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Interactive comment on "Precipitation measurement intercomparison in the Qilian Mountains, Northeastern Tibetan Plateau" *by* R. Chen et al.

Anonymous Referee #3

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1. General comments

The discussion paper 'Precipitation measurement intercomparison in the Qilian Mountains, Northeastern Tibetan Plateau,' by R. Chen et al., presents analysis of manual precipitation measurements using a Chinese standard precipitation gauge (CSPG) in various configurations. The analysis covers four years of measurements using the CSPG in unshielded, single-Alter shield, and pit configurations. Measurements during the last two years were also obtained using a CSPG in a Double-Fence Intercomparison Reference (DFIR) shield, which is the World Meteorological Organization (WMO) recommended reference configuration for snowfall measurements.

Scatter plots comparing measurements from different configurations indicated that the pit and DFIR configurations performed comparably for mixed and solid precipitation, suggesting that the pit configuration could be a viable option for a reference configuration for these precipitation types in similar environments. The pit configuration is a lower-cost option than the DFIR, so this is an important result for operational networks in regions with limited annual snow cover and blowing snow.

Additional plots investigated the influence of wind speed on the catch ratios of precipitation measured by a given configuration to that measured by a reference configuration for events in different precipitation regimes (liquid, mixed, solid). Linear fits to these plots were used to develop equations that could be used to 'adjust' measurements in non-reference configurations for the influence of wind. While these plots certainly provide insight into the catch ratio-wind speed relationships for different configurations and precipitation types, the small number of events and apparent poor fit quality do not impart a high degree of confidence in the use of the resulting equations for adjusting precipitation observations.

Overall, the authors make good use of tables and figures to convey results and analysis that can be a bit cumbersome to follow in the text. The background information and discussion are presented well, but the paper would benefit from some additional description of methods (as discussed further in the Specific Comments, below). The applicability of the findings to operational networks, albeit to a limited number of stations with specific conditions, is the main strength of this paper, and warrants publication for broader distribution and implementation. The broader applicability of the adjustment equations, however, is questionable, and careful consideration should be given to how these are presented in the manuscript.

2. Specific comments

a. Abstract and Introduction

As identified by Reviewer 1, this study focusses on the analysis of the same precipi-

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tation gauge in different configurations, rather than different 'precipitation gauges,' as indicated in the text. The wording and gauge configuration nomenclature proposed by Reviewer 1 should be implemented to help address this issue throughout the paper.

When stating catch ratios in the abstract, it is important to note which configuration is being used as the reference (i.e. the denominator when computing catch ratios).

b. Data and methods

When taking the manual observations, are any additional measures taken if there is frost on the collector, or if there is solid precipitation accumulated on the rim of the collector?

Is the precipitation measured by the DFIR configuration used to calculate the adjusted accumulation in Equation (1) when the Pit gauge is used as the reference?

What is the frequency of each type of observation (precipitation, wind speed, temperature)? This is important in terms of how representative the conditions are for each measurement.

c. Results

As indicated by Reviewer 2, the details of phase discrimination are critical, and must be included in the manuscript.

With the method of phase discrimination used, how representative is the phase for each measurement? How can you be sure, for example, that a certain event was only snow, and not some combination of snow with mixed precipitation, ice pellets, etc.?

In Section 3.1, why is the reference changed for the 2012-2014 rainfall observations? Would it not make more sense to use the same reference (pit) for all rainfall events?

On P. 2208, lines 5-6, you note that 'comparative studies indicate that the Pit gauge CR is superior to that of the DFIR or the other gauges (Fig. 2)'. How is this clear from Fig. 2? I see a near 1:1 relationship between the Pit and DFIR configurations, and no

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comparison plots are shown for the CSPG and Alter relative to the DFIR.

Given the potential for spatial variability in falling precipitation, are the differences among the different configurations significant in rain? Is the Pit configuration really 'superior' if the maximum difference is less than 5%? What is the estimated uncertainty for the manual observations?

In Section 3.2, the Pit configuration catches about 2.5% more mixed precipitation than DFIR – is this significant?

d. Catch ratio vs. wind speed (Section 3.4)

When fitting the data, were any other curve types tried (besides linear)? The R2 values throughout suggest poor fit quality. These poor fits could result, at least in part, from the lower threshold accumulation for precipitation events (1 mm) relative to previous studies (3 mm).

I recommend referring to the application of the equations as 'adjustments' rather than 'calibrations.'

Given the limited number of points and poor fit quality, would you recommend using these equations for adjusting precipitation measurements from a CSPG in unshielded or single-Alter configurations? I think that these results can be presented with the objective of illustrating general trends, but I question the applicability of the resulting adjustment equations, and whether they should be presented with this purpose in mind.

There is so much scatter in Fig. 8a that I don't think you can say that the 'Pit/DFIR CR is approximately 1' (P. 2210, lines 16-18). This statement is based on a linear fit with a very low R2 value.

Also for Fig. 8a – given the scatter observed, one cannot really state with confidence that 'wind speed has little effect' (P. 2210, line 17).

For Fig. 8c, the magnitude of the slope is larger than for Alter/DFIR CR in Fig. 8b, yet

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it is stated that ‘wind speed has no significant effect on Pit/DFIR CR’ (P. 2211, line 10). The scatter in values from about 0.8 to 1.2 should also be noted.

3. Proposed technical corrections

P. 2203, line 3: add comma after ‘sytematic errors’

P. 2203, line 5: change ‘It would affect’ to ‘These errors affect’

P. 2203, line 8: change ‘an UK’ to a ‘UK’

P.2203, line 15: change ‘Reference (DFIR) with a shielded Tretyakov gauge’ to ‘Reference (DFIR) shield with a manual Tretyakov gauge’

P.2203, line 16: change ‘standard snow gauges’ to ‘standard snow gauge configuration’

P.2203, lines 19-20: ‘Considering the automation of precipitation measurements’ – this statement is unclear; please elaborate.

P.2203, lines 24-25: The WMO-SPICE project employs several different reference configurations, not just automatic gauges in the DFIR shield (see, for example, the report from the second session of the SPICE-IOC: http://www.wmo.int/pages/prog/www/IMOP/reports/2012/IOC-SPICE-2.pdf).

P. 2204, line 5: change ‘precipitation is concentrated in warm season’ to ‘precipitation occurs most frequently during the warm season’

P. 2204, line 3: change to ‘The DFIR shield has been operated as part of reference configurations at 25 stations. . .’ and please apply this type of terminology throughout

P. 2204, line 6: change to ‘in the valley site’

P. 2204, line 9: change to ‘at the open Daxigou Meteorological Station’

P. 2204, line 12: change to ‘for the CSPG’

P. 2204, lines 13-14: change ‘neighborhood’ to ‘neighboring’

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P. 2204, line 14: change to ‘accurate precipitation data are urgently needed’

P. 2204, line 15: change to ‘conducted in or reported from’

P. 2204, line 16: change ‘around regions’ to ‘surrounding regions’

P. 2204, line 16: change ‘here it presents four-years gauge intercomparison experiment’ to ‘we present a four-year Intercomparison experiment’

P. 2204, line 23: change to ‘Alter shield (Alter) was selected as another Intercomparison configuration for the present study’

P. 2204, line 28: change to ‘rarely exceed 10 cm in most parts of China’

P. 2205, line 1: Pit and DFIR catch ratios relative to which reference?

P. 2205, line 3: add comma after ‘wind speeds’

P. 2205, lines 7-8: change to ‘mountains, on the northeastern edge of the Tibet plateau’

P. 2205, line 10: change to ‘and is concentrated during the warm season’

P. 2205, line 20: change ‘Alter shelter’ to ‘Alter shield;’ apply this change throughout the manuscript

P. 2205, line 22: change to ‘a Double Fence Intercomparison Reference shield with a Tretyakov-shielded CSPG’

P. 2205, line 24: add comma after ‘precipitation events’, and add ‘the’ between ‘in’ and ‘warm season’

P. 2206, line 2: add comma after ‘warm season’

P. 2206, line 7: change to ‘is the wetting loss’ and ‘is the evaporation loss’

P. 2206, line 10: remove ‘and’ preceding ‘0.30 mm’

P. 2206, line 12: change to ‘value smaller than the other losses’

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P. 2206, line 17: change to ‘number of trace observations per day’

P. 2206, line 18: change to ‘The most important factor’

P. 2207, line 10: change to ‘This field experiment focusses on two key aspects.’

P. 2207, lines 10-11: change ‘observations comparisons’ to ‘observation comparisons’

P. 2207, line 17: change to ‘a total of 578 precipitation observations were recorded’

P. 2207, lines 18-19: change ‘happened’ to ‘occurred’ each time

P. 2207, line 25: change to ‘was selected as the reference configuration for rainfall events, and 479 events’

Fig. 2: text indicates these data are from Sept. 2012 to Sept. 2014, while caption indicates Sept. 2010 to Sept. 2014. Which data are plotted here?

P. 2208, line 12: change ‘liner’ to ‘linear’

P. 2208, line 14: change ‘means’ to ‘suggests that’; the latter is more appropriate, given the limited dataset

P. 2208, line 15: change to ‘Figures 4a and 4b compare 32 mixed’

P. 2208, lines 16-17: consider changing to ‘from which it is evident that the mixed. . .’

P. 2208, line 18: change to ‘. . .to 2 mm, with minimal scatter and no apparent outliers.’

P. 2208, line 22: change to ‘gauge for mixed precipitation’

P. 2208, line 24: change to ‘a total of 26 field observations’

P. 2209, line 4: change to ‘close linear relationships are observed between’

P. 2209, line 5: change to ‘From Fig. 5c, there is a linear correlation between’

P. 2209, line 16: change ‘This means that’ to ‘This suggests that’

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P. 2212, lines 2-3: change to '. . .and the ratios of Pit/CSPG for snowfall and mixed precipitation were 1.199 and 1.078, respectively'

Interactive comment on The Cryosphere Discuss., 9, 2201, 2015.