SNOW ACCUMULATION 1/

By

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Introduction

Snow accumulation and the measurement of it generally is viewed in two different manners; one to the skiers, outdoorsman, and general public as a measurement of snow depth, the other to the hydrologist or engineers as the equivalent water content of the snow. Actually both groups are interested in depth and equivalent water content but tend to place importance only on one or the other.

In the discussion of snow accumulation in this paper most emphasis will be on the equivalent water content with some discussion to measurement of snow depth when used as an indirect observation of equivalent water content.

To repeat, perhaps unnecessarily for this group, the equivalent water content of the snow is the amount of water in the snow. If snow depth is expressed in feet or inches it follows that the equivalent water content is expressed in the same units with metric system centimeters or millimeters used depending upon the quanity.

There is one other comment that can be made concerning measurement of snow depth or equivalent water content, and that is the measurement of the total amount present at any one time or the measurement of an incremental amount over a shorter period of time. This further classification is made since instruments designed for one purpose may not give satisfactory results of the other purpose.

Methods of Measurements and Problems Associated with Measuring Techniques

Precipitation gages, because of the universal use of them in the climatological network, account for more records of snowfall than any other single type of instrument. Since there are conservatively over 100 different types of precipitation gages and this is a subject of itself, and has been covered by the previous speaker, I will limit myself to some of the characteristics of precipitation gages in snow accumulation.

Wind effect is well known and Dr. Warnicks tests, at the University of Idaho, have demonstrated this effect. Wind shields partly overcome this problem but in areas where large snowfall rates occur, shields create another problem or more correctly, aggravate the "capping" of the orifice of the gage. This problem in most areas can best be eliminated by larger gage orifices. Tests at Mt. Hood, 1964 - 65, indicate very good agreement for periods of relative calm wind of incremental snow accumulation between a 12" orifice and other snow measuring methods that will be described later. Differences were of the order of 5 to 15 percent which may appear to be great, however, in as much as these measurements are in the true sense, only an index and the relative rates of snow and distribution was good between the precipitation gage as other methods, it is my opinion that a large orifice gage of 12" or more can accurately provide an index of total snow accumulation. Large heated gages have been designed to catch snow and melt it. Such gages are currently being used to measure very small rates of precipitation as snow.

In summing precipitation gages ability to measure snow it can be stated that the large diameter gage can give accurate results of total precipitation under calm or near ideal conditions of exposure. Capping is a problem with snow although in most instances, the cap will eventually fall into the gage and may not represent as much of a problem as one might expect in measurement of the amount of precipitation as snow. If incremental or rates are desired, obviously capping would prohibit collection of this type of information. Additionally, if only precipitation as snow fall information is desired, a recording

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thermograph would be necessary in order to separate periods of rain and snow from any recording type of precipitation gage.

Volumetric snow samplers are perhaps the most widely used instrument for measuring the seasonal total of the equivalent water content of the snow. A sample core is extracted from the snow and weighed with a scale that is calibrated to yield the equivalent water content directly. The first sampler, no doubt, was a stove pipe which has graduated into the Mt. Rose type over the years. Bindon 3/ reported on nine different types - Work, Stockwell, Freeman, and Beaumont 4/ reported on five different types. Volumetric Samplers can be classed into two main types, the small diameter types, i.e. Federal, Rosen, Bowman; and the large diameter ones, Adirondack, Sovit, Italian and Canadian Prairie samplers. Main difference between use of the small and large diameter is related to snow depth. The larger samplers can only be used in areas where snow depth are 4 to 5 feet in depth. In the case of large diameter samplers it is difficult to retain the snow cores. It is usually necessary to dig down and hold the core in the tube with a shovel or similar piece of equipment. Such equipment is provided in several of the large diameter sampler kits.

There has been little interest for many years of snow surveyors to be of concern for the accuracy of measurements taken with snow tubes. One obvious reason is that the snow survey, like other climatological observations, is merely an index. Frequently this is forgotten and many assume the snow survey as an absolute measurement.

With the advent of additional methods to measure the climate change equivalent water content, i.e. radio active snow gage 5/, pressure pillow and pressure platform 6/, attention was directed to the accuracy of the snow tubes.

In previous cited work of Work, Stockwell, Freeman and Beaumont at Mt. Hood, comprehensive tests were conducted on the accuracy of the snow tubes. In this work it was found that the "Federal snow sampler over measures the water equivalent of snow". The error ranges from an average of about 7 percent in shallow, light density Alaskan snow, to as much as 10 to 12 percent in deep snow of higher density. Further work by Farnes in Montana and by the snow survey group at Mt. Hood, related this over measurement to cutter sharpness with little difference in cutter design or number of teeth per cutter.

These tests additionally showed that a snow tube did give constant results and variation of one sampler under the same or near similar conditions gave near identical results. This latter statement is very important when the data collected is regarded as an index. It has been this writers experience that the lower limit of detection of this over weighing is about 15 to 17 inches of equivalent water content. Below this amount the variation between samples is too great to detect any over weighing due to blunt cutters.

One other method or combination method to measure snow, particularly increments of snow, is the snow board. Various sizes are used usually 3 or 4 feet square and painted white.

Snow boards are placed on the snow and marked with a vertical pole so they can be found after being covered with snow. Samples are taken, sometimes with snowtubes, rain gates or other volumetric samplers. The sample may be melted before being measured or weighed in the case of snow tubes. Wind may be a problem and reduce the actual snow fall as the clean snow board may not have the same catch efficiency as the natural snow surface or bare ground.

Automatic sensors for measurement of the equivalent water content of the snow is still in the development or beginning stage.

One of the first such instruments was the radio-active type gage developed by Gerdel and others in 1954. The equivalent water content of the snow is measured by the attenuation of a radio active source. Several others have worked with the radio active snow gage and several have been installed in the Western United States as well as in Japan, Russia and Europe. Error is reported to be about 5 percent up to a maximum reading ability of about 50 inches of water. Higoske and Itagski reverse the position of the source and the counter to eliminate temperature changes in the counter. A further development of the radio active gage is to read such gages from low flying aircraft. Montana State University developed a prototype such gage for BPA near Bozeman, Montana. Initial cost and potential health hazard of such a gage has prevented universal acceptance of the radio-active snow gage as a network instrument.

In 1957, Inoue 7/ reported on a weighing type snow balance designed by S. Tamura of Met. Research Institute of Japan. This instrument was four meters in diameter and made of triangular plates. The base of the plates rested on a firm foundation. The apex of the triangles was supported by a ring balance. As the weight of the snow increased, the deflection of the ring balance was measured. Accuracy was reported on about 10 percent. Some difficulty was reported measuring the melt rates.

At Mt. Hood, a similar type weighing platform was tested and evaluated. This platform was 12 feet square and supported by four interconnected "Goodyear" storage tanks, 34" x 48". As the snow accumulated, the internal pressure was measured by means of a manometer. This type system did not give a linear readout due to the expansion of the supporting tanks under an increasing load.

Photographic methods have been used to measure the snow for a good many years. In the early thirties the Denver Water Board used a camera to take annual pictures of the Front Range in an effort to relate these data to run off. More recently, weather satellites have taken pictures of the snow covered areas of the globe. These pictures require some subjective analysis to distinguish between clouds and snow cover. There has been some attempt to interpret snow depth from color tones.

Aerial photographs have also been used in connection with snow depth markers. Snow depth markers have been installed in very remote areas to supplement the snow course network. Photography of these markers provide a permanent record and enables a more accurate readings of the markers. Equivalent water content is estimated from the snow depth readings by applying a density factor from a nearby snow course where a measurement has been taken within a few days of the aerial observation. Experience has shown that aerial marker measurements can provide accurate estimates of equivalent water content with errors no greater than 15 percent.

In resume, most snow measurements are made by precipitation gages because of the large number of these instruments in existing networks. Recent experience has indicated large orifice (12") gage can give accurate results under conditions of exposure.

Volumetric samples remain the mainstay of the instruments measuring the equivalent water content directly. Snow tubes do a consistant job of measuring the snow, however, recent analysis indicate cutter sharpness as a major problem affecting the accuracy of results.

Recent years has seen a trend towards automatic instruments. At present the most interest seems to be in the pressure pillow approach. Results to date indicate this to be an accurate and inexpensive method of measuring the equivalent water content of the snow. Some problems have been experienced with the materials in the manufacturing of the pressure pillow, but a switch to other material in the manufacturing should correct these problems.

In the future it is expected that a network of automatic snow sensors measuring the equivalent water content and transmitting this information via radios will become the basic network in remote areas. Snow tubes will, of course, continue to be used in areas that are readily accessable, thus attention should be directed towards a standard sharpness for cutters. This would minimize variation between snow tube due to cutter sharpness.

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