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Interpolation of Precipitation Sensor Measurements using OGC Web Services

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Abstract

The standards developed by the Open Geospatial Consortium (OGC) provide a broad foundation for web-based geographical applications. As one of these the OGC Sensor Web Enablement (SWE), which comprises standards for the consumer- and provider-oriented sensor viewpoint, allows data requests of real-time sensor measurements and observations, abstracting from the inherent sensor particularities. The sensor measurements are essentially raw data which must be interpreted either visually or by using further processing to generate knowledge out of that data. The web-based automated interpolation of precipitation measurements in the Wupper area, presented in this work, shows how a near-real-time processing of sensor data can be used to produce in-situ validation data sets for GMES or environmental models and a user-friendly precipitation distribution map. The OGC Web Services SOS (Sensor Observation Service), WPS (Web Processing Service) and WMS (Web Map Service) are chained opaque to perform the interpolation and provide the result.

1. Introduction

The Wupperverband – one of the water industry associations with a special legal status in North Rhine-Westphalia, Germany – is responsible for managing streams and rivers with a total length of about 2,300 km in the catchment area of the Wupper. To meet these requirements the Wupperverband administrates e.g. barrages for drinking water and water for industrial use, purification points, water gauges and meteorological measurement stations. Due to the geographical exposure of the Wupperverband with mountains up to 483m, there are high regional distinctions in the rainfall amount (Spies 2010, see Figure 1), which have to be analysed.

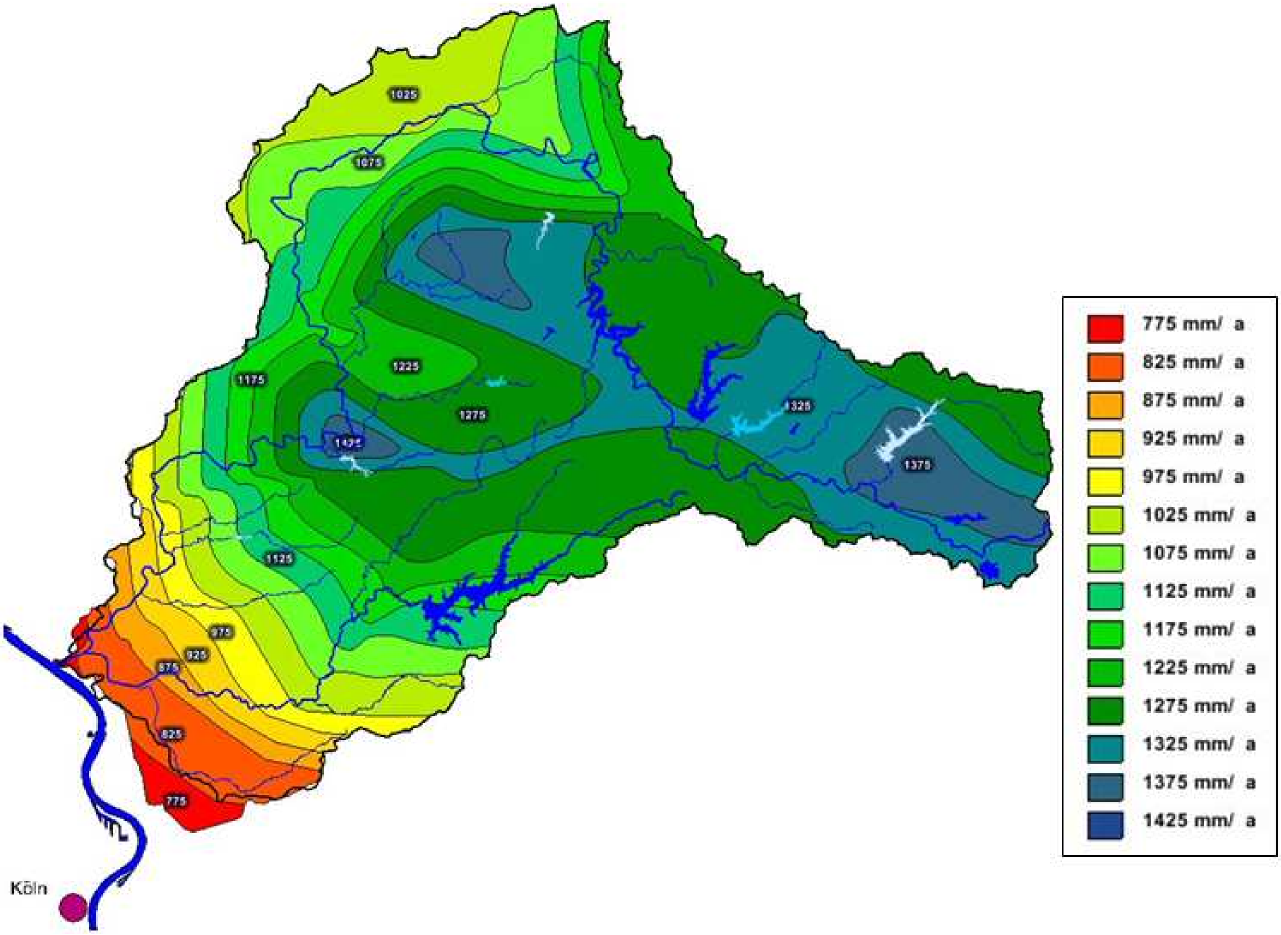

Figure 1: Rainfall amount over a year in the Wupper area

In the course of its integral river basin management, the Wupperverband has opted for advanced communication and information technology and operates the FluGGS river basin geographic information system on the internet[6] (Spies & Förster 2005). The FluGGS spatial information system provides geodata, sensor data and basic spatial analysis functionalities. The Web Services provided by the Wupperverband consist of Web Map Services, Web Feature Services, Sensor Observation Services and Web Processing Services compliant to OGC specifications.

In the joint project of the Technische Universität München and the Wupperverband, presented in this paper, a prototype was developed, providing a new instrument for analysis and visualisation of the precipitation distribution in near-real-time. The interpolated precipitation coverage can be produced by a WPS, chained with the SOS precipitation measurements as input and the WMS as output by an aggregate service. The resulting data can be used for in-situ based validation of remote sensing precipitation images, for service-oriented environmental modelling and for a visual interpretation of the precipitation distribution in the Wupper area.

[6] http://www.fluggs.de

2. Concept for a Web Service-based interpolation

Two use cases have to be considered that can be devised in a user-oriented and a provider-oriented viewpoint but on a higher level compared to the two viewpoints of the SWE:

1) The Administration-User (at the Wupperverband) starts a batch-tool (trigger) for periodically requesting the aggregate service to store the most recent precipitation distribution data into one existing WMS instance. The minimum of parameters that have to be provided must contain the time span and the interpolation method (Inverse Distance Weighting or Kriging).
2) The End-User wants to request the current precipitation distribution from the existing WMS instance providing the recent interpolated precipitation map.

Both use cases are presented by the two different clients in the architectural view in Figure 2. The aggregate service follows the aggregate service architectural design pattern (OpenGIS Consortium 2002) for opaque service chaining, in which, in contrast to transparent and translucent chaining "... the user invokes a service that carries out the chain, with the user having no awareness of the individual services" (OpenGIS Consortium 2002, p.14). This is suitable since the workflow will not be changed for this specific application and neither the End-User nor the Administration-User needs an insight in the internal business logic.

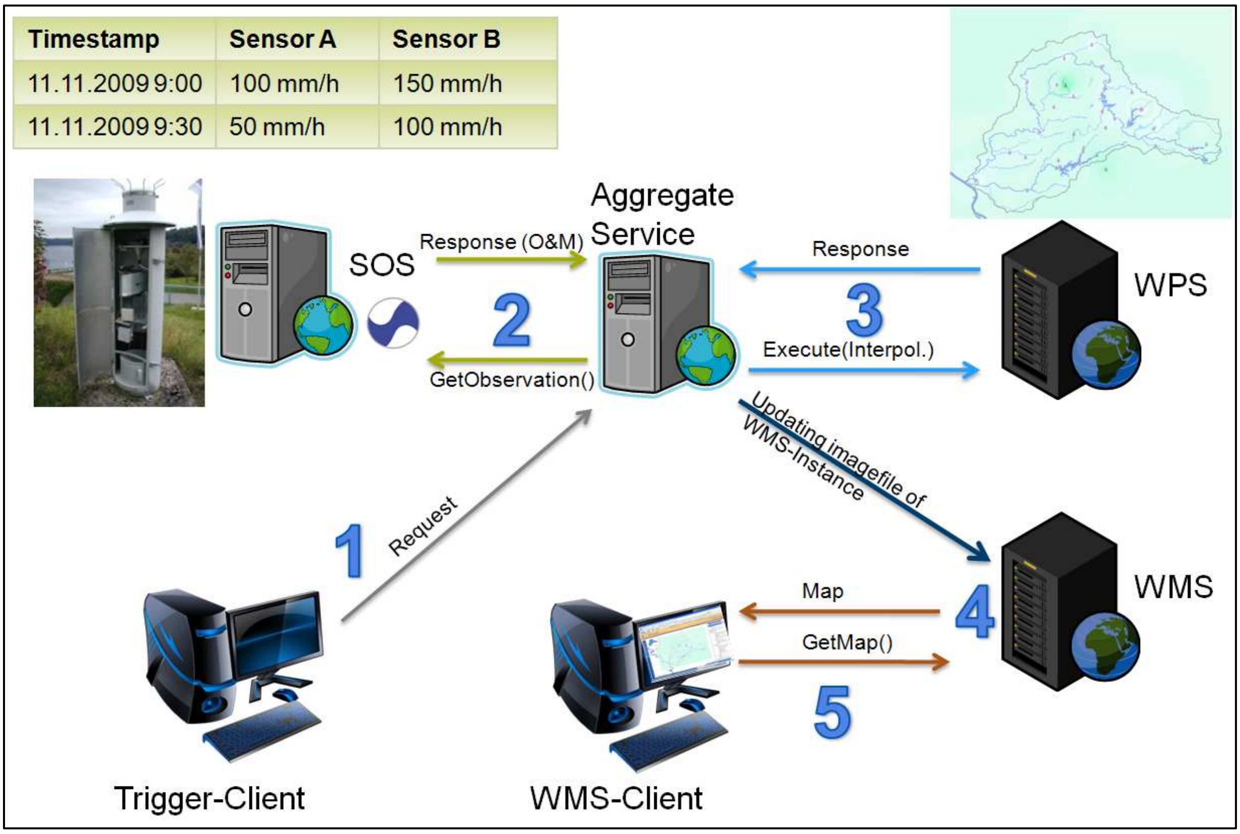

Figure 2: Architectural view of the clients and services, chained to provide near-real-time interpolated precipitation maps

Figure 3 illustrates the sequential interaction of the services, after the Administration-User from the first use case has started the trigger and a HTTP request was sent to the aggregate service. The aggregate service subsequently requests the current precipitation values invoking a GetObservation command on the SOS maintained by the Wupperverband. After sending the data to the WPS for interpolation by calling the Execute operation command, the resulting raster image is fed back to the aggregate service. The aggregate service then copies the raster image into the data directory of the WMS instance. In this way the End-User always accesses the most recent interpolated image, visualized by a Styled Layer Descriptor (SLD) suitable for the occurring precipitation values in the Wupper catchment area, through any WMS client.

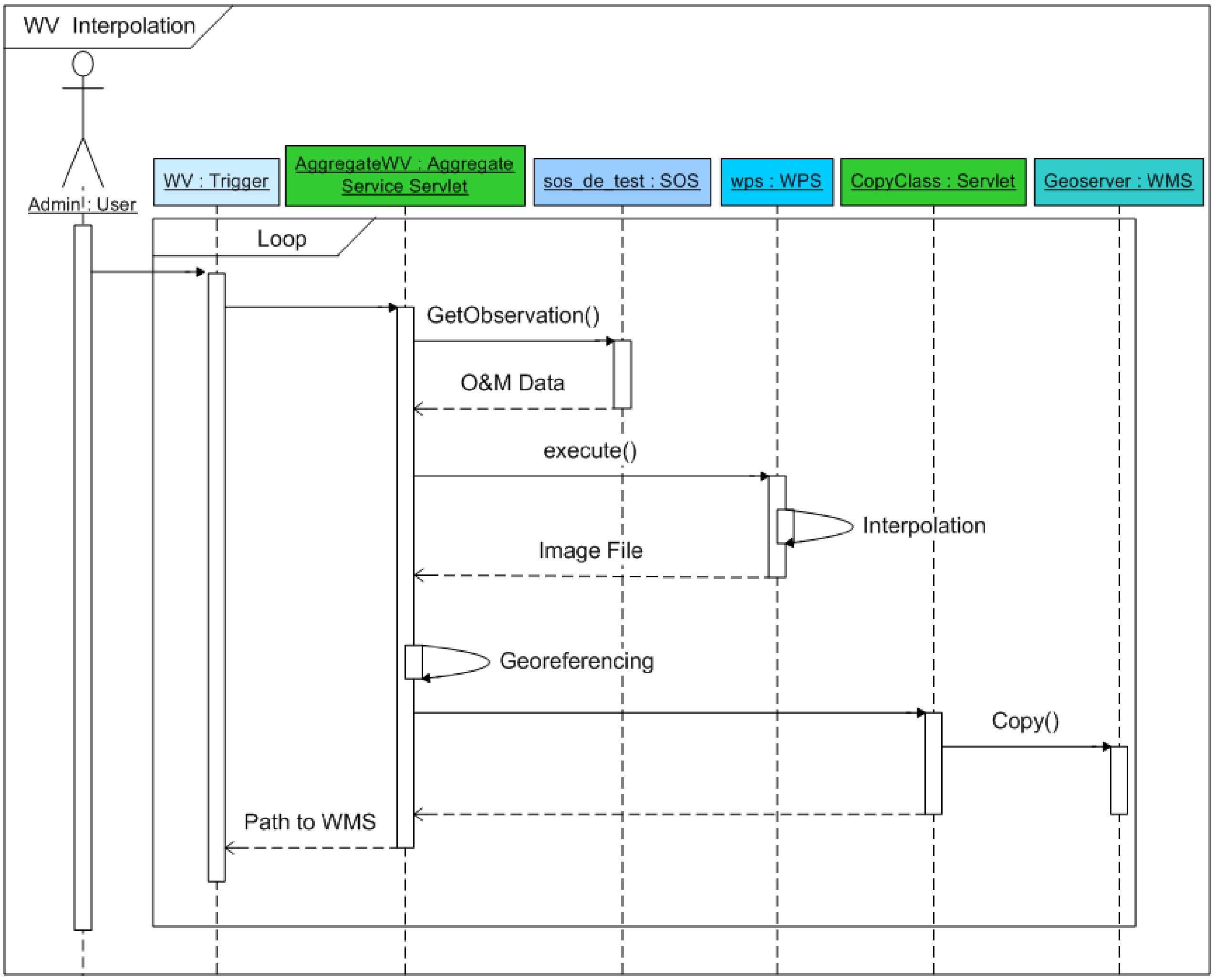

Figure 3: Sequence diagram for use case 1, showing the internal service chain in the aggregate service

3. Implementation of the concept

All software components and services used in this work are open source. The aggregate service is implemented as a Java^{TM} Servlet to manage the workflow and interaction of the different OGC services. The number of HTTP GET parameters were kept short (see Table 1) while full configuration can be achieved by context parameters in the web.xml file of the Servlet.

Table 1: HTTP GET parameters of the aggregate service

Parameter	**Obligation**	**Description**
start	mandatory	Start of measurement period. E.g.: „2010-02-24T00:00:00 0100“
end	mandatory	End of measurement period. E.g.: „2010-02-25T00:00:00 0100“
interpolation	mandatory	Interpolation method. Possible values: idw (default), kriging
bbox	optional	(default values also in web.xml file) Bounding Box parameters must follow the pattern: „xmin,ymin,xmax,ymax“

For the SOS and WPS servers, products from 52 North were used. The WMS instance was created in Geoserver.

4. Results and outlook

The WMS, providing the raster files, can easily be integrated in the FluGGS web-GIS, maintained by the Wupperverband, because of the conformance with the WMS standard. Figure 4 shows the result of an IDW interpolation for the 15th of March till the 16th of March 2010.

The validation of the data and the appropriate set of parameter values for the interpolation must be done by using a validation data set and expert knowledge about the meterological situation in the Wupper area. Afterwards the datasets produced for visualisation can be used as an in-situ reference for GMES remote-sensing data. Interpolated rainfall distribution is also necessary for a number of environmental models. One example is the calculation of the R-factor (rainfall and runoff factor) of the Universal Soil Loss Equation (USLE). For a service-oriented calculation of this factor, as described in Kunert et al. (2010), an OGC web-service solution is necessary, providing the rainfall distribution as shown above.

The prototype system, presented in this work, will be available online on the INSPIRE-GMES Testbed[7], maintained by the “Runder Tisch GIS e.V.” (Kraut, Schilcher & Straub 2009)

[7] http://www.rtg.bv.tum.de/

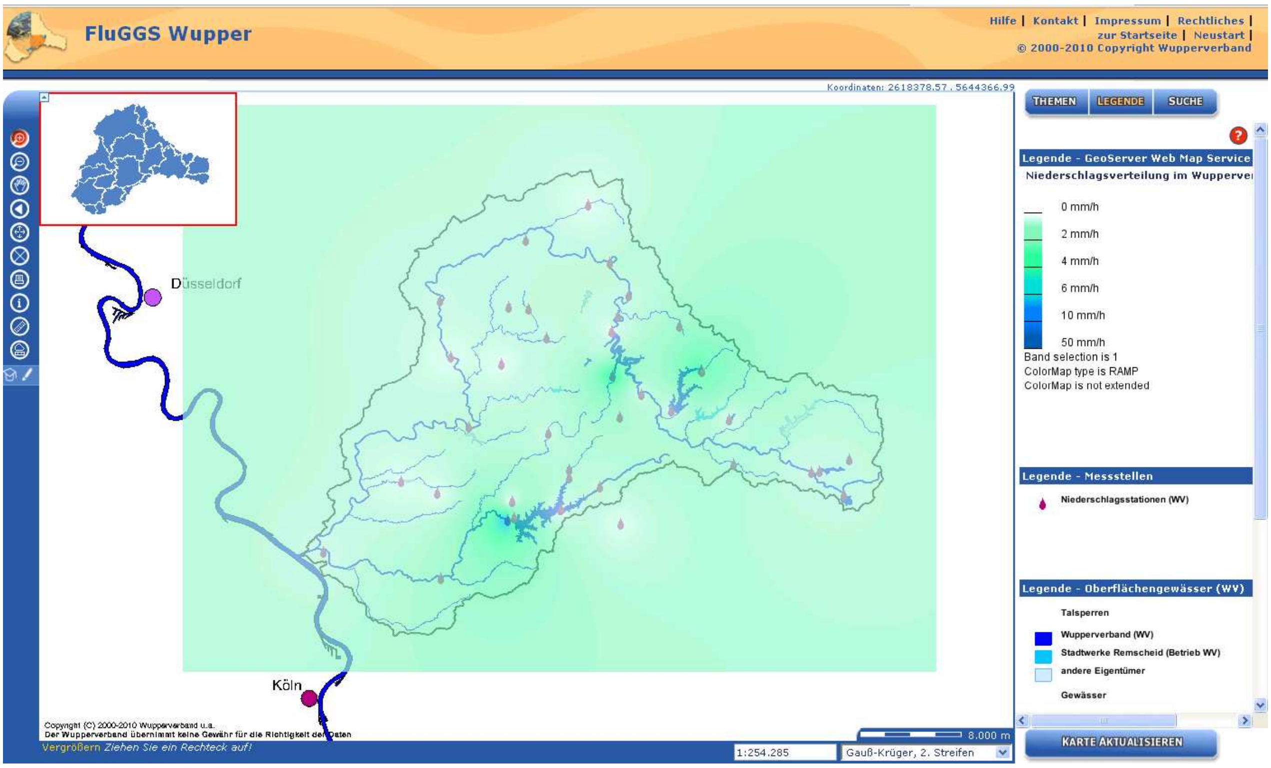

Figure 4: IDW interpolation result integrated in FluGGS via WMS interface

5. Acknowledgement

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6. Literature

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