Current Icing Product

Part I - Mission Connection

Product Description

The Current Icing Product (CIP) is an automatically-generated index suitable for depicting areas of potentially hazardous airframe icing. This version of the CIP was updated in December 2006. The original CIP was implemented in 2002.

The CIP algorithm is rooted in cloud physics principles that have been applied in the practical forecasting of icing probability and severity using research aircraft for nearly a decade. These principles and the resulting methods have also been applied to studies of icing incidents and accidents, as well as daily assessment of icing environments associated with icing pilot reports (PIREPs) over the United States and Canada at all times of the year.

CIP developers at the National Center for Atmospheric Research (NCAR) have discovered methods for gleaning information from operationally available datasets and determine their relevance to specific icing environments and the confidence one can have in the information they provide. The result is a physically based technique that diagnoses the severity of a meteorological icing environment through the balanced integration of information extracted from each data source. This information is then translated into a categorical icing severity index that is designed to cover a wide range of aircraft and provide information to users that is relevant to decision processes related to in-flight icing.

The CIP algorithm combines satellite, radar, surface, lightning and pilot report observations, as well as the icing potential and supercooled large droplet output, with model output to create a weighted consensus estimation of the meteorological severity of the icing environment in terms of an assessment of the liquid water content, drop size and temperature.

Purpose

The CIP suite of products was developed to meet an outstanding need. The original CIP was developed to produce "icing potential." However, FAA regulations have always been associated with standard icing severity categories, such as light, moderate and severe. The CIP now provides icing severity output. Another improvement in the CIP compared to the original CIP is that the general (total) icing potential output has been recalibrated to indicate icing probability values. Probability is a more suitable metric for those who must make critical go/no-go decisions.

This CIP is part of a larger effort to support the NWS Strategic Plan's goal to provide graphical weather products to the flying public.

Product Availability and Transmission Schedule

The CIP is an operational NWS product. It is available in GRIB format at both 20 kilometer (km) and 40 km horizontal resolution over the conterminous United States and adjacent coastal waters (CONUS). The CIP is produced hourly in tandem with the NCEP Rapid Update Model (RUC).

Audience

The CIP is intended for both high-volume users of NWS forecast information (GRIB), as well as individuals who may wish to view the data on a webpage maintained by the NWS or a weather product vendor. The CIP is intended to be used as a supplement, not as a substitute for the icing data contained in AIRMETs and SIGMETs. The regulatory arm of the FAA may restrict the CIP for use by operational meteorologists and trained dispatchers.

Web Interface

The CIP can be visualized in real-time at the following URL:

http://adds.aviationweather.gov/icing/.

See Figures 1 and 2 below for examples of the CIP severity and probability output.

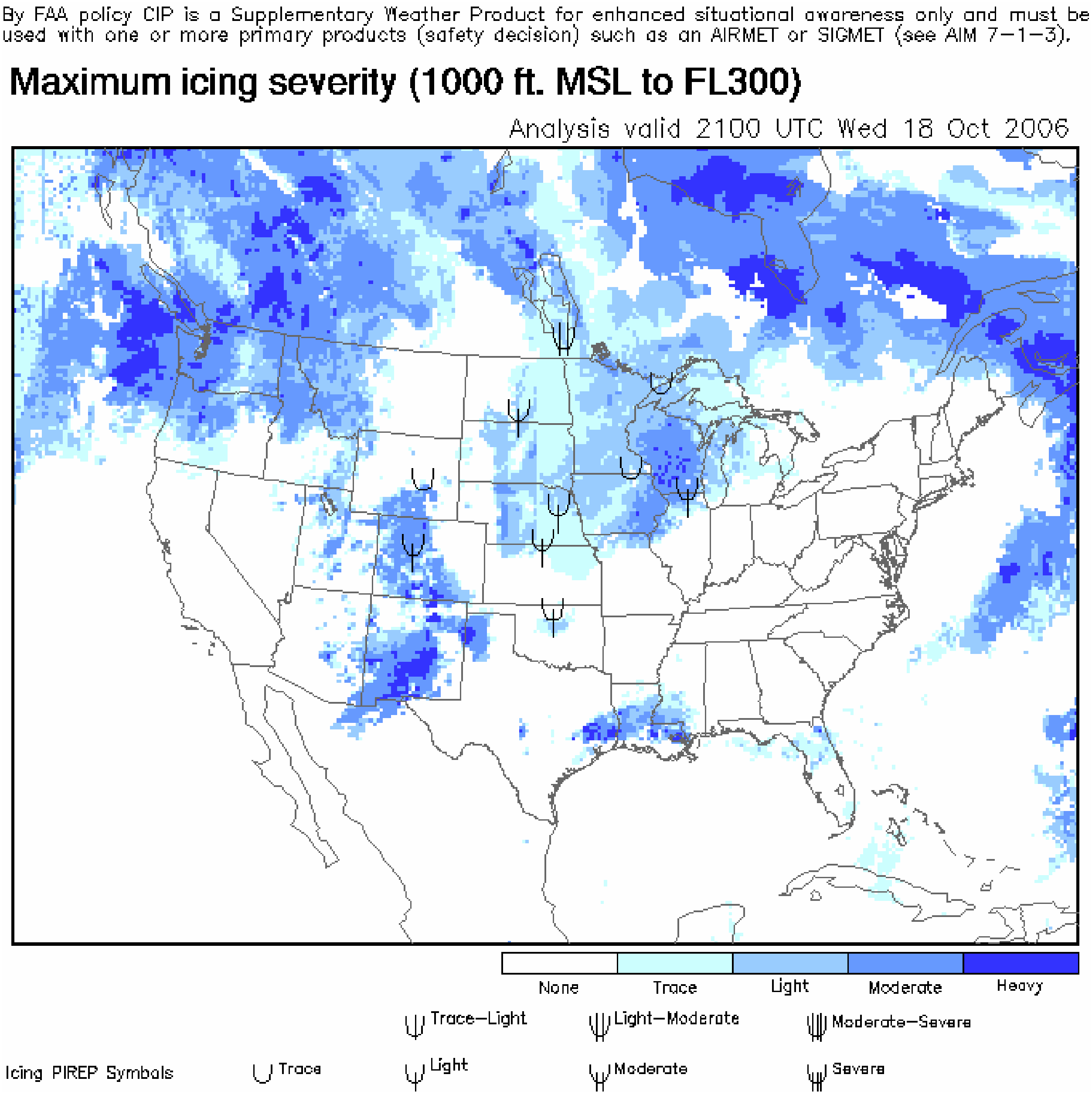

Figure 1: CIP Maximum Icing Severity - valid 2100 UTC 18 October 2006

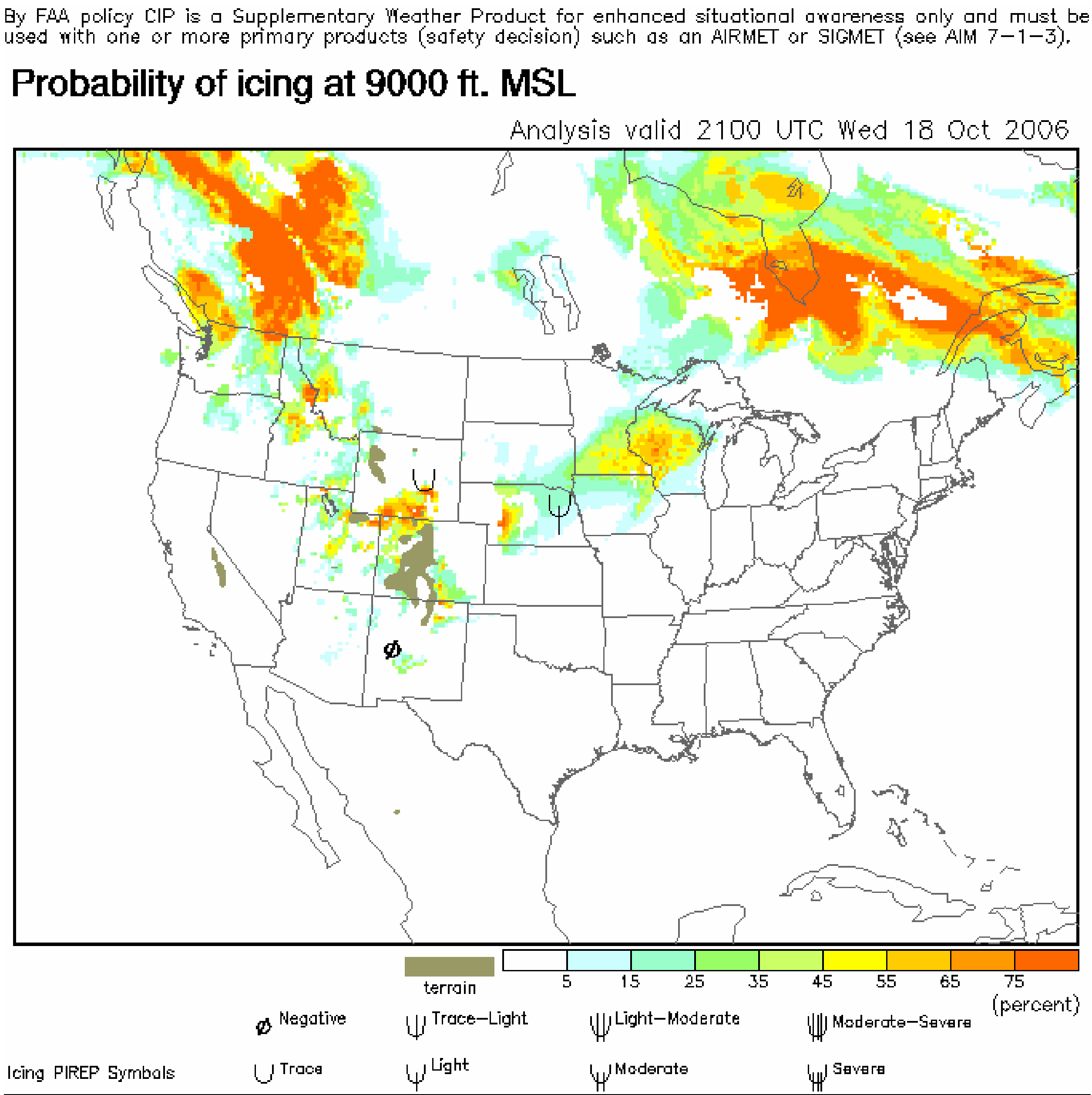

Figure 2: CIP Probability of Icing at 9000 feet MSL - valid 2100 UTC 18 October 2006

<u>Feedback Method</u>

The NWS is always seeking to improve the representation of our products based on user feedback. Comments regarding the CIP may be submitted http://adds.aviationweather.gov/info/feedback.php.

Part II - Technical Description

Input Datasets and Methodology

This section describes the datasets used as input to the CIP algorithm and the fields of interest from each one. A flow chart of the CIP process can be seen below in Figure 3.

(1) Model

The Rapid Update Cycle (RUC) model operated by the National Weather Service is used to define the algorithm domain and grid spacing (grid boxes are approximately 20 km by 20km). Both the pressure and hybrid level output files are ingested. The CIP uses three hour forecasts valid at the CIP diagnosis time whenever possible. If those are not available it will look for the six, nine, and twelve hour forecasts, respectively. The RUC pressure files provide temperature, geopotential height, relative humidity, and vertical velocity every 25 hectopascals (hPa). The RUC files provide five condensate species (cloud water, rain water, cloud ice, graupel, and snow) which are interpolated to the 25 hPa pressure levels.

(2) Satellite

The satellite data are provided by the National Oceanographic and Atmospheric Administration (NOAA) GOES satellites. The data from the two satellites covering the CONUS are stitched together and mapped to the model grid. The fields used are the visible reflectance (channel 1), longwave infrared (channel 4), and the difference between the short and longwave infrared (channel 2 – channel 4). Shortwave reflectance is derived from the channel 2 data, and the solar zenith angle is also calculated for each grid point.

(3) METARs

Surface observations (METARs) provide information on cloud cover, ceiling height, precipitation occurrence and type. The observations are mapped to the model grid using a concentric circles approach. Initially, CIP searches for ceiling and precipitation information from stations within 20 km of the center of a grid box. If appropriate information is not found within this radius, the circle is expanded until such information is found, out to a maximum radius of 125 km, if necessary. A complex hierarchical scheme based on the observational capabilities of each station is used in the determination of precipitation type.

(4) PIREPs

Pilot reports of icing severity from the previous two hours are used to determine a consensus severity and a weighting factor for each grid box. The spatial and temporal distance of the PIREP from a particular grid point determines the relevance of the PIREP information.

(5) Radar

Radar data are supplied via a mosaic of composite National Weather Service NEXRAD reflectivity with 4 km spacing over the CONUS. Values are available in 5 dBZ increments, starting at minimum reflectivity of 5 dBZ. The CIP algorithm uses the 25th and 75th percentiles of the array of reflectivity values found within each model grid box. They are also used to define scenarios by identifying areas of precipitation that are not reported by the METARs.

(6) Lightning

Lightning data are provided by the National Lightning Detection Network. This dataset provides the location of all lightning strikes over the CONUS and is updated every minute. Strikes from the fifteen minutes before the top of the hour are first used to identify the icing situation as "deep convection". The number of strikes within a radius of the center of each grid box is later used in the CIP calculation.

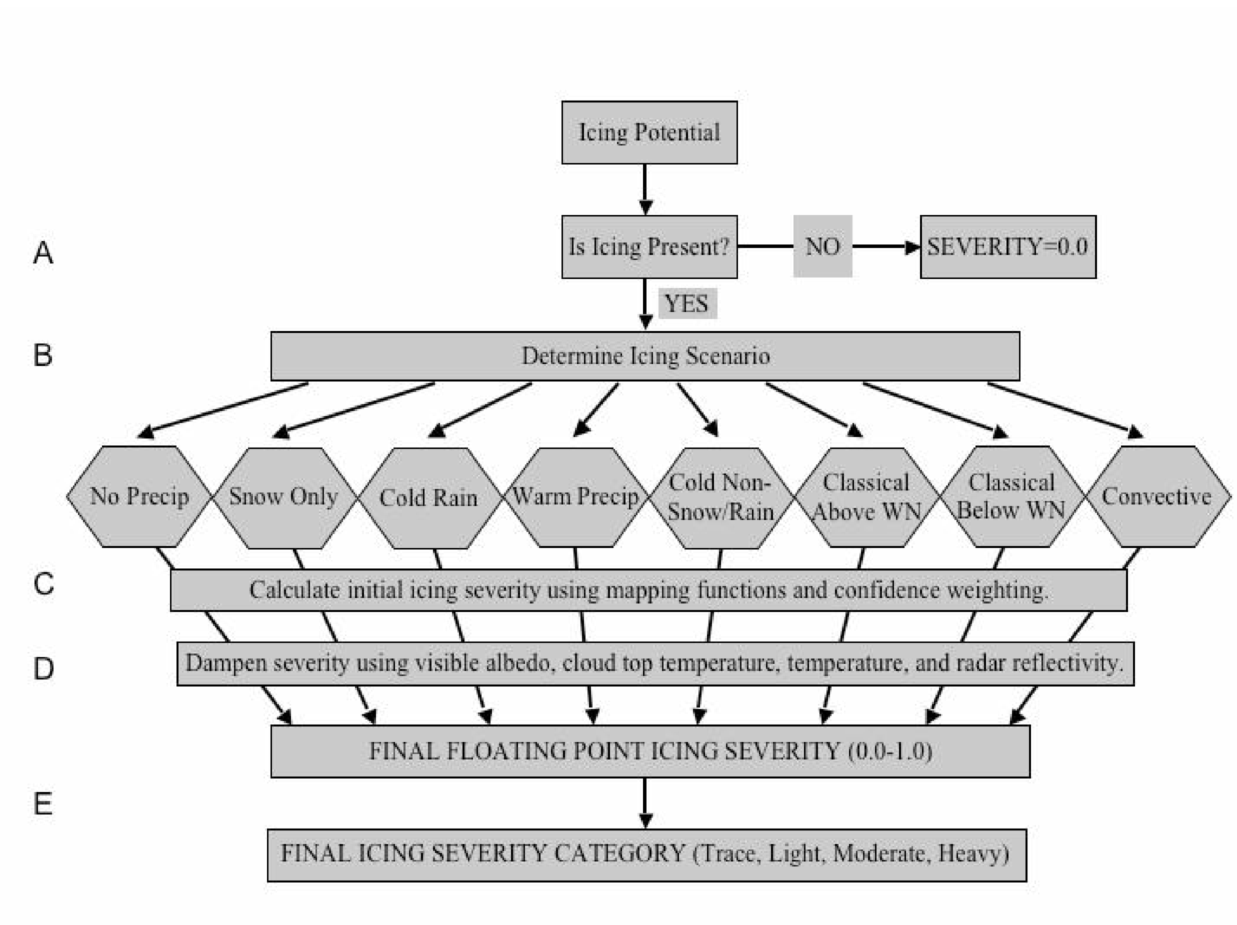

Figure 3: Flowchart of the CIP Processes

CIP Output

The CIP severity output ranges between 0.0 and 1.0, with larger values indicating higher expected severity. To translate this output into meaningful categories for users, the output was compared to thousands of positive and negative icing PIREPs in areas experiencing a large variety of icing situations so that all the icing conditions were well represented.

The following categorical thresholds were chosen:

No Icing: < 0.01
0.01 ≤ Trace ≤ 0.175
0.175 < Light ≤ 0.375
0.375 < Moderate ≤ 0.7
0.7 < Heavy

The severity value calculated is the expected representative icing severity for the grid box for the range of aircraft in the development and verification data set. This brings up an important point regarding the applicability of a single severity index to the wide variety of aircraft that are flying.

Much has been written regarding the relationship between icing severity and aircraft type. It is obvious that different types of aircraft experience different severities of icing in the same atmospheric environments. Severity definitions are currently pilot-based and thus are a function of the aircraft type, flight phase (takeoff/landing, cruise, etc.), aircraft configuration, as well as the pilot's experience and perception of the icing hazard. The goal of researchers and the FAA is to develop accurate definitions of the icing environment in terms of meteorological parameters – liquid water content, drop size and temperature – and allow calculation of an aircraft specific severity from those parameters. To date, however, no single data source or system has accomplished this adequately.

The CIP is designed to glean severity relevant information from each data source available to it, weigh that information appropriately for the icing situation at hand, and create a weighted consensus estimation of the meteorological severity of the icing environment in terms of an assessment of the liquid water content, drop size and temperature. This information can be roughly translated into an ice accretion rate, given an assumed aircraft speed and configuration. Ice accretion rates can be fairly accurately calculated for a range of 9 airfoil sections, but the accretion on a whole aircraft is uncertain. Furthermore, the relationship between accretion and resulting performance degradation is not well understood. The prediction of future accretion is further confounded by how much ice (and location and texture) is already on the aircraft when it encounters an icing condition greatly affects the response to that condition.