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# Special Project

# Status of Inflight Icing Forecasting Products and Plans for Future Development

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# Status of Inflight Icing Forecasting Products and Plans for Future Development

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**Abstract**

The three papers in this Special Project Report were presented at the AIAA Atmospheric and Space Environments Conference in August 2010. They provide the current status of automated inflight icing diagnosis and forecast algorithms, and describe steps for improvement: new data inputs, improved logic, development of human-over-the-loop production methods, and expansion of the domain to cover the globe.

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## Foreword

Inflight icing has been a strong component of the Atmospheric and Space Environment Technical Committee of AIAA. For the most part, inflight icing studies presented at AIAA conferences tend to focus on the effects of the atmospheric environment on the performance of aircraft. However, descriptions of the icing environment, and of forecasting or diagnosing icing conditions, have also had a place in the presentations. This intermingling of related disciplines with a common goal—reducing icing-related accidents—has stimulated discussions and encouraged collaborations that otherwise would not likely have come to pass.

Three papers were presented at the 2010 Atmospheric and Space Environments Conference, held in Toronto, Ontario, Canada describing state-of-the-art automated forecasts and paths to future versions. At the time of the 2010 Conference, products available for inflight icing forecasting included the following:

- Airmen's Meteorological Bulletin (AIRMET): An advisory for widespread moderate or greater structural icing covering a 6-h forecast period, which may be amended.

- Significant Meteorological Information (SIGMET): A weather advisory for severe icing over a 3000-mi$^2$ or 7800 km$^2$ area.

- Current Icing Product (CIP): An hourly diagnosis of inflight icing environmental conditions over the continental United States (CONUS). The product includes probability of encountering icing in any of the 20-km/1000-ft grid boxes, expected severity, and likelihood of supercooled large drop (SLD; drops with diameters exceeding 50 microns, which is outside of the certification conditions). The CIP algorithm combines numerical weather prediction (NWP) model output with observations such as geostationary satellite imagery, NexRad radar reflectivity, surface weather observations, and the national lightning network.

- Forecast Icing Product (FIP): An output updated hourly for each hour up to 12 hours forward in time. FIP is similar to CIP but it uses NWP model surrogates for the observations ingested by CIP.

The automated CIP and FIP do very well at what they are called to do: provide a medium-scale resolution product with a broad-brushed icing severity estimation over the CONUS. The intended user is an aviation meteorologist, dispatcher, or pilot looking for strategic information for flight planning. Graphical depiction, both format and content, is extremely important to these users.

Consider a future air transportation system where aviation weather products are fully integrated into a seamless weather-to-aircraft process. The products will incorporate various components including weather observations, NWP models, algorithms to interpret and combine information, human-over-the-loop methods, communications protocols, and flight planning and control systems. User needs for displays will be taken into account, but for the most part the forecaster, dispatcher, or pilot is not the end-user so much as automated aircraft and ground-based systems that plan for and monitor the many aircraft in the air.

This publication, which comprises three presented papers, offers ideas for extending the existing suite of inflight icing products into new geographic domains, with richer information content and opportunities for forecasters to add additional skill and insight gained from experience and knowledge of the atmosphere. This research, which is underway, forms a solid basis for automated aircraft icing diagnosis and forecasting, which offers the reader a glimpse into future products.

# Potential Upgrades to the Current and Forecast Icing Algorithms

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**The Current and Forecast Icing Product algorithms generate icing diagnoses and forecasts across the CONUS. These have been approved for use in operational decision-making in aviation. However, there is both a desire and need for upgrades to improve accuracy through use of new or improved weather prediction models or observations. This paper describes the upgrades planned at this time and outlines the reasoning behind choosing new candidate information for those upgrades. Two products under consideration for addition to CIP, images from the Advanced Satellite Aviation-Weather Program and grids from the 3-D NexRad radar mosaic produced by the National Severe Storms Laboratory, are described in more detail.**

## I. Introduction

IT is not difficult to provide an automated icing forecast. Looking for moist air in the appropriate temperature range will give a fairly good forecast of icing – this was the basis behind the Schultz-Politovich algorithm[1], which was based on temperature and relative humidity fields from the Nested Grid Model in the early 1990s. If the user is only looking for a broad-based forecast of where icing conditions are likely, this fills the niche very nicely.

However, that's not the entire picture. As the user demands more details such as severity (especially moderate or greater), conditions outside Appendix C (including SLD, supercooled large drops with diameters exceeding 50 microns), higher resolution in time and space (especially vertically) and expanded geographic coverage, the forecast process becomes increasingly more complex. There are many areas in seemingly favorable temperature and humidity ranges that do not include icing conditions.

This paper will describe planned upgrades to the Current and Forecast Icing Products, and how upgrade data and process candidates are chosen. The development and operational transfer of icing products are closely linked to NextGen schedules and requirements; however this paper will focus on technical aspects of the upgrade process.

## II. Algorithm Basics

The Current Icing Product[2] (CIP) provides an hourly diagnosis of icing conditions. The CIP algorithm examines model outputs and observations, and extracts clues about the icing environment from these information sources. The process is straightforward and traceable. It's relatively easy to assess the impact of humidity fields or satellite-derived cloud top temperatures on the final product. The forecast version, FIP, is purely model-based and uses models outputs as surrogates for most of the observations.

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