Climate change and its implications

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Lecture-2

1st lecture: Earth's Atmosphere

- Optical properties of Earth's atmosphere
- Mass of Earth's atmosphere
- Vertical structure of the atmosphere: troposphere, stratosphere, mesosphere, thermosphere
- Temperature, pressure, density variations in the atmosphere

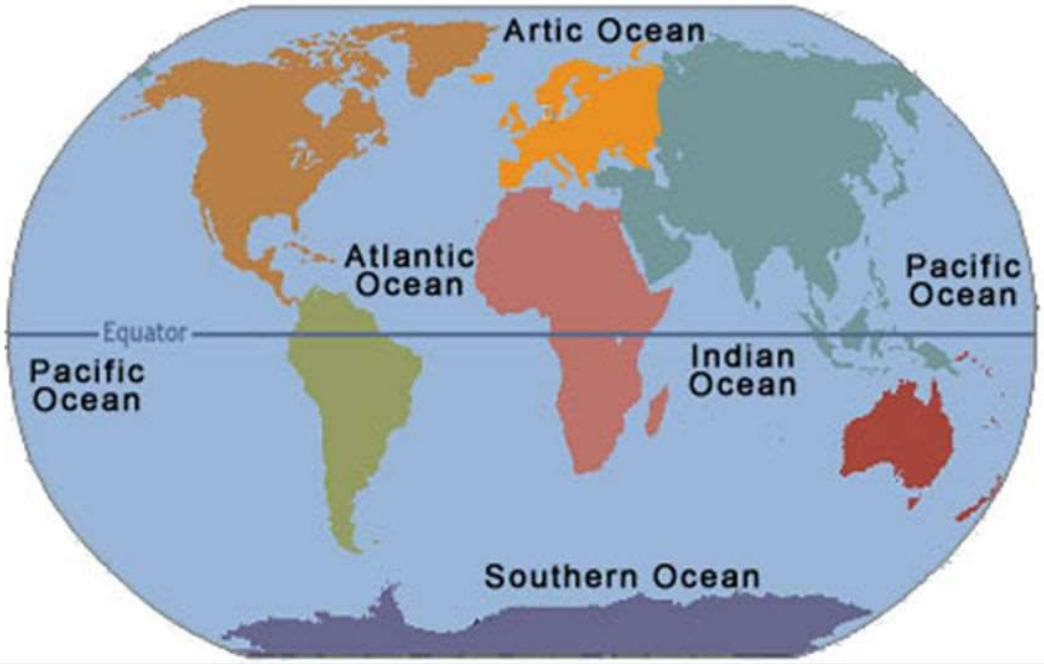
Class outline: Introduction (Conti…)

Earth system components

- Oceans
- Cryosphere
- Biosphere
- Earth’s crust and mantle

- Climate depends on atmosphere as well as physical, chemical, and biological processes involving other components of earth system

The Oceans

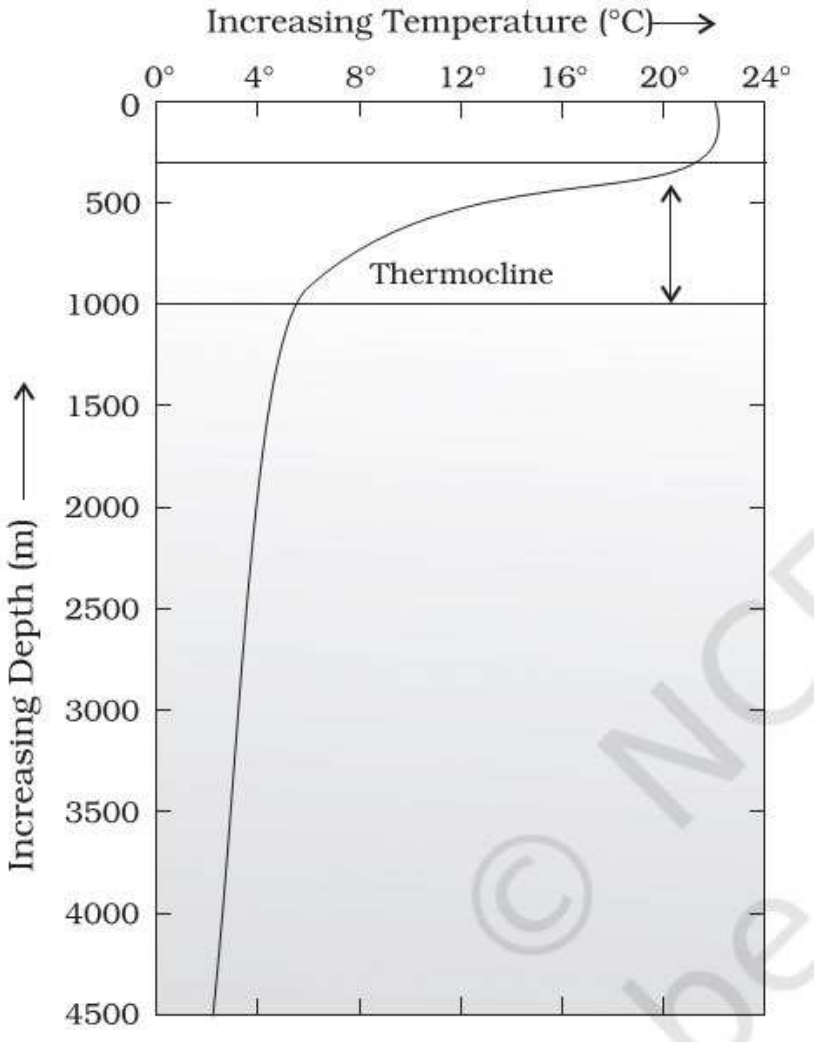


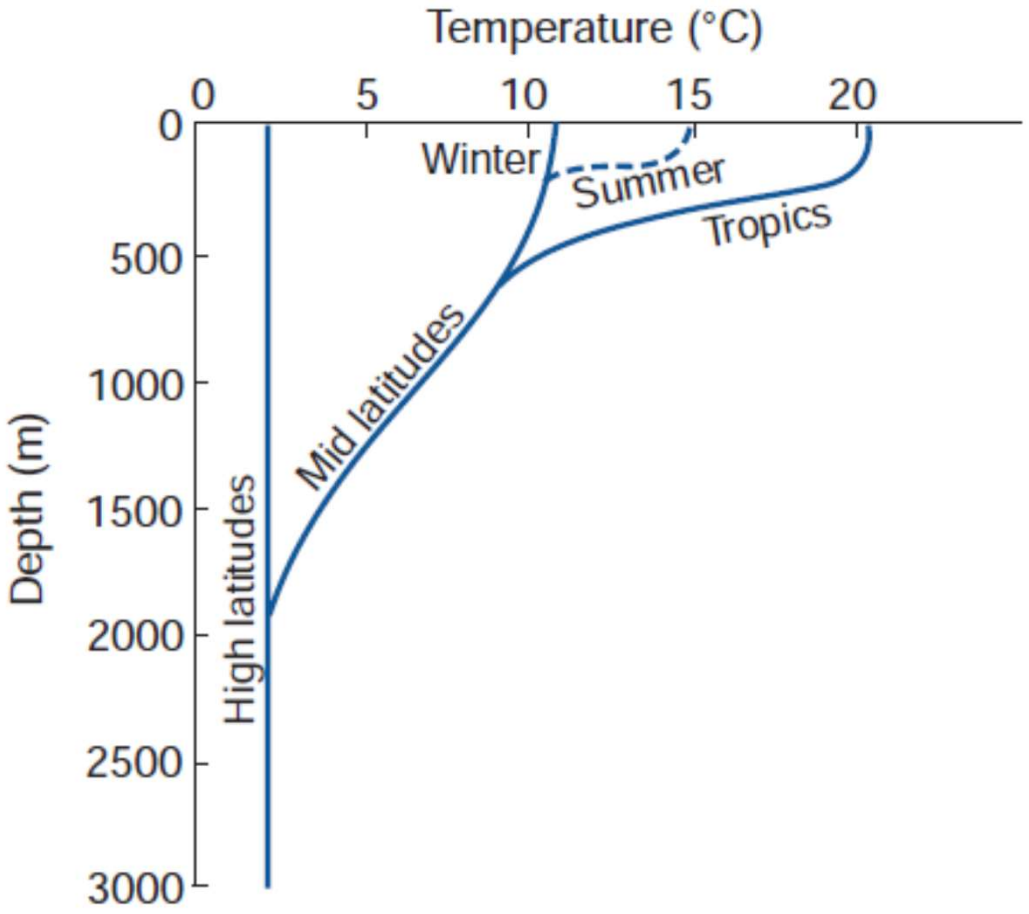
There are 5 Main Oceans
The Pacific Ocean is the largest ocean – by far!

- Oceans cover 72% of the area of the earth's surface
- Reaches to an extreme depth of 11 km
- Mass of the ocean is approx. 250 times as that of atmosphere

Composition and vertical structure of ocean:

- Density of sea water linearly proportional to the concentration of dissolved salt
- Sea water contains salt ~34 -36 g/kg of fresh water
- Sea water is ~ 2.4% denser than fresh water @ same temperature


Increasing Temperature (°C)
0°
4°
8°
12°
16°
20°
24°
0
500
1000
1500
2000
2500
3000
3500
4000
4500
Thermocline
Increasing Depth (m)


Temperature (°C)
0
5
10
15
20
0
500
1000
1500
2000
2500
3000
Depth (m)
Winter
Summer
Tropics
Mid latitudes
High latitudes

- The density of sea water ranges from 1.02 to 1.03 kg/m^3
- Density of water in the wind-stirred layer (mixed layer) is smaller by a few tenths of a percent than density of water below it
- Thermocline: Layer in which there is a strong temperature gradient exist with respect to depth

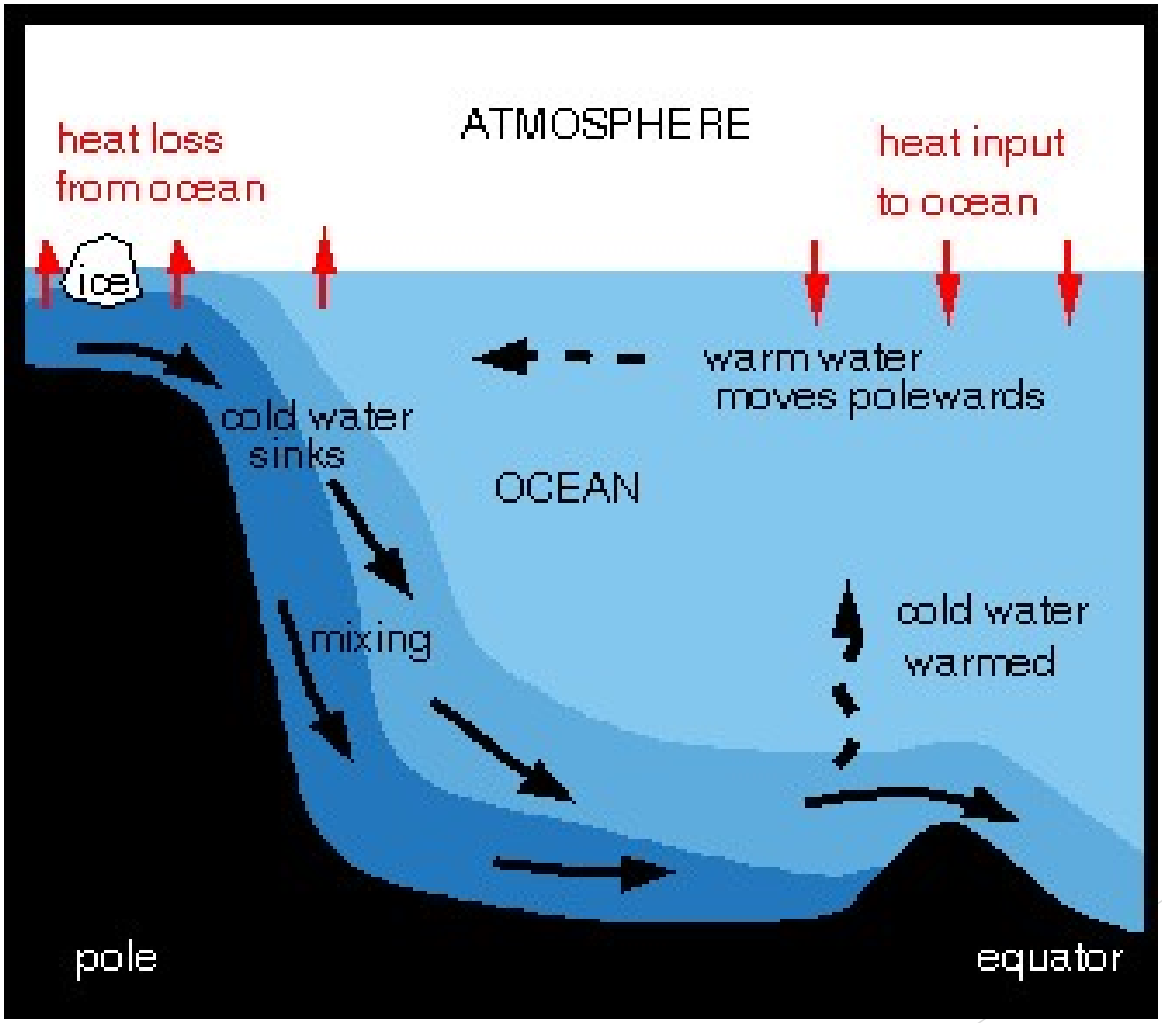
- Precipitation lowers the salinity by diluting the salts that are present in the oceanic mixed layer

- But evaporation increases the salinity by removing fresh water and thereby concentrating the residual salts

Exercise-1

- A heavy tropical storm dumps 20 cm of rainfall in a region of the ocean in which the salinity is 35 g kg-1 and the mixed layer depth is 50 m. Assuming that the water is well mixed, by how much does the salinity decrease?

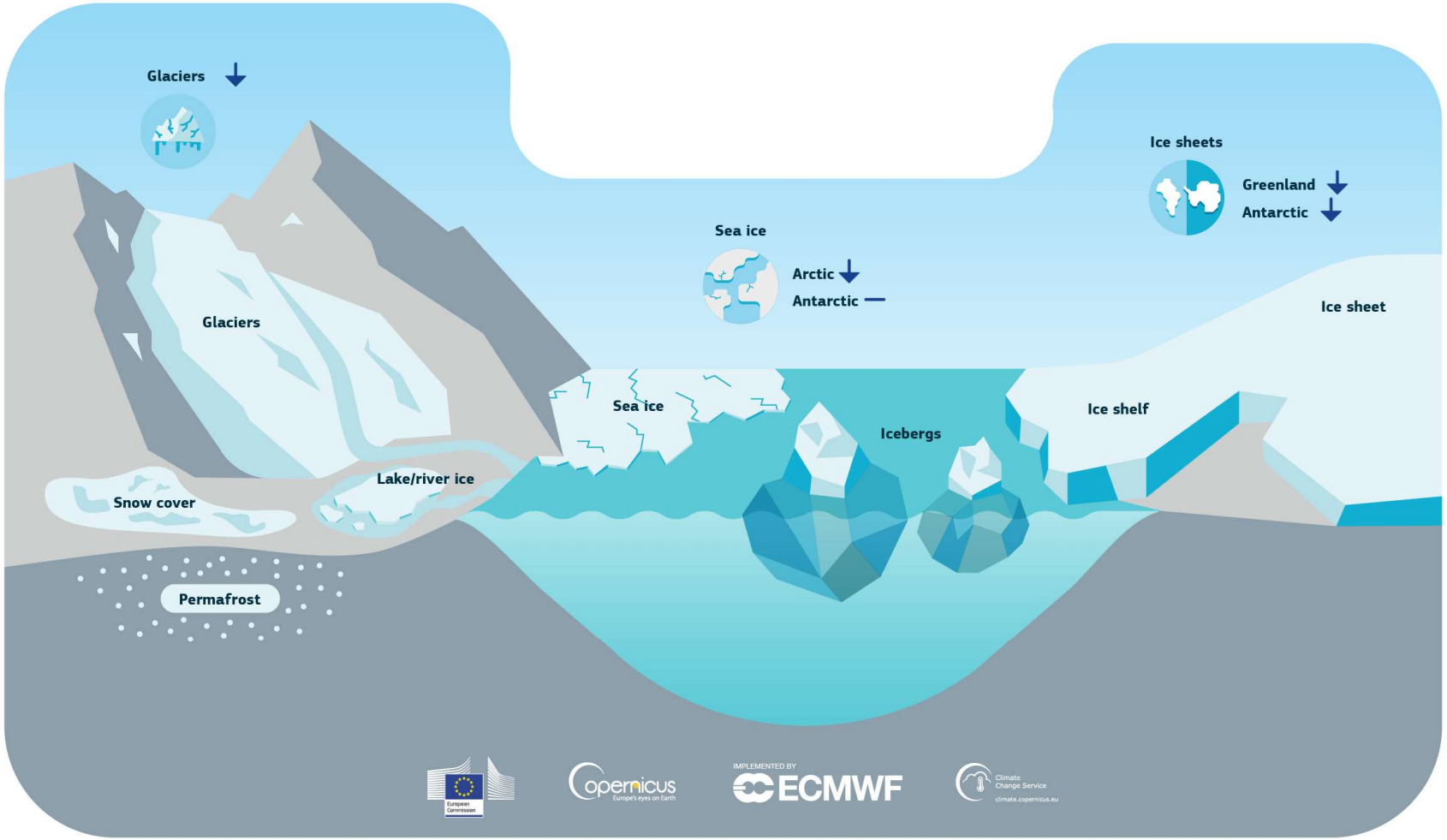
Ocean circulation




8°C

- The ocean circulation is composed of a wind-driven component and a thermohaline (density-dependent) component
- The wind driven circulation dominates the surface currents, and it is restricted to the topmost few hundred meters
- The circulation deeper in the oceans is dominated by the slower thermohaline circulation
- Velocities in wind driven currents are on the order of 10 cm/s
- The timescale in which a parcel completes a circuit of this thermohaline circulation is on the order of hundreds of years

Cryosphere


Glaciers
Ice sheets
Greenland
Antarctic
Sea ice
Arctic
Antarctic
Glaciers
Ice sheet
Sea ice
Ice shelf
Icebergs
Lake/river ice
Snow cover
Permafrost
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ECMWF
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Climate Change Service

- Cryo (frozen)-sphere refers to the components of the earth system comprised of water in its solid state
- Taking up and releasing fresh water in the polar regions and influences oceanic thermohaline circulation
- It stores enough water to significantly influence global sea level
- The continental ice sheets dominated by Antartica and Greenland are the most massive elements of the cryosphere
- Ice sheets are replenished by snowfall

Cryospheric component	Area	Mass
Antarctic ice sheet	2.7	53
Greenland ice sheet	0.35	5
Alpine glaciers	0.1	0.2
Arctic sea ice (March)	3	0.04
Antarctic sea ice (September)	4	0.04
Seasonal snow cover	9	<0.01
Permafrost	5	1

Area is expressed in percentage of the area of the surface of Earth; Mass is expressed in 10^3 kg/m^2

Total surface area of Earth (m^2)=5.12×10^{14}

Land area (m^2)=1.45×10^{14}

- Permafrost is any ground that remains completely frozen (0°C) or colder—for at least two years straight
- These permanently frozen grounds are most common in regions with high mountains and in Earth's higher latitudes—near the North and South Poles

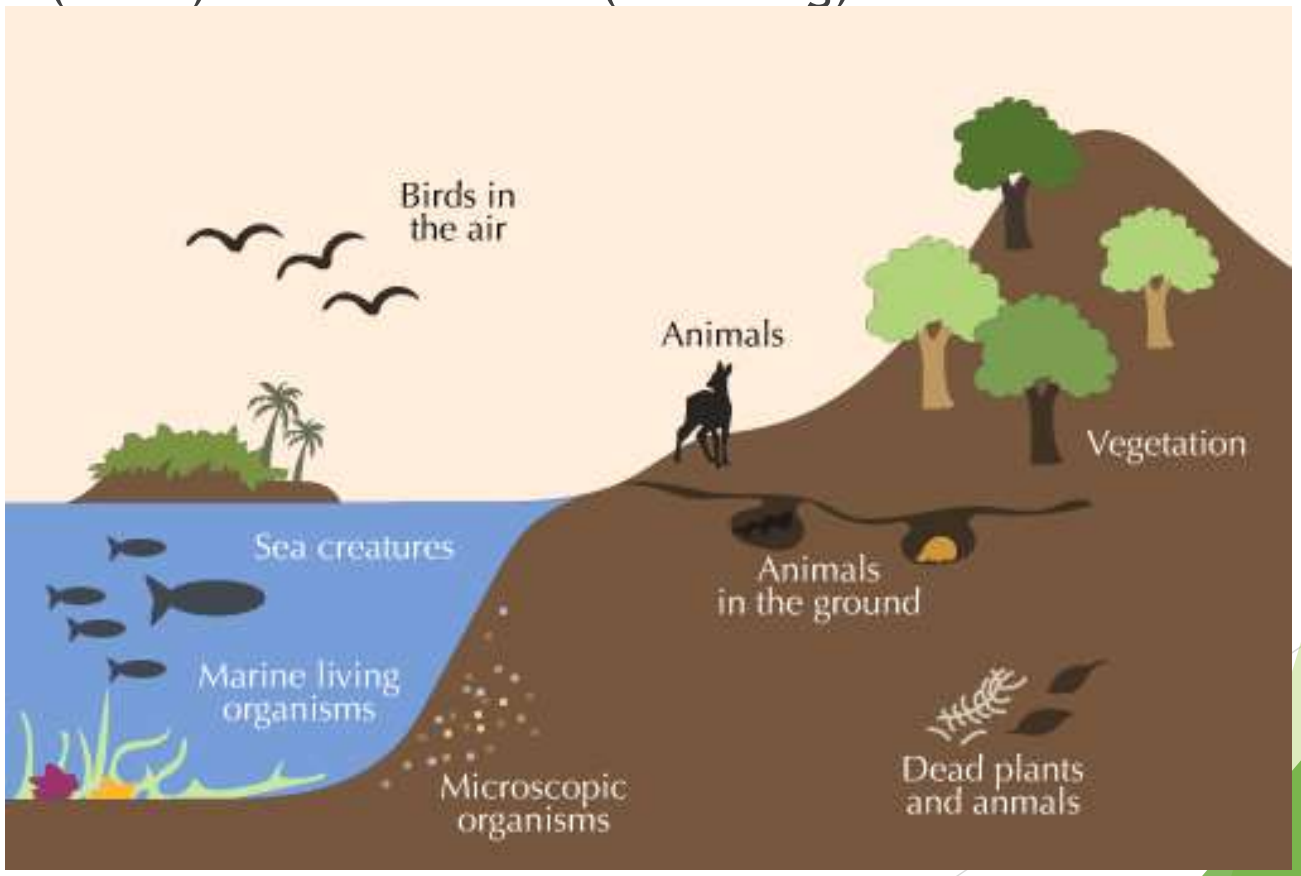
Exercise-2

Estimate how much the sea level would rise if the entire Arctic ice sheet were to melt. Area covered by Arctic sea ice is 3% of the area of the surface of the Earth, land area is 29.5% of the surface of Earth. [Earth's radius=6371 km; mass of Artic ice sheet=0.04 $\times 10^3$ kg/m^2]

Estimate how much the sea level would rise if the entire permafrost were to melt. Area covered by permafrost is 5% of the area of the surface of the Earth, land area is 28.5% of the surface of Earth. [Earth's radius=6371 km; mass of Artic ice sheet=1 $\times$ 10^3 kg/m^2]

Biosphere

- The biosphere is a global ecosystem composed of living organisms (biota) and the abiotic (nonliving) factors



Earth’s crust and mantle