# Natural seeder-feeder process originating from mixed-phase clouds observed with ground-based polarization lidar and radiosonde over Wuhan

**Yun He[(1)], Zhenping Yin[(2)], Fuchao Liu[(1)], Fan Yi[(1)]**

[(1)] *School of Electronic Information, Wuhan University, Wuhan 430072, China., E-mail: heyun@whu.edu.cn*

[(2)] *School of Remote Sensing and Information Engineering, Wuhan University, Wuhan 430072, China.*

The seeder-feeder mechanism is a phenomenon in which ice crystals from an upper cloud, as 'seeds', fall into a lower-lying liquid cloud and then grow larger within the liquid cloud by riming or vapor deposition via the Wegener-Bergeron-Findeisen process. The lower-lying liquid cloud serves as a 'feeder' since it supplies moisture to induce the growth of incoming ice crystals. Natural seeder-feeder processes play an essential role in promoting the icing of clouds, forming and enhancing precipitation. For the natural seeder-feeder mechanism, the significance of cloud seeding in the ice phase and precipitation-formation process has been well reproduced by idealized modeling studies but has not been adequately investigated via field observations. Especially, the cloud-seeding process from mixed-phase clouds is still not well understood due to the lack of sufficient observations.

In this study, we report the natural seeder-feeder processes from mixed-phase clouds (seeder clouds) to lower-lying liquid clouds (feeder clouds) on 19 occasions using ground-based polarization lidar and radiosonde measurements from June 2018 to June 2020 at a mid-latitude plain observatory in Wuhan (30.5°N, 114.4°E), China. The feeder clouds were optically thin, according to our case-selection strategy; therefore, the laser could penetrate them and could then be able to detect the clouds above. In all the cases, the feeder clouds only produced ice virgae when they were seeded so that the ice formation within the feeder cloud must be related to the seeder-feeder process. Ice crystals originating from seeder clouds fell into feeder clouds located 0.2-2.2 km below. The base of the seeder clouds ranged from 3.9 km to 8.9 km. The cloud-base temperatures of the seeder clouds were -3.4 – -23.8℃. During the sedimentation between seeder and feeder clouds, ice crystals partly underwent sublimation when passing through the in-between dry air layers. The feeder clouds inhibited (either alleviated or delayed) those ice crystals from complete sublimation and grew them larger by riming or vapor deposition from a favorable liquid water supply. Subsequently, ice crystals were observed afresh falling from feeder clouds, forming ice virgae descending toward the surface. Owing to cloud seeding, feeder clouds with cloud-top temperatures (CTTs) as warm as -0.2℃– -14.5℃ could produce ice virgae, although these CTTs are generally considered somewhat insufficient to initiate primary ice nucleation. The observed optically thin feeder clouds (with thickness of 0.2-0.6 km) prolonged the survival time/distance of falling ice crystals, indicating that denser feeder clouds may induce enhanced precipitation.