A numerical study of ice nucleation process and crystal habit for Arctic mixed-phase clouds

*Tempei Hashino[1], Gijs de Boer[2], Hajime Okamoto[1]

1. Kyushu University, 2. Univeristy of Colorado at Boulder

In this presentation, the ice nucleation processes and ice crystal habits are investigated numerically for Arctic mixed-phase stratus. Arctic region is well known for its high sensitivity to climate change and the liquid-containing clouds play an important role in the surface energy budgets as well as at TOA. In our previous studies (de Boer et al. 2010, 2013), it was hypothesized that the immersion freezing process is the key self regulating process where the large droplets freeze quickly and fall out of the super-cooled layer. Our 2D LES experiments highlighted the importance of insoluble characteristics of aerosol particles instead of soluble fraction. However, we did not take into account the condensation freezing (or deliquescence freezing) mode. This time we use a classical nucleation theory approach to deal with the ice nucleation modes more rigorously and implement 3D LES experiments.

The dynamic model is UW-NMS (Tripoli 1992) and the cloud microphysical scheme is AMPS (Hashino and Tripoli 2007, 2008, 2011ab). The ice part of AMPS (SHIPS) is particularly unique in that it predicts ice crystal habits explicitly, thus it is suitable to study ice nucleation process for the mixed-phased clouds. The case studies were chosen from SHEBA (Surface Heat Budget of the Arctic Ocean) and ISDAC (Indirect and Semi-Direct Aerosol Campaign) field campaigns. We will discuss the dominant mode of ice nucleation and resulting habits with parcel model settings and LES experiments. Furthermore, to better understand the applicability of the classical nucleation theory approach to cloud-resolving simulations, we will simulate the same cases with larger spatial resolution.

Keywords: Arctic clouds, Ice nucleation, crystal habit

