meteoblue AIR Sounding
Tephigrams for meteorologists

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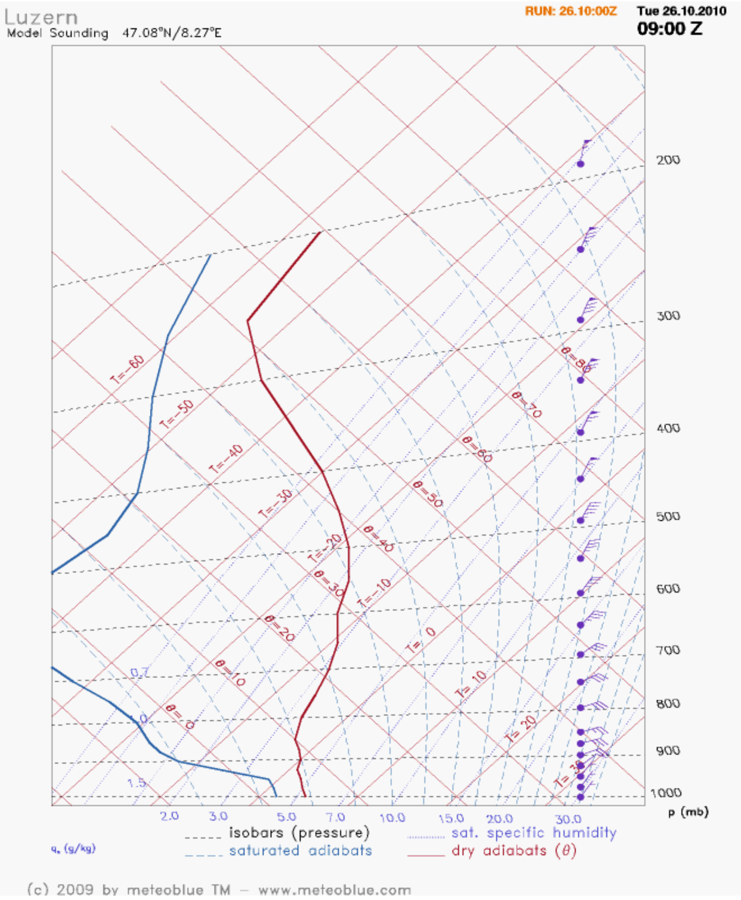

Figure 1. Tephigram produced by meteoblue AIR Sounding.

1 Content

1.1 Overview

meteoblue AIR **Soundings** are virtual tephigrams. Simulating the measurements of a weather balloon from ground to stratosphere level (pressure levels 1013 to 100 hPa, about up to 16km altitude, depending on latitude), they show atmospheric layering in terms of tem perature, wind and moisture. Para meters shown are **temperature**, **dew point temperature,** and **wind speed and direction** on pressure levels 1013 to 200 hPa at a chosen hour. Available forecast intervals are 1 hour within the meteoblue forecast domains and 3 hours outside.

The diagrams are useful for meteorologist for whom real or virtual soundings are a familiar fore - casting tool. They are also useful to compare forecast atmospheric layering to measurements.

1.2 Chart elements

The tephigram contains the following forecast parameters:

1. red continuous line (environmental lapse rate) = air temperature ;
2. blue continuous line (blue curve) = dew-point temperature ;
3. wind symbols (grey circles with barbs) = wind speed and direction.

The chart has the following dimensions (Axes):

1. Black dashed lines (horizontal, slightly dipping to the left) = pressure levels (1000 to 200 hPa);
2. Red fine line (from upper right to bottom left) = temperature levels.
3. Red fine line (from upper left to bottom right) = dry adiabates or potential temperature.
4. 3.Blue dashed curves (bottom to top) = saturated adiabates (for condensing ascent of air parcels)
5. Blue fine transverse line (from upper right to bottom left) = saturated specific humidity (q= g/kg) for the calculation of convection and cloud formation.

The measured and simulated parameters shown as continuous lines on the axis of pressure and temperature can be used for calculations of dry adiabates, moisture and specific energy (see Section 3).

1.3 Availability

meteoblue **Soundings** are available through point+ for any place on earth.

2 Parameters & conversions

2.1 Pressure levels & altitude

Pressure is provided in hPa (hectoPascal; hPa = millibar mBar). In a tephigram, altitude is expressed as standard pressure levels from 1020 to 100 hPa, as defined by ICAO (Inter national Civil Aviation Organisation), and marked by horizontal black dashed lines. The conversion of altitude into pressure or vice-versa for standard atmospheric conditions is shown in Figure 2.

Altitude is given in kilometres above sea level (km asl). The actual altitudes can be calculated from the chart for transformation of air pressure into altitude (Figure 3).

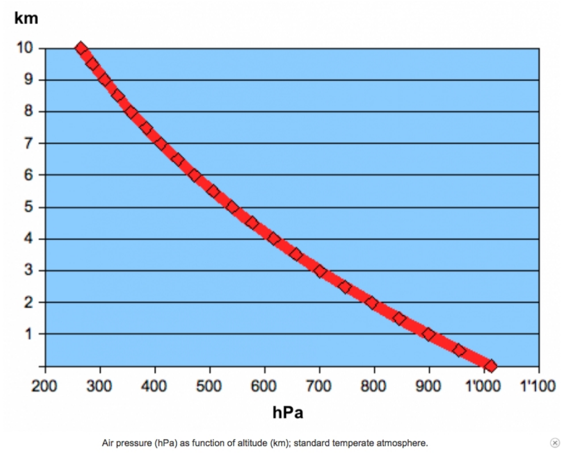

Figure 2. Air pressure (hPa) as function of altitude (km), for standard atmosphere.

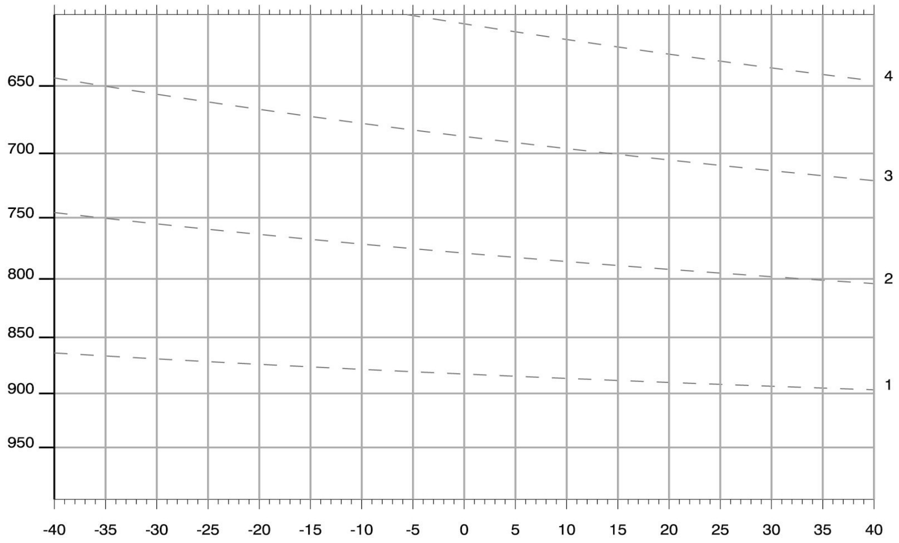

Figure 3. Altitude (km, on right hand scale) as a function of air pressure (mBar, left hand scale) and temperature (°C, horizontal scale).

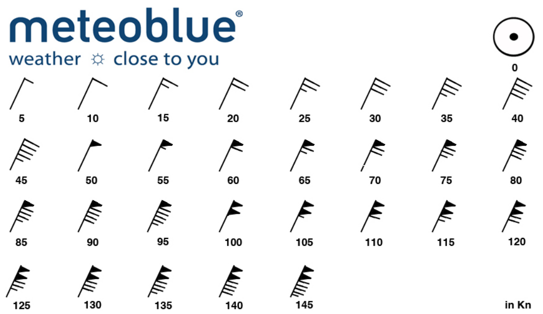

Figure 4. Wind barbs (symbols) indicating the speed (here given in knots) and cardinal directions (N, S, E, W) from which the wind is blowing.

Table 1. Conversions between common units of speed. (Values in **bold face** are exact.)

	m/s	km/h	mph	knot	ft/s
1 m/s =	**1**	**3.6**	2.236936	1.943844	3.280840
1 km/h =	0.277778	**1**	0.621371	0.539957	0.911344
1 mph =	**0.44704**	**1.609344**	**1**	0.868976	1.466667
1 knot =	0.514444	**1.852**	1.150779	**1**	1.687810
1 ft/s =	**0.3048**	**1.09728**	0.681818	0.592484	**1**

2.2 Wind speed and direction

Wind speed and direction at different levels is shown on the vertical axis (to the right of the diagram) with symbols following the international WMO convention.

Wind symbols show the wind for the hour indicated. The line drawn from the circle represents wind direction. The “flags” (short angled lines or triangles) re present speed. The more flags, the stronger the wind: 1/2 line is 0.5 knots (9 km/h), 1 line is 10 knots (18 km/h), a triangle is 50 knots (90 km/h). An overview of wind symbols is shown in Figure 4. Conversions between common units of speed are given in Table 1.

2.3 Altitude

The high resolution meteoblue forecast models take into account the earth’s topography to calculate local surface effects as well as adjusting forecasts to particular locations (p☼int technology), and is determined by the size of the model "grid cell" .

The "grid cell" size determines the area for which the tephigram is valid: the diameter is equivalent to one third of the corresponding rainSP☼T radius (see Pict☼cast) and may vary between forecast domains. Check a location's pict☼cast for the rainSP☼T radius.

The meteoblue AIR Sounding tephigram is not adjusted to reflect the average elevation of a grid cell: it may therefore display data for pressure levels which are actually below the surface at the selected location (e.g. provide a temperature at the 900 hPa level, ~1 km altitude, in an area where average elevation is 3 km). These data can still be useful, for example if there is a sub-scale feature such as a small deep valley in the area. If there is no such low-laying area in the "grid-cell", these lower level data should be disconsidered.

If you need the weather forecast for a specific location on the ground, consult the local p☼int forecast (pict☼cast, mete☼grams).

3 Interpretation

3.1 History

"Tephigrams" and related "Emagrams" were first produced as diagrams to show the results of soundings, the measurements recorded by weather balloon ascents. These balloons are launched from the earth surface and carry measurement instruments for temperature, humidity, pressure, and wind. They rise rapidly after launch and usually reach 10-15 km altitude before exploding due to the low surrounding pressure. The measurements are transmitted to ground stations by radio and used to plot tephigrams, make weather forecasts, and feed weather models.

Tephigrams are amongst the most precious instruments which meteorology has, since the dynamics of the atmosphere are strongest between 1 and 5 km elevation and can neither be well measured with ground weather stations nor with satellites. Tephigrams therefore provide the key information which allow an interpretation of the temperature layering, the moisture and the wind speeds at different altitudes.

Despite their high value for meteorology, regular tephigrams are produced at less than 1000 locations worldwide, corresponding to less than 5% of the number of points for official weather stations. The main reasons are the high cost of sounding flights, the logistic difficulty to conduct them away from research centres, and some limitations in crossing reserved air space.

The meteoblue AIR soundings simulate a weather balloon ascent and provide the resulting tephigram. They can be read and interpreted exactly like a real measurement. Because many meteorologists and pilots are familiar with them, meteoblue offers sounding information for any place on earth.

3.2 Application

Tephigrams are complex diagrams, allowing users to graphically analyse the vertical dynamics of the atmosphere. They can be used to predict

- time of onset of thermal activity
- trigger temperature for thermals
- strength of thermals
- whether clouds will form or not
- altitude of cloud base
- altitude of cloud tops
- Atmospheric stability
- Convective parameters
- And much more

People used to tephigrams can thereby quickly assess the predicted local state of the atmosphere (stability, tendency to form cloud, etc.).

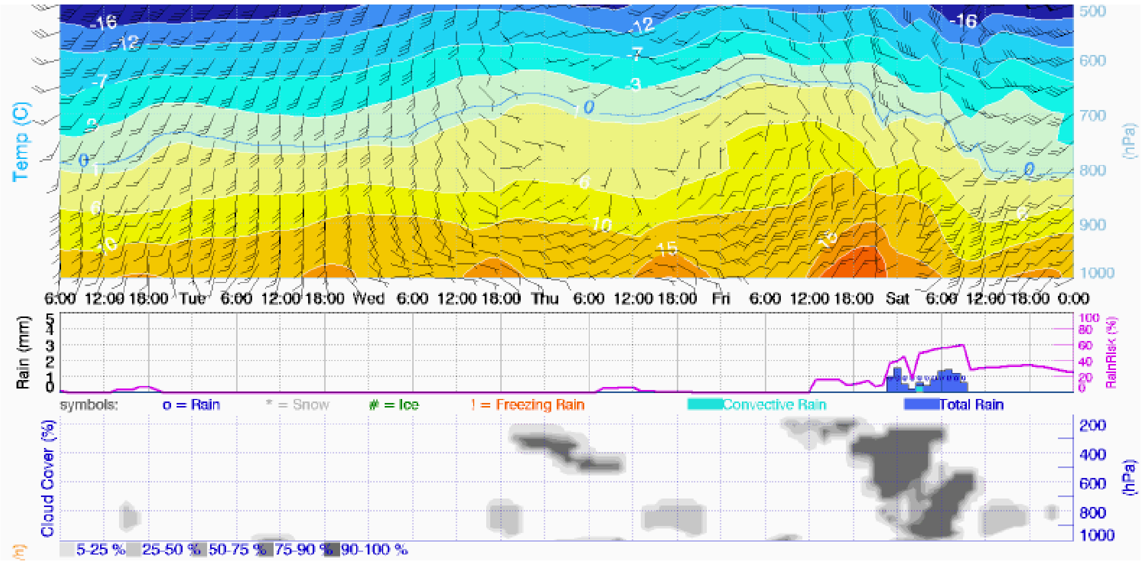

Figure 5. Meteogram showing weather development with passage of a cold front, starting Friday 22:00 UTC (z).

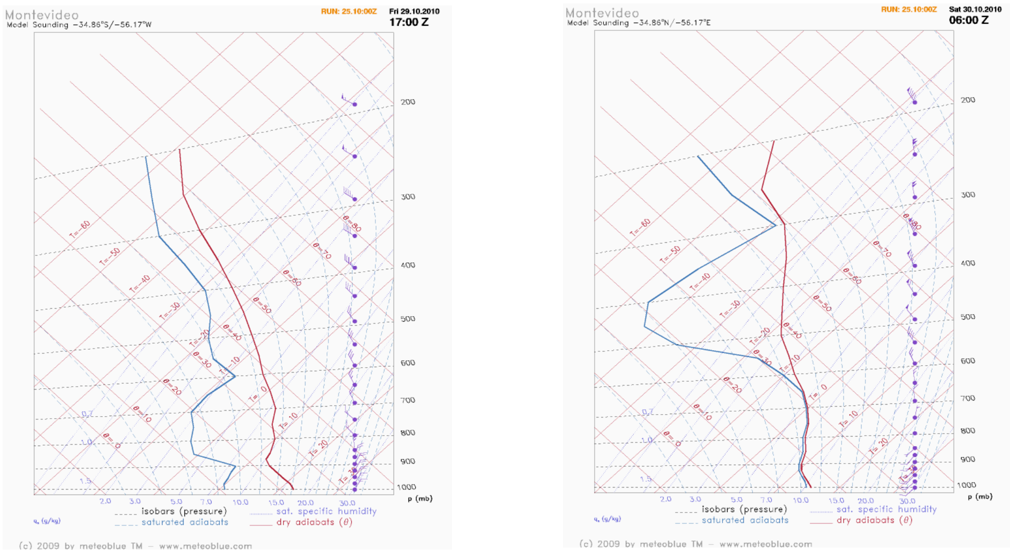

Figure 6. Tephigram before (Fri 17z) and after (Sat 17z) the passing of the cold front.

3.3 Limitations of tephigrams

Tephigrams provide information for the vertical dynamics of the air. For periods of low wind speeds, the vertical dynamics typically dominate the weather, i.e. turbulence, where an when clouds form, etc. Except for wind direction and speed, tephigrams based on measurements give little information of changes in the atmosphere (and to the weather) due to air masses moving into an area.

A forecast model like the ones used by meteoblue can of course provide the full information. With meteoblue AIR Soundings, you can view sequences of tephigrams in 1-hour or 3-hour intervals. These sequences reflect both the vertical and horizontal dynamics of the atmosphere. Figures 5 and 6 illustrate how a sounding changes in response to a passing front.

3.4 Restrictions

When reading meteoblue soundings, it must be considered that these are model outputs designed to support planning. They may, or no some cases not, be close to reality. In case of making decisions with large implications, you must therefore consult local observation data. If no such data exist in the surrounding 10 to 100 km, the tephigram must be interpreted with caution. Measures to avoid risk of deviations between model forecast and reality include:

1. Interpretation based on experience: if you have used tephigrams at a particular location frequently in the past, you probably know under which conditions they correlate best with reality.
2. Frequent comparison to reality: when you make decisions based on tephigrams, compare the actual weather development frequently with the forecast. If the development deviates substantially from the forecast, consider getting new information or changing your plans.
3. Consultation of other media: compare the tephigram output to other weather models. If large discrepancies appear, the weather situation may be(come) unstable.
4. Be cautious in unstable weather situations, such as thunderstorms, large pressure differences, storms, as well as in terrain with large differences in elevation (mountains) or surface properties (land-water, rock-ice) within short distance. Such conditions cause local effects that are not reflected by the data shown in a tephigram.
5. If the observed 2m temperature and humidity at your location correspond to the meteoblue p☼int forecast shown in an air meteogram, your own derivations of cloud base, precipitation etc. will be much less accurate than what the p☼int forecasts predicts, as the meteoblue system considers many more things like turbulence, radiation which is are not possible to include in the tephigram analysis.

If you need help, consult our references, ask a specialist or mail us at info@meteoblue.com, including your question and a description of tephigrams used and situation observed.

4 References

A list of references is shown in Table 2.

Table 2. References for analysis of tephigrams

#	Source [1])	Comment[2])	Level.[3])	.[4])
1.	http://atmo.tamu.edu/class/atmo151/tut/sound/soundmain.html	Step by step tutorial for meteorology students. Easy to follow, with exercises.	Student	
2.	http://www.weatherjackwx.co.uk/tutorials/tut-soundings/tut-snds-01.html	Step by step tutorial for glider pilots, with many application examples.	Glider pilots	
3.	http://rucsoundings.noaa.gov/plot_soundings.cgi?data_source=NAM;latest=latest;start_year=2010;start_month_name=Sep;start_mday=12;start_hour=10;start_min=0;n_hrs=3.0;fcst_len=shortest;airport=;plot=Java-based%20plots;hydrometeors=false&start=latest	Excellent applet giving access to many model soundings, supports interactive interrogation of the sounding	General	
4.	http://meteocentre.com/upper/rs_skewt.php?hist=1&show=0&date=20090221&lang=en&region=fr&stn=06610&hour=00&style=meteocentre	Sounding interpretation explained. Uses wet bulb temperature instead of dew point temperature, though.	General	
5.	http://www.absoluteastronomy.com/topics/Tephigram	Brief explanation of a tephigram; the meteoblue sounding diagrams follow the same layout.	Basic	
6.	http://www.pals.iastate.edu/simulations/Mtnsim/index.html	Great applet simulating ascent of moist air and explaining why Foehn is warm and dry.	Student	
7.	http://weather.uwyo.edu/upperair/sounding.html	Last but not least: measured soundings; few and far between	Student, pilot	

Notes: [1]) Status Oct. 2010. [2]) meteoblue comments. [3]) Target group . [4])