The Thermal Soaring Adiabat Chart
(and other info about lift)

Revised 24 Feb 2000

If you have some tips/ info/ ideas/ etc. that you'd like to share please send them to:

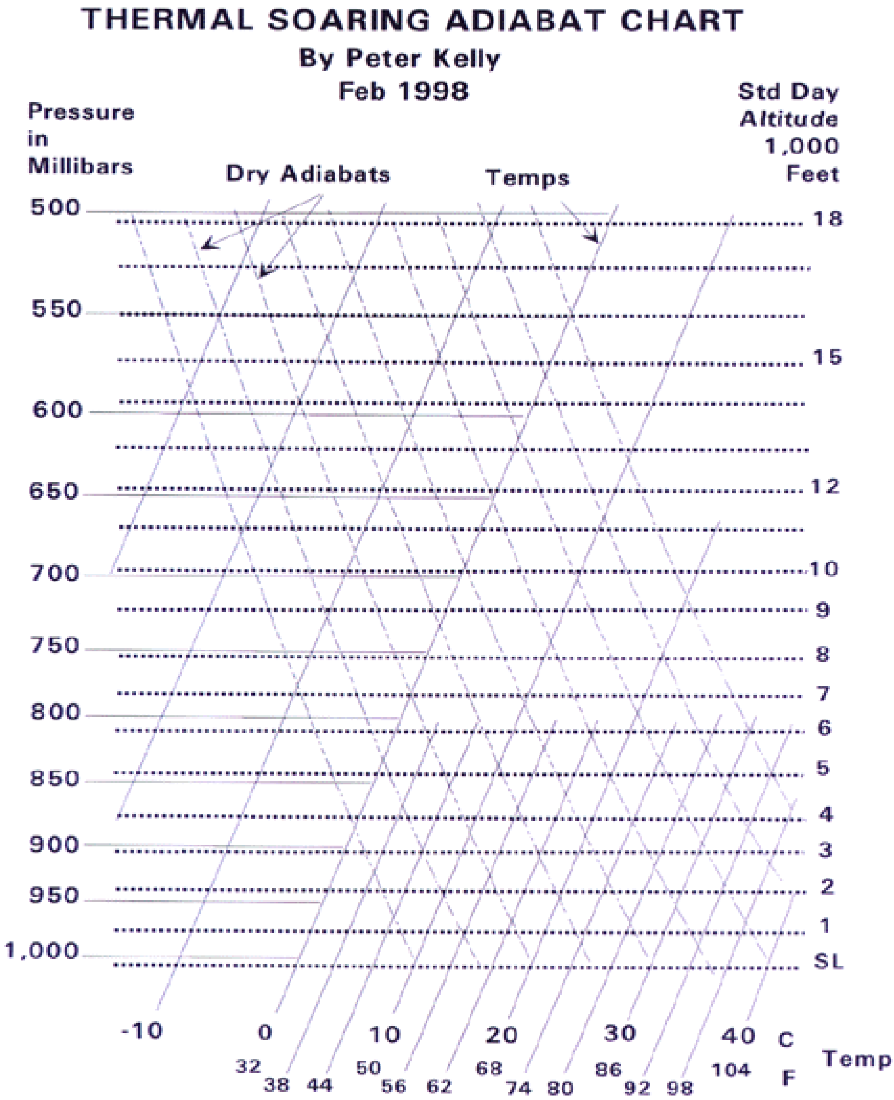
mailto:pjkelly@community.net

Using the info presented here, you will be able to predict the height and strength of the thermals on a daily basis! The application should work anywhere in the world! These methods are a compilation of things I've learned from others. Help out your fellow glider pilots by sharing your ideas on the subject of lift and meterology.

The normal upper-air sounding chart is too difficult for us to use for plotting thermal heights, since we only use the bottom 25 percent of a normal chart. I created the following chart by tracing a portion of a standard sounding graph.

Shown below the Adiabat Chart are instructions which will explain how to compute the height of the thermals on any given day, as well as the strength of the thermals, all using this chart, with one phone call, and a few simple computations.

Note: I encourage you to print this page, rather than try to read it online, and then work with it until you are comfortable using it. The chart and associated methodology will work anywhere in the world, but a particular set of calculations are only valid for a specific location, and are only as good as your estimated temperatures, and even if correct for the moment, they may change after you are airborne. The author does not make any claims regarding the validity or accuracy of the chart or the methods suggested and is not liable for any damage which may result from the application of these methods.



Computation of

Height of the Thermals

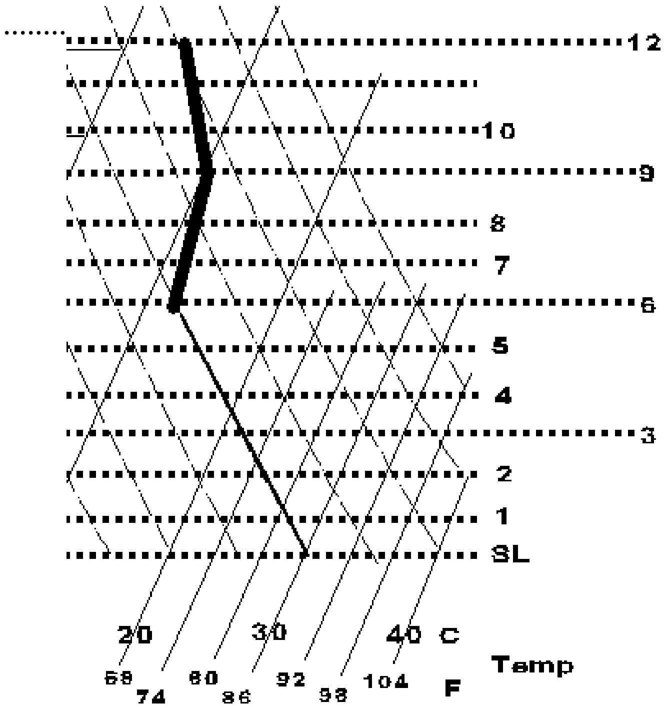
First get the max forecast surface temp. You need to have a good guess at what the maximum **surface** temperature will be at your gliderport, and on the surface in the area you will be flying. Use the TV, radio, newspapers, etc. to determine this. Also, several of the links from the "forecasting weather page" may prove to be good estimates.

Next get the forecast temps aloft. If you phone FSS at 1-800 WX BRIEF, they will tell you the forecast temps **aloft** for your area. Record the temp and wind at each altitude on the right margin of the chart. I will provide example data to illustrate the simplicity of this computation. Here at Williams, the Red Bluff and Sacramento temps and wind are available, so I get the soundings for each area, and interpolate for the area near Williams - these will serve as my "sounding plot". FSS does not provide temps below 6,000 ft., or winds below 3,000 ft.. Winds are in degrees True, not Magnetic, and temps aloft are in C. not F.You could also look at the most recent Oakland Sounding plot, which is very helpful for indicating inversons, and various levels of high moisture.

I will use the following example altitudes, winds, and temps in this example graphic:

- 3,000 ft, 260/8 no temp
- 6,000 ft, 270/7 temp +12
- 9,000 ft, 300/15 temp +10
- 12,000 ft, 290/15 temp +5

Let's assume the max temp for the day will be 86 F, and there is no inversion, and the surface winds aren't breaking up the thermals, then, using the example data above, the tops of the thermals will be at 6,000 as shown on this graphic.

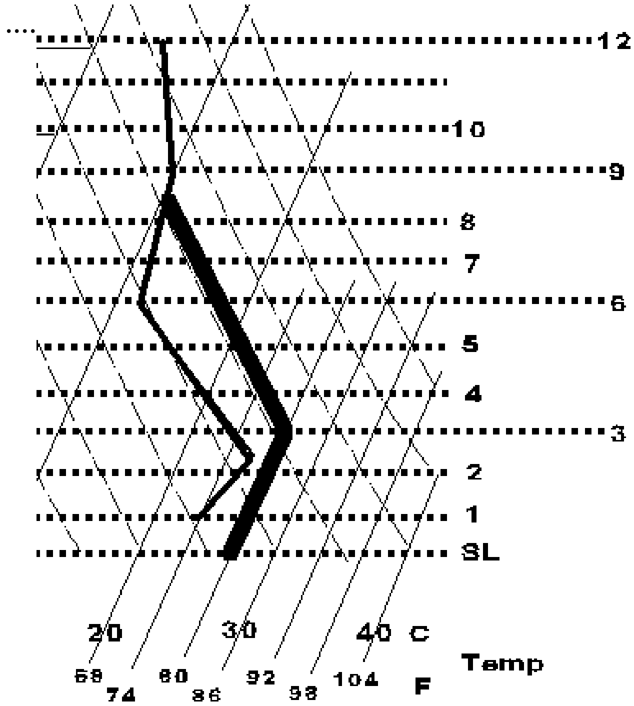


You can see that I plotted the temps, and connected the dots. Next, starting at field elevation (nearly Sea Level in this example), using the max forecast temp of 86 for the day (which I heard from the local radio or TV), I drew a line parallel to the adiabats up and to the left, and where that line hit the "sounding" line, this altitude is the top of the thermals, if the temps are accurate!

In the summer, the inversion in the Sacramento Valley typically eliminates convection over the valley floor, however, there are still good thermals on the hills to the West of the Sacramento Valley! You may have similar geography near your gliderport. Let me know if you are able to apply this method to your location, or tell me what adjustments you find work best for you. I have found that if I reduce the max forecast valley temp for the day by about six degrees F., and I plot that temp at 3,000 ft, I can predict the thermals that will develop along the 7,000 ft hills to the West (Goat Mtn, Snow Mtn, and St John's). In this next graphic, I have plotted the same sounding temps as in the previous example:

- +5 C at 12,000 ft,
- +10 C at 9,000 ft and
- +12 C at 6,000 ft, (the thin line)

In addition to those temps, I also plotted a typical sounding taken from a tow plane up to 3,000 ft, and depicted an inversion. In this example we found +77 F at 2,500 ft. Even if the surface temp gets up to 86 F, you can see there will be no thermals originating at the surface! Ignore the fat line for now, I'll explain it below. Here's the graphic:



However, although it's 77 F at 2,500 ft in the Sacramento Valley, if the surface temp does get up to 86 F, I have found that the temp, on the western edge of the valley, in the hills at about 3,000 ft will be about 6 degrees F lower than the temp on the valley floor. So I estimate the temp at 3,000 to be 80 F. (The fat line starts on the bottom line at Sea Level and 80 F, tracks up the temp line to 3,000 ft, then tracks parallel to the adiabat lines up to the sounding plot, showing thermals to about 8,400 ft). Knowing this, especially if there is a West wind aloft, with an East wind in the valley - confirming that the valley is "feeding" the thermals on the hills, then I often take a 5,000 ft tow to the edge of the hills, contact the thermal above the 3,000 ft hills and go for a long flight (3 to 5 hours), because in this instance, the thermals are forecast to go up to about 8,400 ft. This is typical for June, July and August. I have found this computation to be reliable and consistent over the past three years at Williams Soaring Center. However, I am always prepared to land out, because if the temps are in error - making the calculations incorrect, I can not make it back to the gliderport!

Computation of

Strength of Thermals

Strength of thermals are easily computed by getting an **altitude value** by taking into account the height of the thermal. Secondly, we compute a **temp difference value** by taking the temperature difference between the top of the thermal and the temp at some nominal altitude above the surface. We then take those two values, and use a multiplier on it, yielding the strength of the thermals in feet per minute or knots (1 knot is 6,000 ft per hr, which is 6,000 ft per 60 minutes, which is 100 ft per minute). Here is a sample calculation:

We will compute the thermal strength in the example above which had thermals to 8,400 ft.

For the **altitude value**, always divide the altitude by 100. In this example, the result is 84.

For the **temp difference value**, find the temp at the top of the thermal. Using the example, the top was 8,400 ft, and you can read on the chart that the temp at that altitude, on that line, is about + 11 C. Now look at the temp on that same line at 3,000 ft. We said it was 80 F, which is about 26 C. Take the difference (26 minus 11) and get 15. Always multiply the temp difference times 10. The result in this case is 150.

Now add the two values (Altitude value of 84, plus Temp Diff value of 150, equals 234) and multiply by a constant. Here at Williams we typically use a constant of 4, but if the surface winds are nil - thus thermals will have difficulty forming at the tops of certain canyons, I may decrease that value to a 3, or less. In this case I decide to use a 4... thus 234 times 4 = 936. The result in this case is 936 fpm, ie 9 knot thermals, to 8,400 ft. This isn't theroy. This is a method which I've used dozens of times, and have found it to be quite accurate.

Note: This is a modified version of the basic methodology which I learned from soaring advisor and professional meteorologist Doug Armstrong of Reno Nevada. This approach works in the High Sierras, at both Minden and Air Sailing, if you use the temp at 6,000 ft instead of 3,000 ft, and also, you must use a constant of a numer closer to 8, rather than 4 as your final multiple factor.

Some Reasons Why Thermals were Not as good as Forecast

This falls into just a few basic categories, which I discuss below:

- Not hot enough on the surface
- Air mass too warm
- Bad Winds
- Bad clouds

1. Not hot enough on the surface - Surface temp did not achieve the forecast maximum because:

- Clouds filtered or blocked the sunlight.
- Surface wind cooled the surface.
- It rained.
- Air was descending from the mountains, causing katabatic cooling of surface air.

2. Air mass too warm - Temperature of air mass was hotter than expected because:

- Temp forecast was incorrect because an atmospheric pressure change occurred sooner or later than expected.
- Temp forecast was unknow at lower levels, and you guessed that it would be cooler than it actually was! That is, it was hotter than you guessed it would be at the lower levels.

3. Bad winds - Surface wind was not conducive to thermal development because:

- There was no wind at all, and thermals just bubbled off the hot spots without coalescing.
- The wind was parallel to the ridge lines, causing the thermals to be weak along the ridge tops and isolated at the downwind end of each valley. Rather than allowing the hot air to gently climb the lower slopes, and then up the sides of the ridges from the valley floor, it was channeled downwind along the valley floors.

4. Bad clouds - Clouds were forming in each thermal before the forecast thermal altitude was achieved. Your thermal forecast was correct, but you did not evaluate the moisture content of the air!

- Look at the current sounding for Oakland or Reno, and you will see the dry bulb temp line on the right side, and the wet bulb temp line on the left side (a standard day line is also depicted, just for reference). If both the dry bulb temps and the wet bulb temps are parallel, the relative humidity, or moisture content of the air is about the same all the way up, but this is rarely the case. The level of moisture in the often air varies with altitude. If there is no cloud, then the air was not moist enough to form a cloud. A cloud forms if the invisible moisture becomes visible. This happens whenever the air is cooled sufficiently. If there is too much moisture in the air below the top of your thermals, you

will have clouds forming before you reach the top of your thermals.
- Cumulous fakus clouds are cu's that fool you. After you launch, and you circle directly below the cloud, and you can't seem to find any lift. What's that about? This happens quite often in the Fall and in the Springtime. There is convection. The temp dewpoint spread is close, so there it doesn't take much for the clouds to form. It is free convection - that is there is a mixing of the air aloft, not necessarily beginning at the surface. Nice clouds seem to be shaping up, and then they don't disappear because the air is not dry. The visible moisture (the cloud) does not evaporate. It seems we need to learn the lesson about this type of cloud at least once every year.

5. Bad winds - Thermals existed, but could not be used for climbing because the wind was too strong. This caused the thermals to be:

- strong on the windward side and weaker on the leeward side.
- very narrow.
- intermittent.
- Not as high as fcst - wind caused early mixing of the thermal with the surrounding air.
- more like rotor cloud thermals.
- Blowing downwind of the field. If you are climbing, but are drifting downwind of the field you want to land at, then the thermals are useless to you.

6. Location and frequency of thermals was unusual because:

- thermals were not very high, thus were very close together. This is normal for low thermals, and you just have to be content with weak lift, and take baby steps in the direction you want to fly.
- thermals were very high, but were spaced quite far apart. This is normal for high thermals. When you are low, and do find an area of rising air on a day like this, you need to work it and explore the area until you rise to the level at which they are coalescing into a strong core, and then stay with that lift to the forecast tops, because the next thermal may be a long distance away.
- Both of these explainations follow the old rule of thumb that thermals are spaced apart a distance that is equal to 2 1/2 to 3 times the height of the thermals.

Reasons Why Thermals

Were

Better than Forecast

This too falls into just a few basic categories, which I discuss below:

- Surface hotter than expected
- Air mass cooler than expected
- Good Winds

1. Surface hotter - Surface temperature was hotter than forecast because:

- The TV/ radio weather man thought there would be high cirrus clouds, but they didn't form, thus the sunlight was unfiltered.

2. Air mass cooler - Air mass temperatures were cooler than expected because the atmospheric pressure changed sooner or later than expected.

3. Good winds - Surface wind was perpindicular to the ridge lines, causing better thermals to form at the top of each windward facing canyon, but thermals were weaker along the valley floor.

4. Lack of bad winds - There was no surface wind, causing the hot air to centralize in the large dry lake bed areas of the valley floors, resulting in larger and higher thermals in the valleys but weaker ones along the ridge lines.

Reasons Why Thermals

Were

Unusual!

Thermals are not always in the location we predict, and they are not always in the shape of cylinderical columns. Here are some reasons why:

1. Mountain wave, which formed from a ridgeline up-wind of your location may be forcing cool air down onto the ridge line you are working.

2. A break in the ridge line may be channeling the surface wind at high speeds, preventing thermals at that location.

3. Thermals are forming behind the foot of a ridge line due to the eddy currents in the air mass. The swiliring air mass circles behind the foot, gathering in all of the hot air, and thermals rise near the center of the swirl. A good example of this may be seen using water rather air. While standing on a bridge over a large river, watch the water pass around the pylons supporting the bridge.You will see that the surface of the water is actually higher in the swirls as the water is forced upward.

4. Thermals form downwind of a lake. This can happen if that area of the air mass is stratified. The cool surface lake air is channeled around an area of moderatley warm surface air, and as that surface air ascends into the cooler air well above the surface, it ascends rapidly in the form of a thermal. Such a thermal will be a cooler thermal than those not downwind of a lake. That is, it wouldn't have formed except for the localized area of cool air.

5. Thermals form as the surface air is cooled due to a sea breeze, forcing the warm air aloft. This is common place anywhere a sea breeze (marine layer) comes in during the late afternoon. As the sea breeze moves inland, so does the line of lift. As the line of cool air moves inland, the pockets of warm air release into the cool air that had just passed above.

6. Thermals form due to a convergence of cool air and warm air.

7. And lot's of other reason's - please share your experiences!

What's an Adiabat???

and What's a Thermal???

and What's a Millibar???

Don't be intimidated by the adiabat chart. If you can learn to fly a glider, it won't take you more than a few minutes to learn how to use this info effectively. It does take a bit of practice, because the slightest change in temp will produce vastly different results. So use it on a regular basis, and you will be able to confidently predict thermals.

Thermals are parcels of air, which are forced to rise to higher altitudes because they are warmer than the air surrounding them. When forecasting thermals on this chart, we use adiabat guide lines to move that parcel of hot air upward. Here's why:

Air is a gas which has some weight to it. Gravity holds the air - the atmoshpere, around the earth. The weight of the air is called atmosheric pressure, and this pressure is measured in millibars. A standard has been established which states that at Sea Level, on a Standard Day (temp is 59 F), the pressure of the air is 1013 millibars. This pressure of 1013 mb will hold a column of mercury 29.92 inches high!

The dry adiabat line is a simple relationship between the pressure and the temperature of dry air. Look at the Thermal Adiabat Soaring Chart, and locate the adiabat line at SL and 86 F. Follow that line up to 3,500 feet, and you will see the temp of that same air would be 68 F if it only had 880 millibars of pressure on it. That's a fact. It's just a simple law of physics. If you decrease the pressure on a gas, it expands and cools off. It's as simple as that!

If you have any other tips, or inputs regarding this page, send email to:

mailto:pjkelly@community.net

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