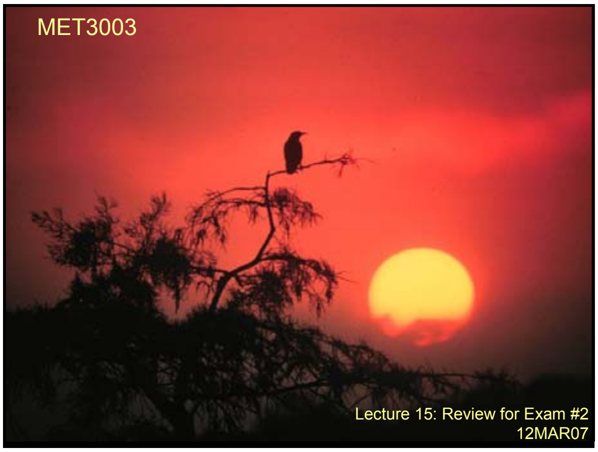


EXAM Wednesday, March 14, 2007

- Covers:
  - From the end of Chapter 4
  - Through Chapter 6
  - No geostrophic wind calculations
- HEW will be traveling
  - March 7-9
  - March 13
  - I will answer email questions over the weekend March 10-11
  - And I will be available Monday March 11
- Composition, as with exam #1
  - 50-60% short answer, multiple guess or true-false
  - 50-40% long answer, problems, draw & explain
  - Worth 100 point, 20% of your grade
- You will need pencils and a scientific calculator

Moisture (Ch 4): Summary

- Know what the ***Hydrologic Cycle*** is and the proportions of global water in oceans, ice caps, runoff, ground water and in the air. Don't memorize percents.
- Know what specific heat is and the general ratios between specific heats of liquid water, ice, vapor, dry air and rock.
- Know what ***Latent Heat*** is and be able to use it in calculations
- Don't use no stinkin' calories
- Know the definitions of ***Evaporation, Condensation, Melting, Freezing, Sublimation***, and ***Deposition***
- Be able to describe the different molecular organizations of ice, liquid water, and vapor
- Understand the concept of ***Saturation***
- Understand how vapor pressure over liquid water varies with temperature
- Memorize the vapor pressure doubles for every 10°C increase in temperatrue rule
- Know that vapor pressure over ice is less than that over liquid water between 0° and -40°C
- Know how to calculate **Dew Point, Relative Humidity, Vapor Pressure, Dew-Point Depression, Mixing Rato,** and **Saturation Mixing Ratio**, given one quantity, the pressure and a table of saturation mixing ratios as a function of temperature
- Know what "conservative" means and that mixing ratio is a conservative property during pressure changes
- Know how heat and humidity affect human comfort, including a understanding of Heat Index
- Know how humidity is measured with a ***Sling Psychrometer***

Relative and Absolute Humidity

- Absolute humidity is amount of water vapor per unit volume, or the water-vapor density
- Relative is the ratio of the density of water vapor actually in the air to what it could hold at saturation, keeping the temperature the same

$$\text{Absolute Humidity} = \rho_v = \frac{e_w}{R_v T},$$

$$\text{Relative Humidity} = 100 \times \frac{\rho_w}{\rho_{ws}} = 100 \times \frac{e_w / R_v T}{e_{ws} / R_v T} = 100 \times \frac{e_w}{e_{ws}}$$

Dew and Frost Points

- ***Dew Point*** (TD or T_d) is the temperature where the existing vapor pressure is the saturation vapor pressure
- ***Frost Point*** is like dew point but for temperatures < 0°C using saturation over ice
- ***Dew Point Depression*** is the difference between the dew point and the temperature = *T - TD*
- They can be used to compute relative humidity (RH)

$$e_w = e_{ws}(T_d), \text{ or } \quad e_i = e_{is}(T_f),$$

$$\text{RH} = 100 \times \frac{e_{ws}(T_d)}{e_{ws}(T)}$$

Mixing Ratio

- Ratio of the density of vapor to that of dry air
- If there is no condensation or evaporation, mixing ratio stays constant following a parcel
- <u>Saturation</u> mixing ratio does change as a function of pressure because
  - The amount of dry air changes,
  - Although the amount of water vapor stays constant when the temperature (or dewpoint) is fixed

$$q = \frac{\rho_v}{\rho_d} = \frac{\dfrac{e}{R_v T}}{\dfrac{p-e}{R_d T}} = \frac{\dfrac{M_w e}{R^* T}}{\dfrac{M_d (p-e)}{R^* T}} = \frac{M_w}{M_d}\frac{e}{p-e} = 0.622 \frac{e}{p-e}$$

PROBLEM

If the pressure is 1000 hPa, the temperature is 20^{o}C, and the dew point is 10 ^{o}C, what are the following quantities?

a. Dewpoint depression ___________,

b. Vapor pressure ___________,

c. Saturation vapor pressure___________,

d. Actual mixing ratio ___________,

e. Saturation mixing ratio ___________,

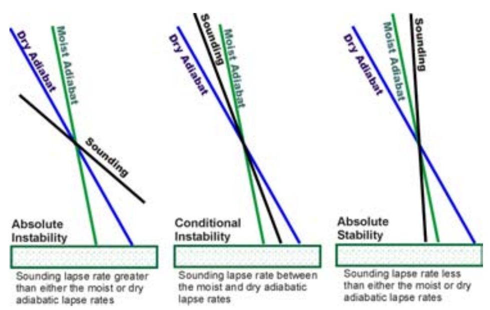
f. Relative humidity ___________.

$T^{o}C$	$es(T)$
0	6.11
5	8.72
10	12.27
15	17.04
20	23.37
25	31.67
30	42.43

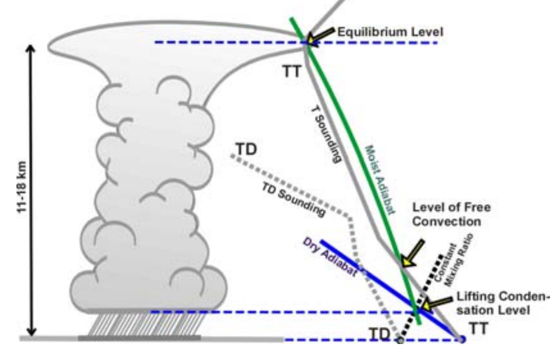
Stability (Ch 4 cont): Summary

- Understand ***Buoyancy***
- Understand the ***Parcel*** concept and the role of density in buoyancy
- Be able to define an ***Adiabatic Process***
- Understand the roles in convection of
  - ***Latent Heat***
  - ***Sensible Heat***
  - ***Pressure work***
- Be able to define environmental (sounding) and parcel ***Lapse Rates***
- Understand ***Dry*** and ***Moist Adiabatic Processes***
- Understand
  - ***Absolute Stability***
  - ***Conditional Instability***
  - ***Absolute Instability*** Understand the structure of a convective cloud in terms or parcel thermodynamics
- Know the definitions of and be able to use
  - ***LCL***: Lifting Condensation Level (cloud base)
  - ***LFC***: Level of free convection
  - ***EL***: Equilibrium Level (cloud top)

Summary of Stability

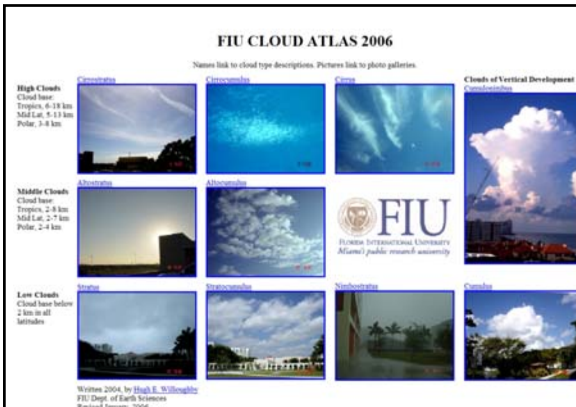


How the Sounding Lets Us Predict Convective Clouds



Clouds (Ch 5): Summary

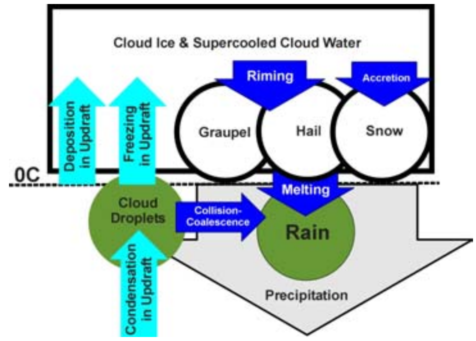
- Know generally how clouds form (more next time)
- Know what ***Cloud Droplets*** and ***Cloud Ice*** are
- Know the four cloud levels or etages
- Know the families of clouds: Stratus, Alto-, Cirrus, Cumulus, and Nimbus
- Be able to recognize and explain the formation of the following clouds: ***Stratus, Stratocumulus, Fog, Altostratus, Altocumulus, Cirrus, Cirrostratus, Cirrocumulus, Fair Weather Cumulus, Towering Cumulus, Cumulus Congestus, Cumulonimbus, Pileus, Lenticular Clouds.***



Hydrometeors (Ch 5): Summary

- Know the definitions of ***Aerosol***, ***Precipitation*** and **Hydrometeors**
- Know the definitions of **Frost, Dew, Virga, Cloud Water (droplets) Cloud Ice (crystals)** and **Terminal Velocity.**
- Be able to explain ***Supercooled Water, Homogeneous*** and ***Heterogeneous Nucleation.***
- Be able to explain how the different structure of maritime and continental cumuli arise from CCN concentrations in the parent air mass.
- Understand the growth of hydrometeors from vapor
- Be able to explain the ***Bergeron-Findeisen Process*** (ice crystal)
- Be able to expain the difference between ***Stratiform*** and ***Convective*** precipitation.
- Be able to explain hydrometeror growth by ***Autoconversion, Collision-Coalescence, Accretion, and Riming***
- Be able to interpret the history of a hailstone from a cross section showing layers of clear and spongy ice
- Be able to explain how precipitation is measured with a rain gauge.

Precipitation Formation



Pressure (Ch 6): Summary

- Understand and be able to use the ***Hydrostatic Law***
- Be able to "weigh" the atmosphere knowing the surface pressure
- Understand the concept of ***Scale Height*** and be able to use it to calculate vertical pressure variation
- Understand ***Isobaric***, or ***Pressure, Coordinates***
- Know what the ***Hypsometric Equation*** is and how it is used
- Understand and be able to draw and explain how horizontal temperature gradients
  - Lead to height gradients
  - Affect the vertical structure of high and low pressure systems
- Know what instruments are used to measure pressure
- Know the difference between ***Station Pressure*** and ***Sea-Level Pressure*** and know how the latter ic calculated from the former

Hydrostatic Pressure and Density

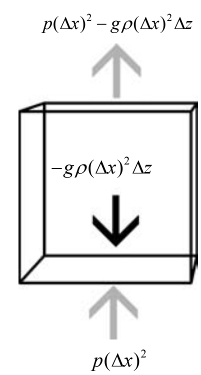
Substituting from the gas law into the hydrostatic equation:

$$\frac{p_{\text{top}} - p_{\text{bottom}}}{\Delta z} = -g\rho = -\frac{gp}{R_d T},$$

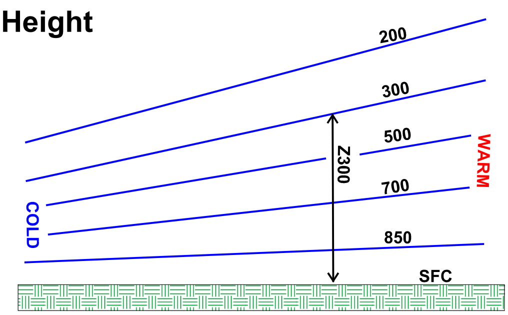
$$\frac{1}{p}\frac{p_{\text{top}} - p_{\text{bottom}}}{\Delta z} = -\frac{g}{R_d T},$$

$H = RT_d / g$ is the "Scale Height."

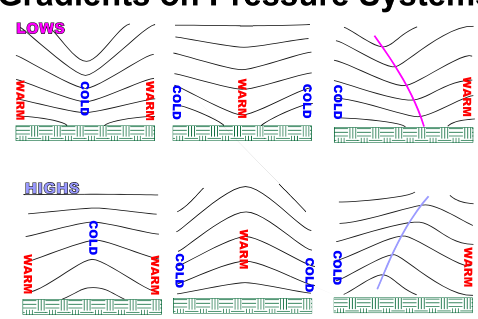
Dimensions of length, i.e. m or km
Typically 6-8 km
Defines atmospheric vertical scale
Pressure can be written $p(z) = p(0)\exp\{-z/H\}$



Horizontal Temperature Gradients Cause Gradients of Thickness and Height



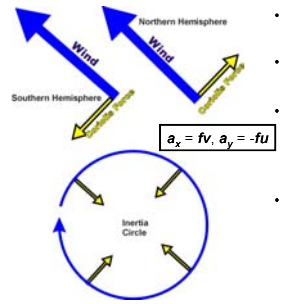
Effect of Horizontal Temperature Gradients on Pressure Systems



Winds (Ch 6): Summary

- Know and be able to apply Newton's laws of motion
- Understand how meteorological coordinates are used in a plane tangent to the spherical Earth
- Be able to explain and use the ***Coriolis Force***
- Be able to explain and use the ***Pressure Gradient Force***
- Be able to explain and use the surface ***Frictional Force***
- Understand how these forces combine to produce the meteorological momentum equations
- Understand the scaling argument for prevalence of ***Geostrophic Balance*** in the Atmosphere and the balance of forces in geostrophic flow
- Be able to calculate the geostrophic wind from a specified pressure distribution
- Be albe to draw and explain wind circulations around centers of high and low pressure in the Northern and Southern Hemispheres
- Be able to explain the effect of friction on the wind
- Be able to explain and interpret ***Thermal Wind*** balance
- Be able to explain and interpret ***Gradient-Wind*** balance

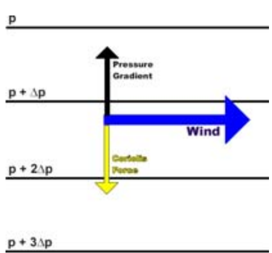
Coriolis Force



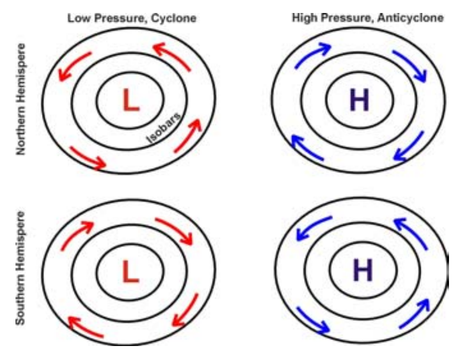
- Only the component of the Earth's rotation around the local vertical is important
- Values of the Coriolis Parameter
  - At 45° Latitude = 1.0×10^{-4}
  - At 20° Latitude = 0.5×10^{-4}
- The Coriolis force always acts perpendicular to the wind
  - To the right in the Northern Hemisphere
  - To the left in the Southern Hemisphere
- Can cause air to move in circular orbits
  - Called "***Inertia Circles***"
  - Period is $2\pi/f$
  - Always rotate anticylonically
  - Period is 24 h at 30° latitude
  - Longer equatorward and shorter poleward

Balance of Forces

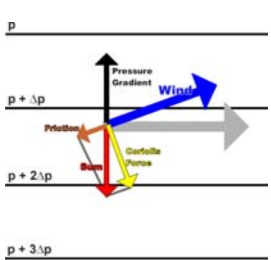
- Pressure gradient pushes toward lo pressure
- Coriolis force pushes back toward high pressure
- Wind deflects to right of pressure gradient
- LAW of STORMS: If the wind is blowing from left-to-right you are facing toward low pressure in the Northern Hemisphere.
- It's right-to-left in the Southern Hemisphere



Wind and Pressure Systems



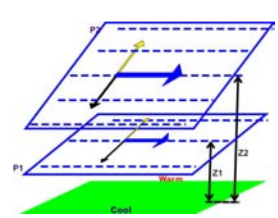
Effect of Friction



- Friction slows the wind.
- The pressure gradient is then stronger than the Coriolis force
- Air starts to accelerate toward low pressure
- Until the combined effects of friction and the new Coriolis force balance the pressure gradient

Thermal Wind

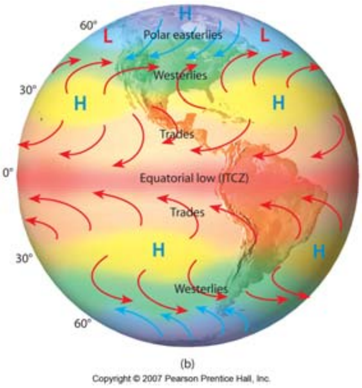
- As we saw last time, temperature gradients lead to changes in isobaric height gradients with altitude.
- This produces changes in geostropic wind.
- Proportional to horizontal gradients of virtual temperature.
- Geostrophic wind aloft minus that at lower levels is called the **Thermal Wind**
- It's relationship to temperature field is like the relationship between the geostrophic wind and pressure



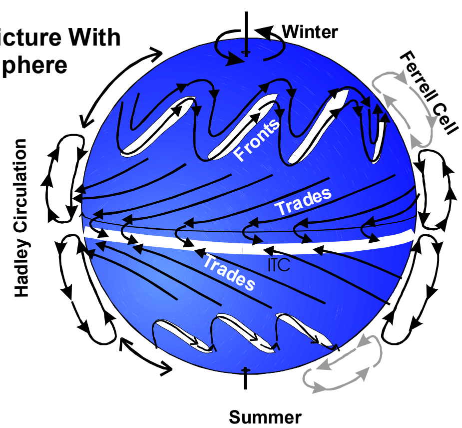
Circulation (Ch 7): Summary

- Memorize and be able to identify ***Microscale, Convective, Mesoscale, Synoptic*** and ***Planetary Scales*** of motion
- Be able to draw and explain the ***Sea/Land*** and ***Mountain/Valley Breezes***
- Be able to draw and explain the three cell model of the general circulation
- Be able to define: ***Hadley Cell, Ferrell Cell, Polar Cell, Westerlies, Trade Winds, Doldrums, Horse Latitudes,*** and ***Intertropical Convergence Zone (ITCZ)***
- Be able to draw and explain the Big Picture of the Atmosphere
- Be able to draw and explain the Asian and North American Monsoons
- Understand how prevailing winds and the general circulation control precipitation patterns
- Be able to relate pressure and temperature patterns to the middle latitude westerlies and ***Polar Front*** and ***Subtropical Jet Streams***
- Be able to explain normal conditions in the equatorial Pacific and contrast them with what happens during El Niño.
- Know the definitions of ***Walker Circulation*** and ***Southern Oscillation Index***

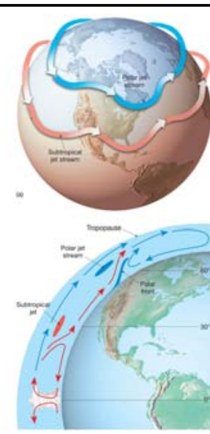
More realistic planetary winds



The Big Picture With the Atmosphere

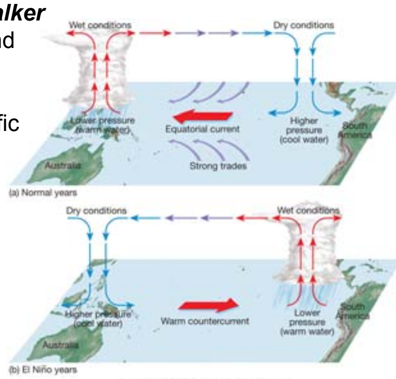


Jet Streams



- Narrow bands of strong westerly winds, generally at high altitudes
- Hypsometric equation predicts strong geostrophic winds above strong horizontal temperature gradients
- ***Subtropical Jet***: Above the sinking branch of the Hadley Cell
- ***Polar Front Jet***: Caused by the strong temperature gradient along the polar front

El Niño, the ***Walker Circulation***, and their effect on weather in the equatorial Pacific



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