Abstract

Clouds and precipitation are among the most challenging aspects of weather and climate prediction. Moreover, our mathematical and physical understanding of clouds is far behind our understanding of a "dry" atmosphere where water vapor is neglected. In this talk, in working toward overcoming these challenges, we present new results on clouds and precipitation from two perspectives: first, in terms of the partial differential equations (PDEs) for atmospheric fluid dynamics, and second, in terms of stochastic models. A new asymptotic limit will be described, and it leads to new PDEs for a precipitating version of the quasi-geostrophic equations, now including phase changes of water. Also, a new energy will be presented for an atmosphere with phase changes, and it provides a generalization of the quadratic energy of a "dry" atmosphere. Finally, it will be shown that the statistics of clouds and precipitation can be described by stochastic differential equations and stochastic PDEs. As one application, it will be shown that, under global warming, the most significant change in precipitation statistics is seen in the largest events – which become even larger and more probable – and the distribution of event sizes conforms to the stochastic models. Such changes have substantial societal consequences, and they can also be quantified in terms of risk ratio.