GLOBAL WARMING AND THE HYDROLOGICAL CYCLE

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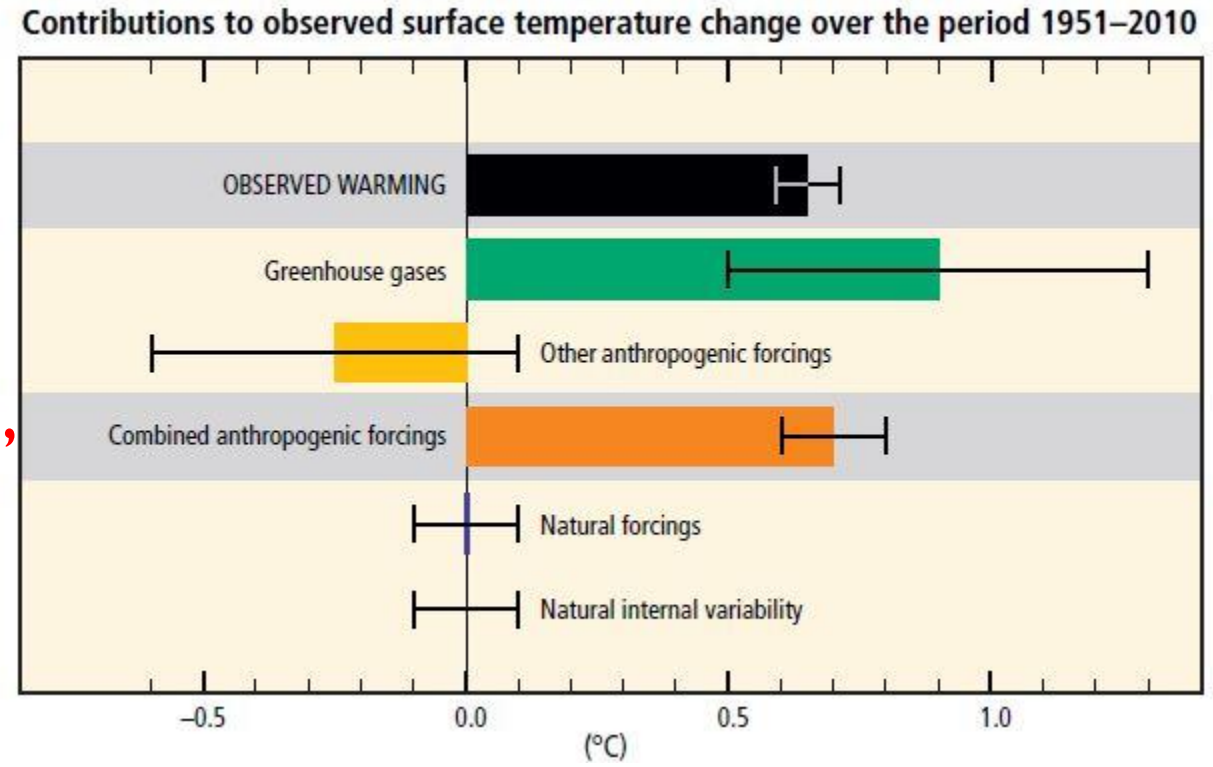
Structure

- Brief description of the Hydrological cycle & Global warming
- Effects of Global Warming
- Global warming impacts on the Hydrological cycle
- Global warming impacts on the Cryosphere
- Conclusions & Discussions

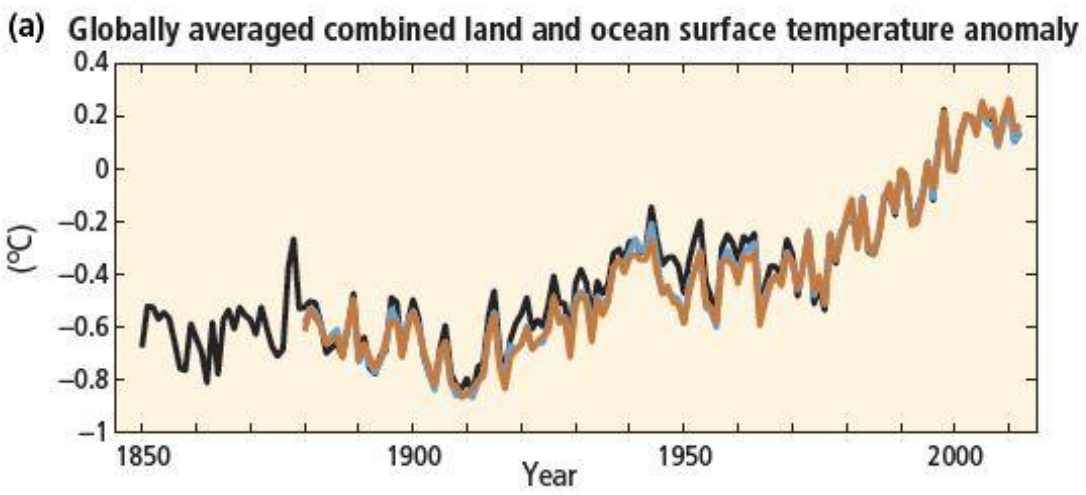
Global Warming

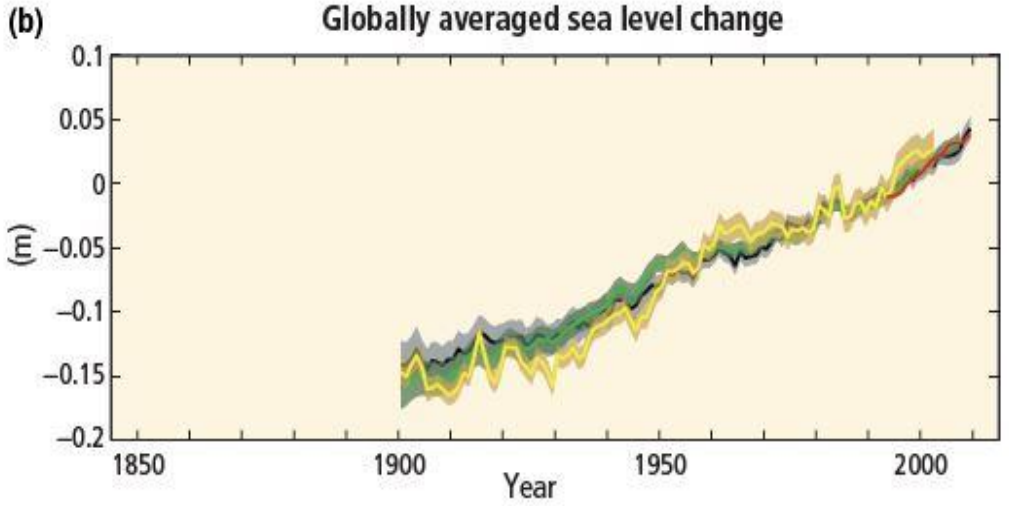
- a gradual increase in the overall temperature of the earth's atmosphere generally attributed to the greenhouse effect caused by increased levels of carbon dioxide, CFCs, and other pollutants.
- Sea level rise as a result of thermal expansion of the ocean, melting of land ice

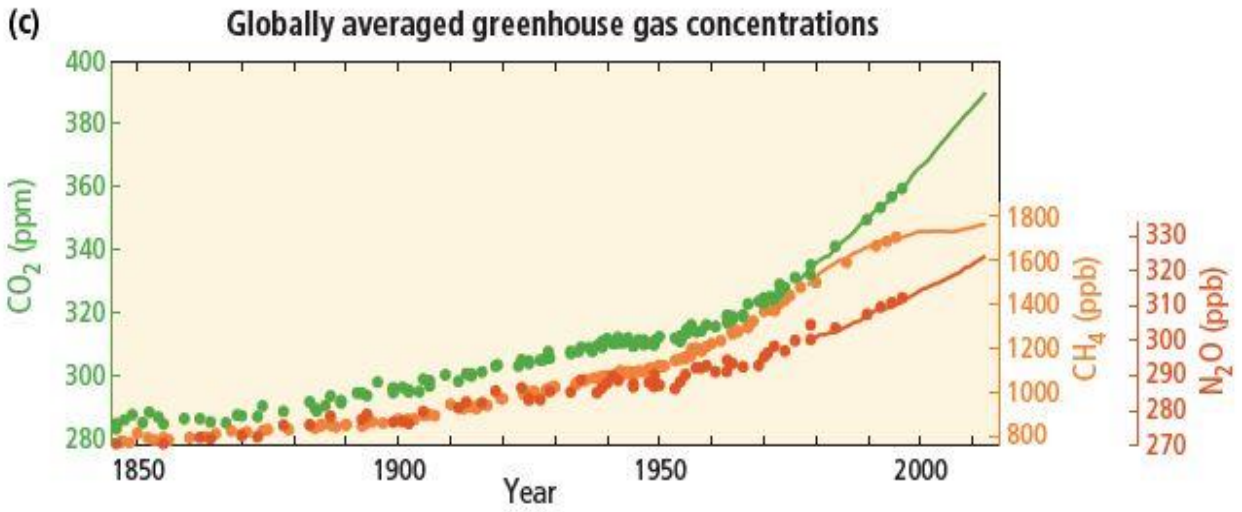


Source: IPCC Assessment Report AR5

Effects of Global Warming







- Warming of the atmosphere and ocean
- Sea level rise
- Melting of land ice

Global Warming of 1.5^0C – IPCC AR5

- Human activities are estimated to have caused approximately 1.0°C of global warming above pre-industrial levels, with a likely range of 0.8°C to 1.2°C.
- Global warming is likely to reach 1.5°C between 2030 and 2052 if it continues to increase at the current rate.
- Warming from anthropogenic emissions from the pre-industrial period to the present will persist for centuries to millennia and will continue to cause further long-term changes in the climate system, with associated impacts (high confidence), such as sea level rise.
- But these emissions alone are unlikely to cause global warming of 1.5°C (medium confidence).

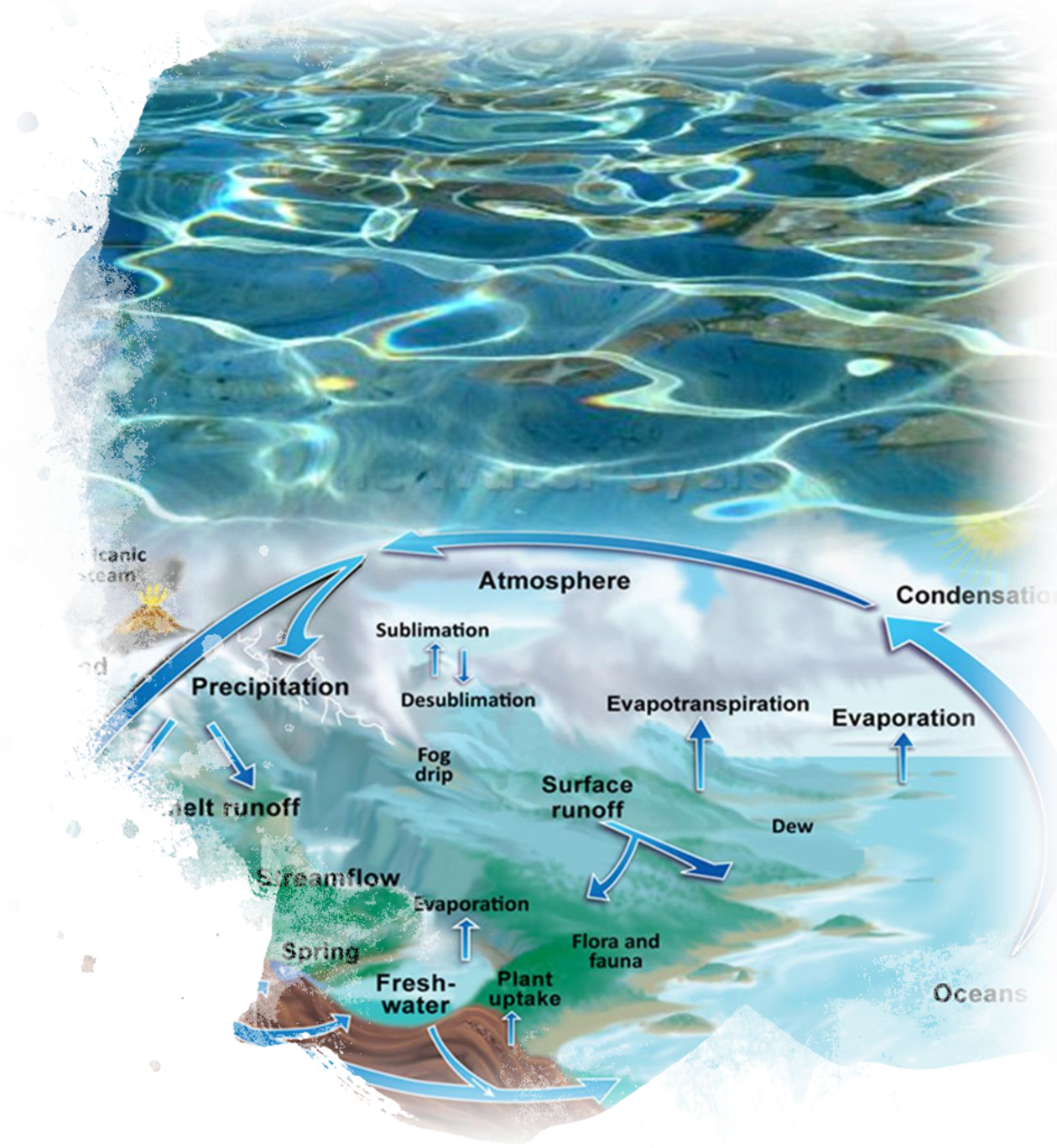
The Hydrological cycle

- cycle that involves the continuous circulation of water in the Earth-atmosphere system.
- water goes through different forms: liquid, solid (ice) and vapor.
- involves the exchange of energy, which leads to temperature changes.

➢ When water evaporates, it takes up energy from the environment and cools the environment

➢ When water condenses, it releases energy and warms the environment.

- These heat exchanges influences climate.

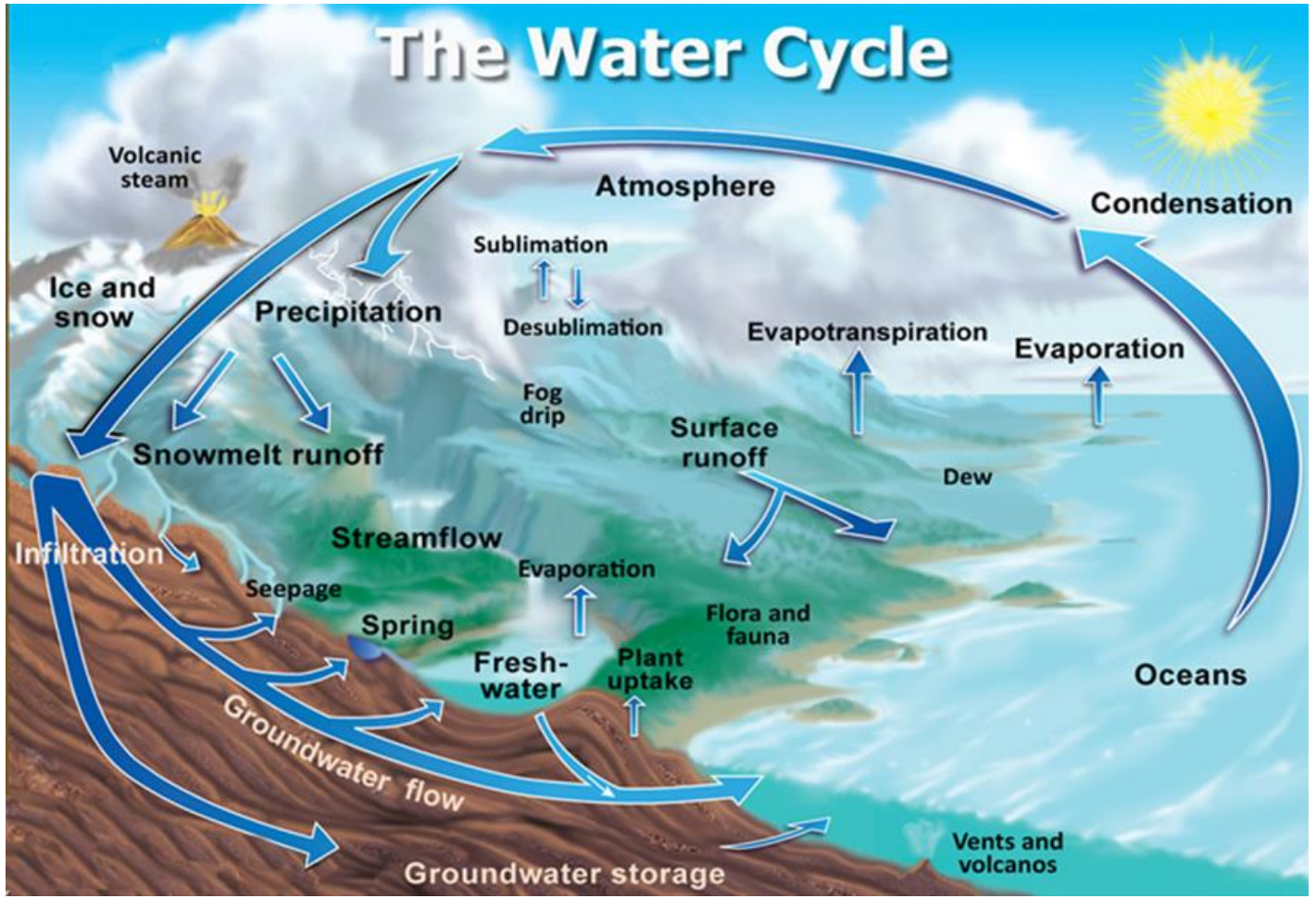


Hydrological processes

- Water enters the atmosphere through **evaporation** from the ground, oceans, etc.
- Combined process of evaporation from soil and transpiration from leaves is referred to as **evapotranspiration**
- It condenses and falls from the atmosphere as **precipitation** (rain, snow, or sleet)
- After precipitation, it follows two pathways:

➢ Returns to the hydrosphere through **runoff** on land surfaces into streams, rivers, lakes and eventually the ocean.

➢ Returns to the lithosphere by **infiltration** into the ground becoming soil water or ground water



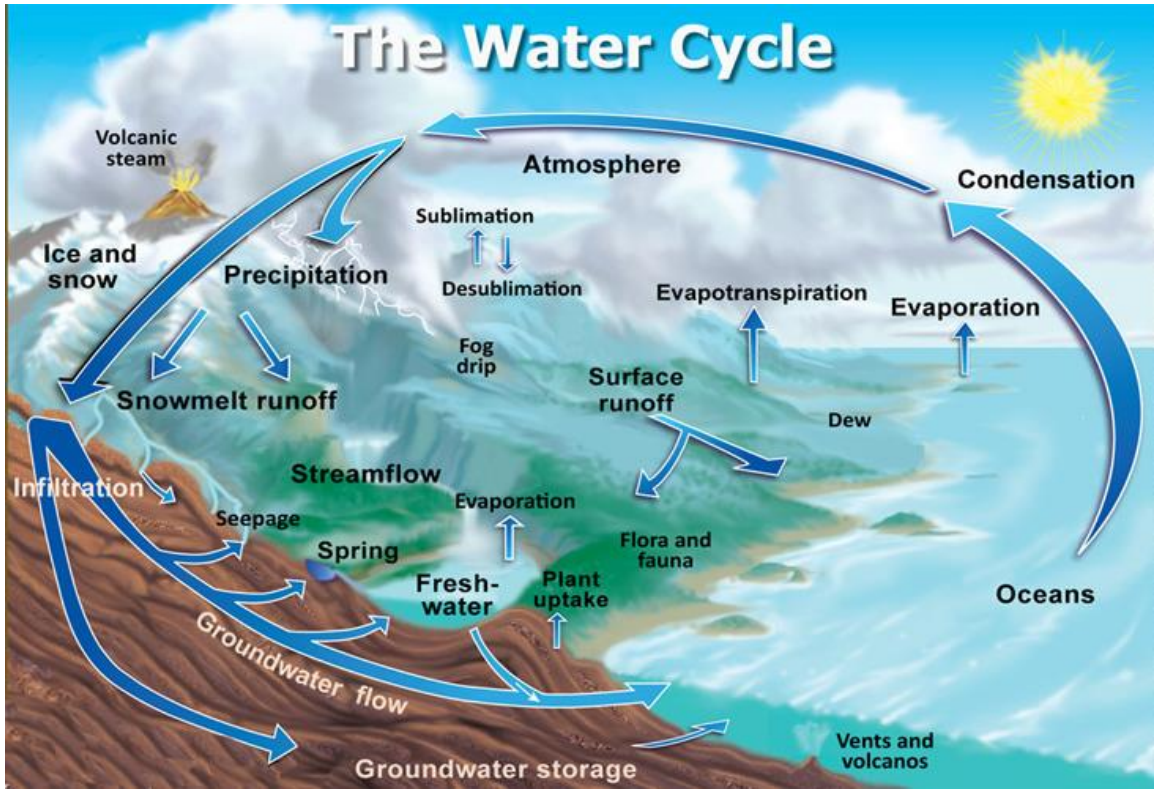
Global Warming effects on the Hydrological cycle

- Intensification of the hydrologic cycle
- Global precipitation and evaporation increase due to temperature increase

➢Higher temperatures mean there is more evaporation from the land and sea into the atmosphere.

➢High latitudes and moist mid- latitude regions will experience greater amounts of precipitation

➢Mid-latitude and subtropical arid-and semi-arid regions will experience more dryness.



Global Warming effects on the Hydrological cycle

- A shift to more intense extreme events.

➢ Intense rainstorms increase the risk of floods.

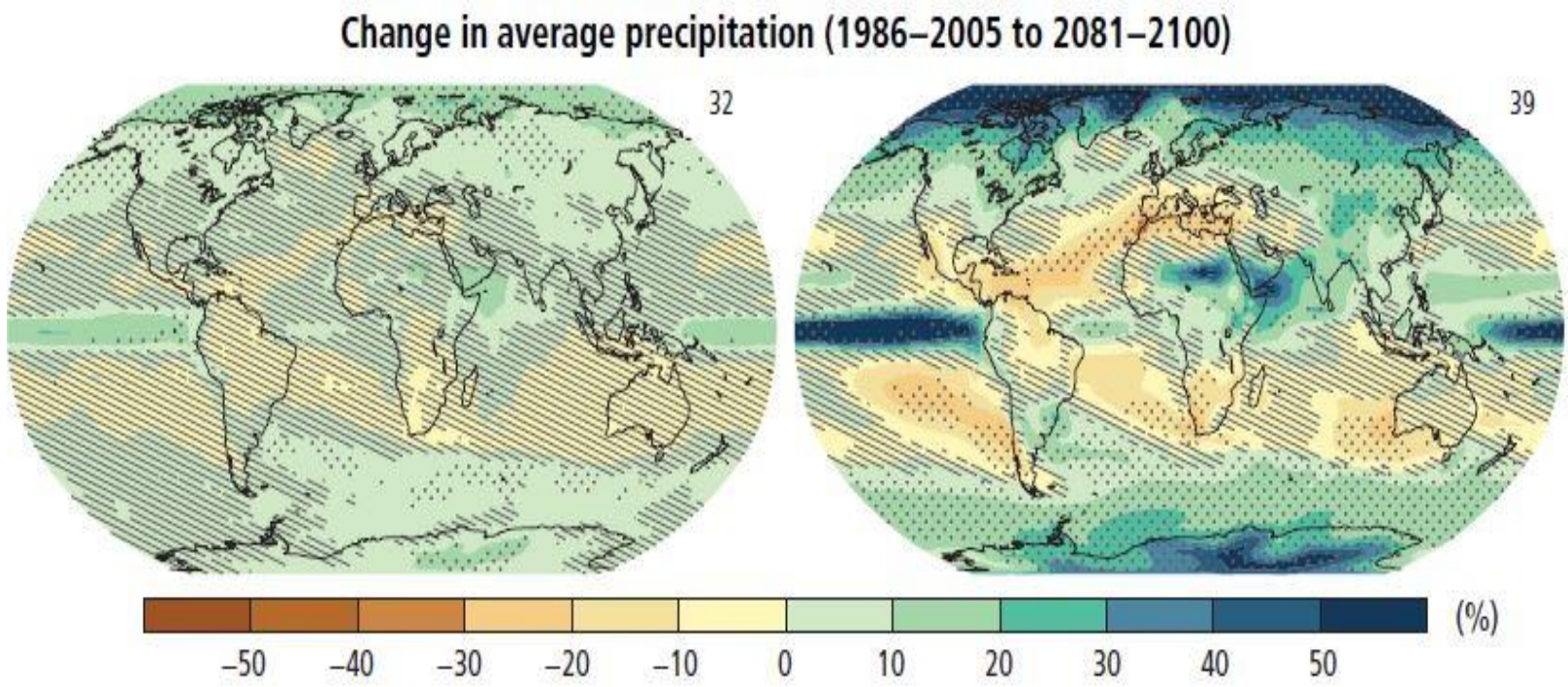
➢ Increased temperatures also means a greater risk of drought, e.g. in mid-continental areas.

➢ Less frequent but more intense rainfall with increased evapotranspiration, particularly in the subtropics.

Global Warming effects on the Hydrological cycle

According to the IPCC AR5 report

- Changes in precipitation globally.
  - ➢ Increase in high latitudes and equatorial Pacific
  - ➢ Decrease in many mid-latitude and subtropical dry regions
  - ➢ Increase in mid-latitude wet regions
  - ➢ More intense and frequent extreme precipitation events over most mid-latitude land masses and over wet tropical regions.
- Monsoon systems will intensify
  - ➢ ENSO related precipitation variability on regional scales will *likely* intensify.



Source: IPCC Assessment Report AR5

Specific changes to water resources and the hydrological cycle also include:

- Changes in mean surface flows
- Changes in the seasonality (or timing) of flows, especially in snow melt basins
- Changes in flows from glaciers due to their retreat
- Decreasing snow and permafrost
- Rising sea levels caused by thermal expansion of seawater and melting of continental glaciers
- Changes in soil moisture

The Cryosphere - Introduction

- Several GCM predict that Global warming will be first obvious and most extreme in polar regions

➢ Snow cover, glaciers and sea ice diminish

➢ Produces further warming due to decreased albedo

➢ Greater extent and duration of dark surfaces

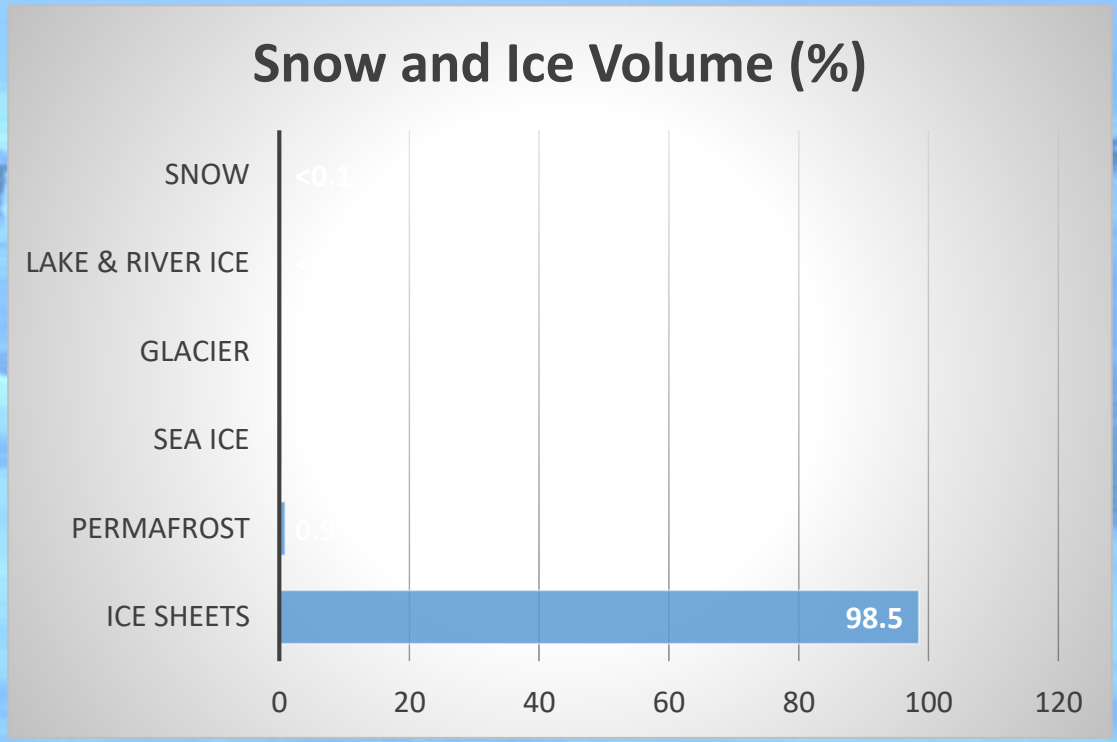
➢ Increased absorption of solar radiation

➢ Thawing of permafrost will release CH4 and GHGs

➢ Positive feedback mechanism

Compartments of the Cryosphere

- Seasonal snow
- Mountain glaciers and ice caps
- Ice sheets and shelves (largest volume of ice proportion, about 3.3km^3)
- Permafrost
- Seasonal frozen ground (the largest area, covers over 5.2km^2)
- River and lake ice
- Sea ice



Source: Slaymaker and Kelly (2007)

Sensitivities of compartments to global warming

Component	Response time
Sea ice	Days to countries
Snow and surface ice	Hours
Lakes and river ice	Days
Soil and vegetation	Days to centuries
Glaciers	Decades to centuries
Ice sheets	Millennia
Mantle's isostatic response	Millennia

- Snow, lake and river ice, sea ice, ice caps and glaciers, seasonal frozen ground, and permafrost are more important than the 98.5% of the ice that is stored in the polar ice sheets and shelves

Three major cryospheric regions of the world are...

- Antarctica
  - Ice sheet, ice shelves, icebergs.
  - East Antartica contains 77% and
  - West Antartica contains 10% of the Earth´s ice

- Arctic Ocean
  - Sea ice or pack ice
  - Greenland Ice Sheet(9% of Earth´s ice) and in permafrost(0.9%)

- Extra-polar regions
  - Contains 0.5% of the earth‘s ice and snow
  - Small ice caps, mountain glaciers, snow and alpine permafrost
  - Their interaction with people is more intense than circumpolar regions.

Past cryospheric changes due to global warming

- The Greenland and Antarctic ice sheets lost mass over the period 1992 to 2011, and more over 2002 to 2011.
- Permafrost temperatures have increased in most regions since the early 1980s in response to increased surface temperature and changing snow cover.
- The annual mean Arctic sea-ice extent decreased over the period 1979 to 2012.
- Strong regional differences in Antarctica, with extent increasing in some regions and decreasing in others

Global Warming effects on the Cryosphere

Projections according to the IPCC AR5 report

- Year-round reductions in Arctic sea ice are projected for all RCP scenarios.
- ➢ Decrease in the area of Northern Hemisphere spring snow cover by 7%
- As GMST increases, near-surface permafrost extent at high northern latitudes will be reduced
- The global glacier volume, excluding glaciers on the periphery of Antarctica (and excluding the Greenland and Antarctic ice sheets), is projected to decrease by 15 to 55% for RCP2.6 and by 35 to 85% for RCP8.5
- Global mean sea level will continue to rise during the 21st century

Questions?

- What is Global Warming?
- Any relationship or difference between Global Warming and Climate Change?
- How does global warming affect the water cycle?
- Why do we have decreased projections in global ice cover excluding Antartica and Greenland?

Sources

- J.A.A. Jones(1997). Global Hydrology. *Processes, resources and environmental management*
- Slaymaker and Kelly (2007). The Cryosphere and Global Environmental Change.
- IPCC Fifth Assessment Report 2007