Geophysical Research Abstracts
Vol. 20, EGU2018-14936, 2018
EGU General Assembly 2018

On the role of mixed-phase clouds in aerosol forcing and climate feedbacks – a combined observational & modeling approach

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Clouds in Earth's atmosphere can be composed of liquid droplet, ice crystals, or a combination of the two. Clouds' thermodynamic phase is largely controlled by temperature, but other factors, most notably ice-nucleating aerosol particles, can also have a significant effect. Because cloud radiative properties are crucially dependent on cloud phase, any cloud phase change, no matter the cause, is bound to have a very powerful impact on Earth's radiation budget. It has been hypothesized that anthropogenic aerosol emissions have impacted mixed-phase clouds since pre-industrial times, and thus imposed a potentially large radiative forcing on Earth's climate. Estimates of how aerosol emissions could have influenced the radiation budget via mixed-phase clouds have recently started to emerge, but so far provide ambiguous forcing estimates, both in terms of magnitude and sign. Intuitively we also expect cloud phase changes to accompany a warming climate, given that temperature exerts a dominant influence on cloud phase. Recent work has revealed that such cloud phase changes represent a very important cloud-climate feedback, particularly at mid- and high latitudes, and that this particular feedback mechanism has been misrepresented in many climate models to date.
I will discuss progress in our understanding of the role of mixed-phase clouds in both climate forcings and feedbacks, from the seminal work of the mid-20th century pioneers in cloud physics to recent breakthroughs made possible by modern satellite missions. I'll end with my view of what is needed next to shed new light on the complicated relationship between mixed-phase clouds and climate.