Tipping bucket rain gauges are used in field research to measure rain fall, plot run off, fog, and canopy throughfall. The tipping bucket works by funneling water to a reservoir that is on an axel; when the water fills to a certain weight it causes the reservoir to tip (Figure 1). Each tip is recorded and should hold the same amount of water.

The tipping bucket for measuring water totals on a daily, weekly or annual basis is well known. (La Barbera, 2002) and has solenoid valves (N/C, 11000 OHM’s) connected to each end (Figure 4, 6a, b). When the top solenoid is open and bottom one is closed the pipe fills with water (Figure 6a). When enough water buoy’s the float to the top of the pipe, the solenoids switch and dump the volume of water (Figure 6b). The datalogger (Campbell CR10T) supplies power to the float switch and to the solenoid valve via two solid state relays (Crydom, D1D07) (Figure 6c). The CR10T runs the program provided below.

The largest change between monthly calibrations for the solenoid buckets was 2.4% (Figure 5) compared to 41.9% for the tipping buckets.

The solenoid bucket is comprised of a vertical PVC pipe that houses a float switch (Strain Measurement Device, 9301-001) and has solenoids valves (N/C, 11000 OHM’s) connected to each end (Figure 4, 6a, b). When the top solenoid is open and bottom one is closed the pipe fills with water (Figure 6a). When enough water buoy’s the float to the top of the pipe, the solenoids switch and dump the volume of water (Figure 6b). The datalogger (Campbell CR10T) supplies power to the float switch and to the solenoid valve via two solid state relays (Crydom, D1D07) (Figure 6c). The CR10T runs the program provided below.

Common sources of error when using tipping buckets include: water flow rate, wind turbulence, snowfall, and evaporation (La Barbera, 2002). As a solution, TERA designed a solenoid bucket, a water collector that uses solenoid valves and a float switch to measure water output (Figure 4). The solenoid bucket calibration data (five month sample) and percent change between calibrations is as follows:

![Figure 3: Solenoid bucket calibration data (five month sample) and percent change between calibrations.](image)

<table>
<thead>
<tr>
<th>Month-Year</th>
<th>Calibrated Volume (mL/dump)</th>
<th>% error margin</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mar-09</td>
<td>56</td>
<td>+/-1.2 mL</td>
</tr>
<tr>
<td>Apr-09</td>
<td>96</td>
<td>+1 mL</td>
</tr>
<tr>
<td>May-09</td>
<td>46</td>
<td>-1 mL</td>
</tr>
<tr>
<td>Jun-09</td>
<td>1</td>
<td>-2% change</td>
</tr>
<tr>
<td>Jul-09</td>
<td>0</td>
<td>+2% change</td>
</tr>
</tbody>
</table>

The solenoid bucket can be programmed and wired to a datalogger for use in the field. Measuring 60 mL per dump, a solenoid bucket can fluctuate between +/-1.2 mL and still be within a 2% change margin. By contrast, an 8 mL tipping bucket can only fluctuate between +/-0.16 mL to be within a similar 1% error margin.

Although the larger volume of a solenoid bucket is less effective for recording the time of small events, it may be a more accurate alternative to the tipping bucket for measuring water totals on a daily, weekly or annual basis.

Future work should compare the error from tipping buckets vs. solenoid buckets when water flow is at varying intensities.

### Conclusions

- The solenoid buckets provided substantially more reliable calibrations than the tipping buckets.
- Solenoid buckets can be programmed and wired to a datalogger for use in the field.
- Measuring 60 mL per dump, a solenoid bucket can fluctuate between +/-1.2 mL and still be within a 2% change margin. By contrast, an 8 mL tipping bucket can only fluctuate between +/-0.16 mL to be within a similar 1% error margin.

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### Reference