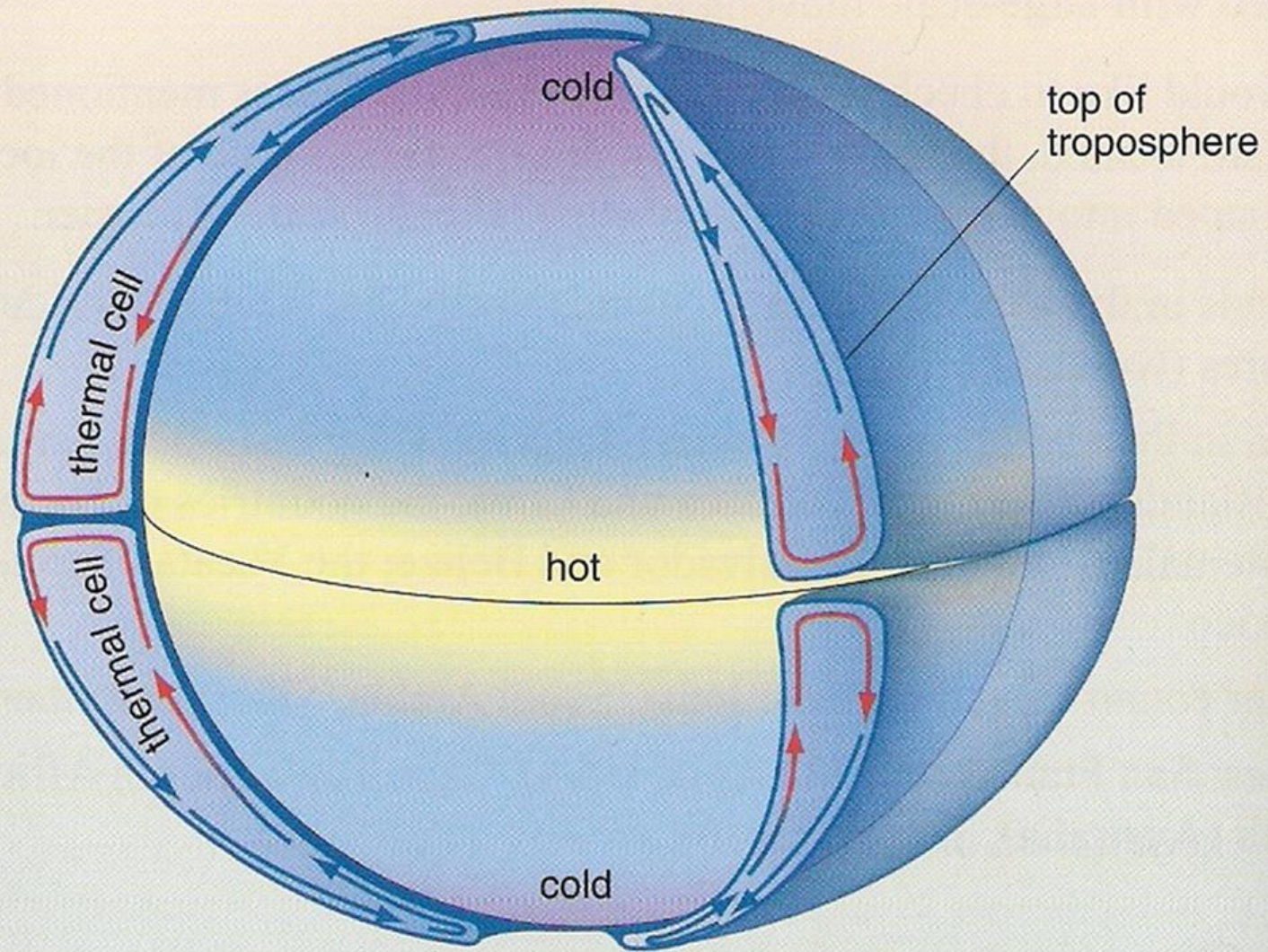




# Understanding weather and the weather forecast

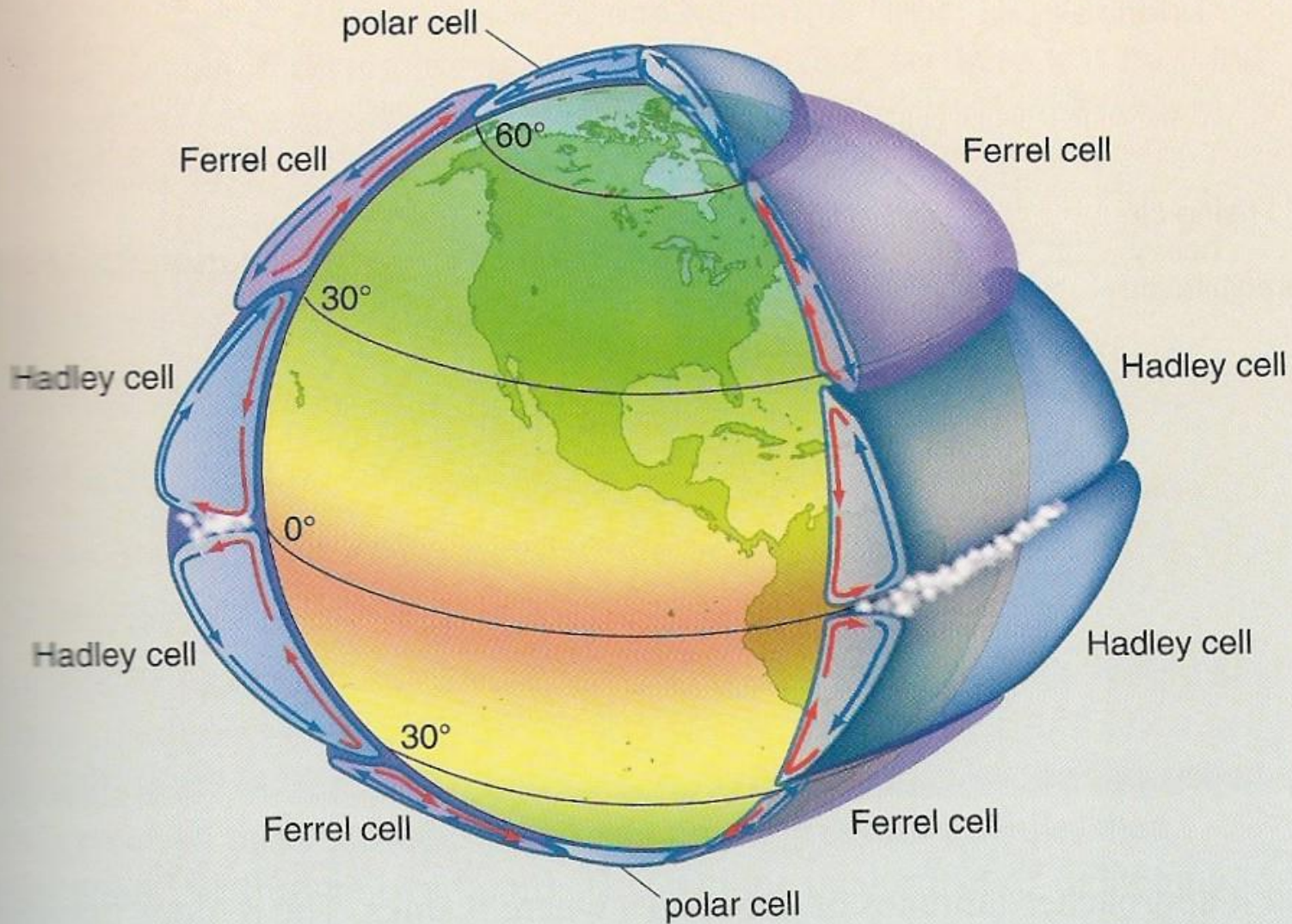
Week 8 Clouds

Terry Hart



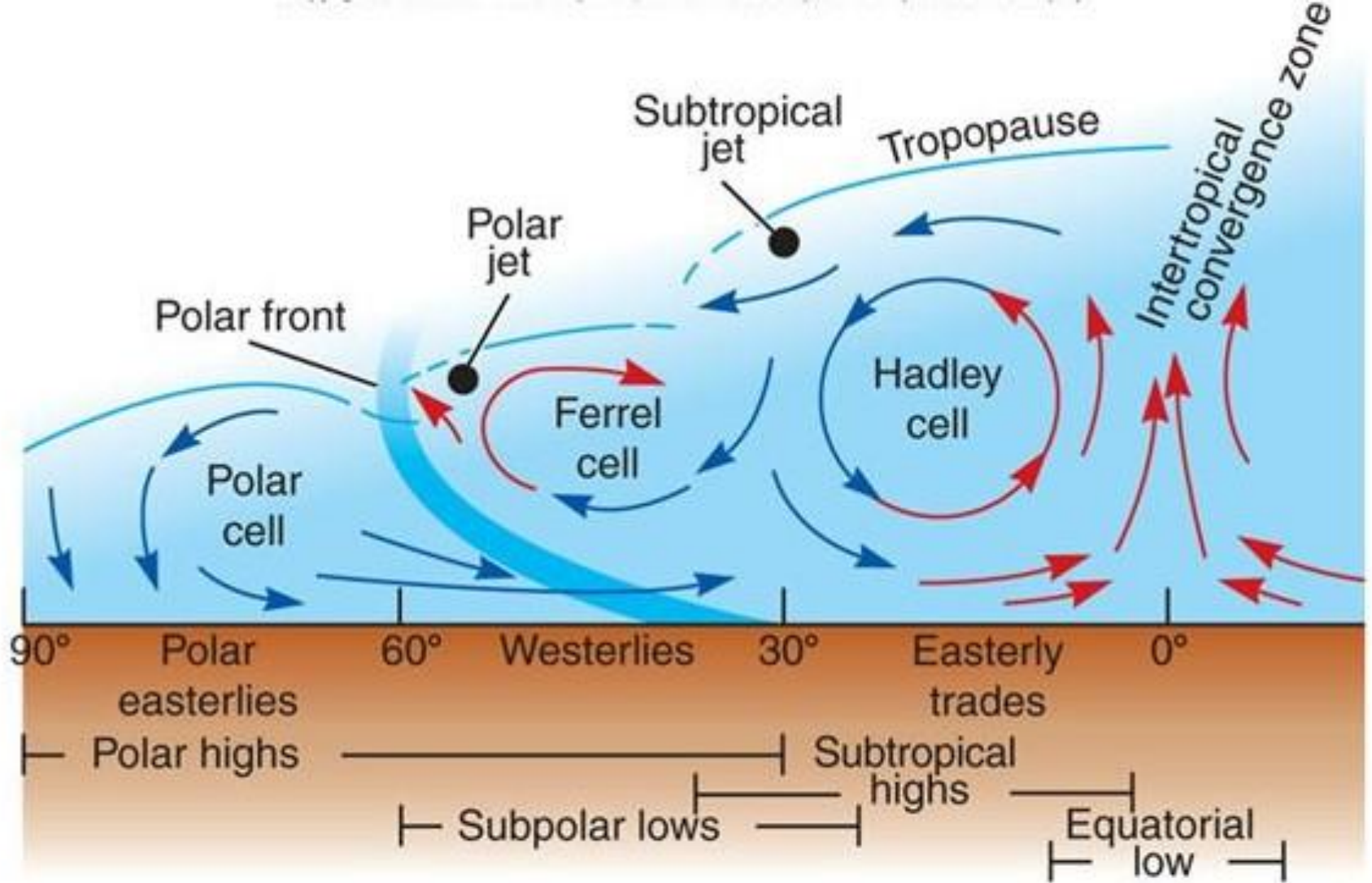
The early concept of the Hadley Cell





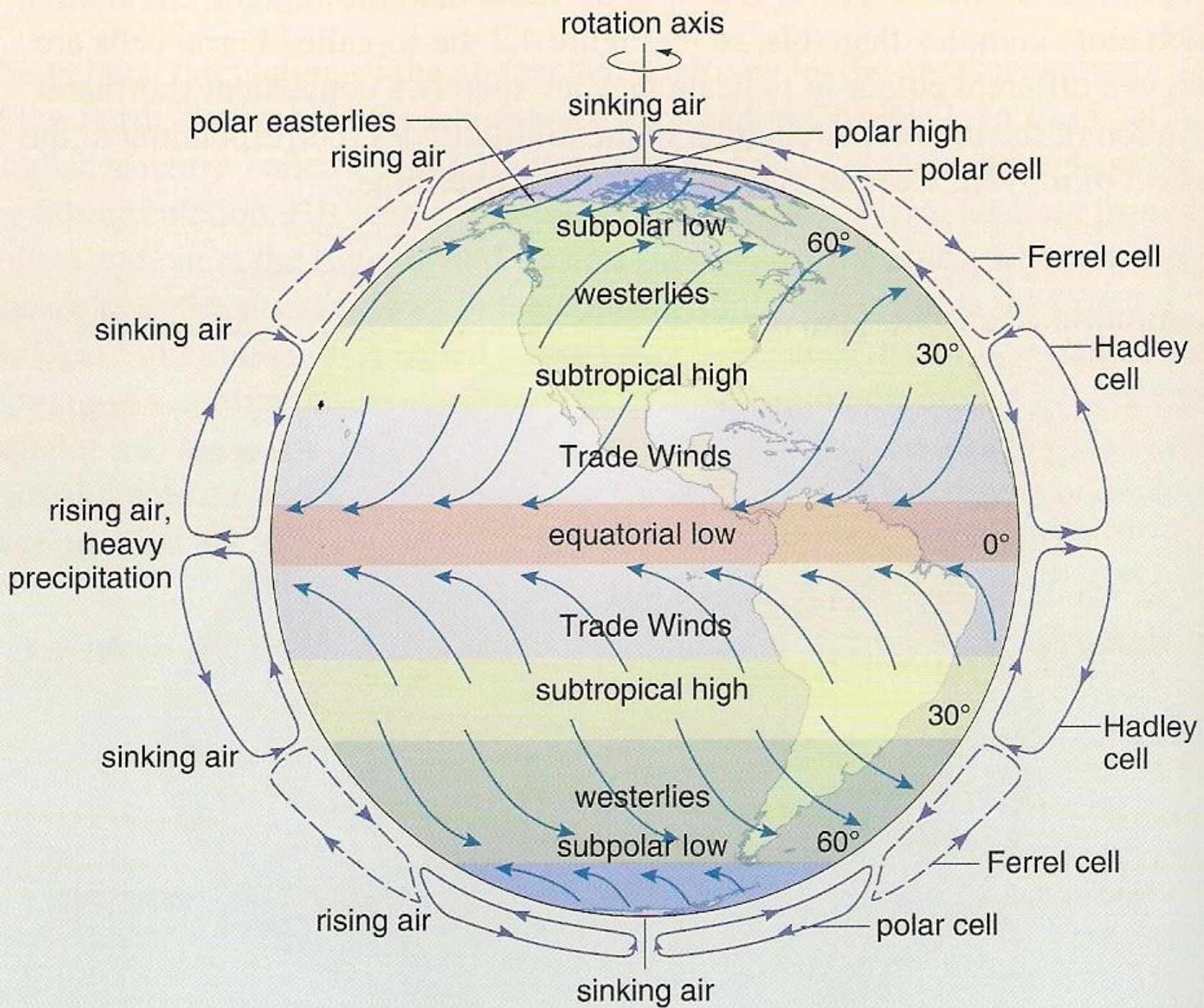
General circulation of the earth's atmosphere (Met Office, UK)

[https://www.youtube.com/watch?v=xqM83\\_og1Fc](https://www.youtube.com/watch?v=xqM83_og1Fc)

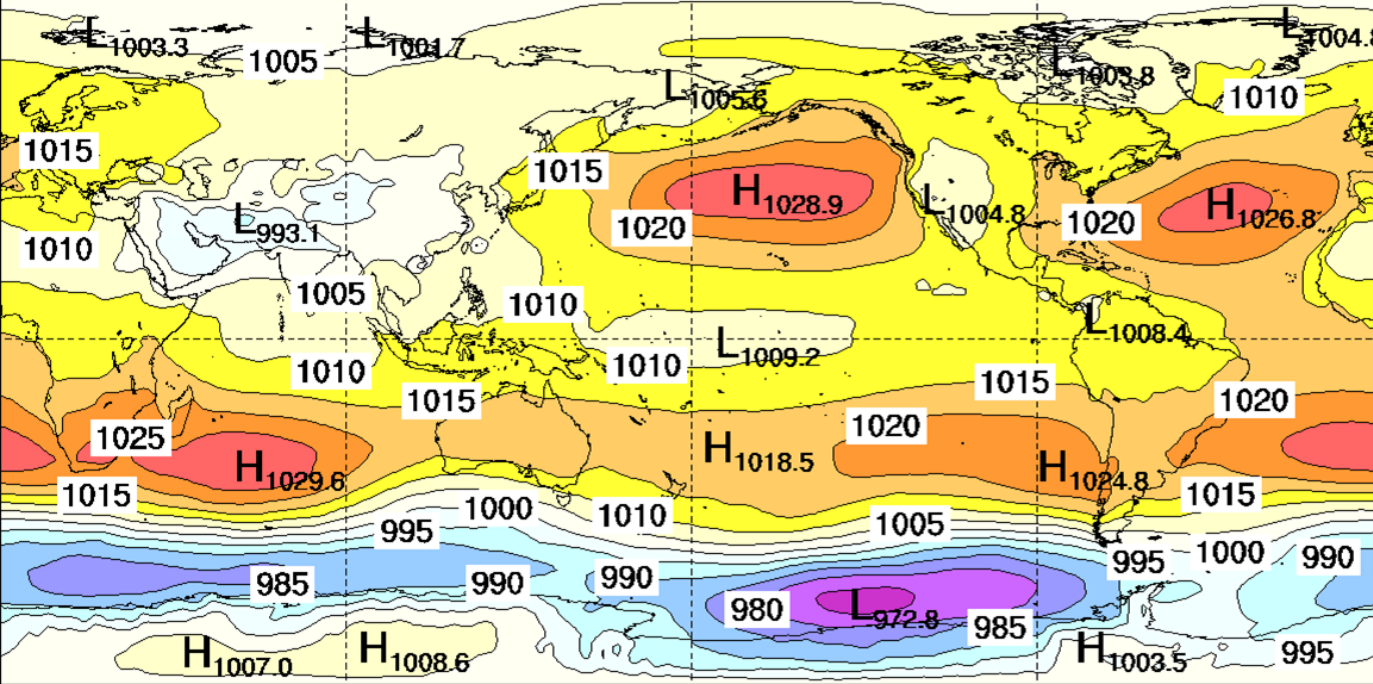


The **Ferrel cell** is really a statistical average of the lows and highs in the zone of westerly winds.

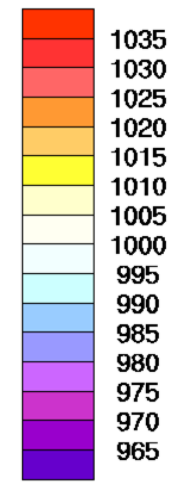






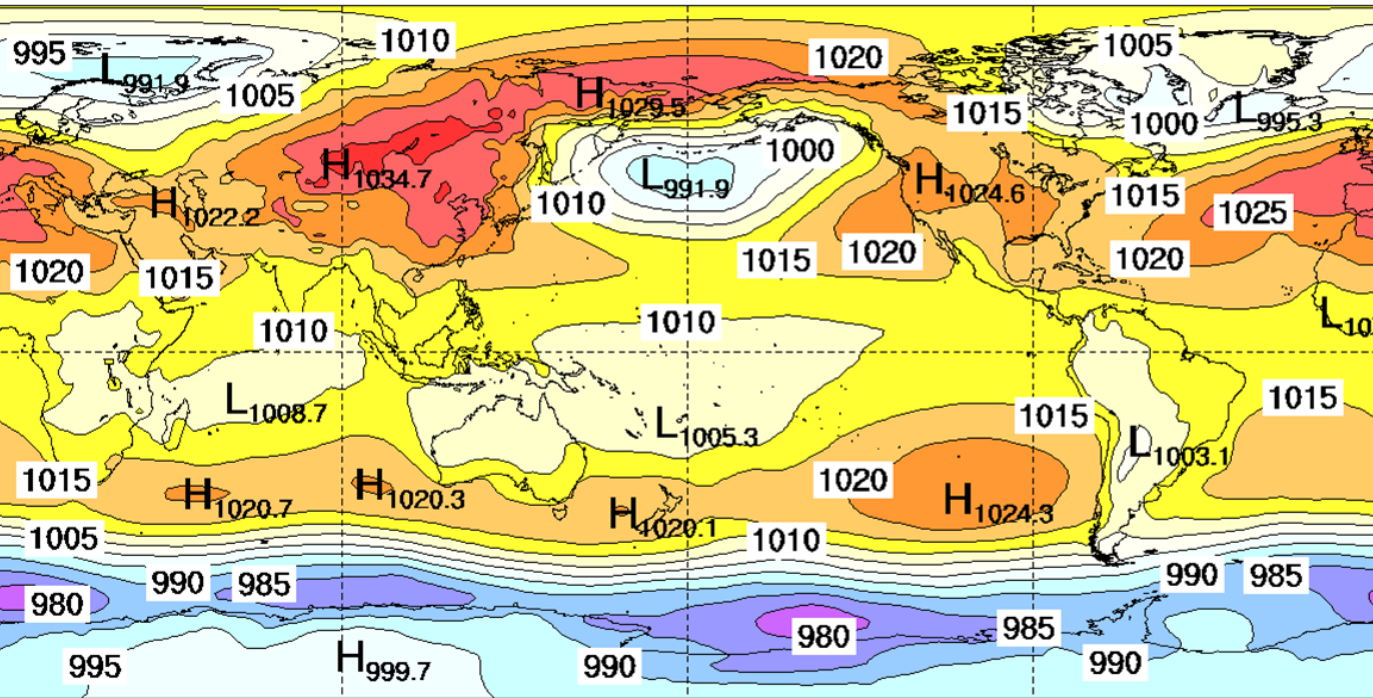


# July 2021

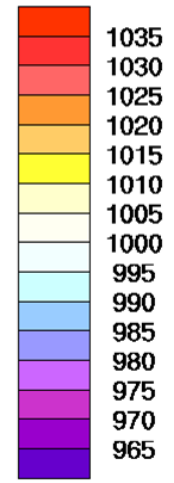


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Issued: 01/08/2021

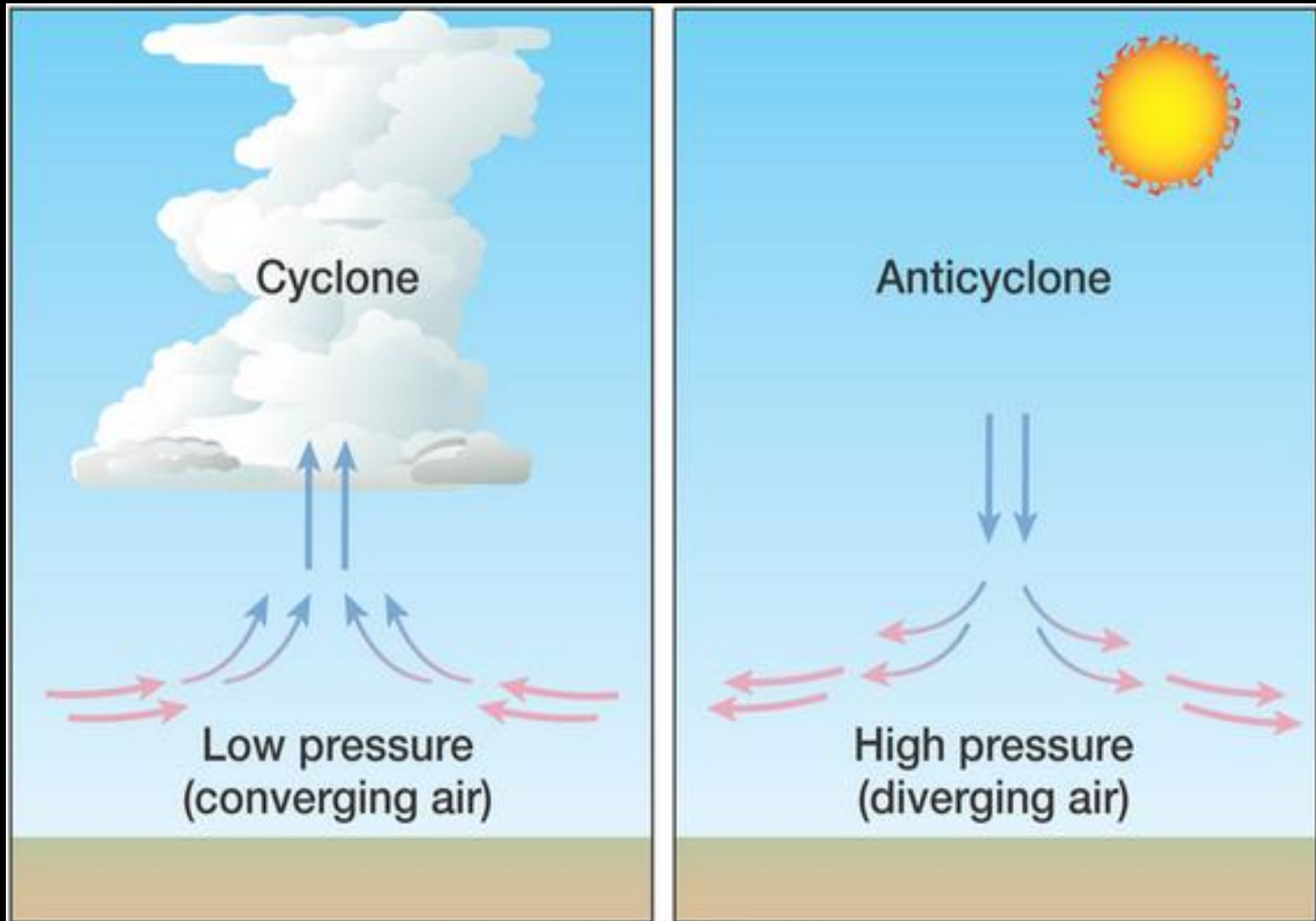


# January 2022



# Wind

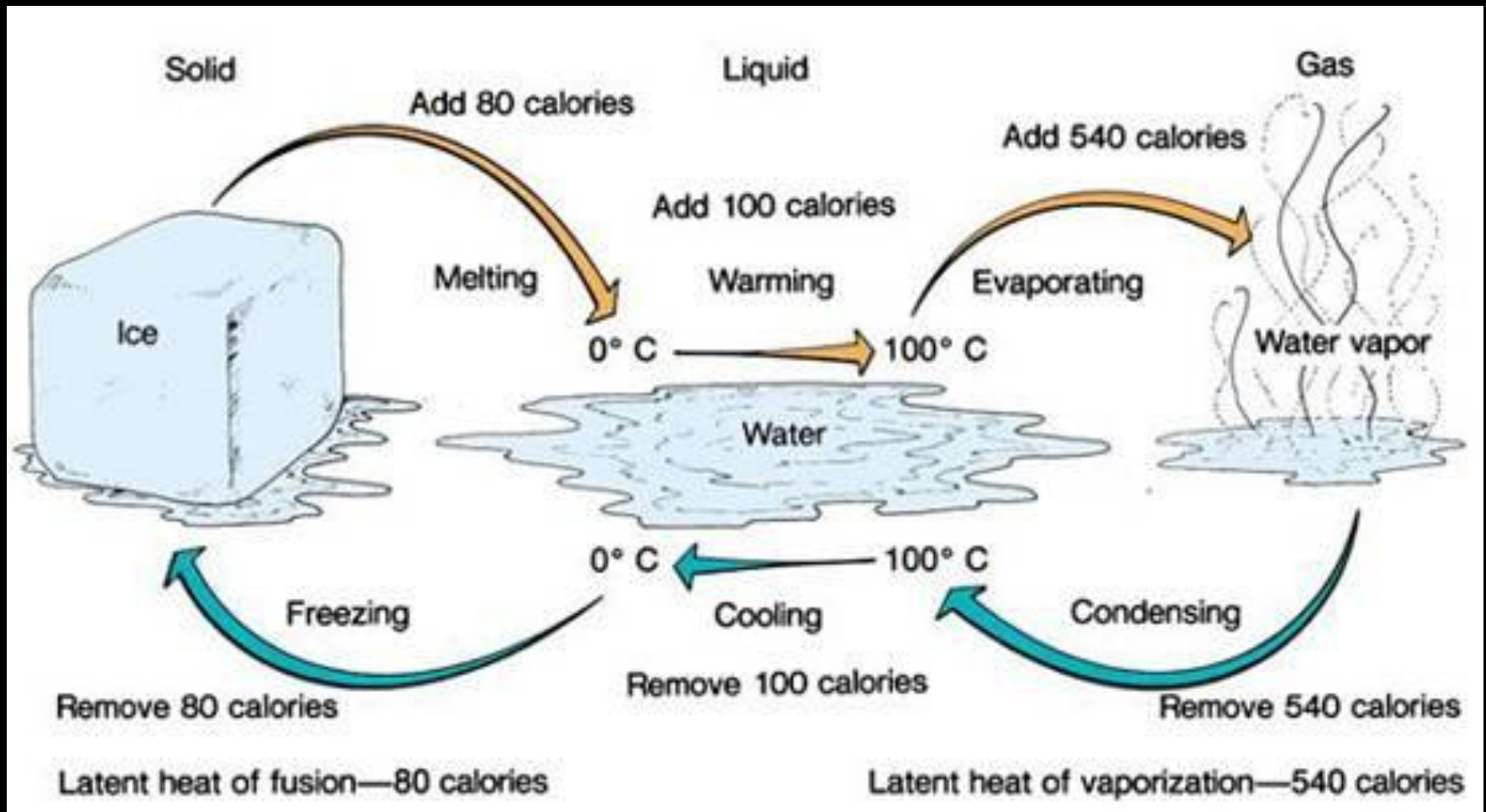
Air moves from areas of high pressure, to areas of low pressure



# Concept of water vapour as fuel for cyclones and storms

Phase changes are important:

Condensation of water vapour to water or ice releases heat in clouds and rain

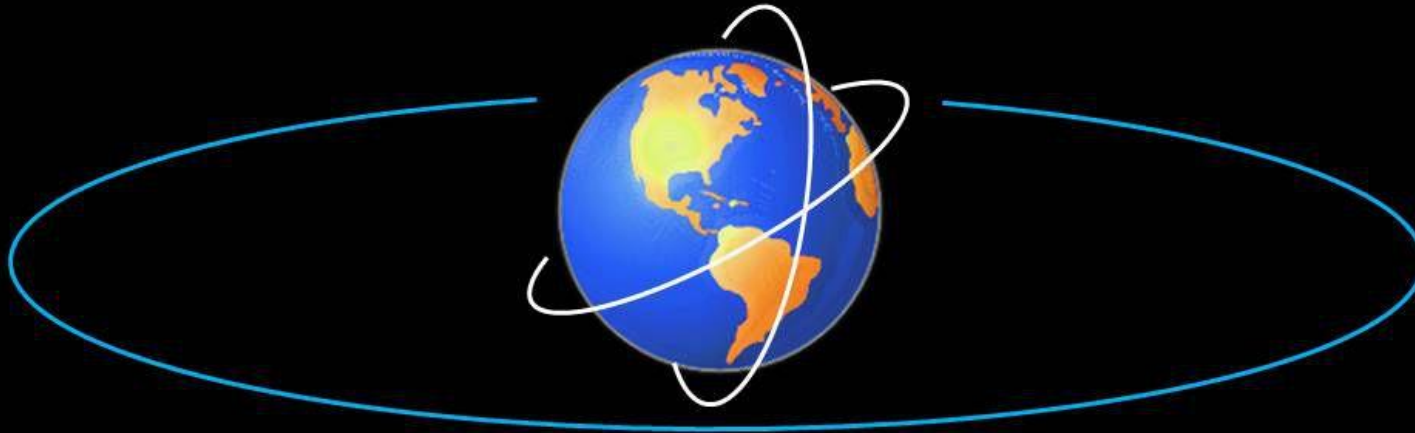




Low Earth Orbit (LEO)

Altitude: 200-2000 km

Satellites travel faster than Earth



A geosynchronous satellite  
above the Equator is  
**geostationary**

Geo Synchronous Orbit (GEO)

Altitude: 35,786km

Satellite speed same as Earth – 24hrs

- A “geostationary” satellite is travelling at 9400 km/hour around the earth.
- Distance to moon: 360,000 – 400,000 km
- There are over 500 geostationary satellites at present!

# Clouds

**The first widely accepted classification – Luke Howard (1803) . It was regarded as the beginning of the formal science of meteorology and Howard is sometimes regarded as “the father of meteorology”**

**Originally had four primary terms (although terms could be combined):**

- **Cirrus (‘curl of hair) for wispy clouds**
- **Stratus (‘layer’) for horizontal sheet-like clouds**
- **Cumulus (‘heap’) for puffy clouds**
- **Nimbus (‘rain’) for rain-bearing clouds**

**Its success was due to use of the universal Latin and his adaptation of the biological (Linnaen) nomenclature – genera, species, varieties**

**1887 – modified to allow for height of cloud – ‘alto’ added for middle level clouds**

**1896 – first International Cloud Atlas**

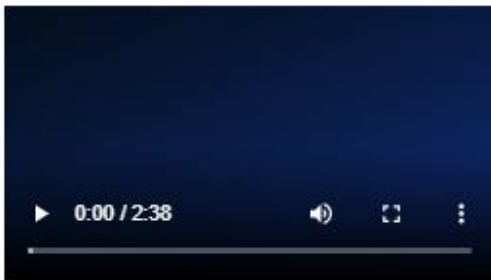
**2017 revised International Cloud Atlas (World Meteorological Organization)**





## International Cloud Atlas Manual on the Observation of Clouds and Other Meteors (WMO-No. 407)

Welcome to the official site of the World Meteorological Organization's (WMO) International Cloud Atlas. This Atlas describes the classification system for clouds and meteorological phenomena used by all WMO Members. The classifications also describe meteorological meteors other than clouds – hydrometeors, lithometeors, photometeors, and electrometeors. [Read More](#)



<https://cloudatlas.wmo.int/en/home.html>

## Useful concepts

(Section 2.2.1)

### Height, altitude, vertical extent

(Section 2.2.1.1)

- Height: Vertical distance from the point of observation on the Earth's surface to the point being measured.
- Altitude: Vertical distance from mean sea level to the point being measured.
- Height/Altitude of cloud base: For surface observations, height of the cloud base above ground level; for aircraft observations, altitude of the cloud base above mean sea level.
- Vertical extent: Vertical distance from a cloud's base to its top.

### Levels

(Section 2.2.1.2)

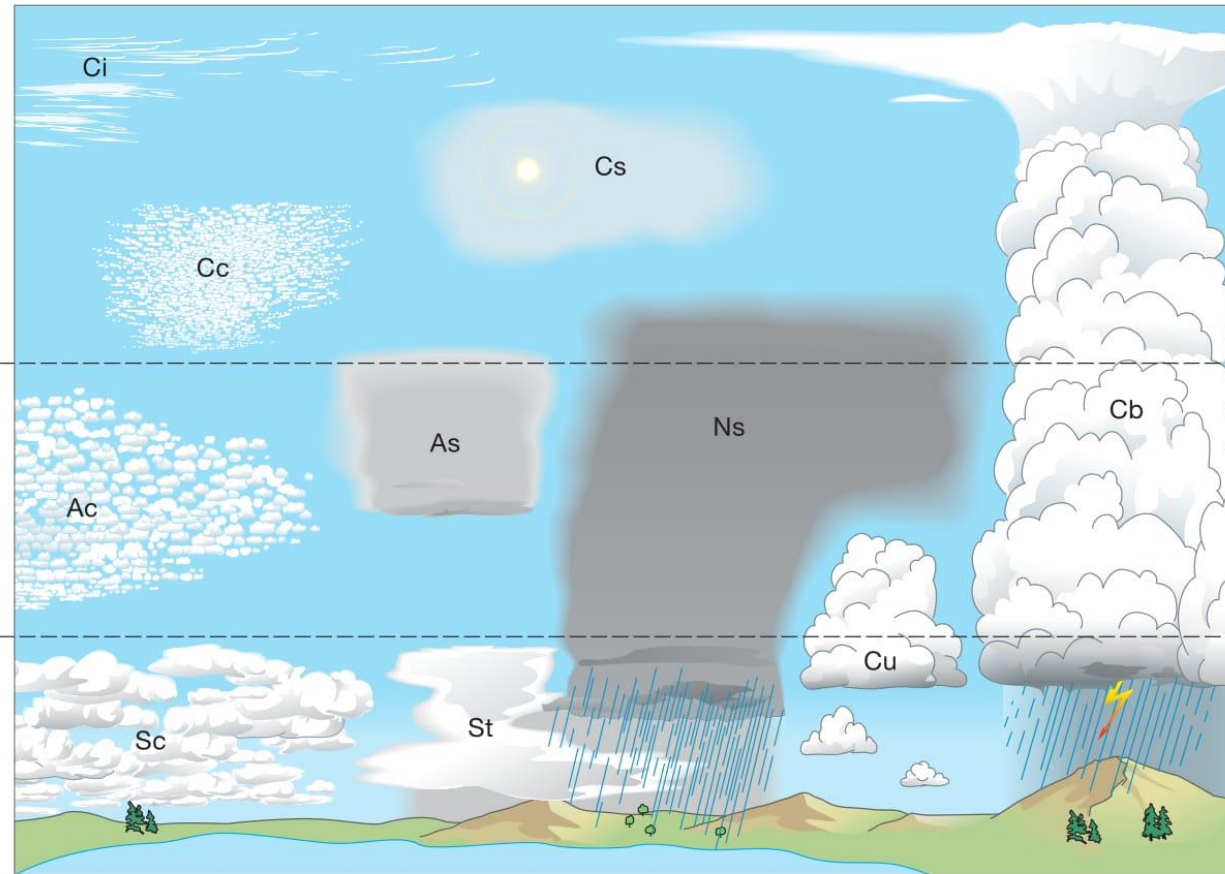
Clouds are generally encountered over a range of altitudes varying from sea level to the top of the troposphere (the tropopause). The troposphere can be vertically divided into three levels, formerly known as "étages": high, middle and low. Each level is defined by the range of heights at which clouds of certain genera occur most frequently. The levels overlap and their limits vary with latitude (see table 6 and figure 1).

Table 6. Approximate heights of each level, and the genera occurring in each.

Level	Genera	Polar region	Temperate region	Tropical region
High	Cirrus Cirrocumulus Cirrostratus	3 – 8 km (10 000 – 25 000 ft)	5 – 13 km (16 500 – 45 000 ft)	6 – 18 km (20 000 – 60 000 ft)
Middle	Altostratus Altostratus Nimbostratus	2 – 4 km (6 500 – 13 000 ft)	2 – 7 km (6 500 – 23 000 ft)	2 – 8 km (6 500 – 25 000 ft)
Low	Stratus Stratocumulus Cumulus Cumulonimbus	From the Earth's surface to 2 km (0 – 6 500ft)	From the Earth's surface to 2 km (0 – 6 500ft)	From the Earth's surface to 2 km (0 – 6 500ft)

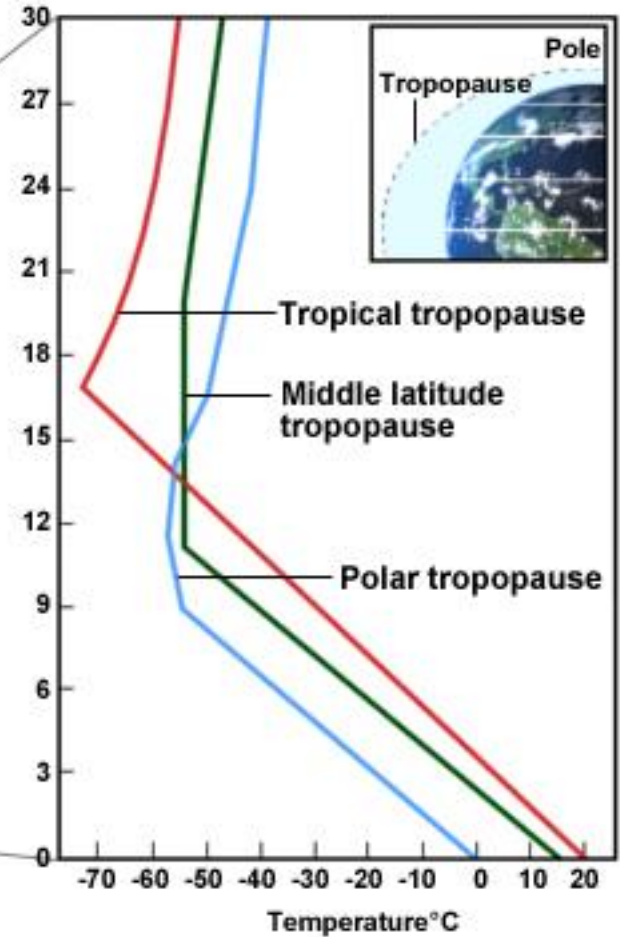
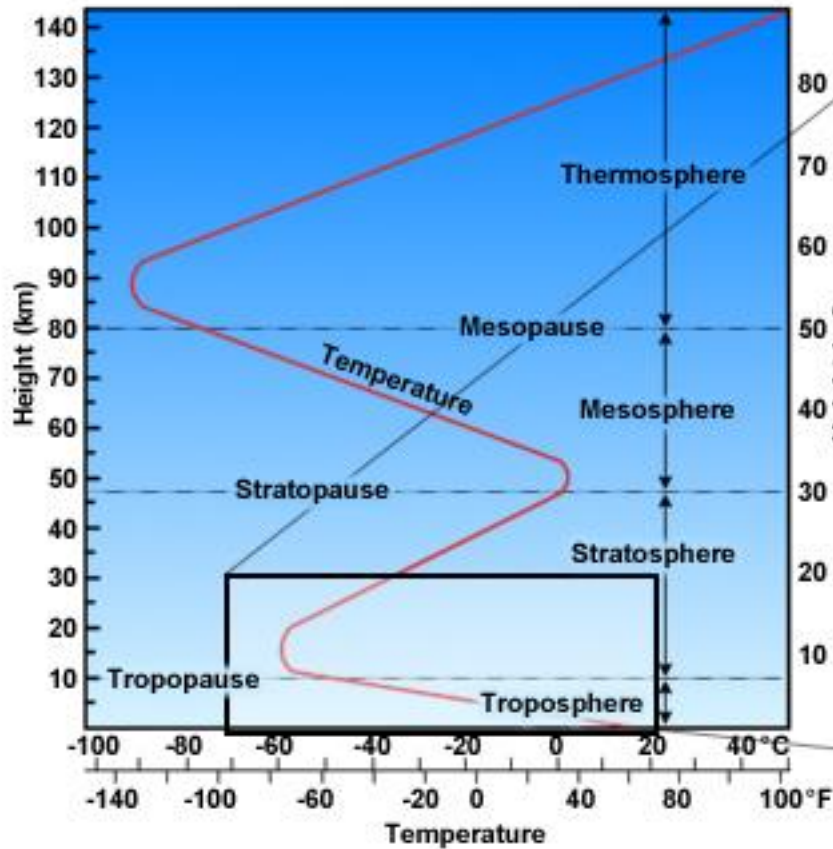


# Cloud Genera



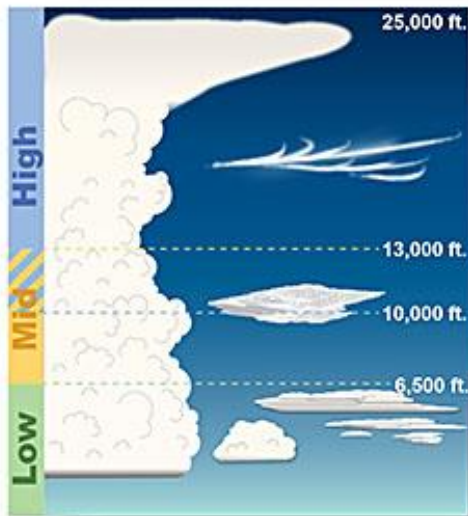
<i>Level</i>	<i>Genera</i>
<b>High</b>	Cirrus Cirrocumulus Cirrostratus
<b>Middle</b>	Altostratus Altostratus Nimbostratus
<b>Low</b>	Stratus Stratocumulus Cumulus Cumulonimbus

# Vertical structure of the atmosphere

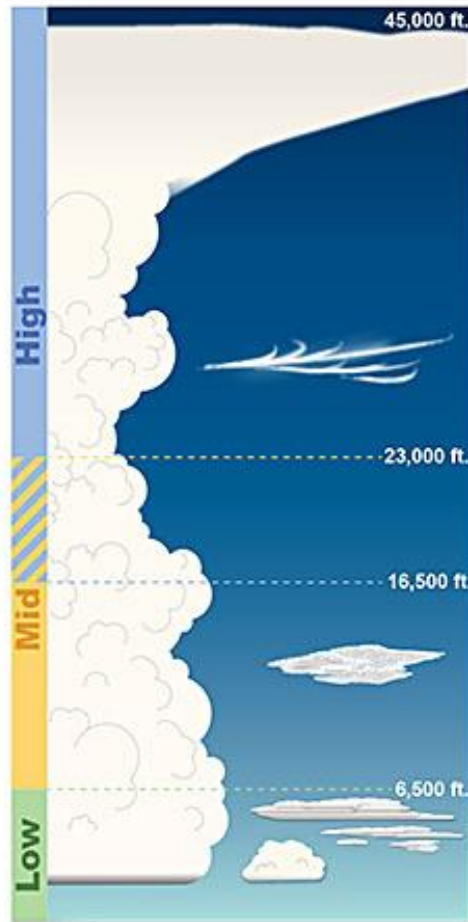




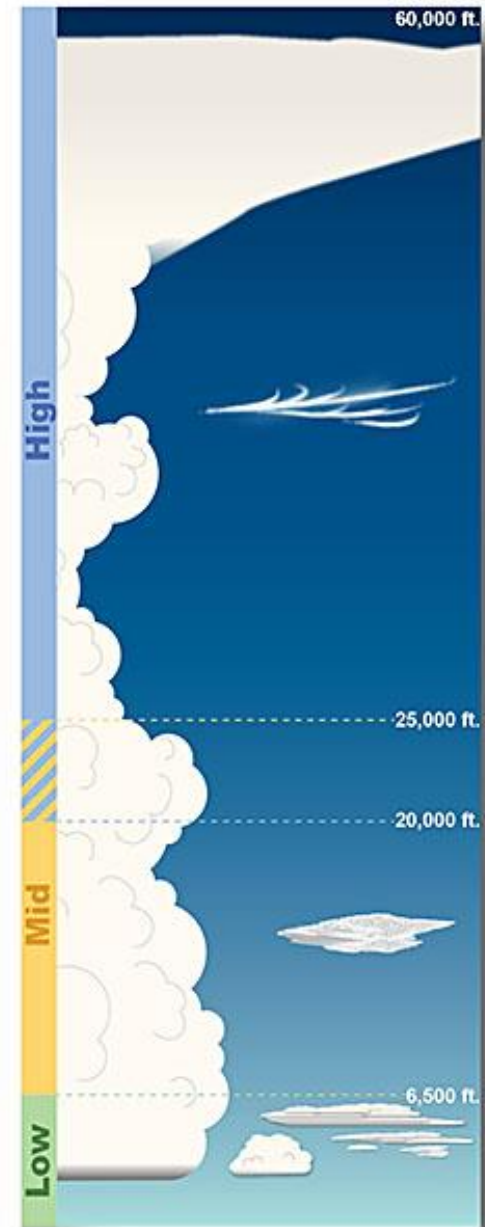
# Cloud Height



Polar Regions

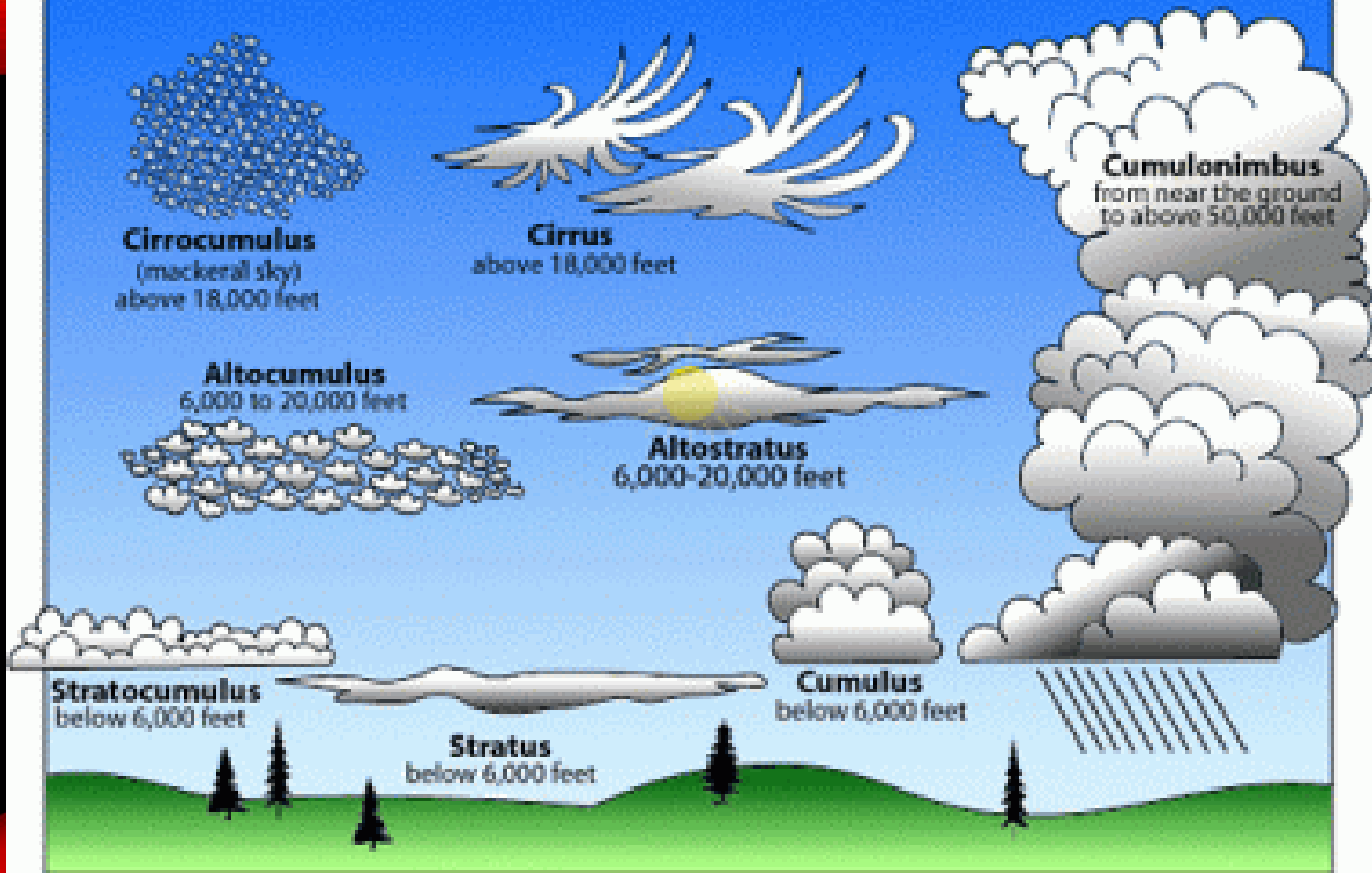


Temperate Regions



Tropical Regions

## Common types of clouds in the troposphere



Video: [A tutorial on cloud types. US NWS](https://www.youtube.com/watch?v=FMagDRCpJ14)

<https://www.youtube.com/watch?v=FMagDRCpJ14>



# Cloud classification and images

Acknowledgements:

Peter Jackson (U3A Geology)

# High level clouds



Cirrus

## Cirrus (Ci)

- Most common high level clouds
- thin white wispy clouds often with hook shape
- strands in tufts called 'mares tails'
- composed of ice crystals formed from super-cooled water droplets
- appear in advance of a low pressure area .



Cirrostratus

## Cirrostratus (Cs)

- Thin, sheet-like clouds composed of ice crystals
- can be 100 metres or more thick but are translucent
- sometimes only obvious by presence of halo around the sun or moon



# High level clouds



Cirrocumulus

## Cirrocumulus (Cc)

- Layered clouds composed of rounded puffs usually in rows
- if extensive, forms 'mackerel sky'
- composed of highly super-cooled droplets, ice crystals or both
- form by shallow convection and small-scale turbulence within moist air

# Low level clouds



Cumulus

## Cumulus (Cu)

- Detached, low level clouds, clear outline
- cauliflower or cotton-like appearance
- flat bases mark the condensation level
- show vertical motion or thermal uplift of air taking place
- may extend to middle level and produce showers.



Cumulonimbus

## Cumulonimbus (Cb)

- Massive, dense, towering clouds commonly with anvil shaped tops
- bases 200-3000m, tops normally ~6000m but can be up to 23,000m
- associated with severe weather (squall lines, thunderstorms, tornadoes)
- occur individually or in clusters
- particularly common in the tropics



# Low level clouds

## Stratus

- Featureless low altitude clouds with diffuse edges
- essentially above ground fog
- form when moist air lifts and expands,
- Can be associated with fronts and rain



Stratus and nimbostratus

## Nimbostratus

- Thick sheets of low to middle level clouds
- associated with persistent rain



Stratocumulus

## Stratocumulus

- Appear as lumpy shallow clouds
- may appear as rounded masses or rolls
- form in weak convective currents with an overlying inversion or stable layer that inhibits vertical development.

# Middle level clouds



Altostratus bands



Altostratus castellanus

## Altostratus (Ac)

- Characterised by globular masses or rolls in layers or patches
- form by convection or wave propagation
- towering altostratus castellanus may indicate impending thunderstorms

# Middle level clouds



Altostratus

## Altostratus (As)

- Featureless, stratiform middle-level cloud
- commonly translucent
- composed of ice crystals or water droplets
- associated with fronts where it can thicken to nimbostratus
- may occur with underlying altocumulus



Altocumulus and altostratus



# Cloud species

Species	Description	Cloud types
calvus	tops of clouds rounded, smooth	Cb
capillatus	cloud tops with anvil or plume	Cb
castellanus	turrets rising from broad base	Cc, Ac, Sc
congestus	huge, towering, base width < height	Cu
fibratus	fibrous appearance	Ci, Cs
floccus	small tufts, like flock of sheep	Cc, Ac
fractus	broken	St, Cu
humilis	low base width < height	Cu
lenticularis	lens shaped	Cc, Ac, Sc
mediocris	moderate base width $\approx$ height	Cu
nebulosis	fog, veil like	Cs, As
spissatus	dense	Ci
stratiformis	layered	Cc, Ac, As, Sc
uncinus	hooked, comma shaped	Ci

# Cloud species



*Cumulus humilis*



*Cumulus mediocris*



*Cumulus congestus*



*Cumulonimbus calvus*

# Cloud species



Cumulonimbus capillatus



Stratus fractus



Altocumulus castellanus



Altocumulus floccus



# Cloud types



*Altostratus lenticularis*



*Altostratus stratiformis*



*Cirrostratus nebulosus*



*Cirrus uncinus*

# Cloud phenomena



## Lenticular clouds

- Form through convection or turbulence
- occur in crests of waves in rising layers separated by sinking layers



## Mammatus clouds

- Pattern of pendant pouches at the base of some Cb
- indicate instability, turbulence, impending storm activity



# Cloud phenomena



## Hole punch cloud

- Large circular gap that can appear in cirrocumulus or altocumulus clouds
- holes form when water droplets are unfrozen because of a lack of ice nucleation particles
- when ice particles do form, it sets off domino effect due to Bergeron process



## Contrails (condensation trails)

- Clouds that can form by condensation around nuclei from aircraft exhaust
- also triggered by decompression (wing tip vortices, flow over wing)
- occur when atmosphere near saturation



# Cloud phenomena



## Nacreous clouds

- Also known as polar stratigraphic clouds
- have white iridescent lustre
- form in lower stratosphere (15 - 25km)
- mainly visible just prior to dawn or after sunset in polar winter



## Noctilucent clouds

- Form in the mesosphere 76-85km above Earth
- thin wispy clouds formed of ice crystals at temperatures  $< -120^{\circ}\text{C}$
- visible at night when sun is below horizon
- generally only visible in summer at high latitudes

# Kelvin - Helmholtz wave clouds

- Form across an interface between moving layers of air of differing velocities (wind shear)
- form on windy days when there is a density difference in the air often associated with a temperature inversion
- observed on other planets e.g. Jupiter, Saturn



Kelvin-Helmholtz  
wave clouds

# Broken Hill 2019





Why are there clouds?

[https://youtu.be/QC2x\\_RRnk8E](https://youtu.be/QC2x_RRnk8E)

How do clouds float?

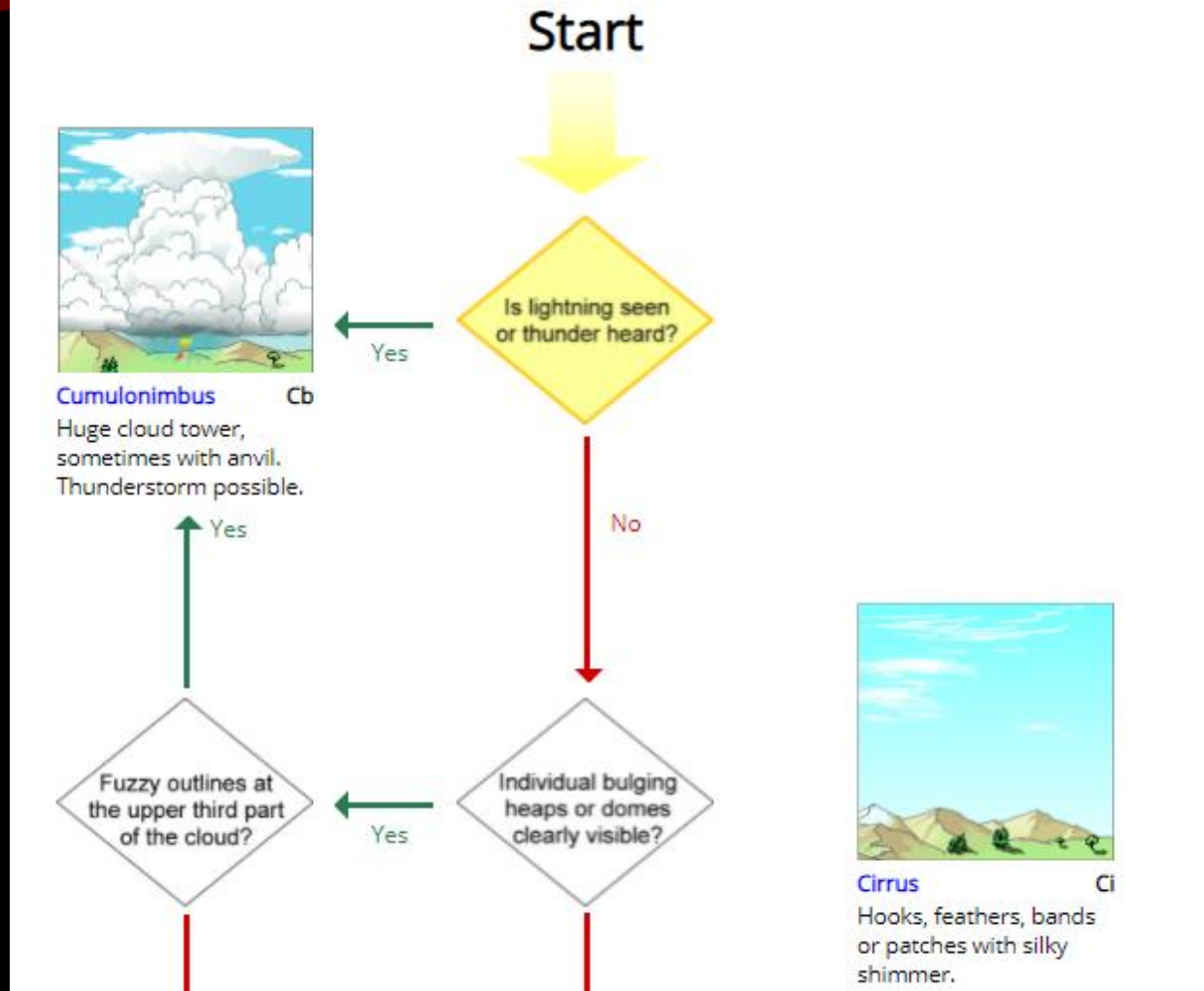
<https://www.youtube.com/watch?v=bjZ-vVOeeRk>

Helpful ABC On-line article

<https://www.abc.net.au/news/2020-04-20/a-guide-to-what-each-cloud-formation-means-for-weather/12157826>

## Cloud identification guide

[Click here to download cloud identification guide](#)



<https://cloudatlas.wmo.int/en/cloud-identification-guide.html>



Cumulus congestus – with shower/downburst Normanton, Queensland

BoM Weather calendar – February 2022





Mammatus clouds – Daylesford, Victoria  
(taken during thunderstorms November 2020)

BoM Weather calendar – March 2022



Altocumulus stratiformis opacus asperitas - Strathgordon, Tasmania  
(new type of cloud added to the WMO International Cloud Atlas in 2017)  
BoM Weather Calendar – April 2022





Thunderstorm – Gunn Point, NT

June 2022





Supercell thunderstorm - Gympie, Qld.

July 2022

THE SUNDAY TIMES BESTSELLER

# The Cloudspotter's Guide

Gavin Pretor-Pinney

'A lovely book, the sort that  
everybody should have in the car  
or on the kitchen windowsill'  
*Daily Telegraph*

Cloud Appreciation Society

<https://cloudappreciationsociety.org/>



# The Cloud Appreciation Society



## OUR CLOUD-A-DAY APP



Hone your cloudspotting skills and use the power of AI to identify the main cloud types with our app, **Cloud-a-Day**.

and see how we are fighting the banality of 'blue-sky' and for, then **join the society** to get your very own **Selector** and to start receiving your 'Cloud-a-Day'

© Pauline Kirby

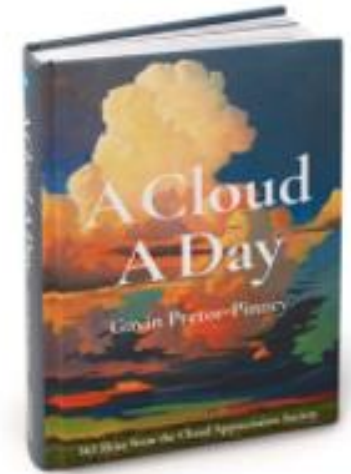
## SOCIETY MEMBERSHIP



Join the Cloud Appreciation Society or join a friend:  
**BUY a membership.**



**RENEW a Membership.**



**A Cloud A Day** is our newest book, beautifully illustrated with 365 skies from members around the world. It will teach you about the sky in a fun and uplifting way, and it will inspire you to spend a moment each day with your head in the clouds.

<https://cloudappreciationsociety.org/>



# Clouds

Rows and floes of angel hair  
And ice cream castles in the air  
And feather canyons everywhere  
I've looked at clouds that way

But now they only block the sun  
They rain and snow on everyone  
So many things I would have done  
But clouds got in my way

*Both Sides Now*, Joni Mitchell