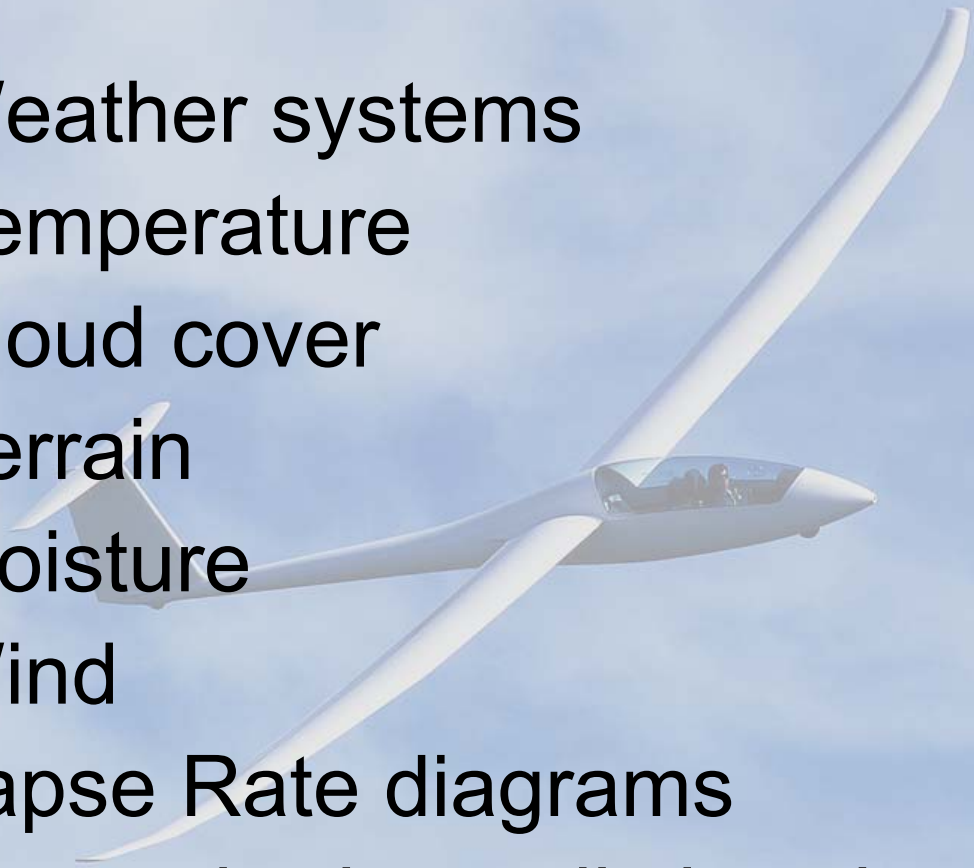
Introduction to Gliding Meteorology

Darling Downs Soaring Club
www.gogliding.org.au

Objectives

- Basic Meteorology principles
  - Atmosphere
  - Clouds
  - Lift
  - Weather maps
- Forecasting for gliding
  - Stability and Instability
  - Thermal lift
  - Skew T diagrams
  - Using NOAA

Forecasting the Weather uses:



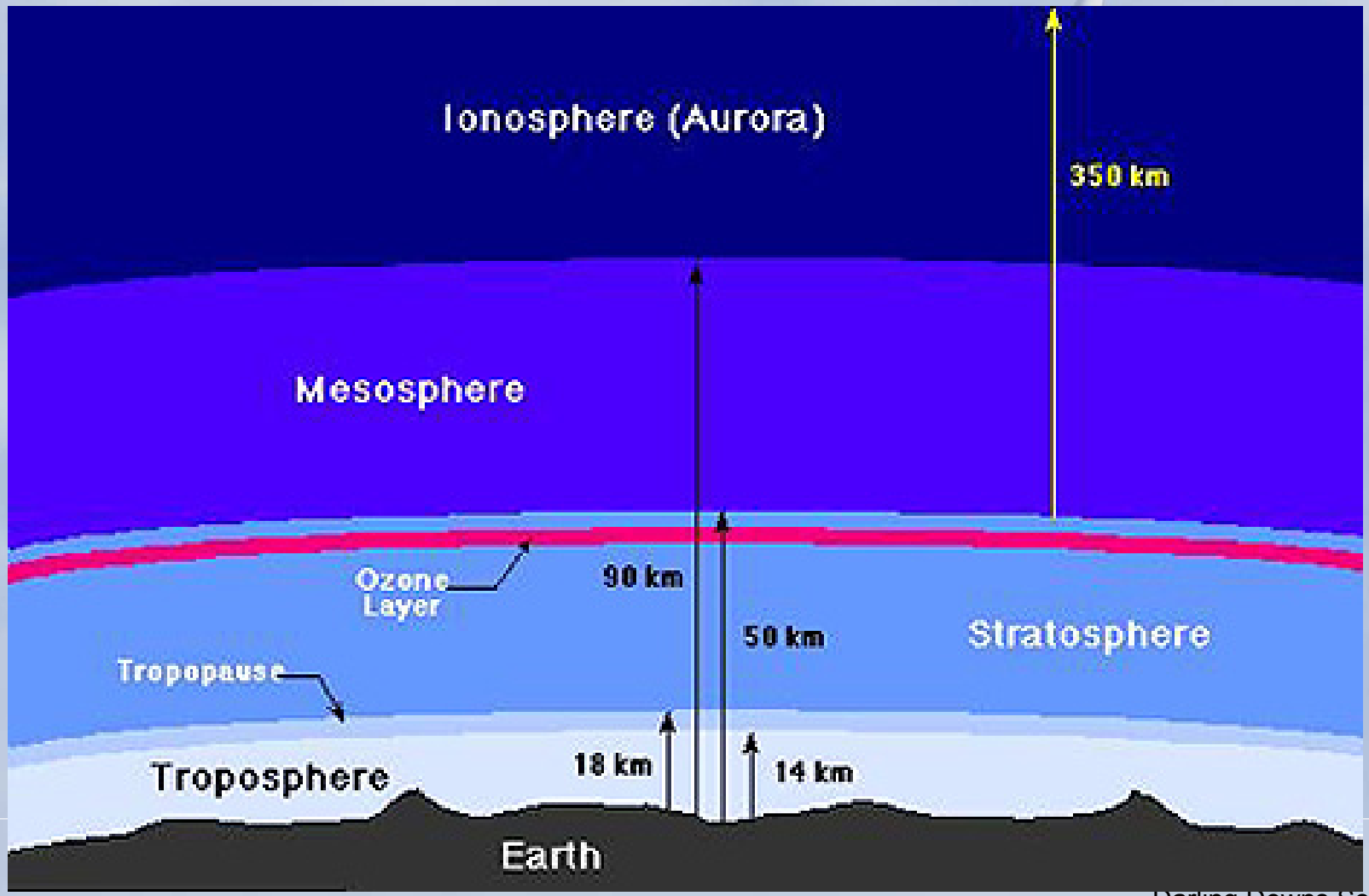
- Weather systems
- Temperature
- Cloud cover
- Terrain
- Moisture
- Wind
- Lapse Rate diagrams
- Atmospheric predictive simulations

Contents:

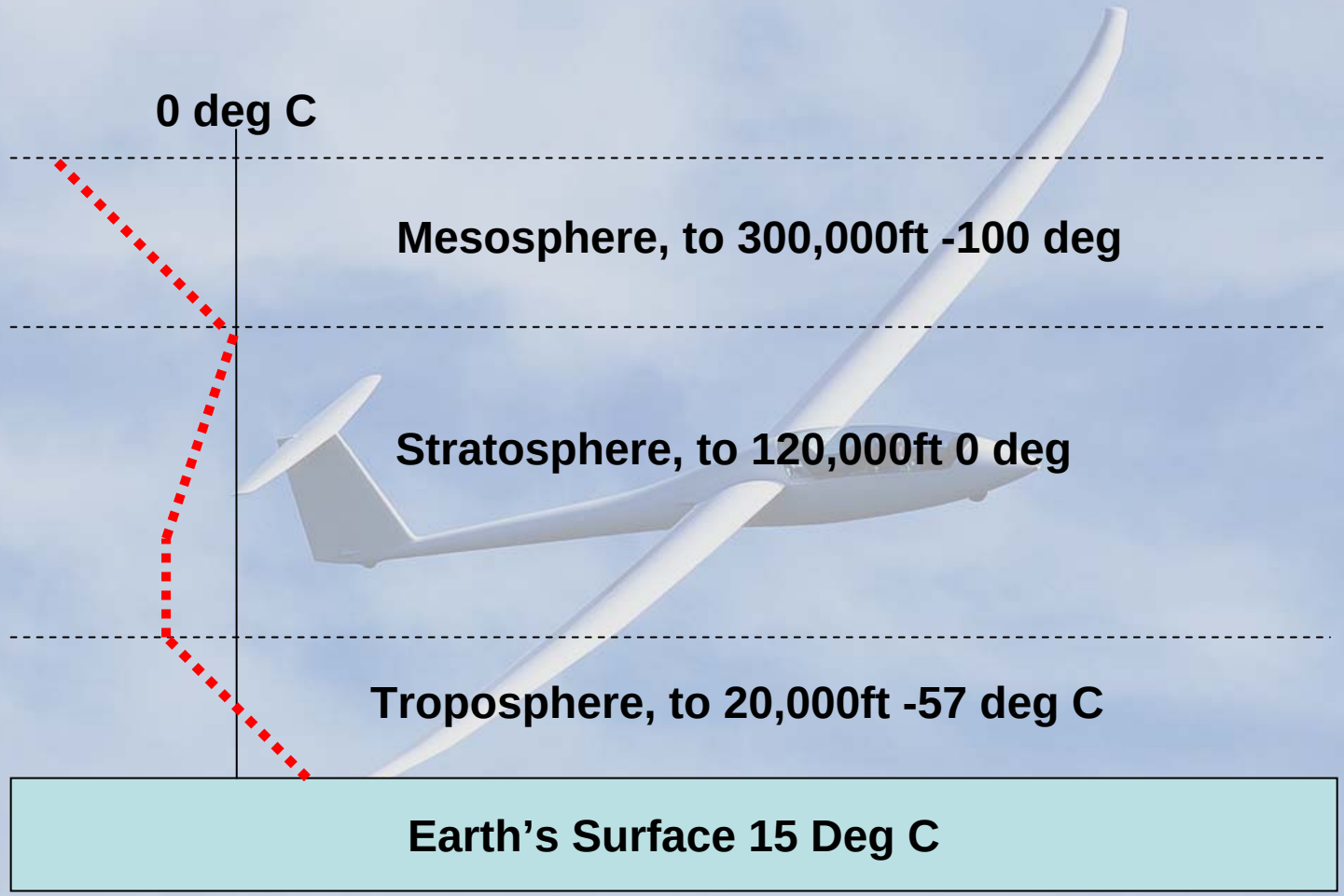
- Part 1 – Atmosphere and Clouds
- Part 2 – Types of Lift
- Part 3 – Synoptic Charts
- Part 4 – Hazardous weather events
- Part 5 – Stability and Instability

Part 1
Atmosphere and Clouds

Our Atmosphere



Temperatures in the Atmosphere



Cloud Classifications

- **High-Level Clouds**
  Cloud types include: cirrus and cirrostratus.
- **Mid-Level Clouds**
  Cloud types include: altocumulus, altostratus.
- **Low-Level Clouds**
  Cloud types include: nimbostratus and stratocumulus.
- **Clouds with Vertical Development**
  Cloud types include fair weather cumulus and cumulonimbus.
- **Other Cloud Types**
  Cloud types include: contrails, billow clouds, mammatus, orographic and pileus clouds.

High Level Clouds

- Form above 20,000 feet
- temperatures are cold at high elevations,
- clouds are primarily composed of ice crystals.
- Typically thin and white in appearance, but can appear in a magnificent array of colours when the sun is low on the horizon.

Mid Level Clouds

- Bases between 6,500 and 20,000 feet
- Composed primarily of water droplets
- Can also be composed of ice crystals when temperatures are cold enough.

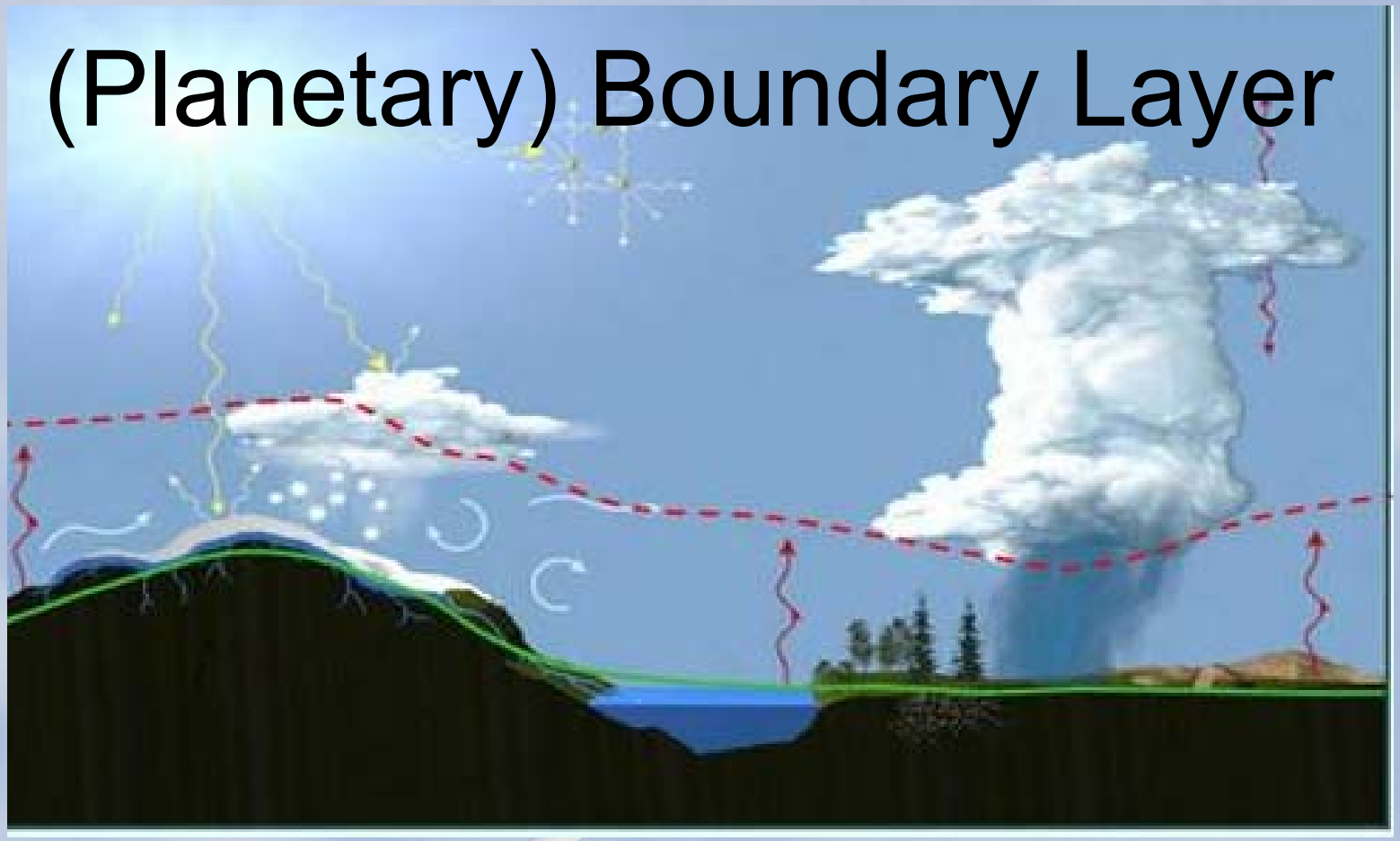
Low Level Clouds

- Mostly composed of water droplets
- bases generally lie below 6,500 feet
- When temperatures are cold enough, these clouds may also contain ice particles and snow.

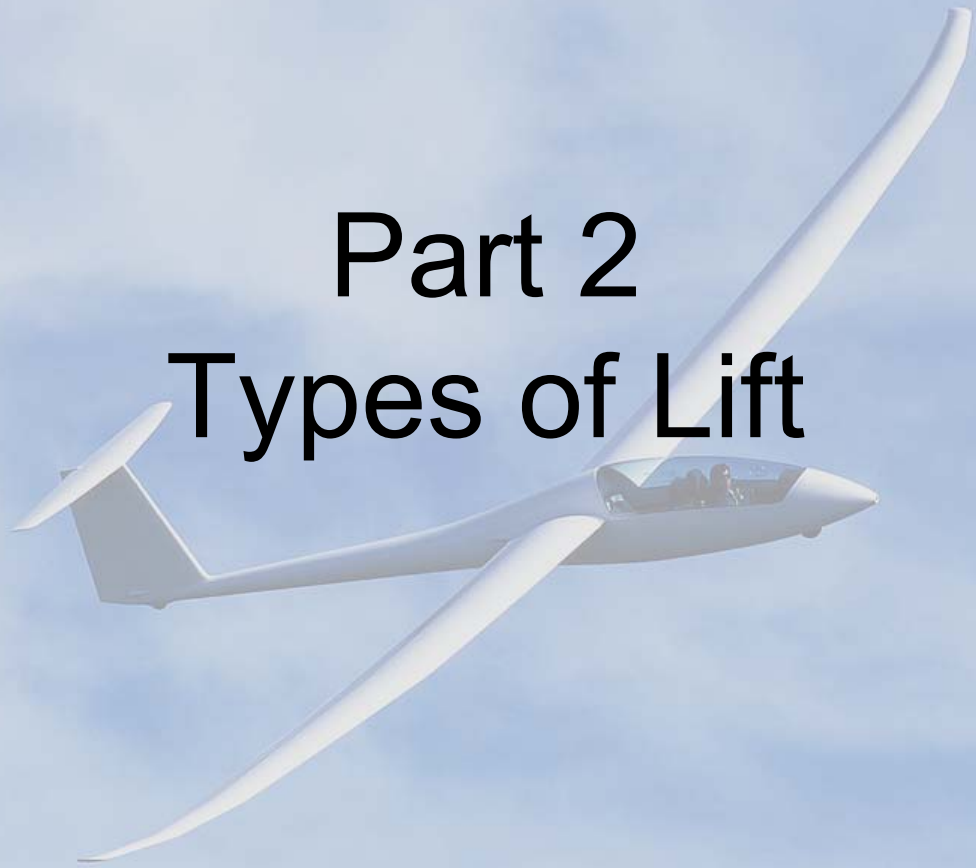
Vertically Developed Clouds

- Generated through either thermal convection or frontal lifting
- Can grow to heights in excess of 39,000 feet releasing incredible amounts of energy through the condensation of water vapour within the cloud itself.

(Planetary) Boundary Layer



The section of the Earth's atmosphere that is closest to the ground, and within which wind is influenced by friction with the Earth's crust. (average up to 3,300 feet)



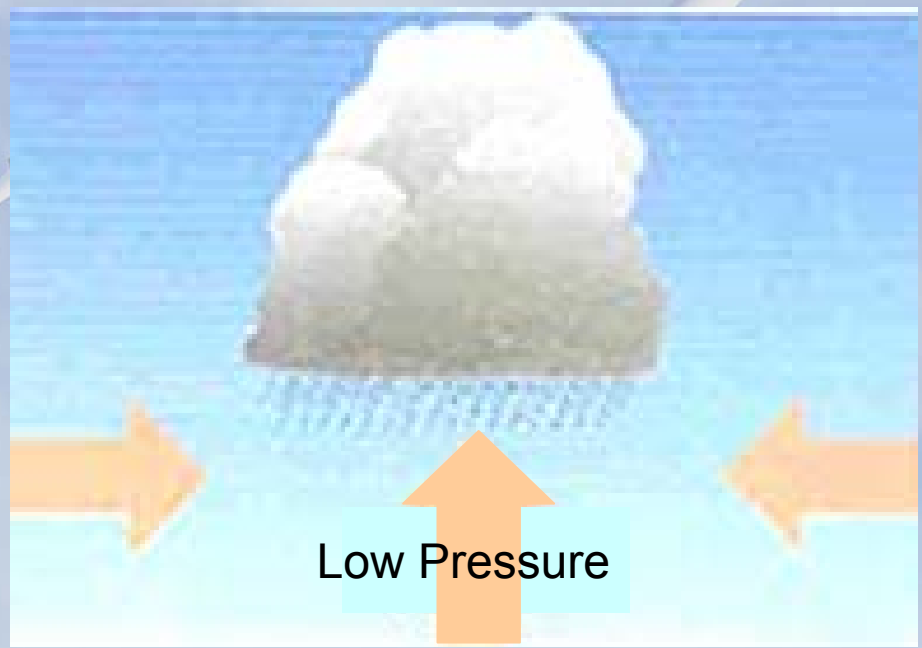
Part 2
Types of Lift

Lifting or Rising of an Airmass - 1

- **Orographic Uplift**: Air moving laterally meets mountains or other features that form topographic barriers, causing the air to rise to get past.

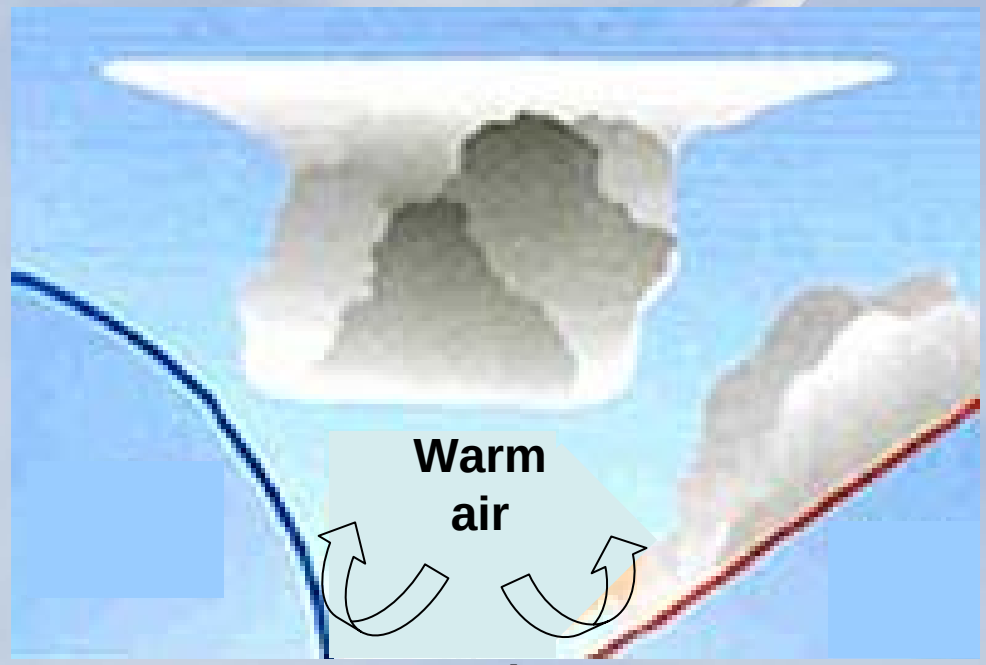
Lifting or Rising of an Airmass - 2

- **Dynamic Convergence**: winds coming together force air to concentrate, squeezing it and causing it to move upwards



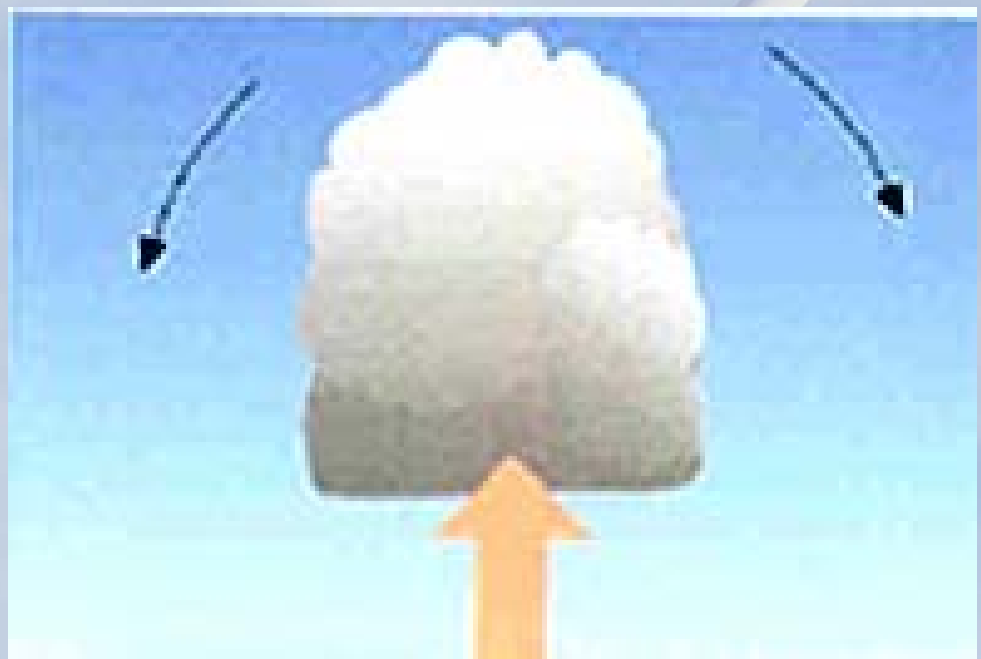
Lifting or Rising of an Airmass - 3

- **Frontal Collision**: two different air masses, one colder than the other, meet, causing the cold air to wedge under the warm air and driving the latter upward.



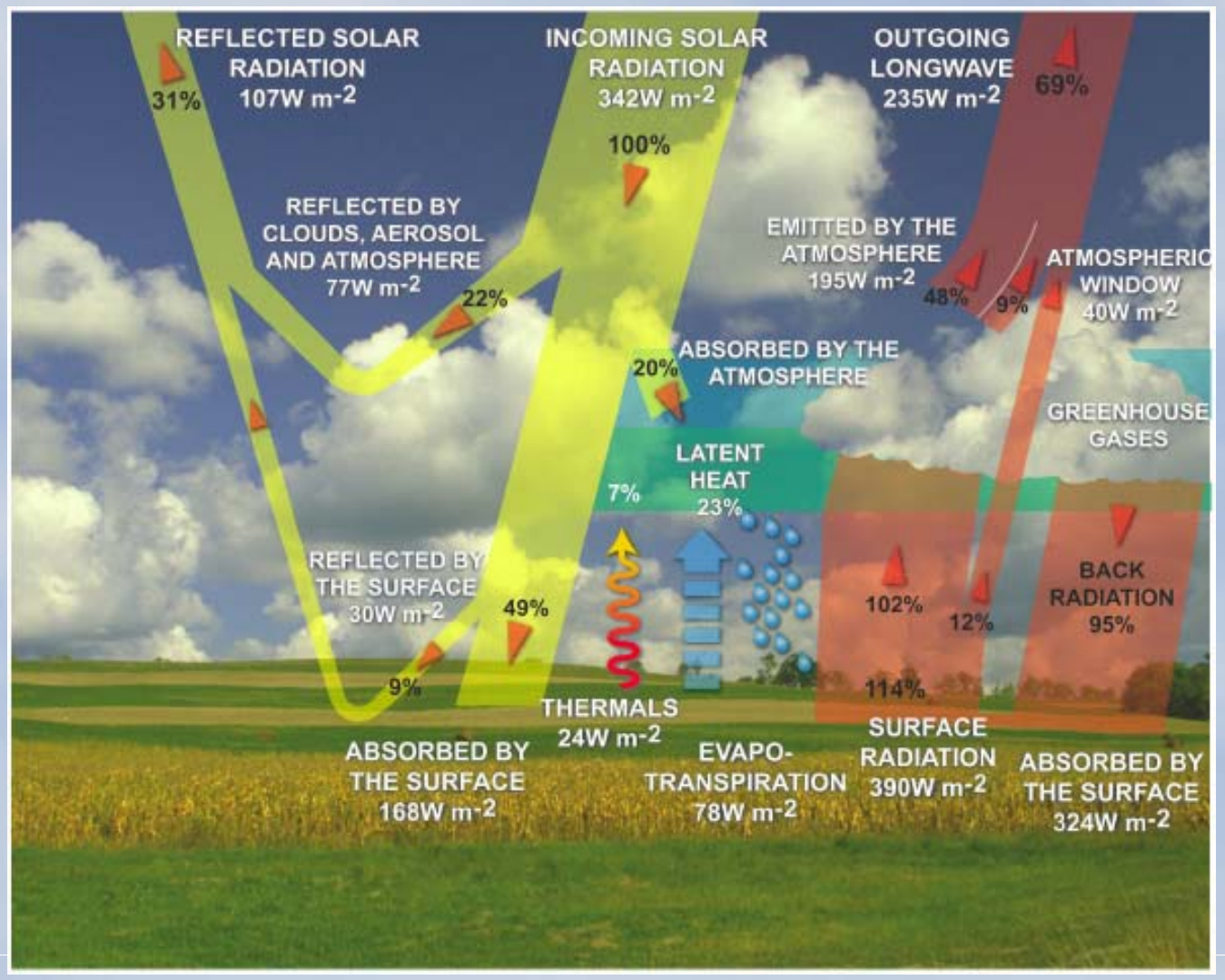
Lifting or Rising of an Airmass -4

- **Thermal Convection**: from surface or lower atmosphere heating.

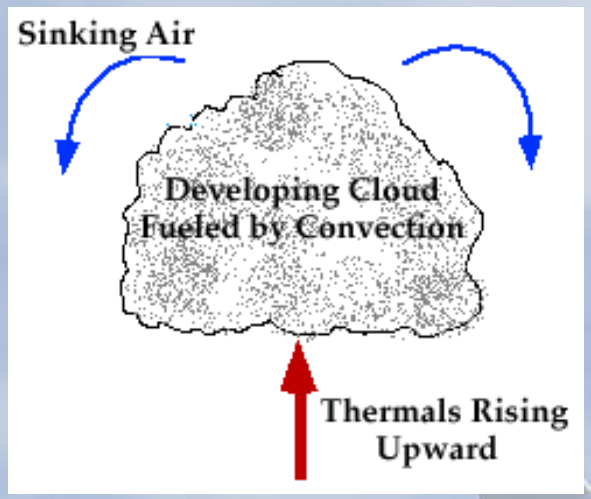


5 kms

Nett radiation - global energy flow



Lifting by Convection

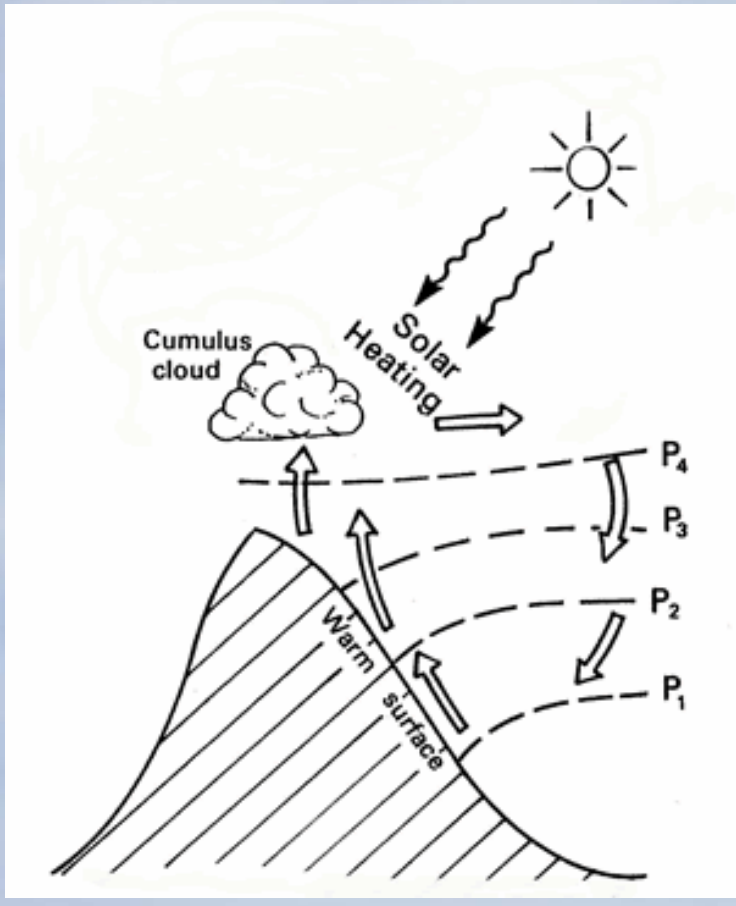


Convection refers primarily to atmospheric motions in the vertical direction.

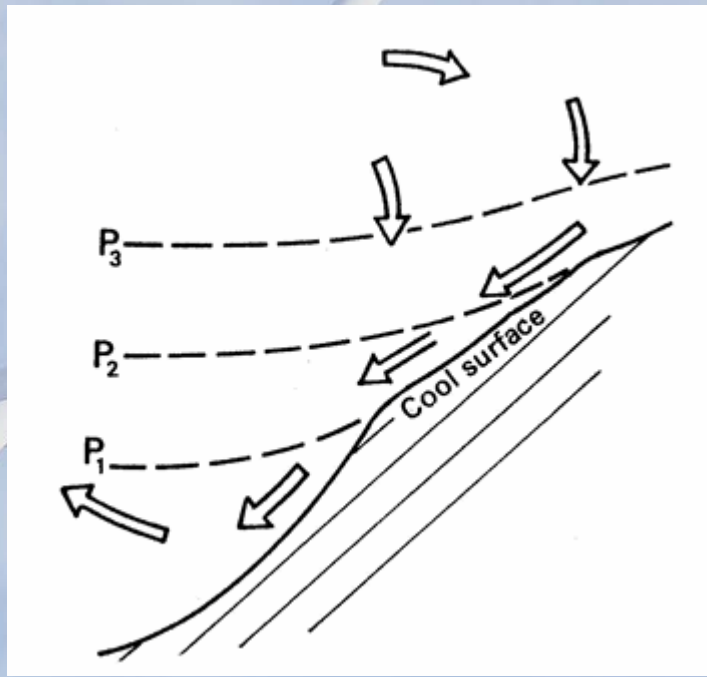
As the earth is heated by the sun, bubbles of hot air (thermals) rise upward from the warm surface. A thermal cools as it rises and becomes diluted as it mixes with the surrounding air, losing some of its buoyancy (its ability to rise).

An air parcel will rise naturally if the air within the parcel is warmer than the surrounding air (like a hot air balloon). Therefore, if cool air is present aloft with warm air at lower levels, thermals can rise to great heights before losing their buoyancy.

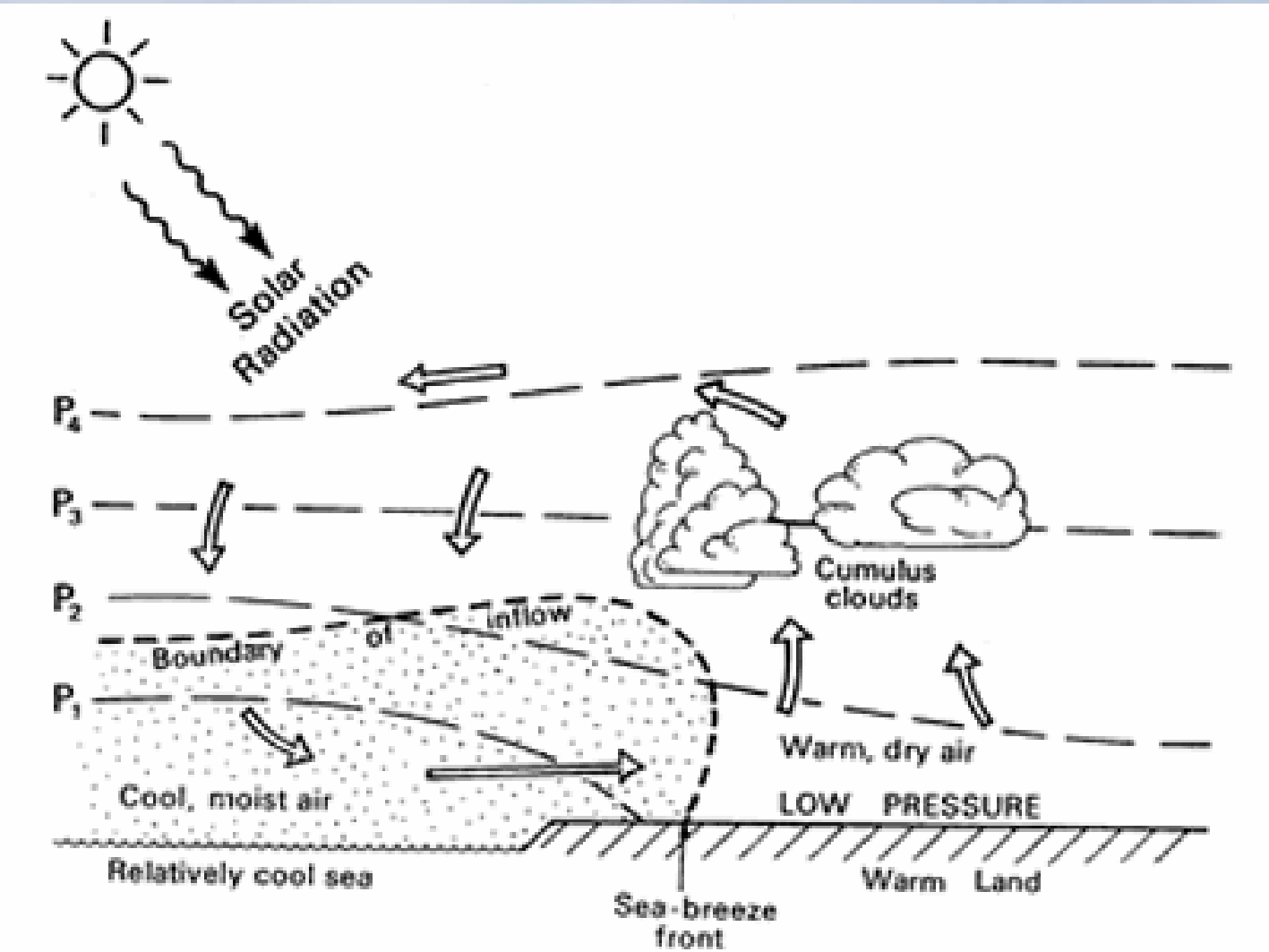
Anabatic Wind



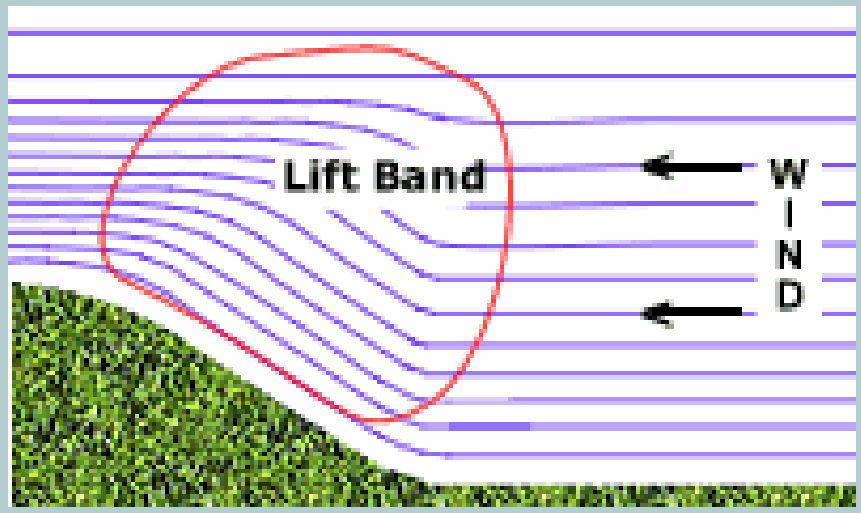
Katabatic Wind



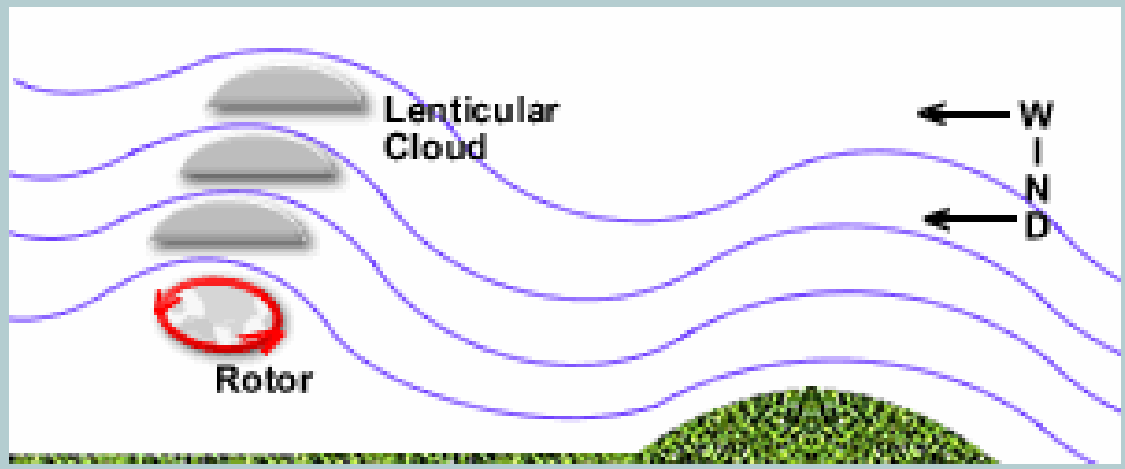
Sea Breezes


Solar Radiation
P_4
P_3
P_2
P_1
Cumulus clouds
Boundary of inflow
Warm, dry air
Cool, moist air
LOW PRESSURE
Relatively cool sea
Warm Land
Sea-breeze front

Ridge Lift

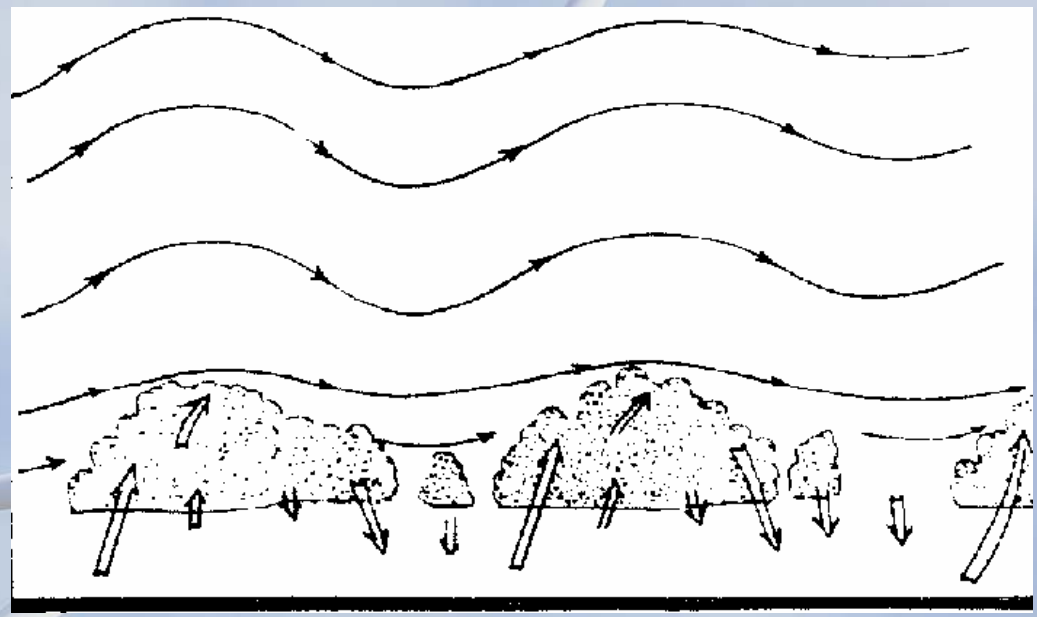


Mountain Wave Lift

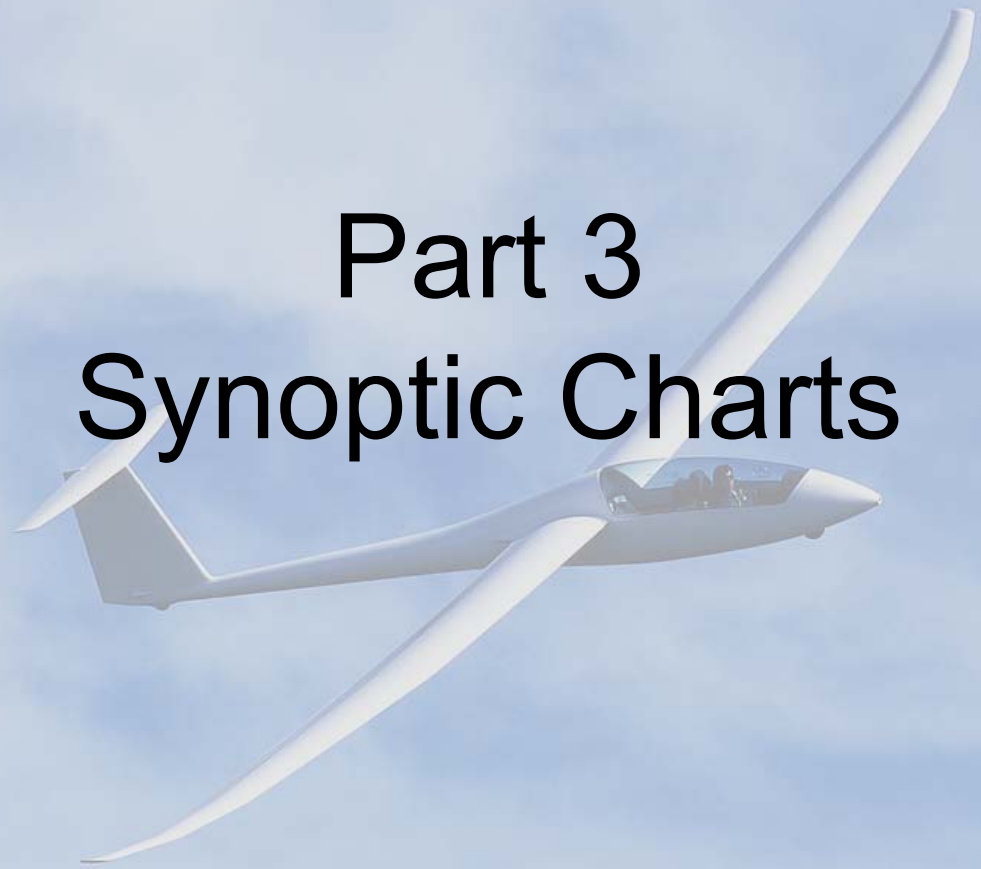


Shear Wave – wave above the streets

- may develop above and at right angles to cloud streets.
- not always marked by lenticular cloud.
- The first wave often occurs at the upwind end of a cloud street.

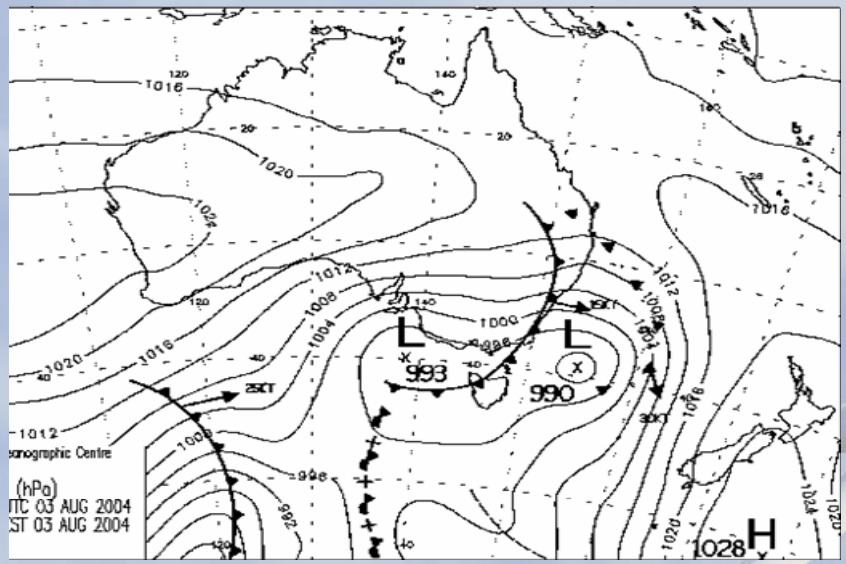


If, when flying along a cloud street, there is a stretch where the usual lift is replaced by sink and then there is a small zone of unusually strong and rough lift it is quite likely that the street is being influenced by the waves above.

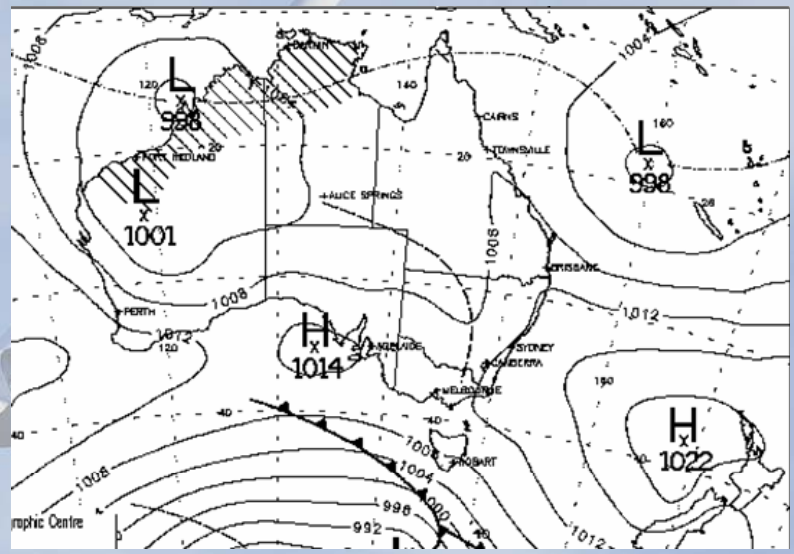


Part 3
Synoptic Charts

Synoptic Charts – Surface Conditions

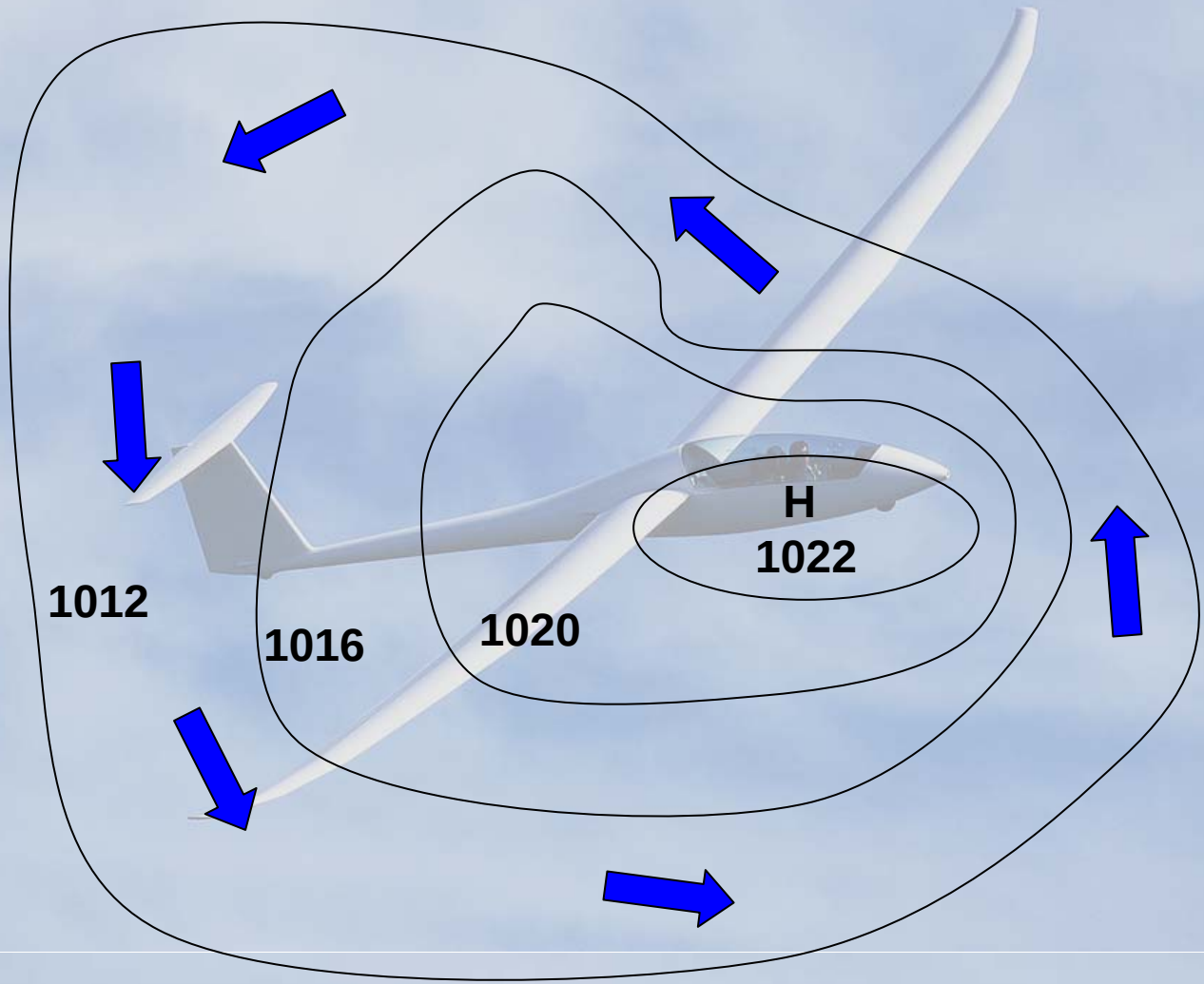


Typical Winter Pattern

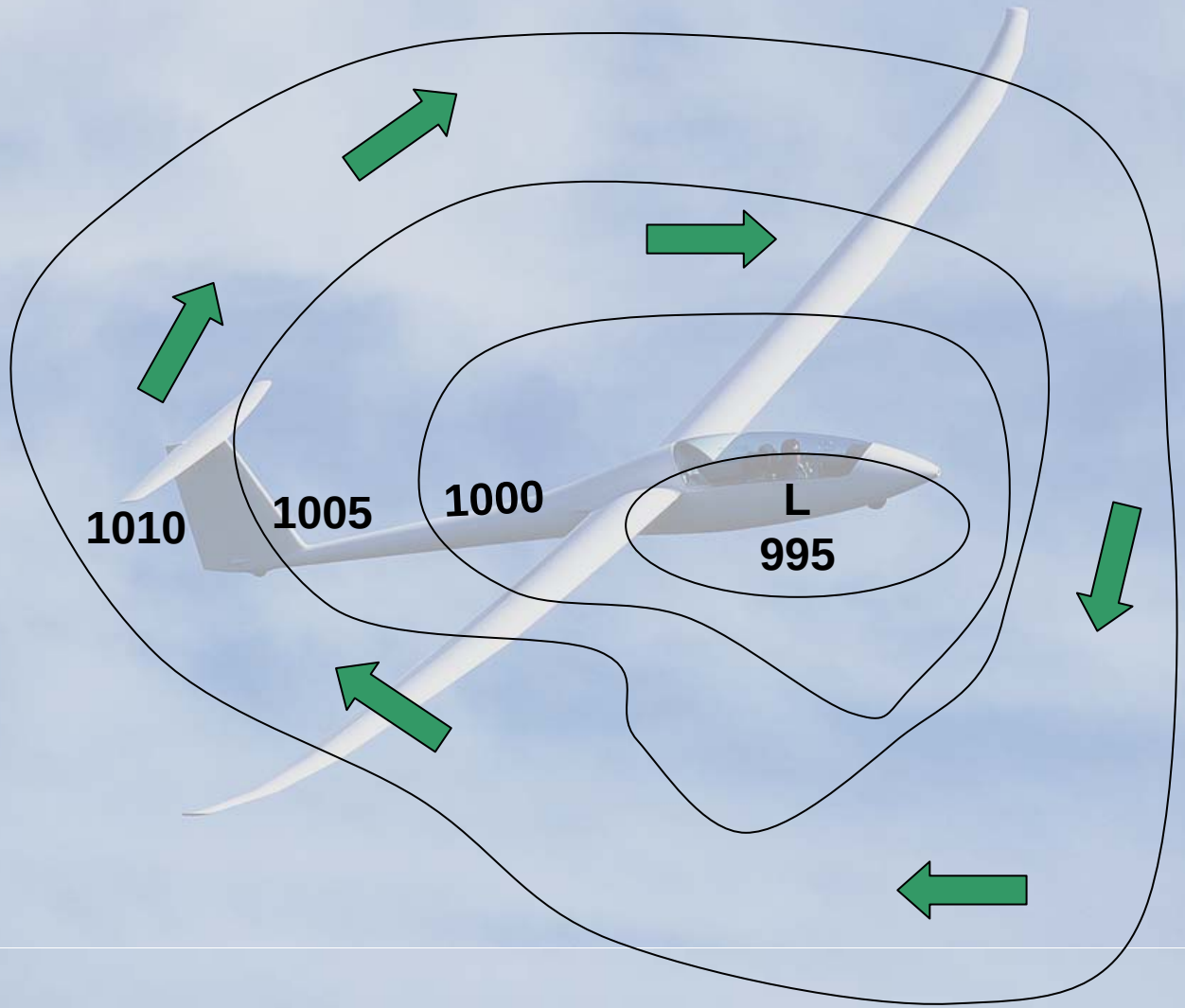


Typical Summer Pattern

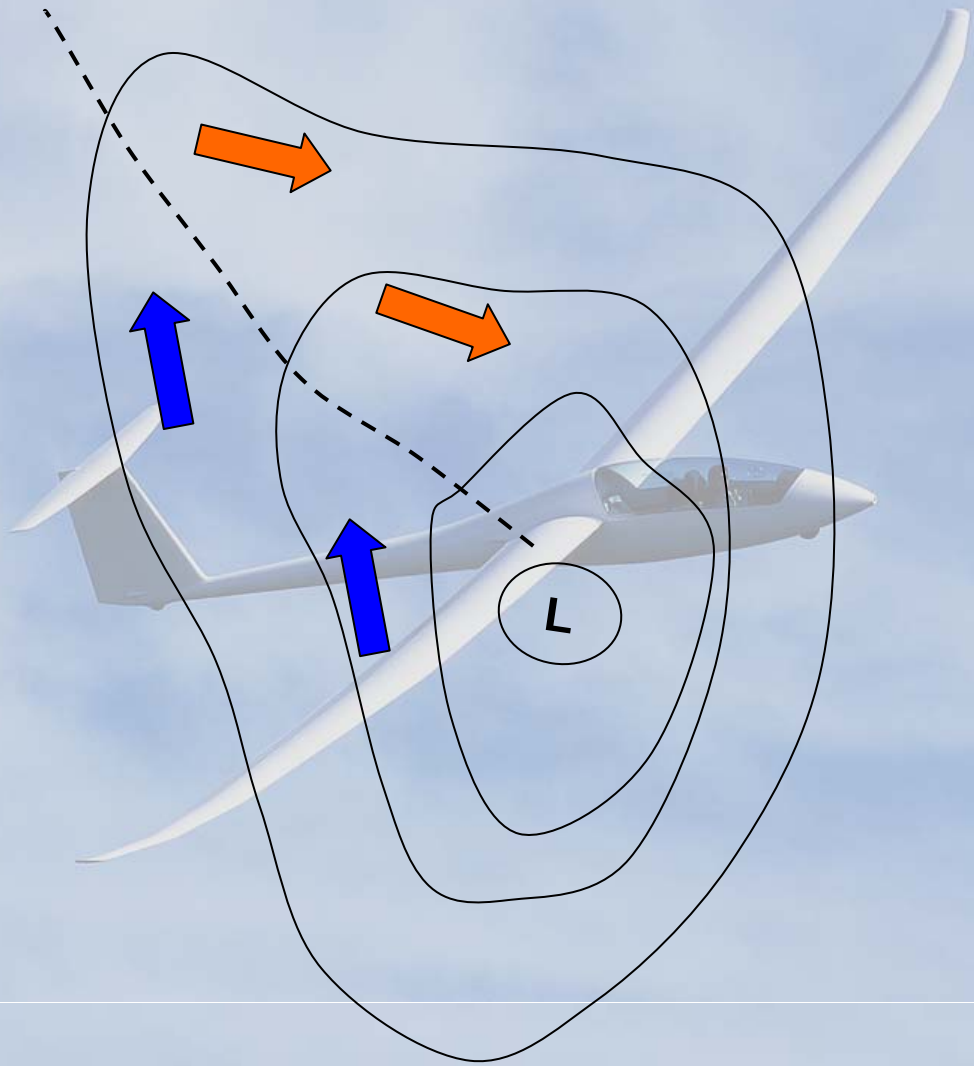
Anticyclones – High Pressure – Stable air



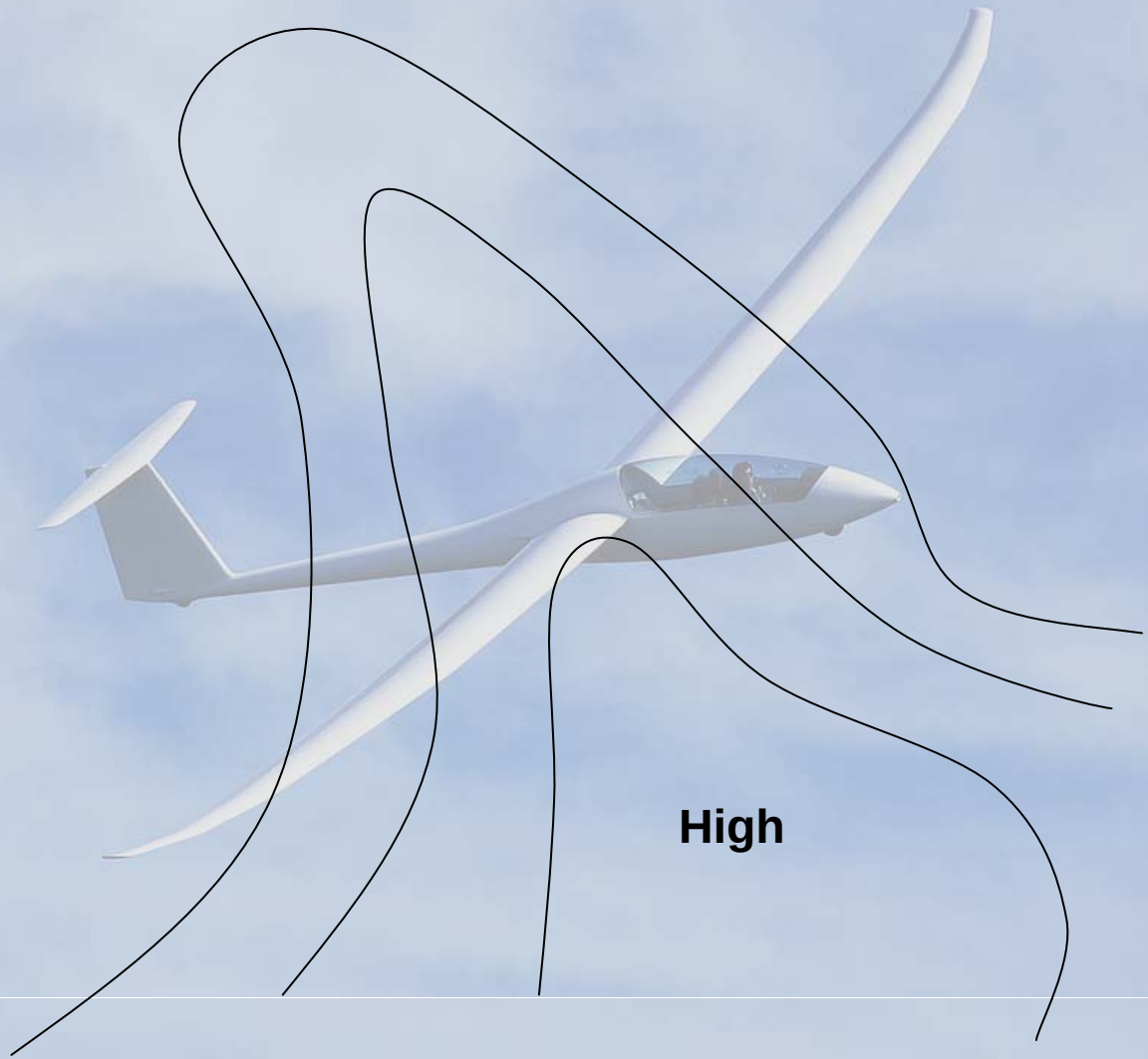
Cyclones – Low Pressure – Unstable air



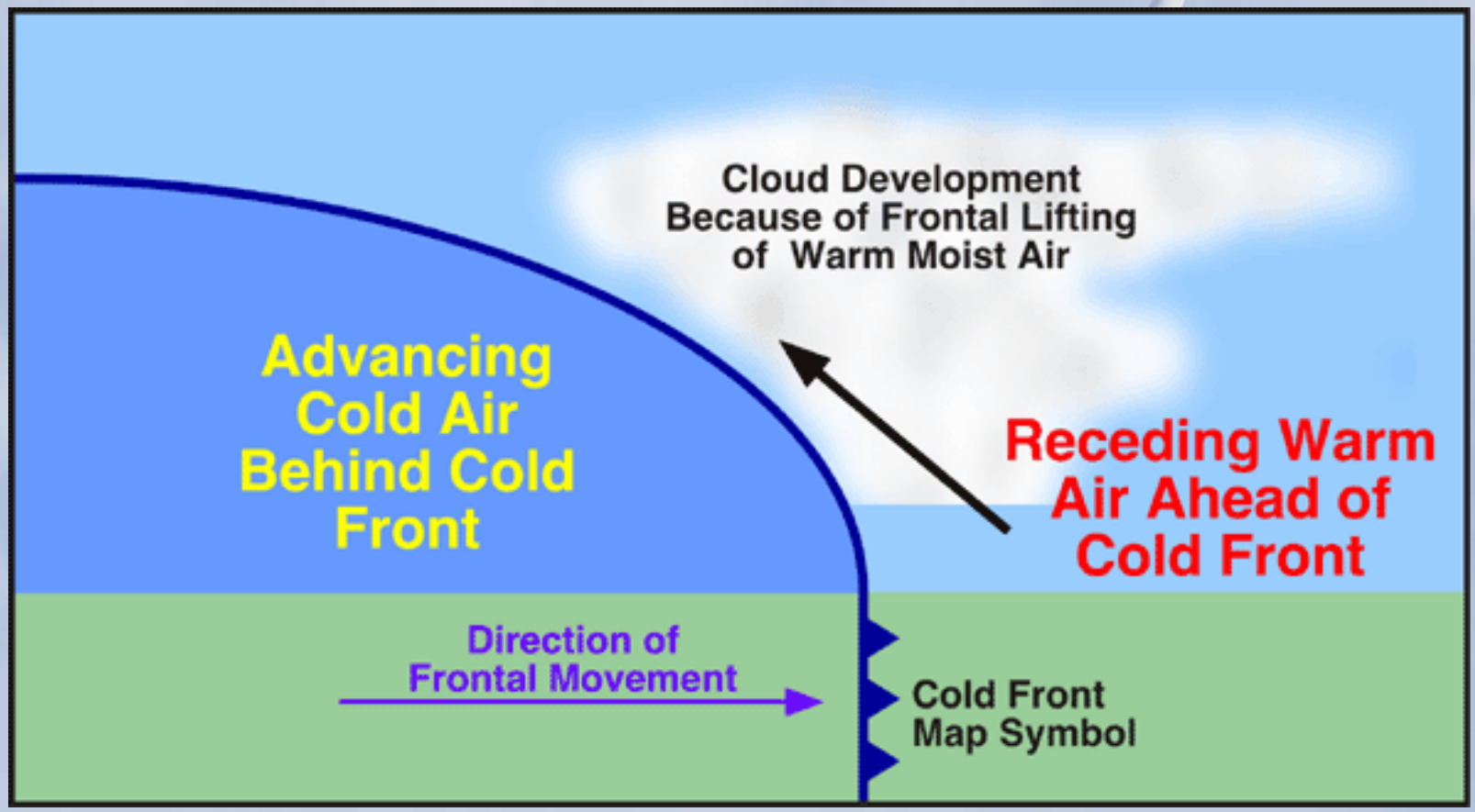
Troughs



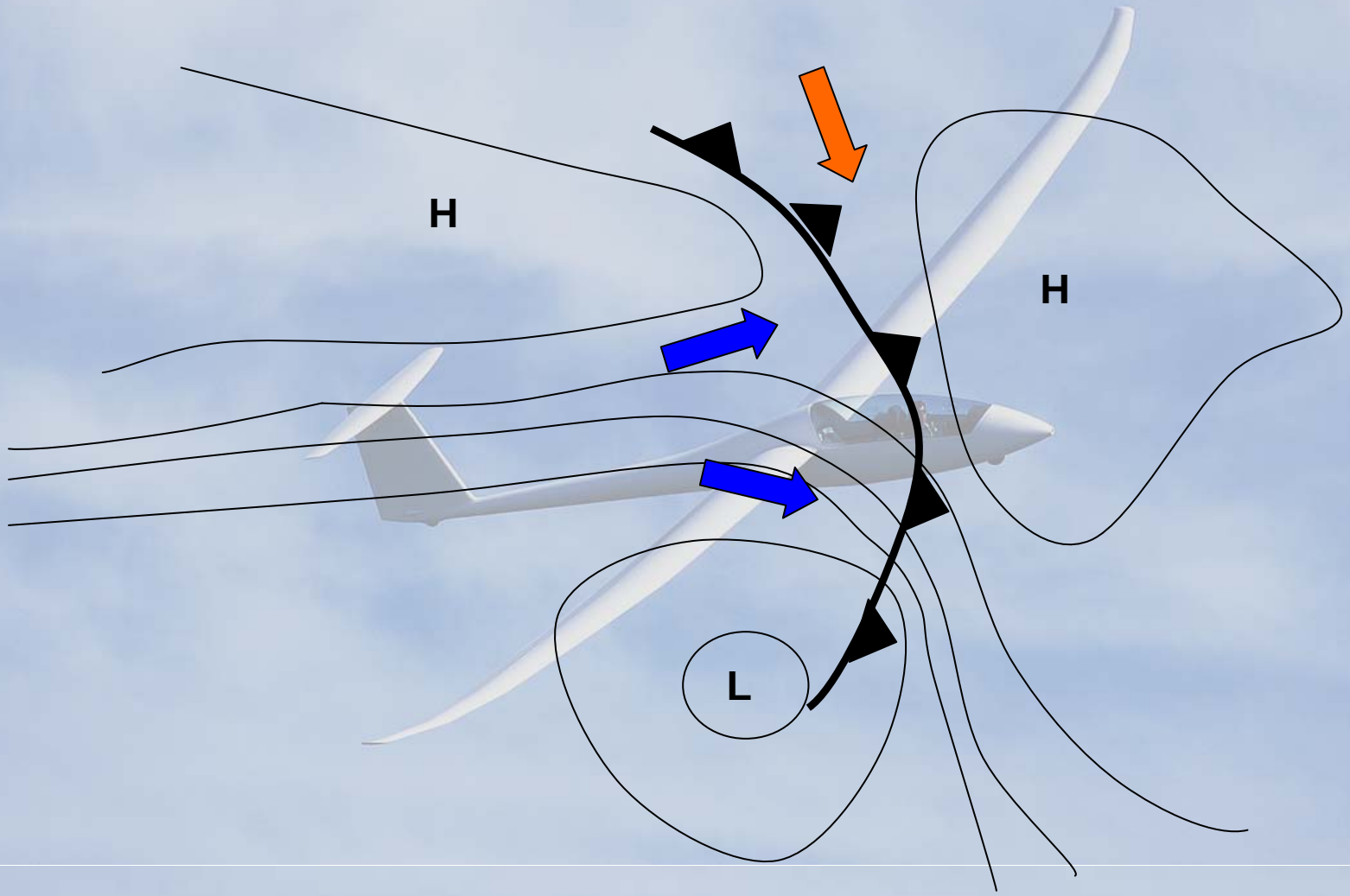
Ridges of High Pressure

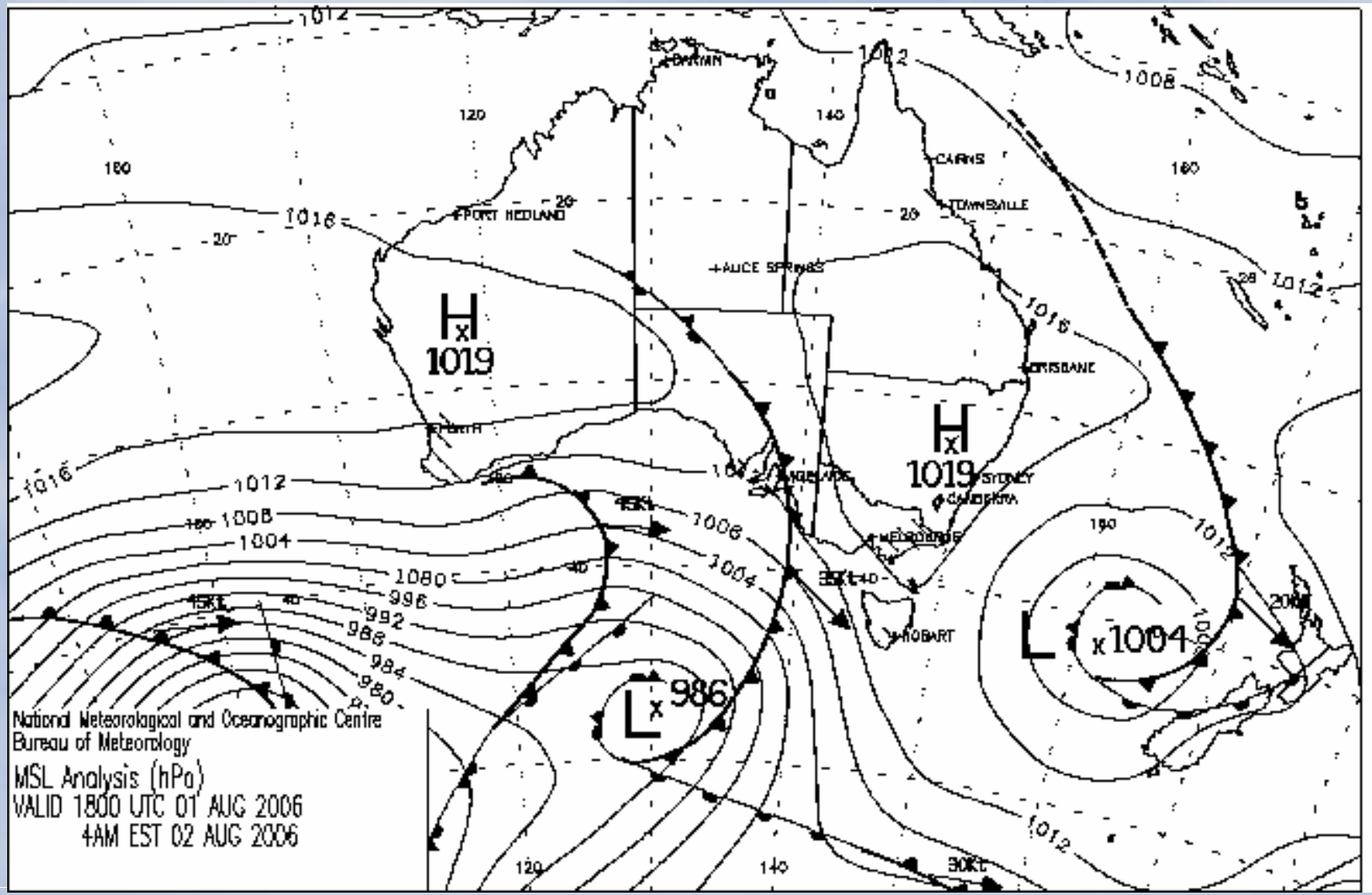


Cold Fronts


Cloud Development
Because of Frontal Lifting
of Warm Moist Air
Advancing
Cold Air
Behind Cold
Front
Receding Warm
Air Ahead of
Cold Front
Direction of
Frontal Movement
Cold Front
Map Symbol

Cold Front




1012
1016
1008
1004
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1019
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986
CAIRNS
TOWNSVILLE
BRISBANE
SYDNEY
HOBART
PORT HEDLAND
ALICE SPRINGS
National Meteorological and Oceanographic Centre
Bureau of Meteorology
MSL Analysis (hPa)
VALID 1800 UTC 01 AUG 2006
4AM EST 02 AUG 2006

Today’s weather map

www.bom.gov.au

Today’s Weather Map

Part 4
Hazardous Weather Events

Dangers of Thunderstorms

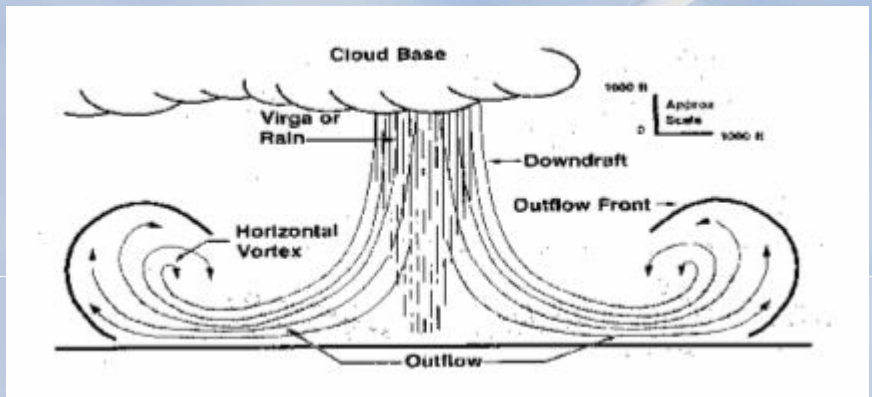
- Extremely powerful lifting forces
- Extremely powerful downforces
- Lightning
- Abrupt and large directional wind changes
- Wind shear near the ground
- Rain
- The effect of the thunderstorm can impact you many kilometres away.
- **AVOID FLYING NEAR THUNDERSTORMS**

Microbursts

- Extreme downdrafts
- Large wind direction changes
- Associated with thunderstorms
- Avoid landing near microbursts if possible and be aware of wind changes.

Dry Microburst

Wet Microburst

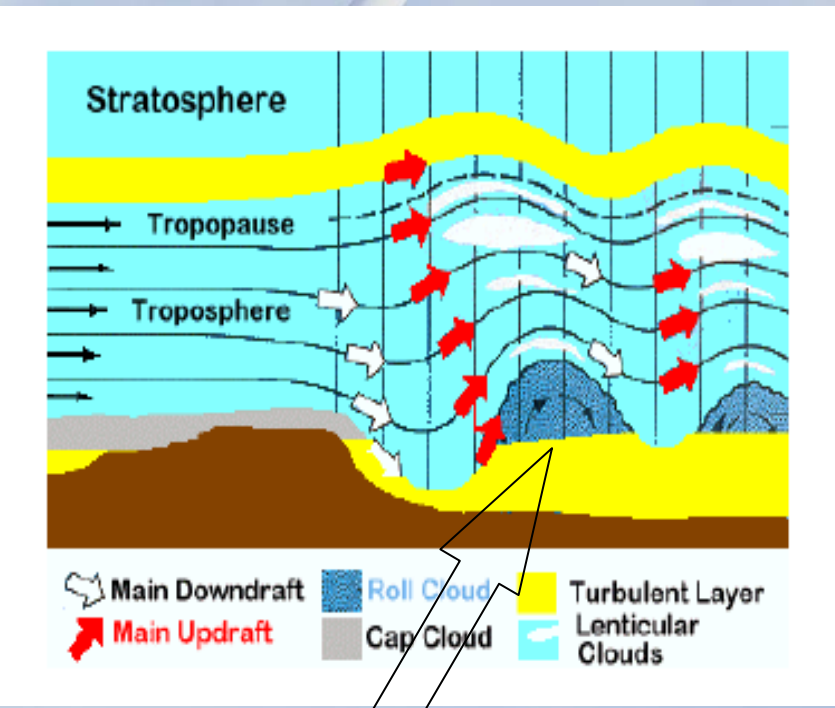


Rain

- Rain on the glider's wings destroys laminar flow and seriously degrades glide performance.
- Rain is often an indication that the lift is exhausted
- Rain on the ground cools the ground and stops lift
- Wet areas on the ground take longer to heat up (latent heat)

Rotor

- Associated with wave systems mostly in mountainous areas
- Extreme down drafts and updrafts
  - up to 5000 ft/min in extreme cases
- May cause structural stress



Entering Cloud

- Never enter cloud –
  - it is illegal in gliders in Australia, and
  - highly dangerous without proper instruments and training.
- It takes 17seconds or less to lose control of the aircraft and over-stress the aircraft
- Cloud can have objects in it (aircraft, hills, mountains)
- Use dive brakes and fly away, to avoid being sucked into cloud

Part 5
Stability and Instability

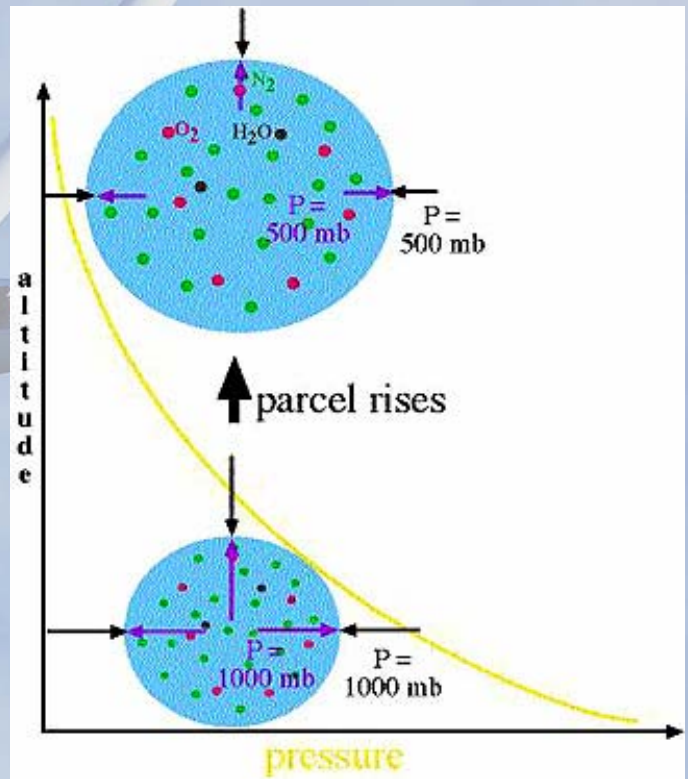
Stability and Instability

- Warm air is less dense than cold air. It is therefore buoyant and rises, when comparing air at the same vertical level.
- Air expands and cools as it rises (adiabatic process).
- If air is pushed upward, compare its new cooler temperature with the surroundings.

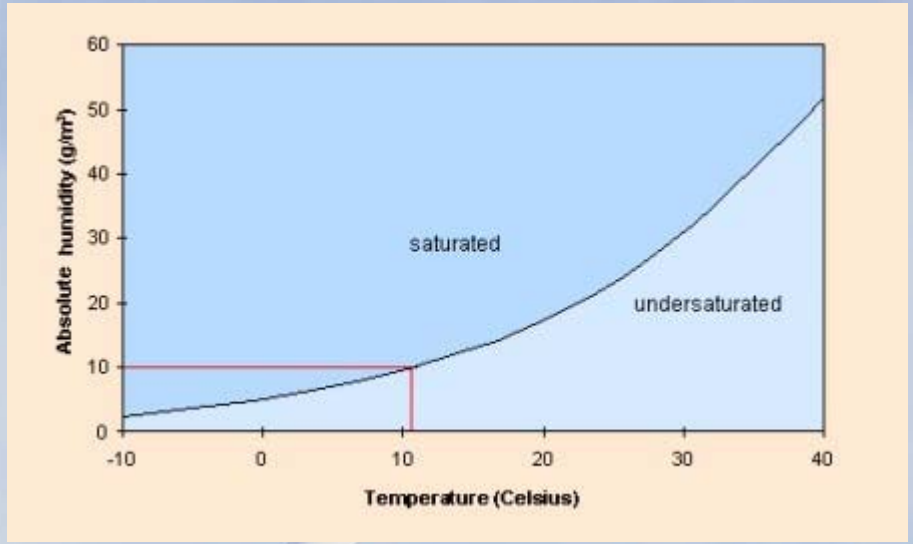
- Instability
  - When lifted (and cooled) air is warmer than its surroundings, it will continue to rise.
- Stability
  - When lifted air becomes cooler than its surroundings, it will sink or oppose lifting.

Adiabatic Principles - no temperature exchange with the surroundings

- As an adiabatic gas expands, it cools.
- fundamental meteorological concept for the inner air shell around the Earth.
- As air is warmed at the surface, pressure initially remains unaltered, but due to its higher temperature, density is less than surrounding air, so it rises.



Dew Point Temperature



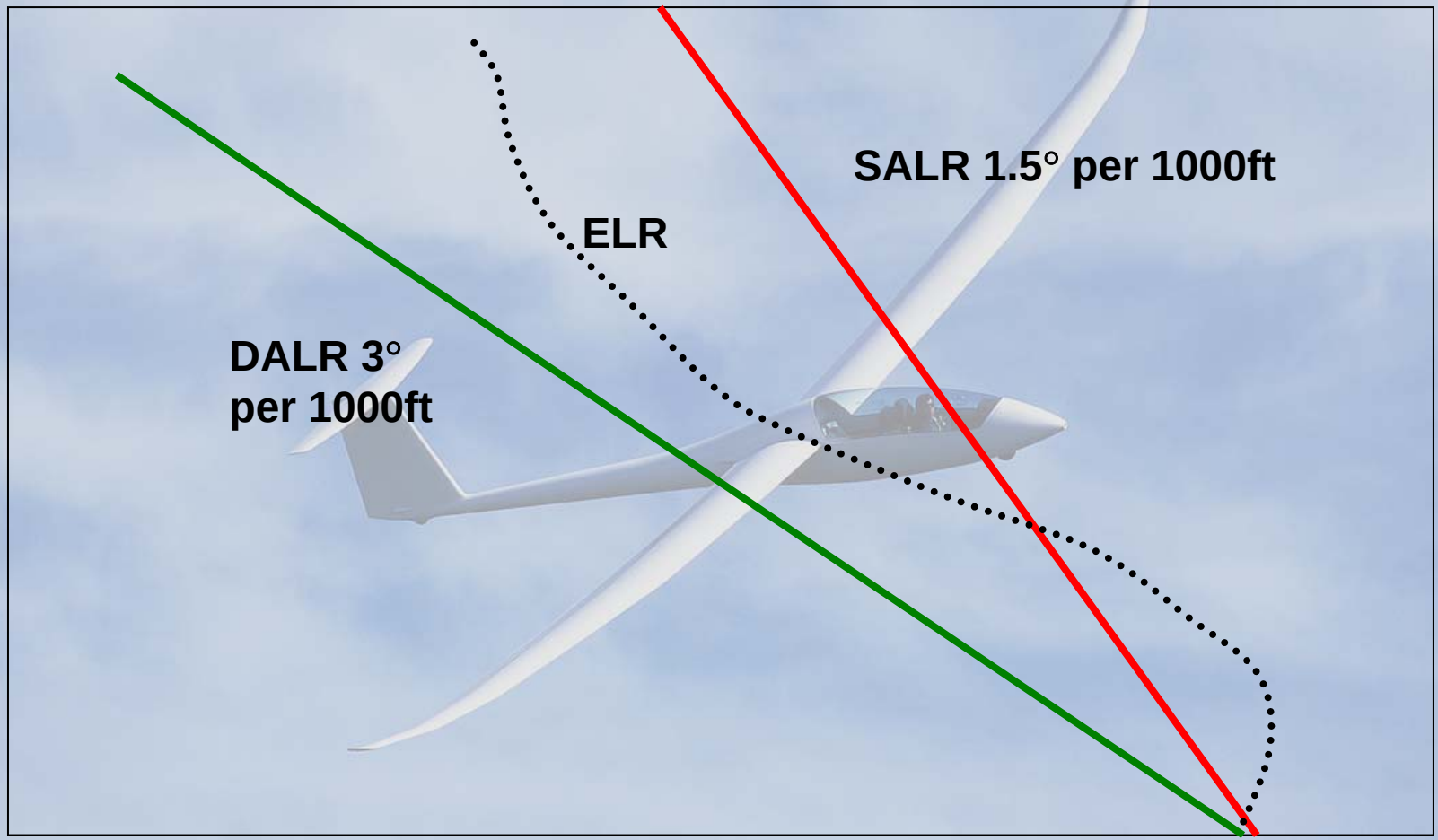
- Air temperature where the moisture in the air begins to condense or change from a vapour to a liquid.
- Associated with relative humidity.
- When the relative humidity is 100%, the dew point is equal to the current temperature.
- With a constant dew point, an increase in temperature will lead to a decrease in relative humidity.

Lapse Rates

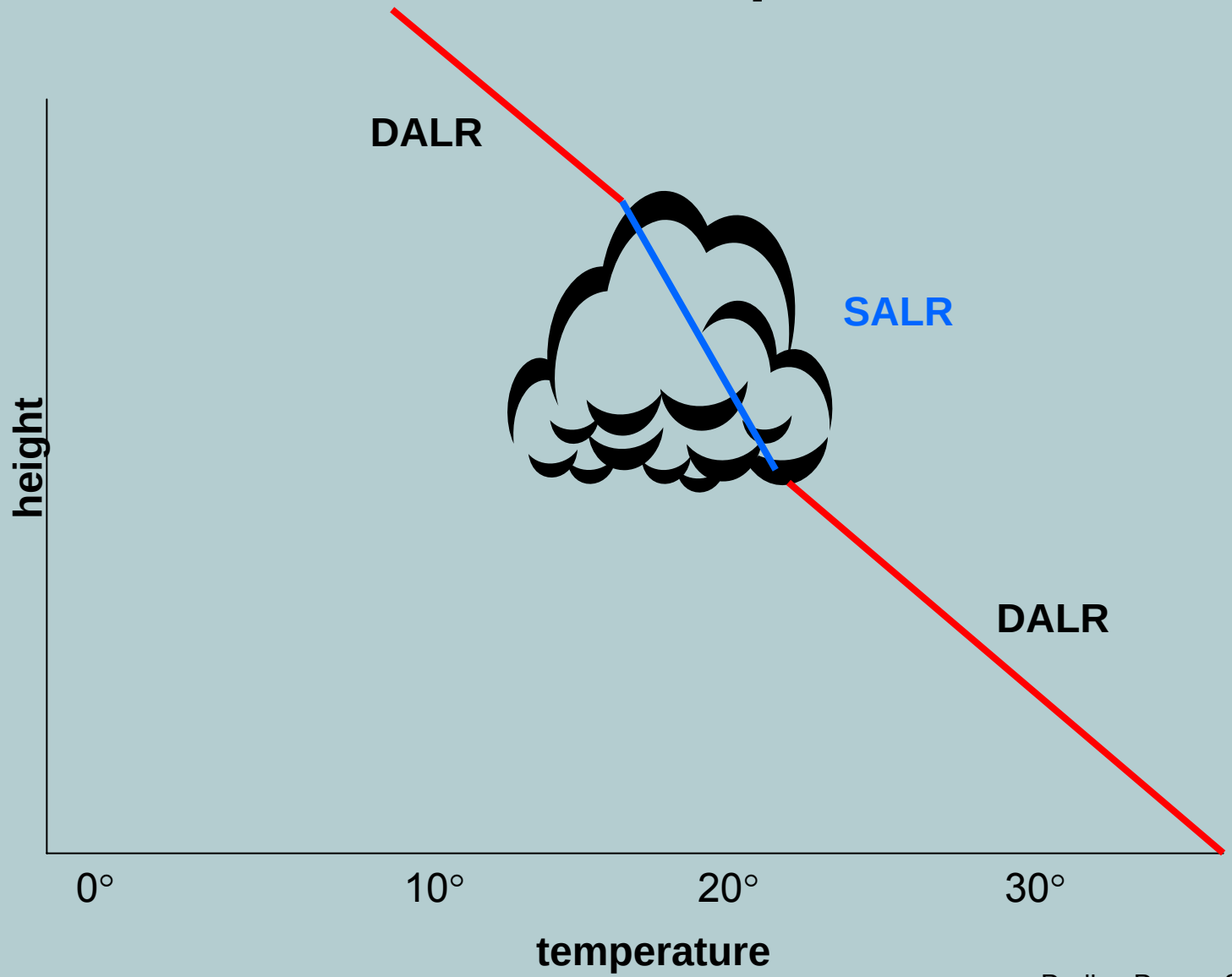
- Rate at which the temperature of the air changes as it ascends (or descends)

- Saturated adiabatic lapse rate (SALR)
  - 1.5° per 1000ft
- Dry adiabatic lapse rate (DALR)
  - 3° per 1000ft
- Environmental lapse rate (ELR) – real atmospheric conditions

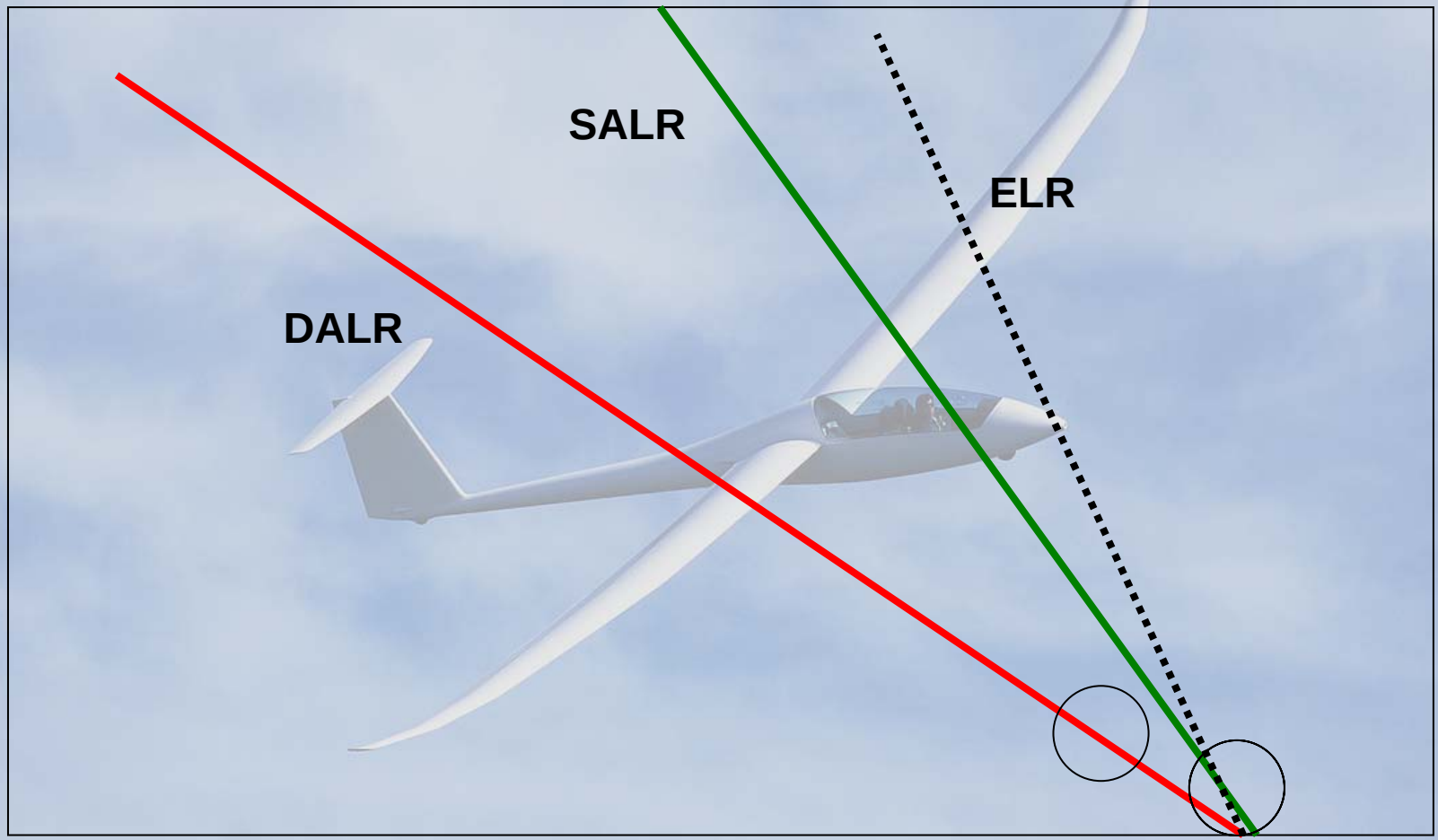
Lapse Rates


SALR 1.5° per 1000ft
ELR
DALR 3°
per 1000ft
Altitude
Temperature

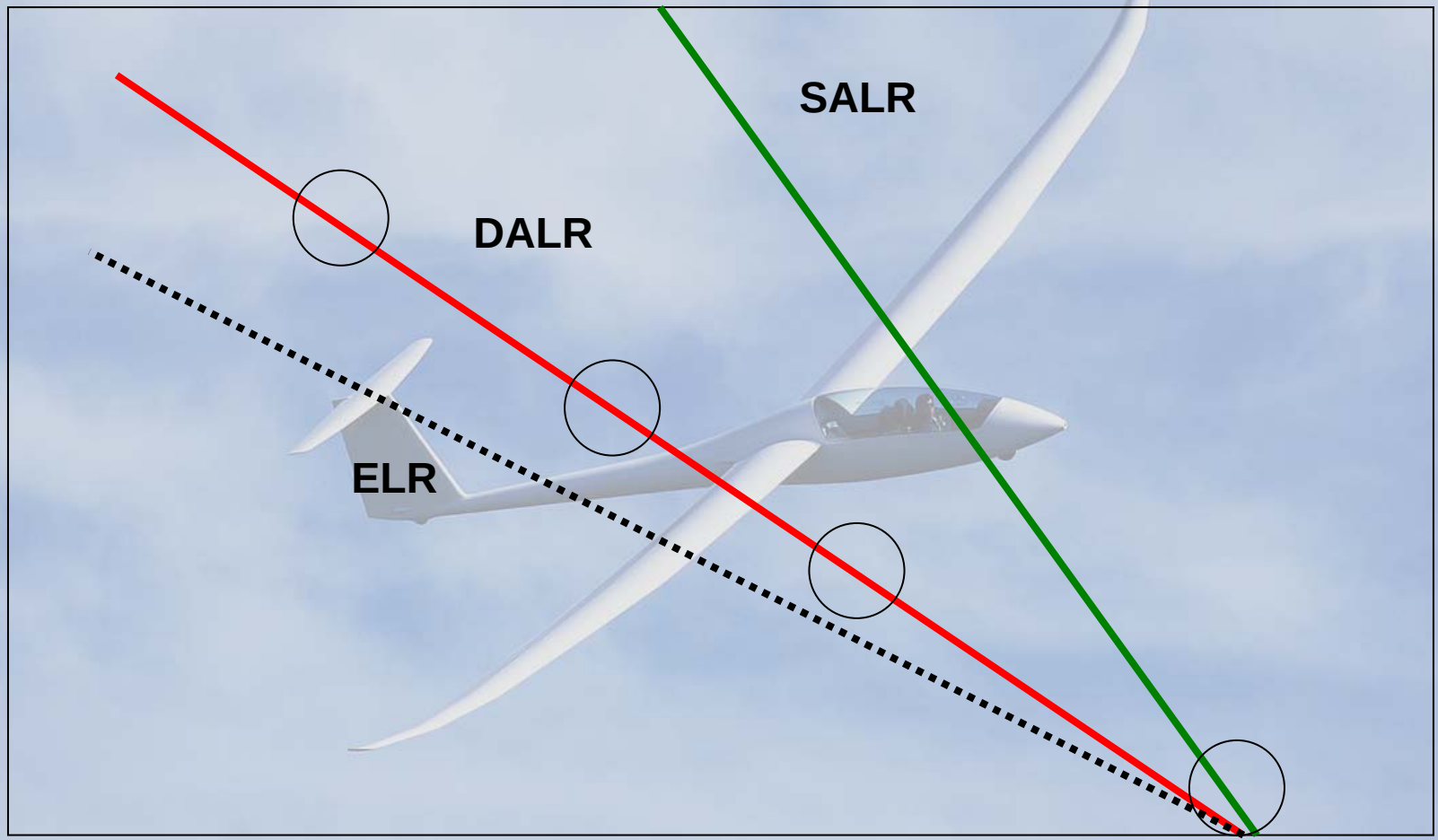
Lower Atmosphere



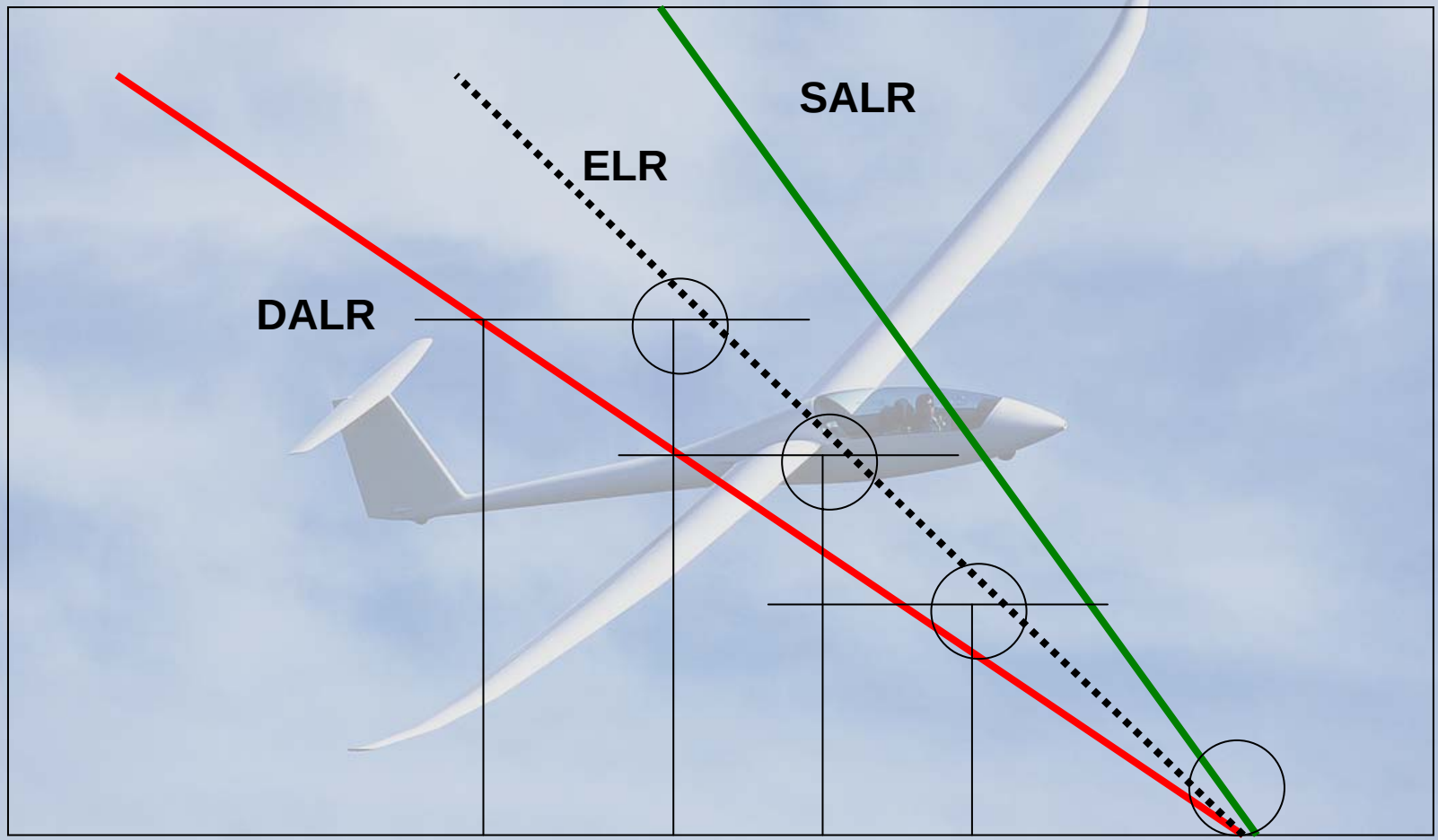
Absolutely Stable air



Absolutely Unstable air



Conditionally Unstable



Rules of Thumb

1. Cloudbase
   - (Max temp – Dew point temp) x 400.
   - E.g. (max temp 32 – dew point 8) x 400 = 9600ft

2. Average climb rate (knots) Australia
   - Cloudbase (or thermal height in blue weather) in thousands of feet.
   - E.g. For a 4,000' cloudbase/1000 = 4 knots.
   - However, this is a very crude method to predict lift because it totally ignores the stability of the atmosphere, cloud cover effects and ground sources, etc

References

- Meteorology and Navigation for Private and Commercial Licences *Trevor Thom, Aviation Theory Centre*
- http://www.meted.ucar.edu/
- www.bom.gov.au
- Pilot's Weather *Ann Welsh*
- Meteorology for Glider Pilots *Wally Wallington*
- Meteorology - Weather and Climate: A Condensed Primer *Dr. Nicholas M. Short* *http://rst.gsfc.nasa.gov/Sect14/Sect14_1a.html*
- Royal Meteorological Society *http://www.rmets.org/index.php*