United States
Environmental Protection
Agency

Research and Development

Environmental Monitoring
Systems Laboratory
Las Vegas NC 89193

EPA/600/S8-87/024 Jan. 1988

EPA

Project Summary

Wet Deposition and Snowpack Monitoring Operations and Quality Assurance Manual

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The manual (User's Guide) summarized herein presents the quality assurance plan and operations protocols for a comparative study of snow collection instruments being conducted on Mt. Evans. Instruments to be compared include the Aerochem Metrics Model 301 wet/dry deposition collector, the Belfort Model 780-5 weighing-rain gage, and 18 inch-diameter flanged bulk samplers. In addition, ground measurements are made to provide a ''ground truth'' standard. Primary project objectives include assessment of operational reliability, estimation of inter-instrument and temporal variability, comparison of water equivalent and matrix chemistry between the collection devices and ground measurements, and recommendation of instruments and sampling intervals for future high altitude, complex terrain monitoring. The protocols related to quality assurance, quality control, calibration, operation, maintenance, processing, analysis, and data management are described. The manual is considered to be of greatest benefit to field operators, laboratory analysts, and project managers.

This Project Summary was developed by EPA's Environmental Monitoring Systems Laboratory, Las Vegas, NV, 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

Established acidic deposition monitoring networks largely neglect the high elevation areas of the western United States. Interest in these areas is growing, particulary for the Rocky Mountain region, because of evidence that precipitation amount, and possibly total chemical loading, is strongly correlated with elevation. Most monitoring equipment and siting criteria were developed for low-elevation, flat-land sites. Meteorology in mountainous terrain is significantly more complex, and precipitation levels are higher than at low-elevation sites. Research on the suitability of existing instruments for use at high altitude is needed before large funding and personnel resources are committed to monitoring acidic deposition in mountainous terrain.

The National Atmospheric Deposition Program (NADP), EPA Region VIII, and U.S. Forest Service are participating in an investigation of equipment performance at high altitude. The EPA Environmental Monitoring Systems Laboratory in Las Vegas, Nevada (EMSL-LV), and the prime contractor for EMSL-LV, Lockheed Engineering and Management Services Company, Inc. (Lockheed-EMSCO), are responsible for equipment installation, field station operation, and data interpretation. EMSL-LV and Lockheed-EMSCO have primary responsibility for construction of the monitoring platform, installation of equipment, operator training, snow density/coring activities, data verification and interpretation, chemical analyses, and quality assurance. Instruments to be evaluated include the Aerochem Metrics Model 301 wet/dry deposition collector, the Belfort weighing-rain gage, and bulk samplers. Snow density, snow coring, and event sampling also are being undertaken to provide a "ground truth" comparison. Samplers are to be evaluated in terms of reliability and ease of operation, catch efficiency, and resultant sample matrix chemistry. Meteorological sensors located on the monitoring platform will provide information on the meteorological environment surrounding the collectors.

The selected site is the High Altitude Laboratory operated by the University of Denver. The High Altitude Laboratory is located adjacent to the Mount Evans highway near Echo Lake, 14 miles south of Idaho Springs, Colorado. The site offers several advantages: the terrain is complex, and the area is subject to large amounts of precipitation and to high winds; the site is accessible even in winter; it has electrical power, and it is inhabited year-round. A National Oceanic and Atmospheric Administration (NOAA) monitoring station located near the monitoring platform can provide additional meteorological information.

This manual details the equipment operation, chemical analyses, and quality assurance plan for the wet deposition and snowpack monitoring project. It is designed to be of primary benefit to the station operator, laboratory analysts, and data analysts. The protocols presented here may be revised over the course of the program to reflect necessary changes and improvements in procedures. Related documents include an operations status report which will be delivered in June 1987 and a final report on the evaluation results which will be provided in January 1988.

Project Description

Snowpack and wet deposition monitoring on Mount Evans is being conducted to assess the suitability of selected collection devices to high altitude, complex terrain situations. Specific objectives of the project are as follows:

- Inter-instrument sampling variability for two colocated wet/dry collectors will be estimated by comparing chemistry and water equivalent for weekly samples.
- Inter-instrument sampling variability for two colocated Belfort weighing-rain gages will be estimated by comparing water equivalent for event and weekly data.
- Temporal variability will be estimated by comparing chemistry and water equivalent of wet/dry collector event samples to weekly samples.
- Inter-instrument sampling variability for two colocated bulk samplers will be estimated by comparing chemistry and water equivalent for weekly samples.
- A "ground truth standard" for estimating the accuracy of all collection instruments will be estimated by comparing sample chemistry to the chemistry of snowpack cores taken to snowboards. The comparison will be made on samples collected after events.
- A "ground truth standard" for estimating the accuracy of all collection instruments will be provided by comparing water equivalent of samples collected after events and collected weekly. The comparison will be made on snow pit density measurements and on snowboard measurement.
- Instruments and sampling intervals for high altitude, complex terrain situations will be recommended based on results of all the above comparisons.
- Operational reliability will be assessed in qualitative terms of types of instrument malfunctions, length of downtime, cause and resolution of problems, ease of operation, frequency and difficulty of maintenance, and sample contamination.

The wet/dry collector and Belfort rain gage are the standard instruments used by NADP and by other major monitoring and research networks. The Belfort gages are unshielded. The bulk sampler design is identical to that used by the United States Geological Survey (USGS) in snow studies. Supplemental instrumentation includes Science Associates Models 424-1 and 424-2 wind speed/wind direction sensors and a data acquisition system (DAS) composed of an IBM at personal computer and Metrobyte logic boards. Snow coring equipment and the Taylor-LaChapelle snow-density kits used are manufactured by Hydro-Tech. Snowboards are fabricated by Lockheed-EMSCO of polyurethane-coated plywood.

The collection devices and meteorological sensors are mounted on a 20-foot diameter octagonal wooden platform erected on a southeast-facing slope at the maximum expected snowpack height (19 feet at the point closest to the ground). Cables connect the sensors to the DAS which is located approximately 275 feet distant in a heated building. The platform is accessed by steps located on the uphill (NNE) side. The closest tree tops subtend an angle of 47° ± 3°. The nearest of several buildings is located 28 feet NNW of the platform. A fireplace in one of these buildings is a possible source of contamination; however, the building is more than 500 feet away and is shielded by other buildings and by trees.

The monitoring equipment and DAS are checked daily by an on-site operator. In addition, a Lockheed-EMSCO scientist visits the site at least once a month. During most of the study, samples are collected from two wet/dry collectors and two bulk samplers on a weekly basis or more frequently as required by event loading. Samples are collected from the third wet/dry collector daily. Snowboard cores and snow pit density measurements are taken weekly. During a 30-day period, two wet/dry collectors are operated on a daily basis, and the third is operated on a weekly basis. Snow cores and snow pit density measurements are taken daily as well as weekly during this same 30-day period.

No analyses are performed in the field. On a weekly basis, all samples are shipped frozen to Lockheed-EMSCO in Las Vegas, Nevada, where water equivalents are determined and where melted samples are processed. Processing includes pH and specific conductance measurements, which are completed immediately after melting, and filtration and preservation of aliquots for subsequent analysis. Analyses for chloride and ammonium are completed approximately every two weeks; analyses for metal cations, nitrate, and sulfate are completed every four weeks. All analyses are completed within recommended holding times for the chemical variable of interest and preservation treatment used.

Data from the field, processing laboratory, and analytical laboratory are compiled into a single database; because of the small size of the database, an IBM-

PC is used for data compilation. Quality control sample data are used to verify the data; data of poor or unknown quality are deleted.

Statistical tests, including paired t-tests, %RSD, and means, are employed to quantify the project objectives. Other interpretative schemes may be developed dependent upon the initial intra- and inter-comparison results.

Quality Assurance Plan

The Quality Assurance (QA) policy of EPA requires that every monitoring and measurement project have a written and approved QA project plan. This requirement applies to all environmental monitoring and measurement efforts authorized or supported by EPA through regulations, grants, contracts, or other formal means. The QA project plan should specify the policies, organization, objectives, functional activities, and specific quality control (QC) procedures designed to achieve the data quality goals of the project. As used herein, QC is the specific procedures and checks used to provide a quality product, while QA is the overall system used to ensure that the QC system is performing. All project personnel should be familiar with the policies and objectives outlined in the operations and QA plan to ensure proper interactions among the field operations, laboratory operations, and data management.

Quality Assurance Objectives

QA objectives are defined in terms of percision, accuracy, completeness, representativeness, and comparability.

Precision and Accuracy

The QA objectives for precision and accuracy of the parameters being measured are given in the manual. Precision, defined as the mutual agreement among individual measurements of the same property, is expressed in terms of percent relative standard deviation (%RSD). Precision is calculated from results of duplicate analyses and repetitive analyses of audit samples and quality control check solutions. Accuracy is the degree of agreement of a measurement with an accepted or true value. It is expressed as percent bias and is determined from the difference between recorded measurements and accepted true values of audit samples, quality control check solutions, and calibration standards.

An additional estimate of precision is provided by the two colocated wet/dry collectors, Belfort rain gages, and bulk samplers. It is common practice in many studies to designate one unit as the primary or routine sampler and the other as a secondary or duplicate sampler. This practice, in effect, designates samples from the secondary unit as QC samples.

Because one of the project objectives is estimation of inter-instrument sampling variability (i.e., quantification of precision limits), units used in this project will not receive primary and secondary designations. Consequently, a field duplicate is not included as one of the QC samples described below. Analysis of the data on colocated samplers is included in the data interpretation scheme, as discussed in the manual.

Field Operations

The equipment installed at the monitoring site includes wet/dry collectors, Belfort rain gages, bulk samplers, wind speed and wind direction sensors and a data acquisition system (DAS). All of these, with the exception of the DAS, are mounted on the raised sampling platform. Additional measurements are taken on the ground within a clearing. Snowboards provide a base for core samples which are collected on an event and weekly basis. Density measurements are performed in a snow pit. Responsibilities of the site operator include sample collection, handling, and shipment; instrument calibration, maintenance, and quality control checks; equipment trouble-shooting and repair; and documentation of all field activities. The following sections detail each of these aspects of field operations; ground-level measurements are treated in a separate section of the manual.

Analytical Operations

All processing and analytical activities are performed by Lockheed-EMSCO in facilities provided by EPA EMSL-LV. Processing operations, including water equivalent determination, aliquot preparation, specific conductance and pH measurements, and field operations support are initiated immediately upon receipt of samples and are concluded within 48 hours of receipt of frozen samples. Every two weeks, the aliquots that have been prepared and accumulated for chloride and ammonium determinators are analyzed; every four weeks the accumulated aliquots for cations (Na, K, Ca, and Mg) and nitrate and sulfate determinations are analyzed. The accumulated aliquots that are analyzed at one time are considered a unique batch.

Data Management

Most data for this program are provided on floppy disk. A limited amount of data must be manually entered (e.g., Belfort rain gage data). Hand-entered data are reviewed for transcription accuracy. Evaluation of data quality is described in the manual. Following this evaluation, data of poor or unknown quality are removed from the data base. Operator records are reviewed, and data corresponding to calibrations, quality control checks, maintenance activities, or malfunctions are removed.

The remaining verified data are analyzed and interpreted in accordance with the project objectives. Inter-instrument comparisons are made for instruments of the same model operating over the same sampling interval. These include the two Belfort rain gages, the two bulk samplers, duplicate weekly and daily snow cores, paired weekly wet/dry collectors, and paired daily wet/dry collectors. Comparisons are made of the water equivalent and chemistry results. Specific comparisons include computation of means, range, %RSD, and paired t-tests.

Comparisons between different instrument models employ statistical tests similar to those described above. All instruments operating over the same sampling interval are intercompared with intercomparison being based on water equivalent and chemistry results. In addition, comparisons are made of same model and different model instruments operating over different sampling intervals. This comparison of daily and weekly samples is made possible by integration of daily samples to create a "synthetic" weekly sample. Graphics are also used to illustrate temporal variability results.

The water equivalent and chemistry results of each instrument are also compared to ground truth measurements. The ground truth measurements include snow pit density measurements (water equivalent only) and snow cores (chemistry and water equivalent). To make these comparisons, the inter-instrument and spatial variability must be quantified; comparisons between instruments and ground truth measurements are generally made on means rather than on individual sample data.

Operational reliability is assessed on the basis of field documentation and data quality. Statistical analyses, comparison to ground truth, and operational reliability are all considered in the evaluation of recommended instruments and sampling intervals; this is the substance of the final project objective.

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The complete report entitled "Wet Deposition and Snowpack Monitoring Operations and Quality Assurance Manual," (Order No. PB 87-212 817/AS; Cost: $18.95, subject to change)
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