# Characteristics of Micrometeorology in the Surface Layer in the Tibetan Plateau①

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ABSTRACT

The data of the meteorological elements in the surface layer have been analyzed which were obtained during the IOP of TIPEX from May to July 1998 in Gêrzê, Damxung and Qamdo. The characteristics of the diurnal variations and the vertical profiles of the wind velocity, temperature and humidity in the surface layer have been investigated. Some interesting results have been obtained. The moisture inversion phenomena occured during the daytime in the surface layer have also been discussed.

**Key words:** Diurnal variation of meteorological element, Vertical profile, Tibetan Plateau

## 1. Introduction

The Tibetan Plateau is the highest and widest plateau in the world with average more than 4000 meters elevation above the sea level, which occupies one fourth of the whole Chinese land. The extraordinary heat and dynamical effects induced by the plateau in large areas and the land–air processes over the plateau play an important role in the climate change and the formation of the severe weather in eastern and southern China, Asia, and even in the whole world. Since there are Gobi and desert over most of the plateau, the observation stations are very sparse and the beginning of the meteorological observation is not far ago in the Tibetan Plateau. The knowledge is very limited on the weather change in the Tibetan Plateau and its effect on local climate (Zhou et al., 2000). The first Tibetan Plateau Meteorological Experiment held in 1979 has studied the diurnal variations of the meteorological elements in the surface of the plateau. However, due to the limitation of the technical condition and observation methods in that time, the studies only focused on the variations of the meteorological elements such as wind velocity, temperature, and moisture in the surface layer of the plateau. Study on the fine structure of the meteorological elements in the surface layer of the plateau needs to be further conducted.

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To study the characteristic of the turbulence flux and the variation of the meteorological elements in the surface layer of the plateau is one of the major contents of the second Tibetan Plateau Experiment (TIPEX). It will provide a more rational parameterization scheme of the surface turbulent fluxes in numerical models for study on the micrometeorological characteristic in the surface layer of the plateau. The micrometeorological characteristic in the surface layer of the plateau has its special character because of its high elevation and specific geographical characteristic. In the second Tibetan Plateau Experiment, from west to east, three stations of atmospheric boundary layer observation were set at Gêrzê, Damxung, and Qamdo. Synchronous observations in three stations were carried out for more than 40 days from June 1998 to July 1998. That was the first experiment held in the Tibetan Plateau from west to east synchronously to observe the structure of the boundary layer and the turbulent transfer process in the surface layer in different location. Many observational data were obtained from the structure of the plateau boundary layer and the turbulence in the surface layer. Those data can help us to obtain more knowledge about the turbulent transfer and the structure of the atmospheric boundary layer in the Tibetan Plateau. The detail about the experiment sites and instruments can be seen in Zhou et al. (2000). The micrometeorological characteristics of the plateau in the surface layer in three observation stations were discussed in this paper.

## 2. Characteristics of meteorological elements in the surface layer of the plateau

### 2.1 *The weather condition during the dry and moist period in the plateau*

Figure 1 shows the distribution of the rainfall during the IOP of TIPEX in Gêrzê, Damxung and Qamdo. The observation period can be divided into dry and moist periods. The rainfall intensity and rainfall amount are different in the three stations from west to east. The first rainfall appeared in Gêrzê station in the west of the Tibetan Plateau from June 28 to June 29, 1998 and on July 18, 1998 gale and hail appeared. During the dry period (from June 7 to June 28, 1998), it was mainly sunny with convective clouds developing at noon. During the moist period (from June 29 to July 14, 1998), it was often cloudy or overcast besides convective weather.

In Damxung station in the middle of the Tibetan Plateau, June 22, 1998 is the date to divide the period into a dry and a moist period. During the dry period, it was sunny and the wind velocity was small in the morning. At noon, clouds mainly cumulus rose from the top of hills and covered the sky gradually and disappeared partly at dusk. Moreover, a strong wind appeared in the afternoon. During the moist period, it was mainly cloudy and overcast with some rainfall. Compared with in Gêrzê and Qamdo, there was also rainfall in Damxung during the dry period.

In Qamdo located the east of the Tibetan Plateau, which is near to the eastern mountain areas, there were plenty of rainfall and the rainfall almost appeared during all the observation period. Since the rainfall amount increased greatly from the end of May, May 23, 1998 can be as the day to divide the period into a dry and a moist period. The rainfall amount and intensity increased gradually from west to east along the section of Gêrzê, Damxung and Qamdo in the Tibetan Plateau. The moist period came earlier gradually from the west to east of the plateau. Compared with the rainfall of the corresponding time in 1979 in Lhasa and Nagqu, it can be found that the moist period in 1998 came later, and the daily maximum rainfall amount and total rainfall amount during intensified observation period of TIPEX were a little

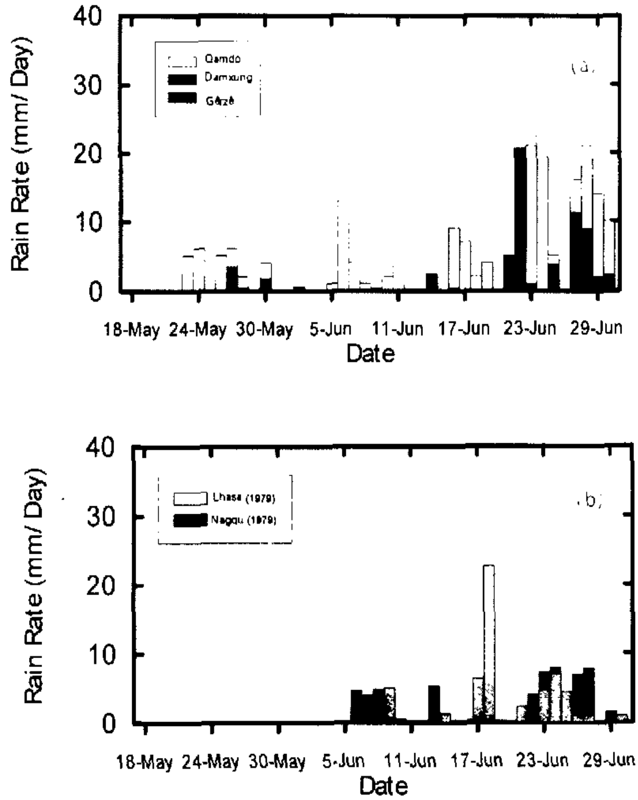


Fig. 1. The distribution of rainfall amount during the observation period. (a) The distribution of rainfall amount in Gêrzê, Damxung and Qamdo during intensified observation period of TIPEX in 1998. (b) The distribution of rainfall amount in Lhasa and Nagqu during the corresponding time in 1979.

smaller than those in 1979.

*2.2 The diurnal variation of the wind velocity in the surface layer of the plateau*

Figure 2 shows the mean diurnal variations of the wind velocity measured at 2 m above the ground in Gêrzê, Damxung and Qamdo during the dry and moist periods. During the dry period, the diurnal variations of the 2 m wind speed were all "one peak and one trough" patterns in three observational stations. The maximum and minimum 2 m wind speed appeared earlier gradually from west to east. The maximum and minimum 2 m wind speed appeared in Gêrzê at 09:00 to 10:00 and 20:00 to 21:00 (Beijing time) respectively, while in Damxung at 07:00 and 18:00, and in Qamdo at 05:00 and about 17:00 respectively (here after the time refers to Beijing time in this paper). The range of the wind speed change in one day gradually decreased from west to east. It may have relation with the local terrain in the observation station. The really reason needs to be studied further.

During the moist period, the diurnal variations of the 2 m wind speed in Qamdo and Gêrzê were also " one peak and one trough" patterns. The maximum 2 m wind speed

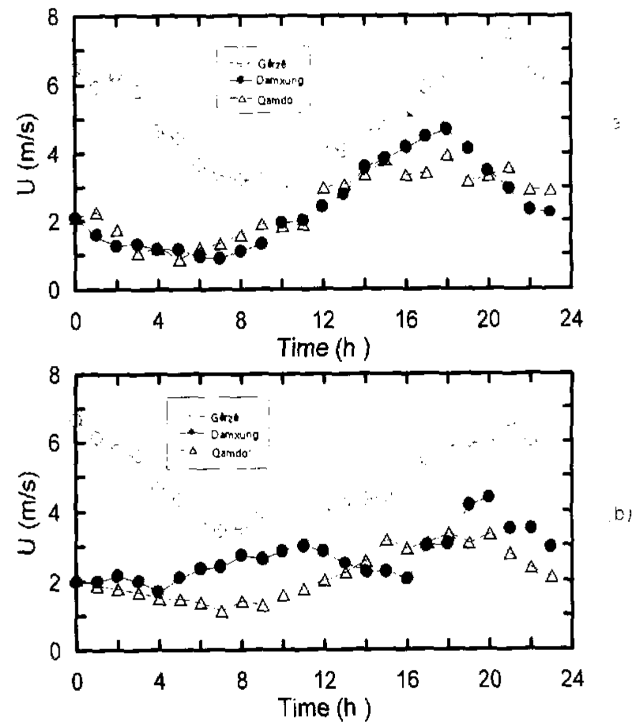


Fig. 2. The mean diurnal variations of the wind speed measured at 2 m above the ground in Gêrzê, Damxung and Qamdo. (a) During the dry period. (b) during the moist period.

appeared almost at the same time as that during the dry period in Qamdo and Gêrzê. The minimum 2 m wind speed appeared slightly earlier than that during the dry period in Gêrzê, while it appeared later than that during the dry period in Qamdo (at about 08:00). The diurnal variation of the 2 m wind speed in Damxung was complex during the moist period and it had more peaks and more troughs. Two minimum wind speeds appeared at 04:00 and 16:00 respectively, while the maximums appeared at 09:00 and 19:00 respectively. That probably has relation with that the observation site in Damxung which is located in a valley (Zhou et al., 2000).

*2.3 The diurnal variation of the temperature in the surface layer of the plateau*

Figure 3 shows the mean diurnal variation of the temperature measured at 2 m above the ground in Gêrzê, Damxung and Qamdo during the dry and moist periods. Figure 4 also shows the diurnal variation of the temperature difference between measured at 0.5 m and 2 m above the ground in three observation stations during the dry and moist periods.

The diurnal variations of the 2 m temperature in the surface layer in the three stations were also " one peak and one trough" patterns. The diurnal difference of 2 m mean temperature during the dry period is larger than that during the moist period. The 2 m mean temperature obviously increased more rapidly in the morning in the dry period than that in the moist period. The minimum 2 m temperature in the dry period is less than that in the moist period.

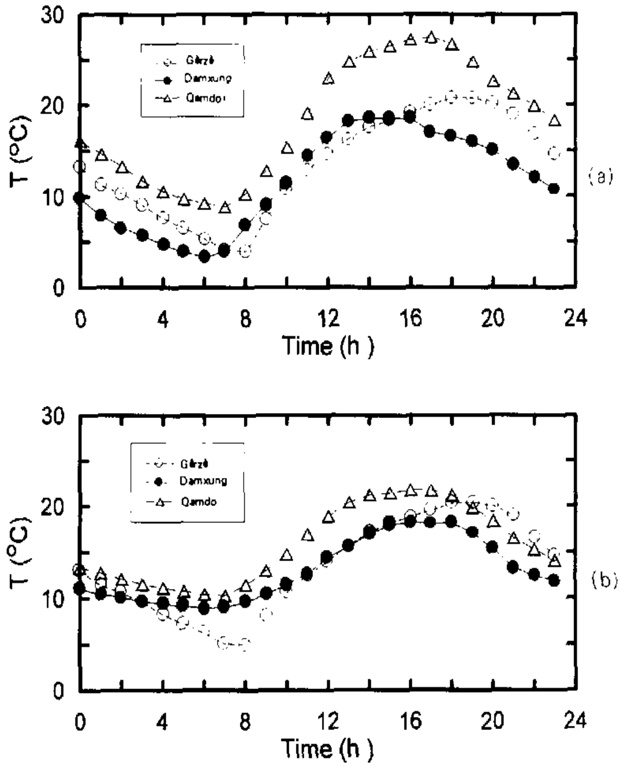


Fig. 3. The mean diurnal variations of 2 m temperature in the surface layer in Gêrzê, Damxung and Qamdo. (a) During the dry period, (b) during the moist period.

In Gêrzê, the minimum 2 m temperature appeared at about 07:00 to 08:00, while the maximum appeared at about 18:00 to 19:00 in the dry and moist periods. The local time in Gê rzê is about two and a half hours later than the Beijing time. The temperature maxima in Gê rzê occurred later than in the noon 14:00 usually (local time) (Wang et al., 1987), which was accorded with observed in desert and Gobi (Sahashi et al., 1994; Pillai et al., 1998). The reason for temperature maxima lag may be explained as follows (Pillai et al., 1998). The soil thermal conductivity was low and evaporation was less at the soil surface, while the soil was very dry in Gêrzê. Although during the moist period in Gêrzê, it came before the rainy season and the soil was still dry. The energy at the land surface–atmosphere interface is transported mainly by sensible heat flux upwards and soil heat flux downwards. Due to low thermal conductivity, the soil heat flux rate is less and needs more time to reach equilibrium. The difference of the 2 m temperature maxima between during the dry period and the moist period in G êrzê is very small.

In Damxung, the minimum 2 m temperature during the dry and moist periods occurred at about 06:00, while the maximum temperature occurred at about 16:00 (Beijing time). The 2 m temperature maxima lag did not occur. The minimum temperature in the dry period is obviously lower than in the moist period, while the maximum temperature in the dry period is

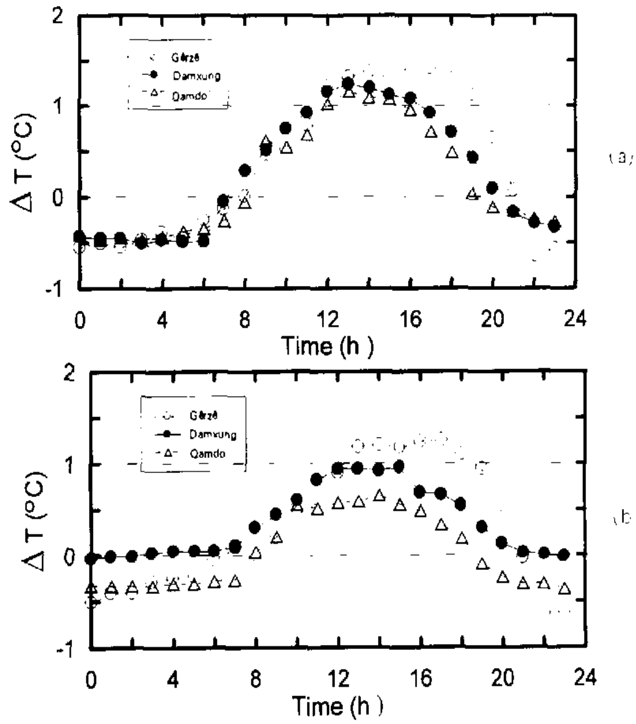


Fig. 4. The mean diurnal variations of temperature differences between measured at 0.5 m and 2 m above the ground in the surface layer in Gêrzê, Damxung and Qamdo. (a) During the dry period; (b) during the moist period.

larger than in the moist period. At night, the temperature in the moist period declined slowly, but the temperature in the dry period changed rapidly.

In Qamdo, the minimum 2 m temperature during the dry and moist periods occurred between 07:00 to 08:00, while the maximum temperature occurred at about 17:00. The 2 m temperature maxima lag did not occurr also. The maximum 2 m temperature in the dry period is obviously larger than that in the moist period, while the minimum temperature in the dry period is lower than in the moist period. At night, the temperature in the dry period declined slowly, while the temperature in the moist period changed smoothly.

The characteristics of the diurnal variation of the temperature–difference between measured at 0.5 m and 2 m above the ground are almost the same during the dry and moist periods in three observation stations. The diurnal variation ranges of temperature–difference between measured at 0.5 m and 2 m in the dry period are larger than in the moist period in the surface in three stations. The diurnal variation range of temperature–difference in Gêrzê was the largest in three stations and deceased gradually from west to east, which was accorded with the variation of solar radiation intensity from the west to the east (Zhou et al., 2000). The temperature differences between measured 0.5 m and 2 m in three stations were positive after sunrise, while the temperature differences were negative after sundown due to the solar radiation.

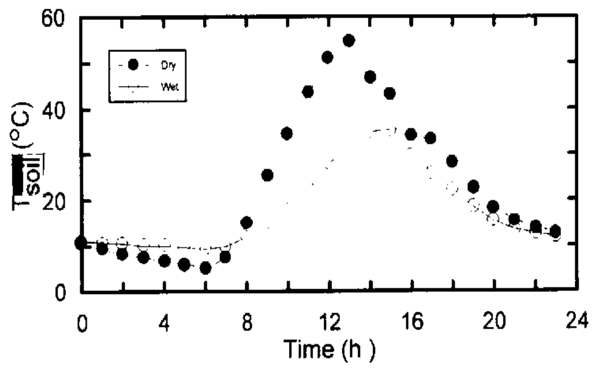


Fig. 5. The diurnal variation of the land surface temperature in Damxung. Points represent the land surface temperature observed in the dry period, while circles represent in the moist period.

The peak values of temperature differences in the surface layer in Gêrzê were all over 1.2°C during the dry and moist periods. The soil moisture was still very small during the moist period in Gêrzê. That is accorded with arid soil and strong solar radiation in Gêrzê.

During the dry period, the peak value of temperature difference in the surface layer in Damxung was near 1.2°C, while it had little decrease during the moist period. In Qamdo, during the dry period, the peak value of temperature difference in the surface layer was near 1.2°C, while during the moist period, it was about 0.6°C. From all above, during the dry period, it was found that the temperature variations in the surface layer in three observation stations of plateau were accorded with those observed in the desert and Gobi area in northwestern China, while during moist period they were similar to those observed in plain area and grassland surface.

Although the measurements of soil temperature at different depth below the ground had been processed in Gêrzê, Damxung and Qamdo, the direct measurements of the land surface temperature were not done in three stations because of the difficulties in its measurements. Here we just discussed the land surface temperature in Damxung, which was calculated from the observational data of soil temperature at different depth and the heat transfer capacity of the soil. Figure 5 shows the diurnal variation of land surface temperature in Damxung. We can find that the diurnal difference of land surface temperature between in the daytime and at night during the dry period can be over 50°C. The minimum land surface temperature occurred at 05:00 before sunrise, while the maximum occurred at 13:00 that the time was slightly earlier than midday. That phenomena was possibly corresponding with the development of cloud in Damxung. During the dry period in Damxung observation station, large proportions of convective cloud in the sky had rapidly developed before the noon and it would weaken the direct heating of the sun to the ground. However, during the moist period, because the land surface was relatively wet, the difference of the land surface temperature in the daytime and at night was just about 25°C. The variation of the land surface temperature was small at night, while the maximum land surface temperature in the daytime appeared at 15:00 or so.

*2.4 The diurnal variation of the specific humidity in the surface layer of the plateau*

Figure 6 shows the mean diurnal variations of the humidity difference between at 0.5 m and 2 m above the ground and the 2 m mean specific humidity (measured at 2 m above the ground) during the observational period in Gêrzê, Damxung and Qamdo. Although the 2 m specific humidity in Gêrzê is small, and the accuracy of humidity difference (between at 0.5 m and 2 m above the ground) in the surface layer is good or not which needs to discuss, the characteristics of mean diurnal variations of humidity difference in the surface layer are almost the same during the dry and moist periods in Gêrzê. The humidity difference in the surface layer is positive from 02:00 to 14:00 in Gêrzê, which the surface humidity is larger than that in the air. After 14:00, the humidity in the air is larger than that in the surface, the phenomenon of the humidity inversion appears.

In Damxung, the 2 m mean specific humidity during the dry period was less than that during the moist period. During the dry period, the mean humidity difference in the surface layer in Damxung increased in the daytime and decreased at night. A slight humidity inversion appeared before sunrise. The mean diurnal variation range of humidity difference in the surface layer during the moist period was larger than that during the dry period, which showed that there was little strong water vapour flux upward during the moist period in Damxung.

Compared with that in Gêrzê and Damxung, the mean diurnal variation of specific humidity at 2 m during the dry period in Qamdo was more obvious. The maximum 2 m specific humidity occurred at about 10:00 to 11:00, while the minimum occurred at about 18:00 to

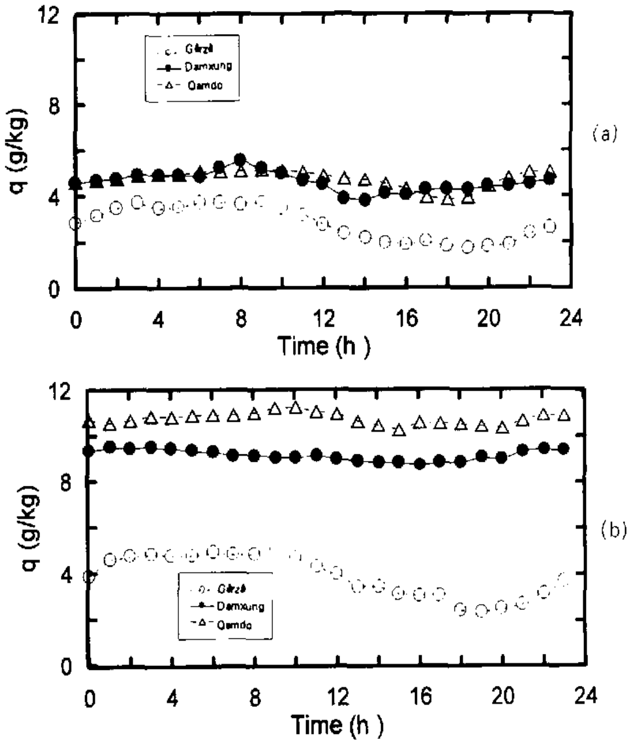


Fig. 6. The mean diurnal variations of humidity in the surface layer at 2 m above the ground in Gêrzê, Damxung and Qamdo. (a) During the dry period; (b) during the moist period.

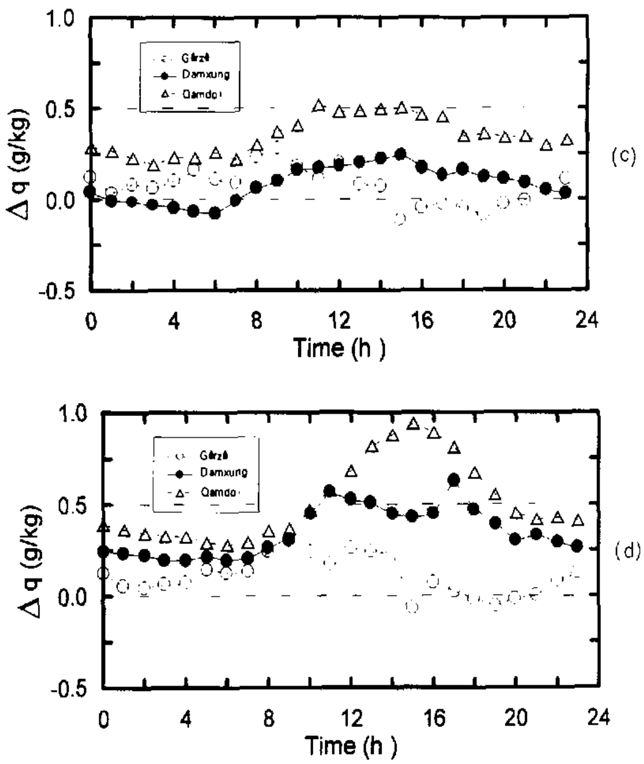


Fig. 6.(continued) The mean diurnal variations of humidity differences between at 0.5 m and 2 m above the ground in the surface layer in Gêrzê, Damxung and Qamdo. (c) During the dry period; (d) during the moist period.

19:00. The mean specific humidity at 2 m increased slowly from later midnight to the noon, while it relatively decreased rapidly in the afternoon and increased rapidly after sundown in Qamdo. During the moist period, the maximum specific humidity appeared at 09:00 and decreases slowly after 12:00, while the minimum appeared about 18:00 to 19:00 after sundown and then it increased. The specific humidity at 2 m in Qamdo is large from night to early morning. That is probably because that the rainfall mostly occurs at night during the observation period. The average diurnal variation range of humidity difference between at 0.5 m and 2 m above the ground in Qamdo during the moist period was larger than that during the dry period. According to the geographical location and synoptic system, the mean specific humidity at 2 m in Qamdo should be larger than that in Damxung during the same period. However, from Fig. 6 we can find that during the dry period, the specific humidity at 2 m in Damxung was very close to that in Qamdo. Maybe it is due to that the rainfall also occurred at night during the dry period in Damxung, while there was no rainfall in Qamdo during the dry condition. During the moist period, the rainfall increased and the specific humidity also increased in Qamdo. The mean specific humidity at 2 m in Qamdo was larger than that in Damxung during the moist period.

## 3. Aerodynamic parameters in the surface layer of the plateau

The surface roughness and the zero–plane displacement lengths are usually the basic parameters in analyzing the profile characteristic of meteorological elements and calculation or parameterization of the turbulent flux in the surface layer.

### 3.1 *The zero–plane displacement length* $d$

The traditional method to determine the zero–plane displacement length $d$ is to use the optimum fitting based on the logarithm profile formula by utilizing the observational data of the wind profile in the surface layer under near neutral condition. That method can determine the aerodynamic surface roughness length $z_0$ at the same time. However, it is difficult to obtain the wind profile data under near–neutral condition, because the transfer is very rapid between the heating in daytime and the cooling at night, and the contrast between them is also very bright in the Tibetan Plateau. On the other hand, the determined value of $d$ has relation with the value of $z_0$ in the traditional method. So it needs high quality data of the wind profile in order to obtain rational (results of $z_0$ and $d$).

It is well known that the height $h$ of a plant or building is the main factor that determines the value of $d$. Now it is accepted that there is direct ratio relation between the zero–plane displacement length $d$ and the height of a plant $h$ (Kustas and Brutsaert, 1986).

In Gêrzê and Damxung, since the vegetation of the surface is very sparse and short, and the height of the plant is just the order of centimeter, the zero–plane displacement length $d$ is set to zero. In Qamdo, based on the height of grass during observational period, the zero–plane displacement length $d$ is set to zero in the beginning of the experiment and 0.1 m in the end according to $d/h = 2/3$.

### 3.2 *The aerodynamic surface roughness length* $z_0$

The aerodynamic roughness length only changes with the height and distribution of roughness elements in the land surface. It does not change with the wind speed, stability and stress usually over homogeneous underlying surface. There are many methods to determine the surface roughness length. The typical values of aerodynamic roughness length over different underlying surfaces have been obtained (Panofsky and Dutton, 1984; Stull, 1988).

As mentioned before, there were few data of the wind profile under near–neutral condition for making a direct fitting in three stations of the plateau. In order to obtain more observational information and more reliable results, some wind profile data under non–neutral condition were also utilized in this paper. The method used in this paper is as follow. Using the observational data of wind velocity profile and making an optimum fitting according to the logarithm wind profile under neutral condition, the apparent surface roughness length $z_{0p}$ of each run can be calculated. Although the data of $z_{0p}$ was scattered, $z_{0p}$ has systematic variation with the stability parameter $Ri$ or $Ri_B$. The value of $z_{0p}$ at $Ri$ (or $Ri_B$) = 0 on the optimum fitting line was the real aerodynamic surface roughness length $z_0$. The methods based on the wind speed profile and the turbulent data are utilized at the same time to determine the value of $z_0$, while the results obtained by each method can be compared and validated each other (Zhang and Chen, 1997).

Table 1 lists the mean aerodynamic surface roughness lengths $z_0$ that are calculated by the gradient method and turbulent method in Gêrzê, Damxung and Qamdo. We can find that the aerodynamic surface roughness lengths $z_0$ calculated by two methods agree well. That

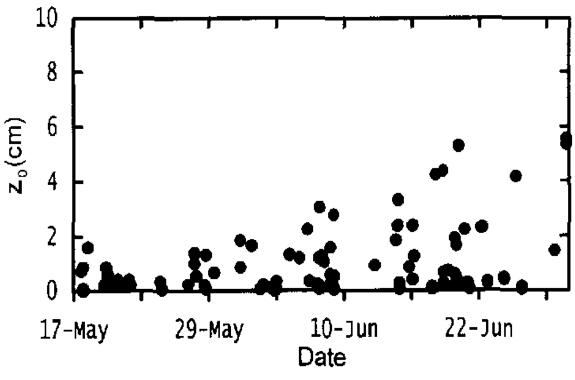


Fig. 7. The change of the aerodynamic surface roughness length with the data in Qamdo.

shows the observation data of wind profile and turbulent fluctuations are reliable. Because there is rarely change in underlying surface during the whole observational period in Gêrzê and Damxung, the surface roughness lengths in two stations can be thought to be constant. However, with the coming of rain season and increasing of precipitation in Qamdo, the vegetation around the station grows and the height of the plant gradually becomes tall. The aerodynamic surface roughness length in Qamdo has a slightly increased trend during the observation period (Fig. 7).

**Table 1.** The aerodynamic surface roughness length in Gêrzê, Damxung and Qamdo

| Observation station | $z_0$ (m) (wind profile) | $z_0$ (m) (turbulent data) |
|---|---|---|
| Gêrzê | 0.0026 | 0.0024 |
| Damxung | 0.0022 | 0.0020 |
| Qamdo | 0.014 | 0.014 |

## 4. Profile of wind velocity, temperature and humidity in the surface layer of the plateau

### 4.1 *The wind velocity profile in the surface layer of the plateau*

The changes of mean wind velocity profile are similar during the dry and moist periods in Gêrzê, Damxung and Qamdo. The mean wind speed increases with the height in the vertical direction, and the gradient of wind velocity decreases with the height. The profile of wind velocity fits the logarithm relation with the height almost. In Gêrzê, the maximum wind speed appeared in the nightfall during the dry period, while it appeared at night during the moist period. There is a inflexion at 5 m or so in the wind velocity profile at noon in Gêrzê (figure omitted).

In Damxung, the wind speed and gradient of wind velocity are large from afternoon to night. The diurnal variation range of wind speed is larger during the dry period than that during the moist period (figure omitted).

In Qamdo, the diurnal variation range of wind speed is also larger during the dry period than that during the moist period as in Damxung. There exists an inflexion point at about 8 m in the wind-velocity profile. That may have relation with the local terrain around the observation site in Qamdo.

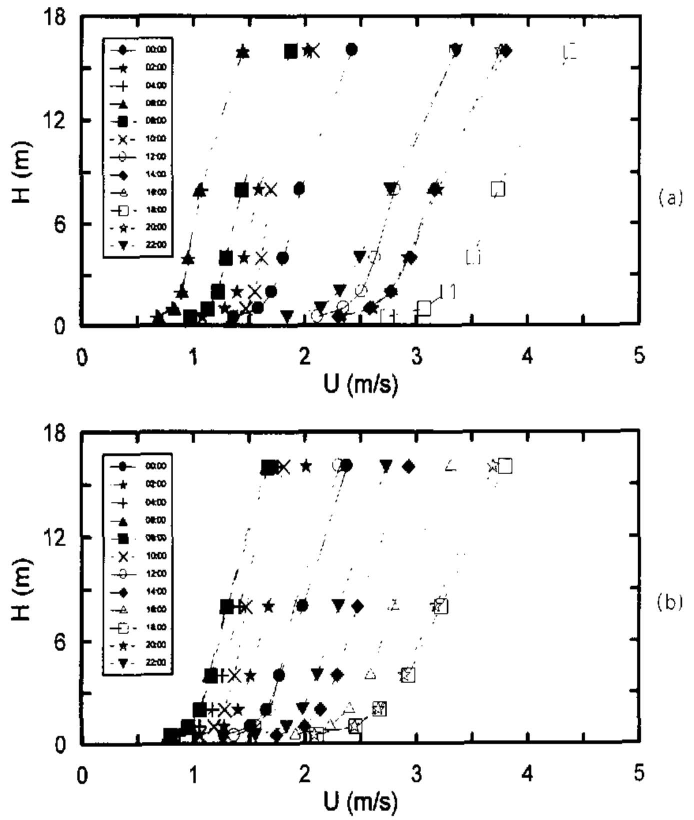


Fig. 8. The wind velocity profile in the surface layer in Qamdo. (a) During the dry period; (b) during the moist period.

### 4.2 *The temperature profile in the surface layer of the plateau*

Because the Bowen ratio system was used in Damxung, there were no measurement of the temperature and humidity profile in the surface layer. Here we just discussed the diurnal variations of the temperature and humidity profiles in the surface layer in Qamdo and Gêrzê. In Gêrzê, the temperature profile in the surface layer during the dry period was similar to that during the moist period. But the diurnal difference of the temperature between daytime and night during the dry period was larger than that during the moist period. At night, the temperature in the surface layer increased with the increase of height, and the temperature inversion occurred. In daytime, the temperature decreased with the increase of height, and the temperature was descending in the surface layer. At about 08:00 to 10:00 after sunrise, the temperature profile changed from increasing by degrees to descending with the height in the surface layer. At about 20:00 to 22:00 after sundown, the temperature profile changed from descending to increasing by degrees in the surface layer. In Gêrzê, the thermal condition in land surface during the dry period was close to that during the moist period. However, the lapse rate of temperature in daytime during the dry period was larger than that during the moist period. That was accorded with that the sensible heat flux during the dry period was larger than that during the moist period (Fig. 9).

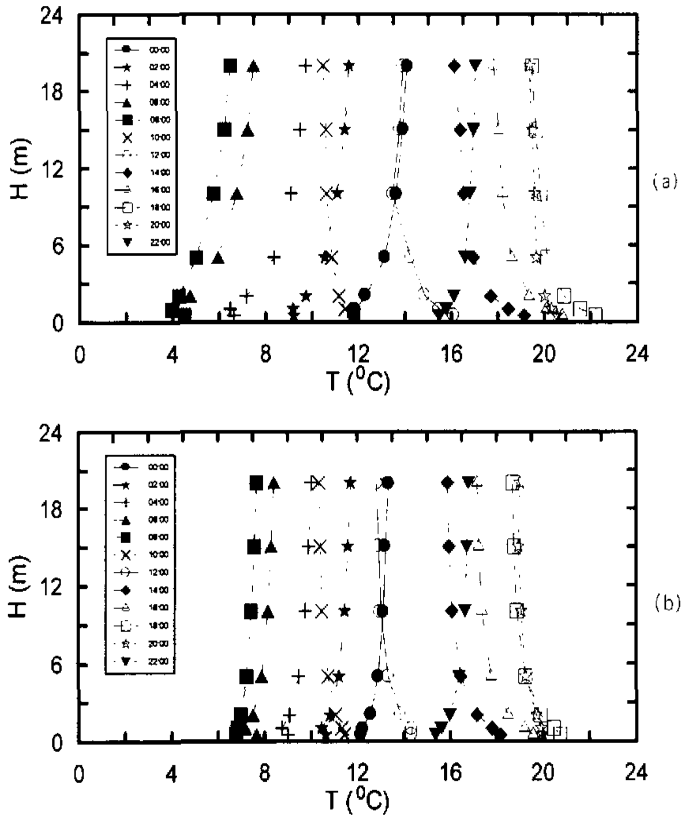


Fig. 9. The temperature profile in the surface layer in Gèrzè. (a) During the dry period; (b) during the moist period.

In Qamdo, the characteristics of temperature profile in the surface layer during dry period were similar to that during the moist period. At 08:00 after sunrise, the temperature profile in the surface layer changed from increasing by degrees to descending with height. At 20:00 after sundown, the temperature profile changed from descending to increasing by degrees. The lapse rate of temperature in the surface layer during the dry period was also larger than that during the moist period.

4.3 *The humidity profile in the surface layer of the plateau*

Figure 10 shows the mean humidity profiles in the surface layer during the dry and moist periods in Qamdo.

In Qamdo, the observational result during the dry period showed that the humidity in the layer near to the underlying surface decreased rapidly with the height and the humidity inversion occurred above 2 m. During the moist period, the humidity in the surface layer decreased rapidly with height from afternoon to midnight and a slight humidity inversion occurred above 8 m. The lapse rate of humidity in the surface layer during the dry period was less than that in the moist period. The variation of humidity profile in the surface layer was similar to that observed in the plain area, but the characteristic of vapor transfer in the surface layer was different with that in the desert and the oasis surface. The specific humidity in desert

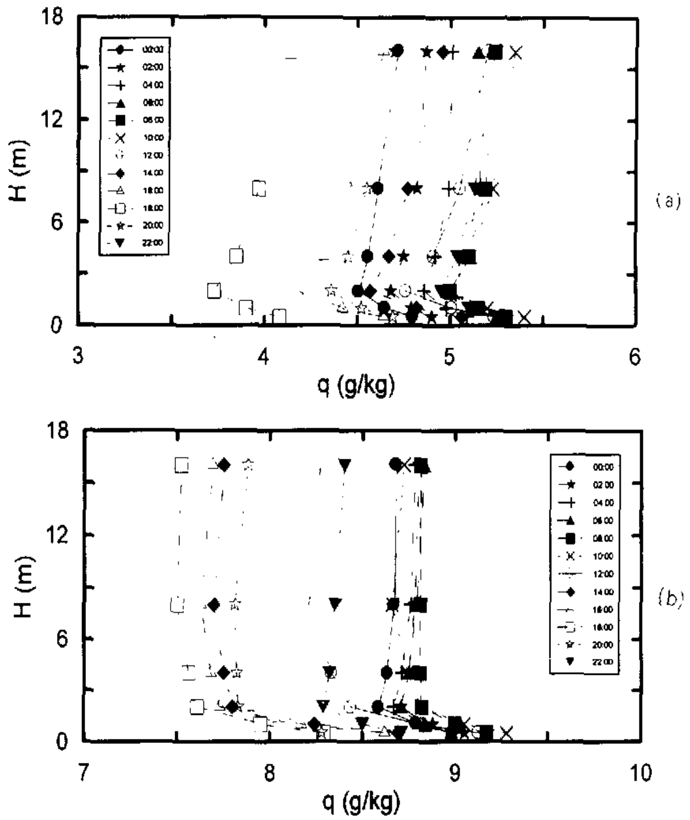


Fig. 10. The humidity profile in the surface layer in Qamdo. (a) During the dry period; (b) during the moist period.

does not change with height and the humidity in oasis often increases by degrees with height in the surface layer (Nai and Hu, 1994).

During the dry period in Gêrzê, the humidity in the surface layer deceased by degrees from 22:00 to 12:00 in next day. There was a humidity shear at about 5 m. The intensity of humidity shear increased by time and it disappeared after noon. The humidity inversion occurred above 10 m. During the moist period, the specific humidity had an obvious increase compared with that during the dry period. The humidity shear at 5 m still existed but the intensity decreased. The humidity inversion also occurred above 10 m (figure omitted).

## 5. Summary

The aerodynamic surface roughness lengths $z_0$ were obtained by utilizing the data about the variation of the meteorological elements in the surface layer during the observational period from May to July, 1998 in Gêrzê, Damxung and Qamdo. The characteristics of the diurnal variations of wind speed, temperature and humidity and its profile in the surface layer have been investigated. The phenomenon of humidity inversion occurred in the surface layer is discussed also. The main results obtained are as follows.

(1) The observational period of TIPEX can be divided into dry and moist periods. The rainfall and the rainy intensity gradually increase from west to east and the date when the moist period comes gradually advances. Compared with the rainfall of the corresponding time in 1979 in Lhasa and Nagqu, it can be found that the moist period in 1998 came later, and the value of daily highest rainfall amount and total rainfall amount during intensified observation period of TIPEX is almost comparative with that in 1979. The mean diurnal variations of temperature are obvious and have a good regulation during the dry and moist periods. The mean diurnal variation of wind speed is " one peak, one trough" pattern during the dry period. The diurnal variations of specific humidity in the surface layer in Damxung and Gêrzê have regulation during the moist period.

(2) The aerodynamic surface roughness lengths in Gêrzê, Damxung and Qamdo are 0.0026 m, 0.0022 m and 0.014 m respectively from the data of the wind velocity profile, which are accorded with that obtained from the turbulent data. During the observational period, the aerodynamic surface roughness lengths can be as a constant in Gêrzê and Qamdo. The aerodynamic surface roughness length $z_0$ in Qamdo has a slightly increased trend with the increase and growing of vegetation in underlying surface during the observation period.

(3) The profiles of wind velocity in the surface layer generally fit the logarithm rule with the height.

(4) In the surface layer of the plateau, the phenomenon of humidity inversion is observed not only in the middle west area which is staying in a dry state for a long time but also in the east area in Qamdo. But there are differences between the intensity, the appearing time and the appearing height of humidity inversion in the surface layer.

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## REFERENCES

Gao Jiabiao, Shen Juecheng et al., 1987: Analysis on the thermal state of Nanjing city. *Collection on the Qinghai-Xizang Meteorological Experiment (III)*, Sciences Press, Beijing, 40–48 (in Chinese).

Kustas, W. P., and W. Brutsaert, 1986: Wind profile constants in a neutral atmospheric boundary layer over complex terrain. *Bound.-Layer Meteor.*, **34**(1/2), 35–54.

Nai Kang, and Hu Yinqiao, 1994: The experiment in the surface layer in desert fit to the oasis. *Plateau Meteorology*, **13**(3), 282–290 (in Chinese).

Panofsky, H. A., and J. A. Dutton, 1984: *Atmospheric Turbulence*, A Wiley-Interscience Pub 397pp.

Pillai, J. S., Saxena Sangeeta, and K. G. Vernekar, 1998: Diurnal variations of meteorological parameters in the land surface interface. *Bound. Layer Meteor.*, **89**, 197–209.

Sahashi, K., O. Tsukamoto, Y. Mitsuta, and J. M. Wang, 1993: Peculiar daily course of the specific humidity and the air temperature over Zhangye field. *Proceedings of International Symposium on HEIFE*, Kyoto, Japan, April 8–12, 430–436.

Stull, R. B., 1988. *An Introduction to Boundary Layer Meteorology*. Kluwer Academic Publishers, U. S. A., 380pp.

Wang Yongsheng et al., 1987: *The Atmospheric Physics*, China Meteorological Press, Beijing.

Zhang Hongsheng, and Chen Jiayi, 1997: The determine of the aerodynamic parameters over non-homogeneous underlying surface. *Quarterly Journal of Applied Meteorology*, **8**(3), 310–315 (in Chinese).

Zhang Jijia, Zhu Baozhen, and Zhu Fukang, 1988: *Advances in the Qinghai-Xizang Plateau Meteorology*, Sciences Press, Beijing, 268pp (in Chinese).

Zhou Mingyu, and Coauthors, 2000: *Observational Analysis and Dynamic Study of Atmospheric Boundary Layer on Tibetan Plateau*, China Meteorological Press, Beijing, 125pp (in Chinese).

# 青藏高原近地面层微气象学特征

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**摘 要**

利用 1998 年 5 月—7 月在改则、当雄和昌都三测站获得的近地面层气象要素变化的观测资料，分析了青藏高原近地面层风速、温度和湿度日变化特征及廓线规律，发现高原近地面层微气象学特征具有其自己的特点；同时还讨论了高原近地面层白天出现的逆湿现象。

**关键词**: 气象要素日变化，廓线，青藏高原