12.Clouds1

Monday, October 14, 2019 3:26 PM

Today: Clouds 1

Handouts:
Skew T worksheet
Cloud name table
in Slack

Admin:
IV2 report due Monday, Clouds First IV due Weds, IV2 Reviews due Friday.
OK? Push reviews to Monday 10/19?
Should we make final assignment a choice of Clouds 2 or IV4? ← yes
BTW, clouds are predicted for today through Sunday…

Looking for student to help with Covid Flow Vis project, analyze videos. Pay ~ $12 to $16/hr, 10 hrs per week.
Also looking for student to be a grader/TA for MCEN 3021 Fluids

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.

- Cloud first image due Weds. Great if you can ID your cloud.
- ***Required: be able to state stable vs unstable atmosphere during critique.***

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

Cirrus
Nimbus
Cirrostratus
cumulonimbus

A more complete list, from the Cloudspotter's Guide: available in Slack

CLOUD CLASSIFICATION TABLE

Clouds are classified according to a Latin 'Linnean' system (similar to the one used for plants and animals), which is based on their heights and appearance. Most clouds fall into one of ten basic groups, known as 'genera'. They can further be defined as one of the possible 'species' for that genus, and any combination of used for plants and animals), which is based on their heights and appearance. Most clouds fall into one of ten basic groups, known as 'genera'. They can further be defined as one of the possible 'species' for that genus, and any combination of the possible 'varieties'. There are also various accessory clouds and supplementary features that sometimes appear in conjunction with the main cloud types.

(If all this Latin freaks you out, don't worry – it freaks me out too.)

GENUS	SPECIES (CAN ONLY BE ONE)	VARIETIES (CAN BE MORE THAN ONE)	ACCESSORY CLOUDS AND SUPPLEMENTARY FEATURES	
Cumulus	humilis		pileus	arcus
	mediocris	radiatus	velum	pannus
	congestus		virga	tuba
	fractus		praecipitatio	
Cumulonimbus *(extends through all three levels)* Thunder head			praecipitatio	pileus
	calvus		virga	velum
	capillatus	(none)	pannus	arcus
			incus	tuba
			mamma	
Flat — Stratus	nebulosus	opacus		
	fractus	translucidus	praecipitatio	
		undulatus		
Stratocumulus		translucidus		
		perlucidus		
	stratiformis	opacus	mamma	
	lenticularis	duplicatus	virga	
	castellanus	undulatus	praecipitatio	
		radiatus		
		lacunosus		
Altocumulus		translucidus		
	stratiformis	perlucidus		
	lenticularis	opacus	virga	
	castellanus	duplicatus	mamma	
	floccus	undulatus		
		radiatus		
		lacunosus		
Altostratus		translucidus	virga	
		opacus	praecipitatio	
	(none)	duplicatus	pannus	
		undulatus	mamma	
		radiatus		
Nimbostratus *(extends through more than one level)*			praecipitatio	
	(none)	(none)	virga	
			pannus	
Cirrus	fibratus	intortus		
	uncinus	radiatus		
	spissatus	vertebratus	mamma	
	castellanus	duplicatus		
	floccus			
Cirrocumulus	stratiformis			
	lenticularis	undulatus	virga	
	castellanus	lacunosus	mamma	
	floccus			
Cirrostratus	fibratus	duplicatus	(none)	
	nebulosus	undulatus		

Fun book on how the clouds got these names, given by Luke Howard in mid 1800s :

Hamblyn, Richard. *The Invention of Clouds: How an Amateur Meteorologist Forged the Language of the Skies*. First Edition. New York: Picador, 2002.
Available for checkout

Best clouds physics book, easy read:

- Gavin Pretor-Pinney, *The Cloudspotter's Guide* (Perigee/Penguin, 2006). Next, (for free)
- Thomas Carney et al., *AC 00-57 Hazardous Mountain Winds and Their Visual Indicators* (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

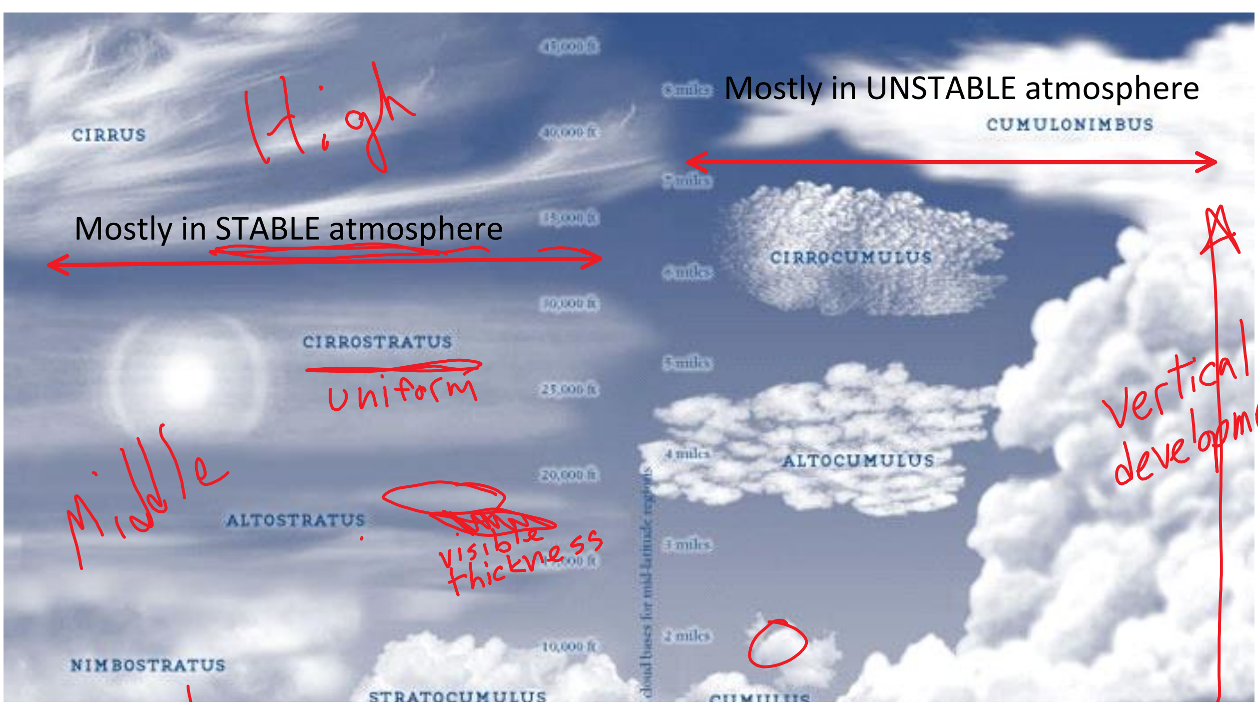
Join the Cloud Appreciation Society

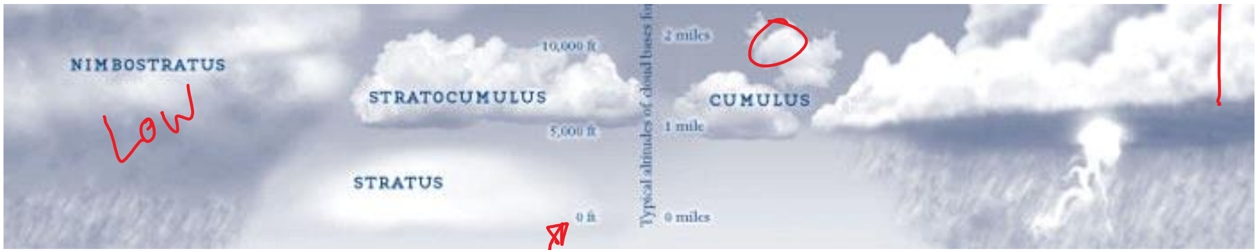
Other cloud and atmospheric science books available for checkout; my office.
TONS of online info, most is OK.
Also, Cloud-a-Day or CloudSpotter phone apps.

Better

Both from C.A.S.

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





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

ABOVE Ground level

Hold out three fingers at arm's length. Can you cover a cloud element (clump) with three fingers? No- then it's a low cloud, cumulus variety
If it's between one and three fingers in width, then it's a mid level, alto- type
Smaller than one finger = cirro- level, high cloud.

No cloud elements, just smooth layers, stratus types? If there is visible darkening on the bottom, then it's a low level or alto level layer. If it's all bright, then it's cirrostratus.

Clouds = droplets or ice MOVING UPWARDS

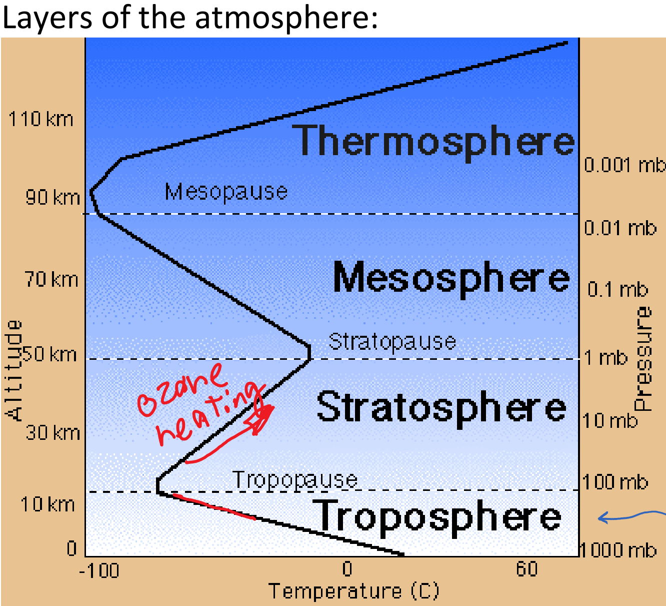
Lift mechanisms determine appearance:

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

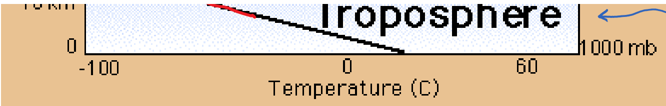
Is most complicated. Start with background physics.

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.



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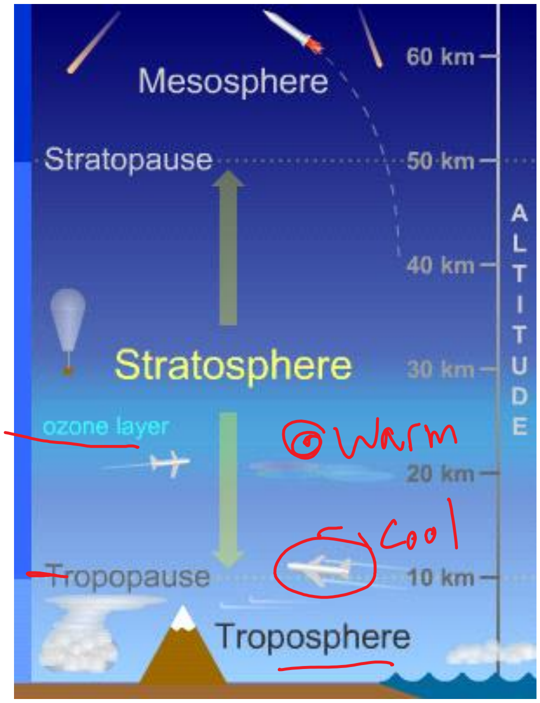


http://www.windows2universe.org/earth/Atmosphere/stratosphere.html

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? Well, OK, how wide is your screen?

Do you estimate in metric or in English units?

A) Metric 5%
B) English 57%
C) I can do both! 38%
D) I can't do either.

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

~30,000

Be approximate, 1 sig fig.

6 miles ~30,000 feet

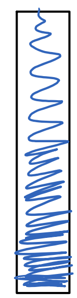
http://www.wolframalpha.com/input/?i=10+km+in+miles
http://www.wolframalpha.com/input/?i=1+mile+in+kilometers

33k ft

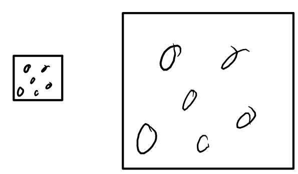
Temperature change with altitude in troposphere:

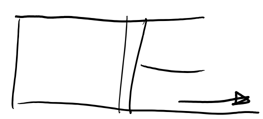
Minute paper in groups: *Why* is it colder on top of a mountain than at the foot? Hint: it's not the ideal gas law.

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).
Same temperature as its neighbors.
Reduce its pressure (surface forces), while allowing <u>no</u> 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





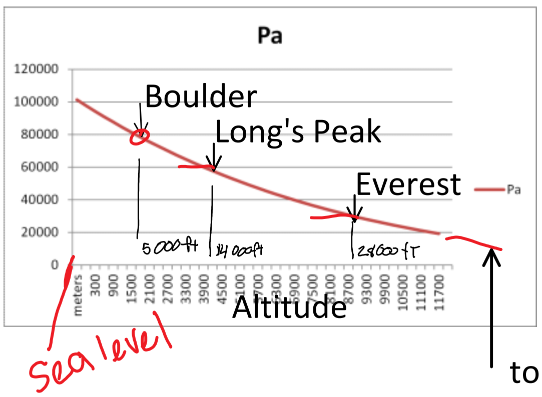
Piston/cylinder

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
Memorize this

top of troposphere

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

2x daily at all major airports

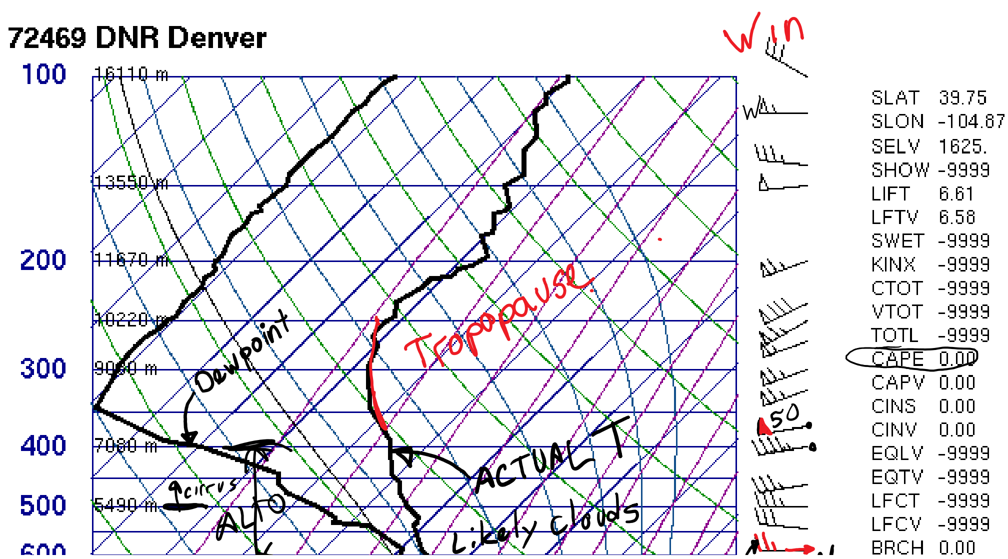
Modern radiosondes measure or calculate the following variables:

- 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.

Pressure in millibars



Definitions

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

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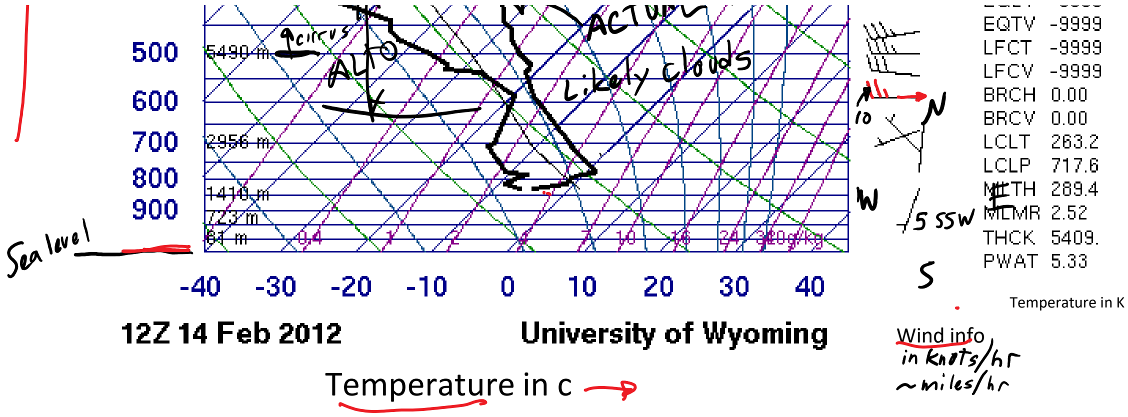
l#CAPE



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

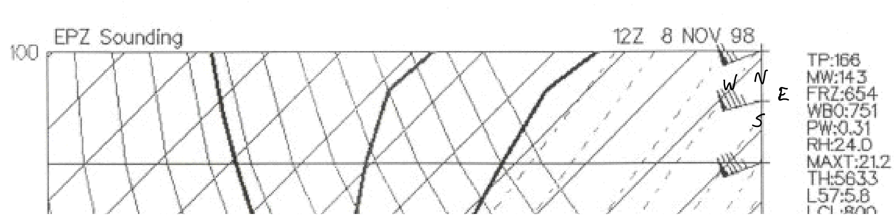
Can get current and predicted cloud heights plus winds and other weather from Windy phone app and http://Windy.com . A bit tricky to navigate, though. Choose location, then Meteogram tab at bottom.

NO VERTICAL GRID?

So many lines! How many kinds?

Horizontal blue	Constant pressure
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
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



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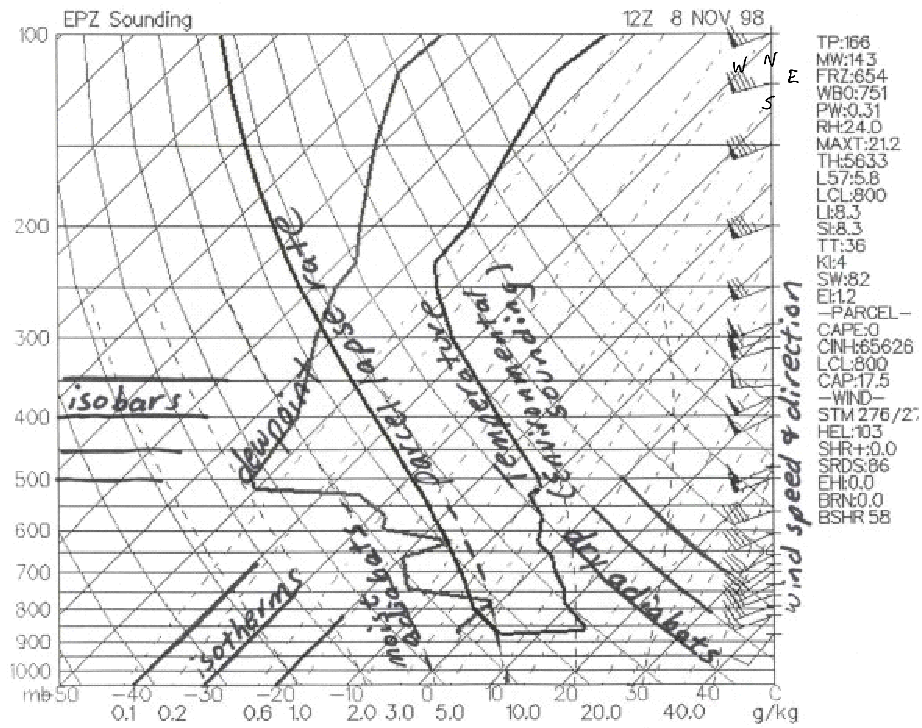
EPZ Sounding
12Z 8 NOV 98
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MW:143
FRZ:654
WBO:751
PW:0.31
RH:24.0
MAXT:21.2
TH:5633
L57:5.8
LCL:800
LI:8.3
SI:8.3
TT:36
KI:4
SW:82
EI:1.2
—PARCEL—
CAPE:0
CINH:65626
LCL:800
CAP:17.5
—WIND—
STM 276/27
HEL:103
SHR+:0.0
SRDS:86
EHI:0.0
BRN:0.0
BSHR 58
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0.1 0.2 0.6 1.0 2.0 3.0 5.0 10.0 20.0 40.0 g/kg
isobars
isotherms
dewpoint
moist adiabats
parcel lapse rate
Temperature (environmental sounding)
dry adiabats
wind speed & direction
W N E S