Clouds in the sky provide new clues to predicting climate change

March 9 2023, by Michael Allen

Clouds play an important role in both warming and cooling the planet. Credit: CC0 via Unsplash

While barely being given a second thought by most people, the masses of condensed water vapor floating in the atmosphere play a big role in global warming.

Predicting how much Earth's climate will warm is vital to helping humankind prepare for the future. That in turn requires tackling a prime source of uncertainty in forecasting global warming: clouds.

Some clouds contribute to cooling by reflecting part of the Sun's energy back into space. Others contribute to warming by acting like a blanket and trapping some of the energy of Earth's surface, amplifying the greenhouse effect.

Puzzle pieces

"Clouds interact very strongly with climate," said Dr. Sandrine Bony, a climatologist and director of research at the French National Centre for Scientific Research (CNRS) in Paris.

They influence the structure of the atmosphere, impacting everything from temperature and humidity to atmospheric circulations.

And in turn the climate influences where and what types of clouds form, according to Bony, a lead author of the Nobel Peace Prize-winning assessment report in 2007 by the United Nations Intergovernmental Panel on Climate Change.

So many processes and feedback loops can affect climate change that it's helpful to break down the issue into smaller parts.

"Every time we manage to better understand one of the pieces, we decrease the uncertainty of the whole problem," said Bony, who coordinated the EUREC4A project that ended last year.

A number of years ago, Bony and her colleagues discovered that small, fluffy clouds common in trade wind regions cause some of the largest levels of uncertainty in climate models. These clouds are known as trade cumulus.

While trade cumulus clouds are small and relatively unspectacular, they are numerous and very widely found in the tropics, according to Bony. Because there are so many of these clouds, what happens to them potentially has a huge impact on climate.

EUREC4A used drones, aircraft and satellites to observe trade cumulus clouds and their interactions with the atmosphere over the western Atlantic Ocean, near Barbados.

Many models assume that the structure and number of these clouds will change significantly as the global temperature warms, leading to possible feedback loops that amplify or dampen climate change. The models that project a strong reduction in such clouds as temperatures rise tend to predict a higher degree of global warming.

Good news

But Bony and her colleagues discovered that trade cumulus clouds change much less than expected as the atmosphere warms.

"In a way, it is good news because a process that we thought could be responsible for a large amplification of global warming does not seem to exist," she said.

More importantly, it means that climatologists can now use models that more accurately represent the behavior of these clouds when predicting the effect of climate change.

Reducing this element of uncertainty in forecasts of the global extent of warming will make predictions of local impacts such as heatwaves in Europe more precise, according to Bony.

"The increase in the frequency of heatwaves very much depends on the magnitude of global warming," she said. "And the magnitude of global warming depends very much on the response of clouds."

Water and ice

Meanwhile, Professor Trude Storelvmo, an atmospheric scientist at the University of Oslo in Norway, has been exploring the processes inside a different type of cloud—mixed-phased clouds—to help improve climate models.

She is fascinated by how processes in clouds that occur on a tiny, micrometer scale can have such a big influence on global-scale atmospheric and climate processes.

Mixed-phase clouds contain both liquid water and ice and are responsible for the majority of rainfall across the globe. In recent years, it has become clear that they also play an important role in climate change.

Storelvmo coordinated the MC2 project, which ran for five years until last month and unearthed new details about how mixed-phase clouds react to higher temperatures. The results highlight the urgency of transitioning to a low-carbon society.

The more liquid water that mixed-phased clouds contain, the more reflective they are. And by reflecting more radiation from the sun away from the Earth, they cool the atmosphere.

"As the atmosphere warms, these clouds tend to shift away from ice and towards liquid," said Storelvmo. "What happens then is the clouds also become more reflective and they have a stronger cooling effect."

Rude awakening

But some years ago, Storelvmo and colleagues discovered that most global climate models overestimate this effect. MC2 flew balloons into mixed-phase clouds and used remote sensing data from satellites to probe their structure and composition.

The researchers discovered that current climate models tend to make the mix of water and ice in mixed-phase clouds more uniform and less complex than in real clouds, leading to overestimations of the amount of ice in the clouds.

Because these model clouds have more ice to lose, when simulations warm them the shift in reflectiveness is greater than in real clouds, according to Storelvmo. This means the models overestimate the dampening effect that mixed-phase clouds have on climate change.

When the team plugged the more realistic cloud data into climate models and subjected it to simulated warming, they made another important finding: the increase in the reflectiveness of mixed-phased clouds weakens with warming.

While with moderate warming the dampening effect on higher temperatures is quite strong, this is no longer the case as warming intensifies.

There comes a point when the ice in the cloud has all melted and the cooling effect weakens—and then completely vanishes. Exactly when this starts to happen is a question for future research.

But, according to Storelvmo, this reinforces the need for urgent reductions in greenhouse-gas emissions.

"Our findings suggest that if we just let greenhouse-gas emissions continue, it won't just be a linear and gradual warming—there could be a rapidly accelerating warming when you get to a certain point," she said. "We really need to avoid reaching that point at all costs."

As new findings on clouds such as these are integrated into models, climate predictions used by policymakers will become more refined.

Provided by Horizon: The EU Research & Innovation Magazine

Citation: Clouds in the sky provide new clues to predicting climate change (2023, March 9) retrieved 3 May 2024 from https://phys.org/news/2023-03-clouds-sky-clues-climate.html