14.Clouds 2 Instability and Stability

Wednesday, October 11, 2023 11:26 PM

Today: Clouds - Instability lift mechanism

Admin:

Reading assignment.

- Up through Clouds 1 - 5

Clouds First post: Edit your post date and time = your cloud image date and time

Several clicker polls today. Please log in.

- Cloud image submission: Include

1) your edited image
2) your original (unedited) image — canvas
3) the appropriate Skew-T diagram. Also put in your report.
4) a short statement of cloud type and stable or unstable atm. Also put in your report.
5) Post on Flowvis.org. Edit your post date to match your cloud date and time.
6) Later, add your report to your post and in Canvas.

Clouds = droplets or ice MOVING UPWARDS

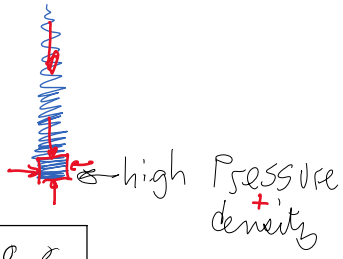
< 100 μm particles

Lift mechanisms determine appearance:

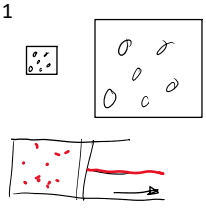
1. Instability. Yes, basically Rayleigh-Taylor. Denser air sinks etc.
2. Orographics: terrain, mountains
3. Synoptic scale weather systems. Both at warm and cold fronts; cold air pushes under in a cold front, warm air overruns in a warm front.
4. Convergence: shoreline temperature differences

Instability Backstory: Why is it colder on top of a mountain?

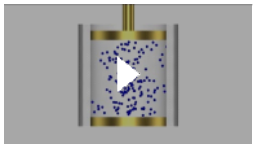
Start with pressure profile in atmospheric column: highest at surface, decreases going up.
Comes from hydrostatics; gravity balanced by pressure.



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

404 - Adiabatic process.

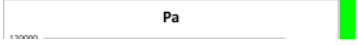


Rising parcels expand, *do work,* lose energy and therefore cool.

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

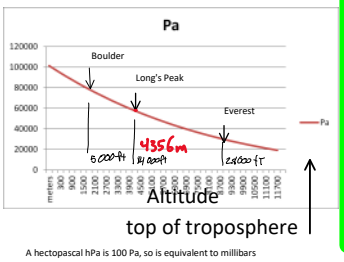
Pressure profile in the atmosphere

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



Standard pressure =
1 bar = 750 mm Hg =
1000 mb = 29.5 in Hg =

altitude-pressure-d_462.html



A hectopascal hPa is 100 Pa, so is equivalent to millibars

Standard pressure =
1 bar = 750 mm Hg =
1000 mb = 29.5 in Hg =
1000 hPa = 401 in H_2O =
100 kPa = 10197 mm H_2O =
14.5 psi
≠ standard atmospheric Pressure
101.3 kPa = 14.7 psi

Memorize this

So, if we perturb a parcel of air, let's say upwards, it will cool. Will it stay there, or continue upwards? Or fall back down? Depends on the neighboring parcels - Is our parcel more or less dense than the neighbors? Is it warmer or cooler?

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

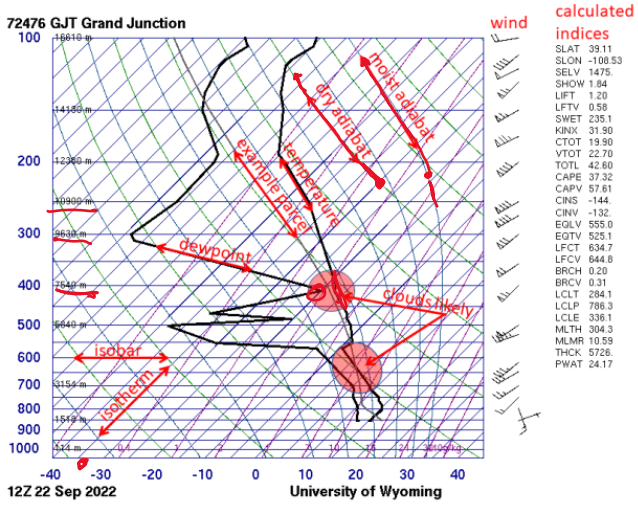
Sounding Data

Modern radiosondes measure or calculate the following variables:

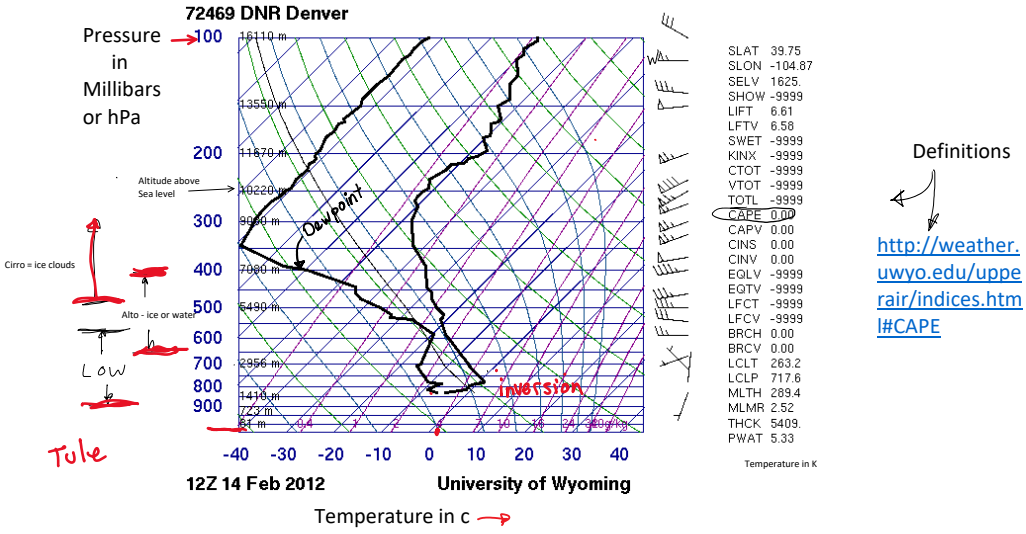
- Pressure
- Altitude
- Geographical position (Latitude/Longitude)
- Temperature
- Relative humidity ~Dew Point
- Wind (both wind speed and wind direction)
- Cosmic ray readings at high altitude

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.



Lifting Condensation Level



Definitions

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

Where are clouds? Where temperature is close to dew point, i.e. where the two heavy black lines come together. This suggests the atmosphere is saturated. 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.

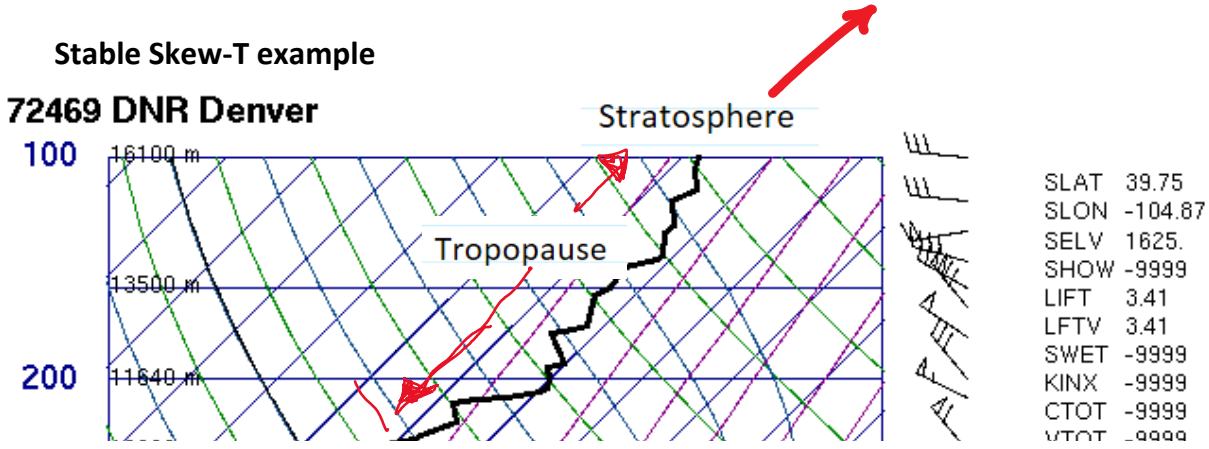
NO VERTICAL GRID?

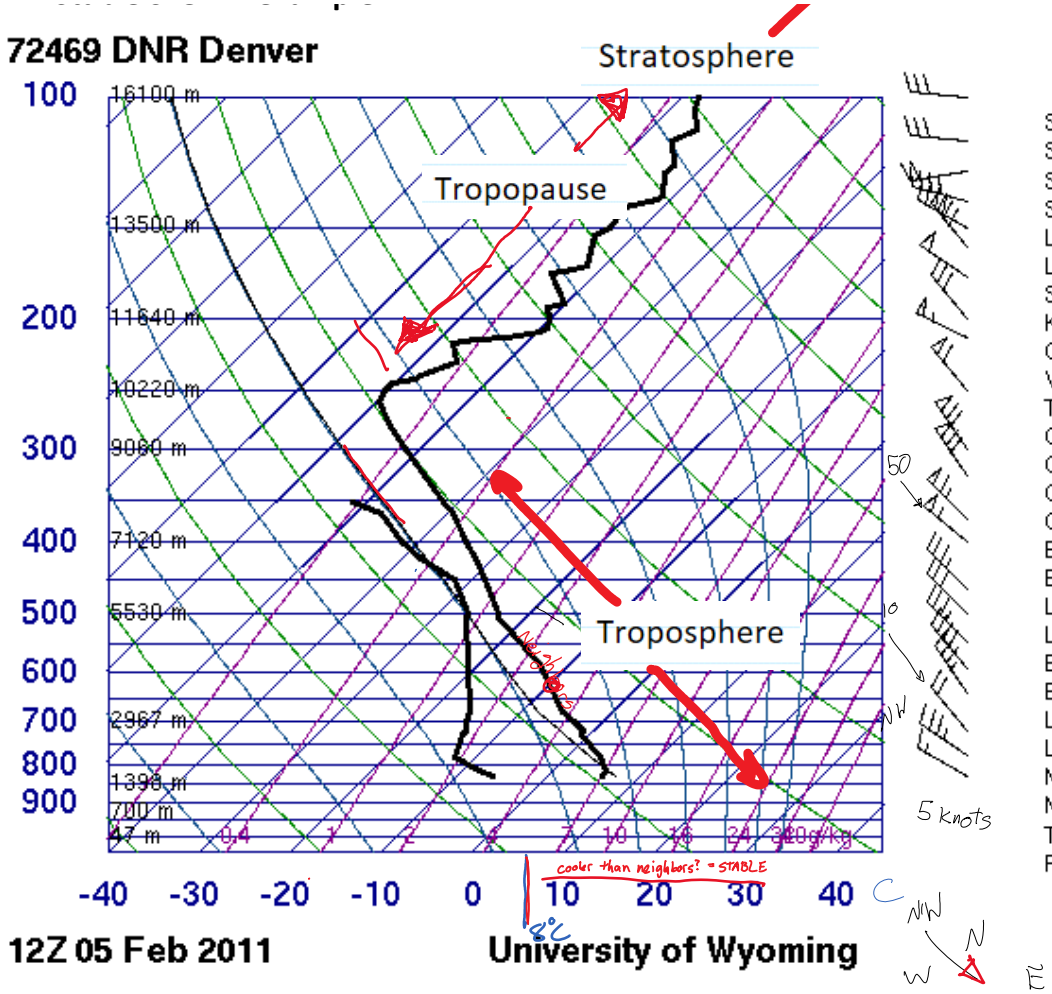
So many lines! How many kinds?

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	Example Adiabat starting at the top of the boundary layer

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

Stable Skew-T example





SLAT	39.75
SLON	-104.87
SELV	1625.
SHOW	-9999
LIFT	3.41
LFTV	3.41
SWET	-9999
KINX	-9999
CTOT	-9999
VTOT	-9999
TOTL	-9999
CAPE	0.00
CAPV	0.00
CINS	0.00
CINV	0.00
EQLV	-9999
EQTV	-9999
LFCT	-9999
LFCV	-9999
BRCH	0.00
BRCV	0.00
LCLT	260.8 K
LCLP	642.2
MLTH	296.0
MLMR	2.36
THCK	5483.
PWAT	5.93

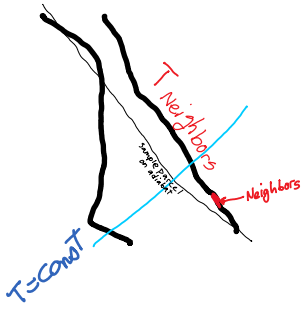
= STABLE

if CAPE > 0 UNSTABLE

1) Starting parcel

2) Raise it, cool it adiabatically (move up along the adiabat) = perturb the system
3) 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
   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.



Is this
a) Stable
b) Unstable
c) I'm still confused

2024	2023	2022
67%	32%	61
33	36	21
0	32	6