

other areas of concern were mentioned for the committee to examine. An example is producing a clear checklist of items that new site proposal presentations should include.

A specific meeting for the Broadband Radiometry Working Group lead by Allison McComiskey was not held formally this year, but relevant topics were discussed in other breakouts and in the plenary sessions at the workshop.

### Workshop Wrap-Up

The final session of the Workshop was comprised of BSRN business and discussions. The first item of business was a discussion of the proposed candidate sites. All proposed sites except the Dubai location will be marked as candidate sites on the BSRN Sites map (<http://bsrn.awi.de/stations/maps.html>), and will be designated as full-fledged BSRN sites upon successful acceptance of quality-assessed data files into the BSRN Archive. The Dubai station was temporarily excluded because of its location within a huge photovoltaic power plant, which influences the thermodynamic status of the lower part of the atmosphere, impacting LW downwelling and SW diffuse components. The second matter was discussing the installment of a deputy BSRN Project Manager, as workloads related to management activities have grown and the cost of travel to workshops could be lowered with two potential attendees. The last item addressed was extending the idea of an “expertise resource” group to include a listing of used and currently unwanted BSRN related equipment. This would help BSRN members with issues such as repairs or even upgrading their sites to include upwelling irradiance measurements. While no specific action was taken, it is hoped this discussion might serve as a seed for future conversation and action.

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## 1<sup>st</sup> ANDEX Workshop

Santiago, Chile

22–24 October 2018

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ANDEX, a scientific research program focused on the hydroclimatology of the Andes and a prospective GEWEX Hydroclimatology Panel (GHP) Regional Hydroclimate Project (RHP), held its first workshop in Santiago, Chile, from 22-24 October 2018. ANDEX is aimed at understanding, modeling, and predicting the dynamics of the water and energy cycles over the Andes cordillera, which runs from 10°N to 53°S and cross Colombia, Venezuela, Ecuador, Peru, Bolivia, Chile, and Argentina. More than 60 million inhabitants rely directly on the water resources provided by the Andes, but they are also exposed to a suite of natural hazards imposed by such impressive geography and climate, ranging from very humid conditions near the equator and western Patagonia to the hyper arid conditions in the subtropics. The Andes also face enormous challenges from human encroachment, urbanization, climate variability, climate change, land use changes, and massive deforestation.

The Santiago workshop was hosted by Prof. R. Garreaud and his team from the Geophysics Department of the Universidad de Chile, and received financial support from the World Meteorological Organization (WMO) through the GEWEX program, the Universidad de Chile, and the Center for Climate and Resilience Research (CR2). The meeting took place 10 months after the foundational ANDEX meeting held in Medellín, Colombia, from 4-6 December 2017, where a group of ten scientists summarized the current understanding of the Andean hydroclimate, identified key outstanding questions, and agreed upon the preparation of a White Book. The first ANDEX workshop in Santiago was attended by 27 scientists (the agenda is located at <https://www.gewexevents.org/events/2018-andex-ghp-inarch-meeting/agenda/andex/>), most of them from South American countries. The workshop benefited from the participation of colleagues who shortly after attended the 2018 GHP Meeting in Santiago and the 4<sup>th</sup> International Network for Alpine Catchment Hydrology (INARCH) Workshop in Portillo. To capitalize on the shared interests of the three groups, a joint ANDEX-GHP-INARCH meeting was held during the morning of October 24 (the agenda is available at <https://www.gewexevents.org/events/2018-andex-ghp-inarch-meeting/agenda/joint-andex-ghp-inarch-meeting/>).

Since RHPs represent the pursuits and collaborative activities of a science community and need to be driven by the interests and efforts of a core group through institutional resources, the ANDEX workshop in Santiago gauged the level of interest in such a GEWEX RHP and assessed whether the level of scientific activity currently underway or planned would be

sufficient to make it a candidate for an RHP. Specifically, the Santiago meeting aimed to:

- Review the status of the ANDEX White Book
- Identify overarching themes and major scientific questions
- Provide a first approach to an implementation plan

### *Meeting Outcomes*

The first day of the meeting was devoted to reviewing the status of the ANDEX White Book, a document envisioned at the Medellin foundational meeting that now involves the contributions of 30 scientists. The objectives of the White Book are to summarize the scientific knowledge and recent advances in Andean hydroclimatology and to identify major gaps in our understanding. The White Book contains the following eight topical chapters:

1. Geographical Context
2. The Hydroclimate of the Andes
3. Climate and Environmental Change
4. High Impact Events
5. Cryosphere of the Andes
6. Observations and Data
7. Science Underpinning Sustainable Development
8. Actions and Challenges

The lead authors presented the status of their respective chapters, showing substantial progress of about 75% completion with some differences among chapters. The group intends to send out the first drafts of the White Book chapters for review in June 2019. During the rest of the first day and into the next morning, diverse colleagues from the region (Jhan Carlo Espinoza, Francina Dominguez, Paola A. Arias, and Jorge Molina), as well as colleagues working outside the region who are involved in Andes-related research, gave presentations on their efforts: Joan Cuxart and Jason Evans of GHP; Thomas Condom from the Glacier and Water Resources in the Tropical Andes; Indicators of Changes in the Environment (GREAT ICE) project in France; Kate Halladay, reporting on convection permitting modeling from the UK Met Office; and Ana P. Barros from Duke University, USA, working on climate-vegetation linkages.

Most of the second day of the meeting was devoted to identifying critical gaps in Andean-related hydroclimate research and pinpointing how these gaps hinder the advance of operational activities in the region (e.g., weather and flood forecasts, climate prediction, etc.). To facilitate this task, participants were split into two groups whose main results were summarized in a plenary session at the end of the second day. An action list emerged from this activity, as summarized below:

- It is imperative to create an updated and comprehensive list of scientists involved in Andean-related research (ANDEX-list). Likewise, we should create an ANDEX website and start uploading content and news to promote community involvement.

- There is a general sense that critical observations in the Andean highlands are lacking. While this is undoubtedly so (e.g., just 10 radiosonde stations near or at the Andes), many research projects have installed new observing systems, as well public and private measurement networks. Therefore, there is an urgent need to create an inventory of hydroclimate observational platforms along the Andes. To this end, a survey on projects and resources will be sent to the ANDEX-list within the next few weeks. Once completed, the survey result will be conveniently displayed in a dynamic map on the ANDEX website.
- The observational survey will ask the responsible researcher about the possibility of sharing station data. If possible, the data will be made available on the ANDEX website. CR2 has enough expertise and technical resources to lead this task. Likewise, freely available information (e.g., weather reports and climate data) will be ingested in the already-available CR2 Climate Explorer.
- The need to develop an ANDEX atmospheric reanalysis was suggested by both groups as another science-enabling product. A high-resolution, fully consistent, long-term atmospheric dataset will benefit the broader community, permitting the description of regional-scale circulations and the forcing of hydrological and vegetation models. Likewise, we also propose a characterization of Andean basins along the whole cordillera, including geomorphological features, soil and land-use characteristics, and human-dimension indices.
- Completion of the ANDEX White Book is a top priority. The first draft is expected in May 2019, which may coincide with a small meeting of the core ANDEX scientists in Quito, Ecuador. After that, it should be sent out to the larger community in June 2019 for feedback, with a final version ready by the end of 2019. In addition to summarizing what is currently known about the Andes hydroclimate, the White Book also needs to make explicit the gaps in our knowledge. This will be the starting point for an ANDEX implementation plan.

In addition to generating these action items, the subgroups contributed to and complemented the overarching ANDEX questions, which were presented by Prof. G. Poveda at the joint ANDEX-GHP-INARCH meeting on Wednesday morning. These questions are:

1. What are the dynamical feedbacks between the Andes and the processes involved in the hydrologic cycle over the Andes (water vapor, precipitation, evapotranspiration, sublimation, soil moisture, infiltration, groundwater, and river flows) at a wide range of spatial and temporal scales, for average and extreme conditions? Among those processes the following were highlighted: water vapor sources and pathways, precipitation recycling, low-level jets and atmospheric and aerial rivers, the Bolivian High anticyclone, the Madden-Julian Oscillation (MJO), tropical easterly waves, and El Niño Southern Oscillation (ENSO). Among the most important extreme events the following



*Participants of the 1<sup>st</sup> ANDEX Workshop*

were identified: intense storms, mesoscale convective systems, floods, droughts, cold spells, hail storms, lightning, fires, Zonda winds, and landslides.

2. What are the physical dynamics of processes involved in the surface energy budget over the Andes across a wide range of spatial and temporal scales?
3. How does the dynamical coupling between 1 and 2 operate across the Andean altitudinal, latitudinal, and longitudinal gradients and from glaciers to deserts?
4. What is the influence of the cryosphere on the surface hydrologic cycle of the Andes, and what is the influence of the atmospheric hydrologic cycle on the Andean cryosphere?
5. What are the current and future human impacts from water diversion and pollution, deforestation, land use and land cover, and climate change on processes and variables involved in water and energy budgets over the Andes?
6. How should these impacts be dealt with from a water (and other life support systems) management perspective?
7. How will the current and future water and energy budgets along the Andes affect ecosystem services, water supply, hydropower generation, food production and food security, natural hazards, and human health?
8. What is the effect of the Andes on pollution in urban valleys and what are the risks for human health?

Summarizing, we are positive that the first ANDEX workshop fulfilled the expectations of the Andean scientific community, as well as the GHP and INARCH communities, in terms of

gathering a larger group of highly interested scientists willing to move this initiative forward. On this basis, our timeline for the next few years includes:

- Presentation of ANDEX activities during the 31<sup>st</sup> Session of the GEWEX Scientific Steering Group (SSG-31), to be held in Geneva, Switzerland: 25 February to 1 March 2019
- Creation of a Logo: March 2019
- Completion of the list of scientists and institutions working on the ANDEX overarching questions and main themes: March 2019
- Creation of a web presence: beginning in April 2019
- Completion of the ANDEX White Book first draft: May 2019 (Quito Meeting)
- Definition of ANDEX governance structure: May 2019 (Quito Meeting)
- ANDEX session at the AGU Fall Meeting: December 2019
- Definition of Scientific Program (Observations and Modeling): March 2020
- ANDEX Open Science Conference: April 2020
- ANDEX Implementation Plan: June 2020

We feel that ANDEX is moving forward and envision it becoming a recognized GEWEX Regional Hydroclimate Project within the next 3 years, a period during which we must translate the ANDEX overarching questions into a concrete implementation plan of a long-due and much-needed research program focused on the world's longest mountain range.