Improvement in Pilot Training for Aircraft Icing Conditions

Cody E. Denver and Melanie A. Wetzel

Department of Applied Aviation Sciences, College of Aviation, Embry-Riddle Aeronautical University, Prescott, AZ

I. Overview

- One of the most dangerous atmospheric hazards in aviation is aircraft icing. Icing effects can be detrimental to any aircraft's ability to successfully remain in flight
- The understanding of cloud physical processes and icing conditions can be gained through the analysis of aircraft measurement case studies (Sand *et al.*, 2000)
- How can we improve pilot knowledge and response to icing conditions though use of specific meteorological forecast products, interactive training modules, and research case studies?

II. Training Modules

- The Cooperative Program for Operational Meteorology Education and Training (COMET) has produced dozens of interactive training modules related to aviation meteorology (www.meted.ucar.edu)
- Examples of the instructional graphics from an interactive module is shown in Figures 1 and 2. These training resources utilize case study research, life experience and modern forecasting technology and put them into easily understood training tools

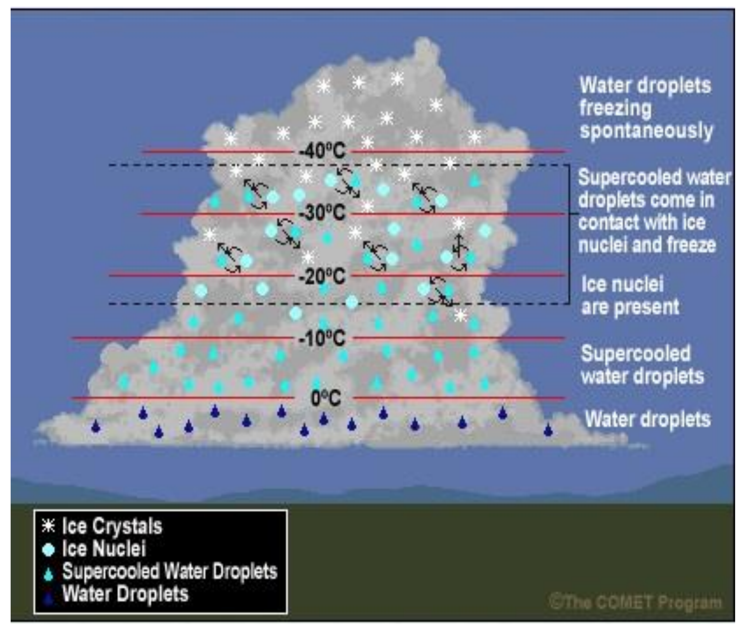

Fig. 1. Freezing transition layers within a cloud; example from the COMET MetEd Module "Forecast Aviation Icing: Icing Types and Severity" (UCAR 2005). Cloud zones primarily containing supercooled droplets create the largest risk for aircraft icing.

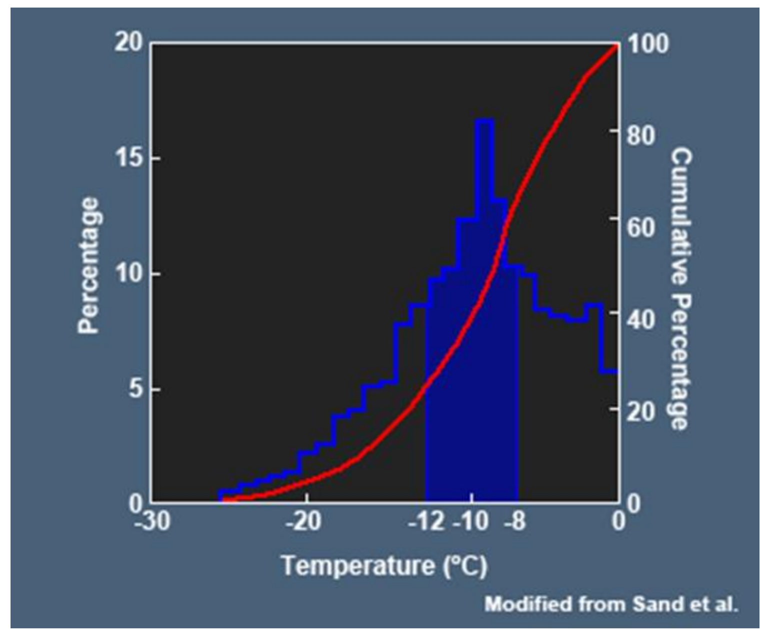

Fig. 2. Air temperature conditions (blue) coincident with the occurrence (percentage and cumulative percentage) of in-cloud icing conditions (red), ; example from the COMET MetEd Module "Forecast Aviation Icing: Icing Types and Severity" (UCAR 2005). Icing is most frequent when air temperature is in the range -8 to -12 C.

III. Operational Forecast Products

- Access to accurate weather information and graphical products is extremely important for pilots for weather hazard avoidance
- Meteorological graphs and figures are not always available on a timely basis from standard pilot websites, so it is important for pilots to have training on data resources
- Fig. 3 is an example of an operational product from the NOAA Aviation Weather office which provides pilots with the ability to view icing conditions predicted along their flight route
- Fig. 4 depicts a time series of vertical wind profiles, cloud/precipitation features and freezing layer heights predicted by an operational forecast model for a given location

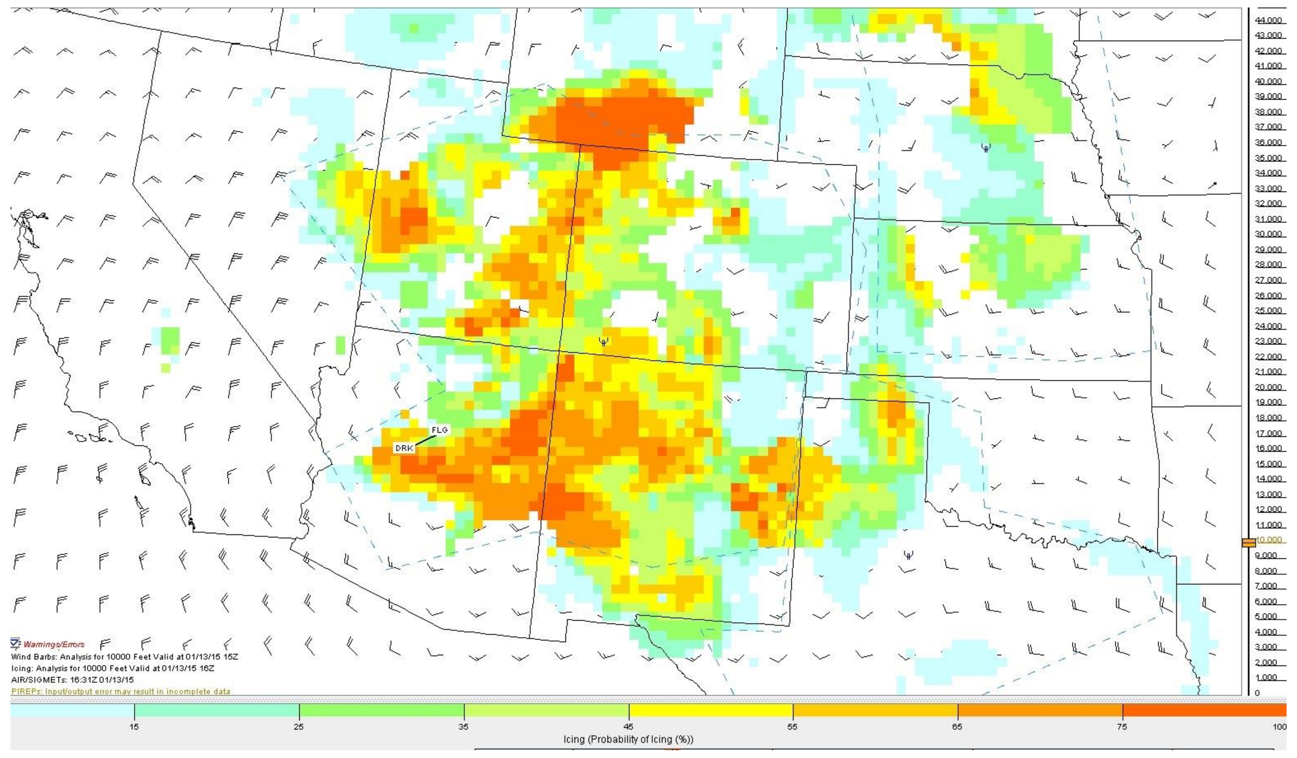

Fig. 3. Picture of icing and wind barb analysis for 10,000 ft. Mean Sea Level (MSL) valid at 01/13/15 15Z acquired from NOAA's Flight Path Tool. The color graph indicates icing probability by %. Light blue represents the lowest probability (1 - 15%) and red represents the highest probability (75 - 100%). http://aviationweather.gov/flightpath

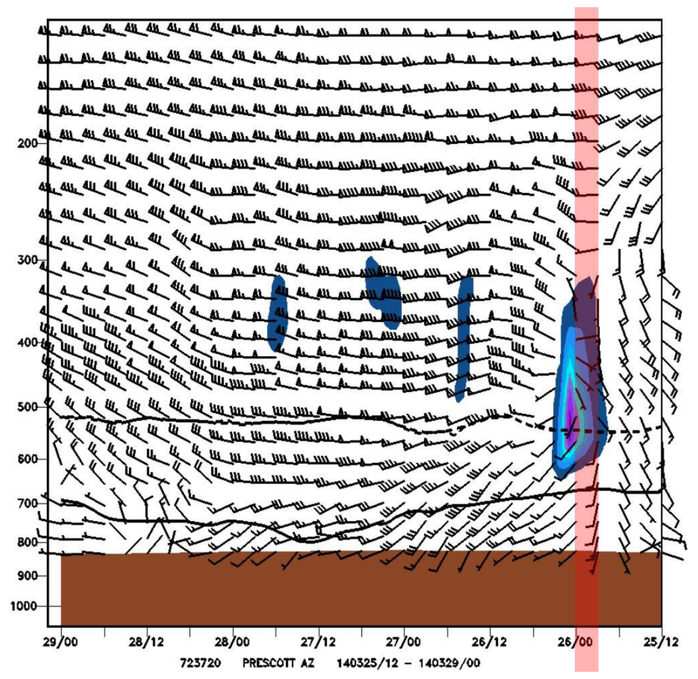

Fig. 4. Time-height depiction of cloud ice/supercooled water content (blue shading), wind (barbs) and isotherms (freezing level is solid black line; -15 C isotherm is dashed black line) predicted for a forecast period of 24 - 29 March 2014.
The horizontal axis indicates the date/time (DD/HH) of the forecast valid times. Red shading has been added to depict the time period of research flight data described in the next section.
http://www.emc.ncep.noaa.gov/mmb/nammeteograms

IV. Lessons from Icing Encounters

- Icing rate is highly dependent on the in-cloud supercooled water concentration and the sizes of the droplet population
- An instrumented aircraft (University of Wyoming King Air) was utilized for a series of research flights near Prescott and obtained measurements of cloud microphysical conditions (Wetzel *et al.*, 2015)
- Fig. 5 presents a time series of icing detector counts and cloud liquid water content, verifying the occurrence of cloud icing as predicted in the forecast product (Fig. 4), and showing the variation between estimates from sensors which measure different droplet size ranges

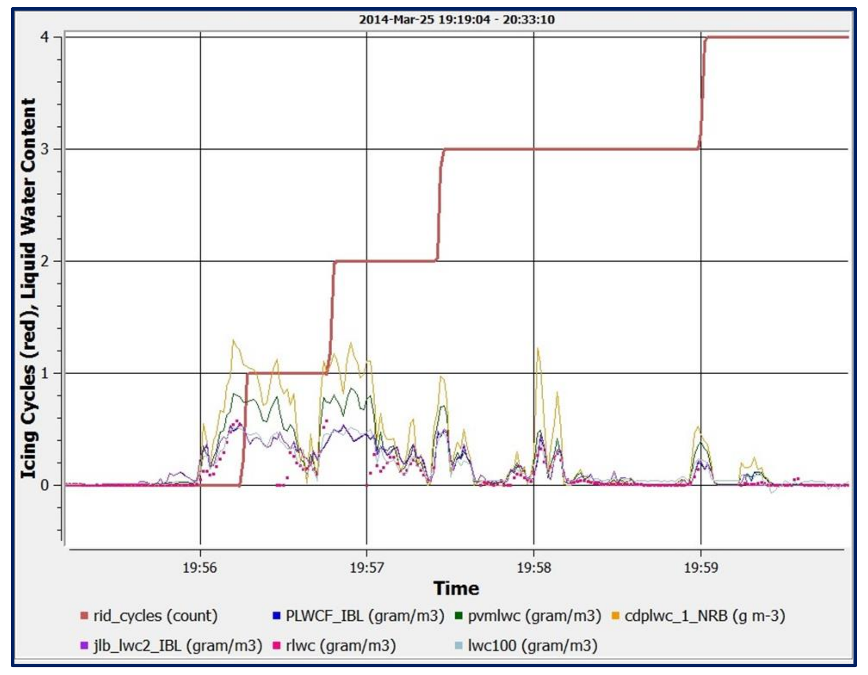

Fig. 5. Time series of Icing Cycles from the Rosemount 871 icing probe [rid_cycles, red], and liquid water content (g m^{-3}) from the FSSP-100 [PLWCF-IBL, blue], PVM-100A [pvmlwc, green], DMT CDP [cdplwc_1_NRB, yellow], FSSP (JLB) Method 2 [jlb_lwc2_IBL, purple], DMT100 [LWC100, light blue], and icing probe [rlwc, pink dotted line] for 19:55-20:00 UTC on 25 March 2014.

V. Summary

- This poster demonstrates training resources and applies theoretical concepts as methods to improve pilot knowledge of icing processes and the ability to diagnose icing risk
- Professional training with MetEd and other similar training aids show us the importance of accessing flight planning tools, forecast products, radar, and satellite images prior to flight
- Instruction on icing physical processes and statistical summaries of occurrence combined with practice in the use of meteorological forecast tools and immersion in case study scenarios, will create safer and more knowledgeable pilots

VI. References

1. Sand, W., W. Cooper, M. Politovich, and D. Veal, 1984: Icing conditions encountered by a research aircraft. *J. Climate. and Appl. Meteor.*, **28**, 856-868.
2. UCAR (University Corporation for Atmospheric Reseach), 2005. Forecasting Aviation Icing: Icing Type and Severity. Retrieved from **http://www.meted.ucar.edu/icing/pcu6/**
3. Wetzel, M.A., D. Ivanova, J. French, L. Oolman, and T. Drew, 2015: Educational deployment of a research aircraft for interdisciplinary education, *24th Symposium on Education*, Annual Meeting of the American Meteorological Society, Phoenix, AZ, Amer. Meteor. Soc., 4-8 January 2015.

Acknowledgements

The ERAU project which provided the University of Wyoming King Air research flight data was sponsored by the National Science Foundation. The authors acknowledge contributions from Embry-Riddle and the University of Wyoming.