UDMT - Urban Drainage Metrology Toolbox: a freeware for training on urban drainage systems monitoring

UDMT – Urban Drainage Metrology Toolbox : un logiciel libre pour la formation au suivi de l'assainissement

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ABSTRACT

Monitoring of urban drainage systems plays a key role in operation, compliance assessment, design, modelling, decision-making, and planning activities. Nevertheless, experience indicates that metrology applied to urban drainage systems is frequently of insufficient quality. That is why the Urban Drainage Metrology Toolbox (UDMT) has been developed in the H2020 European Project Co-UDlabs, aiming to facilitate the adoption and application of best practices and advanced methods in metrology. The UDMT is a unique, free, online, and open-source software tool, available in French, English and Spanish, providing a set of coordinated functionalities including various methods for sensor calibration, data correction, uncertainty assessment, data validation, and tracing experiments. Based on comprehensive documentary resources available on internet, the UDMT is also a tool for both i) education of master and doctoral students, and ii) professional training courses dedicated to practitioners.

ABSTRACT

L'autosurveillance des systèmes d'assainissement urbains joue un rôle clé dans les activités d'exploitation, d'évaluation de la conformité réglementaire, de conception, de modélisation, de prise de décision et de planification. Néanmoins, l'expérience montre que la métrologie appliquée aux systèmes d'assainissement urbains est souvent de qualité insuffisante. C'est pourquoi la boîte à outils métrologiques en hydrologie urbaine (UDMT) a été développée dans le cadre du projet européen H2020 Co-UDlabs, pour faciliter l'adoption et l'application des meilleures pratiques et de méthodes avancées en métrologie. L'UDMT est un outil logiciel unique, gratuit, en ligne et open source, disponible en français, en anglais et en espagnol, qui offre un ensemble de fonctionnalités coordonnées, notamment diverses méthodes d'étalonnage des capteurs, de correction des données, d'évaluation des incertitudes, de validation des données et de débitmétrie par traçage. S'appuyant sur des ressources documentaires détaillées disponibles sur Internet, l'UDMT est également un outil destiné à la fois i) à la formation des étudiants en master et en doctorat, et ii) aux cours de formation professionnelle destinés aux praticiens.

KEYWORDS

Autosurveillance, formation, hydrologie urbaine, logiciel libre, métrologie.
Freeware, metrology, monitoring, training course, urban hydrology.

1 INTRODUCTION

In the context of global challenges (climate change, continuous urbanisation and densification of cities, ageing and deteriorating infrastructures, emerging contaminants, water quality and ecology issues…), knowledge on urban drainage systems (UDS), including both traditional grey and more recent blue-green infrastructures (swales, bioretention filters, green roofs, etc.), and on their functioning must be based on high quality monitoring data, to improve understanding, modelling, planning, adaptation, and decision making. Unfortunately, metrology applied to UDS appears frequently of insufficient quality (Dittmer *et al*., 2015; Pistocchi *et al*., 2019; Perales-Momparler *et al*., 2017). Several reasons may explain these observations: i) lack of staff with advanced skills in metrology in general and applied to UDS in particular, ii) lack of sufficient financial resources devoted to UDS metrology and monitoring, iii) lack of incentives to generate and share high quality data on UDS, and iv) habit to accept poor quality information and to devote insufficient resources to monitoring of UDS.

In the H2020 INFRAIA European Project Co-UDlabs (Building Collaborative Urban Drainage research labs communities), the UDMT – Urban Drainage Metrology Toolbox free software tool was developed as both an online web app and downloadable executable versions for Windows and macOS operating systems. The UDMT aims i) to promote and implement best practices in metrology and standard methods inspired by quality assurance (ISO, 2003), ii) to facilitate their real application by UDS operators/utilities to comply with the new European Directive on wastewater systems (EU, 2024), and ii) to educate and train students and professionals.

2 DESCRIPTION OF THE UDMT

The UDMT is an integrated tool, offering five blocks of functionalities (Figure 1) which can be used to transform raw measured values into final corrected and validated data given with systematic uncertainty assessment. Raw data from sensors are imported from data loggers, Scada systems, etc. They are corrected according to calibration functions established from calibration experiments and their uncertainties are systematically evaluated by combing uncertainties from the sensor, the calibration function, and the monitoring site conditions. The same block of functions also allows to transform raw data from a surrogate sensor into usual parameters, for example to convert turbidity measurements into TSS (total suspended solids) or COD (chemical oxygen demand) concentrations estimated with their uncertainties. A set of predefined parametric tests can be used to automatically pre-validate data and identify problematic values, which can then be substituted or replaced by the user before the final data set is exported for further analyses and processing.

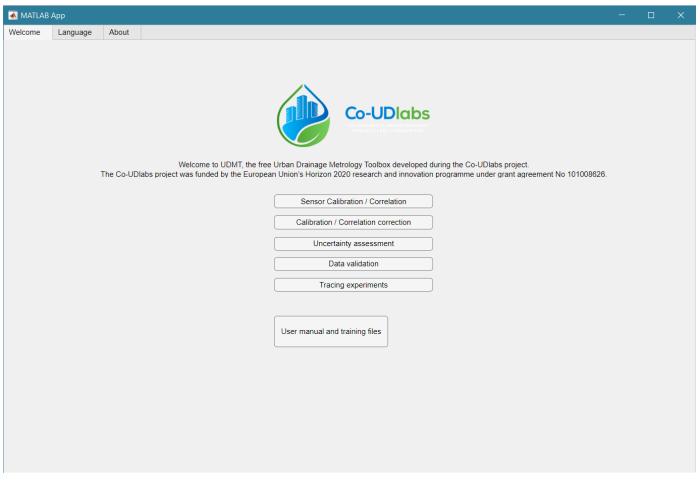

Figure 1: UDMT main user interface window with five blocks of functions.

The five blocks of functions are the following ones:

Sensor calibration / Correlation: to determine i) calibration functions (based on a data set of outputs of a sensor submitted to standards or certified values), and ii) correlation functions (based on a data set of values given by a sensor and corresponding values obtained e.g. with laboratory analyses of samples). Various methods are available: i) ordinary least squares, ii) weighed ordinary least squares, iii) Williamson regression to account to

uncertainties in both coordinates, iv) partial least squares for processing spectral data sets (e.g. UV-visible spectrophotometer data), and v) power function.

Calibration / Correlation correction: to convert automatically single, or time series of raw values provided by a sensor into corrected values according to previously determined calibration or correlation functions. In addition, uncertainties in corrected values are estimated from uncertainties in the sensor raw data, the calibration / correlation function, and the monitoring site conditions.

Uncertainty assessment: to apply standard methods for uncertainty assessment (type A, type B, and Monte Carlo) to various data sets and to any combination of data. In addition, the variograph method is proposed to estimate uncertainties in integrated values (e.g. sums, means, event, daily or annual pollutant loads, etc.).

Data validation: to provide a set of automated pre-validation parametric tests to help the user to validate data according to eight criteria: i) sensor range, ii) measuring range, iii) expert range, iv) gradient of the time series, v) absolute uncertainty, vi) relative uncertainty, vii) redundancy of data, and viii) outlier detection.

Tracing experiments: to calculate a discharge from experimental data collected during salt or dye tracing experiments. Tracing experiments are useful to qualify flowmeters in urban drainage systems and may be used, for example, to establish correction functions.

3 EDUCATION AND TRAINING WITH THE UDMT

3.1 Previous actions

The UDMT has been used several times for education and training purposes since its first version was released in 2022 (Table 1). It can be used internationally thanks to a user interface available in French, English and Spanish. The main task of the user consists of preparing text files to provide information and data to the software, which runs all calculations and generates output data, figures and text files that the user can easily read and save.

Table 1: Main previous educational and training actions with the UDMT.

When	Where	Main objective	Audience
Aug 2022	Graz, Austria	First presentation and demo	Academics
Jun 2023	Webinar (from Lyon, France)	Uncertainty assessment	Professionals
Oct 2023	Angoulême, France	Basics on UDS metrology	Professionals
Oct 2023	Nanjing, China	Basics on UDS metrology	MSc and PhD students
Oct 2023	Lyon, France	Training course	Professionals
Oct 2023	Cartagena, Spain	Training course	Professionals
Oct 2023	Webinar (from Lyon, France)	Presentation and demo	Academics, ZABR
Mar 2024	Lyon, France	Training course (2 days)	Professionals
Jun 2024	St Maurice en V., France	Training course	PhD students, 26th EJSW
Jun 2024	Lyon, France	Data validation & uncertainty evaluation	PhD students, Summer school
Dec 2024	Le Puy-en-Velay, France	Training course (2 days)	Professionals
Jan 2025	Webinar (Lyon, France)	Data validation	Professionals
June 2025	Toulouse, France	Uncertainty assessment	Professionals
Nov 2024, Nov 2025	Lyon, France	Uncertainty assessment course	MSc students, H2O Lyon
Nov 2024, Nov 2025	Lyon, France	Uncertainty assessment course	MSc students, INSA Lyon
Dec 2025	Jiashan, China	Presentation and demo	Academics and professionals
Jun 2026	St Maurice en V., France	Training course	PhD students, 28th EJSW

3.2 Online resources

The five UDMT blocks are based on various methods which are described in detail (principles, equations, examples of application) in Bertrand-Krajewski *et al*. (2021), which is an exhaustive and open-access companion reference document. A comprehensive UDMT User Manual (UDMT, 2025) is also available on internet and allows users to train themselves with several examples.

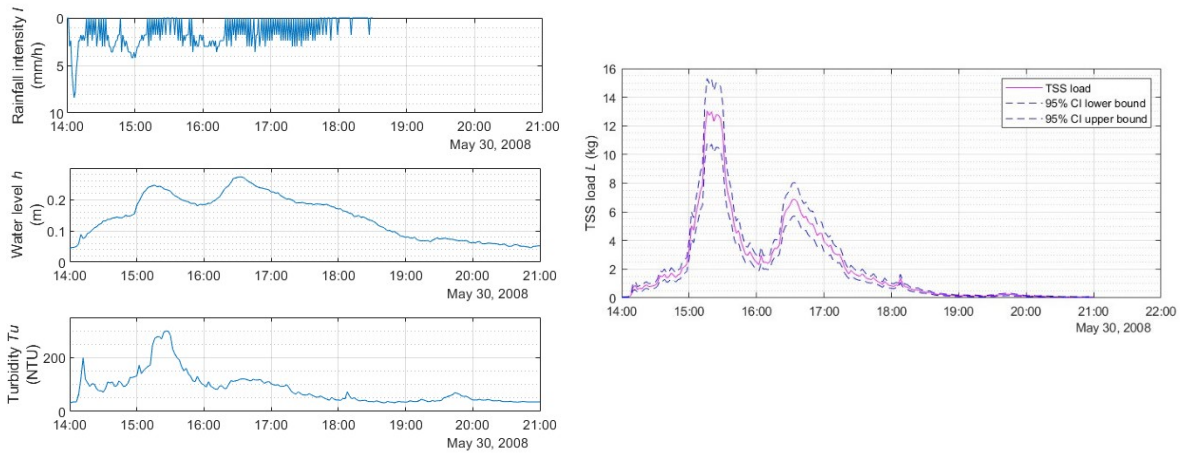

Figure 2: Left: raw data measured on 30 May 2008 from 14:00 to 21:00 in Chassieu, Lyon, France. From top to bottom: rainfall intensity I (mm/h), water level h (m) and turbidity Tu (NTU); right: TSS load time series and its 95% coverage interval calculated with the UDMT. (source: Bertrand-Krajewski *et al*., 2025).

In addition, a detailed example of application (estimation of an event stormwater pollutant load and of its uncertainty, calculated from both discharge and turbidity online measurements at the outlet of a separate sewer system, see Figure 2) has been published as an open-access paper, with all files available on internet as supplementary material (Bertrand-Krajewski *et al*., 2025).

The free UDMT software, the user manual and the examples files are all available on internet at https://u.pcloud.link/publink/show?code=kZegnQVZM53qyjRJ4cHn7Pi5WzrR9HJ0PL4V .

The UDMT software is fully transparent for the user and complies with the GDPR: all methods are public, all outputs are available in text files and figures, all Matlab source codes are publicly available in Zenodo (UDMT source codes, 2025) and none of the uploaded nor calculated data are stored.

The methods implemented in the UDMT are generic and can be applied to a diversity of topics related not only to urban drainage, but also to other fields. For example, the 2-day training course in Le Puy-en-Velay was an opportunity to apply the uncertainty assessment block to river discharge measurements based on a set of vertical velocity profiles.

4 CONCLUSIONS

The UDMT software can be considered as a contribution to the dissemination of best practices in metrology applied to UDS. It is a precious tool for educational and training activities, by incentivizing a very active involvement of trainees, who can learn from proposed examples and apply the methods to their own studies and research. It may also be an incentive to develop new tools and new functionalities for more advanced applications.

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