WMO Solid Precipitation Intercomparison Experiment(SPICE)
: Overview and results of Gochang site

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ABSTRACT

The Korea Meteorological Administration (KMA), for the purpose of standardizing observation methods and technologies, has been operating three standard observatories (Chupungnyeong, Gochang, and Boseong) since 2010. To support Chupungnyeong's mission as a CIMO Lead Center for evaluation of precipitation, Gochang has participated in WMO SPICE (Solid Precipitation Intercomparison Experiment) program since the winter of 2013. Through technical exchange and cooperation, Gochang is expected to contribute to improve the accuracy of the measurement of solid precipitation during the winter season, and to compare and analyze the performance of observation devices measuring snow depth and snowfall. This experiment aims to establish the most effective snowfall observation system by defining field reference system of solid precipitation observation and evaluating the performance and accuracy of various snowfall and snow depth sensors.

This research quantified errors of snowfall/snow depth observation equipments using the data observed in Gochang site during the winter from 2012 to 2013 and produced errors in observing snowfall according to the observation environment by comparing them with that of the snowfall observation reference system, and then evaluated the accuracy of snowfall observation during that period.

1. Introduction

Snowfall is influenced not only by wind, but also by its particle shape, size and density which are varied depending on space and time. Thus, it is difficult to accurately measure snowfall using the existing rain gauges, such as tripping bucket type. (Nitu, 2013) Recently, with a growing need for accurate snowfall observation, the Solid Precipitation Intercomparison Experiment (SPICE) is underway led by World Meteorological Organization. The purpose of SPICE is to establish the most effective snowfall observation system by defining automatic field reference system of solid precipitation through the experiment and evaluating the accuracy of various automatic snowfall/snow depth measuring systems. (WMO, 2012) To participate SPICE, the KMA also has established observation facilities including two DFIRs in Gochang. The site is located at 35.34 N, 127.36 E, 52 m above mean sea level with agricultural surroundings in Jeollabuk-do, Republic of Korea. It is also one of the operational observation site of KMA. Gochang's climate is characterized by the heavy snow caused by the cold surge over the Yellow Sea during winter time. Therefore, several kinds of automatic snow depth and precipitation measuring instruments are installed at the experiment field of Gochang and it has started to observe solid precipitation since 2012 and formally participated in SPICE since 2013. In addition, the KMA rearranged Gochang site layout

including equipment configurations according to the recommendation and the protocols suggested by WMO SPICE Project Team.
This research quantified errors of snowfall/snow depth observation using the data observed in Gochang station from 2012 to 2013 and produced errors in observing snowfall by comparing them with that the snowfall observation reference system, and then evaluated the accuracy of snowfall observation.

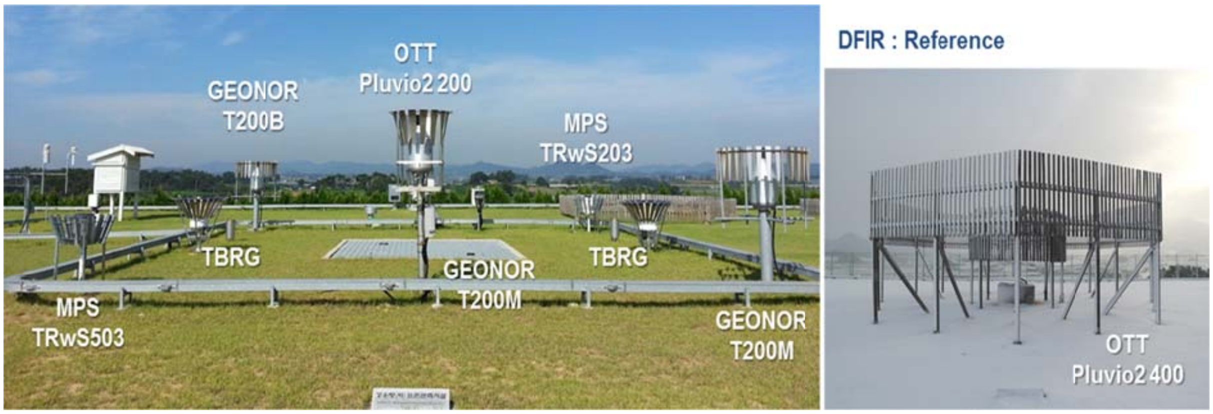


Fig. 1. The site configuration

2. Site configuration and Data

2.1. Data

For the comparison of snowfall amounts, we set up 2 sets of Geonor weighing-recording gauge with Alter-type wind shield, 1 set of Geonor with PIT gauge, 1 set of Pluvio with DFIR(Double Fence Intercomparison Reference), 1 set of Pluvio with Tretyakov-type wind shield, 2 TRwS, and 2 sets of Tipping bucket rain gauge(Table 1). Measurements have been done for Dec. 1 2012 ~ Feb. 28 2013. Here, reference system is Pluvio weighing gauge with DFIR. Events of daily precipitation more than 3.0 mm and snow depth with positive quantity of reference snowfall measurement system are selected for comparison analysis.

Table 1. Specifications of the Rain Gauges

Rain Gauges	GEO	GEO	OTT	OTT	MPS	TBRG
Wind Shield	Alter	PIT	Tretyakov	DFIR	Tretyakovr	-
Collecting Surface (cm^2)	200	200	200	400	200	314
	200				500	314
Bucket Capacity (mm)	600	1000	1500	750	750	-
	1000				240	-
Orifice Height (cm)	170	0	150	300	97	50
	170				97	50

(GEO : Geonor, TBRG : Tipping Buckets type gauge)

Measurements of snow depth have been done with two different ultrasonic ranging devices (1-‘KMA04’ and 2-‘SL37’), one optical type device, and four manual eye measurements.

2.2. Re-allocation of instruments

KMA(Korea Meteorological Administration) participated SPICE since 2013 and re-allocated several instruments following WMO recommendations. Two DFIR systems equipped Geonor T200M-3 weighing gauge was set up, so GEONOR instrumental random error was able to be assessed. And each rain gauge model was paired with Alter-type shield gauge and non-shield gauge. Two sets of ultrasonic snow depth measurement system(KMA04), three sets of multi-laser system, one optical type system, and three manual measurements were equipped. Also, instruments employing emerging technologies e.g. 2DVD(2-Dimensional video desdrometer), POSS(Precipiataion Occurrence Sensor System), MRR(Micro Rain Radar), PARSIVEL(PARticle Size VELocity), VertiX(X-band vertically pointing radar) were operated.

Fig. 2. Gochang site configuration

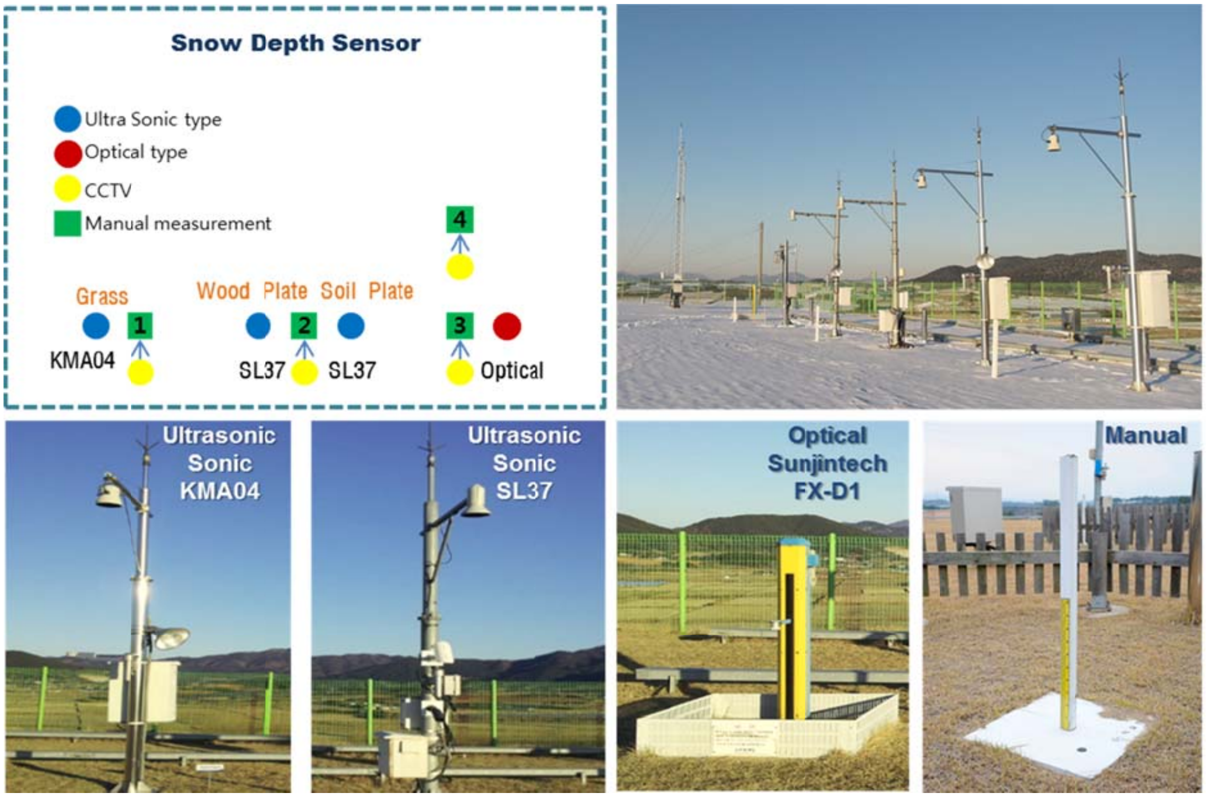


Fig. 3. Snow Depth Sensor

3. Methods

In this measurement research, 1-min. precipitation amount were estimated by filtering the noise data of weighing rain gauge and minimizing the effects of gauge empty, anti-freezing liquids or oil addition, and out of order sensor. Each instrumental random error was analyzed based on the six pairs of identified rain gauge measurements data. Snowfall amount of reference system was adjusted using the method of Yang(1993) for the dry snow. The catchment ratio was estimated as the precipitation observed with non-reference system divided by the adjusted snowfall amount. Here, wind at the height of rain-gauge was converted from 10m-height AWS wind with the roughness length of 0.01m for winter season and 0.03m for summer season. Manually observed snow-depth at four locations was compared with automatic measurement depending on the snow-measuring plates. Measurement errors were estimated following the equations. And each error was normalized as divided by mean x value.

$$\text{Bias Error(BE)} = \frac{1}{N}\sum(y - x)$$

$$\text{Mean Absolute Error(MAE)} = \frac{1}{N}\sum|y - x|$$

$$\text{Root Mean Square Error(RMSE)} = \left[\frac{1}{N}\sum(y - x)^2\right]^{0.5}$$

$$\text{Bias Removed RMSE(BRRMSE)} = \left[\frac{1}{N}\sum(y - x - BE)^2\right]^{0.5}$$

$$\text{CORRelation Coefficient(CORR)} = \frac{(\sum xy - n\bar{x}\bar{y})^2}{(\sum x^2 - n\bar{x}^2)(\sum y^2 - n\bar{y}^2)}$$

4. Results

Figure 4 shows the normalized RMSE of 1-min precipitation amount measurement with seven different rain gauges depending on the accumulation time. Pluvio and tipping-bucket type rain gauge indicated higher normalized RMSE, however that of each instruments showed similar results when accumulation time was longer than 60-min.

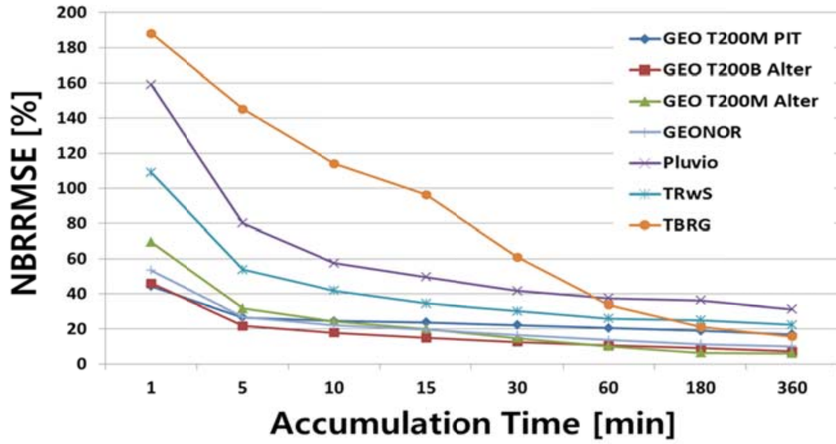
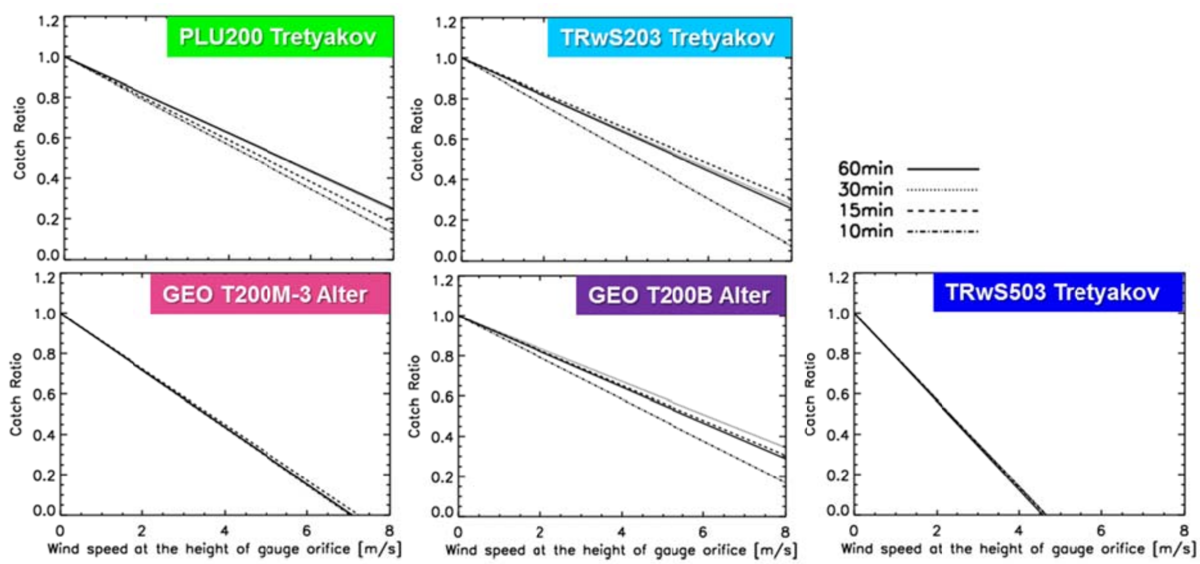


Fig. 4. Instrumental uncertainties of seven different gauges as a function of accumulation time.

The catch ratio decreased depending on the increase of wind velocity and the reduction ratio of TRwS503 with Tretyakov type wind shield was the highest (Fig. 5). In case of TRwS503, the catch ratio for wind speed of 2.0m/s was 57.0%. It means that cumulative precipitation of TRwS503 was 3.4mm when cumulative precipitation of standard observation facilities was 6.0mm.



30min

	PLU200	TRwS203	TRwS503	GEO T200M-3	GEO T200B
2m/s	81.0 %	81.8 %	57.0 %	71.8 %	83.6 %
4m/s	62.0 %	63.6 %	14.0 %	43.6 %	67.2 %
6m/s	43.0 %	45.4 %	-	15.4 %	50.8 %

Fig. 5. Catch ratios of different gauges at different wind shields as a function of wind speed at the height of gauge orifice.

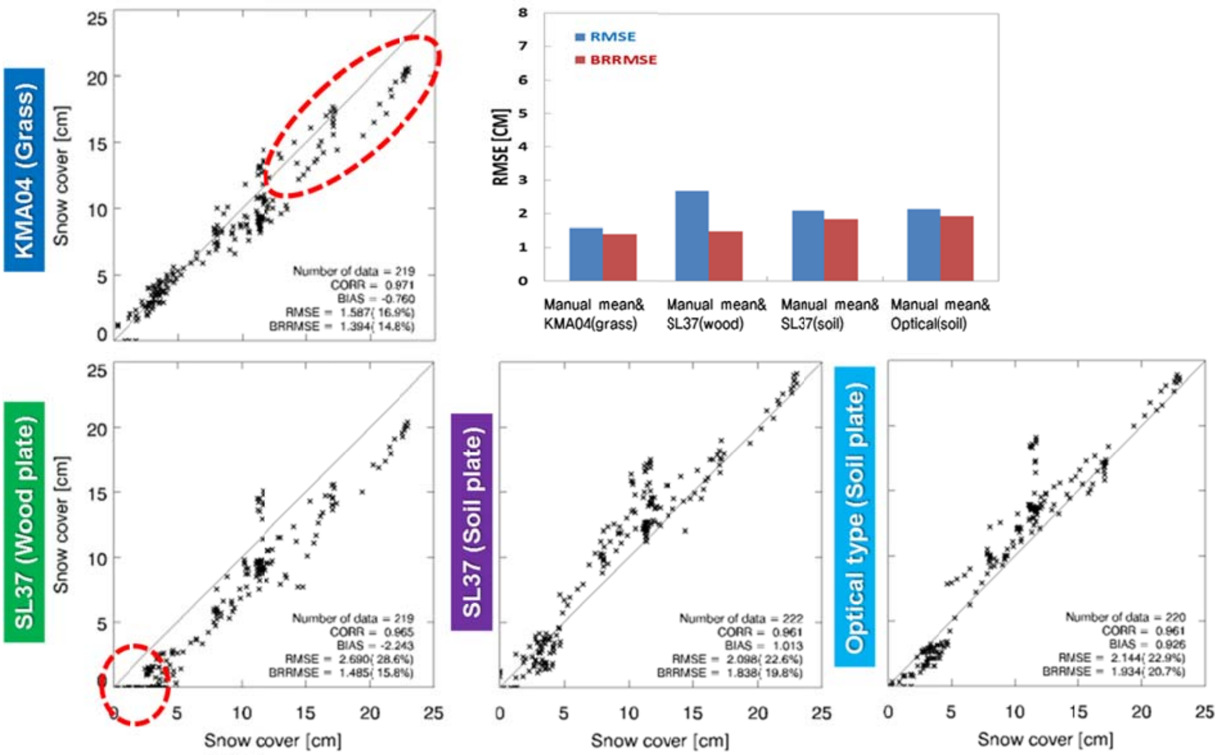


Fig. 6. Scatter plots of snow cover measured by automatic instruments and average snow cover of manual observation.

Fig.6 is the scatter plots of snow cover measured by automatic instruments and average snow cover of manual observation. Comparing SL37 soil plate with SL37 wood plate, the soil plate was inclined to overestimate snow depth and the wood plate had a tendency to underestimate it.

In the wood plate, we couldn't observe snow depth of 0~3cm. It is identified that the snow cover measured at soil plate showed nonlinearity in the scatter plot of SL37 soil plate and optical soil plate. KMA 04 measurement on the grass was most similar to manual observation, but underestimated in the snow cover depth ranging 15~25cm.

5. Summary and Conclusions

This research compared and analyzed snowfall and snow accumulation observed in Gochang station from 2012 to 2013. We calculated the mechanical error of each rain gauge as the function of time and analyzed the catch ratio change depending on wind speed. We also evaluated the observation accuracy of instruments and the types of snow measuring plate by comparing with manual observation.

As a result of comparison between mechanical error of each instrument, the error of low resolution rain gauge (PLU-0.1mm, TBRG-0.5mm) was high and the errors of all rain gauges showed similar results when accumulation time was longer than 60-min(below 40%). The catch ratio of TRwS503 with Tretyakov type wind shield was the lowest as 14% and that of Geonor T200B with Alter type wind shield was the highest(67.2%) when the wind speed was 4m/s for accumulation time of 30 minutes.

By comparing and analyzing the data of manual measurements, we estimated the mean error of manual measurement as 0.31cm. And we also analyzed the observational errors of snow cover instrument and snow board by comparing each equipment. KMA04 measurement on the grass was the most similar to manual measurement and snow depth had a tendency to be underestimated on the wood plate and overestimated on the soil plate.

6. Reference

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