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Accurate Predictions of In-Flight Icing

Preventing Accidents, Supporting Safer Flight

Since the 1990s, scientists and engineers in NSF NCAR's Transportation Meteorology Applications Program have worked toward better understanding, assessing, and forecasting the atmospheric conditions that lead to inflight icing.

Our research on inflight icing is focused on aviation safety. Armed with this research, pilots, air-traffic personnel, and weather forecasters today have greater access to timely diagnoses and accurate forecasts of in-flight icing conditions, as well as the tools to identify and avoid them.

Pinpointing Icing Conditions

In-flight icing continues to be a factor in aircraft accidents and causes significant disruptions to flight operations. These events can now be more effectively avoided due to improvements in the diagnoses and forecasts of aircraft icing conditions, including their operational availability, resolution, and accuracy. Scientists and engineers at NSF NCAR have developed a gridded depiction of in-flight icing conditions with high temporal and spatial resolution, based on coupling operational model output with real-time weather data.

The Current Icing Product (CIP), developed at NSF NCAR, is an approved operational product available from the National Weather Service's Aviation Weather Center. CIP provides an hourly forecast of

Benefits & Impacts

- Hourly updated diagnoses of icing conditions for flight planning
- Hourly updated forecasts of icing conditions 1-18 hours into the future
- Advanced synthesis of weather forecasts with real-time weather information
- Studies of precise liquid-water content and drop size in accordance with FAA requirements

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the potential of encountering airframe icing conditions over the CONUS at 3-km horizontal and 500-ft vertical resolution spanning 500 to 30,000 ft. Probability, expected severity, and the potential for supercooled large drop conditions (freezing rain and freezing drizzle) are included in the output files and displays.

The CIP algorithm combines numerical model output with weather information from satellite imagery, radar reflectivity, surface observations, lightning data, and pilot reports to deduce likely locations for in-flight icing conditions. A fuzzy-logic technique, based on physical concepts, as well as forecaster experience, is used to merge the data sets and produce the final icing product.

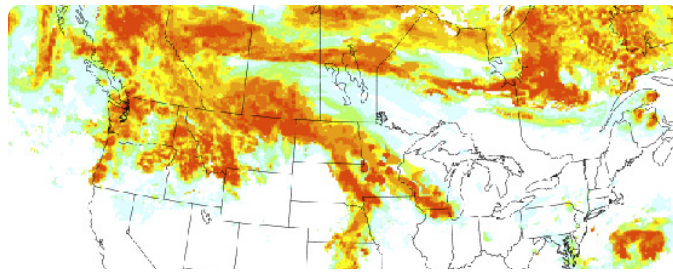
CIP's forecast companion, the Forecast Icing Product (FIP) provides forecasts of icing conditions from 1-18 hours into the future. FIP shares the same horizontal and vertical characteristics of CIP, but produces output over both the CONUS and Alaska. CIP and FIP outputs can be viewed on the National Weather Service's Aviation Weather Center website, aviationweather.gov.

Versions of CIP and FIP are being implemented in locations spanning the globe. NSF NCAR is developing a new version of CIP to address the challenging problems faced in Alaska both with different weather situations producing icing and a lack of observations when compared with the CONUS. Versions of CIP and FIP have been adapted and implemented operationally by the Taiwanese Civil Aviation Administration. A global version of FIP, covering remote areas used in oceanic aircraft routes, has been developed in partnership with the National Weather Service.

Developing weather & impact guidance to support operational decisions under uncertainty.

Improving Predictions

The NSF NCAR in-flight icing program also supports the development of numerical weather model microphysics parameterizations. These modules within numerical weather models have improved the prediction of supercooled liquid water in clouds, as well as freezing precipitation at the surface. The improved parameterizations were included in the latest NCEP Rapid Update (WRF-RAP) and



Maximum icing probability in a vertical column

High-Resolution Rapid Refresh (HRRR) versions of the Weather Research and Forecasting model. Application of this explicit microphysics information for use in icing prediction methods is the subject of current research.

Icing Detection By Radar

NSF NCAR has partnered with NASA on their Icing Remote Sensing System (NIRSS) consisting of a K-band radar, microwave profiling radiometer and ceilometer, demonstrating that this suite of instruments had a high success rate in detecting icing conditions aloft. Using lessons learned from working with these technologies, NSF NCAR developed the Radar Icing Algorithm (RadIA) using the National Weather Service (NWS) network of WSR-88D operational radars.

RadIA uses the dual-polarization measurements from the WSR-88D radars and the most recent numerical weather prediction model temperature profiles to detect icing-hazard regions. RadIA consists of several algorithms designed to identify hazards from different icing scenarios.

New Frontiers

To further support the FAA's mission of safety and efficiency, NSF NCAR researchers are developing improved high-resolution diagnoses and forecasts of in-flight icing conditions. Research in numerical modeling, improved observation techniques, and innovative methods for blending this information will result in improved accuracy of liquid-water content and drop-size predictions. These parameters, along with temperature, may allow for aircraft-specific predictions of severity by being used as input to calculations of ice accretion and resting flight performance degradation, which can be developed by aeronautical engineers.

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