

# Climate Change and Food Safety

**AGSC 5540: Food Policies and Regulations**

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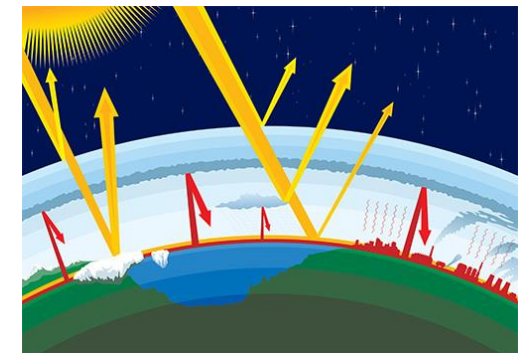
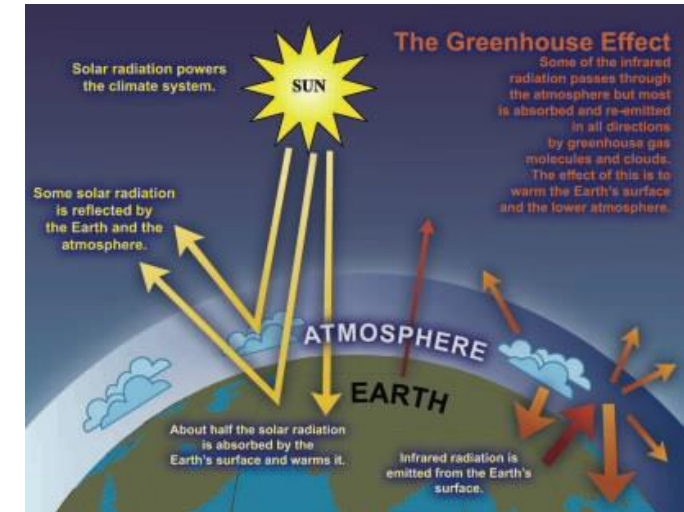
# Weather and Climate: Variability and Change

- Weather is the **temperature, humidity, precipitation, cloudiness and wind** that we experience in the atmosphere at a **given time** in a specific **location**.
- Climate is the **average weather over a long time period** (30 – 50 years) in a region.
- Climate variability refers to **natural variation in climate** that occurs over months decades. El Niño, which changes temperature, rain and wind patterns in many regions over about **2 – 7 years**, is a good example of natural climate variability, also called natural variability.
- Climate change is “a systematic change in the long-term state of the atmosphere over **multiple decades or longer**.”
- Based on statistical **modeling**: **There is <1% chance that** current warming of atmosphere **since 1950** could be result of **climate variability**.



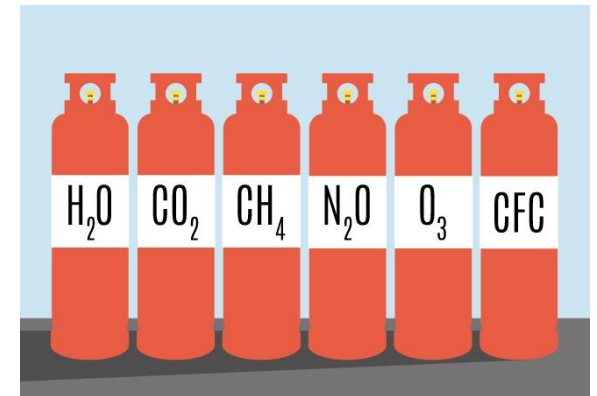
# What is the Cause of Climate Change?

- Climate change: caused by **change in the earth's energy balance**
- Energy balance: How much of the energy from sun that **enters the earth** is **released back** to space.
- Since industrial revolution from 1760s:
  - **Human activity**: Elevated greenhouse gasses (GHG) in atmosphere
  - **GHG trap suns energy** rather than reflecting back to space
  - High concentration of GHG: **Too much heat is trapped**
  - Leads to: The **earth temperature rising outside the range of natural variability**
- There many GHG, with different half-life
- GHG are also called **Climate Active Pollutants**
- Because: Most have **negative health effects for human**



# Greenhouse Gases

- Carbon Dioxide (CO<sub>2</sub>):
  - Responsible for **greatest amount of warming to date**
  - Accounts for **82% of human-caused GHG** emission in the U.S.
  - Most **CO<sub>2</sub> emission**:
    - **Incomplete combustion of coal, oil and gas**
    - These used for **electricity production, transportation, and industrial processes** (80% of CO<sub>2</sub> release in atmosphere)
- **Other important GHGs**:
  - Methane
  - Nitrous oxide
  - Fluorinated gases
  - Pure carbon from fuel combustion



# Greenhouse Gases

- Global Warming Potential (GWP): A measurement of ability to trap heat
- The GWP for **CO<sub>2</sub>** is set at “1” e.g. other GHG are compared to CO<sub>2</sub>

GHG	% of US Emission	Source	Lifetime in Atmosphere	GWP
Carbon Dioxide (CO <sub>2</sub> )	82%	Electricity production; transportation; industrial processes	c. 50-200 years	1
Methane (CH <sub>4</sub> )	10%	Livestock manure; <b>food decomposition</b> ; extraction of natural gas	12 years	25
Nitrous Oxide (N <sub>2</sub> O)	5%	Vehicles; industrial processes	115 years	298
Pure Carbon	>1%	Diesel engines; wildfire; household cook stoves (developing countries)	c. Days to weeks	3,200
Fluorinated gasses (PFC, HFC, NF <sub>3</sub> , SF <sub>6</sub> )	>5%	No natural sources: Synthetic pollutants in coolants, pesticides, solvents, fire extinguishers	Some 1 year some >5,000 years	7,000-22,800



Source: 2016 Public Health Institute/Center for Climate Change and Health



# Greenhouse Gases

- Short-Lived Climate pollutants (SLCP):
- Have **short lifetime** but high **Global Warming Potential**
- **Includes:** Methane, Pure carbon, and some fluorinated gases.
- Their **global warming impact** will be occur **sooner**
- **CO2** has low **GWP**, it impact will be **felt later**
- **Ultimately, we would need:**
- Transition to **carbon-free (or carbon neutral) transportation and energy system**
- Because: **CO2 is the greatest threat to climate health**
- **Reducing Short-Lived Climate pollutants** may “**buy time**” while making the transition



## *Short Term Plan: Reducing Short-Lived Climate pollutants*

- **Reducing Short-Lived Climate Pollutants (SLCP) significantly by 2030:**
  - Reduce global level of sea level rise by **20% before 2050**.
  - **Cut global warming in half by 2050**
  - Prevents **2.4 million premature death globally each year**
  - Improves **health for disadvantage communities**.
- 
- Health Benefits of reducing SLCP (**Climate Change Mitigation Co-Benefit**):
  - Reducing **air pollution** related hospitalization
  - Promotion of reduced **meat consumption**
  - **Stricter emission standard** specially for diesel vehicles
  - **Cleaner household cook stoves** in developing countries



# Climate Change and Global Environmental Changes

- (1) Warming Temperature of Earth Surfaces and the Oceans:
  - The earth has warmed **0.13°C/decade** since 1957
  - This rate is **twice as fast as the previous century**
- (2) Changes in the Global Water Cycle (Hydrologic Cycles):
  - The past century has experienced major change in **annual precipitation**.
  - Many areas: **severe, long-term drought; some increased precipitation; increase in intensity storms.**
- (3) Declining Glacier and Snowpack:
  - Decreasing in volume and mass of glaciers.
  - Affecting **1 billion people living in river watersheds** fed by glaciers

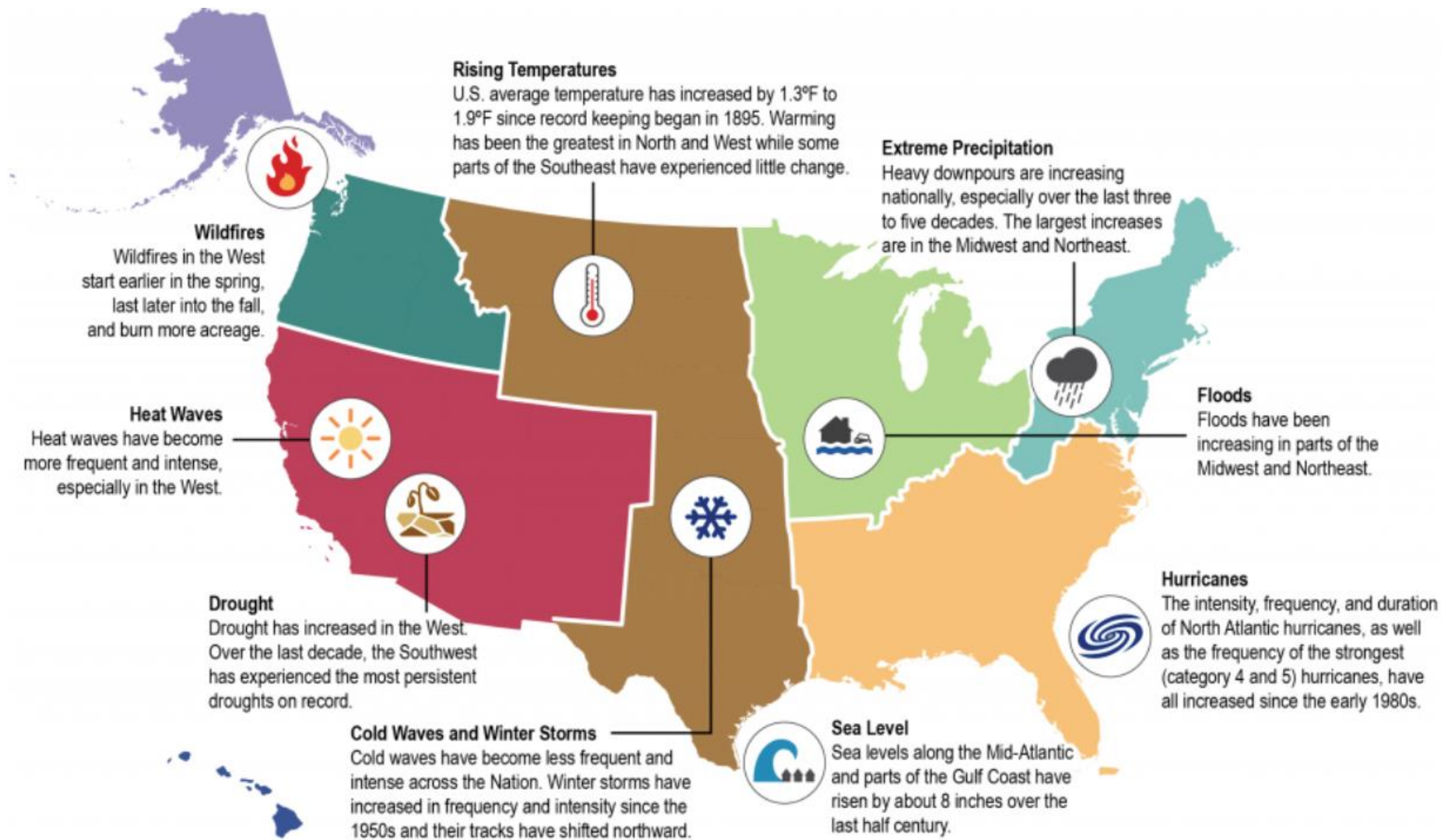




# Climate Change and Global Environmental Changes

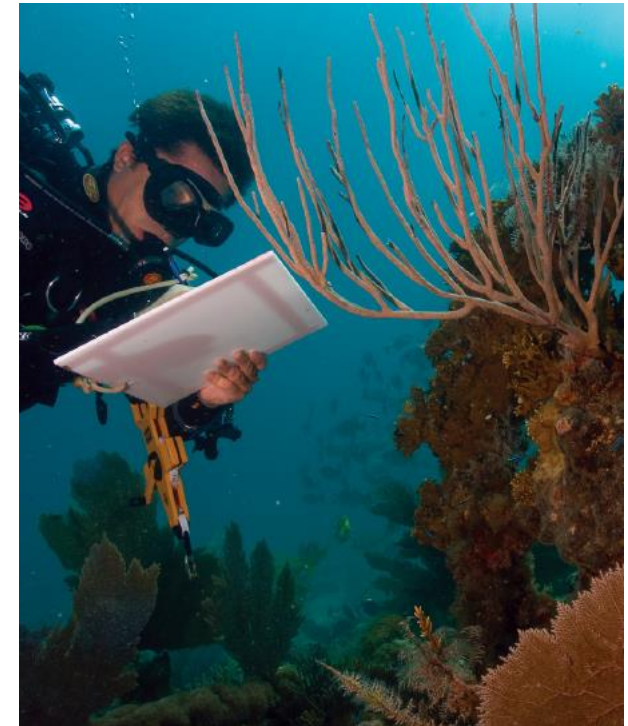
- (4) Sea Level Rise:
  - Warmer water has higher expansion in volume
  - Melting glaciers and snowpacks also contribute to **ocean rise**
  - Leads to: **Loss of land**, occurring in many parts of the world (Maldives as an example)
  - Current rate is around **1.7 cm/year**, accelerated in recent years/
- (5) Ocean Acidification:
  - Oceans absorb **25% of emitted CO<sub>2</sub>**
  - This leads to acidification of sea water acidification (**carbonic acid production**)





# Overall Effects of Climate Change

- Overall effects of Climate change:
- **Greater variability**, with “wetter wets”, “drier dries” and “hotter hots”
- **More frequent and severe extreme heat events**
- **More severe droughts**
- **Intense precipitation**, such as severe rains, winter storms and hurricanes
- **Higher average temperatures and longer frost-free seasons (entomology concern)**
- **Longer wildfire seasons and worse wildfires**
- **Loss of snowpack and earlier spring runoff**
- **Recurrent coastal flooding with high tides and storm surges**



# *What can we do about Climate Change*

- **Climate Solutions:**

- (1) Mitigation
- (2) Adaption
- (3) Resilience



- **Mitigation:** “measures to reduce the amount and speed of future climate change by reducing emissions of heat-trapping gases or removing carbon dioxide from the atmosphere.”
- **Adaptation:** “adjustments in natural or human systems.”
- **Resilience:** “capability to anticipate, prepare for, respond to, and recover from significant threats with minimum damage to social well-being, the economy, and the environment.”

# Climate Change Mitigation

- Purpose of Climate Change Mitigation:

- Prevent reaching or surpassing “**tipping points**”

*e.g.* **Collapse of the West Antarctic Ice Sheets:** could lead to very **rapid sea level rise**

*e.g.* **Melting of permafrost:** large release of methane gas

- **Catastrophic climate changes:** surpass our ability to adapt

*e.g.* Parts of **Southwest Asia** may have recently passed body’s **survival threshold for heat**

**IPCC Report** (International Governmental Panel on Climate Change)

- **Currently** global temperature **1°C higher than pre-industrial level.**

- **Business as usual:** Earth temperature **rises > 4°C** by end of century

- **Paris agreement in 2015 (200 countries) :** keep temperature **rise below 1.5°C** compare to preindustrial level (**some climate scientists: not enough**)





# Climate Change Mitigation

- Climate Change Mitigation Strategies:
- Use of clean and renewable energy for **electricity production**
- **Walking, biking**, using **low-carbon (or zero-carbon) vehicles**
- **Reducing meat consumption**
- **Less flying**
- **Changing agricultural practices (lab-grown meat?, insects?; climate-smart agriculture)**
- **Limiting deforestation**
- **Planting trees**



# *Climate Change Adaptation*

- Purpose of Climate Adaption:

- Reduce harmful impact of climate change
- Allow communities to thrive in the face of climate change

- Developing Resilience:

- **Cool roofs and air conditioning:** adapt to **heat waves**
- **Seawalls and restoration of wetlands:** adapt to **sea level rise**
- **Emergency preparedness planning:** **extreme weathers and vector-borne diseases**



# Exercise 1

- What is Weather, Climate, Climate Variability, and Climate Change? Based on statistical models, what is the chance that current global warming since 1950 is due to climate variability?
- What are the main greenhouse gases?
- What is Global Warming Potential (GWP)? What is the GWP, current US emission, and lifetime of Carbon Dioxide, Methane, Nitrous Oxide, Fluorinated gases, and pure carbon?
- What are Short-Lived Climate Pollutants (SLCP) and why are they important?
- What are Climate Change Co-Benefits of reducing Short-Lived Climate Pollutants?
- What are the five negative effects of climate change and global warming?
- What are the main climate change threats to various regions of the United States?
- What is the purpose of Climate Change Mitigation and what are some practices examples?
- What is IPCC?
- According to IPCC what is the current temperature increase compared to pre-industrial level? What would be temperature increase under “business as usual” scenario? What is the goal of Paris agreement for control of temperature in the current century?
- What is the purpose of Climate Change Adoption and what are some practical examples?

# *Climate Change and Food Safety*

- Three Effects of Climate Change on Food Safety
- Climate change (direct effects): Changes in survival and transmission patterns of bacteria, viral, and parasitic agents.
- Climate-dependent (indirect effects): Temperature and moisture affects fungal growth and formation of mycotoxins.
- Extreme weather events and natural disasters: Climate change increases frequency and severity extreme weather events.



# Climate Change: Bacteria, Viruses, and Parasitic Protozoa

- Bacteria, Viruses, and Parasitic Protozoa

- Collectively estimated to cause **2 billion illness** globally
- Causing **31 million (DALY) Disability-Adjusted Life Year**
- **29% of these disease are estimated to be foodborne.**

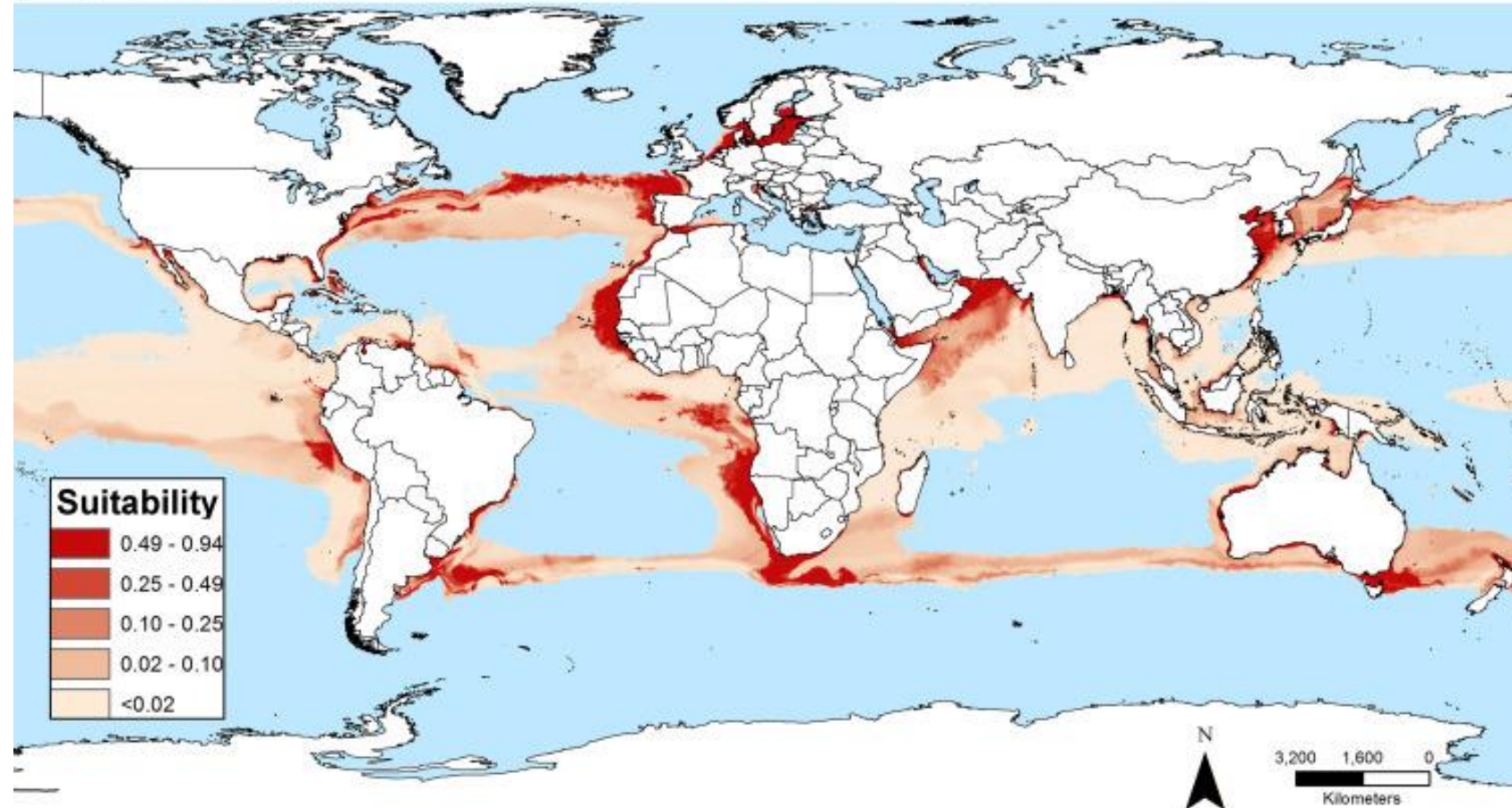


- Temperature and humidity could greatly affect the growth of organisms:
- ***Salmonella* as an example:** 50,000 global death in 2010.
- **1°C increase** (above 5°C) in weekly temperature lead to **5 to 10% increases in cases** (WHO, 2018) **[US 1M illnesses, 100,000 hospitalization]**
- ***Vibrio Cholerae*:** currently 760,000 global illness/24,000 death per year.



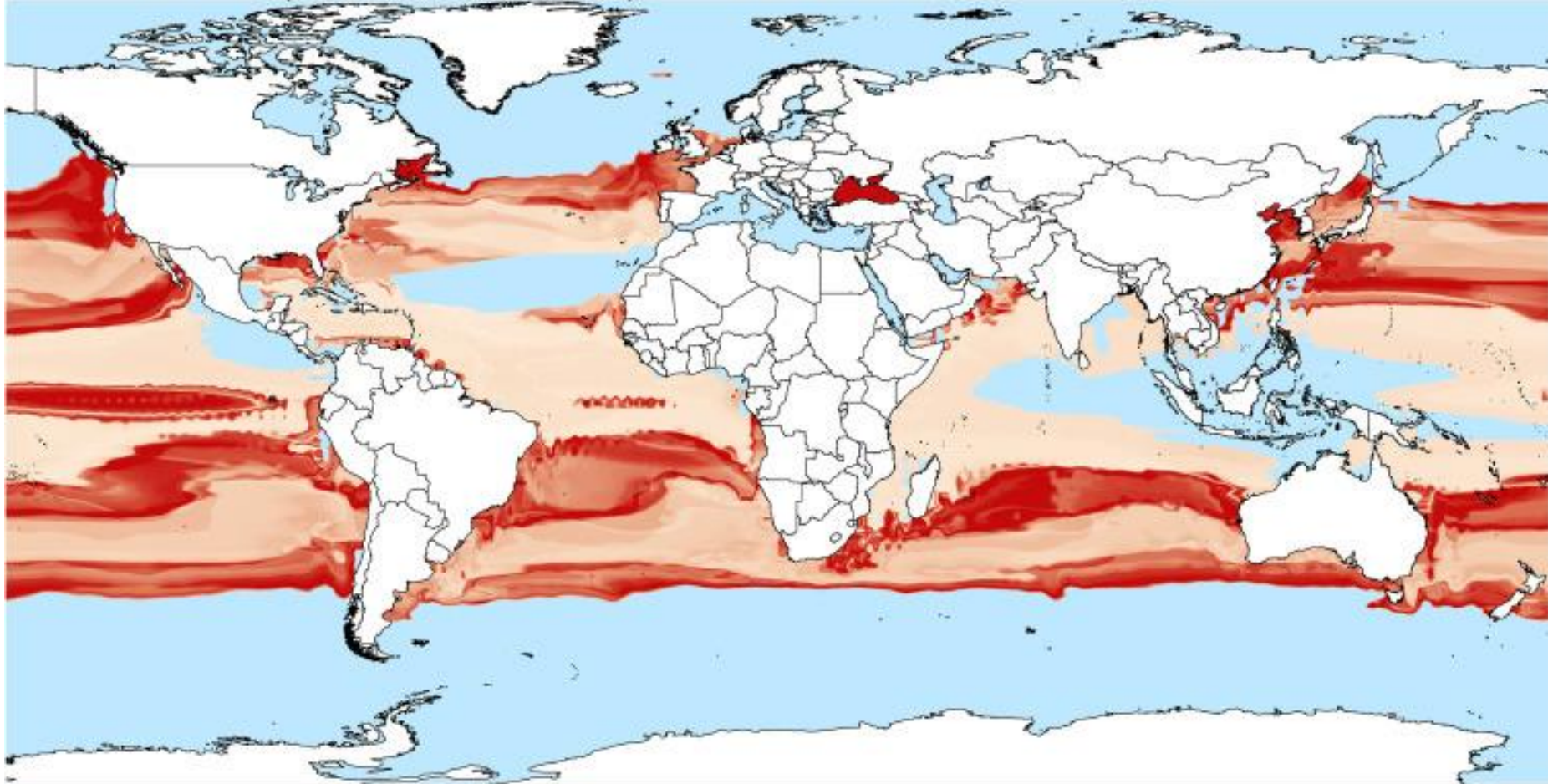
# *Vibrio cholerae* proliferation in sea water: **Current Climate**

Current climate



# *Vibrio cholerae* proliferation in sea water: *Business-as-Usual Projection in 2100*

Future climate (model transference)



# Climate Change: Mycotoxin and Phycotoxins

## ○ Mycotoxins:

- Compounds produced by **variety of fungi**
- At very **high concentrations acute health problem** and death
- **Long-term exposure:** various **forms of cancer**
- Estimated **25% of world's yearly crop** contaminated with mycotoxins
- Occur more frequently in **hot and humid regions**

## ○ **Human exposure:**

- **Dietary exposure: direct** (contaminated crop) or **indirect** (animal derived food consumed contaminated feed)
- Change in climate could **increase moisture** in some areas **12-14%** (FAO, 2016)





# Climate Change: Mycotoxin and Phycotoxins

- Mycotoxins:
- At 2°C increase, **aflatoxin** growth will become an emerging concern in **North America** and **Europe**.
- At 1°C increase, **6% reduction in global wheat yield**, could lead to longer storage of food and increased **aflatoxin** contamination.
- Similar trends could lead to **Fusarium** production in **Maize products**
- **Elevated climate: increases in algal bloom**, algae produce toxins= **phycotoxins**
- **Phycotoxins:** a concern in **water-filtering organisms** such as **mussels and clams**
- Another exp. of **phycotoxins: Ciguatoxins** from algae: **Ciguatera fish poisoning**
- **Ciguatera fish poisoning:**
  - *Most common seafood poisoning*
  - *Has been increasing in last two decades*



# Climate Change: Zoonosis

- Zoonosis, Vectorborne Diseases, and other Animal Diseases:
- **Elevated temperature could result in:**
  - Survival and **proliferation of the pathogen** (*e.g. Salmonella* serovars)
  - Changes in **migration pathways** (*e.g. for avian influenza*)
  - Changes in **carriers and vectors** (*e.g. Zika virus*)
  - Changes in **natural ecosystem** (*e.g. Ciguatera fish poisoning*)
- **These changes could lead to:**
  - Increased **outbreak and sporadic cases**
  - Increased need for **antibiotics and antimicrobials**





# Climate Change: Veterinary Drugs

- Elevated temperature could lead to:
  - Enhanced **survival** of pathogens
  - Increases in **vector-borne** diseases
  - Increases in **parasite prevalence** in animals (FL, TN)
  - Heat-stress: **increases susceptibility of animals to diseases**
- These require **increase in veterinary drugs use**, may lead to:
  - **Increased residue** in animal foods (chronic and acute human health)
  - Increased **antimicrobial resistance** in human and animal pathogens



# *Climate Change: Pesticides*

- Increases in extreme temperature and rainfall:
  - Attraction of **pests, plant diseases, weeds**
  - Changes in **pesticide use pattern** is likely
  - Excessive rainfall could: **water pollution with pesticides**
  - Specially of concern for: Polychlorinated Biphenols (**PCBs**) and **dioxins (environmentally stable chemicals)**.
- Mitigation:
  - Use of **draught-resistant crops**
  - Changing **planting and harvest dates**
  - **High-yield water-sensitive crops**



## *Exercise 2*

- What are the three main effects of climate on food safety?
- Please name two main foodborne bacteria that could cause enhanced public health problems in the changing climate?
- Please name two main mycotoxins that could cause enhanced public health problems in the changing climate?
- What are phycotoxins? Please provide one example of foodborne phycotoxins?
- What is the effects of climate change on zoonosis diseases?
- What is the effects of climate change on pesticides use and how the negative effects could be mitigated?

Thank you

