EXPLORING PRISTINE MOUNTAIN AIR HELPS RESEARCHERS FIND OUT WHAT THE ATMOSPHERE WAS LIKE DURING THE PRE-INDUSTRIAL PERIOD. THIS MIGHT JUST BE THE KEY TO UNDERSTANDING THE PRESENT CLIMATE, TOO

Higher chemistry

"Sometimes I wake up in the middle of the night and feel that I can't breathe. Fortunately, it passes." This is how chemist and postdoctoral researcher Federico Bianchi describes the feeling of being at an altitude of more than 5,000 metres. He has only recently returned from an expedition to the Everest Base Camp of the Himalayas. Up there he studied how aerosol particles are formed in the higher layers of the atmosphere.

Bianchi is young and athletic. Perhaps surprisingly, sportiness does not appear to be a main prerequisite for doing well in low-pressure extreme conditions, however. "Some people simply adapt easier than others, independent of their physical strength or age. I have never been overcome by nausea or mountain sickness, like many of my colleagues," says Bianchi.

It is easy to see that he enjoys the adventures and risks connected with rough terrains. However, most of his research tasks are anything but glamorous expeditions. He runs his everyday scientific duties in the laboratory or in a small office located at the University of Helsinki, Finland. Bianchi works in the Finnish Centre of Excellence in Atmospheric Sciences and, like many of his nearest colleagues, he specialises in the formation process of atmospheric particles.

Studying molecules

Atmospheric particles are tiny molecular clusters in the air. Some of them come from human influence but some originate in Nature itself. In the latter case, the particles are born as a by-product of photosynthesis, for example.

Despite their nanometre-class size, the atmospheric particles have a great effect on weather conditions and observable macro properties of the climate and climate change. This is because the ubiquitous atmospheric particles influence the radiation balance of the Earth. First, the particles scatter light. Second, some of them might, after a series of complex microphysical reactions, grow up and become the seeds of new clouds. According to Bianchi: "It is not exaggeration to say that to cope with the climate change, or to halt it, we first have to know the chemistry and dynamics of aerosol particle formation."

Lately, he and his colleagues have found some interesting results on the theme: "Earlier we thought that the early stages of the formation process of the particles are heavily dependent on certain chemical substances like sulphuric acid. Sulphuric acid mainly comes from industrial emissions or is emitted by volcanoes.

"Now, however, we have made laboratory experiments with a special, ultra-clean chamber. The results indicate that the role of sulphuric acid is perhaps not so crucial. With the help of the chamber, we also succeeded in evaluating in what way and to what extent galactic cosmic rays enhance new particle formation," explains Bianchi.

This, in turn, is exactly the reason why he climbs mountains. He wants to find out whether the field measurements would give the same result as the one they reached in laboratory conditions. The air at the altitude of 5,000 metres is pristine compared to many other terrains, thus resembling the ultra-clean chamber and mimicking the pre-industrial atmosphere.

Federico Bianchi at work in the Swiss Alps

Mount Everest

"If we succeed – that is to say, if enough measurements in clean air confirm our laboratory results – we will have found an important reference point with which to compare our many indexes and indicators of the changing climate," explains Bianchi.

Helicopters and spectrometers

Bianchi will soon prepare for a new expedition to the mountainous region of Bolivia to visit the highest station in the world. The endeavour is not only physical and cognitive; it is quite a heavy effort of logistics, too.

The mass spectrometer is used to determine the chemical composition of the aerosol particles. In rough terrain, some instruments have to be transported by helicopter

First, Bianchi cannot simply go and buy his measurement instruments from the store soon after landing on a new continent. There are no suitable instruments ready and waiting for shoppers. When it comes to science in general, chemists and physicists have to develop, construct and calibrate the instruments by themselves.

Bianchi needs, among other things, a mass spectrometer – a vehicle which helps in determining the chemical composition of the aerosol particles. The gadgets he takes along with him weigh more than 1,000kg altogether, and they have to be carefully packed and protected to fly over the Atlantic Ocean.

Any scientist in this situation would probably feel like a violinist who has to put their Stradivarius into the cargo hold of the aeroplane.

"I am always afraid that my mass spectrometer is perhaps handled carelessly in the airports and during cargo loading. I have nightmares that the most important instrument is damaged somehow and the first thing to do in a new continent is to start repairing and calibrating or, even worse, searching for spare parts which do not exist anywhere. A delay like this might cause a loss – not only of money but also of unique measuring conditions."

If nothing goes wrong during the flight or cargo handling, then the next chance for 'Murphy's Law' to come true is during the transport of the heavy spectrometer up to the mountains.

Atmospheric scientists co-operate with CERN

CERN, the European Organization for Nuclear Research, is famous for its giant accelerator reaching from France to Switzerland. CERN physicists and scientists explore the fundamental particles of the atom to understand the basic structure of the Universe.

The scientific instruments and equipment developed in CERN are probably the best – and most complex – in the world. This is why Finnish atmospheric scientists have done as numerous other science groups have and sought to co-operate with CERN.

Atmospheric particles as such do not have much in common with elementary particles. The atmospheric clusters are, despite their nanometre-class size, quite colossal entities compared with electrons, hadrons or other research objects of CERN scientists. Despite this and a few other fundamental differences in the fields of specialisation between CERN scientists and atmospheric researchers, their co-operation has turned out to be fruitful for both.

Bianchi and his colleagues visit CERN regularly: "We usually stay there for two to three months each year. Our recent results concerning the formation of biogenic aerosols without sulphuric acid would not have been possible had we not had the special chamber of CERN at our disposal."

The Finnish Centre of Excellence in Atmospheric Sciences is headed by the physicist Academy Professor Markku Kulmala, the most cited geoscientist in the world. It was originally Kulmala and his group who got in touch with CERN at the beginning of the millennium.

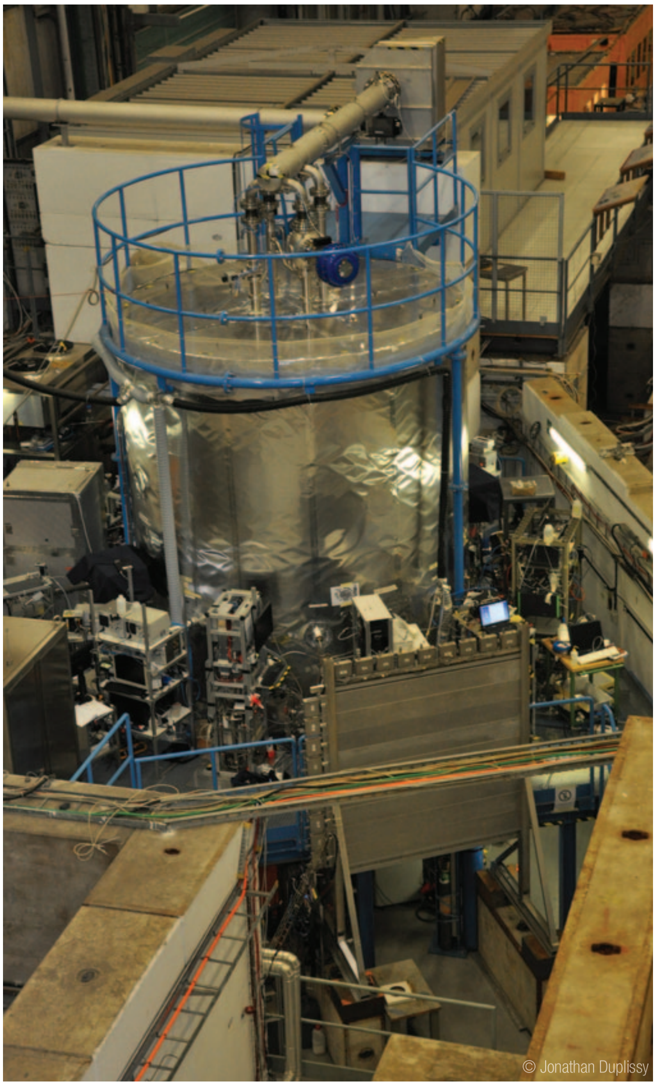
"Originally, Finnish atmospheric scientists were mainly physicists; thus it was relatively easy for them to create networks with CERN experts. Nowadays, however, our group is supplemented with chemists. Quite a few research problems of the atmosphere are actually questions of chemistry and timing."

Bianchi also participates in quantum modelling. To simplify, 'quantum' refers to the subatomic world which can be only be understood with the help of complex probability mathematics. At the subatomic level, physics and chemistry are practically the same field of science.

After all, the atmospheric clusters basically consist of electrons, hadrons and other non-observable oddities and energy states – like everything in our world.

"We usually hire a helicopter – there are plenty of private firms offering services like this. They are horribly expensive, however. The transport and maintenance of a few scientists is much cheaper than all the logistics with the equipment."

Field measurements described by Bianchi do not always have to be this difficult. The Finnish centre of excellence has several permanent observational stations in Finland, Estonia and China, and soon also in Siberia. The SMEAR stations are measuring the interlinks between the Earth's surface and the atmosphere, and are thus equipped with measurement towers, field laboratories and technical staff. They cannot, however, substitute observations made higher in the troposphere or in pristine areas. This is why Bianchi and his colleagues have to be prepared to leave for uninhabited regions in the future – a fact that does not seem to make him unhappy at all.



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Atmospheric scientists study the influence of galactic cosmic rays on aerosols and clouds with the help of a special chamber. The chamber is located in CERN, the European Organization for Nuclear Research

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