13 Clouds Lift Mechanisms

Monday, October 7, 2024 3:26 PM

Skew T worksheet
Available on class page

Today: Clouds - Instability lift mechanism

Admin:

Reading assignment.
Up through Clouds 1, 2 3 and 4.
Clouds First post: Edit your post date and time = your cloud image date and time
Several clicker polls today. Please log in.
Late reports- means others don't get feedback. See me if you are having trouble

Review

	Monday, September 30, 2024	Team First						Critique
week 6	Wednesday, October 2, 2024					Macro HW due		12 Exposure: shutter speed
	Friday, October 4, 2024				Get Wet		Clouds 1 Names	13 ISO, Cloud names
	Monday, October 7, 2024			Team First			Clouds 2 , 3 and 4 Instability and Clouds	14 Clouds: Instability, skew-T
week 7	Wednesday, October 9, 2024					Team Second plan due	Clouds 5 - Orographics	15 Clouds: Cumulus types, orographic
	Friday, October 11, 2024	CloudsFirst					Clouds 6 - Weather Systems	16 Clouds: Stratus and weather systems
	Monday, October 14, 2024	CloudsFirst			Team First			Critique
week 8	Wednesday, October 16, 2024	CloudsFirst						Critique

Due

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 Friday. Try to ID your cloud. Experts will assist during critique
- ***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!

1 5 4
2 4+6 3
3 5 2

Cumulus
Cirrus
Nimbostratus
Cumulonimbus
Stratus
Stratocumulus
Altostratus
cirrostratus

Great list!
A more complete list, from the Cloudspotter's Guide:

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 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)*			praecipitatio	pileus
	calvus		virga	velum
	capillatus	(none)	pannus	arcus
			incus	tuba
			mamma	
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		

Low

mid

high

Most complete list, from the authority, the World Meteorological Organization:
https://cloudatlas.wmo.int/en/cloud-classification-summary.html

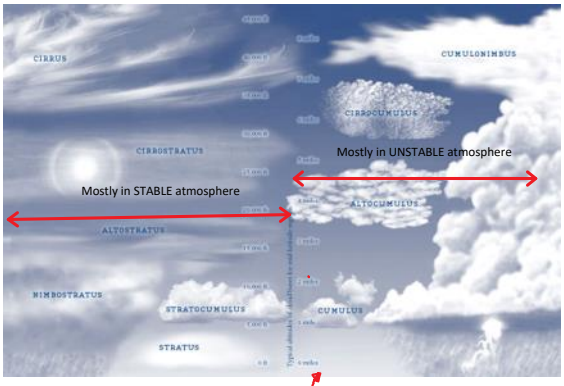
Fun book on how the clouds got these names, given by Luke Howard in mid 1800s :
Hamblyn, Richard. The Invention of Clouds: How an Amateur Meteorologist Forged the Language of the Skies. First Edition. New York: Picador, 2002.
Available for checkout

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), PDF in Zotero library.
- 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.
TONS of online info, most is OK.
Also, Cloud-a-Day phone app. Has AI assistance.

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



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

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: altocumulus
Smaller than one finger = cirro- level, high cloud. Cirrus, cirrocumulus

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: altostratus. If it's all bright, then it's cirrostratus.
Uniformly dark or low: stratus. Raining? Nimbostratus.

In between, kinda clumpy, kinda flat, medium to low? Stratocumulus. Very common.

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

Clouds = droplets or ice MOVING UPWARDS

Lift mechanisms determine appearance:

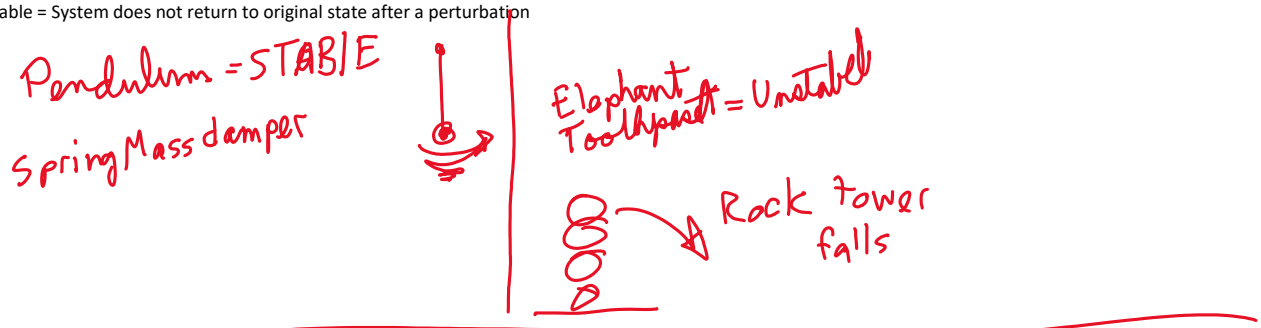
1. Instability. Yes, basically Rayleigh-Taylor. Denser air sinks etc.
2. Orographics: terrain, mountains
3. Synoptic scale weather systems. Both at warm and cold fronts; cold air pushes under in a cold front, warm air overruns in a warm front.
4. Convergence: shoreline temperature differences

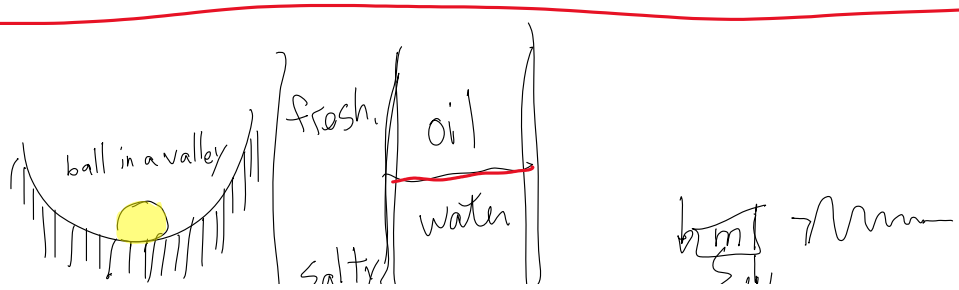
1. Instability

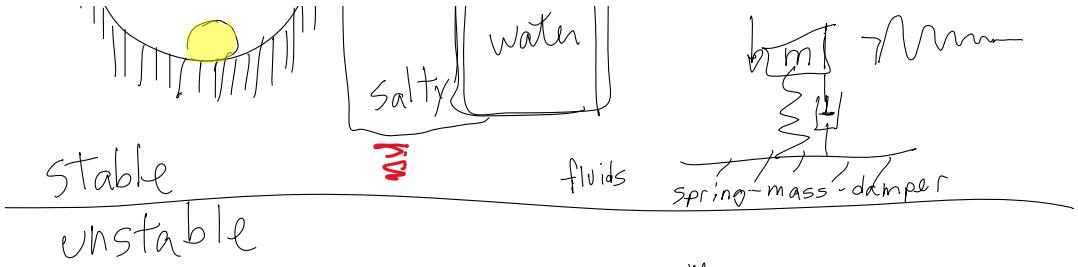
Is most complicated but most relevant for our summer clouds. Start with background physics.

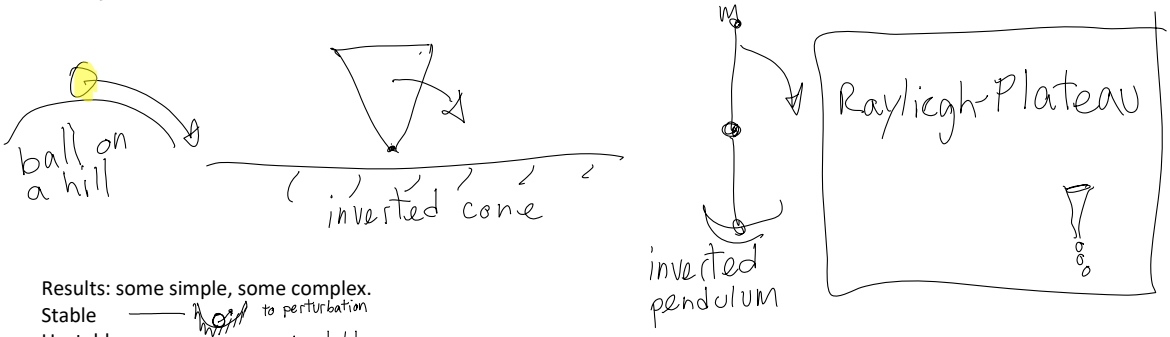
What is instability? In groups, give example of
1. a stable and
2. an unstable situation

Stable = System returns to original state after a perturbation.
Unstable = System does not return to original state after a perturbation

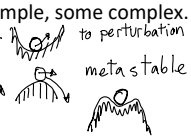








Results: some simple, some complex.
Stable — to perturbation
Unstable — metastable

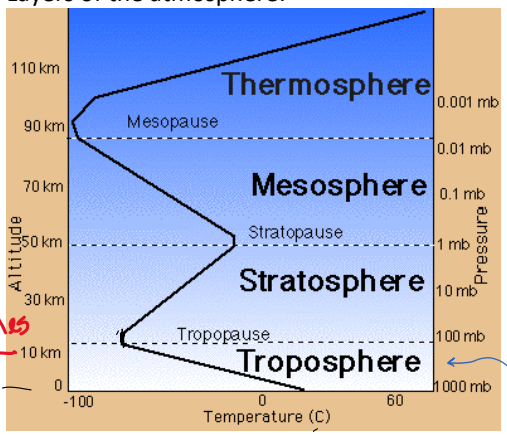


https://en.wikipedia.org/wiki/List_of_hydrodynamic_instabilities_named_after_people

Stably Stratified

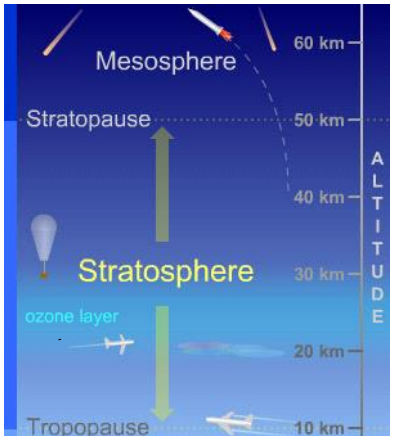
So - the atmosphere can be stable or unstable, and this determines what kind of clouds you get and why.

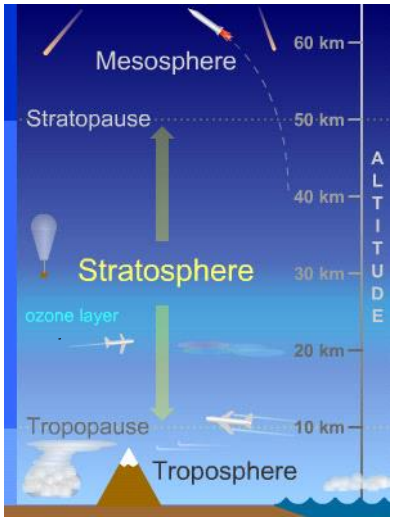
Layers of the atmosphere:



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?

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

2024	2023	2022
	13%	23
	33	32
	50	41
	0	0

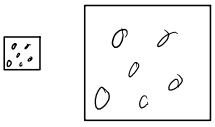
< Minute paper: In your head, 10 km = X miles, = Y thousand feet.
Be approximate, 1 sig fig.

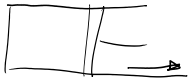
6 miles ~30,000 feet

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 <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,* lose energy and therefore cool.

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