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The single-particle mixing state and cloud scavenging of black carbon at a high-altitude mountain site in southern China

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In the present study, a ground-based counterflow virtual impactor (GCVI) was used to sample cloud droplet residual (cloud RES) particles, while a parallel PM2.5 inlet was used to sample cloud-free or cloud interstitial (cloud INT) particles. The mixing state of black carbon (BC)-containing particles and the mass concentrations of BC in the cloud-free, RES and INT particles were investigated using a single particle aerosol mass spectrometer (SPAMS) and two aethalometers, respectively, at a mountain site (1690 m a.s.l.) in southern China. The measured BC-containing particles were extensively internally mixed with sulfate, and were scavenged into cloud droplets (0.05–0.45) to a similar (or slightly lower) extent as all the measured particles (0.07–0.6) over the measured size range of 0.1–1.6 μm. The results indicate the preferential activation of larger particles and/or that the production of secondary compositions shifts the BC-containing particles towards larger sizes. BC-containing particles with an abundance of both sulfate and organics were scavenged less than those with sulfate but limited organics, implying the importance of the mixing state on the incorporation of BC-containing particles into cloud droplets. The mass scavenging efficiency of BC with an average of 33% was similar for different cloud events independent of the air mass. This is the first time that both the mixing state and cloud scavenging of BC in China have been reported. Our results would improve the knowledge on the concentration, mixing state, and cloud scavenging of BC in the free troposphere.