

Rethinking Measurement

Smarter, deeper, better: how multi-sensor data, Bayesian statistics and affordable computing change the way we measure, monitor and decide

Erik van der Werff · Qualimetric · Version 1.0 · October 2026 · First published on qualimetric.eu, 22 May 2025

Summary

Modern analytical instruments no longer deliver a single result: they produce multi-dimensional data from many sensors, with overlapping, correlated and sometimes conflicting streams of information. Models built on a single "true" value and a frequentist uncertainty cannot capture that. Bayesian statistics can, and with today's affordable multi-core computing the required calculations have become practical. This paper describes the shift from simplistic models to measurement systems that adapt to changing conditions and maintain their reliability over time, and argues that the moment to move from promise to practice has arrived.

1. A dense forest of sensors

In the chemical industry and analytical laboratories, traditional models have long struggled with the complexity of modern measurement systems. Today's instruments no longer deliver just a single result: they generate multi-dimensional data landscapes, fed by a dense forest of sensors, each contributing overlapping, correlated, and sometimes conflicting streams of information. This can be an overwhelming amount of data. So how do we make sense of it all, and turn it into smarter, more reliable decisions?

2. The limits of a single true value

In the past, sensor data was approached very differently. Models were typically based on relatively simplistic representations, estimating a single "true" value and its associated measurement uncertainty using principles of frequentist statistics. These methods worked well for straightforward systems, but they struggled to capture the nuanced, dynamic nature of modern, multi-sensor environments.

3. Bayesian statistics, now within reach

Bayesian statistics offers a powerful way to handle this complexity. And even better, by incorporating more and more complex variables and better modelling uncertainty, measurement systems can now adapt to changing conditions and maintain reliability over time. But for years, the required computations were simply too demanding. That is no longer the case. With today's affordable, high-performance multi-core computing, what was once theoretical has become practical. And the impact is real: more accurate measurements, deeper insight into uncertainty, and faster, smarter decisions. Best of all, the investment is no longer a leap of faith: it pays off quickly.

4. From promise to practice

Now, the moment belongs to the scientific community. The tools are here. The potential is clear. It is time to move from promise to practice. The way we measure, monitor and decide is about to change.

Stay tuned. The future of measurement has only just begun.

5. How NexChrom and GasCatena apply this

NexChrom, Qualimetric's software for handling gas chromatography data, reports every mole fraction with its uncertainty, propagated according to the GUM from a calibration that weighs the uncertainty of both the certified reference gases and the instrument responses, and keeps the covariance of the calibration coefficients in every result. GasCatena, Qualimetric's software for the gravimetric preparation of calibration gases, carries the covariance between the mole fractions of a prepared gas into its ISO 6976 properties. Both are built on the principle set out above: a measurement is more than a single number, and the data behind it deserve a model that respects their structure. More information and demonstrations are available at nexchrom.nl.

About the author

Erik van der Werff has worked for 25 years as an independent consultant in gas analysis, chemometrics and measurement uncertainty through Qualimetric. He is a member of ISO/TC 193/SC 1 (natural gas analysis), ISO/TC 28/WG 2 (precision of test methods) and ASTM D02, and the author of ISO 4259-5. He develops NexChrom. · qualimetric.eu · nexchrom.nl