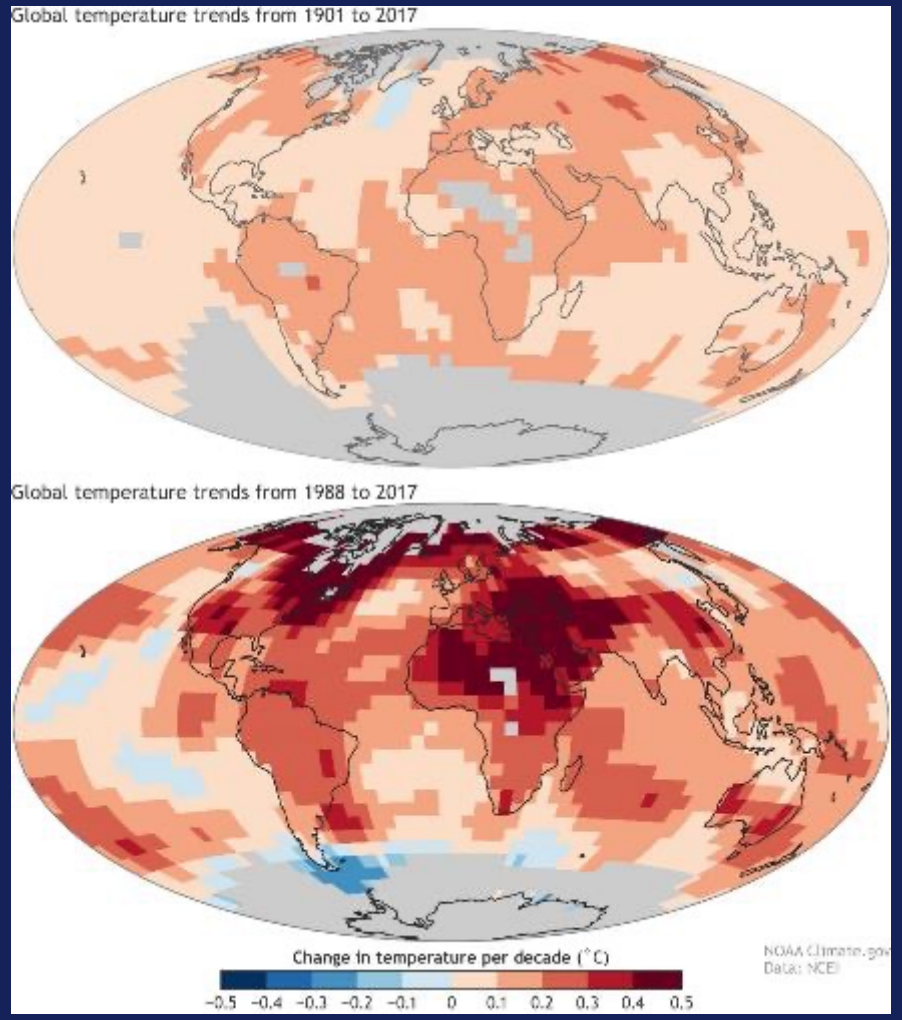
Mitigating the public health effects of climate change

Sten H. Vermund, MD, PhD
Anna M.R. Lauder Professor and Dean
Yale School of Public Health

Climate Change Conversations
Yale Alumni Academy

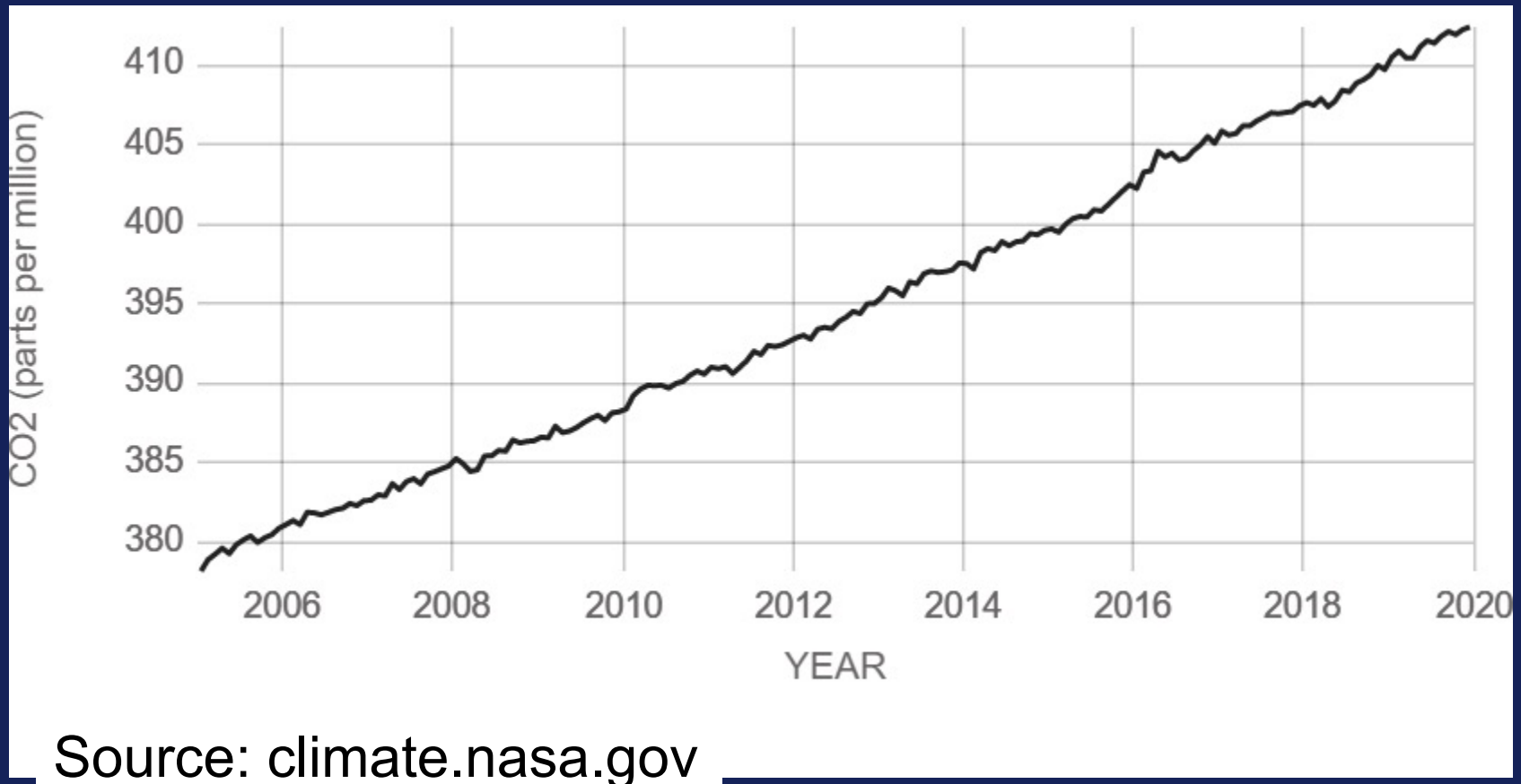
November 15, 2021

Annual Mean Surface Temperature Anomaly (°C)

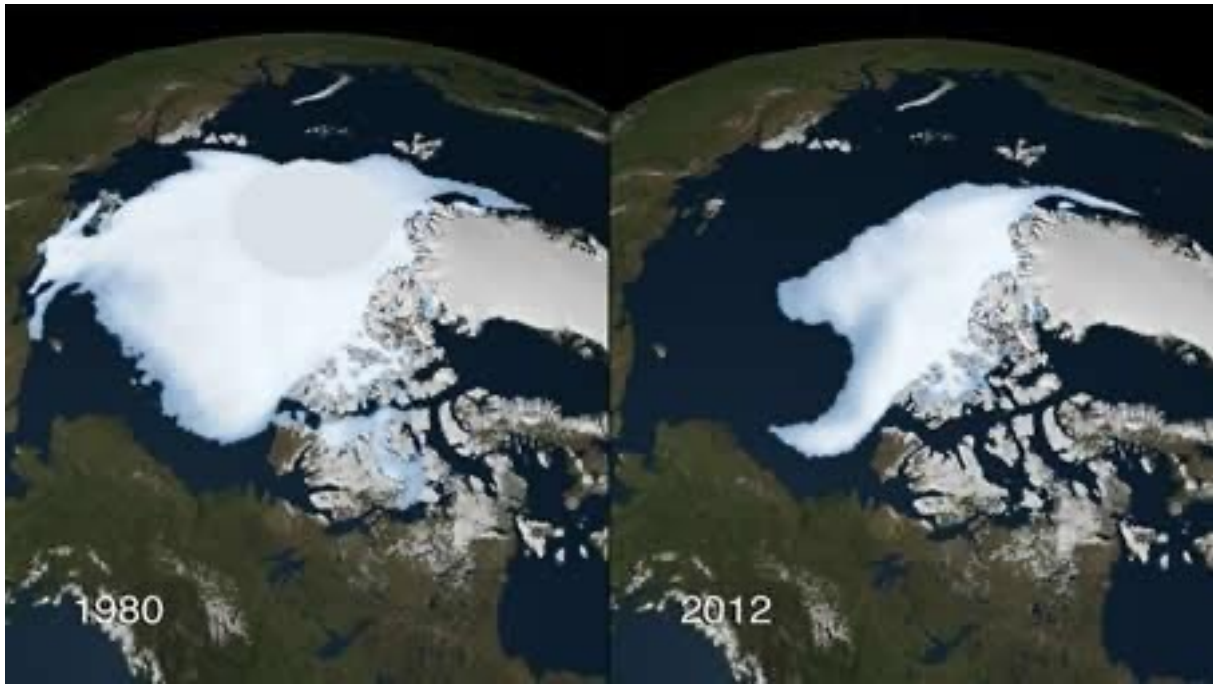


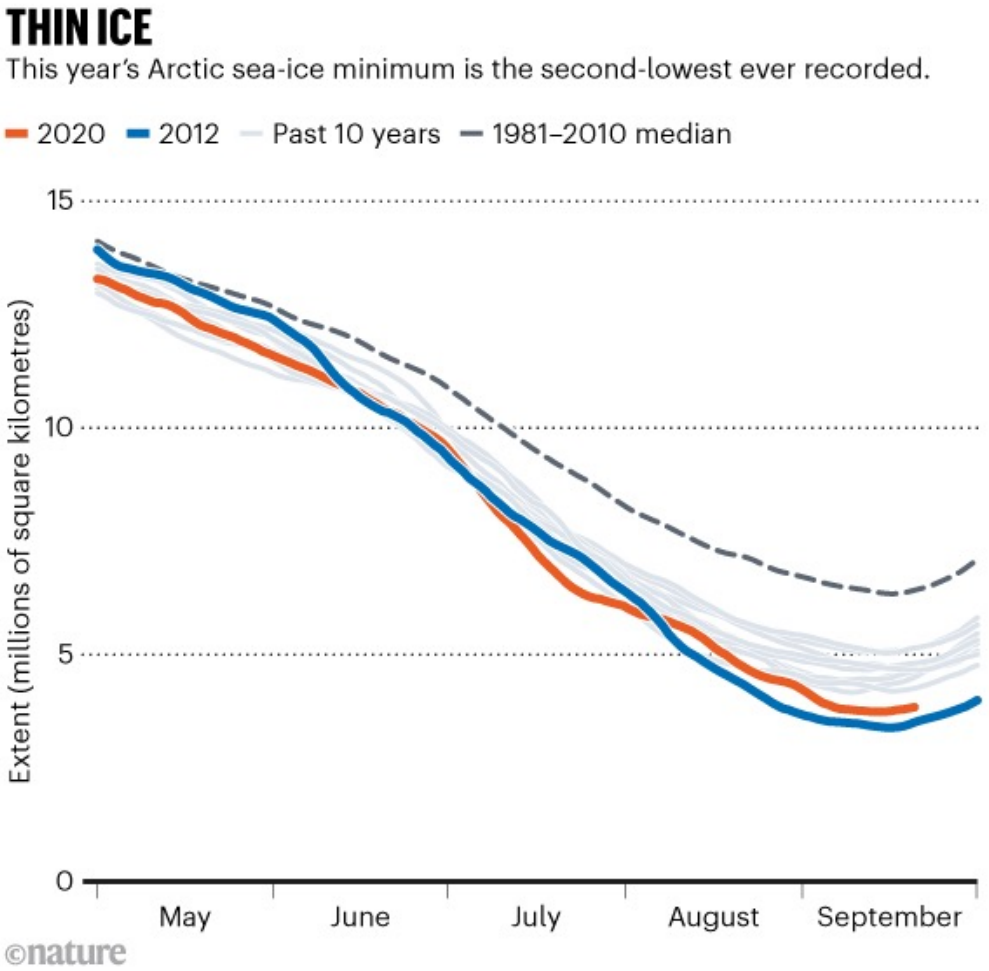
- The past 7 years are the warmest in recorded history: 2014–2020
- 2016 & 2020 globally averaged temp. were 1.02° C. (1.84°F.) hotter than 1951-1980 baseline
- Results: Massive loss of sea ice and ice sheet mass, sea level rise, longer intense heat waves, major habitat changes

CO_2 trends from 2006-2020



Source: climate.nasa.gov





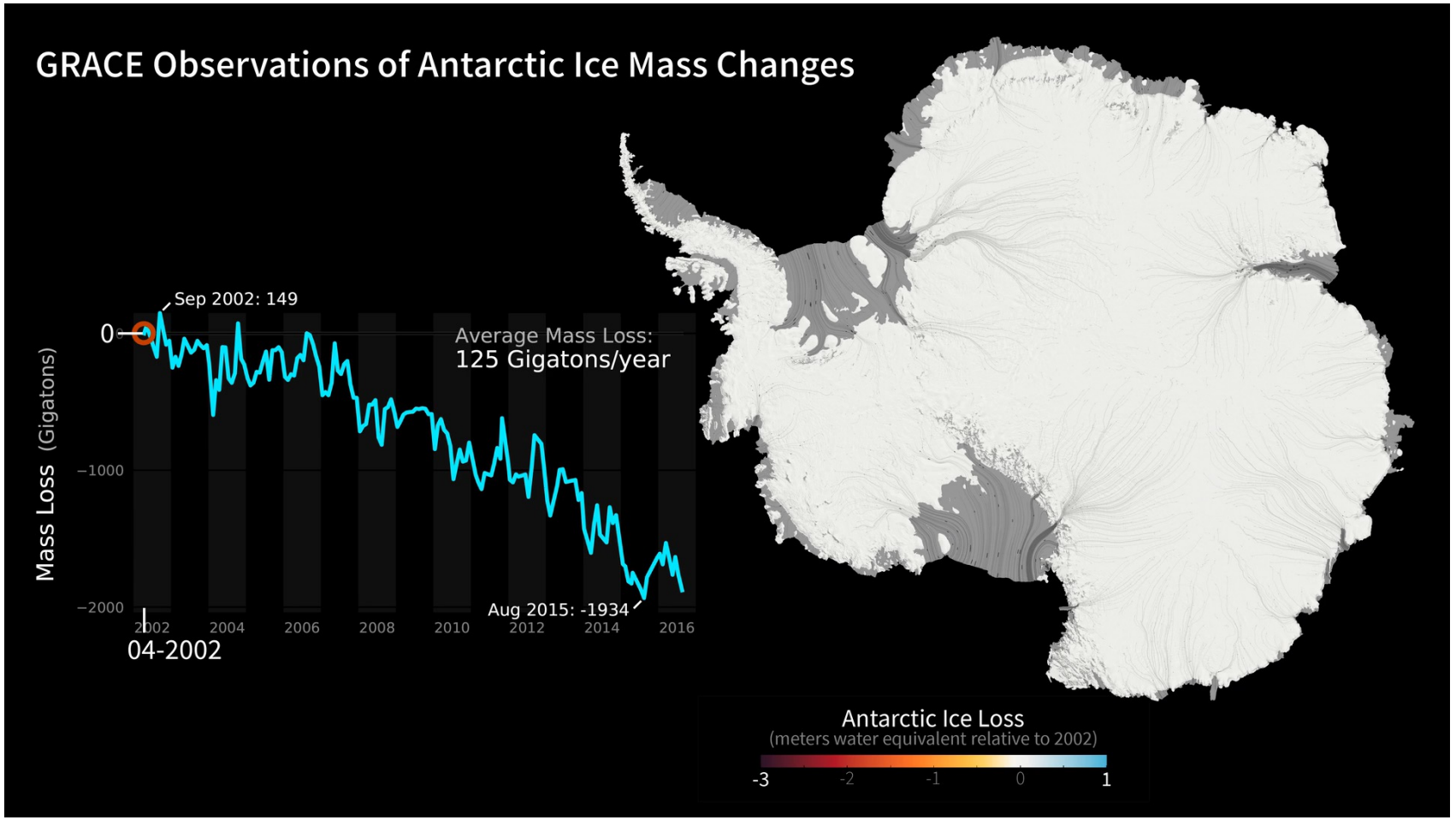
Summer Arctic polar ice cap shrinking 9% per decade

Past 10 years loss equals that of the previous 10,000 years.

Nadir of 3 M sq.km vs. 7 M sq.km. in 1981-2010 median, nearly 60% loss.

- https://sites.google.com/a/seoulforeign.org/erica-kim-s-science-journal/Home/global-environmental-issue
- Witze A. Arctic sea ice hits second-lowest level on record. *Nature* 2020 https://www.nature.com/articles/d41586-020-02705-7

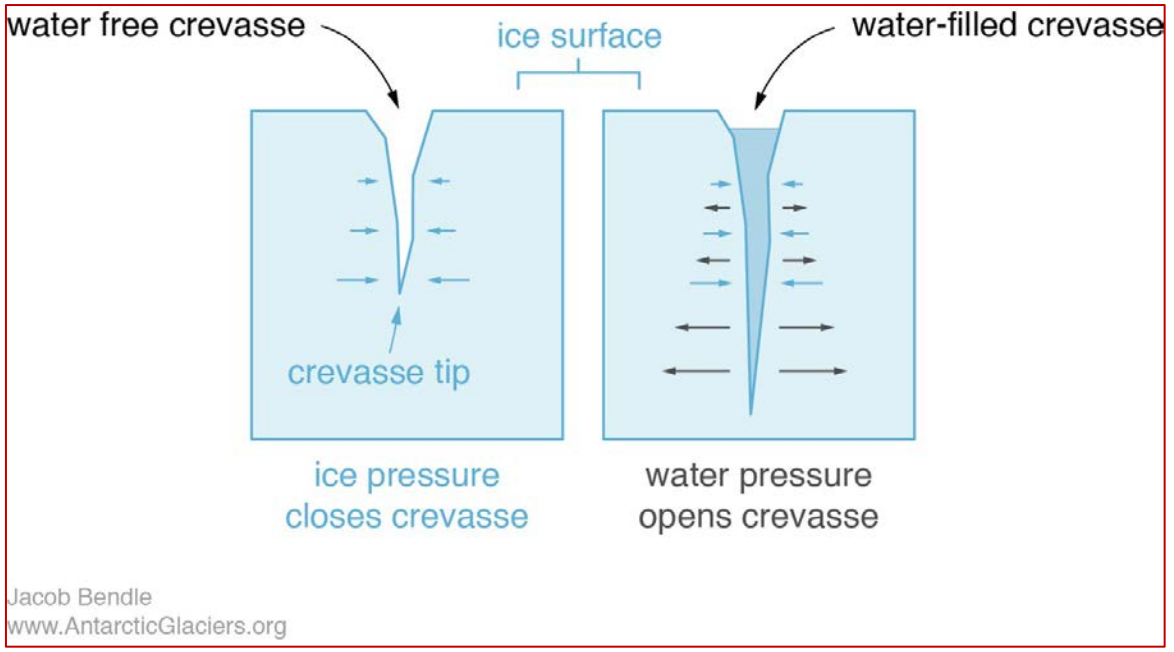
Video: Antarctic ice loss: 2002-2016

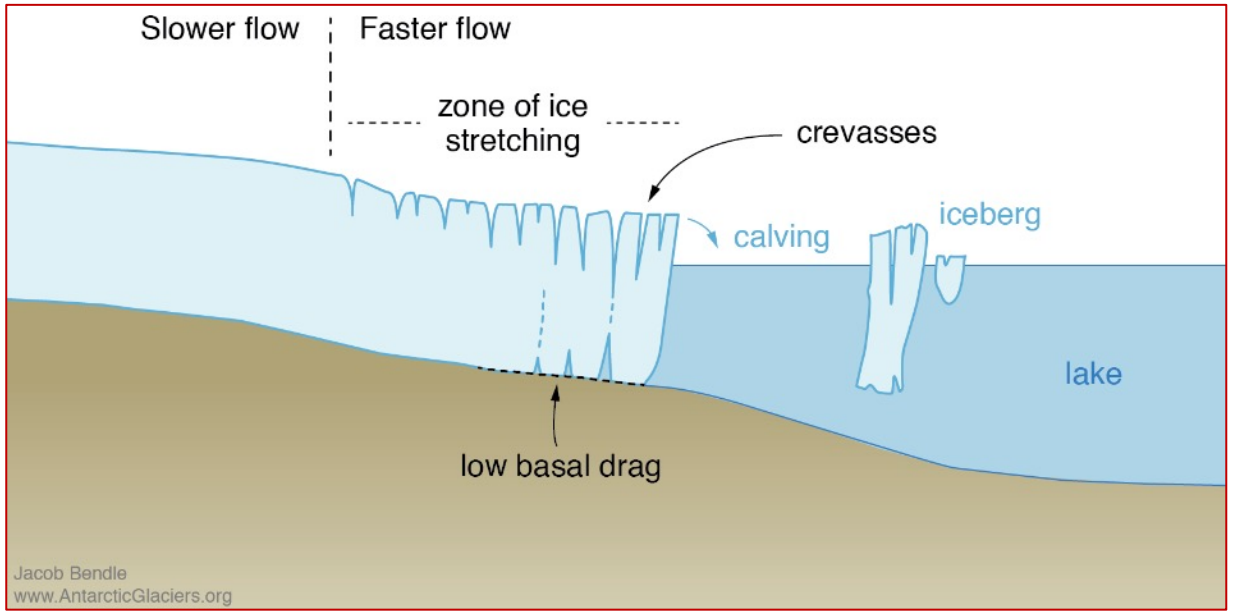


Glacial Calving

- Breaking off large ice masses from the forward leading end of a glacier.
- Ice calving the size of RI observed in Antarctica
- Melting of icebergs very gradual, but inevitable

- Benn DI, et al. Calving processes and the dynamics of calving glaciers. *Earth-Science Reviews* 2007

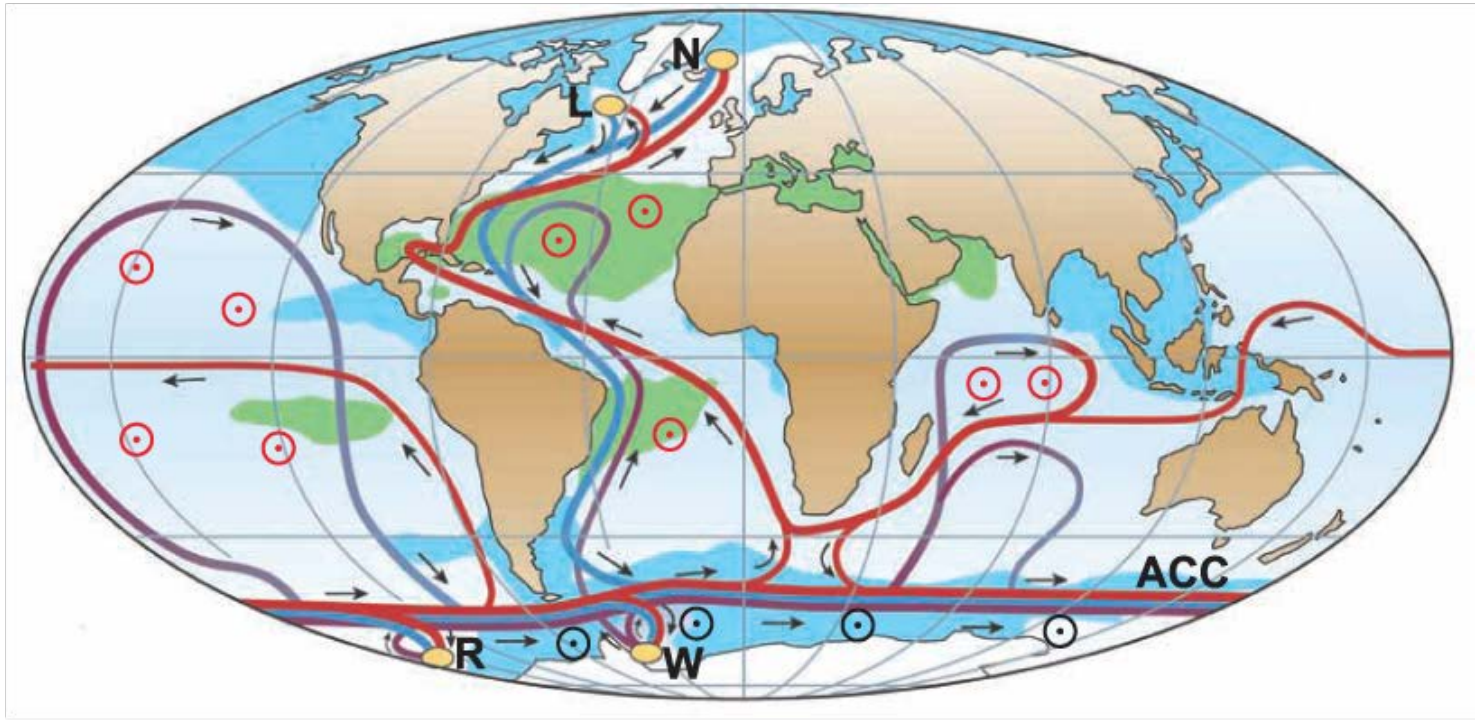




Thermohaline Circulation

The ocean is a vast heat store and North-South, East-West circulator

Atlantic current: Meridional overturning circulation (MOC)



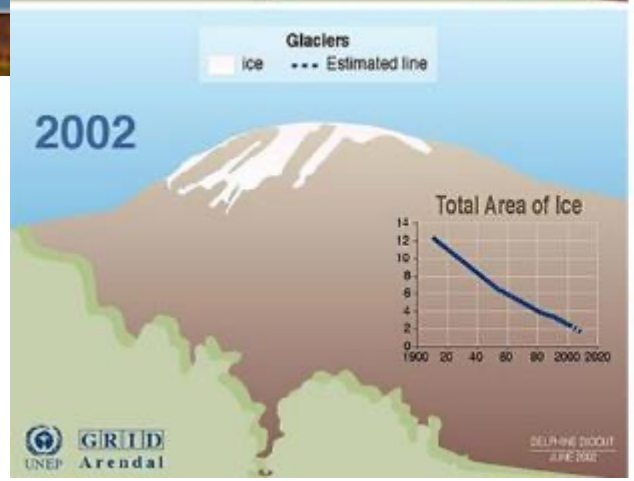
"This suggests that internal variability from the Atlantic Ocean may have dampened the magnitude of global warming over the historical era. Taking into account this AMOC weakening over the past decades means that it will be harder to avoid crossing the 2 °C warming threshold."

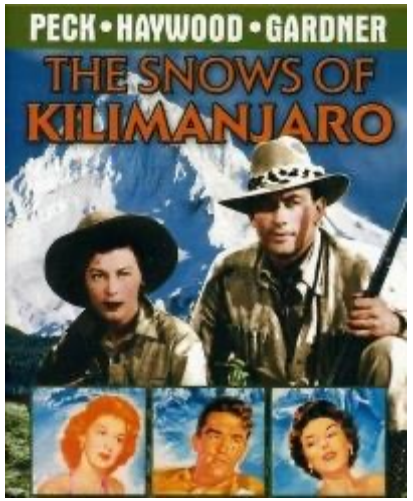
Bonnet R, et al. Increased risk of near-term global warming due to a recent AMOC weakening. *Nature Communications* 2021.

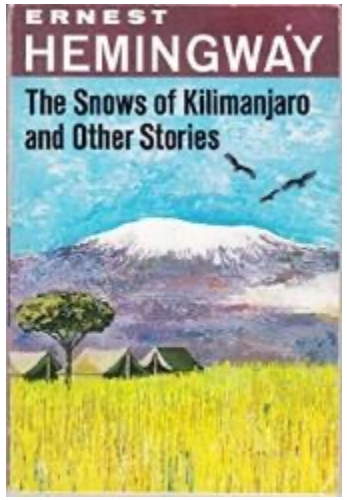
http://www.eoearth.org/view/article/150290/

Fresh water dynamics: Example of Mount Kilmanjaro: Africa's highest peak

- Deforestation and global warming







Evidence for global climate change as a consequence of man-made GHG emissions

- Irrefutable and overwhelming association, as convincing as:
  - HIV and AIDS; HPV and cervical cancer; SARS-CoV-2 and COVID-19
  - Asbestosis and mesothelioma; Smoking and lung cancer
- Scientists who disagree are typically on the payrolls of interested parties, e.g., fossil fuel industry and their media and political advocates
- Major climate change denial “experts” brought to debate climate change scientists on TV are typically paid lobbyists without any scientific background

Health Issues

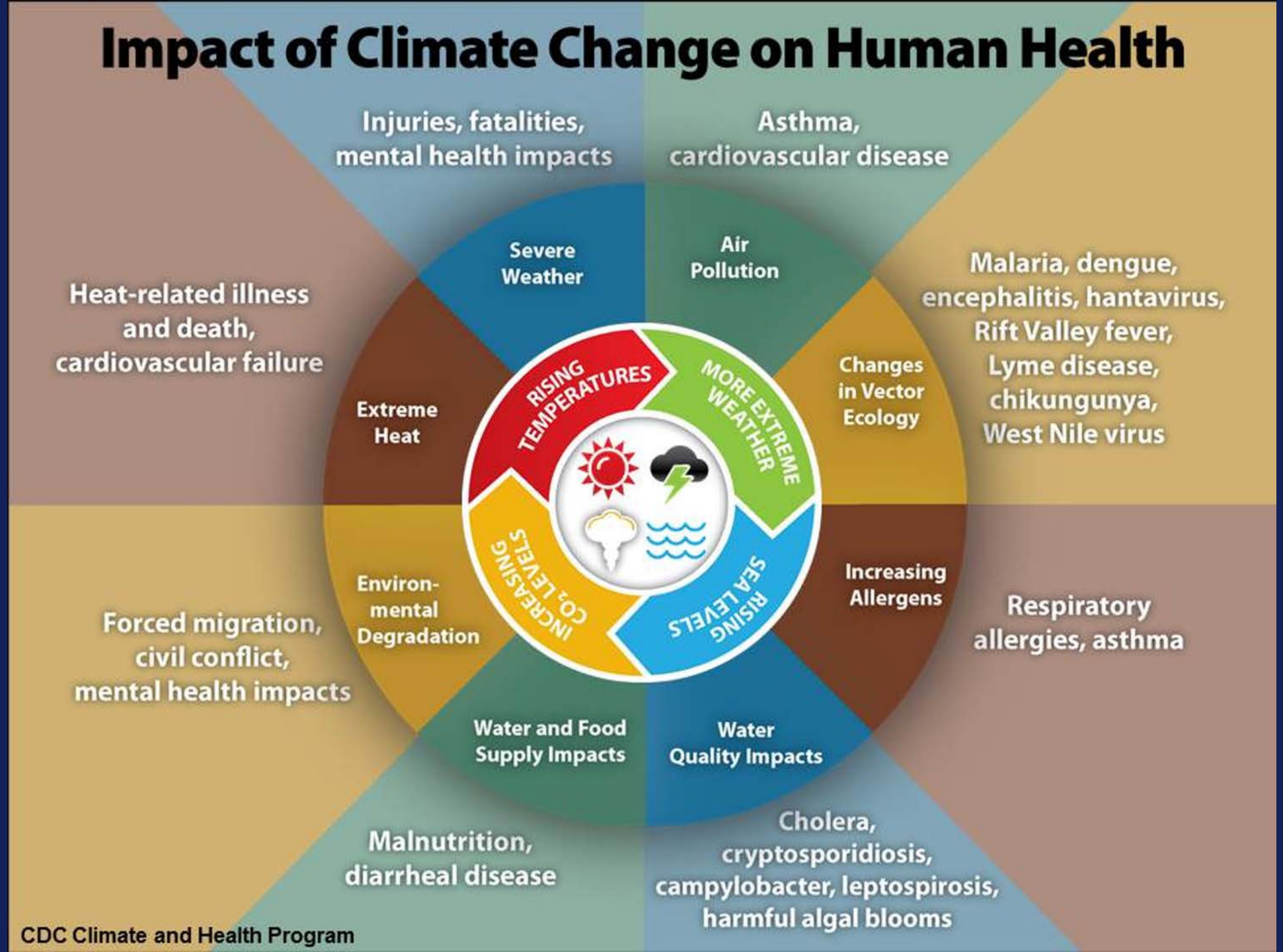
1. **Direct effects of heat**
2. Climatological displacement (climate refugees) and extreme weather events
3. Vector-borne diseases
4. Population pressures → shrinking land/water assets
5. Evolving drought and flood cycles --> famine risk

Global threats to the environment of human origin

- **Global climate change** (known as "global warming", until renamed by a political lobbyist; now seen as a better description)
- Direct human effects[1]
  - Hotter and drier summers (heat related deaths)[1]
  - Warmer and wetter winters (loss of polar/glacial ice)
  - Increased extreme weather (adverse events) [2]
  - Property (especially coastal) and crop loss [3]
  - Loss of reef ecosystems, fish (ocean biodiversity)

1. Ebi KL, et al. Extreme weather & climate change: Population health & health system implications. *Annu Rev Public Health* 2021
2. Emanuel K. Increasing destructiveness of tropical cyclones over the past 30 years. *Nature* 2005
3. Li L, Chakraborty P. Slower decay of landfalling hurricanes in a warming world. *Nature* 2020

Impact of Climate Change on Human Health



Health Issues

1. Direct effects of heat
2. **Climatological displacement (climate refugees) and extreme weather events**
3. Vector-borne diseases
4. Population pressures → shrinking land/water assets
5. Evolving drought and flood cycles --> famine risk

39 Countries and 5 Territorial Regions Especially Vulnerable to Climatological Events

Alliance of Small Island States

https://www.aosis.org/

AOSIS Statement at the High-Level Event on Global Climate Action, Glasgow, Nov. 2021

United Nations climate conference in Glasgow

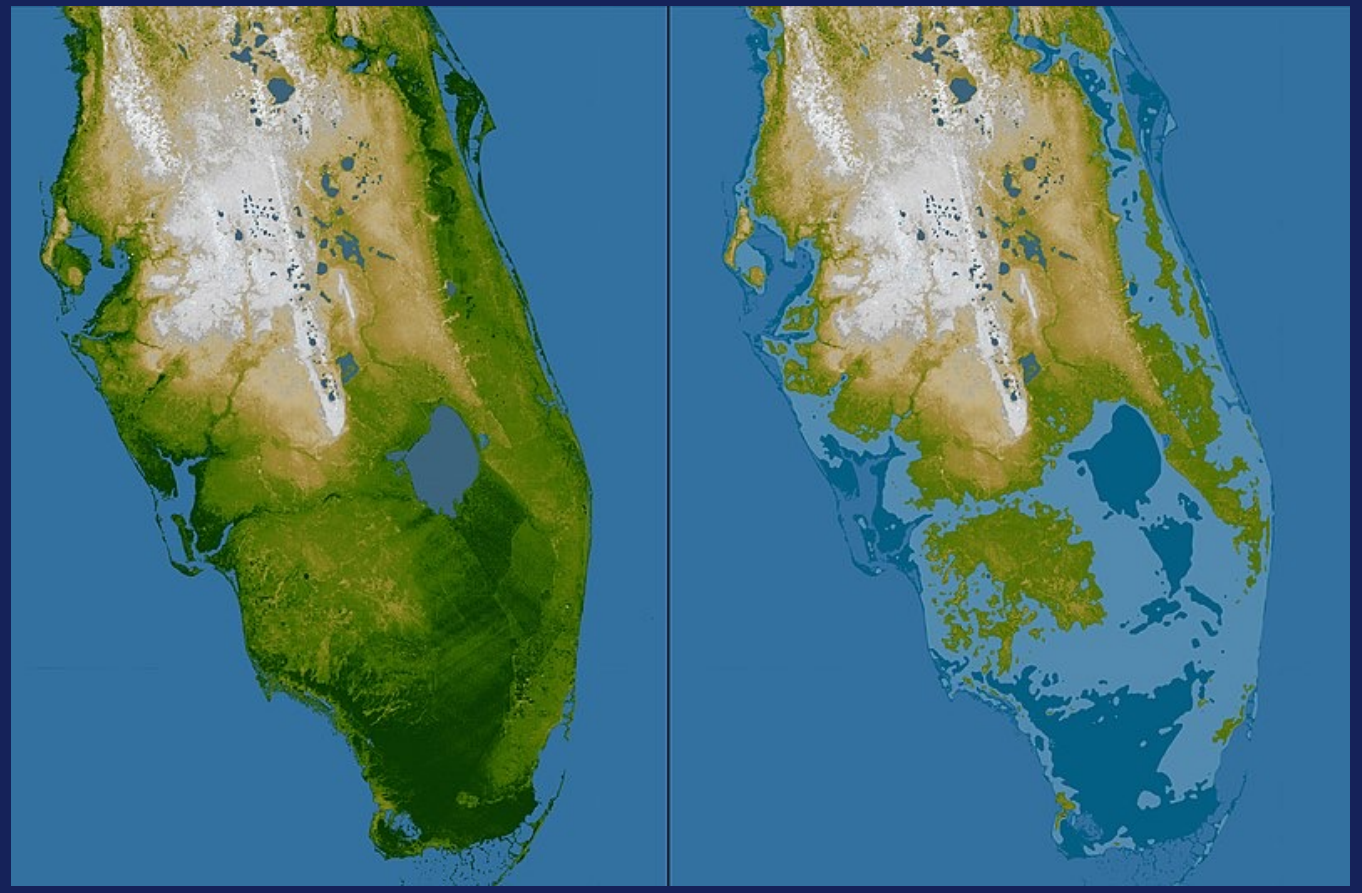
Tuvalu's Minister for Justice, Communication & Foreign Affairs Simon Kofe gives a COP26 statement on Nov. 8, 2021

United Nations climate conference in Glasgow

Tuvalu's Minister for Justice, Communication & Foreign Affairs Simon Kofe gives a COP26 statement on Nov. 8, 2021

Areas in Florida subjected to inundation with a 1 meter rise in sea level

Kennedy Space Center



Sources: Corell RW. Impacts of a warming Arctic. *Arctic Climate Impact Assessment.* Cambridge University Press, 2004; NASA/JPL-Caltech Shuttle Radar Topography Mission, launch 02/11/2000

How global warming affects storm formation and intensity (e.g., hurricanes, cyclones, tornados)

- As temperatures rise, more and more water vapor evaporates into the atmosphere → "fuel" for storms
- More heat and water in the atmosphere combined w/warmer ocean surface temperatures → increases the wind speeds of tropical storms
- Analogous phenomena with temperature inversions → drive tornados on land
- Snow reflects heat while rock absorbs it (freshwater snowpack and glacier losses) → new cycles of floods, then droughts

http://earthobservatory.nasa.gov/Features/RisingCost/rising_cost5.php

Vast costs: Hurricanes Katrina (2005), Harvey, Irma, Maria (2017), and Dorian (2019)

Not accounting for inflation, 15 Atlantic hurricanes have resulted in >US$10 B. in damage each, incl. 3 each from 2004, 2005, & 2017. Costliest were Katrina in 2005 & Harvey in 2017, both w/ uninflated damage totaling to $125 B.

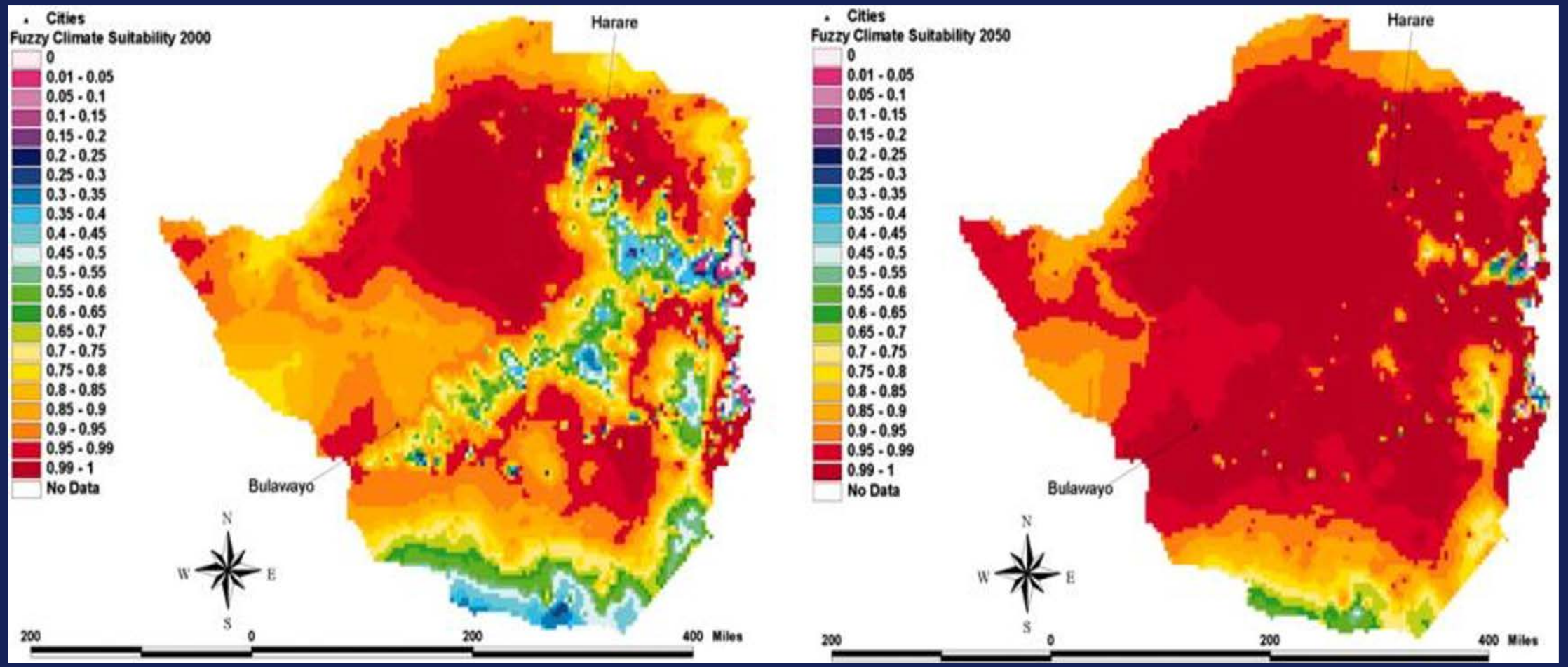
Health Issues

1. Direct effects of heat
2. Climatological displacement (climate refugees) and extreme weather events
3. **Vector-borne diseases**
4. Population pressures → shrinking land/water assets
5. Evolving drought and flood cycles --> famine risk

Spread of vector-borne diseases

- Mosquito-related infections
  - Malaria
  - Arboviruses
    - Dengue Fever, Yellow Fever, Zika virus
- Other vector-related infections
  - Filariasis/Onchocerciasis (Blackflies)
  - Schistosomiasis (Snails)
  - Hantaviruses (Rodents)
  - Trypanosomiasis (In Africa, tsetse fly; In Americas, Reduviid bug)
  - Tick-borne diseases, e.g., Lyme disease
- Water-borne diseases, e.g., cholera

Malaria in the highlands of Zimbabwe



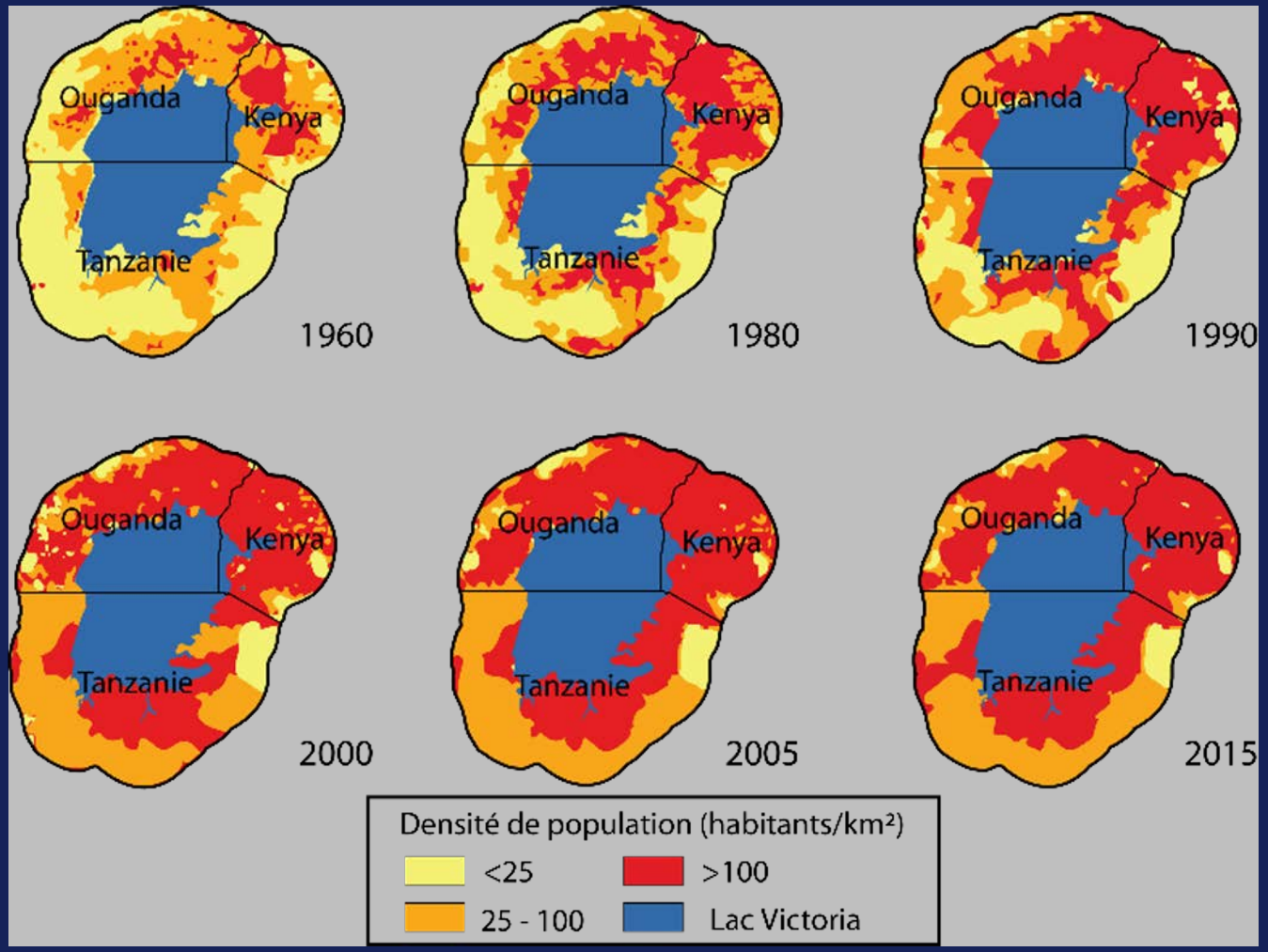
Health Issues

1. Direct effects of heat
2. Climatological displacement (climate refugees) and extreme weather events
3. Vector-borne diseases
4. **Population pressures → shrinking land/water assets**
5. Evolving drought and flood cycles --> famine risk

- Education, especially for girls and women
- Unmet need for birth spacing via access to contraception and family planning, with concomitant improved maternal and child health and survival
- Sustainable economic empowerment for women and families

Population Growth Pressure around Lake Victoria

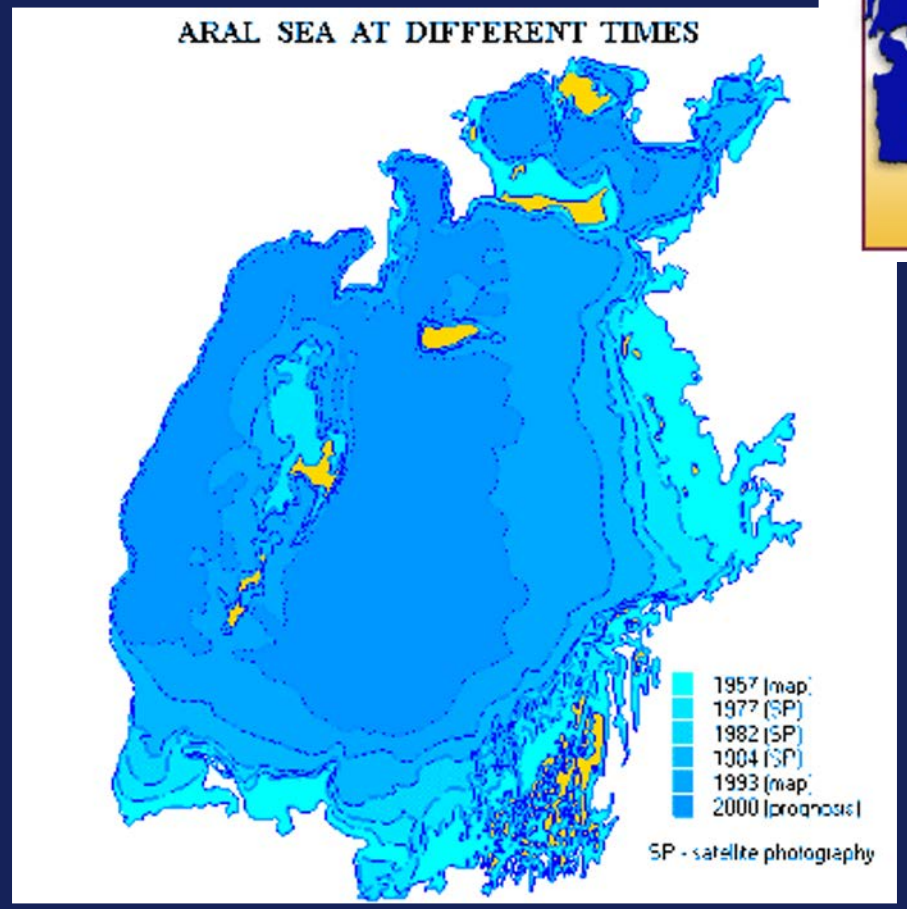
- Overfishing
- Overgrazing
- Farmland pressures
- Hunger and climate refugees related to changing freshwater dynamics AND overpopulation



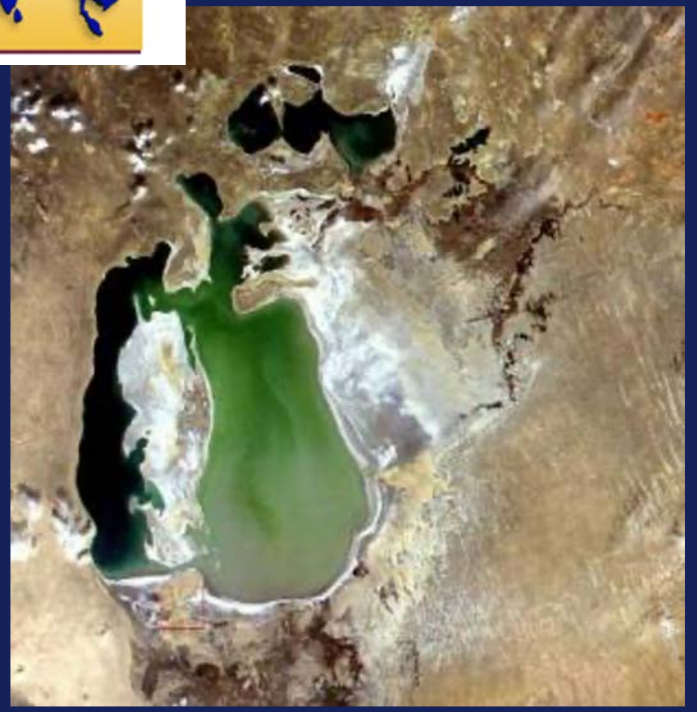
UNEP

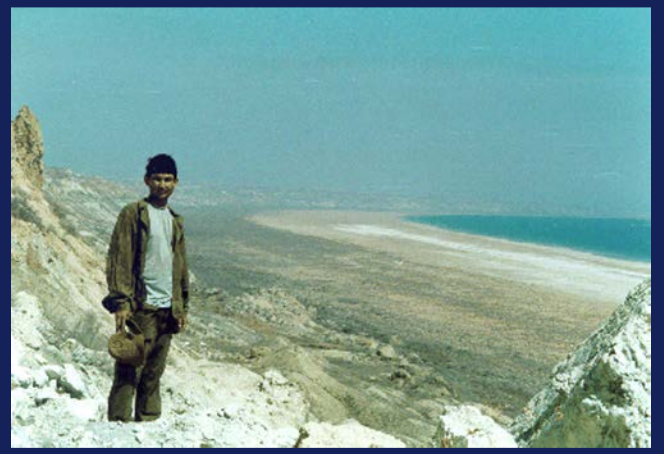
Yale SCHOOL OF PUBLIC HEALTH

Aral Sea is vanishing
as are Lake Chad, California's Mono Lake, many others



Cotton growing with river diversions, pesticides and fertilizer, Aral Sea salinization





The Sahel

- Sahel means “shore” in Arabic
- Lies between the desert and fertile grassland or rain forest to the south
- Long, dry seasons & wet seasons
- Drought has brought famine, misery, & hardship
- The Sahara is taking over large swathes of the Sahel

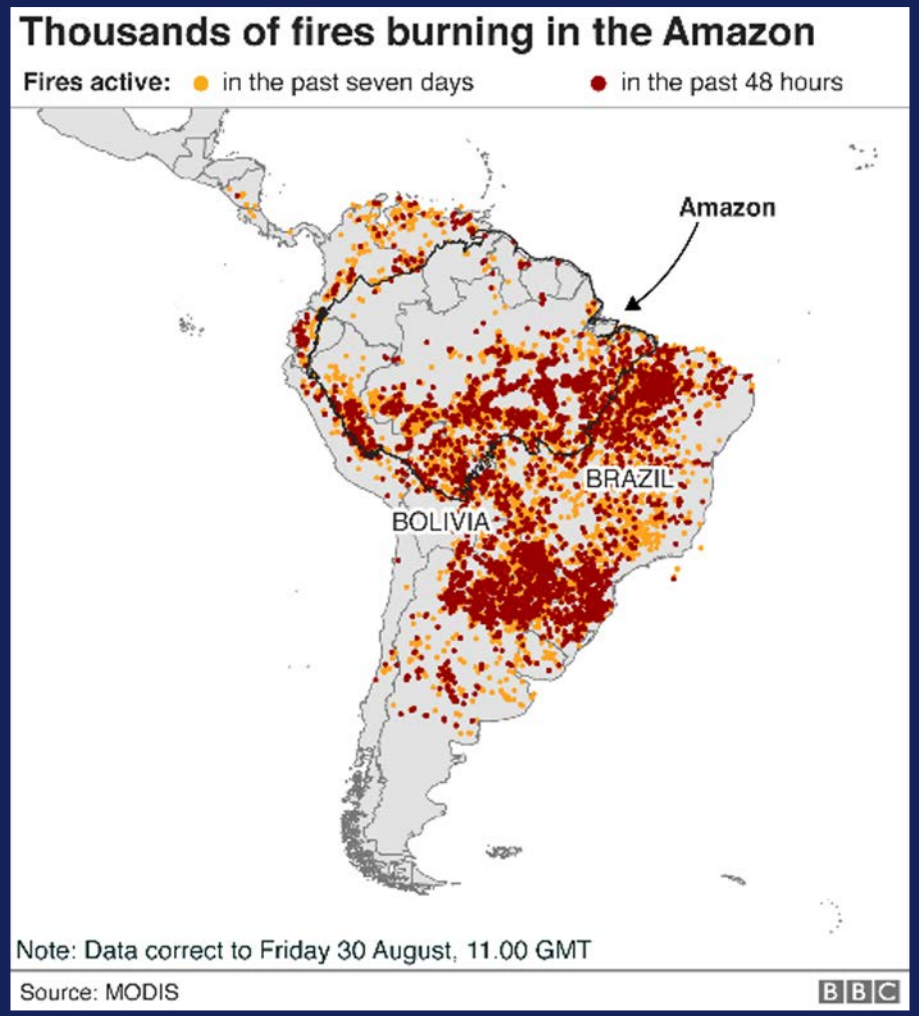
Desertification

- Sahel is under stress from overuse of land (farming, grazing) and global warming and climate variability
- If vegetation and animals cannot survive, people must migrate

How the Sahel is an example of desertification

- climate change
- agricultural practices
- political process
- population pressures

Deforestation: Encroaching upon ecosystems that mitigate C02 emissions



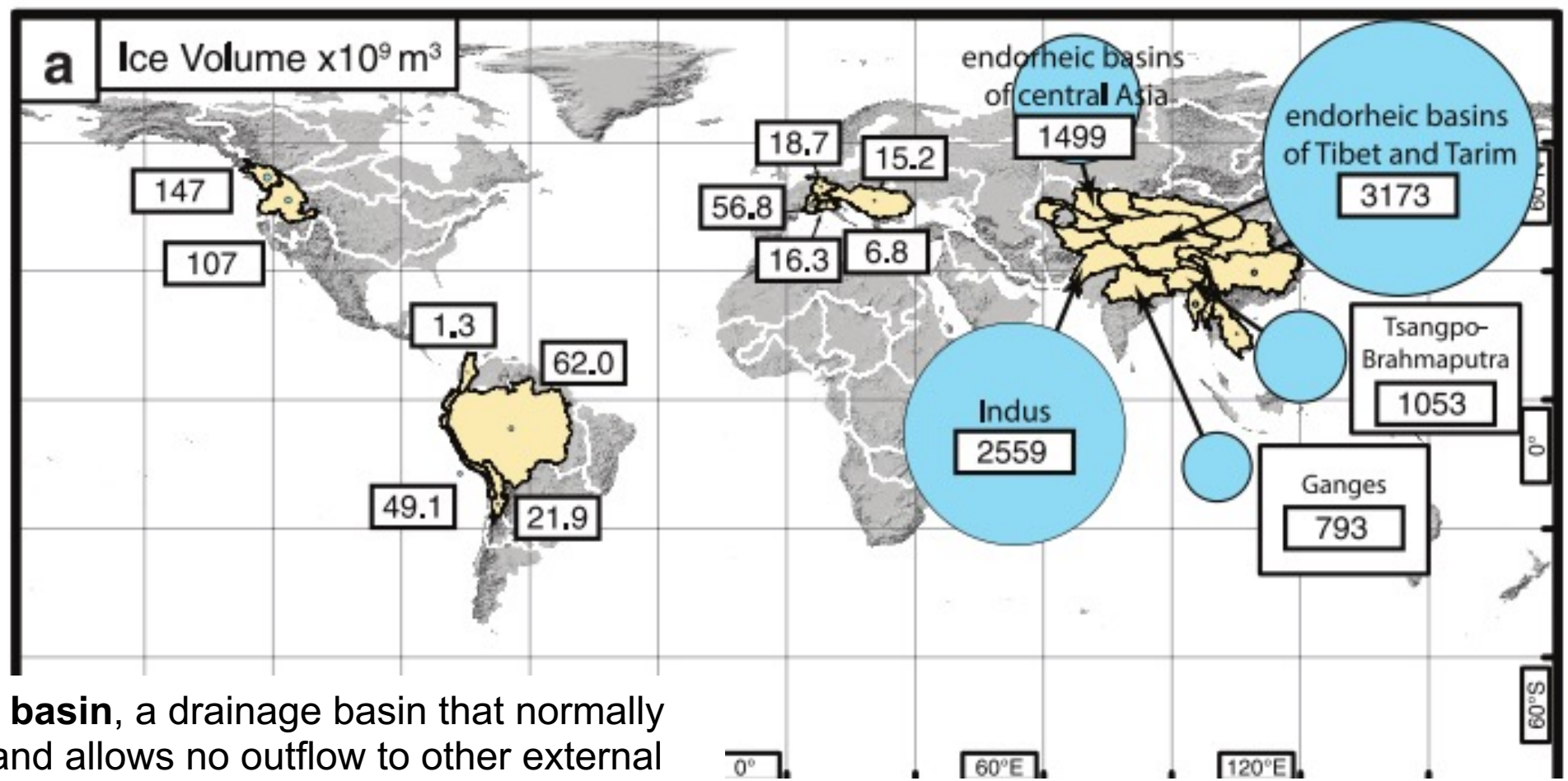
Climate Change and Health: 2020-21 Events

- Australian and Western USA Wildfires
  - Smoke exposure and poor air quality
  - Mental health impacts
- Temperature Records
  - "Hottest day ever" records broken all over the world, from Siberia to Arizona
  - 2020 and 2016, the hottest years in recorded history
- COVID-19
  - Impacts on CO^2 emissions were favorable
  - Food supply chain impacts were complex

Health Issues

1. Direct effects of heat
2. Climatological displacement (climate refugees) and extreme weather events
3. Vector-borne diseases
4. Population pressures → shrinking land/water assets
5. **Evolving drought and flood cycles --> famine risk**

Context: Importance of Frozen Water



An **endorheic basin**, a drainage basin that normally retains water and allows no outflow to other external bodies of water, but drainage converges instead into lakes or swamps that equilibrate through evaporation.

Image Credit: Huss et al., 2017

Context: Glacier Changes

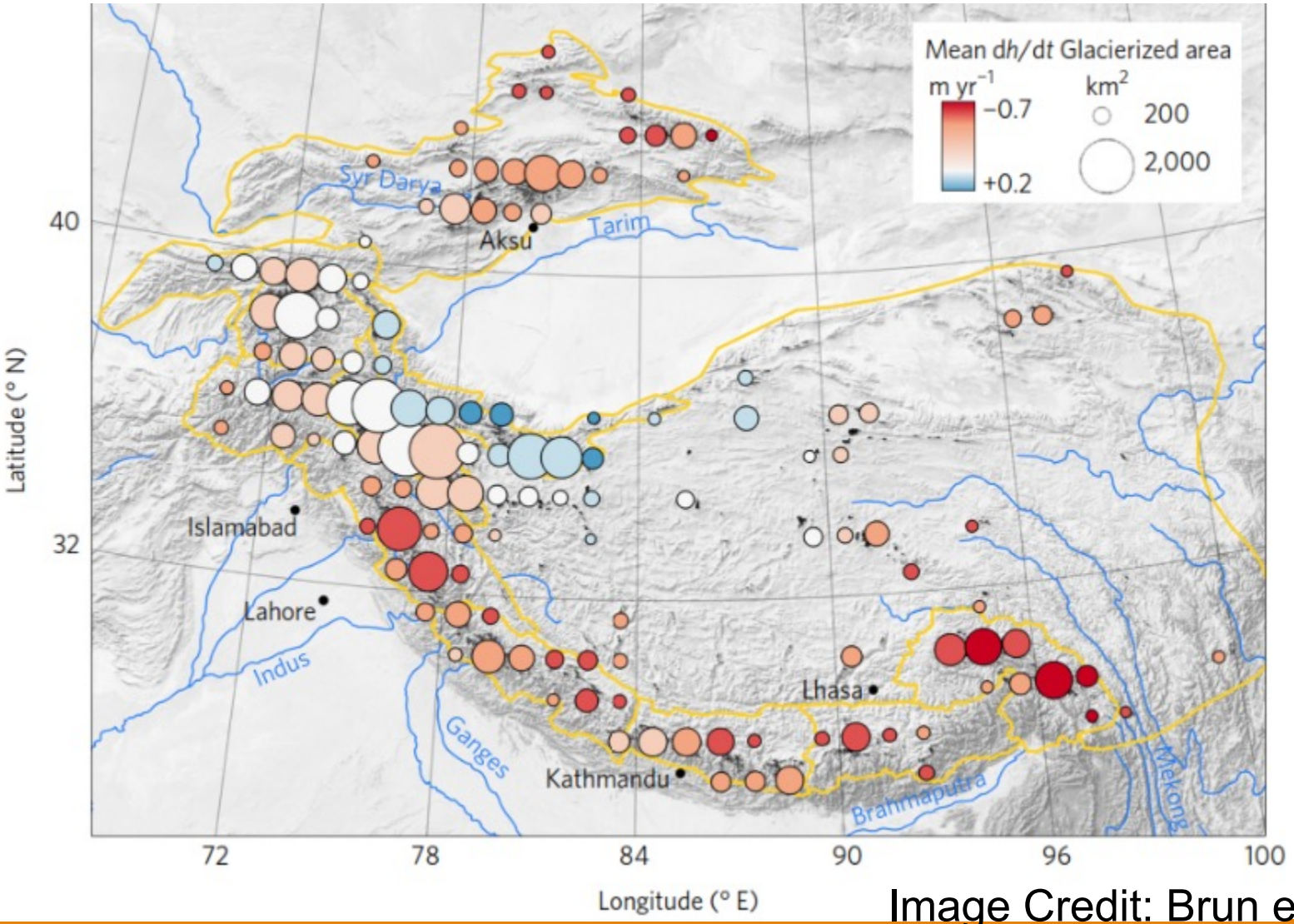


Image Credit: Brun et al., 2017

Himalayan glaciers/snowpack and human health

- Snowmelt onset and end dates are occurring earlier in the year, in the context of overall glacier shrinkage and warming of the earth
- Snowmelt period (e.g., how long snow takes to melt off) is shrinking, about a 3-week shift in snowmelt onset and end dates
- Trends show less snow, melting earlier and faster. The future: (a) run out of water earlier in the year (intermittent droughts) & (b) more early-season floods (rain falls on snow)
- Rainfall may be increasing; the overall amount of water is less critical than the TIMING changes, reducing water consistency for planting, harvesting, drinking, & hydropower
- 1.5 billion people will be affected: Indus, Ganges/Brahmaputra, and Mekong River basins

- Smith T, Bookhagen B. Changes in seasonal snow water equivalent distribution in High Mountain Asia (1987 to 2009). *Sci Adv* 2018
- Smith T, Bookhagen B. Chapter 8. Remotely Sensed Rain and Snowfall in the Himalaya. In: Dimri AP, et al. (eds.), *Himalayan Weather and Climate and their Impact on the Environment*. Basel: Springer. 2020: pp. 119-139

Research, Policy, Education, Action:

Feasible and necessary

Global Climate Change
Loss of Biodiversity
Overpopulation

Global, National, Local Policy/Action to stabilize CO2 Atmospheric Levels

- Efficient Transportation (solar panels → power electric cars, buses, trains)
- Energy Conservation (air conditioning vs. fans; Automatic shut-offs; LEED)
- Sustainable Energy Sources (aolar, wind, water, wave, entropy capture)
- Sustainable Land Use and Population Stabilization
- Economic incentives (cap and trade; carbon credits; tax credits)
- Political change and commitment
  - Moratorium on fossil fuel exploration with massive shift to alternative energy sources
  - Commitment to conservation with policy shifts (20ºC. in winter, 22ºC. in summer) as done with tobacco use, DUI,
  - Preservation of wild places to enhance biodiversity and CO_2 mitigation
  - 26th UN Climate Change Conference of the Parties (COP26) - Glasgow

Mitigation

- Emergency responses and planning
  - Heat waves, drought, extreme weather
  - Relocation of persons due to flooding or storms
- Anticipatory work
  - Ocean barriers
  - Air cooling/hydration planning for vulnerable populations
  - Prior relocations when inundation is likely
  - Re-forestation, not de-forestation
  - Control of air and water pollution
- Vector control; water and hygiene innovation
- Making contraception available to meet unmet needs

CNN World > Kids around the world plan to skip school this Friday to demand action on climate change

Live TV U.S. Edition

Kids around the world plan to skip school this Friday to demand action on climate change

By Harmeet Kaur, CNN
Updated 6:32 AM ET, Wed March 13, 2019

More from CNN

Jacqui Saburido, who became the face of an anti-drunk driving...

A Texas couple has been sentenced to 7 years in prison for...

Ad closed by Google
Stop seeing this ad
Why this ad?

The New York Times

South Africa Crippled by Rolling Blackouts, Weeks Before an Election

ctpost News Sports UConn Nation Business Real Estate Entertainment Living

Solar energy powering popular CT farm

By Jack Kramer, CTNewsJunkie.com Updated 8:53 am EDT, Friday, April 19, 2019

Divestment protesters to appear before ExComm

ASHA PRIHAR & CARLY WANNA | 1:38 AM, APR 22, 2019
STAFF REPORTERS

Reuben Ng

EDUCATION! e.g., YSPH online climate change & health certificate program

- First online certificate program on this topic offered by a US school of public health
- Blends convenience of working independently with real-time online interactions with faculty and peers
- Three Courses--18 weeks; Learners worldwide
  - https://ysph.yale.edu/climate
- MPH Climate change & health concentration in 2019: Mini-masters, MOOC, Exec. MPH, K-12

Yale Program on Healthcare Environmental Sustainability

- Mission: To develop and support efforts that measure, mitigate, and adapt to pollution, **uniquely focusing on healthcare delivery.**

- **Interdisciplinary** collaboration between:
  - Healthcare professionals; Bioinformatics scientists
  - Sustainability scientists and engineers; Entrepreneurs and innovators
  - Health economists; Public policy and legal experts
  - Business management and healthcare administrators

Sten H. Vermund @SVermund @YaleSPH
sten.vermund@yale.edu
www.ysph.yale.edu

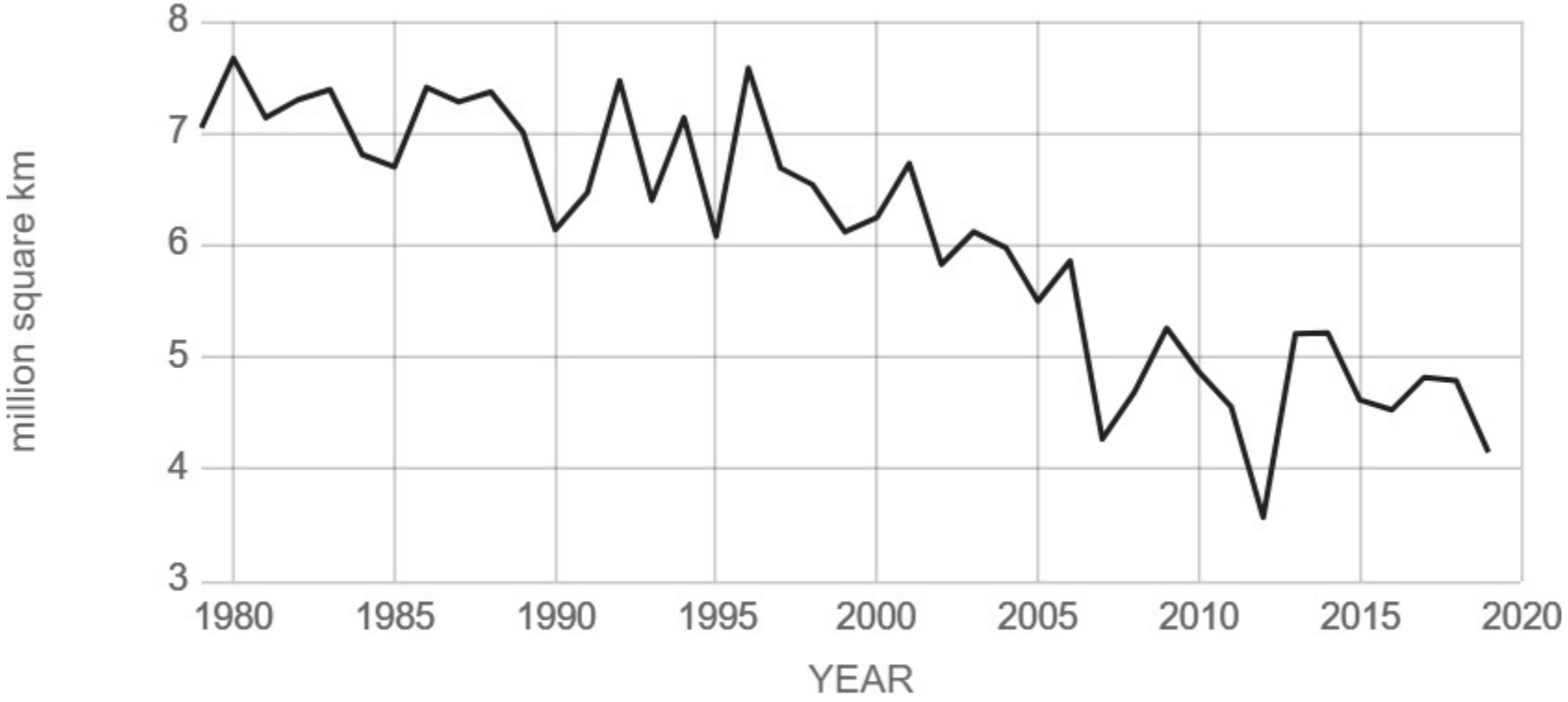
- Yale Center for Climate Change and Health
- https://ysph.yale.edu/climate/
- Certificate program in CC and Health
- https://ysph.yale.edu/cchcert/
- https://www.coursera.org/specializations/climate-change-and-health
- Yale Program on Climate Change Communication
- https://climatecommunication.yale.edu/
- Yale Program on Healthcare Environmental Sustainability
- https://ysph.yale.edu/climate/phes/

Yale SCHOOL OF PUBLIC HEALTH

Yale SCHOOL OF PUBLIC HEALTH

Strategic Development Goals for 2030

Global Sea Ice Halved in past 40 years



Source: climate.nasa.gov

Hurricane Sandy: 29-31 Oct. 2012

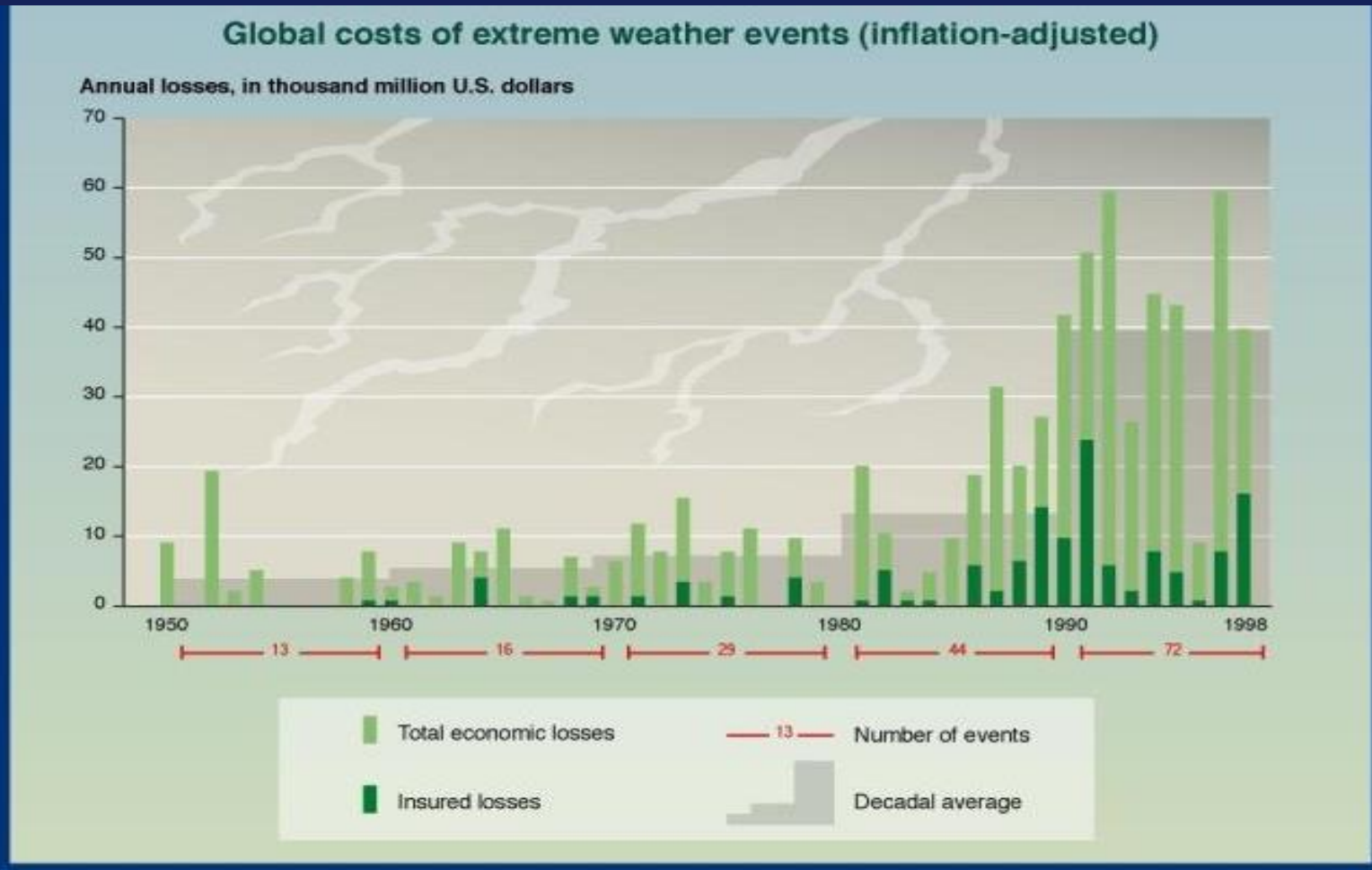
Record rain, wind, and storm surges

- 23,000 homeless and 8.5 M no power in NJ, NY, and 12 states

Costs incurred within just one year…

- $1.4 B in Individual Assistance provided to >182,000 victims
- $2.4 B in low-interest disaster loans approved by the SBA
- >$7.9 B in National Flood Insurance Program payments made
- FEMA approval for $3.2 B for emergency response and rehab

Costs of Extreme Weather Events



SYR - FIGURE 2-7

WMO UNEP

INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE

Context: Importance of Frozen Water

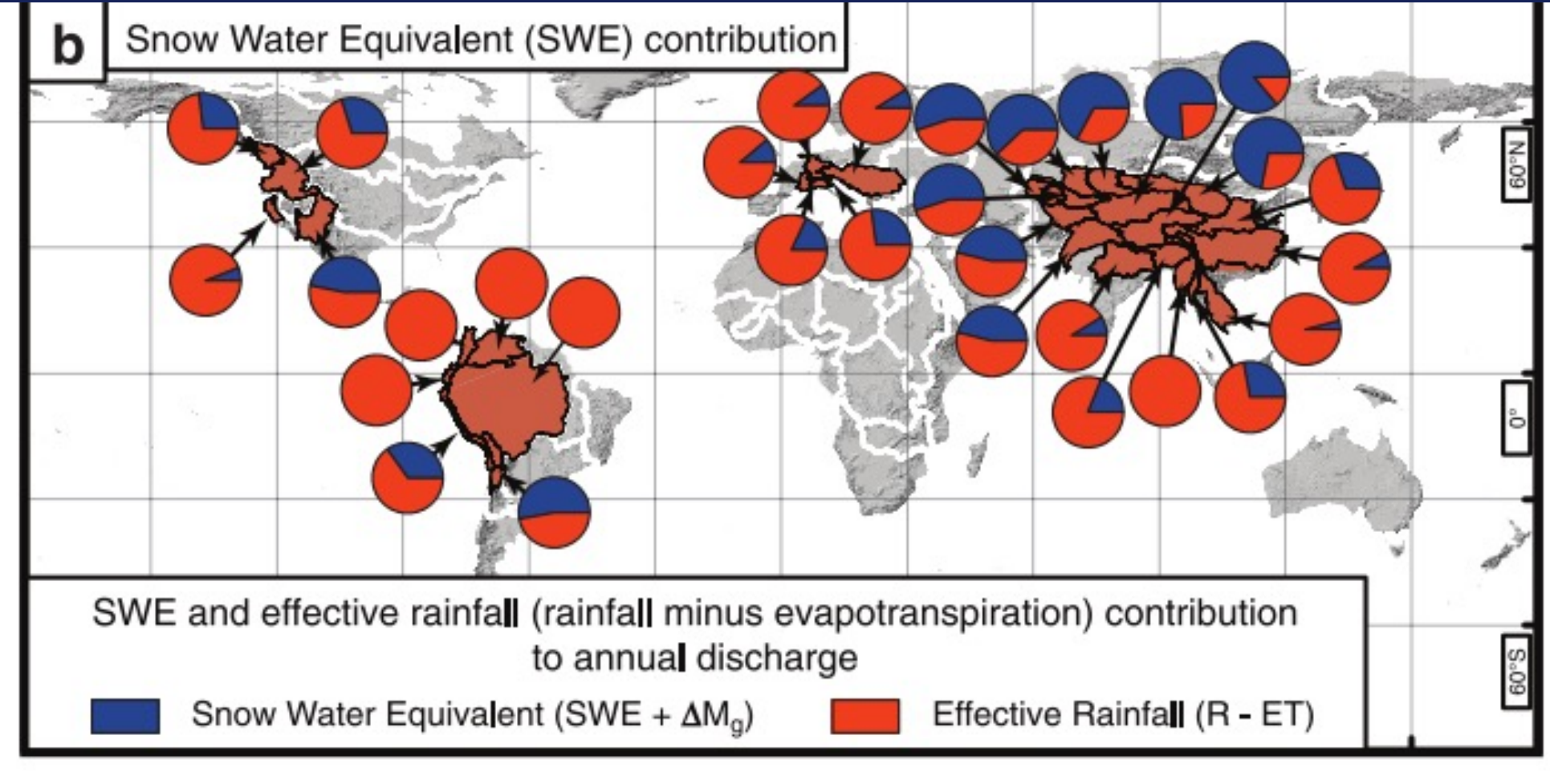


Image Credit: Huss et al., 2017

Y-PHES Vision: ***To lead the transformation of the healthcare sector to a sustainable, circular economy, in alignment with the U.N. Sustainable Development Goals.***

Scientific Research	Policy Research	Education
Patient-oriented	Eliminating excessive waste/pollution	Curriculum development
Life cycle assessment	Infection control vs. public health	Mitigation
Green engineering/ sustainable design	Single use > circular life cycle	Adaptation
Bioinformatics, procurement, facilities data	Performance metrics/incentives • Pay-for-performance • Resource consumption • Environmental emissions • Cost	Disaster preparedness
Alternative clinical pathways		
Reusable vs. disposable device management		
Pharmaceuticals	Patient outcomes	
Compare high/mid/low-resource nations; adopt best practices		

Why don't the politicians reflect the views of a majority of the people?

- Campaign donations and lobbying by the fossil fuel industry
  - Documented by The Center for Responsive Politics https://www.opensecrets.org/industries/indus.php?ind=e01

- Data for donations from oil and gas companies to the Trump-Clinton presidential election cycle released by Federal Election Commission on April 16, 2016
  - Highest donors, by far: Koch Industries