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World Meteorological Organization: scaling the peaks for social benefits

By Jane Qiu

Climate change is tightening its grip on high mountains. Yet, unlike their island counterparts, the ordeals facing mountain communities are under-studied and under-appreciated. But that's about to change. The World Meteorological Organization (WMO) is looking to enable better understanding of the physical processes in mountainous regions, especially their glaciers and ice fields at high elevations, by bringing together meteorological and research communities around the world. This will help identify the key stressors in the mountain environment and facilitate disaster reduction, as well as support decision making and sustainable development.

In a forum chaired by David Grimes, WMO's President, and Tandong Yao, former Director of the Institute of Tibetan Plateau Research, Chinese Academy of Sciences, and co-chair of the Third Pole Environment, a panel of international scientists with diverse backgrounds discussed which priority areas WMO should focus on, how the organization can improve data sharing, how to address climate risks and water scarcity, and how the work can benefit the societal needs of mountain communities.

Joan Cuxart
Researcher and lecturer on meteorology at the University of the Balearic Islands, Spain

Soroosh Sorooshian
Hydrologist at the University of California Irvine, USA

Michael Ek
Meteorologist at the National Center for Atmospheric Research in Boulder, USA

Wenjian Zhang
Assistant Secretary-General of the World Meteorological Organization in Geneva, Switzerland; former Deputy Administrator of the China Meteorological Administration, China

Suhaib Bin Farhan
Climate scientist at the Pakistan Space and Upper Atmosphere Research Commission, Pakistan

David Grimes (Chair)
President of the World Meteorological Organization in Geneva, Switzerland; assistant deputy minister of Environment Canada, Canada

Anil Kulkarni
Glaciologist at the Indian Institute of Science, India

Tandong Yao (Chair)
Co-chair of the Third Pole Environment; former Director of the Institute of Tibetan Plateau Research, Chinese Academy of Sciences, China

Grimes: Improving observations and forecasts in high mountains are one of WMO's key areas of focus. These objectives are really in line with the mandate of the Third Pole Environment (TPE). We are in the process of framing our plans and actions to allow us to prioritize the core areas of focus as we move forward. We recognize that there are a lot of mountains to climb and we are eager to work with meteorological and research communities around the world.

Yao: It's a great opportunity that WMO is interested in the activities in the Third Pole region. As many of you know, the Third Pole refers to the Tibetan Plateau and surrounding mountain ranges. With an area of 5 million square kilometres and an average elevation of 4 000 metres above sea level, it has the largest stock of ice outside the Arctic and the Antarctic. It gives rise to Asia's major rivers and is one of the most biodiverse regions in the world. What happens there can affect over 1.4 billion people and have regional and global ramifications. I look forward to a fruitful collaboration with WMO and colleagues working on other mountain ranges. Perhaps WMO's Assistant Secretary-General Jianwen Zhang could provide the context for what the organization aims to achieve.

Zhang: WMO is a specialized agency under the United Nation's Economic and Social Council. One of its key mandates is to make a contribution to social and economic development. We are also a science and technology organization and emphasize regional cooperation. There are two elements of input—observation and research—and the output is a variety of products and services, whereby we meet society's needs in areas such as weather, climate, water, sustainable development, and economic growth.

In WMO's current strategic planning (2016–2019), the number-one priority is disaster reduction because weather disasters, especially storms and floods, are still the largest source of economic loss. Now WMO has come to a critical phase to meet the global climate services requirements, especially in polar and high-mountain regions. A big challenge is data quality and availability. We also have to clearly define the key elements we need for climate services. Particular emphasis should be placed on climate-relevant cryosphere data, in particularly snow cover, snow depth, glacier monitoring, permafrost, lake and river ice.

As we all know, the progress in weather and climate forecasting in the past half century was mainly due to atmospheric observations: for every 50 kilometres and every 3 hours we can give one profile with global cover. However, WMO has limited data from the land, cryosphere, and the oceans (especially open oceans). That's a big challenge for WMO. For better forecast climate variability, we'd need observational data from the atmosphere, land surface, oceans, and sea-ice data. Without this, we would have no basis to continue to improve our climate services and even weather services.

So what's the solution? This brings us to the WMO Integrated Global Observation System. I'd like to focus on WMO Global Cryosphere Watch, a new programme joining earlier ones such as Global Atmosphere Watch and Global Climatological Observation. It provides the framework for reliable, comprehensive, sustained observation of the cryosphere through a coordinated and integrated approach on national to global scales to deliver quality-assured global and regional products and services. The latest WMO congress report raises the importance of the cryosphere in high mountains, especially the studies of air–water–ice–ecosystem–human interactions. Of particular importance is the shift in intensity and distribution of precipitation patterns in those regions, with significant implications for water resources and flood management.

> "What happens [in the Third Pole] can affect over 1.4 billion people and have regional and global ramifications."
> —Tandong Yao

Ek: That's really interesting. I'm from an operational weather centre, with the National Ocean and Atmospheric Administration being the parent organization. We try to improve our weather and seasonal climate models because we make forecasts all the time. The perspective I have is that high mountains are one of many regions around the world that are poorly represented in our model. There are a few points I'd like to stress. First, we need sustained observations to improve our models and, in this case, we want to turn those into that process for modelling snow and the cryosphere. We are moving towards an Earth-system model; it's no longer just the atmosphere. The atmosphere should also be coupled with land, ocean, ice, and aerosols. You need to bring all the components together. And you need to recognize that these things need to be solved simultaneously.

Second, the effect that is hard for us to put in the model to account for is human management. An example is water management. High-mountain regions, like everywhere else, need to accommodate the fact that there is some kind of water management and human influence. The hardest thing for me as a scientist is to incorporate those effects because there are no necessary governing equations for human behaviour when it comes to water or everything else. It's a rather tall order.

Madan L. Shrestha (Nepal Academy of Science and Technology in Kathmandu): Mountainous regions face a lot of major challenges, especially climate change, but little research has been done that can be helpful to meteorological services. It's not easy to make the link between academic research and meteorological services—because the research community tends to focus on publishing high-impact papers, whereas the meteorological community focuses on developing products and services. A better integration of the two communities is critical. Perhaps one way forward is to have a research component in meteorological administrations so they can keep up with what's going on in academia.

In mountainous regions, the main issue is water resources, which are depleting. Different stakeholders, such as agricultural communities and water-management communities, need information for decision making in the context of climate change. How can we provide that kind of service? I guess that's part of what WMO wants to achieve. But such services need to make use of quality observation and research, which are lacking in mountainous regions, especially at high elevations.

Farhan: In my opinion, indeed, observational data of glaciers and hydrology are crucial for reliable climate prediction and modelling, especially seasonal forecast, which is critical for managing water and agriculture. One issue is that different research groups use different data formats/standards, methods

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>
> —Madan Shrestha

and have different accuracies. There is a dire need to establish a framework for standardization of data and methods so the data can be used in various initiatives around the world. I also appreciate the efforts of WMO in organizing and coordinating observational research in high-mountain regions; however, we need to think now how such global programmes can benefit local communities and societies.

Cuxart: My perspective is mainly on the research side. While I was previously an active member of the Spanish meteorological services, now I work in a university doing research on the Earth system. I'm pleased to learn about this WMO initiative, which is rather cryosphere-oriented. In my view, snow measurements and atmospheric measurements over it, which could improve climate models and estimates of water resources, should be a focus. Many mountains have seasonal snow cover, but it's extremely challenging to characterize them accurately. We should also aim for better understanding the processes and improving their representations in models. I have had the opportunity to work on data from mountains; it's very difficult to represent them well and many processes are still poorly represented. For instance, we still don't fully understand how the wind system in valleys works.

The good news is the time for mountains has come. There are a lot of activities around the world trying to understand them. They are gathering momentum. There is interest in setting up a programme in the Andes similar to the TPE, though the socioeconomic situation is quite different. In the Third Pole, you have large countries that may initiate and sustain the necessary activities. In the Andes, there is a community of countries geographically apart, which makes management quite difficult. Finally, there have been many research activities in the Alps for a long time. The last major campaign there took place nearly two decades ago. Now the community plans to have another campaign in a few years.

Sorooshian: The focus of my research group is to use satellite-based observations, in particular precipitation. There has been major investment in various countries, especially the US–Japan partnership in the launch of the Global Precipitation Mission (GPM) that is providing precipitation estimates globally. But what you measure has to be substantiated by what reaches the ground, and this is particularly challenging in high mountainous areas because *in situ* observations that can be used to test and validate models are few and far between.

But there are mountains and there are mountains. In addition to the big mountain chains, such as the Andes, the Himalayas, and the Alps, there are smaller mountain chains that are just as important to the people who live near them and downstream of rivers originating from them. Managing the water-resource needs of various communities anywhere requires various types of information, including precipitation. The good thing about satellites is that they observe Earth from hundreds to thousands of kilometres above our heads irrespective of borders between countries and are not subject to the politics of data sharing. They can measure at global scales and the data are processed and posted, and anybody can access them. But ground-based observations from gauges and radars are still needed to augment space-based observations and provide the necessary data to test and calibrate their estimates.

Data sharing will be the biggest challenge. Some countries really feel that if they release hydrometeorological information, they would be at a disadvantage in preserving their national interests. I don't want to name countries but it's quite common. The question is how to overcome the barrier for the common good. In this regard, we will continue to minimize barriers to data sharing. I hope before I say goodbye to the planet Earth, I can see these barriers overcome.

Kulkarni: The 'Glacier Gate' [in which the Fifth Assessment Report 5 (AR5) of the Intergovernmental Panel on Climate Change (IPCC) released in 2007 wrongly claimed that all Himalayan glaciers would disappear by 2035] was a big shock to the scientific communities and those who lived in that part of the world. In the past decade or so, a significant amount of work has been done in the Himalayas, in particular to better understand the glaciers.

But I see a contrast between work done by meteorological communities and that by glaciological communities. Historically, most of the meteorological work is institutionalized to national agencies. But work carried out in glaciology is done by individual scientists and, if the institution allows them, they would put the data on the institute's website. But more often than not, the data do not reach the larger scientific community. It would be a great service if we can institutionalize the data through WMO.

Another issue is that researchers and the media tend to focus on big glaciers, but it's the much smaller and much less glamorous glaciers and ice fields that are going to affect mountain communities the most. If you go to many parts of the Himalayas, you'd realize that nobody lives near big glaciers because it's not suitable for human settlement. Many communities live around small glaciers and ice fields, which are going to be affected very quickly in the future. How can we design our programme in such a way that we can help those communities to understand how the availability of water is going to change in the future and how that will impact agriculture and other activities? Having societal impact is also critical if we want to get government involvement.

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> —Suhaib Bin Farhan

Finally, there are a large number of glaciological models. We need to think about how we can integrate them to come up with useful products.

Grimes: I agree. The aspect of government involvement should be taken into consideration as should the elements of where we should be putting emphasis. It would be great to gather more perspectives from around the world and to think about what roles WMO should play to help facilitate positive outcomes.

Mats Ericsson (International Centre for Integrated Mountain Development in Kathmandu, Nepal): It's indeed great news that WMO is interested in coordinating observation and research in high mountains. There have been a number of efforts for the mountain communities to raise the stakes, such as the Conference of the Parties (COP) to the United Nations Framework Convention on Climate Change (UNFCCC) in Copenhagen. There should be a strong message about why we should place emphasis on mountains. This is because of the services that mountains provide for downstream communities, starting with the cryosphere. The Third Pole, for instance, is also known as Asia's water tower and provides services for over 1.3 billion people downstream.

Another important point is that mountain communities have very small carbon footprints but shoulder disproportionate burdens of climate change.

Finally, IPCC is in the process of finalizing a special report on the cryosphere and oceans. It's along the same kind of thinking, that mountains are neither isolated nor obscure. They are really fundamental resource areas.

Jun Yu (Chinese Meteorological Administration): My observation from this panel can be summarized in one word: communities—for example, research communities, meteorological services, satellite communities, academic institutes, and international programmes. My question is how will WMO and its 129 members (most of which are governments) take this opportunity to enhance cooperation between these communities of polar and high mountains?

Sorooshian: It's a challenging task. There is always a lot of diplomacy involved to get nations to see the common good and how they can participate to provide the type of information that can generate wider community benefits. I wonder, however, how many initiatives there are within WMO that are related to mountainous regions. Hydrology is a good example. WMO's hydrology programme may and can cover some of the data-gathering needs in mountainous regions. Rather than reinventing the wheel, it might be important to ask the existing WMO programmes such as the World Weather Research Programme (WWRP) and the World Climate Research Programme (WCRP) to go through their reports and see what they have done in high-elevation regions, what worked and what did not work, and what lessons can be learned, so we are not going to make the same mistakes.

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>
> —Anil Kulkarni

Zhang: The WMO mission is indeed to promote cooperation between different communities. Our president is a co-chair of the Executive Council Panel of Experts on Polar and High Mountains Observations, Research and Services. It consists of more than 50 scientists (two-thirds of whom are from outside the WMO) and sustains investment in research. This was key to the success of World Weather Watch, which invested heavily in the global research community in the first 20 years of the programme. The roadmap for high mountains should be the same. We shouldn't reinvent the wheel. We have wonderful research communities that have been working in high mountains for decades. It's a win–win strategy for WMO and research communities to work together to facilitate user-driven operational data exchange.

Shichang Kang (Cold and Arid Regions Environmental and Engineering Research Institute, CAREERI, Chinese Academy of Sciences): We have two systems in China: CAS and CMA. Most of the observations in high mountains in China are operated by the Chinese Academy of Sciences (CAS), especially the Institute of Tibetan Plateau Research and CAREERI. Altogether, we have a lot of stations, up to 5 000 metres above sea level around the Third Pole. Those data are only for research purposes, not for services operated by the China Meteorological Administration (CMA). It would be great for the two systems to collaborate, but it's not easy.

We fully support the WMO initiative. It may help facilitate collaboration between Chinese institutions, which is critical for better forecasting of weather, climate and related natural disasters. For flood forecasts and early-warning systems, for instance, you'd need observations upstream to get an estimate of the amount of precipitation. It gets more complicated when concerning transboundary rivers, and becomes an international affair, not just about one country.

Shrestha: There should be a close link between research and meteorological communities. I have worked in both sectors for a long time. In Nepal, many research communities operate on a project-by-project basis. When setting up stations, they take advice from the meteorological department, which has a large network and a mandate to make observations for a long period of time. In that way, when a project is finished, it's much easier to hand the stations and data over to the meteorological services.

Grimes: In 2009, we established a polar panel for the purposes of enhancing coordination amongst the community. One key issue focused on service with the aim to better facilitate the transportation of goods and services around and through the Arctic and Antarctica. A second area of emphasis was to improve the coordination functions among different research facilities and different countries. Enhancing the coordination has led to good outcomes, better cooperation amongst the research community and the establishment of coordinated observation programmes.

In this regard WMO has played the catalytic and enabler roles; we advocate for and support various organizations that carry out the work.

In the past few years, we gained the commitment of those countries that operate in Antarctica to establish the Antarctic Observing Network (AntOn), to adopt a set of data standards, foster data exchanges, and to upgrade their technical capacities. This is primarily a research-oriented operation. Researchers have access to a more robust infrastructure by WMO members that meets standards. We worked with universities and Antarctic surveys to collect data, which are shared and accessed by all. Everybody gains.

If you now put that in the context of mountains, we have the potential to do the same thing. Generally we have small communities living in mountain regions. These communities are dependent on water resources furnished by snow and ice, but are also at risk from the natural hydrometeorological hazards. This is the public dimension. Together, we can better service and connect these communities and better organize the science infrastructure they require. One of the primary beneficiaries are actually the researchers that are working in these environments. This is possible. It is a question of how you approach it from the point of view of governance and organization.

Another important point is that the impacts and changes that we observe in mountains implicate other domains as well. I coined a phrase about a decade ago that what happens in the polar regions doesn't stay in the poles. This equally applies to the high-mountain regions of the world: what happens in the mountains doesn't stay in the mountains. There is a common element among these extremes of the Earth system, in the sense that processes in mountainous and polar regions have much broader influence on both the weather and climate patterns, and the quality of life in many parts of the world. As we consider this from a societal point of view, a better understanding of the mountains will benefit not only local communities but also those that are far away from those mountains. This is why I believe it's an important mission. It's about the fact that mountains are one of the drivers of the Earth system. They are part of the whole system and we need to understand these factors better.

Cunde Xiao (Northwestern University in Xi'an, China): We need to think about what kind of outcome or products we are expecting out of the initiative. To build momentum and raise awareness, perhaps we could consider having an International High-Mountain Decade between 2020 and 2030—similar to the International Hydrological Decade beginning in 1965.

Yongkang Xue (University of California, USA): I think such initiatives are very timely and important. It's an important step for WMO to engage with local and regional communities, such as the TPE, to generate momentum. We need to promote high-quality mountain research. The challenge for WMO is how to persuade agencies, such as the US National Science Foundation, NOAA (National Oceanic and Atmospheric Administration), and NASA (National Aeronautics and Space Administration), to support this idea. We might want to have a white paper to outline the importance of the initiative, specific goals, and how we plan to go about it.

> "What happens in the mountains doesn't stay in the mountains.
>
> —David Grimes"

An important point is that glaciated areas at high elevations affect not only local- but large-scale processes. The Rocky Mountains in the USA and the Tibetan Plateau here have a lot of influence on regions to their east—the Great Plains in the USA and eastern China, respectively—regarding the propensity of flooding or drought. The effects cannot be explained by sea-surface temperatures.

Zhang: A key purpose of the WMO Polar and High Mountain Activities is to facilitate national-level cooperation between the operational community and research community. In this regard, we'd like to have the meteorological-service side be more proactive. At the national level, cooperation is like a marriage. You have to convince each other that this is a win–win situation. It will take time.

Toshiko Kolke (International Centre for Water Hazard and Risk Management, Japan): I would like to share my perspective on China–Japan collaboration. We have over two dozen stations on the eastern fringe of the Tibetan Plateau in Sichuan. We have made tremendous efforts to standardize the data and the output. It's tough but certainly worthwhile. The system has significantly improved the forecasting of precipitation in the Yangtze River region. And all the data are submitted to the CMA.

We are very interested in WMO's high-mountain initiative. I propose to have three objectives. First, to improve our understanding of the physical processes of regional dynamics, such as topographic effects, many of which are unique to high mountains. Second, to improve our understanding of the role of high mountains in regional and global processes. Finally, to improve modelling capability. Current models have lots of problems and generally don't work well in topographically complex regions, such as high mountains, due to lack of observations and poor understanding of the physical processes. If we can have observations and more frequent data sets in higher-mountain regions, we will be able to improve our understanding of the processes and model representations.

Lijuan Ma (National Climate Centre, China): The Third Pole is Asia's water tower. It's warming twice as fast as the global average. Disasters associated with the cryosphere and water—such as floods, snow avalanches, and glacier surging—are the main problems for high-mountain regions; these need to be addressed urgently to prevent economic loss. We propose to establish an Asia High Mountain Climate Centre, consisting of people from CMA, CAS and universities, to address such risks to prevent economic loss.

Yao: I'm pleased to hear that WMO and our panellists and participants are interested in high mountains, especially the Third Pole. We all agree on the importance of high mountains. You have made several points why it's important. A key point I'd like to stress is that we must take a holistic approach. In the past

decade, the TPE community has been studying the system as a whole, in an attempt to better understand the interactions between atmosphere, water, ice, ecosystems and human activities.

A pressing need is to better understand the underlying physical processes, which is the basis of modelling. And observations are the key. We need to find a way to encourage research communities to really raise their observation and modelling capacity—in line with the WMO standards—and meet societal needs.

China has a long tradition of mountain research. The first observation station was set up in the Tanggula Mountain in the Tibetan Plateau nearly 30 years ago, in collaboration with our Japanese colleagues. We now have a network of over 30 stations across the plateau, mainly motivated by the research interests of different institutes. It would be great to work with WMO and mountain-research communities around the world. The time is right to do this kind of collaboration. The Third Pole is certainly a strong base to bring international communities together.

Grimes: We have had a very good discussion and there are several good points for consideration. Thank you for your support and the recognition that the scope is larger than just the weather community. Today, WMO members are active beyond weather, engaging in better understanding of water, climate, air quality and transport, the cryosphere, interaction between ice and oceans, and Earth-modelling research.

There is a lot to be built upon and to build forward. I suggest we focus, at least initially, on four to five prominent areas to highlight the work that should be done. We have very good and active collaborations amongst the hydrometeorological communities. There is also a strong push within the scientific community to better understanding and forecasting of climate-change extremes, which is highly relevant to high-mountain regions. Let's reach for the peaks and meet the challenges together.

Jane Qiu writes for NSR from Beijing.