
Cloud Convection and Atmospheric Temperature Rising over the Eastern part of the Tibetan plateau in Pre-Monsoon season

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Background & Purpose

- ✦ Tibetan plateau was thought to be an important component of the Asian summer monsoon.
- ✦ Atmospheric heating over the plateau has been discussed from various aspects:

Luo and Yanai (1984) ...

Dry thermal convection is responsible for the deep heating in pre-monsoon phase.

Yanai et al.(1992)...

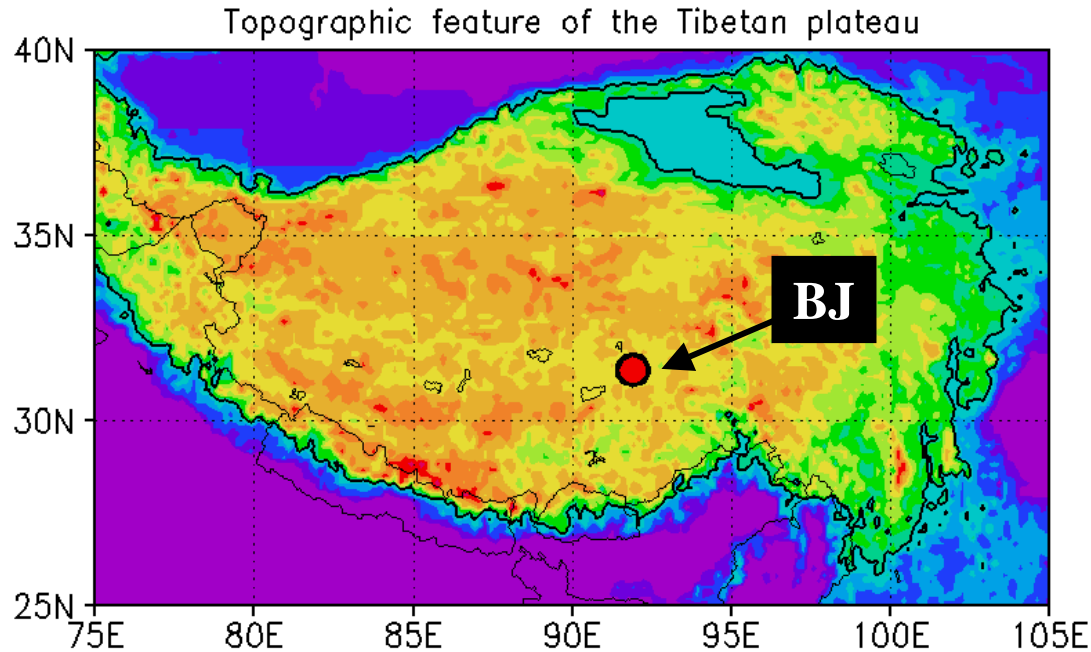
About the heat source over the eastern part of the plateau

- Mainly **sensible heat** from April to the beginning of June.
- Contribution of **latent heat** becomes large after June.

for short of observation data, understanding is not enough

By field observation and satellite data analysis, try to unveil the mechanism of temperature rise over the Tibetan plateau.

Overview of the observation



Site :

Eastern part of the Tibetan Plateau, Naqu (BJ), 91.8987E, 31.3687E, 4509mASL

Period :

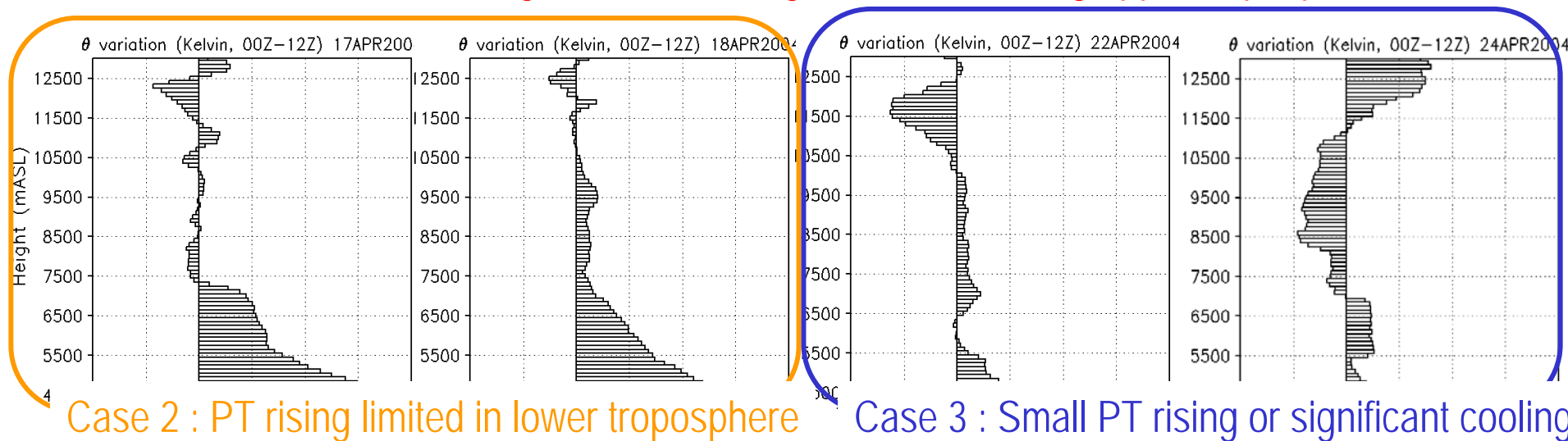
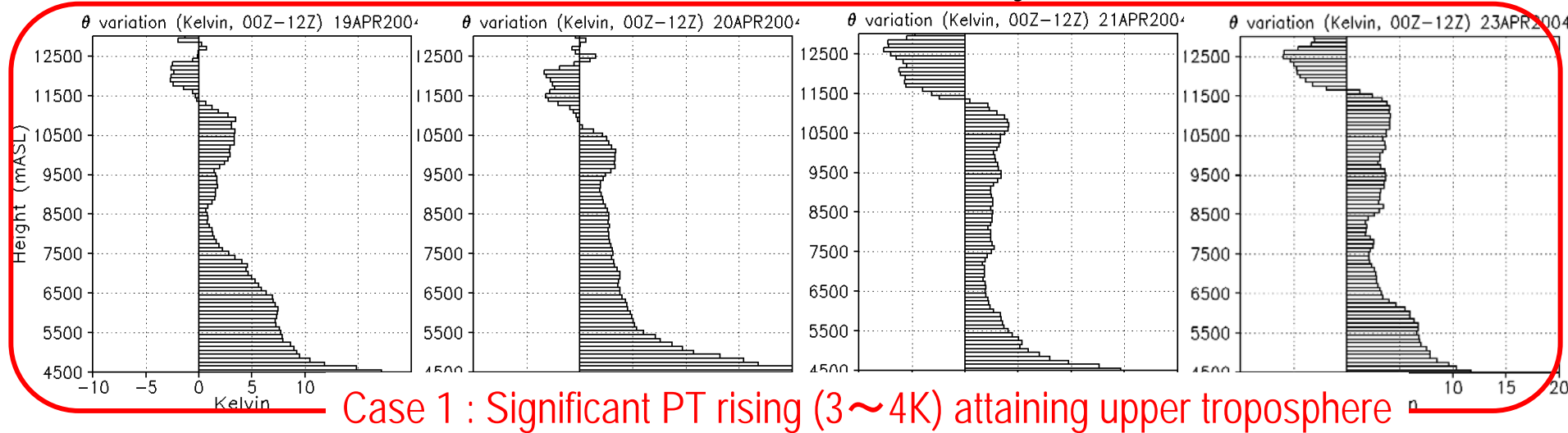
Apr. 15th – Apr. 24th, 2004

Items :

Radiosonde (every 2 hours, 00UTC-12UTC, 8 times a day),
AWS, LIDAR, Wind profiler

Increase of PT in daytime during the observation period

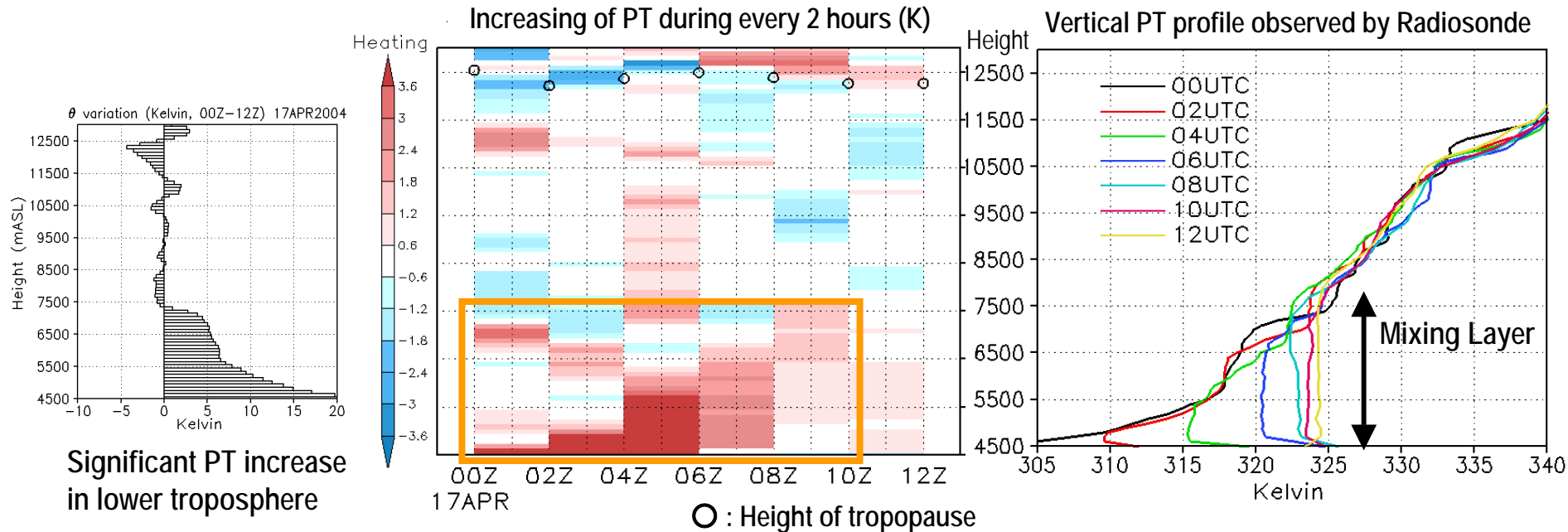
Difference of PT between 12UTC and 00UTC (observed by radiosonde)



➡ What processes cause the difference of daytime PT increasing?

Diurnal variation of PT (PT rising limited in lower troposphere)

Results of April 17th

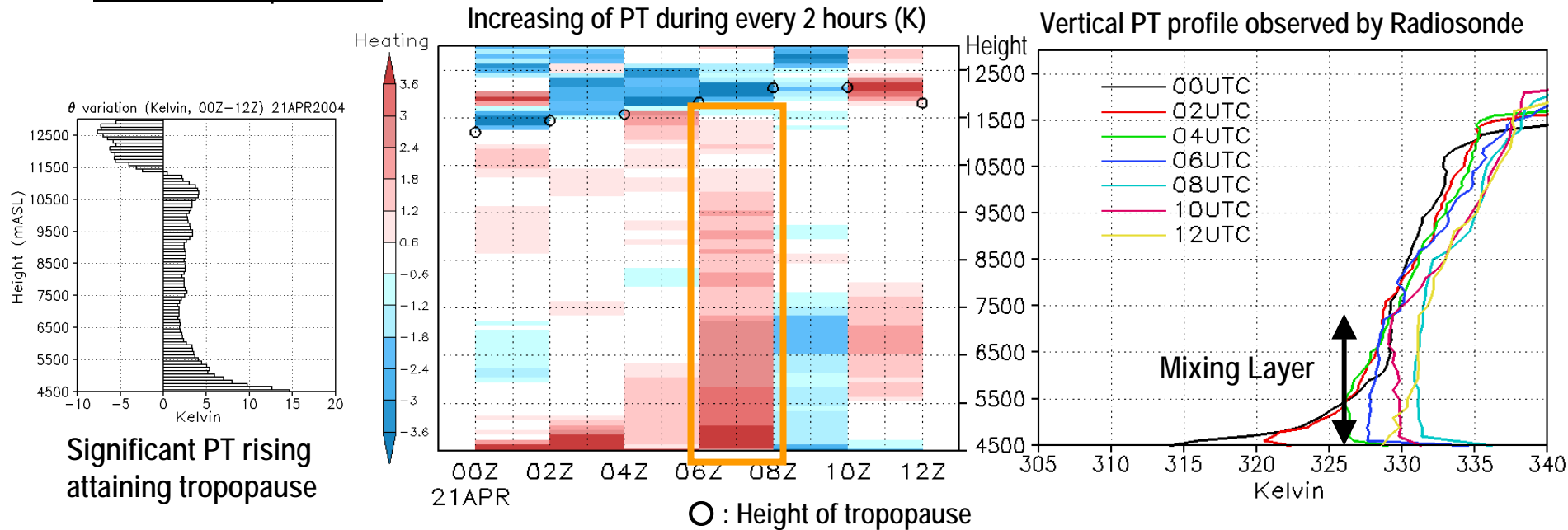


- ✦ Large PT rising near the ground surface
- ✦ Deep mixing layer developed by surface heating contribute to the PT rising in lower part of troposphere

→ Corresponding to the past studies (Li and Yanai (1984), Yanai et al. (1992), etc)

Diurnal variation of PT (Significant PT rise in upper troposphere)

Results of April 21st



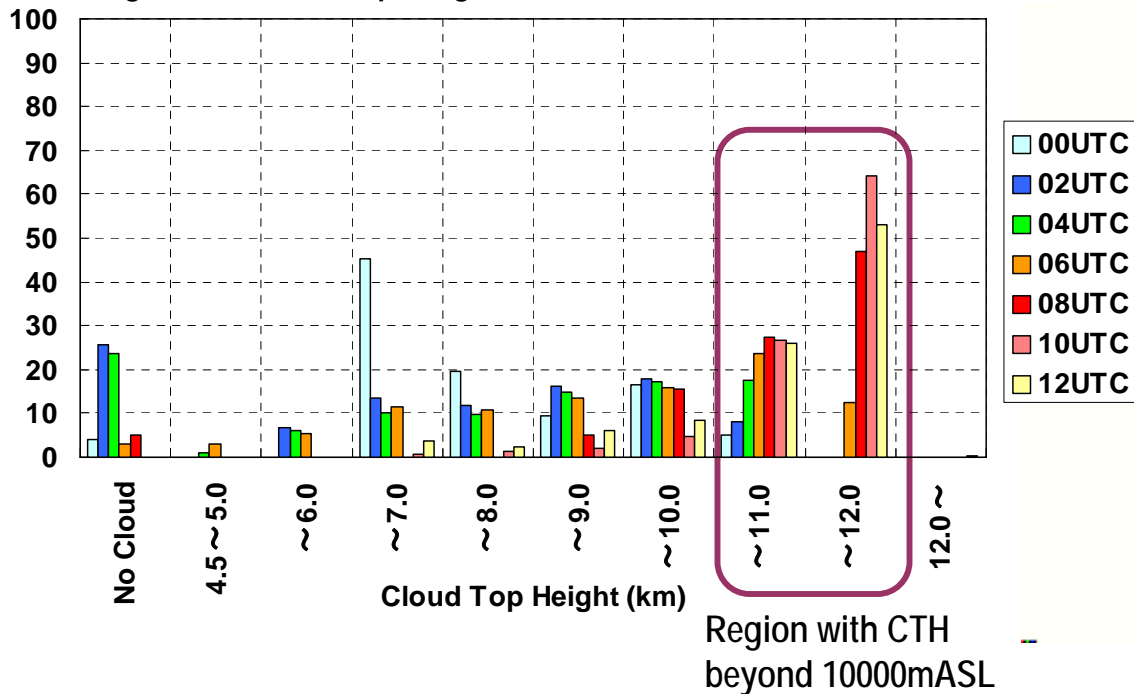
- ⊕ Large PT rising near the ground surface
- ⊕ PT rising in lower troposphere by development of mixing layer
- ⊕ Increasing of PT goes above 10000mASL during 06-08UTC
- ⊕ Height of mixing layer is 7500mASL at most

⇒ Dry thermal convection (= development of ML) **CAN NOT** explain the PT rising

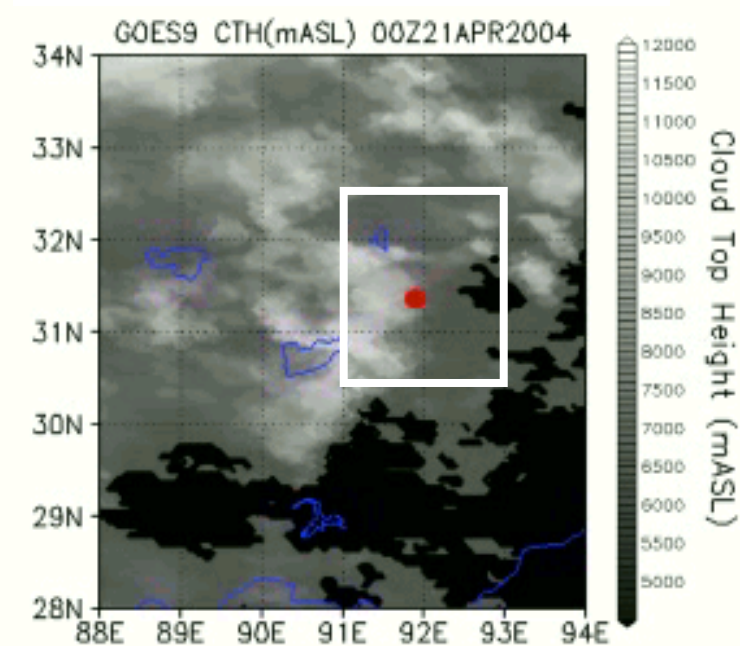
⇒ What process can make PT rising attaining tropopause?

Diurnal variation of CLOUD activity in case of PT rising in upper air (April 21st)

% Histogram of Cloud Top Height derived from GOES-9 and radiosonde



Distribution of CTH around observation site

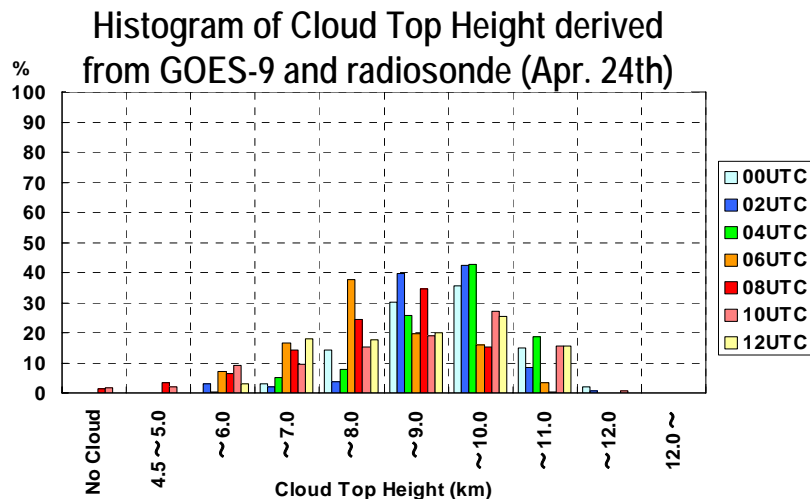
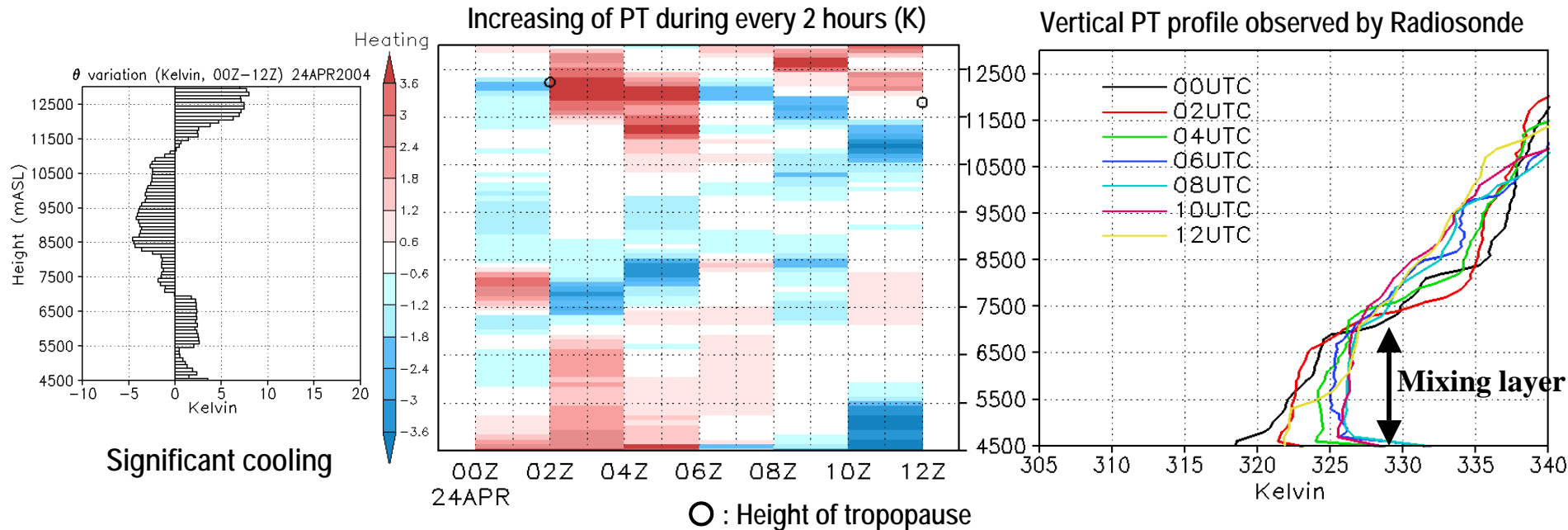


- ☉ Cloud activity with clear diurnal variation
- ☉ Cloud Top Height beyond 10000mASL around the observation site
- ☉ Increasing of PT in the upper troposphere was thought to be caused by strong upward flow and latent heat release in active convective cloud

Convective cloud can be important in heating in upper troposphere

Diurnal variation of PT (Significant atmospheric cooling)

Results of April 24th



- ✦ Lower troposphere - PT rising by surface heating
- ✦ Mid-Upper troposphere - Cooling almost all day
- ✦ Cloud activity is not negligible

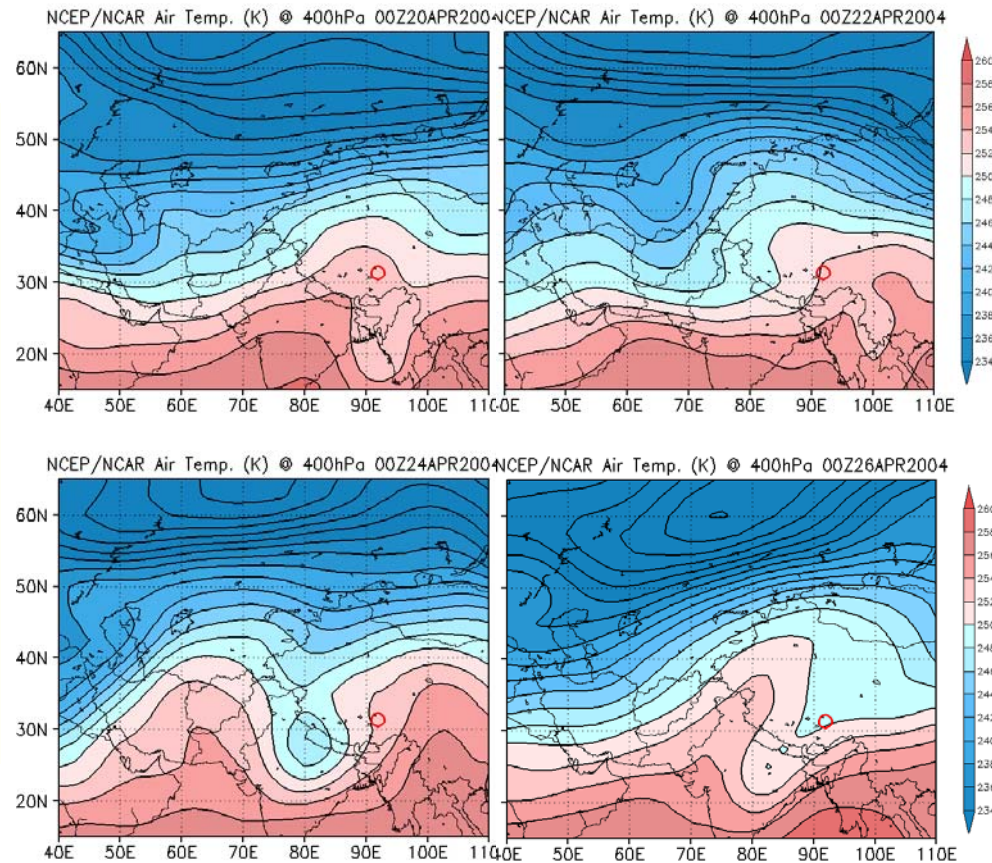
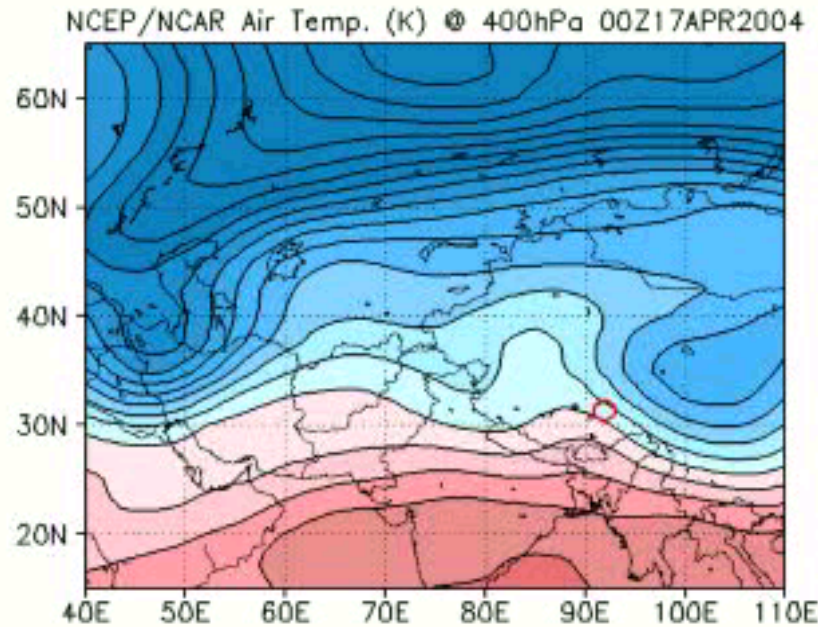
Why PT decreases?



Consider the large scale condition

Synoptic scale condition (Significant atmospheric cooling)

Air Temperature at 400hPa

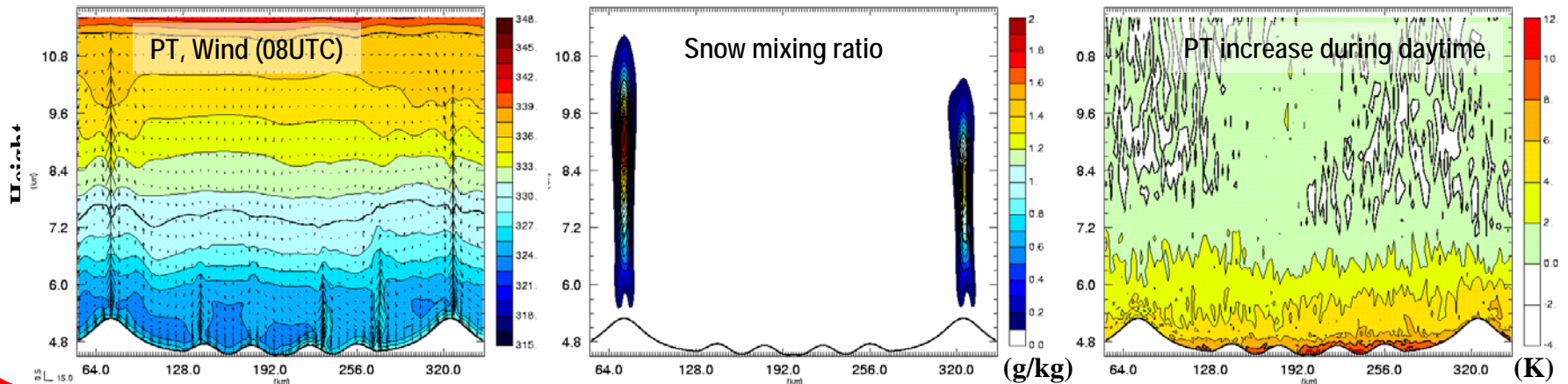


✦ Cooler air mass approaching to the observation site caused the atmospheric cooling.

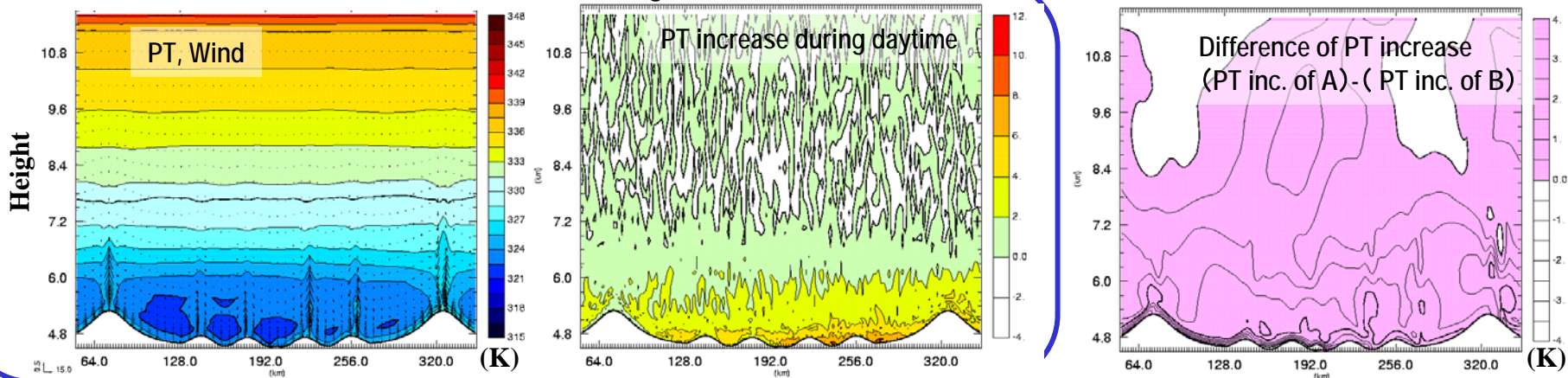
➔ Interaction of synoptic and regional scale atmospheric activity must be considered to understand the heating over the Tibetan plateau

Numerical simulations for verification of the effect of convective cloud on atmospheric temperature increase (by ARPS)

A : WITH MOIST PROCESS (Convective cloud generates)



B: WITHOUT MOIST PROCESS (Cloud DOES NOT generate)



- WITH moist process, PT rising occurs in upper troposphere
- Dry thermal convection developed to 7500nASL, no significant PT increase in the upper air
- ➔ Cloud activity is indispensable for temperature rise in upper troposphere in early spring

Summary and Conclusions

- Increasing of atmospheric temperature in early spring was investigated by using in-situ observation data and satellite data.
- Development of mixing layer can be cause heating in lower troposphere, but can not explain the temperature rise in upper troposphere.
- Cloud activity with clear diurnal variation in early spring
 - ➔ Some studies have pointed (Asai et al.(1998), Fujinami and Yasunari(2001))
- In case of significant temperature rise in upper air, strong cloud convection was recognized.
 - ➔ **In early spring, cloud convection can have an important role in atmospheric heating over the Tibetan plateau.**
- Interaction of synoptic and regional scale atmospheric activity must be considered to understand the heating over the Tibetan plateau

Thank you.



Development of convective cloud over the Tibetan plateau
(around BJ, 21st Apr. 2004)