RESULTS OF SOLID PRECIPITATION MEASUREMENT INTERCOMPARISON IN THE ALPINE AREA OF ÜRÜMQI RIVER BASIN

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I. INTRODUCTION

Many studies have shown that precipitation gages offer lower precipitation to some extent, that is, the measured precipitation (P_m) is lower than the true one (P_t), because of the systematic errors caused by the deformation of the wind field over gages' orifices[1] (wind effect, ΔP_a), the adhesion of rain drops and snow-melted water to the inner walls of the gages (wetting loss, ΔP_w) and the evaporation of the rain water from the containers of the gages (evaporation loss, ΔP_e), i.e.

$$P_t = P_m + \Delta P_a + \Delta P_w + \Delta P_e. \tag{1}$$

Among the errors mentioned above wind effect is the largest, and it can reach 50 — 100% in snowfall measurement. The wetting and evaporation losses generally do not exceed 10% and 4%[2]. In order to correct the errors and develop new method of measuring snowfall, mainly the automatic instruments, WMO/CIMO initiated a programme of the Solid Precipitation Measurement Intercomparison in 1986. An octagonal vertical double fence surrounding a USSR Tretyakov precipitation gage was designated as the reference for the intercomparison. A detailed instruction for the construction of the Double Fence Intercomparison Reference (DFIR) and the method of data collection and analysis were outlined[3]. The importance of the accuracy of precipitation measurement and the systematic error correction have been widely recognized in recent years in China[4—6]. In this note the accuracy of precipitation measurement with Chinese standard precipitation gage in alpine area has been studied according to WMO intercomparison of soild precipitation measurements.

II. METHOD AND INSTRUMENTS

The wind effect on precipitation measurement can be defined by means of the intercomparison with different types of precipitation gages placed at the observing site so as to establish the correlation among the wind caused error and the wind speed, type and rate of precipitation. The Ürümqi river basin is far from the ocean; the climate of its alpine area, ranging from 3400 to 4500 m a.s.l., is relatively wet with the annual precipitation measured around 450 mm according to the records of the runoff station (43.06°N, 87.15°E; 3693 m a.s.l.) in front of glacier No. 1, of which 80% is concentrated in the period of May to August. Because of the high altitude and low air temperature in the research area, 43% and 35% of the summer precipitation occur in the types of wet snow and sleet respectively. Therefore measuring precipitation in this area mostly deals with snow problem, and wind effect on snowfall measurement must be considered completely. In July of 1987 an intercomparison site, surrounded by hills in both the south and the north and glacier No. 1 in the west, was situated at the flat bottom (3720 m a.s.l.) of the river valley. The instruments involved were as follows:

a) Golubev Double Snow Fence (GDSF). It is an octagonal vertical fence of 50% exposure. The top of the outer fence of 12 m in diameter should be 3.5 m above the ground and the inner fence of 4 m in diameter should be 3.0 m high in which a Tretyakov shielded USSR precipitation gage is placed with its orifice at the same elevation as the top of the inner fence according to WMO (1985). Because the maximum snow depth is less than 1 m in winter in the research area, a double fence shield has been set up with the top of the inner and the outer fence at 2.0 m and 2.5 m respectively in order to save material. The other modification was made by using a Chinese standard precipitation gage instead of the Tretyakov gage in the fence because of the small difference between their receiving areas and the same method of measurement so as to get a reference gage for the intercomparison (Fig. 1).

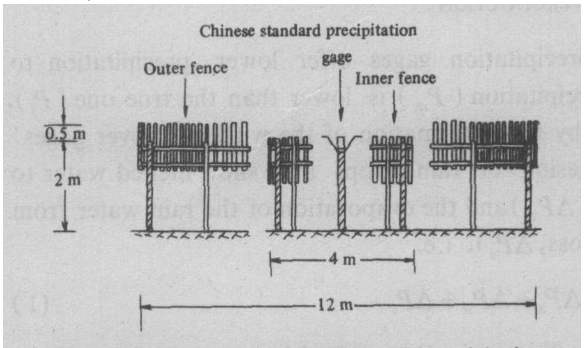

Fig. 1. Reference gage for the WMO solid precipitation measurement intercomparison.

b) Hellmann gage. It is the Swiss standard precipitation gage with receiving area of 200 cm^2, i.e. 16 cm orifice in diameter. One Hellmann gage without shield has been placed at 2.0 m above the ground, and the measurements have been made manually.

c) Chinese standard precipitation gage (CSPG). It is a cylinder of galvanized iron, 65 cm long and 20 cm in diameter. For solid precipitation measurement the gage is unshielded and its funnel and glass bottle are removed. The standard elevation of the gage's orifice is 0.7 m. Two CSPGs have been mounted 0.7 m and 2.0 m above the ground for the intercomparison.

d) A Screen. Air temperature and relative humidity were recorded automatically 24 h a day.

III. Results

In the period of late June of 1987 to July of 1989, 176 daily precipitation data were collected in the types of rain, sleet, wet snow and dry snow. The wetting losses of an unshielded CSPG without funnel and glass container range from 0.35, 0.30 to 0.29 mm in each rainfall, sleet and snow measurement, and it decreases to 0.23 mm in every rainfall measurement for the CSPG with the funnel and glass bottle[4]. Compared with Canadian Nipher gage, USSR Tretyakov gage[7] and Hellmann gage[8], the wetting loss of the CSPG is larger, especially for solid precipitation measurement. All the CSPGs used in the intercomparison were free of the funnel and glass bottle. Correcting the wetting loss by the product of the average wetting loss (mm/event) and the wetted event in consideration of different types of precipitation, we get the summary of the intercomparison as shown in Table 1.

Table 1
Summary of the Intercomparison

Type of Precipitation	Event (day)	GDSF Total (mm)	CSPG (2 m)/GDSF (%)	CSPG (0.7 m)/GDSF (%)
Rain (May-Sept.)	24	133.6	90.0	96.4
Sleet (May-Sept.)	40	305.5	84.2	87.6
Wet snow (May-sept.)	88	566.7	82.6	84.8
Dry snow (Oct.-Apr.)	24	102.5	76.7	78.8
Mixture	176	1108.3	83.2	86.2

Obviously the following conclusions can be drawn.

1. The measurements of the GDSF always keep the highest in measurement of all types of precipitation, while the partner of the GDSF without shield at the same elevation (2.0 m) catches the least precipitation and the CSPG at 0.7 m gets the value measured in between the GDSF and its partner. The difference indicates that the shielding effect of the double fence and the Tretyakov wind shield and the wind speed decrease towards ground as well.

2. The ratio (%) of the measurements of a gage to GDSF changes significantly with the type of precipitation, i. e. with the big and small ratios in rain and dry snow measurements respectively and the middle one for wet snow and sleet.

3. The average catch ratio of the CSPG at 0.7 m for different types of precipitation is 86.2%, which is much higher than those of the Hellmann gage, Tretyakov gage and Metra gage[9], because the maximum daily wind speed in rainfall or snowfall days never exceeds 6 m/s and 88% of the yearly total precipitation takes place in the condition of daily wind speed below 3 m/s according to the climatic data of Daxigou Meteorological Station (43.06 °N, 86.50 °E; 3540 m a.s.l.) on the open site in the head area of the river basin.

The cases of the intercomparison in heavy storms also show the strong dependence of the catch ratio on the type of precipitation. For the rainfall case on June 6, 1987, the measurements of the gages were very close to each other in spite of the middle wind speed. While in the snow cases, very slight wind leads to a big difference among the measurements, especially for the dry snow case (Fig. 2).

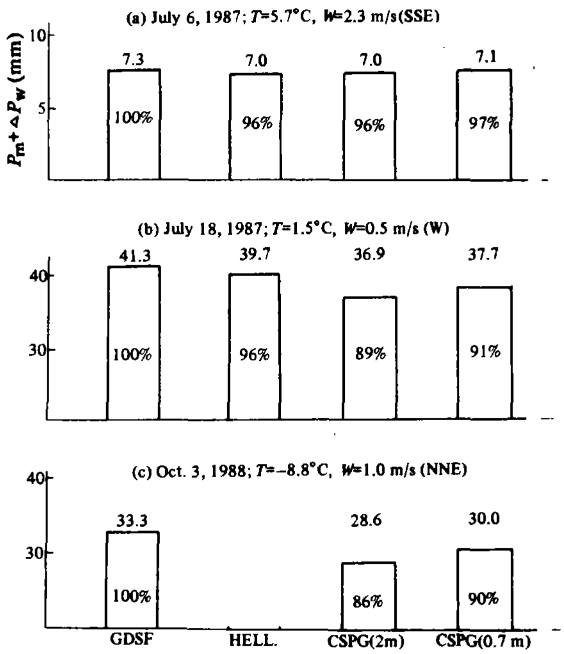

Fig. 2. Cases of the intercomparison.
(a) Rain ; (b) wet snow; (c) dry snow.

Continuous wind speed measurement was not possible because of the power and instrument problems at the intercomparison site. Analysis of the intercomparison data of precipitation measurement at Daxigou Meteorological Station in 1986, where the wind speed at 10 m height was recorded 24 h a day automatically, indicated the relationship between the catch ratio or catch efficiency (R) of the CSPG to the ground level gage and the averaged wind speed (W) during storm as follows:

$$R=\begin{cases}\exp(-0.056\,W), & (0\leqslant W\leqslant 6.2),\quad \text{snow},\\ \exp(-0.041\,W), & (0\leqslant W\leqslant 7.3),\quad \text{rain}.\end{cases} \qquad (2)$$

When $W=5.0$ m/s, R of the CSPG ranged from 75.6% for snowfall measurement to 81.5% for rainfall measurement.

IV. Summary

It is absolutely important to know the accuracy of the measurements of the GDSF in various climatic and topographic conditions because this instrument has been designated as the reference for the intercomparison and its low catch efficiency or overestimation certainly has a considerable effect on accurately assessing the value of new measuring method, the catch efficiency of all the gages involved in the intercomparison and on the reliability of wind effect correction as well. Gunther[9] stated that the double fence reduced the wind speed at the gage orifice by 65 — 75% when the wind speed out of the fence reached 5.0 m/s and on the average of 2300 events of wind speed measurements, it reduced the wind speed by 60%. This does not mean that gage within the fence could catch the true snowfall. In fact it is a question if the fence makes turbulence over gage orifice. Golubev[10] had found out a method for correcting the GDSF for wind speed according to the snow depth measurements in the forest area. Goodison[7] applied it to Canadian intercomparison data and improved the correlation between the catch efficiency and wind speed. We will use snow board and measure new snow depth and its density on the ground around the GDSF so as to define the accuracy of the instrument in the high alpine area.

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