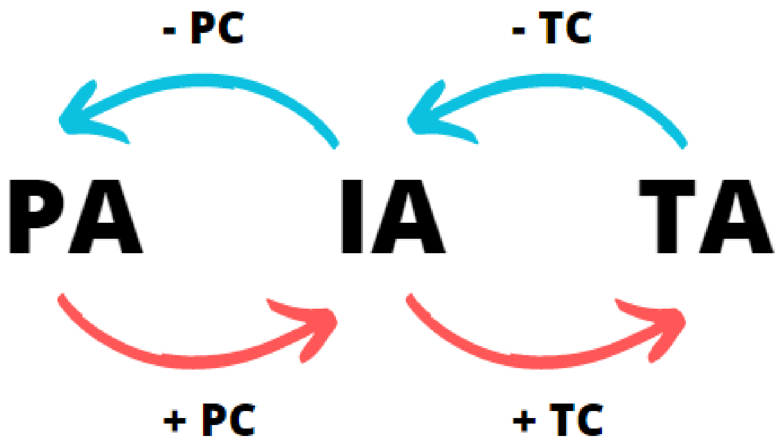
Meteorology

Altimetry

[PC] Pressure correction = 30 * (QNH-1013)
[TC] Temperature correction = ± 4% every ± 10° C (AGL/AAL, so use IA – altitude of the AD to correct TC)
For TC use: true altitude – met station elevation

PA = pressure altitude (FL)
IA = indicated altitude (altimeter)
TA = true altitude (AGL)



QNH = QFE = QFF when at MSL

QNH = (Elevation/27ft) + QFE | highest QNH with lowest QFE and highest elevation

QNH = QFE reduce to MSL using the standard atmosphere
QFF = QFE reduce to MSL using the actual atmosphere

QNH (Airfield elev.) x (ISA dev)

(+) (+) and (-) (-) = (+) (QNH > QFF) *QFF is lower than QNH

(+) (-) and (-) (+) = (-) (QNH < QFF) * QFF is greater than QNH

Buy Ballot law:

- **North hemisphere**: with the **wind on your back**, **low pressure** is on the **LEFT**
- **South hemisphere**: with the **wind on your back**, **low pressure** is on the **RIGHT**

The atmosphere

Low pressure = Cyclone | High pressure = Anticyclone

Conduction: Ground heats the air directly [GND level]
Convection: Hot air rises, cool air replaces it, creating a circulation [greatest at mid altitude during summer in afternoon]
Advection: Air moves horizontally, carrying its heat with it

Low – Mid level heat transfer: conduction and turbulence

High level heat transfer: Terrestrial Radiation

The absence of regular convection in the stratosphere due to warmer layers higher up and cooler ones lower down, makes it generally turbulence free.

Earth is warmed up from above by insolation

Earth atmosphere is warmed up by infrared radiation emitted from below by the Earth surface

Clouds by day reflect solar radiation and by night absorb infrared radiation emitted by Earth surface

Inversion: where the temperature increases with an increase in altitude (in the troposphere)

Warm air + valley = inversion | Clear night + terrestrial radiation = inversion

Subsidence inversions and radiation inversion occur in high pressure systems (northern continents in winter and over subtropical oceans)

Ozone may be present at cruise altitude in concentrations potentially hazardous to crew and pax (aircraft have ozone filters).

Ozone resides in the stratosphere between the top of the troposphere and about 50 km altitude

The temperature increase in the stratosphere is mainly due to the absorption of UV radiation by ozone molecules, which leads to the production of heat.

Short-wave radiation from The Sun heats the Earth, and the Earth loses its heat through long-wave radiation

Isobars on a Surface weather chart represent lines of equal pressure reduced to sea level

Atmospheric heating occurs below the tropopause due to the greenhouse effect, which traps infrared radiation

Tropopause is higher in summer than in winter season and has a significant change in temperature lapse rate

Warming is greatest (at the same latitudes) above rocks or sand and lowest above the seas

Air pressure 50% at FL 180 | Air density 50% at FL 220

Tropopause height (ft) = (16 x cos Lat) x 3 280

- Over land for winter = subtract 3 000 ft
- Over land in summer = add 3 000 ft

Altitude [FL]	Air pressure [mmHg]
50	800
100	700
150	600
200	500
250	400
300	300
350	250
400	200

The tropopause is not always one continuous surface

Tropopause Poles: 25000-35000 ft [8 km] | T = -50°C

Tropopause mid latitudes: 35000-40000 ft [11 km] | T = -56.5 °C

Tropopause equator: 50000-60000 ft [16 km] | T = -75°C

Tropopause break are useful as jet stream core may be located near them

Stratosphere (the layer above the tropopause) is absolutely stable and generally turbulence free (clouds may exist)

The lower part of the stratosphere (up to FL650) has a constant temperature. It is higher in summer and lower in winter

Lowest temperature over land is 30 minutes after sunrise

Thermodynamics

Humidity

Relative humidity describes the amount of water vapor held by a given quantity of air.

Relative Humidity = 100 - 5 x (Temperature - Dew Point)

Air Temperature ↑, Relative Humidity ↓ (air capacity to hold water increases), Dew point = constant

Dew point is the temperature at which the relative humidity reaches 100% (the temperature at which saturation occurs)

Dew point ↓ when Altitude ↑

Dew point is higher over ice than over water

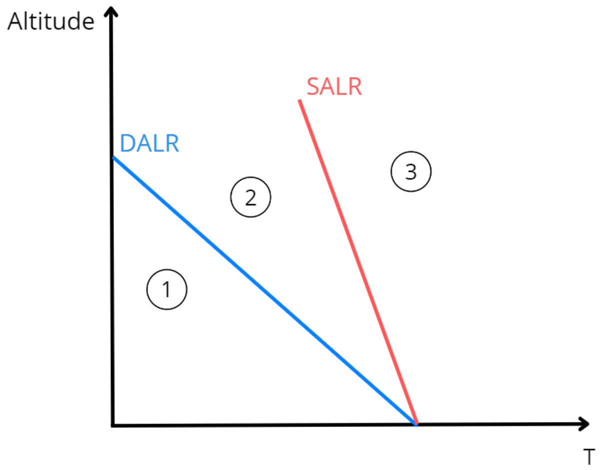
Water vapor pressure is higher over water than over ice

If an air parcel is saturated and temperature decreases (V=constant), air condenses so the amount of water vapor decreases and dew point decreases (the actual water vapor content decreases to remain equal to the saturated water vapor content)

The amount of water vapor at saturation increases exponentially with an increase in temperature.

The approximate distribution of water vapor is almost 0 g/m^3 at the polar caps and as much as 25 g/m^3 at the equator.

% of air in the lower troposphere consisting of water vapor: 0-5%



Change of state of water

Condensation nuclei (micrometric solid and liquid particles) contributes to initiate the condensation process

Sublimation is both solid to gas directly and vice versa [According to EASA]

Dry adiabatic lapse rate = **DALR** = 3°C/1000 ft | 1°C/100 ft

Saturated adiabatic lapse rate = **SALR** = 1.8°C/1000 ft | 0.6°C/100 ft

Environmental lapse rate = **ELR** = 2°c

3) Absolute Stability: ELR < SALR |ELR < DALR (ex. 1°C/1000 ft)

Neutral Stability: ELR = DALR or ELR = SALR

1) Absolute Instability: ELR > DALR (ex. 4°C/1000 ft)

2) **Conditional Stability**: DALR > ELR > SALR

Isothermal layer (stable): ELR = 0°C/1000 ft

If air is saturated and temperature ↓, water vapor is released and its pressure ↓

At very high altitudes, temperature is really low and there’s low humidity → SALR ≈ DALR (in cirrus cloud)

Processes **increasing** atmospheric **stability** (low visibility at low level): WOC - Warm over Cold [Inversion]

Processes **decreasing** atmospheric **stability** (good visibility at low level): COW - Cold over Warm [Convection]

Air masses and Fronts

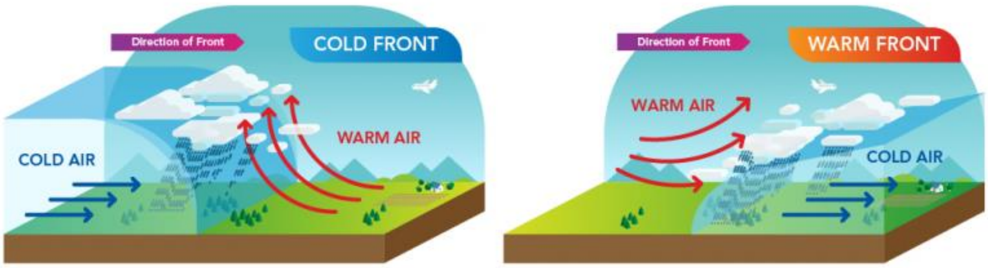
Types of air masses:

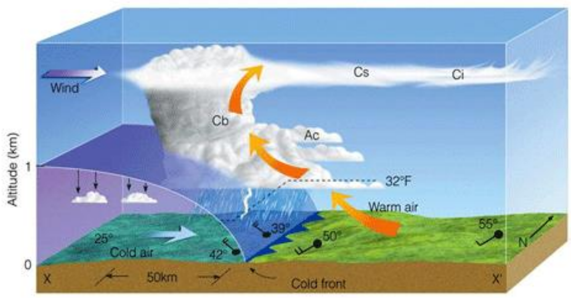
- Artic Maritime: Stable, very cold and dry
- Polar Maritime: Stable, cold, absolute humidity low, relative humidity high
- Polar Continental: Stable, very cold and dry (colder than artic maritime)
- Tropical Maritime: Warm, stable, absolute humidity high, RH high
- Tropical Continental: Warm, dry, stable

Tropical air may have cold air mass temperature and humidity properties

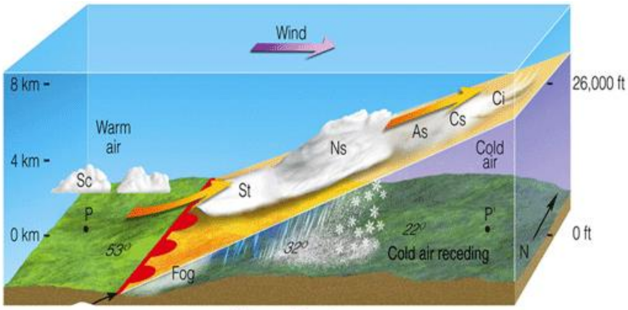
Regarding stability, all air masses are stable at source

Wind over land backs (counterclockwise) in direction (a wind from NW over land backs going W)



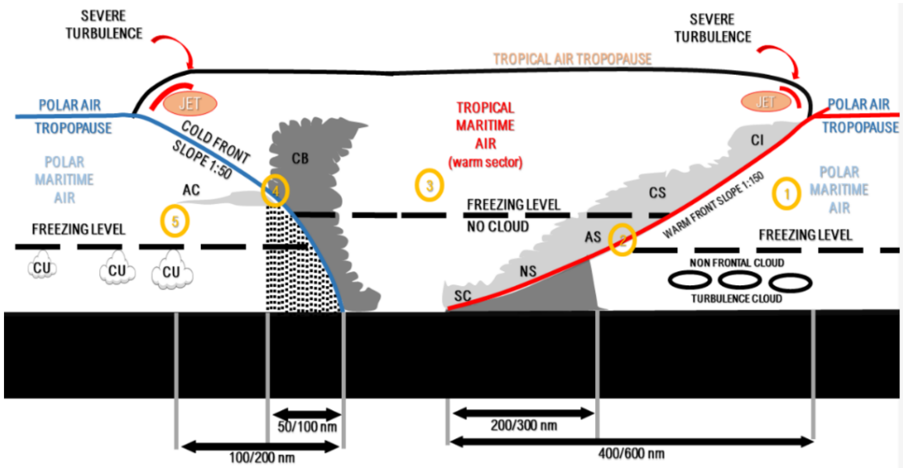


Cold Front



Warm Front

Image Curtsey: © Thomson Higher Education



Warm front 

Average slope: 1:150 | Speed ~ 10 kts | 800 – 300 rule

Winds: from S to SW ↗ | T ↑ dew point ↑ QNH ↓

Slower than the cold front

Rain belt: 200 – 300 NM

In winter: often accompanied by dense fog, low cloud ceiling and freezing drizzle at surface (FZDZ at the front, -DZ in warm sector)

In summer: can sometimes produce heavy thunderstorms

Advection fog is found in advance of the front while frontal fog and stratus clouds are found after it has passed

A warm front passing a mountain range may become a front aloft (the warm front may rise above the orography without returning to the ground given its density)

Wind back slightly ahead of the front and veers after it

If a warm front is forecasted and is not possible to avoid it:

- In the planning phase: plan to pass through it in the shortest way
- In flight: orbit

Cold front 

Average slope: 1:50 – 1:80 | Speed ~ 25 kts and increasing while advancing

Winds: from NW to SE ↘ | T ↓ dew point ↓ QNH ↑

Faster than the warm front

Gusty winds

Rin belt: 50 – 100 NM

Fast cold front = inactive (more common during summer)

Slow cold front (more time to develop) = active with convective clouds, CBs, thunderstorms, precipitation and turbulence

A slow cold front over warm land in summer is more active and aggressive than a slow cold front over cold land

Prefrontal thunderstorms can occur ahead of cold fronts (due to warm unstable air ahead of the front)

Showery precipitation and CU clouds behind

If NS is present is a stable Cold front

If Cu or CB are present is an unstable cold front

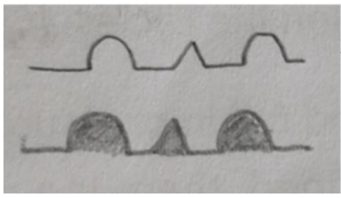
Warm sector

- Stable air (TM) in Winter with stratified clouds, drizzle, light rain and mist, but can become unstable in summer
- Isolated air mass thunderstorm (summer + continental area)
- Frontal fog
- In summer 5 – 10 km visibility

Occluded front 

If the line of the occlusion follows the warm front, it's a warm occlusion.

If the line of the occlusion follows the cold front, it's a cold occlusion.



Above the surface

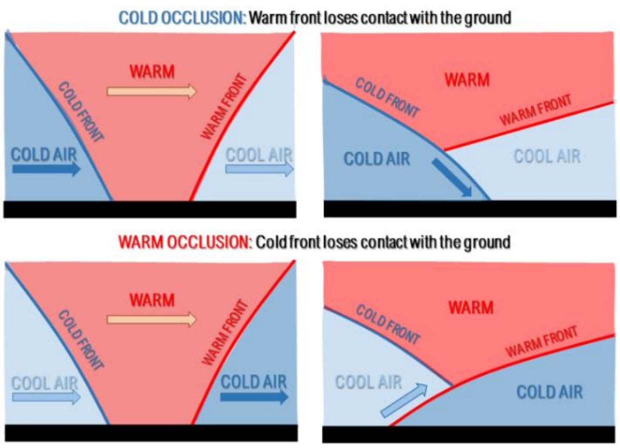
Below the surface

In Europe, we usually see **cold occlusions in Summer** and **warm occlusions in Winter** because the winds into Western Europe are from the Atlantic and, in Summer, the ground is warmer than the water, so the front sector (which has already reached ground) is warmer than the back sector (still over water).

Warm Occlusion (Cool → Colder): a cold front catches up to and overtakes a warm front. The **cold front loses contact with the ground**. The air ahead of the warm front is colder than the air behind the cold front. (the air that is pushing is the warmer)

- Warm moist and unstable air is lifted
- Extra cold front forces air upwards causing embedded CBs
- It resembles a warm front at surface level
- Embedded CB

Cold occlusion (Colder → Cool): a warm front catches up to and overtakes a cold front. The **warm front loses contact with the ground**. The air behind the cold front is colder than the air ahead of the warm front.



Stationary front (also valid for Quasi stationary front)

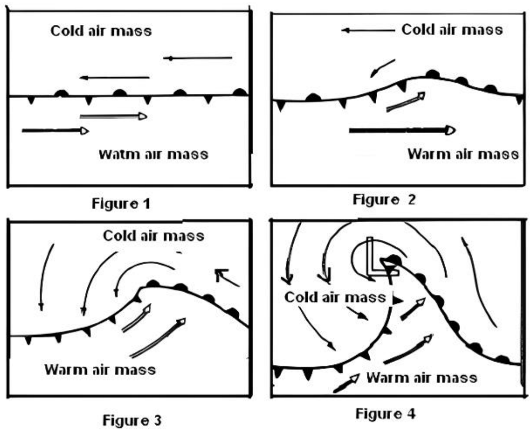
It forms when a cold front or warm front stops moving. Air masses move parallel with the front while **frontal boundary is not moving**. This happens when two masses of air are pushing against each other but neither is powerful enough to move the other.

Conditions resemble those encountered along warm front weather: extensive cloudiness and continuous rain of various intensity. A wide area of precipitation can be expected on the cold-air side.

Artic front is the boundary between polar and artic air

Polar front depression:

- Winter: Florida to SW England (more south than in summer)
- Summer: Newfoundland to N Scotland
- It is the boundary between polar and tropical air
- The whole life cycle takes over 3-5 days
- Movement according to warm sector isobars
- Develops over the sea
- Small depression
- Can produce severe weather, heavy precipitation and strong surface wind
- Air distribution:
    - Warm sector: Tropical air
    - Air East of the depression: Polar air
    - Air West of the depression: Polar air
    - Air North of the depression: Artic air



4 stages of a mid-latitude depression life cycles: [CDOF]

- Cyclogenesis: a disturbance and fall in pressure causes cyclonic circulation
- Developed: fronts are well defined, there is a pronounced warm sector
- Occlusion: the cold front has caught up with the warm front, the warm air has been partially lifted up
- Frontolysis: all the warm air has been lifted up

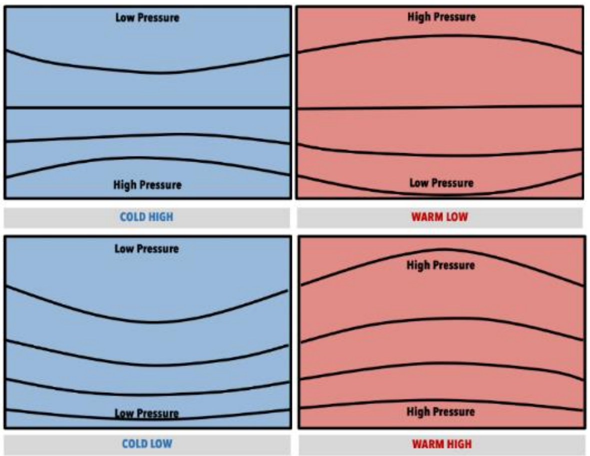
Mid latitude depression life: 3-7 days

Frontal depression in Europe: 7-10 days (Western Europe = 4 days)

Pressure systems

High pressure system = anticyclone | sinking air | isobars pointing ↑ |

- Generated by air subsidence
- Divergence at low level
- Wind veers (CW)
- Can create inversion, with moderate to poor visibility
- Winter: drizzle
- Summer: haze



Low pressure system = cyclone | rising air | isobars pointing ↓ |

- Convergence at low level
- Wind backs (CCW)

To identify the different possible configurations:

- Top = temperature (up = warm, down = cold)
- Bottom = pressure (up = high, down = low)

When asked for convergence / divergence in relation ho a high or low pressure system, consider the surface movement (what happens at the surface)

Predominant pressure system between 30° - 65° N in the North Atlantic region:

- Azores high
- Weak low over NE Canada

Blocking high (quasi stationary anticyclone): can be both warm high and cold high

Land breeze: From land to sea (can occur at any latitude) | Night time | Weaker

Sea breeze: From sea to land (can occur at any latitude) | Day time | Stronger

Air mass subsidence (= sinking air) enhances atmospheric stability and dissolves clouds at upper levels.

Buys Ballot's law: in the N hemisphere if an observer stands with his back to the wind, the low-pressure area is on the LEFT. If an aircraft is subject to starboard (right) drift, it is flying towards low pressure

Polar lows

- Formed over water only (relatively warm water)
- Tend to decay rapidly with landfall due to lack of warm moisture from warm sea
- Much smaller and transient than a regular mid-latitude depression
- Duration: 12-36 hours

Thermal lows (heat lows)

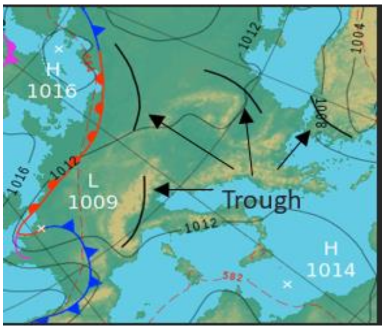
- Formed over land in summer but also water (when sea temperature is high enough)
- Heavy showers with good visibility outside of them
- Moderate to severe turbulence
- Land is heated by solar heating which heats the lowest layer of the atmosphere. The resulting hotter air is less dense than surrounding cooler air. This, combined with the rising of the hot air, results in the formation of a low-pressure area

Orographic depression

- Wind perpendicular to the mountain range flows around it instead of going over the top
- Low pressure is created in the leeward side of the mountain (the side opposite to the wind direction)

Secondary depression

- Small depression enclosed within the circulation of a larger depression
- Can grow off the tail end of a primary cold front in a wave-like form
- Associates with gales (storms)
- Clockwise rotation (as the depression)

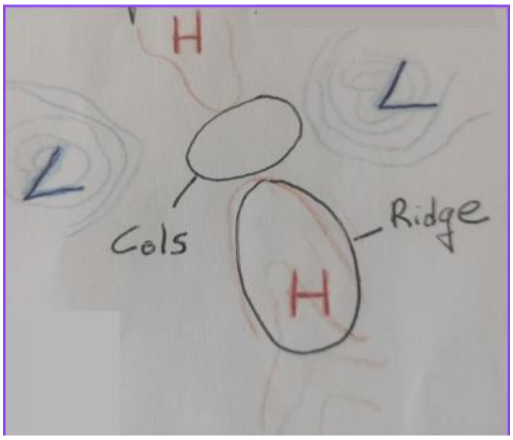


Trough

- Weather similar to that of a depression
- Showers or snow showers (during winter) with variable intensity
- Poor visibility in precipitation, good otherwise
- Winds are strong and variable in direction

Ridge

- Interposed between 2 depressions
- Finger like protrusion from the high-pressure system
- Isobars are curved and extend outwards from the anticyclone
- Weather similar to the main high-pressure system
- Cumulus cloud and improved visibility
- Short duration



Cols

- Area not under the influence of a high or low pressure system
- It is in the middle between 2 highs and 2 lows
- Isobars are widely spread (light wind and variable direction)
- Over land and sea weather is: thundery (summer) or foggy (winter)

Tropical revolving storm (TRS)

- Developing over warm tropical oceans
- Life cycle is measured in weeks
- Difficult to predict their movement
- Normally not occur in S Atlantic Ocean due to low Temperature
- 500 km diameter in mature stage
- Most severe weather is in the quadrant right of the track of the storm
- Most dangerous zone is in the wall of clouds around the eye
- Wind speed > 64 kts to be considered from TRS to tropical cyclones (< 64 kts is a tropical storm)
- Air in the eye is descending
- Clouds are up to 16 km
- Hurricane: [JUNO]
    - 17/18 times per year TRS, 6 becoming hurricane
    - July to October
    - N hemisphere – Atlantic and E Pacific
    - Movement: 10°-15° N, in a Northerly direction
- Typhoon: [JUNO]
    - 20 times per year
    - June to November
    - N hemisphere – W Pacific and South China Sea

Name	Occurrence per year	Period	Region
Hurricane	18 → 6	JUNO	West Atlantic + East Pacific
Typhoon	20	JUNO	West Pacific + South China Sea
Cyclones (Asia)	12	MADE	Indian Ocean
Cyclones (Africa)	9	DECA	East Africa + Australia + West Pacific

- Cyclones (Asia): [MADE]
    - 12 times per year
    - March – December, mainly April – May + October – November
    - Indian ocean
- Cyclones (Africa): [DECA]
    - 9 times per year
    - December to April
    - E coast of Africa + S hemisphere W Pacific [AUS] (Willy – Willy)

Clouds

Cloud amount is measured in Oktas (8):

- Few [FEW]: 1-2
- Scattered [SCT]: 3-4
- Broken [BKN]: 5-7
- Overcast: [OVC]: 8

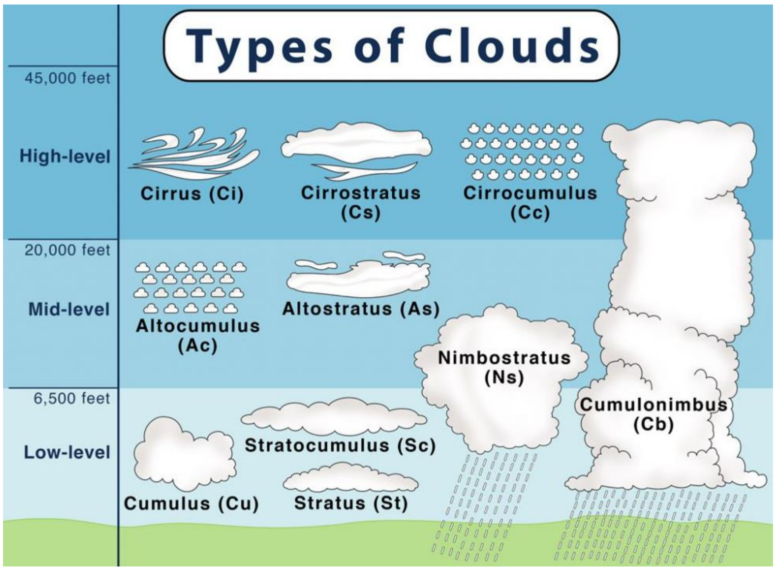
In METAR and TAF cloud base is AAL

In area forecast cloud base is MSL

Cloud Base [ft] = (Temperature - Dew Point) x 400

Cloud base ↑ when temperature ↑

Cloud suffix ''nimbus'' means rain bearing



- Low level clouds: 0 – 6500 ft
    - Stratus (ST)
    - Stratocumulus (SC)
    - Cumulus (CU)
    - Cumulonimbus (CB)
    - Nimbostratus (NS) [may also be medium level]

- Medium level clouds: 6500 – 23000 ft [Alto]
    - Altostratus (AS)
    - Altocumulus (AC)
    - Nimbostratus (NS)
- High level clouds: 16500 – 45000 ft [Cirro]
    - Cirrostratus (CS)
    - Cirrocumulus (CC)
    - Cirrus (CI)

Stratiform clouds

- form in a stable atmosphere [COW]
- form when warm air covers cold surface
- Nimbostratus can produce freezing rain
- May be generated when stable air is forced to rise against a mountain range and keep remaining stable.

Cumuliform clouds

- Formed in an unstable atmosphere [WOC]
- Formed through convection and triggered by heating from below
- May be limited by a temperature inversion
- Towering cumulus [TCU]
    - Also known as cumulus congestus

- Cauliflower lookalike
- Great vertical development
- Can lead to CBs, thunderstorms and squalls
- Moderate to Severe turbulence and icing can be present
- Shower of rain or snow may be produced

- Cumulonimbus
    - It is a low-level cloud
    - CB Capillatus is characterized by the shape of an anvil
    - Produces showers
    - May reach up to 50000 ft at the equator

Altostratus clouds

- Ligth to moderate icing
- AC has a higher probability for turbulence than AS
- Altocumulus lenticularis are an indication of the presence of mountain waves

Cirrus clouds visibility > 1000 m

Ice crystals are present, no ice accretion on airframe or engines is unlikely

Fog

Fog: visibility < 1000 m with RH = 100%

Mist: visibility between 1000 – 5000 m and RH ≥ 95%

Drizzle: visibility between 500 – 3000 m

Haze: visibility > 5000 m (given by solid particles: sand, dust, smoke,…)

Shallow fog: objects can be seen from above, but not at the runway level

Freezing fog: occurs when fog forms in temperatures that are below freezing, and the tiny water droplets in the air remain as liquid. They become supercooled water droplets remaining liquid even though they are below freezing temperature.

There are 5 types of fog:

- **Radiation fog**
    - Caused by loss of heat from the earth surface at night
    - Air in contact with the ground is cooled by conduction and if it reaches the dew point, water vapor condenses into water droplets and fog will form
    - Vertical extent < 500 ft
    - 3 conditions must prevail to form:
        - Clear sky (clouds trap heat near the surface)
        - Sufficient moisture in the air so that cooling will result in saturation
        - Light wind (2-8 kts). If wind > 8 kts fog is lifted to form stratus cloud

      Such conditions are usually present in anticyclonic condition (high pressure systems) and are common just after dawn (alba)

- **Hill fog | Orographic**
    - It forms when moist, stable air is forced to rise over high ground (it is in fact a cloud touching the ground)
    - It tends to form orographic clouds
    - Visibility in fog will be < 200 m
    - Dissipation occurs by solar radiation or if there is downslope wind (katabatic wind) or strong wind

- **Advection fog [WOC]**
  - It creates when warm, moist air moves across a cold surface
  - The temperature of the surface must be such that the air moving over it is cooled below its dew point
  - Wind speed ~ 15 kts and air must have a high HR
  - Common around coastlines and is also called sea fog
  - Dissipate via inflow of unstable air, dissipating any surface inversion

- **Frontal fog**
  - It forms ahead of some warm and occluded frontal system both by day and night
  - Heavy precipitations from the warm into the colder air cause the colder air to reach saturation and form fog.
  - The belt of frontal fog can extend up to 200 NM ahead of the front itself
  - The fog will clear once the front has passed as there is no more cold air to cool the humid air close to the surface

- **Artic smoke | Steam fog | Sea smoke [COW]**
  - Very stable cold air moves from the land to a relatively warm, moist surface (sea). This may cause a small amount of water vapor above the moist surface to condense, forming a shallow layer of fog.
  - It forms in little to no wind conditions
  - Dissipates with an increase in wind speed and/or change of wind direction
  - Difference in temperature between air and water has to be > 10 °C
  - Look for an inversion
  - Extension: 0 - 500 ft

Precipitation

Freezing rain: warm air aloft from which rain is falling into air with a temperature < 0 °C. can be encountered ahead of a warm front in winter

Bergeron-Findeisen process: occurs in high cold clouds and water is present as water vapor, liquid water droplets and ice crystals. Ice crystals grow faster than droplets at the expenses of super cooled water droplets, but when they reach the ground, can be melted and be rain already. Precipitation forms under supercooled conditions. The process is mainly based on the difference of maximum vapor pressure over water and over ice of the same temperature.

Coalescence process: occurs within relatively warm clouds with tops warmer than -15 °C. The collision of falling and rising droplets is what allows them to grow large enough to fall to the ground as precipitation. At mid latitudes it produces only drizzle and very light rain

Mixed clouds are composed of both supercooled water droplets and ice crystals. Most precipitation from these clouds starts out as snow. Whether it hits the surface as snow or rain depends on the temperature conditions through which the snowflake falls. Ice crystals crow at the expense of Super cooled water droplets.

Steady precipitation falls from stratiform clouds with little or no turbulence.

Showery precipitation falls towering cumulus or CBs with moderate to severe turbulence

Visibility in precipitation with large snowflakes is worse than in rain

Snow grains fall mostly from stratiform clouds or from fog, and never in the form of a shower.

Soft hail (also called Graupel) falls from CBs and can be associated with moderate to severe turbulence

Freezing precipitation occurs in the form of freezing rain or freezing drizzle

Ice pellets = rain is freezing at a higher altitude

Snow grains fall from stratus

Type of precipitation	Dimension
Drizzle [DZ]	0.2 – 0.5 mm
Rain [RA]	0.5 – 5.5 mm
Snow [SN]	Grains: < 1 mm Pellets: 2 – 5 mm Flakes: > 4 mm
Hail [GR]	5 – 50 mm
Ice pellets [PL] Soft hail/Graupel [GS]	< 5 mm

Wind

METAR: The wind speed in degrees TRUE represents the average speed over a 10-minute period. If there is a gust observed that is at least 10 knots higher than the average wind speed, it is reported.

ATIS: The wind information report or tower average wind is based on the average speed over a two-minute period.

Friction layer increase with mixing and this occurs in the following conditions:

- Rought surface
- High wind speed
- Unstable air
- Warm afternoon

Higher turbulence and friction layer during late afternoon in summer than in winter

At night, the extent of the friction layer decreases as the surface of the Earth cools and air is much more stable and consequently the intensity of the convection and the surface wind decreases

Surface wind: It is measured at a standard height of 10 m above ground and is the airflow near the surface reduced in strength by the effect of friction

Over Land in the N Hemisphere, the **surface wind backs by 30°** compared to the geostrophic wind and **speed is reduced by 50%.** (opposite in the S hemisphere where wind veers by 30°)

Over sea friction is much less, and the surface winds are closer to geostrophic values. In the N hemisphere the surface wind **backs by 10°** from the geostrophic wind and **speed reduces by 30%** (opposite in the S hemisphere where wind back by 10°)

Coriolis Force= 2ΩρVsinϑ: This force is due to the Earth's rotation. It causes moving air to be deflected to the right in the Northern Hemisphere and to the left in the Southern Hemisphere. It is proportional to latitude and wind speed

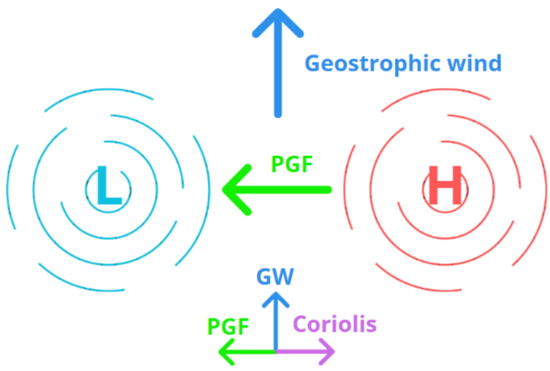
Pressure Gradient Force (PGF): This force arises from differences in atmospheric pressure. It pushes air from regions of higher pressure to regions of lower pressure. It is higher at the Poles and 0 at the equator.

Geostrophic Balance (aka wind at altitude outside the friction layer): Geostrophic wind occurs when the Coriolis force and the pressure gradient force are balanced. This balance results in straight, parallel wind lines at a constant speed. Geostrophic winds are **weaker near the equator** because the Coriolis force is minimal. They become **stronger at higher latitudes** where the Coriolis force increases.

NOTE: The same spacing between isobars at high latitudes gives a slower wind speed when compared to lower latitudes. Because SPEED = distance / time. and if it takes the same time to cover a larger distance (earth circumference), it means that the speed of the wind is increasing when approaching the equator.

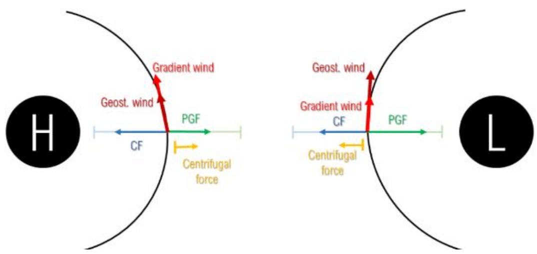
Gradient wind = depends on the curvature of the isobars. High around a High and Low around a Low

Gradient wind = PGF + Coriolis + Centrifugal force



Geostrophic wind:

- Perpendicular and Directly Proportional to the Horizontal Pressure Gradient
- Stronger when travelling towards EQUATOR because there is less Coriolis force
- Lower when travelling towards POLES because the Coriolis force is greater
- Parallel to the isobars
- Intensity is inversely proportional to latitude



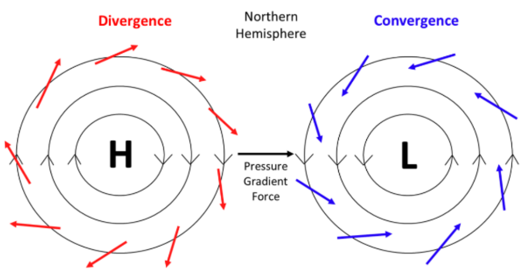
Atmospheric Divergence: **away** from the area of convergence, **across** the isobars marked on the chart

Atmospheric Convergence: **towards** the area of convergence, **across** the isobars marked on the chart

Cyclone: Low pressure – wind back | Gradient wind < Geostrophic wind

Anticyclone: High pressure – wind veer | Gradient wind > Geostrophic wind

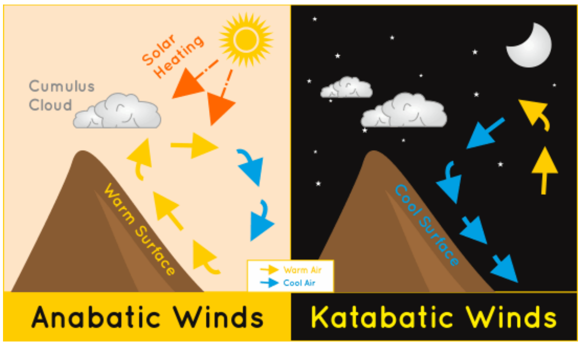
If both a cyclone and anticyclone have the same spacing of the isobars, the higher wind is within the anticyclone



<u>Low level jet stream</u>

Anabatic wind: on sloping terrain, during the day, the land will warm and in turn warm the air adjacent to the surface. This air will start to flow up the slope, replaced by cold air flowing from elsewhere. The up flowing wind is called anabatic wind with a speed of ~ 5 kts.

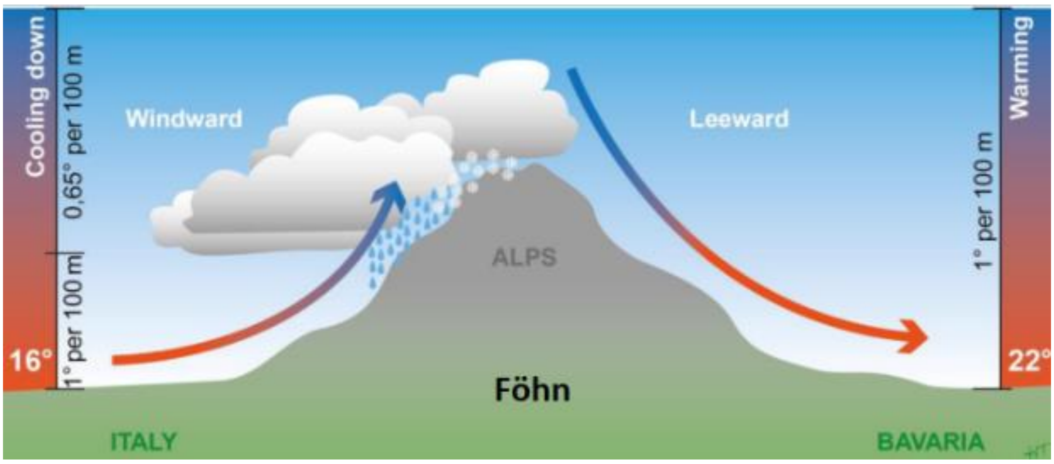
Katabatic wind: during the night the process of the anabatic wind is reversed. The colder air on the surface will sink down the sloping terrain, collecting in the valley below all the night. If dew point is reached this can lead to the formation of valley fog. Katabatic wind speed is ~ 15 kts



In a valley, if an anticyclone is present, at night an inversion is formed, so in the morning after passing through it (with bumpiness due to wind shear) and entering the cold section, engine performance increases.

Flying through a valley → Venturi effect → + wind speed → - pressure → true altitude lower than indicated

Föhn effect: it describes a wind blowing down the lee of a mountain which is warmer and drier than the air moving up the windward side, at the same height. Unsaturated air rises up the mountain side, cooling at DALR. When air becomes saturated, clouds will form, possibly accompanied by precipitations (up to the top of the mountain). From that point air will continue to cool at SALR. When it descends on the leeward side of the mountain it will have lost most of its water vapor content, consequently it will heat up while descending (with a DALR) giving rise to warm, dry valley winds. It is a **katabatic type of wind**.



Mountain waves

They can reach up to FL600 in altitude and 600 NM horizontally

Wind direction will stay approximately constant with altitude

Fly at 90° to the range of the mountain and decrease the airspeed

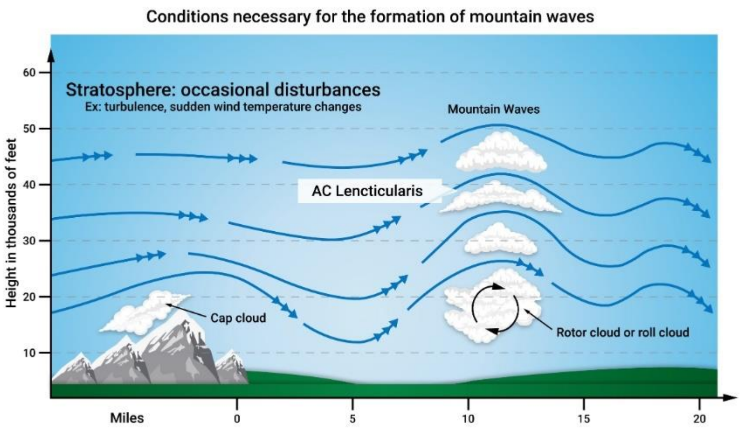
Moderate = 350 – 600 ft/min

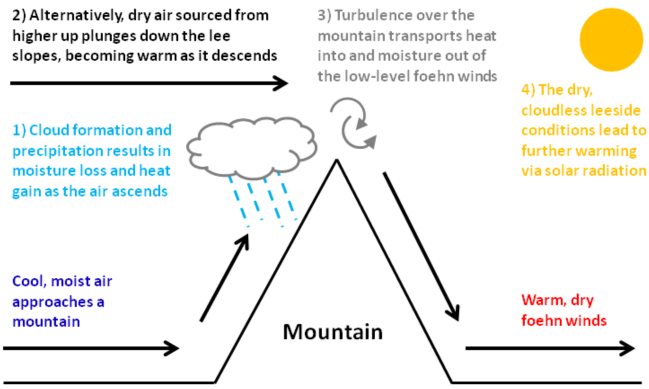
Severe = + 600 ft/min

Higher clouds on the lees side than in the windward side

Condition for the formation:

- Stable air mass
- Wind speed > 15 kts (increasing with altitude)
- Wind direction ~ 90° to the range of hills or mountains





The **low-level jet stream** is a term used for a **wind at around 5000 ft** above the surface, which forms due to either intense, **uneven surface cooling at night**, or the movement of a **cold mass of air over the ground**. The movement of this cold mass of air pushes under the warmer air and creates an inversion that looks exactly like a small cold front

A **Nocturnal low-level jet** is a fast-moving air current in the lower atmosphere during night time when the skies are clear. As air temperatures near the ground drop after sunset, an inversion layer is formed in the lower atmosphere during the night. A Nocturnal jet is likely to form just above the inversion.

Jet streams

Winds below the tropopause exceeding 60 kts (usually westerly) caused by large mean temperature differences in the horizontal.

They are named after the direction from which they come from.

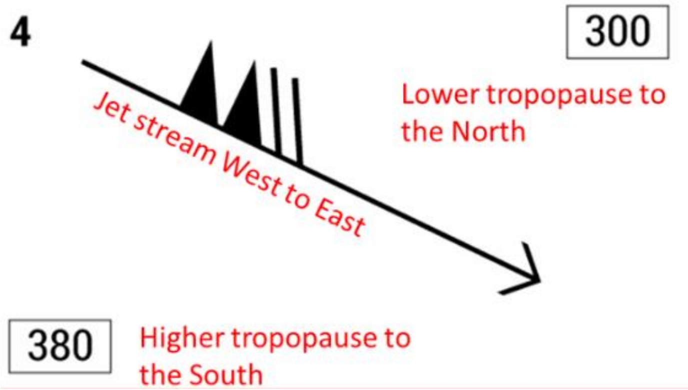
They may be recognized by windblown wisps of cirrus cloud blowing 90° to the cloud at lower level.

Jet streams and CAT are always found in warm air/tropical air masses.

The most severe CAT is on the polar/cold air SIDE, not air.

Avoid flying below or near the jet core to avoid area where turbulence is most likely to be present.

The core of the jet stream is below the tropopause, in the tropical (warmer) air mass



There are different types:

- Tropical (equatorial) – 50000 ft
  - Easterly wind
  - Stronger in summer in N hemisphere
- Subtropical – 40000 ft
- Polar front – 30000 ft
  - Most CAT areas are found in the cyclonic (cold/polar) side of the jet stream
  - Stronger during winter
  - Strongest in an area between a trough and a ridge
  - Largely dependent on the position of weather fronts
- Artic – 20000 ft

Significant curves (change in direction) are most common in the Polar jet stream in the N hemisphere, because of a much bigger presence of land, with a much more irregular movement as a result.

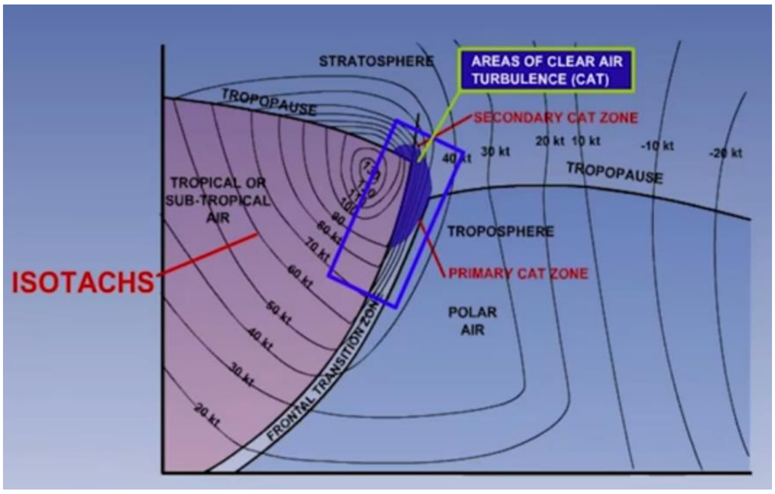
The Jetstream therefore sits in front of the warm front (300 – 500 NM) and behind the cold front (50 – 200 NM).

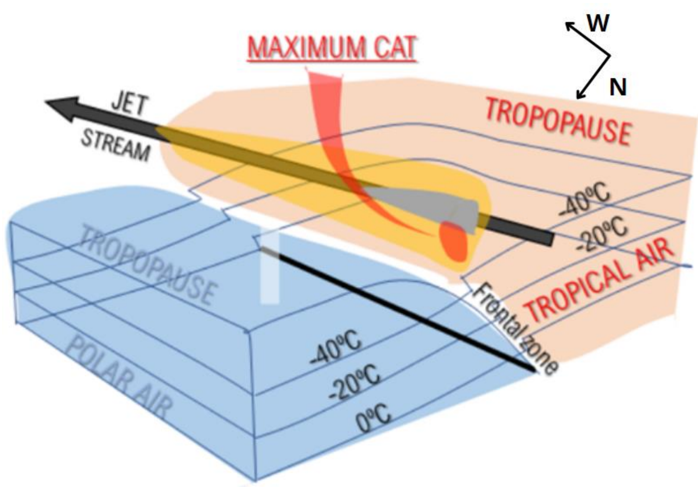
At the point where the temperature in the warm air is the same as that in the cold air stratosphere, you will find the jet stream core.

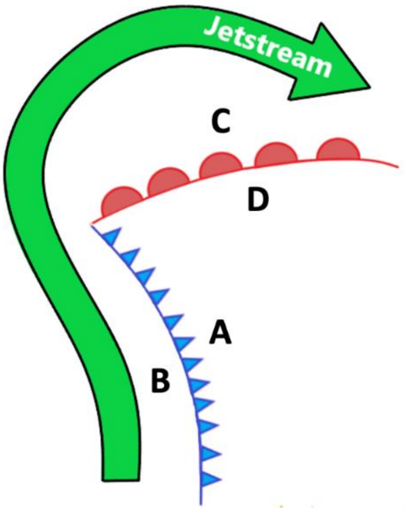
Tropopause gap or break exists where 2 masses of different temperature come together. They indicate the position of strong upper wind (jetstream)

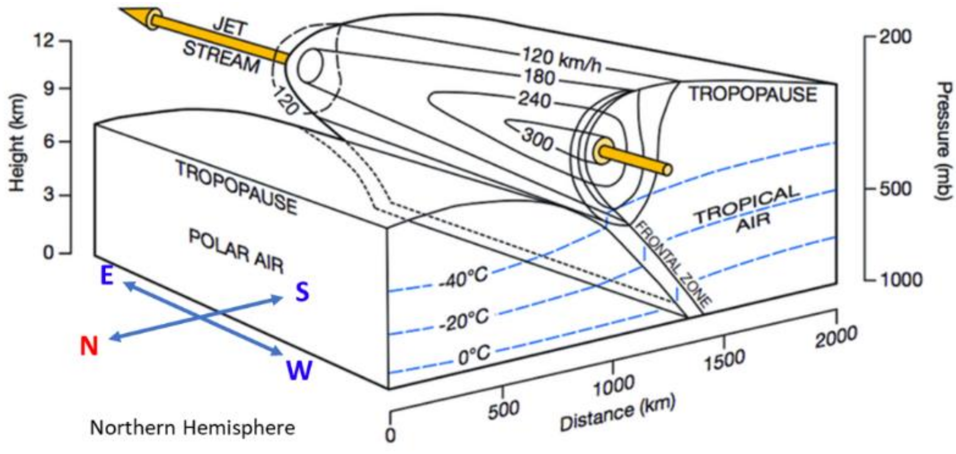
Mid latitude jet stream:

- Length: 1500 NM
- Width: 200 NM
- Vertical extent: 12000 – 18000 ft

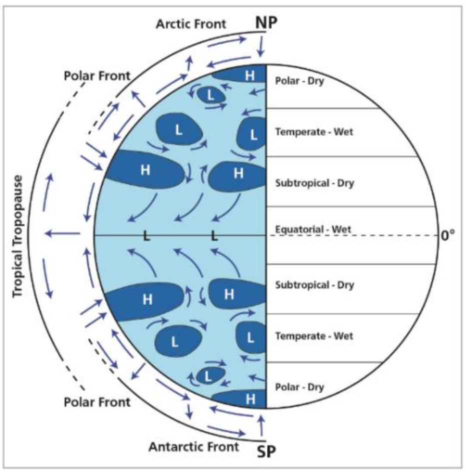


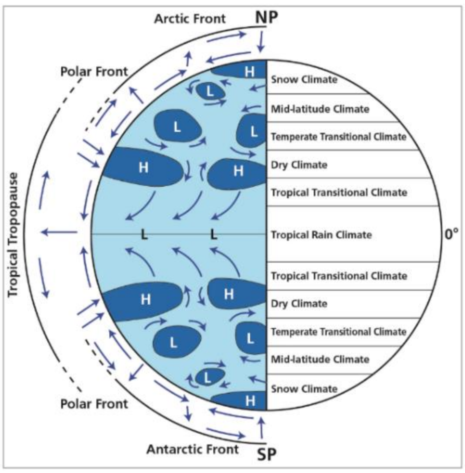


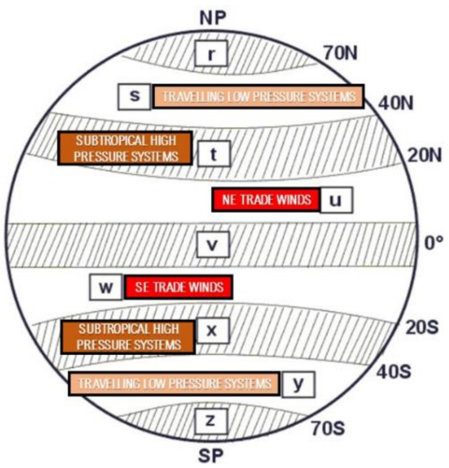


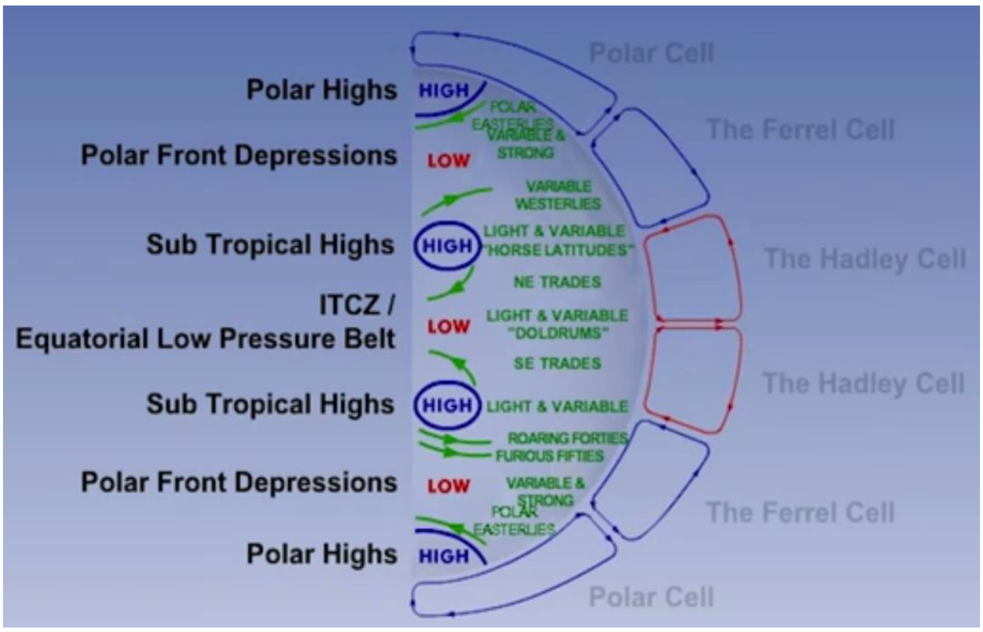


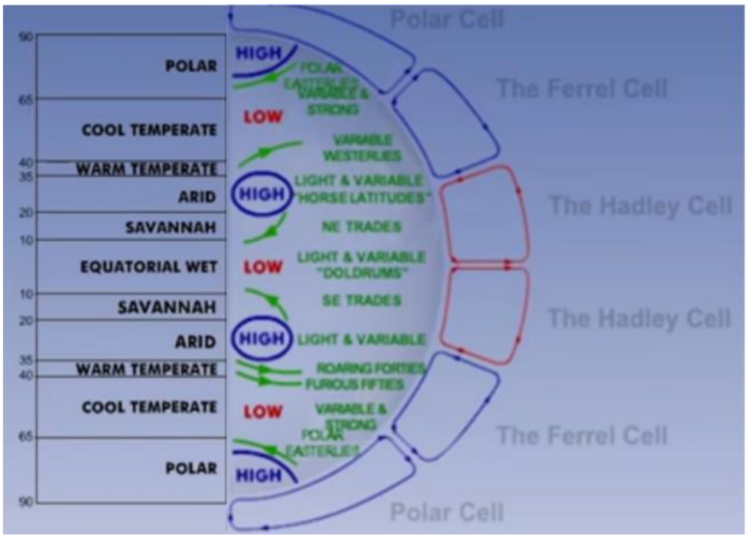
Global climatology

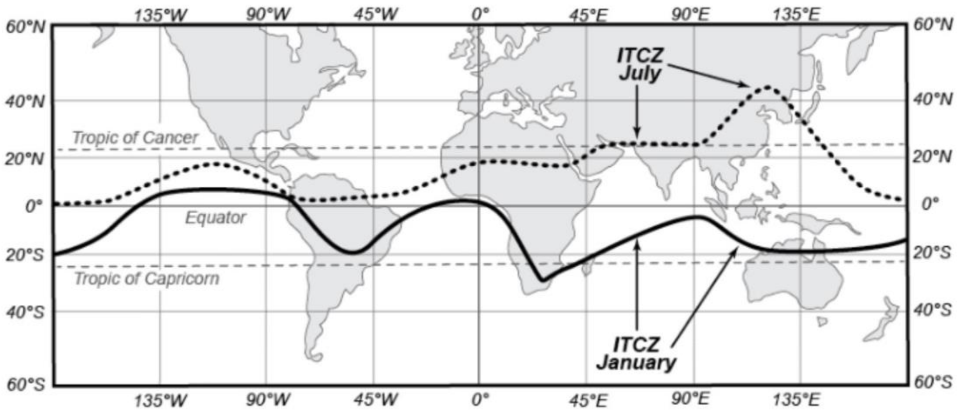






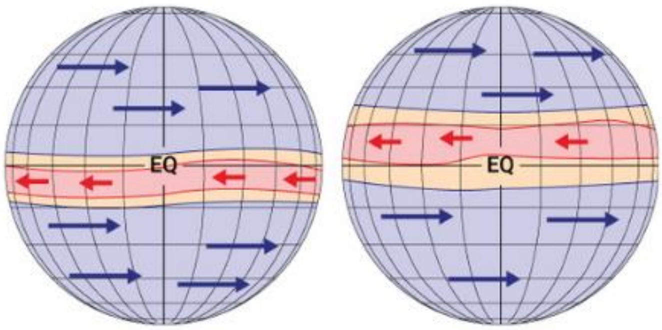






Basic atmospheric circulation structure remains fairly constant because it is determined by:

- Earth rotation rate
- Passage from high to low pressure
- Unequal heating of land and sea



ITCZ January ITCZ July

Surface value for the tropical rain climate:

- Temperature: 28 °C
- Relative humidity: 80%
- Freezing level: FL 150

Climate zones are influenced at a particular placed by:

- Latitude
- Air masses
- Heat exchange from ocean currents
- Distribution of mountain barriers

ITCZ

- Formed when N and S trade winds converge thus forming the air up into the atmosphere, generating convective storms, which are short in duration and can be accompanied by intense rainfall (also due warm and humid oceans)
- The variation of the ITCZ location over oceans is smaller because the temperature varies less than over land
- Seasonal movement given by yearly Earth movement around the Sun and its tilt of rotational axis
- Thunderstorms, showers and strong winds most probable near noon (due to intense solar heating)
- Icing: FL160 – FL260 [suppose a 30°C at surface]
- Freezing: FL120 – FL 160

Trade winds:

- Between horse latitudes and doldrums (equatorial wind)
- In Summer: Fair weather CU or SC
- Converge from the subtropical high belt (high moisture over Atlantic Ocean) to the equatorial zone (ITCZ)
- Passing the equator, they change direction of curvature
- NE in the N hemisphere [note: NE means coming from NE]
- SE in the S hemisphere [note: SE means coming from SE]
- Low level winds: < 10000 ft
- More pronounced over the ocean due to reduced friction

Monsoon

- More frequent in West Africa and South Asia
- Winter – Offshore wind – NE monsoon [December – February]
- Summer – Onshore wind –SW monsoon [June – August]
- Transition from NE to SW monsoon occurs in September – November
- NE monsoon: cool and dry continental air, clear weather
- NW monsoon: convective clouds (Cu, CB) and thunderstorm [Australia and New Guinea]
- SW monsoon: Moderate to severe turbulence and heavy precipitation from convective clouds. During summer in the NH it goes above the equator (but below the ITCZ)

Sub-tropical high

- Latitude: 20°-35°
- Includes horse latitudes
- Light and stable light winds
- Clear skies and warm temperatures

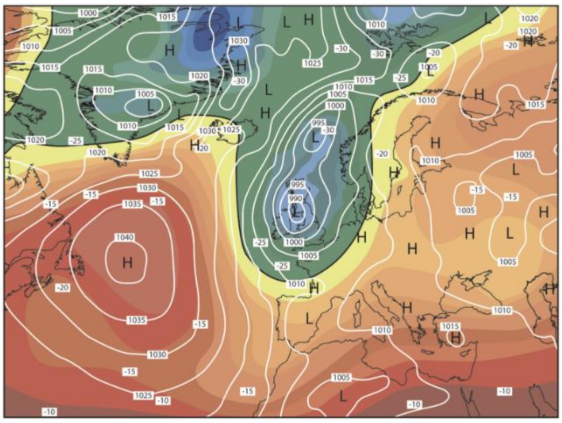
Tundra climate

- High pressure weather in winter with sub-soil being frozen
- Found at about 70N

Random facts to remember:

- Rainy season in equatorial Africa: March to May (spring) and October to November (autumn)
- Melbourne (Mediterranean – warm temperate climate zone) in July is influenced by subtropical high pressure with the occasional passage of fronts originating in the adjacent zone of westerly waves
- Prevailing climatic zone in Australia is the dry climate
- Squall line: narrow band of thunderstorms containing severe weather and accompanied by strong wind, convective rains and long anvil clouds
- Sand grain: 0.08 mm and a wind > 20 kts to decrease visibility
- In the tropics cloud **mean tops** can be up to **50000 ft**. Clouds can **grow up to 60000 ft**.
- Polar Air Outbreaks impact Northern and Central China + Central and Southern US during winter months.
- Flat pressure pattern: distant isobars, most frequent during summer with calm or light wind with warm air rising and creating possible TS in the afternoon
- Westerly winds exist between 40° - 60° latitude (average latitude 50°)
- Central Europe is mid latitude climate
- Polar climate means temperature below 10°C all months

A **cold-air drop**:



- is a **low-pressure** system with **unstable air** that only exists in the **upper troposphere** - it’s a cooler-than-normal pocket of air in the higher levels of the atmosphere.
- It is formed by the advection of cold air in the upper levels to the S of the normal Polar front. They primarily form nearer to the poles in the cold Polar air masses, and (in the Northern Hemisphere), extend South towards warmer air, past the Polar front.
- At some point, they become detached from the cold Polar air and become a “cold pool” of air in the upper troposphere that has quite an effect on the weather in that region, due to the instability they bring.
- Weather associated is convective, especially over land in summer where TS can be expected
- They cannot be detected on surface analysis charts.
- Can be identified by looking at the upper wind and temperature situation [500 hPa]
- Unpredictable direction of movement = difficult to forecast
- 2-3 days duration

<u>Local winds</u>

- Valley winds
    - Mistral: air funneling through a mountain gap or down a valley (valley wind) [between Massif central and the Alps]. It is a cold and strong wind giving clear skies
    - Bora: strong, cold squally downslope wind at the Adriatic coast. Speed is 70-100 kts and is a katabatic wind.
- Mediterranean winds
    - Sirocco
    - Ghibli
    - Khamsin
- Squalls
    - Pampero (cold air in South America)
    - Sumatra
- Harmattan: NE trade cool wind which blows mostly during winter. It forms from a low-pressure center over the north coast of the Gulf of Guinea and a high-pressure center located over northwestern Africa. It carries **large amounts of dust** reducing visibility to below 1000 m. Dust layer may extend to 7000 or 10000 ft or more, and visibility improves towards the coast.
- Föhn

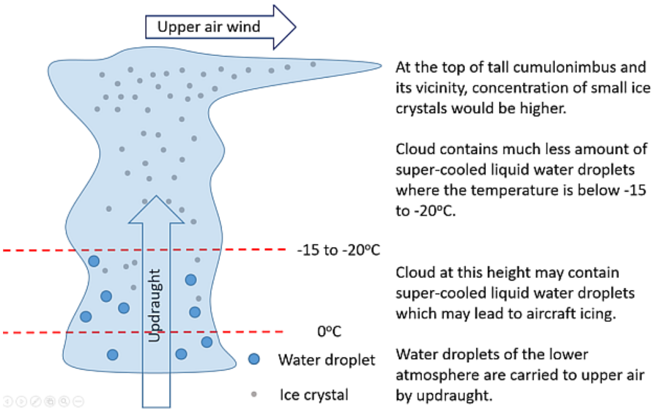
Flight hazards

Icing

Ice Water content (IWC) is a measure of how much ice is present in a certain volume of air. It can be measured in g/m^3. A high IWC is usually caused by tropical storms bringing a very large amount of moisture very high up in the atmosphere and the region around the tops of these clouds (and within those clouds) is the most dangerous location for experiencing Ice Crystal Icing.

Ice crystal icing (ICI) condition refers to aircraft experiencing icing inflight in high altitude due to high concentration of small ice crystals. It is created by deposition (EASA wrongly call the process sublimation) from water vapor to ice with regards to CB cloud. It is dangerous for the engines!

High crystals ice concentration appears to be within and downwind of CB clouds close to the tropopause in tropical regions in the area of the anvil or "overshooting top" of the cell. It is recommended to fly upwind (it means that the wind is blowing the cloud away from you, so you could think of it that you feel the wind first, and then that same wind hits the cloud later on). Fly upwind and above the tropopause



0°C isothermal at FL 60 and NS at FL 70: if raining, the lowest FL for severe icing is FL60 otherwise its FL70 because icing is only present within the cloud if rain is not present.

Icing can occur in clear air (airframe cold, moist air)

Cold soak effect: air just > 0°C and airframe < 0°C

Temperatures:

- Supercooled water droplets: 0°C to -15°C
- Supercooled Water Droplets + Ice Crystals: -15° to - 40°C
- Ice crystals: < - 40°C

The **most severe icing** on the airframe is usually present:

- in the temperature range 0°C to -15°C
- with large droplets
- with thin/sharp wing profile (Sharp wing profiles accumulate ice more easily than thick wing profiles)

Types of airframe icing

- **Rime ice**: small supercooled water droplets as they hit the airframe a small part will freeze instantly as they hit the surface trapping air inside, giving granular and opaque appearance.
- **Clear ice**: large supercooled water droplets where part of the droplet directly in contact with the surface will freeze instantly, while the other part flow back over the airfoil, freezing gradually and creating a layer of clear, heavy, adhesive and air-free ice (supported by orographic lifting)
- **Freezing rain**: occurs when precipitation falls from warm air into colder air at subzero temperature (warm front, occluded front or temperature inversion)
- **Hoar frost**: aircraft surface at lower temperature than air surface + sublimating nuclei. For this reason it can develop outside of clouds and both in flight and on ground
- **Mixed ice**: a combination of rime and clear ice

Cloud icing

- **Cumuliform clouds** can support significant numbers of LARGE, supercooled water droplets. The pilot may then expect moderate or severe clear ice. As updraughts are strong in this cloud, icing risk will be severe.
- **Stratiform clouds** as they lack of vertical development, there will be usually only SMALL droplets, therefore only light, rime ice is likely to form.
- **Nimbostratus cloud**s may well contain the upcurrents able to support large supercooled water droplets, making icing risk moderate to severe.

Icing severity

- **Light**: Conditions less than moderate icing
- **Moderate**: Conditions in which change of heading and/or altitude may be considered desirable.
- **Severe**: Conditions in which immediate change of heading and/or altitude is considered essential.

Induction system icing

- Impact ice
- Carburetor icing (refrigeration icing): 0° to 15°C | High Humidity = -10° to + 30°C | Relative humidity > 50%
- Fuel icing

<u>Turbulence</u>

CAT: The erratic movement of air in the **absence** of any significant **visual clues** is caused by bodies of air moving at very different speeds. CAT is caused by the vertical and horizontal wind shear of jet streams, especially in the cold side of the jet, so be careful in their vicinity. It is nor vertical nor horizontal only. [according to EASA you can find CAT in a squall line]

Gust: a **rapid change of wind velocity** (speed and/or direction) above the prevailing strength, with a **duration < 1 min** and at least 10 kts more than the prevailing wind. Gustiness describes the frequency and strength of gusts.

Turbulence: an **irregular** and instantaneous **motion of air**, which can be made up of a number of small eddies that travel in the general air current. It is associated with specific weather patterns, meaning that it does not occur randomly.

There are 2 types of turbulence:

- Mechanical/frictional: given by friction between the air and the ground, especially irregular terrain and man-made obstacles causes eddies and turbulence in the lower levels. It occurs within the friction layer (2000 – 3000ft). Conditions for this type of turbulence are:
  - Irregular/rough terrain
  - Stronger wind speed
  - Unstable air

- Convective/thermal: expected on warm summer days when the sun heats the earth's surface unevenly. Insolation gives rise to convection currents with warm air rising and cool air descending, responsible for bumpy conditions. It is greatest around 1500 h on clear sunny days (when the highest temperatures are reached)

<u>Wind shear</u>

It is the sudden change in speed and/or direction of the wind including vertical currents.

- **Vertical Windshear**: change in speed and/or direction with change of height [kts/100 ft]
- **Horizontal Windshear**: change in speed and/or direction in the horizontal plane [kts/1000 ft]

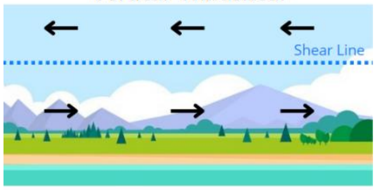
Windshear can be associated with:

- Convective precipitation
- Gust fronts
- Frontal zone
- Strong low-level inversion

Most windshear happens with microbursts that are produced by thunderstorms.

Windshear is expected in the core of the CB.

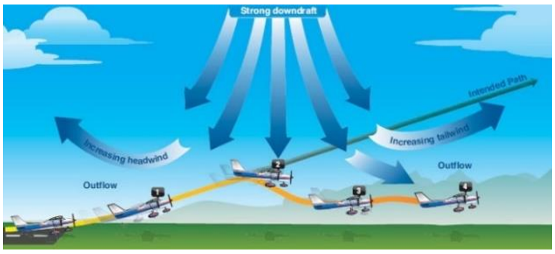
Vertical Windshear



Horizontal Windshear

Microbursts are powerful and intense downdrafts with a diameter of up to 4 km.

Macrobursts similar to microburst but with a diameter of more than 4 km.



There can be wet or dry microbursts:

- Wet microbursts are normally associated with heavy rain.
- Dry microbursts are associated with Virga.

Virga is rain that evaporates before it reaches the ground, normally in drier climates. The rain will then evaporate which causes a cooling of the air, which causes a downdraft. A ring of blowing dust on the ground is another visual sign of a potential dry microburst.

Squall lines can be visually identified (also) by a distinct roll cloud followed by a sudden and rapid increase in wind.


Squall lines with roll clouds

Thunderstorms

Types:

- Heat: triggered by convection, convergence or orographic uplift in an unstable atmosphere. They are generally isolated and form over land (summer)
- Frontal: formed at cold fronts and are often embedded in layered clouds. They form over land and during winter months.

If embedded CB are reported in the vicinity of the airfield, the pilot can use a stormscope to locate and avoid the cells [According to EASA].

Stages of development:

- Initial stage
  - 20 minutes duration to produce a cloud up to 5 NM across and 25000 ft high (CU congestus or TCU)
  - Strong updraft
  - Rapid vertical cloud growth
- Mature stage
  - Up to 30 minutes
  - Strong updraft and downdraft
  - Upcurrents can attain 10000 fpm and grow upwards by 5000 fpm
  - Downdrafts bring cold heavy air down to lower levels, within and below the clouds
  - Precipitation (rain or hail)
  - Creation of the fibrous anvil top
  - Top of the cloud becomes charged positively, the bottom negatively (Earth is charged negatively, so lightning is generated)
  - Microburst are created
  - Gust fronts marks a rapid change in wind direction and speed + temperature drops
- Dissipating stage
  - It begins when the anvil top becomes fully developed
  - Duration: 1.5 – 2.5 h
  - Downdraft predominate but updraft may prevail at the summit
  - Precipitations are heavy but more widespread and less intense than in the mature stage
  - Isolated thunderstorm begins to dissipate once precipitations commence

TS must be avoided by at least:

- Vertically: 5000 ft
- Horizontally: 10 NM

TS develop from CB and can reach altitudes up to the tropopause (rarely the stratosphere)

While flying through air that is electrically charged the aircraft is likely to become a charge carrier itself and can initiate a lightning discharge

Tropical rain can lead to visibility < 10 m

Types of lightning:

- Intra-Cloud lightning: The most common type of lightning. It happens inside the cloud, jumping between different charge regions in the cloud.
- Cloud-to-air lightning: Referring to a discharge (or a portion of a discharge) jumping from a cloud into clear air.
- Cloud-to-cloud lightning
- Cloud-to-ground lightning

Supercell thunderstorm forms when, in addition to a traditional thunderstorm very moist air at low level and wind shear that increases with altitude are present

Convective weather phenomena:

- Wind gust
- Low-level windshear
- Hail
- Lighting
- Heavy rain
- Thunderstorms
- Severe icing and turbulence
- Tornadoes

St. Elmo's Fire is an electric discharge from the aircraft caused by static built-up on the airframe. It occurs when the atmosphere becomes charged and an electrical potential strong enough to cause a discharge is created between an object and the air around it.

__Tornadoes__

Average speed: 20 kts | Create a low-pressure area

In North America they are present in Spring and Summer

Hurricane: Summer - Autumn in North America

They are wider and have a bigger vertical extent than dust devil and originate from a cloud, while dust devil builds upward from the ground surface.

Tornadoes may be present in Europe.

If the column of air doesn't touch the ground is a Funnel cloud

The **West African Tornado** (WAT) is an Easterly Wave. Easterly waves are disturbances in the area close to the ITCZ which take the form of a line of thunderstorms (**squall lines**) **orientated North - South moving from East to West.** They occur between March and November - being most common from March to May and October to November.

+ 1000 in USA and ≈ 300 in Europe

__Inversion__

Radiation inversion develops during cold winter nights with clear skies and calm or very light winds

Vertical Wind shear may develop as above and below the inversion the wind may shift because below the inversion there is little to no mixing.

When climbing through an inversion, the temperature rises with altitude, resulting in reduced aircraft performance

Desert experiences the most marked ground inversion

If an inversion is experiences at surface level, a reduction in visibility may be present

Below an inversion, the wind speed will be light and the wind just above the inversion may be relatively strong

In valleys, inversions are also called cold-air pools and form as a result of both cooling of the ground due to long-wave radiation and nocturnal down-slope winds (Katabatic winds)

Mountainous areas

It is more dangerous to fly toward a mountain with a Headwind than a Tailwind, because that mean you are in the leeward side (air descending from the top) where turbulence and mountain wave are present with heavy downdraft. With Tailwind generally we are subject to updraft being in the windward side.

The first rotor cloud occurs at the same height or under the crests of strong waves downwind of the ridge.

The wind direction at the lower side of the rotor is opposite to the prevailing wind direction

Visibility reducing phenomena

Obscuration: widespread dust/sand in the air

Low drifting sand is when sand has been raised by the wind, but does not obscure visibility at eye level, and therefore is less than 2m (6 feet).

Shallow fog may allow us to see the runway from well above the surface, but while approaching it we may lose the required visual reference.

Worst visibility: Heavy snow

Worst obscuration: sand

Sandstorm/dust storm visibility:

- Moderate: < 200 m and sky not obscured | between 200 – 600 m
- Heavy: < 200 m and obscured sky

Blowing snow is the meteorological term for any loose snow lifted from the ground surface and suspended by strong winds to a height of 2 m (6 ft) or more above the surface. Visibility can be reduced to < 1m.

Landing at sunset time on runway 27 with surface visibility 1500 m in haze, inversion at 500 ft AAL and sky clear above. The pilot expects to see the runway at less than 1 500 m because the sunlight reflecting from the top of the haze layer will reduce air-to-ground visibility.

Meteorological information

Observation

Vertical visibility is to be reported whenever the height of the cloud base cannot be measured and the sky is obscured by fog or heavy precipitation. It should be reported in steps of 30 m up to 600 m (100 ft up to 2 000 ft)

Horizontal visibility refers to a light of 1000 candelas on an unlit background

RVR is passed to pilots by Datalink (D-ATIS or D-VOLMET) and Aeronautical broadcast (ATIS or VOLMET) when the visibility decreases < 1500 m.

RVR is reported in steps of:

- 25 m if RVR < 400 m
- 50 m if RVR between 400 – 800 m
- 100 m if RVR > 800 m

Unit of measurement:

- meter or ft → ICAO requirements
- meter or ft → at state discretion
- meter → Annex 3

Psychrometer measures humidity

Usually RVR > visibility

Visual images reflect, while infrared depends on the radiation emitted.

The warmer the cloud, the 'more' radiation, the darker the image.

For visual images it can be:

- White = very dense cloud (the denser, the more reflection)
- Dark = almost no reflection = no cloud or very thin cloud

For infrared it can be:

- White = Cold (high clouds)
- Dark = Warm (can also be the surface)

Possible combinations are:

- Dense + Cold = Cb – Cu
- Cold + Thin = Cirrus
- Warm + Dense = Nimbostratus
- Warm + Thin = most probably Terrain

How to analyze the images:

- If both images are bright in the same area => very likely that you can find a very high and thick cloud with high convective activity over that area. Note: Convective cumulus clouds develop puffy cotton shaped profiles.
- If you get cloud returns on a visible imagery but not on an IR image => most likely a low cloud
- If you get a white return on an IR imagery, along with a translucent whitish layer on a visible imagery => it is most likely a high wispy cloud - a thin layer of cirrostratus.

Fog and low clouds can be difficult to be detected by IR

To estimate the height of the top of CU it is necessary to have IR + visual

METAR, SPECI: 10 minutes as wind period of observation | wind is TRUE

ATIS: 2 minutes as period of observation | wind is MAGNETIC

To measure the wind the anemometer should be positioned 10 m (33 ft) above aerodrome level

Radiosondes are used to measure temperature humidity and pressure aloft.

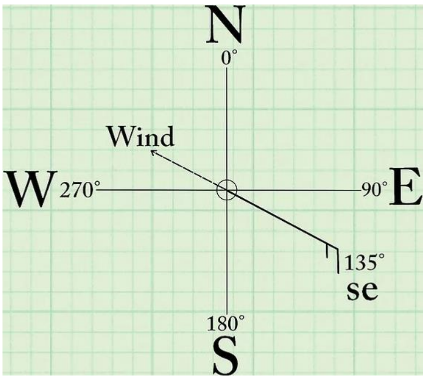
With the annex below:

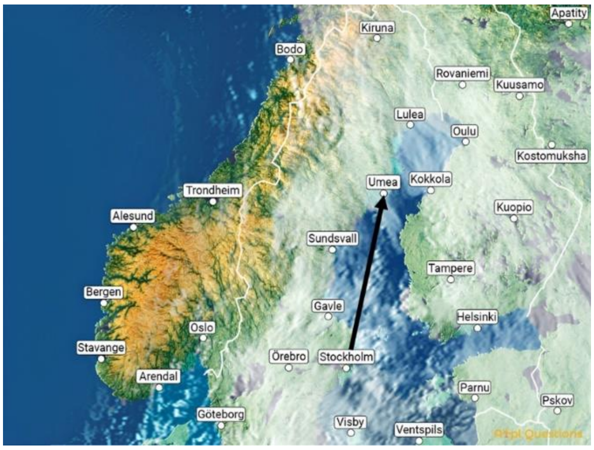
- Cold front
- Temperature and pressure decreasing
- Mountain waves

AWR Severe storm patterns: Hooks (or pendants), bows, fingers, and crescent shaped echoes

Weather charts

Pressure Levels	
FL50	850 hPa
FL100	700 hPa
FL140	600 hPa
FL180	500 hPa
FL24	400 hPa
FL30	300 hPa
FL340	250 hPa
FL39	200 hPa
FL450	150 hPa

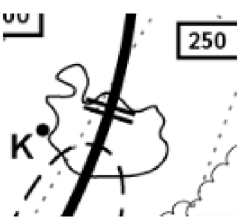




Jet stream where the wind is above 80 kt: Lower limit: FL150 | Higher limit: FL480

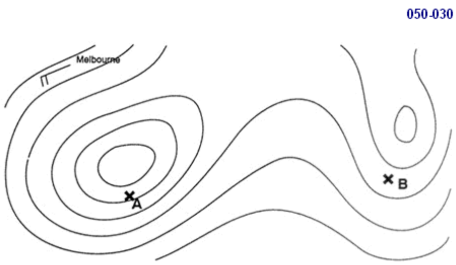
Change bars. Two thin lines perpendicular to the jet core line may be used to indicate changes in windspeed of 20 KT along the jet stream where there is insufficient space to include pennant/feather symbols or where the jet core height changes by 3 000 FT.

In the example below, the core wind speed is 120 kts but at its vertical boundary (FL150 and FL480) is 80 kts.



The tighter packed Isohypses show lower true elevations, wider spaced isohypses show higher true elevations

Indication of highest (H) and lowest (L) altitude limit for tropopause



At higher levels, wind is expressed with reference to True North

Visualization of CB by flight planners is created using CB horizontal extent and cloud top height

Gridded 3D datasets are produced by WAFC (World Area Forecast Centers) for:

- Flight Level and Temperature of the tropopause
- Upper air temperature and humidity
- Direction and speed of maximum wind
- Cumulonimbus clouds, icing and turbulence + CAT

Being a 3D Grid, data to be defined are:

- Lat
- Long
- Vertical data (Height or Pressure)

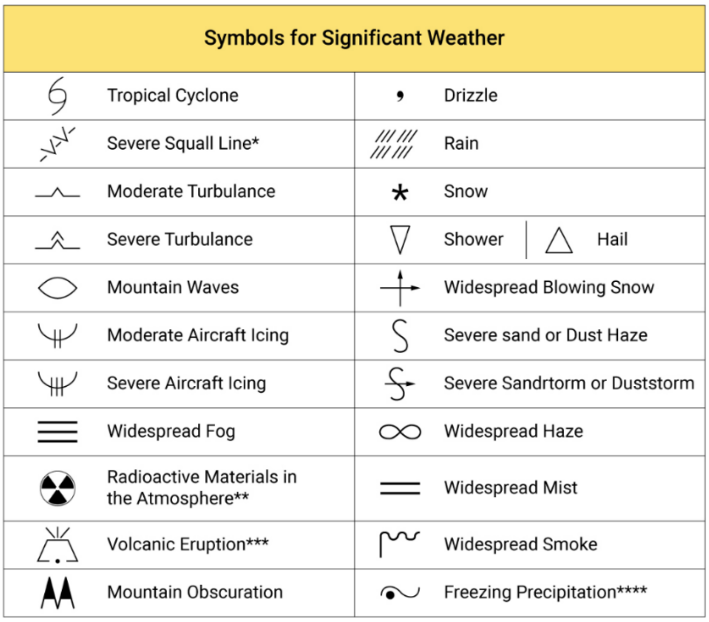
PIREP are processed into weather models to improve subsequent WAFC forecasts

Merging and processing data from gridded forecast, automated aircraft detection and reports from pilots is useful because can be shared with flight crews via their EFBs to enhance situational awareness

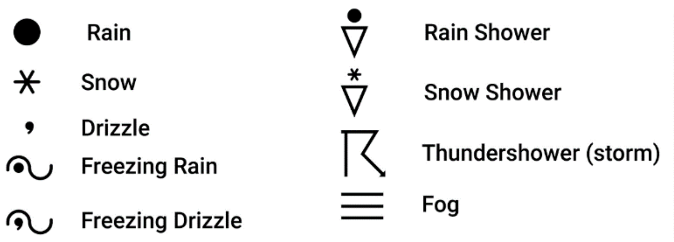
ISOL < 50% → separated

OCNL 50 – 75% → well separated

FRQ > 75% → not separated



Symbols for Significant Weather	
Tropical Cyclone	Drizzle
Severe Squall Line*	Rain
Moderate Turbulance	Snow
Severe Turbulance	Shower / Hail
Mountain Waves	Widespread Blowing Snow
Moderate Aircraft Icing	Severe sand or Dust Haze
Severe Aircraft Icing	Severe Sandrtorm or Duststorm
Widespread Fog	Widespread Haze
Radioactive Materials in the Atmosphere**	Widespread Mist
Volcanic Eruption***	Widespread Smoke
Mountain Obscuration	Freezing Precipitation****



<u>Information for flight planning</u>

ATIS contains meteorological and operational information (MET REPORT/SPECIAL not METAR/SPECI)

VOLMET: Provision of current METAR, SPECI, TAF and SIGMET by means of continuous and repetitive voice broadcasts.

SPECI: issued for near the airfield information (ex. Volcanic ash clouds)

SIGMET: issued for enroute information

CAVOK: no cloud below 1500 m (5000 ft) and visibility > 10 km

TREND forecasts are indicated by BECMG or TEMPO. [according to EASA are LANDING forecast]. It express what is expected over the next 2 hours.

TEMPO: possibility that it reverts back to old permanent weather conditions (TAF = 60 min ; METAR = 120 min)

BECMG: change of permanent character (once the change occurs, you can now relate to the changes noted in the BECMG report as prevailing)

NOSIG replaces the TREND group when no significant changes are forecast to occur during the 2 hours forecast period.

PROB:

- It indicates the probability of the occurrence of specified weather phenomena.
- It can be followed by a time group of its own, and/or by an indicator, such as BECMG or TEMPO.
- Only 30 or 40 are used.
- 30 = low probability
- 40 = highly probable

NSW = No Significant Weather. To indicate the end of significant weather.

NOSIG = No significant changes in the next 2 hours

VC = In the vicinity: Between approximately 8 and 16 km of the aerodrome reference point and used only in METAR and SPECI with present weather.

STNR = Stationary

WKN = Weakening

CNL = Cancel

MTW = Mountain waves

- Moderate = MOD = 350-600 ft/min
- Severe = SEV = > 600 ft/min

SS = Sandstorm

Tropical cyclone advisory information

C = atmospheric center of pressure

TCAC = name of the Tropical Cyclone Advisory Centre

TC = name of the tropical cyclone

INTST CHANGE = intensity change

MOV = Movement

- SLW = slowly: < 3 kts
- STNR = stationary: < 1 kts

Runway conditions in a METAR include:

- Runway designator
- Extent of contamination
- Depth of deposits
- Breaking coefficient

SPECI issuance criteria includes significant changes of:

- Surface winds [MPS = m/s]
- Visibility
- Cloud base height
- Occurrence of severe weather

Meteorological Watch Office (MWO) responsibilities are to preparing and disseminate SIGMETs and other information relating to a specific FIR

World area forecast center (WAFC) is a meteorological center designated to prepare and issue significant weather forecasts and upper-air forecast. They prepare Gridded Area Forecast

World Meteorological Organization (WMO)**:** establish and implement with ICAO a global regulatory framework for aviation meteorological services