Traps in warm air-masses

Warm air can be quite „moody“ - but it undoubtedly also has potential, otherwise top flights in hot countries would not be possible at all. So it makes sense to get acquainted with its nature and, above all, to know its pitfalls, then the „puddle“ can provide us with dreamlike conditions.

Author: Henry Blum

Cumulus clouds with lower limit at 5300 meters

Unlike warm air, cold air masses are considered "honest" by glider pilots! They provide us with good thermals early on and reliably deliver good updrafts, even under a sky with different degrees of overcast. And this in almost all landscapes, where we normally fly.

Warm air masses, in contrary, do not have a good reputation: they are considered "capricious", sometimes even "sneaky": Thermals start late, updrafts vary between meager and excellent. Lift is depending on the cloud base altitude and the climb rates also depend heavily on the degree of cloud cover. And to make matters worse, mountainous terrain has an advantage over the plains.

In many places, warm air is therefore regarded as puddle in which one can rarely expect good thermals. Nonetheless, areas like Texas or Namibia regularly demonstrate the enormous potential of warm or even hot air masses. At least as long as they do not tend to overdevelop and possibly wash us out of the sky. You just must know their characteristic properties and when they come into play. Their undisputed strengths can then be used well. And at the same time, one does not have to fall into the pitfalls that also exist at the same time.

It is precisely those traps, that the following article deals with. We will take a closer look at seven typical pitfalls and illustrate some of them with examples.

How do thermals work in warm air?

A bit of theory can help us answer this question first. Updrafts are caused by density differences of the rising air compared to the ambient air around it. Classic example: Warm air is lighter than cold air and therefore rises. Thus, the sun is the engine of our weather. Less known, but much more relevant: Humidity differences also cause density differences. The more water vapor is stored in a parcel of air, the lower its density. So air enriched with moisture is lighter than dry air. And, in addition, the higher the air temperature, the more gaseous water it can store. Air thus acts like a sponge in this respect. The warmer it is, the more water in gaseous form it can absorb.

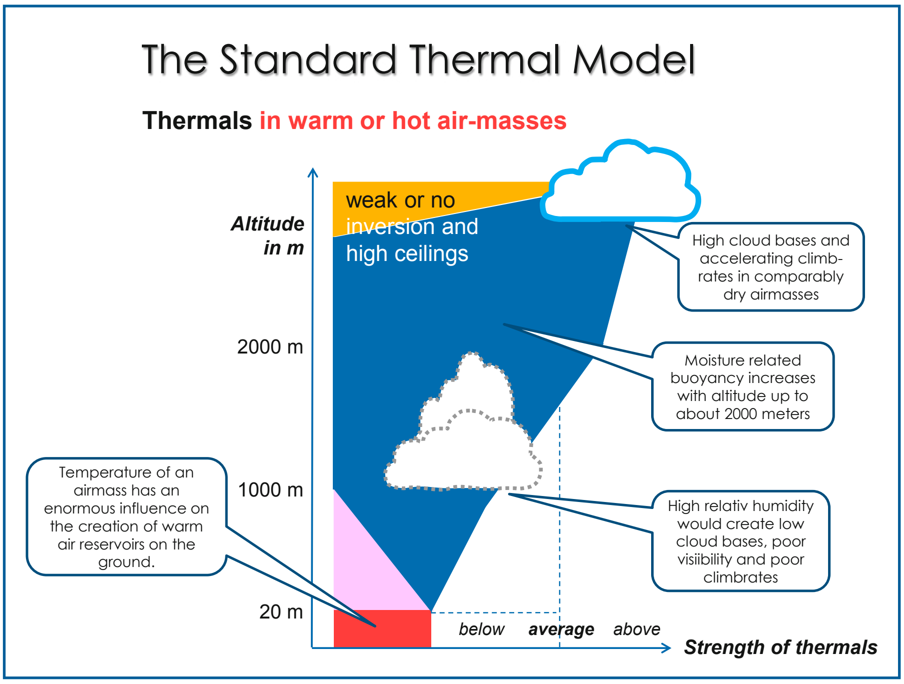
Possible differences in moisture content between the thermal air and its surroundings therefore also produce much greater density differences in warm air masses. Thus, they are causally responsible for the very different climb rates we experience. And here lies the key to understanding thermals in warm air.

Before we move on, let's go first through the individual aspects of the formation of updrafts in a warm air mass using the "standard model" of thermals. The following graphic shows the decisive factors at a glance (***picture 1***)

Let's start with the generation of hot air reservoirs on the ground. The proportion of solar radiation available for thermal generation, i.e. generating warm air on the ground, the so-called thermal yield, is relatively small in warm air masses. It therefore takes time before a sufficiently large reservoir of warm air is created, which later can carry a glider in a bubble (or plume) during release and ascent. For this reason alone, warm air thermals tend to be bubbly and poorly structured close to the ground. What's more, flyable thermals only develop later in the day and when the sun has risen relatively high.

So, on some days convection in earnest starts around noon or even later. E. g. on July 4, 2023 at the Women's World Gliding Championships in Garray Sorianuma/Spain, the field of participants was not towed until about 01:00 pm at about 25 °C. (Please note Garray elevation is at 1036 m above MSL! At sea level about 35 °C would have been expected). Although there were cumulus

Picture 1 Major factors influencing thermals in warm vs. cold air masses (dashed lines)



clouds visible everywhere since the late morning, four ladies had to land and be towed again. Fully loaded with water ballast, they had not been able to find a reasonable connection to the thermals.

In warm air masses, therefore, various pitfalls exist, which should be known by glider pilots, and which can be explained more easily on the basis of the theoretical aspects described above.

Trap 1

If you want to go cross country early or too early, you may have to spend a lot of energy staying aloft in a weak climb or even making progress on course. This can cost personal energy that may be lacking later on, when, as we will see, things can really get going. This would be trap number 1. It's illustrated by another example down below, based on a flight by Alexander Müller in Namibia (***picture 2***).

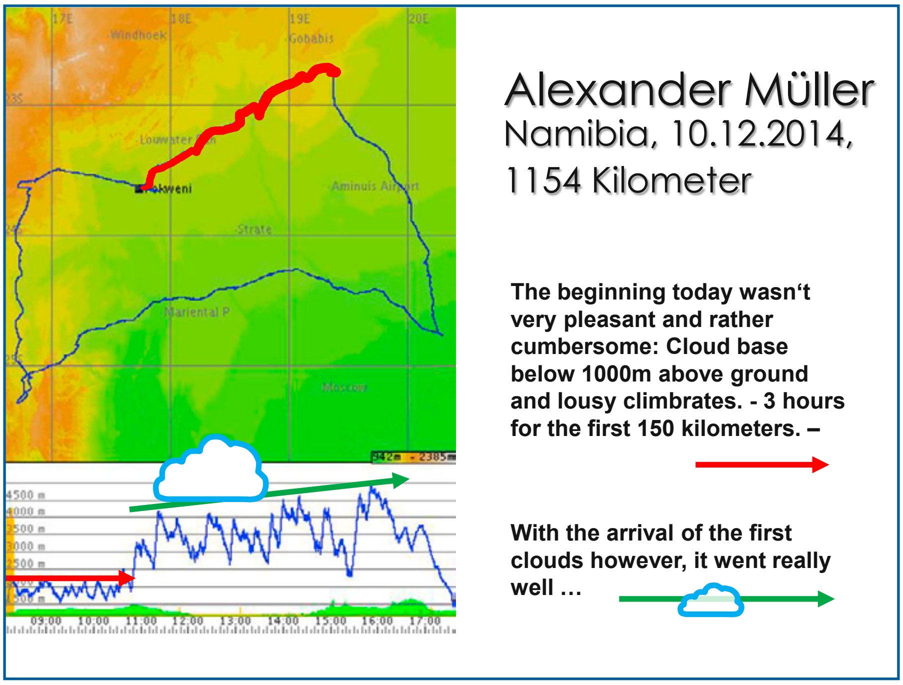
Trap 2

Because the thermal yield in warm air is so low, the slopes facing the sun have an advantage. The stronger irradiation here favors the formation of warm air pockets. Mountainous terrain thus develops better and faster than plains. Consequently, flat terrain is at a disadvantage when flying cross country. This is where trap number 2 lurks – the forests, which otherwise serve so reliably as a trigger for thermals, become also somewhat weaker release points. While cities, contrary to classic doctrine, are very rarely good sources of thermals normally, hot rooftops can now make a difference, especially late in the afternoon.

Trap 3

Cirrus shields can become trap number three. Thin high clouds reduce the insulation only moderately, but in combination with the already weak thermal yield, this becomes noticeable much faster in warm air than in cold air. This also applies to higher degrees of opacity of cumulus clouds (more than 3/8).

Picture 2 The flight of Alexander Müller



Alexander Müller
Namibia, 10.12.2014,
1154 Kilometer

The beginning today wasn't very pleasant and rather cumbersome: Cloud base below 1000m above ground and lousy climbrates. - 3 hours for the first 150 kilometers. –

With the arrival of the first clouds however, it went really well ...

Let us continue with the standard model

For further considerations, let's look again at the graph of our standard thermal model. The initial temperature advantage of the thermal over the ambient air quickly disappears and with it, its density difference that generates lift. Thus, at the latest from about 1000 meters above ground onwards, temperature differences are no longer measurable. At this altitude, the humidity differences between updraft and ambient air exist, but can still be relatively small and therefore do not contribute significantly to lift. Thus, the next obstacle arises and with it the next pitfalls.

Trap 4 and 5

As long as the net lift of the thermal cannot compensate for the sink of a glider, the maximum working altitude is reached here. – Fortunately, cumulus clouds intensify humidity differences. (The why of this will be investigated another time). But if there are no clouds, or if there are only clouds with a low base, the thermals remain weak: we cannot climb higher up well, nor do we make good progress. This is the main reason for the bad reputation of warm air masses. They are often charged with moisture from the Mediterranean region and produce low altitude cumulus clouds with relatively poor visibility. The result: the well-known warm air puddle.

If, however, if the ambient air is not sealed off by an inversion and if the lapse rate of the higher atmosphere also displays a moist, unstable condition, the resulting cumuli can continue to grow rapidly. Overdevelopment with showers and thunderstorms can set in and a flight in thermals could quickly become a short-term pleasure. That would be pitfall no. 5.

The drier the air however, the better the visibility and the higher the cloud ceilings. The humidity differences between the thermal and the surrounding area are now all the greater, and with them the density differences that make thermals possible in the first place. At the latest from about 2000 meters cloud base upwards, this becomes noticeable also for us glider pilots by clearly better climb rates. Even more, the increasing humidity difference with altitude ensures that the lift can even increase with altitude. With a correspondingly high cloud base and only about 1 - 3/8 cumulus clouds, we may experience fantastic conditions. Under certain circumstances, the dials on our instruments can even hit their limits.

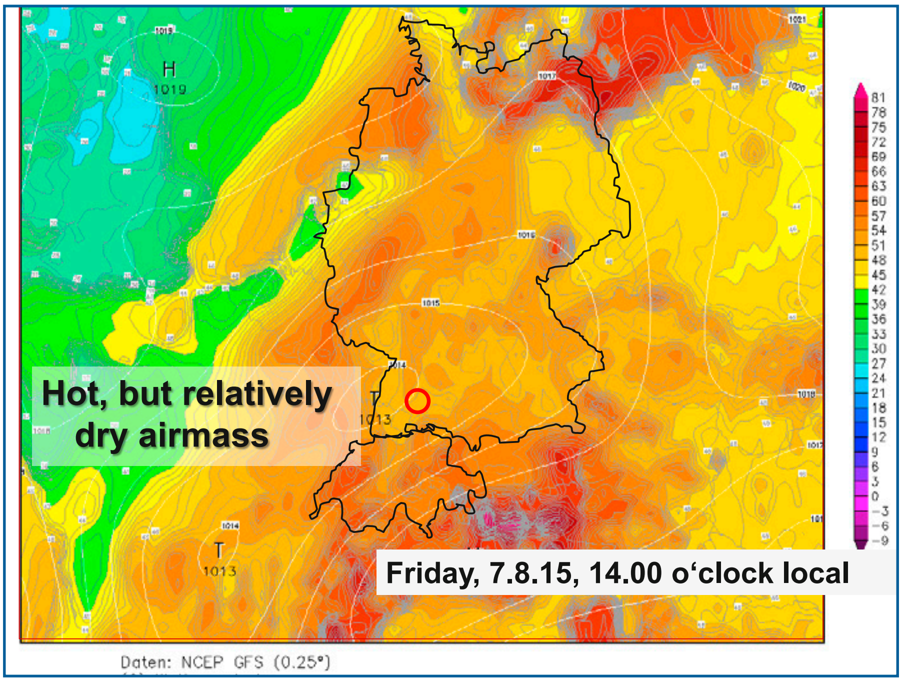
Trap 6

But be careful! Woe can betide anyone who flies down too low in expectation of a good climb under such dreamlike conditions. He will have difficulties to find a good climb again. Under certain circumstances, he (or she) may even have to drop water ballast in order to "survive" at all. This would already be trap number 6. A practical example from the World Cup 2018 in Hosin/Czech Republic can be found below.

Trap 7

At this point, I would like to comment on the (weak) inversion shown in the graph (figure 1) as a yellow triangle. This barrier often develops as a subsidence inversion under the influence of high pressure and then reliably seals off the convection area towards the top. The good news: Annoying overdevelopments and showers are thus prevented. At the same time, the high-pressure influence ensures unhindered insolation, which in turn favors the development of thermals.

Picture 3 The air mass weather chart for the 850 hpa pressure level overlaid with the ground weather map (white lines)



However, especially in warm air masses with a high cloud base, an inversion can be a hindrance also. Especially strong inversions are often formed below 2500 meters above MSL and thus prevent the formation of cumulus clouds with high ceilings in dry air. However, it is precisely these cumulus clouds that we need for warm air thermals to develop their full potential. So, contrary to all expectations, a lower air pressure and thus a weak (or no) inversion is a prerequisite for good gliding weather in warm air masses. The normally advantageous high-pressure influence then becomes trap number 7.

Fortunately, especially in central Spain (Fuentemilanos) or Namibia (Bitterwasser, Kiripotip, Pokweni, Veronica etc.) heat lows often develop with weak or not measurable barrier layers in their wake. Even in Germany, we occasionally experience such weather situations. The low humidity of the air, which makes the high cloud ceilings possible in the first place, is then often no longer sufficient to trigger overdevelopments. This eliminates the need for a sufficiently strong inversion layer. Dreamlike gliding conditions then await us despite high temperatures. The picture on the cover, for example, shows cumulus clouds with a ceiling at 5300 meters MSL in Namibia.

Practical suitability

Enough theory for now. Let's take a look at some practical examples. Namibia is a model country for good gliding weather in warm air masses: On December 10, 2014 Alexander Müller flew a quadrangle of 1154 kilometers starting in Pokweni (***picture 2 previous page***). Interesting are especially his barogram and his comment in the OLC.

In Bitterwasser, a take-off is often not possible until the air temperature has risen to 30 °C in the shade. Here Alexander Müller went on course already around 08:20 UTC but did not

Picture 4 View from the slope edge of the Klippeneck to the west.
First developments are visible and above it fields with Alto-Cumulus Castellanus

get above 1000 meters above ground for the first three hours. (The Kalahari plateau is about 1300 meters above MSL). Only when the updrafts reached high enough to form cumulus clouds, the thermals suddenly “exploded”. Such weak initial conditions are typical for thermals in warm air and correspond to the above-mentioned traps no.1 and 4. Similar conditions also presented themselves at the Klippeneck competition in 2015. The following figure shows a very hot air mass (map of 850 hpa Aeq.Pot.T. in degrees C and ground pressure overlaid in white). The isobars show a weak local low over the competition area with a core pressure of only 1014 hpa (***picture 3***).

Around noon the first cumuli formed (***picture 4***, but please do not confuse the small wisps with the AC castellanus above. As precursors of thunderstorms, they played a decisive role later).

The field could be towed around 01:00 pm at the earliest. Nevertheless, for the Open Class, for example, tasks over 356 kilometers were announced. The winner of the day, Markus Gäumann, started his race not before 4 pm local time and came back with the best average speed

of all Klippeneck competitions up to that time: 151 km/h (***picture 5***).

How was that possible? In the Black Forest, well lined up cumulus clouds formed little by little. Their base rose to over 2900 m MSL in the late afternoon and the climb values were often at vario stop! But only as long as one stayed in the upper third of the convection area.

The 18-meter-class, on the other hand, had the misfortune to have a local thunderstorm develop from one of the Alto-Cumulus Castellanus fields on their track. Its shielding forced almost all pilots to “land outside” for lack of thermals. Only two exceptional talents from Belgium, Dennis Huybreckx and Jeroen Jennen, managed the feat of getting around the thunderstorm. And then only on their third attempt. Since they had to start again relatively low each time, their barograms provided a fascinating climb profile of the air mass (***picture 6***).

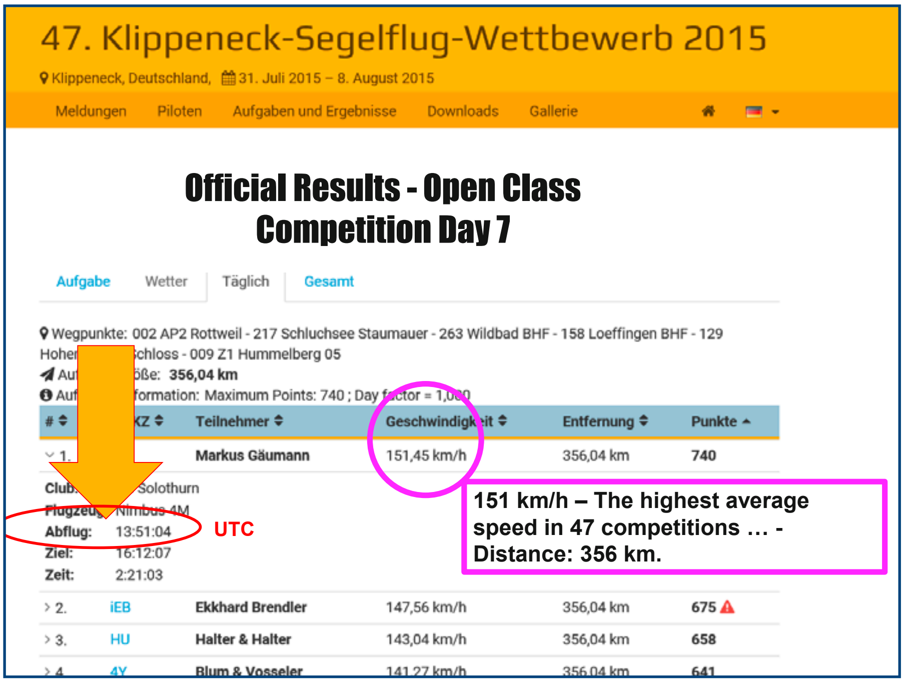
The climb profile of the third attempt (V.3), for example, shows very nicely how the climb rates improved with altitude: starting from 0.73 m/s, they quadrupled to 3 m/s at the top. And this at about 06:20 pm local time.

Trap number 5 in action

Another example illustrates the influence of warm air and the increasing climb rates with altitude. It is about a day at the World Cup 2018 in Hosin in the Czech Republic. The air mass is dry and hot with more than 30 °C measured in the shade. The cloud base is close to FL 100. Two excellent pilots fly the same task almost at the same time. The later winner of the day (blue) and a follower (red), a former world champion.

The next picture shows the situation shortly before the first turn point at about 04:40 pm local time (***picture 7***).

The corresponding altitude graphs in the next figure show their different climb rates (***picture 8***).



47. Klippeneck-Segelflug-Wettbewerb 2015

Klippeneck, Deutschland, 31. Juli 2015 – 8. August 2015

Official Results - Open Class
Competition Day 7

Wegpunkte: 002 AP2 Rottweil - 217 Schluchsee Staumauer - 263 Wildbad BHF - 158 Loeffingen BHF - 129 Hoher chloss - 009 Z1 Hummelberg 05

Au öße: **356,04 km**

Auf formation: Maximum Points: 740 ; Day factor = 1,000

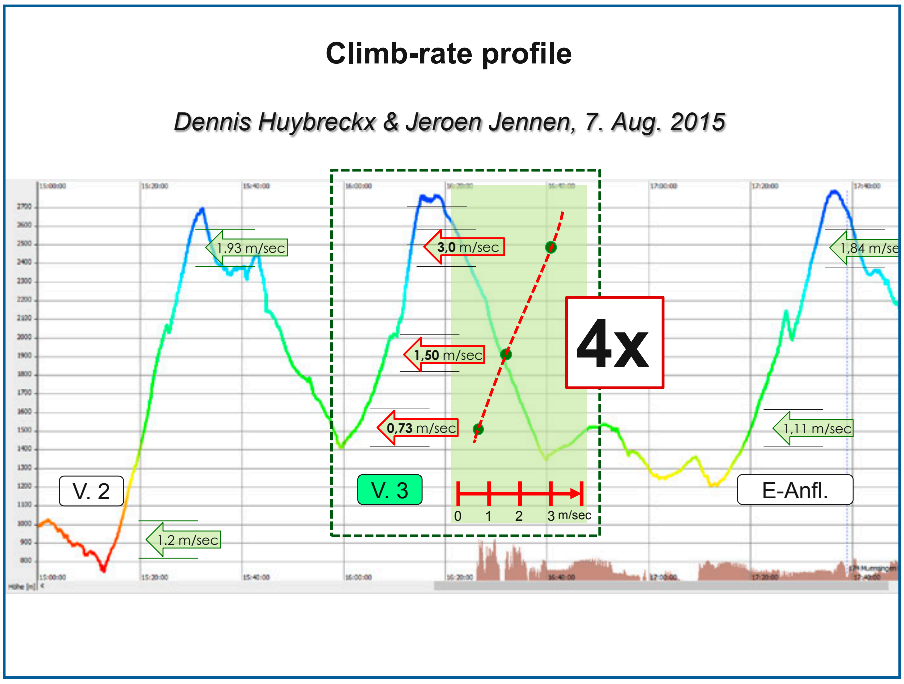
#	KZ	Teilnehmer	Geschwindigkeit	Entfernung	Punkte
1.		**Markus Gäumann**	151,45 km/h	356,04 km	**740**
2.	iEB	**Ekkhard Brendler**	147,56 km/h	356,04 km	**675** ⚠
3.	HU	**Halter & Halter**	143,04 km/h	356,04 km	**658**
4	4Y	**Blum & Vosseler**	141,27 km/h	356,04 km	**641**

Club: Solothurn
Flugzeug: Nimbus 4M
Abflug: 13:51:04
Ziel: 16:12:07
Zeit: 2:21:03

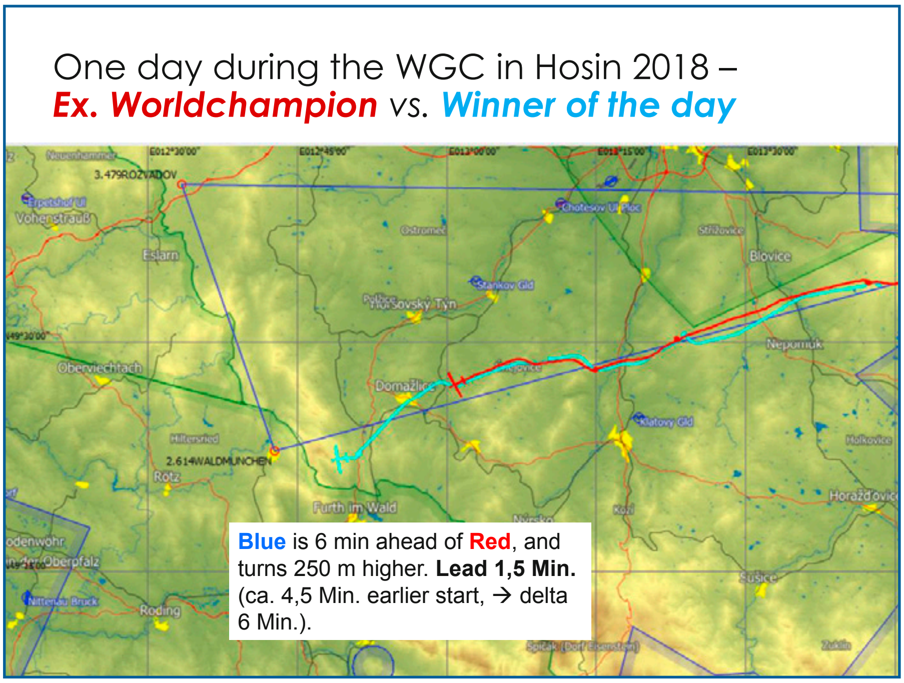
UTC

151 km/h – The highest average speed in 47 competitions … - Distance: 356 km.

Picture 5 Daily scores of the Open Class



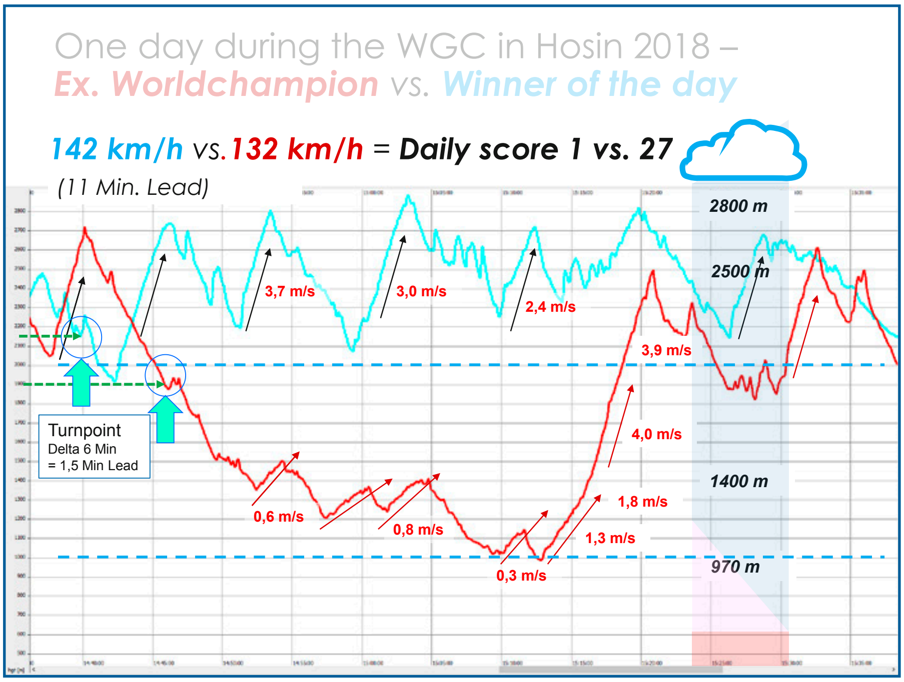
Picture 6 The barogram of Dennis Huybreckx and Jeroen Jennen during their attempts to fly around the thunderstorm



One day during the WGC in Hosin 2018 –
Ex. Worldchampion vs. **Winner of the day**

Blue is 6 min ahead of **Red**, and turns 250 m higher. **Lead 1,5 Min.** (ca. 4,5 Min. earlier start, → delta 6 Min.).

Picture 7 Flight tracks and situation just before reaching the first turnpoint



One day during the WGC in Hosin 2018 –
Ex. Worldchampion vs. **Winner of the day**

142 km/h vs. **132 km/h** = **Daily score 1 vs. 27**
(11 Min. Lead)

Picture 8 Very different climb at different altitudes

The later winner of the day stays in the upper third of the convection area and "pulls" mainly thermals at 3 m/s. The pursuer, on the other hand, pushes deeper and deeper in order to make the best possible use of the working height in the best possible thermal. But it never came. Finally, he must engage 1.3 m/s in the lower third. Only at higher altitudes does the climb rate improve again, catapulting him to the base with just under 4 m/s. Result: The winner of the day (red) finishes the task with a 140 km/h average speed. Blue "only" achieves a 130 km/h. A one-minute lead at the start of the episode turned into eleven minutes by the time he crossed the finish line. For the follower, this meant 27th place at the end of the day and thus a score deficit that can no longer be made up at a world championship.

Known how

What do we learn from this? Warm air masses are sometimes better than their reputation. You just have to know what's important. And you should know the typical pitfalls and – if possible – avoid them:

- Thermals start very late and are rather bubbly torn at the beginning, but
- climbing improves significantly with cloud development,
- especially when high cloud ceilings are expected, lift is lousy close to the ground (water ballast!) but gets increasingly better with altitude. Under such circumstances, dream-like conditions can be expected.
- Shielding and high cloud coverage, on the other hand, have a negative effect on climb rates.
- The mountainous area offers distinct advantages over the plains.

Warm air masses with their chances and risks prove once again the thermal theory. Please note: The sun is the engine of our sport, but humidity is the soul of thermals! ♦