Exploring Soil Moisture Protocol Alternatives
For the Classroom Setting

Garrett Smith[1, 2], Erika Podest[2], Narendra Das[2]
[1]California State University, Long Beach, CA, USA, [2]Jet Propulsion Laboratory, California Institute of Technology Pasadena, CA, USA.

Introduction

Climate change poses a direct threat to future water resources but current climate models suffer from uncertainties regarding the availability of regional water. SMAP or the Soil Moisture Active Passive mission seeks to make improvements to climate models by taking highly accurate, high resolution measurements of global soil moisture. To engage students around the world in a collection of meaningful data that may support the SMAP satellite mission, the Global Learning and Observations to Benefit the Environment program or GLOBE, has forged a partnership with NASA and JPL. GLOBE brings the power of citizen science to the SMAP mission, empowering youth around the world to participate in scientific research. To ensure global participation, this project seeks to develop a safe and economically feasible soil moisture protocol for all students, focusing on alternatives for heating soil.

Heat Alternatives

This research compares the following alternatives to a conventional laboratory oven:

250 Watt Lamp

Space Heater

DIY Solar Oven

DIY Solar Tube

Project Goals and Requirements

Project Aim:
Adapt and expand upon current Gravimetric-based GLOBE soil moisture protocol to better fit the needs of the Volumetric-based measurements that will be acquired by the SMAP mission

- ✓ Design and explore alternative soil heating methods
- ✓ Compare alternative methods to Laboratory Oven standard
- ✓ Develop grade level-appropriate research projects relating to soil moisture
- ✓ Develop a volumetric soil moisture instructional video

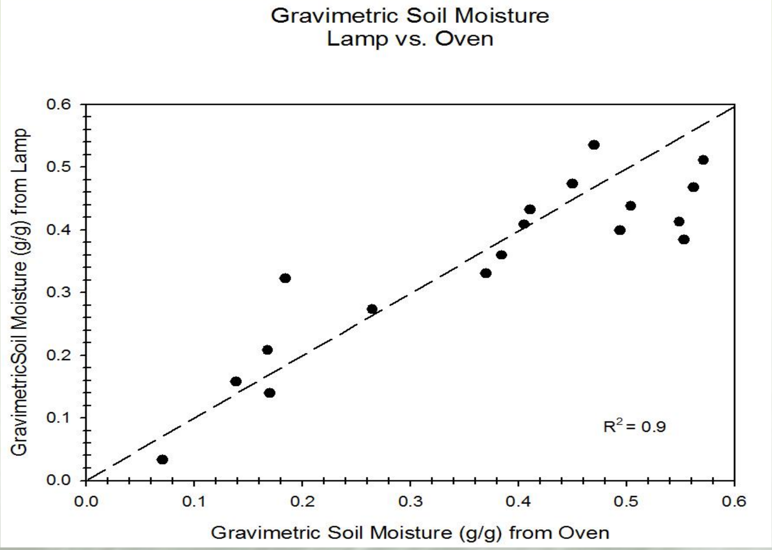
The alternative methods of heating soil must be:

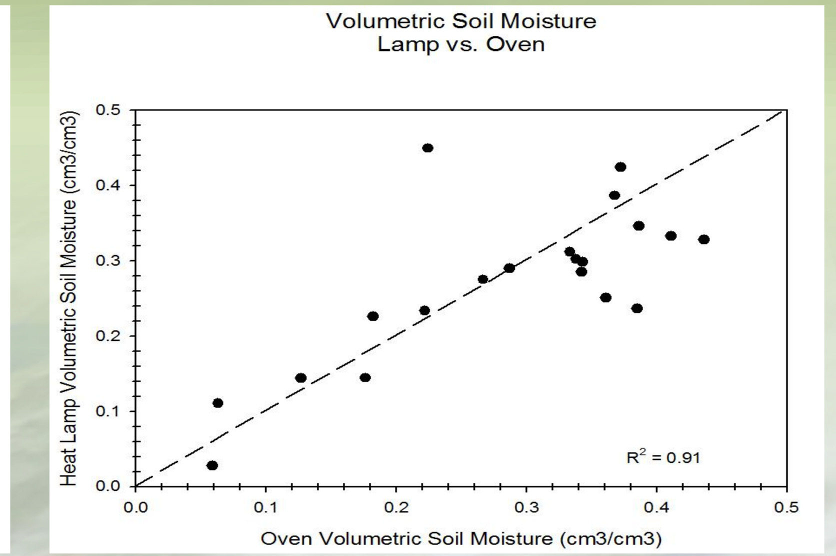
- ❖ Safe for the classroom setting
- ❖ Economically feasible
- ❖ Widely available
- ❖ Reliable all over the world
- ❖ Able to reach temperatures of 65-90^{o} C

Results

The preliminary results are generated from the collection of 17 samples from the JPL lab site. Gravimetric Soil Moisture measurements are the result of comparing the mass of soil with and without moisture. We compared the soil moisture samples dried with a traditional Laboratory Oven and a 250 watt Infrared Heat Lamp and results yielded an R^2 value of 0.9.

Volumetric Soil Moisture measurements require in addition to Gravimetric Soil Moisture measurements, a measure of the volume of the soil collected. Volume alone, however does not account for varying soil densities. Soil Bulk Density is the measure of how dense and tightly packed a sample of soil is. It is determined by measuring the mass of dry soil per unit of volume (g/cm^3). The Average Bulk Density of all 17 can samples is 0.725 g/cm^3. The Standard Deviation of bulk densities is 0.258. Volumetric Soil Moisture (g/cm^3) is the product of Gravimetric Soil Moisture (g/g) and Bulk Density (g/cm^3). Using Volumetric Soil Moisture measurements to compare the Laboratory Oven and the Heat Lamp results in an R^2 value of 0.91 suggesting that the Lamp is a sufficient method of drying soil for the purpose of obtaining Volumetric Soil Moisture.





In order to determine the effectiveness of the 250 watt Heating Lamp the samples are weighed, dried for two days and weighed again. The samples are then placed in the Laboratory Oven for an additional day then weighed a final time. Any significant difference in weight would indicate that the samples were not dried sufficiently using the Heat Lamp. Results show the Average Difference in mass between Dry Mass 1 and Dry Mass 2 for the 250 watt Heating Lamp is 0.332 g. The Standard Deviation of the difference between Dry Mass 1 and Dry Mass 2 for the 250 watt Heating Lamp is 0.281. These results indicate that the Heat Lamp is a reliable method of drying.

Methodology

Sampling

Massing*

Drying

Volume

*Massing occurs at three points: Container Mass, Wet Mass, Dry Mass

Conclusion

Method	Heating Capacity	Cost	World-Wide Availability	Other Constraints
Lab Oven	Standard	High	Low	Cost/availability
Heating Lamp	Great	Affordable	Low	NA
Solar Oven	Undetermined	Low	High	Sunlight-Dependent
Solar Tube	Undetermined	Low	Unknown	Sunlight-Dependent
Space Heater	Undetermined	Affordable	High	NA

Because data on the Space Heater is preliminary, the recommendation of this project is to adapt the Volumetric Soil Moisture Protocol to include the 250 watt Infrared Heating Lamp as well as to continue research on more alternative sources of heat.

This material is based upon work supported by the Chevron Corporation, Howard Hughes Medical Institute, the National Marine Sanctuary Foundation, National Science Foundation, and S.D. Bechtel, Jr. Foundation. Any opinions, findings, and conclusions or recommendations expressed in this material are those of the authors and do not necessarily reflect the views of the funders.
The STAR program is administered by the Cal Poly Center for Excellence in STEM Education (CESAME) on behalf of the California State University.