Geospatial Data Fusion for Water Resources Assessment

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1. INTRODUCTION

In the Mediterranean basin, climate changes and especially global warming are likely to alter water resources in the future. Those changes will certainly complicate current water management strategies, then modelling this alteration could help to prevent water scarcity and increase public awareness of this issue. In this context, the VULCAIN[1] project was launched to provide a transdisciplinary model of the impact of both climatic and socioeconomic changes on water supplies. The water consumption estimation method developed for this project provides combinations of a lot of data diffused by several providers. However it is at the moment carried out through an Excel-based processing, which is not user-friendly at all. Furthermore, all the used data are uncertain as well as the results built from them. Pointing out those uncertainties is essential in order to provide a valid assessment of water resources.

As most of the combined data can easily be linked to spatial entities, we suggest to implement a Spatial Data Infrastructure (SDI) dedicated to water resources assessment. Technically, this water consumption estimation process would be achieved thanks to geospatial data fusion enabled by web services. This will enable to serve the data and the processes from a centralised framework, offering functionalities adapted to every kind of users. For water experts, it will be a tool to process data, defining its own parameters to obtain a specific water resource assessment. For regional politicians, it will provide decision support tools or maps. For the general public it will be an informative website.

2. A SDI BASED SOLUTION TO ENHANCE WATER RESOURCES ASSESSMENT

The first step of the project consists in studying the water consumptions Excel spreadsheets to identify raw data, processes and output data. In a second step, we will then provide both data and processes as Open Geospatial Consortium (OGC) web services to offer a fully interoperable system. In a third step, we will design a SDI that would enable users to exploit the data and the methods used and developed during the VULCAIN project in a user-friendly framework (figure 1).

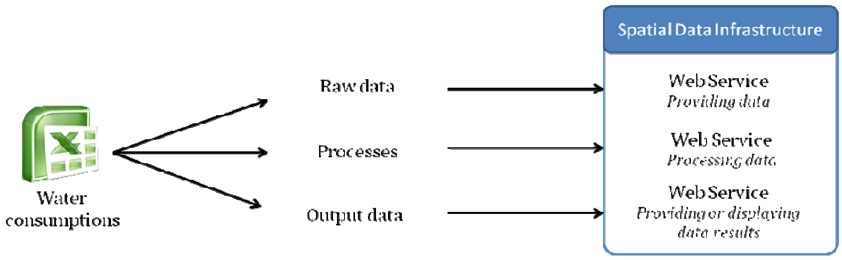

Figure 1: Schema of the project.

Identification of data and processes is particularly important as it determines the architecture of the proposed web services. Raw data needed for water consumption estimation are diffused by several providers at different spatial scales and granularities. The water consumption estimating method developed for VULCAIN provides the combination of those data considering both spatial and temporal heterogeneity.

1 http://agire.brgm.fr/VULCAIN_GB.htm

2.1 Web Services architecture

Using web services instead of flat files or databases offers many advantages. From the data provider point of view, it allows a better control on the distributed resources. From the user point of view, it gives assurance to always have the latest update of the data. To encourage the use of web services for geospatial data and ensure interoperability between GIS, OGC defines several standards that would fit to the data user and provider needs.

The Web Map Service (WMS) [OGC, 2006] is used to display final results that are not designed to be processed. Three other web services will be used to provide processable data: the Web Coverage Service [OGC, 2010], the Web Feature Service (WFS) [OGC, 2005], and the Sensor Observation Service (SOS) [OGC, 2007]. Those web services are complementary: WCS enables to provide geospatial gridded data such as digital elevation models, WFS returns discrete geospatial features and SOS provides access to sensors observations such as the precipitations and water flows measures.

To process data, the Web Processing Service (WPS) [OGC, 2007 bis] is the de-facto OGC web service to use. It offers the opportunity to use algorithms for altering data. The algorithms can be as simple as adding a number to a numeric value, and as complicate as conceiving an interpolation map with kriging method. Today, several kinds of implementations are provided, among them PyWPS[2], 52°NorthWPS[3], Deegree3[4], and The Zoo Project[5]. Both are based on the latest 1.0 version of the WPS specification and enable a user to develop its own processes. For this purpose, we choose the Zoo Project which allows use of various programming languages to develop processes.

2.2 Expressing and propagating uncertainty

Each geographic dataset aims to provide a representation of reality, and inevitably leaves its user with uncertainty about the nature of the real world that is represented. This uncertainty may deal with location, attributes or topological relationships [De Smith, 2006].

Data quality and uncertainty estimation are hot topics and several authors propose their own solutions to offer a critical point of view to the provided data [Azzi, 2010]. However, in predictive models such as the VULCAIN one, giving an estimation of the raw data is not enough. The aim is to express the reliability of the final results. This can only be done by propagating the uncertainty of the result from the raw data through the chaining processes. However it is particularly complex when performing processes with heterogeneous data.

To propagate uncertainty we will develop specific algorithms following the Guide of the expression of Uncertainty Measurements (GUM) recommendations [JCGM, 2008] and provide them through WPS. The mean value is calculated through a F algorithm from two input data (X and Y) and process parameters, whereas uncertainty calculation is provided by a G algorithm that also depends on X and Y uncertainties (respectively u(X) and u(Y)). Those two calculus are provided by two WPS and the results of both processes will then be concatenated into a single web service (figure 2).

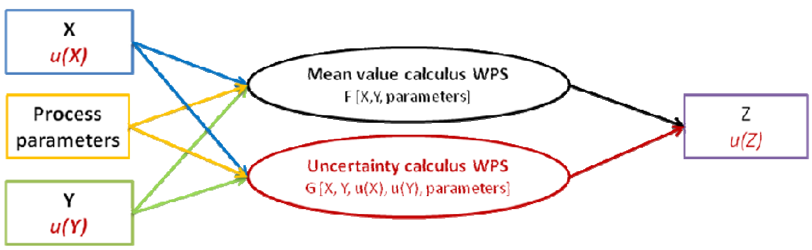

Figure 2: Propagating data uncertainty through WPS.

2 http://pywps.wald.intevation.org/
3 http://52north.org/maven/project-sites/wps/52n-wps-site/
4 http://wiki.deegree.org/deegreeWiki/deegree3/ProcessingService
5 http://www.zoo-project.org/

3. PERSPECTIVES

The transdisciplinary method developed for the VULCAIN project combines several heterogeneous data to provide a technico-economic water resources assessment. Integrating all those processes into a SDI will simplify the estimation of the water consumptions and provide new capabilities: diffusing data and processes on the internet through fully interoperable web services, offering a user-friendly framework for hydrologic and hydrogeological experts but also for regional politicians and general public.

To enhance the water consumptions estimation method provided by VULCAIN, we also proposed basic principles to express and propagate the data uncertainty through the web processing services. This method is at the moment restricted to the attribute parameters but we plan to expand it to deal with geospatial and temporal uncertainties. This task is particularly important when estimating unavailable required information from spatially or timely closest data and will be studied.

In the near future, we will first serve raw data through SOS and WFS and develop WPS that provide the operations and algorithms realised for the water estimation method. Finally we will specify the interfaces and tools to propose to our several final users.

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