Assessing Climate impacts on the Quantity and quality of WAter

Deliverable Data.3 : Remote-sensing data online - month 12

Dissemination level: Public

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Submitted: September 30. 2009; Validated: October 25. 2009

This deliverable is prepared from task 2.3 Remote-sensing data.

1. Introduction

1.1 Presentation of the ACQWA project

As the evidence for human induced climate change becomes clearer, so too does the realization that its effects will have impacts on socio-economic systems and terrestrial ecosystems. Some regions are more vulnerable than others, both to expected physical changes and to the consequences they will have for ways of life. Mountains are recognized as particularly sensitive physical environments with populations whose histories and current social positions often strain their capacity to accommodate intense and rapid changes to their resource base. This proposal aims to assess the impacts of a changing climate, focusing on the quantity and quality of water originating in mountain regions, particularly where snow- and ice melt represent a large, sometimes the largest, streamflow component. There, they represent a local resource (freshwater supply, hydropower generation, irrigation), but in most cases also considerably influence the runoff regime of the downstream rivers and the related water availability. Such an influence is reflected mainly in the amount of surface water available for supplying irrigated agriculture and water supply systems, but also in the amount of groundwater recharge that can take place in river–fed aquifers. An increasing number of evidences of glacier retreats, permafrost reduction and snowfall decrease have been observed in many mountainous regions, thus suggesting that climate modifications may seriously affect streamflow regimes, in turn threatening the availability of water resources, increasing the downstream landslide and flood risk, impacting hydropower generation, agriculture, forestry, tourism and, last but not least the water dependent ecosystems. As a consequence, socio-economic structures of downstream living population will be also impacted, calling for better preparedness in developed countries and strategies to avoid the exacerbation of the already conflictual situation in many developing countries, like those in Central Asia and South America.

The goal of the project is to use advanced modelling techniques to quantify the influence of climatic change on the major determinants of river discharge at various time and space scales, and analyse their impact on society and economy, also accounting for feedback mechanisms (Figure 1). The focus will be on continuous transient scenarios from the 1960s up to 2050. In comparison to many existing studies, the limitation of the modelling horizon to mid of the 21st century allows to develop more realistic assessment of the progressive impact on the social, economical and political systems, which we expect to evolve typically in an adaptive mode on shorter time scales than the centennial ones, eventually shifting to new equilibria when forced abruptly.

The data required for the multiple model applications will be managed in the form of a "data warehouse" that will begin collecting and centralizing the data for the entire ACQWA community from the start of the project. The specification of data and the data formats will be defined in collaboration with the partners within the first 2-5 months of the project, and by the end of the first year, data will be available through the Internet for use in the different Work Packages. Additional data, such as remote sensing information, will be ready by the end of the second year, while the socioeconomic data required for many of the non-physical impacts studies will be brought online from the inception of ACQWA through to the end of the project. The data warehouse will be continuously updated and maintained for the entire duration of the project.

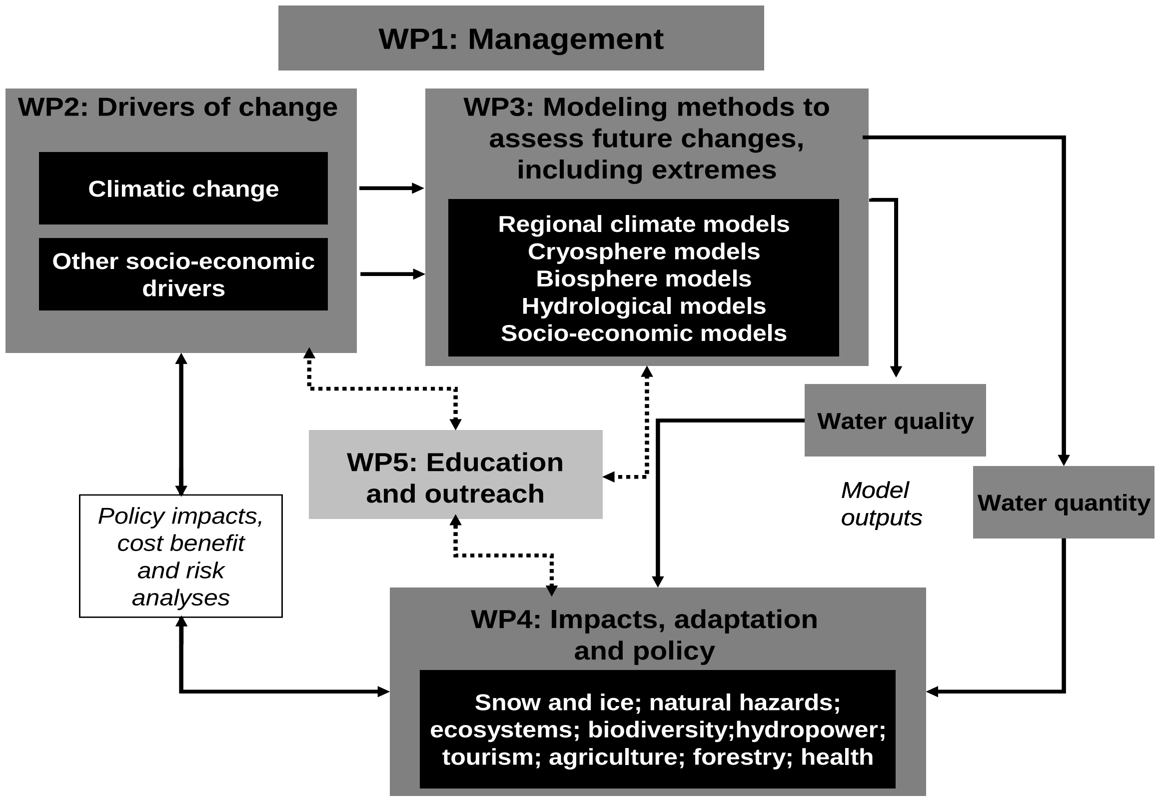

Figure 1: Flowchart illustrating the various work packages of the project.

See also Figure 2.2 in Section 2.3 of this proposal for more detailed information on interactions between the work-packages and the team members.

1.2 Presentation of Workpackage 2: Climate and Socio-Economic Drivers of Change

WP 2 will provide a quantitative description of the primary (or direct) driver, climate change (CC), and of the indirect (or secondary) driver, the socio-economic factors. Specifically:

1) the CC driver will be described by means of recent climatic scenarios for validation of models and large and regional scale scenarios respectively from GCMs and RCMs simulations according to selected IPCC emission scenarios;
2) validation of spatial and temporal extent of snow cover at global to local scale computed by spatially explicit models under different climate scenarios;
3) validation of timing and amount of runoff generated from snow pack at a fine temporal scale estimated under different climate scenarios;
4) the socio-economic factors will be quantified by means of scenarios of socio-economic developments, such as drivers of land use changes, drivers of energy demand, changes in agricultural policies, etc.

1.3 Scope and Purpose of the Task 2.3: Remote-sensing data

Because the proposal concentrates on modelling the response of snow and ice dominated mountain regions, a specific Task is foreseen to generate remote sensing optical products, which will be used for validation of both climatic and hydrological models, used in Task 3.1 and 3.2 respectively, with respect to the spatiotemporal evolution of snow cover and the surface characteristics (e.g. the snow grain size) of the snowpack in the present climate at the regional, basin and local scales. Such validation is necessary to verify that both the climate and the hydrological models can capture the variability observed, and, particularly, that which has characterized extreme years with rapidly evolving snow cover.

Accordingly, enhanced snow cover products will be produced from daily large scale image, i.e. 500m to 250m MODIS/TERRA database, and validated to local scale representative case using monthly ASTER vs SPOT HRVIR data (respectively 15m and 10m). Specific MODIS products such as the surface reflectance (MOD09, Bands 1-7, 500 m), the cloud mask (MOD35), the geometry (MODMGGAD) will be used, jointly with the DISORT Snow Spectral Library (Bands 1-7) and the relevant Digital Elevation Models (DEMs) of the investigated areas.

1.4 Scope and purpose of Deliverable Data.3

This document aims to provide an overview on how to access the database storing climate model results from the ENSEMBLES project.

This report is part of a set of guidelines and are linked with:

- D.Data.1: ACQWA Database ready for uploads
- D.Data.2: ACQWA RCM data online
- D.Data.4: ACQWA Socio-economic data online
- D.Data.5: ACQWA Data warehouse

1.5 Contributors to the deliverable

Jean-Pierre Dedieu:

Dr. Jean-Pierre Dedieu is a permanent research scientist (senior) of CNRS since 1986. Specialized in Remote Sensing of the cryosphere since 20 years (optical to SAR), his experience is largely dedicated to snow and ice monitoring in high mountains regions (climate and hydrology). Many publications were focused on the use of optical data (visible to infra-red) for snow characteristics retrieval: (i) Snow Covered Area (SCA) percentage mapping at the sub-pixel size, important issue for meteorological application and hydrological modelling of runoff; (ii) Snow Grain Size (SGS) at the snow surface mapping, important effect on the snow albedo and important parameter for any study which needs energy balance at the surface. A strong experience is also acquired in active radars (SAR) for dry and wet snow mapping inferred from dual- and quad-polarization sensors (Envisat, SIR-C) under high elevation conditions. The objective is to retrieve the snow pack water equivalent (SWE) using field measurements network points to calibrate the model. Then, publications were published concerning the use of optical remote sensing data for time-series mass balance reconstruction in the French Alps.

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

2.1 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.

2.2 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).

2.3 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).

2.4 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.

2.5 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.