A few molecules of organic vapours; a pinch of sulphuric acid; remember to mix all the ingredients carefully with a nanosized spoonful of dimethylamine; increase the temperature slowly….

This may sound like a witch’s cook book, but it is anything but magic: it is the draft of an experimental setup planned by several scientists. Physicist Katrianne Lehtipalo and her team specialise in atmospheric research. Currently, they study the formation and growth of aerosol particles, the tiny clusters suspended in air. For this purpose, they need to create nature-like conditions inside a special chamber.

In layman’s terms, the chamber looks like a huge kettle surrounded by versatile apparatus. To Katrianne Lehtipalo and other experts, it is a genuine clean box inside which one can empirically explore the microphysics of the atmosphere. “To see the big picture of the climate and the way it is changing, we first need detailed knowledge of the molecular level,” Lehtipalo explains.

The best clean box in the world is located in CERN, the European Organization for Nuclear Research. This is why Lehtipalo and her colleagues stay in Switzerland for two months every year. They have studied, amongst other things, how cosmic rays affect the atmosphere, and, further, the climate.

Lehtipalo is a true physicist, but as an atmospheric researcher she is used to co-operating with chemists. Many scientists argue that “most phenomena connected with aerosol particles are questions of chemistry and timing,” Lehtipalo said, agreeing. Currently, she is examining the role of sulphuric acid and organic vapors in aerosol formation.

**Computations and mixtures**

Some aerosol particles are borne by Nature itself; they are a byproduct of photosynthesis, and as such, a result of complex reaction chains. Other particles come from human action, such as traffic or industrial emissions. What is more, the way particles are formed varies with the environment. This is why Lehtipalo sketches many different conditions to be imitated inside the chamber.

“I like cooking. Perhaps this is one of the reasons why I enjoy drafting versatile plans for the optimal mixture of chemical substances in the chamber”, says Lehtipalo.

On a more serious note, the planning of an experiment is a meticulous task with endless computations and detailed calculations. Part of Lehtipalo’s time is thus spent standing in front of a flip-chart drawing excel-tables of gas concentrations, temperatures, and so on. There is a lot to worry about: first, nano-sized molecular clusters are difficult to observe, not to mention...
measuring them. Second, to create conditions exactly like the ones in nature is no easy task. Last but not least, the experiments performed with the complex technical devices offered by CERN are expensive. The total costs of one single experiment with the chamber may reach some €10,000 per day. The sum consists, first of all, of the implementation and maintenance of up-to-date scientific apparatus and the salaries of the technicians and scientists. In addition to this, the air needed in the experiment must be ultraclean. The researchers mix it themselves out of nitrogen and oxygen. Finally, most researchers arrive to CERN as visitors, and so the time available for group work is limited.

To put it simply, if something in the jigsaw puzzle described above goes wrong, there is probably no opportunity to start from the beginning, Lehtipalo explained, adding: “On the other hand, the complex optimisation is actually the best part of my work.”

A multitude of research groups visit CERN every year from all over the world. Lehtipalo comes from Helsinki, Finland, where she works as a researcher in the Institute of Atmospheric and Earth Surface Research, as do most members of her team. When it comes to financing, Lehtipalo is lucky: she was recently awarded with a Marie Skłodowska Curie Individual Fellowship Grant, which guarantees her projects for the next three years.

Construction workers and roadies

The preparations for a visit to CERN are lengthy: Lehtipalo and her team take a few scientific devices from Finland along with them. “The clean chamber alone is not enough. To observe the forming clusters, we have to combine our own lab equipment with it,” Lehtipalo said.

Before the team leaves their home laboratories, they work like a forwarding agency. For example, a mass spectrometer which measures the chemical composition of the aerosol particles weighs up to 1,000 kilograms. It has to be taken to pieces and packed and sent as a special cargo, after which the team must reassemble it at the other end. This takes time, and without experienced experts like Lehtipalo and her colleagues, something could easily go wrong. For them, there is nothing new in a situation like this: natural scientists often work not only with their brain but also frequently employ the skills of a craftsman as well.

Lehtipalo has been doing hands-on science from the beginning of her career. She graduated with an MSc in physics in 2007, and since then she has been part of a research group which develops...
and builds the measurement instruments and methods needed in atmospheric research.

The Finnish Center of Excellence is famous for its spin-off firms Airmodus Inc and Karsa Ltd, which manufacture particle counters and special sensors. Regarding the former one, Lehtipalo participated in the somewhat tedious stage of developing a prototype of a counter into a commercial product.

Lehtipalo said: “I am probably not a technical genius, but I am used to testing new devices in the field and in the versatile conditions of Nature. I have also learned to analyse and interpret the measurement results we obtained with the help of the self-made equipment we had in the beginning. I think this kind of experience has helped me a lot better.

“We are much better off nowadays when it comes to the level of technology we have for the detection of the smallest particles, but I would not give away the knowledge I gathered during my early years. It provided me with the scientific instinct needed for this kind of work.

“I also think that to lead a research team one has to go through all the stages of scientific work, starting from the everyday routines of field laboratories. It is a slow process but, at least for me, it is the best way to become a responsible scientist,” she concluded.

Atmospheric scientists co-operate with CERN

CERN, the European Organization for Nuclear Research, is famous for its giant accelerator, the Large Hadron Collider (LHC) reaching from France to Switzerland. CERN physicists and scientists explore the elementary 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, and numerous other science groups, have and sought to co-operate with CERN.

Atmospheric particles do not have much in common with elementary particles, however. The atmospheric clusters are, despite their nanometre-class size, downright colossal entities compared with electrons, hadrons or other research objects explored by CERN scientists.

Nevertheless, despite the fundamental difference in the fields, CERN scientists and atmospheric researchers find their co-operation fruitful. Some atmospheric researchers even participate in quantum modelling, which refers to the subatomic world reachable only with help of complex mathematics.

At the very basic level, atmospheric particles do consist of electrons, positrons, other non-observable oddities and energy states—just like everything else in the Universe. This is why ecosystem research benefits from the technology developed for measuring nuclear and subatomic events.

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