Calculating U.S. Cave Temperatures

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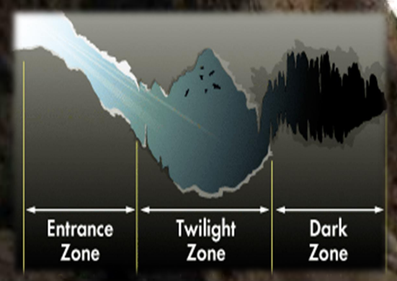
This poster is based on Connor Powell's Senior Thesis.

INTRODUCTION

If one divides a cave into three zones: entrance (light), twilight (less light), and the dark zone (no light); it has long been recognized that the dark zone of most caves maintains a stable temperature. And that the temperature in the dark zone of the cave often reflects the average annual temperature at its surface. Surface temperature fluctuations are stabilized at depth, such that the country rock from which the cave is formed acts as a heat source – assuming here that there is only a single heat source. Surface temperatures are themselves influenced by the geographic position of the cave – latitude and altitude. It is this relationship between surface temperatures and cave temperatures that has allowed the development of basic empirically derived equations to calculate cave temperatures.



REFERENCES:

Choppy, J. 1990. Temperature de l'air, In: Volume 113 of Synthèses spéléologiques et karstiques: Processus climatiques dans les vides karstiques, Published by the Spéléo-Club de Paris, 73pp.

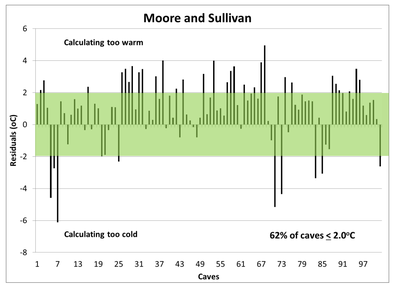
Moore, G.W. and G.N. Sullivan, 1978. Speleology: The Study of Caves, Cave Books, St. Louis, MO, 150 pp.

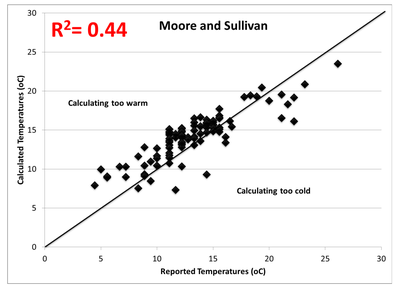
Earlier Equations

Moore and Sullivan (1978): T = 38 - (0.6*L) - (0.002*A)
Choppy's Law (1990): T = 44 – (0.8*L) – (0.0066*A)

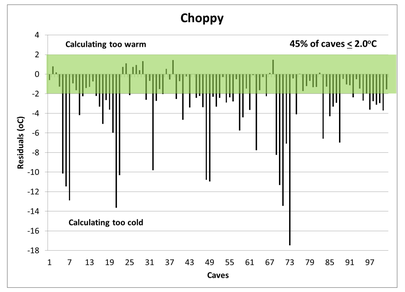
Where T = temperature (Celsius)
L = latitude (degrees)
A = altitude (meters)

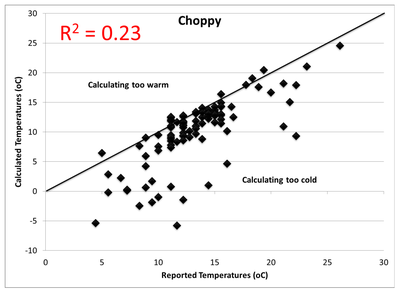
Residuals provide the plus/minus errors between reported and calculated cave temperatures.





Moore and Sullivan

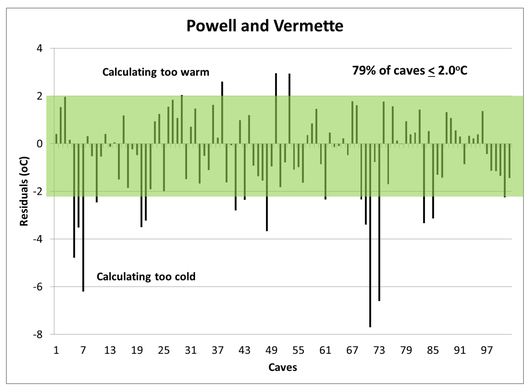


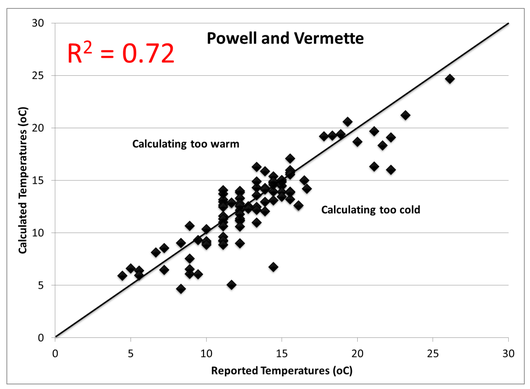


Choppy

New Equation

Powell and Vermette (2013): T = 44 - (0.8*L) - (0.0018*A)





Powell and Vermette

Developed by using regression equations based on temperature, latitude and altitude from 103 caves. While independent of the earlier two equations, the reader cannot help but notice that the coefficients of the Powell and Vermette equation appear as a hybrid – latitude coefficients resemble Choppy's Law, and the altitude coefficient resembles that of the Moore and Sullivan equation.

METHODOLOGY

To evaluate each of these formulas we gathered self-reported cave temperatures and locational data from 103 caves in North America. The data were obtained from commercial cave web sites and e-mail responses. The cave data are representative of 29 states. The data ranged in latitude from as far north as 46.7°N to as far south as 23.9°N. Surface elevations ranged from 27 m to 2,263 m above sea level.

RESULTS

The Powell and Vermette equation provides the best first approximation of cave temperature (explaining 72% of temperature variability) based on the caves latitude and altitude, as compared to 23% to 44% using earlier equations. For any particular cave, a variation (residuals) from the calculated temperature provides an opportunity to explore and quantify other influences on temperatures within the cave.