New insights into cloud formation

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Clouds have a profound effect on the climate, but we know surprisingly little about how they form. Erika Sundén, researcher at the University of Gothenburg, Sweden, has studied how extremely small cloud particles can dispose of excess energy. This knowledge is necessary to understand processes in the atmosphere that affect global climate change.

The models that have been built to describe climate change contain a major source of uncertainty, namely the effects of clouds. The UN Intergovernmental Panel on Climate Change points out in its climate report for 2007 that new knowledge is needed in this field. It is namely the case that clouds can act in two ways: they may be a mirror that reflects radiation from the sun back into space, and they may be a blanket that seals in the heat emitted by the Earth. Mapping the formation and dispersion of clouds may, therefore, be a key step in climate research.

"One important stage is understanding the fundamental properties of the particles involved", says Erika Sundén, doctoral student at the Department of Physics, University of Gothenburg.

Ammonia may play an important role

Erika has studied small particles known as "clusters", which contain between 3 and 300 molecules. One line of research has investigated how water clusters dissipate excess energy, and this will help to understand how water droplets grow and how they evaporate. These are the processes by which ice and liquid water are transformed into water

vapour (gas).

Another line has investigated how the clusters are influenced by ammonia, which is an important component of the atmosphere.

"I investigated water clusters that contained a small fraction of ammonia, and compared these with pure water clusters. I was able to show that the ammonia contributed to the stability of the clusters, and prevented them evaporating so rapidly. It may be that ammonia plays an important role in the early stages of cloud formation", she says.

Temperatures of -100 degrees

It is not easy to measure the heat capacity of clusters, and an important part of her research has been to develop a method that can be used in future studies. Put simply, you could say that she has created water clusters in air, drawn them into a vacuum, and then examined them as they disintegrate. This method led her to an unexpected discovery.

"The temperature inside these clusters was around -100 °C, so one would expect that their heat capacity would correspond to that of ice. Despite this, the heat capacity of medium-sized clusters was greater, intermediate between that of ice and liquid water. The importance of this for how clouds form will be the subject of further research", she says.

New insights into space clouds

Erika Sundén presents in her thesis also studies into the cooling rate and radiation of carbon particles, which may be a component of space clouds. It has long been uncertain whether molecules can exist in the empty space between the stars and planets, since the density of atoms is

so low. The first negatively charged carbon molecules were discovered in 2006, however, after which work has continued surveying the molecules that are present in space clouds.

"First radiation from space is measured, and then it's a case of creating models that can explain the observations. We create in the lab charged molecules that may be present in these clouds, and investigate whether these molecules emit radiation and, if so, to what extent", she says.

More information: Erika Sundén's thesis "Thermal Properties of Clusters and Molecules – Experiments on Evaporation, Thermionic Emission, and Radiative Cooling" was successfully defended on 24 February. It can be downloaded from: gupea.ub.gu.se/handle/2077/28349

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