IN-FLIGHT ICING PROGRAM

Aviation Weather Research Program

NextGEN

Federal Aviation Administration

The Federal Aviation Administration (FAA) Aviation Weather Research Program (AWRP) conducts applied weather research to enhance the safety and efficiency of the National Airspace System. The goal of the research is to transition new or improved weather capabilities into evolving air traffic management decision support tools and/or incorporation by the National Weather Service (NWS) to improve delivery of FAA-required services and enhance aviation safety and efficiency.

In-Flight Icing (IFI) continues to be a safety issue for aviation as it can distort the flow of air over the wing and adversely affect handling qualities. An airplane may stall at much higher speeds and lower angles of attack than normal. It can roll or pitch uncontrollably, and recovery may be impossible.

Aircraft after being unable to climb to 5,000 feet "We were starting to pick up moderate rime icing but the boots were still shedding the ice"

The latest National Transportation Safety Board findings showed that during the period 2008 – 2016, there were 46 aircraft accidents and 52 fatalities that identified structural, in-flight icing as a cause or factor.

Ice accumulation on National Research Council of Canada (NRC) Convair-580 during In-Cloud Icing and Large-drop Experiment (ICICLE) Field Campaign

In addition, regulatory and policy changes have resulted in a shift in IFI research strategy. Traditional IFI forecasts focused on the potential and intensity of icing ranging from trace, light, moderate, to severe. FAA policy changes in Title 14, Code of Federal Regulations Part 25 [Airworthiness Standards: Transport Category Aircraft], Appendix C and Appendix O have been created to improve the safety in in-flight icing and super-cooled large drop (SLD) conditions.

These regulatory and policy changes have resulted in the following new icing categories for aircraft certification:

- No cloud
- Cloud but no icing
- Appendix C icing conditions with maximum drop diameters (Dmax) < 100 microns
- Appendix O icing conditions with Dmax 100 – 500 microns (Freezing Drizzle)
- Appendix O icing conditions with Dmax > 500 microns (Freezing Rain)

To mitigate the in-flight icing safety hazard, the IFI research is focused on enhancing automated diagnostic and forecast capabilities used by pilots, dispatchers and meteorologists to make timely decisions on icing threat areas, optimum routings, and areas to avoid in compliance to updated regulations and policy changes.

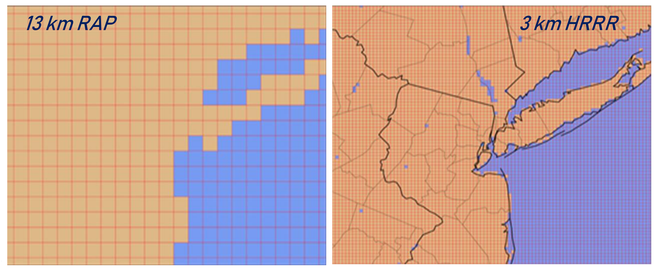
Appendix O icing conditions running back on wing surface of an aircraft

The current IFI related operational capabilities are:

- Current Icing Product (CIP) - an hourly diagnostics tool that makes use of satellite imagery, numerical weather prediction (NWP) model output, national radar and lightning data, surface weather observations, and pilot reports by combining individual data sources into an integrated algorithm that makes use of the strengths of each capability while simultaneously minimizing individual weaknesses.
- Forecast Icing Product (FIP) - a forecast version of CIP designed to mimic the technique of combining information from various sources to provide forecasts out to 18 hours.

The IFI program is focused on improving CIP and FIP by incorporating enhancements in NWP, weather satellites, and weather radar, and developing enhancements for Appendix C and O guidance.

The NWP model output will transition to the High Resolution Rapid Refresh (HRRR) model that has a horizontal grid spacing of 3 kilometers with 50 vertical levels.



13 km Rapid Refresh (RAP) horizontal grid spacing vs. 3 km HRRR

The newest generation of Geostationary Operational Environmental Satellites (GOES) provides an opportunity to enhance real time detection of aircraft icing hazards. CIP will also be modified to incorporate Next Generation Weather Radar (NEXRAD) dual-polarization data from the Multi-Radar Multi-Sensor (MRMS) national mosaic. Research will also be conducted into the ability to diagnose inflight icing conditions based on Appendix C and O drop size.

CIP/FIP v1.x

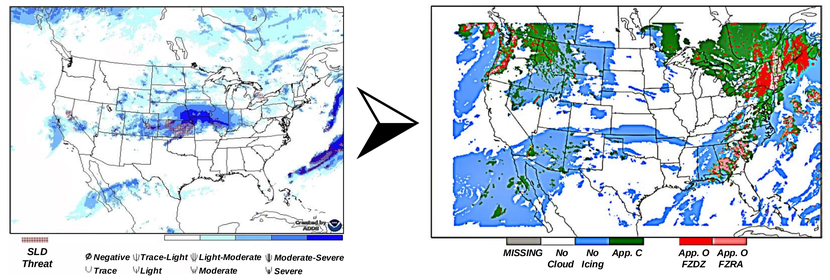
- Inputs from NWP model and observations
- Derivation of icing conditions largely based on interpretation of meteorological scenario
- Rules-based algorithms applied
- Information blended with fuzzy logic methodology
- Output products are icing probability, icing severity category, SLD potential

CIP/FIP v2.x

- Inputs from NWP model and observations
- Explicit use of model microphysics fields plus meteorological scenario analyses
- Ensemble-based methods for ingesting model forecasts
- Rules-based algorithms; adapted for HRRR fields
- Information blending
- Icing probability and severity plus drop size classification product

CIP and FIP enhancements (Version 2.x) are targeted for initial NWS operational implementation in 2023. However, the capabilities of providing drop size information are dependent upon a full and complete analysis of the ICICLE field campaign data which provides valuable in-cloud measurements of in-flight icing parameters. Future versions will add other refinements for improved accuracy and applicability to emerging aviation users.

Current icing severity CIP on left and possible new icing category product (Appendix C and O) on the right



Maximum icing severity (1000ft. MSL to FL300) *APPENDIX OC COMP* *03 HOUR FORECAST*

Weather in Alaska presents a special challenge for icing detection and forecasting due to terrain, air-sea interaction, variation in weather across the state, and the lack of observations. An IFI product, *Icing Product Alaska (IPA)*, provides experimental guidance for Alaska and surrounding areas. IPA was developed using the CIP and FIP as a foundation. IPA enhancements will include additional observational sources for Alaska such as polar orbiting weather satellites and will continue to use technologies developed for CIP and FIP. The initial operational version of IPA is expected in 2023.

IFI Research Support Team:

National Center for Atmospheric Research (NCAR), Boulder, CO
National Oceanic and Atmospheric Administration (NOAA) Earth System Research Laboratory (ESRL) Global Systems Lab (GSL), Boulder, CO
NOAA NWS National Centers for Environmental Prediction (NCEP) Aviation Weather Center (AWC), Kansas City, MO
FAA William J. Hughes Technical Center Aviation Weather Demonstration and Evaluation (AWDE) Services, Atlantic City, NJ

Reference Documents:

Aircraft Owners and Pilots Association (AOPA) Air Safety Foundation, Safety Advisor (SA-11-04/08), Aircraft Icing
Bernstein, B. C., F. McDonough, M. Politovich, B. Brown, T. Ratvasky, D. Miller, C. Wolff, and G. Cunning: Current Icing Potential: Algorithm Description and Comparison with Aircraft Observations, Journal of Applied Meteorology, July 2005
FAA AWRP Inflight Icing Project Plan, April 2020 – March 2021, Version 1.2, February 2020