Today: Clouds - Instability lift mechanism

Admin:
- Reading assignment.
  - Up through Clouds 1, 2 and 3.
  - Clouds First post: Edit your post date and time = your cloud image date and time
- Several clicker polls today. Please log in.

Clouds = droplets or ice MOVING UPWARDS

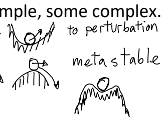
Lift mechanisms determine appearance:
1. Instability. Yes, basically Rayleigh-Taylor. Denser air sinks etc.
2. Orographics: terrain, mountains
3. Synoptic scale weather systems. Both at warm and cold fronts; cold air pushes under in a cold front, warm air overruns in a warm front.
4. Convergence: shoreline temperature differences

1. Instability

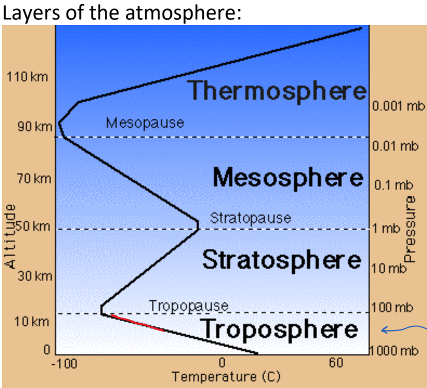
Is most complicated but most relevant for our summer clouds. Start with background physics.

What is instability? In groups, give example of
1) a stable and
2) an unstable situation

Results: some simple, some complex.
Stable
Unstable

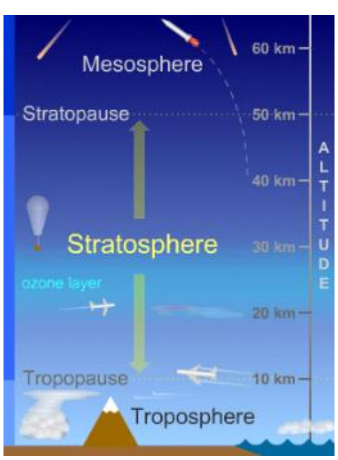


Layers of the atmosphere:



http://www.aerospaceweb.org/question/atmosphere/atmosphere/layers.gif

All weather happens in troposphere.
Driven by what happens at 500 mb level.



http://www.windows2universe.org/earth/Atmosphere/stratosphere.html

O_3 absorbs sunlight, heats stratosphere

Warm over cold
Less dense over more dense = STABLE. Hold that thought.

Weather data comes as a mix of English and metric systems.
Back to SCALES; how big....
How big is this? Well, OK, how wide is your screen?

Do you estimate in metric or in English units?
13% A) Metric
33% B) English
58% C) I can do both!
D) I can't do either.

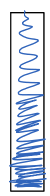
< Minute paper: In your head, 10 km = X miles, = Y thousand feet.
Be approximate, 1 sig fig.

6 miles ~30,000 feet

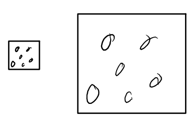
http://www.wolframalpha.com/input/?i=10+km+in+miles
http://www.wolframalpha.com/input/?i=1+mile+in+kilometers

33k ft

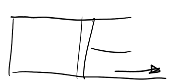
Temperature change with altitude in troposphere:
Minute paper in groups: *Why* is it colder on top of a mountain than at the foot? Hint: it's not the ideal gas law.



Start with pressure profile in atmospheric column: highest at surface, decreases going up.
Comes from hydrostatics; gravity balanced by pressure.



Consider a parcel of air (imaginary little cube, 1 inch to 10 feet^3). Same temperature as its neighbors.
Reduce its pressure (surface forces), while allowing no heat transfer.
It expands = *adiabatic* expansion
In expanding, it *does work* on its neighbors
Loses internal energy; cools.
= Conservation of Energy, 1st Law of Thermo.
NOT the Ideal Gas Law



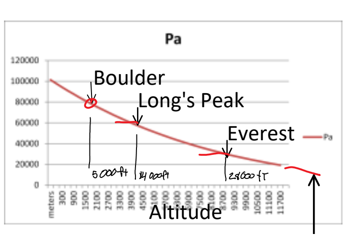
Piston/cylinder

Rising parcels expand, *do work,* lose energy and therefore cool.

Vice versa is true too; descending parcels get compressed (work is done on them) and warm up.

Pressure profile in the atmosphere

http://www.engineeringtoolbox.com/air-altitude-pressure-d_462.html



1 ATM =
1 bar =
1000 mb
14 psi
101 kPa
Memorize this

Memorize this

top of troposphere

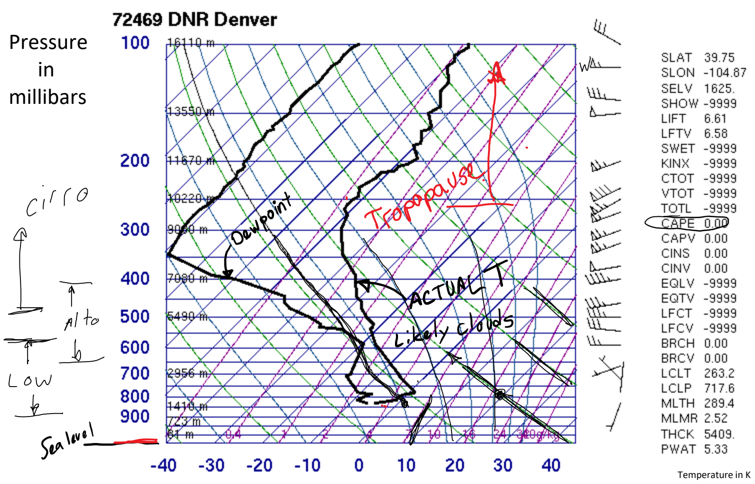
Actual temperature profile in the TROPOSPHERE
Comes from *sounding data*; weather balloons

Modern radiosondes measure or calculate the following variables:

- Pressure
- Altitude
- Geographical position (Latitude/Longitude)
- Temperature
- Relative humidity
- Wind (both wind speed and wind direction)
- Cosmic ray readings at high altitude

Pasted from <http://en.wikipedia.org/wiki/Radiosonde>

Here's what it looks like: SKEW-T
http://weather.uwyo.edu/upperair/sounding.html
YOU will do this for the date of your image
Open the skew T worksheet, so you can take notes on it.



Definitions

http://weather.uwyo.edu/upperair/indices.html#CAPE

Temperature in c

Where are clouds? Where temperature is close to dew point, i.e. where the two heavy black lines come together.
Also, kink CW towards more steep in T line suggests clouds at that level.
Condensation = warming (opposite of evaporation = cooling on your skin)

Can also get **local cloud height** from ATOC CU Boulder observation:
http://skywatch.colorado.edu/ or Flowvis.org>Links>Weather

Can get current and predicted cloud heights plus winds and other weather from Windy phone app and http://Windy.com . A bit tricky to navigate, though. Choose location, then Meteogram tab at bottom.

NO VERTICAL GRID?

So many lines! How many kinds?

Horizontal blue	Constant pressure isobar
Angled blue	Constant temperature; isotherm. Angle / SKEW T
Angle/curve green	Dry adiabat. A dry parcel will follow this temperature line if cooled adiabatically
Angle/curve blue	Moist, saturated adiabatic lapse rate. Rising parcel will follow this through a cloud.
Purple	Lines of constant mixing ratio; absolute humidity for saturation.
Heavy black	Right line is temperature profile. Left line is dew point
Light black	Adiabat starting at the top of the boundary layer

through a cloud.

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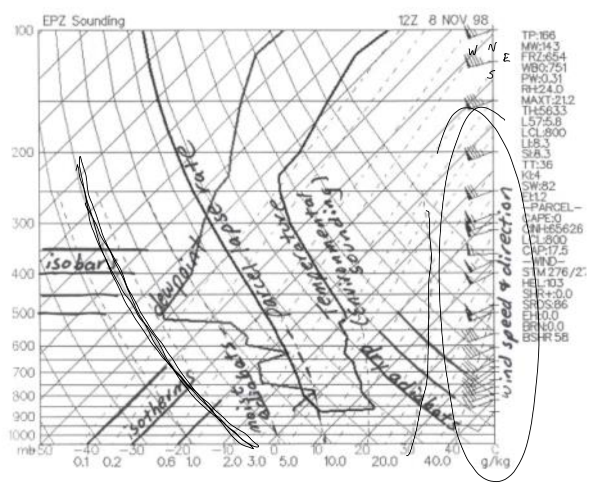
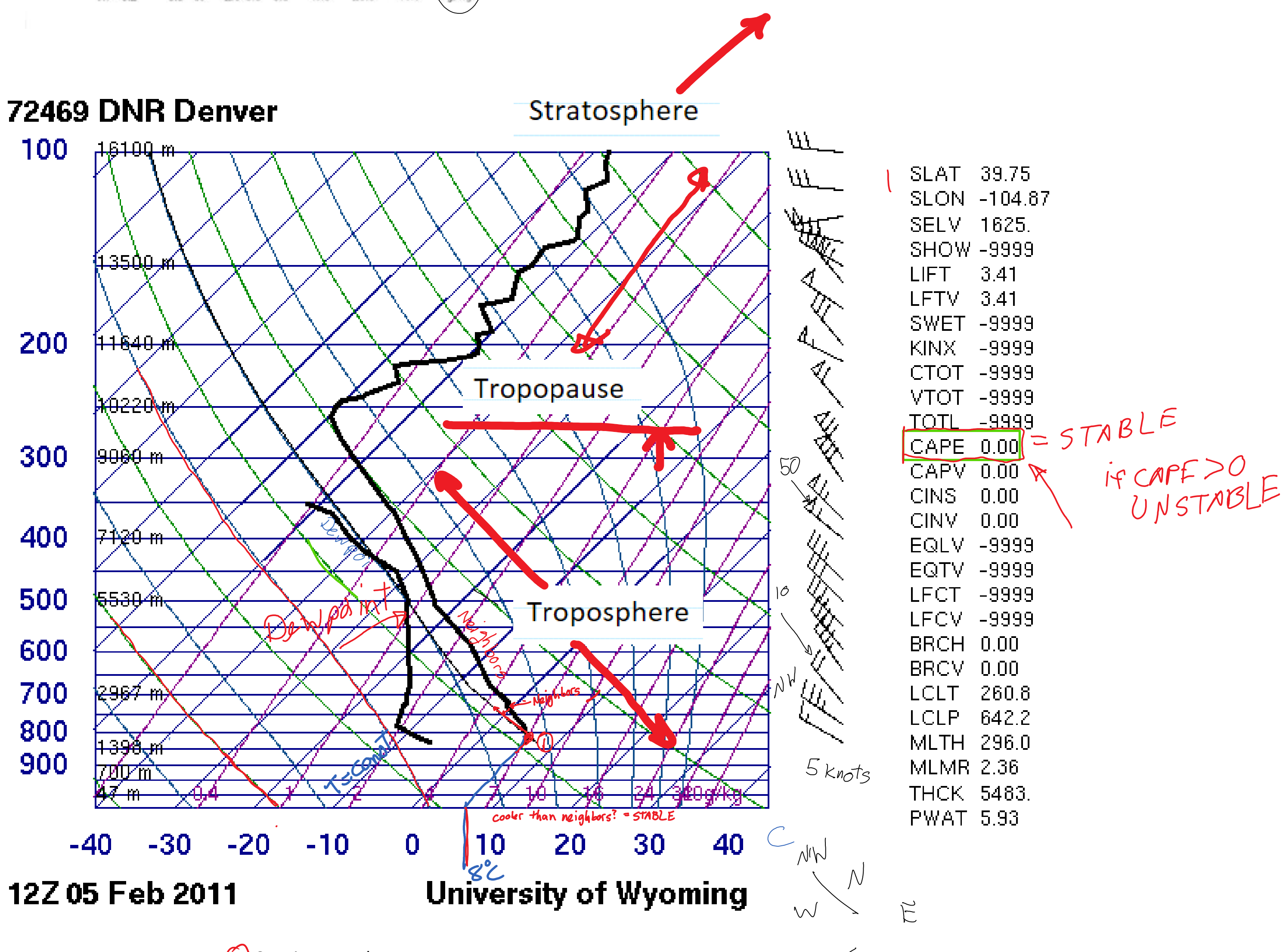
Basics: http://www.theweatherprediction.com/thermo/skewt/
Skew T Mastery: Free online course from UCAR.
https://www.meted.ucar.edu/lesson/225/login





① Starting parcel

② Raise it, cool it adiabatically (move up along the adiabat), perturb the system

Check it, is my parcel warmer or cooler than the actual neighboring parcels?

i. Cooler: more dense, wants to sink again, go back to origin STABLE

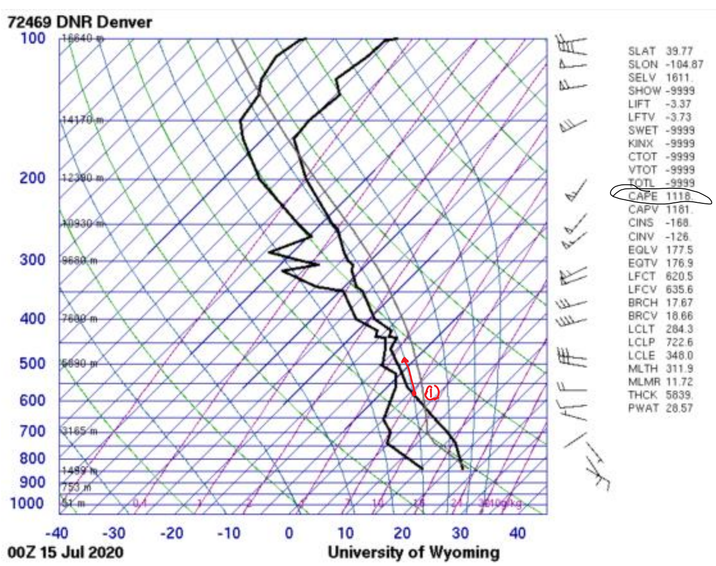
i. Cooler; more dense, wants to sink again, go back to origin STABLE
ii. Warmer; less dense, wants to keep going up! UNSTABLE

Can start at any point on the actual temperature line. Go parallel to the adiabats. Choose dry adiabat (green) if below likely cloud level or wet (blue, saturated) if in a cloud.

Stable clouds = flat STRATUS type
Unstable clouds = puffy CUMULUS family

Atmosphere is all **stable if CAPE = 0** Convective Available Potential Energy
Has unstable layers if CAPE > 0. Thunderstorms if CAPE > 500 or so.

Unstable Skew-T example



From 1 follow moist adiabat; is probably in a cloud (above LCLP at 722 mbar). Stays warmer than neighbors: UNSTABLE

What was the surface weather on a given day?
https://www.wunderground.com/history

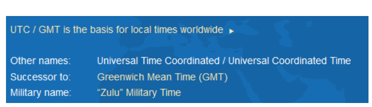
RH

Dew point: Temperature a parcel would have to be cooled to in order to get condensation (dew)
Relative humidity: How much water the air currently holds compared to how much it could hold at this temperature. For a given absolute water vapor concentration, RH is high for low temperatures (close to dew point) and low for high temperatures. So T and RH time plots move opposite.

Other info on Skew-T: wind indicators. LCL = lifting condensation level, cumulus have flat bottoms at this altitude.

OK, now look at skew-T for your date:
http://weather.uwyo.edu/upperair/sounding.html

Skew-T download tips: Skew-T Times:



Z indicates Zulu time = UTC = GMT = Greenwich Mean Time = Time at date line in England.

12Z, Feb 14 = ~6 am Feb 14 here. Sunrise.
00Z, Feb 1**5** = ~6 **p**m Feb 14 here. Sunset.

1. Choose correct date. 12z Feb X is the 6 am sounding, 00z X+1 is the 6 pm sounding for date X
2. Choose plot, not text
3. Will open in next browser tab

Your date

Tomorrow