NOWCASTING FLIGHT ICING CONDITIONS USING OPERATIONAL SATELLITE DATA

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ABSTRACT

At NASA Langley Research Center (LaRC), we developed a Flight Icing Threat (FIT) algorithm to provide near-real time estimation of icing probability, intensity and vertical range using operational satellite data. The FIT algorithm uses satellite-derived cloud parameters as input. The algorithm is validated using Pilot Reports (PIREPS) and NASA Icing Remote Sensing System (NIRSS) data during winter months in 2008 to 2010. The algorithm is currently being run routinely using data taken from a variety of satellites across the globe and is providing useful information on icing conditions at high spatial and temporal resolution that are unavailable from any other source.

1. INTRODUCTION

Flight icing is one of the most frequent causes of weather-related aviation accidents. Icing could result in loss of lift, reduced airspeed, control problems, and potentially lead to fatal accidents. Satellite data have been proven useful to estimate aircraft icing conditions with a number of distinct benefits. An advanced satellite-based Flight Icing Threat (FIT) algorithm has been developed at NASA LaRC. This paper describes the FIT algorithm, product and validation.

2. DATA

In this study, VISST (Visible Infrared Solar-infrared Split-window Technique) and SIST (Solar-infrared Infrared Split-window Technique) cloud products (Minnis et al. 2011) derived from GOES Imager data were fed into the FIT algorithm, and the resulting icing products were verified using PIREPS (winter months of 2008 to 2010) over the Continental United States, and NIRSS data at NASA Glenn Research Center in Cleveland, Ohio (2008 to 2010). A case study over South America on August 21, 2011 is presented and analyzed using the VISST-GOES cloud product along with the collocated CALIPSO Vertical Feature Mask (VFM).

3. FIT ALGORITHM AND PRODUCT

Meteorological factors related to flight icing include cloud temperature (Tc), cloud phase, liquid water content (LWC) and the concentration of large droplets. Liquid water path (LWP) and effective radius (R_e) can be used as surrogates for LWC and the particle size, respectively. We found that super-cooled liquid water path (SLWP) is linearly related to PIREPS icing intensity. The probability of moderate or greater (MOG) icing increases with SLWP. The probability of no icing decreases with SLWP.

The FIT product includes icing mask, icing probability and intensity, vertical range and icing threat indices. Icing area is identified when optically thick water cloud pixels with Tc below the freezing point. The vertical icing range is from icing cloud top to icing bottom. The FIT icing probability and intensity are functions of SLWP and R_e, which were derived from correlations with PIREPS data. The FIT algorithm is documented in Smith et al. (2012).

4. RESULTS

An icing case over southern Brazil on August 21, 2011 is analyzed to demonstrate the FIT product. The FIT icing mask, probability and intensity derived from the VISST-GOES12 cloud product at 17:45 UTC are presented in Fig. 1, where the black dash line is the CALIPSO track with the time stamps when CALIPSO flew over the cloud system.

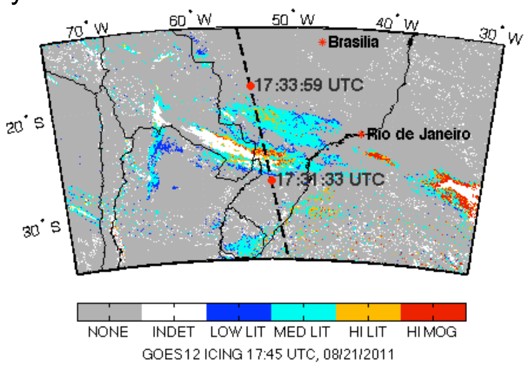

Fig. 1 GOES12 FIT Icing at 17:45 UTC

The vertical cloud type in the CALIPSO Vertical Feature Mask (VFM) product between 17:31 and 17:34 UTC is superimposed with the FIT icing intensity and range in Fig. 2, where the right vertical color bar presents the CALIPSO cloud phase, the top row of legend describes the GOES cloud phase, and the second row of legend denotes the FIT icing intensity. In this case, the retrieval of the cloud top and

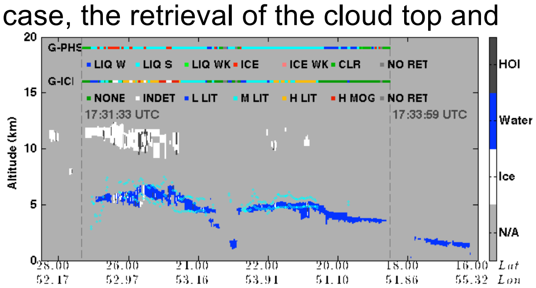

Fig. 2 Vertical slice of the cloud structure along CALIPSO track (Fig. 1) and collocated VISST-GOES12 icing detection. Cyan dots are icing range detected by the FIT algorithm.

base height is only slightly affected by the high-level ice cloud. The icing range detection is generally accurate for the low level cloud without the obstruction of high level ice clouds.

5. VALIDATION

The FIT icing mask and intensity are verified using ground-truth observations (PIREPS winter months in 2008-2010), and ground-based remote sensing system (NIRSS in 2008-2010). The algorithm performs reasonably well during the daytime. The accuracy of icing detection is above 90% when high level ice clouds do not obscure the icing layers. The accuracies of icing intensity detection for overcast super-cooled clouds range from 60% to 75% using PIREPS and NIRSS data as ground truth, despite many challenges associated with characterizing intensity, either in-situ or remotely.

6. DISCUSSIONS

The satellite FIT product appears to provide timely flight icing information with wide coverage, high spatial and temporal resolution to aviation communities. The FIT icing mask, icing probability, intensity and range estimations provide valuable information that could help pilots avoid dangerous airspace.

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