Experiment ices award for aviation weather team

Ice coats the windshield of a Convair 580 during a flight to gather data for ICICLE.

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Ice is a menace to safe flight. As ice coats and accumulates on an aircraft, the decreased thrust and lift, along with increased weight and drag it causes, contribute to an average of four accidents and five fatalities every year, according to the National Transportation Safety Board.

With those losses in mind and to mitigate the risk of encountering icing, the FAA led the In-Cloud Icing and Large-drop Experiment (ICICLE) in 2019, part of the FAA Aviation Weather Research Program. The multi-agency international field campaign produced a substantial set of useful data influencing the weather field.

“ICICLE has set a high standard for the extensiveness of measurements and has already proven to validate improvements in icing detection and forecasting,” said Danny Sims, physical scientist and inflight icing project lead in the NextGen Weather Research Branch. “It will enhance the safety of aviation operations around the world for years to come.”

Sims was part of the FAA team with Stephanie DiVito, a research meteorologist in the NextGen Propulsion and Aircraft Icing Section in the FAA Aviation Research Division. ICICLE's contributions to aviation meteorology gained attention and earned the team the 2022 National Weather Association's Aviation Meteorology Award.

Instruments attached to the wing--including (counterclockwise from upper left) a forward scattering spectrometer probe, Rosemount air data probe, and cloud droplet probes--measure different cloud particle sizes and concentrations.

"It's nice to be recognized by peers in the meteorological community," Sims said. "They know that it is an important scientific achievement. It was a fantastic effort by everyone involved."

DiVito managed the experiment from initial planning to post-event analysis as the ICICLE program lead.

"I'm so proud of this team and all we accomplished, and continue to accomplish, with the ICICLE program, and to receive an award for it is really the icing on the cake," she said.

The experiment collected data to evaluate the accuracy of current and developmental icing forecast tools and products for terminal and en route flights, as well as further understand the physical details of clouds.

ICICLE prioritized large drop icing environments, which include freezing drizzle and freezing rain, because despite the substantial threat they pose to aircraft, they are not explicitly diagnosed or forecasted in icing products.

While pilots normally try to avoid icing conditions, the pilots in this experiment pursued them. In a Convair 580 twin-engine turboprop airplane owned and operated by National Research Council Canada (NRC), the crew flew more than 110 hours during 26 flights, day and night, out of Rockford, Illinois, into icy weather in Illinois and surrounding states from January 28 to March 7, 2019.

“A field campaign can be dicey. We needed the weather to be right, and it went so well,” Sims said. “We filled those hours with icing conditions on every flight. It exceeded our expectations. We collected a treasure trove of data.”

Also necessary for success was the cooperation of all participants. Sims said each organization brought its strengths and worked together to determine how to conduct the experiment, such as when to fly and what to sample.

Mengistu Wolde, principal research officer with the National Research Council Canada (right), gives a tour of the aircraft used for ICICLE to Randy Bass, acting manager for the Aviation Weather Division. Bass oversaw and provided funding for the campaign. Wolde served as the NRC overall lead and as a member of the executive steering committee. He prepared and managed the research aircraft. (Photo by Danny Sims)

“The expertise, professionalism, patience, and dedication this team has is something special,” DiVito said. “Flight programs are hard work, long hours, and demanding schedules, not just during deployment but even in planning beforehand and analyses afterwards.”

Equipped with multiple onboard instruments, the aircraft enabled scientists and engineers to observe, document, and characterize different icing conditions while capturing the environmental parameters for small and large drop icing from freezing drizzle, freezing rain, and sleet.

Complementing the flight data was icing-relevant information from weather radars and satellites, icing forecasting tools, ground-based instrumentation, and meteorological sounding sites across the primary ICICLE area. Onboard cloud and precipitation radars let scientists describe the quality of clouds around the aircraft.

Collaboration continued after collecting the data as Environment and Climate Change Canada (ECCC) and NRC processed the airborne data and checked its quality and validity. The experiment data then became available to the wider meteorological research community in September 2022. National Center for Atmospheric Research (NCAR) scientists are maintaining the data archive and have

started analyses, focusing on specific case studies with some initial results of icing tool performance.

For example, NCAR determined that the National Oceanic and Atmospheric Administration (NOAA) High Resolution Rapid Refresh Model overestimated the occurrence of frozen-only particles at the expense of mixed and liquid-only conditions. The model also showed more small-drop icing and freezing rain while capturing a small percentage of freezing drizzle conditions as determined by drop diameter calculations.

These initial results and further analyses are expected to contribute to improvements in the microphysical processes in NOAA weather prediction models, enhancements to current icing tools, and the development of new tools that will be dedicated to airport terminal environments and potential applications to unmanned aircraft systems.

Icing primarily affects general aviation aircraft, but charter flights are also prone to it, Sims said. “It’s an ongoing safety issue. Unmanned aircraft are going to be susceptible to icing. There are going to be challenges. ICICLE lays the groundwork for how we look at those operations.”

Predicting icing remains difficult because there is no single source that directly observes and classifies an icing environment, Sims explained. Forecasters have to make an educated guess of the conditions based on satellites, radars, and subjective pilot reports.

“We’re still going to infer from multiple sources, but with ICICLE, we now have a good idea of how to forecast the phenomena,” he said.

In addition to the FAA, federal agencies participating in ICICLE were NOAA and NASA. International partners were the NRC, ECCC, Deutscher Wetterdienst (German Meteorological Service), Meteo-France, and the United Kingdom Meteorological Office. Other team members were from NCAR, Leading Edge Atmospherics LLC, Desert Research Institute, Northern Illinois University, Iowa State University, the University of Illinois at Urbana-Champaign, and Valparaiso University.

Pilots, aircraft ground support team, and project scientists who supported each flight on the ground or in the air, and two NRC managers pose by the Convair 580 parked at Rockford Airport used to collect data on icing during ICICLE. These staff were part of a larger crew participating as project scientists rotated in and out during the field campaign.