Assessing Climate impacts on the Quantity and quality of WAter

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1. Foreword from the Project Coordinator and Project Director

It is always a daunting challenge at the start of a major new project involving 37 partners that need to work in close synergy over a period of 5 years. In addition, the numerous administrative and scientific requirements that form part of the normal process of EU framework projects puts additional pressure on the scientists to deliver their results not only in terms of scientific quality, but also within the deadlines stipulated by the contracts that link the research community to the European Commission. Furthermore, the particular context of the Copenhagen conference of the Parties to the Framework Convention on Climate Change (FCCC/COP-15), that aims to examine the post-Kyoto process has placed many scientists in a rather unique position at the interface between science and policy, thereby extending the "normal mandate" of a researcher compared to other disciplines.

The ACQWA Project, whose focus is on water resources in mountain regions – that represent over half of the source areas of surface waters around the globe – is particularly timely, since the aim of COP-15 is to discuss not only greenhouse-gas abatement measures, but also to address the complex and interlinked environmental, social and economic issues related to adaptation. Water, being arguably the most important single resource that climatic change may impact upon into the future, will obviously be on top of numerous policy agendas, in particular for regions where water may exhibit more scarcity in total amount and/or in terms of seasonality. The ACQWA project with its numerous environmental and socio-economic components is thus clearly at the forefront of the current and future adaptation-related negotiations and should in time be able to provide appropriate policy-relevant guidance.

It is thus with great pleasure and with significant relief that we, from the coordination of the project, can report very positively as to the progress that has been accomplished in the first year of ACQWA, that began on October 1, 2008. In terms of both observations and theoretical investigations, the different teams have already delivered much scientific information of high quality. Indeed, this translates into over 110 papers in the peer-reviewed literature (journals and book series) and over 130 presentations at major international conferences or within specific meetings aimed at informing national and local policymakers as to the issues involved in terms of climatic change and water resources in mountain environments. This productivity is well at the upper bound of EU projects of similar magnitude and thus highlights the general scientific dynamics and robustness of the project within just a few months – especially when considering the fact that many partners have not even begun their activity. This is because of the structure of the work-packages and the staggering of the data and information flow between the "model prediction work package" (WP3) and the "impacts and adaptation work package" (WP4). New results can be viewed at www.acqwa.ch.

In this second newsletter, you will find interesting new information on data availability and a short summary of first results emerging from the project. We look forward to communicating further with you in the future through these newsletters that will be available twice a year.

Martin Beniston, Project Coordinator *Markus Stoffel, Project Director*

2. ACQWA General Assembly 2009 in Courmayeur: message from the local Minister of the Environment of the region of Aosta, Italy

The following is a translation of the remarks made by the local government officials during the 2009 meeting, to highlight the interest of stakeholders and policy makers in the Aosta Valley to the issues addressed by the ACQWA Project.

(M.Zublena, Assessore Territorio e Ambiente della Regione Autonoma Valle d'Aosta)

"*Welcome to the 2nd ACQWA general assembly, a special greeting to the project coordinator Mr. Martin Beniston.*

Courmayeur has been chosen for this meeting as a symbol of the engagement of our regional project partners ARPA VdA (Regional Agency for Environmental Protection of the Aosta Valley), Fondazione Montagna Sicura and Compagnia Valdostana delle Acque in the study, management and conservation of water resources in the Aosta Valley.

As Regional Minister for the Environment, I want to express the utmost appreciation for this project. We are aware of living in the heart of the alpine system, a territory with very particular characteristics, in which water resources have always played a central role. Water has been the driving force of traditional and industrial production in this part of the Alps and of course the essential resource for the development of agriculture in our area of complex topography.

Today, the use of this resource requires new paradigms of economic value and vulnerability. The first is related to the characteristics of renewability and absence of greenhouse gas emissions, the second to the need of preserving the integrity of environmental systems where many elements are dynamically inter-linked.

To deal effectively with these complex challenges, there is a crucial need for a dialogue between scientists, economic and social stakeholders, as well as the policymakers who are ultimately responsible for decisions concerning sustainability and the environment.

Personally, I come from the world of prevention and environmental protection and my personal training accompanies me in every moment of my political role in service of society. You have my full backing for this interesting project!"

3. ACQWA and the EU FP6 project ENSEMBLES

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ACQWA WP2 – Task 2.2.

In the first part of the ACQWA project, climate model simulations from the EU FP6 integrated project ENSEMBLES are used to drive hydrological discharge models. The ENSEMBLES project aimed at developing ensemble prediction systems for climate change, quantifying and reducing the uncertainty in the representation feedbacks in the Earth System, and maximising the exploitation of the results by linking the outputs of the ensemble prediction system to a range of applications.

For the ENSEMBLES project the participating climate modeling institutes performed simulations with different regional climate models at a spatial resolution of 25km for the European domain. The regional climate models were driven at the lateral boundaries by ERA40 reanalysis for the period 1951 to 2000 for the purpose of validation. Moreover, A1B scenario simulations have been performed using different global climate models to force the regional climate models. These simulations span the time period 1950 to 2050, and some of these runs have been extended to the year 2100. The regional climate model ensemble simulations allow for quantifying various sources of model uncertainties and assessing the robustness of results.

In the ACQWA project two of those regional climate models, RegCM (Pal et al. 2007) and REMO (Jacob 2001, Jacob et al. 2007), will be used to perform the dedicated high-resolution simulations. These high-resolution simulations will use the respective ENSEMBLES 25km runs as lateral boundary conditions.

The ENSEMBLES regional climate model database

The climate model simulations are stored in a database maintained by the Danish Meteorological Institute. The climate model data are now publicly available through the Internet by accessing the page http://ensemblesrt3.dmi.dk/. The conditions of use have to be accepted and an email address provided in order to download the data. A list of all participating regional climate models and the corresponding driving global climate models is provided on the same homepage.

The regional climate model data are in NetCDF format. This is a binary format that has become a standard as an interface between climate modelers and data users. All the variables coming from the climate model simulations are stored as monthly mean and daily mean values. There are also 6-hourly values available, but these are instantaneous values that are not recommended to be used for driving hydrological models.

An example of the results of the ENSEMBLES simulations is shown in Figure 1.

The temperature change signal (difference between the means over the period 1961 to 2000 and the mean over the period 2030 to 2050) is depicted for mean winter temperature and all the regional climate models participating in ENSEMBLES.

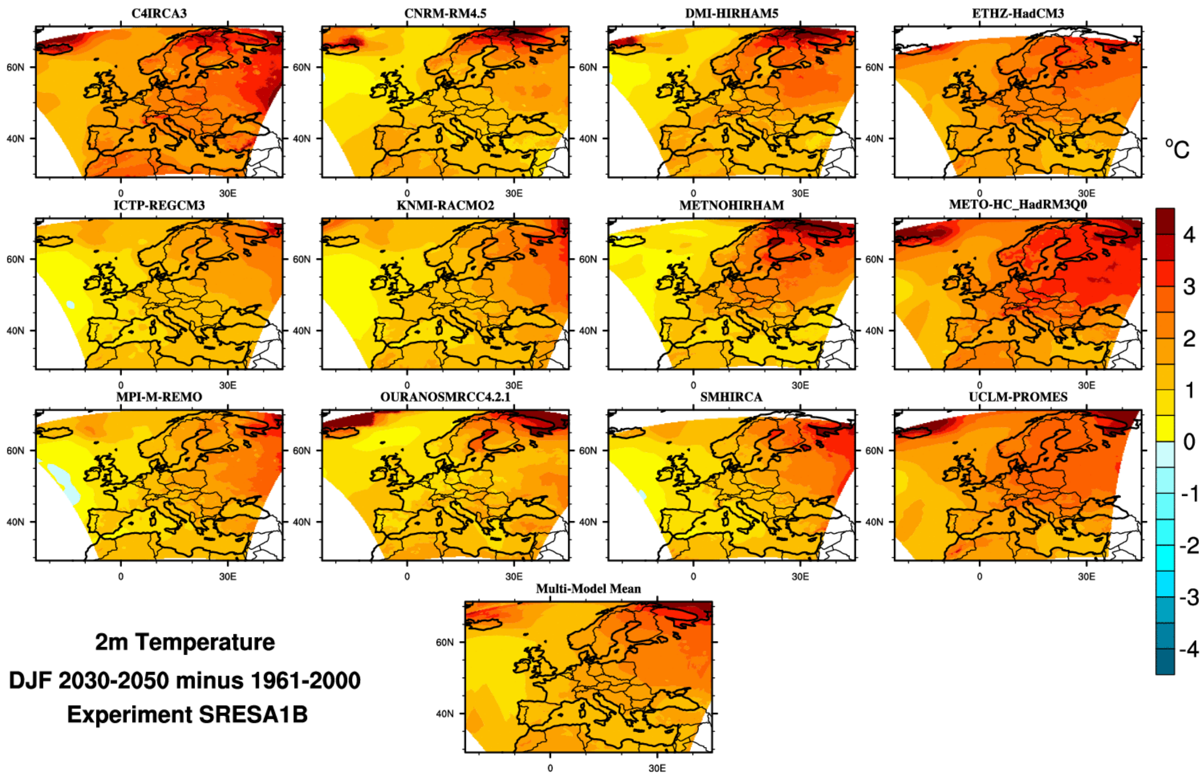

Figure 1: *Winter temperature (℃) change signal of the perio d 1961- 2000 compared to the period 2030- 2050 for all of the ENSEMBLES models.*

Since all the climate model data that have been produced in ENSEMBLES are publicly available through the ENSEMBLES data portal, there will be no separate database for these simulations in ACQWA. Researches in ACQWA who want to use these data can access them directly through the ENSEMBLES database.

In case of the two regional climate models RegCM and REMO, that are also participating in the ACQWA project, the ENSEMBLES 25km simulations can be provided in higher temporal resolution: 3-hourly in the case of RegCM, and hourly in the case of REMO. The distribution of these climate model data will organized through the ftp-servers of the corresponding institutes ICTP and MPI-M, respectively. The ACQWA partner Wegener Center of the University of Graz will apply a bias correction scheme to these data. The corrected data will be stored in the ACQWA data warehouse.

The climate model simulations performed in ACQWA

Both climate modeling institutes participating in ACQWA, ICTP and MPI-M, will provide dedicated additional high-resolution regional climate model simulations nested in the 25 km ENSEMBLES runs for the ACQWA project.

The RegCM3 high-resolution simulation will be at 15 km resolution with a sub-grid of 3 km on a domain encompassing the region in Figure 2.

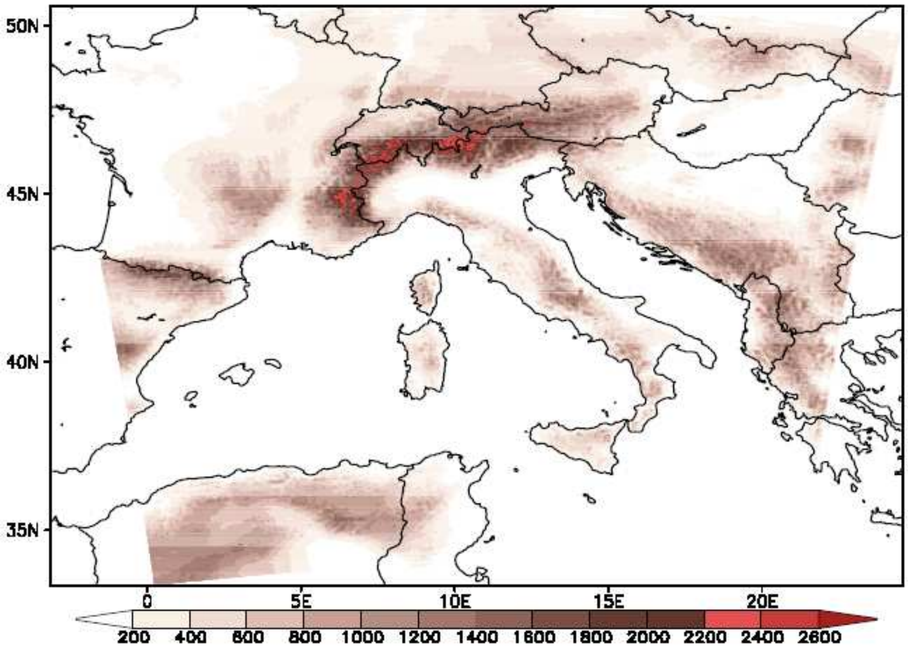

Figure2: *RegCM domain for the ACQWA simulation at 3km.*

MPI-M will perform regional climate model simulations using REMO at a resolution of 10km. The model domain is depicted in Figure 3.

Here as well the data will be provided through the ftp-server of the institute that performs the climate model simulations. Simulations that are post-processed by the ACQWA partner of the Wegener Center Graz will again be stored in the ACQWA data warehouse.

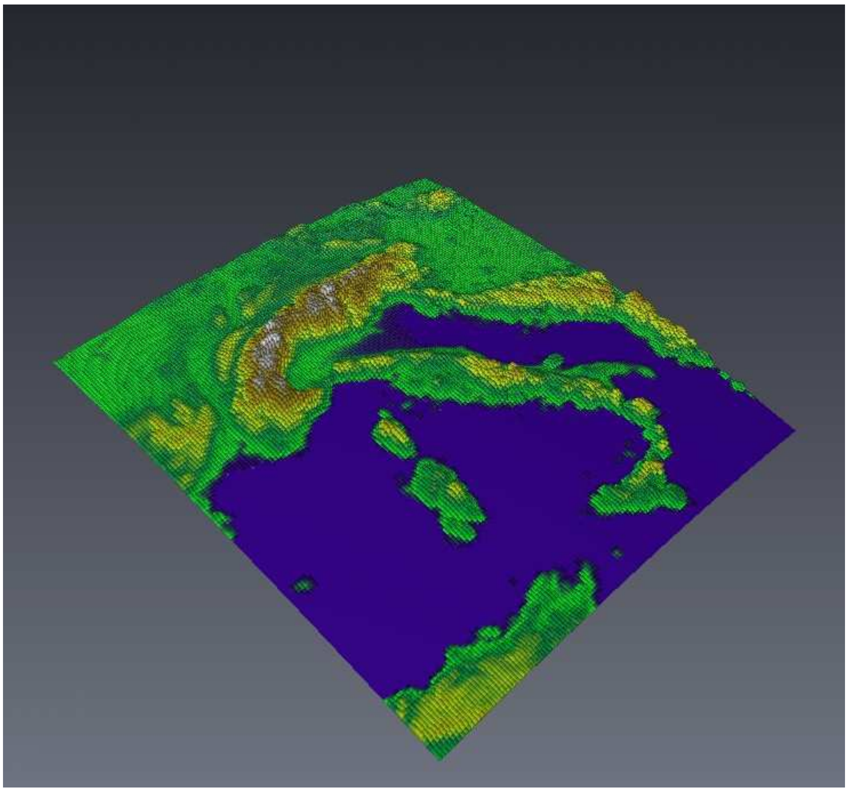

Figure 3: *REMO domain for the ACQWA simulations at 10km resolution.*

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4. Snow cover retrieval over Rhone and Po river basins from MODIS optical satellite data

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ACQWA WP2 – Task 2.3.

Context and Objectives:

Estimation of the Snow Covered Area (SCA) is an important issue for meteorological application and hydrological modeling of runoff. With spectral bands in the visible, near and middle infrared, the MODIS optical satellite sensor can be used to detect snow cover because of large differences between reflectance from snow covered and snow free surfaces. At the same time, it allows separation between snow and clouds. Moreover, the sensor provides a daily coverage of large areas (2,500 km range).

However, as the pixel size is 500m x 500m, a MODIS pixel may be partially covered by snow, particularly in Alpine areas, where snow may not be present in valleys lying at lower altitudes. Also, variation of reflectance due to differential sunlit effects as a function of slope and aspect, as well as bidirectional effects may be present in images. Nevertheless, it is possible to estimate snow cover at the Sub-Pixel level with a relatively good accuracy and with very good results if the sub-pixel estimations are integrated for a few pixels relative to an entire watershed.

Data :

Integrated into WP2.3 task of ACQWA Project, Year-1, this approach has been first applied over Alpine area of Rhone river basin upper Geneva Lake: Canton du Valais, Switzerland (5 375 km²). And in a second step over Alps, rolling hills and plain areas in Po catchment: Val d'Aosta and Piemonte regions (37 190 km²). Catchment boundaries were provided under vector file respectively by GRID (CH) and ARPA (IT) partners and validated by ACQWA coordinator. The complete satellite images database was extracted from the U.S. MODIS/NASA website (http://modis.gsfc.nasa.gov/) for MOD09_B1 Reflectance images, and from the MODIS/NSIDC website (http://nsidc.org/index.html) for MOD10_A2 snow cover images. Only the Terra platform was used because images are acquired in the morning and are therefore better correlated with dry snow surface, avoiding cloud coverage of the afternoon (Aqua Platform).

Methodology:

The MOD9 Image reflectance and MOD10_A2 products were respectively analyzed to retrieve (i) Fractional Snow cover at sub-pixel scale, and (ii) maximum snow cover. All products were retrieved at 8-days over a complete time period of 10 years (2000-2009), giving 500 images for each river basin.

Digital Model Elevation was given by NASA/SRTM database at 90-m resolution and used (i) for illumination versus topography correction on snow cover, (ii) geometric rectification of images. Geographic projection is WGS84, UTM 32.

Fractional Snow cover mapping was derived from the NDSI linear regression method (Salomonson et al., 2004). Cloud mask was given by MODIS-NASA library (radiometric threshold) and completed by inverse slope regression to avoid lowlands fog confusing with thin snow cover (Po river basin). Maximum Snow Cover mapping was retrieved from the NSIDC database classification (Hall et al., 2001).

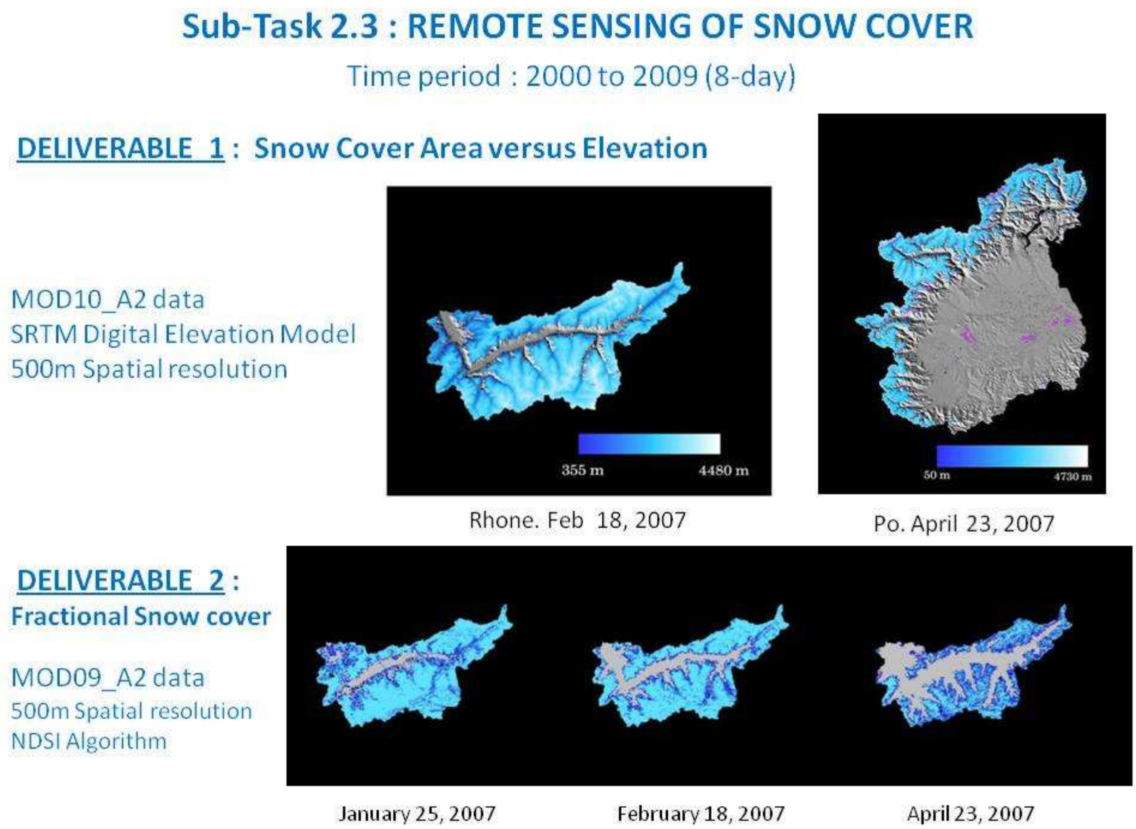
Preliminary results :

Maps and statistical results will be integrated at Geotiff and Ascii export format into the ACQWA data warehouse, where partners are exchanging data using a secured FTP site, while a web application is now available to store and search metadata (ACQWA GeoNetwork), and a second web application allows users to visualize project outputs (ACQWA Data Viewer). See Figure example.

Footsteps :

Year-2 of WP2.3 task (2010) will be dedicated to validate and publish the 2000-2009 time series results (close to 1000 images) with WP3 partners involved in hydrological modelling (ETH-Zürich, ARPA-Aosta/Piemonte) using snow pits data network and runoff inputs versus the Snow Cover package (maps and statistics).

Finally, the method will be reproduced for 2 other ACQWA river basins: Aconcagua basin (Chile) and Syrdaria catchment (Kyrgyzstan) in Central Asia.



5. Responding to our changing environment, the need for data sharing

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ACQWA WP2 – Task 2.5.

Today we are living in a globalized world where everything is changing rapidly (growing population, environmental deterioration,...) and where communication means have taken a remarkable place in our life. Every day we access an enormous and continuous flow of information and much of them refer to a position or a specific place on the surface of our planet, they are georeferenced.

In the last 30 years, the amount of georeferenced data available has grown dramatically following the evolution of the communication means and due to the rapid development of spatial data capture technologies such as Global Positioning System (GPS), remote sensing images, sensors,... (Philips et al., 1999) and over the last ten years with the advent of applications like Google Earth, we have seen that geoinformation has been incorporated and routinely embedded into business and workflows of agencies at all levels of government, as well as in the private sector (Booz et al., 2005).

Despite the fact that administrations and governments are recognizing that spatial information is important and must be part of the basic information infrastructure that need to be efficiently coordinated and managed for the interest of all the citizens (Ryttersgaard, 2001), this huge amount of geospatial data is stored in different places, by different organizations and the vast majority of those data are not being used as effectively as they should.

Moreover at the United Nations Conference on Environment and Development in Rio de Janeiro in 1992, the so-called Agenda 21 resolution fosters the importance of georeferenced information to support decision-making and management on the degradation and threats that are affecting the environment (GSDI, 2004) meaning that the need for availability and access to appropriate information, development of databases and exchange of information are the conditions for creating the basis for a sustainable development and supporting the information management needs of implementing and monitoring sustainable development policies and goals like the UN Millennium Development Goals (UNGIWG, 2007).

Thus geospatial information is a critical element underpinning decision making for many disciplines (Rajabifard and Williamson, 2001) and is indispensable to make sound decisions at all levels, from the local to the global. Experiences from the developed countries show that more than two-third of human decision-making are affected by georeferenced information (Ryttersgaard, 2001).

However, geospatial information is an expensive resource, it is time consuming to produce, and for this reason it is of high importance to improve the access and availability of data, and promote its reuse. Many of the decisions that different organization need to make depend on good and consistent georeferenced data, available and readily accessible (Rajabifard and Williamson, 2001).

In 1998, the former vice-president of the United States, Al Gore, has presented its visionary concept of a Digital Earth (Gore, 1998), "a multi-resolution, three-dimensional representation of the planet, into which we can embed vast quantities of georeferenced data". As of today this vision is clearly not fully realized, but gives us an interesting support to our purpose as it is still actual.

Talking about the geospatial data, Al Gore (1998) mentions that the difficult part of taking advantage of this vast amount of information will be "making sense of it, turning raw data into understandable information" because at the moment we have more information than we can handle and they are stored in "electronic silos of data" and remains mostly unused. He envisioned applications where "information can be seamlessly fused with the digital map or terrain data" allowing the user to move through space and time, but of course, to achieve this vision, a collaborative effort (from government, industry, academia and citizens) is needed.

All the technologies and capabilities required to realize this vision and to build a Digital Earth are already available:

- computational science: even a simple desktop computer could process complex models and simulations and with the potential that technologies such as the Grid are offering new insights into the data, giving us the ability to simulate phenomena that are impossible to observe, and simultaneously to better understand data from observations.

- mass storage: storing tera-bytes of data on a desktop computer is actually no more a problem.
- satellite imagery: a lot of satellites are continuously observing the Earth offering high spatial and temporal observations.
- broadband networks: are already a reality giving the ability to connect different databases together.
- interoperability: this is a key point to allow communication and integration of distributed data, allowing the geospatial data generated by one software to be read by another.
- Metadata: are important as they describe the data, allowing a user to evaluate and discover the data before using them.

Even if all the technologies are ready, organizations and agencies around the world are still spending billions of dollars every year to produce, manage and use geographical data but they still do not have the information they need to answer the challenges our world is facing (Rajabifard and Williamson, 2001). These authors also highlight the facts that most organizations and/or agencies need more data than they can afford, they often need data outside their jurisdictions, and the data collected by different organizations are often incompatible. This inevitably leads to inefficiencies and duplication of effort, and thus it is evident that countries can benefit both economically and environmentally from a better management of their data (UNGIWG, 2007; GSDI, 2004).

In consequence, it is now essential to make these data easily available and accessible in order to give the opportunity to the user to turn them into understandable information with a clear and broad benefits for the society and the economy because "working together, we can help and solve many of the most pressing problems facing our society..." (Gore, 1998).

It's clear that there are a lot of challenges to face, both tangible and intangible, when we start sharing data but we have to overcome them in order to improve our knowledge, share our experiences and try to build a better informed society. To achieve the goal of a sustainable development requires the integration of a large number of different types of data from different sources. Through agreed common standards and a clear political will, these data can be interchanged and integrated in an interoperable way, leading to a new collaborative approach to decision-making.

In conclusion, for Arzberger et al. (2004), ensuring that data are easily accessible, so that they can be used as often and as widely as possible is a matter of sound stewardship of public resources. Availability should be restricted only in certain specific cases like national security. He argues that " publicly funded research data should be openly available to the maximum extent possible", because publicly funded data are a public good, produced in the public interest.

It seems to be the right time to really work together and to share our data in order to provide a state-of-the-art spatial data infrastructure for ACQWA project.

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