MEASURING SNOWFALLS

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One of nature's phenomenon that is enthusiastically enjoyed by weather observers is the rare occasion of a record-breaking snowstorm. Great snowstorms happen infrequently but they create problems that frustrate even the most experienced observer. You may be deprived of the satisfaction of experiencing a blizzard or a historic snowstorm if your data appears erratic or imprecise. The snowfall may be a new record for the area but can you be confident in your methods and equipment?

Great snows are the greatest challenge to measure. Ones like the blizzard of January 6 - 7th, 1996 along the East Coast consisted of a cold, dry snow of great depth and strong winds. I found accurate measurements during this storm required methods to account for variance in temperature, wind speed, and snow compacting.

These are some methods, accompanied by my commentary, offered by the Metro- politan Washington Volunteer Weather Network (MWVWN) for measuring snow under particular weather situations.

Gauges to use when wind is less than 10 mph

Whether temperatures are above or below freezing, melting the amount caught by a Tru-Check (Tm) Rain Gauge will usually give a reasonably accurate water equivalent when winds are light. If you have a 4.5 inches diameter Lake or Long-Term Gauge and sleet is expected, the outer cylinder should be used because the lip on the funnel of this gauge is not deep enough to prevent some sleet from bouncing out of the funnel.

Snow depth is most accurately measured with a snow board.

Lay a large, flat, white board across two bricks so that about two inches of air space separates the board from the ground (this is important when the ground is warm). Measuring snow depth on this board rather than the ground eliminates measurement difficulties caused by ground warmth and ground cover height. Without a snow board, I have found the next best surface to measure snowfall is the flat top of an automobile if there is very little wind, the vehide has been idle long enough to reach ambient temperature, and is parked in an open area away from obstrucfions such as buildings and trees. Ample judgment must be used; e.g., the car surface should be level and measurements taken toward the center and not along edges, and away from a sloping windshield. It helps if you own the car or your observation point may unexpectedly drive off.

In reporting snowfall MWVWN would like to receive two figures (measured to the nearest tenth of an inch if possible): 1) the snow depth on the ground at the time you measure it; 2) an the maximum new snow depth on the ground for the particular storm. Sometimes the second value may have to be estimated. For example, you leave for work in the morning and during the late morning it begins to snow. It snows hard for a few hours, accumulating three inches by 2 PM. Then the snow changes to rain and the warmer temperatures begin to melt the snow away. By the fime you get home from work at 5 PM, there is only one inch left on the ground. From talking to your family and neighbors, you estimate that 2.8 inches was on the ground at your station at 2 PM before the snow changed to rain. In this case, you would report 2.8 inches as the estimated maximum new snow depth and your recorded snow depth measurement of one inch measured at 5 PM.

Gauges to use with mixed snow and rain and winds greater than 10 mph

By far, this is the most common type of snowstorm affecting the Washington area. With winds greater than 10 mph, my experience is the Tru-Check (Tm) Gauge will not catch all the snow that falls due to turbulence and eddy effect. To measure a more exact water equivalent, MWVWN recommends using a larger mouth gauge such as the 4.5 inches diameter Lake or Long- Term Gauge or, even better, a 20 centimeter diameter (about 8 inches) standard weather service gauge. This method is recommended as a check against other methods, particularly when situations are difficult.

When to use a core sample for water equivalent

A core sample is an accurate way of measuring water equivalent only if snow or sleet falls with a temperature below freezing for the entire precipitation period. Select an area where the snow has not drifted (your snow board may be a good site). Thrust the open end of the outer cylinder Long-Term Gauge into the snow until you reach the ground (or snow board). Then, slip a thin piece of cardboard or sheet metal under the mouth of the gauge to avoid spilling, turn the gauge right side up again and melt the snow in the gauge. This melted amount is a core sample water equivalent. Averaging several core samples gives a more representative water equivalent. Compare the core sample water equivalent with the water equivalent determined directly from the gauge and use the larger of the two readings or do another core sample for comparison.

How to measure wind-driven, dry, powdery, drifting snow

This is the most difficult to handle of all the snow situations mentioned. It is not very common in the Washington area but presents the greatest challenge. With 30 mph winds, the Tru-Check (Tm) Gauge will catch less than 75 percent of the snow that falls. Level-One Stations also have measurement difficulties. Larger gauges are recommended in this situation. Gauges also should be positioned so snow from near-by roofs does not blow into the gauge. A slatted wind guard around the gauge helps to cut wind turbulence. Pavel and Legates stated in the February 1992 issue of *The American Meteorological Society* : Only about 200 US rain-collecting gauges have shields to prevent wind from blowing snow away from them. A core sample may still be good if you can locate an area where the snow has not drifted. The snow board should be used with caution, since strong winds will often blow accumulated snow off the top or may drift snow onto the boards in sheltered areas. If the wind is greater than 30 mph and the snow is severely blowing, a ground measurement where the snow has not drifted may be your best option for measuring snow depth. Seek out a low, reasonably flat terrain surrounded by trees or houses, take your observation at a distance of at least twice the height of surrounding objects. This area could be a park near your weather station.

How to measure snow depths greater than five inches

When the snow is deeper than five inches the snowfall loses depth due to compacting under its own weight. It appears that snows of higher snow-to-liquid ratios (greater than 12:1 ratio) incur more packing. These high ratio snows are often associated with the deeper dry snows, strong winds, and drifting snow.

The following example illustrates the problem. Observer M routinely takes observations at 2400 (midnight) and observer S routinely takes observations at 1700 (sunset). A great snowstorm begins at 1900 on January lst and one inch of snow falls each hour for the duration of the storm, ending at 1600 January 2nd. Therefore, observer M should record 5.0 inches of snow at 2400 January lst and 16 inches of snow at 2400 January 2nd. Observer S observes no snow on January lst. The next day observer S should record 21 inches of snow, the total accumulation. However, observer M actually recorded 5.0 inches on January lst and 13.5 inches on January 2nd for a total of 18.5 inches. Observer S actually recorded a total of 16.2 inches at 1700 January 2nd. Observer S measured 2.3 inches less snow than observer M as a result of increased settling due to the greater snow depth before measurement. (Refer to link to Graph A one page back)

Snow measured on a snow board every hour and then cleared and repositioned above the old snow for the next hour's reading is referred to as a running total. The method of allowing snow to reach a depth not greater than five inches and then clearing the snow board to start new measurements is referred to as a five inch clearing method. This regimen gives measurements that are more representative of the significant snowstorms (greater than six inches). Not surprisingly, the greatest errors in measurement occur during historically large storms. Storms that set snowfall records exhibit the greatest range of observer measurement for snow accumulation and serve to amplify the importance of proper procedures. My recent observations of a recent storm illustrate the divergence point in the measurement methods.

On 12 January 1996 a coastal low gave a small snow-to-water ratio because there was not an abundance of cold air. I found there was no departure between the running total method and the total snow accumulation using a measuring stick until the depth was greater than five inches. (Refer to link to Graph B one page back)

Another interesting observation was made during the January 6-7th storm that relates to the compacting of snow. I noticed the large precipitation gauge, which measures nine inches in diameter and stands 41 inches in height, had a snow depth greater than the surrounding snow. The snow falling into this gauge did not compact as much due to the friction and added support of the surrounding cylinder walls. The snow surface in the gauge was sloped due to the air flow across the opening and was measured after the storm ended on January 8th. The highest point of the slope measured 26 inches, the lowest point measured 19 inches, yielding an average depth of 22.5 inches. This amount compared favorably with the running total method which was 23.5 inches. Even with the support of the cylinders walls there was one inch of compacting!

On February the 16th we obtained 10.8 inches of snow in a storm with a very high snow to water ratio of 21:1 and there was only 0.1 inch of compacting to a depth of 7.2 inches. But after this depth the departure increased at a faster rate. With high ratio snows (link to Graph C on page back) the snow reaches a greater depth before compacting is observed because the snow does not have the weight to compact the snow. It is also interesting that time becomes a factor in relation to snowfall rate. Observe that during the 13th and 14th hour in (Graph C) the snow continued but the rate of settling equaled the snow accumulation rate. The faster the snow falls the less time for settling to occur. The snow of February 16th was composed of large snow flakes that trapped large amounts of air but fell at a faster rate than the January 6-7th snowfall. Thus the departure in the running total and the snow accumulation was comparable until the snowfall rate decreased near the end of the storm on the 16th. Between 14 and 15 hours when only a trace of new snow was recorded the snow accumulation decreases by 0.4 inches from settling therefore increasing the departure.

It would make an interesting experiment if a similar study was performed where ratios are equal to or greater than 30:1 as Colorado experiences. It is my hypothesis that under these conditions there would even be more settling and greater departures in the two methods of measurement.

How to measure snow equivalents for deep snows

Have you ever noticed that snow-to-water equivalents decrease generally as snow depths increase? This is a two-fold result: 1) as the coastal low gets closer it pulls warmer Atlantic air aloft and decreases the snow-to-water ratio; and, 2) compacting occurs with greater snow depths. Observers normally take the total depth of snow and divide it by the quantity of water melted from the snow. This is a satisfactory method if the snowfall is not a deep snow. For example, in the blizzard of 1996 at midnight January 7th, I recorded 1.95 inches of water and a ratio of 10.7:1 (running total method, snowfall depth of 20.9 inches). The accumulation total method to that time yielded 16.1 inches that even with the small amount of sleet and graupel gave an unbelievably small ratio of 8.3:1 and did not represent the actual ratio. I used four different precipitation gauges at this station to obtain the melted snowfall totals.

US Department of Commerce, Weather Bureau current instructions on measuring new snow

In the 1940s the Weather Bureaus Form 1009 gave straightforward but vague instructions for measuring new snow that had fallen in the preceding 24 hours. Succinctly stated, a measuring stick was used and where drifting occurred an average was calculated from several points of least drift and entered.

Today the instructions are more sophisticated Two types of snow depth are reported: 1) the depth of new snow having fallen since the previous scheduled time of observation; and, 2) the total depth of new and old snow on the ground, reported to the nearest whole inch. Measurement is still done with the measuring stick, but the instructions now advise on factors effecting sample points, particularly where drifting has occurred. Namely, seek a flat area away from buildings and trees, and use an average of places where the snow is more evenly distributed. The instructions contain advice on measuring fresh snow fallen on old snow, but clearly states that snow boards are the best method with most situations. Subsequent text is devoted to procedures to compensate for not having a snow board.

Comments on reporting significant storms

The early records of snowfall were made by using a yard stick when the snow had ended or obtained its greatest depth. To compare current snows with historic snows, we must continue to use that method. However, we can better profile significant storms today by using more refined methods. The snow board is a cheap and simple piece of equipment and no serious weather observer should be without one or more. A slatted grate around your gauge is a little more complicated but hardly more than a trip to the hardware store. Considering the improvement in observed data, it is a wonder that these devices are not more common.

To use the running total method would be too time consuming for most observers. However, use of the five-inch clearing method takes little extra time and yields greatly improved results. Snows greater than five inches are not that common over most of the United States and when they happen we usually have that extra time due to work and school closures. Even a 15 inch predicted snow would only require two additional observations. These observations could be placed under the remarks column when snow of greater depths occur.

Seeing my data document the Blizzard of 1996 by use of these simple but improved methods gave me a fuller experience of one of nature's rare phenomenon. I encourage all of you to use these methods and when significant or great snowstorms occur, report your five inch clearing method for snow accumulations in addition to your observed greatest depth on ground and new accumulation since last observation.

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