Meteorological Conditions Favourable for Long Closed Circuit Soaring Flights over England

T.A.M. Bradbury, Meteorological Office Bracknell, England
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Summary
An analysis was made of conditions which proved suitable for long closed circuit gliding flights over England. Three diagrams are presented combining pairs of parameters found useful as predictors of good soaring conditions. These were: (a) previous air trajectory and isobaric curvature, (b) 850 mg wind speed and direction and (c) the surface to 850 mb lapse rate and the dew point depression at the surface.

Introduction
Many glider pilots hope to complete their Diamond badge with a flight of 500 km round a closed circuit. Since there are few days in the year when such a flight is possible over England it is useful to know what Meteorological conditions are needed for such flights and, if possible, how to predict them. In order to collect a fair sample of good soaring days a list was made of every day when a pilot from the Lasham gliding centre was able to make a closed circuit flight of 400 km or more during the period 1968 to 1977. In addition all days when flights of more than 200 km were made were listed for the years 1975 to 1977. On many occasions the conditions for flights of more than 400 km appeared no better than those for the shorter flights. This supports a suggestion by Malpas (1977) that there was often little difference between a suggestion by Malpas (1977) that there was often little difference between the weather for 300 km and 500 km flights flown over Central France.

Essential Conditions for Long Soaring Flights
Almost all long soaring flights over England were carried out using thermals; the conditions needed for long wave flights have not been considered in this study. The requirements for long flights in thermals are:

(a) A regular supply of evenly distributed thermals, strong enough for a pilot to achieve a sustained rate of climb of about 2 m s⁻¹, which continue for more than 5 hours (8 or 9 hours is desirable).
(b) Wind speeds in the convective layer should be less than 10 m s⁻¹ (about 20 knots).
(c) The cloud base should be more than 1000 metres (3300 ft) above the general ground level and a cloud base of 1500 metres (about 5000 ft) is desirable.

Meteorological Factors
Previous air trajectory: Nearly all good soaring days occurred when a fresh cold air mass was advected over England. Fig 1 shows the directions from which the air reached England on good soaring days. Trajectories from the NW, N and NE are in the majority and there is a striking absence of good soaring days when the air mass had come from the south.

Curvature of isobars: Anticyclonic curvature of the isobars was one of the best single indicators of good soaring conditions. Marked anticyclonic curvature was found on the majority of days when flights exceeded 400 km.

Wind speed: If the wind in the convective layer exceeded 10 m s⁻¹ (about 20 knots) many pilots found difficulty in completing a long closed circuit flight. The average wind speed for all good soaring days was just over 5 m s⁻¹ (about 11 knots). The following tables shows the ranges of wind speed observed at midday on good cross country days.

The distribution is shown in table 1.

The figure marked by an asterisk in the top right hand column of table I represents an occasion when a pilot was able to use long cumulus streets to complete an out and return flight of 300 km. He was able to travel more than 50 km into wind without stopping to circle.

It may be seen that more than 90% of all flights took place when the 850 mb wind was not more than 20 knots.

The distribution of wind direction is shown in table 2. It may be seen that

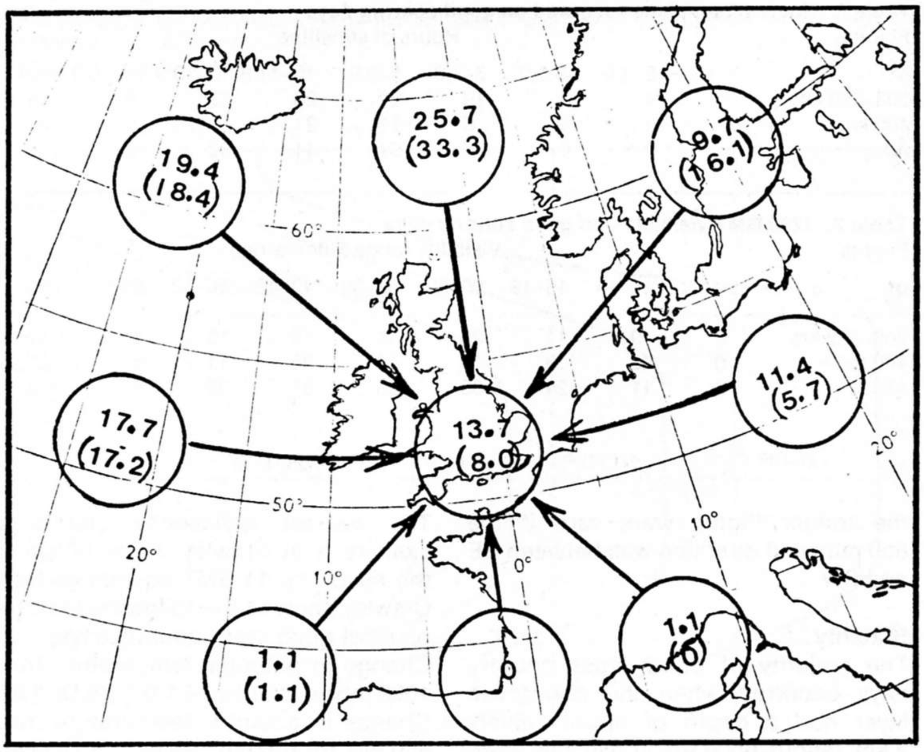

Fig. 1: Air trajectories preceding cross country days. Figures show percentage of days with trajectories in each main direction. Upper figures are for 200–399 km days, lower figures (in brackets) are for days when more than 400 km were flown. Figures in central circle show percentage of days when air had remained stationary over England for more than 24 hours.

Table 1. 850 mb wind speed

Flights of	Wind speed ranges (knots) 1–5	6–10	11–15	16–20	21–25	26–30	31–35	36–40	total
200–399 km	17	25	22	14	8	1	0	1*	88
400 km+	11	33	25	12	5	1	0	0	87
All	28	58	47	26	13	2	0	1	175

Table 2. 850 mb wind directions (for speeds of 10 knots or more)

Flights of	Wind Directions N	NE	E	SE	S	SW	W	NW	under 10 knots	total
200–399 km	10	12	4	2	2	8	6	9	35	88
400 km+	12	13	7	1	2	0	8	9	35	87
All	22	25	11	3	4	8	14	18	70	175

Table 3. Surface Dew Point Depression at time of maximum temperature

Flights of	Dew point depression (°C) 7–8	9–10	11–12	13–14	15–16	17–18	19–20	21–22	Total
200–399 km	5	8	21	25	9	12	4	4	88
400 km+	1	7	29	19	21	6	3	1	87
All	6	15	50	44	30	18	7	5	175

Table 4. Mean Sea Level Pressure on good soaring days.

Flights of	Pressure range (millibars) 1001–05	1006–10	1011–15	1016–20	1021–25	1026–30	1031–35
200–399 km	0	12	20	29	18	6	3
400 km+	1	3	9	19	36	14	5
All	1	15	29	48	54	20	8

Table 5. Pressure change between 0900 and 1200 GMT on good soaring days

Flights of	3 hours tendency (millibars) +2.0	+1.5	+1.0	+0.5	0.0	–0.5	–1.0	–1.5	–2.0	–2.5	–3.0	total
200–399 km	1	3	9	6	17	31	15	3	0	3	0	88
400 km+	0	1	3	11	22	32	11	6	0	0	1	87

Table 6. Hours of sunshine recorded on good soaring days

FLights of	Hours of sunshine 0–1.9	2–3.9	4–5.9	6–7.9	8–9.9	10–11.9	12–13.9	14–15.9	total
200–399 km		3	3	19	20	20	13	9	88
400 km+	0	0	30	6	11	21	37	9	87
All	1	3	6	25	31	41	50	18	175

Table 7. 1200 GMT visibilites on good soaring days

Flights of	Visibility range (kilometres) under 10	10–14	15–19	20–29	30–39	40–49	50–59	60+	total
200–399 km	2	9	11	23	14	12	15	2	88
400 km+	0	2	13	15	15	25	11	6	87
All	2	11	24	38	29	37	26	8	175

the longer flights were rare if the 850 mb wind direction was between SE and SW.

Stability

The majority of good cross country days occurred when the convective layer had a depth of approximately 2 km (about 6500 ft). Above this level the air was generally sufficiently stable to prevent convective clouds from extending above the 700 mb level.

The nearest radiosonde staton to Lasham is at Crawley, some 50 km to the east. The 11 GMT soundings from Crawley showed the following features on most good cross country days:

Change in potential temperature from 1000 mb to 850 mb +1.0°C (S.D. 1.97)

Change in potential temperature from 850 mb to 700 mb +9.6°C (S.D. 3.45)

By mid afternoon when the surface temperature reached its maximum the change of potential temperature from the surface to 850 mb was –2.8°C (S.D. 1.88). This represents a superadiabatic lapse rate. The value of –2.8 shows good agreement with the value of 2.54°C found by Booth (1978) for the decrease of potential temperature between the surface and 1500 m on good soaring days. The 850 mb level is usually about 1500 metres on an English summer day.

Humidity

Although humidity is often of critical importance it is a difficult parameter to predict. The most useful representation of humidity for gliding forecasts is the dew point depression. This value is reported in radiosonde messages and can be derived from synoptic reports from land stations. From the value of the dew point depression one may readily calculate the lifting required to produce condensation in a parcel of air. The average values of dew point depression on good soaring days had the following values at 11 GMT

Pressure	Dew point Depression	Standard deviation
1000 mb	9.4°C	2.09
850 mb	6.4°C	4.14
700 mb	14.7°C	7.29

The value was lowest at 850 mb because this was near the level at which cumulus cloud formed.

By mid afternoon the surface dew point depression was usually more than 10°C. The distribution is shown in table 3.

It may be seen that the majority of days when flights exceeded 400 km had dew point depressions in the range 11–16°C. The shorter flights showed a wider spread with more examples in the lower and also higher ranges. Low values of dew point depression indicate a low cloud base, very high values may indicate either very high cloud bases or no cumulus at all.

Mean sea level pressure

It was noticed that nearly 80% of flights longer than 400 km took place when the MSL pressure was in the range 1016 to 1030 mb. These longer flights showed a marked peak in the pressure distribution in the range 1021–1025 mb. The distribution is shown in table 4.

Pressure Tendency.

Pressure changes were small on the majority of good soaring days. Nearly 90% of all flights occurred on days when the midday pressure tendency was within the range +1.2 to −1.2 mb. The distribution is shown in table 5.

Sunshine
Unless there is bright sunshine for at least half the hours of daylight it appears that the supply of thermals may not be sufficiently regular for pilots to achieve the fast speeds necessary for long flights. 77% of the occasions when flights exceeded 400 km had 10 or more hours of bright sunshine. The distribution is shown in table 6.

Visibility
Good visibility is important because in hazy conditions pilots find it harder to keep on track and are less able to recognise areas of poor convection ahead. It has been observed that a decrease in visibility often coincides with a reduction in the strength of thermals. The majority of long flights took place on days when the visibility was better than 30 km. The distribution is shown in table 7.

Lack of surface moisture
Moist ground covered by growing vegetation is less likely to provide a good source of thermals because a large proportion of the net radiation received at ground level is absorbed as latent heat used for evapotranspiration. A long dry spell, such as occurred in 1976, allows a much more widespread development of thermals than on a moist year. When flights of 400 km and more were recorded it was found that there was no measureable rain reported overnight on 97% of occasions and the state of ground was observed to be dry at 06 GMT on 76% of occasions.

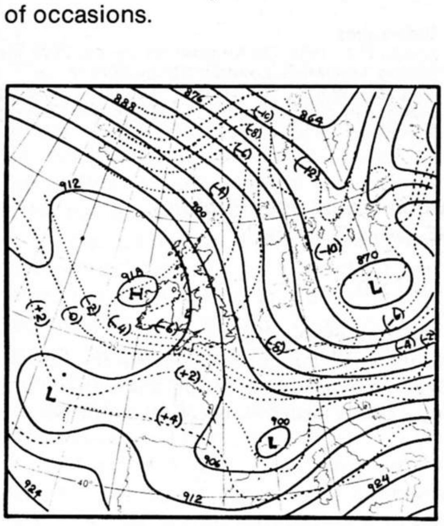
Fig. 5: 28 April 1976. 850 mb isotherms (pecked lines) with 300 mb contours (full lines) superimposed. Particularly good soaring conditions were observed where the cold tongue at 850 mb extended across East Anglia and the Midlands of England.

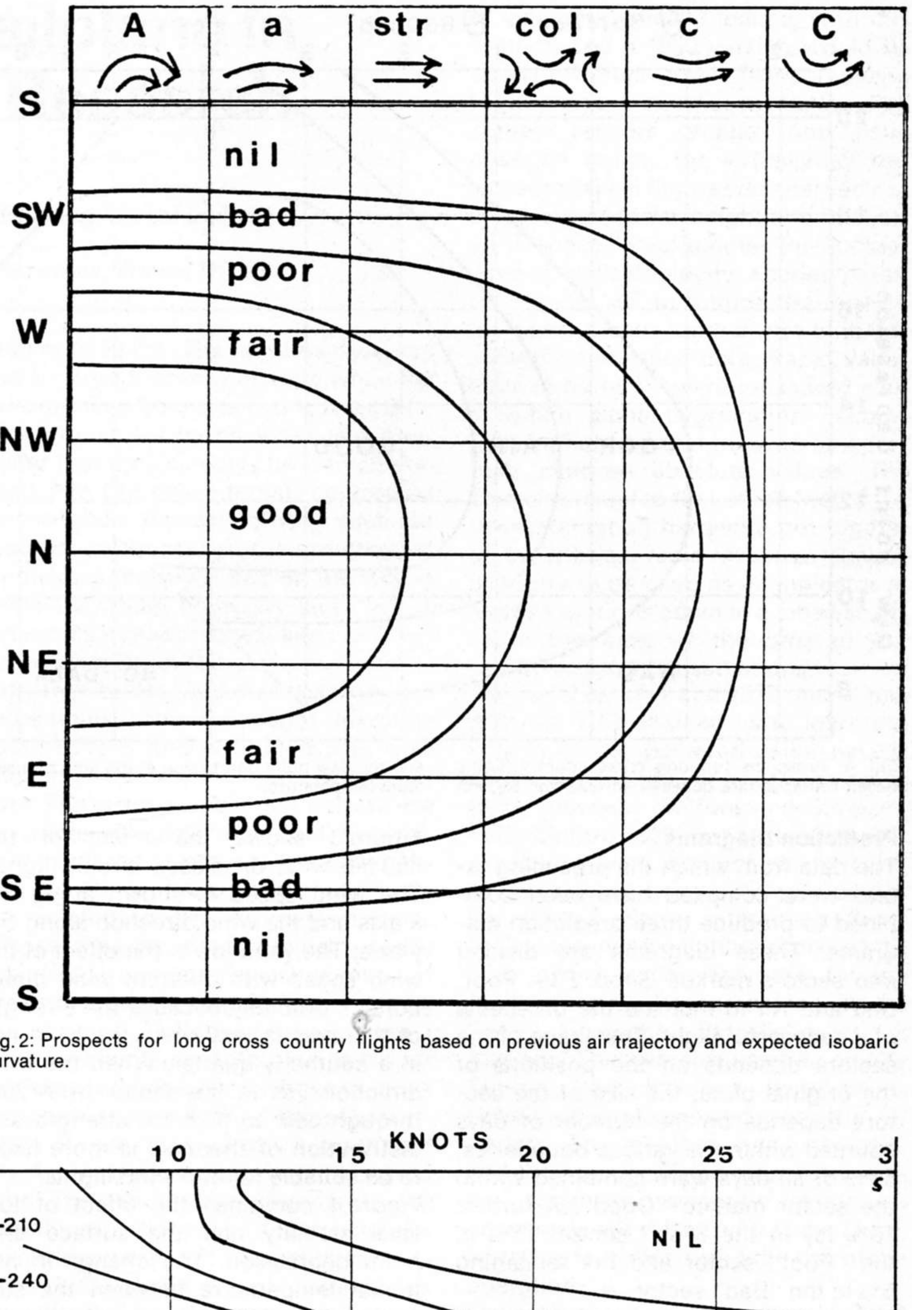

Fig. 2: Prospects for long cross country flights based on previous air trajectory and expected isobaric curvature.

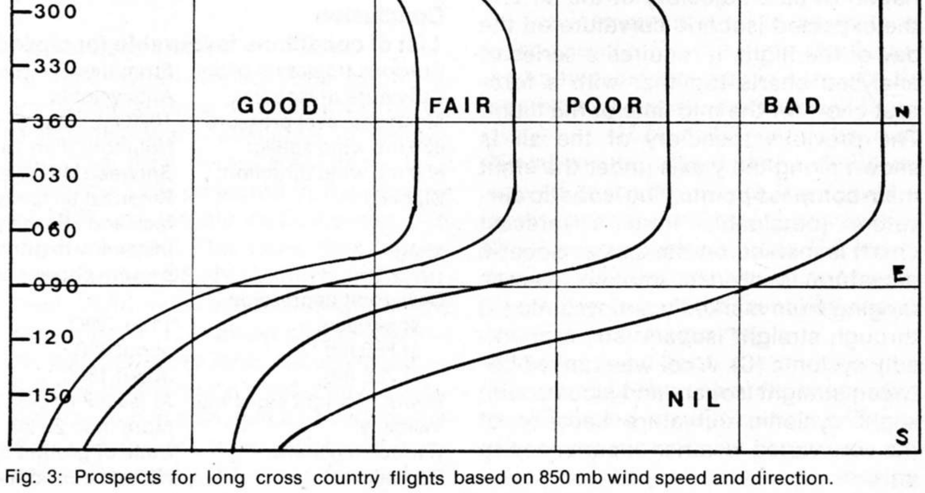

Fig. 3: Prospects for long cross country flights based on 850 mb wind speed and direction.

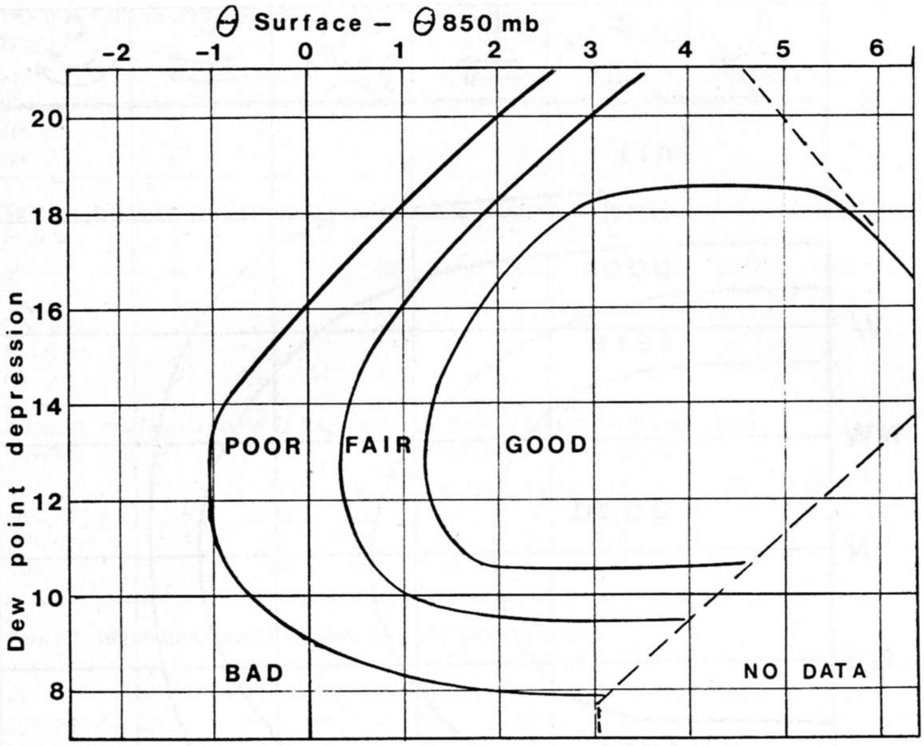

Fig. 4: Prospects for long cross country flights based on lapse rate between surface and 850 mb and the dew point depression at the time of maximum temperature.

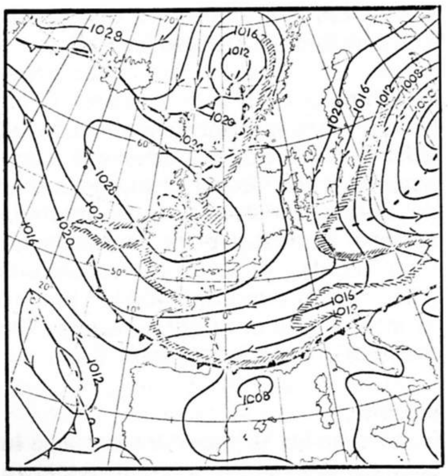

Fig. 6: 1200 GMT surface chart for 28 April 1976. The pecked lines with cross hatching marks the boundary of major cloud masses seen on satellite pictures. Soaring conditions were outstandingly good over central and southern England. One 760 km triangle and several 500 km triangles were flown.

Prediction Diagrams

The data from which the preceding tables were compiled have been combined to produce three prediction diagrams. These diagrams are divided into sectors marked Good, Fair, Poor, Bad and Nil to indicate the prospects of a successful flight. The shape of the sectors depends on the positions of the original plots; the size of the sectors depends on the number of days counted within the various boundaries. 65% of all days were contained within the sector marked "Good". A further 15% lay in the "Fair" sector, 15% in the "Poor" sector and the remaining 5% in the "Bad" sector.

Figure 2 is intended to show the cross country prospects based on a combination of past trajectory of the air and the expected isobaric curvature on the day of the flight. It requires a series of analysed charts together with a forecast chart for the mid time of the flight. The previous trajectory of the air is shown along the y axis under the eight main compass points. The isobaric curvature (obtainable from a forecast chart) is marked on the x axis. Isobaric curvature is divided into six classes ranging from markedly anticyclonic (A) through straight isobars (str) to markedly cyclonic (C). A col was ranked between straight isobars and isobars with slight cyclonic curvature because of the very varied weather experienced in cols.

Figure 3 shows the effect of the 850 mb wind on closed circuit flights. The wind speed is shown along the x axis and the wind direction along the y axis. The variation in the effect of the wind speed with different wind directions is probably because the strength of thermals is less when the wind lies in a southerly quarter. When the wind direction lies in the sector from 290° through 360° to 070° the strength and distribution of thermals is more likely to be suitable for into wind flights.

Figure 4 combines the effect of low level stability and the surface dew point depression. The change in potential temperature between the surface and the 850 mb level at the time of maximum temperature is shown along the x axis. Positive values indicate a superadiabatic lapse rate. The dew point depression at the surface is shown along the y axis.

These two parameters were combined because it is important that the lower levels of the air should be both unstable and relatively dry for good soaring. If the air is unstable but also moist the condensation level will be low and the cloud amount is likely to become excessive.

Most of these requirements were found to be satisfied on days when closed circuit flights of more than 400 km were completed. All the criteria were satisfied on occasions when the longest flights of between 600 and 800 km were completed.

References

Booth, B.J., 1978 On forecasting dry thermals for gliding. Met. Mag., London, 107 pp 48–61.

Malpas, W.E., 1977 Cross Country soaring weather in central France. Sailplane and Gliding (Leicester). 28 pp. 89–101.

Conclusion

List of conditions favourable for closed circuit flights over England

Previous trajectory of air:	From the NW, N or NE. (Never from the S
Curvature of isobars:	Anticyclonic
Mean sea level pressure:	1023 mb (plus or minus 7 mb)
850 mb wind speed:	Not more than 16 knots
850 mb wind direction:	Between WNW and ENE through North.
Stability:	Potential temperature decreasing about 3°C between the surface and 850 mb at the time of maximum temperature. Depth of instability restricted by a stable layer below 700 mb sufficient to prevent shower activity.
Dew point depression	
at surface:	11 to 18°C
at 850 mb	about 6°C
at 700 mb	about 15°C
Hours of bright sunshine:	At least 8 hours.
Visibility:	More than 20 km
Surface moisture:	State of ground dry at 0600 GMT
Rainfall:	No rain during the previous night.