Estimation of Mesoscale Atmospheric Latent Heating Profiles from TRMM Rain Statistics Utilizing a Simple One-Dimensional Model

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Abstract: In this study, a model is developed to estimate mesoscale-resolution atmospheric latent heating (ALH) profiles. It utilizes rain statistics deduced from Tropical Rainfall Measuring Mission (TRMM) data, and cloud vertical velocity profiles and regional surface thermodynamic climatologies derived from other available data sources. From several rain events observed over tropical ocean and land, ALH profiles retrieved by this model in convective rain regions reveal strong warming throughout most of the troposphere, while in stratiform rain regions they usually show slight cooling below the freezing level and significant warming above. The mesoscale-average, or total, ALH profiles reveal a dominant stratiform character, because stratiform rain areas are usually much larger than convective rain areas.

Sensitivity tests of the model show that total ALH at a given tropospheric level varies by less than \( \pm 10 \% \) when convective and stratiform rain rates and mesoscale fractional rain areas are perturbed individually by \( \pm 15 \% \). This is also found when the non-uniform convective vertical velocity profiles are replaced by one that is uniform. Larger variability of the total ALH profiles arises when climatological ocean- and land-surface temperatures (water vapor mixing ratios) are independently perturbed by \( \pm 1.0 \text{ K} (\pm 5 \%) \) and \( \pm 5.0 \text{ K} (\pm 15 \%) \), respectively. At a given tropospheric level, such perturbations can cause a \( \pm 25 \% \) variation of total ALH over ocean, and a factor-of-two sensitivity over land. This sensitivity is reduced substantially if perturbations of surface thermodynamic variables do not change surface relative humidity, or are not extended throughout the entire model evaporation layer.

The ALH profiles retrieved in this study agree qualitatively with tropical total diabatic heating profiles deduced in earlier studies. Also, from January and July 1999 ALH-profile climatologies generated separately with TRMM Microwave Imager and Precipitation Radar rain statistics, it is shown that ALH profiles can be retrieved utilizing diverse satellite-derived rain products that offer convective and stratiform discrimination. Therefore, the ALH retrieval model developed in this study can be used to make regional estimates of total diabatic heating profiles in the future Global Precipitation Measurement mission, and to assimilate these profiles into numerical weather forecast and climate models.