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Meteorological features in Langtang Valley, Nepal Himalayas, 1985-1986

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Abstract

Meteorological observations were carried out in Langtang Valley, Nepal, from July 1985 to July 1986. The meteorological conditions at Kyangchen (3920 m) in the Valley are discussed and the climate of this district is outlined. The annual precipitation was about 1200 mm, characterized by light showers in the rainy season and heavy rain caused by large scale atmospheric disturbances. The seasonal trend of air temperature is characterized by a smooth curve in the rainy season and variations with a period of about 15 days in the dry season in response to radiation. The annual mean air temperature was 2.7°C at Kyangchen. The Lapse rate of temperature with altitude was 6.0×10^{-3} °C/m between the altitudes of 3920 m and 5090 m. The ground temperature at the depth of 1 m was higher than the air temperature almost throughout the year. The wind speed was high from after the rainy season to winter, and low in April and May before the rainy season. The solar radiation and net radiation showed high values from March to June, varying with a period of about 15 days.

1. Introduction

Along Langtang Valley in the Nepal Himalayas, many glaciers are distributed, from which a large amount of meltwater flows into rivers. In order to use this abundant river water as for irrigation and hydroelectricity, it is necessary to understand the effect of meteorological conditions on the river water. The meteorological conditions are also important for climatological studies, especially the monsoon climate in this region which is characterized by rainy and dry seasons. In this district, however, there has been no weather station, and no meteorological report throughout the year.

We carried out meteorological observations in Langtang Valley for one year, from July 1985 to July 1986, simultaneously with the hydrological studies (Fukushima *et al.*, 1987) and glaciological observations (Iida *et al.*, 1987). In this report, the obtained seasonal trends of meteorological conditions are briefly discussed and the climate in the Langtang Valley is outlined.

2. Observations

The main observation site 'Base House', called BH hereafter in this paper, was located at Kyangchen (3920 m above sea level) on the junction of the Langtang River and the Lirung River in Langtang Valley (Fig. 1). At BH, the following meteorological elements were obtained by self-recording instruments : air temperature, relative humidity, wind speed, ground temperature at the depth of 10 cm, solar radiation, net all-wave radiation and precipitation. The elements observed by visual or manual observations were weather condition, cloud amount, cloud forms, wind direction, visibility, radiative temperature and ground temperature at depths of 5 cm, 30 cm and 1 m. A summary of the main meteorological elements has

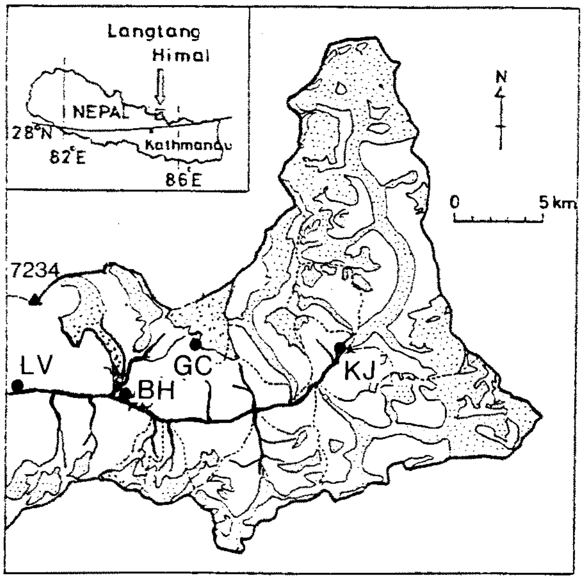

Fig. 1. Location of meteorological observation sites. BH : Base House at Kyangchen, GC: Glacier Camp at Yala Glacier, LV: Langtang Village, and KJ: Kyijungphu.

reported by Takahashi *et al.* (1987).

Three unmanned observation sites were set up at Langtang Village (LV) (3500 m) from July 1985 to June 1986, at Kyijungphu (KJ) (4200 m) from August to November 1985, and at 'Glacier Camp' (GC) on the terminal moraine of Yala Glacier (5090 m) from July 1985 to June 1986 (Fig. 1). Air temperature and relative humidity were recorded in screen boxes at these three sites, and precipitation was recorded at LV and GC.

As the observation time, we used Nepal Standard Time which is GMT plus 5 h 40 m.

We discuss mainly the meteorological conditions at BH in the following chapters.

3. Precipitation

The climate of the Nepal Himalayas is considerably influenced by the Indian monsoon (called 'monsoon' hereafter) which is characterized by rainy and dry seasons. In Langtang Valley, the onset of the monsoon was at the end of June in 1985 and the monsoonal rainfall continued until the middle of October. The dry season was from October to next May.

In Fig. 2, the observed precipitation and snow depth in winter are shown. The precipitation was measured by a rain gauge which was observed every day, and by a self-recording rain gauge of tipping-bucket type, which agreed well with each other. The precipitation in winter was obtained by weighing the daily snowfall.

The annual precipitation from July 1985 to June 1986 was 1225 mm. In the monsoon season from July to October and in June 1986, precipitation was 953 mm (78 % of the annual value), while in the dry season it was 271 mm (22 %) including about 150 mm (12 %) of the snowfall in winter.

In the monsoon season, precipitation was characterized by daily light shower less than 10 mm. In this season, the weather regularly varied diurnally as follows. While it was clear at first in the early morning, clouds came up from the west along Langtang Valley at 08 or 09 h, and then light showers fell in early afternoon and stopped in the evening. On occasion, showers also fell at night.

In the end of the monsoon season, three heavy rainstorms were observed : 102 mm Septmber 16-17, 169 mm between October 9-11, and 172 mm October 17-18, 1985. These rains were considered to be caused by large-scale atmospheric disturbances. After the last precipitation of October, there was completely no precipitation until the snowfall at the end of December.

In winter from December to February, there were only three heavy snowstorms : 82 mm (in water) December 26-27, 1985, 41 mm on February 10, 1986 and 20 mm February 14. The maximum snow depth of 77 cm was recorded on February 10.

In spring from March to May, there was occasional light precipitation less than 10 mm per day. The precipitation in those three months was 129 mm.

The precipitation from July to September and in the following June was 671 mm in Langtang Valley ; its ratio to the annual amount was 55 %. This ratio is less than that of the Khumbu Himal in eastern Nepal, which was 75 % in 1973 and 81 % in 1974 (Inoue, 1976). This difference can be explained by the heavier snowfalls in winter of Langtang Valley than that of Khumbu Himal. Since the observation site is located behind the main ridgeline of the Himalayas, the annual precipitataion of these districts is rather small than that of the southern slope of the Himalayas by its "barrier effect" (Yasunari and Inoue, 1978).

Light showers in the monsoon season are associated with locally developed cumulus clouds. Comparing the precipitation at BH with that at other sites,

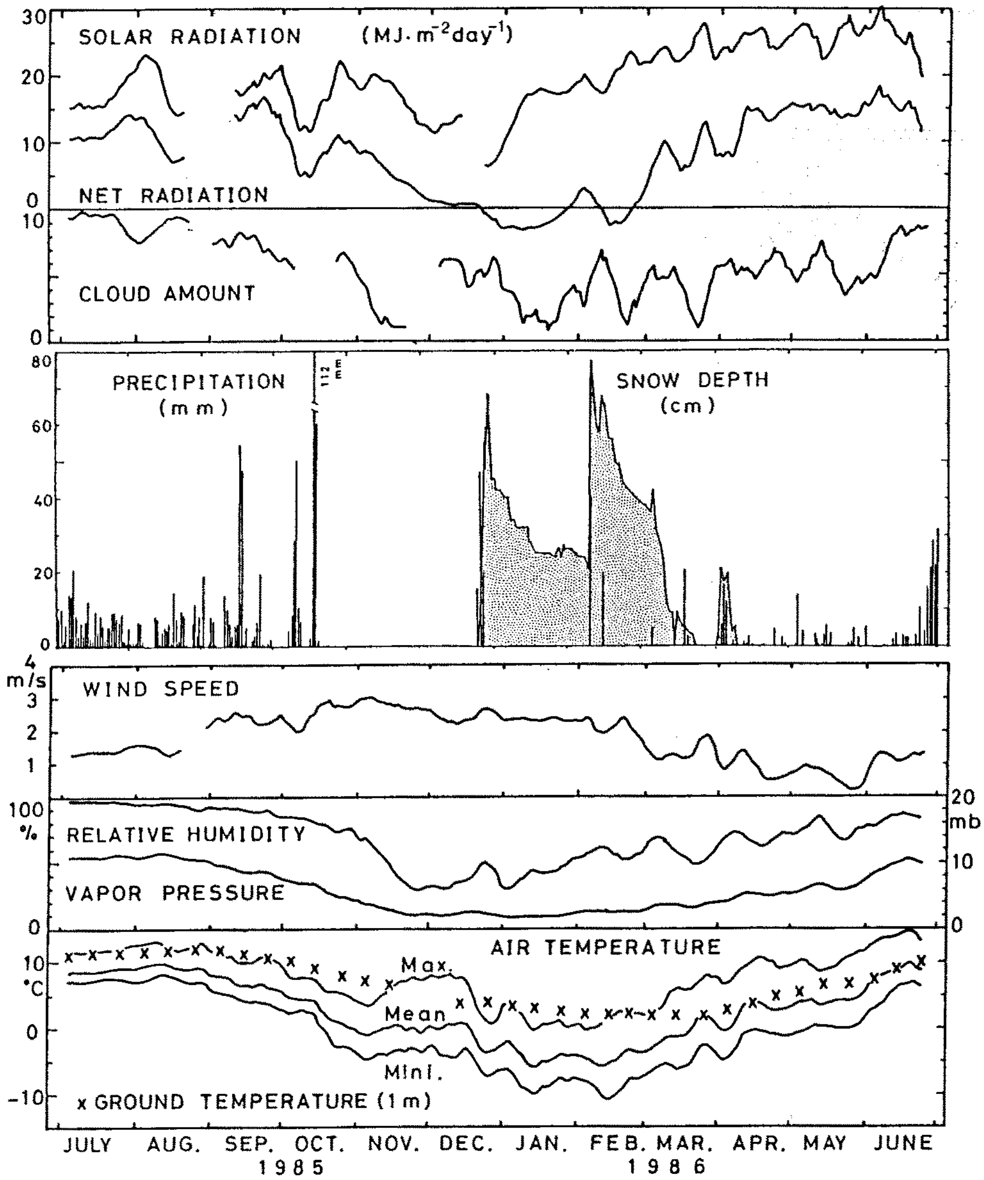

Fig. 2. Meteorological conditions at BH in Langtang Valley. Precipitation and snow depth are daily data, ground temperature is 10-day mean data, and others are 10-day running mean data.

further discussion of this local cloud development and synoptic scale disturbance is given by Seko (1987).

4. Temperature

At BH in Langtang Valley, the annual mean air temperature was 2.7°C between July 1985 and June 1986. The maximum temperature was 16.3°C on June 23, 1986, and the minimum temperature was −13.2°C on February 17, 1986.

In Fig. 3a, the seasonal trend of 5-day running mean temperature is shown. The trend in the monsoon season is a smooth curve without small variations, whereas the trend in the dry season had a large variation with a period of 10 to 15 days, which corresponded to the solar radiation variation described in Section 8. This tendency is clearly found in the annual variation of diurnal temperature change in Fig. 3b ; the hour of isotherms varied periodically in the

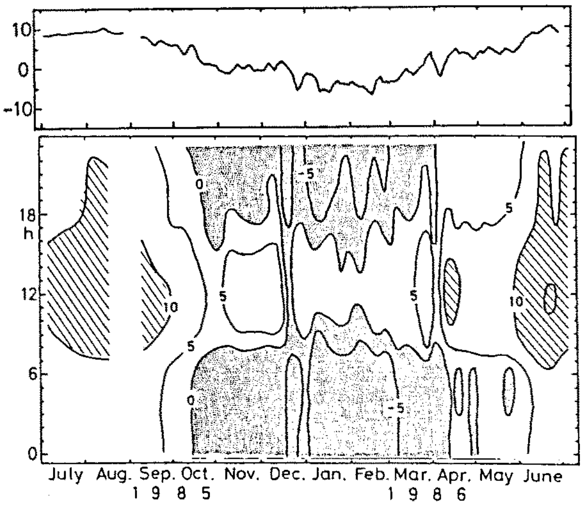

Fig. 3. a) (above) Variation of 5-day running mean of air temperature (°C).
b) (below) Annual variation of diurnal change of air temperature. The hatched area is above 10°C and the gray area below 0°C.

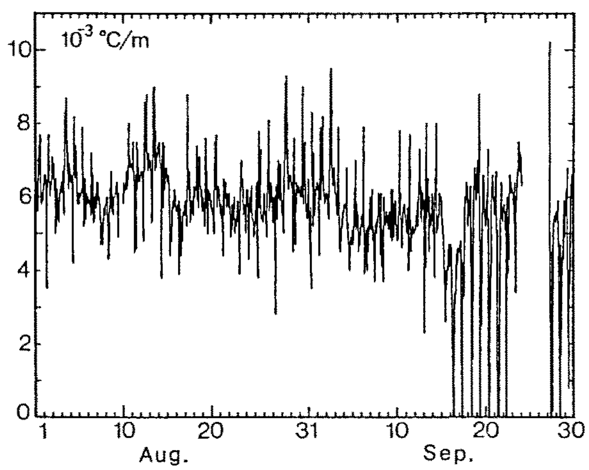

Fig. 4. Lapse rate of temperature with altitude between BH (3920 m) and GC (5090 m).

dry season.

This tendency is explained as follows. The temperature constancy in the monsoon season is due to the persistent thick clouds, whereas the periodic variation in the dry season is caused by large scale atmospheric disturbances related to planetary waves. As a result, the diurnal temperature variation was small in the monsoon season and large in the dry season (Fig. 2).

The temperature lapse rate with altitude was obtained from the temperatures observed at BH (3920 m) and GC (5090 m). The variation of lapse rate is shown in Fig. 4. After the middle of September, GC was covered with snow and the lapse rate was abnormally small in daytime. The reason is that the screen box at GC was heated from the bottom by solar radiation reflected from the snow and the temperature increased, because it had a single-plate bottom and a double-plate roof. This temperature increase at GC resulted in a small lapse rate. Excluding this case, the average lapse rate was 6.0×10^{-3} °C/m.

The lapse rate is important to investigate glacier formation and glacier run-off. Using this lapse rate value, Morinaga *et al.* (1987) pointed out the close relation between the snow line and 0°C temperature altitude.

5. Ground temperature

The ground temperature at depth 1 m was remarkably higher than the air temperature. As shown in trends of 10 day-running mean in Fig. 2, the ground temperature was higher than the air temperature almost throughout the year. The annual mean ground temperature at BH was 6.8°C, which was 4.1°C higher than the annual mean air temperature.

Even taking account of the snowcover in winter, the ground temperature was still high. One possible explanation (besides terrestrial heat) is as follows. The ground surface is a heat source for the atmosphere due to the strong solar radiation in this district, while air temperature tends to decrease adiabatically due to the prevailing up-valley wind. Therefore, the surface temperature and consequently the ground temperature become higher than the air temperature.

6. Humidity

As shown in Fig. 2, the trends of 10-day running mean of relative humidity and vapor pressure represent the monsoon climate in this district. The vapor pressure was more than 10 mb in the monsoon season with the maximum in August, gradually decreased to about 2 mb in the end of November, stable in winter, and gradually increased from March to the next monsoon season. Adding to this variation, the relative humidity varied with the temperature variation.

The last monsoon precipitation was in the middle of October, but the vapor pressure decreasing continued until the end of November. This delay indicates that the moist air left by the monsoon circulation is not replaced immediately by dry air after the last rainfall. It may take time for the prevailing westerly wind to shift from north of Tibet to the south of the Himalayas.

7. Wind

The wind speed in Langtang Valley was relatively small throughout the year ; the annual mean at BH was 1.8 m/s. The trend of 10-day running mean of wind speed is shown in Fig. 2. The wind speed shows a maximum of about 3 m/s at the beginning of November, remaining at 2 to 3 m/s until February, and decreasing to less than 1 m/s in April and May.

In Khumbu Himal, on the contrary, the running mean of wind speed was a constant 5 m/s throughout the year (Inoue, 1976). The difference can be explained as follows.

Langtang Valley runs west-east whereas Inoue's observations were made in the valley running north-south. Therefore, the surface wind in Langtang Valley is more influenced by the westerly wind. The large post-monsoon wind speed in Langtang Valley is due to the prevailing westerly wind after it shifts from the north of Tibet highland to the southern part of the Himalayas, and the small pre-monsoon value is explained by weakening of the westerly wind before it shifts northward. In the monsoon season, the wind speed is maintained by the up-valley wind. On the contrary, the wind speed at the observation site in Khumbu Himal is hardly affected by this westerly wind variation.

Relating to the precipitation mechanism, further discussion of the westerly wind in the dry season and the up-valley wind in the monsoon season is given by Seko (1987).

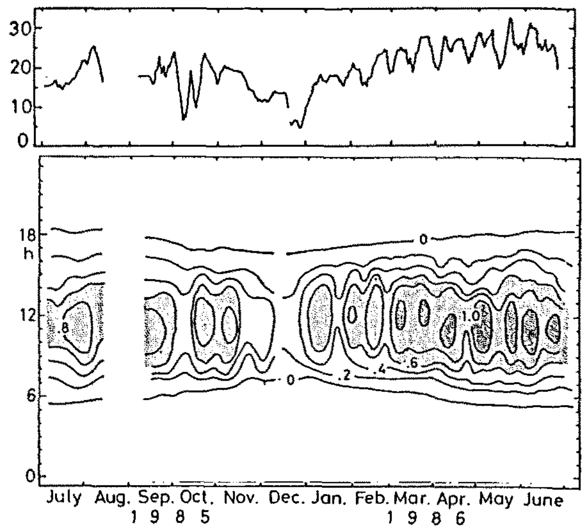

Fig. 5. a) (above) Variation of 5-day running mean of solar radiation (Mj m^{-2} day^{-1}).
b) (below) Annual variation of diurnal change of solar radiation (kW m^{-2}). The dark gray area is above 1.0 kW m^{-2} and the gray area above 0.6 kW m^{-2}.

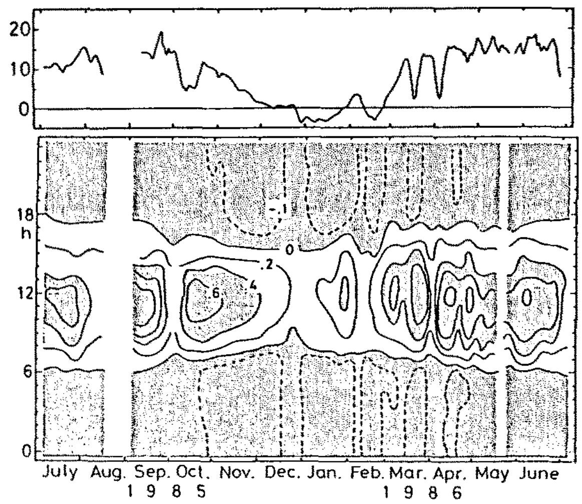

Fig. 6. a) (above) Variation of 5-day running mean of net all-wave radiation (Mj m^{-2} day^{-1}).
b) (below) Annual variation of diurnal change of net all-wave radiation (kW m^{-2}). The gray area is above 0.4 kW m^{-2} or below 0 kW m^{-2}.

8. Radiation

The 5-day running mean and annual variation of diurnal change of solar radiation are shown in Fig. 5. The solar radiation reached a minimum in December near the winter solstice, while the maximum was not seen in June near the summer solstice but in May before the rainy season. In the pre-monsoon season from March to June, the solar radiation occasionally rose to more than 1 KW/m^2 in fine weather.

The annual mean daily solar radiation was 19.8 MJ/m^2 day ; the maximum was 33.9 MJ/m^2 day on May 23, 1986.

In addition to the seasonal variation, a periodic variation with a period of about 15 days was clearly found, corresponding to the temperature variation described above. This period agrees with one for Indian monsoon fluctuations pointed out by Murakami (1976).

The 5-day running mean and annual variation of diurnal change of net all-wave radiation are shown in Fig. 6. The net radiation is usually positive in the daytime and negative at night. In winter, the daytime net radiation became fairly small owing to the high albedo of snowcover, and the daily net radiation was frequently negative. Though smaller than the solar radiation, the net radiation varied similarly to it. The annual mean net radiation was 8.3 MJ/m^2 day.

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