Indian Institute of Technology, Kanpur
Department of Earth Sciences

ESO213A: Fundamentals of Earth Sciences

Lecture 35. Climate System

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Aims of this lecture

- Components of Climate System

Reading:
- Grotinger & Jordan's book (Chapter 15)

The Climate and Weather

❏   **WEATHER**: Short term changes (minutes to weeks) in the Atmosphere

Combination of temperature, humidity, precipitation, cloudiness, visibility, and wind

❏   **CLIMATE**: Long term (approximately 30 years or more) changes in the Atmosphere

Climate to look for trends or cycles of variability, such as the changes in wind patterns, ocean surface temperatures and precipitation over the Gangetic Planes or Bay of Bengal or other phenomena into the bigger picture of possible longer term or more permanent climate changes.

The Climate and Weather

❏   **Are weather and climate treated separately?**

Technically, NO, particularly in the context of weather forecasting and climate predictions.

What will the temperature be tomorrow? Will it rain? How much rain will we have? Will there be thunderstorms? Etc. are common weather forecasters' questions.

The weather forecasts are based on numerical models (often ML is used) with the measured input data (air pressure, temperature, humidity and winds).

The accuracy of weather forecasts depends on both the model and on the forecaster's skill. Short-term weather forecasts are accurate for up to a week.

Climate predictions try to answer questions like are we facing global warming? How much will sea level rise?

Climate predictions are made using global climate models. Unlike weather forecast models, climate models cannot use observations because there are no observations in the future. But experience from the PAST.
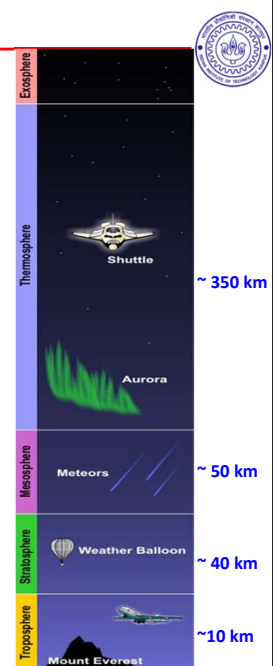
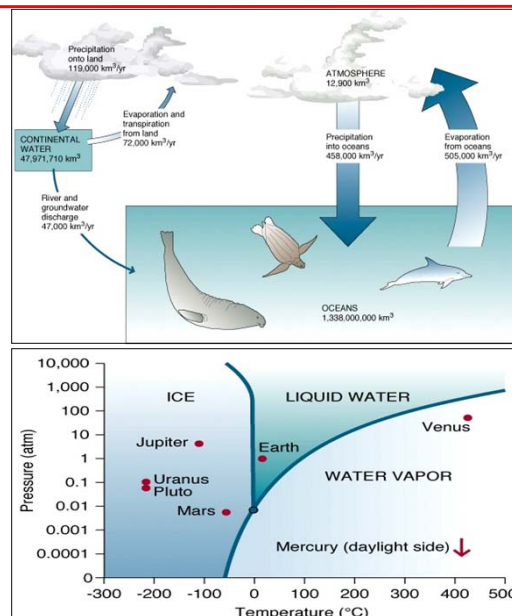# The components of the Climate
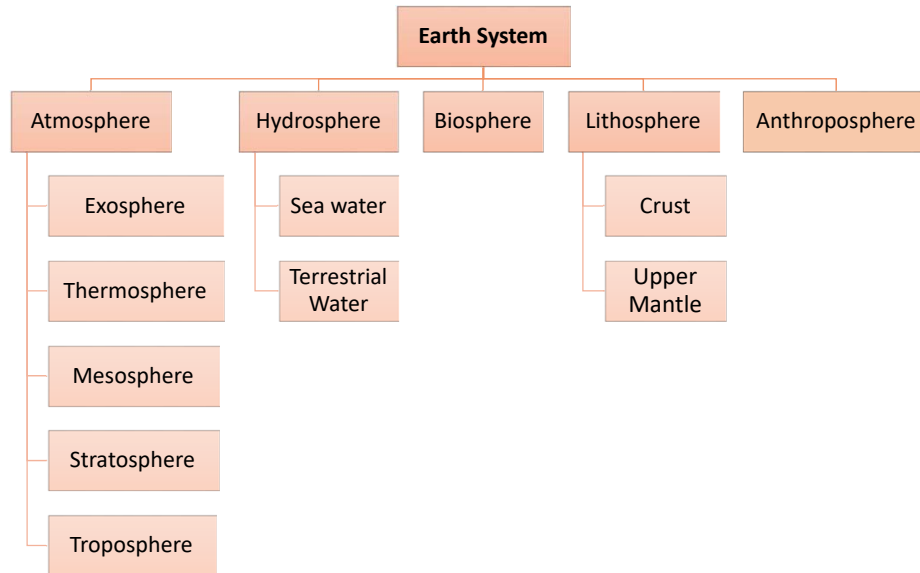
The components of the Climate
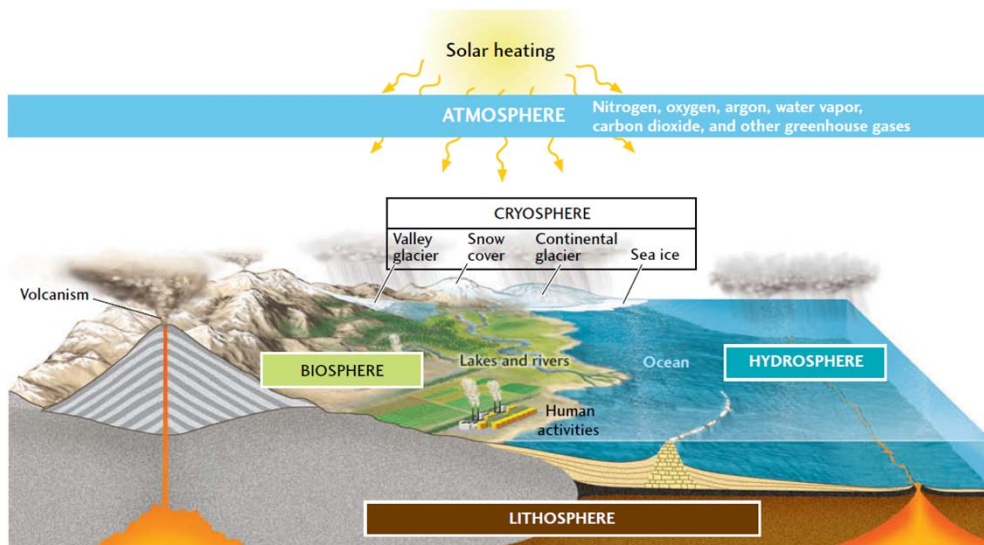
The Atmosphere

- The earth's atmosphere is a very thin layer wrapped around a very large planet

- Two gases make up the bulk of the earth's atmosphere: nitrogen (78% of the atmosphere), and oxygen (21%). Various trace gases make up the remainder.

- Based on temperature, the atmosphere is divided into four layers: the **troposphere**, **stratosphere**, **mesosphere**, and **thermosphere**. The outermost layer is exosphere.

- Energy is transferred between the earth's surface and the atmosphere via conduction, convection, and radiation.

- Ocean currents (and winds, too) play a significant role in transferring this heat poleward. Major currents, such as the northward flowing Gulf Stream, transport tremendous amounts of heat poleward and contribute to the development of many types of weather phenomena.

Exosphere

Thermosphere

Shuttle

~ 350 km

Aurora

Mesosphere — Meteors — ~ 50 km

Stratosphere — Weather Balloon — ~ 40 km

Troposphere — ~10 km — Mount Everest

The Hydrosphere

- Earth- the only watery planet! The BLUE planet.

- All forms of H_2O: water, ice (cryosphere), water-vapour (atmosphere).

- Responsible for many of the landform and surface features on continents.

- Without surface water, there would be no rivers, valleys, glaciers etc.

- 33 million cubic km of ice (cryosphere), primarily in the ice caps of the polar regions, seasonal exchange of which with water in important in climate system.

Precipitation onto land 119,000 km³/yr

ATMOSPHERE 12,900 km³

Evaporation and transpiration from land 72,000 km³/yr

CONTINENTAL WATER 47,971,710 km³

Precipitation into oceans 458,000 km³/yr

Evaporation from oceans 505,000 km³/yr

River and groundwater discharge 47,000 km³/yr

OCEANS 1,338,000,000 km³

ICE — LIQUID WATER

Pressure (atm)

Jupiter — Earth — Venus

Uranus / Pluto — WATER VAPOR

Mars

Mercury (daylight side)

Temperature (°C)

4

The Hydrosphere

- water circulation is slower in the oceans than air in the atmosphere. As water can store much more heat energy, the ocean currents transport heat energy very effectively and give rise to large-scale circulation patterns within ocean basins (both vertically and horizontally due to temperature and salinity gradients).
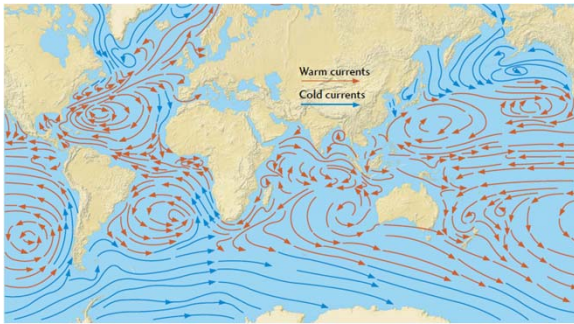
Currents at the surface of the oceans are generated by winds
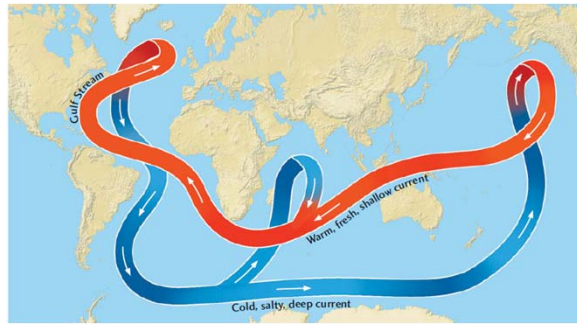
Conveyer belt like Ocean water circulation

# The Hydrosphere

A movie from NASA and the satellite Aquarius

The Biosphere

- Considers the living world - microbes, plants, and animals. Age- 3.5 billion years.

- The biosphere extends to any place that life of any kind might exist. The biosphere extends to the upper areas of the atmosphere where birds and insects can be found. It also reaches to dark caves deep in the ground or to the bottom of the ocean at hydrothermal vents.

- Factors, that control the existence and diversity of the Biosphere

  - Big factors: distance from sun, tilt of earth, seasonal variation

  - Small factors: climate, daily weather, erosion, earthquake

  - Micro-factors: chemical erosion, oxidation, reduction.

  - What about US! Are we also a factor to biosphere?
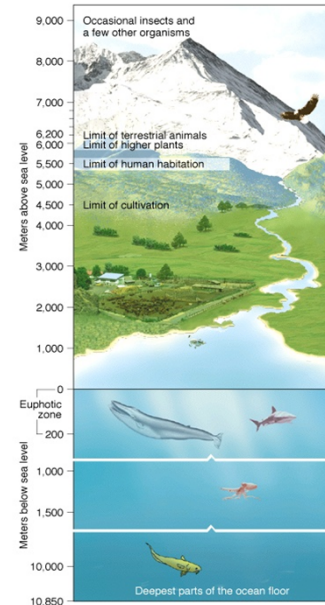
The Biosphere

Global change of biosphere (last 20 years) - NASA
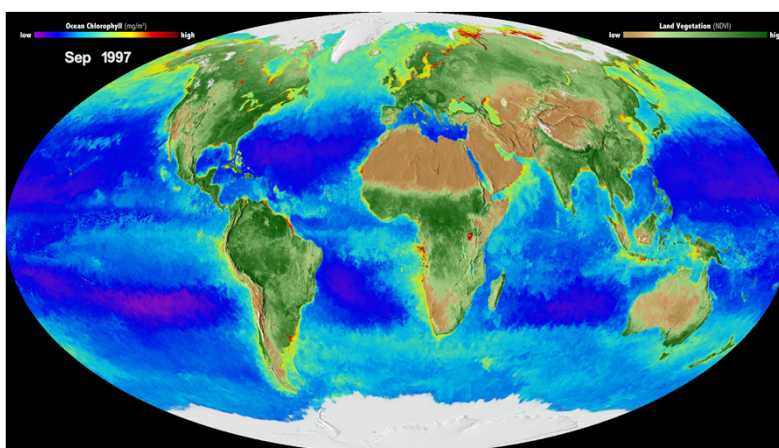
In the ocean, dark blue to violet represents warmer areas where there is little life due to lack of nutrients, and greens and reds represent cooler nutrient-rich areas. The nutrient-rich areas include coastal regions where cold water rises from the sea floor bringing nutrients along and areas at the mouths of rivers where the rivers have brought nutrients into the ocean from the land.

On land, green represents areas of abundant plant life, such as forests and grasslands, while tan and white represent areas where plant life is sparse or non-existent.

The Lithosphere

- Mostly land-surface of the earth, which can absorb and desorb the Solar Energy (and Earth's internal heat)

- Atmosphere is also heated by the surface of the Earth, and most of the time in uneven manner (albedo)

- One of the major sources of Water

- Change of wind directions due to topography, temperature gradient

PDF TOOLS SHARE

DEVELOPMENTS IN EXPLORING LITHOSPHERE AND ATMOSPHERE[1]

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In earth science the greatest advantures were those concerned with the exploration of the surface of our planet. The centuries between the fifteenth and the nineteenth are packed with the

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Feedback Loops

Positive feedbacks tend to amplify changes in a system, whereas **negative feedbacks** tend to stabilize the system against change.

Water vapor feedback:

Radiative damping:

Plant growth feedback:

Albedo feedback:

Grotinger & Jordan's book (page 415)

Atmosphere