Turbulent Dance of Cloud Droplets

Rama Govindarajan models how turbulence influences the growth of droplets in clouds, information relevant to understanding the influence of these billowy masses on climate.

By Michael Schirber

In her imagination, Rama Govindarajan sees clouds as frenetic dance floors, where water droplets twirl around and fall into each other's arms in a lasting embrace. This "waltz" can change the size of the droplets, leading to darker clouds and eventually to rain. Climate modelers have difficulty simulating this droplet behavior across an entire cloud. But Govindarajan—who works for the Tata Institute of Fundamental Research at the International Centre for Theoretical Sciences, India—can take a small section of the dance floor and precisely determine how the twirling motion of turbulence influences the growth rate of droplets. Her work could help climate scientists better understand the effect of clouds on Earth's temperature.

Govindarajan's fascination with clouds is driven by her desire to understand nature at its most basic level. She spoke with *Physics Magazine* about this "blue-sky research," which ironically focuses on cloudy days and monsoon rains. She also discussed some of the challenges that face women scientists in India.

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All interviews are edited for brevity and clarity.

What do scientists want to know about clouds?

We know that approximately 70% of Earth is covered by clouds at any given time. We don't know if those clouds warm or cool the planet. That's partly because we don't fully understand how large-scale cloud patterns depend on small-scale turbulence inside the cloud. Looking up from the ground, we see these big puffy objects, and we think that they are so innocent and tame, but they are places with violently moving air. We experience that violent turbulence if a plane we are in passes through clouds.

Why study cloud turbulence?

I am interested in the role that turbulence plays in coalescing cloud droplets into rain. A cloud is full of tiny droplets that are about 10 μm across. We need 1 million of these droplets to collide and fuse together to make a single 1-mm-wide raindrop. The problem is that the droplets in clouds are spread out to such an extent that they should collide too infrequently to explain rain formation. Turbulence could help increase the collision rate, but the underlying mechanisms are unclear.

To understand the impact of turbulence on droplet coalescence, scientists must solve the fluid-motion equations, but no computer today can accurately do that for an entire cloud. The

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strategy that my colleagues and I instead take is to focus on a smaller section of a cloud—a meter-wide box—and solve the fluid-motion equations for droplets inside that box.

What do you find in your cloud box?

We find that droplets collide at higher rates in regions around a turbulent vortex. The vortex spins the droplets around and then ejects them along trajectories that cross those of other droplets, resulting in collisions. Because the collision rate depends on the size and strength of the vortex, we can estimate the strength of turbulence required to get droplet growth and eventually rain.

How might your results be used?

Knowing the conditions that lead to rain could help climate modelers estimate the effects of warmer temperatures on cloud lifetimes, as well as on cloud patterns that relate to monsoons and other seasons. Of course, my work won't tell you if it will rain in Bengaluru tomorrow. But it provides a fundamental understanding of some of the messy behavior inside clouds. Explaining things in the simplest terms is the biggest motivator for me.

Are you able to find students who share your love for fundamental science?

Young people in India are often attracted to lucrative careers in computer science and medicine. But there is growing interest in pursuing pure science. I hear more young people saying, "I'll follow my dream," rather than, "I'll study what gives me the best salary."

You have been outspoken about the difficulties facing women in STEM. Can you describe the situation in India?

In the past, scientific institutions rarely hired Indian women for STEM positions. That situation seems to be improving, with universities and research facilities starting to appoint more women scientists.

But the main obstacle for Indian women is their place within the family. It's traditional for parents to give more resources to their sons than to their daughters. This disparity widens when a woman gets married and goes to live with her husband's family. The opportunities are very different for a daughter-in-law compared to a son, as more of the household responsibilities fall on her. I know many women who—even at a late stage in their career, when they've reached a senior position—struggle because they must look after their mother-in-law or father-in-law.

What advice would you give someone thinking of becoming a scientist?

Don't think that you can't do it; you can. Looking for the truth is very important, whether it's a popular belief or not. And of course, like many others who live on Earth, I am terrified about the future of the planet. I think we need more young people studying the climate.

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