Air-borne Measurements of the Temperature Field over the Nepal Himalayas*

—A Preliminary Observation—

Tetsuzo Yasunari** and Chotaro Nakajima***

Abstract

Air temperature over two regions of the Nepal Himalayas (Shorong-Khumbu Himal and from Langtang Himal through the Indian Plain) were measured by thermistor and psychrometer set up on a Pilatus Turbo Porter aircraft. The results suggest that the air temperature field over the Himalayas is affected by high altitude orography and surface conditions.

1. Introduction

It is often supposed that the distribution of air temperature over the large scale orography such as the Himalayan ranges and Tibetan Plateau is somewhat different from that of the free atmosphere. However, the measurements of the air temperature over the Himalayas by the use of air-borne instruments have not been made up to the present, except some attempts of reading the values of the thermometer outfitted on aircrafts.

The preliminary measurements of air temperature by air-borne thermistor and the dry bulb of an Assman psychrometer were made during the post monsoon season of 1976 over Shorong-Khumbu Himal and Langtang Himal, respectively. The results of these measurements of the air temperature are reported in the present paper.

2. Air temperature measurements over Nepal Himalayas

2-1 Air temperature over Shorong and Khumbu Himal

The air temperature over Shorong and Khumbu Himal was measured on November 4 using the thermistor set up under the wing of a Pilatus Turbo Porter aircraft, as shown in Fig. 1. The temperature was recorded by electronic recorder (TOA EPR-2T) in the cabin. The flight course is shown in Fig. 2. As the flight speed was at most 130 knots (240 km/hr), errors in the temperature measurement due to the frictional effect on the sensor of the thermistor was considered to be negligible (Gamo *et al.*, 1972). The time constant of this thermister is considered to vary 10 seconds to 30 seconds depending on the wind speed around the sensor, and its supposed temperature differences from actual environmental temperature are at most 0.5°C in ascending (or discending), and 0.1°C during level flight, respectively (Middleton *et al.*, 1953). Therefore, the following discussions will be made roughly enough to neglect the errors mentioned above.

Fig. 1. Thermistor set up under the wing of Pilatus Turbo Porter aircraft. The sensor was put in the normal direction to the main wind direction being protected by the plastic cylinder.

* *Glaciological Expedition of Nepal, Contribution No.* 48

** *Disaster Prevention Research Institute, Kyoto University, Uji, Kyoto* 611 (*Present adress:*)*The Center for Southeast Asian Studies, Kyoto University, Kyoto* 606)

*** *Disaster Prevention Research Institute, Kyoto University, Uji, Kyoto* 611

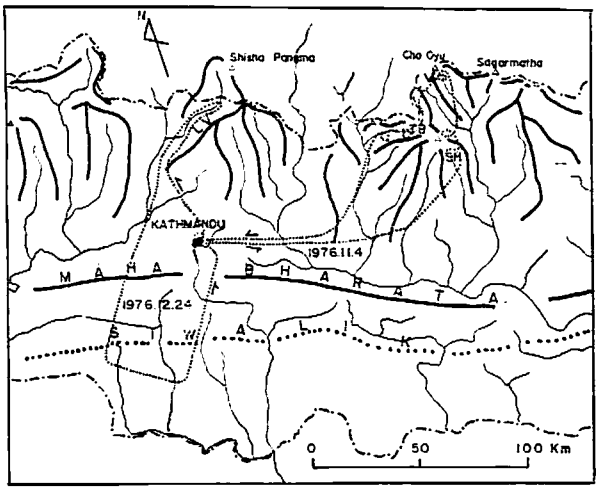

Fig. 2. Flight courses for Shorong-Khumbu Himal (1976. 11. 4) and for Langtang valley through Indian Plain side (1976. 12. 24). The initial letters in the figure show the names of the places as follows: SH: Shorong Himal, TB: Tolam Bau Glacier, LV: Langtang valley.

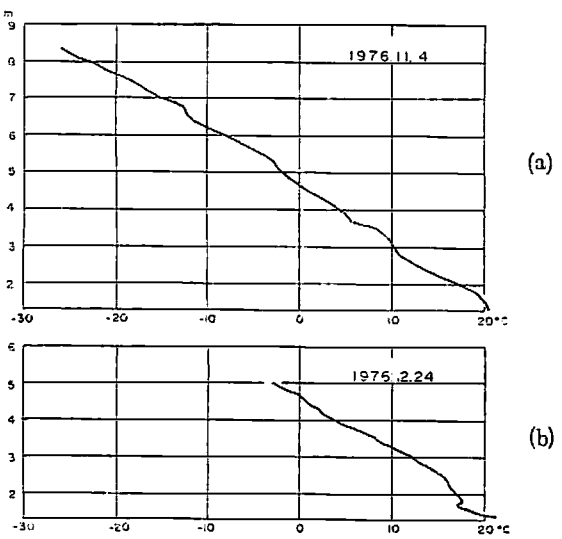

Fig. 3. Temperature profiles during take-off from Kathmandu airport (1350 m), on (a) November 4, 1976 (from 11:07 to 12:29), (b) December 24, 1976 (from 12:40 to 12:55).

The aircraft rose gradually to an altitude of about 8000 m over the Khumbu region. The temperature profile from the ground surface (Kathmandu airport; 1350 m) to 8300 m is shown in **Fig. 3(a).** The lapse rate was estimated to be 0.65°C/100 m on the average. Discontinuous layers seemed to exist at the 2800-3500 m level and also 6400-6800 m level, where the lapse rates were very small (0.2-0.4°C/100 m). The temperature at the 500 mb level (about 5800 m) was −6.5°C, which was nearly the same value as that obtained from the 500 mb weather chart on this day. After reaching the Khumbu region, the aircraft flattened out to level flight at about 8000-8300 m, where the air temperature stayed around −25°C. To eliminate the effect of the small deviation of altitude on air temperature, the temperature has reduced to the 8000 m level by the use of the mean lapse rate between 6800 m and 8300 m (0.85°C/100 m) in Fig. 3(a). The reduced temperature is shown in **Fig. 4(a).** In this figure, the surface altitude directly under the aircraft is also shown.

As the variation of the reduced temperature is very small (at most 1°C), it is very difficult to verify the effect of the orography and the surface conditions on the air temperature field. Nevertheless, relatively low temperature can be seen over the high snowy mountain areas of Shorong (Nup r Mts.) and Khumbu (Cho Oyu Mts. and Tolam Bau Glacier) Himal, observed at around 11^h50^h (Shorong Himal) and at 12^h00^m through 12^h20^m (Khumbu Himal). On the contrary, relatively high temperatures can be seen over the bare ground surface at lower altitude, observed mainly at around 11^h55^m and at 12^h30^m through 12^h50^m. Over the snowy areas, the distances from the aircraft to the surface were around 1000-2000 m.

2-2 Air temperature measurements over Langtang Himal through Mahabarat Lekh and the Indian Plain

Air temperature ovre Langtang Himal and along the route southward through Mahabarat Lekh to the Indian Plain were measured on December 24, by the use of dry bulb of an Assman psychrometer set up outside of the window of the co-pilot seat of the Pilatus Turbo Porter aircraft. This time, the flight course was chosen in a direction normal to the main Great Himalayan range. After spiralling up almost vertically over the Kathmandu basin, we held the flight altitude at the level of 5000 m, to examine the effect of the orography of the Great Himalayas on the air temperature distribution. The flight course is shown in Fig. 2. The temperature profile from the ground surface (Kathmandu airport; 1350 m) to the level of 5000 m in taking off is shown in Fig. 3(b). It is well known that over the Kathmandu basin a ground inversion layer appears frequently in the morning during this season, but at this time of the day (12^h40^m), it might already have disappeared. However, another inversion layer was found at the 1700-1800 m level over the Kathmandu basin. On this day, a weak

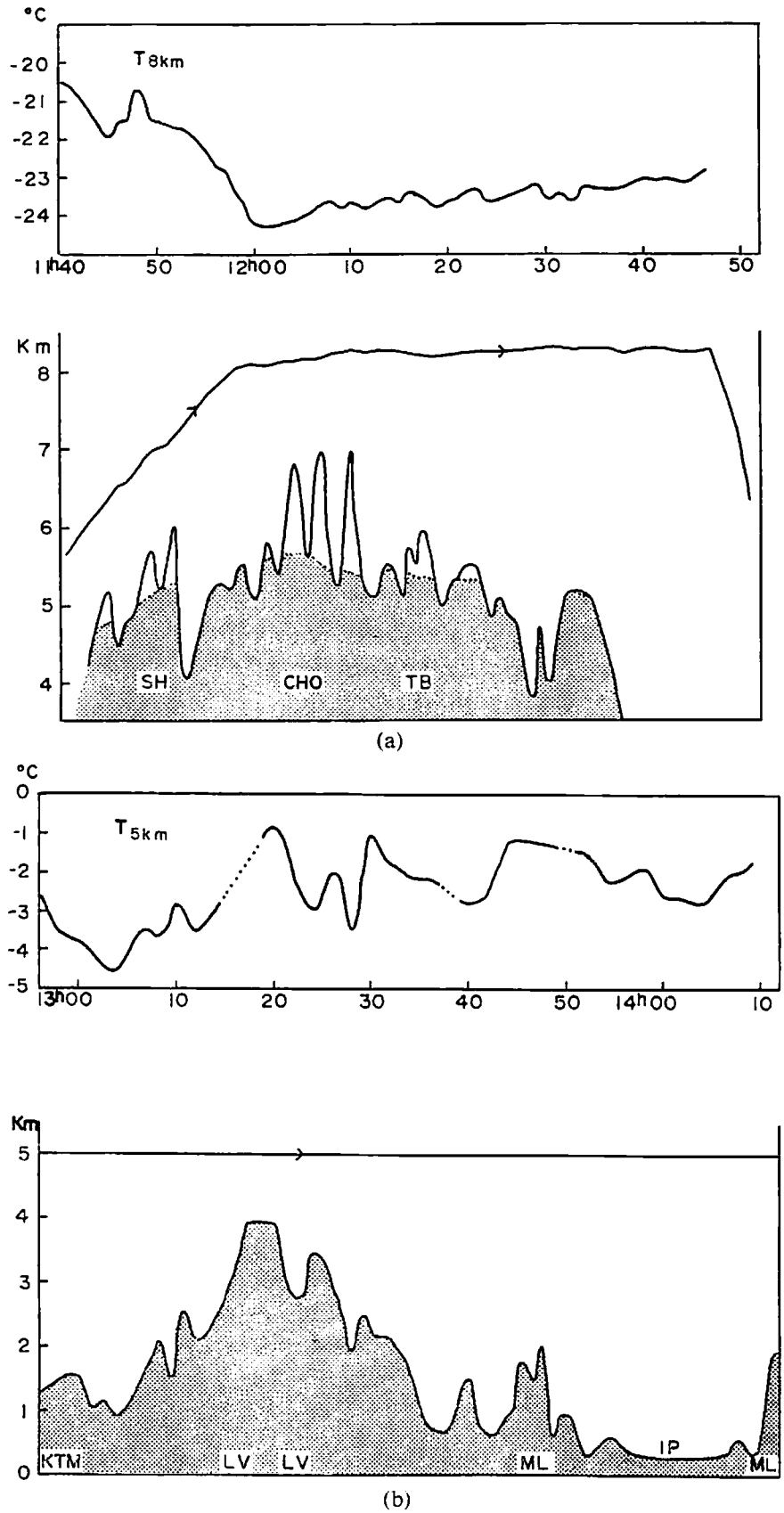

Fig. 4. Time cross-sections of measured air temperature, flight altitude and profile of surface orography under the aircraft in the cases of (a) November 4, 1976, and (b) December 24, 1976. Non-shaded areas of the profile of the surface orography in Fig. 4(a) indicate the snow covered areas. The initial letters in the figure correspond to the names of the places as follows: SH: Shorong Himal, CHO: Cho Oyu mountains, TB: Tolam Bau Glacier, KTM: Kathmandu, LV: Langtang Valley, ML: Mahabharat Lekh, IP: Indian Plain.

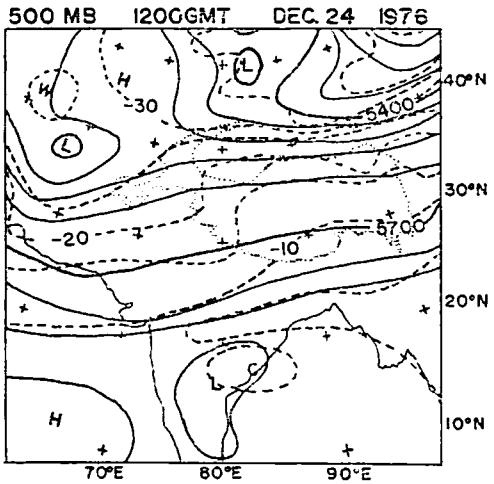

Fig. 5. 500 mb weather chart for 1200 GMT, December 24, 1976. The Himalayan and Tibetan highlands are indicated by the contour line of 4000 m (dotted line).

pressure ridge at the 500 mb level stayed over Nepal as shown in Fig. 5, but it was not clear whether or not this inversion layer was formed by the subsidence of air over the relatively cold air at the bottom of Kathmandu basin. The lapse rate over the inversion layer was 0.7°C/100 m on the average. The temperature value extrapolated to 500 mb level (the altitude was about 5700 m as shown in Fig. 5) was nearly −7°C, which was a slightly higher value than that obtained from the 500 mb weather chart (Fig. 5) on this day. The air temperature variation at the 5000 m level along the course is shown in Fig. 4(b). The surface altitude directly under the aircraft is also shown. The systematic variation of the air temperature along the course could not be found so clearly, but relatively higher temperatures were observed around the inner part of the Langtang valley and also over Mahabarat Lelkh. Many factors should help to produce the relatively high temperature over these two areas. For example, the effect of relatively warm air advection along the valley bottom to the innerside of Langtang valley, and the effect of thermal convection over Mahabarat Lekh should be considered.

3. Summary

The results of air temperature measurements by aircraft over two regions of the Nepal Himalayas have been described. Through the measuring methods were simple and conventional, it is suggested that unlike the free atmosphere the temperature field over the Himalayas is affected by the high altitude orography and the surface conditions (such as widely snow covered or bare) even at a level of 5000 m through 8000 m. However, to verify these effects more clearly, more exact observations should be made.

Acknowledgements

The authors would like to express their gratitude to Captain E.J. Wick of RNAC for carrying out the difficult flights exactly according to the requested courses.

References

Gamo, M., T. Yamamoto and Yokoyama, N. (1972): Airborne measurement of Atmospheric Boundary Layer Structure —On the airborne sensor system—. Pollution Control. 7, 173-185 (in Japanese).

Middleton, W.E.K., and Spilhaus, A.F., (1953): Meteorological Instruments. Univ. of Toronto Press, Toronto, 65pp.