Building the IDECi-UIB: the Scientific Spatial Data Infrastructure Node for the Balearic Islands University

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ABSTRACT

Technical and methodological enhancements in Information Technologies (IT) and Geographical Information Systems (GIS) has permitted the growth in Spatial Data Infrastructures (SDI) performance. In this way, their uses and applications have grown very rapidly. In the scientific and educational working fields, different institutions and organisations have bet for its use enforcing information exchange that allows researchers to improve their studies as well as give a better dissemination within the scientific community. Therefore, the GIS and Remote Sensing Service (SSIGT) at the Balearic Islands University (UIB) has decided to build and launch its own SDI to serve scientific Geo-Information (GI) throughout the Balearic Islands society focussing on the university community. By these means it intends to boost the development of research and education focusing on the field of spatial information. This article tries to explain the background ideas that form the basic concept of the scientific SDI related to the concepts of e-Science and e-Research. Finally, it explains how these ideas are taken into practice into the new University Scientific SDI.

INTRODUCTION

The technological advance of these last decades has had a very positive influence in GIS. This advancement has been reflected with the appearance of different geo-spatial cyber-infrastructures that serve geo-information increasing accessibility and availability to restricted user communities or to everyone from anywhere with internet access (Yang, et. Al, 2010).

These platforms, known as Spatial Data Infrastructures (SDI) work as portals to access to geo-databases for visualization or download (through geoservices) and web applications like viewers. They can also serve to disseminate geoprocessing tools or even data in real time through LBS[1] (Peng, et al. 2003). It is demonstrated that the rise of the SDIs has favoured the expansion of GIS applications and by those means, it is considered as a strategic advantage to many businesses, administrations or other public institutions (Williamson, et al. 2003).

Science is also continuously evolving. Research produces every day more information and therefore the difficulties to manage these amounts of information increase dramatically. In line with this, publications and discoveries once produced are stored, but if they are not accessed by anyone they rest stored when they could be used for further investigation (Watson, et al., 2010).

The IDECi-UIB wants to give response to all those questions. Thus, the aim of this article will show what the ideals of this SDI are and how it is build in order to respond to all these needs.

SCIENTIFIC GRIDS AND SDI: KEY TOOLS FOR E-RESEARCH

In the last ten years different organisations worldwide have had the need to find a system to store and catalogue produced scientific information. This has been done in order to save and retrieve it's information for research, enhancing the capacity to find new discoveries (e-SciDR, 2008), following

[1] LBS refer to Location-Based Services defined as "*wireless, mobile, and mostly handheld devices that use wireless communications to deliver information that conveys a geographical reference through location-determination technologies such as GPS or Wi-Fi to calculate a specific latitude and longitude of the device*" (Shekhar, et al. (dir.), 2007, p. 623)

the ideals to create an e-Science network with *Scientific Grids*[2]. After some initiatives in the UK, the European Union created in 2006 the e-SciDR (e-Science Digital Repositories) Program to promote the creation of a scientific grid in Europe. *"It is formed by different nodes working as inter-connected scientific information suppliers"* (Shekhar, and Xiong, 2008, p.419).

These networks work on any kind of scientific discipline. In GISciences *Scientific Geospatial Grids* connect different nodes that offer distributed GI through the net to share and exchange it among the scientific community (Shekhar and Xiong, 2008). There are several examples in the international context like the GEON Grid, focused on Earth Science Investigation, made between different universities in the US (GEON, 2011) or the Earth System Grid working in a global context with atmospheric research (ESG, 2011). Focussing in the Spanish territory scientific grids are neither so common nor developed; however some projects have been done in this direction: The CESGA[3] has developed a Scientific Grid with extensions on GIS issues (CESGA, 2011). Others like the CSIC[4] is also collaborating on a joined effort with the University of Valencia to create a Grid in Oceanography that involves GIS a part of working on an own Scientific Grid for the CSIC (Gómez, 2010).

Definitely, Scientific Geospatial Grids are not really a new concept, but nevertheless they are rare and not necessarily related to educational purposes. As cited before (e-SciDR, 2008) some organisations work with GI, and others apply the grid concept to Geosciences and GIS (Giuliani, et al. 2011) but a network with the application of GI in every research project belonging to any scientific discipline is something not so common.

So far, grids are made of interconnected nodes that work as GI providers (Shekhar and Xiong, 2008) and permit information sharing in between. Therefore it is easy to understand that nodes work in a lower hierarchical level, also providing information to the corresponding users. In the field of GISciences a *Scientific Geospatial Grid* might be created interconnecting nodes that share a common aim: the support to e-research based on GI. From here Scientific SDI nodes are derived (*Figure 1*).

Like the generic ones, Scientific SDIs work to disseminate GI focussing on the placement of scientific research projects in space, giving an added value to information exploiting the relationship between the studied features and the territory, making evidence of the surrounding geographic context.

The relation between Scientific SDI nodes and Scientific Geospatial Grids might grow if they achieve enough stability and confidence. Actually, it is expected that geospatial grids are going to be increasingly important in the comming years (Shekhar, and Xiong, 2008) due to *the accumulation of digitized data, information and Knowledge (DIK), of which 80% are geospatially related* (Shekhar, and Xiong, 2008, p.423). Therefore the Scientific SDI grows as an strong concept to develop.

[2] **Scientific Grid** refers to a specific kind of network that interconnects different nodes with the aim of producing science to exchange and share information enhancing the support systems for research and the production of e-Science. Moreover, *it takes a leading role since it addresses issues related to access provisioning, coordinated resource sharing, usage and security policies, etc* (Bosin, et al. 2011).

[3] **CESGA**: stands for "*Centro de Supercomputación de Galícia"* (Galician Supercomputation Centre) (CESGA, 2011)

[4] **CSIC**: stands for "*Consejo Superior de Investigaciones Científicas"* (Spanish National Research Council) (CSIC, 2010)

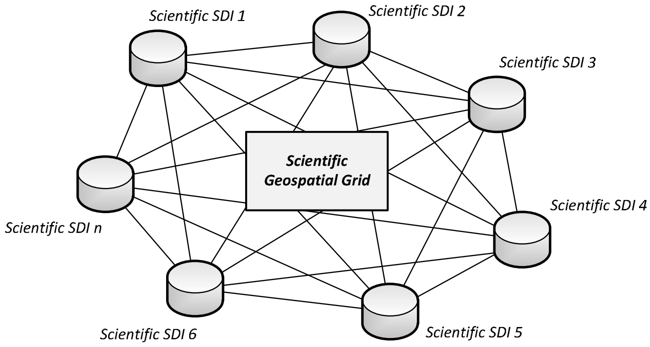

***Figure 1**:* Conceptual idea for the Scientific SDIs and the Scientific Geospatial Grid.
Own production in January 2011.

THE CASE OF THE IDECI-UIB: A GATEWAY FOR SCIENCE

Keeping all these ideas in mind, the GIS and Remote Sensing Service (SSIGT) from the Balearic Islands University (UIB) has started developing its own Scientific SDI node: the IDECi-UIB[5]. In it, GI will be accessible for UIB users but also for the whole Balearic Islands community and therefore for everyone, becoming a semi-open platform. In this platform geo-information, understanding it as thematic geo-data, geoprocessing models and project results will be available for visualization and download. Nevertheless, it is considered semi-opened because only some of the contents are fully available to any user on the internet, and the rest are restricted to research members. This is going to promote a progressive growth in the use of GIS in education, research and a better geographic knowledge for Balearic citizens about their territory.

The website overview

Figure 2 shows the IDECi-UIB website. In it, users can find a Geo-information Catalogue to access geodata and services through metadata; a window to access a collection of visors on thematic datasets with the possibility to download data selecting by location; In third place, the section for e-Research gives access to Research projects (restricted access) that incorporate geotools, data and results and a section for Volunteered Geographical Information (Haklay, 2010) known as *Geoforum*, consisting in a site where users can upload self-collected geo-data. A part from that, secondary sections like information about the IDECi-UIB, the SSIGT Service, SDI documentation, news or links are provided.

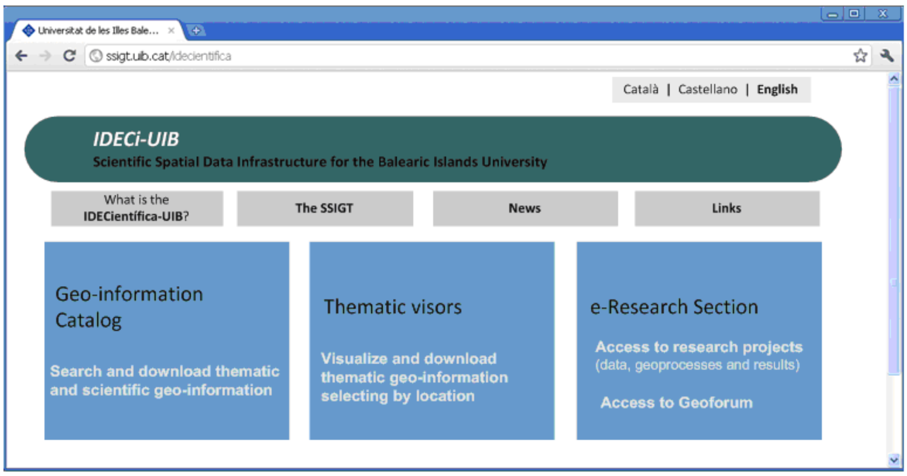

***Figure 2**:* Previsualization on the *IDECi-UIB*'s website.
Own production, January 2011.

[5] IDECi-UIB stands for *"Infrastructura de Dades Espacials Científica de la Universitat de les Illes Balears"* (in catalan). The English translation would be: *Scientific Spatial Data Infrastructure for the Balearic Islands University*

Infrastructure needs: storage, access, retrieval and information sharing

In order to make the site accessible to the widest public, the SDI is being designed to be opened. Ideally an interoperable service should use standard communication methods to exchange heterogeneous data without caring about file or database formats or operating systems (Giuliani, et al., 2011). The IDECi-UIB indeed uses OGC standards to catalogue data and geoservices with proper metadata[6], and fulfils the minimum requirements made by the Spanish Legislation in GI (CNIG, 2006). Finally it is also adapted to the INSPIRE Programme to be compatible with all other European SDIs. This is made by instances like the use of its GI thematic classification or with the use of ETRS89 standardized projection (INSPIRE, 2011).

So far, one of the main goals of the IDECi-UIB is to compile the maximum amount of scientific projects created by the Balearic Islands University that have an spatial component from any scientific discipline to place it in the geoportal: permitting a permanent access to any user with permission and storing it within a catalogue to ensure safety and retrieval (Watson, et al. 2010). The continuous storage of research projects into it will mean a big collection of spatial-based projects available for e-research in a medium-long term, ensuring its use for further investigation.

Moreover, the added value for researchers will be that they will have a gateway where others can access to their projects for visualisation, download or even collaboration, improving the research capacity and creating a space where all knowledge related with spatial information can be found.

A part from the e-research side there is the option to access to thematic data that can be used for own projects development. These geodatasets are catalogued and archived in a database, and by different means (in archives or services WMS, WFS or WCS), they will be accessible through viewers and geoservices. Data comes through external providers, mainly public administrations.

Figure 3 shows how the SSIGT works only as a GI service between the university users, serving GI from the external providers and investigators through the geoportal considering human, financial and technological resources and established standards and policy statements.

A necessary key development item to achieve such a GI Library is security. Researchers are sensitive to the safety of their produced information, and therefore they want a precise guaranty that it is only accessed by the desired users (Watson, et al. 2010). These conditions are met through data transfer agreements with each researcher that gives a totally open or more restricted access depending on their level of access privileges (Figures 3). In any case, everyone will have access to metadata to be able to know what is available at the IDECi-UIB.

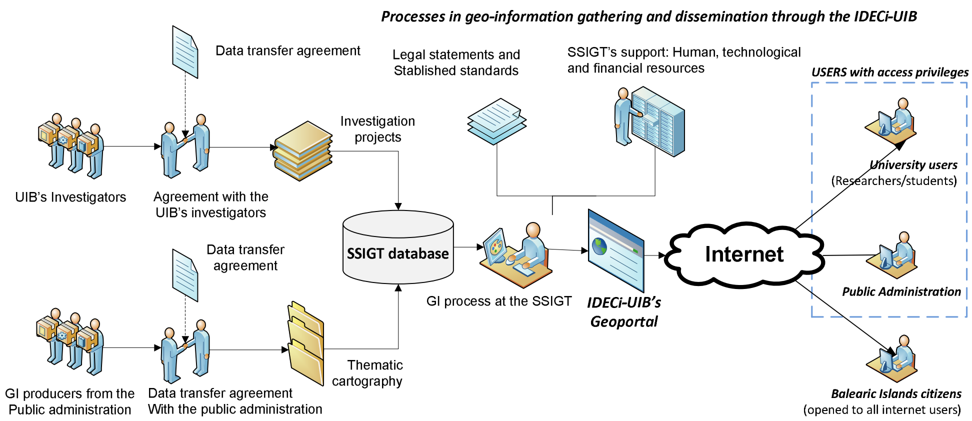

Figure 3: Processes of Geo-Information gathering and dissemination through the IDECi-UIB. Own production, January 2011.

[6] Metadata files within the SDI are structured following the ISO 19115 and ISO 19131 standards as the OGC defines.

Serving more than geo-data: towards distributed GIS

A part from the most popular OGC geoservices like Mapping Services (WMS) and the not so extended geoservices with possibilities on download like the Web Feature services (WFS) for vector information and the Web Coverage Services (WCS) for rasters (Giulani, et al. 2011) other services will permit to offer more than geo-data.

Web Processing Services (WPS) are rather new OGC standards (Schut, 2007) that permit the use of geoprocessing tools in a web service environment (Giuliani, et al., 2011). This technologic advance included in the IDECi-UIB permits the enclosure of the methods used to create the investigation projects provided at the SDI. WPS allow *the publication of reusable and interoperable software tools to allow other researchers, managers, and conservation practitioners to repeat analyses without reengineering them from scratch, to integrate them into larger scientific and management workflows, and ultimately to leverage them in an operational context*" (Roberts, et al. 2010, p. 1197). These complex analysis operations will be available for users even if they don't have such software capacities (Giuliani, et al., 2011). Additionally, other metadata for geoprocessing services will have to be made, explaining in detail what parameters and data is required to give a proper result in operations.

Since most of scenarios in study cases are not able to be approached with simple operations, workflows are necessary (Giuliani, et al., 2011). These workflows models allow users to change parameters, so it is possible to re-process and download data that will extract the information they need using that model. The performance of these services will be achieved through ESRI software. Therefore WPS will be limited to models created with ArcGIS Desktop Model Builder or through Python scripts (ESRI, 2010). Nevertheless there is the option to upload models made with Python which can be written freely in open-source software and are even compatible with other programming languages like C/C++ or MATLAB (Roberts, et al. 2010). However investigators may require a notable notion on programming languages that they may not have (Roberts, et al. 2010).

This technical advance gives a step forward towards a platform working in distributed GIS, where users do not require any specific GIS software and can freely work through the internet browser (Peng, et al. 2003); a part gives an added value providing geo-data but also methods and however it is just an approximation that must be improved in the future.

Geoforum, an option for open e-research

The implication of users in this Scientific SDI is notable counting the amount of investigators that work as GI providers. However, not only investigators are able to collect scientific information. Considering the existence of mobile and wireless GIS devices, other people with enough background and ability could collect GI that might be interesting to study.

Thus, the IDECi-UIB will make this system available to permit the open upload of scientific geo-data or associated GI to the SDI. Instances of this might be GPS samples of endangered species in remote areas, location of services with related attributes or videos and pictures. This system will work as Figure 4 and 5 depict: a first data upload through a FTP[7] connection by users will point to the SSIGT server; that information will be evaluated and catalogued to be included in the database for further studies or thematic layers development, which later on will be added to the SDI.

[7] **FTP** stands for File Transfer Protocol; it serves as a protocol to copy files from a host through the Internet (Internetsoft Corporation, 2004)

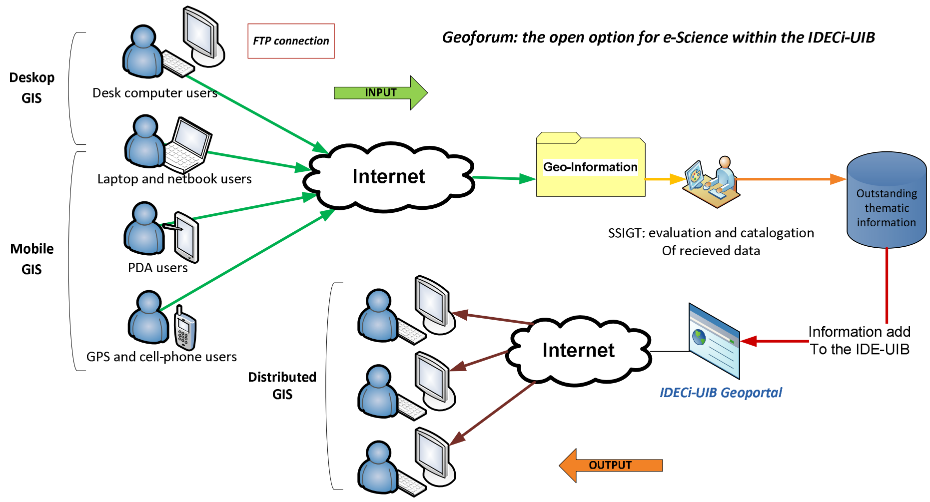

Figure 4: Working system of Geoforum: the open option for e-Science into the IDECi-UIB. Own production, December 2010.

Network architecture design

The enclosure of all these services and applications needs a clear structure to support a proper system performance. At the present two main system architectures are available: the Service-Oriented Architecture (SOA) and the Cloud Architecture. From those, the most innovative and promising one for distributed GIS and a scientific grids is cloud architecture (Watson, et al. 2010; Giuliani et al, 2011). The problem comes with the needed expertise on GI management skills that most researchers do not have. Since they will interact in the SDI, it is convenient to have an independent responsible team to manage with the infrastructural changes and reviews, data management or security. On the other hand, Cloud Architecture is quite unfamiliar with the SDI development team. Therefore, the more common standard and tested SOA has been selected as architectural model, reducing difficulties when building the system. Future structural changes may happen when users are ready for such a change in possibilities and responsibilities.

SOA "*provides the framework and rules for service description, discovery, interaction and execution*" (Giuliani, et al., 2011, p. 293), and therefore can include all SDI services and applications. This architecture defines a centralized infrastructure where all data is provided from a central server and clients (users) tend to have a lower responsibility grade (Peng, et al. 2006).

System architecture

The database at the SSIGT server works as central data repository for all existing GI sources in the IDECi-UIB. However, not all users access by the same way due to different accessibility and action roles.

The system structure depicted is clearly explained in Figure 5. The SSIGT Database is the central source of Geo-Information divided in three main blocks: the Thematic Information Block where the descriptive layers are stored and catalogued per theme; the Scientific Information Block where all research projects are stored (including data, geoprocessing models and resulting layers); and finally the Associated Geo-Information Block, which includes information related to space like multimedia files (pictures, videos…), scientific project reports (related to the research projects), amongst others.

However, information blocks are not static. Since scientific research is based on the production of new information, resulting layers from investigation projects can become thematic layers (Tintoré and Ruiz, 2007). That means that at some point part of these Scientific Block layers will pass to the Thematic Block. That will be made by the SSIGT managers who will decide which layers should be moved. It is symbolized in Figure 5 with an orange arrow.

This GI can be accessed using the IDECi-UIB Geoportal through the Internet or through a direct link into the DB using the server's IP address. The Geoportal access, the most common, is based on the creation of geo-services through ArcGIS Server. Between those services some have an opened access and others are restricted to specific users. Due to the thematic data openness the SSIGT will give free access to the most of these datasets. However for scientific GI accessibility will be much more restricted: only researchers and users allowed to have access to these projects will have the possibility to view, process or download that GI. For that reason every project will need the proper user name and password to access it.

As explained before (Figure 1), the IDECi-UIB geoportal gives access to GI through three main sites, all of them working directly or indirectly with services. Thematic Viewers are applications that pull WMS or WPS to show selected datasets and give capabilities to use simple geoprocessing tools. Secondly, the Catalog works as a searching engine that looks into metadata to give availability and access to services. Finally the e-Research site gives access to the Project Viewers (with restricted access) where projects can be visualized and run through the WPS models existing in each project. The last option in this subsection is the Geoforum; an opened site to any user able to upload geo-data or associated GI through a FTP directory that later on will be included in one of the DB blocks.

However the DB can also be accessed directly through its IP address, giving the possibility to directly manage with files. This type of connection is only possible for UIB researchers, students and SDI administrators at the SSIGT. Between them, there is a clear differentiation in operational roles: When SDI administrators (thick clients) have edition privileges onto the DB and can manage it through Desktop, SDE and Server GIS, researchers and students[8] can only access to data for visualization and download through their Desktop GIS.

[8] The direct access to the SSIGT database by students is only permitted to thematic datasets and the opened access projects.

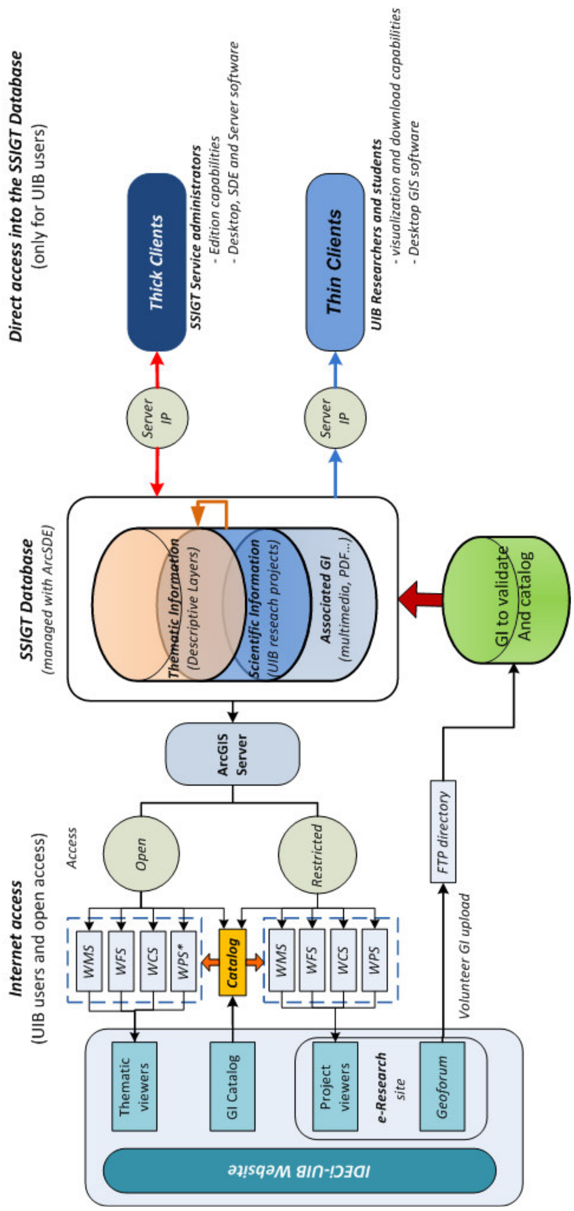

***Figure 5**:* System architecture structure and access to GI at the IDECi-UIB.
Own production on January 2011

Documentation and reviewing processes

The IDECi-UIB will be a reality in short. However this is the beginning of a long time project that may continue for several years expanding its content and complexity. Therefore it is necessary to document all used methods to build the infrastructure, creating procedure protocols for future SDI developers who will continue with this job.

Besides this, it is demonstrated that *"when developing SDI initiatives it is increasingly important to assess their outcomes in order to justify the resources spent on those infrastructure"* (Grus, et al. 2007, page 33). This is the case of the SDI's Strategic Plan, which following the Information System Development Technology method (ISDM) defines a base for system follow-up, review and improvement (Revee & Petch, 1999).

CONCLUSIONS

This project grows as one of the main SSIGT efforts since it supports its main mission and objectives: firstly reinforcing the use and application of GI to improve education and research tasks. Secondly, it is supporting the participation and activities transference I+D+i in geographic and environmental matters. And finally, it is managing and enlarging a GI database derived from the academic activity at the University opened to the Balearic society and the international scientific community through the SDI (SSIGT, 2011). Moreover the SDI also promotes the growth of GIS use and applications either at the university or in businesses and administrations.

On the other hand, and looking to the prospects expected from GIScience in the coming years (Goodchild, 2009), the IDECi-UIB ideas go in the same way: expecting a progressive growth on the citizen participation for GI production and use; working on the trend towards easy-to-use and opened systems helping to e-Research development; and finally working towards real-time or at least gain in higher temporal resolution, *less focused on the present like an snapshot* (Goodchild, 2009, p. 1041).

In terms of education, the recently implanted Bologna Process at the UIB (2009-2010) requires a new high quality learning methodology. In that sense, the creation of the Scientific SDI gives another support resource for students and professors.

In any case the development of this Scientific SDI represents a very important step forward for e-research, education and GI use and applications. Finally it is expected that the characterization of the concept of Scientific SDI gains value and expands to permit in a mid-long term a real expansion in GI use, application and exchange for research worldwide in universities.

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