SoilMAP: An Open Source Python Library for Developing Algorithms and Specialized User Interfaces that Integrate Multiple Disparate Data Sources Including Near-Real-Time Sensor Data for Streamlined Monitoring of Experiments and Analysis.

Jerry Bieszczad[1], Mattheus Ueckermann[1], Rachel Gilmore[1], and Marek Zreda[2]

[1]Creare LLC
[2]Univ Arizona

November 22, 2022

Abstract

COSMOS soil moisture sensors provide meso-scale area-averaged soil moisture estimates, presenting a unique opportunity for validating remotely sensed soil moisture data from satellite sensing platforms such as SMAP. New, roving COSMOS sensors can provide greater spatial coverage than their stationary counterparts. However, COSMOS sensors require careful site-specific calibrations, which are not available for roving sensors. As such, it is critically important for researchers to monitor roving COSMOS collection campaigns in near-real-time. However, specialized user interfaces are needed for rapid analysis. Moreover, harmonizing remotely sensed data (such as Landsat, SSURGO, MODIS, SMAP, and SRTM) with a roving COSMOS sensor is non-trivial and requires great care that cannot be accomplished on-the-fly in the field. To address these problems, we are developing the open source SoilMAP (Soil Moisture Analysis and Processing) software, which is a specialized analysis application for COSMOS and SMAP soil moisture data. We are developing this application using PODPAC (https://podpac.org/), a cloud-ready open source Python library for large-scale analysis and on-demand processing of raw earth science data. Our soil moisture analysis application aims to provide (1) customizable, rapid, near-real-time visualization and analysis of COSMOS and SMAP data; (2) unified data access and automated data wrangling to harmonize roving COSMOS measurements and SMAP L3 data; and (3) a streamlined workflow for developing roving COSMOS sensor calibrations with uncertainty estimates. We will demonstrate on-demand processing of raw soil moisture data retrieved from COSMOS sensors and SMAP L3 data using our SoilMAP software framework. We will also show our user workflows specialized for (1) staging data from various remotely-sensed and in-situ sensors, (2) monitoring a COSMOS data collection campaign in near-real-time, and (3) analyzing the resultant data with comparison to SMAP soil moisture. We will outline the steps required to build and customize this application. SoilMAP greatly reduces the burden of analyzing, comparing, and validating soil moisture data using measurements from roving COSMOS sensors.

NS21B-0814
AGU100 ADVANCING EARTH AND SPACE SCIENCE

SoilMAP: An Open Source Python Library for Developing Algorithms and Specialized User Interfaces to Streamline Analysis and Remote Monitoring of Experiments

Creare LLC
J. Bieszczad
M. Ueckermann
R. Gilmore
University of Arizona
M. G. Zreda

Motivation

- **COSMOS sensors** use cosmogenic neutrons to estimate **meso-scale** area-averaged **soil moisture**
- **Roving COSMOS sensors** can cover large areas, and present a unique opportunity for **validating** remotely-sensed soil moisture data from satellites platforms such as **SMAP**
- **COSMOS** sensors **require site-specific calibrations**
- When **collecting soil state data** using roving COSMOS sensors, it can take **hours to days** before the data can be:
  - **Visualized**
  - **Compared** to other data sources
  - **Integrated** into an analysis or derived product
- **Automated harmonization** of varying observational input datasets is needed to rapidly **integrate and validate** new sensor data
- **Near-real-time analysis** of field data is needed to **monitor** and **improve data quality**
- **Customized user interfaces (UIs)** are needed for **rapid analysis** while operating **in the field**

Project Objectives

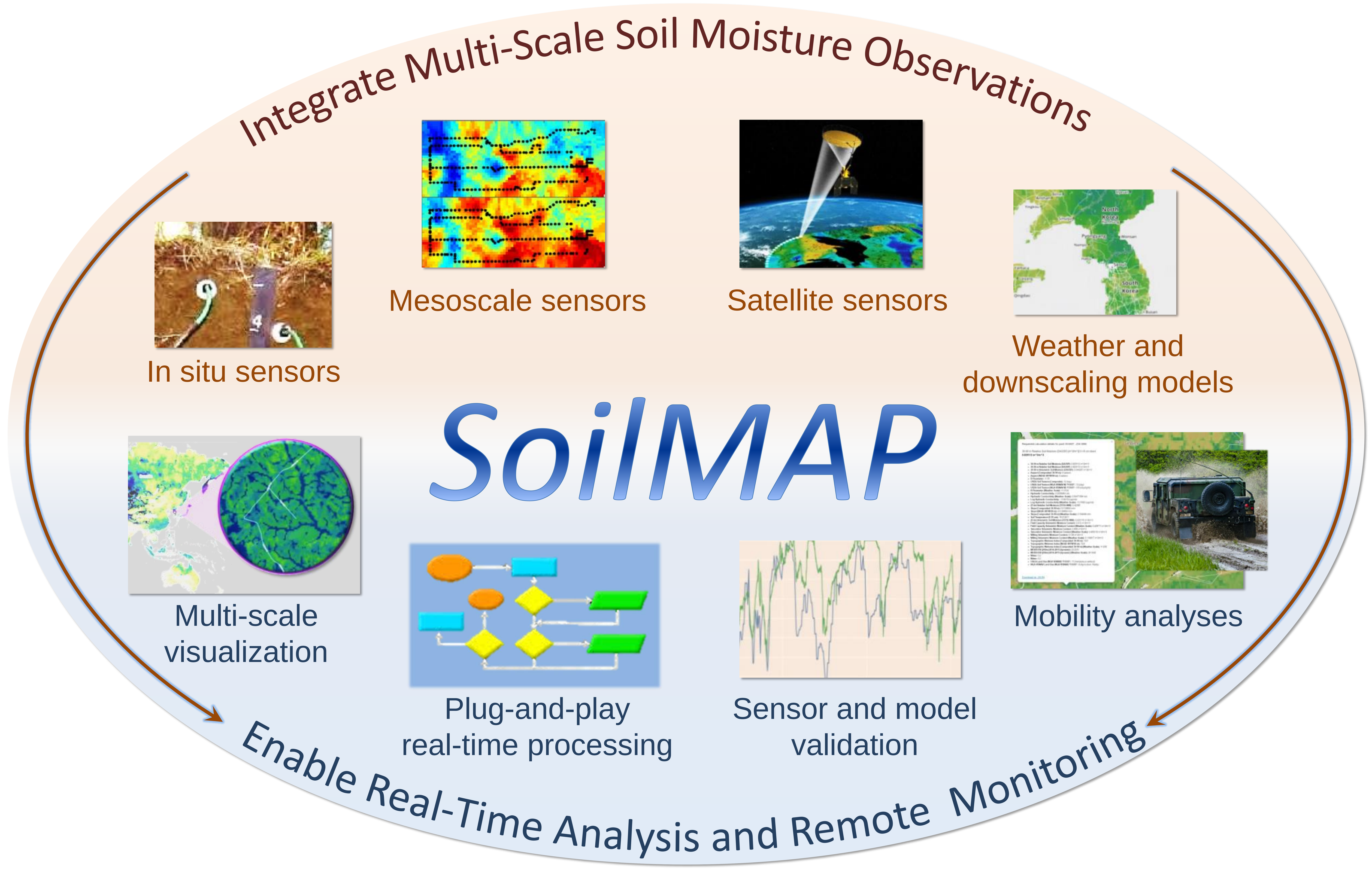
- Develop SoilMAP software with specialized analysis application for COSMOS and SMAP soil moisture data
- Create customizable UI for rapid, near-real-time visualization and analysis for COSMOS and SMAP data
- Develop unified data access and automated data harmonization to facilitate comparison of roving COSMOS measurements and SMAP L3 data
- Create streamlined UI for developing customized COSMOS sensor calibrations with uncertainty estimates
- Generalize UI development framework allowing users to customize and build UIs using high-level schemas

Open Source Development

- SoilMAP is built using PODPAC, which is open-source software available at https://podpac.org

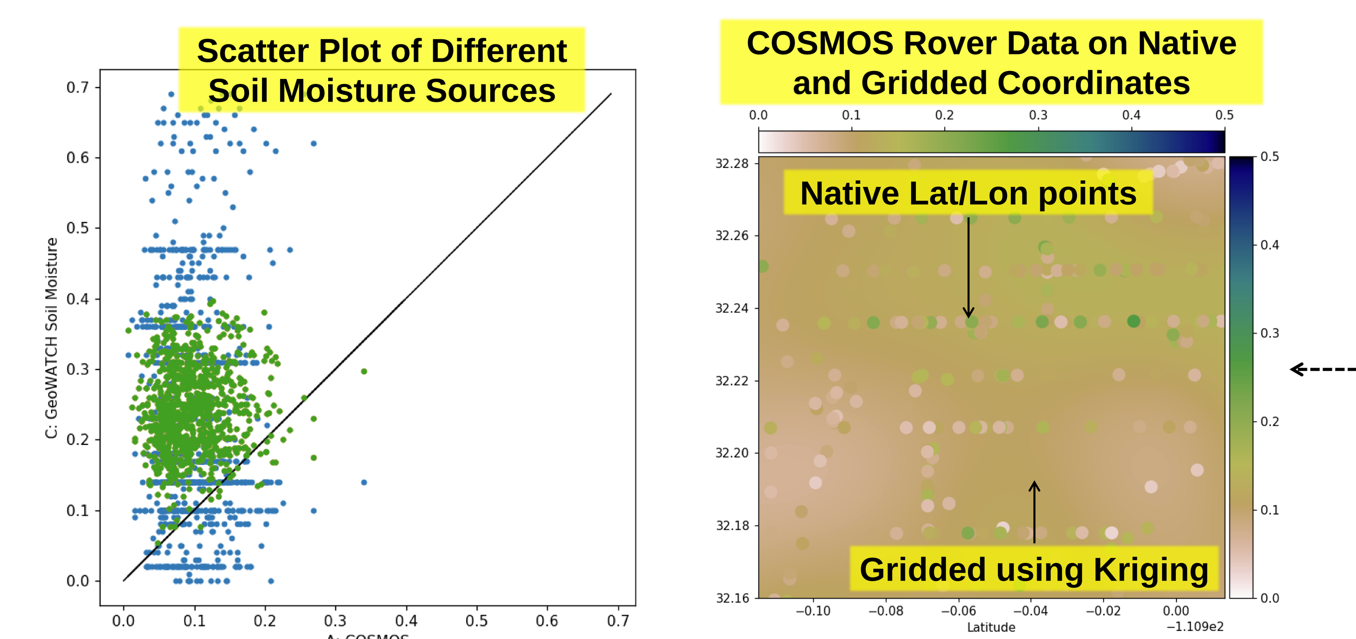
Acknowledgement

- This research is supported by the US Army ERDC under SBIR Phase II Contract No. W9132V19C0002



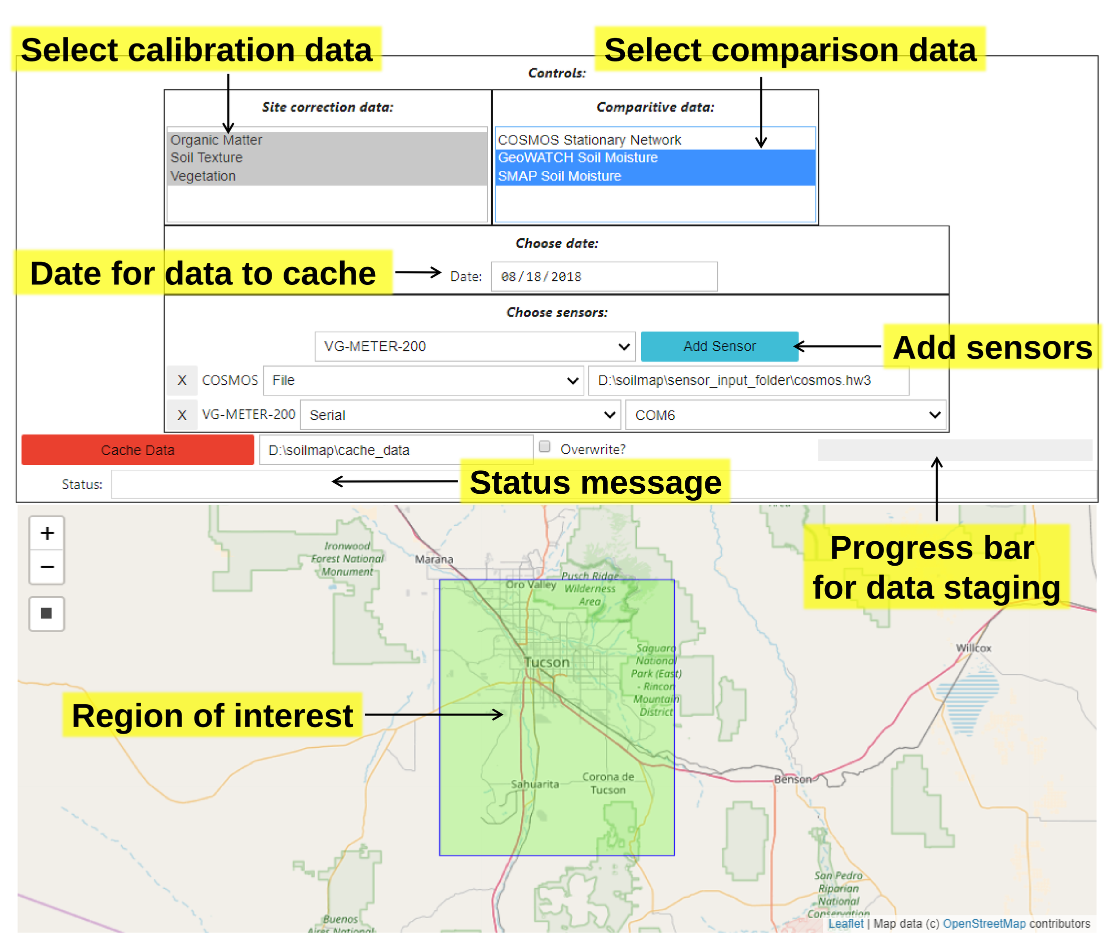
Technology

- Leverages Jupyterlab framework to build interactive, customizable UIs
- Uses open source scientific Python stack



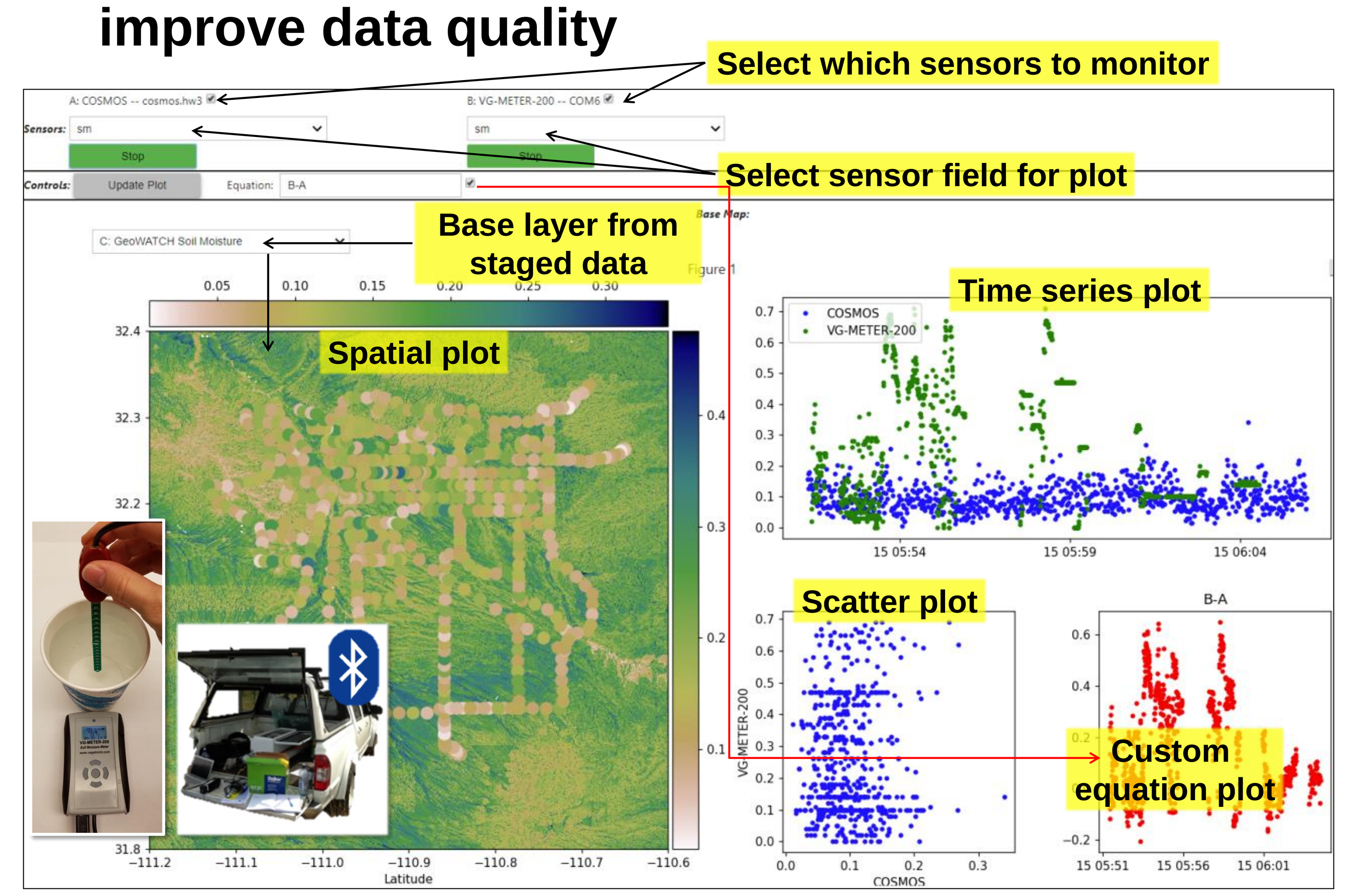
COSMOS Use Case Application

1. **Field Data Collection. Experimentalist wants to store data for offline access in the field**



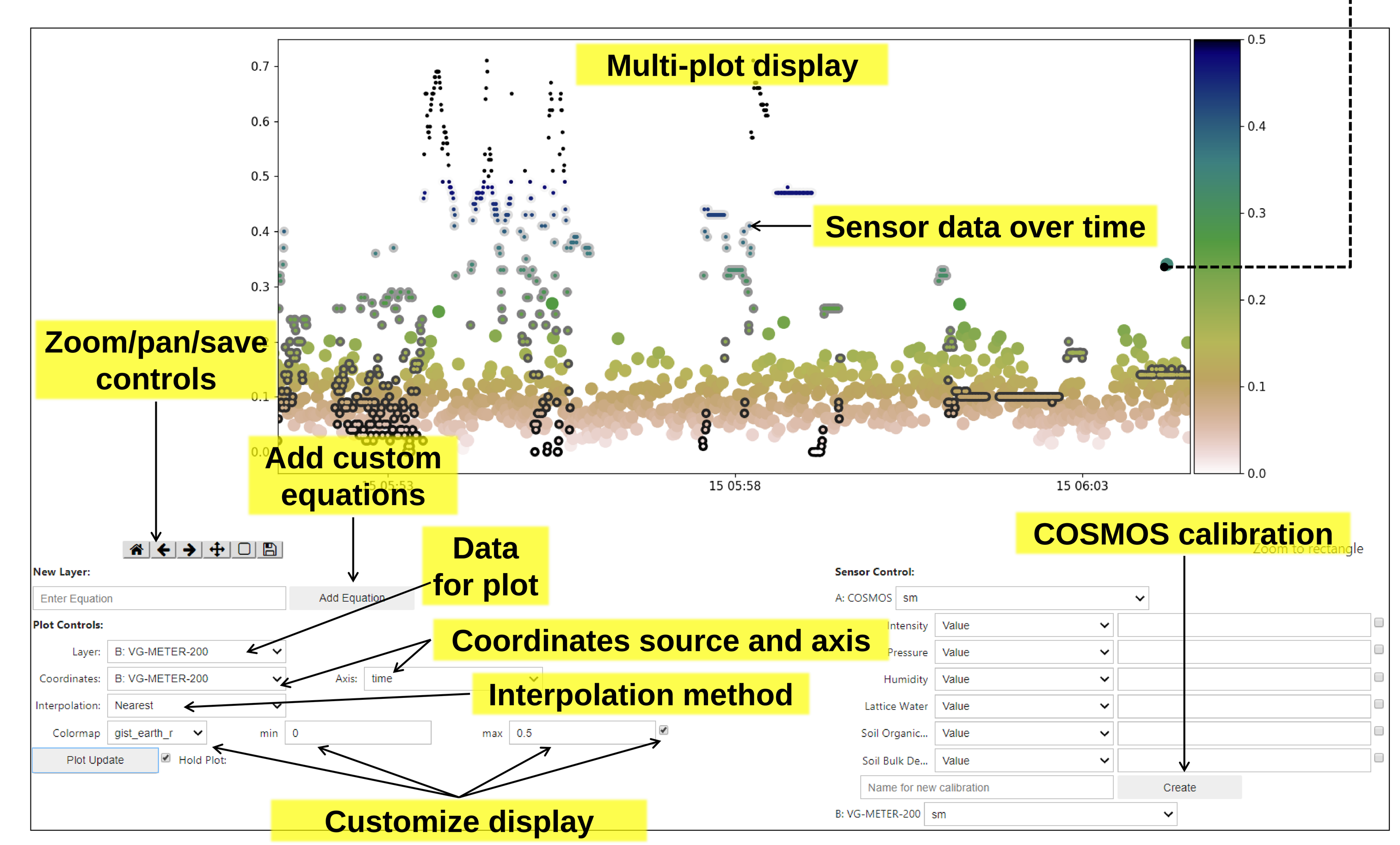
SoilMAP UI stages data

2. **Remote Monitoring. PI wants to monitor experiment to direct resources and improve data quality**



SoilMAP ingests sensor data and plots in near-real-time

3. **Post Analysis. Researcher wants to analyze experimental results to improve COSMOS calibration**



SoilMAP allows rapid plotting, data harmonization, and creation of custom COSMOS calibrations