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Potential icing cloud detection from geostationary satellites using machine learning approaches

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Although anti-ice coating and de-icing technologies have been improving, aviation icing is still a kind of critical aerial hazards as ever. Aviation icing is a phenomenon in which an ice film is formed on the surface and/or engine of the aircraft. When icing is formed, well-organized aerodynamic balance is contaminated, resulting aviation misleading. Super-cooled droplets (SCDs) rich clouds are considered as potential icing conditions, thus identifying those clouds are the key to prevent icing. Therefore, many studies about detecting icing potential clouds are conducted with the numerical weather prediction (NWP) and satellite remote sensed data. However, icing potential clouds are typically present in spatiotemporally inconstant forms, thus, geostationary satellite observations could be useful, while NWP has coarser spatiotemporal resolution. The current icing potential (CIP) system is in operation using meteorological products from Geostationary Operational Environmental Satellite (GOES) series, and the flight icing threat (FIT) system is being prepared to provide icing potential cloud warnings in the US. However, although several geostationary satellite sensor systems are available in East Asia, there are no operationally available icing detection models. In this study, two icing potential cloud detection systems are proposed, which are based on Communication, Ocean and Meteorological Satellite (COMS) Meteorological Imager (MI) sensor, and Himawari-8 Advanced Himawari Imager (AHI) products. COMS MI provides data in 5 channels in 15-minute intervals since April 2011, and Himawari-8 AHI provides data in 16 channels in 10-minute intervals since July 2015 till now. Two types of machine learning techniques are used to simulate potential icing identification—random forest (RF) and multinomial log-linear model (MLM) via neural networks. Quality controlled pilot reports (PIREPs) were used as reference data. Results showed that the COMS RF model produced a detection accuracy of 90% and a false detection rate of 20% while MLM produced a detection accuracy of 70% and a false detection rate of 15%. When the FIT model was applied to the same validation data, it resulted in a detection accuracy of 30% and a false detection rate of 45%. Both RF and MLM methods yielded the same detection and false-detection rates (i.e. 75% and 0%) for Himawari-8. However, reference data for Himawari-8 are not yet sufficient to develop robust machine learning models. The models for Himawari-8 will be further refined when more quality controlled PIREPs are available.