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Project Summary

Progress Report: Comparison of Precipitation Measurements by Nipher-Shielded and Standard Belfort Recording Rain Gages at NADP/NTN Sites

Carol L. Simmons and David S. Bigelow

Persistent concern by the scientific community that wet deposition was being incorrectly calculated due to underestimation of snow fall prompted EPA to install devices on the field sampling gages to improve catch efficiency. Some evidence indicated that snow fall was being underestimated due, in part, to windy conditions. A shield was installed on the regular collection gage to improve catch during snow and windy conditions. The data collected during this study was compared to data collected at the same sites using the normal system.

This Project Summary was developed by EPA's Atmospheric Research and Exposure Assessment Laboratory, Research Triangle Park, NC, to announce key findings of the research project that is fully documented in a separate report of the same title (see Project Report ordering information at back).

Introduction

A widely recognized source of error in precipitation estimates is incomplete collection of snow by precipitation gages, particularly under windy conditions. The Belfort Universal recording precipitation gage, the type used in most weekly monitoring networks in the United States, has been shown to underestimate snowfall by as much as 50%, even when equipped with an Alter shield to deflect the wind. In recent years, a precipitation gage known as the Canadian MSC Nipher-Shielded snow gage has received considerable attention as an improved gage for monitoring snowfall. This gage has been shown to capture 90-l00% of "ground-true" snowfall under a wide range of environmental conditions. The superior performance of this gage has led to its designation as the official snow gage in Canada. Canadian scientists have adapted the Nipher shield for use on standard Belfort and Fisher and Porter recording precipitation gages. In tests outside of Toronto, Canada, the Nipher-modified Belfort gage collected 92-93% of the snowfall captured by the MSC Nipher- shielded snow gage.

In late l987, the US-EPA installed Nipher-shielded Belfort recording precipitation gages at nine NADP/NTN sites to allow comparison of precipitation measurements from the Nipher-shielded gages with those from the standard Belfort recording precipitation gages already in use at the sites. A primary objective of the study was to assess the relative performance of the two gages under standard NADP/NTN operating protocols. Although the Nipher shield was designed specifically to improve snow capture, a second objective was to compare measurements by the paired gages for various types of precipitation. This information is important for networks that utilize a single recording precipitation gage during sampling intervals that contain both rain and snow. If the existing gages are modified for winter use by installing the Nipher shield at the onset of winter, there is a high probability that some rain will fall after the Nipher shield is in place. This progress report summarizes preliminary results from approximately the first year of the comparison study.

Discussion of Results and Conclusions

Weekly precipitation values from collocated Nipher-shielded and standard Belfort recording rain gages were analyzed for significant differences in volume. The effects of site, precipitation magnitude and precipitation type on the differences were evaluated . In addition, the daily amounts from two sites were analyzed and correlated against concurrent wind speed and temperature measurements in an attempt to elucidate the nature of the variability between the two types of gages.

Study sites were selected to represent a variety of snow collection conditions. The Nipher-shielded rain gages are located within two to 15 m of the standard rain gages, and are operated and maintained by the site personnel in the same manner as are the standard NADP/NTN rain gages. Maintenance includes charging the gages with antifreeze at the onset of winter. At the beginning of the study, the rain gages were calibrated.

Weekly precipitation totals were calculated by summing the daily amounts. Daily records of precipitation type and amount were used to classify the weekly precipitation as to type (snow, rain, mixed or unknown). The weekly precipitation was classified as "snow" if $\geq$ 67 percent of the total precipitation during the week occurred as snow, or "rain" if $\geq$ 67 percent occurred as rain. Other combinations were classified as "mixed", unless $\geq$ 33 percent of the total amount was "unknown", in which case the precipitation for the entire week was classified as "unknown". Only those weeks for which one or both gages indicated that precipitation occurred, for which valid measurements were available from both gages, and for which the precipitation type was known were used in the analyses of weekly data. One site was excluded entirely because of insufficient data.

At all sites the mean difference between the gages was positive (i.e., the Nipher gage recorded more precipitation than the standard gage), but the bias was significant ($P<0.05$) at only five of the eight sites. The magnitude of the total difference ranged from 0.04 in. to 2.88 in. (water equivalent). On a percentage basis, the Nipher-modified gage measured up to 17% more precipitation (in total) than the standard gage. There was no clear relationship between the gages, nor did the presence or absence of an Alter shield surrounding the standard gage appear to play a critical role in determining whether a significant difference between gages was observed.

An objective of the current analysis was to evaluate, on a site-by-site basis, the effect of the precipitation type on the difference between the gages. This analysis was constrained by small sample sizes for some precipitation types at some sites; however, mean differences between the gages were found to be highly significant (paired t-test, $P<0.01$) for snow at two sites, and for rain at three sites. The largest percentage difference between the gages for snow occurred where the Nipher gage recorded 37% more snow (in total) than the standard gage. This percentage difference represents an absolute difference of only 1.46 in. (water equivalent). The largest percentage difference for rain was 17%. The lack of significance for some site-type combinations may be attributable, in part, to small sample sizes.

To circumvent the problem of small sample sizes, the effects of precipitation type were also evaluated using the combined data from all sites. The difference between the gages was found to be highly significant for each of the three precipitation categories analyzed (rain, snow, and mixed); however, the mean differences for each of the three types were not significantly different from one another. This result is surprising, given the fact that previous studies have shown that error in precipitation gage measurements is greater for solid than for liquid precipitation. The Nipher-shielded gages may have overestimated rainfall by capturing droplets that had splashed off of the shield. Although some field observers reported that rain did appear to be splashing off of the shield into the gage, without "ground true" information it cannot be determined whether this phenomenon results in an overestimate of the rainfall.

The examination of both weekly data and daily data is important to the interpretation of the differences (or lack of differences) between the gages. The daily data permit finer resolution in the classification of precipitation type, while the weekly data are used by NADP/NTN to calculate deposition and weighted-mean concentrations. Daily data are more likely than weekly data to be affected by the carry-over of snow from one day to the next due to the tendency for wet snow to stick in the gage orifice.

The lack of significant differences between the gages at some sites is puzzling, given the fact that previous studies have shown that the Nipher modification enhances snow capture. The age of some of the standard rain gages in the current study and the conditions under which NADP sites are operated may contribute to greater "noise" in the current study than has been the case in previous studies, making it more difficult to detect small differences between the gages. Larger sample sizes should help address this problem . It is also possible that the environmental conditions at the study sites are sufficiently different from those in previous study areas to account for the differences in the results.

Uncertainties in the measurements made by the Belfort recording rain gages used in this study and throughout the network may be due to a number of factors, with the relative importance of the factors varying from site to site. First, at very windy sites, the rain gage is subject to "wind shake". Wind-induced vibrations cause the precipitation pen to oscillate, thereby increasing the uncertainty in the interpretation of the chart. The Nipher-shield appears to increase wind shake under some conditions, causing even greater uncertainty in the interpretation of the Nipher gage chart. Second, although all gages used in the study were calibrated at the beginning of the study, the gages tend to lose their calibration over time and most NADP site operators do not have the necessary skill to calibrate the gages. Older gages may lose their calibration more rapidly than newer gages. Although calibration checks were made during the period of the study, the analysis of potential impacts of lack of calibration (if any) on the differences between the gages was beyond the scope of this preliminary analysis. Third, because the cumbersome Nipher-shield must be removed in order to access the catch bucket, operators may be more likely to operate the Nipher-shielded gage on the back traverse of the gage where at sites where the collector is installed on a platform that provides little room for maneuvering, as is often the case at sites with large amounts of snow. Finally, because the gages are maintained weekly, rather than daily, there is limited opportunity to detect and rectify problems such as "capping over" of the Nipher gage that can lead to inaccuracies in precipitation measurement.

The preliminary results of this study do not provide convincing evidence that the adoption of the Nipher-shielded rain gage for snow measurements would enhance precipitation capture on a network-wide basis; the effects of the shield appear to be highly site-specific. The site-to-site differences are not clearly attributable to differences in amounts of snow and wind.

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Carol L. Simmons and David S. Bigelow are with the Natural Resources Ecology Laboratory, Colorado State University, Fort Collins, CO 80523
***S.M. Bromberg** is the EPA Project Officer (see below).*
The complete report, entitled "Progress Report: Comparison of Precipitation Measurements by Nipher-Shielded and Standard Belfort Recording Rain Gages at NADP/NTN Sites," (Order No. PB90-261 538AS; Cost: $15.00 cost subject to change) will be available only from:

National Technical Information Service
5285 Port Royal Road
Springfield, VA 22161
Telephone: 703-487-4650

The EPA Project Officer can be contacted at:

Atmospheric Research and Exposure Assessment Laboratory
U.S. Environmental Protection Agency
Research Triangle Park, NC 27711

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