Looking for climate answers in the clouds

A unique EU-funded research project investigates how clouds even in the most remote places respond to changes in pollution. After measurements in the Arctic, the researchers are now set to explore the clouds above Mt Helmos in Greece.

Unpredictable weather, extreme rainfall or snow increasingly leads to challenges for people and nature. Paradoxically, less air pollution and cleaner clouds could lead to more extreme events. To understand how clouds will respond to changes in pollution, and in a post-fossil world is key for the world's ability to plan for the future. This is at the heart of the EU-funded research project CleanCloud.

An important part of CleanCloud is about monitoring the inner workings of clouds and how they are modulated by particles that form cloud droplets and ice crystals – as expected in a post-fossil world. That demands a great deal of handling extreme conditions in remote areas, explained Dr. Athanasios Nenes, professor of atmospheric processes at the Ecole Polytechique Federale de Lausanne (EPFL) in Switzerland and associate researcher at the Institute of Chemical Engineering of FORTH in Patras. Dr Nenes is one of two project coordinators of CleanCloud.

Since the project was launched in January, CleanCloud researchers have conducted observations of the clouds and how they respond to aerosols from natural or anthropogenic sources, during spring and summer in the remote Arctic Villum research station in North Greenland (81°36' N, 16°40' W).

Villum research station is located in one of the most remote and extreme environments on Earth, which makes it an exceptional site for studying the Arctic climate, atmosphere, and ecosystem, which are particularly sensitive to global climate change, said Dr. Ulas Im, a senior scientist at Aarhus University, Department of Environmental Science, and coordinator of the CleanCloud project.

Villum Research Station is known for having some of the cleanest air on Earth, which provides researchers with the ability to study atmospheric processes and pollution levels without much interference from local human activities. The Arctic, compared to other regions of the globe, has unique characteristics that make measurements of aerosol-cloud interactions particularly valuable for models.

The Arctic is warming up to 4 times the global average, leading to rapid ice melting and a drastic change of the sources of aerosols and their impact on clouds. Natural aerosols are also a major driver of these changes. Monitoring of these changes is extremely sparse, especially in the most remote regions where harsh conditions make it difficult to carry out even simple measurements over time. Because of this, models of climate change for this remote region are virtually unconstrained by observations, making predictions highly uncertain. CleanCloud addresses important knowledge gaps, both by providing observations of Arctic aerosols and their interactions with clouds, and by testing algorithms used for remote sensing and even developing new ones.

Having successfully conducted measurements in the Arctic, CleanCloud researchers will begin their observations of aerosols and clouds from the top of the Mt Helmos in Greece on October 1st. Mt Helmos, rising to a height of 2,355 meters above sea level, is considered ideal for cloud and climate research.

Mt. Helmos sits at the crossroads of many different air masses, and in a “climate hotspot”, which like the Arctic, is changing much faster compared to the global average. This allows particles of almost any kind to interact with clouds, from wildfire smoke to pollution and highly processed particles from continental Europe, to sea salt from the Mediterranean and dust from Sahara, to pollen, bacteria, and fungal spores transported from thousands of kilometres away or the forest below, said Dr. Nenes.

At the mountaintop station (called $(HAC)^2$) researchers can directly observe inside clouds and "see” the interactions that are to be described in models, At the same time a whole array of remote sensing instruments can be placed at the base of the mountain – cloud radars, lidars – and remotely observe the clouds. Altogether, the data will improve the understanding of aerosol-cloud interactions and serve as a testbed for evaluating existing and new remote sensing algorithms.

There has never been a deployment like this before. The measurements of Mt Helmos will continue to mid-January. For the first part of the mission, among several ground based and remote sensing instruments, we will use drones and balloons, but as they can’t fly under extreme conditions this will not be possible when winter sets in, Dr. Nenes said.

A successful mission was already conducted in 2021, which provided important results that laid the ground for the current campaign – called CHOPIN (Cleancloud Helmos OrograP hic sIte experimeNt).

The researchers expect to be able to directly observe how cloud properties change with the particles in the air and by that contribute to the understanding of future climate impacts.

CleanCloud has received funding from Horizon Europe programme under Grant Agreement No. 101137639.