Intraseasonal changes of temperature inversions over the Indochina Peninsula related to winter monsoonal cold surge

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1. Introduction

Over the Indochina peninsula, temperature inversion layers (hereafter `inversion') frequently appear at a height of around 4 km in late dry seasons (Liu 1990). In the climatological mean, the center height of these inversions is about 2 km in early dry seasons and increases to about 5 km in late dry seasons (Nodzu et al., 2004). Inversions are intensively statically stable layers. Thus, they disturb the mixture of the air (including aerosol, heat, vapor and so on) below and above themselves and will play a crucial role in the seasonal march of the convective activity from dry to rainy seasons.

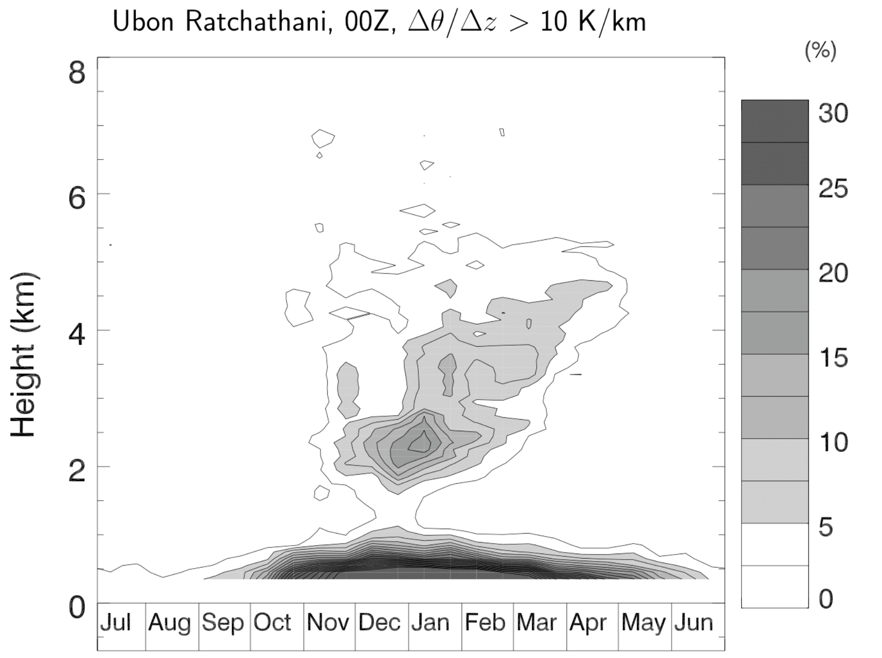


Figure 1: A time-height cross-section of the stable layer frequency (%) obtained from the morning data at Ubon Ratchathani (15° 15' N, 104° 52' E). The horizontal axis is taken from July to June in order to make the months in the dry season continuous.

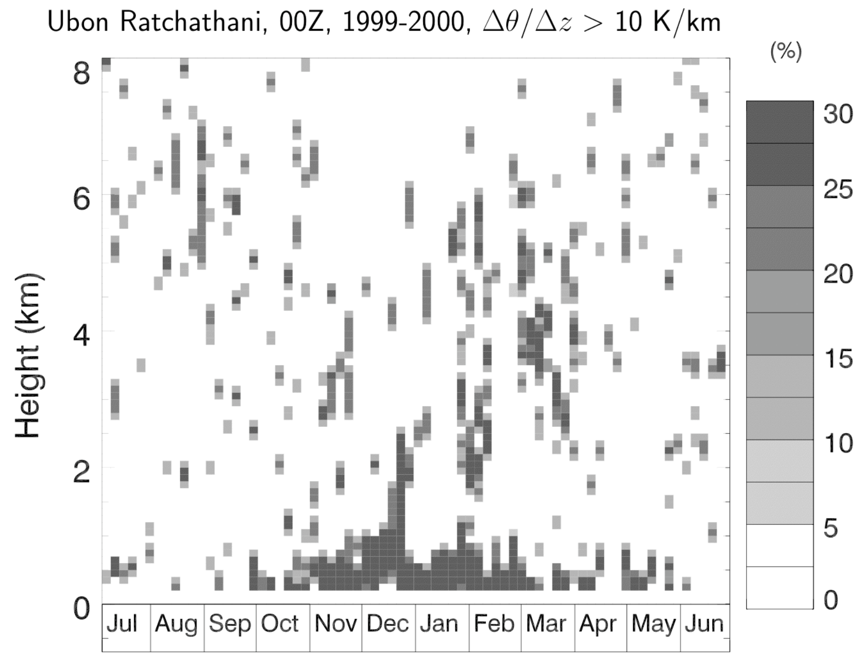


Figure 2: Same as Fig. 1 but for from July 1999 to June 2000. The frequencies in these panels were evaluated at every pentad and at every 100 m level.

In the winter of 1999-2000, a fluctuation of inversions appearance with periods of 30-40 days can be seen. In this poster, we will show the relation between the inversions appearance expressed with the high vertical gradient of potential temperature ($\Delta\theta/\Delta z$) and the periodical monsoonal cold surges.

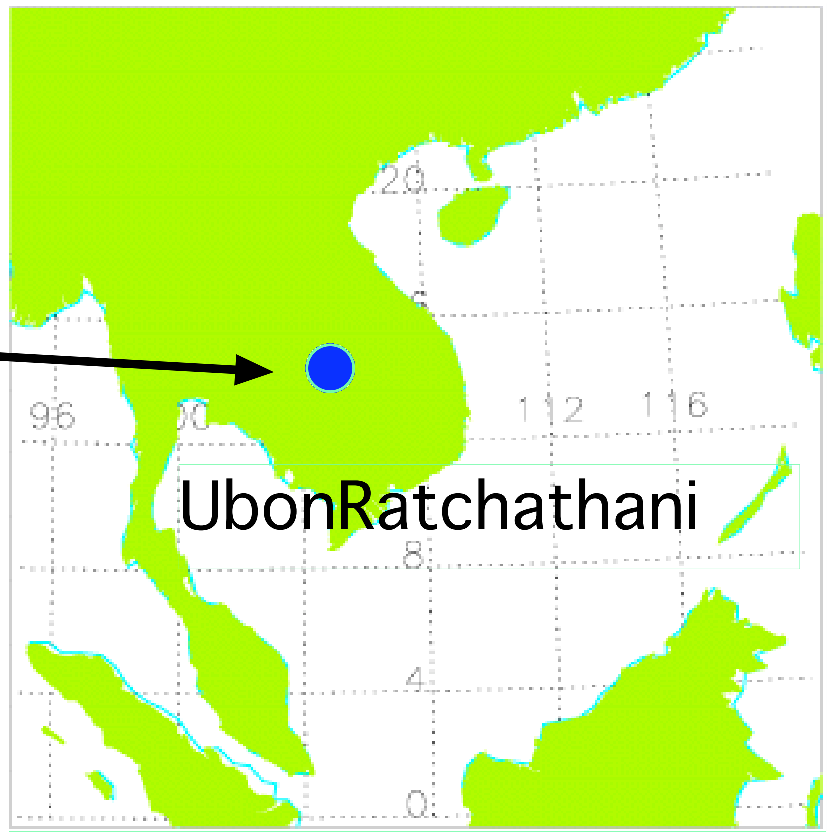
2. Data

NCEP/NCAR Reanalysis 1: 2.5° x 2.5° data set

- ◇Temperature
- ◇Geopotential Height
- ◇Wind

(Jul 1999 - Jun 2000)

The time height cross sections is shown at 15° N, 105° E near Ubon Ratchathani



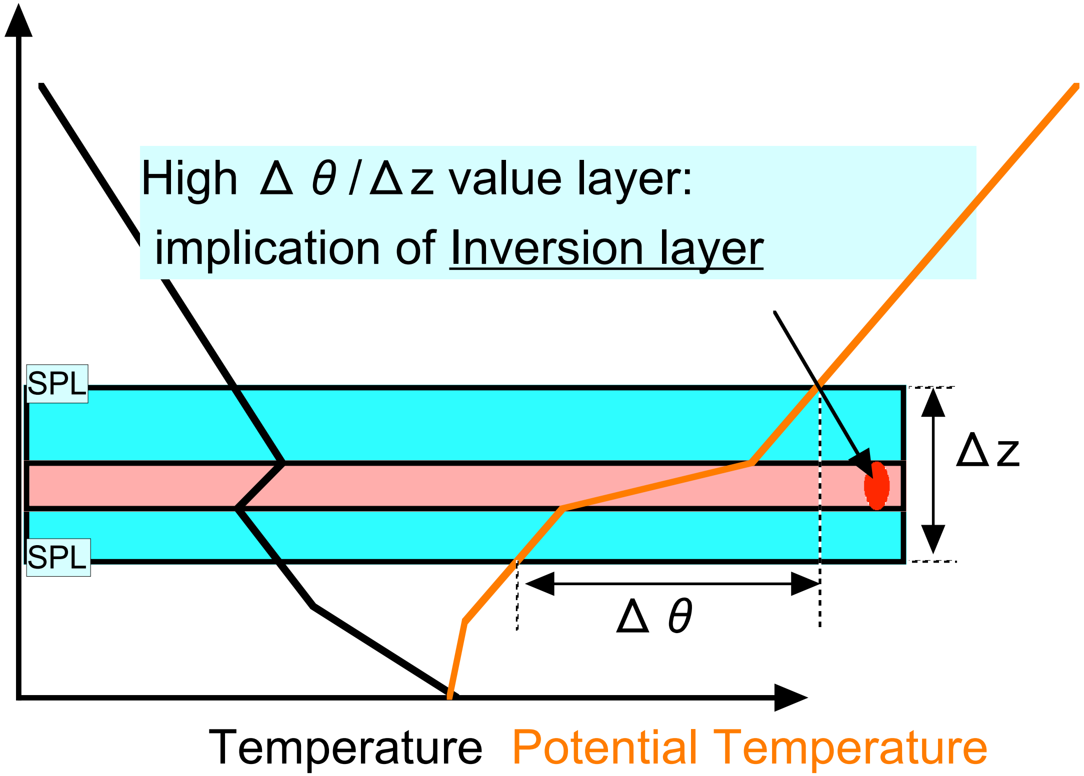
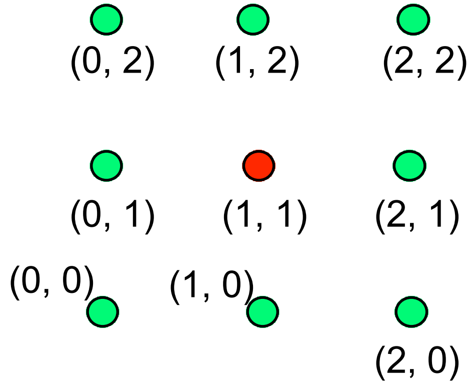


Fig. 3: Relation between an inversion and high IRP layer (`IPR' is Increasing rate of Potential temperature).



$$\nabla \theta = \Delta \theta / \Delta x + \Delta \theta / \Delta y$$

$$\boldsymbol{u} \cdot \nabla \theta = u \Delta \theta / \Delta x + v \Delta \theta / \Delta x$$

(if $u > 0$; $\Delta \theta / \Delta x = (\theta(0,1) - \theta(1,1))/(x(0,1) - x(1,1))$

if $u < 0$; $\Delta \theta / \Delta x = (\theta(2,1) - \theta(1,1))/(x(2,1) - x(1,1))$

if $v > 0$; $\Delta \theta / \Delta y = (\theta(1,0) - \theta(1,1))/(y(1,0) - y(1,1))$

if $v < 0$; $\Delta \theta / \Delta y = (\theta(1,2) - \theta(1,1))/(y(1,2) - y(1,1))$)

Fig. 4: Procedure to calculate horizontal advection.

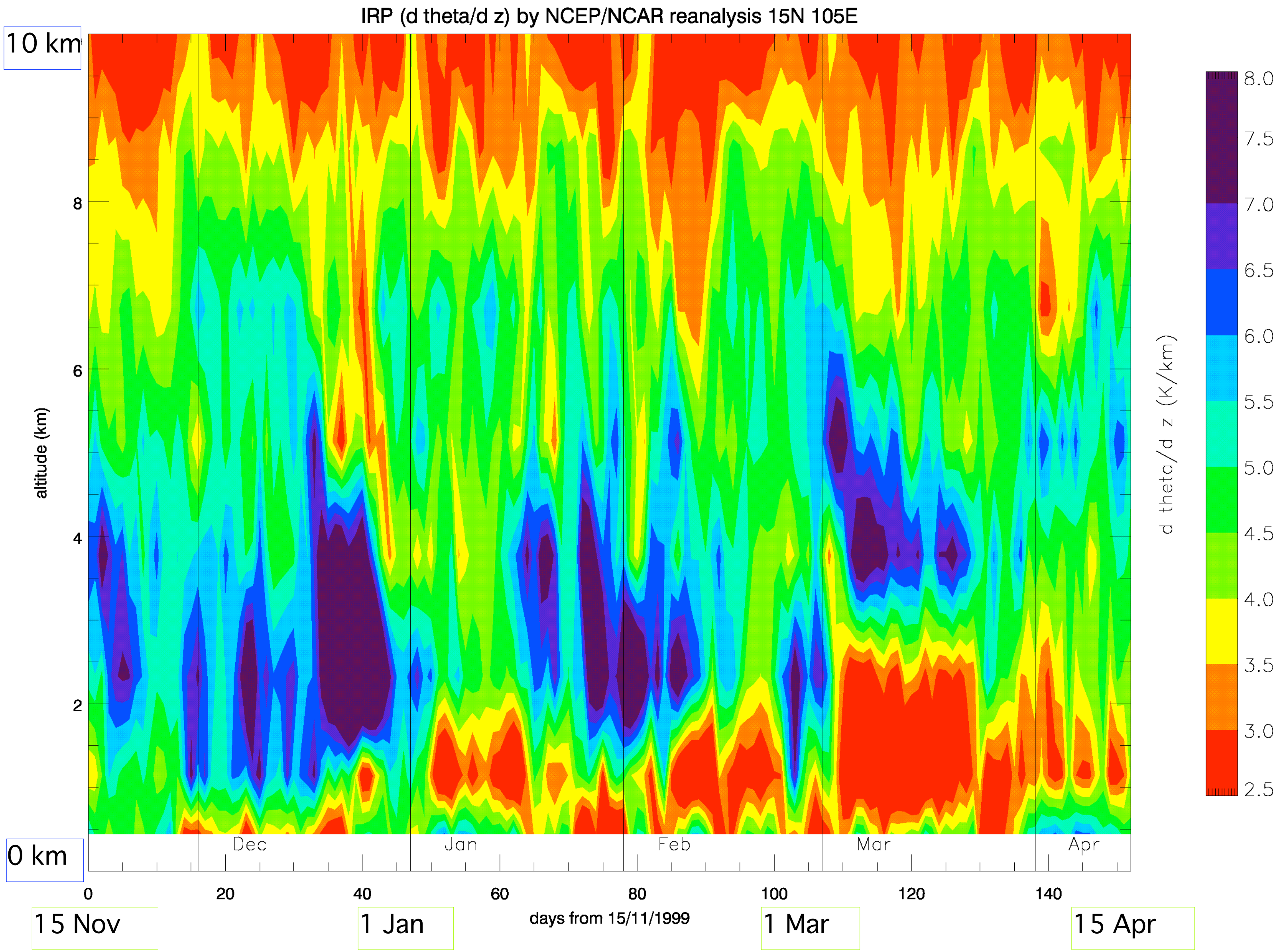


Fig. 5: Seasonal variation of IRP ($\Delta\theta / \Delta z$) from 16 November 1999 to 15 April 2000 at 15° N, 105° E. (with daily averaged values) Cold and warm colored regions show strong and weak stability, respectively.

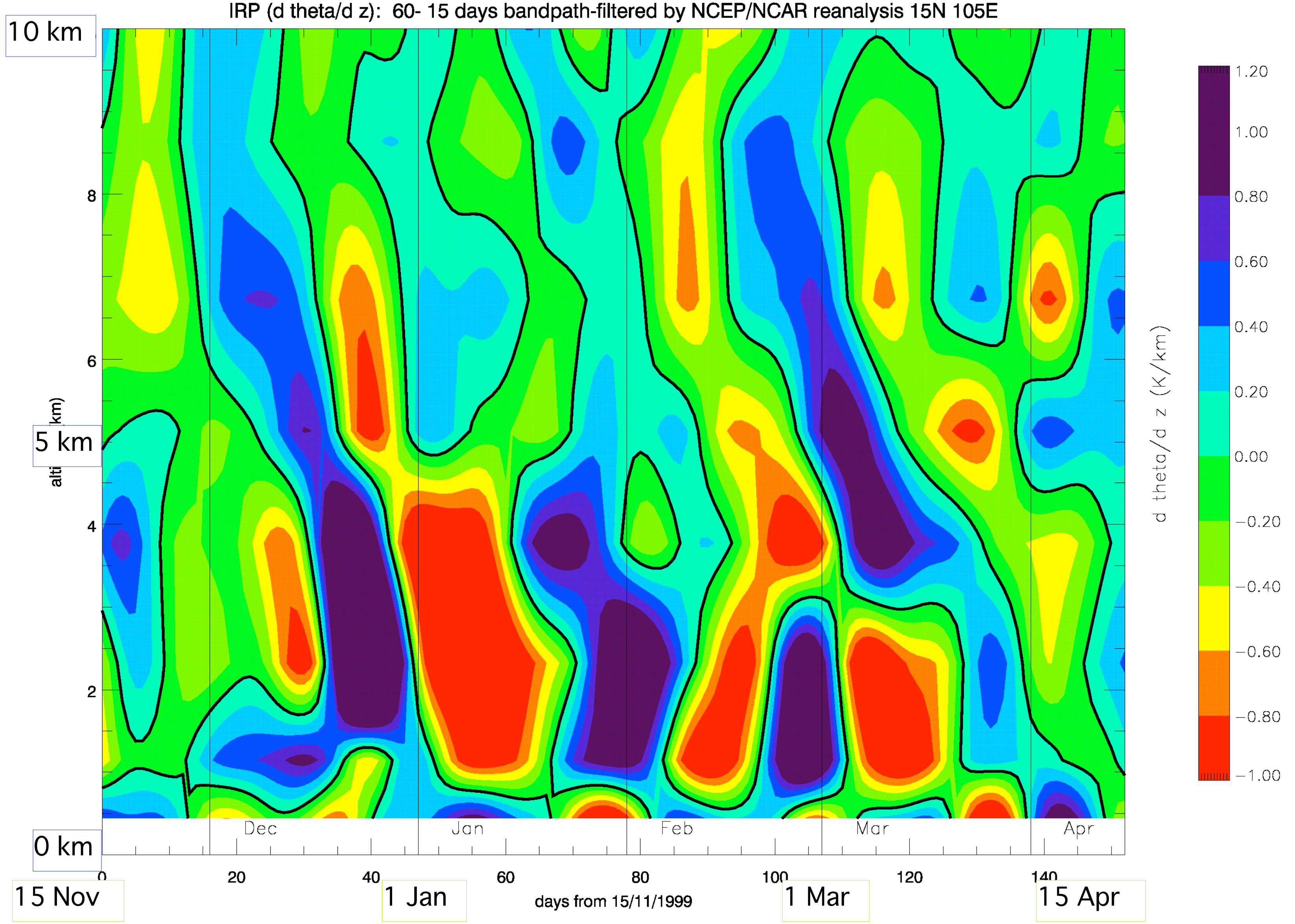


Fig. 6: Same as Fig. 5, but for 15-60 day filtered.

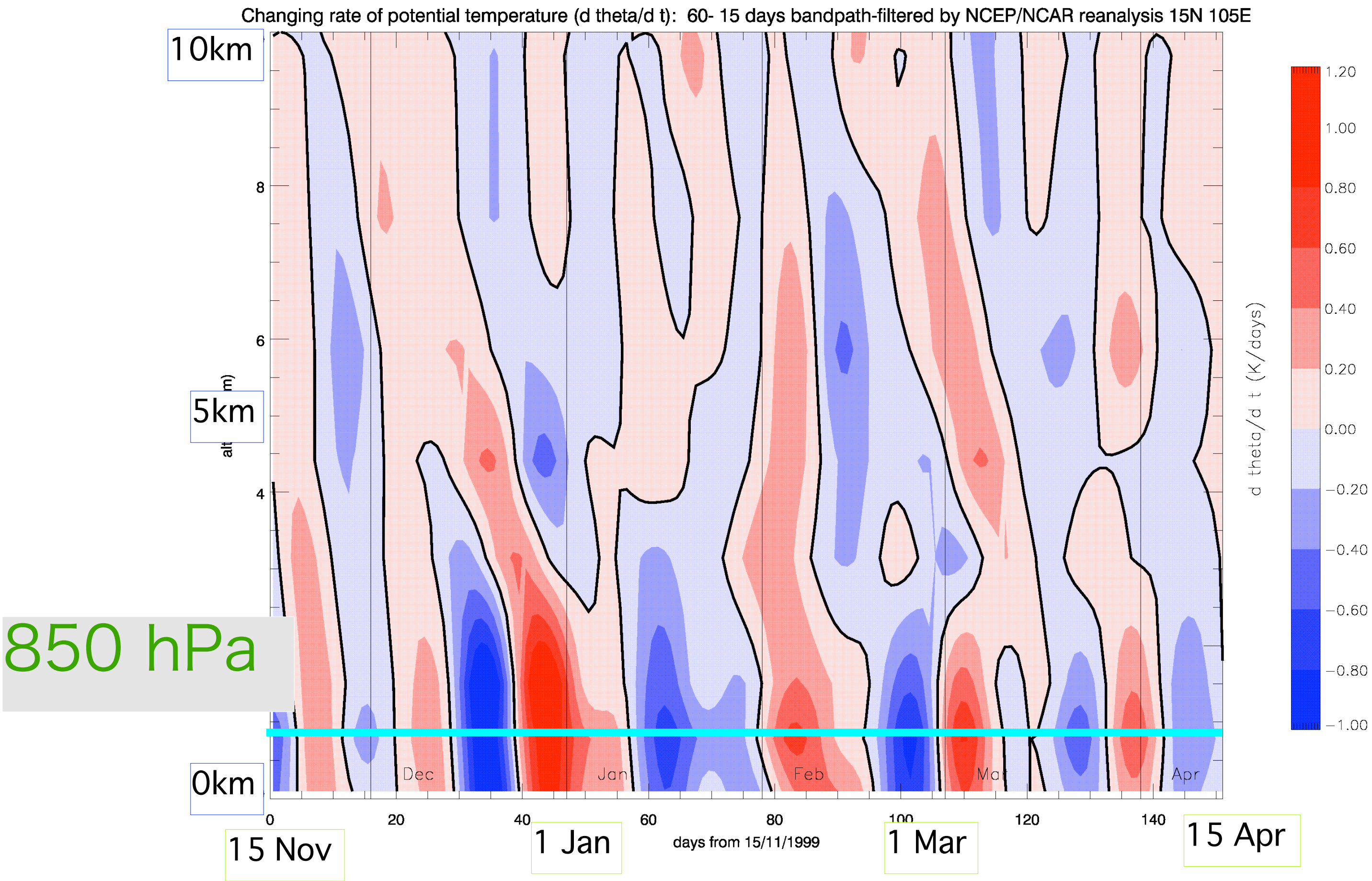


Fig. 7: Same as Fig. 5, but for 15-60 day filtered changing rate of Potential Temperature (Δθ/Δt).

- **Stability (Δθ/Δt):**

  Oscillation in about 35 days period
- **Potential temperature change:**

  mainly below the inversions (strong stability layers)

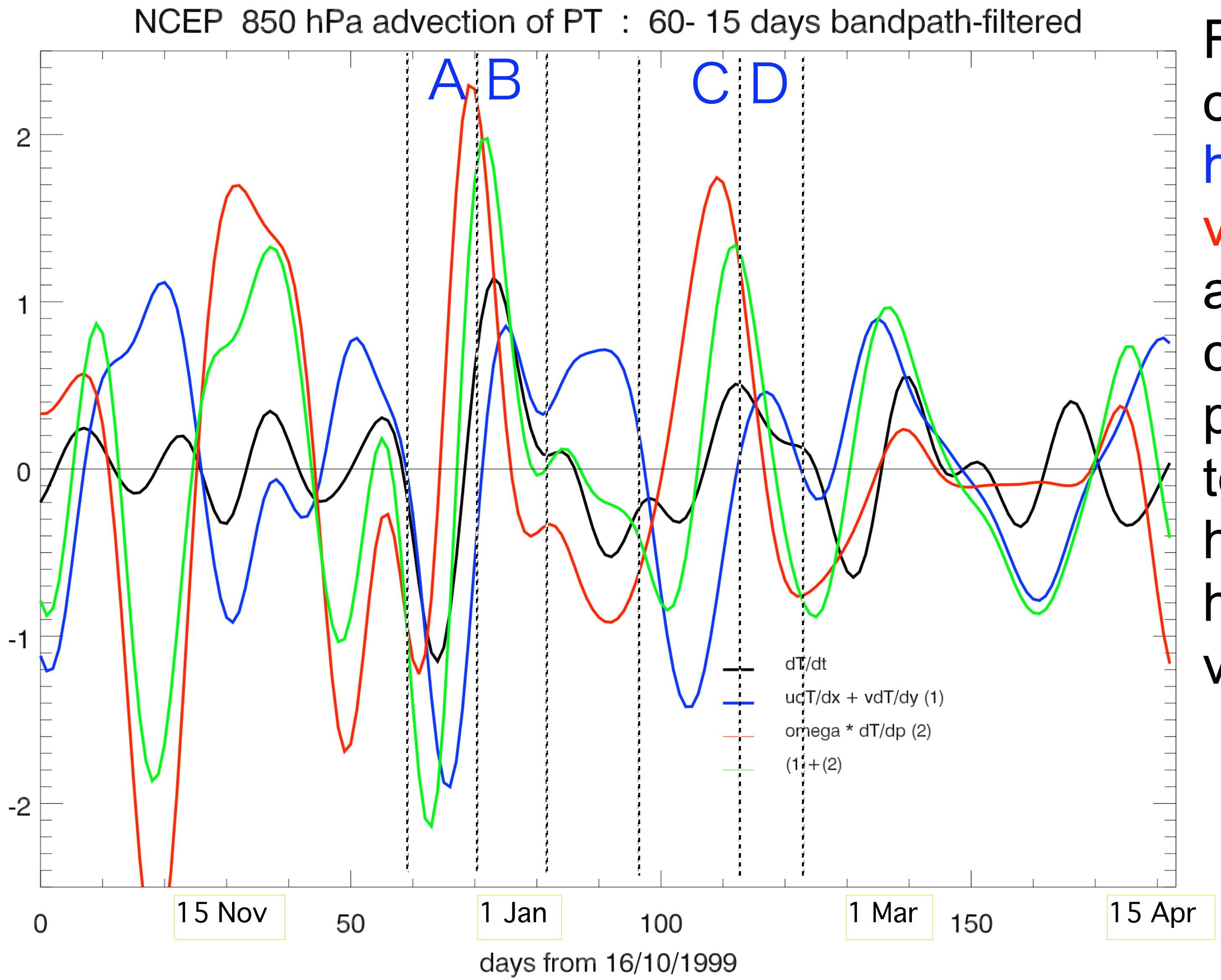
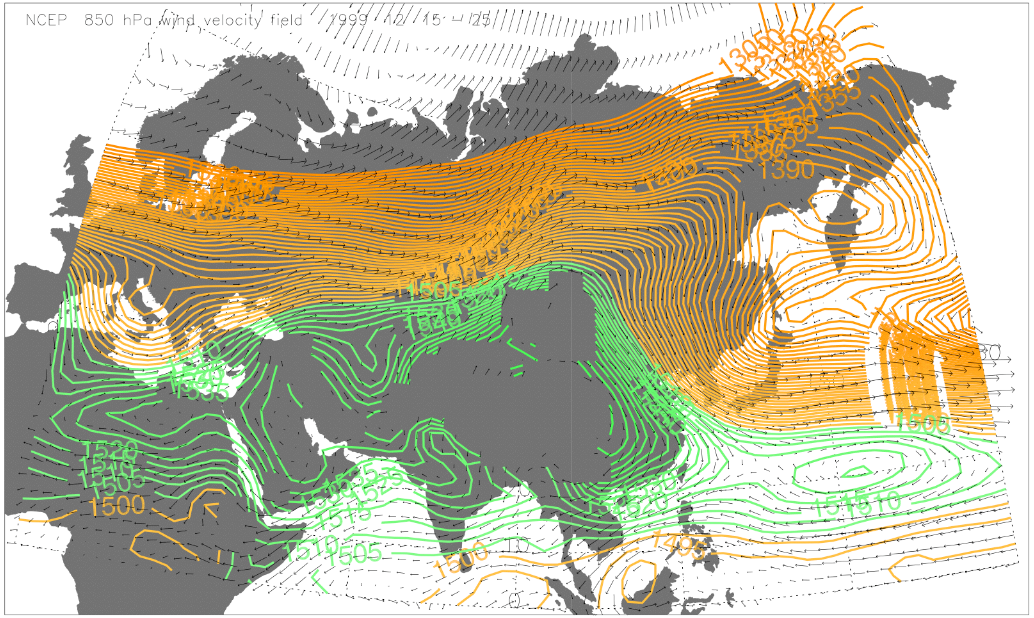


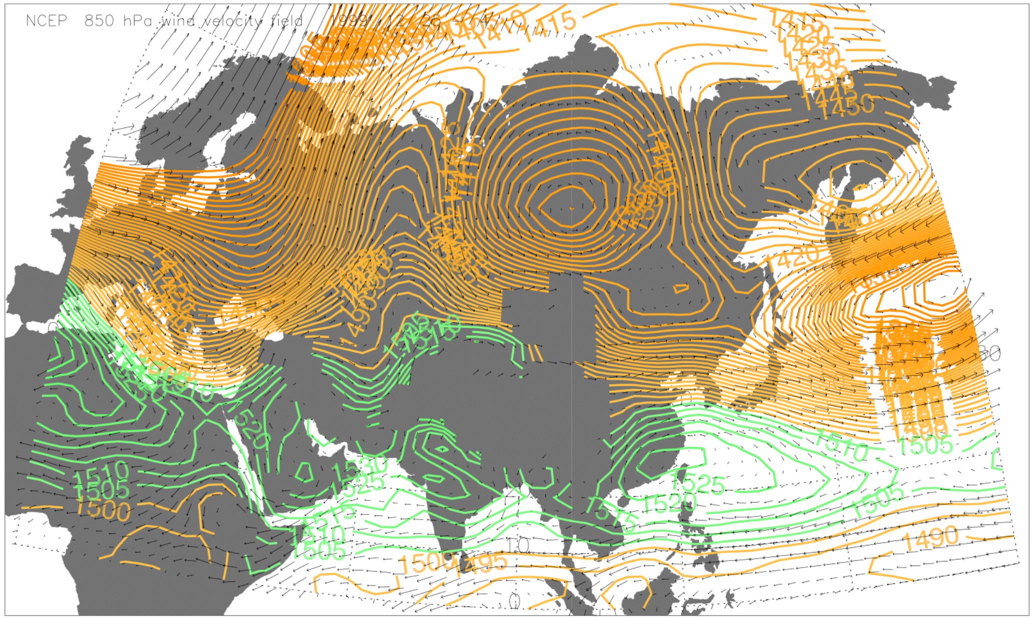
Fig. 8: Time series of 15-60 day filtered horizontal (---) and vertical (---) advections and changing rate (---) of potential temperature on 850 hPa. (--- is sum of horizontal and vertical advections)

Considerable contribution of horizontal advection to changing rate of potential temperature

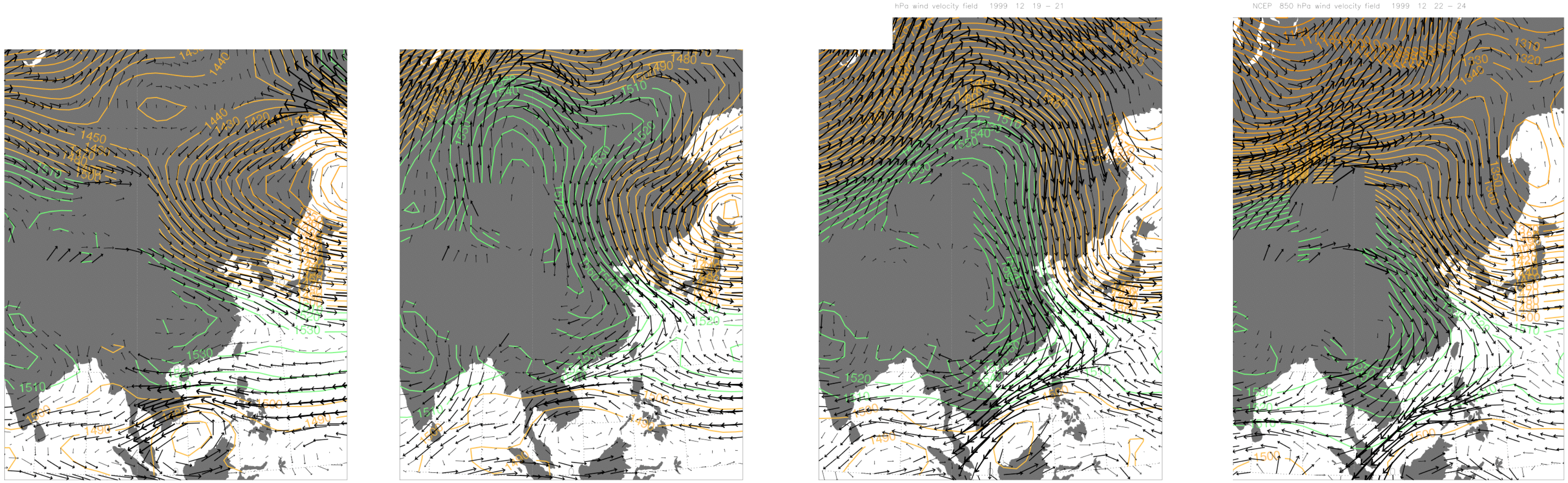
Figs. 9 Horizontal distribution of geopotential height and wind on 850 hPa surface in the period A and B.



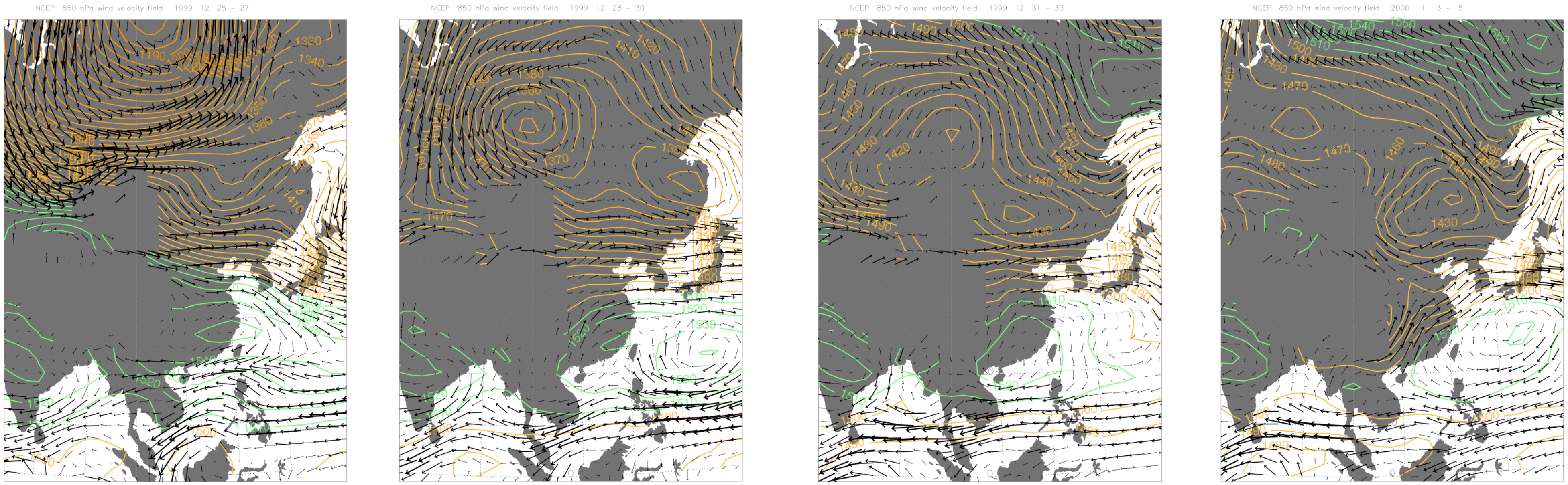
Period A (15 Dec - 25 Dec 1999)

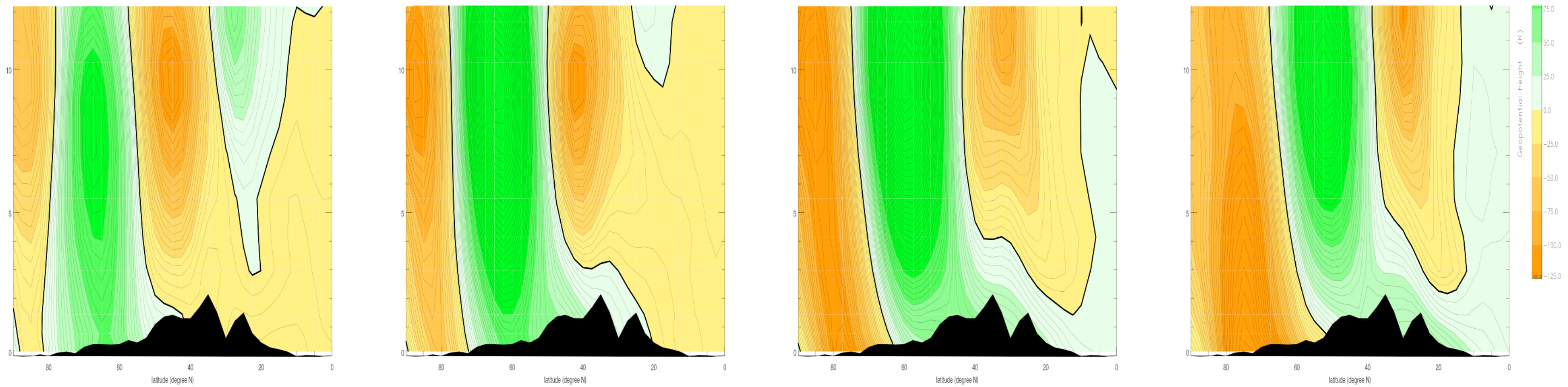


Period B (26 Dec 1999 - 4 Jan 2000)

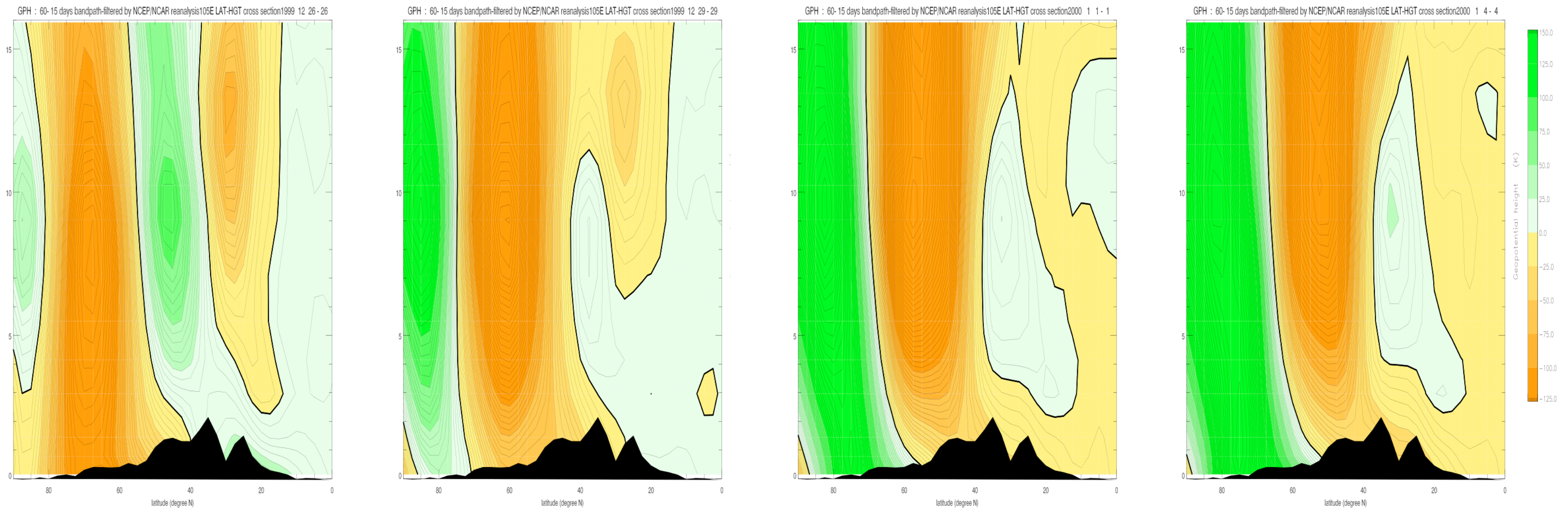


Figs. 10 Horizontal distribution of geopotential height and wind on 850 hPa surface in the period A (13 - 15, 16 - 18, 19 - 21, and 22 - 24 Dec (from left to right, the right 4 panels)) and the period B (25 - 27, 28 - 30 Dec, 31Dec - 2 Jan, 3 - 5 Jan (from left to right, the right 4 panels)





Figs. 11 Latitude-height cross section of geopotential height in the period A (14, 17, 20, and 23 Dec (from left to right, the right 4 panels)) and the period B (26, 29 Dec, 1 Jan and 4 Jan (from left to right, the right 4 panels)



- **Cooling period (A)**
  - **High pressure over from Siberia to southern China**
  - **Wind passing over Indo-China: from Siberia of cold region**
- **Heating period (B)**
  - **Low pressure over from Siberia to northern China and Subtropical High over Indo-China**
  - **Wind passing over Indo-China: from Philippine of warm region**

- **High and Low over East Asia**
  - **Horizontal scale: 3000 - 5000 km**
  - **Vertical scale:**
    - **almost overall the troposphere (and lower stratosphere)**
    - **centered on 300 hPa**
    - **lower part (below 700 hPa) extends southward**

4. Summary

Using the NCEP/NCAR reanalysis data, we examined the thermodynamic process of the intraseasonal inversions variation of the winter from 1999 to 2000.

The inversion strength in 2-5 km fluctuates dominantly in about 35 days period. This inversion fluctuation was mainly caused by the temperature change below the inversion. This temperature change was substantially contributed by the horizontal cold and warm advections. The advections were affected by the high and low pressure fluctuations over the region from Siberia to China.