Thermodynamical interpretations of generation and decay of stable layers over the Indochina Peninsula in the dry season

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Abstract

The thermal and moisture budget analyses were investigated on intraseasonal variations of stable layers over the Indochina Peninsula in the dry season from 1999 to 2000. The result indicates the diversity of factors of the generation and decay processes of stable layers and implies a weak tendency that a specific mechanism is important in the early dry season.

Keyword: temperature inversion, intraseasonal oscillation, monsoon onset

1. Introduction

We have investigated seasonal variations of the atmospheric stability in the lower troposphere and their mechanisms in order to understand the role of the strong stable layer seen in the lower troposphere in the dry season. We have shown that strong stable layers frequently appear at a height of about 2 km in the early dry season and that their mean height increases up to about 5 km and become weak in the late dry season as a climatological characteristic. We have also shown that intermittent appearances of generation and decay of stable layers with a time scale from ten to fifty days dominate in a seasonal advance of each year (Nodzu et al., 2004, submitted to J. Climate). In this paper, we investigate the generation and decay mechanisms of stable layers with the intraseasonal time scale in terms of thermodynamics.

2. Analysis procedure

In this study, stability is defined with the vertical gradient of potential temperature. In this definition, the temporal change of stable layer strength can be interpreted as increase or decrease in difference between the potential temperatures above and below the stable layer. We consider, therefore, that heating or cooling which bring the potential temperature difference is a cause of generation and decay of a stable layer. We estimate the heating and cooling rate by the thermal and moisture budget analysis.

NCEP/DOE AMIP-II reanalysis data (http://wesley.wwb.noaa.gov/reanalysis2/) are utilized in the theramal and moisture budget analysis. The budget is calculated over the triangle region in the western inland of the Indochina Peninsula which includes six grid points ((20.0º N, 100.0º E), (17.5º N, 100.0º E), (15.0º N, 100.0º E), (17.5º N, 102.5º E), (15.0º N, 102.5º E), (15.0º N, 105.0º E)). The analysis duration is from October 1999 to May 2000.

3. Results

First, we describe an example of generation and decay of stable layers. During the period from 11 to 25 April 2000, just before the onset of rainy season, a stable layer was generated around a height of 500 hPa and decayed (Fig. 1a). When it was generated, increase of the potential temperature above 500 hPa dominated and the potential temperature change below 500 hPa was not significant. On the other hand, when it was decayed, relatively large increase of the potential temperature was recognized below 500 hPa. It is found that the heating above 500 hPa during the stable layer generation was caused by the horizontal warm advection and that the heating below 500 hPa during the decay was caused by the horizontal warm advection and the Q_1 (apparent heat source) (Fig. 1b). It is inferred from a comparison of temporal and spatial variations of Q_1 and Q_2 that the heating by Q_1 below 500 hPa during the decay was mainly caused by the release of latent heat. In this example, therefore, the stable layer is considered to have been generated by the upper horizontal warm advection and decayed by the lower horizontal warm advection and the latent heat release.

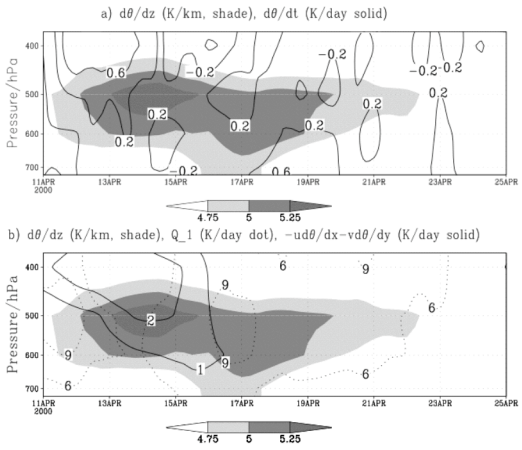

Fig. 1: An example of generation and decay events of stable layers over the western part of the inland Indochina Peninsula. The horizontal axes show the period from 11 to 25 Apr 2000. a) Stability (shade) and changing rate of potential temperature (solid contour). b) Same as a) but for the stability, horizontal potential temperature advection (solid contour) and Q_1 (dotted contour).

Next we summarize the generation and decay mechanisms for all the ten cases with a time scale from ten to fifty days. The cause of generation is lower horizontal cold advection for six cases, upper horizontal warm advection for two cases and upper Q_1 for two cases.

The cause of decay is lower vertical warm advection for four cases and lower Q_1 for three cases including two cases in which the latent heating is considered to be the main cause of the heating. It is, therefore, said that one mechanism did not always dominate every event. It should be noted, however, in the early dry season stable layers were generated frequently by the lower horizontal cold advection and decayed frequently by the lower vertical warm advection, on the other hand, in the late dry season the other reasons caused the variation of stable layers in the late dry season.

4. Summary

The thermodynamical interpretation of generation and decay mechanisms were performed on intraseasonal variations of stable layers over the Indochina Peninsula in the dry season from 1999 to 2000 by the thermal and moisture budget analysis. We did not find a common particular mechanism explaining all the generation and decay processes. However, we found a weak tendency that a specific mechanism becomes important in the early dry season. These findings will be confirmed by expanding the analysis duration into twenty-five dry seasons from 1979 to 2004.