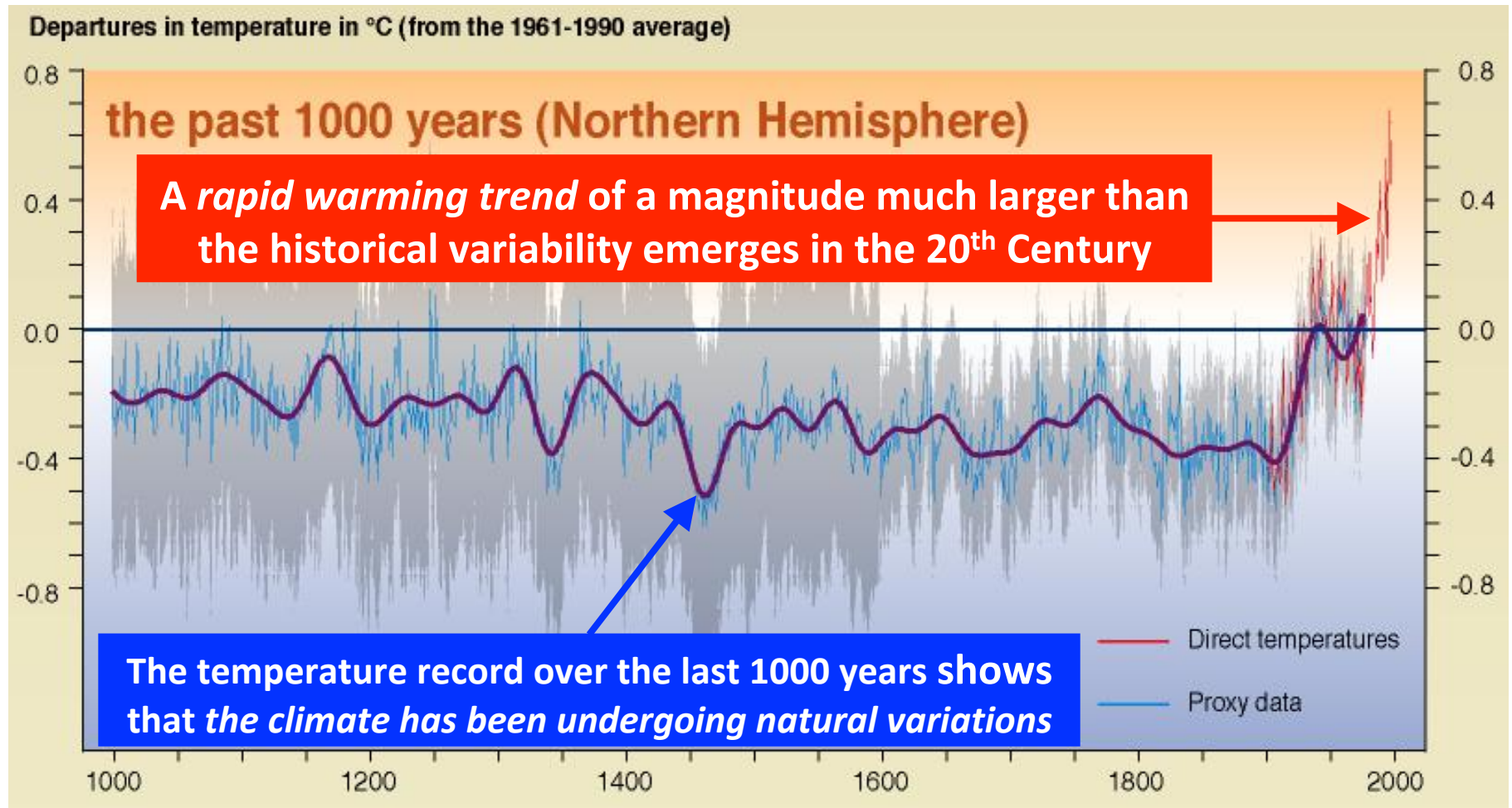


Climate Change

An illustration depicting the impact of climate change. A large polar bear is perched on a small, isolated ice floe in a body of water. To the right of the bear, a young man in a blue shirt and orange pants sits on the edge of the ice, looking down at a smartphone. The background features a city skyline with various buildings under a large, bright yellow sun, suggesting a sunset or sunrise. The overall scene conveys the isolation and vulnerability of Arctic wildlife due to melting ice.

Climate variation is a natural process

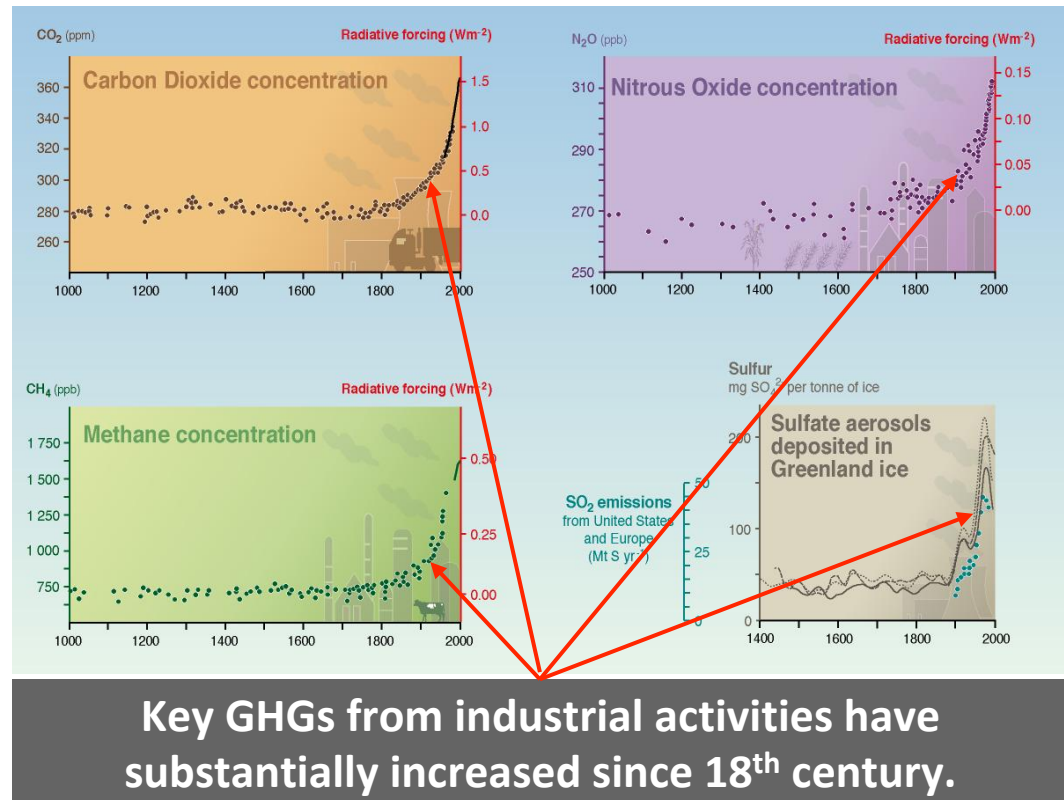
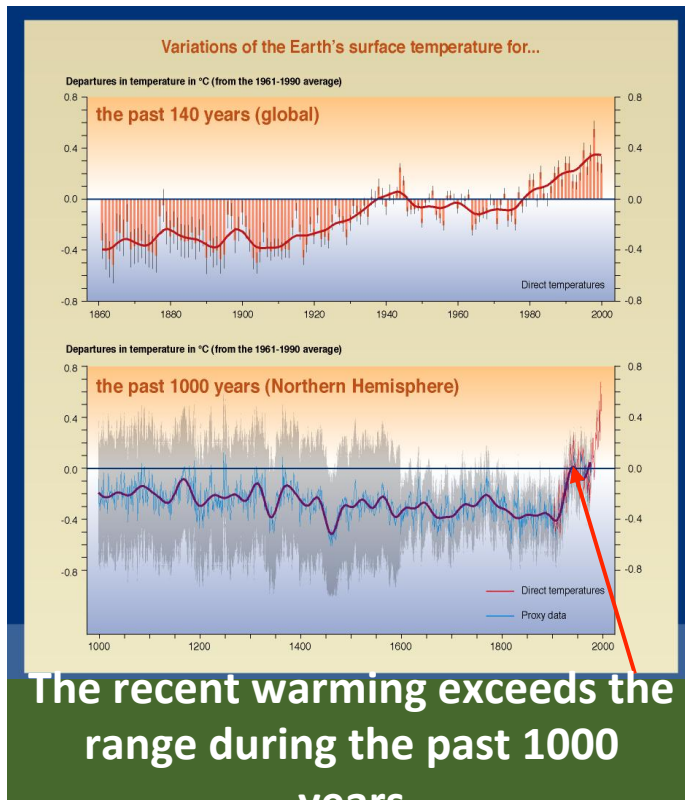


We may be seeing a *Climate Change* since the 20th century

What's causing climate variations & change?

- Climate varies by both **natural** and **anthropogenic** causes
- The key natural forcing includes **volcanic activities**, **the solar cycle (11 yrs)** and other **celestial cycles** such as the Milankovitch cycles:
 - **Eccentricity** of the earth's orbit ~ **100K** yrs
 - **Obliquity** (earth's tilt relative to the orbital plane) ~ **41K** yrs
 - **Precession** (earth's wobble around its axis) ~ **26K** yrs
- **Human activities** also affect climate

Clues for the warming from observations



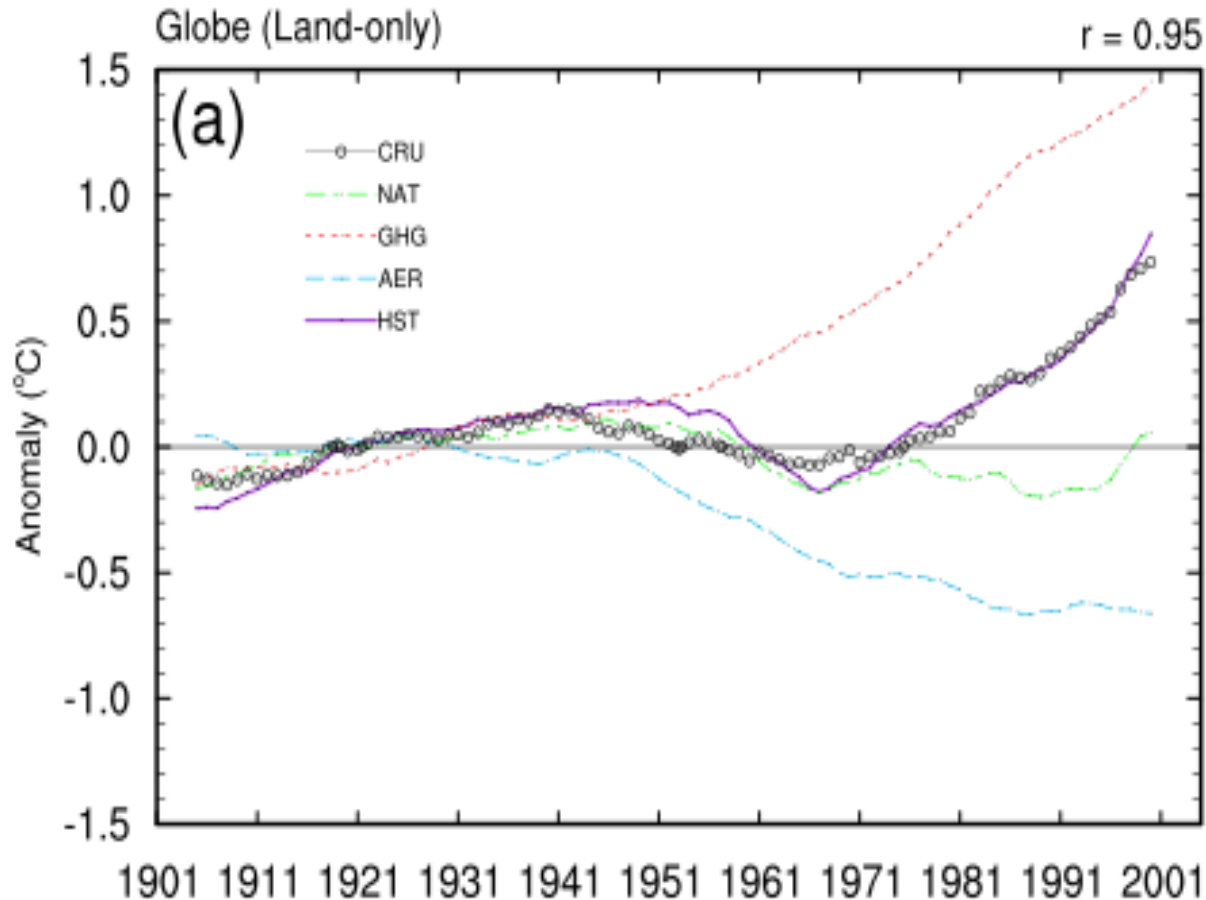
- Observations show that *the recent warming trend coincides well with the increased trace gas concentrations from industrial sources*
- Some industrial emissions (CO₂, CH₄, Nitrous Oxide) are potent greenhouse gases (GHG)
- The industrial GHGs can induce warming via the greenhouse effects

The Greenhouse Effect



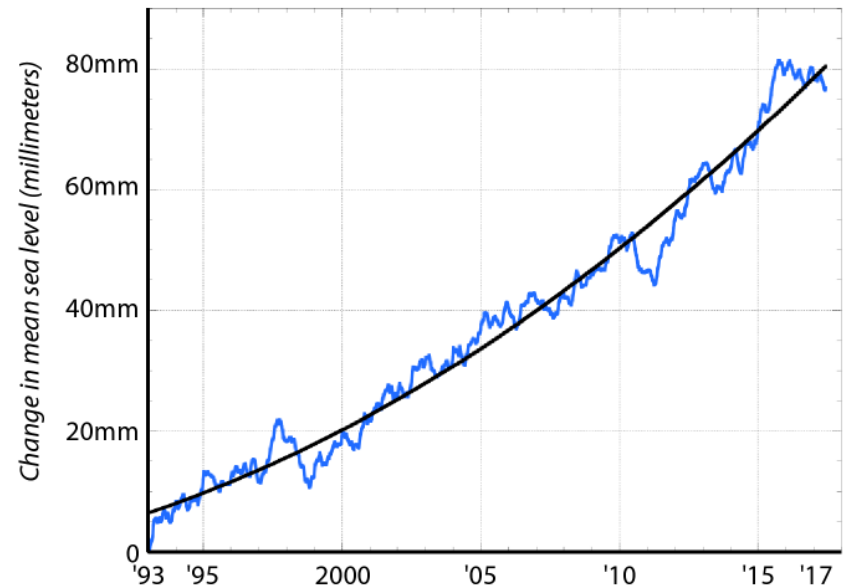
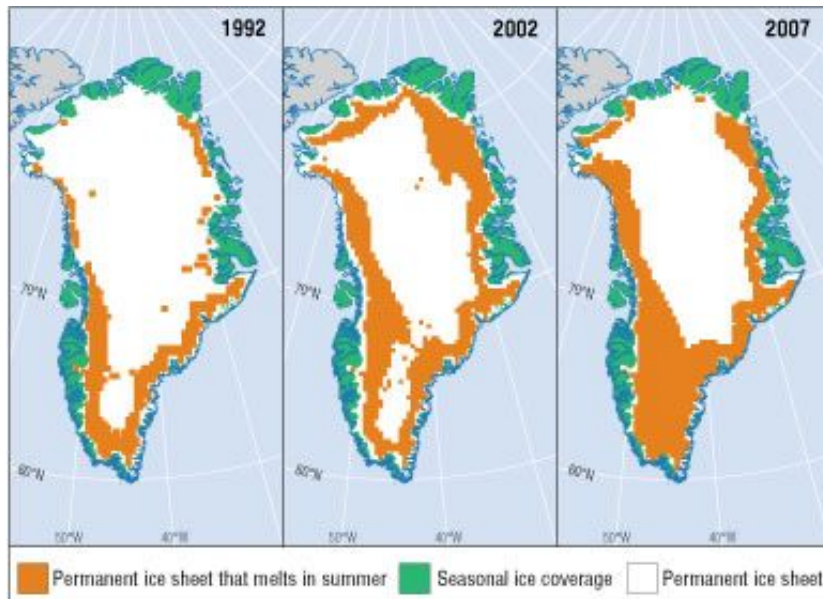
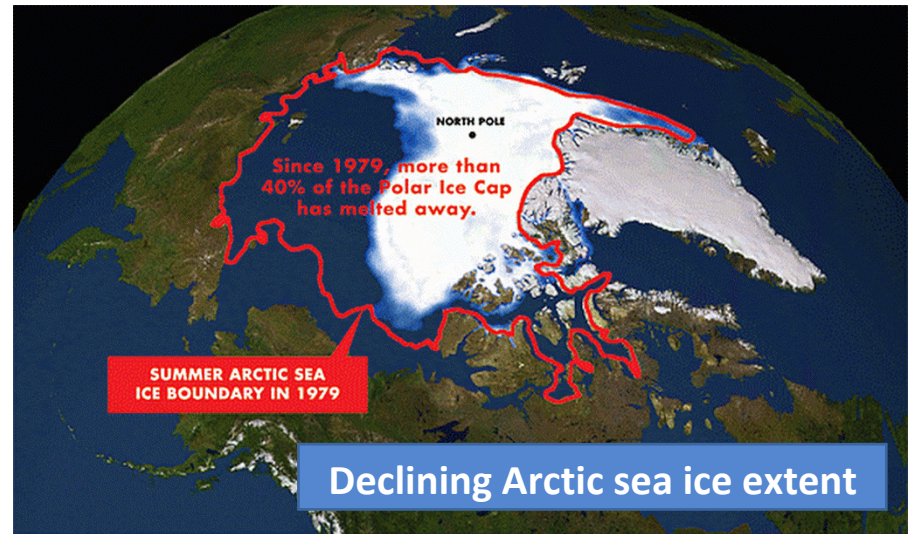
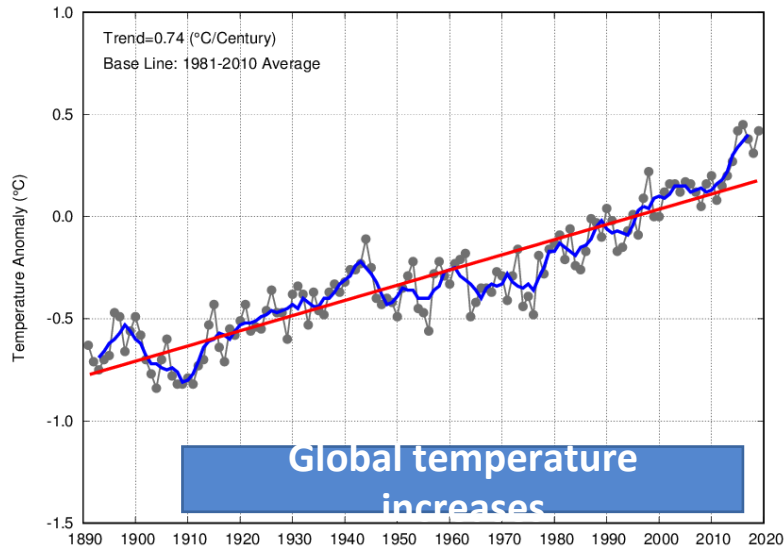
- The greenhouse effect **warms the earth's surface beyond its radiative equilibrium temperature** by absorbing and re-radiating the energy emitted by the earth; an essential process for the present ecosystems
- The anthropogenic GHGs can enhanced the greenhouse effects to

Climate model experiments



- Climate models allow separate examination of each forcing
- The *natural forcing* cannot explain the observed temperature trend
- The observed temperature trend can be explained by the *combined forcing* mainly by the anthropogenic *greenhouse gases* and *aerosols*

Observed impacts of the climate change

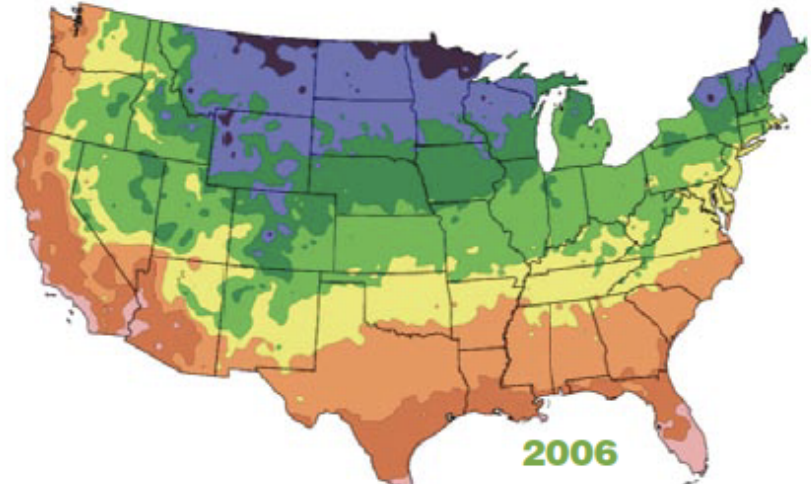
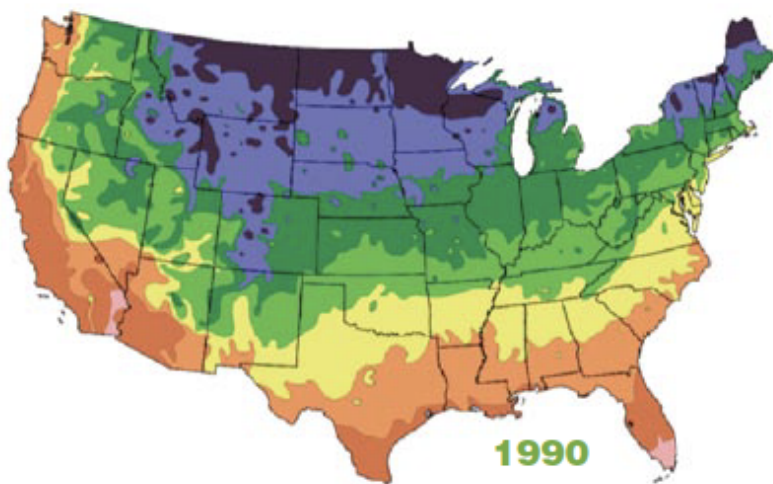


Shrinking ice sheets in the Greenland & Antarctica

Rising Sea Level

Observed impacts of the climate change

- Intense tropical cyclones have increased; 8/10 most damaging hurricanes in US occurred since 2004
- The sea-level rise make coastal storms more damaging by increased severe coastal flooding
- Milder winters and hotter summers
- Extreme weather events like heatwaves and heavy precipitation
- The warming cause more frequent and severer droughts
- The northern limits for warm-climate plants moved further north



Climate change projections

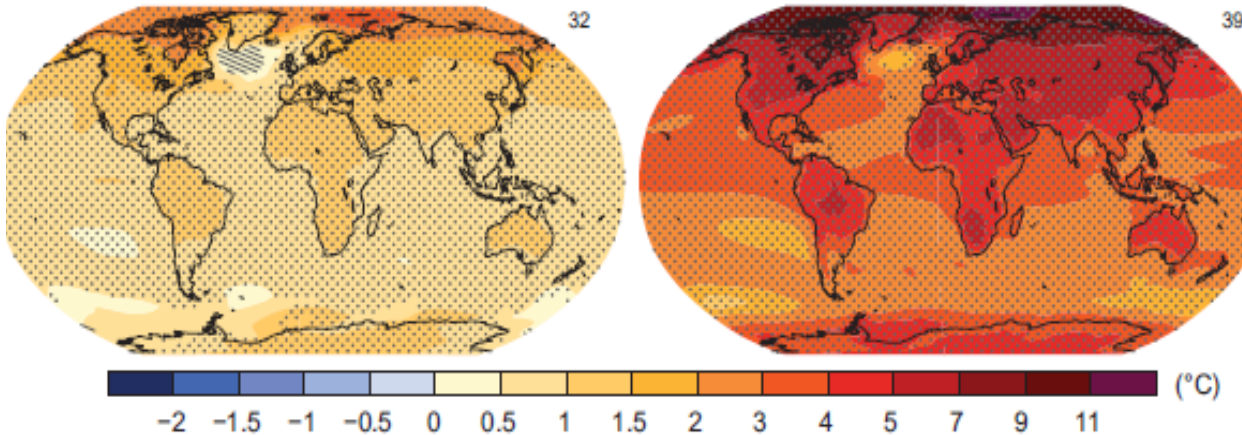
- The anthropogenic climate change affects the human society and ecosystems; in most cases, we don't know exactly how we will be affected
- We cannot avoid industrial activities for our survival, thus the anthropogenic climate change is inevitable
- Long-term projections of the consequences of human activities on future climate is necessary for developing plans for sustainable development
- Global climate models (GCMs) are used in projecting future climate
- IPCC has been working to conduct internationally coordinated projects to advance our understanding of climate and to project future changes.

Projected temperature and precipitation change

RCP 2.6

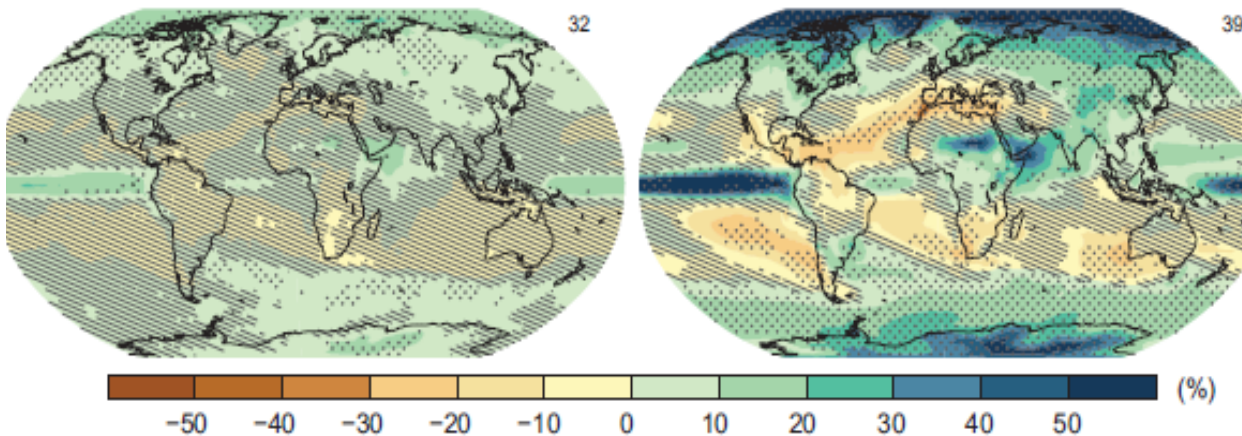
RCP 8.5

Change in average surface temperature (1986–2005 to 2081–2100)



The magnitude of the warming increases with increasing emissions; Large regional variations in the warming signals.

Change in average precipitation (1986–2005 to 2081–2100)



Precipitation change is more complicated than the temperature change; Regional variations in the precipitation change increase as emissions increase

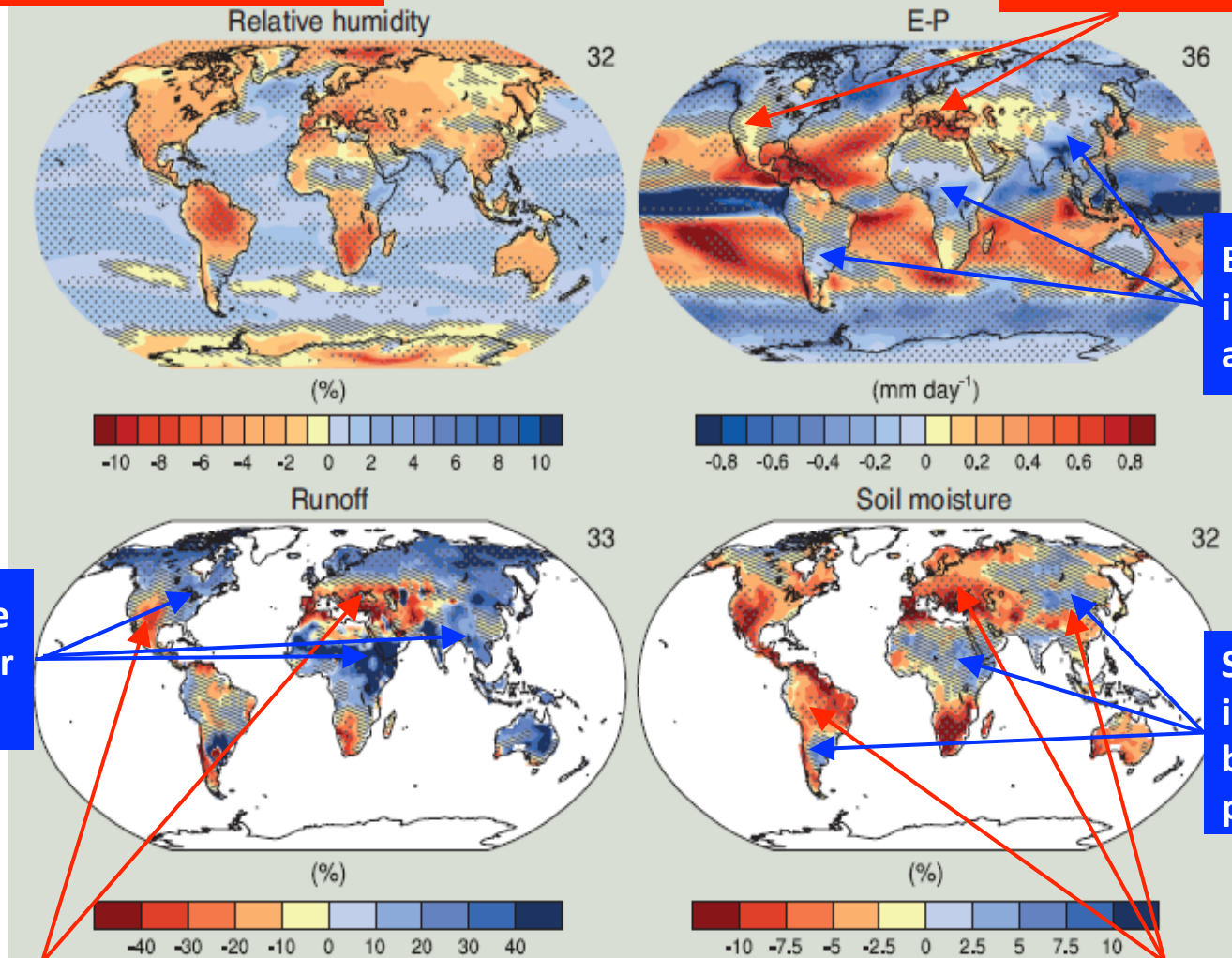
Projected changes in weather events

- Further **increases in intense tropical cyclones** – the total number of tropical cyclones may decrease
- Coastal flooding will increase due to the sea-level rise and the increase in intense storms
- Winters will become milder; summers will become hotter
- Increased heatwaves
- More frequent and severer droughts
- **NOTE: Uncertainties in the projected changes in regional weather and hydrology are large.**

Projected hydrology changes (2081-2100 vs. 86-05)

The RH decrease will increase the water demand for evaporation.

E-P increases to result in reduced water availability.



E-P decreases to increase water availability.

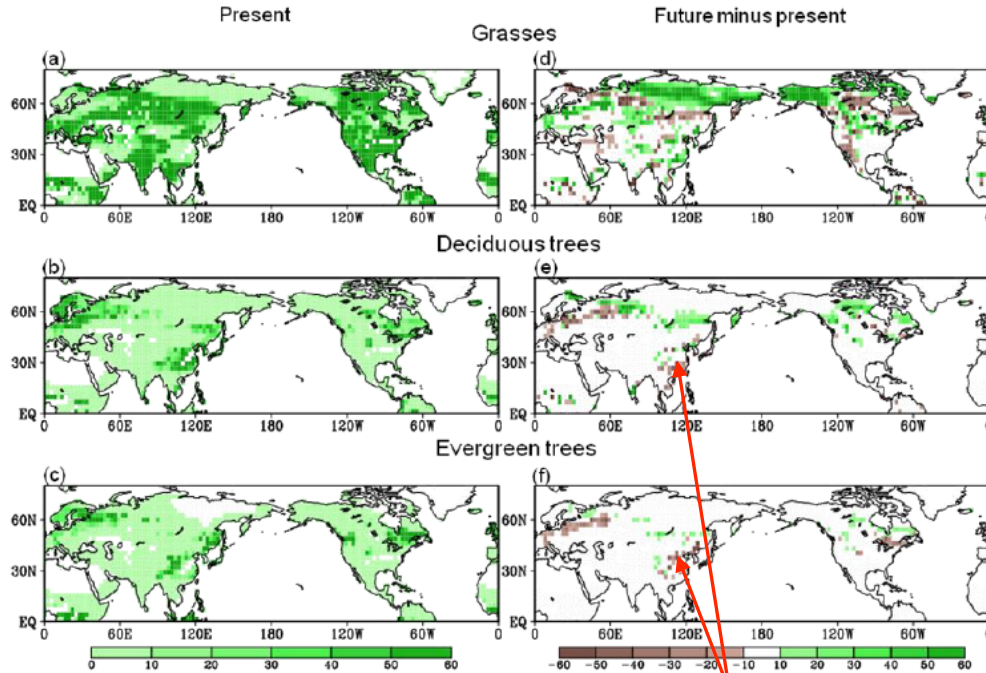
Soil moisture increases will benefit food production.

Runoff decreases, decreasing water resources in dry regions.

Drier soil in major crop-producing regions will reduce food production.

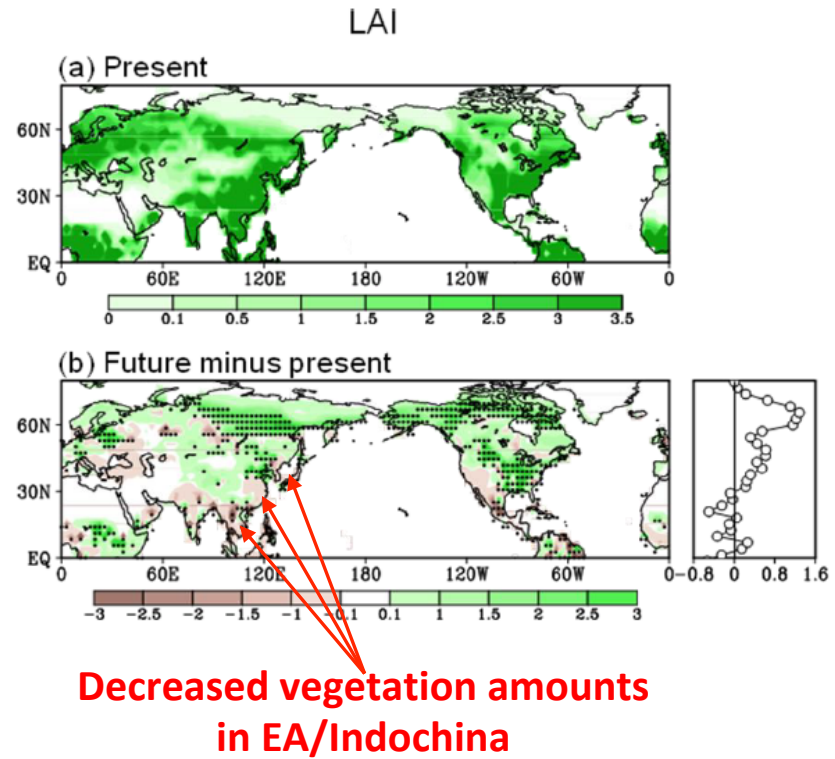
Responses of vegetation in late 21st century

Coverage of individual vegetation Functional Types (%)



Decreased evergreen/deciduous forests

Vegetation amounts



Decreased vegetation amounts in EA/Indochina

- The high-latitude grassland increases – Greening of the arctic.
- The vegetation amount increases in the middle and high latitude regions.

Summary

- It has been scientifically confirmed that the emissions of GHGs from industrial activities started to induce climate change beyond the natural variability since the early 20th century
- The climate change can affect humans and ecosystems
- The global warming has affected some sensitive sectors such as the polar ice sheets and glaciers
- It is expected that we will experience increases in extreme weather events as the climate warms
- Not all climate change impacts are negative; exact consequences of climate change on humans and ecosystems remain uncertain
- We need to find a way to balance industrial activities and their impacts on climate change for our long-term survival
- Conservation will be a key component of the plan for sustainable development