Temperature Concepts and Measurement

- Temp. is a measure of kinetic energy
- Avg. energy of motion of molecules
- Heat is the transfer/flow of energy
- Three standard scales of measurement

Thermometer and Instrument Shelter

![Thermometer and Instrument Shelter](image)
Importance of Temperature

- Temperature is a major component of climate which impacts:
  - landform processes
  - vegetation
  - soil development
  - economic development
  - patterns of human activity - culture
Latitude

Determines intensity and duration of insolation.
Most important factor influencing mean annual and mean monthly temperature.

Altitude/Elevation

As elevation ↑, density of atm. ↓ and reduces ability to absorb or reradiate heat.

Cloud Cover

Less insolation = lower daytime temp
Increased counter-radiation = higher nighttime temps
**Land-Water Heating Differences**

- Result of four (not five) major differences between physical properties of land and water:
  1. evaporation
  2. transparency
  3. specific heat
  4. circulation

- Note: in the book circulation is divided into movement and ocean currents & sea surface temperatures

---

**L vs. W: Evaporation**

- Moderates temps over water
  - Much more Q used for LE during day
  - Less Q for H
  - Condensation releases Q at night

---

**L vs. W: Transparency**

- Land is opaque
  - SW used to heat surface only
  - Rapidly reradiates LW

- Water is nearly transparent
  - SW transmitted to depth
  - Greater opportunity for absorption
**L vs. W: Specific Heat**

Specific heat of water 4x greater than land  
Water heats slower, and losses it's heat energy slower  
Stores a much greater quantity of heat energy

<table>
<thead>
<tr>
<th>Material</th>
<th>Specific Heat</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lead</td>
<td>0.033</td>
</tr>
<tr>
<td>Glass</td>
<td>0.820</td>
</tr>
<tr>
<td>Iron</td>
<td>0.109</td>
</tr>
<tr>
<td>Copper</td>
<td>0.385</td>
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<tr>
<td>Steel</td>
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<tr>
<td>Clay</td>
<td>0.875</td>
</tr>
<tr>
<td>Aluminum</td>
<td>0.241</td>
</tr>
<tr>
<td>Wood</td>
<td>0.100</td>
</tr>
</tbody>
</table>

**L vs. W: Circulation**

Vertical mixing redistributes heat energy and increases storage capacity  
Horizontal motion redistributes Q to higher latitudes

**Land-Water Heating Differences**

- Continental temperature conditions mark extreme heat warming and cooling rates  
- Marine temperature conditions evoke moderate-water warming and cooling rates  
- Less evaporation for land  
- Surface ice forms  
- Land has a lower specific heat  
- Land has slower mixing  
- Saltier Water  
- Greater evaporation for water  
- Higher specific heat  
- Water has a higher boiling point  
- Water has more soluble minerals  
- In 3000 ocean currents
To summarize: temperature patterns can be explained by primary temperatures controls:

1. Latitude
2. Elevation
3. Cloud Cover
4. Proximity to Water (L vs. W differences)
Global Mean Temperatures: January

Figure 5.13

Bending of Continental Isotherms

January: equatorward

July: poleward

Figure 5.16

Global Mean Temperatures: July

Figure 5.16
**Annual Temperature Range**

**Apparent Temperature**
- Wind Chill
  - Increased cold due to wind speed
  - More discomfort with high wind and high humidity
- Humidex
  - Increased heat due to higher humidity
  - More discomfort with high humidity and low wind

**Wind Chill Temperature Index**
Atmospheric Circulation (chapter 6)

- Basic element of atmospheric circulation is wind
  - Primary Circulation = global
  - Secondary Circulation = regional
  - Tertiary Circulation = local

- Redistributions heat energy

- Causes oceanic circulation

Wind Essentials

Wind defined by:
- Speed, as measured with an anemometer
- Direction of origin, as indicated by wind vane
Driving Forces

- Force of Gravity
- Pressure Gradient Force
- Coriolis Force
- Friction Force

Gravity

- Force of gravity produces atm. pressure
- Without gravity there would be:
  - no atmospheric pressure
  - no variations in atmospheric pressure
  - no atmospheric motion
  - and oh . . .,
  - by the way,
  - no atmosphere

Pressure Gradient Force
Areas of high pressure: air descends (hence, higher pressure) and diverges at Earth's surface.

Areas of low pressure: air ascends (so lower surface pressure) and is replaced by converging flow (inflow).
But the red arrows on this map are not moving directly from high to low.

Something must be affecting their path?

Coriolis Force

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Coriolis Force

Friction Force

Cyclones and Anticyclones
Result of:

differential heating & moisture characteristics

OR

dynamic forces

Primary High- & Low-Pressure Areas

Figure 6.9a

Primary High- & Low-Pressure Areas

Figure 6.9b
Resulting Weather Patterns

Generalized Circulation Model

Cross-section of One Hemisphere

Equatorial Low (ITCZ)

- Result of differential heating
  - high sun angle
  - constant daylength
- Warm, moist air, less dense, so rises
  - Converging, ascending air
- Migrates seasonally with thermal equator
- Locally calm winds
Equatorial Low (ITCZ)

Surface flow toward ITCZ results in Trades winds
Deflection produces Northeast trade winds and southeast trade winds
Trade winds are warm and increasingly moist lots of latent heat storage

Trade Winds

Subtropical High-Pressure

Divergence aloft over ITCZ results in upper atm. flow toward subtropics
Cool air is forced to descend and warms adiabatically (due to increase in pressure)
High pressure results from descending, diverging air
mid-latitude deserts
Generalized Circulation Model

Hadley Cell

Atlantic Sub-Tropical High

Westerlies
- Result of surface flow from subtropical high toward mid-latitudes
- Deflection produces prevailing westerly circulation

Figure 6.13 Subtropical high-pressure system in the Atlantic. Characteristic circulation in the Northern Hemisphere. Note deserts extend to the shores of Africa, which has offshore cool currents, whereas the southeastern United States is moist and humid, with offshore warm currents.
Polar High and Easterlies

- Result of cold dry air over poles
- Descending and diverging air
- Results in a dome of high pressure
- Deflection produces polar easterlies

Subpolar Low

- Result of uplift along polar front
- Conflict between cold dry air and warm, moist air
- Mechanical lifting at frontal boundary
- Results in cool, moist air

Generalized Circulation Model

- Polar Front
- Development of Mid-latitude Cyclones
Jet Streams

Regional Winds - Monsoonal Winds

Local Winds
- Land-sea breezes
- Mountain-valley breezes
- Katabatic winds
- Chinooks
Chinook Winds

- Occur when strong prevailing winds cross a mountain range
- Air is warmed and dried descending the leeward side
- Warm, dry, windy weather with variable cloudiness
Oceanic Currents

Thermohaline Circulation – The Deep Currents

Weather and Climate (chapter 10)

- Weather is:
  - temperature
  - precipitation
  - pressure
  - humidity
  - wind

  at a particular place and time
Weather and Climate (chapter 10)

Climate: variability of daily and seasonal weather characteristics averaged over a long period of time

Components of Climate

- Insolation
  - determined by duration & intensity
- Temperature
  - Latitude
  - Altitude
  - Cloud Cover
  - Land-Water Heating Differences:
    - Evaporation (LE)
    - TRANsparency
  - Specific Heat
  - Circulation
- Atmosphere Circulation
  - Primary/Secondary Winds
  - Ocean Currents
  - Semi-Permanent High and Low Pressure Areas
- Precipitation
  - the W&C course

Climate Variability
Climate Variability

Climate influences the physical and biotic environment:
- Landforms/landscapes
- Soil conditions/fertility
- Natural vegetation
- Wildlife

and in turn is influenced by the physical and biotic environment.
Global Climate Systems

Study of the spatial and temporal patterns of climate is called climatology.

Classification of Climatic Regions

- Genetic classification
  - Based on knowledge of causes of climate

- Empirical classification
  - Based on grouping areas with similar climate data or calculated normals

Koppen-Geiger Classification

- Criteria include measures of:
  - mean monthly temperature
  - mean monthly precipitation
  - and mean annual precipitation

- Does not consider:
  - winds, temperature extremes, precipitation intensity, amount of sunshine, cloud cover, or net radiation
General Classification Categories

Six main climatic regions designated:
A - Tropical
C - Mesothermal
D - Microthermal
E - Polar
H - Highland
B - Dry

Classification Subgroups

Subgroups identified by second letter indicating seasonal precipitation patterns
- f - no dry season
- m - monsoonal
- w - winter dry
- s - summer dry
- W - arid B climates
- K - semiarid B climates

Classification Subgroups

Third letter indicates temperature characteristics of subgroups
- a - hot summers
- b - warm summers
- c - cool summers
- d - very cold winters
- h - hot B climates
- k - cold B climates
Exceptions to the above are:

- E climates:
  - ET polar tundra
  - EF polar frost
  - EM polar marine

- H climates, which are not further subdivided
Climographs

- Typically depict:
  - mean monthly precip (vertical bar)
  - mean monthly temp (line)
- May also include:
  - location
  - mean annual temp
  - mean annual precip
  - elevation
  - population
- Provide a graphic illustration of the variability and seasonality of temp and precip characteristics