15.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
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.

Canvas

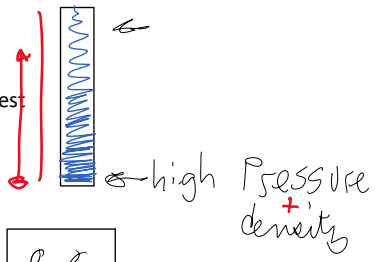
Clouds = droplets or ice MOVING UPWARDS

< 100 μm particles

Lift mechanisms determine appearance:

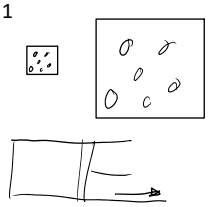
1. Instability. Yes, basically Rayleigh-Taylor. Denser air sinks etc.
2. Orographics: terrain, mountains
3. Synoptic scale weather systems. Both at warm and cold fronts; cold air pushes under in a cold front, warm air overruns in a warm front.
4. Convergence: shoreline temperature differences

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

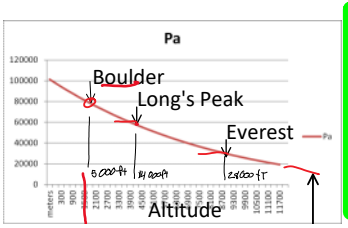


Rising parcels expand, *do work,* lose energy and therefore cool.

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

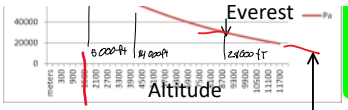
Pressure profile in the atmosphere

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



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

hPa



101 kPa
Memorize this

hPa

top of troposphere

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

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

Sounding Data

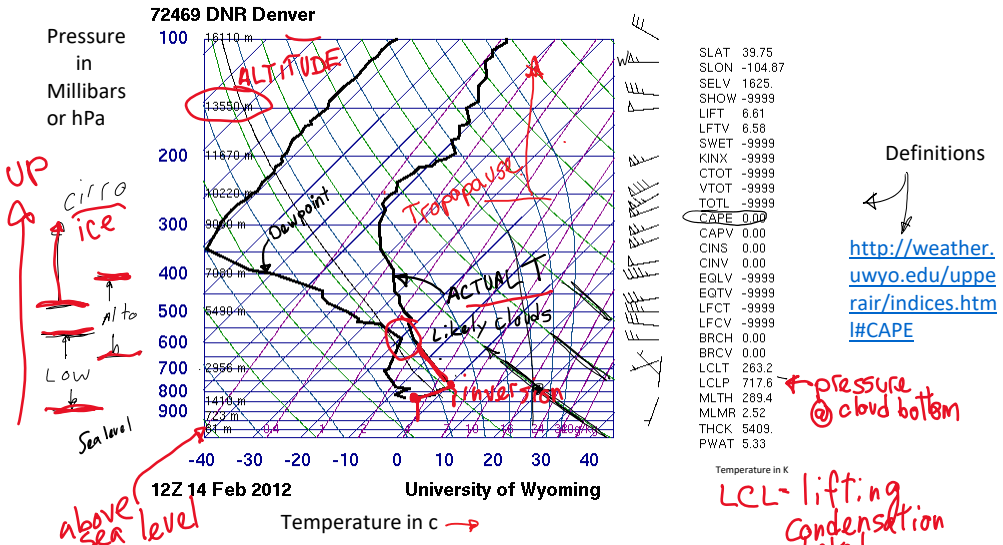
Modern radiosondes measure or calculate the following variables:

- 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.

Pressure in Millibars or hPa



UP

above sea level

Definitions

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

pressure @ cloud bottom

LCL - lifting Condensation Level

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?

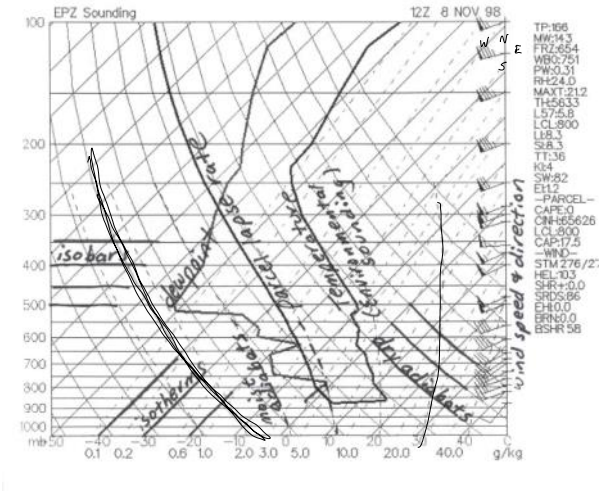
So many lines! How many kinds?
Horizontal blue Constant pressure isobar
Angled blue Constant temperature: isotherm. Angle ↗ SKEW T

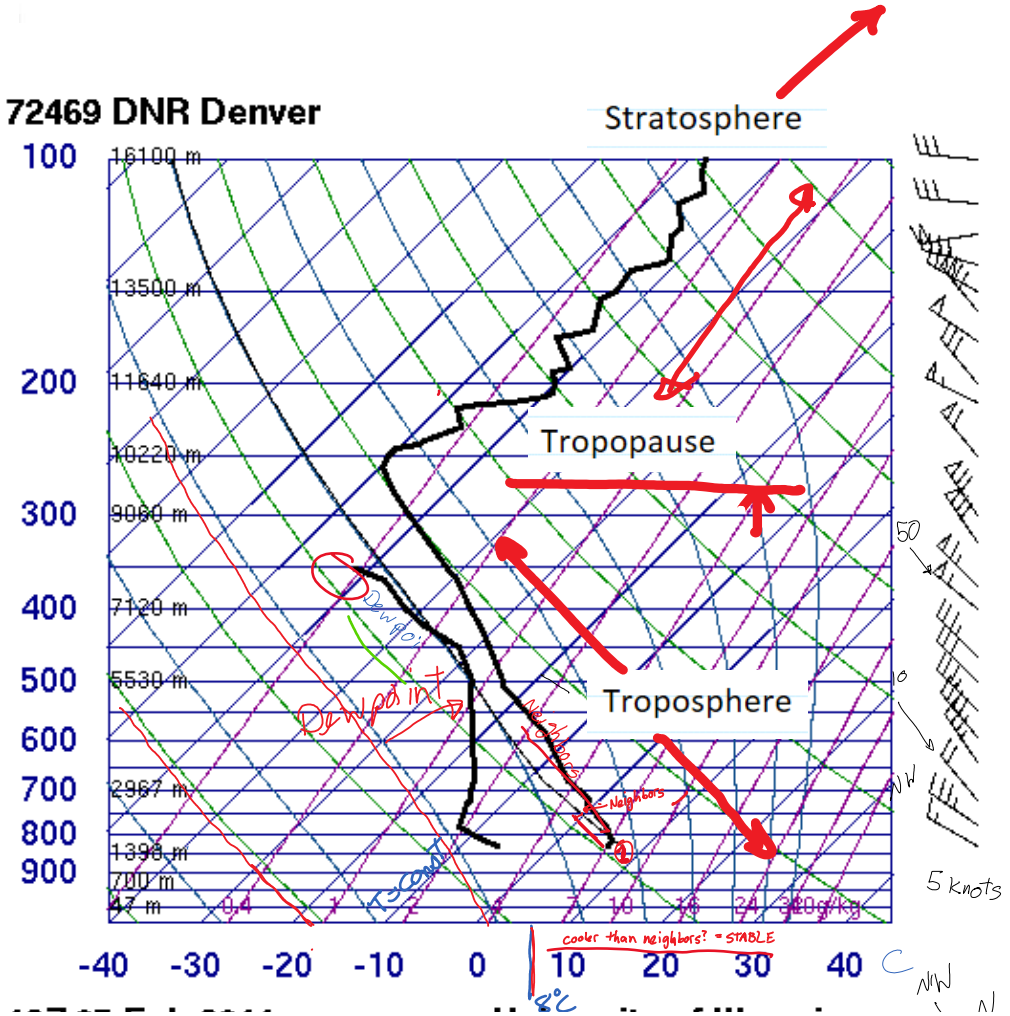
NO VERTICAL GRID!

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

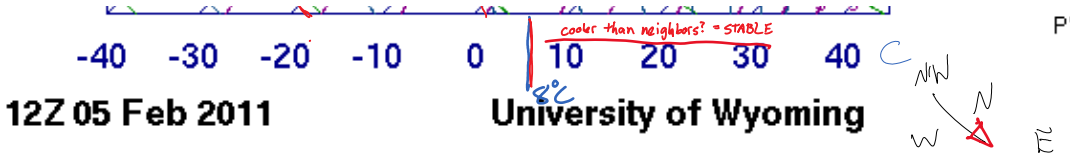
Basics: http://www.theweatherprediction.com/thermo/skewt/
Skew T Mastery: Free online course from UCAR.
https://www.meted.ucar.edu/lesson/225/login





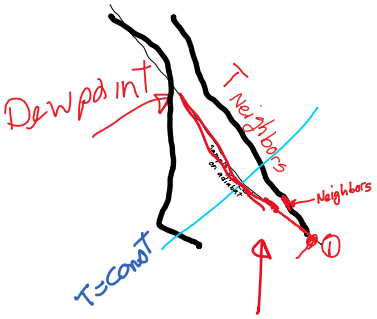
SLAT 39.75
SLON -104.87
SELV 1625.
SHOW -9999
LIFT 3.41
LFTV 3.41
SWET -9999
KINX -9999
CTOT -9999
VTOT -9999
TOTL -9999
CAPE 0.00 = STABLE
CAPV 0.00
CINS 0.00
CINV 0.00
EQLV -9999
EQTV -9999
LFCT -9999
LFCV -9999
BRCH 0.00
BRCV 0.00
LCLT 260.8 K
LCLP 642.2
MLTH 296.0
MLMR 2.36
THCK 5483.
PWAT 5.93

if CAPE > 0 UNSTABLE



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
   - ii. Warmer; less dense, wants to keep going up! UNSTABLE

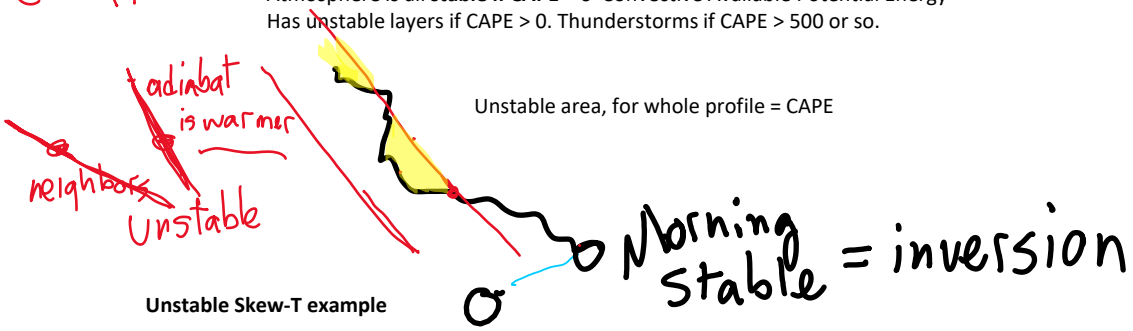
Can start at any point on the actual temperature line. Go parallel to the adiabats. Choose dry adiabat (green) if below likely cloud level or wet (blue, saturated) if in a cloud.



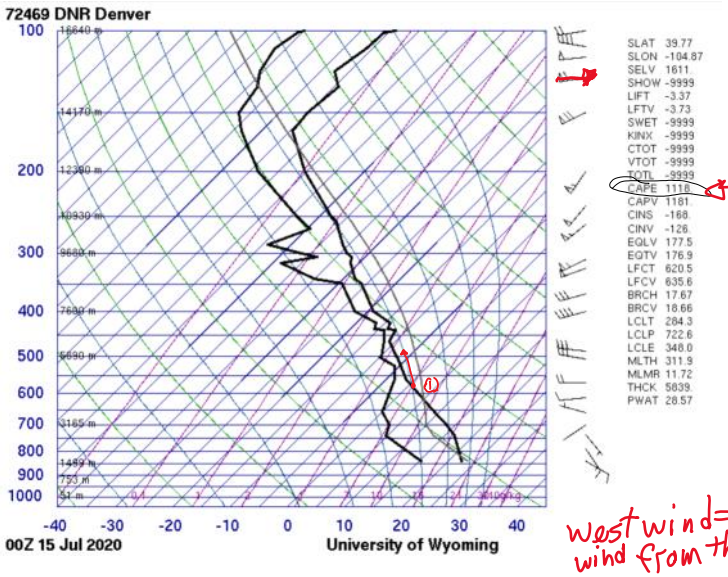
Is this
a) Stable
b) Unstable
c) I'm still confused

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



convective available potential energy

Cape = 0 = stable

Cape > 1000 thunderstorm

westwind = wind from the west

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

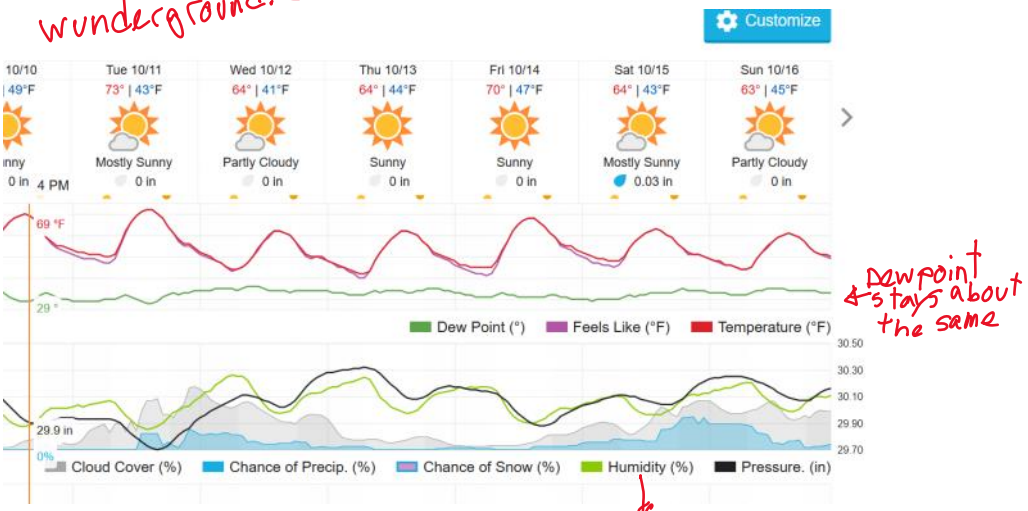
What was the surface weather on a given day?

https://www.wunderground.com/history

RH

Dew point: Temperature a parcel would have to be cooled to in order to get condensation (dew). ~ Absolute humidity.
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.

wunderground.com



Dewpoint stays about the same

https://www.wunderground.com/forecast/us/co/boulder/40.02,-105.27

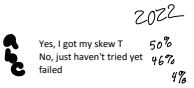
RH goes inverse to temperature

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

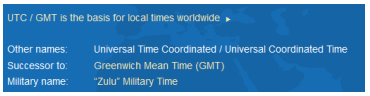
OK, now look at skew-T for your date:

http://weather.uwyo.edu/upperair/sounding.html

2022



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 15 = ~6 pm Feb 14 here. Sunset.

1. Choose closest location and date/time. 12z month/day 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

your tomorrow