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News: Q&A

A sky-high eye on climate change

Measuring aerosols and radiation at dizzying altitudes is all in a day's work for Angela Marinoni.

Jane Qiu

Angela Marinoni is living the high life. *Paolo Vilani*

Angela Marinoni is a climate scientist who likes to be close to the action — on and among the world's highest mountains. A researcher at the Institute of Atmospheric Sciences and Climate in Bologna, Italy, part of the country's National Research Council, she spends part of her year 5,000 metres above sea level at the Pyramid Laboratory in the Khumbu Valley on Everest's south side. Marinoni has helped to build a series of cutting-edge weather stations in the Nepalese Himalayas, allowing her to witness climate change at first hand.

At the 2nd Third Pole Environment Workshop held last week in Kathmandu, Nepal, *Nature* caught up with Marinoni to find out what it was like to build a weather station at 8,000 metres and what Pyramid research has revealed about the environment around Everest.

Why are these high-altitude studies important?

At high altitudes, mountains are a pristine environment, far away from human influence, and are very sensitive to climate change. But we know little about what's going on in such environments, especially in the Himalayas. At the Pyramid, we try to fill that data void by carrying out long-term atmospheric observation and monitoring changes in glaciers and biodiversity. Together with high-altitude stations in other parts of the world, such as the Alps in Europe and the Rwenzori Range in Uganda, we will be able to build a complete picture of how the high-altitude environment is responding to climate change.

What is the Pyramid like?

The Pyramid is literally in the middle of nowhere. The only way to get there is by foot from the nearest Nepalese village, Lukla. It takes about six days walking past very different types of terrain along the Khumbu Valley. The station is in a treeless, rocky environment at the foot of the Khumbu Glacier. It is powered by 160 solar panels with around 140 batteries and a small power generator. A satellite connection allows remote control of the instruments and real-time data access. The Pyramid is the centre of a network of nine weather stations along the valley, starting from 2,660 metres at Lukla to 8,000 metres at the South Col [a pass between Everest and Lhotse, the fourth highest mountain in the world].

How do these high-altitude weather stations compare with others elsewhere in the Himalayas?

The Pyramid Laboratory is only accessible by foot. *Paolo Vilani*

There are very few high-altitude weather stations in the Himalayas. The South Col station, which broke down in May 2009 after making continuous measurements for nearly a year, was certainly the highest station in the world. The station near the Pyramid, the Nepal Climate Observatory-Pyramid at 5,079 metres, is one of the two stations in the Himalayas that are part of the Global Atmosphere Watch network [a United Nations World Meteorological Organization programme including 300 stations around the world sited in locations important for building a complete picture of the global climate]. The other one, the Waliguan station at about 3,810 metres in China's Sichuan Province, operates in a very different climate. We also have two weather stations above 3,000 metres in the Karakorum region in Pakistan. The climate there is dominated by the Westerlies [prevailing mid-latitude winds from the west], rather than the Indian monsoon in the Eastern Himalayas.

Why did you set up a weather station at 8,000 metres?

There were few meteorological measurements at this altitude. But it's very important to calibrate and validate climate models using real data, especially from complex geological settings and high altitudes. Another motivation is to develop a state-of-the art technological system for monitoring high mountains. The South Col is an ideal natural laboratory for testing and improving probes and sensors under extreme conditions. For example, we had to modify the instruments so they could work properly under low pressure and strong winds and to find ways to reduce ice formation around them.

What was it like to set up the South Col station at such high altitude?

The station was installed by three Italian climbers and five Nepalese sherpas. They all took technical training courses beforehand to learn how to set up weather stations. The team first hiked to the Everest Base Camp. From there, they went up to the South Col with several stops along the way to acclimatize and to bring all the stuff up for the station. To fix the station on the ridge, they had to drill deep into the ground so the masts would be stable in harsh conditions for as long as possible. It was an enormous challenge at such high elevation.

What have you learned from data collected at the South Col station?

One striking finding is that we recorded above-zero temperatures at the South Col. They coincided with massive ice falls, presumably because above-zero temperatures caused snow melting and triggered avalanches farther down the mountain. The information is very important for climbers, so this may be a way to assess climbing conditions. We have also run the data through some climate models. The models and observations seem to match pretty

well in general. But parameters such as precipitation and radiation, which are known to be difficult to model, fit the models less well. It's particularly important to have data for such parameters to improve the climate models.

What are the other major findings coming out of the Pyramid?

The Nepal Climate Observatory-Pyramid has additional capacity to measure aerosols. We were surprised to find short pulses of pollutants [including black carbon, possibly from India, Nepal and China] in concentrations typical for urban environments in such a pristine environment. When the air mass changed from clean to polluted, we often saw a burst of new cloud condensation. This happens surprisingly frequently, about 50% of the days in a year, and could have a lot of effects on aspects of the climate system, such as radiation balance and precipitation. Another interesting finding is that black carbon deposition could increase snow and ice melting of a typical Himalayan glacier by 12-34% through reducing the surface albedo [a measure of how strongly a surface reflects light][1].

How can the studies carried out at the Pyramid benefit the local community in Nepal?

The Pyramid is jointly run with the Nepal Academy of Science and Technology. We have training courses to improve the scientific and technical capacity of the local community. A central mission of the Pyramid is to better understand the impact of anthropogenic activities, especially pollutant transport and deposition, on water resources in the region. Other projects include generating a biodiversity inventory and a seed bank for the Nepalese Himalayas and monitoring vegetation responses to climate change.

What do you plan to do next in the Himalayas?

We will further improve capacity at the Nepal Climate Observatory-Pyramid by, for example, adding additional instruments for ultraviolet and carbon monoxide measurements. We are working on a new set of probes and sensors for the South Col station. We are also testing a portable climate station that can take basic meteorological measurements as well as monitor ozone and aerosols. It's completely automatic, doesn't require an external energy source and can be left anywhere for several months. The idea is to have a brief characterization of a place we know little about without having to construct a new station.

References

1. Yasunari, T. J. *et al. Atmos. Chem. Phys.* **10**, 6603 - 6615 (2010). | **Article** | **OpenURL**