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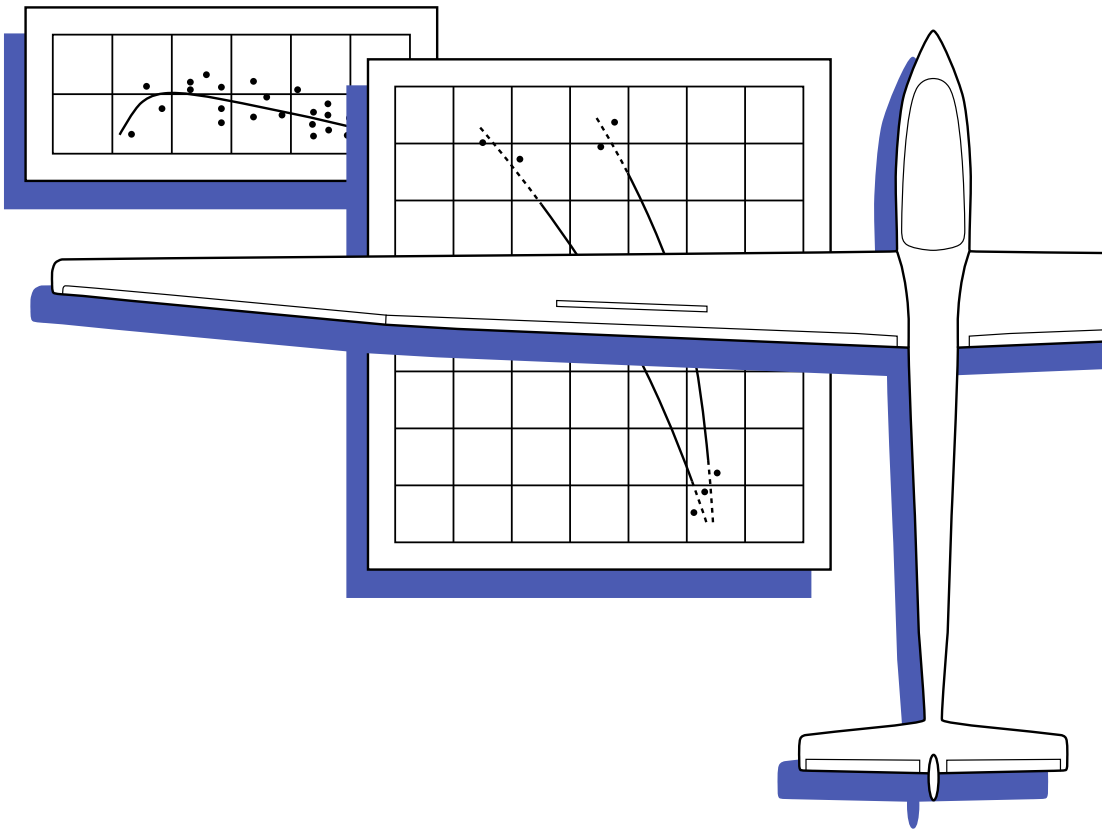

- **Automatic forecasts of the Hungarian Meteorological Service**

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Acknowledgments Inclusion of support and/or sponsorship acknowledgments is strongly encouraged.

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From the Editor

Publication Date

This issue is the third of Volume 44 of *TS*, corresponding to July-September 2020. For the record, the issue was published in November, 2020.

Acknowledgements

We gratefully acknowledge Associate Editor Zafer Aslan, who oversaw the review of the Fövényi paper in this issue.

Very Respectfully,

Arne Seitz
Editor-in-Chief, *Technical Soaring*
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Automatic forecasts for flying sports on the website of the Hungarian Meteorological Service

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Abstract

Between 2008 and 2013 the headcount of our division decreased by 25%, so we had not enough human capacity for making forecast for flying sports manually, as we did it earlier. So, we developed new, automatic methods based on numerical weather prediction model data for calculation of thermal lifting, Cumulus probability and other important elements. We had several meetings with pilots; we had different permission procedures connected to our new homepage. Our new website – www.aviation.met.hu – is operational since November 2016.

Introduction

Between 2008 and 2013 the headcount of our division decreased from eleven to eight persons (the minimum was six at the end of 2016), so we had not enough human capacity to issue our old manually made – Microsoft Office Word format – Thermal Activity Forecast, Mountain Wave Forecast and Hot Air Ballooning forecast [1] [2]. So, we developed new methods for calculating of thermal activities, and we created different meteorological charts and time-cross section meteograms for gliders, hang gliders, Para gliders and hot air ballooning pilots. New charts, meteograms, etc. are made by the visualization system of the Hungarian Meteorological Service, called HAWK (**H**ungarian **A**dvanced **W**or**K**station). Between 2013 and 2015 we had a lot of meetings with the pilots, we described our new products with them, and we modified the products, if they suggested. In 2015-2016 we had different permission procedures connected to our new homepage by the Aviation Authority (NSA) and Hungarian National Authority for Data Protection and Freedom of Information. Between June and October 2016 our new homepage was tested by the pilots and the above mentioned authorities, and since November 2016 it is operational.

Calculation of thermal activity parameters Data and methods

Between 2011 and 2013 we developed new methods for calculating thermal lifting and Cumulus probability and forecast of the amount of Cu clouds. We used the GPS data of soaring airplanes (International Gliding Committee or IGC files), temperature and humidity data of Budapest and Szeged radiosonde stations, temperature and humidity data of AROME.HU model analysis fields. Using these sets of data we got the next formulas for thermal lifting, probability of Cu clouds appearing and amount of Cu clouds:

$$L = C + A_i \cdot f(HTT) \tag{1}$$

Here, L denotes the maximum or, respectively, average lifting in m/s, while C is a constant, which comes to $C = -0.151173$ for maximum and $C = 0.02$ for average lifting. The A_i are calculated from

$$A_i = A_{max} \cdot a_i$$

with a_i being a function of HTT (the height of the thermal top or top of the atmospheric boundary layer measured in m) and $Gr_{HTT/HTT+500}$ which is the temperature lapse rate between HTT and $HTT + 500$ m:

$$a_i = f(HTT, Gr_{HTT/HTT+500}).$$

For free thermal, this evaluates to $a_i = 1$ while a_i becomes minimal in case of an inversion. A_{max} is for free thermal and has a value of 0.00155462 1/m for maximum and 0.000977 1/m for an average lifting.

In case of calculating an average lifting, the value of $C = 0.02$ is close to 0 and may be neglected. Furthermore, since $A_{max} = 0.000977\ 1/\text{m} \approx 0.001\ 1/\text{m}$ Equation 1 can be simplified according to:

$$L = a_i \cdot (HTT/1000). \tag{2}$$

Here, the dimension of the output lifting L is in m/s provided the thermal top height HTT is input in m. It should be noted that without a_i, Equation 2 is the same as it was published in 2014 by Hindman [3].

The probability of Cu clouds appearing, PCu in %, is given as function of thermal top height HTT and cumulus condensation level CCL:

$$PCu = f(HTT, CCL), \tag{3}$$

This article was peer reviewed by two independent, anonymous reviewers.

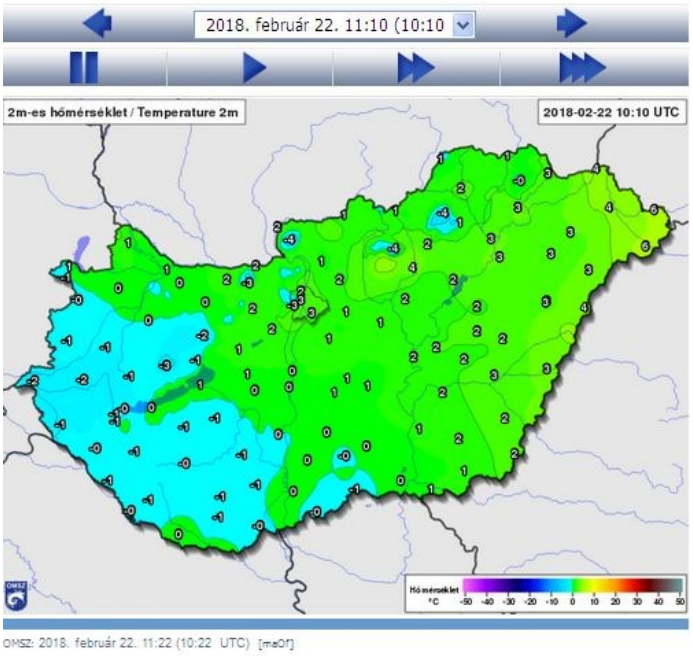

Fig. 1: 2 m Temperature chart (10 min time step)

with $PCu = 100\%$ for $CCL - HTT \leq 30\,\text{m}$ and $PCu = 0\%$ for $CCL - HTT \geq 30\,\text{m}$.

The amount of Cu clouds appearing, ACu in % or octas, can be calculated by

$$ACu = PCu \cdot f(RH_{HTT/HTT+500}), \tag{4}$$

with RH the relative humidity between HTT and $HTT + 500\,\text{m}$ height. If $PCu \leq 50\%$, then $ACu = 0\%$.

Results of our thermal activity forecasts

We tested our methods by using GPS data of soaring aircraft (IGC files), 2 m temperature data, height of thermal top, compared to 3 limited area models AROME.HU, ALADIN.HU and WRF models, and we got the best scores using AROME.HU model (non-hydrostatic, horizontal resolution 2.5 km, vertical resolution 60 levels) data. So, we have been using the data of AROME.HU model for making automatic forecasts. We tested our methods for 41 flying days, for more than 1000 flights. Using AROME.HU model data the forecasted lifting was the same (difference ≤ 0.25 m/s) in 76% of the cases, the forecasted lifting was stronger than the real in 18% of the cases (mainly in thunder stormy situations), and in 6% of the cases the lifting was underestimated. The amount of Cu clouds was relatively well predicted. The places where the least and the most Cu cloud appeared in the sky were well predicted, where the amount was less than 5 octas (62.5%) the amount was well predicted, but where more than 5 octas Cu clouds appeared in the sky the amount was overestimated by 10-15%. In many cases the structure of Cu clouds was recognizable too. For example, Cu clouds formed around Lake Balaton, and nowhere else, or Cu cloud-lines, as thea are called “cloudway Cumulus” by Hungarian glider pilots.

About our new homepage

A pilot can login to our homepage – www.aviation.met.hu – after registration (e-mail, first name, last name, date of birth, place of birth, tax number, if you are a non-natural person). Your data is kept for one year after the last login, so if you had an accident we can justify for the Police or Aviation Authority whether you had up-to-date meteorological information at the time of the accident, or not. Our website is available in Hungarian and English as well, and also compatible with smart phones.

Our website is free of charge for some services and organizations, like Air Ambulance, Air Police, Air Traffic Controllers or Hungarian Air Force pilots. But if you are a civil pilot you may be charged.

One part of our homepage is free: The Hungarian actual weather information (temperature (Fig.1), dew point, relative humidity, QNH, visibility/cloud base conditions in NATO color code, current weather, wind gusts (10-60 min time step), radar charts (10 min time step). These sets of information are not controlled by meteorologists, they are automatic information. METAR-TAF-SIGMET-AIRMET-GAMET messages, and Regional Area Forecast for VFR Flights (Fig.2) are controlled by forecasters or observers, these sets of information are handmade.

If you want to see the other part of our homepage, a fee is charged. (Registration fees in HUF – 32000/year, 23000/180 days, 15000/90 days, 7500/30days, 5000/15 days and 2500/7 days – 1 EUR 310 HUF). There you can see the Low Level Significant chart for Central Europe [4] (it is made by an aviation forecaster),Fig. 3. There you can find the automatic model forecasts for flying sports. All time is in UTC, and all automatic forecasts are made in 1-hour time steps. You can watch

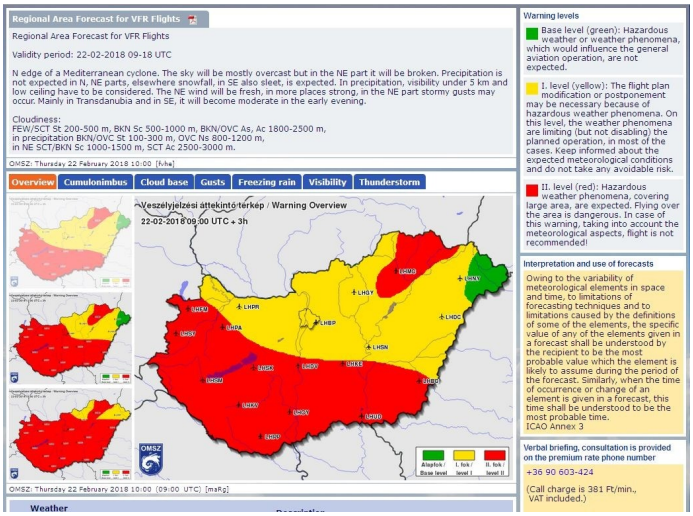

Fig. 2: Regional Area Forecast for VFR Flights (3 hour time step).

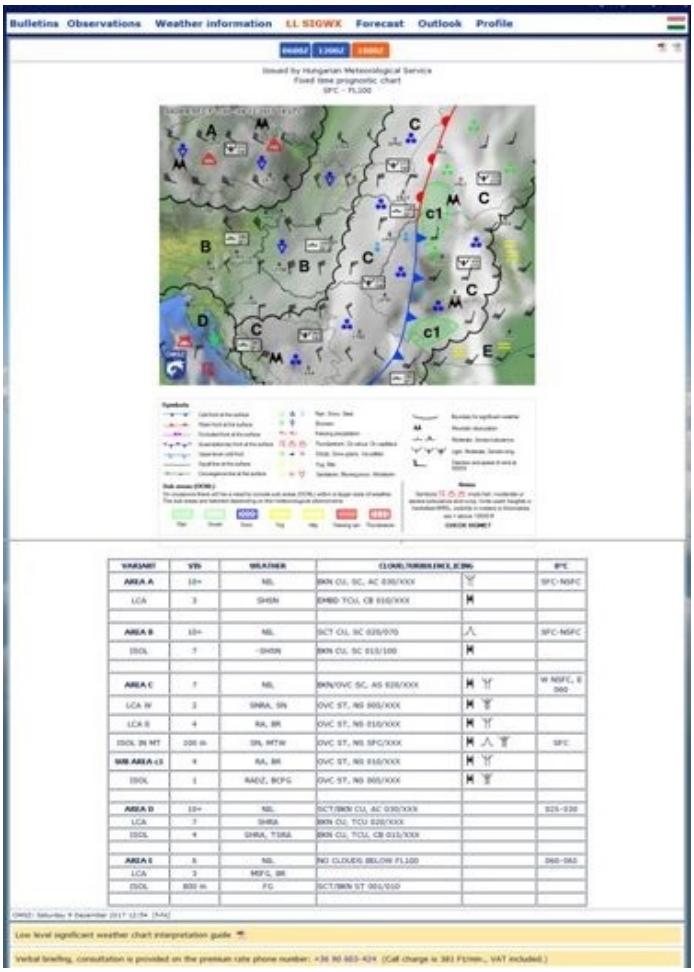

Fig. 3: Low Level Significant Weather Chart.

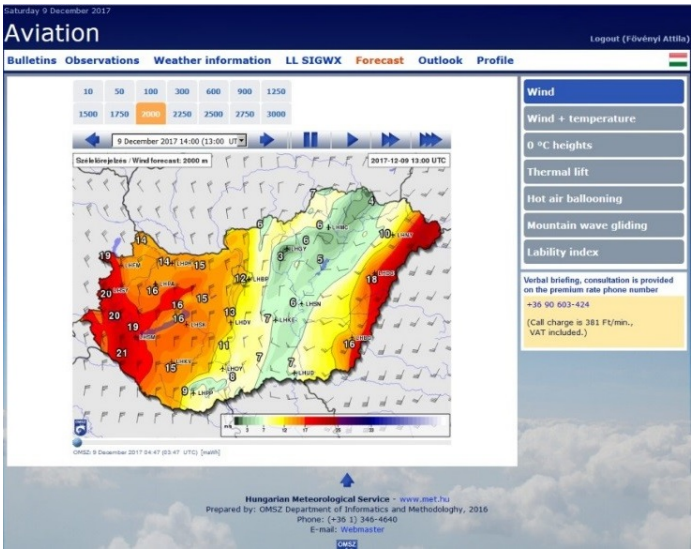

Fig. 4: Wind chart (2000 m) (wind barbs and wind speed).

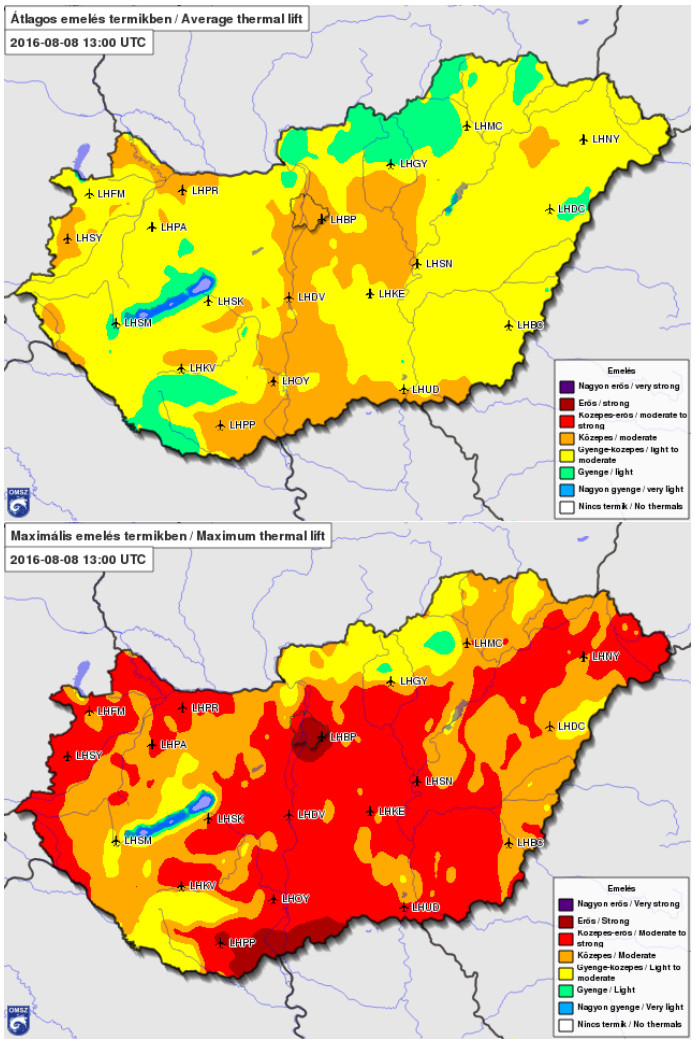

Fig. 5: Forecast of thermal lift (average/maximum) – 08-08-2016 13 UTC.

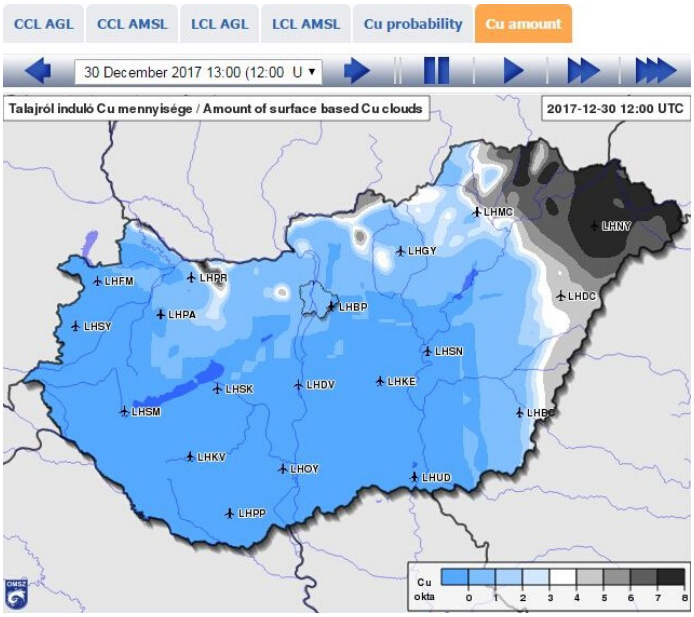

Fig. 6: Amount of surface based Cu clouds (octas) – 30-12-2017 12 UTC.

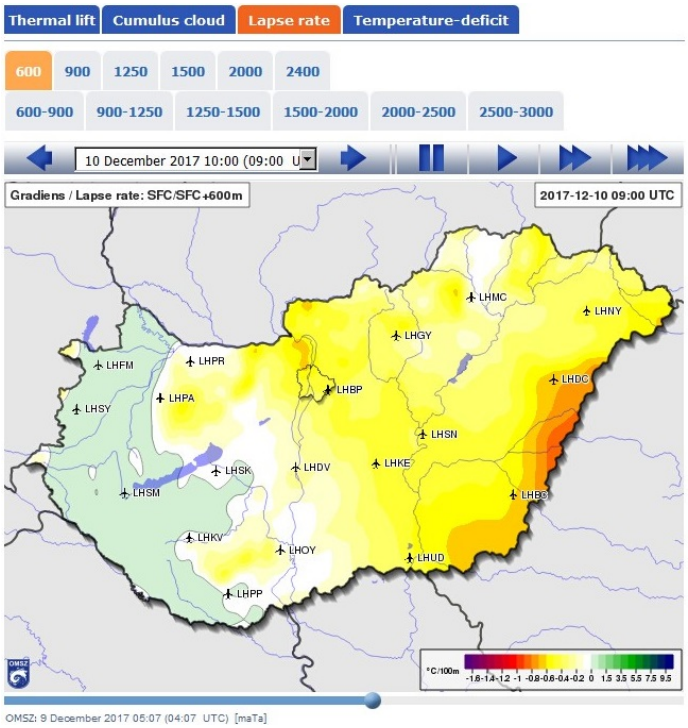

Fig. 7: Lapse rate forecast – 10-12-2017 09 UTC.

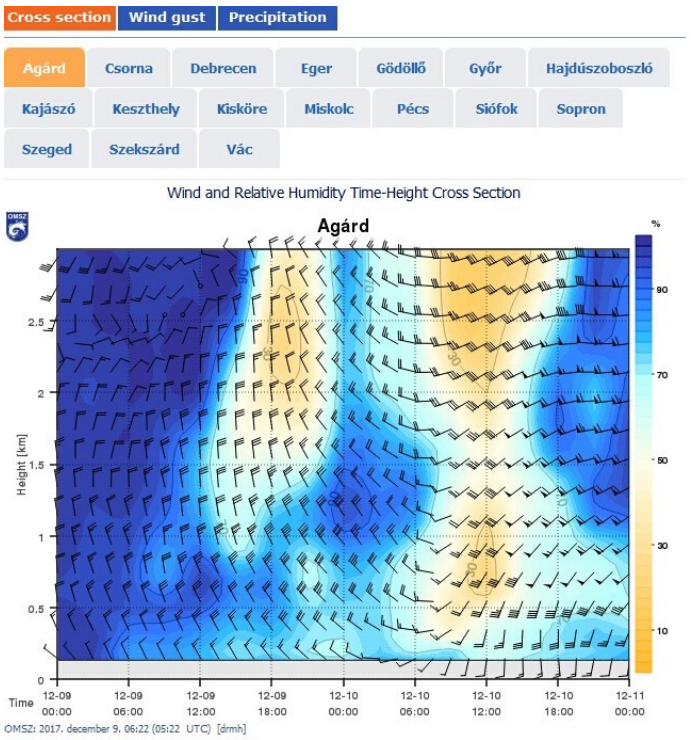

Fig. 8: Relative humidity/Wind Time-Height cross section meteogram for hot air balloonists.

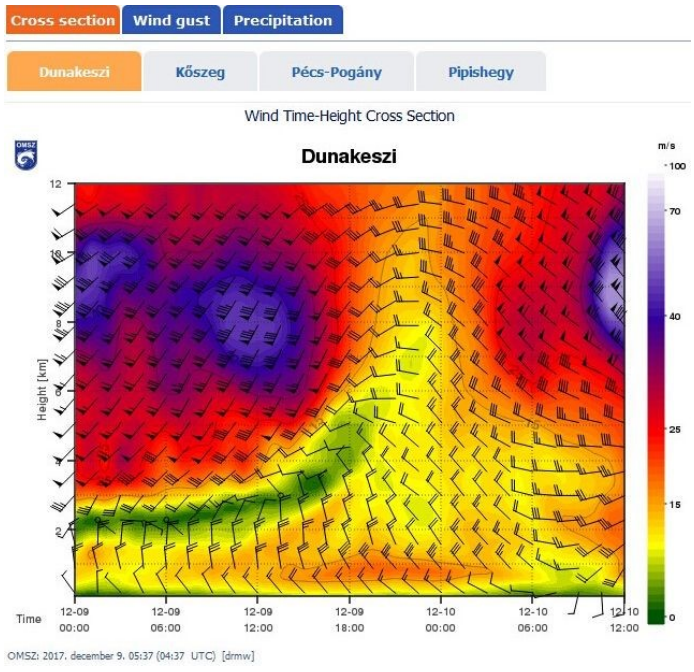

Fig. 9: Wind Time-Height cross section meteogram for mountain wave gliders.

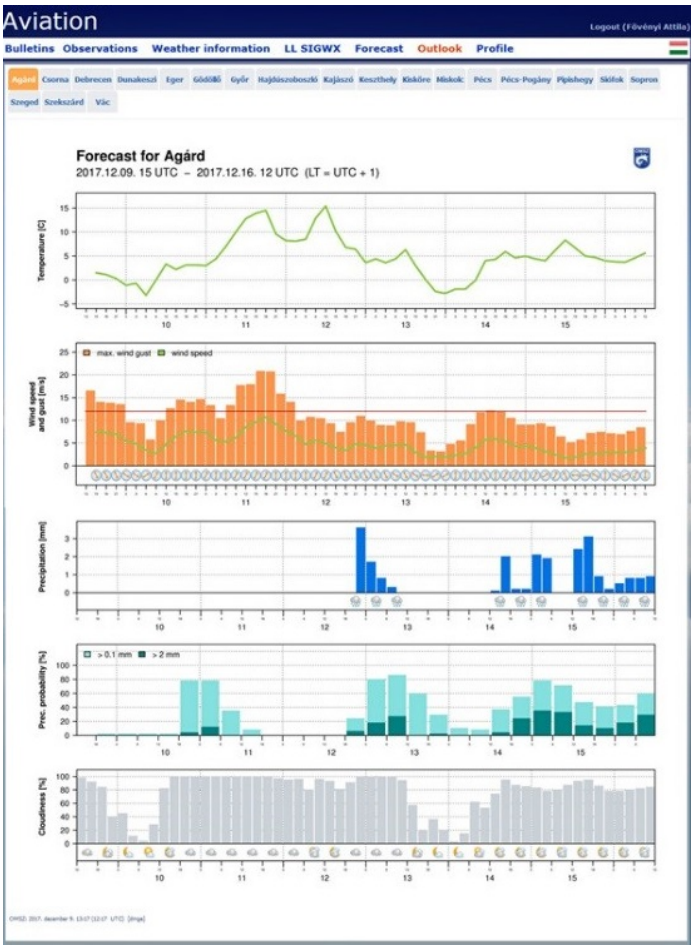

Fig. 10: 7 day long forecast in meteogram format.

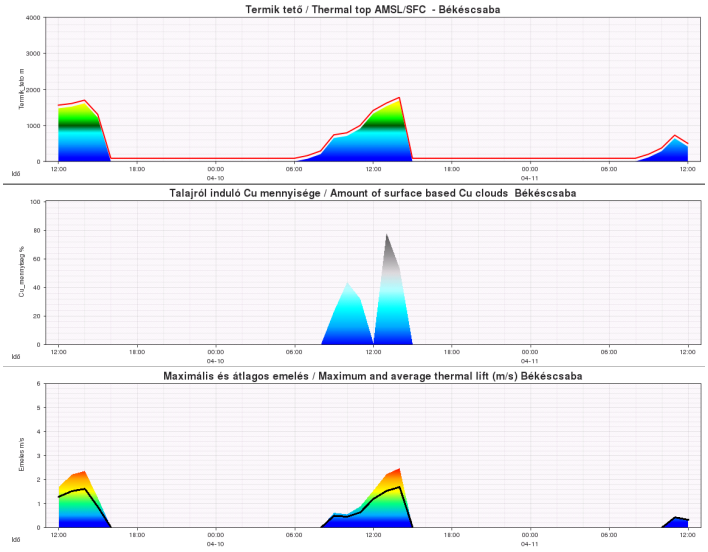

Fig. 11: Thermal activity meteograms for Airport Békéscsaba 09-04-2018 12 UTC - 11-04-2018 12 UTC.

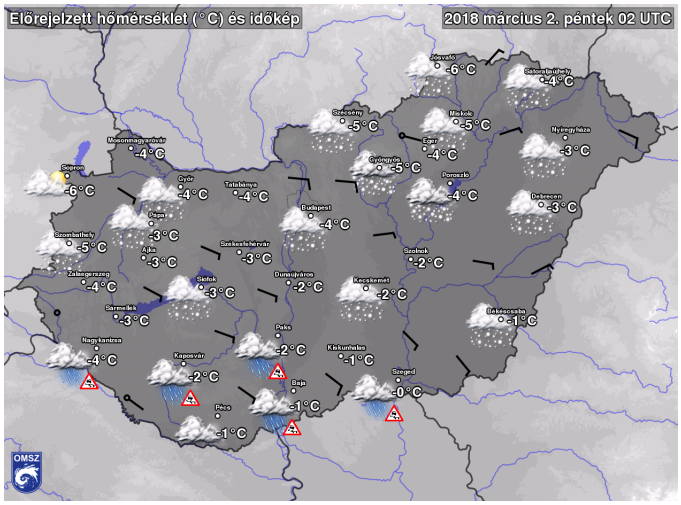

Fig. 12: Chart format temperature-current weather-wind forecast.

the charts step-by-step or in film format. Our hand-made products can be downloaded in pdf-file format.

The website displays the following products (not all products are displayed here):

- Charts of stability indices (SSI, K-index, Total Totals).
- Wind and temperature charts for different levels between the surface and 3000m altitude from which the height(s) of 0°C level(s) can be obtained, Fig. 4.
- Sets of thermal information (average lift, maximum lift, etc., Fig. 5).
- Top of thermals, CCL and LCL, Cu probability, amount of Cu clouds, Fig. 6.
- Lapse rate between surface and 600-2400 m height, Fig. 7, and the lapse rate in different layers between 600-3000m height.
- Temperature deficiency charts between SFC/900-700 hPa pressure level. These charts are in color chart format.
- Precipitation and wind gust forecasts in chart format are available for hot air ballooning and Relative humidity/Wind Time-Height Cross Section meteograms, Fig. 8, are available for many Hungarian cities.
- Pilots desiring to fly in mountain wave can use the Wind Time-Height Cross Section meteograms, Fig. 9.
- Forecasts for a seven-day period for many Hungarian cities in meteogram format are available: Temperature, wind, wind gust, precipitation, precipitation probability, cloudiness, Fig. 10.

Future plans

Our future plans are as follows:

- Produce thermal meteograms (thermal top, amount of Cu clouds, average/maximum thermal lift) for soaring flights at airports in Hungary, Fig. 11.
- Produce mountain wave forecast charts using Scorer-parameter.
- Produce horizontal wind/relative humidity cross-section meteograms for hot air ballooning pilots.
- Produce a 1-hour time-step current weather-wind-temperature forecast chart, Fig. 12.

Conclusions

Our new homepage is more favourable than the old one. Pilots like the visual information (charts, meteograms, etc.) much better than the old text messages. The most popular sites are: Regional Area Forecast for VFR Flights (warning charts), actual weather charts – temperature and dew point (calculation of Cu cloud base), 10 m wind and windgust (it is very important for hot air balloonists), – thermal activity charts – thermal lift, thermal top, amount of surface based Cu clouds, – wind charts, LLSIGWX chart and K-index charts (K-index is the most popular stability index between the pilots).

We would like to increase the number of Hungarian and foreigner users. At the end of 2017 we had more than 3300 registered users, about 60 meteorologists, about 200 foreign pilots, and about 3000 Hungarian pilots or pilot trainers. The total number of pilot licenses is about 5200 in Hungary. So, about the 55% of the pilots use or know of our homepage.

Finally, Mr. László Hegedűs (his nick name, by which he is well known, is Bagoly, which means Owl) is one of the most famous Hungarian sailplane pilots. He holds more than 50 Hungarian, 8 continental (European, African) and 1 world record in soaring flight. He said:"I subscribed to the aviation meteorological homepage of the Hungarian Meteorological Service, for half a year, 15th of March – 15th September. The cost was 23.000 HUF (about 74 EUR). In the vast majority of the cases their forecasts were successful. It was useful for me."

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