A Prototype Method for Diagnosing High Ice Water Content in Near-Real-Time Using Passive Satellite Imagery

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Abstract
High concentrations of ice particles, i.e., HIWC, have been linked to aircraft engine power loss events at cruise altitudes where the existence of supercooled water droplets is extremely improbable. In-situ ice water content measurements were matched to satellite cloud property retrievals in order to develop an algorithm to estimate the probability of high ice water content PHIWC in satellite imagery. Most observed HIWC had PHIWC greater than 0.2. HIWC frequently occurs within 60 km of over-shooting cloud tops (OTs). Therefore, a database of OT detections from high temporal resolution satellite imagery is extremely valuable. Next-generation sensors such as the Advanced Baseline Imager (ABI) on GOES-R and the Advanced Himawari Imager (AHI) on Himawari-8 offer the necessary capabilities for such a database. Doppler Radar System Airborne (RASTA) IWC retrievals from the HAC campaigns will be used for additional analyses and validation. This additional dataset should help mitigate problems due to small sample sizes.

The OT and HIWC detection algorithms are currently run in real-time over the CONUS using due to small sample sizes.

The OT detection algorithm is a set of statistical and spatial frequency analyses of IR and VIS satellite imagery. The OTs are generated using the Vis/IR model. (1) Quantification of cloud texture in 1-km visible imagery via a univariate analysis. Values greater than 0.5 indicate strong vertical motions and severity of gravity wave activity, and large values correspond to classic OT "fuzzier"-like textures. (2) Spatial/temporal collocation: 1) 14-aircraft were matched to each segment of the flight tracks and the mean cloud top temperature, water vapor and IR channel differences (BTD) were calculated. 2) The presence of deep convection (via BT differences in the water vapor and IR channels, denoted BTD) was used to select the target region of interest. The presence of deep convection (via BTD) was used to select the target region of interest. The presence of deep convection (via BTD) was used to select the target region of interest. (3) Microphysical variability at cloud top indicative of HIWC below cloud top (via cloud optical depth COD). (4) Active updraft regions where HIWC is likely generated (via COD). Active updraft regions where HIWC is likely generated (via COD). Active updraft regions where HIWC is likely generated (via COD).

Methodology
The goal of the PHIWC product (PHIWC) is to optimally combine a set of satellite-derived products to identify HIWC: (a) Visible cloud top features that are higher and presumably more intense than others in the area via VIS imagery. (b) The presence of deep convection via IR differences in the water vapor and IR channels, denoted BTD. (c) Active updraft regions where HIWC is likely generated (via COD). (d) Microphysical variability at cloud top indicative of HIWC below cloud top (via cloud optical depth COD). (e) The presence of deep convection (via BTD) was used to select the target region of interest. The presence of deep convection (via BTD) was used to select the target region of interest. The presence of deep convection (via BTD) was used to select the target region of interest. These four parameters are used to trigger and how they may be avoided. This paper presents a method to the 2-parameter (a), 3-parameter (b, c, d), and 4-parameter (a, b, c, d) models.

Results and Examples
The wavelet transform of the retrieved PHIWC product is illustrated below with example imagery from the Darwin (MTSAT-1R) and Cayenne (Himawari-8) regions. High PHIWC tends to be located near areas of VIS texture and/or high OT probability ratings. MTSAT-1R 10-minute snapshots of PHIWC retrievals were generated using the validation dataset. Most observed HIWC had PHIWC greater than 0.2. HIWC frequently occurs within 60 km of over-shooting cloud tops (OTs). Therefore, a database of OT detections from high temporal resolution satellite imagery is extremely valuable. Next-generation sensors such as the Advanced Baseline Imager (ABI) on GOES-R and the Advanced Himawari Imager (AHI) on Himawari-8 offer the necessary capabilities for such a database. Doppler Radar System Airborne (RASTA) IWC retrievals from the HAC campaigns will be used for additional analyses and validation. This additional dataset should help mitigate problems due to small sample sizes.

Conclusion
The OT and HIWC detection algorithms are currently run in real-time over the CONUS using due to small sample sizes.

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