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Dynamic Rain Gauge Calibration System

A new calibration system recently implemented at the SGP site will verify the operation of the ARM Climate Research Facility (ACRF) rain gauges and improve the accuracy of rainfall reported throughout the SGP domain. ACRF personnel collaborated with staff at the University of Iowa to develop the new dynamic rain gauge calibration system.

Accurate measurement of precipitation is the most challenging of ACRF's surface meteorology tasks. A rain gauge can only measure the precipitation that falls into its collection funnel; consequently, measuring a wind-driven rain accurately is almost impossible. Rain gauges also give unreliable values for frozen precipitation, such as snow or sleet, because what falls into the gauge must melt before it can be measured.

The tipping-bucket rain gauge used at the SGP site (Figure 1) is the most common instrument used to measure rainfall. This gauge has a funnel collector that directs rain to a tipping-bucket assembly below. The tipping bucket has two small, adjacent "buckets" mounted at a central pivot point that allows the apparatus to tip to one side when full, like an old-fashioned see-saw. The bucket apparatus is balanced about the pivot point, so that when one bucket is filled to capacity it empties itself and positions the second bucket under the funnel. Each bucket tips at the equivalent of 0.01 inch of rain. As the bucket tips to empty, it activates a magnetic reed switch and sends a signal to a data acquisition system that records the time of each tip.

Figure 1. A tipping-bucket rain gauge (foreground) used at the SGP site. The white cylinder is the instrument housing and contains the collector funnel (ARM photo).

Field technicians inspect the rain gauges at the SGP site once every two weeks. The tipping buckets are checked for debris that can accumulate in the buckets or on the screen at the base of the funnel and can keep the mechanism from tipping freely. Animals and insects can deposit debris inside the gauge, and snakes sometimes wrap themselves around the base of the bucket mechanism. Physical wear and tear on the pivots can also hamper tipping

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Technical Contact: Brad W. Orr
Phone: 630-252-8665
Email: brad.orr@anl.gov
Editor: Donna J. Holdridge
Website: http://www.arm.gov

or put the buckets out of level and cause inaccurate measurements.

Two types of calibrations can be done for rain gauges. The first and most common, the static calibration, ensures that the bucket tips when 0.01 inch of rain is collected. Set screws allow adjustment of the height where the bucket rests. Raising the rest point allows progressively smaller amounts of water to cause a tip, while lowering the rest point has the opposite effect. This method allows the bucket to tip accurately for each 0.01 inch of rain collected, but it does not account for the rate at which the water flows into the bucket. To do this, a dynamic calibration is required.

In a dynamic calibration, the rain gauge is tested at 12 different rain rates, ranging from less than 1 inch per hour to 5 inches per hour. The measured output is compared to the expected output, and a mathematical calibration equation is determined. This equation is used to correct the measured rainfall so that it accurately reflects the actual rainfall.

Tipping-bucket gauges work fairly well when rainfall intensity is light to medium. However, during downpours, tipping buckets cannot keep up with the flow of water exiting the collector funnel. As the bucket tips rapidly, some rain fails to enter the bucket or splashes away and is not measured. In this case, the reported rainfall and calculated rainfall rates are lower than what actually occurred.

Rain rate measurements are very useful for hydrologists making flood forecasts and analyzing stream flow. Knowing only the amount of rainfall for a given event is not as critical as knowing how quickly the rain is falling; this knowledge allows timely broadcasting of flood warnings. Rain rates are also needed for hydrologic modeling to identify regions with general flooding conditions and potential stream flooding.

Figure 2. The dynamic rain gauge calibration system in use at the SGP central facility (ARM photo).

To ensure that ACRF precipitation measurements are as accurate as possible, the SGP rain gauges are inspected every two weeks, are statically calibrated in the field every six months, and will be dynamically calibrated on an annual basis at the SGP Central Facility using the dynamic rain gauge calibration system (Figure 2) to ensure that the ARM precipitation measurements are as accurate as possible.