International Civil Aviation Organization

WAFSOPSG/7-WP/15
5/7/12

WORKING PAPER

WORLD AREA FORECAST SYSTEM OPERATIONS GROUP (WAFSOPSG)

SEVENTH MEETING

Lima, Peru, 17 to 21 September 2012

Agenda Item 6: Development of the WAFS
6.2: Improved GRIB 2 forecasts for CB clouds, icing and turbulence

VERIFICATION OF WAFS ICING GRIDS

(Presented by the WAFC Provider States)

SUMMARY

This paper discusses verification methodology and results for WAFS harmonized icing grids.

1. INTRODUCTION

1.1 The World Area Forecast Centres (WAFCs) began producing experimental icing grids in 2006. The United States WAFC generates its grids with a unique algorithm, running on the United States Global Forecast System (GFS) model. The United Kingdom WAFC generates its icing grids from a slightly different set of algorithms, running on the UKMO's Unified model. This results in differences between the two forecast data sets.

1.2 The two world area forecast system (WAFS) Provider States reported to sixth meeting of the World Area Forecast System Operations Group (WAFSOPSG/6) that they were going to resolve the differences between their two individual forecasts by harmonizing the separate forecast grids. The final forecast is provided in two sets, a mean grid output and a maximum grid output, that give the user the average of the two individual grids and the maximum of the two grids.

1.2.1 A separate Working Paper (WP) presented to this meeting further documents the harmonization process, and also provides more details about the algorithms, resolution and delivery times of the grids themselves.

1.3 For reference, WAFSOPSG/6 Conclusion 6/18 stated:

> "That, in view of the expected successful harmonization of the WAFS gridded data sets for icing, turbulence and CB clouds, and the expected positive results of the forthcoming verification of the forecasts at WAFSOPSG/7, as well as the provision of updated guidance material on the new gridded data, the Note 1 at Paragraph 1.2.2 of Appendix 2 to Annex 3 regarding the experimental label "trial forecasts", be removed as part of Amendment 76."

1.4 WAFSOPSG/6 Decision 6/14 complemented Conclusion 6/18, stating:

> "That, the WAFS gridded icing forecast be endorsed as operationally acceptable for use in extended range operations by twin-engined aeroplanes (ETOPS) flight planning."

1.5 The two WAFCs posted a user's guide for the grids on the WAFSOPSG website and first made the harmonized WAFS forecasts available in November, 2011.

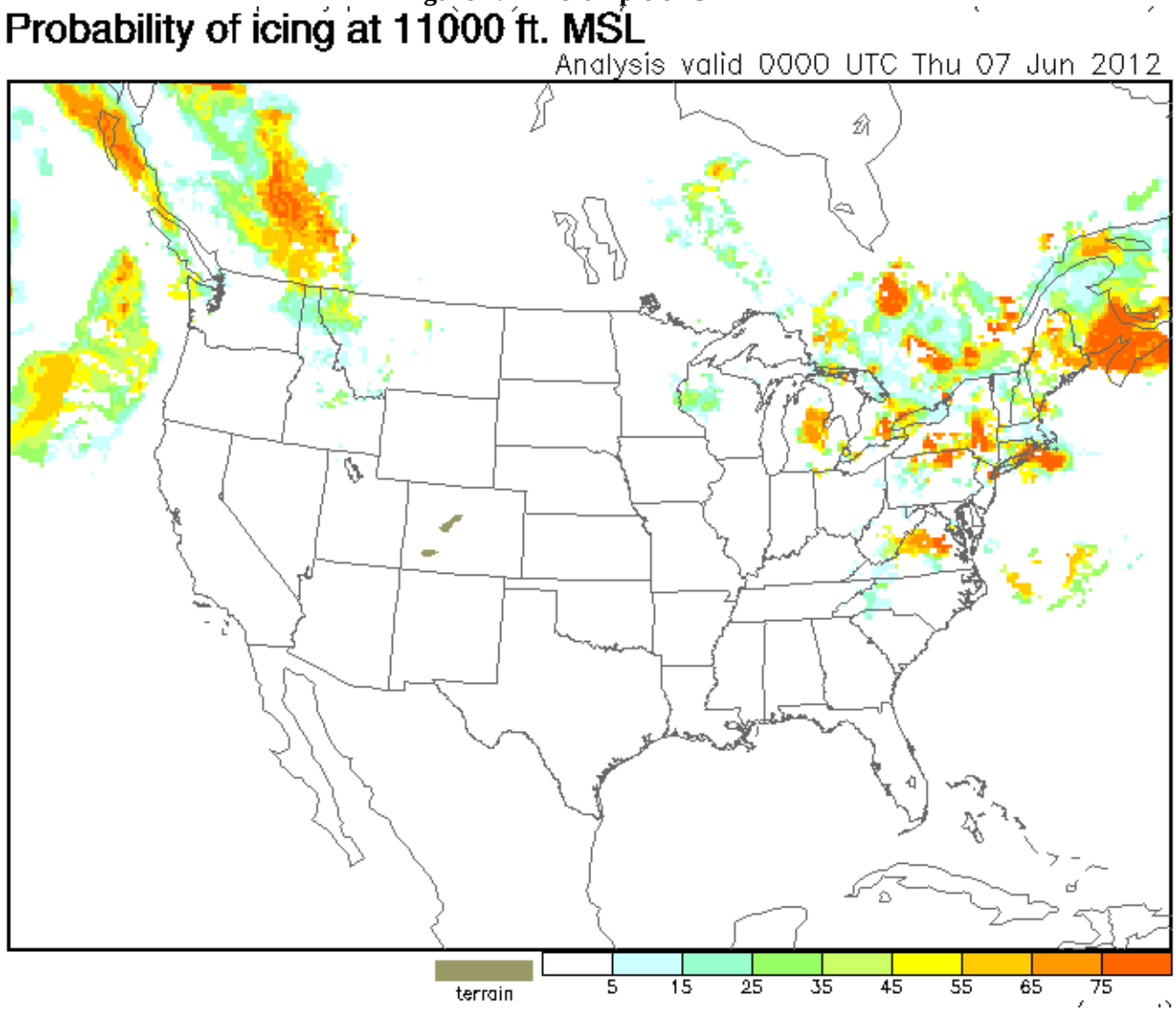
1.6 This WP will provide the verification information for icing grids that was requested by WAFSOPSG/6. It will demonstrate that the harmonizing process improves the accuracy of the grids, and that the harmonized grids can predict the potential of icing.

2. VERIFICATION METHODOLOGY

2.1 Direct observation of icing is very difficult. Pilot reports of icing are rare, as pilots avoid forecasted areas of icing, and transcontinental and transoceanic commercial flights are flown well above the optimum icing altitudes. It is also not directly detectable by radar or satellite observations, and there are very few automated sensors on aircraft. Icing must instead be inferred, using a combination of pilot reports, radar, satellite imagery and initial model analysis. This data is evaluated by a sophisticated analysis package that creates a Current Icing Potential (CIP) grid, which can then be used to verify the WAFCs icing forecast grids.

2.2 A simple explanation of CIP is that it is an observation of icing potential that starts with finding areas of super-cooled liquid water in the GFS model's initial analysis. These areas are then adjusted by comparing them to locations of clouds detected by satellite. Further adjustment is done by comparing the areas to radar, lightning data and surface observations, and then a final adjustment is done via comparison with any available pilot reports.

Figure 1: An example of CIP



2.3 As it is not an in situ measurement, the CIP product (figure 1) can only provide an observed potential of icing. It does not give a binary yes/no observation of icing. The CIP values range on a scale of zero to 100 percent.

2.4 Studies by the U.S. National Center for Atmospheric Research show that the CIP product compares well with available pilot reports, as well as with other icing observation systems, such as the polar orbiting Cloudsat satellite.

2.5 The CIP product is only available over the continental United States, due to a lack of input data over other areas of the world. However, CIP, and icing verification will be expanded to other areas as data becomes available for those areas. See the Appendix to this paper for a list of data required for CIP.

3. VERIFICATION RESULTS

3.1 Since CIP is an observed potential of icing, it was decided to verify thresholds of forecast icing potential in the WAFS grids against the corresponding observed CIP icing potential. For example, a WAFS icing forecast of 0.5 is considered correct if the corresponding CIP value is 0.5 or greater.

3.2 Recalling that WAFSOPSG/6 made the recommendation of using a WAFS icing grid threshold of 0.1 as the threshold for icing avoidance when planning for ETOPS, Table 1 gives verification performance statistics for the WAFC London, WAFC Washington and the harmonized icing grids at a threshold of 0.1 for the 24 hour forecast period.

Table 1: FL100 – 24hr forecast WAFS Icing Forecast vs Observed Current Icing Potential (CIP) Verification Period November 5th, 2011 through June 5th, 2012.

	Hit Rate	False Alarm Rate	Bias	Num of Events
WAFC London Mean	0.91	0.18	2.37	2379692
WAFC Washington Mean	0.38	0.03	0.59	2379692
Harmonized Mean	0.89	0.16	2.19	2379692
WAFC London Max	0.93	0.21	2.67	2379692
WAFC Washington Max	0.79	0.14	1.92	2379692
Harmonized Max	0.95	0.24	2.96	2379692

Verification statistics for other thresholds, as well as for FL140, another important level for ETOPS planning, are available through examining Figures 2 through 5. All values are for forecast hour 24.

Figure 2: FL100 Relative Operating Characteristics Curve

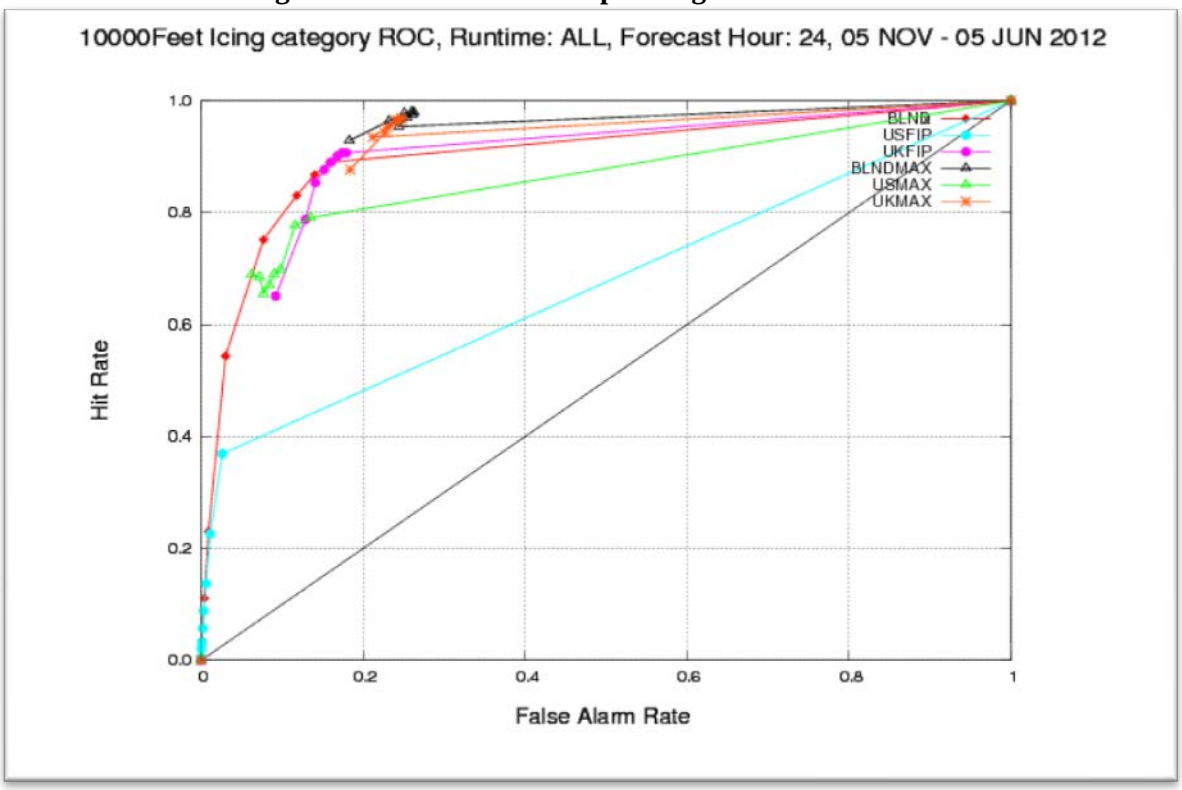


Figure 3: FL100 Bias

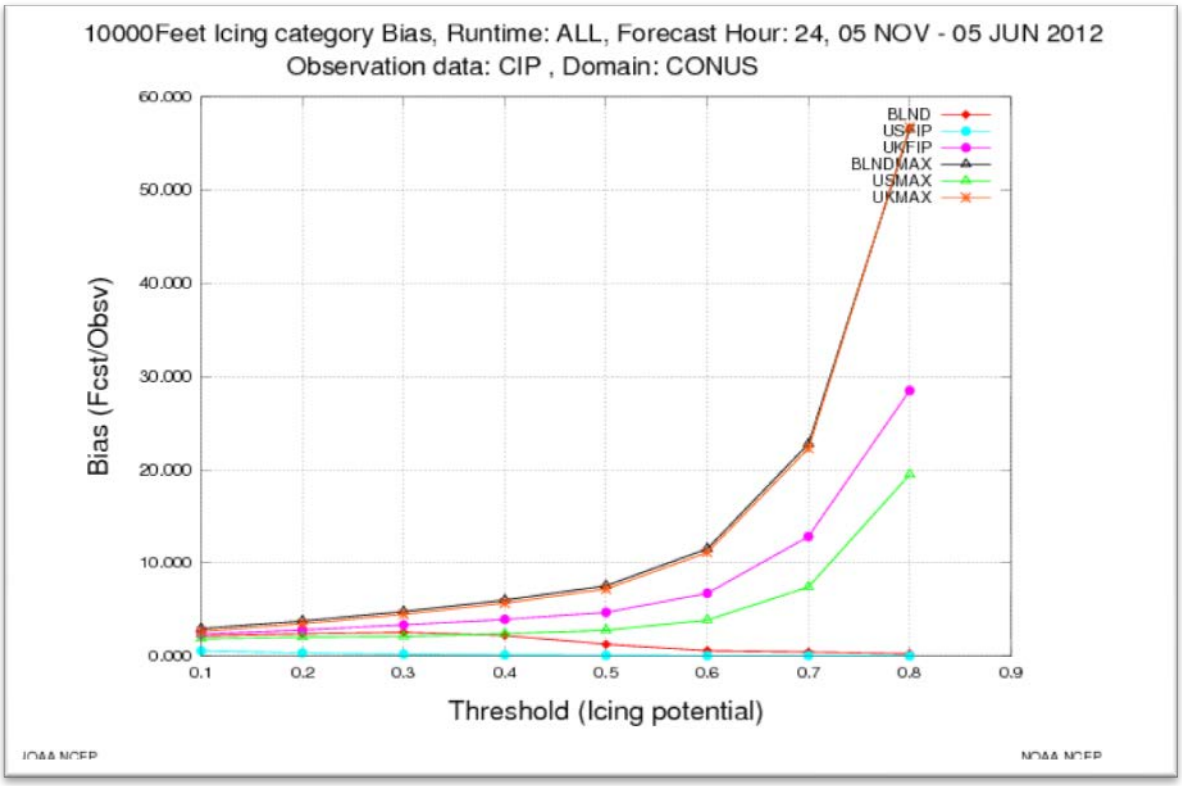


Figure 4: FL140 Relative Operating Characteristics Curve

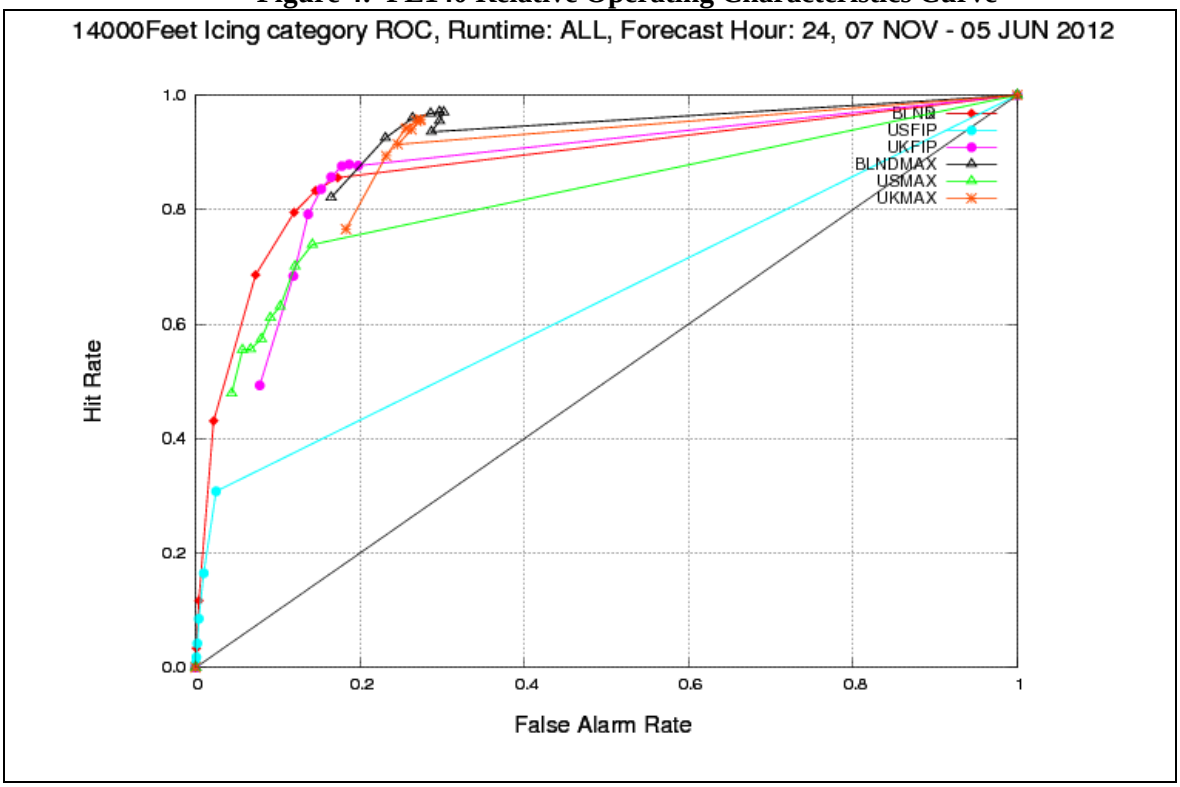
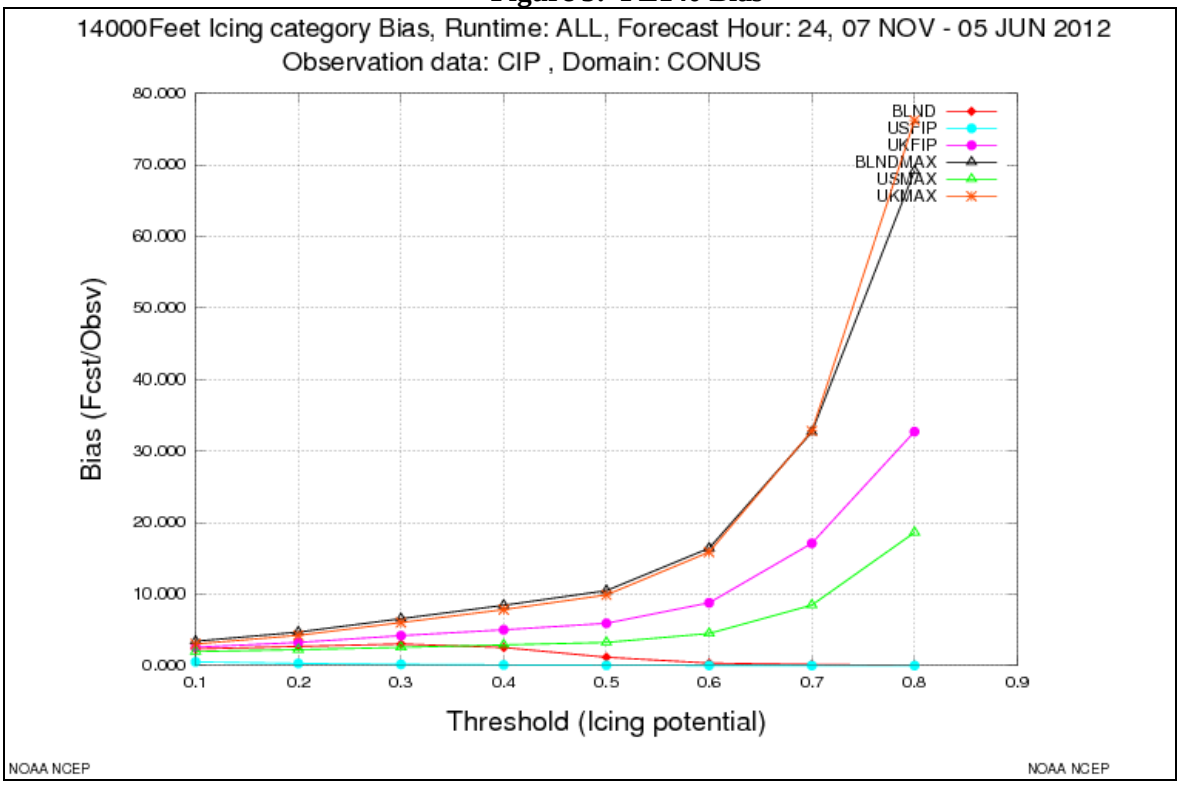


Figure 5: FL140 Bias



4. CONCLUSION

4.1 Due to its higher hit rate for the recommended icing potential threshold of 0.1 for ETOPS planning, the WAFS harmonized Maximum icing forecast provides a more conservative forecast of icing than either of the individual WAFS grids.

4.2 Other thresholds may be useful for other purposes. For example, the WAFS harmonized Mean potential of 0.1 has an 89 per cent hit rate, with only a 16 per cent false alarm rate and a relatively lower bias of 2.19. Operators should examine the verification statistics to find the threshold value that best supports their operations.

4.3 The verification statistics have been calculated for all flight levels and all forecast times that are available in the WAFS icing grids. The verification results could be published on the WAFCs website. Consideration should be given to extending the verification systems globally where suitable observational datasets exist.

4.4 The group is invited to consider the following draft conclusion.

Conclusion 7/xx — Verification of WAFS forecasts for icing

That,

a) the group consider the gridded, harmonized forecast of WAFS icing meets operational requirements; and

b) the WAFCs be invited to make available the icing verification results available on their websites.

5. ACTION BY THE WAFSOPSG

5.1 The WAFSOPSG is invited to:

a) note the information contained in this working paper; and

b) decide on a draft conclusion for the group's consideration.

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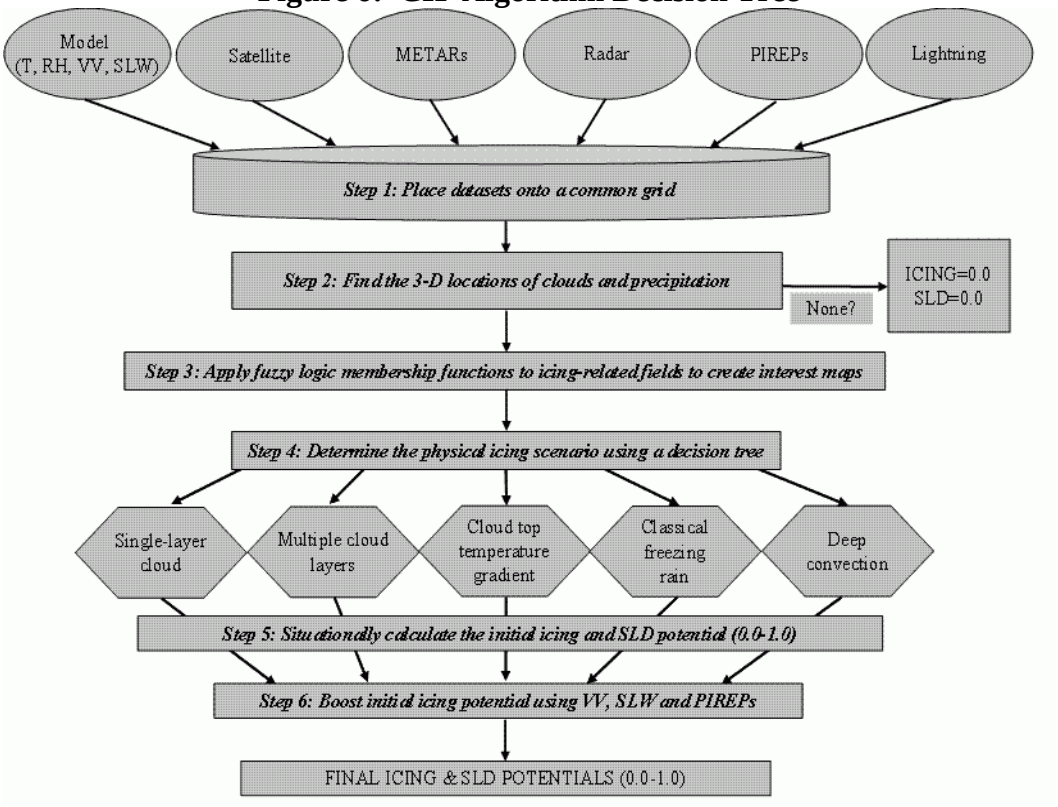
APPENDIX

CIP PROCESS OVERVIEW

List of data required to produce CIP:

1) Initial (00 hour) model analysis of temperature, relative humidity, vertical velocity and super cooled liquid water content.
2) Radar reflectivity.
3) Satellite – brightness temperatures of infrared, shortwave infrared and visible.
4) Surface Observations.
5) Lightning strike locations.
6) Pilot Reports, if any exist.

Figure 6: CIP Algorithm Decision Tree



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