NOTES AND CORRESPONDENCE

Comments on “The Importance of the Correction of Precipitation Measurements on the Tibetan Plateau” by

K. Ueno and T. Ohata (J. Meteor. Soc. Japan, Vol. 74, No. 2, pp 211–220)

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Abstract

Ueno and Ohata (1996) pointed out the importance of the correction of precipitation measurements on the Tibetan Plateau. The present author offers some comments to evaluate more quantitatively their results, which are summarized as follows: (1) the validity of the correction of precipitation should be checked for the individual cases, along with the total amount; (2) the diameter of the gauge should be investigated for any systematic bias of the measured precipitation; (3) the increment obtained through the correction procedure should be quantitatively compared with the standard error of the corresponding regression analysis; and (4) the effect of the correction should be looked at from various viewpoints, *e.g.*, quantitative comparisons of the corrected precipitation with precipitation estimates from space, as well as with the surface energy budget on the Tibetan Plateau.

1. Introduction

Ueno and Ohata (1996, hereafter referred to as UO96) carried out detailed investigations into the underestimation of the *in situ* precipitation in the Tanggula basin (33°N, 92°E), situated nearly in the center of the Tibetan Plateau. The correction procedure was based on the application of some empirical formulae developed in Germany and Russia, mainly with the use of meteorological data obtained through the CREQ (Cryosphere Research on Qingzang Plateau) project in 1993 (Ageta *et al.*, 1994). Several points that follow, however, are lacking quantitative discussion of the obtained results. The present author hopes that these comments will increase our understanding of the hydrological cycle of the Tibetan Plateau, and clarify the role of the Plateau in the variation of the Asian monsoon.

2. Concrete comments

2.1 Interpretation of Table 1

In Table 1 of UO96 (p.212), seven cases of measured precipitation (MP) from 13 May to 12 June, 1989 were converted to corrected precipitation (CP) by applying the formula of Lapin (1989), which incorporates the important effect of wind on the precipitation measurements. The correction was conducted when nocturnal snowfall greater than 3 mm/12 h was observed from 2000 to 0800 Beijing standard time. After correction, CP was compared with the water equivalent of new snow (WS).

When the totals of CP and WS are compared directly, they show similar values of 75.9 mm and 72.6 mm, respectively. Since WS is considered to be the more correct value, this comparison demonstrates the importance of the correction of MP as mentioned in UO96 (the right column of p.212). Detailed inspection of Table 1, however, shows that the correction is not always effective.

Among the seven measurements and corrections listed in Table 1, the majority (data of 27 May, and 5, 6, and 12 June) show the following characteristic:

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$$|MP - WS| < |CP - WS|. \quad (1)$$

This inequality means that the value of CP in these days is more different from WS than MP is. This feature, in turn, shows that an individual correction procedure is not always effective. Moreover, systematic features are not found among MP, CP, and WS in Table 1. That is, WS is not always larger than MP.

From Table 1, the effect of Lapin's correction is apparently found on 13 and 26 May. The synoptic feature, the type of precipitation, and its diurnal cycle on these days should be made clear. Also, these characteristics should be compared with those of the other days listed in Table 1.

Since the totals of MP, CP, and WS are their accumulations of each measurement and correction, the effect of the correction of MP should not be judged by a direct comparison between the totals of CP and WS alone. As stated in UO96, the disregard of the types of gauge or precipitation by the correction formula may be responsible for the characteristic shown by Eq. (1). Concerning this problem, it is necessary to carry out further investigation.

2.2 Systematic bias caused by the orifice area of the gauge

In UO96, one of the reasons for the systematic underestimation of the measured precipitation is attributed to the difference in the orifice area of the gauge (item 4 in the right column of p.213). According to Kawabata (1961), any type of raingauge is practical if the diameter of the orifice is larger than 10 cm.

As an interpretation of the equation, $TRETX = 0.83 \times TIP + 0.56$, which appeared in the right column of p.213, it is concluded that the gradient 0.83 is derived from the undercatch of precipitation by the TRET due to a smaller area of the orifice. Here, TRET, TIP, TRETX are the acronyms of the Tretyakov precipitation gauge, precipitation measured by a tipping bucket type gauge, and the corrected precipitation of the TRET incorporating the evaporation loss, respectively. In order to make the orifice-difference conclusion, the structure of the TRET, including its diameter, should be specified in Section 2 (Observation, p.213). Then, after citing Kawabata (1961), it should be clearly noted that the diameter of the TRET is smaller than 10 cm.

2.3 Standard error of each regression analysis of Table 3

On the bottom line of Table 3 of UO96 (p.215), the mean increase rates of each correction step are listed as numbers. These steps are: (1) $TIP \Rightarrow TRETX$, (2) $TRETX \Rightarrow DFIR$, and (3) $DFIR \Rightarrow BUSH$, and all steps are based on a regression analysis. Here, DFIR and BUSH are the abbreviations for a double fence intercomparison reference with a

Russian Tretyakov manual gauge and a bush gauge, respectively. In the regression analysis, the obtained increment (corrected value minus measured value) must be compared with the corresponding standard error, in order to evaluate the effect of the correction quantitatively.

A standard error is inevitable in the regression analysis. When the obtained increment is smaller than the corresponding standard error, it is useless to make a quantitative discussion of the effect of the correction. As for step 2, the description of the standard error should be carefully examined in the original article (WMO-CIMO, 1992).

Step 3 is classified into four categories according to the type of precipitation, *i.e.*, dry snow, rain with snow, snow with rain, and rain. It is found that each coefficient of determination (R^2 of UO96), however, is fairly low (the maximum of R^2 is 0.38, see the left column of p.212). This fact implies that the standard error is large for whichever equation is applied to the correction. The present author is concerned about the quantitative significance of this correction procedure.

In any case, precise evaluation of possible errors is necessary for a quantitative discussion of the obtained results.

2.4 Contents of section 5 (Discussions)

The characteristics of precipitation in the Tanggula basin are worthy of discussion. Nonetheless, the present author would have asked UO96 to mention the following items in Section 5 (Discussions, p.216 ~):

1. The quantitative assessment of the relationship between the corrected precipitation and the standard error of the regression analyses,
2. The quantitative assessment of the relationship between the corrected precipitation and precipitation estimates from space,
3. The quantitative assessment of the relationship between the surface energy budget and the corrected precipitation, *i.e.*, the effect of the correction on the increase in the latent heat flux on the ground.

Since item 1 was already mentioned, it is not repeated here.

As for item 2, the increments of precipitation from TIP to BUSH are derived from Table 3 of UO96. They vary from 59.2 mm (D100, the precipitation station at 4,800 m a.s.l.) to 107.5 mm (TS, the precipitation station at 5,206 m a.s.l.) during the period from 23 May to 28 July, 1993. Since "mm/month" nearly equals " W/m^2 ", the corrected precipitation corresponds to an increase in the latent heat flux of $30 \sim 50 W/m^2$. The present author

thinks that such a large difference can be detected by outgoing longwave radiation (OLR), as Gadgil *et al.*, (1992) tried to estimate continental-scale precipitation from space. This method is expected to prove the effect of the correction of UO96.

It is very important to look at the same phenomenon from various other viewpoints. In another paper published recently (Ueno, 1997), Ueno discussed the distribution of satellite-measured precipitation on the Tibetan Plateau; however, the relationship to the corrected precipitation was not mentioned. This comparison should be made in the near future.

Concerning item 3, the effect of the correction should be compared with the results of Endo and Yasunari (1996), who investigated the surface energy budget of the Tanggula basin from May to September, 1993. This is because the energy budget is closely connected with the water budget through evapotranspiration. Endo and Yasunari (1996) made clear that sensible heat flux dominates in the pre-monsoon season, while latent heat flux dominates after the onset of the monsoon. If the increment of the corrected precipitation directly corresponds to the greater evapotranspiration as was concluded in UO96, the characteristics of the surface energy budget of the Tanggula basin, depicted by Endo and Yasunari (1996), should be re-examined carefully. Indeed, the increase rate of precipitation is especially large (more than 150 %) in the pre-monsoon season as displayed in Fig. 1 of UO96. If this is true, Endo and Yasunari (1996) will come to the different conclusion that latent heat flux does not show a significant difference before and after the onset of the monsoon. This characteristic is derived from a visual inspection of the extra latent heat flux of the $30 \sim 50 \text{ W/m}^2$ in Fig. 2 of Endo and Yasunari (1996). Conversely, the observed latent heat flux can be utilized to check the validity of the correction of precipitation. This emphasizes the importance of looking at the same phenomenon from various points of view.

3. Toward a further understanding of the hydrological cycle of the Tibetan Plateau

The present author is also interested in the applicability of the empirical formulae developed in Germany and Russia for the correction of precipitation in the Tibetan Plateau. So far, the installation of DFIR and the intercomparison of various types of precipitation gauges are planned by GAME/Tibet

(GEWEX Asian Monsoon Experiment, Global Energy and Water Cycle Experiment, Koike, 1995). A re-examination of this applicability is one of the scientific objectives of this ongoing project.

The present author fully agrees with the conclusion presented in UO96, which emphasized the importance of the correction of precipitation and its effect on the increase of recycling water between the atmosphere and land surface on the Tibetan Plateau. Without a discussion from the viewpoint of the large-scale circulation, however, previous studies such as UO96 would be limited to the hydrological cycle on the Tibetan Plateau. The present author asks participants of GAME/Tibet to clarify not only the hydrological cycle within the Plateau, but also to the role of the Tibetan Plateau in the variation of the Asian monsoon.

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上野健一・大畑哲夫「チベット高原における降水量補正の重要性について」
(気象集誌 74 巻 2 号, pp 211–220) に関するコメント

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