Cloud Microphysics Observational and Modeling Studies: Weather and Climate

CIMMS researchers in the cloud microphysics group are conducting observational and modeling studies to investigate the impact of cloud microphysical processes on weather and climate. **The most fundamental and complex problems in climate and weather research today are our poor understandings of the basic properties of clouds and our inability to determine quantitatively the many effects cloud processes have on weather and climate.** Current climate models indicate that Earth's average surface temperature will warm from 1.5 to 4.5°C by 2100 due to increases in greenhouse gases, with the large uncertainty attributed to different treatments of clouds in climate models. Winter weather significantly impacts the transportation and power industries, schools and businesses, and severe thunderstorms can cause significant damage and flooding. Improved quantitative precipitation forecasts require a greater understanding of how cloud processes and the related energy release affect the structure and dynamics of storms. Research within the cloud microphysics group addresses the overarching theme of clouds and their relation to climate and weather using a combination of field observations, satellite retrievals and numerical modeling studies. *This work aims at making fundamental advances in our understanding of cloud properties and processes, and improving our ability to represent clouds in weather and climate models*.

Current projects in the cloud microphysics group are advancing our understanding of 1) the microphysical structure of snow bands in winter cyclones; 2) the role of cloud microphysical processes in mesoscale convective systems (MCSs) and storms; 3) the properties of tropical clouds (habits, sizes and phases of cloud particles) generated by deep convection; 4) the role of cloud microphysical processes in the rapid intensification of tropical cyclones; 5) processes controlling the amount of supercooled water and freezing drizzle in clouds; 6) how aerosols and other processes affect the evolution of clouds in the Arctic and over the Southern Oceans; 7) the transmission of radiation through the cloudy atmosphere; 8) the representation of clouds in climate and weather models, and especially the development of a stochastic framework for representing cloud processes; 9) the impact of anthropogenic aerosol particles on the water and energy budgets of clouds; 9) the impact of biomass burning aerosols on cloud properties; 10) the retrieval of cloud properties from space-, air- and ground-based remote sensors; 11) the evolution of warm rain; and 12) the use of air- and ship-based instrumentation for measuring the properties of clouds.

In addition to funding from the National Oceanic and Atmospheric Administration (NOAA), funding is also received from the National Science Foundation (NSF), the Department of Energy (DOE), and the National Aeronautics and Space Administration (NASA) for these activities. In the past few years, group members have participated in field projects in Darwin Australia (tropical cirrus), Hobart Australia (Southern Ocean clouds), Cayenne French Guiana (clouds with high ice contents), Swakopmund Namibia (effect of biomass aerosols on cloud properties), Sao Tome Africa (effect of biomass aerosols on cloud properties), Salina Kansas (mesoscale convective systems), Barrow Alaska (arctic mixed-phase clouds), Peoria Illinois (winter storms), and Boulder Colorado (performance of cloud probes). Data collected during these projects are being linked with numerical models having a variety of temporal and spatial scales, including cloud resolving, mesoscale and single column models. Future projects are planned for the Philippines (cloud-aerosol interactions), Kiruna Sweden (cold air outbreaks), Greenland (arctic clouds), Virginia (Nor'easters) and the Galapagos Islands (stratus and cumuli clouds).

Figure 1: Members of the cloud physics group and collaborators in front of the NASA P-3 in São Tomé, Africa during the ObseRvations of Aerosols above CLouds and their IntEractionS (ORACLES) project designed to quantify the impact of biomass burning aerosols from Africa on the persistent stratocumulus deck off the west coast of Africa.

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