THE EARTH’S HYDROSPHERE

- Distribution of Water on Earth
- The Hydrosphere and the Hydrologic Cycle
- Earth’s Cryosphere
THE EARTH’S HYDROSPHERE

- The Earth’s liquid water constitutes the **hydrosphere**.
- The vast majority of Earth’s water is in the oceans (salt water), with smaller, but geologically important, quantities of fresh water in lakes, rivers, and ground water.
- The components of the hydrosphere, as well as the **cryosphere** (frozen water), the atmosphere, and the **biosphere**, participate in the global **hydrologic cycle**.
- Earth’s water supply has had, since Earth was created, major influences on Earth’s climate, its landscape and mineralogy, the composition of its atmosphere, and on the origin and evolution of life.
  - The total mass of Earth’s water is about 300 times the mass of the atmosphere.
  - Without water, which facilitates the formation of carbonate rock, the atmospheric content of CO$_2$ would be far higher than it is.
## THE EARTH’S HYDROSPHERE: Distribution of Water on Earth

<table>
<thead>
<tr>
<th></th>
<th>Volume</th>
<th>Percent of Total</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>OCEANS</strong></td>
<td>$1,350 \times 10^{15}$ m$^3$</td>
<td>97.3</td>
</tr>
<tr>
<td><strong>CRYOSPHERE</strong></td>
<td>$29 \times 10^{15}$ m$^3$</td>
<td>2.1</td>
</tr>
<tr>
<td>(Glaciers &amp; Polar Ice)</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>UNDERGROUND</strong></td>
<td>$8.4 \times 10^{15}$ m$^3$</td>
<td>0.6</td>
</tr>
<tr>
<td>(Aquifers)</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>LAKES &amp; RIVERS</strong></td>
<td>$0.2 \times 10^{15}$ m$^3$</td>
<td>0.01</td>
</tr>
<tr>
<td><strong>ATMOSPHERE</strong></td>
<td>$0.013 \times 10^{15}$ m$^3$</td>
<td>0.001</td>
</tr>
<tr>
<td><strong>BIOSPHERE</strong></td>
<td>$0.0006 \times 10^{15}$ m$^3$</td>
<td>$4 \times 10^{-5}$</td>
</tr>
</tbody>
</table>
Distribution of Water on Earth

- Oceans: 97.2%
- Hydrosphere: 2.8%

Nonocean Component (% of total hydrosphere):
- Glaciers: 2.15%
- Groundwater: 0.62%

Other Components:
- Freshwater lakes: 0.009%
- Saline lakes and inland seas: 0.008%
- Soil moisture: 0.005%
- Stream channels: 0.0001%
- Atmosphere: 0.001%
Major Topographic Divisions and Profile of the North Atlantic Ocean Basin
The World’s Ocean Floors
The Earth’s Hydrosphere

- The hydrosphere, along with the atmosphere and cryosphere, are primarily responsible for weathering and erosion of land surfaces.
- Rain water, in combination with atmospheric CO$_2$, is primarily responsible for chemical weathering by carbonic acid, H$_2$CO$_3$.
- The amount of CO$_2$ dissolved in the oceans is much larger than that currently in the atmosphere. Since the solubility of CO$_2$ in water decreases with temperature, global warming could produce a positive feedback effect by releasing oceanic CO$_2$.
- Man-made and volcanic pollution can increase weathering by providing much stronger acids (“acid rain”; e.g. H$_2$SO$_4$), and by increasing atmospheric CO$_2$.
- Rain, plus the river and stream components of the hydrosphere, also provide mechanical erosion of rocks and convert them to soils and sediments.
Table 16–1 Average Surface Temperature (°C) of the Oceans Between Parallels of Latitude

<table>
<thead>
<tr>
<th>North latitude</th>
<th>Atlantic Ocean</th>
<th>Indian Ocean</th>
<th>Pacific Ocean</th>
<th>South latitude</th>
<th>Atlantic Ocean</th>
<th>Indian Ocean</th>
<th>Pacific Ocean</th>
</tr>
</thead>
<tbody>
<tr>
<td>70°–60°</td>
<td>5.60</td>
<td>...</td>
<td>...</td>
<td>70°–60°</td>
<td>− 1.30</td>
<td>− 1.50</td>
<td>− 1.30</td>
</tr>
<tr>
<td>60°–50°</td>
<td>8.66</td>
<td>5.74</td>
<td>...</td>
<td>60°–50°</td>
<td>1.76</td>
<td>1.63</td>
<td>5.00</td>
</tr>
<tr>
<td>50°–40°</td>
<td>13.16</td>
<td>9.99</td>
<td>...</td>
<td>50°–40°</td>
<td>8.68</td>
<td>8.67</td>
<td>11.16</td>
</tr>
<tr>
<td>40°–30°</td>
<td>20.40</td>
<td>18.62</td>
<td>...</td>
<td>40°–30°</td>
<td>16.90</td>
<td>17.00</td>
<td>16.98</td>
</tr>
<tr>
<td>20°–10°</td>
<td>25.81</td>
<td>27.23</td>
<td>26.42</td>
<td>20°–10°</td>
<td>23.16</td>
<td>25.85</td>
<td>25.11</td>
</tr>
<tr>
<td>10°–0°</td>
<td>26.66</td>
<td>27.88</td>
<td>27.20</td>
<td>10°–0°</td>
<td>25.18</td>
<td>27.41</td>
<td>26.01</td>
</tr>
</tbody>
</table>
Hurricanes, Typhoons and Cyclones
The exchange of water, heat, and momentum between the atmosphere and ocean is responsible for the circulation in both. This leads to distinct patterns of the ocean circulation related to the distribution of winds.
THE EARTH’S CRYOSPHERE

- Earth’s supply of frozen water, the cryosphere, is second only to the oceans in water content.
- The cryosphere consists mainly of the permanent ice caps of Antarctica and Greenland, with much smaller amounts in Arctic and mountain glaciers.
- Major changes in sea level can occur during times of global climate change (ice ages and global warming), due to associated changes in the water content of the cryosphere.
- During ice ages, glaciers can cover major parts of Earth’s land area year-round for hundreds or thousands of years.
- The advance and retreat of glaciers can also produce major erosion and re-configuration of the landscape.
- Ice ages and global warming can have major effects on the biosphere as well.
Permafrost in Land Areas

- Land areas in polar regions, such as Antarctica and Greenland, and the north slopes of Alaska and Siberia, have zones below their surfaces in which ground water remains frozen year-round.

- Regions in which soil water is permanently frozen constitute what is known as permafrost.
Ice Cover of Greenland and Antarctica
Figure 9-21
Generalized geographic map of North America showing the maximum extent of glaciation in Pleistocene time. Arrows indicate direction of ice movement. [After U.S. Geological Survey.]
Sea Level Changes due to Ice Ages and Ice Cap Melting