VG 01

Evaluating weather predictions using glider flights, fall 2006 and spring 2007, Pennsylvania USA

VG 02

Summary

A numerical weather prediction model coupled with a glider flight algorithm was developed for Colorado USA during my 2005-06 sabbatical and shown to be successful in predicting long-distant glider flights. (~500km) The model-algorithm system was adapted in fall 2006 for the region surrounding Fairfield PA USA, the site of the Region 4 North contest. Additionally, the system was expanded in the spring of 2007 to cover the Reedsville PA region, the site of the 15m Nationals. These east coast contests provide an ideal source of data with which to investigate the system in climatic conditions almost the opposite to those found in Colorado.

The weather forecasting model (the Regional Atmospheric Modeling System, RAMS) was based at Colorado State University for the R4N contest and run remotely from CCNY. In spring 2006, the model was moved to CCNY for the 15m Nationals. The model was run each day of the contest to produce the necessary weather forecasts.

The glider flight planning and evaluation algorithm, called TopTask Competition (TTC), was developed by Liechti and Lorenzen. TTC used the RAMS forecasts to predict the feasible contest tasks and task speeds.

It will be shown in this talk the weather prediction and flight planning capabilities of the RAMS-TTC system were accurate for contest days with winds < 20 knots and, therefore, can be used to help plan flights in future Pennsylvania contests and elsewhere on the East Coast USA. The system requires additional study to handle wind speeds > 20 knots.

VG 03
Procedures
Collect the flight recorder files

To determine the characteristics of the glider flights during the contests, the GPS flight recorder files (*.igc) were obtained from the Contest Scorer at the end of the contest. The files were for first- and second-place finishers in each class for each contest day.

Collect weather data

To validate the RAMS forecasts, the atmospheric sounding data and satellite images for each day of the contests were collected. The sounding data came from www.arl.noaa.gov/ready/amet.html. The satellite images came from www.rap.ucar.edu/weather/satellite/.

VG 04
Construct the RAMS-TTC interface files

The meteorological predictions (T, T_d, horizontal winds, cloud and precipitation mixing ratios, etc) were made by the RAMS on a grid with 12km resolution. The predictions were made every 30-minutes between 07 and 19 LST at each grid-point and at about 75m intervals from the surface to about 3km. These calculations took between 3 and 4 hours on a standard computer workstation. Therefore, the 00GMT (19LST) data were used to initialize the model to produce, by the early-morning of the next-day, the required predictions.

The grid-point meteorological predictions were averaged over forecast regions to interface with the TTC. The regions were areas with relatively similar topography (e. g. ridges, valleys, etc). The predictions at all grid point in a region were averaged to produce one set values for the entire region.

VG 05

Here is an example of the RAMS-TTC predictions for one forecast region: CBL depth, climb rates, 1000m AGL winds, potential flight distance (task speed), and onset to convective clouds.

VG 06

Determine the convective boundary layer (CBL) depth

The actual and predicted depths of the CBL at Fairfield and Reedsville were determined as follows. The *RAOB* program (www.raob.com) was used with the atmospheric sounding text files to determine the actual depth of the CBL for the convective cycle and for each contest day. The corresponding predicted depth for the forecast region containing FFD and RED was read from the TTC display.

Determine actual and predicted glider climb rates

The *SeeYou* program was used to determine the average climb rates from the *.igc files of the 1st and 2nd place finishers for the contests The average climb rates were determined from the Flight Statistics section using the Circling Total values.

The predicted climb rates were determined using TTC. The flight track was displayed in TTC and the period the pilot was in each forecast region was estimated and the individual rates were averaged.

Determine the 1000m AGLwinds

The atmospheric soundings were analyzed to determine the 1000 m winds. The wind speed and directions measured above and below 1000 m for the Fairfield and Reedsville Forecast Regions were linearly interpolated to find the values at 1000 m. The predicted winds were read from the TTC display.

Determine actual and predicted task speeds

The TTC was used to determine the actual and predicted task speeds. The actual speed is the flown distance divided by the flight time. The procedure to determine the predicted speed is, briefly, the algorithm utilizes the RAMS weather prediction, the sailplane polar and speed-to-fly-theory to simulate a flight along the flight track recorded in the file.

Determine the onset of convective clouds

The hourly satellite images for each contest day were inspected. The time that convective clouds first appeared in the vicinity of Fairfield and Reedsville was recorded. Then, the TTC display of the weather for that region was inspected. The time the first convective cloud was predicted to appear was recorded.

Discussion of results

The results were analyzed to establish the performance of the RAMS-TTC system for the regions surrounding Fairfield and Reedsville PA. From these analyses, the strengths and weaknesses of the RAMS-TTC system were identified. This study is the first application of the system on the East Coast USA. The first application of the system in the USA was in Colorado and was recently published in 'Technical Soaring'.

VG 07

Convective boundary layer depths

The actual and predicted CBL depths as a function of time-of day were averaged and the predictions systematically were too high by 105 m (FFD) and 399 m (RED). Additional analyses showed the RAMS T and T_d predictions were accurate and the surface T and T_d values from the soundings were, respectively, too cool and moist. This result explains the discrepancy between the actual and predicted CBL depths.

The linear regression analyses show scatter among the values. Nevertheless, the R^2 values are above 0.60 producing a satisfactory linear correlation coefficient ($R \sim 0.8$) meaning good prediction skill was demonstrated. Therefore, the RAMS-TTC system predicted accurate CBL depths at FFD and RED through the daily convective cycle.

VG 08

Climb rates

The average actual and predicted climb rates were 1.3 and 1.1 m/s, respectively, for FFD and 1.5 and 1.6 m/s for RED. So, the actual and predicted values were quite close.

Closer inspection of the results, however, reveals systematic differences. The predicted values on 13 and 14 October 2006 were almost a factor of two smaller than the actual values and similarly for 15 and 19 May 2007. This was due to the strong predicted winds of greater than 20 kts (which verified). The wind-factor in the climb rate algorithm reduces the climb rates for wind speeds greater than 20 knots.

Consequently, the climb rates were re-analyzed by removing the wind-factor. Now, the average actual climb rate is almost identical to the predicted rate: 1.3 and 1.2 m/s for FFD and 1.5 and 1.7 m/s for RED. There is no significant difference between the means. Plus, the linear regression analysis shows R^2 values of 0.070 and -1.24, an improvement from the earlier values of -0.82 and -3.5 when the strong-wind values were included)(the small and negative R^2 values resulted from 'driving' the regression line through the origin). However, due to the large scatter, the correlation coefficients are poor. Therefore, the RAMS-TTC system made accurate average climb rate predictions, but inconsistent individual rates for days with 1000 m AGL wind speeds less than 20 knots. For days with speeds > 20 knots, additional studies are required and are detailed later.

VG 09

1000 m AGL winds

The speed and direction analyses revealed the average actual and predicted speeds were almost identical at 12 and 13 m/s for FFD and 15 m/s each for RED and the corresponding directions were, respectively, 214 and 239 degrees at FFD and 227 and 254 degrees for RED. So, the wind directions differed by about 26 degrees at both locations.

The linear regression analyses of the speeds for FFD and for RED shows scatter between the values. As a result, the correlation coefficients are modest (R = 0.84 and 0.81 for FFD and RED, respectively) meaning useful skill was demonstrated.

The linear regression analyses of the directions for FFD and for RED show some scatter. Nevertheless, the correlation coefficients (R = 0.90) for FFD and (R = 0.99) for RED are high meaning useful skill was demonstrated. Therefore, the RAMS-TTC system made accurate wind speed and direction predictions.

VG 10

Task speeds

The average actual and predicted task speeds were, respectively, 84 and 68 kph for FFD and 109 and 86 kph for RED. The significantly faster actual speed was due to the much faster actual speeds on 13 and 14 October 2006 at FFD and on 15 and 19 May 2007 at RED. On these days, the predicted wind speeds were

between 25 and 35 knts which caused an under prediction of the climb rates and the reduced climb-rates caused TTC to "land out" the fleet. That is, TTC predicted the tasks could not be completed for all classes.

But, the pilots were able to fly in these windy conditions by using "aligned lift": cumulus cloud ‘streets', wave and ridge lift. The TTC version used in this and the Colorado study does not account for these types of lift; the version is strictly for “thermal-only” lift. A version of TTC has been developed that accounts for these types of lift. But, it will take additional study to improve the RAMS-to-TTC interface programs to extract these types of lift from the RAMS forecasts.

If the 13-14 October and 15 and 19 May flights are removed, the actual and predicted average speeds are not significantly different (74 vs 79 kph) for FFD and (99 vs 95 kph) for RED. Thus, the RAMS-TTC system made accurate task speed predictions for days with wind speeds < 20 knts (“thermal-only” flights).

VG 11

Onset of convective clouds

It can be seen in that three of the five contest days were cumulus-free “blue days” at FFD and at RED. The RAMS-TTC system exhibited significant skill in identifying these days. Furthermore, of the seven days during which cumulus formed, the onset was predicted exactly on three and, on-average, one-hour later than the actual onset on four days. Consequently, the predictions of cumulus formation ranged from on-time to late by about 1-hour.

VG 12

Comparison of this study and the Colorado study

Listed the CBL depths, climb rates, 1000 m AGL winds and task speeds resulting from this study and those from the Colorado study recently published in ‘TS”. The differences between the values from the two regions are much larger that the differences within the regions. This result illustrates the robustness of the RAMS-TTC system; the system has produced realistic results for these two topographically extreme regions.

VG 13

Additionally, the PA and CO actual and predicted task speeds are displayed here. It can be seen that the actual speeds are slower than the predicted speeds for the lower speeds and vice versa for the higher speeds. Perhaps the systematically under predicted higher than normal climb rates and vice versa is one cause of this result.

VG 14

Conclusions

For the glider contest near Fairfield PA between 8 and 14 October 2006 and the contest near Reedsville PA between 15 and 24 May 2007, the RAMS-TTC system produced:

- accurate predictions of CBL depths through the daily convective cycle.
- accurate predictions of average climb rates, but inconsistent individual rates, for days with 1000 m AGL wind speeds less than 20 knots.
- accurate predictions of 1000 m AGL wind speeds and directions.
- accurate predictions of task speeds for days with wind speeds less than 20 knots.
- accurate predictions of “blue days” and the onset of cumulus, on average, was predicted to be on-time to about 1-hour late.

The results achieved in this study are comparable to those achieved in the Colorado study indicating the robustness of the RAMS-TTC system. The system requires additional studies to produce reliable predictions for days with wind speeds > 20 knots.