Soundings - Page 1

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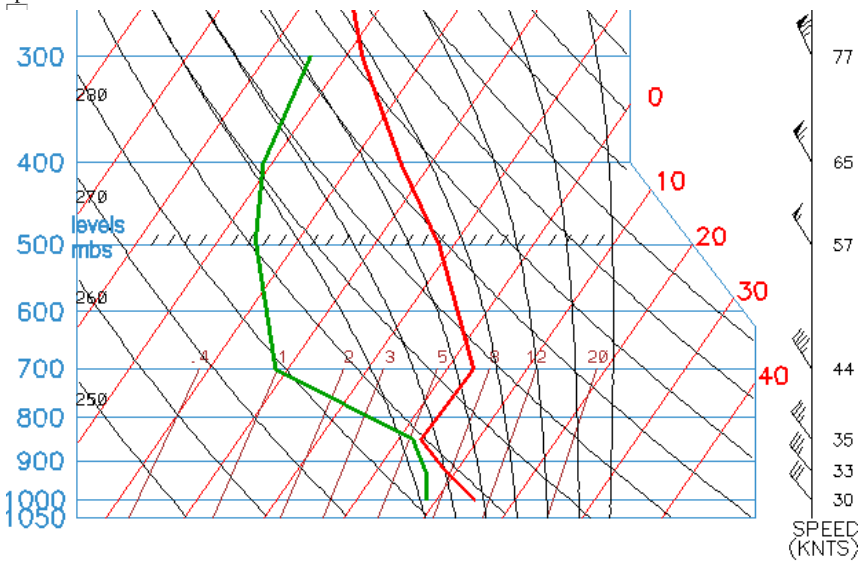


NOTE
Not all charts use quite the same axes nor the same colour schemes and units.

These diagrams are theoretical, simplified Skew-T's .

It might be worthwhile printing out these pages.

If you experience difficulty, best method might be to use Print Screen key top right of keyboard.

Then paste into eg 'Word'

millibar (hpa) pressure levels are on the **left** in **blue**
Surface pressure is normally around 1000 to 1025 mbs
Each mb corresponds to about 30 ft (in lowest part of the atmosphere)
850 mbs is about 5,000 feet *an important level*
700 mbs is about 10,000 feet
500 mbs is about 18,000 feet
300 mbs is about 30,000 feet *(cirrus level)*

Wind arrows (and numbers) are down the **right hand** side
short dash is 5 knots long dash is 10 triangle 50 knots
The direction is shown by the arrows.
Difference between true and magnetic can be ignored.
In this example :
At 500 mbs triangle and short dash means 320°/55 kts
At 30,000 feet (300 mbs) the wind is approx 340°/75

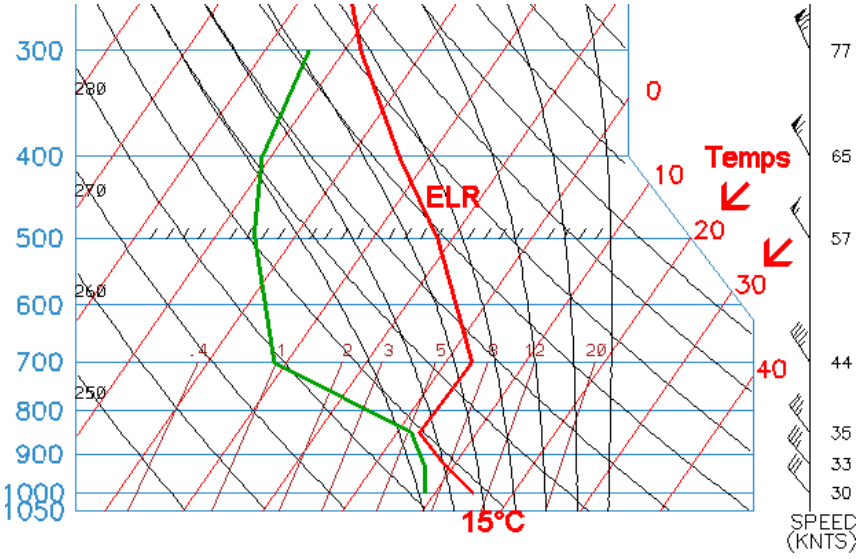
Temperature lines

The **red arrows** point to numbered red diagonal lines.
These are temperatures. eg, 0, 10, 20 etc
The **red line** that wiggles its way up the page is the **environmental lapse rate** **line** **(ELR) ie** a plot of temp with height.

It can be seen that the environmental line meets the bottom **horizontal** 1000 mbs line roughly midway between the two red diagonal lines marked 10 and 20
This is the surface temp of around 15°C (before any heating raises it later).

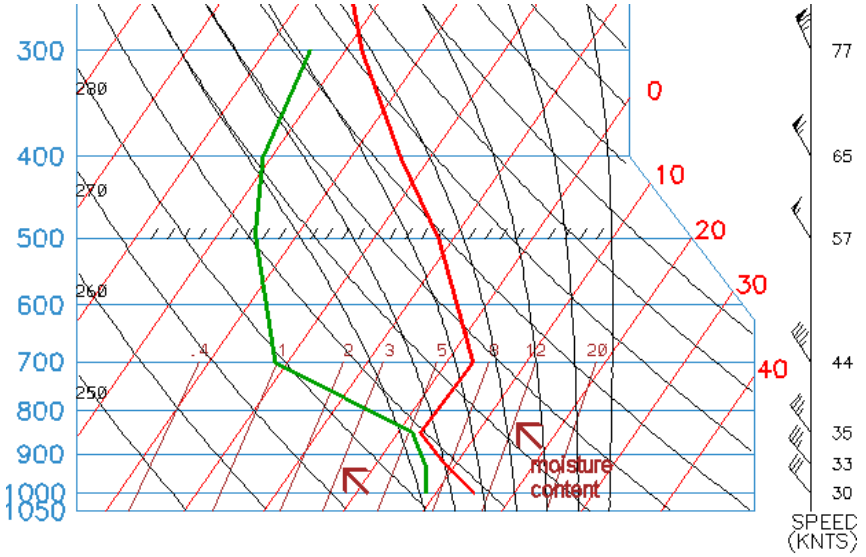
Now follow the ELR up to the 850 mb level.
Here the temperature is about 3°C
At the 700 mbs level, it also happens to be 3°C in this example, ie there is an isothermal between 850 & 700 mbs.

At 300 mbs the temperature is -38°C



Moisture content

Yet more lines



Reminder - the **red line is the ELR (environmental lapse rate)**

The **green line** represents the dewpoint against height.
Thus at 10,000 feet, the dewpoint is -22°C.
At the baseline, it is 8°C, ie surface dewpoint 8°C

The dewpoint is the temperature at which the air can hold no more water vapour, ie it is saturated.
Surface dewpoint is of major importance.

On the real sounding on the next page, the dewpoint line is not green, but is a the solid line on the left.

These two arrows point to **brownish/red lines** .
These indicate the mass of water the air can hold at various temperatures.
For example the arrowed example on the right can hold 12 gms of water/kg of air.
In the colder air on left, it is much less at 3 gm/kg air.

At the surface dewpoint (green line intercepting base), the mass of water the air can hold at that temp is indicated.
As that air rises in a thermal, it expands, cools (3°/1000) until it becomes saturated and cloud forms.
But - *and this is important* - the total water the air is holding has not changed from that it held at the surface.

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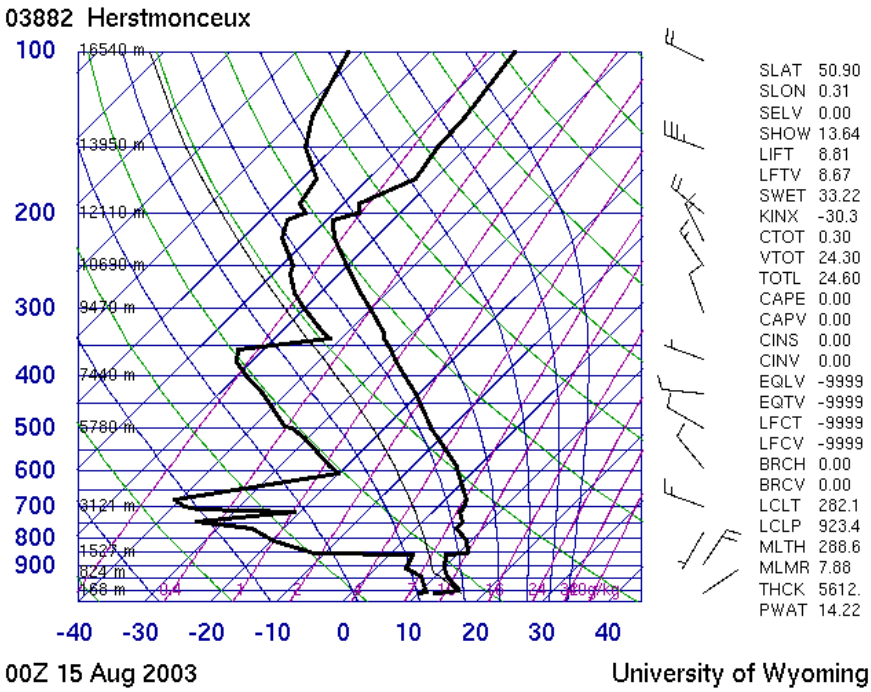

Look at this new graph

It shows yet another type of presentation that is available on the internet
(Uni Wyoming)
In fact, this is a Skew-T and is very like the demonstration charts seen earlier but with minor variations.

The sounding is the midnight one on what was arguably "the day of the year" when many big flights were achieved

Points to note:
Very strong inversion at 850 mbs thus convection limited to about 5,000 feet
An inversion is when the temperature increases with height - more usually it decreases

At 850 mbs the air is very dry (the left dewpoint line is well separated from the right environmental line)

Winds are light at all levels, but near coasts, sea breezes need to be considered

Not shown on this Skew-T, but using information from other sources, cooler air between 850 and 800 mbs was expected to move in from the west during the day raising the depth of convection. That was taken into account when making the forecast for 15th August

Sea Breeze rule of thumb
Deep penetration inland only likely if total depth of convection, including cumulus tops, is between 3,500 and 10,000 feet. Less or greater depth will probably mean any sea breezes confined to very near the coast.
So with light winds and appropriate depth of convection on 15th August, sea breezes were forecast to move well inland. See the separate tutorial on sea breezes

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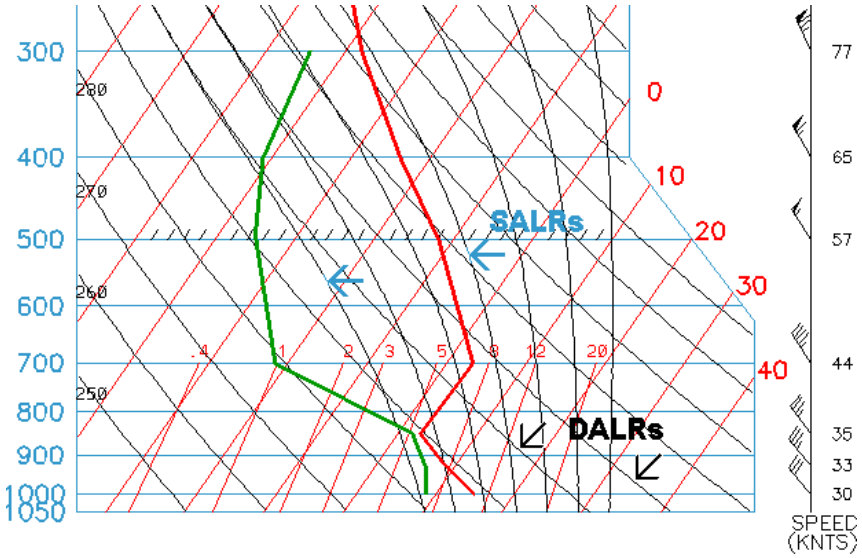
Adiabatic Lapse Rates

Two final lines on this chart.



Straight lines (**arrowed in black**) run diagonally up at 45° from the bottom right to the top left.
These are the **Dry Adiabatic Lapse Rate** (DALR) lines.
Adiabatic means no external heat added nor taken away from the air mass.

A rising parcel of air cools (because it expands) at the DALR until such time as it becomes saturated.

DALR can be taken as being about 3°C per 1,000 feet.
So a thermal which leaves the surface with a temperature of 20°C will have cooled to 14°C by the time it has reached 2,000 feet.

When the thermal rises far enough and cools sufficiently for condensation to occur, cloud forms. Condensation takes place if the air continues to rise, and latent heat is given out by the condensation process. Thus the temperature in the cloudy thermal falls off rather more slowly than it does in a dry thermal.
At low levels, this can be taken to be roughly 1½°C per 1,000 feet.

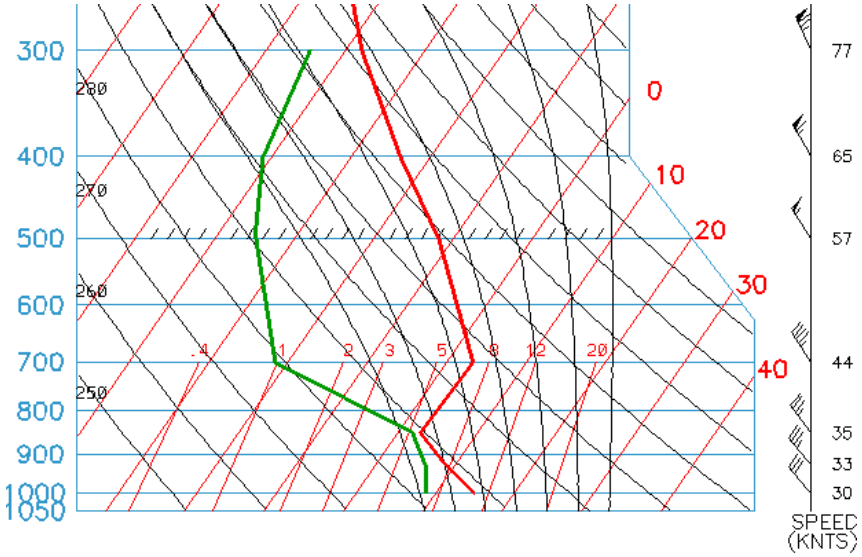
These **Saturated Adiabatic Lapse Rates** lines (SALR) are curved and indicated by the **blue arrows**

NOTE : Air behaves either as being dry or saturated. It is not a gradual process of change between one state and the other .

Now we should know what all the various lines mean.

So how do we use them?

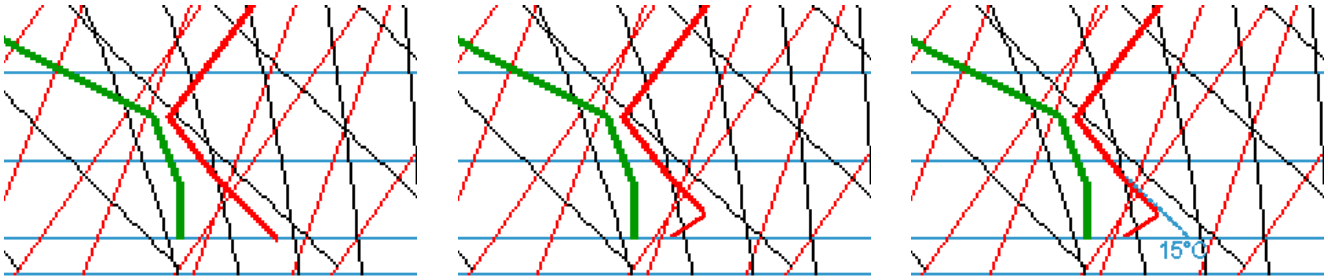
Let's recap.



The **red ELR line** starts from about the 1000 mb level.
Now using those red temperature lines that go diagonally upwards to the right, it can be seen that the ELR reaches the surface at about 15°C
Just to the right of this point, there is a black DALR lines (they go diagonally up to the left) which intercepts the 1000 mb surface at about 16°C
So if the surface temperature reaches 16°C, then a bubble of air (being warmer than the environment) will rise as a thermal and follow that DALR line (temperature decreasing by 3°C every 1,000 feet as it does so).

Eventually, that thermal reaches the **red ELR line** at about 850 mbs (5,000 feet) and if it were somehow able to rise above that point, would in fact be cooler than the environment. This cannot happen, (ignoring orographic effects) so where this particular DALR line from a surface temperature of 17°C reaches the environmental line, the air stops rising, and this marks the *top of the thermal.*

Possible limitations of this simplistic interpretation are given below.



These are rather "coarse" forecast soundings and don't always model the profiles in great detail.
Above left is an enlargement of part of the larger diagram. It might simply show that at 15°C, there is a dry adiabatic to around 850 mbs
But it might hide an early morning inversion as shown in the middle picture.
The right hand diagram shows that 15°C is needed as trigger to "break the inversion".

Some of the more detailed soundings such as those from Dr.Jack and Meteoblue deal with these lower levels rather better, but still have their limitations.
In this illustration, formation of cumulus has deliberately been ignored as a simplification. That will be considered later.

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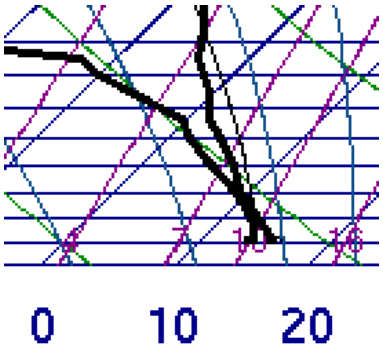
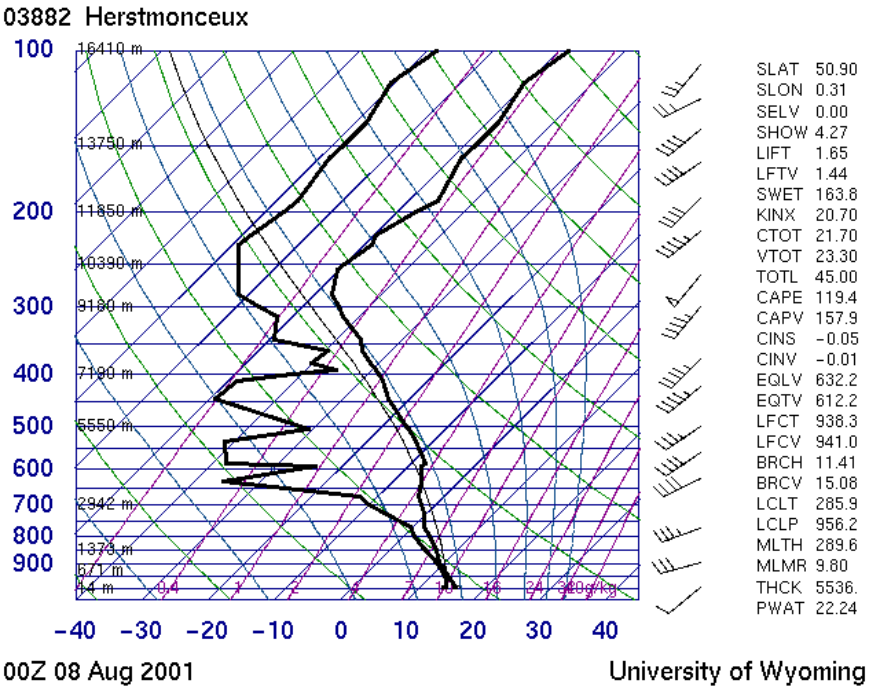
This tutorial is probably the most difficult so far.
Take a deep breath.

This was a midnight sounding on the right.
It looks dreadful, doesn't it?

Lets blow up the bottom bit





With some difficulty, it can be seen that the dry and the dewpoint lines are very close or even coincide near the surface.
The surface dewpoint Tdew and dry temperature Tdry are both about 14°C.
Tdew probably won't change much during the day. But Tdry will rise to an expected 20°C (obtained from various forecast sources).

From the expected surface temperature of 20° follow the dry adiabatic line upward diagonally to the left until it meets the environmental line.
This occurs at about 880 mbs.

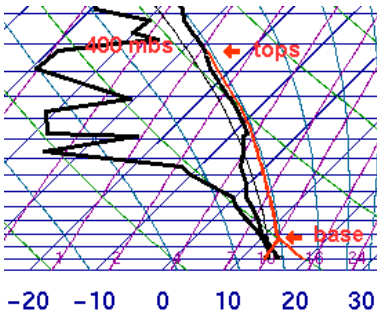
However, now we must consider the moisture content of the air.
From the surface dewpoint of about 14°, follow (or parallel) a purple/brown line upwards to the right.

This will intersect the dry adiabatic from 20° surface at about 920 mbs. This is the expected cloudbase.

A cross check using the Bradbury 400 ft / degree rule would come up with the same result - ie 6° difference means cloudbase of 2,400 feet. So we have confirmed expected cloud base.
Remember that the 400 ft / degree rule is only appropriate if cumulus develops and cannot be used to determine thermal depth on blue days.

The relevant part of the sounding is shown

The maximum temperature is assumed to be 20°C



Earlier, we saw how to work out the cloud base.

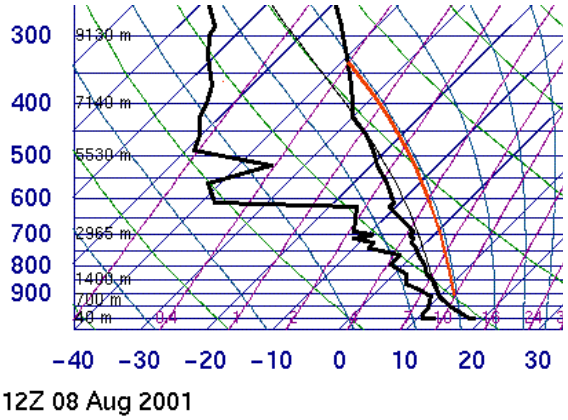
But the convection does not stop at cloud base. It continues at the SALR until reaching the ELR at around 400 mbs (~23,000 feet).

Blue Haze caps or Cumulus?
On a later page, we will see how it can be determined (with, it must be said, a certain degree of uncertainty) whether or not it will be a blue day.

How tall will the clouds grow?
It is important to have an idea how tall the cloud might grow as this gives an indication of potential shower activity (or otherwise).
Showers are unlikely if the cloud tops do not penetrate the height at which -10°C occurs.
In this example, clouds do indeed go to heights where the temperature is -25°C

The later midday sounding shows that we were correct with the earlier interpretations. Indeed, the airmass looks even more likely to result in heavy showers - there is a bigger area between the black and the red line.
(to be technical, larger CAPE).

And it all went to plan:



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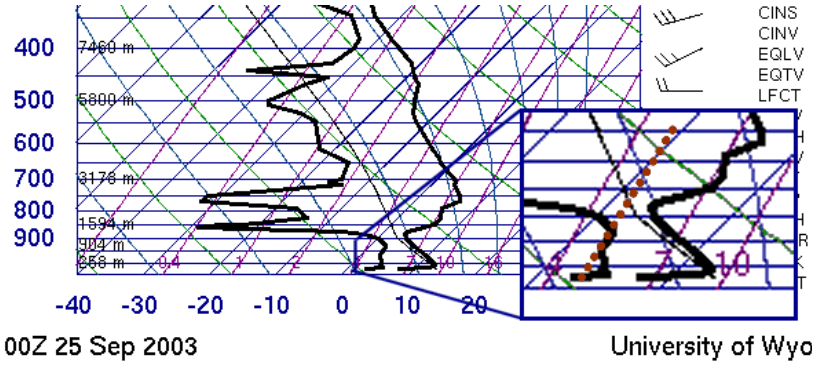
Blue or not blue?

This was a fairly predictable blue day.

Let's see why.



The surface dewpoint Tdew on this chart is around 3°C
Follow the moisture content (purple line) up to the right.
It does not intercept the ELR (black line to right).
Therefore, no condensation can occur - the day is blue.

If Tdew were a little higher, or the air at 900 to 800 mbs a little cooler, then cumulus would develop.

Many days are touch and go whether or not blue. Forecast soundings can be used to see the likelihood of a blue day, but all these factors make predicting with certainty very difficult in some situations.

Some days are easy to predict
It might be be possible to say with certainty that there will be cumulus.
On other days, it will definitely be blue.
But many days in Britain are borderline and very difficult.

The dewpoint has to be assessed accurately.
It might fall during the day (as air from aloft mixes with that at the surface)
Alternatively, the dewpoint might rise a couple of degrees as overnight fog or deposited dew clears.

Use sources such as Expert weatheronline, X/c weather

When forecasting, there has to be inspired (and experienced) interpretation. The 900 to 800 mb temperature might change.
Cooler air aloft could move in (cold advection). This would probably be good and cumulus might occur after all.
But, if an anticyclone is pushing in from the west, then the air aloft will warm and thus what initially is a day with small cumulus becomes blue later.

Rule of thumb - Blue or not Blue? (very rough quick check - don't worry about the technical background)
Call the Surface dewpoint = Tdew and Temperature at 850 mbs (5,000 ft) = T_{850}

Tdew greater than T_{850} +2 then CUMULUS probable. Use Bradbury for cloudbase.	Tdew less than T_{850} then almost certainly BLUE. Bradbury CANNOT be used.	if Tdew is between these ranges (on left), then borderline blue / haze caps / cumulus Bradbury might give a clue to "bases".

Conclusions
Some of this tutorial has considered actual balloon soundings.
However, fewer balloons are sent up nowadays, so forecast soundings assume greater importance. After all that is what the Met Office and other forecasting organizations use.
There are several links on the weather page, eg NOAA, Basel, Dr.Jack (not yet linked as still undergoing trials), Net Weather (subscription service).

Use these forecast soundings to make your own predictions. Good luck.

BACK TO BEGINNING of tutorial