EGU24-2859, updated on 14 Oct 2024
https://doi.org/10.5194/egusphere-egu24-2859
EGU General Assembly 2024

Importance of Age of Convective Clouds for Explosive Ice Crystal Number Growth via Secondary Ice Production

Deepak Waman[1,2], Sachin Patade[2], Arti Jadav[2], Vaughan Phillips[2], and Corinna Hoose[1]
[1]Karlsruhe Institute of Technology, Department of Tropospheric Research, Karlsruhe, Germany
[2]Department of Physical Geography and Ecosystem Science, Lund University, Lund, Sweden

In many aircraft studies of natural convective clouds (CCs), it has long been observed that at subzero levels warmer than –38°C, the number concentrations of ice particles exceed the number concentration of available active ice nuclei particles (INPs). This suggests that following initial primary ice formation via INP activity at these levels in CCs, there must be some natural mechanisms present to enhance the number concentration of ice crystals, known as secondary ice production (SIP) mechanisms. SIP may form 1) during riming of supercooled cloud droplets between –3 and –8°C (Hallett-Mossop [HM] process), and during 2) fragmentation of freezing raindrops, 3) ice-ice collision, and 4) sublimation of ice particles. However, the relative importance of these SIP processes may differ for differing cloudy conditions.

The present study discusses the importance of the age of the simulated CCs in their lifecycle to determine which SIP process is active. The degree of enhancement in the number concentrations of ice crystals due to SIP activity is defined using the term called 'ice enhancement' (IE) ratio. A line of CCs observed during the MC3E campaign in 2011 over Oklahoma, USA was simulated using the WRF-based Aerosol-Cloud (AC) model for a 3D mesoscale domain. AC initiates primary ice by predicting the INP activity of solid aerosol particles such as mineral dust, black carbon, and biological particles. Furthermore, AC forms secondary ice from the SIP processes mentioned above. The simulated microphysical characteristics of the MC3E clouds agree well with the coincident aircraft, ground-based, and satellite observations, with errors of ±30%.

It is predicted that for relatively young developing CCs, with their tops warmer than –15°C, the HM process and raindrop-freezing fragmentation dominate the overall ice enhancement, creating an IE ratio as high as 10^4. As the cloud goes through its lifecycle, becoming mature, fragmentation in ice-ice collision becomes prolific, forming IE ratios of about 10^3, both in updraft and downdraft regions. While it is weak (IE ratios < 10) in the updraft regions, fragmentation in sublimation is predicted to create IE ratios of up to about 10^2.