

The National Ecological Observatory Network's Automated Terrestrial Measurements: Data Flow and Quality Control Approaches



neon
National Ecological Observatory Network

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Background

The National Ecological Observatory Network's Fundamental Instrument Unit (NEON-FIU) is responsible for making automated sensor measurements at 60 different sites across the continent. FIU will provide data on key local physical, climate and chemical forcings, as well as the biotic responses (CO₂, H₂O, and energy exchanges; phenology; and fine root turnover). FIU instrumentation will be automated with at continual temporal coverage, 24/7/365. The FIU sub-system dovetails with the other NEON sub-systems in an overall nested design covering spatio-temporal scales, from seconds to decades, and sub-metre to continent, respectively, all contributing toward a continental-scale observatory. All data will be freely available to scientists, policy makers, and citizens to enhance the understanding and education of climate change and other ecological issues.

Site Measurement Suite

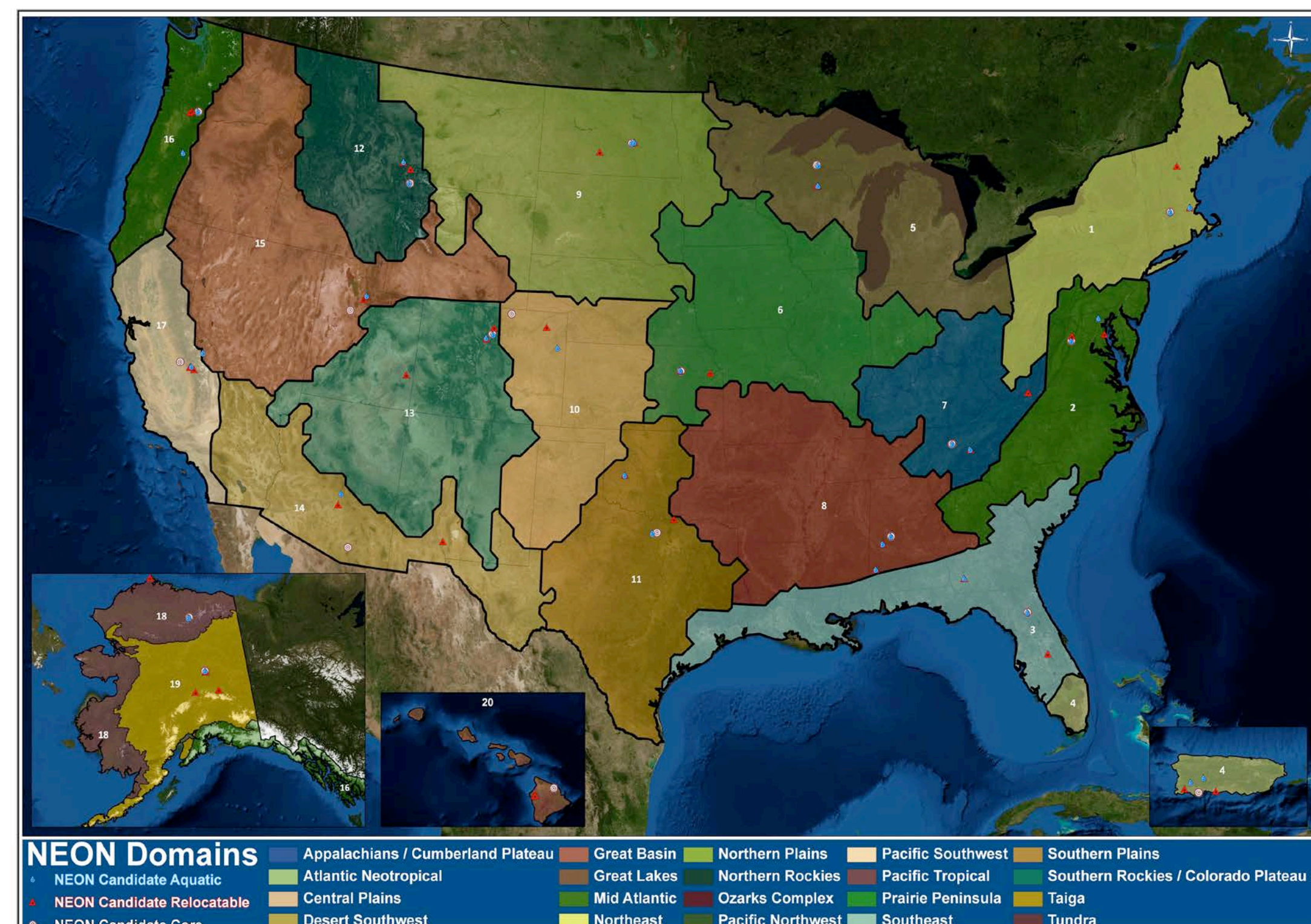
Measurements	Sampling freq.	Measurements	Sampling freq.
CO ₂ conc. & flux	20 Hz	Air temperature	1 min
O ₃ conc. & flux	1 Hz	2D wind speed & direc.	1 min
NO-NO _y conc. & flux	1 Hz	Barometric pressure	1 min
3D wind speed & direc.	20 Hz	PAR	1 min
Dust (TSP)	2 wk	CO ₂ & C ¹³ conc.	1 Hz
Dust (Particulate)	1 Hz	H ₂ O vapor & O ¹⁸ & DH	1 Hz
Aerosol optical depth	30 min	Primary Precip. (DFIR)	1 Hz
Secondary precipitation	1 min	Soil CO ₂ profile	1 min
H ₂ O conc. & flux	1 Hz	Fine root image (minirhizotron)	~2 wk (site/season specific)
PAR	1 min	Soil heat flux	1 min
Direct & Diffused radia.	1 min	PAR at soil surface	1 min
Pyranometer	1 min	Soil temperature profile	1 min
Net SW & net LW radia.	1 min	Soil water content profile	1 min
Biological temperature	1 min	Throughfall	1 min
Wet depos. chemistry & precip. isotope	2 wk		

Data Challenge

Unlike traditional academic science networks, NEON is tasked with delivering data products on a rigorous schedule. Furthermore, the amount of raw data that must be processed is on a scale that is unprecedented in ecology.

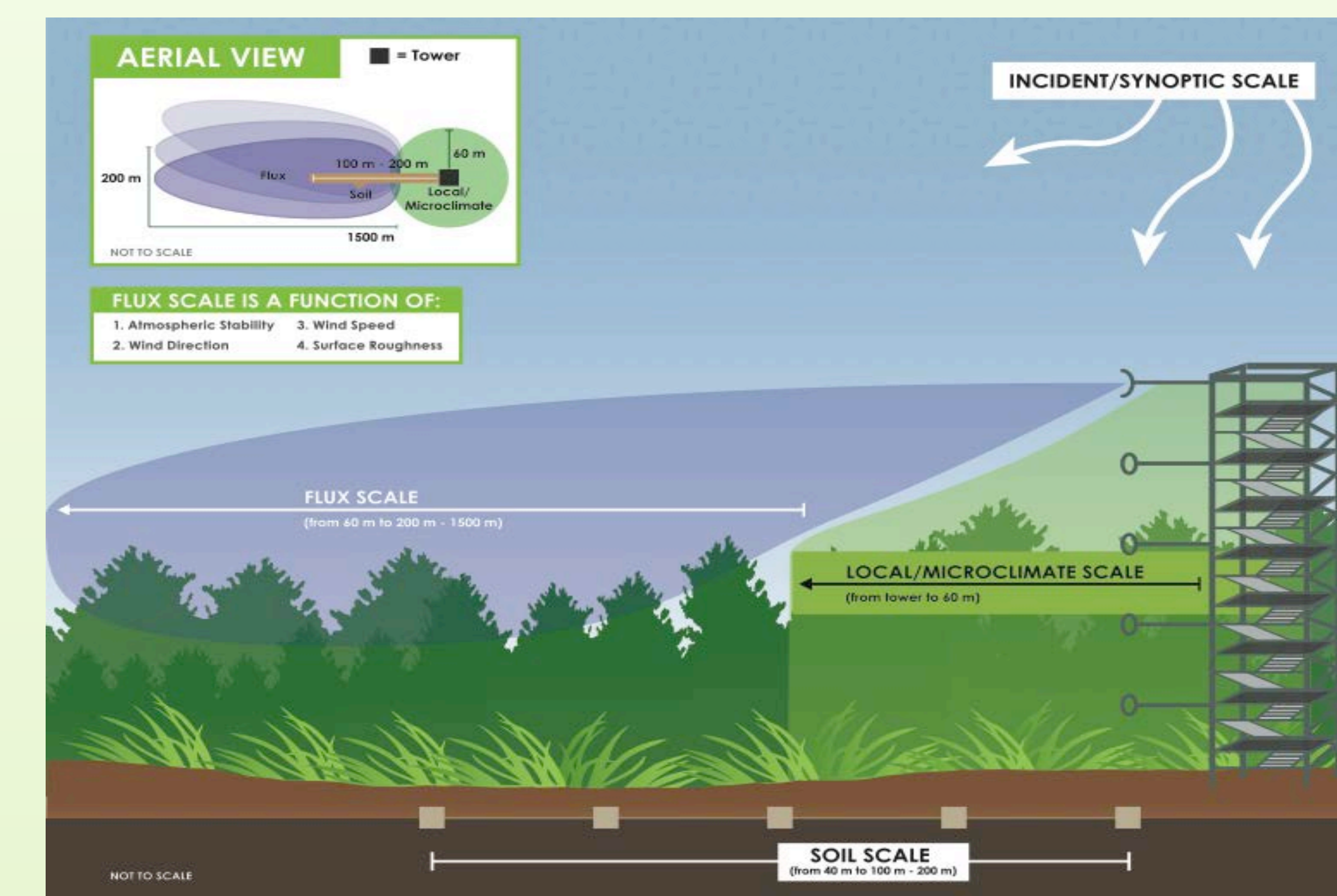
FIU is responsible for managing data production from the following:

- 60 sites + 10 mobile deployment platforms
- ~ 14 000 sensors
- ~ 50 000 data streams
- > 45 Tb of raw data per year
- Provisional Level 1 data produced quasi-daily
- Published Level 1 data produced with 30-60 day latency

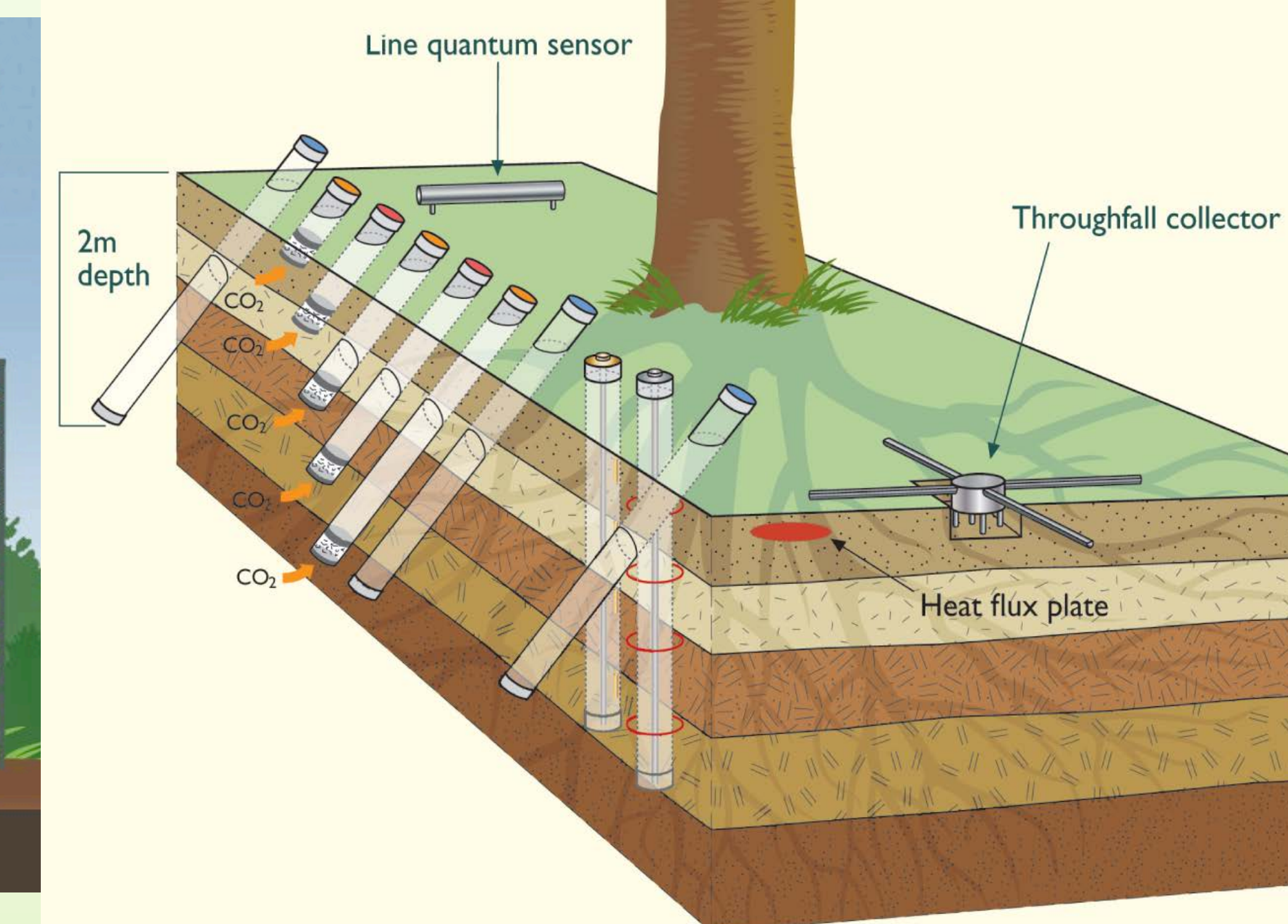


Automated Instrumentation

Sensor observations scale from the sub-metre to synoptic scales

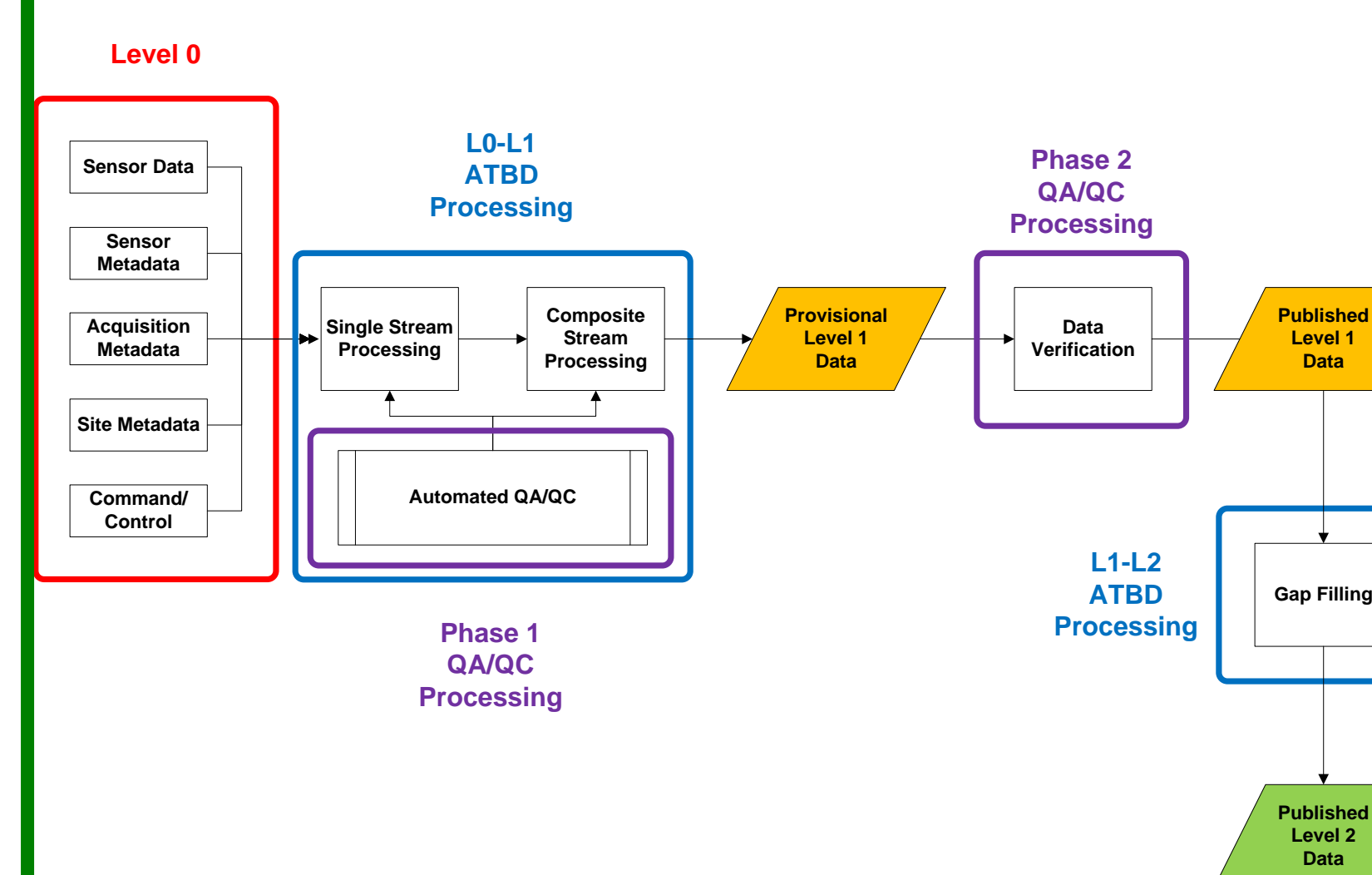


Sensor-based soil plot design

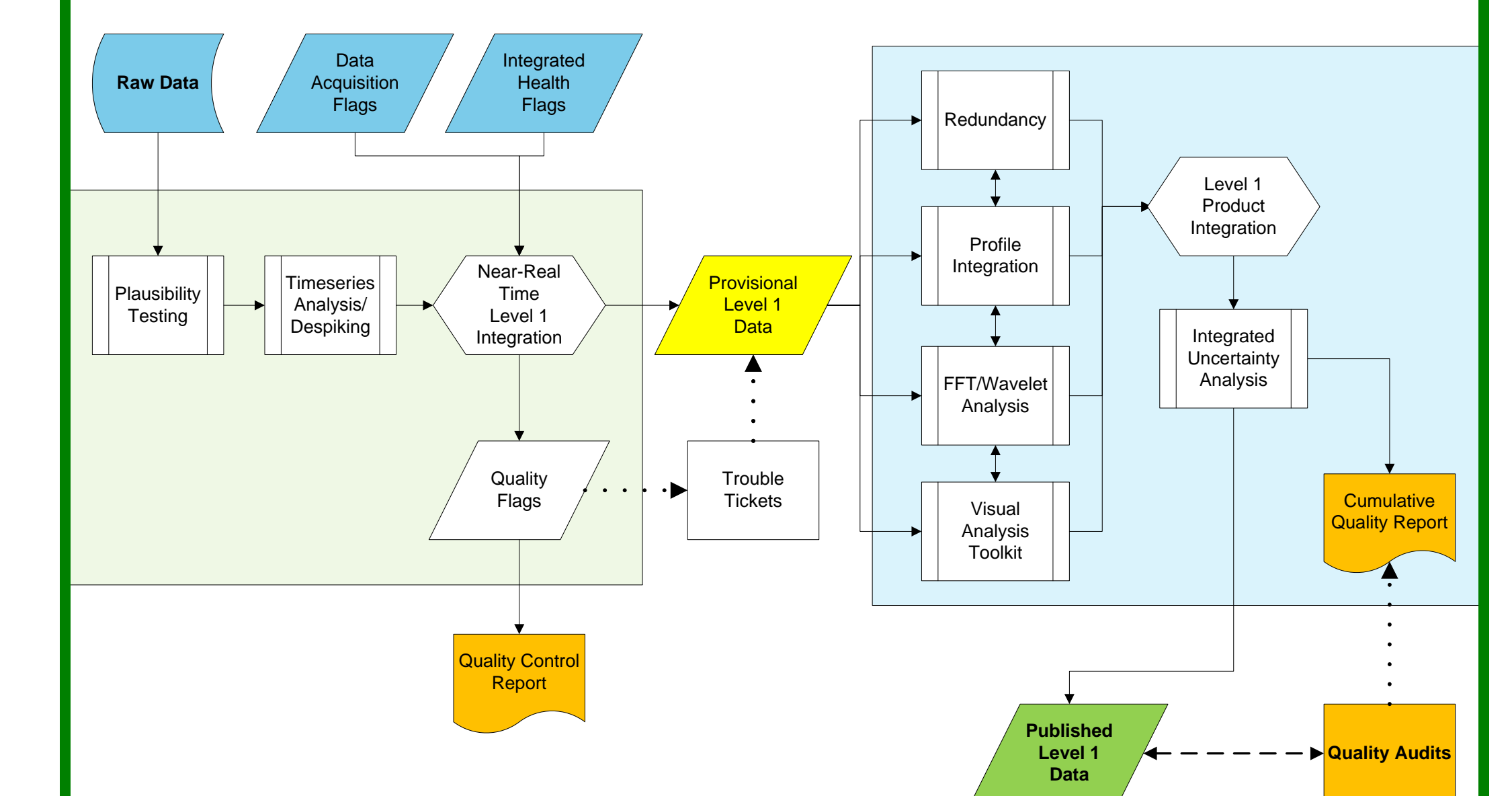


QA/QC Example: Plausibility Testing of Temperature Data

NEON Data Processing: Level 0 to Level 2



Automated QC



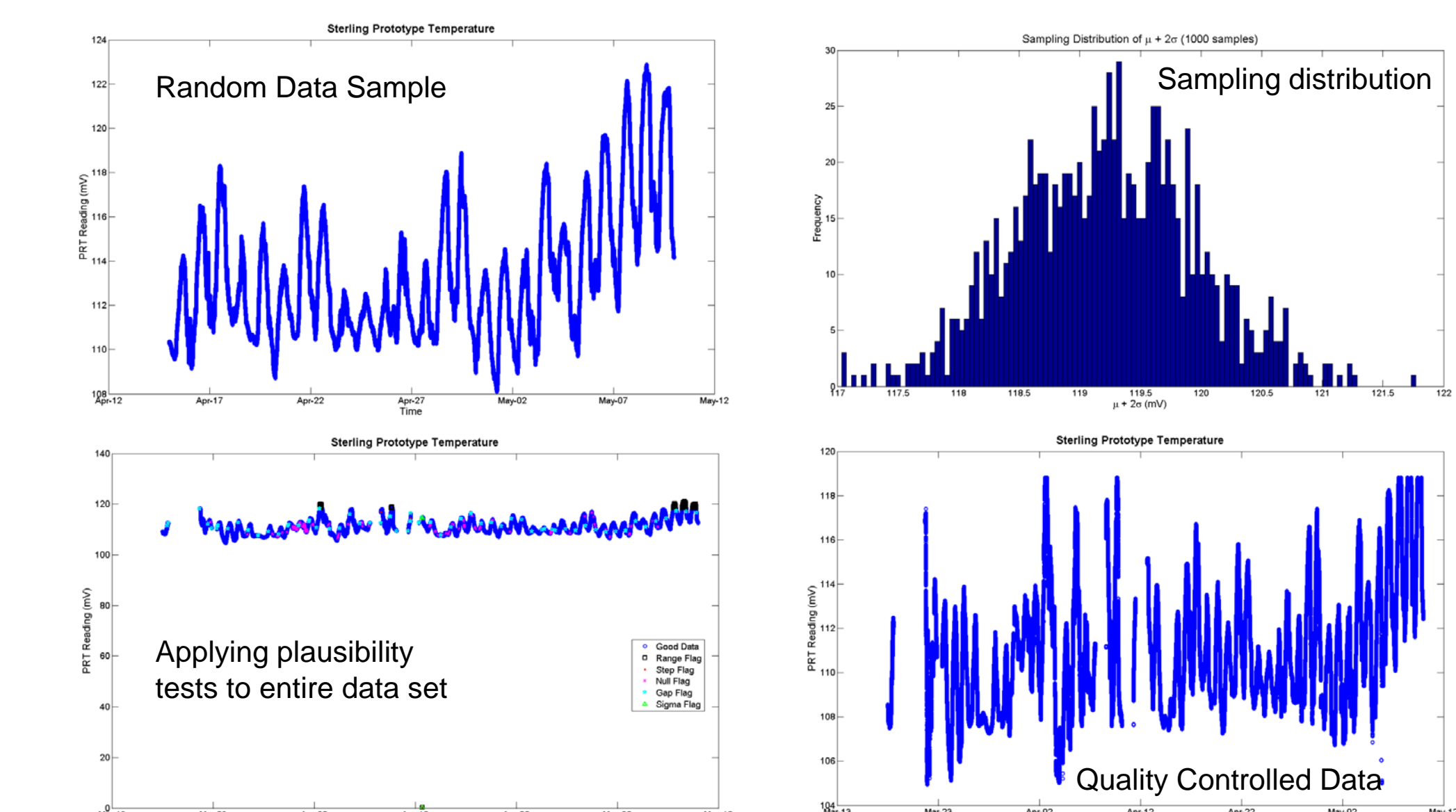
QA/QC: Existing Data Quality Control and Assurance Models

	Cal lab activities	Field acquisition	Data quality control		
ARM	In-house performance verification / Lab Acceptance testing	Dynamic SOPs Swapping sensors* Transfer standards	Level 1 (data ingest) Automated QA/QC Conv. to SI units	Level 2 'eyes on' QA/QC Sophisticated QA/QC	Level 3 Instrument Mentors Review panel Reprocessing data
US Climate Reference Network	In-house performance verification / Lab Acceptance testing	Dynamic SOPs Swapping sensors*	Level 1 (data ingest) Automated QA/QC Conv. to SI units	Level 2 'eyes on' QA/QC Sophisticated QA/QC	Level 3 NOAA Dept analyses NCDC / NWS /
DLN/NEON	In-house performance verification Fact. Accept.	Dynamic SOPs	Level 1 (data ingest) Automated QA/QC Conv. to SI units	Level 2 'eyes on' QA/QC Sophisticated QA/QC	Level 3 User community
CANADIAN CLIMATE PROGRAM	PI-driven, ad hoc performance verification	Dynamic SOPs Transfer standards	Level 1 (data ingest) Automated QA/QC Conv. to SI units	Level 2 'eyes on' QA/QC Sophisticated QA/QC	Level 3 Env. Canada QA/QC User community
AmeriFlux	PI-driven, ad hoc performance verification	Ad hoc SOPs Transfer standards Roving system	Level 1 (data ingest) Conv. to SI units Non-standard. flags	Level 2 Ad hoc QA/QC <site post doc>	Level 3 CDIAC QA/QC User community
Agricultural Research Service	In-house performance verification Fact. Accept.	Dynamic SOPs	Level 1 (data ingest) Automated QA/QC Conv. to SI units	Level 2 'eyes on' QA/QC Sophisticated QA/QC	Level 3 USDA data Archive User community

Thus far, we have focused on novel approaches that advance the principles and dataflow used historically (DOE ARM, AmeriFlux, USDA ARS, OK Mesonet) to new state-of-the-art functionality. These automated and semi-automated approaches also employ automated problem tracking to assist field technicians. The overarching philosophy relies on attaining the highest levels of accuracy, precision, and traceability while optimizing operational time. The primary challenge is to define NEON's standards for QA/QC maintenance by building upon these existing frameworks. These preliminary results focus on automated implementation of sensor command/control, QA/QC, and data verification of FIU observations. Future work will prototype the development and implementation of these plans.

The data acquisition system has been prototyped with temperature data. As part of the QA/QC process, these automated plausibility tests have been applied (below):

Plausibility Test	Underlying Statistical Sampling Distribution	Calculation
Range	Extreme Values	Max: $\mu+2\sigma$, Min: $\mu-2\sigma$
Sigma	Standard Deviation	$\mu-2\sigma$
Delta	Differences of Subsequent Pairs	$\mu-2\sigma$ (or defined by sampling)
Step	Differences of Subsequent Pairs	$\mu+2\sigma$
Null	Missing Data	$\mu-\sigma$ (or defined by sampling)
Gap	Large Gap of Missing Data	Defined by Sampling



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