METEOROLOGICAL SUPPORT FOR GLIDING, HANG-GLIDING AND HOT AIR BALLOON CHAMPIONSHIPS

A Summary of Practical Experiences

by H. Trimmel

Federal Office of Civil Aviation, Austria

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1. General introduction

It is essential to discern the relevant scales of motion which are important to gliders, hang-gliders and hot air balloons respectively.

2. Preparation for championships

2.1 Selection of a suitable period

The Alps are located in the mean position of the westerlies, and are thus subject to a large climatological variance. The strong annual variation in temperature and wind conditions predetermines suitable periods for different contests. The best time for hot air ballooning is generally found in autumn, when stable anticyclonic conditions prevail. Thermal stability is high, but the occurrences of fog are still rare and confined to the early morning.

For gliders and hang-gliders, conditions are most favorable from late March to the end of August, whereby the best period tends to be from the beginning of May to the middle of July. In order to determine the optimum period within this interval for the next championships planned for 1989 in Austria/Wr. Neustadt a meteorological-climatological investigation has been carried out.

The governing aspects were to find two-week-periods with a maximum of usable days for flying and to avoid periods where there is a danger that a minimum of 4 usable days would not be guaranteed. The investigation was based on 34 years of observations and indicate a preference for the middle of May.

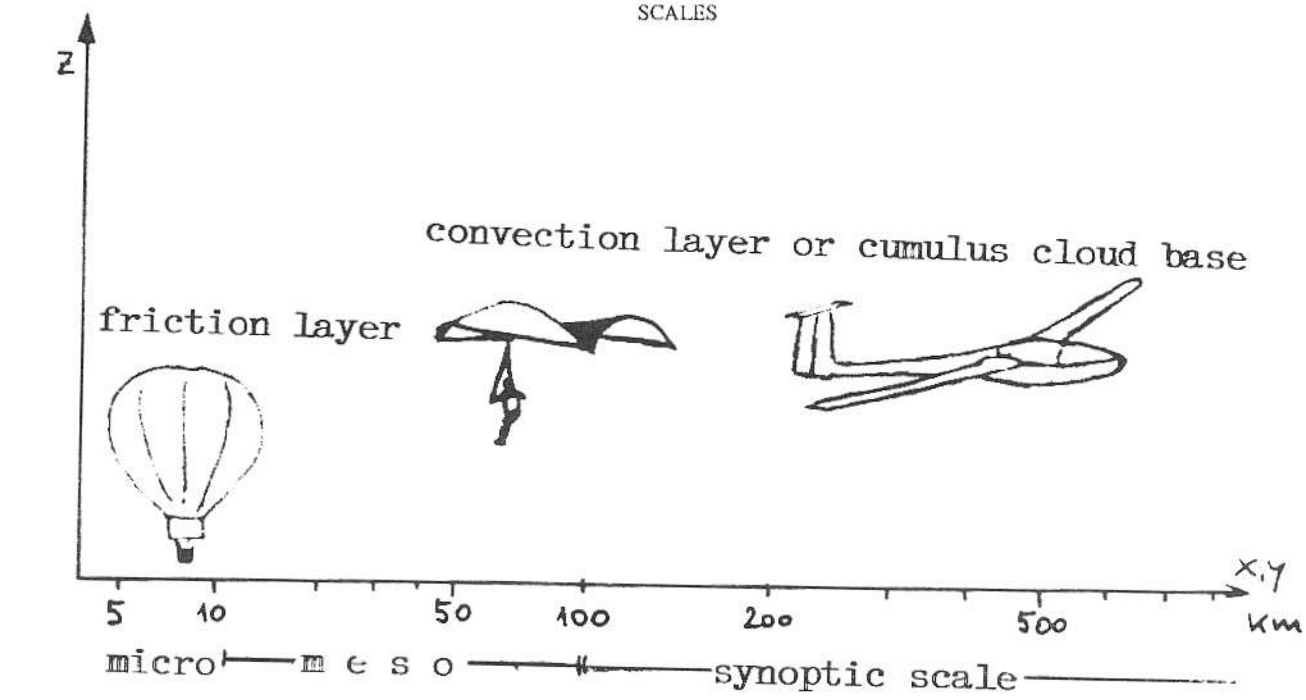

FIGURE 1-Space

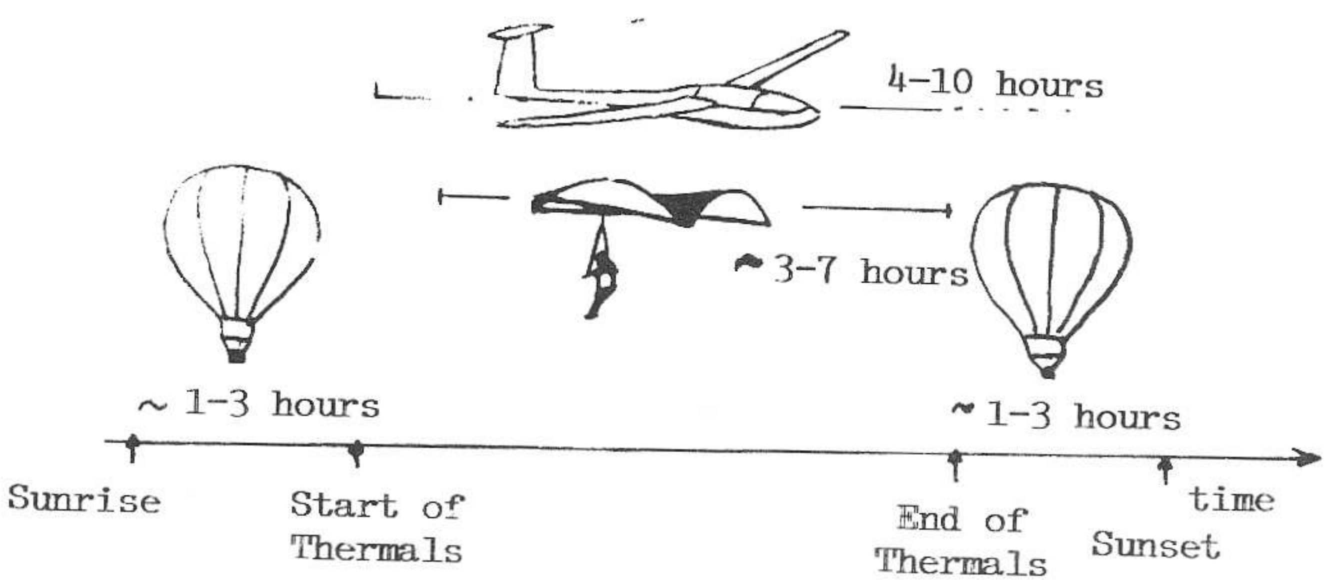

FIGURE 2-Time

2.2 Technical equipment

The graphical material needed for forecasting (charts, satellite pictures, tephigrams, etc.) are transmitted to the location of the contest via a telefax-printer. A local satellite receiver and real-time access to a meteorological data base are highly desirable.

In-situ measurements of meteorological parameters are instrumental in coming to grips with local, especially topographical effects. A thermo-hygrograph, for example, permits to determine the onset of thermal convection and the height of cumulus-base. Pilot balloons on the other hand, can give vital insights in the local wind-systems.

3. Gliders

3.1 Statistical analysis of meteorological parameters

The glider pilot is mostly interested in the strength, frequency and spatial distribution of updrafts. These micro-scale parameters are neither measured nor predicted by routine meteorological methods and it is therefore necessary to find correlations between them and measurable quantities in the mesoscale. Such relationships have been determined in papers by T.A.M. Bradbury[2] for England, G. Truog[3] for Switzerland, M. Kreipl[4] for Germany and H. Trimmel[5] for Austria, and show reasonable agreement as regards wind, pressure and humidity dependence. Significant differences are found, however, between results given for homogenous terrain and mountainous areas.

Statistical relationships are a useful tool for a forecaster who is trying to familiarize himself with gliding problems, and should be complemented by personally gained local experience.

3.2 Methodology of actual forecasting

In determining suitable tasks for a competition, the forecaster has to find the answer to the following two questions:

1. What is the area unaffected by synoptic disturbances?
2. How will the updrafts in this area develop during the day?

The tools used to solve these problems are presented below.

3.2.1 Interpretation of direct model output produced by the ECMWF model 8 different forecast charts are used for 06Z, 12Z and 18Z of the day (based on 12Z data of the previous days).

- 1000 and 500 hPa geopotential
- Relative topography and precipitable water content of the 500/850 hPa layer
- Frontal parameter, based on the gradient of above mentioned Rel.Top. and humidity
- Vorticity and temperature advection
- Model precipitation

3.2.2 Satellite images and trajectories are used to predict advection of cloud areas modified by the predicted vertical motions.

3.2.3 Dynamically-interpreted model output

Time honored algorithms such as convective indices are applied to grid-point data and give surprisingly good results in predicting convective activity, weather elements and wind values.

3.2.4 Vertical temperature profiles

As characteristics of updrafts are closely related to the diurnally evolving vertical temperature profiles, their prediction is the essential problem in forecasting thermals. Considering the uncertainty of the initial conditions (a local radiosonde is usually not available), the advective changes during the day and the dynamical effects (e.g. subsidence), the difficulties for the forecaster are exacting. In mountainous terrain the problem is compounded by orographic effects, valley wind systems, etc.

The method outlined below is used to tackle this difficult problem:

3.2.4.1 The effect of advection at different levels is taken into account by following backward trajectories at 850, 700 and 500 hPa to the origin of the airmass expected in-situ at a certain time, and by constructing a "composite tephigram" based on actual 00Z-soundings in the areas of origin.

3.2.4.2 Dynamical effects are qualitatively estimated by applying vertical motion at synoptic scales to temperature and moisture profiles.

3.2.4.3 In mountainous terrain, where the calculated advection at lower levels is deemed unreliable, the help of data from mountain observatories is enlisted. One has to be careful in using these data, as local effects may seriously influence meteorological parameters.

The "composite temperature profile" derived in the above mentioned way is then carefully evaluated to predict the evolution of thermal conditions. This should be done following the guidelines given in the "Handbook of Meteorological Forecasting for Soaring Flight"[1].

It may be of interest to discuss in more detail the effects relevant to thermal conditions in mountainous terrain:

- Better radiative heating rates in valleys compared to flat terrain due to a bigger ratio of absorbing surface to heated volume (see M.E. Reinhardt[6]) lead to a deeper convection layer and stronger updrafts. A connection between the depth of the convective layer and the strength of the updrafts was found with similar results to those given by H. Leykauf[7].

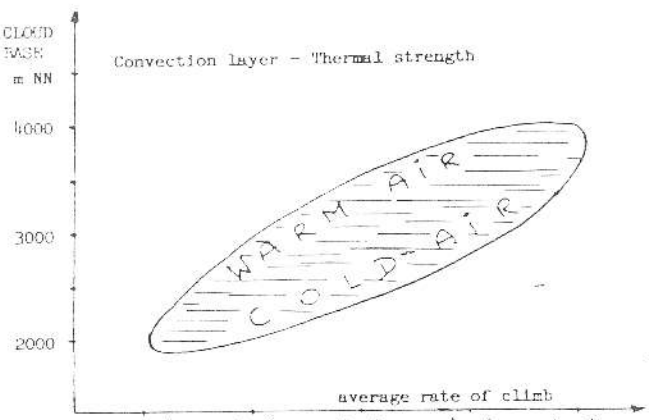

FIGURE 3-Convection layer-Thermal Strength

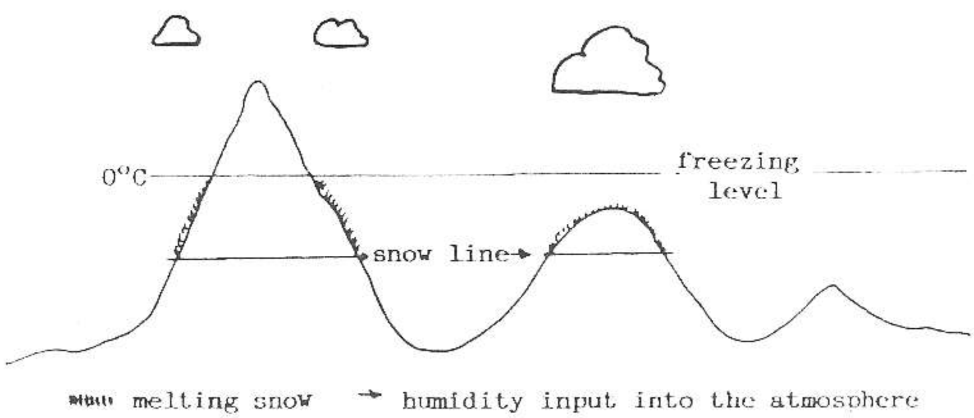

FIGURE 4-Ilumidity

• Height of inversions: Inversions below the height of a significant proportion of the relief are not much of a problem, as enough heated surfaces are located above the cold air masses. Depending on the height distribution of the local relief this is a "critical height" of the inversion which, if exceeded, seriously affects prospects for gliding.

• Moisture sources over snow and glacier ice below freezing level.

• Valley wind systems can affect the onset of convection far out into surrounding lowlands.

3.3 Selection of tasks according to prevailing meteorological conditions

Two cases from the Austrian National Gliding Championships in 1986 are used to illustrate this problem. Friesach/Hirth, the venue of that competition, is located to the south of the main alpine divide at the fringe of the Klagenfurt basin. The elevation of the airfield is 615m MSL, the crest height of the surrounding mountains varies between 1000 and 1800m MSL.

Case 1: 25 May 1986

On the rear of the coldfront high pressure influence is increasing. Marked inversions are forming at 2000m and 3500m MSL.

Due to the limited depth of convection the tasks for the day are confined to the Klagenfurt basin, where relief heights are moderate. Fast legs were flown below 2000m in areas of high updraft density. Isolated updrafts piercing the inversion near higher mountain tops further afield, which were used by some pilots, failed to improve their results.

Case 2, one day later, 26 May 1986

We are on the warm side of the high, the downward motion is now prevailing down to the surface. The flow is back to the south and warming occurs at all levels. Convection is consequently suppressed over the plains but over the tops of the Alps excellent conditions for fast long distance flights are encountered.

4. Hang-gliders

4.1 Differences between gliding and hang-gliding championships

Whereas speed is an important criterion in gliding competitions, distance alone makes or breaks the hang-glider. Tasks are usually "out and return" or triangle flight, sometimes including repeated short rounds. The following differences have been observed between hang-gliding and gliding (K. Panosch, personal communication): a thermal regarded as poor by a glider pilot will be termed medium by a hang-glider. This can be explained by the radii of turning circles which are much smaller for hang-gliders, thus allowing them to take advantage of the strong vertical motion in the core of the updraft.

Accordingly, one would expect that hang-glider competitions could start earlier, making use of the weak convection in the onset period. The exact opposite is true: the poor gliding ratio of the hang-glider does not permit long crossings between individual updrafts which are few and far apart during the earlier hours. Owing to the fact that hang-gliders start from the ground, even though elevated, he cannot afford to lose height in the early stages of a flight.

4.2 Connection between met parameters and tasks

A "checklist" developed by Truog and Kreipl has been adapted to the local conditions in Kossen by K. Panosch (Appendix A). This "thermal activity score" has been compared to the maximum distances covered on each day of a competition.

A high correlation between score and achieved distances depends, of course, on a good prediction of the meteorological parameters on which the score is based.

5. Hot air balloons

5.1 Specific problems of HAB's

While thermal conditions are the governing factor for gliders and hang-gliders, the wind profile is the critical aspect for HAB's. The variation of wind with height determines the degrees of freedom for the HAB pilot. Large wind variations are usually connected to stable layering and are, therefore, most common in the early hours of the morning and during late afternoon.

Most tasks in competitions center around flights to predetermined targets. Special tasks are, among others, so called "judge-declared goals," "pilot-declared goals" and "fly ins" (the pilot selects a starting point from where he tries to come as close as possible to the target, or "elbows" (maximum change of direction)). Distances flown are in the order of 10-20kms.

5.2 Selection of tasks according to prevailing meteorological conditions

Example, 4 September 1986, Schiellciten (A)

With a moderate southwesterly flow aloft the wind field in the planetary boundary layer is determined by local topographic effects. In the morning an "elbow" was chosen as task. For the first leg most piltos made use of the katabatic outflow below 200m which was directed to the southeast. After marking the turning point the HAB's rise into the level of geostrophic southwesterly wind. The change of direction achieved was around 90 degrees. Few pilots managed to find a thin layer with a weak counter-current which brought the back near the starting point.

With the diurnal change in the valley wind system (low level flow becomes southeasterly towards the mountains, and changes gradually and in an organized fashion into the southwesterly flow aloft. This situation permits a controlled flight and reasonable accuracy in reaching a predetermined target.

This example shows the typical diurnal evolution of a local wind system from an intricate pattern of sometimes knife-edge-thin layers with low windspeeds, but significant directional shear into a well-mixed Ekman-type boundary layer.

5.3 A case of man-made induction of convection

On 18 September 1986, during the preheating of the HAB's, a sudden gust causes near havoc among the balloons, and only quick and decisive action by pilots and support crews prevents major damage. A post-mortem analysis of the synoptic situation explained this incident:

With a cold front approaching from the north vertical stability is low above a thin stable layer near the ground. The heat generated by the burners (around 50 in a small field) was sufficient to trigger local mixing in the lowest 100-200m, and the gradient wind gusted down to the surface.

6. Final remarks

Experience has shown the value of on-site meteorological support for aeronautical competitions. The better insight in local phenomena, the immediate feedback from pilots and the possibility to take measurements when and where needed cannot be compensated by the easier logistics of a head-office based support.

The observations made by pilots of gliders, hang-gliders and hot air balloons are an invaluable source of information to complement our very scarce knowledge of the "micro and mesoscale structure of the atmosphere's first mile," particularly over inhomogeneous terrain. An increasing degree of sophistication of on-board equipment in gliders will produce quantified information and hitherto unmeasurable quantities like updraft strength and density, vertical wind and tempera-

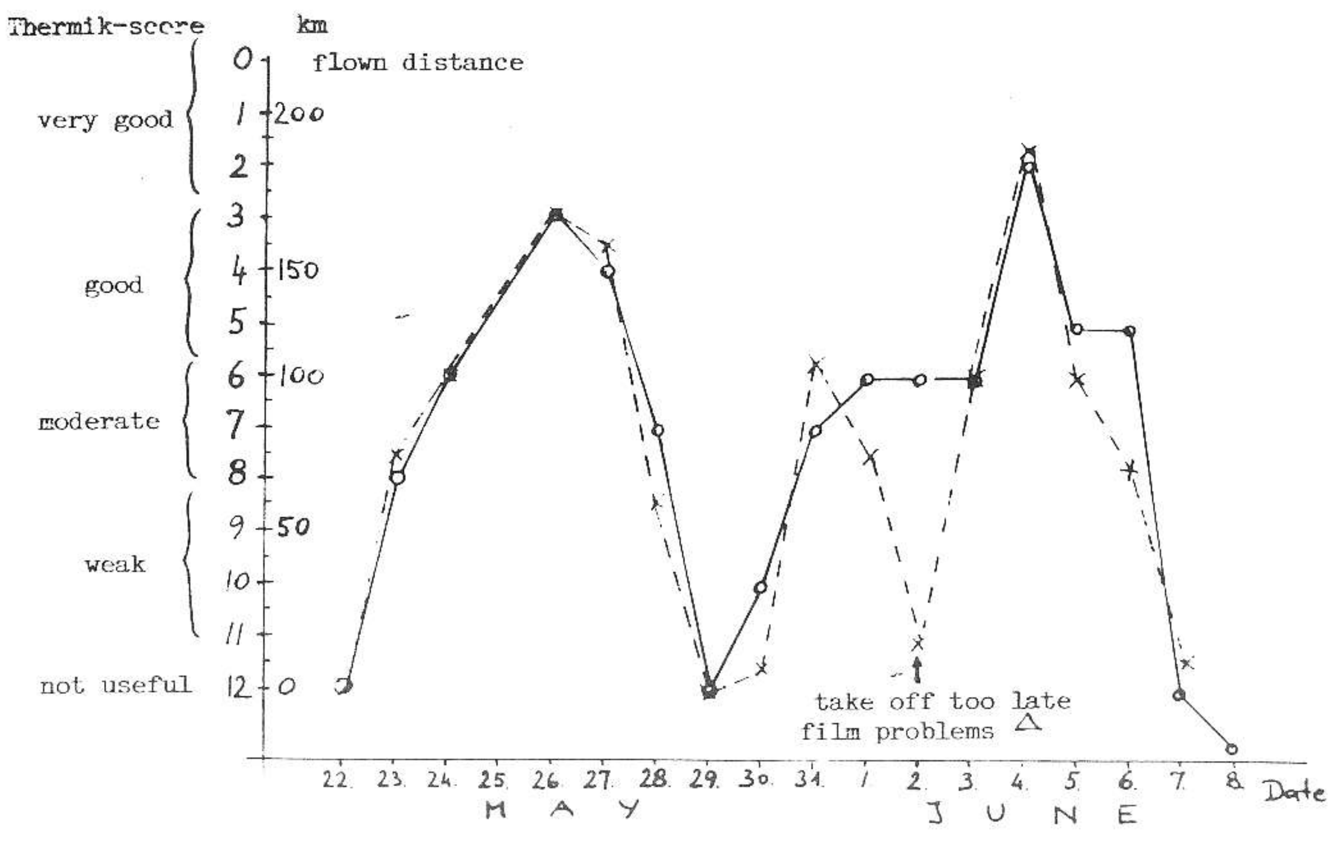

FIGURE 5-Thermal activity score and maximum distances on competition days

ture variations and small-scale turbulence; HAB's as very visible tracers of microscale wind systems provide detailed insights in the mechanics of valley-wind systems.

This host of information, when carefully and systematically evaluated by meteorologists, would close some of the more embarrassing gaps in our knowledge about the atmosphere immediately around us.

Acknowledgements

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APPENDIX A

CHECKLISTE ALPEN – Wettkampfgebiet TIROL

erfüllt = +
nicht erfüllt = -

Isohypsenkrümmung 850 hPa nicht zyklonal		....
Windrichtung 850 hPa W – N – E oder variabel		....
Windstärke 850 hPa kleiner 15 Knoten		....
Isohypsenkrümmung 700 hPa nicht zyklonal		....
Windstärke 7oo hPa kleiner 15 Knoten		....
Isohypsenkrümmung 500 hPa nicht zyklonal		....
Wind der entspr. Radiosonde in 500 hPa W–N–E , dabei Windstärke kleiner 15 Knoten		....
Taupunktdifferenz der repr. Radiosonde 00 UTC in 850 hPa 6 – 10 Grad (= Spread)		....
das_selbe in 500 hPa , jedoch größer 10 Grad		....
Luftdruckänderung Bergstation ± 1 hPa / 3 Stunden (evtl. Zugspitze, Sonnblick, Hohenpeißenberg)		....
Luftdruck (QFF) Innsbruck 06 UTC 1016 bis 1023 hPa		....
Luftdruckunterschied AlpensÜd – zur –nordseite ± 2 hPa (evtl. Mailand – Innsbruck)		....
Windrichtung Bergstation (s.o.) 06 UTC S – W oder windstill		....
Windstärke Bergstation (s.o.) 06 UTC kleiner 15 kt		....
Sicht Bergstation (s.o.) 06 UTC größer 25 km		....
Gesamtbewölkung Bergstation (s.o.) 06 UTC kleiner 4/8		....
Temperaturdifferenz Hohenpeißenberg – Zugspitze 12 bis 15 Grad		....
Niederschlag Alpen Vortag 18 – 06 UTC vereinzelt leichter bzw. kein Regen	(2x)	....
Niederschlag Alpen Vortag 06 – 18 UTC kein Regen oder höchstens örtlich	(2x)	....
Temperaturdifferenz 850 – 500 hPa kleiner 25 Grad		....

Totalminuspunkte : ____________

Föhnindikator :

Druckunterschied zwischen Bozen und Innsbruck ab 3 hPa : föhnig
ab 6 hPa : Föhn greift durch.

Temperaturdifferenz über 14 Grad : Patscherkofel – Innsbruck : Föhntendenz bis zum Boden