GRANDE
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MODELS, MODERN TOOLS FOR DECISION MAKING

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I am pleased to take this opportunity to praise the progress being made by the joint project involving researchers of Tohoku University and the Universidad Mayor de San Andrés in La Paz, who are working hard on issues related to climate change and its effects on the retreat of tropical glaciers.

Water quality model for reservoir is developed by Tohoku University and applied to our study area which is Tuni Reservoir, the main water supply for the cities of La Paz and El Alto. This reservoir receives meltwater from Mount Tuni Condoriri of the western Andes, which reaches 5800 meters above sea level. Tohoku University scientists are sharing their expertise in reservoir modeling with researchers of the Universidad Mayor de San Andrés.

Together, Japanese and Bolivian researchers are developing a user manual for the model to assesse water quality in reservoirs, which can be transferred to national agencies and other relevant organizations like the providers of city water and sanitation services in La Paz and El Alto. These agencies will use the model results to guide their actions in the face of possible water shortages in the region due to the shrinkage of glaciers. The manual will explain the model in terms of five components: glaciology, hydrology, sedimentology, water quality, and water resources management.

Our intent is to build on this model and manual by establishing an ongoing group that will capitalize on the experience gained in the GRANDE project to continue research in the area of climate change and glacial retreat. We greatly appreciate the efforts of the scientific community of Tohoku University and their generosity in transferring their knowledge. We hope to continue with research that leads to a better understanding of the phenomena that affect our communities and future urban centers.

Best Regards.

Activity Report

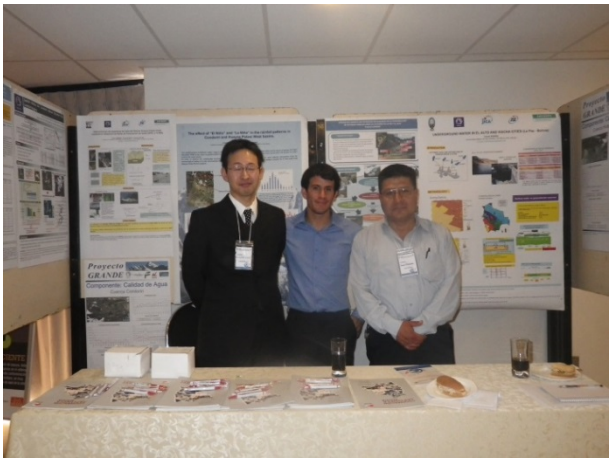
Joint Coordinating Committee 2013

A meeting of the Joint Coordinating Committee (JCC) was held in La Paz on November 25, 2013, to evaluate current activity against the plan and to discuss the plan for the following year. Project leader Prof. Hitoshi Tanaka, the president of San Andres University (UMSA), and the dean of the UMSA Department of Engineering signed the minutes.

Prof. Tanaka presented the progress of research by project scientists. He delivered a preliminary projection of water resources under a scenario of glacial extinct, and the committee discussed the need for adaptation to climate change and glacier retreat in water management by Bolivian water agencies. Project activity in the next year will center around promoting research results on the impact of glacier recession on water resources to a wide range of water managers. The committee agreed to hold the second GRANDE International Symposium in La Paz in August 2014 to report on project activity and present research results to interested parties. Prof. Angel Alliaga of San Andrés University was appointed chair of the executive committee. The committee decided to send Bolivian and Japanese researchers from the GRANDE project to present their results at the 2014 congress of the Latin American Division of the International Association for Hydraulic Research, to be held in Chile during August.

XV Bolivarian Congress of Sanitary and Environment Engineering at Cochabamba

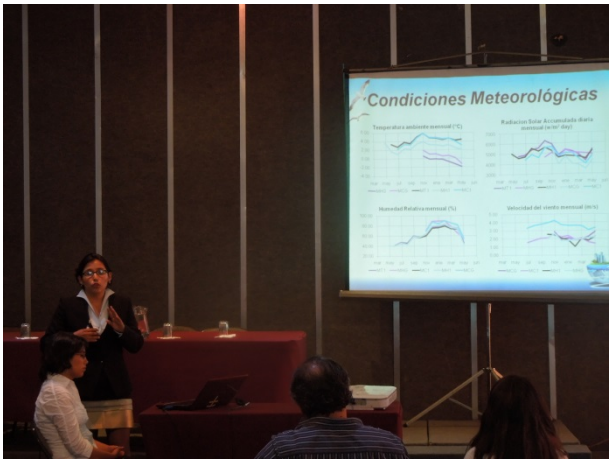
During November 20–22, 2013, four GRANDE researchers made presentations at the XV Congreso Bolivariano de Ingeniería y Medio Ambiente (XV Bolivarian Congress of Sanitary and Environmental Engineering) in Cochabamba, Bolivia. Dr. Yoshihiro Asaoka delivered a keynote speech on glacier recession and water resources in Bolivia. The GRANDE project also had a booth to show our research activities and results. The topic of adaptation to climate change attracted a lot of attention, especially given concerns in the city of Cochabamba after the traumatic “water war” of 2000 . GRANDE scientists were interviewed by local media and handled many inquiries from participants. We received a certificate of gratitude for our activities from the conference committee.



National Workshop on Mathematical Modeling of Water Resources

On November 25 and 26, 2013, a national workshop on mathematical modeling of water resources held at La Paz was organized by the Ministry of the Environment and Water and the Pilot Program for Climate Resilience in Bolivia. Dr. Ramiro Pillco of San Andrés University was the principal chairman of this workshop The purpose of this workshop is to disseminate the techniques of hydrological modeling for water resources management. The GRANDE project sent four researchers to this workshop. Mr. Pablo Fuchs presented an improved melt and runoff model for tropical glaciers. Mr. Gonzalo Leonardini presented a land surface model to account for the energy exchange between tropical glaciers and the atmosphere. Ms. Fabiola Ledezma presented the effects of glaciers on river discharge using a distributed runoff model. Dr. Asaoka gave a presentation on the impact of extreme annual climate conditions on river discharge and water resources in heavy snow areas in Japan.

In Bolivia, the commercial software in common use for water management was developed for the different environments of other countries. The hydrological model developed by the GRANDE project, in contrast, is tailored to the tropical glaciers and study catchment in Bolivia. The models from GRANDE are expected to aid effective water resources management and to be updated by Bolivian researchers.



Temperature rise in La Paz and El Alto for the 2040s from CMIP5

Using climate projection data from the Coupled Model Intercomparion Project Phase 5 (CMIP5), we analyzed temperature changes in the La Paz and El Alto area for the 2040s. The underlying climate projection was based on the RCP4.5 scenario combining long-term global emissions of greenhouse gases, short-lived atmospheric species, and land-use cover practices, which stabilizes radiative forcing at 4.5 W/m2 (approximately 650 ppm CO_2 equivalent) in the year 2100 without exceeding that value (Allison et al., 2011) . Climate projections for the La Paz and El Alto area from nine general circulation models show that mean annual temperature in the 2040s (2036–2055) increases by 1.2 to 2.2 ºC over levels in the 1990s (1985–2005) and mean annual precipitation in the 2040s is 0.85 to 1.15 times that in the 1990s.

Hydrological and hydraulic models that consider glaciers, runoff, sediment transport, and water quality are being developed for our study site by the GRANDE project. We plan to apply this model to project future water resources given the anticipated climate change. These results are expected to be useful for making decisions related to adaptation in water management.

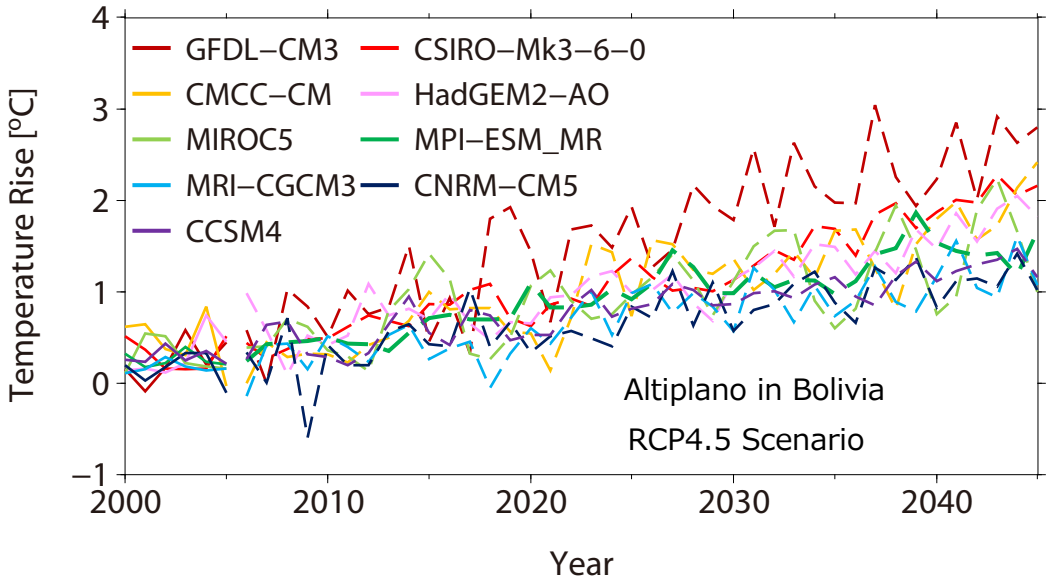


Figure Temperature rise projected by CMIP5

GRANDE Students

Evelin Humerez, Ph. D student, Tohoku University

My name is Evelin Humerez and I am from Bolivia. In April 2012, I enrolled as a Ph.D. student in the Hydraulics and Environmental Laboratory at Tohoku University. Since then, I have been part of the GRANDE project with the support of JICA, JST and SATREPS, to which I extend my grateful acknowledgment. I also extend thanks to my Ph.D. supervisor, Dr. Makoto Umeda and the other researchers of the GRANDE project, who have supported me during my studies at Tohoku University and fieldwork in Bolivia.

I have had a great experience since I arrived in Japan. It is very convenient and comfortable to live and study in Sendai. This city is quiet, clean and calm, providing a good environment for studying. The people are kind and always willing to help. I have not only enhanced my knowledge in my field of research, but also have learned many helpful things during my daily life in Japan. It has been a very meaningful and unforgettable time.

My research study is directed at aquatic ecosystems in Bolivia's tropical glaciers, lakes, rivers, and wetlands, which have been little studied. My goal is to develop a water quality model for the Condoriri River Basin in order to predict the current and future water conditions in this complex area. My first step was to collect water samples from the principal streams of Condoriri and Huayna Potosi basins and Tuni Lake. I strongly believe that getting field data has been valuable for understanding this watershed.

I did fieldwork in Bolivia during July 2012 and February 2013, and I had the opportunity to join Dr. Umeda and Nakano during their fieldwork in August 2013. We measured physicochemical parameters in situ, including pH, temperature, dissolved oxygen, and electric conductivity. Filtered and unfiltered water samples were taken from 17 points from the main stream and the lakes of the Condoriri River Basin. Organic matter (total organic carbon and dissolved organic carbon), nutrients like total nitrogen, total phosphorus and silica, and major ions (SO_4^{2-}, NO_3^-, NO_2^-, Cl^-, NH_4^+, Ca^{2+}, Mg^{2+}, Na^+ and K^+) were analyzed. In addition, water samples from the glacier ice, meltwater, and precipitation were taken to determine the origin of the ions and nutrients. Macrophytes and periphyton were harvested from the streams to determine the biomass. Primary production was estimated at two points in the middle of the basin.

Seasonal and spatial variations were found along the course of the Condoriri River for all the nutrients and ions studied. The concentrations of major ions were higher during the dry season (July 2012 and August 2013) than in the wet season (February 2013). In the upper reaches of the basin, more chemical reactions occurred due to weathering of carbonate, sulfate, and silicate rocks, particularly at the base of the glacier where the highest concentrations were found. In contrast, I found that nutrients and organic carbon had higher concentrations during the wet season than the dry season. This tendency can be attributed to the influence of primary production, rain, groundwater, soil, and vegetation.

The source of the ions was identified as the weathering of rocks like gypsum and carbonates, as the values found in rain and glacier ice were lower than those found in streamwater. Organic matter stored in lake algae and macrophytes influenced the total organic carbon and nutrient concentrations of the water downstream from the lakes. Major loads of ions, organic carbon, and nutrients were transported in the wet season. The total precipitation was 624 mm in September–April and 19 mm in May–August. I found that the rise in water level, greater discharge, and transport of nutrients provide favorable conditions for growth of aquatic vegetation. Seasonal variations of macrophyte biomass were documented in all sampling locations, being greater during the wet season than the dry season. The presence of aquatic plants is closely related to primary production, which was also high in the summer season of February 2013.

Using all of this information, I will develop a novel model that takes into consideration the influence of chemical reactions in the upper reaches, aquatic vegetation, soil, changes in atmospheric conditions, and discharge. I believe that enhancing understanding of current water conditions in the target basin can contribute to better management of the highland water resources. It is crucial to understand this watershed

considering its importance for the largest cities in Bolivia, as global warming is causing serious impacts on tropical glaciers.

After the completion of this study, I expect to continue to work in this interesting field and to motivate other researchers. As a contribution to the project, I hope to transfer my knowledge and acquired experience to the present and future generations of Bolivia and other South American countries, which are suffering the consequences of climate change.

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