Climatological Assessment of Aircraft Icing Conditions and Associated Cloud Properties Derived from Satellite Data and Icing PIREPS

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Objectives

This poster describes the climatology of icing conditions derived from satellite data in single (SL) and multi-layered (ML) cloud system over Continent United States (CONUS). Specific questions being addressed include:

(1) Distribution of annual icing occurrences over CONUS;

(2) Seasonal variations of icing frequencies and associated cloud conditions;

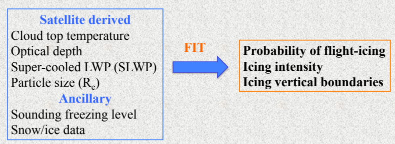
(3) Quantify the accuracy and utility of the satellite icing analyses by comparing

- **Satellite icing detection vs. icing PIREPS;**
- **Icing climatology based on satellite observations (FIT algorithm) and balloonborne soundings (CIP algorithm);**
- **Icing boundaries detected by satellite vs. PIREPS icing altitude;**

(4) To what extent can ML icing detection increase the ability to detect icing under the ice cloud top condition.

FIT Algorithm and Performance

The FIT algorithm is developed for application to cloud parameters retrieved from operational satellite data, such as MODIS, GOES Imager, SEVIRI and GOES-R.



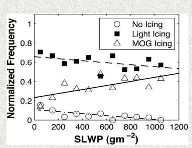


Fig. 1 PIREPS icing intensity is linearly related to super-cooled liquid water path (SLWP).

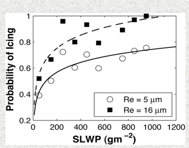


Fig. 2 PIREPS icing intensity weakly depends on the effective radius.

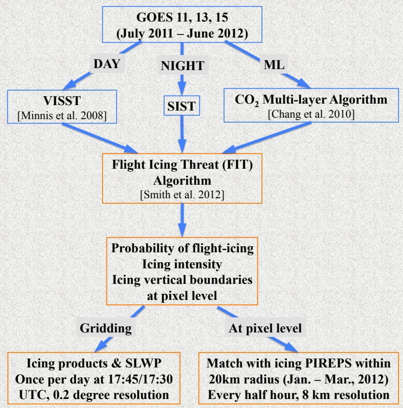
Validation (Table 1):

- icing PIREPS (2008-2010 winters)
- NASA Icing Remote Sensing System (NIRSS, 2008-2010)
- Topospheric Airborne Meteorological Data Reporting (TAMDAR, 2005)

Table. 1 FIT algorithm performance for unobscured cloud conditions

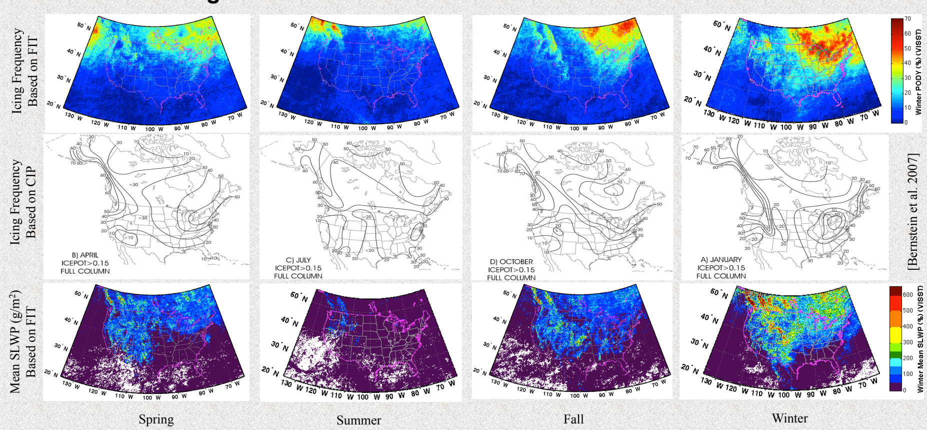
Dataset	Day/night	PODY (%)	Accuracy (%)	Intensity accuracy (%)
PIREPS	Night	64	63	-
PIREPS	Day (all)	98	93	58
PIREPS	Day (filtered)	-	-	67
NIRSS	Day	100	90	77
TAMDAR	Day	87	53	-

Data Processing and Methods



We calculated the annual mean, seasonal mean and monthly mean of super-cooled liquid water, icing vertical boundaries, and icing frequencies.

Seasonal Change



Icing frequencies based on FIT:

- Two major icing centers develop in the fall and reaches maxima in the winter
- Two icing maxima retreat to north in the spring and reaches minimum in the summer
- Have very similar pattern comparing to icing frequencies based on Current Icing Potential (CIP) algorithm
- Able to capture fine features of icing distribution with much higher resolution

Mean SLWP:

- Reaches local maximum in the winter and minimum in the summer

Annual Icing Climatology

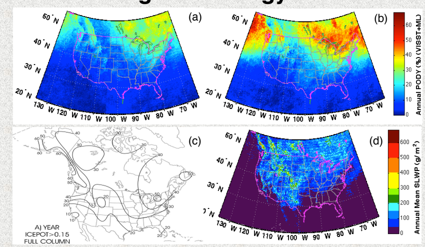


Fig.3 Annual icing frequencies (%) using (a) single layer icing product; (b) single layer and multi-layer combined icing product. (c) Icing frequencies based on CIP [Bernstein et al. 2007]. (d) Mean SLWP.

There are two major icing maxima over CONUS (Fig.3b):

- The first maximum extends southwestward and westward from Maine, NY to the Great Lakes, and Ohio Valley.
- The second maximum is along the Pacific Northwest.

Single layer icing (Fig.3a) vs. SL+ML icing (Fig.3b):

- SL icing missed significant amount of icing cases due to high level ice cloud

Icing frequency FIT vs. CIP:

- Patterns of two major icing maxima are same.
- FIT icing reveals a third icing maxima at the junction of Idaho and Montana, extending northwest into Canada.

Icing FIT vs. PIREPS

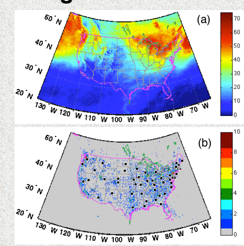
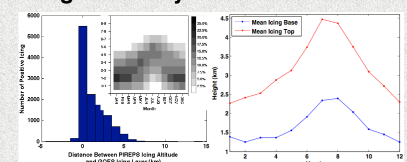


Fig. 4 Icing frequencies based on (a) FIT SL+ML; and (b) PIREPS, in winter months of 2012.

- PIREPS icing is biased high around the major airports (black dots) and flight paths.

Icing Boundary FIT vs. PIREPS



Conclusions

Using the Flight Icing Threat (FIT) algorithm developed for satellite applications,

- We are first time enabled to study icing climatology over the CONUS domain with satellite observations in high spatial and temporal resolutions;
- One year of GOES icing data and associated cloud parameters are used to create geographic and altitude distributions annually and seasonally;
- Three months of GOES Single Layer (ML) icing are compared to icing PIREPS;
- The comparison of satellite-based icing climatology and a previous study is discussed.

The results extended our understanding of the benefits and limitations associated with current satellite-based icing diagnoses, and will help guide future improvements, particularly for advanced satellite sensors, such as the GOES-R Advanced Baseline Imager, scheduled for operational use in 2017.

References

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