

# Module 1: Overview of the Earth's Climate System and its Components

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# Module Outline

- An introduction to the Earth's Climate System
  - Atmospheric General Circulations
  - Ocean Circulation Systems
  - The Hydrologic Cycle, and its Observed Climatology
  - The Observed Climatology of the Cryosphere
  - Land Surface and Biosphere
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# Components of the Global Climate System

## Five components:

- Atmosphere
- Hydrosphere
- Cryosphere
- Land surface
- Biosphere

*What is exchanged across the interfaces among different components?*

- heat
- momentum
- water

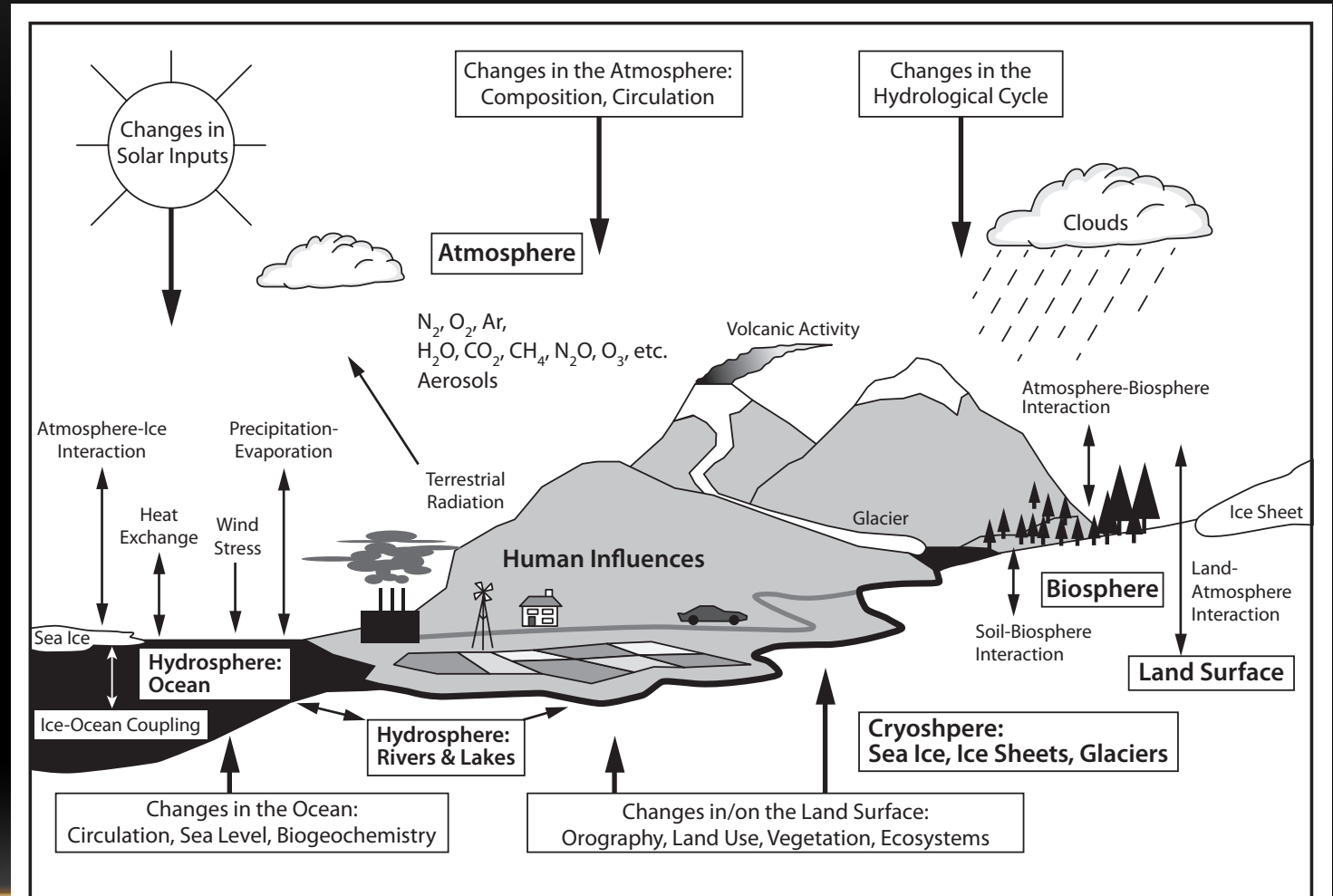
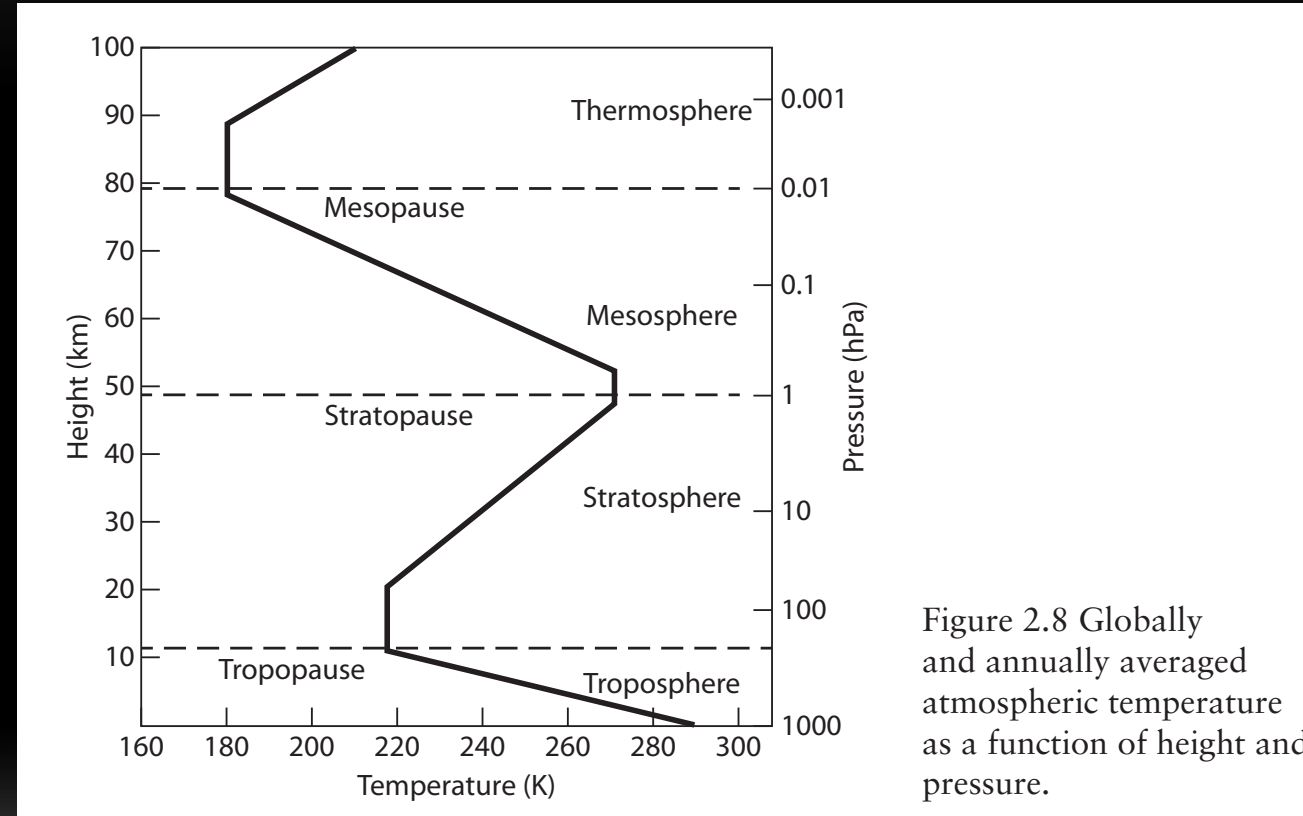


Figure 1.1 Schematic of the components of the global climate system (bold), their processes and interactions (thin arrows) and some aspects that may change (bold arrows). From IPCC, 2001.

# Different Components of the Global Climate System

- **Atmosphere:**
  - It is the most unstable and rapidly changing part of the climate system
  - Its composition and circulation both affect weather and climate
  - We are most interested in the troposphere and stratosphere.



From Climate Dynamics by K. H. Cook 2013

# Different Components of the Global Climate System

- **Hydrosphere:** comprises all liquid surface and subterranean water, both fresh water, including rivers, lakes and aquifers, and saline water of the oceans and seas
  - covers approximately 70% of the Earth's surface
  - stores and transports a large amount of energy owing to its large thermal inertia
  - dissolves and stores great quantities of carbon dioxide
  - a source of natural climate variability, in particular on the seasonal and longer time scales (such as the ENSO and the Atlantic multi-decadal oscillation)

## Different Components of the Global Climate System (cont'd)

- **Cryosphere:** *“That portion of the earth where natural materials (water, soil, etc.) occur in frozen form. Generally limited to the polar latitudes and higher elevations.”* (AMS Glossary)
  - includes the ice sheets of Greenland and Antarctica, sea ice, continental glaciers and snow fields, and permafrost
- *The cryosphere covers only about 13% of the earth's surface (Barry and Gan, 2011) but is important for the global climate system. Why?*
  - high reflectivity (albedo) for solar radiation
  - low thermal conductivity
  - large thermal inertia
  - playing a critical role in driving deep ocean water circulation



# Different Components of the Global Climate System (cont'd)

- **Land Surface:**
  - controls how energy received from the Sun is returned to the atmosphere: soil and vegetation affect the surface heat fluxes
  - Roughness affects the momentum transport between the earth surface and the atmosphere.
  - Land cover and land-use change, such as clearing forest for farming, contributes to climate change.
- **Biosphere:** *“That transition zone between earth and atmosphere within which most forms of terrestrial life are commonly found; the outer portion of the geosphere and inner or lower portion of the atmosphere.”* (AMS Glossary)
  - the marine and terrestrial biospheres have a major impact on the atmosphere's composition. For example, marine and terrestrial plants play an important role in the carbon cycle.

# Interactions among the components

- The different components of the climate system interact with each other via **physical, chemical and biological processes**.
- The interaction processes are manifested in the **exchange** of heat, momentum and water.
  - For example, evaporation from the ocean surface is part of the hydrological cycle and leads to condensation, cloud formation, precipitation and runoff, and supplies energy to weather systems. Meanwhile, precipitation affects the sea surface salinity, its distribution and the thermohaline circulation.
- Interaction between different climate components also leads to **low-frequency climate modes**. For example, ENSO is due to the interaction between the atmosphere and the tropical Pacific ocean.
- The slowly varying components (such as the ocean and land surface conditions) and low-frequency climate modes are important **sources of predictability** for the atmosphere on the climate time scales.



# References

1. The Climate System: an Overview – IPCC (2018): Section 1.1  
<https://www.ipcc.ch/site/assets/uploads/2018/03/TAR-01.pdf>
2. Cook, K. H., 2013: Chapter 1