The Kellogg Soil Survey Laboratory Facilitates Soil Spectroscopy Research on a Global Scale

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Mid-infrared (MIR) soil spectrometry offers a rapid, cost-effective technique for reliably estimating soil properties (such as clay, organic carbon, pH, etc.) for soil classification, mapping, monitoring, and decision making for soil conservation. Calibrating an MIR spectrometer is like calibrating a pH meter, but instead of the single instrument response of a pH meter, an MIR spectrum comprises hundreds of overlapping instrument responses for different soil properties, requiring a higher order of calibration method. The Natural Resources Conservation Service (NRCS) Soil and Plant Science Division (SPSD) invested in soil MIR spectroscopy based on proofs-of-concept established by trailblazers, many outside the United States, and on the realization that most of the hard work needed to prepare MIR calibrations was already done: soil samples had been collected, described, analyzed and stored in the Kellogg Soil Survey Laboratory (KSSL) national soil archive. In 2017 and 2018, SPSD piloted MIR technology to the Salina, Kansas, field office, with outstanding results (Application of Mid-Infrared Spectroscopy in Soil Survey – Seybold – 2019 – Soil Science Society of America Journal – Wiley Online Library). As of 2023, MIR technology has been deployed to NRCS SPSD field offices from Puerto Rico to Alaska.

Even as MIR spectroscopy sees widespread practical applications across the globe, it is also an open area of research. One topic concerns the transferability of calibrations among different makes and models of MIR spectrometers. Calibrations built on spectral data collected on a modern MIR spectrometer are stable and, in principle, last forever. This is important because robust MIR calibrations typically require hundreds of samples and weeks or months of work to collect the data. The daily re-calibration required for most laboratory instruments would never be practical for MIR. That said, calibrations built for MIR instrument model “A” are, strictly speaking, meant for instrument model “A” and instruments like “A” and not necessarily directly transferable to MIR instrument model “B” with different configuration. Understanding and solving calibration transfer among instruments would greatly increase the value and applicability of MIR spectral libraries, such as growing the KSSL MIR spectral library.

Two years ago, in the interest of facilitating research around limitations and best approaches for calibration transfer, the KSSL furnished 60 diverse samples with reference data to the Woodwell Climate Research Center (WCRC – formerly Woods Hole Research Center). USDA National Institute of Food and Agriculture (NIFA) Award 2020-67021-32467 funds the WCRC “Soil Spectroscopy for the Global Good” initiative (https://soilspectroscopy.org/about/). WCRC then distributed these samples to 20 spectroscopy facilities worldwide to compare instrument responses towards answering key questions around the transferability of calibrations among instruments and optimal data processing methods for doing so (fig. 1).

These efforts resulted in the December 2023 article in Geoderma – An Interlaboratory Comparison of Mid-Infrared Spectra Acquisition: Instruments and Procedures Matter – ScienceDirect. In the soil spectroscopy world, this major paper is making soil spectroscopy more accessible by illuminating limitations and details for optimal calibration transfer. Additionally, the KSSL is mentioned about 50 times, showcasing the KSSL's participation in this high-quality, necessary, progressive, and cutting-edge global soil spectroscopy research endeavor. Please have a look!

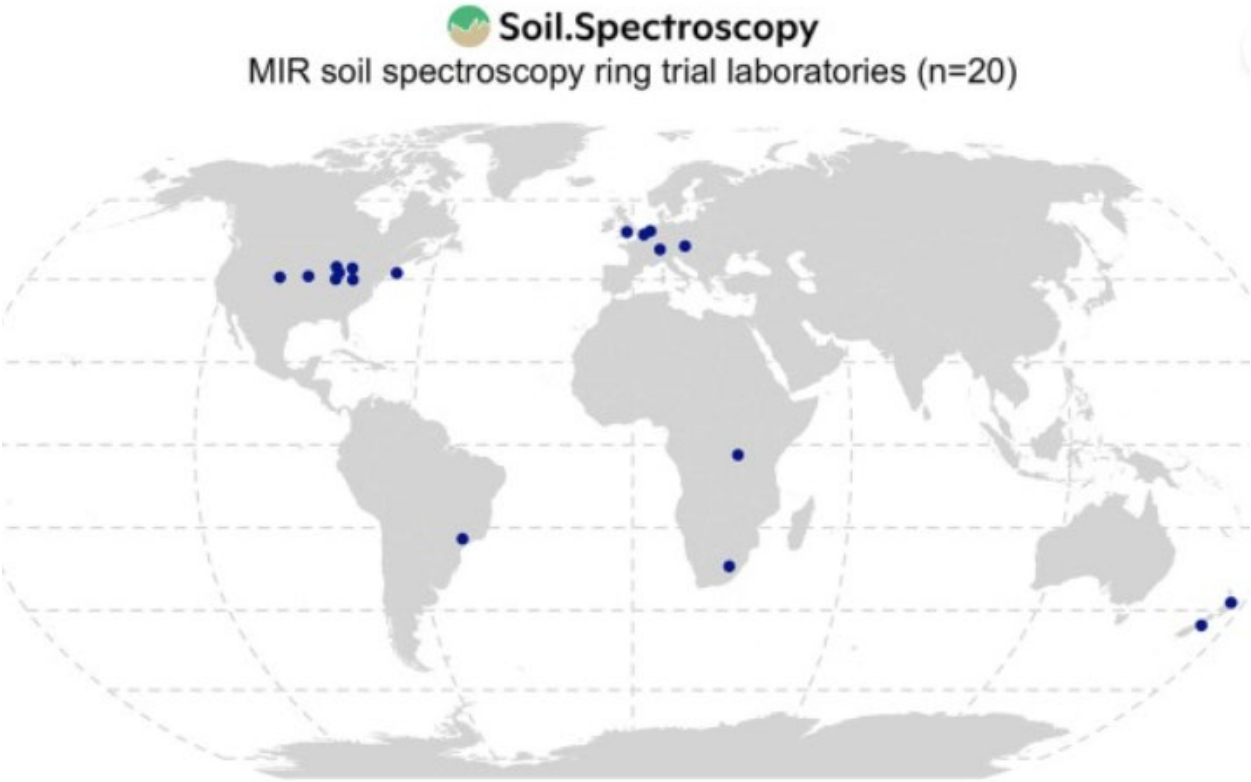

Figure 1. World map identifying the location of the 20 MIR soil spectroscopy ring trial laboratories using blue dots.