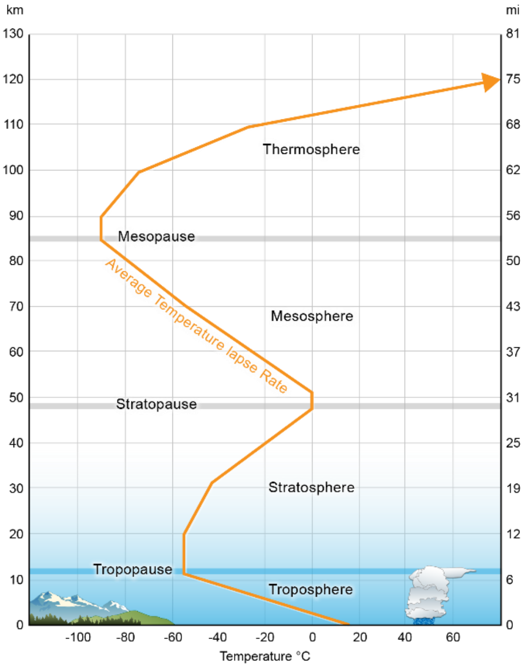
Met Revision Fact sheet

The Atmosphere

Oxygen 21%, Nitrogen 78% and all the rest 1% incl water vapour

Troposphere/Stratosphere/Mesosphere/Thermosphere (Ionosphere)



Tropopause Average 36,090 feet/11km -56.5C.
At Poles = 26000feet/8km -50C.
At Equator = 60000 feet/18km -75C.

Stratosphere 50km, temp 0C.
Isothermal layer (-56.5C) up to 20km then increases.

Mesosphere 80km/-90C.

Thermosphere 2000C. Ionoshpere layer will affect radio waves so nav eqpt

ISA: Temperature: +15 C;
Pressure: 1013.25;
Density: 1.225kg/m3

ISA Temperature lapse rate (uniform)

1.98 C/1000' or 0.65 C/100m up to a height of 11km/36,090'.

ISA Pressure lapse rate (non-uniform)

1013.25 hPa/500 hPa (about half) 18,000/300 hPa 30,000'

Lapse rate greater closer to surface. Pressure is assumed to decrease at 1hPa for every 27 feet up to 10,000ft.

ISA Density (non-uniform) lapse rate

1.225kg/m3 Surface/0.609kg/m3 (about half) 22,000/0.302(quarter) 40,000'

Heating the Atmosphere

Scales: Celsius 100C, Kelvin 373 and Fahrenheit 212F.

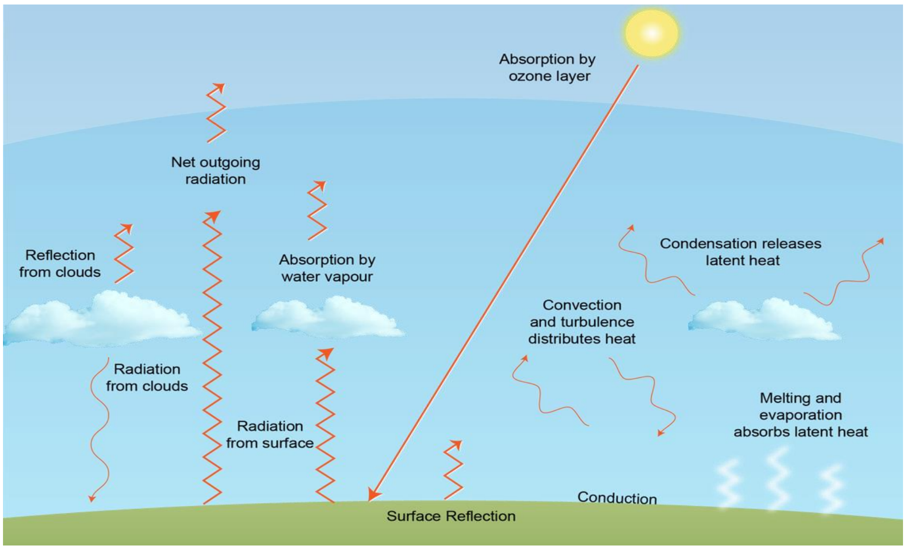
Stevensons screen, placed about 4' above the surface

Earth heated by **Insolation**.

Rates of heating vary by surface, latitude, time of year.

Energy transferred from surface in to atmosphere by:

Long wave **Radiation, Conduction, Convection, Turbulence/Advection, Latent Heat**



Diurnal variation of temperature

Hottest/coldest time of day

Inversions

Ground, Valley, Subsidence, Frontal, Tropopause Inversion

Atmospheric Pressure

ISA surface pressure: 1013.25hPa/29.92insHg/760mmHG.

Features on **barometric chart**: Isobars, H, L, COL, TROUGH, and RIDGE

QFF: MSL pressure in actual conditions (varies)

QNH: MSL pressure calculated using ISA lapse rate (27'/hPa)

QFE: Pressure at field elevation (Relationship between QFE & QNH is airfield elevation)

SPS: 1013.25hPa – Pressure altitude

Comparing QFF to QNH only possible if temperature given: amsl, warmer than ISA QFF will be lower value than QNH.

To find true altitude: use 27'/hPa for pressure correction. ***High to Low - Look Out Below.***

Temperature Error Correction (TEC): 4% (of altitude) per 10˚C of ISA deviation.

Warmer than ISA – true altitude will be more than indicated (under-read/safe)

Colder than ISA – true altitude will be less than indicated (over-read/danger)

Atmospheric Density

Density affects aircraft performance – take off roll etc. Colder air more dense than warm air.

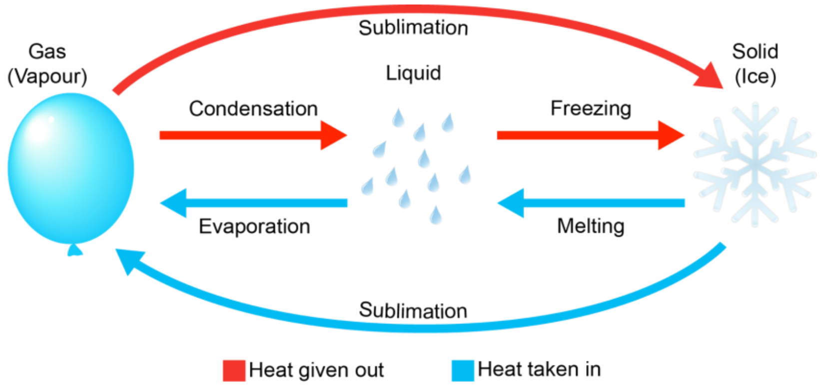
Worst scenario = high humidity, high temperature, high altitude (low pressure)

Calculate density altitude by applying 120ft correction for every 1C ISA deviation.

Humidity

Water cycle – change of state

Condensation, freezing, melting, evaporation, sublimation, deposition - **Latent Heat**



Absolute Humidity g/m3, HMR g/kg,

<u>Average weight (g) of water vapour per kg dry air (HMR)</u>

Temp deg C:	-20	-10	0	+10	+20	+30
WV gms:	0.8	1.8	3.8	7.8	15	28g

Relative Humidity - saturated when relative humidity is 100%, dry if 99%

Relative Humidity increases with a decrease in temperature.

RH Diurnal variation – inversely proportional to diurnal temperature range

Adiabatic cooling: Temp reduces with altitude due to reduction in pressure; temp increases closer to surface due increase in pressure.

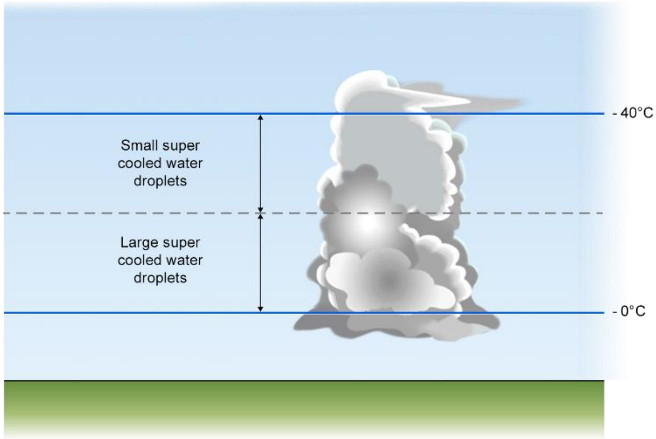
Rising air cools adiabatically, reaches dew point then condenses on to **hygroscopic nuclei**. If insufficient nuclei present then air is super-saturated at temp above 0C or forms **super-cooled water droplets below 0C**. SCWD = Icing risk.

Cloud Formation

Triggers Convection, Orographic, Turbulence, Convergence, Frontal

Rising air …….. Adiabatic cooling ……. Condensation …….. Cloud

Hygroscopic nuclei required for vapour to change to liquid or ice.



0C to -10C = mostly large SuperCooledWaterDroplets

-10C to -40C = smaller SCWD and ice particles

Below -40 = almost all ice particles.

Stability and instability:

DALR – 3 deg C/1000' or 1 deg C/100m;

SALR – 1.8 deg C/1000' or 0.6 deg C/100m

ELR – actual lapse rate measured using radiosonde data so varies.

Why DALR greater than SALR – release of latent heat with condensation reduces rate of cooling. SALR increases at higher altitudes due less vapour content so less condensation.

Weather characterisitics due stability of atmosphere

Unstable: Cumuliform, showers, good vis, mod – severe turb. **Cu** unstable

Stable air: none or stratus, continuous rain, poor vis, light/mod turb. **St** stable

Cloud Classification

Clouds form when triggers (Terrain, frontal, convection, convergence) **cause air to rise, air cools adiabatically.**

If saturation (dew point) reached then condensation occurs, clouds form.

Type of cloud formation depends on stability of atmosphere

Cloud base: lowest level of cloud measured using ceilometer.

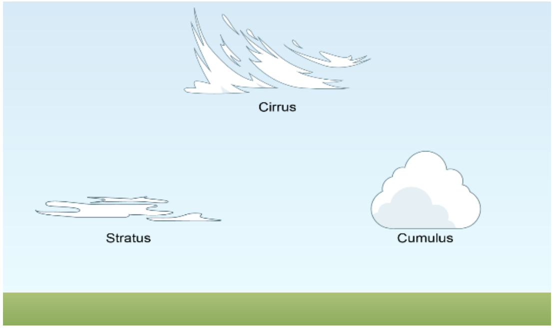
Cloud ceiling: lowest level of cloud obscuring +50% of sky (BKN/OVC)

Cloud Tops measured by radar, satellite, visual obs or triangulation.

Classification of cloud coverage

COVERAGE	DESCRIPTION
0 oktas	SKC (sky clear)
1-2 oktas	FEW
3-4 oktas	SCT (scattered)
5-7 oktas	BKN (broken)
8 oktas	OVC (overcast)

Appearance (3 main **shapes)**:



cirriform
Stratiform
Cumuliform

10 Basic Types (Genera)

Ci, Cc, Cs, Ac, As, Ns, Sc, St, Cu, Cb

High Cloud (ice clouds) – 16500 to 45000 (20000 to 60000 tropics). No precipitation

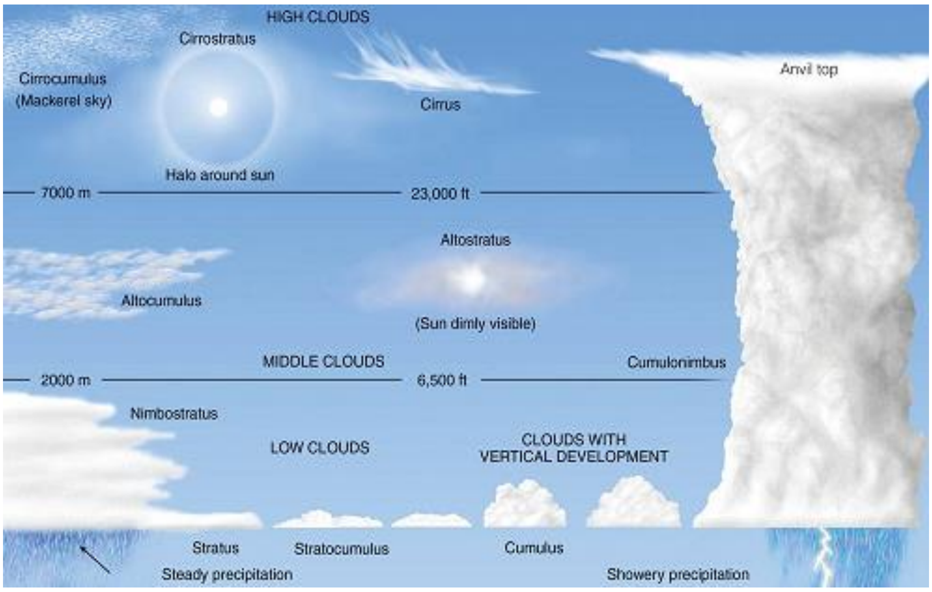
(Ci) Cirrus – wispy, **Cs Cirrostratus** – Halo. **Cc Cirrocumulus** – more bumpy.

Med Cloud (mixed clouds) – 6500 to 23000

As Altostratus- Layered cloud. Light precipitation – virga.

Ac Altocumulus – Lumpy blanket. Light precipitation, rain or virga.

Low Cloud (pure water clouds) – surface to 6500 (all regions)



Ns Nimbostratus – grey layered cloud, rain (continuous).

St Stratus – greyish white layered cloud

Sc Stratocumulus – layered with lumps, patchy coverage.

Cu Cumulus – Cauliflower, build vertically, flat base, showers.

Cumuliform Clouds

Cu Humilis – slight vertical extent;

Cu Mediocris – moderate vertical extent,

Cu Congestus – great vertical extent.

Cumulonimbus Calvus - developing TS cloud.

Cb Cumulonimbus – Great vertical extent. Intense precipitation.

Cloud species: Fractus (broken),

Castellanus (castle like),

Mammatus (downward protruding),

Lenticularis (lens shaped),

Capillatus (capped, anvil top)

Precipitation

Wegener-Bergeron-Findeisen theory: All precipitation starts as ice crystals. Grow through sublimation where super cooled water droplets exist.

Coalescence theory: Precipitation forms in clouds at temps above freezing. Water (cloud) droplets grow through collision with other droplets until fall with gravity from cloud.

The greater the depth of the cloud, the further the droplet travels and the bigger it is likely to grow.

St = thin layer = light rain/drizzle.

Cu = deep vertical extent = large droplets/heavy rain/showers.

Temp at cloud base determines type of precipitation.

Cloud/water droplets: 0.02mm diameter. Max terminal velocity of 0.012 (m/s)

Drizzle (DZ): Diameter less than 0.5mm. Max terminal velocity of 4metres per second (m/s). Falls from stratiform cloud.

Rain (RA): Diameter 0.5mm – 5.5mm. Max term velocity of 9m/s. Falls from thick As and Ns

Ice crystals (IC): Unbranched crystals. Fall as needle shaped crystals.

Snow (SN): Branched Ice crystals. Temps +4 to -5 deg C. The colder the temp the smaller the flakes. Falls from thick As and Ns.

Snow grains (SG): Tiny grains of ice (pin head) less than 1mm. From St or supercooled fog

Snow pellets: Size about 2 – 5 mm, bigger than grains and softer (tiny snow balls). Soft hail

Ice pellets (PL); Like snow pellets but larger and made of clear ice.

Sleet: Mixture of rain and snow. Serious threat as can easily freeze onto airframe/runways.

Hail (GR) Small Hail (GS): Formed in CBs from frozen droplet caught in up and down draughts. Diameter Hail 5 – 50mm. Largest reported weighed 1kg. Small hail less than 5mm.

Freezing Rain (FZRA): Supercooled rainfall. Forms when cloud in warmer air (Ns) produces rain which falls into colder air (below freezing). Typical example is a warm front.

Precipitation and cloud type

Precipitation	Clouds
Rain	Sc, Ns, As, Cu, CB
Freezing rain	Sc, Ns, As
Drizzle	St
Freezing drizzle	St
Snow	Sc, Ns, As, Cu, CB
Snow grains	St
Snow pellets	Sc, CB
Hail & Small hail	CB
Ice crystals	St
Ice pellets	Ns, As

Reporting Precipitation
Continuous = 60 minutes or more usually stratus **(As or Ns)**
Intermittent = continuous with breaks usually **As or Sc**. Snowfall likely Sc
Showers = Short outbreaks associated with cumulus clouds

Thunderstorms

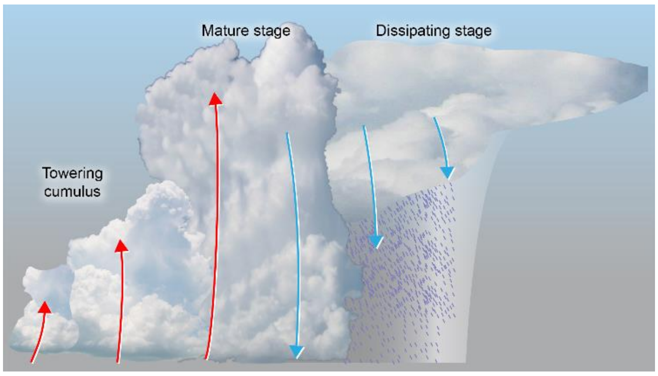
NEED: Deeply unstable air
A lot of moisture
A trigger to cause the air to rise.

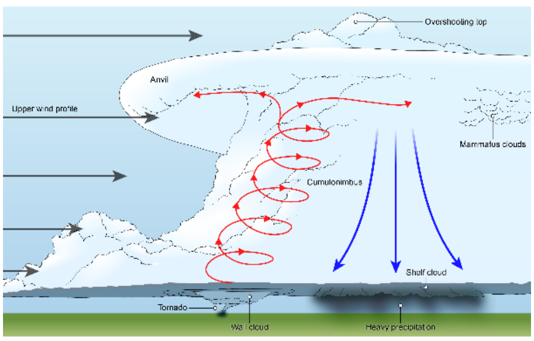
Types – Heat (thermal)/Air mass/Frontal/Squall

Building Phase – updraughts, 20 minutes

Mature phase - Updraughts and downdraughts,20 minutes

Dissipating phase – Downdraughts, 1 – 2.5 hours.





Self-propagating storm - super-cell/Multi-cell (squall, cluster)

THUNDERSTORM HAZARDS

Microbursts

Gust Front

Turbulence & Windshear

Icing

Hail

Tornadoes

Water ingestion

Virga

Lightning

Static

Instrument error

Tornadoes: Most common mid-west USA in spring/summer;
- windspeeds 100-200kts in funnel;
- groundspeed 20 – 40kts;
- Average diameter 100 – 150m;
- Lasts up to 30mins.

Airborne Weather Radar (AWR) - sensitive to wet precipitation. Can mask multiple cells of precipitation.

TS avoidance: 20nm over 20,000' 10nm below.

Icing

Effect on aircraft: **centre of gravity**, **stall speed**, **lift, drag, thrust, control surfaces, instrument sensors, engine intake**, **carburettor**, **visibility**

Factors: **Speed**, **Wing shape, Temp,** SCWD (0˚C to -40˚C), highest risk = 0 to -10˚C.

Cloud types *High risk of severe icing in cumuliform clouds in the range 0˚C to –20˚C.*

High (Ci, Cc, Cs) – IC, low icing risk

Med (As, Ac) – IC & small SCWD low to mod icing risk

Low (St, Sc) – large & small SCWD, poss some IC, low to mod icing risk

Ns, Cu, Cb – large SCWD at colder temps than normal, mod to sev icing risk

Orographic effect - Greatly increases icing risk

Types of icing

Hoar frost - Sublimation. No cloud.

Rime ice - small SCWD. freeze on leading edges. Opaque and brittle. Stratiform cloud.

Clear/Glaze/Rain Ice - Large SCWD. Most hazardous. Heavy. Cu/Cb/Ns

Freezing Rain - ahead of a warm front. Risk of clear ice. Ns

Mixed Ice – Clear ice and rime ice. Opaque, rough. Most often Ns.

Packed Snow– snow flakes stick to wet wing

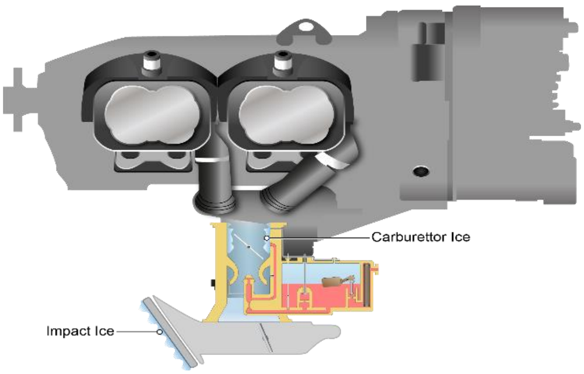
Cloudy Ice - ice crystals stick to wet wing.

Engine Icing: Carb ice (humid air) up to temps +25C;

Fuel Ice;

Intake ice;

Ice crystal ice (strong convective currents).



Visibility

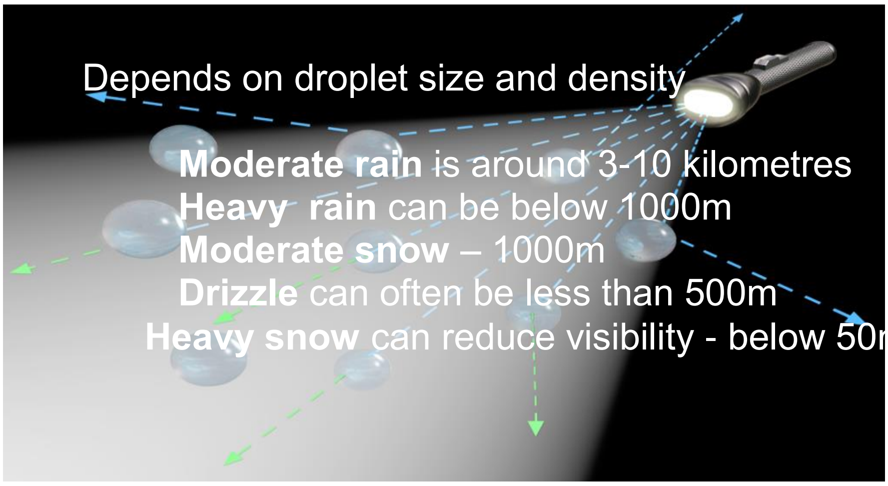
In Cloud Low level (incl Cu, Cb) - 10m to 30m;

Mid-level – 20m to 1000m;

High – +1000m

In precipitation

Worst: Heavy or blowing snow - 100m.



Drizzle – 500m.
Moderate snow/heavy rain – 1000m.
Best: Moderate rain – 3-10km

FOG = water droplets and solids, vis **less than 1000m** (999m).

MIST = water droplets and solids, vis **1000 and 5000m.**

HAZE = **solid particles,** vis less than 5000m.

General Met viz (MOR –Met Optical Range) expressed in M to 5000 then KM

Types of Fog

Radiation: most common type inland fog. Forms over night.Ground cooling. Need: Clear skies (great diurnal temp range); High RH; Light wind 2 – 8 kt. Average depth 500'agl, can extend to 1500'. Often **isothermal** fog layer, inversion above. Often in valleys (**Valley fog**), due cold air descends into moist valley air. Dispersed by Sun/Wind - form St/Sc.

Advection Fog: Warm, moist, stable air over colder surface. Affects coasts (sea/land temps). Need: Wind up to 15 kt to move mass along; High RH; Cooler surface. Dispered by change of air mass, wind increase/direction change. Can lift to form st/Sc

Evaporation/Steam Fog/Arctic sea smoke: Opposite to advection fog. High latitudes in winter.

Frontal Fog: Approaching warm front. 200 miles wide and hundreds of miles long. Dispersed with passage of front.

Orographic/Hill fog/Cap cloud: Stable, humid air. Condenses into cloud/fog. Dispersed by increase in temp/wind.

Haze: Reduction in visibility due to solid particles (5000m). Dispersed by winds to lift smog or daytime heating to break inversion

Volcanic Ash: Damage to airframe and engines is the more significant threat.

Dust and Sandstorm: Wind exceeds 15 to 20 knots – 3000ft. Harmattan & Haboob = dry dusty wind, N Africa – can affect up to 15,000'.

Windshield Icing: Reduces visibility. Need to apply anti-icing.

Rising and setting sun: Glare and sun can reflect off top of clouds, haze or fog.

Slant or Air-to-ground visibility Oblique vis range in fog. Shallow angle, reduced vis range.

Reporting visibility: Metres. 2nd vis given if area less than 50% prevailing or below 1500m.

RVR: Surface vis in direction of landing. Transmissometer (IRVR). 7.5' up (cockpit height).

IRVR **3 readings**: threshold (300m), mid (1000-1500m), stop (300m), updates 60 seconds.

Averaged over 1 min ATC, 10 mins METAR and SPECI.

'U' upward tendency

'D' downward tendency.

Vertical Visibility. Fog/Haze. Measured in feet using e.g. VV002 = 200ft.

Wind

Surface wind **measured** at 10m by anemometer. Upper winds measured by tracked radiosonde/pilot reports

Units: knots, m/s, k/h. 1 kt = 0.52m/s = 1.85k/h.1 MPS = 1.94kts = 3.6k/h

Calm: less than 1kt;

Lull: sudden drop in wind;

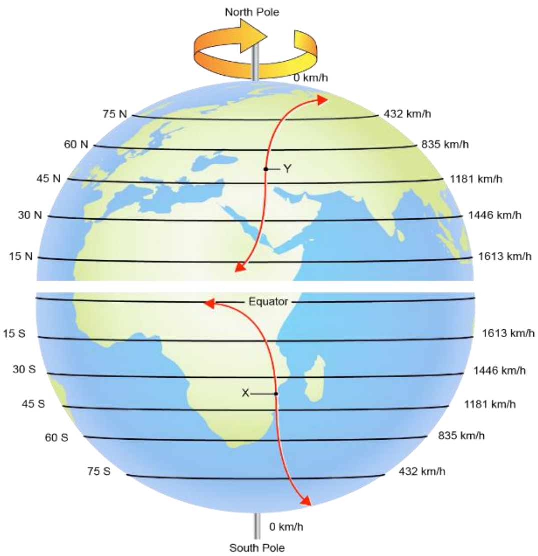
Gust: sudden increase of +10kts;

Gale: wind speed 34 – 47 kts;

Storm: 48 – 63 kts;

Hurricane: +64 kts

Air moves high to low pressure = Pressure Gradient Force (**PGF**).



Coriolis force (CF) deflects fluid in motion to right in N Hemi and to left in S Hemi.

Increase in latitude (towards poles) causes increase in **Coriolis effect**.

Coriolis proportional to speed of object/wind.

CF = 2ΩρV sin Φ

CF = 2x *angular rotation of earth* x *density* x *wind speed* x sin of *latitude.*

Geostrophic wind = PGF and CF equal and opposite. **Straight isobars.**

Gradient wind = PGF, CF and centrifugal force. **Curved isobars**.

Centrifugal force acts **with** PGF around high but **against** PGF around low therefore wind faster around high for equal isobar spacing.

Surface wind & friction layer: **N Hemi – backs and reduces at surface**/veers & increases with altitude. Opposite in S Hemi.

Over land: direction of surface wind changes by 30 deg and speed reduces by 50% of 2000FT wind.

Over sea: 10 degree change at surface and speed reduces by 25%.

Over night friction layer shallows, windspeed reduces more.

LOCATION	DEFLECTION OF SURFACE WIND FROM 3,000FT WIND	SPEED OF SURFACE WIND AS A % OF THE 3,000FT WIND
Over the Sea	10°	70%
Over the Land by Day	30°	50%
Over the Land by Night	45°	25%

Local Winds

Sea Breeze: sunny day, airfield near coast.10kts (mid-latitudes), 10 – 15 miles inland and up to about 1000' AMSL.

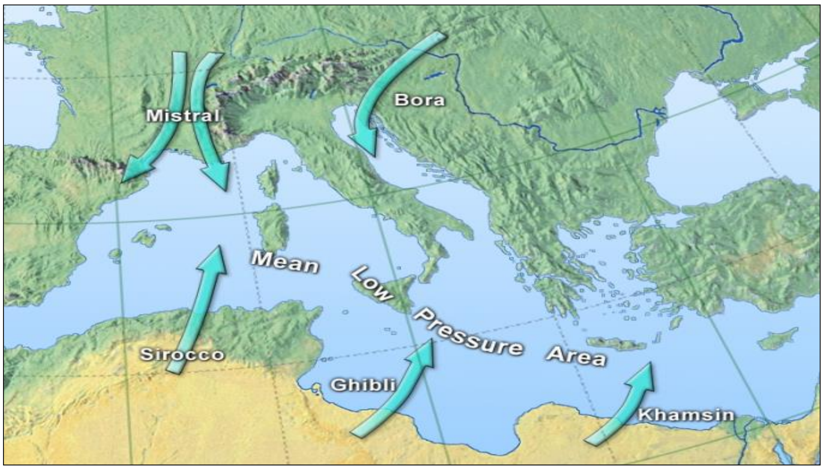
Night time: **land breeze** (not as strong).

Mountain winds: **Anabatic** – upslope, day time. Can create valley wind in afternoon.

Katabatic (**Bora**, Adriatic, 70-100kts) – cold downslope, night time. Can create mountain wind flowing out of valley during night.

Mistral: valley wind flows down Rhone valley out into Mediterranean.

Foehn wind: Alps. Warm, dry mountain wind; cap cloud top of mountain. Called the Chinook in Rocky Mountains, USA.



Scirocco – Dry, dusty, southerly wind from N Africa to French coast. Can bring fog, drizzle, stratus.

Khamsin – dry, dusty, southerly wind from Egypt.

Ghibli – dry, dusty, southerly wind from Libya

Upper Winds

Upper winds/thermal winds: caused by different air mass temperatures.

Isohypses - lines of equal pressure (above surface).

Isotachs - lines of equal wind speed.

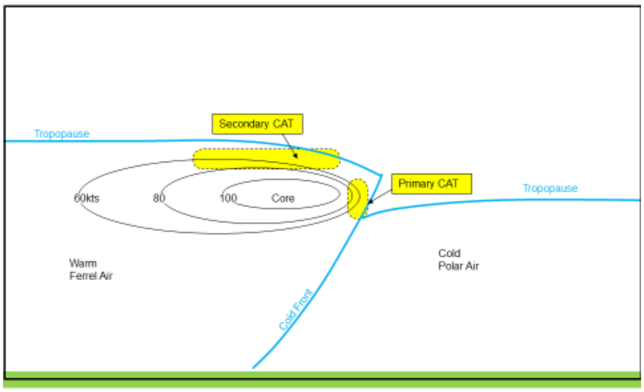
Jet Stream: wind of 60kts or more. Only appears on SigWX chart if min 80kts.

Sub-Tropical jet - (FL400, 30 – 40N/S), west to east, all year round.

Polar Front jet - (FL300, 50 – 60N/S) - west to east all year round.

Seasonal jets – **Arctic** (west to East), winter, 70N (50N USA), FL200;

Equatorial/easterly jet – east to west, summer, 10-20N, FL500.



Turbulence Around Jet Streams

Jet Stream forms in warmer air mass below tropopause.

- About 200 miles wide, 2 miles deep, 2000 miles long

- Fastest at core

- Travels at speeds above 60kt, only reported on charts if over 80kt.

- Clear Air Turbulence (CAT) - most severe on cold air side.

Turbulence

Reporting Criteria (Above FL150)

Light turbulence/chop: slight strain against seatbelts, Food service continues.

Moderate turbulence/chop: definite strain against seatbelts, Food service difficult.

Severe turbulence: severe strain against seatbelts, Food service/walking impossible.

Mechanical: Mountains, strength affected by wind speed, height of obstacle.

Thermal: day time (most severe at 15:00), over land, unstable air.

Vertical Windshear - change in wind speed/direction with altitude, kts/100ft

Horizontal Windshear – wind change in horizontal plane, kts/1000ft

Worst windshear associated with **TS;** also Frontal passage, inversions.

Mountain Waves/Standing Waves/Lee waves:

- turbulence 50 - 100nm downwind.
- Stable air at top of mountain,
- wind speed min 15/20kts
- wind direction 90 degrees to mountain range.
- Cap, lenticular, rotor or roll cloud can develop,
- vertical windspeed 1000’/min, waves 1500’ deep.

Pressure Systems

(L) **Low Pressure/Depression**: Convergence, rising air, cloud, precipitation. Air flow anti-clockwise N Hemi/clockwise S Hemi.

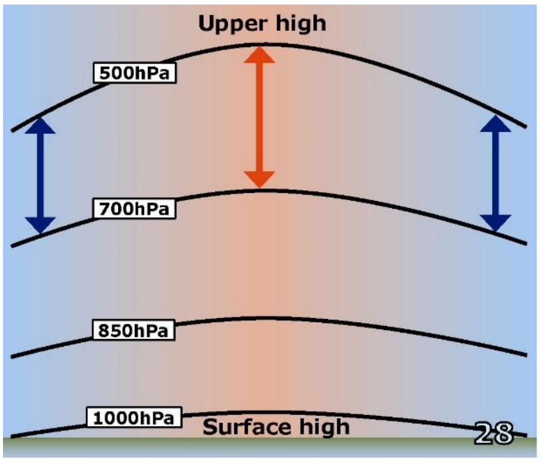
(H) **High Pressure/Anti-cyclone**: Divergence, sinking air, calm, haze, poss fog (winter), TS (Summer). Air flow clockwise N Hemi/anticlockwise S Hemi.

Trough of **Low** Pressure: increased convergence, cloud, precipitation.

Ridge or **Wedge** of **High** Pressure: calm, same as (H).

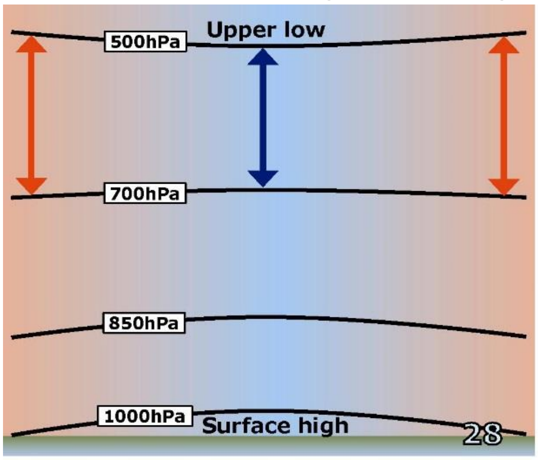
Col: between 2xH, 2xL. Calm, haze, fog, poss TS over land in summer.

Warm anti-cyclone/High Pressure: warmer air at core so pressure levels bulge upwards away from surface e.g. Azores High, Pacific High.



Blocking anti-cyclone/High Pressure: (often warm H i.e. Azores) blocks path of Polar Front Depressions forcing them to deviate from usual track.

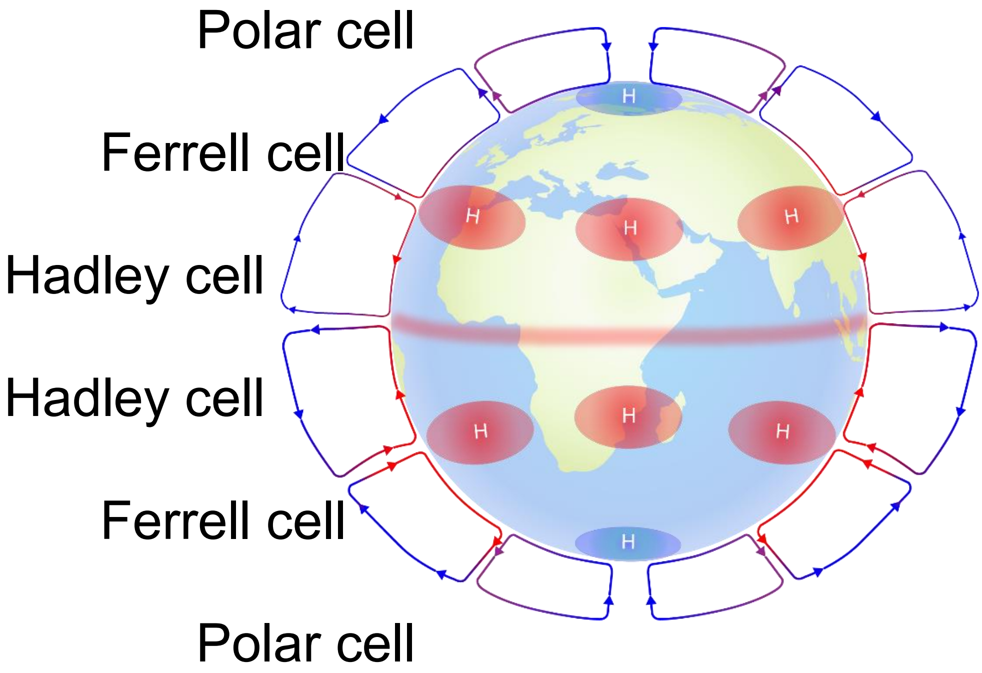
Cold anti-cyclone: colder air at core so pressure levels bulge upwards close to surface, downwards at altitude e.g. Siberian High/Canadian High.



Temporary Cold Anti-cyclone: forms between two travelling polar front depressions (mid-latitudes), relative High in cold polar air mass.

<u>Global Air Circulation Cells:</u> **Hadley/Ferrell/Polar Cells.**

Air rising from ITCZ forms global pressure belts i.e. Equatorial low pressure belt (L) - Sub-tropical Highs (H) - Mid-latitude Lows (L) - Polar Highs (H)

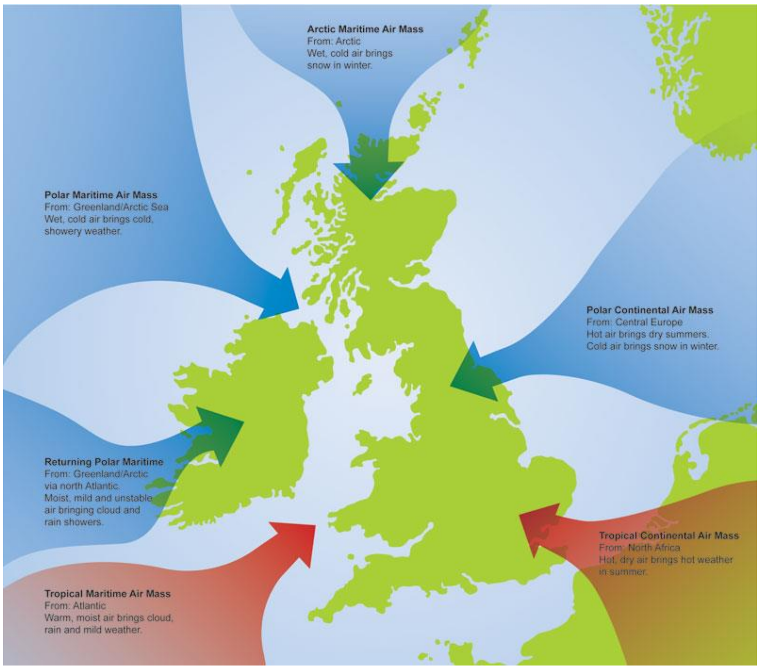


Dominant Pressure systems: January = Siberian & Canadian Highs; Icelandic & N Australian Lows. July = Azores & Pacific Highs; Asian Low.

<u>**Air Masses**</u> All Stable at source

Either: **Tropical(T)/Polar(P)/Equatorial(E)** or **Arctic (Antarctic)(A/AA)** plus either:

Maritime (M) or **Continental (C)**



Tropical Maritime – warm, moist, Atlantic, tracks NE so **cools, stability increases, RH** increases. WX: **Low level stratus or turbulence cloud, fog, drizzle, poor visibility.**

Polar Maritime – cold, moist, polar region, tracks S over sea, warms, more moist, stability **decreases. WX: CB, showers, good visibility.** Winter frost, summer convection.

Arctic Maritime - Very cold, WX: **Cu, CB, rain, sleet or snow showers over N Scotland**

Tropical Continental (summer) N Africa/S Europe. WX: **Clear skies, hot and hazy**. Poss fog in English channel. Poss Cbs/Cu on S Coast UK, TS late afternoon.

Polar Continental (winter) - Russia, very cold, low humidity. WX: **Clear skies, Low temps, frost poss snow showers.**

Returning Polar Maritime – PM tracks S (unstable layer) then N (lower stable layer). WX: low level St, poor vis. Winter drizzle, summer coastal mist, poss Cb.

Fronts

Front is where two different air masses meet e.g. the **Polar Front** between polar and tropical air masses. Located approx. 50 - 60N & S, July Canada to Norway/January Florida to SW UK.

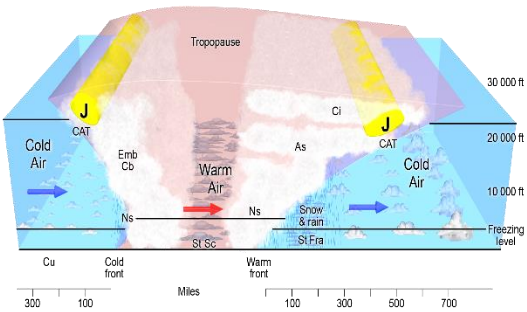
Mediterranean Front only exists in winter between Pc over Europe and Tc over N Africa.

Arctic and Antarctic Fronts sit between arctic and polar continental air masses in winter.

ITCZ less defined (25 – 300nm wide), moves north in N Hemi summer months and south in N Hemi winter.

Stationary front: nil/stable weather, poss stratiform cloud and precipitation if humid enough. Precipitation will be long lasting/continuous and can be moderate or heavy.

Polar Front Depressions (Westerly Waves)



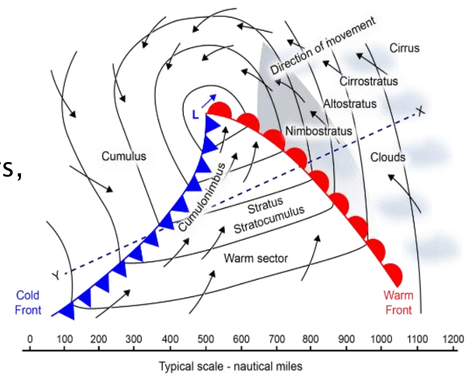
Cold polar air forms a cold front (slope 1:50). Warm tropical air forms warm front (slope 1:150). Wedge of warm tropical air in between is the warm sector.

Warm Front Cloud Formation – stratiform; Ci, Cs, As, Ns, St. WX: Rain/snow (Ns), poss fog ahead of the front. Wind southerly. WX extends 500-700nm belt ahead of surface position. **Warm sector weather** – TM air; low St/Sc. WX: fog or drizzle, poor vis. Wind westerly.

Cold Front Cloud Formation – cumuliform; Cu, Cb. WX: Rain showers, poss TS & squalls. Wind northerly. WX extends 50-100nm belt behind surface position.

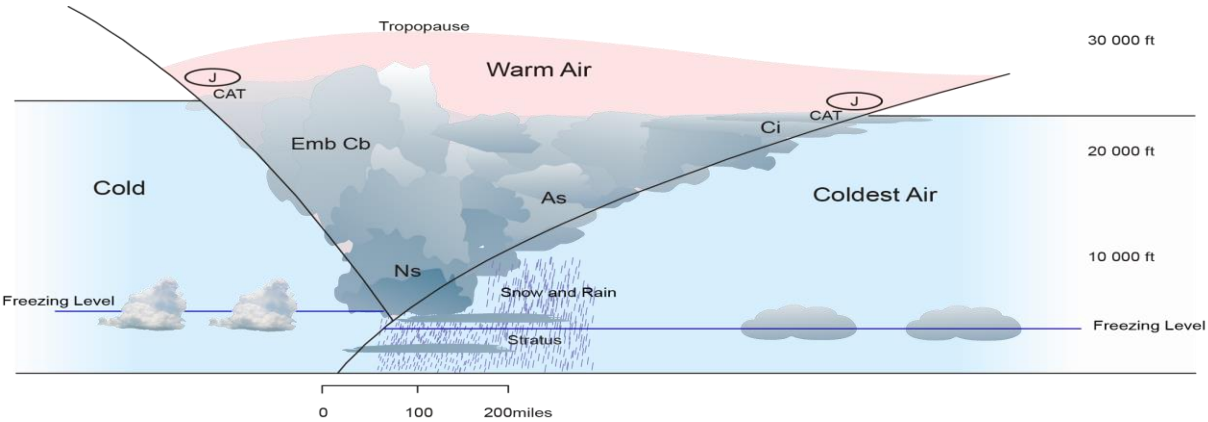
Cold Sector Weather - PM or PC. Cumuliform cloud. WX: showers, good vis (except in SH). Wind north westerly.

Pressure decreasing with approach of warm front, steady in warm sector, increasing behind cold front; **Wind** southerly ahead of warm front, veers at warm front, veers at cold front.

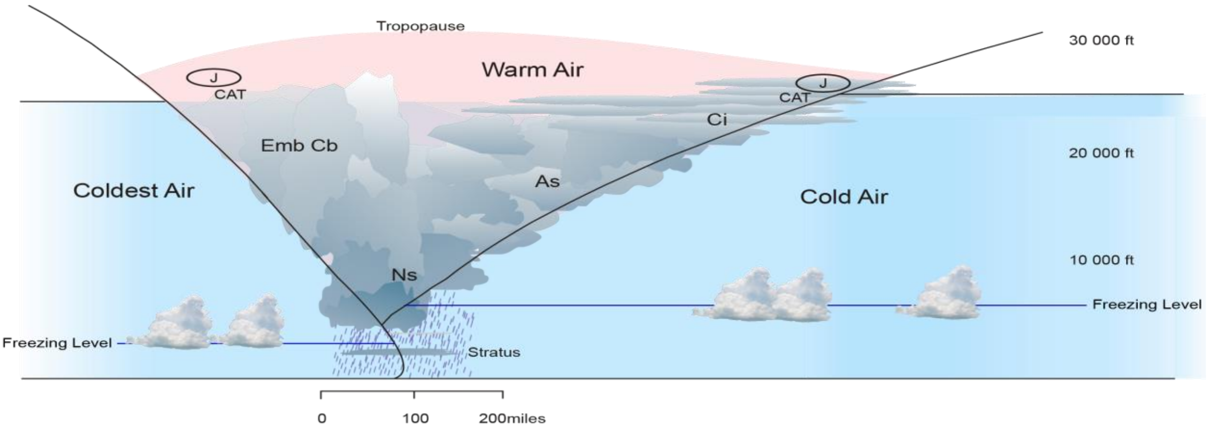


Warm front travels at 2/3 speed of cold front so cold catches up with warm front = occluded front. Mix of cold and warm front cloud formations, poss embd CBs.

Warm occlusion: (why warm = looks like letter 'y') cold air ahead of warm front is colder than air behind cold front so less cold air (PM?) forced to rise over coldest air (PC?). More often in winter. Precipitation falls **ahead** of occluded front (warm front characteristics).



Cold occlusion: cold air behind the cold front is colder (more dense) than the air in front of the warm front it will undercut the less cold air. More often in summer. Narrow rain belt both sides but mostly ahead or surface occlusion. Narrow belt of precipitation both sides but **mostly ahead** of surface occlusion.



Back-bent occlusions: Extend from centre of depression where occlusion starts. Belt of rain in cold air behind cold front, sometimes TS.

<u>Non-frontal Depressions</u>

Secondary Depressions: Form within circulation of primary low; can be thermal or orographic

Orographic Depressions: strong wind, mountains, low on leeward side.
If unstable air can expect Cu or Cb. Showers, TS, Hail. Worse with cold front passing over e.g. Alps in N Italy in winter – squalls, heavy showers.

Thermal Depressions: due thermal lifting causing low pressure at surface. If **unstable** air, can be active up to the tropopause, Cu, Cb, TS, hail.

- **Over water lows (Winter):** PC air over relatively warmer seas/lakes – Med, Black Sea.

- **Polar Air Depression/Polar Lows:** Arctic Maritime air - Norwegian, Barents, Sea of Japan, Gulf of Alaska.

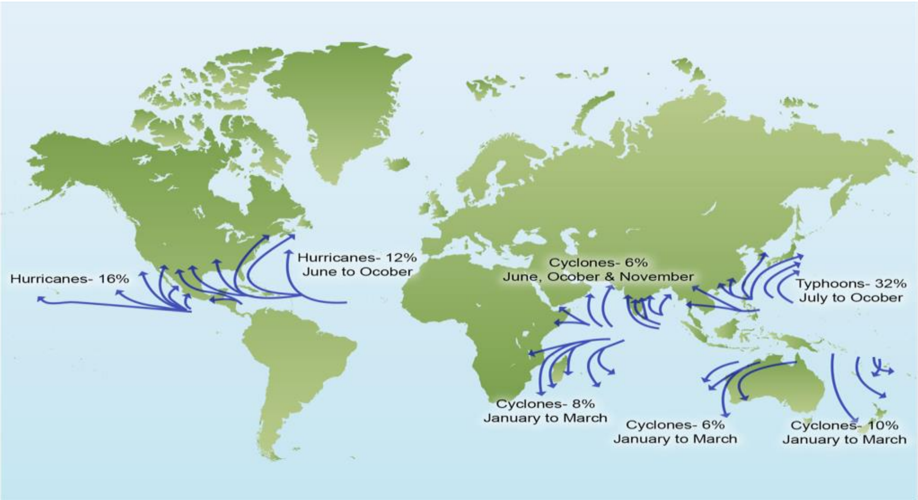
Polar Air Outbreaks: unseasonably cold weather, snowfall lower latitudes (30˚ - 50˚).

Cold Air Pools: mid-troposphere, undetectable on surface pressure chart. Very unstable conditions; Lasts several days; 300nm - 600nm wide; 10 000ft to 30 000ft deep.

- **Over-land lows (Summer):** high temps - thermal low – TS e.g. **Asian Low** July/August, ITCZ overhead.

Tropical Revolving Storms (Thermal lows): Hurricanes, Cyclones, Typhoons. **Need** unstable air, Sea temp min 26.5C & 200 - 300ft deep, Trigger, within 5 – 25 deg N and S. Travel **west**ward then curve away from equator and head **east**.

Occurrences: Occur N Hemi June – Oct, S Hemi Dec – April. 32% S China Sea.

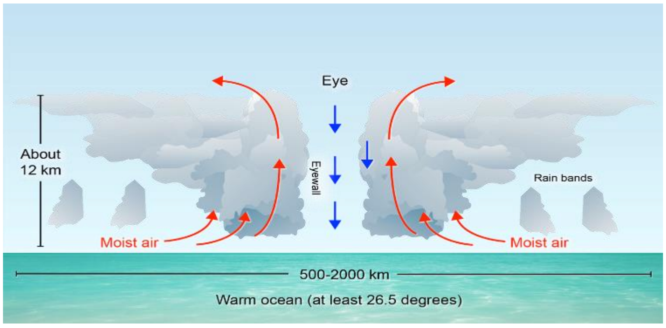


- **Annual number of hurricanes occurring in N Atlantic?**
- *10 or less is best answer if given choice. 7 – 9 otherwise.

- **Annual number of Cyclones occurring off NE coast of Australia?**
- 9 per season
-
- Other occurrences:
- S China Sea – 25 (16 mentioned in exam!)
- NE Pacific – 16 or 17
- N India – 5 or 6
- Madagascar – 10 or 11
- W Australia – 7

N Australia (Darwin) - 2

Easterly waves: Low pressures along ITCZ meet outflow from Azores high to form 'waves' Frequent TS from Africa travel east, trigger TRS, account for 80% annual USA hurricanes.



Tropical Depression – 20-33kts;
Tropical Storm – rotating 34 – 63kts.
Tropical Cyclone – above 64kts.
Travel 15 – 20kts across surface. Die as hit land or colder sea.
Eye - calm, clear skies. Diameter 20 – 50km.
Spiral rain bands.
Eye walls – worst conditions.

Ch 21 Remote Sensing/Met Observation

Weather Radar: Reflects wet precipitation. **Ground based** weather surveillance radar (WSR). **Airborne weather radar (AWR):** mounted in aircraft. **Tilt Control** to assess returns depth.

Limitations: - **Blind Alley effect:** threats between weather cells;
- **Masking:** heavy precipitation may cloak weather cells behind.
-

TS avoidance: Above 20,000' – 20nm. Below avoid by 10nm.
Lightning Detectors: Stormscope/Strikefinder if not integral to AWR.

Geostationary Satellites: 35,786km above equator, e.g. GOES, Meteosat, and EUMETSAT. View whole planet but images relatively poor resolution. Identify TRS activity.

Polar Orbiting Satellites: Orbit twice daily 850 km. e.g. NOAA, MetopA, Meteor and RESURS. Better resolution and detection of weather fronts.

Visual Imagery: reflects sunlight; shows cloud patterns/storm systems/snow cover/weather fronts.
Disadvantages: daylight only; Difficult to distinguish low from high clouds and snow from clouds in winter.

Infra-red Imagery: senses heat (day and night). High altitude cloud = cold, low-level cloud = warm. Helps identify location of clouds, fronts, jet streams.

Most effective use of imaging is to compare visual with infra-red.

Ch 22 Reporting and Forecasting

Met Services: ICAO set up World Meteorological Organisation (WMO) to standardise weather reporting and data dissemination then WAFS in 1982 for digitalised reports and forecasts.

Information Source Organisations within WAFS:
World Area Forecast Centres (upper air SIGWX). London & Washington
Meteorological offices (TAF) All over world
Meteorological Watch Offices (SIGMET)
Meteorological Stations (METAR, SPECI, TREND) Aerodrome based
Volcanic Ash Advisory Centre (VAAC) 9 across the world
Tropical Cyclone Advisory Centre (TCAC)

Data collected from aircraft in flight (AMDAR)

Pre-flight planning/briefing sources:
Routine Reports: METAR (issued every 30 or 60 mins);
Landing forecast/Trend (as required);
SPECI (change of operational significance, as required.)

Routine Forecasts: TAF (every 3 or 6 hours. Valid 9-36hrs);
SIGWX charts (every 6 hrs, upper levels);
GAMET (Forecast low-level, text format);
GAFOR (Low level vis/cloud (VFR))

En route reports: VOLMET (METAR for up to 10 aerodromes. Wind **True**);
ATIS (wind **Magnetic**);
Weather Warnings (SIGMET/AIRMET)

N.B. Surface wind speed and direction averaged over 10 minutes before METAR update. Given in **°True** in METAR and TAF but in degrees **°Magnetic** by ATC & ATIS.