



United Nations
Educational, Scientific and
Cultural Organization



International
Hydrological
Programme



Flanders
State of the Art

Final Meeting Report

Coordination Meeting

3-4 September, Santiago, Chile

THE IMPACT OF GLACIER RETREAT IN THE ANDES

International Multidisciplinary Network
for Adaptation Strategies



[Access](#) to the meeting webpage

INTERNATIONAL HYDROLOGICAL PROGRAMME
Division of Water Sciences

1. Introduction

The Andes – the world longest continental mountain range – extends in South America through seven different countries, namely Venezuela, Colombia, Ecuador, Peru, Bolivia, Chile and Argentina. The population of these countries account for more than 160 million people representing more than 40% of the continent’s total population. Many Andean valleys are seasonally dry and glacier runoff is crucial to maintain a more constant flow of fresh water throughout the year. In fact, much of the snow falling is initially stored as ice in mountain glaciers before being gradually released over time. Therefore, glaciers act as critical buffers against highly seasonal precipitation and provide water for domestic, agricultural and industrial use during the dry season.

However, climate change over the 20th century, especially global warming, has led to Andean glaciers increasingly being out of equilibrium with their current climate. As a result, rapid glacier retreat has been observed in every country of the Andean region. The trend has intensified since the 1990s, as temperature rise has accelerated and projections for the 21st century confirm this tendency. Several studies indicate that for the end of the century, Andean temperature will be significantly warmer and exhibits a much larger interannual variability. These climate changes will affect environmental services, biodiversity and socioeconomic activity in every country of the region.

It is clear that adaptation strategies should be implemented without delay from a multidisciplinary approach, yet at the same time the scientific knowledge is not really sufficiently advanced to adequately guide such implementations.



The UNESCO IHP project “The Impact of Glacier Retreat in the Andes: International Multidisciplinary Network for Adaptation Strategies” foresees in a set of deliverables related to diagnostics of current conditions of glaciers in Andean countries, the identification of their vulnerability to climate change, as well as current and future opportunities for the implementation of policies on climate change adaptation strategies. To identify these strategies, a set of regional activities were organized since 2012, strengthening the science-policy dialogue in the Andean Region on these topics. These on-going activities together with follow-up activities and possible linkages with other regional activities were presented and discussed in the coordination meeting. Additionally the networking has been strengthened between the different partners involved in the project.

As supportive reading material four background papers were developed and shared among the participants in the preparation of the meeting. These papers identify the current gaps and opportunities related to climate change and adaptation potential.



2. Opening Session

The meeting was opened by [Jorge Sequeira](#), president of UNESCO Chile. As representative of UNESCO worldwide and especially as regional UNESCO host office in Santiago, he started with a warm welcome. He emphasized the difficulty nowadays to overestimate the concern of glacier retreat in Andean region, with as emblematic example the northern region of Chile. That's why this theme and in concrete terms, this project, has all the support of UNESCO.

Secondly [Patrick De Beyter](#), Belgian Ambassador in Chile, gave a short introduction, highlighting the essential character of glaciers as natural source. These Andean countries are facing a big challenges for future generations. Since Belgium included Climate Change as a crucial theme in its policy of foreign affairs and international cooperation, the interest increases to support projects like this. The great strength of this project is bringing together scientists and decision makers, which are two very diverse views on the matter. Thus, there is hope for a productive meeting to generate a significant contribution to reduce the impact of melting glaciers in our society.

Mathias Vuille, coordinator from the ACCION project, highlighted the strong synergies between the Glacier Melt Project and the ACCION project, that have led to the joint implementation of meetings, trainings and workshops and joint publications since the start of the project in 2011.

Gert Verreet, representative of the Flanders UNESCO Science Trust Fund, main financing support of the Glacier Melt Project, gave his word of welcome and emphasized the importance of build-up of scientific knowledge in these crucial topics. The results UNESCO Chile has carried out the past years strongly stimulate the good practice and value of the support of Flanders' government.

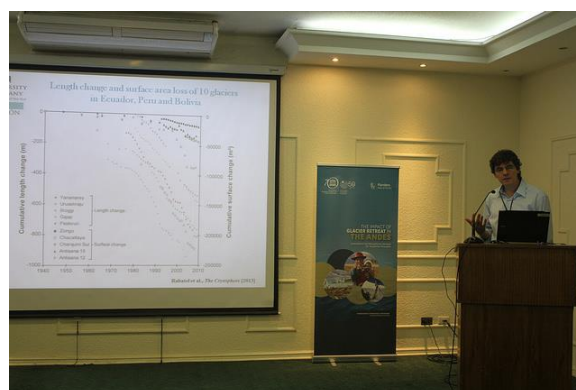
Finally [Koen Verbist](#), the programme specialist in Hydrological Systems and Global Change of UNESCO Santiago, gave a general overview of the project and related IHP activities, both to demonstrate the progress in the field of study and dialogue as well as to present the audience the future challenges we are facing.

3. Session: Advances of the Glacier Retreat Project/ ACCION project

In this first thematic session updates were given on current research and activities of the partner institutions of the Glacier Retreat Project and the associated ACCION Project (Andean Climate Change Interamerican Observatory Network). The following topics were presented:

3.1. 'Climate change and Tropical Andean Glacier Retreat - Update and Perspectives for Adaptation' – [Mathias Vuille](#), University at Albany, SUNY

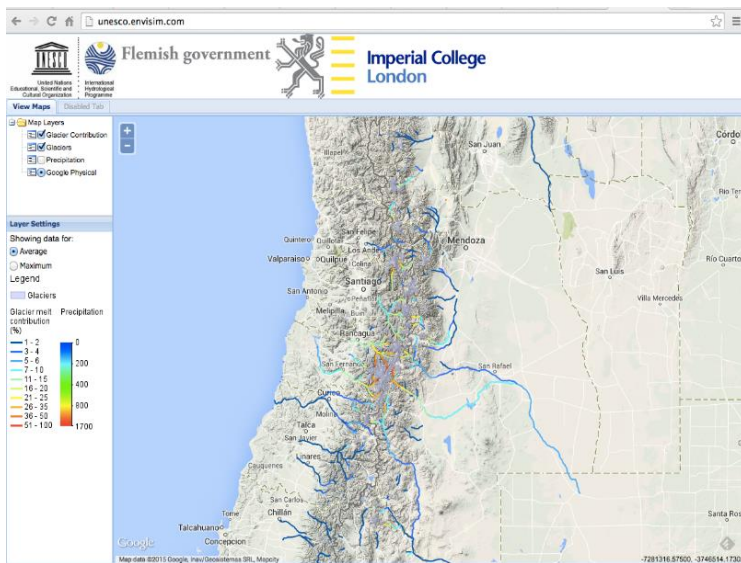
As a follow up on the [background paper](#) 'Climate Change and Tropical Andean Glacier Retreat' of Franquist and Vuille (2011), an update has been given of monitoring and analytical results on this topic. Based on the different glacier monitoring efforts, a growing negative mean annual area loss rate is observed in all tropical Andean glaciated zones as a global trend and rising freezing line of numerous glaciers has been observed. Recent publications indicate different temperature trends between the tropical and extra-tropical Andes, stressing the vulnerable nature of the tropical regions. Comparing PDO-based temperature stations with higher altitude observations suggests that the latter temperatures are already outside the range of natural variability and can be related to human influence. Precipitation is more difficult to evaluate and exhibits higher uncertainty. All trends and scenarios based on predictions of climate models will have an impact on mean annual and seasonal runoff both on the short and long term. Bearing in mind that adaptation strategies for Andean populations require, among others, strengthening between scientific research and policy makers a policy brief has been developed by ACCION and UNESCO-IHP, that is currently being published.



3.2. 'Vulnerability mapping of glacier melt impact in Andean Countries' - [Bert de Bievre](#), CONDESAN, Peru

In this presentation and related [background paper](#) the contribution of glacier melt to human water consumption (domestic, irrigation and hydropower) has been quantified, as main approach to characterize the vulnerability of glacier melt on the Andean population. The assessment starts from the basic principle of both a water supply and a demand model, with meteorological data, the implementation of the bodyko water balance model, a linear reservoir routing model, monthly discharge calibration data, demand data from

various institutions and high resolution maps on e.g. land use as input data. The advances of this vulnerability mapping is kept up to date on the following [website](#). The glacier contribution can be expressed in four scenarios: both as a long term average and extreme drought annual average, as well as for both options the month with the highest contribution. In this way a comparison between the mayor cities in Ecuador, Peru and Bolivia show for example a significant higher vulnerability of La Paz. This analysis indicates that adaptation strategies to the impact of melting glaciers should take these spatial differences into account.



3.3. 'Glacial Mass Balance with the glaciological method and current advances of the glaciology laboratory of the CECS, Valdivia' - Andrés Rivera, CECS, Chile

This presentation highlighted recent results obtained by CECS during the implementation of a monitoring program in the upper Maipo basin, and provide a discussion on the glacier mass balance methods and the recent glacier changes in the region.

The majority of Chilean glaciers have been retreating in recent decades in response to high-altitude atmospheric warming and a general trend of rainfall reductions. Smaller and lower-altitude glaciers have been more drastically affected, in some cases disappearing entirely and in others experiencing high fragmentation and area reductions. Recent dry conditions explained by the more frequent La Niña events since 2007 have reduced water levels in the regional dams to a minimum, stressing irrigation for agriculture activities. These conditions have forced the authorities to implement hydrological emergency plans in several basins, most of them having runoff partially contributed by glacier and snow melting in spring and summer. Among the most affected areas by these dry conditions are the central Andes of Chile where glaciers are contributing meltwater to the city of Santiago. In the Maipo basin a shrinkage of 25% glaciated area has been observed in 2010, since 1955. This trend has also been observed in nearby basins. The main glaciated area of the Maipo River is the upper Olivares basin, where Glaciers Olivares Alfa and Beta have been monitored in detail since 2012, including mass, energy

and hydrological balance. Among the main results, a high negative mass balance obtained in the last two hydrological years could be mentioned, when both glaciological, as well as geodetic methods were applied. The comparison between these methods has shown discrepancies and biases in the mass balance determination. The main conclusion is the need for error assessments for each mass balance program. Precisely, this is one of the main aims of a Mass Balance Manual, already prepared by CECs and the University of Albany that will be published by UNESCO in 2015.

3.4. 'Vulnerability and threats to snow and glaciers in the Southern Andes' - [Gino Casassa](#) Geoestudios, Santiago and Universidad de Magallanes, Chile & Lucas Ruiz, IANIGLA, CONICET, Argentina

The focus of this prospective background paper is laid on changes in glaciers in the Southern Andes, in between Chile and Argentina, counting with a glaciated area of about 25.000 km², in which debris-covered ice and rock glaciers represent the major part. Glacier morphology studies have shown a main shift from glacial to peri-glacial landscape. In some cases in Central-Chile this is reflected in the transformation of debris-covered glaciers to rock glaciers, which affects albedo properties and thus has a deglaciation effect.

There is a clear evidence for glacier retreat along the entire Andes, but comparisons of mass loss data analysis give rise to the distinction of 3 regions: north-central Andes, southern Andes and the sub Antarctic Islands, with a decreasing volume imbalance from north to south. This slower melting rate in Patagonia can partly be motivated by the observed regional cooling in southern Chile, as an anomaly in a warming planet. Precipitation predictions show clear negative trends for almost the entire Chilean coast, but these are less certain for Patagonia. But nevertheless an increased area of glacier lakes manifests glacier retreat in Patagonia as well.

In general the melting of the 'deglaciation discharge dividend' induces a maximum peak level of water supply at a certain moment in time, followed by a discharge drop when the glacier cannot maintain the base flow anymore. A case study in watersheds in the Metropolitan region of Chile demonstrates this with a trend of higher glacial contribution to superficial discharge. However this contribution will reduce on medium-long term, and will be manifested through droughts in central Chile.

Finally some extra research sources have been mentioned e.g. the use of snow precipitation analysis to identify and quantify pollution of urbanized areas close to the Andes.

3.5. Draft background paper on ‘Existing climate change adaptation policies and challenges and opportunities for their implementation’ – [Elma Montaña](#), IAI, Uruguay

The draft version of this [background paper](#) has been presented as a thorough introduction to the science-policy dialogue. It is clear that in decision making scientists only play one role among various other stakeholders, sometimes with conflicting interests. Besides, scientific contributions can be vague, contradictorily or poorly interpreted. Glacier conservation in Argentina has been presented as an example of the complexity of legislation regarding this topic. Several factors interfered in the clear and easy implementation of this law e.g. difficulties in glacier inventory, defining glaciers and periglacial landforms in legal terms and the political power of sub-national provinces. The latter has undermined the application of this law, in some concrete cases, leading to several social conflicts and disputes. This example shows the difference between legitimacy, credibility and real trust in the process of gaining social license. This process is difficult to implement when the power balance between different actors is unequal. Useful recommendations for better science – policy relations have been included such as balanced participation of all stakeholders in specific legislation related conflicts, explicit and detailed scientific consultation, long term support of research programs and inter/transdisciplinary problem/solution science, amongst others.



4. Session: Linkages with National and Regional Projects

In this session relevant research, programmes and organizations were presented, in view of exchanging ideas, visions and methodologies or a possible cooperation in the future. The following presentations were given:

4.1. Advances and challenges of glacio-hydrological modelling and its integration into watershed models: a case study of the Rio Maipo - [Sebastian Vicuna and James McPhee](#), Universidad de Chile, Chile

A glacio-hydrological modelling of the Maipo watershed (the WEAP model) has been elaborated by the University of Chile, within the framework of the MAPA project. The latter concerns the establishment of an adaptation plan regarding the variability of climate change in the Maipo catchment, starting with a vulnerability analysis of the different water users. The importance of water resources here is reflected by the multiple water uses, amongst others, potable water for the growing population of the country's capital city, Santiago. The decrease rate of the multiple glaciers varies around 1-2%/year, but depends strongly on the size and other characteristics of the glaciers. In the past 30 years the reduction of glaciated area has been estimated to be 25.2%. The results are validated with several other monitored glaciers in central Chile. Within a continuing climate change scenario the glacier retreat will

proceed. Rock glaciers have different answers to global warming. This depends on the thickness of the debris mantle. Most of them are suffering from thermokarst processes, expressed as internal collapses. This effect occurs up till 3-5m deep, depending on the latitude and altitude where the glaciers are located. When the debris mantle is thicker, the isolations starts to be effective. It has to be mentioned that rock glaciers constitute a complex family of landforms of both glacial and periglacial origin. Light or partially covered rock glaciers are more sensible to warming than clean or with glaciers.

4.2. Climate change action in developing countries with fragile mountainous ecosystems from a sub-regional perspective – [Miguel Saravia](#), CONDESAN, Peru

This project has been launched by UNEP, GRID ARENDAL, and the Austrian Developing Agency in 5 mountainous regions in the world, including the (tropical) Andes. CONDESAN (Consortio para el desarrollo Sostenible de la Ecoregión Andina) is the regional partner of the project. The main objective is to assess vulnerability and impacts of mountainous developing countries and to integrate specific climate change adaptations for these regions into policy. Apart from participatory assessments the establishment of inter (regional) cooperation platforms will be fostered as well. In the first phase of the project sub-region-specific existing information related to climate change impacts, risks and vulnerabilities in the targeted mountain areas will be collected and analyzed. States and trends of climate change will be drawn, vulnerability will be assessed and priority areas will be designated for future action. Further more relevant existing national plans, strategies and policies will be evaluated and policy gaps will be identified. The second phase has the objective to generate policy action based on the scientific and participatory information. In this phase the participation of all relevant stakeholders is a key factor to define commonly agreed objectives and best practice strategies. The third phase is devoted to the further sharing of these experiences and information with other mountain regions and to communicate mountain trends and formulate policy action at the global level.

4.3. Cryosphere, Atmosphere, Climate and Anthropogenic impacts in the Andes: Research structures and observation networks - [Ginot Patrick](#), IRD, Bolivia

The Glacier Monitoring Programme of the IRD (Institut de Recherche pour le Développement) and its recent updates are presented. This includes multi-decadal efforts made by several institutions from Colombia to Bolivia of glaciological data measurements (in situ as well as from computed aerial photographs) and analysis. The main research axes are evolution of the cryosphere in mountainous catchments and its link with climate change, quantification of available water resources, impacted by anthropogenic modifications and the reconstruction of past climate and environmental changes using ice core archives. Looking at the

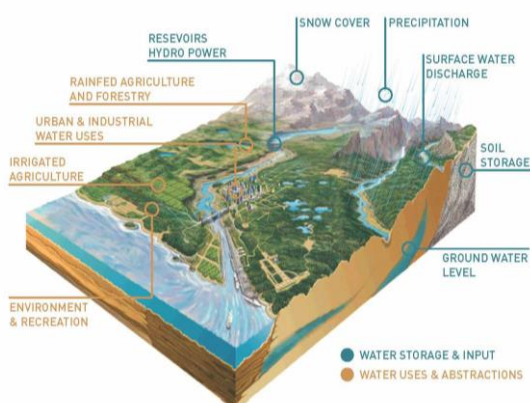


contribution of glaciers to water resources and human consumption, it shows that we've passed already its peak water delivery for the Intertropical Andes.

The monitoring part of the project is based on observatory networks and makes, amongst others, use of a global network of reference glaciers. All results of long term in situ monitoring is available on [GLACIOCLIM](#). Glacier observations and trends in Bolivia are given as examples, e.g. the almost disappearing Chacaltaya glacier close to the city of La Paz.

Many factors can be pointed out as causes of glacier melt but especially the strong contribution of increasingly Black Carbon in the air is highlighted. From this perspective the project CLAP (CLimate relevant Aerosol Properties from near surface Observations) has been established, to foster worldwide investigation on atmospheric aerosols. As a conclusion the importance of glaciers and their ice (cores) are pointed out e.g. the danger of losing non-polar ice cores as important climatic archives, to encourage scientists to handle this topic. 'Saving Ice in Danger' is the founded scientific overarching project born from this idea.

4.4. Regional Adaptation Activities on River Basin Level - [Alexandra Nauditt](#), ITT-UKöln, Germany



The local project of the Institute for Technology and Resources Management in the Tropics and Subtropics (ITT) in the Andean region focuses on water resources assessment and management in the Limarí catchment in Central Chile. An information system is established and monitoring elaborated to improve water use efficiency in this basin. The results of the data collection of hydrological inputs and user demands are available [here](#). Glacier contribution to water resources are crucial in this semiarid region and account for 85% of the water security of its water users. The comprehensive structure of the monitoring strategy, data management and modelling has

been explained. For the drought management frequent and good quality data and automatized data transfer is crucial. Drought assessment is also strongly site dependent regarding indicators e.g. for rainfed agriculture SPI and Vegetation based indices are used while for irrigated agriculture threshold methods are preferred. A well-considered model is chosen depending on hydrological characteristics of the catchment. Tracer methods with stable isotopes have shown that stream water is mainly fed by snowmelt in spring and by groundwater in summer and autumn. The hydrology does not count with deep or fossil ground water. Finally, some international capacity building projects on the development of methodological learning units related to water resources management were demonstrated. A relevant upcoming course for this Glacier Retreat in the Andes project is the Symposium and professional Training on 'Understanding the Role of Andean Hydrology for Water Management: tools and concepts' 17th-20th November 2015 in Santiago de Chile. The main topics will be tools for hydrology assessment, modelling, forecasting and tracer methods regarding glacier contribution to water resources. The website for the training and inscription form can be accessed [here](#).

4.5. The WMO Global Cryosphere Watch – [Gino Casassa](#), Geoestudios and Universidad de Magallanes, Chile

The [Global Cryosphere Watch](#) is an initiative of the WMO developed with governmental agencies and other institutions that measure, monitor, or archive cryosphere data and information from in-situ and satellite research and operational networks and model sources. Current activities are the development of a core standardized network of surface observations and of measurement guidelines, refining observational requirements and product intercomparison, amongst others. In this way the GCW will drive performance and provide motivation for high quality observations.

The [International Association of Cryospheric Sciences](#) (IACS) is the Ice and Snow Science part of the International Union of Geodesy and Geophysics (IUGG). It concerns a body that forms a 'cryospheric community', in which research is promoted, an international foundation is laid for discussion and publication of results, standardization of measurements are facilitated and education and public awareness are promoted.

4.6. Impacto del retroceso de los Glaciares dentro de Áreas Silvestres Protegidas del Estado – [Piero Caviglia](#), CONAF, Chile

As an introduction the SNASPE (Sistema Nacional de Áreas Silvestres Protegidas del Estado) is explained. This is the legal framework in which Chilean nature reserves, parks and monuments are protected, administrated by CONAF. Within the objectives (conserving biodiversity and contributing to the improvement of living quality of the society) local communities play a major role. The region of Aysen, southern Chile, includes three main icefields (a total of 5.126.000 ha), of which 43% is located in the nature park Bernardo O'Higgins. From an investigative point of view, and apart from observing glacier movements and changes, CONAF is monitoring native plants, birds and especially the endemic Huemul as a base line of this nearly virgin area. Up till now this park receives almost no visitors and thus has a noticeably touristic potential. The large size of the territory and the small knowledge about it are the main challenges of this incentive. Developing a more touristic nature park will only be considered if local communities are involved in the exploitation of services and conservation of the park. Driving forces are sustainability and ecotourism, adapted to the carrying capacity of the region and its ecosystems.





4.7. Project GRANDE: Glacier Retreat impact Assessment and National Policy Development – [Edson Ramirez](#), UMSA, Bolivia

The GRANDE project has as main objective the development of a support system for the formulation of strategies for water resources management under climate change scenarios, in the cities of La Paz and El Alto. In practical terms, this concerns the Condoriri, Tuni and Hyuana Potosi glaciers. Investigation is elaborated, cooperation with several universities and research institutes of Bolivia and Japan, on the different facets within the framework of a large water resources model: glaciers, runoff, sediment, and water quality and water management. Achieved results are an initial version of a data catalogue, a water resources platform and exchange of students between the involucrated countries.

5. Round Table Discussion

A brief and concise introduction on the advances of glacier protection legislation in Chile has been given by Daniel Melo, deputy of the Chilean Congress. This law is still in its infancy since only at the end of May 2014 the bill of the Glacier law was sent to the executive authority. It has already been supported by several deputies across parties but there is still disagreement about the definition of a glacier as such and its environment. This bill of law has as objective the protection, preservation and conservation of the national glaciers, which are considered as Strategic Glacier Reserve. The draft of the law identifies the DGA (Dirección General de Aguas) as responsible organism of reporting the status of Chilean glaciers by identifying a glacier inventory. Up till now the objectives of the law and the definition of a glacier and its catchment are approved, but there is still disagreement about the setting of a strategic environment of glaciers. One of the bottlenecks is to define the method of protection, and either protect all glaciers identified in the inventory by default, or to identify these glacier that are under potential threat and protect them case by case.

In the round table discussion several actors were present, with each a different point of view and different level of involvement in the process of glacier legislation: Ezio Costa Cordella (University of Chile and executive director of the NGO FIMA), Dr. Francisco Ferrando Acuña (University of Chile, professor in hydrology, glaciology and Natural Risks), Carlos Urenda (General Manager of Consejo Minero, Chile), Javiera Espinoza (geographer in the NGO TERRAM) and Matías Asun (Director of Greenpeace Chile). The proposed questions for the debate were about the contribution of the Glacier Retreat Project to policy, but the focus was also put on the glacier legislation process in Chile. The main topics discussed included: Until what grade can sustainability and the right to water be balanced with economic development, which is currently still highly dependent on the mining industry? How can glaciers be protected if costly and time consuming monitoring is delayed, on which policy decision are based? What should be the preferred process of glacier protection, and what is the role of the currently existing Environmental Evaluation System, it's strengths and weaknesses? What type of glaciers should have priority: extensive glaciers, located in southern Chile, that have a large contribution in size, but that are less affected by retreat due to the influence of climate change, or rather small sized glaciers

that are more out of equilibrium with its environment, more vulnerable for climate change and which drain towards areas with a stronger water shortage. How can the scientific community provide more input to the legislation process (in Chile), to ensure that the technical aspects are in line with scientific findings? What is the role of industry in strengthening long-term monitoring capacities of glaciers?

6. Working Group on Snow and Ice

The first day of the conference [Wilson Suarez](#) (SENAMHI, Peru) gave a brief introduction on the Working Group on Snow and Ice and an overview of its past and ongoing activities per country. It concerns a team of researchers and professionals in glaciology and other relevant sciences with the main objective to strengthen the knowledge of glaciers in the Andes. Investigation and knowledge is raised and exchanged in and between Andean countries. Investigation topics are glaciology, volcanism, landslides, water resources, subglacial hydrology and ice- ocean interaction, depending on the relevance in each involved country. the different research topics in each country were presented individually:

- *Argentina*

Monitoring of glacier Vinciguerra by CADIC and mass balance method of glaciers in the Antarctic Peninsula by the Antarctic Argentinian Institute.

- *Bolivia*

Updated national glacier inventory until 2010 using stereoscopic images and the set-up of the GRANDE-project (see 4.7).



- *Brazil*

Investigation of glaciers that contribute to the base flow of the Amazon River, e.g. the Nevado Illimani glacier in Bolivia and investigation in the Brazilian Antarctica Program.

- *Colombia*

Monitoring of the national glaciers by IDEAM (Instituto de Hidrología, Meteorología y Estudios Ambientales), mass balance method since 2006, energy balance method since 2013 and extension of the hydro-glacial monitoring network.

- *Chile*

Monitoring network in the semiarid part of Chile by CEAZA, inventorying using the mass balance method (glaciological and geodesic) in central Chile by CECS and baseline study in the southern region by CECS and DGA.

- *Ecuador*

Detailed update in 6.1.2.

- *Mexico*

Climatology, mass and energy balance methods, geophysics, development of new methodologies and periglacial systems.

- *Peru*

Cooperation in glacier monitoring with the glaciology unit of ANA (Autoridad Nacional del Agua), foundation of the National Institute of Glaciers and Ecosystems (INAGIEM) and exploration and mass balance method of glaciers in the peninsula Antarctica in collaboration with SENAMHI and UGRH.

- *Venezuela*

Glacier inventory in collaboration with the Universidad de Los Andes, Universidad Joseph Fourier-Francia and Universidad Central de Venezuela and research on psychrophilic microorganisms that colonize glaciers in the Venezuelan Andes.

6.1. New Developments

6.1.1. Glacier Monitoring Network in Chile - [Jorge Huenante](#), DGA, Chile

As it has the largest share of glaciers in South America, the inventory strategy of the Chilean government (Dirección General de Aguas) has been presented. The Inventory work started in 2009 and was complemented with monitoring of changes in glacier surface and volume in 2011. There exists a linear relationship between the surface area of a glacier and its volume, which is useful to make direct volume estimates from satellite images. Water Ice Volume equivalent is obtained by a combination of LIDAR and RADAR results. Direct measurements in the field are currently elaborated in 24 stations in the most important zones of central and southern Chile. 88% of the Chilean glaciers are located in the austral zone (Patagonia). The only bottleneck of the inventory is the frequency of updates, which is every 10 years. The disappearance of small (parts of) glaciers can be expected to occur in a smaller time range due to climate change.

6.1.2. El Programa Glaciológico Ecuatoriano - [Bolívar Caceres](#), INAMHI, Ecuador

The main updates of the glacial monitoring programme of Ecuador are the following:

- Evolution of the use of the mass and the energy balance method for two particular glaciers in Ecuador
- The updated glacier inventory for the period 2012-2015
- Follow-up investigation of two glaciers subjected to the influence of volcanism e.g. Cotopaxi volcano
- Specific study of a glacier on the Peninsula of Antarctica (INAE)
- The CATCOS-II project, glacier 15 del Antisana (Meteoswiss)

- Participation in two Cryospheric observatories (ORE – CRIONET)
- A future implementation of measurements for two additional glaciers (BID)

6.1.3. BID- project: 'Monitoreo De Glaciares Tropicales Andinos en un contexto de Cambio Climático' - [Jorge Ceballos](#), IDEAM, Colombia

This project is meant to strengthen the glacier monitoring network in the Andean region, up to now concerning specific measurements in Bolivia, Colombia, Ecuador and Peru. The subcomponents of the project are monitoring as such, training to improve the obtained results and management and usage of the generated information.

6.1.4. La ley de protección de glaciares y el inventario en Argentina – [Pierre Pitte](#), CONICET / El programa de balance de masa del Inventario Nacional de Glaciares de Argentina - [Lucas Ruiz](#), IANIGLA, CONICET, Argentina

The glacier protection law in Argentina had been promulgated in 2010. Glaciers in Argentina are considered as public goods. The executive authority is the Secretary of Environment and Sustainable Development. The 'Instituto Argentino de Nivología, Glaciología y Ciencias Ambientales' (IANIGLA), an executive unit within 'Consejo Nacional de Investigaciones Científicas y Técnicas' (CONICET) is the institution that is commissioned to be in charge of the national glacier inventory. Up till now already 80% of the inventory work has been completed. But the major bottleneck is the remaining lack of communication and publication of data towards legislative bodies and decision makers. Scientific research and inventorying has to be supported by decision makers on the longer term.



Argentina counts with 5651 km² glaciated area, most of which is located in the Santa Cruz province. The [inventory](#) consists of a hierarchical plan of three levels:

- the inventory as such
- changes of glaciers over time
- Mass balance: what is the relation with the climate, what is their volume, how much contribution occurs towards rivers

Per region a reference glacier is chosen and subjected to a profound monitoring in terms of mass balance, velocity, ice thickness, flow, dimension changes,... e.g. glacier Alerce in the Rio Negro province. What still has to be included in the inventory project are discharge measurements, focus on monitoring in the central Andes and future projections of ice volume and water flow.

6.2. Planning Working Group Activities

Following goals and activities for the Working Group on Snow and Ice are the implementation of a general website or platform where all information is gathered and ideas and methodology can be exchanged, through a data portal tool. A second goal is the publication of the mass balance with geodesy methodology manual in Spanish. Finally a practical workshop with a specialization course is planned and can be expected in 2016 or 2017. The venue still has to be defined.

7. Project activities foreseen on 2015/2016 – [Koen Verbist](#), UNESCO-IHP, Chile

In the first place the following background paper will soon be completed and published; *'Vulnerability and threats to snow and glaciers in the Southern Andes'* by Gino Casassa. Furthermore, a pilot catchment is targeted to elaborate a mountainous watershed case study as an example of the usage of climate information to understand water availability at catchment scale, comparing different methodologies (measurements, modelling,...). A proposed catchment of this kind is the Huasco basin in Central Chile. For this test bed a comprehensive [training course on mountain hydrology](#) is planned for 17th-20th November 2015, in collaboration with ITT of the University of Cologne (4.4). In the framework of vulnerability assessment in the Andean Region, all available information and data will be collected and bundled, edited and published for a broad and general public, presenting a Water Availability Atlas for the Andean Region. Towards policy makers the policy brief *'Existing climate change adaptation policies and challenges and opportunities for their implementation'* by Elma Montaña, will be completed soon and published as well.

Several other remarks during the project meeting will be considered for future activities or improvement of the project. First of all, in the round-table discussion the question was raised to make the information of the project available to the general public in Spanish, as well as to the school community. There is a need to reach the lower levels with relevant information. A second remarkable comment was on permafrost. The role of this phenomenon is still unclear in this discussion, and should be taken as part of the Working Group of Snow and Ice, as its influence on the water balance can be significant, especially in arid areas. Also the inclusion of watershed related topics in this working groups



is very important, to identify the impact on water resources. Furthermore, a new summer school was announced by Gino Casassa in La Paz in 2016 and a new Mountain Forum was announced by CONDESAN, where exchange can take place. Also, specific training of communication media on Climate Change issues should be strengthened. Finally CIIFEN indicated the need to identify socio-economical vulnerability to climate change, and indicated the development of pilot studies in Ecuador that could be used as a guidance.

8. List of Participants

Nr	First Name	Surname	Institute	Country	E-mail
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9. Agenda

Thursday 3 September	
8:30 – 9:00	Registration of participants
9:00 – 9:40	<p>Welcome</p> <ul style="list-style-type: none"> - Jorge Sequeira, Director UNESCO Santiago <p>Opening Session</p> <ul style="list-style-type: none"> - Patrick De Beyter, Belgian Ambassador in Chile - Gert Verreet, Flemish Government - Mathias Vuille, University at Albany/ACCION
09:40 – 10:00	<ul style="list-style-type: none"> - General Overview of the project and related IHP activities Koen Verbist & Anil Mishra, UNESCO IHP
10:00 – 10:20	<ul style="list-style-type: none"> - Glacier Legislation in Chile – H. Senador Antonio Horvath, Chile
10:20 – 10:50	Coffee Break
Advances of the Glacier Retreat Project / ACCION Project – Chair: Miguel Saravia, CONDESAN	
10:50 – 11:10	<ul style="list-style-type: none"> - Background paper on ‘Climate change and Tropical Andean Glacier Retreat (Update)’ – Mathias Vuille, UAlbany
11:10 – 11:30	<ul style="list-style-type: none"> - Vulnerability mapping of glacier melt impact in Andean Countries – Bert De Bievre, CONDESAN
11:30 – 11:50	<ul style="list-style-type: none"> - Project Publication: ‘Balance de masa glaciar con el método glaciológico’ - Andrés Rivera, CECS, Valdivia
11:50 – 12:10	<ul style="list-style-type: none"> - Background paper on ‘Vulnerability and threats to snow and glaciers in the Southern Andes’ – Gino Casassa, Geoestudios and Universidad de Magallanes
12:10 – 12:30	- Questions and Answers Session -
Linkages with National and Regional Projects – Chair: Mathias Vuille, UAlbany	
12:30 – 12:50	<ul style="list-style-type: none"> - Advances and challenges of glaciohydrological modelling and its integration into watershed models: the case study of the Rio Maipo - Sebastian Vicuña, UC and James McPhee, UChile
12:50 – 13:00	- Questions and Answers Session -
13:00 - 14:00	Lunch
Advances of the Glacier Retreat Project / ACCION Project – Chair: Koen Verbist, UNESCO	
14:00 – 14:30	<ul style="list-style-type: none"> - Draft background paper on ‘Existing climate change adaptation policies and challenges and opportunities for their implementation’ – Elma Montaña, IAI
14:30 – 15:30	<ul style="list-style-type: none"> - Group discussion on the Background Paper - Elma Montaña, IAI
15:30 – 15:50	<ul style="list-style-type: none"> - An overview of activities of the Working Group on Snow and Ice – Wilson Suarez, SENAMHI & Francisca Bown, CECS
15:50 – 16:00	- Questions and Answers Session -
16:00 - 16:30	Coffee Break
Linkages with National and Regional Projects – Chair: Gino Casassa, Geoestudios	
16:30 – 16:50	<ul style="list-style-type: none"> - Climate change action in developing countries with fragile mountainous ecosystems from a sub-regional perspective – Miguel Saravia, CONDESAN
16:50 – 17:10	<ul style="list-style-type: none"> - Glacier Monitoring Programme of IRD - GINOT Patrick, IRD

17:10 – 17:30	- Water resources assessment and management in a data scarce Andean catchment, Limarí, Central Chile - Alexandra Nauditt, ITT-UKöln
17:30 – 17:50	- The WMO Global Cryosphere Watch – Gino Casassa, Geoestudios and Universidad de Magallanes
17:50 – 18:10	- Impacto del retroceso de los Glaciares dentro de Áreas Silvestres Protegidas del Estado – Piero Caviglia, CONAF
18:10 – 18:30	- Questions and Answers Session -

Friday 4 September	
09:00 – 09:30	Registration of new participants (optional) Additional time for remaining presentations of Thursday
Linkages with National Projects – Chair: Mercedes Meneses, Ministry of Foreign Affairs	
09:30 – 10:00	Advances in glacier protection legislation in Chile – Daniel Melo, Diputado del Congreso de Chile
10:00 – 11:00	Round Table Discussion <ul style="list-style-type: none"> • Ezio Costa Cordella , Universidad de Chile and FIMA • Francisco Ferrando, Universidad de Chile • Javiera Espinoza, Fundación TERRAM • Matías Asun, Greenpeace • Carlos Urenda, Consejo Minero - Are messages emerging for policy? - How can the project contribute to the current glacier legislation process in Chile? - What are the possible further actions to make the project results most useful in policy and practice context?
11:00 – 11:30	Coffee Break
Presentation of project activities foreseen in 2015/2016 – Chair: Koen Verbist, UNESCO	
11:30 – 11:50	<ul style="list-style-type: none"> - Background papers and policy briefs - Mountainous Watershed Case study - Training course on mountain hydrology and ecosystem services - Strengthening of ongoing mass balance research - Vulnerability assessment in the Andean Region: outreach - Policy assessment in the Andean Region - Linkages with the Water Security Project - Linkages with the Sustainable Development Goals
11:50 – 12:30	- Round table discussion on project agenda and its implementation in 2015 and 2016 -
Working Group on Snow and Ice – Chair: Zelmira May, UNESCO	
<i>1) New developments (regional and country level)</i>	
12:30 – 12:45	- Glacier Monitoring Network in Chile - María Belén Varela/Jorge Huenante/Gonzalo Barcaza, DGA
12:45 – 13:00	- El Programa Glaciológico Ecuatoriano - Bolívar Cáceres, INAMHI
13:00 - 14:30	Lunch

<i>1) New developments (regional and country level) – continued</i>	
14:30 – 14:45	- Proyecto BID: Monitoreo De Glaciares Tropicales Andinos en un contexto de Cambio Climático - Jorge Luis Ceballos, IDEAM
14:45 – 15:00	- La ley de protección de glaciares y el inventario en Argentina – Pierre Pitte, CONICET
15:00 – 15:15	- El programa de balance de masa del Inventario Nacional de Glaciares de Argentina - Lucas Ruiz, IANIGLA, CONICET
<i>2) Planning Working Group Activities 2015-2016</i>	
15:15 – 15:45	- Website implementation - Publication of country activities / Brochure
15:45 – 16:00	- Scientific Conference, Valdivia 2016
16:00 - 16:30	Coffee Break
16:30 – 17:00	Closing Session - Zelmira May, UNESCO - Koen Verbist, UNESCO - Gert Verreet, Flemish Government - Mathias Vuile, University of Albany/ACCION