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The impact of charged aerosols on cloud-condensation nuclei formation with GEOS-Chem

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The ionization caused by Cosmic Rays (CR) in the atmosphere can influence the growth of aerosols that will modify the density of cloud-condensation nuclei (CCN). In fact, the flux of CR in the atmosphere has been reported to correlate with cloud and aerosol properties. Several mechanisms have been proposed and tested to explain this effect, leading to the conclusion that the induced effects were minor. Still, these studies did not completely disprove the link between CR and clouds (i.e., climate). Since then, different mechanisms that could be relevant to aerosol growth have been proposed. One of them is the diffusion-charging mechanism by which aerosols acquire charges by diffusion of atmospheric ions onto their surface. Charging and aerosol coagulation can influence each other and impact the particle charge and size distributions in the atmosphere. Previous works have developed approaches to explicitly solve all the equations governing charge and size distribution in particles. However, since aerosols can acquire a large number of charges, the number of equations to solve would be immense and very computationally expensive. Fortunately, other approaches have also been developed that allow diffusion charging to be implemented more efficiently. In this work, we use for the very first time a global chemistry transport model (GEOS-Chem) to implement the effects of diffusion charging from CR on the microphysical development of aerosols following those approaches. We compare the variations of CCN concentrations between the solar maximum and the solar minimum (i.e., different atmospheric ionization scenarios) to test the sensitivity of the effect. Results indicate that the influence of diffusion charging can be relevant under several atmospheric conditions. In such cases, the change in the concentrations of CCN between the solar maximum (high cosmic-ray flux) and the solar minimum (low cosmic-ray flux) is found to be larger than 1%, which may become relevant for cloud formation.