Today:
Last few Team First image critiques
Clouds, 1 of 2 or 3 lectures
Admin:
- Scott Kittelman is still available if your team wants to do the ATOC experiments.
- 5 minutes, chat with your group. If your team isn't here, set up a meeting. Schedule a meal together in the next 2 days. Team Second plans due today; just let me know what you all are planning, especially which resources from the list you'll want.
- Cloud first image due Monday. Great if you can ID your cloud. At least be able to state stable vs unstable atmosphere during critique.

CLOUDS

Learning Objectives:
1. Be able to identify cloud types
2. Describe air motion and atmospheric stability that govern the appearance of basic cloud types.
3. Interpret weather data with respect to likely clouds, including Skew-T plots and wind soundings.

Name Race: in one minute, in your group of 3-4 students, how many separate cloud names can you recall? No internet allowed!

Cumulonimbus
Funnel
Stratus
Altocumulus
Rotor cloud
Cirrus
Altostratus
Lenticular
Mammatus
Cumulus
Arcus
Contrail

Best clouds physics book, easy read:
- Gavin Pretor-Pinney, *The Cloudspotter's Guide* (Perigee/Penguin, 2006). Guest lecturer, April 18

Next, (for free)
- Thomas Carney et al., *AC 00-57 Hazardous Mountain Winds and Their Visual Indicators*

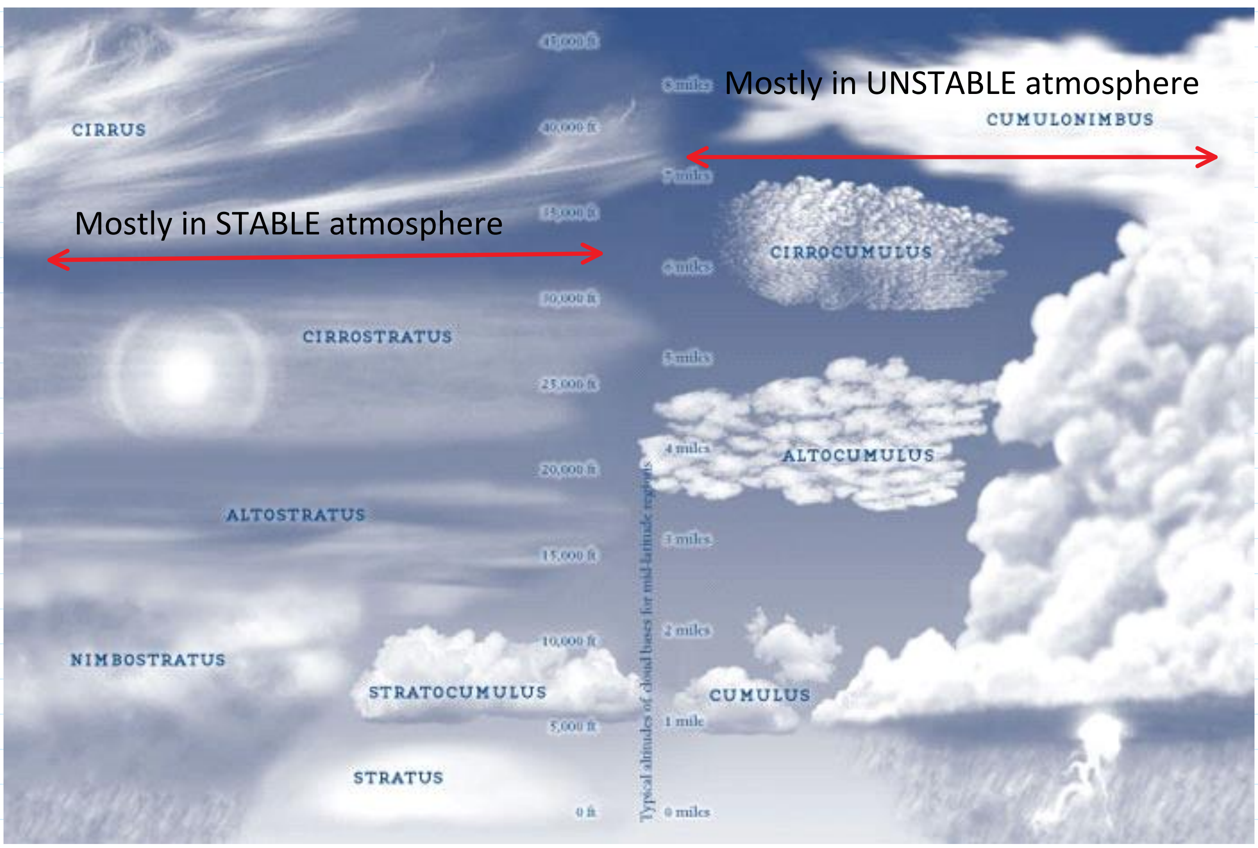
Join the Cloud Appreciation Society

(Federal Aviation Administration, 1997), http://rgl.faa.gov/Regulatory_and_Guidance_Library/rgAdvisoryCircular.nsf/0/780437D88CBDAFD086256A94006FD5B8?OpenDocument.

- https://www.metoffice.gov.uk/binaries/content/assets/mohippo/pdf/r/cloud_types_for_observers.pdf

Other cloud and atmospheric science books available for checkout; my office.
Office hours ~~Tuesday 2-3, ECME 220~~ check online
TONS of online info, most is OK.
Also, CloudSpotter phone app.

Following info partially adapted from Mike Baker, local NOAA Weather Service forecaster.

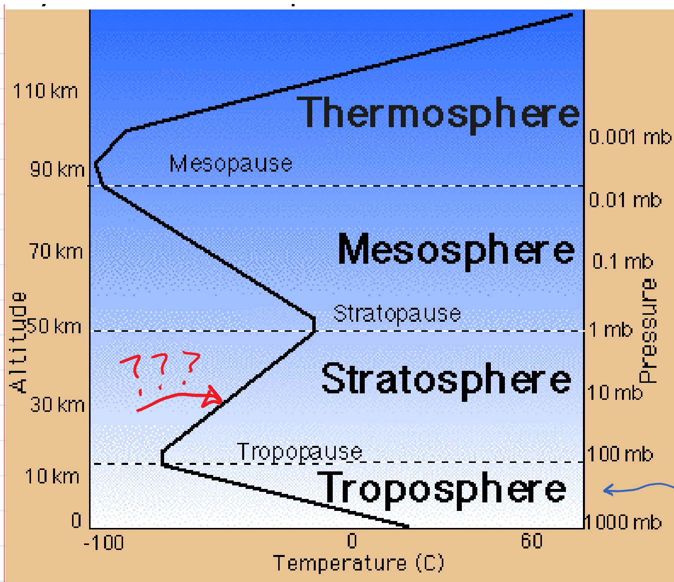


Pretor-Pinney, Gavin. *The Cloudspotter's Guide*. Perigee/Penguin, 2006.

Cloud types depend primarily on atmospheric stability. Need background to understand how.

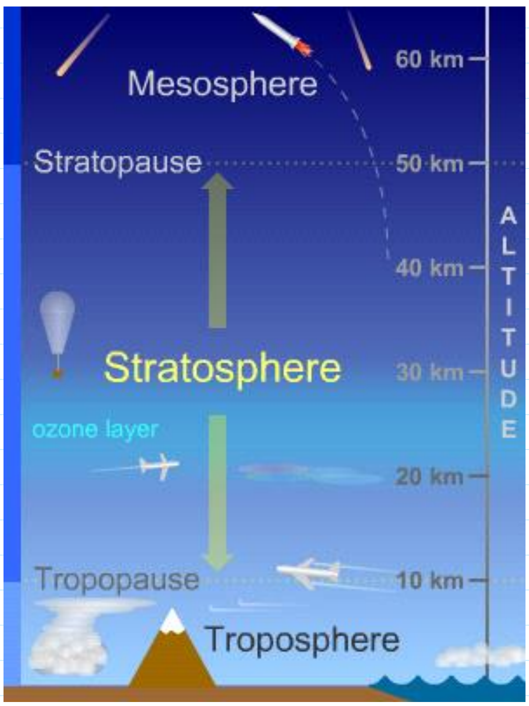
Layers of the atmosphere:

http://www.aerospaceweb



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

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



$O_3 + UVC \rightarrow O + O_2 + heat$

Lower $O + O_2 \rightarrow O_3$

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.

Back to SCALES; how big….

How big is this?

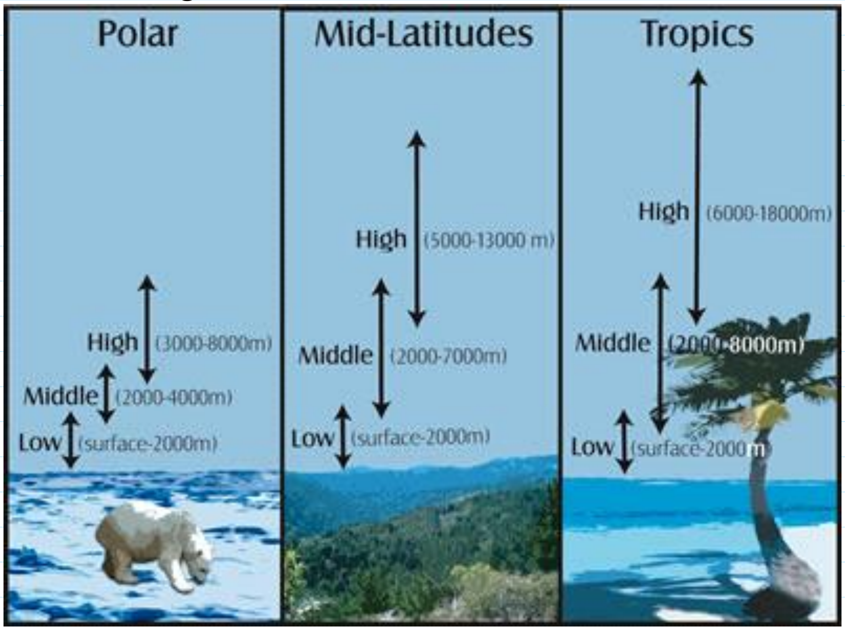
Do you estimate in metric or in English units?

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

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

33k ft

Order of magnitude estimates are VERY USEFUL.



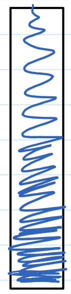
colder, denser
shorter atm.

Sea level air pressure = uniform worldwide, except +/- 2% due to weather (high, low pressure systems)

Height of atm goes with seasons too; higher in summer with hot air.

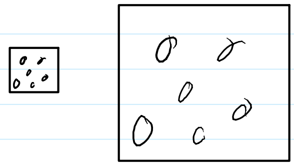
Temperature change with altitude in troposphere:

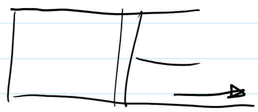
Minute paper in groups: *Why* is it colder on top of a mountain than at the foot?



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).
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



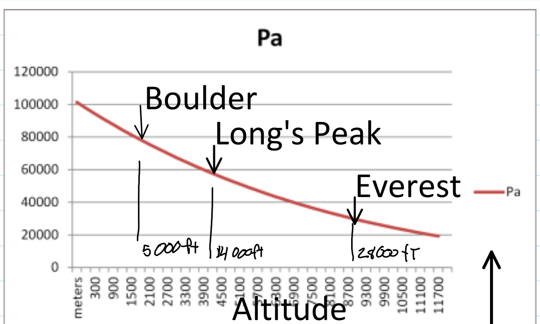


Piston/cylinder

Rising parcels expand, *do work* 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

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

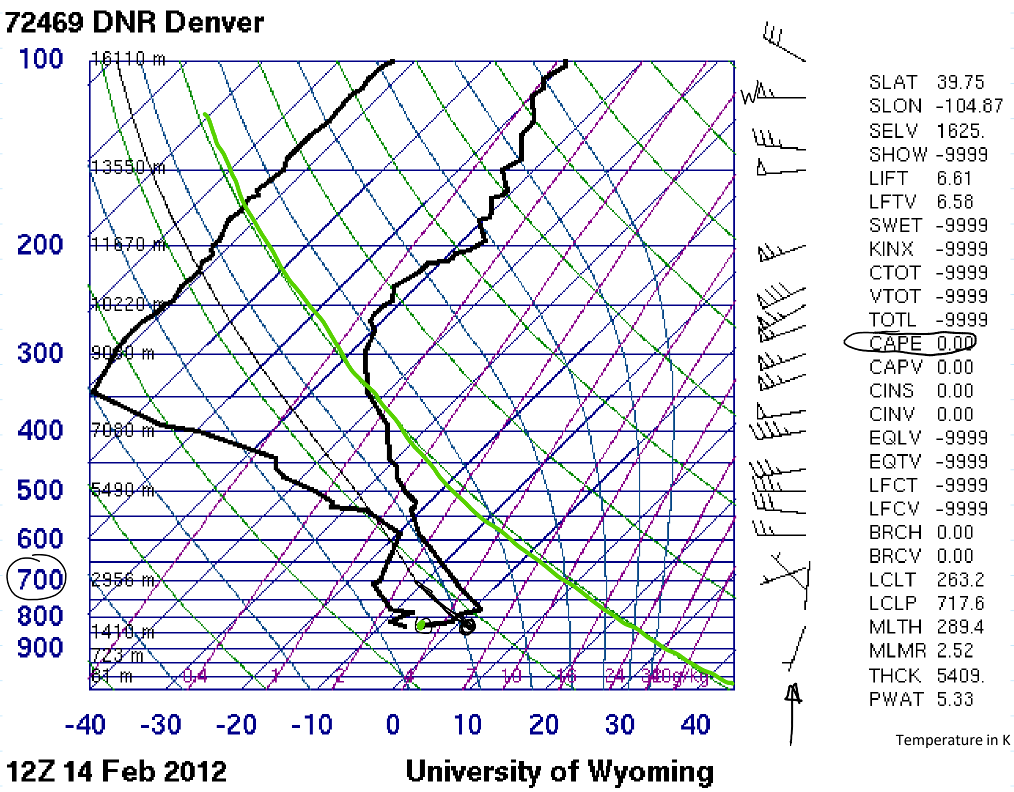
Pasted from <http://en.wikipedia.org/wiki/Radiosonde>

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

Pressure in millibars



Temperature in K

Temperature in c

Definitions

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

NO VERTICAL GRID?

So many lines! How many kinds?

Horizontal blue	Constant pressure
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
Purple	Lines of constant mixing ratio; absolute humidity for saturation.
Heavy black	Right line is temperature profile. Left line is dew point

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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

Basics: http://www.theweatherprediction.com/thermo/skewt/
Skew T Mastery: https://www.meted.ucar.edu/loginForm.php?urlPath=mesoprim/skewt#