Project Summary

Aircraft icing poses a significant hazard to commuter and regional aircraft operations. Considering that in-flight aircraft icing was considered a significant factor in three major aircraft accidents in the past 5 years (1994: ATR-72 at Roselawn, 1997: Embraer-120 at Detroit, 1999: Canadair Regional Jet at Fredericton), it is evident that the icing environment can exceed the capabilities of some aircraft and that icing forecast products need to be improved significantly. The Federal Aviation Administration Inflight Aircraft Icing Plan was developed in 1997 to address safety concerns relating to in-flight icing. Task 3 of this plan is to '*Accelerate development of airborne technologies that remotely assess icing conditions*'. The work conducted in this Phase II research, the evaluation of a ground-based sensor package for remotely detecting inflight icing conditions, was focused directly on this task.

SPEC Incorporated designed, assembled and evaluated a ground-based "combined sensor package" intended for remote measurement of supercooled liquid water content (SLWC), i.e., inflight icing conditions. The sensor package consisted of a dual-wavelength (X and K_a-Band) radar system and a dual-frequency (22 and 37 GHz) microwave radiometer. A Learjet research aircraft was equipped for making microphysical measurements and was used to make in situ comparisons with the radar and radiometer observations. New instrumentation installed on the Learjet (i.e., a cloud particle imager and a Nevzorov liquid and total water content probe) provided vastly improved particle and liquid water content measurements in icing conditions. This research was not intended to demonstrate the feasibility of a commercially available "combined sensor package" for remotely detecting inflight icing conditions. Instead, the research was geared at demonstrating the feasibility of the remote measurement methodology.

The radiometer measures the total liquid water along the path in the direction the antenna is pointed. The instrument is based on physical first principles, i.e., the emission characteristics of liquid and vapor water molecules. The radar system measurement of liquid water is based on the differential absorption of the two radar signals by liquid water molecules. That is, it is also a first principles instrument. However the nearly ubiquitous presence of Mie scattering particles (ice too large for the Raleigh scatter assumptions) interspersed with the liquid water particles makes the straightforward derivation of liquid water contents from the radar signals intractable. Therefore three different algorithms for deriving liquid water content profiles were used and compared in this study. A neural net algorithm developed by the University of Massachusetts (UMASS) appeared to provide the best results.

Data were collected during the Alliance Icing Research Study (AIRS) field project in January – February 2000. In addition to the SPEC radar system, UMASS operated a K_a-Band and W-Band radar and McMaster University operated an X-band radar at the Mirabel airport. Due to limited weather opportunities, only six Learjet ascents were made up the radar/radiometer beams. In addition to data collected by the Learjet, the NRC Convair executed spiral descents and stepped-ascent level flight legs in the vicinity of the Mirabel airport. A portion of this data set was also used to evaluate the performance of the combined sensor package. Also, data from the UMASS and the McMaster radar were incorporated into this analysis.

Based on the limited data collected, combined radiometric and radar measurements produced a reliable method to identify regions with SLWC > ~0.1 g m^{-3} that extended for at least 2 km.

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