Weather Is Dependent on the Sun

No sport is more dependent on the right weather than soaring. If you want to be successful at flying sailplanes across country, you must learn to predict good soaring days. This section will review general meteorology and provide practical information about how to recognize a good soaring day. We will start from the beginning.

Circulation of Air Around the Globe

The major force in making all our weather, good and bad, is the sun.

The cold air needed for a good soaring day starts near the equator and passes by the Northern polar ice caps before getting to the Continental U.S.

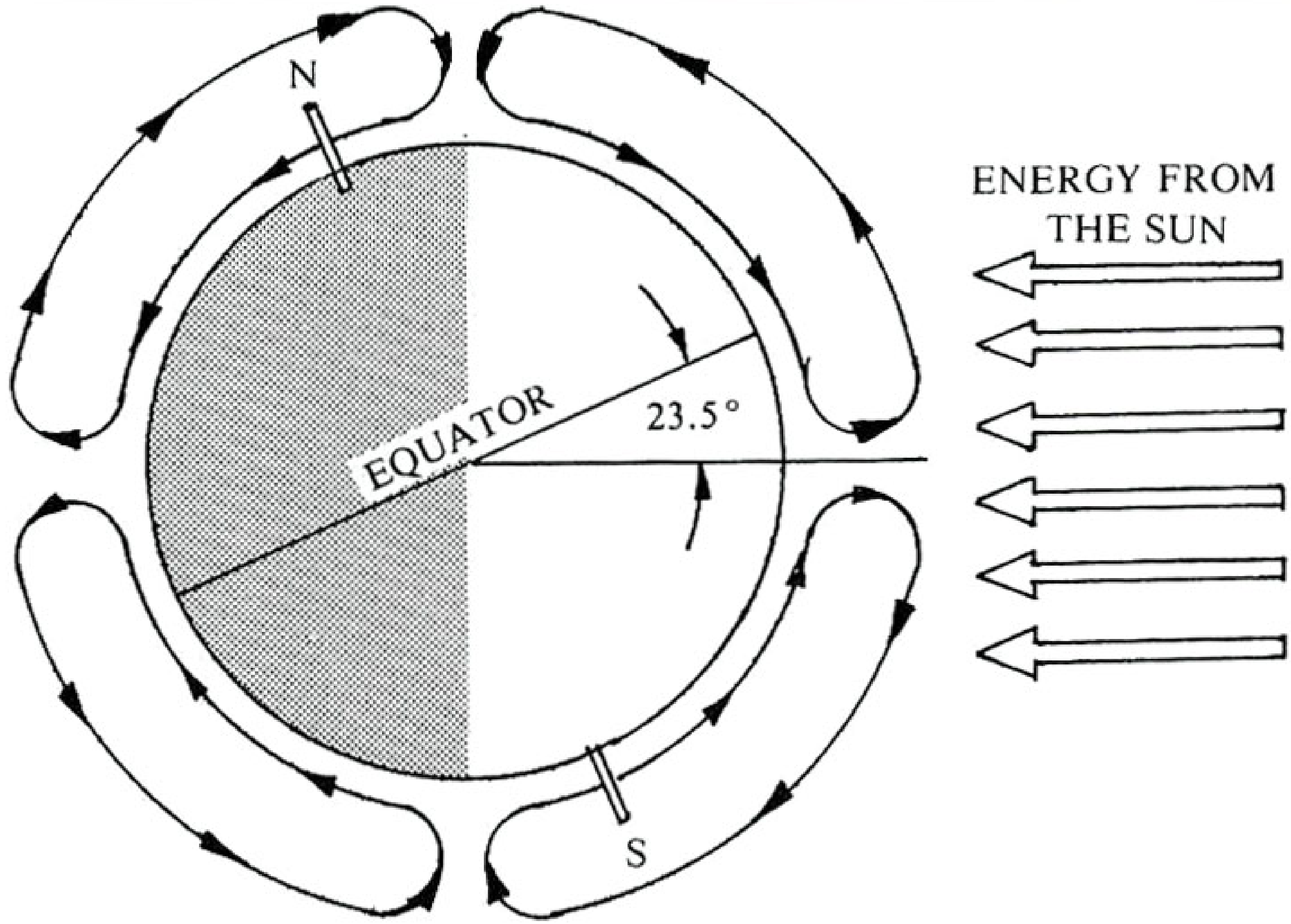


Figure 39 - General Circulation

Most of the Figures in this presentation come from - *Understanding the Sky* - by Dennis Pagen (Dennis Pagen Publishers, Mingoville, Pa)

Circulation Induced by Uneven Heating and Cooling

The circulation induced by the flux of air from the equator to the poles also creates the jet streams and the areas of polar high pressure.

It is these huge domes of cold air that create the good weather needed for soaring (at least on the east coast of the U.S.)

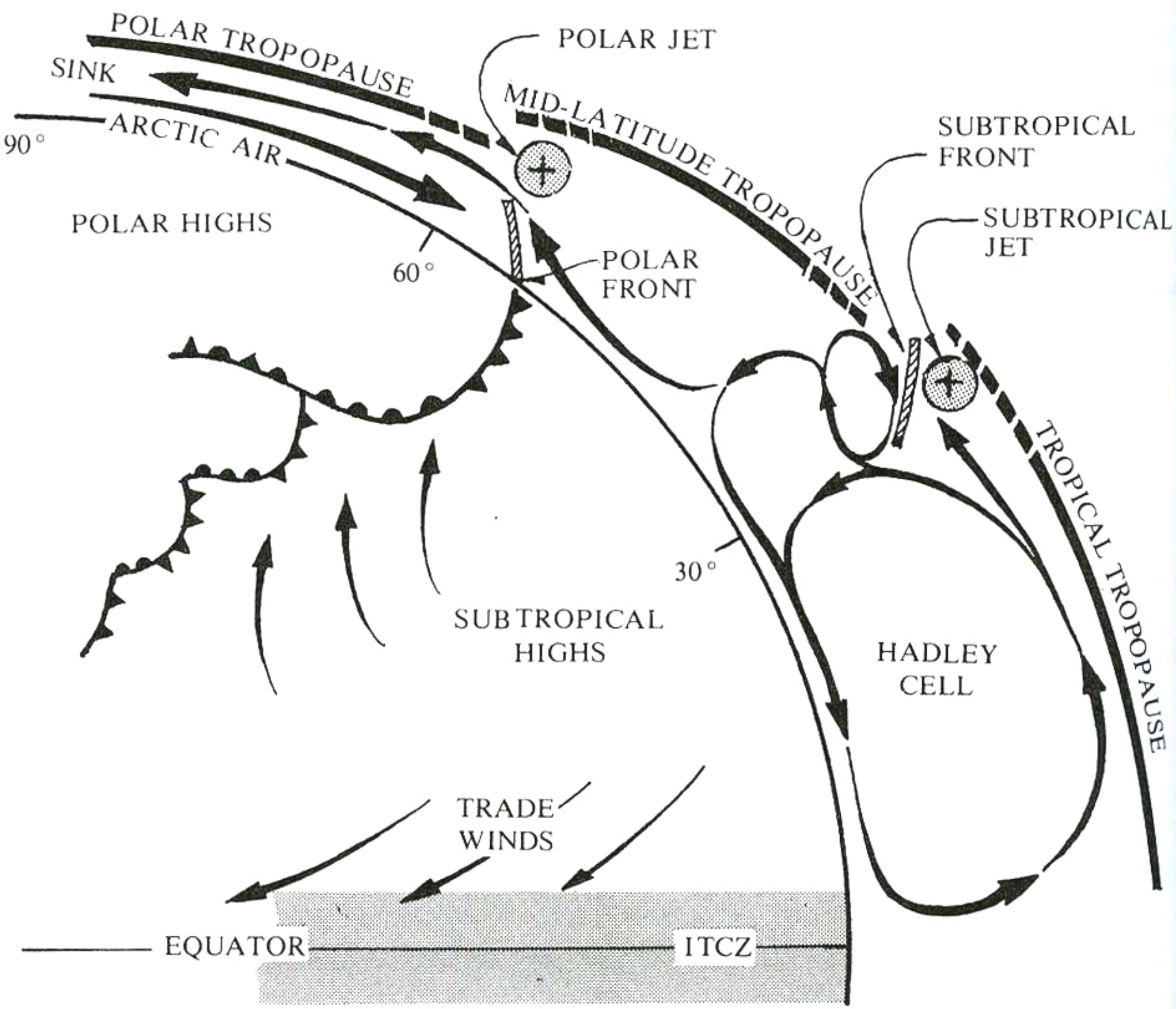
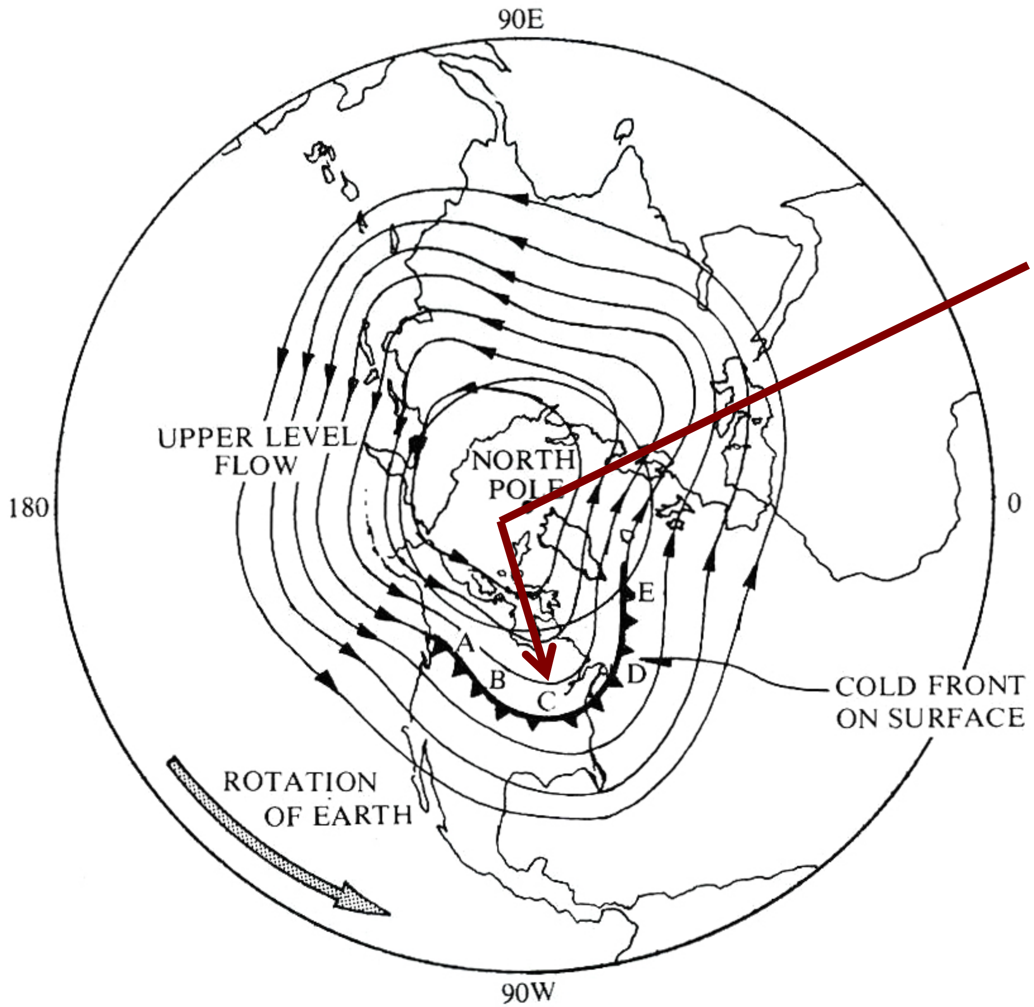


Figure 43 - The Lower Atmosphere in Cross Section

Prevailing Winds Set Up Circulation Around the North Pole

As the air cools over the North Pole, it descends. The path of high pressure as it descends is to head South. The descending paths and the rotation of the earth set up the circulation shown in the figure below. This and the earth's rotation help give us our westerly winds and produces low pressure areas.

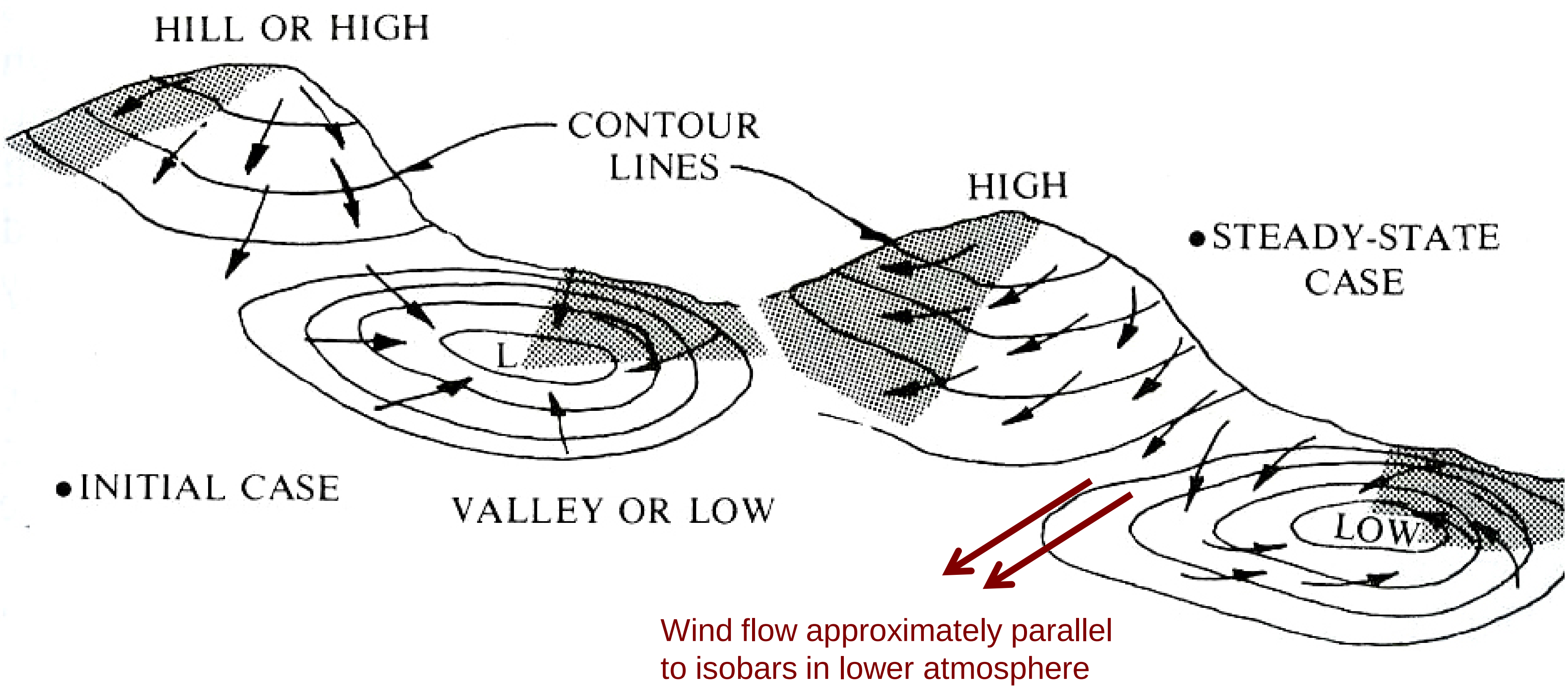


Polar air filling in behind a cold front moving West to East

Figure 58 - Upper Level Circulation

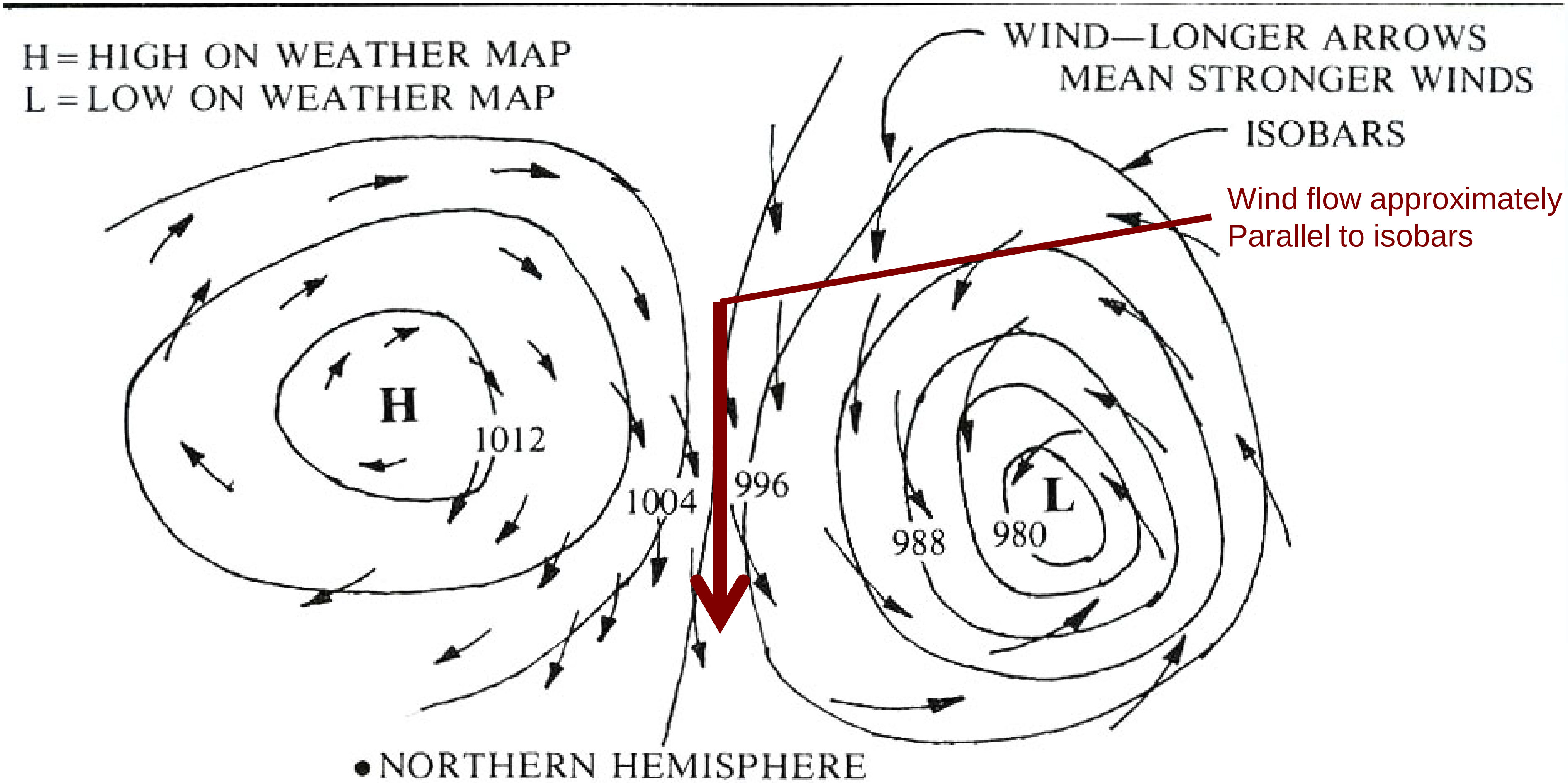
Highs and Lows Set Up the More Local Winds

Each area of high pressure (and low pressure) spawned by the cold air at the poles has its own pattern of circulation - causing wind. The air begins moving from a high pressure dome to an area of low pressure (left side of diagram) along the pressure gradient (isobars). Because of the Coriolis effect induced by the rotation of the earth, the moving air is deflected to the right (in the Northern hemisphere) and the flow ends up more or less parallel to the isobars (right side of diagram).



Winds Around Highs and Lows

More on circulation around highs and lows - this time in two dimensions as shown on the weather charts. Note - the strength of the wind is dependent on the spacing of the isobars.

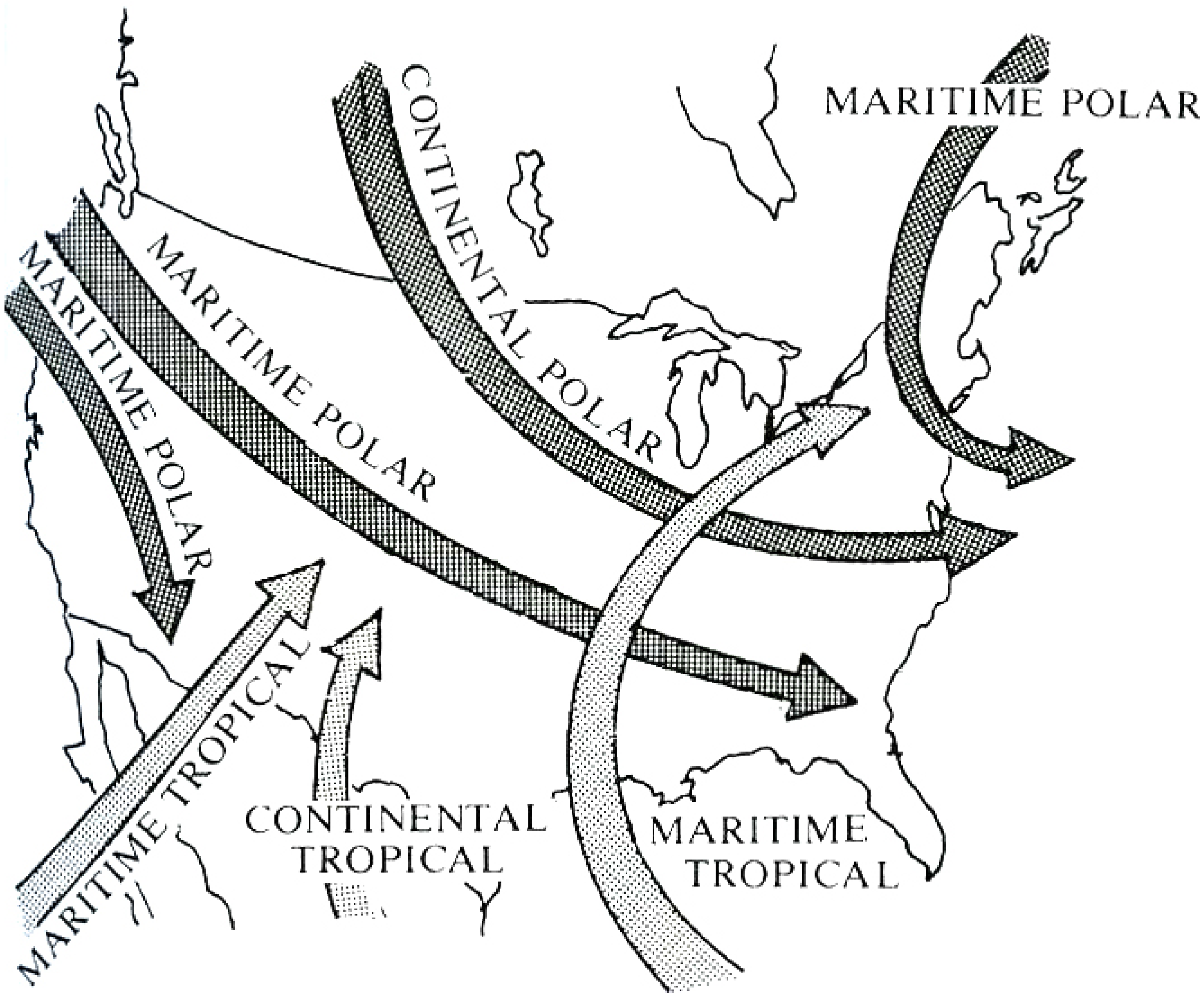


Types of Air Masses

The domes of cold air descending from the North pole can take many paths to reach the continental U.S. Generalized paths are shown in the diagram below. The air masses that we desire most for cross country soaring are the "continental polar" air masses coming out of Canada. About 80% of successful badge flights in the Eastern U.S. are made in this type of airmass.

Why the Continental Polar air masses are favorable for soaring

- The cold, dry air provides excellent visibility.
- The cold, dry air is unstable.
- The cold, dry air provides high cloud bases.
- The cold, dry air gives a large thermal index. Lift goes to 6000 - 10,000 feet MSL.
- During April - October, instability will provide a long soaring day (~11 AM - 7 PM).



Influence of the Jet Stream on Frontal Positions

The position of the Jet Stream has a major effect on the intrusion of polar air masses into the U.S. If the Jet Stream runs near the Canadian Border (as it often does In July and August), it blocks the influx of polar air and we do not get large masses of continental polar air over the east coast. When the Jet Stream dips deep into the U.S. - we do get these air masses.

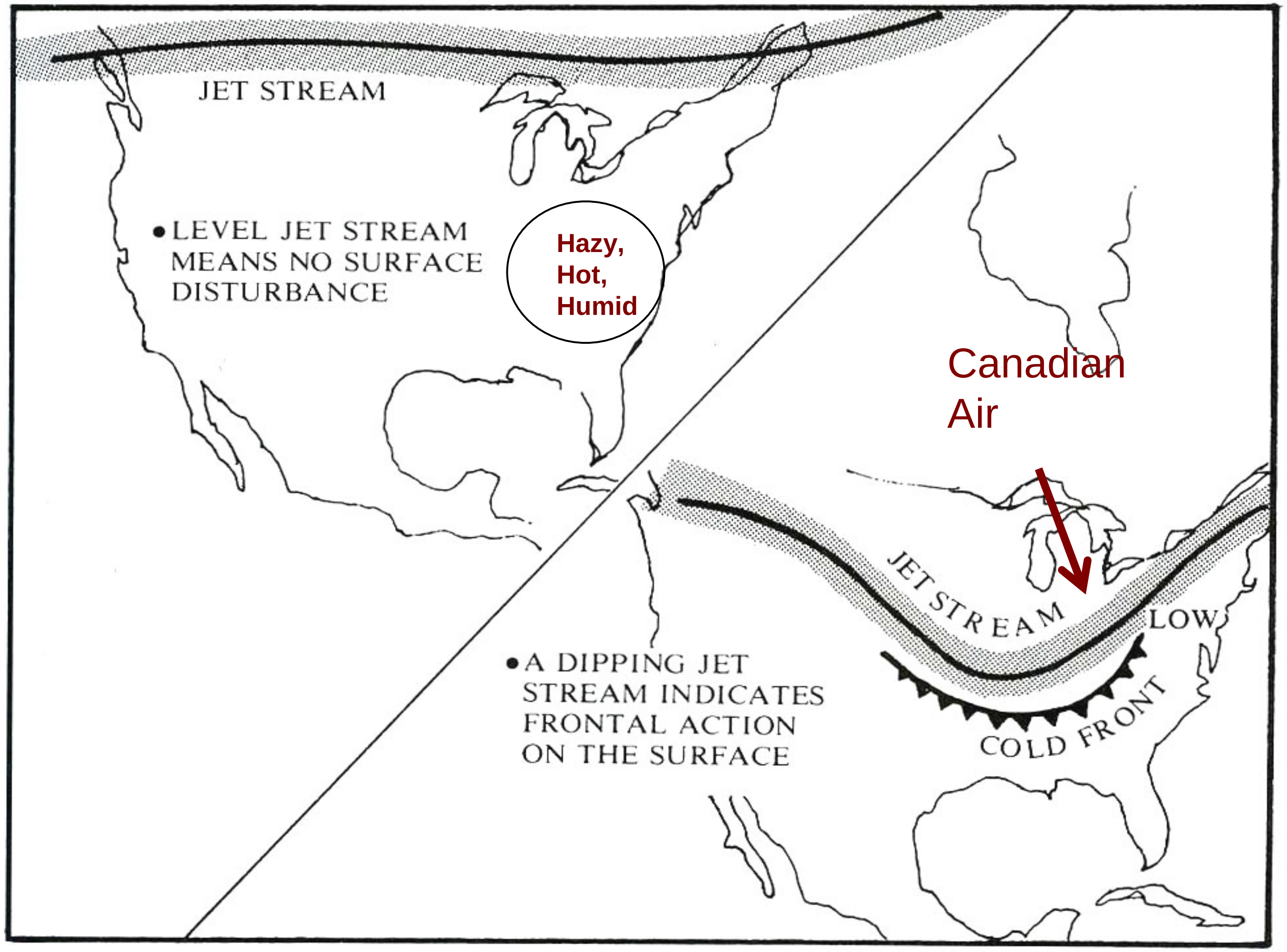


Figure 68 - Jet Stream Effect

Bad Weather Occurs When Air Masses Collide

Air masses are very large. Thus, similar air will cover large areas of the continent at any one time.

More Importantly - when warm and cold air masses collide (as they are about to here) bad weather develops.

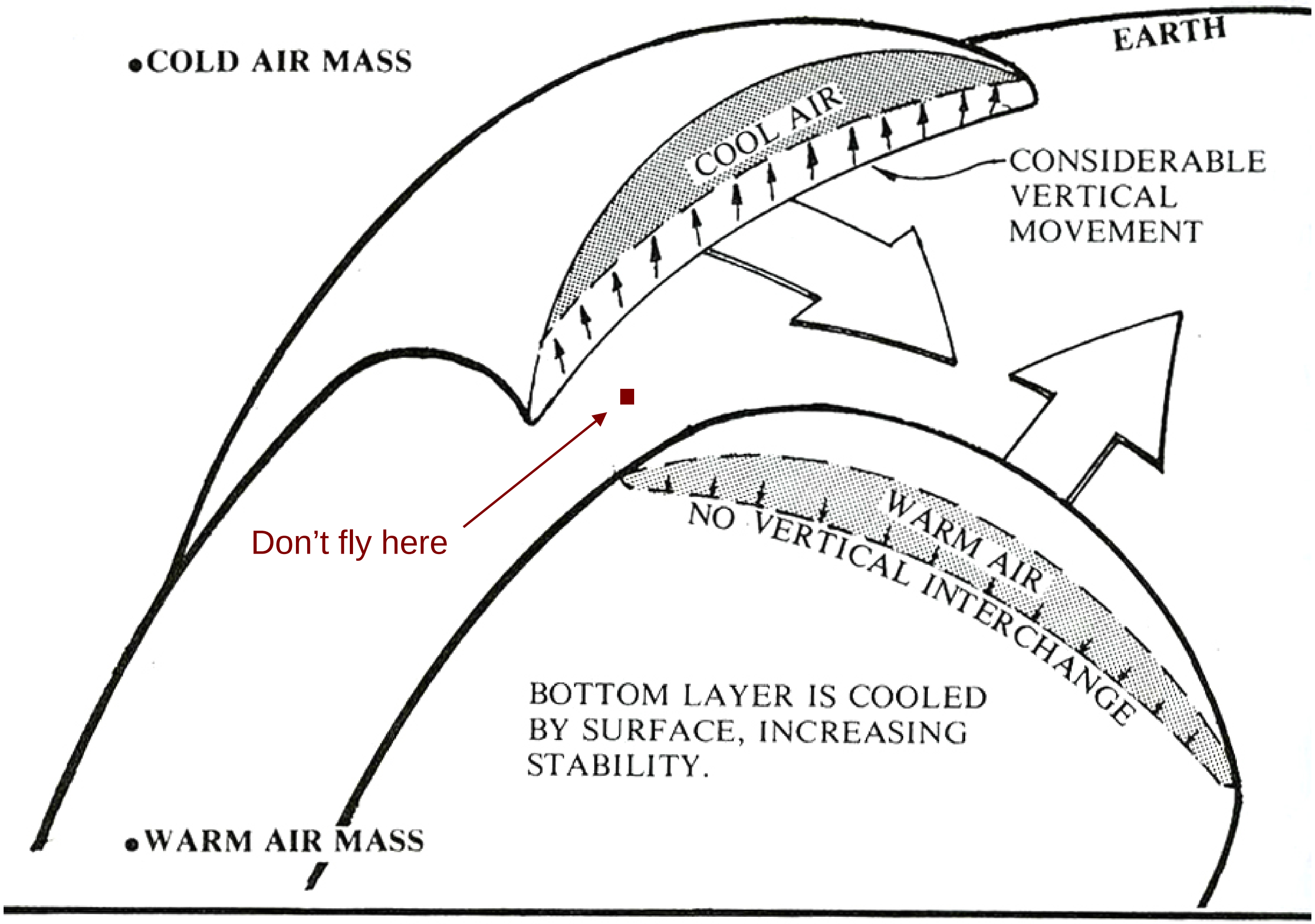


Figure 42 - Air Mass Stability

Fronts Slicing Into Warm Air Generate Different Types of Storms

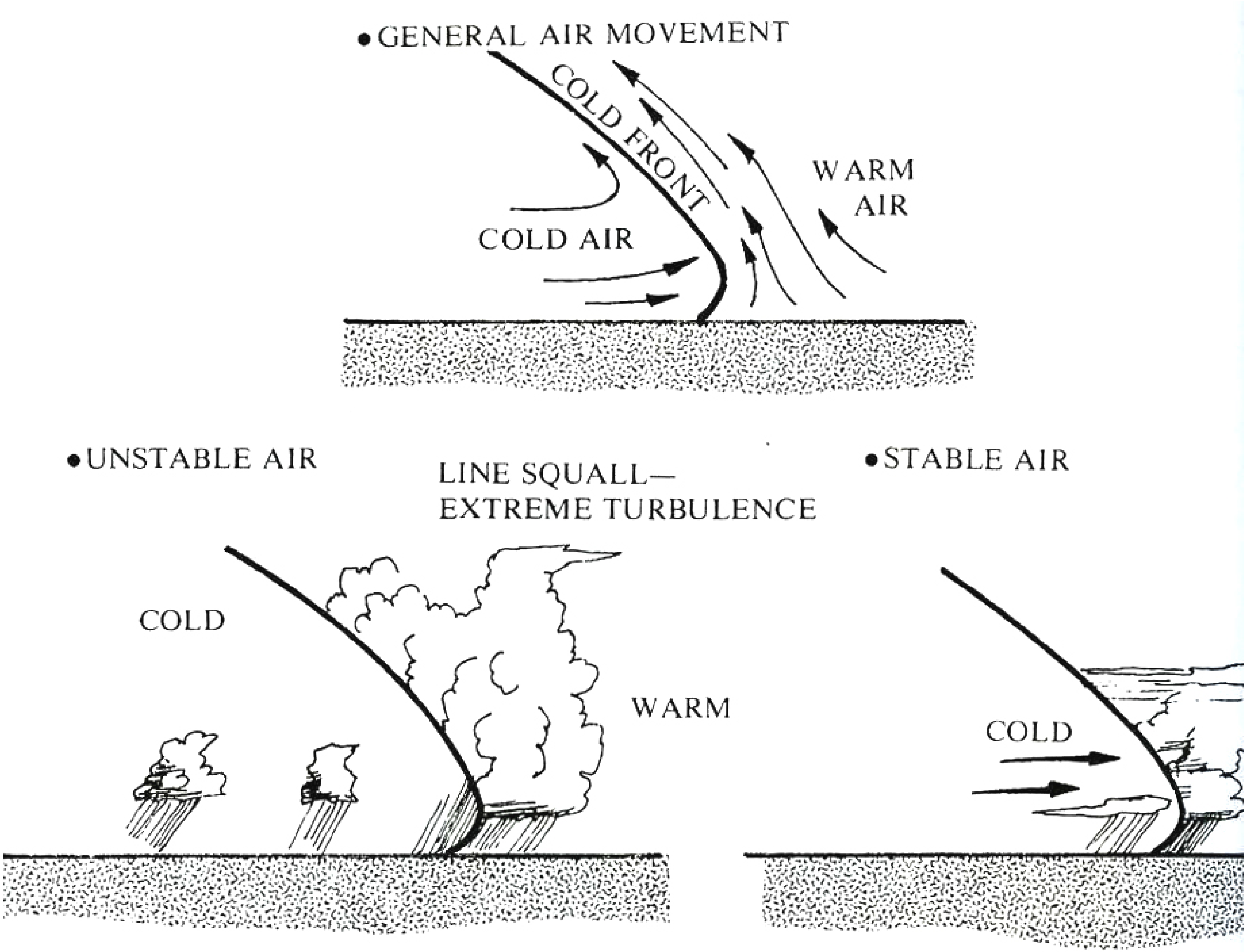


Figure 46 - Cross-Sectional View of a Cold Front

The Expansion and Contraction of Air With Pressure is Essential to Understanding Instability and Thermals

When air is lifted - It *expands* and *cools*.

It will cool about 3 ^{o}C For each increase of 1000 feet in altitude This is about 5.5 ^{o}F

This is called the Dry Adiabatic Lapse Rate (DALR). Adiabatic means no heat exchange.

The lapse rate of the air a bubble of air heated by the sun encounters as it rises determines stability and instability and whether thermals exist

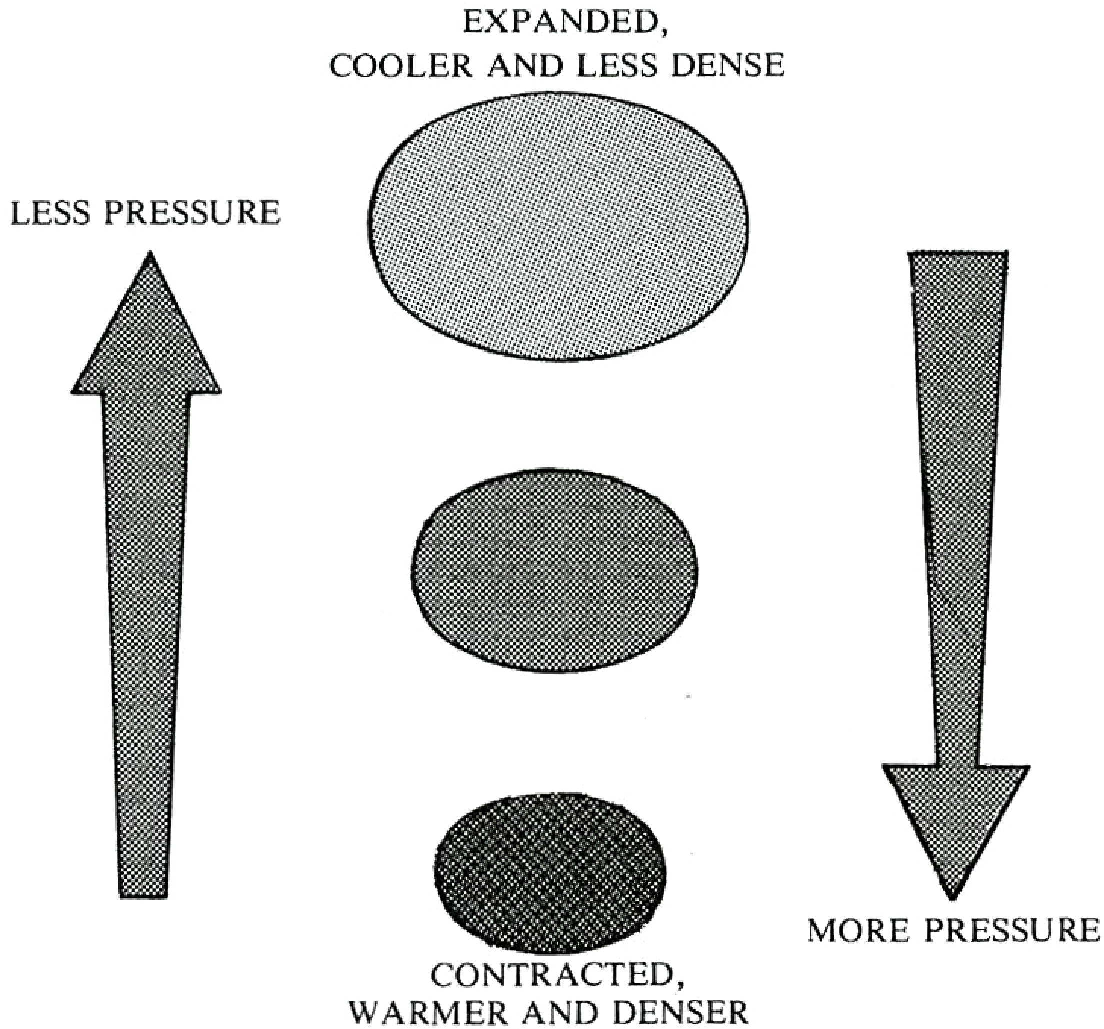


Figure 4 - Expansion and Compression of Air

Lapse Rate and Why Air is Stable

STABLE AIR occurs when the lapse rate of the airmass is *less than* the Dry Adiabatic Lapse Rate.

A displaced bubble of air will quickly find a point of equilibrium and stop moving.

No Thermals !!

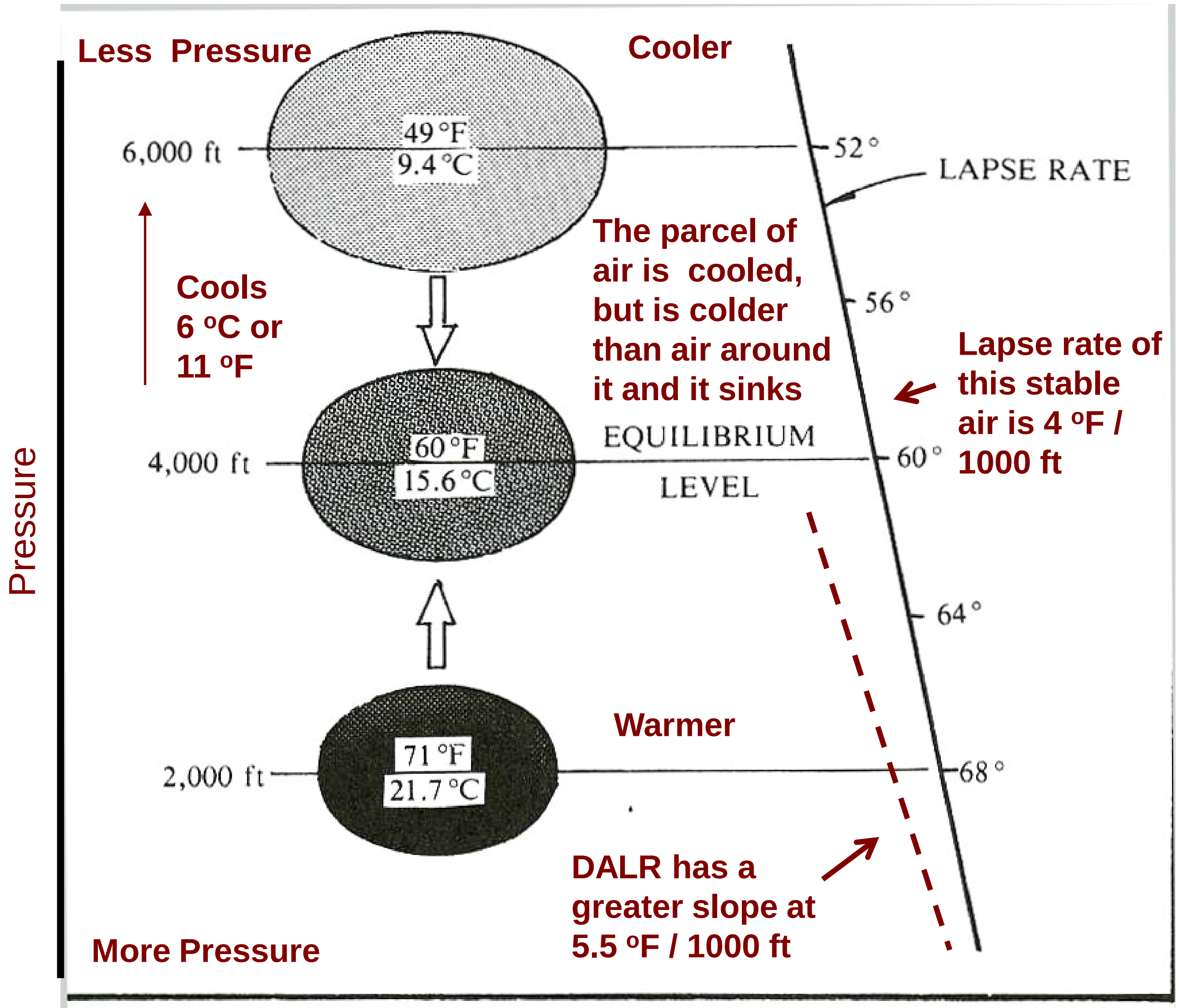


Figure 12 - The Meaning of Stability

Lapse Rate and Why Air is Unstable

UNSTABLE AIR occurs when the lapse rate of the airmass is *greater than* the Dry Adiabatic Lapse Rate.

A displaced bubble of air is warmer than the surrounding air and will keep moving up --

Thermals !!

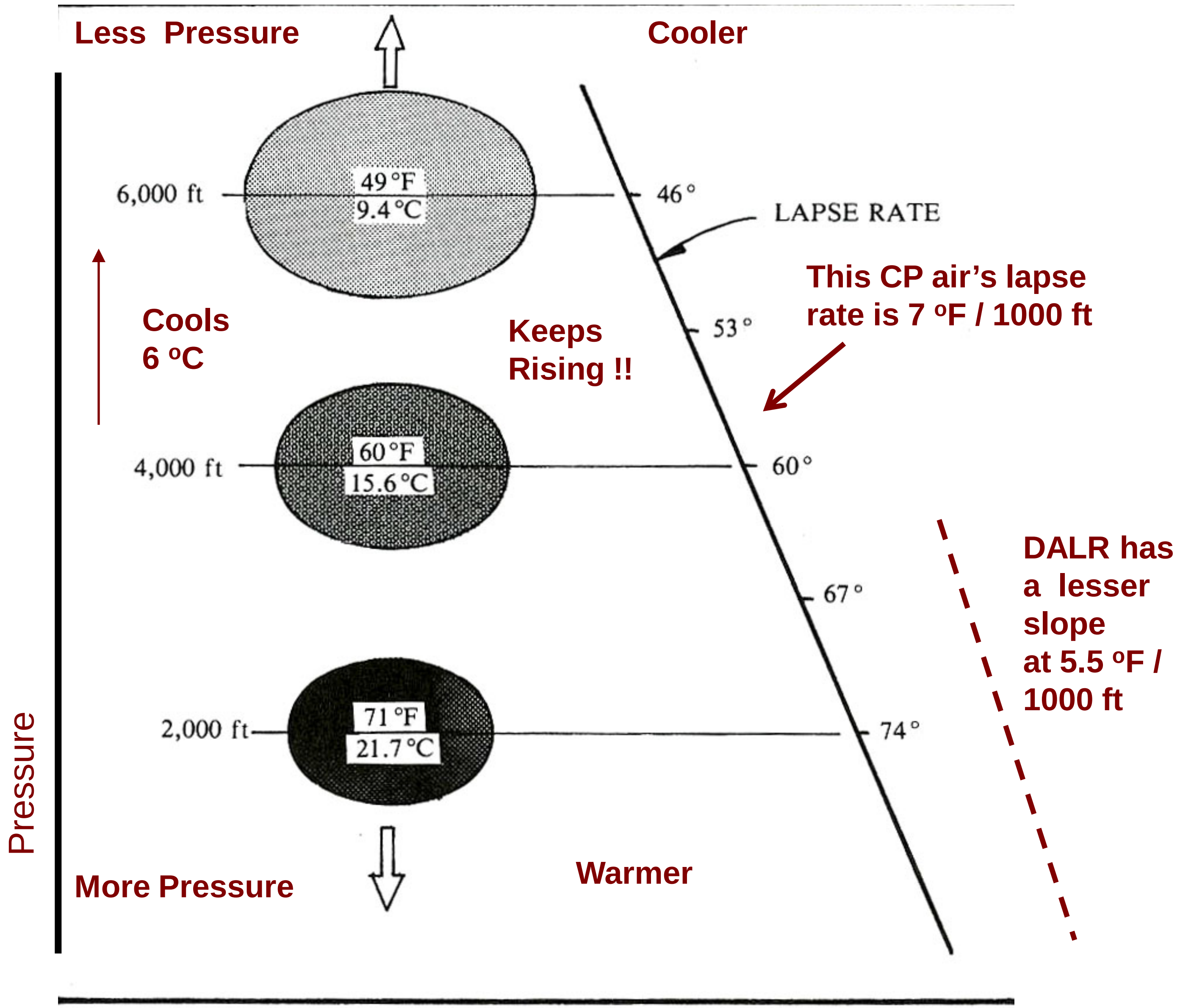
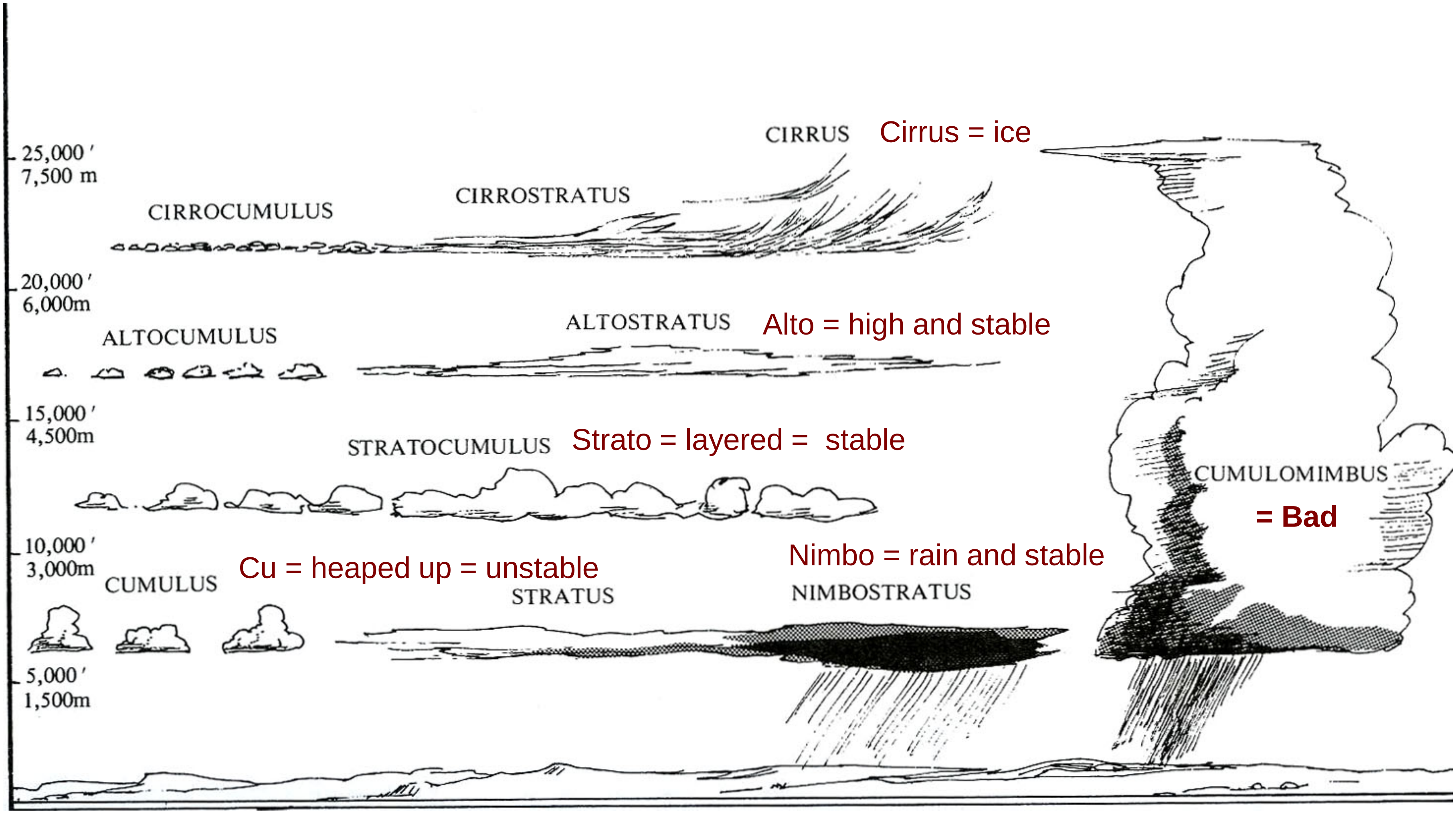


Figure 13 - The Meaning of Instability

What The Clouds are Telling You



Differences in Stability Behind a Cold Front

This diagram shows that stability and instability can also differ widely in different parts of an airmass brought in by a cold front. This finding explains why the first day after the passage of a cold front usually provides the best weather for soaring (on the East Coast). As the the High moves east and the air mass settles in the air becomes more stable and thermals are weaker.   Visibility decreases as well.

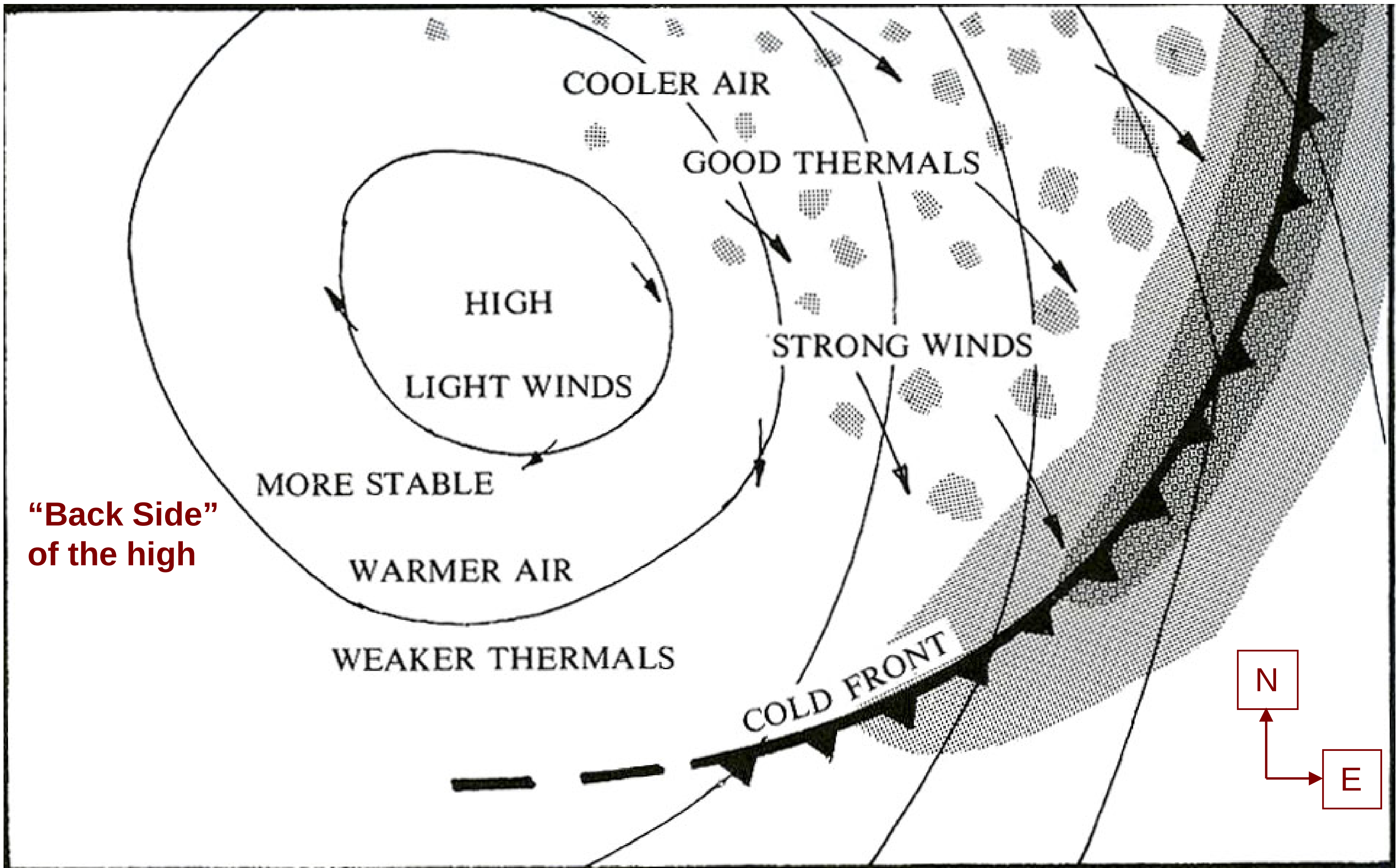
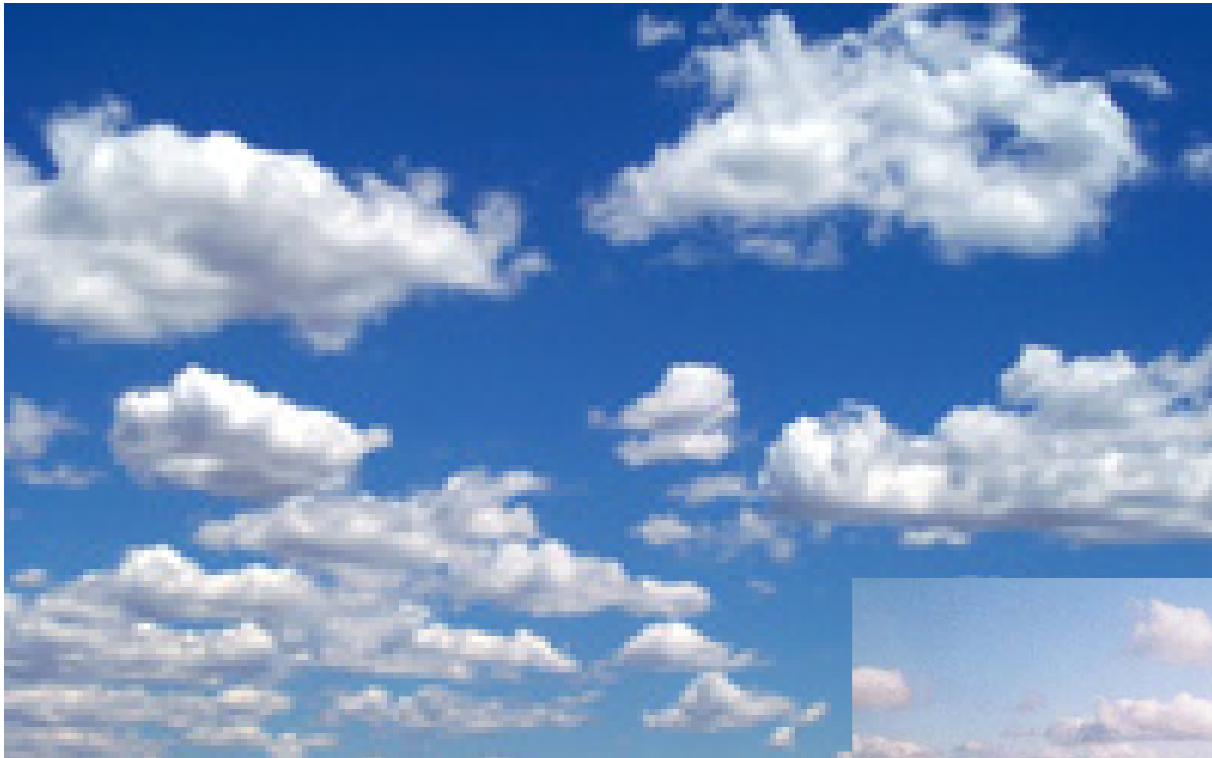


Figure 220 - Post-Frontal Conditions

Ahh….. Yes Thermals and Cu's



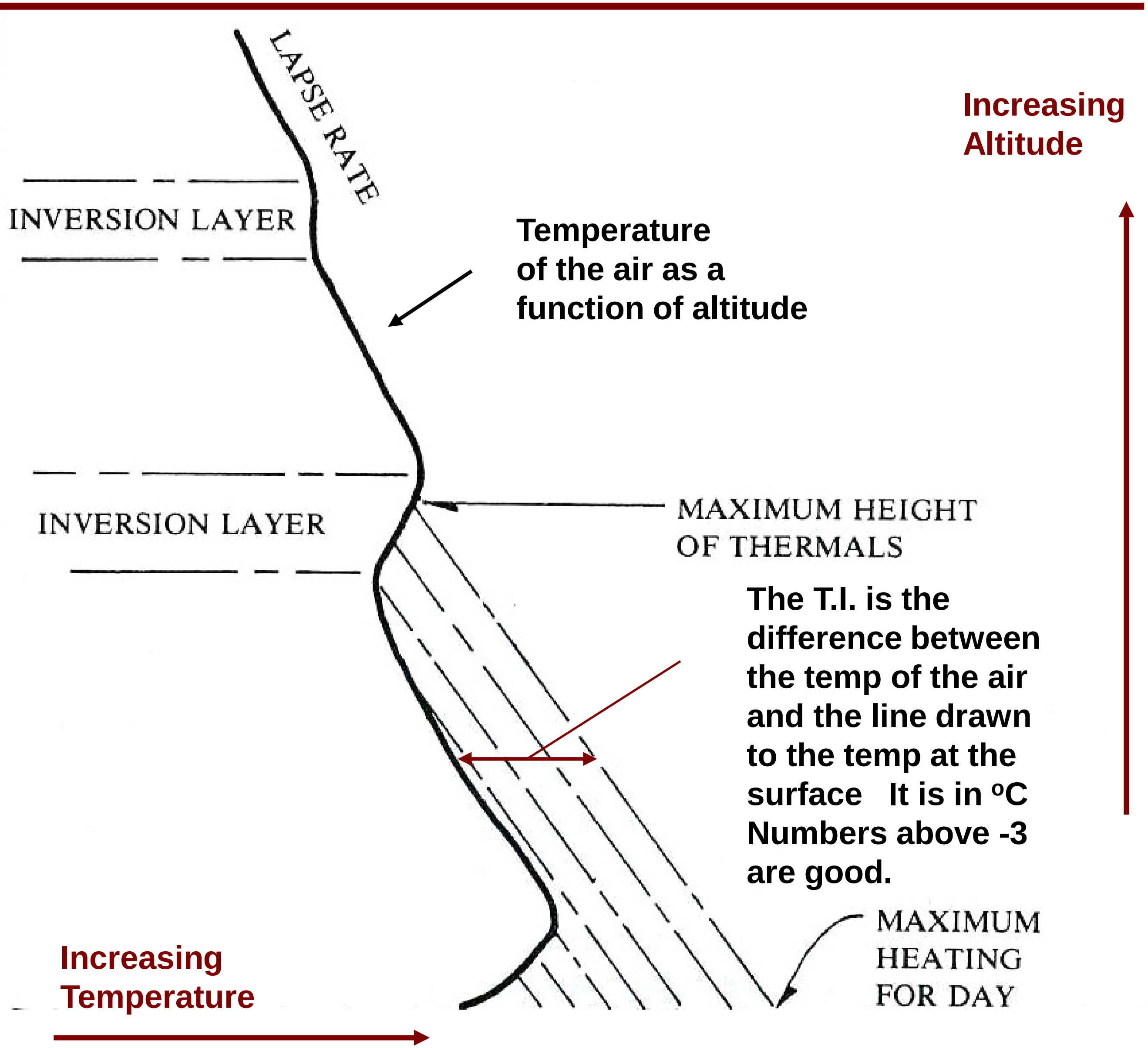
How do you predict this Wonderfulness with some accuracy – use the SkewT – Log P Plot

How Can I Predict Air Mass Instability ??
Use the SkewT-Log P Plot and the Thermal Index

The thermal index (TI) at a given altitude is the difference between the actual air temperature and the temperature that a parcel of air would have if it started at the surface and rose adiabatically to that altitude (as it does in a thermal). Data comes from a Skew T-Log P Plot (as discussed next)

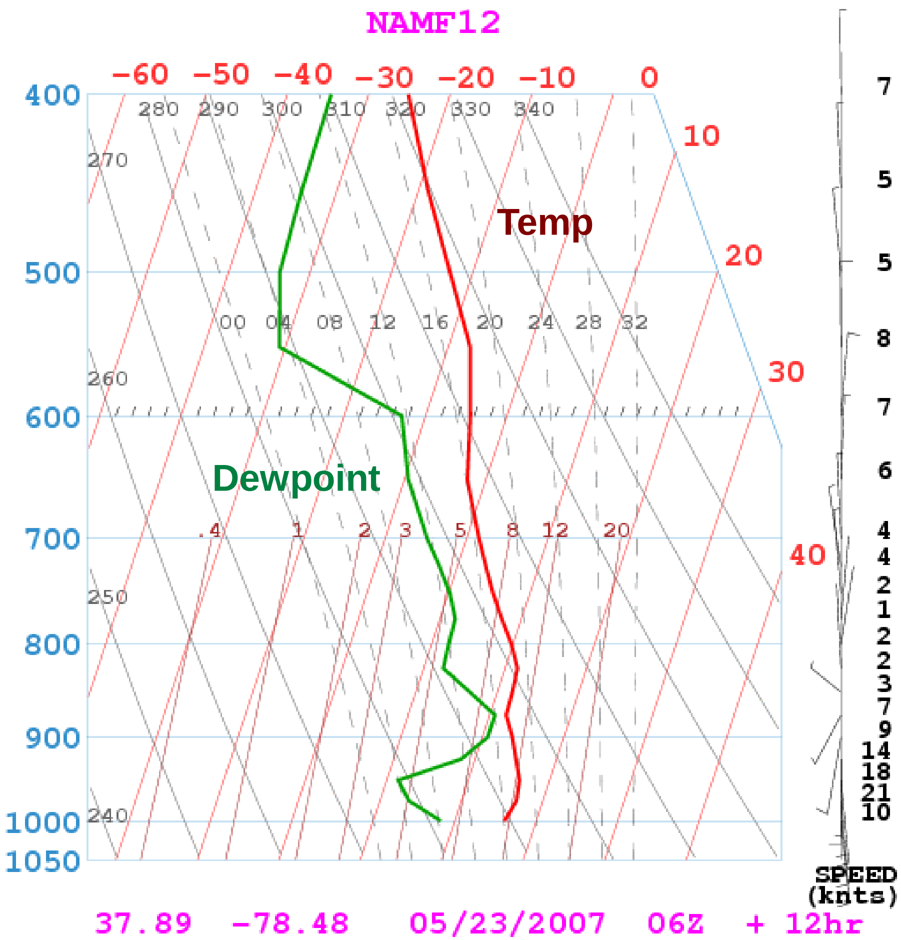
Negative values mean that the air parcel is at a higher temperature than the surrounding air, and therefore the air will continue to rise (see the previous diagrams). The altitude for which the TI reaches zero can be used as an approximation for the maximum height of thermals for the day.

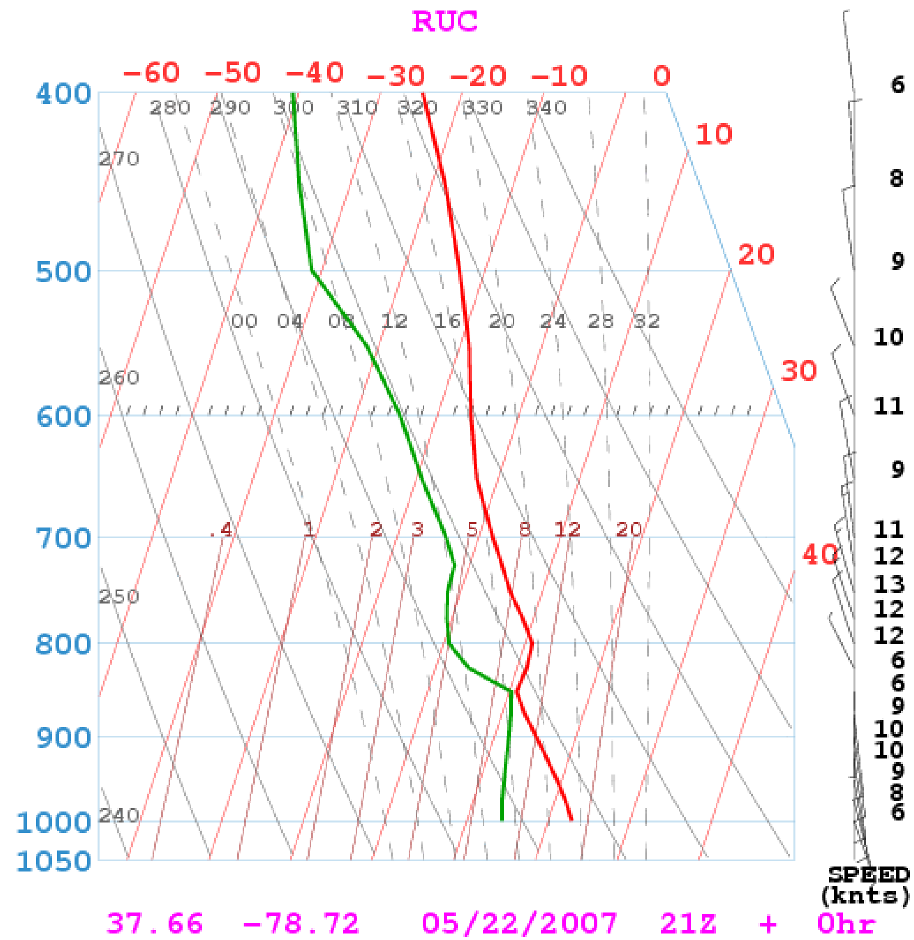
The maximum altitude a sailplane will reach may be lower. A threshold TI value of -3 is often used to estimate the height a sailplane will reach.



The SkewT - LogP Plot

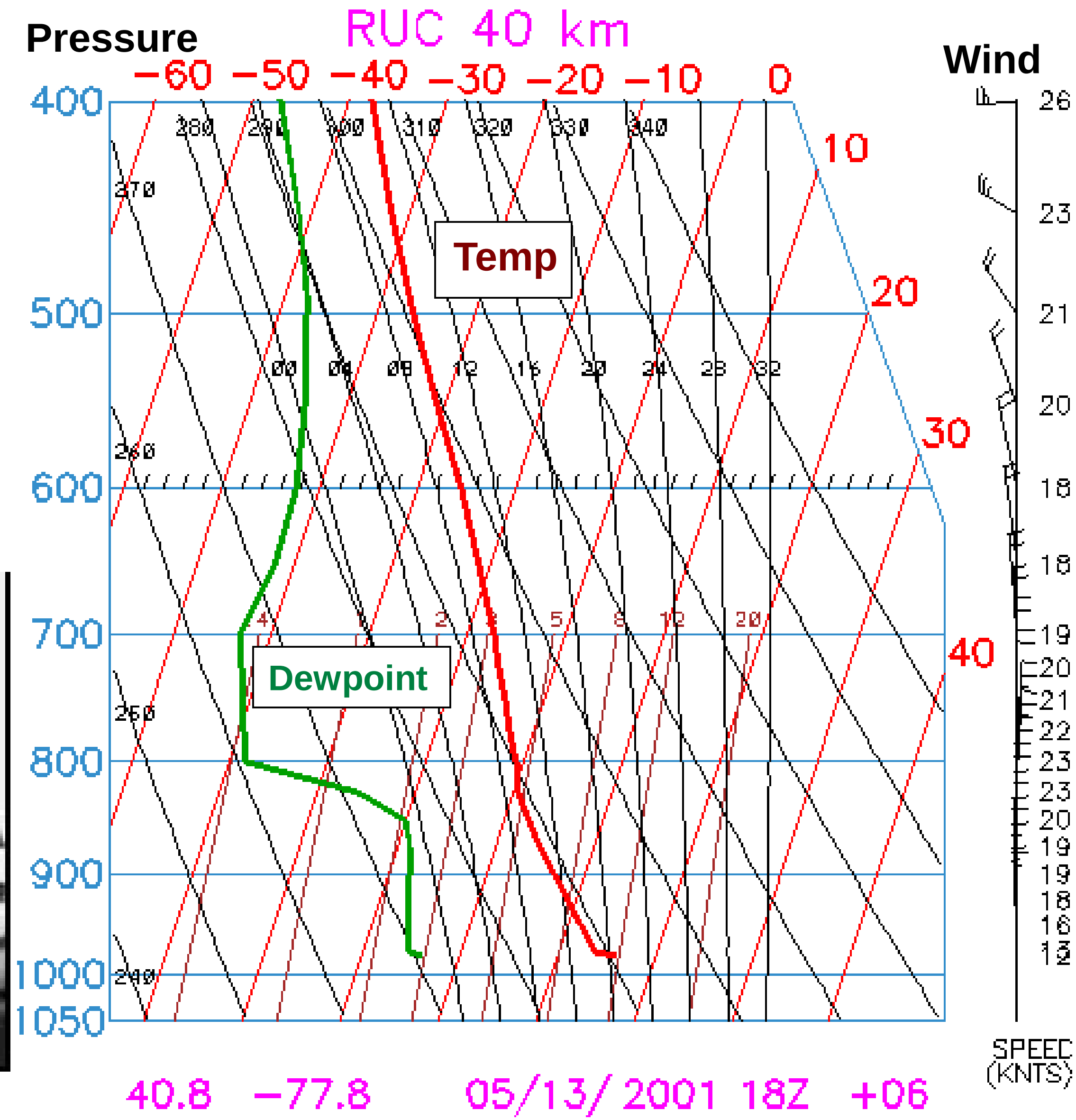
The two diagrams below are graphs of the atmospheric data which can be used to predict much about how a soaring day will develop. They present the temperture of the atmosphere as a function of altitude (pressure) and the saturation of the airmass (dewpoint). They also show the wind at various altitudes. This data is *predicted* by computer models and *measured* directly each day all over the world. It is a primary WX forecasting tool.





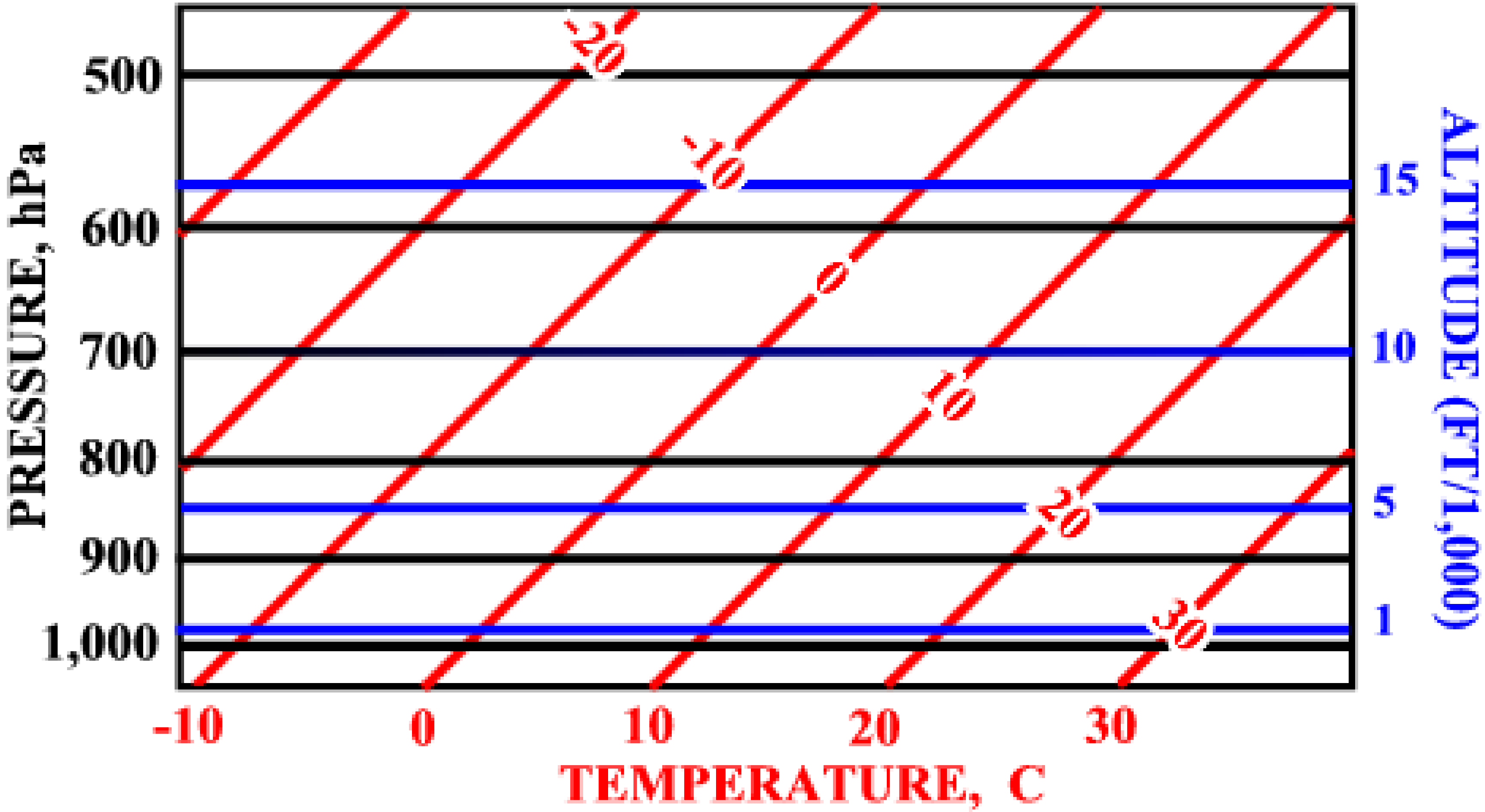
So -- Now I Have My SkewT - LogP Plot -- What Do I Do With It ???

What do all these lines and numbers mean ??



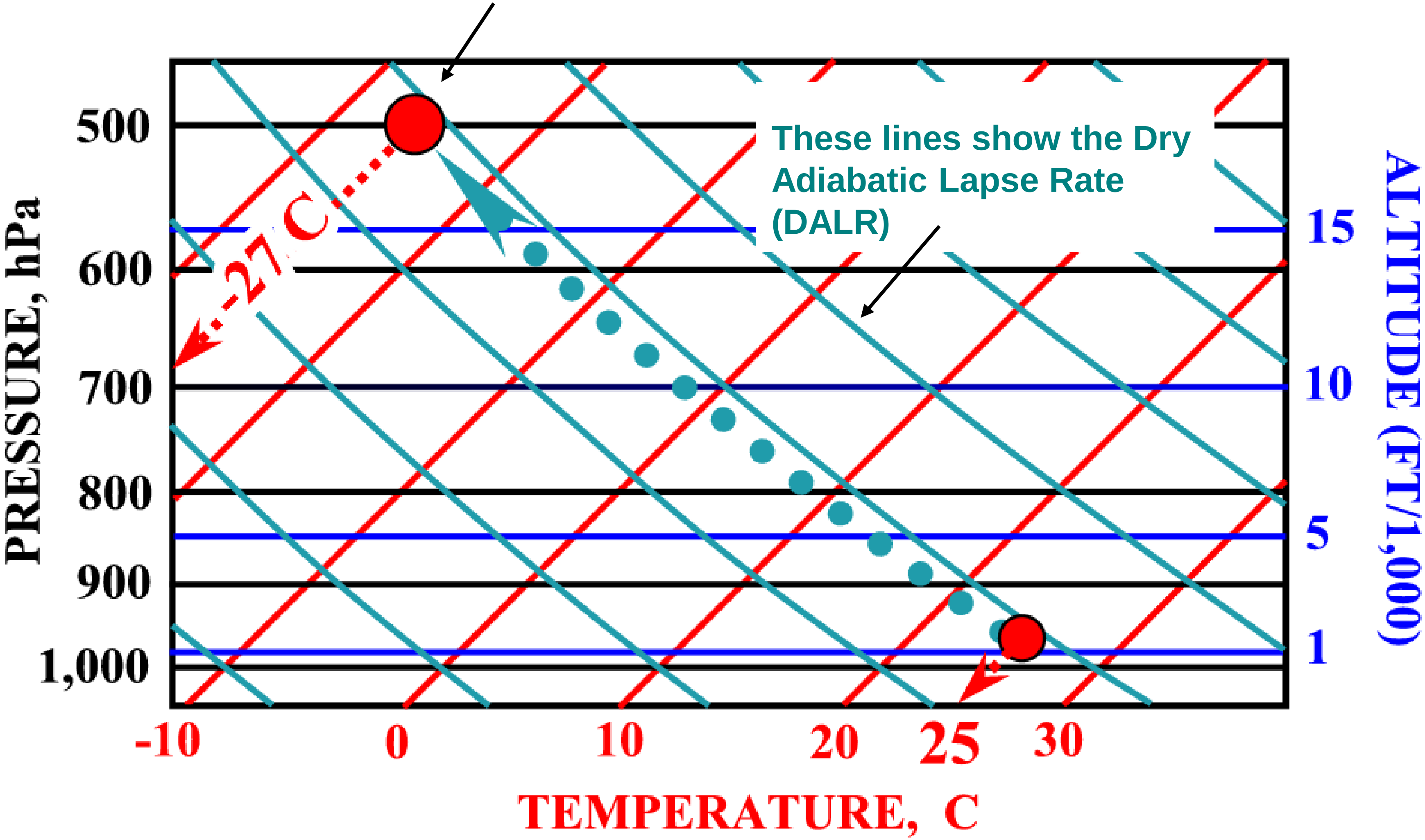
Deciphering the SkewT-LogP Plot – Pressure

The next section comes from Richard Kellerman's June 2001 article in *Soaring*.   I have used the figures from the article so that you can use it to review the details if needed. Horizontal black and blue lines are pressure and altitude - angled red lines are temperature



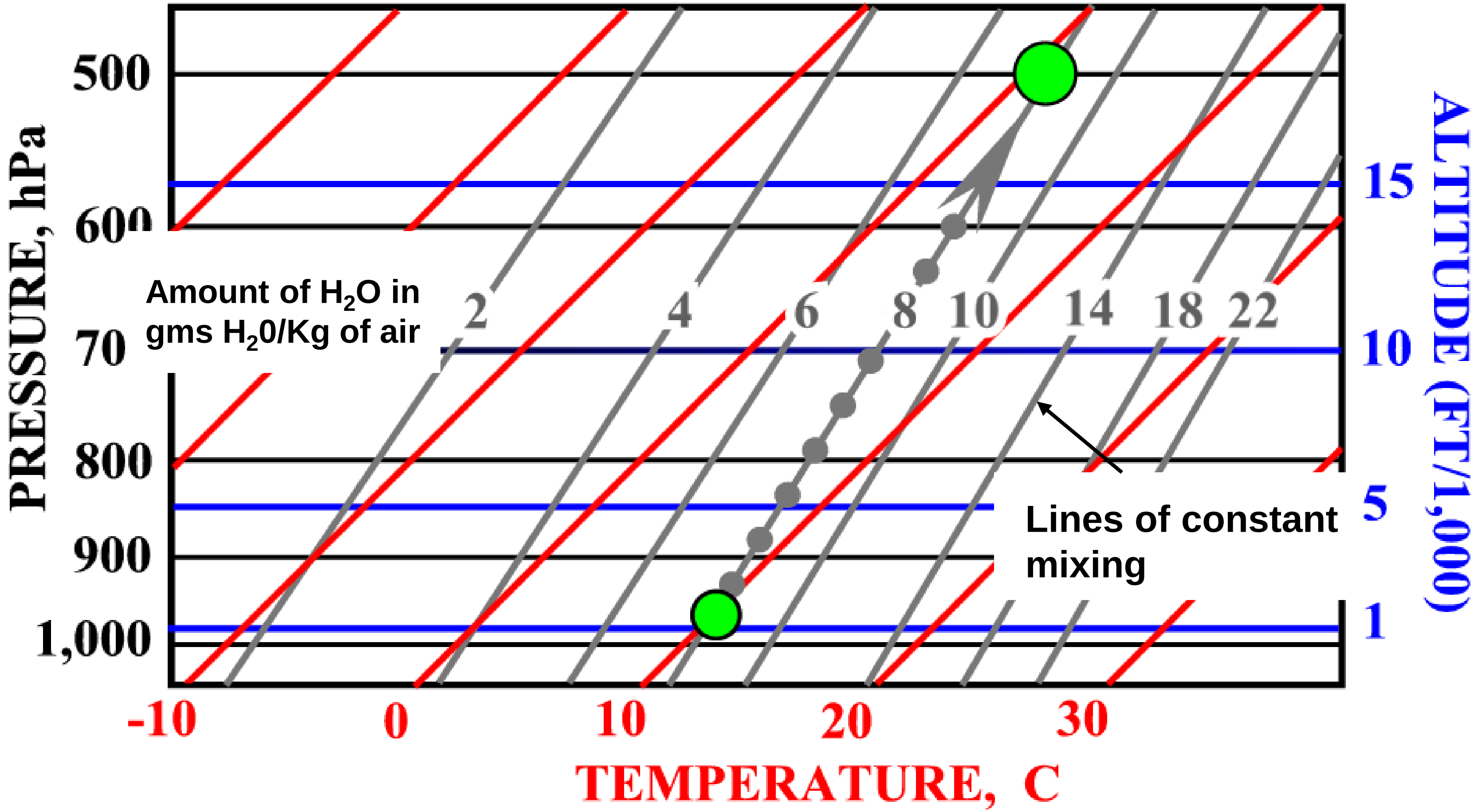
Deciphering the SkewT-LogP Plot - Temp

Adiabatic means no heat exchange -- An air bubble at 25 ºC, rising from sea level to 500 mbars (or ~18,000 ft) has cooled to from ~25 ºC to -27 ºC (with no exchange)



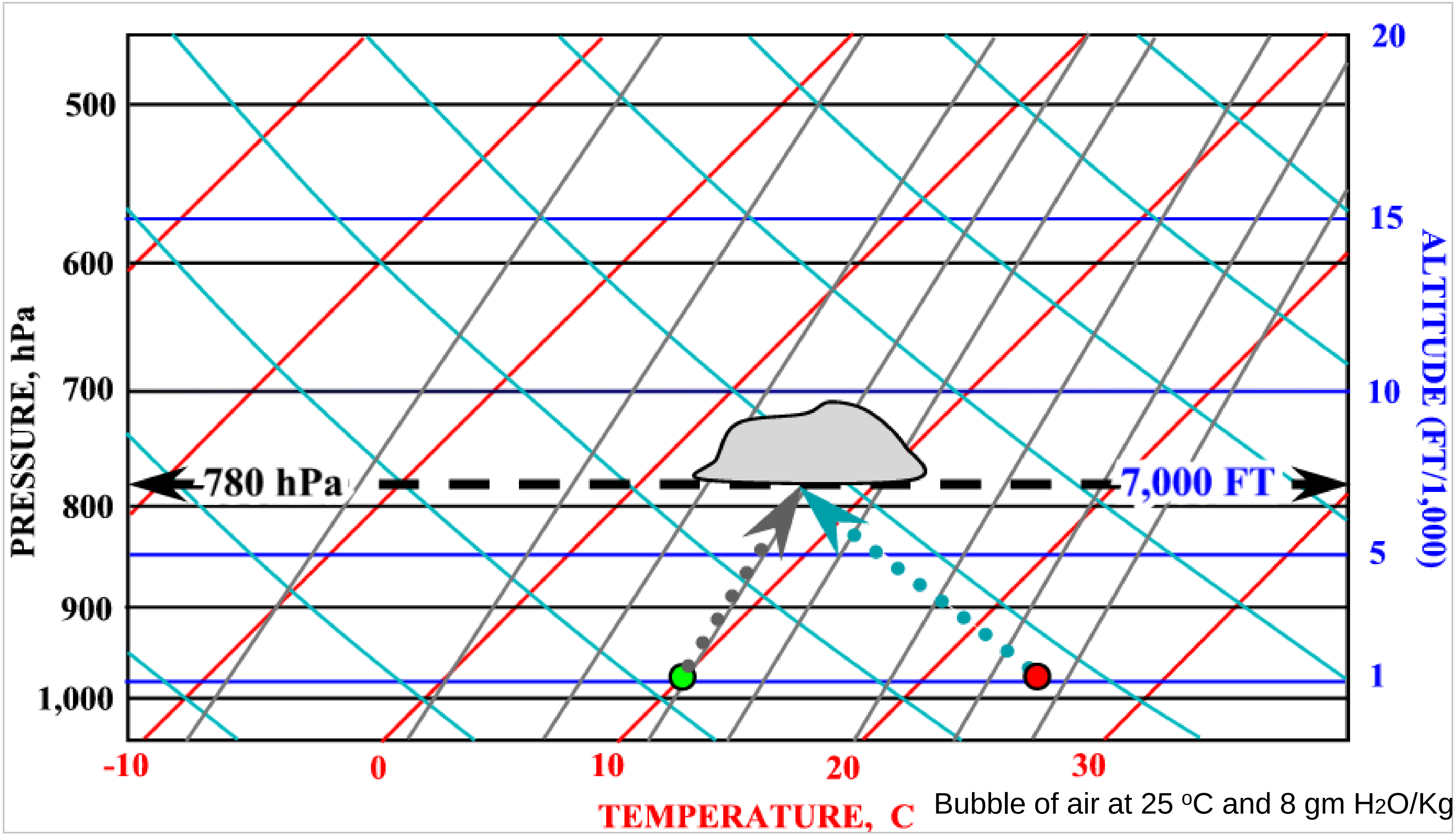
Deciphering the SkewT-LogP Plot - Dewpoint

No air in the real world is really dry - One has to consider the Dewpoint. The grey lines are lines of constant mixing. They show the change in dewpoint of a parcel of rising air. In the example, it drops from 10 °C at the surface to 2 °C at 18,000 feet



Deciphering the SkewT-LogP Plot -- Cloud Bases

Putting the last two figures together, we see that when our parcel of air containing about 8 gm of H_2O per Kg of air is raised to 7000 MSL, will condense the H_2O enough to form a cloud



Bubble of air at 25 ^{o}C and 8 gm H_2O/Kg

Calculation of Cloudbase from the Temp - Dewpoint Spread

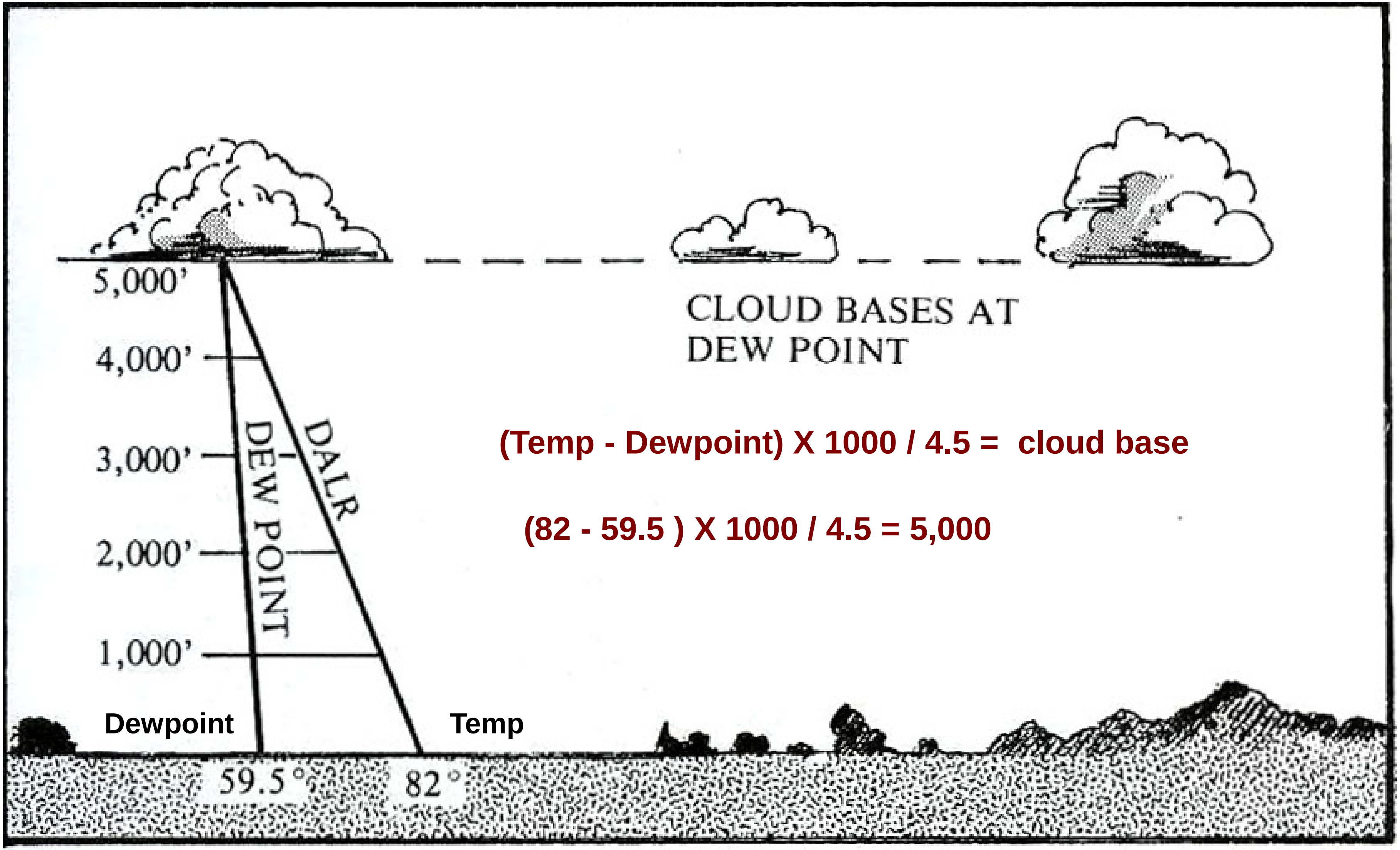
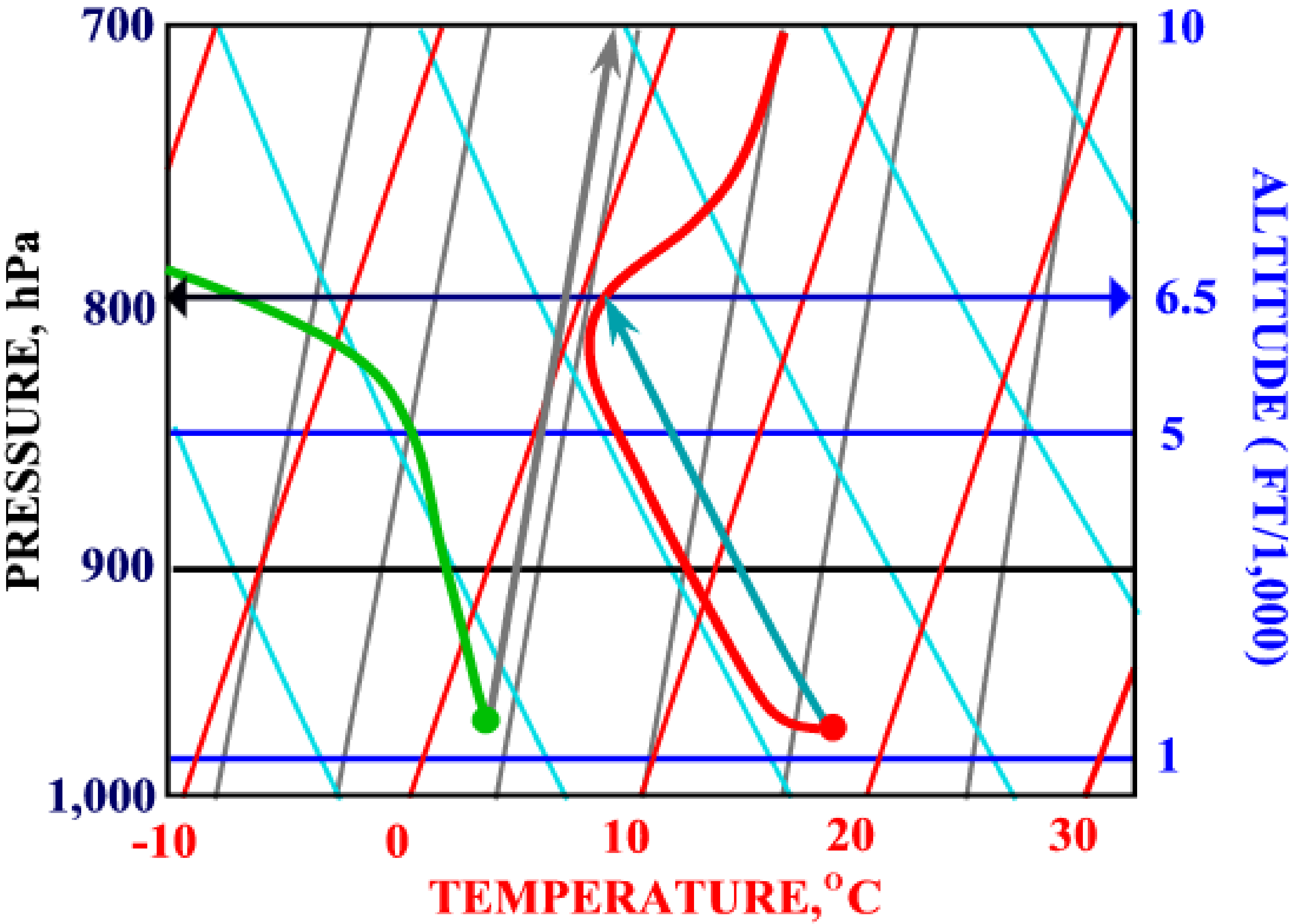
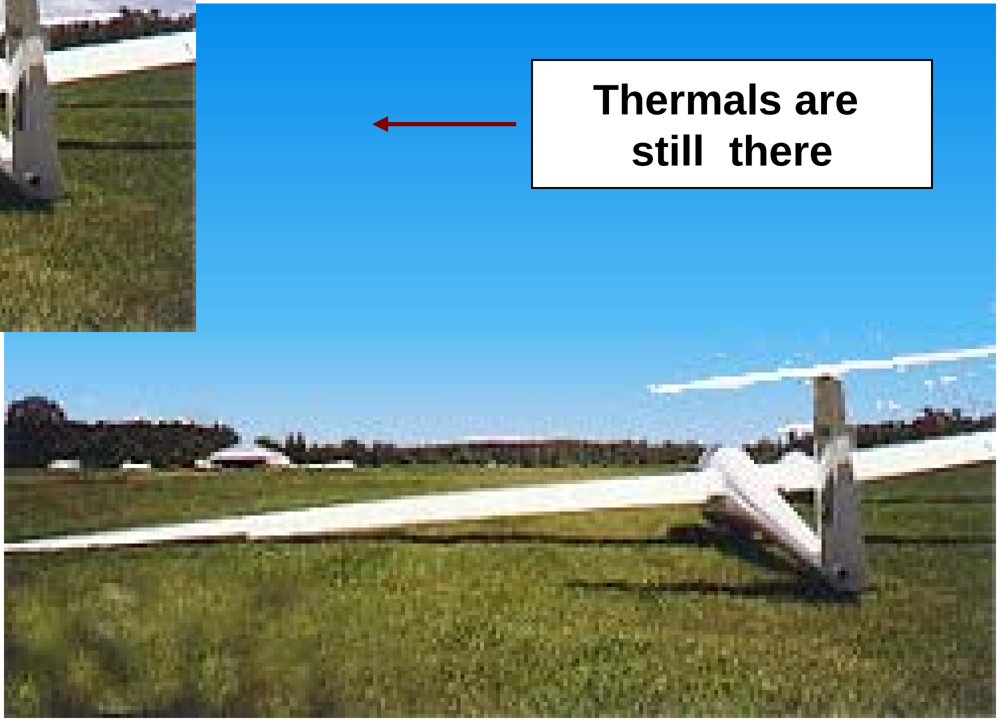


Figure 20 - Finding Cloud Base Height

Deciphering the SkewT-LogP Plot - Clouds or Blue ??



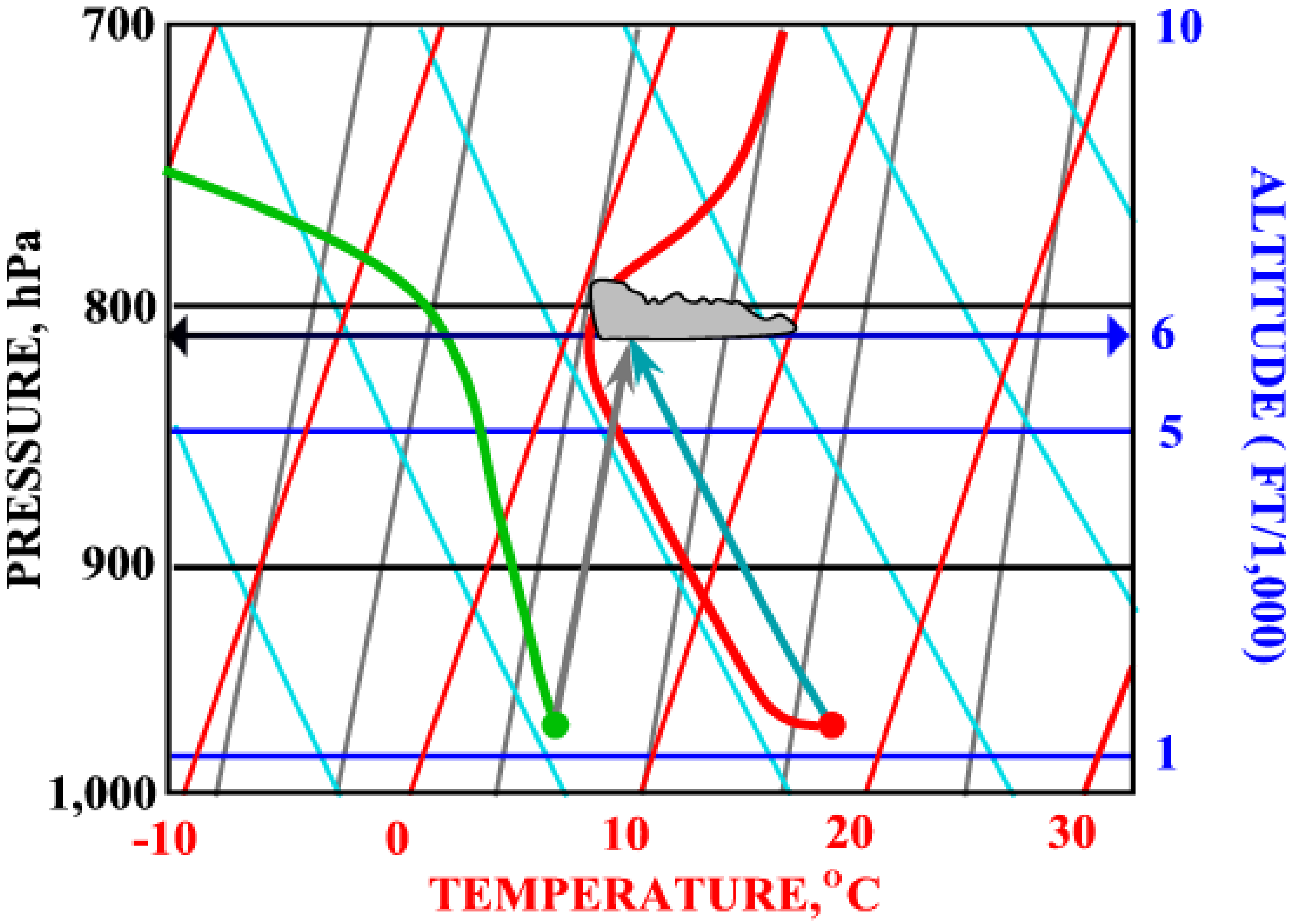
A Slight Change in the Dewpoint Can Make You Blue



Thermals are still there

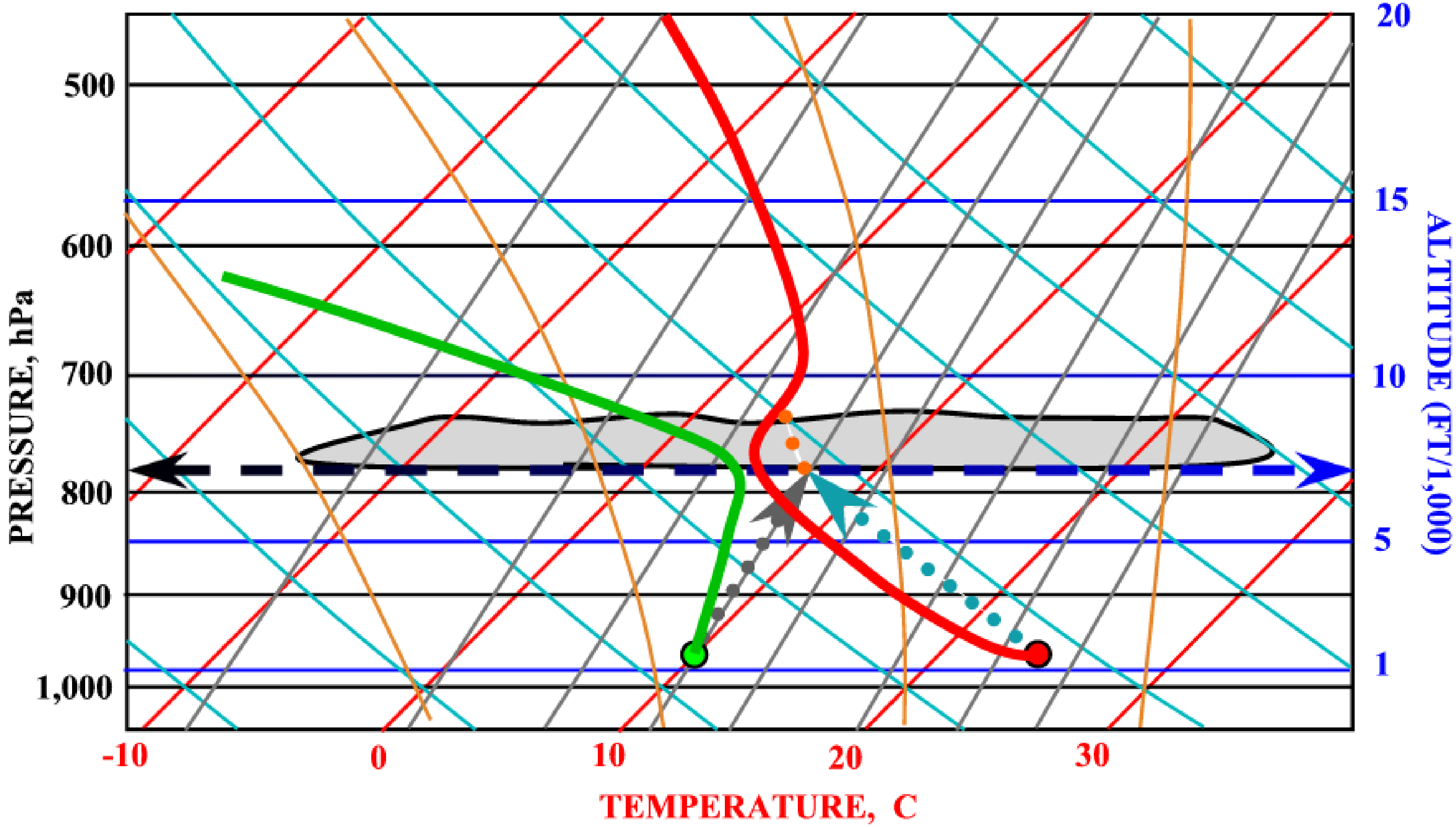
Deciphering the SkewT-LogP Plot – Cloud Spread

Here is an example of an inversion and a dewpoint high enough to cause clouds to spread because the condensation point is well below the inversion. The lift will continue past cloud base to the inversion. Light Winds help



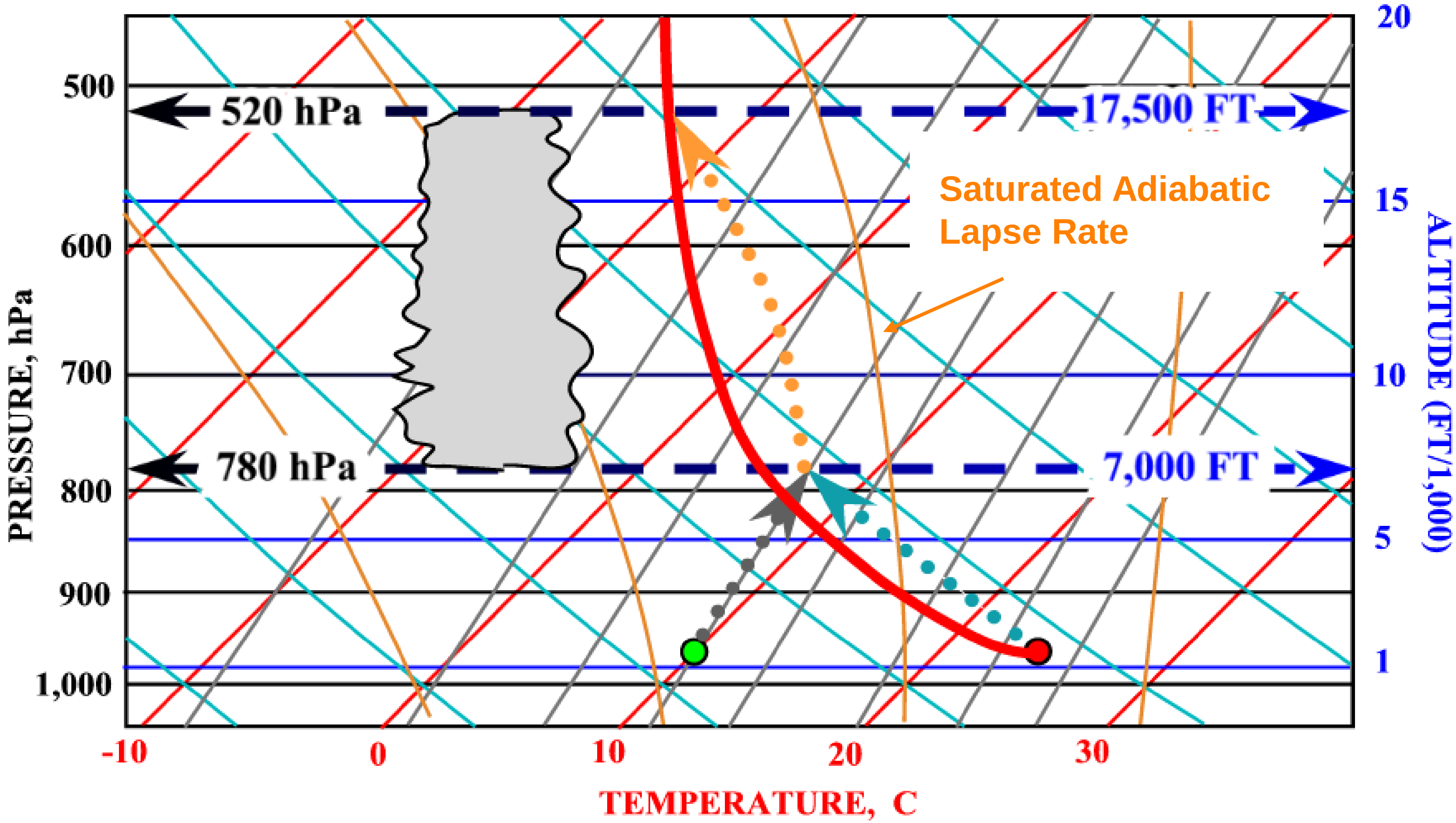
Deciphering the SkewT-LogP Plot – Cloud Spread

If the difference between the condensation point and the inversion is big enough, the clouds could spread so much that they begin to decrease surface heating. Causes a good day to go bad by 2-3 PM.



Deciphering the SkewT-LogP Plot - TRW

Bigger problems -- TRW Storms. In this case the air is wet and the temperature profile does not stop the rising bubble of air - it allows it to continue. Since the condensation of H_2O forming the cloud releases heat, we follow a new line, the Saturated Adiabatic Lapse rate (the gold lines). Following this line and releasing heat and water, our rising bubble of air forms a cloud 10,000 feet thick.



Thunderstorms - Possible Part of a Soaring Day

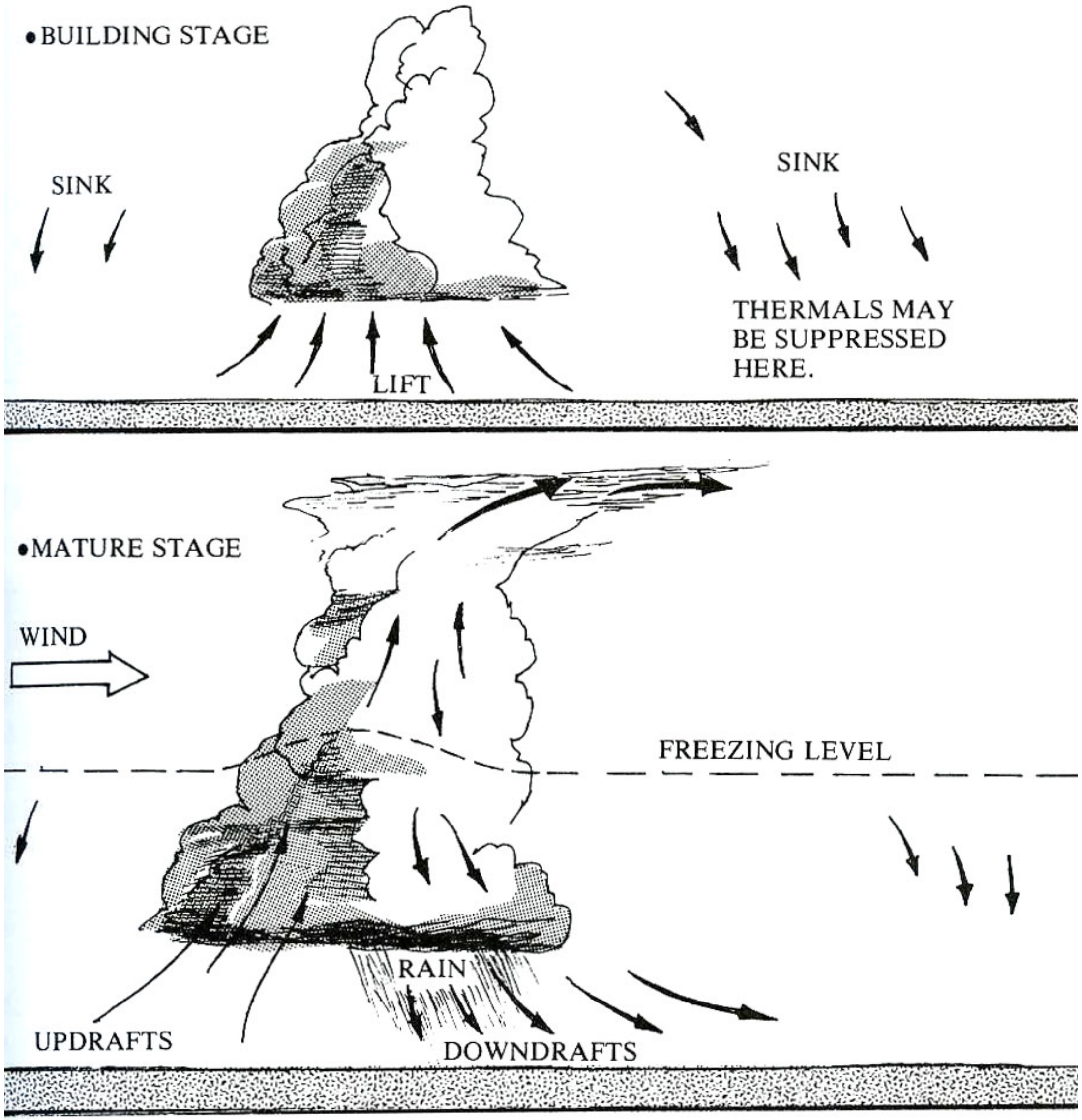


Figure 211 - The Building and Mature Stages of a Thunderstorm

Thunderstorm Caused by Cold Front Movement

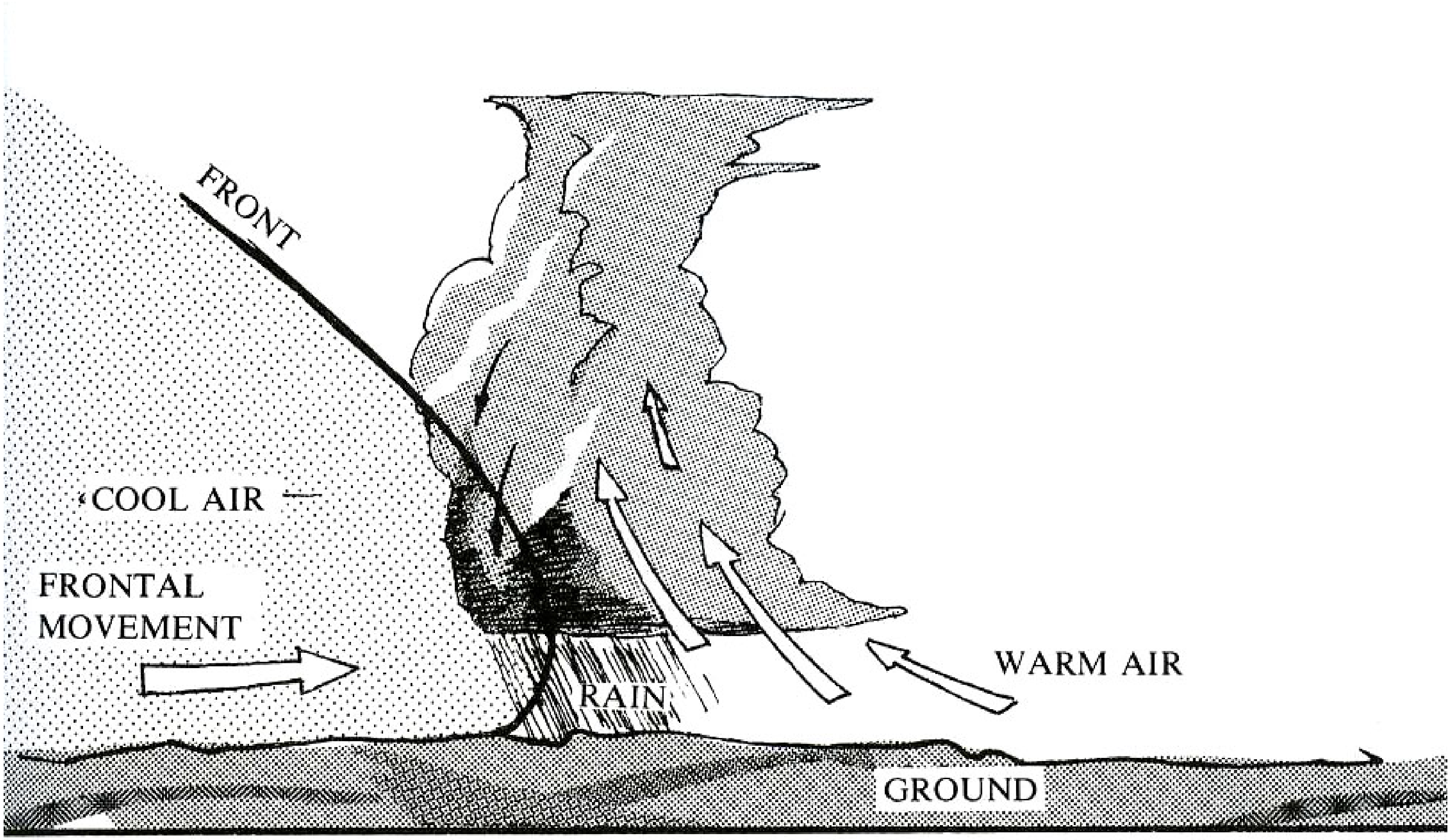


Figure 214 - Thunderstorms Due to Cold Front Movement

A Really Bad Day - Gust Fronts and Storms

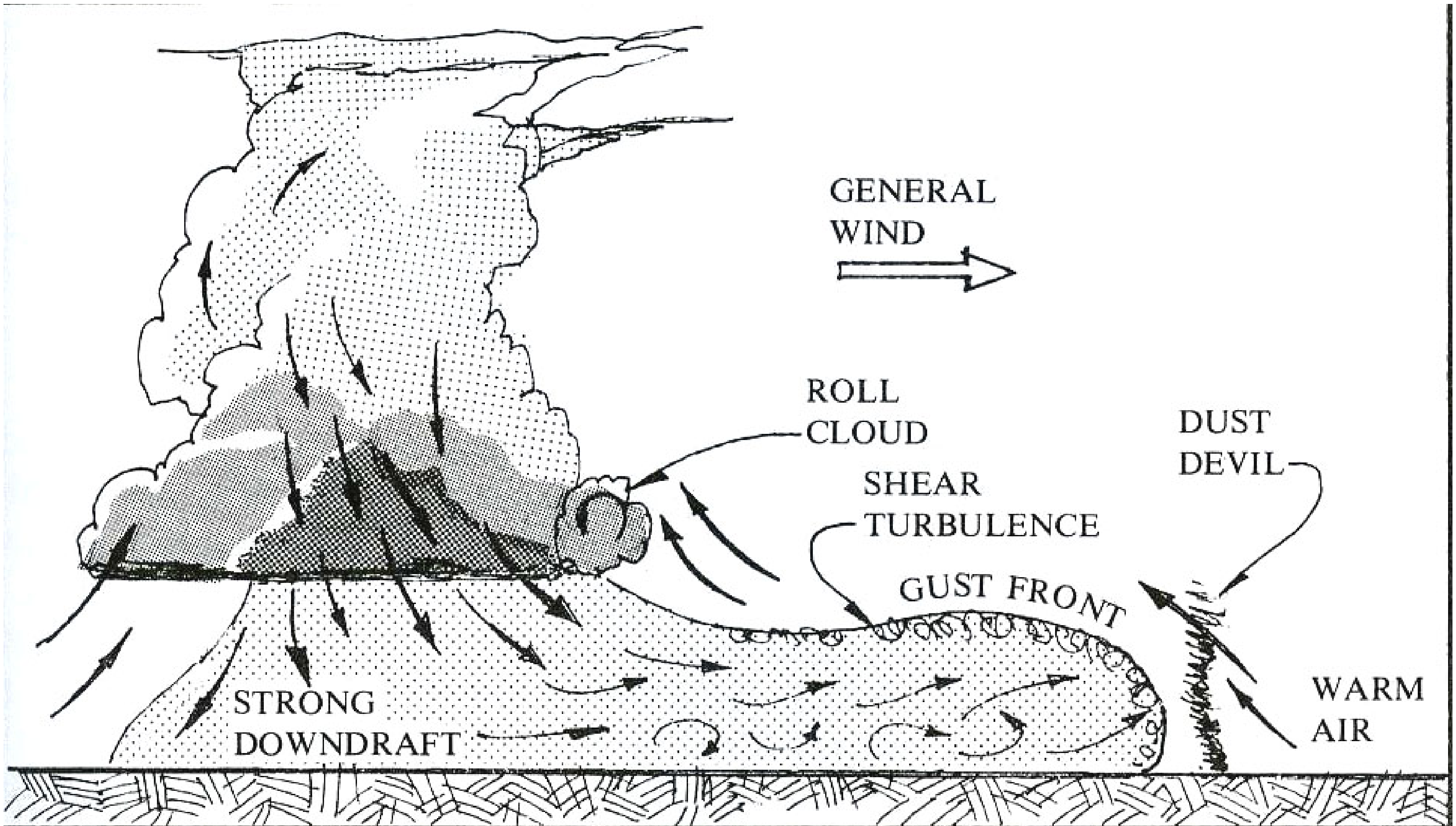


Figure 218 - Thunderstorm Gust Front

Escaping a Gust Front – Go To the Side

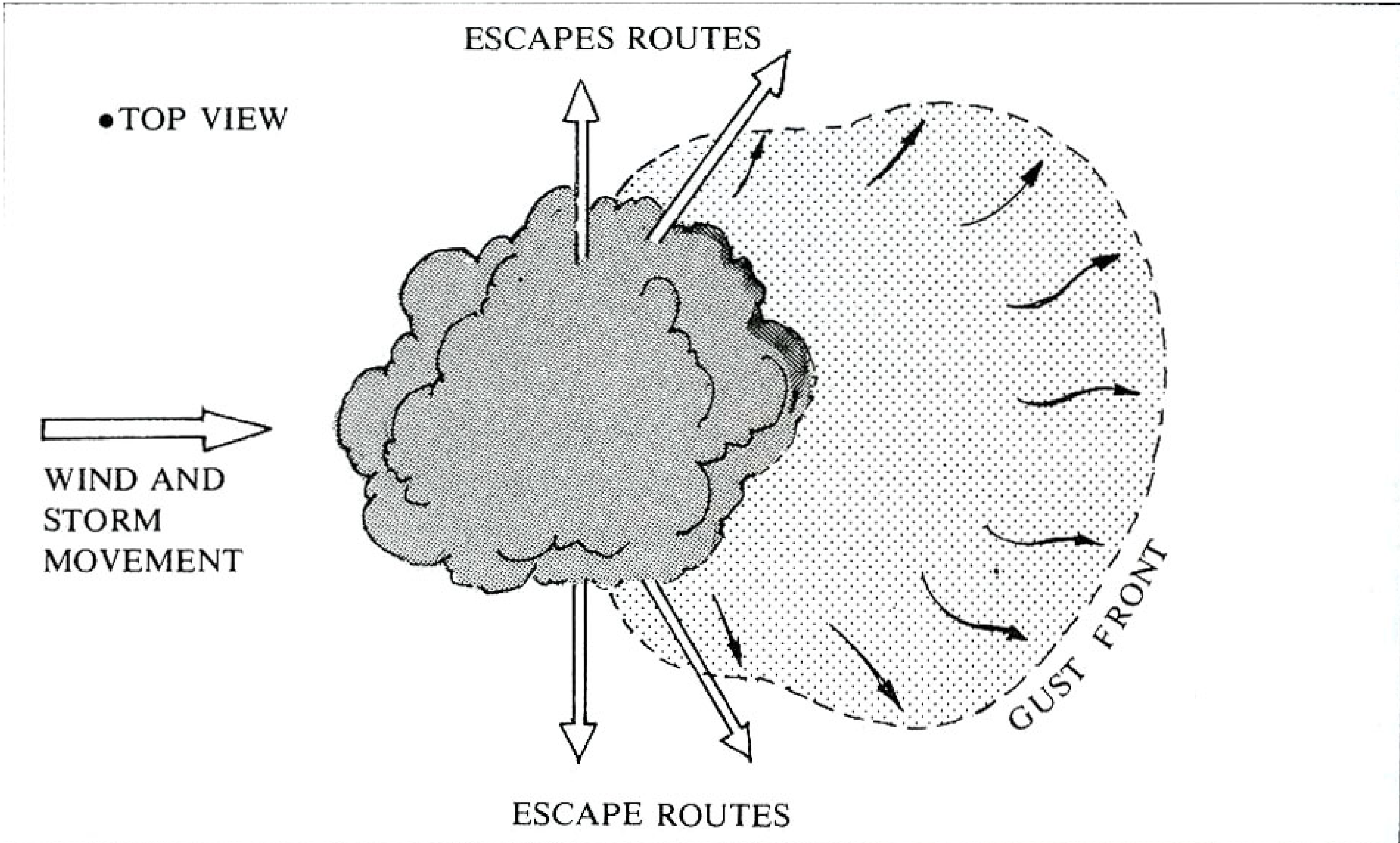


Figure 219 - Escaping a Thunderstorm

Exercises

- **Begin to watch the weather patterns and predict weather for good soaring.**
- **Use the Internet resources available to you for your predictions.**
- **Confirm your predictions from your office window (sigh).**
- **Better yet, go to the airport and test your prediction by flying.**
- **Make WX prediction part of your preparation for Sat and Sun flying.**
- **If your prediction is wrong, try to figure out why.**

END