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SPECTRAL RETRIEVAL OF LATENT HEATING PROFILES FROM TRMM PR DATA: COMPARISON OF LOOK-UP TABLES

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1. INTRODUCTION

The Spectral Latent Heating (SLH) algorithm has been developed for the TRMM PR (Shige et al. 2004, manuscript submitted to J. Appl. Meteor.). Heating profile lookup tables for the three rain types; convective, shallow stratiform, and anvil rain (deep stratiform with a melting level) were produced with numerical simulations of tropical cloud systems in TOGA-COARE. In this study, we examine the universality or regionality of the lookup table for global application of the SLH algorithm to TRMM PR data.

2. METHOD

Here the 2-D version of the Goddard Cumulus Ensemble (GCE) model (Tao and Simpson, 1993) is used. Numerical simulations were conducted with the large-scale forcing data from TOGA-COARE over the western Pacific warm pool (Ciesielski et al., 2003), GATE over the eastern Atlantic (Sui and Yanai, 1986), SCSMEX over the South China Sea (Johnson and Ciesielski, 2002).

3. RESULTS AND DISCUSSIONS

A consistency check of the SLH algorithm is performed. The algorithm-reconstructed heating profiles from CRM-simulated precipitation profiles are compared to CRM-simulated “true” heating profiles. Here GATE and SCSMEX simulations are used to examine universality of the lookup table produced from COARE simulations (Fig. 1). The COARE table produces good agreement between SLH-algorithm reconstructed and GCE simulated heating profiles for GATE. On the other hand, the COARE table poorer agreement between SLH-algorithm reconstructed and GCE simulated heating profiles for SCSMEX than GATE. The top heaviness of reconstructed total heating profile using the COARE table is weaker than simulated one. There are two major reasons for the disagreement between reconstructed and GCE simulated heating profile. First, the reconstructed convective heating decrease more rapidly with height above the freezing level than the simulated one does. Second, the reconstructed cooling maximum in the stratiform region locates lower level than the simulated one.

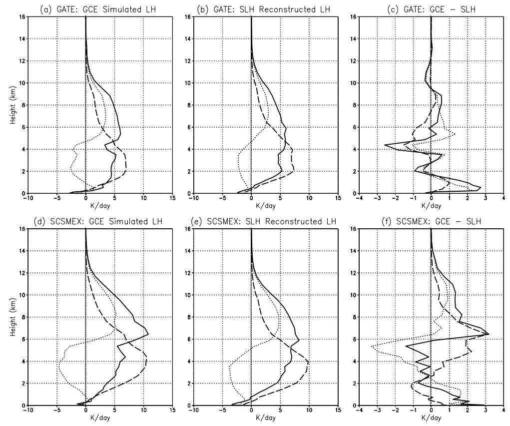

Figure 1: Profiles of latent heating rate in total (solid), convective (dashed), and stratiform (dotted) regions simulated from the GCE model for (a) GATE (Sep 1-7 1974) and (d) SCSMEX (Jun 2-11 1998). Reconstructed using the SLH algorithm with the COARE table for (b) GATE and (e) SCSMEX. Simulated minus reconstructed for (c) GATE and (f) SCSMEX.

Fig. 2a–c show lookup tables for the convective region produced from COARE, GATE and SCSMEX simulations. The latent heating profiles are sorted referring to the precipitation top height (PTH) with a threshold of 0.3 mm h^{-1}. It should be noted that latent heating is normalized by the convective rain fall. The GATE table is similar to the COARE table. Both COARE and GATE convective cells have latent heating concentrated below the freezing level, indi-

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*Corresponding author address: Dr. Shoichi Shige, JAXA/Earth Observation Research Center, Harumi Island Triton Square, Office Tower X, 1-8-10 Harumi, Chuo-ku, Tokyo, 104-6023 Japan; e-mail: shige@eorc.jaxa.jp cating "oceanic" characteristics with enhanced liquid water processes. On the other hand, SCSMEX convective cells have stronger latent heating above the freezing level, indicating "continental" characteristics with significant ice processes. These differences account for the disagreement between reconstructed and GCE simulated heating profile in convective regions. Similar differences are found in precipitation profiles above the freezing level, suggests additional use of strong precipitation top height to distinguish convective characteristics between the two regimes.

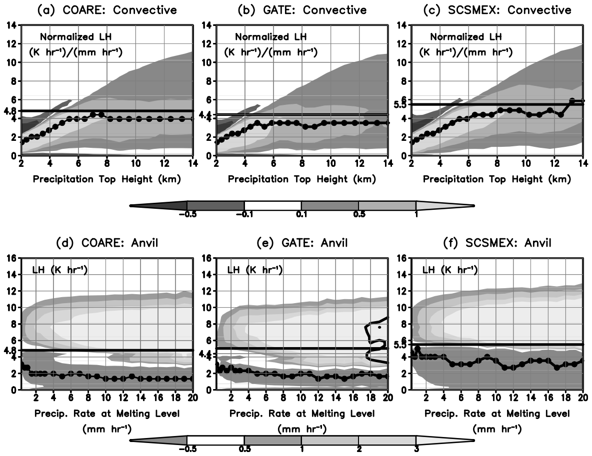

Figure 2: Lookup tables for the convective region produced from (a) COARE, (b) GATE, and (c) SCSMEX simulations and for the stratiform region produced from (a) COARE, (b) GATE, and (c) SCSMEX simulations. Horizontal lines indicate the 0 ^{o}C levels. Closed circles indicate heating maximum in convective tables and cooling maximum in stratiform tables.

Fig. 2d–f show lookup tables for the anvil (deep stratiform with a melting level) regions produced from COARE, GATE and SCSMEX simulations. Considering the insensitivity of PR to the small ice-phase hydrometors, the precipitation rate at the melting level is selected instead of PTH as a parameter for the lookup table for the anvil regions in the SLH algorithm. In the COARE and GATE tables, the maximum cooling locates in z = 1 km to z = 2 km. On the other hand, in the SCSMEX table, the maximum in cooling locates in z = 3 km to z = 4 km, much higher than the COARE and GATE tables. These differences explain the disagreement between reconstructed and GCE simulated heating profile in convective regions.

Fig. 3 shows relationship among convective heating, stratiform cooling and rear inflow (RI) in COARE December 24, SCSMEX June 5, and COARE February 11. The depth of stratiform cooling is consistent with that of RI that brings dry air into the system. Stratiform cooling and RI are shallow in the COARE Dec case, while those are deep in the SCSMEX case. What determines the depth of RI? Pandya and Durran (1996) suggested that RI is the gravity wave response to convective heating. It is inferred from their results that the depth of convective heating determines that of RI. Actually, convective heating is shallow with its maximum at 2 km in COARE Dec case ("oceanic"), while that is deep with its maximum at 4 km in the SCSMEX ("continental"). The results from the COARE February 11 case confirm the above relationship. In this case, the convective heating has "continental" characteristic and are deep with maximum at 4 km. RI is also deep, and thus the depth of stratiform cooling is similar to that of the SCSMEX case than that of the COARE Dec case. These results suggests the possibility of the parameterization of stratiform cooling shape as a function of the convective heating maximum.

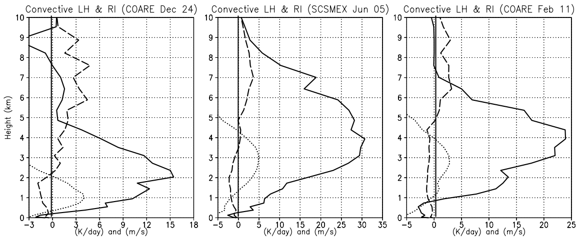

Figure 3: Profiles of convective heating (solid), stratiform cooling (dashed), and rear inflow (RI: dotted) in COARE December 24, SCSMEX June 5, and COARE February 11.

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