

# Environmental Vulnerability and Adaptation to Global Climate Change

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Session of Science for the Preservation of the Life of Mother Earth  
and the Human Being

Peace Integration Summit – CUMIPAZ 2017

October 16-21, 2017

Panama City, Panama



# Weather, climate, climate change and natural variability

- **Weather** is the state of the atmosphere at some place and time.
- **Climate** is a statistical concept involving averages and frequency of occurrence and intensity of severe weather events and hurricanes.
- **Climate change** refers to long-term shifts that can be characterized by a uniform trend or by stronger or even sudden fluctuations.
- **Natural variability** refers to fluctuations about a mean that does not change. The time series is stationary.

# Climate and Society

## The importance of climate studies for human endeavors

- Climate is variable, but is changing at an unprecedented rate due to the burning of fossil fuels.
- Human activities link humans to the Earth's natural systems making climate change more complex.
- **Mitigation** - actions that reduce sources of gases which contribute to the warming of the climate system and enhance the mechanisms that remove them from the atmosphere.
- Gases that contribute to the warming of the climate system are known as **greenhouse gases**.



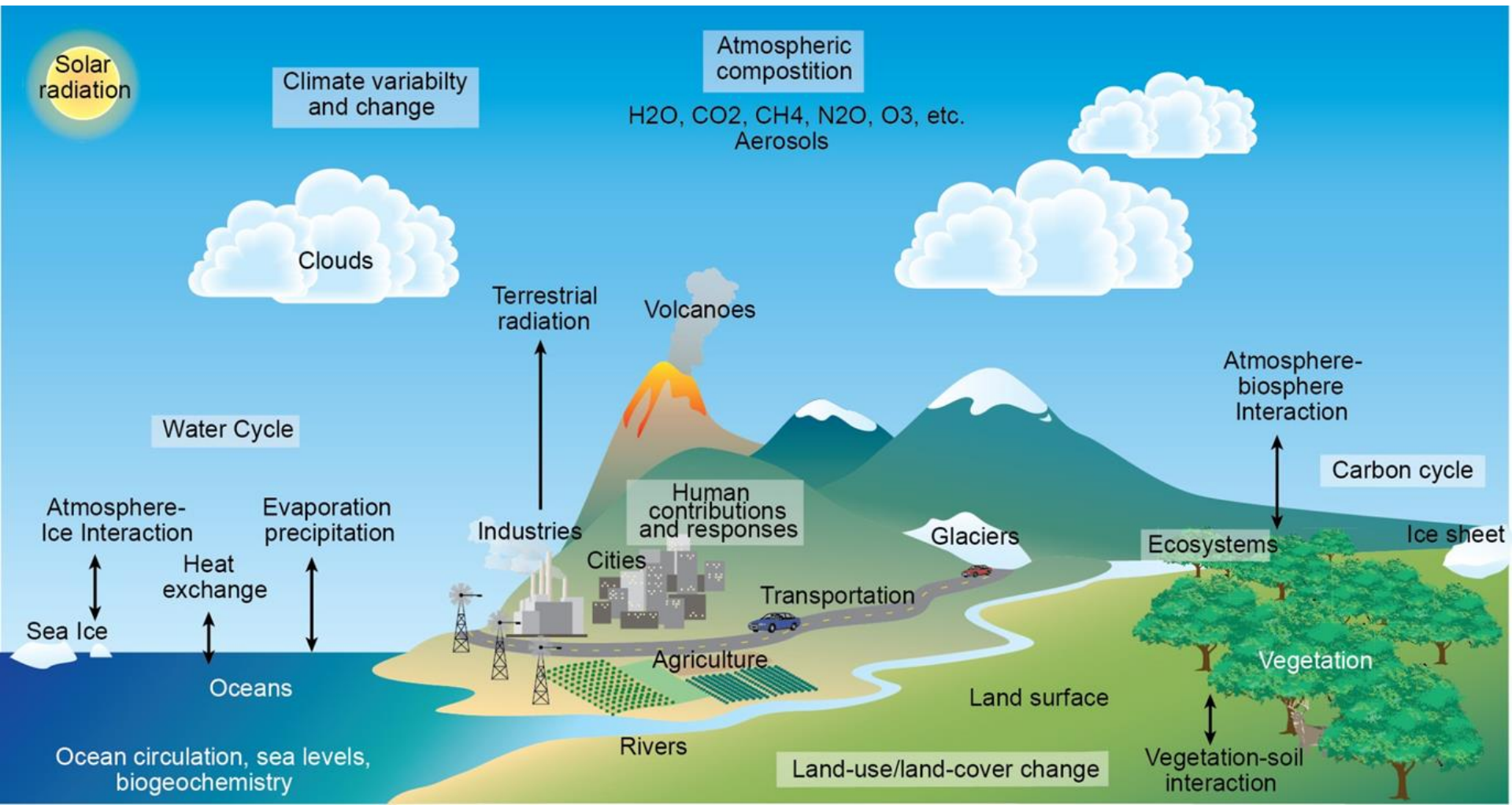
# Climate Change Adaptation and Sustainability

- **Adaptation** is the adjustment in natural or human systems to actual or expected climatic stimuli or their effects, which moderates harm or exploits beneficial opportunities.
- Climate change heightens the vulnerabilities of societies and ecosystems.
- Affect is both global and local
  - Economic interdependence enhance the global component .
- **Sustainability**
  - Capacity to meet the needs of the present without compromising the ability of future generations to meet their own needs.
  - Balancing mitigation attempts with economic impacts can cause resistance

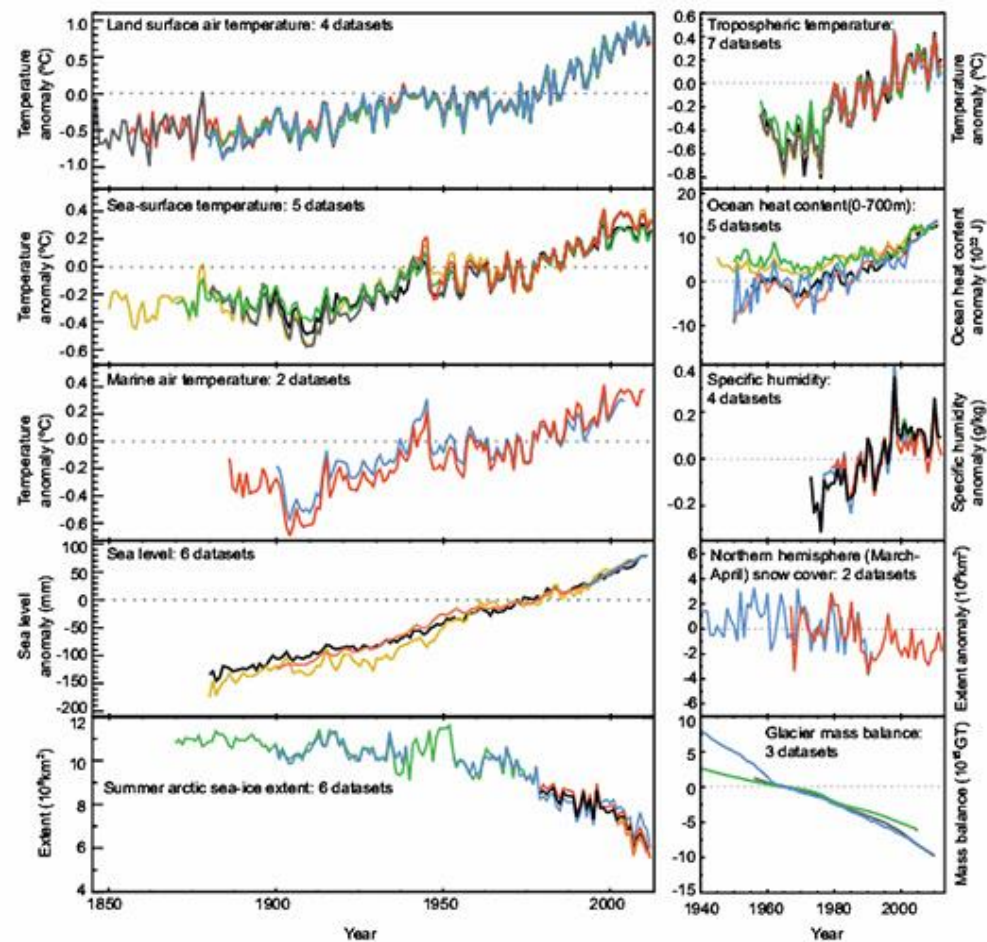
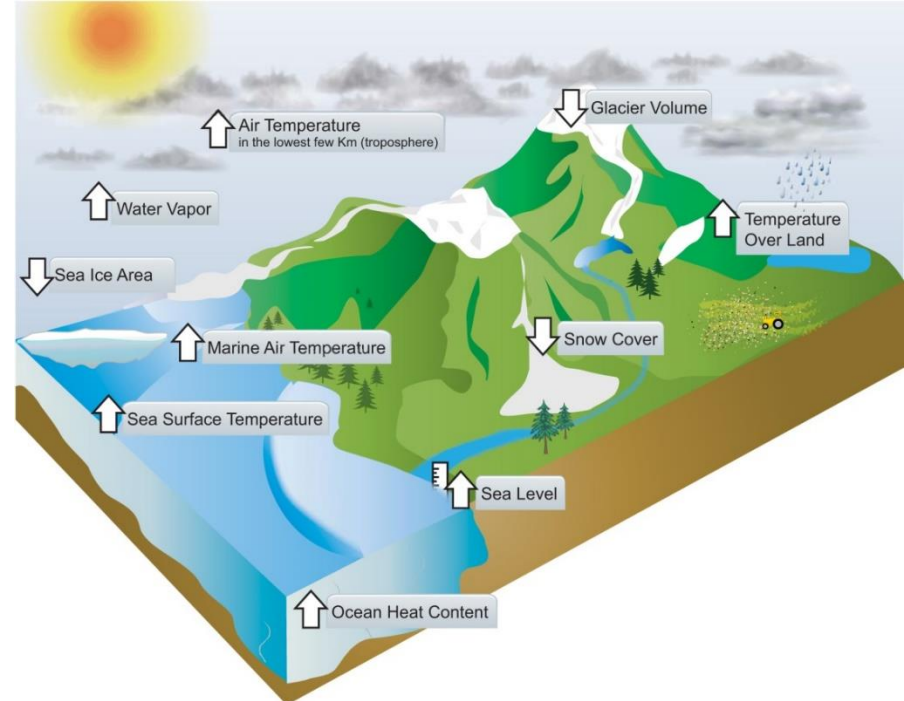
# Climate Change Paradigm

## Atmosphere

[NOAA, Geophysical Fluid Dynamics Laboratory (GFDL)]

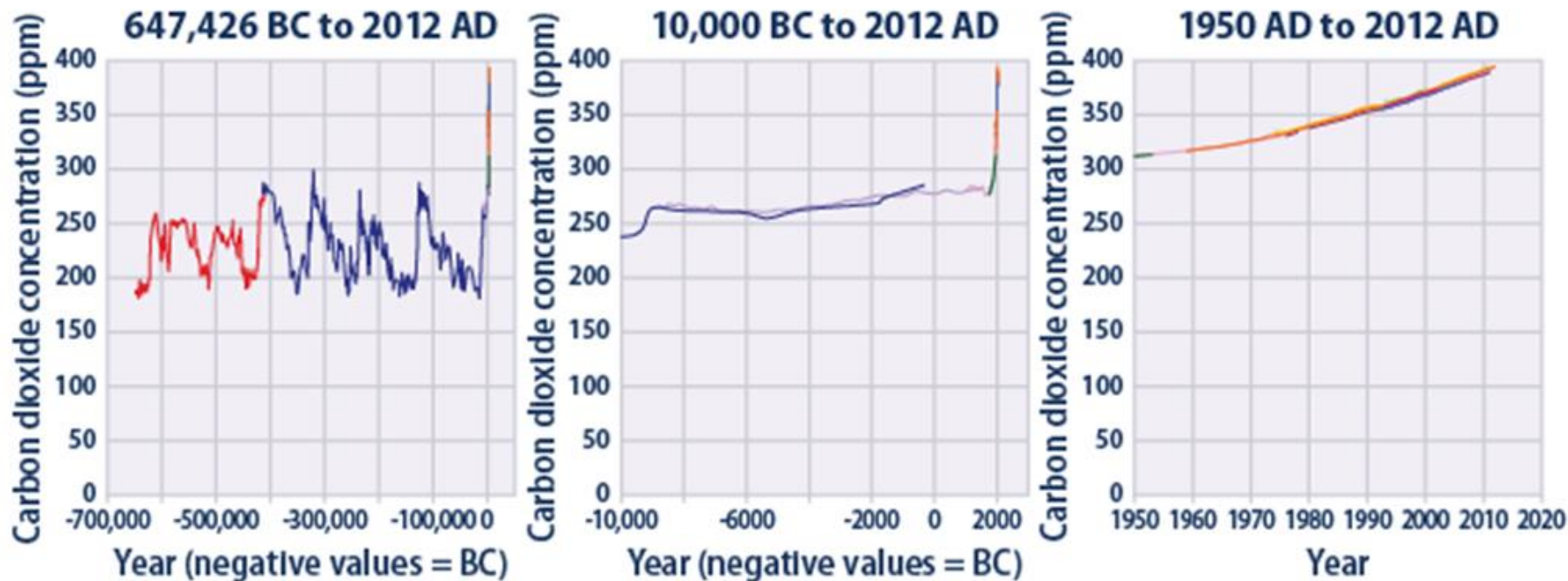


# Multiple Indicators of Changing Global Climate



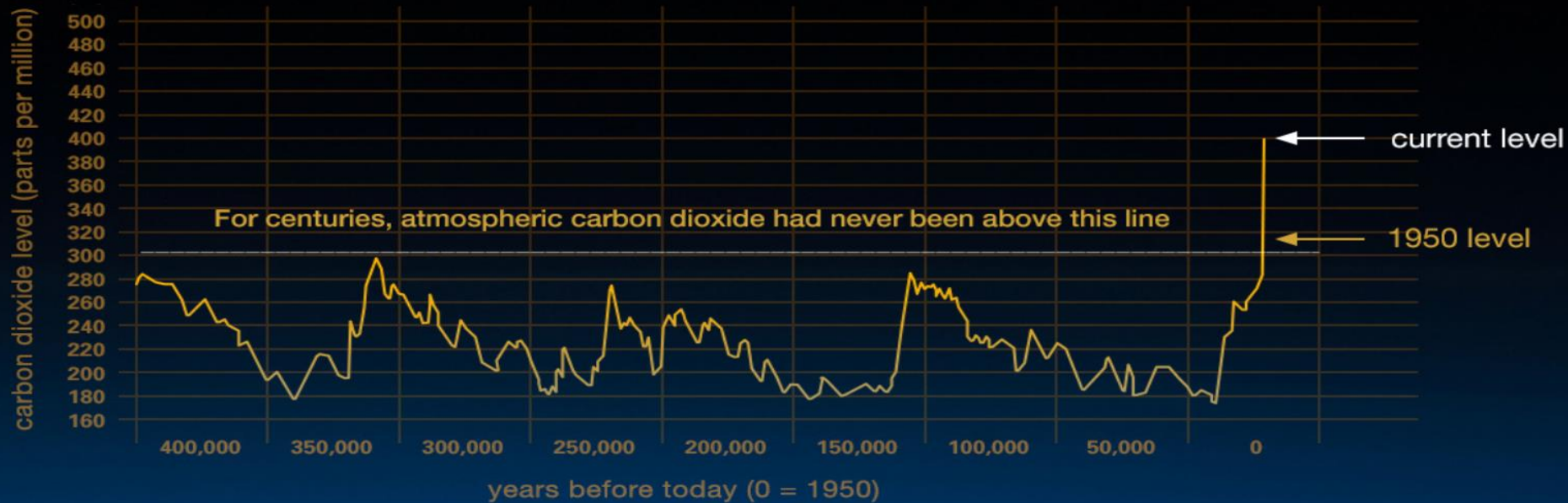
Stocker et al., 2013: In: *Climate Change: The Physical Science Basis. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change*

## Global Atmospheric Concentrations of Carbon Dioxide Over Time



Data source: Compilation of 12 underlying datasets. See [www.epa.gov/climatechange/science/indicators/ghg/ghg-concentrations.html](http://www.epa.gov/climatechange/science/indicators/ghg/ghg-concentrations.html) for specific information.

For more information, visit U.S. EPA's "Climate Change Indicators in the United States" at [www.epa.gov/climatechange/indicators](http://www.epa.gov/climatechange/indicators).



## If we don't restrain CO<sub>2</sub>

- Heat stress on people and crops
- Sea-level rise
- More floods and droughts
- Strongest storms can grow stronger
- Tropical diseases no longer frozen
- Ecological stresses and extinctions
- Losses especially for poor people in hot places who release little CO<sub>2</sub>



GLOBAL TEMPERATURE

↑ 1.7 °F since 1880

ARCTIC ICE MINIMUM

↓ 13.3 percent per decade

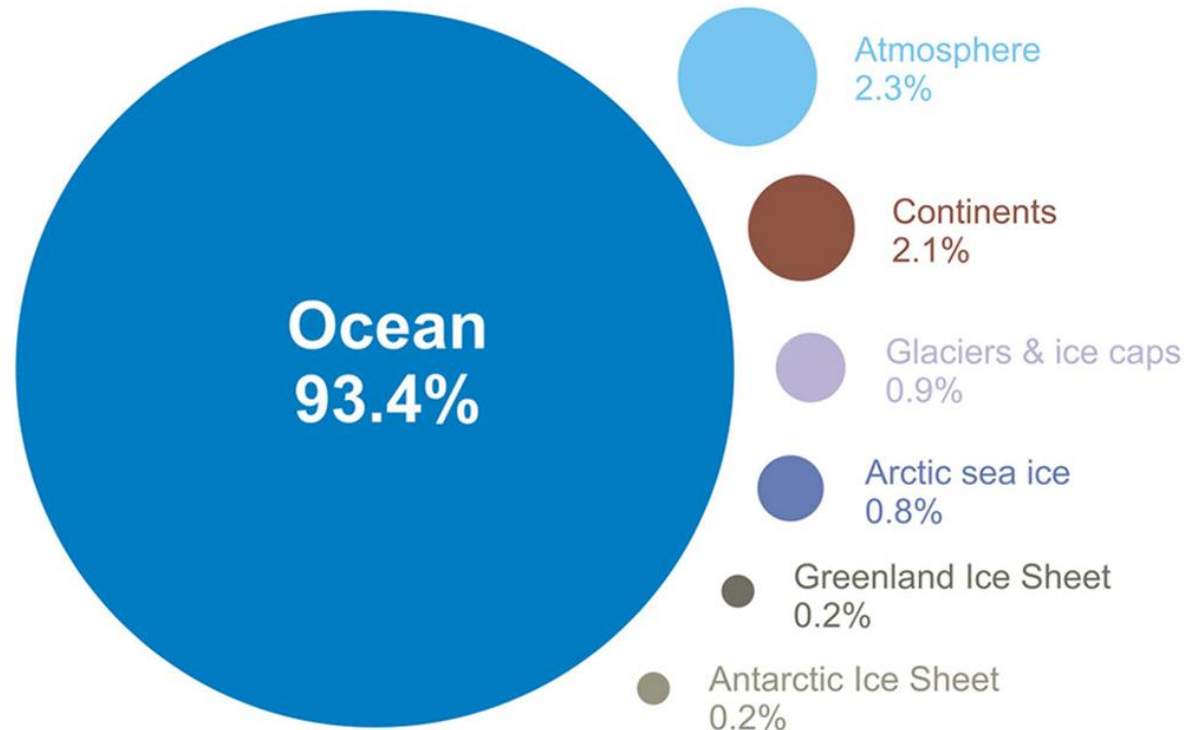
LAND ICE

↓ 286.0 Gigatonnes per year

SEA LEVEL

↑ 3.4 millimeters per year

## Where is global warming going?



- Ocean is warming more than any other location
  - Much of this energy is likely stored in the deep ocean

Percentages calculated from the IPCC AR4 5.2.2.3 Report, [Skeptical Science, [http://www.skepticalscience.com/graphic\\_s.php?g=12](http://www.skepticalscience.com/graphic_s.php?g=12)]

CARBON DIOXIDE

↑ 406.94 parts per million

GLOBAL TEMPERATURE

↑ 1.7 °F since 1880

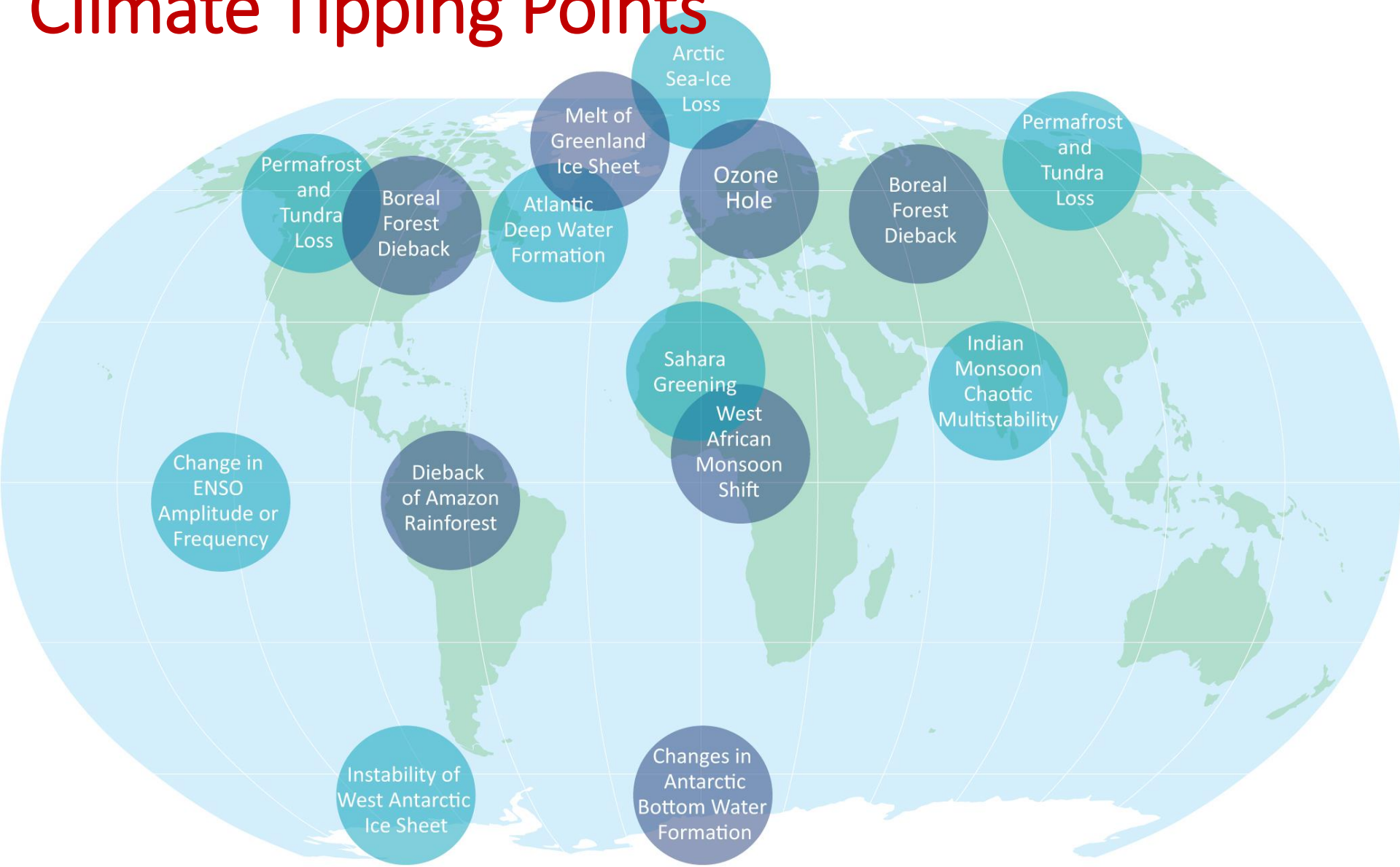
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LAND ICE

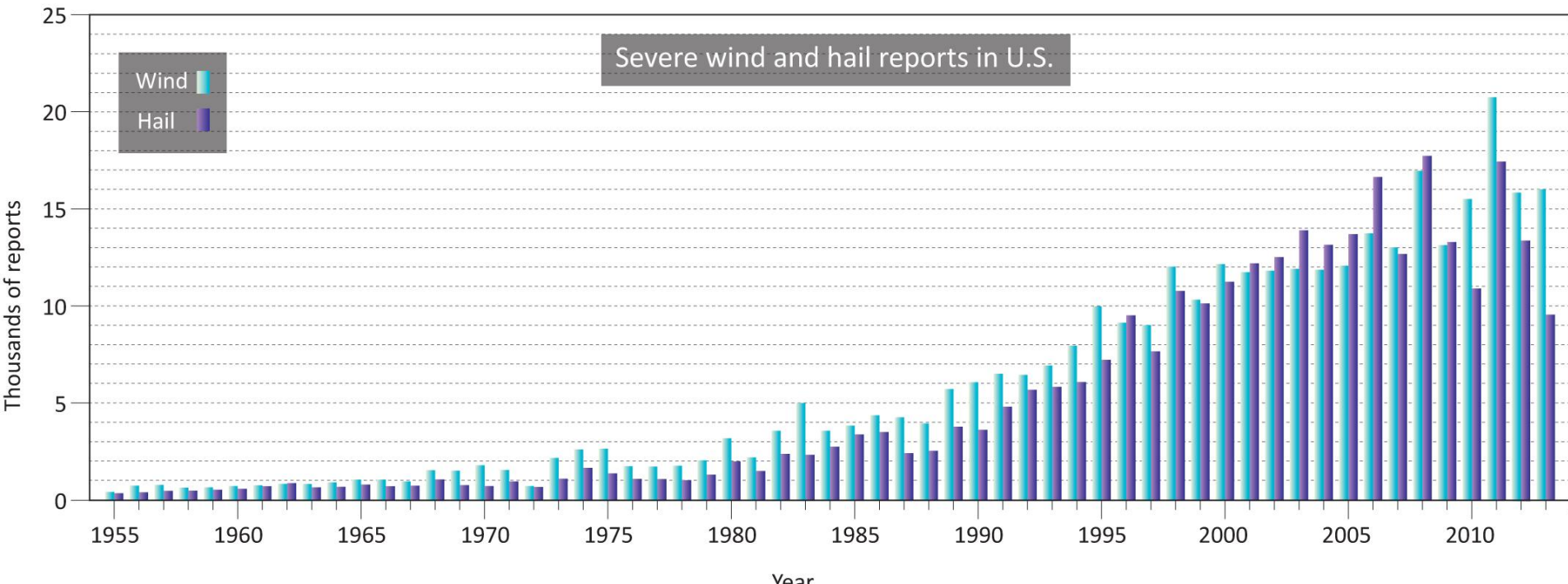
↓ 286.0 Gigatonnes per year

# Climate Tipping Points



# Changes in Extreme Events

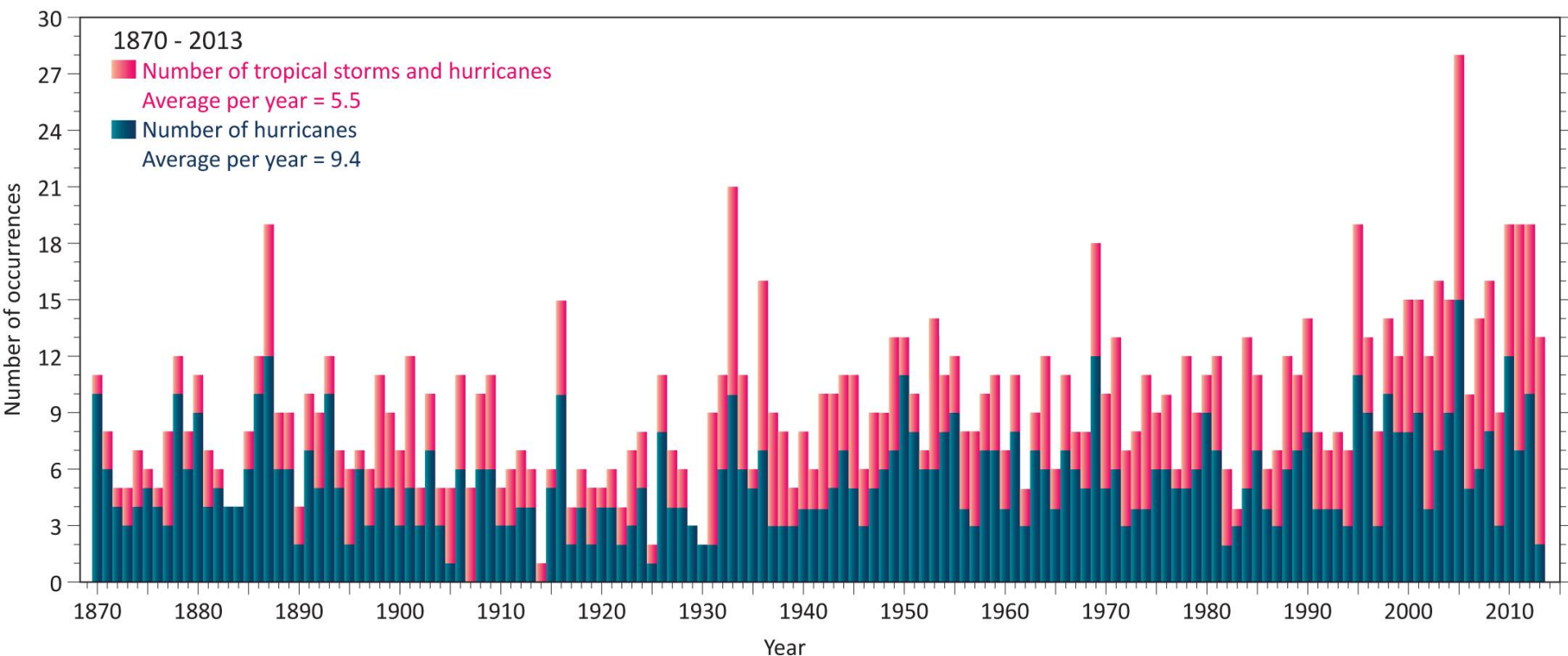
## Tornado Climatology



- Annual number of severe hail reports in the contiguous U.S. increased exponentially from less than 350 in 1955 to about 17,300 in 2011 (SPC).

# Search for Changes in Extreme Events

## Tropical Cyclones – Climatological Causes



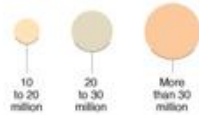
[Adapted from Historical Climatology Series 6-2, *Tropical Cyclones of the North Atlantic Ocean, 1851-2006*, C.J. McAdie et al., National Hurricane Center, and G.R. Hammer, National Climatic Data Center, Asheville, NC, July 2009, p. 19, with additional data from the National Hurricane Center.]

# Tomorrows Climate Problems include..

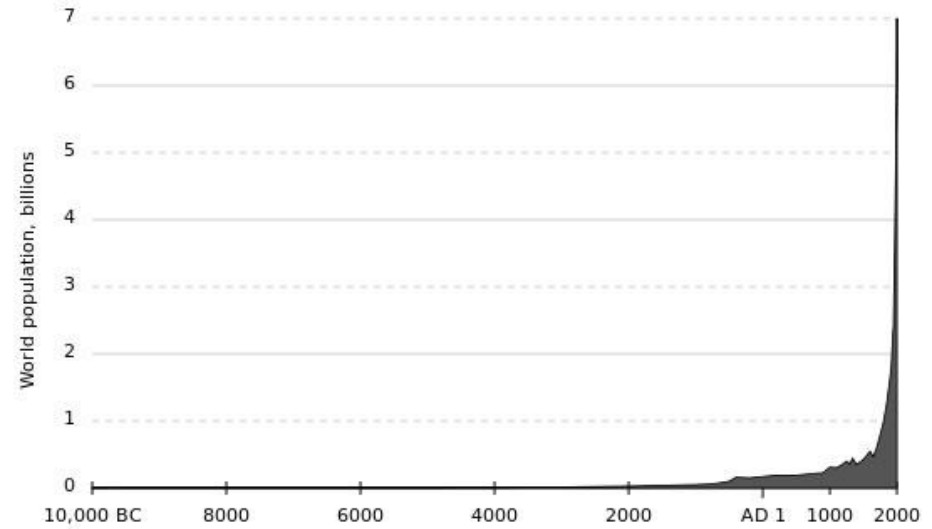
## World's largest urban areas sit along coasts

15 of 20 largest urban areas are near the coast, 14 of 20 largest urban areas are in Asia

An urban area is defined as a continuously built up land mass of urban development that is within a labor market (metropolitan area or metropolitan region) and has no rural land



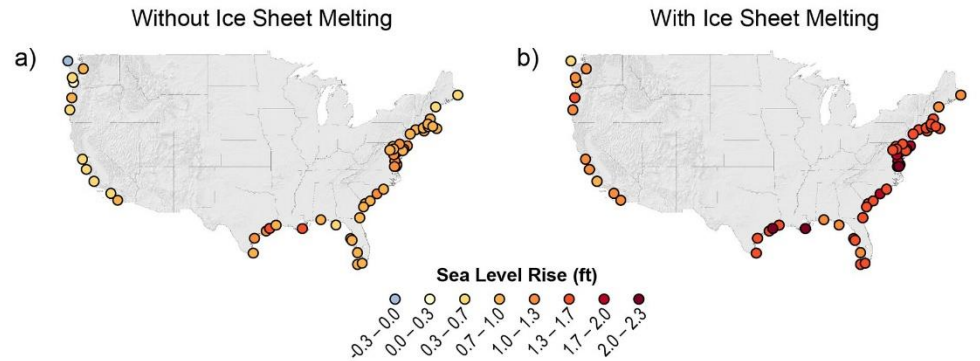
Source: Demographia World Urban Areas, 10th Annual Edition, March 2014



National Security & Accelerating Risks of Climate Change; Copyright 2014 CNA Corporation]

Rising Sea levels  
Coastal Mega Cities  
Population increase

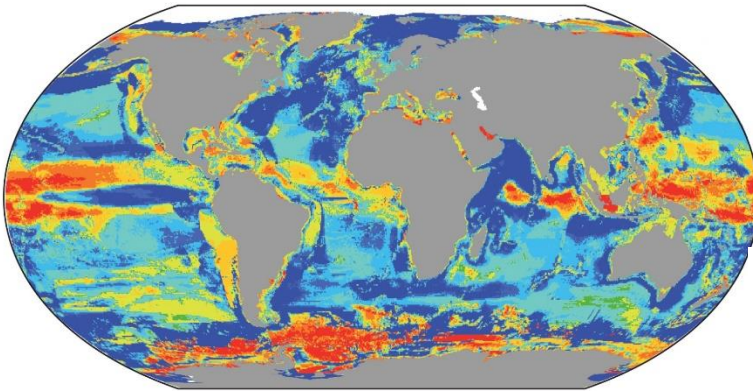
## Projected Sea Level Rise by 2050



[Adapted from the Third National Climate Assessment]

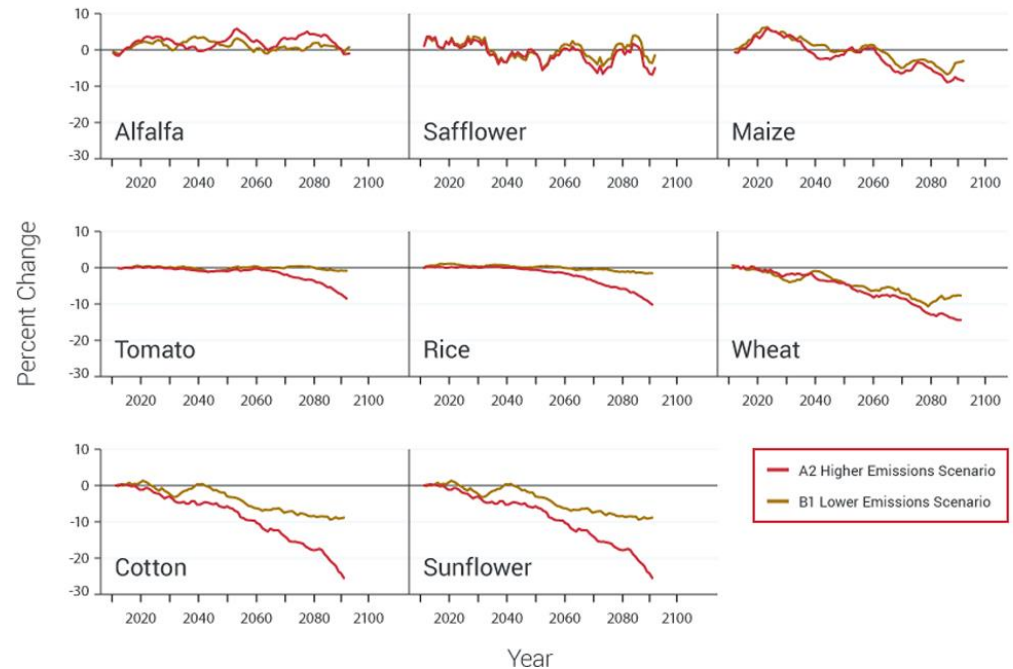
# Tomorrows Climate Problems include..

CHANGE IN MAXIMUM CATCH POTENTIAL (2051-2060 COMPARED TO 2001-2010, SRES A1B)



(SPM.6 IPCC, 2014)

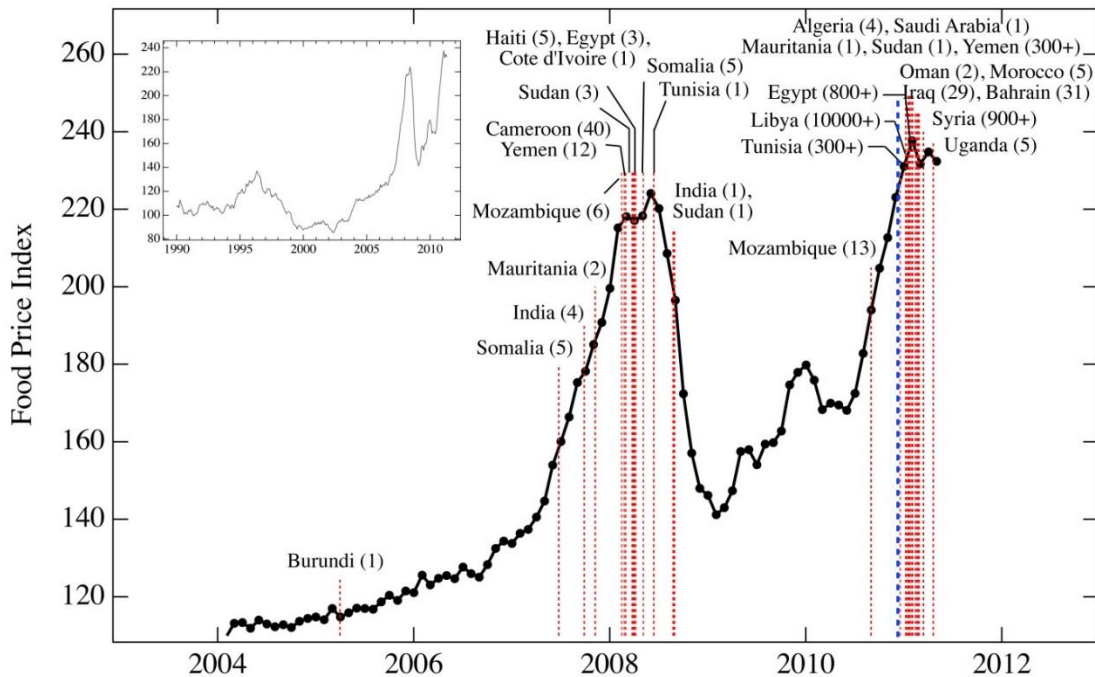
Crop Yield Response to Warming in California's Central Valley



Reduced Crop Yields  
Reduction in Fisheries

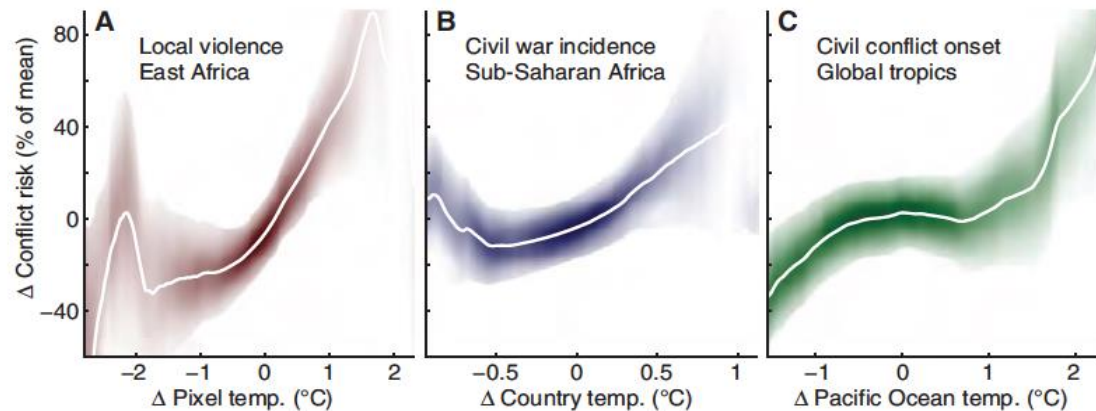
[Third National Climate Assessment, Figure 6.4]

# Tomorrows Climate Problems include..



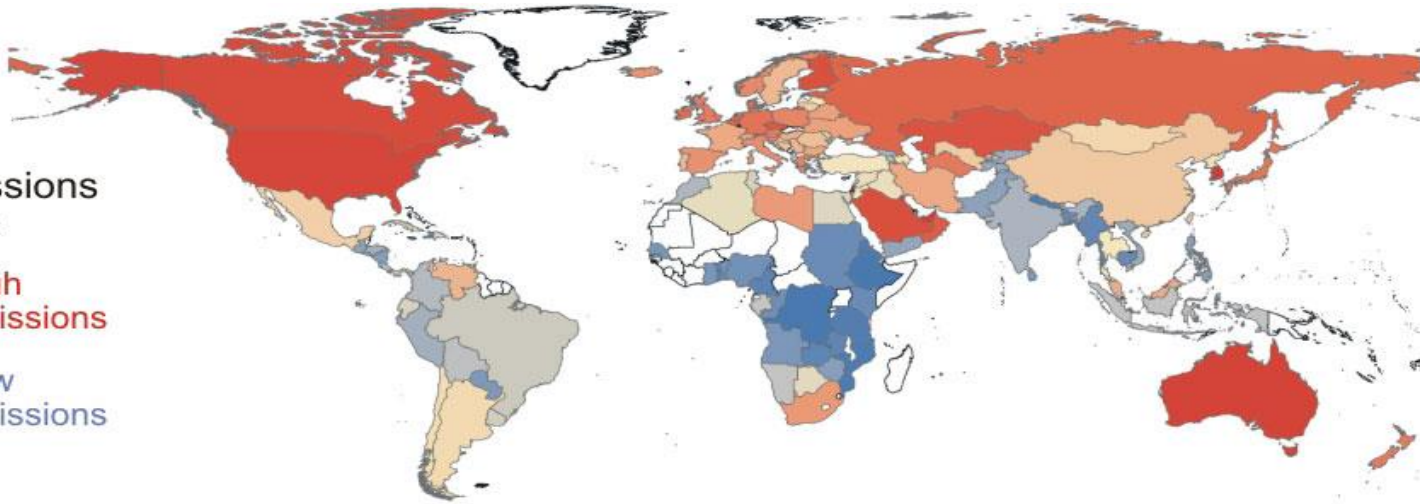
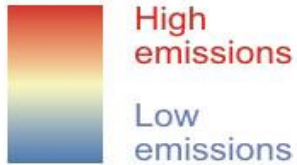
Periods of social unrest and violence correlate strongly to disruptions in food production or sudden spikes in food prices

Social unrest



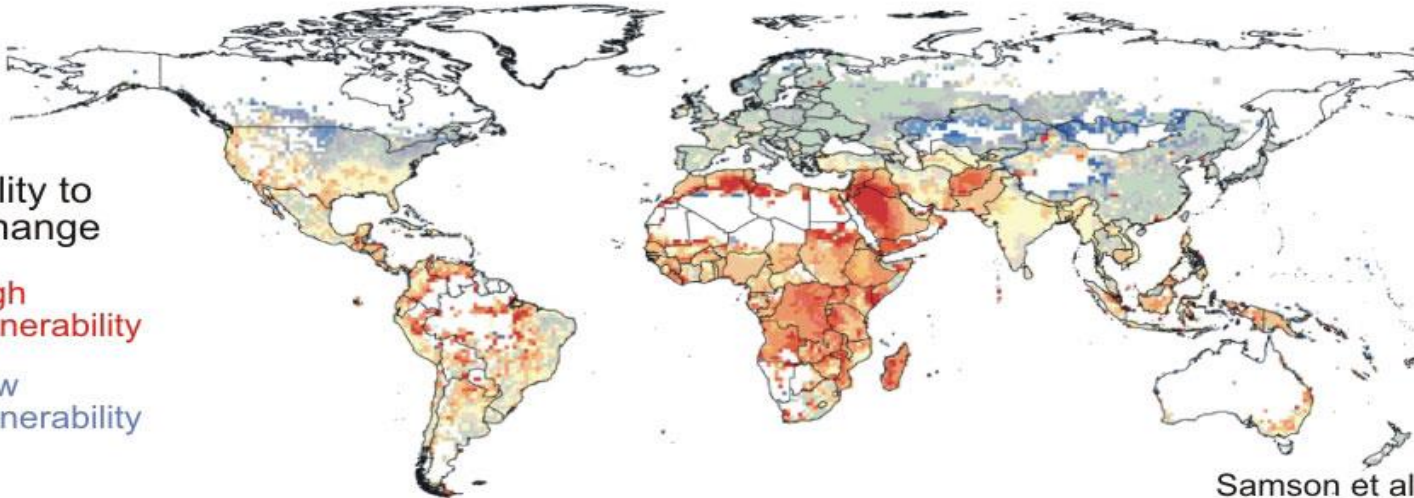
Hsiang et al., 2013, Science

CO2 emissions  
per capita



Those who contribute the least greenhouse gases  
**will be most impacted by climate change**

Vulnerability to  
climate change

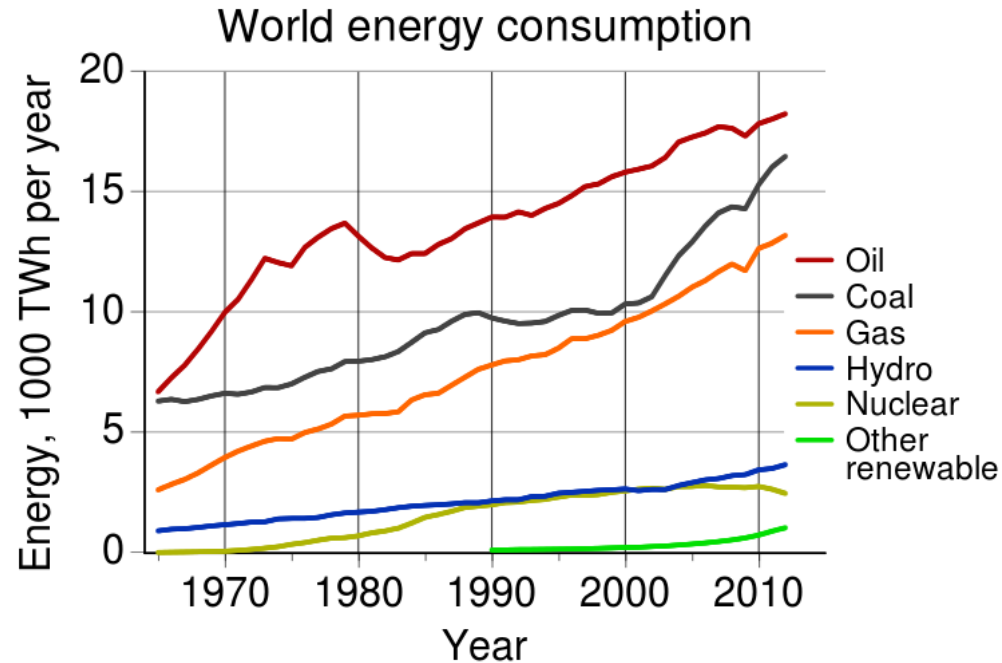


Samson et al 2011

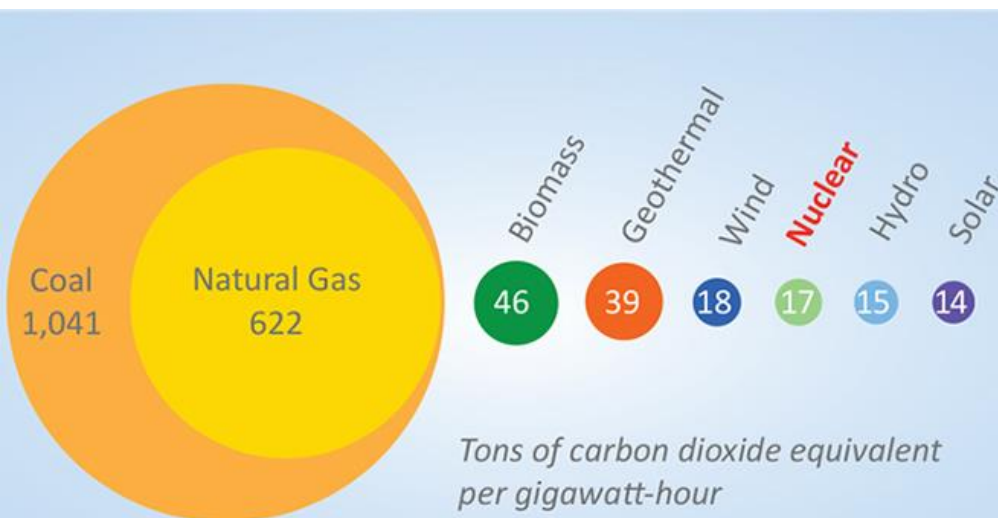


# The Energy-CO<sub>2</sub> Connection

- Population and energy usage closely related.



(BP, Creative Commons Attribution, <http://creativecommons.org/licenses/by-sa/3.0>)



Abundant source of electricity that emits almost zero air pollution if properly contained.

# Managing Anthropogenic Climate Change

## Renewable Energy Sources

- Scientists are developing ways to more efficiently convert solar energy to electricity on a large scale.
  - Power tower system – heliostats track the Sun and focus its radiation on single heat collection point
- **Concentrating solar power (CSP)** – power-tower that falls into a utility-scale category of solar energy extraction.

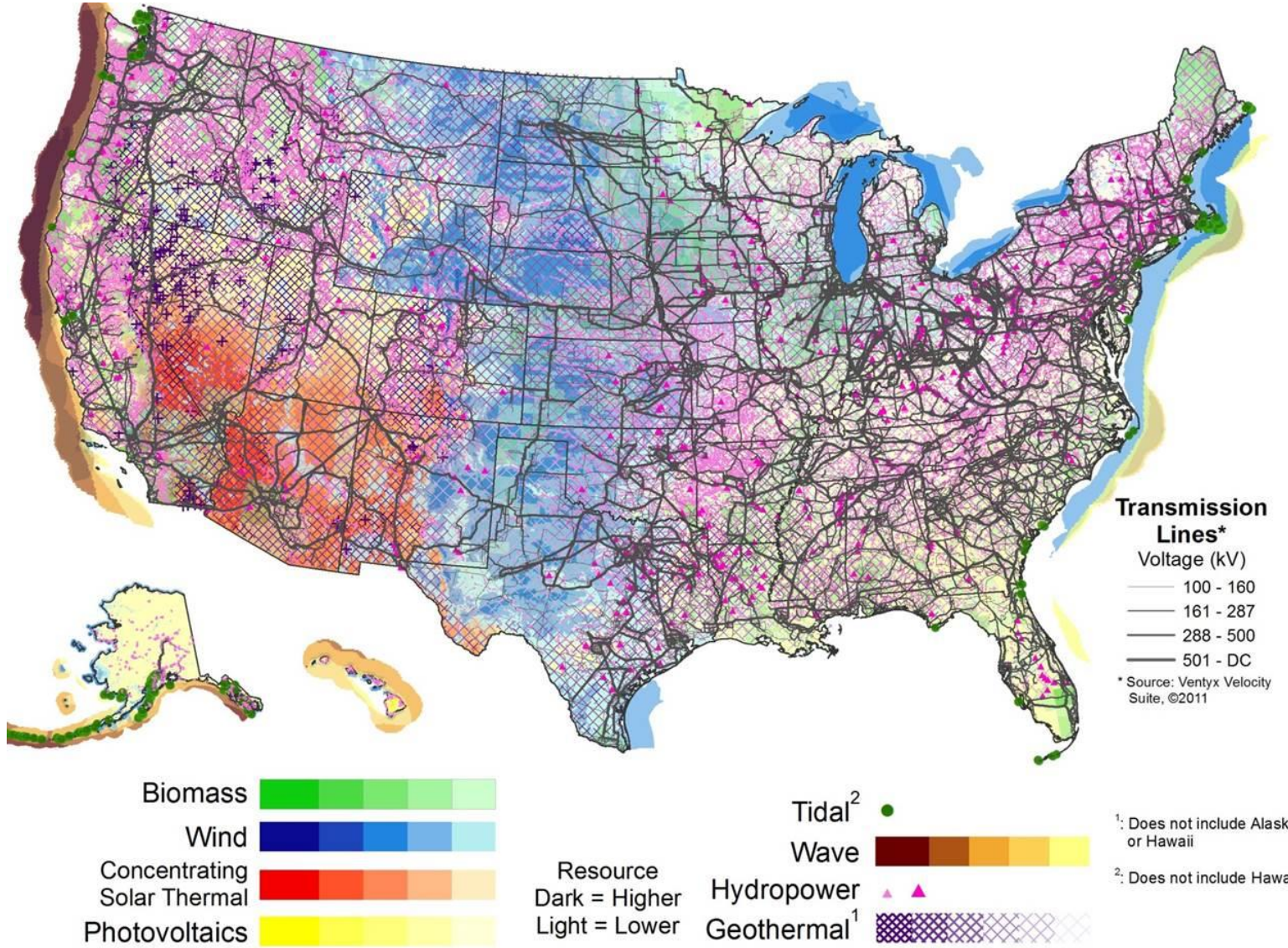


Windfarms on land and offshore



# Managing Anthropogenic Climate Change

## Renewable Energy Sources



# Conclusion

- Global warming is real.
- Human activity is responsible for large majority of warming since about the mid-20<sup>th</sup> century.
- Human reliance on fossil fuels is at the heart of anthropogenic climate change.
- Mitigation seeks to cut emissions via cap-and-trade, carbon capture and storage, and higher energy efficiency in generation of electricity, transportation and built environment.
- Adaptation makes communities more resilient.
- Skepticism in science is healthy; denying well-understood evidence is not.
- The hope is that with greater education and more effective communications, public perception will align with scientific consensus.

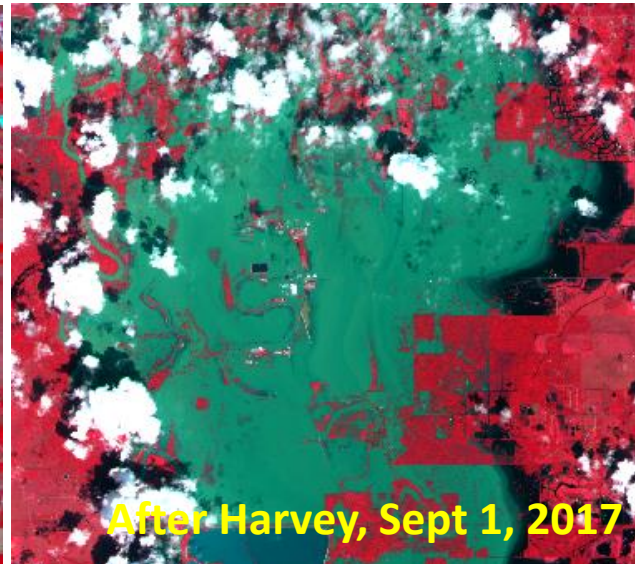
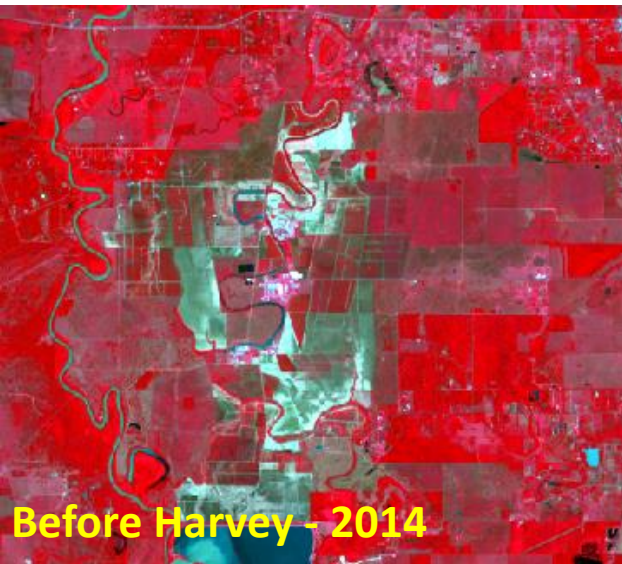


[http://www.democraticunderground.com/discuss/duboard.php?az=view\\_all&address=389x3899732](http://www.democraticunderground.com/discuss/duboard.php?az=view_all&address=389x3899732)

**A New Orleans Police Department officer peers over the Industrial Canal levee wall from the lower 9th Ward at the high water driven in by Hurricane Gustav. In the background, upper right is the flooded offices of Southern Scrap.**



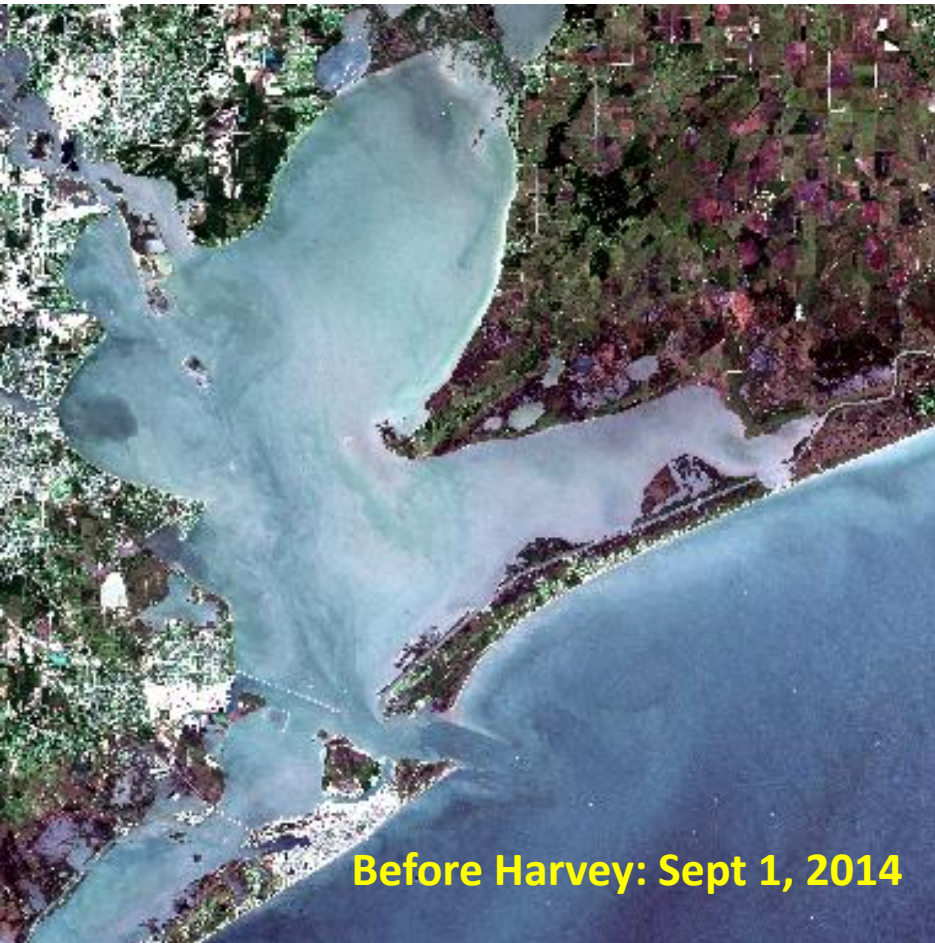
## Brazos River Flooding in Fort bend and Brazos Counties after Hurricane Harvey



Landsat 8, Sentinel 2 and ASTER data from 2014, Sept 1 and Sept 5, 2017 respectively. The Bands 3, 4 and 5 are shown as Blue, Green, and Red and for Sentinel 2 the Bands 3, 4 and 8 are shown as Blue, Green, and Red and for Sentinel 2 and the bands 1, 2 and 3 are shown as Blue, Green, and Red for ASTER.

# Galveston Bay storm water runoff after Hurricane Harvey

About 50 inches of rainfall received in 4 day period from Aug 25-29,2017 in Harris County, TX



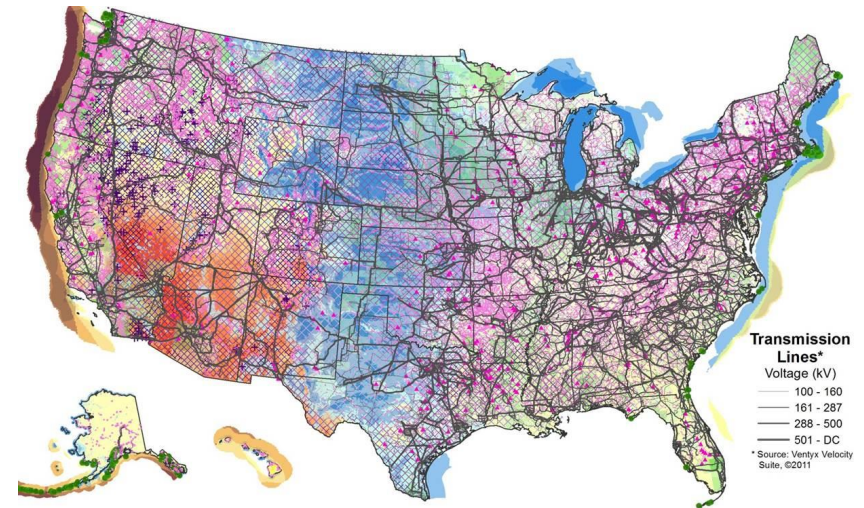
Sentinel 2 data from May 24 and Sept 1, 2017 respectively. The Bands 2, 3 and 4 are shown as Blue, Green, and Red

## Greater Opportunities

- Stronger economy
- More jobs
- Greater national security
- Cleaner environment
- More consistent with the Golden Rule



# Questions?



<sup>1</sup>: Does not include Alaska or Hawaii  
<sup>2</sup>: Does not include Hawaii