Introduction to Skew-T Diagrams

Have a think about a few things I'm going to throw to you…it will hopefully make you think a little outside the square!

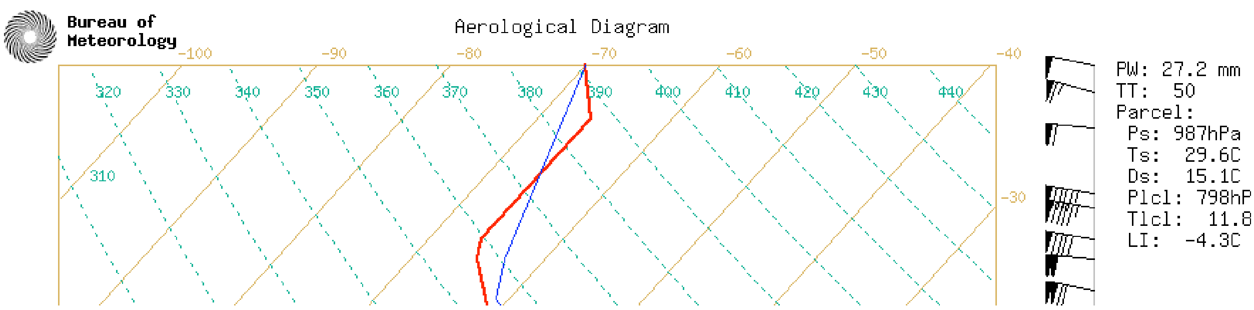
- LIs of -15 can give you clear skies
- LIs of 0 can give you tornadoes

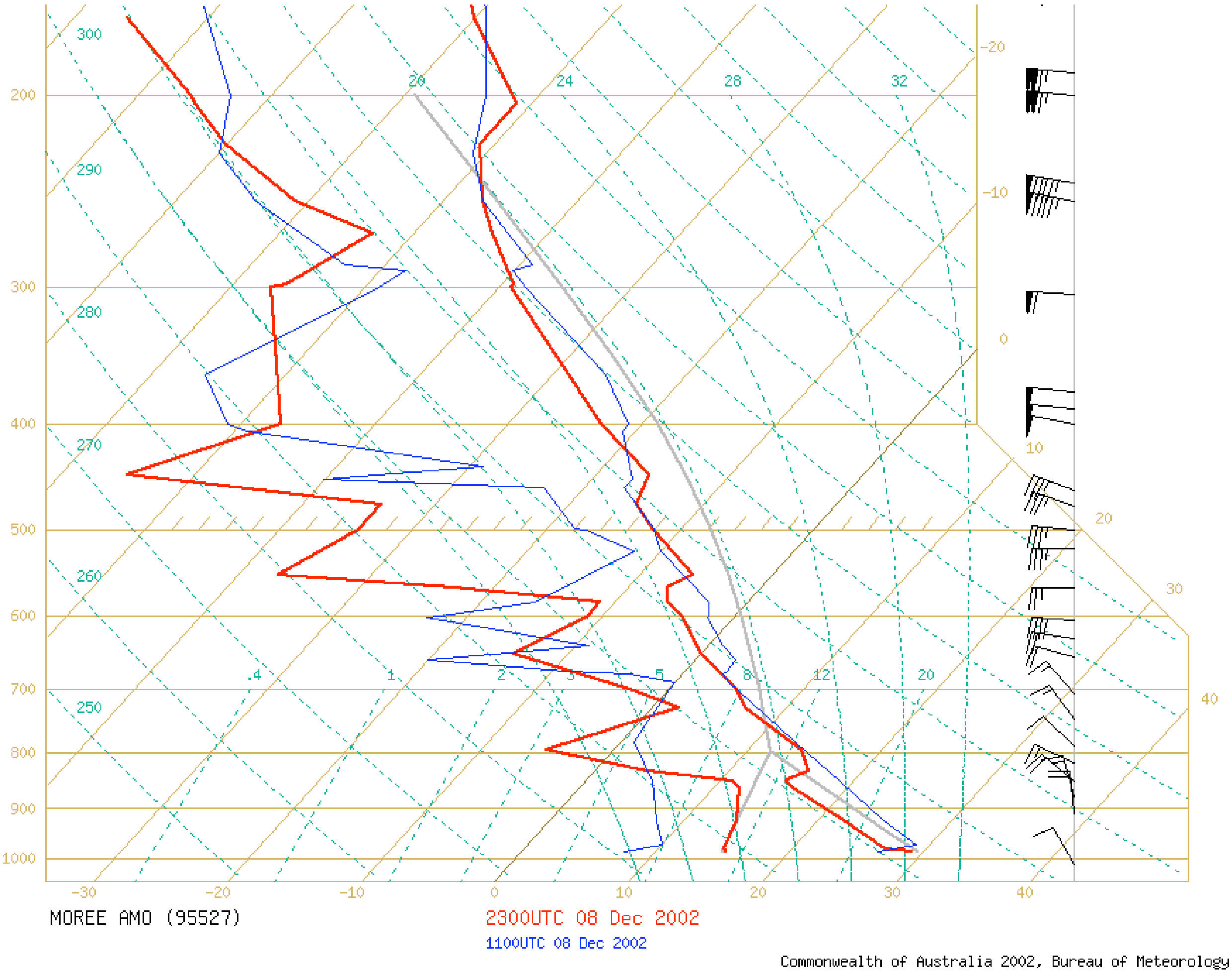
This may seem odd, but it makes a lot of sense when you really understand what LIs are in the overall picture of stability and instability. We only know if one level is stable or unstable – but what about the rest of the atmosphere, what is it doing? Perhaps it's very unstable to the 550mb level, but then stable higher then this? If the air is extremely cold, storms may not reach the 500mb level! Conversely, what about caps? Sure we can look at the 850mb temperatures, but what about other levels? What if the main cap is at 900mb? 800mb? 700mb? Are you going to load up each individual chart for each of the levels forecast in the atmosphere? If so, you're going to waste a lot of time! Surely there's an easier and better way! I've mentioned these diagrams throughout the first part, but here I'll describe what I mean and point out the limitations of using some of the common thunderstorm indicies, and how they can better be used as a guide, and perhaps show a better way of determining the local potential for the day using Skew-Ts.

While daunting and somewhat menacing by their unusual appearance, Skew-T's are an extremely effective method of reading a vertical slice of the atmosphere. Just by glancing at a Skew-T, one can tell the amount of moisture, the lapse rates, see inversions, see shear profiles, and see the potential for the coming day by making adjustments to the surface measurements. While charts generally give you a horizontal layer of the atmosphere, Skew-T's able you to see the vertical component, which is essential in forecasting. So often horizontal charts appear to suggest great storm activity, with fantastic shear, high CAPE, low LIs and low upper level moisture. But they don't tell you whether the LI's have been 'corrupted' through too much low level moisture (eg rain area) or whether there's a strong cap just above that will not let a hint of convection through, or whether there's dry air immediately aloft (thus upsetting any surface CAPE calculations). Not to mention, the most common indicies (LI and CAPE) rely heavily on the temperature and dewpoint at and near the surface. So in order to calculate the LI and CAPE for an area, a forecast model must also forecast temperature and dewpoint. But in my experience, models can sometimes have inaccurate dewpoints or temperatures, being either too high or too low. This is especially the case for AVN (one of the most widely used LI/CAPE models in Australia), it tends to under-forecast surface temperatures, but also has a tendancy to over-forecast dewpoints (for Australia at least!) Normally they're pretty good and indicies such as LI and CAPE give a good idea of instability potential, **but just because there's a bullseye of -6 or +2 LIs doesn't mean you're definitely going to get storms, or there are no storms on the cards for you whatsoever!**

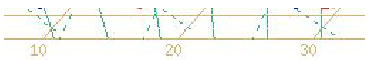
The downside of using Skew-T's is that they can only give a general 'accurate' approximation for the area around them of about 200km. None the less, they can still be very useful if you are forecasting for the immediate area around a sounding station.

I hope that people can find this part of the guide useful, but I would also like to emphasize that this guide is my interpretation of Skew-T's and how I personally read them. Each person will have their own ideas on how a Skew-T should be interpreted, and all of them are not necessary the correct or incorrect method. I originally made this using the University of Wyoming soundings, and even though they're world wide - they've since changed to a (much worse) format. So I'll use the Australian BoM soundings in the examples, however the BoM normally plots the maximum potential on their soundings, and we don't want that quite yet...so I had to settle for this example:

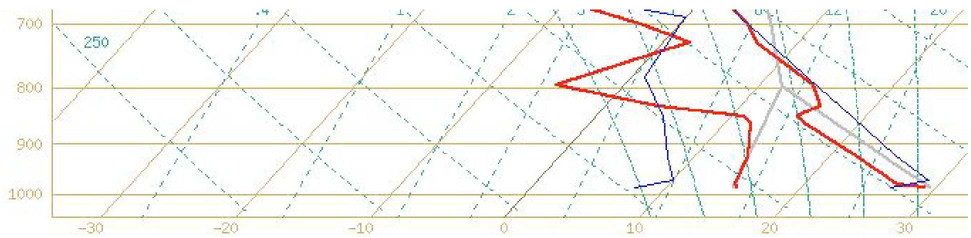




The **pale yellow/brown lines** that originate from the bottom of the Skew-T and travel diagonally upwards to the right are the temperature lines. The scale is on the bottom of the Skew-T. This increases by 10C increments.



Upon learning this, we can now interpret part of the Skew-T. The **large thick red line on the right**, is the temperature line. The **red line on the left**, is the dew point line. The temperature line is always to the right of the dew point, although in very moist situations, they can be overlaid over each other, indicating 100% humidity at a particular level(s). The red lines correspond to the time in red on the bottom of the Skew-T. The blue lines are the previous sounding (normally around 12 hours before), and corresponds to the time in blue at the bottom of the Skew-T. There is one other line, the grey line, which is the theoretical air parcel line, it is probably the most important line in the Skew-T, however it's behaviour and interpretation is somewhat more complex and less straight-forward, we will deal with this a little later on.



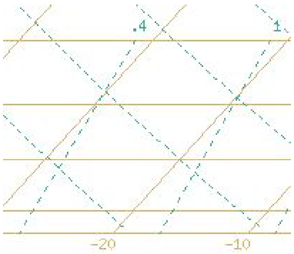
The **horizontal dark yellow lines** are the height and pressure lines. These are fair uniform, however if you look closely, they dip in slightly towards the left of the graph. This is where the colder temperatures are, and denote how cold air causes the air to be more dense, hence heights are lower. This is the same as geopotential height, where colder air above, has a smaller geopotential height – as cold air is denser then warm air, and therefore causes a lowering in height with pressure. Unfortunately, the BoM soundings don't display the height, but if you look at [University of Wyoming soundings](#) then you will see the height (in metres) at which these levels occur in the atmosphere. Remember that these heights are not constant, and only apply to the particular atmosphere the sounding was taken in! It's also important to note that pressure decreases with height. So that 700mb is actually higher than say 800mb. The reason for this is because air becomes compressed at the surface with the weight of all the air above it. So the pressure at the surface is greater then a few kilometres up in the atmosphere.

Ok, in knowing that we're ready to interpret part of our Skew-T. Lets read some temperatures off it and get an idea on what it's trying to tell us! Lets look for the 800mb temperature, see where the red line crosses the 800mb line? The temperature at 800mb there is around 14C, simply follow the diagonal lines down to read the temperature off. What about dewpoint? We use the same method! Here we can tell that the dewpoint is around -5C at 500mb. The surface dewpoint is around 15 degrees (bottom part), note that the surface is not 1000mb here because Moree is actually around 200m above sea level, so the surface pressure here is actually closer to around 980mb. Remember this, it will come in handy for later! One of the advantages the BoM Skew-Ts do give us though is the previous sounding before hand, here we can see that the surface DP has increased from around 7.5C to 15C in the last 12 hours! Scroll back up and have a look at the temperatures too - what can we tell about the atmosphere? Lets compare...

Level	Current Temperature	Previous Temperature	Temperature Difference
700mb	6C	6C	0C
600mb	-4.5C	-2C	-2.5C
500mb	-12C	-12C	0C
400mb	-23C	-21C	-2C
300mb	-39C	-38C	-1C

When you get used to looking at Skew-Ts, you won't have to do this - you'll see it straight away (perhaps you already can), that the overall trend in the upper atmosphere is a cooling one. And from what we learnt in the previous section, upper atmospheric cooling will enhance instability!

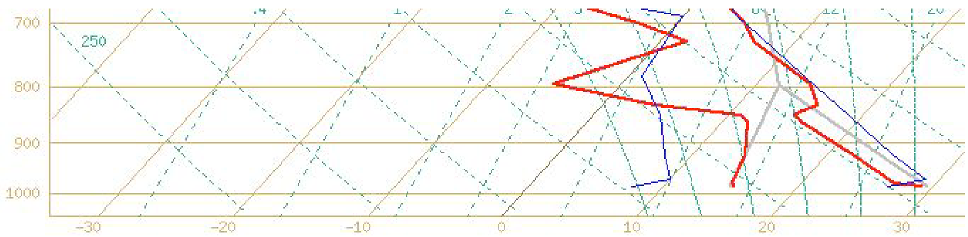
Ok, so we can read temperatures and dewpoints off the Skew-T, what else? How about those **dashed green lines** that rise diagonally to the right, but not quite parallel to the temperature lines? They are the saturated mixing ratio lines. This is expressed in terms of grams of water vapor, per saturated kg of air, or g/kg. The importance of these will be highlighted later.



Still with me? Ok, this is going to get wordy now...but it's important to understand these concepts...

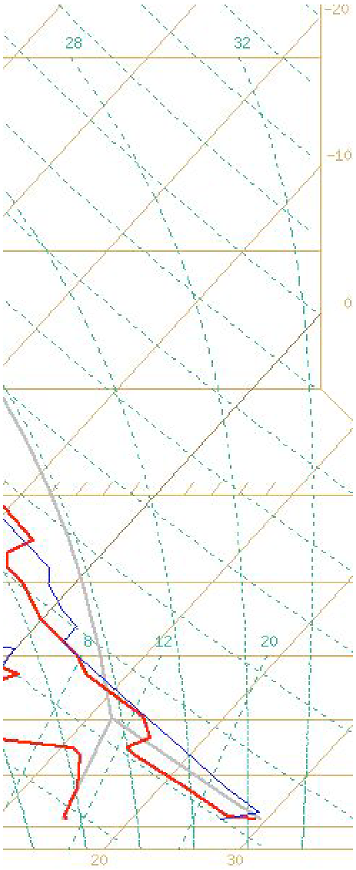
The **dashed green lines** that originate from the bottom, and **rise diagonally to the left**, represents the Dry Adiabatic Lapse Rate – abbreviated DALR. That is, the path that a parcel of unsaturated air will rise in the atmosphere. Unsaturated is air of which the humidity is less then 100%. As air rises, the pressure is less, and thus air being a gas obeys the gas law and expands under lower pressure. This expansion causes the air to cool – the air does not cool due to temperature exchange with its surroundings, in fact very little of this occurs as air is a poor conductor of heat. Hence, we arrive at the term "adiabatic," which essentially means without any exchange of heat. The reason why the air cools as it expands is because there is no heat added into it, yet the overall size of the parcel is increased. So the heat that was spread in the small parcel near the surface, now has to be distributed into a much larger parcel higher in the atmosphere. Thus, the heat is less concentrated, and causes the air to become cooler. An analogy that could be used, would be the difference between a 1000W heater in a small bedroom, compared to a 1000W heater in an open lounge room. The same amount of heat is present, but the lounge room will be cooler (assuming the air mixes well), as there's more space to heat than in the bedroom.

Unsaturated air cools rather quickly, 9.8C/km and frequently will become colder then its surroundings if it rises at this rate for a long period of time. And, as soon as it becomes colder then the surrounding air, it begins to descend as cold air is denser than warm air, it sinks. Given this, we could already begin to make the assumption that dry air (unsaturated air), will cool very quickly, and descend back to the ground without traveling very far into the atmosphere. This indicates that dry air is not conductive of convective environments, although there are always exceptions and these will be discussed later. The lines that represent the DALR are in 10C increments and start at the same point the temperature lines do.



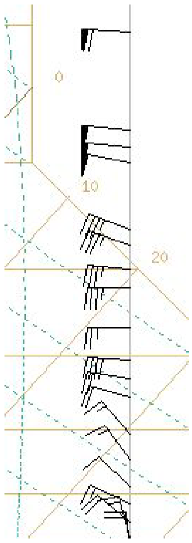
The **dashed green lines** that originate at the bottom of the Skew-T, but appear to go almost straight up first before veering towards the left is the Saturated Adiabatic Lapse Rate – abbreviated SALR. That is, the path that a parcel of saturated air will rise in the atmosphere. Saturated air is air that has 100% humidity. It also cools as it rises in the atmosphere, it loses heat just as quickly as an unsaturated parcel, however it also has heat added into it by the process of water vapour condensing into droplets. The reason for this is because in order to create water into water vapor or steam, we need to add heat to it (imagine boiling water on a stove). The water vapour in the air, exists because heat was added to cause it to 'vaporise.' Now, heat is simply a form of energy, and energy must always be conserved – i.e., it cannot be destroyed. Condensing is the opposite of vaporising, and thus as it condenses, it releases heat. This is called "latent heat" – essentially meaning "hidden heat." As soon as a parcel of air hits 100% saturation, if it cools any further, it'll begin to condense moisture. So – as it expands, it cools, but there's also heat added into the parcel as it

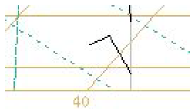
condenses, but the rate of expansion cooling is still greater then the latent heat added to it, this is why it stills cools, however not quite as fast. The warmer the condensed parcel of air is, then the more heat that is released by this process occurs. This is a an important note, as it explains why in very moist surface situations, just a small fluctuation in moisture can have significant impacts on CAPE, LI and instability.



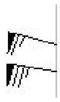
Notice on the Skew-T, how the SALR lines tend to 'bulge' out, at first glance it looks like the air is actually getting warmer as the air rises! However, remember that the temperature lines are diagonal, so the SALR lines are skewed somewhat. If you look at it closely, you can see that they are still cooling, just much slower. Also, notice how the SALR lines begin to follow the shape of the DALR lines as height increases? This is because as water gets condensed out, the parcel of air begins to lose its moisture, eventually the small amount of water that is condensing is so insignificant, that the air parcel begins to cool at the DALR.

On the right hand side of the Skew-T, you'll see flags along the side at different levels. This tells you the wind direction and strength at that level (just follow the pressure line and read the level that wind is on). When looking at the wind flags, the direction is quite easy to read, but might be a little difficult to comprehend for the first time. The part of the flag with the barbs points to the direction the wind is coming from. The end point (pointy section) points to the direction the wind is travelling to. On a skew-t, if the barb section points towards the top of the page, then the wind is coming from the direction of 0 degrees. If it points towards the right of the page, the wind is coming from 90 degrees. And so forth. Effectively, imagine you have a 360 degree compass on the page, with the top of the page being north/0 degrees. The direction can be a combination, so can point in any one of the 360 divisions.



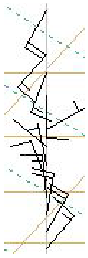


The barbs tell you how fast the wind is travelling. Half a barb stands for 5kn, a full barb stands for 10kn, and a bold barb stands for 50kn. Simply add all the barbs up together to get the wind speed. The direction from the bottom wind barb in the above example is NW at a speed of 10 knots.



Here's an example. The top wind flag has a wind speed of 65 knots (one bold barb, one full barb and one half barb), and then the bottom has a wind speed of 75 knots (one bold barb, two full barbs and one half barb). Both of the winds here are from the WNW (almost W).

Still not sure? Here's another example:



Winds at the bottom are from the NE at 15 knots here, and towards the top they're from the SW at 20 knots. It's easy once you get the hang of it!

That's the basics of Skew-Ts - once you get the hang of it you'll be able to read them in seconds! Ok, but how do we tell whether the atmosphere is stable or unstable? I think that needs a new section...