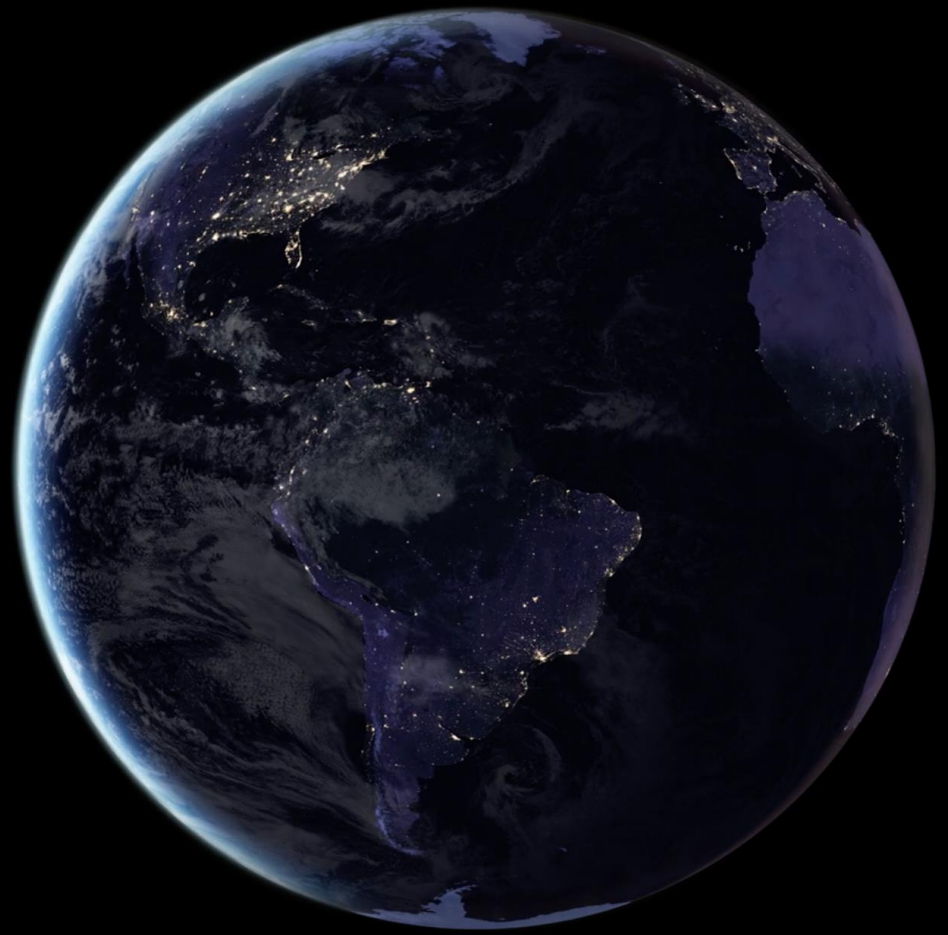
Changing Climate as Seen from Space

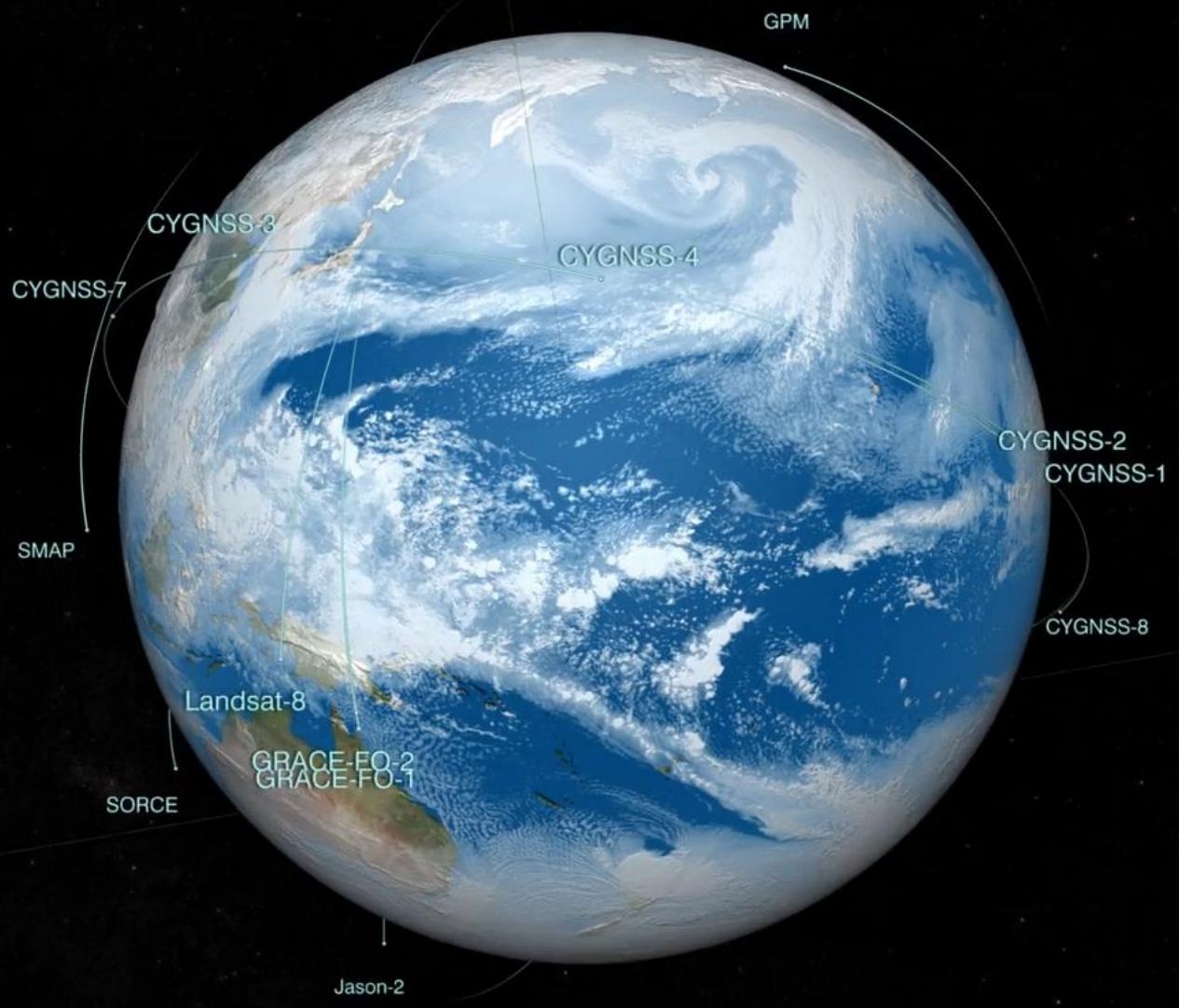
Implications for Public Health



- Water & Food Security
- Disasters
- Climate Applications
- Air Quality & Public Health
- Sustainable Development
- New Missions
- Chesapeake Bay

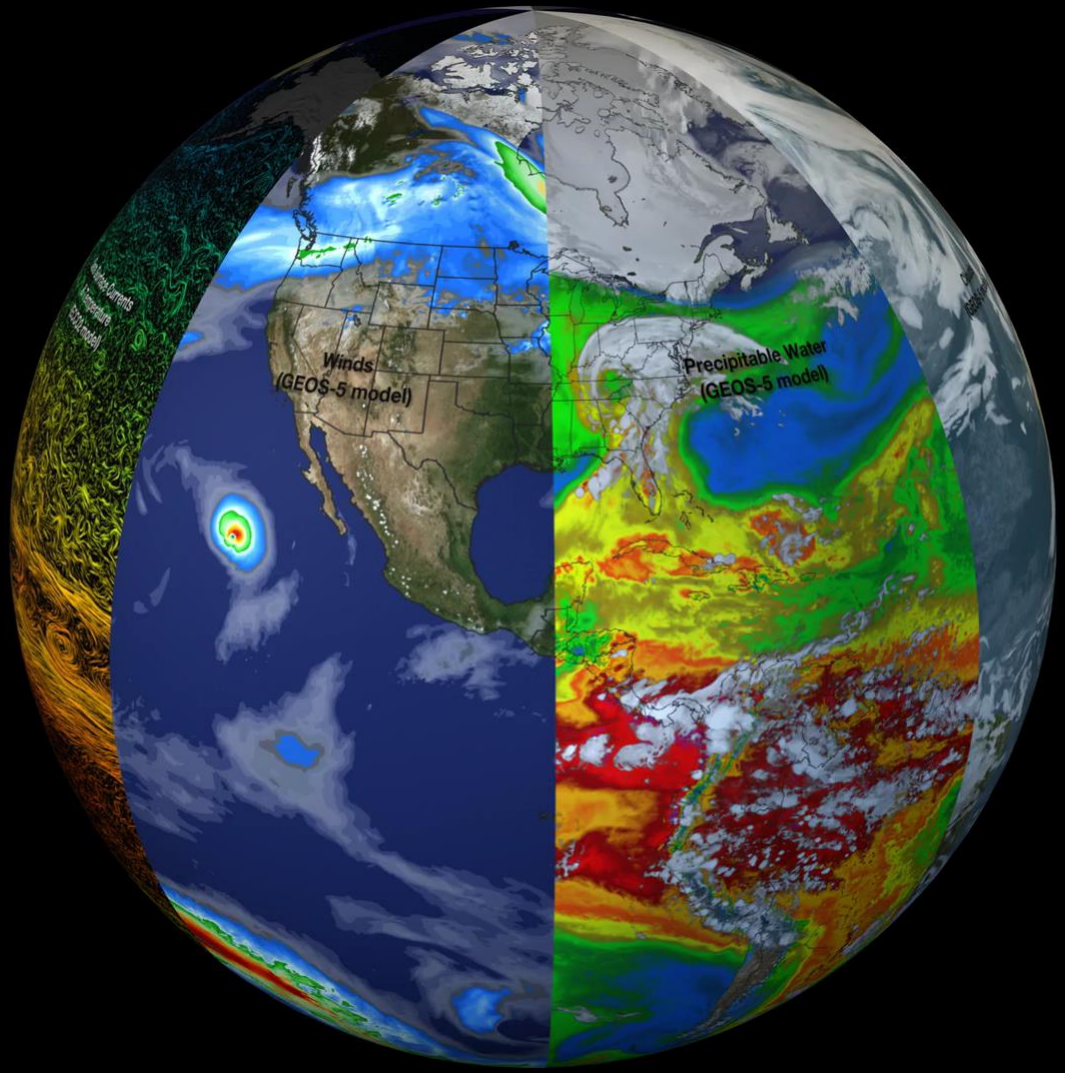
Stephanie Schollaert Uz, PhD
Applied Sciences Manager, NASA Goddard

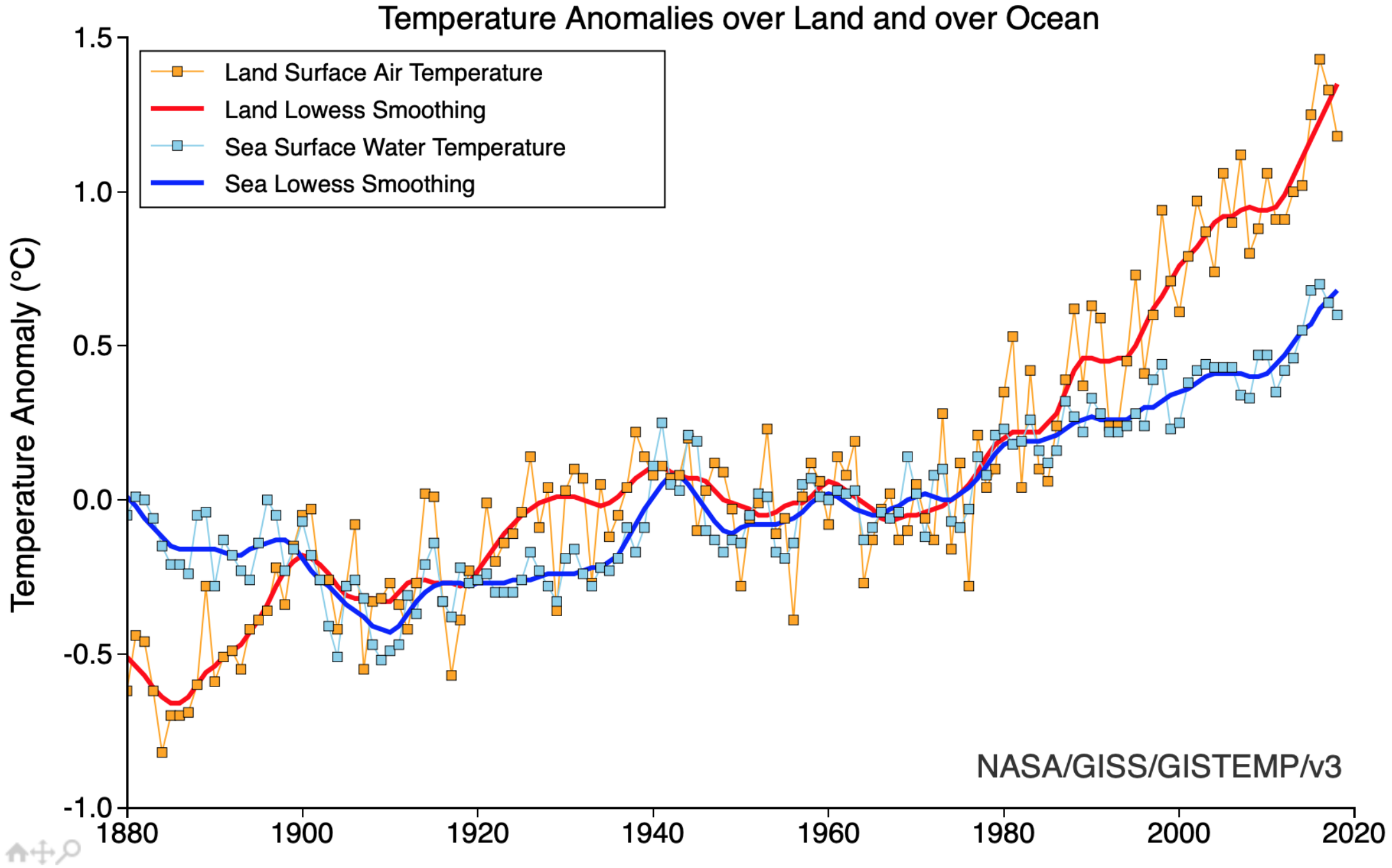
Earth Observing Satellites



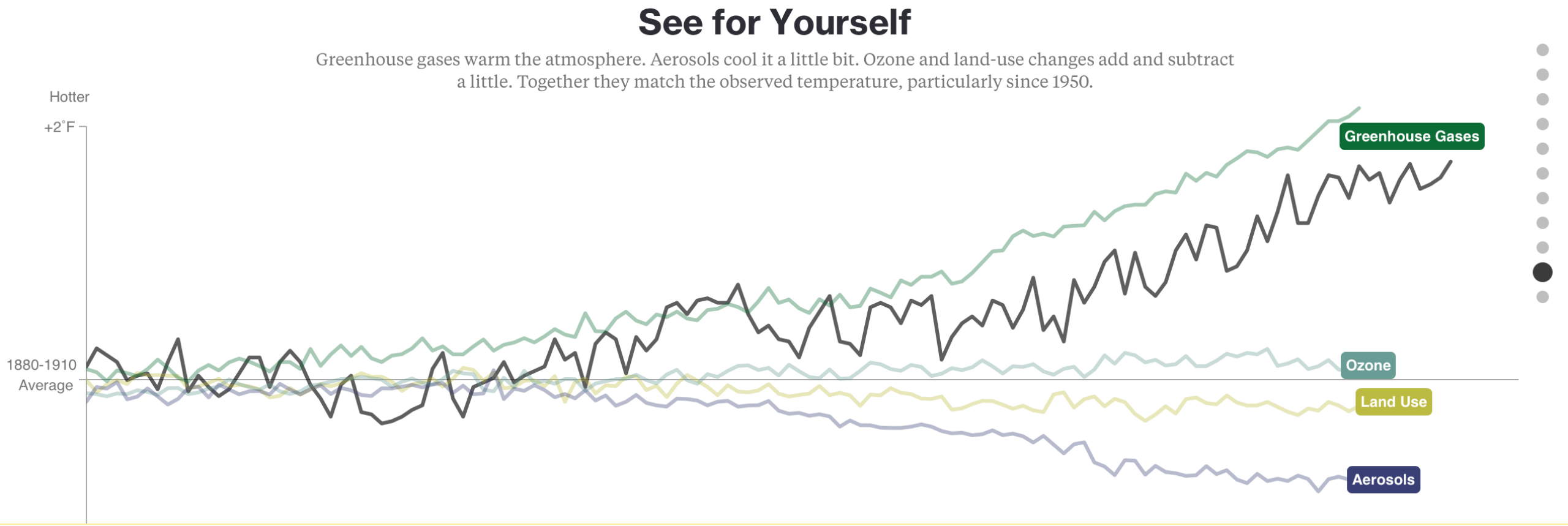
Goddard
SPACE FLIGHT CENTER

Earth as a system: energy, water, carbon cycles



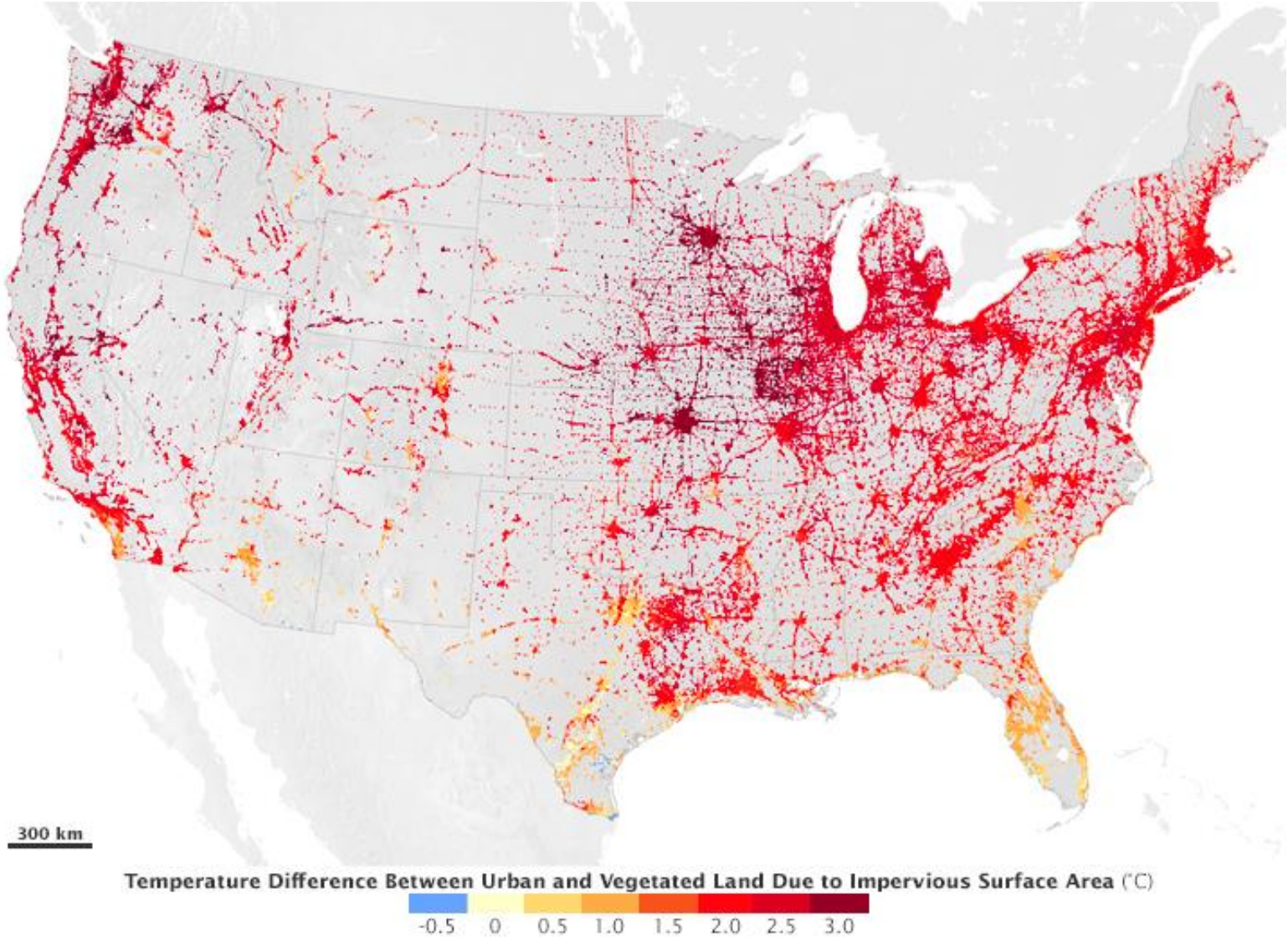

Temperature Anomalies over Land and over Ocean
Land Surface Air Temperature
Land Lowess Smoothing
Sea Surface Water Temperature
Sea Lowess Smoothing
Temperature Anomaly (°C)
1.5
1.0
0.5
0.0
-0.5
-1.0
1880
1900
1920
1940
1960
1980
2000
2020
NASA/GISS/GISTEMP/v3

Contribution of different factors to temperature trend



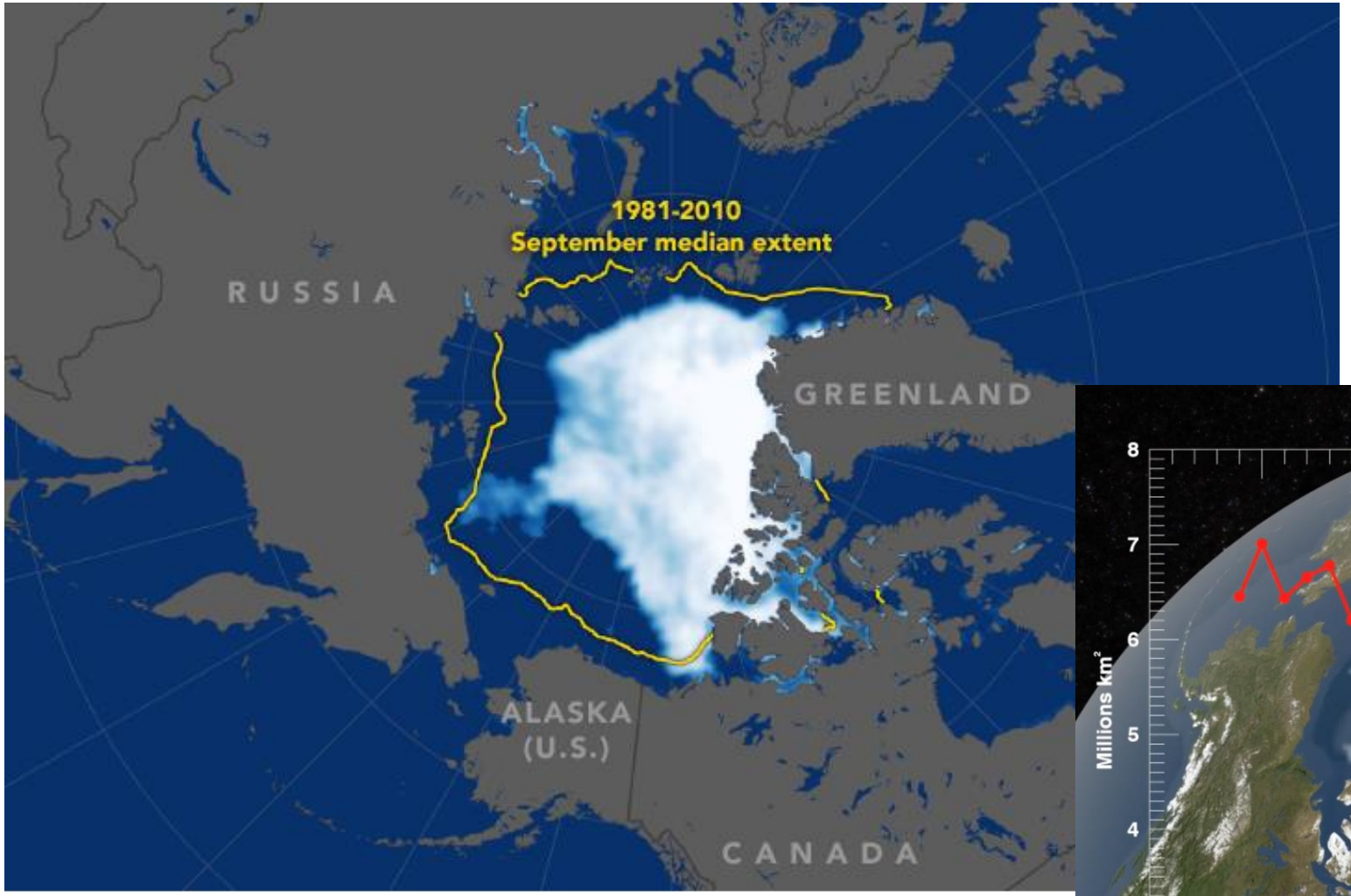
Bloomberg Business graphic of output from "ModelE2" by NASA's Goddard Institute for Space Studies (GISS), run on a supercomputer at the NASA Center for Climate Simulation in Greenbelt, Maryland

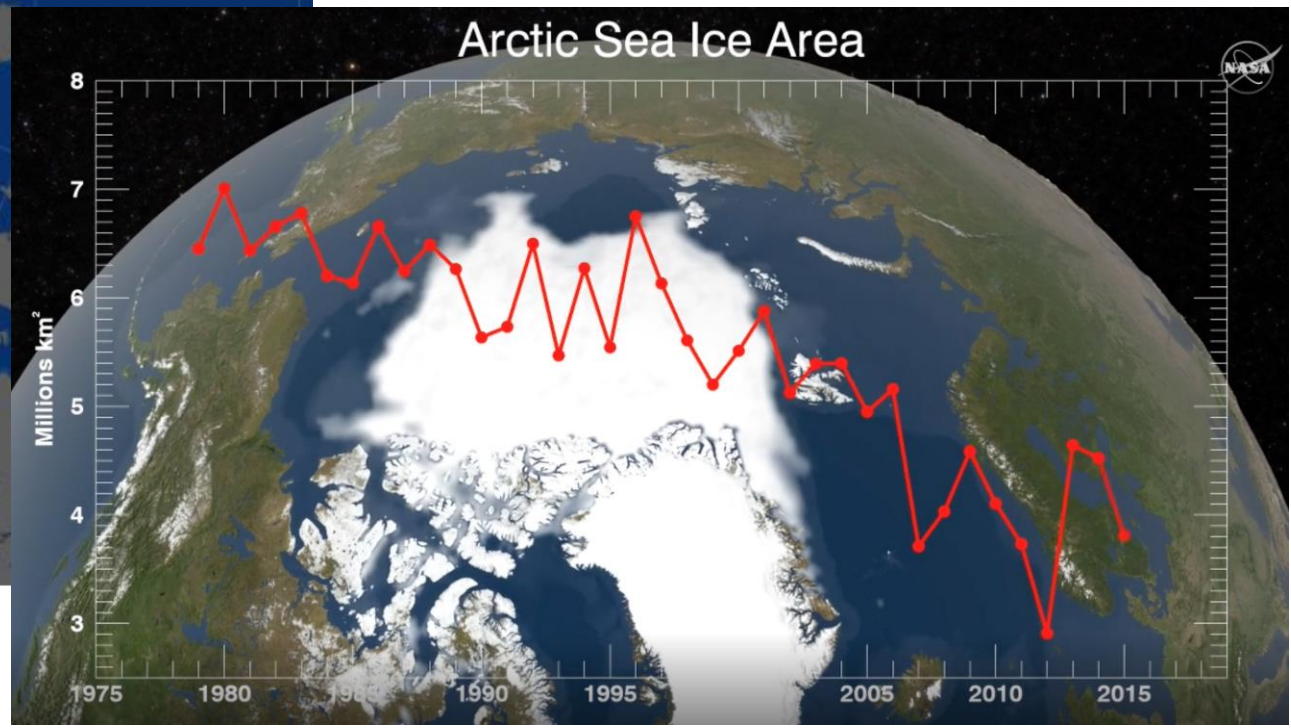
Warming exacerbated in Urban Heat Islands



Vegetation Limits City Warming Effects - New research quantifies how plants along urban roads, in parks, and in wooded neighborhoods can regulate the warming effects of urbanization. *NASA Earth Observatory Image of the Day August 26, 2015*

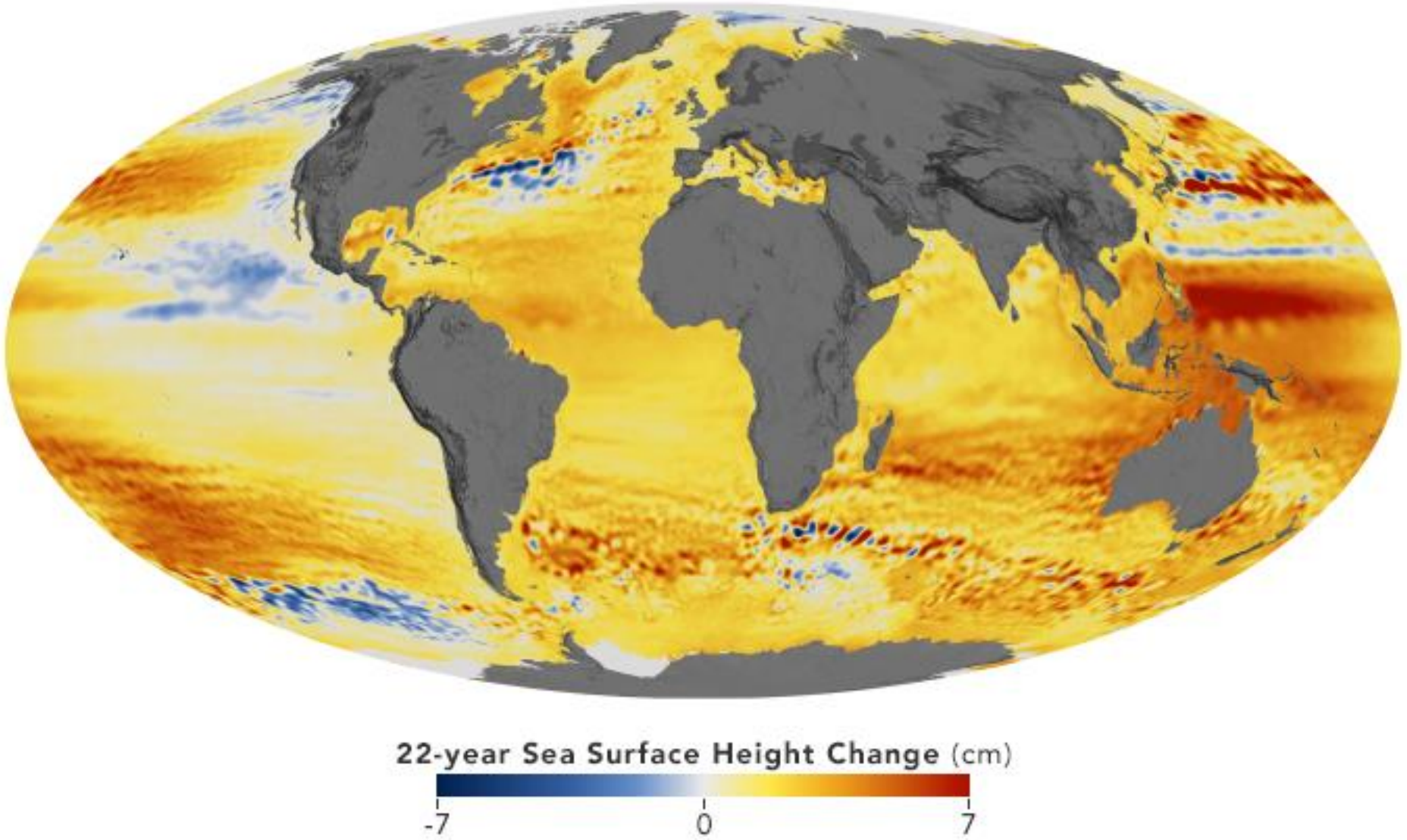
Cryosphere: Ice Sheets, Glaciers, Sea Ice





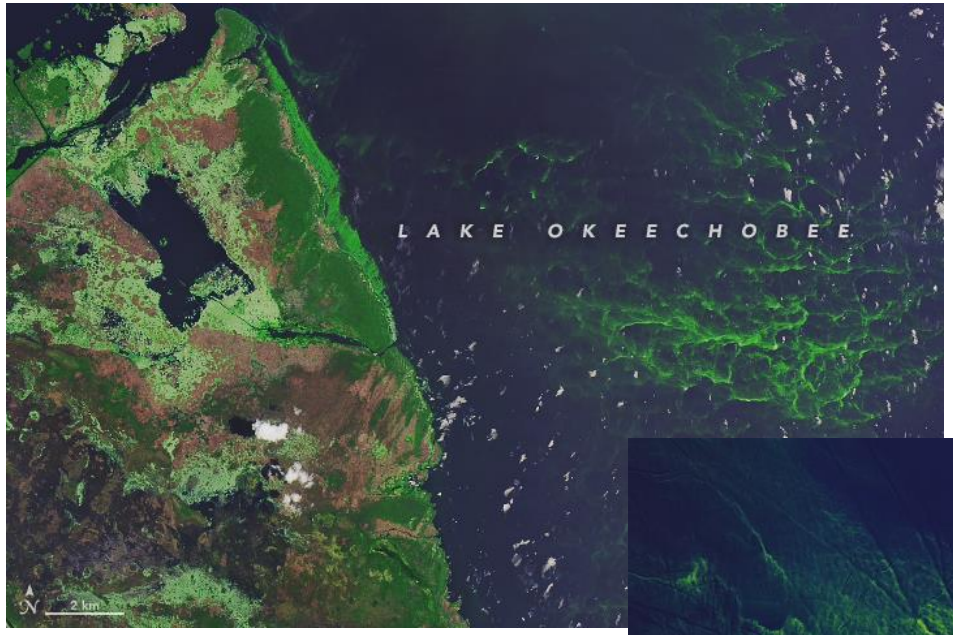
Arctic Sea Ice Reaches 2018 Minimum - The ice cap tied for the sixth lowest extent on record, continuing a long-term decline.
NASA Earth Observatory Image of the Day September 28, 2018

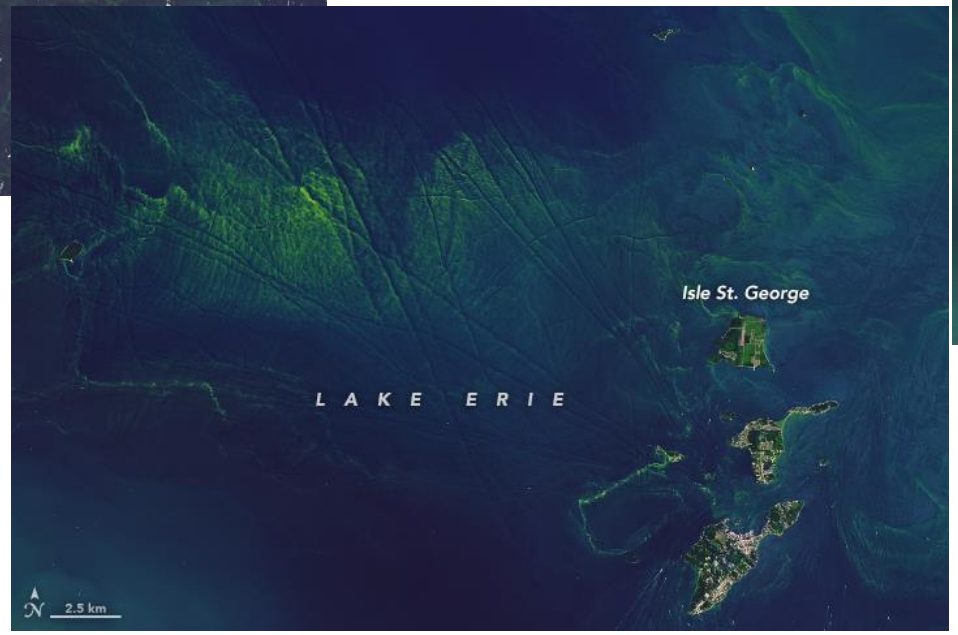
Sea Level Rise is Accelerating

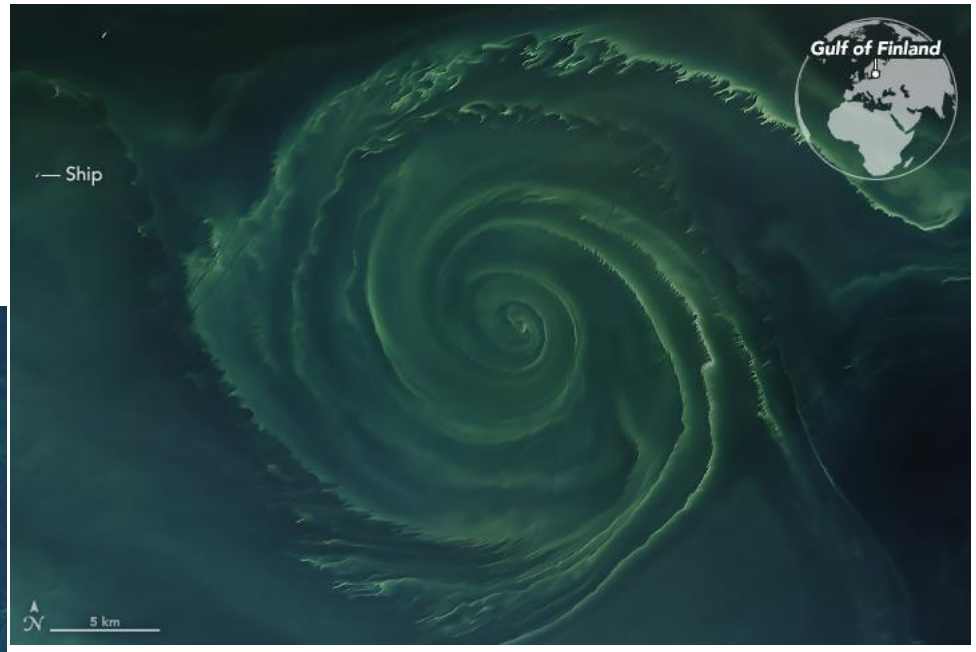


The acceleration has been driven mainly by increased ice melting in Greenland and Antarctica, and it has the potential to double the total sea level rise projected by 2100. *NASA Earth Observatory Image of the Day February 20, 2018*

Marine and Aquatic Ecosystems are Changing

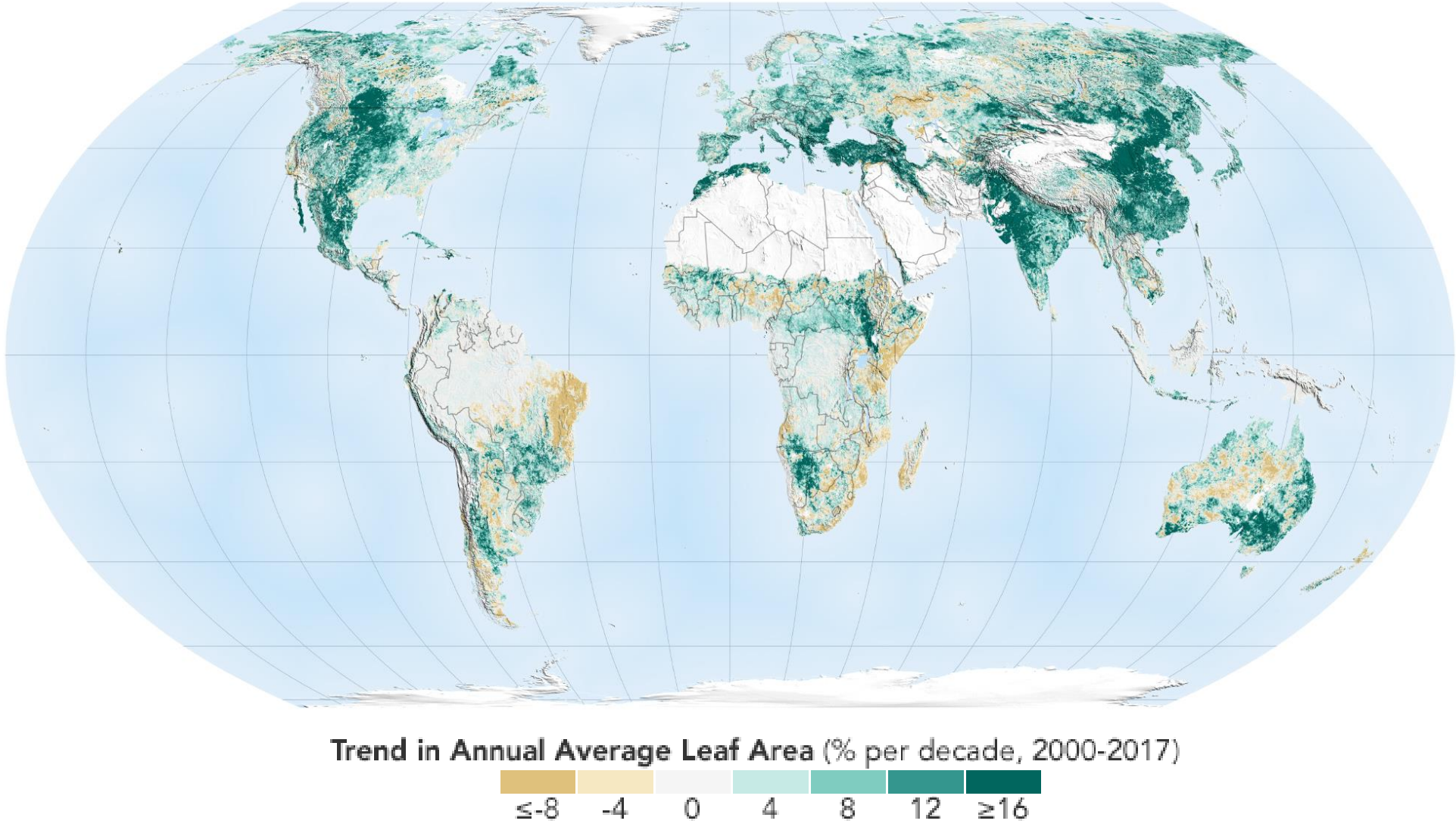






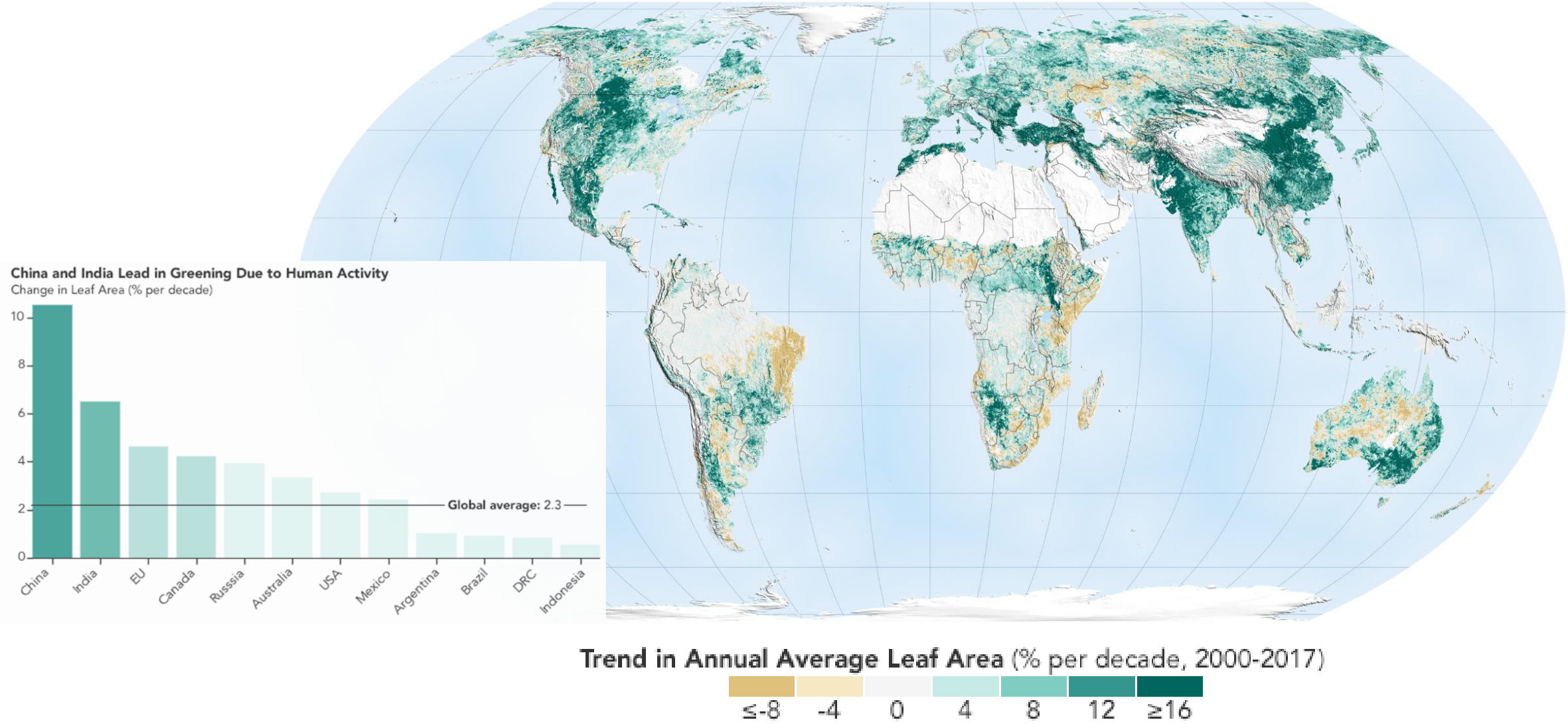
Summer Blooms in North American Lakes - Cyanobacteria have become a regular summer phenomenon in Lake Okeechobee and Lake Erie.
NASA Earth Observatory Image of the Day July 18, 2018 (and Baltic Sea on July 28, 2018)

Land Use and Land Cover Changes



China and India Leading the Way in Greening - Ambitious tree-planting programs and intensified agriculture have led to more land area covered in vegetation. *NASA Earth Observatory Image of the Day February 12, 2019*

Land Use and Land Cover Changes

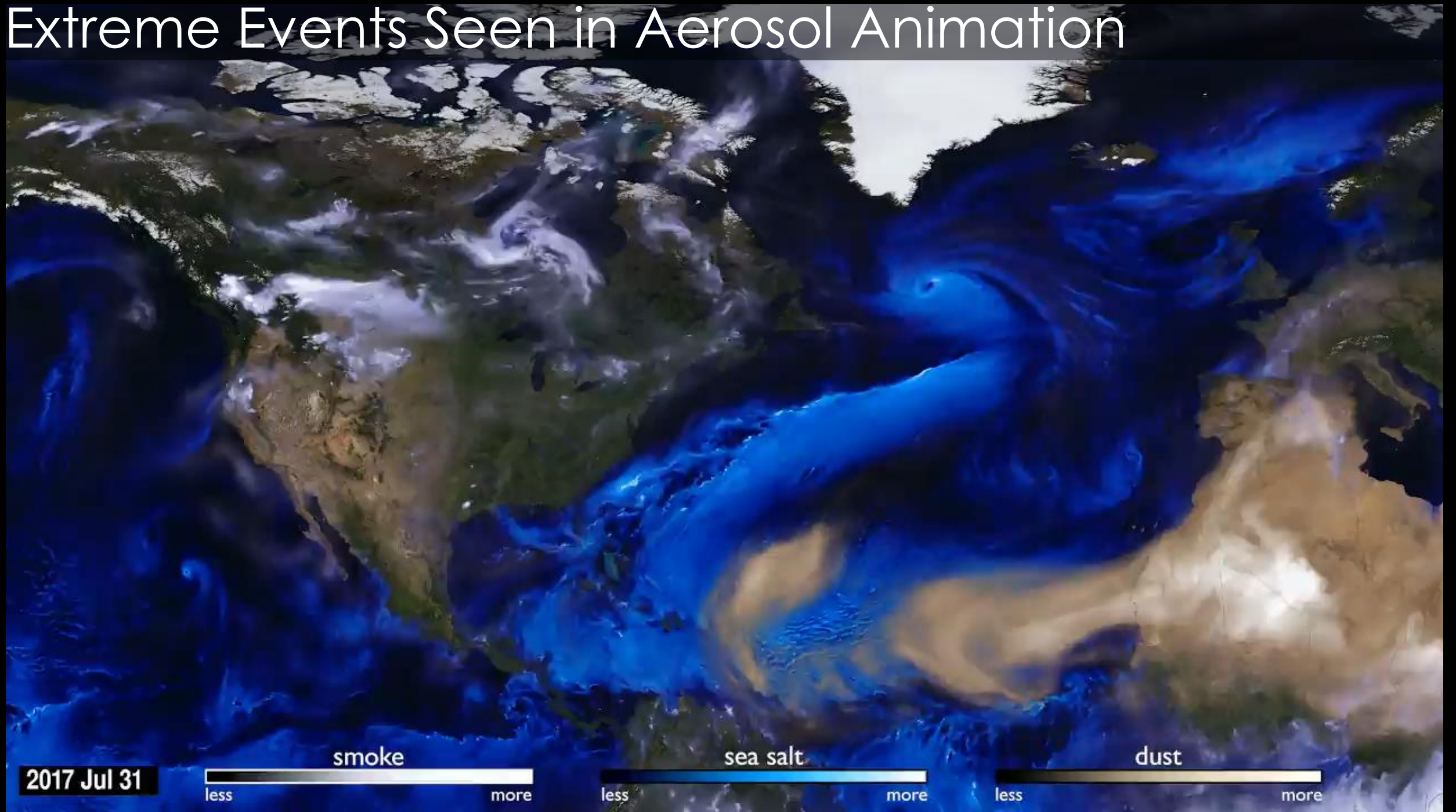


China and India Leading the Way in Greening - Ambitious tree-planting programs and intensified agriculture have led to more land area covered in vegetation. *NASA Earth Observatory Image of the Day February 12, 2019*

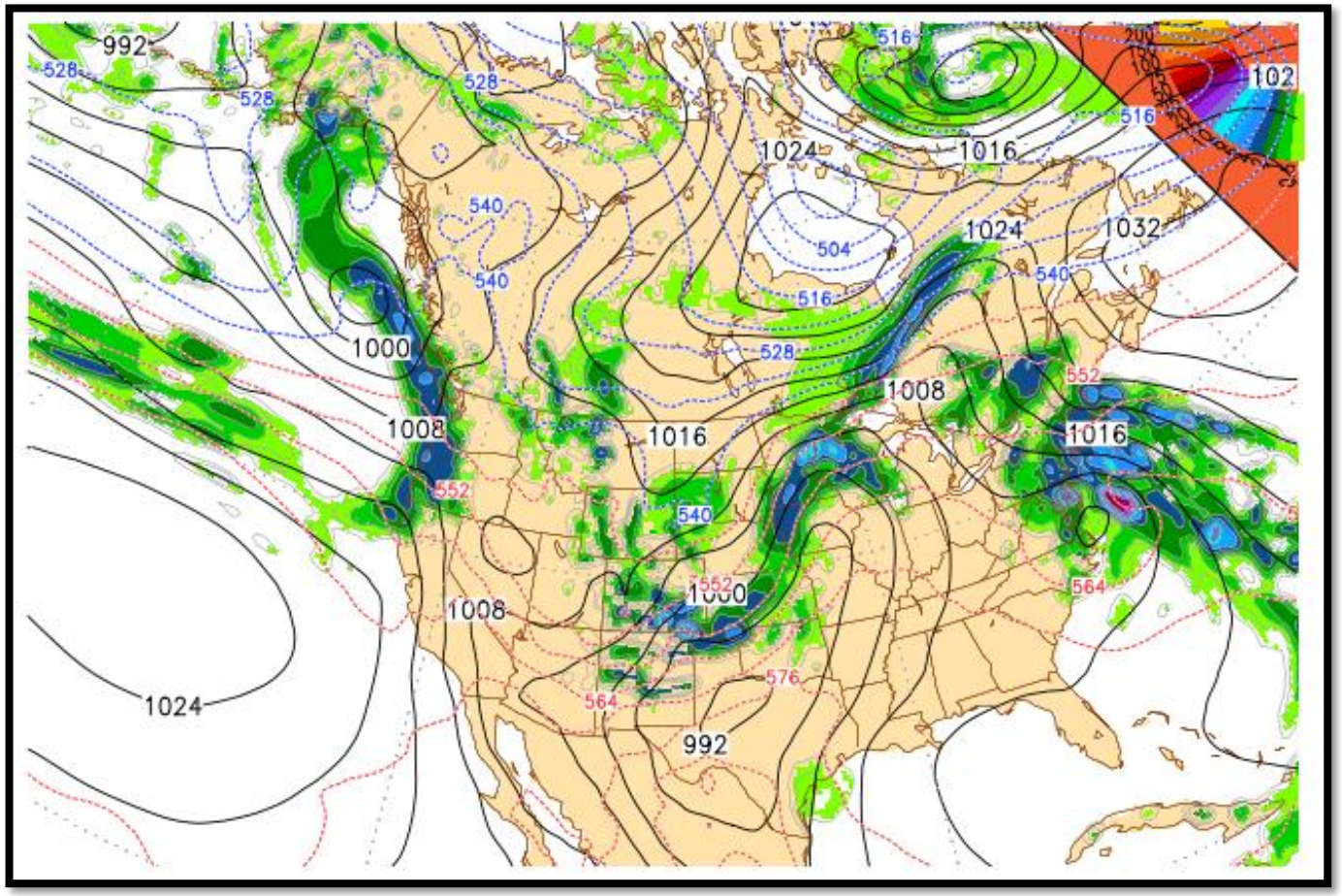
Monitoring and Predicting Extreme Events

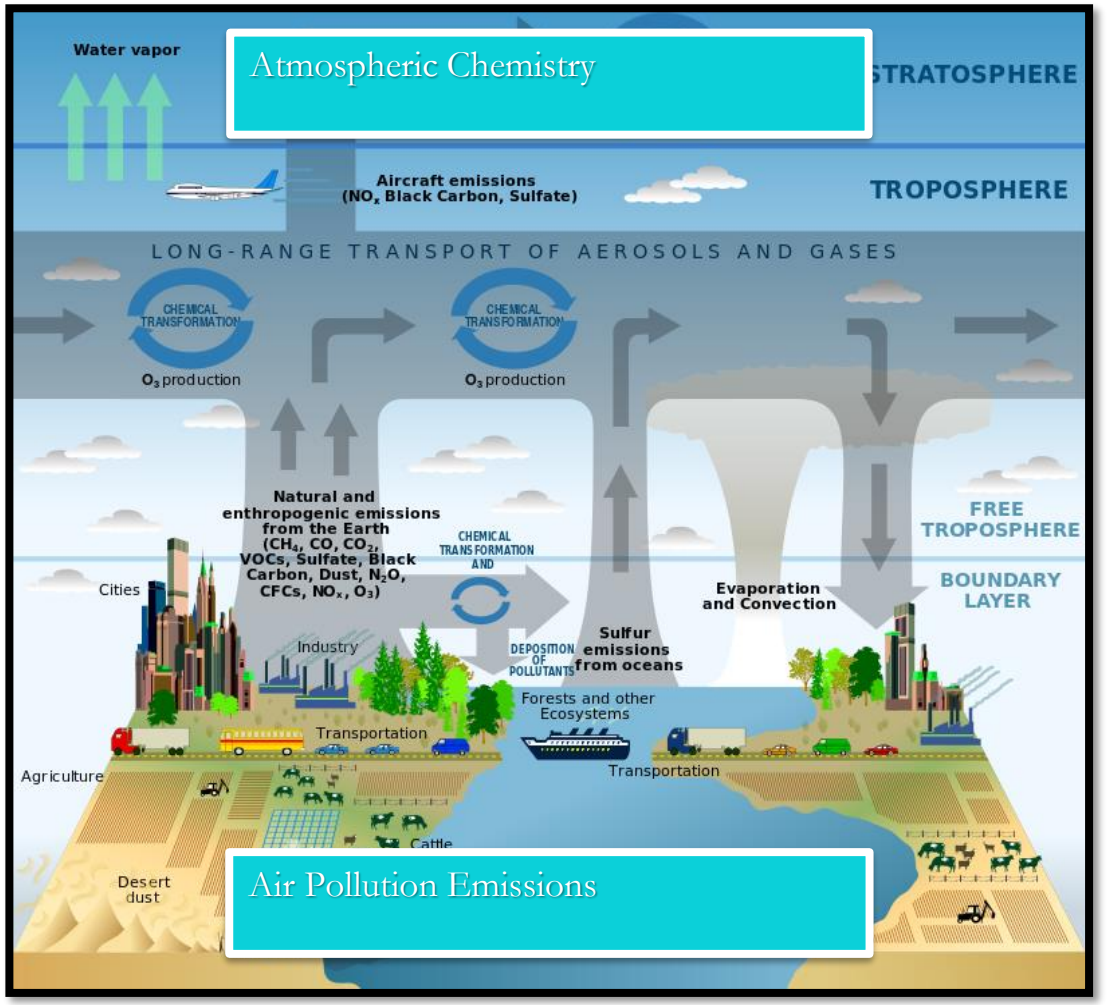
Flooding Along the Arkansas River | Flooding in the Carolinas from Hurricane Florence – Torrential rainstorms led to widespread flooding and runoff impacting water quality. *NASA Earth Observatory Image of the Day May 30, 2019* | *September 22, 2018*

Extreme Events Seen in Aerosol Animation



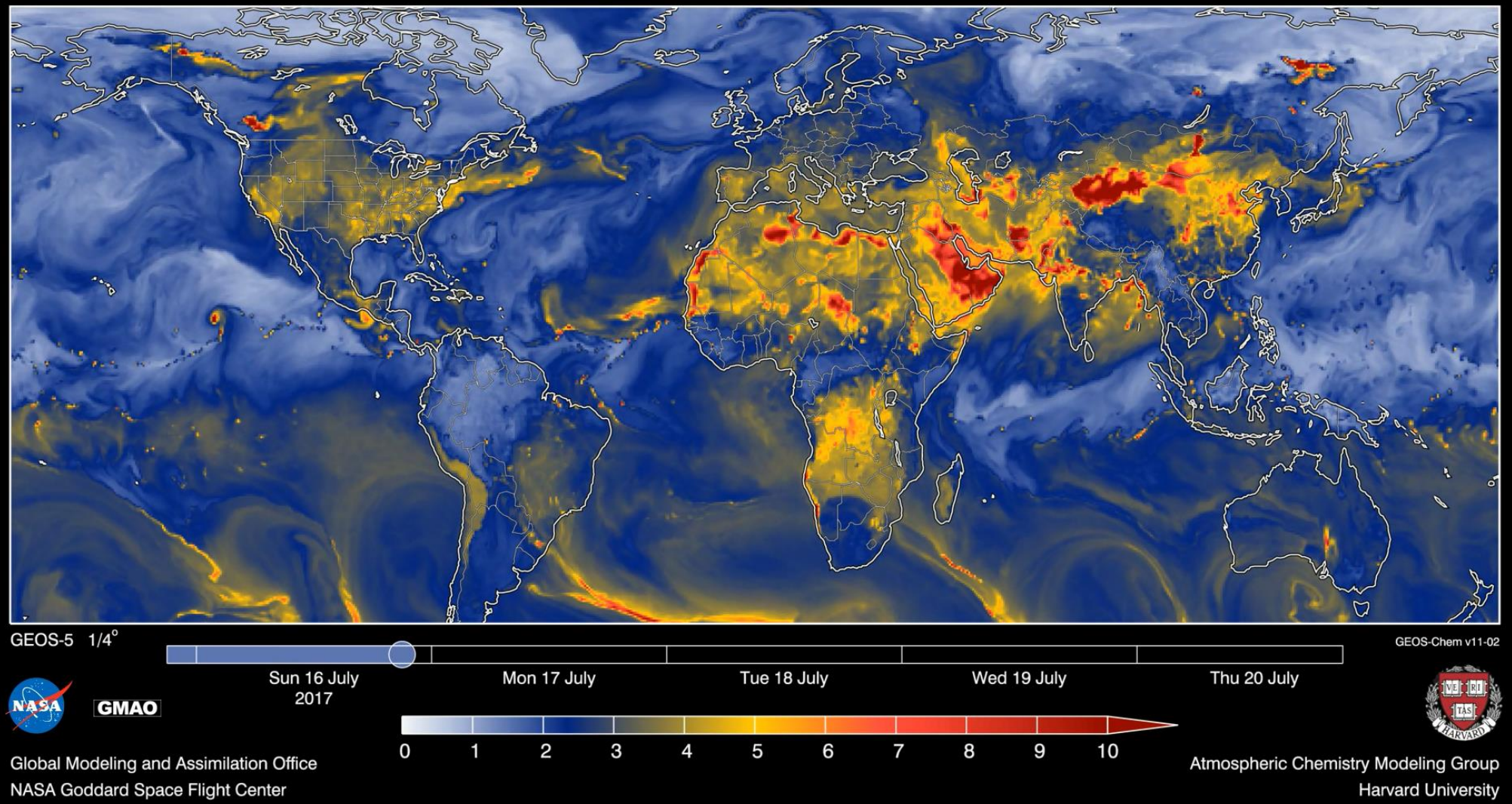
Global Atmospheric Composition Forecasts





NASA GEOS-5 model provides daily to seasonal forecasts of weather and recently introduced an air quality forecast

Health Air Quality Index Forecasts



1-3 = good 3-6 = moderate 6-9 = unhealthy 10 = very unhealthy

Upcoming Satellite Missions

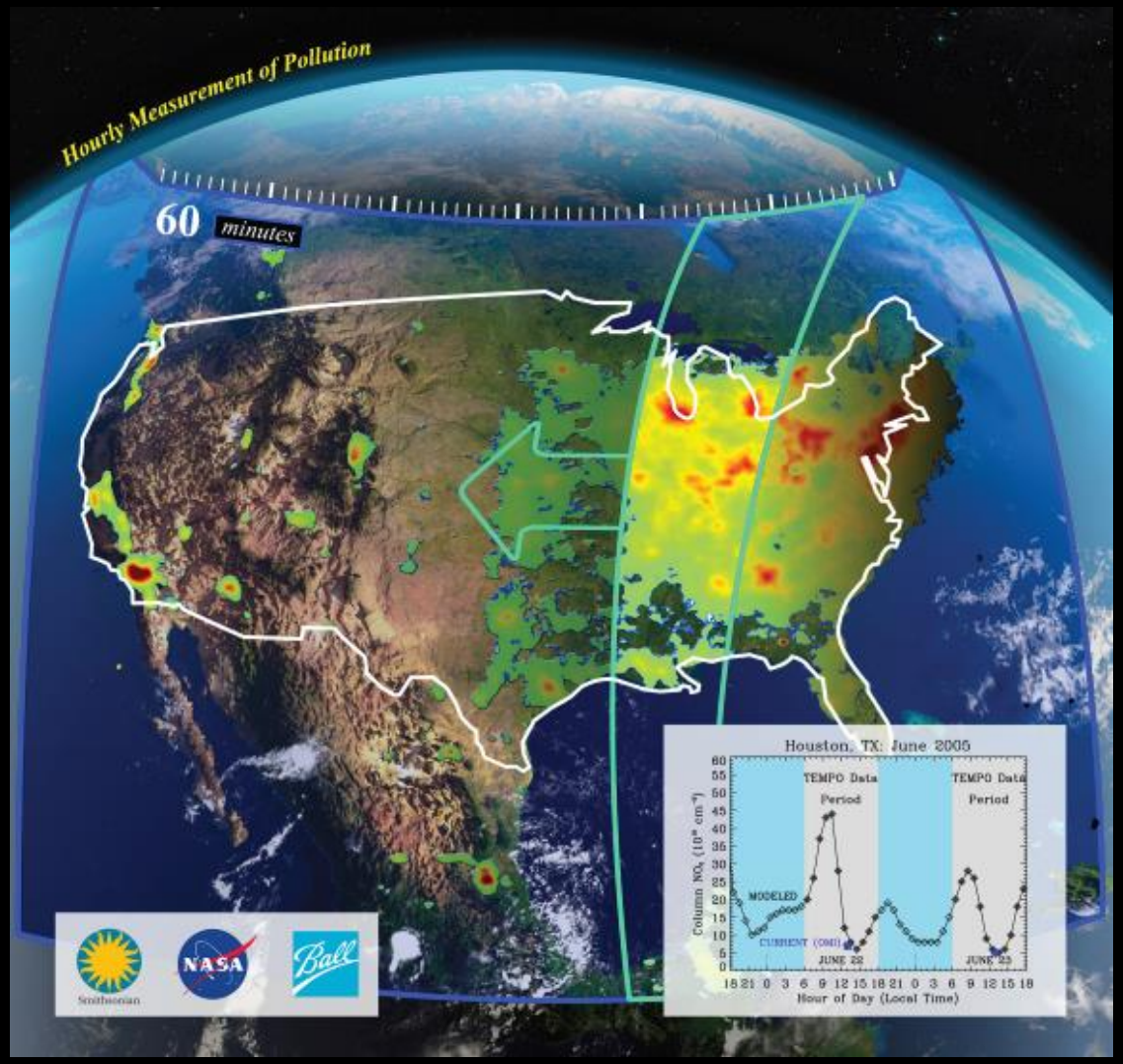
Tropospheric Emissions:
Monitoring of Pollution

Similar heritage as TROPOMI & OMI

Atmospheric Trace Pollutants (NO_2, SO_2, HCHO)

Unprecedented spatio-temporal resolution
Hourly data over N. America (geosynchronous vs polar orbit)

For more about TEMPO: https://tempo.si.edu/



Launching in 2022...

Four Designated Observable Studies

2017-2027 Decadal Survey for Earth Science & Applications from Space

Surface Biology and Geology (SBG)

- Terrestrial vegetation physiology, traits, and health
- Inland and coastal aquatic ecosystems
- Snow, ice accumulation, melting, and albedo
- Changing land effect on surface energy, water, momentum, and carbon fluxes
- Managing agriculture, natural habitats, water use/quality, and urban development

Mass Change (MC)

- Surface water and groundwater
- Coastal vulnerability
- Climate impacts on water cycle and ice sheets
- Height system and land management
- Risk assessment of natural hazards

Surface Deformation and Change (SDC)

- Biomass, vegetation type, status
- Subsidence
- Snow cover, type
- Snow water equivalent and soil moisture
- Flood extent

Aerosols/Clouds, Convection and Precipitation (A/CCP)

- Interaction of aerosols, clouds, and precipitation
- Structure and cycle of clouds and precipitation
- Life cycle of natural and anthropogenic aerosols
- Weather, air quality, human health, public safety, climate

Chesapeake Bay water quality efforts

New proposed research with Maryland Dept of Environment Shellfish Monitoring Section, Virginia Dept of Health Shellfish Safety, UMD, NOAA, USDA-ARS to combine sampling of biology, chemistry, physics with optical measurements (in water, above water, satellite) to identify poor water quality from space.

Photo credit: John 'Rusty' McKay/MDE

- Aquaculture is a growing industry world-wide
- Harmful algal blooms and fecal coliform runoff cause shellfish bed closures
- Early warning of poor water quality could guide sampling
- Remotely sensed optical proxies are being explored
- Developing AI for water quality

Partners: VDH UNIVERSITY OF MARYLAND NOAA USDA

Bacteria* Impairments in Virginia for 2016

Sources: Virginia Department of Environmental Quality
Virginia Geographic Information Network
United States Geological Survey

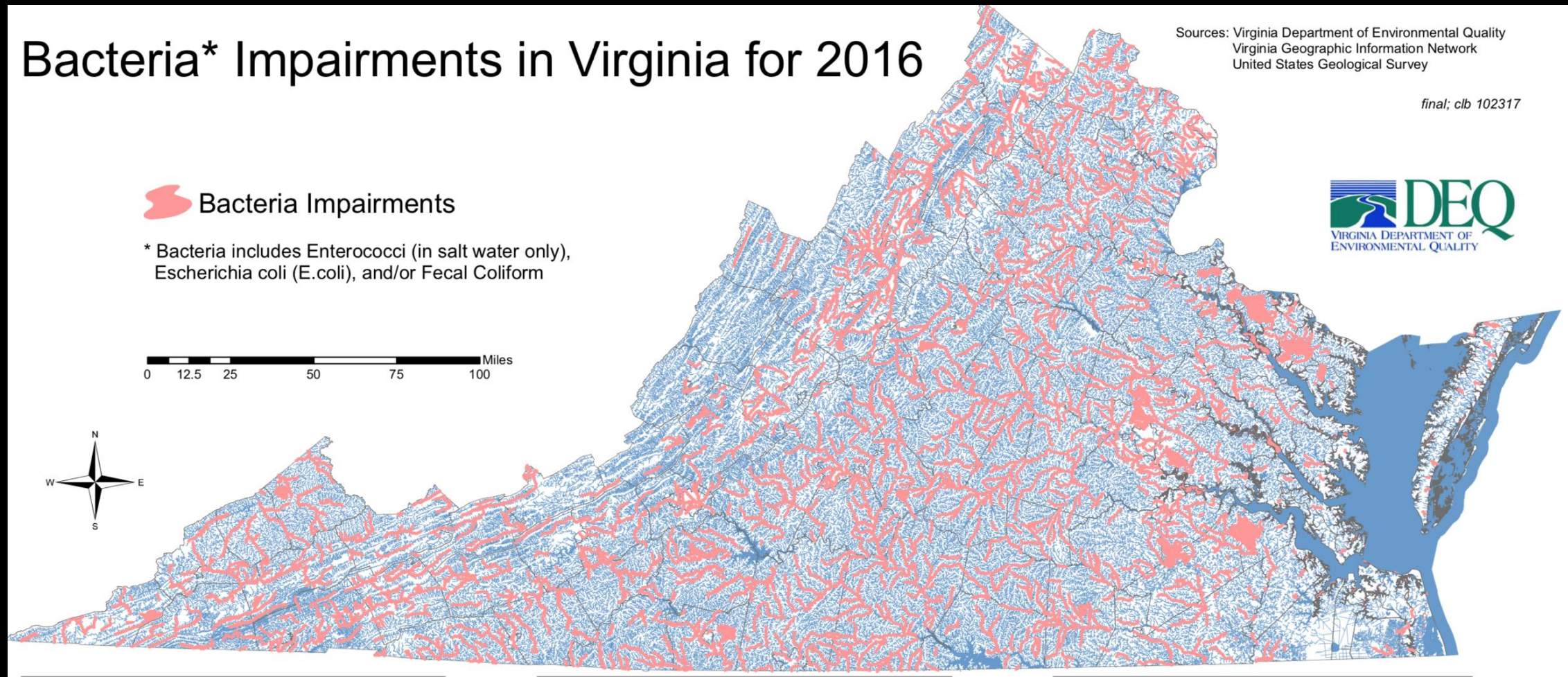
final; clb 102317

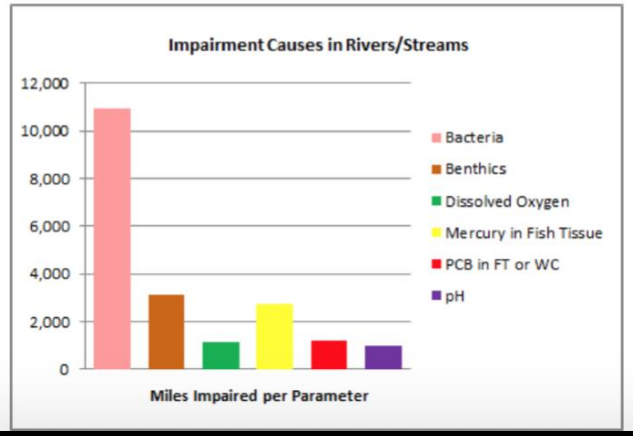
Bacteria Impairments

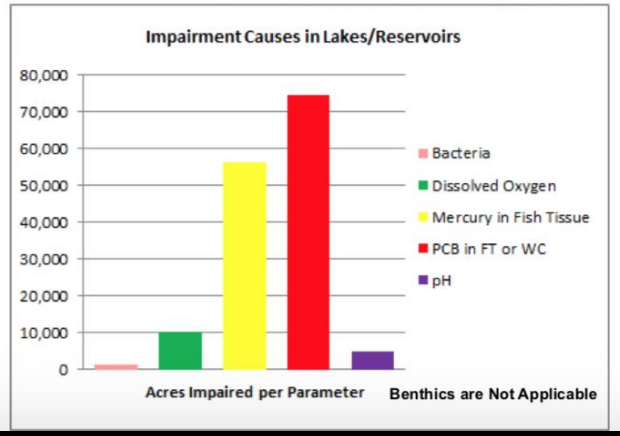
* Bacteria includes Enterococci (in salt water only), Escherichia coli (E.coli), and/or Fecal Coliform

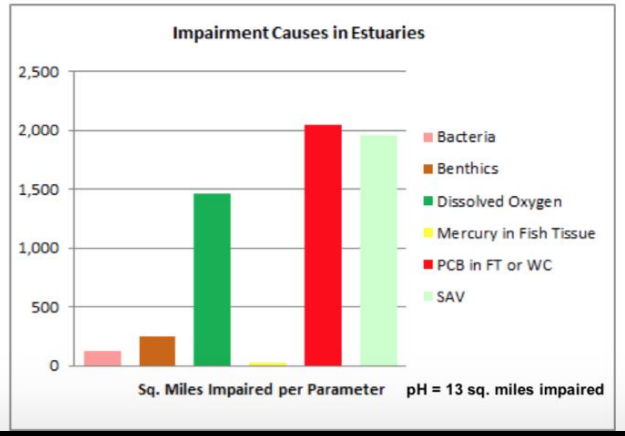
0 12.5 25 50 75 100 Miles

N W E S









Climate change and its impacts across the Southeast U.S

Dr. Chip Konrad

Director of the NOAA Southeast Regional Climate Center

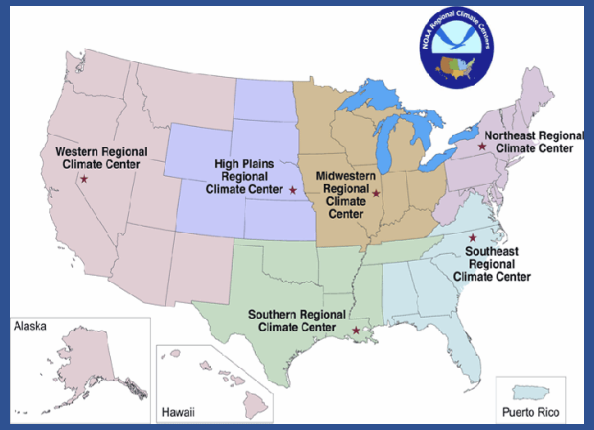
Co-PI Carolina Integrated Science and Assessments (CISA)

Certified Consulting Meteorologist

Professor, Department of Geography

University of North Carolina at Chapel Hill

The NOAA Southeast Regional Climate Center (SERCC)



- Distribution & quality control of weather & climate data and information
- Engagement with communities & stakeholders affected by weather and climate & events
- Development web-based decision support tools
- Education of stakeholders on emerging regional climate issues
- Work with various state and federal entities, including the National Weather Service & state climatologists

NOAA Carolinas Integrated Science and Assessments (CISA)

Applied research that incorporates climate information into water, health and coastal management and decision making.

- Advance scientific understanding of climate processes and impacts in the Carolinas
- Provide decision support through the development of targeted and tailored information
- Advance climate adaptation
- Support and foster climate information networks

SERCC and CISA work closely together to identify climate/health vulnerabilities and assist stakeholders and communities in increasing their resilience to extreme weather events.

OUTLINE

1. Introduction
   - climate variability vs. climate change

1. Trends in temperature

2. Trends in precipitation

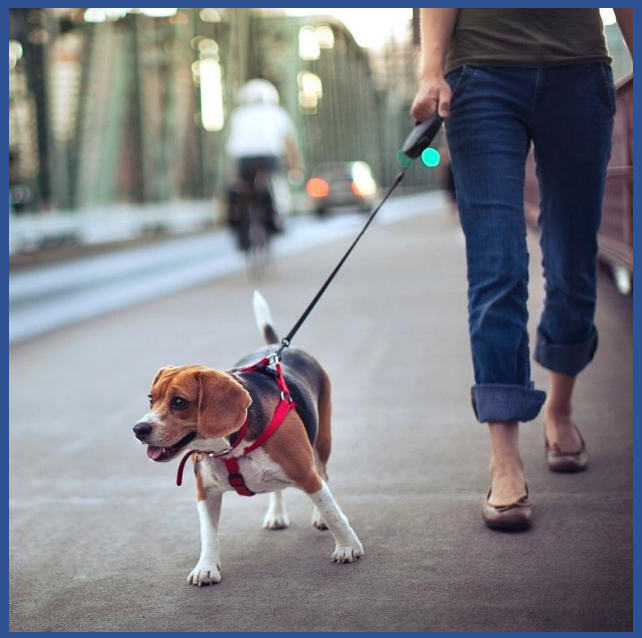
3. Trends in extreme weather events
   - Heavy rainfall, droughts, heat waves and hurricanes

   - Public health implications of these Trends

Weather/climate variability vs. climate change

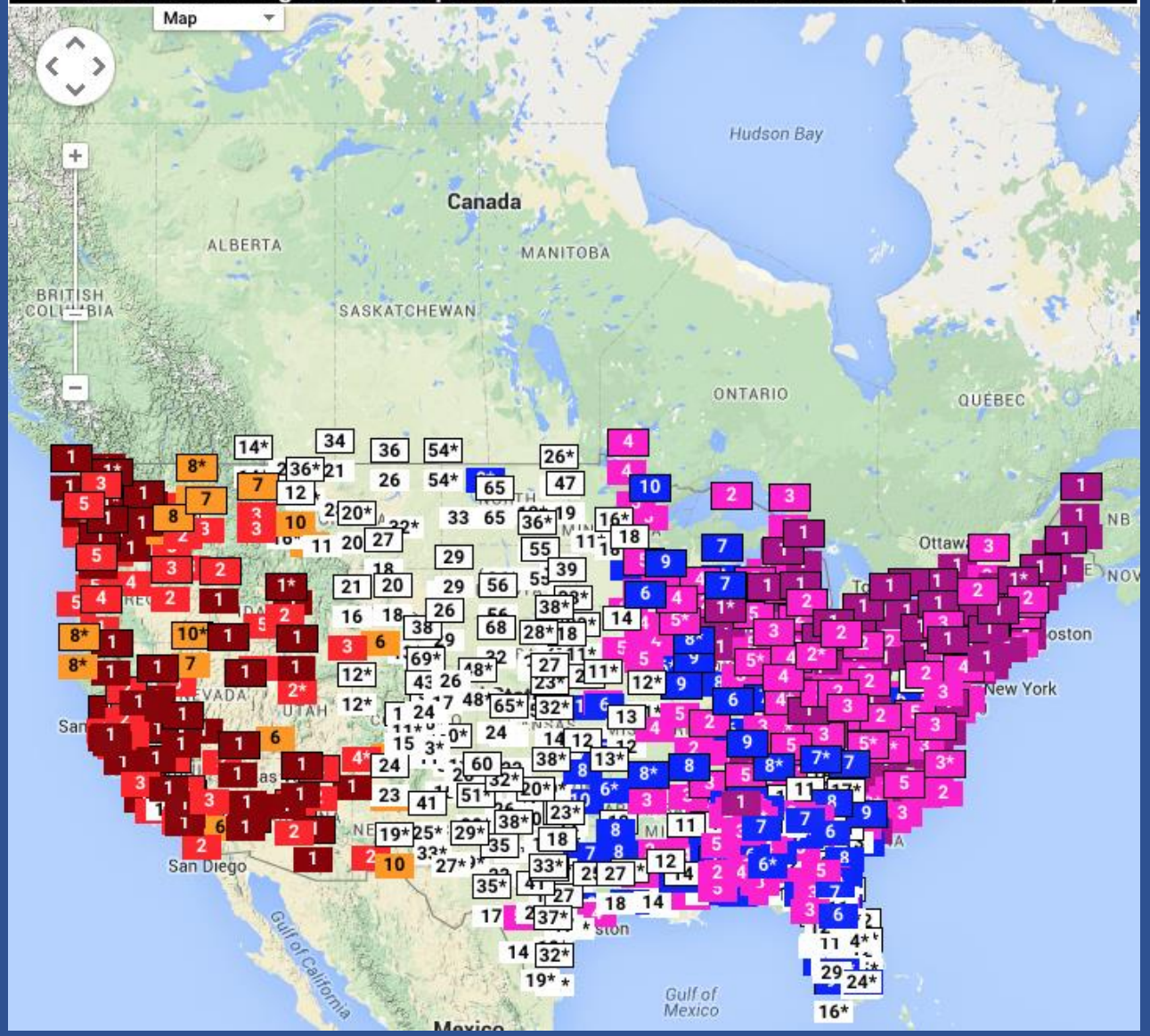
- Weather & climate variability = short-term occurrence
- Climate change = long-term changes in is normal weather and frequencies of extreme weather events

Climate change is the leash, weather is the dog's nose

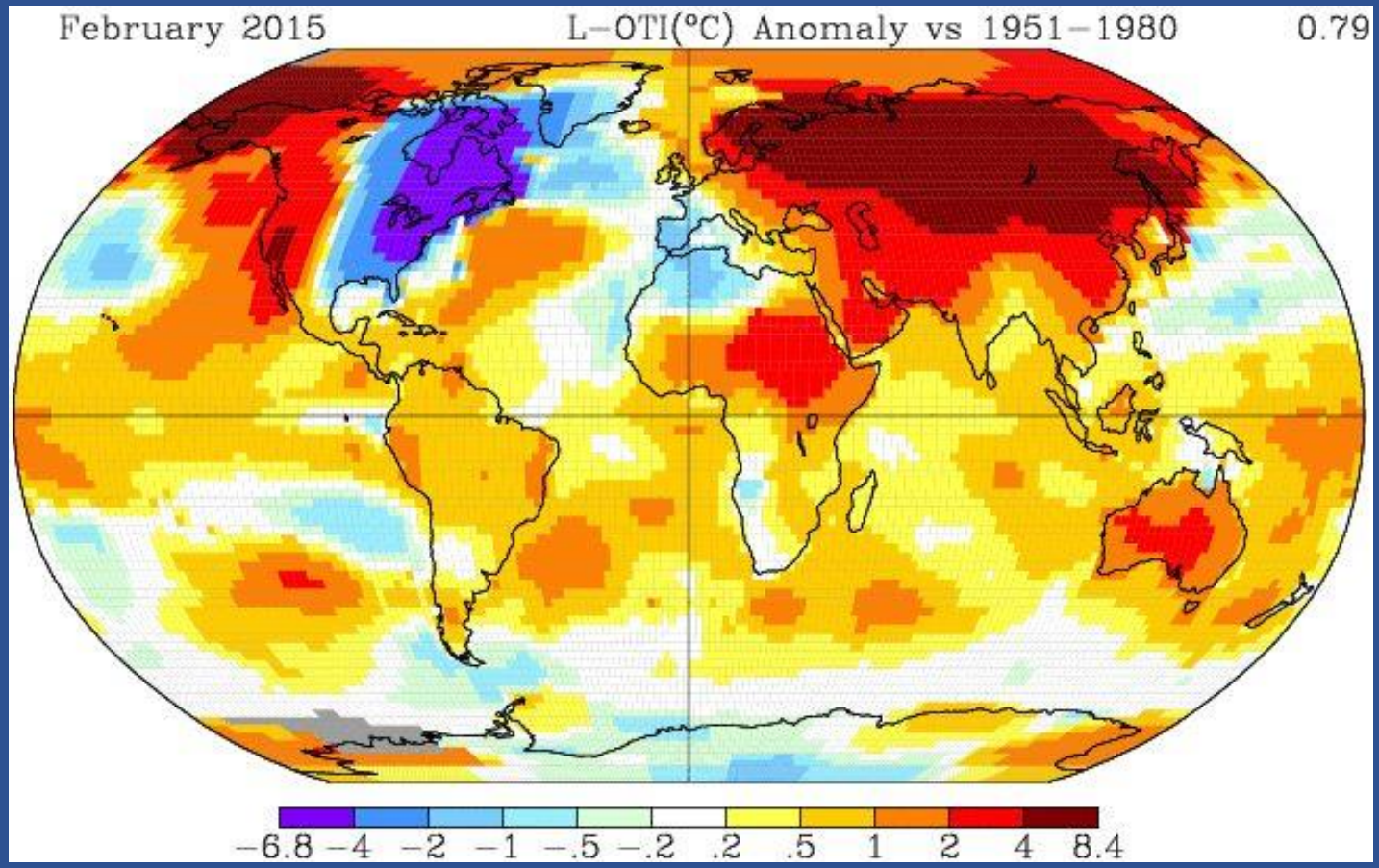


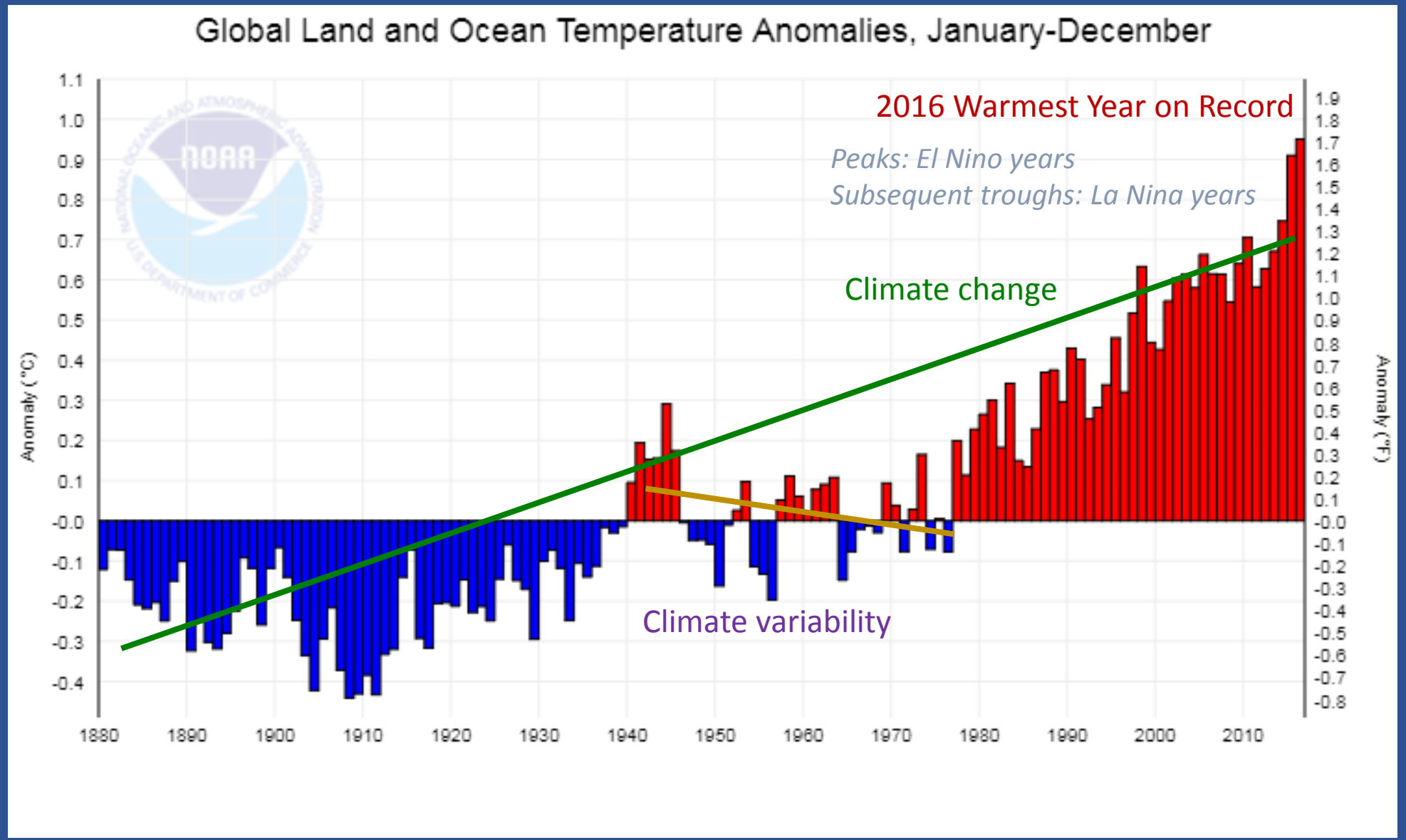
Station Perspectives | Regional Map Perspectives | Streaks & Thresholds

Observed Average Mean Temperature for Feb 1 2015 to Feb 28 2015 (783 stations)

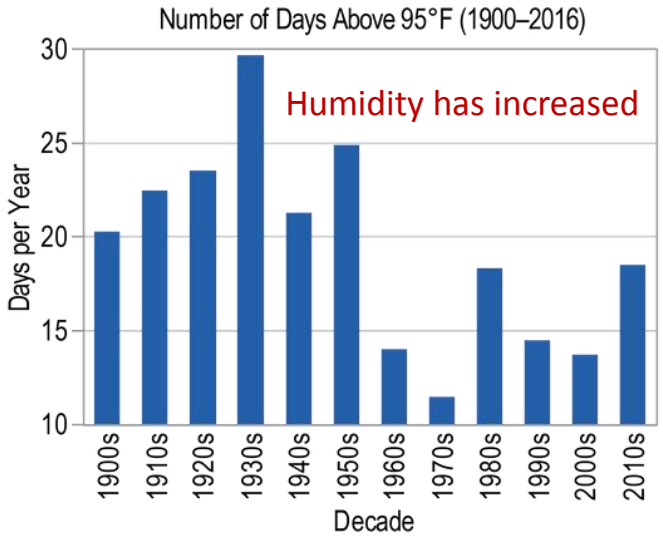


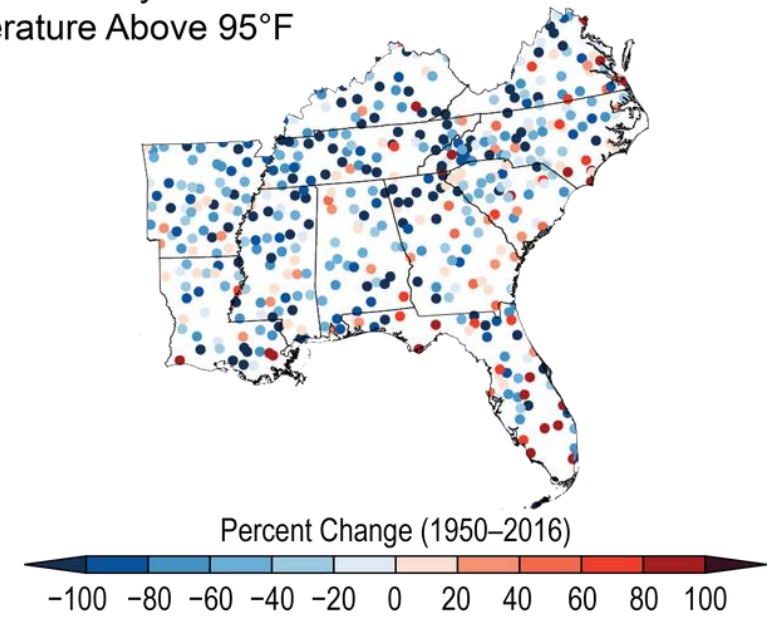
Extreme Temperatures associated with Climate Variability



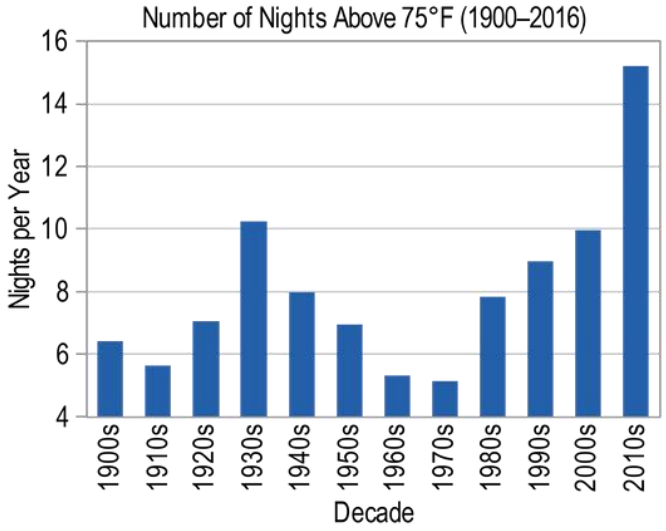

Global Land and Ocean Temperature Anomalies, January-December
2016 Warmest Year on Record
Peaks: El Nino years
Subsequent troughs: La Nina years
Climate change
Climate variability
Anomaly (°C)
Anomaly (°F)
1.1
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
-0.0
-0.1
-0.2
-0.3
-0.4
1.9
1.8
1.7
1.6
1.5
1.4
1.3
1.2
1.1
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
-0.0
-0.1
-0.2
-0.3
-0.4
-0.5
-0.6
-0.7
-0.8
1880
1890
1900
1910
1920
1930
1940
1950
1960
1970
1980
1990
2000
2010

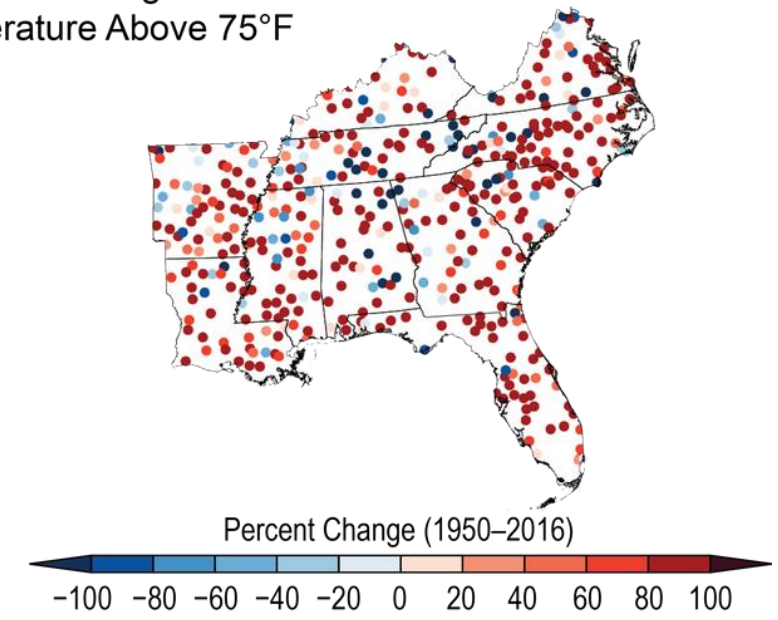
Number of Hot Days
Maximum Temperature Above 95°F





Number of Warm Nights
Minimum Temperature Above 75°F





https://nca2009.globalchange.gov/hazard-related-deaths-us/index.html

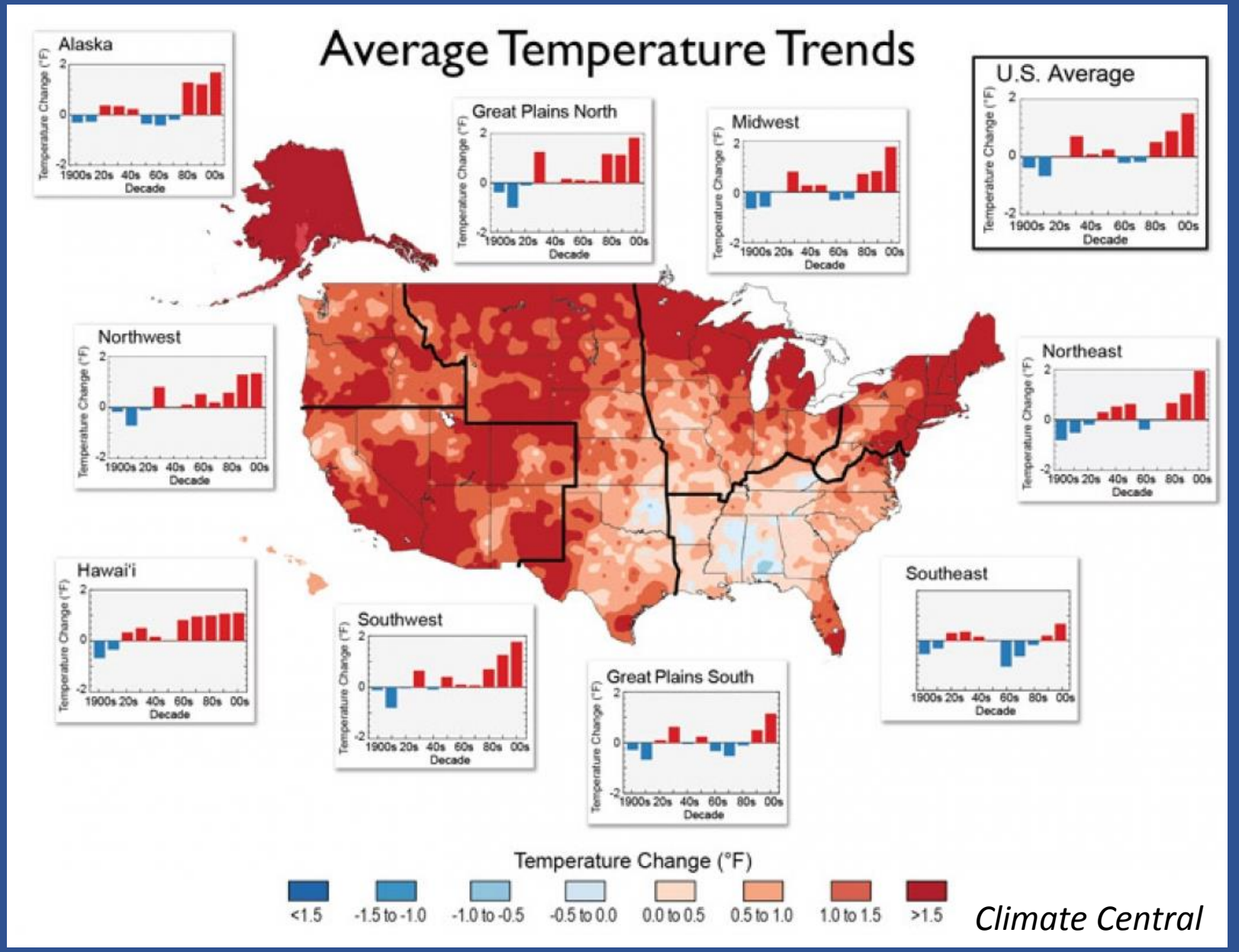
Recent weather conditions provide great examples of increased variability that can be tied to a changing climate

Climate perspective on recent early season heat wave in Richmond.

Past 3 Weeks 05/17/19 - 06/06/19 View History	100% 21 Daily	Value	87 °F	63.7 °F	75.3 °F	3.05 in	Savannah, GA Max: 86.8 °F Min: 65.4 °F
		DFN	*+6.3 °F*	*+5.2 °F*	*+5.8 °F*	*+0.3 in*	
		Ranking	*1st warmest*	*T-5th warmest*	*1st warmest*	*39th wettest*	
		Similar DOY	Jun 8-Jun 28	Jun 2-Jun 22	Jun 5-Jun 25	-	

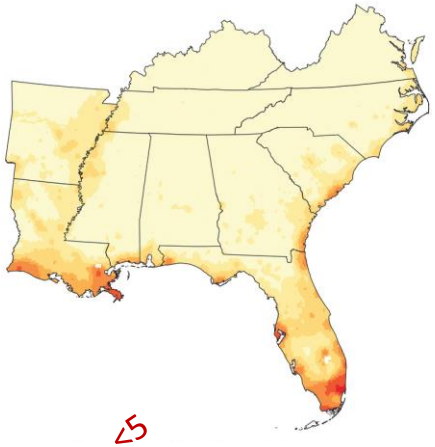
You can get a climate perspective on recent weather conditions in your community by going to:

https://sercc.com/perspectives



Climate Central

Historical number of very warm nights

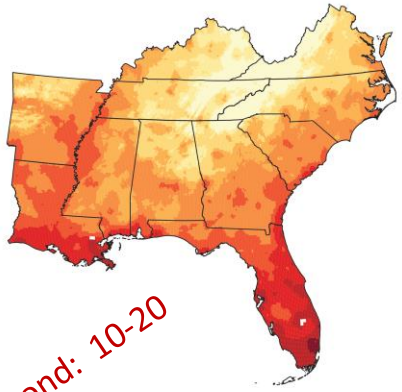


Richmond: <5

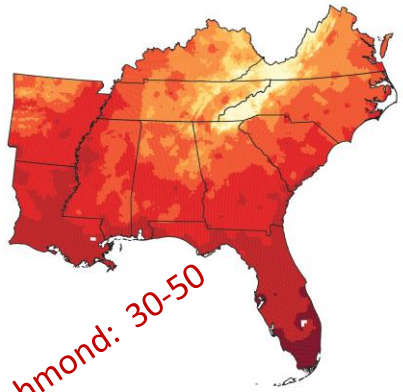
Mid-21st Century

Late 21st Century

Higher Scenario (RCP8.5)

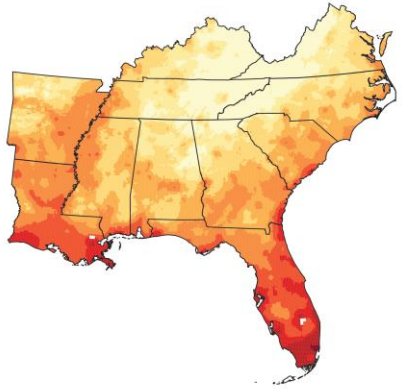


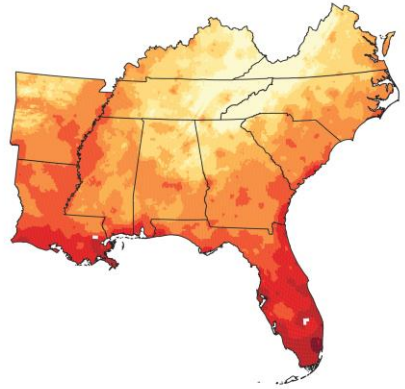
Richmond: 10-20



Richmond: 30-50

Lower Scenario (RCP4.5)



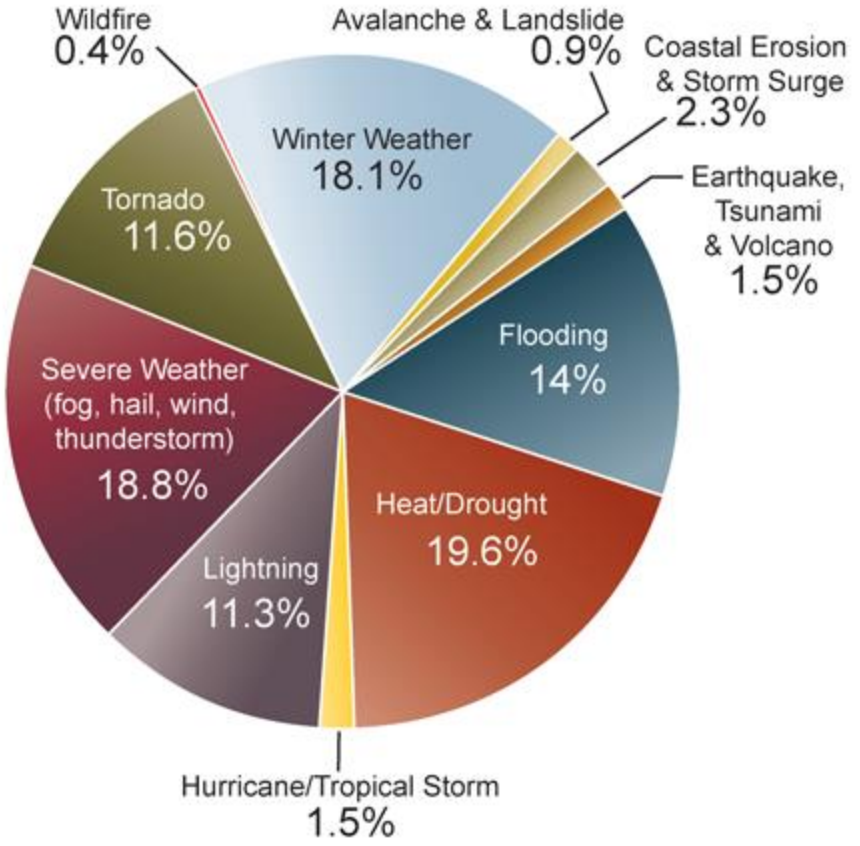


Number of Nights with a
Minimum Temperature Greater than 75°F

https://nca2009.globalchange.gov/hazard-related-deaths-us/index.html

Impacts of heat

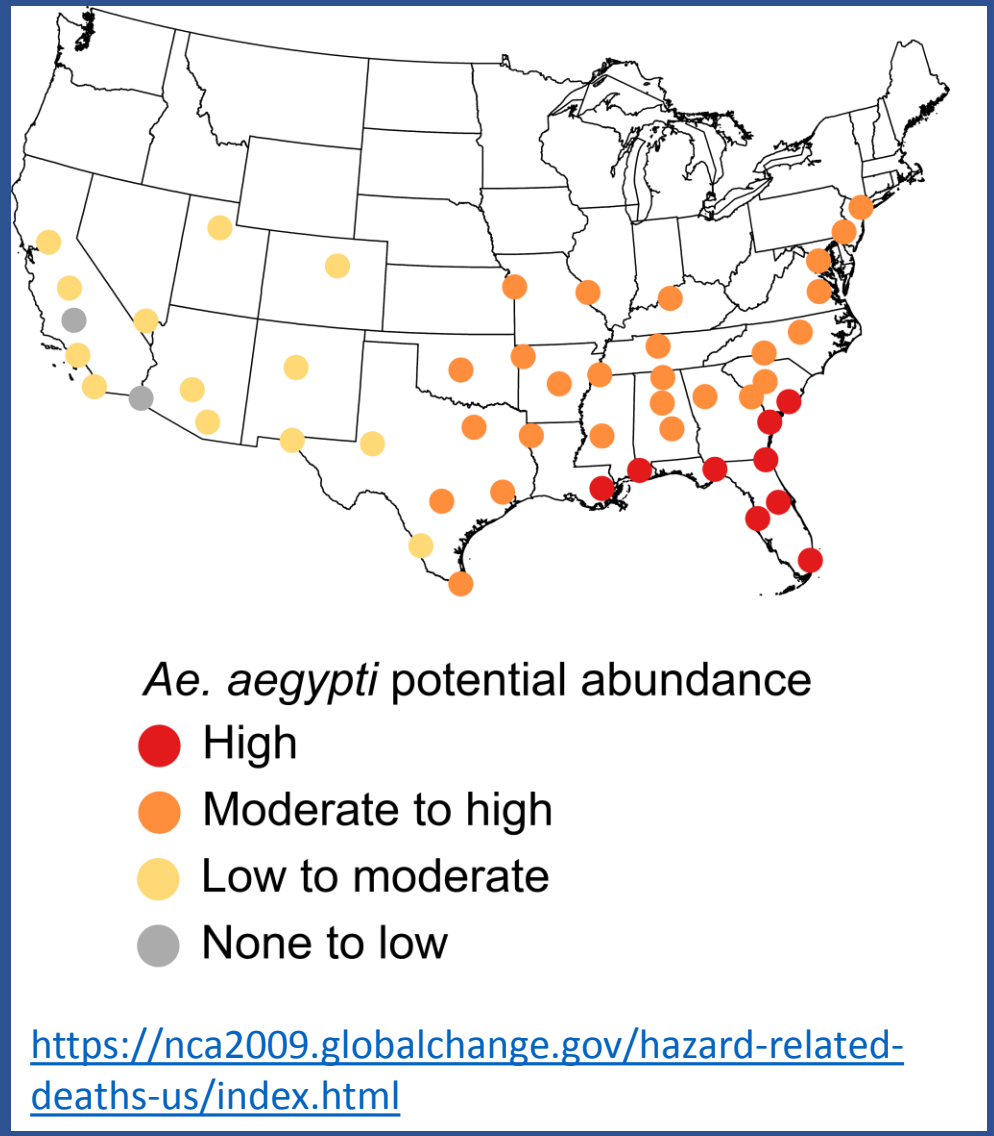
Weather-related deaths



https://nca2009.globalchange.gov/hazard-related-deaths-us/index.html

Warmer temperatures lead to increases in insects & vector borne disease

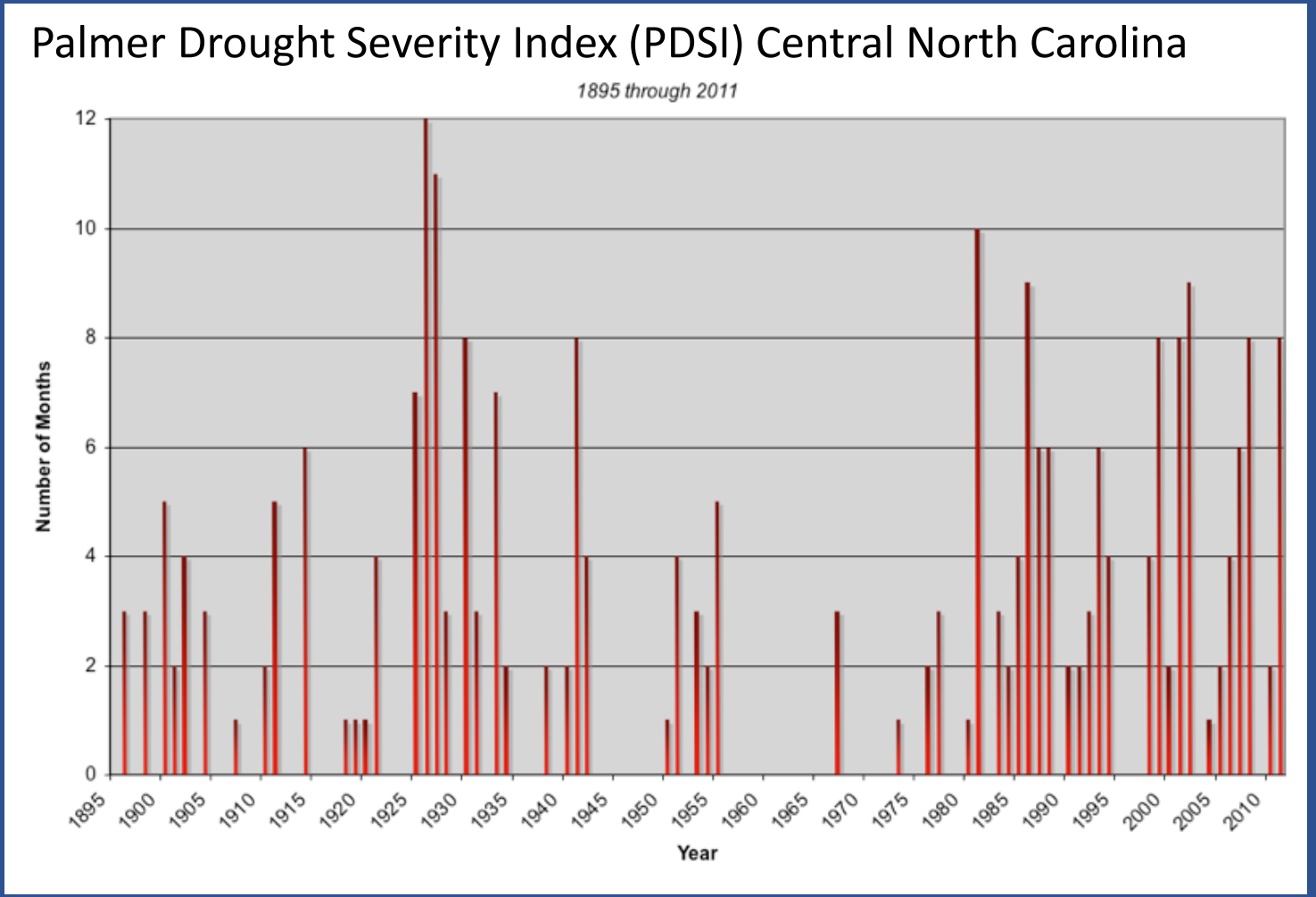
Aedes aegypti mosquitoes can spread several important diseases, including dengue fever, chikungunya, and Zika fever



https://nca2009.globalchange.gov/hazard-related-deaths-us/index.html

Droughts

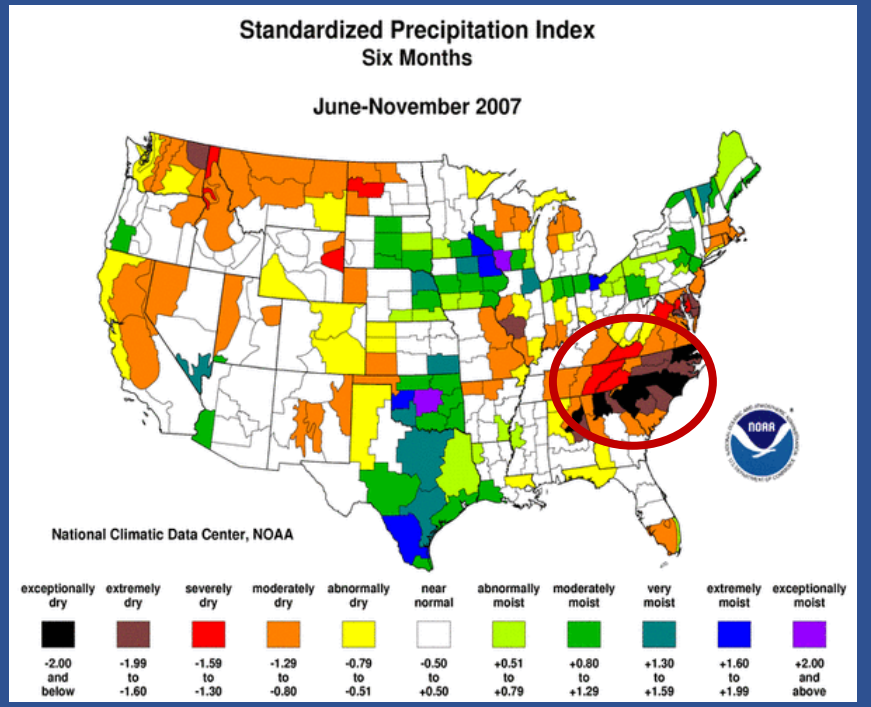
→ Warmer temperatures → more evaporation & higher soil drying rates



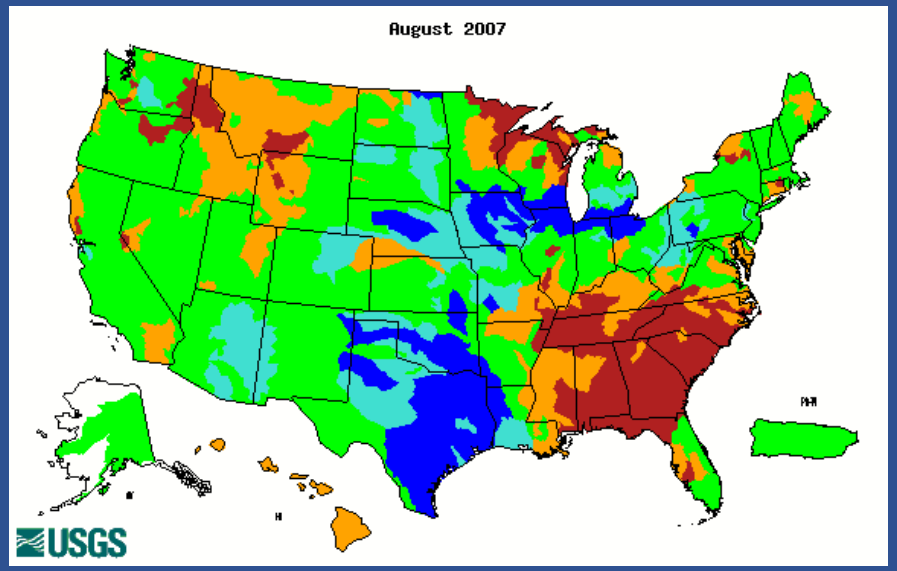
- Increased frequency but no long term trend in severity

Drought vulnerability, however, has increased greatly

Example: 2007 “Flash Drought” across Carolinas and North Georgia

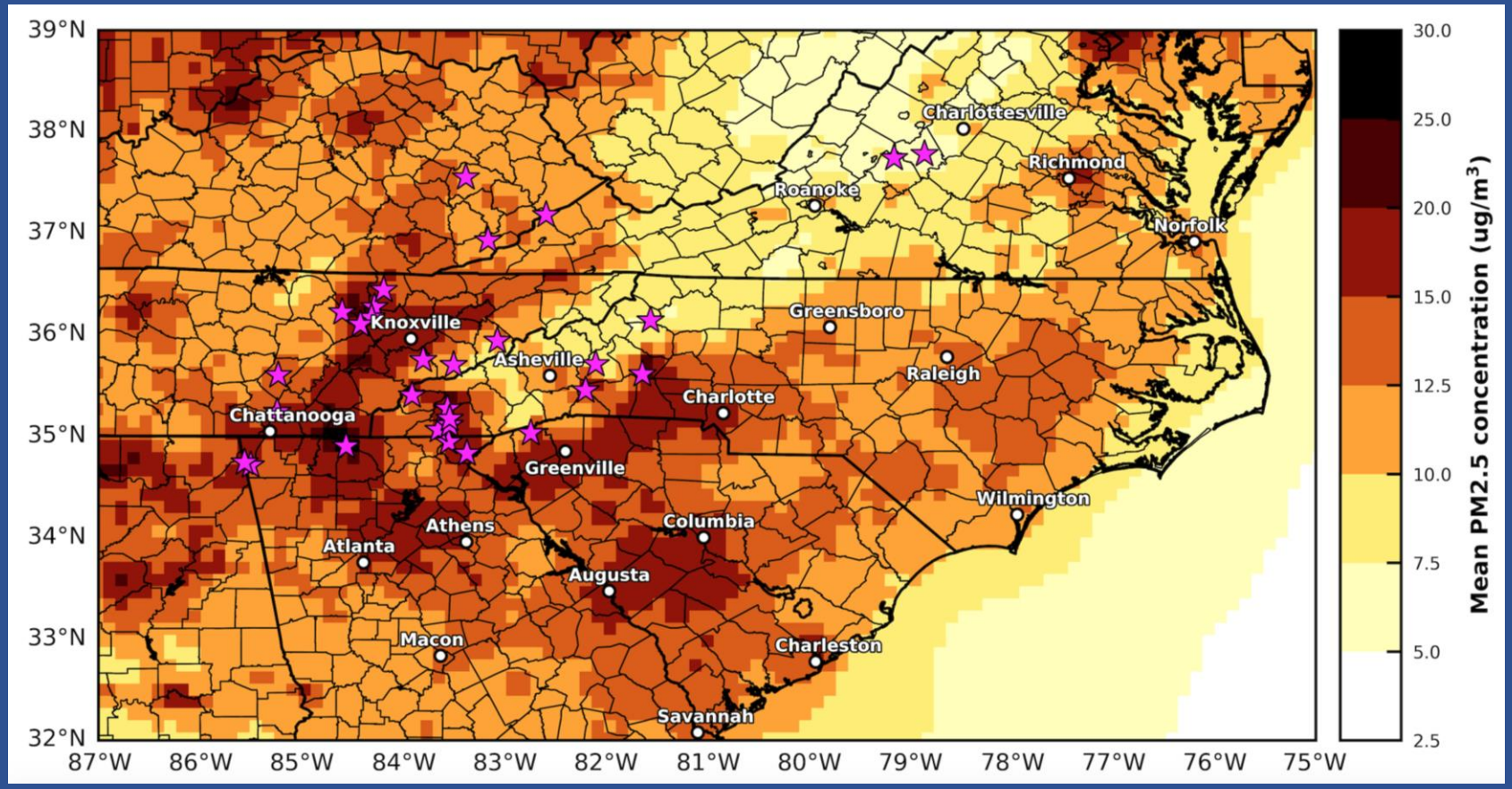


Stream flow (red = <10th percentile)



Falls Lake Reservoir in Wake Co. NC

Drought increases incidence of wildfires and wildfire smoke

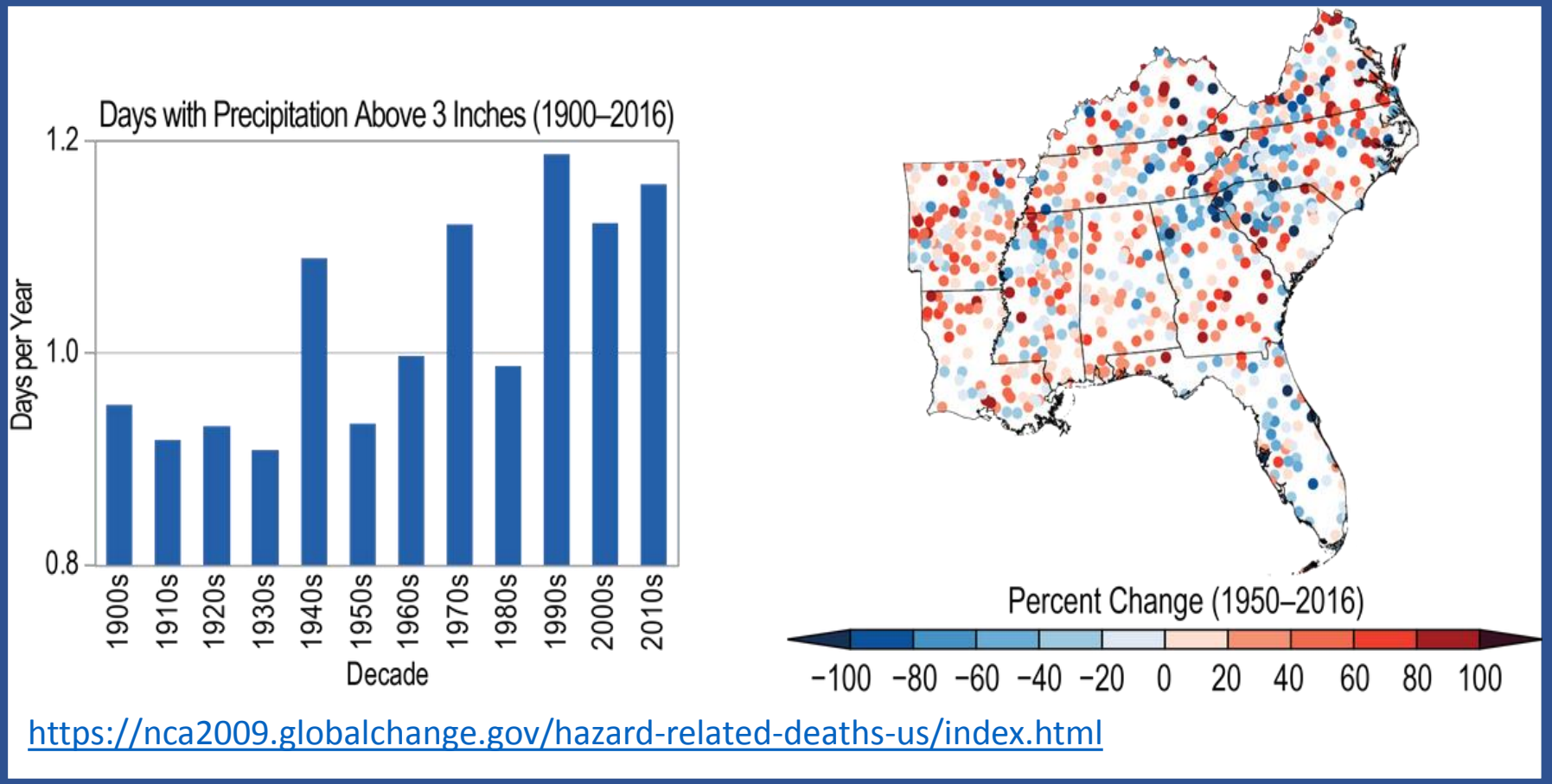


Average PM2.5 concentration (ug/m^3) from November 5–19, 2016.
Each star represents a major wildfire

Generated by data provided by EPA's National Exposure Research Laboratory

Increases in heavy rainfall and flooding

Warmer sea & atmosphere → more evaporation, more water vapor, higher rainfall rates

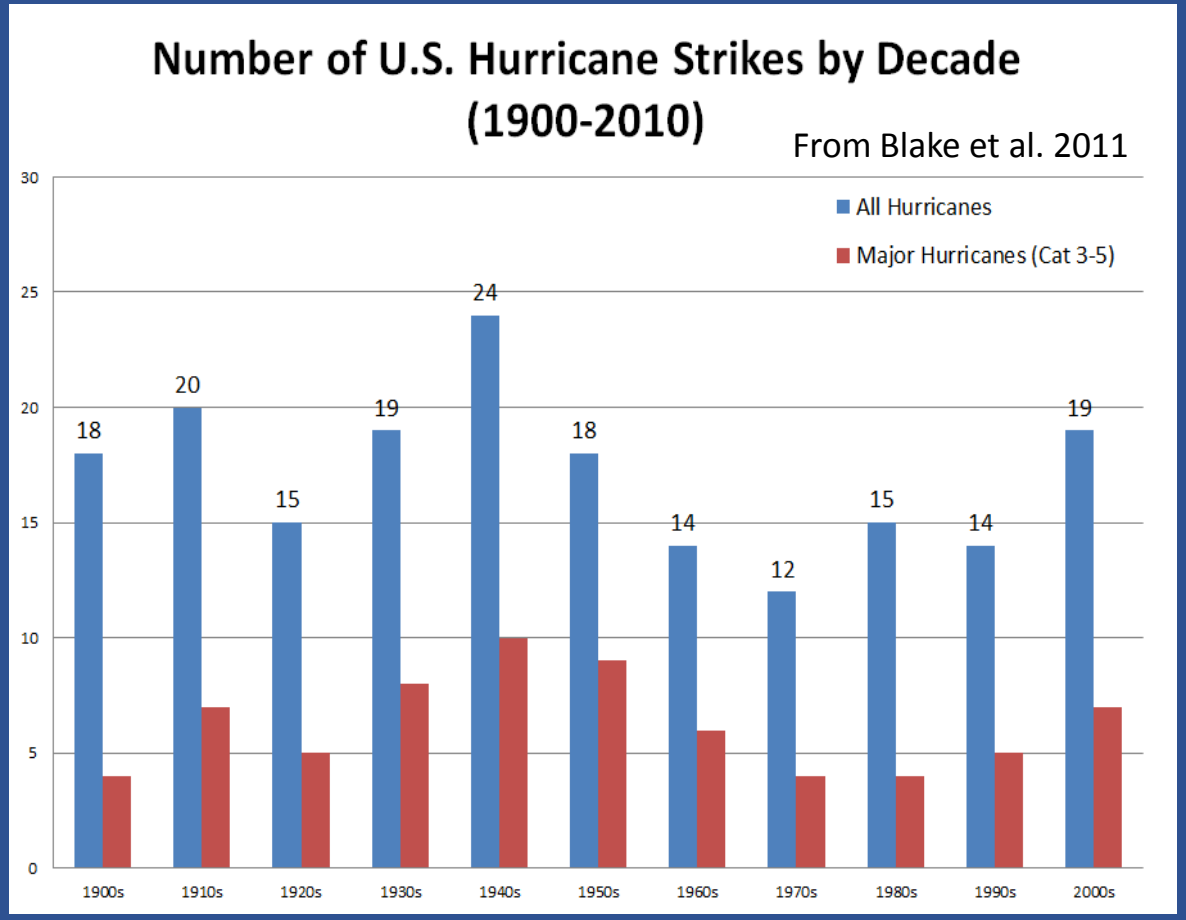


https://nca2009.globalchange.gov/hazard-related-deaths-us/index.html

Increase in strong hurricanes

Little change or slight decrease in tropical storms and weak hurricanes

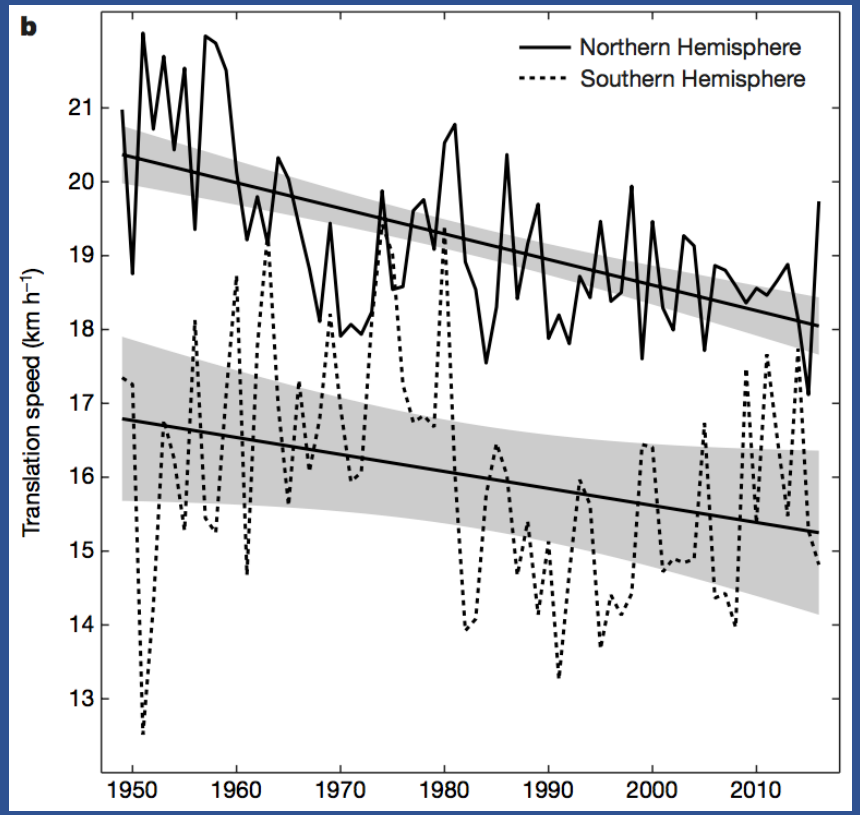
- Increase in sea surface temperatures ↑ hurricanes
- Stronger winds aloft ↓ hurricanes



Decreases in Hurricane Translation Speed

-10.0% Globally
-12.2% Northern Hemisphere
-20.0% Land areas around Atlantic Basin

Kossin, James P Nature (2017)



More wetter & slower hurricanes → Heavier rainfall rates over a longer duration

Impacts of hurricanes and public health implications

- Much coastal development, greatly increasing vulnerability/impacts.
- Sea level increase (e.g. Tidewater), further increasing vulnerability.
- Heavier precipitation of long durations → more freshwater flooding.
- Storm surge increases

More public health impacts of flooding and its aftermath

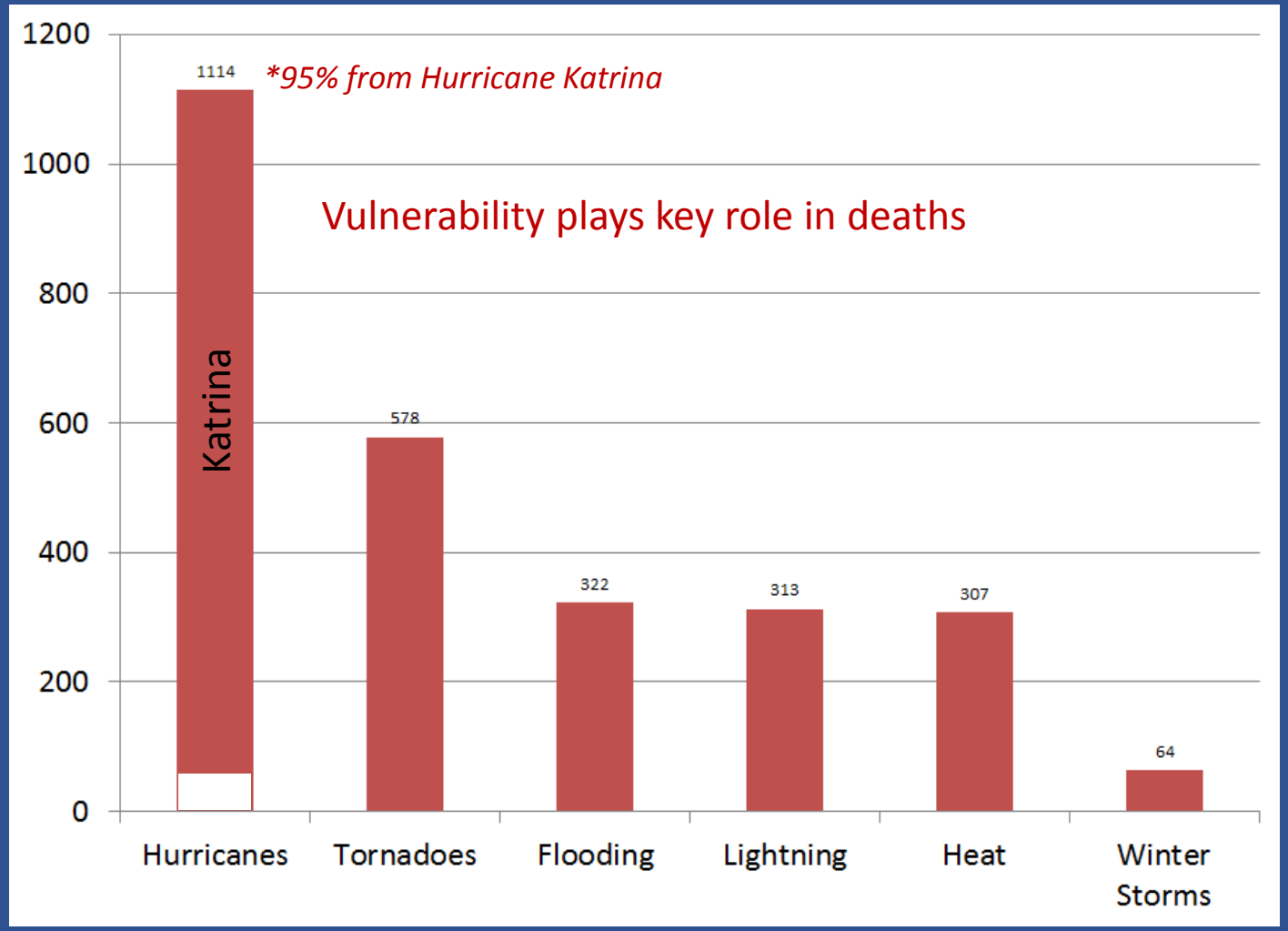
The costliest hurricanes to affect the United States (1900-2010)

6 of the 7 $10 billion+ hurricanes have occurred in the past 9 years, all impacting the Southeast region. Why? – Rapid population increases & coastal development

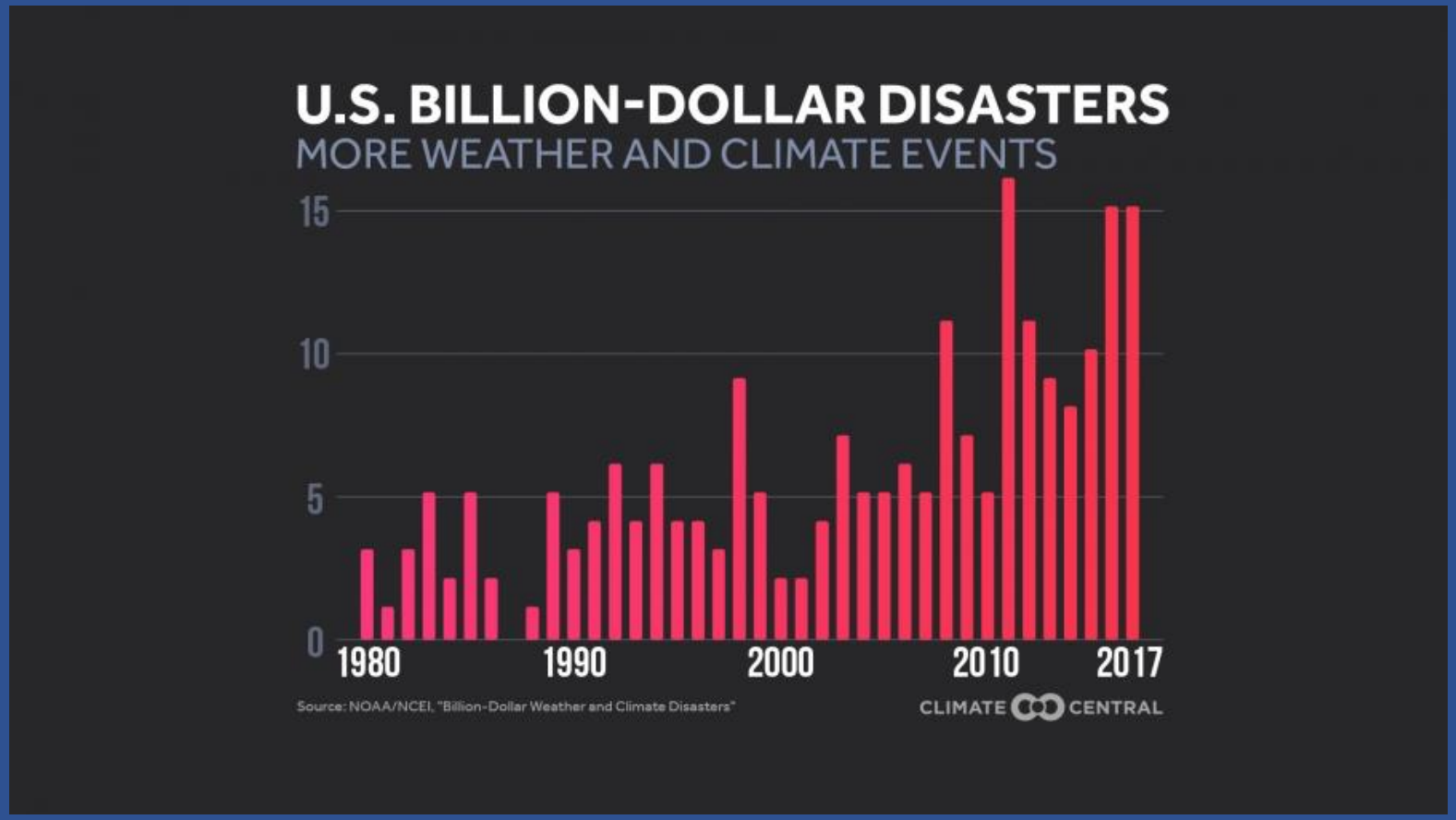
RANK	TROPICAL CYCLONE	YEAR	CATEGORY	DAMAGE (U.S.)
1	*KATRINA* (SE FL, LA, MS)	2005	3	$108,000,000,000
2	*IKE (TX, LA)*	2008	2	29,520,000,000
3	*ANDREW* (SE FL/LA)	1992	5	26,500,000,000
4	*WILMA* (S FL)	2005	3	21,007,000,000
5	*IVAN* (AL/NW FL)	2004	3	18,820,000,000
6	*CHARLEY* (SW FL)	2004	4	15,113,000,000
7	*RITA* (SW LA, N TX)	2005	3	12,037,000,000
8	*FRANCES* (FL)	2004	2	9,507,000,000
9	*ALLISON* (N TX)	2001	TS	9,000,000,000
10	*JEANNE* (FL)	2004	3	7,660,000,000
11	*HUGO* (SC)	1989	4	7,000,000,000
12	*FLOYD* (Mid-Atlantic & NE U.S.)	1999	2	6,900,000,000
13	*ISABEL* (Mid-Atlantic)	2003	2	5,370,000,000
14	*OPAL* (NW FL/AL)	1995	3	5,142,000,000
15	*GUSTAV* (LA)	2008	2	4,618,000,000
16	*FRAN* (NC)	1996	3	4,160,000,000
17	*GEORGES* (FL Keys, MS, AL)	1998	2	2,765,000,000
18	*DENNIS (NW FL)*	2005	3	2,545,000,000
19	*FREDERIC (AL/MS)*	1979	3	2,300,000,000
20	*AGNES (FL/NE U.S.)*	1972	1	2,100,000,000

Data from Blake et al. 2011

Fatalities Due to Extreme Events in the Southeast (1995-2010)



Source: National Weather Service


U.S. BILLION-DOLLAR DISASTERS
MORE WEATHER AND CLIMATE EVENTS
15
10
5
0
1980
1990
2000
2010
2017
Source: NOAA/NCEI, "Billion-Dollar Weather and Climate Disasters"
CLIMATE CENTRAL

THANK YOU!

Questions?

Dr. Chip Konrad
NOAA Southeast Regional Climate Center
konrad@unc.edu