MOISTURE EFFECTS ON SOARING THERMAL FORECASTS

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1. INTRODUCTION

Sailplane pilots preparing for recreational or local weekend soaring as well as for cross-country flying need or want to know trigger temperature and time of occurrence, height of thermals and thermal strength. The contest pilot has this information furnished by a formally trained meteorologist after an exhaustive examination of meteorological data not available to the recreational soaring pilot. My 1991 paper, "Do-It-Yourself Soaring Thermal Forecasting" presented a simple, easy to use method, including a single page reproducible forecasting form, enabling the enthusiast to reach a "go" or "no-go" decision in less than 10 minutes before driving to the gliderport. The system has proven correct 97% of the time in the southwestern United States as well as Istanbul, Turkey as reported at the XXIII OSTIV Congress, Broiling, Sweden in 1993, Aslan, et al, (1993).

This paper records further findings since the publication of my original paper. Of particular interest are the discoveries and quantification of the effect of moisture on both thermal altitudes and trigger temperatures. The result is an improved forecast form including cloud base forecasting. This updated method is based on analysis of recorded forecasts and flight results of 480 of my flights over an eleven-year period.

2. MOISTURE EFFECTS ON SOARING FORECASTS

The generally accepted theory is that the thermal height attained is explained by the thermal column being at a higher temperature than, and hence more buoyant than the surrounding air, thus causing it to rise until the temperature matches that of the surrounding ambient air, thereby establishing the maximum height attainable by a thermaling sailplane. This underlies the generally accepted approach, described in my paper, of drawing a line from the forecast maximum surface temperature at the field elevation, parallel with the dry adiabat to intersect the plotted ambient lapse rate, on a pseudo-adiabatic chart.

My averaged flight results generally exceed the above ambient lapse rate intersection by approximately 200 feet at the lower elevations increasing to 500 feet at the higher elevations. This excess was not addressed in my original paper because it did not detract from the simplistic method for nominal altitude forecasting.

However the Figure 1 plot was based on a best fit using linear regression analysis of 260 flights and had a correlation coefficient of 0.966, which is a highly significant correlation and helped confirm the closeness of the

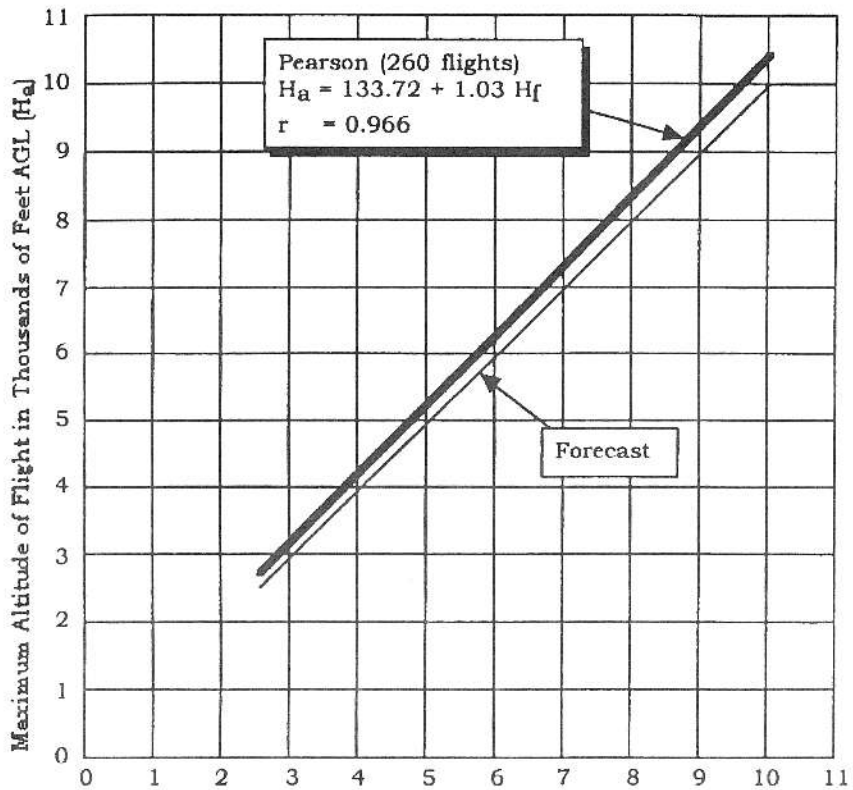


FIGURE 1. Flight Height vs. Dry Adiabat/Lapse Rate Intersect [excerpt from Figure 5, Pearson (1991)].

variables. In fact the coefficient of determination is 0.933 indicating that 93% of the total variation was explained by the regression equation. This analysis of actual flights shows that some mechanism must be involved to result in flight altitudes that exceed those explained by the dry adiabat lapse rate intersect approach. It is believed that the greater achieved heights are explained by additional considerations of either momentum or buoyancy or a combination thereof.

2.1 MOMENTUM

The momentum effects appear to be minor, on the order of 50 to 100 feet at most, and are dependent on too many thermal variables, e.g. vertical speed, thermal structure, etc. to permit a reliable estimate to be made.

2.2 BUOYANCY

The late Prof. C.E. Wallington suggested the buoyancy effects of moisture on thermal height forecasting should be investigated. He sent me a copy of an article Wallington (1983) and referred me to his discussion of virtual temperatures in his books, Wallington (1961) and Wallington (1977).

A. Wallington states in his 1983 paper "Developments In Gliding Meteorology" that:

"Almost always a basic assumption has been that a thermal should be warmer than its surroundings.

However, it was predictable and became known many years ago that the temperature excess was likely to be very small and possibly negligible, above a shallow low level super-adiabatic layer.

In the past few years motor glider met research flights have not only confirmed this, but also made measurements with enough accuracy and resolution to indicate that in a middle range (between the shallow surface superadiabatic layer and an uppermost shallow layer where the thermal is decaying) the temperature excess may even be noticeably negative.

Some flight recordings show a strong inverse relationship between temperature and humidity; temperature goes down as humidity goes up.

Because water vapor is less dense than dry air the density of the cooler, more dry air can still be less than that of the surrounding air. This temperature drop and humidity rise does not occur in all convective situations, but even its occasional occurrence underlines the fact that temperature and humidity can not be considered as separate parameters in quests for thermal location or prediction techniques."

B. Wallington also states in his third edition 1977:

"As long as the thermals are buoyant relative to the air surrounding them they will continue to rise. Furthermore, a thermal is not necessarily warmer than the air around it. Water vapor in the air complicates the question of buoyancy. Because water vapor (which is a gas) is less dense than dry air, buoyancy in a thermal can also be the result of thermal having slightly more water vapor than the surrounding air. Experiments indicate that at heights of more than a few hundred feet or so above the ground, thermals often do have more water vapor than the surrounding air, and it appears that the buoyancy of a thermal is more likely to be due to this slight excess of water vapor than a slight excess of temperature."

C. Wallington characterizes the water vapor effects on buoyancy in his 1961 first edition:

"Because water vapor is a gas whose density is about five-eighths that of dry air, a mixture of dry air and water vapor is less dense than completely dry air at the same temperature and pressure. When discussing buoyancy forces this density difference is sometimes taken into account by converting the temperature of the air into a 'virtual temperature' - that is the temperature at which completely dry air would have the same density as the damp air being considered."

$$T' + 273 = (T + 273)\left(\frac{1000 + \frac{8}{5}V}{1000 + V}\right)$$

Where: T' = the virtual temperature in ° centigrade
T = the actual temperature in ° centigrade
V = water vapor content in grams per kilogram of dry air

D. My combined forecast/flight records for 1991 include 16 flights in which forecast flight altitudes, using the classic method previously described, were exceeded. Six of these records included minimum temperatures for the day as well as maximum. Wallington's formula, was used with minimum temperatures representing the dew point, to determine water vapor content using the derived "virtual temperature" in place of the maximum surface temperature. In each case the new lapse rate intersect indicated the actual realized altitude. For example, an 8/21/91 flight that had exceeded the dry adiabat lapse rate intersection forecast of 5,000 feet by some 1,100 feet was now explained. The blue thermal example in section 3.6 shows a similar result. It is apparent that the buoyancy effects of moisture have a pronounced and measurable impact on thermal heights. Therefore, my forecast/flight record data sheet has been expanded to include humidity information and assess the impact on future thermal forecasting.

2.3 MOISTURE MEASUREMENTS

The prime input variable needed to calculate the "virtual temperature" is the water vapor content of the moist air. The weight of saturated water vapor, in grams per kilogram of dry air, can be readily established from steam tables if the dew point is known as shown in Table 1. There are several methods available for the sailplane pilot to determine the dew point as follows;

A. Take morning low temperature as representative of the dew point by use of a max/min thermometer or from newspaper forecasts. Although this method worked it generally proved to be less accurate than the following methods.

B. Measurement of the wet and dry bulbs at the airport with a sling psychrometer and plotting the wet and dry bulb on a psychometric chart will result at an intersect determining dew point as well as relative humidity. Obviously, this is the most accurate method but requires a sling psychrometer and being at the airport at the time of forecast, so does not meet the objective of forecasting before leaving home.

C. The method used now, is to obtain the early morning dew point of an airport near the glider field from the Federal Aviation Administration (FAA) in either of two ways, (l) obtain the information with my winds and temperatures aloft forecast by telecon with a Flight Service Station (FSS) or (2) access Direct User Access Terminal (DUAT) calling up Surface Observation (SA) or Weather Trend (WT) for the closest reporting airport (March AFB) at the same time as requesting Winds and Temperatures Aloft Forecast (FD). A forecast can then be made before deciding whether to go to the gliderport or not.

2.4 THERMAL ALTITUDE

Forty two forecast/flight records were collected during 1992 using data sheets modified to record dew points at March Air Force Base (AFB) some 18 miles, upwind, from the Hemet gliderport and the records indicated 31 flight days with enough moisture to affect the thermal altitude forecast.

The actual heights realized for these 31 flights were compared with those forecast using virtual temperature calculated as in 2.2 to reflect the buoyancy effect of moisture on thermal altitude.

It was found for all 31 flights (increases of 1 to 4° F) using the virtual temperatures in place of the maximum surface temperatures and then following the dry adiabat up to the lapse rate intersect determined the actual altitudes reached in flight.

Early on it was apparent that the virtual temperature calculation was too awkward and time consuming to be useful. First a correlation was explored with ranges of relative humidity (RH) but as autumn with lower temperatures approached it became apparent that the moisture effects on virtual temperature were a function of actual moisture content or absolute humidity as reflected more appropriately by the dew point. Analysis of combinations of dew points from 35 to 65° Fahrenheit (F) and maximum surface temperatures from 50 to 100° F showed that the virtual temperature increases with constant dew point only varied by a tenth of a degree F across the range of maximum surface temperatures of 50 to 100° F using a spread sheet

TABLE 1. Virtual Temperature Variances

Dew Point (Deg F)	Saturated Water Vapor (gm/kg)	Virtual Temp Corr (c)
35	4.268	1.0
40	5.202	1.5
45	6.320	2.0
50	7.640	2.5
55	9.200	3.0
60	11.050	3.5
65	13.230	4.0

Notes:
1. Add to forecast max surface temp (deg F) before plotting.
2. Subtract from virtual trigger temp (deg F) after plotting.

computer program. Table 1 displays the virtual temperature variances, to be added to the maximum surface temperatures before plotting, as a function of dew point over the range of dew points from 35 to 65° F as normally experienced with soaring weather and blue thermals. The variance or correction factor (c) from Table 1 is added to the forecast maximum surface temperature before plotting as described in Section 3.6, Step 7, A. A simple easy to remember approximation is as follows;

A. Dew points 35 to 45° F - Add 1° F to max surface temp.

B. Dew points 46 to 55° F - Add 2° F to max surface temp.

C. Dew points 47 to 65° F - Add 3° F to max surface temp.

2.5 TRIGGER TEMPERATURE

The first objective of recreational pilot forecasting is to decide whether thermals are going to be high enough for a good flight. The main item of concern is, "What is the trigger temperature?" Pearson (1991) presented the use of a 2,500 feet above ground level (AGL) lapse rate intercept as representing the optimum surface temperature for launch to minimize relights and obtain a maximum flight duration for the day.

Ross McNee found that a 2,000 foot AGL lapse rate intersection was most definitive of trigger temperatures during the summer of 1992 at Hemet. We jointly noticed that as the weather cooled in the fall, the apparent trigger temperature gradually climbed to 2,500 feet AGL again. These observations seem to match those of my former paper, Pearson (1991).

These observations baffled us until we realized that moisture induced buoyancy most probably would have a lowering effect on trigger temperature and apparent trigger altitude. Ross' records of observed trigger temperatures and my dew point records showed that the apparent rise of trigger altitudes in the fall correlated with decreasing dew points as the weather got cooler.

The approach used to assess moisture effects had to be altered somewhat from that for altitude forecasts in that the driver was reversed and was the altitude desired not the temperature required to determine altitude. By examination, it was observed that the same variances would obtain as those in Table 1, except they would be subtractions from the plotted virtual trigger temperature determined from the 2,500 foot AGL intercept instead of additions as in the thermal altitude assessment.

Therefore, the approach was taken of backing in to the problem and finding the ground temperature required which when corrected for moisture effects would result in a trigger temperature associated with sustaining a 2,500 foot AGL flight as follows;

$$Tc = \left[\frac{(T' + 273)}{\left(\frac{1000 + \frac{8}{5} V}{1000 + V} \right)} \right] - 273$$

Where: Tc = the actual trigger temperature in ° C corrected for moisture.

T′ = the trigger temperature as plotted from the 2,500 foot AGL intercept, the virtual temperature equivalent, in ° C

V = water vapor content in grams per kilogram of dry air

Obviously the determination of a lower actual trigger temperature, because of moisture effects, has a significant effect on flight planning in that it identifies an earlier flight start time resulting in earlier takeoffs and therefore longer flights.

3. "DO-IT-YOURSELF" FORECAST REVISIONS

The following sections include findings, verifications and revisions to my single page reproducible forecasting form derived during the last four years.

3.1 STRENGTH OF THERMALS

The objective of competition and record setting pilots is to fly as fast as possible. The "Do-It-Yourself" forecasting method was developed for the recreational flier who seldom flies more than 50 miles from his gliderport. However, even the recreational pilot occasionally flies badge attempts or plans local flights within 50 miles where it is desirable to optimize his speed and therefore is interested in forecasting thermal strengths to assist in planning his/her flight.

Ten different quantitative methods of forecasting thermal strengths were identified in Pearson (1991) and five others, equally different, have been identified in the four years since the original paper. The article by Bradbury (1991) presents a graph devised by the French that displays strengths for blue thermals and a range of cloud covers. An attempt to correlate my flight results with theirs showed that their blue thermal lift predictions were much higher than mine. It is noted that Bradbury also found that lifts were much higher than the averages experienced in the United Kingdom.

The fact that my average thermal strength regression equation for blue thermals is almost identical with the averages predicted by Senn (1987) gives me a great deal of satisfaction, since his were arrived at from a far more extensive background and experience.

The wide variation in reported thermal strengths is partially due to pilot reports and barograph studies from competition pilots who never or very seldom go to the top of a thermal and therefore cannot correlate strength with actual thermal height. In other words their experiences would generally result in higher thermal strength reports.

Since the vertical thermal lift is greater than that of the sailplane net climb rate, it was decided to develop an empirical mean rate of climb related to thermal height for a typical recreational sailplane that accounted for the sailplane sink rate in a typical thermaling operation. A sink rate of 2 knots (1 m/s), typical of that experienced by a Standard Libelle or Schweizer 1-35 in a 40 degree angle of bank, was established as representative from subjective inputs from five pilots and aircraft of this type during my recording period. It is noted that this sink rate criterion is similar to that suggested in the OSTIV Handbook of Forecasting, WMO (1993).

My new total of recorded 480 blue thermal flights indicate that a mean rate of climb is still characterized by the slope and regression equation shown in Pearson(1991).

Avg. Lift (ft/min) = 41.49 + 0.07 x Thermal Ht (feet AGL)

This equation is further simplified into the following, easy to use, nominal mean rate of climb (plus or minus one kt) for blue thermal lift as included on my revised forecast form,

Mean Rate of Climb (kts) = (Blue Thermal Height AGL /1,000) x 0.7 and for cloud capped thermals (with small cumulus),

Mean Rate of Climb (kts) = (Cloud Base AGL / 1,000) x 0.9

3.2 CLOUD BASE

Since data were being collected and analyzed on moisture effects (dew points) on forecasting, the studies were expanded to attempt to explain some of the cloud base forecasting anomalies.

The basic approach for estimating cumuliform cloud bases FAA (1975) utilizes a surface temperature-dew point spread. Since unsaturated air in a convective air current cools at about 5.4° F (3° C) per 1,000 feet and dew point decreases at about 1° F (5/9° C) the temperature and dew point converge at about 4.4° F (2.5° C) per 1,000 feet. Therefore we can get a quick estimate of a convective cloud base in thousands of feet by rounding these values and dividing into the spread or by multiplying the spread by their reciprocals.

Bradbury (1993) recommends that the morning minimum temperature approximates the dew point and suggests multiplying the daily temperature range in °C by 400 to estimate cloud base.

However, my experience shows that actual cloud base is higher than that estimated by either of the aforementioned methods. At first actual dew points were utilized rather than the representative minimum temperature. Since this did not improve the height estimation accuracy completely, diurnal dew point excursions were investigated, on an hourly basis, from before sun-up through sundown for our nearest recording airport on more than 45 different seasonal days. It was found that the afternoon dew points were on average 2° F lower than the morning dew point low.

It is noted that flight in Class E airspace requires a separation distance below clouds of 500 feet for cloud base elevations up to 10,000 feet MSL and 1,000 feet below clouds over 10,000 feet MSL. This separation distance is approximated by the difference noted above from the 2° F afternoon lower dew point. Therefore I conservatively propose using the calculated cloud height from the morning dew point as being that allowed for legally flying under a cloud.

Dew point lapse rate lines (pecked lines) were added to the new forecasting form to eliminate any calculation requirements. Bradbury (1993) states "The pecked lines show how the dew point changes as a thermal rises. Condensation occurs when the dry adiabat crosses the dew point line." The intersection will indicate the maximum allowable soaring height under a cumulus cloud at max surface temperature in the afternoon. See the typical cloud soaring forecast example in section 3.6.

3.3 AMBIENT LAPSE RATES

The prime objective of this "Do-It-Yourself" forecasting method is to make a "go" or "no-go" decision at breakfast, to decide whether soaring conditions would be good enough to justify a 2-hour driving trip to the gliderport as stated in my original paper, Pearson (1991).

The method proposed of obtaining a "winds and temperatures aloft" forecast from the nearest FSS up wind of your soaring site as representative of the local ambient lapse rate remains valid after 480 forecast/flight result evaluations. This method of developing the ambient lapse rate, based on temperatures at three elevations, was accurate in access of 97% with my usage and 99% with the Turkish Air League as reported in Aslan, et al, (1993).

Other investigations and verifications over the last four years follow;

A. It has been found that requesting the forecast for the period before 1800Z is most accurate for our use. Also the FSS updates their forecast at 1700Z based on the 1200Z RAOB resulting in a more timely 5-hour forecast Since this revision usually occurs just prior to trigger time, I frequently call for a new update from the gliderport and revise my forecast accordingly if required. Occasionally a minor revision to the forecast is required.

B. Morning RAOB soundings from Edwards AFB (85 miles northeast of Hemet) and San Diego (50 miles south of Hemet) have been compared on a daily basis. Findings indicate that the FSS interpretations for Ontario, CA (45 miles northeast) are more accurate because of the surrounding terrain effects on the air movements. Surely an interested sailplane pilot can find the most representative FSS report by examining and comparing FSS "wind and temperatures aloft" forecasts from surrounding airports with his/her local conditions.

C. There is now a parachute jump school adjacent to our gliderport operation. They use the same FSS source for their winds and temperatures aloft requirements and informed me that the temperatures never vary by more than 1° for our location at 12,000, 9,000 and 6,000 feet mean sea level (MSL). After I arrive at the airport, at about 10 a.m., they read temperatures at 6,000, 5,000 and 4,000 feet MSL on their return trips as a check against my extrapolation from 6,000 to 4,000 feet MSL as a courtesy. There has been an almost exact match of temperatures. The largest variation found to date is 1° F. In other words the extrapolation of the 6,000 to 4,000 feet MSL reading from the FSS, at Hemet (elevation 1,500 feet MSL is a proven realistic extrapolation to the nocturnal inversion height (trigger elevation) experienced at this location.

3.4 DIURNAL TEMPERATURE PROGRESSIONS

The diurnal temperature progressions presented in Pearson (1991) were developed for applications at Latitude 35° North. The expanded seasonal diurnal progressions for different daily temperature ranges (Δ) in nomograph form for use at all latitudes between 25 and 50° North are presented in section 3.6, step 6. For use in the southern hemisphere the Summer and Winter Solstice seasonal delineations should be reversed.

My original paper demonstrates why the use of these diurnal progressions is more accurate than the straight-line method of time progression in common usage. Examples were displayed in Pearson (1991) that show how trigger temperature forecast times can be off by as much as two hours when forecast by the straight-line method.

3.5 METRIC CONVERSIONS

The report Aslan, et al (1994) shows a form they derived from my forecast form with metric annotation. My form has now been modified for universal use by including a metric elevation scale. The form already includes correlated Centigrade (C) and Fahrenheit (F) scales.

The only conversion now required is related to lift. A simple approximation is that 1 meter per second equals approximately 2 knots equals approximately 200 feet per minute.

3.6 NEW FORM AND METHODOLOGY

Make copies of the, reproducible, 1994 version of the "Do-It-Yourself" Soaring Thermal Forecast form, included as the last page of this paper, or apply a coating or a transparent cover to permit multiple use. Reference example Figures 2 and 3 based on the following instructions. (Note: The form can also be used with a local sounding if available as it provides the convenience of single page data gathering, forecasting and flight recording.

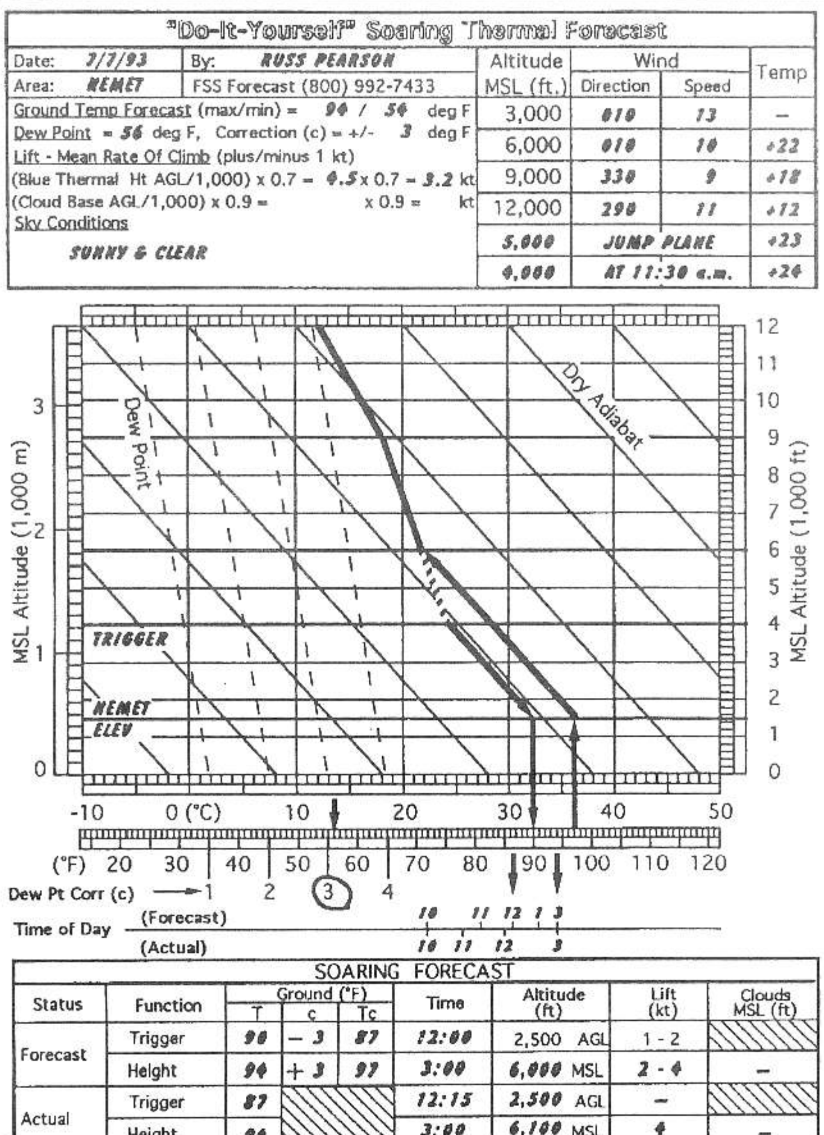


FIGURE 2. Typical Blue Thermal Soaring Forecast.

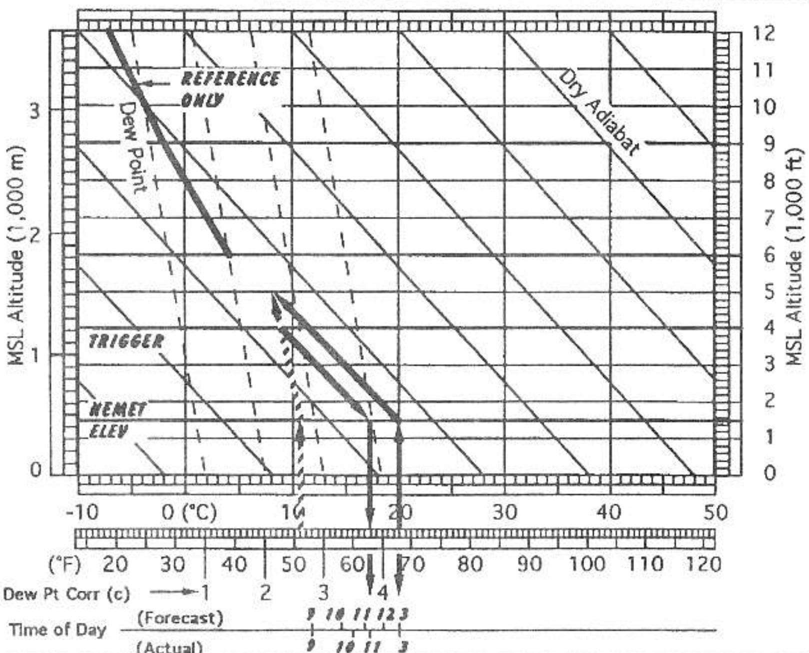
Step 1 - Call your closest Flight Service Station (FSS) and ask for winds and temperatures aloft up through 12,000 feet MSL for your soaring area and the dew point for the closest airport (remember to ask for the forecast conditions to occur before 1800 Zulu). Obtain the forecast min/max temperatures (daily temperature range) for your soaring area from your local newspaper or other reliable source. Fill in the form at the top of the page as shown in examples Figures 2 and 3. (FSS forecast temperatures are in ° C)

Step 2 - Determine the dew point correction factor (c) for assessing moisture effects on trigger temperature and thermal altitude by examination of the indications below the Fahrenheit scale for the dew point recorded in Step 1. Select a rounded dew point correction factor and enter in the form (the dew point correction factor of 3° F is indicated for a 56° F dew point as shown in the example of Figure 2).

Step 3 - Plot your field elevation as shown with a horizontal line (Hemet is 1,500 feet MSL as shown in Figures 2 and 3).

Step 4 - Plot the local ambient lapse rate as shown, using the data obtained in Step 1. It is noted that no forecast temperatures are available, from the FSS, at 3,000 feet MSL or below. The

"Do-It-Yourself" Soaring Thermal Forecast					
Date: *10/13/94*	By: *RUSS PEARSON*	Altitude	Wind		Temp
Area: *HEMET*	FSS Forecast (800) 992-7433	MSL (ft.)	Direction	Speed	
Ground Temp Forecast (max/min) = *68 / 52* deg F		3,000	*310*	*14*	–
Dew Point = *51* deg F, Correction (c) = +/- *N/A* deg F		6,000	*320*	*10*	+4
Lift - Mean Rate Of Climb (plus/minus 1 kt)					
(Blue Thermal Ht AGL/1,000) x 0.7 = x 0.7 = kt		9,000	*320*	*17*	-2
(Cloud Base AGL/1,000) x 0.9 = *3.5* x 0.9 = *2.5* kt		12,000	*310*	*20*	-7
Sky Conditions					
SCATTERED CUMULUS					



SOARING FORECAST								
Status	Function	Ground (°F) T	Ground (°F) c	Ground (°F) Tc	Time	Altitude (ft)	Lift (kt)	Clouds MSL (ft)
Forecast	Trigger	*63*	*–N/A*	--	*11:30*	2,500 AGL	1 - 2	
	Height	*68*	*+N/A*	–	*3:00*	-- MSL	*2 - 4*	*5,000*
Actual	Trigger	*63*			*11:00*	*2,500* AGL	*2*	*2,800*
	Height	*68*			*3:00*	-- MSL	*4*	*5,400*

FIGURE 3. Typical Cloud (Cumulus) Soaring Forecast.

method for constructing the ambient lapse rate is to connect the 12,000 and 9,000 foot MSL temperature points with a straight line. A straight line between 9,000 and 6,000 feet MSL is then extrapolated to the trigger elevation at 2,500 feet AGL at the airport.

Step 5 - Draw a line parallel with the dry adiabat from the intersection of the extended ambient lapse rate and the trigger elevation (2,500 feet AGL) down to the field elevation. Extend the line vertically down from the field elevation and read off the ground temperatures in ° F. This is the forecast dry trigger temperature (T).

Subtract the dew point correction factor (c) from this dry trigger temperature (T) to establish the actual trigger temperature (Tc) corrected for the buoyant effects of moisture for a blue thermal (subtracting the dew point correction factor of 3° F from (T) in Figure 2 indicates an actual thermometer reading of 87° F, that was realized as a trigger temperature). See Step 7,B for trigger determination with working cumulus clouds.

Step 6 - Utilize the current dated temperature forecasting nomograph template, from Figure 4, for your latitude based on the days forecast daily temperature range (Δ), to plot the forecast temperature coordinated maximum surface temperature and trigger times of occurrence on the "time of day" line below the temperature scales as shown in Figure 2.

When available, set the right hand template temperature marking directly under the reliable forecast maximum surface temperature (uncorrected for moisture effects) and plot to the left to determine trigger time. The trigger time is forecast by projecting a line vertically down from the moisture corrected trigger temperature (Tc) determined in Step 5 to the time of day forecasts as shown in Figure 2.

If a reliable maximum surface temperature is not available, set the early morning time/ template marking directly below a morning gliderport observed temperature and plot to the right to determine forecast trigger and maximum surface temperature relationships.

Step 7 - Thermal heights.

A. Blue Thermals - Correct the forecast maximum surface temperature (T) for moisture effects by adding the dew point correction (c) from Step 2 to the forecast maximum to obtain the moisture corrected equivalent (Tc).

Draw a line vertically from this corrected surface temperature (Tc) for the day up to the field elevation. Draw another line up from that intersection parallel with the dry adiabat until it intersects the plotted ambient lapse rate and read predicted maximum thermal altitude in feet MSL to the right or in meters MSL to the left as shown in Figure 2.

B. Cloud Base - If clouds are forecast locally, legal cloud base can be estimated by drawing a line up vertically from the dew point, read from the temp scale, for the day up to the field elevation. Draw another line up from that intersection parallel with the dew point lapse rate until it intersects the dry adiabat projected up from the uncorrected maximum surface temperature and read the estimated legal cloud base in feet MSL to the right or in meters to the left as shown in Figure 3.

Trigger temperature is determined by drawing a line parallel with the dry adiabat from the intersection of the dew point lapse rate and the trigger elevation (2,500 feet AGL) down to the field elevation to determine the actual

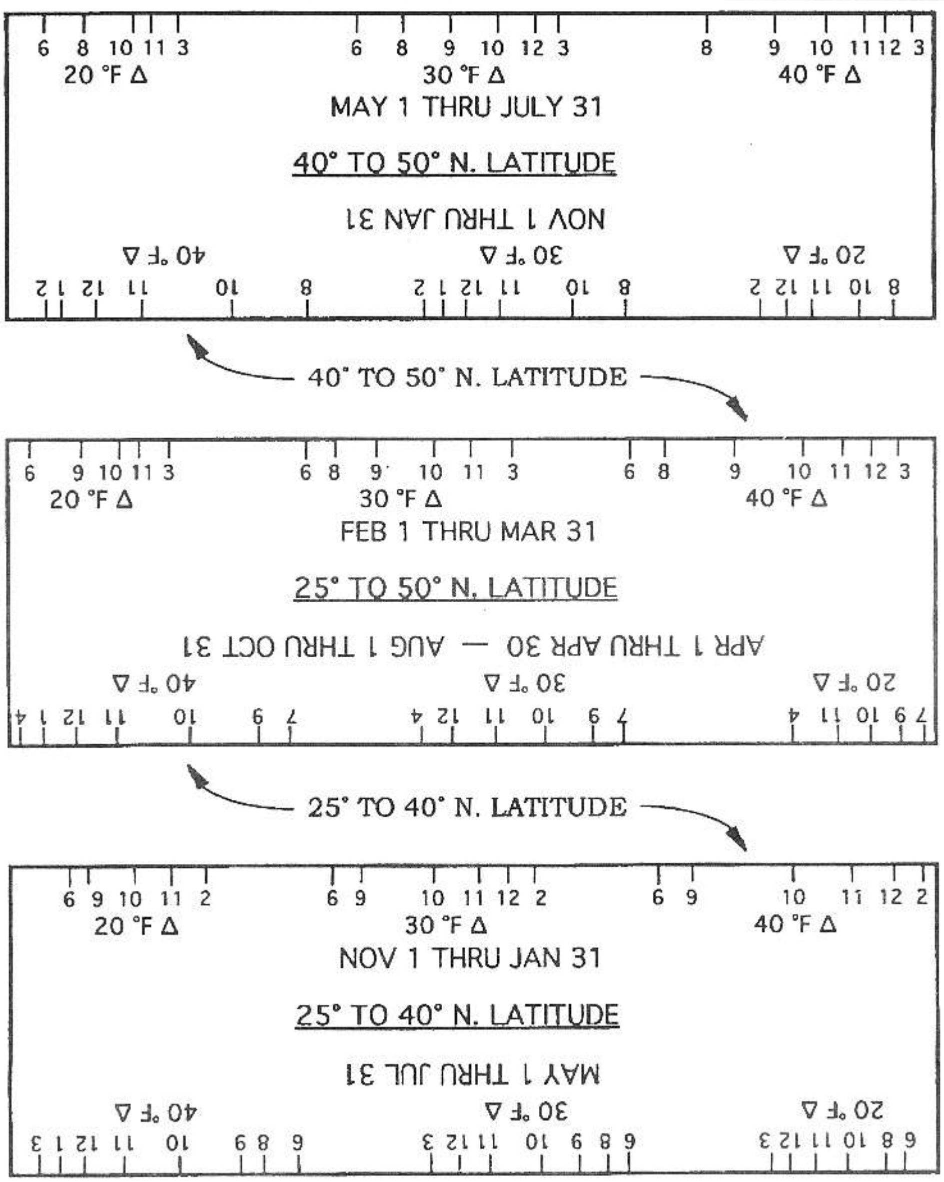


FIGURE 4. Diurnal Temperature Nomographs.

trigger temperature in ° F as shown in Figure 3.

Step 8 - The thermal strength as a mean rate of climb, with a tolerance of plus or minus one knot can be estimated as follows;

A. Blue Thermals - (see Figure 2)

Mean Rate of Climb (kts) = (Blue Thermal Height AGL / 1,000) X 0.7

B. Cumulus Capped Thermals - (see Figure 3)

Mean Rate of Climb (kts) = (Cloud Base AGL / 1,000) X 0.9

Step 9 - After 1700Z call FSS for updated "winds and temperatures aloft" forecast and revise soaring forecast if needed or desired. If you receive other local sounding temperatures from a tow plane or jump plane use the blank spaces provided to record and change lapse rate extrapolation if significant.

Step 10 - Go have a predictably fun soaring day and after the day's flight note results in the actual" spaces at the bottom of the form, for future improvements or subjective modifications to this method of forecasting.

ACKNOWLEDGMENTS

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REFERENCES

Aslan, Z., Oney,S., and Turksoy,F., "Thermic Potential for Soaring at Inonu," Masalk-Istanbul, Turkey, *Technical Soaring*, Vol.XVIII, No. 2, (1994).

Bradbury, T., "Thermal Prediction From the Tephigram", *Sailplane and Gliding,*, June/July (1991).

Bradbury, T., "Just Give Me the Fax", *Sailplane and Gliding*, June/July (1993).

FAA, "Aviation Weather", Federal Aviation Administration, Advisory Circular AC-6A, Rev'd (1975)

Pearson, R.O., "Do-It-Yourself Thermal Forecasting", *Technical Soaring*, Vol. XV, No. 4 (1991).

Senn, H.V., "What Kind of Weather Do You Really Want", *Soaring*, July (1987).

Wallington, C.E., "Developments in Gliding Meteorology", *Australian Gliding*, May (1986).

Wallington, C.E., "Meteorology for Glider Pilots", first edition (1961).

Wallington, C.E., "Meteorology for Glider Pilots", third edition (1977).

WMO, No. 495, "Handbook of Meteorological Forecasting for Soaring Flight", World Meteorological Organization, OSTIV Technical Note No. 158, 2nd ed. (1993).