Overview of Climate Dynamics
Today

Water is the Key to Earth’s Climate system
• Absorption and storage of sun’s heat affected by presence of liquid water
• High Heat Capacity
  – Ability of a material to absorb heat
• Ratios of heat capacity
  Water:ice:air:land
  60 : 5 : 2 : 1

Atmosphere
• Low heat capacity
• Rapid response to external influences
  – E.g. Daily heating and cooling
  – Response time 1 month or less
• Coupled to others through
  Energy exchanges
  – Atmospheric Boundary Layer (ABL)

Oceans
• High Heat Capacity
  – Store large amounts of energy
  – Slower response to outside influences
  – Response time
    • months to years for surface waters
      – E.g. warmest beach temperatures in late summer
    • Centuries to millennia for deeper waters
      – E.g. replacement of world’s deep water
    – Chemical Balance of Atmosphere
      • Esp. CO2 levels
Land Sea Heat Imbalances

- mountain glaciers, ice sheets and seasonal snow and ice coverage (land and sea)
- 8% permanently covered by snow and ice
- seasonal expansion causes it to double
  - Variability in response times
    - E.g. sea ice quick response time (seasonal)
    - E.g. glaciers slow response time (decades-centuries-millennia)

Atmospheric Circulation

Cyrosphere

- mountain glaciers, ice sheets and seasonal snow and ice coverage (land and sea)
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Video clip Sea Ice at Antarctica

- Go to:

  http://www.windows.ucar.edu/tour/link=/earth/polar/sea_ice/sea_ice_south_animate.html
### Albedo

<table>
<thead>
<tr>
<th>Surface</th>
<th>Albedo Range (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fresh Snow/Ice</td>
<td>60-90</td>
</tr>
<tr>
<td>Old, melting snow</td>
<td>40-70</td>
</tr>
<tr>
<td>Clouds</td>
<td>40-90</td>
</tr>
<tr>
<td>Desert Sand</td>
<td>30-50</td>
</tr>
<tr>
<td>Soil</td>
<td>5-30</td>
</tr>
<tr>
<td>Tundra</td>
<td>15-35</td>
</tr>
<tr>
<td>Grasslands</td>
<td>18-25</td>
</tr>
<tr>
<td>Forest</td>
<td>5-20</td>
</tr>
<tr>
<td>Water</td>
<td>5-10</td>
</tr>
<tr>
<td><strong>Average</strong></td>
<td><strong>10</strong></td>
</tr>
</tbody>
</table>

### Biosphere

- Vegetation affects
  - Albedo, roughness and evapotranspiration characteristics of a surface
    - E.g. forested land differs greatly from scrubland
  - Atmospheric composition
    - Removal of CO2
    - Production of aerosols and Oxygen
  - Response time
    - Years (individuals) to centuries (communities)
  - Carbon sequestration
    - 30% lower during LGM than today

### LGM to present Vegetation Changes

Maps of spruce pollen from 21,000 years ago to present in 3000 year intervals. Green is 20% or higher amounts of spruce pollen.

### Unequal Radiation

- **Incoming solar radiation (insolation)**
Latitudinal Heat Imbalances

Atmospheric Heat Transfer

Surface Ocean Circulation

Sinking Surface Water