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# A new laboratory facility to study gas-aerosol-cloud interactions in a turbulent environment: The Π Chamber

Dennis Niedermeier (1), Will Cantrell (1,2), Kelken Chang (1), David Ciochetto (1), Jim Bench (3), Raymond Shaw (1,2)

(1) Department of Physics, Michigan Technological University, Houghton, MI, USA, (2) Atmospheric Sciences Program, Michigan Technological University, Houghton, MI, USA, (3) Russells Technical Products, Holland, MI, USA

A detailed understanding of interactions of aerosols, cloud droplets/ice crystals, and trace gases within the turbulent atmosphere is of prime importance for an accurate understanding of Earth's climate system. But despite extensive research activity during the last decades these interactions are still poorly understood and ill quantified. For example: Every cloud droplet in Earth's atmosphere (~$10^{25}$) was catalyzed by a preexisting aerosol particle. While every cloud droplet began as an aerosol particle, not every aerosol particle becomes a cloud droplet. The particle to droplet transformation, known as activation, requires that the particle be exposed to some critical concentration of water vapor, which differs for different combinations of particle size and chemical composition. Similarly, the formation of ice particles in the atmosphere is often catalyzed by aerosol particles, either activated or not. Even in the simplest scenarios it is challenging to gain a full understanding of the aerosol activation and ice nucleation processes, but at least two other factors contribute greatly to the complexity observed in the atmosphere. First, aerosols and cloud particles are not static entities, but are continuously interacting with their chemical environment, and therefore changing in their properties. Second, clouds are ubiquitously turbulent, and therefore thermodynamic and compositional variables, such as water vapor or trace gas concentration, fluctuate in space and time. Indeed, the coupling between turbulence and microphysical processes is recognized as one of the major research challenges in cloud physics today.
We have developed a multiphase, turbulent reaction chamber - called the Π Chamber because of the internal volume of 3.14 $m^3$ (with cylindical wall installed) - designed to address the open issues outlined above. It is capable of pressures ranging from sea level to ~60 mbar, and can sustain temperatures of +55 to -55 ºC, well within the range of mixed phase tropospheric clouds. The chamber can be operated in expansion, static diffusion, or turbulent mode, depending on the requirements of a particular experiment. The turbulent environment is created via a temperature difference between the top and bottom surfaces within the chamber, inducing turbulent Rayleigh-Benard convection. Interior surfaces are electropolished stainless steel to facilitate cleaning before and after chemistry experiments. Supporting instrumentation includes a suite of aerosol generation and characterization techniques, temperature, pressure and humidity sensors, a laser Doppler interferometer, and a holographic cloud particle imaging system.
We will present detailed specifications, an overview of the supporting instrumentation, initial characterization experiments as well as first results of turbulence and cloud droplet size distributions within the chamber.

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