Abstracts

Wednesday, April 30

Session G3: Continuous Monitoring: Uncertainty and Bias and Precision… Oh My!

10:00 – 11:30 am | Room 261

Sensor Signal Integrity and Data Quality Management: Who is Doing What?

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Abstract
Using water quality sensors to collect data of known and documented quality is a process that involves multiple people operating at different levels. Sensor performance testing is common at all levels, but each level has its own role and requirements. At the Technology Development level (*e.g.*, fluorescent quenching for measuring dissolved oxygen), researchers run myriad of tests to prove that the measurement idea actually works and can produce a reliable signal that correlates well with the monitored characteristic. At the sensor Model level, manufacturers working on building a specific sensor model need to prove the functionality of that model as an established measurement system and conduct comprehensive tests to derive the specifications for that model. At the level of an individual Instrument, the Project person who opens the shipment box and prepares the instrument for use needs to go through a series of tests to assure that this instrument is functional and to establish its performance criteria as manifested in the environment relevant to his/her Project. The fourth level is the Measurement (Activity in STORET language), *e.g.*, a batch of data from one deployment episode. At this level, the field operator is implementing actions to Affect, Check, Record, and Report the quality of each data batch. This fourth level also involves a sequence of Data Quality Management functions, using sensor's diagnostic tests (*i.e.*, physical and electronic operating conditions) to prove signal integrity, and using quality check outcomes to validate the data and to evaluate the extent of error and/or uncertainty. This paper reviews the major roles and the helpful tools that have been introduced by the Aquatic Sensors Workgroup, a workgroup of the Methods and Data Comparability Board affiliated with the National Water Quality Monitoring Council.

High Quality Monitoring at the Water's Edge Using In Situ *Automatic Measurement Stations That Incorporate Real- Time Data Quality Analysis Tools*

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Abstract
To guarantee the ecological quality of a water body, the development of a management plan is crucial and the application of a consistent monitoring strategy is a key component of such a plan. With this in mind, there has been increased interest in and application of *in situ* water quality sensors that enable the continuous monitoring at high frequency irrespective of the goal (describe pollution dynamics, identify trends ...). In theory, continuous monitoring enables the timely detection of disturbances and provides an opportunity to take remedial action when necessary. However, in real world applications, the data collected with those continuous systems is not without errors due to the intrinsically challenging measurement conditions. Consequently, the reality is that these systems tend to collect vast amounts of data, but not all the data will have sufficient quality and poor quality data can drastically affect the use of the data (*e.g.*, river basin management models, occasional discharge detection, process understanding, cause-effect relationships between water quality and quantity variables ...). Manual data evaluation and validation is tedious and becomes unrealistic when huge data sets need to be analyzed and interpreted. Therefore, automatic data quality assessment tools become crucial to ensure that the data quality is

sufficient for the intended application. Such tools should consider sensor status/diagnosis data, reference samples and time series information.

The development and practical application of software tools for automatic data quality assessment are the focus of this work. In contrast to traditional model-based academic approaches, the presented data-driven tools attempt to extract useful information from the time series of individual and multiple measurement signals in the absence of exact process knowledge. It is the goal of these tools to detect corrupt, doubtful and/or unreliable data, outliers, noise, missing values and potential sensor faults. The proposed tools have been successfully tested on water quality time series data obtained from *in situ* monitoring stations collecting a large amount of data in different water systems with point and diffuse pollution loads (raw wastewater, overflows, storm and river water quality). Improved data reliability has been achieved and is the objective of ongoing developments.

Quantifying Uncertainty: Adding Value to USGS Time-Series Water-Quality Data

Stewart Rounds[1], Stacey Archfield[2], Rob Ellison[3], Janice Fulford[4], Brian Gouge[5], Stuart Hamilton[5], David Holtschlag[6], Brian Pellerin[7], Pat Rasmussen[8] and Susan Wherry[1]

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Abstract

The U.S. Geological Survey (USGS) collects large quantities of data at thousands of sites nationwide, but does not yet have procedures to calculate, store, and communicate uncertainties associated with those data. Current USGS methods for processing time-series data include a qualitative assessment of data quality (ratings of Excellent, Good, Fair, and Poor), but that assessment is not quantitative, not stored in the USGS database, and not communicated to data users. Simply rounding the value of a reported result is insufficient as a characterization of uncertainty, as data collected by a freshly cleaned and calibrated water-quality probe inherently have a lower uncertainty than data from a fouled probe with a drifting calibration, yet both results are reported in the same way.

At the same time, USGS is working to find new and innovative ways to add value to its data. Applying defensible methods of computing uncertainty for every data point would increase the value of USGS data to almost all data users. Knowing the uncertainty of data would allow modelers, regulators, and resource managers to make better decisions and create better and more accurate products and tools. With a known and quantitative data uncertainty, USGS data not only could be compared to standards and criteria for the protection of human health and the environment, but the probability that such a standard or criterion is exceeded could be computed.

A team of scientists from USGS and private companies is working to recommend methods and guidelines that can be used to quantify the uncertainty associated with time-series water-quality data, with the aim of storing that information in the USGS database and communicating it to data users. The team is drawing upon a wealth of published research and reports regarding methods for assessing and propagating uncertainty. All sources of uncertainty associated with the collection and processing of time-series water-quality data are being identified, and methods will be recommended to assess the uncertainty of each. A framework for quantifying data uncertainty that can be applied to all USGS data will be proposed, as well as specific methods for quantifying data uncertainty for time-series water-quality data.

Estimating the Uncertainty of Mean Daily Water Temperature Using the GUM

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Abstract

A group of USGS scientists and private companies are collaborating to recommend methods and guidelines for quantifying the uncertainty of hydrologic measurements. One uncertainty method being considered by the group is the “Guide to the Expression of Uncertainty in Measurement” or GUM by the Joint Committee for Guides in Metrology. The GUM is used to estimate the uncertainty of the daily mean computed from water temperatures collected at set time intervals using continuous monitors to explore the method. A data reduction equation is proposed for use with the GUM. Sources of measurement uncertainty for the mean daily water temperature are identified and estimates of the uncertainty contributed by each source are discussed. The method is then demonstrated with water temperature data collected with a continuous water temperature sensor that has weekly check measurements available for comparison.