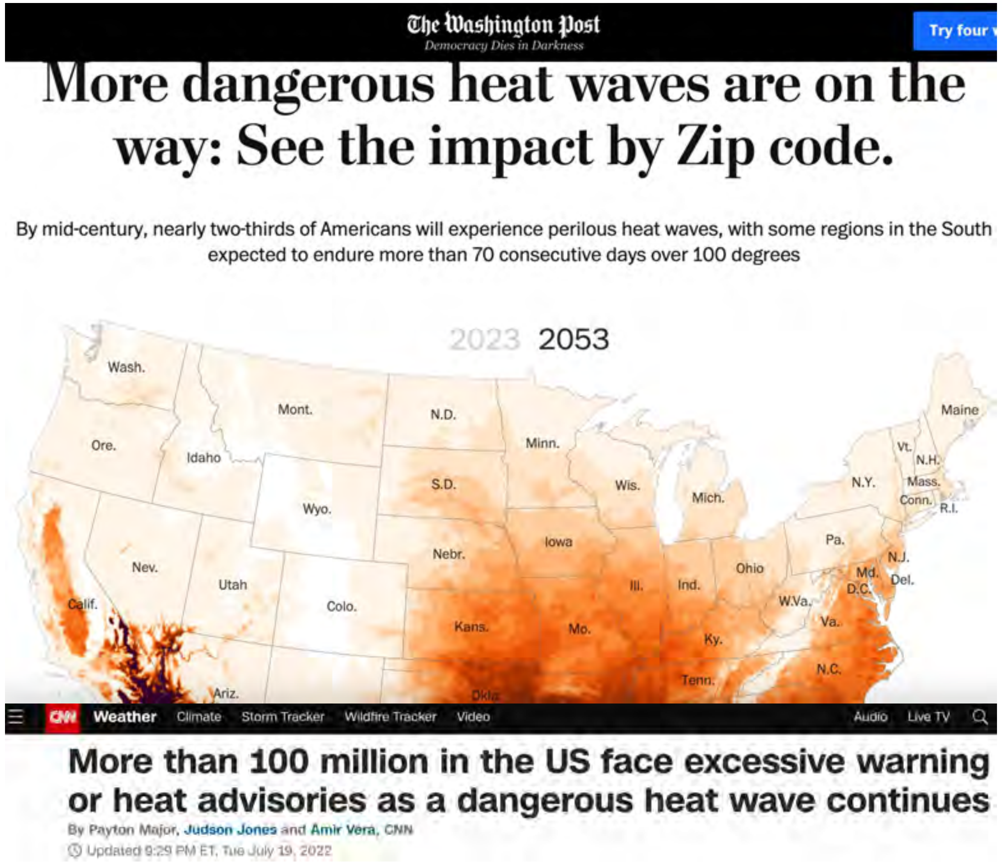
Schmitt, R.J.P., Kittner, N., Kondolf, G.M.. Kammen, D.M. *Nature* **569** 330-332

UNIVERSITY Research WEEK

UNC RESEARCH

Lunch & Learn

Changing Climate



- Anthropogenic greenhouse gases, especially CO_2, generated from fossil fuels
- Increased frequency and intensity of extreme weather
- Question: How do we build energy and public health resilience to extreme heat?

Lunch & Learn

Household Energy Consumption

Lunch & Learn

Extreme Events Increasing

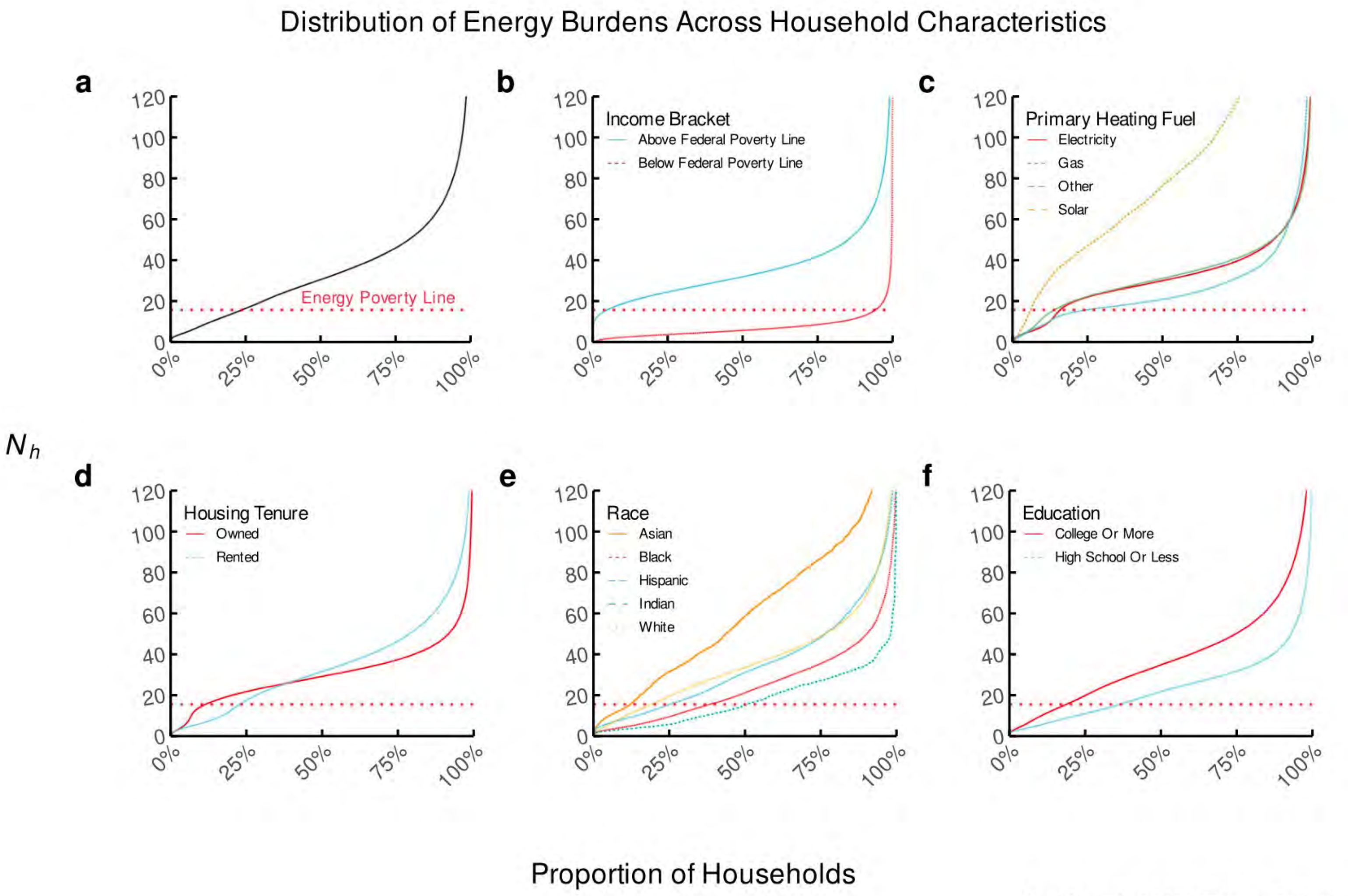
Genaro Molina / Los Angeles Times via Getty Images

https://blog.sentry-equip.com/prevent-pipeline-freezing

US Household Energy Burdens

More than 5.2 million households above Federal Poverty Line face energy poverty (Scheier & Kittner, 2022)

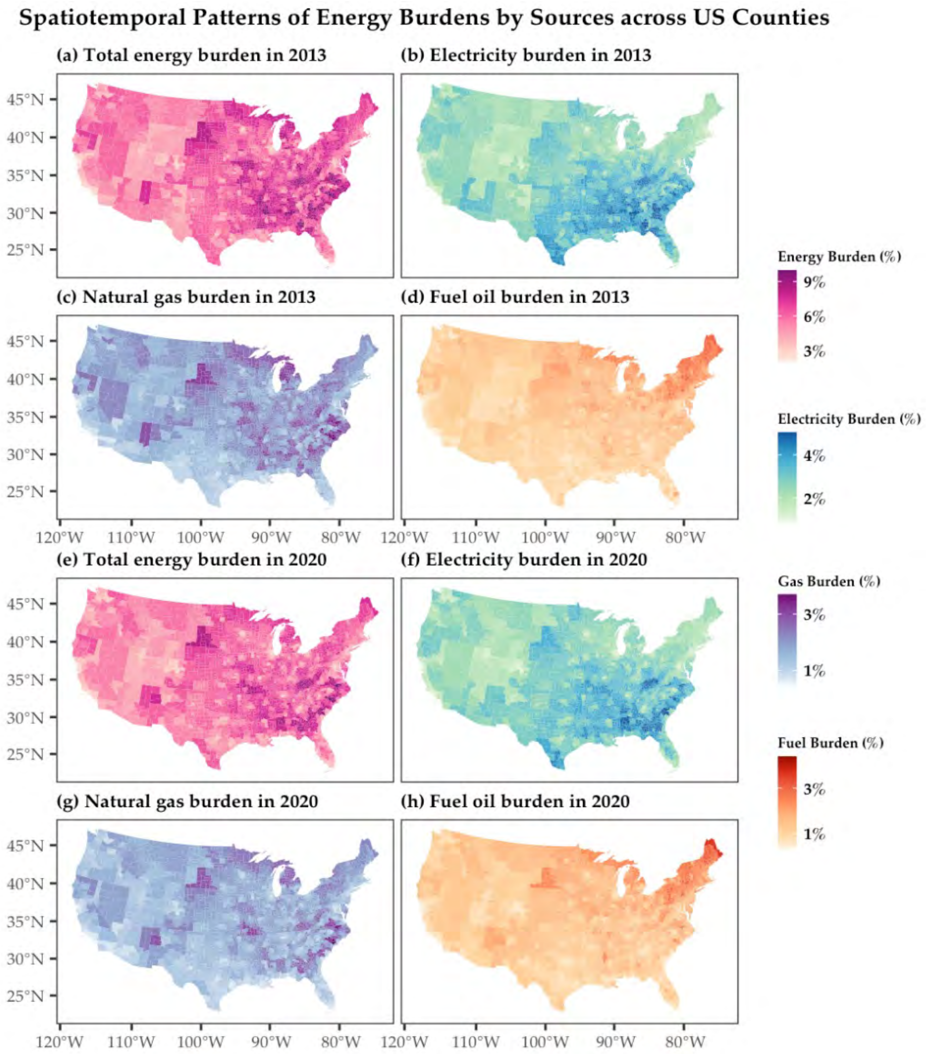
Households and Energy Poverty



Scheier & Kittner (2022)
Nature Communications

N_h : Household Net Energy Return

Energy Burden and Heat



Yu & Kittner (*forthcoming*) Env. Research Letters

Lunch & Learn

Green Energy and Reducing Health Risk

Health Challenges

Cardiopulmonary risks

Heat stress and heat-related mortality more deaths than other severe weather events

Poor ventilation and air quality

Fire safety due to fossil fuel infrastructure and pipeline delivery

Potential solutions

Inflation Reduction Act = $$ Heat Pump Tax Credits

Electrification could induce new challenges and risks => Energy storage solutions

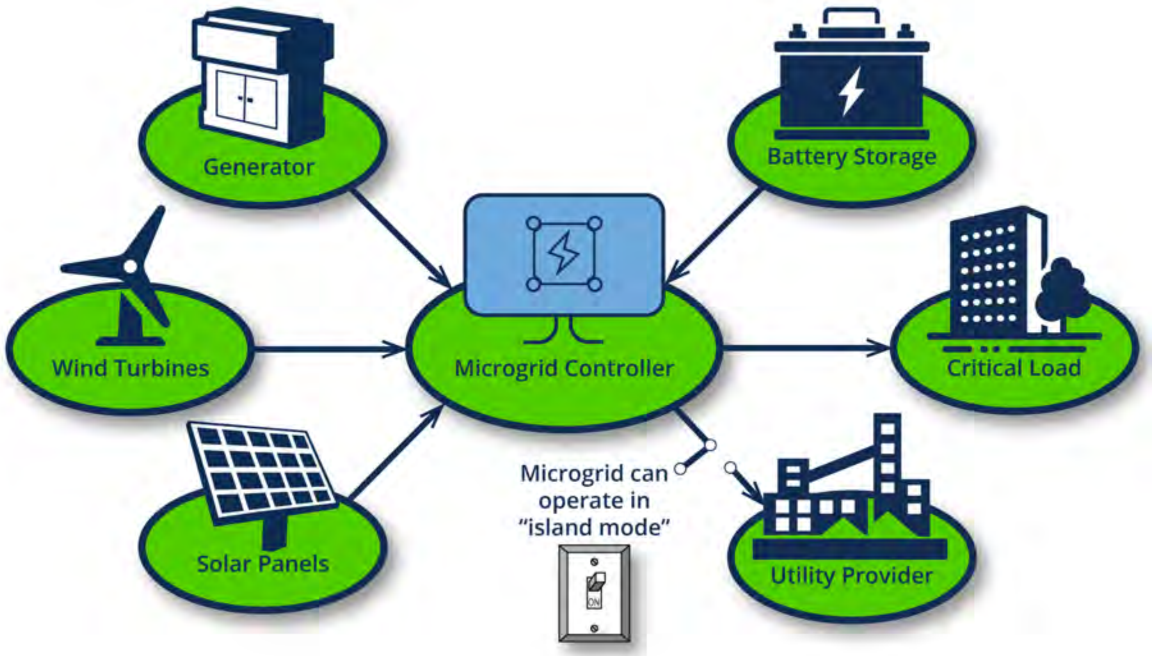
Potential Solutions

Energy storage systems for grid resilience

- Electric school buses
- Long-duration flow batteries
- Lithium-ion

Microgrid solutions

- Virtual Power Plants
- Home battery backup + solar power



Thank you!

Contact Noah Kittner at
kittner@email.unc.edu

Lunch & Learn

Hans Paerl

Professor, Department of Environmental Sciences and Engineering, UNC Gillings School of Global Public Health; Professor, Department of Marine Sciences, UNC College of Arts and Sciences; W.R. Kenan Jr. Distinguished Professor, UNC Institute of Marine Sciences

University Research Week

UNC Research

Lunch & Learn

Proliferating Harmful Cyanobacterial Blooms in a World Facing Human Perturbation and Climate Change

Hans Paerl, UNC-Ch EMES/Instit. of Marine Sciences and Dept. of Environmental Sciences and Engineering











UNIVERSITY Research WEEK

UNC RESEARCH

Cyanobacterial Harmful Blooms (CyanoHABs): Symptomatic of human and climatic alteration of aquatic environments

Urban, agricultural and industrial expansion

↓

Increasing nutrient (Nitrogen & Phosphorus) inputs

↓

Water use, hydrologic modification and climate change (warming. more extreme wet/dry cycles) play interactive roles

↓

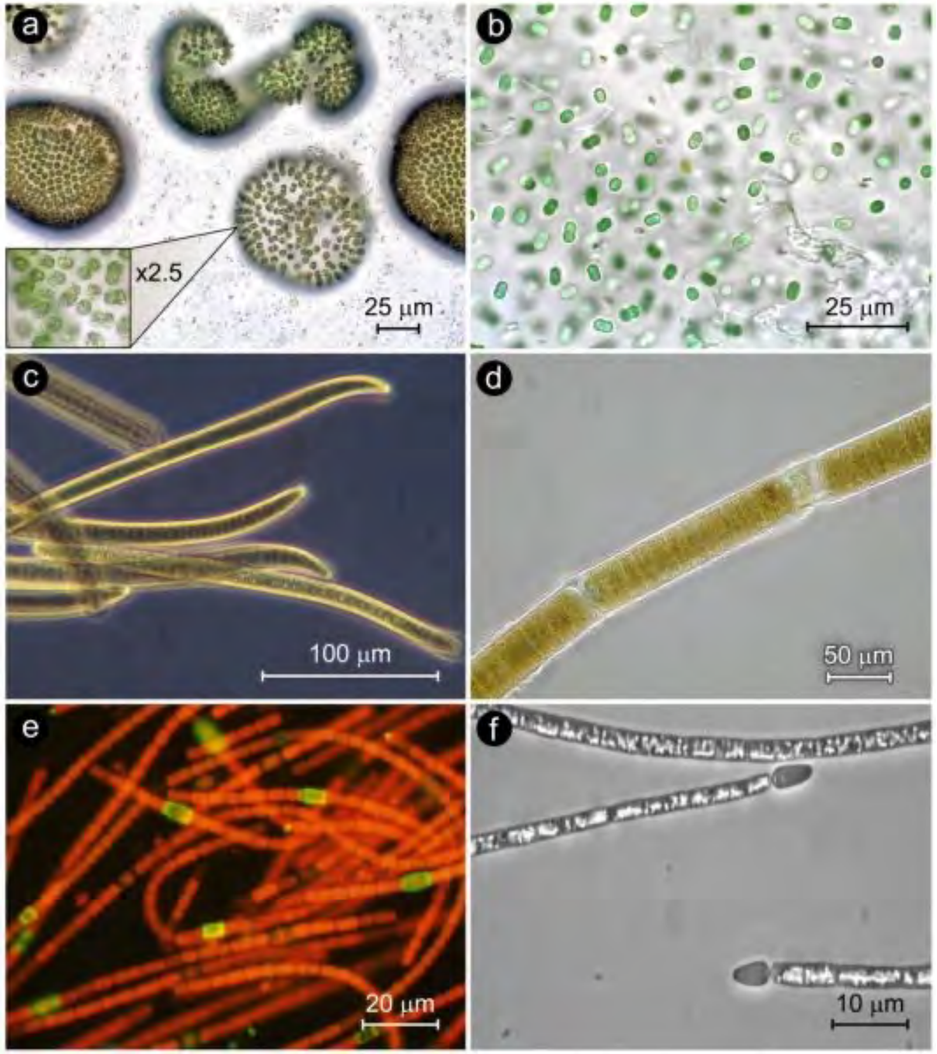
Blooms are intensifying and spreading

The CyanoHAB "Players" and their toxins

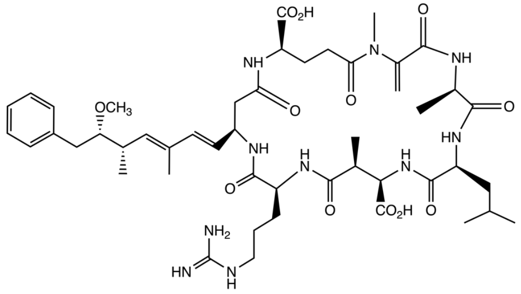
Coccoid, solitary/colonial (e.g. *Microcystis* & picocyanos). Most do not fix N_2

Filamentous, non-heterocystous (e.g. *Lyngbya, Oscillatoria*). Some species fix N_2

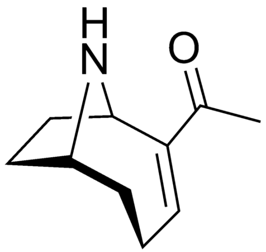
Filamentous, heterocystous (e.g. *Dolichospermum, Nodularia, Cylindrospermopsis*). All fix N_2



Common Cyanotoxins



Microcystins, liver/digestive toxin



Anatoxin a, neurotoxin

Lunch & Learn

Why the concern about CyanoHABs?

- Toxic to zooplankton, fish, shellfish, domestic animals and humans
- Cause hypoxia and anoxia, leading to fish kills
- Odor and taste problems
- loss of drinking water recreational, fishing use/sustainability


TRIBUNE

It's back to class for St. Lucie students

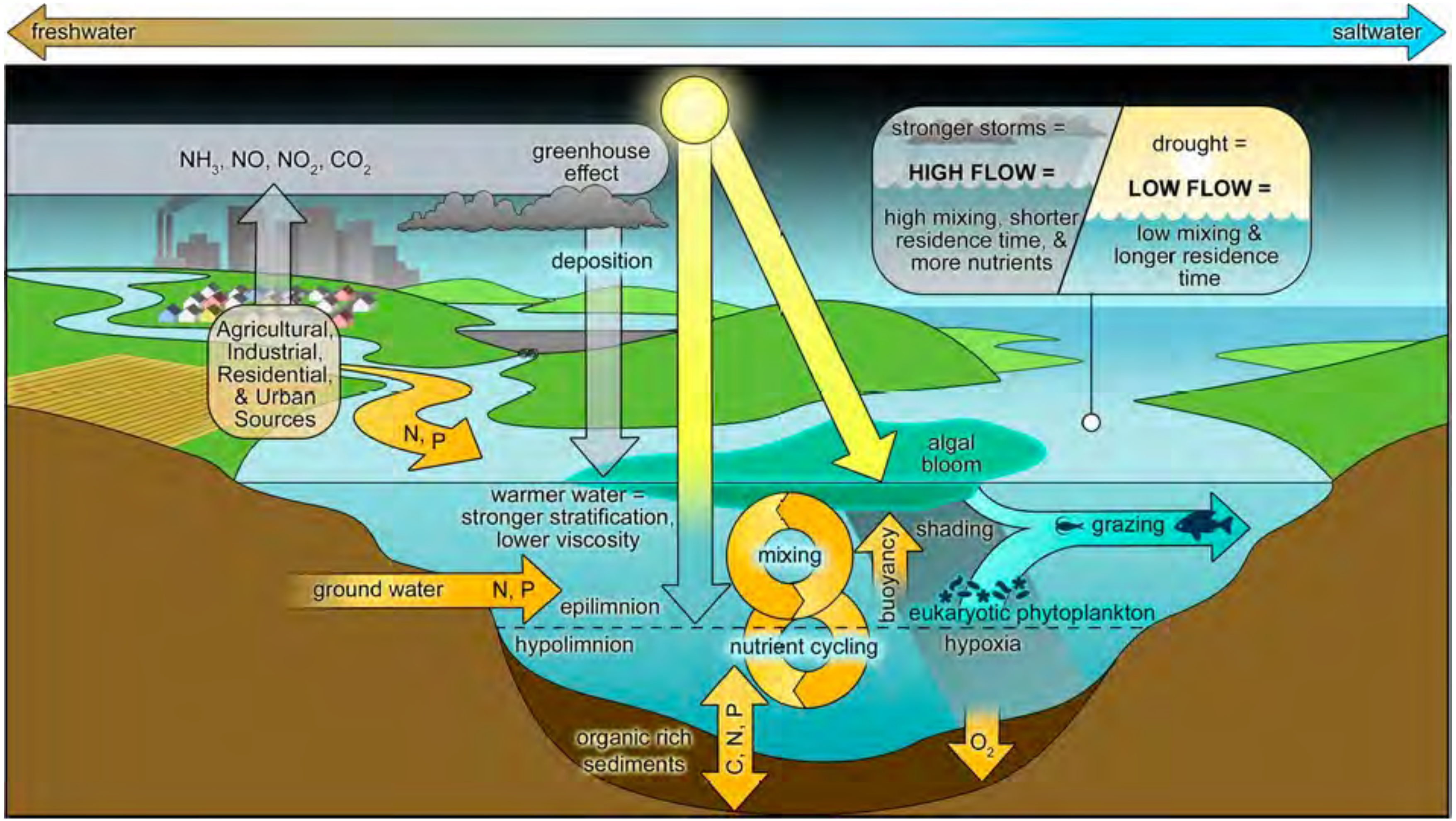
Ewww! River's a 'mess'

Energy bill not a quick fix, says Bush at signing

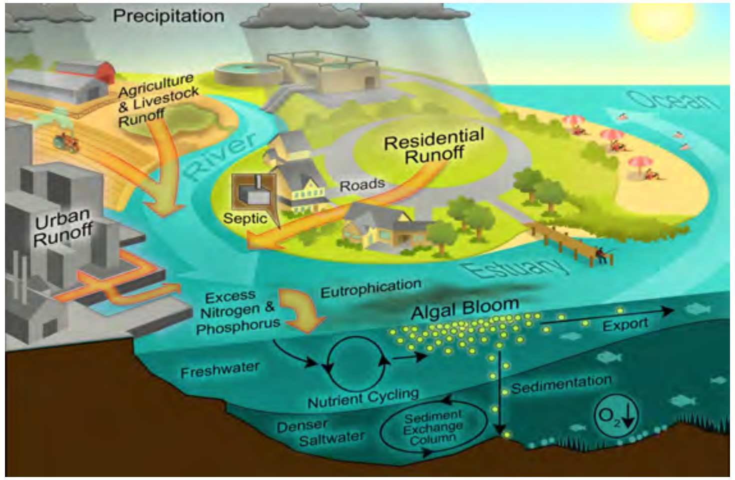
UNIVERSITY Research WEEK

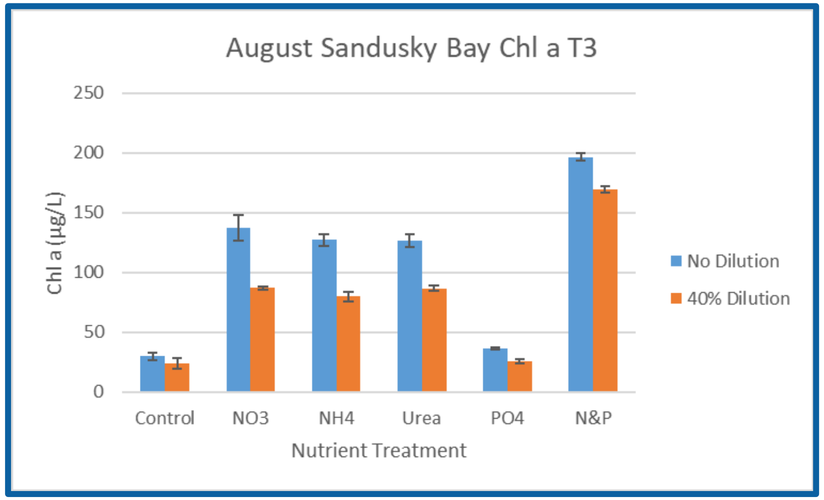
UNC RESEARCH

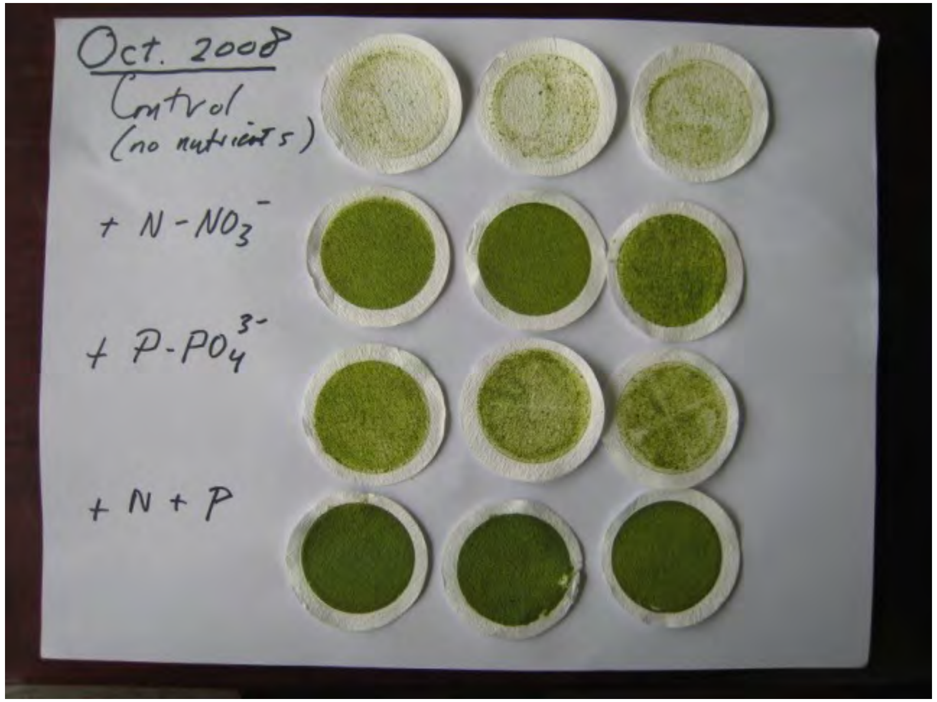
What drives CyanoHABs? Interactive physical, chemical and biotic factors



Human nutrient enrichment: A key driver of CyanoHABs

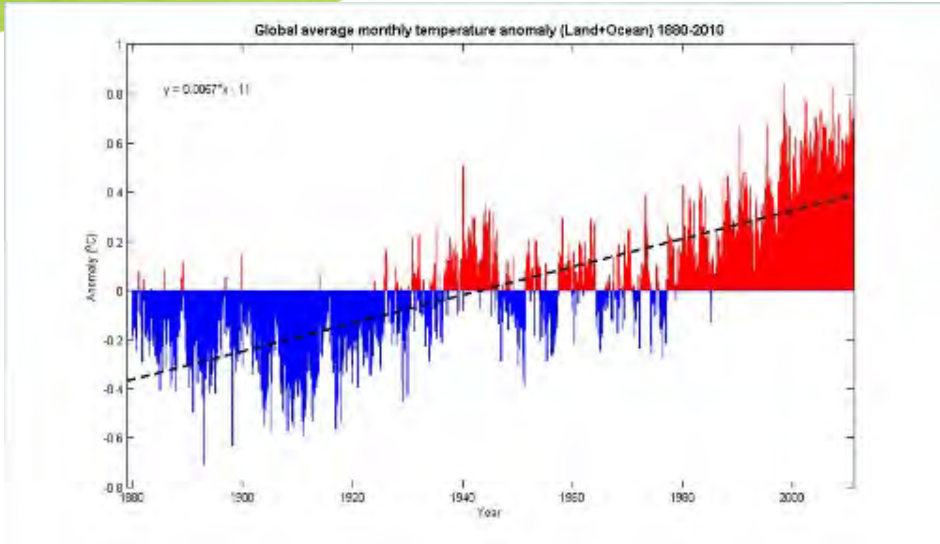




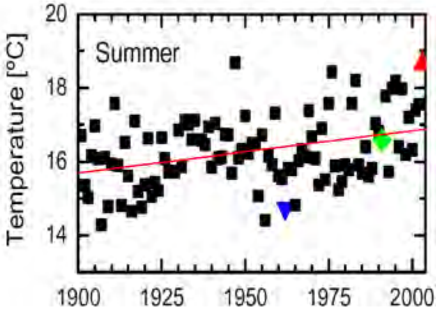


Paerl et al. 2018; Barnard et al. 2021

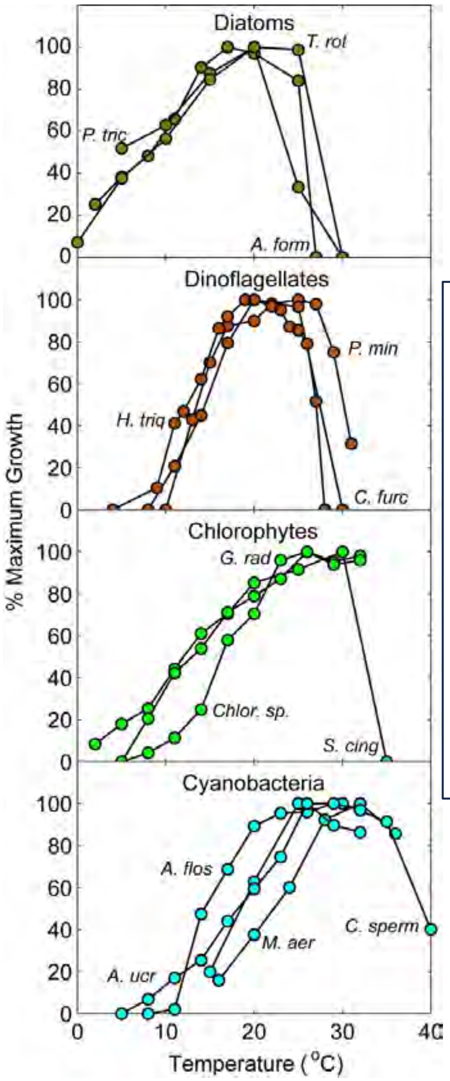
Also: Its Getting Warmer, and CyanoHABs “like it hot”



2003 hottest summer in 500 years in Europe! Since then, record heat waves. 2005, 2009, 2014, 2016, 2018, 2020, 2023 were the hottest summers ever in N. America. 2010, 2017, 2022 hottest year in central Asia



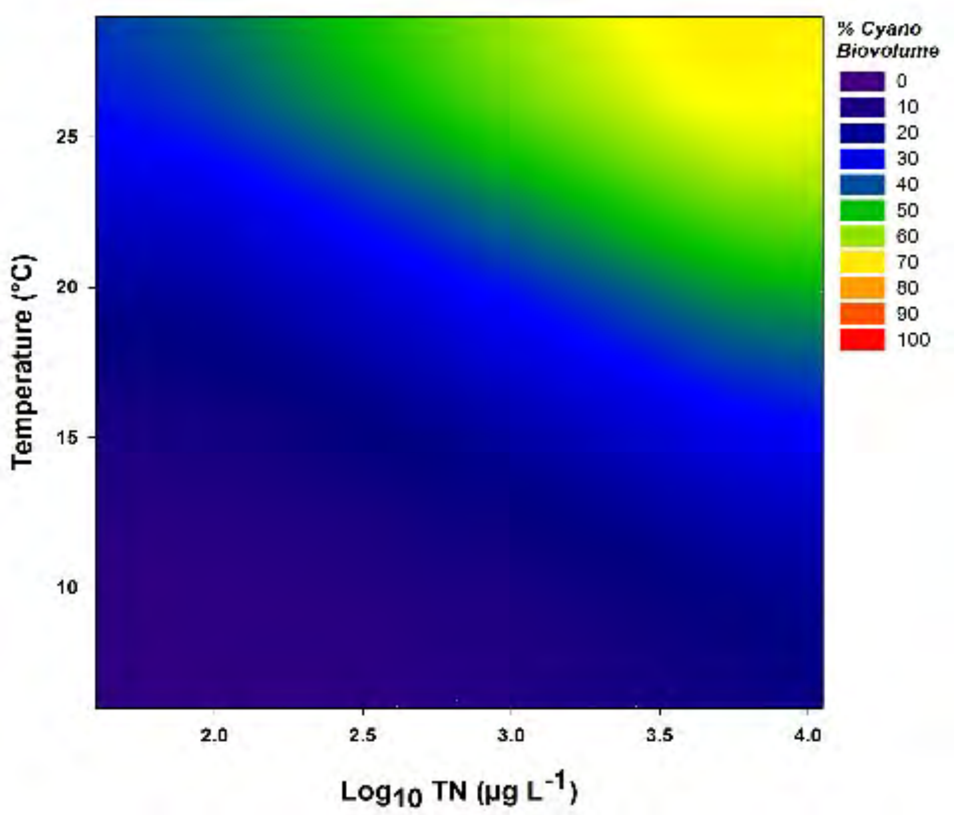
Huisman et al. 2006
Mean epilimnetic
Temp.In Dutch lakes

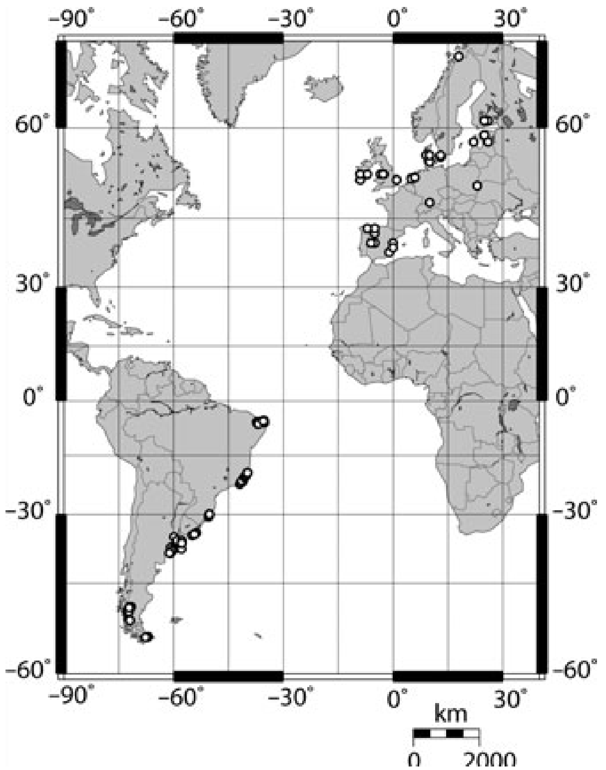


Cyanobacteria exhibit
Maximum growth rates
At high water temperatures
Relative to other algal groups

Paerl and Huisman 2008
Paerl et al. 2011

Cyanobacterial dominance along temperature & nutrient (TN) gradients in 143 lakes

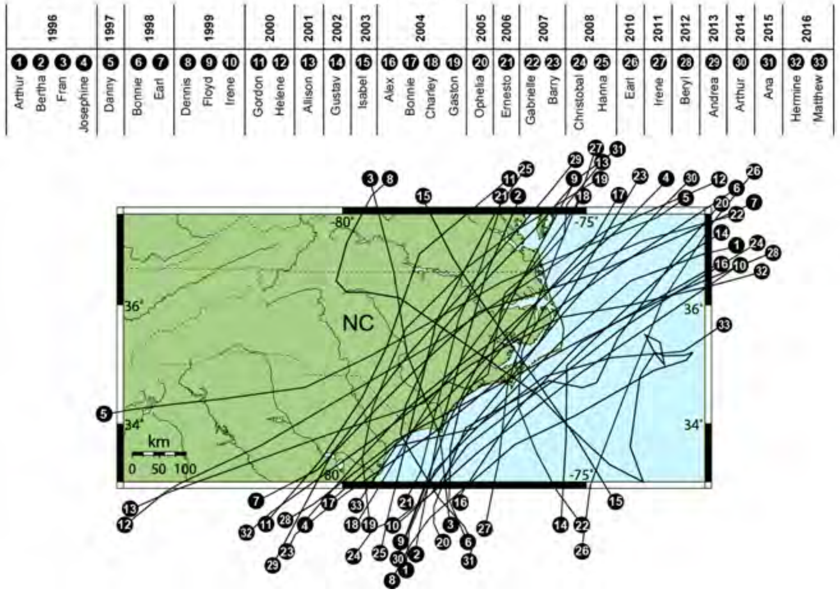




Percentage of cyanobacterial biovolume in phytoplankton communities as a function of water temperature and nutrients in 143 lakes along a climatic gradient in Europe and South America.
(a)Combined effects of temperature and nutrients as captured by a logistic regression model
(b) Response surface obtained from interpolation of the raw data using inverse distance weighting.

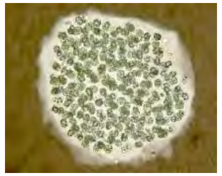
Data replotted from Kosten et al. (2011). Global Change Biology DOI: 10.1111/j.1365-2486.2011.02488.x

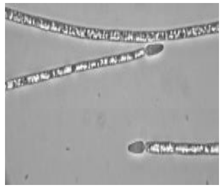
CyanoHAB expansion into NC's Albemarle Sound is promoted by more extreme events (tropical cyclones),elevated nutrient discharge followed by droughts



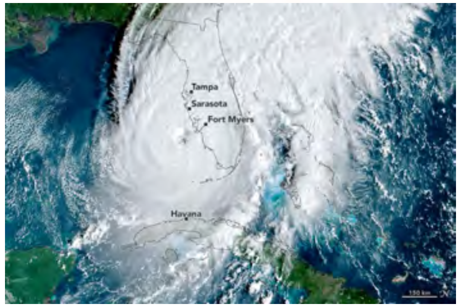
Paerl et al., 2018

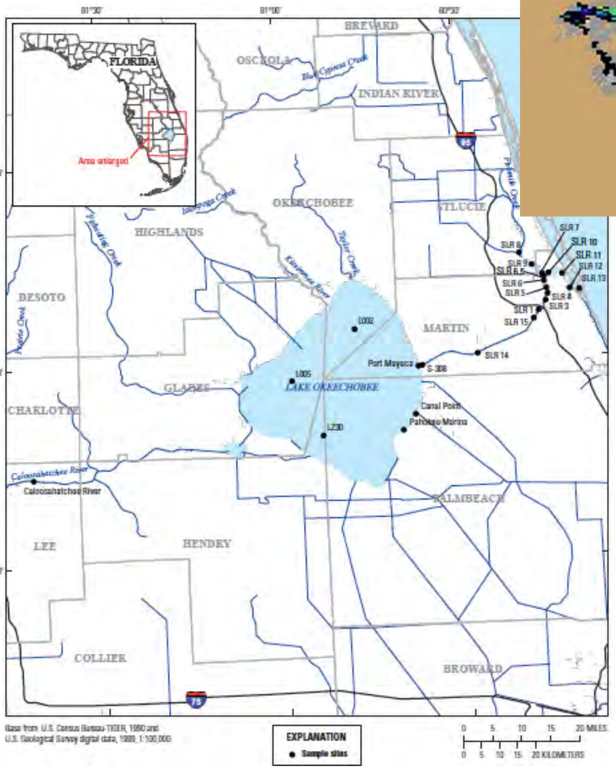
Image from Cyanobacteria Assessment Network:
EPA/NASA/NOAA/USGS
(epa.gov/cyanoproject)

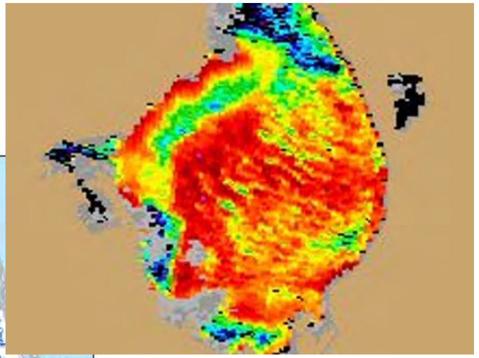




CyanoHABs on the move: Lake Okeechobee to Florida's East/West Coasts (2016)



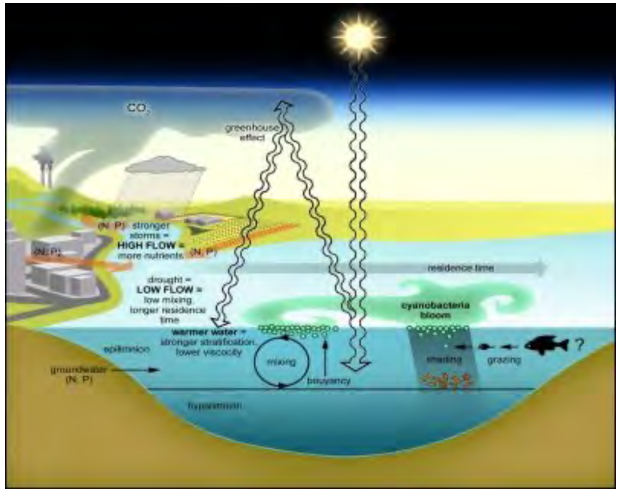




Rosen et al., 2017: Cyanobacteria of the 2016 Lake Okeechobee and Okeechobee Waterway harmful algal bloom USGS Open-File Report 2017-1054

Lunch & Learn

Recommendations for CyanoHAB Management in an era of human nutrient over-enrichment and climatic changes

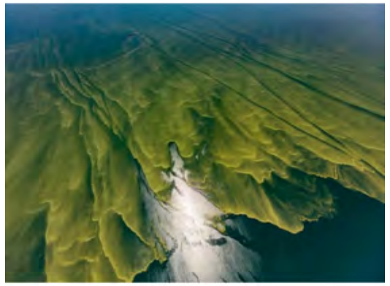


Reduce <u>both</u> N & P inputs along the freshwater-to-marine continuum

- Nutrient-bloom threshold are system-specific
  - However, in many cases >30% reductions should be targeted
- Salinity is not necessarily a barrier to CyanoHAB expansion
- May need to reduce N and P inputs even more in a warmer, stormier world
  - Blooms "like it hot"
  - Episodic & extreme events favor CyanoHABs (floods, droughts)

Impose nutrient input restrictions year-round

- Residence time is long in large lakes and coastal waters (> 6 months)
- Warmer, longer growing seasons (earlier ice off, later ice on)



University Research Week
NSF
NIH NIEHS
GREAT LAKES CENTER FOR FRESH WATERS AND HUMAN HEALTH AT BOWLING GREEN STATE UNIVERSITY BGSU
NC Environmental Quality
Sea Grant North Carolina

Thank you!

Contact Hans Paerl at hpaerl@email.unc.edu

Lab website: paerllab.web.unc.edu

UNIVERSITY Research WEEK

Lunch & Learn

UNC | RESEARCH

Thank you for participating in this Lunch & Learn presentation

UNC-Chapel Hill students, please scan the QR-code above to receive your CLE credit