the Bulletin

BROOKHAVEN NATIONAL LABORATORY

Vol. 58 - No. 30 August 27, 2004

When it Rains, It Pours

New theory on drizzle formation says a few big drops get all the water

In research that could lead to more accurate weather forecasts and climate models, BNL scientists Robert McGraw and Yangang Liu, both of the Environmental Sciences Department, say that a physical limit on the number of cloud droplets that grow big enough to form drizzle paradoxically makes drizzle form faster. Those few droplets that cross the drizzle "barrier" readily collect enough surrounding droplets to fall — instead of staying stuck in the clouds competing for a limited water supply and never getting quite big enough.

Joseph Rubino D0250804

Robert McGraw (left) and Yangang Liu

McGraw, lead author of the study, presented this research on Thursday, August 26, at the 228th national meeting of the American Chemical Society in Philadelphia, Pennsylvania. The research, which will also be published in an upcoming edition of *Physical Review E*, was funded by the Office of Biological & Environmental Research within DOE's Office of Science.

"Drizzle is an important cloud process that plays a crucial role in regulating Earth's energy balance and water cycle, because drizzle affects how long clouds persist," says McGraw. "So, understanding drizzle formation will help scientists predict both local weather and the effects of clouds on global climate."

Older theories of drizzle formation left scientists with a puzzle: None explained how drizzle could form within the typical cloud lifetime. In these earlier models, droplets simply coagulated with each other to reach larger size. In this process, many droplets are free to begin growing, but they all end up competing for the available cloud water at the same time. This competition prevents any of them from quickly reaching a size large enough to begin falling as drizzle.

The new theory resolves the puzzle through the discovery of a statistical barrier to the number of drops that achieve drizzle size, a barrier that paradoxically speeds up drizzle formation.

Under the new theory, the rate of drizzle drop formation depends on the cloud liquid water content, the droplet concentration, and turbulence. Atmospheric turbulence causes fluctuations in the rates of droplet growth and evaporation in clouds. Once a drop grows large enough to fall under gravity, it begins to collect the smaller cloud droplets that surround it.

This process is called collection and it refers to the volumetric gain of a specified drop large enough to have a significant gravitational fall velocity so as to accrete the smaller, slower falling droplets that typify the main population of the cloud. Collection is thus an additional growth mechanism that, following the axioms 'the rich get richer,' or, 'when it rains, it pours,' becomes available to those relatively few droplets that, through chance fluctuations, reach fall velocity size.

"Those few droplets that do cross the barrier experience less competition for available cloud water and, thus, rapidly reach collection size," McGraw says.

"Of course, if the barrier is too high — as it often is in polluted clouds with high droplet concentrations — then no droplets can cross and drizzle can't form," he adds. "Other things being equal, such drizzle suppression tends to increase the lifetimes of clouds formed in polluted areas, as compared to those formed in unpolluted areas, such as over the ocean." This could have important implications for understanding the climate effects of aerosol pollutants via their influence on cloud lifetime and cloud cover.

In the future, the scientists plan to test the drizzle theory by comparing it with aircraft and remote-sensing data on drizzle formation. They expect that this research will allow weather forecasters and climate modelers to improve their predictions.

— Karen McNulty Walsh