JP1.24 INCORPORATING DATA FROM GOES AND POES PLATFORMS INTO AN INTEGRATED IN-FLIGHT ICING DIAGNOSTIC ALGORITHM FOR ALASKA

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1. INTRODUCTION

Though the aviation safety record in Alaska has improved, general aviation accidents still occur which are related to mesoscale in-flight icing conditions that are not well forecast with models and algorithms available to aviation forecasters. As part of the FAA's In-flight Icing Product Development Team, we have been developing a version of the National Center for Atmospheric Research/ Research Applications Program (NCAR/RAP) Integrated Icing Diagnostic Algorithm (IIDA; McDonough and Bernstein 1999) suitable for Alaskan application that utilizes the Penn State/NCAR MM5 mesoscale modeling system (e.g, Grell *et al.* 1994; Chen and Dudhia 2001).

In this paper we focus on the methodology of the Alaska-specific IIDA (hereafter referred to as the UAF IIDA) that we have developed at the University of Alaska Fairbanks, including the satellite aspects. We will describe the procedures used in incorporating data from the GOES-10 platform and merging this data with other data sources. We also briefly discuss possibilities for incorporating POES data, which, to achieve optimal icing diagnoses, will require a blending of data from GOES and POES along the appropriate POES swath at the time of interest.

2.OVERVIEW OF THE NCAR/RAP IIDA

Many elements of the UAF IIDA are heavily based upon the NCAR/RAP version. The NCAR/RAP version is fully described in McDonough and Bernstein (1999). Here we present a brief overview of the algorithm to provide a context for the modifications we have made, presented in the following section.

The NCAR/RAP IIDA utilizes several different types of meteorological data as input: a) output from the Rapid Update Cycle II model (RUCII) numerical weather prediction model; b) conventional surface observations (METARs); c) the national radar mosaic, d) pilot reports (PIREPs), and e) National Weather Service (NWS) GOES-8 satellite data including the visible (0.67 mm), short-wave infrared (3.7 µm), and long-wave infrared (10.8, 12.0µm) channels as well as the short-wave reflectance.

A combination of the GOES-8 data and model output is used to eliminate cloud-free areas from further consideration and determine cloud top temperature and cloud top height. METARs are introduced in a concentric scanning approach as the primary means of determining cloud base height. Once cloud parameters have been established, the METARs are again scanned for the occurrence of precipitation, with a focus on areas of freezing precipitation, frozen precipitation, rain and drizzle.

The next step in the algorithm is to apply the temperature, cloud top temperature and relative humidity to a series of 'interest maps'. This process utilizes fuzzy logic and is designed to relate the fields to the potential for the existence of supercooled liquid water (SLW) within a RUC II model grid column. SLW is a prime ingredient in many in-flight icing scenarios. The functional form of the maps is based on *in-situ* observations of various cloud types (e.g, Sassen *et al*., 1985) and icing environments (e.g, Miller *et al.* 1998) as well as past experience with the performance of previous algorithms as validated by PIREPs (e.g., Schultz and Politovich 1992).

The likelihood of icing suggested by the interest maps is further modified based upon the particular meteorological scenario (thermodynamic structure, multiple cloud layers, etc.) and the information provided by surface observations of precipitation type and the radar mosaic, drawing from the current state of knowledge regarding the occurrence of aircraft icing in these situations. For icing diagnoses, positive icing PIREPs obtained within 60 minutes of the diagnosis time at a distance no greater than 150 km (300m) horizontally (vertically) from the RUCII grid cell are used to further enhance the icing potential. Detailed discussion of five common icing scenarios and how such modifications occur can be found in McDonough and Bernstein (1999).

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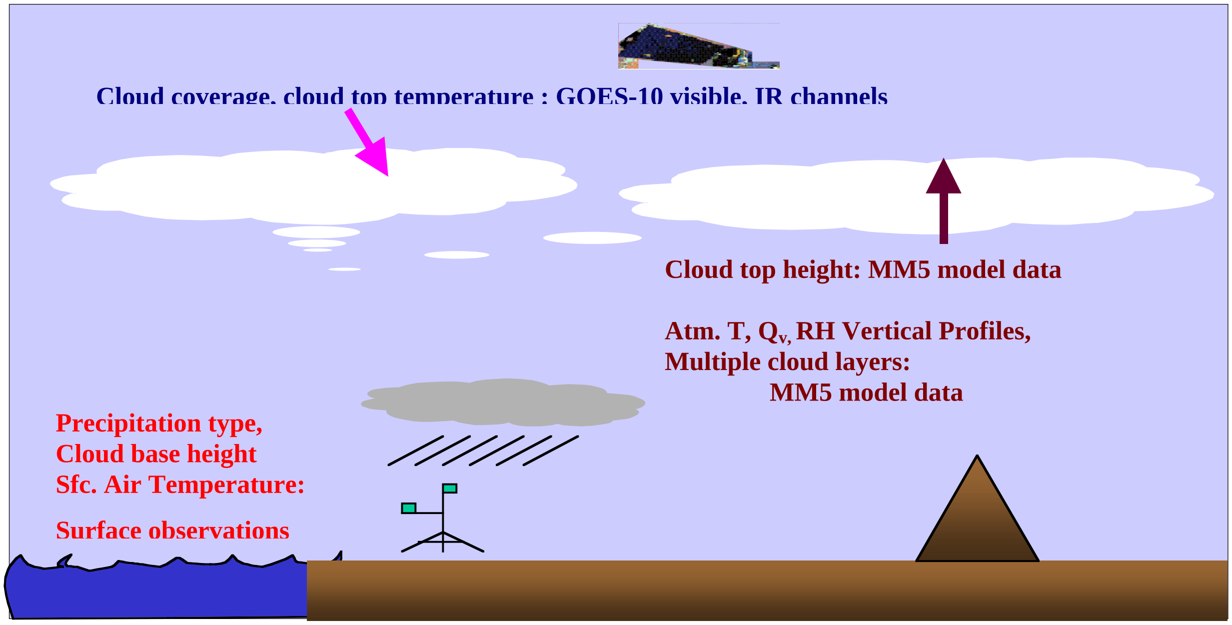

Figure 1. Schematic of UAF IIDA algorithm. See text for detailed description of elements.

3. UAF IIDA MODIFICATIONS

The current implementation of the NCAR/RAP IIDA has provided us with an excellent starting point for development of an Alaska-specific IIDA. However, some elements of the NCAR/RAP IIDA are not well suited for Alaska applications. Some of the data sources used in the NCAR IIDA are not available to the same extent or from the same platform. For example, while there are seven NEXRAD Doppler radars in the state, they are not geographically distributed to be utilized optimally by an icing algorithm, being concentrated in southern Alaska. Further, some of these sites have substantial terrain blocking to contend with, reducing considerably the volume of airspace for which useful radar information is available. In addition, the RUC II model is not available for Alaska, and GOES-8 satellite coverage does not extend far enough north or west to be useful.

Thus, to develop an IIDA that is optimal for Alaska, the NCAR IIDA must be modified. A schematic diagram of our algorithm is provided in Figure 1. The following paragraphs address our approach to dealing with each of the problems specific to Alaska applications.

First, while the RUC II model is not available for Alaska, there are versions of the Eta, Nested Grid Model, Aviation Model and the PSU/NCAR MM5 mesoscale model available in real to near-real-time. The first three of these models are available via the National Weather Service, whose Fairbanks office is co-located with UAF. The latter model is run operationally over Alaska and vicinity by the Air Force Weather Agency (AFWA). The AFWA MM5 data are made available to UAF via a special arrangement with the Air Force for this work as well as other research. Given positive experience with the use of MM5 in forecasting for icing field studies (e.g., Rasmussen *et al.,* 1992) and our own experience in evaluating MM5

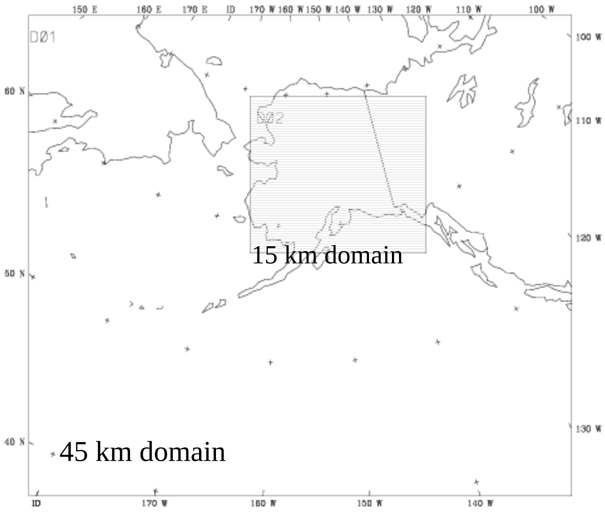

Figure 2. AFWA MM5 forecast domains at grid resolutions 45 km (no shading) and 15 km (shaded area) respectively. Only the 15 km domain is utilized in the UAF IIDA.

predictions of SLW (Tilley *et al.* 1999), we elected to utilize the MM5 model in the UAF IIDA.

Some information on the MM5 model configuration used in the UAF IIDA is given in Tilley *et al.* (2002). For the case presented, we have implemented the UAF IIDA on an 18-km grid. Our rationale for doing so involves the fact that routine icing forecasts for Alaska often involve large spatial areas for relatively long time periods (often 12 hours or more). Our objective in performing mesoscale tests was to see how much reduction in areal and volume coverage of icing forecasts might be attainable by providing finer scale model input to the UAF IIDA. Our previous work (e.g, Tilley *et al.,* 1999) suggests that in some cases significant reductions in forecast icing volume might be possible.

Next, given relatively sparse quality radar data, we feel that more study is needed on the potential usefulness of this data before including it in an Alaska-specific IIDA. In addition to coverage issues, little observational work has been done on both cloud microphysics in high latitudes or the robustness of current radar retrieval algorithms in these environments.

As an alternative to using the actual NEXRAD datastream, in the UAF IIDA we utilize a calculation of simulated radar reflectivity from MM5 output mixing ratios of rain, snow and graupel developed by Mark Stoelinga at the University of Washington (e.g, Stoelinga, 2001).

Conventional surface observations are also sparse over Alaska compared to the mid-latitudes. Many of these stations are sited in areas that are not representative due to mesoscale topography within the area comprising an MM5 grid box. As such, the 150 km search radius for the concentric scanning process may not be optimal. Testing may suggest a better value for this parameter.

4. INCORPORATION OF GOES DATA

The GOES-8 satellite has insufficient geographic coverage for an Alaska-specific IIDA, though the Pacific-centered GOES-10 does provide coverage for much of our area of interest. We have modified the IIDA to accept this data.

GOES-10 data is received at UAF at the Alaska Data Visualization and Analysis Laboratory (ADVAL) and processed at ADVAL using a SeaSpace TeraScan system. During this initial processing, the data is prepared so that it may be used in the same way that GOES-8 data is used in the NCAR/RAP IIDA. TeraScan functions are used to: a) subset the data for Alaska (function "fastreg"), b) fix bad data points (function "outliers"), and c) compute latitude, longitude, satellite and solar zenith angles, and relative azimuth angles (function "angles"). Channel 2 reflectance data is computed closely following code developed by Greg Thompson for the NCAR IIDA (Thompson, pers. comm.) which follows Turk *et al.* (1998). Finally, the TDF format file output by this procedure is converted to an HDF format for use by the UAF IIDA.

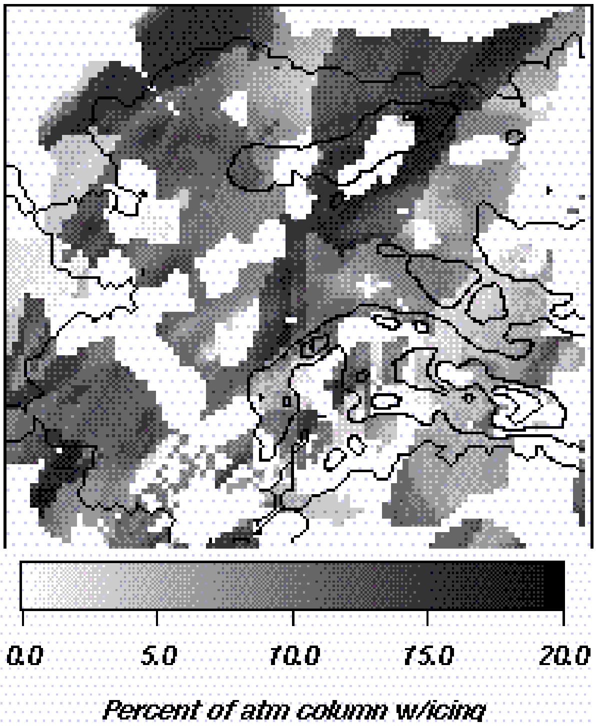

Figure 3. Column-Integrated Icing potential at 00 UTC June 15 1998 from the UAF IIDA. Values indicate the percentage of the atmospheric column with any icing potential.

While this input is sufficient as a start, we recognize that over much of our domain a geostationary satellite will be viewing the area from a large tangential angle, with increasing degradation in resolution with increasing latitude. Following a brief description of initial results, we will present our plans to deal with this shortcoming and its impact on the icing diagnosis as a whole.

5. RESULTS FROM A TEST CASE

Figure 3 shows a sample of IIDA output for a test period in mid summer 1998. This period is the focus of two companion papers (Kramm and Tilley 2002; Tilley et. al. 2002). Some potential for in-flight icing exists over a substantial area of the state; the column-integrated output provides a worst-case scenario as far as spatial areas that could be potentially affected by icing. We are encouraged that the algorithm indicates the highest values in areas that are climatologically reasonable for this time of year (e.g., the North Slope, Brooks Range and southwest Alaska). We will present more results and verification at the conference.

6. FUTURE PLANS: POES DATA

As latitude increases, each pixel of data in a GOES-10 image covers a larger geographical area due to the increased viewing angle from the vertical. For Alaska, this may mean a biased icing diagnosis where the sideways viewing angle contributes to an inaccurate reflectance, primarily in the northern half of the State. To overcome this effect at high latitudes, it is desirable to incorporate polar orbiter (POES) AVHRR data for Alaska into the IIDA.

For most passes, POES data will not be available for the entire domain. We anticipate an approach where data from the two sources are merged in time as well as space, since the POES pass times rarely coincide exactly with available GOES images. For initial tests we will omit the temporal merging given that the difference in time between a POES pass and a corresponding GOES image should be under 15 minutes. Except for convective episodes, dramatic differences in cloud top temperature and height over such a time period should be relatively small and not impact the diagnosis.

Other issues include the different channels in the AVHRR and GVAR sensors, and proper registration of the POES swaths before blending with the GOES data. We will explore these issues further at the conference.

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