Topics for today:

- Daily Temperatures
- Role of clouds, latitude, land/water

Today’s Weather Map

http://www.wpc.ncep.noaa.gov/sfc/namussfcwbg.gif
Thursday’s Forecast

http://www.wpc.ncep.noaa.gov/national_forecast/natfcst.php

Why is the sky blue?

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How does energy interact with the atmosphere?

The atmosphere absorbs energy only at certain wavelengths and transmits at others. This figure shows what percentage of energy is able to travel through the atmosphere.

Atmospheric Absorption

The Sun releases energy at shorter wavelengths (UV, visible, near-infrared)

The Earth releases energy at longer wavelengths (IR)

Absorption is the opposite of transmittance
Atmospheric Absorption

This slide shows how much radiation is absorbed by the atmosphere at different wavelengths.

Example, at 0.1 μm the atmosphere absorbs 100% of the incoming radiation from the sun.
Atmospheric Absorption from $O_2$ and $O_3$

Fig 2.11: Essentials of Meteorology

Atmospheric Absorption from $CH_4$

Fig 2.11: Essentials of Meteorology
Atmospheric Absorption from N₂O

Fig 2.11: Essentials of Meteorology

Atmospheric Absorption from CO₂

Fig 2.11: Essentials of Meteorology
Atmospheric Absorption from H₂O

Earth without the Greenhouse Effect

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Earth with the Greenhouse Effect

What happens when the “blanket gets too thick?”
Energy Budget cont.

We’ve discussed the composition of the atmosphere...
&...
How energy is transferred throughout the atmosphere...
...
Now we’ll discuss how composition and the seasons affects surface temperature

(I know….I’m excited about this, too!!!)

Solar Zenith Angle

Zenith – the point directly over your head
Solar Zenith Angle – the angle between the sun and a point directly overhead

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Solar Zenith Angle – the angle between the sun and a point directly overhead
Solar Zenith Angle

The intensity of light reaching the surface decreases as the sun lowers in the sky.

As SZA ↑ Intensity ↓

Thickness of the atmosphere is important, too.
Solar energy reaching the Earth’s surface

Sunlight in the tropics is more intense because the sun is higher in the sky than near the polar regions.

Less solar energy makes it through the atmosphere to the poles than the equator.

The polar regions have a higher albedo than the tropics. Why?

All of these together lead to an energy imbalance.
Global Energy Balance

The Seasons

In winter, the sun is lower on the horizon and sun beams are more spread out.

In summer, the sun is high in the sky and solar energy is more concentrated.
The Seasons

Daily Temperatures

Day (February 2014)
Solar energy is most intense at noon.

Suns rays are more “focused” at noon.

Solar radiation (incoming radiation) greater than surface radiation (outgoing radiation) until later in afternoon.

Lowest temperature occurs shortly after sunrise when outgoing radiation is greater than incoming.

**Air temperature data**

- **Daily mean temperature** determined two ways
  1. average of max. and min. temperatures for the day
  2. average of 24 hourly temperatures

- **Daily temperature range** – difference between max. and min. temperatures

- **Monthly mean temperature** – average of daily mean for the month

- **Annual mean temperature** – average of monthly means

- **Annual temperature range** – difference between coldest monthly mean and warmest monthly mean
As the sun rises, the ground warms.

Air in contact with ground warms, too.

On calm days, air above the surface is cooler.

On windy days, the air is mixed so the difference in temperature between the surface and air above is smaller.
Nighttime Temperatures

As the sun sets, the ground cools by radiating its heat to space.

Air radiates some heat to the ground and the ground radiates this heat away, too.

As the night progresses, the ground and the air just above the surface cool more rapidly than the air above.

Increase in temperature above the ground is called a “radiation inversion” 

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Daily Temperatures

Daily temperature changes are largest near the surface

Fig 4.14: Weather: A Concise Introduction

Role of Clouds

Fig 3.14: Essentials of Meteorology
Daytime Temperatures: Clouds

Clouds have a high albedo and will reflect incoming solar radiation.

Nighttime Temperatures: Clouds

Clouds prevent heat from surface from going out to space.

Fig 4.15: Weather: A Concise Introduction
Temperature: Cloud Influence

Effect of Cloud Cover

Fig 3-14  Meteorology: Understanding the Atmosphere

Temperature: Latitude Variations

Effect of Latitude

Fig 3-6  Meteorology: Understanding the Atmosphere
Temperature: Latitude Variations

Both cities are around the same latitude.
Temperature: Surface Variations

<table>
<thead>
<tr>
<th>Substance</th>
<th>Specific Heat (cal/g/°C)</th>
<th>Specific Heat (J/kg/°C)</th>
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</thead>
<tbody>
<tr>
<td>Water</td>
<td>1.0</td>
<td>4,186</td>
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<tr>
<td>Ice</td>
<td>0.50</td>
<td>2,093</td>
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<tr>
<td>Air</td>
<td>0.24</td>
<td>1,005</td>
</tr>
<tr>
<td>Sand</td>
<td>0.19</td>
<td>795</td>
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</tbody>
</table>

\[ C_p = \text{heat capacity or "specific heat"} \]

SeaWiFS Project, NASA/Goddard Space Flight Center, ORBIMAGE
Average Temperature

**Fig 3.17: Essentials of Meteorology**

<table>
<thead>
<tr>
<th>Month</th>
<th>Temp °F</th>
<th>Temp °C</th>
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<tbody>
<tr>
<td>J</td>
<td>20</td>
<td>7</td>
</tr>
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<td>7</td>
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<td>N</td>
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<td>-1</td>
</tr>
<tr>
<td>D</td>
<td>10</td>
<td>2</td>
</tr>
</tbody>
</table>

San Francisco
- Average annual temperature: 15°C (59°F)
- Annual temperature range: 7°C (12°F)
- Record high: 39°C (102°F)
- Record low: -3°C (27°F)

Richmond
- Average annual temperature: 15°C (59°F)
- Annual temperature range: 22°C (42°F)
- Record high: 42°C (107°F)
- Record low: -24°C (-12°F)

(a) San Francisco, California, 38°N
(b) Richmond, Virginia, 38°N