Field Trial of the CoCoRaHS TROPO Precipitation Gauge

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The rain gauge was first invented in 1441, and measured rainfall amounts to determine tax rates. Later, in 1662, inventor Christopher Wren created the first tipping bucket rain gauge, along with the help of Robert Hooke. The standard rain gauge here in the UK for many years now has been the five-inch 'Snowdon Pattern' Rain Gauge. An article in the July 1921 edition of the 'Meteorological Magazine' *(Vol 56 p142)* states *"The prototype of the approved gauge is the "Snowdon " rain gauge. The "Meteorological Office" pattern gauge, the "Bradford" gauge and the " Seathwaite " gauge are variants of this type which embody the essential features of the " Snowdon" gauge and are therefore also satisfactory."* Originally made from copper, more recently the UK Met Office have introduced one made of steel based on the 'Snowdon' design.

The Snowdon Rain Gauge consists of a five-inch collecting funnel, with an inner collecting can with a glass / plastic collecting bottle. The instrument is set into the ground so that the collecting funnel is 12" / 30cm above short grass.

In the United States the standard rain gauge is the 8-inch gauge used by used in the National Weather Service for official rainfall measurements. The gauge has a capacity of 20 inches *(508mm)* with the inner measuring tube holding 2.0 inches of precipitation. Due to snowfall in the US, gauges are mounted on supports with the bottom of the gauge about 10-15 *(25 – 38cm)* inches above the ground. In areas that experience deep snowpack, however, the installed height above the ground is often significantly higher.

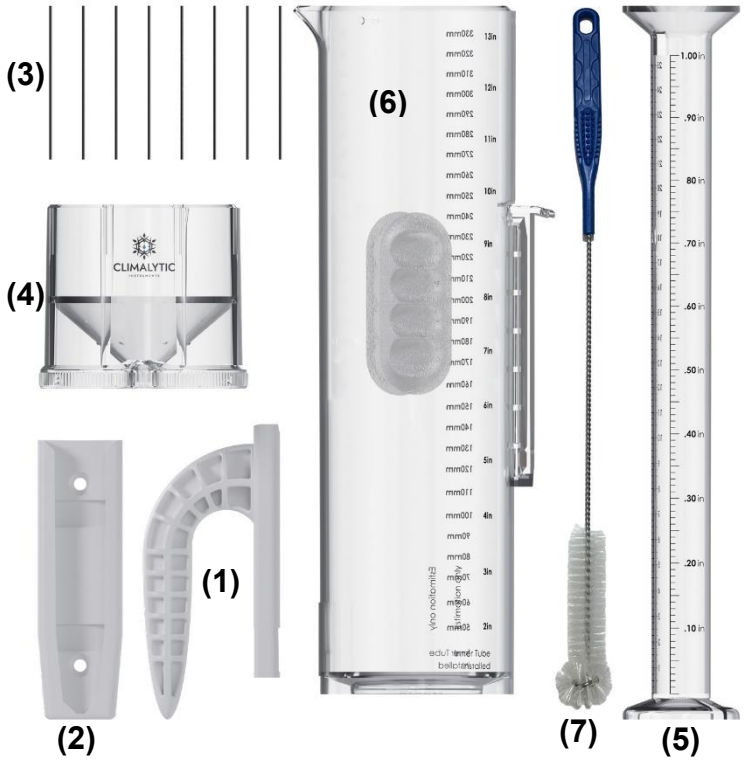
In the UK, the Climatological Observers Link *(**COL**)* established in 1970 is the main amateur organisation for the exchange of weather data. In the United States CoCoRaHS an acronym for the **C**ommunity **C**ollaborative **R**ain, **H**ail and **S**now Network is a unique, non-profit, community-based network of volunteers of all ages and backgrounds working together to measure and map precipitation.

To measure rainfall and snow water equivalent, CoCoRaHS observers use a 4-inch diameter plastic rain gauge known as 'The Stratus Precision Rain Gauge' (*CoCoRaHS Gauge*). Comparisons at the Colorado State University campus weather station in Fort Collins, CO suggest that the 4" CoCoRaHS gauge has a collection efficiency of 101-105% in rain with respect to the NWS 8" standard rain gauge. The difference appears to be that the standard rain gauge made from copper loses some precipitation before it enters the inner measurement cylinder due to evaporation. In snow, it is likely that the CoCoRaHS gauge has reduced collection efficiency relative to the standard rain gauge, especially in open areas.

Recently a new rain gauge has come on the market manufactured by Climalytic Instruments LLC based in Colorado, USA and designed in partnership with CoCoRaHS – The TROPO Precipitation Gauge. It is the first comprehensive refresh of the Stratus Precision Rain Gauge, which was first introduced in 1973. Based on the design of NOAA's National Weather Service official standard 8" rain gauge, the TROPO Precipitation Gauge uses the same dual cylinder design to measure precipitation with a resolution of 0.01" *(.25 mm)*. The inner cylinder holds 1 inch *(25 mm)* of precipitation, while the extra-large outer cylinder holds another 12.5 inches *(317.5 mm)* of precipitation when the inner tube is full. The inner cylinder and funnel top cap are removable to allow catchment of snowfall or other frozen precipitation, which can then be melted down or weighed to determine a liquid equivalent.

Since November 2021 I have been running a Voluntary Climate Observing Site for the UK Met Office here in the far north of Scotland. I have two five-inch Snowdon Rain Gauges, one copper, one steel. The steel gauge is the one supplied by the Met office and is the 'official' gauge used for the daily rainfall readings. Daily rainfall measurements are made at 0900 UTC and the data submitted to the Met Office using the WOW Weather Website. Data is also sent to the Scottish Environmental Protection Agency *(SEPA)* using their Citizen Science Portal '*Rainfall Observers.'* This steel gauge supplied by the Met office is the comparison gauge used in this trial.

In May 2023 I obtained a TROPO Rain Gauge from Climalytic Instruments which consists of the following :



1 Handle
2 Universal Mounting Bracket
3 Bird Deterrent Rods (x8)
4 Cap/Funnel
5 Inner Tube (with dual unit increments)
6 Outer Tube (with dual unit increments)
7 Cleaning Brush
In addition to the above, also included are: *Bubble Level x 1, Cable Ties (x2) Wood Screws (x2), Adhesive Strip x 1 Installation Guide*

The gauge has been mounted onto a wooden post sunk into the ground with the funnel at the recommended height of 24". The installation guide which comes with the gauge states: "*Determining gauge height is important to reduce under catch of precipitation from wind.* ***In open areas, the top of the gauge should be approximately 2-3 feet (.6 - .9 m) off the ground,*** *whereas in developed areas the top of the gauge should be approximately 5-6 feet (1.5-1.8 m) off the ground".*

The gauge is made from polycarbonate plastic that is resistant to impact and UV damage. The outer container has a pour spout which makes it easy to pour rain in excess of one 25.4mm *(1")* back into the inner tube for measuring and the supplied carrying handle is useful if you wish to take the gauge inside to measure any precipitation collected in the outer can. There are also non-slip finger grips moulded into each side of the outer tube which allows a better grip while removing and replacing the rain gauge on its mount. While most observers will use metric *(mm)* as a guide the outer tube is engraved with two scales in inches and millimetres. The inner collecting container is clearly marked in in 0.1 inch and 0.2mm increments. The top of the inner container has an overflow notch allowing rainfall in excess of 25mm *(1")* to flow into the outer container. There is a generous flare at the top of the inner tube. With another flare at the bottom of the tube adding stability when placing the inner container back into the outer and replacing the funnel. The funnel is easy to remove and replace and has been designed to fit into depressions on the inside of the funnel's base to "lock" it into place. The gauge also comes with eight bird spikes that fit securely into ribs on the outside surface of the funnel should they be needed.

The trial was run at the Lyth Climate Observing Site in the far north of Scotland. The site has been inspected and approved by the UK Met Office as one of their Climate Sites. The topography of the site is generally flat open fields and farmland. Due to slight over exposure to the south a 1m high x 10m long windbreak fence has been erected on existing open wire mesh fencing. This is 2.8m south of the rain gauge.

Lyth Climate Observing Site, Northen Scotland looking Southwest showing rain gauges.

The TROPO Rain Gauge was installed at the beginning of June and data collected for a period of six months. During that time there were only two occasions when the TROPO Gauge **overread** by 1mm or more than the Met Office gauge however, given the wind conditions at the time and the fact that the TROPO Gauge is mounted at twice the height of the Met Office Snowdon gauge, this is not entirely surprising.

Date	Wind Direction °	Wind Speed / Gust (kn)	MO Gauge mm	TROPO Gauge mm	Difference (mm)
20th October 2023	ESE (110°)	29 G 41	14.2	15.2	1.0
21st October 2023	ENE (070°)	20 G **33**	27.5	26.2	1.3

Under less extreme wind and weather conditions the overall difference is very small but looking at the occasions when there was a difference of plus or minus **0.4mm or more** during the trial period the following dates came up:

Date	Met Office Five Inch Gauge	TROPO Gauge	Difference (mm)
19th June 2023	7.5	8.2	**+0.7**
1st July 2023	5.2	5.6	**+0.4**
14th July	12.2	11.8	-0.4
27th July	4.7	4.2	-0.5
13th August 2023	6.4	6.8	**+0.4**
18th August	7.1	6.6	-0.5
19th August	7.1	6.7	-0.4
18th September 2023	20.6	20.2	-0.4
19th September	9.8	9.4	-0.4
21st September	2.0	2.4	**+0.4**
22nd September	1.5	2.0	**+0.5**
27TH September	12.4	11.8	-0.6
13th October 2023	7.1	7.5	**+0.4**
28th October	5.8	5.3	-0.5
2nd November 2023	9.7	8.9	-0.8
23rd November	3.3	4.0	**+0.7**

What is interesting is that despite any *daily* rainfall differences between the gauges overall the *monthly* difference for the six-month trial period was as below:

Month	Met Office Gauge (mm)	TROPO Gauge (mm)	Difference (mm)
June 2023	38.4	39.0	+0.6
July	76.0	75.9	-0.1
August	81.0	80.8	-0.2
September	91.0	91.4	+0.4
October	113.8	113.9	+0.2
November	70.7	71.3	+0.6
December	180.7	176.1	4.6*
• *Snowfall 19th – 28th inclusive*			

Due to the variability of rainfall and weather conditions there will always be small differences between rain gauges even ones situated close together. My five-inch copper Snowdon rain gauge situated 2 metres from the Met Office gauge can, on occasions read anything from -0.2mm under to +1.0mm over. For the 20th and 21st October data given earlier, the was a difference of +1.3mm and +1.4mm, respectively.

There are various methods to measure snow to obtain the water equivalent, here in the UK the normal practice with a standard five-inch gauge is to pour a measured amount of warm water using the rain measure into the gauge funnel to melt any snow/ice then subtract this figure from the total amount measured. Depending on the amount and type of snow, which can be wet or dry, it can take several millimetres poured into the funnel to melt the snow/ice. When it comes to the TROPO Gauge, the recommended practice is to remove the funnel and inner tube allowing any snow to collect in the outer container. This works reasonably well in moderate/heavy snowfall with light winds but in high winds and with any build-up of snow around the rim, this does affect the accuracy of your readings.

Overall, the TROPO Precipitation Gauge performs very well however, exposure and siting are crucial if comparable results against a standard rain gauge are required. I believe if the TROPO gauge were to be mounted any higher with open exposure then rainfall loss would be greater.

The TROPO Gauge is now available in the UK from Prodata Weather Systems - https://www.weatherstations.co.uk/precipitation-rain-gauge.htm