A NEW APPROACH TO THE CLIMATOLOGY OF CONVECTIVE ACTIVITY

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Presented at the XXV OSTIV Congress, St. Auban, France (1997)

Summary

This paper describes a new approach to the climatology of thermal soaring conditions that allows a systematic comparison of different sites. The key idea is to apply a numerical convection model to a series of operationally measured radiosoundings and to calculate the potential flight distance (PFD) in a thermal cross-country flight for each day. A climatology of thermal soaring conditions can be based on these PFDs. It could be useful for the preparation of soaring championships and also for opening up new exciting soaring sites. A climatological map based on the PFD would show atmospheric and topographical influences on thermal soaring.

As a case study we selected the Sahara site Tamanrasset (DZ, Algeria, 22°49'N, 5°24'E) located near the Tropic of Cancer and used all operationally measured radiosoundings for the year 1996 to compute the daily potential flight distances with the numerical convection model <<ALPTHERM>>.

The height of convection reveals a bi-seasonal characteristic. In summer (from the middle of May through the end of October) it reaches 4000±500 m AGL. In winter (from November through the end of February) heights of 2000±500 m AGL are typical. March and April are transition months with the height of convection varying between 1500 and 380Q m AGL.

Potential flights distances mainly reflect the annual variation of the length of the day. The lowest PFDs in winter are around 300 km. From March through October 500 km are possible. From the middle of April through the end of August 600 km is a typical figure. Cumulus formation is rare. On the rare days with cumulus formation (20% of the days from April through September over the plateau of Tamanrasset) the potential flight distance exceeds 750 km. The highest PFD obtained was 921 km. Cumulus formation should be more frequent over the desert mountains (Hoggar, Tibesti, Atlas).

1. Introduction

We have learned about many excellent places for soaring since the early days of our sport. Soaring is possible over plains, hills, and mountains and it is based on convective, ridge, and wave lift. Where are the best

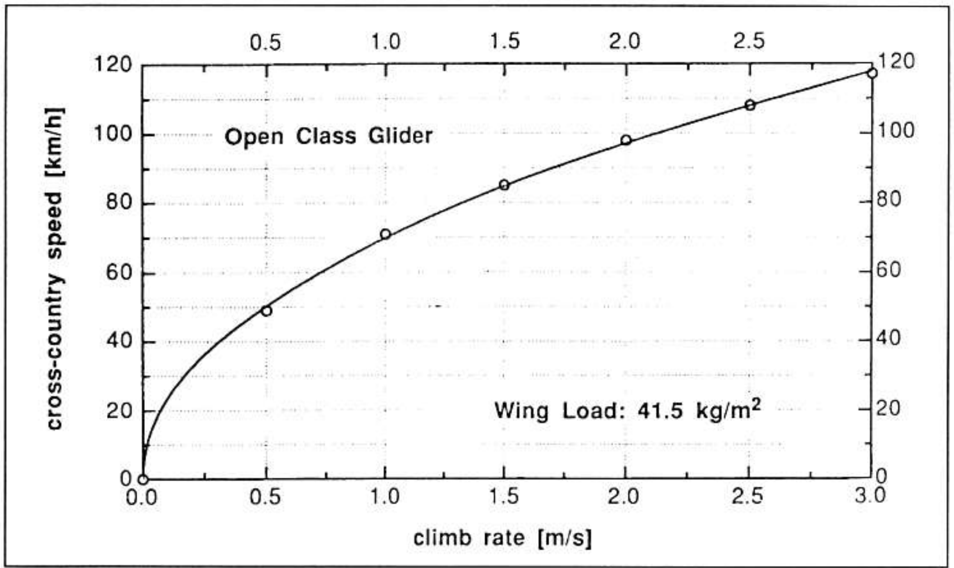

Figure 1. Cross-country flight speed vs. climb rate for an open class sailplane.

sites for soaring on our planet? In this paper we would like to describe an approach to this question that allows a systematic comparison of different sites with respect to their convective activity. The key idea of this paper is to apply a numerical convection model to an extended series of operationally measured radiosoundings and to evaluate the obtained distributions of potential flight distances for the different seasons. Such evaluations could be useful for the preparation of championships and for the promotion of existing and new soaring sites.

2. Definition of the potential flight distance

In order to asses the soaring potential of a particular day we suggest calculating the potential flight distance (PFD) for a thermal cross-country flight. MacCready's theory described in (l) provides a relation between the climb rate of a glider and the resulting cross-country flight speed (Figure 1). With radiosonde data and a numerical convection model time-altitude cross-sections of convective lift rates (Figure 2) can be calculated. The duration of convective activity, the climb rates and the characteristics of the polar of the glider determine the total flight distance of a cross-country flight.

Minima should be defined in terms of height of convection and achievable climb rates. We suggest to use a minimum depth of the convective boundary layer of 1000 meters above the median elevation of the orography and a minimum achievable climb rate of 0.5 meter per second for conditions to be sufficient for cross-country soaring (Figure 3). With poor conditions the risk of landing out increases. Locating lift and selecting the best lift at hand within the range of the glider is normally more efficient, if convection is marked by cumulus cloud. The cumulus cloud cover in octals should be considered in the transformation of the computed lift rates into the climb rates achievable in a glider. Without cumulus clouds the achievable climb rates are reduced to 50% of the model lift rates, between 1 and 4 octals no reduction is applied to the computed lift rates, and above 4 octals achievable climb rates become progressively smaller (steps of 25% per octal) than the computed lift rate (Figure 4).

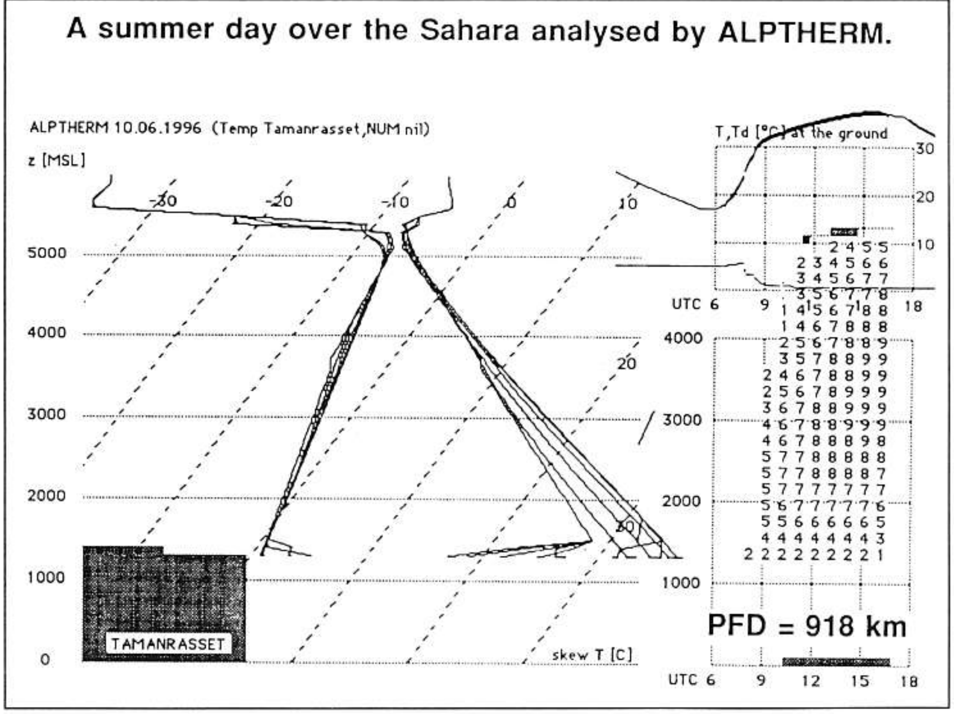

Figure 2. Simulation of convection by ALPTHERM. Evolution of the thermodynamic profiles (left), time-altitude cross-section of lift-rates and convective cloud cover (lower right), evolution of ground values (upper right).

With these definitions the excellent soaring day of

Gliding Forecast for SCHWAEBISCHE ALB on 21. April 1997

ALPTHERM [Temp Stuttgart,ASTA 04z,NUM 00z.alb]

UTC hh:mm	T [C]	Td [C]	Lift profile [0.5m/s] 1km 2km 3km 4km	Climb [m/s]	Cumulus [octas]	Base....Top [m] ... [m]	Ac/Ci [octas]	T	PFD [km]
06:00	-2	-6	--.----:----:----:---			1000		m	
06:30	-1	-5	--..---:----:----:---	0.1		1200		m	
07:00	0	-4	-1.11--:----:----:---	0.3	*	1300		m	
07:30	1	-4	-222*--:----:----:---	0.9	*	1300...1500		m	33
08:00	2	-4	-333**-:----:----:---	1.5	*	1400...1700		m	42
08:30	2	-4	-3443**:----:----:---	1.7	*	1500...1800		m	45
09:00	3	-5	-3455**:----:----:---	1.9	*	1600...1900		m	47
09:30	3	-5	-23444**----:----:---	1.7	*	1700...2000		m	45
10:00	4	-5	-33455***---:----:---	1.9	*	1800...2200		m	47
10:30	4	-6	-234453**---:----:---	1.7	*	2000...2300		m	45
11:00	5	-6	-2345553**--:----:---	1.9	*	2100...2500		m	47
11:30	5	-6	-23455544*--:----:---	2.0	*	2300...2500		m	49
12:00	6	-7	-23455554**-:----:---	2.1	*	2400...2600		m	50
12:30	6	-7	-23456665**-:----:---	2.3	*	2400...2700		m	52
13:00	7	-7	-234566655*-:----:---	2.3	*	2500...2700		m	52
13:30	7	-7	-234566665*-:----:---	2.4	*	2500...2700		m	53
14:00	7	-7	-234566665*-:----:---	2.4	*	2500...2700		m	53
14:30	7	-7	-234566665*-:----:---	2.3	*	2500...2700		m	52
15:00	7	-7	-234455554*-:----:---	2.0	*	2600...2700		m	49
15:30	8	-7	-123444432*-:----:---	1.5	*	2500...2700		m	42
16:00	8	-7	-112233321*-:----:---	1.0	*	2500...2700		m	35
16:30	8	-8	-..111...---:----:---	0.2		2200		m	
17:00	7	-8	--:----:----:----:---					m	
17:30	7	-8	--:----:----:----:---					m	
18:00	7	-8	--:----:----:----:---					m	

Potential Flight Distance for the day: 839 km

Figure 3. Calculation of the potential flight distance from the time-altitude cross-section of convection.

that day.

3. Climatology of the convective boundary layer

For soaring purposes climatology of thermal activity can be based on the potential flight distance. Candidates for world record flights might be interested in the maxima of the PFD for a given site, potential championship and holiday sites could be compared by two week average values of the PFD. Finally the climatology of the potential flight distance might also have some relevance for migrating birds.

A climatology of the height of the convective boundary layer could be of interest in air quality issues like tropospheric ozone or tropospheric aerosols.

April 21, 1997 results in a potential flight distance of 839 km (Figure 5) for the Schwaebische Alb in the south of Germany. According to (2) several flights over distances of more than 1000 km have been achieved on

4. Case study for a desert site

Deep convective boundary layers can be expected to occur in arid climates where little or no heat flux is used up for evaporation. Mountain ranges in such climates should further favor intense convection because of the volume effect (3). Our first interest was the Atlas range in Marokko and Algeria, particularly its central valleys and its southern slope at the northern edge of the Sahara. Unfortunately there are no operationally available radiosonde data for this area. So we turned our attention to the WMO station Tamanrasset (DZ, Algeria, 22°49'N, 5°24'E, elevation 1362 mASL). It is located in the southern part of the Sahara and south of the Hoggar mountains. We used all radiosounding data avail-

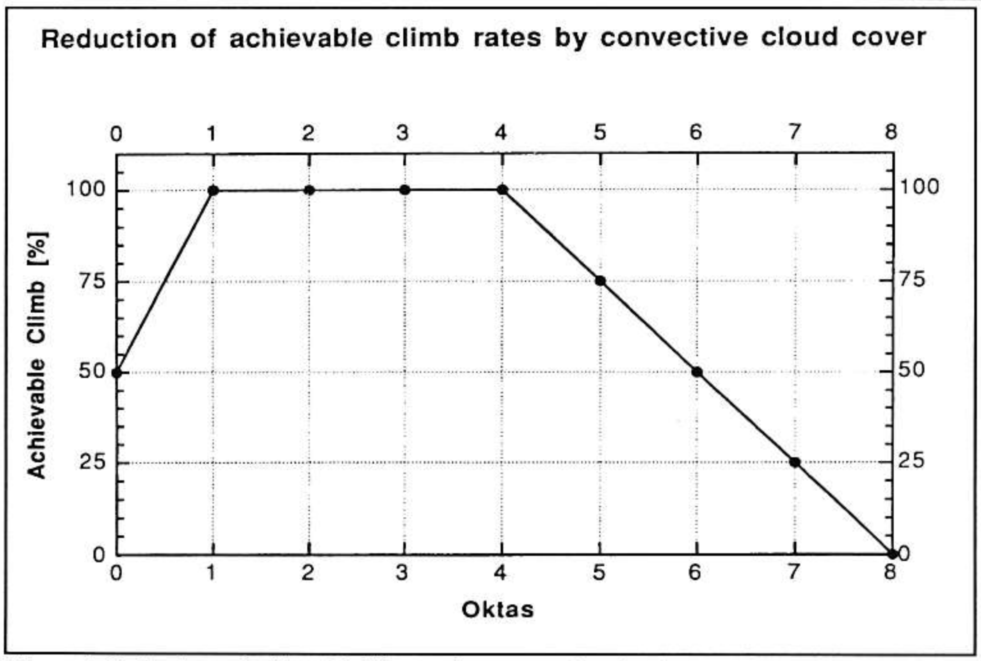

Figure 4. Reduction of achievable lift rates by convective cloud cover.

A 1000 km day over Germany as predicted by ALPTHERM.

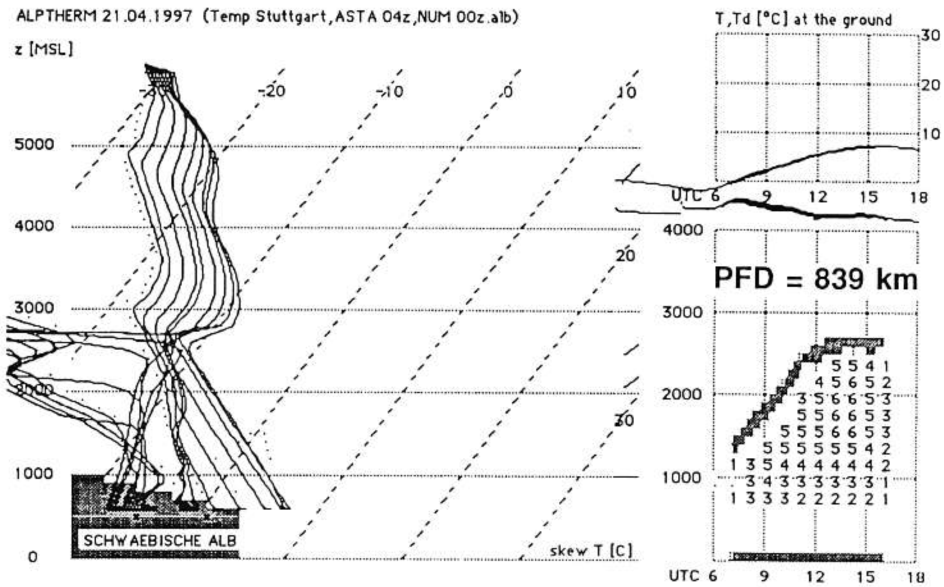

Figure 5. A 1000 km day over Germany as predicted by the operational version of ALPTHERM. The potential flight distance amounts to 839 km.

able to the weather services for the year 1996. The numerical convection model ALPTHERM is described in (3). It considers the area height distribution of the orography and its surface characteristics albedo, ground heat flux, latent and sensible heat flux. We selected an area-height distribution for Tamanrasset that represents a plateau with elevations ranging from 1300 to 1400 mASL. Its surface characteristics were set according to the arid desert climate of the area. The ratio of latent to sensible heat flux was 1:9. In moderate climates with vegetation this ratio is on the order of 1:1 (Figure 6).

ALPTHERM was initialized with the first radiosounding of 1996 measured at Tamanrasset. The model then simulated the surface fluxes and the resulting convective motions for the full year of 1996 in a single run. The vertical profiles of temperature and moisture were continually updated with all available measured profiles at O and 12 UTC. The surface characteristics were adjusted by minimizing the discontinuities of the surface temperature and humidity that occur at these update times. Invariant surface characteristics were used for the whole year. ALPTHERM dumped the computed values for the height of convection, the average lift rate, the cloud cover, the altitudes of cloud base and cloud top at a temporal resolution of half an hour and a vertical resolution of 100 m to a file. In a second process the PFDs were calculated for all days of 1996.

The time-series of PFDs for the year of 1996 provides an overview of the soaring conditions during 1996 (Figure 7). It is completed by the time series of the depth of the convective boundary layer (Figure 8). The height of convection reveals a bi-seasonal characteristic. In summer (from the middle of May through the end of October) it reaches 4000±500 m AGL. In winter (from November through the end of February) heights of 2000±500 m AGL are typical. March and April are transition months with the height of convection varying between 1500 and 3800 m AGL.

Potential flights distances mainly reflect the annual variation of the length of the day. The lowest PFDs in winter are around 300 km. From March through October 500 km are possible. From the middle of April through the end of August 600 km is a typical figure. Cumulus formation is rare. On the few days with cumulus formation (20% of the days from April through September over the plateau of Tamanrasset) the potential flight distance exceeds 750 km. The highest PFD obtained was 921 km.

For this climatology of the soaring conditions at Tamanrasset we only used a flat topography. A topographic area-height distribution representative e.g. for the Hoggar mountains was not considered. It can be expected that the PFDs would be slightly higher with such an area-height distribution because convection would start earlier at elevations above the nocturnally formed inversion in lower elevations. Cumulus formation should also occur more frequently over the desert mountain ranges (e.g. Hoggar, Tibesti, and Atlas) and favor longer flights.

Wind information available in the radiosonde data has not been used for this climatology of convection. Wind could be integrated into the computation of the PFD as a reducing factor when wind speed becomes high.

5. Conclusions

Based on time series of radiosoundings and on a numerical convection model it is possible to model the climatology of thermal soaring conditions. We suggest that the climatology is based on the potential flight distance as an index for a soaring day. Finally we recom-

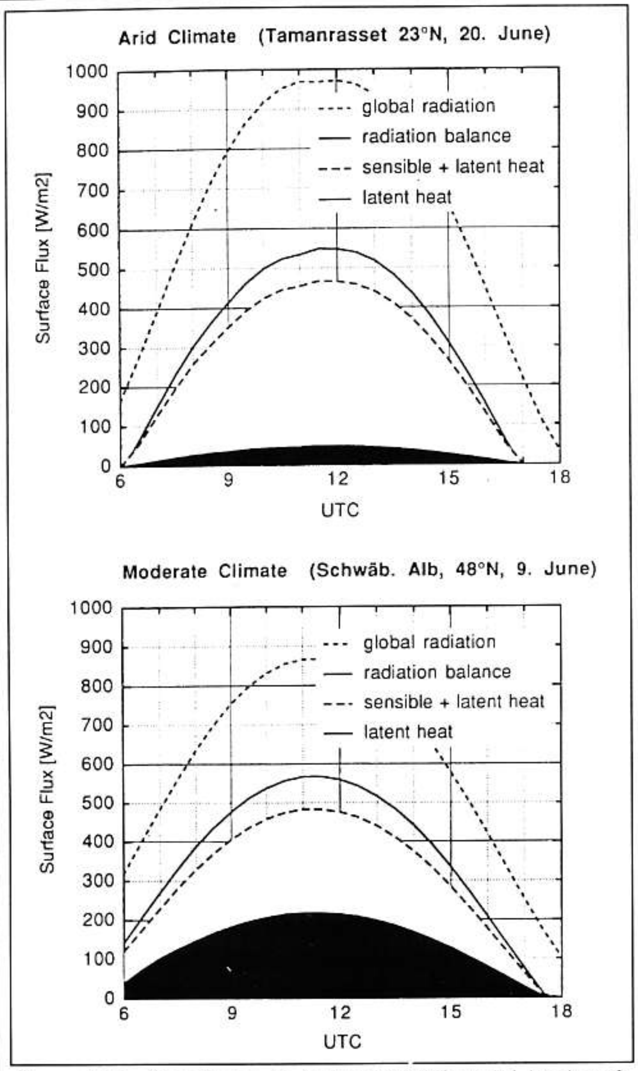

Figure 6. Surface fluxes in ALPTHERM for arid (top) and moderate (bottom) climates.

mend that forecasts of soaring conditions based on numerical convection models should include an assessment of the potential flight distance.

References

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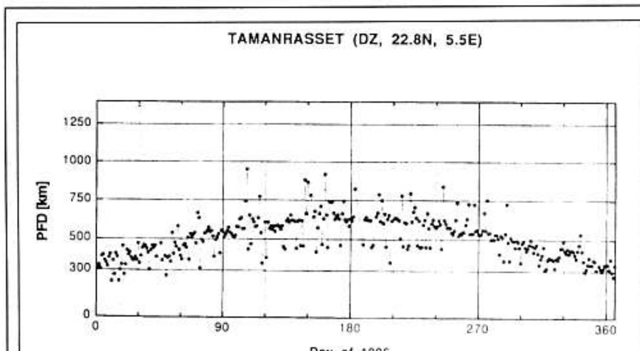

Figure 7. Potential flight distances for Tamanrasset (DZ) in 1996.

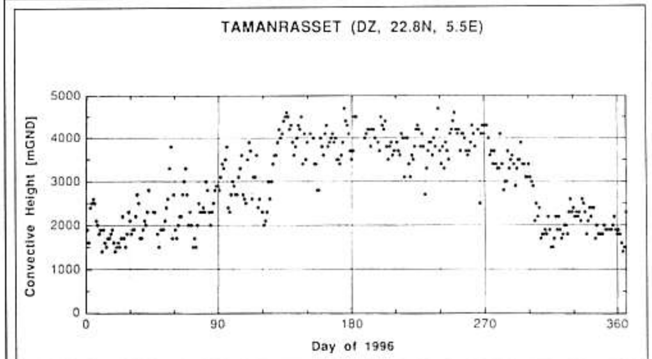

Figure 8. Height of convection at Tamanrasset (DZ) in 1996.