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Composition and size distribution of wintertime inorganic aerosols at ground and alpine regions of northwest China

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Water-soluble ions (WSIIs) serve as indicators of atmospheric pollution sources, typically constitute 20% to 80% of the total mass concentration within $PM_{2.5}$. WSIIs play a pivotal role in atmospheric chemical reactions, particularly influencing the formation of secondary particulate matter. Alpine regions experience a distinct atmospheric conditions characterized by low temperature, high humidity, and strong solar radiation, differing from those in lowland areas. A comprehensive grasp of the vertical distribution of WSIIs in atmospheric particles holds immense significance in understanding the diffusion and transportation of these pollutants. This study investigates the WSIIs of $PM_{2.5}$ and size-segregated particles at the top (~2060 m a.s.l) and foot of Mt. Hua during the winter of 2020. All the measured ions present significant higher concentrations (1.9~6.9 times) at the foot than the top. Cl^- and K^+ at the foot are more than 4 times of those at the top, whereas Ca^{2+} and Mg^{2+} are only 1.3-1.9 times higher. The particle size distribution of NO_3^-, SO_4^{2-}, K^+ and Cl^- demonstrate a single peak distribution (0.7-1.1 μm) at the foot, but with a bimodal distribution (0.7-1.1 μm and 4.7-5.8 μm) at the top. These differences suggest that the aerosol at the alpine region is mainly transported *via* long-distance from Northwest/North China, but limited influenced by vertical transport through valley breeze. The changes of concentration and size distribution of WSIIs in dust event and non-dust period indicate that the effects of dust event on aerosols at ground surface were weaker than that of the free troposphere of Guanzhong Plain. Notably, our study underscores the dominant influence of NO_3^- in shaping the gas-particle distribution of ammonia within the winter free troposphere. Our results highlight the significant role of long-range transport on aerosols in the free troposphere in Guanzhong Plain, Northwest China.