Fig. 1

Merging the Colorado State University Regional Atmospheric Modeling System and the European TopTask system to improve the prediction and analysis of soaring flights in the USA

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Background:

The Colorado State University (CSU) Regional Atmospheric Modeling System (RAMS) is a multipurpose, numerical prediction model that simulates atmospheric circulations ranging in scale from an entire hemisphere to convection in the planetary boundary layer (Cotton, et al., 2003, *rams.atmos.colostate.edu/realtime/*). For example, the RAMS was used successfully by Hindman, et al. (2005) to accurately analyze an unusually high summertime wave flight in the USA (**Fig. 2**).

The Cotton Soaring Index (CSI**)**, developed from the RAMS (**Fig. 3**), is calculated using the difference between the forecasted air temperature 1600m above ground level and the temperature of an adiabatically lifted parcel to that level. Negative CSI values indicate convection will reach that level, the more negative the values the better the thermals. However, the CSI does not include the effect of clouds and precipitation. So, the corresponding precipitation forecast must be consulted.

The ALPTHERM (Liechti and Neininger, 1994) and REGTHERM (Liechti, 2002) numerical prediction models of convection in mountainous terrain include the effects of clouds and precipitation (**Fig. 4)**. Further, Liechti and Lorenzen (1998) and Liechti (2001) developed a potential flight distance (PFD) from the predictions of convection and glider characteristics. In the case shown in Figure 4 for 17 August 2005 in central Germany, 500 km flights should have been possible.

The data in Figure 4 were obtained by EH using his pc which contained the *pc_met* program available to almost any glider pilot in Europe (*www.dwd.de/de/SundL/Luftfahrt/pcmet/pcmet.htm*). Lorenzen gave EH a demonstration copy last summer during his visit to the Deutscher Wetterdienst (DWD) in Offenbach Germany.

Liechti and Lorenzen (2005) have developed a glider flight-planning system called TopTask. The system couples predictions of convection and horizontal winds from the REGTHERM (a. k. a. TOPTHERM) model with glider and pilot characteristics to automatically produce flight plans for individual flight tasks (**Fig. 5**). The REGTHERM model is driven by the DWD meso-scale model and is accessible through *pc_met*. Shown in Figure 5 is a 251 km triangle task that was forecasted to be flown at an average speed of 82 km/h on 17 August 2005 in central Germany.

At the November 2004 OSTIV Meteorological Panel meeting, Liechti presented an impressive verification of TopTask forecasts for the Swiss championships at Birrfeld (**Fig. 6**, www.pa.op.dlr.de/ostiv) and, at this meeting (Liechti, 2005, personal communication), for the Viking-Glide 2005 in Sweden. This information demonstrates the usefulness of this state-the-art flight planning and analysis system.

TopTask will help contest forecasting in the USA as well as help all USA glider pilots. So, on an experimental basis, mating TopTask to the RAMS for use in Colorado is EH's 2005/06 sabbatical project at CSU.

<u>Procedures</u>:

Following Liechti and Lorenzen (2005), the RAMS Grid-3 will be subdivided, based on climatology and geography, into regions with homogeneous cloud base altitudes on convective days. The forecast regions are defined by polygons. Regions with uniform CSI values (eg. **Fig. 3**) and the hydro-climate regions of Colorado from Doesken and McKee (1998) were used to define the first-approximation forecast regions (**Fig. 7**).

A RAMS output file for each forecast region will be constructed that contains the information needed by TopTask. There are two formats for the output file, a complete version and an abbreviated version (**Fig. 8**). The complete version allows the display of lift and cloud profiles (**Fig. 4**) and to plan a flight (**Fig. 5**) using *pc_met*. The abbreviated version allows flight planning and flight analyses using the new TopTask Competition (Liechti, 2005, personal communication) as shown in **Fig. 9**.

<u>Results</u>:

Preliminary results from TopTask Competition applied to Viking Glide 2005 in Sweden (preparation for the World Gliding Championships in 2006) are given in **Fig. 9**. It can be seen in the graph in Figure 9 that for 8 June 2005 a 500 km flight was forecasted at a speed of 93 km/h if departure occurred at about 1145 UTC+2 (Swedish summertime). The actual departure was at 1054 UTC+2 and the flight achieved 416 km at 85 km/h. The horizontal green line in the graph indicates the length of the task that can be flown as a function of the time of departure.

A task that can be completed appears in the graph in **Figure 9** with a horizontal section in the green line. This horizontal section is the departure period for task completion. A departure before the period results in a very small flight distance corresponding to the pure gliding flight from the departure altitude to the ground without finding thermals. A departure after the period results in a partial completion of the task because thermals end before the task is completed. Each departure within the period will lead to a task speed. The task speeds for complete tasks are displayed as a separate speed curve (blue line) in which the fastest speed is marked and indicated. A task that is too big and can not be completed will show no horizontal section in the green line.

TopTask Competition uses recorded flights to verify the forecasts. The actual flight track is approximated by short legs (at least 1 km horizontal or 50 m vertical change) and a flight plan is calculated for this actual task with the corresponding weather forecast. In **Figure 9**, the jagged line is the actual barogram trace, the smoother line following the expected cloud base (bottom line of gray regions) is the barogram trace according to the TopTask calculation. The diagonal lines are the flown distances for the actual flight (blue) and the forecasted flight (purple). Their slopes reflect the actual and the calculated task speeds. A perfect weather forecast leads to identical slopes and an actual barogram trace with peak altitudes at cloud base altitude during the entire flight.

<u>Conclusions</u>:

The experimental RAMS-TopTask system will revolutionize glider flight planning and flight analyses in Colorado and, in time, throughout the USA (**Fig. 10**).

<u>References</u>:

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