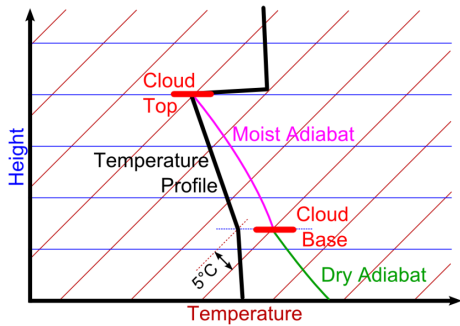




Rogers and Yau [RY89]:

$$F_B = \mathbf{g}B = \mathbf{g} \left( \frac{T}{T'} - (1+q) \right)$$

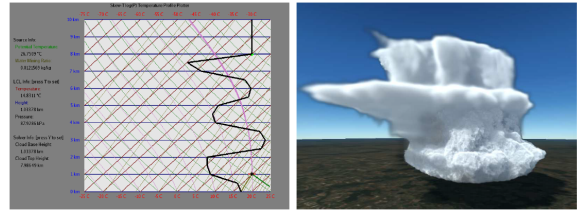
where  $\mathbf{g}$  is the gravitational acceleration vector,  $T$  is the atmospheric parcel temperature,  $T'$  is the ambient environment temperature taken from our background atmospheric description and  $q$  is the parcel's total mixing ratio of all condensates (all water categories except vapour).



**Figure 2:** Our ‘reverse’ skew-T tool. The user clicks for cloud base and cloud height, the tool automatically generates the background temperature profile and calculates the moisture and temperature seed levels required to produce this cloud.

Our work addresses the task of controlling the ambient environment temperature value  $T'$ . Whereas previous CG approaches have used a fixed function that defines  $T'$  as a function of height, i.e. the simulation’s ‘lapse rate’, our system adds a level of directability by allowing users to define this vertical temperature profile manually. This user-defined function allows the cloud simulation to generate more varied results, including layered clouds (Figure 3). To simplify user input – the provision of a list of numbers is not intuitive and rather difficult to control or predict – some form of graphical user interface is needed.

Meteorologists use the skew-T log-P graph (commonly referred to as a skew-T log-P thermodynamic chart [AWS90]) to plot atmospheric profiles showing how temperature varies with height, i.e. to visually present this same data that users are meant to provide to our system. Inspired by this analysis tool we have developed the ‘Reverse Skew-T’ user interface (Figure 1) as a tool for specifying vertical temperature profiles for cloud simulation. Using the skew-T, specifying a cloud base and a cloud height becomes a relatively straight-forward problem for users of our system (Figure 2). From this, the atmospheric temperature profile and the required temperature and moisture of a source that will generate the desired cloud can be automatically determined by our system.



**Figure 3:** Layering effects achieved by manually adjusting the temperature profile with our tool. Cloud formation is enhanced in regions where the profile is to the left of the moist adiabate (the thick pink line in the skew-T view), rising from the lifted condensation level (LCL – the point above which the cloud will start forming). Cloud formation is reduced in regions to the right of the curve. The result is three layered regions, of which the mid-height one is the best defined.

#### 4. Discussion and Future Work

We have presented a cloud simulation user interface that allows users to visually define the background atmospheric description using temperature profiles that can be arbitrarily set and changed rather than being confined to a specific lapse rate. The amount of control that our system offers is a substantial improvement on previous work, allowing us to generate more varied results than are achievable with existing systems, but we believe that the control is still rudimentary and can be improved further, which we hope to address in the future.

#### References

- [AWS90] AIR WEATHER SERVICE SCOTT AFB I.: *The Use of the Skew T, Log P Diagram in Analysis and Forecasting. Revision.* Defense Technical Information Center, 1990. 2
- [DKNY08] DOBASHI Y., KUSUMOTO K., NISHITA T., YAMAMOTO T.: Feedback control of cumuliform cloud formation based on computational fluid dynamics. In *ACM SIGGRAPH 2008* (2008), pp. 1–8. 1
- [HBSL03] HARRIS M. J., BAXTER W. V., SCHEUERMANN T., LASTRA A.: Simulation of cloud dynamics on graphics hardware. In *HWWS '03: Proceedings of the ACM SIGGRAPH/EUROGRAPHICS conference on Graphics hardware* (2003), pp. 92–101. 1
- [MDN02] MIYAZAKI R., DOBASHI Y., NISHITA T.: Simulation of cumuliform clouds based on computational fluid dynamics. In *Proceedings of EUROGRAPHICS 2002 Short Presentations* (2002), pp. 405–410. 1
- [RY89] ROGERS R. R., YAU M. K.: *A Short Course in Cloud Physics*, third ed. International Series in Natural Philosophy. Butterworth Heinemann, Cambridge, UK, 1989. 2