An On-line Meteorological Self-briefing System for Glider Pilots

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Abstract

An on-line glider pilot meteorological self-briefing system is operational in Europe at the German Weather Service (DWD). During the 2009 soaring season, as an experiment, the system was expanded to include the East Coast USA and Colorado. The system was validated using data from glider contests and, with a few qualifications, found successful. Consequently, the system was made available to East Coast and Colorado pilots during the 2010 soaring season. Thirty-four pilots chose to use the system and the six evaluations received were enthusiastic. The system was unavailable for the 2011 season and remains unavailable as of this writing because a USA numerical model is needed to replace the DWD model. Therefore, examples are given of useful 2012 predictions made with the European system for isolated convective lift and wave lift.

Background

My colleagues Drs. Olivier Liechti (Analysen und Konzepte (AuK) of Winterthur CH) and Ralf Thehos of the German Weather Service (DWD) have developed a glider pilot self-briefing system for Europe. The system resides at the DWD (www.flugwetter.de). Using the system, a pilot is able to 'fly' a planned task through a numerical weather prediction (NWP) to determine the task's feasibility. After the flight, the forecast can be checked using the resulting flight-recorder file.

I learned the system working with Liechti and Stephen Saleeby of Colorado State University during my 2005-06 sabbatical at CSU [1]

During the 2009 soaring season, as an experiment, we operated the system for the East Coast USA and Colorado. We validated the East Coast system using data from glider contests and, with a few qualifications, found it successful (no contests occurred in Colorado) [2].

In this paper, I will explain and demonstrate this revolutionary system.

The System in Europe

As shown in Fig. 1, the system consists of nested NWP models of the DWD (Thehos's expertise) and Liechti's TOPTHERM convection model [3]. The global model (GME) with coarse 40 km grid-point spacing initializes the higher resolution 7 km grid-point spacing regional model (COSMO-EU) and the regional model initializes the TOPTHERM convection model. The TOPTHERM predicts the local weather in so-called forecast regions; regions of relatively uniform topography and ground cover. The different colors (grey-shades) of the regions in Fig. 1

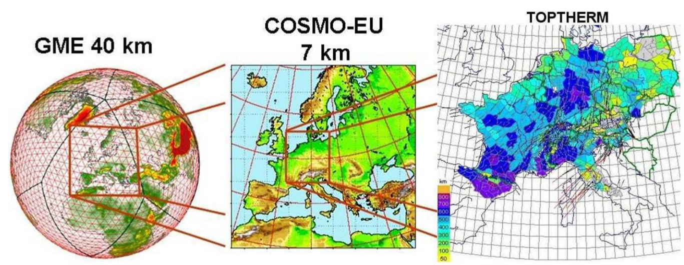

Figure 1: The nested numerical weather prediction models.

denote the potential flight distance (PFD, the distance a Standard Class glider can fly from the first-to-last randomly-spaced thermal) where yellow (lighter grey shades) represents 50 km and purple (darker shade) represents 700 km . So, on the day illustrated (2 June 2009), the best flying using thermals was predicted to be in the eastern Pyrenees Mountains.

The system for the East Coast USA

The DWD global model, by its name, covers the eastern USA. To see this, in Fig. 2 please imagine the globe rotated so the East Coast USA is in the box. However, the DWD regional model, as you might guess, does not cover the eastern USA. So, TOPTHERM was predicting with 'one hand tied behind its back'.

The following scientific question, then, was explored. Can a high-resolution atmospheric model (e. g. the COSMOS-EU) be replaced with a coarser global model (e.g. the GME) and still allow TOPTHERM to produce soaring forecasts of a quality useful for glider pilot self-briefing? To produce the forecasts, Liechti's flight planning algorithm, called Java TopTask (jTT) [4], was connected to TOPTHERM. As we reported ear-

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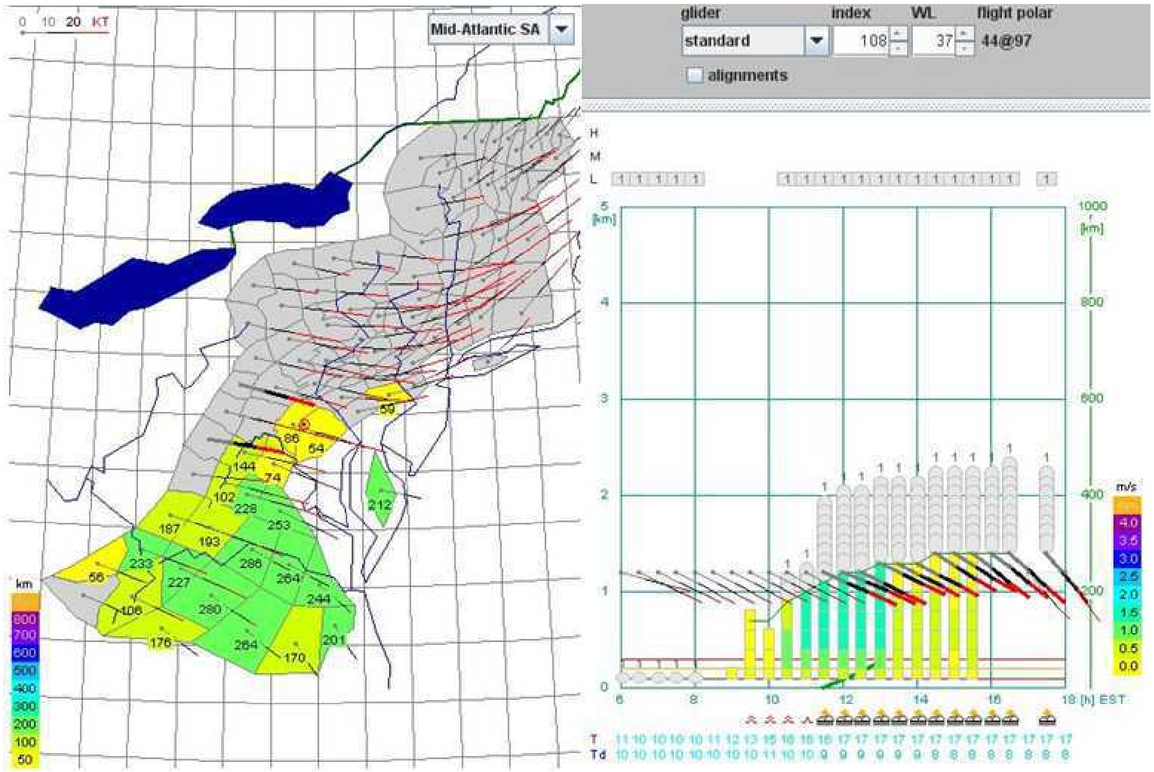

Figure 3: The TOPTHERM forecast for 13 October 2009 for random convective lift.

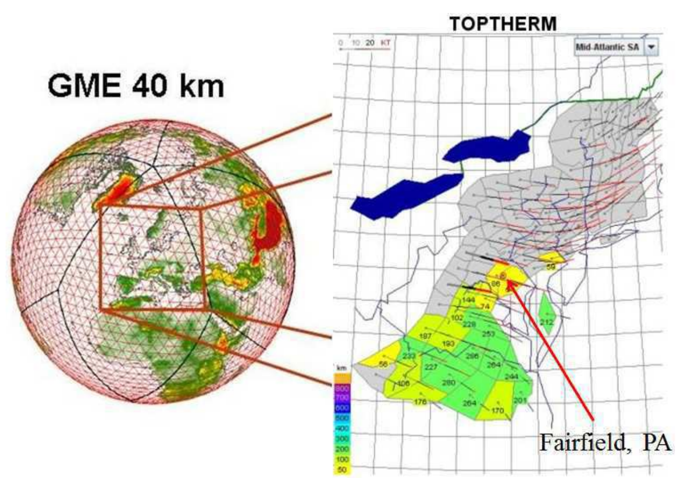

Figure 2: The system for the NE USA (please imagine the globe rotated so the NE USA is in the box).

lier, the answer is ‘yes’ for the northeast USA but with qualifications.

Here are some additional comments on what you are viewing in the right panel of Fig. 2. The light grey regions in the north mean the PFD values are near zero due to the over 30 knot predicted winds in the convective boundary layer (CBL). The thick wind ‘strings’ upwind of the Fairfield PA contest site indicate the possibility of convective lift aligned with the wind.

The TOPTHERM forecast for 13 October 2009

Random convective lift

The atmospheric soundings predicted by the GME model at 60-minute intervals for each forecast region were utilized by the TOPTHERM atmospheric model to predict the daily evolution of the CBL (an atmospheric sounding provides the vertical distribution of temperature, moisture and winds). The TOPTHERM predictions are displayed as a map of PFDs (Fig. 3, left panel) and as a barogram showing the CBL evolution (Fig. 3, right panel). These predictions are for the forecast region surrounding Fairfield PA for 13 October 2009.

The map shows Fairfield was at the northern end of the regions with the largest PFD values (best soaring weather). The barogram shows the CBL was predicted to be about 1.4km MSL by 1500EST. The strong afternoon winds were predicted to align the convection (shown in the barogram by the fat, long wind strings and the row of cumulus icons above the surface temperature (T) and dew-point (Td) values). Notice the strongest lift (blue, darker grey shades) was around noontime and weakened (yellow, lighter shades) as the winds strengthened.

For this day, a PFD of 54 km was predicted for an unballasted, Standard Class glider using randomly-spaced convection.

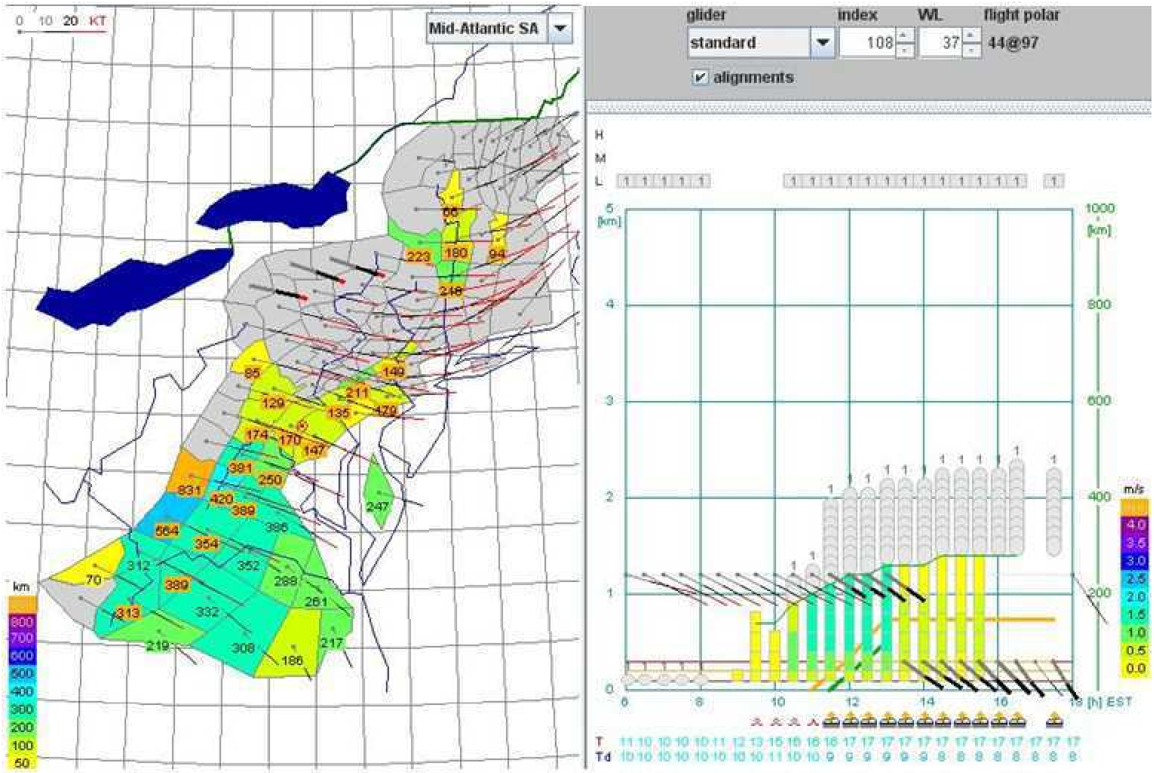

Figure 4: The TOPTHERM forecast for 13 October 2009 for aligned convective and ridge lift.

Aligned convective and ridge lift

Predictions are made for aligned convection, ridge and wave lift. If the pilot were to use aligned lift, then the PFD would increase from 54 to 147 km (Fig. 4, left panel); the orange (light grey) line represents the PFD (Fig. 4, right panel). In the right panel, the wind-strings drop down from the same display in Fig. 3 indicating the flight would be at ridge-level in 15 knot northwesterly winds.

Flight plan for 13 October 2009 for aligned convective and ridge lift

By inspecting the TOPTHERM forecasts, our experienced local pilot knew that aligned lift would be required to fly any distance on 13 October 2009. Further, our pilot knew the task should head west from Fairfield using cloud streets to cross the Chambersburg Valley and run the first ridge. Then, a return to the windward ridges on the east side of the valley would complete the task.

Using the point-and-click feature of jTT, a 339 km task was entered (Fig. 5, left panel) and the 'optimum' start-time and 'aligned' lift boxes were checked (Fig. 5, right panel). As indicated, the task should start at 1400EST and be completed by 1809EST with a speed of 82 kph.

Analysis of the 13 October 2009 flight

After the flight, the recorder trace was analyzed by jTT (Fig. 6): the distance was 588km and the speed was 154kph (Fig. 6, upper-left). The barogram shows the initial climb was made in convection, then a dive onto the upwind ridges and the final climb in convection prior to final glide. Also, notice in the barogram the unusual uniformity of the pilot's flight speed (the red line superimposed over the straight, black diagonal line (distance/time)).

The jTT uses the recorded flight trace to 'fly' the glider through the predicted weather. If the flight had relied solely on random convective lift, a landout was predicted: the flight trace in the map loses color and wind strings at the point of the landout and no speed is displayed in the barogram (Fig. 7). If the pilot used aligned lift, once again a landout was predicted after 1800 EST (Fig. 8, barogram). The jTT 'pilot' was unable to return across the valley (Fig. 8, map). So, the pilot flew much better than predicted.

Forecasts validated using data from 2009 East Coast USA contests

The GME-TOPTHERM-Java TopTask system was evaluated [2] for the northeast USA using meteorological and flight recorder data collected from glider contests held in the spring, summer and fall of 2009 in the following states: New York (Sports Class), Pennsylvania (R2, R4N) and Virginia (R2S). The

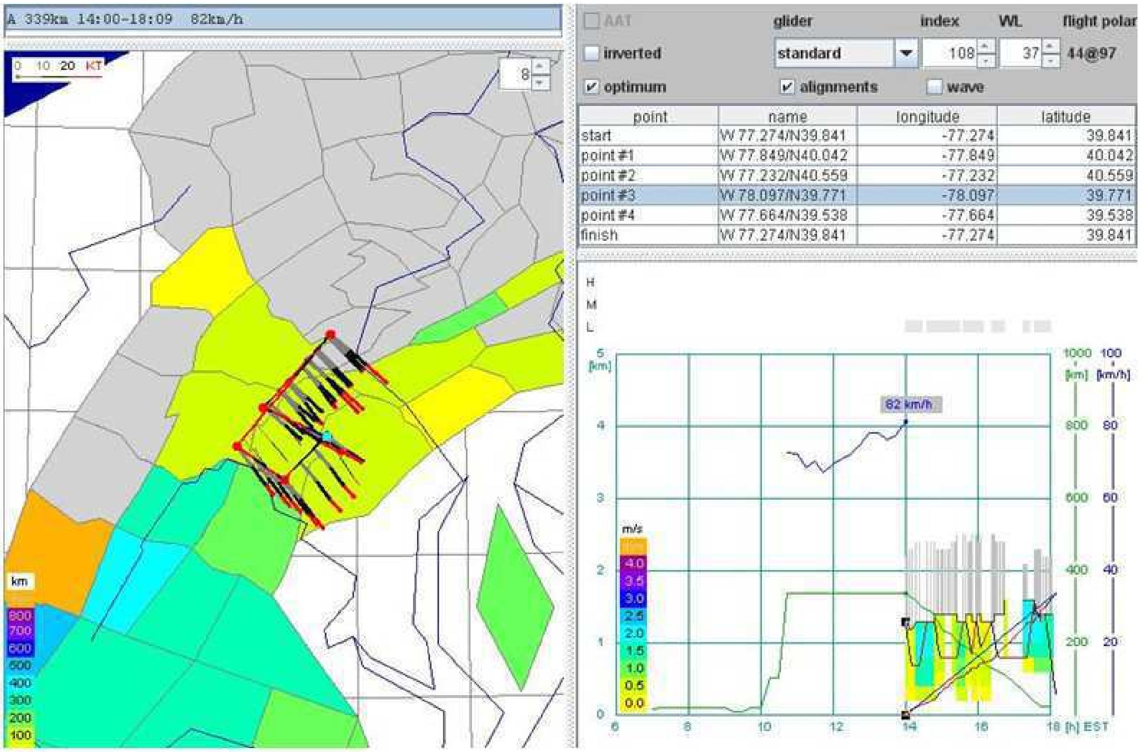

Figure 5: Flight plan for 13 October 2009 for aligned convective and ridge lift.

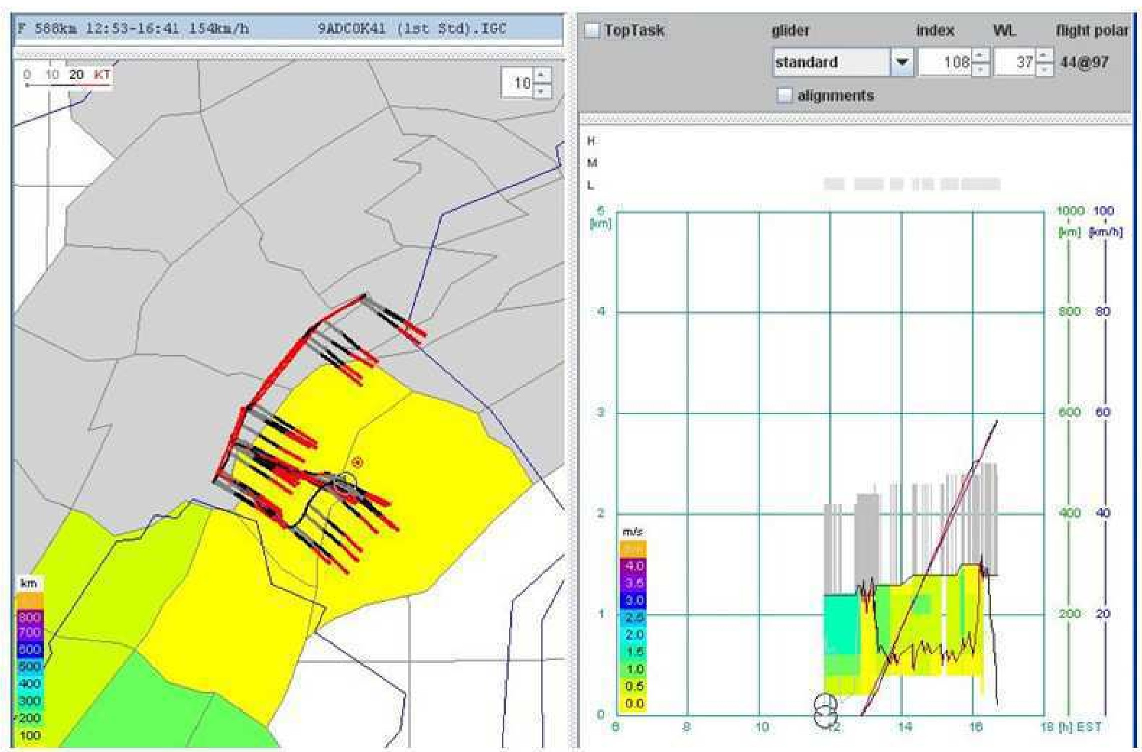

Figure 6: Analysis of the 13 October 2009 flight.

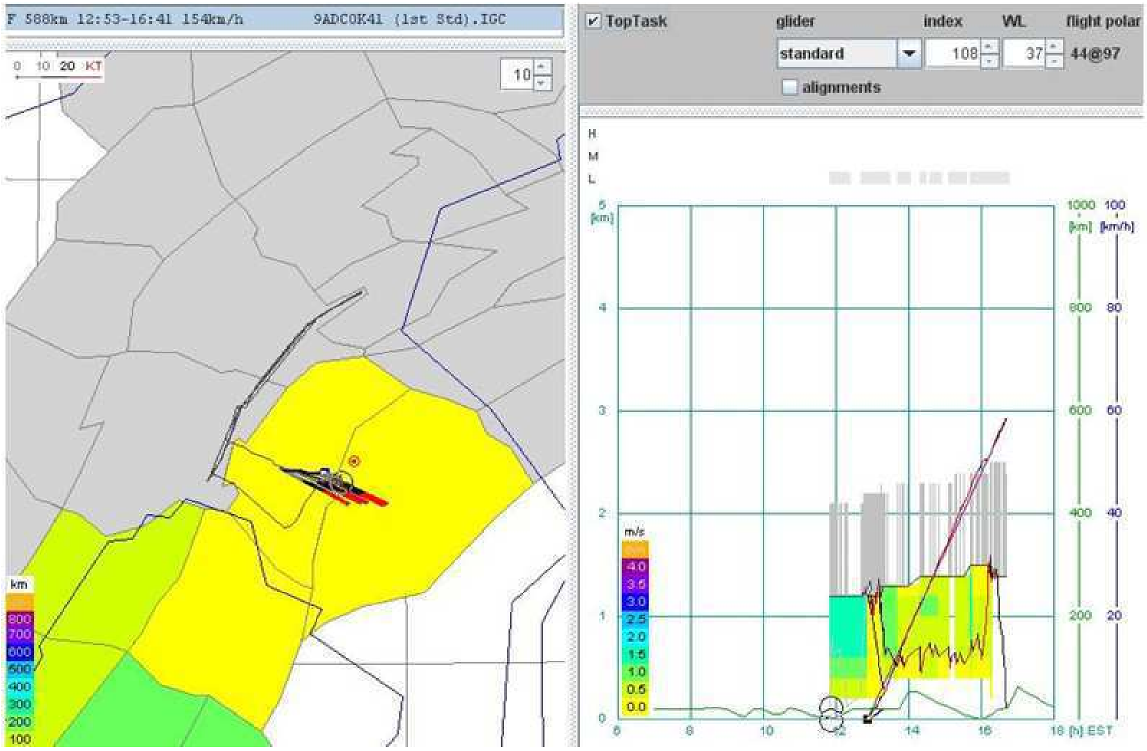

Figure 7: Validation of the TOPTHERM forecast for random convective lift.

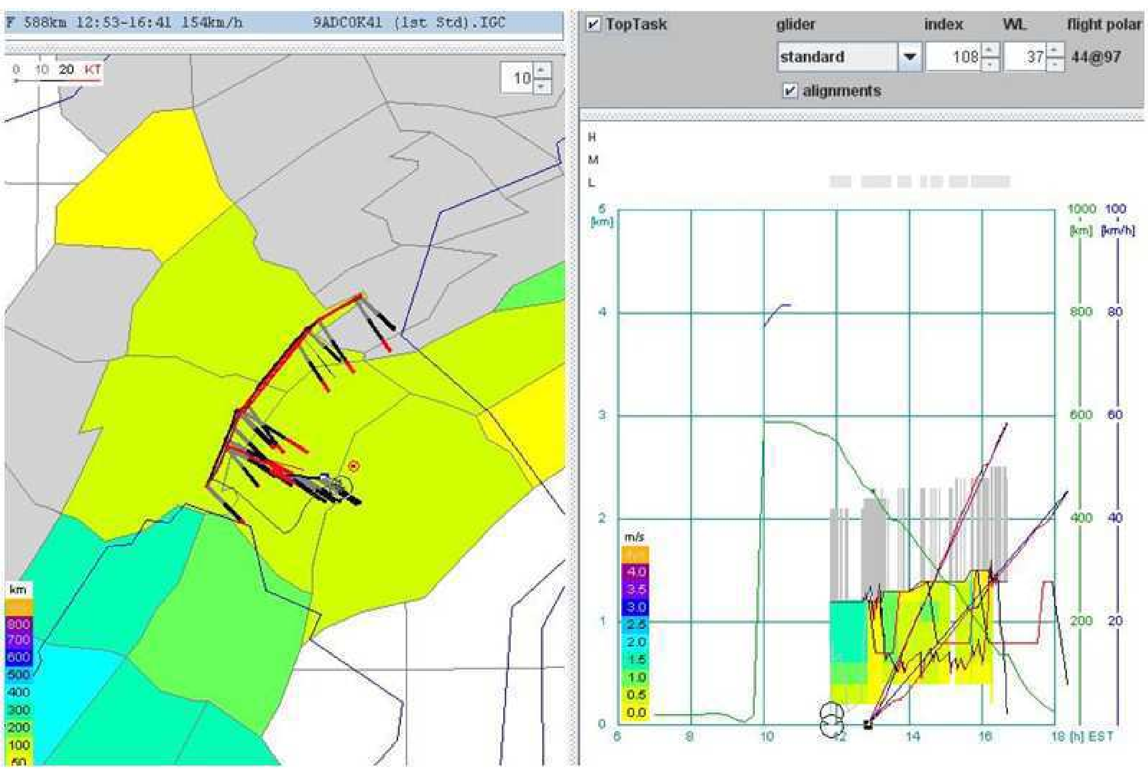

Figure 8: Validation of the TOPTHERM forecast for aligned lift.

system made useful predictions of the convective boundary layer (CBL) depth, the flight speed and the Potential Flight Distance (PFD) with the following qualifications:

- The CBLs developed more slowly and lasted longer than the actual CBLs.
- More accurate surface T and Td predictions would improve the CBL predictions.
- For flights in random convection, CBL depths were under-predicted by 75 m, flight speeds were under-predicted by 7 kph and PFDs were twice the actual flight distances.
- The jTT successfully predicted flights that utilized a mixture of aligned convective and ridge lift, the longer the task the better the prediction. The actual threshold for weak aligned lift seems to be somewhat lower than the threshold assumed in jTT.

These findings are encouraging for setting up the system anywhere on the globe. Due to the coarse resolution of the global model, limitations exist for convective lift in extremely complex terrain (e.g. Alps, Himalayas), whereas wind generated aligned lift (ridge, wave) may be predicted anywhere. Improvements in T and Td values have been achieved by adjusting the surface sensible heat and latent heat fluxes [2]. This improved predictions of the CBL growth and the predicted base of cumulus clouds. Additionally, the assimilation of surface measurements of temperature and dew-point should further improve the prediction of cumulus (onset, base and depth) as is known from current German Weather Service operational runs.

The USA experiment

The system was evaluated by USA glider pilots flying in the mid-Atlantic and northeast States and Colorado (Fig. 9). To encourage pilot participation, the system on www.flugwetter.de was provided, free-of-charge, for the 2010 soaring season (1 March to 1 November). This invitation was made in the March 2010 SSA e-news and April issue of *Soaring*: Pilots flying in the regions depicted in Figs. 2 and 9 that wished to evaluate the system were instructed to contact pcmet@dwd.de and identified themselves as a USA glider pilot desiring to participate in the DWD-AuK-CCNY experiment.

Thirty-four pilots signed up and six e-mailed me the results of their evaluation. The evaluations were positive. Nevertheless, the system was unavailable for the 2011 season and remains unavailable as of this writing because a USA numerical model is needed to replace the DWD model.

For completeness, an on-line meteorological self-briefing system for the world's glider pilots that mimics the GME-TOPTHERM-jTT system is available at www.xcskies.com.

Addendum

Since the 2010 experiment, Liechti [5] improved the COSMO-TOPTHERM forecasts by reducing the lateral entrainment to let the CBL grow higher and obtain more realistic convective cloud cover and added important seasonal variations of the latent heat flux (with vegetation being active/developed or not). Two examples of the improved forecasts follow.

Liechti's flight on 28 May 2012 in his club's ASG-29/18m (AE) in random convective lift is given in Fig. 10. It can be seen (top figure) a 720 km flight was planned and the predicted flight speed was 110 kph. The actual flight (bottom figure) was 911 km at 102 kph; jTT flew the track at 99 kph. This result confirms the documented satisfactory performance of the system for random convective lift [6].

Liechti's and co-pilot Michael Keller's flight on 28 April 2012 in their club's ASH-25 (AM) in wave lift is given in Fig. 11. It can be seen (top figure) a 860 km flight was planned and the predicted flight speed was 135 kph. The actual flight (bottom figure) was 1059 km at 119 kph; jTT flew the track at 140 kph. This result demonstrates the pioneering wave simulation described by Liechti [3] needs additional improvement. Finally, Liechti wrote me this flight had the most extreme climb and sink rates he and Keller ever experienced in their gliding activities that combine to total about 5,000 hrs.

References

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[5] Liechti, O., Personal Communication, July 2012.

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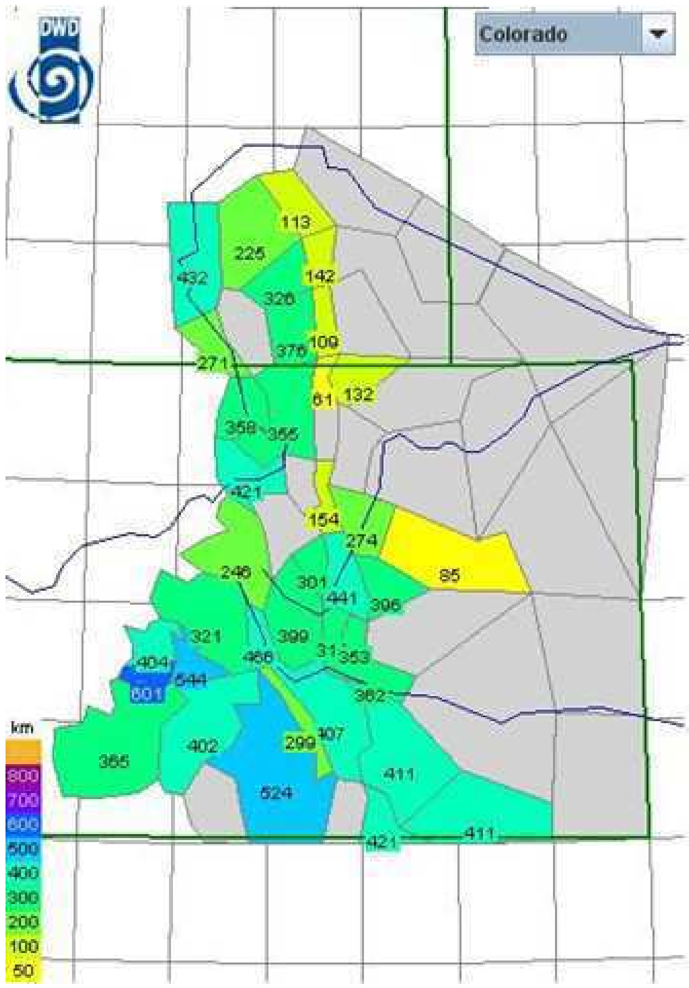

Figure 9: TOPTHERM forecast for 13 October 2009 for Colorado

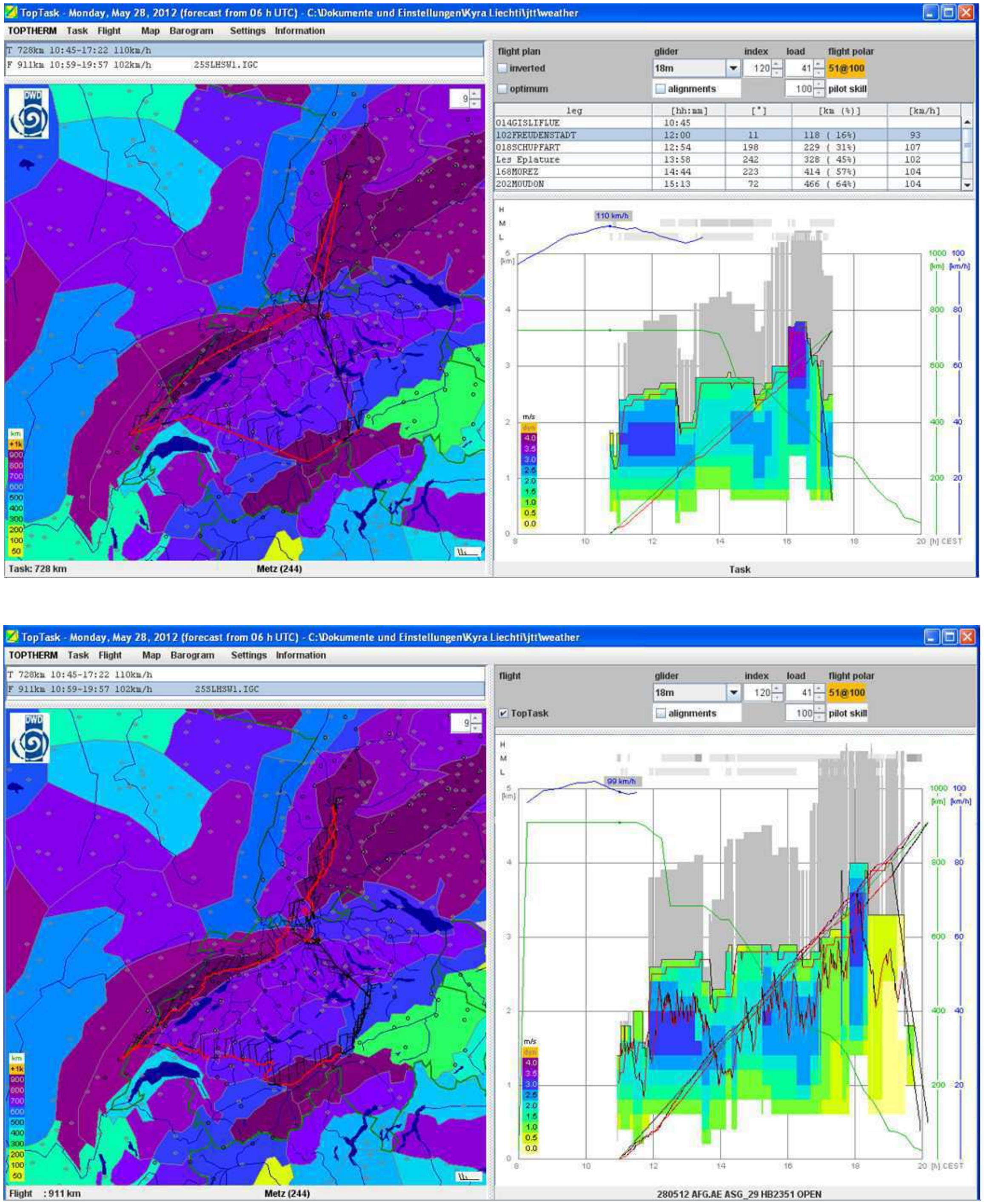

Figure 10: (Top) jTT analysis of a planned five-turn point 720 km flight from the northern foothills of the Swiss Alps: departure 1045h and expected finish at 1722h at 110 kph. (Bottom) jTT analysis of the flight recorder file: departure 1059h and finish at 1957h at 102 kph and distance 911 km. jTT flight along the track: departure 1059h and finish at 2010h at 99 kph.

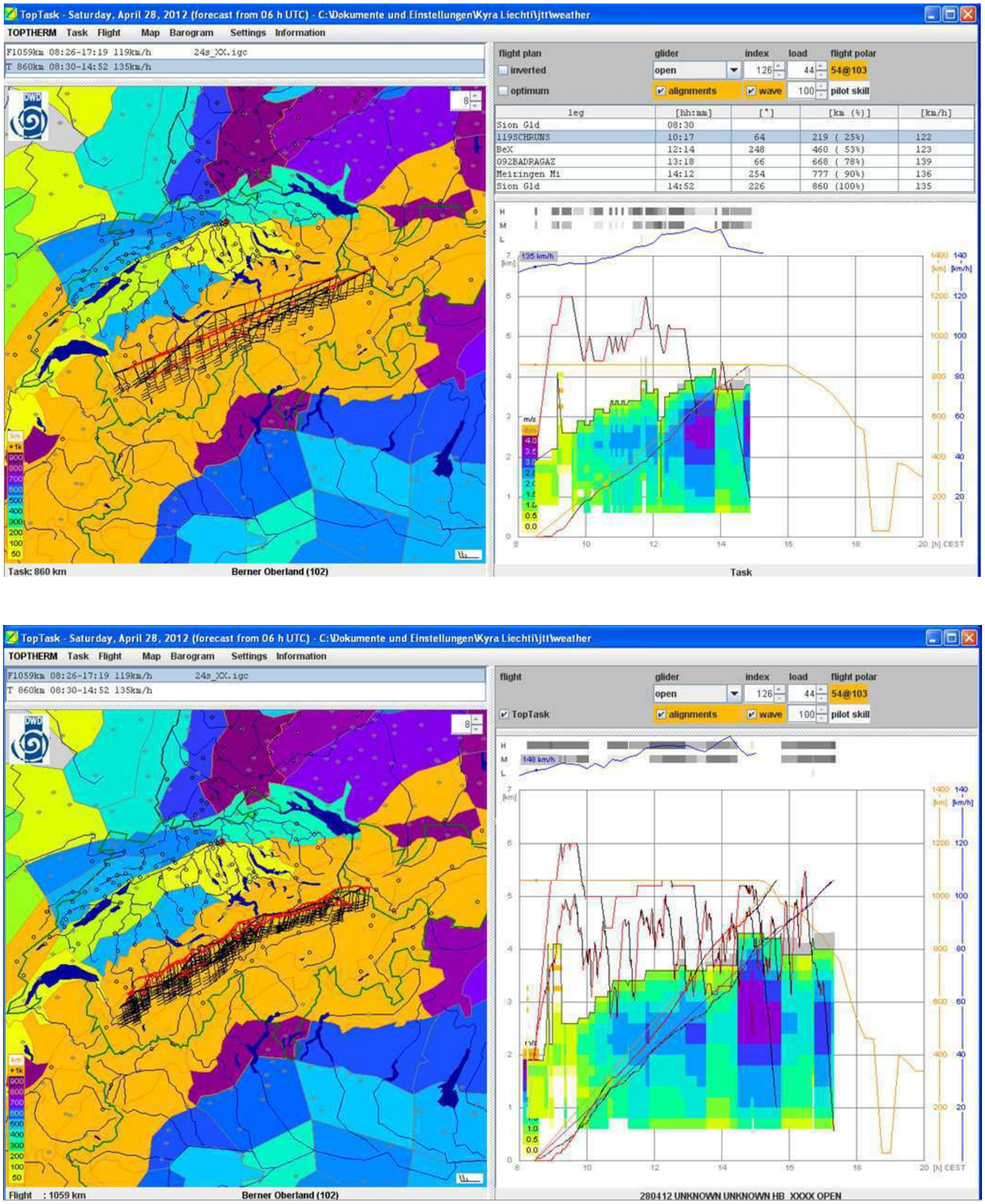

Figure 11: (Top) jTT analysis of a planned four-turn point 860 km flight from Sion (CH): departure 0830h and expected finish at 1452h at 135 kph. (Bottom) jTT analysis of the flight recorder: departure 0826h and finish at 1719h at 119 kph and distance 1059 km. jTT flight along the track: departure 0826h and finish at 1540h at 140 kph.