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Serving Climatic Data Series, an OGC WMS Approach to Facilitate Use by Means of Interoperability

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Abstract: Viewing and manipulating climatic information is useful in many different scientific and social domains, and in many different software/hardware platforms. On the other hand, climatic data are characterised by its geographical distribution, its time dependent variability and storing size requirements. Providing public and broad access to this kind of information is a public service in the mind of many organisations such as the UN Health World Organisation. Interoperability arises as a key software issue to facilitate access to these services for different users and uses. This work presents a technological approach to deal with these services based on the OGC Web Map Service specification, and several use cases. The paper also deals with some limitations of the specification such as temporal series and geodata accessing.

1 Introduction

Climatic information is a kind of geographical information useful in many different interest areas (agriculture, environment, tourism, public health…). This data is interesting by itself (i.e. weather information), integrated with other kinds of geographical data (i.e. for more detailed tourist maps, or natural resources management [Mayer et. al., 2000]) or as input to different predicting models (i.e. epidemiology [Estrada-Peña, 1998]).

Climatic data is naturally suited to be represented in temporal series, as it varies constantly. This data is most useful in temporal series in order to develop models and make predictions, as seen for example in epidemiology [Estrada-Peña, 1998], public health [Fonseca Nobre et. al., 1995], or climatic change studies [Webster et. al., 2001].

Publishing this kind of information on Internet is thus relevant to many researchers in different areas. Many efforts have been made to publish climatic data on Internet, through different map servers or by means of simple coverages download (see as several among many examples [López Agostini et. al., 2000], [Tuffery et. al., 2000], [CDC, 2002], [Acacia, 2002], [NCDC, 2002]). Efforts need to be done in order to increase the accessibility of this information for different kinds of uses and users.

2 Temporal Series of Climatic Data

Satellite images are taken periodically, processed, analysed, stored and prepared for visualization, access and thematic maps production [Markov et. al., 2000]. An enormous quantity of information is generated. This information is prepared for its integration in GIS as coverages, layers, for different formats and computer systems.

When the same data are taken periodically on the same geographical area, the result is a temporal series. Temporal series are a particular case of layer aggregations, where a layer aggregation is a set of layers that share many metadata, and where the main differences in their metadata may be considered parameters (time or date in temporal series of the same region, sensor type in satellite raster coverages of the same area, etc.). Treating a set of satellite images as a layer aggregation, in a GIS context, makes it possible to take advantage of their common metadata, while treating it as a set of unrelated layers would have at least two drawbacks to give access to them:

- Describing the common metadata in every layer in an aggregation is a waste of space, or a waste of bandwidth in a network environment.

- For the user would be more convenient to know that several layers are in fact a layer aggregation because this way would be able to select the parameters of his/her interest instead of having to browse all the layers as if they were different. Analysis can also be more convenient if the software is aware of the fact that layers are an aggregation.

Climatic data in several areas is most useful in time series, in order to make temporal analysis and proper predictions. Agriculture and public health are two good examples:

- Agriculture and products from natural resources are subject to the vagaries of weather (the manifestation of fast atmospheric hydrologic processes) and climate (the long-term statistical measures of these hydrological processes). Thus, even relatively small changes in weather and climate could potentially have important consequences. Observation and monitoring of temperature, rainfall, and other environmental conditions over both short and long time scales are critical tools for making effective land use and resource management decisions.
- "Public health practice needs timely information on the course of disease and other health events to implement appropriate actions. Most epidemiological data have a location and time reference. Knowledge of the new information offered by spatial and temporal analysis will increase the potential for public health action. Geographic information systems (GIS) are an innovative technology ideal for generating this type of information" [Fonseca Nobre et. al., 1995].

3 Offering Temporal Series of Climatic Data on the Web

Internet is the best place to offer geographical information like climatic data because, as it is constantly changing, an easily updateable and accessible place is needed. As shown before, climatic data is most useful in temporal series, so the problem of giving access to climatic data time series on Internet must be addressed. There are several solutions for different kinds of users and user needs.

3.1 Simple Data Exploration

In order to show simple maps on the web much software is not needed. Publishing a simple map image with a legend does not require from any special server side software. It is not very useful though. Users cannot browse the data in any way or make any kind of queries. Exploration of the data is thus not possible. To offer these exploration capabilities, the existence of some kind of web map server is a requirement.

Thus, there are several configurations and combinations of clients and servers with an increasing degree of utility for the user:

1. Fixed maps produced off-line and published as simple static web pages. No special Internet software is required but a web map server can be used. In fact using one would make updates and changes much more simple than having to generate the map images again for every change. Useful as simple ways to show a fixed zone, in a fixed moment of time. Users don't need to be able to do anything besides been able to view a web page. For example, a weather forecast for the current date can be provided with this simple configuration. The temporality of the data is revealed through simple periodical updates of the maps.
2. Maps of a fixed region of interest but with the capability to select dates, or times, and maybe with a limited thematic selection. This solution allows for temporal series of data, including historical data, or even predictions about the future, while maintaining great simplicity. A web map server is not required, but may be used given the different types of use it offers through the use of clients of different complexity. Again using one would make easier updates. This interactive solution can be used for offering weather forecasts of several days ahead or when historical climatic information about a determinate area is needed (i.e. studying climatic change of a fixed area).
3. Interactive web maps offering layer and dates selection and tools for browsing the maps (zooming, panning, etc.). These maps are more customizable by the users because they have more choices, layers shown, area selected, date, etc., but more complex to use too. Offering the option of printing a map once customized by the user gives more possibilities to this solution. Some kind of web map server is needed to implement this. The client software may be a more or less simple HTML page, depending on the options given to the users. A more complex solution for the clients could be based in Java, giving a Java applet to the users with similar options to those found in desktop applications (see Figure 1). The client does not need to see all the capabilities offered by the map server. This way the same map server can be used for different needs, with customized client software adequate for distinct necessities. Maps offering data at different detail levels need to offer this kind of interactive access for allowing users to select the region, dates and themes (layers) of interest for them. This solution can be applied when different climatic parameters are of interest and they are presented in several layers. For example, for epidemiological models where temperature and humidity are inputs [Estrada-Peña, 1998].

4. One step beyond the last solution would be providing access to different map servers with different content on the same map. Interoperation between map servers would allow for data being developed, maintained and changed in different places (they may be different departments in a company or different places in the world) but shown together in the same map. This would allow for adding extra value to existing maps by allowing to overlap on them information from other places. Climatic data for example is very useful in areas so different as agriculture, biology or tourism. Maps providing this kind of information would benefit from being able to connect to a server with climatic data of their areas of interest and show the climatic information on top of the maps they already provide. If they already serve temporal data (i.e. annual crops for the last years), they can benefit from the temporal series of climatic data offered by the climatic servers they are interoperating with, to highlight trends and relationships hidden before for not having had access to that specific climatic data.

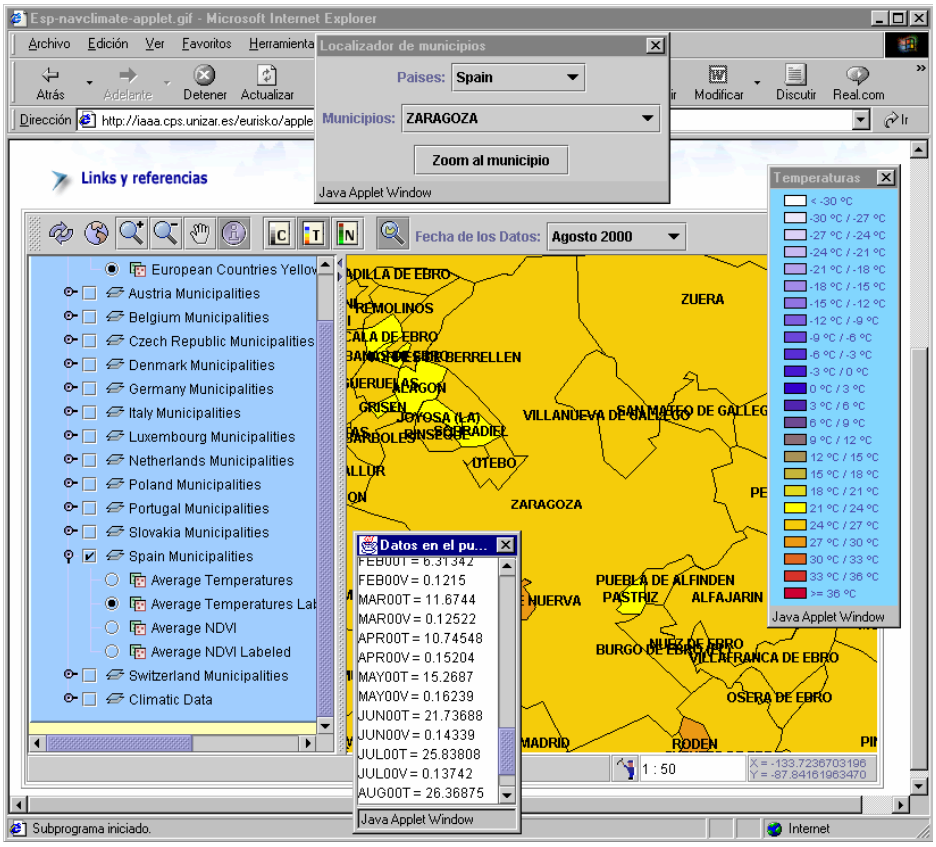

Figure 1: An example of an advanced climatic map server client [Eurisko, 2002]

3.2 Advanced Data Exploration

There are users with more specialized needs. They may need to fully access to the capabilities of the map server, in order to know the different coordinate systems that they can use to retrieve the maps, all of the layers and styles offered by the map server in order to compose the maps exactly as they need them or the full range of the different parameters needed to retrieve certain layers. They may be interested for example in maps showing the raw data (i.e. radiometer values) used for calculating some climatic parameters (i.e. temperature) before they have been processed and composed for visualization.

Other users may even need to download the complete coverages to work locally. The interactive mapping tools offered for browsing the data in the map server are thus used as a means of exploring these data to find and download exactly the needed information.

5. Any client able to connect to a web map server can be used as the tool for this kind of user, from Java applets embedded in web pages to complete desktop applications. This kind of software should be able to offer the user the possibility to see the capabilities published by the selected map server, provided

that the map server publishes them, in order to find out all the metadata they may need to know, such as coordinate systems of the layers, all the layers and styles offered by the map server, data about the maintainer of the coverages etc. Other interesting option is the ability to connect to different map servers selected by the user, provided that he knows their URL and interoperation is possible. This allows for composing maps exactly as the user desires and makes it possible to find new ways to put together different kinds of geographic data offered by different map servers. It would allow for the same type of uses than option 4, but with more precise geographical tools.

6. Servers may also be extended with new functionality. One of interest would be allowing for downloading the coverages the user has selected and browsed by means of the standard interfaces of the map server. A customized client can exploit the fact that browsing the map is already in the functionality of the generic client software, and add the options needed to download the coverages the user is seeing after browsing the map server. This way climatic data series can be used locally by researchers in the fields, listed before, that need them.

3.3 Data Exploitation

If the web map server is flexible in what relates to graphic formats offered, it may be used as a very limited coverage server. Asking this server just one of its raster layers in a graphic format suited to the needs of the user, the different layers in the server may be accessed through the standard interfaces.

7. A desktop application able to exploit this possibility could benefit from the advantages offered by working directly with data in the server
   - When coverages are updated in the server, the client automatically works with the new data. There is no need to notify the clients the change or to make them download the new coverages. Temporality of the climatic data makes this option very convenient, as users can access to the latest information as it is being made accessible.
   - The same map server can be used for browsing through the coverages the client does not need complete, reducing thus the traffic from the server and increasing the speed, and for downloading the coverages the client does need.
   - Users can work from different places or computers because data is stored in the web. A user does not need to carry the coverages from one place to another or from one computer to another. Provided that the computer is connected to Internet, data is always there.
   - Remote and local coverages can be managed together in the same way, because the desktop application can access both. Climatic data can be integrated with local models to improve them, or the check the validity of their predictions.
   - There is no need to download an entire, potentially very large, coverage if the user just uses one geographical area.

Figure 2 illustrates this scenario.

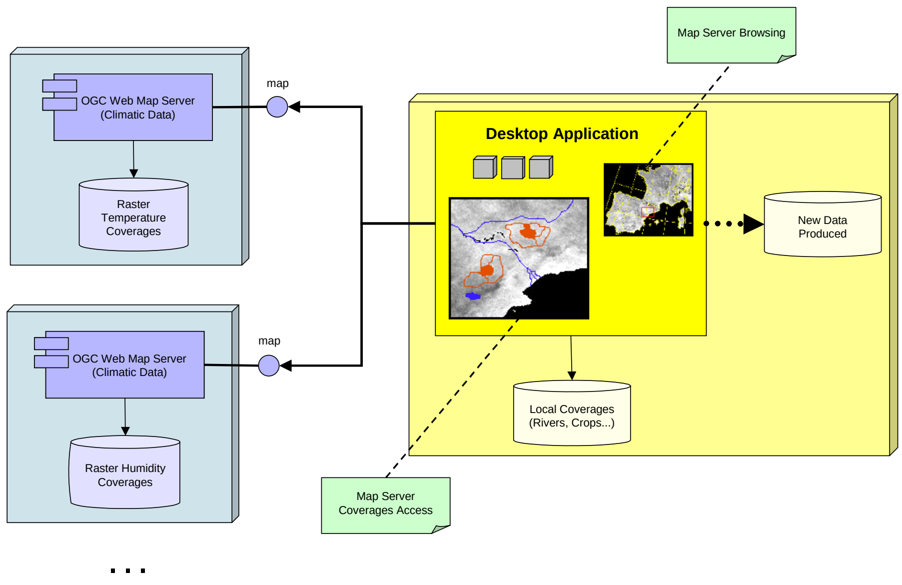

Figure 2: Data Exploitation Scenario Through Interoperable Web Map Servers

3.4 Summary

The next table shows a summary of the characteristics of the different options described before to give access to climatic data time series.

Table 1: Climatic Data Web Map Servers Uses Summary

	Show map	Parameter (date/time) selection	Map navigation	Several data sources (map servers)	User selection of data sources	Coverage downloads	Work with local data	Map Server required?
1	Yes							No. May be used
2	Yes	Yes						No. Should be used
3	Yes	Yes	Yes					Yes
4	Yes	Yes	Yes	Yes				Yes
5	Yes	Yes	Yes	Yes	Yes			Yes
6	Yes	Yes	Yes	Yes	Yes	With a proper extension		Yes
7	Yes	Yes	Yes	Yes	Yes	On the fly, not stored	Yes	Yes

Comentario [l1]:

4 OGC Web Map Server to Facilitate Access to Temporal Series of Climatic Data

Offering the temporal series of climatic data through a standard web map server, with well-known interfaces, makes it possible to interoperate with other systems (platform-level interoperability [Yétongnon et. al., 2000]), allowing for different uses of the information, from simple map visualization to direct access to the layers from complex desktop applications.

OpenGIS Consortium [OGC, 2002] Web Map Service [Doyle A. (ed.), 2000], [de La Beaujardière, J. (ed.), 2001] is becoming the standard specification for Internet mapping. It allows for publishing maps on the Internet and, by means of its well-known interfaces, interoperation with other compatible software, including other web map servers, desktop applications etc.

4.1 Overview of an OpenGIS Web Map Server

The web map service (WMS) interface proposed by OpenGIS is a set of requests that a server must be able to answer. Basically it is an application running with a web server that can generate maps to fulfil a specific request with a certain number of known parameters like spatial reference system, format of the answer, size or geographic zone. The interface is composed by a set of service descriptions for serving maps on Internet. Each implementation must follow the services, methods, conventions and naming that the interface proposes.

The web map server specification has three different types of requests: map, feature info, and capabilities. Map requests are sent to the server in order to obtain a specific map (basically an image) covering a zone of interest; some other parameters, like format of the answer file, reference system, or the information to compose the map, are needed. The feature info request (optional) is an extension of the map request. Selecting a pixel on the map, the client informs the map server that he wants information about the elements located under that pixel. The WMS will return the information as a text or XML file. Finally a capabilities request refers to the characteristics of the map server. On the response to this request, the map server reports all the services it can perform, the available map data, and the formats and reference systems supported for the answers.

4.2 Temporal Series in the OpenGIS Web Map Server

Until latest version, 1.1.0 [de La Beaujardière, J. (ed.), 2001], has not been addressed the fact that several of the layers offered by a map server may share many metadata (layer aggregations), and be different in one or more parameters (i.e. the time when the data were obtained). With a map server compliant with the latest version though, it is possible to implement solutions concerning temporal series of data without the limitations imposed by previous versions (replication of metadata, or making it more difficult to retrieve the desired layers).

If the only version available is 1.0 [Doyle A. (ed.), 2000] or a previous one, it is always possible to develop an extension, possibility addressed in the standard specification, to deal specifically with layer aggregations. Such a solution would be based on the capabilities extension mechanism provided by the standard and would have two objectives:

- Allowing the description of layer aggregations in a different way as layer sets that are not aggregations. The description should take advantage of the fact that layers in an aggregations share common metadata to minimize its size.
- Enabling the parameterization of the layer aggregations to allow asking for a concrete layer in the aggregation just by referencing to the aggregation and the value of the parameter chosen

4.3 A solution to server temporal series of climatic data through an OGC Web Map Server

A web map server compliant with OpenGIS specification (extended to support layer aggregations and parameterizations if only compliant with version 1.0 or previous) can be used to provide very different levels of access to time series of climatic data, exploiting the interoperability possibilities offered by its well-known interfaces and the option of developing client software specifically suited to different user needs, as these may impose several constraints or requirements on the software [Brinkhoff T., 2000]. Such a map server offers most of what is needed for the most advanced ways of serving temporal series of climatic data described before:

- Interoperability through its well-known standard interfaces (option 4).
- It makes public its capabilities thus allowing users to know them (option 5).
- It is flexible in what relates to graphic formats offered (data exploitation).
- It is extendible through the "vendor specific capabilities" (option 6).

Figure 3 shows an example of architecture able to support all the different options described in the previous chapter by interoperation between several kinds of clients and OpenGIS compliant web map servers.

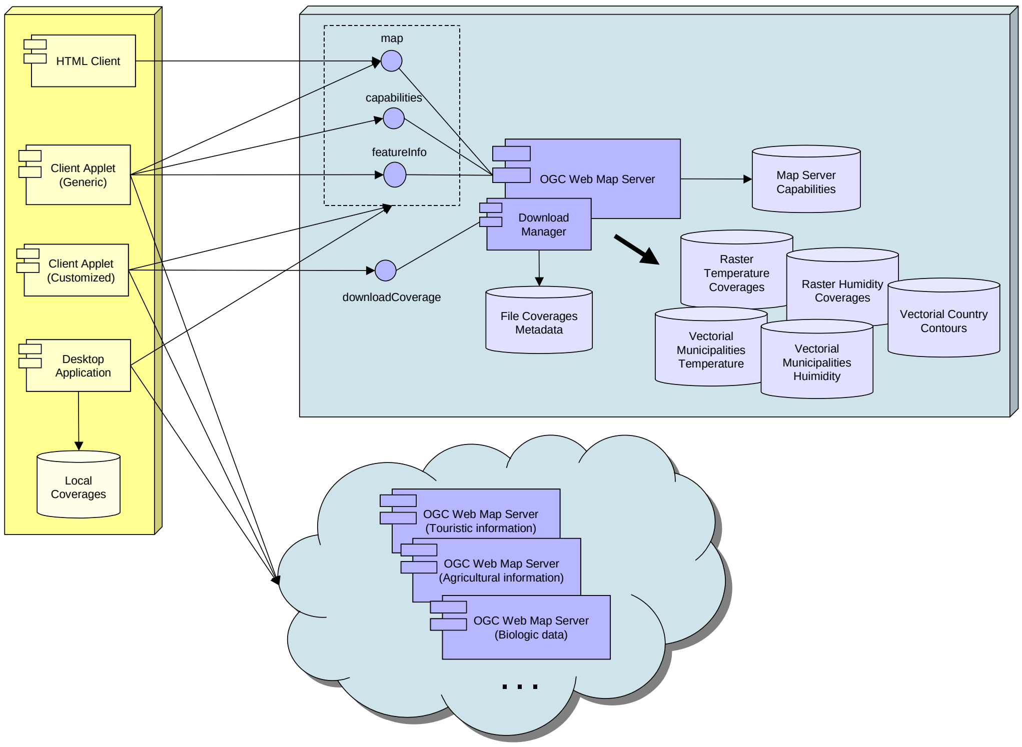

Figure 3: Climatic OpenGIS Web Map Servers Sample Architecture

5 Conclusions

In this paper has been shown the interest of climatic data time series in many different research areas, what makes it an important issue to facilitate access to this information.

Seven scenarios have been listed, showing different levels of complexity in the access to this kind of data, with different tools for the different needs of users from curious people to serious researchers. The use of interoperable web map servers to give access to this information has been proposed as a means to increase accessibility and as a means to provide all the tools the different scenarios need.

Finally, the use of web map servers compliant with the standard web map service proposed by OpenGIS Consortium is proposed as a solution, because they are adequately suited to solve most of the problems presented before and are flexible enough to support extensions for giving more options. A sample architecture showing how the different scenarios could be addressed is also outlined.

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