

Comment on soil-2021-72

Anonymous Referee #2

Referee comment on "An underground, wireless, open-source, low-cost system for monitoring oxygen, temperature, and soil moisture" by Elad Levintal et al., SOIL Discuss., <https://doi.org/10.5194/soil-2021-72-RC2>, 2021

Environmental monitoring is changing towards distributed measurements over large areas using wireless sensor networks since many years. The next logical step is to extend this technology to underground operation. The main aspects are related to the electromagnetic wave propagation of the radio, power supply for long term operation (and water proofness).

The strong point of this paper is that it provides a guided path to a low cost underground wireless sensor network using readily available components. It is a good description and the open source nature of this project is highly appreciated. Therefore is a great starter for anyone interested in this field of research and encourages others to become part of this project. I guess this is one of the main goals of this paper, therefore a significant achievement and worth to be published.

There are two aspects which lack a bit:

1.) Underground wireless sensor networks already have entered the commercial domain. The first systems appeared on the market for farmers and for irrigation control in municipalities. In some parts of Europe LoRaWAN (and NB-IoT narrow band internet of things) networks are nationwide available even offering underground connectivity at some places. E.g. Czech IoT companies offer IP68 rated underground wireless soil moisture sensing for farming, golf courses and municipal parks. A short reference to such systems may be helpful.

2.) The authors may comment on using their proprietary LoRa radio protocol versus the standard LoRaWAN protocol. I understand that they wanted to optimized the protocol and it may be simpler to implement, but LoRaWAN has some good points as well like adaptive datarate and multichannel reception. Adaptive datarate can help to save power

consumption when being close to the gateway. Multichannel could be beneficial in case of multipath propagation. The authors may also comment on the choice of the frequency. Usually lower frequencies are better for penetration soil. Besides 433 MHz instead of 900 MHz in some countries even a frequency around 170 MHz can be used which allows for a much larger range. As far as I understood the authors change only power level. What about changing LoRa spreading factor? Please also specify your LoRa settings. It may be looked up on Github, but would be good to see it in the paper.

Some further comments:

One reviewer mentioned that power regulations may vary between regions. In Europe there are also some frequencies in the 868 MHz range allocated for higher power (27dBm, but bandwidth and duty cycle dependent). So in order to comply with regulations a very thorough look into the frequency band plan is required, especially if higher power levels are requested. I am a bit confused with the power levels mentioned. In the summary of hardware components the RFM95 module is mentioned. According to the manufacturers datasheet a maximum output power of 20 dBm is possible. Do you really get 23 dBm out of the module?

As already stated by another reviewer battery technology is important. Lithium thionyl chloride batteries are state of the art with extremely low self discharge and relatively low costs. The reviewer is using D-cells with less than 1% self discharge per year and 19 Ah. Double D cells with 35 Ah are also available (size of underground enclosure is usually not critical). Energy harvesting may be an option for unlimited lifetime but is still not mature enough and suffers from principle physical limits.

It may be a bit too deep in technical details, but please be careful when using the SDI-12 Arduino library with just the IO ports of the controller and not having an appropriate hardware interface according to the SDI-12 specification (see sdi-12.org) . It may work, but may be out of specification.

The authors discussed the range of their underground wireless system. I think there is still some demand for further research in modelling underground electromagnetic wave propagation, probably not within this paper but in future research.