PRACTICAL INTERPRETATION OF RASP SOUNDINGS

Jean Oberson, www.soaringmeteo.ch, © February 2010.

Emagram (better referred to SkewT thermodynamic diagram) is actually a simple xy graph. The x axis represents the values of temperature T and temperature dew point Td (i.e. humidity) and the y-axis the altitude in pressure and distance units. The x axis is tilted downward so that the isotherms, perpendicular to x, are inclined to the right. See Figure 1. On a real Emagram, the x-axis is not represented, i.e. the grey area is hidden. Only the isotherms and isobars as well as 3 other kinds of line, which I shall not speak about in order not to complicate the matter, are shown. The red curve of T and the blue one of Td are then placed on this graph and constitute the aerological profile of the atmosphere in precise place and moment like a snapshot of the local atmospheric state. Recall that Td is the temperature at which we must reduce the parcel of air for condensation to occur in liquid water. Td can be equal (saturation-condensation) or smaller than T but never greater. At a determined altitude, the difference between T and Td is called the “spread”. Smaller is the spread means damper is the air and more there is a risk of clouds and/or rain. The two curves can merge (air saturated with moisture) on a more or less thick vertical portion but never the blue curve is on the right of the red curve. Emagram is a kind of useful 2D slide rule for meteorologist. You will understand the following text better if you read about CBL (Convective Boundary Layer) before (see the document about CBL in the same website www.soaringmeteo.ch).

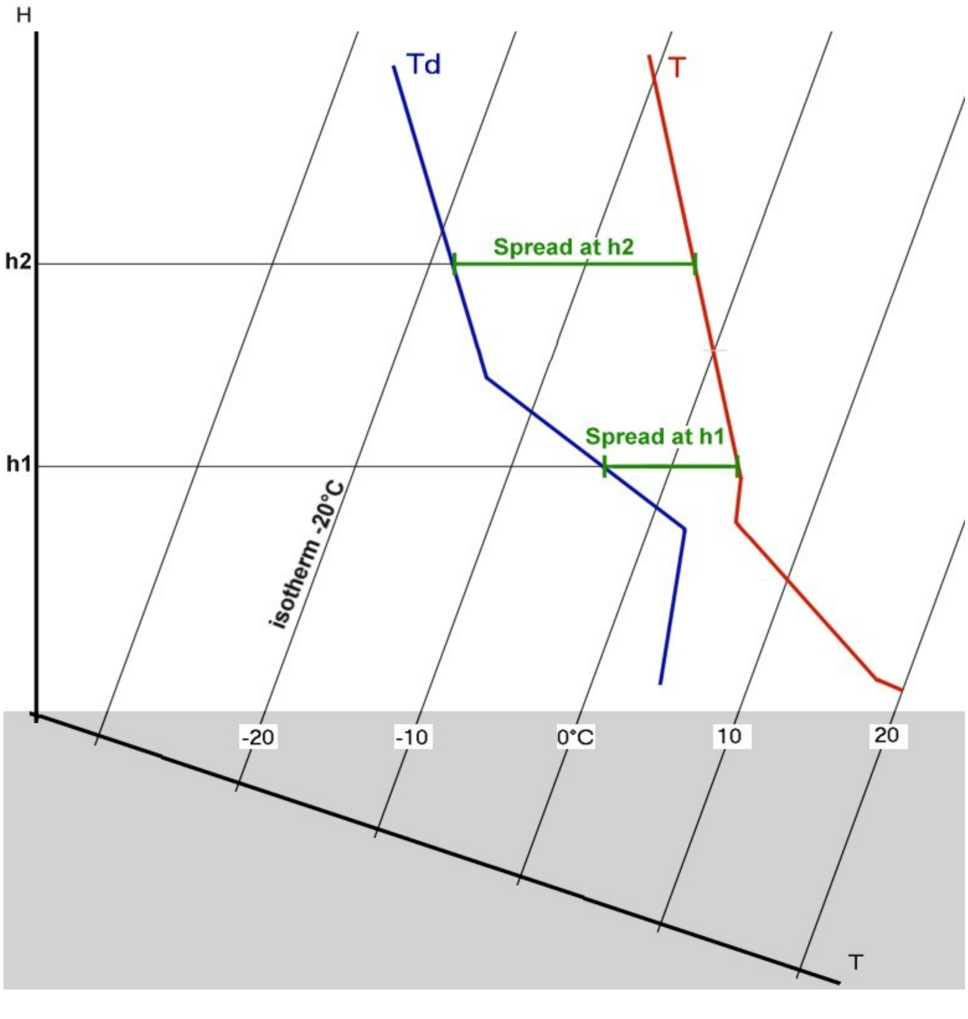

Figure 1: principle of an emagram. Only some isotherms and isobars h1 and h2 are shown.

The classical method used to forecast the top of thermals and the cumulus basis is called the "thermal index". There is many website speaking about this method. I shall not insist here because I shall not use it here and because the daily forecast practice using it is disappointing by its inaccuracy. There are two main reasons for this failure:

1. You have to use the midnight radiosounding profile of a too often remote location from your flight site. However, you fly during the following afternoon i.e more than 12 hours later. Meanwhile, in addition to the normal convective heating, the atmosphere can evolve and no longer have the same structure as midnight e.g. because an advection or a subsidence may happen just above the CBL.

2. The atmospheric structure over the flat land of the radiosounding location is mostly very different from that over the flight area, usually the mountains.

Unlike the radiosounding, which provides the **measured** aerological profile at midnight and at noon UTC above a few scarce specific locations, RASP **calculates** (**forecast**) the aerological profile by complex differential equations for each model point at various time. It takes account of topography and land cover at mesoscale as well as the overall evolution of the atmosphere. RASP can therefore provide the computed probable mesoscale profile on the area of your flight and during your flight's time. Moreover, you will soon see that it is somewhat paradoxically more simple and immediate to interpret a model's computed profile than to tediously trace the "thermal index" with a measured radiosounding on an emagram.

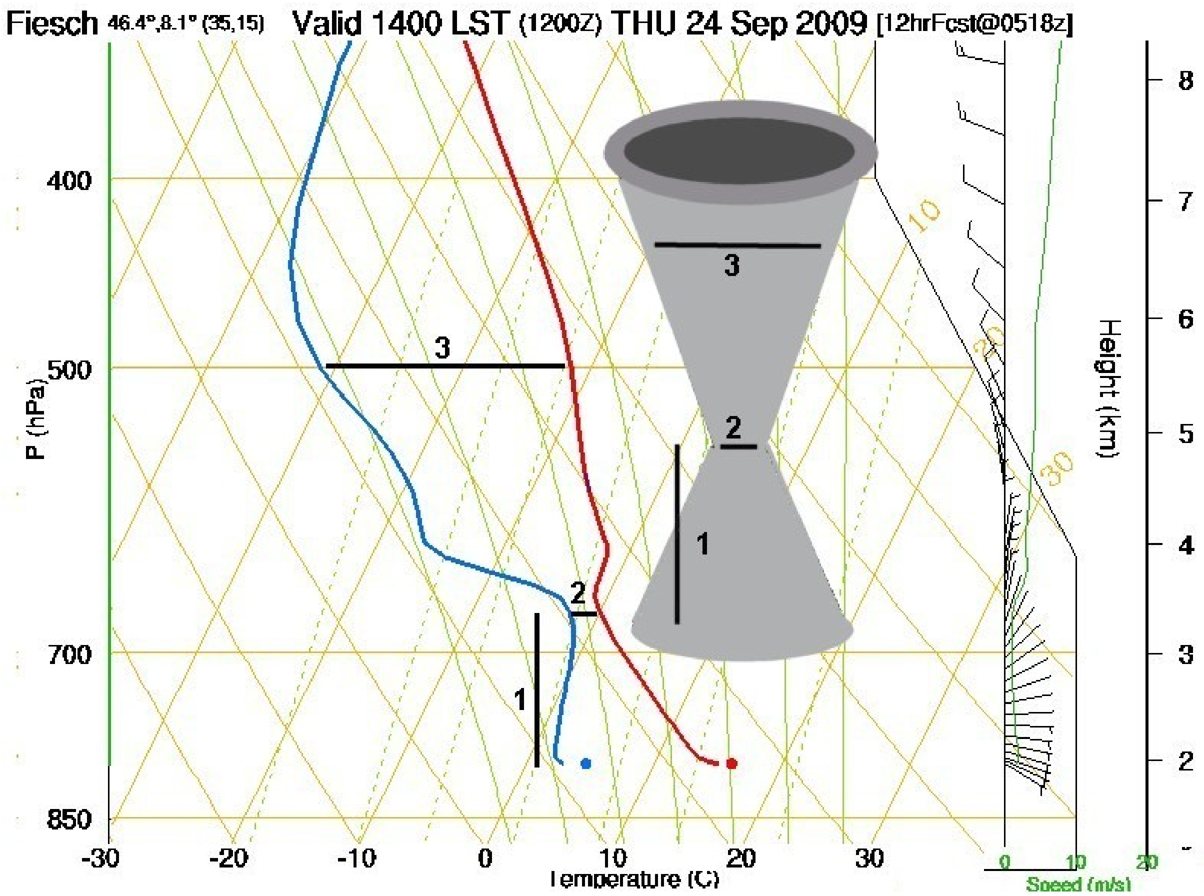

Figure 2: ideal vase-shaped aerological profile. Three easy parameters should be remembered.

In daily routine practice for flying conditions forecast, the use of RASP sounding should therefore replace the method of "thermal index" whose simplistic methodology cannot rival the complexity and the quantity of model calculations. Certainly, despite their high-technology, models are a coarse schema of the actual micro-infinitesimal atmosphere, but there is no better today.

Let's consider an example of ideal profile on the figure 2. Save this mantra in your mind! It represents the perspective of good flying conditions, whatever the region. With a little practice you should recognize it at the first glance. The red T and blue Td curves outline a vase with a narrow neck and both upper and lower conical large mirroring parts. The lower part represents the convective boundary layer (CBL). At this level the T and Td gradients (lapse rate) are about 1 °C/100m (adiabatic lapse rate) and 0.2 °C/100m (saturated humidity mixing ratio lapse rate) respectively. The neck is narrow, corresponding to the top of the CBL. Just above it, there is often but not always a very stable layer (isothermal or T inversion) associated with a drop of air moisture (sudden spreading to the left of the blue Td curve). The upper part of the vase corresponds to the troposphere above the CBL where the temperature lapse rate is about 0.5 to 0.8°C/100m but never reaches 1°C/100m. Near the ground surface there is often a thin superadiabatic (more than 1°C/100m) layer due to the overheated air in contact with the sunned ground. It is on this only occasion we meet superadiabatic lapse rate. Three mensurations are to remember:

1. The thickness (height of the lower part of the vase) of the CBL should be as large as possible. 1500 m or more seems favourable. The convection will then have a good vertical extension and velocity.

2. At the neck i.e at the top of the CBL, the spread (narrow diameter of the neck) should empirically be about 2-4 °C to get nice and high cumulus inviting to soar. Lower values may lead to horizontal clouds overdevelopment. Higher values may lead to blue thermals.

3. Still above, a greater spread than 10-15°C (large diameter of the upper part of the vase) prevents the development of high clouds and / or vertical cumulus congestus or cumulonimbus.

It's no more complicated than this in practice. But we must consider the prediction of CBL depth and top by RASP as a mesoscale tendency. In general, the average soaring ceiling is slightly lower than the expected top of the CBL because at this altitude the thermals do not usually become strong enough to offset the descent rate of the glider. On the other hand, not all the thermals do come up on the CBL's top and if you are in a very local "blue hole", not detectable at mesoscale, you will not meet your good expected thermal. Conversely, above the narrow and high peaks which are not "seen" by RASP (peaks of small-scale topography which is not resolved by the model's smoothed grid-averaged topography), the ceiling can be very locally higher than predicted.

I should also highlight a significant advantage of the mountain's thermals compared to the flat lands. The mountain's thermals take their heating source then slip on the sunny slopes below the ridge, finally detach from it and climb freely up in the CBL. Their vertical extent are consequently quite larger than the thickness of the CBL above the ridges. In plain, thermals detach from their sources and therefore do not have this additional extension.

Here are some real examples. Aerological profile on the figure 3 is very close to the ideal case of the figure 2. The sky's picture is taken at approximately 14:00 CEST (Central European Summer Time) in the region of Gstaad, swiss western Prealps. Cumulus, attractive and high, invite to soar. The profile is forecast from early morning, for the same region and at the same time as the picture. In Figure 4, the webcam image shows the overcast sky of the swiss western Riviera on September

15, 2009 at 13:15 CEST. The forecast profile of the region at 14:00 highlights a portion of humid air between 2500 and 4000 meters. In Figure 5, the thickness of the CBL (first parameter) is about 1000 m in the central swiss western Alps (Valais) region around 17:00 CEST, on September 23, 2009. The extension of convections should be thus not very important. In addition, at the top of the CBL, the spread is about 5 °C (second parameter). The cumulus clouds are so infrequent and thermals probably most often weak and blue. Finally, on September 30, 2009 at 14:00 CEST in the region of Gstaad, the webcam shows a cumulusless sky but with a few thin cirrus. The corresponding profile shows some moisture in the upper troposphere (third parameter). The spread at the top of the CBL (second parameter) is quite large (about 6 °C), which explains the absence of cumulus despite a significant vertical extent (about 1500 m) of the CBL (first parameter). We can therefore expect blue thermals there at this time.

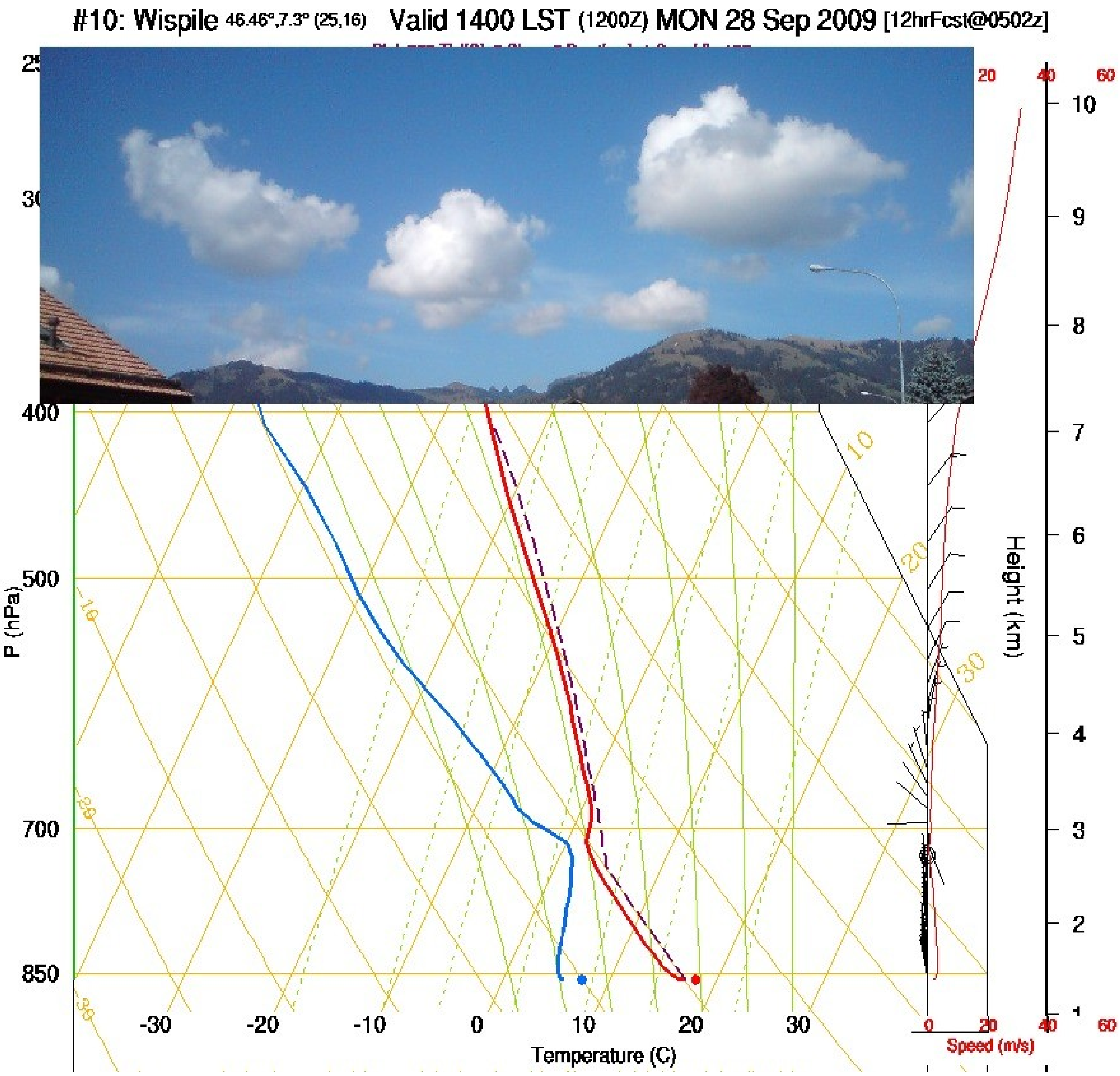

Figure 3: Example of an ideal day for thermal soaring flight on September 28, 2009, at approximately 14:00 CEST in the prealpine region of Gstaad.

On RASP 's emagrams, two other very useful information can be still noticed. On the right border, there is the speed (thin curve in m/s, green or red depending on the scale of speed) and the direction (arrows) of wind at various altitudes. On the left side, there is sometimes a more and less vertical thin black curve (e.g. Figure 4) showing the likely fraction of cloudiness on a vertical portion of the troposphere. The green curve beside the black one provide some rain tendency.

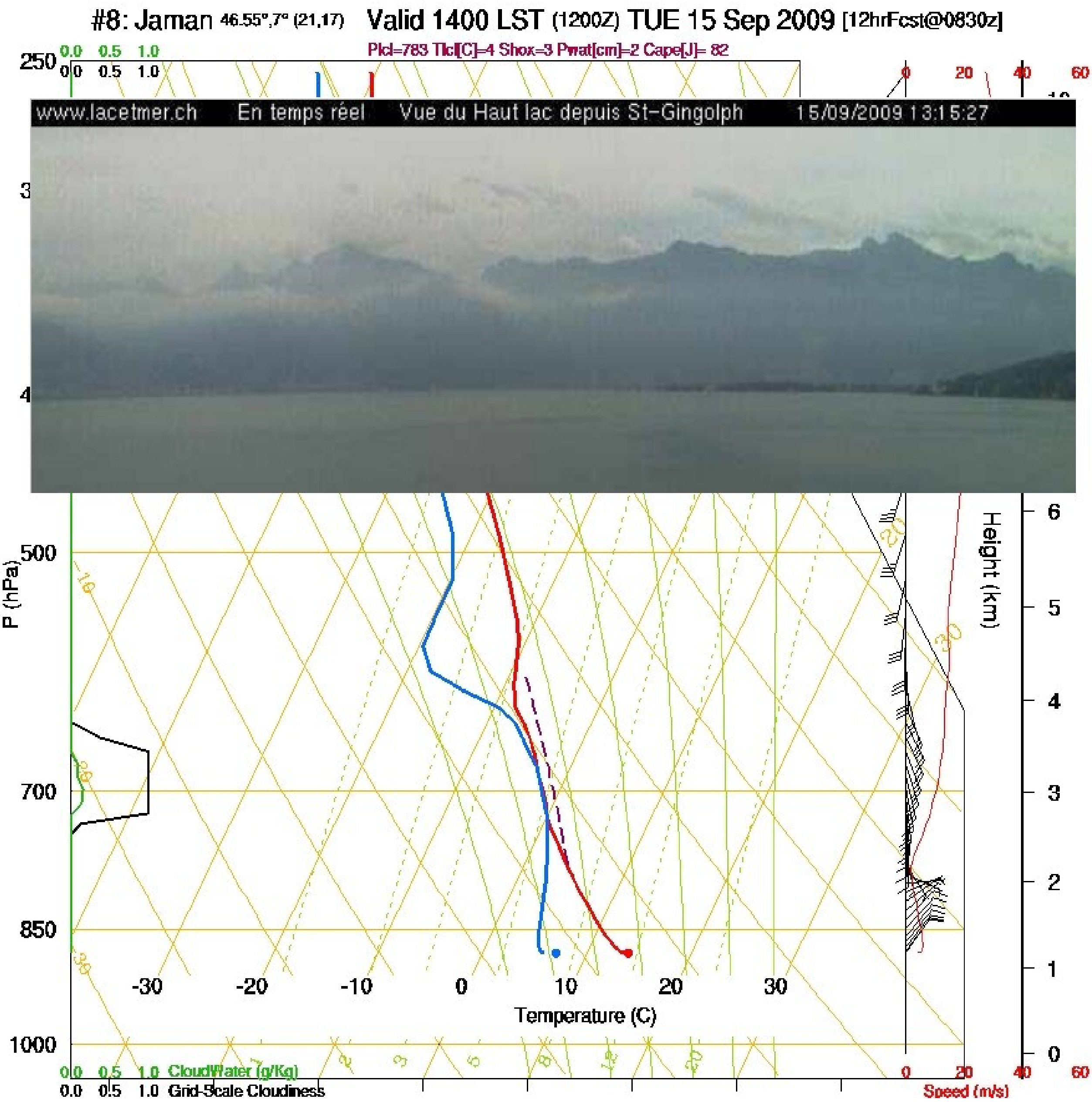

Figure 4: Example of a damp and cloudy day, September 15, 2009, at approximately 14:00 pm CEST in the region of the swiss western Riviera. Note on the left side, at around 3000m (700 hPa), the black curve indicates 100% cloud cover.

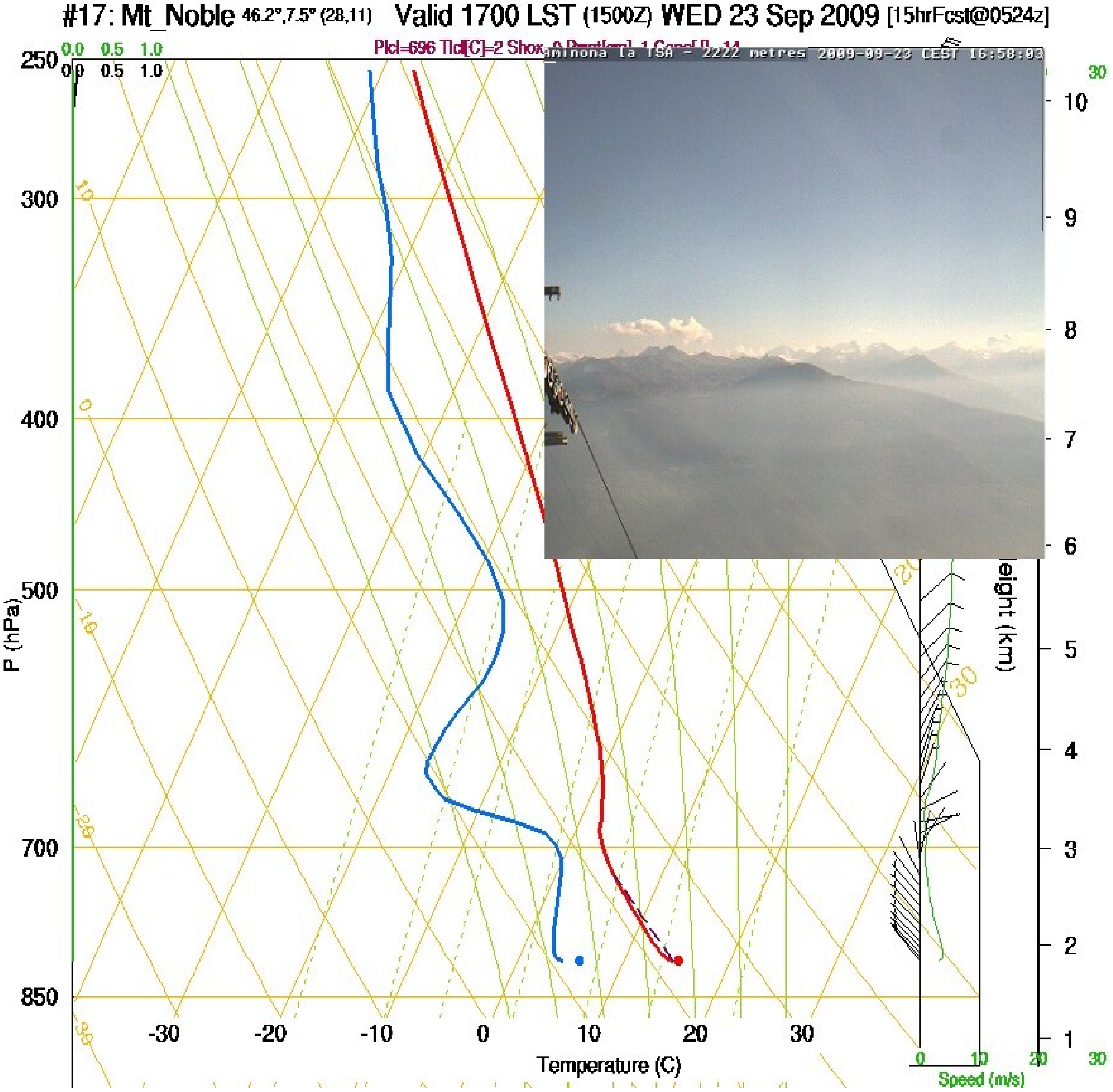

Figure 5: Example of a day with probably small blue thermal, September 23, 2009, around 17:00 CEST in the central alpine region of Valais.

When vertical wind shear is strong (due to wind varying with height in direction and in speed), or convection weak, the BL top then results from small-scale mixing caused by wind shear rather than from usable thermals. In such cases the "BL height" will not be reached, since small-scale eddies cannot support a glider. Therefore such a BL height has little relationship to the height that a glider will reach, though smoke released from the ground would be expected to eventually reach that height. On the other hand, for safe and good flying conditions in the Alps, it is important that the winds are weak and homogeneous inside the CBL. For example (fig. 6) there is a sharp wind change at the upper third part of the CBL with west wind below and south winds above, leading to a vertical wind shear. So we can expect in this case turbulent and a disorganized blue thermals.

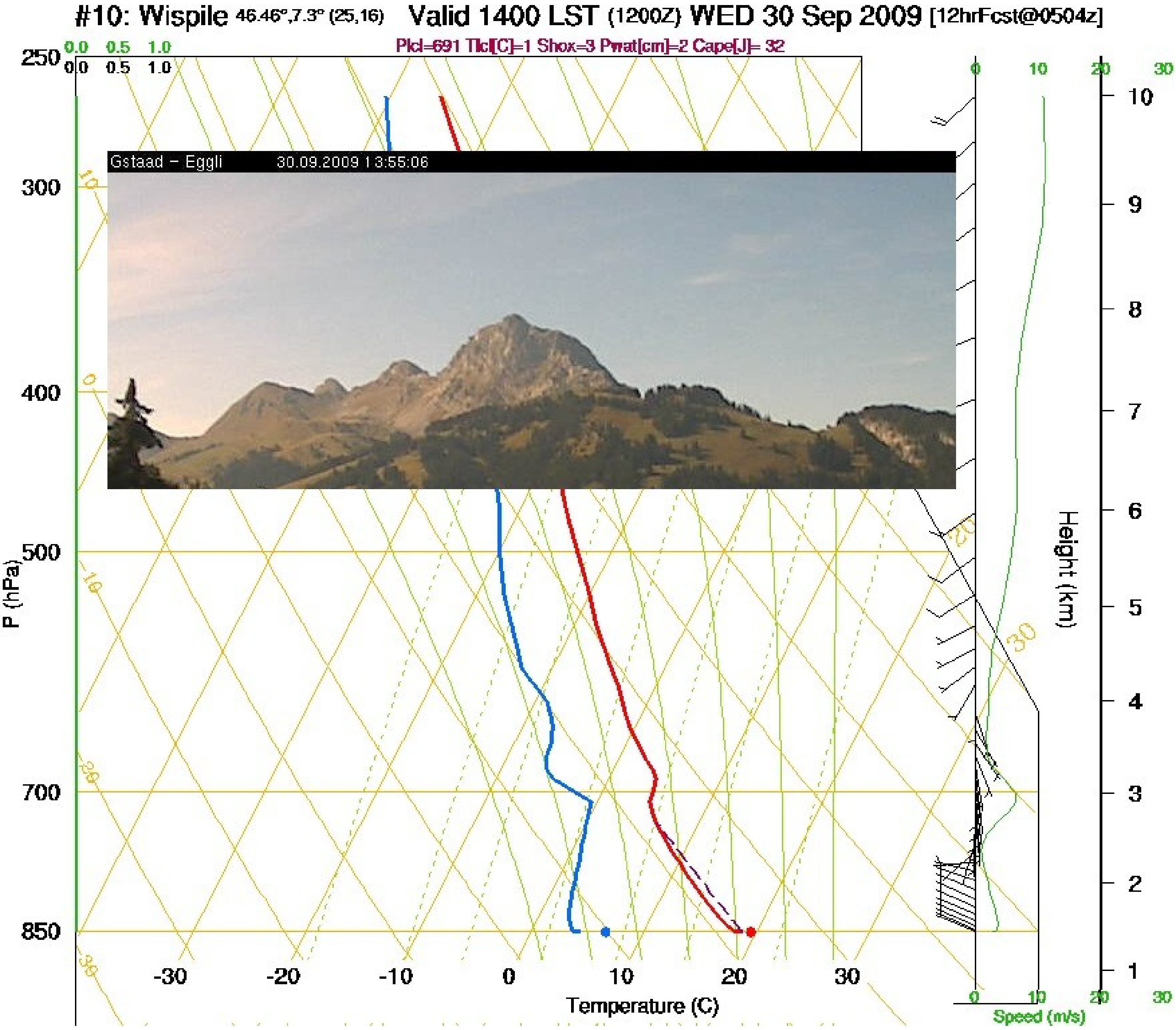

Figure 6: Example of a day with blue thermal and some small cirrus, September 30, 2009, at approximately 14:00 CEST in the region of Gstaad. At about 2500 m, there is a sharp wind direction change (from W to S) which can disorganizes thermals and also create unsafe turbulences for paragliders.

Finally, note that the name of a profile's location does not mean that it is the aerological profile over this location exactly. It does rather mean that it is the mesoscale profile tendency over the flying area (especially on the slopes and the ridges and not over the valleys of this area) around this location !