# Advancing ecosystem research with reliable soil $CO_2$ measurements

VAISALA

Case Study

**The client:**

NEON operated by Battelle

**Vaisala solution:**

CARBOCAP® Carbon Dioxide Probe GMP343

The U.S. National Science Foundation's National Ecological Observatory Network (NEON), operated by Battelle, is a vast, continental-scale facility dedicated to gathering long-term ecological data. Its goal is to advance the understanding of ecological processes to inform sustainable ecosystem management and track diverse ecosystems with 81 freshwater and terrestrial field sites.

## THE CHALLENGE:

### Accurate, long-term soil $CO_2$ measurements

An important part of NEON's Terrestrial Instrument System (TIS) Science is to measure $CO_2$ concentration in soil air at given depths. The $CO_2$ concentration data can be used to understand soil respiration. This is a valuable observation because soil respiration represents one of the largest fluxes of carbon from ecosystems to the atmosphere.

Most of the $CO_2$ that escapes from the soil into the atmosphere comes from the respiration of organisms living within it, such as plant roots, microorganisms and soil animals. Soil respiration is a key indicator of biological activity and the main route for carbon stored in soils to enter the atmosphere. A small change in the soil respiration rate can thus have a major impact on the whole atmospheric $CO_2$ budget and on the global ecosystem.

## THE APPROACH:

### Exceptionally accurate and robust measurement technology

Soil properties can vary significantly over short distances, making it difficult to obtain representative samples. Each terrestrial field site has five sensor-based soil plots, spaced up to 40 meters apart, to capture variability in the locally dominant soil type.

The process involves measuring soil $CO_2$ concentrations at three different depths (typically from 2 cm to 12 cm, deepest at 20 cm below-ground) using Vaisala CARBOCAP® Carbon Dioxide Probes model GMP343, which have a measurement range of 0 to 2%. With the $CO_2$ concentration obtained from three sensors, a $CO_2$ concentration profile with depth is created and when combined with soil $CO_2$ diffusivity data, can be used to estimate soil respiration rates and $CO_2$ efflux into the atmosphere.

*GMP343 sensors are located inside access tubes within a soil plot (Source: NEON Doc. #: NEON.DOC.003633 NEON Preventive Maintenance Procedure: Soil $CO_2$ Concentration)*

Sensors installed in soil face several common challenges: Condensation, corrosion, and changing environmental conditions can compromise design integrity and measurement consistency.

To combat various soil conditions at multiple TIS location, the science team has designed a robust soil assembly to protect the sensor from corrosion and wet soils. The vertical installation was selected to allow regular calibration and maintenance of the sensors to be performed while maintaining an undisturbed soil profile. To ensure accurate $CO_2$ measurement, the probe has an internal temperature sensor in the gas sampling area plus an internal algorithm for pressure, humidity, temperature and oxygen compensations if these measurements are available.

## THE RESULTS:

### A field proven device providing long term data in NEON network

Battelle completed the full NEON network construction in 2019.

The probes — about 700 in all — have been providing critical soil $CO_2$ concentration data, accurately and consistently. This allows NEON to continuously capture patterns and cycles across various time periods, ranging from seconds to years. With comprehensive, accurate and long time series of datasets, scientists are better equipped to predict how ecosystems respond to climate change.

As the global leader in weather and environmental measurements, Vaisala provides trusted weather observations for a sustainable future. With nearly 90 years of innovation and expertise plus customers in 170+ countries from the North and South Poles to Mars, we help provide the most reliable and accurate weather and climate information for better and safer daily lives.

Our instruments and intelligence are known as the gold standard for precision and reliability. As a sustainability leader we enable meteorology professionals to better understand, forecast and explain climate change. We continue to channel our curiosity into climate action and new ways of enabling a better planet for all.

Ref. B213066EN-A