Hail Estimation: How Good Are Your Spotters?

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The views expressed are those of the authors and do not necessarily represent those of the National Weather Service.
Motivation

- Gain perspective on the accuracy and behavior of our spotter hail reports.
Methodology: Year One

- 63 balls placed into a box ranging from 0.50 to 3.50 inches in diameter.
- Spotters drew one ball out and wrote an estimate to the nearest 1/8 inch.
- Spotters replaced the ball and redrew for a second estimate.
- Statistics calculated.
  - Known as the “number” dataset (NUM).
Methodology: Year Two

- 63 balls placed into a box ranging from 0.50 to 3.50 inches in diameter.
- Spotters drew one ball out and circled the closest estimate from a list of known objects.
  - Allowed for number entry.
- Spotters drew only one ball.
- Statistics calculated.
  - Known as the “known object” dataset (KO).
Methodology: Year Two

- The “known object” (KO) form.

Draw ONLY 1 ball. Circle the size of the ball below. Please do not discuss your answer with others until you enter your estimate. **Your Ball Number is:** ________

<table>
<thead>
<tr>
<th>Dime</th>
<th>Baseball</th>
</tr>
</thead>
<tbody>
<tr>
<td>Quarter</td>
<td>Penny</td>
</tr>
<tr>
<td>Pea</td>
<td>Half-Dollar</td>
</tr>
<tr>
<td>Nickel</td>
<td>Tennis Ball</td>
</tr>
<tr>
<td>Golfball</td>
<td>Softball</td>
</tr>
<tr>
<td>Marble</td>
<td>Walnut</td>
</tr>
</tbody>
</table>

If the ball size is not represented above, fill in your estimate to the nearest 1/8” here________.  

- Pea 0.25”
- Dime 0.75” (0.71” actual)
- Penny 0.75”
- Nickel 0.88”
- Quarter 1.00”
- Half-Dollar 1.25”
- Walnut 1.50”
- Golfball 1.75”
- Tennis Ball 2.50”
- Baseball 2.75”
- Softball 4.50”
Methodology

- Very technological
  - Space-age cardboard
  - Highest-end industry glues
  - Bounty paper towel
  - Permanent marker

- Total Cost: $15.63
  - Grant not funded by NSF
Methodology

Data/Controls:

- Balls were drawn separately - no comparing! (NUM)
- Spotters were able to hold the “hail”.
- About 725 NUM “hail size” estimates were made.
- About 388 KO “hail size” estimates were made.
  - Less because only one draw allowed.

Golden, CO
KO: few attempts 0.75” and below.
KO has less absolute error than NUM.

KO error growth slightly less than NUM as size increases.
Data: Percent Error

- KO remains 5-15% and lower than NUM.
- NUM 21% errors around 0.75”, decreasing with size.
Data: Standard Deviation

- KO STD
  lower overall, especially above 1.50”.
- Near 0.75”, NUM STD nearly 0.25”.

Ball Size Diameter (inches)
Data: Bias

- **NUM** underestimates all below 3.5”.
- **KO** bias less and also negative except 1.50”.
  - Special 0.50” KO case

![Bias Per Size Graph](image)

- **KO**
- **NUM**

Ball Size Diameter (inches)
KO better average estimates overall.

Data: Average Estimate

Average Estimate Per Size

KO

NUM

Perfect

High

Low

Ball Size Diameter (inches)
Data: 0.5” Distribution

- Few draws.
- NUM underestimates.

![Bar graph showing size guesses and their frequency. The x-axis represents size guessed in inches (0.25, 0.38, 0.50, 0.63, 0.75) and the y-axis represents the number of times guessed. The colors red and blue represent different categories, with red indicating KO and blue indicating NUM. The values shown areKO: 4
NUM: 17.
Data: 0.75” Distribution

- Few KO draws.
- NUM: 50% underestimates.
- KO signs of more accurate.

![Histogram](chart.png)

- **KO**
- **NUM**

0.75 inch Distribution

<table>
<thead>
<tr>
<th>Size Gessed</th>
<th># of Times Guessed</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.25</td>
<td>1</td>
</tr>
<tr>
<td>0.38</td>
<td>1</td>
</tr>
<tr>
<td>0.50</td>
<td>1</td>
</tr>
<tr>
<td>0.63</td>
<td>2</td>
</tr>
<tr>
<td>0.75</td>
<td>19</td>
</tr>
<tr>
<td>0.88</td>
<td>4</td>
</tr>
<tr>
<td>1.00</td>
<td>1</td>
</tr>
<tr>
<td>1.13</td>
<td>1</td>
</tr>
<tr>
<td>1.75</td>
<td>1</td>
</tr>
</tbody>
</table>

TOTALS 09

NUM: 49
Data: 1.00” Distribution

- **NUM**: 50% underestimates.
- **KO** more accurate.
Data: 1.25” Distribution

- NUM and KO show underestimation toward 1.00”.
- 1/8” size estimates not preferred.
Data: 1.50” Distribution

- NUM 50% underestimate.
- KO shows strong bias toward golfball (1.75”).
- Only KO size with positive bias.
Data: 1.75” Distribution

- NUM 45% underestimates.
- KO hits many! Low error and STD!
Data: KO Draw vs. Estimated

- People drawn toward the Quarter and Golfball sizes.
- Half-Dollar and Walnut poor KO’s?
Data: KO Draw vs. Estimated

- Fewer reports for 1.25” and 1.50” also in Baumgardt and King (Fig. 1, 1998).

Summary: Limitations

- NUM dataset has double draw. Does that lead the witness on guess #2?

- Larger diameter balls drawn more. KO family <0.75” not large in number.

- Unfamiliar with Walnut size (vs. Ping-pong)?

- Large amount of data discarded – people can’t follow directions.
Be aware that spotters tend to underestimate hail overall.

Having spotters associate hail size to known object is more accurate than numeric estimates.

- Encourage spotters to measure hail size directly.

Using numeric estimates produces a large number of underestimates: 40-50%. If they report above 0.50” to 0.75”... it is likely severe! (bias ~ -0.15”)

As “hail” sizes grow, more deviation from the truth occurs.

For 1.00-1.75” diameter sizes, people tend to go toward Quarter and Golfball sizes.
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