Towards accurate measurement of soil freezing characteristic curves

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Challenges

- Accurate temperature control
- Accuracy of measurement
- Accomodation of volume change
- Calibrating results with reference measurement
- Fast experiments

Approach

- Temperature control in dense liquid (glycol and water)
- Measurement of dielectric spectra (kHz to MHz range)
- Cylindrical sample cell to accomodate volume change
- Temperature control software using sample temperature
- Sample cell to allow drying in oven to obtain water mass

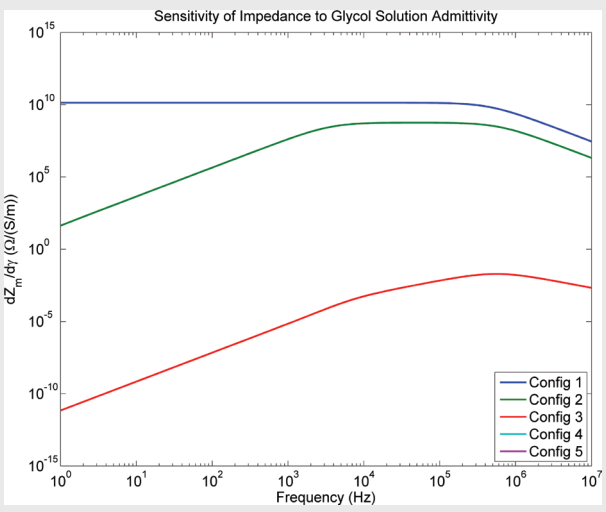
Progress

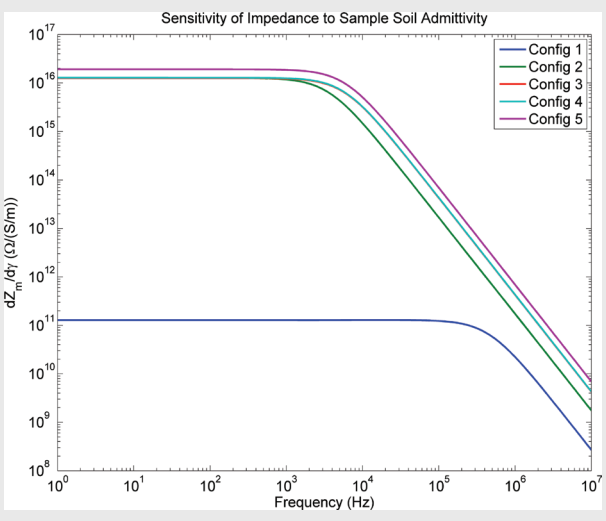
- Optimised sample cell design based on simulating loaded cell in glycol bath
- Prototype of sample cell built for temperatuer range of -25°C to 110°C.
- Temperature control achieves equilibration within +/- 0.01°C
- Automatic temperature cycling with variable step size as small as 0.02°C.
- First test measurements of dielectric spectra

Preliminary results

Cell design and simulation

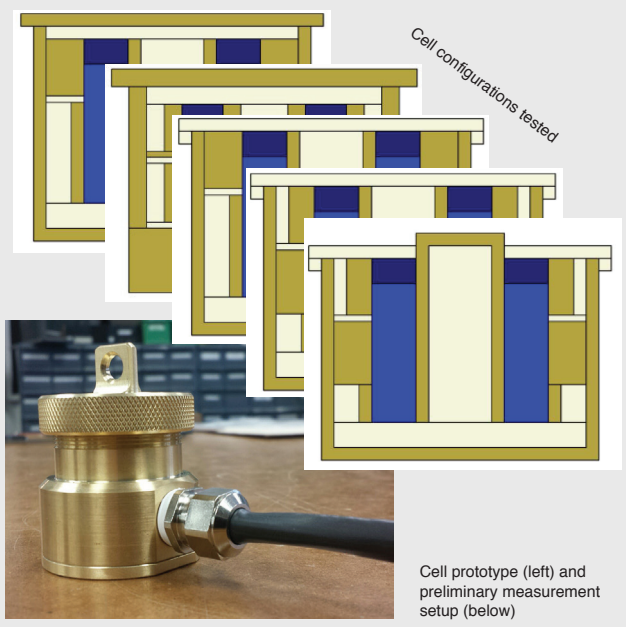
Differing configurations of the sample cell were tested in a numerical simulation in order to optimise the soil measurement.



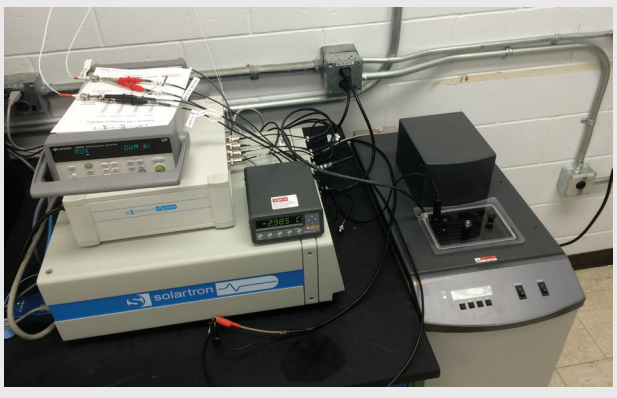


Measurement setup

A prototype was built based on simulation results. The setup contains a calibration bath, a reference thermometer, a data acquisition unit to measure thermistors, a frequency analyser, and a computer for experiment control.

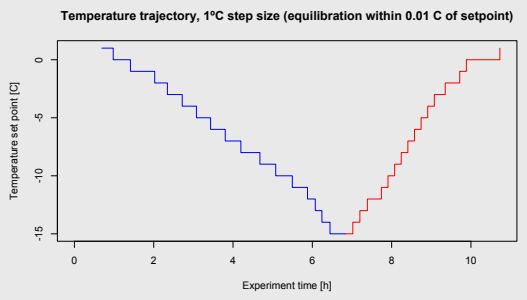


Cell prototype (left) and preliminary measurement setup (below)

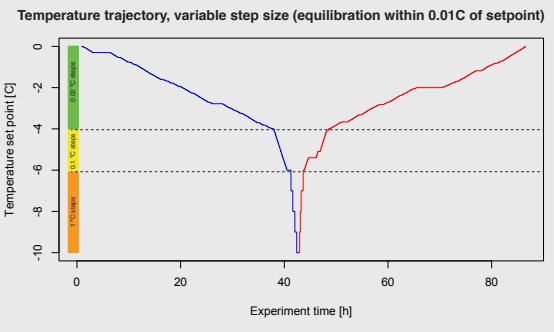


Temperature control

Temperature equilibration is quantified with two thermistors, one in the outside wall and one in the central electrode of the sample cell. Heating is faster than cooling for large temperature step sizes.



Experiments can run with variable step size. For fine step sizes of 0.02 °C, equilibration times are mostly below 10 minutes but few large deviations require about 40% of experiment time. Deviations are partly related to soil freezing.



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