Monitoring Dust Storms in Central Asia with Open-Source WebGIS Assistance

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Abstract: The "Long Term Ecological Research Program for Monitoring Aeolian Soil Erosion" was initiated in November 2005 as a joint four-year EU–NIS (European Union, New Independent Countries) project. The goal was to understand the impact of aeolian dust on ecosystems, to establish a long-term monitoring system on current emission sites, to study the frequency of dust storms, the qualitative and quantitative properties of dust/salt deposits and to create effective tools that reclaim man-induced environmental damage. Aeolian erosion as dust-storms is a problem occurring in semi-arid and arid regions and over extensive areas. This phenomenon has a spatial dimension and occurs over extensive areas evolving several countries at the same time. Asian dust storms is the phenomena that lots of fine dust (or sand) particles are uplifted into the air by the strong surface wind in the source regions, transported far away and then finally deposited on the ground creating social, economic and environmental problems.

The nature of this phenomenon, the dispersion and different technical backgrounds of user that need to access information about dust-storms creates the need for the development of a unified WebGIS system for data storage and analysis. The WebGIS implemented was based on the MapServer system which was developed by University of Minnesota and NASA, and is based on the Open-Source licensing. This allows to build a system with a very low Total Operation Cost (TCO) and the use of freely available databases like PostGIS (based on PostgreSQL). The MapServer system was built using Linux as operating system (OS) running an APACHE server for HTTP requests. The programming and access call to MapServer were based on PHP functions (MapScript), while on the user side it was used AJAX (JavaScript/XML) to deal with the requests to the server and to process the GIS data This Linux-Apache-PHP-Mapserver connection is very flexible and extremely stable since the all the components have extensive documentation available on the net. This system allows for the users to retrieve several types of data, either as raster images from satellite or simple weather data stations data.

Key-Words: Aeolian, Erosion, Dust storms, Reclamation, Monitoring, WebGIS, Mapserver, Open-Source

1 Introduction

Aeolian processes as manifested by sand and dust storms are natural events that occur world-widely in arid and semi-arid regions. The storms can be both a symptom of serious anthropogenic land degradation, and a problem in its own right with dire consequences. In Central Asia, where sand and dust storms are common due to the vast areas of sandy, solonchak and clayey deserts, scarcity of vegetation cover and strong winds, large-scale anthropogenic

environment to run, slowing the execution of the applet it self.

The solution adopted by the CALTER project was to use the MapServer system as the WebGIS platform, this software is based on the Open-Source Software License therefore it can be used and modified without the need for licensing fees, this solution has a lower Total Cost of Operation (TCO) compared with ArcIMS, the TCO can decrease even more when using the Mapserver system in a Linux Operating System (OS) with PostGIS as spatial database.

MapServer was originally developed by the University of Minnesota (UMN) in cooperation with NASA and the Minnesota Department of Natural Resources (MNDNR). Presently, the MapServer project is a NASA sponsored project between the UMN and consortium of land management interests.

The MapSever system is more dependent on HTML/Javascipt compared to the JAVA approach of ArcIMS, also it supports several types of Scripting languages like PHP, Pearl, Phyton, C#. The Language used to access the MapServer functions is normally referred as MapScript independently of being PHP, Perl or any other language used for the programming.

The MapServer system doesn't have a strong ability for the use of client-side JAVA applets, because the main strategy is to use MapScript as programming tool for manipulation of HTML/JavaScript data-streams that will be displayed as a simple webpage to the end-user. This increases the need for computation need for the server-side, still the WebGIS based on Mapserver seem to be faster than ArcIMS.

One solution to increase the client-side computations and tools available for data analysis is to use AJAX, which stands for Asynchronous JavaScript and XML (Extensible Markup Language), AJAX is not a technology in itself, but a term that refers to the use of a group of technologies together [1], This technology is very recent and is mainly being implemented by Google Earth.

The AJAX technology has some advantages like:

-It doesn't need a run-environment, therefore running faster than other systems like JAVA

-It doesn't require special installation of plugins, since JavaScript is present in all the browsers

-It reduces the traffic between the user-server, since there is no need to reload all the webpage.

- Total integration with PHP on the server-side

But also has some disadvantages:

- There is lack of a standard language, mainly caused by different types of Javascript.
- The developer has to program more code to deal with the differences in browsers.
- Users may not be aware of the update of data because there is no reload of the webpage (flickering of the webpage)
- The use of the browser's back-button will produce problems. Normally this function needs to be deactivated.

The AJAX technology can solve the problem of the development of the tools necessary for the user to access and process the information provided by the WebGIS.

MapServer is not a stand-alone application and basically needs to be run inside a HTTP server like Apache and to use some scripting language like PHP to work properly. The use of PHP is relatively common on the internet and aside from the Mapserver webpages it has been applied in other scientifical project regarding the dissemination of data [4] and modeling [10]. PHP will work as the major language for creating the webpage and manipulating all requests and data accesses of the mapserver.

The use of Mapserver, PHP and AJAX will produce an application model as shown in figure 2.

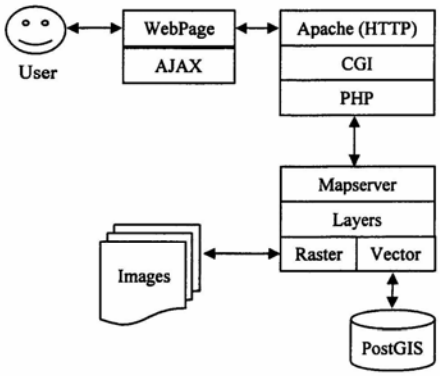

Figure 2. General schematics of data transfer between user, webpage, internet-server, MapServer and raster map or vector data

The MapServer works like any other GIS with layer of data (figure 3), these layers can be Raster or Vector type. For example satellite images

changes lead to the formation of new salt/dust-emitting sites.

The CALTER project is a 4 year project funded by the European Union, Sixth Framework Programme, and with the participation of Israel, Portugal, Germany, Russia, Kazakhstan, Turkmenistan and Uzbekistan (Figure 1).

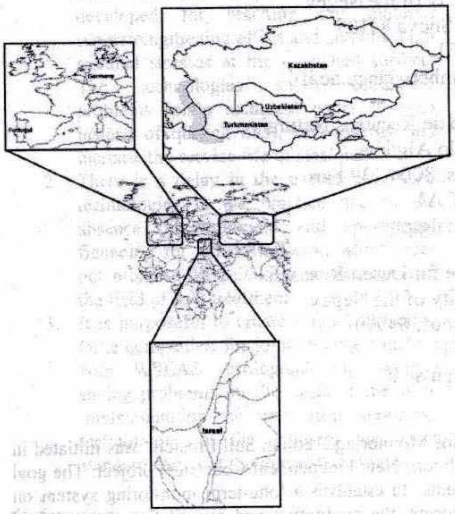

Figure 1. Location of the study area and participating countries.

For the duration of the project, several working groups dealing with Aeolian erosion ,sand and dust storms, phyto-ameliorative measures will study these processes within central Asia in general and specifically within the boundaries of the participating countries.

The information gathered by the several working groups needs to be agreed and easily available to all member of the project. One solution is the use of a common WebGIS for all participants.

The WebGIS should use common software/programming tools based on the open-source license so that costs can be kept at a minimum and without problems regarding the legality of the licensing system.

The objective of the present work was to develop and demonstrate an interactive WebGIS and geodatabase for Central Asia deserts providing map and data services, with the use of open-source tools.

2 Problem Formulation

The CALTER project involves several working groups, located in different countries, with different objectives, which in the end will create several types of data and conclusions based on different data sets.

The WebGIS platform should be able to store several types of information, and perform several types of GIS operations:

- Landsat, SPOT, and EnviSAT satellite images for analysis, classification, decision support.
- Digital elevation models and other elevation data like contour lines.
- Physical environment: climate (rainfall and wind erosion potential map), soils, surface, lithoedaphic type of desert, hydrographic (rivers, irrigation and drainage network).
- Ground-Data from meteorological stations of the local workgroups.
- Perform specific queries regarding spatial and temporal situations, which are returned to the user as a set of numerical data or images
- Run decision-support systems based on the available data.

3 Problem Solution

Several types of WebGIS can be found in the literature, in some cases it was used for tracking development of disease, [5] and [7], for land use monitoring [9], for air quality monitoring [1] and for location management of wireless internet structures [2].

The use of WebGIS makes geographic information available to larger audiences than conventional GIS packages [5] or data files stored in a simple server[6] it also enables the integration of geospatial datasets of land and water resources or other spatial information [9]. This allows real-time access to a high volume of data for all users that need it [8]. The geospatial information has to be easily accessible to all participants of the CALTER project independent of the user's platform or equipment used to access such data.

The majority of the WebGIS projects presented in the literature are based on the ArcIMS platform, developed by ESRI, which is proprietary software with high license fees. The ArcIMS platform uses JAVA applets on the user-side for data analysis and communication to the server; reducing the internet traffic and the need of computational power from the server [6], but this has the disadvantage that JAVA applets requires a proper

are Raster layer, since there is information for each pixel. In the case of data gathered are in a form of points or lines then layers should be in a vector structure, stored in some sort of spatial database like PostGIS. One example of vectorial data is the climatic data gathered from weather stations, this data is point specific, therefore is better displayed as a spatial point.

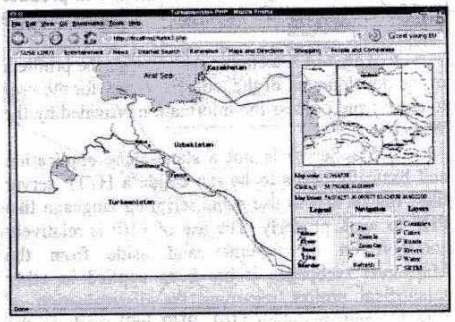

Figure 3. The WebGIS providing map services.

4 Conclusion

The used of WebGIS as tool of research is of fundamental importance when working with disperse users and there is the need of aggregating several types and forms of data so that they can be easily accessed to anyone. The use of WebGIS permits the integration, organization and retrieval of data from any internet access point. The WebGIS based on MapServer-Linux-Apache-PHP-PostGIS connection can be flexible enough to store all the data necessary for analysis of the sand-storm phenomena, also the use of this technology is money-saving since all the tools are based on the Open-Source Licensing.

The tools necessary for the data analysis can be programmed using AJAX and working mainly on the user's side, saving bandwidth and server resources.

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