A COMPARISON BETWEEN SATELLITE AND AIRCRAFT OBSERVATIONS FOR WINTERTIME NON-PRECIPITATING MIXED-PHASE CLOUDS

Yoo-Jeong Noh[1], Curtis Seaman[1,2], and Thomas H. Vonder Haar[1,2]

[1]Department of Defense Center for Geosciences/Atmospheric Research, Cooperative Institute for Research in the Atmosphere, Colorado State University, Fort Collins, Colorado, USA
[2]Department of Atmospheric Science, Colorado State University, Fort Collins, Colorado, USA

1. INTRODUCTION

Clouds are a crucial factor in the study of weather forecast and global climate. In the Earth's atmosphere, mixed-phase clouds in which supercooled liquid water coexists with ice are more common than single-phase clouds [1]. Although understanding of mixed-phase clouds with both liquid and ice phase hydrometeors is important for satellite retrievals, numerical weather prediction (NWP) and climate modeling, many details of the microphysical and dynamic processes that determine their formation and dissipation are not fully understood [2]. In particular, studies of cloud phase-composition for mixed-phase clouds have been significantly limited by a lack of intensive in situ measurements that can first discriminate between the ice and liquid phases and make direct measurements of these cloud properties. Our limited knowledge of mixed-phase cloud structure and characteristics leads to many uncertainties in radiative transfer modeling and satellite retrievals and inhibits these clouds from being accurately represented in NWP and climate models. In this study, we attempt to understand and characterize the lifecycle, microphysics, dynamics and radiative properties of these clouds by analyzing the fusion of three types of satellites and also special aircraft measurements taken during the joint C3VP/CLEX-10 field experiment.

2. DATA

The Tenth Cloud Layer Experiment (CLEX-10), which is part of an ongoing effort for the study of non-precipitating, mid-level, mixed-phase clouds funded by the Department of Defense's Center for Geosciences/Atmospheric Research (CG/AR), collaborated with the Canadian CloudSat/CALIPSO Validation Project (C3VP, refer to www.c3vp.org) that took place between 31 October 2006 to 1 March 2007 over Southern Ontario and Southwestern Quebec. Spaceborne radar and lidar observations and airborne microphysical probe measurements are analyzed in order to better understand the microphysical structures and radiative properties of non-precipitating, mid-level, mixed-phase clouds (i.e. altostratus and altocumulus). Observations from CloudSat, CALIPSO, and MODIS (Moderate-Resolution Imaging Spectroradiometer) instruments from the A-Train

constellation of satellites [3] and simultaneous aircraft measurements taken during mixed-phase cloud cases from C3VP/CLEX-10 are used.

3. RESULTS AND SUMMARY

This work presents a study of non-precipitating, mid-level, mixed-phase clouds using satellite (remote sensing) and aircraft (in situ) observations. The spatial distribution of liquid and ice hydrometeors and other atmospheric and cloud properties are examined for both the satellite remote sensing and in situ probe measurements, and the results are compared. CloudSat retrieval products of liquid water and ice water contents (LWC and IWC) are compared with aircraft data through frequency probability density function (PDF) and structure function analyses [4]. This provides a foundation for the improvement of the satellite retrieval algorithms.

In the preliminary results as shown in Fig. 1, these cases show that a large number of liquid droplets exist at or near cloud-top at very low temperatures (below -10 °C), consistent with previous CLEX studies of mid-level, mixed-phase clouds [5-7]. Also, comparisons between CloudSat retrievals and in situ microphysical data indicate that some hydrometeors classified as ice by the CloudSat retrieval algorithm are actually supercooled liquid water. It has also been found that many areas in the MODIS cloud-phase product classified as "unknown" are more appropriately classified as "mixed-phase" based on the results of C3VP/CLEX-10. Additional details will be included.

4. REFERENCES

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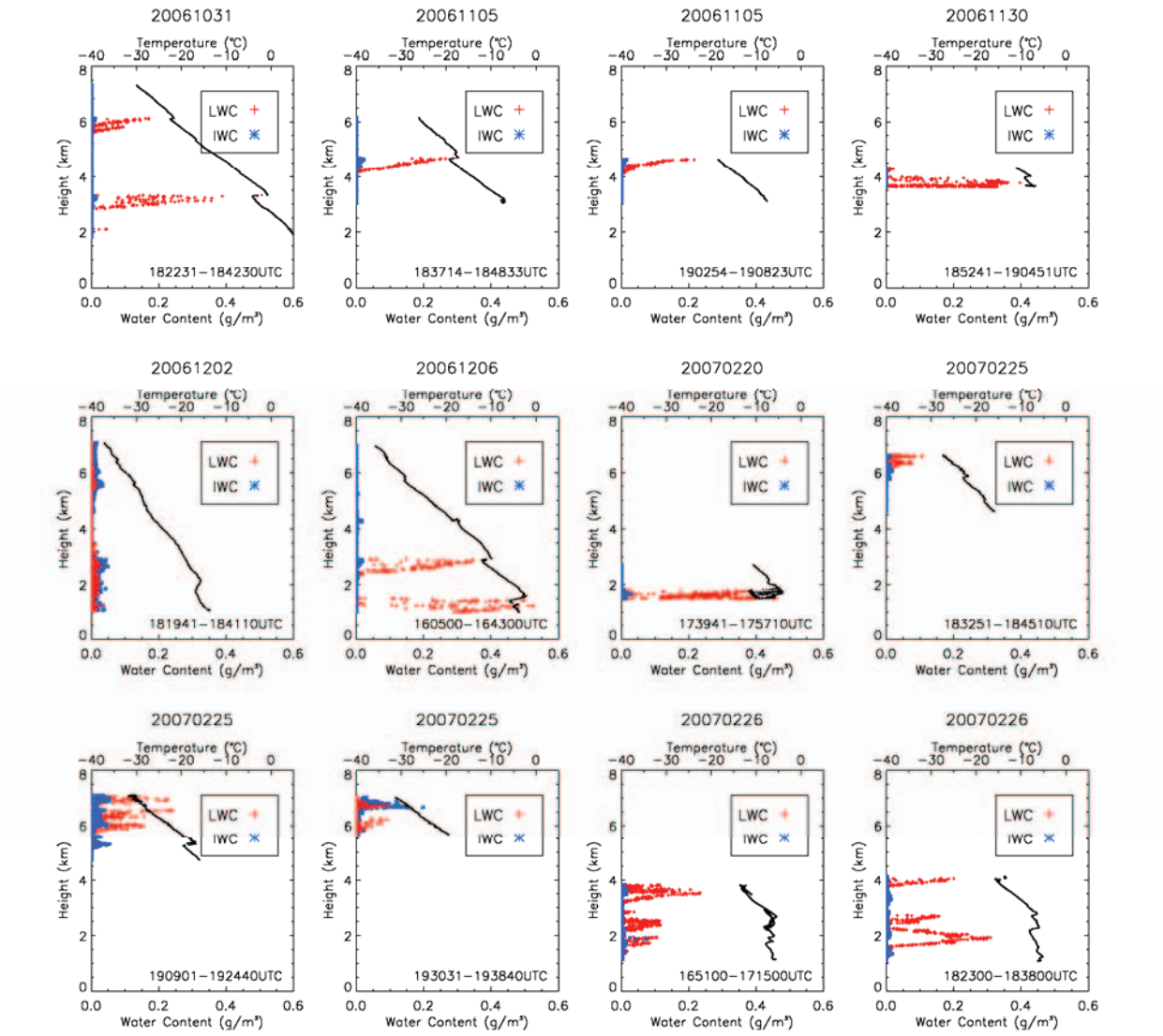

Figure 1. Vertical profiles of liquid and ice water contents (LWC and IWC) with temperatures (black) observed during C3VP/CLEX-10.