# GEO Mountains Workshop: Interdisciplinary Monitoring, Data & Capacity Sharing across the Andes

Movich Hotel, Bogotá, Colombia
20-22 February 2024

Final Report (for dissemination)

Report date: 25 April 2024

Organised by:

MOUNTAIN RESEARCH INITIATIVE

GEO MOUNTAINS
Observing Mountain Environments

In partnership with:

WORLD METEOROLOGICAL ORGANIZATION

CONDESAN
Consorcio para el Desarrollo Sostenible de la Ecorregión Andina

AmeriGEO
Earth Observations for the Americas

INSTITUTO HUMBOLDT COLOMBIA

INTER-AMERICAN INSTITUTE FOR GLOBAL CHANGE RESEARCH
IAI

IDEAM

Part of:

ADAPTATION AT ALTITUDE
Taking Action in the Mountains

GEO GROUP ON EARTH OBSERVATIONS

Supported by:

Schweizerische Eidgenossenschaft
Confédération suisse
Confederazione Svizzera
Confederaziun svizra

Swiss Agency for Development and Cooperation SDC

**Suggested citation:** GEO Mountains (2024). Interdisciplinary Monitoring, Data, and Capacity Sharing across the Andes, Bogotá, Colombia, 20–22 February 2024. Workshop Report. Bern: Mountain Research Initiative. doi: 10.48350/196032.

Cover photo credit: IDEAM, Bogotá, 22 February 2024

**Contents**

## 1. Introduction & Workshop Aims

The workshop was the final event of a series of regional engagements undertaken in 2023–24 by the Mountain Research Initiative (MRI) in its role co-leading the Global Network on Observation and Information in Mountain Environments (GEO Mountains) under the Adaptation at Altitude programme (A@A). The workshop for the Andean region took place from Tuesday 20 to Thursday 22 February 2024, at the Movich Hotel in Bogotá, Colombia and was co-convened by the Inter-American Institute for Global Change Research (IAI), the Consorcio para el Desarrollo Sostenible de la Ecorregión Andina (CONDESAN), the Instituto de Hidrología, Meteorología y Estudios Ambientales (IDEAM), the Humboldt Institute, AmeriGEO, and the World Meteorological Organization (WMO).

The workshop sought to bring together data providers and data users from a range of disciplines working across the Andes. More specifically, through a series of invited presentations and group discussion activities, the workshop sought to:

- Build on and follow up on the outcomes identified via a consultation survey and online workshop held in October 2021 (see Section 2);
- Identify examples of good practices, challenges, and solutions / opportunities regarding mountain monitoring, data exchange, and capacity sharing;
- Enhance the sharing of data, capacities, and training resources between monitoring authorities (e.g. National Hydrological and Meteorological Services; NHMSs) and researchers, as well as identify opportunities for students / Early Career Researchers (ECRs) to (further) engage in mountain monitoring;
- Explore opportunities to enhance the thematic scope of existing monitoring efforts; and
- Propose future projects with the potential for high scientific, practical, and/or policy impact which could be conducted collaboratively by some of the workshop participants going forwards.

Researchers, representatives of national environmental monitoring agencies, and other local institutions attended the workshop. In total, 69 participants attended the workshop, of whom 40 attended in person and 29 online. Participants came from across the region, including Colombia, Peru, Ecuador, Venezuela, Paraguay, Chile, Argentina, and Bolivia. In addition, researchers working in the region or in a co-convening role from the USA, Switzerland, and Romania were in attendance. For the full list of in-person attendees, please see Annex 2.

This report presents the workshop proceedings and summarises the key points, outcomes, and recommendations that arose from the discussions.

## 2. Previous Online Workshop & Consultation (2021)

The event built upon a previous survey and online workshop held for the Andean region in October 2021. Selected outcomes of the virtual consultation following that engagement are as follows:

- A survey was made available from 12 October 2021 to 22 July 2022, with 13 respondents, most of whom were from universities / research institutions, although government agencies, charities / NGOs, and the private sector were also represented;
- Most respondents consider themselves to be both data providers and data users, with the next most common category being exclusively data users;
- The professional activities of most respondents rely not on one single type of data (e.g. in situ, remotely sensed, tabular / statistical, or simulated), but rather a combination of different data types;
- Many different disciplines or topics were identified by participants as being important for their roles, with climate change (including mitigation and adaptation) and sustainable development both strongly represented;
- Most respondents work at either local or regional (e.g. catchment, administrative districts) scale, with comparatively fewer individuals working across the entire mountain range, or across scales;
- A majority of respondents work primarily on historical time horizons (which includes ongoing long-term monitoring), with a smaller proportion of respondents working across multiple and future time horizons;
- Respondents suggested that a reasonable proportion (but by no means all) of the datasets they require for their work are actually being developed / exist;
- Respondents rely on a diverse range of methods to discover potentially useful datasets, with word of mouth and standard web searches featuring most prominently;
- Half of the respondents would consider sometimes paying a fee to access important datasets, although others would never consider paying such fees;
- Many respondents either frequently experience difficulties in discovering, accessing, or using datasets that are necessary of their work;
- Respondents identified several specific datasets that they currently lack, including socio-economic / livelihood data, local-scale data on disaster events (e.g. fires, landslides), long-term deforestation, land use, biodiversity loss, and ecosystem change/degradation data, data capturing traditional or local knowledge on climate change adaptation, climate and hydrological data at higher spatio-temporal resolutions, and soil data;
- Respondents suggested that technical or computational constraints sometimes limit their ability to obtain results or insights from the available data and information;
- Respondents reported that that addressing the most critical data gap(s) identified would greatly improve the efficiently and impact of their work;
- Most data providers generally make their own data freely available to others for research / non-commercial purposes, and this is mostly done via institutional repositories, although a proportion do not;
- Where applicable, a variety of motivations for sharing data were given, including service to the community, “quid pro quo”, and being mandated to do so by one’s institution;
- Making and processing the actual measurements, finding a suitable persistent and discoverable repository, and creating informative metadata were considered problematic steps of the data life-cycle by many participants;

- Limited time / funding, limited technical capacities, and inter-institutional competition were perceived to be the major barriers for more routine and/or extensive data sharing and exchange;
- A large proportion of the participants use all of the listed methods (word of mouth / from colleagues, from reading journal articles and technical reports, via web-searches, from conference / virtual presentations, and by searching dedicated geospatial catalogues) to discover potentially useful datasets;
- Whilst half of the respondents were either concerned that data they share could be misused (i.e., applied to an inappropriate purpose), almost all of respondents considered Open Data / Open Science, including "data publications", to be positive developments and either extremely important or important for the advancement of their disciplines and associated policy and practice; and
- A clear majority of respondents consider a dedicated regional data inventory / portal to be extremely important, but diverse responses were given to the question of what functionality an online geodata portal would ideally have (approximately equal proportions).

This situation therefore represented the point of departure for the in-person workshop held in February 2024 reported here.

**3. Workshop Programme & Key Points**

In this section, the workshop programme is presented. Beneath each programme agenda item, a few key points made by the presenters or during the discussions regarding data availability, exchange, use, and outstanding challenges (as applicable) are stated. For further details regarding the presentations given, please see the slides which were presented (the link is provided in Annex 1).

***Day 1***

*Tuesday 20 February 2024*

**08:30 – 09:00: Arrival & Registration**

**09:00 – 09:15:** Welcome from **Dr. Carolina Adler** – Executive Director, Mountain Research Initiative (MRI); **Dr. Edwin Castellanos** – Science Director, Inter-American Institute for Global Change Research (IAI); **Dr. Ghisliane Echeverry** – Director, Instituto de Hidrología, Meteorología y Estudios Ambientales, Colombia (IDEAM).

Dr. Thornton introduced himself, and welcomed the Directors of the MRI, the IAI, and IDEAM, respectively, to give some words of welcome and opening remarks. Dr. Thornton then provided some information on the context of the workshop (the A@A programme) and thanked all partner organisations for their excellent collaboration in the event's preparation (especially Dr. Mauricio Romero Torres, from IAI).

**09:15 – 09:30: James Thornton,** GEO Mountains Coordinator (MRI) – *Workshop Objectives, Expectations & Agenda*

Dr. Thornton invited all participants to share their expectations and ideas for the workshop in an online tool (Mentimeter) and looked at the results together (shown in the Figure 1 below).


Figure 1. Results of the initial live survey regarding participants' ideas and expectations of the workshop.

34 participants participated in this short survey, giving 117 separate responses. The main expectations for the workshop can be gathered into two categories:

1. **Network development** (e.g. "networking/networks", "collaboration", and "exchange").
2. **Research and applications** (e.g. "impact", "funding").

**09:30 – 09:50: James Thornton, GEO Mountains Coordinator (MRI) –** ***GEO Mountains: Introduction & Recent Activities***

Dr. Thornton summarised the objectives that GEO Mountains' hoped to achieve during the workshop (see the link to the slides in Annex 1). Dr. Thornton then proceeded to give a brief introduction to GEO Mountains' and its key activities and outputs over the last few years (e.g. the development of data portals, hosting other workshops, and generation of policy-relevant outputs).

Participants were encouraged to contribute metadata on monitoring sites they operate (or are aware of), and/or any gridded datasets they have developed or feel could be useful to the wider mountain community, to GEO Mountains' In Situ and General Inventories, respectively. A policy brief that was developed on "Mountain Observations" and the *Mountains Uncovered* Series –

which provides intercomparable, multi-thematic information on 100 global mountain ranges – were also mentioned; both resources are available via the GEO Mountains website.

Dr. Thornton also introduced the Mountain Observatories Working Group, which aims to help establish regional and eventually global networks of long-term, multi- and inter-disciplinary, multi-method, and multi-scale mountain monitoring "hubs" or "super-sites" (Shahgedanova et al., 2021). The types of data / specific variables that such sites would ideally monitor were presented.

Then, some examples of existing sites that largely meet the definition of "Mountain Observatories" were drawn from Central Asia. Indeed, several of these sites (and their operating institutions) have already been consolidated into a formalised network – the Central Asia Mountain Observatories Network (CAMON). Participants involved in such sites were warmly invited to join the Working Group.

**09:50 – 10:10: Mauricio Romero Torres, Science, Technology and Policy Fellow, IAI – *IAI's mission and Belmont Forum calls***

Dr. Romero Torres presented the Inter-American Institute for Global Change Research (IAI), which was established in 1992. The institute has undergone a significant transformation in its approach since inception. Originally emphasising social sciences, IAI now adopts a transdisciplinary stance, aligning its three pillars: government and policy, a science program with a focus on co-design and transdisciplinary science, and capacity development through teaching programs. The IAI's mission revolves around developing regional capacities, fostering science-based decision-making, and promoting regional cooperation. The scientific agenda spans a wide spectrum, encompassing topics from biodiversity to climate change. In particular, the current focus in Colombia centres around IDEAM, emphasising the importance of intercomparable data records and the replicability of scientific methods.

The Belmont Forum, an international network of funding organisations, science councils, and consortia working in transdisciplinary science, was also presented. More than 20 Collaborative Research Actions (CRA) have now been launched and 155 projects funded. IAI also has an online library of freely available transdisciplinary resources (courses, tools, publications) online both in Spanish and English.

**10:10 – 10:45**: **BREAK & GROUP PHOTO**

**10:45 – 12:00: Invited flash talks on existing research-oriented mountain observatories / experimental basins / networks (I) (10 minutes each, including Q&A)**

**Bryan Mark,** Ohio State University, USA & The Transdisciplinary Andean Research Network (TARN) – *Sustaining intercomparable hydroclimate mountain observations with distributed and open access networks in Peru and Nevada*

Dr. Mark discussed the challenges of maintaining sustainable observations in mountainous regions. He introduced the concept of Embedded Sensor Networks (ESN) – a low-cost methodology for sustaining long-term, distributed, in situ observations in heterogeneous mountainous environments at fine spatial resolutions that complement weather stations. The

Great Basin Experience (GBEX) is an annual research excursion involving diverse activities such as lake coring to capture different microenvironments along ridge lines and within valleys.

**Jan Erik Arndt,** Universidad de Concepción, Chile & Cold-Blooded Lab – *Mountain research in the central-south Chilean Andes*

Dr. Arndt presented the ANILLO project's three-year journey, comparing mass balance with geomorphology and satellite data in the central-south Chilean Andes. He highlighted additional activities, including a seminar cycle available on YouTube and the QFuego project, which was funded by the GEO Mountains Small Grants Scheme 2023 and makes available a variety of spatial data for Patagonia in a QGIS environment.

**Marcos Andrade** – Universidad Mayor de San Andrés – *The highest Global GAW Station in the world: Chacaltaya, Bolivia*

Dr. Andrade discussed the Global Atmospheric Watch (GAW) station in Chacaltaya, Bolivia, which is the highest such station in the world (5240 masl). Most GAW stations are located in Europe and North America, while South America and Africa have only a few between them. The Chacaltaya site is particularly interesting due to its proximity to the ocean and the altiplano. Continuous measurements since 2011 include variables like black carbon, ozone, carbon dioxide, methane, atmospheric particles, and others. The station can be reached by road vehicle. Andrade emphasized the need for funding for long-term monitoring, expressing concerns about the lack of such funding in Bolivia.

**Roberto Rondanelli,** Universidad de Chile & Centro de Ciencia del Clima y la Resiliencia ($CR^2$), Chile – *The Cerro Tres Puntas high-elevation site*

Dr. Rondanelli introduced the Cerro Tres Puntas site in the Chilean Andes, located at 3,700 m a.s.l. Mountains in Chile have historically been somewhat neglected in monitoring efforts; the national aviation authority was responsible for monitoring, and placed many stations near airports. The Cerro Tres Puntas site offers freely downloadable data from 2002 from its website.

**Fabian Drenkhan,** Pontificia Universidad Católica del Perú – *Observatorios y acceso de datos de montaña en el Perú: avances y desafíos*

Dr. Drenkhan provided an overview of mountain data accessibility in Peru, noting advancements in geodata distribution and access policies, with the opening of free Geoportals (e.g. Autoridad Nacional del Agua; ANA). Challenges include a lack of training, limited culture of collaboration, and in some cases quality. The PISCO precipitation, temperature, and evapotranspiration dataset was highlighted. Dr. Drenkhan then discussed challenges in decision-making due to political and social issues, but concluded by presenting positive perspectives from CONCYTEC, a programme open to international collaboration and scholarships, and Ciencia*Climática,* which aims to reach a broader audience.

**Norma Salinas,** Pontificia Universidad Católica del Perú & Andes Biodiversity and Ecosystems Research Group (ABERG) – *Cambios ecosistémicos en los Andes-Amazonía: Monitoreo de bosques tropicales a largo plazo*

Dr. Salinas discussed long-term monitoring of tropical forests along the Andes-Amazonia region, employing transects to understand ecosystem variations at different elevations. ABERG collaborates with local communities, providing alternatives for cattle removal such other agricultural activities (e.g. growing crops).

**12:00 – 13:30**: **LUNCH**

**13:30 – 15:15: Invited flash talks on existing research-oriented mountain observatories / experimental basins / networks (II) (10 minutes each, including Q&A)**

**Francisco Cuesta**, Universidad de Las Américas, Ecuador & GLORIA Andes

Dr. Cuesta's presentation focused on standardising protocols within the GLORIA Andes network to ensure data comparability and interoperability. The goal is to implement a South–South cooperation system to strengthen capacities. GLORIA Andes, encompassing 19 sites and 264 dataloggers across seven countries and four biomes, monitors a wide variety of species on mountain summits. Distribution patterns are changing significantly, and the challenge lies in understanding whether species can adapt quickly enough as they migrate upwards. A key consideration raised during the Q&A session was the importance of sufficient independence from funding organizations for operational sustainability, allowing researchers to gather their data effectively.

**J. Sebastián Tello,** Missouri Botanical Garden, USA & Andean Forest Network

Dr. Tello's presentation introduced the Andean Forest Network, which was created in 2011 and seeks to improve understanding of Andean forests, their dynamics, and their future. Numerous researchers from different countries contribute (all except Chile, currently), some of whom also work in GLORIA sites. 390 individual monitoring parcels ("lots"), and more than 3,600 tree species have been surveyed.

PhD students are supported and integrated, and a dedicated website is operational. Standard methods / protocols are applied across sites to measure multiple tree variables. Taxonomical work done through the Andes is heavily relied upon to identify the species. Monitoring also extended to characterising the climatological characteristic at many sites. Many scientific papers have been published, sharing research results (for example forest responses to climate change). For example, upscaling work was done from the local measurements to estimate carbon storage dynamics across broader areas. Andean forests are shown to be carbon sinks, despite deforestation.

**Manuel Peralvo,** CONDESAN, Ecuador – *The Chocó Andino Learning Site*

Dr. Peralvo presented the Chocó Andino Learning Site, which lies in the Quito region of Ecuador. Historically, the region has undergone considerable deforestation and been subject to mining. The activities seek to support more sustainable land use and management practices. 10 years of work has now been completed, during which time various monitoring initiatives have been established. In particular, the aim is to link land use practices with their impacts on key ecosystem services.

Specific examples of projects were introduced, including assessing water quality via micro-invertebrate monitoring, and ecosystem restoration projects. Monitoring the broader impacts of such restoration projects on the broader systems could be enhanced. Several challenges were mentioned, including the divergent spatial and temporal scales on which information is required, costs of maintaining monitoring, and integrating a diverse set of stakeholders from different groups. Future work seeks to overcome these challenges.

**Luis Daniel Llambí,** CONDESAN, Venezuela – *Primary Succession in the Last Venezuelan Glacier: Cronosequence and permanent plot approaches*

Dr. Llambí gave a presentation on monitoring primary vegetation succession in the forefield of the last Venezuelan glacier – the Humboldt Glacier, which is almost extinct. Tropical glaciers are retreating faster than those in other regions, and their dynamics can be reconstructed using aerial imagery and photographs. Yet, new high elevation ecosystems are emerging in the glacier's forefield colonization front (superpáramos) and in the adjacent areas (e.g. wetlands, lakes). The cover of several species has been quantified (lichens, mosses, vascular plants). Several plots have been monitored, and the results show that organic matter increases with distance from the glacier (i.e. with time since deglaciation), but soil formation is very slow. Lichens and mosses are the pioneer growth forms, and community complexity increases through time. Dispersion is initially dominated by wind. After 100 years, the pollination network is comprised of only six flowering plants and 5 pollinator species. A recommendation is to combine synchronic and diachronic approaches to monitor such areas.

**Daniel Ruiz-Carrascal**, Sistema de Alerta Temprana del valle de Aburrá (SIATA), Colombia – *The Poleka Kasué Mountain Observatory*

The group had interest in exploring the phenomenon of enhanced warming at high elevations in the northern Andes, with a view to assessing the impacts on of any such warming on extremely rich and valuable hydrological and ecological systems. A site with the necessary characteristics was found in the central Colombian Andes. The region provides habitat for several endemic species. Seven lines of action are followed.

A network was established with 28 data loggers (measuring temperature and humidity) at 300 m elevation intervals. The data from this network, which now spans approximately 15 years, has been combined with various other sources of information to reach the major conclusion that change processes are indeed accelerating, and recent temperature increases are without precedence since the last glacial period (30 to 50 times faster). The group has a strong desire to maintain the network for future decades. Participants were invited to visit the site, and attention was drawn to a web portal (developed through one of the GEO Mountains Small Grants Projects) which provides data visualisation and access.

**Ana Belén Hurtado Martilletti,** Humboldt Institute, Colombia – *The Strategy for Integrated Monitoring of High Mountain Ecosystems in Colombia (EMA)*

Dr. Hurtado presented the Strategy for Integrated Monitoring of High Mountain Ecosystems (EMA) in Colombia, discussing the approach and methodologies for comprehensive ecosystem monitoring. Their main project, called Páramos para la vida, aims to generate a conceptual framework for the analysis of high mountain ecosystem transformation processes and their effects

on biodiversity, as well as human well-being, at different scales. Workshops involving communities have been an important part of the work.

**Julieta Carilla,** Universidad Nacional de Tucumán (UNT) – Consejo Nacional de Investigaciones Científicas y Técnicas (CONICET), Argentina – *Red de Observatorios Socioecológicos Andinos (ROSA)*

Dr. Carilla presented the Red de Observatorios Socioecológicos Andinos (ROSA), which is a South–South collaborative initiative on integrated monitoring for territorial management in the Andes. The network is taking a bottom-up approach to consolidate ecological and socio-economic monitoring initiatives by integrating them into a series of mountain observatories. Future challenges for the network are to promote science-policy-stakeholder dialogue and co-production of knowledge, as well as increasing ROSA's visibility.

**15:15 – 15:45: BREAK**

**15:45 – 17:15**: **Discussion I: Towards more coordinated research-oriented monitoring and enhanced data availability and capacity exchange: good practices, challenges & opportunities (All)**

Participants were divided into five groups of approximatively 4-5 people each. A breakout room for online participants was also created. Each group was invited to appoint one or more rapporteur(s), and then independently discuss the following question:

*With respect to the coordination of research-oriented monitoring and exchanging associated data and capacities, what examples could you give of:*

- *Good practices*
- *Current challenges*
- *Potential solutions / future opportunities?*

All participants then reconvened for a reporting session in Plenary. The main outcomes, combined across all groups, were as follows:

Throughout the discussions, several good practices were identified. Trends towards the standardisation of measurement protocols and enhancing data collection methods were recognized as successful efforts. Collaborative partnerships with other institutions, joint funding calls, and a focus on diverse skills and abilities were highlighted as effective strategies. The importance of freely accessible and unrestricted data was also acknowledged. The existence of well-established regional and international networks operating across the Andes was a further example of good collaborative practice.

Common challenges identified in the discussions included issues with in situ devices, such as vandalism and lack of communication with local communities and other societal actors. Political instability, funding uncertainties, and a lack of government support were noted as challenges affecting research projects. Other challenges including underfunding of staff, cultural boundaries, and a shortage of human resources, were prevalent. Challenges also extended to professionals earning degrees abroad and not returning, posing potential "brain drain" issues. The need for

long-term sustainability in monitoring efforts and integrating social sciences networks was emphasised.

Opportunities for improvement were a key focus in the discussions. Enhancing communication strategies at all levels, engaging communities, and improving the inclusion of women were seen as ways to protect devices / installations, and to sustain long-term observations. The need for more effective device repairs, fostering a collaborative networking culture among scientists, and addressing challenges in science-policy interfaces were highlighted as opportunities. Encouraging transdisciplinary work, promoting joint degree programs between Andean countries, and fostering science in Latin America were likewise identified as opportunities to explore. Networking and obtaining funding were also identified as crucial opportunities.

Further details of each group's answers are available in Annex 3.

**17:15 – 17:20: Summary of the Day's Proceedings (James Thornton)**

A summary of the day was given, before participants were invited to proceed to attend the drinks reception.

***Day 2***

Wednesday 21 February 2024

**09:00 – 09:05: Welcome & Introduction to Day 2**

**09:05 – 09:50: Keynote: Daniel Vila Espigo**, World Meteorological Organization (WMO) – Introduction to WMO Regional Association (RA) III and its perspectives on operational mountain monitoring

Dr. Vila's keynote presentation on behalf of the World Meteorological Organization (WMO) provided a comprehensive overview of the organization's role as the UN specialized authority for weather and climate. Emphasising the global interconnectedness of atmospheric conditions, he highlighted the WMO's three strategic lines: climate action, increased communication and transparency, and enhanced support of member countries. The strategic objectives shared for the period 2022-2027 place a particular focus on the challenges presented by the cryosphere and high mountain areas.

Given the intricate topography of these regions, forecasting weather and climate becomes inherently difficult. Specific objectives outlined included closing gaps in high mountain regions, improving system predictions, and collaboratively developing warning systems with scientists and policymakers. The presentation stressed the integration of various mountain data into numerical weather predictions (NWP) and other models for applications in mountain regions. Thus, the WMO is encouraging member countries to improve their mountain monitoring and observation programs, while maintaining efforts to coordinate monitoring in their mountain regions more broadly. Finally, the importance of regional initiatives such as ENANDES and ENANDES+, both of which were supported by diverse stakeholders, were highlighted. These projects showcased collaborative efforts aimed delivering crucial climate services at a regional and national level.

**09:50 – 10:30: Keynote: Waldo Sven Lavado Casimiro**, World Meteorological Organization (WMO) Research Board & Servicio Nacional de Meteorología e Hidrología del Perú (SENAMHI) (Online) – Hydrometeorological data and decisions: Activities of the WMO Research Board in RAIII & SENAMHI in Perú

The focus of the keynote presentation by Dr. Lavado, representing the World Meteorological Organization (WMO) Research Board and Servicio Nacional de Meteorología e Hidrología del Perú (SENAMHI), was on the crucial role of hydrometeorological data in decision-making processes – particularly in dealing with extreme weather and climate events, including those involving the cryosphere. Highlighting the increasing demand for evidence-based actions, Dr. Lavado emphasised the need to transition from research to operation and use data to help inform decision-making. The presentation also delved into the WMO Research Board's (RB) activities in Regional Association III (RAIII), stressing the importance of advancing scientific knowledge and improving capabilities.

Insights were shared into how meteorological services can effectively make use of science to make decisions and help in this research-to-operation transition by drawing upon the example of Peru, which significantly improved products and forecasts working with time and numerical

models. One of the challenges faced was the lack of dense networks for country-wide decisions. The implemented solution involved creating a gridded hydrometeorological data product at a national level going back to 1981 (in the PISCO project). The importance of real-time information for risk exposure management was also highlighted. In conclusion, Dr. Lavado emphasised the long-term nature of the process, calling for an increase in the number of stations in the regions and advocating for free access to hydrometeorological data.

**10:30 – 10:50: Short intervention from Adina Croitoru, WMO & Babeş-Bolyai University**

Dr. Croitoru, also representing the WMO RB, highlighted the three major research programs – the World Weather Research Programme (WWRP), the World Climate Research Programme (WCRP), and GAW – as well as the WMO Executive Committee Panel of Experts on Polar and High Mountains Observations, Research and Services (PHORS), which addresses polar and high mountain regions. The importance of regional-level engagement, whereby each country can tailor their priorities according to specific needs and challenges, was emphasised. Dr. Croitoru moreover stressed the importance of the ongoing consultations with research communities that the Research Board's Task Team on Data Exchange with the Research Sector are conducting in order to identify case studies and examples of good practices with regards to data sharing.

The remainder of the presentation acknowledged the diversity of issues and approaches that have been encountered across different (global) regions consultations so far, even among neighbouring countries within the same region. For instance, it was noted that in many regions, hydrological data access is often much more limited than meteorological data access. Dr. Croitoru encouraged participants to become part of the international research and academia network for monitoring the progress in Data Exchange Policy implementation in order to share their views with regards to which data are required for which purposes, and where possible to identify joint benefits associated with collaboration on sharing data between the research sector and National Meteorological and Hydrological Services (NMHSs).

Finally, attention was also drawn to the recommendations that the RB provides on its website regarding optimal data sharing practices, such as installing infrastructure that confirms WMO standards and providing metadata. Using English language where possible, and preparing various tutorials and training materials on how to access and use the data would improve the accessibility to and usability of data.

**10:50 – 11:30**: **BREAK**

**11:30 – 12:45**: **Invited flash talks on operational mountain monitoring and associated data sharing infrastructure (10 minutes each, including Q&A)**

**Jorge Luis Ceballos,** IDEAM, Colombia

Dr. Luis Ceballos presented comprehensive activities encompassing glacier and weather monitoring with the active participation of diverse groups, including children. The initiative involves monitoring weather conditions near coffee plantations and engaging with schools to enhance

community resilience and promote ecotourism. During La Niña events, strong and severe rainfall was noted, and interannual variability of precipitation analysed.

Implementing projects with schools enables students to be educated about the risks associated with different weather conditions, such as the possible impacts of intense precipitation on school infrastructure. Students have become involved in activities like calibrating instruments, recording weather information on calendars, and understanding weather differences. With the engagement of 22 high mountain rural schools and three local citizen science groups, this initiative, which is part of the MAPAM project, serves as a good example of community involvement, capacity development, and network creation.

**Paula Rodriguez Imazio**, Servicio Meteorológico Nacional (SMN), Argentina – *Operational mountain monitoring and associated data sharing infrastructure in Argentina*

Dr. Rodriguez highlighted various aspects of the monitoring and prediction system in Argentina, including volcanic ash monitoring (VAAC), satellite image acquisitions, and collaboration with the Barcelona Supercomputing Centre. Daily and monthly monitoring data conducted by SMN freely available, and more detailed information can also be requested. VAAC Buenos Aires provides information helping the public understand warnings and alerts.

An inventory of glaciers across five regions was shown. The data series are currently viewable online, although download functionality is not yet available without download availability. Finally, several ongoing and upcoming projects, including one focused on cloud information around the Drake Passage in southern Patagonia.

**Bolívar Caceres**, Instituto Nacional de Meteorología e Hidrología (INAMHI), Ecuador – *Monitoreo Glaciar en Ecuador*

Dr. Caceres presented glacier monitoring activities in Ecuador, highlighting collaboration with institutions both in the region and elsewhere in the world. The presentation focused on the Antizana glacier, which has been monitored for 29 years, and is therefore one of the most studied glaciers in Latin America within the World Glacier Monitoring Service (WGMS) database.

A second observation site that is in Antarctica was presented. Here, balance measurements indicate general glacier retreat over the past two decades, with only four years showing growth. Dr. Caceres showed a 3D model of the glacier that been created, based on mass balance and energy balance information.

**Luis Suarez**, Geophysical Institute of Peru (IGP), Perú – *The Observatory of Huancayo*

Dr. Suarez's presentation focused on a station located at 3,300 m a.s.l. in Peru, surrounded by agricultural activities. The station collects comprehensive data. Recent years have seen increased government support, leading to enhanced resources and funds. These improvements

facilitated the acquisition of new, expensive equipment and funding for radars to study storm information and validate implemented models.

More generally, various measurements are conducted in northern Peru under the Global Atmosphere Watch (GAW); a region which is significantly influenced by the Amazon. In particular, vegetation burning affects atmospheric composition. From Dr. Suarez's perspective, a challenge for Peru is to work towards enhancing the amount of centralised and accessible data.

**Paola Arias,** Universidad de Antioquia, Colombia & **Leandro Cara,** Instituto Argentino de Nivología, Glaciología y Cienc (IANIGLA), Argentina – *ANDEX and the Andean Snow Observatory*

The joint presentation by Dr. Arias and Dr. Cara introduced ANDEX, a regional climatic initiative within the World Climate Research Programme (WCRP). ANDEX aims to strengthen local level understanding of physical hydroclimatic processes, including energy exchanges and other aspects, along the entire Andes.

ANDEX is comprised of two programs. One focuses on biosphere and atmosphere interactions, and the other on water resources and security. Dr. Arias' presentation emphasised the need for an integrated perspective on climatology to enhance understanding and forecasting capabilities. Scientific development and sovereignty were identified as crucial goals, which ANDEX hopes to achieve by promoting interaction platforms with communities and decision-makers.

ANDEX outputs to date include publications, a reference list (which is updated monthly) on of documents on hydroclimatic issues in the Andes, a policy brief on hydroclimate resilience and adaptation, ListANDEX which is an interdisciplinary discussion group, and JovenANDEX – a network of young researchers.

Dr. Cara then presented the Andean Snow Observatory, which is a platform for visualising and providing access to snow data. Multiple input data sources are integrated, and current 24 years of resultant snow data are available.

**Angelica Gutierrez** – National Oceanic and Atmospheric Administration (NOAA), USA – *The role of the Regional GEOs to advance decision-making through GEOGLOWS*

Dr. Gutierrez presented GEOGLoWS, which (alongside GEO Mountains) is an Initiative of the Group on Earth Observation (GEO). The first version of GEOGLoWS presented streamflow forecasts for over 1 million river / stream reaches, receiving more than 60,000 daily web requests. The GEOGLoWS Hydroviewer provides graphical access. GEOGLoWS collaborates with institutions such an INAMHI to deliver operational flood forecasts at national level.

The importance of refining the standard forecasts through the integration of in situ data (specifically, via bias correction) to enhance their local utility was stressed. Planned future steps were presented. In particular, an invitation was made to the GEO Mountains community to contribute in situ streamflow and other observations to from mountain settings.

**Luis Daniel Llambí,** CONDESAN, Venezuela – *Adaptation at Altitude in the Andes: Progress & Outlook*

Dr. Llambí provided insights into climate change adaptation policies in the Andes region. Some of the main outcomes of Phase 1 of the Adaptation at Altitude (A@A) programme were presented, including synthesis publications, the A@A solutions portal (which showcases 22 case studies in the northern and central Andes), and a platform of Social and Ecological Indicators for the Andes.

Dr. Llambí then discussed activities which will be undertaken during Phase 2 of the programme, such as conducting comparative analyses and monitoring the effectiveness of adaptation solutions. In addition, emphasis will be placed on strengthening long-term monitoring initiatives, consolidating science-policy dialogue spaces, enhancing integrated knowledge management and communication through the establishment of an Andean Information Hub, and solidifying existing platforms.

Overall, the presentation underscored the ongoing commitment to addressing climate change impacts in the Andes, and highlighted the importance of continuous assessment and adaptation to ensure the resilience of communities and ecosystems.

**12:45 – 13:45**: **LUNCH**

**13:45 – 15:00 Discussion II: Towards enhanced exchange of data and capacities between the research and operational monitoring communities: Good practices, challenges & opportunities (All; led by Dr. Croitoru & Dr. Vila)**

Participants once again formed small discussion groups before reconvening for Plenary reporting. The specific questions posed during this segment of the workshop were as follows:

1. *What kind(s) of data are (freely) shared in your country between the NHMSs and the research sector? (record length, frequency, variables…)*
2. *What are the limitations / barriers for such data sharing? (e.g., data policy, infrastructure, capacity, data format)*
3. *What kind of support (e.g. from WMO) would be needed to share more data?*
4. *What other possibilities can be explored to enhance data exchange and capacity?*

All answers were collected in pre-printed tables, and rapporteurs were designated to summarise the main aspects of each group's discussions. Below, the main responses and perspectives are given; further details are provided in Annex 3.

**Group 1** was composed of participants from Argentina, Colombia, and the USA. The group identified open data policies in several countries which make satellite data, meteorological data, and model forecasts available, in some cases online (e.g. in the cloud). Participants pointed out challenges such as sporadic data availability, (lack of) credibility of data sources, and commercial interests affecting data sharing. The group suggested tackling these challenges by improving technical support, investing in capacity building, and exploring opportunities to publish data and associated scientific papers. They also emphasised the need to enhance different types of data exchange and funding systems to make more data freely available.

**Group 2** was composed of participants from Colombia, Argentina, Peru, and Chile. Meteorological, hydrological, air quality, and water quality were identified as available. Such data are mainly generated and shared by the academic sector, and sometimes by the private sector (e.g. some companies). Difficulties in finding and accessing data was highlighted as a limitation, as was the availability of homogenous data. Further challenges reported included incomplete spatial data coverage (e.g. above a certain elevation) and difficulties in accessing certain data time-series. Opportunities identified included the digitalisation of analogue historical datasets and developing monitoring infrastructure maintenance and sustainability. Finally, newsletters and online portals were highlighted as important channels to share data and information.

**Group 3** was formed by representatives from Colombia and Chile, and discussed restrictions on public and private data. In Chile, the national meteorological agency, as well as regional governmental and agricultural organisations, make their data available by using various online portals. Efforts are underway to combine these diverse data sources. In both countries, as well as in Peru, digital datasets are available from the 1940s, prior to which only analogue observation records exist. Metadata are often limited or not available; for example, information regarding the equipment or instruments used to collect data is often missing. Improvements could be made in creating homogeneous databases and in improving cooperation with private institutions.

**Group 4** was composed of participants from Colombia, Venezuela, and Ecuador, and tackled challenges faced by Venezuela and Ecuador. The group reported that in Venezuela, the meteorological service has largely collapsed meteorological, while Ecuador faces issues related to information access. In Colombia, many initiatives have been established, and so current limitations relate more to the use of the resultant information. Recommendations included promoting information sharing, specifying data usage policies, and placing due attention on training for hydrological and meteorological staff.

**Group 5** included representatives of Ecuador, Peru, and Bolivia, and highlighted deficiencies in maintenance of the equipment and websites equipment, as well as on quality control and/or validation. Contradicting policies around data availability posed challenges; in some cases, governments mandate accessibility (i.e., national data policies are in place), but the responsible institutions implement restrictions and impose costs for providing data due to the financial scarcity. The group noted the deficient coverage of climate and hydrology stations in the high mountains, as well as in the Amazon basin. Future opportunities included leveraging WMO support, training experts, and building local capacities. Establishing regional centres for hydrological and meteorological training was also a suggestion, to complement existing WMO training centres in RAIII, which were deemed valuable for developing human resources.

**Panel Discussion**

A panel discussion then ensued featuring the rapporteurs from the previous discussion and the WMO representatives, Adina Croitoru and Daniel Vila Espigo, who posed the questions.

**Question:** *Are there established national policies for data exchange, and if there is conflicting information on this matter, could you provide more details? Additionally, considering the challenge*

*of managing extensive volumes, is there a need at a national level for data processing storage infrastructure and for data(base) management capacity building?*

The responses from the panel included the following:

- Regarding conflicting policies on data sharing: A challenge arises when data is freely available, but the associated processing incurs costs to the recipient, contradicting the broader policy framework. Peru, Ecuador, and Bolivia encounter such issues;
- The need for training has been raised, to enhance the efficiency of data analysis and preparation, which is crucial for facilitating improved data sharing;
- Unsustainability of initiatives: The continuity of projects is not guaranteed, with the risk of losing trained personnel and their knowledge upon departure.
- A perspective on legislation from Chile: Despite legal mandates for the national hydrometeorological service to collect data from both public and private sources, the absence of a clear implementation protocol hinders the achievement of this goal. Human resources remain a critical aspect. Some platforms serve as positive examples for data sharing. Satellite data storage capabilities pose challenges, lacking parity with countries like the US.
- Regarding collaboration with public institutions: Public data providers seeking profit by purchasing certificates from national services create hurdles in obtaining data for free. The absence of open-source policies, coupled with logistical challenges such as providing datasets as non-open-source format files (e.g., .xls files), further complicates the data-sharing landscape.

**Question:** *How has the sharing of data from private companies been addressed or experienced in this context?*

- In Colombia, obtaining data is feasible, depending on the use (research use, for instance, may be eligible for free access).
- Obtaining data from private companies is highly challenging in Ecuador. Although mandated by law, institutions often fail to comply, highlighting a substantial gap between policy and implementation.
- The private sector presents opportunities, and the establishment of relationships and collaborative endeavours should be strongly encouraged.
- Formal spaces, like research networks and institutions, need expansion to facilitate more extensive connections on this specific topic. Mountain observatories can serve as platforms for joint work and collaboration.
- The collapse of the system in Venezuela means that little if any data remains available from national agencies in the country. Consistent support is needed/requested on behalf of the research community from international organisation (WMO).
- Governments should make data exchange a priority.

The WMO representatives concluded the discussion highlighting that they have limited scope to intervene at national level, but that their role is to enhance cooperation and communication between members and regions.

In addition, following the discussion sessions and based on the presentations delivered, two countries – Argentina and Peru – were identified as possible exemplars of good data sharing practices. The representatives from these countries were invited to document their experiences of the process to make data freely available (including challenges, opportunities, and benefits). Once received, these examples will be considered for publication on the WMO Unified Data Exchange Policy website.

**15:00 – 15:30**: **BREAK**

**15:30 – 16:45**: **Interactive Activity:** Extending the thematic scope of existing observatories and opportunities to enhance involvement of Early Career Researchers / use of observatories for student projects (**All**)

An interactive activity then took place. Small groups self-organised by country / region. On a large-scale printed map based on GEO Mountains In Situ Inventory, participants identified their existing (mostly research-oriented) sites, adding additional information about the measurements made, where applicable. They also added sites which were not currently included, and gave their more general reflections on the monitoring conducted within their country, opportunities for possible collaboration, and explanations of any apparent spatial monitoring gas. Participants agreed to share full metadata on their sites with GEO Mountains, so that it can be included in the next release of the In Situ Inventory.

**16:45 – 17:00: Presentation of the evening's programme (Workshop Dinner from 18:00 at Niebla Bistró Andino)**

In the evening, an informal workshop dinner was held at a restaurant in central Botogá.

***Day 3***

Thursday 22 February 2024

**08:30 – 08:35**: Welcome & Introduction to Day 3

**08:35 – 09:10**: Invited flash talks on applications of mountain data and information for decision-making and policy formation (10 minutes each, including Q&A)

**Diana Espinoza,** Centro Internacional para la Investigación del Fenómeno de El Niño (CIIFEN), Ecuador – *Community-Based Early Warning Systems as Risk Management Mechanisms: Case Studies from the Andean Region*

Ms. Espinoza presented community-based early warning systems for risk management, with particular focus on activities in the Andean region. CIIFEN, a centre with a 21-year history of studying El Niño, collaborates with the United Nations Office for Disaster Risk Reduction (UNDRR) and the WMO to bridge the gap between research and policy. Their mission involves strengthening scientific research on El Niño and climate, working with various stakeholders such as governmental agencies, municipal governments, NGOs, and local communities.

**Carolina Santacruz** (International Science Council), Colombia – *The International Science Council: Regional presence and work at the global science-policy interface*

Dr. Santacruz highlighted the International Science Council (ISC)'s regional presence and its role at the global science-policy interface. Emphasising the crucial link between science and policies, ISC aims to be a unified global voice for science, contributing effectively to policymaking and promoting science as a global public good. The organisation operates in many regions including Latin America, Asia, the Pacific, and Africa, aligning its priorities with UN global policies.

With memberships, affiliates, and a think tank, ISC focuses on fostering collaboration, capacity building, and connecting at regional and global levels, particularly for young academies and early-career researchers (for whom a forum has recently been launched). The ISC's strategy involves working groups to advance the science-policy interface and have broader impact through diverse expertise and effective communication.

**Lina María Pico Roa,** IDEAM, Colombia – *Climate services and adaptation capacity in vulnerable rural communities to extreme hydroclimatic events in Cauca Colombia*

Ms. Pico Roa presented a project in the Cauca Valley in Colombia, conducted in the frame of the ENANDES project, focusing on climate services and adaptation capacity in vulnerable rural communities facing extreme hydroclimatic events. The project explores the value chain of climate services to inform decision-making. Language and results are tailored to local communities and territories, and efforts are made to maximise the social benefits within the value chain.

The presentation outlined four components and highlighted efforts in data quality and standardisation under ENANDES, involving community-friendly materials and compiling recommendations from community engagements. Initiatives like Volunclima, a community-driven climate observation project, aim to strengthen environmental projects in schools, promoting learning by doing and integrating climate information into educational programs.

**09:10 – 10:15**: **Plenary Discussion:** Identifying potential high impact collaborative, inter/transdisciplinary future projects (**All**)

The workshop's final activity consisted of a general Plenary discussion to identify potential future collaborative projects. Dr. Thornton asked some questions to stimulate the discussion:

1. *How can we take collaborations forward from this workshop?*
2. *What are the scientific, policy or practical challenges in the region that have not been yet addressed, but that could be (for instance by combining the cross-discipline, sector and region data and expertise that the workshop participants and their institutions represent)?*

The discussion first lead to defining what could be considered "high impact", and which associated impact indicators are important to consider. Several suggestions and points were raised by the participants:

- The participation of the community is crucial, especially in the generation of raw data. It enhances ownership and capacity building, with broader socio-economic benefits.
- Monitoring and integrating data and information on health impacts, including different agricultural practices, malnutrition indicators linked to health, food security, and water security, were emphasised.
- A past project underscored the importance of focusing on supporting decision-making: by disaggregating hydro-climatic information, many variables were obtained, allowing the benefits associated with sustainable water management at catchment scale to be quantified. A model was also developed carbon sequestration and enabled the cost-benefit relationship to be evaluated. The same group developed a forest strategy to support restoration and help decision-making around forest management.
- In vulnerability and risk analyses, the specification of impact indicators is often challenging. The same methodologies are often used without modification for many years.
- At IDEAM, health indicators have been applied in a past project to explore the impacts of weather and climate on health.
- Projects which promote and accommodate strong community involvement and validation are more effective; merely generating numerous external documents is insufficient, as they are not owned nor taken up by local communities.
- A good strategy for ensuring impact involves generating indicators in conjunction with communities by understanding their needs and aligning projects with their interests.
- Accessing health data is, however, sometimes complex due to necessary privacy considerations; one proposal is to use for research purposes the anonymised microdata;
- In terms of project work, further expanding observatories and networks in Andean mountain regions was suggested; there are many opportunities to learn from one another and together have an impact. In a long-term process, more social data and community engagement can be integrated over time, likewise the identification of mountain super sites where numerous independent monitoring efforts exist that could be convened within a monitoring framework

- The scientific community is great at creating reports, but they are often not read by decision-makers. Bridging the gap between scientific data and government action is vital, and scientists can show the alternative possibilities and scenarios. At the same time, all of this science-policy work should not necessarily fall to scientists themselves, who have to focus on conducting the research in the first place. A facilitating interface with individuals working and facilitating this exchange through boundary roles is often essential.
- Practical strategies for impactful research were proposed. Effective communication and innovative approaches, such as developing mobile apps, were proposed for reaching decision-makers and securing funding.
- Five key elements can ensure high impact: recruit regional talents, avoid duplication, create synergy, establish capacity, guarantee process continuity, and develop clear methodologies.
- Establishing greater synergies requires time and personal meetings.

To conclude, the discussion highlighted certain difficulties that can be encountered when seeking to define and achieve impact, which can be seen through several lenses of concrete relevance to people and their wellbeing, including health, safety, water quality, food security. Generating indicators with the community and developing research and strategies that respond to their needs, have been identified as a promising strategy for ensuring positive impact. Mountain observatories have also been identified as excellent vehicles through which long-term progress in interdisciplinary mountain research can be driven. There is scope to better incorporate socio-economic variables, and from observatories to continue to learn from one their respective experiences, failures, and successes, via a networked approach.

The session highlighted the need to support in engaging with the several well-established and broad networks already operating in the region. For example, several summer schools and collaborative projects are already being implemented. Rather, the priorities would seem to lie on improving science communication and outreach efforts, such that for instance the conclusions of scientific papers reach, and can be applied by decision-makers. Thus, future projects should place more focus on communicating the science and bridging the gap with decision-makers.

**10:15 – 10:30**: Workshop Conclusions & Next Steps

**10:30 – 11:00**: Transport to IDEAM HQ (Calle 25 D No. 96 B - 70 Bogotá D.C.)

**11:00 – 12:30**: Tour / Visit of IDEAM HQ

The group enjoyed an informative visit and tour of IDEAM HQ, including the organisation's live operations room and server room.

**12:30 – 13:15**: **LUNCH**

**13:15 – 13:45**: Transport to "El Venado de Oro" (Humboldt Institute, Av Circunvalar #1620, Bogotá, Colombia)
**13:45 – 16:00**: Tour / Visit of "El Venado de Oro" (Humboldt Institute)

The group enjoyed an informative and relaxing visit to the Humboldt Institute, including a visit to various lab facilities and gardens. In addition, the Institute's web page and data resources were demonstrated.

**16:00:** Return to Hotel Movish

## 4. Conclusions

The workshop addressed challenges and opportunities in data exchange, collaboration, and capacity building. Invited presentations featured representatives from the research community and NHMSs from several countries, each of whom shared insights into their monitoring efforts and experiences. Extensive discussions around data-sharing practices, limitations, and the support needed ensued. Traditionally prominent topics were covered, such as weather, climate, cryosphere, and hydrological monitoring. Several presentations focused on vegetation and ecosystem monitoring. Socio-economic monitoring, science-policy initiatives and projects involving mountain communities were likewise presented, demonstrating the wide variety of approaches in the region.

The participants highlighted many good practices regarding data sharing and availability and highlighted the considerable advantage of well-established local networks. The impediments raised concerned especially long-term monitoring, which implies sustainable funding, as well as the gap between science and the decision-making process; fostering science communication and transdisciplinarity were raised as important steps.

The three representatives from WMO emphasised the mutual benefits of enhancing data exchange between research and operational communities, as well as the policies and infrastructure that are in place to support this. Specific objectives outlined were closing the gaps in high mountain regions, improving monitoring infrastructure, and improving the transition from science to operations to effectively support decision-making processes.

The concluding discussions highlighted the desire to enhance communication and training, to build capacities to foster impact-driven projects, and to further bridge current gaps between the research communities and operational, decision-making actors. Participants' expectations were generally met.

In closing, the organizers warmly thanked the co-organisers from IDEAM, CONDESAN, IAI, the WMO, the Humboldt Institute and AmeriGEO, all invited speakers for their excellent contributions, and all participants for sharing their time and expertise.

All participants were invited to complete a workshop evaluation survey.

---

**Authors / Note takers**: Alexandrine Massot, James Thornton & Adina Croitoru

## Annex 1. Link to Presentations

All presentations given during the workshop are publicly accessible from this online repository. The recordings made are available upon request (geomountains@mountainresearchinitiative.org). The photos taken by IDEAM and GEO Mountains are also available via the respective links.

## Annex 2. Lists of Attendees

The full list of in-person workshop attendees is provided below.

| # | Last Name | First Name | Affiliation | Country |
|---|---|---|---|---|
| 1 | Adler | Carolina | MRI | Switzerland |
| 2 | Alvarez | Oscar | Emergente Energía Sostenible | Colombia |
| 3 | Andrade | Juliana | Universidad de Nariño y organización de mujeres indígenas "Tejiendo Pensamiento" | Colombia |
| 4 | Andrade | Marcos | Chacaltaya research station (Bolivian Andes) | Bolivia |
| 5 | Angel | Enrique | Universidad EIA | Colombia |
| 6 | Arias | Paola | ANDEX | Colombia |
| 7 | Arndt | Jan Erik | Universidad de Concepción | Chile |
| 8 | Caceres | Bolívar | Instituto Nacional de Meteorología e Hidrología | Ecuador |
| 9 | Cara | Leandro | IANIGLA-CONICET | Argentina |
| 10 | Carilla | Julieta | ROSA | Argentina |
| 11 | Castellanos | Edwin | IAI | Guatemala |
| 12 | Ceballero | Lina | IDEAM | Colombia |
| 13 | Ceballos | Jorge Luis | IDEAM | Colombia |
| 14 | Croitoru | Adina | Babes-Bolyai University | Romania |
| 15 | Cuesta | Francisco | GLORIA ANDES | Ecuador |
| 16 | Diaz | Renny | Instituto de Investigacion en Glaciares y Ecosistemas de Montaña | Perú |
| 17 | Drenkhan | Fabian | Pontificia Universidad Católica del Perú | Perú |
| 18 | Echeverry | Ghisliane | IDEAM | Colombia |
| 19 | Espinoza | Diana | CIIFEN | Ecuador |
| 20 | Gutierez | Maria | Universidad EIA | Colombia |
| 21 | Gutierrez | Angelica | AmeriGEO | USA |
| 22 | Hurtado Martilletti | Ana Belén | Humboldt Institute / EMA (Integrated Strategy for Monitoring Mountain Ecosystems in Colombia) | Colombia |
| 23 | Linares-Palomino | Reynaldo | Smithsonian's National Zoo and Conservation Biology Institute | Perú |
| 24 | Llambí | Luis Daniel | CONDESAN & GLORIA Andes | Venezuela |
| 25 | Mantilla | Gilma | IAI | Colombia |
| 26 | Mark | Bryan | TARN | USA |
| 27 | Massot | Alexandrine | MRI | Switzerland |
| 28 | Melo Luna | Juan Carlos | Humanitarian OpenStreetMap Team | Colombia |
| 29 | Peralvo | Manuel | CONDESAN & Chocó Learning Site | Ecuador |
| 30 | Pico Roa | Lina María | IDEAM | Colombia |
| 31 | Rodriguez Imazio | Paola | Servicio Meteorologico Nacional (SNM) | Argentina |

| | | | | |
|---|---|---|---|---|
| 32 | Romero | Mauricio | IAI | Colombia |
| 33 | Rondanelli | Roberto | Centro de Ciencia del Clima y la Resiliencia – CR2 | Chile |
| 34 | Ruiz | Daniel | Independent Researcher / Poleka Kasué Mountain Observatory | Colombia |
| 35 | Salinas | Norma | Andes Biodiversity and Ecosystem Research Group | Perú |
| 36 | Santacruz | Carolina | Director regional office (LAC) of the International Science Council | Colombia |
| 37 | Suarez | Luis | Instituto Geofisico del Peru | Perú |
| 38 | Thornton | James | MRI | Switzerland |
| 39 | Vila Espigo | Daniel | WMO | Paraguay |
| 40 | Zamuriano | Marcelo | Universidad Mayor de San Simón (UMSS | Bolivia |

A total of 110 participants registered for online participation, with 29 joining the meeting online at some point during the three days.

## Annex 3. Detailed discussion outcomes

### 3.1 Discussion I – Tuesday 20 February.

**Group reports:**

*Group 1:*

- **Good practices:** Successful efforts have been made in standardizing measurement protocols and enhancing data collection methods.
- **Challenges:** There are issues with maintaining installed devices, including vandalism and lack of communication with society. Social science-related challenges, such as underfunding, lead to a shortage of researchers in some areas. Harsh climate conditions can also be problematic.
- **Opportunities:** There are opportunities for improvement in communication strategies, including community engagement and increased inclusion of women. There need for more effective and agile device repairs, fostering a collaborative networking culture among scientists, and addressing challenges at science-policy interfaces were also highlighted. Furthermore, there is a need for financial support, effective communication with funding agencies, and the definition of regional scientific priorities – which could all be considered opportunities.

*Group 2:*

- **Good practices: T**he science is generally open and data are accessible easily. Science-based decision-making and trans/multidisciplinary processes are also good practices identified by the group.
- **Challenges:** Finding and maintaining old or legacy data, which are often not digitalised, is an important challenge. Another relates to the need for research projects to transcend political contexts, for example dealing with funding instability and / or uncertainty in public and political support, and obtaining government backing to purchase for expensive equipment. Finally, a need was expressed to place more emphasis on increasing capacity and motivation for research within society, especially among young individuals.
- **Opportunities:** Learning from successful experiences, increasing research skills for your people / ECRs, digitising old data, and enhancing participatory monitoring are opportunities that could be developed. The group identified several needs that could be seen as opportunities for improvement, such as obtaining funding for developing capacities and to support project and database management activities. The benefits of multi-disciplinary approaches were underscored.

*Group 3:*

- **Good Practices:** The group acknowledged progress made by international networks, with specific praise for Chile's resource management initiatives.
- **Challenges:** Challenges identified include finding common interests among countries, working with decision-makers in politically unstable environments, and addressing limited employment opportunities for skilled individuals.

- **Opportunities:** Collaboration between countries could help develop more standard and comparable data structures. Encouraging transdisciplinary work from an early stage, promoting joint degree programs between Andean countries, and fostering science in Latin America by attracting regional students were additional opportunities highlighted.

*Group 4:*

- **Good Practices:** Highlighted several freely accessible data-sharing initiatives, databases, and successful networks in the region, such as the International Research Institute for Climate and Society (IRI) Data Library.
- **Challenges:** The need for long-term sustainability in monitoring efforts, integrating social science researchers and networks, enhancing communication with official (governmental) environmental institutions, and dealing with professionals earning degrees abroad and not returning were regarded as challenges.
- **Opportunities:** Researchers undertaking more political advocacy activities was highlighted.

*Group 5:*

- **Good Practices:** Good practices identified included the existence of effective collaborative partnerships between institutions, including to engage in joint calls and promote diverse skills and abilities.
- **Challenges:** Challenges identified included securing long-term financial stability for programs, maintaining high data quality standards, and working in a transdisciplinary fashion (e.g. lack of transdisciplinary training and difficulties that can be encountered to engage individuals from different fields.
- **Opportunities:** Networking, obtaining funding, and closer integration between research and operations were identified as opportunities. The group also saw an opportunity to advocate further for data being free, accessible, and unrestricted. Enhanced horizontal collaboration among stations, bringing instruments and funds for infrastructure as well as improved capacities, is a major opportunity. Finally, with regards to data quality, to group saw an opportunity to explore / apply a tiered approach, where different levels of quality control are applied in each tier.

### 3.2 Discussion II and III – Wednesday 21 February.

The scanned tables completed by the groups and photographs of the interactive activity are available here.