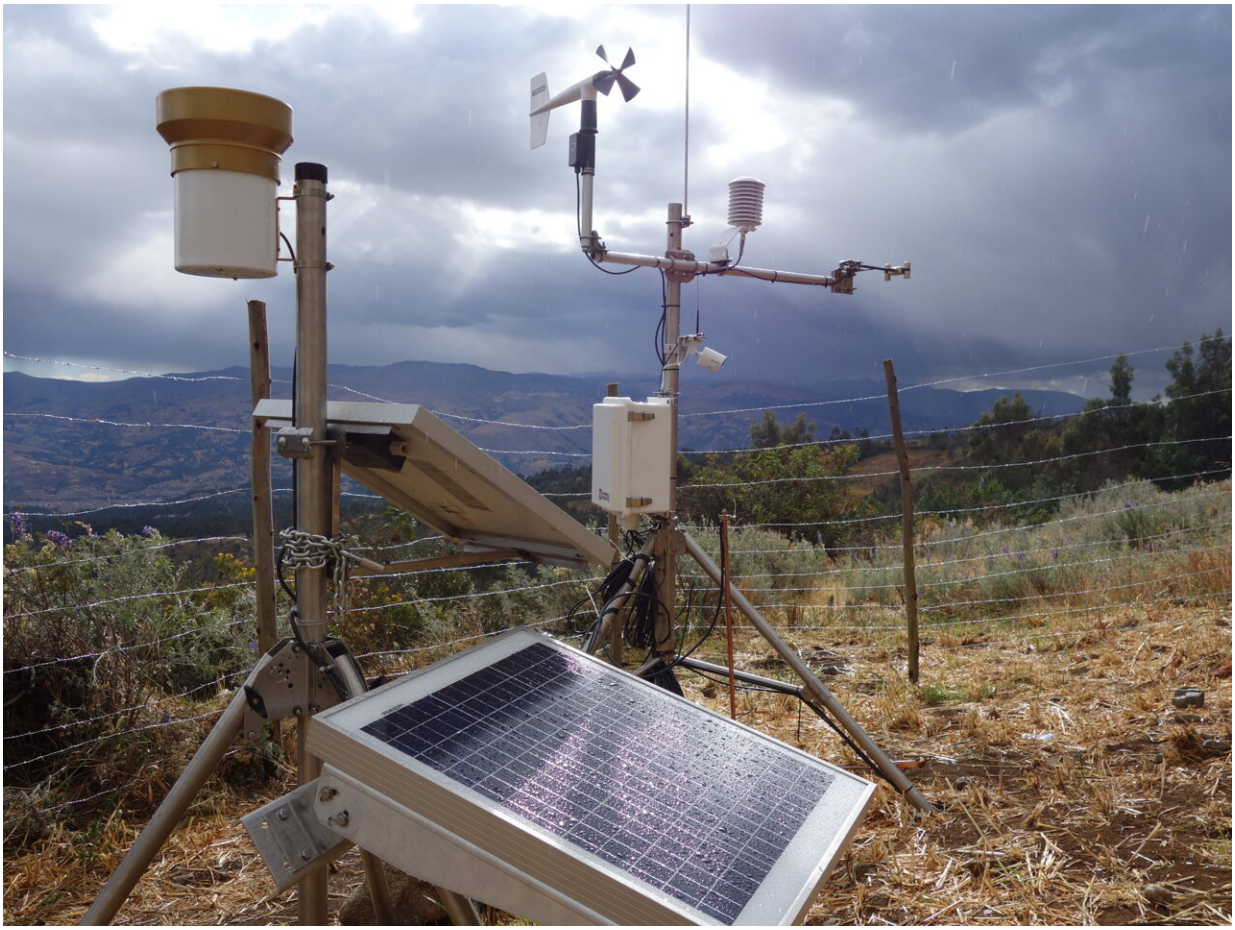
From glaciers to rainfall: Understanding unexpected rain

November 15 2023



A scientifc weather station in the rain. Credit: Wolfgang Gurgiser

In 2018, a group of students from the Universities of Innsbruck, Austria,

and Hamburg, Germany, were on a research excursion close to the village of Llupa in the Rio Santa valley in the Peruvian Andes. While they were busy installing a weather station in preparation for their research project, they were surprised by unexpected rainfall—a brief yet notable shower.

To the students, this seemed highly unusual. It was August, months into the Andean dry season.

The Rio Santa valley, located at about 3000 meters, lies at the foothills of the impressive snow-capped peaks of the Cordillera Blanca mountain range that attracts thousands of hikers, climbers, and other tourists every year. The valley is home to many small-scale farmers who grow crops like wheat, maize, and potatoes, which they depend on for their self-subsistence and for trade in the markets of Huaraz, the region's capital.

Traditional farming here relies on the experience and memories gained by generations of farmers who are deeply rooted in the valley.

Research teams from the University of Innsbruck and Hamburg have studied the regions' water cycle for decades. In the beginning, they used weather station data and models to understand the state of the rapidly retreating glaciers. These studies were essential to understanding the underlying physical processes that accelerate the melting process, as tropical glaciers behave very differently to those in the European Alps.

Following the meltwater downstream, researchers examined how the water was used by local communities. Conversations with local farmers highlighted the importance of seasonal rainfall for farming, as few farms have direct access to irrigation systems with year-round water availability. These discussions prompted the researchers to shift their focus from glacier dynamics to atmospheric processes and their impact on vegetation and farming.

This is how the research project "AgroClim Huaraz"came into being. Formed by an international collaboration of researchers from institutions in Peru, Austria, the UK, France, and Switzerland, the project set the new goal to better understand precipitation patterns in the region, how they affect rain-fed agriculture, and how they changed in the past and might change in the future.

Unreliable rain

But let's go back to the rainfall that surprised the students in 2018. Intrigued by this event, the researchers set out to understand more. Talking to local farmers, they soon found out that these rains were referred to as "Pushpa" and are of crucial importance to farmers in the Rio Santa Valley.

Pushpa rains mark the end of the dry period and the beginning of the rainy season and typically occur between August and September. They moisten the soil for the first time after the dry season, and farmers await them eagerly, to begin with the sowing of their crops.

"Small-scale farmers in Huaraz are highly dependent on the rain, because, for most, it is the only source of water," says Wolfgang Gurgiser from the University of Innsbruck's research area "Mountain Regions," who was involved in several of the project's studies. "The water coming from the glaciers is contaminated by naturally occurring heavy metals, which makes it unusable for consumption or irrigation in some watersheds."

Hence, predicting rain is highly important. Which makes it all the more concerning that the Pushpa rains are very unreliable.

From interviews with farmers, scientists were made aware of several perceived changes and threats: according to the farmers' observations,

Pushpa rainfall had become increasingly delayed over the last years, had occurred less regularly, and had become more intense, which locals believe may be a consequence of climate change. Farmers reported the experienced changes were threatening their traditional practices and livelihoods.

Rolando Cruz Encarnación, a local expert from the National Water Authority in Peru, adds, "The light rainfalls are supposed to announce the beginning of the rainy season, but if farmers decide to sow and Pushpa is followed by a dry period, this has negative implications for the entire season."

Understanding Pushpa

"Until then, Pushpa was undocumented in the scientific literature. Hearing about these rains moved our focus into a completely new and interesting direction," says Cornelia Klein, a former postdoc at the Department of Atmospheric and Cryospheric Sciences of the University of Innsbruck and now at the UK Centre for Ecology and Hydrology in Wallingford.

"How is Pushpa rainfall different from the rainfall in the core of the wet season? And how did it change in the past?" These new questions motivated her and Cornelia Zauner, a former Masters student at the University of Innsbruck.

The resulting study, published in the journal Environmental Research Communications, is the first to describe the mechanisms behind the Pushpa rains in the Rio Santa valley under a scientific scope.

Surprisingly, Pushpa rains are found to be connected to dry winds coming from the Pacific in the west, which are typical for August and usually bring dry conditions—or, as now discovered, light rain. After the

dry season, the winds turn and bring the towering heavy rain clouds from the Amazon basin in the east. Pushpa rains are indeed of a different nature than the intense rain in the wet season.

By looking at model rainfall data representing the past 40 years, Dr. Klein and her colleagues also found that the Pushpa rains are highly variable, alternating between abundant and scarce years. This is also supported by an observational study conducted by Lorenz Hänchen, Ph.D. student at the Department of Ecology of the University of Innsbruck, and published in the journal Earth System Dynamics.

"By looking at years of satellite data of plant greenness, we found that the start of the growing season can vary by up to two months from one year to another," says Hänchen. "This is certainly a very difficult situation for agricultural planning."

Data and memories

"Our data suggests that Pushpa rain is highly variable but did not significantly change over the past 40 years," says Klein. This means that the farmers' observations couldn't be confirmed scientifically. The reason for this remains an open question.

"Memories are tricky data to rely on, because of psychological effects. Highly unusual events are easier to remember than common ones," says Gurgiser. "This doesn't change the fact that we hold the farmers' knowledge in high regard. Our studies and the available data have limitations, which are all mentioned in our publications."

"We use academic approaches but are fully aware of traditional knowledge systems, like those of the farmers, who have known these lands over generations. We can only compare our results to their observations and speculate why they might differ. And the challenges of

the irregular Pushpa rains, although not directly connected to climate change, remain."

"The sum of precipitation, which we have observed to remain similar for the last decades, isn't as important to farmers as how it is spread over the agricultural season. This is similar to what we are currently witnessing in Austria: rain is not becoming less, but more variable in its occurrence and intensity."

A future of extreme precipitation and droughts

This increase in intensity is also projected to happen throughout the Peruvian Andes. Dr. Emily Potter, a former project member and now a postdoc at the University of Sheffield, produced climate data on an unprecedented detailed scale for the project, combining computer simulations with data from local weather stations.

The study, published in the journal npj Climate and Atmospheric Science, draws an unsettling picture of future changes to temperature and precipitation in the region. The projections suggest a significant increase in both temperatures and rainfall by the end of this century. Increasingly extreme rainfall is predicted to occur together with periods of severe droughts enhanced by higher temperatures and evaporation.

"Like everywhere else in the world, poorer communities are more likely to suffer from the consequences of climate change," says Potter. "We find that in scenarios with a drastic reduction of our greenhouse gas emissions, the changes in rainfall and temperature are less intense. This would give more time to the communities to prepare for the challenges to come."

More information: Cornelia Klein et al, Farmers' first rain: investigating dry season rainfall characteristics in the Peruvian Andes,

Environmental Research Communications (2023). DOI: 10.1088/2515-7620/ace516

Lorenz Hänchen et al, Widespread greening suggests increased dry-season plant water availability in the Rio Santa valley, Peruvian Andes, *Earth System Dynamics* (2022). DOI: 10.5194/esd-13-595-2022

Emily R. Potter et al, A future of extreme precipitation and droughts in the Peruvian Andes, *npj Climate and Atmospheric Science* (2023). DOI: 10.1038/s41612-023-00409-z

Provided by University of Innsbruck