WaterJPI project

SMARTControl

Smart framework for real-time monitoring and control of subsurface processes in managed aquifer recharge (MAR) applications

Deliverable D3.1

Setup of real-time observation platform

Connection of UIT´s SENSOweb with INOWAS platform

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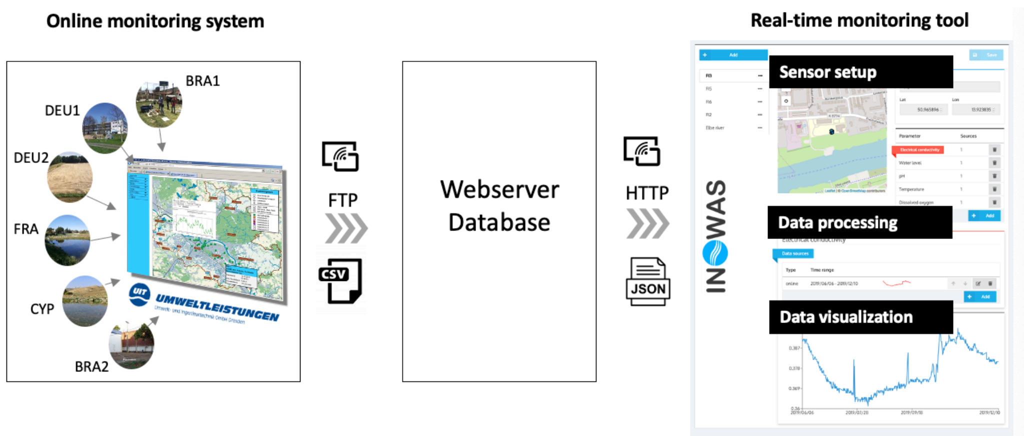

https://www.smart-control.inowas.com

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Short summary

The present report describes the software infrastructure developed in the SMART-Control project to enable the import of third-party data into the INOWAS platform. Using two different transfer approaches, pre-formatted datasets are either uploaded to a FTP webserver as CSV files or retrieved from public APIs using the open-source monitoring and alerting toolkit Prometheus.

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ABSTRACT

The core idea of the SMART-Control project is to develop and test a prototype system for using datasets from in-situ observation systems to update web-based groundwater models in real-time. The groundwater models are running on a free, web-based simulation platform developed by the research group INOWAs at Technische Universität Dresden, Germany (https://www.inowas.com). To achieve this goal, groundwater monitoring systems at six managed aquifer recharge (MAR) sites worldwide are developed with smart multi-probe sensors that are equipped with data loggers and GSM-based telemetry options. Datasets collected from these sensors are stored on SENSOweb, a webserver developed by the project partner UIT. The data from SENSOweb is transferred in CSV format to the INOWAS platform using a FTP webserver and stored in dedicated databases. The project allows also the import of external data sources from third-party webservers through public APIs. For this, a software interface was developed using the open-source service Prometheus whose powerful query language is used to periodically retrieve the data of interest and store it efficiently on the INOWAS platform. The present report provides a brief description of the software architecture developed to enable these two functionalities: the transfer of sensor data from SENSOweb and from external third-party sources.

CONTENT

FIGURES

1. INTRODUCTION

1.1 ABOUT THE SMART-CONTROL PROJECT

"SMART-Control" is an international research project funded through the Water Joint Programming Initiative (WaterJPI) and implemented by nine institutions from Germany, France, Cyprus and Brazil. The main objective of the project is to reduce the risks associated to MAR by the development of an innovative web-based real-time monitoring and control system (RCMS) in combination with risk assessment and management tools. The SMART-Control approach relies on coupling a real-time in-situ observation system consisting of state-of-the-art online sensors and a web-based groundwater monitoring and modelling platform. The resulting system shall provide operators and managers of MAR schemes with automatic decision support tools for monitoring, controlling and prediction of processes occurring during MAR. The approach is tested and validated at six MAR sites under different environmental and operating conditions. More information about SMART-Control is available at: https://www.smart-control.inowas.com.

1.2 MOTIVATION

The web-based platform used in the SMART-Control project is based on the free groundwater modelling platform developed by the Research Group INOWAS at Technische Universität Dresden, Germany (https://www.inowas.com). This simulation platform will be amended by four additional web-based tools that make use of real-time monitoring data from in-situ observation systems installed at selected MAR case studies (for more information about the tools visit: https://www.smart-control.inowas.com/tools).

To develop the technological prototype, new sensors are installed at all six case studies in the project. If the MAR scheme already has a functional sensor-based monitoring scheme in place, this will be amended by sensors that provide additional information about a certain parameter or process occurring during MAR. Data collected in real-time will be then processed by a web-based monitoring tool and fed into numerical groundwater flow models running and updated automatically on the INOWAS platform (Figure 1).

The technical challenge posed by this approach was how to collect the information transmitted by the sensors and what is the best way to unify the data harvested from all case studies?

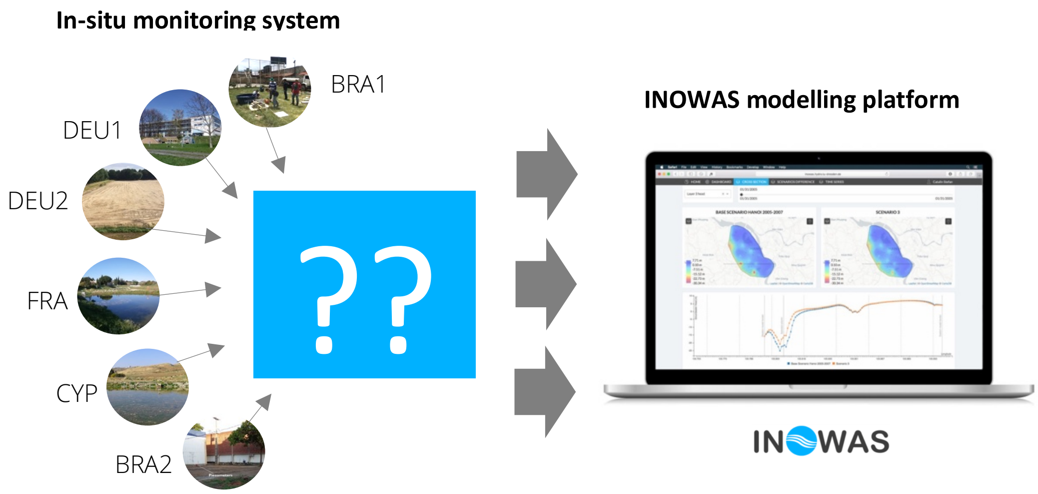


Figure 1. Data collected by sensors installed at fix MAR sites needs to be unified and fed in real-time to the web-based INOWAS modelling platform

1.3 OBJECTIVE

To simplify the technical infrastructure, in the development phase it was proposed that all sensors used by the project to be manufactured by the project partner Umwelt- und Ingenieurtechnik GmbH Dresden (UIT). This solution had the major advantage that the UIT sensors equiped with GSM-based telemetry functions already transmit their measurements to SENSOweb, a centralised web-based platform developed by the company UIT for collecting and vizualisation of online data (more info about the SENSOweb system: https://www.uit-gmbh.de/de/softwareloesungen__723/getProdInfos_-_2388/). Once the datasets are centralised in the SENSOweb server, a connection to the INOWAS platform would enable the utilisation of these time series as input to the simulation tools.

The main objective of the work package 3 is thus to develop and implement a real-time observation system including the installation of monitoring and data transfer solutions, first at one test site in Pirna, Germany, then followed by replication at the other MAR sites. The aim of the task 3.1 was the development and implementation of necessary software infrastructure for data transfer and visualisation, together with the real-time server-based connection between SENSOweb and the INOWAS platform.

The present report provides a short description of the technical software solutions implemented for data transfer and processing.

2. DATA TRANSFER SOLUTIONS

2.1 GENERAL DATA TRANSFER PRINCIPLES

When measuring data in the field and storing this data in the cloud, there are two fundamental principles how to get the data.

1. The **PUSH** principle where measurement devices (sensors) are sending data to a server, for example by automatically uploading CSV files to the server. In SMART-Control, we use this principle to collect monitoring data transmitted by the UIT sensors to SENSOweb and transfer it in to the INOWAS platform.

2. The **PULL** (or poll) principle which implies that a server is periodically requesting the data from an external source (e.g. directly from the sensors or from the servers of the sensor operators). In this case, the queries are customizable so different parameters from different sensor locations can be obtained from a single source. We use this approach to "pull" data from external sources other than the UIT sensors.

In the SMART-Control project we decided to accommodate both functionalities so different solutions were implemented for each of the two cases. The section 2.2 provides a brief description of the available data formats and the software infrastructure implemented for transmitting datasets between SENSOweb and the INOWAS platform (the "push" principle), while section 2.3 describes how the datasets provided by third-party sources are imported) using the OpenMetrics standard (https://www.openmetrics.io) – the "pull" principle.

2.2. TRANSFER OF DATA FROM SENSOWEB TO THE INOWAS PLATFORM

The UIT company (https://www.uit-gmbh.de) is the developer, manufacturer and supplier of smart sensor probes for measuring water quality and hydrological parameters combined with ultra-low power data loggers and remote terminals (RTU). The SMART-Control project uses diverse multi-probe sensors for groundwater monitoring equipped with data loggers and GSM-based telemetry options. Data transmitted by the sensors is stored internally in databases on the UIT webservers. For data visualization, the company provides the comfortable SENSOweb interface (https://www.uit-gmbh.de/de/softwareloesungen__723/getProdInfos_-_2388/). Currently, SENSOweb does not have an API from where the data can be pulled directly from the UIT servers, but it offers an automatic CSV data upload to a configured FTP server.

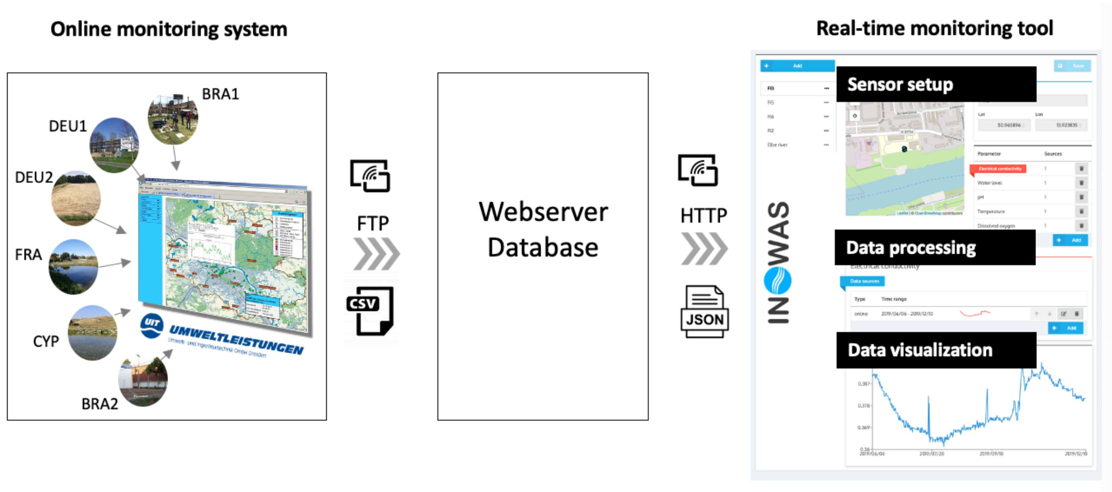


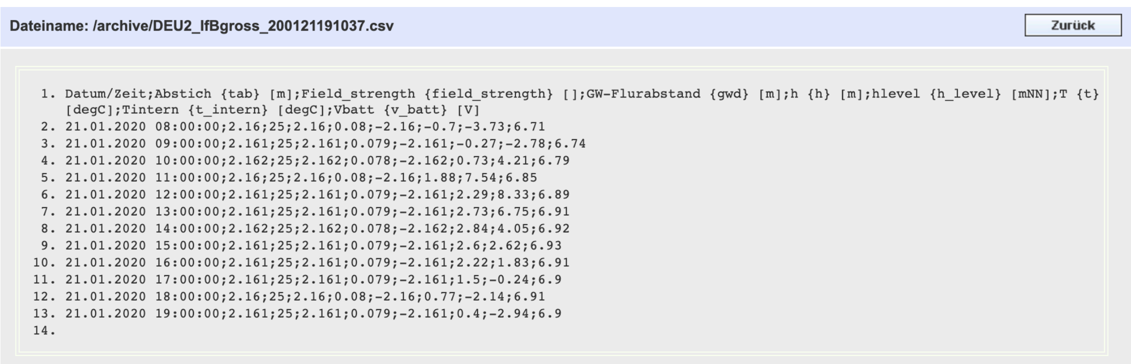
Figure 2. Data transfer from the UIT sensors to the real-time monitoring tool on the INOWAS platform

So the solution adopted was the configuration of a "push" protocol that automatically sends pre-formatted datasets to a FTP webserver on the INOWAS platform. The data is transmitted in CSV format with header and it is stored on the server incrementally, so only new datapoints are uploaded. The structure of the uploaded files includes the project and the sensor names according to the following template:

<SITE>_<SENSOR>_<TIMESTAMP>.csv

For example, the file **DEU1_I-5_200121171131.csv** provides measurements from the site *DEU1* (which is the code for Pirna, Germany) collected from the sensor *I-5* with the timestamp: *2020-01-21T17:11:31*.

Figure 3 shows an example of dataset transferred from SENSOweb to the INOWAS platform:



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1. Datum/Zeit;Abstich {tab} [m];Field_strength {field_strength} [];GW-Flurabstand {gwd} [m];h {h} [m];hlevel {h_level} [mNN];T {t} [degC];Tintern {t_intern} [degC];Vbatt {v_batt} [V]
2. 21.01.2020 08:00:00;2.16;25;2.16;0.08;-2.16;-0.7;-3.73;6.71
3. 21.01.2020 09:00:00;2.161;25;2.161;0.079;-2.161;-0.27;-2.78;6.74
4. 21.01.2020 10:00:00;2.162;25;2.162;0.078;-2.162;0.73;4.21;6.79
5. 21.01.2020 11:00:00;2.16;25;2.16;0.08;-2.16;1.88;7.54;6.85
6. 21.01.2020 12:00:00;2.161;25;2.161;0.079;-2.161;2.29;8.33;6.89
7. 21.01.2020 13:00:00;2.161;25;2.161;0.079;-2.161;2.73;6.75;6.91
8. 21.01.2020 14:00:00;2.162;25;2.162;0.078;-2.162;2.84;4.05;6.92
9. 21.01.2020 15:00:00;2.161;25;2.161;0.079;-2.161;2.6;2.62;6.93
10. 21.01.2020 16:00:00;2.161;25;2.161;0.079;-2.161;2.22;1.83;6.91
11. 21.01.2020 17:00:00;2.161;25;2.161;0.079;-2.161;1.5;-0.24;6.9
12. 21.01.2020 18:00:00;2.16;25;2.16;0.08;-2.16;0.77;-2.14;6.91
13. 21.01.2020 19:00:00;2.161;25;2.161;0.079;-2.161;0.4;-2.94;6.9
14.
```

Figure 3. Content of a CSV file transferred from SENSOweb

The CSV data submitted by the SENSOweb service has to be stored in a database on the INOWAS servers. To achieve this, a periodically running process, written in PHP, checks the availability of new uploaded files and integrates them in a database. All processed files are thus archived automatically. After writing the data to the database, all sensor values can be accessed over a HTTP-Rest Interface. For more details about the visualization of sensor data on the INOWAS platform see the tool T2. Real-time monitoring and control (https://smart-control.inowas.com/tools/). Following this protocol, both a list of all sensors with measured parameters and their latest values and the timeseries of a specific parameter with optional time bounds can be retrieved for each specified project (Figure 4). With an increasing amount of projects and time-series data it would be useful to switch to an advanced time-series database, such as for example InfluxDB (https://www.influxdata.com).

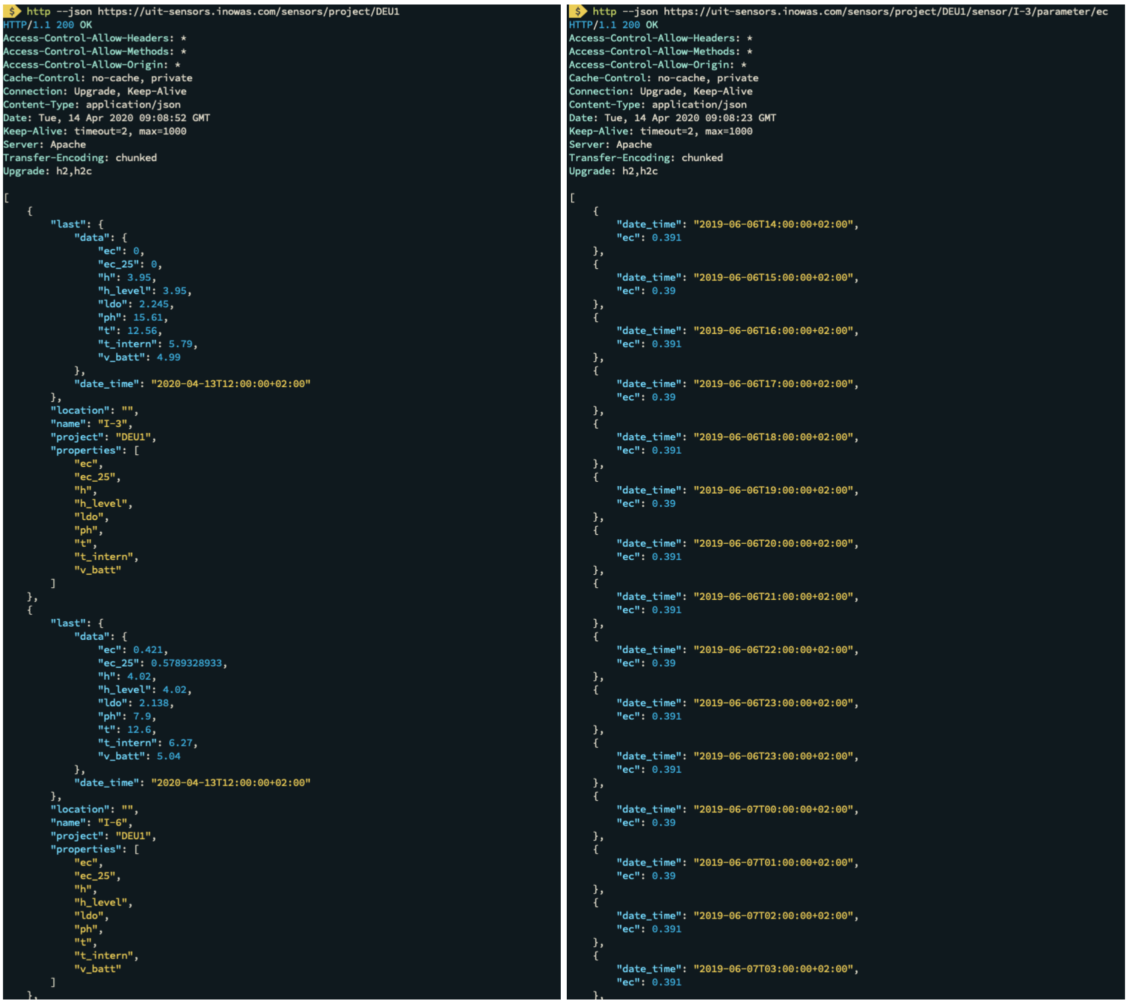

Figure 4. API calls for sensor list (left) and parameters time-series (right)

2.3 REAL-TIME IMPORT OF THIRD PARTY DATA

In addition to the case study specific groundwater monitoring data, the simulations models can use further datasets such as river stages, rainfall, runoff etc. Many web services provide such datasets in real time through public APIs. The Pegel Online website (https://www.pegelonline.wsv.de/webservice/ueberblick) offers for example automatic retrieval of real-time data through REST-APIs or XML-based webservices.

In order to properly store these values with adequate timestamps, the higly-specialized open-source monitoring and alerting toolkit Prometheus (https://prometheus.io/) was implemented on the INOWAS platform (Figure 5). Prometheus is a powerful tool that is used for different tasks:

1. to “pull” the measured values periodically from external servers;
2. to store the datasets efficiently on the INOWAS platform;
3. to retrieve data using a poweful query language.

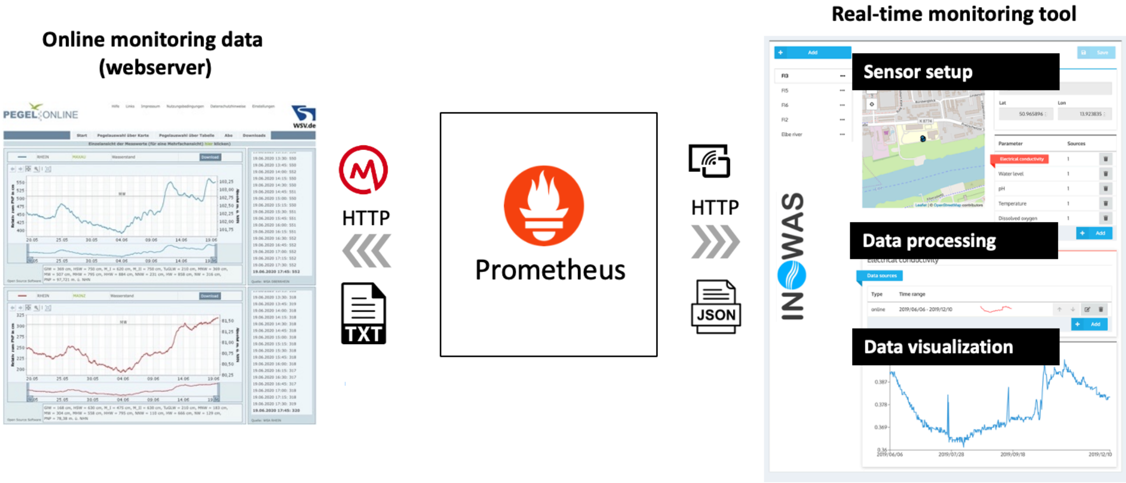

Figure 5. Connecting third-party APIs of webservices with the INOWAS platform

Since Prometheus offers support for the OpenMetrics standard (https://openmetrics.io), the easiest way to integrate data from third-party websites is to read the real-time API data and transform it into OpenMetrics format. Many open-source libraries are already developed for a wide range of programming languages.

3. CONCLUSIONS

The present report describes the software infrastructure developed in the SMART-Control project to enable the import of third-party data into the INOWAS platform. Using two different transfer approaches based on PUSH and PULL principles, pre-formatted datasets are either uploaded to a FTP webserver as CSV files or retrieved from public APIs using the open-source monitoring and alerting toolkit Prometheus. Data transferred to the INOWAS platform can be visualized and processed using the tool T2 "Real-time monitoring and control". The interface allows the incorporation of real-time measurements into the web-based groundwater models (tools T3 and T4).