Temperature inversions over the pre-monsoon Indochina Peninsula and their role in the seasonal transition

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Abstract

Characteristics of several days variations in intensity and height of strong stable layers which frequently appear over the Indochina Peninsula in the dry season were described, and physical mechanism of the variations were examined by thermal and moisture budget analysis. We found that the vertical advection of temperature is one of the important processes which cause the several days variations of strong stable layers heights.

Keyword: inversion layers, Indochina Peninsula, monsoon onset, seasonal transition.

1. Introduction

The Indochina peninsula is the peculiar region where the rainy season starts earliest among the other Asian monsoon regions. To clarify the reason for this peculiarity is one of the most important issues among the Asian monsoon studies. Several processes which control the beginning of the rainy season over the Indochina peninsula are considered: large scale subsidence, temperature inversion, transported humid air from the ocean, sensible heat flux, synoptic scale disturbances propagating from midlatitude, and so on. Among these processes, the role of temperature inversion is of our interest.

2. Several days variation of strong stable layers

Several days variations of intensity and height of strong stable layers are dominantly seen over the Indochina Peninsula in the dry season. Figure 1 shows an example of such variations observed by the GAME-T intensive radiosonde observations at UbonRatchathani (15N, 105E) on March 1, 1997. It is found that strong stable layers existed in the height range from 2 to 4 km. The height of the stable layer increased from day 0 to 1, decreased from day 1 to 4, and increased again from day 4 to 6. The stability of the stable layer decreased gradually from day 1 to 4. It is also found that above this layer another stable leyer existed in 4–6 km in height and that it also desended from day 1 to 5.

3. Thermal budget

Figure 1 also shows temporal variation of potential temperature. A clear relation between $\partial\bar{\theta}/\partial z$ and $\partial\bar{\theta}/\partial t$ is seen. The $\partial\bar{\theta}/\partial t$ had large values where the $\partial\bar{\theta}/\partial z$ was large. The $\partial\bar{\theta}/\partial t$ was positive when the stable layer was decreasing and negative when increasing. This relation strongly suggests that the height variation of the stable layers were due to vertical advection of potential temperature.

In order to quantify the vertical advection of potential temperature and other thermo-dynamical quantities, the thermal and moisture budget analysis was performed by

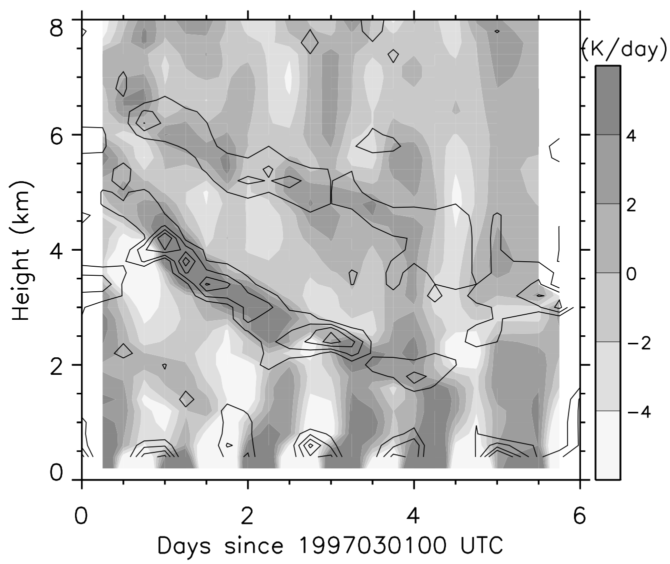

Figure1 Time-height section of (countour lined) vertical gradient of potential temperature ($\partial\bar{\theta}/\partial z$) (contour levels: 2, 6, 10, 14, 18 K/km) and (shade) temporal change rate of potential temperature ($\partial\bar{\theta}/\partial t$) obtained at Ubon Ratchathani, Thailand during 6 days from 00UTC March 1, 1997.

using radiosonde data at Chiang Mai (19N 99E), Bangkok (14N, 101E) and UbonRatchathani. Figure 2 shows estimated heating rate due to vertical advection of potential temperature. It is clearly found that the positive potential temperature change during 2nd and 3rd of March (Fig. 1) coincides with the heating due to vertical (downward) warm advection of potential temperature (Fig. 2), and that the negative potential temperature change between 5th and 6th of March coincides with the cooling due to vertical (upward) cold advecdtion of potential temperature.

However, vertical advective cooling was not estimated in the 3–4 km (700–600 hPa) altitude range on 1st of March, in spite that the height increase of strong stable layer with negative potential temperature change was observed there. Therefore, this negative potential temperature change is needed to be related with a cooling process other than the vertical advection. It is considered that this cooling is possibly related with a radiative process and/or an evaporation accompanied with shallow convetive clouds, because on the day, high values of relative humidity were observed just below the strong stable layer.

It must be noted that the estimated vertical advection shown above is much (more than 10 times) greater than the potential temperature change even if we take an effect due to a radiative cooling (1–4 K/day) into consideration. This is due to over-estimate of vertical velocity using the mass conservation law, and must be improved in the further analysis.

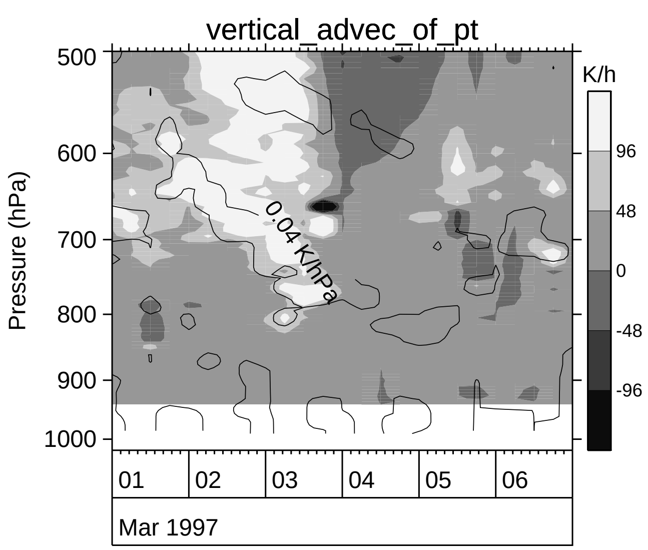

Figure2 Heating rate due to vertical advection of potential temperature (shade). The contour lines show 0.04 K/hPa of vertical gradient of potential temperature ($\partial\bar{\theta}/\partial z$) indicating the location of the strong stable layers. Note that this figure is drawn in a pressure coodinate.